

# SIEMENS

## SINUMERIK 840D sl

### Basic Functions

#### Function Manual

Valid for

*Control*  
SINUMERIK 840D sl/840DE sl

*Software*  
NCU system software for 840D sl/840DE sl

*Version*  
1.5/2.5

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## Safety Guidelines

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

 <b>DANGER</b>
indicates that death or severe personal injury <b>will</b> result if proper precautions are not taken.
 <b>WARNING</b>
indicates that death or severe personal injury <b>may</b> result if proper precautions are not taken.
 <b>CAUTION</b>
with a safety alert symbol, indicates that minor personal injury can result if proper precautions are not taken.
<b>CAUTION</b>
without a safety alert symbol, indicates that property damage can result if proper precautions are not taken.
<b>NOTICE</b>
indicates that an unintended result or situation can occur if the corresponding information is not taken into account.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

## Qualified Personnel

The device/system may only be set up and used in conjunction with this documentation. Commissioning and operation of a device/system may only be performed by **qualified personnel**. Within the context of the safety notes in this documentation qualified persons are defined as persons who are authorized to commission, ground and label devices, systems and circuits in accordance with established safety practices and standards.

## Prescribed Usage

Note the following:

 <b>WARNING</b>
This device may only be used for the applications described in the catalog or the technical description and only in connection with devices or components from other manufacturers which have been approved or recommended by Siemens. Correct, reliable operation of the product requires proper transport, storage, positioning and assembly as well as careful operation and maintenance.

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## Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

# Preface

## SINUMERIK® Documentation

The SINUMERIK documentation is organized in three parts:

- General documentation
- User documentation
- Manufacturer/service documentation

A monthly updated publications overview with respective available languages can be found in the Internet under:

<http://www.siemens.com/motioncontrol>

Select the menu items "Support" → "Technical Documentation" → "Overview of Publications".

The Internet version of DOConCD (DOConWEB) is available under:

<http://www.automation.siemens.com/doconweb>

Information on the range of training courses and FAQs (frequently asked questions) are available on the Internet under:

<http://www.siemens.com/motioncontrol> under menu item "Support".

## Target group

This publication is intended for:

- Project engineers
- Technologists (from machine manufacturers)
- System startup engineers (Systems/Machines)
- Programmers

## Benefits

The function manual describes the functions so that the target group knows them and can select them. It provides the target group with the information required to implement the functions.

## Standard version

This documentation only describes the functionality of the standard version. Extensions or changes made by the machine tool manufacturer are documented by the machine tool manufacturer.

Other functions not described in this documentation might be executable in the control. This does not, however, represent an obligation to supply such functions with a new control or when servicing.

Further, for the sake of simplicity, this documentation does not contain all detailed information about all types of the product and cannot cover every conceivable case of installation, operation or maintenance.

## Installation

Structure of this Function Manual:

- Inner title (page 3) with the title of the Function Manual, the SINUMERIK controls as well as the software and the version for which this version of the Function Manual is applicable and the overview of the individual functional descriptions.
- Description of the functions in alphabetical order (e.g. A2, A3, B1 etc.)
- Appendix with:
  - List of abbreviations
  - Fax template for feedback for documentation
  - Overview
- Index of terms

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### Note

For detailed descriptions of data and alarm see:

- Machine and setting data:
    - Detailed description of machine data (only electronically on DOConCD or DOConWEB)
  - NC/PLC interface signals:
    - Function Manual, Basic Functions; NC/PLC Interface Signals (Z1)
    - Function Manual, Basic Functions; NC/PLC Interface Signals (Z2)
    - Function Manual, Special Functions; NC/PLC Interface Signals (Z3)
  - Alarms:
    - Diagnostics Manual
-

## Notation of system data

The following notation is applicable for system data in this documentation:

Signal/Data	Notation	Example
NC/PLC interface signals	... NC/PLC interface signal: Signal data (signal name)	When the new gear step is engaged, the following NC/PLC interface signals are set by the PLC program: DB31, ... DBX16.0-2 (actual gear stage A to C) DB31, ... DBX16.3 (gear is changed)
Machine data	... machine data: <Type><Number> <Complete Designator> (<Meaning>)	Master spindle is the spindle stored in the machine data: MD20090 \$MC_SPIND_DEF_MASTER_SPIND (Position of deletion of the master spindle in the channel).
Setting Data	... Setting data: <Type><Number> <Complete Designator> (<Meaning>)	The logical master spindle is contained in the setting data: SD42800 \$SC_SPIND_ASSIGN_TAB[0] (Spindle number converter)

## Data types

The following elementary data types are used in the control system:

Type	Meaning	Value range
INT	Signed integers	-2147483646 ... +2147483647
REAL	Figures with decimal point acc. to IEEE	$\pm(2.2 \cdot 10^{-308} \dots 1.8 \cdot 10^{+308})$
BOOL	Boolean values: TRUE/FALSE	TRUE $\neq$ 0; FALSE = 0
CHAR	1 ASCII character corresponding to the code	0 ... 255
STRING	Character string, number of characters in [...], maximum of 200 characters	Sequence of values with 0 ... 255
AXIS	Axis identifier	Axis identifier for all channel axes
FRAME	Geometrical parameters for translation, rotation, scaling, and mirroring	

Arrays can only be formed from similar elementary data types. Up to 3-dimensional arrays are possible.

## Quantity structure

Explanations concerning the NC/PLC interface are based on the absolute maximum number of sequential components:

- Mode groups (DB11)
- Channels (DB21, etc.)
- Axes/spindles (DB31, etc.)

## Technical Support

If you have any technical questions, please contact our hotline:

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### Note

Country specific telephone numbers for technical support are provided under the following Internet address:

<http://www.siemens.com/automation/service&support>

Calls from the German fixed line network are charged (e.g. at 0.14 €/min).  
Charges of other phone services may be different and may vary.

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## Questions about the manual

If you have any queries (suggestions, corrections) in relation to this documentation, please send a fax or e-mail to the following address:

Fax: +49 9131 - 98 63315

E-mail: <mailto:docu.motioncontrol@siemens.com>

A fax form is available in the appendix of this document.

## SINUMERIK Internet address

<http://www.siemens.com/sinumerik>

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# Various NC/PLC Interface Signals and Functions (A2)

## 1.1 Brief description

### Content

The PLC/NCK interface comprises a data interface on one side and a function interface on the other. The data interface contains status and control signals, auxiliary functions and G functions, while the function interface is used to transfer jobs from the PLC to the NCK.

This Description describes the functionality of interface signals, which are of general relevance but are not included in the Descriptions of Functions.

- Asynchronous events
- Status signals
- PLC variable (read and write)

## 1.2 NC/PLC interface signals

### 1.2.1 General

#### NC/PLC interface

The NC/PLC interface comprises the following parts:

- Data interface
- Function interface

#### Data interface

The data interface is used for component coordination:

- PLC user program
- NC
- HMI (operator components)
- MCP (Machine Control Panel)

Data exchange is organized by the basic PLC program.

#### Cyclic signal exchange

The following interface signals are transferred cyclically, i.e. in the clock grid of the OB1, by the basic PLC program:

- NC and operator-panel-front-specific signals
- Mode group-specific signals
- Channel-specific signals
- Axis/spindle-specific signals

#### NC and operator-panel-front-specific signals (DB10)

PLC to NC:

- Signals for influencing the CNC inputs and outputs
- Keyswitch signals (and password)

NC to PLC:

- Actual values of CNC inputs
- Setpoints of CNC outputs
- Ready signals from NC and HMI
- NC status signals (alarm signals)

### **Channel-specific signals (DB21, ...)**

PLC to NC:

- Control signal "Delete distance-to-go"

NC to PLC:

- NC status signals (NCK alarm active)

### **Axis/spindle-specific signals (DB31, etc.)**

PLC to NC:

- Control signals to axis/spindle (e.g. follow-up mode, servo enable, etc.)
- Control signals to drive (bytes 20, 21)

NC to PLC:

- Status signals from axis/spindle (e.g. position controller active, current controller active, etc.)
- Control signals from drive (bytes 93, 94)

### **Function interface**

The function interface is generated by function blocks (FB) and function calls (FC). Function requests, e.g. to traverse axes, are sent from the PLC to the NC via the function interface.

### **References**

For detailed information about the following subject areas, please refer to:

- Description of the basic PLC program:
  - Function Manual, Basic Functions, Basic PLC Program (P3)
- Description of the event-driven signal exchange (Auxiliary and G functions):
  - Function Manual, Basic Functions; Auxiliary Function Output to PLC (H2)
- Overview of all interface signals, functional and data components:
  - Parameter Manual

## 1.2.2 Ready signal to PLC

### DB10 DBX104.7 (NC-CPU-Ready)

The NC CPU is ready and registers itself cyclically with the PLC.

### DB10 DBX108.1 (HMI-CPU2-Ready)

HMI CPU2 is ready and registers itself cyclically to NC.

**References:**

/FB2/ Function Manual, Extended Functions; Several Control Panels on Multiple NCUs, Decentralized Systems (B3)

### DB10 DBX108.2 (HMI-CPU1-Ready, HMI an MPI)

The HMI CPU1 is ready and registers itself cyclically with the NC. Operator unit connection via MPI interface.

### DB10 DBX108.3 (HMI-CPU1-Ready, HMI at BTSS)

The HMI CPU1 is ready and registers itself cyclically with the NC. Operator unit connection via OPI interface.

### DB10 DBX108.6 (611D-Ready)

Group signal: All available SIMODRIVE 611D drives ready.

Condition: Readiness of all machine axes:

DB31, ... DBX93.5 (Drive Ready) = 1

611D Ready is only output in conjunction with SIMODRIVE 611D drives.

### DB10 DBX108.7 (NC-Ready)

The NC is ready.

### **1.2.3 Status signals to PLC**

#### **DB10 DBX103.0 (remote diagnosis active)**

The HMI component reports to the PLC that the remote diagnostics (option) is active i.e. the control is done via an external PC.

#### **DB10 DBX109.6 (ambient temperature alarm)**

The ambient temperature or fan monitoring function has responded.

#### **DB10 DBX109.7 (NCK battery alarm)**

The battery voltage has dropped below the lower limit value. The control can still be operated. A control system shutdown or failure of the supply voltage will lead to loss of data.

#### **DB10 DBX109.0 (NCK alarm pending)**

The NC signals that at least one NC alarm is pending. The channel-specific interface can be scanned to see which channels are involved and whether this will cause a processing stop.

#### **DB21, ... DBX36.6 (channel-specific NCK alarm pending)**

The NC sends this signal to the PLC to indicate that at least one NC alarm is pending for the affected channel. See also:

DB21, ... DBX36.7 (NCK alarm with processing stop present)

#### **DB21, ... DBX36.7 (NCK alarm with processing stop present)**

The NC sends this signal to the PLC to indicate that at least one NCK alarm, which has interrupted or aborted the current program run (processing stop), is pending for the affected channel.

### 1.2.4 SINUMERIK 840Di-specific interface signals

For a detailed description of the SINUMERIK 840Di-specific interface signals, please refer to:

**References:**

/HBI/ SINUMERIK 840Di Manual

### 1.2.5 Signals to/from panel front

#### DB19 DBX0.0 (screen bright)

The screen blanking is disabled.

#### DB19 DBX0.1 (darken screen)

The operator panel screen is darkened.

If the interface signal is used to actively darken the screen:

- It is no longer possible to switch the screen bright again on the keyboard (see below).
- The first keystroke on the operator panel already triggers an operator action.

---

**Note**

In order to prevent accidental operator actions when the screen is darkened via the interface signal, we recommend disabling the keyboard **at the same time**.

DB19 DBX0.1 = 1 **AND** DB19 DBX0.2 = 1 (key disable)

---

#### Screen darkening via keyboard/automatic screen saver

If no buttons are pressed on the operator panel front within the assigned time (default = 3 minutes):

MD9006 \$MM\_DISPLAY\_BLACK\_TIME

(time for screen darkening), the screen is automatically darkened.

The screen lights up again the first time a button is pressed following darkening. Pressing a button to lighten the screen will not generate an operator action.

Parameterization:

DB19 DBX0.1 = 0

MD9006 \$MM\_DISPLAY\_BLACK\_TIME > 0

#### DB19 DBX0.2 (key disable)

All inputs via the connected keyboard are inhibited.

### **DB19 DBX 0.3/0.4 (Delete cancel alarms/Delete recall alarms)**

Request to delete all currently pending alarms with Cancel or Recall delete criterion. Deletion of the alarms is acknowledged via the following interface signals.

- DB19 DBX20.3 (cancel alarm deleted)
- DB19 DBX20.4 (recall alarm deleted)

### **DB19 DBX0.7 (Actual value in WCS, 0=MCS)**

Switching over of actual-value display between machine and workpiece coordinate system:

- DB19 DBX0.7 = 0: Machine coordinate system (MCS)
- DB19 DBX0.7 = 1: Workpiece coordinate system (WCS)

### **DB19 DBB12 (control of V24 interface) (HMI Embedded only)**

Job interface to control RS-232C. The jobs relate to the user control files in the interface signals:

DB19 DBB14 (control of the V24 interface)

DB19 DBB15 (control of the V24 interface)

### **DB19 DBB13 (control of the file transfer via hard disk) (HMI advanced only)**

Job byte to control file transfer via hard disk. The jobs relate to the user control file in the interface signals:

DB19 DBB16 (parts program handling: Number of the control file for user file names)

DB19 DBB17 (parts program handling: Index of the file to be transmitted from the user list)

### **DB19 DBB14 (control of V24 interface) (HMI Embedded only)**

Description byte to specify the PLC index of the axis, channel or TO number for the standard control file. The standard control file is processed in accordance with the job in the interface signal:

DB19 DBB12

### **DB19 DBB15 (control of the V24 interface) (HMI embedded only)**

Description byte to specify the line in the standard/user control file in which the file to be transferred is stored.

### **DB19 DBB16 (control of file transfer via hard disk) (HMI Advanced only)**

Control byte for file transfer via hard disk to define the index for the control file (job list). This file is handled according to the job in the interface signal:

DB19 DBB13

**DB19 DBB17 (control of file transfer via hard disk) (HMI Advanced only)**

Control byte for file transfer via hard disk to indicate the line in the user control file in which the control file to be transferred is stored

**DB19 DBB24 (control of V24 interface) (HMI Embedded only)**

Status byte for current status of data transfer for "RS-232 ON", "RS-232 OFF", "RS-232 EXTERNAL", "RS-232 STOP", etc., or if an error occurred during data transfer.

**DB19 DBB25 (control of V24 interface) (HMI Embedded only)**

Output byte for RS-232 data transmission error values.

**DB19 DBB26 (control of the file transfer via hard disk) (HMI advanced only)**

Status byte for current status of data transfer for "select", "load" or "unload", or if an error occurred during data transmission.

**DB19 DBB27 (control of the file transfer via hard disk) (HMI advanced only)**

Output byte for error values for data transfer via hard disk.

## 1.2.6 Signals to channel

**DB21, ... DBX6.2 (delete distance-to-go)**

The rising edge on the interface signal generates a stop on the programmed path in the corresponding NC channel with the currently active path acceleration. The path distance-to-go is then deleted and the block change to the next part-program block is enabled.

## 1.2.7 Signals to axis/spindle

### DB31, ... DBX1.0 (drive-test travel enable)

If machine axes are traversed by special test functions such as "function generator", an explicit drive-test-specific enable is requested for the movement:

DB31, ... DBX1.0 = 1 (drive test travel request)

The movement is carried out once the movement is enabled:

DB31, ... DBX1.0 == 1 (drive-test travel enable)

NOTICE
It is the sole responsibility of the machine manufacturer/system startup engineer to take suitable action/carry out appropriate tests to ensure that the machine axis can be traversed during the drive test without putting personnel or machinery at risk.

### DB31, ... DBX1.3 (axis/spindle disable)

#### Axis disable when machine axis is at rest

No traversing request (manual or automatic) is carried out for a machine axis at rest and NC/PLC interface signal:

DB31, ... DBX1.3 == 1 (axis/spindle disable)

The traversing request is maintained. If the axis disable is cancelled when a traversing request is pending DB31, ... DBX1.3 = 0 the movement is carried out.

#### Axis disable when machine axis in motion

When machine axis is in motion and NC/PLC interface signal DB31, ... DBX1.3 == 1 the movement of the machine axis is decelerated to a standstill via the axis-specific brake characteristics currently active or, if it is part of an interpolated path movement or coupling, it is decelerated on a path or coupling-specific basis.

The movement is continued if the axis disable is canceled by another pending traversing request: DB31, ... DBX1.3 = 0.

#### Spindle disable

The response is determined by the current spindle mode:

- Control mode: Speed setpoint = 0
- Positioning mode: See above "Axis disable".

### DB31, ... DBX1.4 (follow-up mode)

"Follow-up mode" is only effective in conjunction with the NC/PLC interface signal:

DB31, ... DBX2.1 (servo enable)

DB31, ... DBX2.1	DB31, ... DBX1.4	Function
1	Ineffective	Normal operation (machine axis in closed-loop control mode)
0	1	Follow-up
0	0	Hold

#### Function: Follow-up

During follow-up, the setpoint position of the machine axis is continuously corrected to the actual position (setpoint position = actual position).

The following interface signals have to be set for the follow-up function:

DB31, ... DBX2.1 = 0 (servo enable)

DB31, ... DBX1.4 == 1 (tracking mode)

Feedback:

DB31, ... DBX61.3 = 1 (follow-up mode active)

---

#### Note

When the servo enable is set from follow-up mode, if the part program is active, the last programmed position is approached again internally in the NC (*REPOSA*: Approach along line on all axes). In all other cases, all subsequent movements start at the current actual position.

---

During "follow-up", clamping or zero-speed monitoring are **not active**.

#### Function: Hold

The hold function does not correct the setpoint position of the machine axis to the actual position. If the machine axis moves away from the setpoint position, a following error (difference between setpoint and actual position) is generated. This error is corrected "suddenly" when the servo enable is set by the position controller, without observing the axial acceleration characteristic.

The following interface signals have to be set for the hold function:

DB31, ... DBX2.1 = 0 (servo enable)

DB31, ... DBX1.4 == 0 (follow-up mode)

Feedback:

DB31, ... DBX61.3 = 0 (follow-up mode active)

During "hold", clamping or zero-speed monitoring are **active**.

NOTICE
--------

With the "hold" function, once the servo enable has been set, the setpoint/actual-value difference is corrected directly by the position controller, i.e. without following the axial acceleration characteristic.
--



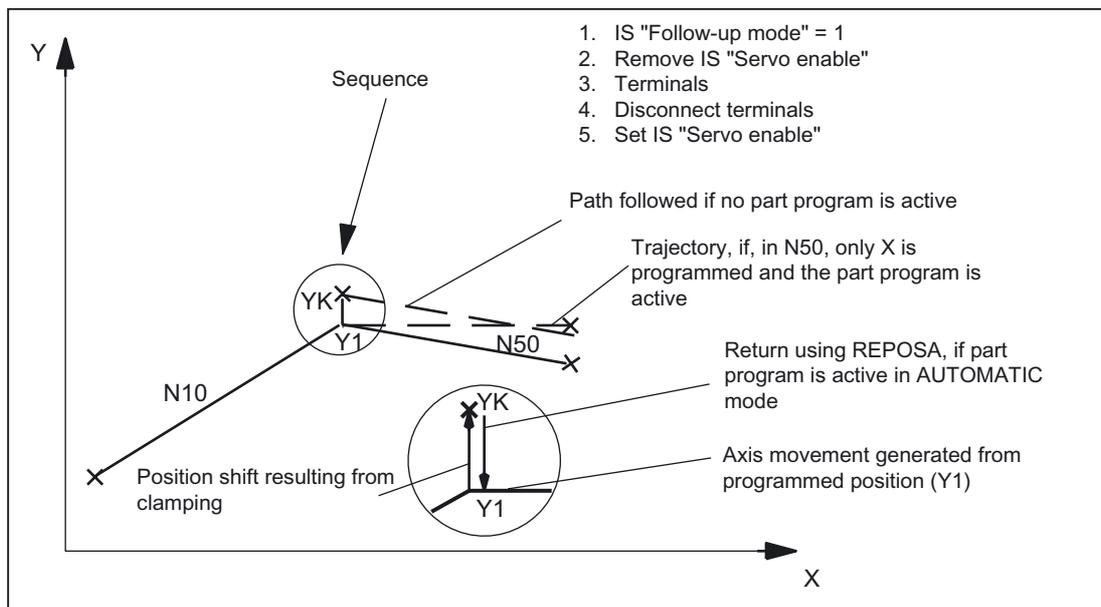


Figure 1-3 Trajectory for clamping and "follow-up"

### Drives with analog setpoint interface

A drive with an analog setpoint interface is capable of traversing the machine axis with an external setpoint. If "follow-up mode" is set for the machine axis, the actual position continues to be acquired. Once follow-up mode has been cancelled, homing is not required.

The following procedure is recommended:

1. Activate follow-up mode:
  - DB31, ... DBX2.1 = 0 (servo enable)
  - DB31, ... DBX1.4 = 1 (follow-up mode) (in the same or preceding OB1 cycle)
  - The axis/spindle is operating in follow-up mode
2. Deactivate external servo enable and external speed setpoint
  - Axis/spindle moves with external setpoint
  - NC continues to detect the actual position and corrects the setpoint position to the actual position
3. Deactivate external servo enable and cancel external speed setpoint
  - Axis/spindle stops
4. Canceling follow-up mode
  - DB31, ... DBX2.1 = 1 (servo enable)
  - DB31, ... DBX1.4 == 0 (follow-up mode)
  - NC synchronizes to current actual position. The next traversing movement begins at this position.

---

**Note**

"Follow-up mode" does not have to be canceled because it only has an effect in combination with "servo enable".

---

**Canceling follow-up mode**

Once follow-up mode has been canceled, the machine axis does not have to be homed again if the maximum permissible encoder limit frequency of the active measuring system was not exceeded during follow-up mode. If the encoder limit frequency is exceeded, the controller will detect this:

- DB31, ... DBX60.4/60.5 = 0 (homed/synchronized 1/2)
  - Alarm: "21610 Encoder frequency exceeded"
- 

**Note**

If "follow-up mode" is deactivated for a machine axis, which is part of an active transformation (e.g. TRANSMIT), this can generate movements as part of repositioning (REPOS) other machine axes involved in the transformation.

---

**Monitoring**

If a machine axis is in follow-up mode, the following monitoring mechanisms will not act:

- Zero-speed monitoring
- Clamping monitoring
- Positioning monitoring

Effects on other interface signals:

- DB31, ... DBX60.7 = 0 (position reached with exact stop fine)
- DB31, ... DBX60.6 = 0 (position reached with exact stop coarse)

**DB31, ... DBX1.5/1.6 (position measuring system 1/2)**

2 measuring systems can be connected to one machine axis, e.g.

- Indirect motor measuring system
- Direct measuring system on load

Only one measuring system can be active at any one time. All closed-loop control, positioning operations, etc. involving the machine axis always relate to the active measuring system.

1.2 NC/PLC interface signals

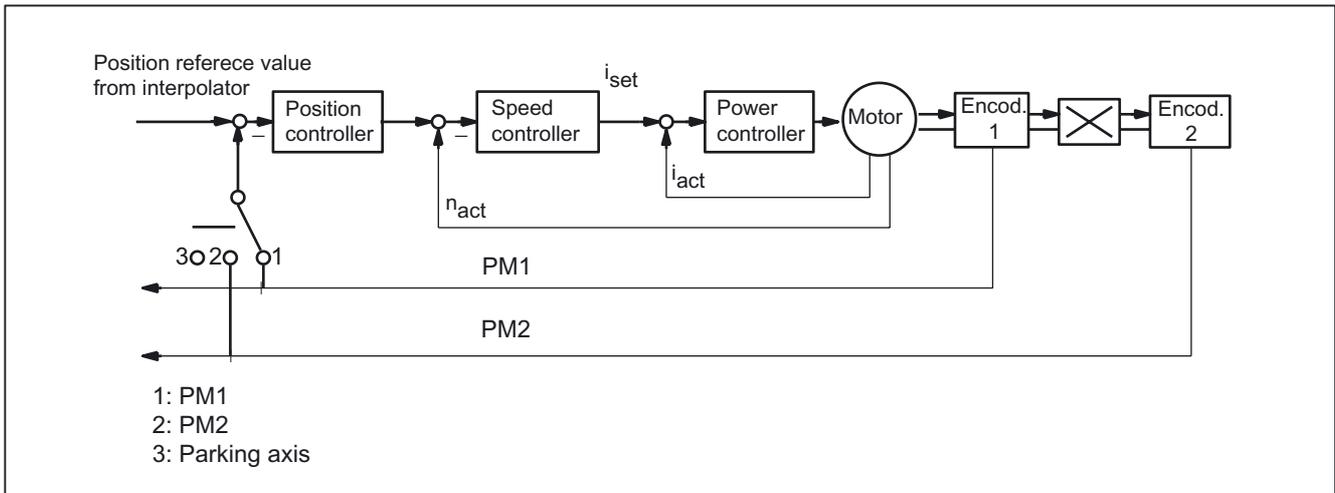


Figure 1-4 Position measuring system 1 and 2

The table below shows the functionality of the interface signals in conjunction with the "servo enable".

DB31, ... DBX1.5	DB31, ... DBX1.6	DB31, ... DBX2.1	Function
1	0 (or 1)	1	Position measuring system 1 active
0	1	1	Position measuring system 2 active
0	0	0	"Parking" active
0	0	1	Spindle without position measuring system (speed-controlled)
1 -> 0	0 -> 1	1	Switchover: Position measuring system 1 → 2
0 -> 1	1 -> 0	1	Switchover: Position measuring system 2 → 1

**DB31, ... DBX2.1 (servo enable)**

Setting the servo enable closes the machine axis position control loop. The machine axis is in position control mode.

DB31, ... DBX2.1 == 1

Canceling the servo enable opens the machine axis position control loop and, subject to a delay, the machine axis speed control loop:

DB31, ... DBX2.1 == 0

**Activation methods**

The closed-loop servo enable for a machine axis is influenced by:

- PLC user program by means of the following NC/PLC interface signals:
  - DB31, ... DBX2.1 (servo enable)
  - DB31, ... DBX21.7 (pulse enable)
  - DB31, ... DBX93.5 (drive ready)
  - DB10, DBX56.1 (EMERGENCY STOP)

- NCK-internal

Alarms that trigger cancellation of the servo enable on the machine axes. Alarms, which cancel the servo enable, are described in:

**References:**

/DA/Diagnostics Manual

**Canceling the servo enable when the machine axis is at standstill:**

- The machine axis position control loop opens
- DB31, ... DBX61.5 = 0 (position controller active)

**Canceling the servo enable when the machine axis is in motion:**

If a machine axis is part of an interpolatory path movement or coupling and the servo enable for this is canceled, all axes involved are stopped with a fast stop (speed setpoint = 0) and an alarm is displayed:

Alarm: "21612 Servo enable reset during movement"

- The machine axis is decelerated taking into account the parameterized temporal duration of the brake ramp for error states with a fast stop (speed setpoint = 0):

MD36610 \$MA\_AX\_EMERGENCY\_STOP\_TIME (max. time duration of the braking ramp in event of errors)

An alarm is displayed:

Alarm: "21612 Servo enable reset during movement"

---

**Note**

The servo enable is canceled at the latest when the cutout time expires:

MD36610 \$MA\_AX\_EMERGENCY\_STOP\_TIME

---

- The machine axis position control loop opens. Interface signal:

DB31, ... DBX61.5 = 0 (position controller active).

The time for the parameterized cut-off delay of the servo enable is started by the machine data:

MD36620 \$MA\_SERVO\_DISABLE\_DELAY\_TIME (switch-off delay servo enable)

- As soon as the actual speed has reached the zero speed range, the drive servo enable is canceled. Interface signal:

DB31, ... DBX61.6 = 0 (speed controller active)

- The position actual value of the machine axis continues to be acquired by the control.

- At the end of the braking operation, the machine axis is switched to follow-up mode, regardless of the corresponding NC/PLC interface signal. Zero-speed and clamping monitoring are not effective. See the description above for the interface signal:

DB31, ... DBX1.4 (follow-up mode).

**Synchronizing the actual value (homing)**

Once the servo enable has been set, the actual position of the machine axis does not need to be synchronized again (homing) if the maximum permissible limit frequency of the measuring system was not exceeded during the time in which the machine axis was not in position-control mode.

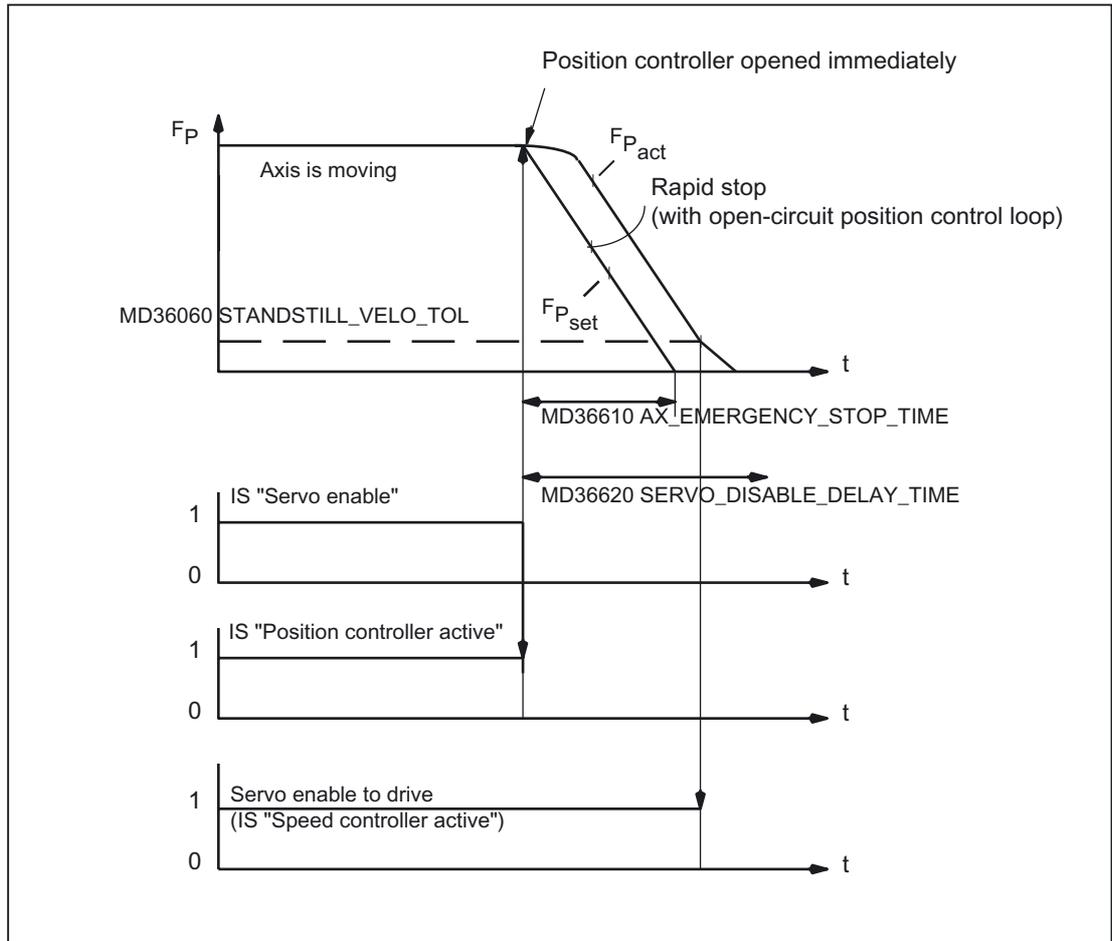


Figure 1-5 Canceling the servo enable when the machine axis is in motion

**DB31, ... DBX2.2 (Delete distance-to-go/Spindle reset (axis-/spindle-specific))**

"Delete distance-to-go" is effective in AUTOMATIC and MDA modes only in conjunction with positioning axes. The positioning axis is decelerated to standstill following the current brake characteristic. The distance-to-go of the axis is deleted.

**Spindle reset**

A detailed description of the spindle reset can be found in:

**References:**

/FB1/ Function Manual, Basic Functions; Spindles (S1)

**DB31, ... DBX9.0/9.1/9.2 (controller parameter set selection)**

The PLC user program sends a **binary** code request via the "controller parameter set selection" to activate the corresponding parameter set of the NC.

DBX9.2	DBX9.1	DBX9.0	Parameter-set number
0	0	0	1
0	0	1	2
0	1	0	3
0	1	1	4
1	0	0	5
1	0	1	6
1	1	0	6
1	1	1	6

Parameter-set changeover must be enabled via the machine data (not required for spindles):

MD35590 \$MA\_PARAMSET\_CHANGE\_ENABLE = 1 or 2

More information about parameter set changeover can be found in:

**References:**

/FB1/ Function Manual, Basic Functions; Spindles (S1);

Chapter: Configurable gear adjustments > parameter set selection during gear stage change

**Parameter set changeover when machine axis is in motion**

The response to a parameter-set changeover depends on the consequential change in the closed-loop control circuit gain factor Kv:

MD32200 \$MA\_POSCTRL\_GAIN (KV-Factor) (KV-Factor)

- "Identical servo gain factors" or "position control not active":

The NC responds immediately to the parameter-set changeover. The parameter set is also changed during the movement.

- "Non-identical servo gain factors" or "position control active":

In order to effect a changeover as smoothly as possible, changeover is not activated until the axis "is stationary", i.e. once the parameterized zero speed has been reached or undershot:

DB31, ... DBX61.4 = 1 (axis/spindle stationary)

MD36060 \$MA\_STANDSTILL\_VELO\_TOL (threshold velocity/speed 'axis/spindle stationary')

**Parameter set changeover from the parts program**

For parameter-set changeover from the parts program, the user (machine manufacturer) must define corresponding user-specific auxiliary functions and evaluate them in the PLC user program. The PLC user program will then set the changeover request on the corresponding parameter set.

More information about auxiliary function output can be found in:

**References:**

/FB1/ Function Manual, Basic Functions; Auxiliary function output (H2)

**DB31, ... DBX9.3 (disable parameter-set default setting by NC)**

Parameter-set changeover request will be ignored.

## 1.2.8 Signals from axis/spindle

**DB31, ... DBX61.0 (drive test travel request)**

If machine axes are traversed by special test functions such as "function generator", an explicit drive-test-specific enable is requested for the movement:

DB31, ... DBX61.0 == 1 (drive test travel request)

The movement is carried out once the movement is enabled:

DB31, ... DBX1.0 == 1 (drive-test travel enable)

**DB31, ... DBX61.3 (follow-up mode active)**

The machine axis is in follow-up mode.

**DB31, ... DBX61.4 (axis/spindle stationary)**

"Axis/spindle stationary" is set by the NC if:

- No new setpoints are to be output **AND**
- The actual speed of the machine axis is lower than the parameterized zero speed:  
MD36060 \$MA\_STANDSTILL\_VELO\_TOL (threshold velocity axis stationary)

**DB31, ... DBX61.5 (position controller active)**

The machine axis position control loop is closed and position control is active.

**DB31, ... DBX61.6 (speed controller active)**

The machine axis speed control loop is closed and speed control is active.

**DB31, ... DBX61.7 (current controller active)**

The machine axis current control loop is closed and current control is active.

**DB31, ...DBX69.0/69.1/69.2 (controller parameter set)**

Active parameter set Coding accordingly:

DB31, ... DBX9.0/9.1/9.2 (controller parameter set selection)

### DB31, ... DBX76.0 (lubrication pulse)

Following a control POWER ON/RESET, the signal status is 0 (FALSE).

The "lubrication pulse" is **inverted** (edge change), as soon as the machine axis has covered the parameterized traversing distance for lubrication:

MD33050 \$MA\_LUBRICATION\_DIST (distance for lubrication by PLC)

## 1.2.9 Signals to axis/spindle (digital drives)

### DB31, ... DBX20.1 (ramp-function generator fast stop)

A "fast stop" is requested for the drive. The drive is then stopped without a ramp function (speed setpoint 0). Servo enable is maintained.

### DB31, ... DBX20.2 (torque limit 2)

Request for torque limit 2. The limit value is specified in the drive parameters.

### DB31, ... DBX20.3 (speed setpoint smoothing)

Request to smooth the speed setpoint.

### DB31, ... DBX21.0/21.1/21.2 (drive parameter set selection A, B, C)

Request to change over drive parameter set:

DBX 21.2	DBX 21.1	DBX21.0	Parameter-set number
0	0	0	1
0	0	1	2
0	1	0	3
0	1	1	4
1	0	0	5
1	0	1	6
1	1	0	7
1	1	1	8

The feedback signal is sent via the interface signals:

DB31, ... DBX93.0,1/93.2 (active drive parameter set)

### DB31, ... DBX21.3/21.4 (Motor selection A, B)

Selection of motor/operating mode.

DBX 21.4	DBX 21.3	Motor number	Operating mode
0	0	1	1
0	1	2	2
1	0	3	3 <sup>1)</sup>
1	1	4	4 <sup>1)</sup>

1) Can only be used on SIMODRIVE 611D Performance2 control module and SIMODRIVE 611U

Only operating modes 1 and 2 are valid on main spindle drive:

- Operating modes 1: Star
- Operating modes 2: Delta

### DB31, ... DBX21.5 (Motor selection done)

The PLC user program sends this signal to the drive to indicate successful motor selection. For example, in the case of star/delta switchover on the SIMODRIVE 611D or 611U, a message or signal must be provided when the motor contactor has switched. The pulses are then enabled by the drive.

### DB31, ... DBX21.6 (integrator disable, n-controller)

The PLC user program inhibits the integrator of the speed controller for the drive. The speed controller is thus switched from PI to P controller.

Note

If the speed controller integrator disable is activated, compensations might take place in certain applications (e.g. if the integrator was already holding a load while stationary).

Feedback via the interface signal:

DB31, ... DBX93.6 = 1 (integrator n-controller disabled)

### DB31, ... DBX21.7 (pulse enable)

The pulse enable for the drive module is only requested if all enable signals (hardware and software) are pending:

- Trigger equipment enable
- Servo and pulse enable (terminal 63)
- Pulse enable (safe operational stop) (terminal 663)
- Stored hardware input
- Setpoint enable (terminal 64)
- "Status ready for traverse" (terminal 72/73)
  - No 611D drive alarm (DClink1 error)

- DC link connected
- Ramp-up completed

See also:

DB31, ... DBX93.7 (pulses enabled)

### 1.2.10 Signals from axis/spindle (digital drives)

#### DB31, ... DBX92.0 (setup mode active)

On the drive, "setup mode" is active.

#### DB31, ... DBX92.1 (ramp-function generator fast stop active)

The drive signals back to the PLC that ramp-function-generator fast stop is active. The drive is thus brought to a standstill without the ramp function (with speed setpoint 0).

#### DB31, ... DBX92.2 (torque limit 2 active)

The drive signals back to the PLC that torque limit 2 is active for the axis/spindle. The torque limit value is defined with the drive parameters.

#### DB31, ... DBX92.3 (speed setpoint smoothing active)

The PLC user program requests speed-setpoint smoothing filter for the axis/spindle. The smoothing is activated in the drive module only under certain conditions.

#### DB31, ... DBX93.0, 1, 2 (active drive parameter set A, B, C)

The drive module sends this checkback to the PLC to indicate which drive parameter set is currently active. With bit combination A, B, C, eight different drive parameter sets can be selected by the PLC for the SIMODRIVE 611D.

#### DB31, ... DBX93.3, 4 (active motor A, B)

The drive module (MSD) sends this checkback to the PLC to indicate which of the 4 motor types or motor operating modes is active.

The following selections can be made on the main spindle drive:

- Star mode (A=0, B=0)
- Delta mode (A=1, B=0)

On the 611D with Performance2 controller module and 611U, combinations A = 0, B = 1 and A = 1, B = 1 may also be selected.

**DB31, ... DBX93.5 (DRIVE ready)**

Checkback signal indicating that the drive is ready. The conditions required for traversing the axis/spindle are fulfilled.

**DB31, ... DBX93.6 (integrator n-controller disabled)**

The speed-controller integrator is disabled. The speed controller has thus been switched from PI to P controller.

**DB31, ... DBX93.7 (pulses enabled)**

The pulse enable for the drive module is available. The axis/spindle can now be traversed.

**DB31, ... DBX94.0 (motor temperature prewarning)**

The motor temperature has exceeded the warning threshold. If the motor temperature remains at this level, the drive will be stopped after a defined time (drive MD) and the pulse enable removed.

**DB31, ... DBX94.1 (heat-sink temperature prewarning)**

The heat-sink temperature has exceeded the warning threshold. The pulse enable will be removed for the drive module in question after 20 seconds.

**DB31, ... DBX94.2 (ramp-up function completed)**

This signal indicates that the actual speed value has reached the new setpoint allowing for the tolerance band set in drive machine data:

MD1426 \$MD\_SPEED\_DES\_EQ\_ACT\_TOL (indicate tolerance band for 'nsoll=nist')

The acceleration procedure is thus completed. Any subsequent speed fluctuations due to load changes will not affect the interface signal.

**DB31, ... DBX94.3 ( $|M_d| < M_{dx}$ )**

This signal indicates that the current torque  $|M_d|$  is lower than the parameterized threshold torque  $M_{dx}$ :

MD1428 \$MD\_TORQUE\_THRESHOLD\_X (threshold torque)

The threshold torque is entered as a percentage of the current speed-dependent torque limitation.

**DB31, ... DBX94.4 ( $|n_{act}| < n_{min}$ )**

This signal indicates that the actual speed  $|n_{act}|$  is lower than the set minimum speed  $n_{min}$ :

MD1418 \$MD\_SPEED\_THRESHOLD\_MIN ( $n_{min}$  for 'nist<nmin' message)

**DB31, ... DBX94.5 ( $|n_{act}| < n_x$ )**

This signal indicates that the actual speed  $|n_{act}|$  is lower than the set threshold speed  $n_x$ :  
MD1417 \$MD\_SPEED\_THRESHOLD\_X (nx for 'nist<nx'message)

**DB31, ... DBX94.6 ( $n_{act} = n_{setp}$ )**

An indication on the the PLC states that the actual speed  $n_{act}$  has reached the new setpoint allowing for the tolerance band set in drive machine data:

MD1426 \$MD\_SPEED\_DES\_EQ\_ACT\_TOL (tolerance band for 'nsoll=nist' message)  
and that it is within the tolerance band.

**DB31, ... DBX94.7 (variable signaling function)**

Using the variable signaling function, it is possible to monitor digitally for any axis any variable from SIMODRIVE 611 to check if it violates a certain threshold and to signal as an interface signal to the PLC.

The variable to be monitored is specified with 611D machine data.

**DB31, ... DBX95.0 (DC link voltage < warning level)**

The drive signals to the PLC that the DC link voltage  $U_{DC\ link}$  has fallen below the DC link undervoltage warning threshold:

MD1604 \$MD\_LINK\_VOLTAGE\_WARN\_LIMIT (ZK link undervoltage warning threshold)

**DB31, ... DBX95.7 ( $i^2t$  monitoring)**

The variable signaling function can be used to protect the power section of the SIMODRIVE 611 universal and SIMODRIVE 611 digital drives against continuous overload. The PLC is signaled for each axis indicating whether the  $i^2t$  monitoring has been initiated.

The variable to be monitored is specified with 611D machine data.

## 1.3 Functions

### 1.3.1 Screen settings

Contrast, monitor type, foreground language, and display resolution to take effect after system startup can be set in the operator panel machine data.

#### Contrast

MD9000 \$MM\_LCD\_CONTRAST (contrast)

For slimline operator panels with a **monochrome** LCD, the contrast to be applied following system startup can be set.

There are 16 different contrast settings (0: dark, 15: light).

#### Monitor type

MD9001 \$MM\_DISPLAY\_TYPE (monitor type)

Indicate the relevant monitor type for optimum color matching.

#### Foreground language

MD9003 \$MM\_FIRST\_LANGUAGE (foreground language)

In case of SINUMERIK 840D/840Di 2 languages are available simultaneously. The foreground language can be used to set the language to be displayed following control ramp-up.

The language can be changed in the DIAGNOSTICS operating area on the HMI user interface. Once the control has ramped up, the foreground language will be restored.

#### Display resolution

MD9004 \$MM\_DISPLAY\_RESOLUTION (display resolution)

The number of places after the decimal point for the position display of the axes is defined in the display resolution. The position display consists of max. 12 characters including sign and decimal point. The number of digits after the decimal point can be set to between 0 and 5.

The default setting for the number of digits after the decimal point is 3, corresponding to a display resolution of 10<sup>-3</sup> [mm] or [degrees].

## REFRESH suppression

MD10131 \$MN\_SUPPRESS\_SCREEN\_REFRESH (screen refresh in case of overload)

Default setting for screen-refresh strategy with high NC utilization:

- Value 0: Refresh of current values is suppressed in **all channels**.
- Value 1: Refresh of current values is suppressed in **time-critical channels**.
- Value 2: Refresh of current values is **never** suppressed.

## 1.3.2 Settings for involute interpolation

### Introduction

The involute of the circle is a curve traced out from the end point on a "piece of string" unwinding from the curve. Involute interpolation allows trajectories along an involute.

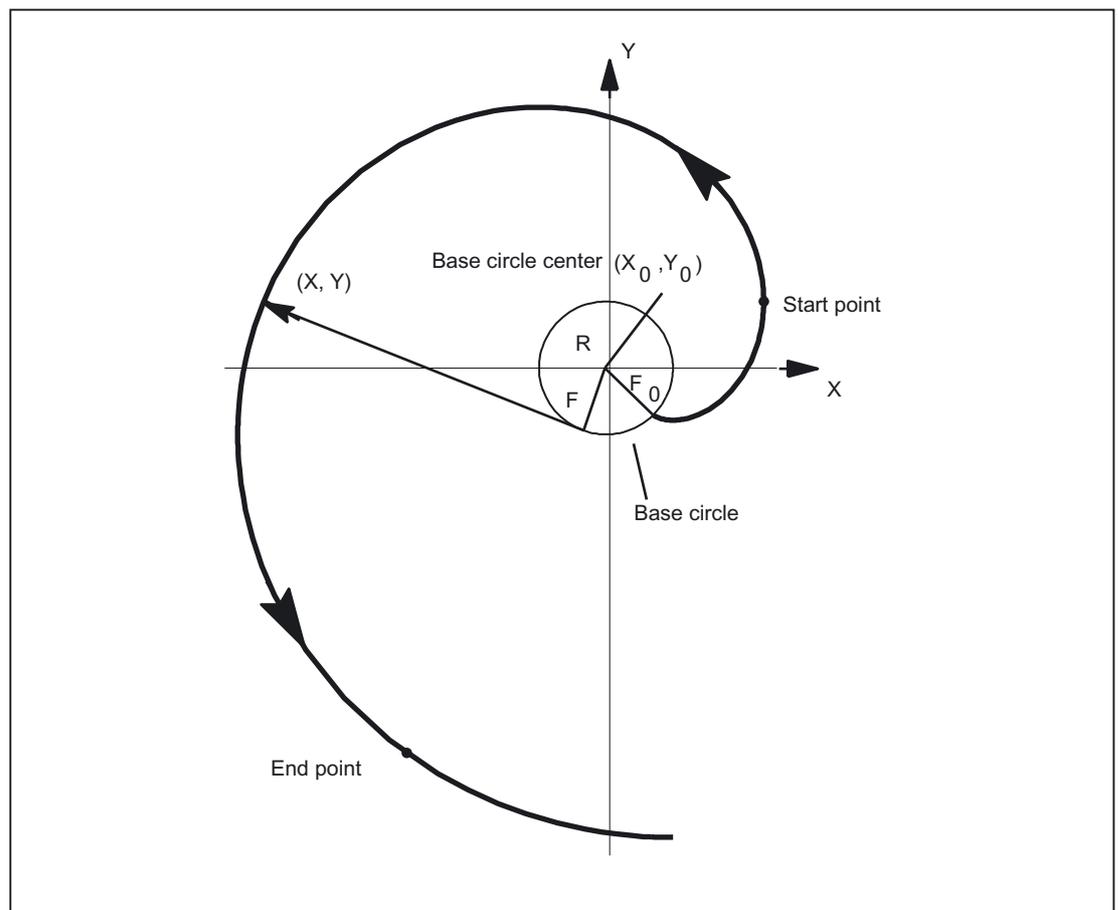


Figure 1-6 Involute (unwound from base circle)

### Programming

A general description of how to program involute interpolation can be found in:

**References:**

/PG/ Programming Manual Fundamentals

In addition to the programmed parameters, machine data are relevant in two instances of involute interpolation; these data may need to be set by the machine manufacturer/end user.

### Accuracy

If the programmed end point does not lie exactly on the involute defined by the starting point, interpolation takes place between the two involutes defined by the starting and end points (see illustration below).

The maximum deviation of the end point is determined by the machine data:

MD21015 \$MC\_INVOLUTE\_RADIUS\_DELTA(end point monitoring for involute)

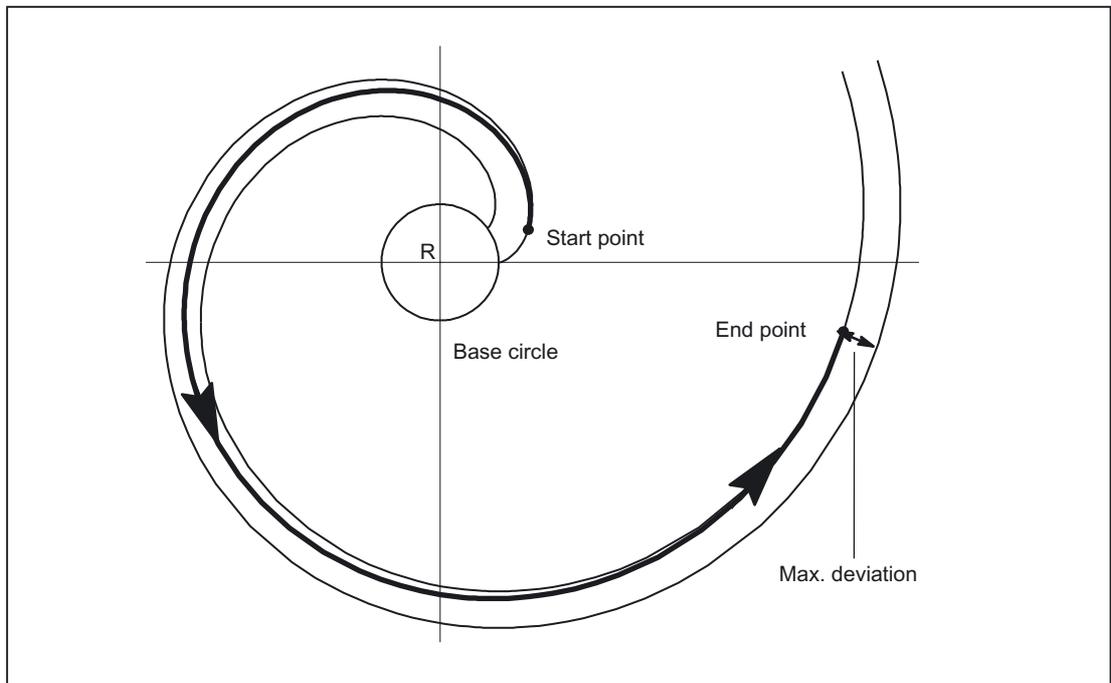


Figure 1-7 MD21015 specifies the max. permissible deviation

### Limit angle

If AR is used to program an involute leading to the base circle with an angle of rotation that is greater than the maximum possible value, an alarm is output and program execution aborted.

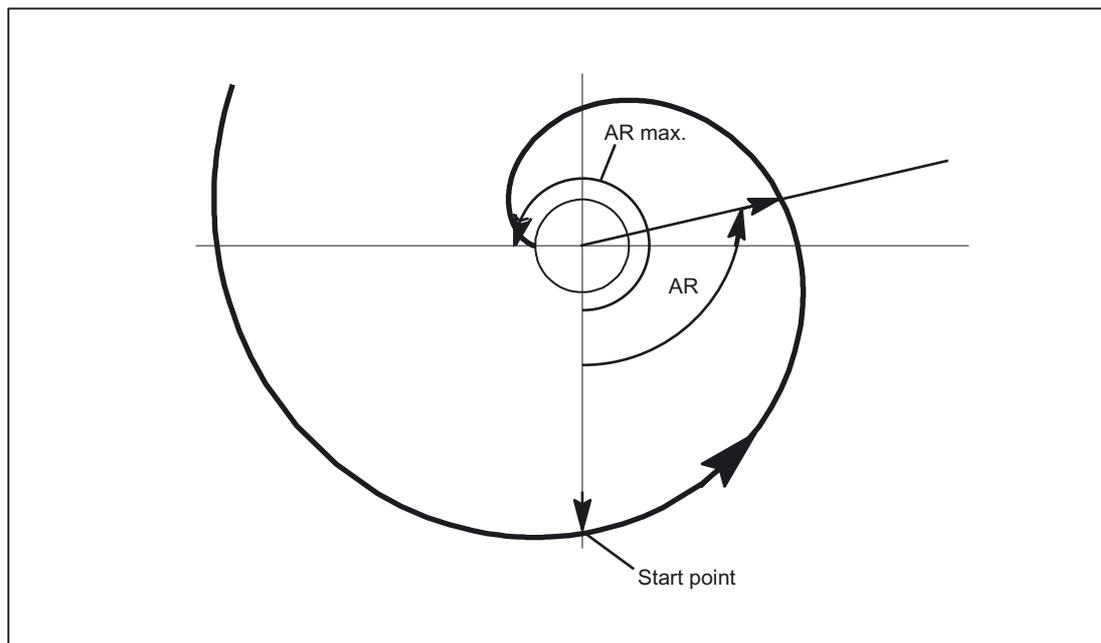


Figure 1-8 Limited angle of rotation towards base circle

The alarm display can be suppressed using the following parameter settings:

MD21016 \$MC\_INVOLUTE\_AUTO\_ANGLE\_LIMIT = TRUE (automatic angle limitation for involute interpolation)

The programmed angle of rotation is then also limited automatically and the interpolated path ends at the point at which the involute meets the base circle. This, for example, makes it easier to program an involute, which starts at a point outside the base circle and ends directly on it.

### Tool radius compensation

2 1/2 D tool-radius compensation is the only tool-radius compensation function permitted for involutes. If 3D tool-radius compensation is active (both circumferential and face milling), when an involute is programmed, machining is interrupted with alarm 10782.

With 2 1/2 D tool-radius compensation, the plane of the involute must lie in the compensation plane. or else alarm 10781 will be generated. It is however permissible to program an additional helical component for an involute in the compensation plane.

### Dynamic response

Involutes that begin or end on the base circle have an infinite curvature at this point. To ensure that the velocity is adequately limited at this point when tool-radius compensation is active, without reducing it too far at other points, the "Velocity limitation profile" function must be activated:

MD28530 \$MC\_MM\_PATH\_VELO\_SEGMENTS > 1 (number of memory elements for limiting the path velocity)

A setting of 5 is recommended. This setting need not be made if only involute sections are used, which have radii of curvature that change over a relatively small area.

### 1.3.3 Activate DEFAULT memory

#### GUD start values

The DEF.../REDEF... NC commands can be used to assign default settings to global user data (GUD). These default settings must be permanently stored in the system if they are to be available after certain system states (e.g. RESET).

The memory space for this is taken from the memory area that was assigned via the machine data:

MD18150 \$MM\_GUD\_VALUES\_MEM (number of additional parameters according to MD18170)

The setting for activating the stored default values is made in machine data:

MD11270 \$MN\_DEFAULT\_VALUES\_MEM\_MASK (activation default values for NC language elements)

#### References:

/FB1/ Function Manual, Basic Functions; S7: "Memory Configuration"

/PGA/ Programming Guide Job Planning

### 1.3.4 Read/write PLC variable

#### High-speed data channel

For high-speed exchange of information between the PLC and NC, a memory area is reserved in the communications buffer on these modules (dual-port RAM). Variables of any type (I/O, DB, DW, flags) may be exchanged within this memory area.

The PLC accesses this memory using 'Function Calls' (FC) while the NCK uses '\$ variables'.

#### Organization of memory area

The user's programming engineer (NCK and PLC) is responsible for organizing (structuring) this memory area.

Every storage position in the memory can be addressed provided that the limit is selected according to the appropriate data format (i.e. a DWORD for a 4-byte limit, a WORD for a 2-byte limit, etc.).

The memory is accessed via the data type and the position offset within the memory area.

## Access from NC

To allow the NC to access PLC variables (from a part program) quickly, \$ variables are provided in the NCK. The PLC uses a function call (FC) to read and write \$ variables. Data are transferred to and from the NCK immediately.

\$ variables can be accessed (by the NCK) during preprocessing and in synchronized actions.

Data type information is determined by the \$ variable data type, the position index is specified as an array index (in bytes).

The following \$ variables are available:

\$A_DBB	Data byte (8 bits)
\$A_DBW	Data word (16 bits)
\$A_DBD	Data double word (32 bits)
\$A_DBR	Real data (32 bits)

## Ranges of values

\$A_DBB(n)	$\leq x \leq 255$
\$A_DBW(n)	$-32768 \leq x \leq 3276$
\$A_DBD(n)	$-2147483648 \leq x \leq 2147483647$

## Access from PLC

The PLC uses function calls (FC) to access the memory. These FCs ensure that data are read and written in the DPR immediately, i.e. not just at the beginning of the PLC cycle. FCs receive data type information and the position offset as parameters.

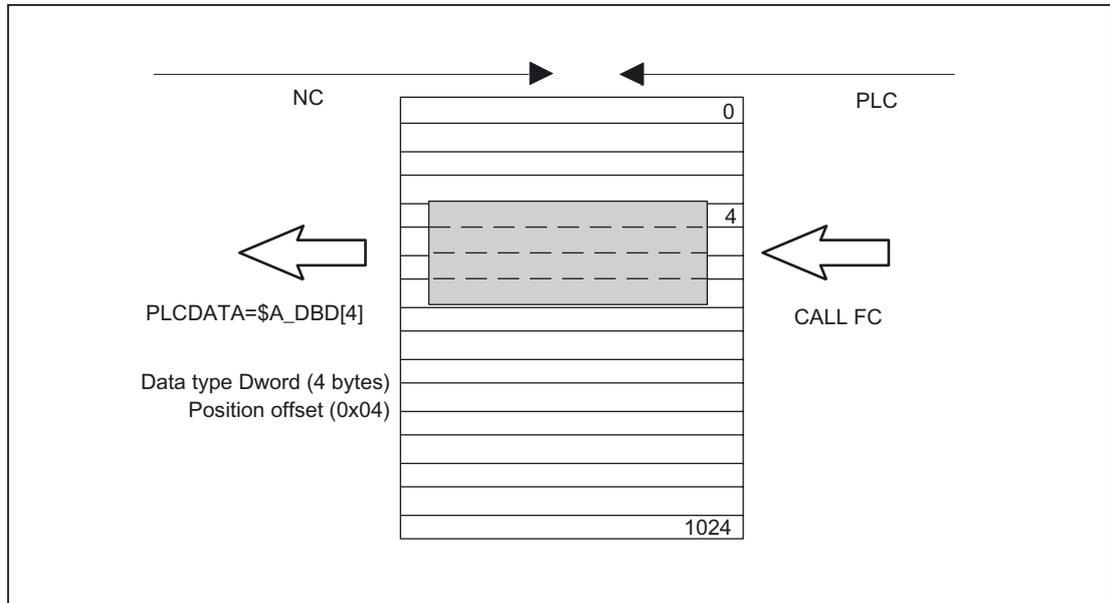


Figure 1-9 Communications buffer (DPR) for NC/PLC communication

### Supplementary conditions

- The user's programming engineer (NCK and PLC) is responsible for organizing the DPR memory area. No checks are made for inconsistencies in the configuration.
- A total of 1024 bytes are available in the input and output directions.
- Single-bit operations are not supported and must be linked back to byte operations by the user (programming engineer).
- Since the contents of variables are manipulated directly in the communications buffer, the user must remember that intermediate changes in values occur as a result of multiple access operations where a variable is evaluated several times or when variables are linked (i.e. it may be necessary to store values temporarily in local variables or R parameters or to set up a semaphore).
- The user's programming engineer is responsible for coordinating access operations to the communications buffer from different channels.
- Data consistency can be guaranteed only for access operations up to 16 bits (byte and word). The user's programming engineer is responsible for ensuring consistent transmission of 32-bit variables (double and real). A simple semaphore mechanism is provided in the PLC for this purpose.
- The PLC stores data in 'Little Endian' format in the DPR.
- Values transferred with \$A\_DBR are subject to data conversion and hence to loss of accuracy. The data format for floating-point numbers is DOUBLE (64 bits) on the NCK, but only FLOAT (32 bits) on the PLC. The format used for storage in the dual-port RAM is FLOAT. Conversion takes place respectively before/after storage in the dual-port RAM.

If a read/write access is made from the NCK to a variable in the dual-port RAM, the conversion is performed twice. It is impossible to prevent differences between read and written values because the data are stored in both formats.

**Example**

Bypassing the problem by means of comparison on "EPSILON" (minor deviation)

Block number	Program code
N10	DEF REAL DBR
N12	DEF REAL EPSILON = 0.00001
N20	\$A_DBR[0]=145.145
N30	G4 F2
N40	STOPRE
N50	DBR=\$A_DBR[0]
N60	IF ( ABS (DBR/145.145-1.0) < EPSILON ) GOTOF ENDE
N70	MSG ( "error" )
N80	M0
N90	END:
N99	M30

**Activation**

The maximum number of simultaneously writable output variables is adjustable via: MD28150 \$MC\_MM\_NUM\_VDIVAR\_ELEMENTS (number of elements for writing PLC variables)

**Example**

A WORD is to be transferred from the PLC to the NC.

The position offset within the NCK input (PLC output area) should be the fourth byte. The position offset must be a whole-number multiple of the data width.

- Writing from PLC:

Program code (extract)	Comment
. . .	
CALL FC21 (	
Enable :=M10.0,	;if TRUE, then FC21 active
Funct :=B#16#4,	
S7Var :=P#M 104.0 WORD1,	
IVAR1 :=04,	
IVAR2 :=-1,	
Error :=M10.1,	
ErrCode :=MW12);	
. . .	
)	

- Reading in part program

Program code (extract)	Comment
. . .	
PLCDATA = \$A_DBW[4];	// Read a word
. . .	

### Behavior during POWER ON, block search

The DPR communications buffer is initialized during "POWER ON".

During a "block search", the PLC variable outputs are collected and transferred to the DPR communications buffer with the approach block (analogous to writing of analog and digital outputs).

Other status transitions have no effect in this respect.

## 1.3.5 Access protection via password and keyswitch

### 1.3.5.1 Access protection via password and keyswitch

#### Access authorization

Access to functions, programs and data is user-oriented and controlled via 8 hierarchical protection levels. These are subdivided into:

- Password levels for Siemens, machine manufacturer and end user
- Keyswitch positions for end user

#### Multi-level security concept

A multi-level security concept to regulate access rights is available in the form of password levels and keyswitch settings.

Protection level	Type	User	Access to (examples)
0	Password	Siemens	All functions, programs and data
1	Password	Machine manufacturer: Development	defined functions, programs and data; for example: entering options
2	Password	Machine manufacturer: Startup engineer	defined functions, programs and data; for example: Bulk of machine data
3	Password	End user: Service	Assigned functions, programs and data
4	Keyswitch position 3	End user: Programmer, machine setter	less than the protection level 0 to 3; established by the machine manufacturer or end user
5	Keyswitch position 2	End user: Skilled operator without programming knowledge	less than the protection level 0 to 3; established by the end user

Protection level	Type	User	Access to (examples)
6	Keyswitch position 1	End user: Trained operator without programming knowledge	Example: Program selection only, tool wear entry, and work offset entry
7	Keyswitch position 0	End user: Semi-skilled operator	Example: no inputs and program selection possible, only machine control panel operable

### Access features

- Protection level 0 provides the greatest number of access rights, protection level 7 the least.
- If certain access rights are granted to a protection level, these protection rights automatically apply to any higher protection levels.
- Conversely, protection rights for a certain protection level can only be altered from a higher protection level.
- Access rights for protection levels 0 to 3 are permanently assigned by Siemens and cannot be altered (default).
- Access rights can be set by querying the current keyswitch positions and comparing the passwords entered. When a password is entered it overwrites the access rights of the keyswitch position.
- Options can be protected on each protection level. However, option data can only be entered in protection levels 0 and 1.
- Access rights for protection levels 4 to 7 are only suggestions and can be altered by the machine tool manufacturer or end user.

#### 1.3.5.2 Password

##### Set password

The password for a protection level (0 – 3) is entered via the HMI user interface.

Example: HMI Advanced

DIAGNOSTIC operating area, softkey: SET PASSWORD

##### References:

/BAD/ Operator's Guide HMI Advanced

### Delete password

Access rights assigned by means of setting a password remain effective until they are explicitly revoked by deleting the password.

Example: HMI Advanced

DIAGNOSTIC operating area, softkey: DELETE PASSWORD

#### References:

/BAD/ Operator's Guide HMI Advanced

#### Note

Access rights and password status (set/deleted) are not affected by POWER OFF/ON!

### Maximum number of characters

A password may contain up to eight characters. We recommend that you confine yourself to the characters available on the operator panel when defining the password. Where a password consists of less than eight characters, the additional characters are interpreted as blanks.

### Defaults

The following default passwords are defined for protection levels 1 to 3:

- Protection level 1: SUNRISE
- Protection level 2: EVENING
- Protection level 3: CUSTOMER

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#### Note

Following NC-CPU ramp-up in commissioning mode (NCK commissioning switch: position 1) the passwords for protection levels 1 – 3 are reset to the default settings. For reasons of data protection, we strongly recommend that you change the default settings.

---

### 1.3.5.3 Keyswitch settings (DB10, DBX56.4 to 7)

#### Key switch

The keyswitch has four positions, to which protection levels 4 to 7 are assigned. The keyswitch comprises a number of keys in a variety of colors, which can be set to different switch positions.

Switch position	Retraction pos.	DB10, DBB56	Protection level
Position 0 	-	Bit 4	7
Position 1 	0 or 1 black key	Bit 5	6
Position 2 	0 or 1 or 2 green key	Bit 6	5
Position 3 	0 or 1 or 2 or 3 red key	Bit 7	4

Figure 1-10 Switch positions 0 to 3

#### Switch positions

Switch position 0 has the most restricted access rights. Switch position 3 has the least restricted access rights.

DB10, DBX56.4/.5/.6/.7 (switch positions 0/1/2/3)

Machine-specific enables for access to programs, data and functions can be assigned to the switch positions. For detailed information, please refer to:

**References:**

/IAM/ Startup CNC Part 2 (HMI); Access Protection

#### Default settings via the PLC user program

The keyswitch switch positions are transferred to the NC/PLC interface via the basic PLC program. The corresponding interface signals can be modified via the PLC user program. In this context, from the point of view of the NC, only one switch position should ever be active, i.e. the corresponding interface signal set to 1. If, from the point of view of the NC, a number of switch positions are active at the same time, switch position 3, i.e. the keyswitch position with the least restricted access rights, will be activated internally by the NC.

1.3 Functions

1.3.5.4 Parameterizable protection levels

**Parameterizable protection level**

The parameter level can be freely parameterized for a variety of functions and data areas. The protection level is set via operator-panel machine data, designated as follows:  
\$MM\_USER\_CLASS\_<Function\_DataArea>

Examples:

\$MM_USER_CLASS_READ_TOA	Read tool offsets
\$MM_USER_CLASS_WRITE_TOA	Write tool offsets
\$MM_USER_CLASS_READ_PROGRAM	Read part programs
\$MM_USER_CLASS_WRITE_PROGRAM	Write/edit part programs

**Default values**

On delivery or following standard commissioning, with very few exceptions, the default value for the protection level will be set to 7, i.e. the lowest protection level.

## 1.4 Examples

### Parameter set changeover

A parameter-set changeover is performed to change the position-control gain (servo gain factor) for machine axis X1 from  $v = 4.0$  to  $K_v = 0.5$ .

### Prerequisites

The parameter set changeover must be enabled by the machine data:

MD35590 \$MA\_PARAMSET\_CHANGE\_ENABLE [AX1] = 1 or 2 (parameter set change possible)

The 1st parameter set for machine axis X1 is set, in accordance with machine data with index "0" NC/PLC interface:

DB31, ... DBX9.0 - DBX9.2 = 0 (controller parameter set)

### Parameter-set-dependent machine data

Parameter-set-dependent machine data are set as follows:

Machine data	Remarks
MD32200 \$MA_POSCTRL_GAIN [0, AX1] = 4.0	Servo gain setting for parameter set 1
MD32200 \$MA_POSCTRL_GAIN [1, AX1] = 2.0	Servo gain setting for parameter set 2
MD32200 \$MA_POSCTRL_GAIN [2, AX1] = 1.0	Servo gain setting for parameter set 3
MD32200 \$MA_POSCTRL_GAIN [3, AX1] = 0.5	Servo gain setting for parameter set 4
MD32200 \$MA_POSCTRL_GAIN [4, AX1] = 0.25	Servo gain setting for parameter set 5
MD32200 \$MA_POSCTRL_GAIN [5, AX1] = 0.125	Servo gain setting for parameter set 6
MD31050 \$MA_DRIVE_AX_RATIO_DENOM [0, AX1] = 3	Denominator load gearbox for parameter set 1
MD31050 \$MA_DRIVE_AX_RATIO_DENOM [1, AX1] = 3	Denominator load gearbox for parameter set 2
MD31050 \$MA_DRIVE_AX_RATIO_DENOM [2, AX1] = 3	Denominator load gearbox for parameter set 3
MD31050 \$MA_DRIVE_AX_RATIO_DENOM [3, AX1] = 3	Denominator load gearbox for parameter set 4
MD31050 \$MA_DRIVE_AX_RATIO_DENOM [4, AX1] = 3	Denominator load gearbox for parameter set 5
MD31050 \$MA_DRIVE_AX_RATIO_DENOM [5, AX1] = 3	Denominator load gearbox for parameter set 6
MD31060 \$MA_DRIVE_AX_RATIO_NUMERA [0, AX1] = 5	Counter load gearbox for parameter set 1
MD31060 \$MA_DRIVE_AX_RATIO_NUMERA [1, AX1] = 5	Counter load gearbox for parameter set 2
MD31060 \$MA_DRIVE_AX_RATIO_NUMERA [2, AX1] = 5	Counter load gearbox for parameter set 3
MD31060 \$MA_DRIVE_AX_RATIO_NUMERA [3, AX1] = 5	Counter load gearbox for parameter set 4
MD31060 \$MA_DRIVE_AX_RATIO_NUMERA [4, AX1] = 5	Counter load gearbox for parameter set 5
MD31060 \$MA_DRIVE_AX_RATIO_NUMERA [5, AX1] = 5	Counter load gearbox for parameter set 6
MD35130 \$MA_AX_VELO_LIMIT [0..5, AX1]	Setting for each parameter set*)
MD32800 \$MA_EQUIV_CURRCTRL_TIME [0..5, AX1]	Setting for each parameter set*)
MD32810 \$MA_EQUIV_SPEEDCTRL_TIME [0..5, AX1]	Setting for each parameter set*)
MD32910 \$MA_DYN_MATCH_TIME [0..5, AX1]	Setting for each parameter set*)

\*) The appropriate line must be specified separately for each parameter set according to the applicable syntax rules.

## Changeover

In order to switch over the position-control gain, the PLC user program selects the 4th parameter set for machine axis X1.

- Request by PLC user program:  
DB31, ... DBX9.0 – DBB9.2 = 3 (controller parameter set)
  - A request to change over to the 4th parameter set is sent for machine axis AX1.
  - The parameter set is changed over once a delay has elapsed.
  - Parameter set 4 is now active, in accordance with machine data with index "3"
- Feedback by NC:  
DB31, ... DBX69.0 – DBX69.2 = 3 (controller parameter set)
  - The NC confirms/acknowledges the parameter-set changeover.

## 1.5 Data lists

### 1.5.1 Machine data

#### 1.5.1.1 Drive-specific machine data

Number	Identifier: \$MD_	Description
1403	PULSE_SUPPRESSION_SPEED	Shut-off speed for pulse suppression
1404	PULSE_SUPPRESSION_DELAY	Time for pulse suppression
1417	SPEED_THRESHOLD_X	$n_x$ for $n_{act} < n_{setp}$ signal
1418	SPEED_THRESHOLD_MIN	$n_{min}$ for $n_{act} < n_{setp}$ signal
1426	SPEED_DES_EQ_ACT_TOL	Tolerance band for $n_{set} = n_{act}$ signal
1427	SPEED_DES_EQ_ACT_DELAY	Delay time $n_{set} = n_{act}$ signal
1428	TORQUE_THRESHOLD_X	Threshold torque
1429	TORQUE_THRESHOLD_X_DELAY	Delay time $n_d < n_{dx}$ signal
1602	MOTOR_TEMP_WARN_LIMIT	Maximum motor temperature
1603	MOTOR_TEMP_ALARM_TIME	Time for motor temperature alarm
1604	LINK_VOLTAGE_WARN_LIMIT	DC link under voltage warning threshold

#### 1.5.1.2 Memory specific machine data

Number	Identifier: \$MM_	Description
HMI Advanced	HMI Embedded	
9000	9000	LCD_CONTRAST Contrast
9001	9001	DISPLAY_TYPE Monitor type
	9002	DISPLAY_MODE External monitor (1: black and white, 2: color)
	9003	FIRST_LANGUAGE Foreground language
9004	9004	DISPLAY_RESOLUTION Display resolution
	9005	PRG_DEFAULT_DIR Basic setting Program directory
	9006	DISPLAY_BLACK_TIME Time setting for screen saver
	9007	TABULATOR_SIZE Tabulator length
9008	9008	KEYBOARD_TYPE Keyboard type (0: OP, 1: MFII/QWERTY)
9009	9009	KEYBOARD_STATE Shift behavior of keyboard during booting
9010		SPIND_DISPLAY_RESOLUTION Display resolution for spindle values
9011	9011	DISPLAY_RESOLUTION_INCH Display resolution for INCH_system of units
9012	9012	ACTION_LOG_MODE Set action mode for action log

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1.5 Data lists

Number	Identifier: \$MM_	Description	
	9013	SYS_CLOCK_SYNC_TIME	System clock synchronizing time
9020	9020	TECHNOLOGY	Basic configuration for simulation and free contour programming
	9030	EXPONENT_LIMIT	Number of places to be displayed without exponent
	9031	EXPONENT_SCIENCE	Technical exponent representation in three steps
	9180	USER_CLASS_READ_TCARR	Protection level read tool carrier offsets general
	9181	USER_CLASS_WRITE_TCARR	Protection level write tool carrier offsets general
9200	9200	USER_CLASS_READ_TOA	Protection level read tool offsets general
9201	9201	USER_CLASS_WRITE_TOA_GEO	Protection level write tool geometry
9202	9202	USER_CLASS_WRITE_TOA_WEAR	Protection level write tool wear data
9203	9203	USER_CLASS_WRITE_FINE	Protection level write fine
9204		USER_CLASS_WRITE_TOA_SC	Protection level change total tool offsets
9205		USER_CLASS_WRITE_TOA_EC	Protection level change tool setup offsets
9206		USER_CLASS_WRITE_TOA_SUPVIS	Protection level change tool-monitoring limit values
9207		USER_CLASS_WRITE_TOA_ASSDNO	Change D No. assigned to a tool edge
9208		USER_CLASS_WRITE_MAG_WGROUP	change wear group magazine location/mag.
9209	9209	USER_CLASS_WRITE_TOA_ADAPT	Protection level write tool adapter data
9210	9210	USER_CLASS_WRITE_ZOA	Protection level write settable zero offset
9211	9211	USER_CLASS_READ_GUD_LUD	Protection level read user variables
9212	9212	USER_CLASS_WRITE_GUD_LUD	Protection level write user variables
9213	9213	USER_CLASS_OVERSTORE_HIGH	Protection level extended overstore
9214	9214	USER_CLASS_WRITE_PRG_CONDIT	Protection level program control
9215	9215	USER_CLASS_WRITE_SEA	Protection level write setting data
	9216	USER_CLASS_READ_PROGRAM	Protection level read part program
	9217	USER_CLASS_WRITE_PROGRAM	Protection level enter part program
9218	9218	USER_CLASS_SELECT_PROGRAM	Protection level part program selection
9219	9219	USER_CLASS_TEACH_IN	Protection level TEACH IN
9220	9220	USER_CLASS_PRESET	Protection level PRESET
9221	9221	USER_CLASS_CLEAR_RPA	Protection level delete R parameters
9222	9222	USER_CLASS_WRITE_RPA	Protection level write R parameters
	9223	USER_CLASS_SET_V24	Protection level for RS-232C interface parameterization
	9224	USER_CLASS_READ_IN	Protection level for import data

Number	Identifier: \$MM_	Description
9225	USER_CLASS_READ_CST	Protection level standard cycles
9226	USER_CLASS_READ_CUS	Protection level user cycles
9227	USER_CLASS_SHOW_SBL2	Skip single block2 (SBL2)
9228	USER_CLASS_READ_SYF	Access level select directory SYF
9229	USER_CLASS_READ_DEF	Access level select directory DEF
9230	USER_CLASS_READ_BD	Access level select directory BD
9231	USER_CLASS_WRITE_RPA_1	Write protection for first RPA area
9232	USER_BEGIN_WRITE_RPA_1	Start of the first RPA area
9233	USER_END_WRITE_RPA_1	End of the first RPA area
9234	USER_CLASS_WRITE_RPA_2	Write protection for second RPA area
9235	USER_BEGIN_WRITE_RPA_2	Start of the second RPA area
9236	USER_END_WRITE_RPA_2	End of the second RPA area
9237	USER_CLASS_WRITE_RPA_3	Write protection for third RPA area
9238	USER_BEGIN_WRITE_RPA_3	Start of the third RPA area
9239	USER_END_WRITE_RPA_3	End of the third RPA area
9240	USER_CLASS_WRITE_TOA_NAME	Change tool designation and duplo
9241	USER_CLASS_WRITE_TOA_Type	Change tool type
9460	PROGRAMM_SETTINGS	Reset-proof data storage for settings in the PROGRAM operating area
9461	CONTOUR_END_TEXT	String to be added to end of contour on completion of input
9478	TO_OPTION_MASK	Variants of tool offsets
9500	NC_PROPERTIES	NC_properties: Bit 0: Digital drives, bit 1: Software start-up switch
9510	USER_CLASS_DIRECTORY1_P	Protection level for network drive 1 for PROGRAM operating area
9511	USER_CLASS_DIRECTORY2_P	Protection level for network drive 2 for PROGRAM operating area
9512	USER_CLASS_DIRECTORY3_P	Protection level for network drive 3 for PROGRAM operating area
9513	USER_CLASS_DIRECTORY4_P	Protection level for network drive 4 for PROGRAM operating area
9516	USER_CLASS_DIRECTORY1_M	Protection level for network drive 1 for MACHINE operating area
9517	USER_CLASS_DIRECTORY2_M	Protection level for network drive 2 for MACHINE operating area
9518	USER_CLASS_DIRECTORY3_M	Protection level for network drive 3 for MACHINE operating area
9519	USER_CLASS_DIRECTORY4_M	Protection level for network drive 4 for MACHINE operating area

1.5 Data lists

1.5.1.3 NC-specific machine data

Number	Identifier: \$MN_	Description
10350	FASTIO_DIG_NUM_INPUTS	Number of active digital NCK input bytes
10360	FASTIO_DIG_NUM_OUTPUTS	Number of active digital NCK output bytes
10361	FASTIO_DIG_SHORT_CIRCUIT	Short-circuit digital inputs and outputs
11120	LUD_EXTENDED_SCOPE	Activate program-global variables (PUD)
11270	DEFAULT_VALUES_MEM_MSK	Active. Function: Save DEFAULT values of GUD.
18150	MM_GUD_VALUES_MEM	Reserve memory space for GUD

1.5.1.4 Channel-specific machine data

Number	Identifier: \$MC_	Description
21015	INVOLUTE_RADIUS_DELTA	NC start disable without reference point
21016	INVOLUTE_AUTO_ANGLE_LIMIT	Automatic angle limitation for involute interpolation
27800	TECHNOLOGY_MODE	Technology in channel
28150	MM_NUM_VDIVAR_ELEMENTS	Number of write elements for PLC variables
28530	MM_PATH_VELO_SEGMENTS	Number of storage elements for limiting path velocity in block

1.5.1.5 Axis/spindle-specific machine data

Number	Identifier: \$MA_	Description
30350	SIMU_AX_VDI_OUTPUT	Output of axis signals for simulation axes
33050	LUBRICATION_DIST	Lubrication pulse distance
35590	PARAMSET_CHANGE_ENABLE	Parameter set definition possible from PLC
36060	STANDSTILL_VELO_TOL	Maximum velocity/speed when axis/spindle stationary
36610	AX_EMERGENCY_STOP_TIME	Length of the braking ramp for error states
36620	SERVO_DISABLE_DELAY_TIME	Cutout delay servo enable

## 1.5.2 System variables

Names	Description
\$P_FUMB	Unassigned part program memory ( <b>Free User Memory Buffer</b> )
\$A_DBB[n]	Data on PLC (data type BYTE)
\$A_DBW[n]	Data on PLC (WORD type data)
\$A_DBD[n]	Data on PLC (DWORD type data)
\$A_DBR[n]	Data on PLC (REAL type data)

## 1.5.3 Signals

### 1.5.3.1 Signals to NC

DB number	Byte.Bit	Description
10	56.7	Keyswitch setting 0 to 3

### 1.5.3.2 Signals from NC

DB number	Byte.Bit	Description
10	103.0	Remote diagnostics active (HMI alarm is pending)
10	103.5	AT box ready
10	103.6	PCU temperature limit
10	103.7	Operator unit battery alarm
10	104.7	NCK CPU Ready
10	108.1	HMI CPU2 Ready (HMI to OPI or MPI)
10	108.2	HMI CPU1 Ready (HMI to MPI)
10	108.3	HMI CPU1 Ready (HMI to OPI, standard connection)
10	108.6	Drive Ready
10	108.7	NC Ready
10	109.0	NCK alarm is active
10	109.5	NCU573 heat-sink temperature alarm
10	109.6	Air temperature alarm
10	109.7	NCK battery alarm

1.5 Data lists

1.5.3.3 Signals to operator panel front

DB number	Byte.Bit	Description
19	0.0	Screen bright
19	0.1	Darken screen
19	0.2	Key disable
19	0.3	Delete Cancel alarms (HMI Advanced only)
19	0.4	Delete Recall alarms (HMI Advanced only)
19	0.7	Actual value in WCS
19	10.0	Programming area selection
19	10.1	Alarm area selection
19	10.2	Tool offset selection
19	10.7	ShopMill control signal
19	12.2	COM2 active (job byte of PLC)
19	12.3	COM1 active (job byte of PLC)
19	12.4	RS-232 stop (job byte of PLC)
19	12.5	RS-232 external (job byte of PLC)
19	12.6	RS-232 OFF (job byte of PLC)
19	12.7	RS-232 ON (job byte of PLC)
19	13.5	Unload part program
19	13.6	Load part program
19	13.7	Part program selection
19	14.7	File system active/passive (for HMI Embedded, always active)
19	16.7	File system active/passive (for HMI Advanced, always passive)
19	44.0	Mode change disable

1.5.3.4 Signals from operator panel front

DB number	Byte.Bit	Description
19	20.1	Screen is dark
19	20.7	Switch over MCS/WCS
19	24.0	Error (Acknowledgment byte for current RS-232 status)
19	24.1	O.K. (Acknowledgment byte for current RS-232 status)
19	24.2	COM2 active (Acknowledgment byte for current RS-232 status)
19	24.3	COM1 active (Acknowledgment byte for current RS-232 status)
19	24.4	RS-232 stop (Acknowledgment byte for current RS-232 status)
19	24.5	RS-232 External (Acknowledgment byte for current RS-232-C status)
19	24.6	RS-232 OFF (Acknowledgment byte for current RS-232 status)
19	24.7	RS-232 ON (Acknowledgment byte for current RS-232 status)
19	26.0	Error (Part program handling status)

DB number	Byte.Bit	Description
19	26.1	O.K. (Part program handling status)
19	26.3	Active (Part program handling status)
19	26.5	Unload (Part program handling status)
19	26.6	Load (Part program handling status)
19	26.7	Select (Part program handling status)
19	42.0	FC9: Measure in JOG mode
19	45.0	FC9 Out: Active
19	45.1	FC9 Out: Done
19	45.2	FC9 Out: Error
19	45.3	FC9 Out: StartErr

### 1.5.3.5 Signals to channel

DB number	Byte.Bit	Description
21, ...	6.2	Delete distance-to-go (channel-specific)

### 1.5.3.6 Signals from channel

DB number	Byte.Bit	Description
21, ...	36.6	Channel-specific NCK alarm is active
21, ...	36.7	NCK alarm with processing stop present
21, ...	318.7	Overstore active

### 1.5.3.7 Signals to axis/spindle

DB number	Byte.Bit	Description
31, ...	1.3	Axis/spindle disable
31, ...	1.4	Follow-up mode
31, ...	1.5	Position measuring system 1
31, ...	1.6	Position measuring system 2
31, ...	2.1	Servo enable
31, ...	2.2	Delete distance-to-go (axis-specific)/Spindle reset
31, ...	1, 2	Parameter set switchover (request)
31, ...	20.0	Ramp-up times
31, ...	20.1	Ramp-function-generator fast stop
31, ...	20.2	Torque limit 2
31, ...	20.3	Speed setpoint smoothing

1.5 Data lists

DB number	Byte.Bit	Description
31, ...	21.2	Drive parameter set selection A, B, C
31, ...	21.4	Motor selection A, B
31, ...	21.5	Motor selection to follow
31, ...	21.6	Speed controller integrator disable
31, ...	21.7	Pulse enable

1.5.3.8 Signals from axis/spindle

DB number	Byte.Bit	Description
31, ...	60.4/60.5	Referenced, synchronized 1/Referenced, synchronized 2
31, ...	61.3	Follow-up mode active
31, ...	64.6/64.7	Traverse command minus/plus
31, ...	61.3	Follow-up mode active
31, ...	61.4	Axis/spindle stops
31, ...	61.5	Position controller active
31, ...	61.6	Speed control loop active
31, ...	61.7	Current controller active
31, ...	1, 2	Parameter set switchover (feedback)
31, ...	76.0	Lubrication pulse
31, ...	92.0	Setup mode active
31, ...	92.1	Ramp-function-generator fast stop active
31, ...	92.2	Torque limit 2 active
31, ...	92.3	Speed setpoint smoothing active
31, ...	93.2	Active drive parameter set A, B, C
31, ...	93.4	Active motor A, B
31, ...	93.5	Drive Ready
31, ...	93.6	Speed controller integrator disabled
31, ...	93.7	Pulses enabled
31, ...	94.0	Motor temperature prewarning
31, ...	94.1	Heat-sink temperature prewarning
31, ...	94.2	Ramp-up function completed
31, ...	94.3	$ M_d  < M_{dx}$
31, ...	94.4	$ n_{act}  < n_{min}$
31, ...	94.5	$ n_{act}  < n_x$
31, ...	94.6	$n_{act} = n_{set}$
31, ...	94.7	Variable signaling function
31, ...	95.0	$U_{DC\ link} < \text{warning threshold}$

## Axis Monitoring, Protection Zones (A3)

### 2.1 Brief description

#### 2.1.1 Axis monitoring functions

##### Function

Comprehensive monitoring functions are present in the control for protection of people and machines:

- Contour monitoring
- Position monitoring
- Zero-speed monitoring
- Clamping monitoring
- Speed-setpoint monitoring
- Actual-velocity monitoring
- Measuring System- Monitoring
- Limit switch monitoring
- Monitoring of the working area limitation

#### 2.1.2 Protection zones

##### Function

With the help of protection zones, elements of the machine (e.g. spindle chuck, tool changer, tool holder, tailstock, movable probe, etc.) and the workpiece can be protected against collisions.

During automatic execution of part programs in the AUTOMATIC or MDI mode, the NC checks at the start of every part-program block whether a collision between protection zones can occur upon moving along the programmed path.

After manual deactivation of an active protection zone, the zone can be entered. After leaving the protection zone, the protection zone automatically becomes active again.

The definition, activation and deactivation of protection zones takes place via part program instructions.

## 2.2 Axis monitoring

### 2.2.1 Contour monitoring

#### 2.2.1.1 Contour error

Contour errors are caused by signal distortions in the position control loop.

Signal distortions can be linear or nonlinear.

#### Linear signal distortions

Linear signal distortions are caused by:

- Speed and position controller not being set optimally
- Different servo gain factors of the feed axes involved in creating the path

With the same servo gain factor for two linear-interpolated axes, the actual position follows the set position along the same path but with a time delay. With different servo gain factors, a parallel offset arises between the set and actual path.

- Unequal dynamic response of the feed drives

Unequal drive dynamic responses lead to path deviations especially on contour changes. Circles are distorted into ellipses by unequal dynamic responses of the two feed drives.

#### Nonlinear signal distortions

Nonlinear signal distortions are caused by:

- Activation of the current limitation within the machining area
- Activation of the limitation of the set speed
- Backlash within and/or outside the position control loop

When traversing a circular path, contour errors occur primarily due to the reversal error and friction.

During movement along straight lines, a contour error arises due to a reversal error outside the position control loop, e.g. due to a tilting milling spindle. This causes a parallel offset between the actual and the set contour. The shallower the gradient of the straight line, the larger the offset.

- Nonlinear friction behavior of slide guides

### 2.2.1.2 Following error monitoring

#### Function

In control engineering terms, traversing along a machine axis always produces a certain following error, i.e. a difference between the set and actual position.

The following error that arises depends on:

- Position control loop gain  
MD32200 \$MA\_POSCTRL\_GAIN (servo gain factor)
- Maximum acceleration  
MD32300 \$MA\_MAX\_AX\_ACCEL (Maximum axis acceleration)
- Maximum velocity  
MD32000 \$MA\_MAX\_AX\_VELO (maximum axis velocity)
- With activated feedforward control: Precision of the path model and the parameters:  
MD32610 \$MA\_VELO\_FFW\_WEIGHT (factor for the velocity feedforward control)  
MD32800 \$MA\_EQUIV\_CURRCTRL\_TIME (Equivalent time constant current control loop for feedforward control)  
MD32810 \$MA\_EQUIV\_SPEEDCTRL\_TIME (equivalent time constant speed control loop for feedforward control)

In the acceleration phase, the following error initially increases when traversing along a machine axis. After a time depending on the parameterization of the position control loop, the following error then remains constant in the ideal case. Due to external influences, more or less large fluctuations in the following error always arise during a machining process. To prevent these fluctuations in the following error from triggering an alarm, a tolerance range within which the following error may change must be defined for the following-error monitoring:

MD36400 \$MA\_CONTOUR\_TOL (Contour monitoring tolerance range)

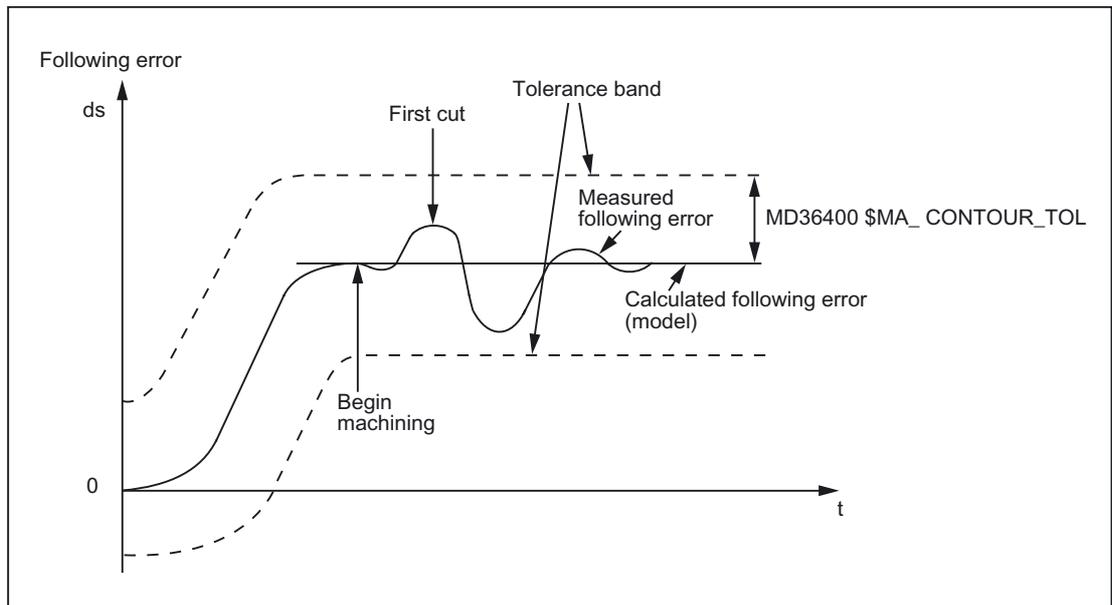


Figure 2-1 Following-error monitoring

### Effectivity

The following-error monitoring only operates with active position control and the following axis types:

- Linear axes with and without feedforward control
- Rotary axes with and without feedforward control
- Position-controlled spindles

### Fault

If the configured tolerance limit is exceeded, the following alarm appears:

25050 "Axis <Axis identifier> Contour monitoring"

The affected axis/spindle is stopped via the configured braking ramp in follow-up mode:

MD36610 \$MA\_AX\_EMERGENCY\_STOP\_TIME

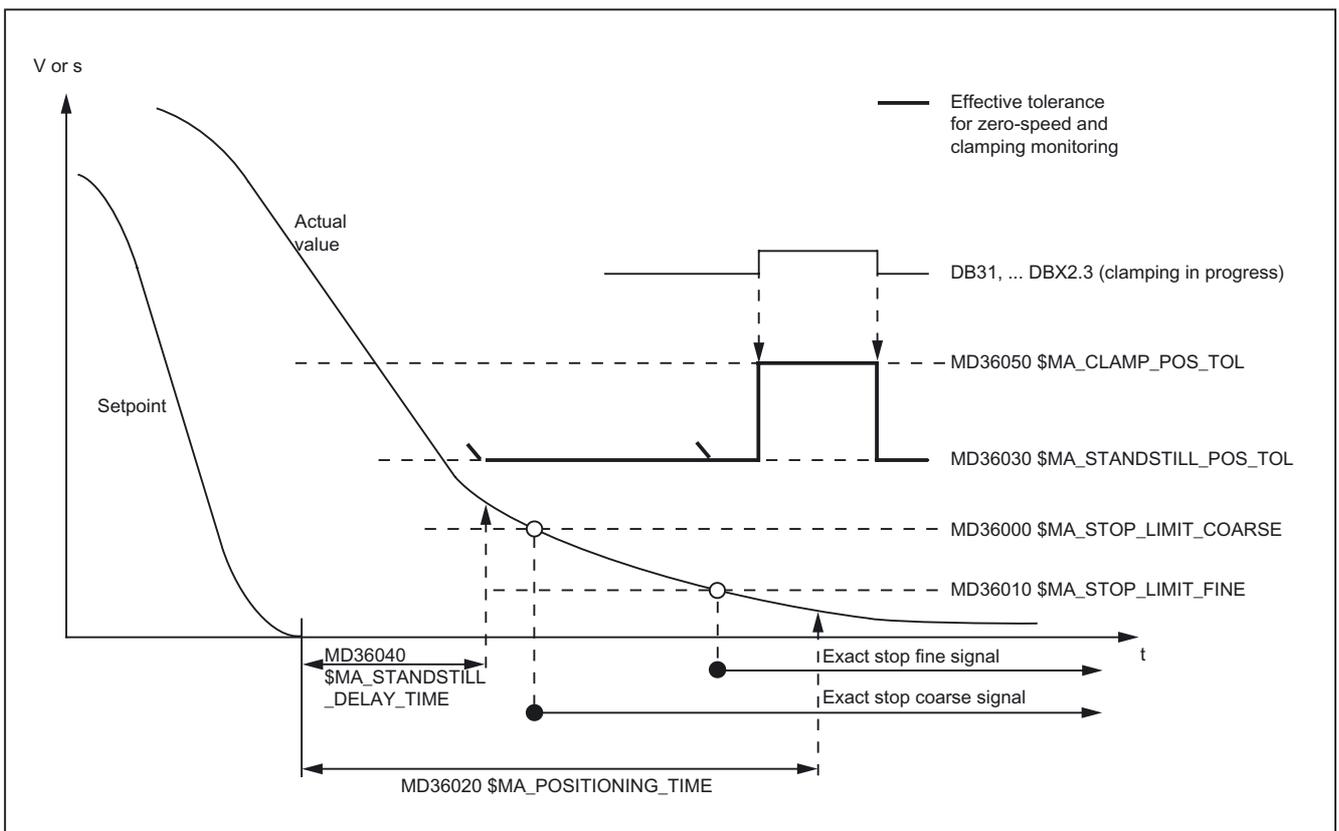
(Maximum time for braking ramp when an error occurs)

## 2.2.2 Positioning, zero speed and clamping monitoring

### 2.2.2.1 Correlation between positioning, zero-speed and clamping monitoring

#### Overview

The following overview shows the correlation between the positioning, zero speed and clamping monitoring functions:



### 2.2.2.2 Positioning monitoring

#### Function

At the end of a positioning operation:

- Set velocity = 0 **AND**
- DB31, ... DBX64.6/64.7 (motion command minus/plus) = 0

checks the position monitoring to ensure that the following error of every participating machine axis is smaller than the exact-stop fine tolerance during the delay time.

MD36010 \$MA\_STOP\_LIMIT\_FINE (exact stop fine)

2.2 Axis monitoring

MD36020 \$MA\_POSITIONING\_TIME (delay time exact stop fine)

After reaching "Exact stop fine", the position monitoring is deactivated.

**Note**

The smaller the exact stop fine tolerance is, the longer the positioning operation takes and the longer the time until block change.

**Rules for MD setting**

MD36010 \$MA_STOP_LIMIT_FINE	MD36020 \$MA_POSITIONING_TIME
large	can be selected relatively short
small	must be selected relatively long

MD32200 \$MA_POSCTRL_GAIN (servo gain factor)	MD36020 \$MA_POSITIONING_TIME
small	must be selected relatively long
large	can be selected relatively short

**Effectivity**

The position monitoring only operates with active position control and the following axis types:

- Linear axes
- Rotary axes
- Position-controlled spindles

**Fault**

If the configured position-monitoring time is exceeded, the following alarm appears:

25080 "Axis <Axis identifier> Position monitoring"

The affected axis is stopped via the configured braking ramp in follow-up mode:

MD36610 \$MA\_AX\_EMERGENCY\_STOP\_TIME  
(Maximum time for braking ramp when an error occurs)

### 2.2.2.3 Zero speed monitoring

#### Function

At the end of a positioning operation:

- Set velocity = 0 **AND**
- DB31, ... DBX64.6/64.7 (motion command minus/plus) = 0

checks the zero-speed monitoring to ensure that the following error of every participating machine axis is smaller than the standstill tolerance during the delay time.

MD36040 \$MA\_STANDSTILL\_DELAY\_TIME (Zero-speed monitoring delay time)

MD36030 \$MA\_STANDSTILL\_POS\_TOL (standstill tolerance)

After reaching the required exact-stop state, the positioning operation is completed:

DB31, ... DBX60.6/60.7 (position reached with exact stop coarse/fine) = 1

The position-monitoring function is deactivated and is replaced by the zero-speed monitoring.

Zero-speed monitoring monitors the adherence to the standstill tolerance. If no new travel request is received, the machine axis must not depart from the standstill tolerance.

#### Effectivity

The zero-speed monitoring only operates with active position control and the following axis types:

- Linear axes
- Rotary axes
- Position-controlled spindles

#### Fault

If the delay time and/or the standstill tolerance is exceeded, the following alarm appears:

25040 "Axis <Axis identifier> Zero-speed monitoring"

The affected axis is stopped via the configured braking ramp in follow-up mode:

MD36610 \$MA\_AX\_EMERGENCY\_STOP\_TIME

(Maximum time for braking ramp when an error occurs)

#### 2.2.2.4 Exact stop and standstill tolerance dependent on the parameter set

##### Common factor for position tolerances

For adaptation to different machining situations and/or axis dynamics, e.g.:

- Operating state A: High precision, long machining time
- Operating state B: Lower precision, shorter machining time
- Changing of the mass relationships after gear change

the positioning tolerances:

- MD36000 \$MA\_STOP\_LIMIT\_COARSE (exact stop coarse)
- MD36010 \$MA\_STOP\_LIMIT\_FINE (exact stop fine)
- MD36030 \$MA\_STANDSTILL\_POS\_TOL (standstill tolerance)

can be weighted with a common factor depending on the parameter set:

MD36012 \$MA\_STOP\_LIMIT\_FACTOR (exact stop coarse/fine and standstill factor)

Because the factor applies in common for all three position tolerances, the relationship between the values remains constant.

#### 2.2.2.5 Clamping monitoring

##### Clamping monitoring

For machine axes that are mechanically clamped upon completion of a positioning operation, larger motions can result from the clamping process (> standstill tolerance). As a result, zero-speed monitoring is replaced by clamping monitoring during the clamping process.

Clamping monitoring monitors the adherence to the configured clamping tolerance:

MD36050 \$MA\_CLAMP\_POS\_TOL (Clamping tolerance)

##### Activation

The clamping monitoring is activated by the following interface signal:

DB31, ... DBX2.3 (clamping in progress)

---

##### Note

The clamping monitoring is not active in "follow-up mode" (DB31, ... DBX1.4 = 1).

---

## Fault

If the clamping tolerance is exceeded, the following alarm appears:

26000 "Clamping monitoring"

The affected axis is stopped via the configured braking ramp in follow-up mode:

MD36610 \$MA\_AX\_EMERGENCY\_STOP\_TIME

(Maximum time for braking ramp when an error occurs)

## Automatic stopping for removal of the clamp

If a clamped axis must be traversed again in continuous-path mode, the NC stops the path motion for Look Ahead at the start of the motion block of the clamped axis until the clamped axis can once again be traversed. If the clamping is released before stopping, the path motion is not stopped.

### Parameterization:

MD36052 \$MA\_STOP\_ON\_CLAMPING = 'H01' (Special function for clamped axis)

---

### Note

The NC detects whether an axis is clamped based on the "servo enable" state of the axis:

DB31, ... DBX2.2 = 0: no servo enable ⇒ axis is clamped

DB31, ... DBX2.2 = 1: servo enable ⇒ axis is not clamped

---

### Prerequisites for the PLC user program

- The axis is always removed from the clamp when a travel command is pending.
- The following is always valid for the axis:

DB31, ... DBX2.2 (servo enable) = 0: Axis is clamped.

DB31, ... DBX2.2 (servo enable) = 1: Axis is not clamped.

The following image shows an example of the interface signals and states upon releasing of the axis clamp:

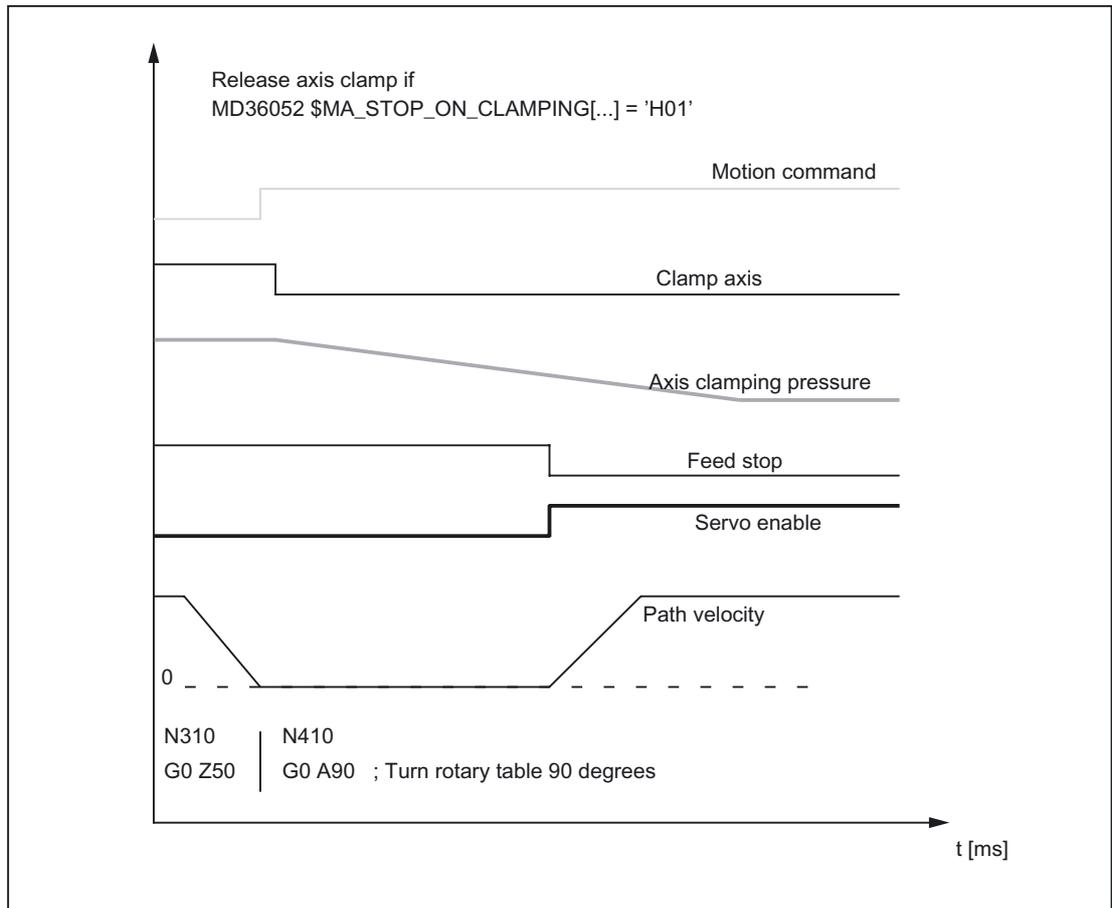


Figure 2-2 Release axis clamp if MD36052 \$MA\_STOP\_ON\_CLAMPING = 'H01'

The part-program blocks N310 and N410 refer to the following programming example:

```

N100    G0 X0 Y0 Z0 A0 G90 G54 F500
N101    G641 ADIS=.1 ADISPOS=5
N210    G1 X10 ; Edit
N220    G1 X5 Y20
N310    G0 Z50 ; Retraction
N410    G0 A90 ; Turn rotary table
N510    G0 X100 ; Approach
N520    G0 Z2
N610    G1 Z-4 ; Edit
N620    G1 X0 Y-20
    
```

### Optimized releasing of the axis clamp via travel command

If a clamped axis is to be traversed in continuous-path mode, a travel command is issued for the clamped axis in the rapid traverse blocks (G0) immediately before the traversing block of the clamped axis. This way, the PLC user program can release the axis clamp again in time. (The travel command is set a maximum of two rapid travers blocks prior (including intermediate blocks) to retain the reference to the initiating part program block).

#### Parameter assignment:

MD36052 \$MA\_STOP\_ON\_CLAMPING = 'H03' (Special function for clamped axis)

#### Prerequisites regarding the PLC Application programs

- The axis is removed from the clamp as soon as a travel command is pending.
- The axis may be removed from the clamp even if only during positioning (G0).

The following image shows an example of the interface signals and states upon releasing of the axis clamp:

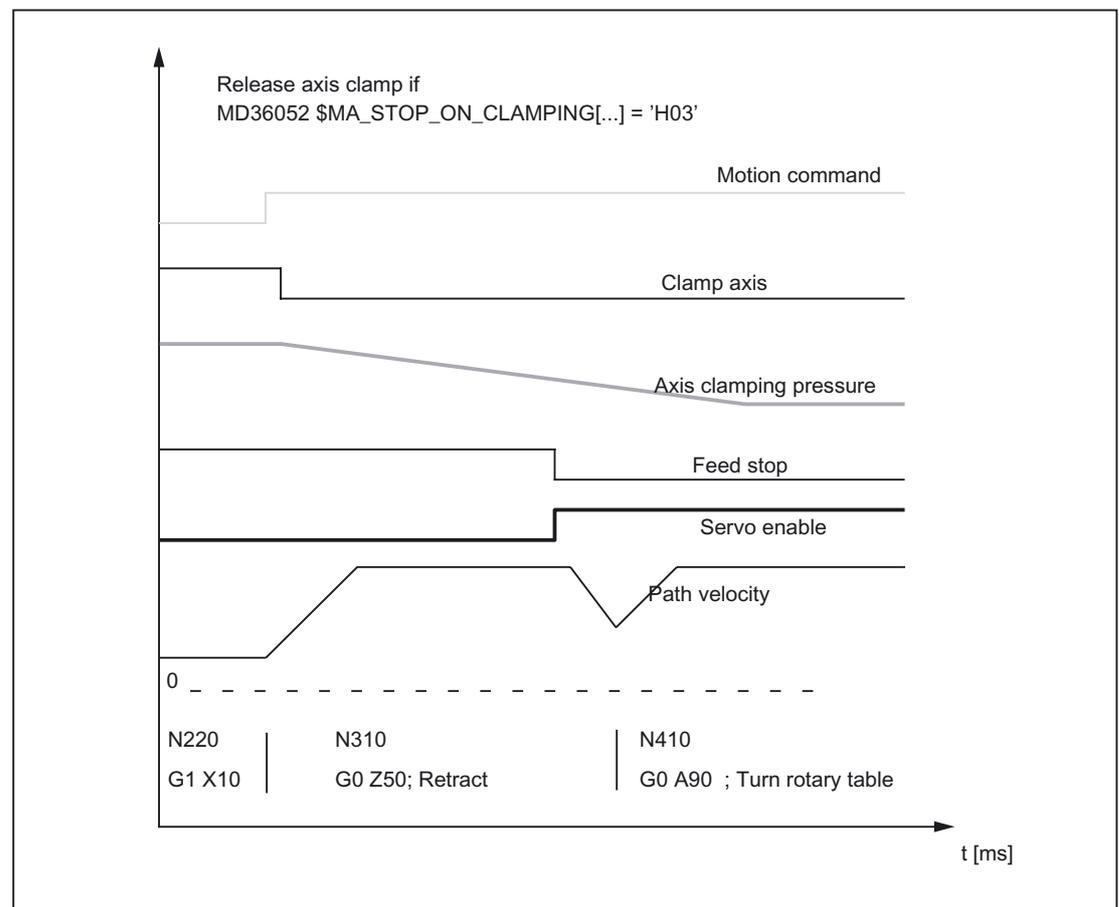


Figure 2-3 Release axis clamp if MD36052 \$MA\_STOP\_ON\_CLAMPING = 'H03'

### Automatic stopping for setting of the clamp

If an axis is to be clamped in continuous-path mode, the NC stops the path motion before the next "Non-rapid traverse block" if the axis has not been clamped by then, i.e. the PLC has set the feedrate override value to zero.

#### Parameter assignment:

MD36052 \$MA\_STOP\_ON\_CLAMPING = 'H04' (Special function for clamped axis)

#### Prerequisites regarding the PLC Application programs

- The axis is always clamped when no travel command is pending.
- The axis does not have to be clamped during positioning of the other axes.

It can be seen whether the axes are being positioned depending on whether rapid traverse (G0) is programmed.

The stop command is therefore not set immediately at the beginning of the block containing the axis, but at the beginning of the next machining block (traversing block, that is not traversed with rapid traverse).

- The axis is clamped if the feed rate override of a machining block is not equal to 0.

If the axis is clamped before the next machining block, i.e. the feedrate override is other than 0 again, no stop is generated.

The following image shows an example of the interface signals and states upon setting of the axis clamp. The part program blocks N410, N510, N520 and N610 refer to the schematic example under certain boundary conditions.

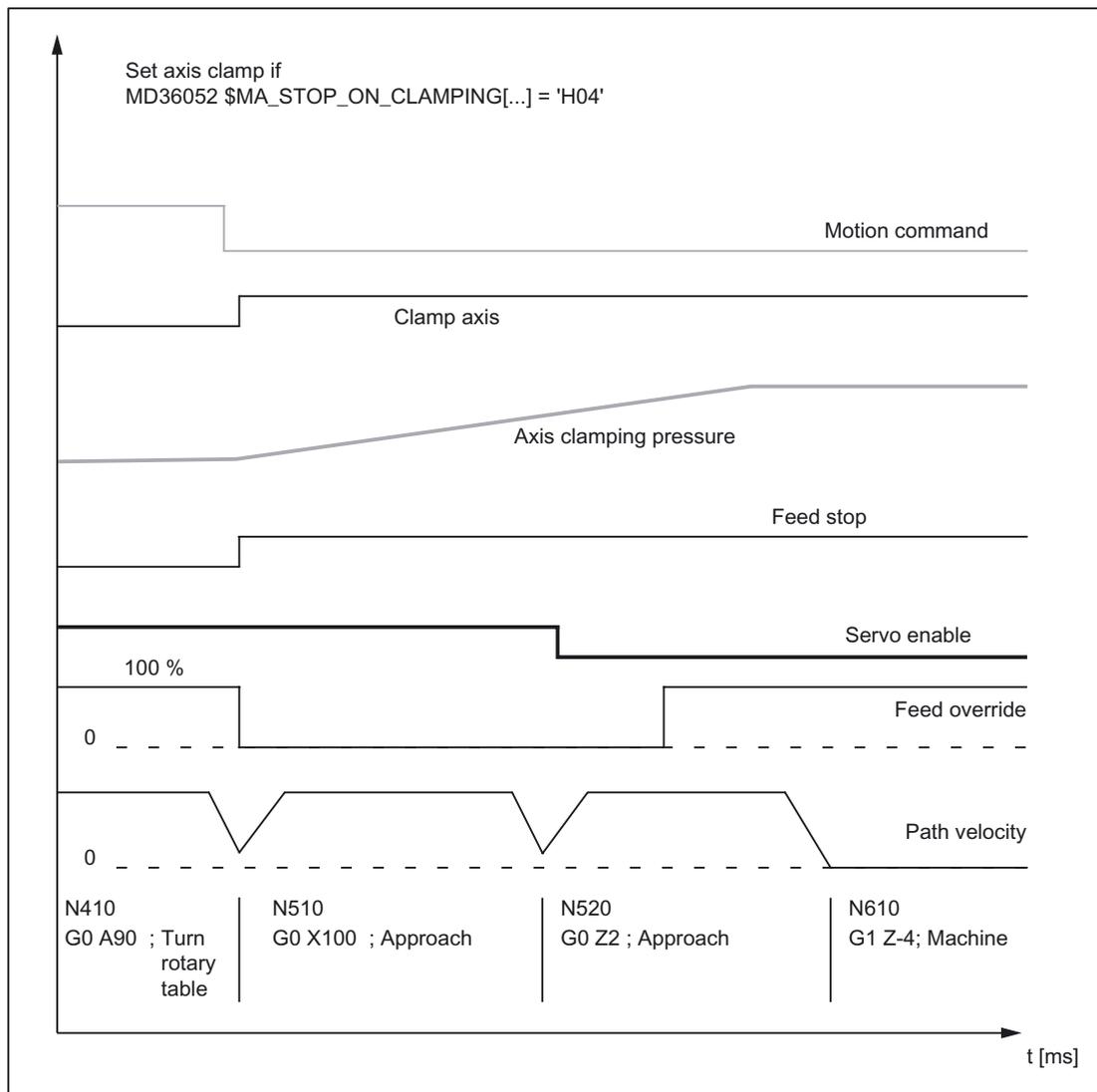


Figure 2-4 Set axis clamp if MD36052 \$MA\_STOP\_ON\_CLAMPING = 'H04'

## Constraints

### Continuous-path mode

For the above-mentioned functions:

- Automatic stopping for releasing the clamps
- Optimized release of the axis clamp through traverse command
- Automatic stopping for setting the clamps

the "Look Ahead" function must be active.

Part-program blocks without path motion (e.g. M82/M83) interrupt continuous-path mode and thus also the "Look Ahead" function.

Example:

The part-program blocks N320 and N420 are inserted in the programming example used.

```

N100      G0 X0 Y0 Z0 A0 G90 G54 F500
N101      G641 ADIS=.1 ADISPOS=5
N210      G1 X10                                ; Edit
N220      G1 X5 Y20
N310      G0 Z50                                ; Retract
N320      M82                                    ; no path motion
N410      G0 A90                                ; Turn rotary table
N420      M83                                    ; no path motion
N510      G0 X100                               ; Approach
N520      G0 Z2
N610      G1 Z-4                                ; Edit
N620      G1 X0 Y-20
    
```

The function behaves as follows:

- MD36052 \$MA\_STOP\_ON\_CLAMPING = 'H03'

No longer has an effect.

The travel command is set in Look Ahead mode only for blocks with active continuous-path mode. M82 generates a stop and thus interrupts the continuous-path mode. The Look Ahead stopping on N410 would not be necessary because stopping occurs anyway.

- MD36052 \$MA\_STOP\_ON\_CLAMPING = 'H04'

Generates a stop irrespective of M83, which is executed as a function of "feedrate override 0%". The axis is thus stopped before the first machining block.

---

#### Note

#### MD36052 \$MA\_STOP\_ON\_CLAMPING = 'H01' or 'H04'

Both functions can be used irrespective of the clamping of axes:

- MD36052 \$MA\_STOP\_ON\_CLAMPING = 'H01'

Generates a Look Ahead stop for the path motion if no servo enable signal is active for the relevant axis.

- MD36052 \$MA\_STOP\_ON\_CLAMPING = 'H04'

Generates a Look Ahead stop for the path motion if the feed rate overrate = 0% at the transition from the part-program blocks with rapid traverse to part-program blocks without rapid traverse.

Both functions ensure that the path motion in continuous-path mode is already stopped before the start of the relevant part-program block and not just within the part-program block.

---

**Block-change criterion: Clamping tolerance**

After activation of clamp monitoring:(DB31, ... DBX2.3 = 1) the block-change criterion for traversing blocks, in which the axis stops at the end of the block, no longer acts as the corresponding exact-stop condition but the configured clamping tolerance:

MD36050 \$MA\_CLAMP\_POS\_TOL (clamping tolerance with interface signal "Clamping active")

**Behavior upon releasing of the clamp**

If the axis was moved by the clamping process, it is returned by the NC to the position setpoint after releasing of the clamp and setting of the servo enable state. Repositioning depends on whether "Follow-up mode" was activated for the axis:

Without follow-up mode:	Repositioning by position controller
With follow-up mode:	Repositioning by interpolator

See also interface signal:

DB31, ... DBX1.4 (follow-up mode)

**Note**

The following interface signals can be evaluated by the PLC user program as the criterion for activation of the "Follow-up mode":

DB31, ... DBX60.6/60.7 (position reached with exact stop coarse/fine)

### 2.2.3 Speed-setpoint monitoring

#### Function

The speed setpoint comprises:

- Speed setpoint of the position controller
- Speed setpoint portion of the feedforward control (with active feedforward control only)
- Dift compensation (only for drives with analog setpoint interface)

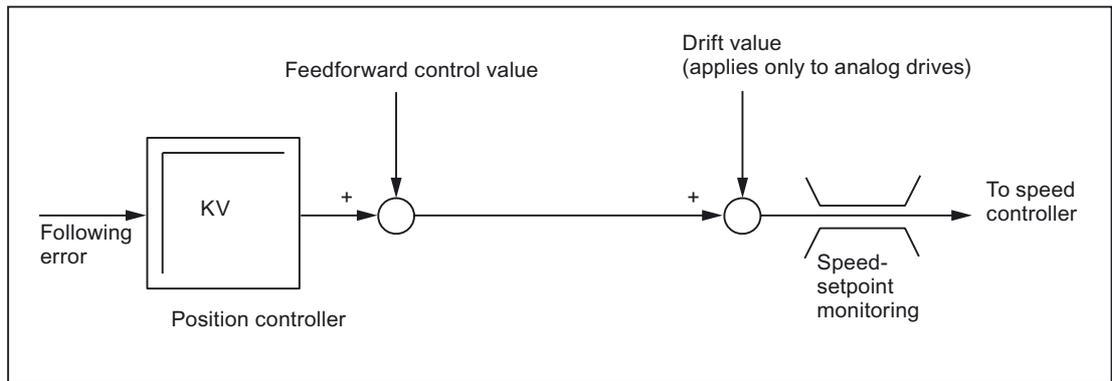


Figure 2-5 Speed setpoint calculation

The speed-setpoint monitoring ensures by limiting the control or output signal (10V for analog setpoint interface or rated speed for digital drives) that the physical limitations of the drives are not exceeded:

MD36210 \$MA\_CTRLOUT\_LIMIT (Maximum speed setpoint)

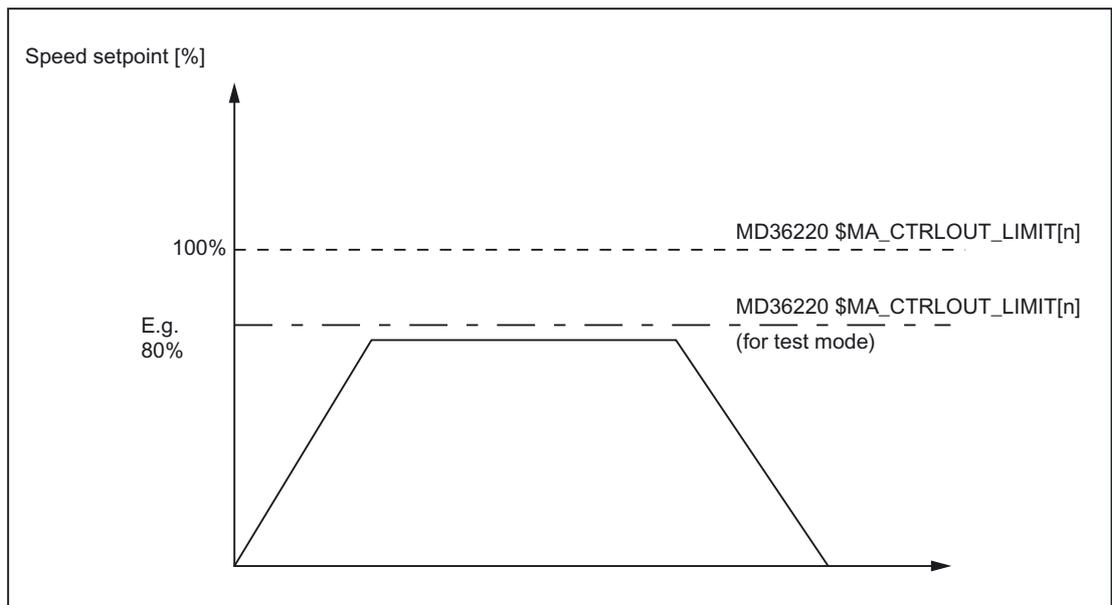


Figure 2-6 Speed setpoint limitation

### Speed-setpoint monitoring delay

To prevent an error reaction from occurring in every speed-limitation instance, a delay time can be configured:

MD36220 \$MA\_CTRLLOUT\_LIMIT\_TIME (Speed-setpoint monitoring delay)

Only if the speed limitation is required for longer than the configured time does the corresponding error reaction occur.

### Effectivity

The speed-setpoint monitoring is only active for closed-loop position-controlled axes and cannot be deactivated.

### Fault

If the configured delay time is exceeded, the following alarm appears:

25060 "Axis <Axis identifier> Speed-setpoint monitoring"

The affected axis is stopped via the configured braking ramp in follow-up mode:

MD36610 \$MA\_AX\_EMERGENCY\_STOP\_TIME

(Maximum time for braking ramp when an error occurs)

---

#### Note

Upon reaching the speed-setpoint monitoring, the position feedback loop of the axis becomes non-linear due to the limitation. Contour errors result if the axis is involved in generating the contour.

---

## 2.2.4 Actual velocity monitoring

### Function

The actual-velocity monitoring checks that the current actual velocity of a machine axis/spindle does not exceed the configured threshold:

MD36200 \$MA\_AX\_VELO\_LIMIT (velocity-monitoring threshold)

The threshold should be 10-15% above the configured maximum velocity.

- For axes:

MD32000 \$MA\_MAX\_AX\_VELO (maximum axis velocity)

- For spindles:

MD35110 \$MA\_GEAR\_STEP\_MAX\_VELO\_LIMIT[n] (maximum speed of gear stage)

If you use this setting the speed will not normally exceed the velocity-monitoring threshold (exception: drive error).

### Activation

The actual-velocity monitoring is activated as soon as the active measuring system returns valid actual values (encoder limit frequency not exceeded):

DB31, ... DBX1.5/1.6 (position measuring system 1/2)

### Effectivity

The actual-velocity monitoring only operates with active position control and the following axis types:

- Linear axes
- Rotary axes
- Open loop controlled and position controlled spindles.

### Fault

If the threshold is exceeded, the following alarm appears:

25030 "Axis <Axis identifier> Actual-velocity alarm limit"

The affected axis is stopped via the configured braking ramp in follow-up mode:

MD36610 \$MA\_AX\_EMERGENCY\_STOP\_TIME

(Maximum time for braking ramp when an error occurs)

## 2.2.5 Measuring-system monitoring (systems with SIMODRIVE 611D)

### 2.2.5.1 Encoder-limit-frequency monitoring

#### Function

The encoder-limit-frequency monitoring checks that the encoder frequency does not exceed the configured encoder limit frequency.

MD36300 \$MA\_ENC\_FREQ\_LIMIT (encoder limit frequency)

Encoder-limit-frequency monitoring always refers to the active measuring system selected in the NC/PLC interface:

DB31, ... DBX1.5/1.6 (position measuring system 1/2)

#### Effectivity

The encoder limit frequency is operative for:

- Linear axes
- Rotary axes
- Open loop controlled and position controlled spindles.

#### Fault

Upon exceeding of the encoder limit frequency, the following occurs:

- Message to the PLC:

DB31, ... DBX60.2 or 60.3 = 1 (encoder limit frequency exceeded 1 or 2)

- Spindles

Spindles are not stopped but continue to turn with speed control.

If the spindle speed is reduced so much that the encoder frequency passes below the encoder limit frequency, the actual value system of the spindle is automatically resynchronized.

- Axes

The following alarm is displayed:

21610 "Channel <Channel number> Axis <Axis identifier> Encoder <Encoder number> Frequency exceeded"

The affected axis is stopped via the configured braking ramp in follow-up mode:

MD36610 \$MA\_AX\_EMERGENCY\_STOP\_TIME  
(Maximum time for braking ramp when an error occurs)

**Note**

If the encoder limit frequency is exceeded, the position-controlled machine axis must be re-referenced.

**References:**

/FB1/ Function Manual, Basic Functions; Reference Point Approach (R1)

**2.2.5.2 Zero mark monitoring**

**Function**

Zero-mark monitoring serves as a plausibility check for the actual values of the relevant machine axis.

**Note**

The zero-mark monitoring is only active beneath the configured encoder limit frequency:  
MD36302 \$MA\_ENC\_FREQ\_LIMIT\_LOW (encoder limit frequency for encoder resynchronization)

The type of zero-mark monitoring depends on the type of encoder used:

MD30240 \$MA\_ENC\_TYPE (encoder type of actual-value acquisition)

Encoder type	Meaning
0	Simulation
1	Raw signal generators (voltage, current, EXE etc.) → High resolution
2	Rectangular signal encoder (standard, no. of PPRs quadrupled)
3	Reserved
4	Absolute encoder with EnDat interface
5	Absolute encoder with SSI interface

**Activation/deactivation**

The function is activated/deactivated with machine data:

MD36310 \$MA\_ENC\_ZERO\_MONITORING (Zero-mark monitoring)

MD36310	Meaning
0	No zero-mark monitoring.
> 0	Zero-mark monitoring active.
100	No zero-mark monitoring and all encoder alarms concealed.

### 2.2.5.3 Zero-mark monitoring for incremental encoders

#### Function

Incremental encoders with one or more zero marks use the zero-mark signals to check the plausibility of the actual values.

Monitoring starts with the first zero-mark signal once the encoder has been switched on (fault counter = 0). The function checks whether the number of incremental signals is plausible after each zero mark (if equidistant zero marks) or after every second zero mark (if distance-coded zero marks). This is the case, for example, if the number of incremental signals from straight-line axis motions matches the value required for the distance between two relevant zero marks. In the event of a non-plausible deviation, the fault counter increases by 1. The zero-mark monitoring is tripped (alarm) if several non-plausible deviations occur in direct sequence and the fault counter exceeds the configured permissible number of deviations:

MD36310 \$MA\_ENC\_ZERO\_MONITORING (Zero-mark monitoring)

If a plausible value is recorded before this threshold is reached, the fault counter is reset to 0. This ensures that the non-plausible deviations only trigger an alarm if they occur in direct sequence and in a non-tolerable number.

---

#### Note

If using external zero marks (BERO) instead of encoder zero marks, you must deactivate zero-mark monitoring:

MD36310 \$MA\_ENC\_ZERO\_MONITORING = 0

---

#### Fault

##### Alarm 25020

If zero-mark monitoring is tripped in the **active** measuring system, alarm 25020 appears:

"Axis <Axis identifier> Zero-mark monitoring of active encoder"

The affected axis is stopped via the configured braking ramp in follow-up mode:

MD36610 \$MA\_AX\_EMERGENCY\_STOP\_TIME  
(Maximum time for braking ramp when an error occurs)

##### Alarm 25021

If zero-mark monitoring is tripped in the **passive** measuring system alarm 25021 appears:

"Axis <Axis identifier> Zero-mark monitoring of passive encoder"

There is no further alarm response.

#### 2.2.5.4 Zero-mark monitoring for absolute encoders

##### Function

Absolute encoders use the absolute values supplied by the measuring system to check the plausibility of the actual value.

During the check, the NC compares the cyclic position value held in the position control cycle clock based on the incremental information from the encoder with a new position value generated directly from the absolute and incremental information and checks that the calculated position difference does not exceed the configured permissible deviation.

MD36310 \$MA\_ENC\_ZERO\_MONITORING

The permissible deviation is indicated in 1/2 rough lines. It is generally sufficient to enter a 1/2 rough line.

---

##### Note

The "zero-mark monitoring" of absolute encoders specifically detects all deviations caused by dirt on the absolute track or by faults when transferring the absolute value. However, small errors in the incremental track (burst interference, impulse errors) are not detected. In such instances the zero-mark monitoring only responds to deviations in the millimeter range. This form of monitoring should therefore serve as additional monitoring to assist the diagnosis of absolute-position faults.

---

##### Fault

###### Alarm 25020

If zero-mark monitoring is tripped in the **active** measuring system, alarm 25020 appears:

"Axis <Axis identifier> Zero-mark monitoring of active encoder"

The affected axis is stopped via the configured braking ramp in follow-up mode:

MD36610 \$MA\_AX\_EMERGENCY\_STOP\_TIME  
(Maximum time for braking ramp when an error occurs)

###### Alarm 25021

If zero-mark monitoring is tripped in the **passive** measuring system alarm 25021 appears:

"Axis <Axis identifier> Zero-mark monitoring of passive encoder"

There is no further alarm response.

###### Alarm 25022

If the absolute value transfer is interrupted, alarm 25022 appears:

"Axis <Axis identifier> Encoder <Encoder number> Warning <Error fine identification>"

There is no further alarm response.

**Note**

In the event of a fault, the adjustment of the absolute encoder is lost and the axis is no longer referenced. The absolute encoder must be readjusted.

**References:**

/FB1/ Function Manual, Basic Functions; Reference Point Approach (R1);  
Chapter: Referencing with absolute encoders

**NOTICE**

Errors in the incremental track that cannot be detected with amplitude monitoring can cause position deviations in the millimeter range. The deviation depends on the lattice pitch/line count and the traversing velocity of the axis when the error occurs.

Complete position monitoring is only possible through redundancy, i.e. through comparison with an independent second measuring system.

### 2.2.5.5 Customized error reactions

#### Customized zero-mark monitoring

You can customize the default alarm and reaction behavior of zero-mark monitoring using system variables. This allows you to perform your own monitoring using a synchronized action or OEM application and to use all of the reaction options available in this application, e.g.:

- Transmit alarm
- Use cycles (e.g. approach tool-change position)
- ...

**Example:**

Users can adjust the alarm and reaction behavior so that when machining an expensive workpiece, which could be damaged if the axis is stopped as a result of an alarm, machining stops before the machining quality of the workpiece is assessed using appropriate synchronized action commands.

**Effectivity**

Customized monitoring can be activated in parallel to or as an alternative to standard zero-mark monitoring, depending on the setting in machine data:

MD36310 \$MA\_ENC\_ZERO\_MONITORING (Zero-mark monitoring)

MD36310	Meaning
0	Customized monitoring is active, standard zero-mark monitoring is deactivated.
> 0	Customized monitoring and standard zero-mark monitoring operate in parallel.
100	All encoder monitoring functions are deactivated.

If both monitoring functions are active (MD36310 > 0), you can perform **cascaded monitoring**.

Example:

If a value falls below the threshold specified in MD36310, customized monitoring triggers a prewarning; standard zero-marking monitoring will only detect a fault if the threshold is exceeded and will then deactivate automatically.

**System variables**

You can implement customized error reactions using the following system variables:

**Measuring systems with incremental encoders**

System variable	Meaning
\$VA_ENC_ZERO_MON_ERR_CNT[n,ax]	Contains the current number of detected zero-mark errors. Power on and the selection/deselection of parking positions triggers a zero reset; reset does not reset the counter.

- n: Encoder number
- ax: Machine axis

## Measuring systems with absolute encoders

System variable	Meaning
\$VA_ENC_ZERO_MON_ERR_CNT[n,ax]	Contains the current position difference between the cyclic position value held in the position control cycle clock based on the incremental information from the encoder and a new position value generated from the encoder's absolute and incremental information.  Power on and the selection/deselection of parking positions triggers a zero reset; reset does not reset the counter.
\$VA_ABSOLUTE_ENC_ERR_CNT[n,ax]	Contains the current number of errors detected when transferring the absolute values. Monitors the reliability of the absolute value transfer process.  Power on and the selection/deselection of parking positions triggers a zero reset; reset does not reset the counter.
\$VA_ABSOLUTE_ENC_STATE[n,ax]	Determines the last error status of the absolute-encoder interface.

n: Encoder number

ax: Machine axis

## 2.2.5.6 Monitoring of hardware faults

## Function

This monitoring function monitors the measuring systems of a machine axis for hardware faults (e.g. measuring system failure, open circuit).

## Fault

**Alarm 25000**

If a hardware fault is detected in the **active** measuring system, alarm 25000 appears:

"Axis <Axis identifier> Hardware fault active encoder"

The affected axis is stopped via the configured braking ramp in follow-up mode:

MD36610 \$MA\_AX\_EMERGENCY\_STOP\_TIME

(Maximum time for braking ramp when an error occurs)

### Alarm 25001

If a hardware fault is detected in the **passive** measuring system, alarm 25001 appears:

"Axis <Axis identifier> Hardware fault passive encoder"

There is no further alarm response.

<b>NOTICE</b>
For hardware faults, the referencing status of the machine axis is reset: DB31, ... DBX60.4/60.5 = 0 (referenced/synchronized 1/2)

## 2.2.6 Measuring-system monitoring (systems with PROFIBUS drives)

The NC has no direct access to the measuring-system hardware for systems with PROFIBUS drives and therefore measuring-system monitoring is mainly performed by the drive software.

### References:

Drive Functions SINAMICS S120

/FBU/SIMODRIVE 611 universal Function Manual

### Encoder-limit-frequency monitoring

In the case of systems with PROFIBUS drives, encoder-limit-frequency monitoring is also performed in the NCK.

### Zero-mark monitoring

#### PROFIBUS drives with incremental encoders

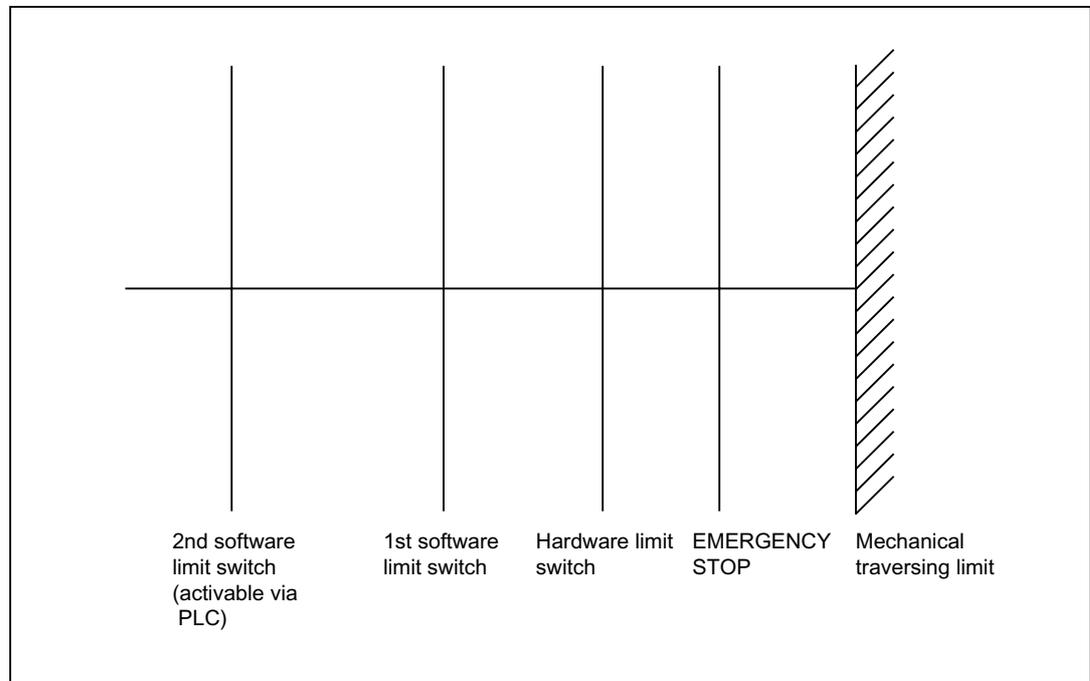
Zero-mark monitoring is performed by the drive software.

#### PROFIBUS drives with absolute encoders

The drive software performs the monitoring function, while the plausibility check is carried out in the NCK (as for SIMODRIVE 611D systems).

## 2.2.7 Limit switch monitoring

Overview of the end stops and possible limit switch monitoring:



### 2.2.7.1 Hardware limit switches

#### Function

A hardware limit switch is normally installed at the end of the traversing range of a machine axis. It serves to protect against accidental overtravelling of the maximum traversing range of the machine axis while the machine axis is not yet referenced.

If the hardware limit switch is triggered, the PLC user program created by the machine manufacturer sets the corresponding interface signal:

DB 31, ... DBX12.0/12.1 = 1 (Hardware limit switch minus/plus)

#### Parameterization

The braking behavior of the machine axis upon reaching the hardware limit switch is configurable via the machine data:

MD36600 \$MA\_BRAKE\_MODE\_CHOICE (Braking behavior on hardware limit switch)

Value	Significance
0	Braking with the configured axial acceleration
1	Rapid stop (set velocity = 0)

### Effectivity

The hardware limit-switch monitoring is active after the control has ramped up in all modes.

### Effect

Upon reaching the hardware limit switch, the following occurs:

- Alarm 21614 "Channel <Channel number> Axis <Axis identifier> Hardware limit switch <Direction>"
- The machine axis is braked according to the configured braking behavior.
- If the axis/spindle is involved in interpolation with other axes/spindles, these are also braked according to their configured braking behavior.
- The traversing keys of the affected machine axis are blocked based on the direction.

### 2.2.7.2 Software limit switch

#### Function

Software limit switches serve to limit the traversing range of a machine axis. Per machine axis and per traversing direction, two (1st and 2nd) software limit switches are available:

MD36100 POS\_LIMIT\_MINUS (1st software limit switch minus)

MD36110 POS\_LIMIT\_PLUS (1st software limit switch plus)

MD36120 POS\_LIMIT\_MINUS2 (2nd software limit switch minus)

MD36130 POS\_LIMIT\_PLUS2 (2nd software limit switch plus)

By default, the 1st software limit switch is active. The 2nd software limit switch can be activated for a specific direction with the PLC user program:

DB31, ... DBX12.2/12.3 (2nd software limit switch minus/plus)

#### Effectivity

The software limit switches are active:

- immediately after the successful referencing of machine axis.
- in all operating modes.

#### Constraints

- The software limit switches refer to the machine coordinate system.
- The software limit switches must be inside the range of the hardware limit switches.
- The machine axis can be moved to the position of the active software limit switch.

- **PRESET**  
After use of the function `PRESET`, the software limit-switch monitoring is no longer active. The machine must first be re-referenced.
- **Endlessly rotating rotary axes**  
No software limit-switch monitoring takes place for endlessly rotating rotary axes:  
`MD30310 $MA_ROT_IS_MODULO == 1` (Modulo conversion for rotary axis and spindle)  
Exception: Setup-rotary axes

## Effects

### Automatic operating modes (AUTOMATIC, MDI)

- Without transformation, without overlaid movement, unchanged software limit switch:  
A part program block with a programmed traversing motion that would lead to overrunning of the software limit switch is not started.
- With transformation:  
Different reactions occur depending on the transformation type:
  - Behavior as above.
  - or
  - The part program block with a programmed traversing motion that would lead to overrunning of the software limit switch is started. The affected machine axis stops at the active software limit switch. The other machine axes participating in the traversing motion are braked. The programmed contour is left during this process.
- With overlaid motion  
The part program block with a programmed traversing motion that would lead to overrunning of the software limit switch is started. Machine axes that are traveling with overlaid motion or have traveled with overlaid motion stop at the active software limit switch in question. The other machine axes participating in the traversing motion are braked. The programmed contour is left during this process.

### Manual operating modes

- JOG without transformation  
The machine axis stops at the software limit switch position.
- JOG with transformation  
The machine axis stops at the software limit switch position. Other machine axes participating in the traversing motion are braked. The preset path is left during this process.

### General

- Changing of the software limit switch (1st ↔ 2nd software limit switch)

If the actual position of the machine axis after changing lies behind the software limit switch, it is stopped with the maximum permissible acceleration.

- Overrunning the software limit switch in JOG mode

If the position of the software limit switch is reached and renewed pressing of the traversing button should cause further travel in this direction, an alarm is displayed and the axis is not traversed farther:

Alarm 10621 "Channel <Channel number> Axis <Axis identifier> is at the software limit switch <Direction>"

## 2.2.8 Monitoring of the working area limitation

### 2.2.8.1 General

#### Function

The function "working area limitation" limits the traversing range of geometry axis and special axis in the working area and monitors the adherence to the limits during the traversing of the axes.

The following versions are available:

- Working area limitation in BCS

The coordinate data for limiting the working area refer to the basic coordinate system.

- Working area limitation in WCS/ENS

The coordinate data for limiting the working area refer to the workpiece coordinate system (WCS) and settable zero system (ENS).

Both the working area limitation monitorings are independent of each other. If both monitoring functions are active, that limit becomes effective which the axis motion first reaches.

## Reference point at the tool

Taking into account the tool data (tool length and tool radius) and therefore the reference point at the tool when monitoring the working area limitation depends on the activity of certain transformations:

- **Transformations are not active**

Without transformations during traversing motion with an active tool the position of the tool tip P is monitored, i.e. during the monitoring the tool length is considered automatically.

Consideration of the tool radius must be activated separately:

MD21020 \$MC\_WORKAREA\_WITH\_TOOL\_RADIUS (Consideration of the tool radius in the working area limitation)

- **Transformations are active**

In the case of certain transformations the monitoring of the working area limitation may differ from the behavior without transformation:

- The tool length is a component of the transformation (\$MC\_TRAFO\_INCLUDES\_TOOL\_X = TRUE):

In this case the tool length is not considered, i.e. the monitoring refers to the tool carrier reference point.

- Transformation with change in orientation:

In this case the monitoring always refers to the tool center point. MD21020 has no influence.

---

### Note

The machine data \$MC\_TRAFO\_INCLUDES\_TOOL\_X is analyzed only in certain transformations. Condition for a possible evaluation is that the orientation of the tool with respect to the base coordinate system cannot be changed by the transformation. With standard transformations, the condition is only fulfilled for the "inclined axis transformation".

---

## Effectivity

The monitoring of the working area limitation is active:

- Immediately after the successful referencing of machine axis.
- In all operating modes.

## Constraints

- The working area limitation must lie within the range of the software limit switch.
- PRESET  
After use of the function PRESET, the monitoring of working area limitation is no longer active. The machine must first be re-referenced.
- Endlessly rotating rotary axes  
In case of rotary axes rotating endlessly:  
MD30310 \$MA\_ROT\_IS\_MODULO == 1 (Modulo conversion for rotary axis and spindle)  
there is no monitoring of the working area limitation. This is activated explicitly via the axial NC/PLC interface signal:  
DB31, ... DBX12.4 (Traversing range limitation for modulo rotary axes)

## Effects

### Automatic operating modes

- With/without transformation  
The part program block with a programmed traversing motion that would lead to overrunning of the working area limitation is not started.
- With overlaid motion  
The axis, which would violate the working area limitation due to the overlaid movement, is braked without jerk limitation and will come to the position of the working area limitation. Other axes involved in the movement are braked corresponding to the currently applicable acceleration. The preset path is left during this process.

### Manual operating modes

- JOG with/without transformation  
The axis is positioned at the working area limitation and then stopped.

## General

- Activation of the working area limitation  
If the actual position of an axis after activation is located outside of the working area limitation, it is stopped with the maximum permissible acceleration without jerk limitation.
- Overrunning of the working area limitation in JOG mode  
If the position of the working area limitation is reached and renewed pressing of the traversing button should cause further travel in this direction, an alarm is displayed and the axis is not moved farther.

- Geo-axis replacement

Through the following machine data it is adjustable, whether during geometry axis change the active working area limitation is retained or deactivated:

MD10604 \$MN\_WALIM\_GEOAX\_CHANGE\_MODE

= 0: The working area limitation is deactivated during the geometry axis change.

= 1: The working area limitation remains activated during the geometry axis change.

## 2.2.8.2 Working area limitation in BKS

### Application

Using the "working area limitation in BKS", the working area of a machine tool is limited so that the surrounding devices (e.g. tool revolver, measuring stations) are protected against damage.

### Working area limits

The lower and upper working area limits of each axes are adjusted through setting data or programmed through part program instructions:

#### Working area limitation through setting data

The adjustments are done through the immediately effective axis-specific setting data:

SD43420 \$SA\_WORKAREA\_LIMIT\_PLUS (Working area limitation plus)

SD43430 \$SA\_WORKAREA\_LIMIT\_MINUS (Working area limitation minus)

#### Programmed working area limitation

The programming is done using the G commands:

G25 X... Y... Z... lower working area limitation

G26 X... Y... Z... upper working area limitation

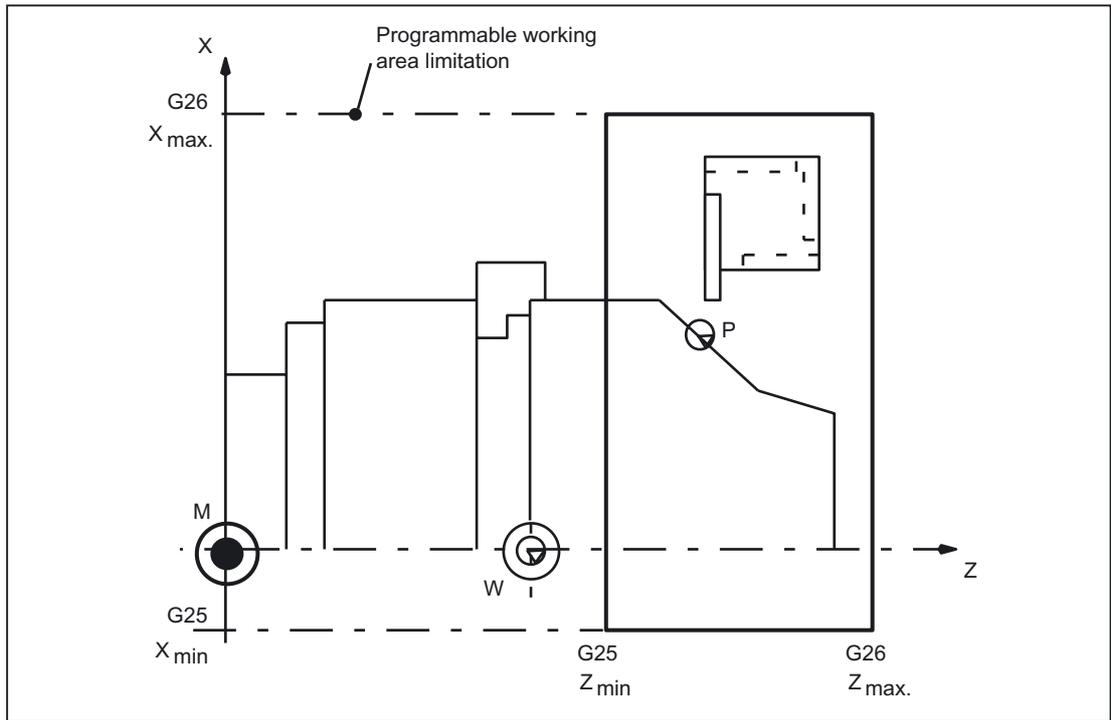


Figure 2-7 Programmed working area limitation

The programmed working area limitation has priority and overwrites the values entered in SD43420 and SD43430.

### Activation/deactivation

#### Working area limitation through setting data

The activation/deactivation of the working area limitation for each axis takes place in a direction-specific manner via the immediately effective setting data:

SD43400 \$SA\_WORKAREA\_PLUS\_ENABLE (Working area limitation active in the positive direction)

SD43410 \$SA\_WORKAREA\_MINUS\_ENABLE (Working area limitation active in the negative direction)

Value	Significance
0	The working area limitation in positive or negative direction is <b>switched off</b> .
1	The working area limitation in positive or negative direction is <b>active</b> .

### Programmed working area limitation

The activation of the total "working area limitation in BKS" is done through the part program instruction:

```
WALIMON      Working area limitation ON
or
WALIMOF      Working area limitation OFF
```

### Changing the working area limitation

#### Working area limitation through setting data

HMI user interface: Operating area "Parameter"

- Automatic modes:
  - Changes: possible only in the RESET state
  - Effective: immediately
- Manual operating modes:
  - Changes: always possible
  - Effective: at the start of the next traversing motion

#### Programmed working area limitation

New programming of the working area limitation through: G25/G26 <Axis identifier><Value>

Changes are immediately effective.

The newly programmed working area limitation is retained even after NC-RESET, if a permanent security is provided in the active file system for SD43420 and SD43430 after the overwriting:

```
MD10710 $MN_PROG_SD_RESET_SAVE_TAB[0] = 43420
```

```
MD10710 $MN_PROG_SD_RESET_SAVE_TAB[1] = 43430
```

### Limitations/secondary conditions

The RESET position with regard to WALIMON/WALIMOF is configurable via:

```
MD20150 $MC_GCODE_RESET_VALUES (RESET position of G groups)
```

### 2.2.8.3 Working area limitation in WKS/ENS

#### Application

The "working area limitation in WKS/ENS" mainly serves for the working area limitation for conventional lathes. It enables the machine setter, to "manually" establish "stops" during the movement of the axes and with that to limit the working area specific to tool.

#### Working area limitation group

In order not to write the working area limitations afresh every time while switching over to the transformation or while switching over to the active frames, the user has at his disposal up to 10 working area limitation groups. A working area limitation group contains the values for all axes in the channel and the coordinate system, for which the working group limitation group will apply.

The number of the working area limitation groups is set in the machine data:

MD28600 \$MC\_MM\_NUM\_WORKAREA\_CS\_GROUPS

#### Working area limits

The working area limits of each axis are defined by the following channel-specific system variables:

System variable	Significance
\$AC_WORKAREA_CS_PLUS_ENABLE [WALimNo, ax]	Validity of the working area limitation in the positive axis direction.
\$AC_WORKAREA_CS_LIMIT_PLUS [WALimNo, ax]	Working area limitation in the positive axis direction. Only effective, if: \$AC_WORKAREA_CS_PLUS_ENABLE = TRUE
\$AC_WORKAREA_CS_MINUS_ENABLE [WALimNo, ax]	Validity of the working area limitation in the negative axis direction.
\$AC_WORKAREA_CS_LIMIT_MINUS [WALimNo, ax]	Working area limitation in the negative axis direction. Only effective, if: \$AC_WORKAREA_CS_PLUS_ENABLE = TRUE

**Parameter:**

<WALimNo>: Number of the working area limitation group.

<ax>: Channel axis name of the axis for which the value is valid.

The definition is given by writing the system variables through the user interface or in the part program.

## Selection of the coordinate system

A working area limitation group can refer to the workpiece coordinate system (WKS) or the settable zero system (ENS). The selection is made through the channel-specific system variable:

`$AC_WORKAREA_CS_COORD_SYSTEM [WALimNo]`

Value	Significance
1	Working area limitation is applicable in WKS.
3	Working area limitation is applicable in ENS.

## Activation

The "working area limitation in the "WCS/SZS" is activated by selecting a working area limitation group. The selection is made in the part program by calling one of the following G commands:

```

WALCS1      Activating working area limitation group No. 1
...
WALCS10     Activating working area limitation group No. 10

```

## Deactivation

The deactivation of the active "working area limitation in WKS/ENS" is done in the part program by calling the G command:

```
WALCS0
```

## Changing the working area limitation

- **Working area limits**

`$AC_WORKAREA_CS_PLUS_ENABLE [WALimNo, ax]`

`$AC_WORKAREA_CS_LIMIT_PLUS [WALimNo, ax]`

`$AC_WORKAREA_CS_MINUS_ENABLE [WALimNo, ax]`

`$AC_WORKAREA_CS_LIMIT_MINUS [WALimNo, ax]`

- **Changes:**

The system variables can be described any time through the user interface and the part program.

- **Effective:**

The changes become effective with reselection of the corresponding working area limitation group.

- **Selection of the working area limitation group**

- **Changes:**

Changes are made through reprogramming of `WALCS1 ... WALCS10`.

- **Effective:**

Changes are immediately effective.

## Data storage and security

### Data storage

The values of the system variables for the definition of the "working area limitations in WKS/ENS" are stored in the static NC memory.

---

### Note

For the storage of the limiting values for the linear axes, the default setting is considered for the system of units (MD10240 \$MN\_SCALING\_SYSTEM\_IS\_METRIC).

---

### Data backup

The values of the system variables can be saved in specific backup files:

Backup file	For the backup of:
_N_CHx_WAL	Values of the system variables for the channel x.
_N_COMPLETE_WAL	Values of the system variables for all channels.

---

### Note

The values of the system variables for the definition of the "working area limitations in WKS/ENS" are also component of the file "\_N\_INITIAL\_INI".

---

## Limitations/secondary conditions

### Rotating frame active

If a rotating frame is active, **all** geometry axes must have been referenced for the activation of the "working area limitation in WKS/ENS".

## Effects

### JOG mode

If in the JOG-mode several geometry axes are traversed simultaneously (e.g. using several handwheels) **and** a rotating frame is active between the base coordinate system and the reference coordinate system of the working area limitation (WKS or ENS), then a response of the monitoring leads to the fact that the movements of the involved geometry axes are continued in a straight line and stopped at the working area limits.

## 2.3 Protection zones

### 2.3.1 General

#### Function

Protection zones are static or moveable in 2- or 3-dimensional ranges within a machine to protect machine elements against collisions.

The following elements can be protected:

- Permanent parts of the machine and attachments (e.g. tool-holding magazine, swiveling probe). Only the elements that can be reached by possible axis constellations are relevant.
- Moving parts belonging to the tool (e.g. tool, toolholder)
- Moving parts belonging to the workpiece (e.g. parts of the workpiece, clamping table, clamping shoe, spindle chuck, tailstock).

Protection zones are defined via part program instructions or system variables so that they completely surround the element to be protected. The activation and deactivation of protection zones also takes place via part program instructions.

Protection-zone monitoring by the NC is channel-specific, i.e. all the active protection zones of a channel monitor one another for collisions.

#### Definition of a protection zone

It is possible to define 2-dimensional or 3-dimensional protection zones as polygons with a maximum of ten corner points. The protection zones can also contain arc contour elements.

Polygons are defined in a previously defined plane.

Expansion in the third dimension can be limited between  $-\infty$  bis  $+\infty$ .

The following four cases are possible:

- Dimension of the protection zone from -1 to +1
- Dimension of the protection zone from -1 to upper limit
- Dimension of the protection zone from lower limit to +1
- Dimension of protection zone from lower limit to upper limit.

#### Coordinate system

The definition of a protection zone takes place with reference to the geometric axis of a channel in the basic coordinate system.

## Reference

- Tool-related protection zones  
Coordinates for tool-related protection zones must be given as absolute values referred to the tool carrier reference point F.
- Workpiece-related protection zones  
Coordinates for workpiece-related protection zones must be given as absolute values referred to the zero point of the basic coordinate system.

---

### Note

If no tool-related protection zone is active, the tool path is checked against the workpiece-related protection zones.

If no workpiece-oriented protection zone is active, protection-zone monitoring does not take place.

---

## Orientation

The orientation of the protection zones is determined by the plane definition (abscissa/ordinate), in which the contour is described, and the axis perpendicular to the contour (vertical axis).

The orientation of the protection zones must be the same for the tool and workpiece-related protection zones.

## 2.3.2 Types of protection zone

### Machine-defined and channel-defined protection zones

- Machine-defined protection zone  
Data for machine-related protection zones are defined once in the control. These protection zones can be activated by all channels.
- Channel-defined protection zones  
Data for channel-related protection zones are defined in a channel. These protection zones can be activated only by this channel.

### Example: Double-slide turning machine

- The tool-related protection zones are assigned to channel 1 or 2.
- The workpiece-related protection zones are assigned to the machine.
- The coordinate system must be identical for both channels.

### Maximum number of protection areas

The maximum definable number of machine- and channel-related protection zones is set via:

MD18190 \$MN\_MM\_NUM\_PROTECT\_AREA\_NCK (Number of files for machine-related protection zones)

MD28200 \$MC\_MM\_NUM\_PROTECT\_AREA\_CHAN (Number of files for channel-specific protection zones)

### Coordinates

The coordinates of a protection zone must always be programmed as absolute values with respect to the reference point of the protection zone. When the protection zone is activated via the part program it is possible to apply a relative offset to the reference point of the protection zone.

### Examples

In the following figures some examples for protection zones have been presented:

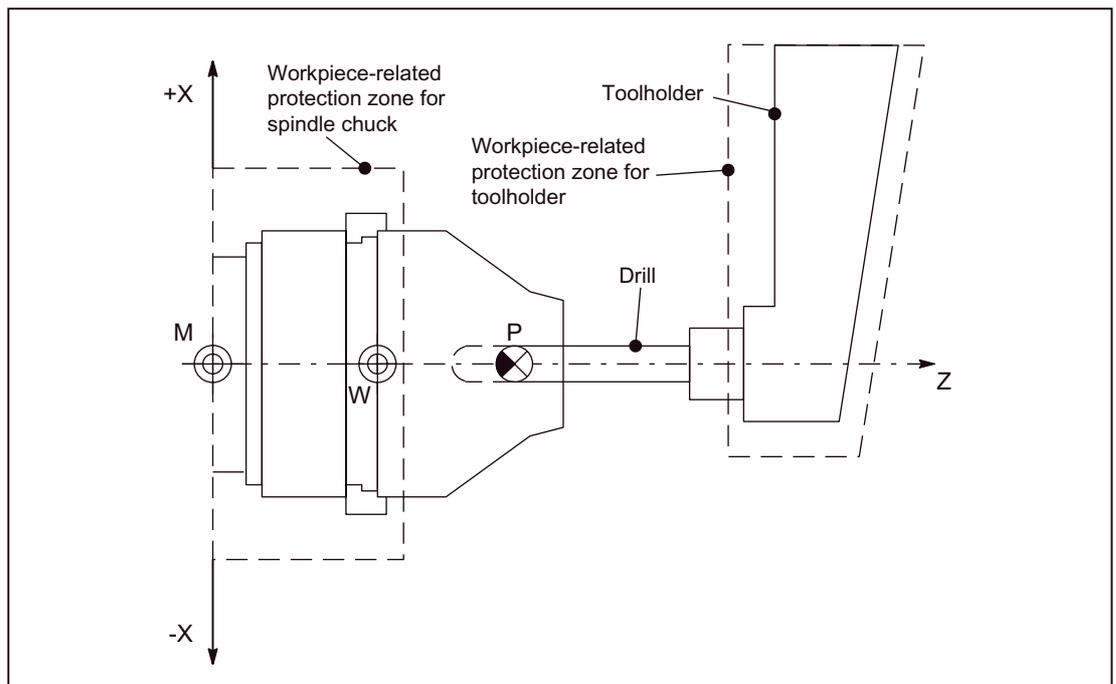


Figure 2-8 Example of application on turning machine

2.3 Protection zones

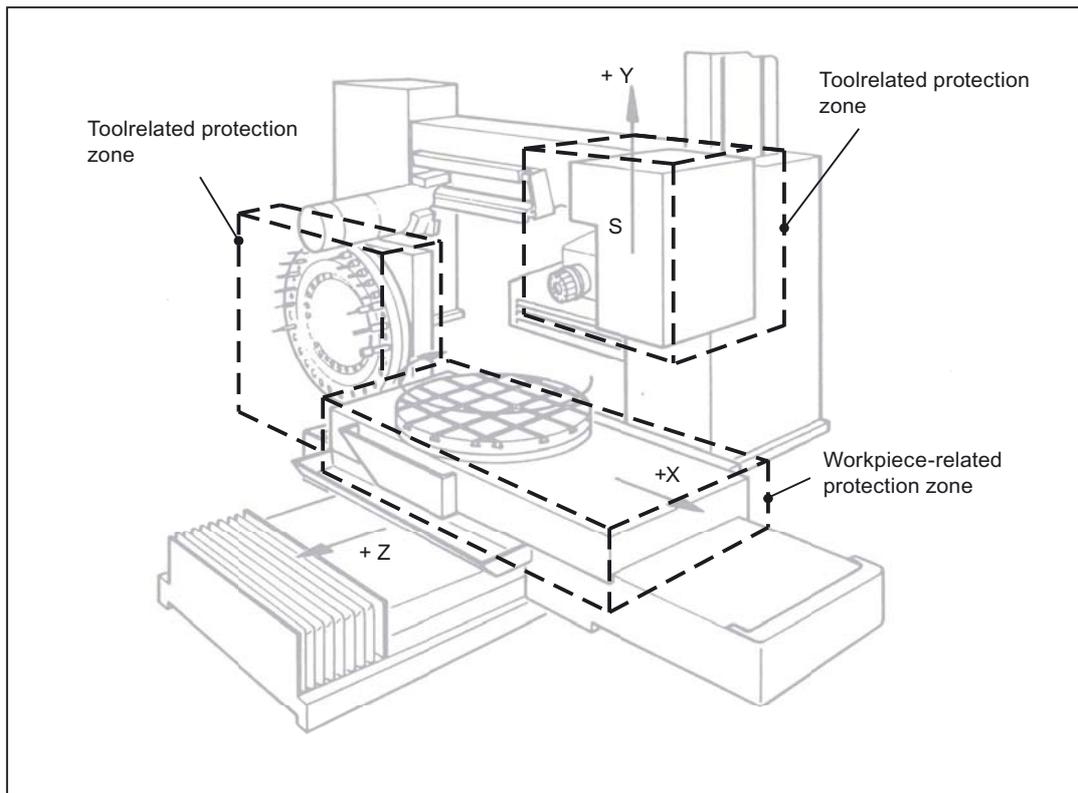


Figure 2-9 Example of a milling machine

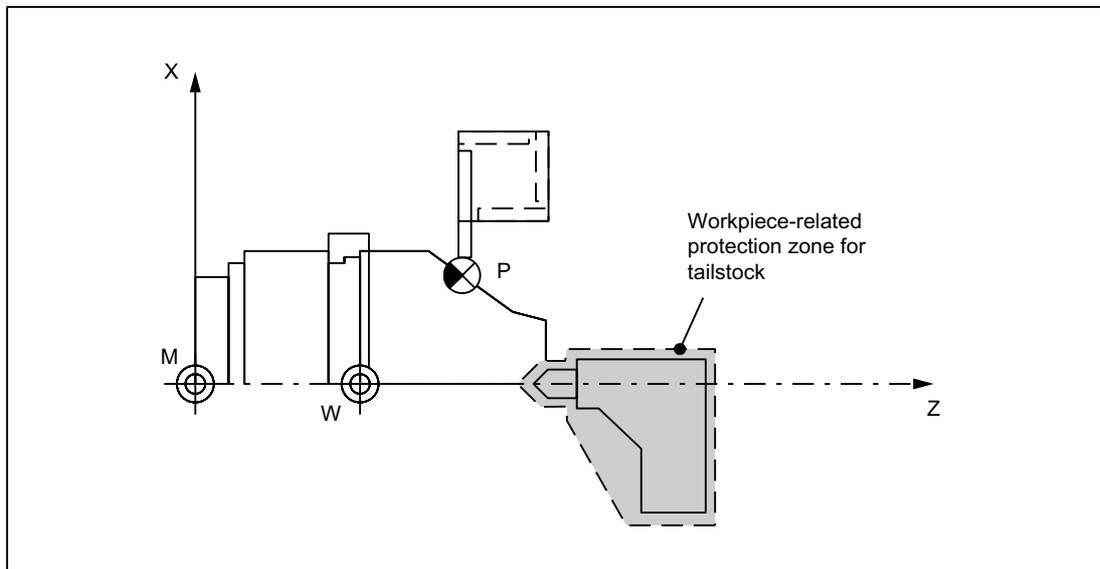


Figure 2-10 Example of a turning machine with relative protection zone for tailstock

### 2.3.3 Definition via part program instruction

#### General

A protection-zone definition must contain the following information:

- Protection zone type (workpiece- or tool-related)
- Orientation of the protection zone
- Type of limitation in the third dimension
- Upper and lower limit of the protection zone in the third dimension
- Activation type ("Protection zone immediately active": only possible via system variable)
- Contour elements

#### Definition of protection zones

The following systematics must be maintained in the definition of protection zones:

- Definition of the working plane: G17, G18 or G19
- Definition beginning
  - Channel-specific protection zones: CPROTDEF ( . . . )
  - Machine or NC-specific protection zone: NPROTDEF ( . . . )
- Contour description for protection zone
- End of definition: EXECUTE ( . . . )

#### Definition of the working plane

The desired working plane to which the contour description of the protection zone refers must be selected with G17, G18, G19 before start of the definition. It may not be changed before the end of the definition. Programming of the applicator is not permitted between start and end of the definition.

### Definition beginning

The definition start is defined by the corresponding subroutine:

- CPROTDEF(n, t, applim, appplus, appminus)
- NPROTDEF(n, t, applim, appplus, appminus)

Parameters	Type	Description	
n	INT	Number of defined protection zone	
t	BOOL	Protection zone type	
		TRUE	Tool-oriented protection zone
		FALSE	Workpiece-related protection zone
applim	INT	Type of limitation in the third dimension	
		0	No limitation
		1	Limit in plus direction
		2	Limit in minus direction
		3	Limit in positive and negative direction
appminus	REAL	Value of the limit in the negative direction in the 3rd dimension <sup>1)</sup>	
appplus	REAL	Value of the limit in the positive direction in the 3rd dimension <sup>1)</sup>	
<sup>1)</sup> The following must be true: appplus > appminus			

### Contour description for protection zone

The contour of a protection zone is described with traversing motions. These are not executed and have no connection to previous or subsequent geometry descriptions. They only define the protection zone.

The contour of a protection zones is specified with up to eleven traversing movements in the selected working plane. The first traversing movement is the movement to the contour. The last point in the contour description must always coincide with the first point of the contour description. In the case of rotation-symmetrical contours (e.g. spindle chuck), the whole contour must be described (not merely the contour to the turning center).

The valid protection zone is the zone left of the contour:

- Internal protection zone  
The contour of an internal protection zone must described in the counter-clockwise direction.
- External protection zones (permitted only for workpiece-related protection zones)  
The contour of an external protection zone must be described in the clockwise direction.

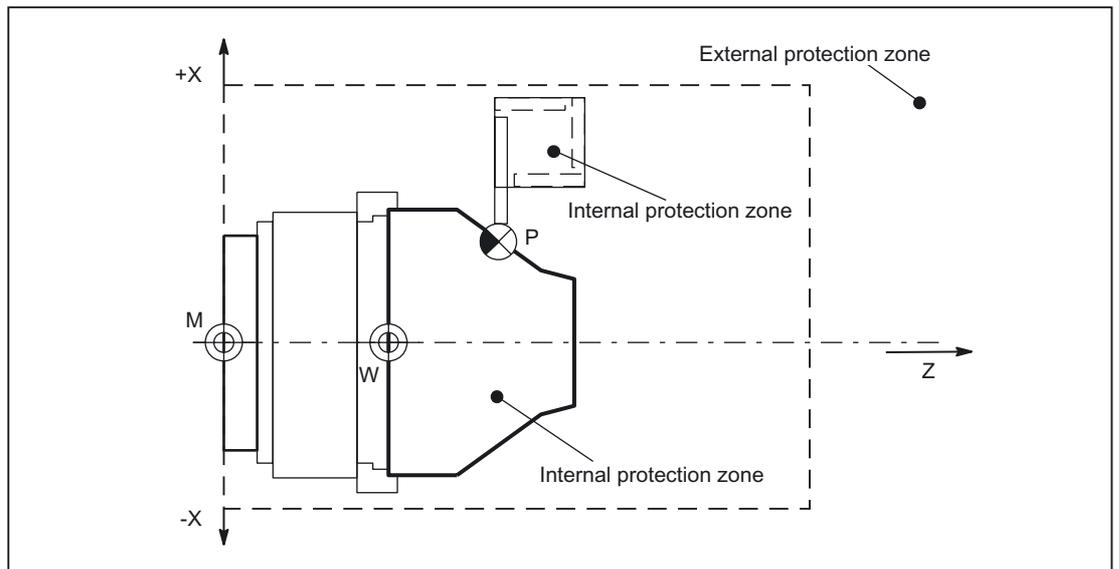


Figure 2-11 Examples: External and internal protection zone

Tool-related protection zones must be convex. If a concave protection zone is required, the protection zone must be divided up into several convex protection zones.

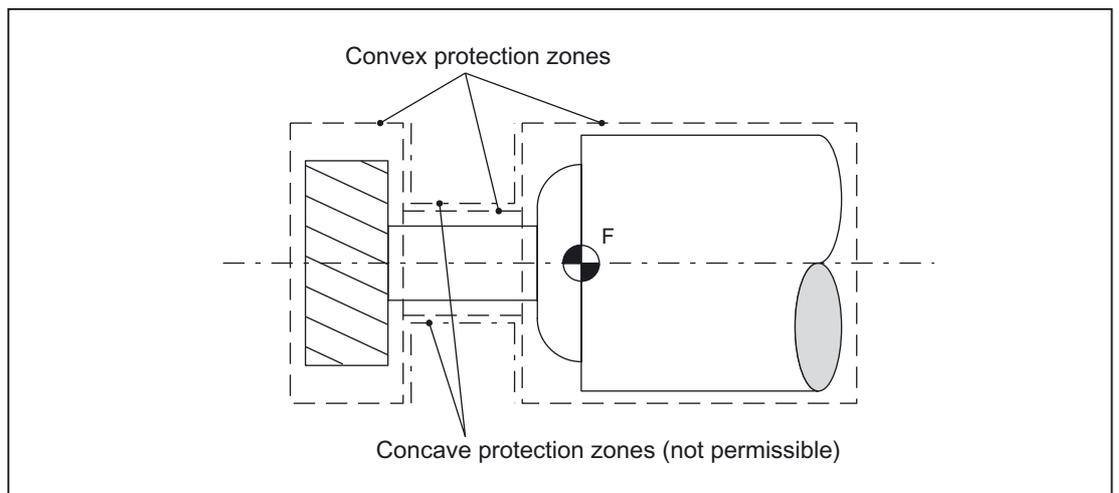


Figure 2-12 Examples: convex and concave tool-related protection zones

### Contour elements

The following contour elements are permissible:

- G0, G1 for straight contour elements
- G2 for circle segments in the clockwise direction  
Permissible only for workpiece-related protection zones.

Not permissible for tool-related protection zones because they must be convex.

- G3 for circular segments in the counter-clockwise direction

A protection zone cannot be described by a complete circle. A complete circle must be divided into two half circles.

The sequence G2, G3 or G3, G2 is not permitted. A short G1 block must be inserted between the two circular blocks.

### Constraints

During the definition of a protection zone, the following functions must not be active or used:

- Tool radius compensation (cutter radius compensation, tool nose radius compensation)
- Transformation
- Reference point approach (G74)
- Fixed point approach (G75)
- Dwell time (G4)
- Block search stop (STOPRE)
- End of program (M17, M30)
- M functions: M0, M1, M2

Programmable frames (TRANS, ROT, SCALE, MIRROR) and configurable frames (G54 to G57) are ineffective.

Inch/metric switchovers with G70/G71 or G700/G710 are effective.

### End of definition

The end of definition is defined by the following subroutine:

EXECUTE (NOT\_USED)

Parameters	Type	Description
NOT_USED	INT	Error variable has no effect in protection zones with EXECUTE.

The definition of a machine-specific or channel-specific protection zone is completed with the subroutine EXECUTE (n) .

## 2.3.4 Definition via system variable

### General

If the protection zones are defined with part program instructions (see Chapter: Definition for each part program instructions), the protection zone data are stored in system variables. The system variables can also be written directly so that the definition of protection areas can also be performed directly in the system variables.

The same supplementary conditions apply for the definition of the contour of a protection zone as for a protection-zone definition via part program instructions.

### System variables

The protection zone definitions cover following system variables:

System variable	Type	Significance
\$SN_PA_ACTIV_IMMED[n] \$SC_PA_ACTIV_IMMED[n]	BOOL	Activation type The protection zone is active/not active immediately after the power up of the control and the referencing of the axes.
		FALSE   not immediately active
		TRUE   immediately active
\$SN_PA_T_W[n] \$SC_PA_T_W[n]	INT	Protection zone type
		0   Workpiece-related protection zone
		1   reserved
		2   reserved
\$SN_PA_ORI[n] \$SC_PA_ORI[n]	INT	Orientation of the protection zone, i.e. polygon definition in the plane of:
		0   1st and 2nd geometry axis
		1   3rd and 1st geometry axis
		2   2nd and 3rd geometry axis
\$SN_PA_LIM_3DIM[n] \$SC_PA_LIM_3DIM[n]	INT	Type of limitation in the third dimension
		0   No limitation
		1   Limit in plus direction
		2   Limit in minus direction
\$SN_PA_PLUS_LIM[n] \$SC_PA_PLUS_LIM[n]	REAL	Value of the limit in the positive direction in the 3rd dimension
		\$SN_PA_MINUS_LIM[n] \$SC_PA_MINUS_LIM[n]
\$SN_PA_CONT_NUM[n] \$SC_PA_CONT_NUM[n]	INT	Number of valid contour elements
\$SN_PA_CONT_TYP[n, i] \$SC_PA_CONT_TYP[n, i]	INT	Contour type[i], contour type (G1, G2, G3) of the nth contour element
\$SN_PA_CONT_ABS[n, i] \$SC_PA_CONT_ABS[n, i]	REAL	End point of the contour[i], abscissa value

2.3 Protection zones

System variable	Type	Significance
\$SN_PA_CONT_ORD[n, i] \$SC_PA_CONT_ORD[n, i]	REAL	End point of the contour[i], ordinate value
\$SN_PA_CENT_ABS[n, i] \$SC_PA_CENT_ABS[n, i]	REAL	Center point of the circular contour[i], absolute abscissa value
\$SN_PA_CENT_ORD[n, i] \$SC_PA_CENT_ORD[n, i]	REAL	Center point of the circular contour[i], absolute ordinate value
<p>\$SN_... are system variables for NC and machine-specific protection zones.                      \$SC_... are system variables for channel-specific protection zones.                      The index "n" corresponds to the number of the protection zone: 0 = 1st protection zone                      The index "i" corresponds to the number of the contour element: 0 = 1st contour element                      The contour elements must be defined in ascending order.</p>		

**Note**

The system variables of the protection-zone definitions are not restored with REORG.

**Data of the protection-zone definitions**

**Data storage**

The protection-zone definitions are stored in the following files:

File	Blocks
_N_NCK_PRO	Data block for NC-specific protection zones
_N_CHAN1_PRO	Data block for channel-specific protection zones in channel 1
_N_CHAN2_PRO	Data block for channel-specific protection zones in channel 2

**Data backup**

The protection-zone definitions are saved in the following files:

File	Blocks
_N_INITIAL_INI	All data blocks of the protection zones
_N_COMPLETE_PRO	All data blocks of the protection zones
_N_CHAN_PRO	All data blocks of the channel-specific protection zones

## 2.3.5 Activation and deactivation of protection zones

### General

The activation status of a protection zone is:

- Preactivated
- Preactivated with conditional stop
- Enabled
- Deactivated

A protection zone is monitored for violation only when it is activated.

#### Activation

The activation of a protection zone can take place through:

- Part program instruction
- Automatically after the control powers up
- PLC user program

For activation through the PLC user program, the protection zone must be first preactivated via a part program.

The preactivation, deactivation and activation of all protection zones always takes place channel-specifically. A protection zone can also be active in multiple channels simultaneously (application example: Double-slide single-spindle machine with one quill and two machining slides).

Protection zones are activated immediately after the runup of the control, if the corresponding system variable \$SN\_PA\_ACTIV\_IMMED[n] or \$SC\_PA\_ACTIV\_IMMED[n] has been set.

---

#### Note

Machine-related protection zones are activated after the runup of the control in all channels.

---

An activated protection zone is only taken into account after the successful referencing of all participating geometry axes.

#### Preactivation

Only preactivated protection zones can be activated from the PLC user program.

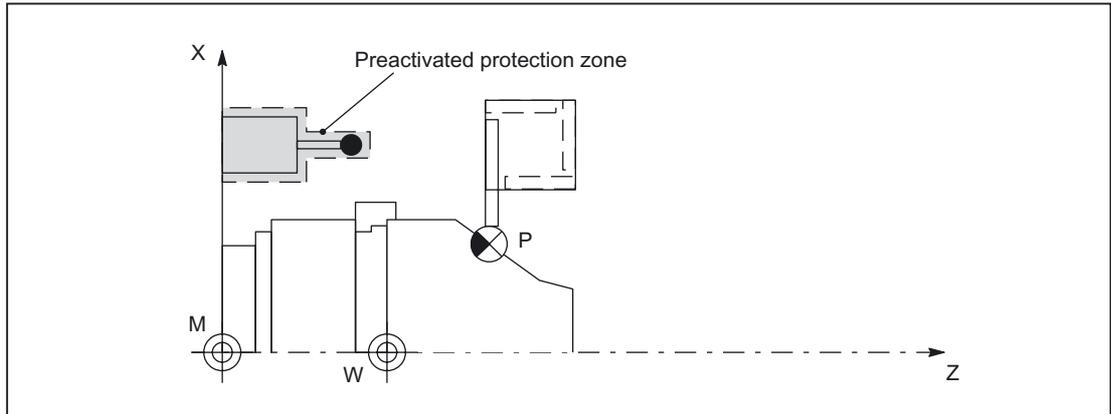


Figure 2-13 Example: Turning machine with preactivated protection zone for a sensor.

### Deactivation

A protection zone can be deactivated from a part program. Additionally an active, preactivated protection zone can be set again in the preactivated (= ineffective) state through the PLC user program.

### RESET response

The activation status of a protection zone is retained even after NC-RESET and program end.

## Memory requirements

The memory requirement of the persistent memory is determined with following machine data:

MD18190 \$MN\_MM\_NUM\_PROTECT\_AREA\_NCK (Number of available machine-defined protection zones)

MD28200 \$MC\_MM\_NUM\_PROTECT\_AREA\_CHAN (Number of available channel-defined protection zones)

The memory requirement in the dynamic part with regard to the protection zones is established with following machine data:

MD28210 \$MC\_MM\_NUM\_PROTECT\_AREA\_ACTIVE (Maximum number of protection zones that can be activated simultaneously in the channel)

MD28212 \$MC\_MM\_NUM\_PROTECT\_AREA\_CONTUR (Maximum number of definable contour elements per protection zone)

## Deactivation, preactivation, activation via part program

The activation status of a channel- or machine-specific protection zone is defined by the corresponding subroutine:

- Channel-specific protection zone:  
CPROT (n, state, xMov, yMov, zMov)
- Machine or NC-specific protection zone:  
NPROT (n, state, xMov, yMov, zMov)

Parameters	Type	Description
n	INT	Number of the protection zone
state	INT	Activation status
		0   Deactivated
		1   Preactivated
		2   Enabled
xMov, yMov, zMov	REAL	Offset values of the previously defined protection zone in the geometry axes

## Offsets

During preactivation or activation of the protection zone, an offset can be entered in 0 to 3 dimensions. The offset refers to:

- Workpiece-related protection zones: Machine zero
- Tool-related protection zones: Tool holder reference point F

---

### Note

A protection zone cannot be activated in a single channel with different offsets simultaneously.

---

## Activation via PLC user program

A protection zone preactivated in the part program can be activated in the PLC user program.

### Preactivated protection zones

The NC indicates the preactivated protection zones:

DB21, ... DBX272.0 to 273.1 (machine-related protection zone 1 - 10 preactivated)

DB21, ... DBX274.0 to 275.1 (channel-specific protection zone 1 - 10 preactivated)

### Protection-zone violation

Activated and preactivated protection zones that are or would be violated by the programmed traversing motions of the current part-program block if the PLC user program would activate the preactivated protection zone:

DB21, ... DBX276.0 to DBX277.1 (machine-related protection zone 1 - 10 violated).

DB21, ... DBX278.0 to DBX279.1 (channel-specific protection zone 1 - 10 violated).

### Activate

The preactivated protection zones can be activated from the PLC user program:

DB21, ... DBX8.0 to DBX9.1 (Activate machine-related protection zone 1 - 10)

DB21, ... DBX10.0 to DBX11.1 (Activate channel-specific protection zone 1 - 10)

### Deactivation

Protection zones activated from the part program cannot be deactivated by the PLC user program.

---

**Note**

It follows from the rules listed above that protection zones that should be activated via the PLC user program are intended specially for this. Preactivation in the part program is only useful for these protection zones.

For protection zones that are known only in the part program and not in the PLC user program, only activation in the part program makes sense.

---

**Automatic activation after the control powers up**

The configuration for automatic activation of a protection zone after the control powers up is performed via the following system variable:

- Channel-specific protection zone:  
\$SC\_PA\_ACTIV\_IMMED[ n ]
- Machine or NC-specific protection zone:  
\$SN\_PA\_ACTIV\_IMMED[ n ]

With automatic activation, no relative offset of the protection zone is possible.

**Block search with calculation**

For block search with calculation, the last programmed activation state of a protection zone is always taken into account.

**Program test**

In automatic modes, activated and preactivated protection zones are monitored even during program control: PROGRAM TEST.

**2.3.6 Protection-zone violation and temporary enabling of individual protection zones**

**Function**

Workpiece and tool-related protection zones that are activated or deactivated are monitored for collision. If a protection-zone violation is detected, behavior in the individual operating modes is as follows.

**Terminating temporary enabling**

Temporary enabling of a protection zone is terminated after the following events:

- after NC RESET
- Operating modes AUTOMATIC or MDA End of block is outside the protection zone
- Manual operating modes: End of movement is outside the protection zone
- Activating a protection zone

On NC RESET all the enabled protection zones become active again. If the part program or jog mode is started again, the protection zones must be re-enabled. If the current position lies within a protection zone that becomes active again after NC RESET, this protection zone must be enabled again on the first path movement.

#### **Preactivated protection zones**

Protection zones can be preactivated with part programs. To make them fully operative, they must also be set to the "operative" state by the PLC.

In contrast to AUTOMATIC mode, a change in the NC/PLC interface signals "Make preactivated protection zones operative" only has an effect on stationary axes in the geometry system. This means: If an inoperative protection zone is made "operative" once a motion has been started, it is not evaluated until the axes have stopped, possibly resulting in the output of an alarm.

If a preactivated protection zone is made "operative" during traversing, the alarm 10704 "Protection-zone monitoring is not guaranteed" and the PLC interface signal are set:

DB31, ... DBX39.0 (protection-zone monitoring not guaranteed).

#### **Deactivation of tool-related protection zones**

Tool-related protection zones can be deactivated only in the part program or, if they have been preactivated, by being rendered "inoperative" by the PLC.

#### **Geometry axis change and transformation change**

Through the following machine data it is adjustable, whether active protection zones are retained or deactivated during the geometry axis change or transformation change:

MD10618 \$MN\_PROTAREA\_GEOAX\_CHANGE\_MODE

Bit	Value	Significance
0	0	Protection zones are deactivated during the transformation change.
	1	Active protection zones remain active after a transformation is changed.
1	0	Protection zones are deactivated during the geometry axis change.
	1	Active protection zones remain active after a geometry axis change.

#### **Monitoring of overlaid motion**

Axes that have been assigned to another channel are not taken into account. The last position to be approached is taken to be the end position. It is not taken into account whether the axis has traversed after changing channels.

**Behavior in the AUTOMATIC and MDI operating modes**

Protection zones are not overrun in Automatic modes:

- If the movement in a block is from outside into the protection zone (N30), deceleration is executed toward the end of the previous block (N20) and the movement is stopped.
  - If the protection zone is preactivated but not activated by the PLC, machining is continued (case 1).
  - If the protection zone is activated or preactivated and activated by the PLC, machining is stopped (case 2).
- If the starting point of the block is inside the protection zone, the movement is not started.

In case of violation of protection zone for the workpiece-related protection zone, the alarm: 10700 "NCK-protection zone in v or MDI violated" or 10701 "channel-specific protection zone in AUTOMATIC or MDI violated" is given.

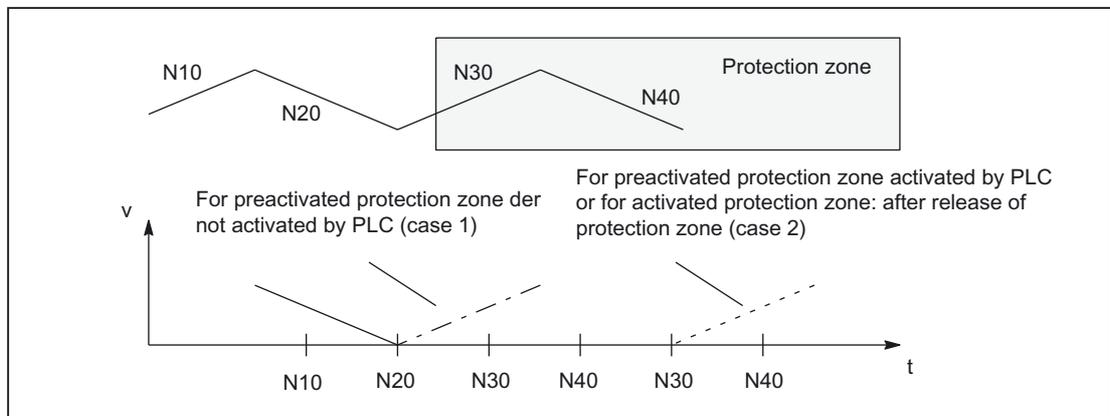


Figure 2-14 Behavior of the path velocity when entering a protection zone

**Overlaying several axis motions**

Overlaid motions of external ZO (zero offsets) or DRF are taken into account if they are executed at a sufficiently early point in time.

If an overlaid motion occurs while a protection zone is active or operative, an alarm is output as a warning. This alarm has no effect on the machining operation and resets itself if the transferred motion has been fully taken into account. The PLC interface signal is set at the same time as alarm 10704:

DB31, ... DBX39.0 (protection-zone monitoring not guaranteed).

**Enabling of workpiece-related protection zones**

When a workpiece-related protection zone has been violated, the operator can enable it temporarily with NC start in the AUTOMATIC and JOG modes so that it can be traversed. This clears the alarm and travels into the protection zone in the AUTOMATIC and MDI operating modes.

Only workpiece-related protection zones can be enabled temporarily with NC start and traversed by all tool-related protection zones including the programmed path.

If on NC-START the preactivated tool or workpiece-related protection zone is deactivated by the PLC after the alarm, machining is continued without the protection zone being enabled temporarily.

If a fully operative, preactivated protection zone causes a machining interruption and the output of an alarm owing to protection-zone violation, machining can be resumed on NC start if the PLC makes the zone inoperative again.

If enabling of a protection zone is to be safeguarded better than with a simple NC start, NC start must be disabled or made dependent on other conditions in the PLC user program when this alarm is triggered.

If the user does not want to permit overrunning the protection zone, he can terminate the traversing movement with `NC RESET`.

If several protection zones are violated at the same time by the movement, acknowledgment is required for each of these protection zones. With NC start the individual protection zones can then be enabled one after the other.

#### **Application for temporary enabling:**

Drilling a turned part: The drill is allowed to enter the protection zone of the spindle chuck.

#### **Monitoring of overlaid motion**

On preparation of the NC blocks, part of the offsets of geometry axes resulting from the overlaid motions are taken into account.

If further offsets occur that could not be taken into account on preparation of the blocks, the channel-specific PLC interface signal is set.

DB31, ... DBX39.0 (protection-zone monitoring not guaranteed).

This signal is set while offsets are active that cannot be taken into account. The signal can be set and reset within a block.

Simultaneously with the PLC interface signal, a self-canceling alarm 10704 "Protection-zone monitoring is not guaranteed" is output.

The following overlaid motions of geometry axes are taken into account in the preparation of blocks:

1. DRF offsets
2. Work offsets external
3. Fine tool offsets
4. Rapid retraction
5. Offsets generated by compile cycles
6. Oscillation
7. Concurrent positioning axes
8. Positioning axes

The alarm is canceled or the PLC interface signal reset when the offsets from the overlaid motions are taken into account again or when the offsets are reduced to zero again.

**Note**

The end position for positioning axes is taken to be a position in the whole block. This means that the alarm 10704 "Protection zones not guaranteed" is output when the positioning axis starts to move. The overlaid motions themselves are not limited, nor is there any intervention in processing of the program.

**Behavior in JOG mode**

**Overlaying several axis motions**

In JOG mode traversing can be performed simultaneously in several geometry axes even when protection zones are active. However, safe monitoring of protection zones can then no longer be guaranteed. This is indicated as follows:

- Alarm: " 10704 Protection-zone monitoring is not guaranteed"
- DB31, ... DBX39.0 = 1 (protection-zone monitoring not guaranteed)

The traversing range of the geometry axes is limited in all directions by the protection zones with the same effect as they had at the start point.

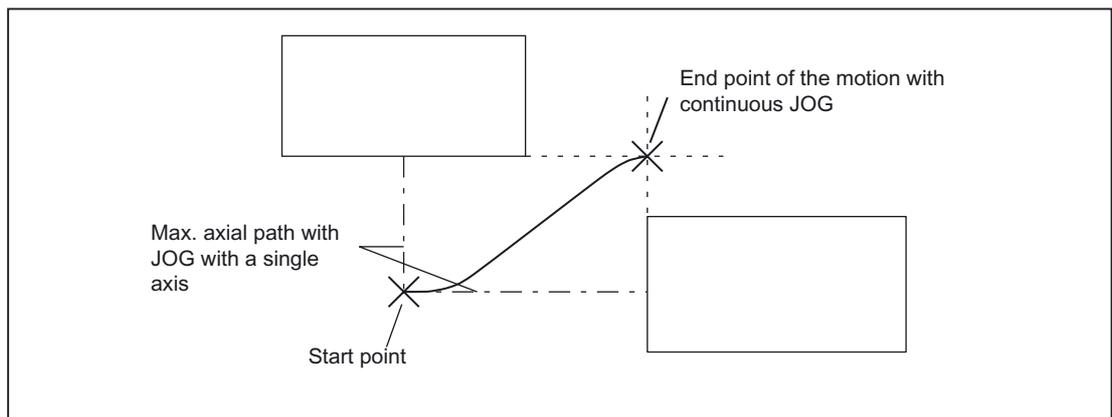


Figure 2-15 Motion boundaries of axes

When the geometry axes have completed their movements (end of interpolation), the alarm is automatically reset and the final position checked to see whether it is within one or several protection zones.

There are three possible situations in this case:

1. If the position is outside all active protection zones, the next traversing motion can be started normally. The appropriate PLC interface signals "Machine-specific or channel-specific protection zone violated" are set for the protection zones that are enabled or just preactivated, but not yet operative.
2. If the position is within an active protection zone, the alarm "Protection zone violated in JOG" is generated, thereby disabling any traversing motions. The appropriate PLC interface signals "Machine-specific or channel-specific protection zone violated" are also set.

The alarm is reset by:

- Temporary enabling of the affected protection zones

- Deactivation of the relevant protection zones if they are preactivated
  - Deactivation of the protection zone in MDI
3. If the position is on the protection zone limitation (position is still valid), no alarm is generated.

---

**Note**

While any one axis in the geometry system is still oscillating, the status "Motions of axes in geometry system completed" cannot be reached.

The warning remains active, the other axes in the geometry system can continue to traverse.

The alarm "Protection zone reached in JOG" is not output if the motion of the first axis to be started is terminated by the limitation determined prior to the motion.

---

**Monitoring (pre)activated protection zones**

(Pre)activated protection zones are also monitored in manual modes (JOG, INC, handwheel).

**Limitation of traversing motion of an axis**

Axis motions are limited in JOG mode by means of software limit switches or the working area limitation. The protection zones are an additional limiting element on the traversing motion of the geometry axes.

If the traversing motion of an axis is limited because it has reached a protection zone, then a self-resetting alarm "Protection zone reached in JOG" is generated. The alarm text specifies the violated protection zone and the relevant axis. It is assured that no protection zone will be violated when one axis is traversing in JOG. (This response is analogous to approaching software limit switches or a working area limitation).

The alarm is reset:

- when an axis is traversed along a path that does not lead into the protection zone
- when the protection zone is enabled
- on NC RESET.

If an axis starts to move towards a protection zone when it is at a protection zone limit, then a self-resetting alarm "Protection zone reached in JOG" is output and the motion is not started.

**Enabling of workpiece-related protection zones**

When a workpiece-related protection zone has been violated, the operator can also enable it temporarily in JOG mode so that it can be traversed. This resets the alarm and the motion is started in the manual operating modes after a new travel command.

### Temporary enabling of protection zones

Protection zones can be enabled in JOG mode when:

1. the current position is within a protection zone (alarm active)
2. a motion is to be started on the protection zone limit (alarm active)

A protection zone is enabled when:

- a positive signal edge arrives at the PLC interface "Temporary enabling of protection zones" (this enable resets the active alarm).
- if the axis then starts to move again into the same protection zone.

Start of the motion causes:

- the protection zone to be enabled
- the appropriate PLC interface signals "Machine-specific or channel-specific protection zone violated" to be set.
- the axis to start moving.

The enabling signal is canceled if a motion is started that does not lead into the enabled protection zone.

If the current position is located in other active protection zones or the limit for other protection zones must be crossed with the motion that has been started, then alarms 10702, 10703 or 10706, 10707 are output. The PLC interface signal "Temporary enabling of protection zones" can be set again to enable the protection zone for which an alarm is output.

The enabling signals for the individual protection zones are still valid on switchover to operating modes AUTOMATIC or MDA, and vice versa, the enabling signals of protection zones that were output in AUTOMATIC and MDA remain valid.

If the end position is located outside the relevant protection zone the next time the axes in the geometry system stop:

- the enabling signals of the individual protection zones are canceled
- the appropriate PLC interface signal "Machine-specific or channel-specific protection zone violated" is reset.

## 2.3.7 Restrictions in protection zones

### Restrictions in protection-zone monitoring

No protection-zone monitoring is possible under the following conditions:

- Orientation axes
- Protection-zone monitoring for fixed machine-related protection zones with transmit or peripheral surface transformation.

Exception: Protection zones defined with rotation symmetry around the spindle axis. Here, no DRF offset must be active.

- Mutual monitoring of tool-related protection zones

### Positioning axes

For positioning axes, only the programmed block end point is monitored.

An alarm is displayed during the traversing motion of the positioning axes:

Alarm: "10704 Protection-zone monitoring is not guaranteed".

### Axis exchange

If an axis is not active in a channel because of an axis replacement, the position of the axis last approached in the channel is taken as the current position. If this axis has not yet been traversed in the channel, zero is taken as the position.

### Machine-related protection zones

A machine-related protection zone or its contour is defined using the geometry axis, i.e. with reference to the basic coordinate system (BCS) of a channel. In order that correct protection-zone monitoring can take place in all channels in which the machine-related protection zone is active, the basic coordinate system (BCS) of all affected channels must be identical (position of the coordinate point of origin with respect to the machine zero point and orientation of the coordinate axes).

## 2.4 Supplementary conditions

### 2.4.1 Axis monitoring functions

#### Settings

For correct operation of the monitoring, the following settings must be made or checked, in addition to the machine data mentioned:

##### General

- MD31030 \$MA\_LEADSCREW\_PITCH (Leadscrew pitch)
- MD31050 \$MA\_DRIVE\_AX\_RATIO\_DENOM (Denominator load gearbox)
- MD31060 \$MA\_DRIVE\_AX\_RATIO\_NUMERA (Numerator load gearbox)
- MD31070 \$MA\_DRIVE\_ENC\_RATIO\_DENOM (Denominator measuring gearbox)
- MD31080 \$MA\_DRIVE\_ENC\_RATIO\_NUMERA (Numerator measuring gearbox)
- MD32810 \$MA\_EQUIV\_SPEEDCTRL\_TIME (Equivalent time constant speed control loop for feedforward control)
- Encoder resolution

The corresponding machine data is described in:

##### References:

/FB1/ Function Manual, Basic Functions; Velocities, Setpoint/Actual Value Systems, Closed-Loop Control (G2)

##### Only drives with analog speed setpoint interface

- MD32260 \$MA\_RATED\_VELO (Nominal motor speed)
- MD32250 \$MA\_RATED\_OUTVAL (Nominal output voltage)

## 2.5 Examples

### 2.5.1 Axis monitoring

#### 2.5.1.1 Working area limitation in WKS/ENS

##### Available channel axes

4 axes are defined in the channel: X, Y, Z and A  
The A-axis is a rotary axis (not modulo).

##### Parameterize number of working area limitation groups

Three working area limitation groups will be provided:  
MD28600 \$MC\_MM\_NUM\_WORKAREA\_CS\_GROUP = 3

##### Define working area limitation groups

Additionally 2 working area limitation groups will be defined:

###### Working area limitation group 1

In the first working area limitation group the axes in the ENS coordinate system will be limited:

- X axis in the plus direction: 10 mm
- X axis in the minus direction: No limitation
- Y axis in the plus direction: No limitation
- Y axis in the minus direction: 25 mm
- Z axis in the plus direction: No limitation
- Z axis in the minus direction: No limitation
- A axis in the plus direction: 10 degrees
- A axis in the minus direction: -40 degrees

The system variables are assigned as follows:

```
N1 $AC_WORKAREA_CS_COORD_SYSTEM[1] = 3 ; The working area limitation
of the working area
limitation group 1 applies
in the ENS.

N10 $AC_WORKAREA_CS_PLUS_ENABLE[1,X] = TRUE
N11 $AC_WORKAREA_CS_LIMIT_PLUS[1,X] = 10
N12 $AC_WORKAREA_CS_MINUS_ENABLE[1,X] = FALSE
N20 $AC_WORKAREA_CS_PLUS_ENABLE[1,Y] = FALSE
N22 $AC_WORKAREA_CS_MINUS_ENABLE[1,Y] = TRUE
N23 $AC_WORKAREA_CS_LIMIT_MINUS[1,Y] = 25
N30 $AC_WORKAREA_CS_PLUS_ENABLE[1,Z] = FALSE
N32 $AC_WORKAREA_CS_MINUS_ENABLE[1,Z] = FALSE
N40 $AC_WORKAREA_CS_PLUS_ENABLE[1,A] = TRUE
N41 $AC_WORKAREA_CS_LIMIT_PLUS[1,A] = 10
N42 $AC_WORKAREA_CS_MINUS_ENABLE[1,A] = TRUE
N43 $AC_WORKAREA_CS_LIMIT_MINUS[1,A] = -40
```

#### Working area limitation group 2

In the second working area limitation group the axes in the WKS coordinate system can be limited:

- X axis in the plus direction: 10 mm
- X axis in the minus direction: No limitation
- Y axis in the plus direction: 34 mm
- Y axis in the minus direction: -25 mm
- Z axis in the plus direction: No limitation
- Z axis in the minus direction: -600 mm
- A axis in the plus direction: No limitation
- A axis in the minus direction: No limitation

The system variables are assigned as follows:

```
N51 $AC_WORKAREA_CS_COORD_SYSTEM[2] = 1 ; The working area limitation
of working area limitation
group 2 applies in the WCS.

N60 $AC_WORKAREA_CS_PLUS_ENABLE[2,X] = TRUE
N61 $AC_WORKAREA_CS_LIMIT_PLUS[2,X] = 10
N62 $AC_WORKAREA_CS_MINUS_ENABLE[2,X] = FALSE
N70 $AC_WORKAREA_CS_PLUS_ENABLE[2,Y] = TRUE
N73 $AC_WORKAREA_CS_LIMIT_PLUS[2,Y] = 34
N72 $AC_WORKAREA_CS_MINUS_ENABLE[2,Y] = TRUE
```

```
N73 $AC_WORKAREA_CS_LIMIT_MINUS[2,Y] = -25
N80 $AC_WORKAREA_CS_PLUS_ENABLE[2,Z] = FALSE
N82 $AC_WORKAREA_CS_MINUS_ENABLE[2,Z] = TRUE
N83 $AC_WORKAREA_CS_LIMIT_PLUS[2,Z] = -600
N90 $AC_WORKAREA_CS_PLUS_ENABLE[2,A] = FALSE
N92 $AC_WORKAREA_CS_MINUS_ENABLE[2,A] = FALSE
```

### Activate working area limitation group 2

In order to activate the working area limitation group 2, following instruction must exist in the part program:

```
...
N100 WALCS2 ...
...
```

## 2.5.2 Protection zones

### 2.5.2.1 Definition and activation of protection zones

#### Requirement

The following internal protection zones are to be defined for a turning machine:

- One machine- and workpiece-related protection zone for the spindle chuck, without limitation in the third dimension
- One channel-specific protection zone for the workpiece, without limitation in the third dimension
- One channel-specific, tool-related protection zone for the toolholder, without limitation in the third dimension

The workpiece zero is placed on the machine zero to define the protection zone for the workpiece.

When activated, the protection zone is then offset by 100mm in the Z axis in the positive direction.

2.5 Examples

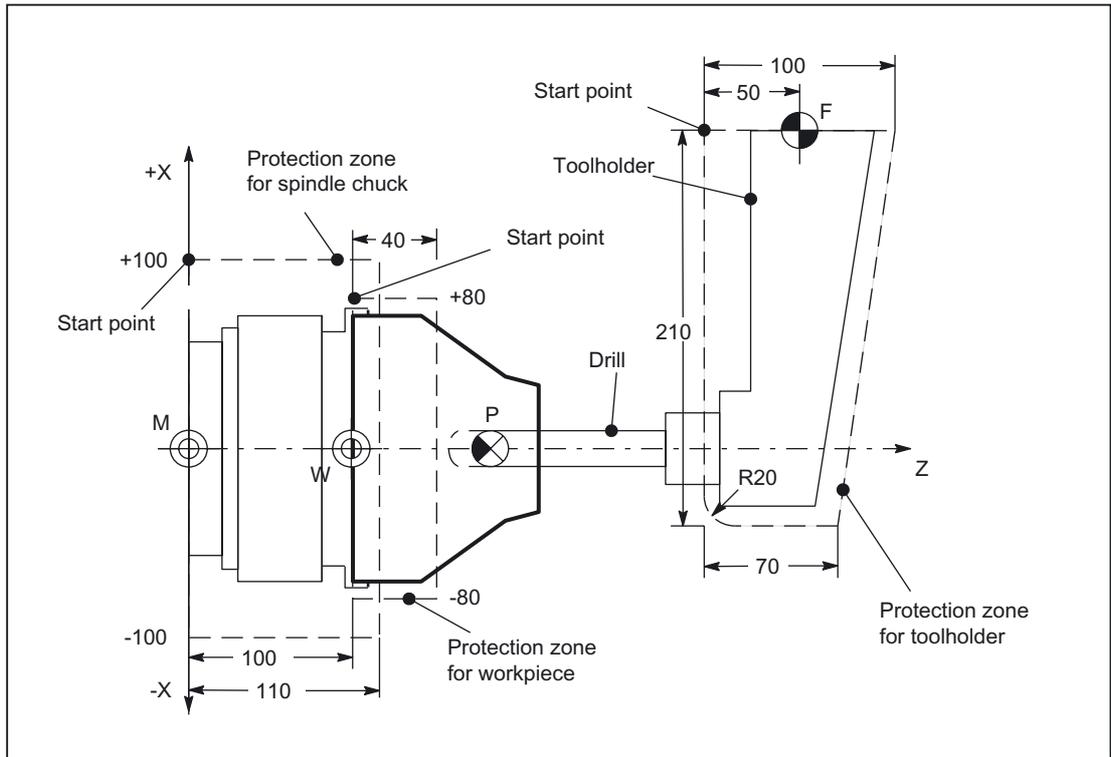


Figure 2-16 Example of protection zones on a turning machine

Protection-zone definition in the part program

Table 2-1 Part program excerpt for protection-zone definition:

DEF INT AB	
G18	; Definition of the working plane
NPROTDEF(1,FALSE,0,0,0)	; Definition beginning: Protection zone for spindle chuck
G01 X100 Z0	; Contour description: 1st contour element
G01 X-100 Z0	; Contour description: 2nd contour element
G01 X-100 Z110	; Contour description: 3rd contour element
G01 X100 Z110	; Contour description: 4th contour element
G01 X100 Z0	; Contour description: 5th contour element
EXECUTE(AB)	; End of definition: Protection zone for spindle chuck
CPROTDEF(1,FALSE,0,0,0)	; Definition beginning: Protection zone for workpiece
G01 X80 Z0	; Contour description: 1st contour element
G01 X-80 Z0	; Contour description: 2st contour element
G01 X-80 Z40	; Contour description: 3rd contour element
G01 X80 Z40	; Contour description: 4th contour element
G01 X80 Z0	; Contour description: 5th contour element
EXECUTE(AB)	; End of definition: Protection zone for workpiece

```

CPROTDEF(2,TRUE,0,0,0)           ; Definition beginning: Protection zone for
                                ; tool holder
G01 X0 Z-50                      ; Contour description: 1st contour element
G01 X-190 Z-50                   ; Contour description: 2nd contour element
G03 X-210 Z-30 I-20              ; Contour description: 3rd contour element
G01 X-210 Z20                    ; Contour description: 4th contour element
G01 X0 Z50                       ; Contour description: 5th contour element
G01 X0 Z-50                      ; Contour description: 6th contour element
EXECUTE(AB)                      ; End of definition: Protection zone for tool
                                ; holder

```

### Protection-zone definition with system variables

Table 2-2 Protection zone: Spindle chuck

System variable	Value	Comment
\$\$SN_PA_ACTIV_IMMED[0]	0	; Protection zone for spindle chuck not immediately active
\$\$SN_PA_T_W[0]	" "	; Machine-related protection zone for spindle chuck
\$\$SN_PA_ORI[0]	1	; Orientation of the protection zone: 1= 3rd and 1st geometry ; axis
\$\$SN_PA_LIM_3DIM[0]	0	; Type of limitation in the third dimension: 0 = No limit
\$\$SN_PA_PLUS_LIM[0]	0	; Value of the limit in the positive direction in the ; 3rd dimension
\$\$SN_PA_MINUS_LIM[0]	0	; Value of the limitation in the negative direction in the ; 3rd dimension
\$\$SN_PA_CONT_NUM[0]	4	; Number of valid contour elements
\$\$SN_PA_CONT_TYP[0,0]	1	; Contour type[i] : 1 = G1 for even, ; Protection zone for spindle chuck, contour element 0
\$\$SN_PA_CONT_TYP[0,1]	1	; Contour type[i] : 1 = G1 for even, ; Protection zone for spindle chuck, contour element 1
\$\$SN_PA_CONT_TYP[0,2]	1	; Contour type[i] : 1 = G1 for even, ; Protection zone for spindle chuck, contour element 2
\$\$SN_PA_CONT_TYP[0,3]	1	; Contour type[i] : 1 = G1 for even, ; Protection zone for spindle chuck, contour element 3
\$\$SN_PA_CONT_TYP[0,4]	0	; Contour type[i] : 0 = not defined, ; Protection zone for spindle chuck, contour element 4
\$\$SN_PA_CONT_TYP[0,5]	0	; Contour type[i] : 0 = not defined, ; Protection zone for spindle chuck, contour element 5
\$\$SN_PA_CONT_TYP[0,6]	0	; Contour type[i] : 0 = not defined, ; Protection zone for spindle chuck, contour element 6
\$\$SN_PA_CONT_TYP[0,7]	0	; Contour type[i] : 0 = not defined, ; Protection zone for spindle chuck, contour element 7
\$\$SN_PA_CONT_TYP[0,8]	0	; Contour type[i] : 0 = not defined, ; Protection zone for spindle chuck, contour element 8
\$\$SN_PA_CONT_TYP[0,9]	0	; Contour type[i] : 0 = not defined, ; Protection zone for spindle chuck, contour element 9

2.5 Examples

\$SN_PA_CONT_ORD[0,0]	-100	; Endpoint of contour[i], ordinate value ; Protection zone for spindle chuck, contour element 0
\$SN_PA_CONT_ORD[0,1]	-100	; Endpoint of contour[i], ordinate value ; Protection zone for spindle chuck, contour element 1
\$SN_PA_CONT_ORD[0,2]	100	; Endpoint of contour[i], ordinate value ; Protection zone for spindle chuck, contour element 2
\$SN_PA_CONT_ORD[0,3]	100	; Endpoint of contour[i], ordinate value ; Protection zone for spindle chuck, contour element 3
\$SN_PA_CONT_ORD[0,4]	0	; Endpoint of contour[i], ordinate value ; Protection zone for spindle chuck, contour element 4
\$SN_PA_CONT_ORD[0,5]	0	; Endpoint of contour[i], ordinate value ; Protection zone for spindle chuck, contour element 5
\$SN_PA_CONT_ORD[0,6]	0	; Endpoint of contour[i], ordinate value ; Protection zone for spindle chuck, contour element 6
\$SN_PA_CONT_ORD[0,7]	0	; Endpoint of contour[i], ordinate value ; Protection zone for spindle chuck, contour element 7
\$SN_PA_CONT_ORD[0,8]	0	; Endpoint of contour[i], ordinate value ; Protection zone for spindle chuck, contour element 8
\$SN_PA_CONT_ORD[0,9]	0	; Endpoint of contour[i], ordinate value ; Protection zone for spindle chuck, contour element 9
\$SN_PA_CONT_ABS[0,0]	0	; Endpoint of contour[i], abscissa value ; Protection zone for spindle chuck, contour element 0
\$SN_PA_CONT_ABS[0,1]	110	; Endpoint of contour[i], abscissa value ; Protection zone for spindle chuck, contour element 1
\$SN_PA_CONT_ABS[0,2]	110	; Endpoint of contour[i], abscissa value ; Protection zone for spindle chuck, contour element 2
\$SN_PA_CONT_ABS[0,3]	0	; Endpoint of contour[i], abscissa value ; Protection zone for spindle chuck, contour element 3
\$SN_PA_CONT_ABS[0,4]	0	; Endpoint of contour[i], abscissa value ; Protection zone for spindle chuck, contour element 4
\$SN_PA_CONT_ABS[0,5]	0	; Endpoint of contour[i], abscissa value ; Protection zone for spindle chuck, contour element 5
\$SN_PA_CONT_ABS[0,6]	0	; Endpoint of contour[i], abscissa value ; Protection zone for spindle chuck, contour element 6
\$SN_PA_CONT_ABS[0,7]	0	; Endpoint of contour[i], abscissa value ; Protection zone for spindle chuck, contour element 7
\$SN_PA_CONT_ABS[0,8]	0	; Endpoint of contour[i], abscissa value ; Protection zone for spindle chuck, contour element 8
\$SN_PA_CONT_ABS[0,9]	0	; Endpoint of contour[i], abscissa value ; Protection zone for spindle chuck, contour element 9
\$SN_PA_CENT_ORD[0,0]	0	; Midpoint of contour[i], ordinate value ; Protection zone for spindle chuck, contour element 0
\$SN_PA_CENT_ORD[0,1]	0	; Midpoint of contour[i], ordinate value ; Protection zone for spindle chuck, contour element 1
\$SN_PA_CENT_ORD[0,2]	0	; Midpoint of contour[i], ordinate value ; Protection zone for spindle chuck, contour element 2
\$SN_PA_CENT_ORD[0,3]	0	; Midpoint of contour[i], ordinate value ; Protection zone for spindle chuck, contour element 3

\$SN_PA_CENT_ORD[0,4]	0	; Midpoint of contour[i], ordinate value ; Protection zone for spindle chuck, contour element 4
\$SN_PA_CENT_ORD[0,5]	0	; Midpoint of contour[i], ordinate value ; Protection zone for spindle chuck, contour element 5
\$SN_PA_CENT_ORD[0,6]	0	; Midpoint of contour[i], ordinate value ; Protection zone for spindle chuck, contour element 6
\$SN_PA_CENT_ORD[0,7]	0	; Midpoint of contour[i], ordinate value ; Protection zone for spindle chuck, contour element 7
\$SN_PA_CENT_ORD[0,8]	0	; Midpoint of contour[i], ordinate value ; Protection zone for spindle chuck, contour element 8
\$SN_PA_CENT_ORD[0,9]	0	; Midpoint of contour[i], ordinate value ; Protection zone for spindle chuck, contour element 9
\$SN_PA_CENT_ABS[0,0]	0	; Midpoint of contour[i], abscissa value ; Protection zone for spindle chuck, contour element 0
\$SN_PA_CENT_ABS[0,1]	0	; Midpoint of contour[i], abscissa value ; Protection zone for spindle chuck, contour element 1
\$SN_PA_CENT_ABS[0,2]	0	; Midpoint of contour[i], abscissa value ; Protection zone for spindle chuck, contour element 2
\$SN_PA_CENT_ABS[0,3]	0	; Midpoint of contour[i], abscissa value ; Protection zone for spindle chuck, contour element 3
\$SN_PA_CENT_ABS[0,4]	0	; Midpoint of contour[i], abscissa value ; Protection zone for spindle chuck, contour element 4
\$SN_PA_CENT_ABS[0,5]	0	; Midpoint of contour[i], abscissa value ; Protection zone for spindle chuck, contour element 5
\$SN_PA_CENT_ABS[0,6]	0	; Midpoint of contour[i], abscissa value ; Protection zone for spindle chuck, contour element 6
\$SN_PA_CENT_ABS[0,7]	0	; Midpoint of contour[i], abscissa value ; Protection zone for spindle chuck, contour element 7
\$SN_PA_CENT_ABS[0,8]	0	; Midpoint of contour[i], abscissa value ; Protection zone for spindle chuck, contour element 8
\$SN_PA_CENT_ABS[0,9]	0	; Midpoint of contour[i], abscissa value ; Protection zone for spindle chuck, contour element 9

Table 2-3 Protection zone: Workpiece and tool holder

System variable	Value	Comment
\$SN_PA_ACTIV_IMMED[0]	0	; Protection zone for workpiece not immediately active
\$SN_PA_ACTIV_IMMED[1]	0	; Protection zone for tool holder not immediately active
\$SC_PA_TW[0]	" "	; Protection zone for workpiece, channel-specific
\$SC_PA_TW[1]	'H01'	; Protection zone for toolholder, channel-specific
\$SC_PA_ORI[0]	1	; Orientation of the protection zone: 1= 3rd and first ; geometry axis ; Protection zone for workpiece
\$SC_PA_ORI[1]	1	; Orientation of the protection zone: 1= 3rd and first ; geometry axis ; Protection zone for tool holder

2.5 Examples

\$SC_PA_LIM_3DIM[0]	0	; Type of limitation in the third dimension: 0 = no limitation ; Protection zone for workpiece tool holder 0
\$SC_PA_LIM_3DIM[1]	0	; Type of limitation in the third dimension: 0 = no limitation ; Protection zone for tool holder
\$SC_PA_PLUS_LIM[0]	0	; Value of limitation in positive direction in the third dimension ; Protection zone for workpiece
\$SC_PA_PLUS_LIM[1]	0	; Value of limitation in positive direction in the third dimension ; Protection zone for tool holder
\$SC_PA_MINUS_LIM[0]	0	; Value of limitation in negative direction in the third dimension ; Protection zone for workpiece
\$SC_PA_MINUS_LIM[1]	0	; Value of limitation in negative direction in the third dimension ; Protection zone for tool holder
\$SC_PA_CONT_NUM[0]	4	; Number of valid contour elements, ; Protection zone for workpiece
\$SC_PA_CONT_NUM[1]	5	; Number of valid contour elements, ; Protection zone for tool holder 1
\$SN_PA_CONT_TYP[0,0]	1	; Contour type[i] : 1 = G1 for even, ; Protection zone for workpiece, contour element 0
\$SN_PA_CONT_TYP[0,1]	1	; Contour type[i] : 1 = G1 for even, ; Protection zone for workpiece, contour element 1
\$SN_PA_CONT_TYP[0,2]	1	; Contour type[i] : 1 = G1 for even, ; Protection zone for workpiece, contour element 2
\$SN_PA_CONT_TYP[0,3]	1	; Contour type[i] : 1 = G1 for even, ; Protection zone for workpiece, contour element 3
\$SN_PA_CONT_TYP[0,4]	1	; Contour type[i] : 1 = G1 for even, ; Protection zone for workpiece, contour element 4
\$SN_PA_CONT_TYP[0,5]	0	; Contour type[i] : 0 = not defined, ; Protection zone for workpiece, contour element 5
\$SN_PA_CONT_TYP[0,6]	0	; Contour type[i] : 0 = not defined, ; Protection zone for workpiece, contour element 6
\$SN_PA_CONT_TYP[0,7]	0	; Contour type[i] : 0 = not defined, ; Protection zone for workpiece, contour element 7
\$SN_PA_CONT_TYP[0,8]	0	; Contour type[i] : 0 = not defined, ; Protection zone for workpiece, contour element 8
\$SN_PA_CONT_TYP[0,9]	0	; Contour type[i] : 0 = not defined, ; Protection zone for workpiece, contour element 9
\$SN_PA_CONT_TYP[1,0]	1	; Contour type[i] : 1 = G1 for even, ; Protection zone for tool holder, contour element 0
\$SN_PA_CONT_TYP[1,1]	3	; Contour type[i] : 3 = G3 f. Circuit element, counter-clockwise, ; Protection zone for tool holder, contour element 1
\$SN_PA_CONT_TYP[1,2]	1	; Contour type[i] : 1 = G1 for even, ; Protection zone for tool holder, contour element 2
\$SN_PA_CONT_TYP[1,3]	1	; Contour type[i] : 1 = G1 for even, ; Protection zone for tool holder, contour element 3
\$SN_PA_CONT_TYP[1,4]	1	; Contour type[i] : 1 = G1 for even, ; Protection zone for tool holder, contour element 4

\$SN_PA_CONT_TYP[1,5]	0	; Contour type[i] : 0 = not defined, ; Protection zone for tool holder, contour element 5
\$SN_PA_CONT_TYP[1,6]	0	; Contour type[i] : 0 = not defined, ; Protection zone for tool holder, contour element 6
\$SN_PA_CONT_TYP[1,7]	0	; Contour type[i] : 0 = not defined, ; Protection zone for tool holder, contour element 7
\$SN_PA_CONT_TYP[1,8]	0	; Contour type[i] : 0 = not defined, ; Protection zone for tool holder, contour element 8
\$SN_PA_CONT_TYP[1,9]	0	; Contour type[i] : 0 = not defined, ; Protection zone for tool holder, contour element 9
\$SN_PA_CONT_ORD[0,0]	-80	; Endpoint of contour[i], ordinate value ; Protection zone for workpiece, contour element 0
\$SN_PA_CONT_ORD[0,1]	-80	; Endpoint of contour[i], ordinate value ; Protection zone for workpiece, contour element 1
\$SN_PA_CONT_ORD[0,2]	80	; Endpoint of contour[i], ordinate value ; Protection zone for workpiece, contour element 2
\$SN_PA_CONT_ORD[0,3]	80	; Endpoint of contour[i], ordinate value ; Protection zone for workpiece, contour element 3
\$SN_PA_CONT_ORD[0,4]	0	; Endpoint of contour[i], ordinate value ; Protection zone for workpiece, contour element 4
\$SN_PA_CONT_ORD[0,5]	0	; Endpoint of contour[i], ordinate value ; Protection zone for workpiece, contour element 5
\$SN_PA_CONT_ORD[0,6]	0	; Endpoint of contour[i], ordinate value ; Protection zone for workpiece, contour element 6
\$SN_PA_CONT_ORD[0,7]	0	; Endpoint of contour[i], ordinate value ; Protection zone for workpiece, contour element 7
\$SN_PA_CONT_ORD[0,8]	0	; Endpoint of contour[i], ordinate value ; Protection zone for workpiece, contour element 8
\$SN_PA_CONT_ORD[0,9]	0	; Endpoint of contour[i], ordinate value ; Protection zone for workpiece, contour element 9
\$SN_PA_CONT_ORD[1,0]	-190	; Endpoint of contour[i], ordinate value ; Protection zone for tool holder, contour element 0
\$SN_PA_CONT_ORD[1,1]	-210	; Endpoint of contour[i], ordinate value ; Protection zone for tool holder, contour element 1
\$SN_PA_CONT_ORD[1,2]	-210	; Endpoint of contour[i], ordinate value ; Protection zone for tool holder, contour element 2
\$SN_PA_CONT_ORD[1,3]	0	; Endpoint of contour[i], ordinate value ; Protection zone for tool holder, contour element 3
\$SN_PA_CONT_ORD[1,4]	0	; Endpoint of contour[i], ordinate value ; Protection zone for tool holder, contour element 4
\$SN_PA_CONT_ORD[1,5]	0	; Endpoint of contour[i], ordinate value ; Protection zone for tool holder, contour element 5
\$SN_PA_CONT_ORD[1,6]	0	; Endpoint of contour[i], ordinate value ; Protection zone for tool holder, contour element 6
\$SN_PA_CONT_ORD[1,7]	0	; Endpoint of contour[i], ordinate value ; Protection zone for tool holder, contour element 7
\$SN_PA_CONT_ORD[1,8]	0	; Endpoint of contour[i], ordinate value ; Protection zone for tool holder, contour element 8

2.5 Examples

\$SN_PA_CONT_ORD[1,9]	0	; Endpoint of contour[i], ordinate value ; Protection zone for tool holder, contour element 9
\$SN_PA_CONT_ABS[0,0]	0	; Endpoint of contour[i], abscissa value ; Protection zone for workpiece, contour element 0
\$SN_PA_CONT_ABS[0,1]	40	; Endpoint of contour[i], abscissa value ; Protection zone for workpiece, contour element 1
\$SN_PA_CONT_ABS[0,2]	40	; Endpoint of contour[i], abscissa value ; Protection zone for workpiece, contour element 2
\$SN_PA_CONT_ABS[0,3]	0	; Endpoint of contour[i], abscissa value ; Protection zone for workpiece, contour element 3
\$SN_PA_CONT_ABS[0,4]	-50	; Endpoint of contour[i], abscissa value ; Protection zone for workpiece, contour element 4
\$SN_PA_CONT_ABS[0,5]	0	; Endpoint of contour[i], abscissa value ; Protection zone for workpiece, contour element 5
\$SN_PA_CONT_ABS[0,6]	0	; Endpoint of contour[i], abscissa value ; Protection zone for workpiece, contour element 6
\$SN_PA_CONT_ABS[0,7]	0	; Endpoint of contour[i], abscissa value ; Protection zone for workpiece, contour element 7
\$SN_PA_CONT_ABS[0,8]	0	; Endpoint of contour[i], abscissa value ; Protection zone for workpiece, contour element 8
\$SN_PA_CONT_ABS[0,9]	0	; Endpoint of contour[i], abscissa value ; Protection zone for workpiece, contour element 9
\$SN_PA_CONT_ABS[1,0]	-50	; Endpoint of contour[i], abscissa value ; Protection zone for tool holder, contour element 0
\$SN_PA_CONT_ABS[1,1]	-30	; Endpoint of contour[i], abscissa value ; Protection zone for tool holder, contour element 1
\$SN_PA_CONT_ABS[1,2]	20	; Endpoint of contour[i], abscissa value ; Protection zone for tool holder, contour element 2
\$SN_PA_CONT_ABS[1,3]	50	; Endpoint of contour[i], abscissa value ; Protection zone for tool holder, contour element 3
\$SN_PA_CONT_ABS[1,4]	-50	; Endpoint of contour[i], abscissa value ; Protection zone for tool holder, contour element 4
\$SN_PA_CONT_ABS[1,5]	0	; Endpoint of contour[i], abscissa value ; Protection zone for tool holder, contour element 5
\$SN_PA_CONT_ABS[1,6]	0	; Endpoint of contour[i], abscissa value ; Protection zone for tool holder, contour element 6
\$SN_PA_CONT_ABS[1,7]	0	; Endpoint of contour[i], abscissa value ; Protection zone for tool holder, contour element 7
\$SN_PA_CONT_ABS[1,8]	0	; Endpoint of contour[i], abscissa value ; Protection zone for tool holder, contour element 8
\$SN_PA_CONT_ABS[1,9]	0	; Endpoint of contour[i], abscissa value ; Protection zone for tool holder, contour element 9
\$SN_PA_CENT_ORD[0,0]	0	; Midpoint of contour[i], ordinate value ; Protection zone for workpiece, contour element 0
\$SN_PA_CENT_ORD[0,1]	-190	; Midpoint of contour[i], ordinate value ; Protection zone for workpiece, contour element 1
\$SN_PA_CENT_ORD[0,2]	0	; Midpoint of contour[i], ordinate value ; Protection zone for workpiece, contour element 2

\$SN_PA_CENT_ORD[0,3]	0	; Midpoint of contour[i], ordinate value ; Protection zone for workpiece, contour element 3
\$SN_PA_CENT_ORD[0,4]	0	; Midpoint of contour[i], ordinate value ; Protection zone for workpiece, contour element 4
\$SN_PA_CENT_ORD[0,5]	0	; Midpoint of contour[i], ordinate value ; Protection zone for workpiece, contour element 5
\$SN_PA_CENT_ORD[0,6]	0	; Midpoint of contour[i], ordinate value ; Protection zone for workpiece, contour element 6
\$SN_PA_CENT_ORD[0,7]	0	; Midpoint of contour[i], ordinate value ; Protection zone for workpiece, contour element 7
\$SN_PA_CENT_ORD[0,8]	0	; Midpoint of contour[i], ordinate value ; Protection zone for workpiece, contour element 8
\$SN_PA_CENT_ORD[0,9]	0	; Midpoint of contour[i], ordinate value ; Protection zone for tool holder, contour element 9
\$SN_PA_CENT_ORD[1.0]	0	; Midpoint of contour[i], ordinate value ; Protection zone for tool holder, contour element 0
\$SN_PA_CENT_ORD[1.1]	-190	; Midpoint of contour[i], ordinate value ; Protection zone for tool holder, contour element 1
\$SN_PA_CENT_ORD[1.2]	0	; Midpoint of contour[i], ordinate value ; Protection zone for tool holder, contour element 2
\$SN_PA_CENT_ORD[1.3]	0	; Midpoint of contour[i], ordinate value ; Protection zone for tool holder, contour element 3
\$SN_PA_CENT_ORD[1.4]	0	; Midpoint of contour[i], ordinate value ; Protection zone for tool holder, contour element 4
\$SN_PA_CENT_ORD[1.5]	0	; Midpoint of contour[i], ordinate value ; Protection zone for tool holder, contour element 5
\$SN_PA_CENT_ORD[1.6]	0	; Midpoint of contour[i], ordinate value ; Protection zone for tool holder, contour element 6
\$SN_PA_CENT_ORD[1.7]	0	; Midpoint of contour[i], ordinate value ; Protection zone for tool holder, contour element 7
\$SN_PA_CENT_ORD[1.8]	0	; Midpoint of contour[i], ordinate value ; Protection zone for tool holder, contour element 8
\$SN_PA_CENT_ORD[1.9]	0	; Midpoint of contour[i], ordinate value ; Protection zone for tool holder, contour element 9
\$SN_PA_CENT_ABS[0,0]	0	; Midpoint of contour[i], abscissa value ; Protection zone for workpiece, contour element 0
\$SN_PA_CENT_ABS[0,1]	-30	; Midpoint of contour[i], abscissa value ; Protection zone for workpiece, contour element 1
\$SN_PA_CENT_ABS[0,2]	0	; Midpoint of contour[i], abscissa value ; Protection zone for workpiece, contour element 2
\$SN_PA_CENT_ABS[0,3]	0	; Midpoint of contour[i], abscissa value ; Protection zone for workpiece, contour element 3
\$SN_PA_CENT_ABS[0,4]	0	; Midpoint of contour[i], abscissa value ; Protection zone for workpiece, contour element 4
\$SN_PA_CENT_ABS[0,5]	0	; Midpoint of contour[i], abscissa value ; Protection zone for workpiece, contour element 5
\$SN_PA_CENT_ABS[0,6]	0	; Midpoint of contour[i], abscissa value ; Protection zone for workpiece, contour element 6

2.5 Examples

\$SN_PA_CENT_ABS[0,7]	0	; Midpoint of contour[i], abscissa value ; Protection zone for workpiece, contour element 7
\$SN_PA_CENT_ABS[0,8]	0	; Midpoint of contour[i], abscissa value ; Protection zone for workpiece, contour element 8
\$SN_PA_CENT_ABS[0,9]	0	; Midpoint of contour[i], abscissa value ; Protection zone for workpiece, contour element 9
\$SN_PA_CENT_ABS[1.0]	0	; Midpoint of contour[i], abscissa value ; Protection zone for tool holder, contour element 0
\$SN_PA_CENT_ABS[1.1]	-30	; Midpoint of contour[i], abscissa value ; Protection zone for tool holder, contour element 1
\$SN_PA_CENT_ABS[1.2]	0	; Midpoint of contour[i], abscissa value ; Protection zone for tool holder, contour element 2
\$SN_PA_CENT_ABS[1.3]	0	; Midpoint of contour[i], abscissa value ; Protection zone for tool holder, contour element 3
\$SN_PA_CENT_ABS[1.4]	0	; Midpoint of contour[i], abscissa value ; Protection zone for tool holder, contour element 4
\$SN_PA_CENT_ABS[1.5]	0	; Midpoint of contour[i], abscissa value ; Protection zone for tool holder, contour element 5
\$SN_PA_CENT_ABS[1.6]	0	; Midpoint of contour[i], abscissa value ; Protection zone for tool holder, contour element 6
\$SN_PA_CENT_ABS[1.7]	0	; Midpoint of contour[i], abscissa value ; Protection zone for tool holder, contour element 7
\$SN_PA_CENT_ABS[1.8]	0	; Midpoint of contour[i], abscissa value ; Protection zone for tool holder, contour element 8
\$SN_PA_CENT_ABS[1.9]	0	; Midpoint of contour[i], abscissa value ; Protection zone for tool holder, contour element 9

Activation

Table 2-4 Part program excerpt for activating the three protection zones for spindle chuck, workpiece, and toolholder:

```

NPROT(1, 2, 0, 0, 0) ; Protection zone: Spindle chuck
CPROT(1, 2, 0, 0, 100) ; Protection zone: Workpiece with 100mm offset in the
                        Z axis.
CPROT(2, 2, 0, 0, 0) ; Protection zone: Toolholder
    
```

## 2.6 Data lists

### 2.6.1 Machine data

#### 2.6.1.1 NC-specific machine data

##### Axis monitoring

Number	Identifier: \$MN_	Description
10604	WALIM_GEOAX_CHANGE_MODE	Working area limitation during switchover of geometry axes
10710	PROG_SD_RESET_SAVE_TAB	Setting data to be updated

##### Protection zones

Number	Identifier: \$MN_	Description
10618	PROTAREA_GEOAX_CHANGE_MODE	Protection zone for switchover of geo axes
18190	MM_NUM_PROTECT_AREA_NCK	Number of files for machine-related protection zones

#### 2.6.1.2 Channel-specific machine data

##### Axis monitoring

Number	Identifier: \$MC_	Description
20150	GCODE_RESET_VALUES[n]	Reset G groups
21020	WORKAREA_WITH_TOOL_RADIUS	Allowance for tool radius with working area limitation
24130	TRAFO_INCLUDES_TOOL_1	Tool handling with active transformation 1.
24230	TRAFO_INCLUDES_TOOL_2	Tool handling with active transformation 2.
24330	TRAFO_INCLUDES_TOOL_3	Tool handling with active transformation 3.
24426	TRAFO_INCLUDES_TOOL_4	Tool handling with active transformation 4.
24436	TRAFO_INCLUDES_TOOL_5	Tool handling with active transformation 5.
24446	TRAFO_INCLUDES_TOOL_6	Tool handling with active transformation 6.
24456	TRAFO_INCLUDES_TOOL_7	Tool handling with active transformation 7.
24466	TRAFO_INCLUDES_TOOL_8	Tool handling with active transformation 8.
24476	TRAFO_INCLUDES_TOOL_9	Tool handling with active transformation 9.
24486	TRAFO_INCLUDES_TOOL_10	Tool handling with active transformation 10.
25106	TRAFO_INCLUDES_TOOL_11	Tool handling with active transformation 11.

2.6 Data lists

Number	Identifier: \$MC_	Description
25116	TRAFO_INCLUDES_TOOL_12	Tool handling with active transformation 12.
25126	TRAFO_INCLUDES_TOOL_13	Tool handling with active transformation 13.
25136	TRAFO_INCLUDES_TOOL_14	Tool handling with active transformation 14.
25146	TRAFO_INCLUDES_TOOL_15	Tool handling with active transformation 15.
25156	TRAFO_INCLUDES_TOOL_16	Tool handling with active transformation 16.
25166	TRAFO_INCLUDES_TOOL_17	Tool handling with active transformation 17.
25176	TRAFO_INCLUDES_TOOL_18	Tool handling with active transformation 18.
25186	TRAFO_INCLUDES_TOOL_19	Tool handling with active transformation 19.
25196	TRAFO_INCLUDES_TOOL_20	Tool handling with active transformation 20.
28600	MM_NUM_WORKAREA_CS_GROUPS	Number of coordinate system-specific working area limitations

Protection zones

Number	Identifier: \$MC_	Description
28200	MM_NUM_PROTECT_AREA_CHAN	Number of files for channel-specific protection zones
28210	MM_NUM_PROTECT_AREA_ACTIVE	Number of simultaneously active protection zones in one channel
28212	MM_NUM_PROTECT_AREA_CONTUR	Elements for active protection zones (DRAM)

2.6.1.3 Axis/spindle-specific machine data

Axis monitoring

Number	Identifier: \$MA_	Description
30310	ROT_IS_MODULO	Modulo conversion for rotary axis and spindle
30800	WORK_AREA_CHECK_TYPE	Type of checking of working area limits
32200	POSCTRL_GAIN [n]	Servo gain factor
32250	RATED_OUTVAL	Rated output voltage
32260	RATED_VELO	Rated motor speed
32300	MAX_AX_ACCEL	Axis acceleration
32800	EQUIV_CURRCTRL_TIME	Equivalent time constant current control loop for feedforward control
32810	EQUIV_SPEEDCTRL_TIME	Equivalent time constant speed control loop for feedforward control
32910	DYN_MATCH_TIME [n]	Time constant for dynamic matching
35160	SPIND_EXTERN_VELO_LIMIT	Spindle speed limitation via PLCC
36000	STOP_LIMIT_COARSE	Exact stop coarse
36010	STOP_LIMIT_FINE	Exact stop fine
36020	POSITIONING_TIME	Time delay exact stop fine
36030	STANDSTILL_POS_TOL	Zero speed tolerance

Number	Identifier: \$MA_	Description
36040	STANDSTILL_DELAY_TIME	Delay time zero-speed monitoring
36050	CLAMP_POS_TOL	Clamping tolerance with IS "Clamping active"
36052	STOP_ON_CLAMPING	Special functions for clamped axis
36060	STANDSTILL_VELO_TOL	Maximum velocity/speed "Axis/spindle stationary"
36100	POS_LIMIT_MINUS	Software limit switch minus
36110	POS_LIMIT_PLUS	Software limit switch plus
36120	POS_LIMIT_MINUS2	Software limit switch minus
36130	POS_LIMIT_PLUS2	Software limit switch plus
36610	AX_EMERGENCY_STOP_TIME	Length of the braking ramp for error states
36200	AX_VELO_LIMIT	Threshold value for velocity monitoring
36210	CTRLOUT_LIMIT	Maximum speed setpoint
36220	CTRLOUT_LIMIT_TIME	Delay time for speed-setpoint monitoring
36300	ENC_FREQ_LIMIT	Encoder limit frequency
36302	ENC_FREQ_LIMIT_LOW	Encoder limit frequency re-synchronization
36310	ENC_ZERO_MONITORING	Zero mark monitoring
36400	CONTOUR_TOL	Tolerance band contour monitoring
36500	ENC_CHANGE_TOL	Maximum tolerance for position actual value switchover
36510	ENC_DIFF_TOL	Measuring system synchronism tolerance
36600	BRAKE_MODE_CHOICE	Deceleration behavior on hardware limit switch
36620	SERVO_DISABLE_DELAY_TIME	Cutout delay servo enable

## Protection zones

None

## 2.6.2 Setting data

### 2.6.2.1 Axis/spindle-specific setting data

## Axis monitoring functions

Number	Identifier: \$SA_	Description
43400	WORKAREA_PLUS_ENABLE	Working-area limitation active in positive direction
43410	WORKAREA_MINUS_ENABLE	Working-area limitation active in negative direction
43420	WORKAREA_LIMIT_PLUS	Working-area limitation plus
43430	WORKAREA_LIMIT_MINUS	Working-area limitation minus

## Protection zones

None

## 2.6.3 Signals

### 2.6.3.1 Signals to channel

#### Axis monitoring

None

#### Protection zones

DB number	Byte.Bit	Description
21, ...	1.1	Enable protection zones
21, ...	4.7	Feedrate override
21, ...	6.0	Feed disable
21, ...	8.0	Activate machine-related protection zone 1
	:	:
21, ...	8.7	Activate machine-related protection zone 8
21, ...	9.0	Activate machine-related protection zone 9
21, ...	9.1	Activate machine-related protection zone 10
21, ...	10.0	Activate channel-specific protection zone 1
	:	:
21, ...	10.7	Activate channel-specific protection zone 8
21, ...	11.0	Activate channel-specific protection zone 9
21, ...	11.1	Activate channel-specific protection zone 10

### 2.6.3.2 Signals from channel

#### Axis monitoring functions

None

#### Protection zones

DB number	Byte.Bit	Description
21, ...	272.0	Machine-related protection zone 1 preactivated
	:	:
21, ...	272.7	Machine-related protection zone 8 preactivated
21, ...	273.0	Machine-related protection zone 9 preactivated
21, ...	273.1	Machine-related protection zone 10 preactivated
21, ...	274.0	Channel-specific protection zone 1 preactivated

DB number	Byte.Bit	Description
	:	:
21, ...	274.7	Channel-specific protection zone 8 preactivated
21, ...	275.0	Channel-specific protection zone 9 preactivated
21, ...	275.1	Channel-specific protection zone 10 preactivated
21, ...	276.0	Machine-related protection zone 1 violated
	:	:
21, ...	276.7	Machine-related protection zone 8 violated
21, ...	277.0	Machine-related protection zone 9 violated
21, ...	277.1	Machine-related protection zone 10 violated
21, ...	278.0	Channel-specific protection zone 1 violated
	:	:
21, ...	278.7	Channel-specific protection zone 8 violated
21, ...	279.0	Channel-specific protection zone 9 violated
21, ...	279.1	Channel-specific protection zone 10 violated

### 2.6.3.3 Signals to axis/spindle

#### Axis monitoring functions

DB number	Byte.Bit	Description
31, ...	1.4	Follow up operation
31, ...	1.5/1.6	Position measuring system 1/2
31, ...	2.1	Servo enable
31, ...	2.3	Clamping in progress
31, ...	3.6	Velocity/spindle speed limitation
31, ...	4.3	Feed stop
31, ...	12.0/12.1	Hardware limit switch minus/Hardware limit switch plus
31, ...	12.2/12.3	Software limit switch minus/2nd software limit switch plus
31, ...	60.2/60.3	Encoder limit frequency exceeded 1/2
31, ...	60.4/60.5	Referenced/synchronized 1/2
31, ...	64.6/64.7	Traverse command minus/plus

#### Protection zones

None



## Continuous-Path Mode, Exact Stop, LookAhead (B1)

### 3.1 Product brief

#### 3.1.1 General

##### Exact stop mode

In exact stop traversing mode, all axes involved in the traversing motion (except axes of modal traversing modes) are decelerated at the end of each block until they come to a standstill. The transition to the next block occurs only when all axes involved in the traversing motion have reached their programmed target position with subject to the selected exact stop criterion.

##### Exact stop

Exact stop is a state of a machine axis that refers to the position difference relative to its setpoint position at the end of the traversing motion. The machine axis reaches the "exact stop" state, as soon as its following error is less than the specified position difference (exact stop limit).

##### Continuous-path mode

In continuous-path mode, the NC attempts to keep the programmed path velocity as constant as possible. In particular, deceleration of the path axes at the block limits of the part program is to be avoided.

##### LookAhead

"LookAhead" is a function for optimizing the continuous path mode.

Smooth machining of workpieces is necessary to ensure a high-quality surface finish. For this reason, path velocity variations should be avoided during machining whenever possible. Without "Look Ahead", the NC only takes into consideration the block immediately following the current block to determine the possible path velocity. If the following block contains only a short path, the NC must reduce the path velocity (decelerate in the current block) to be able to stop in time at the end of the next block, if necessary.

When the NC "looks ahead" over an parameterizable number of blocks following the current block, a much higher path velocity can be attained under certain circumstances because the NC now has more blocks and more path available for calculation.

### 3.1 Product brief

This results in the following advantages:

- Machining with higher path velocities on average
- Improved surface quality by avoiding deceleration and acceleration processes

#### Smoothing the path velocity

"Smoothing the path velocity" is a function especially for applications (such as high speed milling in mold and die production) that require an extremely steady path velocity. Deceleration and acceleration processes that would cause high-frequency excitations of machine resonances are avoided with the "Smoothing the path velocity" function.

This results in the following advantages:

- Improved surface quality and machining time by avoiding excitation of machine resonances.
- Constant profile of path velocity and cutting rates by avoiding "unnecessary" acceleration processes, i.e. acceleration processes that do not greatly improve the program run time.

#### Dynamic response adaptation

In addition to the "Smoothing the path velocity" function, "Dynamic response adaptation" is another function for avoiding high-frequency excitations of machine resonances while optimizing the dynamic path response. To this end, highly frequent changes in path velocity are automatically executed with lower jerk or acceleration values than the dynamic response limit value parameters assigned in the machine data.

Thus, with low-frequency changes in path velocity, the full dynamic response limit values apply, whereas with high-frequency changes, only the reduced dynamic response limit values act due to the automatic dynamic response adaptation.

#### NC block compression

When a workpiece design is completed with a CAD/CAM system, the CAD/CAM system generally also compiles the corresponding part program to create the workpiece surface. To do so, most CAD/CAM systems use linear blocks to describe even curved sections of the workpiece surface. Many interpolation points are generally necessary to maintain the required contour accuracy. This results in many linear blocks, typically with very short paths.

The "NC block compressor" function uses polynomial blocks to perform a subsequent approximation of the contour specified by the linear blocks. During this process, an assignable number of linear blocks is replaced by a polynomial block. Furthermore, the number of linear blocks that can be replaced by a polynomial block also depends on the specified maximum permissible contour deviation and the contour profile.

Use of polynomial blocks provides the following advantages:

- Reduction of the number of required part program blocks for describing the workpiece contour
- Higher maximum path velocities

### Combine short spline blocks

A spline defines a curve, which is formed from polynomials of 2nd or 3rd degree. With spline interpolation, the controller can generate a smooth curve characteristic from only a few specified interpolation points of a set contour.

#### References:

/PGA/ Programming Manual, Job Planning, Special motion commands,  
Section: Spline interpolation

The advantages of the spline interpolation as compared to the linear interpolation are:

- Reduction of the number of required part program blocks for describing a curved contour.
- Soft, mechanical system-limiting curve characteristic also during transition between the part program blocks.

The disadvantages of the spline interpolation as compared to the linear interpolation are:

- For a spline curve no exact curve characteristic, but only a tolerance band can be specified, within which the spline curve should lie.

As in the case of the linear interpolation even while processing of splines so short blocks can result, hence the path velocity must be reduced in the interpolation of these spline blocks. This is also the case, when the spline actually has a long, smooth curve. The "Combine short spline blocks" function allows you to combine these spline blocks such that the resulting block length is sufficient and does not reduce the path velocity.

---

#### Note

##### NC block compressor

The NC-block-compressor (`COMPON`, `COMPCURV` or `COMPCAD`) cannot be employed while compressing spline blocks, since with this only linear blocks can be compressed.

---

### 3.1.2 Parameterization of the RESET response

The channel-specific basic position is activated via a RESET:

MD20150 \$MC\_GCODE\_RESET\_VALUES (RESET position of G groups)

The initial setting can be specified for exact stop and continuous path modes and exact stop criterion.

Detailed description of initial settings can be found in:

#### References:

/FB1/ Function Manual Basic Functions; BAG, Channel, Program Operation, Reset Response (K1)

### 3.1.3 Block change and positioning axes

If path axes are traversed in continuous path mode in a part program, traversing positioning axes can also simultaneously affect both the response of the path axes and the block change.

A detailed description of the positioning axes can be found in:

**References:**

/FB2/ Function Manual, Extended Functions; Positioning axes (P2)

### 3.1.4 Block change delay

Even if all path axes and special axes traversing in the part program block have satisfied their specific block transition criteria, the block change can still be delayed due to other unsatisfied conditions and/or active functions:

**Examples:**

- Missing auxiliary function acknowledgement by the PLC
- Non-existent following blocks
- Active function "Empty buffer"

**Effects**

If a block change cannot be executed in continuous path mode, all axes programmed in this part program block (except cross-block traversing special axes) are stopped. In this case, contour errors do not occur.

The stopping of path axes **during machining** can cause undercuts on the workpiece surface.

## 3.2 Exact stop mode

### Exact stop or exact stop mode

In exact stop traversing mode, all path axes and special axes involved in the traversing motion that are not traversed modally, are decelerated at the end of each block until they come to a standstill. The transition to the next block occurs only when all axes involved in the traversing motion have reached their programmed target position with subject to the selected exact stop criterion.

This results in the following response:

- All path axes and non-modal special axes involved in the traversing motion are decelerated at the end of the block until they reach a standstill.
- The program run time is considerably longer compared to continuous path mode due to the deceleration of the axes and the wait time until "Exact stop" status is reached for all machine axes involved.
- In exact stop mode, undercuts can occur on the workpiece surface during machining.

### Status "Exact stop"

The state of a machine axis that refers to the position difference relative its setpoint position at the end of a traversing motion is also designated as an exact stop. The machine axis reaches the "exact stop" state, as soon as its following error is less than the specified position difference (exact stop criterion).

### Use of the exact stop mode

Exact stop mode should always be used when the programmed contour must be executed exactly.

### Activation of exact stop mode

Exact stop mode is activated in the part program by programming the following G-functions:

G function	Meaning
G60	Exact stop on, modal
G09	Exact stop on, non-modal

### Exact stop criteria "Exact stop coarse" and "Exact stop fine"

The two exact stop criteria "Exact stop coarse" and "Exact stop fine" are used to specify the applicable tolerance window for reaching the "Exact stop" state of a machine.

### Parameterization of the exact stop criteria "Exact stop coarse" and "Exact stop fine"

The tolerance windows of the exact stop criteria are specified with the following machine data:

MD36010 \$MA\_STOP\_LIMIT\_FINE (exact stop fine)

MD36000 \$MA\_STOP\_LIMIT\_COARSE (exact stop coarse)

---

#### Note

##### Tolerance window

The tolerance windows of the exact stop criteria "Exact stop coarse" and "Exact stop fine" should be so assigned, that the following requirement is fulfilled:

"Exact stop coarse" > "Exact stop fine"

---

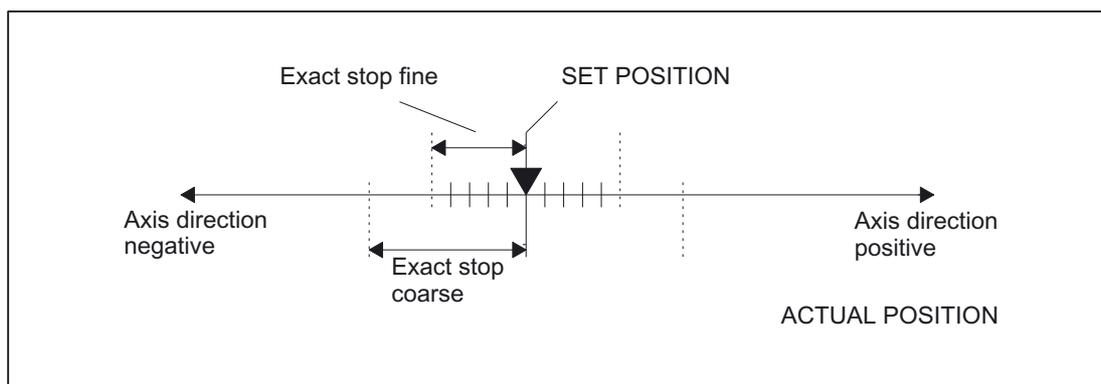


Figure 3-1 Tolerance windows of exact stop criteria

### Exact stop criterion "Interpolator End"

In the case of the exact stop criterion "interpolator end" the block change to the next traversing block takes place, as soon as all path axes and special axes involved in the traversing motion, which do not traverse extending up to block, have reached their position according to set point programmed in the block. That is, the interpolator has executed the block.

The actual position and the following error of the relevant machine axes are not taken into consideration for exact stop criterion "Interpolator end". Thus, depending on the dynamic response of the machine axes, this can result in a relatively large smoothing of the contour at the block changes in comparison to the exact stop criteria "Exact stop coarse" and "Exact stop fine".

### Activation of an exact stop criterion

An exact stop criterion is activated in the part program by programming the following G functions:

G function	Meaning
G601	Exact stop fine
G602	Exact stop coarse
G603	Interpolator end

### Block change depending on exact-stop criteria

The figure below illustrates the block change timing in terms of the selected exact stop criterion.

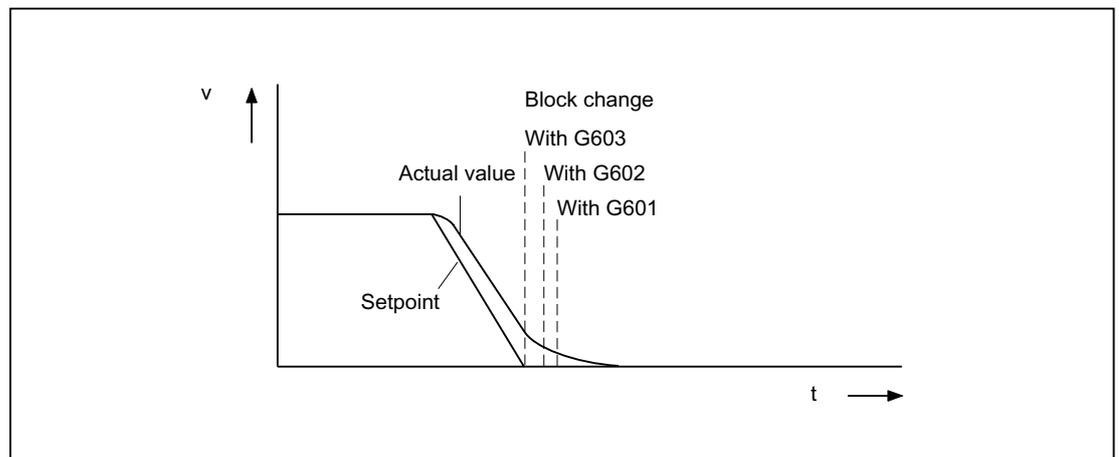


Figure 3-2 Block change accordance to selected exact stop criterion

### Evaluation factor for exact stop criteria

A parameter set-dependent evaluation of the exact stop criteria can be specified via the following axis-specific machine data:

MD36012 \$MA\_STOP\_LIMIT\_FACTOR (exact stop coarse/fine and standstill factor)

#### Applications

- Adaptation of the positioning response to different mass ratios, such as after a gearshift
- Reduction in positioning time, depending on various machining states, such as roughing and finishing

**Assignable specification of the active exact stop criterion**

The active exact stop criterion can be permanently specified for the part program commands of the first G-group irrespective of the exact stop criterion programmed in the part program. This specification can be made independently for each of the following part program commands:

- Rapid traverse: G0
- Machining commands: G1, G2, G3, CIP, ASPLINE, BSPLINE, CSPLINE, POLY, G33, G34, G35, G331, G332, OEMIPO01, OEMIPO02, CT

The setting is done in a channel-specific manner via the following machine data:

MD20550 \$MC\_EXACT\_POS\_MODE (exact stop conditions for G00 and G01)

**Coding**

Each exact stop criterion is location-coded:

- Ones position E: Rapid traverse
- Tens position Z: all other part program commands in the first G-group

MD20550 \$MC\_EXACT\_POS\_MODE = < ZE >

Z or E	Active exact stop criterion
0	Programmed exact stop criterion
1	G601 (Exact stop window fine)
2	G602 (Exact stop window coarse)
3	G603 (Interpolator end)

**Example**

MD20550 \$MC\_EXACT\_POS\_MODE = 02

Ones position = 2:

With rapid traverse, exact stop criterion G602 (exact stop window coarse) is always active, irrespective of any programming in the part program.

Tens digit = 0:

For traversing with all other part program commands of the first G-group, the exact stop criterion programmed in the part program is active.

### Assignable exact stop criterion for rapid traverse transitions in continuous path mode

The behavior at the block transition of part program blocks before and after rapid traverse blocks can be parameterized via the following channel-specific machine data:

MD20552 \$MC\_EXACT\_POS\_MODE\_G0\_TO\_G1 = < *value* > (Exact stop condition for G00-G01 transition)

Value	Meaning
0	No additional stop at the block transition.
1	Stop at block transition: Same behavior as in the case of G601 (Exact stop window fine)
2	Stop at block transition: Same behavior as in the case of G602 (exact stop window coarse)
3	Stop at block transition: Same behavior as G603 (interpolator end)
4	Like 0, in addition, the override of the next non-G00 block is taken into account with LookAhead in the G00 block during the transition from G00 to non-G00.
5	Like 0; in addition, the override of the next block is taken into account with LookAhead during the transition from G00 to non-G00 and non-G00 to G00.

## 3.3 Continuous-path mode

### 3.3.1 General functionality

#### Continuous-path mode

In the continuous-path mode the path velocity is **not** decelerated for the block change in order to permit the fulfillment of an exact stop criterion. The objective of this mode is to avoid rapid deceleration of the path axes at the block-change point so that the axis velocity remains as constant as possible when the program moves to the next block. To achieve this objective, the "LookAhead" function is also activated when the continuous path mode is selected.

Continuous-path mode causes the smoothing and tangential shaping of angular block transitions by local changes in the programmed contour. The extent of the change relative to the programmed contour can be limited by specifying the overload factor or rounding criteria.

Continuous-path operation causes:

- Contour rounding
- Shorter machining times through elimination of braking and acceleration processes that are required to comply with the exact-stop criterion
- Improved cutting conditions because of the more constant velocity

Continuous-path mode is suitable if:

- A contour must be traversed as quickly as possible (e.g. with rapid traverse).
- The exact contour may deviate from the programmed contour within a specific tolerance for the purpose of obtaining a continuous contour.

Continuous-path mode is suitable if:

- A contour is to be traversed precisely.
- An absolutely constant velocity is required.

#### Implicit exact stop

In some cases, an exact stop needs to be generated in continuous-path mode to allow the execution of subsequent actions. In such situations, the path velocity is reduced to zero.

- If auxiliary functions are output before the traverse motion, the previous block is only terminated when the selected exact-stop criterion is fulfilled.
- If auxiliary functions are to be output after the traverse motion, they are output after the interpolator end of the block.
- If an executable block (e.g. starting a positioning axis) contains no travel information for the path axes, the previous block is terminated on reaching the selected exact-stop criterion.

- If a positioning axis is declared to be the geometry axis, the previous block is terminated at the interpolator end when the geometry axis is programmed.
- If a synchronized axis is programmed that was last programmed as a positioning axis or spindle (initial setting of the special axis is positioning axis), the previous block is ended at the interpolator end.
- If the transformation is changed, the block previously processed is terminated with the active exact-stop criterion.
- A block is terminated on interpolator end if the following block contains the switchover of the acceleration profile `BRISK/SOFT`.

For more information about `BRISK` and `SOFT`:

**References:**

/FB1/ Function Manual basic function; acceleration (B2)

- If the "empty buffer" function is programmed, the previous block is terminated when the selected exact-stop criterion is reached.

### Velocity = 0 in continuous-path mode

Regardless of the implicit exact-stop response, the path motion is braked down to zero velocity at the end of the block in cases where:

- Positioning axes have been programmed with syntax `POS` and have a travel time that exceeds that of the path axes. The block change occurs when the "exact stop fine" of the positioning axes is reached.
- The time taken to position a spindle programmed with syntax `SPOS` is longer than the travel time of the path axes. The block change is carried out when the "exact stop fine" of the positioning spindle is reached.
- The current block contains traversing commands for geometry axes and the following block traversing commands for synchronized axes or, alternatively, the current block contains traversing commands for synchronized axes and the subsequent block traversing commands for geometry axes.
- Synchronization is required

### Auxiliary function output during traversal

In continuous-path mode with auxiliary-function output during motion and short traversing blocks, the path velocity is decelerated prior to PLC acknowledgment of the auxiliary functions.

The axes are decelerated to standstill respecting the acceleration limits at the end of the block. At the end of the block acknowledgment is awaited before motion can continue.

#### Acknowledgment during deceleration

Acknowledgment during deceleration accelerates the velocity back to the programmed path velocity.

In order to prevent this happening in continuous-path mode, the following machine data can be used to set a time for the CNC during which the PLC will safely acknowledge the auxiliary functions for the CNC:

`MD10110 $MN_PLC_CYCLE_TIME_AVERAGE` (average PLC acknowledgement time)

#### **Acknowledgment outside of travel time**

The path velocity for the block ahead is reduced to the point that the block duration corresponds to the specified time if the traversing time is less than the time specified in the machine data MD10110 based on the programmed path length and velocity of the block with auxiliary function output.

If acknowledgment is not received within the time, the following prepared block cannot be processed and the axes are braked to standstill with setpoint = 0 without considering the acceleration limits.

#### **Acknowledgment not received by end of block**

If the acknowledgment is not received by the end of the block in long blocks in which the velocity has not needed to be reduced on account of the PLC acknowledgment time, the velocity is maintained until the end of the block and then reduced as described above.

#### **Acknowledgment during braking**

If the acknowledgment arrives while the axis is decelerating, the axis is not accelerated back up to the requested velocity.

---

#### **Note**

The machine data MD10110 \$MN\_PLC\_CYCLE\_TIME\_AVERAGE (average PLC acknowledgment time) is no longer evaluated for the auxiliary function output in the continuous path motion starting from SW 5.1, since the parameterization from SW5.1 onwards is done directly via the PLC.

---

### **3.3.2 Velocity reduction according to overload factor**

#### **Velocity reduction according to overload factor**

The function lowers the path velocity in continuous-path mode until the non-tangential block transition can be traversed in one interpolation cycle while respecting the deceleration limit and taking and overload factor into account.

With the reduced velocity, axial jumps in velocity are produced with a non-tangential contour at the block transition. These jumps in velocity are also performed by the coupled motion synchronized axes. The jump in velocity prevents the path velocity dropping to zero. This jump is performed if the axial velocity was reduced with the axial acceleration to a velocity from which the new setpoint can be reached with the jump. The magnitude of the setpoint jump can be limited using an overload factor. Because the magnitude of the jump is axial, the minimum jump of the path axes which are active during the block change is considered during block transition.

With a practically tangential block transition, the path velocity is not reduced if the permissible axial accelerations are not exceeded. In this way, very small angular changes in the contour can be overtraveled directly.

## Overload factor

The overload factor restricts step changes in the machine axis velocity at block ends. To ensure that the velocity jump does not exceed the maximum load on the axis, the jump is derived from the acceleration of the axis.

The overload factor indicates the extent by which the acceleration of the machine axis (MD32300 \$MN\_MAX\_AX\_ACCEL) may be exceeded for an IPO-cycle.

The velocity jump results as follows:

Velocity jump = axis acceleration \* (overload factor-1) \* interpolator cycle.

The overload factor is saved in the machine data:

MD32310 \$MN\_MAX\_ACCEL\_OVL\_FACTOR (overload factor for axial velocity jumps)

Factor 1.0 means that only tangential transitions with finite velocity can be traversed. For all other transitions, the velocity is reduced to zero by changing the setpoint. This behavior is equivalent to the function "Exact stop with interpolator end". This is undesirable for continuous-path mode, so the factor must be set to greater than 1.0.

For startup and installation, please note that the factor must be reduced if the machine is likely to be subject to vibrations during angular block transitions and rounding is not to be used.

By setting the following machine data, the block transitions are rounded independent of the set overload factor with G641/G642:

MD20490 \$MC\_IGNORE\_OVL\_FACTOR\_FOR\_ADIS (G641/G642 irrespective of the overload factor).

## Selection and deselection of velocity reduction

### Selection

Continuous-path mode with velocity reduction according to overload factor can be selected modally in every NC part program block by means of program code G64.

### Interruption

The continuous-path mode G64 can be interrupted by selecting:

- Exact stop G09

### Deselection

The continuous-path mode G64 can be deselected by selecting:

- Exact stop G60
- Rounding G641

## Implicit continuous-path mode

If it is not possible to insert approximate positioning blocks due to the very short block path lengths (e.g. zero-clocked blocks) in continuous-path mode with rounding G641, the mode is switched over to continuous-path mode G64.

Method of operation

The figure below shows how the function velocity drops according to an overload factor.

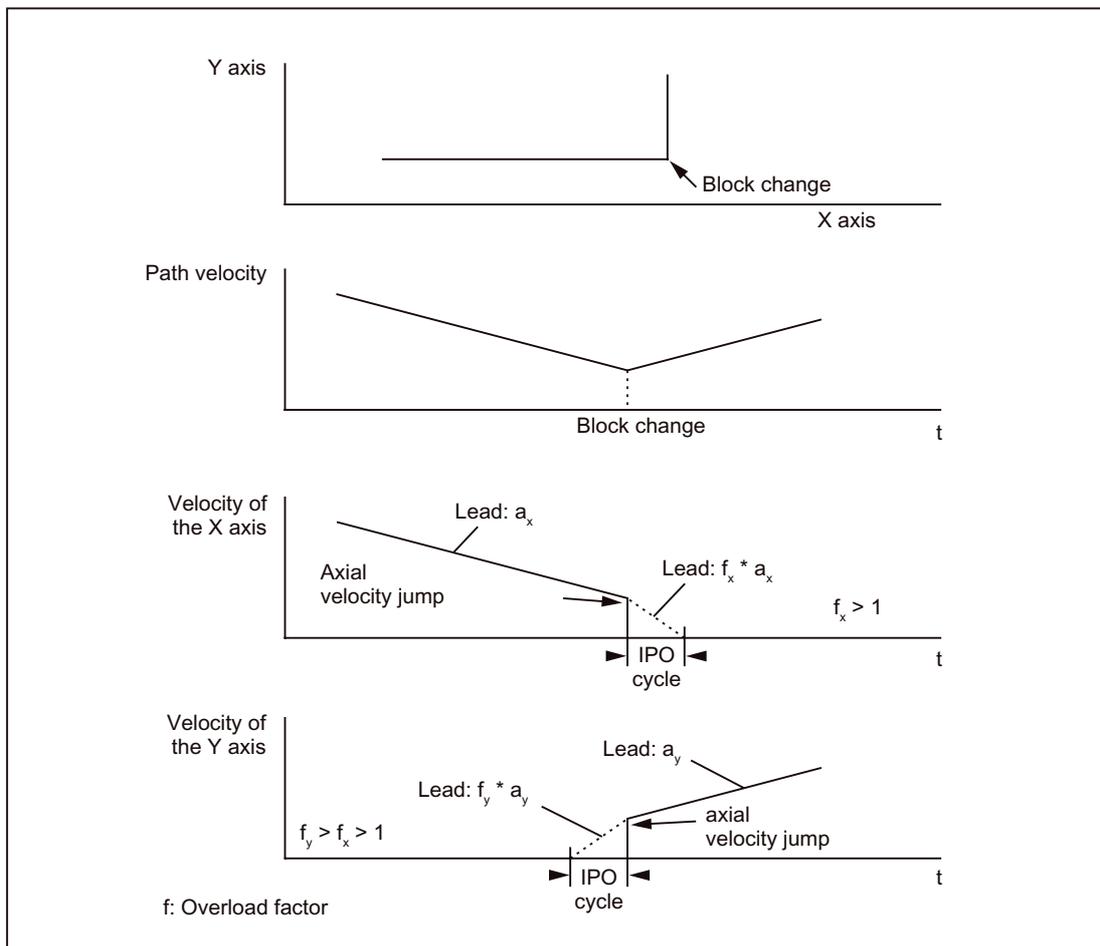


Figure 3-3 Axial velocity change on block transition

### 3.3.3 Rounding according to path criterion

#### Blending

Rounding means that an angular block transition is changed to a tangential block transition by a local change to the programmed feedrate.

Rounding replaces the area in the vicinity of the original angular block transition (including transitions between blocks inserted by the CNC) by a continuous contour. In this case, it is not only the geometry axes that are taken into account, but all machine axes, which are traversing synchronously. The rounding function therefore smoothes the traversing path of orientation axes as well as general velocity step changes in synchronized axes.

---

**Note**

Smoothing cannot and should not replace the functions for defined smoothing: RND, RNDM, ASPLINE, BSPLINE, CSPLINE.

If a rounding movement initiated by G641, G642, G643, G644 is interrupted, the corner point of the original contour will be used for subsequent repositioning, rather than the interruption point.

---

Rounding is initiated by shortening discontinuously adjoining blocks and inserting one or two intermediate blocks at this point. The original block boundary is removed and can no longer be used for synchronization conditions (e.g. auxiliary function output parallel to motion, stop at end of block).

With rounding, all synchronization conditions are best referred to the end of the shortened first block and not to the end of the intermediate rounding block. The following block is thus not started and with a stop at end of block, the contour of the following block can still be changed.

Rounding is only performed if the block transition is to be traveled with finite velocity. The maximum path speed is influenced by the curvature. The maximum acceleration values of the axes are not exceeded. A block without traverse information for the path axes requires velocity "zero" and therefore no rounding.

Rounding is also used if the traversal of the block transition requires a velocity that lies below the permissible velocity at the end of the block according to G64 (see overload factor). This means that very small knees in the contour (e.g. 0.5 degrees) can be overtraveled directly.

### No intermediate rounding blocks

An intermediate rounding block is not inserted in the following situations:

- The axis stops between the two blocks.

This occurs when:

- The following block contains an auxiliary function output before the movement.
- The following block does not contain a path movement.
- An axis is traversed for the first time as a path axis for the following block when it was previously a positioning axis.
- An axis is traversed for the first time as a positioning axis for the following block when it was previously a path axis.
- The previous block traverses geometry axes and the following block does not.
- The following block traverses geometry axes and the previous block does not.
- Before tapping, the following block uses G33 as preparatory function and the previous block does not.
- A change is made between BRISK and SOFT.
- Axes involved in the transformation are not completely assigned to the path motion (e.g. for oscillation, positioning axes).

- The rounding block would slow down the part program execution.

This occurs when:

- A rounding block is inserted between very short blocks.

Since each block requires at least one interpolation cycle, the added intermediate block would double the machining time.

- A block transition G64 (continuous-path mode without rounding) can be traversed without speed reduction.

Corner rounding would increase the machining time. This means that the value of the permitted overload factor (MD32310 \$MA\_MAX\_ACCEL\_OVL\_FACTOR) affects whether a block transition is rounded or not. The overload factor is only taken into account for corner rounding with G641/G642. The overload factor has no effect for corner rounding with G643 (this behavior can also be set for G641 and G642 by setting MD20490 \$MC\_IGNORE\_OVL\_FACTOR\_FOR\_ADIS to TRUE).

- Rounding is not parameterized.

This occurs when:

- For G641 in G0 blocks ADISPOS== 0 (default!).
- For G641 in non-G0 blocks ADIS== 0 (default!).
- For G641 on transition from G0 and non-G0 or non-G0 and G0 respectively, the smaller value from ADISPOS and ADIS applies.
- For G642/G643, all axis-specific tolerances are zero.

- The block does not contain traversing motion (zero block).

This occurs when:

- Synchronized actions are active.

Normally, the interpreter eliminates zero blocks. However, if synchronous actions are active, this zero block is included and also executed. In so doing, an exact stop is initiated corresponding to the active programming. This allows the synchronous action to also switch.

- Zero blocks are generated by program jumps.

### Synchronized axes

If a number of paths need to be synchronized (e.g. contour, special axis), then every path must always have its own rounding area.

There are no practical means of achieving this exactly. Therefore, on the basis of the specific meaning of the contour (geometry axis), the following procedure is applied:

Rounding behavior with synchronized paths		
Original path for		Result for
Geometry axes	Orientation axis/ synchronized axis	rounding path
Smooth	Smooth	Defined path is traversed exactly
Smooth	Angular path	Intermediate blocks, the geometry axes follow the path exactly, all orientation/synchronized axis paths are smoothed
Angular path	Smooth	intermediate block, the geometry axes perform rounding, all orientation/synchronized axis paths are smoothed
Angular path	Angular path	intermediate block, the geometry axes perform rounding, all orientation/synchronized axis paths are smoothed

### Path criterion

The size of the rounding area can be controlled by path criteria `ADIS` and `ADISPOS`.

`ADIS` and `ADISPOS` describe the distance, which the rounding block may begin, at the earliest, before the end of the block or the distance after the end of block within which the rounding block must be terminated.

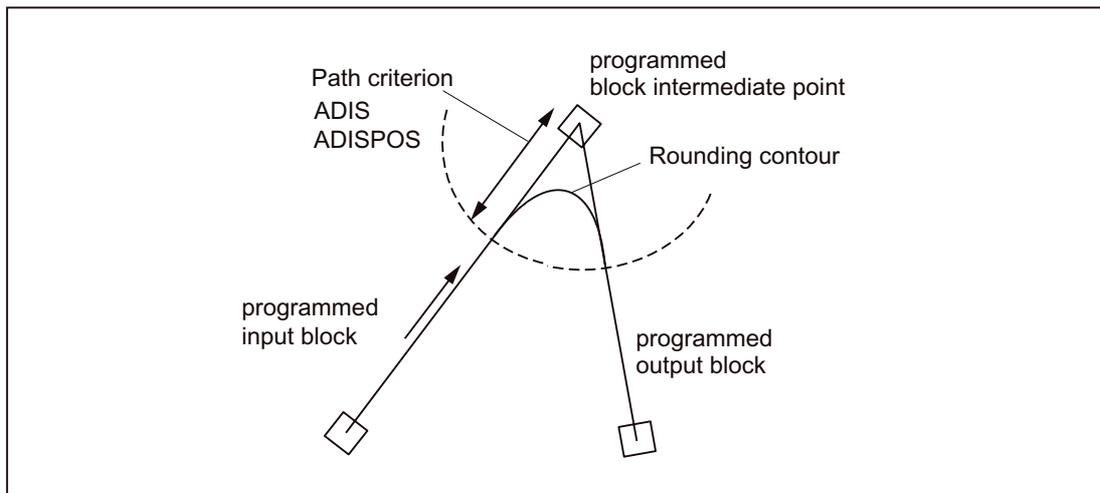


Figure 3-4 Example for rounding an angular block transition

Acute angles produce rounding curves with a large degree of curvature and therefore cause a corresponding reduction in velocity.

### Parameterization of the path criterion

- **ADISPOS** is programmed in the same way as **ADIS**, but must be used specifically for movements in rapid traverse mode **G00**.
- **ADIS** and **ADISPOS** are preset in the part program.

For example, **ADIS=0.3** indicates a path criterion with a rounding distance of 0.3 mm (**ADISPOS** is the same).

### Scope of the path criterion

- **ADIS** or **ADISPOS** must be programmed. If the default is "zero", **G641** behaves like **G64**.
- If only one of the blocks involved is rapid traverse **G00**, the smaller rounding distance applies.
- If a very small value is used for **ADIS**, the control must make sure that every interpolated block, even an intermediate rounding block, contains at least one interpolation point. The maximum path velocity is thereby limited to **ADIS/interpolation cycle**.
- Irrespective of **ADIS** and **ADISPOS**, the rounding area is limited by the block length.

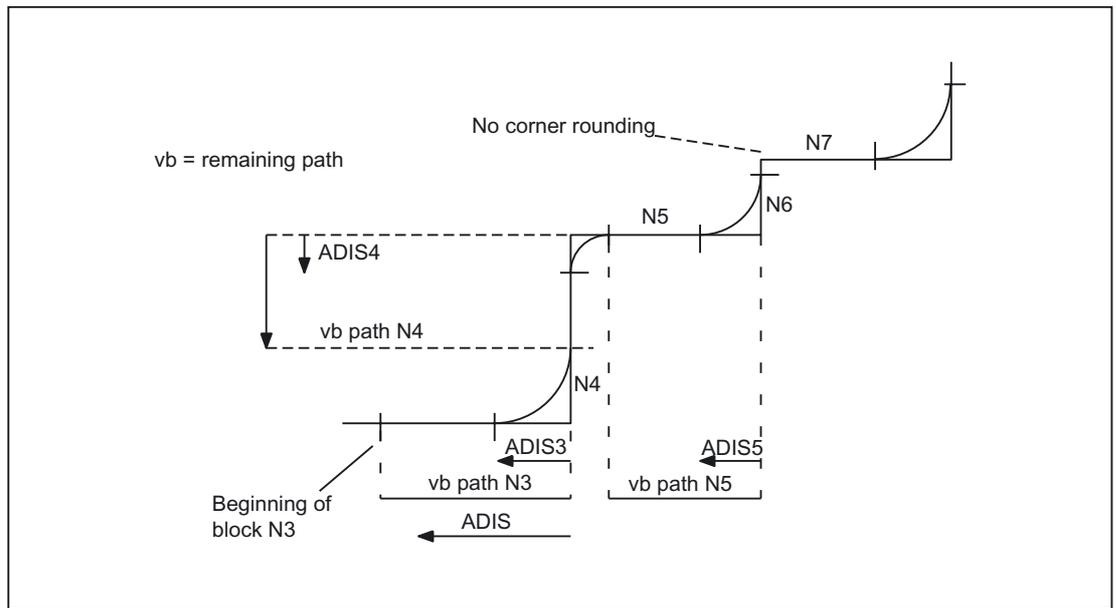


Figure 3-5 Path with limitation of ADIS

### Programming example

```

N1 G641 Y50 F10 ADIS = 0.5
N2 X50
N3 X50.7
N4 Y50.7
N5 Y51.4
N6 Y51.0
N7 X52.1
    
```

In blocks with short distances (distance  $< 4 * ADIS$  and  $< 4 * ADISPOS$  respectively), the rounding distance is reduced so that a traversable part of the original block is retained. The remaining length depends on the axis path and is approximately 60% of the distance still to be traversed in the block.

$ADIS$  or  $ADISPOS$  is therefore reduced to the remaining 40% of the distance to be traversed. This algorithm prevents a rounding block being inserted for a very small change in contour. In this case, switchover to continuous-path mode G64 is automatic until rounding blocks can be inserted again.

### Selection and deselection of rounding blocks

#### Selection

Program code G641 can be inserted in any NC part program block to modally select rounding according to a path criterion. Before or on selection, the path criteria ADIS/ADISPOS must be specified.

#### Interruption

The continuous-path mode G641 can be interrupted by selecting:

- Exact stop G09

#### Deselection

The continuous-path mode G641 can be deselected by selecting:

- Exact stop G60
- Continuous path mode with reduced velocity as per the overload factor (G64)

### 3.3.4 Rounding by maintaining the defined tolerances

#### Function

Along with rounding as per the path criteria (G641), in which the rounding takes place in an area defined with ADIS or ADISPOS respectively, there are also rounding functions, in which the rounding is done by adhering to the defined tolerances. In normal cases, this is the maximum permitted path deviation. Instead of these axis-specific tolerances, the maintenance of the maximum contour deviation (contour tolerance) or the maximum angular deviation of the tool orientation (orientation tolerance) can be configured.

---

#### Note

Expansion to include contour tolerance and orientation tolerance exists only in systems with options for polynomial interpolation. When rounding under maintenance of the orientation tolerance, the additional option of orientation transformation is also necessary.

---

#### Activation

The modal selection of rounding under maintenance of defined tolerances can be done in each NC part program block through the program codes G642 or G643.

### Differences between G642 - G643

With regard to their rounding behavior, commands G642 and G643 differ as follows:

G642	G643
<p>With G642, the rounding travel is determined based on the shortest rounding travel of all axes. This value is taken into account when generating a rounding block.</p> <p>With G642, the rounding area results from the smallest tolerance setting.</p>	<p>In the case of G643, the rounding travel of each axis can be different. The rounding travels are taken into account axis-specifically and block-internally (⇒ no separate rounding block).</p> <p>Very different specifications for the contour tolerance and the tolerance of the tool orientation can only have effect with G643.</p>

### Parameter assignment

#### Maximum path deviation

The maximum path deviation permitted with G642/G643 is set for each axis in the machine data:

MD33100 \$MA\_COMPRESS\_POS\_TOL

#### Contour tolerance and orientation tolerance

The contour tolerance and orientation tolerance are set in the channel-specific setting data:

SD42475 \$SC\_SMOOTH\_CONTUR\_TOL (maximum contour deviation)

SD42466 \$SC\_SMOOTH\_ORI\_TOL (maximum angular deviation of the tool orientation)

The settings data can be programmed in the NC program and can in this way be specified differently for each block transition.

---

#### Note

The setting data SD42466 \$SC\_SMOOTH\_ORI\_TOL is effective only in active orientation transformation.

---

3.3 Continuous-path mode

**Configuration**

Rounding with G642 and G643 are configured via the machine data:

MD20480 \$MC\_SMOOTHING\_MODE (rounding behavior with G64x)

The units positions (**E**) define the behavior for G643, the tens positions (**Z**) the behavior for G642:

Value E or Z	Description
0	<b>All Axes:</b> Rounding by maintaining the maximum permitted path deviation: MD33100 \$MA_COMPRESS_POS_TOL
1	<b>Geometry axes:</b> Rounding by maintaining the contour tolerance: SD42465 \$SC_SMOOTH_CONTUR_TOL <b>Remaining axes:</b> Rounding by maintaining the maximum permitted path deviation: MD33100 \$MA_COMPRESS_POS_TOL
2	<b>Geometry axes:</b> Rounding by maintaining the orientation tolerance: SD42466 \$SC_SMOOTH_ORI_TOL <b>Remaining axes:</b> Rounding by maintaining the maximum permitted path deviation: MD33100 \$MA_COMPRESS_POS_TOL
3	<b>Geometry axes:</b> Rounding by maintaining the contour tolerance and the orientation tolerance: SD42465 \$SC_SMOOTH_CONTUR_TOL SD42466 \$SC_SMOOTH_ORI_TOL <b>Remaining axes:</b> Rounding by maintaining the maximum permitted path deviation: MD33100 \$MA_COMPRESS_POS_TOL
4	<b>All Axes:</b> The rounding length programmed with ADIS or with ADISPOS is used (as in case of G641). Any axis-specific tolerance or contour and orientation tolerance specifications are ignored.

**Profile for limit velocity**

The use of a speed profile while rounding can be controlled via the machine data:

MD20480 \$MC\_SMOOTHING\_MODE (rounding behavior with G64x)

The setting is done via the hundreds position:

Value	Description
< 100:	A profile of the limit velocity is calculated within the rounding area, based on the defined maximum values for acceleration and jerk on the participating axes or path.  This can lead to an increase in the path velocity in the rounding area and therefore to the acceleration of the participating axes.
≥100:	A profile of the limit velocity is not calculated for rounding blocks with G641/G642. A constant velocity limit is specified instead.  This prevents the participating axes being accelerated into the rounding area during rounding with G641/G642. However, in certain cases, this setting can cause the rounding blocks to be traversed too slowly, especially in large rounding areas.
1xx:	No velocity profile for G641
2xx:	No velocity profile for G642

**Note**

**See also:**

MD28530 \$MC\_MM\_PATH\_VELO\_SEGMENTS (number of memory elements for limiting the path velocity)

**Constraints**

Restriction for protection zones with active radius compensation and tool orientation:

Although tool radius compensation is applied for a tool orientation, which is not perpendicular to one of the three datum planes of the basic coordinate system, the protection zones are not rotated onto the corresponding plane.

For G643 the following must be true:

MD28530 \$MC\_MM\_PATH\_VELO\_SEGMENTS > 0 (number of memory elements for limiting the path velocity)

If this condition is met, then it must be applicable for all axes:

MD35240 \$MC\_ACCEL\_TYPE\_DRIVE = FALSE (acceleration characteristic line DRIVE for axes on/off)

### 3.3.5 Rounding with maximum possible dynamic response on each axis

#### How this type of rounding differs from existing types

Unlike existing rounding types, which are activated with G codes G641, G642 and G643, in this case, the maximum possible dynamic response on each axis takes priority.

#### Activating

Rounding with the maximum possible dynamics is activated with the G-code G644.

#### Parameter assignment

Rounding with G644 is configured with the machine data:

MD20480 \$MC\_SMOOTHING\_MODE (rounding behavior with G64x)

The settings for G644 are done via the thousand and ten-thousands positions:

Value	Description
<b>Thousand's place:</b>	
0xxx:	When rounding with G644, the maximum deviations of each axis specified with the following machine data are used: MD33100 \$MA_COMPRESS_POS_TOL If the dynamics of the axis permit, then any specified tolerance is not utilized.
1xxx:	Input the maximum rounding path by programming ADIS=... or ADISPOS=...(as for G641)
2xxx:	Input the maximum possible frequencies of each axis in the rounding area using the machine data: MD32440 \$MA_LOOKAH_FREQUENCY (smoothing frequency for Look Ahead) The rounding area is defined so that no frequencies in excess of the specified maximum can occur while the rounding motion is in progress.
3xxx:	Any axis that has a velocity jump at a corner traverses around the corner with the maximum possible dynamic response (maximum acceleration and maximum jerk). <b>SOFT:</b> If <b>SOFT</b> is active, the maximum acceleration <b>and</b> the maximum jerk of each axis is maintained. <b>BRISK:</b> If <b>BRISK</b> is active, only the maximum acceleration and <b>not</b> the maximum jerk of each axis is maintained. With this setting, neither the maximum deviations nor the rounding distance are checked. The resulting deviations or rounding distances are determined exclusively by the dynamic limits of the respective axis and the current path velocity.

Value	Description
4xxx:	As in case of 0xxx, the maximum deviations of each axis specified with the following machine data are used: MD33100 \$MA_COMPRESS_POS_TOL Contrary to 0xxx, the specified tolerance is also utilized, if possible. Therefore, the axis does not attain its maximum possible dynamics.
5xxx:	As in case of 1xxx, the maximum possible rounding path is specified through programming of ADIS=... or ADISPOS= respectively. Contrary to 1xxx, the specified rounding path is also utilized, if possible. Therefore, the axes involved do not attain their maximum possible dynamics.
<b>Ten thousands digit</b>	
0xxxx	The speed profiles of the axes are determined in the rounding area without jerk limitation for BRISK and without jerk limitation for SOFT.
1xxxx	The speed profiles of the axes are determined in the rounding area always with jerk limitation, regardless of whether BRISK or SOFT is active.

When specifying the maximum axial deviations (MD33100 \$MA\_COMPRESS\_POS\_TOL) or the maximum rounding distance (ADIS/ADISPOS) the available rounding path is normally not used, if permitted by the dynamics of the axes involved. Through this, the length of the rounding path depends on the active path feedrate. In case of lower path speeds, one gets lower deviations from the programmed contours. However, it can be set that in these cases the specified maximum axial deviation or the specified rounding distance is utilized, if possible. In this case the deviations depend on the programmed contour independent of the programmed path feedrate.

**Note**

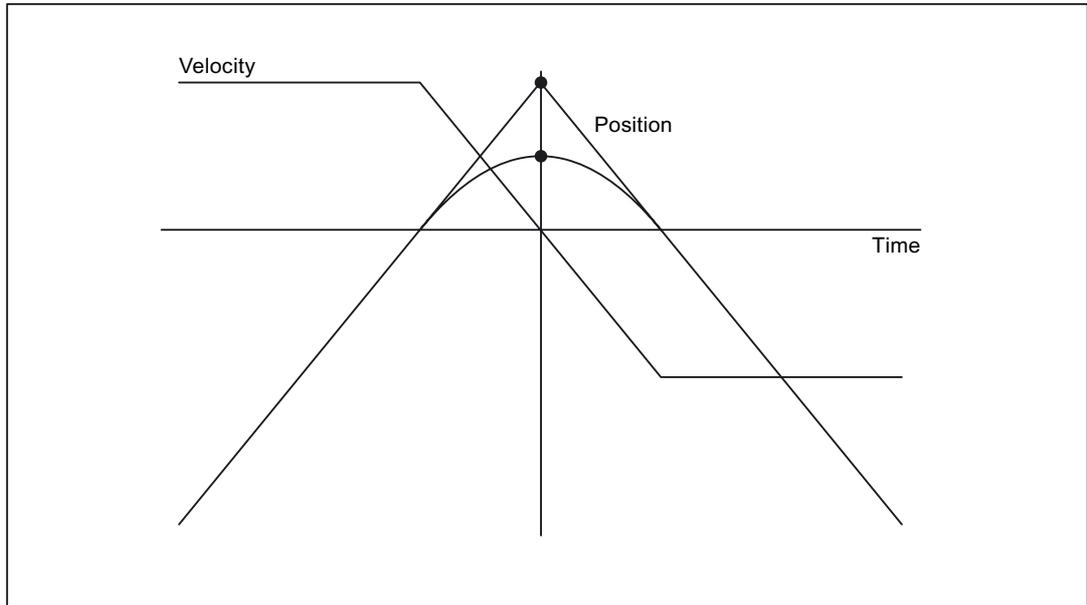
Apart from the ones mentioned, the following limitation can also become active additionally:  
The rounding distance cannot exceed half the length of the original participating blocks.

**Jerk limitation**

The smoothing of the velocity jump on each axis and thus the shape of the rounding path depends on whether an interpolation is performed with or without jerk limitation.

Without jerk limitation the acceleration of each axis reaches its maximum value in the entire rounding area.

3.3 Continuous-path mode



With jerk limitation, the jerk of each axis is limited to its maximum value within the rounding area. The rounding motion thus generally consists of 3 phases:

- **Phase 1**

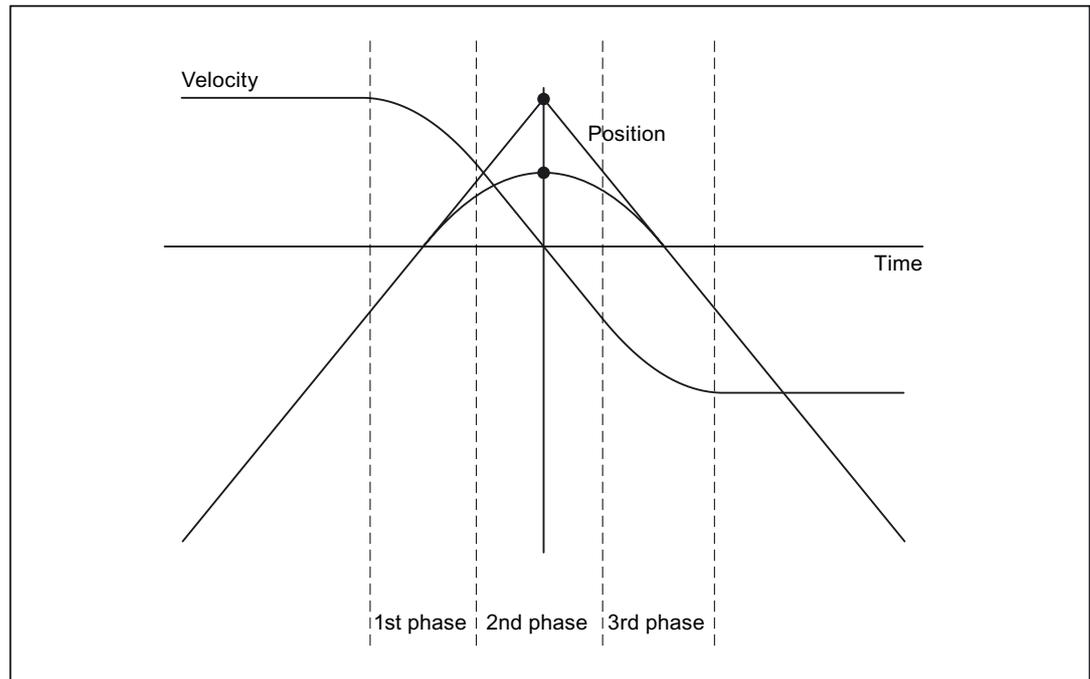
During phase 1, each axis builds up its maximum acceleration. The jerk is constant and equal to the maximum possible jerk on the respective axis.

- **Phase 2**

During phase 2, the maximum permissible acceleration is applied.

- **Phase 3**

During phase 3, which is the last phase, the acceleration of each axis is reduced back to zero with the maximum permissible jerk.



### Boundary conditions

Rounding with G644 is possible only when:

- all the axes involved contain only a linear motion in both the observed blocks.
- **No** kinematic transformation is active

In case an involved axis contains a polynomial (polynomial programmed], spline active, compressor active) or a kinematic transformation is active, the block transition is rounded with G642.

### 3.3.6 Smoothing the path velocity

#### Response without smoothing

The velocity control function utilizes the specified axial dynamic response. If the programmed feedrate cannot be achieved, the path velocity is brought to the parameterized axial limit values and the limit values of the path (velocity, acceleration, jerk). This can lead to repeated braking and acceleration on the path.

If a short acceleration takes place during a machining function with high path velocity, and is thus followed almost immediately by braking, the reduction in the machining time is only minimal. Acceleration of this kind can, however, have undesirable effects if, for example, it results in machine resonance.

### Smoothing the path velocity

In some applications in mold making, especially in the case of high speed cutting, it is desirable to achieve a constant path velocity. In these cases, it can therefore be reasonable to sacrifice transient acceleration processes in favor of a smoother tool path velocity.

Benefits:

- Avoidance of excitations of possible machine resonance due to continuous, transient braking and acceleration processes (in the area of less IPO cycles).
- Avoiding of constantly varying cutting rates due to acceleration which brings no significant shortening of the program running time.

### Decision-making criteria

The control system makes a decision based on the following criteria:

- Smoothing frequency for the tool path velocity (MD)
- Tolerable loss in productivity when suppressing accelerations/decelerations (MD).

### Activating

The smoothing of the path speed is activated with the machine data:

MD20460 \$MC\_LOOKAH\_SMOOTH\_FACTOR (smoothing factor for Look Ahead)

In the default setting (= 0) the function is deselected.

A change in the MD setting is made effective through NewConfig.

### Parameter assignment

#### Tolerable extension of the machining time

The tolerable extension of the machining time is specified as percentage value. The setting is programmed in machine data:

MD20460 \$MC\_LOOKAH\_SMOOTH\_FACTOR (smoothing factor for Look Ahead)

The percentage value defines how much longer a machining step without accelerations may be than the corresponding step when performing the accelerations/decelerations.

This would be a "worst-case" value, if all accelerations within the part program, except the initial approach motion, were smoothed.

The actual extension will always be smaller, and may even be 0, if the criterion is not met by any of the accelerations.

Values between 50 and 100% may also be entered without significantly increasing the machining time.

**Consideration of the programmed feed**

The following machine data sets, whether the programmed feed is considered when smoothing the path velocity.

MD20462 \$MC\_LOOKAH\_SMOOTH\_WITH\_FEED (path smoothing with programmed feedrate)

Value	Description
0	Programmed feedrate is not considered.
1	Programmed feedrate is considered (default setting).

When considering the programmed feedrate the specified smoothing factor from MD20462 \$MC\_LOOKAH\_SMOOTH\_FACTOR is maintained better (when the override is at 100%).

**Specification of the resonance frequency of the axes involved**

In the following machine data the smoothing frequency for Look Ahead is defined:

MD32440 \$MA\_LOOKAH\_FREQUENCY (smoothing frequency for Look Ahead)

Acceleration and deceleration processes, which run with a high frequency, are smoothed depending upon the parameterization of the following machine data or else are reduced in dynamics:

MD20460 \$MC\_LOOKAH\_SMOOTH\_FACTOR (smoothing factor for Look Ahead)

MD20465 \$MC\_ADAPT\_PATH\_DYNAMIC (adaptation of the dynamic path response)

Functional description:

The minimum value for this MD32440 is calculated as  $f_{Path}$  on the basis of the axis involved in the path. For the smoothing only those acceleration processes are taken into consideration, in which the start and the end velocity of this motion are reached within the time given below:

$$t = t_2 - t_1 = 2l / f_{Path}$$

**Note**

If vibration is excited in the mechanical system of this axis (with a minimum of MD32440) and if the corresponding frequency is known, this MD should be set to a value smaller than this frequency.

The needed resonance frequencies can be calculated using the built-in measuring functions.

**Note**

The smoothing of the path velocity does not lead to contour errors.

Variations in axis velocity due to curvatures in the contour at constant path velocity may continue to occur and are not reduced at this point.

Variations in path velocity due to the input of a new feedrate are not changed either. This remains the responsibility of the programmer of the subprogram.

**Example**

The following parameters are assumed:

MD20460 \$MC\_LOOKAH\_SMOOTH\_FACTOR = 10% (smoothing factor for Look Ahead)

MD32440 \$MA\_LOOKAH\_FREQUENCY[AX1] = 20 Hz (smoothing frequency for Look Ahead)

MD32440 \$MA\_LOOKAH\_FREQUENCY[AX2] = 20 Hz

MD32440 \$MA\_LOOKAH\_FREQUENCY[AX3] = 10 Hz

The path involves the 3 axes X = AX1, Y = AX2, Z = AX3.

The minimum value of MD32440 for these 3 axes is thus 10 Hz. This means that any acceleration, which is completed within a period of  $t_2-t_1 = 2/10 \text{ Hz} = 200 \text{ ms}$ , is examined. The time  $t_2$  is the time after which, following acceleration from velocity  $v_1$ , the velocity returns to this velocity  $v_1$ . The extending of the execution time is also only considered within this range.

A time  $t_2-t_1$  in excess of 200 ms or additional program processing time  $t_3-t_2$  greater than 10% (= MD20460) of  $t_2-t_1$ , produces the following time characteristic:

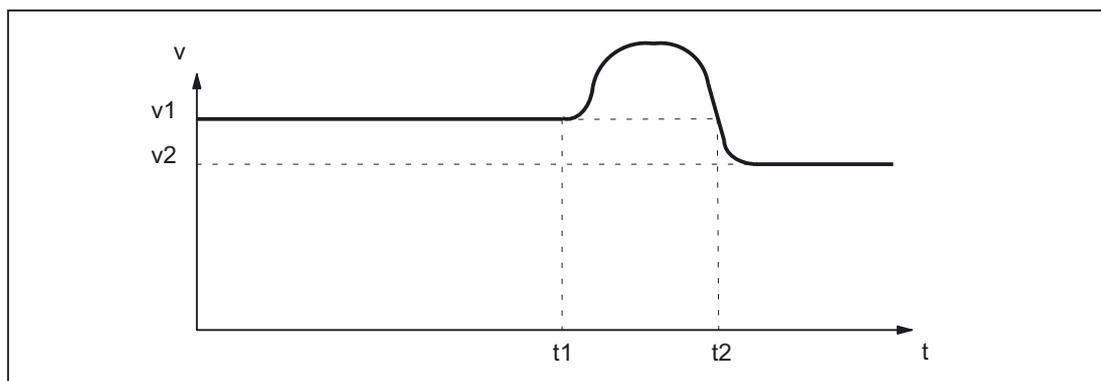


Figure 3-6 Characteristic of time-optimum path velocity (without smoothing)

However, a time  $t_2-t_1$  below 200 ms and additional program processing time  $t_3-t_2$  no greater than 10% of  $t_2-t_1$  produces this time characteristic:

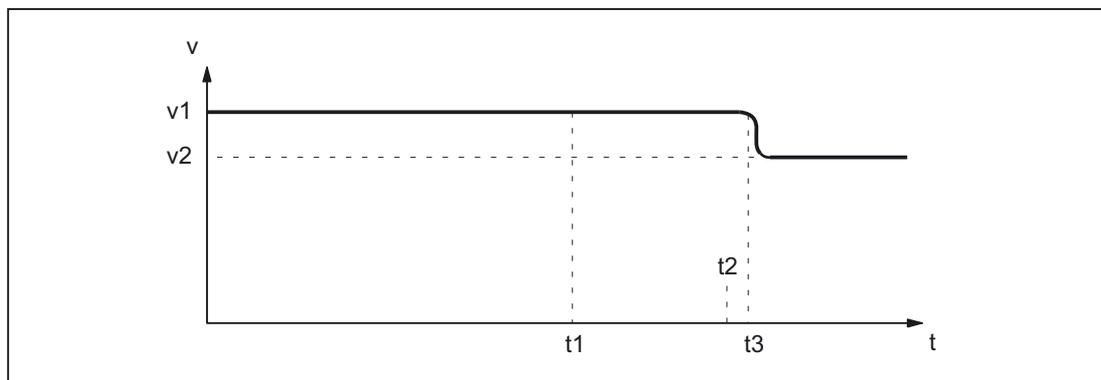


Figure 3-7 Characteristic of the smoothed path velocity

### 3.3.7 Dynamic response adaptation

#### Function

Highly dynamic acceleration and deceleration processes during machining can cause excitation of mechanical vibrations of machine elements and consequently a reduction of the surface quality of the workpiece. The function "Dynamic response adaptation" thus provides the option of adapting the dynamic response of the acceleration and deceleration processes to the machine conditions.

#### Parameter assignment

##### Adaptation factor of the dynamic path response

Via the adaptation factor of the dynamic path response, temporary changes in the path velocity are executed with smaller dynamic response limit values. The adjustment factor can be set for each channel for traversing motions with acceleration with or without jerk limiting.

- Traversing motions with acceleration without jerk limiting (**BRISK**):

MD20465 \$MC\_ADAPT\_PATH\_DYNAMIC[ 0 ] (adaptation of the dynamic path response)

The adaptation factor acts on the acceleration.

- Traversing motions with acceleration with jerk limiting (**SOFT**):

MD20465 \$MC\_ADAPT\_PATH\_DYNAMIC[ 1 ]

The adaptation factor acts on the jerk.

##### Excitation frequency

The dynamic response limiting should only be active during deceleration and acceleration processes that trigger mechanical vibrations larger than a specific limiting frequency, thus causing excitation of machine resonances.

This excitation frequency, after which the dynamic response limiting activates, can be axis-specifically specified via the machine data:

MD32440 \$MA\_LOOKAH\_FREQUENCY (smoothing frequency for Look Ahead)

During the processing, the NC cyclically determines, for all the axes in the path, the minimum value of their excitation frequencies as the limiting frequency for the adaptation of the dynamic response.

#### Boundary conditions

The dynamic response adaptation considers only the resulting path and not the deceleration and acceleration processes of the individual axes involved in the path. For this reason, critical deceleration and acceleration processes of the axes with respect to the excitation of mechanical vibrations can occur due to discontinuous contour profiles or kinematic transformations, even with a constant path velocity profile.

## Activation

The dynamic response adaptation is only active during path motions:

- Continuous-path mode (G64, G64x)

In continuous-path mode, the optimal effect of the dynamic response adaptation is attained with an active 100% override. Considerable deviations from this value or functions that cause the path axes to decelerate (e.g. auxiliary function outputs to the PLC) greatly reduce the desired action.

- Exact stop (G60)

In addition, the dynamic response adaptation is **not** active under the following boundary conditions:

- Programmed rapid traverse (G0)
- Changes in the override value
- Stop requests during motion, e.g. NC-STOP, NC-RESET
- Active function "velocity-related path acceleration" (DRIVE)

## Activation

The dynamic response adaptation is activated by an adaptation factor greater than 1:

MD20465 \$MC\_ADAPT\_PATH\_DYNAMIC > 1 (adaptation of the dynamic path response)

When the dynamic response adaptation is activated in continuous path mode, the **"Smoothing the path velocity" function is always activated as well**. In case of a parameterized smoothing factor MD20460 \$MC\_LOOKAH\_SMOOTH\_FACTOR (smoothing factor for Look Ahead) of 0% (= deactivated; default setting), a smoothing factor of 100% is used. For a smoothing factor other than 0%, the parameterized value is used.

## Adaptations

In order to clarify the adaptation processes sketched below, please note the following basic principles:

The size of the time window is  $t_{\text{adapt}} = 1 / f$ .

1. The time needed to change the velocity is less than  $t_{\text{adapt}}$ :

The acceleration rates are reduced by a factor greater than 1 and less than the value written in machine data:

MD20465 ADAPT\_PATH\_DYNAMIC (adaptation of the path dynamics)

The reduction in acceleration rate increases the time taken to change the velocity.

The following cases are different:

- The acceleration rate is reduced with a value less than MD20465 so that the process lasts for  $t_{\text{adapt}}$  [s]. The permitted reduction does not need to be fully utilized.
- The acceleration time is reduced with the value written in MD20465. The process lasts less than  $t_{\text{adapt}}$  despite the reduced acceleration. The permitted reduction was fully utilized.

- The time needed to change the velocity is greater than  $t_{\text{adapt}}$ :

No dynamic response adaptation is required.

**Example 1: Effect of dynamic response adaptation; acceleration mode: BRISK**

**Parameter assignment**

Machine data

$\$MC\_ADAPT\_PATH\_DYNAMIC[0] = 1.5$   
 $\$MC\_LOOKAH\_SMOOTH\_FACTOR = 1.0$  See note  
 $\$MA\_LOOKAH\_FREQUENCY[AX1] = 20 \text{ Hz}$   $T_{AX1} = 1/20 \text{ Hz} = 50 \text{ ms}$   
 $\$MA\_LOOKAH\_FREQUENCY[AX2] = 10 \text{ Hz}$   $T_{AX2} = 1/10 \text{ Hz} = 100 \text{ ms}$   
 $\$MA\_LOOKAH\_FREQUENCY[AX3] = 20 \text{ Hz}$   $T_{AX3} = 1/20 \text{ Hz} = 50 \text{ ms}$

**Note**

A smoothing factor other than 0% prevents the default value of 100% from being used to smooth the path velocity. To illustrate this effect, in contrast to Example 2 the smoothing of the path velocity is practically deactivated.

**AX2**

For path motions in which axis AX2 is involved, all deceleration and acceleration processes that would last less than  $T_{AX2}$  are adapted.

**AX1, AX3**

If only axes AX1 and/or AX3 are involved in path motions, all deceleration and acceleration processes that would last less than  $T_{AX1} = T_{AX3}$  are adapted. This time is designated  $t_{\text{adapt}xy}$  in the following diagrams:

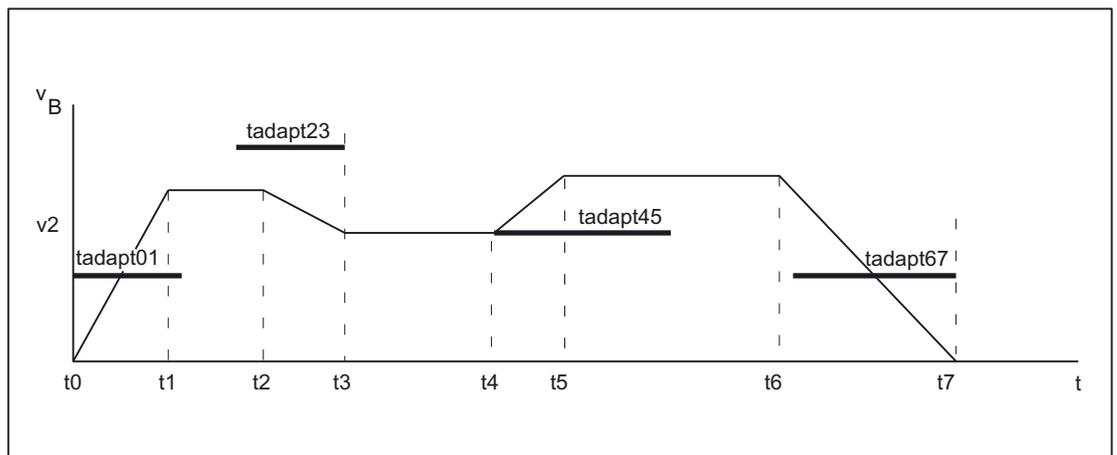


Figure 3-8 Path velocity profile optimized for time without smoothing or dynamic adaptation response

3.3 Continuous-path mode

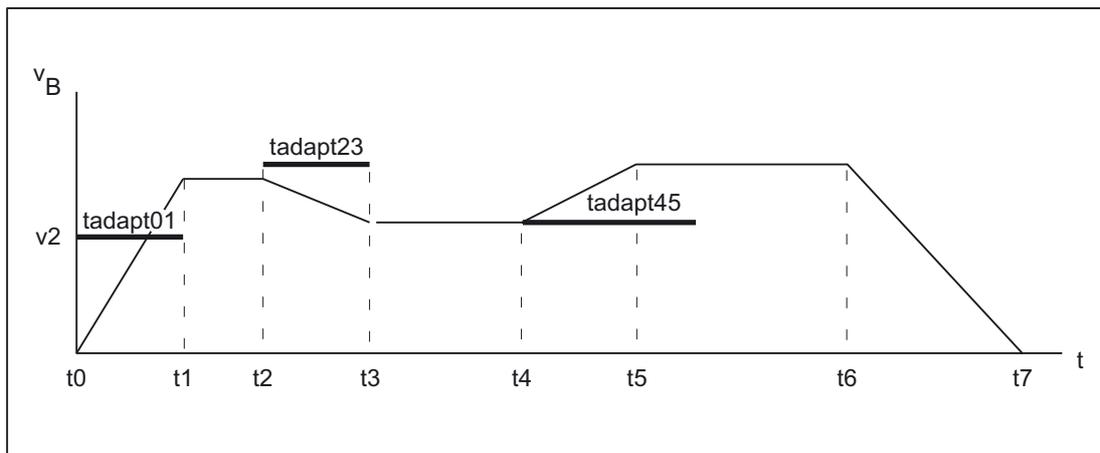


Figure 3-9 Path velocity profile with adaptation of dynamic response

- Interval: t0 - t1 and t2 - t3  
The acceleration process between t0 - t1 and the deceleration process between t2 - t3 are lengthened in time due to an adaptation of the acceleration to time  $t_{adapt01}$  or  $t_{adapt23}$ .
- Interval: t4 - t5  
The acceleration process between t4 - t5 is executed with an acceleration reduced by the maximum adaptation factor of 1.5. However, the acceleration process is completed before time  $t_{adapt45}$ .
- Interval: t6 - t7  
The deceleration process between t6 - t7 remains unchanged, as it lasts longer than  $t_{adapt67}$ .

**Example 2: Effect of smoothing the path velocity and dynamic response adaptation; acceleration mode: BRISK**

**Parameter assignment**

Machine data

\$MC_ADAPT_PATH_DYNAMIC[0] = 3	
\$MC_LOOKAH_SMOOTH_FACTOR = 80%	
\$MA_LOOKAH_FREQUENCY[AX1] = 20 Hz	$T_{AX1} = 1/20 \text{ Hz} = 50 \text{ ms}$
\$MA_LOOKAH_FREQUENCY[AX2] = 20 Hz	$T_{AX2} = 1/20 \text{ Hz} = 50 \text{ ms}$
\$MA_LOOKAH_FREQUENCY[AX3] = 20 Hz	$T_{AX3} = 1/20 \text{ Hz} = 50 \text{ ms}$

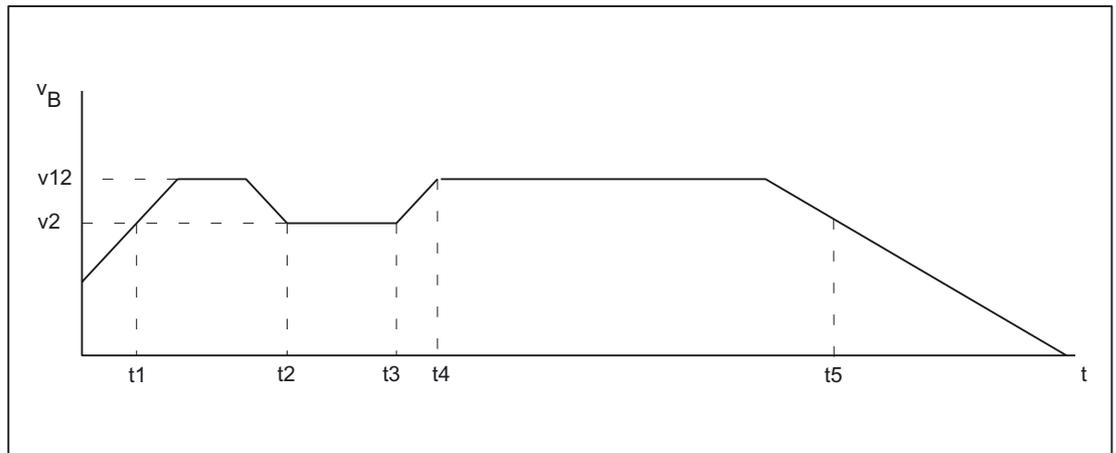


Figure 3-10 Path velocity profile optimized for time without smoothing or dynamic adaptation response

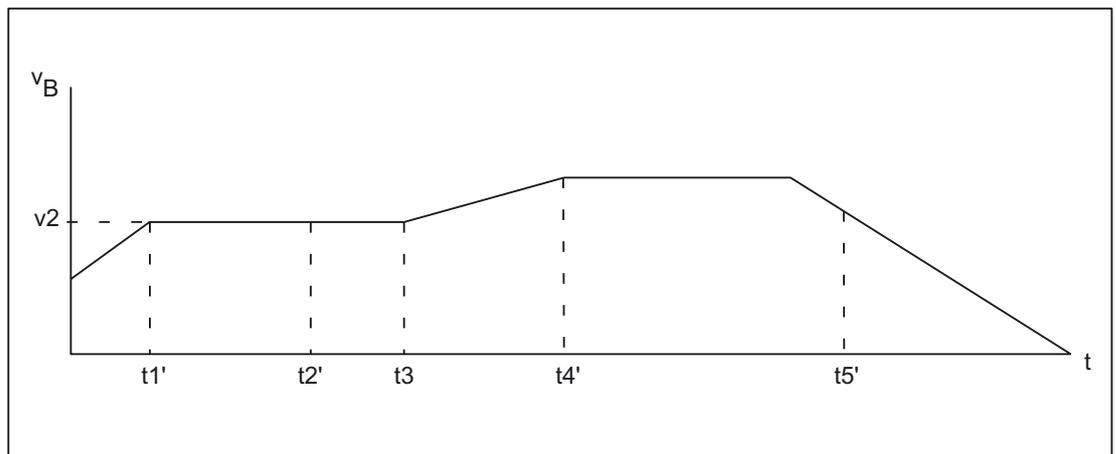


Figure 3-11 Path velocity profile with path smoothing and adaptation of dynamic response

#### Effects of path smoothing

- Interval:  $t1 - t2$

The acceleration and deceleration process between  $t1 - t2$  does not take place because the lengthening of the machining time without the acceleration process to  $v12$  is less than the resulting time if a smoothing factor of 80% is applied.

- Interval:  $t3 - t5$

The acceleration and braking profile between  $t3$  and  $t5$  does not fulfill this condition or takes longer the parameterized smoothing time:  $T_{AXn} = 2/20 \text{ Hz} = 100 \text{ ms}$ .

#### Effects of the dynamic response adaptation

- Interval:  $t3 - t4$

The acceleration process between  $t3 - t4$  is shorter than  $\text{MIN}(T_{AXn}) = 1/20 \text{ Hz} = 50 \text{ ms}$  and is therefore executed with an acceleration reduced by an adaptation factor of 3.

3.3 Continuous-path mode

- Interval: up to t1

The acceleration up to t1 left over after path smoothing is stretched to the time period up to t1' by the dynamic response adaptation.

**Conclusion**

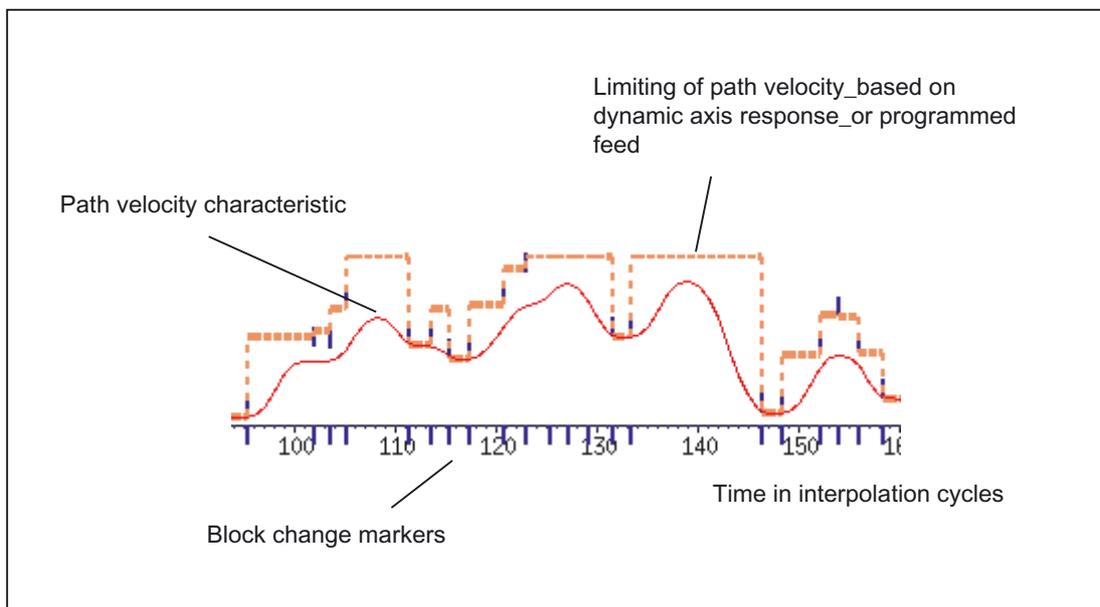
This example shows the interaction of path smoothing and dynamic response adaptation in continuous-path mode. Only those acceleration or deceleration processes that were not eliminated by the path smoothing are subsequently optimized by the dynamic response adaptation. For this reason, both functions should always be activated, if possible.

**Example 3: Effect of adaptation and smoothing the path velocity; acceleration mode: BRISK**

**Parameter assignment**

\$MC_ADAPT_PATH_DYNAMIC[1] = 4	
\$MC_LOOKAH_SMOOTH_FACTOR = 100%	
\$MA_LOOKAH_FREQUENCY[AX1] = 10 Hz	$T_{AX1} = 1/10 \text{ Hz} = 100 \text{ ms}$
\$MA_LOOKAH_FREQUENCY[AX2] = 10 Hz	$T_{AX2} = 1/10 \text{ Hz} = 100 \text{ ms}$
\$MA_LOOKAH_FREQUENCY[AX3] = 20 Hz	$T_{AX3} = 1/20 \text{ Hz} = 50 \text{ ms}$

**Without path dynamic response adaptation or path smoothing**

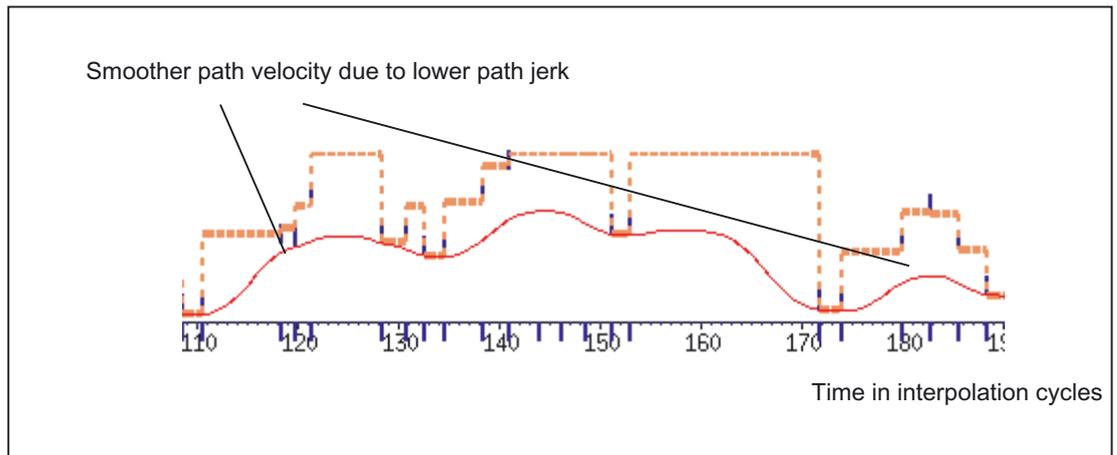


The path-velocity characteristic has been obtained through deselection of path dynamic response adaptation and path smoothing.

This corresponds to the following parameter settings:

```
$MC_ADAPT_PATH_DYNAMIC[1] = 1
$MC_LOOKAH_SMOOTH_FACTOR = 0%
```

**With path dynamic response adaptation, without path smoothing**

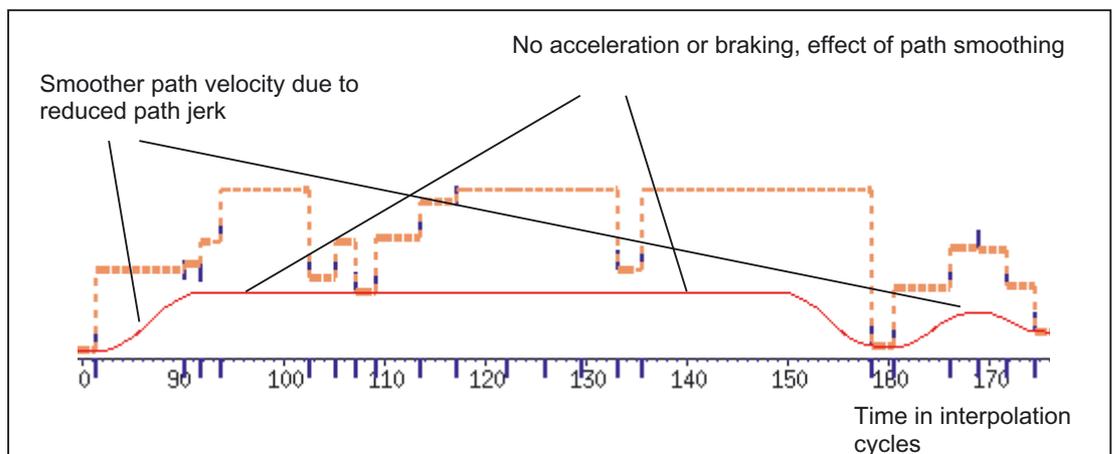


The path-velocity characteristic has been obtained through selection of path dynamic response adaptation with minimum, and thus virtually inactive, path smoothing.

The following parameter settings were made:

```
$MC_ADAPT_PATH_DYNAMIC[1] = 4
$MC_LOOKAH_SMOOTH_FACTOR = 1%
```

**With path dynamic response adaptation and path smoothing**



### 3.3 Continuous-path mode

The path-velocity characteristic has been obtained through selection of path dynamic response adaptation and path smoothing.

The standard path rounding parameter settings for deselected path smoothing and active path dynamic response adaptation were selected:

```
$MC_ADAPT_PATH_DYNAMIC[1] = 4  
$MC_LOOKAH_SMOOTH_FACTOR = 0%  
(same meaning as $MC_LOOKAH_SMOOTH_FACTOR = 100%)
```

### Installation and startup

The basic prerequisites for starting up the path dynamic response adaptation function are as follows:

- Determination of the natural frequency of the path axes for parameter assignment of dynamic response adaptation:  
MD32440 \$MA\_LOOKAH\_FREQUENCY (smoothing frequency for Look Ahead)
- Determination of the dynamic response limiting values: Velocity, acceleration, and jerk

#### Determination of the dynamic response limiting values

The determination of the dynamic response limiting values for the traversing of path axes by means of acceleration with jerk limiting (SOFT) is described below. This procedure can be transferred analogously to the case of acceleration without jerk limiting (BRISK).

1. Deactivate the dynamic response adaptation:  
MD20465 \$MC\_ADAPT\_PATH\_DYNAMIC[1] = 1 (adaptation of the path dynamic response)
2. Observe the positioning behavior of each path axis at different traversing velocities. When doing so, set the jerk such that the desired positioning tolerance is maintained.

#### Note

The higher the traversing velocity from which the positioning process is started, the higher in general the jerk can be set.

3. Use the maximum permissible jerk determined for the least critical traversing velocity:  
MD32431 \$MA\_MAX\_AX\_JERK (maximum jerk)
4. Determine the  $F_{APD}$  factor for all of the path axes using:  
 $F_{APD} = (\text{largest determined jerk}) / (\text{smallest determined jerk})$

#### Note

The smallest determined jerk is the value for the jerk during the most critical traversing velocity.

5. Enter the largest  $F_{APD}$  factor that was determined via all the path axes as the value for the dynamic response adaptation:  
MD20465 \$MC\_ADAPT\_PATH\_DYNAMIC[ 1 ] =  $F_{APD}$

### 3.3.8 Technology G group

#### Dynamic response settings for technology G groups

Different settings can be stored and programmed for five different machining sections, e.g. tapping, roughing, smoothing, and smooth-finishing. For example, roughing can be performed optimized for time and smoothing, optimized for surface.

After RESET, the basic setting technology G group can be set with the machine data:

```
MD20150 $MC_GCODE_RESET_VALUES (RESET position of G groups)
```

Only the dynamic response of the path axes is determined when the technology group G code is activated. This has **no effect** on:

- Positioning axes
- PLC axes
- Command axes
- Movements based on axis coupling
- Overlaid movements with handwheel
- JOG movements
- Reference point approach (G74)
- Fixed point travel (G75)
- Rapid traverse movements (G0)

The dynamic response for these axis movements is still derived from the machine data of the DYNORM default setting.

#### Technology G group

Five dynamic response settings are available in G code group 59 technology:

- DYNORM for standard dynamic response
- DYNPOS for positioning mode, tapping
- DYNROUGH for roughing
- DYNSEMIFIN for finishing
- DYNFINISH for smooth-finishing

For further information about programming, see:

**References:**

/PG/ Programming Manual Fundamentals, path traversing behavior.

### Enabling selected dynamics groups only

Some G codes can be deactivated by the machine manufacturer. If deactivated G codes are programmed alarm 14011 is output. G codes DYNPOS for positioning mode and DYNSEMIFIN for finishing, for example, can be deactivated with the following setting.

```
MD10712 $MN_NC_USER_CODE_CONF_NAME_TAB[0]="DYNPOS" (list of reconfigured NC codes)
```

```
MD10712 $MN_NC_USER_CODE_CONF_NAME_TAB[1]=" "
```

```
MD10712 $MN_NC_USER_CODE_CONF_NAME_TAB[2]="DYNSEMIFIN"
```

```
MD10712 $MN_NC_USER_CODE_CONF_NAME_TAB[3]=" "
```

### Configuring the dynamic response values.

The values for each technology group are stored in the following machine data:

- Axis

```
MD32300 $MA_MAX_AX_ACCEL[n] (axis acceleration)
```

```
MD32431 $MA_MAX_AX_JERK[n] (maximum axial jerk for path motion)
```

```
MD20600 $MA_MAX_PATH_JERK[n] (path-related maximum jerk)
```

```
MD32432 $MA_PATH_TRANS_JERK_LIM[n] (max. axial jerk at the block transition in continuous-path mode)
```

```
MD32310 $MA_MAX_ACCEL_OVL_FACTOR[n] (overload factor for axial jumps in velocity)
```

```
MD32433 $MA_SOFT_ACCEL_FACTOR[n] (scaling of the acceleration limitation with SOFT)
```

- Path

```
MD20602 $MC_CURV_EFFECT_ON_PATH_ACCEL[n] (influence of path curvature on dynamic path response)
```

```
MD20603 $MC_CURV_EFFECT_ON_PATH_JERK[n] (influence of path curvature on path jerk)
```

Value frange for index n = 0 to 4

Example of programming with index:

```
MD32300 $MA_MAX_AX_ACCEL[3, AX1]=1
```

```
R1=MD20602 $MC_CURV_EFECT_ON_PATH_ACCEL[4]
```

**NOTICE**

**Writing** the machine data **without an index** places the same value in all field elements of the machine data in question.

**Reading** the machine data **without an index** always supplies the value of the field with index 0.

These configurations may occur:

1. Write from the part program MD32300 \$MA\_MAX\_AX\_ACCEL[AX1]=1 sets all five field elements to value 1 (unit of measurement metric or inch depending on axis type and reference system).
2. Read in archive files from software versions earlier than SW 7.2.

**Activate parameter sets for dynamic response**

By programming G codes, the machine data affecting dynamics are activated and assigned as follows:

Active parameter set	G CODE of group 59 technology:
Index 0: Value for:	DYNNORM
Index 1: Value for:	DYNPOS
Index 2: Value for:	DYNROUGH
Index 3: Value for:	DYNSEMIFIN
Index 4: Value for:	DYNFINISH

**Note**

We recommend suppressing **G codes that are not used** with the machine data:

MD10712 \$MN\_NC\_USER\_CODE\_CONF\_NAME\_TAB[n] (list of reconfigured NC codes).

This will prevent these G codes from being programmed accidentally and activating unconfigured machine data.

### 3.4 LookAhead

#### Function

LookAhead is a procedure in continuous-path mode (G64, G641) that achieves velocity control with LookAhead over several NC part program blocks beyond the current block.

If the program blocks only contain very small paths, a velocity per block is achieved that permits deceleration of the axes at the block end point without violating acceleration limits. This means that the programmed velocity was not actually reached although a sufficient number of prepared blocks with virtually tangential path transitions was available.

With the LookAhead function it is possible to plan the acceleration and deceleration phase with approximately tangential path transitions in order to achieve a higher feedrate with shorter distances. Deceleration to velocity limits is possible with LookAhead such that violation of the acceleration and velocity limit is prevented.

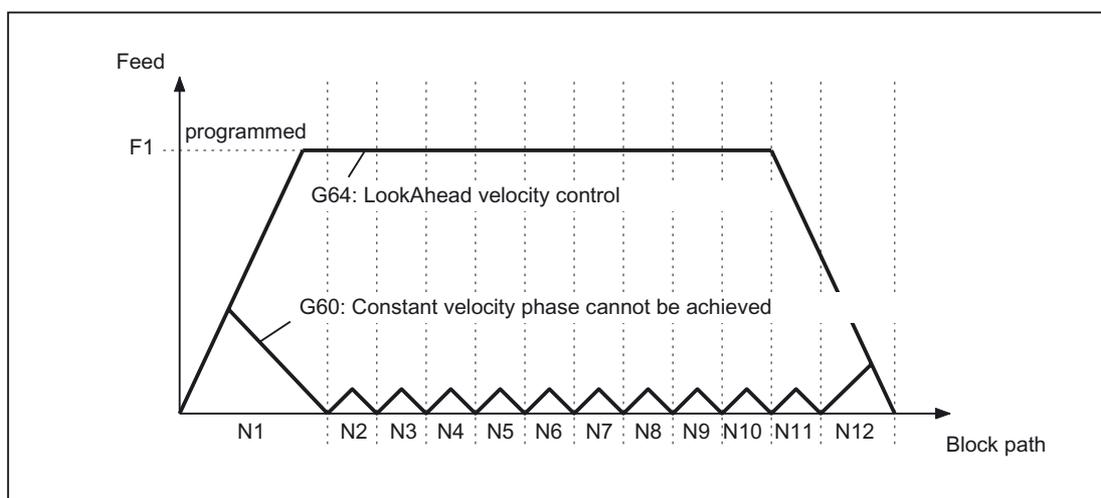


Figure 3-12 Comparison of velocity response with exact stop G60 and continuous-path mode G64 with LookAhead with short traversing paths.

LookAhead takes plannable velocity limits into consideration such as:

- Exact stop at block end
- Velocity limit in the block
- Acceleration limit in the block
- Velocity limit on block transition
- Synchronization with block change at block transition

## Scope

The LookAhead function is only available for path axes and not for spindles and positioning axes.

LookAhead carries out a block-specific analysis of velocity limits and specifies the required brake ramp profile based on this information. LookAhead is adapted automatically to block length, braking capacity and permissible path velocity.

For safety reasons, the velocity at the end of the last prepared block must initially be assumed to be zero because the next block might be very small or be an exact-stop block and the axes must have been stopped by the end of the block.

With a series of blocks with high set velocity and very short paths, the speed can be increased in each block depending on the velocity value currently calculated by the LookAhead function in order to achieve the required set velocity. After this it can be reduced so that the velocity at the end of the last block considered by the LookAhead function can be zero.

This results in a serrated velocity profile (see the following fig.) which can be avoided by reducing the set velocity or increasing the number of blocks considered by the LookAhead function.

## Number of blocks

To achieve reliable axis traversal in continuous-path mode, the feedrate must be adapted over several blocks. The number of blocks considered by the LookAhead function is calculated automatically and can, if required, be limited by a machine data. The standard setting is 1, which means that LookAhead only considers the following block for velocity control.

Because LookAhead is especially important for short blocks (relative to the deceleration path), the number of blocks required is of interest for LookAhead braking (see fig. below). It is enough to consider the path length to be equal to the deceleration path that is required to brake from maximum velocity to standstill.

For a machine with a low axial acceleration of  $a = 1\text{m/s}^2$  and a high feedrate of  $v_{\text{path}} = 10\text{ m/min}$ , the following number of blocks for the control is obtained with an attainable block cycle time of the control of  $TB = 10\text{ ms}$ .

$$n_{\text{LookAhead}} = \text{Deceleration path/Block length} = (v_{\text{path}}^2 / (2a)) / (v_{\text{path}} * TB) = 9$$

Considering these aspects, it is advisable to adapt the feedrate over 10 blocks. The number of blocks entered for the LookAhead function forecast does not change the LookAhead algorithm and memory requirement.

As, in a program, the machining velocity is very often set to a lower value than the maximum velocity, more blocks than are required would be predicted, overloading the processor unnecessarily. For this reason, the required number of blocks is derived from the velocity which is calculated from the programmed velocity multiplied by the value in the machine data:

MD12100 \$MN\_OVR\_FACTOR\_LIMIT\_BIN (limit for binary coded override switch)

Another possibility is multiplication with the 31st override value of the machine data:

MD12030 \$MN\_OVR\_FACTOR\_FEEDRATE (evaluation of the path feed rate override switch)

3.4 LookAhead

The 31st override value must tally with the override factor most frequently used.

The number of blocks considered by the LookAhead function is limited by the possible number of NC blocks in the IPO buffer.

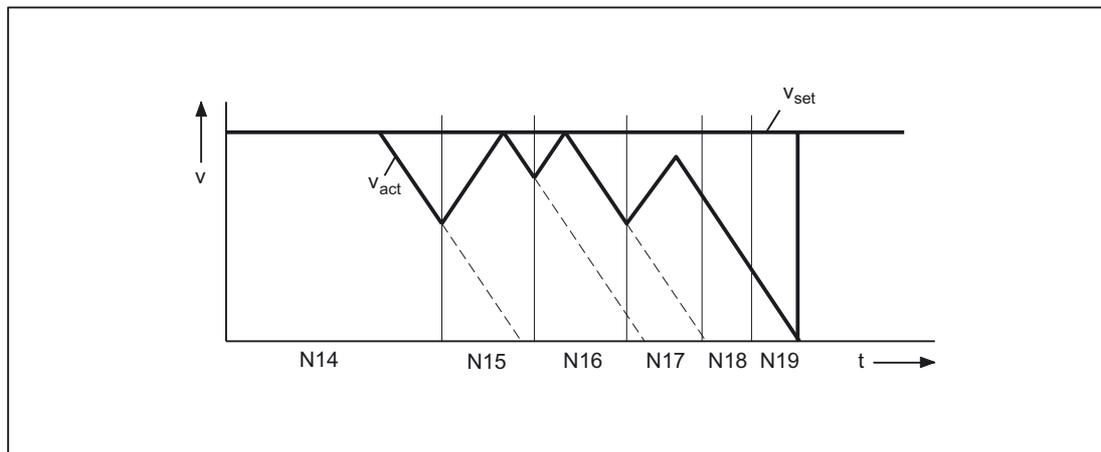


Figure 3-13 Example for modal velocity control (number of blocks considered by the LookAhead function = 2)

### Velocity profiles

In addition to the fixed, plannable velocity limitations, LookAhead can also take account of the programmed velocity. This makes it possible to achieve a lower velocity by applying LookAhead beyond the current block.

### Following block velocity

One possible velocity profile contains the determination of the following block velocity. Using information from the current and the following NC block, a velocity profile is calculated from which, in turn, the required velocity reduction for the current override is derived.

The calculated maximum value of the velocity profile is limited by the maximum path velocity. With this function it is possible to initiate a speed reduction in the current block taking override into account such that the lower velocity of the following block can be achieved. If the reduction in velocity takes longer than the travel time of the current block, the velocity is further reduced in the following block. Velocity control is only ever considered for the following block.

This function is activated by machine data:

MD20400 \$MC\_LOOKAH\_USE\_VELO\_NEXT\_BLOCK (LookAhead at programmed following block velocity)

## Override points

If the velocity profile of the following block velocity is not sufficient because, for example, very high override values, e.g. 200%, or constant cutting rate G96/G961 are being used, with the result that the velocity must be further reduced in the following block, LookAhead provides a way of reducing the programmed velocity over several NC blocks.

By defining override points, LookAhead then calculates a limiting velocity profile for each value. The required velocity reductions for the current override are derived from these profiles.

The calculated maximum value of the velocity profile is limited by the maximum path velocity.

The upper point should cover the velocity range that will be reached by the maximum value set in the machine data:

MD12030 \$MN\_OVR\_FACTOR\_FEEDRATE (evaluation of the path feed rate override switch)

It can also be reached via the value of the machine data:

MD12100 \$MN\_OVR\_FACTOR\_LIMIT\_BIN (limit for binary coded override switch)

In this way, a reduction of the velocity continuing into the block in which it is programmed can be avoided. If velocity reductions across block boundaries are required already at 100% override, a point must be set in the lower override range as well.

The number of override points used per channel is specified in the machine data:

MD20430 \$MC\_LOOKAH\_NUM\_OVR\_POINTS (number of override switch points for LookAhead)

The associated points are stored in the machine data:

MD20440 \$MC\_LOOKAH\_OVR\_POINTS (prepared override velocity characteristics with LookAhead)

A combination of both procedures can be used to calculate the velocity profile and is generally recommended, because the preset machine data for these functions already takes the widest range of override-specific velocity limits into account.

Plannable velocity limits restrict override-specific velocity limits.

If neither of the two procedures has been activated, the setpoint velocity is always applied in the current block.

3.4 LookAhead

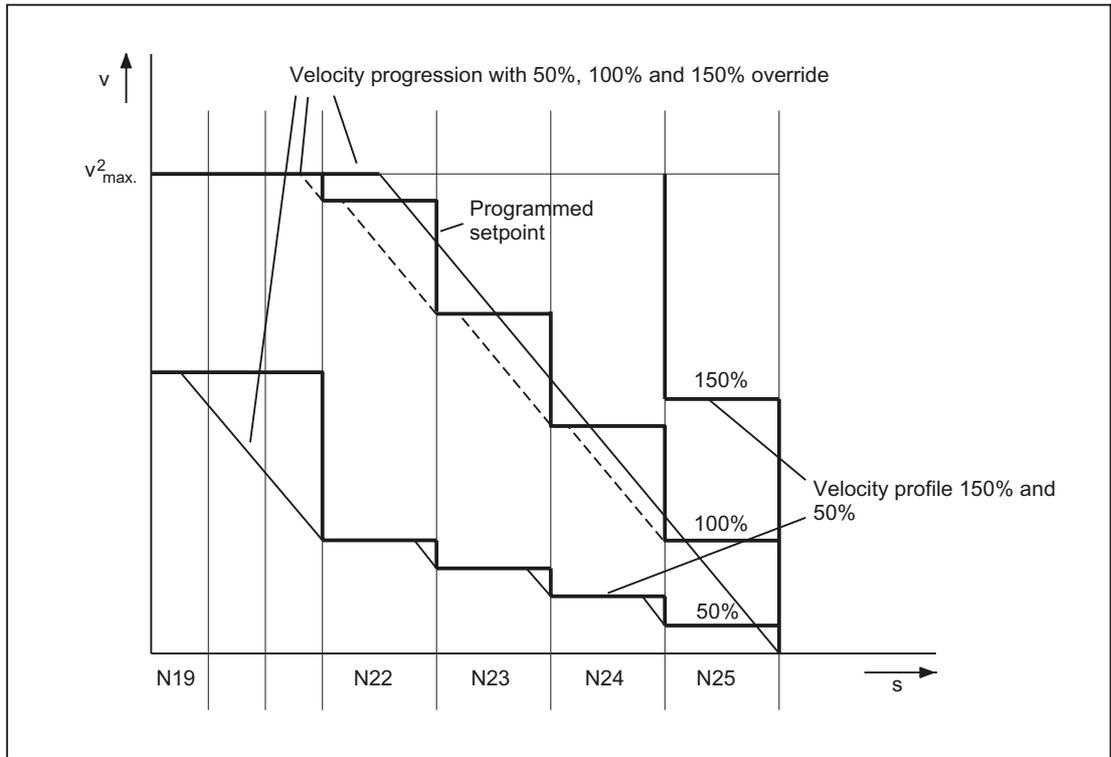


Figure 3-14 Example for limiting velocity characteristics with number of LookAhead blocks = 4

... and the following settings:

```
MD20430 $MC_LOOKAH_NUM_OVR_POINTS = 2
MD20440 $MC_LOOKAH_OVR_POINTS = 1.5, 0.5
MD20400 $MC_LOOKAH_USE_VELO_NEXT_BLOCK = 1
```

**Block cycle problem**

Block cycle problems are encountered in cases where the traversing distances of the NC blocks to be processed are so short that the LookAhead function has to reduce the machine velocity to provide enough time for block processing. In this situation, constant braking and acceleration of path motion may occur.

Velocity fluctuations of this type can be dampened by the machine data:

```
MD20450 $MC_LOOKAH_RELIEVE_BLOCK_CYCLE (relieving factor for the block cycle time)
```

### **Selection and deselection of LookAhead**

The LookAhead function is selected and deselected with continuous-path mode G64 or G641 respectively.

### **Special cases of LookAhead**

Axis-specific feed stop and axis-specific axis disable are ignored by LookAhead.

If an axis is to be interpolated that should on the other hand be made stationary by axis-specific feed stop or axis disable, LookAhead does not stop path movement before the block in question but decelerates **in** the block itself.

If this response is not wanted, an **axis**-specific feed stop can be transferred to a **channel** via the PLC to stop the path immediately.

See also:

/FB1/ Function Manual, Basic Functions; Axis Jamming (A3).

## 3.5 NC block compression

### Function

#### COMPON, COMPCURV

The compression function COMPON or COMPCURV collects a series of linear blocks during linear interpolation (the number is limited to 10) and approximates them within a tolerance specified in machine data via a 3rd order (COMPON) or 5th order (COMPCURV) polynomial. One traversing block is processed by the NC instead of a large number of small blocks.

#### COMPCAD

The compressor function COMPCAD generates mutually overlapping polynomial blocks with constant acceleration. With adjacent paths, deviations head in the same direction.

The accuracy of the interpolation can be specified through machine data. The number of blocks to be compressed is not limited to 10.

The aim of COMPCAD is an optimization regarding the surface finish and speed.

Since COMPCAD makes intensive use of computing time and memory area, it should only be used if measures to improve the surface cannot be taken by the CAD/CAM program in advance.

### Rated conditions

- The NC block compression can only be executed for linear blocks (G1).
- Only blocks that comply with a simple syntax are compressed:  
`N... G1X... Y... Z... F... ;comment`  
All other blocks are executed unchanged (no compression).
- Motion blocks with extended addresses such as `C=100` or `A=AC(100)` are also condensed.
- The position values do not have to be programmed directly, but can also be indirectly specified using parameter assignments, e.g. `X=R1*(R2+R3)`.
- If the option "orientation transformation" is available, then NC blocks in which the tool orientation (and where relevant, also the tool rotation) is programmed using direction vectors can also be compressed.

#### References:

Function Manual, Special Functions; 3 to 5-Axis Transformation (F2),  
Chapter: "Compression of the orientation"

- It is interrupted by any other type of NC instruction, e.g. an auxiliary function output.

## Parameter assignment

### Maximum path length

The maximum path length for the compression is set with the machine data:

MD20170 \$MC\_COMPRESS\_BLOCK\_PATH\_LIMIT

Longer blocks are not compressed.

The recommended setting is 20 [mm].

### Axis accuracy

A tolerance can be specified for each axis. This value specifies the maximum deviation of the generated spline curve from the programmed end points.

The setting is done via the following machine data:

MD33100 \$MA\_COMPRESS\_POS\_TOL

The higher the values, the more blocks can be compressed.

---

### Note

Experience has shown that a value of 0.01 is suitable for most applications: If not, the value can be increased to 0.02.

---

### Contour accuracy

The maximum deviation of the contour is specified via the following setting data:

SD42475 \$SC\_COMPRESS\_CONTUR\_TOL (maximum contour deviation for compressor)

### Maximum deviation of the path feedrate FLIN and FCUB

The maximum permissible deviation of the path feedrate for active compressor function COMPON or COMPCURV can be specified in the machine data together with FLIN and FCUB:

MD20172 \$MC\_COMPRESS\_VELO\_TOL

The recommended setting is 100 [mm/min].

### Corner limit angle for COMPCAD

A threshold angle can be defined for the compressor function COMPCAD via the following setting data, starting from which a block transition is interpreted as angle:

SD42470 \$SC\_CRIT\_SPLINE\_ANGLE

Values between 10 and 40 degrees are useful. The recommended setting is 36.

---

### Note

The angle serves only as an approximate measure for the corner identification. Owing to plausibility considerations, the compressor can also classify flatter block transitions as corners and also eliminate larger angles as outliers.

---

**Corresponding machine data**

The following machine data influence the compressor function. They should contain the following values:

Machine data	Recommended value
MD18360 \$MN_MM_EXT_PROG_BUFFER_SIZE (FIFO buffer size for processing from external)	100
MD28520 \$MC_MM_MAX_AXISPOLY_PER_BLOCK (maximum number of axis polynomials per block)	3
MD28530 \$MC_MM_PATH_VELO_SEGMENTS (Number of memory elements for limiting the path velocity)	5
MD28540 \$MC_MM_ARCLENGTH_SEGMENTS (number of memory elements for displaying the arc length function)	10
MD28070 \$MC_MM_NUM_BLOCKS_IN_PREP (number of blocks for block preparation)	60
MD28060 \$MC_MM_IPO_BUFFER_SIZE (number of NC blocks for block preparation)	100
MD32310 \$MA_MAX_ACCEL_OVL_FACTOR[AX1] (overload factor for axial jumps in velocity)	<Value for G64 operation>
MD32310 \$MA_MAX_ACCEL_OVL_FACTOR[AX2]	Value for G64 operation
MD32310 \$MA_MAX_ACCEL_OVL_FACTOR[AX3]	<Value for G64 operation>
MD20490 \$MC_IGNORE_OVL_FACTOR_FOR_ADIS (G641/G642 irrespective of the overload factor).	1

The new settings are activated with NEW\_CONF.

**Programming**

Compressor functions are activated using the modal G codes COMPON, COMPCURV or COMPCAD.

The rounding function G642 and jerk limitation SOFT can be used to achieve improvements in surface quality. These commands must be entered at the start of the program:

```
COMPCAD SOFT G642
```

COMPOF terminates the compressor function.

**References**

The programming of the compressor functions is described in:  
/PGA/ Programming Manual Job Planning

The use of the compressor function with active orientation transformation is described in:  
/FB3/ Function Manual, Special Functions; 3 to 5 axis transformation (F2),  
Chapter: "Compression of the orientation"

## 3.6 Combine short spline blocks

### Function

During the processing of splines short blocks can so occur, that the path velocity for the interpolation of these spline blocks must be reduced. This is also the case, when the spline actually has a long, smooth curve.

The "Combine short spline blocks" function allows you to combine these spline blocks such that the resulting block length is sufficient and does not reduce the path velocity.

---

### Note

#### NC block compressor

The NC-block-compressor (COMPON, COMPCURV or COMPCAD) cannot be employed while compressing spline blocks, since with this only linear blocks can be compressed.

---

### Activation

The function "overview of short spline blocks" can be activated for following cases independent of each other:

- BSPLINE active
- BSPLINE/ORICURVE active
- CSPLINE active

The activation is done using machine data:

MD20488 \$MC\_SPLINE\_MODE (setting for spline interpolation).

Bit	Value	Meaning
Function "Combining shorter spline blocks":		
0	0	for BSPLINE not active
	1	for BSPLINE active
1	0	for BSPLINE/ORICURVE not active
	1	for BSPLINE/ORICURVE active
2	0	for CSPLINE not active
	1	for CSPLINE active

**Boundary conditions**

- NC-blocks can be combined only if no other details have been programmed except the axial motions and the feed rate. If, for example, auxiliary functions are programmed, which must be given to the PLC, then this block cannot be omitted, since it must be active in the interpolator. This is analogous to the possible compression of G1-blocks with the compressors COMPON, COMPCURV and COMPCAD.
- The maximum number of blocks, which can be combined into a program part one after the other, depends on the size of the available memory for blocks in the block processing. This memory is established by the machine data:  
MD28070 \$MC\_MM\_NUM\_BLOCKS\_IN\_PREP (number of blocks for block preparation)

**Example**

The programming lines show an NC program with BSPLINE-interpolation.

In order to attain a higher path velocity when processing the program, the following MD-parameterization is set:

MD20488 \$MC\_SPLINE\_MODE, Bit 0 = 1

Programming	Comment
N10 G1 G64 X0 Y0 Z0 F10000	
N20 G91 BSPLINE	; Activate BSPLINE-interpolation with combination of short spline blocks.
N30 X0.001 Y0.001 Z0.001	
N40 X0.001 Y0.001 Z0.001	
N50 X0.001 Y0.001 Z0.001	
N60 X0.001 Y0.001 Z0.001	
N70 X0.001 Y0.001 Z0.001	
N80 X0.001 Y0.001 Z0.001	
...	
N1000 M30	

## 3.7 Supplementary conditions

### 3.7.1 Rounding and repositioning (REPOS)

#### Repositioning within the rounding area

If the traversing motion of the path axes within the corner rounding area is interrupted for traversing blocks with programmed rounding (part program command G641, G642, G643 or G644), repositioning occurs as follows in the event of a subsequent REPOS operation, depending on the current REPOS mode:

#### REPOS mode

RMB	Block start of interrupted traversing block
RMI	Block end of interrupted traversing block
RME	Block end of interrupted traversing block
RMN	Block end of interrupted traversing block

#### Example

Two traversing blocks N10 and N20 with programmed rounding G641. In the rounding area, the traversing motion is interrupted and the axes are subsequently traversed, e.g. manually to the REPOS starting point. Repositioning on the contour takes place differently, depending on the active REPOS mode.

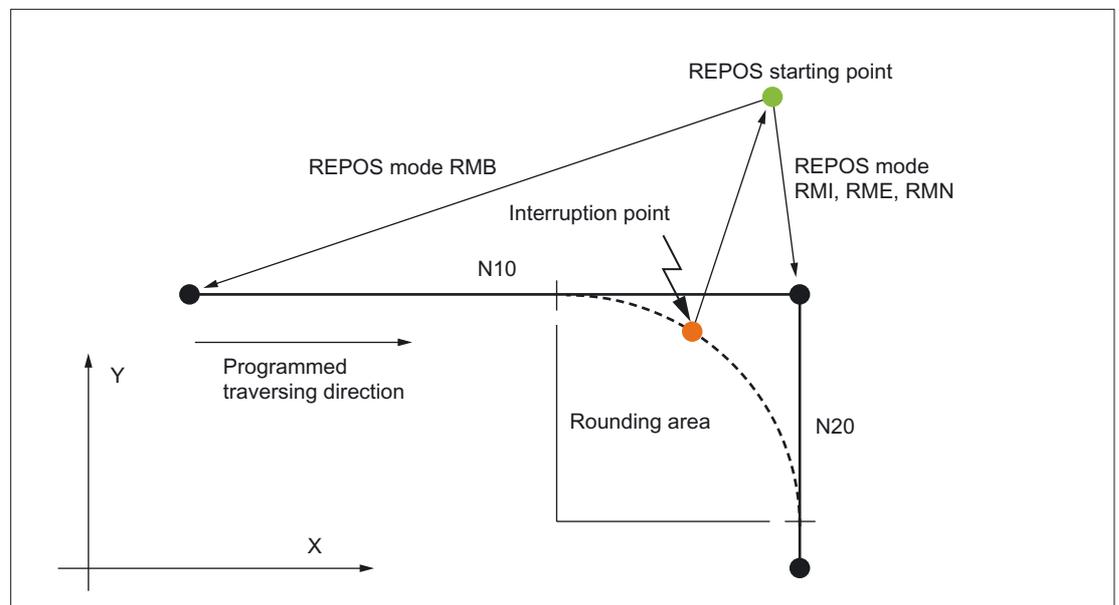


Figure 3-15 Example of Rounding and REPOS

### **3.7.2 Smoothing the path velocity**

#### **Several blocks with SOFT and BRISK**

Smoothing of the path velocity is only effective in continuous-path mode with LookAhead over several blocks with `SOFT` and `BRISK`, but not with `G0`.

The cycle times of the control must be parameterized such that the preprocessing is provided with enough blocks to be able to analyze an acceleration process.

## 3.8 Examples

### 3.8.1 Example of jerk limitation on the path

```
...
N1000 G64 SOFT           ; Continuous-path mode with SOFT acceleration
                          ; characteristics
N1004 G0 X-20 Y10
N1005 G1 X-20 Y0        ; Straight
N1010 G3 X-10 Y-10 I10 ; Block transition with jump in path curvature
                          ; (straight - circular)
N1011 G3 X0 Y0 J10      ; Block transition with continuous path curvature
N1020 G2 X5 Y5 I5       ; Block transition with jump in path curvature
                          ; (circular - circular)
N1021 G2 X10 Y0 J-5
...
```

## 3.9 Data lists

### 3.9.1 Machine data

#### 3.9.1.1 General machine data

Number	Identifier: \$MN_	Description
10110	PLC_CYCLE_TIME_AVERAGE	Maximum PLC acknowledgment time
18360	MM_EXT_PROG_BUFFER_SIZE	FIFO buffer size for processing from external

#### 3.9.1.2 Channel-specific machine data

Number	Identifier: \$MC_	Description
20170	COMPRESS_BLOCK_PATH_LIMIT	Maximum traversing length of NC block for compression
20400	LOOKAH_USE_VELO_NEXT_BLOCK	LookAhead for constant acceleration velocity control
20430	LOOKAH_NUM_OVR_POINTS	Number of override switch points for LookAhead
20440	LOOKAH_OVR_POINTS	Override switch points for LookAhead
20450	LOOKAH_RELIEVE_BLOCK_CYCLE	Relief factor for the block cycle time
20460	LOOKAH_SMOOTH_FACTOR	Smoothing factor for LookAhead
20462	LOOKAH_SMOOTH_WITH_FEED	Smoothing takes feedrate into account
20465	ADAPT_PATH_DYNAMIC	Adaptation of path dynamic response
20480	SMOOTHING_MODE	Rounding behavior with G642, G643, G644
20488	SPLINE_MODE	Setting for spline interpolation
20490	IGNORE_OVL_FACTOR_FOR_ADIS	G641/G642 irrespective of overload factor
20550	EXACT_POS_MODE	Exact-stop conditions with G0/G1
20602	CURV_EFFECT_ON_PATH_ACCEL	Influence of path curvature on path dynamic response
20603	CURV_EFFECT_ON_PATH_JERK	Influence of path curvature on path jerk
28060	MM_IPO_BUFFER_SIZE	Number of NC blocks in IPO buffer (DRAM)
28070	MM_NUM_BLOCKS_IN_PREP	Number of NC blocks for block preparation (DRAM)
28520	MM_MAX_AXISPOLY_PER_BLOCK	Maximum number of axis polynomials per block
28530	MM_PATH_VELO_SEGMENTS	Number of storage elements for limiting path velocity in block
28540	MM_ARCLENGTH_SEGMENTS	Number of storage elements for arc length function representation per block

### 3.9.1.3 Axis/spindle-specific machine data

Number	Identifier: \$MA_	Description
32310	MAX_ACCEL_OVL_FACTOR	Overload factor for velocity jump
32431	MAX_AX_JERK	Maximum axis jerk for path motion
32432	PATH_TRANS_JERK_LIM	Maximum axial jerk of a geometry axis at block boundary
32433	SOFT_ACCEL_FACTOR	Scaling of acceleration limitation for SOFT
32434	G00_ACCEL_FACTOR	Scaling of acceleration limitation for G00
32435	G00_JERK_FACTOR	Scaling of axial jerk limitation for G00
32440	LOOKAH_FREQUENCY	Smoothing limit frequency for LookAhead
33100	COMPRESS_POS_TOL	Maximum deviation with compensation
36000	STOP_LIMIT_COARSE	Exact stop coarse
36010	STOP_LIMIT_FINE	Exact stop fine
36012	STOP_LIMIT_FACTOR	Exact stop coarse/fine factor and zero speed monitoring
36020	POSITIONING_TIME	Delay time exact stop fine

## 3.9.2 Setting data

### 3.9.2.1 Channel-specific setting data

Number	Identifier: \$SC_	Description
42465	SMOOTH_CONTUR_TOL	Max. contour deviation on rounding
42466	SMOOTH_ORI_TOL	Max. deviation of the tool orientation on rounding
42470	CRIT_SPLINE_ANGLE	Limit angle for spline and polynomial interpolation and compressor

### **3.9.3 Signals**

#### **3.9.3.1 Signals from channel**

---

<b>DB number</b>	<b>Byte.Bit</b>	<b>Description</b>
21, ...	36.3	All axes stationary

---

#### **3.9.3.2 Signals to axis/spindle**

---

<b>DB number</b>	<b>Byte.Bit</b>	<b>Description</b>
31, ...	60.6	Position reached with exact stop coarse
31, ...	60.7	Position reached with exact stop fine

---

## Acceleration (B2)

### 4.1 Brief description

#### 4.1.1 General

##### Scope of functions

The Description of Functions covers the following sub-functions:

- Acceleration
- Jerk
- Knee-shaped acceleration characteristic

##### **Acceleration and jerk**

The effective acceleration and jerk can be optimally matched to the machine and machining situation concerned using axis- and channel-specific programmable maximum values, programmable acceleration profiles in part programs and synchronized actions, and dynamic adaptations and limitations.

##### **Knee-shaped acceleration characteristic**

The knee-shaped acceleration characteristic means that, in the case of machine axes featuring a motor (in particular stepper motors) with a torque characteristic that is highly dependent upon speed, acceleration can be set at the level required to ensure optimum utilization of the motor whilst at the same time protecting it against overload.

## 4.1.2 Features

### Acceleration

#### Axis-specific functions:

- Programmable maximum acceleration value
- Acceleration profile that can be selected via part-program instruction:  
Acceleration without jerk limitation (`BRISKA`)
- Setting of maximum value using part-program instruction (`ACC`)
- Specific maximum value for programmed rapid traverse (`G00`).
- Specific maximum value for traverse with active jerk limitation
- Excessive acceleration for non-tangential block transitions

#### Channel-specific functions:

- Acceleration profile that can be selected via part-program instruction:  
Acceleration without jerk limitation (`BRISK`)
- Programmable constant travel time for the purpose of avoiding extreme sudden acceleration
- Programmable acceleration margin for overlaid traversing
- Adjustable acceleration limitation
- Adjustable acceleration for specific real-time events
- Programmable acceleration margin for radial acceleration

### Jerk

#### Axis-specific functions:

- Acceleration profile that can be selected via part-program instruction:  
Acceleration with jerk limitation (`SOFTA`)
- Programmable maximum jerk value for single-axis interpolation
- Programmable maximum jerk value for path interpolation

#### Channel-specific functions:

- Acceleration profile that can be selected via part-program instruction:  
Acceleration with jerk limitation (`SOFT`)
- Adjustable jerk limitation
- Adjustable path jerk for specific real-time events
- Specific maximum value for programmed rapid traverse (`G00`)
- Excessive jerk for block transitions without constant curvature

### **Knee-shaped acceleration characteristic**

A knee-shaped acceleration characteristic is parameterized using the following characteristic data:

- Maximum velocity  $v_{\max}$
- Maximum acceleration  $a_{\max}$
- Creep velocity  $v_{\text{red}}$
- Creep acceleration  $a_{\text{red}}$
- Nature of the acceleration reduction (constant, hyperbolic, linear)

## 4.2 Functions

### 4.2.1 Acceleration without jerk limitation (BRISK/BRISKA) (channel-/axis-specific)

#### 4.2.1.1 General Information

##### General Information

In the case of acceleration without jerk limitation (jerk = infinite) the maximum value is applied for acceleration immediately. As regards acceleration with jerk limitation, it differs in the following respects:

- **Advantages**

Shorter processing times with the same maximum values for velocity and acceleration.

- **Disadvantages**

Increased load on the machine's mechanical components and risk of inducing high-frequency and difficult-to-control mechanical vibrations.

##### Acceleration profile

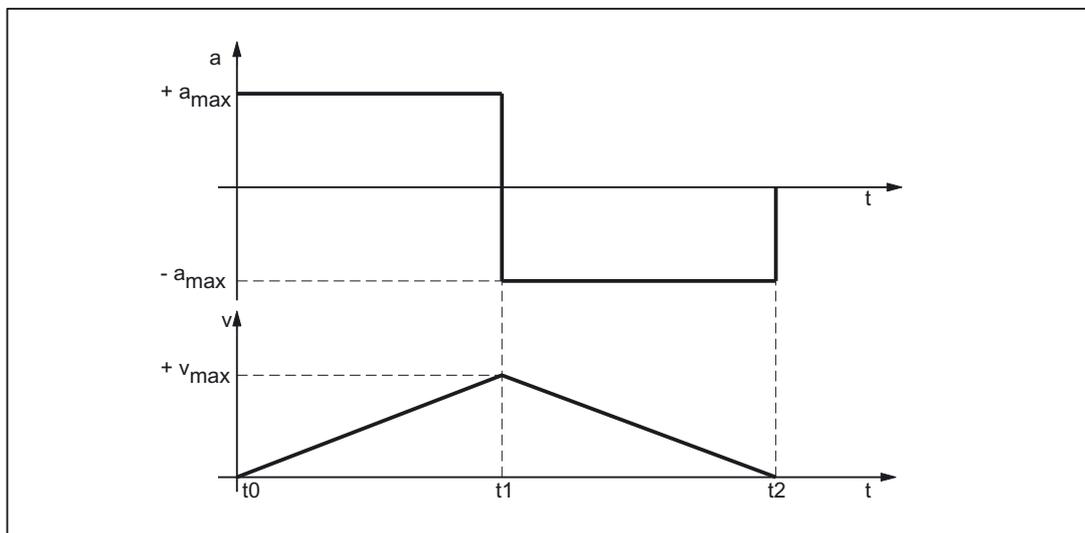


Figure 4-1 Velocity and acceleration schematic for stepped acceleration profile

$a_{max}$ : Maximum acceleration value

$v_{max}$ : Maximum velocity value

$t$ : Time

The following features of the acceleration profile can be identified from the figure above:

- Time:  $t_0$   
Sudden acceleration from 0 to  $+a_{\max}$
- Interval:  $t_0 - t_1$   
Constant acceleration with  $+a_{\max}$ ; linear increase in velocity
- Time:  $t_1$   
Sudden acceleration from  $2 * a_{\max}$  with immediate switchover from acceleration to braking

---

#### Note

The sudden acceleration can normally be avoided by specifying a constant velocity time (see Section: "Sudden acceleration with constant velocity phase").

---

- Interval:  $t_1 - t_2$   
Constant acceleration with  $-a_{\max}$ ; linear decrease in velocity

### 4.2.1.2 Programmable maximum value (axis-specific)

#### Function

The maximum acceleration value can be set for each specific machine axis:

MD32300 \$MA\_MAX\_AX\_ACCEL (maximum axis acceleration)

The path parameters are calculated by the path planning component during preprocessing so that the programmed maximum values of the machine axes that are of relevance for the path are not exceeded.

#### Exceeding of maximum value

It is possible for the maximum value to be exceeded in connection with specific machining situations (see Section: Acceleration matching (ACC) and System variable (\$AC\_PATHACC)).

### 4.2.1.3 Parameterization

#### Programming

The maximum values are parameterized for specific axes using machine data:

MD32300 \$MA\_MAX\_AX\_ACCEL (maximum axis acceleration)

#### 4.2.1.4 Programming

##### Path acceleration without jerk limitation (BRISK)

###### Syntax

BRISK

###### Functionality

The BRISK part-program instruction is used to select the "without jerk limitation" acceleration profile for the purpose of path acceleration.

G group: 21

Effective: Modal

###### Reset response

The channel-specific initial setting is activated via a reset:

MD20150 \$MC\_GCODE\_RESET\_VALUES[20]

###### Supplementary conditions

If the acceleration profile is changed in a part program during machining (BRISK/SOFT) an exact stop is performed at the end of the block.

##### Single-axis acceleration without jerk limitation (BRISKA)

###### Syntax

BRISKA (*axis*{*axis*})

###### Function

The BRISKA part-program instruction is used to select the "without jerk limitation" acceleration profile for single-axis movements (JOG, JOG/INC, positioning axis, reciprocating axis, etc.).

G group: -

Effective: Modal

*Axis:*

- Value range: Axis identifier for channel axes

###### Axis-specific initial setting

Acceleration without jerk limitation can be set as the axis-specific initial setting for single-axis movements:

MD32420 \$MA\_JOG\_AND\_POS\_JERK\_ENABLE = FALSE

## Reset response

The axis-specific initial setting is activated via a reset:

MD32420 \$MA\_JOG\_AND\_POS\_ENABLE

## 4.2.2 Constant travel time (channel-specific)

### 4.2.2.1 General Information

#### Overview

In the case of acceleration without jerk limitation, sudden acceleration of  $2 * a_{max}$  occurs on switchover between acceleration and braking. In order to avoid this sudden acceleration, a channel-specific constant travel time can be programmed. The constant travel time defines the time taken to traverse between the acceleration and braking phases at constant velocity:

MD20500 \$MC\_CONST\_VELO\_MIN\_TIME (minimum time with constant velocity)

#### Note

The constant travel time is ineffective:

- Active function: Look Ahead
- In traversing blocks with a travel time that is less or equal to the interpolation cycle time.

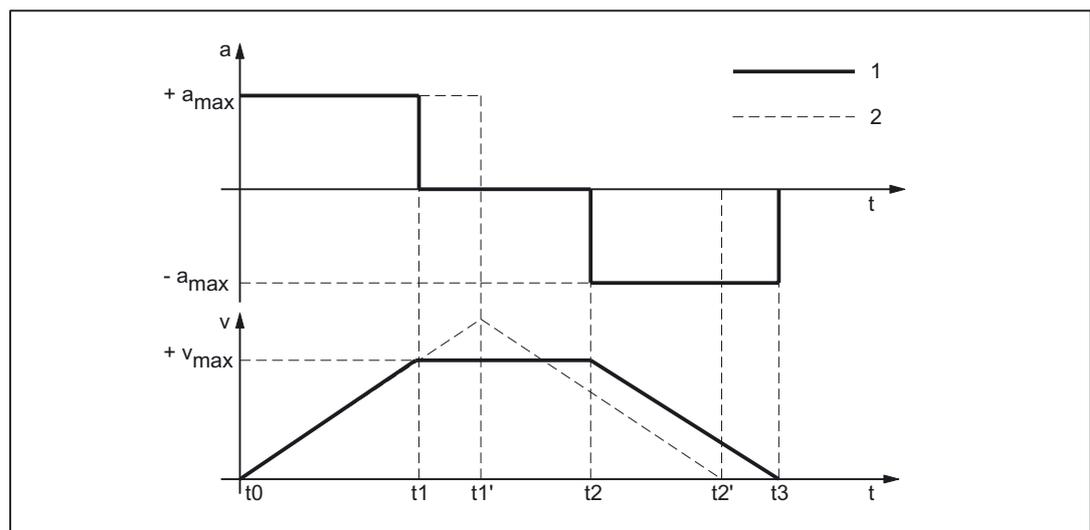


Figure 4-2 Schematic for abrupt acceleration

- 1: Characteristic with constant travel time
- 2: Characteristic without constant travel time
- $a_{max}$ : Maximum acceleration value
- $v_{max}$ : Maximum velocity value
- t: Time

The effect of the constant travel time can be seen from the figure above:

- Time:  $t_1$   
End of acceleration phase with sudden acceleration  $1 * a_{max}$
- Interval:  $t_1 - t_2$   
Acceleration 0; constant velocity using the parameterized constant travel time
- Time:  $t_2$   
Start of braking phase with sudden acceleration  $1 * a_{max}$

The times  $t_0$ ,  $t_1'$  and  $t_2'$  indicate the characteristic that would have been produced had no constant travel time been defined.

### 4.2.2.2 Parameterization

#### Function

The constant travel time is parameterized for specific channels using machine data:  
MD20500 \$MC\_CONST\_VELO\_MIN\_TIME  
(minimum time with constant velocity)

### 4.2.3 Acceleration matching (ACC) (axis-specific)

#### 4.2.3.1 General Information

#### Function

A part-program instruction (`ACC`) can be used to match the acceleration of specific axes to the current machining situation. The range used for this purpose is anywhere between greater than 0% and less than or equal to 200% of the maximum value programmed in the machine data.

#### Effective

<b>Effective</b>	Acceleration matching is effective for all types of interpolation in AUTOMATIC and MDA operating modes as well as with dry-run feed.
<b>Ineffective</b>	Acceleration matching is ineffective in JOG and JOG/REF (reference point approach) operating modes. Acceleration matching is also ineffective if the machine axes have been brought to a standstill via a quick stop due to the detection of a fault (setpoint = 0).

#### 4.2.3.2 Programming

#### Syntax

`ACC[axis] = adjustment factor`

#### Functionality

The `ACC` part-program instruction is used to adjust the maximum acceleration value of a machine axis.

Axis:

- Value range: Axis identifier for the channel's machine axes

Adjustment factor:

- Value range:  $0 < \text{adjustment factor} \leq 200$

- Unit: Per cent

Deactivate: ACC[*axis*] = 100

Effective: Modal

### Reset response

The behavior during channel RESET or M30 can be controlled via MD32320 \$MA\_DYN\_LIMIT\_RESET\_MASK:

Bit 0: 0 The programmed ACC value is reduced to 100 % with channel RESET/M30.

Bit 0: 1 The programmed ACC value is retained beyond channel RESET/M30.

## 4.2.4 Acceleration margin (channel-specific)

### 4.2.4.1 General Information

#### General information

Under normal circumstances, preprocessing makes maximum use of the parameterized maximum values of the machine axes for the purpose of path acceleration. In order that an acceleration margin may be set aside for overlaid movements, e.g. within the context of the "Rapid lift away from the contour" function, path acceleration can be reduced by a programmable factor. When, for example, a factor of 0.2 is applied, preprocessing will only use 80% of the maximum possible path acceleration. 20% is set aside as an acceleration margin for overlaid movements.

### 4.2.4.2 Parameterization

#### Parameterization

Parameters for the acceleration margin are assigned for each channel by means of machine datum:

MD20610 \$MC\_ADD\_MOVE\_ACCEL\_RESERVE  
(acceleration margin for overlaid motions)

## 4.2.5 Path-acceleration limitation (channel-specific)

### 4.2.5.1 General Information

#### General Information

To enable a flexible response to the machining situations concerned, setting data can be used to limit the path acceleration calculated during preprocessing for specific channels:

SD42500 \$SC\_SD\_MAX\_PATH\_ACCEL (maximum path acceleration)

The value specified in the setting data is only taken into account if it is smaller than the path acceleration calculated during preprocessing.

The limitation must be activated for specific channels using setting data:

SD42502 \$SC\_IS\_SD\_MAX\_PATH\_ACCEL = TRUE

### 4.2.5.2 Parameterization

#### Parameterization

Parameterization is carried out for specific channels using setting data:

SD42500 \$SC\_SD\_MAX\_PATH\_ACCEL (maximum path acceleration)

SD42502 \$SC\_IS\_SD\_MAX\_PATH\_ACCEL (activation of path-acceleration limitation)

### 4.2.5.3 Programming

#### Limit value

#### Syntax

`$SC_SD_MAX_PATH_ACCEL = limit value`

#### Functionality

The path-acceleration limitation can be adjusted for the situation by programming the setting data.

*Limit value:*

- Value range:  $\geq 0$
- Unit: m/s<sup>2</sup>

Application:

- Part program
- Static synchronized action

## Switch ON/OFF

### Syntax

`$SSC_IS_SD_MAX_PATH_ACCEL = value`

### Functionality

The path-acceleration limitation can be activated/deactivated by programming the setting data.

Parameter: *Value*

- Value range: TRUE, FALSE

Application:

- Part program
- Static synchronized action

## 4.2.6 Path acceleration for real-time events (channel-specific)

### 4.2.6.1 General Information

#### General Information

So that no compromise has to be made between machining-optimized acceleration on the one hand and time-optimized acceleration in connection with the following real-time events on the other:

- NC-STOP/NC-START
- Feedrate override modifications
- Modification of the velocity default for "safely reduced velocity" within the context of the "Safely Integrated" function

the path acceleration can be set for the real-time events specified above using a channel-specific system variable:

`$AC_PATHACC = path acceleration`

Real-time event acceleration will only be active for the duration of the change in velocity in respect of one of the real-time events specified above.

#### Limitation

If the specified path acceleration exceeds the capabilities of the machine axes that are of relevance for the path, a limit will be imposed on the path acceleration within the control so that the resulting axial acceleration ( $a_{res}$ ) is restricted to less than 2x the parameterized maximum axial value ( $a_{max}$ ).

$a_{res} = 2 * a_{max}$ , mit  $a_{max} = MD32300 \$MA\_MAX\_AX\_ACCEL$

**Note**

Real-time-event path acceleration is enabled, irrespective of the radial acceleration.

**Effective**

<b>Effective</b>	<p>Real-time event acceleration is only enabled in AUTOMATIC and MDA operating modes in conjunction with the following real-time events:</p> <ul style="list-style-type: none"> <li>• NC-STOP/NC-START</li> <li>• Override modifications</li> <li>• Modification of the velocity default for "safely reduced velocity" within the context of the "Safely Integrated" function</li> </ul>
<b>Ineffective</b>	<p>Path acceleration for real-time events is ineffective for changes in path velocity that are attributable to path planning during preprocessing for the channel, such as contour curvatures, corners, kinematic transformation limitations, etc.</p> <p>Real-time-event path acceleration is ineffective if the programmed value is smaller than the path acceleration calculated during preprocessing for the path section concerned.</p>

**Programming**

For information about programming system variables in the part program or synchronized actions, see Chapter: Programming.

**4.2.6.2 Programming**

**Syntax**

$\$AC\_PATHACC = \textit{path acceleration}$

**Functionality**

Real-time-event path acceleration is set via the channel-specific system variables.

Parameter: *Path acceleration*

- Value range: Path acceleration  $\geq 0$
- Unit: m/s<sup>2</sup>

Deactivation:  $\$AC\_PATHACC = 0$

Application:

- Part program
- Static synchronized action

### Reset response

Real-time-event path acceleration is deactivated on reset.

### Supplementary conditions

Programming `$AC_PATHACC` in the part program automatically triggers a preprocessing stop with REORG (`STOPRE`).

## 4.2.7 Acceleration with programmed rapid traverse (G00) (axis-specific)

### 4.2.7.1 General Information

Frequently, the acceleration for the machine axes involved in the machining process must be set lower than the machine's performance capability officially allows because of the supplementary conditions associated with the specific process concerned.

For time-optimized traversing of the machine axes with programmed rapid traverse (part-program instruction `G00`), a specific maximum value can be programmed for the axis-specific acceleration.

### JOG setup mode

This function does not affect acceleration in respect of a rapid traverse override in JOG setup mode.

### 4.2.7.2 Parameterization

The maximum value for axis-specific acceleration with programmed rapid traverse is parameterized (`G00`) using the axis-specific machine data:

MD32434 `$MA_G00_ACCEL_FACTOR`  
(scaling of the acceleration limitation with `G00`)

This is used to generate the maximum value for axis-specific acceleration with programmed rapid traverse (`G00`) that is taken into account by the path planning component during preprocessing:

Acceleration[axis] =  
MD32300 `$MA_MAX_AX_ACCEL` \* MD32434 `$MA_G00_ACCEL_FACTOR`

## 4.2.8 Acceleration with active jerk limitation (SOFT/SOFTA) (axis-specific)

### 4.2.8.1 General Information

#### Function

Compared with acceleration without jerk limitation, acceleration with jerk limitation results in a certain degree of time loss, even when the same maximum acceleration value is used. To compensate for this time loss, a specific maximum value can be programmed for the axis-specific acceleration as far as traversing of the machine axes with active jerk limitation (SOFT/SOFTA) is concerned.

The maximum value for acceleration with active jerk limitation is parameterized using a factor calculated in relation to the axis-specific maximum value. This is used to generate the maximum value for axis-specific acceleration with active jerk limitation that is taken into account by the path planning component during preprocessing:

$$\text{Acceleration}[\text{axis}] = \text{MD32300 } \$\text{MA\_MAX\_AX\_ACCEL} * \text{MD32433 } \$\text{MA\_SOFT\_ACCEL\_FACTOR}$$

### 4.2.8.2 Parameterization

#### Function

The maximum value for acceleration with active jerk limitation (SOFT/SOFTA) is parameterized using the axis-specific machine data:

MD32434 \$MA\_SOFT\_ACCEL\_FACTOR  
(scaling of the acceleration limitation with SOFT)

## 4.2.9 Excessive acceleration for non-tangential block transitions (axis-specific)

### 4.2.9.1 General Information

#### Function

In the case of non-tangential block transitions (corners), the programmable controller may have to decelerate the geometry axes significantly in order to ensure compliance with the parameterized axis dynamics. For the purpose of reducing/avoiding deceleration in connection with non-tangential block transitions, a higher level of axis-specific acceleration can be enabled.

Excessive acceleration is parameterized using a factor calculated in relation to the axis-specific maximum value. This is used to generate the maximum value for axis-specific acceleration with non-tangential block transitions that is taken into account by the path planning component during preprocessing:

$$\text{Acceleration[axis]} = \text{MD32300 \$MA\_MAX\_AX\_ACCEL} * \text{MD32310 \$MA\_MAX\_ACCEL\_OVL\_FACTOR}$$

### 4.2.9.2 Parameterization

#### Function

Excessive acceleration for non-tangential block transitions is parameterized using the axis-specific machine data:

MD32310 \$MA\_MAX\_ACCEL\_OVL\_FACTOR  
(overload factor for velocity jumps)

## 4.2.10 Acceleration margin for radial acceleration (channel-specific)

### 4.2.10.1 General Information

#### Overview

In addition to the path acceleration (tangential acceleration), radial acceleration also has an effect on curved contours. If this is not taken into account during parameterization of the path parameters, the effective axial acceleration during acceleration and deceleration on the curved contour can, for a short time, reach 2x the maximum value.

Effective axial acceleration =  
 Path acceleration + radial acceleration =  
 $2 * ( \text{MD32300 } \$\text{MA\_MAX\_AX\_ACCEL } )$

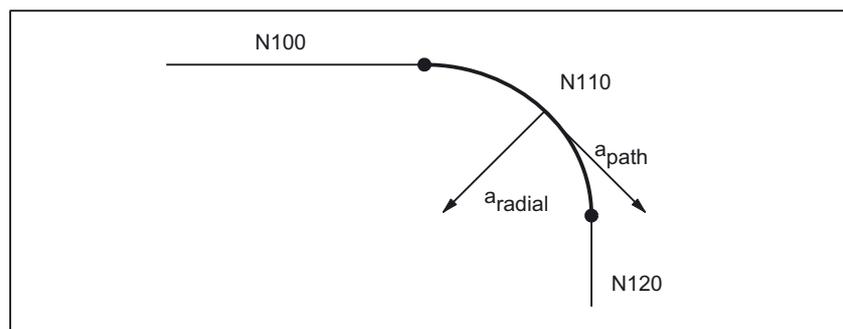


Figure 4-3 Radial and path acceleration on curved contours

The channel-specific machine data:

MD20602  $\$MC\_CURV\_EFFECT\_ON\_PATH\_ACCEL$   
 (influence of path curvature on dynamic path response)  
 can be used to set the proportion of the axis-specific acceleration that is to be taken into account for radial acceleration.

When, for example, a value of 0.75 is applied, 75% of the axis-specific acceleration will be made available for radial acceleration and 25% for path acceleration.

The corresponding maximum values are generally calculated as follows:

Radial acceleration =  
 $\text{MD20602 } \$\text{MC\_CURV\_EFFECT\_ON\_PATH\_ACCEL} * \text{MD32300 } \$\text{MA\_MAX\_AX\_ACCEL}$

Path acceleration =  
 $(1 - \text{MD20602 } \$\text{MC\_CURV\_EFFECT\_ON\_PATH\_ACCEL}) * \text{MD32300 } \$\text{MA\_MAX\_AX\_ACCEL}$

**Example**

The following machine parameters apply:

- MD32300 \$MA\_MAX\_AX\_ACCEL for all geometry axes: 3 m/s
- Maximum path velocity with a path radius of 10 mm due to mechanical constraints of the machine: 5 m/min.

The radial acceleration is calculated as follows:

$$a_{\text{radial}} = \frac{v_{\text{path}}^2 \text{ [m/min]}}{r \text{ [mm]} * 3.6 \text{ [m/s}^2\text{]}} = \frac{5^2}{10 * 3.6} = 0.694 \text{ m/s}^2$$

The acceleration margin is set as follows:

$$\text{MD20602 } \$\text{MC\_CURV\_EFFECT\_ON\_PATH\_ACCEL} = \frac{a_{\text{radial}} \text{ [m/s}^2\text{]}}{\text{MD32300 } \$\text{MA\_MAX\_AX\_ACCEL [m/s}^2\text{]}} = \frac{0.694}{3} \approx 0.23$$

**Linear motions**

The acceleration margin referred to above is ineffective in the case of linear motions (linear interpolation) without active kinematic transformation.

**4.2.10.2 Parameterization****Function**

The proportion of maximum available axis acceleration to be taken into account as an acceleration margin for radial acceleration on curved contours is parameterized using the channel-specific machine data:

MD20602 \$MC\_CURV\_EFFECT\_ON\_PATH\_ACCEL  
(influence of path curvature on dynamic path response)

## **4.2.11 Jerk limitation with path interpolation (SOFT) (channel-specific)**

### **4.2.11.1 General Information**

#### **Overview**

As far as the functionality described in the rest of this document is concerned, constant acceleration, i.e. acceleration with jerk limitation (jerk = infinite value), is the assumed acceleration profile. In the case of acceleration with jerk limitation, linear interpolation is applied in respect of acceleration from 0 to the maximum value.

#### **Advantages**

Minimal load on the machine's mechanical components and low risk of high-frequency and difficult-to-control mechanical vibrations thanks to constant excessive acceleration.

#### **Disadvantages**

Longer machining times compared with stepped acceleration profile when the same maximum velocity and acceleration values are used.

Acceleration profile

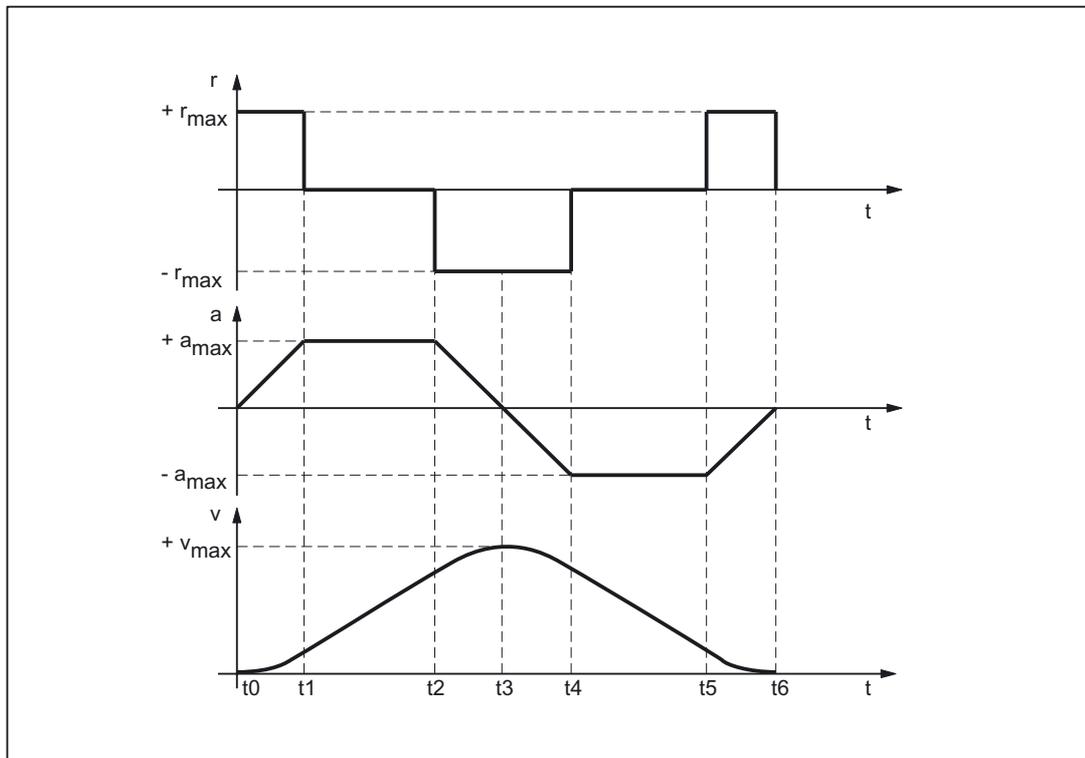


Figure 4-4 Jerk, acceleration and velocity schematic with jerk limitation acceleration profile

- $r_{max}$ : Maximum jerk value
- $a_{max}$ : Maximum acceleration value
- $v_{max}$ : Maximum velocity value
- $t$ : Time

The following features of the acceleration profile can be identified from the figure above:

- Interval:  $t_0 - t_1$   
Constant jerk with  $+r_{max}$ ; linear increase in acceleration; quadratic increase in velocity
- Interval:  $t_1 - t_2$   
Constant acceleration with  $+a_{max}$ ; linear increase in velocity
- Interval:  $t_2 - t_3$   
Constant jerk with  $-r_{max}$ ; linear decrease in acceleration; quadratic decrease in excessive velocity until maximum value  $+v_{max}$  is reached

- Interval:  $t_3 - t_4$   
Constant jerk with  $+r_{\max}$ ; linear increase in braking acceleration; quadratic decrease in velocity
- Interval:  $t_4 - t_5$   
Constant braking acceleration with  $-a_{\max}$ ; linear decrease in velocity
- Interval:  $t_5 - t_6$   
Constant jerk with  $-r_{\max}$ ; linear decrease in braking acceleration; quadratic decrease in velocity reduction until zero velocity is reached  $v = 0$

#### 4.2.11.2 Maximum jerk value (axis-specific)

##### Function

The maximum jerk value can be set for each specific machine axis using the following machine data:

MD32431 \$MA\_MAX\_AX\_JERK (maximum axis jerk)

The path parameters are calculated by the path planning component during preprocessing so that the programmed maximum values of the machine axes that are of relevance for the path are not exceeded.

##### Exceeding of maximum value

It is possible for the maximum value to be exceeded in connection with specific machining situations (see following Section: System variable (\$AC\_PATHJERK)).

#### 4.2.11.3 Maximum jerk value (channel-specific)

##### Function

As well as it being possible to set the maximum jerk value for specific axes, it can also be assigned as a channel-specific path parameter using the following machine data:

MD20600 \$MC\_MAX\_PATH\_JERK (path-related maximum jerk)

To prevent the axis and channel-specific maximum jerk values interfering with one another, the channel-specific value must be set to a value greater than the maximum axial values.

#### 4.2.11.4 Parameterization

##### Function

The axis- and channel-specific maximum values are parameterized using the following machine data:

MD32431 \$MA\_MAX\_AX\_JERK (maximum axis jerk)

MD20600 \$MC\_MAX\_PATH\_JERK (path-related maximum jerk)

#### 4.2.11.5 Programming

##### Syntax

SOFT

##### Functionality

The `SOFT` part-program instruction is used to select the acceleration profile with jerk limitation for the traversing operations of geometry axes in the channel.

G group: 21

Effective: Modal

##### Reset response

The channel-specific initial setting is activated via a reset:

MD20150 \$MC\_GCODE\_RESET\_VALUES[20]

##### Supplementary conditions

If the acceleration mode is changed in a part program during machining (`BRISK` ↔ `SOFT`), a block change is performed at the point of transition with an exact stop at the end of the block, even in continuous-path mode.

#### 4.2.12 Jerk limitation with single-axis interpolation (SOFTA) (axis-specific)

##### 4.2.12.1 General Information

##### Overview

The maximum jerk value can be set for each specific machine axis for single-axis movements (setup modes e.g. JOG, JOG/INC, positioning axis, reciprocating axis, etc.):

MD32430 \$MA\_JOG\_AND\_POS\_MAX\_JERK (maximum axis jerk)

##### Initial setting

Acceleration with jerk limitation can be set as the axial initial setting:

MD32420 \$MA\_JOG\_AND\_POS\_JERK\_ENABLE  
(initial setting of axial jerk limitation)

#### 4.2.12.2 Parameterization

##### Function

The function's initial setting and the maximum values are parameterized for specific axes using machine data:

MD32420 \$MA\_JOG\_AND\_POS\_JERK\_ENABLE  
(initial setting of axial jerk limitation)

MD32430 \$MA\_JOG\_AND\_POS\_MAX\_JERK (maximum axis jerk)

#### 4.2.12.3 Programming

##### Syntax

SOFTA (*Axis* {*Axis*})

##### Functionality

The SOFTA part-program instruction is used to select acceleration with jerk limitation for single-axis movements (positioning axis, reciprocating axis, etc.)

G group: -

Effective: modal

*Axis*:

- Value range: Axis identifier for channel axes

##### Axis-specific initial setting

Acceleration with jerk limitation can be set as the axis-specific initial setting for single-axis movements:

MD32420 \$MA\_JOG\_AND\_POS\_JERK\_ENABLE = TRUE

##### Reset response

The axis-specific initial setting is activated via a reset:

MD32420 \$MA\_JOG\_AND\_POS\_ENABLE

## 4.2.13 Path-jerk limitation (channel-specific)

### 4.2.13.1 General Information

#### Overview

To enable a flexible response to the machining situations concerned, setting data can be used to limit the path jerk calculated during preprocessing for specific channels:

SD42510 \$SC\_SD\_MAX\_PATH\_JERK (maximum path jerk)

The value specified in the setting data is only taken into account in the channel if it is smaller than the path jerk calculated during preprocessing.

The limitation must be activated for specific channels using setting data:

SD42512 \$SC\_IS\_SD\_MAX\_PATH\_JERK = TRUE

### 4.2.13.2 Parameterization

#### Function

Parameterization is carried out for specific channels using setting data:

SD42510 \$SC\_SD\_MAX\_PATH\_JERK (maximum path jerk)

SD42512 \$SC\_IS\_SD\_MAX\_PATH\_JERK  
(activation of path-jerk limitation)

### 4.2.13.3 Programming

#### Maximum path jerk

#### Syntax

`$SC_SD_MAX_PATH_JERK = jerk value`

#### Functionality

The path-jerk limitation can be adjusted for the situation by programming the setting data.

*Jerk value:*

- Value range:  $\geq 0$
- Unit: m/s<sup>3</sup>

Application:

- Part program
- Static synchronized action

## Switch ON/OFF

### Syntax

`$SC_IS_SD_MAX_PATH_JERK = value`

### Functionality

The path-jerk limitation can be activated/deactivated by programming the setting data.

Parameter: *Value*

- Value range: TRUE, FALSE

Application:

- Part program
- Static synchronized action

## 4.2.14 Path jerk for real-time events (channel-specific)

### 4.2.14.1 General Information

#### Overview

So that no compromise has to be made between machining-optimized jerk on the one hand and time-optimized jerk in connection with the following real-time events on the other:

- NC-STOP/NC-START
- Feedrate override modifications
- Modification of the velocity default for "safely reduced velocity" within the context of the "Safely Integrated" function

the path jerk can be set for the real-time events specified above using a channel-specific system variable:

`$AC_PATHJERK = path jerk`

Path jerk for real-time events will only be active for the duration of the change in velocity in respect of one of the real-time events specified above.

#### Limitation

As the jerk is not a physical variable of any relevance to the drive, **no** limit is imposed on the jerk set.

**Effective**

<b>Effective</b>	<p>Path jerk for real-time events is only enabled in AUTOMATIC and MDA operating modes in conjunction with the following real-time events:</p> <ul style="list-style-type: none"> <li>• NC-STOP/NC-START</li> <li>• Override modifications</li> <li>• Modification of the velocity default for "safely reduced velocity" within the context of the "Safely Integrated" function</li> </ul>
<b>Ineffective</b>	<p>Path jerk for real-time events is ineffective for changes in the path velocity that are attributable to path planning during preprocessing for the channel, such as contour curvatures, corners, kinematic transformation limitations, etc.</p> <p>Path jerk for real-time events is ineffective if the programmed value is smaller than the path jerk calculated during preprocessing for the path section concerned.</p>

**Programming**

For the purpose of setting the jerk for real-time events in accordance with the acceleration, the system variables can be set as follows:

$\$AC\_PATHJERK = \$AC\_PATHACC / \text{smoothing time}$

- $\$AC\_PATHACC$ : Path acceleration [m/s<sup>2</sup>]  
 Smoothing time: Freely selectable, e.g. 0.02 s

For information about programming system variables in the part program or synchronized actions, see Chapter: Programming.

**4.2.14.2 Programming**

**Syntax**

$\$AC\_PATHJERK = \textit{path jerk}$

**Functionality**

The path jerk for real-time events is set via the channel-specific system variables.

*Jerk value:*

- Value range: Path jerk  $\geq 0$
- Unit: m/s<sup>3</sup>

*Application:*

- Part program
- Static synchronized action

## Reset response

The function is deactivated on reset.

## Supplementary conditions

Programming \$AC\_PATHJERK in the part program automatically triggers a preprocessing stop with REORG (STOPRE).

## 4.2.15 Jerk with programmed rapid traverse (G00) (axis-specific)

### 4.2.15.1 General Information

#### Overview

Frequently, the maximum jerk for the machine axes involved in the machining process must be set lower than the machine's performance capability officially allows because of the supplementary conditions associated with the specific process concerned.

For time-optimized traversing of the machine axes with programmed rapid traverse (part-program instruction G00), a specific maximum value can be programmed for the axis-specific jerk.

#### JOG setup mode

This function does not affect jerk in respect of a rapid traverse override in JOG setup mode.

### 4.2.15.2 Parameterization

#### Function

The maximum value for axis-specific jerk with programmed rapid traverse is parameterized (G00) using the axis-specific machine data:

MD32434 \$MA\_G00\_ACCEL\_FACTOR  
(scaling of the acceleration limitation with G00)

This is used to generate the maximum value for axis-specific jerk with programmed rapid traverse (G00) that is taken into account by the path planning component during preprocessing:

Jerk[axis] =  
MD32431 \$MA\_MAX\_AX\_JERK \* MD32435 \$MA\_G00\_JERK\_FACTOR

## 4.2.16 Excessive jerk for block transitions without constant curvature (axis-specific)

### 4.2.16.1 General Information

#### Overview

In the case of block transitions without constant curvature (e.g. straight line > circle), the programmable controller has to decelerate movement of the geometry axes significantly in order to ensure compliance with the parameterized axis dynamics. For the purpose of reducing/avoiding deceleration in connection with block transitions without constant curvature, a higher level of axis-specific jerk can be enabled.

The excessive jerk is parameterized using a dedicated axis-specific maximum value.

### 4.2.16.2 Parameterization

#### Function

The excessive jerk for block transitions without constant curvature is parameterized using the axis-specific machine data:

MD32432 \$MA\_PATH\_TRANS\_JERK\_LIM  
(excessive jerk for block transitions without constant curvature)

## 4.2.17 Jerk filter (axis-specific)

### 4.2.17.1 General Information

#### Overview

In certain application scenarios, e.g. when milling free-form surfaces, it may be beneficial to smooth the position setpoint characteristics of the machine axes. This enables surface quality to be improved by reducing the mechanical vibrations generated in the machine.

For the purpose of smoothing the position setpoint characteristic of a machine axis, a jerk filter can be activated at position controller level, independently of the channel- and axis-specific jerk limitations taken into account at interpolator level.

The effect of the jerk filter must be as strong as possible without having an unacceptable impact on contour accuracy. The filter should also have as "balanced" a smoothing effect as possible, i.e. if the same contour is traversed forwards and backwards, the contour smoothed by the filter should be as similar as possible in both directions.

To enable the jerk filter to be optimally matched to the machine conditions, various filter modes are available:

- 2nd-order filter (PT2)
- Sliding mean value generation
- Bandstop filter

#### Mode: 2nd-order filter

Owing to the fact that it is a simple low-pass filter, "2nd-order filter" mode can only meet the requirements specified above where relatively small filter time constants (around 10 ms) are concerned. When used in conjunction with larger time constants, impermissible contour deviations are soon manifest. The effect of the filter is relatively limited.

This filter mode offers advantages if very large filter time constants are needed and contour accuracy is only of secondary importance (e.g. positioning axes).

For historical reasons, this filter mode is set as the default.

#### Mode: Sliding mean value generation

Where minimal contour deviations are required, filter time constants within the range of 20-40 ms can be set using the "sliding mean value generation" filter mode. The smoothing effect is largely symmetrical.

The display of the calculated servo gain factor (KV factor), e.g. in the HMI Advanced "Axis" service screen, shows smaller values than would normally be expected for the filter. The contour accuracy is in fact higher than the displayed KV filter appears to suggest.

When changing from "2nd-order filter" to "sliding mean value generation" filter mode, the displayed KV factor may, therefore, drop (with identical filter time constant), even though there is an improvement in contour accuracy.

**Mode: Bandstop filter**

The bandstop filter is a 2nd-order filter in terms of numerator and denominator:

$$H(s) = \frac{\frac{s^2}{(2 * \pi * f_Z)^2} + \frac{2 * s * D_Z}{(2 * \pi * f_Z)}}{\frac{s^2}{(2 * \pi * f_N)^2} + \frac{2 * s * D_N}{2 * \pi * f_N}}$$

where:

- f<sub>Z</sub>: Numerator natural freq.
- f<sub>N</sub>: Denominator natural freq.
- D<sub>Z</sub>: Numerator damping
- D<sub>N</sub>: Denominator damping

Since a vibration-capable filter setting is not expected to yield useful results in any case, as with the jerk filter's "2nd-order filter" (PT2) low-pass filter (PT2) mode there is no setting option for the denominator damping D<sub>N</sub>. The denominator damping D<sub>N</sub> is permanently set to 1.

The bandstop filter can be parameterized in 2 different ways:

- Real bandstop filter
- Bandstop filter with additional amplitude response increase/decrease at high frequencies

**Real bandstop filter**

The real bandstop filter is applied when identical numerator and denominator natural frequencies are selected:

- $f_Z = f_N = f_{\text{block}}$  (blocking frequency)

If numerator damping setting = 0 is selected, the blocking frequency is equivalent to complete attenuation. In this case the 3 dB bandwidth is calculated as follows:

- $f_{3 \text{ dB bandwidth}} = 2 * f_{\text{block}}$

If instead of complete attenuation, a reduction by a factor of k is all that is required, then numerator damping should be selected in accordance with k. In this case the above formula for calculating the 3 dB bandwidth no longer applies.

**Bandstop filter with additional amplitude response increase/decrease at high frequencies**

In this case, the numerator and denominator natural frequencies are set to different values. The numerator natural frequency determines the blocking frequency.

By selecting a lower/higher denominator natural frequency than the numerator natural frequency, you can increase/decrease the amplitude response at high frequencies. An amplitude response increase at high frequencies can be justified in most cases, as the controlled system generally possesses a low-pass characteristic itself, i.e. the amplitude response drops at high frequencies anyway.

### Supplementary conditions

If too high a numerator natural frequency is selected, the filter is disabled. In this case the limiting frequency  $f_{Zmax}$  depends on the position-control cycle:

$$f_{Zmax} = \frac{1}{2 * \pi * T_{Zmin}} = \frac{1}{2 * \pi * T_{Position-control\ cycle}} \quad (\text{Shannon Theorem})$$

The limitation is enabled for specific axes using machine data:

MD32400 \$MA\_AX\_JERK\_ENABLE (axial jerk limitation)

and set with time specifications for the smoothing filter using machine data:

MD32410 \$MA\_AX\_JERK\_TIME (time constants for the axial return filter).

With **SW 5.1** and higher, it is also possible to control the jerk limitation in the position controller with a new filter based on a smoothing method that incurs few contour errors:

MD32402 AX_JERK_MODE = 1	;	2nd-order filter (default)
		corresponds to SW 1 to SW 4.4
MD32402 AX_JERK_MODE = 2	;	Sliding mean value generation
		(New jerk filter with SW 5.1 and higher).
MD32402 AX_JERK_MODE = 3	;	Bandstop filter with SW 6.3 and higher

**Modus 2** requires a bit more computation time, but with the same smoothing effect, it results in lower contour errors or, with the same accuracy, in a smoother contour with smoother movements. Mode 2 is recommended. Mode 1 is the default mode in SW 1 to SW 4.4 for compatibility reasons.

For more information about how the jerk filter available with SW 5.1 and higher works (balancing filter for improving the position setpoints of the position controller), please refer to:

#### References:

/FB1/ Function Manual, Basic Functions; Velocities, Setpoint/Actual-Value Systems, Regulatory Control (G2), Chapter: "Control Optimization"

#### Mode 3

There are 2 parameterization options for the bandstop filter:

- "Real bandstop filter":

When identical numerator and denominator natural frequencies are selected (=blocking frequency). If you select (numerator) damping setting zero, the blocking frequency is equivalent to complete attenuation.

In this case the 3 dB bandwidth is determined on the following basis:

$$f_{bandwidth} = 2 * f_{block}.$$

If instead of complete attenuation, a reduction by a factor of k is all that is required, then the numerator damping should be selected in accordance with k.

- "Bandstop filter with additional amplitude response increase/decrease at high frequencies":

In this case, the numerator and denominator natural frequencies are set to different values. The numerator natural frequency determines the blocking frequency. By selecting a lower (higher) denominator natural frequency than the numerator natural frequency, you can increase (decrease) the amplitude response at high frequencies. An amplitude response increase at high frequencies can be justified in most cases, as the controlled system generally possesses a low-pass characteristic itself, i.e. the amplitude response drops at high frequencies anyway.

#### 4.2.17.2 Parameterization

##### Activation

The jerk filter is activated using the machine data:

MD32400 \$MA\_AX\_JERK\_ENABLE = TRUE

The jerk filter is active in all operating modes and with all types of interpolation.

##### Filter mode

The mode is selected using the machine data:

MD32402 \$MA\_AX\_JERK\_MODE = *mode*

Mode = 1	(2nd-order filter)
Mode = 2	(Sliding mean value generation)
Mode = 3	(Bandstop filter)

#### 4.2.18 Knee-shaped acceleration characteristic curve

##### 4.2.18.1 Adaptation to the motor characteristic curve

##### Function

Various types of motor, particularly stepper motors, have a torque characteristic that is highly dependent upon speed and shows a steep decrease in torque in the upper speed range. To ensure optimum utilization of the motor characteristic curve, it is necessary to reduce the acceleration once a certain speed is reached.

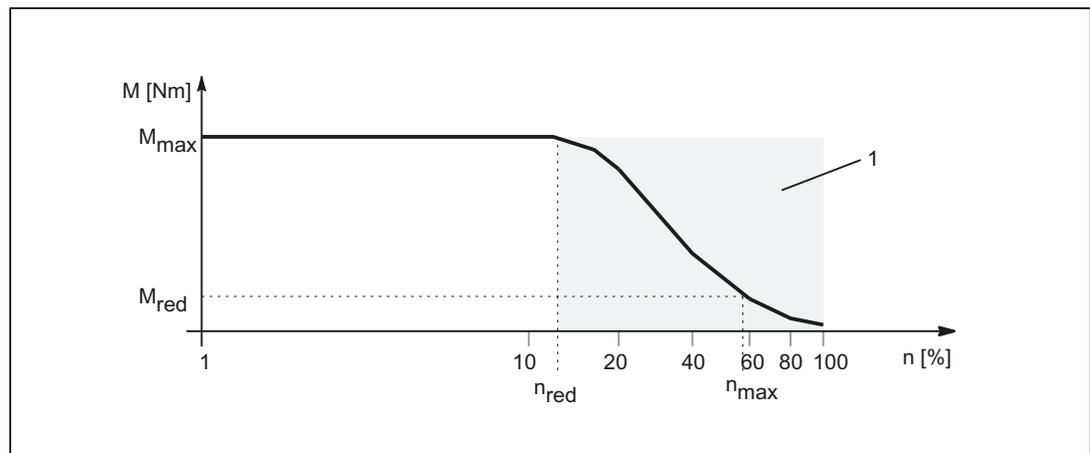


Figure 4-5 Torque characteristic curve of a motor with torque characteristic that is highly dependent upon speed

- 1: Torque decrease zone
- $n_{red}$ : Speed above which reduced torque has to be assumed
- $n_{max}$ : Maximum speed
- $M_{max}$ : Max. torque
- $M_{red}$ : Torque at  $n_{max}$  (corresponds to creep acceleration)

### Simulation of torque characteristic

For the purpose of simulating the torque characteristic of the motor characteristic curve, the machine data:

MD35242 \$MA\_ACCEL\_REDUCTION\_TYPE = *characteristic*

can be used to select various types of characteristic curve:

0	= Constant characteristic
1	= Hyperbolic characteristic
2	= Linear characteristic

The following figures show typical velocity and acceleration characteristic curves for the respective types of characteristic:

**Constant characteristic**

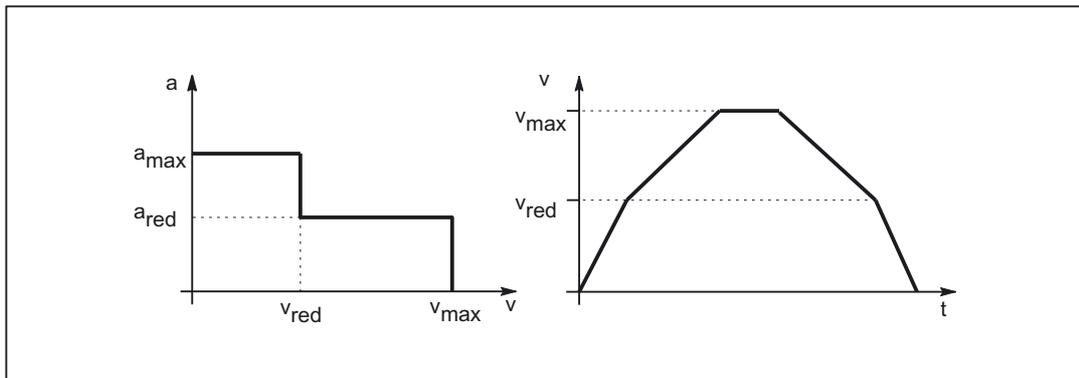


Figure 4-6 Acceleration and velocity characteristic with acceleration reduction: 0 = constant

**Hyperbolic characteristic**

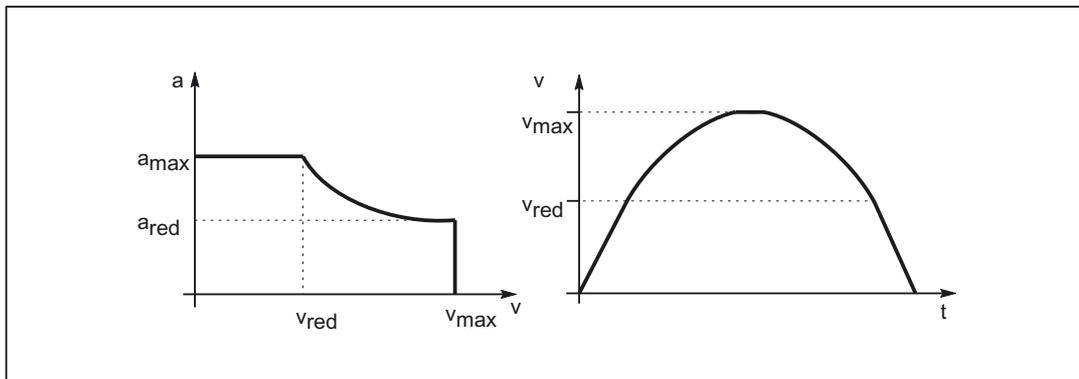


Figure 4-7 Acceleration and velocity characteristic with acceleration reduction: 1 = hyperbolic

**Linear characteristic**

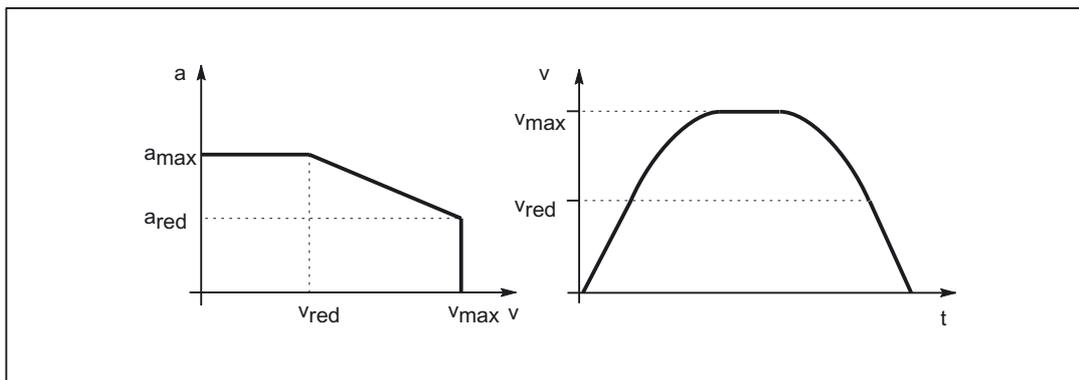


Figure 4-8 Acceleration and velocity characteristic with acceleration reduction: 2 = linear

The key data for the characteristic curves equate to:

$$\begin{aligned}v_{\max} &= \$MA\_MAX\_AX\_VELO \\v_{\text{red}} &= \$MA\_ACCEL\_REDUCTION\_SPEED\_POINT * \$MA\_MAX\_AX\_VELO \\a_{\max} &= \$MA\_MAX\_AX\_ACCEL \\a_{\text{red}} &= (1 - \$MA\_ACCEL\_REDUCTION\_FACTOR) * \$MA\_MAX\_AX\_ACCEL\end{aligned}$$

#### 4.2.18.2 Effects on path acceleration

##### Function

The path acceleration characteristic curve is generated on the basis of the types of characteristic for the axes that are of relevance for the path. If axes with different types of characteristic curve are interpolated together, the acceleration profile for the path acceleration will be determined on the basis of the reduction type that is most restrictive.

The following order of priorities applies, whereby 1 = top priority:

1. Acceleration reduction: 0 = constant characteristic
2. Acceleration reduction: 1 = hyperbolic characteristic
3. Acceleration reduction: 2 = linear characteristic
4. No acceleration reduction effective

A situation, whereby no acceleration reduction is active, arises for example when:

MD35220  $\$MA\_ACCEL\_REDUCTION\_SPEED\_POINT = 1$

and/or

MD35230  $\$MA\_ACCEL\_REDUCTION\_FACTOR = 0$

---

##### Note

Machine axes featuring stepper motor and DC drive can be interpolated together.

---

### 4.2.18.3 Substitute characteristic curve

#### Function

If the programmed path cannot be traversed using the parameterized acceleration characteristic curve (e.g. active kinematic transformation), a substitute characteristic curve is generated by reducing the dynamic limit values. The dynamic limit values are calculated to ensure that the substitute characteristic curve provides the best possible compromise between maximum velocity and constant acceleration.

#### Substitute characteristic curve with linear path sections

Limitation to this value is applied if the programmed path velocity is greater than that at which 15% of the maximum acceleration capacity is still available ( $v_{15\%a}$ ). Consequently, 15% of the maximum acceleration capacity/motor torque always remains available, whatever the machining situation.

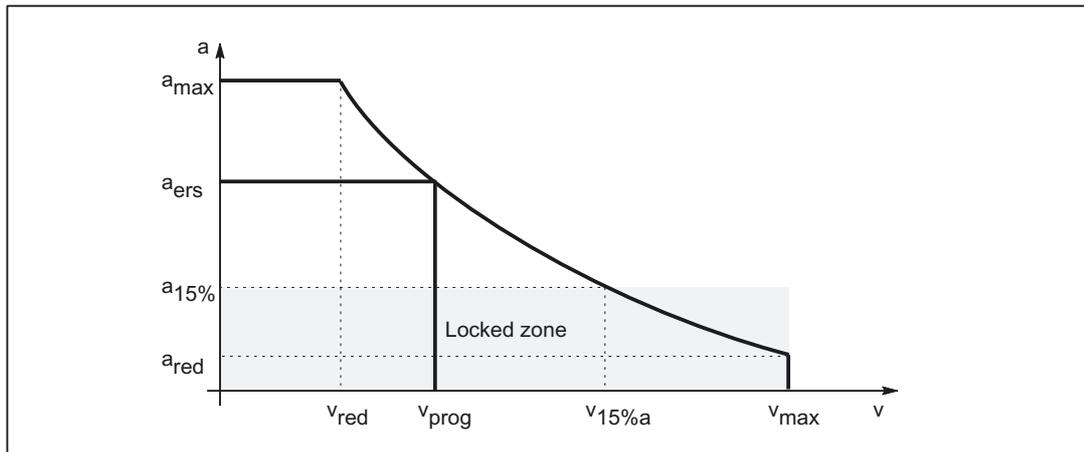


Figure 4-9 Substitute path characteristic curve: Linear path

- $a_{ers}$ : Substitute characteristic curve constant acceleration
- $a_{15\%}$ : Minimal constant acceleration  

$$a_{15\%} = 0.15 * (a_{max} - a_{red}) + a_{red}$$
- $v_{ers}$ : Substitute characteristic curve velocity
- $v_{prog}$ : Programmed velocity
- $v_{15\%a}$ : Velocity at  $a_{15\%}$

#### Substitute characteristic curve with curved path sections

In the case of curved path sections, normal and tangential acceleration are considered together. The path velocity is reduced so that only up to 25% of the speed-dependent acceleration capacity of the axes is required for normal acceleration. The remaining 75% of the acceleration capacity is set aside for the tangential acceleration, i.e. deceleration/acceleration on the path.

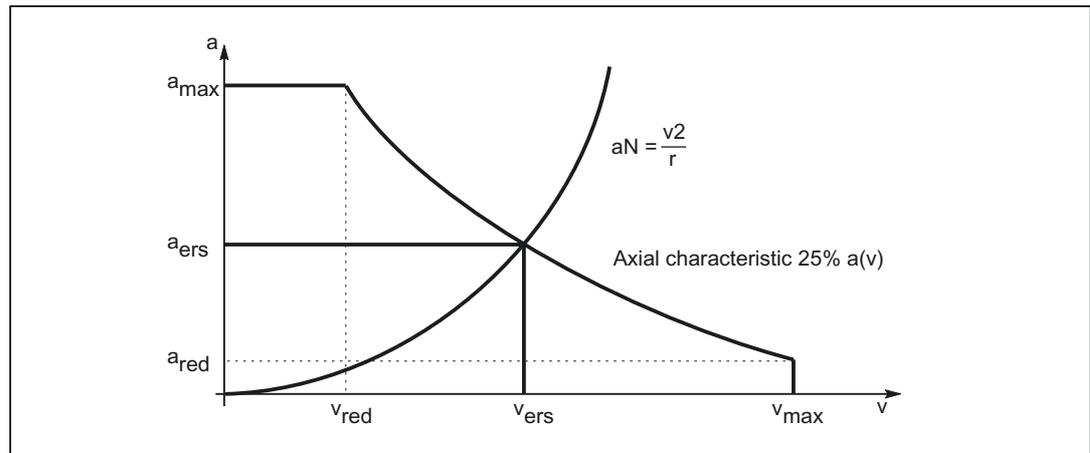


Figure 4-10 Substitute path characteristic curve: Curved path

- $a_N$ : Normal acceleration
- $a_{ers}$ : Substitute characteristic curve constant acceleration
- $v_{ers}$ : Substitute characteristic curve velocity
- $r$ : Path radius

### Block transitions with continuous-path mode

If continuous-path mode is active, non-tangential block transitions result in axial velocity jumps when the programmed path velocity is used for traversing.

As a result, the path velocity is controlled in such a way that prevents any axial velocity proportion from exceeding the creep velocity  $v_{red}$  at the time of the block transition.

### Deceleration ramp with continuous-path mode and LookAhead

In the case of consecutive part program blocks with short paths, an acceleration or deceleration operation may be spread over several part program blocks.

In such a situation LookAhead also takes into account the parameterized speed-dependent acceleration characteristic.

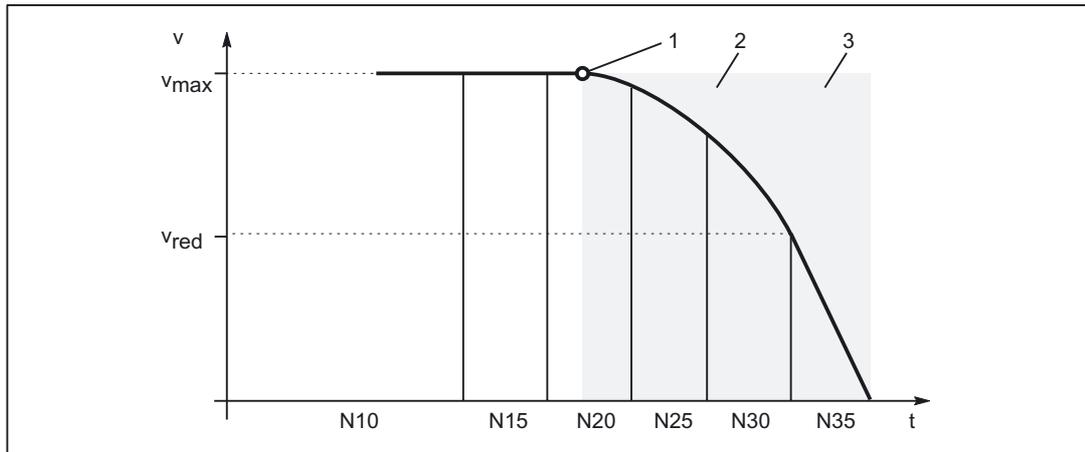


Figure 4-11 Deceleration with LookAhead

- 1: Brake application point
- 2: Torque decrease zone
- 3: Maximum torque zone
- v<sub>red</sub>: Creep velocity
- v<sub>max</sub>: Maximum velocity
- N<sub>xy</sub>: Part program block with block number N<sub>xy</sub>

#### 4.2.18.4 Parameterization

##### Activating

The knee-shaped acceleration characteristics can be activated specific to the machine axis via the machine data:

MD35240 \$MA\_ACCEL\_TYPE\_DRIVE = TRUE

##### Function

The knee-shaped acceleration characteristic curve is parameterized for specific axes using the following machine data:

MD32000 \$MA\_MAX\_AX\_VELO (maximum axis velocity)

MD35220 \$MA\_ACCEL\_REDUCTION\_SPEED\_POINT  
(speed for reduced acceleration)

MD35230 \$MA\_ACCEL\_REDUCTION\_FACTOR (reduced acceleration)

MD32300 \$MA\_MAX\_AX\_ACCEL (Maximum axis acceleration)

MD35242 \$MA\_ACCEL\_REDUCTION\_TYPE  
(type of acceleration reduction: 0 = constant, 1 = hyperbolic, 2 = linear)

#### 4.2.18.5 Programming

##### Channel-specific activation (DRIVE)

###### Syntax

DRIVE

###### Functionality

The knee-shaped characteristic curve is activated for path acceleration using the `DRIVE` part-program instruction.

G group: 21

Effective: Modal

###### Reset response

The channel-specific default setting is activated via a reset:

MD20150 \$MC\_GCODE\_RESET\_VALUES[20]

###### Dependencies

If the knee-shaped acceleration characteristic curve is parameterized for a machine axis, then this becomes the default acceleration profile for all traversing operations.

If the effective acceleration profile is changed for a specific path section using the `SOFT` or `BRISK` part-program instructions, then an appropriate substitute characteristic curve with lower dynamic limit values is used in place of the knee-shaped acceleration characteristic curve.

The knee-shaped acceleration characteristic curve can be reactivated by reprogramming `DRIVE`.

##### Axis-specific activation (DRIVEA)

###### Syntax

DRIVEA (*Axis* {*Axis*})

### Functionality

The knee-shaped characteristic curve is activated for all single-axis interpolations (positioning axis, reciprocating axis, etc.) for specific axes using the part-program instruction.

G group: -

Effective: modal

Axis:

- Value range: Axis identifier for channel axes

### Reset response

The channel-specific default setting is activated via a reset:

MD20150 \$MC\_GCODE\_RESET\_VALUES[20]

### Dependencies

If the knee-shaped acceleration characteristic curve is parameterized for a machine axis, then this becomes the default acceleration profile for all traversing operations.

If the effective acceleration profile is changed for a specific axis using the `SOFTA` or `BRISKA` part-program instructions, then an appropriate substitute characteristic curve is used in place of the knee-shaped acceleration characteristic curve.

It is possible to switch back to the knee-shaped acceleration characteristic curve for a specific axis by programming `DRIVEA`.

#### 4.2.18.6 Boundary conditions

##### Single axis interpolation

After activating the knee-shaped acceleration characteristics in case of single-axis interpolations (positioning axis, oscillating axis, manual motion, etc.), the machine axis is traversed exclusively in the mode `DRIVEA` .

It is not possible to switch over the acceleration profile via the following part program instructions:

- Abrupt acceleration changes (`BRISKA`)
- Acceleration with jerk limitation (`SOFTA`)

##### Path interpolation

If for a machine axis involved in a programmed path the knee-shaped acceleration characteristic parameterized without the part program instruction `DRIVE` is active, then a substitute characteristic curve with reduced dynamic limiting values is determined for the path.

##### Kinematic transformation

The knee-shaped acceleration characteristic is not considered in an active kinematic transformation. With internal control, a switchover is done to acceleration without jerk limitation (`BRISK`) and a substitute characteristic curve becomes active for the path acceleration.

## 4.3 Examples

### 4.3.1 Acceleration

#### 4.3.1.1 Path velocity characteristic

##### Key statement

An excerpt from a part program is provided below, together with the associated acceleration characteristic, by way of an example. These are used to illustrate how the path velocity can be adapted to take account of various events and the resulting change in acceleration.

##### Part program (excerpt, schematic)

```
; Acceleration selection in accordance with fast input 1 ($A_IN[1]):
N53 ID=1 WHEN $A_IN[1] == 1 DO $AC_PATHACC = 2.*$MA_MAX_AX_ACCEL[X]

; Test override profile (simulates external intervention):
N54 ID=2 WHENEVER ($AC_TIMEC > 16) DO $AC_OVR=10
N55 ID=3 WHENEVER ($AC_TIMEC > 30) DO $AC_OVR=100

;Approach
N1000 G0 X0 Y0 BRISK
N1100 TRANS Y=-50
N1200 AROT Z=30 G642

; Contour
N2100 X0 Y0
N2200 X = 70 G1 F10000 RNDM=10 ACC[X]=30 ACC[Y]=30
N2300 Y = 70
N2400 X0
N2500 Y0
M30
```

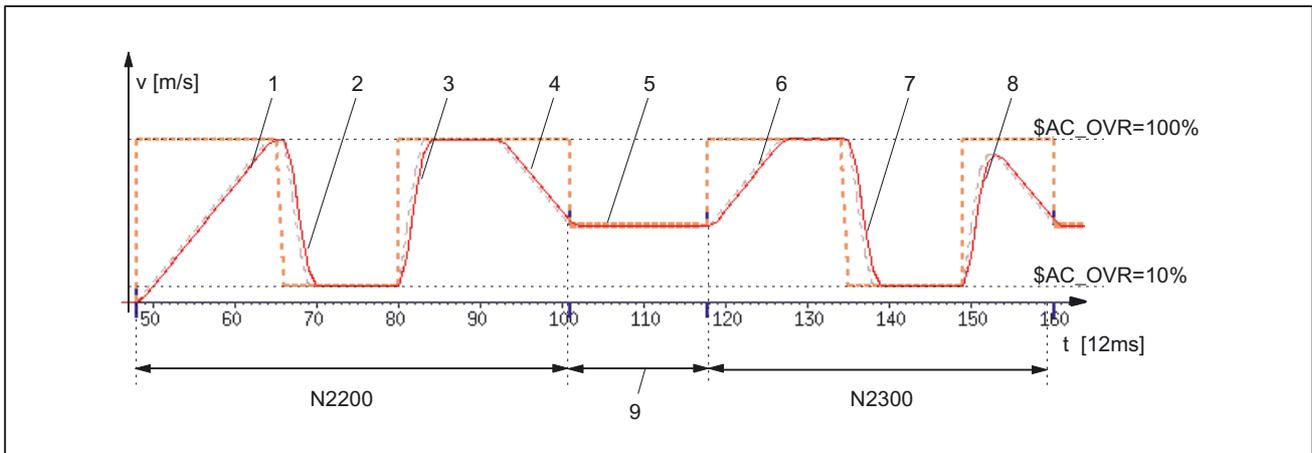


Figure 4-12 Switching between path acceleration specified during preprocessing and real-time acceleration

**Acceleration profile: BRISK**

- 1: Accelerate to 100% of path velocity (F10000) in accordance with acceleration default: ACC (N2200...)
- 2: Brake to 10% of path velocity as a result of override modification (\$AC\_OVR) in accordance with real-time acceleration \$AC\_PATHACC (N53/N54...)
- 3: Accelerate to 100% of path velocity as a result of override modification (\$AC\_OVR) in accordance with real-time acceleration \$AC\_PATHACC (N53/N55...)
- 4: Brake to block end velocity for intermediate smoothing block in accordance with acceleration default: ACC (N2200...)
- 5: Speed limitation as a result of smoothing (see 9)
- 6: Accelerate to 100% of path velocity (\$AC\_OVR) in accordance with acceleration default: ACC (N2300...)
- 7: Decelerate as a result of override modification at a rate of acceleration that is in accordance with real-time acceleration \$AC\_PATHACC (N53/N54...)
- 8: Accelerate to 100% of path velocity as a result of override modification (\$AC\_OVR) in accordance with real-time acceleration \$AC\_PATHACC (N53/N55...)
- 9: Intermediate block inserted within the control as a result of the programmed smoothing (RNDM) (N2200...)

## 4.3.2 Jerk

### 4.3.2.1 Path velocity characteristic

#### Key statement

An excerpt from a part program is provided below, together with the associated acceleration characteristic, by way of an example. These are used to illustrate how the path velocity can be adapted to take account of various events and the resulting change in jerk.

#### Part program (excerpt, schematic)

```
; Setting of path acceleration and path jerk in the event of external intervention:
N0100 $AC_PATHACC = 0.
N0200 $AC_PATHJERK = 4. * ($MA_MAX_AX_JERK[X] + $MA_MAX_AX_JERK[Y]) / 2.

; Synchronized actions for the purpose of varying the override (simulates external
intervention):
N53 ID=1 WHENEVER ($AC_TIMEC > 16) DO $AC_OVR=10
N54 ID=2 WHENEVER ($AC_TIMEC > 30) DO $AC_OVR=100

;Approach
N1000 G0 X0 Y0 SOFT
N1100 TRANS Y=-50
N1200 AROT Z=30 G642

; Contour
N2100 X0 Y0
N2200 X = 70 G1 F10000 RNDM=10
N2300 Y = 70
N2400 X0
N2500 Y0
M30
```

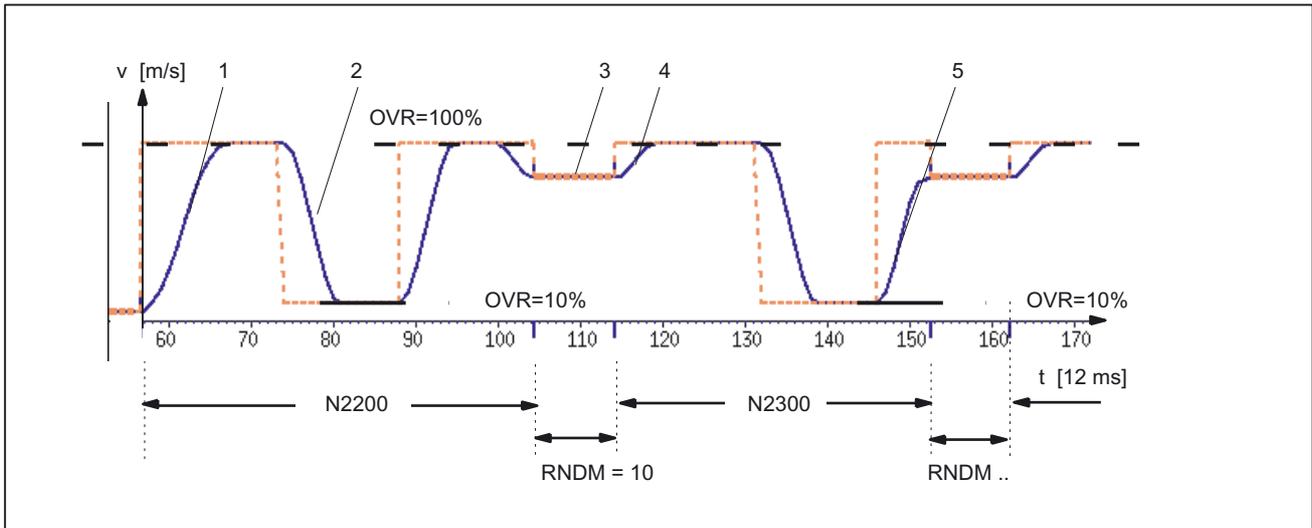


Figure 4-13 Switching between path jerk specified during preprocessing and \$AC\_PATHJERK

**Acceleration profile: SOFT**

- 1: Jerk according to \$MA\_MAX\_AX\_JERK[.]
- 2: Jerk according to \$AC\_PATHJERK
- 3: Jerk according to \$MA\_MAX\_AX\_JERK[.] (approach block end velocity)
- 4: Velocity limit due to arc
- 5: Jerk according to \$AC\_PATHJERK

### 4.3.3 Acceleration and jerk

#### Key statement

In the following example a short part program is used to illustrate the velocity and acceleration characteristic for the X-axis. It also shows the connection between specific velocity and acceleration-related machine data and the contour sections they influence.

#### Part program

```

N90 F5000 SOFT G64          ; Continuous-path mode, acceleration with jerk limitation
N100 G0 X0 Y0 Z0          ; Rapid traverse
N110 G1 X10                ; Straight line
N120 G3 CR=5 X15 Y5        ; Circular arc, radius 5 mm, block transition: tangential
N130 G3 CR=10 X5 Y15       ; Circular arc, radius 10 mm, block transition: tangential
N140 G1 X-5 Y17.679        ; Straight, 15° bend
N200 M30
    
```

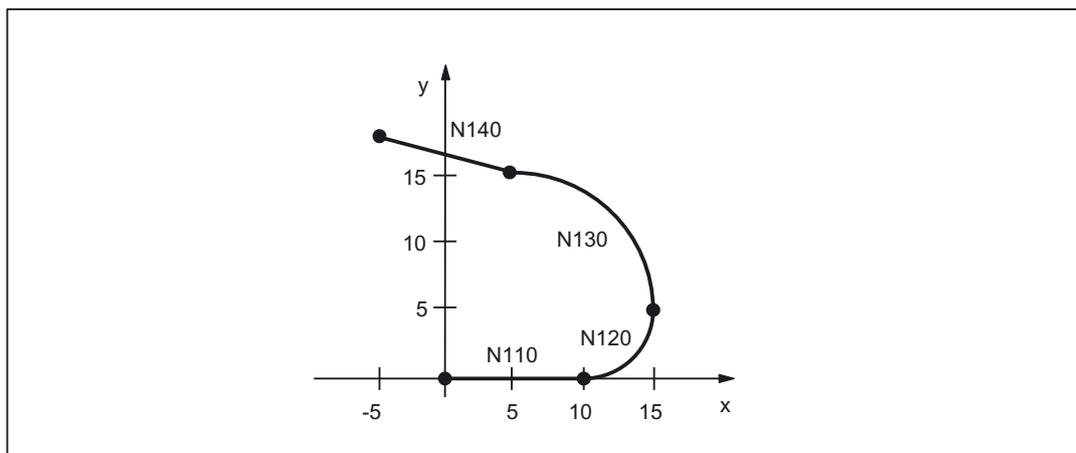


Figure 4-14 Part program contour

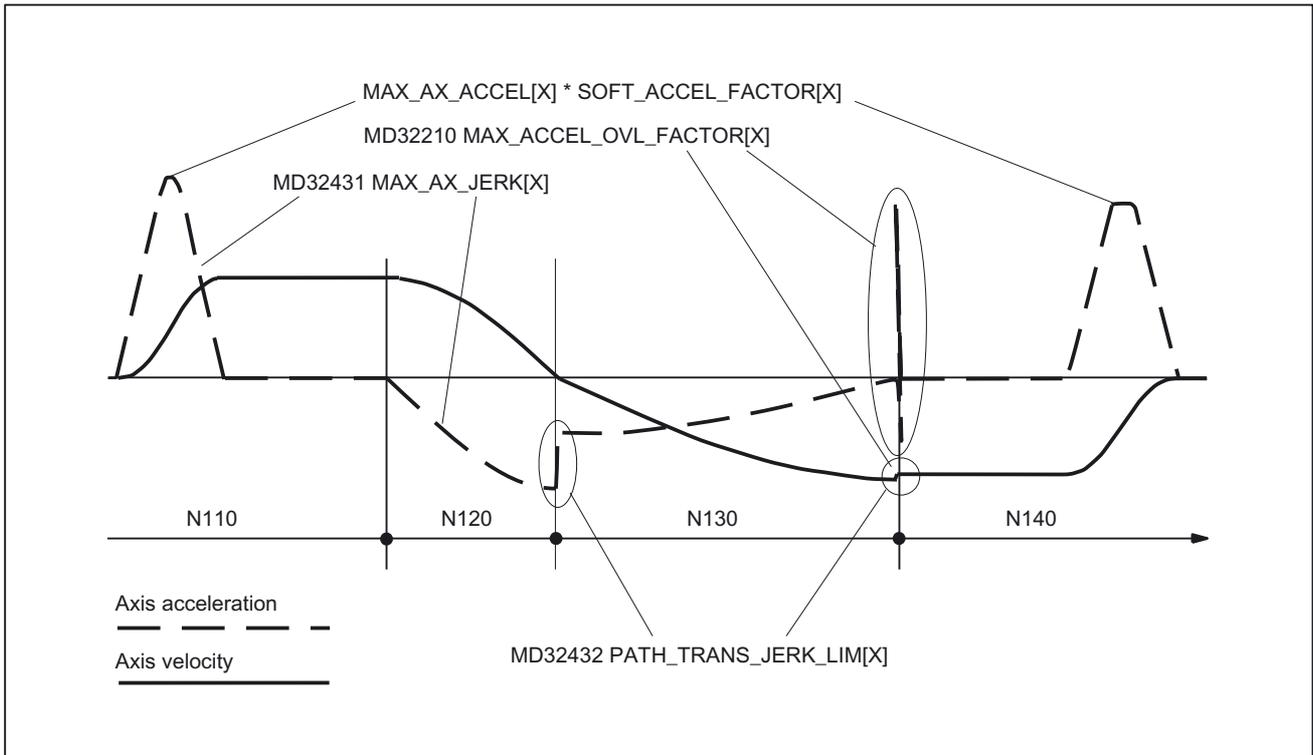


Figure 4-15 X axis: Velocity and acceleration characteristic

### 4.3.4 Knee-shaped acceleration characteristic curve

#### 4.3.4.1 Activation

##### Key statement

The example given illustrates how the knee-shaped acceleration characteristic curve is activated on the basis of:

- Machine data
- Part program instruction

##### Machine data

- Parameterizing the characteristic curve (example only)

```
X axis
MD35220 $MA_ACCEL_REDUCTION_SPEED_POINT[X] = 0.4
MD35230 $MA_ACCEL_REDUCTION_FACTOR[X] = 0.85
MD35242 $MA_ACCEL_REDUCTION_TYPE[X] = 2
MD35240 $MA_ACCEL_TYPE_DRIVE[X] = TRUE

Y axis
MD35220 $MA_ACCEL_REDUCTION_SPEED_POINT[Y] = 0.0
MD35230 $MA_ACCEL_REDUCTION_FACTOR[Y] = 0.6
MD35242 $MA_ACCEL_REDUCTION_TYPE[Y] = 1
MD35240 $MA_ACCEL_TYPE_DRIVE[Y] = TRUE

Z axis
MD35220 $MA_ACCEL_REDUCTION_SPEED_POINT[Z] = 0.6
MD35230 $MA_ACCEL_REDUCTION_FACTOR[Z] = 0.4
MD35242 $MA_ACCEL_REDUCTION_TYPE[Z] = 0
MD35240 $MA_ACCEL_TYPE_DRIVE[Z] = FALSE
```

- Activation by setting as the channel-specific default setting  
MC\_GCODE\_RESET\_VALUE[20] = 3 (DRIVE)

### Part program (excerpt)

N10 G1 X100 Y50 Z50 F700	Path motion (X,Y, Z) with DRIVE
N15 Z20	Path motion (Z) with DRIVE
N20 BRISK	Switchover to BRISK
N25 G1 X120 Y70	Path motion (Y, Z) with substitute characteristic curve
N30 Z100	Path motion (Z) with BRISK
N35 POS[X] = 200 FA[X] = 500	Positioning motion (X) with DRIVEA
N40 BRISKA(Z)	Activate BRISKA for Z
N40 POS[Z] = 50 FA[Z] = 200	Positioning motion (Z) with BRISKA
N45 DRIVEA(Z)	Activate DRIVEA for Z
N50 POS[Z] = 100	Positioning motion (Z) with DRIVE
N55 BRISKA(X)	results in error message
...	

## 4.4 Data lists

### 4.4.1 Machine data

#### 4.4.1.1 Channel-specific machine data

Number	Identifier: \$MC_	Description
20150	GCODE_RESET_VALUES	Initial setting of G groups
20500	CONST_VELO_MIN_TIME	Minimum time with constant velocity
20600	MAX_PATH_JERK	Path-related maximum jerk
20602	CURV_EFFECT_ON_PATH_ACCEL	Influence of path curvature on dynamic path response
20610	ADD_MOVE_ACCEL_RESERVE	Acceleration reserve for overlaid movements

#### 4.4.1.2 Axis/spindle-specific machine data

Number	Identifier: \$MA_	Description
32000	MAX_AX_VELO	Maximum axis velocity
32300	MAX_AX_ACCEL	Maximum axis acceleration
32310	MAX_ACCEL_OVL_FACTOR	Overload factor for velocity jump
32320	DYN_LIMIT_RESET_MASK	Reset behavior of dynamic limits
32400	AX_JERK_ENABLE	Axial jerk limitation
32402	AX_JERK_MODE	Filter type for axial jerk limitation
32410	AX_JERK_TIME	Time constant for axial jerk filter
32420	JOG_AND_POS_JERK_ENABLE	Enabling axial jerk limitation
32430	JOG_AND_POS_MAX_JERK	Max. axial jerk for JOG and POS
32431	MAX_AX_JERK	Maximum axis jerk for path motion
32432	PATH_TRANS_JERK_LIM	Max. axial jerk of a geometry axis at block boundary
32433	SOFT_ACCEL_FACTOR	Scaling of acceleration limitation for <i>SOFT</i>
32434	G00_ACCEL_FACTOR	Scaling of acceleration limitation for <i>G00</i>
32435	G00_JERK_FACTOR	Scaling of axial jerk limitation for <i>G00</i>
35220	ACCEL_REDUCTION_SPEED_POINT	Speed for reduced acceleration
35230	ACCEL_REDUCTION_FACTOR	Acceleration reduction factor
35240	ACCEL_TYPE_DRIVE	"DRIVE" acceleration characteristic curve: ON/OFF
35242	ACCEL_REDUCTION_TYPE	Type of acceleration reduction

## 4.4.2 Setting data

### 4.4.2.1 Channel-specific setting data

Number	Identifier: \$SC_	Description
42500	SD_MAX_PATH_ACCEL	Max. path acceleration
42502	IS_SD_MAX_PATH_ACCEL	Analysis of SD 42500: ON/OFF
42510	SD_MAX_PATH_JERK	Max. path-related jerk
42512	IS_SD_MAX_PATH_JERK	Analysis of SD 42510: ON/OFF

## 4.4.3 System variables

Identifier	Description
\$AC_PATHACC	Path acceleration for real-time events
\$AC_PATHJERK	Path jerk for real-time events



## Diagnostic Tools (D1)

### 5.1 Brief description

#### Diagnostic tools

Integrated and external diagnostic tools are available for operating the SINUMERIK control. In addition, the NC assists with error delimitation for drive problems by providing the option of simulating the drive interface of machine axes.

#### Integrated diagnostic tools

The following information is displayed via the HMI user interface:

- Display of alarms and messages from the control system or drives in plaintext
- Status displays for:
  - Interface signals from NC, HMI, PLC and I/O modules
  - Data blocks
  - PLC flags, timers and counters
  - Inputs and outputs of the PLC.
- Service displays
  - Nominal values, actual values and status data for axes/spindles
  - Communication error log for NC, PLC and HMI
  - Logbook
  - Display showing version of system software installed

## **External diagnostic tools**

The 611D commissioning software (to be installed on an external computer) is used to configure and set parameters for SIMODRIVE 611-D drives.

The 611D commissioning software provides the following functions:

- First commissioning through direct input of drive parameters
- Commissioning by transferring standard data records that are derived from motor/power section combinations
- Automatic controller setting (self-optimization)
- Measurement functions for evaluating speed and position control loops and regulating torque in the time and frequency range without external measurement equipment.
- Fast Fourier Transformation (FFT) for analysis of the control loop setting and machine kinematics
- Circularity test
- Archiving drive and control data

By means of the DAC configuration, the 611D drive modules enable the output of all important control loop variables of the position, speed and torque levels to external measurement devices (e.g. oscilloscope, signal plotter) via measuring sockets.

## **References**

A detailed description of the 611D commissioning software can be found in:  
/FBA/ Function Manual, Drive Functions, Speed Control Loop (DD2)

A detailed description of the circularity test can be found in:  
/FB2/ Function Manual, Extended Functions, Compensations (K3)

## 5.2 Description of diagnostic tools

### Scope

The Function Manual deals with displays of the user interface, system functions, procedures for determining system statuses and, if necessary, measures for avoiding undesirable conditions for the NC control, PLC and drives.

### General

#### Alarm and signal status displays

The currently active or not yet acknowledged alarms and messages are displayed in the Diagnostics operating area.

#### Alarm log

The alarm log contains the alarms that have occurred and the time. Detailed information on the individual alarms can be found in:

##### References:

/DA/ Diagnostics Manual or in the case of systems with HMI Advanced see **Online Help**.

---

##### Note

The corresponding explanations for alarms and messages which the machine tool manufacturer issues (range of values .....),  
can be found in the machine tool manufacturer's documentation.

---

### Alarm handler

#### Application

The alarm handler provides an infrastructure for activating and managing alarms on the NCK.

#### Functions

- Buffering of a maximum of 16 alarms that have been activated since system power-up and which have not yet been reset.
- Alarm reactions can be programmed as channel-specific, mode-group-specific or NCK-specific reactions.
- The "NoReady" alarm reaction can also be programmed as a channel-specific reaction.

### Activation

The alarm handler is activated when an error status is detected in the NCK, causing an alarm to be output.

It is possible to trigger an alarm in a part program using the **SETAL** command.

**References:** /PGA/ Programming Manual Job Planning

---

#### Note

The currently active alarms in the NCK are read via the operator panel interface.

It is not possible to set alarms externally in the NCK.

---

Alarms with an alarm ID in the 60000 to 60999 range can be activated in a part program.

### Data backup

On **Power ON**, the alarm-handler data are reinitialized completely, since they are not stored in the buffered SRAM.

### Compatibility

As of SW 4

As of SW 4.1 and later, it is possible to set the channel-specific signal CHANNEL\_NOREADY in the VDI interface in response to alarms.

Up to SW 3.x

Machine data:

MD11412 \$MN\_ALARM\_REACTION\_CHAN\_NOREADY

controls whether the channel-specific signal CHANNEL\_NOREADY function is used. This ensures that earlier PLC versions remain compatible.

**Default setting:** CHANNEL\_NOREADY signal is not used.

Alarms that have specified a channel-specific NOREADY signal are reconfigured to the mode-group-specific NOREADY signal.

### Clearing criterion

For each alarm, you must specify how the alarm can be cleared again. The following clearing criteria are possible:

- **POWERONCLEAR**  
The alarm is cleared by switching the control off and then on again.
- **RESETCLEAR**  
When the Reset key is pressed, the alarm is cleared in the channel in which it occurred.
- **CANCELCLEAR**  
The alarm is cleared in any channel when the Cancel key is pressed. The alarm can also be cleared by means of an NC start or Reset.

- **NCSTARTCLEAR**  
The alarm is cleared in the channel in which the alarm occurred by starting a program. The alarm can also be cleared by means of a Reset.
- **CLEARHIMSELF**  
The alarm is not cleared by an operator input or action, but explicitly by a "clearAlarm" programmed in the NCK source code.
- **BAGRESETCLEAR**  
The alarm is cleared by a "BAGRESETCLEAR" command or by executing a Reset in every channel of this mode group.
- **NCKRESETCLEAR**  
The alarm is cleared by an "NCKRESETCLEAR" command or by executing a Reset in every channel.

### **Alarm display control**

The scope of the alarm outputs can be modified using machine data.

- MD11410 \$MN\_SUPPRESS\_ALARM\_MASK (mask for suppressing special alarm outputs)
- MD11411 \$MN\_ENABLE\_ALARM\_MASK (mask for enabling special alarm outputs)

For details of this machine data, please refer to chapter 4.

## 5.3 Service displays

### Conditions of use

Conditions for the use of service displays are specified. Service displays are differentiated between in terms of axis/spindle, drive and profibus DP

### Operation

For how to operate the service displays see:

#### References:

/BAD/ "HMI Advanced Operator's Guide"

/BEM/ "HMI Embedded Operator's Guide"

---

#### Note

On HMI Advanced, it is possible to switch between the displays using the vertical soft key for Part view/Overall view. The data in the partial view are updated at significantly shorter intervals.

---

### General

In principle, the following service displays are available:

- Axis/spindle service displays
- Drive service displays
- Profibus-DP service displays

---

#### Note

##### System dependencies

The availability of individual service displays depends on the particular system, e.g.:

- Drive service displays: for digital drives only
  - Profibus-DP service displays: for SINUMERIK 840Di only
-

## 5.4 Axis/spindle service display

### Values and statuses

Displays showing values and statuses on the control's user interface allow the operating status of the axes and spindles to be evaluated.

### Accessing the diagnostic options

For the purposes of commissioning and diagnosing

- axes and
- spindles,

the information shown in the following figure can be called up for each axis/spindle in the "Diagnostics" operating area via the operator panel.

This information is used for

- checking the setpoint branch  
(e.g. **position setpoint, speed setpoint, spindle speed setpoint prog.**)
- checking the actual value branch  
(e.g. **actual position value measuring system 1/2, actual speed value**)
- optimizing the position control loop  
(e.g. **following error, control deviation, servo gain factor**)
- checking the whole control loop of the axis  
(e.g. by comparing the position setpoint and the actual position value, speed setpoint and the actual speed value)
- checking hardware errors  
(e.g. by checking the encoder: If the axis is physically moved, a change in the actual position value must result)
- setting and checking axis monitoring functions.

Descriptions on how to select and operate the "Diagnostics" area can be found in:

**References:**

/BAD/ "HMI Advanced User Manual"  
/BEM/ "HMI Embedded User Manual"

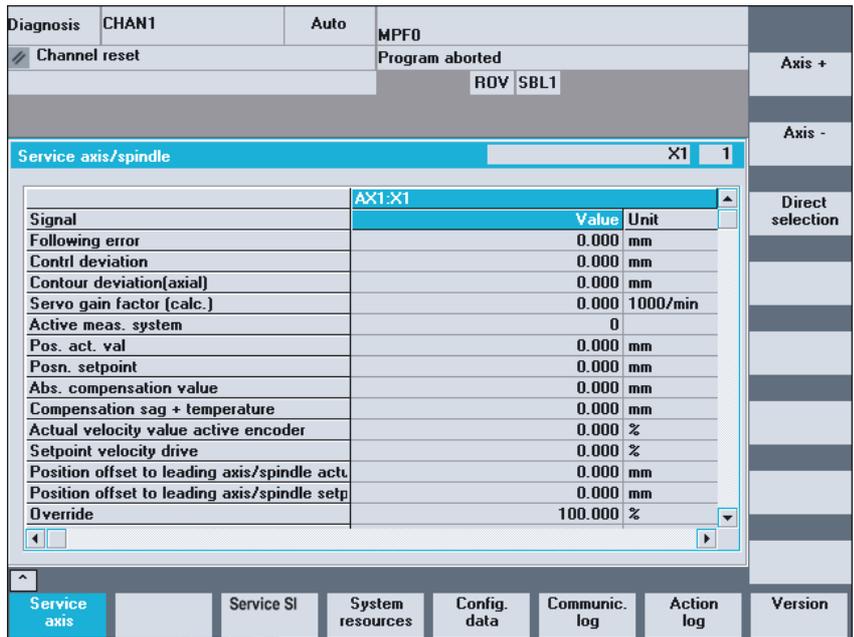


Figure 5-1 Example for service axis/spindle HMI Advanced

**Following error**

The difference between the position setpoint and the actual position value of active measuring system 1 or 2.

Unit: mm, inch or degrees

**Error signal**

The difference between the position setpoint at the position controller input and the actual position value of active measuring system 1 or 2.

Unit: mm, inch or degrees

**Contour deviation**

The current contour deviation is displayed with this value (variations of the following error caused by settling operations on the speed controller due to load changes).

The contour deviation results from the difference between an actual position pre-calculated from the position setpoint and the actual position value of active measuring system 1 or 2.

Unit: mm, inch or degrees

### Servo gain factor (calculated)

The servo gain factor in the display is calculated by the NC according to the following equation:

$$\text{Servo gain factor} = \frac{\text{Speed setpoint}}{\text{Following error}} ;$$

$$\text{Unit (with standard setting): } \frac{[\text{m/min}]}{[\text{mm}]} ;$$

Velocity setpoint = setpoint currently being output to the axis/spindle.

#### References:

/FB1/ Function Manual, Basic Functions; Velocities, Setpoint/Actual Value Systems, Closed-Loop Control (G2)

### Active meas. system

This line indicates whether measuring system 1 or 2 is active.

### Position actual value measuring system 1/2

The actual position of the axis as measured via measuring system 1/2. The position is displayed in the machine coordinate system (no work offsets or tool offsets included).

Unit: mm, inch or degrees

### Position reference value

Specified position transferred from the interpolator to the position control.

Unit: mm, inch or degrees

### Compensation value meas. system 1 or 2

Display of absolute compensation value for measuring system 1 or 2.

The compensation value consists of the sum of backlash and leadscrew error compensation for the actual axis position

Unit: mm, inch or degrees

### Sag and temperature compensation

Display of the compensation value calculated for the current axis position based on the total of the sag and temperature compensations.

Unit: mm, inch or degrees

### Velocity actual value of active encoder (only 840Di)

Display of velocity actual value of the currently active encoder.

### Velocity setpoint of drive (only 840Di)

Display of velocity setpoint of drive.

### Speed actual value

The pulses supplied by the encoder are evaluated by the NC and displayed.

Unit: %

100% means maximum speed (corresponds to 10 V for analog interface; maximum speed for SIMODRIVE 611 digital, specified by machine data:

MD1401 \$MD\_MOTOR\_MAX\_SPEED (speed for maximum useful motor speed).

### Speed setpoint

Speed setpoint transferred to the drive (= speed setpoint from position controller and feed forward control).

Unit: %

100% corresponds to the maximum speed setpoint (10 V for an analog interface, maximum speed for SIMODRIVE 611 digital).

### Spindle speed setpoint prog.

Speed setpoint programmed by the user.

Unit: rpm

e.g.: Input: S1000; display: 1000 rpm

Display applies to spindles only.

### Spindle speed setpoint current

Current active speed setpoint with correct sign, including calculated compensation value and any operative speed limitation (programmed by means of setting or machine data).

Unit: rpm

Display applies to spindles only.

### Override

The effective correction factor of the feed or spindle correction switch is displayed.

Unit: %

### Position offset for master axis/spindle actual value

The currently applicable position offset value is displayed here (relative to the actual value) if such a position offset (angular offset between master and slave axes) has been programmed for the "Synchronous spindle" function.

Unit: mm, inches, degrees

**References:**

/FB2/ Function Manual, Extended Functions, Synchronous Spindle (S3)

### Position offset for master axis/spindle setpoint value

The currently applicable position offset value is displayed here (relative to the setpoint) if such a position offset (angular offset between master and slave axes) has been programmed for the "Synchronous spindle" function.

Unit: mm, inches, degrees

**References:**

/FB2/ Function Manual, Extended Functions, Synchronous Spindle (S3)

### Current gear stage

The current actual gear stage is displayed here.

With axes, this is only displayed if a spindle is assigned to the axis. This display corresponds to IS DB31, ... DBX16.0 to 16.2 ("Actual gear stage").

**References:**

/FB1/ Function Manual, Basic Functions; Spindles (S1)

Displays which of the 6 parameter sets of the position controller is active. A parameter set changeover takes place, for example, with a gear shift.

**References:**

/FB1/ Function Manual, Basic Functions; Velocities, Setpoint/Actual-Value Systems, Closed-Loop Control (G2)

### Controller mode

Displays the current controller modes.

0:	Position Control
1:	Speed Control
2:	Stopping
3:	Parking
4:	Follow-up
5:	Braking

For a more detailed description of controller modes, refer to:

**References:**

/FB1/ Function Manual, Basic Functions; Various Interface Signals (A2)

### "Referenced" status display

Status display for reference point approach (axis).

Bit0=Status 0: The machine axis is not cross-referenced using position measurement system 1 or 2.

Bit0=Status 1: The machine axis has reached the reference point (incremental measuring system) and/or target point (length measuring system with distance coded reference marks) during reference point approach.

Bit1=Status 0: No obligation to cross-reference (NC start possible without cross-referencing this axis)

Bit1=Status 1: There is no obligation to cross-reference for the NC start.

Depending on machine data:  
MD34110 \$MA\_REFP\_CYCLE\_NR  
and  
MD20700 \$MC\_REFP\_NC\_START\_LOCK

Display corresponds to  
IS DB31, ... DBX60.4 and 60.5 ("Referenced/synchronized 1 or 2").

**References:**

/FB1/ Function Manual, Basic Functions; Reference Point Approach (R1)

### QEC learning active

Indicates whether or not the learning process for quadrant error compensation for the axis is active.

### Fixed stop reached

Indicates whether or not the axis has fulfilled the conditions for "Fixed stop reached" when the "Travel to fixed stop" function is active (IS DB31..., DBX62.5).

**References:**

/FB1/ Function Manual, Basic Functions; Travel to Fixed Stop (F1)

### Torque limitation value

Indicates the value programmed by means of  
FXST[x] or  
SD43510 \$SA\_FIXED\_STOP\_TORQUE  
or the value defined with machine datum:  
MD37010 \$MA\_FIXED\_STOP\_TORQUE\_DEF  
for the clamping torque for "Travel to fixed stop".

Unit: % of maximum torque

**References:**

/FB1/ Function Manual, Basic Functions; Travel to Fixed Stop (F1)

### **Safe actual position of the axis**

Displays the current actual axis position that has been measured via the NC. This actual position should correspond in value to "Safe actual position of drive".

**References:**

/FBSI/ Description of Functions Safety Integrated

### **Safe actual position of drive**

Displays the current actual axis position that has been measured via the drive. This actual position should correspond in value to "Safe actual position of axis".

**References:**

/FBSI/ Description of Functions Safety Integrated

### **Safe input signals of the axis**

Displays the safe input signals of the PLC defined for the "Safety Integrated" function. The status of these input signals should correspond to the "Safe input signals of drive" status.

**References:**

/FBSI/ Description of Functions Safety Integrated

### **Safe input signals of the drive**

Displays the safe input signals of the drive (DMP on drive bus) defined for the "Safety Integrated" function. The status of these input signals should correspond to the "Safe input signals of axis" status.

**References:**

/FBSI/ Description of Functions Safety Integrated

### **Safe output signals of the axis**

Displays the safe output signals of the PLC defined for the "Safety Integrated" function. The status of these output signals should correspond to the "Safe output signals of drive" status.

**References:**

/FBSI/ Description of Functions Safety Integrated

### **Safe output signals of the drive**

Displays the safe output signals of the drive (DMP on drive bus) defined for the "Safety Integrated" function. The status of these output signals should correspond to the "Safe output signals of axis" status.

**References:**

/FBSI/ Description of Functions Safety Integrated

The following description contains more information on problems and questions that may arise.



## Checks

### Check of the position controller setting

The position controller settings can be easily managed via the service axis display.

The number 1 (corresponds to servo gain = 1) should be entered in machine data:

MD32200 \$MA\_POSCTRL\_GAIN [n] (servo gain factor).

The change takes effect immediately.

Because the servo gain factor is defined as

$$\text{Servo gain factor} = \frac{\text{Speed setpoint}}{\text{Following error}} ; \frac{[\text{m/min}]}{[\text{mm}]} ; (\text{Default})$$

a **following error** of 1 mm must be measured (with KV = 1 and constant velocity) at a feedrate of 1 m/min.

If the desired servo gain (KV) factor does not correspond to the actual factor, the possible causes and remedial optimization options are as follows.

- Speed or torque feedforward control is activated. A higher servo gain factor is displayed than was set with machine data:  
MD32200 \$MA\_POSCTRL\_GAIN [n] (servo gain factor).
- Filter for jerk limitation or dynamic response adaptation is activated. A lower servo gain factor is displayed than was set with machine data:  
MD32200 \$MA\_POSCTRL\_GAIN [n] (servo gain factor).

### Diagnostics for alarms

This information is also provided as a diagnostic tool for diagnosing the causes of alarms such as:

- "Standstill monitoring"  
⇒ **following error** >  
MD36030 \$MA\_STANDSTILL\_POS\_TOL (standstill tolerance)
- "Contour monitoring"  
⇒ **contour deviation** >  
MD36400 \$MA\_CONTOUR\_TOL (tolerance band for contour monitoring)
- "Speed setpoint limiting"  
⇒ **Speed setpoint** >  
MD36210 \$MA\_CTRL\_OUT\_LIMIT  
(maximum speed setpoint)
- "Positioning monitoring"  
⇒ **following error** >  
MD36010 \$MA\_STOP\_LIMIT\_FINE  
(exact stop fine)
- "Measuring system changeover not available"  
⇒ difference between **actual position value measuring system 1 and 2** >

MD36500 \$MA\_ENC\_CHANGE\_TOL  
(maximum tolerance for actual position value measurement)

- "Clamping monitoring"  
⇒ **following error** >  
MD36050 \$MA\_CLAMP\_POS\_TOL  
(clamping tolerance for "Clamping active" interface signal)

For details on the behavior of the NC control in response to individual alarms, and remedial action, please refer to:

**References:**

/DA/ Diagnostics Manual

### Diagnostics of operational state errors

The following information is also provided to assist in the analysis of operational state errors such as:

- Despite an active motion command, the axis does not move.  
⇒ Check whether controller is enabled. In **controller mode** position control or speed control (with spindle control) must be activated.
- Occurrence of feed fluctuations.  
⇒ Detection via **following error** or **actual speed value**.
- Incorrect positioning.  
⇒ Compare **position setpoint** with **actual position value of measuring system 1/2** and **absolute compensation value of measuring system 1 or 2**.
- The cam is not detected by the PLC during referencing.  
⇒ Check **status display "referenced"**
- An incorrect reference point value was displayed.  
⇒ The wrong measuring system may have been used for referencing.
- Large fluctuations in the **actual speed value** are occurring in the main spindle drive.  
⇒ The selected actual speed range for encoders is too high or the machine datum: MD36300 \$MA\_ENC\_FREQ\_LIMIT [n] (encoder limiting frequency) is set higher than specified in the encoder data sheet.

Incorrect spindle positioning occurs.

⇒ The wrong measuring system may be selected or synchronization may have been performed with the wrong zero mark.

## 5.5 Drive service display (for digital drives only)

### Displays

Displays on the control's user interface that show values and statuses allow for evaluation of the operating statuses of the digital drives.

### Access

For the purposes of commissioning and diagnosing

- feed drives (FDD) and
- main spindle drives (MSD)

"Diagnostic" information are displayed for each axis/spindle via the operator panel front in the operating area.

---

#### Note

The parameters in the "Drive" service display are not necessary for connecting drives via the PROFIBUS-DP. For SINUMERIK 840Di, the drives are defined as PROFIBUS nodes. The appropriate service data is displayed in 840Di-Start-up in the menu Diagnostics --> PROFIBUS.

---

### Application

The diagnostic options are used for:

- checking the status of enabling and control signals  
(e.g. **pulse enable**, **drive enable**, **motor selection**, **setpoint parameter set**)
- checking the status of FDD/MSD operating modes  
(e.g. **setup mode**, **parking axis**)
- displaying temperature warnings
- checking the current setpoint/actual value display  
(e.g. **actual position value measuring system 1/2**, **speed setpoint**, **actual speed value**)
- checking the drive status (drive ready)
- displaying the current ramp-up phase
- displaying the group error message (**message status class 1**)
- displaying the drive status messages  
(e.g. **threshold torque not reached**, **minimum speed not reached**, **actual speed = set speed**)

## Service HMI Advanced Drive

Selection and operation of the "Diagnosis" operating area is described in

**References:**

/BAD/ "Operator's Guide HMI Advanced"

/BEM/ "Operator's Guide HMI Embedded"

## Explanations/Terms

The individual status displays, warnings, messages, etc., are explained in the following sections. For HMI SW 6 and higher, the status is shown in plain text as "yes" or "no" instead of "0" and "1".

For additional information, see:

**References:**

/IAD/ Installation and startup guide

## Drive enable (terminal 64/63)

The display corresponds to the status of terminal 64/63 on the SIMODRIVE611 digital infeed/regenerative feedback unit.

State 1: Central drive enable

State 0: Central drive disable

Display corresponds to machine datum:

MD1700 \$MD\_TERMINAL\_STATE

(status of binary inputs).

## Pulse enable (terminal 63/48)

The display corresponds to the status of terminal 63/48 on the SIMODRIVE611 digital infeed/regenerative feedback unit.

State 1: Central pulse enable

State 0: Central pulse disable

Display corresponds to machine data:

MD1700 \$MD\_TERMINAL\_STATE

(Status of binary inputs).

## Pulse enable (terminal 663)

The display corresponds to the status of terminal 663 (relay: safe operational stop) on the drive module.

State 1: Module-specific pulse enable

State 0: module-specific pulse disable

Display corresponds to machine datum:

MD1700 \$MD\_TERMINAL\_STATE

(status of binary inputs).

### Setup mode (terminal 112) HMI SW 6.3 and later

The display corresponds to the status of terminal 112 on the SIMODRIVE 611 digital infeed/regenerative feedback unit.

State 1: Central drive disable for setup mode  
State 0: Central drive enable, no setup mode

Display corresponds to machine datum:  
MD1700 \$MD\_TERMINAL\_STATE  
(status of binary inputs).

### PLC pulse enable

Indicates whether the pulse enable from the PLC is available for the drive.

State 1: The pulses for the drive module have been disabled by the PLC.  
State 0: Pulse enable for this drive is activated by the PLC.

Display corresponds to IS DB31, ... DBX21.7 ("Pulse enable")

**References:**

/FB1/ Function Manual, Basic Functions; Various Interface Signals (A2)

### Speed controller enable NC

This display indicates whether the speed controller for the drive has been enabled by the NC.

State 1: Speed controller enable = OFF  
State 0: Speed controller enable = ON

### Ramp-up function generator quick stop

Status display for ramp-up function generator quick stop.

State 1: Ramp-up function generator quick stop is not active for the drive.  
State 0: Ramp-up function generator quick stop is active. The drive is stopped without a ramp function with speed setpoint = 0 and without pulse suppression.

Display corresponds to IS DB31, ... DBX92.1 ("Ramp-function generator rapid stop").

**References:**

/FB1/ Function Manual, Basic Functions; Various Interface Signals (A2)

### DC link state (on/off)

The display contains the following drive warning:

State 0: DC link voltage = ON  
State 1: DC link voltage is below warning threshold.

The warning threshold corresponds to machine datum:  
MD1604 \$MD\_LINK\_VOLTAGE\_WARN\_LIMIT (DC link undervoltage warning threshold).

### Enable pulses

Message indicating whether the drive pulses have been enabled.

State 0: The drive module pulses are suppressed. The axis/spindle can therefore not be traversed.

State 1: The drive module pulses are enabled. The axis/spindle can now be traversed.

Display corresponds to IS DB31, ... DBX93.7 ("Enable pulses").

**References:**

/FB1/ Function Manual, Basic Functions; Various Interface Signals (A2).

### Drive ready

Display of the current status of the selected drive.

State 0: The drive is not ready.

State 1: The drive is ready.

Display corresponds to IS DB31, ... DBX93.5 ("Drive Ready").

**References:**

/FB1/ Function Manual, Basic Functions; Various Interface Signals (A2)

Display indicating the current ramp-up phase of the selected drive.

Meaning:

### CRC error

Display of communications errors detected in hardware between NC and drive.

---

**Note**

If the display shows a value other than "0", please contact your SIEMENS Regional Office!

---

### ZK1 Messages

Display indicates whether messages of status class 1 are active.

State 0: There is no pending ZK1 message.

State 1: One or several status class 1 messages are active.

Status class 1 messages are alarms with the following characteristics:

- They lead to internal responses (e.g. regenerative braking, immediate pulse suppression)
- They are modal.

### DC link voltage

indicates the current DC link voltage level within the drive grouping.

Unit: Volts

### Speed setpoint

The displayed speed setpoint represents the unfiltered total setpoint value. It consists of the position controller output component and the speed feedforward branch.

Unit: rpm

Display corresponds to machine data:

MD1706 \$MD\_DESIRED\_SPEED (speed setpoint value).

### Speed actual value

The displayed real value represents the unfiltered actual speed value.

Unit: rpm

Display corresponds to machine data:

MD1707 \$MD\_ACTUAL\_SPEED (actual speed value).

### Smoothed actual current value

Display of the smoothed actual current value. The torque-generating actual current value is smoothed by a PT1 element with parameterizable time constants.

Unit: %

100 % corresponds to the maximum current of the power section.

Display corresponds to machine data:

MD1708 \$MD\_ACTUAL\_CURRENT (smoothed actual current value).

### Motor temperature

Display of motor temperature measured via temperature sensors.

Unit: Degrees Celsius

Display corresponds to machine datum:

MD1702 \$MD\_MOTOR\_TEMPERATURE (motor temperature).

### Speed setpoint filter 1

Status display of speed setpoint smoothing function.

State 0: No speed setpoint smoothing is active.

State 1: Smoothing of the speed setpoint as requested by the PLC using IS DB31, ... DBX20.3 ("Speed setpoint smoothing") takes effect because speed setpoint filter 1 is configured as the low pass.

Display corresponds to IS DB31, ... DBX92.3 ("Speed setpoint smoothing active") and is shown in an updated form as of software version 6.3 and later.

**References:**

/FB1/ Function Manual, Basic Functions; Various Interface Signals (A2)

## 2nd torque limit

Display of active torque limit

State 0: Torque limit 1 is active.

State 1: Torque limit 2 is active.

Display corresponds to IS DB31, ... DBX92.2 ("Torque limit 2 active").

**References:**

/FB1/ Function Manual, Basic Functions; Various Interface Signals (A2)

## Integrator disabling

This display indicates whether the speed controller integrator is active.

State 0: The integrator of the speed controller is enabled. The speed controller functions as a PI controller.

State 1: Deactivation of the speed-controller integrator as requested by the PLC using IS DB 31, ... DBX 21.6 ("Integrator disable speed controller") is active for the drive module. The speed controller has therefore switched from a PI to a P controller.

Display corresponds to IS DB31, ... DBX93.6 ("Speed-controller integrator disabled").

**References:**

/FB1/ Function Manual, Basic Functions; Various Interface Signals (A2)

## Setup mode

Mode display of the SIMODRIVE 611 digital.

State 0: Normal operation is active for the drive.

State 1: Setup mode is active for the drive.

Display corresponds to NST DB31, ... DBX92.0 ("Setup mode active").

**References:**

/FB1/ Function Manual, Basic Functions; Various Interface Signals (A2)

**Parking axis**

Mode display of the SIMODRIVE 611 digital.

State 0: Axis/spindle in normal mode

State 1: Axis/spindle in parking position, i.e. all encoder-specific monitoring and evaluating functions are disabled. This allows the encoder to be withdrawn without initiating an alarm.

**Setpoint parameter set (drive)**

Indicates which of the 8 drive parameter sets of the SIMODRIVE 611 digital are to be activated by the PLC.

Display corresponds to IS DB31, ... DBX21.0 to 21. ("Parameter set selection A,B,C").

**References:**

/FB1/ Function Manual, Basic Functions; Various Interface Signals (A2)

**Actual parameter set (drive)**

Display indicating which of the 8 drive parameter sets of the SIMODRIVE 611 digital is currently active.

Display corresponds to IS DB31, ... DBX93.0 to 93.2 ("Active parameter set A,B,C").

**References:**

/FB1/ Function Manual, Basic Functions; Various Interface Signals

**Operating mode**

Display indicating whether the motor is operating as a feed drive or main spindle drive.

**Motor selection (star/delta)**

Display indicating which motor data set is to be activated by the PLC. At the moment the motor data record is used for the star/delta switchover on main spindle drives.

The following assignment applies:

Motor selection	Application	Coding	
Motor 1	MSD: Star	0	0
Motor 2	MSD: Delta mode	0	1
Motor 3	reserved	1	0
Motor 4	reserved	1	1

The display applies only to main spindle drives.

Display corresponds to NST DB31, ... DBX21.3 to 21.4

("Motor selection A,B").

**References:**

/FB1/ Function Manual, Basic Functions; Various Interface Signals (A2)

**Actual motor (star/delta)**

Display indicating which of the motor data sets is currently active. At the moment the motor data record is used for the star/delta switchover on main spindle drives.

The following assignment applies:

Motor selection	Application	Coding	
Motor 1	MSD: Star	0	0
Motor 2	MSD: Delta mode	0	1
Motor 3	reserved	1	0
Motor 4	reserved	1	1

Display is valid only for main spindle drives.

Display corresponds to NST DB31, ... DBX93.3 to 93.4

("active motor A,B").

**References:**

/FB1/ Function Manual, Basic Functions; Various Interface Signals (A2)

**Position actual value measuring system 1/2**

The actual position of the axis as measured via measuring system 1/2. The position is displayed in the machine coordinate system (no work offsets or tool offsets included).

Unit: mm, inch or degrees

**Power section in i<sup>2</sup>t limitation HMI SW 6.3 and later**

Limitation for protecting the power section against continuous overloading of the SIMODRIVE 611 drives.

State 1: i<sup>2</sup>t-power section limitation has responded

State 0: i<sup>2</sup>t power section limitation has not responded

Display is valid for SIMODRIVE universal and SIMODRIVE digital.

Display corresponds to NST DB31, ... DBX95.7

("i<sup>2</sup>t-monitoring").

**References:**

/FB1/ Function Manual, Basic Functions; Various Interface Signals (A2)

### Heatsink temperature warning

Warning signal output by drive:

State 0: The heat sink temperature monitoring has not responded.

State 1: The heatsink temperature monitoring has responded.

Display corresponds to IS DB31, ... DBX94.1  
("Heatsink temperature prewarning").

**References:**

/FB1/ Function Manual, Basic Functions; Various Interface Signals (A2)

### Motor temperature warning

Warning signal output by drive:

State 0: The motor temperature is below the warning threshold.

State 1: The motor temperature has exceeded the defined warning threshold.

The warning threshold corresponds to the machine data:

MD1602 \$MD\_MOTOR\_TEMP\_WARN\_LIMIT (maximum motor temperature).

Display corresponds to NST DB31, ... DBX94.0 ("Motor temperature prewarning").

**References:**

/FB1/ Function Manual, Basic Functions; Various Interface Signals (A2)

### Ramp-up function completed

Status display of drive.

State 0: The ramp-up function has not yet been completed after a new speed setpoint was defined.

State 1: The actual speed value has reached the speed tolerance band after a new speed setpoint was defined.

The speed tolerance band corresponds to machine datum:

MD1426 \$MD\_SPEED\_DES\_EQ\_ACT\_TOL (tolerance band for 'n<sub>set</sub>-n<sub>actual</sub>' message).

Display corresponds to NST DB31, ... DBX94.2 ("Ramp-up function completed").

**References:**

/FB1/ Function Manual, Basic Functions; Various Interface Signals (A2)

### Torque lower than threshold setting

Status display of drive.

State 0: In the stationary condition (i.e. ramp-up procedure completed), the torque setpoint is greater than the threshold torque.

State 1: In the stationary condition, the torque setpoint has not reached the threshold torque.

The threshold torque corresponds to the machine data:

MD1428 \$MD\_TORQUE\_THRESHOLD\_X (threshold torque).

Display corresponds to IS DB31, ... DBX94.3 ("M<sub>d</sub> < M<sub>dX</sub>").

**References:**

/FB1/ Function Manual, Basic Functions; Various Interface Signals (A2)

### Speed lower than minimum setting

Status display of drive.

State 0: The speed actual value is higher than the minimum speed.

State 1: The actual speed value is smaller than the minimum speed.

The minimum speed corresponds to the machine data:

MD1418 \$MD\_SPEED\_THRESHOLD\_MIN ( $n_{min}$  for ' $n_{is} < n_{min}$ ' message).

Display corresponds to IS DB31, ... DBX94.4

("| $n_{actual}$ | <  $n_{min}$ ").

**References:**

/FB1/ Function Manual, Basic Functions; Various Interface Signals (A2)

### Speed lower than threshold setting

Status display of drive.

State 0: The actual speed value is greater than the threshold speed.

Status 1: The actual speed value is smaller than the threshold speed.

The threshold speed corresponds to machine datum:

MD1417 \$MD\_SPEED\_THRESHOLD\_X

( $n_x$  for ' $n_{actual} < n_x$ ' message).

Display corresponds to NST DB31, ... DBX94.5 ("| $n_{actual}$ | <  $n_x$ ").

**References:**

/FB1/ Function Manual, Basic Functions; Various Interface Signals (A2)

**Actual speed = set speed**

Status display of drive.

- State 0: The actual speed value is outside the speed tolerance band after a new speed setpoint was defined.
- State 1: The actual speed value has reached the speed tolerance band after a new speed setpoint was defined.

The speed tolerance band corresponds to machine datum:  
MD1426 \$MD\_SPEED\_DES\_EQ\_ACT\_TOL (tolerance band for 'n<sub>set</sub>-n<sub>actual</sub>' message).

Display corresponds to NST DB31, ... DBX94.6 ("|n<sub>actual</sub>|= n<sub>set</sub>").

**References:**

/FB1/ Function Manual, Basic Functions; Various Interface Signals (A2)

**Variable signal 1**

Status display of 611D variable signaling function.

With the variable signaling function, any memory location can be monitored to see whether a definable threshold is exceeded. In addition to the threshold, a tolerance band can be defined which is also taken into account when scanning for violation of the threshold value. The signal can be combined with an ON delay or OFF delay time.

State 0: Threshold value not reached

State 1: Threshold value exceeded

Parameters for the variable signal function are set using the following 611D machine data:

MD1620 \$MD_PROG_SIGNAL_FLAGS	(Bits variable signal function)
MD1621 \$MD_PROG_SIGNAL_NR	(Signal number variable signal function)
MD1622 \$MD_PROG_SIGNAL_ADDRESS	(Address variable signal function)
MD1623 \$MD_PROG_SIGNAL_THRESHOLD	(Threshold variable signal function)
MD1624 \$MD_PROG_SIGNAL_HYSTERESIS	(Hysteresis variable signal function)
MD1625 \$MD_PROG_SIGNAL_ON_DELAY	(ON Delay variable signal function)
MD1626 \$MD_PROG_SIGNAL_OFF_DELAY	(OFF Delay variable signal function)

## Diagnostics for alarms

This information is also provided as a diagnostic tool for diagnosing the causes of alarms such as:

- "Ramp-up error"  
⇒ Check the **ramp-up phase** to see which ramp-up phase the drive has reached.
- "Drive malfunction"  
⇒ **Message ZK1** is set.  
⇒ check **specified parameter set, motor selection, DC link status**.  
Check following alarms 300500 to 300515.
- "Zero speed monitoring",  
25050 "Contour monitoring",  
25060 "Speed setpoint limitation"  
25080 "Positioning monitoring"  
⇒ The enabling for the drive may have been omitted (e.g. **pulse enable, drive enable, pulse enable for PLC** not available); this leads to display **pulses enabled = off**.
- "Motor temperature exceeded"  
⇒ Check the current motor temperature.

For details on the behavior of the NC control in response to individual alarms, and remedial action, please refer to:

**References:**

/DA/ Diagnostic Manual

## 5.6 Service display PROFIBUS DP 840Di

The user interface 840Di Start-Up provides diagnostic screen forms for PROFIBUS-DP and its nodes. These diagnostic screens are only intended for information. You cannot modify them.

The following detailed information is displayed:

- PROFIBUS configuration
- Information on the slaves regarding their assignment to PLC/NC
- Detailed information on the slaves and the corresponding slots
- Information on the axes.

To obtain a quick overview, the current states of certain functions are represented by colored lamps. The following general conventions are used for the meaning of the individual colors:

- Green: Function is OK.
- Red: Failure or no communication at the moment
- Gray: Function is not available for the present communication.

### Diagnostic screen PROFIBUS-DP Configuration

The diagnostic screen PROFIBUS-Configuration provides general information about the PROFIBUS-DP.

The following parameters are displayed:

Table 5-1 Diagnostic screen Profibus-Configuration

Function/Part function	Explanation/Meaning
<b>Bus-configuration</b>	
Baudrate in MBd	Transmission rate
Cycle time in msec	Configured bus-cycle time; also defines the position controller cycle at the same time
Synchronous part (TDX) in msec	configured time span for the cyclic data exchange within a PROFIBUS-DP cycle
<b>Status</b>	
Configuration ok	Status of the configuration. <ul style="list-style-type: none"> <li>• Green lamp: DP-Master is powered up.</li> <li>• Red lamp: Error function/no communication</li> </ul>
Bus status	Current bus status is shown in this field. Each bus status is explained briefly in the screen. Possible states are: <ul style="list-style-type: none"> <li>• POWER_ON</li> <li>• OFFLINE</li> <li>• CLEAR</li> <li>• OPERATE</li> <li>• ERROR</li> </ul>

**Diagnostics screen of the DP slaves**

This diagnostic screen provides an overview of the configured slaves and the slaves identified on the bus.

The following information is offered:

Table 5-2 Diagnostic screen Information about slaves

Function/Part function	Explanation/Meaning
Slave no. (DP address)	Configured DP address of the DP slave
Assignment	It is shown, whether the DP slave is assigned to the NC or to the PLC. <ul style="list-style-type: none"> <li>• NC: e.g. one or more drives controlled by the NC.</li> <li>• PLC: e.g. I/O peripherals or an axis controlled by the PLC.</li> </ul>
active on the bus	Shows, whether the DP slave has been identified on the bus. <ul style="list-style-type: none"> <li>• Green lamp: DP slave was identified at the PROFIBUS-DP and the data exchange is working with the assigned component (NC or PLC)</li> <li>• Red lamp: Error function/no communication</li> </ul>
Synchr. with NC	It is shown, whether the DP slave is running synchronously to NC on the bus. <ul style="list-style-type: none"> <li>• Green lamp: DP slave runs synchronously to NC at PROFIBUS-DP i.e. the equidistant data exchange takes place.</li> <li>• Gray lamp: DP slave is not assigned to NC but instead to PLC.</li> <li>• Red lamp: Error function/no communication</li> </ul>
Number of slots	Number of configured slots within the DP slave
Details	By pressing the button another diagnostic screen is opened, which contains the detailed information for the respective DP slave.

**Detailed information of the slots within a slave**

Via the button **Details** the diagnostic screen of detailed information for the slave is opened. This screen shows you detailed information about the slots assigned to the DP slave.

The field Slave shows you the most important information for the currently selected DP slave.

The following information is offered for the slots:

Table 5-3 Diagnostic screen Detailed information for slave

Function/Part function	Explanation/Meaning
<b>Slave</b>	
Slave no. (DP address)	Configured DP address of the DP slave
Assignment	It is shown, whether the DP slave is assigned to the NC or to the PLC. <ul style="list-style-type: none"> <li>• NC: e.g. one or more drives controlled by the NC.</li> <li>• PLC: e.g. I/O peripherals or an axis controlled by the PLC.</li> </ul>
Active on the bus	Shows, whether the DP slave has been identified on the bus. <ul style="list-style-type: none"> <li>• Green lamp: DP slave was identified at the PROFIBUS-DP and the data exchange is working with the assigned component (NC or PLC)</li> <li>• Red lamp: Error function/no communication</li> </ul>

Function/Part function	Explanation/Meaning
Synchronous	It is shown, whether the DP slave is running synchronously to NC on the bus. <ul style="list-style-type: none"> <li>• Green lamp: DP slave runs synchronously to NC at PROFIBUS-DP i.e. the equidistant data exchange takes place.</li> <li>• Gray lamp: DP slave is not assigned to NC but instead to PLC.</li> <li>• Red lamp: Error function/no communication</li> </ul>
<b>Slots</b>	
No.	Slot number within the DP slave
I/O address	I/O address in the I/O address area of the PLC assigned to this slot. For NC axes, the set and the actual value must always be configured on the same I/O address.
logical drive no.	Drive number specified in the NC machine data for the axis.
Length [byte]	Length of the I/O area reserved for the slot in step 7 I/O address area
Type	Specification, whether the slot is input, output or diagnostic slot. If the slot is assigned to an NC axis, then the output is always denoted as setpoint value and the input always as actual value.
Machine axis	Display of the name defined in the machine data for this slot. If the slot is not assigned to any NC axis, <No NC-axis> is shown.
Telegram type	The telegram type of the NC axis configured in the NC machine data. If the slot is not assigned to any NC axis, the telegram type is not filled (-).
State	Current state of slot. Displayed only for NC axes. <ul style="list-style-type: none"> <li>• Green: Slot used by NC, communication active</li> <li>• Gray: No NC axis</li> <li>• Red: Slot used by NC, communication currently not active</li> </ul>

**Diagnostic screen for the axes**

The diagnostic screen AxisInfo shows the axis-specific detailed information. The diagnostic screen enables an NC-oriented view of the axis information.

The following information is offered for the slots:

Table 5-4 Diagnostic screen Axis Info

Function/Part function	Explanation/Meaning
Machine axis	Name of the axis defined in the NC-machine data
<b>Output</b>	
Slave/Slot	Configured routing
State	Current state of slot. Green lamp: Cyclic communication Red lamp: (still) no cyclic communication
Telegram failures	It is shown, how many telegram failures have occurred since the NC-power up. This value is an indication of the quality (susceptibility to faults) of the PROFIBUS-DP strand.
<b>Encoder 1</b>	
Slave/Slot	Configurable routing
State	Current state of slot. Green lamp: Cyclic communication Red lamp: (still) no cyclic communication
Telegram failures	It is shown, how many telegram failures have occurred since the NC-power up. This value is an indication of the quality (susceptibility to faults) of the PROFIBUS-DP strand.
Type	Display of the encoder type configured in the NC-machine data. ABS: Absolute encoder INC: Incremental value encoder
<b>Encoder 2</b>	(If configured, the same display as for encoder 1)

## 5.7 Communication log

### Log assistance

In event of a fault and when developing OEM applications, control logs may assist with the analysis.

### Logs and version

### Communication log

The communication errors which have occurred between the HMI and NC are displayed in chronological order via the soft key **Comm. log** in the "Diagnostics" operating area. This error list assists developers of OEM applications in localizing sporadic errors. The list has no relevance for normal operation.

### Logbook

The logbook display selected by means of soft key **Logbook** in the "Diagnostics" operating area automatically lists details of all alterations to the control that are relevant for the system (e.g. changes in access level).

For SINUMERIK 840Di, the logbook is displayed in 840Di Start-Up.

### Version

in case of service, the integrated HMI or NC software version can be read (Operating area "Diagnosis" under the **Version**) softkey.

The software version of each software module is recorded additionally in a list.

## 5.8 PLC status

PLC status signals can be checked and altered via the operator panel in the "Diagnostics" operating area.

### Application

The end customer or service personnel can use this function on site without a programming device to do the following:

- Check the input and output signals of the PLC I/Os.
- Carry out limited troubleshooting
- Check the interface signals for diagnostic purposes.

### Operation

For information about status display operation and changing PLC signals, refer to the Operator's Guide for the relevant HMI software.

### Status display

The status of the following data can be displayed on the operator panel.

- Interface signals from the machine control panel
- Interface signals to the machine control panel
- Interface signals between the NCK and PLC
- Interface signals between the HMI and PLC
- Data blocks (DB 0-127)
- Flags (FB 0-255)
- Timers (T 0-127)
- Counters (C 0-63)
- Inputs (IB 0-127)
- Outputs (QB 0-127)

For a breakdown of the interface signals (DBx, DBBy), refer to:

#### References:

/LIS2/ Lists (Volume 2)

### Change in status

The status of the above signals can be changed for test purposes. Signal combinations are also possible. A maximum of ten operands can be altered at any one time.

## 5.9 Other diagnostics tools

### 611D commissioning tool

Using the 611D commissioning tool and archiving software, the control can be evaluated and the control status can be saved.

### 611D commissioning tool

One of the functions of this program is to provide a tool

- for evaluating the most important values for the position, speed and current control
- for archiving drive and control data, and
- for analyzing the stated physical properties.

For handling and complete range of functions see:

**References:**

/IAD/ Installation Guide

### Archiving of data

The PCIN software package can be used to archive machine data, setting data, part programs, etc.

A description of how to use this can be found in the associated documentation:

**References:**

/PI/ PCIN 4.3

### 840Di Start-Up

For diagnosing the SINUMERIK 840Di, the WINDOWS program 840Di Start-Up can be used. This provides information, e.g. on the current operating mode and the nodes of PROFIBUS-DP.

## 5.10 Identifying defective drive modules

### Deactivate drives

Drives can be removed from the NC configuration using a piece of machine data.

Troubleshooting may involve a situation where a drive module (SIMODRIVE 611 digital) displayed in an alarm text needs to be removed from the bus in order to determine whether this module has caused the displayed error. :

With machine datum:

MD13030 \$MN\_DRIVE\_MODULE\_TYPE,  
individual modules can be removed from the NC-side drive bus configuration (the affected axes are switched to simulation).

---

#### Note

You must remove the desired module from the drive bus configuration (SIMODRIVE 611 digital) before you activate the function. To do this, connect the drive so as to exclude the module.

Since this internal modification to the machine configuration can result in damage to the machine if implemented incorrectly, the axes are prevented from moving.

If Safety Integrated has been activated for the modules concerned, you must disable it manually (safety, logged, EMERGENCY STOP scheme).

---

### Remove drive module at NC end

A drive module (SIMODRIVE 611 digital) specified in an alarm text must be removed from the bus:

1. Remove the module from the drive bus network
2. Set entries of the drive module in machine datum:  
MD13030 \$MN\_DRIVE\_MODULE\_TYPE  
to zero (zero-axis module).
3. Perform an NC RESET.

The axes which were controlled by the removed drive modules are now replaced by simulated axes. The 611D bus with its drive modules is now in a state in which it could normally move axes, but axis traversal has been disabled internally.

Alarm 300020 "Drive %1 removed for diagnostics" displays this status to the operator.

## Restoring the initial configuration

After completing the diagnostics, the initial configuration on the drive bus must be restored:

1. Replace or re-install the removed drive module.
2. Change entries of the drive module in machine datum:  
MD13030 \$MN\_DRIVE\_MODULE\_TYPE  
back to the original values.
3. Perform an NC RESET.

## Example

The 2-axis module with drive numbers "1" and "2" must be removed from a drive grouping.

### Note

Before activating the function, the module in question must be removed from the drive bus configuration

(SIMODRIVE 611 digital). To do this, connect the drive bus so as to exclude the module.

If Safety Integrated has been activated for the modules concerned, you must disable it manually (safety, logged, EMERGENCY STOP scheme).

Table 5-5 Bus configuration example

Module	Drive no.	Active	Type	Module type	Power section code
1	10	1	ARM/MSD	Axis	6
Left	1	1	SRM/FDD	Axis	14
Right	2	1	SRM/FDD	Axis	14
Left	4	1	HLA	Axis	
Right	5	1	ANA	Axis	
4	12	1	SLM	Axis	11
5	11	1	PER	DMP-C	

Module "2" must now be removed:

- Machine datum:  
MD13030 \$MN\_DRIVE\_MODULE\_TYPE  
is to be selected on the "General MD" MD screen.
- DRIVE\_MODULE\_TYPE[0] = 1  
DRIVE\_MODULE\_TYPE[1] = 2 <- set this entry to zero  
DRIVE\_MODULE\_TYPE[2] = 2 <- set this entry to zero  
DRIVE\_MODULE\_TYPE[3] = 2  
DRIVE\_MODULE\_TYPE[4] = 2  
DRIVE\_MODULE\_TYPE[5] = 1  
DRIVE\_MODULE\_TYPE[6] = 9

- After the changes, the table looks like this:  
DRIVE\_MODULE\_TYPE[0] = 1  
DRIVE\_MODULE\_TYPE[1] = 0  
DRIVE\_MODULE\_TYPE[2] = 0  
DRIVE\_MODULE\_TYPE[3] = 2  
DRIVE\_MODULE\_TYPE[4] = 2  
DRIVE\_MODULE\_TYPE[5] = 1  
DRIVE\_MODULE\_TYPE[6] = 9
- Alarms 300020 "Drive 1 removed for diagnostics" and 300020 "Drive 2 removed for diagnostics" are displayed.

Internally simulated drives are used for all axes which had settings on the removed drive numbers. If the controller is engaged for the drives that are still installed, these drives operate in the normal way. Interpolative traversal of all axes is disabled.

---

**Note**

If alarm 300003 "Axis xx drive yy incorrect module type zz" appears, then you have removed only one part of a 2-axis module. In this case, you should check the module type in the drive configuration display. "NO" axis type is shown for removed modules.

---

## 5.11 Data lists

### 5.11.1 Machine data

#### 5.11.1.1 Drive-specific machine data

Number	Identifier: \$MD_	Description
1401	MOTOR_MAX_SPEED	Speed for max. useful motor speed
1417	SPEED_THRESHOLD_X	$n_x$ for ' $n_{act} < n_x$ ' signal
1418	SPEED_THRESHOLD_MIN	$n_{min}$ for ' $n_{act} < n_{min}$ ' signal
1426	SPEED_DES_EQ_ACT_TOL	Tolerance band for ' $n_{set}-n_{act}$ ' signal
1428	TORQUE_THRESHOLD_X	Threshold torque
1602	MOTOR_TEMP_WARN_LIMIT	Maximum motor temperature
1604	LINK_VOLTAGE_WARN_LIMIT	DC link under voltage warning threshold
1620	PROG_SIGNAL_FLAGS	Bits variable signal function
1621	PROG_SIGNAL_NR	Signal number variable signal function
1622	PROG_SIGNAL_ADDRESS	Address variable signal function
1623	PROG_SIGNAL_THRESHOLD	Threshold variable signal function
1624	PROG_SIGNAL_HYSTERESIS	Hysteresis variable signal function
1625	PROG_SIGNAL_ON_DELAY	ON Delay variable signal function
1626	PROG_SIGNAL_OFF_DELAY	OFF Delay variable signal function
1700	TERMINAL_STATE	Status of binary inputs
1702	MOTOR_TEMPERATURE	Motor temperature
1706	DESIRED_SPEED	Speed setpoint
1707	ACTUAL_SPEED	Speed actual value
1708	ACTUAL_CURRENT	Smoothed current actual value

#### 5.11.1.2 NC-specific machine data

Number	Identifier: \$MN_	Description
11410	SUPPRESS_ALARM_MASK	Mask for suppressing special alarms
11411	ENABLE_ALARM_MASK	Activation of special alarms
11412	ALARM_REACTION_CHAN_NOREADY	Alarm reaction CHAN_NOREADY permitted
11413	ALARM_PAR_DISPLAY_TEXT	Texts as alarm parameters (Siemens Rights)
11420	LEN_PROTOCOL_FILEX	File size for protocol files (KB)
13030	DRIVE_MODULE_TYPE	Module identifier (SIMODRIVE 611 digital)

### 5.11.1.3 Axis/spindle-specific machine data

Number	Identifier: \$MA_	Description
32200	POSCTRL_GAIN [n]	Servo gain factor
32250	RATED_OUTVAL	Rated output voltage
32260	RATED_VELO	Rated motor speed
36010	STOP_LIMIT_FINE	Exact stop fine
36030	STANDSTILL_POS_TOL	Zero speed tolerance
36050	CLAMP_POS_TOL	Clamping tolerance
36210	CTRLOUT_LIMIT	Maximum speed setpoint
36300	ENC_FREQ_LIMIT[n]	Encoder limit frequency
36400	CONTOUR_TOL	Tolerance band contour monitoring
36500	ENC_CHANGE_TOL	Max. tolerance for actual position value acquisition
37010	FIXED_STOP_TORQUE_DEF	Clamping torque
43510	FIXED_STOP_TORQUE	Fixed stop clamping torque

## 5.11.2 Setting data

### 5.11.2.1 Axis/spindle-specific setting data

Number	Identifier: \$SA_	Description
43510	FIXED_STOP_TORQUE	Fixed stop clamping torque

## 5.11.3 Signals

### 5.11.3.1 Signals to axis/spindle

DB number	Byte.Bit	Description
31, ...	16.0 - 16.2	Actual gear stages A, B, C
31, ...	21.0 - 21.2	Parameter set selection A, B, C
31, ...	21.3 - 21.4	Motor selection A, B
31, ...	21.7	Pulse enable

## 5.11.3.2 Signals from axis/spindle

DB number	Byte.Bit	Description
31, ...	60.4	Referenced/synchronized 1
31, ...	60.5	Referenced/synchronized 2
31, ...	62.5	Fixed stop reached
31, ...	92.0	Setup mode active
31, ...	92.1	Ramp-up function generator quick stop
31, ...	92.2	Torque limit 2 active
31, ...	92.3	Speed setpoint smoothing active
31, ...	93.0 - 93.2	Active parameter set A, B, C
31, ...	93.3 - 93.4	Active motor A, B
31, ...	93.5	Drive Ready
31, ...	93.6	Speed controller integrator disabled
31, ...	93.7	Pulses enabled
31, ...	94.0	Motor temperature prewarning
31, ...	94.1	Heat-sink temperature prewarning
31, ...	94.2	Ramp-up function completed
31, ...	94.3	_'M <sub>d</sub> ' < M <sub>dx</sub>
31, ...	94.4	_'n <sub>act</sub> ' < n <sub>min</sub>
31, ...	94.5	_'n <sub>act</sub> ' < n <sub>x</sub>
31, ...	94.6	_'n <sub>act</sub> ' = n <sub>set</sub>



# Travel to Fixed Stop (F1)

## 6.1 Product brief

### Customer benefit

The "Travel to fixed stop" function can be used for operations such as traversing tailstocks or sleeves to an end limit position in order to clamp workpieces.

### Features

- The clamping torque and a fixed stop monitoring window can be programmed in the parts program and can also be altered via setting data once the fixed stop has been reached.
- The "travel to fixed stop" function can be implemented for axes as well as for spindles with axis-traversing capability.
- The function can be implemented for several axes simultaneously and parallel to the motion of other axes.
- Torques or the power can be adjusted to a specific setting.
- Travel with limited torque/power (Force Control, FOC) can be activated.
- The "travel to fixed stop" functions can be enabled from synchronized actions.
- Block search with calculation, multi-channel (SERUPRO).  
Move axes with FXS and FOC in simulation mode.
- Vertical axes can also be moved with FXS to a fixed stop.
- With SW 6.4 and higher, VDI signals can be used to set a REPOS offset for each axis and display the FXS status currently active on the machine after the search target has been located.

## 6.2 General functionality

### 6.2.1 Functional sequence, programming, parameterization

#### Programming

Travel to fixed stop is selected or deselected with the following commands:

`FXS[Machine axis identifier]=1 (selected)`

`FXS[Machine axis identifier]=0 (deselected)`

The commands are modal.

The clamping torque is set with command:

`FXST[Machine axis identifier] = <Torque>`  
adjusted.

It is in % of the static torque for VSA of the drive:

(MD1118 MOTOR\_STANDSTILL\_CURRENT)

or in % of the engine torque for HSA drives:

(MD1130 MOTOR\_NOMINAL\_POWER)

entered.

The command is used for setting the width of the fixed stop monitoring window.

`FXSW[machine axis identifier] = monitoring window`

The unit is dependent on the default setting: mm, inch or degrees.

#### Channel axis identifier

Instead of the machine axis identifiers, it is also possible to use channel axis identifiers if the channel axis identifiers are assigned exactly to one machine axis.

##### Restrictions:

Channel identifiers may not be used (option disabled) for machine axes which have an active transformation or frame.

If the machine axis is a coupled axis (e.g. following axis), programming is prevented and alarm 14092 "Incorrect axis type" is displayed.

The movement to the destination point can be described as a path or positioning axis movement. With positioning axes, the function `FXS` can be performed across block boundaries. The function may also be selected for several machine axes simultaneously.

The `FXST` and `FXSW` commands are optional.

The travel path and the command which activates that function **must be programmed in one block** (exception: Synchronized actions).

## Examples

### With machine axis identifiers:

```
X250 Y100 F100 FXS[X1]=1  
X250 Y100 F100 FXS[X1]=1 FXST[X1]=12.3  
X250 Y100 F100 FXS[X1]=1 FXST[X1]=12.3 FXSW[X1]=2 ; mm  
X250 Y100 F100 FXS[X1]=1 FXSW[X1]=2 ; mm
```

#### References:

/PG/ "Programming Guide: Fundamentals"

### Channel axis identifier with unambiguous machine axis assignment:

For the purpose of illustrating the differences in programming, channel axis X is programmed as the image of machine axis AX1 [or X1 (Name in machine parameter: MD10000 \$MN\_AXCONF\_MACHAX\_NAME\_TAB)]

#### Programming with machine axis identifiers

```
FXS[X1] = 1 ; Selecting X1  
FXST[X1] = 10 ; New torque for X1  
FXSW[X1] = 5 ; New window for X1
```

#### Programming with channel axis identifiers

```
FXS[X] = 1 ; Selecting X ->X1  
FXST[X] = 10 ; New torque X ->X1  
FXSW[X] = 5 ; New window for X -> X1
```

All four of the following programming lines have the same effect when the channel axis X is imaged on the machine axis AX1, X1:

```
Z250 F100 FXS[AX1]=1 FXST[AX1]=12.3 FXSW[AX1]=2000  
Z250 F100 FXS[X1]=1 FXST[X1]=12.3 FXSW[X1]=2000  
Z250 F100 FXS[X]=1 FXST[X]=12.3 FXSW[X]=2000  
Z250 F100 FXS[X]=1 FXST[X1]=12.3 FXSW[AX1]=2000
```

## Functional sequence

The function is explained by the example below (sleeve is pressed onto workpiece).

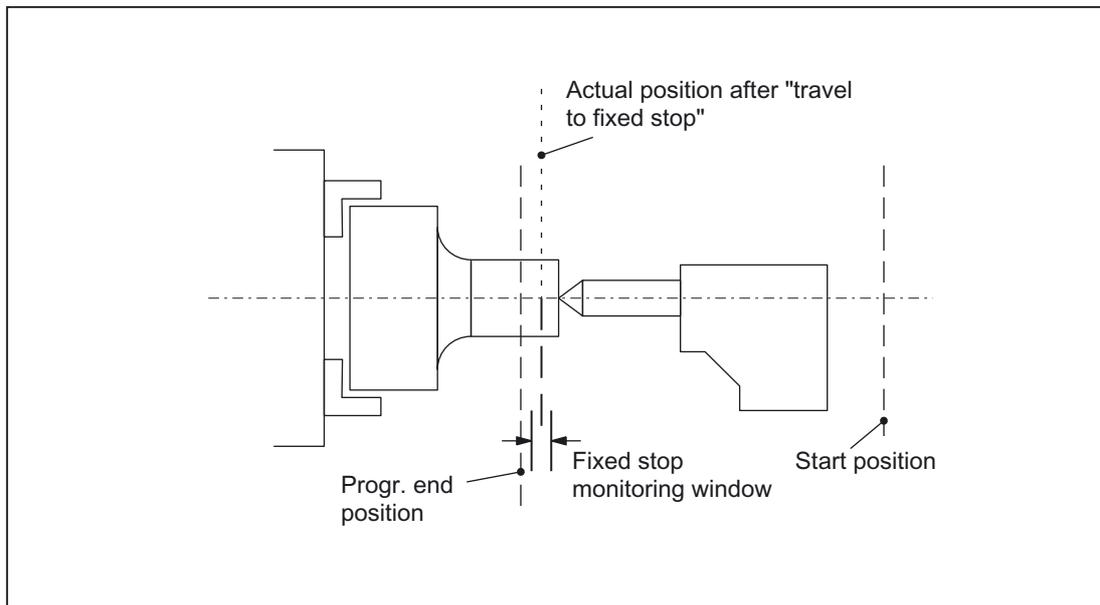


Figure 6-1 Example of travel to fixed stop

### Selection

The NC detects that the function "travel to fixed stop" is selected via the command `FXS[x]=1` and signals the PLC via the NST DB31, ... DBX62.4 ("Activate travel to fixed stop") that the function has been selected.

If the machine data:

`MD37060 FIXED_STOP_ACKN_MASK`

(Monitoring of PLC acknowledgments for travel to fixed stop)

is set correspondingly, the acknowledgement of the PLC via the NST DB31 is, ... DBX3.1 ("Enable travel to fixed stop") is waited for.

The programmed target position is then approached from the start position at the programmed velocity. The fixed stop must be located between the start and target positions of the axis/spindle. A programmed torque limit is effective from the start of the block, i.e. the fixed stop is also approached with reduced torque. Allowance for this limitation is made in the NC through an automatic reduction in the acceleration rate.

If no torque has been programmed in the block or since the start of the program, then the value is valid in the axis-specific machine data:

`MD37010 $MA_FIXED_STOP_TORQUE_DEF`

(Default setting for clamping torque)

## Fixed stop reached

As soon as the axis comes into contact with the mechanical fixed stop (workpiece), the closed-loop control in the drive raises the torque so that the axis can move on. The torque rises up to the programmed limit value and then remains constant.

The "Fixed point reached" status can be calculated as follows depending on the machine data:

MD37040 \$MA\_FIXED\_STOP\_BY\_SENSOR (fixed stop recognition by sensor)

- FIXED\_STOP\_BY\_SENSOR = 0

The "Fixed stop reached" status is achieved when the axial contour deviation (= difference between actual and expected following error) has exceeded the value set in machine data:

MD37030 \$MA\_FIXED\_STOP\_THRESHOLD (Threshold for fixed stop detection)

- FIXED\_STOP\_BY\_SENSOR = 1

External sensor signals the NC via the PLC, with the NST DB31, ... DBX1.2 ("Sensor fixed stop"), the state "Fixed stop reached".

- FIXED\_STOP\_BY\_SENSOR = 2

The "Fixed stop reached" status is active either when the status has been detected by the contour monitoring function or when the external sensor signals this status by a signal change from 0 " 1 to (DB31,...DBX 1.2).

The axis contour deviation is explained in:

### References:

/FB1/ Function Manual, Basic Function; Diagnostics tool (D1)

## Internal processes

Once the NC has detected the "Fixed stop reached" status, it deletes the distance-to-go and the position setpoint is made to follow. The controller enabling command remains active.

Subsequently the PLC is through the NST DB31, ... DBX62.5 ("Fixed stop reached") informed.

If the machine data:

MD37060 \$MA\_FIXED\_STOP\_ACKN\_MASK

is set correspondingly, the acknowledgement of the PLC via the NST DB31 is, ... DBX1.1 ("Acknowledge fixed stop reached") is waited for.

The NC then executes a block change or considers the positioning motion to be completed, but still leaves a setpoint applied to the drive actuator to allow the clamping torque to take effect.

The fixed stop monitoring function is activated as soon as the stop position is reached.

### Monitoring window

If no fixed stop monitoring window was programmed in the block or from program start, then the value is valid in the machine data:

MD37020 \$MA\_FIXED\_STOP\_WINDOW\_DEF

(Default for fixed stop-monitoring window)

If the axis leaves the position it was in when the fixed stop was detected, then alarm 20093 "Fixed stop monitoring has responded" is displayed and the "Travel to fixed stop" function deselected.

The window must be selected by the user such that the alarm is activated only when the axis leaves the fixed stop position.

### Enabling the fixed stop alarms

With the machine data:

MD37050 \$MA\_FIXED\_STOP\_ALARM\_MASK

enabling the fixed stop alarms can be established as follows:

MD 37050 = 0	Fixed stop not reached (suppress alarm 20091)
MD 37050 = 2	Fixed stop not reached (suppress alarm 20091) and fixed stop aborted (suppress alarm 20094)
MD 37050 = 3	Fixed stop aborted (suppress alarm 20094)

All other permissible values of 7 or less do not suppress any alarms.

Using the parts program command `NEWCONF` a new setting can be activated.

### Fixed stop is not reached

If the programmed end position is reached, without detecting the state "fixed stop reached", then depending on the state of the machine data:

MD37050 \$MA\_FIXED\_STOP\_ALARM\_MASK (Release of fixed stop alarms)

the alarm 20091 "Fixed stop not reached" is output.

### Function abort

If the "Travel to fixed stop" function is aborted owing to a pulse cancellation command, cancelation of PLC acknowledgments or a Reset in the approach block, the display or suppression of alarm 20094 can be controlled via machine data:

MD37050 \$MA\_FIXED\_STOP\_ALARM\_MASK

### **Abort without alarm**

The travel to fixed stop can be aborted by the PLC in the approach block without triggering an alarm (for example, when the operator actuates a key), if in the machine data:

MD37050 \$MA\_FIXED\_STOP\_ALARM\_MASK

the alarm 20094 is suppressed.

The Travel to fixed stop function is deselected in response to both "Fixed stop not reached" and "Fixed stop aborted".

### **Interrupts**

If the fixed stop position is not reached when the function is active, alarm 20091 "Fixed stop not reached" is output and a block change executed.

If a travel request (e.g. from the part program, the PLC, from compile cycles or from the operator panel) is provided for an axis after the fixed stop has been reached, the alarm 20092 "Travel to fixed stop still active" is output and the axis is not moved.

If an axis has reached the fixed stop and is then moved out of this position by more than the value specified in

SD FIXED\_STOP\_WINDOW (Fixed stop monitoring window)

from the position, then the alarm 20093 "Standstill monitoring has triggered at the stop" is given, the function "Travel to fixed stop" for this axis is deselected and the system variable is set \$AA\_FXS[x]=2.

### **No termination during alarm**

"Travel to fixed stop" remains active from now on for alarms,  
if the bit values in the machine data:

MD37052 \$MA\_FIXED\_STOP\_ALARM\_REACTION

were set.

IS "Mode group ready" (DB11, ... DBX6.3) remains active.

### **Alarm suppression after new programming**

Travel to fixed stop can be used for simple measuring processes.

For example, it is possible to carry out a check for tool breakage by measuring the tool length by traversing onto a defined obstacle. To do so, the fixed stop alarm must be suppressed. When the function for clamping workpieces is then used "normally," the alarm can be activated using parts program commands.

### Sequence in case of a fault or abnormal termination

The NST DB31, ... DBX62.4 ("Activate travel to fixed stop") is reset.

Depending on the machine data:

MD37060 \$MA\_FIXED\_STOP\_ACKN\_MASK

the acknowledgement of the PLC is awaited through resetting of the NST

DB 31, ... DBX3.1 ("Enable travel to fixed stop") is waited for.

The torque limitation is then canceled and a block change executed.

### Deselection

The NC recognizes the function deselection via programming of the command `FXS[x]=0`. Then an advance stop (`STOPRE`) is internally released, since it can't be foreseen where the axis will be after deselection.

The torque limitation and monitoring of the fixed stop monitoring window are canceled.

The NST DB31, ... DBX62.4 ("Activate travel to fixed stop") and DB31, ... DBX62.5 ("Fixed stop reached") are reset.

Depending on the machine data:

MD37060 \$MA\_FIXED\_STOP\_ACKN\_MASK

the acknowledgement of the PLC is awaited through resetting of the NST

DB 31, ... DBX3.1 ("Enable travel to fixed stop").and/or

DB 31, ... DBX1.1 ("Acknowledge fixed stop reached") is waited for.

The axis will then change to position control. The follow-up mode of the position setpoints is ended and a synchronization to the new actual position is carried out.

A programmed traverse motion can then be executed. This motion must lead away from the fixed stop or else the stop or even the machine may sustain damage.

A block change is executed after the target position has been reached.

### Multiple selection

A selection may only be carried out once. If the function is called once more due to faulty programming (`FXS[Axis]=1`) the alarm 20092 "Travel to fixed stop still active" is initiated.

### Block-related synchronized actions

By programming a block-related synchronized action, travel to fixed stop can be connected during an approach motion.

Programming example:

```
N10 G0 G90 X0 Y0
N20 WHEN $AA_IW[X]>17 DO FXS[X]=1           ; If X reaches a position greater
N30 G1 F200 X100 Y110                       ; 17mm FXS is activated
```

### Changing the clamping torque and fixed stop monitoring window

The clamping torque and the monitoring window can be changed with the commands `FXST[x]` and `FXSW[x]`. The changes take effect before traversing movements in the same block.

Programming of a new fixed stop monitoring window causes a change not only in the window width but also in the reference point for the center of the window if the axis has moved prior to reprogramming. The actual position of the machine axis when the window is changed is the new window center point.

### Terminal 663 with MD37002 controllable

With the machine data:

`MD37002 $MA_FIXED_STOP_CONTROL`

the response in the case of pulse inhibit at the stop is controlled.

Deleting the pulses by terminal 663 or the "Pulse enable" IS DBX31, ...DBX21.7 will not abort the function. As a result, the drive will press against the fixed stop again without any further operating action when the machine is restarted.

The rise time of the torque corresponds to the time needed by the current controller of the drive to reach the limitation again.

If the pulses are deleted when a deselection is active (waiting for PLC acknowledgments), the torque limit will be reduced to zero. If the pulses are reactivated during this phase, torque is no longer built up. Once the deselection has been completed, you can continue traversing as normally.

### FXS commands programmable in synchronized actions

The parts program commands `FXS`, `FXST` and `FXSW` can be programmed in synchronized actions/technology cycles.

The function `FXS[x]=1` can also be activated without movement; the torque is limited immediately. As soon as the axis is moved via a setpoint, the limit stop monitor is activated.

In static and blockrelated synchronized actions, the same commands `FXS`, `FXST`, `FXSW` can be used as in the normal parts program run. The values assigned can result from a calculation.

### Ramp for torque limitation with MD37012

A ramp has been implemented so that the setting of a torque limit is not too jerky.

For this in the machine data:

MD37012 \$MA\_FIXED\_STOP\_TORQUE\_RAMP\_TIME

defining the length of the ramp until the new torque limit is reached.

## 6.2.2 Response to RESET and function abort

### Response to RESET

During selection (fixed stop not yet reached) the function `FXS` can be aborted with `RESET`. The termination is carried out such that an "almost achieved" fixed stop (setpoint already beyond the fixed stop, but still within the threshold for the fixed stop detection) will not result in damage.

This is achieved by synchronizing the position setpoint to the new actual position. As soon as the fixed stop is reached, the function remains operative even after `RESET`.

### Function abort

A function abort can be triggered by the following events:

- EMERGENCY STOP:
  - With an 840D control, the NC and drive are disconnected from the supply after EMERGENCY STOP, i.e. the PLC must react.
  - With an 840Di control, the NC and drive are disconnected from the supply after EMERGENCY STOP, i.e. the PLC must react.



#### CAUTION

Make sure that after canceling the function "travel to fixed stop" by "EMERGENCY STOP," no dangerous machine situation (MD37002 \$MA\_FIXED\_STOP\_CONTROL e.g. canceling pulse disable) can arise.

- The fixed stop monitoring function responds in the case of:
  - Exit from fixed stop position by axis
  - Tool breakage
  - Pulse disable

## 6.2.3 Block search response

### Block search with calculation

The response is as follows:

- If the target block is located in a program section in which the axis must stop at a fixed limit, then the fixed stop is approached if it has not yet been reached.
- If the target block is located in the program section in which the axis must not stop at a fixed limit, then the axis leaves the fixed stop if it is still positioned there.
- If the desired fixed stop status is reached, alarm message 10208 "press NC Start to continue the program" is output. The program can be continued after pressing NC Start to acknowledge.
- At the start of the target block, `FXST[x]` and `FXSW[x]` are set to the same value as they would have during normal program processing.

### Block search without calculation

The commands `FXS`, `FXST` and `FXSW` are ignored.

### FOC

`FOCON/FOCOF` is activated modally. It is already active in the approach block.

### SERUPRO

#### Block search with calculation, multi-channel

The block search in program test mode is designated SERUPRO and is derived from the "Search-Run by Program test." This search mode allows the user a multi-channel block search with calculation of all required status data from the previous history.

The PLC interface is updated in this block search and matching processes, which cover the interaction of several channels executed within the framework of this block search correctly.

#### Search process with FXS and FOC

The user selects `FXS` or `FOC` in a program area of the searched target block in order to acquire all states and functions of this machining last valid. The NC will start the selected program in Program test mode automatically. After the target block has been found, the NC stops at the beginning of the target block, deselects Program test internally again and displays the Stop condition "Search target found" in its block display.

If `FXS` "travel to fixed stop" is located between the beginning of the program and the search target, the instruction is not really executed by the NC. The motion is only simulated up to the programmed end point.

 <b>CAUTION</b>
SERUPRO approach does not really take the statement <code>FXS</code> into account. The approach to the programmed end position of the <code>FXS</code> block is only simulated <b>without torque limitation</b> .

The user can log the turning on and turning off of `FXS` in the parts program. If necessary, the user can start an `ASUB` in order to activate or deactivate `FXS` in this `SERUPRO-ASUP`.

### `$AA_FXS` and `$VA_FXS`

In SW 6.2 and higher, the meaning of system variable `$AA_FXS` is redefined for `SERUPRO` only and completely replaced by variable `$VA_FXS`. Variables `$AA_FXS` and `$VA_FXS` have the same values continuously outside the `SERUPRO` function.

Description	NCK Variables
Axis not at fixed stop	<code>\$AA_FXS = 0</code> and <code>\$VA_FXS = 0</code>
Fixed stop successfully approached	<code>\$AA_FXS = 1</code> and <code>\$VA_FXS = 1</code>
Approach to fixed stop failed	<code>\$AA_FXS = 2</code> and <code>\$VA_FXS = 2</code>
Travel to fixed stop selection active	<code>\$AA_FXS = 3</code> and <code>\$VA_FXS = 3</code>
Fixed stop detected	<code>\$AA_FXS = 4</code> and <code>\$VA_FXS = 4</code>
Travel to fixed stop deselection active	<code>\$AA_FXS = 5</code> and <code>\$VA_FXS = 5</code>

### Course of values

Course of values of system variables `$VA_FXS[ ]` with values 1 to 5

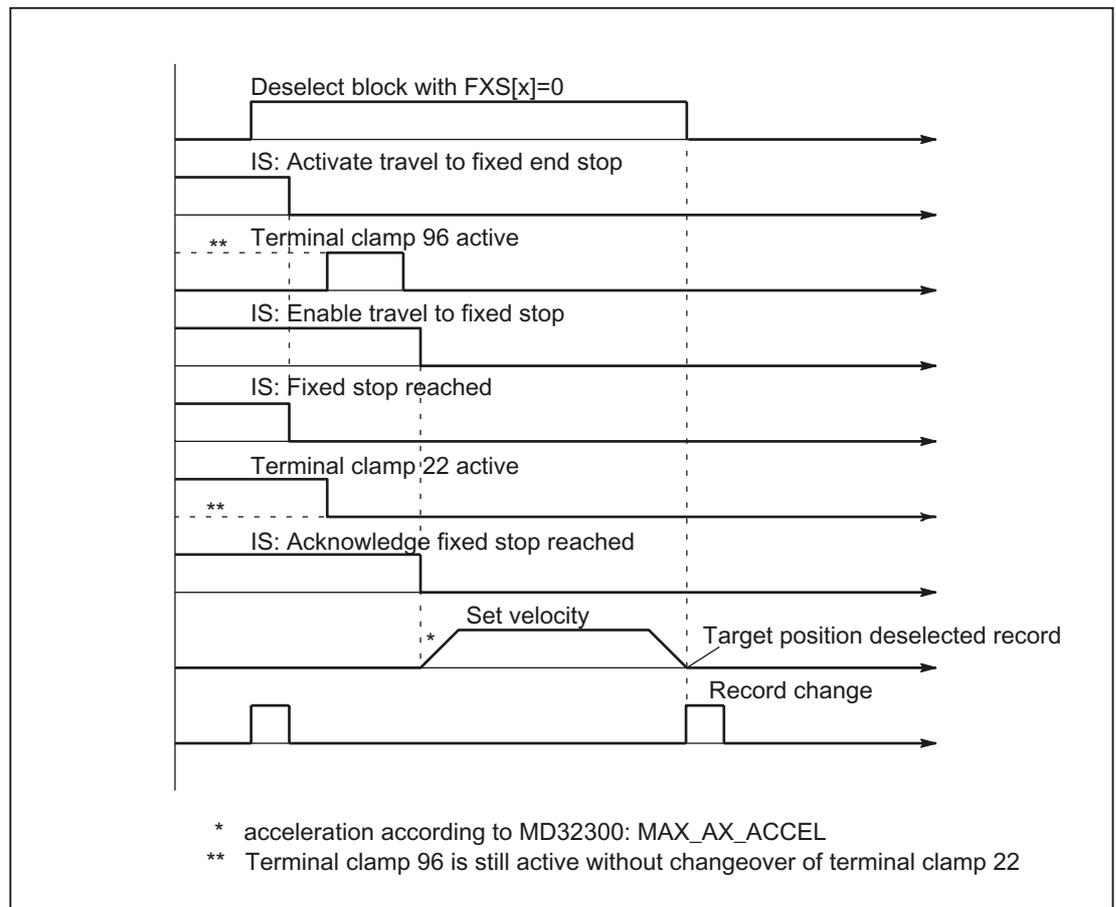


Figure 6-2 Diagram for FXS with a digital drive (611 digital)

### \$AA\_FXS Simulate axis traversal

System variable \$AA\_FXS displays the current status of program simulation "program-sensitive system variable."

### Example

If in the SERUPRO process axis Y traversal is simulated with  $FXS[Y]=1$ , then \$AA\_FXS has a value of 3.

If in the SERUPRO process axis Y traversal is simulated with  $FXS[Y]=0$ , then \$AA\_FXS has a value of 0.

During simulation with SERUPRO, \$AA\_FXS cannot have the values 1, 2, 4, 5, since the actual status of \$VA\_FXS "travel to fixed stop" can never be detected.

### Note

The state \$AA\_FXS = 1 is never reached during the SERUPRO operation. This means that other program branches can be processed which will produce different results due to the simulation.

If after the SERUPRO process axis Y is traversed again, then variables \$AA\_FXS and \$VA\_FXS are assigned the same values again.

### \$VA\_FXS Real machine status

Variable \$VA\_FXS always describes the real machine status.

In this way, the actual existing machine status of the corresponding axis with \$VA\_FXS is displayed.

### Setpoint/actual status comparison

The two system variables \$AA\_FXS and \$VA\_FXS can be used to compare the setpoint and actual states in the parts program. The SERUPRO ASUP routine is then as follows:

#### SERUPRO ASUP

Asup fxsSeruproAsup.mpf

;The setpoint and actual states are compared for the  
;REPOSA block FXS to correspondingly activate or deactivate.

```
N1000 WHEN ($AA_FXS[X]==3) AND ($VA_FXS[X]==0) DO FXS[X]=1  
N2000 WHEN ($AA_FXS[X]==0) AND ($VA_FXS[X]==1) DO FXS[X]=0  
N1020 REPOSA
```

### Display REPOS Offset

Once the search target has been found, for each axis of the FXS-state prevailing on the machine through the axis VDI-signals:

NST DB31, ... DBX62.4 ("Activate travel to fixed stop").

and

NST DB31, ... DBX62.5 ("Fixed stop reached")

displayed.

### Example

If the machine is at the fixed stop, and the block search has reached a block after deselection of FXS, the new target position is displayed via NST DB31, ... DBX62.5 ("Fixed stop reached") as REPOS offset.

### FXS fully automatically in REPOS

With REPOS the functionality of FXS is repeated automatically and designated FXS-REPOS below. This sequence is comparable to the program "fxsSeruproAsup.mpf." Every axis is taken into account and the torque last programmed before the search target is applied.

The user can treat FXS separately in a SERUPRO-ASUP.

The following then applies:

Every FXS action executed in SERUPRO-ASUP automatically takes care of

\$AA\_FXS[X] == \$VA\_FXS[X].

This deactivates FXS-REPOS for axis X.

## Deactivate FXS REPOS

FXS-REPOS is deactivated by:

- an FXS synchronous action which refers to REPOSA  
or
- \$AA\_FXS[X] == \$VA\_FXS[X] in SERUPRO\_ASUP.

---

### Note

A SERUPRO-ASUP **without** FXS handling or no SERUPRO-ASUP results in fully automatic FXS-REPOS.

---

 <b>CAUTION</b>
--

FXS-REPOS moves all path axes in a path grouping to the target position. Axes with and without FXS treatment thus traverse together with the G code and feedrate valid at the time the target block is processed. As a result, the fixed stop may be approached in rapid traverse(G0) or higher velocity.
---

## FOC fully automatically in REPOS

The FOC-REPOS function behaves analogously to the FXS-REPOS function.

---

### Note

A continuously changing torque characteristic cannot be implemented with FOC-REPOS.

---

## Example

A program moves axis X from 0 to 100 and activates FOC every 20 millimeters for 10 millimeters at a time. This torque characteristic is generated with nonmodal FOC and therefore cannot be traced by FOC-REPOS. FOC-REPOS will traverse axis X from 0 to 100 with or without FOC.

For programming examples of FXS "travel to fixed stop," please see:

**References:**

/FB1/ Function Manual, Basic Functions; Mode Group, Channel, Program Operation (K1);  
Section: Program test

## 6.2.4 Miscellaneous

### Setting data

The following axis-specific setting data are provided for the "Travel to fixed stop" function:

SD43500 \$SA\_FIXED\_STOP\_SWITCH (selection of travel to fixed stop)

SD43510 \$SA\_FIXED\_STOP\_TORQUE (clamping torque for travel to fixed stop)

SD43520 \$SA\_FIXED\_STOP\_WINDOW (fixed stop monitoring window)

The setting data are effective only when the axis has reached the fixed stop.

The status of the setting data is displayed via the operator panel in the "Parameters" area.

The commands `FXS[x]`, `FXST[x]` and `FXSW[x]` effect a blocksynchronous change in these setting data.

If `FXST[x]` and `FXSW[x]` are not programmed, then, if "Travel to fixed stop" is activated, the defaults from the machine data:

MD37010 \$MA\_FIXED\_STOP\_TORQUE\_DEF

and

MD37020 \$MA\_FIXED\_STOP\_WINDOW\_DEF

are accepted into the appropriate setting data.

The setting data for clamping torque and fixed stop monitoring window can be changed by the operator and via the PLC. It is thus possible to specify a higher or lower clamping torque or a modified fixed stop monitoring window after the fixed stop has been reached.

### Changing the clamping torque using the ramp and values greater than 100%

A clamping torque change is transferred to the drive step-like. It is possible to specify a ramp always such that a modified torque limit is reached via machine data:

MD37012 \$MA\_FIXED\_STOP\_TORQUE\_RAMP\_TIME

### Clamping torque greater than 100%

Values greater than 100% for the setting data:

SD43510 \$SA\_FIXED\_STOP\_TORQUE

are only meaningful for a short time.

Irrespectively, the maximum torque is limited by the drive.

The drive machine data have a limiting effect, i.e.:

MD1103 Motor current

MD1104 Maximum motor current

MD1105 Reduction in max. motor current

MD1230/1231 Torque limiting value 1/2

For further information, please refer to the Planning Guide SIMODRIVE Three-Phase Motors for Feed and Main Spindle Drives and to the appropriate document regarding the hydraulic module /FBHLA/.

**References:**

/FBHLA/ Description of Functions HLA module

**Status query in the parts program**

System variable \$AA\_FXS[x] indicates the status of the "travel to fixed stop" function.

It has the following coding:

\$AA_FXS=0	Axis not at fixed stop.
\$AA_FXS=1	Fixed stop has been approached successfully (axis is within fixed stop monitoring window).
\$AA_FXS=2	Approach to fixed stop has failed (axis is not at fixed stop).
\$AA_FXS=3	Travel to fixed stop activated.
\$AA_FXS=4	Fixed stop detected.
\$AA_FXS=5	Travel to fixed stop is deselected. The deselection is not yet completed.

Query of the system variable in the parts program initiates a block search stop.

As a result of the status query in the parts program, it is possible, for example, to react to an erroneous operational sequence of the "Travel to fixed stop" function.

The following is assumed in the example below:

MD37050 \$MA\_FIXED\_STOP\_ALARM\_MASK = 0

⇒ No alarm is generated in response to an error. A block change therefore takes place and the error scenario can be evaluated via the system variable

**Example**

```
X300 Y500 F200 FXS[X1]=1 FXST[X1]=25 FXSW[X1]=5
IF $AA_FXS[X1]=2 GOTOF FXS_ERROR
G01 X400 Y200
```

**Inoperative IS signals**

The following IS signals (PLC → NCK) are inoperative for axes at the fixed stop until the function is deselected (incl. traversing motion):

- NST DB31, ... DBX1.3 ("Axis/spindle disable")
- NST DB31, ... DBX2.1 ("Controller enable")

### Actual position at fixed stop

System variable \$AA\_IM[x] can determine the actual position of the machine axis, e.g. for test purposes after successful "travel to fixed stop."

### Combination with other functions

"Measure with deletion of distance to go" (command MEAS) and "travel to fixed stop" cannot be programmed at the same time in one block.

Exception:

One function is acting on a path axis while the other is acting on a positioning axis or both functions are acting on positioning axes.

### Contour monitoring

The axis contour monitoring function is inoperative while "Travel to fixed stop" is active.

### Positioning axes

When "Travel to fixed stop" is applied to POSA axes, block changes are made independently of the fixed stop motion.

### Vertical axes

The "Travel to fixed stop" function can be used for vertical axes even when alarms are active.

Should the traversal of vertical axes be aborted as a result of an FXS alarm, the relevant drives are not disconnected from the supply via the VDI interface.

This functionality has the same effect on vertical axes as an electronic weight compensation and can be configured via machine data:

MD37052 \$MA\_FIXED\_STOP\_ALARM\_REACTION

---

#### Note

For further details about adaptations for SIMODRIVE 611 digital or digital (HLA module), please see:

#### References:

/FB2/ Function Manual, Extended Functions, Compensation (K3); Section: Electronic weight compensation

---

## MD37052

With the machine data:

MD37052 \$MA\_FIXED\_STOP\_ALARM\_REACTION

does not result in disconnection of the drive from the power supply when an alarm is generated, while the NST DB11, ... DBX6.3 ("Mode group ready") remains active.

### Bit value=0:

The alarms have an effect on `FXS` (drive becomes disconnected as previously).

NST DB11, ... DBX6.3 ("Mode group ready") is reset.

### Bit value=1:

The alarms have no effect on `FXS`. NST DB11, ... DBX6.3 ("Mode group ready") remains active.

Bit 0: Alarm 20090	Travel to fixed stop cannot be programmed
Bit 1: Alarm 20091	Fixed stop is not reached.
Bit 2: Alarm 20092	Travel to a fixed stop active.
Bit 3: Alarm 20093	Standstill monitoring on fixed stop is triggered.
Bit 4: Alarm 20094	Travel to fixed stop aborted.

### 6.2.5 Supplementary conditions for expansions

#### Response to pulse blocking

The cancellation of pulse enable either through terminal 663 or through NST DB31, ... DBX21.7 ("Pulse enable") is denoted below as pulse inhibit.

The machine data:

MD37002 \$MA\_FIXED\_STOP\_CONTROL

can be used to influence the interaction of travel to fixed stop and pulse blocking.

Bit 0: Response in case of pulse blocking at stop as follows:

Bit 0 = 0	Travel to fixed stop aborted.
Bit 0 = 1	Travel to fixed stop is interrupted, i.e. the drive becomes powerless.

Once the pulse blocking is canceled again, the drive will press at the limited torque again. The torque is actuated step-like.

At the fixed stop, the drive can be controlled either via:

- NST DB31, ... DBX21.7 ("Pulse enable")
- or
- Drive monitor 663 pulse enable

The NC evaluates the NST DB31, ... DBX21.7 ("Pulse enable") by itself.

Depending on the drive machine data:

MD1012 \$MD\_FUNC\_SWITCH

In the case of FXS the NC responds to a change of state of the terminal 663 as follows:

Bit 2 = 0	The NC does <b>not</b> receive the status of terminal 663.
Bit 2 = 1	The NC does not receive the status of terminal 663.

#### Terminal 663

When pulse enabling is canceled by terminal 663, the drive is de-energized and coasts to a standstill immediately.

In the case of:

MD1012 \$MD\_FUNC\_SWITCH, Bit 2 = 0

this is not signalled to the NC.

The status can be checked in the line "Pulse enable" (terminal 663) in service display service drive.

**Note**

Travel to fixed stop can be aborted by blocking the pulse of NST " DB31, ...DBX21.7 ("Pulse enable") or the terminal 663 only, if:

MD37002 \$MA\_FIXED\_STOP\_CONTROL, Bit 0 = 0

and

MD1012 \$MD\_FUNC\_SWITCH, Bit 2 = 1

is met.

If on the one hand FXS should be interrupted, and on the other hand, "Travel to fixed stop", the following settings are required:

MD37002 \$MA\_FIXED\_STOP\_CONTROL, Bit 0 = 0

and

MD1012 \$MD\_FUNC\_SWITCH, Bit 2 = 0.

---

### Programming FXS in synchronized actions

The function is **not** available for analog axes (PLC acknowledgment cannot be awaited).

**Select FXS[ ]=1:**

The following signal interfaces are set:

Message to PLC:

NST DB31, ... DBX62.4 ("Activate travel to fixed stop").

The FXS selection command can **only** be used in systems with digital drives (VSA, HSA, HLA).

Following condition **must** be observed:

MD37060 \$MA\_FIXED\_STOP\_ACKN\_MASK, Bit 0 = 0

Bit 0 = 1 (waiting for PLC acknowledgement) must **not** be set, otherwise, an interpolator stop would be required to acknowledge the signal, interrupting the movement.

**Deselect FXS[ ]=0:**

The following signal interfaces are reset:

Message to PLC:

NST DB31, ... DBX62.4 ("Activate travel to fixed stop").

The machine data:

MD37060 \$MA\_FIXED\_STOP\_ACKN\_MASK

must contain the value zero for signal deselection **without** motion stop.

### Without ramp

The torque limit is changed without taking into account the ramp if:

- `FXS` is activated with (`FXS [] = 1`), to make sure that the reduction is activated immediately (especially for synchronized actions).
- The drive needs to be de-energized as quickly as possible in the event of a fault.

### Selection of FXS with G64

In the machine data:

MD37060 `$MA_FIXED_STOP_ACKN_MASK`

Bit 0 must be = 0 (Do not wait for PLC-input signal "Enable travel to fixed stop"), since the selection of `FXS` may not initiate a motion stop.

### Modify the torque FXST

The clamping torque can already be modified when approaching the stop.

The torque limit `FXST` acts in addition to the acceleration limitation with `ACC`.

The new torque taking into account the ramp

(MD37012 `$MA_FIXED_STOP_TORQUE_RAMP_TIME`)

becomes active one interpolation cycle after the change in the drive.

A change of the effective torque can be checked by reading the synchronized action variable `$VA_TORQUE[axis]`.

## 6.2.6 Travel with limited moment/force FOC:

### Function

For applications in which torque or force are to be changed dynamically depending on the travel or on the time or on other parameters (e.g. pressing), the following functionality FOC (Force Control) is provided.

Force/travel or force/time profiles are thus possible using the "Interpolation cycle" resolution.

The function allows torque/force to be modified at any time using synchronized actions.

The function can be activated modally or block-related.

### Modal activation (FOCON/FOCOF)

The activation of the function after `POWER_ON` and `RESET` is determined by the machine data:

MD37080 \$MA\_FOC\_ACTIVATION\_MODE

Table 6-1 Controlling the initial setting of the modal limitation of torque/force

	After	Value	Effect
<b>Bit 0</b>	Power On	0	FOCOF
		1	FOCON
<b>Bit 1</b>	RESET	0	FOCOF
		1	FOCON

FOCON: Activation of the modally effective torque/force limitation

FOCOF: Disable torque/force limitation

The modal activation acts beyond the program end.

If already programmed, it is effective with `FXST` set torque/force.

`FXST` can be programmed irrespectively of `FOCON`; it comes into effect, however, only after the function has been activated.

## Programming

The programming of the axis is carried out in square brackets.

The following are permissible:

- Geometry axis identifiers
- Channel axis identifiers
- Machine axis identifiers

### Example:

```
N10 FOCON[X] ; Modal activation of the torque limit
N20 X100 Y200 FXST[X]=15 ; X travels with reduced torque (15%)
N30 FXST[X]=75 X20 ; Changing the torque to 75%.
; X travels with this reduced torque.
N40 FOCOF[X] ; Disable torque limit
```

## Block-related limit (FOC)

The parts program command `FOC` activates the torque limit for a block.

An activation from a synchronized action takes effect up to the end of the current parts program block.

## Priority FXS/FOC

An activation of `FXS` with `FOC` active has priority, i.e. `FXS` is executed.

A deselection of `FXS` will cancel the clamping.

A modal torque/force limitation remains active.

After `PowerOn` the activation takes effect with the machine data:

`MD37010 $MA_FIXED_STOP_TORQUE_DEF.`

This torque can be modified at any time by programming `FXST`.

## Synchronized actions

The language commands `FOC`, `FOCON`, `FOCOF` can also be programmed in synchronized actions as the commands for "travel to fixed stop."

## Determine FOC status

The activation status can be read at any time via the status variable `$AA_FOC`.

If `FXS` is also activated, the status is not changed.

- 0: `FOC` not active
- 1: `FOC` modal active
- 2: `FOC` block-related active

## Determine torque limit status

The system variables \$VA\_TORQUE\_AT\_LIMIT can be used at any time to read in systems with digital drives (FDD, MSD, HLA) whether the currently active torque corresponds to the given torque limit.

- 0: Effective torque less than torque limit value
- 1: Effective torque has reached the torque limit value

## Restrictions

The function FOC is subject to the following restrictions:

- The change of the torque/force limitation representing itself as an acceleration limitation is **only taken into account in the traversing movement at block limits** (see command ACC).
- Only FOC:
  - No monitoring** is possible from the VDI interface to check that the active torque limit has been reached.
- If the acceleration limitation is not adapted accordingly, an increase of the drag distance during the traversing motion occurs.
- If the acceleration limitation is not adapted accordingly, the end-of-block position is possibly reached later than specified in:  
MD36040 \$MA\_STANDSTILL\_DELAY\_TIME

The machine data:  
MD36042 \$MA\_FOC\_STANDSTILL\_DELAY\_TIME  
is introduced for this and monitored in this status.

## Possible application link and container axes

All axes that can be traversed in a channel, i.e. also link axes and container axes, can be traversed to fixed stop.

### References:

/FB2/ Function Manual, Extended Functions; Several Control Panels on Multiple NCUs, Distributed Systems (B3)

The status of the machine axis is kept in the case of a container switch, i.e. a clamped machine axis remains at the stop.

If a modal torque limitation has been activated with FOCON, this is kept for the machine axis even after a container switch.

## 6.3 Travel to fixed stop with analog drives

### 6.3.1 SIMODRIVE 611 digital (VSA/HSA)

#### Selection

The NC detects that the function "travel to fixed stop" is selected via the command `FXS[x]=1` and signals the PLC via the interface signal DB31, ... DBX62.4 ("Activate travel to fixed stop") that the function has been selected.

If the machine data:

MD37050 `FIXED_STOP_ACKN_MASK`

is set correspondingly, the acknowledgement of the PLC via the NST

DB 31, ... DBX3.1 ("Enable travel to fixed stop") is awaited.

and after that the function is started.

This acknowledgment is not required by the NC for digital drives.

The axis now traverses to the target position at the programmed velocity. At the same time, the clamping torque (specified via `FXST[x]`) is transferred to the drive via the digital interface, and this limits its effective torque. In addition, the acceleration is reduced accordingly in the NC automatically acc. to `FXST[x]`).

#### Fixed stop reached

As soon as the axis reaches the fixed stop, the axial contour deviation increases.

If the threshold entered in the machine data:

MD37030 `FIXED_STOP_THRESHOLD`

is exceeded or the NST signal DB31, ... DBX1.2 ("Sensor fixed stop") is set, the control system detects that the fixed stop has been reached.

The NC will then delete the distance to go and will synchronize the position setpoint to the current actual position value. The controller enabling command remains active.

Subsequently the NC triggers the NST DB31, ... DBX62.5 ("Fixed stop reached") on the PLC.

If the machine data:

MD37060 `FIXED_STOP_ACKN_MASK`

is set correspondingly, the acknowledgement of the PLC via the NST DB31 is, ... DBX1.1 ("Acknowledge fixed stop reached") is waited for.

This acknowledgment is not required by the NC for digital drives.

Then a block change is executed. The clamping torque continues to be applied.

### **Fixed stop is not reached**

If the programmed end position is reached, without the state "Fixed stop reached" being recognized, then the torque limitation in the drive is cancelled through the digital interface and the NST DB31, ... DBX62.4 ("Activate travel to fixed stop") is reset.

Depending on the machine data:

MD37060 FIXED\_STOP\_ACKN\_MASK

the acknowledgement of the PLC is awaited through resetting of the NST

DB 31, ... DBX3.1 ("Enable travel to fixed stop") is awaited.

and then a block change is executed.

### **Deselection**

The NC recognizes the function deselection via programming of the command `FXS [x]=0`. Then an advance stop (`STOPRE`) is internally released, since it can't be foreseen where the axis will be after deselection.

The torque limitation and monitoring of the fixed stop monitoring window are canceled.

The NST DB31, ... DBX62.4 ("Activate travel to fixed stop") and DB31, ... DBX62.5 ("Fixed stop reached") are reset.

Depending on the machine data:

MD37060 FIXED\_STOP\_ACKN\_MASK

the acknowledgement of the PLC is awaited through resetting of the NST

DB 31, ... DBX3.1 ("Enable travel to fixed stop").and/or

("Acknowledge fixed stop reached") is waited for. DB 31, ... DBX1.1

The axis will then change to position control. The follow-up mode of the position setpoints is ended and a synchronization to the new actual position is carried out.

A programmed traverse motion can then be executed. This motion must lead away from the fixed stop or else the stop or even the machine may sustain damage.

A block change is executed after the target position has been reached.

### Enabling the fixed stop alarms

With the machine data:

MD37050 FIXED\_STOP\_ALARM\_MASK

enabling the fixed stop alarms can be established as follows:

MD 37050 = 0	Fixed stop not reached (suppress alarm 20091)
MD 37050 = 2	Fixed stop not reached ( suppress alarm 20091) <b>and</b> fixed stop aborted (suppress alarm 20094)
MD 37050 = 3	Fixed stop aborted (suppress alarm 20094)

All other permissible values of 7 or less do not suppress any alarms.

Using the parts program command `NEWCONF` a new setting can be activated.

### Terminal 663 with MD37002 controllable

With the machine data:

MD37002 FIXED\_STOP\_CONTROL

the response in the case of pulse inhibit at the stop is controlled.

Deleting the pulses by terminal 663 or the "Pulse enable" IS DBX31, ...DBX21.7 will not abort the function. As a result, the drive will press against the fixed stop again without any further operating action when the machine is restarted.

The rise time of the torque corresponds to the time needed by the current controller of the drive to reach the limitation again.

If the pulses are deleted when a deselection is active (waiting for PLC acknowledgments), the torque limit will be reduced to zero. If the pulses are reactivated during this phase, torque is no longer built up. Once the deselection has been completed, you can continue traversing as normally.

### Diagram

In the following diagram the progress of motor current, following error and NST signals for DB31, ... DBX62.4 ("Activate travel to fixed stop") and DB31, ... DBX62.5 ("Fixed stop reached") have been presented for digital drive (SIMODRIVE 611 digital).

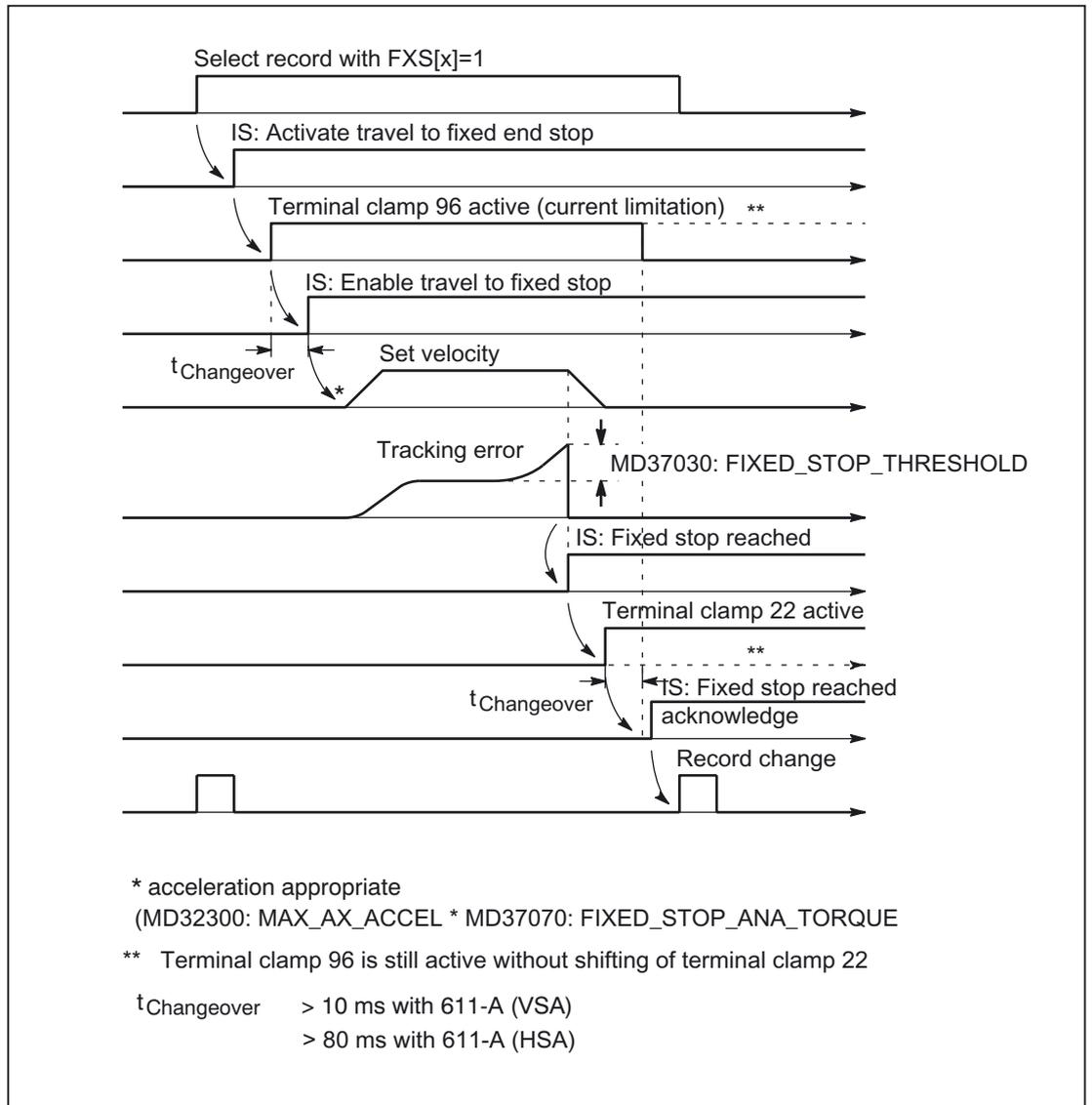


Figure 6-3 Diagram for FXS with a digital drive (611 digital)

### 6.3.2 Travel to fixed stop with hydraulic drives SIMODRIVE 611 digital (HLA module)

#### Velocity/force control

If the function `FXS` (`FXS [x]=1`) is activated for the hydraulic module 611 digital (HLA module), only a change from velocity control to force control takes place. Positioning from the NC is no longer possible in this case.

#### NC

When traveling to fixed stop, the NC evaluates a torque/force limit acting in addition to the limits set on the drive:

- Current
- Force/torque
- Power, pull-out power
- Setup mode

---

#### Note

For relevant explanations on velocity control and force control as well as details about adaptations for SIMODRIVE 611 digital or digital (HLA module), please see:

#### References:

/FBHLA/ Function Manual HLA module; Drive functions firmware

/FB2/ Function Manual, Extended Functions, Compensations (K3); Section: Electronic weight compensation

---

## 6.4 Travel to fixed stop with analog drives

### 6.4.1 SIMODRIVE 611 analog (FDD)

#### Current/torque control

The torque control and limit mentioned in the following text is realized with 611 analog (VSA) as current control and -limit.

#### Fixed clamping torque

A fixed current limitation is preset in the drive actuator by means of a resistor circuit (or via R12). This current limitation is activated by the control via a PLC output (which acts on terminal 96 of the actuator), thus ensuring that a fixed clamping torque is available on the axis.

Setpoints can be injected via terminals 56/14 or 24/20.

#### Programmable clamping torque

In this case, the PLC switches the drive actuator from speed-controlled into current-controlled operation as soon as the fixed stop is reached.

Activation of terminal 22 causes the voltage level applied to terminals 20/24 to take effect as a current setpoint rather than a speed setpoint.

The NC is thus able to specify a variable clamping torque.

Setpoints must be injected via terminals 24/20.

#### References:

/IAA/ Installation and start-up guide SIMODRIVE 611 analog System

#### Selection

The NC detects that the function "travel to fixed stop" is selected via the command `FXS[x]=1` and signals the PLC via the IS "Activate travel to fixed stop" (DB31, ... DBX62.4) that the function has been selected.

The PLC must then activate the current limitation on the actuator (terminal 96).

If the machine data:

`MD37060 FIXED_STOP_ACKN_MASK`

is set correspondingly, the acknowledgement of the PLC via the NST

"Enable travel to fixed stop" (DB31, ... DBX3.1) is awaited

and after that the function is started.

---

**Note**

(This acknowledgment should always be programmed for analog drives for safety reasons, i.e. so that the motion is not started before the torque has been limited).

---

Subsequently the NC internally sets the torque limit on the value specified via the machine data:

MD37070 FIXED\_STOP\_ANA\_TORQUE

(Torque limit while approaching the fixed stop for analog drives).

This must correspond to the torque limit value activated via terminal 96.

In addition, the acceleration is automatically reduced in the NC according to the value in the machine data:

MD37070 FIXED\_STOP\_ANA\_TORQUE

is automatically reduced.

The axis now traverses to the target position at the programmed velocity.

### Fixed stop reached

As soon as the axis reaches the fixed stop, the axial contour deviation increases.

If the recorded threshold in the machine data:

MD37030 FIXED\_STOP\_THRESHOLD

is exceeded or the NST signal

"Sensor fixed stop" (DB31, ..DBX1.2) is set, the controller recognizes

that the fixed stop has been reached.

The position controller then responds by outputting a speed setpoint, corresponding to the value set in the machine data:

MD37070 FIXED\_STOP\_ANA\_TORQUE

The speed controller's output is limited by terminal 96, forcing the drive to the current limit by means of this continuously applied setpoint.

The NC then deletes the remaining distance-to-go and forces the position setpoint to follow. The controller enabling command remains active.

The NC then outputs IS "Fixed stop reached" (DB31 , ... DBX62.5) to the PLC.

If a **programmable clamping torque** input (via `FXST[x]` or setting data), is required from the NC, then the PLC must switch the drive over from speed controlled to current controlled operation.

To do so, it activates terminal 22 and switches off the current limitation (terminal 96) after a period of 10 ms.

The torque set in the machine data:

MD37070 FIXED\_STOP\_ANA\_TORQUE

acts on the drive.

If the machine data:

MD37060 FIXED\_STOP\_ACKN\_MASK

is set correspondingly, the acknowledgement of the PLC via the NST

("Acknowledge fixed stop reached") (DB31, ... DBX1.1) is awaited and then the requested clamping torque is transferred from the select block to the drive steplike.

Then a block change is executed. The clamping torque continues to be applied.

### **Fixed stop is not reached**

If the programmed end position is reached, without the "fixed stop reached" status being detected, then the internal torque limitation set in the machine data:

MD37070 FIXED\_STOP\_ANA\_TORQUE

is cancelled and the NST signal "Activate travel to fixed stop".

(DB31, ... DBX62.4) is reset.

The PLC must then deactivate the current limitation (terminal 96).

Depending on the machine data:

MD37060 FIXED\_STOP\_ACKN\_MASK

the acknowledgement of the PLC is awaited through resetting of the NST

"Enable travel to fixed stop" (DB31, ... DBX3.1)

and then a block change is executed.

### **Deselection**

The NC detects that the function has been deselected on the basis of command  $FXS[x]=0$  and specifies a speed or current setpoint of "0," i.e. zero clamping torque.

Then the NC resets IS "Activate travel to fixed stop" (DB31, ... DBX62.4) and "Fixed stop reached" (DB31, ... DBX62.5).

If current-controlled operation is activated, the PLC must first switch on the current limitation (terminal 96) and switch the drive over to speed-controlled operation (terminal 22) (a speed setpoint of "0" is applied by NC).

Then current limitation must then be deactivated (terminal 96).

Depending on the machine data:

MD37060 FIXED\_STOP\_ACKN\_MASK

the acknowledgement of the PLC is awaited through resetting of the NST

"Enable travel to fixed stop" (DB31, ... DBX3.1) and/or

("Acknowledge fixed stop reached") (DB31, ... DBX1.1).

The axis then switches over to position control mode (follow-up mode is terminated) and synchronization with the new actual position takes place.

The programmed travel motion is then executed.

A block change is executed after the target position has been reached.

## 6.4.2 SIMODRIVE 611 analog (FDD)

### Fixed clamping torque

A fixed clamping torque is implemented by entering a fixed torque limitation in a free gear stage in the drive actuator (setting parameter 039). When the "Travel to fixed stop function" is selected, the PLC switches over to the unassigned gear stage of the drive actuator, thus activating the torque limitation.

Setpoints must be injected via terminals 56/14.

### Programmable clamping torque

In this case, the PLC switches the drive actuator from speed-controlled into torque-controlled operation after the fixed stop is reached. The NC can therefore input a variable clamping torque.

Setpoints must be injected via terminals 56/14.

#### References:

/IAA/ Installation and start-up guide SIMODRIVE 611 analog system

### C-axis operation

The control system has to switch the spindle into C-axis mode before the "Travel to fixed stop" function is selected. The PLC does this by activating one of the programmable terminals E1-D9 (e.g. terminal E1) of the drive actuator.

### Selection

The NC detects that the function "travel to fixed stop" is selected via the command `FXS [x] = 1` and signals the PLC via the IS "Activate travel to fixed stop" (DB31, ... DBX62.4) that the function has been selected.

As a result, the PLC activates the unassigned gear stage, in which the torque limitation is effective, by means of programmable terminals E1 - E9 of the drive actuator. It then switches the speed controller monitor off (one terminal (E1-E9) to deactivate error F11 of drive actuator).

If the machine data:

`MD37060 FIXED_STOP_ACKN_MASK`

is set correspondingly, the acknowledgement of the PLC via the NST

"Enable travel to fixed stop" (DB31, ... DBX3.1) is awaited and after that the function is started.

**Note**

(This acknowledgment should always be programmed for analog drives for safety reasons, i.e. so that the motion is not started before the torque has been limited).

---

Subsequently the controller internally sets the torque limit to the value specified through the machine data:

MD37070 FIXED\_STOP\_ANA\_TORQUE

(Torque limit while approaching the fixed stop for analog drives).

This must correspond to the torque limit value set in the actuator.

In addition, the acceleration is automatically reduced in the NC according to the value in the machine data:

MD37070 FIXED\_STOP\_ANA\_TORQUE

The rotary axis now traverses to the target position at the programmed velocity.

**Fixed stop reached**

As soon as the C-axis reaches the fixed stop, the axial contour deviation increases.

If the threshold entered in the machine data:

MD37030 FIXED\_STOP\_THRESHOLD

is exceeded or the NST signal

"sensor fixed stop" (DB31, ... DBX1.2) is set,

the control system detects that the fixed stop has been reached.

The position controller then responds by outputting a speed setpoint, corresponding to the value set in the machine data:

MD37070 FIXED\_STOP\_ANA\_TORQUE

The speed controller forces the drive to the torque limit by means of this continuously applied setpoint.

The NC then deletes the remaining distance-to-go and forces the position setpoint to follow.

The controller enabling command remains active.

The NC then outputs IS "Fixed stop reached" (DB31 , ... DBX62.5) to the PLC.

If a **programmable clamping torque** input (via `FXST[x]` or setting parameter) is required from the NC, then the PLC must switch the drive over from speed controlled to current controlled operation. To do so, it activates one of the programmable terminals E1 - E9 (e.g. terminal E5) and switches off the torque limitation after a period of > 80 ms by selecting the previous gear stage.

The torque set in machine data:

MD37070 FIXED\_STOP\_ANA\_TORQUE

acts on the drive.

If the machine data:

MD37060 FIXED\_STOP\_ACKN\_ASK

is set correspondingly, the acknowledgement of the PLC via the NST

("Acknowledge fixed stop reached") (DB31, ... DBX1.1) is awaited and then the requested clamping torque is transferred from the select block to the drive steplike.

Then a block change is executed. The clamping torque continues to be applied.

### Fixed stop is not reached

If the programmed end position is reached, without detecting the state "fixed stop reached", then the internal torque limitation in the machine data:

MD37070 FIXED\_STOP\_ANA\_TORQUE

is cancelled and the NST signal "Activate travel to fixed stop".

(DB31, ... DBX62.4) is reset.

The PLC then activates the preceding gear stage, thus deactivating the torque limitation. It also switches on the speed control monitoring function again.

Depending on the machine data:

MD37060 FIXED\_STOP\_ACKN\_MASK

the acknowledgement of the PLC is awaited through resetting of the NST

"Enable travel to fixed stop" (DB31, ... DBX3.1)

and then a block change is executed.

### Deselection

The NC detects that the function has been deselected on the basis of command `FXS[x]=0` and specifies a speed or torque setpoint of "0," i.e. zero clamping torque.

Then the NC resets the NST "Activate travel to fixed stop"

(DB31, ... DBX62.4) and "Fixed stop reached" (DB31, ... DBX62.5)

If torque-controlled operation is activated, the PLC must first select the unassigned gear stage in which the torque limitation is effective and switch the drive over to speed-controlled operation (a speed setpoint of "0" is applied by NC). The PLC must also deactivate the speed controller monitoring function.

The PLC then activates the preceding gear stage, thus deactivating the torque limitation. It also switches on the speed control monitoring function again.

Depending on the machine data:

MD37060 FIXED\_STOP\_ACKN\_MASK

the acknowledgement of the PLC is awaited through resetting of the NST

"Enable travel to fixed stop" (DB31, ... DBX3.1) and/or

("Acknowledge fixed stop reached") (DB31, ... DBX1.1).

The C-axis then switches over to position control mode (follow-up mode is terminated) and synchronization with the new actual position takes place.

The programmed travel motion is then executed.

A block change is executed after the target position has been reached.

### 6.4.3 Diagrams for travel to fixed stop with analog drives

#### FXS selection (fixed stop is reached)

The following diagram shows the sequence of the following error and interface signals for "FXS selection" (fixed stop is reached) on analog drives.

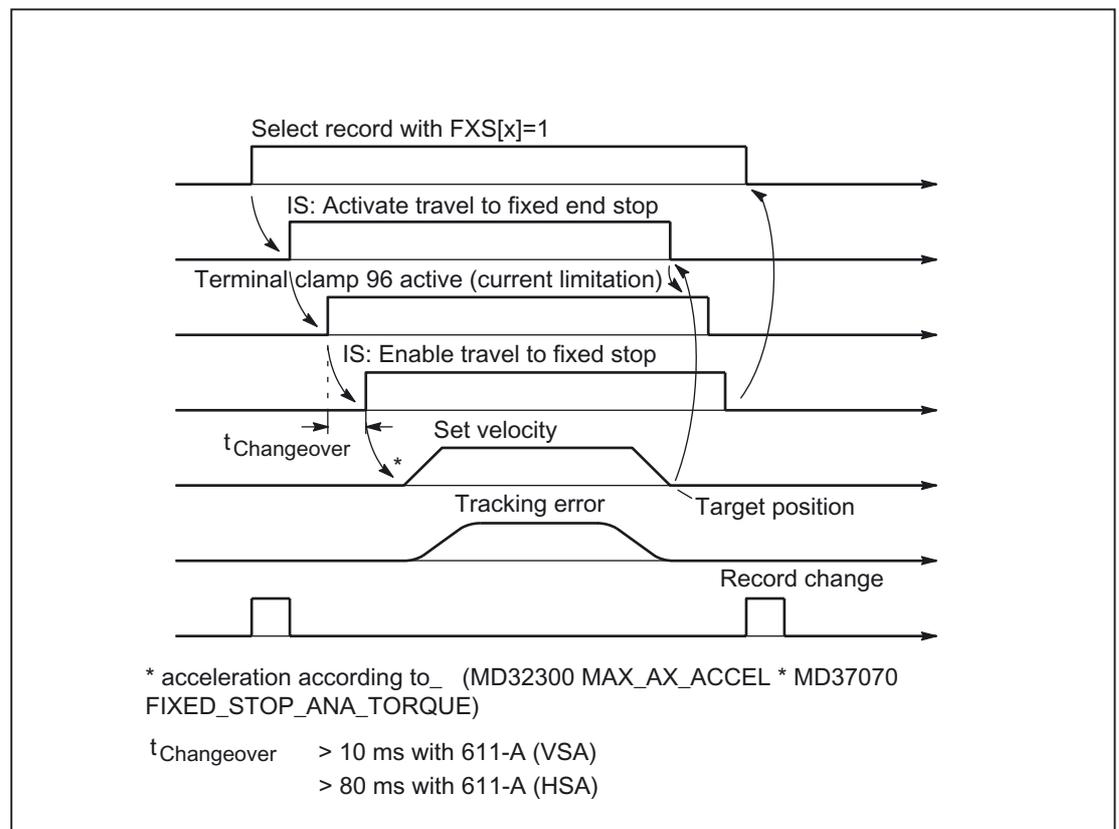


Figure 6-4 Diagram for FXS selection (fixed stop is reached) with analog drive

**FXS selection (fixed stop is not reached)**

The following diagram shows the sequence of the following error and interface signals for "FXS selection" (fixed stop is **not** reached) on analog drives.

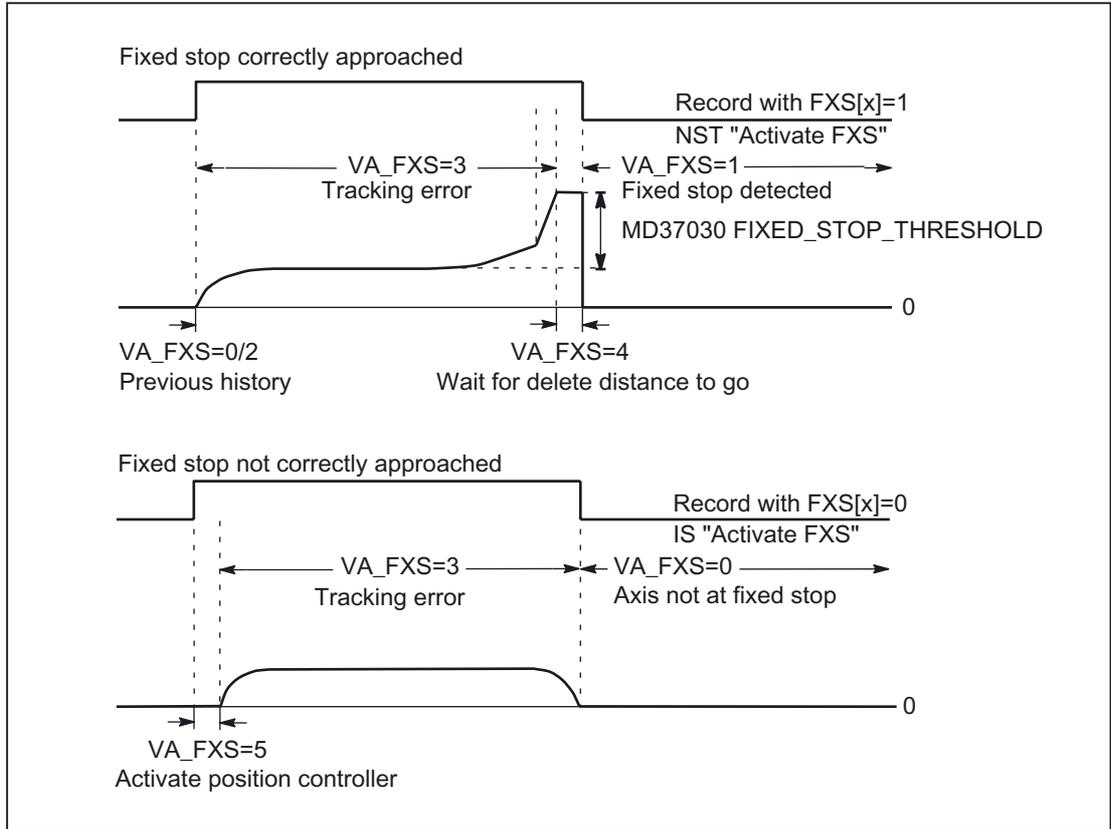


Figure 6-5 Diagram for FXS selection (fixed stop is not reached) with analog drive

**FXS deselection**

The following diagram shows the sequence of the following error and interface signals for "FXS Deselection" on analog drives.

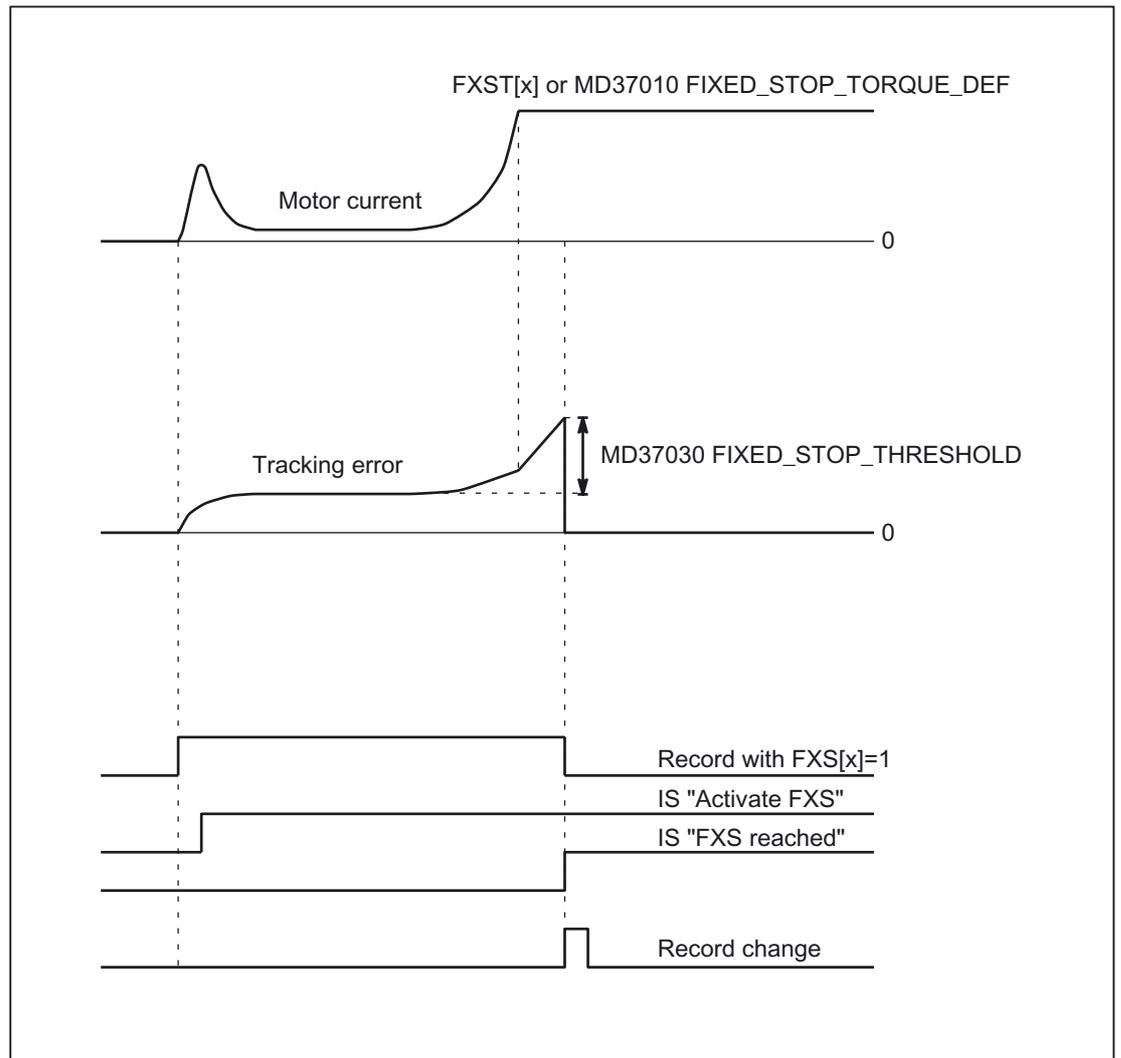


Figure 6-6 Diagram for FXS deselection with analog drive

## 6.5 Examples

### Static synchronized actions

Travel to fixed stop (FXS), initiated by a synchronized action.

```

N10 IDS=1 WHENEVER                ; Activate static synchronized action:
(( $R1==1) AND                    ; By the setting of $R1=1
($AA_FXS[Y]==0)) DO              ; for
$R1=0 FXS[Y]=1                   ; the axis Y FXS is activated
FXST[Y]=10                        ; the active torque is reduced to 10%
FA[Y]=200                          ; and a travel motion to
POS[Y]=150                          ; direction of the stop started

N11 IDS=2 WHENEVER                ; once the stop has been recognized
($AA_FXS[Y]==4) DO              ; ($AA_FXS[Y]==4), the torque is
FXST[Y]=30                          ; increased to 30%

N12 IDS=3 WHENEVER                ; after reaching the stop
($AA_FXS[Y]==1) DO              ; the torque becomes dependent
FXST[Y]=$R0                          ; on R0 controlled

N13 IDS=4 WHENEVER                ; deselection in dependence
(( $R3==1) AND                    ; on R3 and
($AA_FXS[Y]==1)) DO              ; reverse
FXS[Y]=0
FA[Y]=1000 POS[Y]=0

N20 FXS[Y]= 0                      ; normal program run:
G0 G90 X0 Y0

N30 RELEASE(Y)                    ; axis Y for the movement to
                                   ; activate synchronized action

N40 G1 F1000 X100                  ; Movement of another axis
N50 .....

N60 GET(Y)                          ; Include axis Y again in the
                                   ; pathgroup
    
```

## Multiple selection

A selection may only be carried out once. If the function is called once more due to faulty programming (FXS[Axis]=1) the alarm 20092 "Travel to fixed stop still active" is initiated.

Programming code that scans \$AA\_FXS[] or a separate flag (here R1) in the condition will ensure that the function is not activated more than once.

## Programming example (parts program fragment):

```
N10 R1=0  
N20 IDS=1 WHENEVER ($R1 == 0 AND $AA_IW[AX3]>7) DO R1=1 FXS[AX1]=1  
FXST[AX1] = 12
```

## Block-related synchronized actions

By programming a block-related synchronized action, travel to fixed stop can be connected during an approach motion.

### Programming example:

```
N10 G0 G90 X0 Y0  
N20 WHEN $AA_IW[X]>17 DO FXS[X]=1 ; If X reaches a position greater  
N30 G1 F200 X100 Y110 ; 17mm FXS is activated
```

## 6.6 Data lists

### 6.6.1 Machine data

#### 6.6.1.1 Axis/spindle-specific machine data

Number	Identifier: \$MA_	Description
36042	FOC_STANDSTILL_DELAY_TIME	Delay time 0 monitoring with FOC and FXS
37000	FIXED_STOP_MODE	Travel to fixed stop mode
37002	FIXED_STOP_CONTROL	Special function when traveling to fixed stop
37010	FIXED_STOP_TORQUE_DEF	Default setting for clamping torque
37012	FIXED_STOP_TORQUE_RAMP_TIME	Virtual time until reaching the new clamping torque when traveling to fixed stop
37020	FIXED_STOP_WINDOW_DEF	Default for fixed stop monitoring window
37030	FIXED_STOP_THRESHOLD	Threshold for fixed stop detection
37040	FIXED_STOP_BY_SENSOR	Fixed stop detection via sensor
37050	FIXED_STOP_ALARM_MASK	Enabling the fixed stop alarms
37052	FIXED_STOP_ALARM_REACTION	Reaction to fixed stop alarms
37060	FIXED_STOP_ACKN_MASK	Monitoring of PLC acknowledgments for travel to fixed stop
37070	FIXED_STOP_ANA_TORQUE	Torque limit on fixed stop approach for analog drives
37080	FOC_ACTIVATION_MODE.	Status of activation of the modal function FOC

### 6.6.2 Setting data

#### 6.6.2.1 Axis/spindle-specific setting data

Number	Identifier: \$SA_	Description
43500	FIXED_STOP_SWITCH	Selection of travel to fixed stop
43510	FIXED_STOP_WINDOW	Clamping torque when traveling to fixed stop extended to a torque greater than 100%
43520	FIXED_STOP_TORQUE	Fixed stop monitoring window

## 6.6.3 Signals

### 6.6.3.1 Signals to axis/spindle

<b>DB number</b>	<b>Byte.Bit</b>	<b>Description</b>
31, ...	1.1	Acknowledge fixed stop reached
31, ...	1.2	Sensor for fixed stop
31, ...	1.3	Axis/spindle disable
31, ...	2.1	Controller enable
31, ...	3.1	Enable travel to fixed stop

### 6.6.3.2 Signals from axis/spindle

<b>DB number</b>	<b>Byte.Bit</b>	<b>Description</b>
31, ...	62.4	Activate travel to fixed stop
31, ...	62.5	Fixed stop reached



# Velocities, Setpoint/Actual Value Systems, Closed-Loop Control (G2)

# 7

## 7.1 Brief description

The description of functions explains how to parameterize a machine axis in relation to:

- Actual-value/measuring systems
- Setpoint system
- Operating accuracy
- Travel ranges
- Axis velocities
- Control parameters

## 7.2 Velocities, traversing ranges, accuracies

### 7.2.1 Velocities

#### Maximum path and axis velocities and spindle speed

The maximum path and axis velocities and spindle speed are influenced by the machine design, the dynamic response of the drive and the limit frequency of the actual-value acquisition (encoder limit frequency).

The maximum axis velocity is defined in machine data:  
MD32000 \$MA\_MAX\_AX\_VELO (maximum axis velocity).

The maximum permissible spindle speed is defined via machine data:  
MD35100 \$MA\_SPIND\_VELO\_LIMIT (maximum spindle speed).

For more information, see:

**References:**

/FB1/ Function Manual, Basic Functions; Spindles (S1)

As well as limiting using MD32000, the control limits the maximum path velocity in relation to the situation and according to the following formula:

$$\frac{\text{Internal increments/mm}}{\text{Encoder increments/mm}} = \frac{1}{\text{ENC\_RESOL [n]} * \text{internal multiplication}}$$
$$* \frac{\text{DRIVE\_ENC\_RATIO\_NUMERA [n]}}{\text{DRIVE\_ENC\_RATIO\_DENOM [n]}}$$
$$* \frac{\text{DRIVE\_AX\_RATIO\_DENOM [n]}}{\text{DRIVE\_AX\_RATIO\_NUMERA [n]}}$$
$$* \text{LEADSCREW\_PITCH}$$
$$* \text{INT\_INCR\_PER\_MM}$$

For setting the interpolation cycle, see:

**References:**

/FB3/ Function Manual, Special Functions; Cycle Times (G3)

With a high feedrate (resulting from programmed feedrates and feedrate override), the maximum path velocity is limited to  $V_{\max}$ .

This automatic feedrate limiting can lead to a drop in velocity over several blocks with programs generated by CAD systems with extremely short blocks.

### Example

Interpolation cycle = 12 ms

N10 G0 X0 Y0; [mm]

N20 G0 X100 Y100; [mm]

⇒ Path length programmed in block = 141.42 mm

⇒  $V_{max} = (141.42 \text{ mm}/12 \text{ ms}) \cdot 0.9 = 10606.6 \text{ mm/s} = 636.39 \text{ m/min}$

The following restriction applies to the minimum path or axis velocity:

$$V_{min} \geq \frac{10^{-3}}{\text{Computational resolution} \left[ \frac{\text{Incr.}}{\text{mm or degrees}} \right] \cdot \text{interpolation cycle [s]}}$$

The computational resolution is defined via machine data:

MD10200 \$MN\_INT\_INCR\_PER\_MM (computational resolution for linear positions)

or

MD10210 \$MN\_INT\_INCR\_PER\_DEG (computational resolution for angular positions):

If  $V_{min}$  is not reached, no traversing is carried out.

$$\frac{\text{Internal increments/mm}}{\text{Encoder increments/mm}} = \frac{1}{\text{ENC\_RESOL [n]} \cdot \text{internal multiplication}}$$

$$\begin{aligned} & * \frac{\text{DRIVE\_ENC\_RATIO\_NUMERA [n]}}{\text{DRIVE\_ENC\_RATIO\_DENOM [n]}} \\ & * \frac{\text{DRIVE\_AX\_RATIO\_DENOM [n]}}{\text{DRIVE\_AX\_RATIO\_NUMERA [n]}} \\ & * \text{LEADSCREW\_PITCH} \\ & * \text{INT\_INCR\_PER\_MM} \end{aligned}$$

**Example**

MD10200 \$MN\_INT\_INCR\_PER\_MM = 1000 [incr./mm];

Interpolation cycle = 12 ms;

$\Rightarrow V_{\min} = 10^{-3} / (1000 \text{ incr./mm} \times 12 \text{ ms}) = 0.005 \text{ mm/min};$

The value range of the feed rates depends on the selected computational resolution

When the machine data:

MD10200 \$MN\_INT\_INCR\_PER\_MM

(computational resolution for linear positions) (1000 incr./mm)

or

MD10210 \$MN\_INT\_INCR\_PER\_DEG

(computational resolution for angular positions) (1000 incr./degree)

is assigned its default values, the following range of values can be programmed with the specified resolution:

Range of values for path feedrate F and geometry axes:	
Metric system:	Inch system:
0.001 ≤ F ≤ 999,999.999 [mm/min, mm/rev, degrees/min, degrees/rev]	0.001 ≤ F ≤ 399,999.999 [inch/min, inch/rev]

Range of values for feedrate for positioning axes:	
Metric system:	Inch system:
0.001 ≤ FA ≤ 999,999.999 [mm/min, mm/rev, degrees/min, degrees/rev]	0.001 ≤ FA ≤ 399,999.999 [inch/min, inch/rev]

Range of values for spindle speed S:
0.001 ≤ S ≤ 999,999.999 [rpm]

If the computational resolution is increased/decreased by a factor of 10, the ranges of values change accordingly.

## 7.2.2 Traversing ranges

### Range of values of the traversing ranges

The range of values of the traversing range depends on the computational resolution selected.

If machine data:

MD10200 \$MN\_INT\_INCR\_PER\_MM

(computational resolution for linear positions) (1000 incr./mm)

or

MD10210 \$MN\_INT\_INCR\_PER\_DEG

(computational resolution for angular positions) (1000 incr./degree)

are assigned their default values, the following range of values can be programmed with the input resolution:

Table 7-1 Traversing ranges of axes

	G71 [mm, degrees]	G70 [inch, degrees]
	Range	Range
Linear axes X, Y, Z, etc.	± 999,999.999	± 399,999.999
Rotary axes A, B, C, etc.	± 999,999.999	± 999,999.999
Interpolation parameters I, J, K	± 999,999.999	± 399,999.999

The unit of measurement of rotary axes is always degrees.

If the computational resolution is increased/decreased by a factor of 10, the ranges of values change accordingly.

The traversing range can be limited by software limit switches and working areas.

**References:**

/FB1/ Function Manual, Basic Functions; Axis Monitoring, Protection Zones (A3)

The traversing range for rotary axes can be limited via machine data.

**References:**

/FB2/ Function Manual, Extended Functions; Rotary Axes (R2)

For special features of linear and rotary axes with a large traversing range, see:

**References:**

/FB1/ Function Manual, Basic Functions; Reference Point Approach (R1)

### **7.2.3 Positioning accuracy of the control system**

#### **Actual-value resolution and computational resolution**

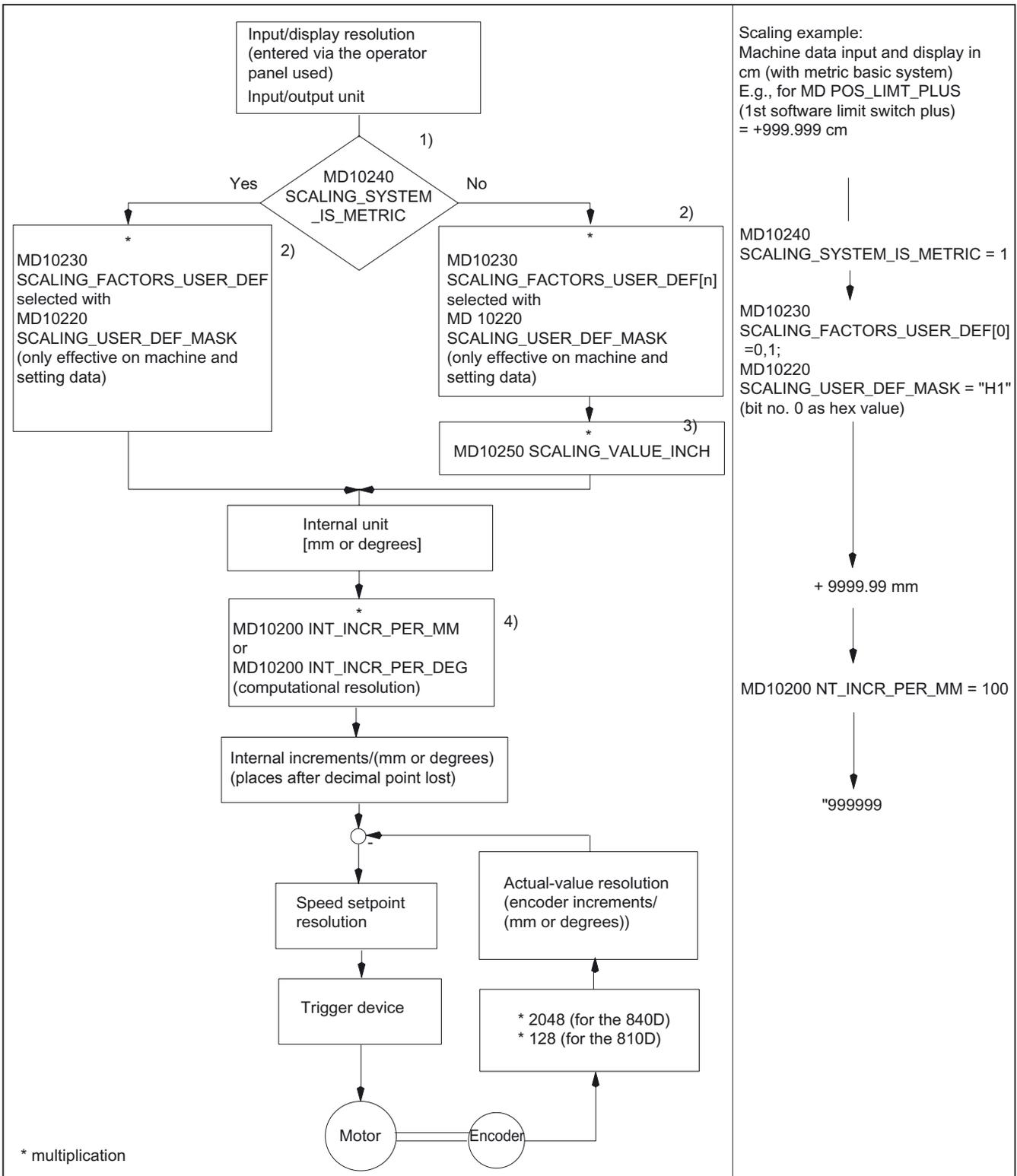
The positioning accuracy of the control depends on the actual-value resolution (=encoder increments/(mm or degrees)) and the computational resolution (=internal increments/(mm or degrees)).

The coarse resolution of these two values determines the positioning accuracy of the control.

The input resolution, interpolator and position-control cycle selections have no effect on this accuracy.

## **7.2.4 Block diagram of resolutions and scaling values**

**Block diagram of units and resolutions**



This diagram shows how input values are converted into internal units.

It also shows the following conversion to internal increments/(mm or degrees), which can cause loss of decimal places if the computational resolution was selected to be coarser than the input resolution.

In addition, it provides an overview of the following topics:

- Selection of measuring system (metric/inch)
- Scaling of physical quantities of machine and setting data
- Conversion of basic system
- Setting of computational resolution

An example is given showing how a physical quantity

(MD36110 \$MA\_POS\_LIMIT\_PLUS)

as a function of machine data parameterization

(MD10230 \$MN\_SCALING\_FACTORS\_USER\_DEF,

MD10220 \$MN\_SCALING\_USER\_DEF\_MASK).

## 7.2.5 Input/display resolution, computational resolution

### Resolutions: Differences

Resolutions, e.g. resolutions of linear and angular positions, velocities, accelerations and jerk, must be differentiated as follows:

- Input resolution  
Data is input via the control panel or parts programs.
- Display resolution  
Data is displayed via the control panel.
- Computational resolution  
Data input via the control panel or parts program is displayed internally.

The input and display resolution is defined via the control panel being used, whereby the display resolution of position values can be changed with machine data:

MD9004 \$MM\_DISPLAY\_RESOLUTION

Machine data:

MD9011 \$MM\_DISPLAY\_RESOLUTION\_INCH

can be used to configure the display resolution of position values using the inch system.

This allows you to display up to six decimal places with the inch setting.

For the programming of parts programs, the input resolutions listed in the Programming Guide apply.

The desired computational resolution is defined via machine data:

MD10200 \$MN\_INT\_INCR\_PER\_MM (computational resolution for linear positions)

or

MD10210 \$MN\_INT\_INCR\_PER\_DEG (computational resolution for angular positions).

It is independent of the input/display resolution but should have at least the same resolution.

The maximum number of places after the decimal point for position values, velocities, etc., in the parts program and the number of places after the decimal point for tool offsets, zero offsets, etc. (and therefore also for the maximum possible accuracy) is defined by the computational resolution.

The accuracy of angle and linear positions is limited to the computational resolution by rounding the product of the programmed value with the computational resolution to an integer number.

To make the rounding clear, powers of 10 should be used for the computational resolution.

### Example of rounding

Computational resolution: 1000 increments/mm

Programmed path: 97.3786 mm

Effective value = 97.379 mm

### Example of programming in the $1/10 \mu\text{m}$ range

All the linear axes of a machine are to be programmed and traversed within the range of values 0.1 to 1000  $\mu\text{m}$ .

⇒ In order to position accurately to 0.1  $\mu\text{m}$ , the computational resolution must be set to  $\geq 10^4$  incr./mm.

⇒ MD10200 \$MN\_INT\_INCR\_PER\_MM = 10000 [incr./mm]:

⇒ Example of related parts program:

```
N20 G0 X 1.0000 Y 1.0000 ; Traverse axes to position
                          X=1.0000 mm, Y=1.0000 mm
N25 G0 X 5.0002 Y 2.0003 ; Traverse axes to position
                          X=5.0002 mm, Y=2.0003 mm
```

## 7.2.6 Scaling of physical quantities of machine and setting data

### Input/output units

Machine and setting data that possess a physical quantity are interpreted in the input/output units below depending on whether the metric or inch system is selected:

Physical quantity:	Input/output units for standard basic system:	
	Metric	Inch
Linear position	1 mm	1 inch
Angular position	1 degree	1 degree
Linear velocity	1 mm/min	1 inch/min
Angular velocity	1 rpm	1 rpm
Linear acceleration	1 m/s <sup>2</sup>	1 inch/s <sup>2</sup>
Angular acceleration	1 rev./s <sup>2</sup>	1 rev./s <sup>2</sup>
Linear jerk	1 m/s <sup>3</sup>	1 inch/s <sup>3</sup>
Angular jerk	1 rev./s <sup>3</sup>	1 rev./s <sup>3</sup>
Time	1 s	1 s
Position controller servo gain	1/s	1/s
Rev. feedrate	1 mm/rev 1	inch/rev
Compensation value linear position	1 mm	1 inch
Compensation value angular position	1 degree	1 degree

The units listed below are used for storage. The control always uses these units internally irrespective of the basic system selected.

Physical quantity:	Internal unit:
Linear position	1 mm
Angular position	1 degree
Linear velocity	1 mm/s
Angular velocity	1 deg./s
Linear acceleration	1 mm/s <sup>2</sup>
Angular acceleration	1 degree/s <sup>2</sup>
Linear jerk	1 mm/s <sup>3</sup>
Angular jerk	1 degree/s <sup>3</sup>
Time	1 s
Position controller servo gain	1/s
Rev. feedrate	1 mm/degree
Compensation value linear position	1 mm
Compensation value angular position	1 degree

The user can define different input/output units for machine and setting data.

For this, the machine data:

MD10220 \$MN\_SCALING\_USER\_DEF\_MASK

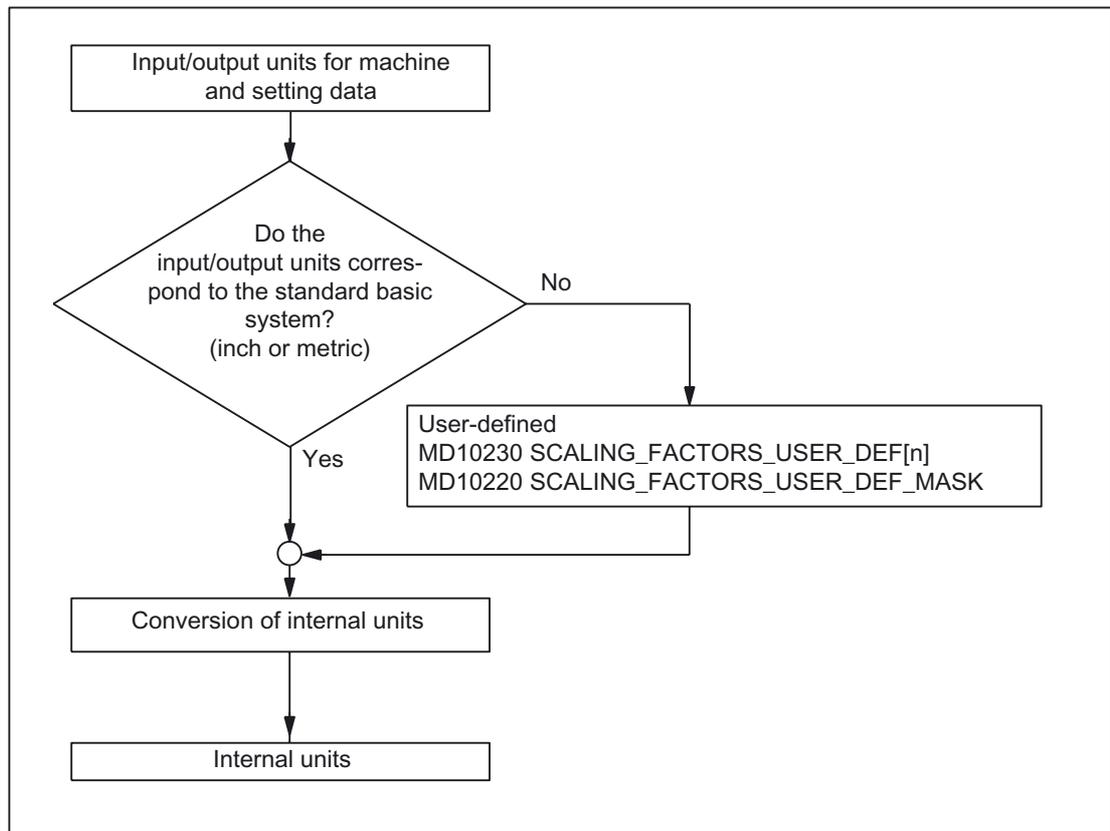
(activation of scaling factors)

and

MD10230 \$MN\_SCALING\_FACTORS\_USER\_DEF[n]

(Scaling factors of physical quantities)

allow you to set the adaptation between the newly selected input/output units and the internal units.



The following applies:

Selected input/output unit = MD10230 \* internal unit

In the machine data:

MD10230 \$MN\_SCALING\_FACTORS\_USER\_DEF[n]

the selected input/output unit printed in each case in the internal units 1mm, 1 degree and 1 s must be input.

**Example 1:**

Machine data input/output of the linear velocities is to be in m/min instead of mm/min (initial state).

(The internal unit is mm/s)

⇒ The scaling factor for the linear velocities is to differ from the standard setting. For this in the machine data:

MD10220 \$MN\_SCALING\_USER\_DEF\_MASK

the bit number 2 must be set.

⇒ MD10220 \$MN\_SCALING\_USER\_DEF\_MASK = 'H4'; (bit no. 2 as hex value)

⇒ The scaling factor for the linear velocities is to differ from the standard setting. For this in the machine data:

MD10220 \$MN\_SCALING\_USER\_DEF\_MASK

the bit number 2 must be set.

⇒ MD10220 \$MN\_SCALING\_USER\_DEF\_MASK = 'H4'; (bit no. 2 as hex value)

⇒ The scaling factor is calculated using the following formula:

$\text{MD10230 SCALING_FACTORS\_USER\_DEF}[n] = \frac{\text{Input/output unit selected}}{\text{Internal unit}}$ $\text{MD10230 SCALING_FACTORS\_USER\_DEF}[n] = \frac{1 \frac{\text{m}}{\text{min}}}{1 \frac{\text{mm}}{\text{s}}} = \frac{\frac{1000 \text{ mm}}{60 \text{ s}}}{1 \frac{\text{mm}}{\text{s}}} = \frac{1000}{60} = 16.667;$ <p>⇒ MD10230 SCALING_FACTORS_USER_DEF[n] = 16.667</p>
---

Index 2 defines the "linear velocity" in the "Scaling factors of physical quantities" list.

**Example 2:**

In addition to the change in Example 1, the machine data input/output of linear accelerations must be in ft/s<sup>2</sup> instead of m/s<sup>2</sup> (initial state).  
(The internal unit is mm/s<sup>2</sup>.)

⇒ MD10220 SCALING_USER_DEF_MASK = H14; (bit no. 4 and bit no. 2 from example 1 as hex value)
⇒ MD10220 SCALING_FACTORS_USER_DEF[n] = $\frac{1 \frac{\text{ft}}{\text{s}^2}}{1 \frac{\text{mm}}{\text{s}^2}} = \frac{12*25.4 \frac{\text{mm}}{\text{s}^2}}{1 \frac{\text{mm}}{\text{s}^2}} = 304.8;$
⇒ MD10230 SCALING_FACTORS_USER_DEF[4] = 304.8

Index 4 defines the "linear acceleration" in the "Scaling factors of physical quantities" list.

## 7.3 Metric/inch measuring system

### 7.3.1 General

The control system can operate with the inch or the metric system of measurement.

#### Initial state

The initial state is defined via the following machine data element:  
MD10240 \$MN\_SCALING\_SYSTEM\_IS\_METRIC (basic metric system).

Depending on the setting in the MD, all geometric values are interpreted either as metric or inch values.

All manual settings also refer to this initial state (e.g. handwheel, INC, JOG feedrate), as do zero offsets, tool offsets, FRAMES, etc., and the associated displays.

#### Supplements

The setting:  
MD10260 \$MN\_CONVERT\_SCALING\_SYSTEM=1  
greatly simplifies a change in the measuring system.

- HMI user interface: Softkey in the "Machine" operating area for changing the measuring system.
- Automatic conversion of active NC data when the measuring system is changed.
- Data backup is performed with the actual measuring system identifier.
- The measuring system for sag compensation is configured in machine data element:

MD32711 \$MA\_CEC\_SCALING\_SYSTEM\_METRIC

**References:**

/FB2/ Function Manual, Extended Functions; Compensations (K3)

- The measuring system for positional data of the indexing axis tables and switching points for software cams is configured in machine data element:  
MD10270 \$MN\_POS\_TAB\_SCALING\_SYSTEM.

**References:**

/FB2/ Function Manual, Extended Functions; Software Cams, Limit Switching Signals (N3)/ Indexing Axes (T1)

## 7.3.2 Conversion of basic system by parts program

### Conversion factor

The factor for the inch to metric conversion for the data input and output can be adapted via the following machine data:  
MD10250 \$MN\_SCALING\_VALUE\_INCH (conversion factor for switchover to inch system)

---

#### Note

The machine data element is not visible unless the password of protection level "Siemens" is set.

---

By changing the default value, the control can be adapted to a customer-specific measuring system.

When programming, it is possible to change over between measuring systems for some workpiece-related specifications with G70/G71/G700/G710. The data that can be influenced by G70/G71/G700/G710 is described in the Programming Guide.

The basic position G70/G71/G700/G710 can be assumed channel-specifically via the initial setting (reset) of the G groups in the machine data:  
MD20150 \$MC\_GCODE\_RESET\_VALUES[12]

When changing the measuring system via the relevant soft key on the HMI, these initial settings are automatically predefined to appropriate settings for the new measuring system with G700 or G710.

The axis-specific machine data:

MD31200 \$MA\_SCALING\_FACTOR\_G70\_G71

(factor for converting values with active G70/G71/G700/G710)

can be used to freely select the conversion factor between metric and inch conversion with G70/G71/G700/G710 programming.

The controller can be adapted to a customized measuring system by changing the predefined settings. The factor only takes effect if parts program programming differs from the initial state.

### Example

Initial state: inch; (MD10240 \$MN\_SCALING\_SYSTEM\_IS\_METRIC=0)

Parts program:

```
N15 G70           ; Factor is not effective, since the setting is exactly the
                  same as the initial state.
N20 G71           ; Factor is effective.
```

The current setting (selected with G70/G71) and the initial state can be the same or differ at any given time. The current setting is channel-specific, the initial state applies to all channels.

## Application

With this function it is possible, for example, with a metric basic system, to machine an inch thread in a metric parts program. Tool offsets, zero offsets and feedrates remain metric.

Machine data are output to the screen in the basic system selected in:  
MD10240 \$MN\_SCALING\_SYSTEM\_IS\_METRIC (basic system metric).

Machine coordinates, tool data and zero offsets are always displayed in the initial state, workpiece coordinate displays are in the current setting.

If programs including data sets (zero offset, tool offset) programmed in the measuring system, which differs from the basic system, are read in from an external source, the initial state must first be changed via machine data MD10240.

Data exchange with the PLC of interface signals containing dimension information, e.g. feedrate for path and positioning axes, is always carried out in the selected basic system.

## Supplements

G700/G710 extends the functionality of G70/G71 as follows:

1. The feedrate is interpreted in the programmed measuring system:

- G700: length parameters [inch]; feedrates [inch/min]
- G710: length parameters [mm]; feedrates [mm/min]

The programmed feedrate is modal and therefore remains active after subsequent G70/G71/G700/G710 commands. If the feedrate is to apply in the new G70/G71/G700/G710 context, it must be re-programmed.

2. System variables and machine data specifying lengths in the parts program are read and written in the programmed measuring system.

This allows you to implement parts programs that are independent of the current default measuring system.

Comparison of the effect of G70/G71 and G700/G710 on machine data and system variables in the parts program:

- With G70/G71: reading/writing in the basic system
- With G700/G710: reading/writing in the programmed measuring system

## Examples

Both parts programs are implemented with a metric setting with:  
MD10240 \$MN\_SCALING\_SYSTEM\_IS\_METRIC=1.

```
N100 R1=0 R2=0
N120 G01 G70 X1 F1000
N130 $MA_LUBRICATION_DIST[X]=10
N140 NEWCONF
N150 IF ($AA_IW[X]>$MA_LUBRICATION_DIST[X])
N160 R1=1
N170 ENDIF
N180 IF ($AA_IW[X]>10)
N190 R2=1
N200 ENDIF
N210 IF ( (R1<>0) OR (R2<>0) )
N220 SETAL(61000)
N230 ENDIF
N240 M30
```

---

### Note

Alarm 61000 is not output if G70 is replaced by G700 in block N120.

---

## Synchronized actions

In order to prevent the current parts program context from changing the positioning behavior of a synchronized action arbitrarily in response to asynchronous trigger conditions, the measuring system must be defined at the time of interpretation. This is the only way to achieve a defined and reproducible positioning behavior of a synchronized action.

### Example 1:

```
N100 R1=0
N110 G0 X0 Z0
N120 WAITP(X)
N130 ID=1 WHENEVER $R1==1 DO POS[X]=10
N140 R1=1
N150 G71 Z10 F10 ;Z=10 mm X=10 mm
N160 G70 Z10 F10 ;Z=254 mm X=254 mm
N170 G71 Z10 F10 ;Z=10 mm X=10 mm
N180 M30
```

**Example 2:**

The definition is made here by programming G71 in the synchronized action.

```
N100 R1=0
N110 G0 X0 Z0
N120 WAITP(X)
N130 ID=1 WHENEVER $R1==1 DO G71 POS[X]=10
N140 R1=1
N150 G71 Z10 F10 ;Z=10 mm X=10 mm
N160 G70 Z10 F10 ;Z=254 mm X=10 mm (X posit. always at 0 mm)
N170 G71 Z10 F10 ;Z=10 mm X=10 mm
N180 M30
```

**Comparison: G70/G71-G700/G710**

Where:

P:	Data is read/written in the programmed measuring system.
G:	Data is read/written in the basic system (MD10240 \$MN_SCALING_SYSTEM_IS_METRIC).
R/W:	Read/Write

Comparison:

Range	G70/G71	G700/G710
	Parts program	Parts program
	R/W	R/W
Display, decimal places (WCS)	P/P	P/P
Display, decimal places (MCS)	G/G	G/G
Feedrates	G/G	P/P
Positional data X, Y, Z	P/P	P/P
Interpolation parameters I, J, K	P/P	P/P
Circle radius (CR)	P/P	P/P
Polar radius (RP)	P/P	P/P
Pitch	P/P	P/P
Programmable FRAME	P/P	P/P
Settable FRAMES	G/G	P/P
Basic frames	G/G	P/P
Work offsets external	G/G	P/P
Axial preset offset	G/G	P/P
Operating range limit (G25/G26)	G/G	P/P
Protection zones	P/P	P/P
Tool offsets	G/G	P/P
Length-related machine data	G/G	P/P
Length-related setting data	G/G	P/P

Range	G70/G71	G700/G710
Length-related system variables	G/G	P/P
GUD	G/G	G/G
LUD	G/G	G/G
PUD	G/G	G/G
R parameters	G/G	G/G
Siemens cycles	P/P	P/P
Jog/handwheel increment factor	G/G	G/G

**References:**

/PG/ Programming Manual, Fundamentals; List of Addresses

### 7.3.3 Manual switchover of the basic system

#### General

The relevant softkey on the HMI in the "Machine" operating area is used to change the measuring system of the controller.

The change in the measuring system occurs only under the following boundary conditions:

- MD10260 \$MN\_CONVERT\_SCALING\_SYSTEM=1
- Bit 0 of MD20110 \$MC\_RESET\_MODE\_MASK is set in every channel.
- All channels are in the Reset state.
- Axes do not traverse with JOG, DRF or PLC.
- Constant grinding wheel peripheral speed (GWPS) is not active.

Actions such as part program start or mode change are disabled for the duration of the measuring system changeover.

If the measuring system cannot be changed, this is indicated by a message to that effect on the user interface. These measures ensure that a consistent set of data is always used for a running program with reference to the measuring system.

The actual change in the measuring system is made by writing all the necessary machine data and subsequently activating them with a `RESET`.

Machine data:

MD10240 \$MN\_SCALING\_SYSTEM\_IS\_METRIC

and the corresponding `G70/G71/G700/G710` settings in machine data:

MD20150 \$MN\_GCODE\_RESET\_VALUES

are switched automatically and consistently for all configured channels.

**The value of machine data:**

**MD20150 \$MC\_GCODE\_RESET\_VALUES[12]**

**changes between G700 and G710.**

This process takes place independently of the protection level currently set.

---

**Note**

The availability of the soft key and, therefore, its functionality, can be configured using the compatibility machine data:

MD10260 \$MN\_CONVERT\_SCALING\_SYSTEM.

If several NCUs are linked by NCU-link, the switchover has the same effect on all linked NCUs. If the prerequisites for a switchover are not fulfilled on one of the NCUs linked, no switchover will take place on none of the NCUs. It is assumed that interpolations between several NCUs will take place on the existing NCUs, whereby the interpolations can provide correct results only if the same unit systems are used.

**References:**

/FB2/ Function Manual, Extended Functions; Several Control Panels on Multiple NCUs, Decentralized Systems (B3)

---

## System data

When changing over the measuring system, from the view of the user, all length-related specifications are converted to the new measuring system automatically.

This includes:

- Positions
- Feedrates
- Acceleration rates
- Jerk
- Tool offsets
- Programmable, settable and work offsets external and DRF offsets
- Compensation values
- Protection zones
- Machine data
- Jog and handwheel factors

After the changeover, all of the above data is available in physical quantities.

Data, for which no unique physical units are defined, is **not** converted automatically.

This includes:

- R parameters
- GUDs (**G**lobal **U**ser **D**ata)
- LUDs (**L**ocal **U**ser **D**ata)
- PUD (**P**rogram global **U**ser **D**ata)
- Analog inputs/outputs
- Data exchange via FC21

The user is prompted to take the current valid measuring system:

MD10240 \$MN\_SCALING\_SYSTEM\_IS\_METRIC

into account.

The current measuring system setting can be read at the PLC interface via the "inch measuring system" signal:

DB10 DBX107.7.

Signal:

DB10 DBB71 (inch/metric measuring system modification counter)

can be used for reading the "measuring system modification counter".

## User tool data

Additional machine data sets are introduced for user-defined tool data:

MD18094 \$MN\_MM\_NUM\_CC\_TDA\_PARAM

and cutting edge data:

MD18096 \$MN\_MM\_NUM\_CC\_TOA\_PARAM:

MD10290 \$MN\_CC\_TDA\_PARAM\_UNIT [MM\_NUM\_CC\_TDA\_PARAM]

MD10292 \$MN\_CC\_TOA\_PARAM\_UNIT [MM\_NUM\_CC\_TOA\_PARAM]

A physical unit can be configured using these machine data. All length-related user-defined tool data are automatically converted to the new measuring system according to the input on switchover.

## Reference point

The reference point is retained. It is not necessary to repeat referencing.

### Input resolution and computational resolution

The input/computational resolution is set in the control via machine data:  
MD10200 \$MN\_INT\_INCR\_PER\_MM.

Default settings:

Metric system	Inch system
1000 (0.001 mm)	0.0001

**Example:**

1 inch = 25.4 mm  $\Rightarrow$  0.0001 inch = 0.00254 mm = 2.54  $\mu$ m

To be able to program and display the last 40 mm, MD10200 must be assigned a value of 100000.

Only with this identical setting for both measuring systems is it possible to change the measuring system without a significant loss of accuracy. Once MD10200 has been set to this value, it will not need to be changed each time the measuring system is switched over.

### JOG and handwheel factor

Machine data:

MD31090 \$MA\_JOG\_INCR\_WEIGHT

consists of two values, which contain the axial increment factors for both measuring systems.

Depending on the current setting in machine data:

MD10240 \$MN\_SCALING\_SYSTEM\_IS\_METRIC,  
the control selects the correct value automatically.

The user defines the two increment factors, e.g. for the first axis, during the installation and startup phase:

- Metric:

MD31090 \$MA\_JOG\_INCR\_WEIGHT[0;AX1]=0.001 mm

- Inch:

MD31090 \$MA\_JOG\_INCR\_WEIGHT[1;AX1]=0.00254 mm  $\triangleq$  0.0001 inch

In this way, MD31090 does not have to be written on every inch/metric switchover.

Remaining distances are not accumulated during incremental traversing with JOG when the measuring system is changed, since all internal positions always refer to mm.

## Data backup

Data sets, which can be read separately from the control and have access to data relevant to the measuring system, receive an INCH or METRIC identifier during the read action, depending on machine data:

MD10260 \$MN\_CONVERT\_SCALING\_SYSTEM.

The identifier corresponds to machine data:

MD10240 \$MN\_SCALING\_SYSTEM\_IS\_METRIC.

This records the measuring system, in which the data were originally read out.

This information is intended to prevent data sets from being read into the control system with a measuring system, which is different from the active system. In this case, alarm 15030 is triggered and the write process is interrupted.

Since the language instruction is also evaluated in parts programs, these can also be "protected" against operator errors as described above. You can, therefore, prevent parts programs containing only metric data, for example, from running on an inch measuring system.

Archives and machine data sets are downward compatible if:

MD11220 \$MN\_INI\_FILE\_MODE = 2.

---

### Note

The INCH/METRIC instruction is only generated if compatibility machine data:

MD10260 \$MN\_CONVERT\_SCALING\_SYSTEM

is set.

---

## Rounding machine data

All length-related machine data are rounded to the nearest 1 pm when writing in the inch measuring system (MD10240 \$MN\_SCALING\_SYSTEM\_IS\_METRIC=0 and MD10260 \$MN\_CONVERT\_SCALING\_SYSTEM=1), in order to avoid rounding problems.

The disturbing loss of accuracy, which occurs as a result of conversion to ASCII when reading out a data backup in the inch system of measurement, is corrected by this procedure when the data is read back into the system.

### 7.3.4 FGROUP and FGREF

#### Programming

It should be possible to program the effective machining feedrate in the usual way as a path feedrate via the F value in processing procedures where the tool, the workpiece or both are moved by a rotary axis (e.g. laser machining of rotating tubes).

In order to achieve this, it is necessary to specify an effective radius (reference radius) for each of the rotary axes involved. You can do this by programming the modal NC address:

`FGREF [ <axis name> ] = reference radius`

The unit of the reference radius depends on the `G70/G71/G700/G710` setting.

In order to include the axes in the calculation of the path feedrate, they must all be specified in the `FGROUP` command.

In order to ensure compatibility with the behavior with no `FGREF` programming, the factor 1 degree = 1 mm is activated on system power-up and RESET.

This corresponds to a reference radius of:

$FGREF = 360 \text{ mm} / (2\pi) = 57.296 \text{ mm}$

This default setting is independent of the active basic system:

`MD10240 $MN_SCALING_SYSTEM_IS_METRIC`

and of the currently active inch/metric G code.

Table 7-2 Special features of the feedrate weighting for rotary axes in `FGROUP`:

```
N100 FGROUP (X, Y, Z, A)
N110 G1 G91 A10 F100
N120 G1 G91 A10 X0.001 F100
```

The programmed F value in block `N110` is evaluated as a rotary axis feedrate in degrees/min, while the feedrate weighting in block `N120` is either 100 inch/min or 100 mm/min, depending on the current inch/metric setting.

The time required to execute the two blocks can be differ greatly.

---

#### Note

The `FGREF` factor also works if only rotary axes are programmed in the block.

The normal F value interpretation as degree/min applies in this case only if the radius reference corresponds to the `FGREF` default setting, when:

- `G71/G710`:  
`FGREF [A]=57.296`
  - `G70/G700`:  
`FGREF [A]=57.296/25.4`
-

### Example

The following example illustrates the effect of FGROUP on the path and the path feedrate.

```

N100 R1=0
N110 FGROUP(X,A)
N120 G91 G1 G710 F100 ; Feedrate=100 mm/min or 100 deg/min
N130 DO $R1=$AC_TIME
N140 X10 ; Feedrate=100 mm/min
; Path=10 mm
; R1=6 s approx.
N150 DO $R2=$AC_TIME
N160 X10 A10 ; Feedrate=100 mm/min
; Path=14.14 mm
; R2=8 s approx.
N170 DO $R3=$AC_TIME
N180 A10 ; Feedrate=100 degrees/min
; Path=10 degrees
; R3=6 s approx.
N190 DO $R4=$AC_TIME
N200 X0.001 A10 ; Feedrate=100 mm/min
; Path=10 mm
; R4=6 s approx.
N210 G700 F100 ; Feedrate=2540 mm/min or 100 deg/min
N220 DO $R5=$AC_TIME
N230 X10 ; Feedrate=2540 mm/min
; Path=254 mm
; R5=6 s approx.
N240 DO $R6=$AC_TIME
N250 X10 A10 ; Feedrate=2540 mm/min
; Path=254.2 mm
; R6=6 s approx.
N260 DO $R7=$AC_TIME
N270 A10 ; Feedrate=100 degrees/min
; Path=10 degrees
; R7=6 s approx.
N280 DO $R8=$AC_TIME
N290 X0.001 A10 ; Feedrate=2540 mm/min
; Path=10 mm
; R8=0.288 s approx.

```

```
N300 FGREF[A]=360/(2*$PI)           ; Set 1 degree=1 inch via the effective radius
N310 DO $R9=$AC_TIME
N320 X0.001 A10                     ; Feedrate=2540 mm/min
                                     ; Path=254 mm
                                     ; R9=6 s approx.
N330 M30
```

---

**Note**

The variable \$AC\_TIME contains the time from the start of the block in seconds. It can only be used in synchronized actions.

---

## 7.4 Setpoint/actual-value system

### 7.4.1 General

#### Control loop

A control loop with the following structure can be configured for every closed-loop controlled axis/spindle:

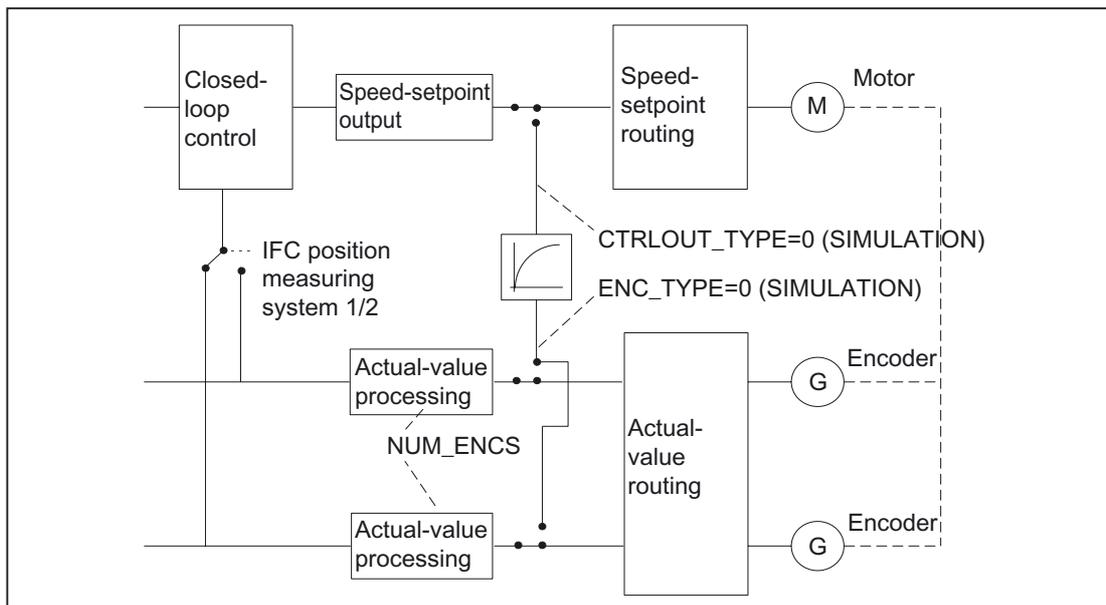


Figure 7-1 Block diagram of a control loop

#### Setpoint output

A setpoint can be output for each axis/spindle. The setpoint output to the sensor is done digitally in SINUMERIK 840D.

#### Actual-value acquisition

A maximum of two measuring systems can be connected for each axis/spindle, e.g. a direct measuring system for machining processes with high accuracy requirements and an indirect measuring system for high-speed positioning tasks.

The number of encoders used is recorded in the machine data:

MD30200 \$MA\_NUM\_ENCS (number of encoders)

In the case of two actual-value branches, the actual value is acquired for both branches.

The active measuring system is always used for position control, absolute value calculation and display. If both measuring systems are activated at the same time by the PLC interface, positioning measuring system 1 is chosen internally by the control.

Reference point approach is executed by the selected measuring system.

Each position measuring system must be referenced separately.

For an explanation of actual-value acquisition compensation functions, see:

**References:**

/FB2/ Function Manual, Extended Functions; Compensations (K3)

For an explanation of encoder monitoring, see:

**References:**

/FB1/ Function Manual, Basic Functions; Axis Monitoring, Protection Zones (A3)

### Switching between measuring systems

One can switch between the two measuring systems through the following NC/PLC interface signals:

DB31, ... DBX1.5 (position measuring system 1)

DB31, ... DBX1.6 (position measuring system 2)

**References:**

/FB1/ Function Manual, Basic Functions; Various Interface Signals (A2)

It is possible to switch over measuring systems at any time, the axes do not have to be stationary to do this. Switchover only takes place if a permissible deviation between the actual values and the two measuring systems has not been violated.

The associated tolerance is entered in the machine data:

MD36500 \$MA\_ENC\_CHANGE\_TOL (Max. tolerance on position actual value switchover)

On switchover, the current difference between position measuring system 1 and 2 is traversed immediately.

The permissible deviation between the actual values of the two measuring systems is to be entered in the machine data:

MD36510 \$MA\_ENC\_DIFF\_TOL

This tolerance setting must not be exceeded during cyclical comparison of the two measuring systems or an error message will be generated.

If the axis is not referenced (at least in the current control measuring system) then the related monitoring is not active if MD36510 = 0 or if neither of the two measuring systems in the axis is active/available).

### Types of actual-value acquisition

The used edcoder type must be defined through the following machine data:

MD30240 \$MA\_ENC\_TYPE (type of actual-value acquisition (actual position value))

### **Simulation axes**

The speed control loop of an axis can be simulated for test purposes.

The axis "traverses" with a following error, similar to a real axis.

A simulation axis is defined by setting the two following machine data to "0":

MD30130 \$MA\_CTRL\_OUT\_TYPE[n] (output value of setpoint)

MD30240 \$MA\_ENC\_TYPE[n] (type of actual-value acquisition)

As soon as the standard machine data have been loaded, the axes become simulation axes.

The setpoint and actual value can be set to the reference point value with reference point approach.

The machine data:

MD30350 \$MA\_SIMU\_AX\_VDI\_OUTPUT (output of axis signals with simulation axes)

can be used to define whether the axis-specific interface signals are to be output on the PLC during the simulation.

### **Actual-value correction**

If actual-value corrections performed by the NC on the encoder selected for position control do not influence the actual value of another encoder defined in the same axis, then this encoder is to be declared as "independent" via the following machine data:

MD30242 \$MA\_ENC\_IS\_INDEPENDENT

Actual-value corrections include the following:

- Modulo treatment
- Reference point approach
- Measuring system comparison
- PRESET

## 7.4.2 Speed setpoint and actual-value routing

### General

In order to carry out speed setpoint and actual-value routing, the following must be defined for each axis/spindle:

- Assignment of 1st measuring circuit
- Assignment of 2nd measuring circuit (if present)
- Assignment of setpoint branch

Multiple assignment is also possible, e.g. using a measuring circuit for position actual-value acquisition for the alternating control of several axes/spindles.

---

#### Note

When a SIMODRIVE 611 universal is operated via the PROFIBUS-DP, various machine data that need to be parameterized for digital and analog drives are not assigned.

---

### Prerequisite for routing

All NC-machine axes must be in machine data:

MD10000 \$MN\_AXCONF\_MACHAX\_NAME\_TAB [n] (machine axis name)

defined uniquely.

This name must be unique throughout the system (all mode groups and channels).

#### References:

/FB1/ Function Manual, Basic Functions;

Axes, coordinate systems, frames (K2)/

Mode group, channel, program operation, reset response (K1)

### Speed setpoint routing

For speed setpoint routing, the following setpoint assignments for parameterizing the relevant machine data must be made:

Setpoint assignment	Number
Drive type:	of the bus segment
Drive/module number:	of the module within a bus segment
Output on drive module/module:	of the setpoint output
Output type of setpoint::	Type of speed setpoint output
Setpoint output is unipolar (only active in conjunction with PROFIBUS-DP)	Polarity of the output driver for speed setpoint output

### Index of MD for speed setpoint routing

The index [n] of the machine data for setpoint routing is coded with 0 for setpoint assignment with default setting 1.

### Speed setpoint routing

The following machine data need to be parameterized for each setpoint branch:

<b>MD30100 \$MA_CTRLOUT_SEGMENT_NR[n] (setpoint assignment of bus segment):</b>	
The number of the bus segment, via which the output is addressed, is entered here. Depending upon the instance of the corresponding SINUMERIK, specific bus segments are permanently assigned.	
• Local bus	= 0
• 611D-Bus (1st DCM)	= 1
• Local P-bus	= 2
• 611D-Bus (2nd DCM)	= 3
• reserved for virtual buses	= 4
• PROFIBUS-DP (NCU 573.2 onward) (PLC-side Profibus-strand for ProfiSafe)	= 5
• PROFIBUS-DP Link module (NCU 573.2 onward)	= 6

<b>MD30110 \$MA_CTRLOUT_MODULE_NR[n] (setpoint assignment: Drive number/module number):</b>	
The number of the module in the bus segment, via which the output is to be addressed, is entered here. The logical number of the axis module via the machine data: MD13010 \$MN_DRIVE_LOGIC_NR[n] can be set for:	
• SINUMERIK 840D as 611 digital drive number	Range of values 0 - 31
• SINUMERIK 840D Profibus at link module	Range of values 0 -125

<b>MD30120 \$MA_CTRLOUT_NR[n] (setpoint assignment: Setpoint output on drive module/module):</b>	
The number of the output is to be entered here, through which the setpoint output is done (SINUMERIK 840D always via output 1).	

<b>MD30130 \$MA_CTRLOUT_TYPE[n] (setpoint output type):</b>	
The speed setpoint output type is entered here.	
0:	Simulation (HW not required)
1:	Standard (differentiated via HW configuration)

<b>MD30134 IS_UNIPOLAR_OUTPUT[n] (setpoint output is unipolar):</b>	
The unipolar speed setpoint output works only in conjunction with PROFIBUS-DP.	

### Actual-value routing

For actual-value routing, the following actual-value assignments for parameterizing the associated machine data must be made:

Actual value assignment	Number:
Drive type:	of the bus segment
Drive/module number:	of the module within a bus segment
Input on drive module/measuring circuit module:	of the setpoint input
Type of actual-value acquisition (position actual value):	The encoder type used
Encoder set independently/dependently	The encoder is independent Actual-value corrections by the NC

### Machine data actual-value routing

The following machine data must be parameterized for each actual-value branch:

MD30210 \$MA_ENC_SEGMENT_NR[n] (actual-value assignment of bus segment):	
The number of the bus segment, via which the encoder is addressed, is entered here. Depending upon the instance of the corresponding SINUMERIK, specific bus segments are permanently assigned.	
• Local bus	= 0
• 611D-Bus (1st DCM)	= 1
• Local P-bus	= 2
• 611D-Bus (2nd DCM)	= 3
• reserved for virtual buses	= 4
• PROFIBUS-DP (NCU 573.2 onward) (PLC-side Profibus-strand for ProfiSafe)	= 5
• PROFIBUS-DP Link module (NCU 573.2 onward)	= 6

MD30220 \$MA_ENC_MODULE_NR[n] (actual-value assignment: drive module number/measuring circuit number):	
The number of the module in the bus segment, via which the encoder is addressed, is entered here. The logical number of the axis module via the machine data: MD13010 \$MN_DRIVE_LOGIC_NR[n] can be set for:	
• SINUMERIK 840D as 611 digital drive number	Range of values 0 - 31
• SINUMERIK 840D Profibus at link module	Range of values 0 -125

MD30230 \$MA_ENC_INPUT_NR[n] (actual-value assignment: Input on drive module/measuring circuit module):	
The number of the input, to which the position actual-value encoder is connected, is entered here.	
• For SINUMERIK 840D:	= 1 or 2 (counting down)

7.4 Setpoint/actual-value system

<b>MD30240 \$MA_ENC_TYPE[n] (type of actual-value acquisition):</b>
Enter the encoder type used here.

<b>MD30242 \$MA_ENC_IS_INDEPENDENT[n]:</b>
To prevent actual-value corrections influencing the actual value of an encoder defined in the same axis, the latter must be declared independent.
0: Encoder is independent
1: Encoder is dependent

**MD index for actual-value routing**

The coding of the machine data index [n] for actual-value routing is:

<b>[encoder no.]</b>	
0	For first encoder
1	For second encoder

**Examples of setpoint/actual-value routing**

**SINUMERIK 840D with SIMODRIVE 611 digital**

For machine axis "X1", the setpoint should be output digitally and actual values acquired on drive module 4 (4th slot = index [3]).

The "logical drive number" of this module is 7.

Encoder number: 1, 2

Therefore, actual values are acquired via a direct and indirect measuring system.

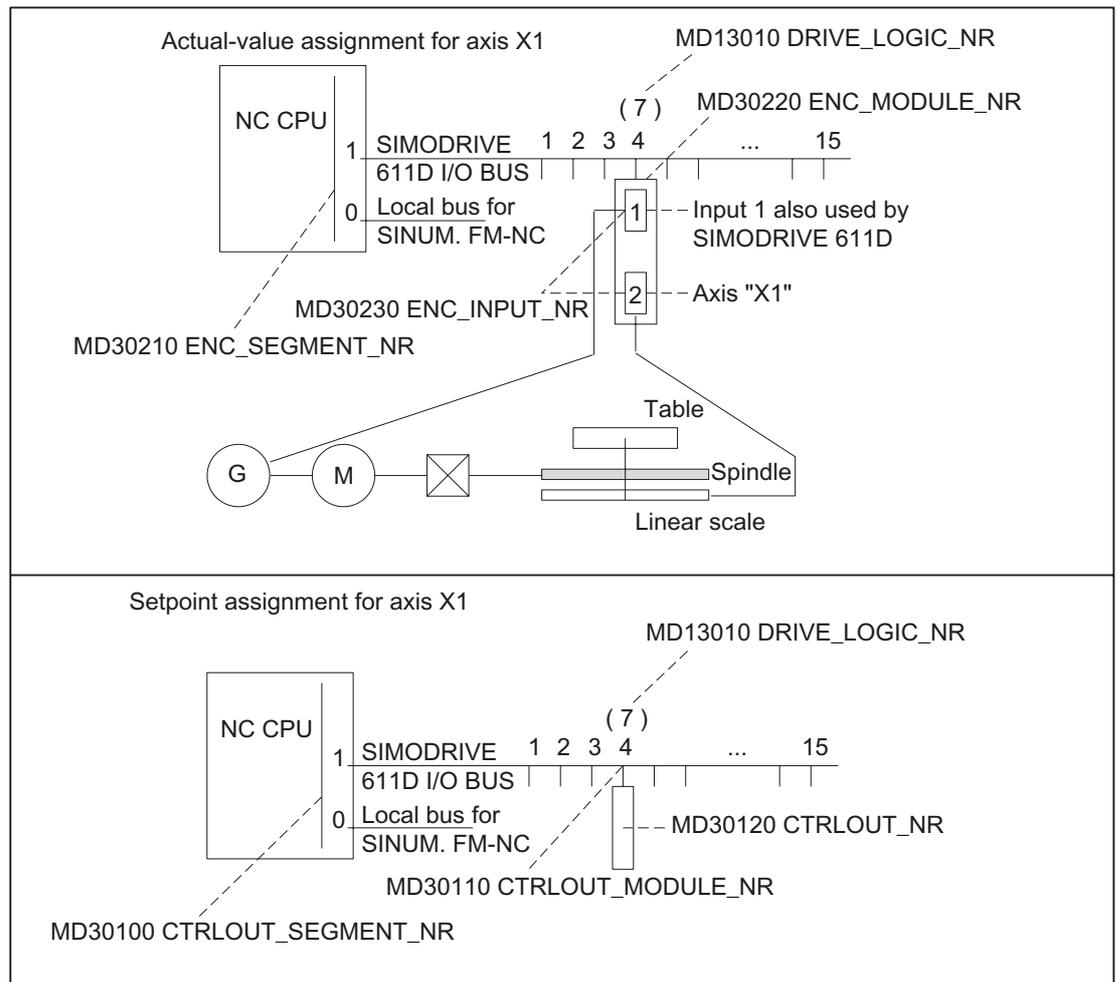


Figure 7-2 Example of setpoint/actual-value routing

Special features of SINUMERIK 840D with SIMODRIVE 611 digital:

- MD30110 \$MA\_CTRLOUT\_MODULE\_NR[n] and MD30220 \$MA\_ENC\_MODULE\_NR[n] of a machine axis always have the same logical axis number in case of indirect measuring systems or when the motor encoder has to be evaluated at the NC-side.
- If direct measuring systems are installed, you can also configure encoders that are connected to other drives.

### 7.4.3 Configuration of drives

#### SINUMERIK 840D with SIMODRIVE 611 digital

##### SINUMERIK 840D with 611D-Drive bus

You can configure the drive in the "Diagnostics" operating area on the operator panel (HMI; Human Machine Interface).

The following machine data are automatically parameterized for each real drive:

- MD13010 \$MN\_DRIVE\_LOGIC\_NR[n] (logical drive number)
- MD13000 \$MN\_DRIVE\_IS\_ACTIVE[n] (activate SIMODRIVE 611 digital drive)
- MD13030 \$MN\_DRIVE\_MODULE\_TYPE[n] (module identifier)
- MD13040 \$MN\_DRIVE\_TYPE[n] (drive type identifier)
- MD13020 \$MN\_DRIVE\_INVERTER\_CODE[n] (power section code of drive module)

The index [n] used in the machine data is the slot number of the real drives. The number is automatically assigned by the NC for all connected drive modules on POWER ON. The index is numbered starting with "0" at the beginning of the drive bus (1st real drive available) and continues in ascending order to the end. Multi-axis modules are assigned consecutive, physical drive numbers (counted from left to right).

MD13010 \$MN\_DRIVE\_LOGIC\_NR (logical drive number)

can also be used to create placeholders for modules that are not yet available.

#### SINUMERIK 840Di with SIMODRIVE 611 universal

##### SINUMERIK 840Di with PROFIBUS-DP

When a SINUMERIK 840Di is operated with the PROFIBUS-DP drive 611 universal, the following MD are **not** used:

- MD13000 \$MN\_DRIVE\_IS\_ACTIVE[n] (activate SIMODRIVE 611 digital drive)
- MD13010 \$MN\_DRIVE\_LOGIC\_NR[n] (logical drive number)
- MD13020 \$MN\_DRIVE\_INVERTER\_CODE[n] (power section code of drive module)
- MD13030 \$MN\_DRIVE\_MODULE\_TYPE[n] (module identifier)
- MD13040 \$MN\_DRIVE\_TYPE[n] (Identification of the drive type)

The following machine data are used instead of MD13000 to MD13040:

- MD13050 \$MN\_DRIVE\_LOGIC\_ADDRESS[n] (drive address)
- MD13060 \$MN\_DRIVE\_TELEGRAM\_TYPE[n]  
(Message frame type for drives connected to PROFIBUS-DP)

- MD13070 \$MN\_DRIVE\_FUNCTION\_MASK[n]  
(DP functions used for drives connected to PROFIBUS-DP)  
Allows adaptation of certain non-standardized PROFIBUS control bits of the SIMODRIVE 611 universal.
- MD13080 \$MN\_DRIVE\_TYPE\_DP[n] (PROFIBUS-DP drive type)  
Selection of external slaves, synchronous, asynchronous or linear drives.

### 7.4.4 Adapting the motor/load ratios

#### Gear types

The following gear types are available for adapting the mechanical ratios:

Gear type	Activation	Adaptation	Installation location
Motor/load gear	Parameter set	Fixed configuration	Gear unit
Measuring gear encoder	Power ON	Sensor-dependent	Sensor-side
Load intermediate gear unit	NewConfig	Load-dependent	Tool-side

#### Local position of gear unit/encoder

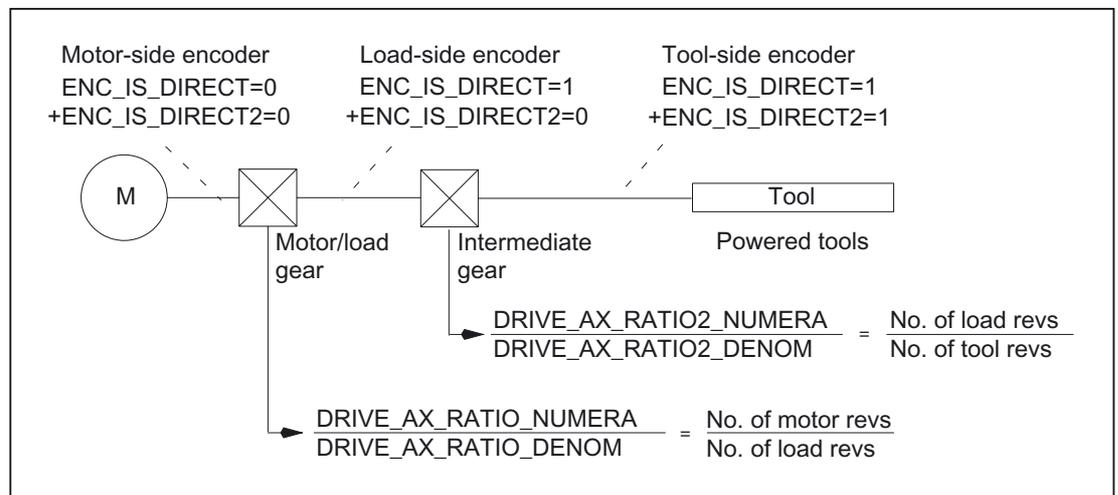


Figure 7-3 Gear unit types and encoder locations

### Motor/load gear

The motor/load gear supported by SINUMERIK is configured via the following machine data:

MD31060 \$MA\_DRIVE\_AX\_RATIO\_NUMERA (Numerator load gearbox)

MD31050 \$MA\_DRIVE\_AX\_RATIO\_DENOM (Denominator load gearbox)

The transmission ratio is obtained from the numerator/denominator ratio of both machine data. The associated parameter sets are used automatically as default by the control to synchronize the position controller with the relevant transmission ratios.

Since a gear stage change is not always carried out automatically, and there are also several ways to request a gear stage change, the position controller is not always incorporated via parameter sets.

---

#### Note

For more information about parameter sets during gear stage change, see:

#### References:

/FB1/ Function Manual, Basic Functions; Spindles (S1).

---

### Intermediate gear

Additional, configurable load intermediate gears are also supported by the control:

MD31066 \$MA\_DRIVE\_AX\_RATIO2\_NUMERA (intermediate gear numerator)

MD31064 \$MA\_DRIVE\_AX\_RATIO2\_DENOM (intermediate gear denominator)

Power tools generally have their "own" intermediate gear. Such variable mechanics can be configured by multiplying the active intermediate gearbox and the motor/load gearbox.

 <b>CAUTION</b>
--

Unlike the motor/load gear, there is no parameter set for the intermediate gear and, therefore, no way of controlling the time-synchronized switchover to parts program or PLC (VDI interface). Part programming during gear change is, therefore, ruled out. It remains the task of the user to match the synchronization of the relevant changed machine data to the corresponding mechanical switchover and activate it. On switchover during a movement, compensations <b>cannot</b> be ruled out due to jumps in the scaling factors. These are not monitored for violation of the maximum acceleration.
---

### Encoder directly on tool

Another connection option is possible for a "tool-side encoder" on the intermediate gear, by configuring machine data:

MD31044 \$MA\_ENC\_IS\_DIRECT2.

### Encoder not directly on tool

The following supplementary conditions apply to a gear change of the intermediate gear in position-control mode:

- The gear ratio to be changed is incorporated in a re-scaling of the encoder information in this case.

In this case, the following applies to axes/spindles in positioning mode:

- A non-abrupt gear change is **only possible at zero speed**.

To do this, the tool-side position before and after a gear change are set equal for a change in the ratio, since the mechanical position does not (or hardly) changes during a gear stage change.

#### Recommendation:

To avoid 21612 "Controller enable reset during motion", changeover should be carried out "only at zero speed". It is still permissible and expedient to switch the axis or spindle to speed-control or follow-up mode before or during a gear change.

## Supplementary conditions

If the encoder to be used for position control is **connected directly at the tool**, the gear stage change only affects the physical quantities at the speed interface between the NC and the drive of the motor/load gear. The internal parameter sets are not changed.

## Reference point and position reference

In the case of gear changes, it is not possible to make a statement about the effect of the reference point or machine position reference on the encoder scaling. In such cases, the control partially cancels the status "Axis referenced/synchronized".

If the position reference to the machine, tool, etc., has been lost, it must first be restored through appropriate adjustment or referencing of the lost reference point. This is especially important for the functions Travel to fixed stop, Referencing to Bero, Cam and Zero marker.

 <b>CAUTION</b>
--

The control cannot detect all possible situations that can lead to loss of the machine position reference. Therefore, it is the responsibility of the commissioning engineer or user to initiate explicit referencing of zero marker synchronization in such cases.
---

---

**Note**

To facilitate re-referencing without a disruptive RESET, machine data:

MD34080 \$MA\_REFP\_MOVE\_DIST

and

MD34090 \$MA\_REFP\_MOVE\_DIST\_CORR

should be reset to NewConfig efficacy.

For more information about referencing, please see:

**References:**

/FB1/ Function Manual, Basic Functions; Reference Point Approach (R1)

---

### 7.4.5 Speed setpoint output

#### Control direction and travel direction of the feed axes

You must determine the travel direction of the feed axis before starting work.

**Control direction**

Before the position control is started up, the speed controller and current controller of the drive must be started up and optimized.

**Travel direction**

With the machine data:

MD32100 \$MA\_AX\_MOTION\_DIR (travel direction).

the direction of motion of the axis can be reversed,

without affecting the control direction of the position control.

#### Speed setpoint adjustment

**SINUMERIK 840D**

In the case of speed setpoint comparison, the NC is informed, which speed setpoint corresponds to which motor speed in the drive, for parameterizing the axial control and monitoring. This comparison is carried out automatically.

**SINUMERIK 840D with PROFIBUS-DP**

For PROFIBUS-DP drives with automatic adjustment of the speed setpoint standardization it is necessary that the machine data:

MD32250 \$MA\_RATED\_OUTVAL[n] (rated output voltage)

be changed from 80% to 0% corresponding to the value "0".

This value is also to be ensured for an NC side adjustment.

For PROIBUS-DP drives, alternatively, the manual speed setpoint comparison is also possible.

- **Manual comparison**

In the machine data:

MD32250 \$MA\_RATED\_OUTVAL

a value not equal to zero is entered.

For more detailed information about motor speed adjustments, please see:

**References:**

/HBI/ Manual SINUMERIK 840Di; "Axes and Spindles"

**SINUMERIK 840D with SIMODRIVE 611 universal**

The speed setpoint comparison for SINUMERIK 840Di with SIMODRIVE 611 universal drives can be performed automatically or manually.

- **Automatic adjustment**

The configuration values for the speed value standardization are adjusted automatically, as long as the machine data:

MD32250 \$MA\_RATED\_OUTVAL[n] = 0

remains.

The speed setpoint comparison through acyclic services at PROFIBUS-DP can be performed automatically.

**SINUMERIK 840D with SIMODRIVE digital**

---

**Note**

**Velocity adjustment and maximum speed setpoint**

Owing to the automatic speed setpoint comparison a velocity adjustment is not necessary for SINUMERIK 840D!

---

### Maximum speed setpoint

In case of SINUMERIK 840D the maximum speed setpoint is the highest value, owing to the maximum speed of the drive machine data set

MD1401/2401 \$MD\_MOTOR\_MAX\_SPEED (maximum useful motor speed)

on which the output of SIMODRIVE 611 digital drive can be done.

MD1401 corresponds to the maximum motor speed on the spindle drive. The desired speed at the spindle is reached via the mechanical gear stage.

The output of the spindle speed is implemented in the NC for SINUMERIK 840D/840Di.

Data for 5 gear stages are realized in the control.

These stages are defined by a minimum and maximum speed for the stage itself and by a minimum and maximum speed for the automatic gear stage changeover. A new set gear stage is output only if the new programmed speed cannot be traversed in the current gear stage.

With the machine data:

MD36210 \$MA\_CTRLOUT\_LIMIT[n] (maximum speed setpoint)

the speed setpoint is restricted percentage-wise

Values up to 200% are possible.

When the speed is exceeded, an alarm is generated.

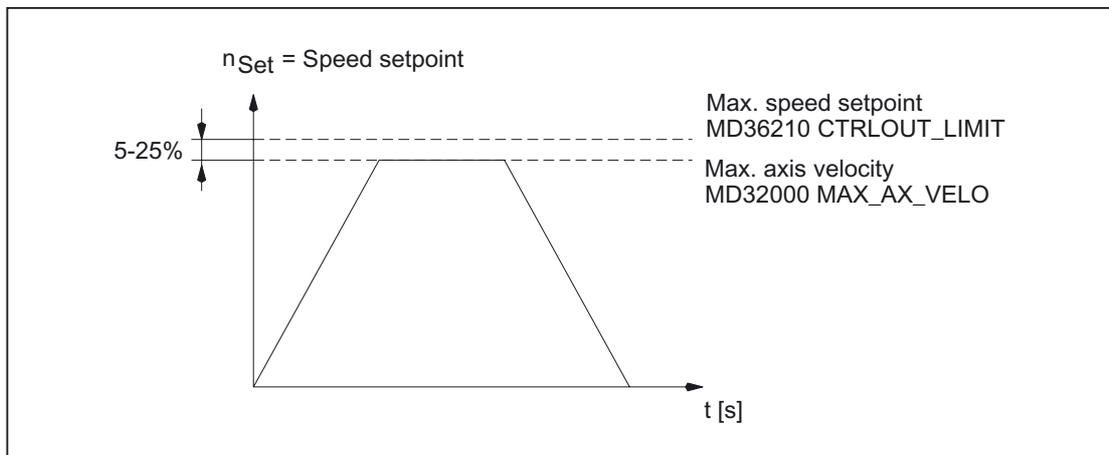


Figure 7-4 Maximum speed setpoint

However, due to control processes, the axes should not reach their maximum velocity (MD32000 \$MA\_MAX\_AX\_VELO) at 100% of the speed setpoint, but at 80% to 95%.

In case of axes, whose maximum speed is attained at around 80% of the speed setpoint range, the default value (80%) of the machine data:

MD32000 \$MA\_MAX\_AX\_VELO (maximum axis velocity)

In case of SINUMERIK 840D/810 the machine data:

MD36210 \$MA\_CTRLLOUT\_LIMIT[n] (maximum speed setpoint)

and

MD1405/2405 \$MD\_MOTOR\_SPEED\_LIMIT (monitoring speed motor)

should match.

---

**Note**

For further explanations for setpoint value adjustment for SIMODRIVE digital drive see:

**References:**

/IAD/ Installation and Startup Guide; Axes and Spindles

For explanations for setpoint standardization for SIMODRIVE analog drives see

**References:**

/FB3/ Function Manual, Special Functions; Analog axes (TE2)

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## 7.4.6 Actual-value processing

### Actual-value resolution

In order to be able to create a correctly closed position control loop, the control system must be informed of the valid actual-value resolution. The axis-specific machine data below are used for this.

The control calculates the actual-value resolution from the settings made in the MD. The control parameter sets of the position control are identified as servo parameter sets.

The machining process of the machine forms the basis of the position actual-value acquisition.

Direct measuring system (DM) is on machine directly:	Load-side encoder
Indirect measuring system (IM) is on motor indirectly:	Motor-side encoder

Depending on the type of axis (linear axis, rotary axis) and the type of actual-value acquisition (directly at the machine, indirectly at the motor), the following machine data must be parameterized to calculate the actual-value resolution:

Machine data	Linear axis	Linear axis		Rotary axis	
	Linear scale/or as direct meas. system	Encoder on motor	Encoder on machine and/or tool	Encoder on motor	Encoder on machine and/or tool
MD30300 \$MA_IS_ROT_AX	0	0	0	1	1
MD31000 \$MA_ENC_IS_LINEAR[n]	1	0	0	0	0
MD31010 \$MA_ENC_GRID_POINT_DIST[n]	Spacing	-	-	-	-
MD34320 \$MA_ENC_INVERS[n]	Opposite direction	-	-	-	-
MD31040 \$MA_ENC_IS_DIRECT[n]	- / (1)	0	1	0	1
MD31044 \$MA_ENC_IS_DIRECT2[n]	- / (1)	0	1	0	1
MD31020 \$MA_ENC_RESOL[n]	-	Pulses/rev	Pulses/rev	Pulses/rev	Pulses/rev
MD31030 \$MA_LEADSCREW_PITCH	-	mm/rev.	mm/rev.	-	-
MD31050 \$MA_DRIVE_AX_RATIO_DENOM[n]	-	Load rev.	-	Load rev.	See note
MD31060 \$MA_DRIVE_AX_RATIO_NUMERA[n]	-	Motor rev. if infeed gear available	-	Motor rev.	See note
MD31070 \$MA_DRIVE_ENC_RATIO_DENOM[n]	-	Encoder rev.	Encoder rev.	Encoder rev.	Encoder rev.
MD31080 \$MA_DRIVE_ENC_RATIO_NUMERA[n]	-	Motor-side encoder*	Motor rev.	Motor rev.	Load rev.

- = Does not apply to this combination

\* The encoder on the motor side is a built-in encoder and, therefore, does **not** have a measuring gear unit. The transmission ratio is always 1:1.

**Note**

These machine data are not required for encoder matching (path evaluation).

However, they must be entered correctly for the setpoint calculation!

Otherwise the required servo gain ( $K_v$ ) factor will not be set.

In machine data:

MD31050 \$MA\_DRIVE\_AX\_RATIO\_DENOM

one enters the load rotations, in machine data:

MD31060 \$MA\_DRIVE\_AX\_RATIO\_NUMERA

the motor rotations.

**Coding of the machine data**

The indices of the following machine data are coded at the encoder [Encoder no.]:

Encoder 0 or 1

Encoder-dependent machine data	Meaning
MD31070 \$MA_DRIVE_ENC_RATIO_DENOM[n]	(Measuring gear denominator)
MD31080 \$MA_DRIVE_ENC_RATIO_NUMERA[n]	(Measuring gear numerator)
MD31000 \$MA_ENC_IS_LINEAR[n]	(Direct measuring system, linear scale)
MD31010 \$MA_ENC_GRID_POINT_DIST[n]	(Distance between reference marks on linear scales)
MD31020 \$MA_ENC_RESOL[n]	(Encoder pulses per revolution) for rotary encoder
MD31040 \$MA_ENC_IS_DIRECT[n]	(Encoder is connected directly at the machine)
MD34320 \$MA_ENC_INVERS[n]	(Length measurement system is inverse)
<b>Further machine data without index</b>	
MD30200 \$MA_NUM_ENCS	(Number of encoders)
MD30300 \$MA_IS_ROT_AX	(rotary axis)
MD31030 \$MA_LEADSCREW_PITCH	(Leadscrew pitch)

Index [n] of the following machine data depend on the servo parameter sets of the position controller, with which the actual-value resolution is calculated automatically in the control:

MD DRIVE\_AX...[servo parameter set no.]: 0-5

Parameter-set-dependent machine data	Description
MD31050 \$MA_DRIVE_AX_RATIO_DENOM[n]	(Denominator load gear unit)
MD31060 \$MA_DRIVE_AX_RATIO_NUMERA[n]	(Numerator load gear unit)

7.4 Setpoint/actual-value system

For the following machine data, the control does not consider any parameter set nor any indices for coded encoders.

NewConfig-dependent machine data	Description
MD31064 \$MA_DRIVE_AX_RATIO2_DENOM	(Intermediate gear denominator)
MD31066 \$MA_DRIVE_AX_RATIO2_NUMERA	(Intermediate gear numerator)
MD31044 \$MA_ENC_IS_DIRECT2	(Encoder on intermediate gear)
MD32000 \$MA_MAX_AX_VELO	(Maximum axis velocity)
MD34080 \$MA_REFP_MOVE_DIST	(Reference point distance)
MD34090 \$MA_REFP_MOVE_DIST_CORR	(Reference point offset)

**Note**

These machine data can be activated in parts programs with the command `NEWCONF` or via the HMI operator panel using a soft key.

**Variants of actual-value acquisition**

The relevant machine data and relational calculations for the different methods of actual-value acquisition are described in the following.

### 7.4.7 Adjustments to actual-value resolution

#### Calculating the ratio

The calculation of the ratio is obtained from the associated machine data and is defined for incremental encoders as follows:

$$\frac{\text{Computational resolution}}{\text{Actual-value resolution}} = \frac{\text{Internal increments}/(\text{mm})}{\text{Encoder increments}/(\text{mm})}$$

For incremental encoders with rotary axis, the following applies:

$$\frac{\text{Computational resolution}}{\text{Actual-value resolution}} = \frac{\text{Internal increments}/(\text{degrees})}{\text{Encoder increments}/(\text{degrees})}$$

The internal pulse multiplication factor provided by the measuring system logic module is

- 2048

For raw signal generators on 840D with SIMODRIVE 611 digital

#### Linear axis with linear scale

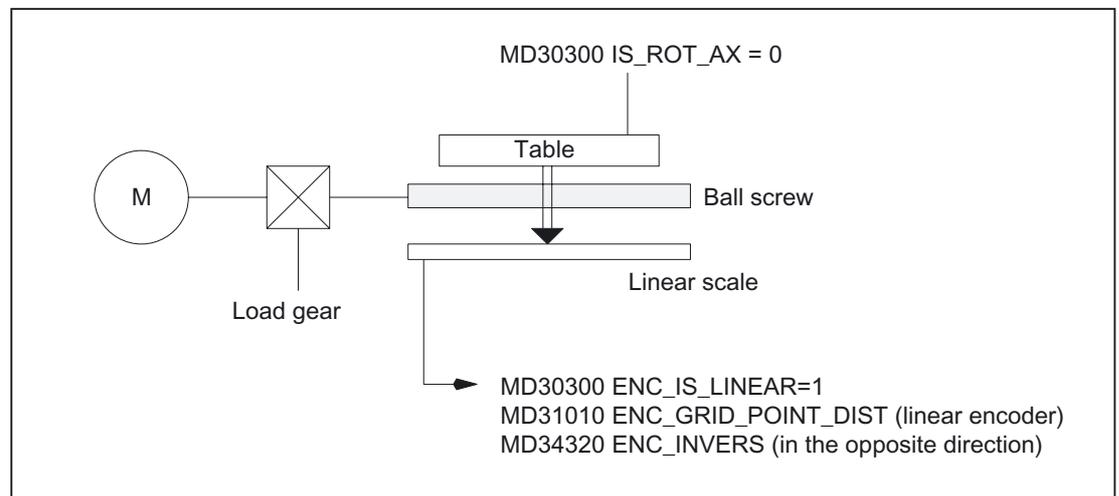


Figure 7-5 Linear axis with linear scale

In order to adapt the actual-value resolution to the calculation resolution, the control calculates the quotients from the "internal increments/mm" and the "encoder increments/mm" as follows:

7.4 Setpoint/actual-value system

$$\frac{\text{Internal increments/mm}}{\text{Encoder increments/mm}} = \frac{\text{ENC\_GRID\_POINT\_DIST [n]} * \text{INT\_INCR\_PER\_MM}}{\text{Internal multiplication}}$$

The distance for linear encoders is based on the pulse increments.

Linear axis with rotary encoder on motor

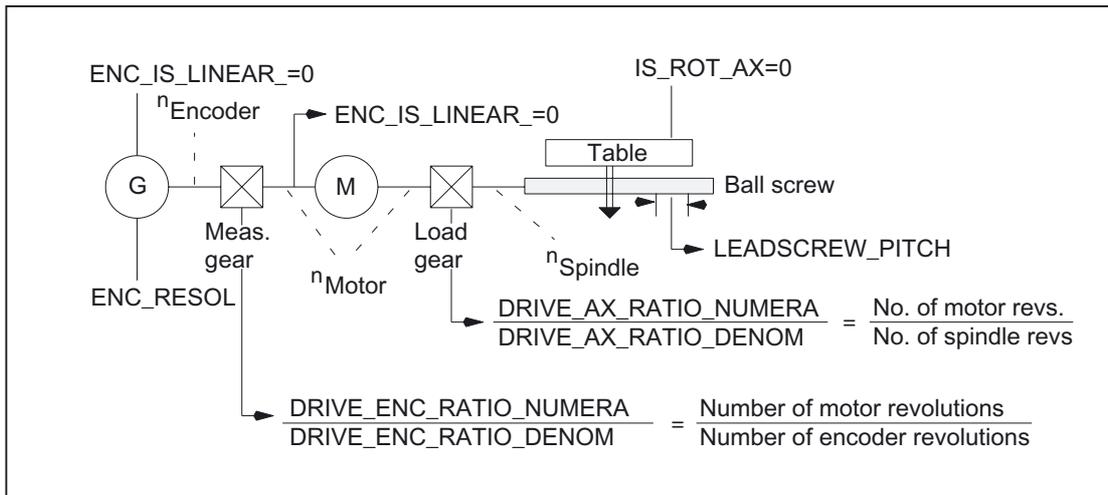


Figure 7-6 Linear axis with rotary encoder on motor

In order to adapt the actual-value resolution to the calculation resolution, the control calculates the quotients from the "internal increments/mm" and the "encoder increments/mm" as follows:

**SINUMERIK example**

**Linear axis with rotary encoder (2048 Impulse) on motor;**

internal multiplication (2048)

- Gear: Motor/leadscrew 5
- Pitch 10 mm
- 10000 increments per mm

$$\frac{\text{Internal increments/mm}}{\text{Encoder increments/mm}} = \frac{1}{\text{ENC\_RESOL [n]} * \text{internal multiplication}}$$

$$* \frac{\text{DRIVE\_ENC\_RATIO\_NUMERA [n]}}{\text{DRIVE\_ENC\_RATIO\_DENOM [n]}}$$

$$* \frac{\text{DRIVE\_AX\_RATIO\_DENOM [n]}}{\text{DRIVE\_AX\_RATIO\_NUMERA [n]}}$$

$$* \text{LEADSCREW\_PITCH}$$

$$* \text{INT\_INCR\_PER\_MM}$$

- ⇒ MD30300 \$MA\_IS\_ROT\_AX = 0
- MD31000 \$MA\_ENC\_IS\_LINEAR[0] = 0
- MD31040 \$MA\_ENC\_IS\_DIRECT[0] = 0
- MD31020 \$MA\_ENC\_RESOL[0] = 2048
- MD31030 \$MA\_LEADSCREW\_PITCH = 10
- MD31080 \$MA\_DRIVE\_ENC\_RATIO\_NUMERA[0] = 1
- MD31070 \$MA\_DRIVE\_ENC\_RATIO\_DENOM[0] = 1
- MD31060 \$MA\_DRIVE\_AX\_RATIO\_NUMERA[0] = 5
- MD31050 \$MA\_DRIVE\_AX\_RATIO\_DENOM[0] = 1
- MD10200 \$MN\_INT\_INCR\_PER\_MM = 10000

$$\Rightarrow \frac{\text{Internal increments/mm}}{\text{Encoder increments/mm}} = \frac{1}{2048 * 2048} * \frac{1}{1} * \frac{1}{5}$$

$$* 10 \text{ mm} * 10000 \text{ incr./mm} = 0.004768$$

**Result:**  
 1 encoder increment corresponds to 0.004768 increments of the internal unit. In practice, the available encoder resolution should not be resolved more accurately than the internal computational resolution.

Linear axis with rotary encoder on the machine

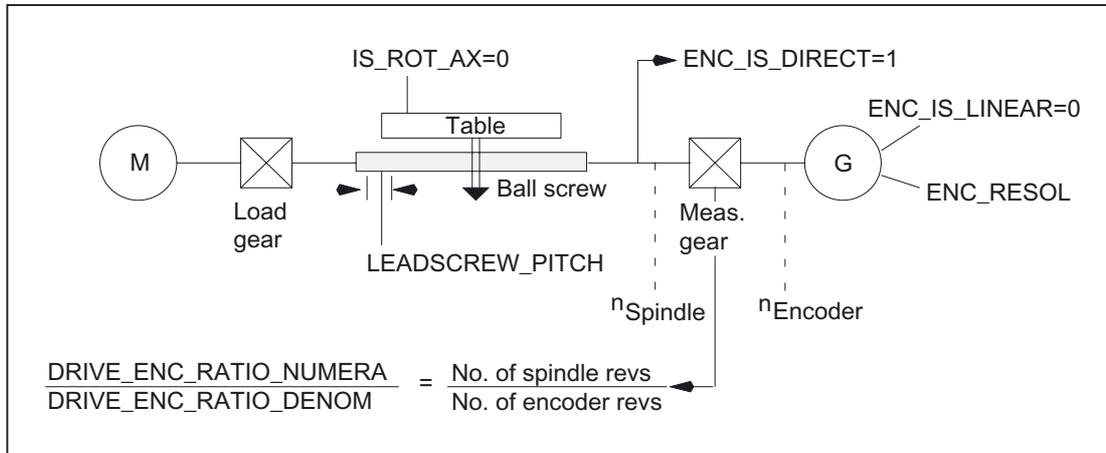


Figure 7-7 Linear axis with rotary encoder on the machine

In order to adapt the actual-value resolution to the calculation resolution, the control calculates the quotients from the "internal increments/mm" and the "encoder increments/mm" as follows:

$$\frac{\text{Internal increments/mm}}{\text{Encoder increments/mm}} = \frac{1}{\text{ENC\_RESOL [n]} * \text{internal multiplication}}$$

$$* \frac{\text{DRIVE\_ENC\_RATIO\_NUMERA [n]}}{\text{DRIVE\_ENC\_RATIO\_DENOM [n]}}$$

$$* \text{LEADSCREW\_PITCH}$$

$$* \text{INT\_INCR\_PER\_MM}$$

Rotary axis with rotary encoder on motor

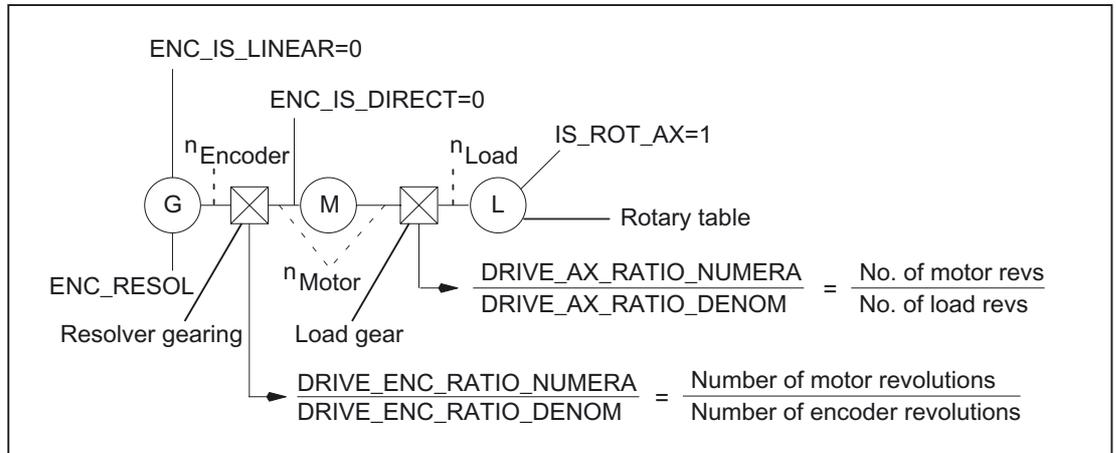


Figure 7-8 Rotary axis with rotary encoder on motor

In order to adapt the actual-value resolution to the calculation resolution, the control calculates the quotients from the "internal increments/degree" and the "encoder increments/degree" as follows:

Example for rotary axis with encoder on motor

**Rotary axis with rotary encoder (2048 Impulse) on motor;**

internal multiplication (2048)

Gear: Motor/rotary axis 5  
1000 increments per degree

$$\frac{\text{Internal increments/degrees}}{\text{Encoder increments/degrees}} = \frac{360 \text{ degrees}}{\text{ENC\_RESOL [n]} * \text{internal multiplication}}$$

$$* \frac{\text{DRIVE\_ENC\_RATIO\_NUMERA [n]}}{\text{DRIVE\_ENC\_RATIO\_DENOM [n]}}$$

$$* \frac{\text{DRIVE\_AX\_RATIO\_DENOM [n]}}{\text{DRIVE\_AX\_RATIO\_NUMERA [n]}}$$

$$* \text{INT\_INCR\_PER\_DEG}$$

- ⇒ MD30300 \$MA\_IS\_ROT\_AX = 1
- MD31040 \$MA\_ENC\_IS\_LINEAR[0] = 0
- MD31040 \$MA\_ENC\_IS\_DIRECT[0] = 0
- MD31040 \$MA\_ENC\_RESOL[0] = 2048
- MD31080 \$MA\_DRIVE\_ENC\_RATIO\_NUMERA[0] = 1
- MD31080 \$MA\_DRIVE\_ENC\_RATIO\_DENOM[0] = 1

7.4 Setpoint/actual-value system

MD31060 \$MA\_DRIVE\_AX\_RATIO\_NUMERA[0] = 5  
 MD31050 \$MA\_DRIVE\_AX\_RATIO\_DENOM[0] = 1  
 MD10210 \$MN\_INT\_INCR\_PER\_DEG = 1000

$$\Rightarrow \frac{\text{Internal increments/degrees}}{\text{Encoder increments/degrees}} = \frac{360 \text{ degrees}}{2048 * 2048} * \frac{1}{1} * \frac{1}{5}$$

\* 1000 incr./degrees = 0.017166

Result:

1 encoder increment corresponds to 0.017166 increments of the internal unit.

The encoder resolution is thus coarser than the computational resolution by a factor of 58.

Rotary axis with rotary encoder on the machine

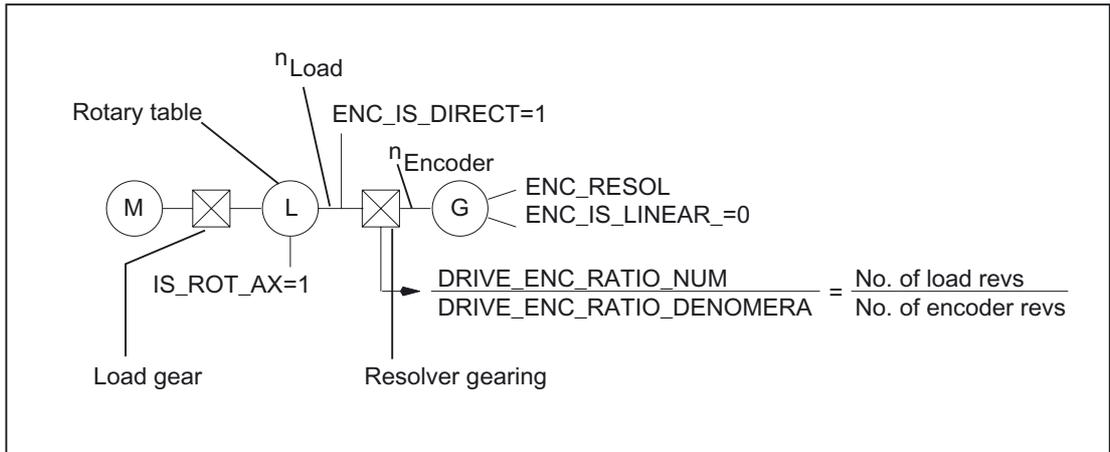


Figure 7-9 Rotary axis with rotary encoder on the machine

In order to adapt the actual-value resolution to the calculation resolution, the control calculates the quotients from the "internal increments/degree" and the "encoder increments/degree" as follows:

$$\frac{\text{Internal increments/degrees}}{\text{Encoder increments/degrees}} = \frac{360 \text{ degrees}}{\text{ENC\_RESOL [n]} * \text{internal multiplication}}$$

\*  $\frac{\text{DRIVE\_ENC\_RATIO\_NUMERA [n]}}{\text{DRIVE\_ENC\_RATIO\_DENOM [n]}}$   
 \* INT\_INCR\_PER\_DEG

Intermediate gear encoder on tool

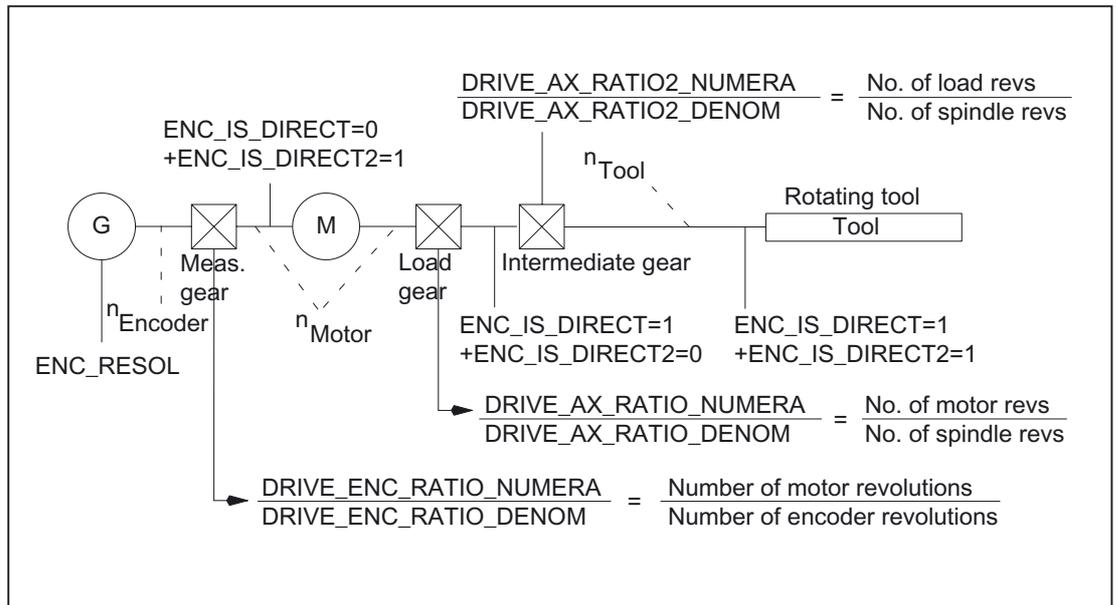


Figure 7-10 Intermediate gear with encoder directly on the rotating tool

In order to adapt the actual-value resolution to the calculation resolution, the control calculates the quotients from the "internal increments/mm" and the "encoder increments/mm" as follows:

$$\frac{\text{Internal increments/degrees}}{\text{Encoder increments/degrees}} = \frac{360 \text{ degrees}}{\text{ENC\_RESOL [n]} * \text{internal multiplication}}$$

$$* \frac{DRIVE\_ENC\_RATIO\_NUMERA [n]}{DRIVE\_ENC\_RATIO\_DENOM [n]}$$

$$* INT\_INCR\_PER\_DEG$$

## 7.5 Closed-loop control

### 7.5.1 General

#### Position control of an axis/spindle

The closed-loop control of an axis consists of the current and speed control loop of the drive plus a higher-level position control loop in the NC.

The speed and current control for SIMODRIVE 611 are explained in:

**References:**

/IAD/ "Installation and Startup Guide" SINUMERIK 840D/SIMODRIVE 611 digital  
 /PJU/ "Configuration Guide" Converter

The basic structure of an axis/spindle position control is illustrated below:

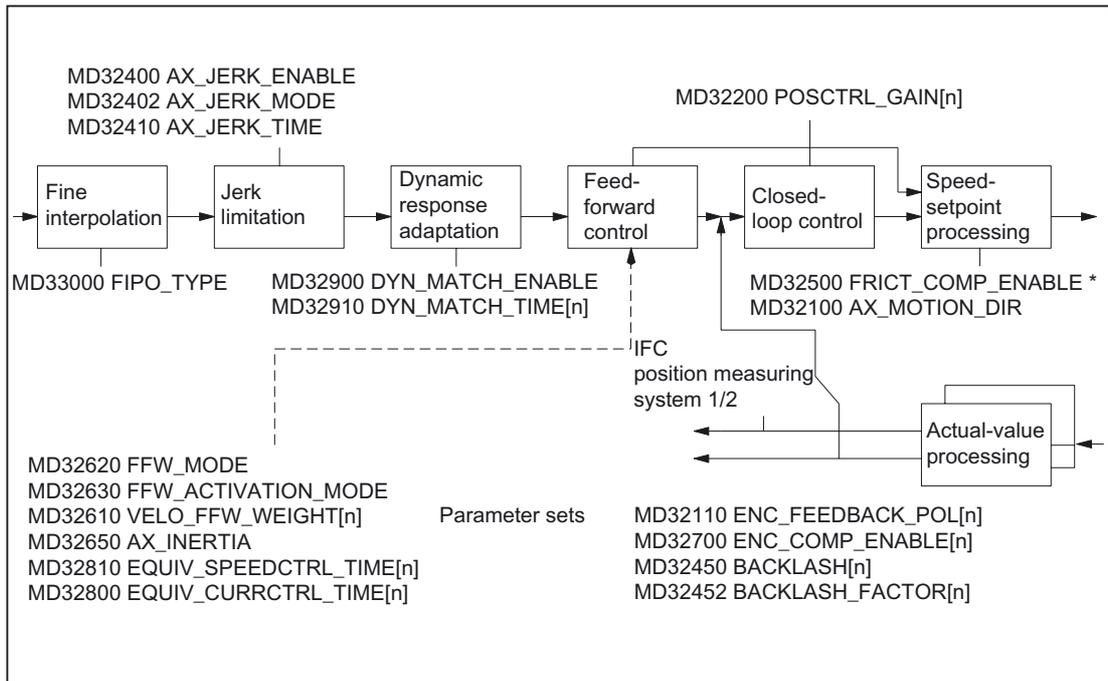


Figure 7-11 Additional servo parameter sets for position control

For a description of the feedforward control, backlash, friction compensation with further machine data, and leadscrew error compensation, see:

**References:**

/FB2/ Function Manual, Extended Functions; Compensations (K3)

For a description of jerk limitation, see:

**References:**

/FB1/ Function Manual, Basic Functions; Acceleration (B2).

## Fine Interpolation

The fine interpolator (FIPO) is used to adjust the setpoint of the (generally lower) interpolator cycle clock to the later position-control cycle.

Fine interpolation further improves the quality of the contour (decreasing the step effect of the speed setpoint).

There are three types of FIPOs:

1:	Differential FIPO
2:	Cubic FIPO
3:	Cubic FIPO, optimized for operation with feedforward control

The type of fine interpolation can be determined through the following machine data:

MD33000 \$MA\_FIPO\_TYPE (fine interpolator type)

A differential FIPO not only performs cycle matching but also calculates a mean value (smoothing) from an IPO cycle.

The cubic FIPO, type 3, supplies the best contour accuracy in addition to the cycle adaptation.

## $K_v$ factor

In order that few contour deviations occur in the continuous path mode, a high  $K_v$ -Factor is necessary:

MD32200 \$MA\_POSCTRL\_GAIN[n]

However, if the servo gain factor ( $K_v$ ) is too high, instability, overshoot and possibly impermissibly high loads on the machine will result.

The maximum permissible servo gain factor ( $K_v$ ) depends on the following:

- Design and dynamics of the drive  
(rise time, acceleration and braking capacity)
- Machine quality  
(elasticity, oscillation damping)
- Position-control cycle

The servo gain factor ( $K_v$ ) is defined as follows:

$$K_v = \frac{\text{Velocity}}{\text{Following error}} ; \frac{[\text{m/min}]}{[\text{mm}]}$$

[m/min]/[mm]: Unit of servo gain factor ( $K_v$ ) according to VDI standard

### Servo<sub>gain</sub>factor setting for SINUMERIK 840D

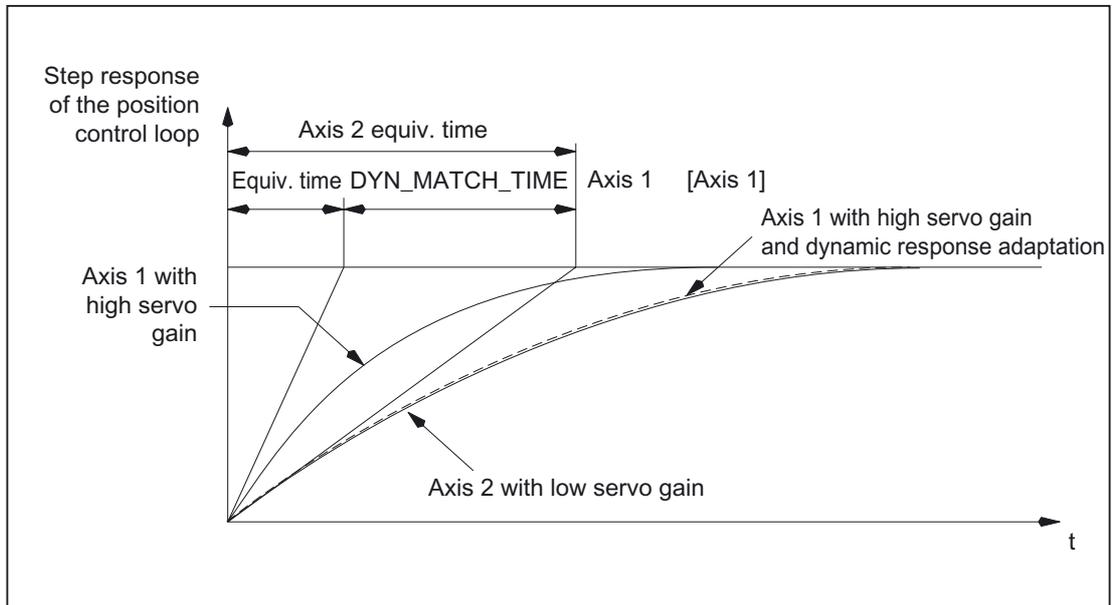


Figure 7-12 Dynamic response adaptation

### Dynamic response adaptation

The purpose of dynamic response adaptation is to set an identical following error for axes with different servo gain factors ( $K_v$ ). The optimum contour accuracy for axes interpolating with each other can thus be achieved without reduced control quality. A high servo gain factor ( $K_v$ ) for an axis can be maintained, which guarantees optimum disturbance suppression of the axis.

The function is activated with the machine data:

MD32900 \$MA\_DYN\_MATCH\_ENABLE (dynamic response adaptation)

The adjustment of the axes is done via the machine data:

MD32910 \$MA\_DYN\_MATCH\_TIME [n] (time constant of dynamic response adaptation)

With this MD the equivalent time constant of the position control loops of the axes with a higher servo<sub>gain</sub> factor is adjusted to the axes with the lowest servo<sub>gain</sub>-factor.

The difference of the equivalent time constants of the "slowest" control loop to the respective axis is to be entered in the machine data:

MD32910 \$MA\_DYN\_MATCH\_TIME [n] (time constant of dynamic response adaptation)

Example of dynamic response adaptation of axes 1, 2 and 3 (without speed feedforward control):

The equivalent time constant of the position control loop is as follows:	
For axis 1:	30 ms
For axis 2:	20 ms
For axis 3:	24 ms

⇒ Axis 1 is dynamically the slowest axis.

⇒ This results in the following values for the machine data MD32910:

Axis 1:	0 ms
Axis 2:	10 ms
Axis 3:	6 ms

### Approximation formulae

The equivalent time constant of the position control loop of an axis is calculated according to the following formula:

- No feedforward control is active

$$T_{\text{Spares}} \approx \frac{1}{\text{MD32200 POSCTRL\_GAIN [1/s]}}$$

- Speed feedforward control

$$T_{\text{Spares}} \approx \text{MD32810 EQUIV\_SPEEDCTRL\_TIME}$$

- Torque feedforward control

$$T_{\text{Spares}} \approx \text{MD32800 EQUIV\_CURRCTRL\_TIME}$$

**Note**

If a dynamic response adaptation is done for a geometry axis, then the same dynamic behavior is necessary for all other geometry axes and is to be activated with the following setting:

MD32900 \$MA\_DYN\_MATCH\_ENABLE= 1

**References:**

/IAD/ Start-up Guide, SINUMERIK 840D/611D

## 7.5.2 Parameter sets of the position controller

### Six different parameters sets

The position control can operate with 6 different servo parameter sets.

They are used as follows

1. Fast adaptation of the position control to altered machine characteristics during operation, e.g. a gear change of the spindle.
2. Matching the dynamics of an axis to another axis, e.g. during tapping.

### Parameter set changeover

The following machine data can be changed by switching over the parameter set during operation:	
Denominator load gearbox	MD31050 \$MA_DRIVE_AX_RATIO_DENOM[n]
Numerator load gearbox	MD31060 \$MA_DRIVE_AX_RATIO_NUMERA[n]
K <sub>v</sub> factor	MD32200 \$MA_POSCTRL_GAIN[n]
Backlash compensation	MD32452 \$MA_BACKLASH_FACTOR[n]
Feedforward control factor	MD32610 \$MA_VELO_FFWEIGHT[n]
Exact stop limits and zero-speed window	MD36012 \$MA_STOP_LIMIT_FACTOR[n]
	MD36000 \$MA_STOP_LIMIT_COARSE
	MD36010 \$MA_STOP_LIMIT_FINE
MD36030 \$MA_STANSTILL_POS_TOL	
Equivalent time constant Current control loop for torque feedforward control	MD32800 \$MA_EQUIV_CURRCTRL_TIME[n]
Equivalent time constant Speed control loop for speed feedforward control	MD32810 \$MA_EQUIV_SPEEDCTRL_TIME[n]
Time constant for dynamic matching	MD32910 \$MA_DYN_MATCH_TIME[n]
Threshold value for velocity monitoring	MD36200 \$MA_AX_VELO_LIMIT[n]

## Tapping or thread cutting

The following applies to **parameter sets for axes**:

- For machine axes **not** involved in tapping or thread cutting, parameter set 1 (index=0) is always used.  
The further parameter sets need not be considered.
- For machine axes involved in tapping or thread cutting, the same parameter set number as for the current gear stage of the spindle is activated.

All parameter sets correspond to the gear stages and must therefore be parameterized.

The current parameter set is displayed in operating area "Diagnostics" in the "Service axis" display. The parameter sets for gear stages 1 to 5 are referred to as interpolation parameters.

## Parameter sets during gear stage change

### Interpolation parameter sets during gear stage change:

In the case of spindles, each gear stage is assigned its own parameter set.

Dependent on the NC/PLC interface signal:

DB31, ... DBX16.0 - 16.2 (actual gear stage)

the corresponding parameter set is activated.

DB31, ... DBX16.0 - 16.2 (actual gear stage)		Active parameter set	
000	1st gear stage	2	(Index=1)
001	1st gear stage	2	(Index=1)
010	2nd gear stage	3	(Index=2)
011	3rd gear stage	4	(Index=3)
100	4th gear stage	5	(Index=4)
101	5th gear stage	6	(Index=5)
110			
111			

For more information on gear stages for spindles see:

### References:

/FB1/ Function Manual, Basic Functions; Spindles (S1)

### 7.5.3 Extending the parameter set

#### Application

Some machines use the same drive for moving various machine parts, which, in view of considerably varying speeds, results in a gear stage change. With each gear stage change, the corresponding parameter set is also switched over.

Now several parameter sets are provided for further practical applications and for setting the feedforward control of the control loop.

#### Functionality

To optimize closed-loop control during startup, these codable parameter sets support practice-oriented startup by substantially reducing configuration expenditure with regard to the new functions, such as backlash compensation, feedforward control factor, exact stop limits, and zero-speed window.

#### New parameter sets

Until now it has been possible to change the gear ratio and other control loop parameters (such as achievable control servo gain) by switching over the servo parameter set. The already existing machine data with parameter set coding are extended as follows:

Parameter set coding (modifiable as a function of parameter set)	
Backlash compensation	MD32450 \$MA_BACKLASH[n] (max. number of encoders)
Feedforward control factor	MD32610 \$MA_VELO_FFWEIGHT[n]
Exact stop limits	MD36000 \$MA_STOP_LIMIT_COARSE MD36010 \$MA_STOP_LIMIT_FINE
Zero-speed window	MD36030 \$MA_STANSTILL_POS_TOL

Weighting factor for parameter set changeover	
Weighting factor for:	<b>MD32452 \$MA_BACKLASH_FACTOR[n]</b>
• Backlash compensation	MD32450 \$MA_BACKLASH[n]
Weighting factor for:	<b>MD36012 \$MA_STOP_LIMIT_FACTOR[n]</b>
• Exact stop limits	MD36000 \$MA_STOP_LIMIT_COARSE MD36010 \$MA_STOP_LIMIT_FINE
• Zero-speed window	MD36030 \$MA_STANSTILL_POS_TOL

## Machine data tried and tested to date

### Further machine data with parameter set coding

The following existing machine data can be coded using parameter sets and have already been tried and tested during the startup of the NC:

Denominator load gearbox	MD31050 \$MA_DRIVE_AX_RATIO_DENOM
Numerator load gearbox	MD31060 \$MA_DRIVE_AX_RATIO_NUMERO
Equivalent time constant current control loop	MD32800 \$MA_EQUIV_CURRCTRL_TIME
Equivalent time constant speed control loop	MD32810 \$MA_EQUIV_SPEEDCTRL_TIME
Time constant for dynamic response adaptation	MD32910 \$MA_DYN_MATCH_TIME
Threshold value for velocity monitoring	MD36200 \$MA_AX_VELO_LIMIT

## Advantages

- The indirect switchover of **a single** function: (e.g. MD32452 not 1)  
The parameter set-dependent function is only relevant if required.
- The indirect switchover of **several** functions: (e.g. MD36012 not 1)  
The common weighting factor forces the ratios of all parameter set-dependent functions within various machine data to remain constant. To switch over several functions, one single machine data can be sufficient.

In this way, configuration errors are avoided and input work reduced.

## Activating the parameter set coding

### Default setting without parameter set coding

Provided that the machine data below retain a value of (1), the control is compatible with earlier software versions:

MD32452 \$MA\_BACKLASH\_FACTOR = 1

MD32610 \$MA\_VELO\_FFW\_WEIGHT = 1

MD36012 \$MA\_STOP\_LIMIT\_FACTOR = 1

### Activating the parameter set coding

If the default setting in machine data:

MD32452 \$MA\_BACKLASH\_FACTOR

is changed to something other than (1.0), the backlash compensation is also changed, depending on the parameter set.

If the default setting in machine data:

MD32610 \$MA\_VELO\_FFW\_WEIGHT

is changed to something other than (1.0), the feedforward control factor is also changed, depending on the parameter set.

If the default setting in machine data:

MD36012 \$MA\_STOP\_LIMIT\_FACTOR

is changed to something other than (1.0), the exact limit stops and the zero-speed window are also changed, depending on the parameter set.

When loading previous archives (from data stored in earlier software versions), machine data:

MD32610 \$MA\_VELO\_FFW\_WEIGHT

is automatically set to the same value for all indices, to ensure that the control remains compatible.

Machine data:

MD32452 \$MA\_BACKLASH\_FACTOR

and

MD36012 \$MA\_STOP\_LIMIT\_FACTOR

are not even available in previous archives.

In this case, the default setting remains active automatically.

The response is also compatible in this case.

## Example

Effects of various parameter sets with backlash compensation:

MD32450 \$MA_BACKLASH[AX1]	= 0.01	
MD32452 \$MA_BACKLASH_FACTOR[0,AX1]	= 1.0	Parameter set 1
MD32452 \$MA_BACKLASH_FACTOR[1,AX1]	= 2.0	Parameter set 2
MD32452 \$MA_BACKLASH_FACTOR[2,AX1]	= 3.0	Parameter set 3
MD32452 \$MA_BACKLASH_FACTOR[3,AX1]	= 4.0	Parameter set 4
MD32452 \$MA_BACKLASH_FACTOR[4,AX1]	= 5.0	Parameter set 5
MD32452 \$MA_BACKLASH_FACTOR[5,AX1]	= 6.0	Parameter set 6

In parameter set 1 (index 0) of the first axis (AX1), a backlash compensation factor with the value 1.0 has the following effect:

$1.0 * MD32450 = 0.01$  mm (or inch or degrees)

The backlash compensation is twice as large in parameter set 2, three times as large in parameter set 3, etc.

The maximum value is 100.

### **Supplementary conditions**

The functional expansion is available for all control variants.

### **Control response on POWER ON, RESET, REPOS**

The new or modified data are activated via the "Enable machine data" soft key or by a RESET or POWER ON. Mode switchover, block search or REPOS have no influence.

## 7.6 Optimization of the control

### 7.6.1 Position controller: injection of positional deviation

#### Application

The stability and positioning response of axes with a low natural frequency (up to approx. 20 Hz) and a mechanical design capable of generating oscillations is improved by active oscillation damping with simultaneous use of the feedforward control.

To illustrate this, the difference in position between two measuring systems is generated and injected as an additional current setpoint for the feedforward control, according to the weighting of machine data:

MD32950 \$MA\_POSCTRL\_DAMPING

The function is used predominantly for axes with strong tendency to vibrate.

#### Functionality

The positional deviation is injected in the NC in the position controller cycle of the higher-level position control loop in the NC.

The difference in position between a direct and an indirect measuring system is generated and injected as an additional current setpoint, depending on the weighting of machine data: MD32950 \$MA\_POSCTRL\_DAMPING.

#### Direct measuring system:

MD31040 \$MA\_ENC\_IS\_DIRECT[1]=1

The encoder for position actual-value acquisition is connected directly to the machining process of the machine (load encoder).

#### Indirect measuring system:

MD31040 \$MA\_ENC\_IS\_DIRECT[0]=0

The encoder for position actual-value acquisition is located on the motor (motor encoder).

## MD32950

The function is activated via the following machine data setting:  
MD32950 \$MA\_POSCTRL\_DAMPING = 1.

It is possible to enter both positive and negative values,  
which will then serve to scale the injection of the positional deviation.

Standard setting:

MD32950 \$MA\_POSCTRL\_DAMPING = 0.

In this case, the injection of positional deviation is inactive.

---

### Note

The weighting of machine data:

MD32950 \$MA\_POSCTRL\_DAMPING

can be set on the basis of step responses, for example.

If the control approaches the stability limit (vibration inclination increases), then the parameter is too large.

---

## Supplementary condition

1. The functional expansion is available for all control variants,  
which use SIMODRIVE 611 digital drives.

2. The function can only be used on axes with two encoders:

MD30200 \$MA\_NUM\_ENCS = 2

One of the encoders **must** be parameterized as an indirect measuring system and the other as a direct measuring system.

If these conditions are not met, reset alarm 26016 will acknowledge the function when an attempt is made to activate machine data:

MD32950 \$MA\_POSCTRL\_DAMPING.

The function remains deactivated internally when this alarm is active.

## 7.6.2 Position controller position setpoint filter: New balancing filter

For speed and torque feedforward control

### Application

With feedforward control active, the position setpoint is sent through a so-called balancing filter before it reaches the controller itself. It is thus possible to feedforward control the speed setpoint at 100%, without resulting in overshoots when positioning.

### Functionality

Until now, it was possible to compensate the negative effects of the balancing filter (a low pass with settable time constant), which has remained unchanged since SW 1 and which has admitted instead of an overshoot also undesired undershoots of some 10 micrometers, as follows:

- Setting a compromise of overshoots and undershoots
- Setting the positioning slightly overshooting and reducing the amplitude of these overshoots by way of position setpoint signal smoothing and jerk limitation
- Setting a speed controller with reference model instead of PI behavior (only possible with 840D)
- Setting the filter time to zero and setting the feedforward control factor to a value less than 100%
- Sacrificing the feedforward control and bringing the machine to a very high position controller gain using dynamic stiffness control. This measure requires a stiff machine.

With SW 5 and higher, a second, improved balancing filter is therefore available. The existing filter is still installed and is active with the same function when transferring existing archives (e.g. in the case of upgrades).

### Advantages

The new balancing filter provides the following improvements:

- An axis with feedforward control has a considerably lower inclination to undershoots when positioning.
- Achieves a higher accuracy at bent contours (can be measured, e.g. using the circularity test) and can be set more easily.
- A part of the setting is carried out by the control system automatically.

**Filter activation with MD32620**

The new filter is activated by changing the axial machine data:

MD32620 \$MA\_FFW\_MODE  
by selecting values 3 and 4.

The desired active feedforward control variant with new balancing is selected as follows via MD32620:

3 =	Speed feedforward control with new balancing
4 =	Torque feedforward control (only possible with SINUMERIK 840D) with new balancing

For reasons of a compatible response of archives that contain only changes compared with the default settings, no default value can be set for these new values 3 and 4 in the new software versions.

**Activation of feedforward control**

Parts programs can be used to activate and deactivate the feedforward control for all axes, using instructions `FFWON` and `FFWOF`, which does not affect machine data: MD32630 FFW\_ACTIVATION\_MODE.

**Control response with POWER ON, RESET, REPOS, etc.**

In the case of POWER ON and RESET, as well as with "Enable machine data", the setting data of the feedforward control are read in anew (see the appropriate values of the machine data). Mode change, block search and repositioning have **no** influence on the feedforward control.

**Supplementary conditions**

The functional expansion is available for all control variants.

**New setting rule for MD32810 and MD32800**

If the new filter is active, the setting rule for machine data:

MD32810 \$MA\_EQUIV\_SPEEDCTRL\_TIME

and

MD32800 \$MA\_EQUIV\_CURRCTRL\_TIME are modified.

This means that, if the old balancing filter had previously been active and is to be changed to the new filter, the following actions must be considered:

#### Setting the equivalent time constant with speed feedforward control

If the previous setting was MD32620 \$MA\_FFW\_MODE = 1:

1. Set MD32620 \$MA\_FFW\_MODE = 3.
2. Set MD32610 \$MA\_VELO\_FFW\_WEIGHT = 1.
3. Reset MD32810 \$MA\_EQUIV\_SPEEDCTRL\_TIME.

#### Setting the equivalent time constant with torque feedforward control

If the previous setting was MD32620 \$MA\_FFW\_MODE = 2:

1. Set MD32620 \$MA\_FFW\_MODE = 4.
2. Set MD32610 \$MA\_VELO\_FFW\_WEIGHT = 1.
3. Reset MD32800 \$MA\_EQUIV\_CURRCTRL\_TIME.

This also applies when you load an older **archive** into the control system, e.g. from a previous version. For example, when changing MD32620 \$MA\_FFW\_MODE from 1 to 3, MD32810 \$MA\_EQUIV\_SPEEDCTRL\_TIME may **not** simply retain its old value, but must be **reset**. Otherwise, no improvement will be achieved, but rather a worsening of the positioning response.

#### Recommended setting in case of recommissioning

If recommissioning, or if previous standard values are loaded (switch position 1 on commissioning switch and POWER ON), the following machine data default values apply:

MD32620 \$MA\_FFW\_MODE = 1

MD32610 \$MA\_VELO\_FFW\_WEIGHT = 1

These are **not** the recommended settings, but are chosen for reasons of compatibility.

However, if recommissioning, the following setting is recommended:

MD32620 \$MA\_FFW\_MODE = 3

The balancing time for the speed feedforward control then just has to be adjusted in machine data:

MD32810 \$MA\_EQUIV\_SPEEDCTRL\_TIME.

## Setting the equivalent time constant of the speed control loop

### MD32810 speed feedforward control

We recommend that the axis be allowed to move in and out in "AUTOMATIC" mode with a part program and that travel-in to the target position, i.e. the actual position value of the active measuring system, be monitored with servo trace (HMI Advanced or programming device). The actual position value can also be output to the drive module's digital-to-analog converter and an oscilloscope can be used for monitoring.

The initial value for setting is the time constant of the speed control loop. This can be read from the reference frequency characteristic of the speed control loop. In the frequent case of a proportional-plus-integral-action controller with special value smoothing, an approximate equivalent time can be read from drive machine data 1500-1503.

Another option would be to trace the speed setpoint and actual value at a constant acceleration using an oscilloscope and to measure the follow-on time of the speed actual value.

This initial value (e.g. 1.5 ms) is then entered:  
MD32810 \$MA\_EQUIV\_SPEEDCTRL\_TIME = 0.0015.

The axis then travels to and fro and the operator monitors a greatly-magnified characteristic of the position actual value at the target position.

The following rules apply to making manual fine adjustments:

Overshoot monitored:	<b>Magnify</b> MD32810 \$MA_EQUIV_SPEEDCTRL_TIME.
Excessively slow approach monitored:	Reduce MD32810 \$MA_EQUIV_SPEEDCTRL_TIME.

### Magnifying MD32810

Magnifying the value in machine data:  
MD32810 \$MA\_EQUIV\_SPEEDCTRL\_TIME  
slows the axis down and increases the geometric contour error on curves.

It has a similar effect to reducing the position controller gain:  
MD32200 \$MA\_POSCTRL\_GAIN.

This can also be watched in the Diagnostics area in the screen form "Service Axis" based on the servo gain value calculated.

### Reducing MD32810

Reducing the value in machine data:  
MD32810 \$MA\_EQUIV\_SPEEDCTRL\_TIME  
speeds the axis up.

Therefore, MD32810 should be assigned as small a value as possible, with the overshoot setting the limit during positioning.

### MD32810 fine adjustment

Experience has shown that the initial value is only modified slightly during fine adjustment, typically by adding or deducting 0.25 ms.

For example, if the initial value is 1.5 ms, the optimum value calculated manually is usually within the range 1.25 ms to 1.75 ms.

In the case of axes equipped with direct measuring systems (load encoders) and strong elasticity, you may possibly accept small overshoots of some micrometers.

These can be reduced with the help of the position setpoint filter for dynamic response adaptation

(MD32910 \$MA\_DYN\_MATCH\_TIME) and for jerk (MD32410 \$MA\_AX\_JERK\_TIME), which also reduces the axis speed.

### Identical axis data within an interpolation group

All the axes within an interpolation group must have **identical settings** in the following data:

MD32200 \$MA\_POSCTRL\_GAIN

MD32620 \$MA\_FFW\_MODE

MD32610 \$MA\_VELO\_FFW\_WEIGHT

MD32810 \$MA\_EQUIV\_SPEEDCTRL\_TIME (or MD32800 \$MA\_EQUIV\_CURRCTRL\_TIME)

MD32400 \$MA\_AX\_JERK\_ENABLE

MD32402 \$MA\_AX\_JERK\_MODE

MD32410 \$MA\_AX\_JERK\_TIME

The servo gain display ( $K_v$ ) in the axis service screen form is used for checking.

If identical values are not possible for the above data, machine data:

MD32910 \$MA\_DYN\_MATCH\_TIME

can be used to make an adjustment.

This allows the same servo gain value ( $K_v$ ) to be displayed; however, this rarely occurs.

Different servo gain values ( $K_v$ ) usually point to the following:

- The gear ratios do not match in one or several axes.
- The feedforward control setting data do not match.
- The jerk filter setting data is incorrect at some point.

**Automatic switchover when changing the position-control cycle**

Previously, if the position-control cycle (MD10050 \$MN\_SYSCLOCK\_CYCLE\_TIME) changed or the acceptance time of the speed setpoints was modified in order to increase the servo gain (Kv) (MD10082 \$MN\_CTRL\_OUT\_LEAD\_TIME), or dynamic stiffness control was enabled (MD32640 \$MA\_STIFFNESS\_CONTROL\_ENABLE), the adjustment of MD32810 \$MA\_EQUIV\_SPEEDCTRL\_TIME had to be repeated, as the optimum value changed significantly.

With setting:

**MD32620 \$MA\_FFW\_MODE = 3 or 4,**

the control takes these changes into account automatically, so that machine data:

MD32810 \$MA\_EQUIV\_SPEEDCTRL\_TIME

no longer has to be reset.

After major changes, however, you should nevertheless check the positioning behavior (via servo trace).

**Example of speed feedforward control**

Programming sample of a selection of the speed feedforward control with new balancing and default setting: FFWON and FFWOF are active.

```
MD32620 FFW_MODE[X1] = 3 ; New mode for speed feedforward
                           control
MD32630 FFW_ACTIVATION_MODE[X1] = 1 ; FFWON and FFWOF are active in NC
                                       program.
```

FFWON now enables the speed feedforward control in the program (with all axes of the channel with the same settings as X1); FFWOF will disable them again.

Machine data:

MD20150 \$MC\_GCODE\_RESET\_VALUES[23] (G group initial setting) can be used to set a default value for FFWON for every channel.

```
MD32620 $MA_FFW_MODE[X1] = 3 ; New mode for speed feedforward
                               control
MD32630 $MA_FFW_ACTIVATION_MODE[X1] = 0 ; FFWON and FFWOF are active in NC
                                           program.
```

In this case, the speed feedforward control with X1 is enabled continuously, also in JOG mode.

MD20150 \$MC\_GCODE\_RESET\_VALUES[ ], FFWON and FFWOF have no effect on X1. This can be useful if the machine is only permitted to run with feedforward control, e.g. for reasons of accuracy, or if you also want to test the feedforward control without a program during startup.

---

**Note**

The setting of the feedforward control must be the same for all axes of an interpolation group.

---

### Setting the equivalent time constant of the current control loop

#### MD32800 torque feedforward control for each additional option

The same rules and recommendations apply to setting the time constant of the current control loop as to the speed feedforward control.

However, as previously, activation of the torque feedforward control filter via:

MD32620 \$MA\_FFW\_MODE = 4

must be enabled both in the drive and **via the option** in order to set the time constant via:

MD32800 \$MA\_EQUIV\_CURRCTRL\_TIME

As with activating the previous filter via:

MD32620 \$MA\_FFW\_MODE = 2,

all other machine data are set in consideration of the corresponding elasticity limits of the machine.

#### Limitation to stiff machines

Experience has shown that this expenditure is only worthwhile in the case of very stiff machines, and requires appropriate experience. The elasticities of the machine are often excited due to the injection of the torque so strongly that the existing vibrations neutralize the gain in contour accuracy.

In this case, it would be worth trialing the use of dynamic stiffness control as an alternative:

MD32640 \$MA\_STIFFNESS\_CONTROL\_ENABLE.

#### Example of torque feedforward control

Programming sample of a selection of the torque feedforward control with new balancing and default setting: FFWON and FFWOF are active.

```
MD32620 $MA_FFW_MODE[X1] = 4           ; New mode for torque feedforward
                                         control
MD32630 $MA_FFW_ACTIVATION_MODE[X1] = 1 ; FFWON and FFWOF are active.
```

FFWON now enables the torque feedforward control in the program (with all axes of the channel with the same settings as X1); FFWOF will disable them again.

Machine data:

MD20150 \$MC\_GCODE\_RESET\_VALUES[23] (G group initial setting) can be used to set a default value for FFWON for every program.

```
MD32620 $MA_FFW_MODE[X1] = 4 ; New mode for torque feedforward control
MD32630 $MA_FFW_ACTIVATION_MODE[X1] = 0 ; FFWON and FFWOF are active.
```

In this case, the torque feedforward control with X1 is enabled continuously, also in JOG mode. MD20150 \$MC\_GCODE\_RESET\_VALUES[ ], FFWON and FFWOF have no effect on X1. This can be practical if the machine is only permitted to run with feedforward control, e.g. for reasons of accuracy, or if you also want to test the feedforward control without a program during startup.

For more information about the effect of the feedforward control relating to the speed and torque position controller setpoints, please refer to:

**References:**

/FB2/ Function Manual, Extended Functions; Compensations (K3), Chapter: "Description of machine data".

---

**Note**

The setting of the feedforward control must be the same for all axes of an interpolation group.

---

### 7.6.3 Position controller position setpoint filter: new jerk filter

#### Application

In some applications, such as when milling sculptured surfaces, it can be advantageous to smooth the position setpoint curves to obtain better surfaces, due to reduced excitations of machine vibrations.

#### Functionality

The filter effect of the position setpoints must be as strong as possible without impermissibly affecting contour accuracy.

The smoothing behavior of the filter must also be as "symmetrical" as possible, i.e. if the same contour was to be traveled in both forward and reverse, the characteristic rounded by the filter should be as similar as possible in both directions.

The effect of the filter can be monitored by means of the effective servo gain factor ( $K_v$ ), which is displayed on the Axis service screen form. The filtering effect rounds the position setpoints slightly, thus reducing the path accuracy so that with increasing filter time a smaller effective servo gain factor ( $K_v$ ) is displayed.

#### Advantages

The filter available since software version 1, which is set via:

MD32400 \$MA\_AX\_JERK\_ENABLE = 1

and

MD32410 \$MA\_AX\_JERK\_TIME = filter time,

meets the requirements for a strong filter effect with smoothing behavior that is as symmetrical as possible for small time constants of up to approximately 10 ms.

A considerably better result is achieved using this new filter type for axial jerk limitation with floating averaging. In this case, filter time constants of approx. 20 to 40 ms can be used, depending on the particular machine.

Thanks to the floating averaging, the new filter achieves lower contour errors with the same smoothing effect, compared with the previous 2nd degree filter type. The contour of the smoothing behavior is to a large degree balanced.

**Filter enable with MD32402**

Machine data:

MD32402 \$MA\_AX\_JERK\_ENABLE

is used to enable the new position setpoint filter,  
and is defined as follows:

MD32402 \$MA_AX_JERK_MODE	= 2	Select new jerk filter mode
MD32410 \$MA_AX_JERK_TIME	= 0.02	Set filter time in seconds (20 ms)
MD32400 \$MA_AX_JERK_ENABLE	= 1	Enable filter calculation

If no filter mode was previously activated:

MD32402 \$MA\_AX\_JERK\_MODE = 2,

POWER ON has to be triggered once.

Otherwise, "Enable machine data" or RESET on the machine control panel are sufficient.

For reasons of compatibility, the default setting is:

MD32402 \$MA\_AX\_JERK\_MODE = 1.

**Note**

For new machines, the new filter is generally recommended:

MD32402 \$MA\_AX\_JERK\_MODE = 2.

Only if very high filter times are needed and contour accuracy plays a minor part (e.g. as sometimes occurs when positioning axes), can the old filter be more advantageous.

**Fine adjustment**

The fine adjustment of the position setpoint filter is carried out as follows:

1. Assess the traversing response of the axis  
(e.g. based on positioning processes with servo trace).
2. Modify the filter time in MD32410 \$MA\_AX\_JERK\_TIME.
3. Activate the modified time via "Enable machine data" or RESET on the machine control panel.

## Disabling

Disabling the position setpoint filter:

1. Disable filter calculation:  
MD32410 \$MA\_AX\_JERK\_ENABLE = 0.
2. Activate the interlock via "Enable machine data" or RESET on the machine control panel.

## Supplementary conditions

The position setpoint filter is available in all control system variants as follows:

- Effective filter times are limited to a range between a minimum of 1 position-control cycle up to a maximum of 32 position-control cycles (31 position-control cycles are available).

Further supplementary conditions regarding the filter effect:

- The display of the calculated servo gain factor ( $K_v$ ) in the Axis service screen form displays smaller values than would be appropriate based on the filter effect.
- Path accuracy is better than the displayed servo gain ( $K_v$ ) suggests.

Therefore, on resetting

MD32400 \$MA\_AX\_JERK\_MODE = 1

to

MD32400 \$MA\_AX\_JERK\_MODE = 2,

the displayed servo gain ( $K_v$ ) can be reduced while retaining the same filter time, although the path accuracy improves.

Axes that interpolate with each other must be set identically.

Once an optimum value has been identified for these axes, the one with the longest filter time should be used as the setting for all axes within the interpolation group.

For more information about jerk limitation on an interpolator level, please refer to:

### References:

/FB1/ Function Manual, Basic Functions; Acceleration (B2)

Chapter: "Axis-oriented jerk limitation"

Chapter: "Axis-specific machine data".

## 7.6.4 Position control with proportional-plus-integral-action controller

### Function

In the default scenario, the core of the position controller is a proportional controller with the above-mentioned upstream override options.

For special uses (such as for electronic gearing), an integral part can be connected. The resulting proportional-plus-integral-action controller then corrects the error between setpoint and actual positions down to zero in a finite, settable time period when the appropriate machine data are set accordingly.

#### CAUTION

When the proportional-plus-integral-action controller is active, overshoots occur in the actual position. In this instance, you must decide whether this effect is admissible or acceptable for the application in question. Expert knowledge of control engineering and measurements taken using servo trace are absolutely essential when using this function. If incorrect settings are made for the relevant machine data, there is a risk of damaging the machine, due to possible instability.

### Background

The transfer function of the proportional-plus-integral-action controller is as follows:

$$G_R(s) = K_R + \frac{1}{T_n} * s$$

$K_R$ : P component gain

$T_n$ : Integral time

### Procedure

1. First optimize the position control loop as a proportional-action controller first using the tools described in the previous subsections.
2. Increase the tolerances of the following machine data while measurements are being taken to determine the quality of the position control with proportional-plus-integral-action controller:
  - MD36020 \$MA\_POSITIONING\_TIME
  - MD36030 \$MA\_STANDSTILL\_POS\_TOL
  - MD36040 \$MA\_STANDSTILL\_DELAY\_TIME
  - MD36400 \$MA\_CONTOUR\_TOL

3. Activate the position control loop as a proportional-plus-integral-action controller by setting the following machine data:  
MD32220 \$MA\_POSCTRL\_INTEGR\_ENABLE ; set value 1  
MD32210 \$MA\_POSCTRL\_INTEGR\_TIME ; integral time [sec.]  
Effect of integral time:
  - $T_n \rightarrow 0$ :  
The control error is corrected quickly; however, the control loop can become unstable.
  - $T_n \rightarrow \infty$ :  
The control error is corrected more slowly.
4. Find the appropriate compromise for  $T_n$  for your application, using these two extreme cases as outer limits.  
 $T_n$  must not be set too close to the instability limit, since there is a risk of damage to the machine if instability should occur.
5. Use servo trace to trace the travel-in of an automatic program traveling to and from a target position.
6. Set the servo trace to display the following:
  - Following error
  - Actual velocity
  - Actual position
  - Reference position
7. Reset the tolerance values in the following machine data to the required values, once the optimum value for  $T_n$  has been identified:
  - MD36020 \$MA\_POSITIONING\_TIME
  - MD36030 \$MA\_STANDSTILL\_POS\_TOL
  - MD36040 \$MA\_STANDSTILL\_DELAY\_TIME
  - MD36400 \$MA\_CONTOUR\_TOL

## Example

Setting result after several iterative processes for  $\kappa R$  and  $T_n$ .

Each of the following quantities - following error, actual velocity, actual position, and position setpoint - has been recorded by servo trace. When traversing in JOG mode, the characteristic of the individual data shown in the following figure was then drawn.

Set machine data:

MD32220 \$MA\_POSCTRL\_INTEGR\_ENABLE = 1

MD32210 \$MA\_POSCTRL\_INTEGR\_TIME = 0.003

MD32200 \$MA\_POSCTRL\_GAIN[1] = 5.0

Parameter set selection 0

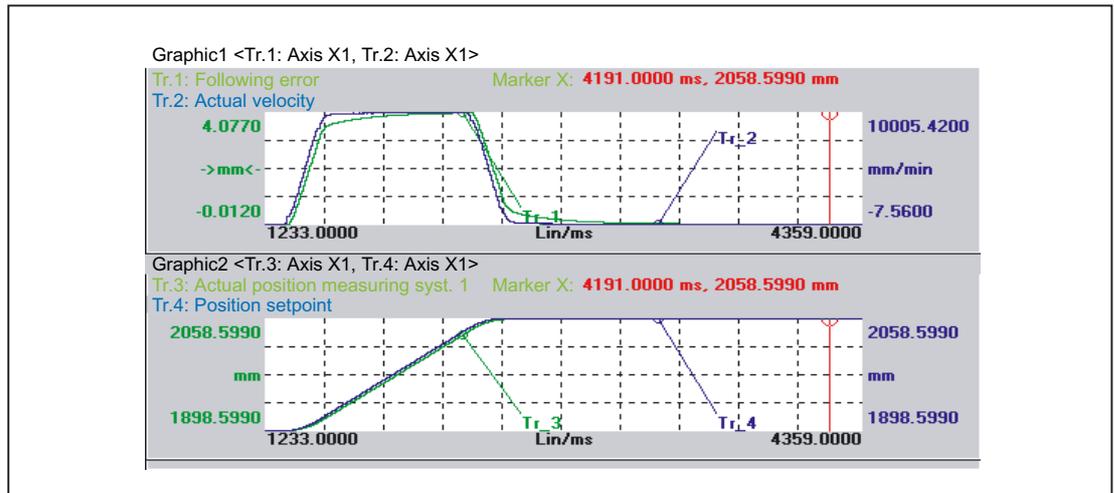


Figure 7-13 Following error (1), actual velocity (2), position actual value (3), position setpoint (4)

## 7.6.5 System variable for status of pulse enable

### Application

For all applications that must quickly react to pulse enabling, the status of the pulse enable is imaged to a new system variable in order to accelerate the braking signal.

This system variable is preferably evaluated in synchronized actions. Using the synchronized action, either a direct output to an NCK output can be carried out or a faster transfer to the PLC.

### Functionality

Since 611D digital drives have no integrated braking signal, the brakes are normally controlled from the PLC. The brake can be closed again by deleting the pulse enable in the PLC.

If the pulse enable is deleted due to external events (611D interface, terminal 663 to the PLC) or due to drive or axis errors, the PLC can close the brake only with a delay, since the transport of the pulse enable signal via servo and interpolator requires 2 to 3 interpolator cycle clocks. In the worst case, the PLC needs another two PLC cycles. With hanging axes and linear motors, this is often slow.

### System variable for enabling the drive power

Since the function must be available for all kinds of drives in the same form (also for non-electrical drives), the variable is given the name "Drive power enable".

Description	NCK variable
Status of the power enable (pulse enable) of a machine axis	\$VA_DPE[machine axis]
Predefined range of values:	
FALSE: no power enable	
TRUE: power enable exists	

### Activation

The variable is predefined and can be used at any time acc. to the data type `BOOL` with `FALSE` or `TRUE`. While communication with the drive is not yet established, the value 0 (`FALSE`) is supplied.

The synchronized actions, in which the variable is evaluated, should preferably be carried out as soon as the control powers up, e.g. by starting an ASUB from the PLC. To make sure that the synchronized actions remain continuously active and are not affected by the mode change, we recommend that they are programmed as "static synchronized actions" (using `IDS` as the vocabulary word).

### Example

Output of the pulse enable of machine axis X1 to the first digital NCK output in all modes

```
IDS = 1 DO $A_OUT[1] = $VA_DPE[X1]
```

### Supplementary conditions

The functional expansion is available for digital drives in all control variants providing synchronized actions.

### Control response with POWER ON, RESET, REPOS, etc.

After `POWER ON`, the value 0 is supplied while communication with the drive is not yet established. Then, the system variable `$VA_DPE` always specifies the pulse enable value acquired at the beginning of the interpolation cycle. The mode-independent evaluation or retransmission should be carried out using static synchronized actions (vocabulary word `IDS`).

## 7.6.6 Expansions for "deceleration axes"

### Application

In the case of design-conditioned non-linearities and elasticities, as often occurs in material handling and high-bay racking technology, it is often necessary to sacrifice the position control due to the unstable position control loop. The axes are, therefore, traversed closed-loop controlled and not open-loop controlled. To this aim, the WF723 module offers the special function of the "deceleration axes".

### Functionality

This "deceleration axes" function blocks any path movements, but allows positioning with approach to the target position by reducing the velocity step by step. The response corresponds to that of a multi-point controller.

For reasons relating to position control loop stability, the position controller algorithm is extended instead of the special positioning function "deceleration axes". It is thus also possible to operate drives that might cause problems using the position control.

### Advantages

Compared with the existing method "deceleration axes", the expansion of the position controller algorithm provides the following advantages:

- The structure of the interpolation and control is extended only slightly. Thus, this axis automatically has all the properties of a normal axis.
- Traversing on the path also becomes possible; exactly which path can be foreseen considerably earlier, e.g. a high-bay racking cage will take at different velocities. A possible collision can thus be avoided.
- It is much easier to configure the function.
- In particular, with feedforward control enabled, the positioning processes are faster.

### Low-pass filter for analog drives

A low-pass filter connected at the position controller output now also allows the position controller gain to be reduced quickly with increasing frequency for analog drives (axes). This suppresses the effect of strong natural frequencies in the form of settable speed setpoint filters.

This functionality is provided as standard for digital drives.

### MD32930/MD32940

The low-pass filter is activated via setting:  
MD32930 \$MA\_POSCTRL\_OUT\_FILTER\_ENABLE = 1.

The filter time constant is input via machine data:  
MD32940 \$MA\_POSCTRL\_OUT\_FILTER\_TIME.

### MD32960 "dead zone"

Non-linearities close to zero speed, such as those, which can occur when simple frequency converters are used, are inhibited by a "dead zone" in the controller.

The threshold for system deviation, under which a speed setpoint of "zero" is output, can be set via machine data:

MD32960 \$MA\_POSCTRL\_ZERO\_ZONE.

The "dead zone" is input in MD32960 for each individual encoder.

### Stability risk

The expanded position controller algorithm will reduce the risks that a stable control admits only a rather poor setting of the gain, or that the position control loop does not remain stable despite the effective extensions, to a minimum.

### Supplementary conditions

The functional expansion is available for all control variants.

The low-pass filter is only activated if dynamic stiffness control is inactive:

MD32640 \$MA\_STIFFNESS\_CONTROL\_ENABLE = 0.

If the low-pass filter is active, the modeled following error is larger than usual during acceleration phases.

It can, therefore, be necessary to increase machine data:

MD36400 \$MA\_CONTOUR\_TOL

above the standard value,

in order to prevent activation of axial contour monitoring (alarm 25050).

If the adjustable "dead zone" of the position controller retains its standard setting:

MD32960 \$MA\_POSCTRL\_ZERO\_ZONE = 0,

this corresponds to an input value, which is the same size as the current encoder fine resolution.

The default setting is therefore compatible with earlier software versions.

If the "dead zone":

MD32960 \$MA\_POSCTRL\_ZERO\_ZONE

is configured to be larger than the zero-speed tolerance:

MD36030 \$MA\_STANDSTILL\_POS\_TOL,

zero-speed monitoring (alarm 25040) could be activated on termination of a positioning process.

With a "dead zone":

MD32960 \$MA\_POSCTRL\_ZERO\_ZONE

greater than the exact stop limits:

MD36000 \$MA\_STOP\_LIMIT\_COARSE,

no exact stop signals are output.

This can trigger the positioning monitoring function (alarm 25080)  
and block the block change.

## 7.7 Data lists

### 7.7.1 Machine data

#### 7.7.1.1 Memory specific machine data

Number	Identifier: \$MM_	Description
9004	DISPLAY_RESOLUTION	Display resolution
9010	SPIND_DISPLAY_RESOLUTION	Display resolution for spindles
9011	DISPLAY_RESOLUTION_INCH	Display resolution for INCH system of measurement

#### 7.7.1.2 NC-specific machine data

Number	Identifier: \$MN_	Description
10000	AXCONF_MACHAX_NAME_TAB[n]	Machine axis name
10050	SYSCLOCK_CYCLE_TIME	System basic cycle
10070	IPO_SYSCLOCK_TIME_RATIO	Factor for interpolator cycle
10060	POSCTRL_SYSCLOCK_TIME_RATIO	Factor for position-control cycle
10080	SYSCLOCK_SAMPL_TIME_RATIO	Division factor of position-control cycle for actual-value acquisition
10200	INT_INCR_PER_MM	Computational resolution for linear positions
10210	INT_INCR_PER_DEG	Computational resolution for angular positions
10220	SCALING_USER_DEF_MASK	Activation of scaling factors
10230	SCALING_FACTORS_USER_DEF[n]	Scaling factors of physical quantities
10240	SCALING_SYSTEM_IS_METRIC	Basic system metric
10250	SCALING_VALUE_INCH	Conversion factor for switchover to inch system
10260	CONVERT_SCALING_SYSTEM	Basic system switchover active
10270	POS_TAB_SCALING_SYSTEM	Measuring system of position tables
10290	CC_TDA_PARAM_UNIT	Physical units of the tool data for CC
10292	CC_TOA_PARAM_UNIT	Physical units of the tool edge data for CC
13000	DRIVE_IS_ACTIVE[n]	Drive activation
13010	DRIVE_LOGIC_NR[n]	Logical drive number
13020	DRIVE_INVERTER_CODE[n]	Power section code of drive module
13030	DRIVE_MODULE_TYPE[n]	Module identifier
13040	DRIVE_TYPE[n]	Identifier of drive type
13050	DRIVE_LOGIC_ADDRESS[n]	Logical drive addresses
13060	DRIVE_TELEGRAM_TYPE[n]	Standard message frame type for PROFIBUS DP

Number	Identifier: \$MN_	Description
13070	DRIVE_FUNCTION_MASK[n]	DP function used
13080	DRIVE_TYPE_DP[n]	Drive type PROFIBUS DP

### 7.7.1.3 Channel-specific machine data

Number	Identifier: \$MC_	Description
20150	GCODE_RESET_VALUES[n]	Reset G groups

### 7.7.1.4 Axis/spindle-specific machine data

Number	Identifier: \$MA_	Description
30100	CTRLOUT_SEGMENT_NR[n]	Setpoint assignment: Drive type
30110	CTRLOUT_MODULE_NR[n]	Setpoint assignment: Drive number/module number
30120	CTRLOUT_NR[n]	Setpoint assignment: Setpoint output on drive module/module
30130	CTRLOUT_TYPE[n]	Output type of setpoint
30134	IS_UNIPOLAR_OUTPUT[n]	Setpoint output is unipolar
30200	NUM_ENCS	Number of encoders
30210	ENC_SEGMENT_NR[n]	Actual-value assignment: Drive type
30220	ENC_MODULE_NR[n]	Actual-value assignment: Drive module number/measuring circuit number
30230	ENC_INPUT_NR[n]	Actual-value assignment: Input on drive module/measuring circuit module
30240	ENC_TYPE[n]	Type of actual-value acquisition (position actual value)
30242	ENC_IS_INDEPENDENT	Encoder is independent
30300	IS_ROT_AX	Rotary axis
30350	SIMU_AX_VDI_OUTPUT	Output of axis signals for simulation axes
31000	ENC_IS_LINEAR[n]	Direct measuring system (linear scale)
31010	ENC_GRID_POINT_DIST[n]	Distance between reference marks on linear scales
31020	ENC_RESOL[n]	Encoder pulses per revolution
31030	LEADSCREW_PITCH	Leadscrew pitch
31040	ENC_IS_DIRECT[n]	Encoder is connected directly to the machine
31044	ENC_IS_DIRECT2	Encoder on intermediate gear
31050	DRIVE_AX_RATIO_DENOM[n]	Denominator load gearbox
31060	DRIVE_AX_RATIO_NUMERA[n]	Numerator load gearbox
31064	DRIVE_AX_RATIO2_DENOM	Intermediate gear denominator
31066	DRIVE_AX_RATIO2_NUMERA	Intermediate gear numerator

7.7 Data lists

Number	Identifier: \$MA_	Description
31070	DRIVE_ENC_RATIO_DENOM[n]	Measuring gear denominator
31080	DRIVE_ENC_RATIO_NUMERA[n]	Measuring gear numerator
31090	JOG_INCR_WEIGHT	Weighting of increment for INC/handwheel
31200	SCALING_FACTOR_G70_G71	Factor for converting values when G70/G71 is active
32000	MAX_AX_VELO	Maximum axis velocity
32100	AX_MOTION_DIR	Travel direction
32110	ENC_FEEDBACK_POL[n]	Sign actual value (feedback polarity)
32200	POSCTRL_GAIN [n]	Servo gain factor (Kv)
32210	POSCTRL_INTEGR_TIME	Integrator time position controller
32220	POSCTRL_INTEGR_ENABLE	Activation of integral component of position controller
32250	RATED_OUTVAL[n]	Rated output voltage
32260	RATED_VELO[n]	Rated motor speed
32450	BACKLASH[n]	Backlash
32500	FRICT_COMP_ENABLE	Friction compensation active
32610	VELO_FFW_WEIGHT	Feedforward control factor for speed feedforward control
32620	FFW_MODE	Feedforward control mode
32630	FFW_ACTIVATION_MODE	Activate feedforward control from program
32650	AX_INERTIA	Moment of inertia for torque feedforward control
32711	CEC_SCALING_SYSTEM_METRIC	System of measurement of sag compensation
32800	EQUIV_CURRCTRL_TIME [n]	Equivalent time constant current control loop for feedforward control
32810	EQUIV_SPEEDCTRL_TIME [n]	Equivalent time constant speed control loop for feedforward control
32900	DYN_MATCH_ENABLE	Dynamics matching
32910	DYN_MATCH_TIME [n]	Time constant for dynamic response adaptation
32930	POSCTRL_OUT_FILTER_ENABLE	Activation of low-pass filter at position controller output
32940	POSCTRL_OUT_FILTER_TIME	Time constant of low-pass filter at position controller output
32950	POSCTRL_DAMPING	Factor for additional damping of position control loop
32960	POSCTRL_ZERO_ZONE[n]	Dead zone position controller
33000	FIPO_TYPE	Fine interpolator type
34320	ENC_INVERS[n]	Length measuring system is inverse
35100	SPIND_VELO_LIMIT	Maximum spindle speed
36200	AX_VELO_LIMIT [n]	Threshold value for velocity monitoring
36210	CTRL_OUT_LIMIT[n]	Maximum speed setpoint
36400	AX_JERK_ENABLE	Axial jerk limitation
36410	AX_JERK_TIME	Time constant for axial jerk filter
36500	ENC_CHANGE_TOL	Max. tolerance for position actual-value switchover
36510	ENC_DIFF_TOL	Measuring system synchronism tolerance
36700	ENC_COMP_ENABLE[n]	Interpolatory compensation

## Auxiliary Function Outputs to PLC (H2)

### 8.1 Brief description

#### 8.1.1 Function

##### General

Auxiliary functions permit activation of the system functions of NC and PLC user functions. Auxiliary functions can be programmed in part program blocks in the following:

- Parts programs
- Synchronized actions
- User cycles

Detailed information on using auxiliary function output in synchronized actions is to be found in:

##### References:

/FBSY/ Function Manual Synchronous Actions

##### Predefined auxiliary functions

Predefined auxiliary functions activate system functions. The auxiliary function is also output to the NC/PLC interface. The following auxiliary functions are predefined:

Type	Function	Example	Meaning
M	Miscellaneous (i.e. special) function	M30	End of program
S	Spindle function	S100	Spindle speed 100 e.g. rpm
T	Tool number	T3	Tool number 3
D, DL	Tool offset	D1	Tool cutting edge number 1
F	Feed	F1000	Feedrate 1000 e.g. mm/min

### User-defined auxiliary functions

There are two uses for user-defined auxiliary functions:

- Extension of predefined auxiliary functions
- User-specific auxiliary functions

#### Extension of predefined auxiliary functions

Extension of predefined auxiliary functions refers to the "address extensions" parameter. The address extension defines the number of the spindle to which the auxiliary function applies. The spindle function M3 (spindle right) is predefined for the master spindle of a channel. If a 2nd spindle is assigned to a channel, a corresponding user-defined auxiliary function must be defined that extends the predefined auxiliary function.

Type	Function	Example	Meaning
M	Miscellaneous (i.e. special) function	M2=3	2nd spindle: Spindle right
S	Spindle function	S2=100	2nd spindle: Spindle speed = 100 e.g. rpm
T	Tool number	T2=3	

#### User-specific auxiliary functions

User-specific auxiliary functions do not activate system functions. User-specific auxiliary functions are output by the NC to the NC/PLC interface only. The functionality of the auxiliary functions must be implemented by the machine manufacturer/user via the PLC user program.

Type	Function	Example	Meaning
H <sup>1)</sup>	Auxiliary function	H2=5	User-specific function

<sup>1)</sup> Recommendation

## **Definition of an auxiliary function**

An auxiliary function is defined by the following parameters:

- Type, address extension, and value

The 3 parameters are output to the NC/PLC interface.

- Output behavior

The auxiliary-function-specific output behavior defines for how long an auxiliary function is output to the NC/PLC interface and when it is output relative to the traverse movement programmed in the same parts program block.

- Group assignment

An auxiliary function can be assigned to a particular auxiliary function group. The output behavior can be defined separately for each auxiliary function group. This becomes active if no auxiliary-function-specific output behavior has been defined. Group membership also affects output of an auxiliary function after block search.

For more detailed information on auxiliary function output to the NC/PLC interface, see:

### **References:**

/FB1/ Function Manual, Basic Functions, Basic PLC Program (P3)

## 8.1.2 Overview of auxiliary functions

### M functions

M (special function)					
Address extension		Value			
Value range	Meaning	Value range	Type	Meaning	Number <sup>8)</sup>
0 (implicit)	- - -	up to 8 digits	INT	Function	5
<b>Remarks:</b> - - -					
Value range	Meaning	Value range	Type	Meaning	Number <sup>8)</sup>
1 - 12	Spindle number	1 – 99	INT	Function	5
<b>Remarks:</b> Example: "Spindle stop" for 2nd spindle of the channel: M2=5. The master spindle of the channel is addressed if no an address extension is specified.					
Value range	Meaning	Value range	Type	Meaning	Number <sup>8)</sup>
0 - 99	Any	2147483647	INT	Function	5
<b>Remarks:</b> User-specific M function					

#### Application

Controlling machine functions in synchronism with the part program.

#### General remarks

- The following M functions have a predefined meaning: M0, M1, M2, M17, M30, M3, M4, M5, M6, M19, M70, M40, M41, M42, M43, M44, M45.
- For each M function (M0 - M99), there is a dynamic signal at the NC/PLC interface that indicates the validity (new output) of the M function. In addition, 64 additional signals can be assigned for user M functions.

#### References:

/FB1/ Function Manual, Basic Functions, Basic PLC Program (P3)

- For subprograms, machine data can be used to set whether an output of the M function should be undertaken for the end of the part program M17, M2 and M30 to the PLC:  
MD20800 \$MC\_SPF\_END\_TO\_VDI (subprogram end to PLC)
- For the predefined M function M40 – M45, only limited redefinition of the output specification is possible.
- The predefined auxiliary functions M0, M1, M17, M30, M6, M4, M5 cannot be redefined.

- M-function-specific machine data:
  - MD10800 \$MN\_EXTERN\_CHAN\_SYNC\_M\_NO\_MIN
  - MD10802 \$MN\_EXTERN\_CHAN\_SYNC\_M\_NO\_MAX
  - MD10804 \$MN\_EXTERN\_M\_NO\_SET\_INT
  - MD10806 \$MN\_EXTERN\_M\_NO\_DISABLE\_INT
  - MD10814 \$MN\_EXTERN\_M\_NO\_MAC\_CYCLE
  - MD10815 \$MN\_EXTERN\_M\_NO\_MAC\_CYCLE\_NAME
  - MD20094 \$MC\_SPIND\_RIGID\_TAPPING\_M\_NR
  - MD20095 \$MC\_EXTERN\_RIGID\_TAPPING\_M\_NR
  - MD20096 \$MC\_T\_M\_ADDRESS\_EXT\_IS\_SPINO
  - MD22200 \$MC\_AUXFU\_M\_SYNC\_TYPE
  - MD22530 \$MC\_TOCARR\_CHANGE\_M\_CODE
  - MD22532 \$MC\_GEOAX\_CHANGE\_M\_CODE
  - MD22534 \$MC\_TRAFO\_CHANGE\_M\_CODE
  - MD22560 \$MC\_TOOL\_CHANGE\_M\_CODE

## S functions

S (spindle function)					
Address extension		Value			
Value range	Meaning	Value range	Type	Meaning	Number <sup>8)</sup>
0 - 12	Spindle number <sup>5)</sup>	0 - +/-3.4028 ex 38 <sup>3)</sup>	REAL	Spindle speed	3
<b>Remarks:</b>					
The master spindle of the channel is addressed if no an address extension is specified.					

### Application

Spindle speed.

### Remarks

- S functions are assigned to auxiliary function group 3 by default.
- Without an address extension, the S functions refer to the master spindle of the channel.
- S-function-specific machine data:
  - MD22210 \$MC\_AUXFU\_S\_SYNC\_TYPE (Output time of the S functions)

## H functions

H (aux. function)					
Address extension		Value			
Value range	Meaning	Value range	Type	Meaning	Number <sup>8)</sup>
0 - 99	Any	-2147483648 - +2147483647	INT	Any	3
		0 - +/-3.4028exp38 2) 3) 4)	REAL		
<b>Remarks:</b> The functionality must be implemented by the user in the PLC user program.					

### Application

User-specific auxiliary functions.

### Remarks

- H-function-specific machine data:  
MD22110 \$MC\_AUXFU\_H\_TYPE\_INT (type of H-auxiliary function is an integer)  
MD22230 \$MC\_AUXFU\_H\_SYNC\_TYPE (Output time of the H functions)

## T functions

T (tool number) <sup>5) 6)</sup>					
Address extension		Value			
Value range	Meaning	Value range	Type	Meaning	Number <sup>8)</sup>
1 - 12	Spindle number (with active tool management)	0 – 32000 (also symbolic tool names for active tool management)	INT	Selection of the tool	1
<b>Remarks:</b> Tool names are not output to the PLC <sup>1)</sup>					

### Application

Tool selection.

### Remarks

- Identification of the tools, optionally via tool number or location number.

### References:

/FBW/ Function Description Tool Management

/FB1/ Function Manual, Basic Functions; Tool Offset (W1)

- When T0 is selected, the current tool is removed from the tool holder but not replaced by a new tool (default setting).
- T-function-specific machine data:  
MD22220 \$MC\_AUXFU\_T\_SYNC\_TYPE (Output time of the T functions)

## D functions

D (tool offset)					
Address extension		Value			
Value range	Meaning	Value range	Type	Meaning	Number <sup>9)</sup>
---	---	0 - 9	INT	Selection of the tool offset	1
<b>Remarks:</b> Deselection of the tool offset with D0; the default is D1					

### Application

Selection of the tool offset.

### Remarks

- Initial setting: D1
- After a tool change, the default tool cut can be parameterized via:  
MD20270 \$MC\_CUTTING\_EDGE\_DEFAULT (Basic position of the tool cut without programming)
- Deselection of the tool offset: D0
- D function-specific machine data:  
MD22250 \$MC\_AUXFU\_D\_SYNC\_TYPE (Output time of the D functions)

## DL functions

DL (additive tool offset)					
Address extension		Value			
Value range	Meaning	Value range	Type	Meaning	Number <sup>9)</sup>
---	---	0 - 6	INT	Selection of the additive tool offset	1
<b>Remarks:</b> The additive tool offset selected with DL refers to the active D number.					

### Application

Selection of the additive tool offset with reference to an active tool offset.

### Remarks

- Initial setting: DL = 0
- DL values cannot be output to the PLC via synchronized actions.
- Default setting of the additive tool offset without an active DL function:  
MD20272 \$MC\_SUMCORR\_DEFAULT (basic setting of the additive offset without a program)
- Deselection of the additive tool offset: DL = 0
- DL-function-specific machine data:  
MD22252 \$MC\_AUXFU\_DL\_SYNC\_TYPE (output time DL functions)

8.1 Brief description

**F functions**

F (feedrate)					
Address extension		Value			
Value range	Meaning	Value range	Type	Meaning	Number <sup>8)</sup>
---	---	0.001 - 999 999.999	REAL	Path feed	6
Remarks:					
---					

**Application**

Path velocity.

**Remarks**

- F-function-specific machine data:  
MD22240 \$MC\_AUXFU\_F\_SYNC\_TYPE (output time of F functions)

**FA functions**

FA (axial feedrate)					
Address extension		Value			
Value range	Meaning	Value range	Type	Meaning	Number <sup>8)</sup>
1 - 31	Axis number	0.001 - 999 999.999	REAL	Axial feedrate	6
Remarks:					
---					

**Application**

Axial velocity.

**Remarks**

- F-function-specific machine data:  
MD22240 \$MC\_AUXFU\_F\_SYNC\_TYPE (output time of F functions)

## Footnotes

- 1) If tool management is active, neither a T change signal nor a T word is output to the interface (channel).
- 2) The type for the values can be selected by the user via MD22110 \$MC\_AUXFU\_H\_TYPE\_INT.
- 3) Because of the limited display options on the operator panel screens, the REAL type values displayed are restricted to:  
-999 999 999.9999 to 999 999 999.9999  
The NC calculates internally but with complete accuracy.
- 4) The REAL values are rounded and output to the PLC when setting the machine data:  
MD22110 \$MC\_AUXFU\_H\_TYPE\_INT = 1 (type of H-auxiliary functions is an integer)  
The PLC user program must interpret the value transferred according to the machine data setting.
- 5) If the tool management is active, the meaning of the address extension can be parameterized. Address extension = 0 means the value must be replaced by that of the master spindle number, i.e. it is equivalent to not programming the address extension.  
Auxiliary functions M19 "Position spindle" collected during a block search are not output to the PLC.
- 6) M6: Value range of the address extension:  
- without tool management: 0 – 99  
- with tool management: 0 – maximum spindle number  
0: replace by the value of the master spindle number or the master tool holder
- 7) If tool management is active, the auxiliary function M6 "Tool change" can only be programmed once in a part program block, irrespective the address extensions that are programmed.
- 8) Maximum number of auxiliary functions per part program block.

## 8.2 Predefined auxiliary functions

### 8.2.1 Predefined auxiliary functions

#### Function

Predefined auxiliary functions are auxiliary functions for activating system functions. The assignment of predefined auxiliary functions to system function cannot be changed.

During execution of a predefined auxiliary function, the corresponding system function is activated and the auxiliary functions are output to the NC/PLC interface.

#### Definition of a predefined auxiliary function

The parameters of a predefined auxiliary function are stored in machine data and can be changed in some cases. All parameters of an auxiliary function have the same index.

- MD22040 \$MC\_AUXFU\_PREDEF\_GROUP[ Index ] (Pre-defined auxiliary function groups)
- MD22050 \$MC\_AUXFU\_PREDEF\_TYPE[ Index ] (Pre-defined auxiliary function type)
- MD22060 \$MC\_AUXFU\_PREDEF\_EXTENSION[ Index ] (Pre-defined auxiliary function extension)
- MD22070 \$MC\_AUXFU\_PREDEF\_VALUE[ Index ] (Pre-defined auxiliary function value)
- MD22080 \$MC\_AUXFU\_PREDEF\_SPEC[ Index ] (output specification)

#### Predefined auxiliary functions

System function														
	Index n (index for the machine data of the parameters of an auxiliary function)													
	Type: MD22050 \$MC_AUXFU_PREDEF_TYPE[ n ]													
	Address extension: MD22060 \$MC_AUXFU_PREDEF_EXTENSION[ n ]													
	Value: MD22070 \$MC_AUXFU_PREDEF_VALUE[ n ]													
	Group: MD22040 \$MC_AUXFU_PREDEF_GROUP[ n ]													
	Output behavior: Bits 0- 8													
	MD22080 \$MC_AUXFU_PREDEF_SPEC[ n ]													
						8	7	6	5	4	3	2	1	0
Stop	0	M	0	0	1	0	1	0	0	0	0	0	0	1
Conditional stop	1	M	0	1	1	0	1	0	0	0	0	0	0	1
End of subroutine	2	M	0	2	1	0	1	0	0	0	0	0	0	1
	3	M	0	17	1	0	1	0	0	0	0	0	0	1
	4	M	0	30	1	0	1	0	0	0	0	0	0	1
Tool change	5	M	(1)	6 <sup>1)</sup>	(1)	(0)	(0)	(0)	(1)	(0)	(0)	(0)	0	1
Spindle right	6	M	(1)	3	(2)	(0)	(0)	(0)	(1)	(0)	(0)	(0)	0	1
Spindle left	7	M	(1)	4	(2)	(0)	(0)	(0)	(1)	(0)	(0)	(0)	0	1

Spindle stop	8	M	(1)	5	(2)	(0)	(0)	(0)	(1)	(0)	(0)	(0)	0	1
Position spindle	9	M	(1)	19	(2)	(0)	(0)	(0)	(1)	(0)	(0)	(0)	0	1
Axis mode	10	M	(1)	70 <sup>2)</sup>	(2)	(0)	(0)	(0)	(1)	(0)	(0)	(0)	0	1
Automatic gear stage	11	M	(1)	40	(4)	(0)	0	0	1	(0)	(0)	(0)	0	1
Gear stage 1	12	M	(1)	41	(4)	(0)	0	0	1	(0)	(0)	(0)	0	1
Gear stage 2	13	M	(1)	42	(4)	(0)	0	0	1	(0)	(0)	(0)	0	1
Gear stage 3	14	M	(1)	43	(4)	(0)	0	0	1	(0)	(0)	(0)	0	1
Gear stage 4	15	M	(1)	44	(4)	(0)	0	0	1	(0)	(0)	(0)	0	1
Gear stage 5	16	M	(1)	45	(4)	(0)	0	0	1	(0)	(0)	(0)	0	1
Spindle speed	17	S	(1)	-1	(3)	0	(0)	(1)	(0)	(0)	(0)	0	0	1
Feed	18	F	0	-1	(1)	0	(0)	(1)	(0)	0	(0)	0	0	1
Cutting edge selection	19	D	0	-1	(1)	0	(0)	(1)	(0)	0	(0)	0	0	1
DL	20	L	0	-1	(1)	0	(0)	(1)	(0)	0	(0)	0	0	1
Tool selection	21	T	(1)	-1	(1)	0	(0)	(1)	(0)	0	(0)	0	0	1
Stop (associated)	22	M	0	-1 <sup>3)</sup>	1	0	1	0	0	0	0	0	0	1
Conditional stop (associated)	23	M	0	-1 <sup>4)</sup>	1	0	1	0	0	0	0	0	0	1
End of subroutine	24	M	0	-1 <sup>5)</sup>	1	0	1	0	0	0	0	0	0	1
Nibbling	25	M	0	20 <sup>6)</sup>	(10)	(0)	(0)	(1)	(0)	0	(0)	(0)	0	1
Nibbling	26	M	0	23 <sup>6)</sup>	(10)	(0)	(0)	(1)	(0)	0	(0)	(0)	0	1
Nibbling	27	M	0	22 <sup>6)</sup>	(11)	(0)	(0)	(1)	(0)	0	(0)	(0)	0	1
Nibbling	28	M	0	25 <sup>6)</sup>	(11)	(0)	(0)	(1)	(0)	0	(0)	(0)	0	1
Nibbling	29	M	0	26 <sup>6)</sup>	(12)	(0)	(0)	(1)	(0)	0	(0)	(0)	0	1
Nibbling	30	M	0	122 <sup>6)</sup>	(11)	(0)	(0)	(1)	(0)	0	(0)	(0)	0	1
Nibbling	31	M	0	125 <sup>6)</sup>	(11)	(0)	(0)	(1)	(0)	0	(0)	(0)	0	1
Nibbling	32	M	0	27 <sup>6)</sup>	(12)	(0)	(0)	(1)	(0)	0	(0)	(0)	0	1

1) The value is dependent upon machine data:

MD22560 \$MC\_TOOL\_CHANGE\_M\_MODE (M function for tool change)

2) The value can be preset with a different value via the following machine data:

MD20095 \$MC\_EXTERN\_RIGID\_TAPPING\_M\_NR (M function for switching over to the controlled axis mode (ext. mode))

MD20094 \$MC\_SPIND\_RIGID\_TAPPING\_M\_NR (M function for switching over to controlled axis mode)

The value 70 is always output to the PLC.

3) The value is set via the machine data:

MD22254 \$MC\_AUXFU\_ASSOC\_M0\_VALUE (additional M function for program stop)

4) The value is set via the machine data:

MD22256 \$MC\_AUXFU\_ASSOC\_M1\_VALUE (additional M function for conditional stop)

5) The value is set via the machine data:

MD10714 \$MN\_M\_NO\_FCT\_EOP (M function for spindle active after reset)

6) The value is set via the machine data:

MD26008 \$MC\_NIBBLE\_PUNCH\_CODE (definition of M functions)

( ) Only values in parentheses can be changed.

### 8.2.2 Parameter: Group assignment

#### Group assignment

A predefined auxiliary function can be assigned to a certain auxiliary function group via the group assignment:

MD22040 \$MC\_AUXFU\_PREDEF\_GROUP[ index ] (group assignment)

If the value is zero, the auxiliary function is not assigned to any auxiliary function group.

### 8.2.3 Parameter: Type, address extension, and value

#### Function

A predefined auxiliary function is programmed via the parameters:

- **Type**

MD22050 \$MC\_AUXFU\_PREDEF\_TYPE[ Index ] (Pre-defined auxiliary function type)

- **Address extension**

MD22060 \$MC\_AUXFU\_PREDEF\_EXTENSION[ Index ] (Pre-defined auxiliary function extension)

- **Value**

MD22070 \$MC\_AUXFU\_PREDEF\_VALUE[ Index ] (Pre-defined auxiliary function value)

**Syntax:**

< type > [ < address extension > = ] < value >

#### Parameter: Type

The identifier of an auxiliary function is defined via the "type," e.g.:

Type	Identifier
M	Additional function
S	Spindle function
F	Feed

The "type" cannot be changed for predefined auxiliary functions.

**Parameter: Address extension**

The "address extension" of an auxiliary function is for addressing different components of the same type. In the case of predefined auxiliary functions, the value of the "address extension" is the spindle number to which the auxiliary function applies.

If no address extension is programmed, the address extension is implicitly set = 0. Auxiliary functions with the address extension = 0 always refer to the master spindle of the channel.

**Example**

Programming	Function
N10 M3	; "Spindle right" for the master spindle of the channel
N20 M0 = 3	; "Spindle right" for the master spindle of the channel
N30 M1 = 3	; "Spindle right" for the 1st spindle of the channel
N40 M2 = 3	; "Spindle right" for the 2nd spindle of the channel

**Grouping together auxiliary functions**

To assign an auxiliary function for all spindles of a channel to the same auxiliary function group, the value "-1" is entered for the "address extension" parameter.

Example:

For all the spindles of the channel, the auxiliary function M3 (machine data index = 6, corresponding to the table in the Section "Predefined Auxiliary Functions") is assigned to the second auxiliary function group.

```
MD22040 $MC_AUXFU_PREDEF_GROUP[ 6 ]      = 2
MD22050 $MC_AUXFU_PREDEF_TYPE[ 6 ]       = "M"
MD22060 $MC_AUXFU_PREDEF_EXTENSION[ 6 ]  = -1
MD22070 $MC_AUXFU_PREDEF_VALUE[ 6 ]      = 3
```

**Parameter: Value**

The parameters "value" and "type" define the meaning of an auxiliary function, i.e. the system function that is activated on the basis of this auxiliary function. The "value" cannot be changed for a predefined auxiliary function. For some predefined auxiliary functions, the "value" can be reconfigured via additional machine data (see Section "Associated Auxiliary Functions").

### 8.2.4 Parameter: Output behavior

#### Function

The "output behavior" defines when the auxiliary function is output to the NC/PLC interface and when it is acknowledged by the PLC:

MD22080 \$MC\_AUXFU\_PREDEF\_SPEC[ index ] (specification of output behavior)

Bit	Value	Meaning
0	1	Output duration one OB1 cycle (normal acknowledgment)
1	1	Output duration one OB40 cycle (quick acknowledgment)
2	1	No predefined auxiliary function
3	1	No output (can only be set as a single bit)
4	1	Spindle response following acknowledgment
5	1	Output prior to motion
6	1	Output during motion
7	1	Output at block end
8	1	The collected auxiliary function is not output after a block search.

#### Bit0: Output duration one OB1 cycle (normal acknowledgment)

An auxiliary function with normal acknowledgment is output to the NC/PLC interface at the beginning of the OB1 cycle. The auxiliary function-specific change signals indicate to the PLC user program that the auxiliary function is valid.

The auxiliary function is acknowledged as soon as organization block OB1 has run once. This corresponds to a complete PLC user cycle.

The auxiliary function with normal acknowledgment is output in synchronism with the part program block in which it is programmed. If execution of the parts program block, e.g. path and/or positioning axis movements, is completed before acknowledgment of the auxiliary function, the block change is delayed until after acknowledgment by the PLC.

In continuous-path mode, a constant path velocity can be maintained in conjunction with an auxiliary function with normal acknowledgment, if the auxiliary function is output by the PLC during the traverse movement and before reaching the end of block.

### **Bit1: Output duration one OB40 cycle (quick acknowledgment)**

An auxiliary function with quick acknowledgment is output to the NC/PLC interface before the next OB1 cycle. The auxiliary function-specific change signal indicates to the PLC user program that the auxiliary function is valid.

The auxiliary function is acknowledged immediately by the PLC basic program in the next OB40 cycle. Acknowledgment of the auxiliary function is not confirmation that the corresponding PLC user function has been executed. The auxiliary function is still executed in the OB1 cycle. Next output of the auxiliary functions to the PLC is therefore not possible until after this OB1 cycle has run completely. This is noticeable in continuous-path mode (drop in path velocity) especially if auxiliary functions with quick acknowledgment are output in several consecutive part program blocks.

With auxiliary functions with quick acknowledgment, it cannot be guaranteed that the PLC user program will respond in synchronism with the block.

---

#### **Note**

Parameterization of the output behavior of auxiliary functions as "quick auxiliary functions" is only possible in conjunction with user-defined auxiliary functions.

---

### **Bit2: No predefined auxiliary function**

A predefined auxiliary function is treated like a user-defined auxiliary function if "No predefined auxiliary function" is set. The auxiliary function then no longer triggers the corresponding system function but is only output to the PLC.

Example:

Reconfiguration of "Position spindle" auxiliary function using Index 9 (see table in Section: Predefined auxiliary functions), to a "user-defined" auxiliary function with normal acknowledgment and output of the traversing movement.

MD22080 \$MC\_AUXFU\_PREDEF\_SPEC [ 9 ] = 'H25' (100101<sub>B</sub>) (output specification)

### **Bit3: No output**

The auxiliary function is not output to the PLC.

### **Bit4: Spindle response following acknowledgment**

The corresponding spindle function is only started after acknowledgment by the PLC.

**Bit5: Output prior to motion**

The auxiliary function is output before the traverse movements programmed in the part program block (path and/or block-related positioning axis movements).

**Bit6: Output during motion**

The auxiliary function is output during the traverse movements programmed in the part program block (path and/or block-related positioning axis movements).

**Bit7: Output at block end**

The auxiliary function is output after completion of the traverse movements programmed in the part program block (path and/or block-related positioning axis movements).

**Bit8: No output after a block search**

The collected auxiliary function is not output after a block search.

---

**Note**

In the case of auxiliary functions for which no output behavior has been defined, the following default output behavior is active:

- Output duration one OB1 cycle
  - Output at block end
- 

**Context: Output duration and output relative to movement**

**Output prior to motion**

- The traverse movements (path and/or block-related positioning axis movements) of the previous part program block end with an exact stop.
- The auxiliary functions are output at the beginning of the current part program block.
- Traverse movements of the current part program block (path and/or positioning axis movements) are started after acknowledgment of the auxiliary functions by the PLC:
  - Output duration one OB1 cycle (normal acknowledgment): after one OB1 cycle
  - Output duration one OB40 cycle (quick acknowledgment): after one OB40 cycle

**Output during motion**

- The auxiliary functions are output at the beginning of the traverse movements (path and/or positioning axis movements).
- The path velocity of the current part program block is reduced so that the time to the end of the block is greater than the time to acknowledgment of the auxiliary functions by the PLC.
  - Output duration one OB1 cycle (normal acknowledgment): one OB1 cycle
  - Output duration one OB40 cycle (quick acknowledgment): one OB40 cycle

#### **Output after motion**

- The traverse movements (path and/or block-related positioning axis movements) of the current part program block end with an exact stop.
- The auxiliary functions are output after completion of the traverse movements.
- The block change is performed after acknowledgment of the auxiliary functions by the PLC:
  - Output duration one OB1 cycle (normal acknowledgment): after one OB1 cycle
  - Output duration one OB40 cycle (quick acknowledgment): after one OB40 cycle

### **8.2.5 Examples of output behavior**

#### **Inputs**

The following figures illustrate the differing behavior regarding:

- Output and acknowledgment of the auxiliary function
- Spindle response (speed change)
- Traverse movement (velocity change)

#### **Parameterized output behavior**

The binary values specified in the examples under "Spec" refer to the parameterized output behavior:

MD22080 \$MC\_AUXFU\_PREDEF\_SPEC[ index ] (output specification)

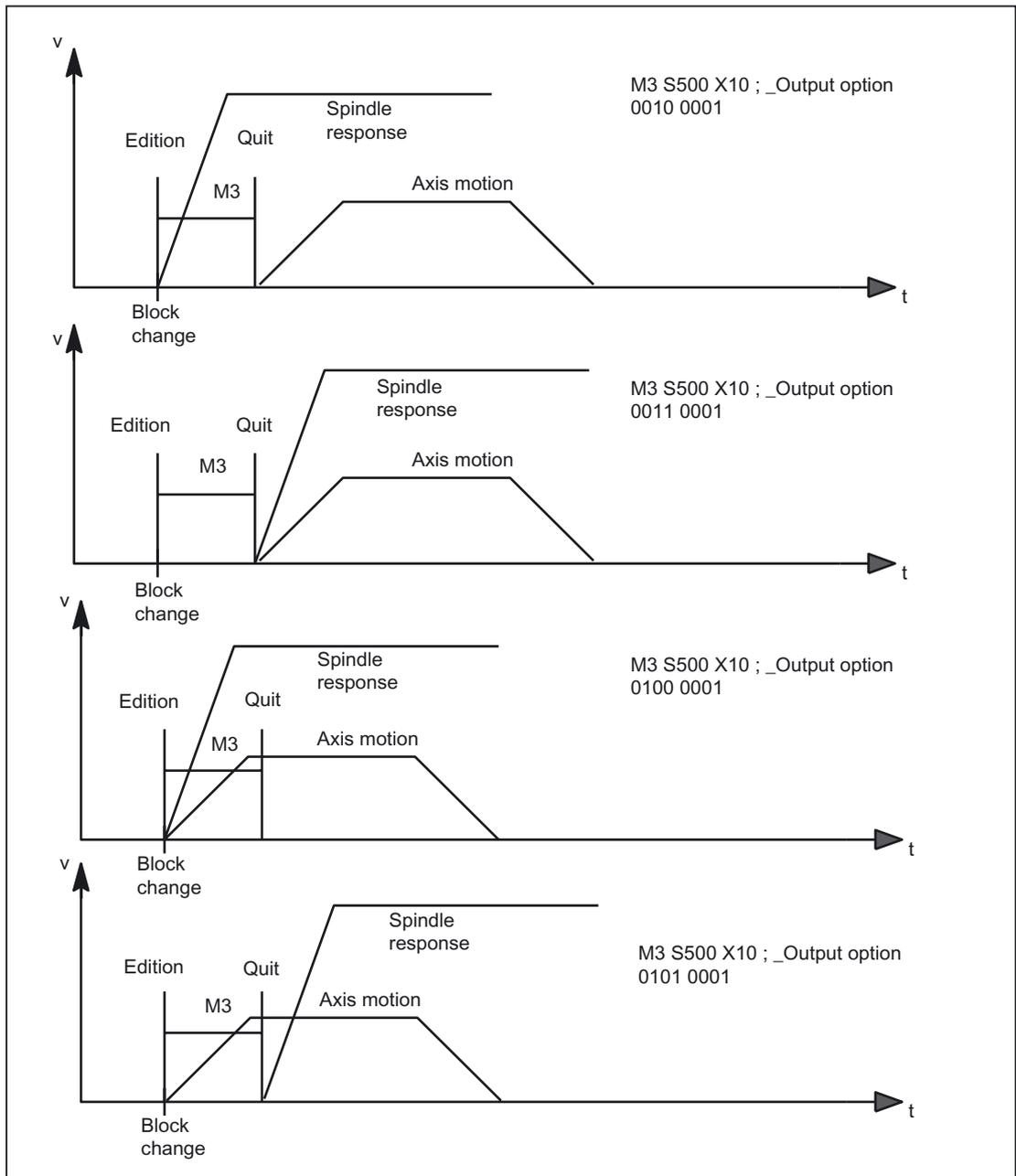


Figure 8-1 Output behavior 1

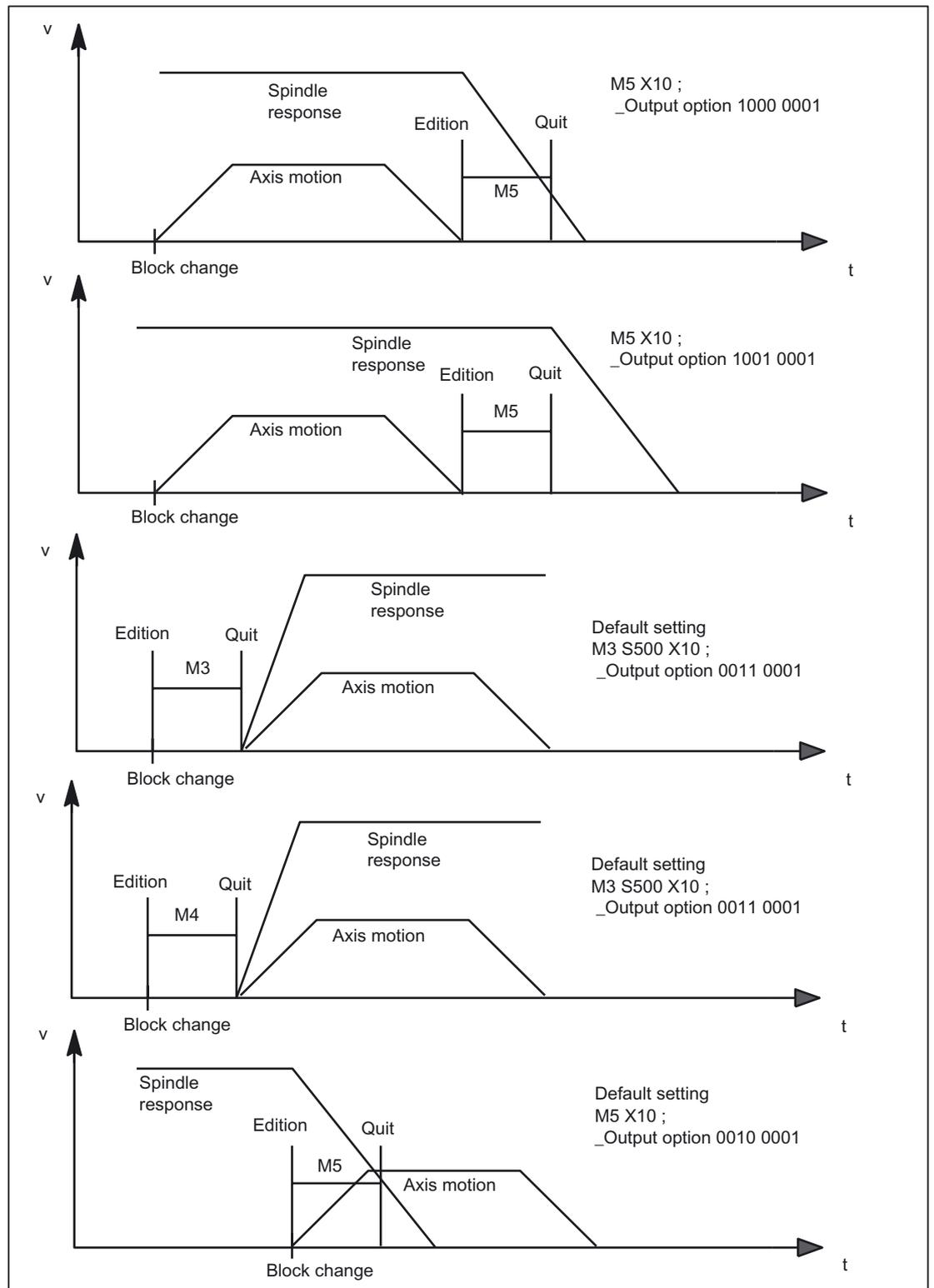


Figure 8-2 Output behavior 2

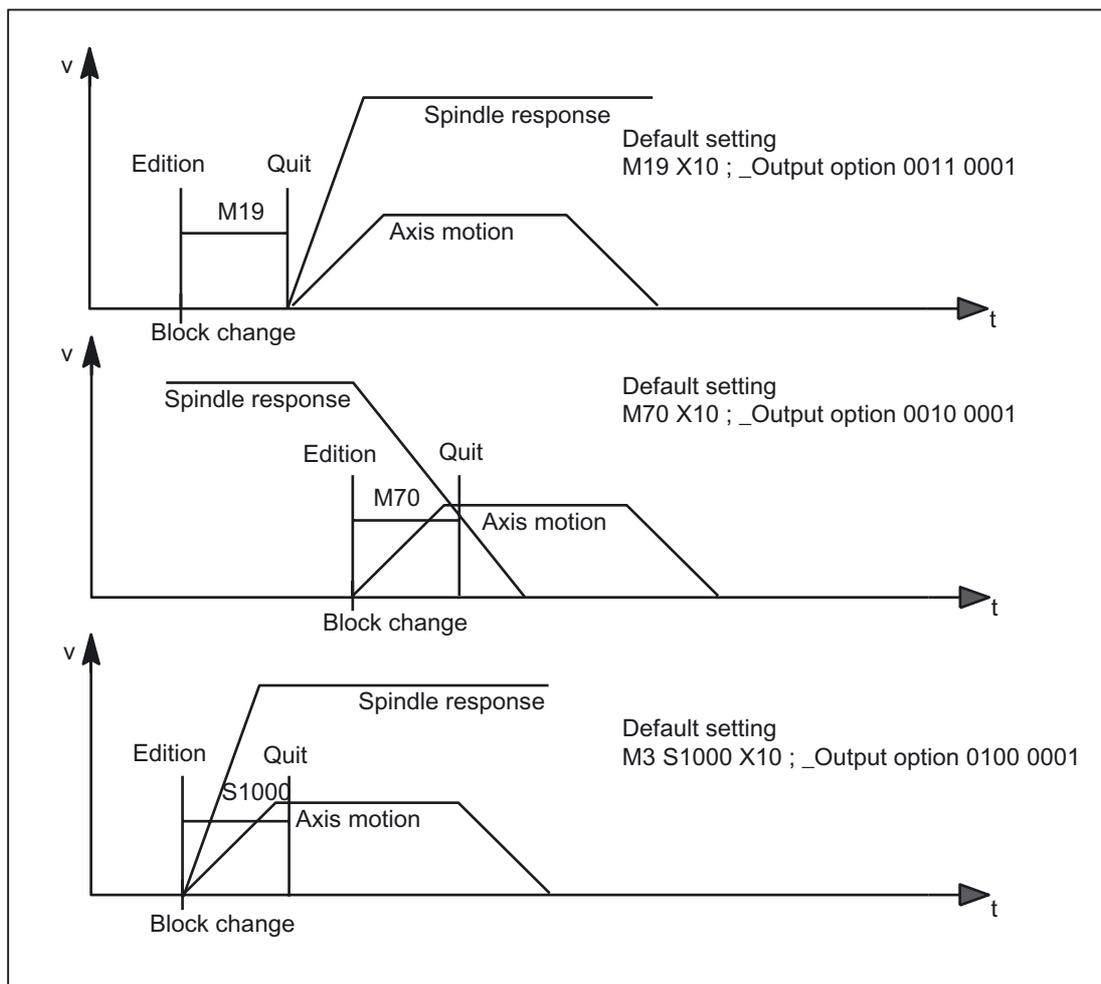


Figure 8-3 Output behavior 3

## **8.3 User-defined auxiliary functions**

### **8.3.1 User-specific and extended predefined auxiliary functions**

#### **Function**

There are two uses for user-defined auxiliary functions:

- Extension of predefined auxiliary functions
- User-specific auxiliary functions

#### **Extension of predefined auxiliary functions**

Extension of predefined auxiliary functions refers to the parameter: "Address extension". The address extension defines the number of the spindle to which the auxiliary function applies.

#### **User-specific auxiliary functions**

User-specific auxiliary functions relate exclusively to user functions. User-specific auxiliary functions do not activate system functions.

### **8.3.2 Maximum number of user-defined auxiliary functions**

#### **Maximum number**

The maximum number of user-defined auxiliary function per channel can be parameterized via the machine data:

MD11100 \$MN\_AUXFU\_MAXNUM\_GROUP\_ASSIGN (maximum number of user-definable auxiliary functions)

### 8.3.3 Extension of predefined auxiliary functions

#### Function

Because there is only one set of machine data for the predefined auxiliary functions, they can only ever be used to address one spindle of the channel. To address further spindles, user-defined auxiliary functions must be parameterized to supplement the predefined auxiliary functions.

Extension of predefined auxiliary functions refers to the "address extensions" parameter. The number of the spindle that the auxiliary function refers to is entered in the "address extension" parameter.

The relevant predefined auxiliary functions can be extended for the following system functions.

System function	Type		
		Address extension <sup>1)</sup>	
			Value
Tool change	M	1	6
Spindle right	M	1	3
Spindle left	M	1	4
Spindle stop	M	1	5
Position spindle	M	1	19
Axis mode	M	1	70
Automatic gear stage	M	1	40
Gear stage 1	M	1	41
Gear stage 2	M	1	42
Gear stage 3	M	1	43
Gear stage 4	M	1	44
Gear stage 5	M	1	45
Spindle speed	S	1	-1
Tool selection	T	1	-1
1) address extension = 1 is the default value used in the auxiliary functions predefined in the machine data.			

## Example

Extension of the predefined auxiliary function for the system function "spindle right" for the second and third spindle of the channel.

Auxiliary function "spindle right" for the second spindle of the channel:

```
MD22010 $MC_AUXFU_ASSIGN_TYPE[ n ]           = "M"  
MD22020 $MC_AUXFU_ASSIGN_EXTENSION[ n ]     = 2  
MD22030 $MC_AUXFU_ASSIGN_VALUE[ n ]         = 3
```

Auxiliary function "spindle right" for the third spindle of the channel:

```
MD22010 $MC_AUXFU_ASSIGN_TYPE[ m ]           = "M"  
MD22020 $MC_AUXFU_ASSIGN_EXTENSION[ m ]     = 3  
MD22030 $MC_AUXFU_ASSIGN_VALUE[ m ]         = 3
```

## 8.3.4 User-specific auxiliary functions

### Function

User-specific auxiliary functions have the following characteristics:

- User-specific auxiliary functions only activate user functions.
- No system functions can be activated by user-specific auxiliary functions.
- A user-specific auxiliary function is output to the PLC according to the parameterized output behavior.
- The functionality of a user-specific auxiliary function is implemented by the machine manufacturer/user in the PLC user program.

### 8.3.5 Parameterization

#### 8.3.5.1 Parameter: Group assignment

##### Group assignment

Group assignment is used to assign a user-defined auxiliary function to an auxiliary function group using the machine data:

MD22000 \$MC\_AUXFU\_ASSIGN\_GROUP[ index ] (group assignment)

If the value is zero, the auxiliary function is not assigned to any auxiliary function group.

For the meanings of the auxiliary function groups, see section: Auxiliary function groups.

#### 8.3.5.2 Parameter: Type, address extension, and value

##### Function

A user-defined auxiliary function is programmed via the parameters:

- **Type**

MD22010 \$MC\_AUXFU\_ASSIGN\_TYPE[ Index ] (type of auxiliary function)

- **Address extension**

MD22020 \$MC\_AUXFU\_ASSIGN\_EXTENSION[ Index ] (auxiliary function extension)

- **Value**

MD22030 \$MC\_AUXFU\_ASSIGN\_VALUE[ Index ] (auxiliary function value)

**Syntax:**

< type > [ < address extension > = ] < value >

##### Parameter: Type

The name of an auxiliary function is defined via the "type".

The identifiers for user-defined auxiliary functions are:

Type	Identifier	Meaning
H	Auxiliary function	User-specific auxiliary functions
M	Additional function	Extension of predefined auxiliary functions
S	Spindle function	
T	Tool number	

**Parameter: Address extension**

The functionality of the address extension is not defined in user-specific auxiliary functions. It is generally used to distinguish between auxiliary functions with the same "value".

**Grouping together auxiliary functions**

If all the auxiliary functions of the same type and value are assigned to the same auxiliary function group, a value of "-1" must be entered for the "address extension" parameter.

Example:

All user-specific auxiliary functions with the value "= 8" are assigned to the tenth auxiliary function group.

```
MD22000 $MC_AUXFU_ASSIGN_GROUP[ 1 ]           = 10
MD22010 $MC_AUXFU_ASSIGN_TYPE[ 1 ]             = "H"
MD22020 $MC_AUXFU_ASSIGN_EXTENSION[ 1 ]       = -1
MD22030 $MC_AUXFU_ASSIGN_VALUE[ 1 ]           = 8
```

**Parameter: Value**

The functionality of the "value" parameter is not defined in user-specific auxiliary functions. The value is generally used to activate the corresponding PLC user function.

**Grouping together auxiliary functions**

If all the auxiliary functions of the same type and address extension are assigned to the same auxiliary function group, a value of "-1" must be entered for the "value" parameter.

Example:

All user-specific auxiliary functions with the address extension "= 2" are assigned to the eleventh auxiliary function group.

```
MD22000 $MC_AUXFU_ASSIGN_GROUP[ 2 ]           = 11
MD22010 $MC_AUXFU_ASSIGN_TYPE[ 2 ]             = "H"
MD22020 $MC_AUXFU_ASSIGN_EXTENSION[ 2 ]       = 2
MD22030 $MC_AUXFU_ASSIGN_VALUE[ 2 ]           = -1
```

**8.3.5.3 Parameter: Output behavior**

**Function**

The "output behavior" of user-defined auxiliary functions can be parameterized via the machine data:

MD22035 \$MC\_AUXFU\_ASSIGN\_SPEC[ index ] (specification of output behavior)

For a description of the individual output parameters, see Section "Parameter: output behavior" of the predefined auxiliary functions. The information given there can be applied analogously to the output behavior of user-defined auxiliary functions.

### 8.3.5.4 Examples

#### Example of the extension of predefined auxiliary functions

For the second spindle of the channel, the auxiliary functions M3, M4 and M5 should be parameterized:

##### Parameterization: M3

- Machine data index: 0 (1st user-defined auxiliary function)
- Auxiliary function group: 5
- Type and value: M3 (spindle right)
- Address extension: 2 as appropriate for the 2nd spindle of the channel
- Output behavior:
  - Output duration one OB1 cycle (normal acknowledgment)
  - Output prior to motion

Machine data	Machine data index	Value
MD22000 \$MC_AUXFU_ASSIGN_GROUP	0	5
MD22010 \$MC_AUXFU_ASSIGN_TYPE	0	"M"
MD22020 \$MC_AUXFU_ASSIGN_EXTENSION	0	2
MD22030 \$MC_AUXFU_ASSIGN_VALUE	0	3
MD22035 \$MC_AUXFU_ASSIGN_SPEC	0	H21

##### Parameterization: M4

- Machine data index: 1 (2nd user-defined auxiliary function)
- Auxiliary function group: 5
- Type and value: M4 (spindle left)
- Address extension: 2 as appropriate for the 2nd spindle of the channel
- Output behavior:
  - Output duration one OB1 cycle (normal acknowledgment)
  - Spindle response following acknowledgment
  - Output during motion

Machine data	Machine data index	Value
MD22000 \$MC_AUXFU_ASSIGN_GROUP	1	5
MD22010 \$MC_AUXFU_ASSIGN_TYPE	1	"M"
MD22020 \$MC_AUXFU_ASSIGN_EXTENSION	1	2
MD22030 \$MC_AUXFU_ASSIGN_VALUE	1	4
MD22035 \$MC_AUXFU_ASSIGN_SPEC	1	H51

**Parameterization: M5**

- Machine data index: 2 (3rd user-defined auxiliary function)
- Auxiliary function group: 5
- Type and value: M5 (spindle stop)
- Address extension: 2 as appropriate for the 2nd spindle of the channel
- Output behavior:
  - Output duration one OB1 cycle (normal acknowledgment)
  - Spindle response following acknowledgment
  - Output at block end

Machine data	Machine data index	Value
MD22000 \$MC_AUXFU_ASSIGN_GROUP	2	5
MD22010 \$MC_AUXFU_ASSIGN_TYPE	2	"M"
MD22020 \$MC_AUXFU_ASSIGN_EXTENSION	2	2
MD22030 \$MC_AUXFU_ASSIGN_VALUE	2	5
MD22035 \$MC_AUXFU_ASSIGN_SPEC	2	H91

### 8.3.6 Programmable output duration

#### Function

User-specific auxiliary functions, for which the output behavior "Output duration of an OB1 cycle (slow acknowledgement)" was parameterized, can be defined for individual outputs via the parts program guide QU (Quick) for auxiliary functions with quick acknowledgement.

#### Syntax

An auxiliary function with quick acknowledgement is defined in a part program block with the following syntax:

< type > [ < address extension > ] = QU(< value >)

#### Example

Different behavior for the output of the auxiliary functions M100 and M200 in a parts program. The output behavior of the auxiliary functions is parameterized as follows:

- M100
  - Output duration one OB1 cycle (slow acknowledgment)
  - Output during motion
- M200
  - Output duration one OB1 cycle (slow acknowledgment)
  - Output prior to motion

8.3 User-defined auxiliary functions

Programming	Comment
N10 G94 G01 X50 M100	Output of M100: during the motion Acknowledgement: slow
N20 Y5 M100 M200	Output of M200: prior to the motion Output of M100: during the motion Acknowledgement: slow
N30 Y0 M=QU(100) M=QU(200)	Output of M200: prior to the motion Output of M100: during the motion Acknowledgement: quick
N40 X0	- - -
N50 M100 M200	Output of M200: immediately <sup>1)</sup> Output of M100: immediately <sup>1)</sup> Acknowledgement: slow
M17	- - -

<sup>1)</sup> Without a traverse movement, auxiliary functions are always output to the PLC immediately.

The following figure shows the time sequence of the part program. Please note the time difference during the processing of parts program blocks N20 and N30.

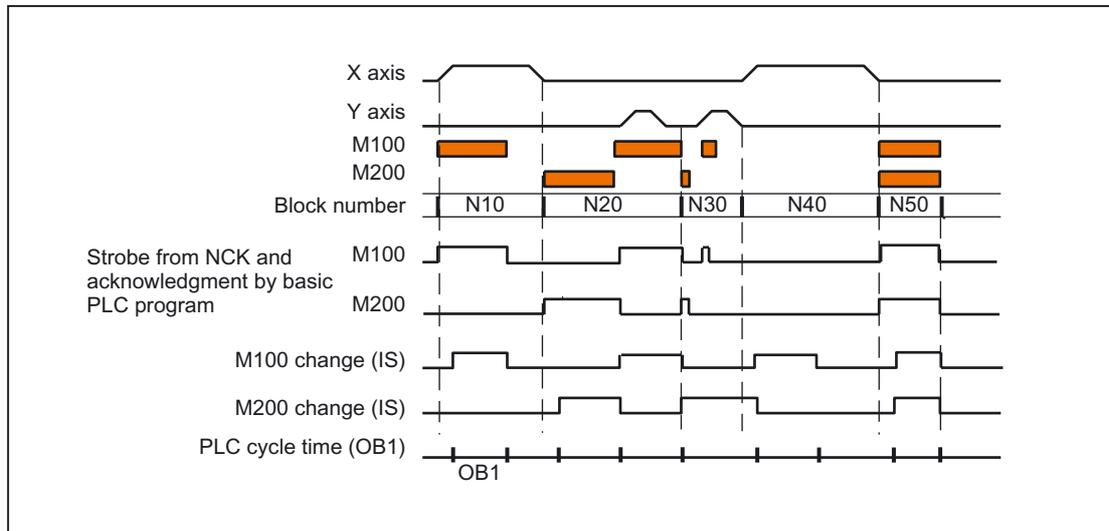


Figure 8-4 Example of auxiliary function output

## 8.3.7 Associated auxiliary functions

### Function

Associated auxiliary functions are user-defined auxiliary functions that have the same effect as the corresponding predefined auxiliary functions. For the following predefined auxiliary functions, user-defined auxiliary functions can be associated:

- M0 (Stop)
- M1 (conditional stop).

### Requirements

The precondition for association of a user-defined auxiliary function with one of the predefined auxiliary functions mentioned is parameterization of a user-defined auxiliary function. Only "M" is allowed as a "type" parameter of the user-defined auxiliary function.

### Parameterization

Association of a user-defined auxiliary function with one of the predefined auxiliary functions mentioned is set in the following machine data:

- MD22254 \$MC\_AUXFU\_ASSOC\_M0\_VALUE (additional M function for program stop)
- MD22256 \$MC\_AUXFU\_ASSOC\_M1\_VALUE (additional M function for conditional stop)

### Group assignment

The group assignment of an associated user-defined auxiliary function is always the group assignment of the corresponding predefined auxiliary function.

### Application

Associated auxiliary functions can be used in:

- Main program
- Subroutine
- Cycle

---

#### **Note**

Associated auxiliary functions may not be used in synchronized actions.

---

### NC/PLC interface signals

In the case of an associated user-defined auxiliary function, the same signals are output to the NC/PLC interface as for the corresponding predefined auxiliary function. To distinguish which auxiliary function has actually been programmed, the value of the user-defined auxiliary function ("value" parameter) is output as the value of the auxiliary function. This means it is possible to distinguish between predefined and user-defined auxiliary functions in the PLC user program.

---

#### Note

A change in the following machine data may require corresponding adjustment of the PLC user program:

- MD22254 \$MC\_AUXFU\_ASSOC\_M0\_VALUE (additional M function for program stop)
  - MD22256 \$MC\_AUXFU\_ASSOC\_M1\_VALUE (additional M function for conditional stop)
- 

#### Specific NC/PLC interface signals

The following specific NC/PLC interface signals are available:

- DB21, ... DBX318.5 (associated M00/M01 active) feedback signal
- DB21, ... DBX30.5 (activate associated M01) activation signal

### Example

Associating the user-defined auxiliary function M123 with M0:

MD22254 \$MC\_AUXFU\_ASSOC\_M0\_VALUE = 123 (additional M function for program stop)

The user-defined auxiliary function M123 thus has the same functionality as M0 (stop).

### Constraints

Please note the following boundary conditions:

- A user-defined auxiliary function may not be multiply associated.
- Predefined auxiliary functions (e.g. M3, M4, M5 etc.) must not be associated.

## 8.4 Type-specific output behavior

### Function

The output behavior of the auxiliary function relative to a traverse motion programmed in the part program block can be defined type-specifically in the following machine data:

- MD22200 \$MC\_AUXFU\_M\_SYNC\_TYPE (output time M functions)
- MD22210 \$MC\_AUXFU\_S\_SYNC\_TYPE (output time S functions)
- MD22220 \$MC\_AUXFU\_T\_SYNC\_TYPE (output time T functions)
- MD22230 \$MC\_AUXFU\_H\_SYNC\_TYPE (output time H functions)
- MD22240 \$MC\_AUXFU\_F\_SYNC\_TYPE (output time F functions)
- MD22250 \$MC\_AUXFU\_D\_SYNC\_TYPE (output time D functions)
- MD22252 \$MC\_AUXFU\_DL\_SYNC\_TYPE (output time DL functions)

### Output behavior

The following output behaviors can be parameterized:

MD \$MC\_AUXFU\_xx\_SYNC\_TYPE = <value>

Value	Meaning
0	Output prior to motion
1	Output during motion
2	Output at block end
3	No output to the PLC
4	Output according to the predefined output specification

For a description of the various output behaviors, see Section "Parameter: Output Behaviors" of the predefined auxiliary functions.

### Note

For the output behaviors that can be set for each type of auxiliary function, please refer to the relevant detailed machine data description.

### References:

/AMD/ Exhaustive Description of Machine Data

**Example**

Output of auxiliary functions with different output behaviors in a part program block with traverse movement.

**Parameterized output behavior**

- T function: Output **before** the motion  
MD22220 \$MC\_AUXFU\_T\_SYNC\_TYPE = 0 (Output time of the T functions)
- M function: Output **during** the motion  
MD22220 \$MC\_AUXFU\_M\_SYNC\_TYPE = 1 (Output time of the M functions)
- H function: Output **at the end of the block**  
MD22230 \$MC\_AUXFU\_H\_SYNC\_TYPE = 2 (Output time of the H functions)

**Parts program block**

```
| N10 G01 X100 M07 H5 T5
```

**Time sequence for auxiliary function output**

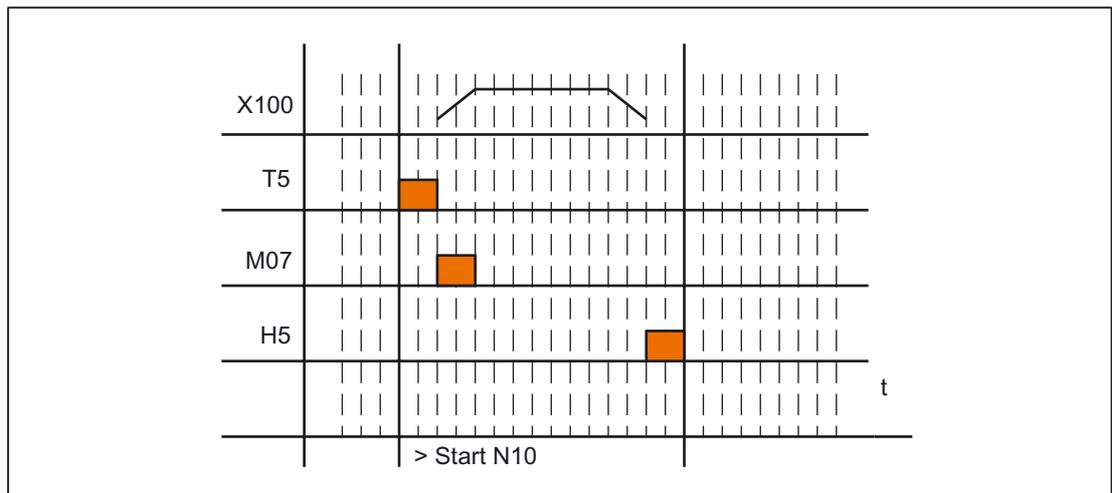


Figure 8-5 Example of auxiliary function output

## 8.5 Priorities of the output behavior

### Areas of the output behavior

The priority must be observed for the following areas in connection with the parameterized output behavior of an auxiliary function:

- Output duration (normal/quick acknowledgment)
- Output relative to motion (prior to/during/after the motion)

#### Priority sequence

The rule for the priority sequence is that the parameterized output behavior with lower priority becomes active if no output behavior with higher priority has been parameterized.

### Area: Output duration

The following priorities apply to the output duration:

Priority	Output behavior	Defined via:
Highest	Specific to auxiliary functions	Part program instruction: QU(...)
	Specific to auxiliary functions	MD22035 \$MC_AUXFU_ASSIGN_SYNC MD22080 \$MC_AUXFU_PREDEF_SYNC
	Group-specific	MD11110 \$MC_AUXFU_GROUP_SPEC
Lowest	Not defined	Default output behavior: Output duration one OB1 cycle

### Area: Output relative to motion

The following rules apply to output relative to motion:

Priority	Output behavior	Defined via:
Highest	Specific to auxiliary functions	MD22035 \$MC_AUXFU_ASSIGN_SYNC MD22080 \$MC_AUXFU_PREDEF_SYNC
	Group-specific	MD11110 \$MC_AUXFU_GROUP_SPEC
	Type-specific	MD22200 \$MC_AUXFU_M_SYNC_TYPE MD22210 \$MC_AUXFU_S_SYNC_TYPE MD22220 \$MC_AUXFU_T_SYNC_TYPE MD22230 \$MC_AUXFU_H_SYNC_TYPE MD22240 \$MC_AUXFU_F_SYNC_TYPE MD22250 \$MC_AUXFU_D_SYNC_TYPE MD22252 \$MC_AUXFU_DL_SYNC_TYPE
Lowest	Not defined	Default output behavior: Output at block end

---

**Note**

**Part program blocks without path motion**

In a part program block without a path motion (even those with positioning axes and spindles), the auxiliary functions are all output immediately in a block.

---

## 8.6 Auxiliary function output to the PLC

### Function

On output of an auxiliary function to the PLC, the following signals and values are passed to the NC/PLC interface:

- Change signals
- "Address extension" parameter
- "Value" parameter

### NC/PLC interface

The change signals and values of the auxiliary functions are within the following data range in the NC/PLC interface:

- Change signals for auxiliary function transfer from NC channel:  
DB21, ... DBB58 - DBB67
- Transferred M and S functions:  
DB21, ... DBB68 - DBB112
- Transferred T, D and DL functions:  
DB21, ... DBB116 - DBB136
- Transferred H and F functions:  
DB21, ... DBB140 - DBB190
- Decoded M signals (M0 - M99):  
DB21, ... DBB194 - DBB206 (dynamic M functions)

### References

A detailed description of the NC/PLC interface is to be found in:

/LIS1/ Lists (Book1); signals from/to channel (DB21 – DB30)

The access methods for the NC/PLC interface are described in:

/FB1/ Function Manual, Basic Functions, Basic PLC Program (P3)

## 8.7 Programming

### Syntax

An auxiliary function is programmed in a part program block with the following syntax:

< Type > [ < Address extension > = ] < Value >

#### Address expansion

If no address extension is programmed, address extension = 0 is implicitly set.

### Symbolic addressing

The values for the "address extension" and "value" parameters can also be specified symbolically. The symbolic name for the address extension must then be stated in brackets.

### Example

Symbolic programming of the auxiliary function M3 (spindle right) for the first spindle:

Programming syntax	Meaning
DEF SPINDEL_NR = 1	; 1st spindle in the channel
DEF DREHRICHTUNG = 3	; Clockwise rotation
N100 M[SPINDEL_NR] = DREHRICHTUNG	; in accordance with: M1=3

---

#### Note

If you use symbolic names to program an auxiliary function, the symbolic name is not transferred when the auxiliary function is output to the PLC. The corresponding numerical value is transferred instead.

---

**Programming examples**

Programming examples of auxiliary functions with the corresponding values for output to the PLC.

Programming syntax	Output to PLC
DEF coolant = 12	---
DEF lubricant = 130	---
H[coolant]=lubricant	H12=130
H=coolant	H0=12
H5	H0=5
H=5.379	H0=5.379
H17=3.5	H17=3.5
H[coolant]=13.8	H12=13.8
H='HFF13'	H0=65299
H='B1110'	H0=14
H5.3=21	Error

## 8.8 Auxiliary functions without block change delay

### Function

For auxiliary functions with parameterized and/or programmed output behavior, too:

- "Output duration one OB40 cycle (quick acknowledgment)"
- "Output before the motion" or "Output during the motion"

there may be drops in velocity in continuous-path mode (short traverse paths and high velocities). This the system has to wait for acknowledgment of the auxiliary function by the PLC toward the end of the block.

To avoid these velocity drops, the block change can be made irrespective of whether such auxiliary functions have been acknowledged using machine data:

MD22100 \$MC\_AUXFU\_QUICK\_BLOCKCHANGE (block change delay with quick auxiliary functions)

### Constraints

Synchronism of auxiliary functions that are output without a block change delay is no longer ensured for the part program block in which they are programmed. In the worst case scenario, acknowledgment comes one OB40 cycle and execution of the auxiliary function comes one OB1 cycle after the change to the next part program block.

## 8.9 M function with implicit preprocessing stop

### Function

Triggering a preprocessing stop in conjunction with an auxiliary function can be programmed via the `STOPRE` part program command. Triggering a preprocessing stop in conjunction with an M function can be programmed explicitly via the `STOPRE` part program command.

Always triggering a preprocessing stop in M function programming can be parameterized for each M function via the following machine data:

MD10713 \$MN\_M\_NO\_FCT\_STOPRE (M function with feed stop)

### Preprocessing stop with M function M88

The user-defined M function `M88` is intended to trigger a preprocessing stop.

#### Parameterization

MD10713 \$MN\_M\_NO\_FCT\_STOPRE [ 0 ] = 88 (M function with feed stop)

#### Application

Parts program (extract)

```

N100 G0 X10 M88                ; Traverse movement and implicit preprocessing stop via
                                M88
N110 Y=R1                      ; N110 is only interpreted after the traverse motion
                                has been completed and
                                ; acknowledgement of the M function.
    
```

### Constraints

If a subroutine called indirectly via an M function in a part program in one of the following ways, no preprocessing stop is performed:

- MD10715 \$MN\_M\_NO\_FCT\_CYCLE (M function to be replaced by subroutine)
- M98 (ISO dialect T/ISO dialect M)

## 8.10 Response to overstore

### Overstore

Before the start, on the SINUMERIK operator interface, of the following functions:

- NC START of a part program
- NC START to resume an interrupted part program

the auxiliary functions that are output at the start can be changed by the "Overstore" function.

Possible applications include:

- Addition of auxiliary functions after block search
- Restoring the initial state to position a part program

### Types of auxiliary functions that can be overstored

The following types of auxiliary functions can be overstored:

- M (special function)
- S (spindle speed)
- T (tool number)
- H (aux. function)
- D (tool offset number)
- DL (additive tool offset)
- F (feed)

### Duration of validity

An overstored auxiliary function, e.g. M3 (spindle right), is valid until it is overwritten by another auxiliary function from the same auxiliary function group, by additional overstoreing or by programming in a part program block.

## 8.11 Block search

### 8.11.1 Behavior on block search with calculation

#### Function

Block searches with calculation collect up auxiliary functions on a group-specific basis. The last auxiliary function in each auxiliary function group is output after NC-START, before the actual reentry block, in a separate part program block that has the following output behavior:

- Output duration one OB1 cycle (normal acknowledgment)
- Output prior to motion

#### Output control

Whether or not the corresponding auxiliary function is output to the PLC after a block search can be configured via bit 8 of the machine data:

MD22080 \$MC\_AUXFU\_PREDEF\_SPEC[index] (output specification)

MD22035 \$MC\_AUXFU\_ASSIGN\_SPEC[index] (output specification)

MD11110 \$MN\_AUXFU\_GROUP\_SPEC[index] (auxiliary function group specification)

This behavior does not affect the display and does not affect variables \$AC\_AUXFU\_M\_STATE[n], \$AC\_AUXFU\_M\_VALUE[n], and \$AC\_AUXFU\_M\_EXT[n]. The auxiliary function is always regarded as collected after a block search, even though it is not output to the PLC. An auxiliary function that is not output after a block search also overwrites an auxiliary function whose Bit 8 is not set during collection. The user can scan the collected auxiliary functions after a block search and, under certain circumstances, output them again by means of the subprogram or synchronous actions.

#### Auxiliary function without auxiliary function group

Auxiliary functions that are not assigned to an auxiliary function group are not collected up.

#### Auxiliary functions of auxiliary function group 1

Auxiliary functions of auxiliary function group 1 are never collected up.

### Overstorage of auxiliary functions

After completion of a block search, the collected auxiliary functions are output on the next NC-START. If it is necessary to output additional auxiliary functions, they can be added via the "overstore" function. See Section: Response to overstore.

### Behavior regarding: M19 (position spindle)

After block completion, the last spindle positioning command programmed with M19 is always carried out, even if other spindle-specific auxiliary functions are programmed between the parts program with M19 and the destination block. Setting the necessary spindle enables must therefore be derived from the interface signals of the traverse commands in the PLC user program:

DB31, ... DBX64.6/64.7 (traverse command minus/plus)

In this case, the spindle-specific auxiliary functions M3, M4, M5 are not suitable because they might not be output to the PLC after the spindle positioning.

For detailed information on the block search, please refer to:

**References::**

/FB1/ Function Manual, Basic Functions; Mode Group, Channel, Program Operation (K1)

## 8.11.2 Output suppression of spindle-specific auxiliary functions

### Function

For example, with a tool change it may be necessary not to output the spindle-specific auxiliary functions collected during the block search in action blocks but to delay output, for example, until after a tool change.

This requires suppression of automatic output of the spindle-specific auxiliary functions after block search. Output can then be performed manually later by overstore or by an ASUB.

### Parameterization

Suppression of automatic output of the spindle-specific auxiliary functions after block search is performed via machine data:

MD11450 \$MN\_SEARCH\_RUN\_MODE, bit 2 (search parameterization)

Bit	Value	Meaning
2	0	Output of the spindle-specific auxiliary functions is performed in the action blocks
	1	Output of the auxiliary functions is suppressed in the action blocks.

### System variables

The spindle-specific auxiliary functions are always stored in the following system variables on block search, irrespective of the programming described above:

System variable	Description
\$P_SEARCH_S [ n ]	Accumulated spindle speed, Value range = { 0 ... Smax }
\$P_SEARCH_SDIR [ n ]	Accumulated spindle direction of rotation, Value range = { 3, 4, 5, -5, -19, 70 }
\$P_SEARCH_SGEAR [ n ]	Accumulated spindle gear level M function, Value range = { 40 ... 45 }
\$P_SEARCH_SPOS [ n ]	Accumulated spindle position, Value range = { 0 ... MD30330 \$MA_MODULO_RANGE (size of the module range)} Accumulated traversing path, Value range = { -100,000,000 ... 100.000.000 }
\$P_SEARCH_SPOSMODE [ n ]	Accumulated position approach mode, Value range = { 0 ... 5 }

For later output of the spindle-specific auxiliary functions, the system variables can be read in an ASUB, for example, and output after the action blocks are output:

DB21, ... DBX32.6 = 1 (last action block active)

#### Note

The contents of the system variables \$P\_S, \$P\_DIR and \$P\_SGEAR may be lost after block search due to synchronization operations.

More detailed information on ASUB, block search, and action blocks is to be found in:

#### References:

/FB1/ Function Manual, Basic Functions; Mode Group, Channel, Program Operation (K1),

Section: Program test

**Example**

Block search for contour with suppression of output of the spindle-specific auxiliary functions and start of an ASUB after output of action blocks:

MD11450 \$MN\_SEARCH\_RUN\_MODE, bit 2 = 1 (search parameterization)

After the block search on N55, the ASUB is started.

**Part program**

```

N05 M3 S200 ; Spindle 1
N10 G4 F3
N15 SPOS = 111 ; Spindle 1 is positioned to 111 degrees in
                the ASUB
N20 M2 = 4 S2 = 300 ; Spindle 2
N25 G4 F3
N30 SPOS[2] = IC(77) ; Spindle 2 traverses incrementally by 77
                    degrees
N55 X10 G0 ; Destination block
N60 G4 F10
N99 M30

```

**ASUB**

```

PROC ASUP_SAVE
MSG ("Output of the spindle functions")
DEF INT SNR=1
AUSG_SPI:
M[SNR] = $P_SEARCH_SGEAR[SNR] ; Output gear level
S[SNR] = $P_SEARCH_S[SNR] ; Output speed (for M40, a
                          suitable gear level is
                          determined)
M[SNR] = $P_SEARCH_SDIR[SNR] ; Output direction of rotation,
                             positioning or axis mode
SNR = SNR+1 ; next spindle
REPEAT AUSG_SPI P=$P_NUM_SPINDLES-1 ; For all spindles
MSG("")
REPOSA
RET

```

### Explanation of example

If the number of spindles is known, outputs of the same type can be written in one part program block to reduce program runtime.

Output of \$P\_SEARCH\_SDIR should be made in a separate part program block because spindle positioning or switchover to axis mode in conjunction with the gear change can cause an alarm.

#### Control response for REPOS

If the started ASUB is ended with REPOSA, spindle 1 remains at position 111 degrees, while spindle 2 is repositioned at position 77 degrees.

If a different response is required, the program sequence for block search (for example) "N05 M3 S..." and "N30 SPOS[2] = IC(...)" requires special treatment.

Whether block search is active can be ascertained in the ASUB via the system variable \$P\_SEARCH:

```
$P_SEARCH == 1 ; Block search active
```

In the case of incremental positioning after speed control operation, the path to be traversed is defined but, in some cases, the final position reached only becomes known during positioning. This is the case, for example, during position calibration on crossing the zero mark when switching on position control. For this reason, the distance programmed after the zero position is accepted as the REPOS position (REPOSA in the ASUB).

### Boundary conditions

#### Collected S values

The meaning of an S value in the parts program depends on the feed type that is currently active:

G93, G94, G95, G97, G971	The S value is interpreted as the speed
G96, G961	The S value is interpreted as a constant cutting rate

If the feed operation is changed (e.g. for a tool change) before output of the system variable \$P\_SEARCH\_S, the original setting from the target block in the parts program must be restored to avoid use of the wrong type of feed.

### Collected direction of rotation

For output of the direction of rotation, the system variable \$P\_SEARCH\_SDIR is assigned default value "-5" at the start of the block search. This value has no effect on output.

This ensures that the last spindle operating mode is retained for a block search across program section in which spindles are not programmed with a direction of rotation, positioning or axis mode.

The programming of M19, SPOS and SPOSA is collected as "M-19" (internal M19) in the system variables \$P\_SEARCH\_SDIR alternatively to M3, M4, M5 and M70.

For the output of "M-19", the positioning data are read internally from the system variables \$P\_SEARCH\_SPOS and \$P\_SEACH\_SPOSMODE. Both system variables can also be written, for example, to make corrections.

---

### Note

Because of the assignments described above (e.g. M[n] = \$P\_SEARCH\_SDIR[n]), the values "-5" and "-19" generally remain hidden from the user and only have to be observed in the case of special evaluation of the system variables in the ASUB.

---

## 8.12 Scan and display of output M-auxiliary functions

### 8.12.1 Information options

#### Information methods

Information on the status of M-auxiliary functions is available using:

- Display on the user interface
- Scan of system variables in part program and synchronous actions

#### 8.12.1.1 Status display on the user interface

#### Operator interface

The output status and acknowledgement status of auxiliary functions can be displayed on the user interface.

#### Requirements

To implement function-oriented acknowledgement and display of M-auxiliary functions, the auxiliary functions must be managed in the PLC and, thus, in the user program itself. Therefore, it is up to the PLC programmer to program the acknowledgement of these auxiliary functions. He has to know which auxiliary functions in which group have to be acknowledged.

#### Default

M-auxiliary functions that are not managed by means of the PLC are identified by the NC as output and transferred to the PLC. There is no functional acknowledgement for these auxiliary functions. All M-auxiliary functions collected after a block search are also displayed so that the operator knows which auxiliary functions will be output after a start following a block search.

#### PLC activities

In the case of auxiliary function groups that are managed by the PLC itself, the PLC user program must acknowledge all auxiliary functions of this groups when **Apply** and **Function End** are activated. The PLC programmer must know all the auxiliary functions of these groups.

### Miscellaneous

Only the **group-specific** M auxiliary functions are displayed. The block-by-block display is also available, as before. Up to 15 groups can be displayed, whereby **only the last M function of a group** that was either collected or output to the PLC is displayed for each group. The M functions are presented in various display modes depending on their status:

### Statuses and their displays

Status	Display mode
The <b>last</b> auxiliary function of the group is displayed.	
Auxiliary function is collected	Inverted with yellow font
Auxiliary function is output from NCK to PLC	Inverted
Auxiliary function has been transferred from NCK to PLC and transport acknowledgement has taken place	Black font on gray background
Auxiliary function is managed by the PLC and has been directly applied by the PLC.	Black font on gray background
Auxiliary function is managed by the PLC, and the function acknowledgement has taken place.	Black font on gray background

### Display update

The display is organized in such a way that the collected auxiliary functions are always displayed first, before those that were managed by the PLC and before those that were managed by the NC. A collected auxiliary function is marked as collected until it has been output from the NCK to the PLC. PLC-managed auxiliary functions are retained until they are displaced by another auxiliary function. In the case of a reset, only the collected auxiliary functions and the NC-managed auxiliary functions are deleted.

### 8.12.1.2 Programming a status check

#### System variables

System variables are available for the status check of group-specific, modal M-auxiliary functions.

The following variables can be used to scan M-auxiliary functions on a group-specific basis in the part program and via synchronous actions. The requirements and conditions described in "Status display on user interface" are applicable.

- Value of the collected or output M auxiliary function of the n+1 group:  
INT \$AC\_AUXFU\_M\_VALUE[n]
- Address extension of the collected or output M auxiliary function of the n+1 group:  
INT \$AC\_AUXFU\_M\_EXT[n]
- Output status of the M auxiliary function of the n+1 group:  
INT \$AC\_AUXFU\_M\_STATE[n]  
0: No auxiliary function  
1: M-auxiliary function was collected via a search  
2: M-auxiliary function has been output to the PLC  
3: M-auxiliary function has been output to the PLC and the transport acknowledgement has taken place.  
4: M-auxiliary function is managed by the PLC and has been applied by the PLC.  
5: M-auxiliary function is managed by the PLC, and the function acknowledgement has taken place.

#### Example

All M-auxiliary functions of the 1st group will be stored in the order they were output.

```
id=1 every $AC_AUXFU_M_STATE[0] == 2 do $AC_FIFO[0,0] = $AC_AUXFU_M_VALUE[0]
```

Additional information on the system variables can be found in:

**References:**

/PGA1/ Lists of System Variables.

## 8.13 Supplementary conditions

### 8.13.1 General constraints

#### Spindle replacement

Because the auxiliary functions are parameterized channel-specifically, if function: "spindle replacement" is used, the spindle-specific auxiliary function must be parameterized immediately in all channels that use the spindles.

#### Tool management

If tool management is active, the following constraints apply:

- T and M<k> functions are not output to the PLC.  
Note:  
k is the parameterized value of the auxiliary function for the tool change (default: 6):  
MD22560 \$MC\_TOOL\_CHANGE\_M\_CODE (auxiliary function for tool change)
- If no address extension is programmed, the auxiliary function refers to the master spindle or the master tool holder of the channel.

Definition of the master spindle:

- MD20090 \$MC\_SPIND\_DEF\_MASTER\_SPIND
- Part program instruction: SETMS

Definition of the master tool holder

- MD20124 \$MC\_TOOL\_MANAGEMENT\_TOOLHOLDER
- Part program instruction: SETMTH

#### Maximum number of auxiliary functions per part program block

A maximum of 10 auxiliary functions may be programmed in one part program block.

#### DL (additive tool offset)

The following restrictions apply to the DL function:

- Only one DL function can be programmed per part program block.
- If DL functions are used in synchronous actions, parameter: "Value" is not output to the PLC.

### 8.13.2 Output behavior

#### Thread cutting

During active thread cutting G33, G34 and G35, the spindle-specific auxiliary functions:

- M3 (spindle right)
- M4 (spindle left)

are always active for the following output behavior:

- Output duration one OB40 cycle (quick acknowledgment)
- Output during motion

The spindle-specific auxiliary function M5 (spindle stop) is always output at the end of the block. The parts program block that contains M5 is always ended with exact stop, i.e. even during active continuous path mode.

#### Synchronized actions

With output auxiliary functions from synchronized actions, the parameterized output behavior is ignored except for the following parameters:

- Bit0: Output duration one OB1 cycle (normal acknowledgment)
- Bit1: Output duration one OB40 cycle (quick acknowledgment)

#### Auxiliary functions: M17 or M2/M30 (end of subroutine)

##### In its own parts program block

If one of the auxiliary functions M17, M2 or M30 is programmed as the only auxiliary function in a part program block and an axis is still in motion, the auxiliary function is not output to the PLC until after the axis has stopped.

##### Overriding the parameterized output behavior

The parameterized output behavior of the auxiliary functions M17 or M2/M30 is overridden by the output behavior that is determined in the following machine data:

MD20800 \$MC\_SPF\_END\_TO\_VDI, Bit 0 (subprogram end/stop to PLC)

Bit	Value	Description
0	0	The auxiliary functions M17 or M2/M30 (subprogram end) are not output to the PLC. Continuous-path mode is not interrupted at the end of the subroutine
	1	The auxiliary functions M17 or M2/M30 (subprogram end) are output to the PLC.

**Auxiliary function: M1 (conditional stop)**

**Overlapping of the parameterized output behavior**

The parameterized output behavior of the auxiliary function M1 is overridden by the output behavior defined in the following machine data:

MD20800 \$MC\_SPF\_END\_TO\_VDI, Bit 1 (subprogram end/stop to PLC)

Bit	Value	Description
1	0	The auxiliary function M01 (conditional stop) is always output to the PLC. A quick acknowledgement is ineffective, because M01 is permanently assigned to the first auxiliary function group and is therefore always output at the end of the block.
	1	The auxiliary function M01 (conditional stop) is only output to the PLC, if the function: "Programmed stop" is activated via the HMI user interface.  In the case of a quick acknowledgement, the M1 is output to the PLC during the motion. While the function is not active, this does not interrupt continuous-path mode.

**Part program blocks without traverse movement**

In a part program block without a traverse movement, all auxiliary functions are output in a block immediately, irrespective of their parameterized output behavior.

## 8.14 Examples

### 8.14.1 Defining auxiliary functions

#### Task

Parameterization of the auxiliary-function-specific machine data for a machine with the following configuration:

#### Spindles

- Spindle 1: Master spindle
- Spindle 2: Second spindle

#### Gear stages

- Spindle 1: 5 gear stages
- Spindle 2: No gear stages

#### Switching functions for cooling water on/off

- Spindle 1
  - "ON" = M50
  - "OFF" = M51
- Spindle 2
  - "ON" = M52
  - "OFF" = M53

#### Requirements

##### Spindle 1 (master spindle)

---

#### Note

##### Default assignments

- The auxiliary functions M3, M4, M5, M70 and M1=3, M1=4, M1=5, M1=70 of spindle 1 (master spindle) are assigned to the second auxiliary function group by default.
  - All S and S1 values of spindle 1 (master spindle) are assigned to the third auxiliary function group by default.
- 

- The gear stage last programmed is to be output after block search. The following auxiliary functions are assigned to the ninth auxiliary function group for this reason:
  - M40, M41, M42, M43, M44, M45
  - M1=40, M1=41, M1=42, M1=43, M1=44, M1=45

- The auxiliary functions M3, M4, M5, M70 and M1=3, M1=4, M1=5, M1=70 (second auxiliary function group) and S and S1 values (third auxiliary function group) should have the following output behavior:
  - Output duration one OB40 cycle (quick acknowledgment)
  - Output prior to motion
- The auxiliary functions for gear changeover M40 to M45 and M1=40 to M1=45 (ninth auxiliary function group) should have the following output behavior:
  - Output duration one OB1 cycle (normal acknowledgment)
  - Output prior to motion

### Spindle 2

- Only one M function for directional reversal may be programmed in one block. The direction of rotation last programmed is to be output after block search. The following auxiliary functions are assigned to the tenth auxiliary function group for this reason:
  - M2=3, M2=4, M2=5, M2=70
- All S2 values are assigned to auxiliary function group 11.
- The auxiliary functions M2=3, M2=4, M2=5, M2=70 (tenth auxiliary function group) and S2 values (auxiliary function group 11) should have the following output behavior:
  - Output duration one OB40 cycle (quick acknowledgment)
  - Output prior to motion

### Cooling water

- It is not permissible to switch the cooling water on and off in one part program block. After a block search, the cooling water will be switched on or off. For this purpose, the following auxiliary functions are assigned, for example, to auxiliary function group 12 or 13:
  - 12th auxiliary function group: M50, M51
  - 13th auxiliary function group: M52, M53
- The auxiliary functions M50, M51 (auxiliary function group 12) and M52, M53 (auxiliary function group 13) should have the following output behavior:
  - Output duration one OB1 cycle (normal acknowledgment)
  - Output prior to motion

**Parameterization of the machine data**

The machine data are parameterized by appropriate programming within a part program.

Programming	Remarks
\$MN_AUXFU_MAXNUM_GROUP_ASSIGN = 21	Number of user-defined auxiliary functions per channel
\$MN_AUXFU_GROUP_SPEC[1] = 'H22'	Output behavior of auxiliary function group 2
\$MN_AUXFU_GROUP_SPEC[2] = 'H22'	Output behavior of auxiliary function group 3
\$MN_AUXFU_GROUP_SPEC[8] = 'H21'	Output behavior of auxiliary function group 9
\$MC_AUXFU_ASSIGN_TYPE[0] = "M"	Description of auxiliary function 1: M40
\$MC_AUXFU_ASSIGN_EXTENSION[0] = 0	
\$MC_AUXFU_ASSIGN_VALUE[0] = 40	
\$MC_AUXFU_ASSIGN_GROUP[0] = 9	... (and analogously for aux. functions 2 to 5)
\$MC_AUXFU_ASSIGN_TYPE[5] = "M"	Description of auxiliary function 6: M45
\$MC_AUXFU_ASSIGN_EXTENSION[5] = 0	
\$MC_AUXFU_ASSIGN_VALUE[5] = 45	
\$MC_AUXFU_ASSIGN_GROUP[5] = 9	
\$MC_AUXFU_ASSIGN_TYPE[6] = "M"	Description of auxiliary function 7: M1 = 40
\$MC_AUXFU_ASSIGN_EXTENSION[6] = 1	
\$MC_AUXFU_ASSIGN_VALUE[6] = 40	
\$MC_AUXFU_ASSIGN_GROUP[6] = 9	. . . (and analogously for aux. functions 8 to 11)
\$MC_AUXFU_ASSIGN_TYPE[11] = "M"	Description of auxiliary function 12: M1 = 45
\$MC_AUXFU_ASSIGN_EXTENSION[11] = 1	
\$MC_AUXFU_ASSIGN_VALUE[11] = 45	
\$MC_AUXFU_ASSIGN_GROUP[11] = 9	
\$MN_AUXFU_GROUP_SPEC[9] = 'H22'	Output behavior of auxiliary function group 10
\$MC_AUXFU_ASSIGN_TYPE[12] = "M"	Description of auxiliary function 13: M2 = 3
\$MC_AUXFU_ASSIGN_EXTENSION[12] = 2	
\$MC_AUXFU_ASSIGN_VALUE[12] = 3	
\$MC_AUXFU_ASSIGN_GROUP[12] = 10	
\$MC_AUXFU_ASSIGN_TYPE[13] = "M"	Description of auxiliary function 14: M2 = 4
\$MC_AUXFU_ASSIGN_EXTENSION[13] = 2	
\$MC_AUXFU_ASSIGN_VALUE[13] = 4	
\$MC_AUXFU_ASSIGN_GROUP[13] = 10	
\$MC_AUXFU_ASSIGN_TYPE[14] = "M"	Description of auxiliary function 15: M2 = 5

Programming	Remarks
<pre>\$MC_AUXFU_ASSIGN_EXTENSION[14] = 2 \$MC_AUXFU_ASSIGN_VALUE[14] = 5 \$MC_AUXFU_ASSIGN_GROUP[14] = 10</pre>	
<pre>\$MC_AUXFU_ASSIGN_TYPE[15] = "M" \$MC_AUXFU_ASSIGN_EXTENSION[15] = 2 \$MC_AUXFU_ASSIGN_VALUE[15] = 70 \$MC_AUXFU_ASSIGN_GROUP[15] = 10</pre>	Description of auxiliary function 16: M2 = 70
<pre>\$MN_AUXFU_GROUP_SPEC[10] = 'H22'</pre>	Specification of auxiliary function group 11
<pre>\$MC_AUXFU_ASSIGN_TYPE[16] = "S" \$MC_AUXFU_ASSIGN_EXTENSION[16] = 2 \$MC_AUXFU_ASSIGN_VALUE[16] = -1 \$MC_AUXFU_ASSIGN_GROUP[16] = 11</pre>	Description of auxiliary function 17: S2 = <all values>
<pre>\$MN_AUXFU_GROUP_SPEC[11] = 'H21'</pre>	Specification of auxiliary function group 12
<pre>\$MC_AUXFU_ASSIGN_TYPE[17] = "M" \$MC_AUXFU_ASSIGN_EXTENSION[17] = 0 \$MC_AUXFU_ASSIGN_VALUE[17] = 50 \$MC_AUXFU_ASSIGN_GROUP[17] = 12</pre>	Description of auxiliary function 18: M50
<pre>\$MC_AUXFU_ASSIGN_TYPE[18] = "M" \$MC_AUXFU_ASSIGN_EXTENSION[18] = 0 \$MC_AUXFU_ASSIGN_VALUE[18] = 51 \$MC_AUXFU_ASSIGN_GROUP[18] = 12</pre>	Description of auxiliary function 19: M51
<pre>\$MN_AUXFU_GROUP_SPEC[12] = 'H21'</pre>	Specification of auxiliary function group 13
<pre>\$MC_AUXFU_ASSIGN_TYPE[19] = "M" \$MC_AUXFU_ASSIGN_EXTENSION[19] = 0 \$MC_AUXFU_ASSIGN_VALUE[19] = 52 \$MC_AUXFU_ASSIGN_GROUP[19] = 13</pre>	Description of auxiliary function 20: M52
<pre>\$MC_AUXFU_ASSIGN_TYPE[20] = "M" \$MC_AUXFU_ASSIGN_EXTENSION[20] = 0 \$MC_AUXFU_ASSIGN_VALUE[20] = 53 \$MC_AUXFU_ASSIGN_GROUP[20] = 13</pre>	Description of auxiliary function 21: M53

## 8.15 Data lists

### 8.15.1 Machine data

#### 8.15.1.1 NC-specific machine data

Number	Identifier: \$MN_	Description
10713	M_NO_FCT_STOPRE	M function with preprocessing stop
10714	M_NO_FCT_EOP	M function for spindle active after NC RESET
11100	AUXFU_MAXNUM_GROUP_ASSIGN	Maximum number of user-defined auxiliary functions per channel
11110	AUXFU_GROUP_SPEC[n],	Group-specific output behavior

#### 8.15.1.2 Channel-specific machine data

Number	Identifier: \$MC_	Description
20110	RESET_MODE_MASK	Definition of control initial setting after part program start.
20112	START_MODE_MASK	Definition of control initial setting after power-up and on RESET or at end of part program
20270	CUTTING_EDGE_DEFAULT	Basic setting of tool cutting edge without programming
20800	SPF_END_TO_VDI	Subprogram end to PLC
22000	AUXFU_ASSIGN_GROUP	Auxiliary function group
22010	AUXFU_ASSIGN_TYPE	Type of auxiliary function
22020	AUXFU_ASSIGN_EXTENSION	Auxiliary function extension
22030	AUXFU_ASSIGN_VALUE	Auxiliary function value
22035	AUXFU_ASSIGN_SPEC	Output specification (user-def. AuxFu)
22040	AUXFU_PREDEF_GROUP	Predefined auxiliary function groups
22050	AUXFU_PREDEF_TYPE	Predefined auxiliary function type
22060	AUXFU_PREDEF_EXTENSION	Predefined auxiliary function extension
22070	AUXFU_PREDEF_VALUE	Predefined auxiliary function value
22080	AUXFU_PREDEF_SPEC	Output specification (predefined auxiliary function)
22100	AUXFU_QUICK_BLOCKCHANGE	Block change without delay

Number	Identifier: \$MC_	Description
22110	AUXFU_H_TYPE_INT	Type of H auxiliary functions
22200	AUXFU_M_SYNC_TYPE	Output timing for M functions
22210	AUXFU_S_SYNC_TYPE	Output timing of S functions
22220	AUXFU_T_SYNC_TYPE	Output timing of T functions
22230	AUXFU_H_SYNC_TYPE	Output timing for H functions
22240	AUXFU_F_SYNC_TYPE	Output timing of F functions
22250	AUXFU_D_SYNC_TYPE	Output timing of D functions
22252	AUXFU_DL_SYNC_TYPE	Output timing of DL functions
22254	AUXFU_ASSOC_M0_VALUE	Additional M function for program stop
22256	AUXFU_ASSOC_M1_VALUE	Additional M function for conditional stop

## 8.15.2 Signals

### 8.15.2.1 Signals to channel

DB number	Byte.Bit	Description
21, ...	30.5	Activate associated M01

### 8.15.2.2 Signals from channel

DB number	Byte.Bit	Description
21, ...	58.0 – 58.4	M function 1 - 5 change
21, ...	59.0 – 59.4	M function 1 - 5 not included in list
21, ...	60.0 - 60.2	S function 1 - 3 change
21, ...	60.4 - 60.6	S function 1 - 3 quick
21, ...	61.0 - 61.2	T function 1 - 3 change
21, ...	61.4 - 61.6	T function 1 - 3 quick
21, ...	62.0 - 62.2	D function 1 - 3 change
21, ...	62.4 - 62.6	D function 1 - 3 quick
21, ...	63.0	E function 1 change
21, ...	63.4	E function 1 quick
21, ...	64.0 - 64.2	H function 1 - 3 change
21, ...	64.4 - 64.6	H function 1 - 3 quick
21, ...	65.0 - 65.5	F function 1 - 6 change

## Auxiliary Function Outputs to PLC (H2)

### 8.15 Data lists

DB number	Byte.Bit	Description
21, ...	66.0 - 66.4	M function 1 - 5 quick
21, ...	67.0 - 67.5	F function 1 - 6 quick
21, ...	68 - 69	Extended address of M function 1 (binary)
21, ...	70 - 73	M function 1 (integer)
21, ...	74 - 75	Extended address of M function 2 (binary)
21, ...	76 - 79	M function 2 (integer)
21, ...	80 - 81	Extended address of M function 3 (binary)
21, ...	82 - 85	M function 3 (integer)
21, ...	86 - 87	Extended address of M function 4 (binary)
21, ...	88 - 91	M function 4 (integer)
21, ...	92 - 93	Extended address of M function 5 (binary)
21, ...	94 - 97	M function 5 (integer)
21, ...	98 - 99	Extended address of S function 1 (binary)
21, ...	100 - 103	S function 1 (real)
21, ...	104 - 105	Extended address of S function 2 (binary)
21, ...	106 - 109	S function 2 (real)
21, ...	110 - 111	Extended address of S function 3 (binary)
21, ...	112 - 115	S function 3 (real)
21, ...	116 - 117	Extended address of T function 1 (binary)
21, ...	118 - 119	T function 1 (integer)
21, ...	120 - 121	Extended address of T function 2 (binary)
21, ...	122 - 123	T function 2 (integer)
21, ...	124 - 125	Extended address of T function 3 (binary)
21, ...	126 - 127	T function 3 (integer)
21, ...	128	Extended address of D function 1 (binary)
21, ...	129	D function 1 (binary)
21, ...	130	Extended address of D function 2 (binary)
21, ...	131	D function 2 (binary)
21, ...	132	Extended address of D function 3 (binary)
21, ...	133	D function 3 (binary)
21, ...	134	Extended address of DL function (binary)
21, ...	136	DL function (real)
21, ...	140 - 141	Extended address of H function 1 (binary)
21, ...	142 - 145	H function 1 (real format)
21, ...	146 - 147	Extended address of H function 2 (binary)
21, ...	148 - 151	H function 2 (real or double integer)
21, ...	152 - 153	Extended address of H function 3 (binary)
21, ...	154 - 157	H function 3 (real format)
21, ...	158 - 159	Extended address of F function 1 (binary)
21, ...	160 - 163	F function 1 (real format)
21, ...	164 - 165	Extended address of F function 2 (binary)

DB number	Byte.Bit	Description
21, ...	166 - 169	F function 2 (real format)
21, ...	170 - 171	Extended address of F function 3 (binary)
21, ...	172 - 175	F function 3 (real format)
21, ...	176 - 177	Extended address of F function 4 (binary)
21, ...	178 - 181	F function 4 (real format)
21, ...	182 - 183	Extended address of F function 5 (binary)
21, ...	184 - 187	F function 5 (real format)
21, ...	188 - 189	Extended address of F function 6 (binary)
21, ...	190 - 193	F function 6 (real format)
21, ...	194	Dynamic M function: M00 - M07
21, ...	195	Dynamic M function: M08 - M15
21, ...	196	Dynamic M function: M16 - M23
21, ...	197	Dynamic M function: M24 - M31
21, ...	198	Dynamic M function: M32 - M39
21, ...	199	Dynamic M function: M40 - M47
21, ...	200	Dynamic M function: M48 - M55
21, ...	201	Dynamic M function: M56 - M63
21, ...	202	Dynamic M function: M64 - M71
21, ...	203	Dynamic M function: M72 - M79
21, ...	204	Dynamic M function: M80 - M87
21, ...	205	Dynamic M function: M88 - M95
21, ...	206.0 – 206.3	Dynamic M function: M96 - M99
21, ...	318.5	Associated M00/M01 active

### 8.15.2.3 Signals to axis/spindle

DB number	Byte.Bit	Description
31, ...	78 - 81	F function for positioning axis (real)

### 8.15.2.4 Signals from axis/spindle

DB number	Byte.Bit	Description
31, ...	86 - 87	M function for spindle (binary)
31, ...	88 - 91	S function for spindle (real)



# Mode Group, Channel, Program Operation, Reset Response (K1)

# 9

## 9.1 Product brief

### Channel

An NC channel represents the smallest unit for manual traversing of axes and automatic processing of part programs. At any one time, a channel will always be in a particular mode, e.g. AUTOMATIC, MDA, or JOG. A channel can be regarded as an independent NC.

### Mode group

A channel always belongs to a mode group. A mode group can also consist of several channels.

A mode group can be identified by the fact that all channels of the mode group are always in the same mode at a particular time, e.g. AUTOMATIC, MDA, or JOG. This is ensured through the NC internal mode logic.

A mode group can be regarded as an independent multi-channel NC.

### Channel gaps

When channels are configured, placeholder channels can be provided in order to create as uniform a configuration as possible over machines in a series. Only the channels that are actually used are then activated.

### Program test

The following options are available for testing or moving in position a new part program.

- Program execution without setpoint outputs
- Program execution in single-block mode
- Program execution with dry run feedrate
- Skip part program blocks
- Block search with or without calculation.

## Block search

The block search function enables the following program simulations for locating specific program points:

- Type 1 without calculation at contour
- Type 2 with calculation at contour
- Type 4 with calculation at block end point
- Type 5 automatic start of the selected program point with calculation of all required data from history
- Automatic start of an ASUB after a block search
- Cascaded block search
- Cross-channel block search in program test mode

## Program operation

The execution of part programs or part program blocks in AUTOMATIC or MDA modes is referred to as program operation. During execution, the program sequence can be controlled by PLC interface signals and commands.

For each channel, basic settings or channel-specific machine data can be specified. These initial settings affect, for example, G groups and auxiliary function output.

A part program can be selected only if the relevant channel is in the Reset state.

Furthermore, all further program runs are handled by PLC interface signals and the corresponding commands.

- Start of part program or part program block
- Part program calculation and program control
- RESET command, program status, and channel status
- Responses to operator and program actions
- Event-driven program calls

## Asynchronous subroutines (ASUBs), interrupt routines

Interrupt inputs allow the NC to interrupt the the current part program execution so that it can react to more urgent events in interrupt routines or ASUBs.

## Single block

With the single-block function, the user can execute a part program block-by-block.

There are 3 types of setting for the single-block function:

- SLB1: = IPO single block
- SLB2: = Decode single block
- SLB3: = Stop in cycle

### Basic block display

A second basic block display can be used with the existing block display to display all blocks that produce an action on the machine.

The actually approached end positions are shown as an absolute position. The position values refer either to the workpiece coordinate system (WCS) or the settable zero system (SZS).

### Program execution from external source

When complex workpieces are machined, the NC may not have enough memory for the programs. The "Execution from external source" function enables subroutines to be called (`EXTCALL`) and executed from an external memory (e.g. from the HMI Advanced hard disk).

### Behavior after POWER ON, Reset, ...

The control-system response after:

- Power up (POWER ON)
- Reset/part program end
- Part program start

can be modified for functions, such as G codes, tool length compensation, transformation, coupled axis groupings, tangential follow-up, programmable synchronous spindle for certain system settings through machine data.

### Subroutine call with M, T and D functions

For certain applications, it may be advantageous to replace M, T or D functions as well as a few NC language commands `SSPOS`, `SPOSA`, by a subroutine call. This can be used, for example, to call the tool change routine.

Relevant machine data can be used to define and control subroutines having M, T or D functions. For example, for a gear stage change.

### Program runtime/part counter

Information on the program runtime and the part count is provided to assist the machine tool operator.

The functions defined for this purpose are **not identical to the functions of tool management** and are intended primarily for systems without tool management.

## 9.2 Mode group (MG)

### Mode group

A mode group combines NC channels with axes and spindles to form a machining unit.

A mode group contains the channels that are required to run simultaneously in the same mode from the point of view of the machining sequence.

The configuration of a mode group defines which channels are to be included in the group.

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#### Note

This description assumes one mode group and one channel.

Functions that need several channels (e.g. axis replacement), are described in:

#### References:

/FB2/ Function Manual, Extended Functions; BAGs, Channels, Axis replacement (K5)

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### Assignment: Channel - Mode group

Axes and/or spindles are assigned to one channel.

The channel, in turn, is assigned to a mode group with the following machine data:

MD10010 \$MN\_ASSIGN\_CHAN\_TO\_MODE\_GROUP (channel valid in mode group)

If the same mode group is addressed in several channels, these channels together form a mode group.

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#### Note

The control system does not recognize mode group-specific data. However, it is possible to make some channel-specific settings that pertain to the mode group.

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### Channel-specific assignments

Axes can be assigned to multiple channels that, in turn, are allocated to different mode groups. The axes can then be interchanged between these channels (axis replacement). Axis replacement functions independently of the mode group.

Machine axes and spindles are assigned to a channel. They differ as follows:

- Geometry axes can be operated in the path grouping.  
Using the master spindle, they can perform functions such as G96, G961, G331, G332, etc.
- Channel axes that are not defined as geometry axes can be moved as path axes, synchronous axes, positioning axes, PLC axes, and command axes.
- Special axes have no geometric relationship with one another.
- Master spindle geometry axes can perform functions using the master spindle.

- Auxiliary spindles are all other spindles/axes in the channel apart from the master spindle.

The `GEOAX` replacement command can be programmed to declare a channel axis as a geometry axis and define its geometry axis number. It is defined with `SETMS`, which spindle in the channel should be the master spindle.

Any axis in the channel can be configured as a spindle. The number of axes per channel depends on the control version. In order to optimize the performance utilization, the available channel and axis configurations are limited depending on the hardware.

With SINUMERIK 840D or 840D sl, the following configurations are permissible depending on the HW/SW version:

- Up to 12 axes/spindles per channel
- Maximum of 31 axes or 20 spindles per NCU

For more information about other axis configurations such as axis containers, link axes, reciprocating axes, master axes, rotary axes, linear axes, master axes, and slave axes and the various versions, please refer to:

**References:**

/FB1/ Function Manual, Basic Functions; Axes, Coordinate Systems, Frames (K2)

/FB1/ Function Manual, Basic Functions; Spindles (S1)

### Mode group-specific interface signals

The exchange of mode group-specific signals to/from the mode group is transferred to DB11 in the user interface. In this way, the mode group can be monitored and controlled from the PLC or NCK.

The following table represents all the mode group-specific interface signals.

Signals from PLC to NCK
Mode group Reset
Mode group Stop axes plus spindles
Mode group Stop
Mode change
Operating mode: JOG, MDA, AUTOM.
Single block: Type A, Type B
Machine function REF, REPOS, TEACH IN,

Signals from NCK to PLC
Mode strobe: JOG, MDA, AUTOMATIC
Machine function strobe: REF, REPOS, TEACH IN
All channels (1 to 10, max.) in Reset state
Mode group Ready
Active mode: JOG, MDA, AUTOMATIC
Digitizing
Active machine function: REF, REPOS, TEACH IN var. INC, 10000 INC ..... 1 INC

### Change in mode group

A configuration change of a mode group with respect to its assigned channels requires a subsequent POWER ON.

The change is made using machine data:

MD10010 \$MN\_ASSIGN\_CHAN\_TO\_MODE\_GROUP.

Mode group numbers must be assigned contiguously starting with 1.

### Machine data

There are no mode group-specific machine data.

### Channel gaps

The channels to which a mode group is assigned with MD10010 are regarded as activated.

Instead of a mode group number, the number "0" can be assigned to channels. The result is as follows:

- The non-activated channel does not take up memory space in the control.
- Series machines with similar designs can be kept uniform during configuration. Only the channels that can actually be used by the machine tool are activated (channels with mode group number greater than 0).

#### Special case:

Channel 1 must always be available!

⇒ If:

MD10010 \$MN\_ASSIGN\_CHAN\_TO\_MODE\_GROUP [0] = 0

is specified, the control automatically sets

MD10010 \$MN\_ASSIGN\_CHAN\_TO\_MODE\_GROUP [0] = 1 (mode group 1).

#### Example configurations:

MD10010 \$MN\_ASSIGN\_CHAN\_TO\_MODE\_GROUP[0] = 1

MD10010 \$MN\_ASSIGN\_CHAN\_TO\_MODE\_GROUP[1] = 2

...

MD10010 \$MN\_ASSIGN\_CHAN\_TO\_MODE\_GROUP[3] = 0 ; gap

...

MD10010 \$MN\_ASSIGN\_CHAN\_TO\_MODE\_GROUP[8] = 1

MD10010 \$MN\_ASSIGN\_CHAN\_TO\_MODE\_GROUP[9] = 2

## 9.2.1 Mode group Stop

### Function

The following NC/PLC interface signals are used to stop the traversing motions of the axes or of the axes and spindles in all mode group channels and to interrupt part program execution:

DB11 DBX0.5 (mode group Stop)

DB11 DBX0.6 (mode group Stop axes plus spindles)

## 9.2.2 Mode group RESET

### Function

A mode group Reset is requested via a mode group-specific NC/PLC interface signal:

DB11 DBX0.7 = 1 (mode group reset)

### Effect

Effect on the channels of mode group:

- Part program preparation (preprocessing) is stopped.
- All axes and spindles are decelerated to zero speed according to their acceleration curves without contour violation.
- Any auxiliary functions not yet output to the PLC are no longer output.
- The preprocessing pointers are set to the interruption point, and the block pointers are set to the beginning of the appropriate part programs.
- All initial settings, (e.g. the G functions), are set to the parameterized values.
- All alarms with "Channel reset" criterion are canceled.

If all the channels of the mode group are in reset state, then:

- All alarms with "Mode group reset" cancel criterion are canceled.
- The NC/PLC interface indicates completion of the mode group Reset and the mode group's readiness to operate:

DB11 DBX6.7 (all channels in the reset state)

DB11 DBX6.3 = 1 (mode group ready)

## 9.3 Mode types and mode type change

### Unique mode

The channels of a mode group operate in one mode.

A mode group is either in **AUTOMATIC**, **JOG**, or **MDA** mode.

Several channels of the same mode group **cannot** be in different modes at the same time. If individual channels are assigned to different mode groups, a channel switchover activates the corresponding mode group. This allows mode changes to be initiated via a channel switchover.

### Modes in the mode group

The following operating modes are available:

- **AUTOMATIC**

Automatic processing of part programs.

- Part program test
- All channels of the mode group can be active at the same time.

- **JOG in Automatic**

JOG in AUTOMATIC is an extension of AUTOMATIC mode intended to simplify use. JOG can be executed without leaving AUTOMATIC mode if boundary conditions so permit.

- **JOG**

Jogging (manual axis traversal)

- The axes can be traversed manually with the handwheel or the traversing keys.
- Channel-specific signals and interlocks are effective in ASUBs and when a movement is activated via IDS synchronized actions. Links are also taken into account.
- Every channel in the mode group can be active.

- **MDA**

Manual Data Automatic (the NC blocks are entered via the operator panel)

- Restricted automatic execution of part programs and sections of part programs (can be only one block or a sequence of blocks).
- Part program test
- A maximum of 1 channel per mode group can be active (applies only to TEACH IN)
- Axes can be manually traversed only in subordinate machine functions such as JOG, REPOS or TEACH IN.

**Applies to all modes****Cross-mode synchronized actions**

Modal synchronized actions can be executed per IDS in all modes for the following functions in parallel to the channel:

- Command axis functions
- Spindle functions
- Technology cycles

**Selection**

The user can select the desired operating mode by means of soft keys on the operator interface.

This selection (AUTOMATIC, MDA, or JOG) is forwarded to interface signals: DB11 DBX4.0 to DBX4.2 (mode strobe) in the PLC, but is not activated at this point.

**Activation and priorities**

The desired mode of the mode group is activated via the interface signals:

DB11 DBX0.0 to DBX0.2 (mode type)

If several modes are selected at the same time, the following priority is in effect:

Priority	Mode	Mode-group signal (NCK → PLC)
1st priority, high	JOG	DB11 DBX0.2
2nd priority, medium	MDA	DB11 DBX0.1
3rd priority, low	AUTOMATIC	DB11 DBX0.0

**Display**

The current mode of the mode group is displayed via the interface signals:

DB11 DBX6.0 to DBX6.2 (active mode)

Mode-group signal (NCK → PLC)	Active operating mode
DB11 DBX6.2	JOG
DB11 DBX6.1	MDA
DB11 DBX6.0	AUTOMATIC

**Global machine function for mode group**

After mode selection, a machine function can be selected, which is then valid globally for the whole mode group.

**Within JOG mode**

Within JOG mode, one of the following machine functions can be selected:

- REF (reference point approach)

**References:**

/FB1/ Function Manual, Basic Functions; Reference Point Approach (R1)

- REPOS (repositioning)

**References:**

/BEMsl/ Operator's Guide HMI Embedded; Chap.: "Repositioning on contour with controlled REPOS"

**Within MDA mode**

Within MDA mode, one of the following machine functions can be selected:

- REF (reference point approach)

**References:**

/FB1/ Function Manual, Basic Functions; Reference Point Approach (R1)

- REPOS (repositioning)

**References:**

/BEMsl/ Operator's Guide

- TEACHIN (teach-in of axis positions)

**References:**

/BEMsl/ Operating Instructions HMI Embedded and /BEM/ Operating Instructions HMI Embedded

**TEACH IN, REPOS or REF**

The selection of the machine functions TEACH IN, REPOS or REF from the user interface is stored under the interface signal:

DB11 DBX5.0 to DBX5.2 (strobe machine function).

The desired machine functions TEACHIN, REPOS or REF are activated with the interface signals:

DB11 DBX1.0 to DBX1.2 (machine function)

The display of the active machine function TEACHIN, REPOS or REF can be seen in the interface signal:

DB11 DBX7.0 to DBX7.2 (active machine function)

## Operating statuses

The following three channel statuses can occur in each mode:

### 1. Channel reset

The machine is in its initial state. This is defined by the machine manufacturer's PLC program, e.g. after POWER ON or at the end of the program.

### 2. Channel active

A program has been started, and the program is being executed or a reference point approach is in progress.

### 3. Channel interrupted

The running program or reference point approach has been interrupted.

## Functions in the modes

Modes are supplemented through user-specific functions. These functions are not related to any particular technology or machine. A subset of the available functions can be selected in each mode, depending on the operating state.

These functions are categorized as follows:

- NCK-specific functions
- Mode group-specific functions
- Channel-specific functions

The individual functions can be started and/or executed from the three individual channel statuses: "channel reset", "channel active", or "channel interrupted". The channel states and program states can be checked on the operator panel.

## Boundary condition for submode TEACH IN

TEACH IN is not permissible for leading or following axes of an active axis grouping, e.g. for:

- gantry axis grouping or a gantry axis pair
- Coupled-axis grouping of master and slave axis

## JOG in AUTOMATIC details

JOG in AUTOMATIC mode is permitted if the mode group is in RESET state and the axis is jog-capable.

RESET for the mode group means:

- All channels in RESET state.
- All programs interrupted.
- No DRF channel active.

**Jog-capable** axis means:

- The axis is **not**:
  - A PLC axis (as a concurrent positioning axis), i.e. the PLC has fetched the axis via axis replacement (e.g. via FC18).
  - A command axis, i.e. the axis was programmed by a synchronous action and the motion has not yet been completed.
  - A rotating spindle, e.g. a spindle rotating despite RESET.
  - An asynchronous reciprocating axis.

Note: The “jog-capable” property is independent of the “JOG in AUTOMATIC” function.

#### Activation

The function "JOG in AUTOMATIC" can be activated with the machine data:

MD10735 \$MN\_JOG\_MODE\_MASK

1. Before POWER ON, the following machine data must be set:  
MD10735 \$MN\_JOG\_MODE\_MASK, Bit 0
2. The user switches to AUTO (PLC user interface DB11 DBX0.0 = 0→1 edge). “JOG in AUTOMATIC” is then active if the NCK previously had channel status “RESET” and program status “Aborted” in all mode group channels. The axis in question must also be “jog-capable”. DRF must be deactivated (if not already deactivated).
3. RESET is initiated or the running program is finished with M30/M2 in all mode group channels that do not have channel status “Reset” and program status “Aborted”.
4. The relevant axis is made "Jog-capable" (e.g. axis replacement PLC→NCK).

Note: In most applications, the axes to be traversed are “JOG-capable” and switching to AUTO will also activate “JOG in AUTOMATIC”!

#### Features of JOG in AUTOMATIC

- The +/- keys cause a JOG movement, and the mode group is switched **internally** to JOG. (i.e. “Internal JOG”).
- Moving the handwheels causes a JOG movement, and the mode group is switched **internally** to JOG, unless DRF is active.
- An ongoing JOG movement is not complete until the end position of the increment has been reached (if this has been set) or the movement has been aborted with “Delete distance-to-go”.

In this way an increment can be stopped using Stop and then moved to the end using Start. The NCK remains in “Internal JOG” during this time. A partial increment is possible, but it must not be interrupted using Stop. There is a mode in which releasing the travel key causes interruption within an increment.

- Without any JOG movement, “JOG in AUTOMATIC” responds in the same way as “Automatic”. In particular, the Start key starts the selected part program and the appropriate HMI softkey initiates a block search.

- If JOG movement is active, the NCK is internally in JOG mode, and, thus, a block search request is refused and a Start cannot start the part program. Start starts any remaining increment or has no effect.
- While a mode group axis is being traversed in JOG mode, the mode group remains internally in JOG mode.  
Remark: This phase can begin with the JOG movement of an axis and end with the end of the JOG movement of *another* axis.
- Axis replacement is not possible for an axis with active JOG movement. (The axis might change mode group). The NCK blocks any axis replacement attempt.
- The PLC user interface indicates "Automatic" mode:
  - DB11 DBX6.0=1
  - DB11 DBX6.1=0
  - DB11 DBX6.2=0
  - DB11 DBX7.0=0
  - DB11 DBX7.1=0
  - DB11 DBX7.2=0
- In "JOG in AUTOMATIC", the PLC user interface displays whether the mode group is in "Mode group RESET". This enables the NCK to now automatically switch internally to JOG, if required.
  - DB11 DBX6.4
  - DB11 DBX26.4; For mode group 2
  - DB11 DBX46.4; For mode group 3
- In "JOG in AUTOMATIC", the PLC user interface displays whether the NCK has automatically switched to "Internal JOG".
  - DB11 DBX6.5
  - DB11 DBX26.5; For mode group 2
  - DB11 DBX46.5; For mode group 3

#### Boundary conditions

"JOG in AUTOMATIC" can only switch internally to JOG if the mode group is in "Mode group RESET" state, i.e. it is not possible to jog immediately in the middle of a stopped program. The user can jog in this situation by pressing the JOG key or the Reset key *in all channels* of the mode group.

Selecting AUTOMATIC disables the INC keys and the user can/must press the INC keys again to select the desired increment. If the NCK switches to "Internal JOG", the selected increment is retained.

If the user attempts to jog the geometry or orientation axes, the NCK switches to "Internal JOG" and the motion is executed. Several axes can be physically moved in this way; they must all be "JOG-capable".

Following the JOG movement, the NCK deactivates "Internal JOG" again and selects AUTO mode again. The internal mode change is delayed until the movement is complete. This avoids unnecessary multiple switching operations, e.g. when using the handwheel. The PLC can only rely on the "Internal JOG active" PLC signal.

The NCK will then switch to "Internal JOG" if the axis is not enabled.

### 9.3.1 Monitoring functions and interlocks of the individual modes

#### Channel status determines monitoring functions

##### Monitoring functions in operating modes

Different monitoring functions are active in individual operating modes. These monitoring functions are not related to any particular technology or machine.

In a particular mode only some of the monitoring functions are active depending on the operating status. The channel status determines which monitoring functions are active in which mode and in which operating state.

##### Interlocking functions in operating modes

Different interlocks can be active in the different operating modes. These interlocking functions are not related to any particular technology or machine.

Almost all the interlocks can be activated in every mode, depending on the operating status.

### 9.3.2 Mode change

#### Introduction

A mode change is requested and activated via the mode group interface (DB11, ...). A mode group will either be in AUTOMATIC, JOG, or MDA mode, i.e. it is not possible for several channels of a mode group to take on different modes at the same time.

What mode transitions are possible and how these are executed can be configured in the PLC program on a machine-specific basis.

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#### Note

The mode is not changed internally until the signal "Channel status active" is no longer pending. For error-free mode change however, all channels must assume a permissible operating mode.

---

## Possible mode changes

The following table shows possible mode changes for one channel.

	AUTOMATIC		JOG			MDA			
			Reset	Interrupt	Interrupt	Reset	JOG without handwheel		AUTO
	Reset	Interrupt	Reset	Interrupt	Interrupt	Reset	Interrupt	active	Interrupt
<b>AUTOMATIC</b>			X	X		X			
<b>JOG</b>	X	X				X	X		X
<b>MDA</b>	X	X	X		X				

Possible mode changes are shown by an "X".

## Special cases

- **Errors during mode change**

If a mode change request is rejected by the system, the error message "Operating mode cannot be changed until after NC Stop" is output. This error message can be cleared without changing the channel status.

- **Mode change disable**

A mode change can be prevented by means of interface signal: DB11, DBX0.4 (Mode change disable).

This suppresses the mode change request.

The user must configure a message to the operator indicating that mode change is disabled. No signal is set by the system.

- **Mode change from MDA to JOG**

If all channels of the mode group are in Reset state after a mode change from MDA to JOG, the NC switches from JOG to AUTO. In this state, part program commands `START` or `INIT` can be executed.

If a channel of the mode group is no longer in Reset state after a mode change, the part program command `START` is rejected and Alarm 16952 is issued.

## 9.4 Channel

### Assignment part program - channel

Part programs are assigned to channels.

Part programs of different channels are largely independent of each other.

### Channel properties

A channel constitutes an "NC" in which one part program can be executed at a time. Machine axes, geometry axes and positioning axes are assigned to the channels according to the machine configuration and the current program status (AXIS CHANGE, GEO AXIS CHANGE, SETMS).

The system assigns each channel its own path interpolator with associated programming. Each channel can run its own machining program, which is controlled from the PLC.

The following channel-specific functions make it possible for the channels to process part programs independently:

- Each channel has its own NC Start, NC Stop, RESET.
- One feedrate override and one rapid traverse override per channel.
- Dedicated interpreter for each channel.
- Dedicated path interpolator for each channel, which calculates the path points such that all the machining axes of the channel are controlled simultaneously from path axes.
- Selection and deselection of tool cutting edges and their length and radius compensations for a tool in a specific channel.

For more information on tool offset, refer to:

**References:**

/FB1/ Function Manual, Basic Functions; Tool Offset (W1)

- Channel-specific frames and frames active in the channel for transforming closed calculation rules into Cartesian coordinate systems. Offsets, rotations, scalings, and mirrorings for geometry axes and special axes are programmed in a frame.

For more information on frames, refer to:

**References:**

/FB1/ Function Manual, Basic Functionse; Axes, Coordinate Systems, Frames (K2), Chapter: "External work offset"

- Display of channel-specific alarm responses.
- Display of current machining sequence (axis position, current G functions, current auxiliary functions, current program block) for each channel.
- Separate program control functions for each channel.

These functions (with the exception of the display functions) are controlled and checked by the PLC with interface signals.

Channels in the same mode group always have to be operated in the same mode (AUTOMATIC, JOG, MDA).

## Channel configuration

Channels can be filled with their own channel name via the following machine data:

MD20000 \$MC\_CHAN\_NAME (channel name)

The various axes are then assigned to the available channels via machine data. There can be only one setpoint-issuing channel at a time for an axis/spindle. The axis/spindle actual value can be read by several channels at the same time. The axis/spindle must be registered with the relevant channel.

Moreover, the following channel-specific settings can also be defined via machine data:

- Position of deletions or the basic program settings of G groups via the machine data:  
MD20150 \$MC\_GCODE\_RESET\_VALUES (RESET position of G groups)
- Auxiliary function groups regarding the combination and the output time.
- Transformation conditions between machine axes and geometry axes
- Other settings for the execution of a part program

## Change in the channel assignment

An online change in the channel configuration cannot be programmed in a part program or PLC user program. Changes in the configuration must be made via the machine data. The changes become effective only after a new POWER ON.

## Container axes and link axes

An axis container combines a group of axes in a container. These axes are referred to as container axes. This involves assigning a pointer to a container slot (ring buffer location within the relevant container) to a channel axis. One of the axes in the container is located temporarily in this slot.

Each machine axis in the axis container must be assigned at all times to exactly **one** channel axis.

Link axes can be assigned permanently to one channel or dynamically (by means of an axis container switch) to several channels of the local NCU or the other NCU. A link axis is a non-local axis from the perspective of one of the channels belonging to the NCU to which the axis is not physically connected.

The assignment between the link axes and a channel is implemented as follows:

- For permanent assignment using machine data:  
Allow the direct logic machine axis image to show link axes.
- For dynamic assignment:  
Allow the axis container slot machine data to show link axes.

For more information on link axes and container axes, refer to

**References:**

/FB2/ Function Manual, Extended Functions; Several Operator Panel Fronts and NCUs, Distributed Systems (B3)

### Interface signals

NCK channel 1 signals lie in DB21 of the user interface, those of channel 2 in DB22. The channel or channels can be monitored and controlled from the PLC or NCK.

### Technology in channel

The machine data can be used to relate the technology specification for the machine to specific channels:

MD27800 \$MC\_TECHNOLOGY\_MODE

Among other functions, this information is used for evaluation in HMI, PLC, and standard cycles.

Siemens supplies standard MD for milling. If the machine tool is not a milling machine, but some other type, a different data/program block can be loaded by the HMI or PLC depending on the technology mode set in the machine data.

### Spindle functions using a PLC

It is possible to control special spindle motions via an axial PLC interface as an alternative to FC18 and to start and stop them using VDI interface signals without executing a part program.

This option is available only if the channel status is in "Interrupted" or "RESET" mode and the program status is in "Interrupted" or "Aborted" mode. This acceptance state will occur in case of RESET and in JOG mode.

A separate spindle start can be set for each spindle. The following spindle functions can be controlled by PLC via interface signals:

- Spindle Stop (corresponds to M5)
- Spindle Start clockwise (corresponds to M3)
- Spindle Start counterclockwise" (corresponds to M4)
- Select gear stage
- Spindle positioning (corresponds to M19)

In the case of multi-channel operation, the spindle started by the PLC becomes active in the channel that is handling the spindle when the start command is received.

For more information about the special spindle interface, see:

**References:**

/FB1/ Function Manual, Basic Functions; Spindles (S1)

### Autonomous single-axis operations

It is possible to decouple a particular axis/spindle in the main run from the channel behavior triggered by the NC program run.

The PLC identifies the corresponding axis/spindle from the axial NC/PLC interface signal:

DB31, ... DBB28.7 (PLC controlled axis) = 1 → assume control

DB31, ... DBB28.7 (PLC controlled axis) = 0 → relinquish control

The following functions can be controlled from the PLC:

- Cancel axis/spindle sequence (equivalent to delete distance-to-go)
- Stop or interrupt axis/spindle
- Resume axis/spindle operation (continue the motion sequence)
- Reset axis/spindle to the initial state

For a detailed description of these stand-alone single axis operations, refer to:

**References:**

/FB1/ Function Manual, Basic Functions; Positioning axes (P2)

For additional information on the channel-specific signal exchange (PLC → NCK), see:

**References:**

/FB1/ Function Manual, Basic Functions; PLC Basic Program (P3)

## 9.4.1 Global start disable for channel

### User/PLC

A global Start disable can be set for the selected channel via the HMI or from the PLC.

### Function

When Start disable is set, no new program starts are accepted for the selected channel. Start attempts are counted internally.

If a start is executed by the PLC before a global block disable is sent from the HMI to the NCK, the program is not stopped by the Start disable and its status is transmitted to the HMI.

NC Start disable and global Start disable have the same effect on the internal counter for starts that have been sent but not executed. (OPI variable startRejectCount).

### Bypassing global Start disable

The interface signal:

DB21, ... DBX7.5 (PLC → NCK)

allows the PLC to temporarily bypass a global Start disable.

- 0: Global Start disable is effective
- 1: Global Start disable is temporarily canceled.

### Messages

If desired, a message can be issued when a Start attempt occurs while a global block disable is active.

The control is exercised using machine data:

MD11411 \$MN\_ENABLE\_ALARM\_MASK Bit 6

- 1: Alarm 16956 appears: Channel %1, Program %2 cannot be started because of "Global Start disable".
- 0: Start attempts when a global block disable is set are not signaled by an alarm.

## 9.5 Program test

Several control functions are available for testing a new part program. These functions are provided to reduce danger at the machine and time required for the test phase. Several program functions can be activated at the same time to achieve a better result.

### Test options

The following test options are described below:

- Program execution without setpoint outputs
- Program execution in single-block mode
- Program execution with dry run feedrate
- Skip part program blocks
- Block search with or without calculation.

### 9.5.1 Program execution without setpoint outputs

#### Function

In the "Program test" status, a part program is executed without the output of axis or spindle setpoints.

The user can use this to check the programmed axis positions and auxiliary function outputs of a part program. This program simulation can also be used as an extended syntax check.

#### Selection

This function is selected via the operator interface in the "Program control" menu.

The selection sets the following interface signal:

DB21, ... DBX25.7 (program test selected)

This does not activate the function.

#### Activating

The function is activated via interface signal:

DB21, ... DBX1.7 (activate program test)

## Display

The corresponding field on the operator interface is reversed and the interface signal in the PLC as a checkback of the active program test:

DB21, ... DBX33.7 (program test active)

## Program start and program run

The part program can be started and executed during the active program test function using interface signal:

DB21, ... DBX7.1 (NC Start)

i.e. using auxiliary function outputs, wait times, G-function outputs, etc.

Safety functions such as software limit switches and working area limits remain valid.

The safety functions such as software limit switch, working area limits continue to be valid.

The only difference compared to normal program operation is that an internal **axis disable** is set for all axes (including spindles). The machine axes do not move, the actual values are generated internally from the setpoints that are not output. The programmed velocities remain unchanged. This means that the position and velocity information on the operator interface is exactly the same as that output during normal part program execution. The position control is not interrupted when this function is active, so the axes do not have to be referenced when the function is switched off.

### CAUTION

The signals for exact stop:  
DB31, ... DBX60.6/60.7 (exact stop coarse/fine)  
mirror the actual status on the machine.

They are only canceled during program testing if the axis is pushed out of its set position (the set position remains constant during program testing).

With signal:  
DB21, ... DBX33.7 (program test active)  
both the PLC program and the part program can use variable  
\$P\_ISTEST  
to decide how to react or branch in response to these signals during testing.

## Note

### Dry run feedrate

"Program execution without axis motion" can also be activated with the function "Dry run feedrate". With this function, part program sections with a small programmed feedrate can be processed in a shorter time.

---

**Note**

**Tool management**

Because of the axis disable, the assignment of a tool magazine is not changed during program testing. A PLC application must be used to ensure that the integrity of the data in the tool management system and the magazine is not corrupted. The toolbox diskettes contain an example of the basic PLC program.

---

## 9.5.2 Program execution in single-block mode

### Function

In case of "Program execution in single block mode" the part program execution stops after every program block. If tool cutter radius compensation or a tool nose radius correction is selected, processing stops after every intermediate block inserted by the control.

The program status switches to "Program status stopped".

The channel status remains active.

The next part program block is processed on NC Start.

### Application

The user can execute a part program block-by-block to check the individual machining steps. Once the user decides that an executed part program block is functioning correctly, he can call the next block.

### Single block types

The following different types of single block are provided:

- Decoding single block

With this type of single block, all blocks of the part program (even the pure computation blocks without traversing motions) are processed sequentially by "NC Start".

- Action single block (initial setting)

With this type of single block, the blocks that initiate actions (traversing motions, auxiliary function outputs, etc.) are processed individually.

Blocks that were generated additionally during decoding (e.g. for cutter radius compensation at acute angles) are also processed individually in single-block mode.

Processing is however not stopped at calculation blocks as these do not trigger actions.

The single block types are determined via the user interface in the menu "Program controls".



**CAUTION**

In a series of G33/G34/G35 blocks, a single block is only operative if "dry run feed" is selected.

Calculation blocks are not processed in single step mode (only if single decoding block is active).

SBL2 is also ineffective with G33/G34/G35.

## Selection

It is possible to select the single block mode:

- via the machine control panel (key "Single Block")
- via the user interface

For an exact procedure see:

**References:**

Operations Manual of the installed HMI Application

---

**Note**

In case of HMI Advanced without machine control panel, a user display must be configured with a corresponding softkey.

---

## Activating

The function is activated through the PLC basic program via the interface signal:

DB21, ... DBX0.4 (activate single block)

## Display

Active single block mode is indicated by a reversal in the relevant field in the status line on the operator interface.

Because of the single block mode, as soon as the part program processing has processed a part program block, the following interface signal is set:

DB21, ... DBX35.3 (program status interrupted)

### Processing without single block stop

Despite the selected single block mode, a processing without the single block stop can be set for specific program runs, e.g. for:

- Internal ASUPs
- User ASUPs
- Intermediate blocks
- Block search group blocks (action blocks)
- Init blocks
- Subroutines with `DISPLOF`
- Non-reorganizable blocks
- Non-repositionable blocks
- Reposition block without travel information
- Tool approach block.

The setting is done via the following machine data:

MD10702 \$MN\_IGNORE\_SINGLEBLOCK\_MASK (Prevent single block stop)

The assignment of the processes to the bits of the machine data is given in:

**References:**

Detailed machine data description

### 9.5.3 Program execution with dry run feedrate

#### Function

During "Program execution with dry run feedrate" the traversing speeds, which have been programmed together with G01, G02, G03, G33, G34 and G35, are replaced by a parameterized feedrate value:

SD42100 \$SC\_DRY\_RUN\_FEED (dry run feed rate)

The dry run feedrate value also replaces the programmed revolutional feedrate in program blocks with G95.

The exact way of working of the parameterized dry run feedrate (SD42100) depends on the setting of another setting data:

SD42101 \$SC\_DRY\_RUN\_FEED\_MODE (Mode for test run speed)

Value	Description
0	Dry run feedrate is the maximum of the programmed feedrate and setting data SD42100. (Default setting!) ⇒ SD42100 becomes effective only when the stored value is greater than the programmed feedrate.
1	Dry run feedrate is the minimum of the programmed feedrate and SD42100. ⇒ SD42100 becomes effective only when the stored value is less than the programmed feedrate.
2	The value in SD42100 acts as the dry run feed rate, regardless of the programmed feedrate.
10	As in the case of "0", except thread cutting (G33, G34, G35) and thread boring (G331, G332, G63). These functions are executed as programmed.
11	As in the case of "1", except thread cutting (G33, G34, G35) and thread boring (G331, G332, G63). These functions are executed as programmed.
12	As in the case of "2", except thread cutting (G33, G34, G35) and thread boring (G331, G332, G63). These functions are executed as programmed.

A dry run feedrate can be selected in the automatic modes and activated on interruption of an automatic mode or end of a block.

For more information on feedrate control, refer to:

**References:**

/FB1/ Function Manual, Basic Functions; Feeds (V1)

#### Application

 <b>DANGER</b>
Workpieces may not be machined when "dry run feedrate" is active because the altered feedrates might cause the permissible tool cutting rates to be exceeded and the workpiece or machine tool could be damaged.

### Selection

This function is selected via the operator interface in the "Program control" menu.

The selection sets the following interface signal:

DB21, ... DBX24.6 (dry run feed rate selected)

This does not activate the function.

### Activating

The function is activated via interface signal:

DB21, ... DBX0.6 (activate dry run feed)

### Display

Active dry run feedrate mode is indicated by a reversal in the relevant field in the status line on the operator interface.

## 9.5.4 Skip part-program blocks

### Function

When testing or breaking in new programs, it is useful to be able to disable or skip certain part program blocks during program execution. For this, the respective records must be marked with a slash.

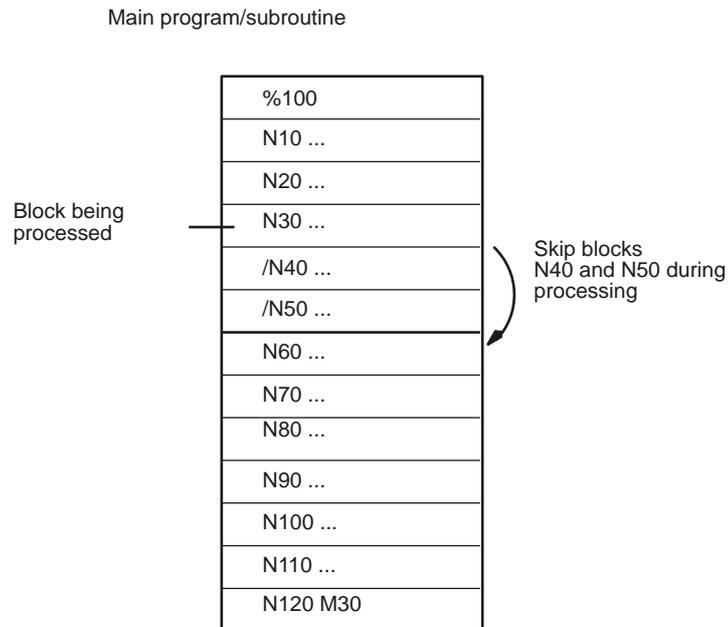


Figure 9-1 Skipping part program blocks

### **Selection**

This function is selected via the operator interface in the "Program control" menu.

The selection sets the following interface signal:

DB21, ... DBX26.0 (skip block selected)

This does not activate the function.

### **Activating**

The function is activated via the interface signal:

DB21, ... DBX2.0 (activate skip block)

---

#### **Note**

The "Skip part programs" function remains active during block searches.

---

### **Display**

Activated "Skip block" function is indicated by a reversal of the relevant field on the operator interface.

## 9.6 Block search

### Function

Block search offers the possibility of starting part program execution from almost any part program block.

This involves the NC rapidly performing an internal run through the part program (without traversing motions) to the selected target block during block search. Here, every effort is made to achieve to the exact same control status as would result at the target block during normal part program execution (e.g. with respect to axis positions, spindle speeds, loaded tools, NC/PLC interface signals, variable values) in order to be able to resume automatic part program execution from the target block with minimum manual intervention.

### Block search types

- **Type 1: Block search without calculation**

Block search without calculation is used to find a part program block in the quickest possible way. No calculation of any type is performed. The control status at the target block remains unchanged compared to the status before the start of the block search.

- **Type 2: Block search with calculation at contour**

Block search with calculation at contour is used to enable the programmed contour to be approached in any situation. On NC Start, the start position of the target block or the end position of the block before the target block is approached. This is traversed up to the end position. Processing is true to contour.

- **Type 4: Block search with calculation at block end point**

Block search with calculation at block end point is used to enable a target position (e.g. tool change position) to be approached in any situation. The end position of the target block or the next programmed position is approached using the type of interpolation valid in the target block. This is not true to contour.

Only the axes programmed in the target block are moved. If necessary, a collision-free initial situation must be created manually on the machine in "JOG REPOS" mode before the start of further automatic part program execution.

- **Type 5: Block search with calculation in "Program test" (SERUPRO) mode**

SERUPRO (search run by programtest) is a cross-channel block search with calculation. Here, the NC starts the selected part program in "Program test" mode. On reaching the target block, the program test is automatically deselected. This type of block search also enables interactions between the channel in which the block search is being performed and synchronized actions as well as with other NC channels.

---

**Note**

For more information on block searches, refer to:

**References:**

/FB1/ Function Manual, Basic Functions; Auxiliary Function Output to PLC (H2),  
Chapter: "Behavior on block search"

---

**Subsequent actions**

After completion of a block search, the following subsequent actions may occur:

- Type 1 - Type 5: Automatic Start of an ASUB

When the last action block is activated, a user program can be started as an ASUB.

- Type 1 - Type 4: Cascaded block search

A further block search with a different target specification can be started from "Search target found".

## 9.6.1 Sequence for block search of Type 1, 2 and 4

### Time sequence

The block search (Types 1, 2, and 4) proceeds as follows:

1. Activate search via input in HMI Advanced or HMI Embedded
2. Search target found, or alarm if target cannot be found
3. NC Start for output of action blocks
4. NC Start for program continuation.

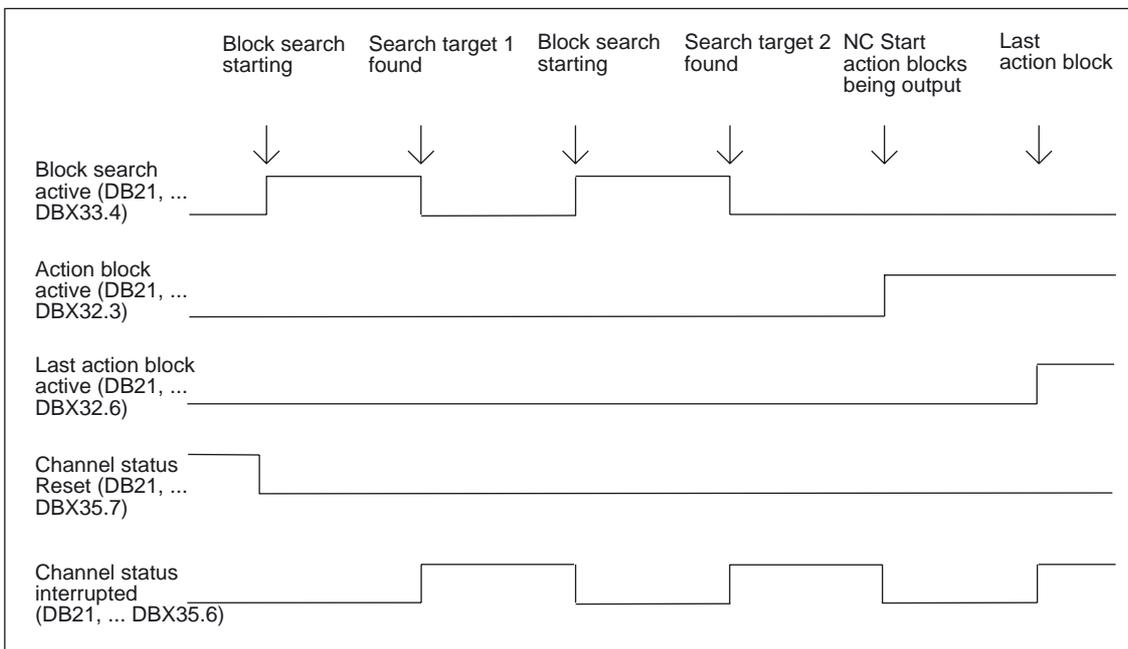


Figure 9-2 Time sequence of interface signals

### Interface signals

In the PLC, the following interface signals are set according to the time sequence shown in the figure:

- DB21, ... DBX33.4 (block search active)
- DB21, ... DBX32.3 (action block active)
- DB21, ... DBX32.4 (approach block active)
- DB21, ... DBX32.6 (last action block active)
- DB21, ... DBX1.6 (PLC action complete)

### Continuation mode after block search

Following the block search, the program can be resumed via interface signal:  
DB21, ... DBX7.1 (NC Start).

If an axis is first programmed after "Block search with calculation at block end point", the incremental value can be added to the value accumulated up to the search target using setting data  
SD42444 \$SC\_TARGET\_BLOCK\_INCR\_PROG.

### Action blocks

Action blocks contain the actions accumulated during "Block search with calculation", such as auxiliary function outputs and tool (T, D), spindle (S), and feedrate programming commands. During "block search with calculation" (contour or block end point), actions such as M function outputs are accumulated in so-called action blocks. These blocks are output on an NC Start after "Search target found".

---

#### Note

With the action blocks, the accumulated spindle programming (S value, M3/M4/M5/M19, SPOS) also becomes active.

The PLC user program must ensure that the tool can be operated and that, if necessary, the spindle programming is reset via PLC signal:  
DB31, ... DBX2.2(spindle reset)  
or the spindle programming is not output.

---

Single-block processing: MD10702 \$MN\_IGNORE\_SINGLEBLOCK\_MASK ()

By setting bit 3 = 1, it is possible to prevent a stop after every action block in single-block mode.

### Boundary conditions for approach block/target block

#### Block search type 2

Interface signal:

DB21, ... DBX32.4 (approach block active)

is **only** set with "Block search with calculation at contour" because a separate approach block is not generated with "Block search with calculation at block end point" (the approach block is the same as the target block).

#### Block search type 4

The approach movement "Search with calculation to block end point" is performed using the type of interpolation valid in the target block. This should be G0 or G1, as appropriate. With other types of interpolation, the approach movement can be aborted with an alarm (e.g. circle end point error on G2/G3).

## 9.6.2 Block search in connection with other NCK functions

### 9.6.2.1 ASUB after and during block search

#### Synchronization of the channel axes

With the start of an ASUB after "block search with calculation", the actual positions of all channel axes are synchronized during preprocessing.

Effects:

- System variable: \$P\_EP (programmed end position)

In the ASUB, the system variable provides: \$P\_EP (programmed end position) the current actual position of a channel axes in the work piece coordinate system.

\$P\_EP == "current actual position of the channel axis"

- System variable: \$AC\_RETPOINT (repositioning point in the ASUB)

In the ASUB, the system variable provides: \$AC\_RETPOINT (repositioning point in the ASUB) the actual position of a channel axis in the workpiece coordinate system accumulated with a block search.

\$AC\_RETPOINT == "collected search position of the channel axis (WCS)"

#### Block search type 2

For block search type 2 (block search with calculation on contour) the following part program command must be programmed at the conclusion of the ASUB:

REPOSA (repositioning on the contour; linear; all channel axes)

Effect:

- All channel axes are moved to their search position that was collected during the block search.
- \$P\_EP == "accumulated search position of the channel axis (WCS)"

**Block search type 4 and part program command REPOS**

After block search type 4 (block search with calculation at block end point) no automatic repositioning is initiated during the following period of time by the part program command REPOS:

- Start: NC/PLC interface signals: DB21,... DBB32, Bit6 (last action block active) == 1
- End: Continuing the part program processing per NC START,.

The start point of the approach movement is represented by the current axis positions of the channel axes at the time of the NC start command. The end point results from the other transversing movements programmed in the part program.

For block search type 4, no approach movement is generated by the NC.

Effect:

- After exiting the ASUB, the system variable \$P\_EP thus provides the actual position, on which the channel axes of the ASUB were positioned (or manual (mode: JOG).  
\$P\_EP == "current actual position of the channel axis"

**9.6.2.2 PLC actions after block search**

To allow activation of PLC actions (starting of ASUBs, call-up of PLC functions) after the end of the block search at a defined point, there is the NCK/PLC interface signal:

DB21, ... DB32.6 (last action block active) == 1

This means that all action blocks are processed and that actions are possible by the PLC (ASUB, FC) or the operator (overstoring, mode change after JOG/REPOS). This allows the PLC to perform another tool change, for example, before the start of the transversing movement.

By default, alarm 10208 is output at this moment to notify the operator that another NC START is needed to continue program execution.

In combination with alarm 10208, the following interface signals are set:

DB21, ... DBX36.7 (NCK alarm with processing stop)

DB21, ... DBX36.6 (channel-specific NCK alarm is present)

**PLC-controlled alarm triggering**

The setting by which alarm 10208 is only triggered after ending the PLC action, is done via machine data:

MD11450 \$MN\_SEARCH\_RUN\_MODE, Bit 0 = 1

Bit	Value	Meaning
0	1	With the change of the last action block after a block search, the following takes place: <ul style="list-style-type: none"> <li>• Execution of the part program is stopped</li> <li>• DB21, ... DBB32.6 (last action block active) = 1</li> <li>• Alarm display: Alarm 10208 only if the following applies: DB21, ... DBX1.6 (PLC action ended) == 1</li> </ul>

### 9.6.2.3 Spindle functions after block search

#### Control system response and output

The behavior with regard to the spindle functions after ending the block search can be set via machine data:

MD11450 \$MN\_SEARCH\_RUN\_MODE, Bit 2

Bit	Value	Meaning
2	0	Output of spindle auxiliary functions (M3, M4, M5, M19, M70) in action blocks.
	1	Output of the auxiliary functions is suppressed in the action blocks. The spindle programmings that accumulated during the block search can be output at a later point in time (e.g. via ASUB). The program data for this is stored in the following system variables: <ul style="list-style-type: none"> <li>• \$P_SEARCH_S</li> <li>• \$P_SEARCH_SDIR</li> <li>• \$P_SEARCH_SGEAR</li> <li>• \$P_SEARCH_SPOS</li> <li>• \$P_SEARCH_SPOSMODE</li> </ul>

#### System variables

The spindle-specific auxiliary functions are always stored in the following system variables on block search, irrespective of the programming described above:

System variables	Description
\$P_SEARCH_S[ n ]	Collected spindle speed, value range = { 0 ... Smax }
\$P_SEARCH_SDIR[ n ]	Collected spindle rotation direction, value range = { 3, 4, 5, -5, -19, 70 }
\$P_SEARCH_SGEAR[ n ]	Collected spindle gear stage M function, value range = { 40 ... 45 }
\$P_SEARCH_SPOS[ n ]	Collected spindle position, value range = { 0 ... MD30330 \$MA_MODULO_RANGE } Collected traverse path, value range = { -100.000.000 ... 100.000.000 }
\$P_SEARCH_SPOSMODE[ n ]	Collected position approach mode, value range = { 0 ... 5 }

For later output of the spindle-specific auxiliary functions, the system variables can be read, for example in an ASUB, and output after output of the action blocks:  
DB21, ... DBX32.6 == 1 (last action block active)

#### Note

The contents of the system variables \$P\_S, \$P\_DIR and \$P\_SGEAR may be lost after block search due to synchronization operations.

**References:**

More detailed information on ASUB, block search, and action blocks is to be found in:

- /FB1/ Function Manual, Basic Functions; Auxiliary Function Output to PLC (H2),  
Section: Output suppression of spindle-specific auxiliary functions
- /FB1/ Function Manual, Basic Functions; Mode Group, Channel, Program Operation (K1)  
Section: Program test
- /FB1/ Function Manual, Basic Functions; Spindles (S1),  
Section: Auxiliary spindle functions after block search

**9.6.3 Automatic start of an ASUB after a block search**

**Parameter assignment**

**Making the function effective**

The automatic ASUB start after a block search is activated by the following MD setting:

MD11450 \$MN\_SEARCH\_RUN\_MODE, bit 1 = 1

**Program to be activated**

In the default setting, the program **\_N\_PROG\_EVENT\_SPF** is activated from the directory **\_N\_CMA\_DIR** as ASUB after the block search by changing the last action block. If another program is to be activated, then the name of this user program must be entered in the following machine data:

MD11620 \$MN\_PROG\_EVENT\_NAME

**Behavior when the single block processing is set**

Via the following channel-specific machine data it can be set, whether the activated ASUB are processed without interruption despite a set single block processing or whether the single block processing is to be made active:

MD20106 \$MC\_PROG\_EVENT\_IGN\_SINGLEBLOCK

Bit	Value	Description
4	0	Single block execution is active.
	1	Single block processing is suppressed.

**Behavior when the read-in disable is set**

Via the following channel-specific machine data it can be set, whether the activated ASUB are processed without interruption despite a set read-in disable (DB21, ... DBX6.1 = 1), or whether the read-in disable is to be made active:

MD20107 \$MC\_PROG\_EVENT\_IGN\_INHIBIT

Bit	Value	Description
4	0	Read-in disable is active.
	1	Read-in disable is suppressed.

---

**Note**

For more information on parameterization of MD11620, MD20108 and MD20107 see "Event-driven Program calls > Parameterization (Page 609)".

---

**Programming**

The event that has started this ASUB can be determined by scanning the system variable \$P\_PROG\_EVENT. In case of an automatic activation after a block search \$P\_PROG\_EVENT returns the value "5".

**Sequence**

Sequence of automatic start of an ASUB after a block search

1. Start block search (with/without calculation, at contour, at end-of-block point).
2. Stop after "Search target found".
3. NC Start for output of action blocks.
4. Last action block is activated.
5. Automatic start of /\_N\_CMA\_DIR/\_N\_PROG\_EVENT\_SPF (default) as an ASUB.
6. The NC will stop after changing the last ASUB block (REPOSA command) and the following NC/PLC interface signal is set:

DB21, ... DBX32.6 (last action block active)

The alarm 10208 "Enter NC-start for program continuation" is generated.

---

**Note**

If bit 0 is set to "1" in MD11450 \$MN\_SEARCH\_RUN\_MODE, then the alarm 10208 is generated only when the PLC requests this by setting the following NC/PLC interface signal:

DB21, ... DBX1.6 (PLC action complete)

---

## 9.6.4 Cascaded block search

### Functionality

The "Cascaded block search" function can be used to start another block search from the status "Search target found". The cascading can be continued after each located search target as often as you want and is applicable to the following block search functions:

- Type 1 block search without calculation
- Type 2 block search with calculation at contour
- Type 3 block search with calculation at block end point

---

#### Note

Another "cascaded block search" can be started from the stopped program execution only if the search target has been found.

---

### Activation

The "cascaded block search" is configured in the existing machine data:  
MD11450 \$MN\_SEARCH\_RUN\_MODE

- Cascaded block search is enabled (i.e. several search targets can be specified) with Bit 3 = 0 (FALSE).
- For compatibility reasons, the cascaded block search can be disabled with Bit 3 = 1 (TRUE). By default, the cascaded block search is set with Bit 3 = 0.

### Execution behavior

#### Search target found, restart search

When the search target is reached, the program execution stops and the search target is displayed as a current block. After each located search target, a new block search can be repeated as often as you want.

#### Change search target specifications

You can change the search target specifications and block search function prior to each block search start.

### Example: Sequence with cascaded block search

- RESET
- Block search up to search target 1
- Block search up to search target 2 → "Cascaded block search"
- NC Start for output of the action blocks → Alarm 10208
- NC Start → Continue program execution

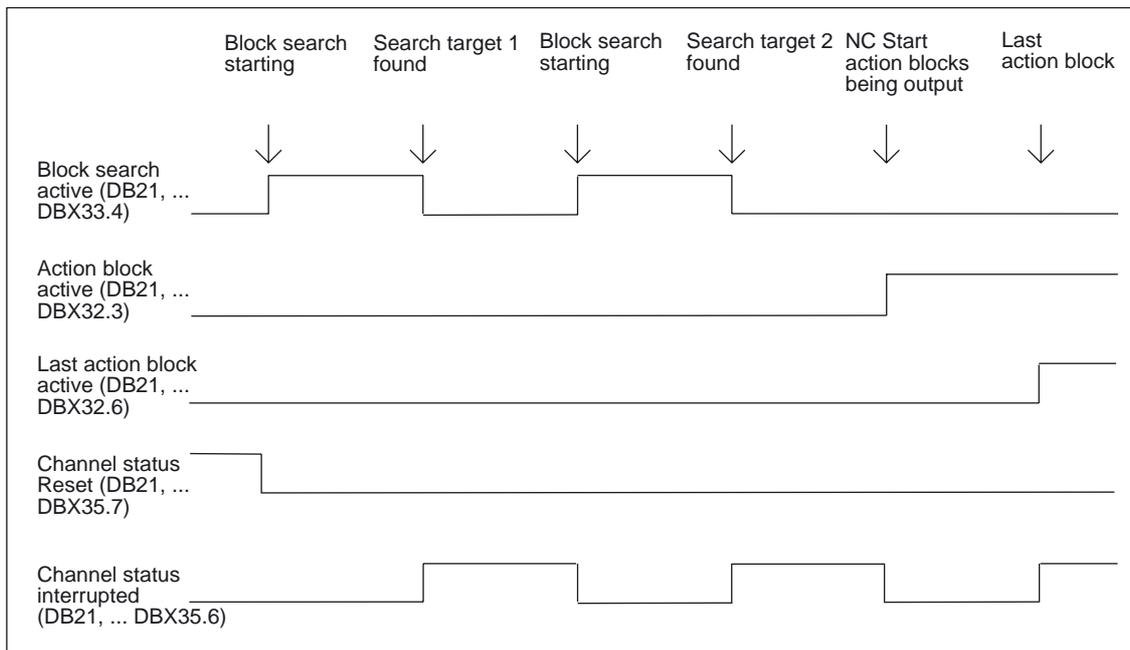


Figure 9-3 Chronological order of interface signals

## 9.6.5 Examples of block search with calculation

### Selection

From the following examples, select the type of block search that corresponds to your task.

#### Type 4 block search with calculation at block end point

Example with automatic tool change after block search with active tool management:

1. Set machine data:
  - MD11450 \$MN\_SEARCH\_RUN\_MODE to 1
  - MD11602 \$MN\_ASUP\_START\_MASK Bit 0 = 1 (ASUB Start from stopped state)

2. Select ASUB "BLOCK\_SEARCH\_END" from PLC via FB4.

#### References:

/FB1/ Function Manual, Basic Functions, Basic PLC Program (P3)

3. Load and select part program "WORKPIECE\_1".
4. Search to block end point, block number N220.
5. HMI signals "Search target found".
6. NC Start for output of action blocks.

9.6 Block search

- 7. With the PLC signal:  
DB21... DB32.6 (last action block active)  
the PLC starts ASUB "BLOCK\_SEARCH\_END" via FC9.

**References:**

/FB1/ Function Manual, Basic Function, Basic PLC Program (P3)

- 8. After the end of the ASUB (can be evaluated, e.g. via M function M90 to be defined, see example for block N1110), the PLC sets signal:  
DB21, ... DBX1.6 (PLC action ended).

Alternatively, the VDI interface signal:  
DB21-DB30 DBB318 Bit 0 (ASUB is stopped)  
can also be scanned.

As a result, Alarm 10208 is displayed, i.e. other actions can now be performed by the operator.

- 9. Manual operator actions (JOG, JOG-REPOS, overstoring)
- 10. Continue part program with NC Start.

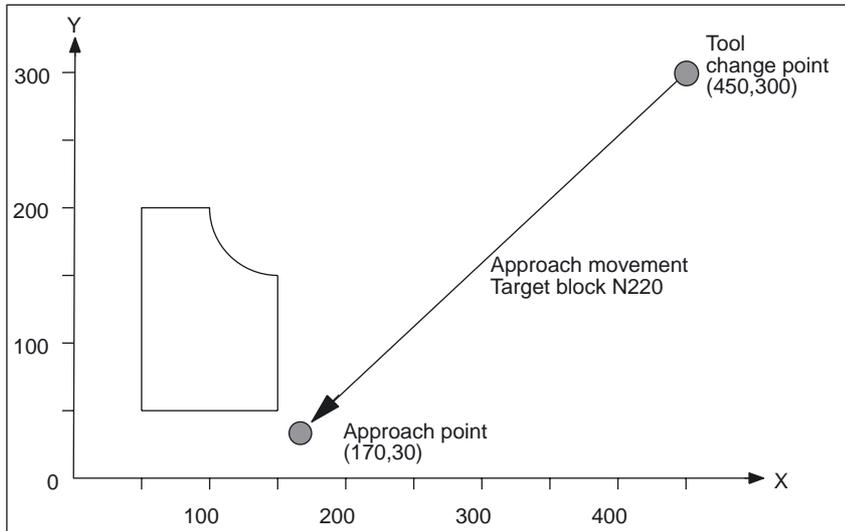


Figure 9-4 Approach movement for search to block end point (target block N220)

**Note**

"Search to contour" with target block N220 would generate an approach movement to the tool change point (start point of the target block).

**Type 2 block search with calculation at contour**

Example with automatic tool change after block search with active tool management:

1. to 3. Same as example for Type 4 block search
4. Search to contour, block number N260
5. to 10. Same as example for Type 4 block search

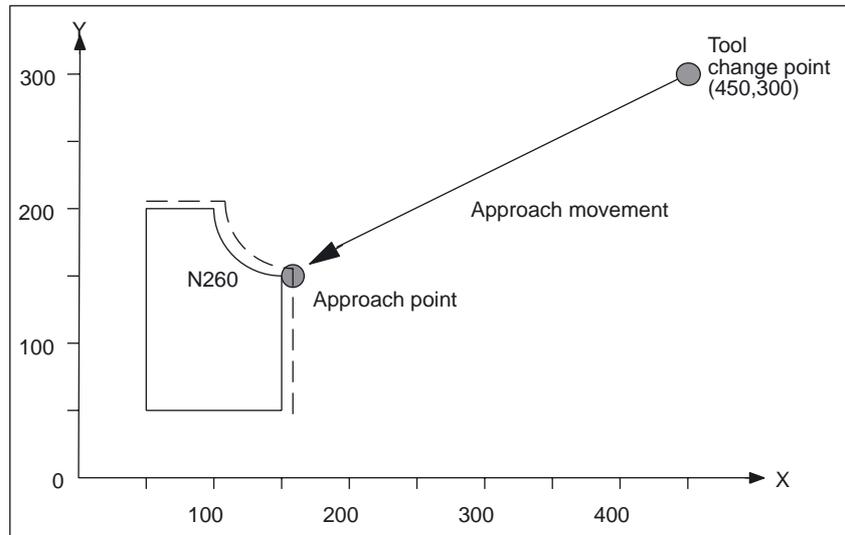


Figure 9-5 Approach movement for search to contour (target block N260)

**Note**

"Search to block end point" with target block N260 would result in Alarm 14040 (circle end point error).

Part programs for Type 4 and Type 2

PROC WORKPIECE\_1

```

;Main program
...
;Machine contour section 1 with "CUTTER_1"tool
...
N100 G0 G40 X200 Y200 ; Deselect radius compensation
N110 Z100 D0 ; Deselect length compensation
;End of contour section 1
;
;Machine contour section 2 with "CUTTER_2"tool
N200 T="CUTTER_2" ; Preselect tool
N210 WZW ; Call tool change routine
N220 G0 X170 Y30 Z10 S3000 M3 D1 ; Approach block for contour section 2
N230 Z-5 ; Infeed
N240 G1 G64 G42 F500 X150 Y50 ; Start point of contour
N250 Y150
N260 G2 J50 X100 Y200
N270 G1 X50
N280 Y50
N290 X150
N300 G0 G40 G60 X170 Y30 ; Deselect radius compensation
N310 Z100 D0 ; Deselect length correction
End of contour section 2
...
M30
PROC WZW
Tool change routine
N500 DEF INT TNR_AKTIV ; Variable for active T number
N510 DEF INT TNR_VORWAHL ; Variable for preselected T number
N520 TNR_AKTIV = $TC_MPP6[9998,1] ; Read T number of active tool
N530 GETSELT(TNR_VORWAHL) ; Read T number of preselected tool
;
;Execute tool change only if tool is not yet active
N540 IF TNR_AKTIV == TNR_VORWAHL GOTOF ENDE
N550 G0 G40 G60 G90 SUPA X450 Y300 Z300 D0 ; Approach tool change position
N560 M6 ; Execute tool change
;
END: M17
PROC SUCHLAUF_ENDE SAVE
ASUB for calling the tool change routine after block search
N1000 DEF INT TNR_AKTIV ; Variable for active T number
N1010 DEF INT TNR_VORWAHL ; Variable for preselected T number

```

```
N1020 DEF INT TNR_SUCHLAUF                ; Variable for T number determined in
                                           search
N1030 TNR_AKTIV = $TC_MPP6[9998,1]        ; Read T number of active tool
N1040 TNR_SUCHLAUF = $P_TOOLNO            ; Read T number determined by search
N1050 GETSELT(TNR_VORWAHL)                ; Read T number of preselected tool
N1060 IF TNR_AKTIV ==TNR_SUCHLAUF GOTOF ASUP_ENDE
N1070 T = $TC_TP2[TNR_SUCHLAUF]          ; T selection by tool name
N1080 WZW                                  ; Call tool change routine
N1090 IF TNR_VORWAHL == TNR_SUCHLAUF GOTOF ASUP_ENDE
N1100 T = $TC_TP2[TNR_VORWAHL]           ; Restore T preselection by tool name
ASUP_ENDE:
N1110 M90                                  ; Check-back signal to PLC
N1120 REPOSA                              ; ASUB end
```

## 9.7 Block search Type 5 SERUPRO

### SERUPRO

The "search via program test" is from now on referred to as **SERUPRO**. This acronym has been derived from "**SE**arch **RU**n by **PRO**gram test".

### Function

SERUPRO can be used for a cross-channel block search.

This search permits a block search with calculation of **all** necessary data from the previous history, so as to acquire all previously valid status data for a particular overall NC status. The **PLC** is hereby updated to the **current status**.

The NC is operated in "Program test" mode during this block search so that interactions between a channel and synchronized actions or between several channels, can take place within an NCU.

### Channels

In combination with the HMI, SERUPRO is provided for the following channels:

- For the current SERUPRO channel only (1)
- For all channels with the same workpiece name as the SERUPRO channel (2)
- For all channels with the same mode group as the SERUPRO channel (3)
- For all channels of the NCU (4)

The scope of channels for SERUPRO is selected by means of configuration file **maschine.ini**, in Section [BlockSearch]:

Section [BlockSearch]	Enable search function for HMI and select search configuration
SeruproEnabled=1	;SERUPRO softkey available for HMI. Default value is (1)
SeruproConfig=1	;Number (1) to (4) of above indicated channel grouping. Default value is (1)

All other channels started with SERUPRO are operated in "Self-Acting SERUPRO" mode. Only the channel in which a target block has been selected can be started with a block search in SERUPRO mode.

## Supported functions

Supported NC functions during **SERUPRO**:

- Gear stage change
- Setpoint and actual value linkages for drives such as "master-slave" as well as "electronic gear" and "axial master value coupling"
- Coupled motion in axis grouping
- Gantry axes
- Tangential follow-up of individual axes
- Superimposed motion interpolation
- Travel to fixed stop
- Synchronous spindle grouping

On reaching the beginning of the target block (see "Time sequence of SERUPRO" below), the user can activate a SERUPRO ASUB.

Special points should be noted during **SERUPRO ASUB** with regard to:

- Reference point approach
- Tool management
- Spindle ramp-up

Other functions after search target was found, such as:

- Continue machining after SERUPRO search target found (REPOS offset)
- Repositioning on contour with controlled REPOS
- Part program expansions for SERUPRO

## Activating

SERUPRO is activated via the HMI. SERUPRO is operated using the "Prog.Test Contour" softkey.

SERUPRO uses REPOS to approach the target block.

### Chronological sequence of SERUPRO

1. Via HMI, softkey "Prog. test contour" and the search target are operated.
2. The NC now automatically starts the selected program in "Program test" mode.
  - In this mode, axes are not traversed.
  - Auxiliary functions \$A\_OUT and the direct PLC IO are output.
  - The auxiliary functions of the target block are not output.
3. Numerous operator actions are permitted during this phase:
  - Start, Stop
  - Axis replacement
  - Deletion of distance-to-go
  - Mode change, ASUBs, etc.

The program and channel statuses of interface signal:  
DB21, ... DBB35  
or system variable:  
\$AC\_PROG  
is supplied analogous to real operation.
4. The part program command WAITM/WAITE/WAITMC will wait for the partner channels involved.

This waiting occurs if the partner channels are:

  - In SERUPRO mode
  - In Program test mode or are actually running
5. Selection of program test and dry run feedrate is rejected with corresponding Alarm 16935.
6. The NC stops at the beginning of the target block, deselects "Program test" internally, and displays the Stop condition "Search target found" in its block display.
7. As required, the user can start an ASUB that is traversed really. This ASUB is referred to below as the **SERUPRO-ASUB**.
8. The user presses Start:

The spindles are started. Then, the path axes start a **REPOS operation** that guides them to the block starting point of the target block.

The REPOS operation is implemented by a system ASUB and can be expanded using the "Editable ASUB" function.

### SERUPRO operation

The sequence of operations in items 2. to 6. corresponds to one **SERUPRO operation**.

## SERUPRO ASUP

An ASUB that can be called optionally when the target block is reached. It is actually executed.

## SERUPRO approach

Approach to the starting point of the target block during a block search in SERUPRO test mode.

## Boundary conditions for block search SERUPRO

The SERUPRO function may only be activated in "AUTOMATIC" mode and may only be aborted in program status (channel status RESET).

If in normal mode **only** the PLC starts commonly several channels, then this can be simulated by SERUPRO in each channel.

If machine data setting:

MD10708 \$MN\_SERUPRO\_MASK Bit 1 = 0

Alarm 16942: "Channel %1 Start program command action %2<ALNX> not possible" aborts the simulation if part program command `START` is used.

Machine data:

MD10707 \$MN\_SERUPRO\_TEST\_MASK

allows program testing to be deactivated in the stopped state without the SERUPRO operation being affected. The default setting allows program testing to be deactivated only in the RESET state.

---

### Note

After program testing has been deactivated, a REPOS operation is initiated that is subject to the same restrictions as a SERUPRO approach operation. Any adverse effects can be inhibited using an ASUB.

---

### Controlling SERUPRO behavior

Machine data:

MD10708 \$MN\_SERUPRO\_MASK

can be used to control the SERUPRO behavior as follows:

Stop at M0 during search phase.

Bit 0 = 0            NC is stopped at M0 during the search phase.

Bit 0 = 1            NC is not stopped at M0 during the search phase.

Allow part program command "START" if alarm 16942 is issued.

Bit 1 = 0            The alarm aborts the search phase during part program START.

Bit 1 = 1            The alarm is suppressed. A program uses part program command "Start(j)" in channel i according to the following sequence:

The preselected program is started in channel j.

Channel j performs a real start with moving axes.

A program test can be selected beforehand in channel j by the user. Channel j will now **not** select a search target.

Bit 2                Reserved

SERUPRO not ended simultaneously.

Bit 3 = 0            Switches the function off. All channels that find the search target (also for self-acting SERUPRO) end SERUPRO at the same time.

Bit 3 = 1            SERUPRO ends as soon as the simulation has found the search target. No further synchronization operations take place in the channels started by SERUPRO.

## Initial setting for SERUPRO

Machine data:

MD20112 \$MC\_START\_MODE\_MASK

is used to define the initial setting of the control for part program start with respect to G codes (especially the current plane and settable zero offset), tool length compensation, transformation, and axis couplings.

The special option exists for the SERUPRO operation of using machine data:

MD22621 \$MC\_ENABLE\_START\_MODE\_MASK\_PRT

to select an initial setting that differs from the normal part program start.

The new setting must be stored in machine data:

MD22620 \$MC\_START\_MODE\_MASK\_PRT.

The meaning of the bits of MD22620 is identical to those of MD20112.

**Example:** The synchronous spindle coupling at the beginning of the SERUPRO operation is retained for the part program start.

```
$MC_START_MODE_MASK = 'H400'           ; synchronous spindle coupling not
                                         configured
$MC_START_MODE_MASK_PRT = 'H00'        ; is switched off
$MC_ENABLE_START_MODE_MASK_PRT = 'H01' ; remains active.
                                         ; $MC_START_MODE_MASK_PRT is
                                         evaluated in SERUPRO instead of
                                         $MC_START_MODE_MASK.
```

### Identification of the active SERUPRO in the interface.

#### DB21, ... DBX318.1

The VDI signal from NCK channel (NCK→PLC)  
DB21, ... DBX318.1 (block search via program test is active)  
has the following meaning and effect:

The NC runs in the internal "Program test" mode until the target block of the search is activated in the main run and the program status changes to "Stopped".

During this time, interface "Block search via program test is active" is set to 1.

#### For user-defined ASUB after the SERUPRO operation

---

#### Note

If the machine manufacturer decides to start an ASUB after the SERUPRO operation as described in item 7, the following must be observed:

#### Stopped status acc. to point 6.:

Machine data:  
MD11602 \$MN\_ASUP\_START\_MASK  
and  
MD11604 \$MN\_ASUP\_START\_PRIO\_LEVEL  
allow the NCK to start the ASUB from stopped status automatically via the FC9 block.

#### Acknowledgement of FC9 only after completion of REPOS block:

The ASUB can only be signaled as complete from the FC9 block with "ASUB Done" if the REPOS block has also been completed.

#### Deselection of assigned REPOS operation after Item 8:

The start of the ASUB deselects the assigned REPOS operation!

Therefore, the ASUB should be ended with REPOSA in order to retain the REPOS operation.

#### Deleting an unwanted REPOS operation:

The unwanted REPOS operation is deleted by completing the ASUB with M17 or RET.

#### Special handling of ASUB:

As a basic rule, an ASUB that ends with REPOS and is started from stopped status receives special treatment.

The ASUB stops automatically before the REPOS block and indicates this via:

DB21, ... DBX318.0 (ASUB is stopped)

---

### Automatic ASUB start

The ASUB in path:  
/\_N\_CMA\_DIR/\_N\_PROG\_EVENT\_SPF  
is started automatically in SERUPRO approach with machine data:  
MD11450 \$MN\_SEARCH\_RUN\_MODE, Bit1 = 1  
according to the following sequence:

1. The SERUPRO operation has been performed completely.
2. The user presses "Start".
3. Automatic ASUB start.
4. The NCK stops automatically **before** the REPOS part program command and Alarm 10208 "Press NC Start to continue the program" appears.
5. The user presses "Start" again.
6. The NCK executes the REPOS movement and continues the part program at the target block.

---

#### Note

The automatic ASUB start with MD11450 requires **Starts** to continue the program.  
The procedure is in this respect similar to other search types.

---

## 9.7.1 REPOS

### MD11470

REPOS occurs according to machine data:

MD11470 \$MN\_REPOS\_MODE\_MASK

#### Case A:

The REPOS operation moves all axes from the current position to the start of the target block in a single block.

MD11470 \$MN\_REPOS\_MODE\_MASK Bit 3 = 1

#### Case B:

The path axes are repositioned together in one block. The SPOS and POS axes are repositioned in the residual block.

MD11470 \$MN\_REPOS\_MODE\_MASK Bit 3 = 0

### 9.7.1.1 Continue machining after SERUPRO search target found

#### User information regarding the REPOS operation

REPOS is generally used to interrupt an ongoing machining operation and to continue machining after the interruption.

In the SERUPRO approach, on the other hand, a program section must be "executed" later. This is the case, when SERUPRO has finished the simulation and is to be moved again to the target block. SERUPRO refers to the existing REPOS function, which the user can adapt as necessary.

#### SERUPRO approach

The user can change the REPOS behavior of individual axes at specific times to reposition certain axis types either earlier, later, or not at all. This affects SERUPRO approach in particular. Repositioning movements of some axes can also be controlled independently of SERUPRO approach during the REPOS operation.

 <b>CAUTION</b>
The REPOS operation moves all axes from the current position to the start of the target block in a single block with the appropriate setting of machine data: MD11470 \$MN_REPOS_MODE_MASK Bit 3.
During this process, the NC cannot detect any possible collisions with the machine or the workpiece!
Protection zones and software limits are monitored.

## Set REPOS response

Machine data:

MD11470 \$MN\_REPOS\_MODE\_MASK

can be used to set bits that specify the behavior of the NC during repositioning.

- |           |   |
|-----------|---|
| Bit 0 = 1 | The dwell time is resumed at the point of interruption in the residual repositioning block.   |
| Bit 1 = 1 | Reserved  |
| Bit 2 = 1 | Prevent repositioning of individual axes using VDI signals.   |
| Bit 3 = 1 | Reposition positioning axes in the approach block during block search via program test (SERUPRO).   |
| Bit 4 = 1 | Positioning axes in approach block on every REPOS.  |
| Bit 5 = 1 | Modified feedrates and spindle speeds are valid immediately in the residual block. Otherwise, not until the next block.   |
| Bit 6 = 1 | After SERUPRO, neutral axes and positioning spindles in the approach block are repositioned as command axis.  |
| Bit 7 = 1 | The level of interface signal:<br>DB31, ... DBX10.0 (REPOSDELAY)<br>is read if REPOSA is interpreted.<br><br>Axes, which are neither geometry nor orientation axes, are then excluded by REPOS and are not moved. |

## Repositioning with controlled REPOS

At any point during processing, a part program can be interrupted and an ASUB started with a REPOS.

For path axes, the REPOS mode can be controlled by the PLC via VDI signals to reposition on the contour. This mode is programmed in the part program and defines the approach behavior. See "Repositioning to contour with controlled REPOS".

The REPOS behavior of individual axes can also be controlled via VDI signals and is enabled with machine data:  
MD11470 \$MN\_REPOS\_MODE\_MASK BIT 2==1.

Path axes cannot be influenced individually. For all other axes that are not geometry axes, repositioning of individual axes can be prevent temporarily and also delayed. VDI signals can be used to subsequently reenable or to continue blocking individual channel axes that REPOS would like to traverse.



Signal:  
DB31, ... DBX2.2 (Delete distance-to-go, axis-specific)  
produces the following dangerous behavior with "Prevent repositioning of individual axes"  
via:  
MD11470 \$MN\_REPOS\_MODE\_MASK (Bit 2==1).  
As long as an axis is programmed incrementally after the interruption, the NC approaches  
different positions than those approached with no interruption (see example below).

**Example: Axis is programmed incrementally**

Axis A is positioned at 11° before the REPOS operation; the programmed operation in the interruption block (target block for SERUPRO) specifies 27°.

Any number of blocks later, this axis is programmed to move incrementally through 5° with:  
N1010 POS[A]=IC(5) FA[A]=1000.

With interface signal:  
DB31, ... DBX10.0 (REPOSDELAY)  
the axis does not traverse in the REPOS operation and is moved to 32° with N1010.

(The user may have to deliberately acknowledge the travel from 11° to 27°.)

**Caution:**  
The axis is programmed incrementally after the interruption.

In the example, the NC moves to 16° (instead of 32°).

**A) Start axes individually**

The REPOS behavior for SERUPRO approach with several axes is selected with:

MD11470 \$MN\_REPOS\_MODE\_MASK BIT 3 == 1

The NC commences SERUPRO approach with a block that moves **all** positioning axes to the programmed end and the path axis to the target block.

The user starts the individual axes by selecting the appropriate feedrate enables. The target block motion is then executed.

**B) Reposition positioning axes in the repositioning block**

Positioning axes are not repositioned in the residual block but rather in the repositioning block, and their effect is not limited to the block search via program test on SERUPRO approach.

MD11470 \$MN_REPOS_MODE_MASK	
Bit 3=1	for block search via program test (SERUPRO)
Bit 4=1	for each REPOS

**Note**

If neither bit 3 nor bit 4 is set, "non-path axes" are repositioned in the residual block in this phase.

**Prefer or ignore REPOS**

Further REPOS adaptations can be made by setting the bits in:

MD11470 \$MN\_REPOS\_MODE\_MASK

- Bit 5 = 1      Modified feedrates and spindle speeds are valid immediately in the residual block and are given priority. This behavior relates to every REPOS operation.
- Bit 6 = 1      Neutral axes and positioning spindles are repositioned after SERUPRO.  
Neutral axes that are not allowed to be further repositioned must receive interface signal:  
DB31, ... DBX10.0 (REPOSDELAY)  
This cancels the REPOS movement.
- Bit 7 = 1      The level of interface signal:  
DB31, ... DBX10.0 (REPOSDELAY)  
is read if REPOSA is interpreted.  
Axes, which are neither geometry nor orientation axes, are then excluded by REPOS and are not moved.  
Note: REPOSDELAY is changed from edge to level evaluation.

**Delayed approach of axis with REPOS offset**

With the axial level-triggered VDI signal axis/spindle (PLC→NCK):  
DB31, ... DBX10.0 (REPOSDELAY)

with the edge of NST:  
DB21, ... DBX31.4 (REPOSMODEEDGE)  
the REPOS offset for this axis is traversed only after the next time it is programmed.

Whether this axis is currently subject to a REPOS offset can be scanned via synchronized actions with \$AA\_REPOS\_DELAY.

 **CAUTION**

Interface signal:  
DB31, ... DBX10.0 (REPOSDELAY)  
has no effect on machine axes that form a path.

Whether an axis is a path axis can be determined with:  
DB31, ... DBX76.4 (path axis).

**Acceptance timing of REPOS VDI signals**

With the 0/1 edge of the channel-specific VDI signal (PLC→NCK):  
DB21, ... DBX31.4 (REPOSMODEEDGE)

the level signals of:  
DB21, ... DBX31.0-31.2 (REPOSPATHMODE0 till 2)

and  
DB31, ... DBX10.0 (REPOSDELAY)

are transferred to the NC.

The levels relate to the current block in the main run. There are two different cases:

**Case A:**

**One** repositioning block of a currently active REPOS operation is contained in the main run.

The active REPOS operation is aborted, restarted and the REPOS offsets controlled via the signals:

DB21, ... DBX31.0-31.2 (REPOSPATHMODE0 till 2)

and  
DB31, ... DBX10.0 (REPOSDELAY).

**Case B:**

**No** repositioning block of a currently active REPOS operation is contained in the main run.

Each future REPOS operation wishing to reapproach the current main program block is controlled by the level of interface signal:

DB21, ... DBX31.0-31.2 (REPOSPATHMODE0 till 2)

and  
DB31, ... DBX10.0 (REPOSDELAY).

**Note**

In the running ASUB affects the NST:  
DB21, ... DBX31.4 (REPOSMODEEDGE)  
does not affect the final REPOS, unless this signal applies to the REPOS blocks.

In Case A, the signal is only allowed in the stopped state.

**Response to RESET:**

**NCK has acknowledged the PLC signal**

If the level of the signals:  
DB21, ... DBX31.4 (REPOSMODEEDGE) = 1  
and  
DB21, ... DBX319.0 (REPOSMODEEDGEACKN) = 1

and  
a RESET occurs in this situation, then the interface signal of the NCK:  
DB21, ... DBX319.1–319.3 (Repos Path Mode Ackn0 to 2)  
is deleted.

**NCK has not yet acknowledged the PLC signal:**

If the level of the signals:  
DB21, ... DBX31. (REPOSMODEEDGE 4) = 1  
and  
DB21, ... DBX319.0 (REPOSMODEEDGEACKN) = 0  
and a RESET occurs in this situation, the NCK cancels interface signal:  
DB21, ... DBX319.0 (REPOSMODEEDGEACKN) = 0  
and  
DB21, ... DBX319.1–319.3 (Repos Path Mode Ackn0 to 2).

---

**Controlling SERUPRO approach with VDI signals**

The SERUPRO approach can be used with:  
DB21, ... DBX31.4 (REPOSMODEEDGE)  
and the associated signals in the following phases:

- Between "Search target found" and "Start SERUPRO ASUB"
- From "SERUPO-ASUB stops automatically before REPOS" to "Target block is executed"

While the SERUPRO ASUB is being executed, e.g. in the program section before the REPOS operation, interface signal:  
DB21, ... DBX31.4 (REPOSMODEEDGE)  
does not affect the SERUPRO approach.

## REPOS operations with VDI signals

### Control REPOS with VDI interface signals

REPOS offsets can be positively influenced with the following channel-specific VDI interface signals **from the PLC**:

DB21, ... DBX31.0-31.2 (REPOSPATHMODE0 to 2) channel-specific \*

DB21, ... DBX31.4 (REPOSMODEEDGE) channel-specific

DB31, ... DBX10.0 (REPOSDELAY) \*axis/spindle  
(This axial interface does **not** affect machine axes that form a path.)

DB31, ... DBX72.0 (REPOSDELAY) axis/spindle

\* These signals are available in the respective DB of the HMI or PLC.

## REPOS acknowledgement signals

The following VDI signals can be used to acknowledge **from the NCK** functions that control the REPOS response via PLC:

DB21, ... DBX319.0 (REPOSMODEEDGEACKN) channel-specific

DB21, ... DBX319.1-319.3 (Repos Path Mode Ackn0 to 2) channel-specific

DB21, ... DBX319.5 (Repos DEFERRAL Chan) channel-specific

DB31, ... DBX70.0 (Repos offset) axis/spindle

DB31, ... DBX70.1 (Repos offset valid) axis/spindle

DB31, ... DBX70.2 (Repos Delay Ackn) axis/spindle

DB31, ... DBX76.4 (path axis) axis/spindle

For further information, see "REPOS offset in the interface"

## REPOS acknowledgement operations

With the channel-specific VDI signal:

DB21, ... DBX319.0 (REPOSMODEEDGEACKN)

if a "handshake" is established by the interface signal:

DB21, ... DBX31.4 (REPOSMODEEDGE)

recognized by the NC and acknowledged with DB21, ... DBX319.0 to the PLC.

---

### Note

If the NCK has not yet acknowledged interface signal:

DB21, ... DBX31.4 (REPOSMODEEDGE)

with interface signal:

DB21, ... DBX319.0 (REPOSMODEEDGEACKN)

a RESET in this situation causes the program to abort, and the REPOS that is to be used to control the REPOSPATHMODE can no longer take place.

---

A REPOS MODE specified by the PLC from NCK with the interface signals:  
DB21, ... DBX319.1-319.3 (Repos Path Mode Ackn0 to 2)

and  
DB31, ... DBX10.0 (Repos Delay)

with:  
DB31, ... DBX70.2 (Repos Delay Ackn)

is acknowledged in the following way:

A part program is stopped at N20 (→ time (2) in figure). The NCK stops according to the braking ramp. After the PLC has specified the REPOSPATHMODE, the NCK accepts the REPOSPATHMODE with the 0/1 edge of REPOS MODEEDGE at → Time (3). Repos Path Mode Ackn remains set until the ASUB is initiated (→ Time (4)). The REPOS command is started in the ASUB (→ Time (5)). The ASUB RESET block is activated again (→ Time (6)):

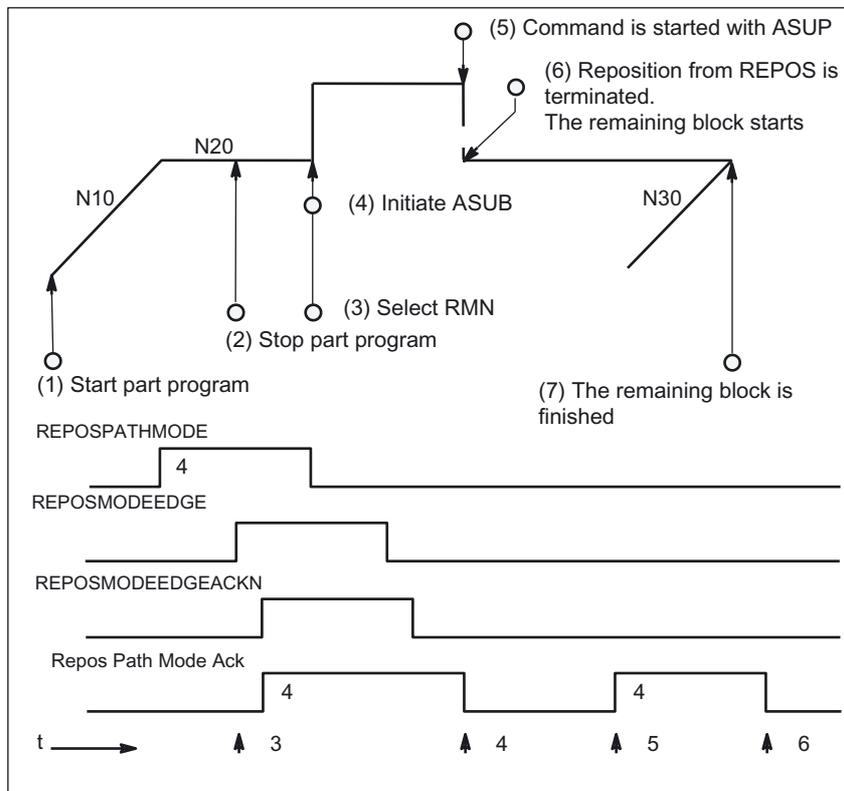


Figure 9-6 REPOS sequence in part program with timed acknowledgement signals from NCK

### NCK sets acknowledgement again

Phase with REPOSPATHMODE still active (residual block of the program stopped at → Time (2) is not yet completely executed).

As soon as the REPOS repositioning motion of the ASUB is executed, the NCK sets the "Repos Path Mode Ackn" again (→ Time (5)). If no REPOSPATHMODE has been preselected via a VDI signal, the programmed REPOS mode is displayed.

"Repos Path Mode Ackn" is canceled when the residual block is activated (→ Time (6)). The part program block N30 following the block at → Time (2) is resumed.

Interface signal:

DB31, ... DBX70.2 (Repos Delay Ackn) is defined in the same way.

DB31, ... DBX70.1 (Repos offset valid) = 1, if:

DB21, ... DBX319.1-319.3 (Repos Path Mode Ackn0 to 2) = 4 (RMN).

### Valid REPOS offset

When the SERUPRO operation is complete, the user can read out the REPOS offset via the axis/spindle VDI signal (NCK→PLC):  
DB31, ... DBX70.0 (REPOS offset).

The effects of this signal on the relevant axis are as follows:

Value 0: No REPOS offset is applied.

Value 1: REPOS offset is applied.

### Range of validity

Interface signal:

DB31, ... DBX70.0 (REPOS offset)

is supplied at the end of the SERUPRO operation.

The REPOS offset is invalidated at the start of a SERUPRO ASUB or the automatic ASUB start.

### Updating the REPOS offset within the scope

Between the SERUPRO end and SERUPRO start, the axis can be moved in JOG mode with a mode change.

In JOG mode, the user manually moves the axis over the REPOS offset path in order to set interface signal:

DB31, ... DBX70.0 (REPOS offset) to the value 0.

Within the range of validity, the axis can also be traversed using FC18, whereby the IS DB31, ... DBX70.0 (REPOS offset) is continuously updated.

### **Displaying the range of validity**

The range of validity of the REPOS offset is indicated with interface signal:

DB31, ... DBX70.1 (REPOS offset valid)

It is indicated whether the REPOS offset calculation was valid or invalid:

Value 0: The REPOS offset of this axis is calculated correctly.

Value 1: The REPOS offset of this axis cannot be calculated, as the REPOS has not yet occurred, e.g. it is at the end of the ASUB, or no REPOS is active.

### **REPOS offset after an axis replacement**

The group signal:

DB21, ... DBX319.5 (Repos DEFERRAL Chan)

can be used to determine whether a valid REPOS offset has taken place:

Value 0: All axes currently controlled by this channel have either no REPOS offset or their REPOS offsets are invalid.

Value 1: Miscellaneous.

### **REPOS offset with synchronized synchronous spindle coupling**

When repositioning with SERUPRO, processing continues at the point of interruption. If a synchronous spindle coupling was already synchronized, there is no REPOS offset of the following spindle and no synchronization path is present. The synchronization signals remain set.

### **Search target found on block change**

The axial VDI signal:

DB31, ... DBX76.4 (path axis)

is 1 if the axis is part of the path grouping.

This signal shows the status of the current block to be executed during block change. Subsequent status changes are ignored.

If the SERUPRO operation is ended with "Search target found", DB31, ... DBX76.4 (path axis) refers to the target block.

### 9.7.1.2 Repositioning on contour with controlled REPOS

#### Approach modes

##### Influence path axes individually

During SERUPRO approach, a REPOS operation is initiated in order to reposition to the contour. A large number of axes, which the user can control by means of interface signals, is frequently moved. The operator panel interface supplies the offsets per channel axis, which REPOS intends to traverse.

Repositioning of the individual path axes can be controlled by the PLC with the interface signals and it therefore has priority over the actual commands *RMI*, *RMB* and *RME* in the part program.

*RMI* Repositioning to interruption point

*RMB* Repositioning to start of block

*RME* Repositioning to end-of-block position

*RMN* Repositioning to next point on path

#### Repositioning with RMN

Like *RMI*, *RMB* and *RME*, *RMN* (REPOS Mode Next) is **redefined** for SUREPRO approach. After an interruption, *RMN* is used not to complete an already started repositioning, but to process from the next path point:

At the time REPOS is interpreted, position (B) is referenced in order to find point C at the interruption block with the shortest distance to B. The repositioning block moves from B to C to the end position.

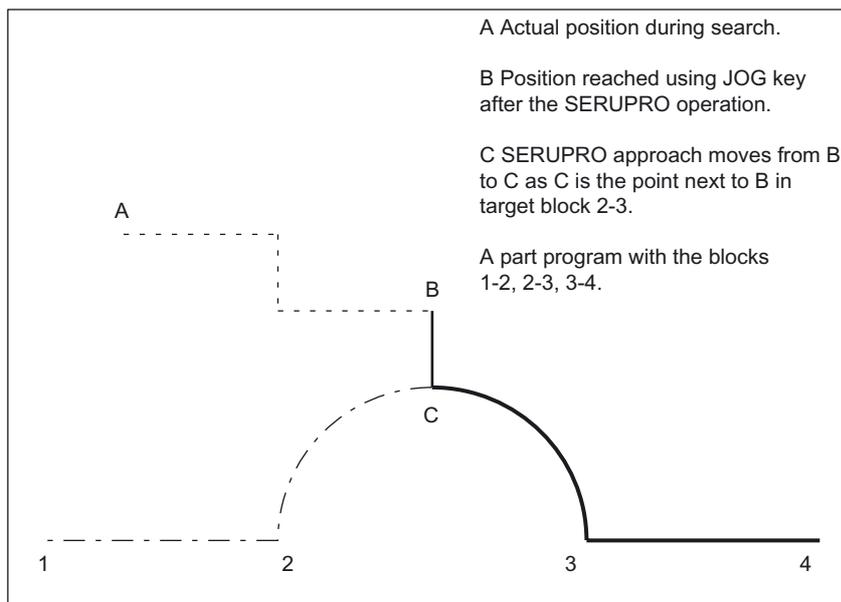


Figure 9-7 SUREPRO approach under *RMN*

## Application and procedure

SUREPRO approach with **RMN** offers the opportunity of using the application shown in the figure: If a program abort is forced by **RESET** at any point when the program is advancing from block 2 to 3,

- **RMN** is used to approach the abort location by the shortest route in order to process just the distance to go from C-3 and 3-4. The user starts a **SERUPRO** operation at the interruption block and uses the **JOG** keys to move in front of the problem component of the target block.
- **RMI** and **RMB** are always approached with **RMI** and **RMB** and the target block thus repeated once completely.

## Selecting REPOS mode

With the channel-specific VDI signal (PLC→NCK)  
DB21, ... DBX31.0-31.2 (REPOSPATHMODE0-2) the concerned function **RMB**, **RMI**, **RME** or **RMN** can be selected with the 3 bits.

### Repositioning point

**RMNOTDEF** REPOS Mode is not redefined

**RMB** Repositioning of block start point or last end point

**RMI** Repositioning interruption point

**RME** Repositioning end-of-block point

**RMN** Repositioning to next path point

DB21, ... DBX31.0-31.2 (REPOSPATHMODE)=0 corresponds to **RMNOTDEF**

DB21, ... DBX31.0-31.2 (REPOSPATHMODE)=1 corresponds to **RMB**

DB21, ... DBX31.0-31.2 (REPOSPATHMODE)=2 corresponds to **RMI**

DB21, ... DBX31.0-31.2 (REPOSPATHMODE)=3 corresponds to **RME**

DB21, ... DBX31.0-31.2 (REPOSPATHMODE)=4 corresponds to **RMN**

With DB21, ... DBX31.0-31.2 (REPOSPATHMODE0 to 2) = 0, no settings are overwritten and the current program is valid. The interface signal responds to the level of the corresponding mode.

---

### Note

**RMN** is a general REPOS extension and it is not restricted to **SERUPRO**. For **SERUPRO** **RMI** and **RMB** are identical.

With DB21, ... DBX31.0–31.2 (REPOSPATHMODE0 to 2), the path as a whole is controlled. The path axes cannot be changed individually.

The behavior of the other axis types can be changed individually using interface signal DB31, ... DBX10.0 (REPOSDELAY). This REPOS offset is not applied immediately, but only when it is next programmed.

For further information on the programming of repositioning point, please refer to

### References:

/PGA/ Job Planning Programming Manual; "Path Behavior" repositioning on Contour

---

### Read REPOS mode in synchronized actions

The valid REPOS mode of the interrupted block can be read via synchronized actions using system variable \$AC\_REPOS\_PATH\_MODE=

0: not defined	Repositioning not defined
1: RMB	Repositioning to beginning
2: RMI	Repositioning to point of interruption
3: RME	Repositioning to block end point
4: RMN	Repositioning to next geometric path point of interrupted block

## 9.7.2 Acceleration measures via MD

### Machine data settings

The processing speed of the entire SERUPRO operation can be accelerated using the following machine data.

MD22600 \$MC\_SERUPRO\_SPEED\_MODE and

MD22601 \$MC\_SERUPRO\_SPEED\_FACTOR

With MD22600 \$MC\_SERUPRO\_SPEED\_MODE == 1, the SERUPRO operation will run at the usual "dry run feedrate".

Through MD22600 \$MC\_SERUPRO\_SPEED\_MODE == 0

MD22601 \$MC\_SERUPRO\_SPEED\_FACTOR is evaluated,

and a further acceleration is permitted. Dynamic monitoring functions are disabled in this mode.

### SPEED factor for channel axes during ramp-up

Machine data MD22600 \$MC\_SERUPRO\_SPEED\_MODE is effective for the following channel axes in the main run throughout the entire SERUPRO operation:

- PLC axes
- Command axes
- Positioning axes
- Reciprocating axes

The functions of MD22600 \$MC\_SERUPRO\_SPEED\_MODE and MD22601 \$MC\_SERUPRO\_SPEED\_FACTOR apply only to SERUPRO and not to program testing. In this case **no axes/spindles are moved**.

**CAUTION**

The NC as a discrete system generates a sequence of interpolation points.  
It is possible that a synchronized action that was triggered in normal operation will no longer be triggered in SERUPRO.

**Mode of functioning with DryRun**

An active SERUPRO SPEED-FACTOR has the following effect on DryRun:

- DryRun is activated simultaneously.

This causes a switch from G95/G96/G961/G97/G971 to G94 in order to execute G95/G96/G961/G97/G971 as quickly as you wish.

- Tapping and thread cutting are performed at the usual velocity for DryRun.

DryRun and SERUPRO affect the spindle/axis with the following G codes:

- G331/G332 causes the spindle to be interpolated as an axis in a path grouping. In the case of tapping, the drilling depth (e.g. axis X) and the pitch and speed (e.g. spindle S) are specified.

In the case of DryRun, the velocity of X is specified, the speed remains constant, and the pitch is adjusted.

Following the SERUPRO simulation, the position for spindle S deviates from the normal position because the spindle S has rotated less during simulation.

### 9.7.3 SERUPRO ASUP

#### SERUPRO ASUB special points

Special points should be noted for SERUPRO ASUB with regard to:

- Reference point approach: Referencing via part program G74
- Tool management: Tool change and magazine data
- Spindle ramp-up On starting a SERUPRO ASUB

#### G74 reference point approach

If statement G74 (reference point approach) is programmed between the program start and the search target, this will be ignored by the NC.

SERUPRO approach does not take this G74 statement into account!

#### Tool management

If tool management is active, the following setting is recommended:

Set MD18080 \$MA\_TOOL\_MANAGEMENT\_MASK BIT 20 = 0.

The tool management command generated during the SERUPRO operation is thus **not** output to the PLC!

The tool management command has the following effect:

- The NC acknowledges the commands automatically.
- No magazine data are changed.
- Tool data are not changed.

Exception:

The tool enabled during the test mode can assume 'active' status. As a result, the spindle may contain the incorrect tool after the SERUPRO operation.

Remedy:

The user starts a SERUPRO ASUB that is actually traversed. Prior to the start, the user can start an ASUB that loads the correct tool.

SERUPRO operation: Functionality: In sequence steps 2. to 6.

SERUPRO ASUB: Functionality: The sequence of point 7.

In addition, machine data setting

MD18080 \$MA\_TOOL\_MANAGEMENT\_MASK Bit 11 = 1 is required because the ASUB may have to repeat a T selection.

Systems with tool management and auxiliary spindle are not supported by SERUPRO!

## Example

### Tool change subroutine

```

PROC L6                                ; Tool change routine
N500 DEF INT TNR_AKTUELL                ; Variable for active T number
N510 DEF INT TNR_VORWAHL                ; Variable for preselected T number

                                        ; Determine current tool
N520 STOPRE                            ; In program testing
N530 IF $P_ISTEST                       ; from the program context
N540 TNR_AKTUELL = $P_TOOLNO           ; the "current" tool is read.
N550 ELSE                               ; Otherwise, the tool of the spindle
                                        ; is read out.
N560 TNR_AKTUELL = $TC_MPP6[9998,1]    ; Read tool T number on the spindle
N570 ENDIF

N580 GETSELT(TNR_VORWAHL)              ; Read T number of preselected tool
                                        ; of the master spindle. Execute tool
                                        ; change only if tool not yet
                                        ; current.
N590 IF TNR_AKTUELL <> TNR_VORWAHL    ; Approach tool change position
N600 G0 G40 G60 G90 SUPA X450 Y300 Z300 D0
N610 M206                               ; Execute tool change
N620 ENDIF
N630 M17

```

### ASUB for calling the tool change routine after block search type 5

```

PROC ASUPWZV2
N1000 DEF INT TNR_SPINDEL               ; Variable for active T number
N1010 DEF INT TNR_VORWAHL              ; Variable for preselected T number
N1020 DEF INT TNR_SUCHLAUF             ; Variable for T number determined in
                                        ; block search
N1030 TNR_SPINDEL = $TC_MPP6[9998,1]   ; Read tool T number on the spindle
N1040 TNR_SUCHLAUF = $P_TOOLNO         ; read T number determined by search
                                        ; run, i.e. that tool determines the
                                        ; current tool offset.
N1050 GETSELT(TNR_VORWAHL)            ; Read T number of preselected tool
N1060 IF TNR_SPINDEL ==TNR_SUCHLAUF GOTOF ;
ASUP_ENDE1
N1070 T = $TC_TP2[TNR_SUCHLAUF]       ; T selection by tool name
N1080 L6                               ; Call tool change routine
                                        ;

```

```
N1085 ASUP_ENDE1: ;
N1090 IF TNR_VORWAHL == TNR_SUCHLAUF GOTOF ;
ASUP_ENDE
N1100 T = $TC_TP2[TNR_VORWAHL] ; Restore T preselection by tool name
;
N1110 ASUP_ENDE: ;
N1110 M90 ; Feedback to PLC
N1120 REPOSA ; ;ASUB end
```

In both of the programs PROC L6 and PROC ASUPWZV2, the tool change is programmed with M206 instead of M6.

ASUB program "ASUPWZV2" uses different system variables to detect the progress of the program (\$P\_TOOLNO) and represent the current status of the machine (\$TC\_MPP6[9998,1] ).

## Spindle ramp-up

When the SERUPRO ASUB is started, the spindle is not accelerated to the speed specified in the program because the SERUPRO ASUB is intended to move the new tool into the correct position at the workpiece after the tool change.

A spindle ramp-up is performed with SERUPRO ASUB as follows:

- SERUPRO operation has finished completely.
- The user starts the SERUPRO ASUB via function block FC 9 in order to ramp up the spindle.
- The start after M0 in the ASUB does not change the spindle status.
- SERUPRO ASUB automatically stops before the REPOS part program block.
- The user presses START.
- The spindle accelerates to the target block state if the spindle was not programmed differently in the ASUB.

---

### Note

Modifications for REPOS of spindles:

The transitions of speed control mode and positioning mode must be taken into consideration in the event of modifications in SERUPRO approach and spindle functionality.

For further information about operating mode switchover of spindles, see

### References:

/FB1/ Function Manual, Basic Functions; Spindles (S1), 2.1 Spindle Modes.

---

## 9.7.4 Self-acting SERUPRO

### Self-acting SERUPRO

The channel-specific function "Self-acting SERUPRO" allows a SERUPRO sequence **without** having to previously define a search target in a program of the associated SERUPRO channels.

In addition, a special channel, the "serurpoMasterChan", can be defined for **each** "Self-acting SERUPRO". A search target can be defined in this channel.

The "Self-acting SERUPRO" function supports the SERUPRO cross-channel block search.

### Function

The "Self-Acting SERUPRO" operation cannot be used to find a search target. If the search target is not reached, no channel is stopped. In certain situations, however, the channel is nevertheless stopped temporarily. In this case, the channel will wait for another channel. Examples are: Wait marks, couplings, or axis replacement.

### Wait phase occurs:

During this wait phase, the NC checks whether the channel "seruproMasterChan" has reached a search target. If no search target is reached, the Wait phase is left.

If the search target is reached, the SERUPRO operation is also ended in the channel. The "serupro-MasterChan" channel must have been started in normal SERUPRO mode.

### No wait phase occurs:

"Self-Acting SERUPRO" is ended by M30 of the part program. The channel is now in Reset state again. A SERUPRO approach does not take place.

### Starting a group of channels

If a group of channels is only started with "Self-Acting SERUPRO", then all channels are ended with "RESET".

Exceptions:

A channel waits for a partner channel that has not been started at all.

A cross-channel block search can be carried out as follows:

- Via the HMI, the user selects the channels that must work together (channel group).
- The user chooses an especially important channel from the channel group for which he wants to select a search target explicitly (target channel).
- The HMI will then start SERUPRO on the target channel and "Self-Acting SERUPRO" in the remaining channels of the channel group.

The operation is complete if **each** channel concerned has deleted "seruproActive".

"Self-acting SERUPRO" accepts no master channel on another NCU.

### Activation

"Self-acting SERUPRO" is activated via the HMI as a block search start for the Type 5 block search for target channel "seruproMasterChan".

No search target is specified for dependent channels started from the target channel.

## 9.7.5 Inhibit specific part of the program in the part program for SERUPRO

### Programmed interrupt pointer

As a general rule, only the user of the machine knows the mechanical situation that is currently being executed in the program. The user can use a "**programmable interrupt pointer**" to suppress SERUPRO at a particular point in the program where complex mechanical conditions prevail to enable user intervention.

Through suitable manipulation of the interrupt pointer, it is possible, with "search for interrupt point", to resume processing to the search-suppressed location **prior** to the **search-suppressed location**. Search-suppressed areas can also be defined in areas of the part program in which the NCK is not allowed to resume processing.

The last block processed before the search-suppressed target area is used as a search pointer.

### Input program section

The `IPTRLOCK` and `IPTRUNLOCK` language commands mark search-suppressed sections of the program. These language commands cannot be used in synchronized actions.

<code>IPTRLOCK</code>	Start of search-suppressed program section
<code>IPTRUNLOCK</code>	End of search-suppressed program section

#### `IPTRLOCK`

Freezes the interrupt pointer at the next "machine function block". This block is referred to below as the **Hold block**. If a program abort occurs after `IPTRLOCK`, then the hold block is used as a search pointer.

#### *Machine function block*

Is a single block (SBL1) that can be executed in the main run with a stop after each function block.

#### `IPTRUNLOCK`

The interrupt pointer is repositioned at the current block at the time of the interrupt for the subsequent program section.

---

#### Note

When a search target is found, the interrupt pointer is set to the hold block. The block search can be repeated for a new search target with the same hold block.

---

A search-suppressed area in the part program can be detected using the `$P_IPRTLOCK` variable.

### Nesting rules

The following features regulate the interaction between NC commands IPTRLOCK and IPTRUNLOCK with nesting and end of subroutine:

1. IPTRLOCK is activated implicitly at the end of the subroutine in which IPTRUNLOCK is called.
2. IPTRLOCK in an untraceable section has no effect.
3. If subprogram1 calls subprogram2 in a search-suppressed area, subprogram2 remains search-suppressed. IPTRUNLOCK in particular has no effect in subroutine 2.

### Examples of nesting with two program levels

Nesting of search-suppressed program sections in two program levels.

```

; Interpretation of the blocks in an illustrative
; sequence.
; Subprogram1 is prepared for the block search:
N10010 IPTRLOCK() ; Program level 1
N10020 R1 = R1 + 1 ;
N10030 G4 F1 ; hold block
; of the search-suppressed program section starts
... ;
N10040 Subprogram2 ; Interpretation of subprogram2
... ; Program level 2
N20010 IPTRLOCK () ; is ineffective
... ;
N20020 IPTRUNLOCK () ; is ineffective
... ;
N20030 RET ;
... ;
N10050 IPTRLOCK() ;
N10060 R2 = R2 + 2 ;
N10070 G4 F1 ; End of search-suppressed program section
```

An interruption in a search-suppressed program section of the above program always returns N10030 G4 F1 block.

### With implicit IPTRUNLOCK

Nesting of search-suppressed program sections in **two program levels with implicit IPTRUNLOCK**. The implicit IPTRUNLOCK in subprogram 1 ends the search-suppressed area.

```

; Interpretation of the blocks in an illustrative
; sequence.
; Subprogram1 is prepared for the block search:
N10010 IPTRLOCK() ; Program level 1
N10020 R1 = R1 + 1 ;
N10030 G4 F1 ; Hold block
... ; of the search-suppressed program section starts
as in previous example ;
N20030 RET ;
... ;
N10060 R2 = R2 + 2 ;
N10070 RET ; End of search-suppressed program section
N100 G4 F1 ; Main program is continued

```

An interruption in a search-suppressed program section of the above program always returns N10030 G4 F1 block.

An interruption at N100 provides N100 again in SPARPRI

### On one program level

Nesting of IPTRLOCK and IPTRUNLOCK on one program level

```

; Interpretation of the blocks in an illustrative
; sequence
; Subprogram1 is prepared for the block search:
N10010 IPTRLOCK() ; Program level 1
N10020 R1 = R1 + 1 ;
N10030 G4 F1 ; hold block
; of the search-suppressed program section starts
... ;
N10050 IPTRLOCK() ; is ineffective
... ;
N10060 IPTRUNLOCK() ; is ineffective
N10070 R2 = R2 + 2 ; End of search-suppressed program section
N100 IPTRLOCK() ; is ineffective
... ;

```

An interruption in a search-suppressed program section of the above program always returns the N10030 G4 F1 block in SPARPI.

An interruption on N100 then provides N100 again.

### Automatic interrupt pointer

In certain applications it can be useful to automatically define a prespecified type of coupling as a search-suppressed area. The automatic interrupt pointer function is activated with machine data

MD 22680 \$MC\_AUTO\_IPTR\_LOCK.

- Bit 0 = 1: Electronic gearbox with EGON
- Bit 1 = 1: Axial leading value coupling with LEADON

This program section begins with the last executable block **before** the activation and ends with the deactivation.

The automatic interrupt pointer is not active for couplings that were activated or deactivated via synchronized actions.

**Example:** To declare axial master value coupling as search-suppressed:

```
N100 G0 X100 ;
N200 EGON(Y, "NOC", X, 1, ; search-suppressed program section starts
1)
N300 LEADON(A, B, 1) ;
... ;
N400 EGOFS(Y) ;
... ;
N500 LEADOF(A, B) ; search-suppressed program section ends
N600 G0 X200 ;
```

A program abort within search-suppressed program section (N200 - N500) always provides the interrupt pointer with N100.

<b>CAUTION</b>
Using an overlap of the "programmable interrupt pointer" and "automatic interrupt pointer" via machine data, the NC selects the largest possible search-suppressed area. A program may need a coupling for almost all of the runtime. In this case, the automatic interrupt pointer would always point to the start of the program and the SERUPRO function would in fact be useless.

## 9.7.6 Special features in the part-program target block

### 9.7.6.1 STOPRE in the part-program target block

#### STOPRE block

The STOPRE block receives all modal settings from the preceding block and can, therefore, apply conditions in advance in relation to the following actions:

- Synchronize program line currently processing with the main run.
- Derive modal settings for SERUPRO in order, for example, to influence this REPOS motion on approach of SERUPRO.

#### Example 1:

Position a Z axis by specifying an X axis setpoint.

When block "G1 F100 Z=\$AA\_IM[X]" is interpreted, the preceding STOPRE block ensures synchronization with the main run. The correct setpoint of the X axis is thus read via \$AA\_IM to move the Z axis to the same position.

#### Example 2:

Read and correctly calculate external zero offset.

```

N10 G1 X1000 F100 ;
N20 G1 X1000 F500 ;
N30 G1 X1000 F1000 ;
N40 G1 X1000 F5000 ;
N50 SUPA G1 F100 X200 ; move external zero offset after 200
N60 G0 X1000 ;
N70 ... ;

```

Via an implicit STOPRE before N50, the NCK can read and correctly and correctly compute the current zero offset.

For a SERUPRO operation on the search target N50 repositioning occurs in the SERUPRO approach to the implicit STOPRE and the speed is determined from N40 with F5000.

### Implicit preprocessing stop

Situations in which interpreter issues an implicit preprocessing stop:

1. In all blocks in which one of the following variable access operations occurs: -  
Programming of a system variable beginning with \$A...  
-Redefined variable with attribute SYN/R/SYNRW
2. On the following part program commands:  
-Part program command MEACALC, MEASURE  
-Programming of SUPA (suppress frames and online offsets)  
-Programming of CTABDEF (start of curve table definition)  
-Part program command WRITE/DELETE (write/delete file)  
-Before the first WRITE/DELETE command in a sequence of such commands  
-Part program command EXTCALL  
-Part program command GETSELT, GETEXET  
-Tool change and active fine tool offset FTOCON
3. On the following commands executions:  
-Finishing of Type 1 search ("Search without calculation") and  
Type 2 search with calculation ("Search at contour end point")  
**Note:** Type 2 search "Block search at contour start point" has the same behavior.

#### 9.7.6.2 SPOS in target block

### SPOS

If a spindle is programmed with M3/M4 and the target block contains an SPOS command, the spindle is switched over to SPOS on completion of the SERUPRO process (search target located). This is indicated on the VDI interface.

#### 9.7.7 Behavior during POWER ON, mode change and RESET

SERUPRO is inactive during POWER ON. The mode change is permitted during SERUPRO. RESET will cancel SERUPRO and deselects the internally selected program test. SERUPRO cannot be combined with other block search types.

## 9.7.8 Special features of functions supported during SERUPRO

SERUPRO supports the following NC functions:

- Traversing to fixed stop: FXS and FOC automatically
- Force Control
- Synchronous spindle: Synchronous spindle grouping with COUPON
- Autonomous single-axis operations: the PLC-controlled axes
- Linkages: Setpoint and actual value couplings can be simulated  
Master/slave for drives. These functions are closely simulated by electronic gears. The relevant Axial master value coupling restrictions must be considered in each case!
- Axis couplings  
Coupled motion: Axis grouping with TRAILON and TRAILOF,  
Traverse gantry axis couplings  
Tangential control: Tangential follow-up of individual axes
- Axis functions  
Axis enable,  
Autonomous axis operations,  
Axis transfer
- Gear stage change: During program test (not fully automatically)
- Overlaid movements: Superimposed motion interpolation

For more information about these functions, see the following subsections.

### 9.7.8.1 Travel to fixed stop (FXS)

#### FXS

The functionality of FOC is repeated automatically with REPOS and designated **FXS-REPOS** below. Every axis is taken into account and the torque last programmed before the search target is applied.

Furthermore, the meaning of system variable \$AA\_FXS is redefined for SERUPRO as follows:

- \$AA\_FXS displays the current status of program simulation.
- \$VA\_FXS always describes the real machine status.

The two system variables \$AA\_FXS and \$VA\_FXS have the same values continuously **outside** the SERUPRO function.

The user can treat FXS and FOC as special commands in a SERUPRO ASUB.

### 9.7.8.2 Force Control (FOC)

#### System variables \$AA\_FOC, \$VA\_FOC

The meaning of system variable \$AA\_FOC is redefined for SERUPRO as follows:

- \$AA\_FOC represents the current status of program simulation.
- \$VA\_FOC always describes the real machine status.

The FOC-REPOS function behaves analogously to the FXS-REPOS function. The functionality of FOC is repeated automatically with REPOS and is designated FOC-REPOS. Every axis is taken into account and the torque last programmed before the search target is applied.

#### Boundary condition

A continuously changing torque characteristic **cannot** be implemented with FOC-REPOS.

#### Example

A program moves axis X from 0 to 100 and activates FOC every 20 increments for 10 increments at a time. This torque characteristic is usually generated with non-modal FOC and cannot, therefore, be traced by FOC-REPOS. FOC-REPOS will traverse axis X from 0 to 100, with or without FOC, according to the last programming.

---

#### Note

For further information about the SERUPRO block search in relation to FXS or FOC, see

#### References:

/FB1/ Function Manual, Basic Functions; Traversing to Fixed Stop (F1), General Functions

---

### 9.7.8.3 Synchronous spindle

#### The synchronous spindle can be simulated.

The synchronous spindle operation with main spindle and any number of following spindles can be simulated in all existing channels with SERUPRO.

For further information about synchronous spindles, see:

**References:**

/FB2/ Function Manual, Extended Functions; Synchronous Spindle (S3)

### 9.7.8.4 Couplings and master-slave

#### Setpoint and actual value couplings

The SERUPRO operation is a program simulation in Program Test mode with which setpoint and actual value couplings can be simulated.

#### Specifications for EG simulation

For simulation of EG, the following definitions apply:

1. Simulation always takes place with setpoint coupling.
2. If under SERUPRO there are only some, i.e. not all, leading axes, the simulation is aborted with Alarm 16952 "Reset Clear/No Start". This can occur with cross-channel couplings.
3. Axes that have only one encoder from the point of view of the NCK and are operated with external data cannot be simulated correctly. These axes must not be integrated in couplings.

 <b>CAUTION</b>
--

In order to be able to simulate couplings correctly, the couplings must have been switched off previously.
--

This can occur with machine data MD10708 \$MA_SERUPRO_MASK.
---

#### Specifications for coupled axes

The SERUPRO operation simulates coupled axes always assuming that they are setpoint couplings. In this way, the end points are calculated for **all** axes that are used as target points for SERUPRO approach. The coupling is also active with "Search target found". The path from the current point to the end point is carried out for SERUPRO approach with the active coupling.

## LEADON

The following specifications apply for the simulation of axial master value couplings:

1. Simulation always takes place with setpoint coupling.
2. SERUPRO approach takes place with active coupling and an overlaid motion of the following axis in order to reach the simulated target point.

The following axis that is moved solely by the coupling cannot always reach the target point. In SERUPRO approach, an overlaid linear motion is calculated for the following axis to approach the simulated point!

### Reaching simulated target point for LEAD with JOG

At the time of "Search target found", the coupling is already active, especially for the JOG movements. If the target point is not reached, SERUPRO approach can be used to traverse the following axis with active coupling and an overlaid motion to the target point.

---

#### Note

For further information about the repositioning of coupled axes, see "Continue machining after SERUPRO search target found".

---

## Master-slave

During the block search, only the link status should be updated without calculating the associated positions of the coupled axis.

A system ASUB can be started automatically after the block search is finished. In this subroutine, the user can control the link status and the associated axis positions subsequently. The information needed can be read from additional block search system variables.

### System variable for master/slave

The following system variables are needed for the position offset between the axes to be coupled with the desired link status:

NCK variables	Description
\$P_SEARCH_MASLD[X] Slave*	Position offset between slave and master axis when the link is closed.
\$P_SEARCH_MASLC[X] Slave*	Current status of a master/slave link was changed during block search.
\$AA_MASL_STAT[X] Slave*	Current status of a master/slave link active.

Slave\* for slave axis identifier

---

**Note**

This block search for the master/slave link is effective only if the position offset between the axes can be determined.

In order to determine the programmed positions, the axes to be linked must be in the same channel at the time of the block search. If this is not the case, the block search is aborted with alarm 15395.

Variables \$P\_SEARCH\_MASLD, \$P\_SEARCH\_MASLC and \$AA\_MASL\_STAT are cleared on MASLON.

---

For further information about the master/slave link, see:

**References:**

/FB3/ Function Manual, Special Functions; Speed/Torque Coupling (TE3), Master-Slave

The system ASUB is called progevent.spf and must be available in the /\_N\_CMA\_DIR directory. The contents might be as follows:

progevent.spf  
X=Master axis, Y=Slave axis

---

**Programming**

```
N10 IF (($S_SEARCH_MASLC[Y]< >0) AND ($AA_MASL_STAT[Y]< >0))
N20 MASLOF(Y)
N30 SUPA Y=$AA_IM[X]-$P_SEARCH_MASLD[Y]
N40 MASLON(Y)
N50 ENDIF
N60 REPOSA
```

To ensure that the ASUB can be automatically started, the following machine data must be set:

MD11602 \$MN\_ASUB\_START\_MASK = 'H03'

MD11604 \$MN\_ASUP\_START\_PRIO\_LEVEL = 100

MD11450 \$MN\_SEARCH\_RUN\_MODE = 'H02'

## Coupled axes

The following coupled axes links are compatible with the SERUPRO operation:

- Coupled motion TRAILON and TRAILOF
- Gantry axes
- Tangential control
- The activatable and deactivatable "master/slave" link as long as activation and deactivation is not selective

---

**Note**

In case of the leading axis, whose following axes are in another channel, with:  
MD22601 \$MC\_SERUPRO\_SPEED\_FACTOR = positive  
the measure for acceleration of the processing speed does not work.

---

### Coupled motion

The motion-synchronous action for coupled motion of an axis grouping with TRAILON, TRAILOF is supported by SERUPRO.

For further information about coupled motion with TRAILON, TRAILOF please refer to **References:**

/FB3/ Function Manual, Special Functions; M3, "Axis Couplings and ESR"  
/PGA/ Job Planning Programming Manual; "Path Behavior" and "Motion-Synchronous Actions"

### Gantry axes

Mechanically linked machine axes can be moved without a mechanical offset using the gantry axis function. This operation is simulated correctly with SERUPRO.

For further information about the functionality of gantry axes, refer to **References:**

/FB3/ Function Manual, Special Functions; G1, "Gantry Axes"

### Tangential control

Tangential follow-up of individual axes is supported by SERUPRO.

For further information about tangential control, see:

**References:**

/FB3/ Function Manual, Special Functions; T3, "Tangential Control"

If "overlaid movements" are used, only the block search via program test (SERUPRO) can be used, since the overlaid movements are interpolated accordingly in the main run. This applies in particular to \$AA\_OFF.

### 9.7.8.5 Axis functions

#### SERUPRO conditions

The special conditions for SERUPRO must be observed with axis enable, autonomous axis operations, and axis replacement.

#### Axis enable

The axial IS DB31, ... DBX3.7 ("Program test axis/spindle enable") controls the axis enables if no closed-loop controller enable is to (or can) be issued at the machine and is active only during the program test or when SERUPRO is active.

It is possible, via the interface signal PLC → NCK

DB31, ... DBX3.7 (program test axis/spindle enable) to do this enabling. If the real servo enable is missing during program testing or SERUPRO, the effect on the axes/spindles is as follows:

- As soon as the simulated program run intends to move an axis/spindle, the message "Waiting for axis enable" or "Waiting for spindle enable" is displayed and the simulation is stopped.
- If, during a simulated movement, the VDI signal DB31, ... DBX3.7 (program test axis/spindle enable) is canceled again, the alarm 21612: "Channel %1 axis %2 VDI signal 'servo enable' reset during motion" is activated.

#### Autonomous axis operations

Autonomous single-axis operations are axes controlled by the PLC that can also be simulated on SERUPRO. During SERUPRO operation, as in normal operation, the PLC can take over or give up control of an axis. If required, this axis can also be traversed using FC18. The PLC takes over control of the axis **before** the approach block and is responsible for positioning this axis. This is valid for all block search types.

For further information about autonomous single-axis operations, see:

**References:**

/FB2/ Function Manual, Extended Functions; P2, "Positioning axes"

### Axis replacement

Problem: A program moves an axis and gives up control before the target block with WAITP(X). X is thus not subject to REPOS and the axis is not taken into account in SERUPRO approach.

Via the machine data MD11470 \$MN\_REPOS\_MODE\_MASK, the following behavior can be achieved for SERUPRO-REPOS:

The neutral axes are moved as "command axes" in the SERUPRO-REPOS. The axis interpolates without a path context even it was last programmed as a path axis. In this scenario, the velocity results from MD32060 \$MA\_POS\_AX\_VELO. After SERUPRO approach, this axis is again neutral.

Neutral axes that are however not allowed to be repositioned must receive the axial VDI signal "REPOSDELAY". This deletes the REPOS movement.

**Example:**

After SERUPRO, one axis is deliberately moved in the synchronized action via technology cycles. The command axes are always moved in the approach block, never in the target block. The target block can only be changed if all command axes have been moved to the end.

 <b>CAUTION</b>
The PLC-controlled axis is not repositioned! Axes enabled by RELEASE(X) before the target block are not repositioned.

### 9.7.8.6 Gear stage change

#### Operational sequences

The gear stage change (GSW) requires physical movements from the NCK in order to shift into a new gear.

In the SERUPRO operation, no gear stage change is required and is carried out as follows:

Some gears can only be changed when controlled by the NC, since either the axis must oscillate or a certain position must be approached beforehand.

The gear stage change can be suppressed selectively for DryRun, program test, and SERUPRO using bits 0 to 2 in MD35035 \$MA\_SPIND\_FUNCTION\_MASK.

The gear stage change must then be performed in REPOS; this will work even if the axis involved is to be in "speed control mode" at the target block. In other cases, the automatic gear stage change is denied with an alarm if, for example, the axis was involved in a transformation or coupling between the gear stage change and the target block.

**Note**

For further information about gear stage changes in DryRun, Program test and SERUPRO, see

**References:** /FB1/ Function Manual, Basic Functions; Spindle Programming (S1)

---

### 9.7.8.7 Superimposed motion

#### Only SERUPRO

If "overlaid movements" are used, only the block search via program test (SERUPRO) can be used, since the overlaid movements are interpolated accordingly in the main run. This applies in particular to \$AA\_OFF.

#### Velocity profile instead of maximum axis velocity

During Program test, a velocity profile must be used, which allows "superimposed movements" to be interpolated during the main run. It is thus not possible to interpolate at the maximum axis velocity.

The axis velocity is set in "Dry run feedrate" mode using SD42100 \$SC\_DRY\_RUN\_FEED.

The velocity of the SERUPRO operation is selected using MD22600 \$MC\_SERUPRO\_SPEED\_MODE.

### 9.7.8.8 REPOS offset in the interface

#### REPOS offset provided or valid

When the SERUPRO operation is finished, the user can use the OPI to read off the REPOS offset applied via the REPOS process.

An axial interface bit is offered for this DB31, ...DBX70.0 (REPOS offset).

**Value 0** No REPOS offset has to be applied to this axis

**Value 1** A REPOS offset has to be applied to this axis.

Scope: The axis-VDI-interface bit "REPOS offset" is provided when the SERUPRO operation is finished. The "REPOS offset" is invalid when a SERUPRO ASUB starts or continues. The axis can be moved in JOG mode with a mode change between the SERUPRO end and start and the "REPOS offset" bit is continuously updated (i.e. the user traverses the REPOS offset by hand and the bit changes to 0). In the scope, the axis can also be traversed using FC18, with the "REPOS offset" continuously being updated.

The scope of "REPOS offset" is displayed with the axial VDI interface bit DB31, ...DBX70.1 (REPOS offset valid):

**Value 0** DB31, ... DBX70.0 (REPOS offset) has not been calculated as valid

**Value 1** DB31, ... DBX70.0 (REPOS offset) has been calculated as valid

### 9.7.8.9 Making the initial settings more flexible

#### Initial setting/initial SERUPRO setting

Machine data MD20112 \$MC\_START\_MODE\_MASK defines the initial setting of the control for part program start with respect to the G codes (especially the current plane and settable zero offset), tool length compensation, transformation, and axis couplings. The special option exists for the SERUPRO operation of using

MD22620 \$MC\_ENABLE\_START\_MODE\_MASK\_PRT

to select an initial setting that differs from the normal part program start. The new setting must therefore be stored in:

MD22620 \$MC\_START\_MODE\_MASK\_PRT

The meaning of the bits of MD22620 is identical to those of:  
MD20112 \$MC\_START\_MODE\_MASK.

#### Example

The synchronous spindle coupling at the beginning of the SERUPRO operation is retained for the part program start.

```

; synchronous spindle coupling not
; configured
$MC_START_MODE_MASK = 'H400' ; is switched off
$MC_START_MODE_MASK_PRT = 'H00' ; remains active
$MC_ENABLE_START_MODE_MASK_PRT = 'H01' ; $MC_START_MODE_MASK_PRT is evaluated
; in SERUPRO instead of
; $MC_START_MODE_MASK
```

## 9.7.9 System variables and variables for SERUPRO sequence

### SERUPRO detection

The SERUPRO sequence can be detected using the following system variables:

\$P\_ISTEST is TRUE (valid also for program test)

\$P\_SEARCH is set to 5 (search in extended program test)

\$AC\_ASUP Bit 20 in system ASUB is set after the search target is found (SERUPRO operation step 8.)

\$P\_ISTEST AND (5 == \$P\_SEARCHL) reliably detects SERUPRO.

\$AC\_SEARCH is **not** supplied by the SERUPRO operation.

---

#### Note

\$P\_SEARCHL is set at the beginning of the SERUPRO operation and

reset on RESET. As a result, \$P\_SEARCHL continues to be set in the SERUPRO ASUB and in the residual part program and can continue to be evaluated.

In contrast, the \$P\_ISTEST variable is set only in the SERUPRO operation and is thus suitable for search-specific adaptation of programs.

---

### Synchronized action

SERUPRO can be scanned in a synchronized action using system variable

\$AC\_SERUPRO = TRUE.

SERUPRO Updated REPOS acknowledgements can be scanned via:

"Program-sensitive system variable"	Description
\$AC_REPOS_PATH_MODE	Type of REPOS MODE
\$AA_REPOS_DELAY	REPOS suppression is currently active for this axis

### \$AC\_SERUPRO and \$P\_ISTEST, if SERUPRO is still active in the main run

---

**Note**

During interpretation of system variables \$P\_ISTEST and \$AC\_SERUPRO, a check is made to determine whether the SERUPRO target block has already been found.

If so, an implicit preprocessing stop is inserted before the two system variables are evaluated.

As a result, interpretation is halted and not continued again until SERUPRO is deactivated in the main run as well. The decision as to whether SERUPRO must be active or inactive is then made correctly.

---

### Additional variable for interpretation during simulation search

In JOG and MDA modes, NC variable "selectedWorkPProg" can be used to select whether the previously selected program or the program to be simulated is to be displayed in the HMI during the simulation, e.g. with SERUPRO. For more information, refer to

**References:** /LIS2/ Lists (Book 2), Section "Variables".

## 9.7.10 Restrictions

### Conditional use

SERUPRO supports the following NC functions subject to certain restrictions:

NCK functionality	Restrictions
Master/slave for drives and SERUPRO	Selective enabling and disabling of the master/slave link with MASLON active
Axis enables and SERUPRO	Real servo enable missing during program testing
Axis replacement and SERUPRO	Axes traversing as path axes before RELEASE are ignored on REPOS

## **9.8 Program operation mode**

### **PLC, MD, operation**

The execution of part programs can be controlled via the HMI in many ways using PLC inputs, machine data settings and operator inputs.

### **Definition**

The execution of part programs or part program blocks in AUTOMATIC or MDA modes is referred to as program operation.

### **Channel control**

Every channel can be manipulated by means of interface signals from the PLC. The control is exercised via mode group-specific or channel-specific interface signals. An overview of these signals is given under data lists in this Description of Functions.

### **Status messages**

Each channel reports its current program operation status to the PLC with interface signals. These signals are, in turn, divided up into mode group-specific and channel-specific signals.

## 9.8.1 Initial settings

### Machine data

Defined conditions can be set via machine data for the program operation or certain implementations of the NC language scope.

### MD settings

### Initial settings

Initial settings can be programmed in channel-specific machine data for each channel. These initial settings affect, for example, G groups and auxiliary function output.

### Auxiliary function output

The timing for output of auxiliary functions can be predefined via machine data AUXFU\_x\_SYNC\_TYPE (MD22200, 22210, 22220, 22230, 22240, 22250, 22260), (output timing for M, S, T, H, F, D, E functions). For further information, see:

**References:**

/FB1/ Function Manual, Basic Functions; Auxiliary Function Outputs to PLC (H2)

### G groups

An initial programming setting can be specified for each of the available G groups using MD20150 \$MC\_GCODE\_RESET\_VALUES (reset state of G groups). This initial setting is automatically active during program start or in Reset until it is deselected by a G command from the same G group.

Via the MD22510 \$MC\_GCODE\_GROUPS\_TO\_PLC (G codes, which are output to interface NCK-PLC after block change/RESET), the output of the G codes to the PLC interface can be activated.

A list of G groups with the associated G functions is available in:

**References:**

/PG/ Programming Manual Fundamentals

### Basic configurations of the NC language scope for SINUMERIK solution line

For SINUMERIK 840D sl, certain basic configurations of the NC language scope can be generated (configurable) via machine data. The options and functions of the NC language scope is specially tailored (configured) to the needs of the user.

## NC language scope

The way that non-active options and functions should be moved with NC language commands can be set via the machine data MD10711

\$MN\_NC\_LANGUAGE\_CONFIGURATION:

**0:** All available language commands can be programmed. Whether or not the needed function is activated can only be recognized upon execution. This corresponds to the default setting for previous controls such as SINUMERIK 840D and 840Di.

If only **certain options** are enabled and **not all operations** are available:

**1:** All **the language commands are known**. Language commands for non-enabled options are already recognized at the beginning of the program interpretation and lead to the alarm 12553 "option/function is not active."

**2:** Only those language commands are known, which correspond to the **current scope of enabled options** of the NCK software. All commands for non-enabled options are not recognized and trigger the alarm 12550 "Name not defined or option/function not available".

---

### Note

Option-free functions also have the status "enable option"

---

If only **certain functions activated** are:

**3:** All **the language commands are known**. Non-activated functions are already recognized at the beginning of the program interpretation and result in the alarm 12553 "Option/function is not active". For example, if the option date is set for the cylinder coat transformation, but the transformation is not activated in machine data MD24100 \$MC\_TRAOF\_TYPE\_1, then the programming of TRACYL triggers the alarm 12553.

**4:** Only those NC language commands are known, which correspond to the **current scope of active functions** of the NCK software. All commands for non-active functions are not recognized and trigger the alarm 12550 "Name not defined or option/function not available". Whether the command in question is generally unavailable in the Siemens NC language or whether this is true only on the corresponding system cannot be distinguished in this scenario.

Whether the current NC language scope of enabled options and active functions is also truly programmable can be checked using the STRINGIS program command, see example.

**Check sample application for NC language scope on cylinder jacket transformation TRACYL**

The cylinder jacket transformation is optional and must be enabled beforehand. In order to check this, the following initial conditions are assumed:

The cylinder coat transformation option is **not** enabled and the machine data \$MN\_NC\_LANGUAGE\_CONFIGURATION = 2; NC language command TRACYL is unknown

**The following program is started**

```
N1 R1=STRINGIS("TRACYL") ;R1 is 0 (TRACYL is an unknown name)
N2 IF STRINGIS("TRACYL") ==204
N3 TRACYL(1, 2, 3) ;block is not interpreted
N4 ELSE
N5 G00
N6 ENDIF
N7 M30
```

**Example of whether STRINGIS result is programmable or not**

The result of STRINGIS = number-coded return value (three-digit)

Number coding of the basic information (1st digit from the left):

000 Name is unknown, programming is denied with Alarm 12550

100: Name is known but cannot be programmed, triggers alarm 12533

200: Name/symbol is known, but interpretation is not possible

2xx: Name/symbol is known, the **command can be programmed**, if xx > 0

Definition for name/symbol:

Name: Any STRING that is checked to see whether it is a component of the NC language in the existing NCK version or configuration.

Symbol: contains the description or significance of an NC language command that is needed for the NC program and cycle interpretation.

Dependent on machine data MD10711

\$MN\_NC\_LANGUAGE\_CONFIGURATION = (set value) results in the following interpretations of the option and function relative to their programmability 2xx:

Table 9-1 Setting options

MD10711 =		0	1	2	3	4
Option	Function	Return value as the basic information (1st digit from the left)				
0	0	2	1	0	1	0
1	0	2	2	2	1	0
1	1	2	2	2	2	2
0	1	2	1	0	1	0

Definition for option/function:

0 corresponds to option not activated or function deactivated

1 corresponds to option/activated or function activated

For more detailed information on the value ranges of 2xx programmable functions, see

**References:**

/PGA/ Job Planning Programming Manual; Other Functions, "STRINGIS"

## 9.8.2 Selection and start of part program or part-program block

### Reset status

### Channel status

A part program can be selected only if the relevant channel is in the Reset state.

### Start command, channel status

There are two possible START commands for initiating processing of a part program or part program block:

- The channel-specific interface DB21, ... DBX7.1 (NC Start), which is usually controlled from the machine control panel key NC Start, starts program execution in the same channel.
- With the NC instruction START, program execution in the first channel can be started from the second channel, for example (for further information, see Section on Channel synchronization).

The START command can only be executed in AUTOMATIC and MDA modes. For this, the channel concerned must be in the following state:

DB21, ... DBX35.7(channel status reset) or

DB21, ... DBX35.6 (channel status interrupted).

### Signals, Alarms

#### Required signal states

The part program can now be enabled for execution in the channel with the START command on the condition that certain signal states exist on the machine.

The following enable signals are relevant on the VDI interface:

- DB11 DBX4.4 (Mode group ready) must be present
- DB11 DBX0.7 (mode group reset) must not be present
- DB21, ... DBX1.7 (activate program test) must not be present
- DB21, ... DBX7.0 (NC start disable) must not be present
- DB21, ... DBX7.2 (NC stop at the block limit) must not be present
- DB21, ... DBX7.3 (NC Stop) must not be present

### 9.8 Program operation mode

- DB21, ... DBX7.4 (NC Stop axes plus spindle) must not be present
- DB21, ... DBX7. 7 (Reset) must not be present
- DB10 DBX56.1 (Emergency stop) may not be present
- No axis or NCK alarm must be active

For a further explanation of the individual signals see Chapter 5.

#### Execution of command

The parts program or the parts program block is automatically executed and the the following interface signals are set:

DB21, ... DBX35.5 (channel status reset)

DB21, ... DBX35.0 (program status running)

The program is processed until the end of the program has been reached or the channel is interrupted or aborted by a STOP or RESET command.

#### Alarms

Under certain conditions the START command will have no effect and one of the following alarms will be triggered:

- 10200 "No NC Start permitted with active alarm"
- 10202 "No NC Start permitted with active command" (see /DA/)
- 10203 "No NC Start permitted for non-referenced axes"

### 9.8.3 Part-program interruption

#### "Interrupted" status

#### Channel status

The STOP command is executed only if the channel concerned has the status IS DB21, ... D35.5 ("Channel active").

#### STOP commands

There are various commands that stop the program execution and set the channel status to "interrupted". These are in particular the interface signals:

- DB21, ... DBX7.2 ("NC stop at the block limit)
- DB21, ... DBX7.3 ("NC stop")
- DB21, ... DBX7.4 ("NC stop, axes plus spindles")
- DB21, ... DBX2.0 ("Single block")
- Programming command "M00" or "M01".

For a further explanation of the individual interface signals, please see

**References:** /FB1/ Function Manual, Basic Functions; NC/PLC interface signals (Z1), for explanations of the individual part program instructions, see:

**References:** /PG/ Programming Guide Fundamentals; see "List of Instructions"

#### Execution of command

After execution of the STOP command, the IS DB21, ... DBX35.3 ("Program status interrupted") is set. Processing of the interrupted program can continue from the point of interruption with the command START.

The following actions are executed when the STOP command is triggered:

- Part program execution is stopped at the next block limit (with NC stop at block limit, M00/M01 or single block), processing is stopped immediately with the other STOP commands.
- Any auxiliary functions of the current block not yet output, are no longer output.
- The axes of each channel are brought to a standstill along a braking ramp and part program execution is then stopped.
- The block indicator stops at the point of interruption.

### Possible actions in the interrupt state

The following actions can be executed when the part program has been interrupted (program status stopped, channel interrupted):

- Overstoring  
**References:**  
/BEM/ Operator's Guide HMI Embedded
- Block search  
**References:**  
/BEM/ Operator's Guide HMI Embedded
- Repositioning at contour (machine function REPOS)  
**References:**  
/BEM/ Operator's Guide HMI Embedded
- Oriented tool retraction  
**References:**  
/PGA/ Programming Manual, Job Planning
- Interrupt routine (see )
- DRF-Function, Displacement of the workpiece zero  
**References:** /FB2/ Function Manual, Extended Functions; Manual and Handwheel Travel (H1)
- Starting the interrupted program with the interface signal:  
DB21, ... DBX7.1 (NC start) or  
via NC instruction START from another channel.

## 9.8.4 RESET command

### Command priority

### Channel status

The RESET command can be executed in every channel state. This command is aborted by another command.

### Commands

#### RESET-Command

The following Reset commands are available:

- DB11, ... DBX0.7 ("mode group reset")
- DB21, ... DBX7.7 ("Reset")

For a further explanation of the individual interface signals, please see

**References:** /FB1/ Function Manual, Basic Functions; NC/PLC interface signals (Z1)

A RESET command can be used to interrupt an active part program or a part program block (in MDA).

After execution of the Reset command, the interface signal DB21, ... DBX35.7 ("Channel status Reset") is set.

The part program cannot be continued at the point of interruption. All the axes of the channel go into exact stop unless they are in follow-up mode. The same applies to the spindles configured in the channel.

The following actions are executed when the RESET command is triggered:

- Part program preparation is stopped immediately.
- Axes and, if they exist, spindles in the channel are decelerated along a braking ramp.
- Any auxiliary functions of the current block not yet output, are no longer output.
- The block indicator is reset to the beginning of the part program.
- All Reset alarms (channel-specific, axis-specific, spindle-specific) are cleared from the display.

### 9.8.5 Program status

#### Interface information

The status of the selected program is displayed in the interface for each channel. The PLC can then trigger certain responses and interlocks configured by the manufacturer depending on the status. The program status is only displayed in the AUTOMATIC and MDA modes. In all other modes the program status is aborted or interrupted.

#### Program statuses

The following program statuses are available at the interface:

- DB21, ... DBX35.4 ("Program status aborted")
- DB21, ... DBX35.3 ("program status interrupted")
- DB21, ... DBX35.2 ("Program status stopped")
- DB21, ... DBX35.1 ("Program status wait")
- DB21, ... DBX35.0 ("Program status running")

For a further explanation of the individual interface signals, please see **References:** /FB1/ Function Manual, Basic Functions; NC/PLC interface signals (Z1)

#### The effect of commands/signals

The program status can be controlled by activating different commands or interface signals. The following table shows the resulting program status when these signals are set (assumption: status before the signal is set -> Program status running).

Table 9-2 Effect on program status

Commands	Program execution statuses				
	Aborted	Interrupted	Stopped	Wait	Running
IS "Reset"	X				
IS "NC Stop"			X		
IS "NC stop at block limit"			X		
IS "NC stop axes and spindles"			X		
IS "Read-in disable"					X
IS "Feed stop, channelsp."					X
IS "Feed stop, axisp."					X
Feed override = 0%					X
IS "Spindle stop"					X
M02/M30 in a block	X				
M00/M01 in a block			X		
IS "Single block"			X		
IS "Delete distance-to-go"					X

Auxiliary functions output to PLC but not yet acknowledged			X		
Wait instruction in program				X	

## 9.8.6 Channel status

### Interface representation

The current channel status is displayed in the interface. The PLC can then trigger certain responses and interlocks configured by the manufacturer depending on the status at the interface.

The channel status is displayed in all operating modes.

### Channel statuses

The following channel statuses are available at the interface:

- DB21, ... DBX35.7 ("channel status reset")
- DB21, ... DBX35.6 ("channel status interrupted")
- DB21, ... DBX35.5 ("channel status reset")

For a further explanation of the individual signals see Chapter 5.

### The effect of commands/signals

The channel status can be modified through the activation of various commands or interface signals. The following table shows the resulting channel status when these signals are set (assumed status before the signal is set - > Channel status active).

The "Channel status active" signal is obtained when a part program or part program block is being executed or when the axes are traversed in JOG mode.

Commands	Resulting channel status		
	Reset	Interrupted	active
IS "Reset"	X		
IS "NC Stop"		X	
IS "NC stop at block limit"		X	
IS "NC stop axes and spindles"		X	
IS "Read-in disable"			X
IS "Feed stop, channelsp."			X
IS "Feed stop, axissp."			X
Feed override = 0%			
IS "Spindle stop"			X
M02/M30 in a block	X		

9.8 Program operation mode

M00/M01 in a block		X	
IS "Single block"		X	
IS "Delete distance-to-go"			X
Auxiliary functions output to PLC but not yet acknowledged			X
Wait instruction in program			X

9.8.7 Responses to operator or program actions

Status transitions

The following table shows the channel and program statuses that result after certain operator and program actions.

The left-hand side of the table shows the channel and program statuses and the mode groups from which the initial situation can be selected. Various operator/program actions are listed on the right-hand side of the table, the number of the situation after the action has been carried out is shown in brackets after each action.

Table 9-3 Responses to operator or program actions

Situation	Channel status			Program status					Active mode			Operator or program action (Situation after the action)
	R	V	A	N	V	S	W	A	A	M	J	
1		x						x	x			RESET (4)
2		x						x		x		RESET (5)
3		x						x			x	RESET (6)
4	x			x					x			NC Start (13); Mode change (5 or 6)
5	x			x						x		NC Start (14); Mode change (4 or 6)
6	x			x							x	Direction key (15); Mode change (4 or 5)
7		x		x						x		NC Start (14)
8		x		x							x	NC Start (15)
9		x			x				x			NC Start (13); Mode change (10 or 11)
10		x			x					x		NC Start (16); Mode change (9 or 11)
11		x			x						x	Direction key (17); Mode change (9 or 10)
12		x				x			x			NC Start (13); Mode change (10 or 11)
13			x					x	x			NC Stop (12)
14			x	x						x		NC Stop (7); at block end (5)
15			x	x							x	NC Stop (8); at JOG end (6)
16			x		x					x		NC Stop (10); at block end (10)
17			x		x						x	NC Stop (11); at JOG end (11)
18			x				x		x			Reset (4); wait for other channel (18)

Channel status	Program status	Operating modes
R --> aborted	N --> aborted	A --> aborted
U --> interrupted	U --> interrupted	M --> aborted
A --> running	S --> stopped	J --> aborted
	W --> waiting	
	A --> running	

### 9.8.8 Part-Program Start

#### Start handling

Table 9-4 Typical program sequence

Sequence	Command	Conditions (must be satisfied before the command)	Comments
1	Load program (via the operator interface or part program)		
2	Select AUTOMATIC mode		
3	Program preselection	Channel preselected Preselected channel in RESET state User ID sufficient for program preselection	
4	NC start for preselected channel	NC start disable not available Reference point approached in all axes	
5			Program execution
6	M02/M30/RESET	None	End of program

### 9.8.9 Example of timing diagram for a program run

#### Signal sequences

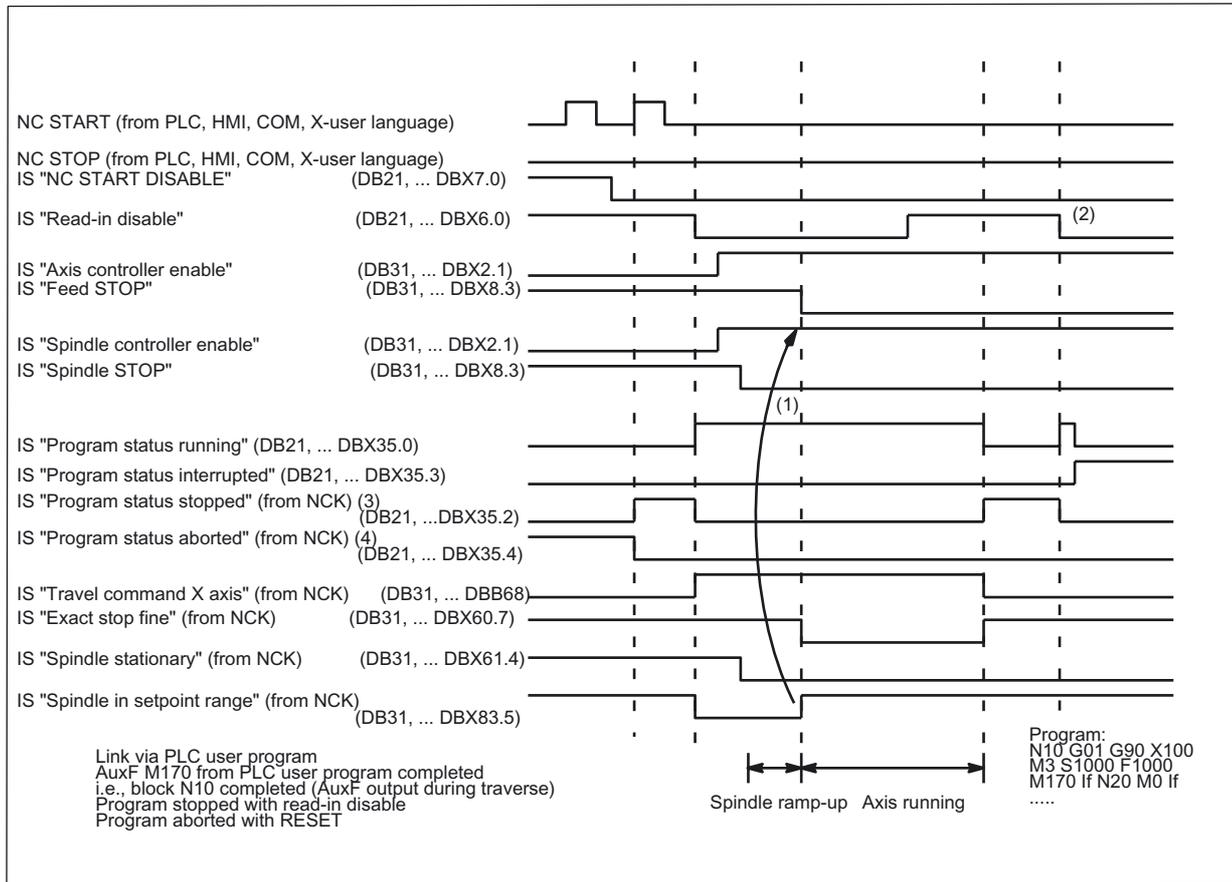


Figure 9-8 Examples of signals during a program run

## 9.8.10 Program jumps

### 9.8.10.1 Jump back to start of program

#### Function

With the function "Jump back to start of the program" the control jumps back from a part program to the beginning of the program. The program is then processed again.

As compared to the function "Program jumps to jump marks", with which a repeated processing of the program can also be implemented, the function "Jump back to the start of the program" offers the following advantages:

- The programming of a jump mark at the start of the program is not necessary.
- The program restart can be controlled through the NC/PLC interface signal:  
DB21, ... DBX384.0 (control program branching)
- The timer for the program runtime can be reset to "0" at the restart of the program.
- The timer for workpiece counting can be incremented by "1" at program restart.

#### Application

The function is used, if the processing of subsequent workpieces is to be done through an automatic program restart e.g. in case of turning machine with bar loader/-changer.

#### Activation

The jump back takes place only when the following NC/PLC interface signal is set:

DB21, ... DBX384.0 (control program branching) = 1

If the signal is at "0", then no jump back is executed and the program processing is continued with the next part program block after the function call.

#### Parameter assignment

##### Program runtime

The runtime of the selected NC program is stored in the system variable \$AC\_CYCLE\_TIME. When starting a new program, the system variable is automatically reset to "0"(see Chapter " Program runtime (Page 702) ")

Via the following machine data it can be set that the system variable \$AC\_CYCLE\_TIME is reset to "0" even in case of a program restart through the function "jump back to start of program":

MD27860 \$MC\_PROCESSTIMER\_MODE (Activation of the program runtime measurement)

9.8 Program operation mode

Bit	Value	Description
8	0	\$AC_CYCLE_TIME is <b>not</b> reset to "0" by the function "jump back to start of program".
	1	\$AC_CYCLE_TIME is reset to "0" by the function "jump back to start of program".

**Note**

In order that the setting of bit 8 can become effective, the measurement of the current program runtime must be active (MD27860 bit 1 = 1).

**Workpiece count**

After the part program end (M02/M30) has been attained, the activated workpiece counters (\$AC\_TOTAL\_PARTS/\$AC\_ACTUAL\_PARTS/\$AC\_SPECIAL\_PARTS) are incremented by "1" (see Chapter " Workpiece Counter (Page 707) ").

Via the following machine data it can be set that the activated workpiece counter is incremented even in case of a program restart through the function "jump back to start of program":

MD27880 \$MC\_PART\_COUNTER (activation of workpiece counters)

Bit	Value	Description
		In case of a program restart through the function "jump back to start of program", the workpiece counter:
7	0	\$AC_TOTAL_PARTS is <b>not</b> incremented.
	1	\$AC_TOTAL_PARTS is incremented.
11	0	\$AC_ACTUAL_PARTS is <b>not</b> incremented.
	1	\$AC_ACTUAL_PARTS is incremented.
15	0	\$AC_SPECIAL_PARTS is <b>not</b> incremented.
	1	\$AC_SPECIAL_PARTS is incremented.

**Programming**

The function is called in the main or the part program via the command GOTOS.

Syntax: GOTOS

Parameters: none

Application in synchronized actions: not possible

**Note**

GOTOS internally initiates a STOPRE (pre-processing stop).

## Example

Programming	Comment
N10 ...	; Beginning of the program
...	
N90 GOTOS	; Jump to beginning of the program
...	

## 9.8.11 Program section repetitions

### 9.8.11.1 Overview

#### Function

The program section repetition allows the repetition of any labeled section of a part program. For more information on labels, please see:

**References:**

/PG/ Programming Manual Fundamentals; Program Jumps and Program Repetitions

#### Definition options of part program sections

The program repetition offers various options for defining a part program section that is supposed to be repeated:

- A single part program block
- A part program section after a start label
- A part program section between a start label and end label
- A part program section between a start label and the key word: ENDLABEL

**References:**

/PGA/ Job Planning Programming Manual; Chapter "Program Coordination"

### 9.8.11.2 Individual part program block

#### Functionality

Via REPEATB (B=Block) in part program block N150, the part program processing branches to the part program block N120 that is labeled START\_1. This is repeated x number of times. If P is not specified, the program section is repeated exactly once. After the last repetition, the part program is continued with the part program block N160 following the REPEATB instruction.

```
:  
N100 ...  
N120 START_1: ... ; Label: START_1  
N130 ...  
N140 ...  
N150 REPEATB START_1 P=n ; Repetition after: START_1  
N160 ...  
:
```

---

#### Note

##### Label search direction

The part program block identified by the label can appear before or after the REPEATB statement. The search initially commences toward the start of the program. If the label is not found, a search is made in the direction of the program end.

---

#### Programming

Syntax: REPEATB <Label> [P=n]  
Label Start label to which the instruction: REPEAT branches  
Type: String  
P Number of repetitions  
n Number of repetitions  
Type: Integer

### 9.8.11.3 A part program section after a start label

#### Functionality

Via REPEAT in part program block N150, the part program processing branches to the part program block N120 that is labeled START\_1. This part program block and all of the following part program blocks (N130 and N140) are repeated x number of times up to the part program block that contains the REPEAT instruction (N150). If P is not specified, the part program section (N120 - N140) is repeated exactly once. After the last repetition, the part program is continued with the part program block N160 following the REPEAT instruction.

```
:  
N100 ...  
N120 START_1: ... ; Start label: START_1  
N130 ...  
N140 ...  
N150 REPEAT START_1 P=n ; Repetition after: START_1  
N160 ...  
:
```

---

#### Note

##### Label search direction

The part program block marked with the Start label **must** come before the REPEAT instruction.

---

#### Programming

Syntax: REPEAT <Label> [P=n]  
Label Start label to which the instruction: REPEAT branches  
Type: String  
P Number of repetitions  
n Number of repetitions  
Type: Integer

### 9.8.11.4 A part program section between a start label and end label

#### Functionality

Via REPEAT in part program block N160, the part program processing branches to the part program block N120 that is labeled START\_1 with a start label. This part program block and all the part program blocks up to and including the part program block marked with the end label END\_1 (N140) are repeated x number of times. If P is not specified, the part program section (N120 - N140) is repeated exactly once. After the last repetition, the part program is continued with the part program block N170 following the REPEAT instruction.

```
:  
N100 ...  
N120 START_1: ... ; Start label: START_1  
N130 ...  
N140 END_1 ... ; End label: END_1  
N150 ...  
N160 REPEAT START_1 END_1 P=n ; Repetition: START_1 until END_1  
N170 ...  
:
```

---

#### Note

##### Label search direction

The program section marked with the Start and End labels can come before or after the REPEAT instruction. The search initially commences toward the start of the program. If the Start label is not found, a search is made in the direction of the program end.

If the REPEAT instruction is between the Start and End label, only the part program section from the Start label to the REPEAT instruction is repeated.

REPEAT instruction repeated.

---

#### Programming

Syntax:	REPEAT <Start_Label> <End_Label> [P=n]
Start_Label	Start label to which the instruction: REPEAT branches. Beginning of the part program section that is repeated. Type: String
End_Label	End of the part program section that is repeated. Type: String
P	Number of repetitions
n	Number of repetitions Type: Integer

### 9.8.11.5 A part program section between a Start label and the key word: ENDLABEL

#### Functionality

Via REPEAT in part program block N150, the part program processing branches to the part program block N120 that is labeled START\_1 with a start label. This part program block and all the part program blocks up to and including the part program block marked with the key word ENDLABEL (N140) are repeated x number of times. If P is not specified, the part program section (N120 - N140) is repeated exactly once. After the last repetition, the part program is continued with the part program block N170 following the REPEAT instruction.

```
:  
N100 ...  
N120 START_1: ... ; Start label: START__1  
N130 ...  
N140 ENDLABEL: ... ; End label: Keyword ENDLABEL  
N150 ...  
N160 REPEAT START_1 END_1 P=n ; Repetition: START_1 until END_1  
N170 ...  
:
```

---

#### Note

##### Label search direction

The program section marked with the Start and End labels can come before or after the REPEAT instruction. The search initially commences toward the start of the program. If the Start label is not found, a search is made in the direction of the program end.

If no keyword ENDLABEL is located between the Start label and the REPEAT instruction, the part program section from the Start label to the REPEAT instruction is repeated.

---

#### Programming

Syntax:	REPEAT <Label> [P=n]
	Label
	Start label to which the instruction: REPEAT branches. Beginning of the part program section that is repeated. Type: String
	P
	Number of repetitions
	n
	Number of repetitions Type: Integer

## 9.8.12 Event-driven program calls

### 9.8.12.1 Function

#### What is the purpose of the function?

The function "Event-driven program calls" offers the possibility of letting an application program run implicitly during certain events, such as for doing the default settings of functions of initializations.

#### Events

Triggering events can be:

- Part program start
- Part program end
- Operator panel reset
- Power-up of the NC control

The triggering events are selected with the machine data MD20108 \$MC\_PROG\_EVENT\_MASK (see chapter "Parameterization").

#### User program

In the default setting the program `_N_PROG_EVENT_SPF` is activated after the triggering event occurs. If a different application program is to be activated, then it must be entered in the machine data MD11620 \$MN\_PROG\_EVENT\_NAME (see chapter "Parameterization").

The application program activated by the event is basically processed in the channel, in which the respective event occurred.

The application program is executed with the lowest priority and so can be interrupted by the user ASUB.

## Processing sequence

### Sequence during activation through part program start

Initial state:

Channel: in the Reset-state  
Mode: AUTO  
AUTO + oversteering or MDA  
TEACHIN

1. NC Start
2. Initialization sequence with evaluation of:  
MD20112 \$MC\_START\_MODE\_MASK (Definition of the control default settings in case of NC START)
3. Implicit call of \_N\_PROG\_EVENT\_SPF as part program
4. Processing of the data part of the main program
5. Processing of the program part of the main program

### Sequence during activation through part program end

Initial state:

Channel: in active status  
Mode: AUTO  
AUTO + oversteering or MDA  
TEACHIN

1. Block with end of part program is changed
2. Control activates reset-sequence with evaluation of machine data:  
MD \$MC\_RESET\_MODE\_MASK  
\$MC\_GCODE\_RESET\_VALUES  
\$MC\_GCODE\_RESET\_MODE
3. Implicit call of \_N\_PROG\_EVENT\_SPF as ASUB
4. Control activates reset-sequence with evaluation of machine data:  
\$MC\_RESET\_MODE\_MASK  
\$MC\_GCODE\_RESET\_VALUES  
\$MC\_GCODE\_RESET\_MODE  
⇒ The G code reset position continues to be set with machine data!

### Sequence during activation through operator panel reset

Initial state:

Channel: any

Mode: any

1. Control activates reset-sequence with evaluation of machine data:  
MD \$MC\_RESET\_MODE\_MASK  
\$MC\_GCODE\_RESET\_VALUES  
\$MC\_GCODE\_RESET\_MODE
2. Implicit call of \_N\_PROG\_EVENT\_SPF as ASUB
3. Control activates reset-sequence with evaluation of machine data:  
\$MC\_RESET\_MODE\_MASK  
\$MC\_GCODE\_RESET\_VALUES  
\$MC\_GCODE\_RESET\_MODE  
⇒ The G code reset position continues to be set with machine data!

### Sequence during activation through power-up

1. Control activates after power-up reset-sequence with evaluation of machine data:  
MD \$MC\_RESET\_MODE\_MASK  
\$MC\_GCODE\_RESET\_VALUES  
\$MC\_GCODE\_RESET\_MODE
2. Implicit call of \_N\_PROG\_EVENT\_SPF as ASUB
3. Control activates reset-sequence with evaluation of machine data:  
\$MC\_RESET\_MODE\_MASK  
\$MC\_GCODE\_RESET\_VALUES  
\$MC\_GCODE\_RESET\_MODE  
⇒ The G code reset position continues to be set with machine data!

### Signal chart

The following diagrams show the signal chart of the NC/PLC interface signals DB21, ... DBB35 ("Program status" and "Channel status") in case of event-driven program call:

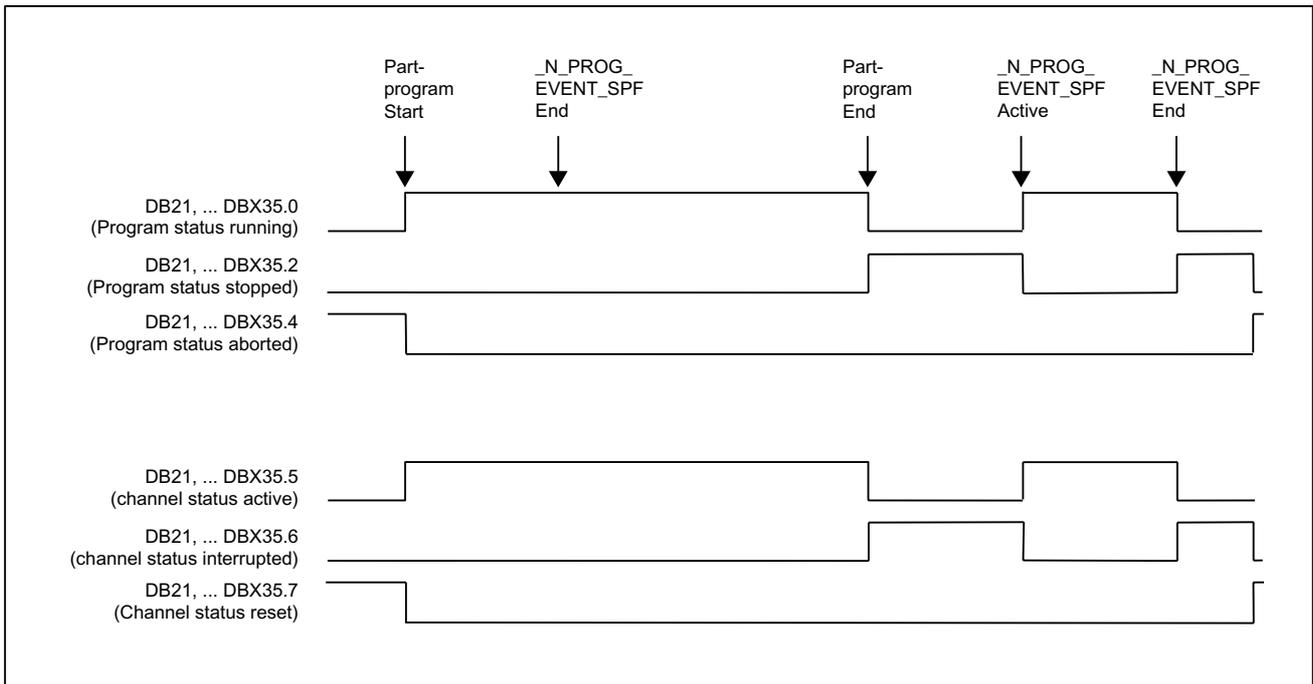


Figure 9-9 Signal chart in case of activation through part program start and part program end

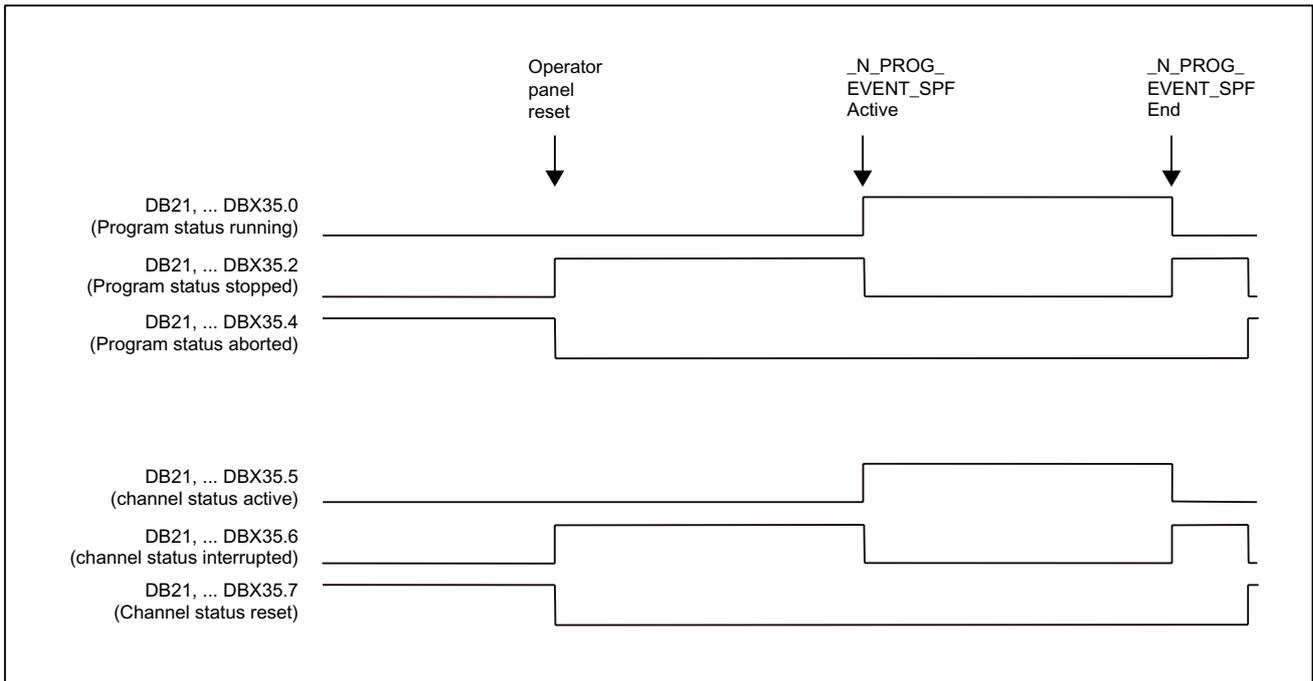


Figure 9-10 Signal chart during activation through operator panel reset

---

**Note**

DB21, ... DBX35.4 ("Program status aborted") and DB21, ... DBX35.7 ("Channel status reset") are only received if event-driven use program is complete. Between program end and the start of the event-driven application program these states are not imported. This is also the case between an operator panel reset and the start of the application program.

---

**Display**

The information about the triggering event is provided to the PLC via the NC/PLC interface byte DB21, ... DBB376.

Bit	Value	Description
0	1	Part program start from the channel status reset
1	1	Part program end
2	1	Operator panel reset
3	1	Ramp-Up
4	1	1st start after block search (see "Automatic Start of an ASUB after block search (Page 530)")

The global query of DB21, ... DBB376 on 0 enables the determination, whether an event-driven application program is active at all.

If the event-driven application program has expired or has been interrupted with RESET, then the related display bit is deleted in the interface. For a very brief program, the corresponding bit remains for at least the duration of a complete PLC cycle.

### 9.8.12.2 Parameter assignment

#### Triggering event

Which events the application program should activate, is set channel-specific in the machine data:

MD20108 \$MC\_PROG\_EVENT\_MASK (event-controlled program call)

Bit	Value	Description
0	1	Activation through <b>part program start</b>
1	1	Activation through <b>part program end</b>
2	1	Activation through <b>Operator panel reset</b>
3	1	Activation through <b>Power up</b> of the NC control

Prerequisite for the activation:

The application program (default setting: `_N_PROG_EVENT_SPF`) must be loaded and cleared.

---

#### Note

MD20108 \$MC\_PROG\_EVENT\_MASK is ignored during the simulation.

---

#### User program

In the default setting after an event set with MD20108 occurs, the program `_N_PROG_EVENT_SPF` is activated from the directory `_N_CMA_DIR`.

If another program is to be activated, then the name of this user program must be entered in the following machine data:

MD11620 \$MN\_PROG\_EVENT\_NAME

The specified program must be present in one of the cycle directories.

The following search path is run when an event set with MD20108 occurs.

1. `/_N_CUS_DIR/` for user cycles
2. `/_N_CMA_DIR/` for manufacturer cycles
3. `/_N_CUS_DIR/` for standard cycles

The first found program with the given name is called.

---

#### Note

The specified name is checked syntactically as in case of a subroutine identifier i.e. the first two characters must be alphabets or underscores (no digits). Prefix (`_N_`) and suffix (`_SPF`) of the program names are added automatically, if not specified.

---

**Note**

The same protection mechanisms that can be activated for cycles (protection levels for writing, reading etc.) are activated.

**Behavior when starting a user ASUB**

The behavior of the function "event-driven program call" upon start of a user ASUB from the channel status reset can be set channel-specific with the machine data:

MD20109 \$MC\_PROG\_EVENT\_MASK\_PROPERTIES

Bit	Value	Description
0	0	The occurrence of an event set with MD20108 (part program start, part program end and/or operator panel reset) leads to the activation of the event-driven user program.
	1	The occurrence of an event set with MD20108 does <b>not</b> lead to the activation of the event-driven user program.

**Behavior when the single block processing is set**

The behavior of the function "event-driven program call" in case of set single block processing can be set channel-specific with the machine data:

MD20106 \$MC\_PROG\_EVENT\_IGN\_SINGLEBLOCK

Bit	Value	Description
		In the event-driven user program:
0		• after an activation through part program start
	0	the single block processing is effective.
	1	the single block processing is suppressed.
1		• after an activation through part program end
	0	the single block processing is effective.
	1	the single block processing is suppressed.
2		• after an activation through operator panel reset:
	0	the single block processing is effective.
	1	the single block processing is suppressed.
3		• after an activation through power-up
	0	the single block processing is effective.
	1	the single block processing is suppressed.

If the single block processing is suppressed, then the event-driven user program is processed without interruption.

**Note**

MD20106 \$MC\_PROG\_EVENT\_IGN\_SINGLEBLOCK affects all single block processing types.

**Note**

The single block processing in the event-driven user program can be switched-off through the following configuration:

MD10702 \$MN\_IGNORE\_SINGLEBLOCK\_MASK (Prevent single block stop) bit 0 = 1

The differentiated settings in MD20106 \$MC\_PROG\_EVENT\_IGN\_SINGLEBLOCK are then ineffective.

**Behavior when the read-in disable is set**

The behavior of the function "event-driven program call" in case of set read-in disable (DB21, ... DBX6.1 = 1) can be set channel-specific with the machine data:

MD20107 \$MC\_PROG\_EVENT\_IGN\_INHIBIT

Bit	Value	Description
		In the event-driven user program:
0		• after an activation through part program start
	0	the read-in disable is effective.
	1	the read-in disable is suppressed.
1		• after an activation through part program end
	0	the read-in disable is effective.
	1	the read-in disable is suppressed.
2		• after an activation through operator panel reset:
	0	the read-in disable is effective.
	1	the read-in disable is suppressed.
3		• after an activation through power-up
	0	the read-in disable is effective.
	1	the read-in disable is suppressed.

**Note**

For bit 0 = 1 (user program is activated after part program start) the following constraint is applicable:

If the user program is ended with the part program command `RET`, then `RET` always leads to an executable block (similar to `M17`).

In case of bit 0 = 0, `RET` interpretation is done in the interpreter and leads to an executable block.

**Suppress updating of the display of the program and channel statuses.**

In order to avoid a flickering of the display of the program and the channel statuses in the operator panel, the updating of the display can be suppressed for the execution of the normally very brief event-driven user program. In the display then, the program and channel status remains visible before activation of the event-driven user program (e.g. "program status cancelled" and "channel state reset").

The parameterization of this function is done with the channel-specific machine data:

MD20192 \$MC\_PROG\_EVENT\_IGN\_PROG\_STATE

Bit	Value	Description
		During execution of an event-driven user program the updating of the display of the program and channel status
1		<ul style="list-style-type: none"> <li>upon an activation through part program end</li> </ul>
	0	is not suppressed.
	1	suppressed.
2		<ul style="list-style-type: none"> <li>upon an activation through operator panel reset:</li> </ul>
	0	is not suppressed.
	1	suppressed.
3		<ul style="list-style-type: none"> <li>upon an activation through power-up</li> </ul>
	0	is not suppressed.
	1	suppressed.

**Note**

The system variables \$AC\_STAT and \$AC\_PROG are not affected by this function, i.e. in the running event-driven user program \$AC\_STAT is set to "active" and \$AC\_PROG to "running".

NC/PLC interface signals DB21, ... DBX35.0-7 ("Program status ..." and "Channel status ...") also remain unaffected.

## Behavior for NC Stop

The behavior of the function "event-driven program call" for NC-Stop (i.e. NC/PLC interface signal DB21, ... DBX7.2, 7.3 or 7.4 is set) can be set channel-specific for the triggering event part program end, operator panel reset and power up with the machine data:

MD20193 \$MC\_PROG\_EVENT\_IGN\_STOP

Bit	Value	Description
		The event-driven user program is:
1		<ul style="list-style-type: none"> <li>upon an activation through part program end</li> </ul>
	0	stopped/prevented at NC stop
	1	despite NC Stop been completely processed.
2		<ul style="list-style-type: none"> <li>upon an activation through operator panel reset:</li> </ul>
	0	stopped/prevented at NC stop
	1	despite NC Stop been completely processed.
3		<ul style="list-style-type: none"> <li>upon an activation through power-up</li> </ul>
	0	stopped/prevented at NC stop
	1	despite NC Stop been completely processed.

In this way, an edge change of the interface signal DB21, ... DBX7.3 (NC-Stop) initiated by the user by activating the NC Stop key in case of reset or power-up is ignored during the execution of the event-driven user program and an undesired stop behavior at the machine is prevented.

### Note

A programming of `DELAYFSTON`/`DELAYFSTOF` in the event-driven user program cannot be provided with the behavior set with MD20193, because the NC Stop can cause an interruption before the execution of the first command `DELAYFSTON`.

### 9.8.12.3 Programming

#### User program

##### End of program

The following must be kept in mind, if the user program is to be activated through the part program start.

- The user program must be ended with `M17` or `RET`.
- A jump back by means of `REPOS` command is not permitted and leads to an alarm.

##### Block display

The display can be suppressed in the current block display using the `DISPLOC` attribute in the `PROC` statement.

##### Processing status

Via the user M function the PLC can be informed about the processing status of the event-driven user program.

#### Scan for triggering event

The event, which causes the activation of the user program, can be queried in the user program with the following system variable:

`$P_PROG_EVENT` (event-driven program call active)

Value	Description
1	Activation through <b>part program start</b>
2	Activation through <b>part program end</b>
3	Activation through <b>Operator panel reset</b>
4	Activation through <b>Power up</b>
5	Activation after output of the last action block after <b>Block search</b> (see "Automatic Start of an ASUB after block search (Page 530)")

#### Query of the current channel

The application program is basically processed in the channel, in which the corresponding event has occurred. The current channel is queried in the user program with the following system variables:

`$P_CHANNO` (query of the current channel number)

---

##### Note

Power up is an event that takes place in all channels.

---

### 9.8.12.4 Boundary conditions

#### Emergency stop/error message

If an error is present when the operator panel is reset or after power-up EMERGENCY STOP or Mode group/NCK-Continue, then the event-driven user program will only be processed after EMERGENCY STOP or the error has been acknowledged in all channels.

---

#### Note

The power up event occurs in all channels at the same time.

---

### 9.8.12.5 Examples

#### Example 1: Call of all events set with MD20108

Parameter assignment:

MD20108 \$MC\_PROG\_EVENT\_MASK = 'H0F'

Call of \_N\_PROG\_EVENT\_SPF for:

- Part program start
- Part program end
- Operator panel reset
- Ramp-Up

Programming:

Program code	Comment
PROC PROG_EVENT DISPLOF	
IF (\$P_PROG_EVENT==1)	; Processing for part program start.
MY_GUD_VAR=0	; Initialize GUD variable
RET	
ENDIF	
IF (\$P_PROG_EVENT==2) OR (\$P_PROG_EVENT==3)	; Processing for part program end and operator panel reset.
DRFOF	; Deactivate DRF offsets
IF \$MC_CHAN_NAME=="CHAN1"	
CANCEL(2)	; Delete modal synchronized action 2
ENDIF	
RET	
ENDIF	

9.8 Program operation mode

Program code	Comment
IF (\$P_PROG_EVENT==4)	; Sequence for power-up
IF \$MC_CHAN_NAME=="CHAN1"	
IDS=1 EVERY \$A_INA[1]>5.0 DO \$A_OUT[1]=1	
ENDIF	
RET	
ENDIF	
RET	

**Example 2: Call through Operator panel reset**

Parameter assignment:

MD20108 \$MC\_PROG\_EVENT\_MASK = 'H04'

Call of \_N\_PROG\_EVENT\_SPF for:

- Operator panel reset

Programming:

Program code	Comment
PROC PROG_EVENT DISPLOF	
N10 DRFOF	; Deactivate DRF offsets
N20 M17	

**Example 3: Initialization of the function**

Section of the startup file (\_N\_INITIAL\_INI):

Program code	Comment
...	
CHANDATA (3)	; Initialization for channel 3
\$MC_PROG_EVENT_IGN_INHIBIT='H04F'	
\$MC_PROG_EVENT_MASK='H04'	
...	

Meaning:

The part program \_N\_PROG\_EVENT\_SPF from the directory \_N\_CMA\_DIR should be started automatically with the RESET key and processed till the end, regardless of whether the read-in disable is activated or deactivated.

### 9.8.13 Influencing the Stop events through Stop delay area

#### Stop Delay Area

The reaction to a stop event can be influenced by conditioned interruptible area in the current part program. Such a program area is called stop delay area.

Within the stop delay areas there should be no stop and the feed should not be changed. Stops do not take effect until the program section has been completed (Example: making of a thread).

A stop delay area is defined with the part program commands:

```
DELAYFSTON      Start a Stop Delay Area
DELAYFSTOF      End a Stop Delay Area
```

#### References:

Programming Manual, Job Planning;

#### Stop events

Overview of the NCK events that cause a stop:

NCK events	Response	Stop criteria
Reset and mode group RESET	immediate	IS: DB21, ... DBX7.7 and DB11 DBX20.7
PROG_END	Alarm 16954	NC prog.: M30
Interrupt	delayed	IS: "FC-9" and ASUP DB10 DBB1
DELDISTOGO_SYNC	immediate	IS: "Delete distance-to-go" DB21, ... DBX6.2 and axial
PROGRESETREPEAT	delayed	IS: "Clear number of subprogram passes" DB21, ... DBX6.3
PROGCANCELSUB	delayed	IS: "Program level abort" DB21, ... DBX6.4
SINGLEBLOCKSTOP	delayed	In the stop delay area: NC stops at the end of the 1st block outside the stop delay area. Single block is active before the stop delay area: IS: "NC Stop at block limit" DB21, ... DBX7.2
SINGLEBLOCK_IPO	delayed	IS: "Activate single-block type 1" DB11 DBX21.7
SINGLEBLOCK_DECODIER	delayed	IS: "Activate single-block type 2" DB11 DBX21.6
STOPALL	immediate	IS: DB21, ... DBX7.4 and DB11 DBX20.6
STOPPROG	delayed	IS: DB21, ... DBX7.3 and DB11 DBX20.5
OVERSTORE_BUFFER_END_REACHED	Alarm 16954	NC prog.: Stop because of empty overstore buffer
PREP_STOP	Alarm 16954	NC prog.: STOPRE and all implicit Stopres
PROG_STOP	Alarm 16954	NC prog.: M0 and M1
STOPPROGATBLOCKEND	delayed	IS: "NC Stop at block limit" DB21, ... DBX7.2
STOPPROGATSUPEND	System fault	SR end should always deselect the stop delay section.
WAITM	Alarm 16954	NC prog.: WAITM
WAITE	Alarm 16954	NC prog.: WAITE
INIT_SYNC	Alarm 16954	NC prog.: INIT with parameter "S"

9.8 Program operation mode

NCK events	Response	Stop criteria
MMCCMD	Alarm 16954	NC prog.: MMC( STRING, CHAR )
PROGMODESLASHON	delayed	IS: DB21, ... DBB26 Activate/switch over skip block
PROGMODESLASHOFF	delayed	IS: DB21, ... DBB26 deactivate skip block
PROGMODEDRYRUNON	delayed	IS: DB21, ... DBX0.6 Activate DryRun
PROGMODEDRYRUNOFF	delayed	IS: DB21, ... DBX0.6 Deactivate DryRun
BLOCKREADINHIBIT_ON	delayed	IS: DB21, ... DBX6.1 Activate read-in disable
STOPATEND_ALARM	immediate	Alarm: Alarm configuration STOPATENDBYALARM
STOP_ALARM	immediate	Alarm: Alarm configuration STOPBYALARM
STOPATIOBUFFER_IEMPTY_ALARM	immediate	Internal: Stop after alarm on empty IPO buffer
STOPATIOBUF_EMPTY_ALARM_REORG	immediate	Internal: Stop after alarm on empty IPO buffer
RETREAT_MOVE_THREAD	Alarm 16954	NC prog.: Alarm 16954 at LFON (Stop & fast lift in G33 not possible)
WAITMC	Alarm 16954	NC prog.: WAITMC
NEWCONF_PREP_STOP	Alarm 16954	NC prog.: NEWCONF
BLOCKSEARCHRUN_NEWCONF	Alarm 16954	NC prog.: NEWCONF
SET_USER_DATA	delayed	OPI: PI "_N_SETUdT"
SYSTEM_SHUTDOWN	immediate	System shutdown for SINUMERIK 840Di
ESR	delayed	Extended stop and retract
EXT_ZERO_POINT	delayed	External work offset
STOPRUN	Alarm 16955	OPI: PI "_N_FINDST" STOPRUN

**Reaction**

The reaction to a stop event can be:

- **immediate**  
Stops immediately even in stop delay section. Is known as a "hard stop event".
- **delayed**  
Does not stop (even short-term) until after stop delay section. Is known as a "soft stop event".
- **Alarm 16954**  
Program is aborted because illegal program commands have been used in stop delay section.
- **Alarm 16955**  
Program is continued, an illegal action has taken place in the stop delay section.

- **Alarm 16957**

The program section (stop delay section) enclosed by `DELAYFSTON` and `DELAYFSTOF` could not be activated. As a result, every stop will take effect immediately and is not subject to a delay! This will always occur when the deceleration begins before the stop delay area but ends within the stop delay area. Likewise, if the stop delay area is entered with an override of 0, the stop delay area also cannot be activated. (example: a `G4` before the stop delay section allows the user to reduce the override to 0. The next block in the stop delay section then begins with override 0 and the described alarm situation occurs.)

---

**Note**

MD11411 `$MN_ENABLE_ALARM_MASK` (activation of warnings) Bit 7 activates this alarm.

---

**Stop criteria**

A stop event can be triggered by the following

- VDI interface signals from the PLC → "Hard" stop event
- Alarms with `NOREADY` response → "Hard" stop event
- Stop key → "Soft" stop event
- Read-in disable → "Soft" stop event
- Single BLock → "Soft" stop event

---

**Note**

Some NCK events are stopped for a short time, in order to perform a switching operation, and restart immediately. These include e.g. the `ASUB` that stops the contour briefly in order to then start the `ASUB` program immediately. These events are also allowed in the stop delay area, however they are pushed back to its end and are thus considered "soft stop events".

---

**Conditions**

The following conditions apply while a stop delay area is being processed:

- A change in the **feed** is ignored while in the stop delay area. A **feed disable** is thus not effective until the program area has been exited, and is stopped.
- None of the main run axes, such as command axes and positioning axes, which are traversed with `POSA`, is stopped.
- Part program command `G4` is permitted in the stop delay area.

Other part program commands that cause a stop in the meantime (e.g. `WAITM`), are not permitted and trigger the alarm 16954.

- A stop delay section entered with an override of 0% will not be accepted!

## 9.9 Asynchronous subroutines (ASUBs), interrupt routines

### 9.9.1 Function

#### 9.9.1.1 General functionality

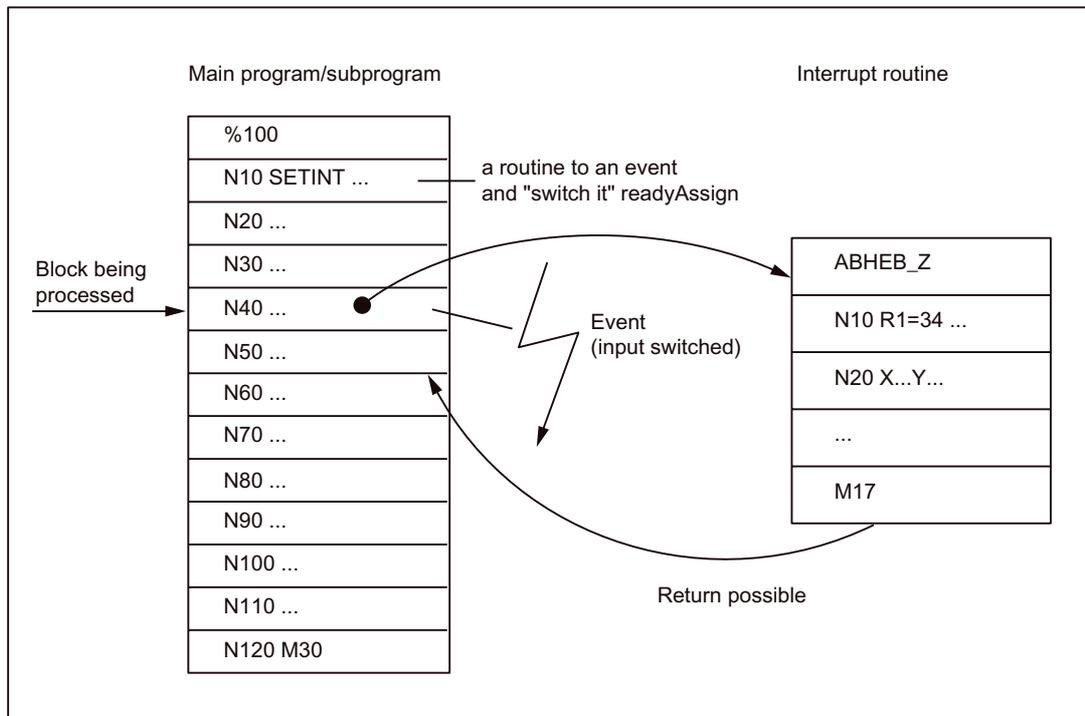
**Note**

The terms "asynchronous subroutines (ASUB)" and "interrupt routines" used alternatively in the description below refer to the same functionality.

#### interrupt routines

Interrupt routines are normal part programs, which are started by interrupt events (interrupt inputs, process or machine status) related to the machining process or the relevant machine status.

Any part program block currently being executed will be interrupted by the routine if it is not specifically declared to be locked against interruption. It is possible to continue the subroutine at the point of interruption at a later stage.



## Definition of interrupt routines

The command `SETINT` or an interrupt signal via the PI service "ASUB" must be assigned to a part program, which is supposed to act as interrupt routine. This turns the part program into an interrupt routine.

## Interrupt signals

- A total of 8 interrupt signals (inputs) are available.
- All inputs can be controlled via the PLC.
- The first four interrupt signals are also controlled via the 4 rapid NC inputs of the NCU module.
- The signal status of the rapid NC inputs can be read out via the PLC interface (DB10).
- The transmission of the rapid NC input signals to the interrupt signals can be disabled via the PLC interface (DB10).

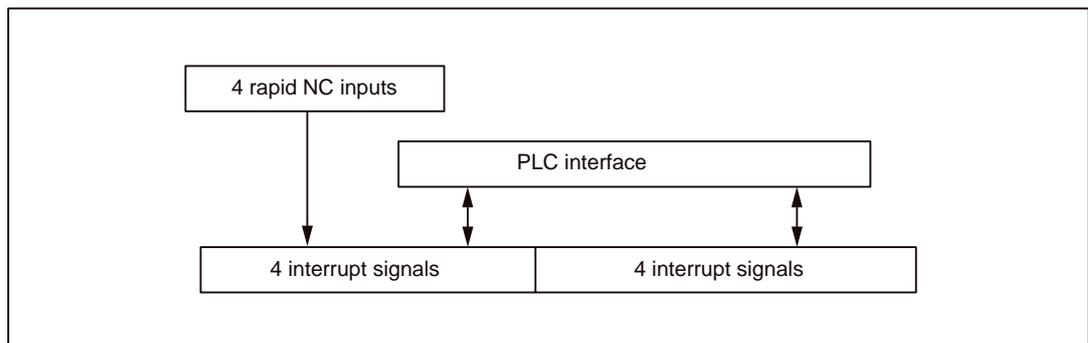


Figure 9-11 Interrupt signals

For more information on PLC control of the rapid NC inputs (interrupt signals) see:

**References:**

Function Manual, Basic Functions; PLC Basic program (P3)

Function Manual, Extended Functions; Digital and analog NCK I/Os (A4)

## Call of interrupt routines

### During program operation

It is possible to call the interrupt routines, when the mode groups are present in program operation. This means that the processing is done either in the mode type AUTOMATIC or MDA part program blocks.

### Outside the program operation

Interrupt routines can also be activated in the following program statuses or mode types:

- JOG, JOG REF
- MDA Teach In, MDA Teach In REF, MDA Teach In JOG, MDA REF, MDA JOG
- AUTOMATIC, stopped, ready
- Not referenced

If an interrupt routine is activated in JOG or REF mode, it will interrupt any jogging and referencing operations in progress.

## Activating

The activation of an interrupt routine can be done:

- By a 0/1 transition of the interrupt signal, triggered by a 0/1 transition at the rapid NC input
- by the call of the "Function Call ASUB"

### References:

Function Manual, Basic Functions; PLC Basic Program (P3)

- an exit is set via the synchronous action, which indirectly sets an interrupt entry via short-circuit (see " Examples (Page 635) ").

### References:

Function Manual, Synchronized Actions

## Display

The activation of an interrupt routine is shown with the following NC/PLC interface signal:

DB21, ... DBX378.0 (ASUB active)

### 9.9.1.2 Sequence of an interrupt routine in program operation

#### Decelerating the axes

Upon activation, all machine axes are decelerated to a standstill according to the acceleration ramp(MD32300 \$MA\_MAX\_AX\_ACCEL), and the axis positions are stored.

#### Reorganization

In addition to decelerating the axes, the previously decoded calculation blocks are calculated back to the interruption block. i.e. all the variables, frames and G codes are assigned the value that they would have at the point of interruption if the part program had not been previously decoded. These values are put in the buffer so that they can be called up again when the interrupt routine is completed.

Exceptions, where no reorganization is possible:

- In thread cutting blocks
- With complex geometries (e.g. spline or radius compensation)

#### Processing of interrupt routine

The Interrupt routine is automatically started on completion of reorganization.

The system handles the interrupt routine like a normal part program (nesting depth, etc.)

#### End of interrupt routine

After the end identifier (M02, M30, M17) of the Interrupt routine has been processed, the axis traverses by default to the end position programmed in the part program block following the interruption block.

A REPOS instruction must have been programmed at the end of the interrupt routine if return positioning to the point of interruption is required, e.g.

```
N104 REPOS L M17
```

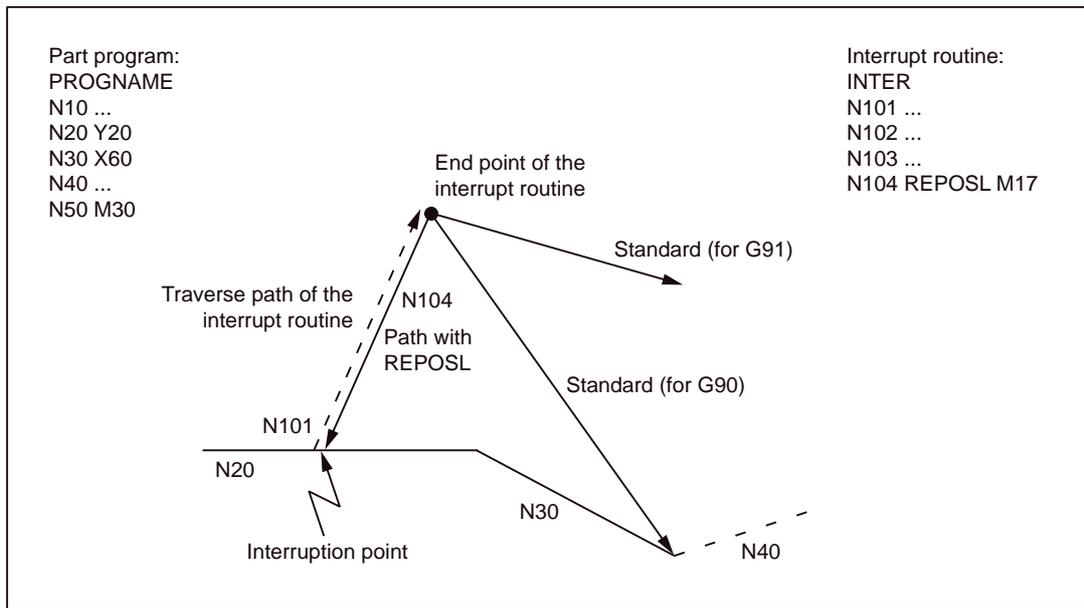


Figure 9-12 End of interrupt routine

### 9.9.1.3 Interrupt routine with REPOSA

If an interrupt routine with REPOSA triggered by the PLC (block FC9) "interrupted" in channel status in program operation is completed, then the following sequence is typical:

1. Before the re-approach to the contour, the controller stops and goes to program status "Stopped". The following NC/PLC-interface signal is set:  
DB21, ... DBX318.0 (ASUB is stopped)
2. The operator presses the START key. Thereupon, the signal DB21, ... DBX318.0 is reset and the re-approach motion starts.
3. At the end of the re-approach motion, the FC9 signal "ASUB done" is set and the path of the interrupted part program is continued.

---

**Note**

The NC/PLC-interface signal DB21, ... DBX318.0 (ASUB is stopped) is available only for the following case: Interrupt "interrupted" in program operation in the channel status.

---

**Note**

In case of interrupt routines that close without REPOS, the signals "Asub-Done" and DB21, ... DBX318.0 (ASUB is stopped) occur at the same time.

---

## 9.9.1.4 NC response

The different reactions of the control to an activated interrupt routine in the various operating states are given in the following table:

Status of NC	ASUB start	Control system reaction
Program is active	Interrupt, (PLC)	<ol style="list-style-type: none"> <li>1. Fast retraction or stop axes</li> <li>2. Interrupt the program for the duration of the ASUB</li> <li>3. Approach of the interruption point, if REPOS in ASUB</li> <li>4. Continuation of the part program</li> </ol>
RESET	Interrupt, (PLC)	<p>The ASUB is executed like a main program. RESET (without M30) is executed at the end of the ASUB. The next control system status depends on the following machine data:</p> <p>MD20110 \$MC_RESET_MODE_MASK MD20112 \$MC_START_MODE_MASK</p> <p><b>References:</b> Function Manual, Basic Functions; Axes, Coordinate Systems, Frames (K2), Chapter: "Workpiece-related actual-value system"</p>
Program operation (AUTOMATC or MDA) + channel stopped	Interrupt, (PLC)	<p>ASUB is executed. At the end of the ASUB the STOP state is reapplied. If REPOS in the ASUB:</p> <ul style="list-style-type: none"> <li>• The ASUB processing is stopped before the approach block.</li> <li>• The approach movement can be initiated with the Start key.</li> </ul>
	Start key	Once the ASUB has been executed, processing of the interrupted program is resumed.
Manual mode + channel stopped	Interrupt, (PLC)	Control system assumes the status "internal program execution mode" for the addressed channel (not evident externally) and then activates the ASUB. The selected operating mode remains valid. The original status is resumed after execution of the ASUB (M17).
JOG AUTO Teach-In AUTO Teach reference pnt.	Interrupt, (PLC)	Stop processing, evaluate: MD11602 \$MN_ASUP_START_MASK MD11604 \$MN_ASUP_START_PRIO_LEVEL
MDA JOG, MDA Teach-In, MDA Teach reference pnt.	Interrupt, (PLC)	Internal switchover to "internal program execution mode" if appropriate, activate ASUB, restore status prior to ASUB start. Any LIFTFAST defined with SETINT is not activated in JOG mode.
Manual mode + channel running	Interrupt, (PLC)	The current active motion is stopped. The distance-to-go is deleted. The remaining sequence of operations is the same as for "Manual mode, channel stopped".
Processing of INITIAL.INI	<b>not possible</b>	The signal "Interrupt request not possible" is generated.
Block search		
Alarm that cannot be removed by NC start.		
Digitalizing active		
Channel in fault condition		

### 9.9.2 Parameter assignment

#### Effect of mode group signals

The effect of the mode group signals (mode group reset, mode group Stop axes plus spindle, mode change disable, ...) on channels of mode group, which are currently processing the interrupt routines, is set in the machine data:

MD11600 \$MN\_BAG\_MASK

Bit	Value	Description
0	0	Mode group signals are applicable.
	1	Mode group signals are not applicable.

MD11600 also controls, whether the internal program execution mode is imported only for the channel, in which the interrupt routine has been activated, or to all channels in the mode group.

Bit	Value	Description
1	0	The mode switchover is done to all channels in the mode group.
	1	An internal mode switchover takes place only in the channel, in which the interrupt routine was activated (possible only if bit 0 is set to "1").

If, via MD 11600, the channel in which the interrupt is running has left the mode group, the mode group signals Mode Group RESET, Mode Group STOP, ... have **no** effect on this channel. In this way the interrupt routines can run without being disturbed by the mode group signals.

#### Ignore stop conditions

In the default setting an ASUB start is prevented under the following conditions:

- Stop by means of Stop key, M0, M01
- Not all axes are referenced yet
- read-in disable is active (DB21, ... DBX6.1 = 1)

Via the following machine data the ASUP Start can also be enabled for these conditions:

MD11602 \$MN\_ASUP\_START\_MASK (ignore stop conditions for ASUB)

Bit	Value	Description
0		Stop reason: <b>Stop key, M0 or M1</b>
	0	Stop reason prevented ASUB start.
	1	An ASUB is started immediately, if the NCK is in the reset status or in the JOG mode. <b>Tip:</b> Without this bit setting, no ASUB can be started in the reset status /JOG mode. <b>Note:</b> <ul style="list-style-type: none"> <li>This bit is set implicitly, if the machine data MD20108 \$MC_PROG_EVENT_MASK in a channel deviates from zero!</li> <li>This bit is set implicitly, if in the machine data MD11450 \$MN_SEARCH_RUN_MODE the bit 1 is set!</li> </ul>
1		Stop reason: <b>Not all axes are referenced yet</b>
	0	Stop reason prevented ASUB start.
	1	ASUB start also permitted, if all axes are not yet referenced.
2		Stop reason: <b>Read-in disable is active</b>
	0	The ASUB is selected internally, but processed only when the read-in disable is cancelled. The value of the machine data MD20116 \$MC_IGNORE_INHIBIT_ASUP is evaluated. In case MD20116=0, then an ASUB is triggered internally immediately, the blocks of the ASUB Program are changed only with the cancellation of the read-in disable. With the triggering of ASUB the path is decelerated immediately (except with the option of BLSYNC). A resetting of the read-in disable is done in the ASUP program.
	1	ASUB start also permitted, when the read-in disable is active. That is, the blocks of the ASUB program are changed and processed immediately. In this way, the machine data MD20116 \$MC_IGNORE_INHIBIT_ASUP becomes ineffective. The NCK behavior corresponds to the machine data allocation: MD20116 \$MC_IGNORE_INHIBIT_ASUP= FFFFFFFF.

**Note****Explicit ASUB start**

If MD11602 is set such that the ASUB may not be started automatically, the routine can still be activated by the **Start key**. Any rapid retraction that may be parameterized is always started.

### Jogging during interruption of a JOG ASUB

In case of single or multi-channel systems the ASUB started automatically in the mode type JOG can be jogged during interruption.

This functionality is enabled via the bit 3 in the machine data:

MD11602 \$MN\_ASUP\_START\_MASK

Bit	Value	Description
3	0	Jogging during interruption of a JOG ASUB is <b>not</b> possible.
	1	Jogging during interruption of a JOG ASUB is possible.

In case of multi-channel systems, the bit 1 must also be set in the machine data MD11600 \$MN\_BAG\_MASK.

After jogging, a REPOS is triggered with the START key and the ASUB is continued at the interruption point.

#### Application example:

In case of a single-slide turning machine a stock removal cycle is started as ASUB in the mode type JOG and with this a shaft several meters long is processed. During processing it is necessary to change the cutting edge of the tool. The machine operator stops the ASUB and jogs away for changing the cutting edge of the tool. After changing the cutting edge, he activates the START key. The interruption point is approached through REPOS. Thereafter, the ASUB is continued.

---

#### Note

The function "Jogging during interruption of a JOG ASUB" acts only for those ASUB, which have been activated from the program status "cancelled" (channel status reset).

The function does not work in multi-channel systems without MD11600 \$MN\_BAG\_MASK Bit1=1.

---

### Effectiveness of MD11602

Priorities are assigned to the interrupt routines, which define the ranking during the processing (see also "Programming"). There are priorities from 1 to 128. Priority 1 corresponds to the highest priority.

Starting from which priority the ASUB start conditions parameterized with MD11602 \$MN\_ASUP\_START\_MASK are to be effective, is determined with the machine data:

MD11604 \$MN\_ASUP\_START\_PRIO\_LEVEL

MD11602 is considered from the priority given here till the highest priority.

### Behavior when the read-in disable is set

Via the following channel-specific machine data it can be set for each interrupt signal, whether the assigned interrupt routines are processed without interruption despite a set read-in disable (DB21, ... DBX6.1 = 1), or whether the read-in disable is to be made active:

MD20116 \$MC\_IGNORE\_INHIBIT\_ASUP

Bit	Value	Description
		In case of a set read-in disable:
0		• after an activation the interrupt routine is assigned to the interrupt signal <b>1</b> :
	0	the read-in disable is effective.
	1	the read-in disable is suppressed.
1		• after an activation the interrupt routine is assigned to the interrupt signal <b>2</b> :
	0	the read-in disable is effective.
	1	the read-in disable is suppressed.
2		• after an activation the interrupt routine is assigned to the interrupt signal <b>3</b> :
	0	the read-in disable is effective.
	1	the read-in disable is suppressed.
...		

---

#### Note

The settings in MD20116 \$MC\_IGNORE\_INHIBIT\_ASUP are ineffective, if the read-in disable in the interrupt routines is ignored through the following configuration:

MD11602 \$MN\_ASUP\_START\_MASK (ignore stop conditions for ASUB) Bit 2 = 1

---

**Behavior when the single block processing is set**

Via the following channel-specific machine data it can be set for each interrupt signal, whether the assigned interrupt routines are processed without interruption despite a set single block processing or whether the single block processing is to be made active:

MD20117 \$MC\_IGNORE\_SINGLEBLOCK\_ASUP

Bit	Value	Description
		In case of a single block processing:
0		• after an activation the interrupt routine is assigned to the interrupt signal <b>1</b> :
	0	the single block processing is effective.
	1	the single block processing is suppressed.
1		• after an activation the interrupt routine is assigned to the interrupt signal <b>2</b> :
	0	the single block processing is effective.
	1	the single block processing is suppressed.
2		• after an activation the interrupt routine is assigned to the interrupt signal <b>3</b> :
	0	the single block processing is effective.
	1	the single block processing is suppressed.
...		

**Note**

MD20117 \$MC\_IGNORE\_SINGLEBLOCK\_ASUP is effective only for the single block processing type 1 (SBL1).

**Note**

The settings in MD20117 \$MC\_IGNORE\_SINGLEBLOCK\_ASUB are ineffective, if the single block processing in the interrupt routines is ignored through the following configuration:

MD10702 \$MN\_IGNORE\_SINGLEBLOCK\_MASK (Prevent single block stop) bit 1 = 1

### Suppress updating of the display of the program and channel statuses.

In order to avoid a flickering of the display of the program and the channel statuses in the operator panel, the updating of the display can be suppressed for the execution of the normally very brief interrupt routines. The program and the channel status before the activation of the interrupt routine then remain visible in the display.

The parameterization of this function is done with the channel-specific machine data:

MD20191 \$MC\_IGN\_PROG\_STATE\_ASUP

Bit	Value	Description
		The updating of the display of the program and channel statuses is:
0		• during execution the interrupt routine is assigned to the interrupt signal <b>1</b> :
	0	is not suppressed.
	1	suppressed.
1		• during execution the interrupt routine is assigned to the interrupt signal <b>2</b> :
	0	is not suppressed.
	1	suppressed.
2		• during execution the interrupt routine is assigned to the interrupt signal <b>3</b> :
	0	is not suppressed.
	1	suppressed.
...		

The activation of an interrupt routine with suppressed display updating is shown with the following NC/PLC interface signal:

DB21, ... DBX378.1 (stopped ASUB active)

---

#### Note

The system variables \$AC\_STAT and \$AC\_PROG are not affected by this function, i.e. in the running interrupt routine \$AC\_STAT is set to "active" and \$AC\_PROG to "running".

NC/PLC interface signals DB21, ... DBX35.0-7 ("Program status ..." and "Channel status ...") also remain unaffected.

---

### Fast retraction from contour (LIFTFAST)

If mirroring is active for execution via frames, then the following machine data can be used to set whether during "fast retraction from the contour" the retraction direction is also to be mirrored:

MD21202 \$MC\_LIFTFAST\_WITH\_MIRROR (fast retraction with mirroring)

The distance for the fast retraction is stored for the 3 geometry axes in the machine data:

MD21200 \$MC\_LIFTFAST\_DIST (Traversing path for fast retraction from the contour)

The maximum axis acceleration (MD32300 \$MA\_MAX\_AX\_ACCEL) effective during the LIFTFAST motion is reduced by a factor, which is specified in the following machine data:

MD20610 \$MC\_ADD\_MOVE\_ACCEL\_RESERVE

This creates an acceleration reserve for an overlaid motion.

## 9.9.3 Programming

### Assignment Interrupt signal ↔ part program

The assignment interrupt signal ↔ part program is done with the command SETINT.

Example

Program code	Comment
...	
N20 SETINT(3) ABHEBEN_Z	; If input 3 switches, then interrupt routine "ABHEB_Z" should start.
...	

Together with SETINT additionally the following commands can be programmed:

- LIFTFAST

When the interrupt signal arrives, a "Fast retraction of the tool from the contour" is executed before the interrupt routine starts. The motion direction for the fast retraction is specified by the program instruction ALF.

- BLSYNC

Upon receiving the interrupt signal, the current program block is processed and only then is the interrupt routine started.

#### Note

The assignment interrupt signal ↔ part program is cleared when the following happens:

- Channel in Reset state
- CLRINT instruction in part program

## Priorities

If several `SETINT` instructions are in the part program and therefore several signals can be simultaneously received, the assigned interrupt routines must be allocated priorities that define the sequence in which the interrupt routines are executed:

`PRIO=<value>`

There are priorities from 1 to 128. Priority 1 corresponds to the highest priority.

### Example

Program code	Comment
...	
N20 SETINT(3) PRIO=2 ABHEBEN_Z	; If input 3 switches, then interrupt routine "ABHEB_Z" should start.
N30 SETINT(2) PRIO=2 ABHEBEN_X	; If input 2 switches, then interrupt routine "ABHEB_X" should start.
...	

The interrupt routines are executed in the sequence of the priority values if the inputs become available simultaneously (are energized simultaneously): First "ABHEBEN\_Z", then "ABHEBEN\_X".

## REPOS-query

Interrupt routines sequences may be generated for which there is no unambiguous return to an interruption point in the block processing sequence (REPOS).

The system variable `$P_REPINF` can be used to scan the ASUB to determine whether a REPOS is possible.

Value	Description
0	Repositioning with REPOS not possible because: <ul style="list-style-type: none"> <li>• not called in ASUB</li> <li>• ASUB ran from reset status</li> <li>• ASUB ran from JOG</li> </ul>
1	Repositioning with REPOS possible in ASUB

## Determine cause of activation

With the system variable `$AC_ASUP` the cause leading to the activation of an interrupt routine, is specified bit-coded and can be read in the part program and in synchronous actions (see "User-specific ASUB for RET and REPOS > Programming (Page 638)").

### Flexible programming

The following commands help in the flexible programming of interrupt routines:

Command	Description
SAVE	If the SAVE command has been used to define the interrupt routine, the G codes, frames and transformations previously active in the interrupted part program become operative again as soon as the interrupt routine is ended.
DISABLE	The DISABLE command can be set to protect part program sections from being interrupted by an interrupt routine. The assignment interrupt signal ↔ part program is maintained but the interrupt routine no longer respond to the 0/1 signal transition.
ENABLE	The DISABLE command can be reset with the ENABLE command. Interrupt routines are not activated until the next 0/1 transition of the interrupt signal.
CLRINT	Clear assignment Interrupt signal ↔ part program

### References

Programming Manual, Job Planning; Chapter: "Flexible NC Programming" > "Interrupt routine (ASUB)"

### 9.9.4 Restrictions

#### Cross-mode Start of interrupt routines

Requirements:

- Option: Cross-mode actions
- MD11602 \$MN\_ASUP\_START\_MASK, at least Bit 0 = 1

For error-free execution of the function, the following settings in particular must be noted:

- MD11600 \$MN\_BAG\_MASK
- MD11604 \$MN\_ASUP\_START\_PRIO\_LEVEL
- Interrupt assignment priority

Recommended settings:

- MD11600 \$MN\_BAG\_MASK = H11
- MD11602 \$MN\_ASUP\_START\_MASK = H111
- MD11604 \$MN\_ASUP\_START\_PRIO\_LEVEL = 7

## 9.9.5 Examples

### Activation of an interrupt routine via synchronous action

1. Define number of active digital inputs/outputs:  
MD10350 \$MN\_FASTIO\_DIG\_NUM\_INPUTS=3  
MD10360 \$MN\_FASTIO\_DIG\_NUM\_OUTPUTS=3
2. Generate short-circuit with the following MD setting:  
MD10361 \$MN\_FASTIO\_DIG\_SHORT\_CIRCUIT[0]='H0102B102'  
MD10361 \$MN\_FASTIO\_DIG\_SHORT\_CIRCUIT[1]='H0202B202'
3. HW assignment of the external NC input byte for NC program interrupt:  
MD21210 \$MC\_SETINT\_ASSIGN\_FASTIN=2 ; better 1 byte more than needed
4. Define input as ASUB trigger:  
SETINT(1) PRIO=1 SYNCASUP
5. IDS=1 EVERY \$\$AC\_PATHN>=0.5 DO \$A\_OUT\_[9]=1

## 9.10 User-specific ASUB for RET and REPOS

### 9.10.1 Function

#### Function

The NCK software supplied contains preprogrammed processes (internal ASUBs) for implementation of the RET and REPOS functions. They can be replaced by user-specific ASUBs written by the machine tool manufacturer.



The machine manufacturer is responsible for the contents of ASUB routines used to replace ASUP.SYF supplied by Siemens.

#### Installation

In the manufacturer directory `_N_CMA_DIR` or in the user directory `_N_CUS_DIR` a routine with the name "`_N_ASUP_SPF`" can be loaded. These must implement the actions desired by the user for the functions RET and REPOS.

## 9.10.2 Parameter assignment

### Activating

The parameters for the activation of the user-specific routine "\_N\_ASUP\_SPF" are set with the machine data:

MD11610 \$MN\_ASUP\_EDITABLE (activation of a user-specific ASUP program).

Bit 0 and bit 1 specify, which of the internal system routines are to be replaced by the user-specific ASUB:

Binary value	Description
0	<b>Neither</b> in case RET <b>nor</b> in case of REPOS the user-specific routine _N_ASUP_SPF is activated.
1	The user-defined routine is activated for <b>RET</b> , the routine provided in the system is activated for REPOS.
2	The user-defined routine is activated for <b>REPOS</b> , the routine provided in the system is activated for RET.
3	<b>As</b> in case RET <b>and</b> also in case of REPOS the user-specific routine is activated.

Bit 2 defines in which directory the user-specific routine is to be searched first in case of activation.

Bit	Value	Description
2	0	The user-specific routine is searched first in the user directory <b>_N_CUS_DIR</b> .
	1	The user-specific routine is searched first in the manufacturer directory <b>_N_CMA_DIR</b> .

### Defining a level of protection

If a user-specific ASUB is to be used for RET and/or REPOS, i.e. when:

MD11610 \$MN\_ASUP\_EDITABLE  $\neq$  0

then a level of protection can be defined for the user-specific routine "\_N\_ASUP\_SPF". The level of protection can have values in the range 0 - 7.

The setting is done via the following machine data:

MD11612 \$MN\_ASUP\_EDIT\_PROTECTION\_LEVEL (level of protection of the user-specific ASUB)

For further information about protection levels, refer to:

**References:**

Startup guide; level of protection concept

9.10 User-specific ASUB for RET and REPOS

**Behavior when the single block processing is set**

Via the following machine data it can be set, that despite a set single block processing the internal ASUB or the user-specific "\_N\_ASUP\_SPF" is processed without interruption:

MD10702 \$MN\_IGNORE\_SINGLEBLOCK\_MASK (Prevent single block stop)

Bit	Value	Description
0	0	A stop is done in each ASUB block.
	1	The ASUB is processed without interruption.

**9.10.3 Programming**

**Determine cause of ASUB activation**

The reason that led to the activation is specified in bit code through the \$AC\_ASUP system variable, and can be read in part program and synchronized actions.

	Bit																			
	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RET							1			1	*		1							
REPOS	1	1	1	1	1	1		1	1		*	1		1	1					

\*: If bit 9 is set, then the behavior depends on MD20114 (see table below)

The significance of the bits of system variable \$AC\_ASUP is as follows:

Bit	Description
0	User interrupt "ASUB with BLSYNC" Continuation: Freely selectable REORG or RET
1	User interrupt "ASUP"; The position at which it was <b>stopped</b> is stored for continuation with REPOS. Continuation: Freely selectable REORG or RET
2	User interrupt "ASUB from channel status Ready" Continuation: Freely selectable REORG or RET
3	User interrupt "ASUB in a manual mode and in channel status not Ready" Continuation: Freely selectable REORG or RET
4	User interrupt "ASUP"; The <b>current</b> position is stored when the interrupt occurs, for continuation with REPOS. Continuation: Freely selectable REORG or RET
5	Abort of the subroutine repeat Continuation: With system ASUB REPOS

Bit	Description
6	Activation of decoder single block Continuation: With system ASUB REPOS
7	Activation of delete distance-to-go Continuation: With system ASUB RET
8	Activation of axis synchronization Continuation: With system ASUB REPOS
9	Mode change Continuation: in case of system ASUP, REPOS or RET depending upon MD20114 \$MC_MODESWITCH_MASK (interruption of MDA through mode change):
	Bit 0 = 0:     → RET
	Bit 0 = 1:     → REPOS
10	Program continuation during TEACHIN or after TEACHIN deactivation Continuation: With system ASUB RET
11	Overstore selection Continuation: With system ASUB REPOS
12	Alarm with reaction correction block with REPOS Continuation: With system ASUB REPOS
13	Retraction motion in case of G33 and Stop Continuation: With system ASUB RET
14	Activation of dry run feedrate Continuation: With system ASUB REPOS
15	Deactivation of dry run feedrate Continuation: With system ASUB REPOS
16	Activation of skip block Continuation: With system ASUB REPOS
17	Deactivation of skip block Continuation: With system ASUB REPOS
18	Activate machine data Continuation: With system ASUB REPOS
19	Make user data effective Continuation: With system ASUB REPOS
20	Activation of system ASUB, after search type SERUPRO has reached the search target Continuation: With system ASUB REPOS

## 9.11 Single block

### Block-by-block processing

With the single-block function, the user can execute a part program block-by-block.

### Single-block types

There are 3 types of setting for the single-block function:

- SBL1 := IPO single block  
When the SLB1 function is active, machining stops or pauses after each machine action block (Ipo block).
- SBL2 := Decode single block  
When the SLB2 function is active, machining always stops or pauses after each part program block. If a part program block is processed in several IPO blocks, machining stops after every Ipo block. Thread cutting is an exception.
- SBL3 := Decode single block  
As for SLB2, but machining also stops in the part program blocks of the cycles.

#### 1. Stopping after every block is undesirable in many situations and/or with certain blocks.

##### – 1st example:

Change after jog operation, if reorganization and/or repositioning is not possible, MD10702, bits 6 and 7.

If a stop occurs in a block at the end of block, which cannot be reorganized and/or repositioned, in this situation Jog mode cannot be selected.

##### – 2nd example:

Change after JOG operation to a STOPRE block, MD10702, bits 6 and 7

If AUTO mode is changed to Jog mode while a STOPRE block is active, in addition to system ASUB2, a continuation start will be followed by

one residual block and one or possibly (with decoder single block) two more STOPRE blocks. A logic operation, which always triggers a part program start in single block and then always changes to Jog mode, remains at the STOPRE block indefinitely.

##### – 3rd example:

DISPOF: Deactivate block display, MD10702, bits 6 and 7

If DISPOF is programmed in a subroutine, the block display is suppressed. The operator must continuously press Start blindly in the single block up to the end of the subroutine.

#### 2. When single block is deactivated there is no stop at end of block.

#### 3. When STOPRE blocks are displayed, the main run and preprocessing are synchronized in the decoding single block.

The following sections describe how to control the behavior of single blocks and prevent stops in particular situations.

### 9.11.1 Decoding single block SBL2 with implicit preprocessing stop

#### Asynchronicity

As a result of preprocessing of part program blocks, the reference between the current block display relative to the main run status of the NCK and the variable values displayed on the HMI can be lost. The operator display then shows implausible variable values.

#### Preprocessing stop for each block

A preprocessing stop is executed for active SBL2 with each block with the channel-specific setting data SD42200 \$SC\_SINGLEBLOCK2\_STOPRE (activate debug mode for SBL2). This suppresses preprocessing of part program blocks and maintains the relationship between the current block display and the variable values display.

---

#### Note

This variant of SBL2 does not maintain an accurate contour. In other words, as a result of the preprocessing stop, a different contour may be generated from the one created without single-block mode or with SBL1.

Application: Debug mode for testing part programs.

---

### 9.11.2 Single block stop: Suppression using SBLOF

#### Single block off

Programs characterized by the `SBLOF` language command are executed completely in one block as with every type of single block.

`SBLOF` is also valid in the called subroutines.

#### SBLOF

Example for subroutine without stop in single block:

```

| PROC EXAMPLE SBLOF
| G1 X10
| RET

```

At the return command, the decision is made whether to stop at the end of the subprogram:

Return jump with M17  
Return jump with RET

Stop at the end of the subprogram  
No stop at end of subroutine

### SBLOF in the program

SBLOF alone must remain in the block. Single-block stop is deactivated from this block onwards up to the next programmed SBLON or up to the end of the active subroutine level.

If SBLOF is active, then this definition is also valid in the called subroutines. SBLON

#### Example for an area in single block mode

The area between N20 and N60 is executed as one step in single-block mode.

```
N10 G1 X100 F1000
N20 SBLOF ; Deactivate single block
N30 Y20
N40 M100
N50 R10=90
N60 SBLON ; Reactivate single block
N70 M110
N80 ...
```

### Asynchronous subprograms

The asynchronous subroutines ASUP1.SYF and ASUP2.SYF started system-internally in REORG/REPOS can process the system ASUP in one step through the programming of SBLOF.

#### Example: ASUP.SPF:

```
N10 SBLOF
N20 IF $AC_ASUP=='H200'
N30 RET ; No REPOS on mode change
N40 ELSE
N50 REPOSA ; REPOS in all other cases
N60 ENDIF
N70 RET
```

### Constraints

- The current block display can be suppressed in cycles with DISPLOF.
- If DISPLOF is programmed together with SBLOF, then the cycle call continues to be displayed on single-block stops within the cycle.
- The preset behavior of asynchronous subroutines in single block mode specified in MD20117 MC\_IGNORE\_SINGLEBLOCK\_ASUP (process interrupt program fully despite single block) can be overwritten on a program-specific basis using SBLOF.

## Cycle

**Example 1:** A cycle is to act like a command for a user.

Main program:

```
N10 G1 X10 G90 F200
N20 X-4 Y6
N30 CYCLE1
N40 G1 X0
N50 M30
```

Program cycle:1

```
N100 PROC CYCLE1 DISPLOF SBLOF          ; Suppress single block
N110 R10=3*SIN(R20)+5
N120 IF (R11 <= 0)
N130 SETAL(61000)
N140 ENDIF
N150 G1 G91 Z=R10 F=R11
N160 M17
```

CYCLE1 is processed for an active single block, i.e. the Start key must be pressed once to process CYCLE1.

**Example 2:** An ASUB, which is started by the PLC in order to activate a modified zero offset and tool offsets, is to be executed invisibly.

```
N100 PROC ZO SBLOF DISPLOF
N110 CASE $P_UIFRNUM OF 0 GOTOF
_G500 1 GOTOF _G54 2 GOTOF _G55 3 GOTOF _G56 4
GOTOF _G57 DEFAULT GOTOF END
N120 _G54: G54 D=$P_TOOL T=$P_TOOLNO
N130 RET
N140 _G54: G55 D=$P_TOOL T=$P_TOOLNO
N150 RET
N160 _G56: G56 D=$P_TOOL T=$P_TOOLNO
N170 RET
N180 _G57: G57 D=$P_TOOL T=$P_TOOLNO
N190 RET
N200 END: D=$P_TOOL T=$P_TOOLNO
N210 RET
```

### 9.11.3 Single block stop: inhibit according to situation

#### Suppress stopping in single cases

Depending on

MD10702 \$MN\_IGNORE\_SINGLEBLOCK\_MASK (Prevent single block stop)

setting bits 0 to 12 = 1 can suppress stopping at the end of the block during the following machining processes.

Program execution must not stop after single blocks in the case of the following even if block-by-block processing is selected:

1. An internal ASUB
2. During a user ASUP
3. Subroutines with the attribute DISPLOF
4. Intermediate blocks
5. Block search group blocks
6. Init blocks
7. Blocks, which cannot be reorganized
8. Blocks, which are not repositionable
9. A repositioning block, which contains no traversing information
10. A prerun/main run/synchronization block, due to REORG
11. At a Tool selection block.
12. At a GET block
13. During a single block type 2

#### Sequence

If an ASUB is activated during the single block, for example, execution of the ASUB is completed. The deceleration movement does not take place until after the end of the ASUB or the first IPO block in which single-block suppression is not activated. If the velocity is too large for the deceleration to be performed in this block (with continuous-path mode G64 active), G64, further block changes are allowed.

For decoding single block, MD10702 is only effective with "internal ASUB", "user ASUB" and "subroutines with the attribute DISPLOF". In these cases, it is already clear at the time of interpretation that the block belongs to one of the above categories. In these cases, further blocks can be generated.

#### SBLON in ASUB

The single block stop of an internal ASUP or user ASUP that is suppressed with MD10702 \$MN\_IGNORE\_SINGLEBLOCK\_MASK can be reactivated in ASUP by programming SBLON.

This functionality can be suppressed again with MD20117 \$MC\_IGNORE\_SINGLEBLOCK\_ASUB. The SBLON command then becomes ineffective.

## Boundary conditions

The following restriction applies to decoding single block SBL2:

- Block search approach blocks
- Block not in ASUB; DISPLOF, SBLOF
- Non-reorganizable and non-repositionable blocks
- Blocks that are not generated in the interpreter, e.g. intermediate blocks

### 9.11.4 Single-block behavior in mode group with type A/B

#### Classifying channels

One mode group channel must be classified as a single-block control channel (KS), while the other mode group channels must be classified as dependent channels (KA) via interface signal. Type A or type B single-block behavior can be selected for KA channels.

Type A determines Stop (analogous to STOP key).

Type B determines Stop (analogous to stop at block limit).

#### Channel classification

In **one** channel (**KS**) in a mode group, the user should select single-block (NST DB21 ... DBX0.4 (activate single block)). Single-block type A or B refers to **other** channels (KA) of a mode group.

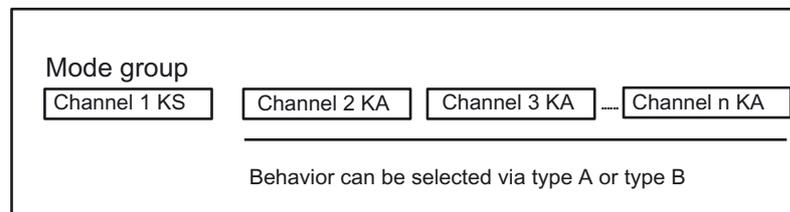


Figure 9-13 Channel classification for single block in mode group 1

#### Type A, NST DB11, ... DBX1.7=1 (single block type A)

- All channels are stopped.
- All channels receive a start (Start key).
- Channel KS stops at the end of the block (due to single-block)
- Channels KA receive a **STOP**. (analogous to STOP key).
- All channels are stopped. (deceleration phase of all KAs)

**Type B, NST DB11, ... DBX1.6=1 (single block type B)**

- All channels are stopped.
- All channels receive a start
- Channel KS stops at the end of the block
- Channels KA receive a **STOPATEND**.  
(analogous with NST DB21, ... DBX7.2 ("NC stop at the block limit).
- All channels are stopped at a block limit (at some point in time).

## 9.12 Program control

### Options

1. Function selection (via operator interface or PLC)
2. Activation of skip levels
3. Adapting the size of the interpolation buffer
4. Program display modes via an additional basic block display
5. Execution from external source (buffer size and number)
6. Execution from external subroutines

### 9.12.1 Function selection (via operator panel front or PLC)

#### Operator interface or PLC

The user can control part program execution via the operator panel front or PLC.

#### Selection, activation, feedback

##### Selection

Different functions are available under the Program control soft key. Selection affects an interface signal in the PLC. These signals are to be understood as selection signals from the operator interface, and do not activate the selected function.

##### Activation

These signal states must be transferred to another area of the data block to activate the selected function. With program control by the PLC the signals are to be set directly.

##### Feedback

The activated functions are partly signaled back to the PLC from the NCK.

9.12 Program control

Table 9-5 Program control: Interface signals

Function	Selection signal	Activation signal	Feedback signal
SKP skip block 0 to 7	DB21, ... DBX26.0 - 26.7	DB21, ... DBX2.0 - 2.7	---
SKP skip block 8 to 9	DB21, ... DBX27.0 - 27.1	DB21, ... DBX31.6 - 31.7	---
DRY dry run feedrate	DB21, ... DBX24.6	DB21, ... DBX0.6	DB21, ... DBX318.6
ROV Rapid traverse override	DB21, ... DBX25.3	DB21, ... DBX6.6	---
Single block:	Preselection of SBL1, SBL2 or SBL3 via program control display of HMI		
SBL1: Action single block	HMI operator panel	DB21, ... DBX0.4	---
SBL2: Decoding single block			
SBL3: In cycle			
M01 (Programmed stop)	DB21, ... DBX24.5	DB21, ... DBX0.5	DB21, ... DBX32.5
Associated M01	DB21, ... DBX24.4	DB21, ... DBX30.5	DB21, ... DBX318.5
DRF selection	DB21, ... DBX24.3	DB21, ... DBX0.3	DB21, ... DBX33.3
PRT program test	DB21, ... DBX25.7	DB21, ... DBX1.7	DB21, ... DBX33.7

**References:**

/FB1/ Function Manual, Basic Functions; NC/PLC Interface Signals (Z1)

/BAD/ Operation Manual HMI Advanced "Operating Area, Machine"

**9.12.2 Activation of skip levels**

*/, /0, ... /9*

It is possible to skip blocks, which are not to be executed every time the program runs. Blocks to be skipped are indicated in the part program by an oblique "/" before the block number.

The skip levels in the parts program are specified by "/0" to "/7".

Only one skip level can be specified for each part program block.

**Number of levels**

The number of skip levels is defined with MD9423 \$MM\_MAX\_SKP\_LEVEL (max. skip levels in the NC program).

**Example signals:**

Blocks which are not to be executed in every program pass can be skipped according to the following diagram (e.g. program test blocks):/ ; block skipped, (DB21, ... DBX2.0) 1st skip level

/ N005 ; block skipped, (DB21, ... DBX2.0) 1. "

/0 N005 ; block skipped, (DB21, ... DBX2.0) 1.

/1 N010 ; block skipped, (DB21, ... DBX2.1) 2. ""

/2 N020 ; block skipped, (DB21, ... DBX2.2) 3. "

/3 N030 ; block skipped, (DB21, ... DBX2.3) 4.

/4 N040 ; block skipped, (DB21, ... DBX2.4) 5. "

/5 N050 ; block skipped, (DB21, ... DBX2.5) 6. "

/6 N060 ; block skipped, (DB21, ... DBX2.6), 7. "

/7 N070 ; block skipped, (DB21, ... DBX2.7) 8th skip level

/8 N080 ; block skipped, (DB21, ... DBX31.6), 9th skip level

/9 N090 ; block skipped, (DB21, ... DBX31.7) 10th skip level

The 10 skip levels "/0" to "/9" are activated by the PLC setting the PLC -> NCK interface signals.

The function is activated from the HMI via the "Program control" menu in the Machine operating area for skip levels

- "/0" to "/7" via interface HMI -> PLC DB21 ... DBB26 (Skip-block selected).
- "/8" to "/9" via interface HMI -> PLC DB21, ... DBX27.0 to DBX27.1.

**References:**

/BAD/ Operation Manual HMI Advanced "Operating Area, Machine"

---

**Note**

The levels to be skipped can only be changed when the control is in the STOP/RESET state.

---

### 9.12.3 Adapting the size of the interpolation buffer

#### MD28060

The channel-specific interpolator executes prepared blocks from the interpolation buffer during the part program run. The maximum number of blocks requiring space in the interpolation buffer at any given point in time is defined by the memory configuring MD28060 \$MM\_IPO\_BUFFER\_SIZE (number of NC blocks in the IPO buffer (DRAM)). For some applications it may be meaningful not to use the full buffer capacity in order to minimize the "interval" between preparation and interpolation.

#### SD42990

The number of blocks in the interpolation buffer can be restricted dynamically to a **smaller** value than in MD28060 \$MC\_MM\_IPO\_BUFFER\_SIZE (number of NC blocks in the IPO buffer (DRAM)), minimum 2 blocks, with the setting data SD42990 \$SC\_MAX\_BLOCKS\_IN\_IPOBUFFER (max. number of blocks in the IPO buffer).

**Values of setting data SD42990 \$SC\_MAX\_BLOCKS\_IN\_IPOBUFFER:**

Value	Effect
< 0	No interpolation buffer limit active. The max. possible interpolation buffer as set in MD 28060: MM_IPO_BUFFER_SIZE is activated.
or 1	The minimum permissible interpolation buffer with 2 blocks is activated.
< < MM_IPO_BUFFER_SIZE	The interpolation buffer is activated with no more than the maximum specified number of blocks.
>= MM_IPO_BUFFER_SIZE	The interpolation buffer is activated with the number of blocks specified in MD 28060: MM_IPO_BUFFER_SIZE.

#### Note

If SD42990 \$SC\_MAX\_BLOCKS\_IN\_IPOBUFFER is set in the part program, the interpolation buffer limitation takes effect immediately if the block with the SD is being preprocessed by the interpreter.

This means that the limitation of the IPO buffer may take effect a few blocks before the intended limitation (see also MD 28070 \$MC\_MM\_NUM\_BLOCKS\_IN\_PREP).

To avoid premature activation and to make the limitation of the IPO buffer take effect in synchronism with the block, a STOPRE (preprocessing stop) must be programmed before the SD is set in the part program.

## Validity

SD42990 \$SC\_MAX\_BLOCK\_IN\_IPOBUFFER has global, channel-specific validity and can also be modified in a part program. This modified value is maintained at program end. If this setting data is to be reset again on defined events, a so-called event-driven program must be created to do this. For example, this setting data could always be set to a predefined value on RESET.

## Application

The IPO buffer limitation can be used whenever the number of blocks between block preparation and interpolation must be minimized, e.g. when actual positions in the part program must be read and processed for other purposes.

## Example

```

N10 ...
N20 ...
.....
N100 $SC_MAX_BLOCKS_IN_IPOBUFFER = 5           ; Limitation of IPO buffer to 5 NC
                                                blocks
N110 ...
N120 ...
.....
N200 $SC_MAX_BLOCKS_IN_IPOBUFFER = -1         ; Cancellation of the IPO buffer
                                                limitation
N210 ...
.....
    
```

## 9.12.4 Program display modes via an additional basic block display

### Basic block display (only for ShopMill/ShopTurn)

A second so-called basic block display can be used with the existing block display to show all blocks that produce an **action on the machine**.

### Look Ahead basic block display

The actually approached end positions are shown as an absolute position. The position values refer either to the workpiece coordinate system (WCS) or the settable zero system (SZS).

The number of Look Ahead display blocks stored in the display buffer depends on the number of prepared blocks in the NCK preprocessing buffer in the relevant processing state. If a preprocessing stop is processed, the number of display blocks is reduced to zero and increases again after the stop is acknowledged. In the case of REORG events (e.g. mode change, ASUB start), the display blocks stored for Look Ahead are deleted and preprocessed again afterwards.

### Processed values

Values processed in the basic block display coincide with the:

- Selected tools
- Feed and spindle speed
- Actually approached position values

Exceptions:

With active tool radius compensation, deviations can occur.

For modulo axes, the programmed value is displayed in the basic block display. This value can also lie outside the modulo range.

---

#### Note

As a basic rule the positions are represented in the WCS or the SZS.

The basic block display can be activated or deactivated with setting data

SD42750 \$SC\_ABSBLOCK\_ENABLE.

---

## 9.12.5 Basic block display for ShopMill/ShopTurn

### Configure basic block display

The basic block display can be configured via the following machine data:

NCK machine data for basic block display	Significance:
MD28400 \$MC_MM_ABSBLOCK	Activate basic block display
MD28402 \$MC_MM_ABSBLOCK_BUFFER_CONF[2]	Size of display buffer
Display machine data	Position values to be set:
MD9004 \$MM_DISPLAY_RESOLUTION	For metric measurements
MD9011 \$MM_DISPLAY_RESOLUTION_INCH	For inch measurements
MD9010 \$MM_SPIND_DISPLAY_RESOLUTION	Settable coordinate system for spindle display resolution
MD9424 \$MM_MA_COORDINATE_SYSTEM	For actual value display in WCS or SZS

These display machine data are copied to NCK machine data MD17200 \$MN\_GMMC\_INFO\_UNIT[0] to MD17200 \$MN\_GMMC\_INFO\_UNIT[3]. allowing them to be accessed from the NCK.

### Activating

The basic block display is activated by MD 28400 \$MC\_MM\_ABSBLOCK by means of Power On. If MD28400 \$MC\_MM\_ABSBLOCK is set to 1, a channel-specific display buffer (FIFO) is created during power-up.

**Size of display buffer (FIFO)** = (MD28060 \$MC\_MM\_IPO\_BUFFER\_SIZE + MD28070 \$MC\_MM\_NUM\_BLOCKS\_IN\_PREP) multiplied by 128 bytes. This corresponds to a size of 6KB in the machine data default setting.

Optimize size of display buffer:

The memory requirement can be optimized by entering a value between 128 and 512. The display blocks preprocessed in the display buffer are transferred to the HMI via a configurable upload buffer.

**Maximum size of upload buffer** is obtained by multiplying (MD28402 \$MC\_MM\_ABSBLOCK\_BUFFER\_CONF[0] + MD28402 \$MC\_MM\_ABSBLOCK\_BUFFER\_CONF[1] + 1) by the block length configured in MD28400 \$MC\_MM\_ABSBLOCK.

The number of blocks **before** the current block is configured in MD28402 \$MC\_MM\_ABSBLOCK\_BUFFER\_CONF[0] and the number of blocks **after** the current block is configured in MD28402 \$MC\_MM\_ABSBLOCK\_BUFFER\_CONF[1].

## Constraints

If the length of a display block configured in MD28400 \$MC\_MM\_ABSBLOCK is exceeded, this display block is truncated accordingly. This is represented by string "..." at the end of the block.

For preprocessed cycles (MD10700 \$MN\_PREPROCESSING\_LEVEL > 1), the display block contains **only** axis positions.

Additional boundary conditions for the basic block display:

- Modal synchronized action blocks with absolute values are not taken into account.
- The basic block display is deactivated during block search with or without computation.
- Polar coordinate programming is not shown in Cartesian system.

## Radius/diameter values

Diameter values shown in the basic block display and position display may be needed as a radius for internal calculation. These values for measurements in radius/diameter according to G code group 29 can be manipulated using the following options:

- G code DIAMCYCOF (expansion of channel-specific diameter programming)  
This G code deactivates the channel-specific diameter programming during the cycle execution. In this way, computations in the cycle can always be done in the radius. The position display and the basic block display are continued according to the state of the diameter programming before DIAMCYCOF.  
In the basic block display, the last displayed value is retained.
- G code DIACYCOFA[AX] (axis-specific diameter programming)  
This G code deactivates the axis-specific diameter programming during the cycle execution. In this way, computations in the cycle can always be done in the radius. In the position display and in the basic block display, this continues according to the state of the diameter programming before DIACYCOFA[AX].  
In the basic block display, the last displayed value is retained.
- MD27100 \$MC\_ABSBLOCK\_FUNCTION\_MASK

Bit0 = 1            Transverse axis setpoints are always shown as diameter values in the basic block display.

### Behavior while the compressor is active

With active compressor and G/Code group 30 not equal to COMPOF, two display blocks are generated. The

- first contains the G/Code of the active compressor.
- The second contains the string "... " as character for missing display blocks.

### Example

```
G0 X10 Y10 Z10      ; Block to be preprocessed for the basic block display
COMPCAD             ; Compressor for optimized surface quality (CAD prog.) A
...                 ; string as character for missing display blocks
```

To avoid bottlenecks in the NCK performance, the basic block display is deactivated automatically. As a sign that the display blocks are missing, a display block with the string "... " is generated.

All display blocks are always generated in the single block.

## 9.12.6 Structure for a DIN block

### Structure of display block for a DIN block

Basic structure of display block for a DIN block

- Block number/label
- G-functions of the first G-group  
(only if changed as compared to the last machine function block).
- Axis position  
(sequence corresponding to MD20070 \$MC\_AXCONF\_MACHAX\_USED (machine axis number valid in the channel)).
- Further modal G functions  
(only if changed as compared to the last machine function block).
- Other addresses as programmed.

The display block for the basic block display is directly derived from the programmed part program blocks according to the following rules:

- Macros are expanded.
- Skip identifiers and comments are omitted.
- Block number and labels are transferred from the original block, but omitted if DISPLOF is active.
- The number of decimal places is defined in display machine data MD 9004, MD 9010 and MD 9011 via the HMI.

9.12 Program control

HMI display machine data	Access in NCK machine data
MD9004 \$MM_DISPLAY_RESOLUTION	MD17200 \$MN_GMMC_INFO_NO_UNIT[0]
MD9011 \$MM_DISPLAY_RESOLUTION_INCH	MD17200 \$MN_GMMC_INFO_NO_UNIT[1]
MD9010 \$MM_SPIND_DISPLAY_RESOLUTION	MD17200 \$MN_GMMC_INFO_NO_UNIT[2]
MD9424 \$MM_MA_COORDINATE_SYSTEM	MD17200 \$MN_GMMC_INFO_NO_UNIT[3]

- Programmed axis positions are represented as absolute positions in the coordinate system (WCS/ENS) specified in MD9424 \$MM\_MA\_COORDINATE\_SYSTEM (coordinate system for actual value display)

**Note**

The modulo correction is omitted for modulo axes, which means that positions outside the modulo range can be displayed. It also means that the basic block display differs from the position display in which values are always modulo-converted.

**Examples**

Comparisons between display block (original block) and basic block display:

- **Programmed positions** are displayed as absolute. The addresses AP/RP are displayed with their programmed values.

Original block:	Display block:
N10 G90 X10.123	N10 X10.123
N20 G91 X1	N20 X11.123

- **Address assignments** (non-DIN addresses) are displayed in the form <address> = <constant>.

Original block:	Display block:
N110 R1 = -67.5 R2 = 7.5	
N130 Z = R1 RND = R2	N130 Z-67.5 RND = 7.5

- **Address indices** (address extensions) are displayed as constants <address> [ <constant> ] = <constant>.

Original block:	Display block:
N220 DEF AXIS AXIS_VAR = X	
N240 FA[ AXIS_VAR] = R2	N240 FA[X] = 1000

- **DIN addresses without address extension** are displayed in the form <din\_address> <constant>.

Original block:	Display block:
N410 DEF REAL FEED = 1.5	
N420 F = FEED	N420 F1.5

The following applies for **H functions**: Each programmed value is displayed irrespective of the output type to PLC

(MD22110 \$MC\_AUXFU\_H\_TYPE\_INT (type of H auxiliary function is integer)).

- For **Tool selection by tool command**  
display information is generated in the form T<value> or T=<string>. If an address extension has been programmed, this is displayed as well.  
  
If several spindles have been configured or the "Tool change via master tool holder" function (MD20124 \$MC\_TOOL\_MANAGEMENT\_TOOLHOLDER (tool holder number)) is active, the T number is always output with address extension.  
  
If no address extension has been programmed, the number of the master spindle or the master toolholder is used instead (T<spindle\_number/tool\_holder>= ).
- For the **Spindle programming** via S, M3, M4, M5, M19, M40 - M45 and M70 (or MD 20094 \$MC\_SPIND\_RIGID\_TAPPING\_M\_NR (M function for switching over in the controlled axis operation)) the following regulation applies regarding the address extension:  
If an address extension has been programmed, then this is also resolved.  
  
If several spindles have been configured, then the address extension is also output. If no address extension has been programmed, the number of the master spindle is used (S<spindle\_number>=).
- **Indirect G code programming** in form G[ <group> ] = <printout> is substituted by the corresponding G code.

Original block:	Display block:
N510 R1=2	
N520 G[8]= R1	N520 G54

- **Modal G codes** that do not generate an executable block are collected and output with the display block of the next executable block if permitted by the syntax (DIN block). If this is not the case (e.g. predefined subroutine call TRANSMIT), a separate display block containing the modified G codes is placed in front of the next executable block.

Original block:	Display block:
N610 G64	G64
N620 TRANSMIT	N620 TRANSMIT

- A display block is always generated for **part program lines** in which the addresses **F** and **FA** appear (including for MD22240 \$MC\_AUXFU\_F\_SYNC\_TYPE = 3 (output time of the F functions)).

Original block:	Display block:
N630 F1000	N630 F1000
N640 X100	N640 X100

- The **display blocks generated for the block display** are derived **directly** from the programmed part program blocks. If intermediate blocks (e.g. tool radius compensation G41/G42, radius/chamfer RNDM, RND, CHF, CHR) are generated in the course of contour preprocessing, these are assigned the display information from the part program block on which the motion is based.

9.12 Program control

Original block:	Display block:
N710 Y157.5 G42	N710 Y157.5 G42
N720 Z-67.5 RND=7.5	N720 Z-67.5 RND=7.5

- With the **EXECTAB** command (processing a table of contour elements), the block generated by EXECTAB is shown in the display block.

Original block:	Display block:
N810 EXECTAB (KTAB[5])	N810 G01 X46.147 Z-25.38

- For the **EXECSTRING** command, the block generated via EXECSTRING is displayed in the display block.

Original block:
N910 DEF STRING[40] PROGSTRING = "N905 M3 S1000 G94 Z100 F1000 G55"
N920 EXECSTRING (PROGSTRING)

Display block:
N905 Z100 G55 G94 M3 S1000 F1000

### 9.12.7 Execution from external

#### Function

The "Execution from external" function can be used to execute programs that cannot be saved directly in the NC memory due to memory shortage from an external program memory.

#### External program memory

Depending on the system (SINUMERIK 840D sl/840D), the available user interface (HMI sl/HMI Advanced/HMI Embedded) and the acquired options, external program memories may be stored on the following data carriers:

- CompactFlash card
- USB drive
- Network drive
- Local hard disk

---

**Note**

**Execution from external source via USB interface with SINUMERIK 840D sl**

If external programs are to be transferred from an external USB drive via a USB interface, only the interface via X203 (named "TCU\_1") can be used.

A USB FlashDrive cannot be recommended as a persistent storage medium.

---

**Note**

**Execution from external source via V24 interface with SINUMERIK 840D**

In HMI Embedded, the "Execution from external source" softkey can be used to transfer external programs across the RS-232 interface onto the NC.

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## Applications

- **Direct execution from external programs**

In principle, any program that is accessible via the directory structure of the interface in the "Execution from external" HMI mode can be selected and executed.

- **Execution of external sub-programs from the part program**

The external subroutine is called through the part program command `EXTCALL` with specification of a call path (optional) and the subroutine identifier (→ refer to Chapter: "Execution from external subroutines").

## Parameterization

A reloading memory (FIFO buffer) must be reserved in the dynamic NC memory for executing a program in the "Executing from external" mode (main program or subroutine).

**Size of FIFO buffer**

The size of the FIFO buffer is set in the machine data:

MD18360 \$MN\_MM\_EXT\_PROG\_BUFFER\_SIZE (FIFO buffer size for processing from external)

Default: 30 kbyte

**Number of the FIFO buffer**

One FIFO buffer must be provided each for all programs (main run or subroutine) that are executed simultaneously in the "Execution from external source" mode.

The number of the FIFO buffer is set in the machine data:

MD18362 \$MN\_MM\_EXT\_PROG\_NUM (number of externally executed program levels executable simultaneously)

### Behavior during RESET, POWER ON

External program calls are aborted through RESET and POWER ON and the concerned FIFO buffers are erased.

A program selected for "Execution from external source" remains selected for "Execution from external source" even after RESET/part program end. A POWER ON deletes the selection.

### 9.12.8 Execution from external subroutines

#### Function

Individual machining steps for producing complex workpieces may involve program sequences that require so much memory they cannot be stored in the NC memory.

In such cases, the user has the option of executing the program sequences as subroutines from an external program memory in the "Execution from external source" mode with the help of the `EXTCALL` part program instruction.

#### Preconditions

The following preconditions are applicable to the execution from external subroutines:

- The subroutines must be accessible via the directory structure of the operator interface.
- A reloading memory (FIFO buffer) must be reserved for each subprogram in the dynamic NC memory.

#### Parameterization

The path for the external subprogram directory can be preset using setting data:

SD42700 \$SC\_EXT\_PROG\_PATH (Program path for the `EXTCALL` external subprogram call)

The entire path of the program to be called along with the subprogram path or identifier specified during programming is derived therefrom.

## Programming

An external subroutine is called by means of parts program command `EXTCALL`.

**Syntax:** `EXTCALL("<path/program_name>")`

**Parameter:**

Path/program name: The path name is optional, i.e. the absolute path (or a relative path) or only the program name (subroutine identifier) can be specified.

The program name can be specified with or without the "\_N\_" prefix and "\_SPF" or "\_MPF" file extension.

Type: STRING

---

**Note**

**SINUMERIK 840D with HMI Embedded**

An absolute path must always be specified for SINUMERIK powerline with HMI Embedded!

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## Effects

**EXTCALL call with absolute path name**

If the subprogram exists at the specified path, it will be executed following the `EXTCALL` call. If it does not exist, program execution is cancelled.

**EXTCALL call with relative path name/without path name**

In the event of an `EXTCALL` call with a relative path name or without a path name, the available program memories are searched as follows:

1. If a path name is preset in SD42700, the data specified in the `EXTCALL` call (program name or with relative path name) is searched for first, starting from this path. The absolute path results from linking the following characters:
  - The path name preset in SD42700
  - The "/" character as a separator
  - The subprogram path or identifier programmed in `EXTCALL`
2. If the called subprogram is not found at the preset path, the data specified in the `EXTCALL` call is then searched for in the user-memory directories.
3. If the called subprogram is not found on the program memory currently being searched (e.g. CompactFlash card), the next program memory (e.g. network drive) is searched in accordance with points 1 and 2.
4. The search ends when the subprogram is found for the first time.  
If the search does not produce any hits, the program is canceled.

## Examples

### 1. Execution from local hard disk

System: SINUMERIK 840D sl/840D with HMI Advanced

The "\_N\_MAIN\_MPF" main program is stored in NC memory and is selected for execution:

```
N010 PROC MAIN  
N020 ...  
N030 EXTCALL ("ROUGHING")  
N040 ...  
N050 M30
```

The "\_N\_ROUGHING\_SPF" subprogram to be reloaded is stored on the local hard disk in the directory "\_N\_WCS\_DIR/\_N\_WST1".

The subprogram path is preset in SD42700:

SD42700 \$SC\_EXT\_PROG\_PATH = "\_N\_WCS\_DIR/\_N\_WST1"

```
N010 PROC ROUGHING  
N020 G1 F1000  
N030 X= ... Y= ... Z= ...  
N040 ...  
...  
...  
N999999 M17
```

### 2. Execution from network drive

Systems: SINUMERIK 840D sl/840D with HMI sl/HMI Advanced/HMI Embedded

The "Contour2.spf" program to be reloaded is stored on the network drive in the directory "\\R4711\\Workpieces".

```
...  
N... EXTCALL("\\R4711\\Workpieces\\Contour2.spf")  
...
```

## 9.13 System settings for power-up, RESET/part-program end and part-program start

### Concept

The control system response can be altered for functions such as G codes, tool length compensation, transformation, coupled axis groupings, tangential follow-up, and programmable synchronous spindle after

- Power up (power ON),
- Reset/part program end and
- Part program start

The

MD20110 \$MC\_RESET\_MODE\_MASK (defining the initial controller setting after Reset/part program start)

MD20150 \$MC\_GCODE\_RESET\_VALUES (RESET position of G groups) and its extension MD20152 \$MC\_GCODE\_RESET\_MODE (defining the initial controller setting during Reset) and

MD20112 \$MC\_START\_MODE\_MASK (defining initial controller setting after part program start)

For certain applications (e.g. grinding) it is advisable not to capture the reset position of individual functions until part program start. This is possible through the appropriate setting of MD20110, MD20150, MD20152 and MD20112.

Table 9-6 Change system settings by means of MD

Status	Can be changed in MD
Power up (POWER ON)	MD20110 \$MC_RESET_MODE_MASK MD20150 \$MC_GCODE_RESET_VALUES
RESET/part program end	MD20110 \$MC_RESET_MODE_MASK MD20150 \$MC_GCODE_RESET_VALUES MD20152 \$MC_GCODE_RESET_MODE
Part program start	MD20110 \$MC_START_MODE_MASK and MD20112 \$MC_RESET_MODE_MASK

### Procedure

Select the desired system response.

- After power-up (POWER ON)  
MD20110 \$MC\_RESET\_MODE\_MASK, Bit 0 = 0 or 1

9.13 System settings for power-up, RESET/part-program end and part-program start

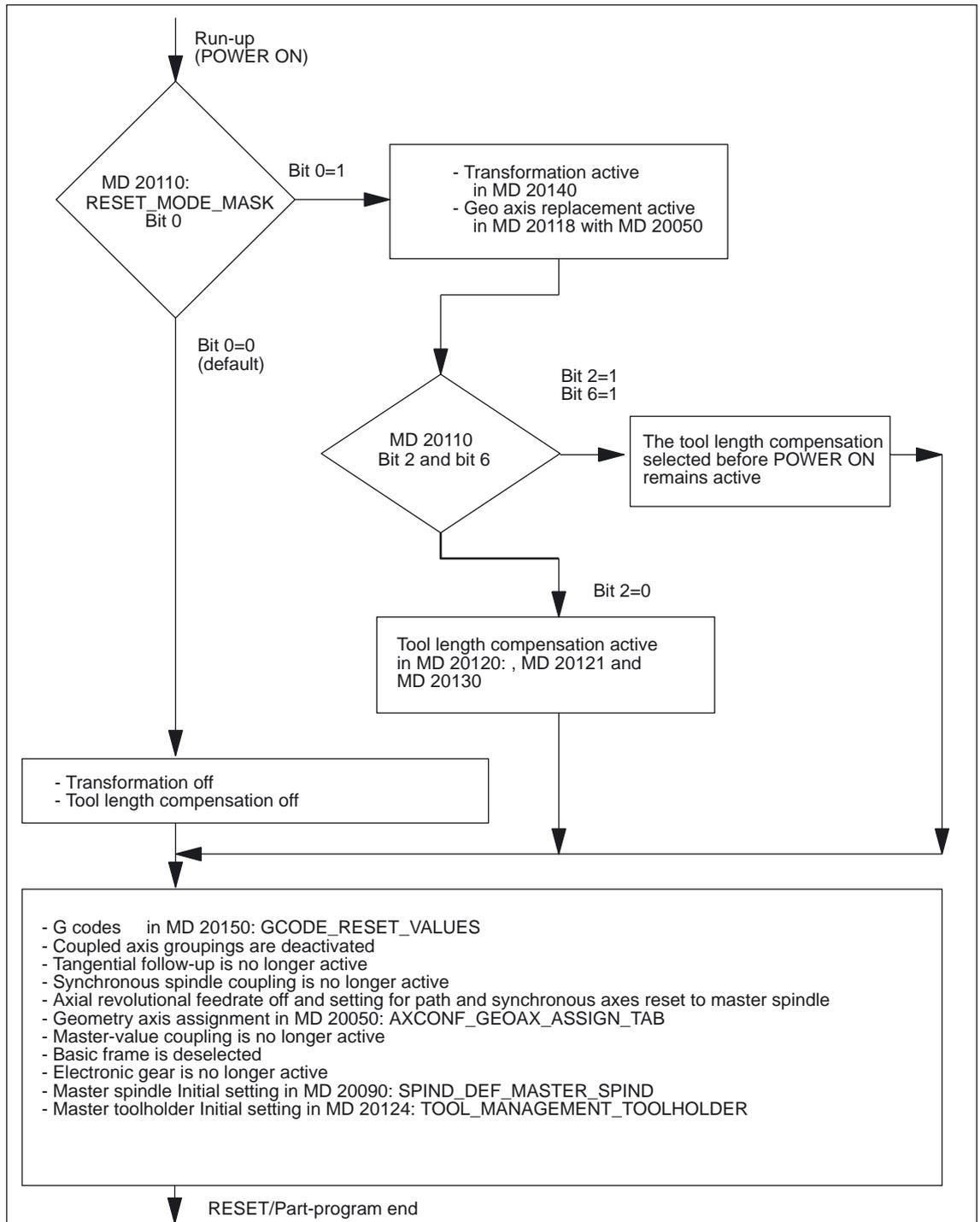


Figure 9-14 System settings after power-up

- After power-up (POWER ON)  
MD20110 \$MC\_RESET\_MODE\_MASK, Bit 0 = 0 or 1

Bits 4 - 13 can be combined optionally.

9.13 System settings for power-up, RESET/part-program end and part-program start

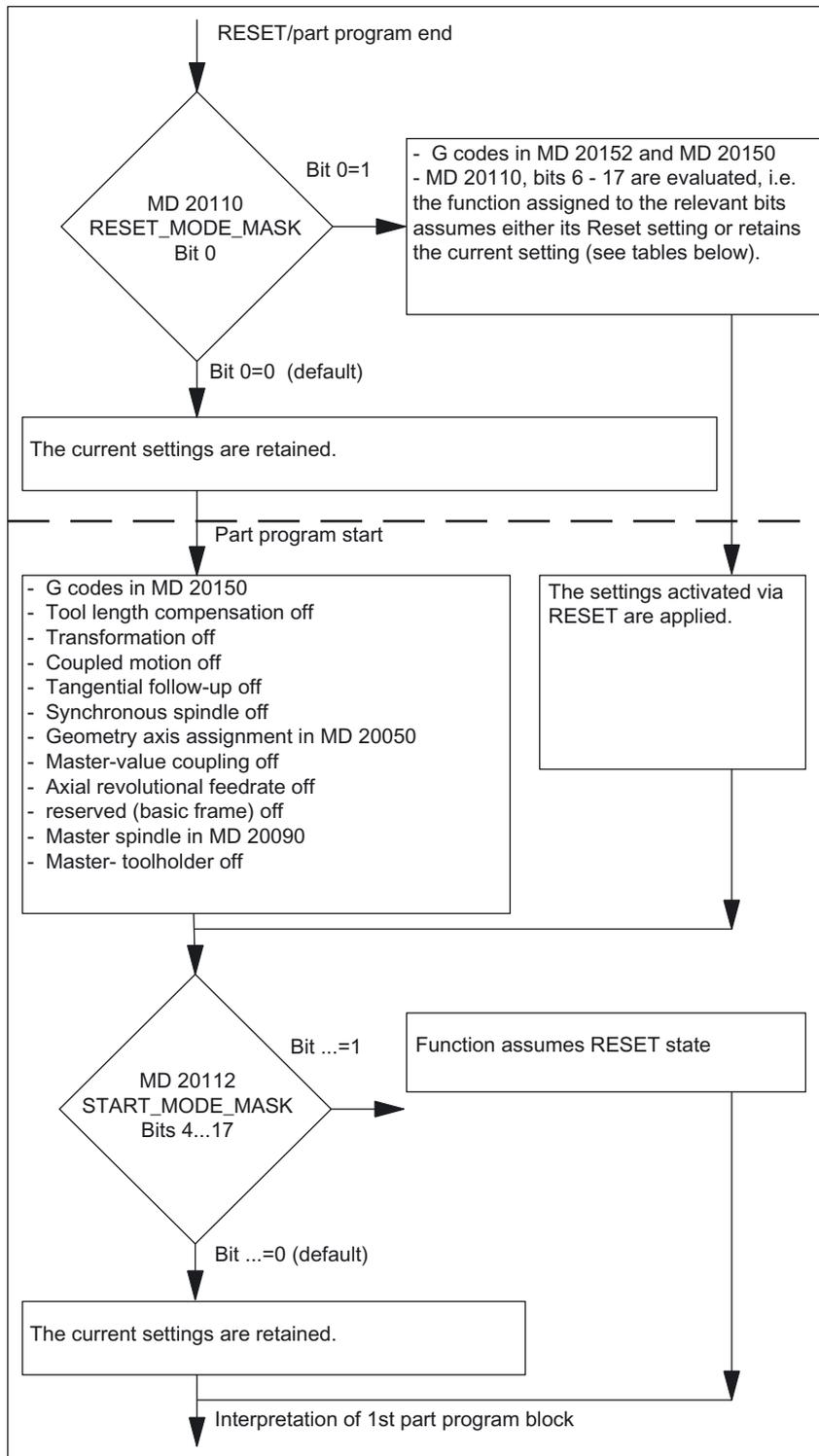


Figure 9-15 System settings after RESET/part program end and part program start

9.13 System settings for power-up, RESET/part-program end and part-program start

Table 9-7 Selection of RESET and power-up response

MD number	RESET_MODE_MASK Definition of control initial setting after power-up and reset/part program end	
Response after	Bit 0 = 0	Bit 0 = 1
Power ON (booting)	<ul style="list-style-type: none"> <li>- Transformation not active</li> <li>- Tool length compensation not active</li>   <li>- G-Codes according to MD20150 \$MC_GCODE_RESET_VALUES</li> <li>- No coupled axis groupings active</li> <li>- No tangential follow-up active</li> <li>- non-configured Synchronous spindle coupling is deactivated</li> <li>- Geometry axis assignment according to MD20050</li> <li>- No master value coupling active</li> <li>- Axial revolutionary feedrate OFF</li> <li>- Basic frame is deselected</li> </ul>	<ul style="list-style-type: none"> <li>- Transformation active according to MD20140 \$MC_TRAFO_RESET_VALUE</li> <li>- Tool length compensation active according to MD20120 \$MC_TOOL_RESET_VALUE, MD20121 \$MC_TOOL_PRESEL_RESET_VALUE and MD20130 \$MC_CUTTING_EDGE_RESET_VALUE, if Bits 2 and 6 in MD20110 = 1, the tool length compensations selected on Power On, otherwise WLK according to MD20120, MD20121, MD20130</li> <li>- G-Codes according to MD20150 \$MC_GCODE_RESET_VALUES</li> <li>- No coupled axis groups active</li> <li>- No tangential follow-on active</li> <li>- Non-configured Synchronous spindle coupling is switched off</li> <li>- Geometry axis assignment according to MD20118, MD20050</li> <li>- No master value coupling active</li> <li>- Axial revolutionary feedrate OFF</li> <li>- Basic frame is deselected</li> </ul>
RESET/end of prog.	The current settings are retained. With the next part program start, the following initial setting is activated:	In the case of configured synchronous spindle couple, the coupling is set in accordance with MD21330 \$MC_COUPLE_RESET_MODE_1.
	<ul style="list-style-type: none"> <li>- G codes according to MD20150 \$MC_GCODE_RESET_VALUES</li> <li>- Tool length compensation not active</li> <li>- Transformation not active</li> <li>- No coupled axis groupings active</li> <li>- No tangential follow-up active</li> <li>- Basic frame is deselected</li> <li>- Geometry axis assignment acc. to MD20050</li> <li>- Axial revolutionary feedrate OFF</li> </ul>	GCODES according to MD20150, MD_20152

Table 9-8 Effect of MD20110 \$MC\_RESET\_MODE\_MASK Bits 0...6

Bit 0 = 1	Bit 1 = 1	Bit 2 = 1	Bit 3 = 1	Bit 4 = 1	Bit 5 = 1	Bit 6 = 1
Initial setting after power up and RESET/end of part program see above	No D, T, M output on tool selection; with active tool management irrelevant	If bit 0=1 and bit 6 =1, the tool offset of the last active tool is active after POWER ON (irrelevant with active tool management)	Use active tool or tool offset from last test program terminated in test mode	Current plane is retained, in SW 5 replaced by MD 20152 index 5 see below	Current settable frame is retained, as of SW 5 replaced by MD 20152 index 7 see below	Active tool offset is retained

9.13 System settings for power-up, RESET/part-program end and part-program start

Bit 0 = 0	Bit 1 = 0	Bit 2 = 0	Bit 3 = 0	Bit 4 = 0	Bit 5 = 0	Bit 6 = 0
Initial setting after power up and RESET/end of part program see above	D, T, M output on tool selection; with active tool management irrelevant	No tool offset active after POWER ON (no effect when tool management active)	Use active tool or tool offset from last program terminated before program testing activated	Plane according to MD20150 \$MC_GCODE_RESET_VALUES; in SW 5 and higher, replaced by MD 20152 index 5 see below	Frame according to MD20150 \$MC_GCODE_RESET_VALUES; in SW 5 and higher, replaced by MD 20152 index 7 see below	WZK according to MD20120 \$MC_TOOL_RESET_VALUE, MD20121 \$MC_TOOL_PRESEL_RESET_VALUE, MD20130 \$MC_CUTTING_EDGE_RESET_VALUE; Output of D, T, M to PLC, depending on bit 1

Table 9-9 Effect of MD20110 \$MC\_RESET\_MODE\_MASK Bits 7 to 12

Bit 7 = 1	Bit 8 = 1	Bit 9 = 1	Bit 10 = 1	Bit 11 = 1	Bit 12 = 1
Active transformation is retained	Coupled-axis groupings are retained	Tangential follow-up is retained	Not configured synchronous spindle coupling remains active	Current setting for revolutionary feedrate is retained	Modified geometry axis assignment is retained

Bit 7 = 0	Bit 8 = 0	Bit 9 = 0	Bit 10 = 0	Bit 11 = 0	Bit 12 = 0
Transformation according to MD20140 \$MC_TRAFO_RESET_VALUE	Coupled-motion groupings are deactivated	Tangential follow-up is deactivated	Not configured synchronous spindle coupling is switched off	Revolutional feedrate is no longer valid	Modified geometry axis assignment is deleted according to MD 20050, depending on MD20118 (because of compatibility)

Table 9-10 Effect of MD20110 \$MC\_RESET\_MODE\_MASK Bits 13 to 17 (in SW 6.4 and higher, Bit 16 to Bit 17)

Bit 13 = 1	Bit 14 = 1	Bit 15 = 1	Bit 16 = 1	Bit 17 = 1	
Active guide value coupling is retained	The current setting of the basic frame is retained.	The active electronic gears are deactivated	The current setting of the master spindle is retained.	The current setting of the master tool holder is retained.	

Bit 13 = 0	Bit 14 = 0	Bit 15 = 0	Bit 16 = 0	Bit 17 = 0	
Guide value coupling is separated	Basic frame is deselected	The active electronic gears are retained	Initial setting for the master spindle according to MD20090	Initial setting for the master tool holder according to MD20124	

**RESET response of master spindle**

Up to SW 6.3 the master spindle setting was reset to the configured value on M30/RESET. Depending on the setting of Bit 0 of MD20110 \$MC\_RESET\_MODE\_MASK, there are two cases:

**Bit 0 = 0:**

No Init blocks are generated. (Default: the current settings are retained)

**Bit 0 = 1:**

Init blocks are generated. The settings activated by RESET become valid.

**MD20152 \$MC\_GCODE\_RESET\_MODE**

In SW 5 and higher, MD20152 \$MC\_GCODE\_RESET\_MODE replaces Bits 4 and 5 from MD20110 \$MC\_RESET\_MODE\_MASK. In addition, the setting options are expanded:

**Up to and including SW 4**

the following applies to Bits 4 and 5 of MD20110 \$MC\_RESET\_MODE\_MASK:

**Bit 4:** Level control

**Bit 5:** Control of settable frames

Each G code group controlled in MD20150 \$MC\_GCODE\_RESET\_VALUES[i] can be selectively controlled with the additional MD20152 \$MC\_GCODE\_RESET\_MODE[i].

MD20152 \$MC_GCODE_RESET_MODE[i] (i = G code group -1)	0	1
MD20150 \$MC_GCODE_RESET_VALUES[i]	The value stored in MD20150 is active	The last active/ current value is active

**Note**

The previous setting option in machine data MD20110 \$MC\_RESET\_MODE\_MASK is omitted!

The corresponding bits of this MD are tagged as reserved. Write operations involving these bits are automatically redirected to the corresponding array elements of MD20150 \$MC\_GCODE\_RESET\_MODE and Alarm 4502 is output.

When MD20110 \$MC\_RESET\_MODE\_MASK is read, the information from the relevant field arrays of MD20150 \$MC\_GCODE\_RESET\_MASK are read again and written to MD20110 \$MC\_RESET\_MODE\_MASK.

The mode of functioning of MD20112 \$MC\_START\_MODE\_MASK remains the same as in SW5.

### Part program start

The initial setting of the control system at part program start, e.g. G codes (especially active plane and active settable zero offset), active tool length compensation, transformation, and axis coupling, is determined according to the following table.

### Application

If a bit is set in MD20112 \$MC\_START\_MODE\_MASK, the reset action of the relevant function can be delayed until the start of the part program.

Table 9-11 Effect of MD20112 \$MC\_START\_MODE\_MASK Bits 1 to 7

Bit 1 = 1	Bit 2 = 1	Bit 3 = 1	Bit 4 = 1	Bit 5 = 1	Bit 6 = 1	Bit 7 = 1
No D, T, M output on tool selection; with active tool management irrelevant	Reserved	Reserved	Plane according to MD20150 \$MC_GCODE_RESET_VALUES	Frame according to MD20150 \$MC_GCODE_RESET_VALUES	WZK according to MD20120 \$MC_TOOL_RESET_VALUE, MD20121 \$MC_TOOL_PRESEL_RESET_VALUE, and MD20130 \$MC_CUTTING_EDGE_RESET_VALUE; Output of D, T, M to PLC, depending on bit 1	Transform. according to MD20140 \$MC_TRAFO_RESET_VALUE

Bit 1 = 0	Bit 2 = 0	Bit 3 = 0	Bit 4 = 0	Bit 5 = 0	Bit 6 = 0	Bit 7 = 0
D, T, M output on tool selection; with active tool management irrelevant	Reserved	Reserved	Current plane is retained	Current settable frame is retained	Active tool length offset is retained	Active transformation is retained

9.13 System settings for power-up, RESET/part-program end and part-program start

Table 9-12 Effect of MD20112 \$MC\_START\_MODE\_MASK Bits 8 to 12

Bit 8 = 1	Bit 9 = 1	Bit 10 = 1	Bit 11 = 1	Bit 12 = 1
Coupled-axis groupings are deactivated	Tangential follow-up is deactivated	Not configured synchronous spindle coupling is switched off	Reserved	Geometry axis assignment is deleted according to MD 20050, depending on MD 20118 (because of compatibility)

Bit 8 = 0	Bit 9 = 0	Bit 10 = 0	Bit 11 = 0	Bit 12 = 0
Coupled-axis groupings are retained	Tangential follow-up is retained	Not configured synchronous spindle coupling remains active	Reserved	Modified geometry axis assignment is retained

Table 9-13 Effect of MD20112 \$MC\_START\_MODE\_MASK Bits 13 to 17

Bit 13 = 1	Bit 14 = 1	Bit 15 = 1	Bit 16 = 1	Bit 17 = 1
Guide value coupling is separated	reserved for basic frame	reserved for electronic gears	Initial setting for master spindle according to MD20090 \$MC_SPIND_DEF_MASTER_SPIND	Only if MD20124 \$MC_TOOL_MANAGEMENT_TOOLH_OLDER > 0: Initial setting for the master tool holder according to MD 20124 \$MC_Otherwise setting for master spindle.

Bit 13 = 0	Bit 14 = 0	Bit 15 = 0	Bit 16 = 0	Bit 17 = 0
Active guide value coupling is retained	reserved for basic frame	reserved for electronic gears	current setting of the master spindle (SETMS) is retained	The current setting of the master tool holder (SETMS) is retained.

**Note**

In MD20110 \$MC\_RESET\_MODE\_MASK, bits set to 1 cause settings to be retained,  
 In MD20112 \$MC\_START\_MODE\_MASK, bits set to 0 cause settings to be retained.

## Significance of the machine data

The channel-specific machine data in the table has the following significance. Details are specified in section "Channel-specific machine data".

- **MD20120 \$MC\_TOOL\_RESET\_VALUE (Restart tool length compensation)**  
Definition of tool (T-No.),  
whose tool length compensation values must be considered during RESET and power-up according to **MD20110 \$MC\_RESET\_MODE\_SCREEN**
- MD20121 \$MC\_TOOL\_PRESEL\_RESET\_VALUE (Preselected tool on RESET)**  
Definition of tool (T-No.) as preselected tool, whose tool length compensation values must be considered during RESET and power-up according to **MD20110 \$MC\_RESET\_MODE\_SCREEN**
- MD20130 \$MC\_CUTTING\_EDGE\_RESET\_VALUE (tool edge length compensation on power-up)**  
Definition of the edge no. (D number) of the tool in  
\$MC\_TOOL\_RESET\_VALUE
- MD20140 \$MC\_TRAFO\_RESET\_VALUE (Power-up transformation data block)**  
Definition of transformation data block (TRAORI, TRAANG,  
from SW 4 TRANSMIT)
- MD20150 \$MC\_GCODE\_RESET\_VALUES (RESET position of G groups)**  
RESET positions of G groups
- MD20152 \$MC\_GCODE\_RESET\_MODE (Reset behavior of G groups)**  
GCODE initial setting during RESET  
  
MD20152 specifies for each entry in MD20150 \$MC\_GCODE\_RESET\_VALUES whether the setting in accordance with MD20150 \$MC\_GCODE\_RESET\_VALUES is taken again (entry in MD20152=0) or the current setting is retained (entry in MD20152=1).
- MD21330 \$MC\_COUPLE\_RESET\_MODE\_1 (Coupling cancel behavior)**  
cancelation of an axis coupling
- MD20050 \$MC\_AXCONF\_GEOAX\_ASSIGN\_TAB (Assignment of geometry axis to channel axis)**  
Assignment of geometry axis to channel axis  
affects Bit 12 in MD 20110/20112
- MD20118 \$MC\_GEOAX\_CHANGE\_RESET (Allow automatic geometry axis change)**  
affects Bit 12 in MD20110/20112

### Example

1. Activate RESET setting on RESET:  
MD20110 = 'H01' (Bit 0)  
MD20112 = '0'
2. Transformation remains active on RESET/part program start:  
MD20110 = 'H81' (Bit 0 + Bit 7)  
MD20112 = '0'
3. Tool length compensation remains active on RESET/part program start:  
MD20110 = 'H41' (Bit 0 + Bit 6)  
MD20112 = '0'
4. Active plane (Bit 4) and settable frame (Bit 5) remain active after RESET and are reset on part program start:  
MD20110 = 'H31' (Bit 4 + Bit 5)  
MD20112 = '30'

---

### Note

for bit 5 and bit 6:

If MD20110/MD20112 are parameterized so that tool length compensation or a frame is active on a part program start/MDA start, the first programming of the axes must use absolute measurements (because of the offset behavior).

Exception: With MD42442/MD42440 the offset behavior for G91 is suppressed.

---

## 9.14 Replacement of NC functions by subprograms

### 9.14.1 General

#### Function

The NC-language offers the option of structuring more complex processing sequences through subprograms. Normally these subprograms are started from the part programs with explicitly programmed subprogram calls. Along with this, there is also the possibility of hiding a subprogram call behind another NC -command (e.g. call of an M function) and thus of replacing the actual command function by the subprogram.

Example Call of the tool change cycle by the auxiliary function M6

The reasons for this are as follows:

- Existing part programs can be adapted to the changed environmental conditions without correcting the part programs themselves.
- An introduced programming style can be maintained.

#### Replaceable NC functions

The following NC functions can be replaced by subprograms:

- M, T, and D/DL auxiliary functions:
  - M Functions for switching operations
  - T Functions for tool selection
  - D/DL-Functions for tool compensation selection
- Spindle-related functions during active synchronous spindle coupling:
  - Gear stage change (automatic change or direct gear stage)
  - Spindle positioning with SPOS, SPOSA and M19

## 9.14.2 Replacement of M functions

### Conditions

The following conditions are applicable for replacing the M functions:

- A maximum of one function replacement is active for each block.
- The block with the function replacement may **not** contain the following elements:
  - M98
  - Modal subroutine call
  - Subprogram return
  - Part program end
- A subroutine call must not be superimposed on M functions with predetermined significance (see Section "Non-configurable M functions").

### Configuration

The numbers of the M functions to be replaced by the subprograms are specified in the machine data:

MD10715 \$MC\_M\_NO\_FCT\_CYCLE[n]

The names of the subprograms that are to replace the M functions specified in MD10715 are entered in the machine data:

MD10716 \$MC\_M\_NO\_FCT\_CYCLE\_NAME[n]

Example

MD10715 \$MC\_M\_NO\_FCT\_CYCLE[0] = 101

MD10716 \$MC\_M\_NO\_FCT\_CYCLE\_NAME[0] = "SUB\_M101"

⇒ Call of the subprogram SUB\_M101 through M101

MD10715 \$MC\_M\_NO\_FCT\_CYCLE[1] = 102

MD10716 \$MC\_M\_NO\_FCT\_CYCLE\_NAME[1] = "SUB\_M102"

⇒ Call of the subprogram SUB\_M102 through M102

## Programming

If the M function configured with MD10715 is programmed in a part program block, the appropriate subroutine is called at the end of the part program block.

If the M function is programmed again within the called subroutine, the M function is not replaced again. In addition, other M function replacements configured with MD10715 or MD10716 are not executed.

Exception:

The M function is also replaced in an ASUB if the ASUB was started in a subroutine that was called via an M function.

### Address extension of M function

Using system variable \$C\_ME it is possible to read the address extension of the M function in the called subroutine.

## M functions that cannot be configured

M Functions that trigger system functions as pre-defined auxiliary functions should not be used to call subroutines. The following M functions have standard predetermined significance:

M function	Remarks
M0 ... M5, M17, M30, M19, M40 ... M45	Predefined auxiliary functions that trigger system functions
M98, M99	with activated external NC language: MD18800 \$MN_MM_EXTERN_LANGUAGE == TRUE

M functions can be defined for specific tasks using the following machine data. Through this, they receive a fixed meaning and, therefore, must not be used to call subroutines:

Machine data	Significance
MD10714 \$MN_M_NO_FCT_EOP	M function for spindle active after RESET
MD10804 \$MN_EXTERN_CHAN_M_NO_SET_INT	M function for ASUB activation (external mode)
MD10806 \$MN_EXTERN_CHAN_M_NO_DISABLE_INT	M function for ASUB deactivation (external mode)
MD10814 \$MN_EXTERN_M_NO_MAC_CYCLE	Macro call via M function
MD20094 \$MC_SPIND_RIGID_TAPPING_M_NR	M function for switchover to controlled axis mode
MD20095 \$MC_EXTERN_RIGID_TAPPING_M_NR	M function for switchover to controlled axis mode (external mode)
MD22254 \$MC_AUXFU_ASSOC_M0_VALUE	Additional M function for program stop
MD22256 \$MC_AUXFU_ASSOC_M1_VALUE	Additional M function for conditional stop

9.14 Replacement of NC functions by subprograms

Machine data	Significance
MD26008 \$MC_NIBBLE_PUNCH_CODE	Definition of M functions (for nibble-specific)
MD26012 \$MC_PUNCHNIB_ACTIVATION	Activation of punching and nibbling functions

**Note**

An exception here is the M function for the tool change configured via the following machine data:

MD22560 \$MC\_TOOL\_CHANGE\_M\_CODE (Tool change with M Function)

This M function is permitted to be replaced by a subroutine (see " Replacement of the M function for the tool change (Page 679) ").

9.14.3 Replacement of T and D/DL functions

9.14.3.1 General

**Conditions**

The following conditions are applicable for the replacement of T or D or DL functions:

- A maximum of one function replacement is active for each block.
- The block with the function replacement may **not** contain the following elements:
  - M98
  - Modal subroutine call
  - Subprogram return
  - Part program end

**Configuration**

**Specification of the replacement subroutine**

The name of the subroutine, which is to become effective in case of **T-Function replacement**, is entered in the machine data:

MD10717 \$MN\_T\_NO\_FCT\_CYCLE\_NAME

The name of the subroutine, which is to become effective in case of **D/DL function replacement**, is entered in the machine data:

MD11717 \$MN\_D\_NO\_FCT\_CYCLE\_NAME

**Note**

The same subroutine should be configured for the T and D/DL replacement subroutine.

**Specification of the D or DL number to the replacement subroutine**

For a simultaneous programming of D or DL and T in a block, D or DL can **either** be specified as parameter to the replacement subroutine **or** executed before calling the replacement subroutine.

The behavior depends on the setting of bit 0 in the machine data:

MD10719 \$MN\_T\_NO\_FCT\_CYCLE\_MODE (Parameterization of the T function replacement)

Bit	Value	Description
0	0	The D or the DL number is specified to the replacement subroutine via the system variable (default setting).
	1	The D or DL number is calculated directly in the block. <b>Note:</b> This function is only active if the tool change was configured with M function: MD22550 \$MC_TOOL_CHANGE_MODE = 1 otherwise the D or DL values are always transferred.

**Call time of the replacement subroutine**

The call time of the replacement subroutine is defined by the setting of bit 1 and bit 2 in the machine data:

MD10719 \$MN\_D\_NO\_FCT\_CYCLE\_MODE

Value of bit 1	Value of bit 2	Call time of the replacement subroutine
0	0	At block end (default) After the replacement subroutine has been executed, the interpretation is resumed with the subprogram line following the line that triggered the replacement operation.
1	0	At block start After the replacement subroutine has been executed, the part program line that controlled the call of the subroutine is interpreted. The T address and the D or DL address and the M function for the tool change are no longer processed.
0/1	1	At block start and block end The replacement program is called twice.

9.14 Replacement of NC functions by subprograms

**Note**

Which replacements are to be performed at the block start and which are to be performed at the block end is up to the user.

**Programming**

**Read activation time of the replacement subroutine**

The \$P\_SUB\_STAT system variables can be used to define the time (block start/block end) when the replacement operation is executed:

Value	Description
0	Replacement subroutine is not active
1	Replacement subroutine is active, call at block start
2	Replacement subroutine is active, call at block end

**Example T function replacement**

**Project design:**

MD22550 \$MC\_TOOL\_CHANGE\_MODE = 0

MD10717 \$MN\_T\_NO\_FCT\_CYCLE\_NAME = "MY\_T\_CYCLE"

MD10719 \$MN\_T\_NO\_FCT\_CYCLE\_MODE = 0

**Meaning:**

Tool change with T function

T replacement subroutine

Programming	Comment
...	
N110 D1	
N120 G90 G0 X100 Y100 Z50	; D1 is active
N130 D2 X110 Z0 T5	; D1 remains active, programmed D2 is provided to the T replacement cycle as a variable.
...	

A comprehensive example for the T function replacement is given in " Examples of M/T function replacement during tool change (Page 684) ".

### 9.14.3.2 Replacement of the M function for the tool change

#### Tool change with M function

MD22550 \$MC\_TOOL\_CHANGE\_MODE = 1

For certain machine types (e.g. milling machine with tool magazine) the T function is not used for the actual tool change, but instead for its preparation i.e. with the T function the new tool is brought to the tool change position parallel to the machining time (without interruption of the processing).

The actual tool change is then called with the M function, which is configured in the following machine data:

MD22560 \$MC\_TOOL\_CHANGE\_M\_CODE (M function for tool change)

#### References:

Function Manual Extended Functions; Tool Change (W3)

#### Replacement of the M function for the tool change

The M function for the tool change configured via MD22560 is replaced by a subroutine, if a corresponding replacement subroutine is configured via both the following machine data:

MD10715 \$MN\_M\_NO\_FCT\_CYCLE[n] (M function to be replaced by a subroutine)

MD10716 \$MN\_M\_NO\_FCT\_CYCLE\_NAME[n] (Name of subroutine for M function)

For more information, see " Replacement of M functions (Page 674) ".

---

#### Note

The configuration of a replacement subroutine for the tool change with M code is dependent on whether the tool change with M code was actually configured with MD22550 \$MC\_TOOL\_CHANGE\_MODE.

---

#### M function replacement with parameter transfer

If an M function replacement is configured with MD10715[n] and MD10716[n], then for this M function replacement a parameter transfer can be set (similar to the parameter transfer for the T function replacement):

MD10718 \$MN\_M\_NO\_FCT\_CYCLE\_PAR = n

The data (parameters) needed for the tool offset or the tool offset selection is passed to the subroutine via the system variables. The parameters stored in the system variables always refer to the part program line in which the M function to be replaced is programmed.

---

**Note**

The address extension and function value of the M function must be explicitly, i.e. constantly, programmed for M function replacements with parameter transfer. An indirection definition via variables is not allowed.

**Permissible programming:**

M<function value>

M=<function value>

M[<address extension>] = <function value>

**Impermissible programming:**

M=<Variable1>

M[<variable2>] = <variable1>

---

**Conflict case: M and T functions for tool change in a block**

If, in addition to the M function replacement with parameter transfer, a T function replacement was configured, the following behavior is applicable in case of a conflict, i.e. T and M function for tool change are in one block:

- The T function replacement does not take place. Instead, the T value is made available to the M function replacement via the appropriate \$C\_T... system variables.
- The programming of the address T in the M function subroutine does not result in another replacement.

### 9.14.3.3 Function replacement with parameter transfer

#### Rules for parameter transfer

The following rules are applicable for the parameter transfer to the replacement subroutines:

- If one of the above-mentioned replacements is active, then all the information required for the tool offset selection (T, D or DL numbers, M function for tool change, address extensions) is transferred to the replacement subroutine.

Exception:

MD10719 \$MN\_T\_NO\_FCT\_CYCLE\_MODE Bit 0 = 1

With this configuration the D or the DL numbers are not transferred to the replacement subroutines.

- In a block, only one replacement subroutine can be processed at a time.  
In case of multiple replacements of the T, D/DL addresses and the M Function for the tool change, only one of the replacement subroutines is always active even under different names. As described above, all the required parameters for the tool offset selection are then made available to it. If configured accordingly, the subroutine is called before and/or after execution of the part program line.
- **One and the same subroutine** can be configured for the replacement of the T, D/DL addresses and the M Function for the tool change. The function to be replaced can then be determined by querying the system variables.



The values passed to the replacement subroutine have not yet been executed and must, therefore, be programmed again in this subroutine.

#### System variables

The programmed values (T, D or DI numbers, M function for tool change, address extensions) can be transferred to the replacement subroutine via the following system variables:

System variable	Description
\$C_T_PROG	Returns the value "1", if address T has been programmed.
\$C_T	Value of the programmed address T
\$C_TE	Address extension of address T
\$C_TS_PROG	Returns the value "1", if the address T has been programmed with a tool identifier of type STRING (only in case of active tool monitoring).
\$C_TS	Returns the string of the tool identifier programmed under address T (only in case of active tool monitoring)
\$C_D_PROG	Returns the value "1", if address D has been programmed.
\$C_D	Value of the programmed address D
\$C_DL_PROG	Returns the value "1", if address DL has been programmed.
\$C_DL	Value of the programmed address DL
\$C_M_PROG	Returns the value "1", if an M function has been programmed for the tool change.

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System variable	Description
\$C_M	Value of the programmed address M There are two different cases: 1. For the tool change with M function, a replacement subroutine is programmed with parameter transfer. \$C_M then returns the value: MD10715 \$MN_M_NO_FCT_CYCLE 2. Only one replacement subroutine was configured for the addresses T and/or D/DL and in the program the M function for the tool change is programmed with the addresses to be replaced. \$C_M then returns the value: MD22560 \$MC_TOOL_CHANGE_M_CODE
\$C_ME	Address extension of the M function for the tool change

Sample parameter transfers

Example 1:

Tool change with M6 should be active. The D/DL number is to be transferred to the replacement subroutine.

Project design:

MD22550 \$MC\_TOOL\_CHANGE\_MODE = 1

MD10717 \$MN\_T\_NO\_FCT\_CYCLE\_NAME = "MY\_T\_CYCLE"

MD10719 \$MN\_T\_NO\_FCT\_CYCLE\_MODE = 0

Meaning:

Tool change with M function

T replacement subroutine

Transfer of the D/DL number

Programming	Comment
...	
N210 D1	
N220 G90 G0 X100 Y100 Z50	; D1 is active
N230 D2 X110 Z0 T5	; D1 remains active, programmed D2 is provided to the T replacement subroutine as a variable.
N240 M6	; Execute tool change
...	

**Example 2:**

Tool change with M6 should be active. The D/DL number is **not** to be transferred to the replacement subroutine.

**Project design:**

MD22550 \$MC\_TOOL\_CHANGE\_MODE = 1

MD10717 \$MN\_T\_NO\_FCT\_CYCLE\_NAME = "MY\_T\_CYCLE"

MD10719 \$MN\_T\_NO\_FCT\_CYCLE\_MODE = 1

**Meaning:**

Tool change with M function

Replacement subroutine for T function

No transfer of the D/DL number

Programming	Comment
...	
N310 D1	
N320 G90 G0 X100 Y100 Z50	; D1 is active
N330 D2 X110 Z0 T5	; D2 is activated, D2 is not transferred to the T replacement subroutine as a variable
N340 M6	; Execute tool change
...	

**Example 3:**

A replacement subroutine (MY\_T\_CYCLE ) is configured for T and M6.

In addition, MD10718 \$MN\_M\_NO\_FCT\_CYCLE\_PAR (M Function replacement with parameters) was used to configure the parameter transfer to M6 replacement subroutine.

If M6 is now programmed in the block with D or DL, then the D or the DL number is also transferred as parameter to the M6 replacement subroutine, when:

MD10719 \$MN\_T\_NO\_FCT\_CYCLE\_MODE = 1

**Project design:**

MD22550 \$MC\_TOOL\_CHANGE\_MODE = 1

MD22560 \$MC\_TOOL\_CHANGE\_M\_CODE = 6

MD10715 \$MC\_M\_NO\_FCT\_CYCLE[3] = 6

MD10716 \$MC\_M\_NO\_FCT\_CYCLE\_NAME[3] = "MY\_T\_CYCLE"

MD10717 \$MN\_T\_NO\_FCT\_CYCLE\_NAME = "MY\_T\_CYCLE"

**Meaning:**

Tool change with M function

M code for tool change

M function to be replaced

Replacement subroutine for M function

Replacement subroutine for T function

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MD10718 \$MN_M_NO_FCT_CYCLE_PAR = 3	Parameter transfer to the replacement subroutine for M6
MD10719 \$MN_T_NO_FCT_CYCLE_MODE = 1	No transfer of the D/DL number

Programming	Comment
...	
N410 D1	
N420 G90 G0 X100 Y100 Z50	; D1 is active
N330 D2 X110 Z0 T5 M6	; D1 remains active, D2 and T5 are transferred to the M6 replacement subroutine as a variable
...	

9.14.3.4 Example of M/T function replacement for tool change

Example 1: Call of subroutine SUB\_M6 through M6 with parameter transfer

<b>Project design:</b>	<b>Meaning:</b>
MD10715 \$MN_M_NO_FCT_CYCLE[2] = 6	M code for tool change
MD10716 \$MN_M_NO_FCT_CYCLE_NAME[2] = "SUB_M6"	Replacement subroutine for M function
MD10718 \$MN_M_NO_FCT_CYCLE_PAR = 2	M function replacement with parameter transfer

Main program:

Programming
PROC MAIN
...
N10 T1 D1 M6
...
N90 M30

Replacement subroutine:

Programming	Comment
PROC SUB_M6	
N110 IF \$C_T_PROG==TRUE	; Scan whether address T has been programmed
N120 T[\$C_TE] = \$C_T	; Execute T selection
N130 ENDIF	
N140 M[\$C_ME] = 6	; Execute tool change
N150 IF \$C_D_PROG==TRUE	Scan whether address D has been programmed.
N160 D=\$C_D	Execute D selection
N170 ENDIF	
N190 M17	

### Example 2: Replacement of T address and D or DL addresses at block start

The following should be true for the example:

- Tool change is done with the address T.
- Tool management not active.
- B axis as indexing axis with Hirth tooth system.

#### Project design:

MD11717 \$MN\_D\_NO\_FCT\_CYCLE\_NAME = "D\_T\_SUB\_PROG"

MD10717 \$MN\_T\_NO\_FCT\_CYCLE\_NAME = "D\_T\_SUB\_PROG"

MD10719 \$MN\_T\_NO\_FCT\_CYCLE\_MODE = 'H2'

MD22550 \$MC\_TOOL\_CHANGE\_MODE = 0

#### Meaning:

Replacement subroutine for D function

Replacement subroutine for M function

Call at block start

Tool change with T function

Main program:

Programming
...
N410 G01 F1000 X10 T1=5 D1
...

Replacement subroutine:

Programming	Comment
N1000 PROC D_T_SUB_PROG DISPLOF SBLOF	
...	

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Programming	Comment
N4100 IF \$C_T_PROG==TRUE	; Scan whether address T has been programmed
N4110	; Replacement for address T with tool no.
N4120 POS[B] = CAC(\$C_T)	; Move revolver to indexing position
N4130 T[\$C_TE] = \$C_T	; Select tool (T selection)
N4140 ENDIF	
N4300 IF \$C_D_PROG==TRUE	; Scan whether address D has been programmed.
N4310	; Replacement for address D
N4320 D=\$C_D	; Select offset (D selection)
N4330 ENDIF	
N4400 IF \$C_DL_PROG==TRUE	; Scan whether address DL has been programmed.
N4410	; Replacement for address DL
N4420 D=\$C_DL	; Select insert offset
N4430 ENDIF	
...	
N9999 RET	

This causes the part program line  
 N410 G01 F1000 X10 T1=5 D1  
 to execute the following program:

Program	Comment
N1000 PROC D_T_SUB_PROG DISPLOF SBLOF	
...	
N4100 IF \$C_T_PROG==TRUE	; Scan whether address T has been programmed
N4110	; Replacement for address T with tool no.
N4120 POS[B] = CAC(\$C_T)	; Move revolver to indexing position
N4130 T[\$C_TE] = \$C_T	; Select tool (T selection)
N4140 ENDIF	
N4300 IF \$C_D_PROG==TRUE	; Scan whether address D has been programmed.
N4310	; Replacement for address D
N4320 D=\$C_D	; Select offset (D selection)
N4330 ENDIF	
N4400 IF \$C_DL_PROG==TRUE	; Scan whether address DL has been programmed.

Program	Comment
N4430 ENDIF	
...	
N9999 RET	
N410 G01 F1000 X10	; Rest of N410 without tool programming

### 9.14.3.5 Conflict resolution in case of multiple replacements

#### Multiple replacements

Multiple replacements mean that several replacement subroutines with different names have been configured, e.g.:

- For Address D and DL:  
MD11717 \$MN\_FCT\_CYCLE\_NAME = "D\_SUB\_PROG"
- For Address T:  
MD10717 \$MN\_FCT\_CYCLE\_NAME = "T\_SUB\_PROG"
- For the M function for the tool change  
MD10715 \$MN\_M\_NO\_FCT\_CYCLE[0] = 6  
MD10716 \$MN\_M\_NO\_FCT\_CYCLE\_NAME[0] = "M6\_SUB\_PROG"  
MD10718 \$MN\_M\_NO\_FCT\_CYCLE\_PAR = 0  
MD22550 \$MC\_TOOL\_CHANGE\_MODE = 1  
MD22560 \$MC\_TOOL\_CHANGE\_M\_CODE = 6

#### Conflict resolution

The following table illustrates how the control system resolves the conflicts in case of multiple replacements:

The following are programmed in one part program line:			Called replacement subroutine:
D and/or DL	T	M6	
-	-	X	M6_SUB_PROG
-	X	-	T_SUB_PROG
-	X	X	M6_SUB_PROG
X	-	-	D_SUB_PROG
X	-	X	M6_SUB_PROG
X	X	-	T_SUB_PROG
X	X	X	M6_SUB_PROG

### 9.14.4 Replacement of spindle-related functions

#### 9.14.4.1 General

##### Function

In case of active synchronous spindle coupling, the following spindle-related functions can be replaced by a subroutine for the leading spindle of this coupling:

- Direct gear stage change with M41 to M45 and automatic gear stage change in case of speed programming with M40
- Spindle positioning with SPOS, SPOSA and M19

##### Conditions

- The replacement of a spindle-related function is executed only when:
  - the programmed spindle is active as leading spindle of a synchronous spindle coupling.
  - Leading and following spindle are present in the same channel.
  - in case of a gear-stage change actually a gear-stage change is present.
- Only one of the possible spindle-related function replacements can be executed in a part program line. Multiple replacements lead to the termination of the part program processing. If still several spindle-related functions have to be replaced, then the respective function calls must be distributed to several part program lines.

##### Configuration

###### Functions to be replaced

The spindle-related functions to be replaced through the subprogram are selected in the machine data:

MD30465 \$MA\_AXIS\_LANG\_SUB\_MASK

Bit	Description
0	Gear-stage change automatic (M40) and directly (M41-M45)
	= 0 No replacement
	= 1 Replacement through the subroutine set in MD15700 and MD15702
1	Spindle positioning with SPOS/SPOSA/M19
	= 0 No replacement
	= 1 Replacement through the subroutine set in MD15700 and MD15702

###### Name of subprogram

The name of the subroutine, which is to replace the spindle-related function selected in MD30465, is to be entered in the machine data:

MD15700 \$MN\_LANG\_SUB\_NAME (Name for the substitution subroutine)

**Path to the subroutine**

The path to the subroutine is set with the machine data:

MD15700 \$MN\_LANG\_SUB\_NAME (call path for the substitution subroutine)

Value	Description
0	Path to the directory with the <b>Manufacturer</b> cycles: /_N_CMA_DIR (default setting)
1	Path to the directory with the <b>User</b> cycles: /_N_CUS_DIR
2	Path to the directory with the <b>Siemens</b> cycles: /_N_CST_DIR

**Call time of the replacement subroutine****Call at block start**

If the replacement subroutine is called at block start, then the part program line that led to the calling of the subroutine is processed after the subroutine is processed. The parts to be replaced from the replacement subroutine are not processed any more.

**Call at block end**

During call at block end, the part program line that lead to the calling of the subroutine is called first. The parts to be replaced in the replacement subroutine are processed. The subroutine is called finally.

**Read activation time of the replacement subroutine**

The \$P\_SUB\_STAT system variables can be used to define the time (block start/block end) when the replacement operation is executed:

Value	Description
0	Replacement subroutine is not active
1	Replacement subroutine is active, call at block start
2	Replacement subroutine is active, call at block end

### 9.14.4.2 Function replacement during gear-stage change

#### Function

If a gear-stage change is to be done for the leading spindle of an active synchronous spindle coupling and the replacement is configured through a subroutine (MD30465 \$MA\_AXIS\_LANG\_SUB\_MASK, Bit 0 = 1), then a replacement subroutine is called for the implementation of the gear-stage change.

The replacement subroutine handles the following tasks:

1. Resolve coupling
2. The gear stage change of the spindles involved in the coupling is executed
3. Close coupling again

#### Call time of the replacement subroutine

The call always takes place at the block start during automatic gear stage change with M40.

In case of programmed gear-stage change with M41 to M45 the time of the call depends on the output response of this auxiliary function to the PLC:

MD22080 \$MC\_AUXFU\_PREDEF\_SPEC[12] (output specification for M41)

...

MD22080 \$MC\_AUXFU\_PREDEF\_SPEC[16] (output specification for M45)

Bit	Value	Description
5	1	Output of the auxiliary function <b>before</b> the motion
6	1	Output of the auxiliary function <b>during</b> the motion
7	1	Output of the auxiliary function <b>after</b> the motion

In case of output **before or during** the motion the subroutine call is made at the **block start**. In case of output **after** the motion the subroutine call is made at the **block end**.

#### Data transfer to the replacement subroutine

The data required for the replacement can be read in the replacement subroutine through the following system variables:

System variable	Description
\$P_SUB_AXFCT	scan for replacement type Returns the value "1", if the replacement for the gear-stage change (M40, M41-M45) is used.
\$P_SUB_GEAR	Programmed gear stage Returns for each spindle the programmed or the calculated gear stage. Outside the replacement program, these variables deliver the gear stage of the leading spindle.

System variable	Description
\$P_SUB_AUTOGEAR	Automatic gear stage change is active Delivery to a spindle-specific replacement the information whether an automatic gear stage change with M40 was active in the part program line that triggered the replacement operation. Outside the replacement operation, this variable delivers the current setting in the interpreter.
\$P_SUB_LA	Leading spindle of the active coupling Returns the axis identifier of the leading spindle of the active coupling, which had triggered the replacement operation. <b>Tip:</b> If the variable is called outside the replacement operation, the program processing is cancelled with an alarm.
\$P_SUB_CA	Following spindle of the active coupling Returns the axis identifier of the following spindle of the active coupling, which had triggered the replacement operation. <b>Tip:</b> If the variable is called outside the replacement operation, the program processing is cancelled with an alarm.

## Example

### Configuration

The replacement subroutine for the gear-stage change is activated:

```
MD30465 $MA_AXIS_LANG_SUB_MASK[AX5] = 'H0001'
```

For the output of M41 to M45 to the PLC an output before the motion is configured:

```
MD22080 $MC_AUXFU_PREDEF_SPEC[12] = 'H21'
```

```
MD22080 $MC_AUXFU_PREDEF_SPEC[13] = 'H21'
```

```
MD22080 $MC_AUXFU_PREDEF_SPEC[14] = 'H21'
```

```
MD22080 $MC_AUXFU_PREDEF_SPEC[15] = 'H21'
```

```
MD22080 $MC_AUXFU_PREDEF_SPEC[16] = 'H21'
```

### Main program:

Programming	Comment
PROC MAIN	
...	
N110 COUPON(S2,S1)	; Activate synchronous spindle coupling
N120 G01 F100 X100 S5000 M3 M43	; Call of _N_LANG_SUB_SPF due to M43
N130 M40	; Automatic gear stage change on
N140 M3 S1000	; Call of _N_LANG_SUB_SPF in case of automatic gear-stage change based on S programming.

9.14 Replacement of NC functions by subprograms

**Replacement subroutine \_N\_LANG\_SUB\_SPF, Variant 1:**

This programming example is optimized for simplicity and speed. The spindles are thus addressed directly (typically the machine manufacturer would know, which following Spindle(s) are affected during spindle positioning and address these spindles directly). In the example S1 is the leading spindle and S2 is the following spindle.

Programming	Comment
N1000 PROC LANG_SUB DISPLOF SBLOF	
N1100 IF(\$P_SUB_AXFCT ==1)	; Replacement due to gear stage change
...	
N1140 DELAYFSTON	; Start Stop Delay Area
N1150 COUPOF(S2,S1)	; Deactivate synchronous spindle coupling
N1160	; Execute gear-stage change separately for main and following spindle:
N1170 M1=\$P_SUB_GEAR M2=\$P_SUB_GEAR	
N1180 DELAYFSTON	; End of Stop Delay Area
N1190 COUPON(S2,S1)	; Activate synchronous spindle coupling
N1200 ENDIF	
...	
N9999 RET	

**Replacement subroutine \_N\_LANG\_SUB\_SPF, Variant 2:**

In this programming example the spindles are not addressed directly, but instead the system variables \$P\_SUB\_LA and \$P\_SUB\_CA are used.

Programming	Comment
N1000 PROC LANG_SUB DISPLOF SBLOF	
N1010 DEF AXIS _LA	; Aux. memory for leading axis/leading spindle
N1020 DEF AXIS _CA	; Auxiliary memory for following axis/following spindle
N1030 DEF INT _GEAR	; Auxiliary memory for gear stage
...	
N1100 IF(\$P_SUB_AXFCT==1)	; Replacement due to gear stage change
N1110 _GEAR=\$P_SUB_GEAR	; Save gear stage to be activated temporarily
N1120 _LA=\$P_SUB_LA	; Save axis identifier of the leading spindle temporarily
N1130 _CA=\$P_SUB_CA	; Save axis identifier of the following spindle temporarily
N1140 DELAYFSTON	; Start Stop Delay Area
N1150 COUPOF(_CA,_LA)	; Deactivate synchronous spindle coupling
N1160	; Execute gear stage change for leading and following spindle:
N1170 M[AXTOSPI(_LA)]=_GEAR M[AXTOSPI(_CA)]=_GEAR	

Programming	Comment
N1180 DELAYFSTOF	End of Stop Delay Area
N1190 COUPON(_CA,_LA)	; Activate synchronous spindle coupling
N1200 ENDIF	
...	
N9999 RET	

### 9.14.4.3 Function replacement during spindle positioning

#### Function

When the leading spindle of an active synchronous coupling with SPOS, SPOSA or M19 is to be positioned and the replacement is configured through a subroutine (MD30465 \$MA\_AXIS\_LANG\_SUB\_MASK, Bit 1 = 1), then a replacement subroutine is called for the implementation of the positioning.

The replacement subroutine handles the following tasks:

1. Resolve coupling
2. The spindles involved in the coupling are positioned separately at the position specified by the leading spindle
3. Close coupling again

#### Application

Parallel processing of workpieces, e.g. in double-spindle machine. The spindles in such a machine are coupled with the help of a coupling factor not equal to one and must, e.g. be positioned at the same position due to a tool change. If the coupling is separated earlier, then each spindle can be positioned at the tool change position separately.

#### Call time of the replacement subroutine

The call of the replacement subroutine during spindle positioning with SPOS or SPOSA always takes place at the block start.

In the programming of M19 the call time depends on the output response of this auxiliary function to the PLC:

MD22080 \$MC\_AUXFU\_PREDEF\_SPEC[9] (output specification for M19)

Bit	Value	Description
5	1	Output of the auxiliary function <b>before</b> the motion
6	1	Output of the auxiliary function <b>during</b> the motion
7	1	Output of the auxiliary function <b>after</b> the motion

In case of output **before or during** the motion the subroutine call is made at the **block start**. In case of output **after** the motion the subroutine call is made at the **block end**.

9.14 Replacement of NC functions by subprograms

Data transfer to the replacement subroutine

The data required for the replacement can be read in the replacement subroutine through the following system variables:

System variable	Description
\$P_SUB_AXFCT	Scan for replacement type Returns the value "2", when the replacement for spindle positioning is active.
\$P_SUB_SPOS	Scan whether spindle positioning with SPOS is active Returns TRUE, when the replacement is activated through SPOS.
\$P_SUB_SPOSA	Scan whether spindle positioning with SPOSA is active Returns TRUE, when the replacement is activated through SPOSA.
\$P_SUB_M19	Scan whether spindle positioning with M19 is active Returns TRUE, when the replacement is activated through M19.
\$P_SUB_SPOSIT	SPOS/SPOSA position Returns the programmed position. <b>Tip:</b> If the variable is called outside the replacement operation, the program processing is cancelled with an alarm.
\$P_SUB_SPOSMODE	Position approach mode Returns the position approach mode for the spindle position returned by \$P_SUB_SPOSIT:
	= 0   No change of the position approach mode
	= 1   AC
	= 2   IC
	= 3   DC
	= 4   ACP
	= 5   ACN
	= 6   OC
	= 7   PC
<b>Tip:</b> If the variable is called outside the replacement operation, the program processing is cancelled with an alarm.	
\$P_SUB_LA	Leading spindle of the active coupling Returns the axis identifier of the leading spindle of the active coupling, which had triggered the replacement operation. <b>Tip:</b> If the variable is called outside the replacement operation, the program processing is cancelled with an alarm.
\$P_SUB_CA	Following spindle of the active coupling Returns the axis identifier of the following spindle of the active coupling, which had triggered the replacement operation. <b>Tip:</b> If the variable is called outside the replacement operation, the program processing is cancelled with an alarm.

## Example

### Configuration

The replacement subroutine for the spindle positioning is activated:

```
MD30465 $MA_AXIS_LANG_SUB_MASK[AX5]='H0002'
```

For the output of M19 to the PLC an output before the motion is configured:

```
MD22080 $MC_AUXFU_PREDEF_SPEC[9]='H0021'
```

For spindle positioning with M19 the spindle position "260" is configured:

```
SD43240 $SA_M19_SPOS[AX5]=260
```

For the position approach mode during spindle positioning with M19 "Approach in positive direction (ACP)" is configured:

```
SD43250 $SA_M19_SPOSMODE[AX5]=4
```

### Main program:

Programming	Comment
PROC MAIN	
...	
N110 COUPON(S2,S1)	; Activate synchronous spindle coupling
N220 SPOS[1]=100	; Position leading spindle with SPOS
...	
N310 G01 F1000 X100 M19	; Position leading spindle with M19

### Replacement subroutine \_N\_LANG\_SUB\_SPF, Variant 1:

This programming example is optimized for simplicity and speed. The spindles are thus addressed directly (typically the machine manufacturer would know, which following Spindle(s) are affected during spindle positioning and address these spindles directly). In the example S1 is the leading spindle and S2 is the following spindle.

The SPOS and SPOSA commands are handled in common in the replacement subroutine. In other words SPOSA is mapped to the SPOS command.

Programming	Comment
N1000 PROC LANG_SUB DISPLOF SBLOF	
...	
N2100 IF(\$P_SUB_AXFCT==2)	
N2110	; Replacement of the SPOS/SPOSA/M19 command for an active synchronous spindle coupling
N2185 DELAYFSTON	; Start Stop Delay Area
N2190 COUPOF(S2,S1)	; Deactivate synchronous spindle coupling
N2200	; Position leading and following spindle
N2210 IF(\$P_SUB_SPOS==TRUE) OR (\$P_SUB_SPOSA==TRUE)	
N2220	; Positioning the spindle with SPOS:

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Programming	Comment
N2230 SPOS[1]=GP(\$P_SUB_SPOSIT,\$P_SUB_SPOSMODE)	
SPOS[2]=GP(\$P_SUB_SPOSIT,\$P_SUB_SPOSMODE)	
N2250 ELSE	
N2260	; Positioning the spindle using M19:
N2270 M1=19 M2=19	; Position leading and following spindle
N2280ENDIF	
N2285 DELAYFSTOF	; End of Stop Delay Area
N2290 COUPON(S2,S1)	; Activate synchronous spindle coupling
N2410 ELSE	
N2420	; Query on further replacements
...	
N3300 ENDIF	
...	
N9999 RET	

**Replacement subroutine \_N\_LANG\_SUB\_SPF, Variant 2:**

In this replacement subroutine the spindles are not addressed directly, but instead the system variables \$P\_SUB\_LA and \$P\_SUB\_CA are used.

Programming	Comment
N1000 PROC LANG_SUB DISPLOF SBLOF	
N1010 DEF AXIS _LA	; Auxiliary memory for leading axis/leading spindle
N1020 DEF AXIS _CA	; Auxiliary memory for following axis/following spindle
N1030 DEF INT _LSPI	; Auxiliary memory for leading spindle number (programmed spindle)
N1040 DEF INT _CSPI	; Auxiliary memory for following spindle number
...	
N2100 IF(\$P_SUB_AXFCT==2)	
N2110	; Replacement of the SPOS/SPOSA/M19 command for an active synchronous spindle coupling
N2120 _LA=\$P_SUB_LA	; Save axis identifier of the leading spindle temporarily
N2130 _CA=\$P_SUB_CA	; Save axis identifier of the following spindle temporarily
N2140 _LSPI=AXTOSPI(_LA)	; Save the number of the leading spindle temporarily
N2180 _CSPI=AXTOSPI(_LA)	; Save the number of the following spindle temporarily
N2185 DELAYFSTON	; Start Stop Delay Area
N2190 COUPOF(_CA,_LA)	; Deactivate synchronous spindle coupling

Programming	Comment
N2200	; Position leading and following spindle:
N2210 IF(\$P_SUB_SPOS==TRUE) OR (\$P_SUB_SPOSA==TRUE)	
N2220	; Positioning the spindle with SPOS:
N2230 SPOS[_LSPI]=GP(\$P_SUB_SPOSIT,\$P_SUB_SPOSMODE)	
SPOS[_CSPI]=GP(\$P_SUB_SPOSIT,\$P_SUB_SPOSMODE)	
N2250 ELSE	
N2260	; Positioning the spindle using M19:
N2270 M[_LSPI]=19 M[_CSPI]=19	; Position leading and following spindle
N2280 ENDIF	
N2285 DELAYFSTOF	End of Stop Delay Area
N2290 COUPON(_CA,_LA)	; Activate synchronous spindle coupling
N2410 ELSE	
N2420	; Query on further replacements
...	
N3300 ENDIF	
...	
N9999 RET	

#### 9.14.4.4 Sequence

The sequence of replacement of a spindle-related function depends on the replacement type (gear-stage change or spindle positioning) and on the time of call of the replacement subroutine (block start or block end).

The most important options are described in more detail below:

#### Sequence of a replacement program for a gear stage change at block start

The leading spindle is located in an active synchronous spindle coupling and an automatic (M40 S...) or a gear stage change programmed with M41 to M45 is determined during the interpretation of a part program line.

##### 1. Call the replacement subroutine

The replacement subroutine set using MD15702 \$MN\_LANG\_SUB\_PATH (call path) MD15700 \$MN\_LANG\_SUB\_NAME is called.

The system variable \$P\_SUB\_AXFCT returns the value "1":

⇒ Replacement for gear-stage change is active.

The system variable \$P\_SUB\_STAT returns the value "1":

⇒ Replacement subroutine is active, call at block start.

##### 2. Transfer of the required data in the replacement subroutine

With the system variable \$P\_SUB\_GEAR the programmed gear stage M41 to M45 or during automatic gear-stage change (M40 S...) the calculated gear-stage is scanned in the replacement subroutine.

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The system variable \$P\_SUB\_LA delivers the axis identifier of the leading spindle and \$P\_SUB\_CA delivers the axis identifier of the first following spindle involved in the coupling.

3. **Resolve coupling, gear-stage change of the spindles involved in the coupling**

The coupling is disabled and the gear-stage change is done separately for the leading and following spindles involved in the coupling.

4. **Close coupling again and continue the part program**

Then the coupling is closed again.

After the replacement subroutine has been executed, the part program line that controlled the call of the subroutine is interpreted. Thus, the S value that lead to calling the replacement subroutine during automatic gear stage change is now active too. In this case, the automatic gear stage change M40 too is restored again. The gear stage request M41-M45 is no longer processed.

**Sequence of a replacement program for a gear stage change at block end**

The part program line that leads to calling the replacement subroutine is executed first, **without** the gear stage change. The replacement subroutine is called finally.

The system variable \$P\_SUB\_STAT returns the value "2":

⇒ Replacement subroutine is active, call at block end.

The further sequence corresponds to the sequence of a replacement program for a gear-stage change at block start.

**Sequence of a replacement program for spindle positioning at the block start**

The leading spindle is located in an active synchronous spindle coupling and the leading spindle is positioned while interpreting a part program line with SPOS, SPOSA or M19.

1. **Call the replacement subroutine**

The replacement subroutine set using MD15702 \$MN\_LANG\_SUB\_PATH (call path) MD15700 \$MN\_LANG\_SUB\_NAME is called.

The system variable \$P\_SUB\_AXFCT returns the value "2":

⇒ Replacement for spindle-positioning is active.

The system variable \$P\_SUB\_STAT returns the value "1":

⇒ Replacement subroutine is active, call at block start.

2. **Transfer of the required data in the replacement subroutine**

With the system variables \$P\_SUB\_SPOS, \$P\_SUB\_SPOSA or \$P\_SUB\_M19 the positioning command to be replaced can be determined.

The system variables \$P\_SUBPOSIT and \$P\_SUBPOS MODE are used to query the travel position and the position approach mode that must be used.

The system variable \$P\_SUB\_LA delivers the axis identifier of the leading spindle and \$P\_SUB\_CA delivers the axis identifier of the first following spindle involved in the coupling.

3. **Resolve coupling, positioning of the spindles involved in the coupling**

The coupling is disabled and the leading and the following spindles involved in the coupling are positioned accordingly.

4. **Close coupling again and continue the part program**

Then the coupling is closed again.

After the replacement subroutine has been executed, the part program line that controlled the call of the subroutine is interpreted. In this case the `SPOS`, `SPOSA` or `M19` command used to trigger the replacement is no longer processed.

### Sequence of a replacement program for a spindle positioning with M19 at block end

The part program line that leads to calling the replacement subroutine is executed first, **without** the spindle positioning.

The system variable `$P_SUB_STAT` returns the value "2":

⇒ Replacement subroutine is active, call at block end.

The further sequence corresponds to the sequence of a replacement program for spindle positioning at block start.

## 9.14.5 Properties of replacement subroutines

### General Rules

- Like any other subroutine, a replacement subroutine can contain a `PROC` statement.
- Replacement subroutines can also be called from the ISO-Dialect mode. The processing of the replacement subroutine is basically done in Siemens standard mode. The return shifts the control back to the language mode.
- No transfer parameters can be defined. The transfer of data to the replacement subroutine always occurs via a system variable.
- The `PROC` statement enables program attributes such as `SBLOF` and `DISPLOF` to be programmed.

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- The behavior in case of active single block and programmed `SBLOF` attribute depends on the setting of bit 14 in the machine data:

MD10702 `IGNORE_SINGLEBLOCK_MASK` (Prevent single block stop)

Bit 14 = 0:

The replacement subroutine behaves like any other subroutine:

- Return jump with `M17`: Stop at the end of the subprogram

**Note:**

The output of the M function at the PLC depends on the setting of bit 0 in the machine data:

MD20800 `$MC_SPF_END_TO_VDI` (subprogram end to PLC)

Bit 0 = 0: no output

Bit 0 = 1: `M17` is output to the PLC.

- Return jump with `RET`: No stop at end of subprogram

Bit 14 = 1:

In a part program line, in which a replacement subroutine is called, **stop is done only once**. Thereby it is not important, whether:

- the replacement subroutine was called at the block start and/or at the block end.
- from the replacement subroutine further subroutines were called.
- the replacement subroutine was exited with `M17` or `RET`.

The single block stop takes place for the replacement of M functions at the end of the replacement subroutine. For the replacement of T functions and D/DL functions the time of the single block stop depends on the call time of the replacement subroutine:

Call at block start ⇒ single block stop at the end of the part program line

Call at block end ⇒ single block stop at the end of the replacement subroutine

- If the replacement subroutine has the `DISPLOF` attribute, the program line that has resulted in the replacement subroutine call is displayed as the current block in the block display.
- With `DELAYFSTON` and `DELAYFSTOF` areas or even the entire replacement subroutine can be protected against interruptions, such as NC stop, read-in disable, etc.
- Replacements do not occur recursively, i.e. the function that has led to the replacement subroutine call is no longer replaced if it is programmed again in the replacement subroutine.

## Output of auxiliary functions to PLC

In the case of replacements that are called due to programmed auxiliary functions, the replacement subroutine call does not result in any output of the auxiliary function to the PLC. The auxiliary function is only output if it is programmed again in the replacement cycle.

## Block-search response

The replacement subroutines are executed as in the normal program mode in case of block search with calculation and SERUPRO.

### 9.14.6 Restrictions

For using the function "Replacement of NC functions through subroutines" the following boundary conditions must be noted:

- Replacements in synchronized actions are not permitted
- Replacements in technology cycles are not permitted
- A part program line that contains language constructs to be replaced at the block start may not be placed in front of any block-wise synchronized actions.
- Spindle-related replacements are executed only if the programmed spindle is the leading spindle of an active synchronous spindle coupling. It is detected by the system only if the leading spindle is located in the channel in which the coupling was closed. If the leading spindle is changed to another channel, then a gear stage change or a repositioning of this spindle does not lead to the desired call in the replacement cycle.
- Only the actions required for the respective replacements can be performed in the replacement cycle.
- in a part program block in which a replacement subroutine is called at the block end, no:
  - modular subroutine call should be active
  - subroutine return should be programmed
  - part program end should be programmed

 **CAUTION**

The system does not monitor whether the user actually replaces the respective function in the replacement cycle. Therefore, if the user fails to implement this correctly, the actual intended function can be omitted.

## 9.15 Program runtime/Part counter

Information on the program runtime and workpiece counter are provided to support the machine tool operator.

This information can be processed as system variables in the NC and/or PLC program. This information is also available to be displayed on the operator interface.

### 9.15.1 Program runtime

#### Function

The "program runtime" function provides internal NC timers to monitor technological processes, which can be read into the part program and into synchronized actions via the NC and channel-specific system variables.

#### NC-specific system variables

The following NC-specific system variables are available:

System variable	Description
\$AN_SETUP_TIME	Time since the last control power-up with default values ("Cold start") in minutes. Is automatically reset to "0" in each control power-up with default values.
\$AN_POWERON_TIME	Time since the last normal control power-up ("Warm start") in minutes. Is automatically reset to "0" in each normal control power-up.

The timers of the NC-specific system variables are always active.

#### Channel-specific system variables

The timers for measuring the program runtimes are:

- available only in the mode type AUTOMATIC
- can be read via channel-specific system variables

Some of the timers are always active, others can be activated/deactivated through MD parameterization.

The following system variables are available for the timers that are always active:

System variable	Description				
\$AC_ACT_PROG_NET_TIME	<p>Actual net runtime of the current program in seconds (Net runtime means that the time, in which the program was stopped, has been deducted.)</p> <p>\$AC_ACT_PROG_NET_TIME is automatically reset to "0" with the part program start in the mode type AUTOMATIC from the channel status RESET.</p> <p><b>Tip:</b> With \$AC_PROG_NET_TIME_TRIGGER, \$AC_ACT_PROG_NET_TIME can be manipulated further.</p>				
\$AC_OLD_PROG_NET_TIME	<p>Net runtime in seconds of the program that has just been correctly ended. ("Correctly ended" means that the program was not interrupted with RESET, but instead ended properly with M30.)</p> <p>If a new program is started, \$AC_OLD_PROG_NET_TIME remains unscanned, till M30 is reached again.</p> <p><b>Tip:</b> The implied copying process of \$AC_ACT_PROG_NET_TIME after \$AC_OLD_PROG_NET_TIME takes place only when \$AC_PROG_NET_TIME_TRIGGER is not written.</p>				
\$AC_OLD_PROG_NET_TIME_COUNT	<p>Changes to \$AC_OLD_PROG_NET_TIME</p> <p>After POWER ON, \$AC_OLD_PROG_NET_TIME_COUNT is at "0".</p> <p>\$AC_OLD_PROG_NET_TIME_COUNT is always increased if the control has newly written to \$AC_OLD_PROG_NET_TIME.</p> <p>If the user terminates the running program with RESET, \$AC_OLD_PROG_NET_TIME and \$AC_OLD_PROG_NET_TIME_COUNT remain unchanged.</p> <p>With \$AC_OLD_PROG_NET_TIME_COUNT it can thus be ascertained, whether \$AC_OLD_PROG_NET_TIME was written.</p> <p>Example: If two programs running consecutively have the same runtime and were ended correctly, then the user can identify this via the changed value in \$AC_OLD_PROG_NET_TIME_COUNT.</p>				
\$AC_PROG_NET_TIME_TRIGGER	<p>Trigger for the runtime measurement</p> <p>Used for selective measurement of program sections i.e. by writing \$AC_PROG_NET_TIME_TRIGGER in the NC program the time measurement can be enabled and disabled again:</p> <ol style="list-style-type: none"> <li>\$AC_PROG_NET_TIME_TRIGGER = 2 starts the measurement and in so doing sets \$AC_ACT_PROG_NET_TIME to "0".</li> <li>\$AC_PROG_NET_TIME_TRIGGER = 1 ends the measurement and copies the value from \$AC_ACT_PROG_NET_TIME into \$AC_OLD_PROG_NET_TIME.</li> </ol> <p>In order to exploit all trigger options, specific values for \$AC_PROG_NET_TIME_TRIGGER are filled with special functions:</p> <table border="1"> <tbody> <tr> <td>0</td> <td>Neutral state The trigger is not active.</td> </tr> <tr> <td>1</td> <td>Exit Ends the measurement and copies the value from \$AC_ACT_PROG_NET_TIME into \$AC_OLD_PROG_NET_TIME. \$AC_ACT_PROG_NET_TIME is set to "0" and then continues to run.</td> </tr> </tbody> </table>	0	Neutral state The trigger is not active.	1	Exit Ends the measurement and copies the value from \$AC_ACT_PROG_NET_TIME into \$AC_OLD_PROG_NET_TIME. \$AC_ACT_PROG_NET_TIME is set to "0" and then continues to run.
0	Neutral state The trigger is not active.				
1	Exit Ends the measurement and copies the value from \$AC_ACT_PROG_NET_TIME into \$AC_OLD_PROG_NET_TIME. \$AC_ACT_PROG_NET_TIME is set to "0" and then continues to run.				

9.15 Program runtime/Part counter

System variable	Description
	2 Start Starts the measurement and in so doing sets \$AC_ACT_PROG_NET_TIME to "0". \$AC_OLD_PROG_NET_TIME is not changed.
	3 Stop Stops the measurement. Does not change \$AC_OLD_PROG_NET_TIME and keeps \$AC_ACT_PROG_NET_TIME constant until it resumes
	4 Resume The measurement is resumed, i.e. a measurement that was previously stopped is continued. \$AC_ACT_PROG_NET_TIME continues to run. \$AC_OLD_PROG_NET_TIME is not changed.
All system variables are reset to 0 as a result of POWER ON!	

**Note**

**Display: Residual time for a workpiece**

If the same workpieces are produced one after the other, then from the timer values:

- Processing time for the last workpiece produced (see \$AC\_OLD\_PROG\_NET\_TIME)
- and
- current processing time (see \$AC\_ACT\_PROG\_NET\_TIME)

the remaining residual time for a workpiece can be determined.

The residual time is displayed on the operator interface in addition to the current processing time.

NOTICE
<p><b>Using STOPRE</b></p> <p>The system variables \$AC_OLD_PROG_NET_TIME and \$AC_OLD_PROG_NET_TIME_CTR do not generate any implicit preprocessing stop. This is uncritical when used in the part program if the value of the system variables comes from the previous program run. However, if the trigger for the runtime measurement (\$AC_PROG_NET_TIME_TRIGGER) is written very frequently and as a result \$AC_OLD_PROG_NET_TIME changes very frequently, then an explicit STOPRE should be used in the part program.</p>

The following system variables are available for the timers that are activated/deactivated through MD parameterization:

System variable	Description
\$AC_OPERATING_TIME	Total runtime of NC programs in Automatic mode (in s) In the automatic mode, the runtimes of all programs between NC start and end of program/reset are summed up. Is automatically reset to "0" in each control power-up.
\$AC_CYCLE_TIME	Runtime of the selected NC program (in seconds) The runtime between NC Start and End of program/NC-Reset is measured in the selected NC program. Is automatically reset to "0" with the start of a new NC program.
\$AC_CUTTING_TIME	Tool action time (in seconds) The runtime of the path axes (at least one is active) is measured without active rapid traverse in all the NC programs between NC start and program end/NC reset in each active tool. The measurement is additionally interrupted during active dwell time. It is reset automatically during each control system run-up with default values.

The activation/deactivation is done using machine data:

MD27860 \$MC\_PROCESSTIMER\_MODE, Bit 0-2

Bit	Value	Description
0	0	Timer for \$AC_OPERATING_TIME not active.
	1	Timer for \$AC_OPERATING_TIME active.
1	0	Timer for \$AC_CYCLE_TIME not active.
	1	Timer for \$AC_CYCLE_TIME active.
2	0	Timer for \$AC_CUTTING_TIME not active.
	1	Timer for \$AC_CUTTING_TIME active.

With MD27860 the behavior of the active time measurements (bit 0, 1, 2 = 1) is also determined during special functions (e.g. dry run feedrate, program test):

Bit	Value	Description
4	0	No measurement during active dry run feedrate.
	1	Measurement during active dry run feedrate.
5	0	No measurement during program test.
	1	Measurement during program test.
6	Only for bit 1 = 1	
	0	\$AC_CYCLE_TIME is reset to "0" also in case of Start through ASUB and PROG_EVENTS.
	1	\$AC_CYCLE_TIME is not reset to "0" in case of Start through ASUB and PROG_EVENTS.

9.15 Program runtime/Part counter

Bit	Value	Description
7	Only for bit 2 = 1	
	0	Timer for \$AC_CUTTING_TIME counts only for the active tool.
	1	Timer for \$AC_CUTTING_TIME counts independent of the tool.
8	Only for bit 1 = 1	
	0	\$AC_CYCLE_TIME is not reset to "0" in case of a jump with GOTOS to the program start.
	1	\$AC_CYCLE_TIME is reset to "0" in case of a jump with GOTOS to the program start.

**Boundary conditions**

- Each active runtime measurement is interrupted automatically by a program status "Program running" and an active override = 0.
- No program runtimes are determined through block searches.
- The duration of a REPOS process is added to the current processing time (\$AC\_ACT\_PROG\_NET\_TIME).

**Examples**

**Example 1: Parameterization of the runtime measurement via MD27860**

- Activating the runtime measurement for the active NC program and hence no measurement in case of active dry run feedrate and program test:  
MD27860 \$MC\_PROCESSTIMER\_MODE = 'H2'
- Activating the measurement for the tool action time and measurement also with active dry run feedrate and program test.  
MD27860 \$MC\_PROCESSTIMER\_MODE = 'H34'
- Activating the measurement for the total runtime and the tool action time measurement also with program test:  
MD27860 \$MC\_PROCESSTIMER\_MODE = 'H25'

**Example 2: Measuring the duration of "mySubProgrammA"**

```

Programming
...
N50 DO $AC_PROG_NET_TIME_TRIGGER=2
N60 FOR ii= 0 TO 300
N70 mySubProgrammA
N80 DO $AC_PROG_NET_TIME_TRIGGER=1
N95 ENDFOR
N97 mySubProgrammB
N98 M30
    
```

After the program has processed line N80, the net runtime of "mySubProgrammA" is located in \$AC\_OLD\_PROG\_NET\_TIME.

The value from \$AC\_OLD\_PROG\_NET\_TIME:

- is kept beyond M30.
- is updated each time the loop is run through.

### Example 3: Measuring the duration of "mySubProgrammA" and "mySubProgrammC"

```

Programming
N10 DO $AC_PROG_NET_TIME_TRIGGER=2
N20 mySubProgrammA
N30 DO $AC_PROG_NET_TIME_TRIGGER=3
N40 mySubProgrammB
N50 DO $AC_PROG_NET_TIME_TRIGGER=4
N60 mySubProgrammC
N70 DO $AC_PROG_NET_TIME_TRIGGER=1
N80 mySubProgrammD
N90 M30

```

## 9.15.2 Workpiece counter

### Function

The function "Workpiece counter" provides various channel-specific system variables for counting the workpieces:

System variable	Description
\$AC_REQUIRED_PARTS	Number of the workpieces to be produced (setpoint number of workpieces)
\$AC_TOTAL_PARTS	Number of completed workpieces in total (actual workpiece total) Is set to default value only in case of control power-up.
\$AC_ACTUAL_PARTS	Number of completed workpieces (actual workpiece total) Is automatically set to "0" upon reaching the setpoint number of workpieces (\$AC_REQUIRED_PARTS).
\$AC_SPECIAL_PARTS	Number of workpieces selected by the user Enables a workpiece counting for the user according to own strategy.

### Properties

Value range: 0 to 999 999 999

Access mode: Write/read

**Activation**

The workpiece counter is activated with the machine data:

MD27880 \$MC\_PART\_COUNTER (activation of workpiece counters)

Bit	Value	Significance
0	1	\$AC_REQUIRED_PARTS is active
1	0	Alarm/signal output in case of: \$AC_ACTUAL_PARTS = \$AC_REQUIRED_PARTS
	1	Alarm/signal output in case of: \$AC_SPECIAL_PARTS = \$AC_REQUIRED_PARTS
4	1	\$AC_TOTAL_PARTS is active.
5	0	\$AC_TOTAL_PARTS is increased by the value "1" through M02/M30.
	1	\$AC_TOTAL_PARTS is incremented by the value "1" through the M command defined with MD27882[0].
6	0	\$AC_TOTAL_PARTS is also active for program test/block search.
7	1	\$AC_TOTAL_PARTS is incremented by the value "1" upon a jump back with GOTOS.
8	1	\$AC_ACTUAL_PARTS is active
9	0	\$AC_ACTUAL_PARTS is increased by the value "1" through M02/M30.
	1	\$AC_ACTUAL_PARTS is incremented by the value "1" through the M command defined with MD27882[1].
10	0	\$AC_ACTUAL_PARTS is also active for program test/block search.
11	1	\$AC_ACTUAL_PARTS is incremented by the value "1" upon a jump back with GOTOS.
12	1	\$AC_SPECIAL_PARTS is active.
13	0	\$AC_SPECIAL_PARTS is increased by the value "1" through M02/M30.
	1	\$AC_SPECIAL_PARTS is incremented by the value 1 through the M command defined with MD27882[2].
14	0	\$AC_SPECIAL_PARTS is also active for program test/block search.
15	1	\$AC_SPECIAL_PARTS is incremented by the value "1" upon a jump back with GOTOS.

**Workpiece counting with user-defined M command**

If the corresponding bit is set in MD27880, then the counter pulse can be triggered via a user-defined M command.

The M command code is defined with the machine data:

MD27882 \$MC\_PART\_COUNTER\_MCODE[ <Index> ] (workpiece counting with user-defined M command)

Index	Significance
0	MD27882[0] defines the M command code, in which \$AC_TOTAL_PARTS is incremented.
1	MD27882[1] defines the M command code, in which \$AC_ACTUAL_PARTS is incremented.
2	MD27882[2] defines the M command code, in which \$AC_SPECIAL_PARTS is incremented.

The respective workpiece counter is incremented by "1", when a user-defined M command is called.

**Boundary conditions**

- All workpiece counters are set to default values in control power-up and can be read and written independent of their activation.
- If \$AC\_REQUIRED\_PARTS = 0, no ID check is performed with the counter pulse for \$AC\_ACTUAL\_PARTS or \$AC\_SPECIAL\_PARTS even if the MD bit is set.
- The counters are not affected by a mode change or NC RESET.

**Examples****Activation of workpiece counter \$AC\_REQUIRED\_PARTS**

MD27880 \$MC\_PART\_COUNTER = 'H3'

Alarm displayed with: \$AC\_REQUIRED\_PARTS = \$AC\_SPECIAL\_PARTS

**Activation of workpiece counter \$AC\_ACTUAL\_PARTS**

MD27880 \$MC\_PART\_COUNTER = 'H10'

MD27882 \$MC\_PART\_COUNTER\_MCODE[0] = 80

With each M02: \$AC\_TOTAL\_PARTS + 1

Note: \$MC\_PART\_COUNTER\_MCODE[0] has no significance.

**Activation of workpiece counter \$AC\_ACTUAL\_PARTS**

MD27880 \$MC\_PART\_COUNTER = 'H300'

MD27882 \$MC\_PART\_COUNTER\_MCODE[1] = 17

With each M17: \$AC\_ACTUAL\_PARTS + 1

**Activation of workpiece counter \$AC\_SPECIAL\_PARTS**

MD27880 \$MC\_PART\_COUNTER = 'H3000'

MD27882 \$MC\_PART\_COUNTER\_MCODE[2] = 77

With each M77: \$AC\_SPECIAL\_PARTS + 1

**Deactivation of workpiece counter \$AC\_ACTUAL\_PARTS**

MD27880 \$MC\_PART\_COUNTER = 'H200'

MD27882 \$MC\_PART\_COUNTER\_MCODE[1] = 50

Note: \$AC\_TOTAL\_PARTS is not active

**Activation of all counters**

MD27880 \$MC\_PART\_COUNTER = 'H3313'

MD27882 \$MC\_PART\_COUNTER\_MCODE[0] = 80

MD27882 \$MC\_PART\_COUNTER\_MCODE[1] = 17

MD27882 \$MC\_PART\_COUNTER\_MCODE[2] = 77

## 9.16 Data lists

### 9.16.1 Machine data

#### 9.16.1.1 General machine data

##### HMI-specific machine data

Number		Identifier: \$MM_	Description
ADV	EMB		
9421	9421	MA_AXES_SHOW_GEO_FIRST	Display geo axes of channel first
9422	9422	MA_PRESET_MODE	PRESET/basic offset in JOG.
9423	9423	MA_MAX_SKP_LEVEL	Maximum number of skip levels

##### NC-specific machine data

Number	Identifier: \$MN_	Description
10010	ASSIGN_CHAN_TO_MODE_GROUP	Channel valid in mode group
10280	PROG_FUNCTION_MASK	Compare commands ">" and "<" compatible to SW 6.3
10700	PREPROCESSING_LEVEL	Program preprocessing level
10702	IGNORE_SINGLEBLOCK_MASK	Prevent single-block stop
10707	PROG_TEST_MASK	Program test modes
10708	SERUPRO_MASK	Block change modes
10710	PROG_SD_RESET_SAVE_TAB	Setting data to be updated
10711	NC_LANGUAGE_CONFIGURATION	Manner of handling the languages, whose related option or function is not activated.
10713	M_NO_FCT_STOPRE	M function with preprocessing stop
10715	M_NO_FCT_CYCLE	M function to be replaced by subroutine
10716	M_NO_FCT_CYCLE_NAME	Subroutine name for M function replacement
10717	T_NO_FCT_CYCLE_NAME	Name of tool change cycle for T function
10718	M_NO_FCT_CYCLE_PAR	M function replacement with parameters
10719	T_NO_FCT_CYCLE_MODE	Parameter assignment for T function replacement
11450	SEARCH_RUN_MODE	Block search parameter settings
11470	REPOS_MODE_MASK	Repositioning properties
11600	BAG_MASK	Mode group response to ASUB
11602	ASUP_START_MASK	Ignore stop conditions for ASUB

Number	Identifier: \$MN_	Description
11604	ASUP_START_PRIO_LEVEL	Priorities, starting from which \$MN_ASUP_START_MASK is effective
11610	ASUP_EDITABLE	Activation of an ASUB for RET/REPOS
11612	ASUP_EDIT_PROTECTION_LEVEL	Protection level of user-specific ASUB
11620	PROG_EVENT_NAME	Program name for PROG-EVENT
11717	D_NO_FCT_CYCLE_NAME	Subroutine name for D function replacement
15700	LANG_SUB_NAME	Name for replacement subroutine
15702	LANG_SUB_PATH	Call path for replacement subroutine
17200	GMMC_INFO_NO_UNIT	Global HMI info (without physical unit)
17201	GMMC_INFO_NO_UNIT_STATUS	Global HMI status info (without physical unit)
18360	MM_EXT_PROG_BUFFER_SIZE	FIFO buffer size for one program level
18362	MM_EXT_PROG_NUM	Number of external program levels (DRAM)

### 9.16.1.2 Channel-specific machine data

#### Basic machine data

Number	Identifier: \$MC_	Description
20000	CHAN_NAME	Channel name
20050	AXCONF_GEOAX_ASSIGN_TAB	Assignment of geometry axis to channel axis
20060	AXCONF_GEOAX_NAME_TAB	Geometry axis name in channel
20070	AXCONF_MACHAX_USED	Machine axis number valid in channel
20080	AXCONF_CHANAX_NAME_TAB	Channel axis name in channel [channel axis no.]: 0...7
20090	SPIND_DEF_MASTER_SPIND	Initial setting of master spindle in channel
20100	DIAMETER_AX_DEF	Geometry axis with transverse axis function
20106	PROG_EVENT_IGN_SINGLEBLOCK	Prog events ignore the single block
20107	PROG_EVENT_IGN_INHIBIT	Prog events ignore the read-in disable
20108	PROG_EVENT_MASK	Event-driven program calls
20109	PROG_EVENT_MASK_PROPERTIES	Prog events properties
20114	MODESWITCH_MASK	Setting for REPOS
20116	IGNORE_INHIBIT_ASUP	Execute user ASUBs completely in spite of read-in disable
20117	IGNORE_SINGLEBLOCK_ASUP	Process user ASUBs completely in spite of single-block processing
20160	CUBIC_SPLINE_BLOCKS	Number of blocks for C spline
20170	COMPRESS_BLOCK_PATH_LIMIT	Maximum traversing length of NC block for compression
20191	IGN_PROG_STATE_ASUP	Do not display the execution of the interrupt routine on the operator panel

9.16 Data lists

Number	Identifier: \$MC_	Description
20192	PROG_EVENT_IGN_PROG_STATE	Do not display the execution of the program events on the operator panel
20193	PROG_EVENT_IGN_STOP	Prog events ignore the Stop key
20210	CUTCOM_CORNER_LIMIT	Max. angle for intersection calculation with tool radius compensation
20220	CUTCOM_MAX_DISC	Maximum value with DISC
20230	CUTCOM_CURVE_INSERT_LIMIT	Maximum angle for intersection calculation with tool radius compensation
20240	CUTCOM_MAXNUM_CHECK_BLOCKS	Blocks for predictive contour calculation with tool radius compensation
20250	CUTCOM_MAXNUM_DUMMY_BLOCKS	Max. no. of dummy blocks with no traversing movements
20270	CUTTING_EDGE_DEFAULT	Basic setting of tool cutting edge without programming
20400	LOOKAH_USE_VELO_NEXT_BLOCK	Look Ahead to programmed following block velocity
20430	LOOKAH_NUM_OVR_POINTS	Number of override switch points for Look Ahead
20440	LOOKAH_OVR_POINTS	Override switch points for LookAhead
20500	CONST_VELO_MIN_TIME	Minimum time with constant velocity
20600	MAX_PATH_JERK	Path-related maximum jerk
20610	ADD_MOVE_ACCEL_RESERVE	Acceleration reserve for overlaid movements
20700	REFP_NC_START_LOCK	NC start disable without reference point
20750	ALLOW_GO_IN_G96	G0 logic in G96
20800	SPF_END_TO_VDI	Subprogram end to PLC
21000	CIRCLE_ERROR_CONST	Circle end point monitoring constant
21010	CIRCLE_ERROR_FACTOR	Circle end point monitoring factor
21100	ORIENTATION_IS_EULER	Angle definition for orientation programming
21110	X_AXIS_IN_OLD_X_Z_PLANE	Coordinate system for automatic Frame definition
21200	LIFTFAST_DIST	Traversing path for fast retraction from the contour
21210	SETINT_ASSIGN_FASTIN	NCK input bytes for interrupts
21202	LIFTFAST_WITH_MIRROR	Lift fast with mirror
21250	START_INDEX_R_PARAM	Number of first channel-specific R parameter

Block search

Number	Identifier: \$MC_	Description
20128	COLLECT_TOOL_CHANGE	Collect tool changes during block search
22600	SERUPRO_SPEED_MODE	Velocity with block search type 5
22601	SERUPRO_SPEED_FACTOR	Velocity factor for block search type 5
22621	ENABLE_START_MODE_MASK_PRT	Enables MD 22620: START_MODE_MASK_PRT for SERUPRO search run
22622	DISABLE_PLC_START	Allow part program start via PLC
22680	AUTO_IPTR_LOCK	Disable interrupt pointer

**Reset response**

Number	Identifier: \$MC_	Description
20110	RESET_MODE_MASK	Initial setting at RESET
20112	START_MODE_MASK	Initial setting at special NC Start after power-up and at RESET
20118	GEOAX_CHANGE_RESET	Allow automatic geometry axis change
20120	TOOL_RESET_VALUE	Tool whose length compensation is selected during power-up (Reset/part program end)
20121	TOOL_PRESEL_RESET_VALUE	Preselected tool whose length compensation is selected in power-up (Reset/part program end)
20130	CUTTING_EDGE_RESET_VALUE	Tool cutting edge on power-up (Reset/part program end)
20140	TRAFO_RESET_VALUE	Active transformation on RESET
20150	GCODE_RESET_VALUES	Reset G groups
20152	GCODE_RESET_MODE	G code basic setting at RESET
20156	MAXNUM_GCODES_EXT	Reset behavior of the external G groups
22620	START_MODE_MASK_PRT	Initial setting at special NC Start after power-up and at RESET

**Auxiliary function settings**

Number	Identifier: \$MC_	Description
22000	AUXFU_ASSIGN_GROUP	Auxiliary function group
22010	AUXFU_ASSIGN_TYPE	Auxiliary function type
22020	AUXFU_ASSIGN_EXTENSION	Auxiliary function extension
22030	AUXFU_ASSIGN_VALUE	Auxiliary function value
22200	AUXFU_M_SYNC_TYPE	Output timing of M functions
22210	AUXFU_S_SYNC_TYPE	Output timing of S functions
22220	AUXFU_T_SYNC_TYPE	Output timing of T functions
22230	AUXFU_H_SYNC_TYPE	Output timing of H functions
22240	AUXFU_F_SYNC_TYPE	Output timing of F functions
22250	AUXFU_D_SYNC_TYPE	Output timing of D functions
22260	AUXFU_E_SYNC_TYPE (available soon)	Output timing of E functions.
22400	S_VALUES_ACTIVE_AFTER_RESET	S function active after RESET
22410	F_VALUES_ACTIVE_AFTER_RESET	F function active after reset
22500	GCODE_OUTPUT_TO_PLC	G functions to PLC
22510	GCODE_GROUPS_TO_PLC	G codes that are output to the NCK/PLC interface on block change/RESET
22550	TOOL_CHANGE_MODE	New tool offset for M function
22560	TOOL_CHANGE_M_CODE	M function for tool change

**Memory settings**

Number	Identifier: \$MC_	Description
25000	REORG_LOG_LIMIT	Percentage of IPO buffer for log file enable
28000	MM_REORG_LOG_FILE_MEM	Memory size for REORG (DRAM)
28010	MM_NUM_REORG_LUD_MODULES	Number of blocks for local user variables for REORG (DRAM)
28020	MM_NUM_LUD_NAMES_TOTAL	Number of local user variables (DRAM)
28030	MM_NUM_LUD_NAMES_PER_PROG	Number of local user variables per program (DRAM)
28040	MM_LUD_VALUES_MEM (available soon)	Memory size for local user variables (DRAM)
28050	MM_NUM_R_PARAM	Number of channel-specific R parameters (SRAM)
28060	MM_IPO_BUFFER_SIZE	Number of NC blocks in IPO buffer (DRAM)
28070	MM_NUM_BLOCKS_IN_PREP (available soon)	Number of blocks for block preparation (DRAM)
28080	MM_NUM_USER_FRAMES	Number of settable Frames (SRAM)
28090	MM_NUM_CC_BLOCK_ELEMENTS	Number of block elements for compile cycles (DRAM)
28100	MM_NUM_CC_BLOCK_USER_MEM	Size of block memory for compile cycles (DRAM)
28400	MM_ABSBLOCK	Dimension basic block display
28402	MM_ABSBLOCK_BUFFER[2]	Dimension size of upload buffer
28500	MM_PREP_TASK_STACK_SIZE	Stack size of preparation task (DRAM)
28510	MM_IPO_TASK_STACK_SIZE	Stack size of IPO task (DRAM)

**Program runtime and workpiece counter**

Number	Identifier: \$MC_	Description
27860	PROCESSTIMER_MODE	Activate the runtime measurement
27880	PART_COUNTER	Activate the workpiece counter
27882	PART_COUNTER_MCODE[ ]	Workpiece counting via M command

**9.16.1.3 Axis/spindle-specific machine data**

Number	Identifier: \$MA_	Description
30465	AXIS_LANG_SUB_MASK	Substitution of NC language commands
30550	AXCONF_ASSIGN_MASTER_CHAN	Reset position of channel for axis change
30600	FIX_POINT_POS	Fixed value positions of axes with G75
33100	COMPRESS_POS_TOL	Maximum deviation with compensation

## 9.16.2 Setting data

### 9.16.2.1 Channel-specific setting data

Number	Identifier: \$SC_	Description
42000	THREAD_START_ANGLE	Start angle for thread
42010	THREAD_RAMP_DISP	Starting and deceleration distance of feed axis in thread cutting
42100	DRY_RUN_FEED	Dry run feedrate
42200	SINGLEBLOCK2_STOPRE	Activate debug mode for SBL2
42444	TARGET_BLOCK_INCR_PROG	Continuation mode after block search with calculation
42700	EXT_PROG_PATH	Name of an external program path for subroutine call EXTCALL
42750	ABSBLOCK_ENABLE	Enable basic block display
42990	MAX_BLOCKS_IN_IPOBUFFER	Control of max. number of blocks in interpolation buffer

## 9.16.3 Signals

### 9.16.3.1 Signals to NC

DB number	Byte.Bit	Description
10	56.1	EMERGENCY STOP

### 9.16.3.2 Signals to mode group

DB number	Byte.Bit	Description
11, ...	0.0	AUTOMATIC mode
11, ...	0.1	MDA mode
11, ...	0.2	JOG mode
11, ...	0.4	Mode changeover inhibit
11, ...	0.5	Mode group stop
11, ...	0.6	Mode group stop axes plus spindles
11, ...	0.7	Mode group reset
11, ...	1.0	Machine function TEACH IN
11, ...	1.1	Machine function REPOS
11, ...	1.2	Machine function REF

9.16 Data lists

9.16.3.3 Signals from mode group

DB number	Byte.Bit	Description
11, ...	4.0	Selected AUTOMATIC mode
11, ...	4.1	Selected MDA mode
11, ...	4.2	Selected JOG mode
11, ...	5.0	Selected TEACH IN machine function
11, ...	5.1	Selected REPOS machine function
11, ...	5.2	Selected REF machine function
11, ...	6.0	Active AUTOMATIC mode
11, ...	6.1	Active MDA mode
11, ...	6.2	Active JOG mode
11, ...	6.3	Mode group ready
11, ...	6.4	Mode group reset
11, ...	6.5	Internal JOG active
11, ...	6.7	All channels in the reset state
11, ...	7.0	Active TEACH IN machine function
11, ...	7.1	Active REPOS machine function
11, ...	7.2	Active REF machine function

9.16.3.4 Signals to channel

DB number	Byte.Bit	Description
21, ...	0.3	Activate DRF, refer to Jog with/without handwheel (H1)
21, ...	0.4	Activate single block
21, ...	0.5	Activate M01
21, ...	0.6	Activate dry run feedrate, refer to Feeds (V1)
21, ...	1.6	PLC action completed
21, ...	1.7	Activate program test
21, ...	2.0 - 2.7	Skip block levels: /0 to /7
21, ...	6.1	Read-in disable
21, ...	6.4	Program level abort
21, ...	7.0	NC start inhibit
21, ...	7.1	NC start
21, ...	7.2	NC stop at block limit
21, ...	7.3	NC stop
21, ...	7.4	NC stop axes plus spindles
21, ...	7.7	Reset
21, ...	31.0 - 31.2	REPOSPATHMODE
21, ...	31.4	REPOSMODEEDGE

## 9.16.3.5 Signals from channel

DB number	Byte.Bit	Description
21, ...	24.3	DRF selected
21, ...	24.4	Select associated M01
21, ...	24.5	M01 selected
21, ...	24.6	Dry run feed rate selected
21, ...	25.0-2	REPOSPATHMODE 0 - 2
21, ...	25.3	Feed rate override selected for rapid traverse
21, ...	25.4	REPOS MODE EDGE
21, ...	25.7	Program test selected
21, ...	26.0-7	Skip-block selected /0 - /7
21, ...	27.0	Skip-block selected
21, ...	27.1	Skip-block selected
21, ...	31.0-2	REPOSPATHMODE 0 - 2
21, ...	31.4	REPOS MODE EDGE
21, ...	31.6	Skip block active /8
21, ...	31.7	Skip block active /9
21, ...	32.0	Execution from external active
21, ...	32.3	Action block active
21, ...	32.4	Approach block active
21, ...	32.5	M00/M01 active
21, ...	32.6	Last action block active
21, ...	33.4	Block search active
21, ...	33.5	M02/M30 active
21, ...	33.6	Transformation active
21, ...	33.7	Program test active
21, ...	35.0	Program status: Running
21, ...	35.1	Program status: Maintaining
21, ...	35.2	Program status: Stopped
21, ...	35.3	Program status: Interrupted
21, ...	35.4	Program status: Aborted
21, ...	35.5	Channel status: Active
21, ...	35.6	Channel status: Interrupted
21, ...	35.7	Channel status: Reset
21, ...	36.4	Interrupt handling active
21, ...	36.5	Channel ready
21, ...	37.6	Read-in enable is ignored
21, ...	37.7	Stop at the end of block with SBL is suppressed
21, ...	208 - 271	Number of the active G function of G function group 1 – n (binary)
21, ...	318.0	ASUB is stopped

9.16 Data lists

DB number	Byte.Bit	Description
21, ...	318.1	Block search via program test is active
21, ...	319.0	REPOS MODE EDGEACKN
21, ...	319.1-3	Repos Path Mode Quitt: 0 - 2
21, ...	319.5	Repos DEFERAL Chan
21, ...	376.0-7	Display of the triggering event in case of event-driven program call
21, ...	378.0	ASUB is active
21, ...	378.1	ASUB with suppressed display update is active

9.16.3.6 Signals to axis/spindle

DB number	Byte.Bit	Description
31, ...	10.0	REPOSDELAY

9.16.3.7 Signals from axis/spindle

DB number	Byte.Bit	Description
31, ...	70.0	REPOS offset
31, ...	70.1	REPOS offset valid
31, ...	70.2	REPOS Delay Ack
31, ...	72.0	REPOSDELAY
31, ...	76.2	Path axis

## Axes, Coordinate Systems, Frames (K2)

### 10.1 Brief description

#### 10.1.1 Axes

##### Machine axes

Machine axes are the axes that actually exist on a machine tool.

##### Channel axes

Every geometry axis and every special axis is assigned to a channel and, therefore, a channel axis. Geometry axes and additional axes are always traversed in "their" channel.

##### Geometry axes

The three geometry axes always make up a fictitious rectangular coordinate system, the basic coordinate system (BCS).

By using FRAMES (offset, rotation, scaling, mirroring), it is possible to image geometry axes of the workpiece coordinate system (WCS) on the BCS.

##### Special axes

In contrast to geometry axes, no geometrical relationship is defined between the special axes.

##### Path axes

Path axes are interpolated together (all the path axes of a channel have a common path interpolator).

All the path axes of one channel have the same acceleration phase, constant travel phase and delay phase.

## Positioning axes

Positioning axes are interpolated separately (each positioning axis has its own axis interpolator). Each positioning axis has its own feedrate and acceleration characteristic.

## Synchronized axes

Synchronous axes are interpolated together with path axes (all path axes and synchronous axes of one channel have a common path interpolator).

All path axes and all synchronous axes of a channel have the same acceleration phase, constant travel phase and deceleration phase.

## Axis configuration

The machine data below are used to assign the geometry axes, special axes, channel axes and machine axes as well as the names of the individual axis types:

MD20050 \$MC\_AXCONF\_GEOAX\_ASSIGN\_TAB (assignment of geometry axis to channel axis)

MD20060 \$MC\_AXCONF\_GEOAX\_NAME\_TAB (name of the geometry axis in the channel)

MD20070 \$MC\_AXCONF\_MACHAX\_USED (machine axis number valid in channel)

MD20080 \$MC\_AXCONF\_CHANAX\_NAME\_TAB (name of the channel axis in the channel)

MD10000 \$MN\_AXCONF\_MACHAX\_NAME\_TAB (machine axis name)

MD35000 \$MA\_SPIND\_ASSIGN\_TO\_MACHAX (assignment of spindle to machine axis)

## Replaceable geometry axes

The "Replaceable geometry axes" function allows the geometry axes in a grouping to be replaced by other channel axes.

Axes that are initially configured as synchronous special axes in a channel can replace any selected geometry axis in response to a program command.

## Link axis

Link axes are axes, which are physically connected to another NCU and whose position is controlled from this NCU. Link axes can be assigned dynamically to channels of **another** NCU. Link axes are not local axes from the perspective of a particular NCU.

The **axis container** concept is used for the dynamic modification of the assignment to an NCU. Axis replacement with `GET` and `RELEASE` from the part program is not available for link axes across NCU boundaries.

The link axes are described in

### References:

/FB2/ Function Manual, Extended Functions; Multiple Operator Panels on Multiple NCUs, Distributed Systems (B3)

## Axis container

An axis container is a circular buffer data structure, in which local axes and/or link axes are assigned to channels. The entries in the circular buffer can be **shifted cyclically**.

In addition to the direct reference to local axes or link axes, the link axis configuration in the logical machine axis image also allows references to axis containers.

This type of reference consists of:

- Axis container number
- A slot (circular buffer location within the corresponding container)

The entry in a circular buffer location contains:

- A local axis
- or
- A link axis

The axis container function is described in

### References:

/FB2/ Function Manual, Extended Functions; Multiple Operator Panels on Multiple NCUs, Distributed Systems (B3)

## 10.1.2 Coordinate systems

### MCS

The machine coordinate system (MCS) has the following properties:

- It is defined by the machine axes.
- The machine axes can be perpendicular to each other to form Cartesian system or arranged in any other way.
- The names of the machine axes can be defined.
- The machine axes can be linear or rotary axes.

### BCS

The basic coordinates system (BKS) has the following properties:

- The geometry axes form a perpendicular Cartesian coordinate system.
- The BCS is derived from a kinematic transformation of the MCS.

### BZS

The basic zero system (BZS) is the basic coordinate system with a basic offset.

## SZS

The settable zero system (SZS) is the workpiece coordinate system with a programmable frame from the viewpoint of the WCS. The workpiece zero is defined by the settable frames G54 to G599.

## WCS

The workpiece coordinate system (WCS) has the following properties:

- In the workpiece coordinate system all the axes coordinates are programmed (parts program).
- It is made up of geometry axes and special axes.
- Geometry axes always form a perpendicular Cartesian coordinate system
- Special axes form a coordinate system without any geometrical relation between the special axes.
- The names of the geometry axes and special axes can be defined.
- The workpiece coordinate system can be translated, rotated, scaled or mirrored with FRAMES (TRANS, ROT, SCALE, MIRROR).

Multiple translations, rotational movements, etc., are also possible.

## Zero offset external

The zero offset external has the following properties:

- At a time defined in the PLC, a predefined additional zero offset between the basic and the workpiece coordinate systems is activated.
- The magnitudes of the offsets can be set by the following for each of the axes involved:
  - PLC
  - Operator Panel
  - Part program
- Activated offsets take effect at the instant the first motion block of the relevant axes is processed after offset activation. The offsets are superimposed on the programmed path (no interpolation).

The velocity, at which the zero offset external is applied, is as follows:

Programmed F value plus +1/2 JOG velocity

The zero offset external is traversed at the end of G0 blocks.

- The activated offsets are retained after RESET and end of program.
- After POWER ON, the last active offset is still stored in the control but must be reactivated by the PLC.

### 10.1.3 Frames

#### FRAME

A FRAME is a closed calculation rule that translates one Cartesian coordinate system into another.

#### FRAME components

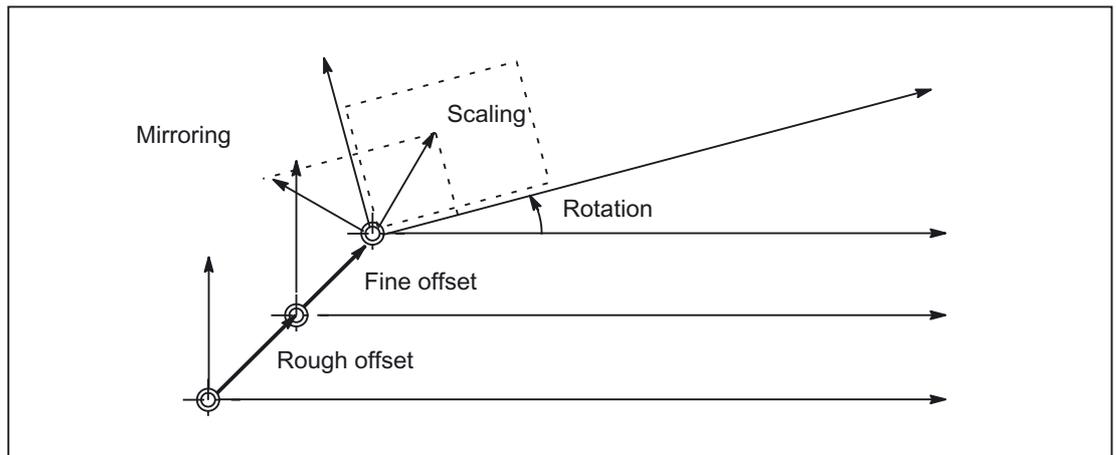


Figure 10-1 FRAME components

A FRAME consists of the following components:

FRAME components		Programmable with:
Offset	Rough offset	TRANS ATRANS (additive translation component) CTRANS (zero offset for multiple axes) G58 (axial zero offset)
	Fine offset	CFINE G59 (axial zero offset)
Rotation		ROT/ROTS AROT/AROTS CROTS
Scaling		SCALE ASCALE
Mirroring		MIRROR AMIRROR

#### Features in relation to axes

The rough and fine offsets, scaling and mirroring can be programmed for geometry and special axes. A rotation can also be programmed for geometry axes.

## Rough and fine offsets

The translation component of FRAMES comprises:

- Rough offset with `TRANS`, `ATRANS` and `CTRANS`

The rough offset is normally specified by the machine setter.

The programmable offsets for all geometry axes and special axes are specified with `TRANS`.

- Fine offset with `CFINE`

This can be defined by the machine operator, within certain input limits.

## G58, G59

G58 and G59 can be programmed to replace the rough and fine offsets of the programmable frame on an axial basis. These functions can only be used when the fine offset is configured.

- Rough offset with G58

G58 changes only the absolute translation component (rough offset) for the specified axis; the total of additively programmed translations (fine offset) is retained.

- Fine offset with G59

G59 is used for axial overwriting of the additively programmed translations for the specified axes that were programmed with `ATRANS`.

## Frame rotations

Orientations in space are defined via frame rotations as follows:

- Rotation with `ROT` defines the individual rotations for all geometry axes.
- Solid angles with `ROTS`, `AROTS`, `CROTS` define the orientation of a plane in space.
- Frame rotation with `TOFRAME` defines a frame with a Z axis pointing in the tool direction.

## Scaling

`SCALE` is used to program the programmable scale factors for all geometry axes and special axes.

If a new scaling is to be based on a previous scaling, rotation, translation or mirroring, then `ASCALE` must be programmed.

## Mirroring

The axis to be mirrored can be set via the following machine data:

MD10610 MIRROR\_REF\_AX (reference axis for the mirroring)

Value	Significance
0	Mirroring is performed around the programmed axis.
1, 2 or 3	Depending on the input value, mirroring is mapped onto the mirroring of a specific reference axis and rotation of two other geometry axes.

## Frame chaining

The current FRAME is composed of the total basic frame, the settable FRAME, the system frames and the programmable FRAME.

The current complete frame is calculated according to the formula below:

$$\begin{aligned} \$P\_ACTFRAME = & \quad \$P\_PARTFRAME : \$P\_SETFRAME : \$P\_EXTFRAME : \\ & \quad \$P\_ISO1FRAME : \$P\_ISO2FRAME : \$P\_ISO3FRAME : \\ & \quad \$P\_ACTBFRAME : \$P\_IFRAME : \$P\_TOOLFRAME : \\ & \quad \$P\_WPFRAME : \$P\_TRAFRAME : \$P\_PFRAME \\ & \quad \$P\_ISO4FRAME : \$P\_CYCFRAME \end{aligned}$$

## Frames with G91

Incremental programming with G91 is defined such that the compensation value is traversed additively to the incrementally programmed value when a zero offset is selected.

The behavior depends on the setting in the setting data:

SD42440 \$SC\_FRAME\_OFFSET\_INCR\_PROG (zero offset in frames)

Value	Significance
1	Zero offset is applied on FRAME and incremental programming of an axis (= default setting).
0	Only the programmed path is traversed.

## Suppression of frames

Current frames can be suppressed with the following instructions:

Command	Significance
G53	Current zero offset (ZO)
G153	Current frame including basic frame
SUPA	Current ZO, incl. programmed offsets

## **NCU global basic frames**

For rotary indexing machine technology, for example, a channel must be used to define frames for other channels. These cross-channel frames are shown in the "NCU global basic frames" below.

Properties of the NCU global basic frames:

- Can be read and written from all channels.
- Can be activated only in the channels
- There are up to 16 NCU global basic frames

Global frames can be used to apply offsets, scale factors and mirroring operations to channel and machine axes.

All basic frames (up to 16 global and 16 channel-specific) are chained to produce total basic frame. The standard configuration is designed in such a way that there is at least one basic frame per channel.

Settable frames can be defined as either NCU global or channel-specific.

## **Channel coordination**

With NCU global frames, the user must ensure channel coordination and activation of the frames (e.g. using the `WAITMC` command), to allow the frames to be calculated at the desired point in the program.

Cross-channel activation of frames is not supported.

## 10.2 Axes

### 10.2.1 Overview

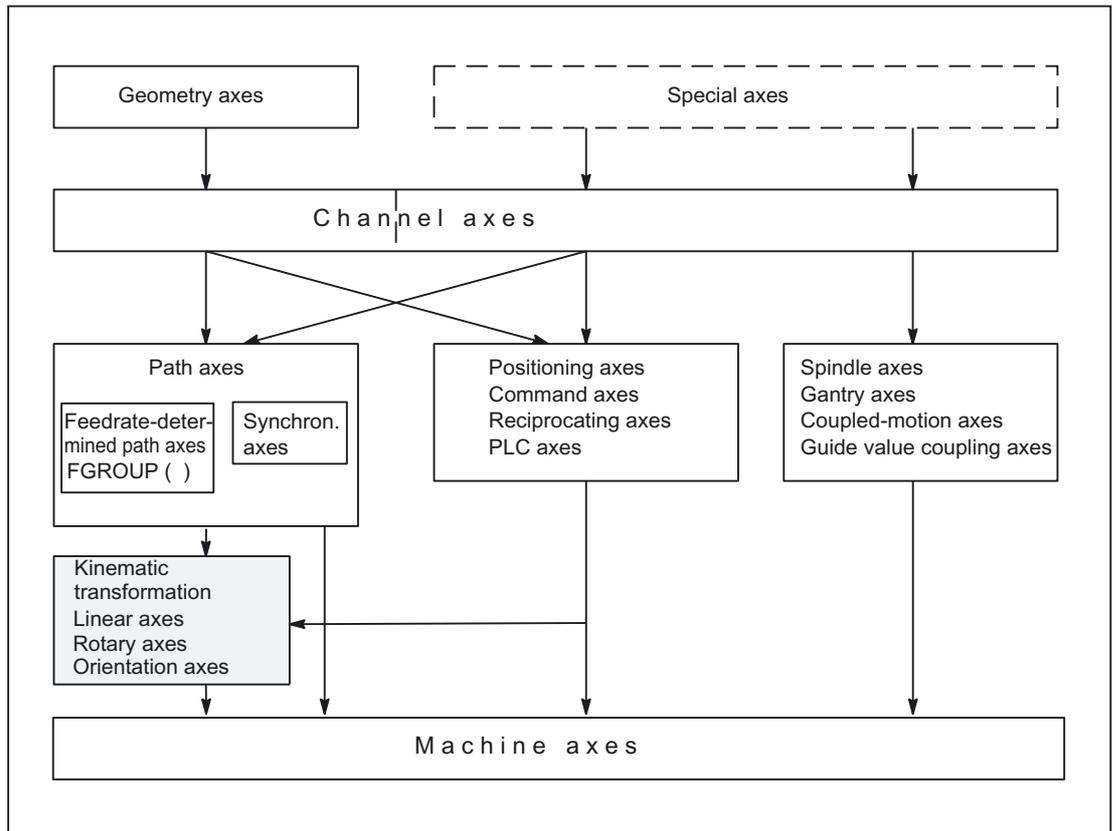


Figure 10-2 Relationship between geometry axes, special axes and machine axes

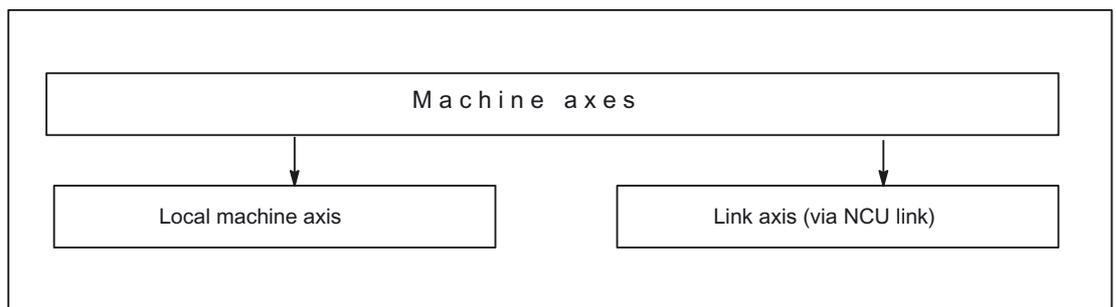


Figure 10-3 Local and external machine axes (link axes)

### 10.2.2 Machine axes

#### Meaning

Machine axes are the axes that actually exist on a machine tool.

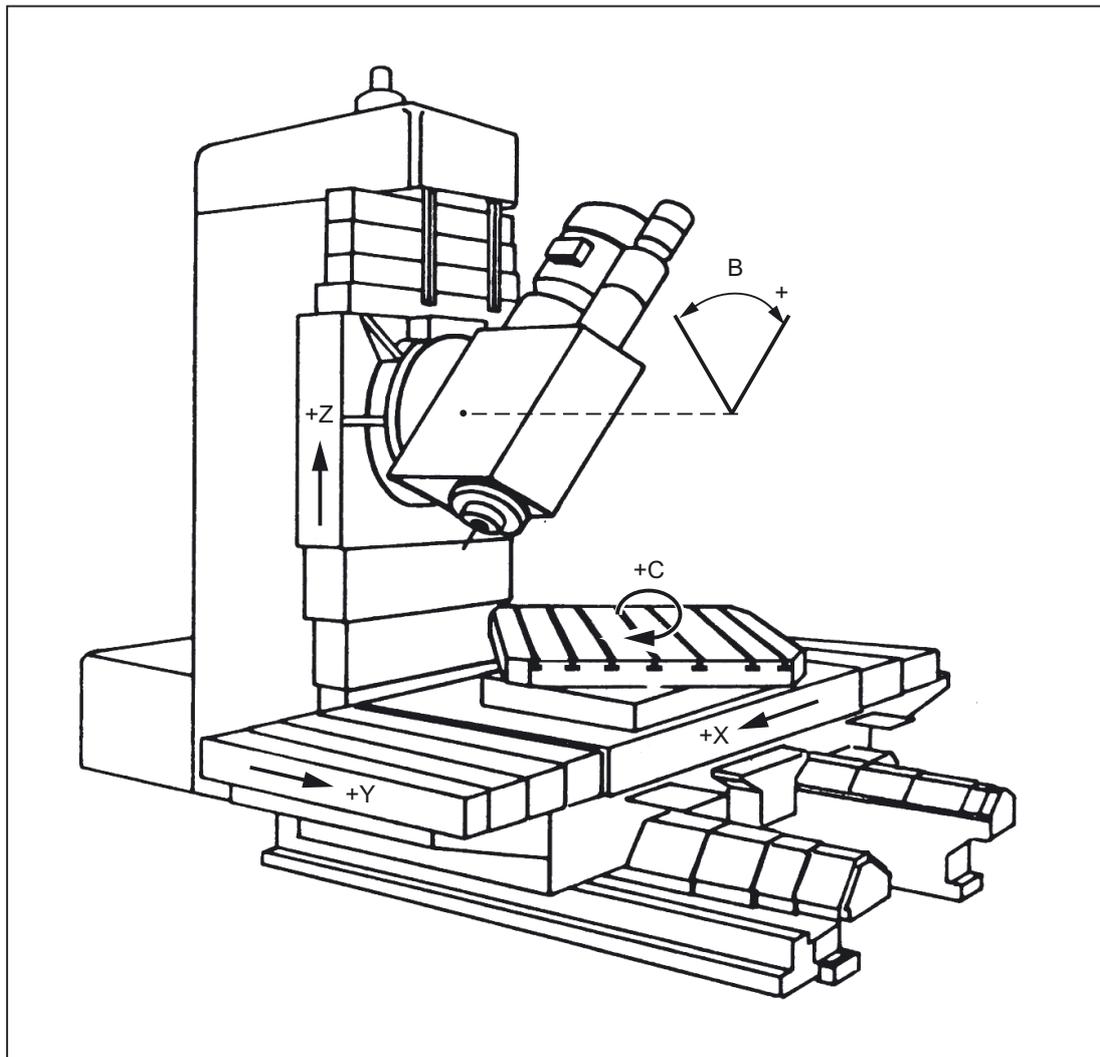


Figure 10-4 Machine axes X, Y, Z, B, S on a Cartesian machine

## Application

The following can be machine axes:

- Geometry axes X, Y, Z
- Orientation axes A, B, C
- Loader axes
- Tool turrets
- Axes for tool magazine
- Axes for automatic tool changer
- Spindle sleeves
- Axes for pallet changers
- etc.

### 10.2.3 Channel axes

#### Meaning

Each geometry axis and each special axis is assigned to a channel. Geometry axes and additional axes are always traversed in "their" channel.

### 10.2.4 Geometry axes

#### Meaning

The three geometry axes always make up a fictitious rectangular coordinate system.

By using FRAMES (offset, rotation, scaling, mirroring), it is possible to image geometry axes of the workpiece coordinate system (WCS) on the BCS.

#### Application

Geometry axes are used to program the workpiece geometry (the contour).

Plane selection G17, G18 and G19 (DIN 66217) always refers to the three geometry axes. That is why it is advantageous to name the three geometry axes X, Y and Z.

## 10.2.5 Replaceable geometry axes

### Significance

The "Replaceable geometry axes" function allows the geometry axes in a grouping to be replaced by other channel axes.

Axes that are initially configured as synchronous special axes in a channel can replace any selected geometry axis in response to a program command.

### Example

On a machine with two Z axes, Z1 and Z2, either of the Z axes can be programmed as the geometry axis in response to an instruction in the part program.

### Activation

Axis replacement is activated by the program command:

```
GEOAX([n, channel axis name]...)
```

n=0:	Removes an axis from the geometry axis grouping.
n=1, 2, 3:	Index of the geometry axis
GEOAX( ):	Establishes the basic setting defined via MD for the assignment of channel axes to geometry axes.
Channel axis name:	Name of channel axis, which is to operate as a geometry axis.

A channel axis, which has been designated a geometry axis, can only be addressed under its geometry axis name. The geometry axes names themselves remain unchanged.

Geometry axes can be replaced either individually or as a group in one command.

### Supplementary conditions

As a basic rule, any channel axis designated as a geometry axis can be replaced by another channel axis.

In this case, the following restrictions apply:

- Rotary axes may not be programmed as geometry axes.
- A geometry axis, which has the same name as a channel axis, cannot be replaced by another channel axis (alarm message). Nor can an axis of this type be removed from the geometry axis grouping. It cannot change its position within the geometry axis grouping.
- Both axes in each of the axis pairs involved in the replacement operation must be block-synchronized.

- The following functions may not be active when geometry axes are replaced:
  - Transformation
  - Spline interpolation
  - Tool radius compensation
  - Tool fine compensation
- Any active DRF offset or zero offset external will remain operative. They both act on channel axes. The channel axis assignment is not affected by the replacement of geometry axes.

### **Replacement of geometry axes**

All frames, protection zones and working area limitations are deleted. They may need to be reprogrammed after the replacement operation.

The system response to replacement of geometry axes is, therefore, identical to its response to a change (switch on/off, switchover) in a kinematic transformation.

### **Tool Length Compensation**

Any active tool length compensation remains operative and is applied to the new geometry axes after replacement.

The system treats tool length compensations as not yet applied for the following geometry axes:

- All geometry axes, which have been newly added to the geometry axis grouping
- All geometry axes, which have changed their positioning within the geometry axis grouping

Geometry axes, which retain their position within the geometry axis grouping after a replacement operation, also retain their status with respect to tool length compensation.

### **RESET**

The reset behavior of the changed geometry axis assignment is defined with the following machine data:

MD20110 \$MC\_RESET\_MODE\_MASK (definition of initial control system settings after RESET/TP end)

MD20118 \$MC\_GEOAX\_CHANGE\_RESET (allow automatic geometry axis change)

**MD20110 \$MC\_RESET\_MODE\_MASK**

Bit	Value	Significance
12	0	In case of set machine data MD20118 \$MC_GEOAX_CHANGE_RESET (allow automatic geometry axis change) a changed geometry axis assignment is deleted during reset or parts program end. The initial setting defined in the machine data for the geometry axis assignment becomes active.
	1	A modified geometry axis assignment remains active after a reset/part-program end.

**MD20118 \$MC\_GEOAX\_CHANGE\_RESET**

Value	Significance
0	The current configuration of the geometry axes remains unchanged on reset and program start. With this setting, the response is identical to older software versions without geometry axis replacement.
1	The configuration of the geometry axis remains unchanged during reset or parts program end as a function of machine data MD20110 \$MC_RESET_MODE_MASK and during parts program start as a function of machine data MD20112 \$MC_START_MODE_MASK (definition of initial control system settings with NC START) or brought to the initial status defined in the machine data MD20050 \$MC_AXCONF_GEOAX_ASSIGN_TAB (assignment of geometry axis to channel axis).

**Program start**

Analogously to the Reset response, the behavior during program start is based on the setting in the machine data:

MD20112 \$MC\_START\_MODE\_MASK (definition of initial control system settings with NC-START)

Bit	Value	Significance
12	0	A modified geometry axis assignment remains active on part-program start.
	1	A modified geometry axis assignment is cleared on part-program start.

**Approaching a reference point**

When the "Reference point approach" mode is selected, the geometry axis configuration defined by the machine data is automatically set.

## M code

A changeover of the geometry axis with `GEOAX ( )` can be communicated to the PLC through the output of an M code:

`MD22532 $MC_GEOAX_CHANGE_M_CODE` (M-Code during tool holder change)

---

### Note

If this machine data is set to one of the values 0 to 6, 17, 30, then no M code is output.

---

## Transformation changeover

The following interrelationships must be noted with respect to kinematic transformation and geometry axis replacement:

- Geometry axis assignments cannot be modified when the transformation is active.
- Activation of a transformation deletes the programmed geometry axis configuration and replaces it by the geometry axis assignment stored in the machine data of the activated transformation.
- The initial setting defined through MD for the geometry axis configuration becomes effective after deactivating the transformation.

Should it be necessary to modify the geometry axis assignment in connection with transformations, then another new transformation must be configured. The total number of the transformations simultaneously available in the channel is equal to 8.

A maximum of two transformations per channel can be available simultaneously from the transformation groups below:

- Orientation transformations  
(3-axis, 4-axis, 5-axis and nutation transformation)
- `TRAANG` (oblique axis)
- `TRANSMIT`
- `TRACYL`

### References:

/FB3/ Function Manual, Special Functions; 3-Axis to 5-Axis Transformation (F2)

/FB2/ Function Manual, Extended Functions; Kinematic Transformation (M1)

**Example**

In the example below, it is assumed that there are 6 channel axes with channel axis names XX, YY, ZZ, U, V, W and three geometry axes with names X, Y, Z. The basic setting is defined in machine data such that the geometry axes are imaged on the first three channel axes, i.e. on XX, YY and ZZ.

```
GEOAX() ; The geometry axis assignment defined via the machine
        data
        MD AXCONF_GEOAX_ASSIGN_TAB
        is effective,
        i.e. XX, YY and ZZ become geometry axes.

G0 X0 Y0 Z0 U0 V0 W0 ; All the axes in rapid traverse to position 0.
GEOAX (1, U, 2, V, 3, W) ; Channel axis U becomes the first, V the second and W
                        the third geometry axis.
GEOAX(1, XX, 3, ZZ) ; Channel axis XX becomes the first, ZZ the third
                    geometry axis. The second geometry axis remains
                    unchanged.
G17 G2 X20 I10 F1000 ; Semicircle in the X, Y plane. Channel axes XX and V
                    traverse.
GEOAX(2,W) ; Channel axis W becomes the second geometry axis. The
            first and third geometry axes remain unchanged.
G17 G2 X20 I10 F1000 ; Full circle in the X, Y plane. Channel axes XX and W
                    traverse.
GEOAX() ; The geometry axis assignment defined via the machine
        data
        MD AXCONF_GEOAX_ASSIGN_TAB
        is effective,
        i.e. XX, YY and ZZ become geometry axes.
GEOAX (1, U, 2, V, 3, W) ; U, V and W become the first, second and third
                        geometry axes.
G1 X10 Y10 Z10 XX=25 ; Channel axes U, V, W each traverse to position 10,
                    XX traverses to position 25.
GEOAX(0,V) ; V is again removed from the geometry axis grouping.
            U and W remain geometry axes. The second geometry
            axis is no longer assigned.
GEOAX (1, U, 2, V, 3, W) ; U, V and W become the first, second and third
                        geometry axes, i.e. U and W remain unchanged.
GEOAX(3,V) ; V becomes the third geometry axis. This means that
            W, which was previously the third geometry axis, is
            removed from the geometry axis grouping. The second
            geometry axis is no longer assigned.
```

## 10.2.6 Special axes

### Significance

In contrast to geometry axes, no geometrical relationship is defined between the special axes.

---

#### Note

Geometry axes have an exactly defined relationship in the form of a right-angled coordinate system.

---

Special axes are part of the basic coordinate system (BCS). With FRAMES (translation, scaling, mirroring), special axes of the workpiece coordinate system can be mapped on the basic coordinate system.

### Application

Typical special axes are:

- Rotary axes
- Machine tool axes
- Tool revolver axes
- Loader axes

## 10.2.7 Path axes

### Meaning

Path axes are interpolated together (all the path axes of a channel have a common path interpolator).

All the path axes of one channel have the same acceleration phase, constant travel phase and delay phase.

The feedrate programmed under address  $F$  (path feedrate) applies to all the path axes programmed in a block, with the following exceptions:

- An axis has been programmed that has been defined as having no control over the path velocity with instruction  $FGROUP$ .
- Axes programmed with instructions  $POS$  or  $POSA$  have an individual feedrate setting (axis interpolator).

### Application

Path axes are used to machine the workpiece with the programmed contour.

## 10.2.8 Positioning axes

### Significance

Positioning axes are interpolated separately (each positioning axis has its own axis interpolator). Each positioning axis has its own feedrate and acceleration characteristic. Positioning axes can be programmed in addition to path axes (even in the same block). Path axis interpolation (path interpolator) is not affected by the positioning axes. Path axes and the individual positioning axes do not necessarily reach their block end points at the same time.

Instructions `POS` and `POSA` are used to program positioning axes and define block change criteria:

- `POS`  
Block change takes place when the path axes and positioning axes have reached their block end points.
- `POSA`  
Block change takes place when the path axes have reached their end of block position. Positioning axes continue to traverse beyond block limits to their block end point.

Concurrent positioning axes differ from positioning axes in that they:

- Only receive their block end points from the PLC
- Can be started at any time (not at block limits)
- Do not affect the execution of current part programs.

### Application

Typical positioning axes are:

- Loaders for moving workpieces away from machine
- Tool magazine/turret

### Reference

#### References:

/FB2/ Function Manual, Extended Functions, Positioning Axes (P2)  
/FB1/ Function Manual, Basic Functions, Spindles (S1)  
FB3/ Function Manual, Special Functions; Gantry Axes (G1)  
/FB3/ Function Manual, Special Functions; Axis Couplings and ESR (M3)  
/FB1/ Function Manual, Basic Functions; Basic PLC Program (P3)  
/FB2/ Function Manual, Extended Functions; Oscillation (P5)  
/FBSY/ Function Manual Synchronized Actions

## 10.2.9 Main axes

### Significance

A main axis is an axis that is interpolated by the main run.

This interpolation can be started as follows:

- From synchronized actions  
(as command axes due to an event via block-related, modal or static synchronized actions)
- From the PLC via special function blocks in the PLC basic program  
(named as a concurrent positioning axis or a PLC axis)
- Via the setting data or from the part program  
(as an asynchronous or block-synchronous oscillating axis)

### Channel control

An axis interpolated by the main axis reacts in terms of:

- NC STOP
- Alarm handling
- Program control
- End of program
- RESET

---

#### Note

The response at the end of the program varies. The axis movement need not always be completed and, therefore, may carry on beyond the end of the program.

---

### Application

Certain axes in the main run can be decoupled at the channel response triggered by the NC program sequence and controlled from the PLC. These axes are also interpolated in the main run and respond independently for the channel and program sequence.

A PLC-controlled axis can then be controlled independently by the NC. This concerns the following actions:

- The sequence for canceling the axis (equivalent to delete distance-to-go)
- Stopping or interrupting the axis
- Continuing the axis (continue sequence of motion)
- Resetting the axis to its basic status

### 10.2.10 Synchronized axes

#### Significance

Synchronous axes are components of the path axes, which are not referenced in order to calculate the tool path velocity. They are interpolated together with path axes (all path axes and synchronous axes of one channel have a common path interpolator).

All path axes and all synchronous axes of a channel have the same acceleration phase, constant travel phase and deceleration phase.

The feedrate (path feedrate) programmed under address **F** applies to all the path axes programmed in a block but not to the synchronous axes.

Synchronous axes take the same time to cover the programmed path as the path axes.

#### FGROUP command

The command **FGROUP** specifies whether the axis is a feed-defining **path axis** (used to calculate the path velocity) or a **synchronous axis** (not used to calculate the path velocity).

#### Example

```

N05 G00 G94 G90 M3 S1000 X0 Y0 Z0      ;
N10 FGROUP (X,Y)                       ; Axes X/Y are path axes,
                                         Z is a synchronous axis.
N20 G01 X100 Y100 F1000                ; Progr. feedrate 1000 mm/min.
                                         Feedrate of axis X = 707 mm/min.
                                         Feedrate of axis Y = 707 mm/min.
N30 FGROUP (X)                         ; Axis X is a path axis,
                                         axis Y is a synchronous axis
N20 X200 Y150                          ; progr. Feedrate 1000 mm/min
                                         Feedrate of Axis X = 1000 mm/min
                                         Feedrate of Axis Y is set to 500 mm/min,
                                         because only half the distance is to be
                                         traversed.
    
```

---

#### Note

The channel axis name must be used for the **FGROUP** command.

This is defined by the machine data:

**MD20080 \$MC\_AXCONF\_CHANAX\_NAME\_TAB** (name of the channel axis in the channel)

---

**Application**

In the case of helical interpolation `FGROUP` can be programmed to determine whether:

- The programmed feedrate should be valid on the path  
(all 3 programmed axes are path axes)
- The programmed feedrate should be valid on the circuit  
(2 axes are path axes and the infeed axis is a synchronous axis)

**10.2.11 Axis configuration**

**Allocation**

The figure below shows the assignment between the geometry axes, special axes, channel axes and machine axes as well as the names of the individual axis types. MD are used for assignment.

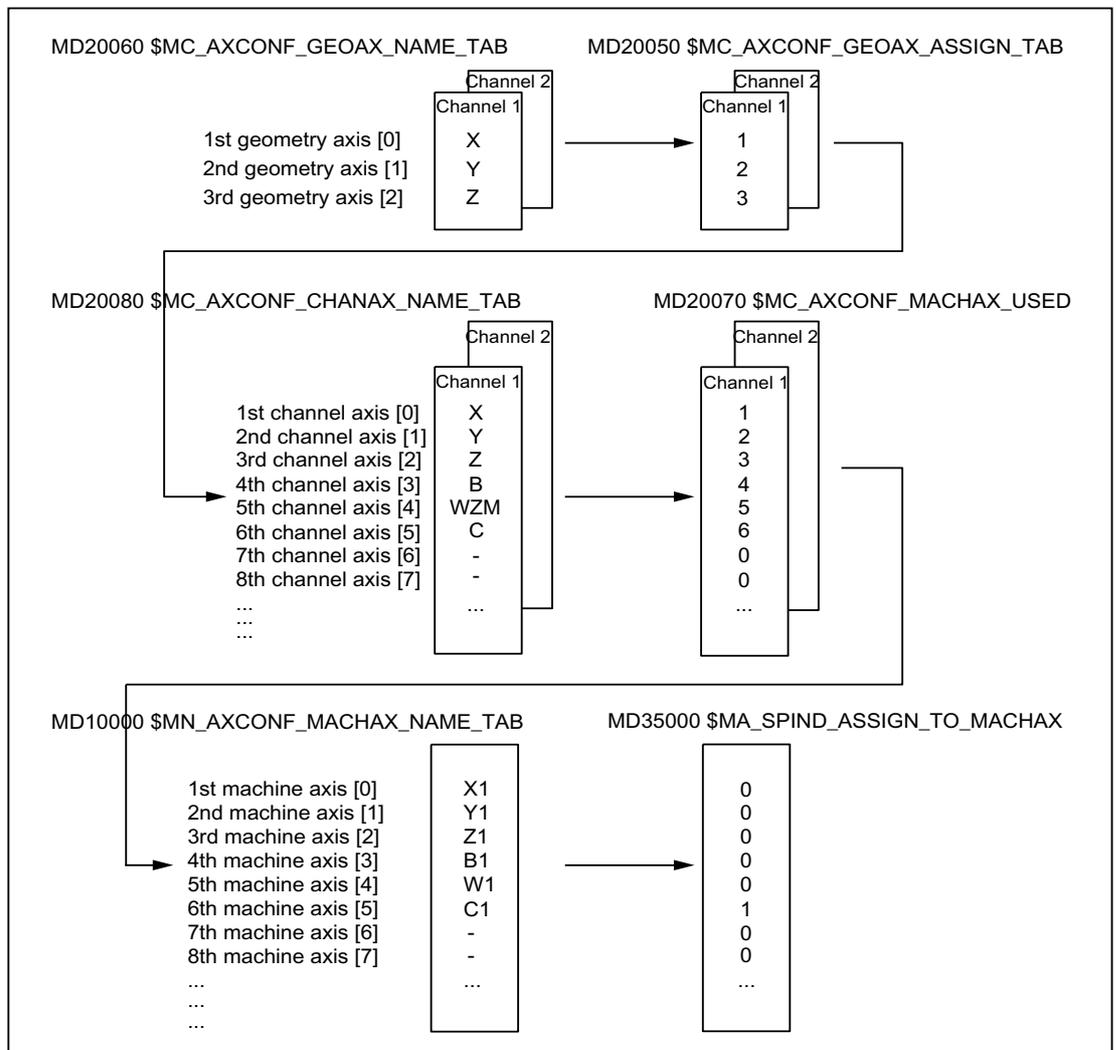


Figure 10-5 Axis configuration

---

**Note**

Leading zeroes in user-defined axis identifiers are ignored.

Example:

MD10000 ` \$MN\_AXCONF\_MACHAX\_NAME\_TAB[0] = X01 corresponds to X1

The geometry axes must be assigned to the channel axes in ascending order leaving no gaps.

---

**Special points to be noted**

- Three geometry axes are assigned to the channel axes in the MD.
- All channel axes that are not assigned to the three geometry axes are special axes.
- The channel axes are assigned to machine axes.
- The spindles are also assigned to machine axes.

**Channel axis gaps**

A machine axis (local or link axis) need not be assigned to every channel axis according to:  
MD20080 \$MC\_AXCONF\_CHANAX\_NAME\_TAB (channel axis name in the channel)  
through:

MD20070 \$MC\_AXCONF\_MACHAX\_USED (machine axis number valid in channel)

If the existing concrete machine has a machine axis, which has been specifically assigned to a certain channel axis, then references to the logical machine axis image:

MD10002 \$MN\_AXCONF\_LOGIC\_MACHAX\_TAB(logical NCK machine axis image)  
are entered in the machine data:

MD20070 \$MC\_AXCONF\_MACHAX\_USED (machine axis number valid in the channel),  
otherwise the value is 0.

Application:

Consistent, semi-defined channel axis names for various machine versions of a manufacturer's machine series.

Advantages:

- Uniform basic configuration of various machines
- Simple reconfiguration on removal of a machine
- Portability of programs

**Reliability of channel axis gaps**

Channel axis gaps must be communicated explicitly through the following machine data:

MD11640 \$MN\_ENABLE\_CHAN\_AX\_GAP (channel axis gaps are allowed in AXCONF\_MACHAX\_USED)

If this is not carried out, an entry of 0 prevents other machine axes being assigned to channel axes in the following machine data:

MD20070 \$MC\_AXCONF\_MACHAX\_USED (machine axis number valid in channel)

**References:**

/FB2/ Function Manual, Extended Functions; Several Control Panels on Multiple NCUs, Decentralized Systems (B3)

**Example**

In the example below, a machine tool channel axis is specified without a real machine axis.

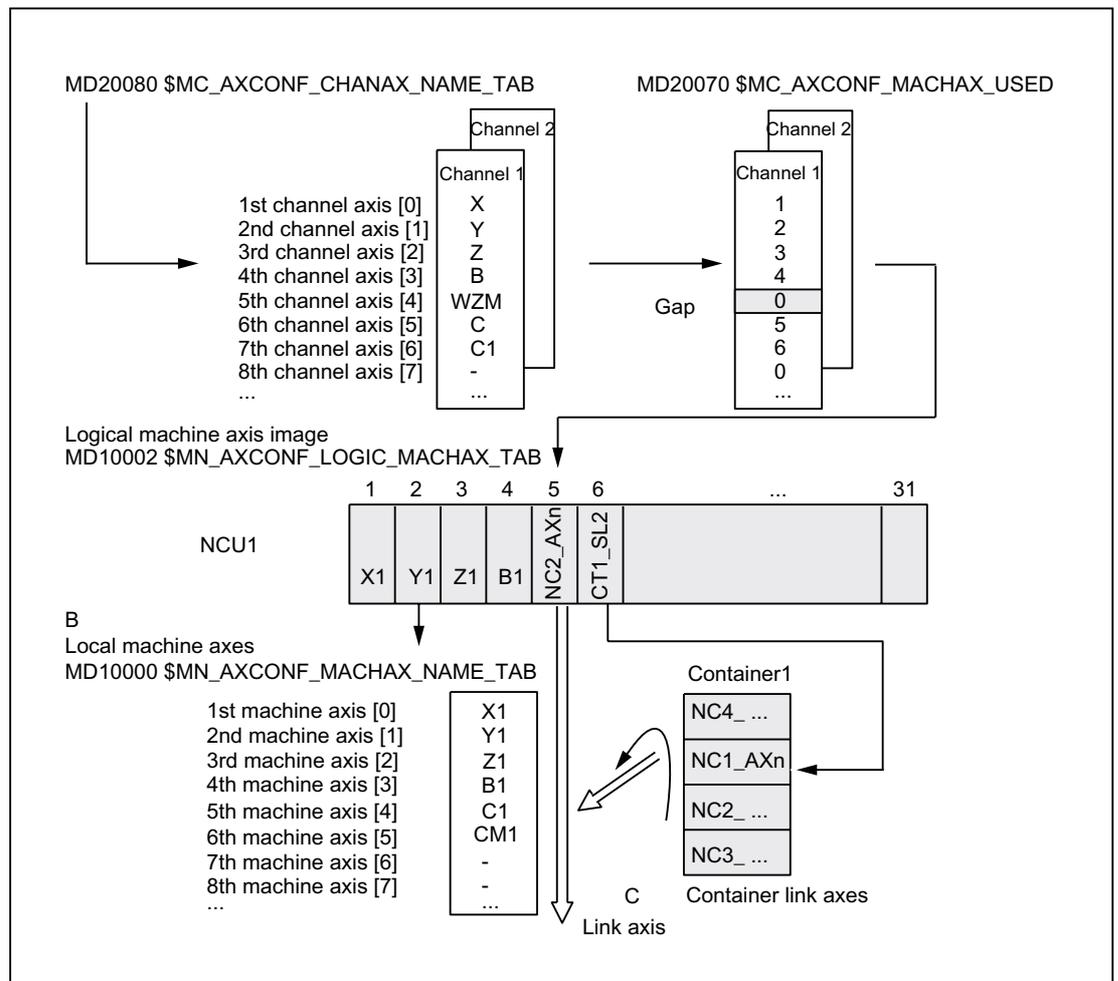


Figure 10-6 Axis configuration with channel axis gap

---

**Note**

The gaps count as axes with reference to the number of channel axes and their indices.

If the following machine data is used to try to define a channel axis gap with the geo axis, then the attempt is rejected without an alarm:

MD20050 \$MC\_AXCONF\_GEOAX\_ASSIGN\_TAB (assignment of geometry axis to channel axis)

Using channel axes in

MD24120ff. \$MC\_TRAFO\_GEOAX\_ASSIGN\_TAB1...

and

MD24110ff. \$MC\_TRAFO\_AXES\_IN1...8

to which no machine axes are assigned (gap) through

MD20070 \$MC\_AXCONF\_MACHAX\_USED (machine axis number valid in the channel), triggers alarms 4346 or 4347.

---

## 10.2.12 Link axes

### Significance

Link axes are axes, which are physically connected to another NCU and whose position is controlled from this NCU. Link axes can be assigned dynamically to channels of a different NCU. From the perspective of a particular NCU, link axes are **non-local** axes.

The **axis container** concept is used for the dynamic modification of the assignment to an NCU. Axis replacement with `GET` and `RELEASE` from the part program is not available for link axes across NCU boundaries.

### Requirements:

- The participating NCUs, NCU1 and NCU2, must be connected by means of high-speed communication via the link module.

#### References:

/PHD/ Configuring Manual NCU 571-573.2; Link Module

- The axis must be configured appropriately by machine data.
- The link axis option must be installed.

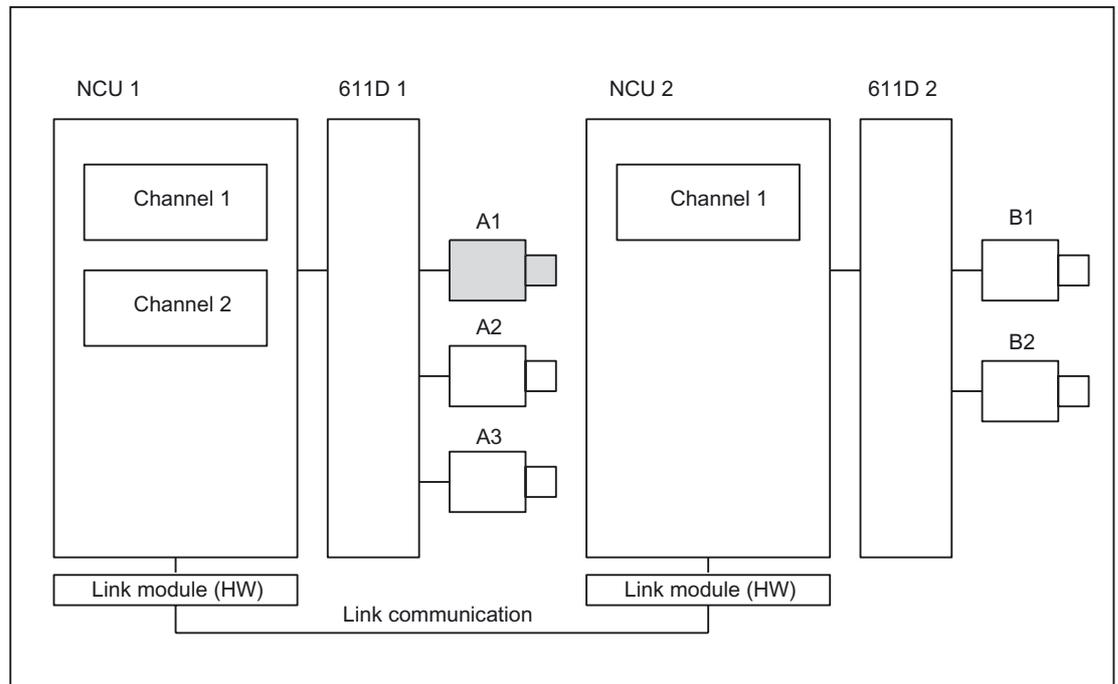


Figure 10-7 Overview of link axes

The link axes are described in

**References:**

/FB2/ Function Manual, Extended Functions; Multiple Operator Panels on Multiple NCUs, Distributed Systems (B3)

**Note**

The link axis functionality is currently not available with the SINUMERIK 840Di.

**Axis container**

An axis container is a circular buffer data structure, in which local axes and/or link axes are assigned to channels. The entries in the circular buffer can be **shifted cyclically**.

In addition to the direct reference to local axes or link axes, the link axis configuration in the logical machine axis image also allows references to axis containers. This type of reference consists of:

- Container number
- a slot (circular buffer location within the container)

The entry in a circular buffer location contains:

- A local axis
- or
- a link axis

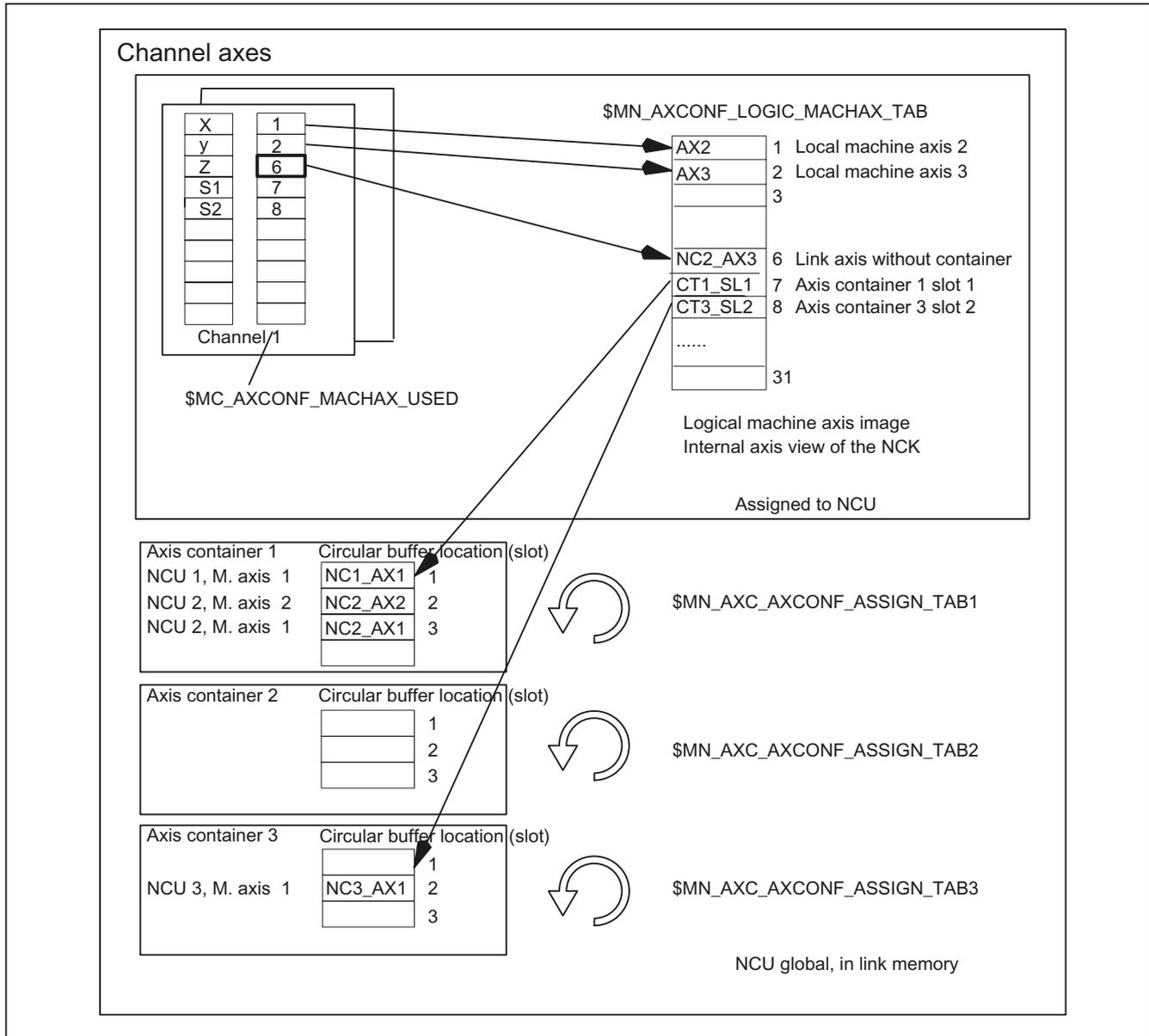


Figure 10-8 Mapping of channel axes onto axis containers via logical machine axis image

Axis container entries contain local machine axes or link axes from the perspective of an individual NCU.

The entries in the logical machine axis image of an individual NCU:

MD10002 \$MN\_AXCONF\_LOGIC\_MACHAX\_TAB  
are fixed.

---

**Note**

The axis container functionality is currently not available with the SINUMERIK 840Di.

---

The axis container function is described in

**References:**

/FB2/ Function Manual, Extended Functions; Multiple Operator Panels on Multiple NCUs, Distributed Systems (B3)

## 10.3 Zeros and reference points

### 10.3.1 Reference points in working space

#### Zeros and reference points

The neutral position of the machine is obtained from the coordinate axes and the constructive characteristics of the machine. The zero of the coordinate system is obtained by defining a suitable reference point on the machine in its neutral position.

The position of the coordinate systems (MCS, BCS, BZS, SZS, WCS) is determined by means of zeros.

Zero points		Reference points	
	<b>M</b> = Machine zero		<b>R</b> = Reference point
	<b>W</b> = Workpiece zero		<b>T</b> = Toolholder reference point

#### Machine zero M

The machine zero M defines the machine coordinate system MCS. All other reference points refer to the machine zero.

#### Workpiece zero W

The workpiece zero W defines the workpiece coordinate system in relation to the machine zero M. The programmed part-program blocks are executed in the workpiece coordinate system WCS.

#### Reference point R

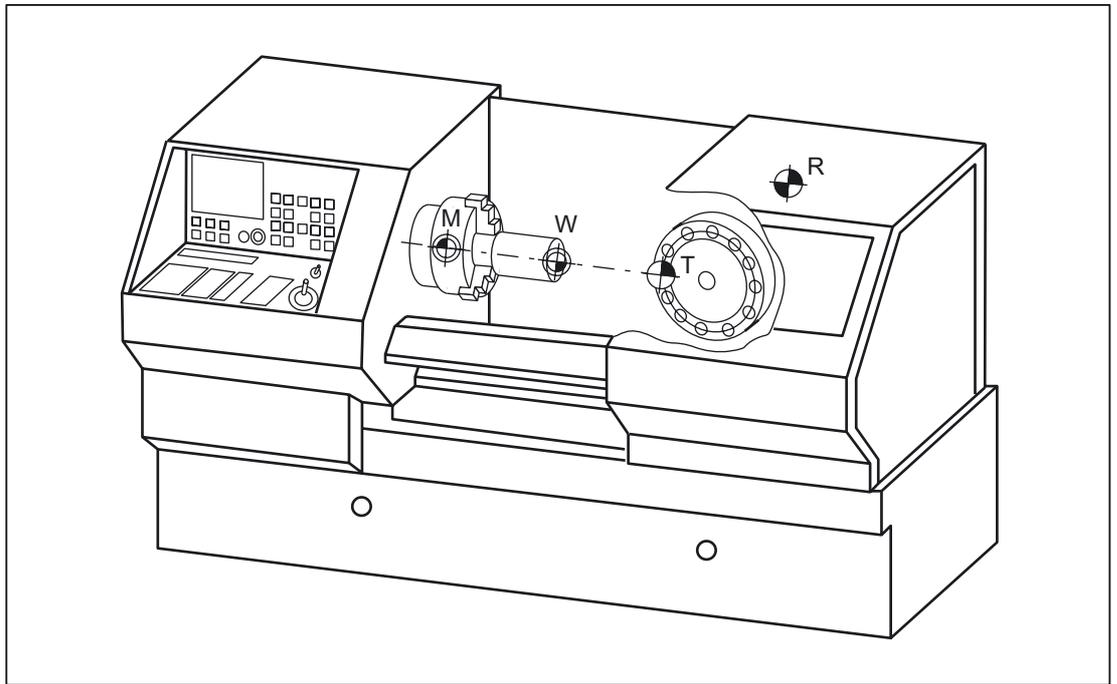
The position of the reference point R is defined by cam switches. Reference point R calibrates the position measuring system.

With incremental encoders, the reference point must be approached every time the control power is switched on. The control can only then work with the measuring system and transfer all position values to the coordinate systems.

#### Toolholder reference point T

The toolholder reference point T is located on the toolholder locator. By entering the tool lengths, the control calculates the distance between the tool tip (TCP Tool Center Position) and the toolholder reference point.

**Example: Zeros and reference points on a turning machine**



### 10.3.2 Position of coordinate systems and reference points

#### Control POWER ON

For incremental measuring probes, the reference point must be approached each time the control is activated so that the control can transfer all position values to the coordinate system.

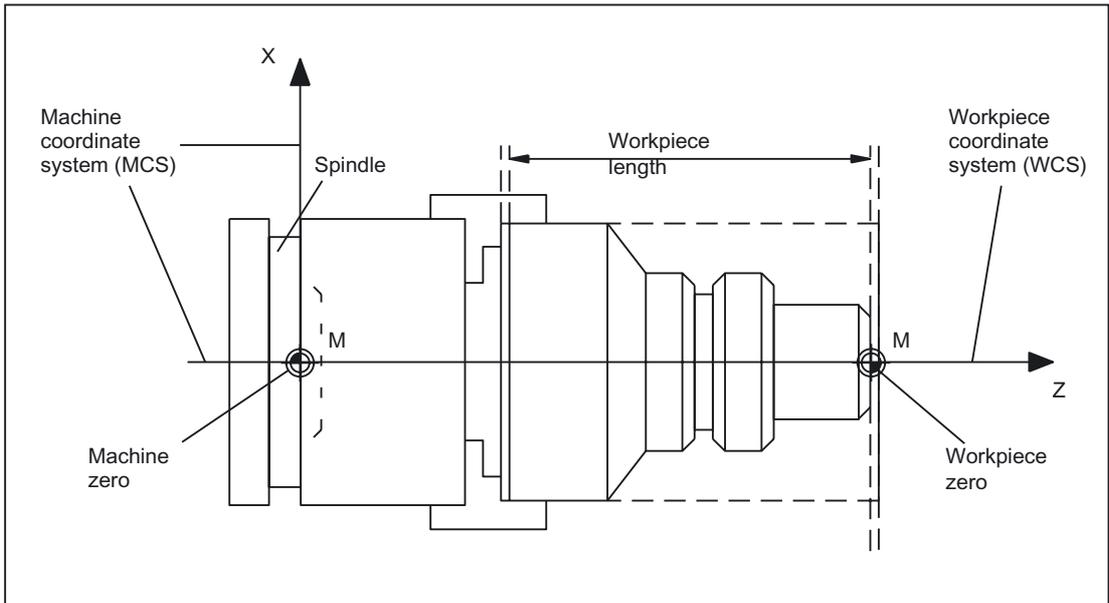


Figure 10-9 Position of coordinate systems by machine zero M and workpiece zero W

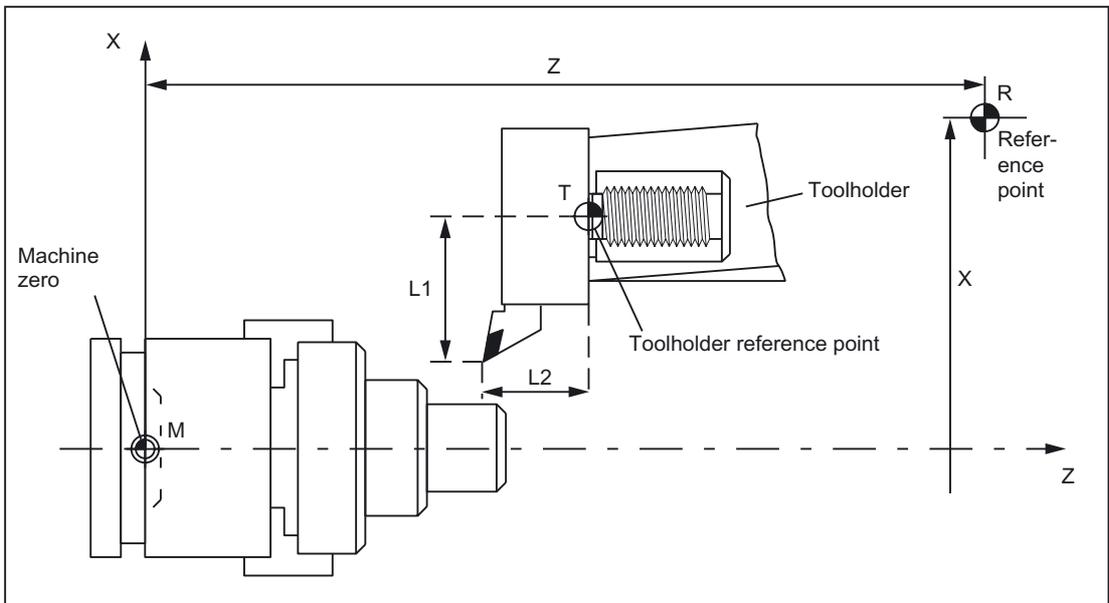


Figure 10-10 Position of reference point in relation to machine zero

## 10.4 Coordinate systems

### 10.4.1 Overview

#### Cartesian coordinate systems

DIN 66217 stipulates that machine tools must use right-angled, rectangular (Cartesian) coordinate systems. The positive directions of the coordinate axes are determined using the "Right Hand Rule". The coordinate system is related to the workpiece and programming takes place independently of whether the tool or the workpiece is being traversed. When programming, it is always assumed that the tool traverses relative to the coordinate system of the workpiece, which is intended to be stationary.

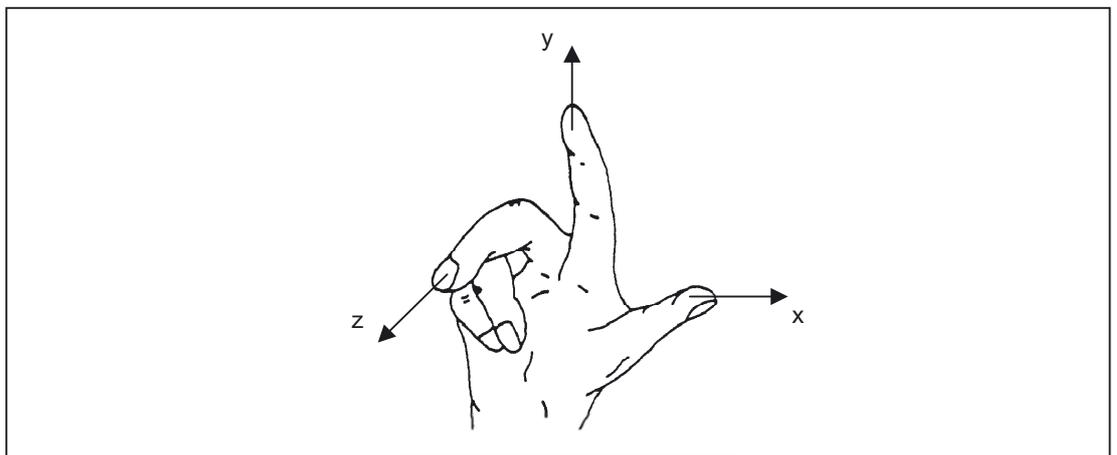


Figure 10-11 Right-hand rule

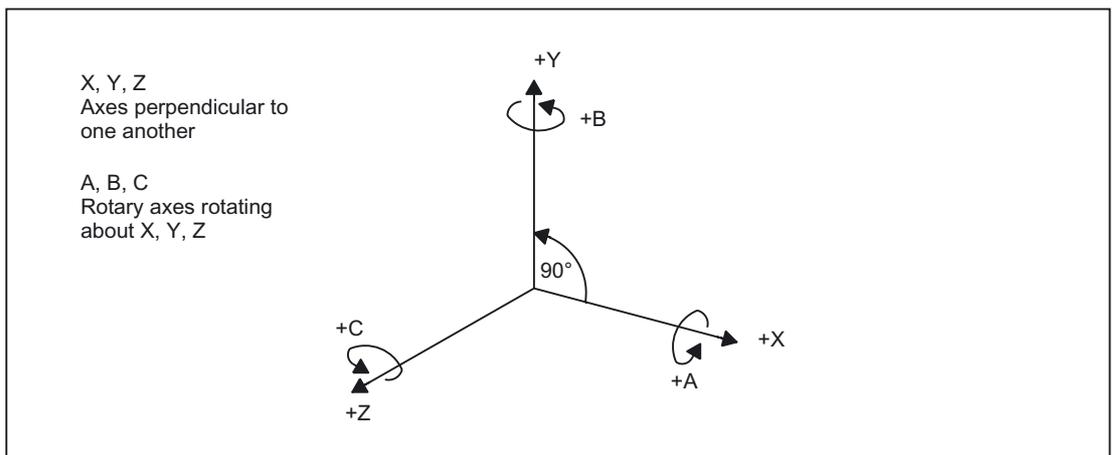


Figure 10-12 Clockwise, rectangular Cartesian coordinate system

The following coordinate systems are defined:

MCS	<b>Machine Coordinate System</b>
BCS	<b>Basic Coordinate System</b>
BZS	<b>Basic Zero System</b>
SZS	<b>Settable Zero System</b>
WCS	<b>Workpiece Coordinate System</b>

### Interrelationships between coordinate systems

The coordinate systems are determined by the kinematic transformation and the FRAMES.

A kinematic transformation is used to derive the BCS from the MCS. If no kinematic transformation is active, the BCS is the same as the MCS.

The basic frame maps the BCS onto the BKS.

An activated adjustable FRAME G54...G599 ENS is derived from the BNS.

The WCS, which is the basis for programming, is defined by the programmable FRAME.

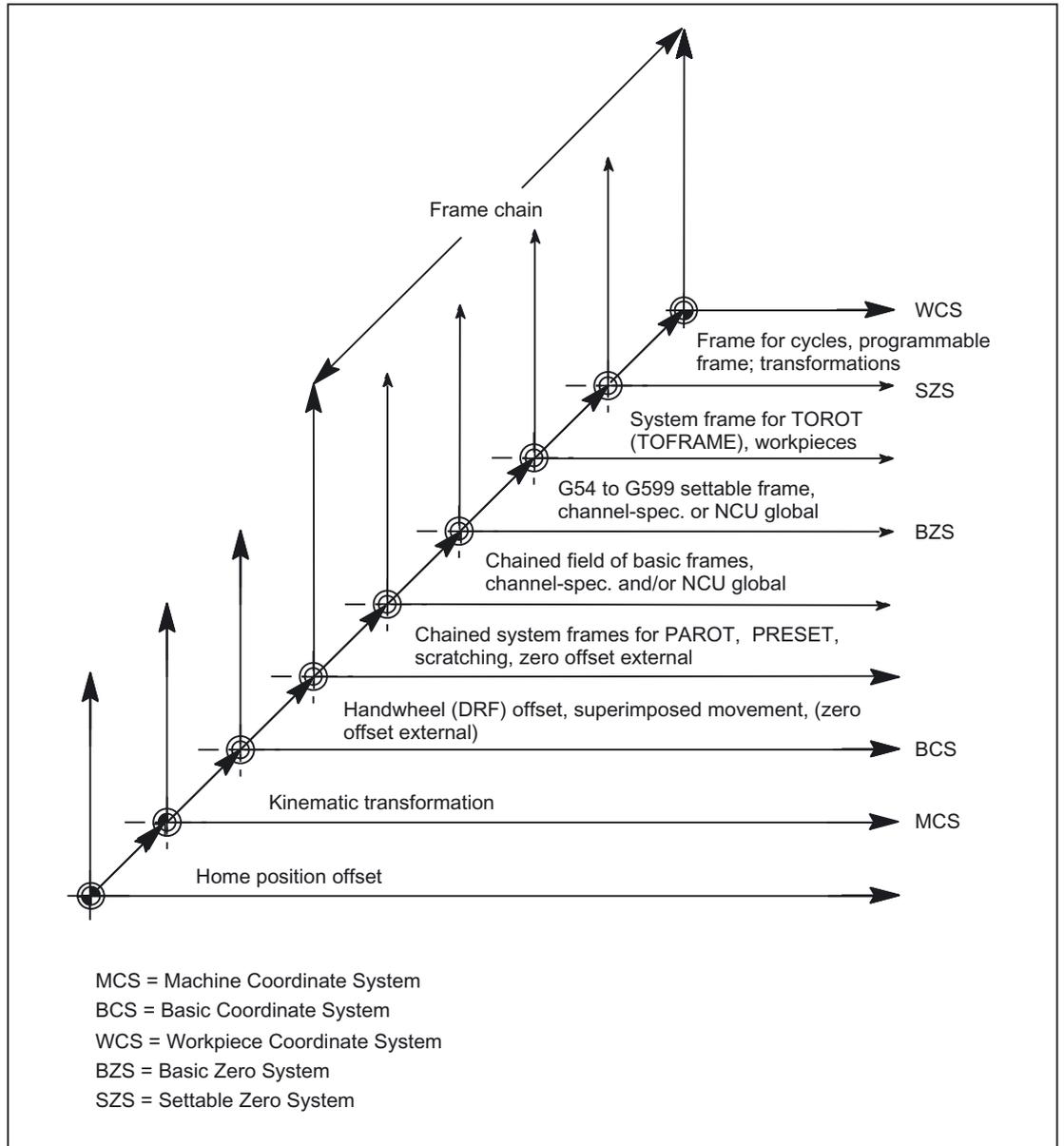


Figure 10-13 Interrelationships between coordinate systems

### 10.4.2 Machine coordinate system (MCS)

#### Machine coordinate system (MCS)

The machine coordinate system (MCS) is made up of all physically available machine axes.

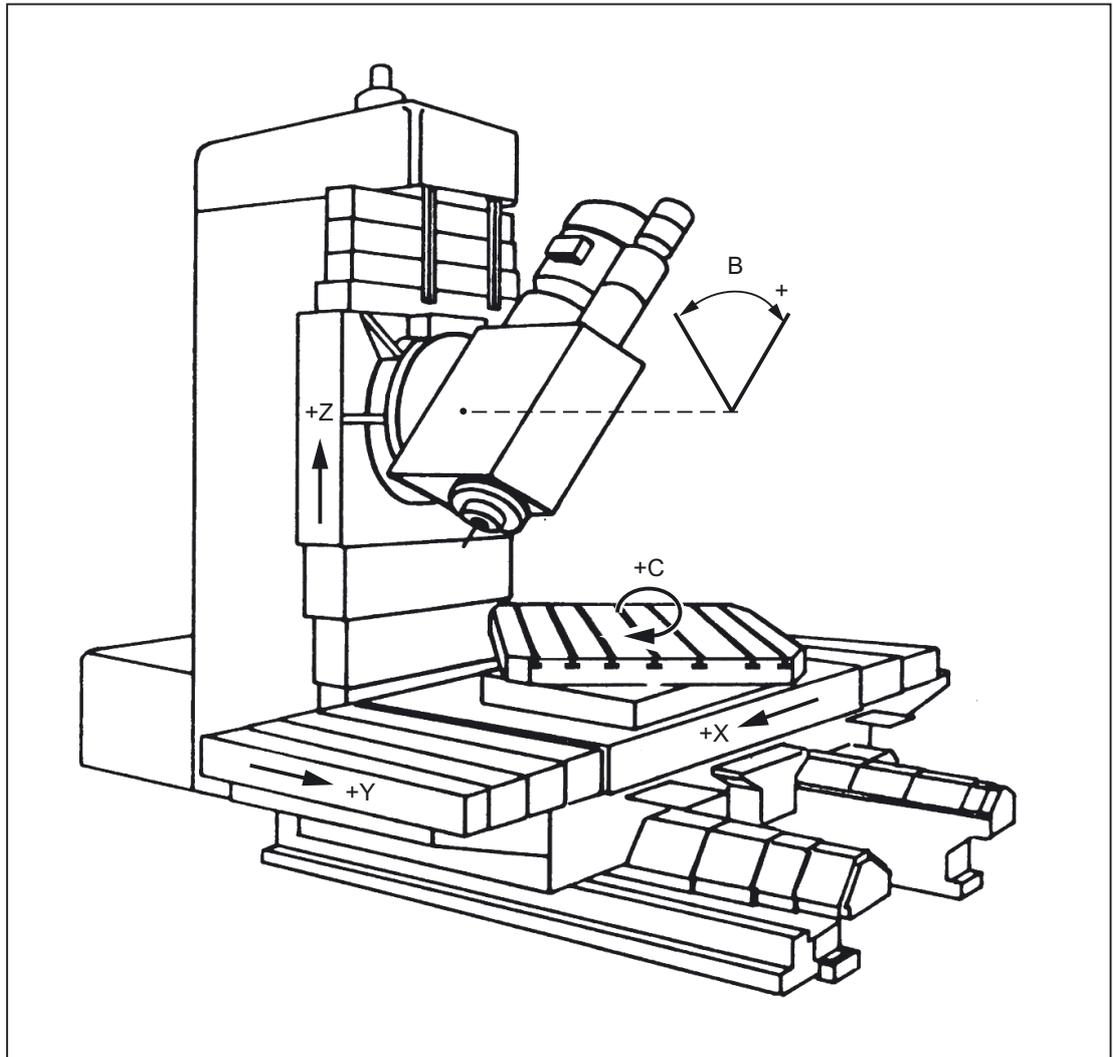


Figure 10-14 MCS with machine axes X, Y, Z, B, C (5-axis milling machine)

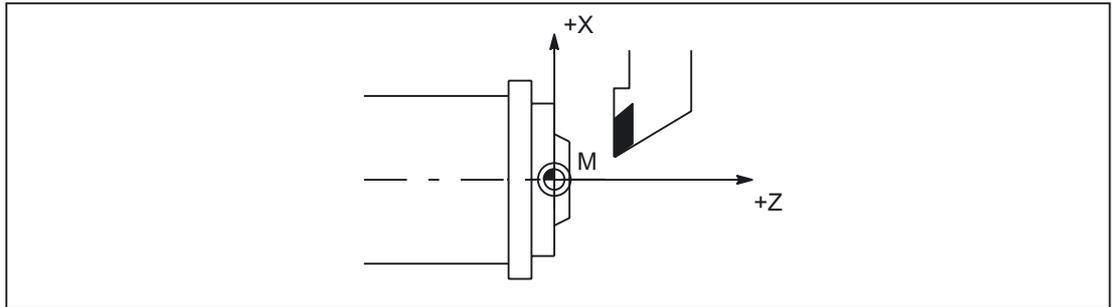


Figure 10-15 MCS with machine axes X, Z (turning machine)

### Axial preset offset

The "Preset" function can be used to redefine the control zero in the machine coordinate system. The preset values act on machine axes. Axes do not move when "Preset" is active.

---

#### Note

After Preset, the reference points are invalid!

If possible do not use this function.

---

### 10.4.3 Basic coordinate system (BCS)

#### Basic coordinate system (BCS)

The basic coordinate system (BCS) consists of three mutually perpendicular axes (geometry axes) as well as other special axes, which are not interrelated geometrically.

#### Machine tools without kinematic transformation

BCS and MKS always coincide when the BCS can be mapped onto the MCS without kinematic transformation (e.g. TRANSMIT/face transformation, 5-axis transformation and up to three machine axes).

On such machines, machine axes and geometry axes can have the same names.

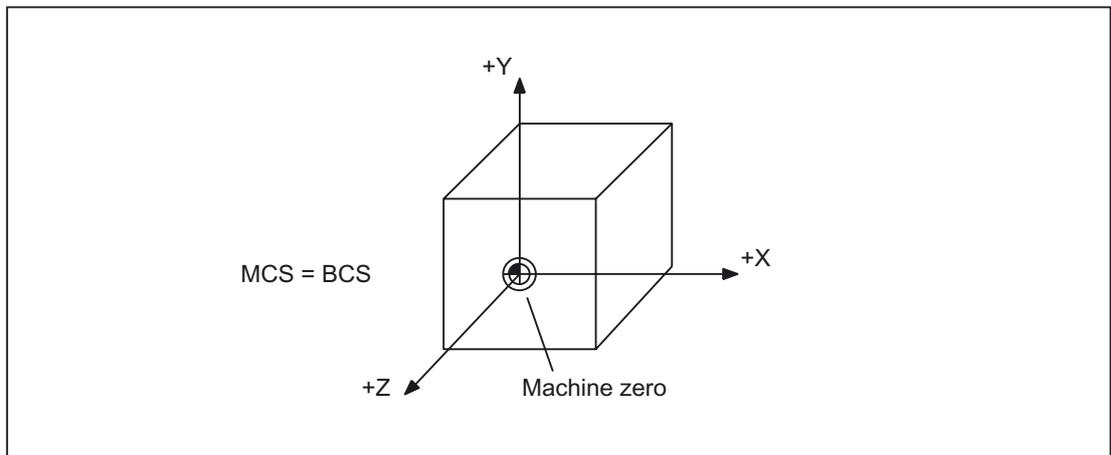


Figure 10-16 MCS=BCS without kinematic transformation

#### Machine tools with kinematic transformation

The BCS and MCS do not coincide when the BCS is mapped onto the MCS with kinematic transformation (e.g. TRANSMIT/face transformation, 5-axis transformation or more than three axes).

On such machines the machine axes and geometry axes must have different names.

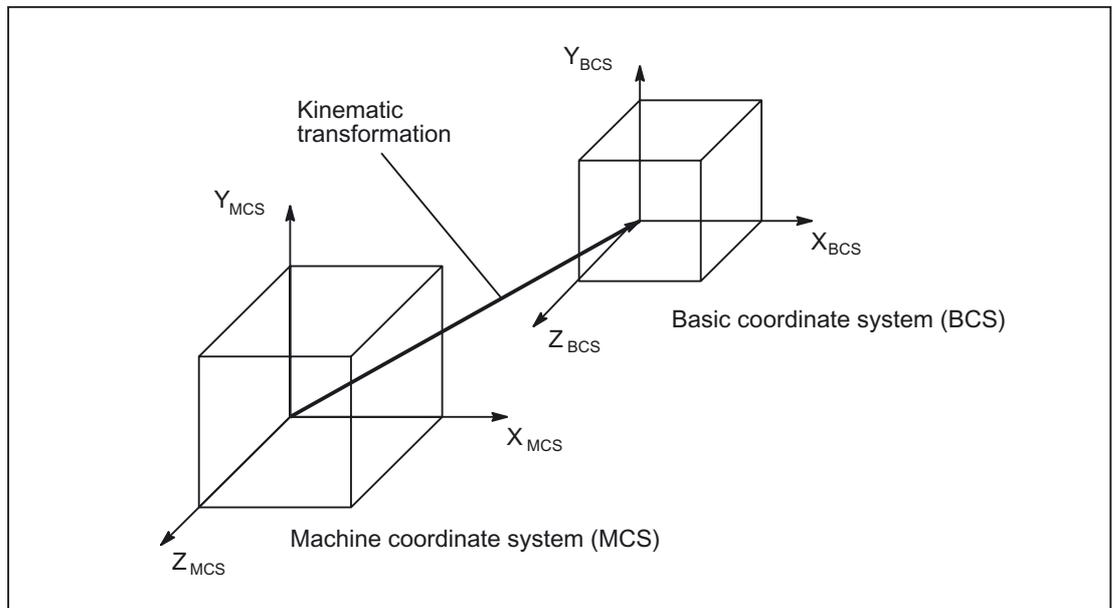


Figure 10-17 Kinematic transformation between the MCS and BCS

### Machine kinematics

The workpiece is always programmed in a two- or three-dimensional, right-angled coordinate system (WCS). However, such workpieces are being programmed ever more frequently on machine tools with rotary axes or linear axes not perpendicular to one another. Kinematic transformation is used to represent coordinates programmed in the workpiece coordinate system (rectangular) in real machine movements.

#### References:

- /FB3/ Function Manual, Special Functions; 3-Axis to 5-Axis Transformation (F2)
- /FB2/ Function Manual, Extended Functions; Kinematic Transformation (M1)

### 10.4.4 Additive offsets

#### Zero offsets external

The "zero offset external" is an axial offset. Unlike with frames, no components for rotation, scaling and mirroring are possible.

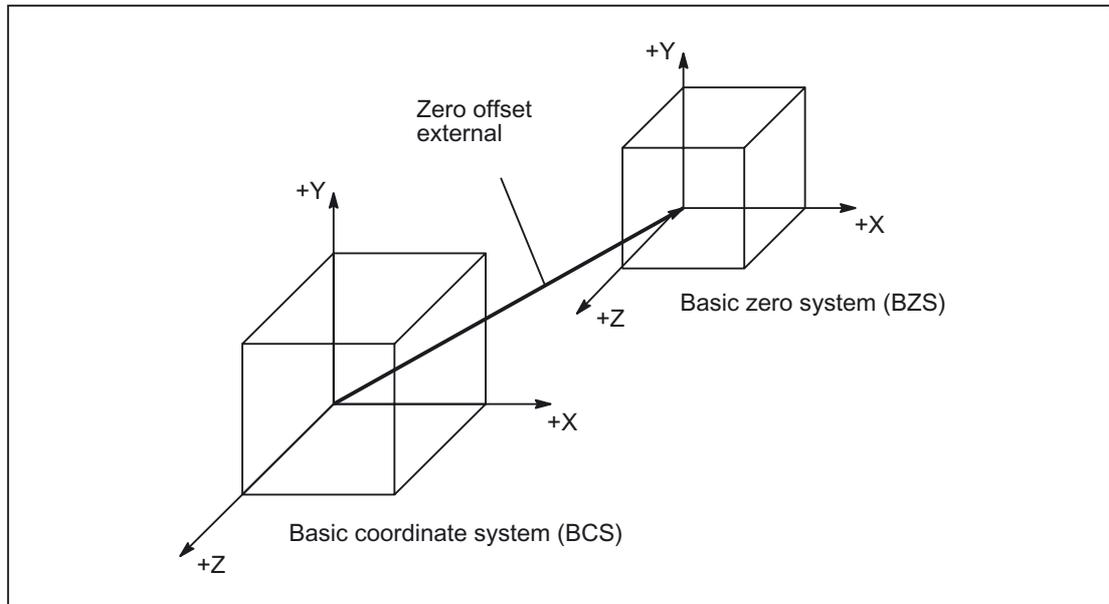


Figure 10-18 Zero offset external between BCS and BZS

#### Setting the offset values

The offset values are set:

- PLC  
By describing system variables
- Via the operator panel  
From menu "Current zero offsets"
- NC Program  
By assigning to system variable `$AA_ETRANS[axis]`

#### Activation of the offset values

The 0/1 edge of the following PLC signal activates the previously defined offset values:

DB31, ... DBX3.0 (accept external zero offset)

The 0/1 edge change is only evaluated in Automatic operating mode.

## Effect of activation

The offset for an axis becomes active when the first motion block for this axis is executed after the offset is activated.

### Example of possible chronological sequence:

```
G0 X100
X150      ; A new "Zero offset external" is activated by the PLC during this
           motion.
X200      ; The new "Zero offset external" is applied due to G0 programming at the
           end of the block (X200), if no velocity reserve is available (100%).
```

The "Zero offset external via system frame" is applied immediately.

Channel-specific system frames can be configured through the following machine data:

MD28082 \$MC\_MM\_SYSTEM\_FRAME\_MASK (System frames SRAM)

## Programming

Setting a new offset via the axis-specific system variables:

\$AA\_ETRANS[axis]=R<sub>i</sub>

The instruction below reads the axis-specific active offset value:

R<sub>i</sub>=\$AA\_ETRANS[axis]

---

### Note

The read value can then differ from the previously set value, if the set value has not yet been activated.

The read value corresponds to a value set previously, if the most recently set value has not yet been activated. The system frame for the "Zero offset external" exists only if it has been configured.

---

## DRF offset

The DRF offset enables the adjustment of an additional incremental zero offset for geometry and additional axes in the basic coordinate system **through handwheel**.

The DRF offset can be read via the axis-specific system variable:

\$AC\_DRF[<Axis>]

### References:

/FB2/ Function Manual, Extended Functions; Jog with/without Handwheel (H1),  
Section: DRF offset

## Overlaid movements

The "Superimposed motion" for the programmed axis can only be accessed from synchronized actions via the system variable `$AA_OFF[axis]`.

## Run-up

After run-up (POWER ON) the last used offset values for the "Zero offset external" are stored and do not become effective again until there is a renewed activation signal.

System frames are retained during Power ON, depending on the following machine data:

MD24008 `$MC_CHSFRAME_POWERON_MASK` (reset system frames after Power On)

## RESET/end of program

The activated values remain active after RESET and program end.

Reset response of channel-specific system frames as follows:

The system frame for the "external zero offset" is active after RESET with the following machine data setting:

MD24006 `$MC_CHSFRAME_RESET_MASK`, Bit 1 = 1

The "external zero offset" in the active system frame is deleted in the data management through the following machine data setting:

MD24006 `$MC_CHSFRAME_RESET_MASK`, Bit 1 = 0

The following frames are active after RESET:

- System frame for:
  - MD24006 `$MC_CHSFRAME_RESET_MASK`, Bit 4 = 1 (workpiece reference point)
  - MD24006 `$MC_CHSFRAME_RESET_MASK`, Bit 5 = 1 (cycles)

## Suppression

The NC program instruction `SUPA` suppresses the "Zero offset external" while the block is being processed.

The command `G74` (reference point approach) and the equivalent operator actions in "Reference point approach" mode suppress the "Zero offset external" for the duration of the reference point approach.

With `G74`, i.e. "Automatic" or "MDA" mode, the previously active "Zero offset external" automatically becomes active again with the next traverse motion in the block.

After a mode change from "Reference point approach" mode, the VDI signal for the referenced axes must be set for reactivation.

## 10.4.5 Basic zero system (BZS)

### Basic zero system (BZS)

The basic zero system (BZS) is the basic coordinate system with a basic offset.

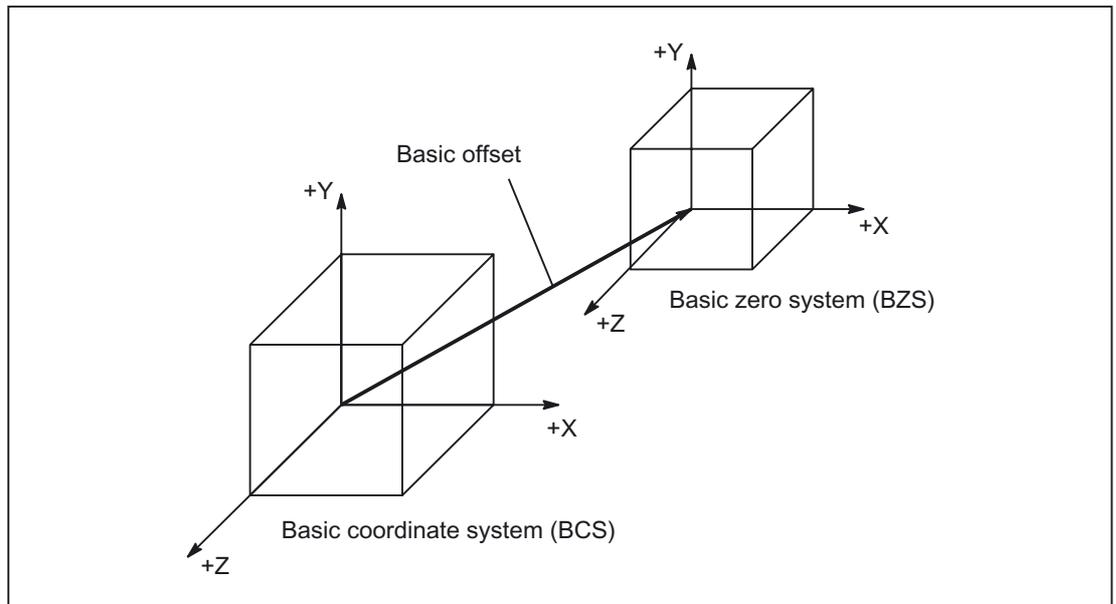


Figure 10-19 Basic offset between BCS and BZS

### Basic offset

The basic offset describes the coordinate transformation between BCS and BZS. It can be used, for example, to define the palette window zero.

The basic offset comprises:

- Zero offset external
- DRF offset
- Superimposed motion
- Chained system frames
- Chained basic frames

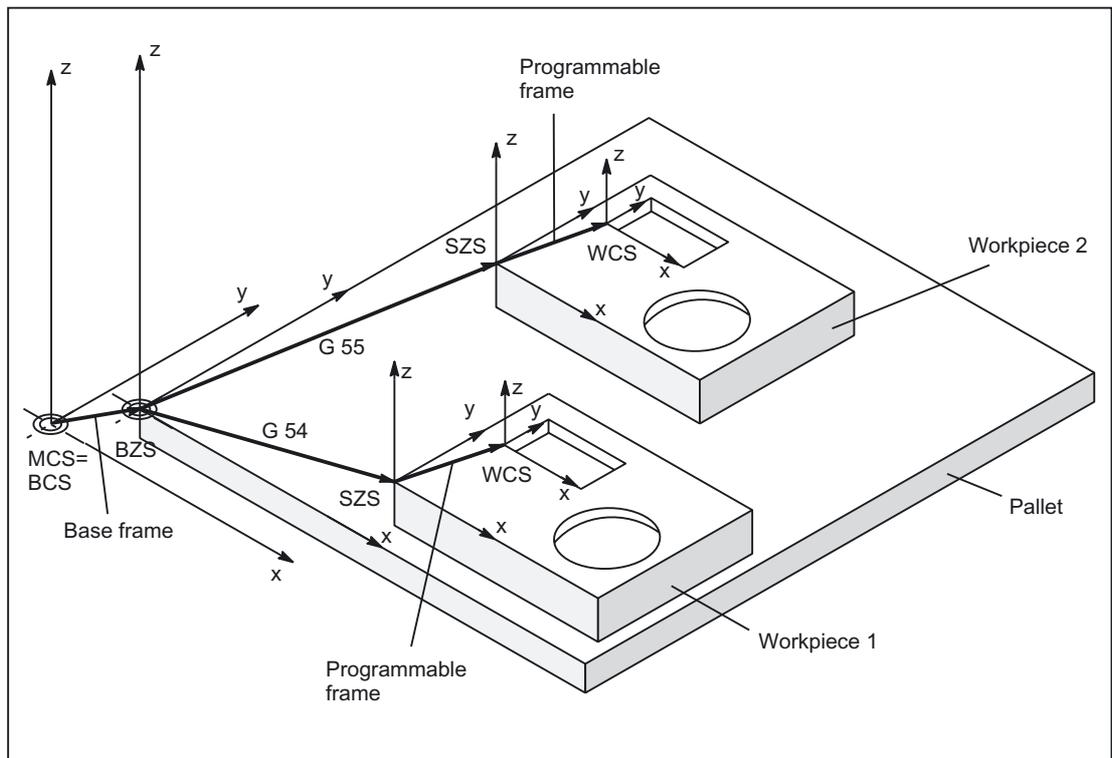


Figure 10-20 Example of the use of the basic offset

The following settings apply:

- The user can change the basic offset from the part program by means of an operator action and from the PLC.
- If the basic offset is to take effect immediately, an ASUB can be started via the PLC using FC9 in order to execute the appropriate G code.

---

**Note**

**Recommendation to the machine manufacturer**

Use the 3rd basic offset onwards for your own applications.

The 1st and 2nd basic offset are reserved for PRESET and the "Zero offset external".

---

## 10.4.6 Settable zero system (SZS)

### Settable zero system (SZS)

The "settable zero system" (SZS) is the workpiece coordinate system WCS with a programmable frame (viewed from the perspective of the WCS). The workpiece zero is defined by the settable FRAMES G54 to G599.

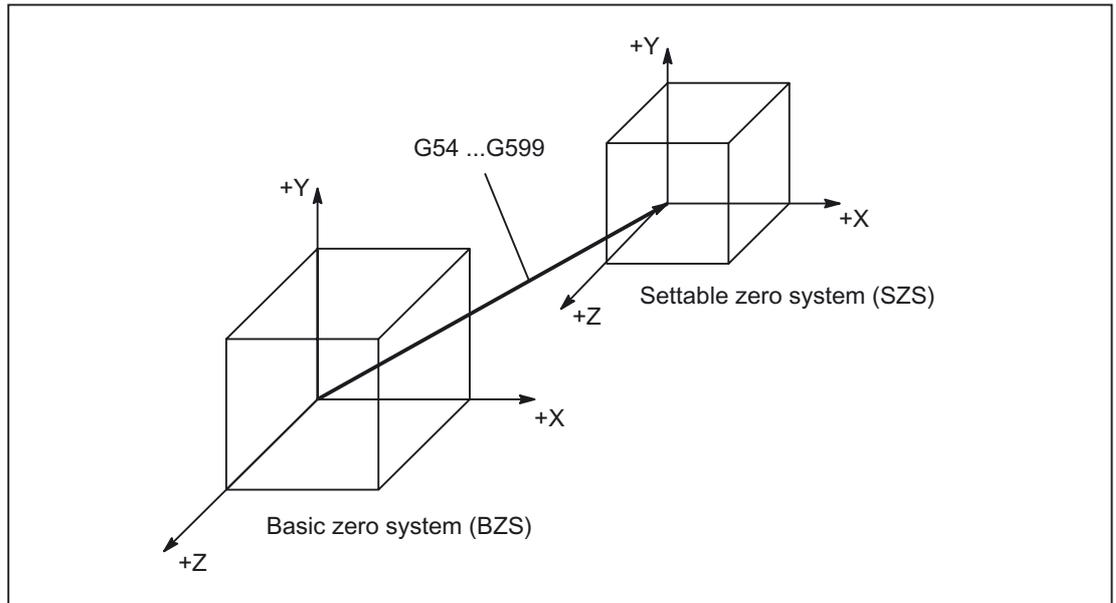


Figure 10-21 Settable FRAME G54 ... G599 between BNS and ENS

Programmable offsets act on the "settable zero system". All programmable offsets refer to the "settable zero system".

### WCS actual-value display in WCS or SZS

The actual values of the axes in the machine coordinate system (MCS) or the WCS can be displayed on the HMI operator interface. For displays in WCS, the actual values can also be displayed in relation to the SZS. The corresponding parameterization takes place through the machine data:

MD9424 \$MM\_MA\_COORDINATE\_SYSTEM (coordinate system for actual value display)

Value	Significance
0	Actual-value display in relation to the WCS
1	Actual-value display in relation to the SZS

#### Note

##### Display of the current coordinate system

When "Actual-value display in relation to the SZS" is active, the WCS is still displayed on the HMI operator interface as the coordinate system to which the actual-value display relates.

**Example**

Actual-value display in relation to the WCS or SZS

Code (excerpt)	Actual value display: Axis X (WCS)	Actual value display: Axis X (SZS)
N10 X100	100	100
N20 X0	0	0
N30 \$P_PFRAME = CTRANS(X,10)	0	10
N40 X100	100	110

**10.4.7 Workpiece coordinate system (WCS)**

**Workpiece coordinate system (WCS)**

The workpiece coordinate system (WCS) is the programming basis.

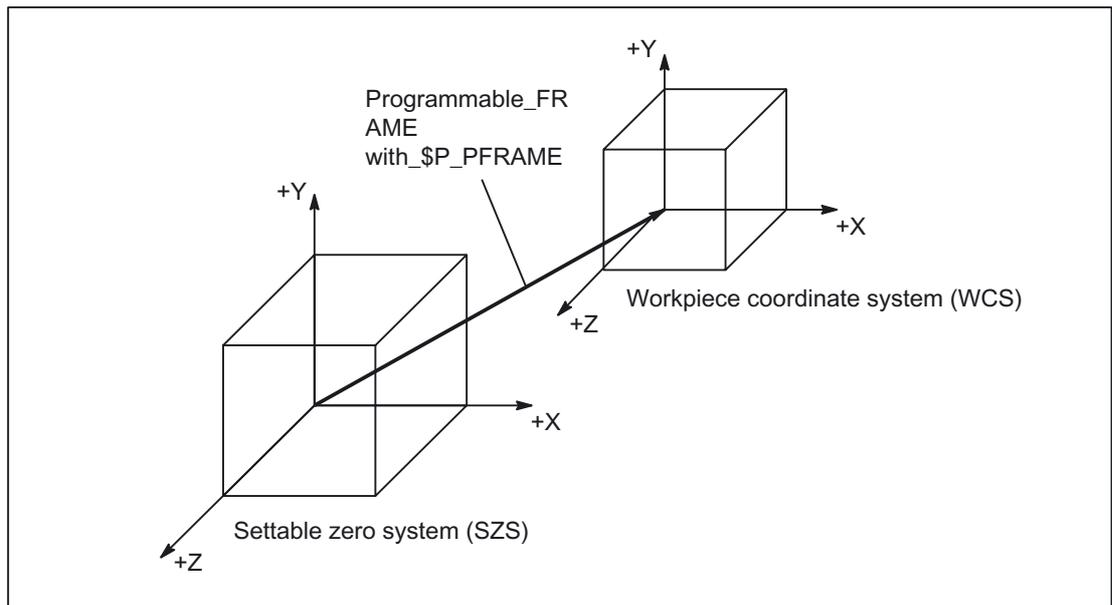


Figure 10-22 Programmable FRAME between SZS and WCS

## 10.5 Frames

### 10.5.1 Overview

#### Frame

A frame is an axis-specific structure through all channel axes, in which there is a value for each axis, for the translation, fine offset, rotation (only for geometry axes) scaling and mirroring.

	TRANS	FINE	ROT	MIRROR	SCALE
x	10.0	0.1	0.0	0	1
Y	0.0	0.0	0.0	1	1
z	0.0	0.0	45.0	0	1
chx	10.0	0.1		0	1
chy	0.0	0.0		1	1
chz	0.0	0.0		0	1
a	2.0	0.1		0	2
b	0.0	0.0		1	1

In global frames, this is valid for all machine axes.

	TRANS	FINE	MIRROR	SCALE
ax1	10.0	0.1	0	1
ax2	0.0	0.0	1	1
ax3	0.0	0.0	0	1
ax4	2.0	0.1	0	2
ax5	0.0	0.0	1	1

Activating a frame causes a **static coordinate transformation** to be carried out via a defined calculation rule.

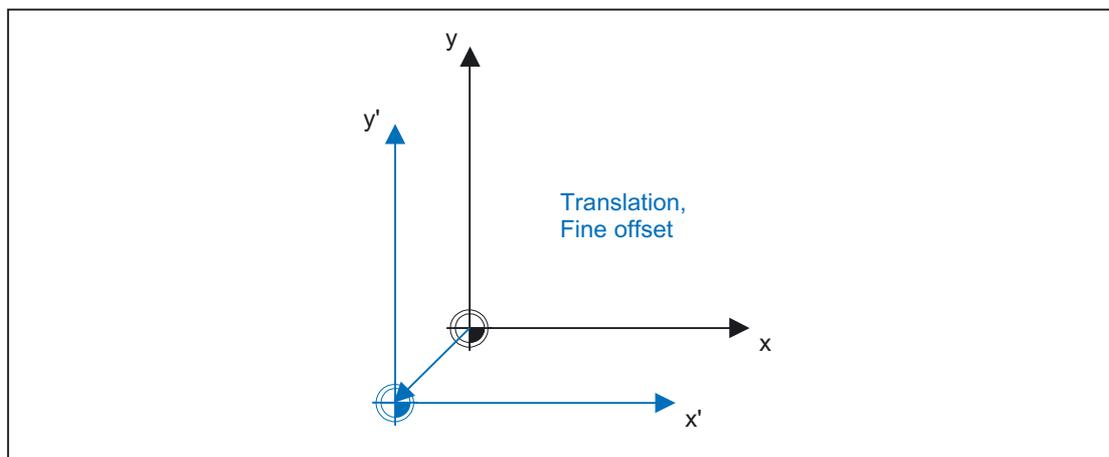
### 10.5.2 Frame components

#### 10.5.2.1 Translation

##### Programming

The program commands below are used to program the translation:

Command	Comment
<code>\$P_UIFR[1] = CTRANS(x,10,y,10)</code>	
<code>\$P_UIFR[1,x,tr] = 10</code>	Frame components
<code>TRANS x=10 y=10</code>	Prog. frame only



#### 10.5.2.2 Fine offset

##### Parameterization

The corresponding fine offset parameterization takes place through the machine data:

MD18600 \$MN\_MM\_FRAME\_FINE\_TRANS (fine offset in FRAME (SRAM))

Value	Significance
0	The fine offset cannot be entered or programmed.
1	Fine offset possible for settable frames, basic frames and the prog. frame via command or program.

## Programming

The fine offset can be programmed in the program using command `CFINE (x, ..., y, ...)`. The coarse offset is defined with `CTRANS(...)`. Coarse and fine offset add up to the total offset.

```
$P_UBFR = CTRANS(x, 10) : CFINE(x, 0.1) : CROT(x, 45)
```

```
$P_UIFR[1]=CFINE(x, 0.5, y, 1.0, z, 0.1)
```

Access to the individual components of the fine offset is achieved through component specification **FI**.

```
finex = $P_UIFR[ $P_UIFRNUM, x, FI ]
```

Fine offsetting can be programmed only if:

```
MD18600 $MN_FRAME_FINE_TRANS = 1
```

if this is not the case, then each assignment of a fine offset to a settable frame and to the basic frame with the alarm "FRAME: fine offset not possible".

A fine offset changed by the operator does not apply until after activation of the corresponding frame, i.e. activation via `G500`, `G54` to `G599`.

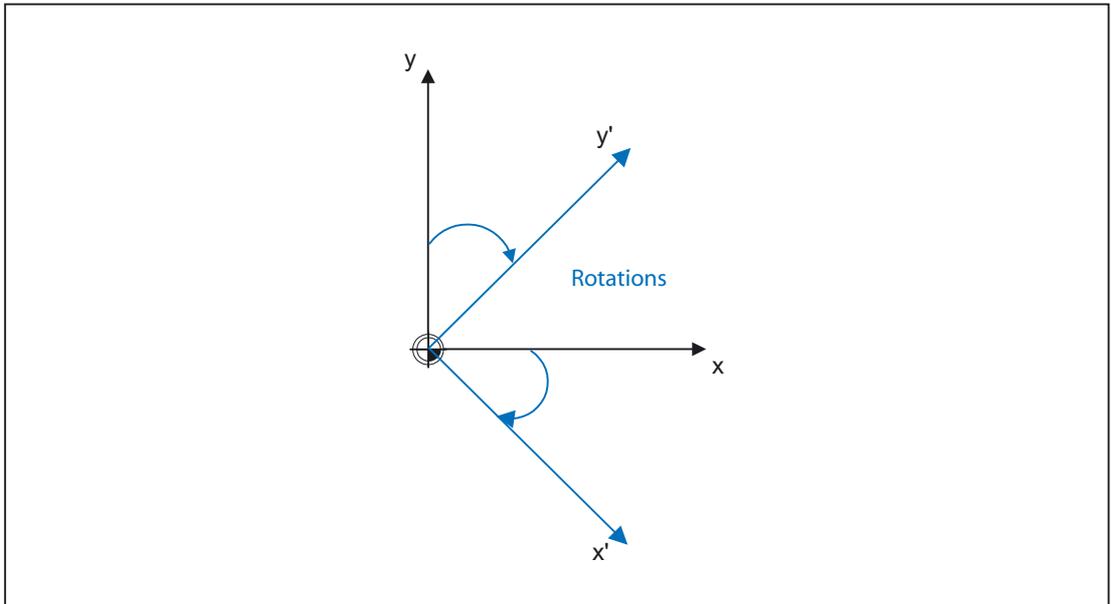
Once activated, a fine offset of a frame remains active the whole time the frame is active.

When the offset of the current frame is displayed, the total offset (coarse offset and fine offset) is output.

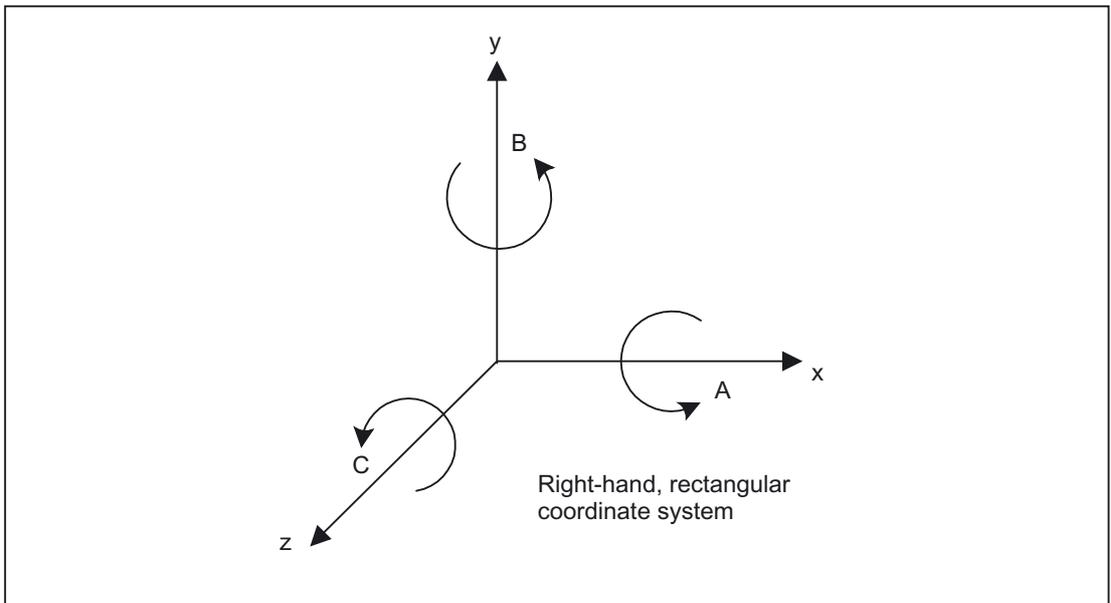
### 10.5.2.3 Rotations for geometry axes

#### Function

The direction of rotation about the coordinate axes is determined by means of a right-hand, rectangular coordinate system with axes X, Y and Z.



If the rotary motion is in a clockwise direction when looking in the positive direction of the coordinate axis, the direction of rotation is positive. A, B and C identify rotations whose axes are parallel to X, Y and Z.



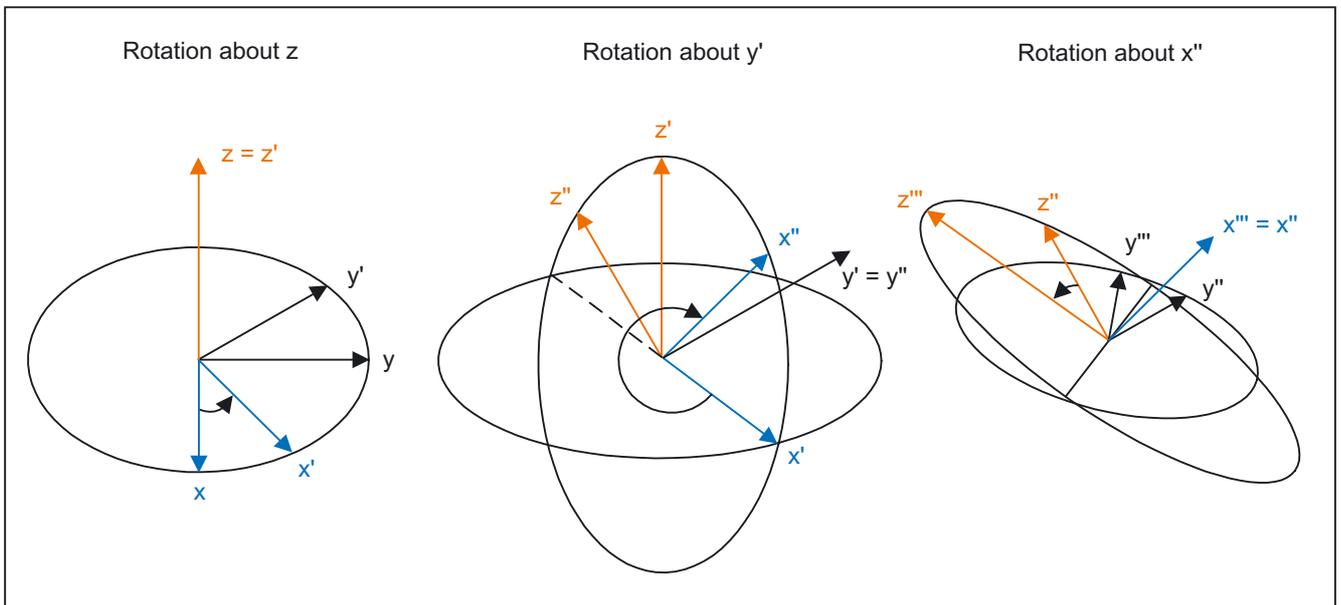
### Parameterization

The corresponding rotation in frame is parameterized through the machine data:  
MD10600 \$MN\_FRAME\_ANGLE\_INPUT\_MODE (rotation sequence in FRAME)

Value	Significance
1	RPY notation
2	Euler angle

### RPY angles

Rotations with a RPY angle are carried out in the order Z, Y', X''.

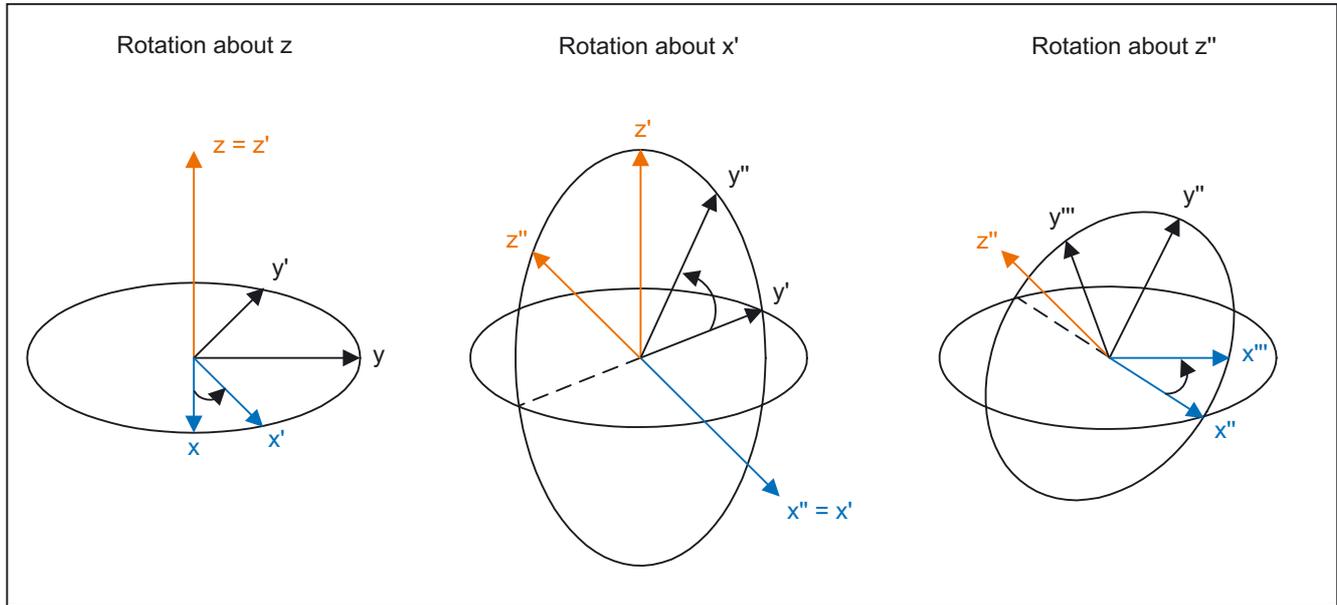


The angles are only defined ambiguously in the following ranges:

$$\begin{aligned}
 -180 &\leq x \leq 180 \\
 -90 &< Y < 90 \\
 -180 &\leq z \leq 180
 \end{aligned}$$

### Euler angle

Rotations with a **Euler angle** are carried out in the order Z, X', Z''.



The angles are only defined ambiguously in the following ranges:

- 0      <=   x   <   180
- 180   <=   Y   <=   180
- 180   <=   z   <=   180

The written angles can be uniquely read back again in these areas. When rotations that are larger than the specified angles are entered, these are converted to a mode of representation that does not exceed the specified range limits.

RPY example		
<code>\$P_UIFR[1]=crot(x,10,y,90,z,40)</code>	returns on reading back	<code>\$P_UIFR[1]=crot(x,0,y,90,z,30)</code>
<code>\$P_UIFR[1]=crot(x,190,y,0,z,-200)</code>	delivers during reading:	<code>\$P_UIFR[1]=crot(x,-170,y,0,z,160)</code>

On writing and reading frame rotation components, these limits should be observed so the same results are achieved on writing and reading, or on repeated writing.

### Programming

The program commands below are used to program the rotation:

```

$P_UIFR[1]=CROT(x,10,y,10)
ROT x=10 y=10
$P_UIFR[1,x,rt]=10
    
```

### CRPL - Constant Rotation Plane

The predefined function "Constant Rotation Plane", allows a rotation to be programmed in any plane for each frame:

FRAME CRPL (INT, REAL)

This method offers the advantage that no axis identifier, around which a rotation should be executed, has to be specified for a geometry coordinate axis.

As a rule, turning machines have only two geo axes, meaning that, up to now, a rotation in the plane could not be programmed.

**Parameter:**

INT	0:	Rotation in the active plane
	1:	Rotation around z
	2:	Rotation around y
	3:	Rotation around x
REAL	Angle of rotation in degrees	
	RPY:	-180 <= x <= 180
		-90 <= y <= 90
		-180 <= z <= 180
	Euler:	-180 <= x <= 180
		0 <= y <= 180
		-180 <= z <= 180
The user must keep to the named angles, in the interests of a unique backward calculation. If the limits are violated, a unique backward calculation is impossible. Entry is not aborted with an alarm.		

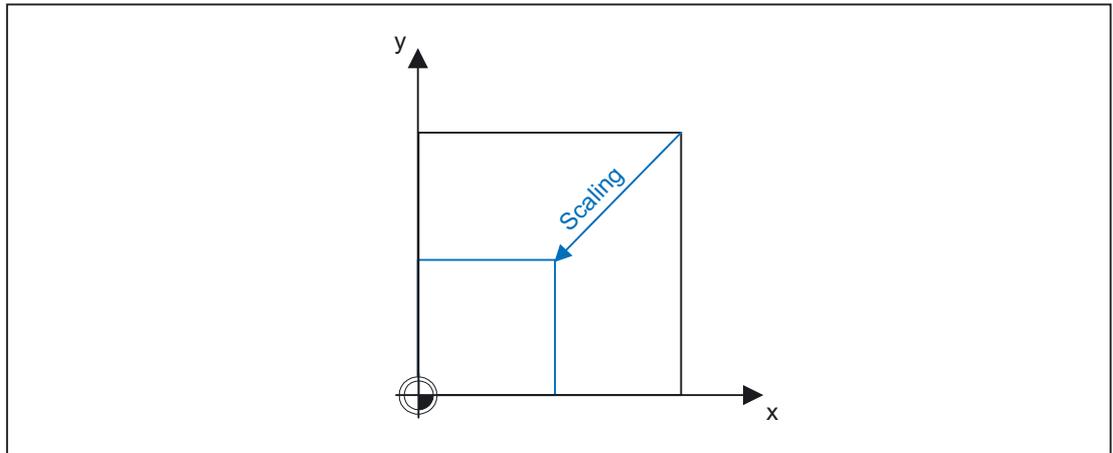
**Chaining with frames**

CRPL () can be chained with frames and known frame functions such as CTRANS (), CROT (), CMIRROR (), CSCALE (), CFINE () .

**Examples:**

```
$P_CYCFRAME = $P_CYCFRAME : CRPL (0, 30)
$P_CYCFRAME = CTRANS (x, 10) : CRPL (1.30)
$P_CYCFRAME = CROT (x, 10) : CRPL (2.30)
$P_CYCFRAME = CRPL (3, 30) : CMIRROR (y)
```

### 10.5.2.4 Scaling

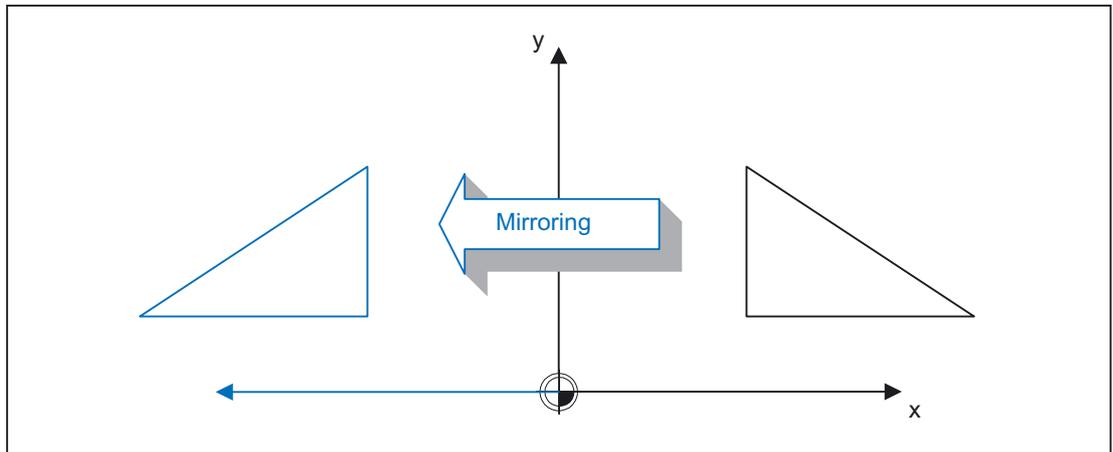


#### Programming

The program commands below are used to program the scaling:

```
$P_UIFR[1] = CSCALE(x, 1, y, 1)  
SCALE x = 1 y = 1  
$P_UIFR[1, x, sc] = 1
```

### 10.5.2.5 Mirroring



#### Programming

The program commands below are used to program a mirroring:

```
$P_UIFR[1] = CMIRROR(x, 1, y, 1)  
MIRROR x = 1 y = 1  
$P_UIFR[1, x, mi] = 1
```

### 10.5.2.6 Chain operator

Frame components or complete frames can be combined into a complete frame using the chain operator (:).

### 10.5.2.7 Programmable axis identifiers

Geo, channel and machine axis identifiers can be used in the frame commands. The programmed axis must be known to the channel-specific frames in the channel.

## SPI

When programming frame instructions, the SPI(<spindle number>) axis function can be used in place of an axis identifier.

SPI(<spindle number>) forms the reference of the spindle to the channel axis.  
 → refer to MD35000 \$MA\_SPIND\_ASSIGN\_TO\_MACHAX[ ] (assignment of spindle to machine axis)

The following frame instructions can be programmed with SPI(spino):

```
CTRANS ()
CFINE ()
CMIRROR ()
CSCALE ()
```

A spindle can only be assigned to one rotary axis at a time. The CROT(. .) function can therefore not be programmed with SPI(), as only geometry axes are permitted for CROT().

The channel axis identifier or machine axis identifier of the axis belonging to the spindle is always output when decompiling frames, even when axis identifiers have been programmed in the part program with SPI(. .).

If the spindle is assigned e.g. to the Channel Axis A then the programming:

```
N10 $P_UIFR[1] =
CTRANS(SPI(1), 33.33, X, 1) : CSCALE(SPI(1), 33.33) : CMIRROR(SPI(1))
```

during recompilation:

```
$P_UIFR[1]=CTRANS(X, 1, A, 33.33) : CSCALE(A, 33.33) : CMIRROR(A)
```

If a spindle and an assigned axis are programmed in a frame instruction, then Alarm 16420 "Axis % multiply programmed" is output.

#### Example:

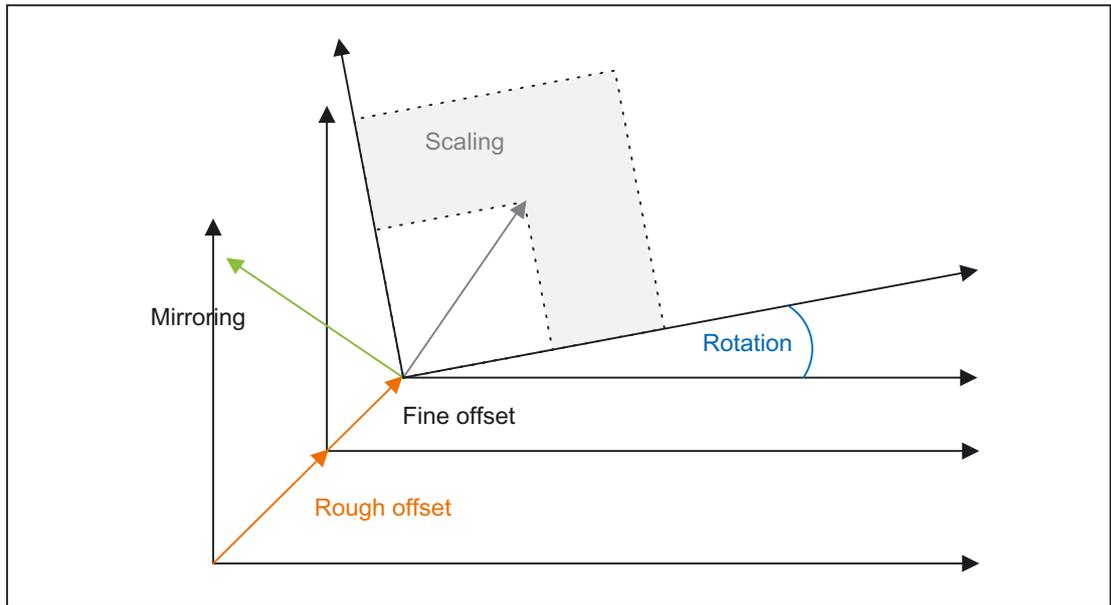
```
$P_UIFR[1] = CTRANS(SPI(1), 33.33, X, 1, A, 44)
```

(The spindle is assigned to Axis A.)

## Programming examples

```
$P_PFRAME[SPI(1), TR]=22.22
$P_PFRAME=CTRANS(X, axis value, Y, axis value, SPI(1), axis value)
$P_PFRAME=CSCALE(X, Scale, Y, scale, SPI(2), scale)
$P_PFRAME=CMIRROR(S1, Y, Z)
$P_UBFR=CTRANS(A, 10) : CFINE(SPI(1), 0.1)
```

10.5.2.8 Coordinate transformation



The formulae below are used to discover the coordinate transformation for geometry axes:

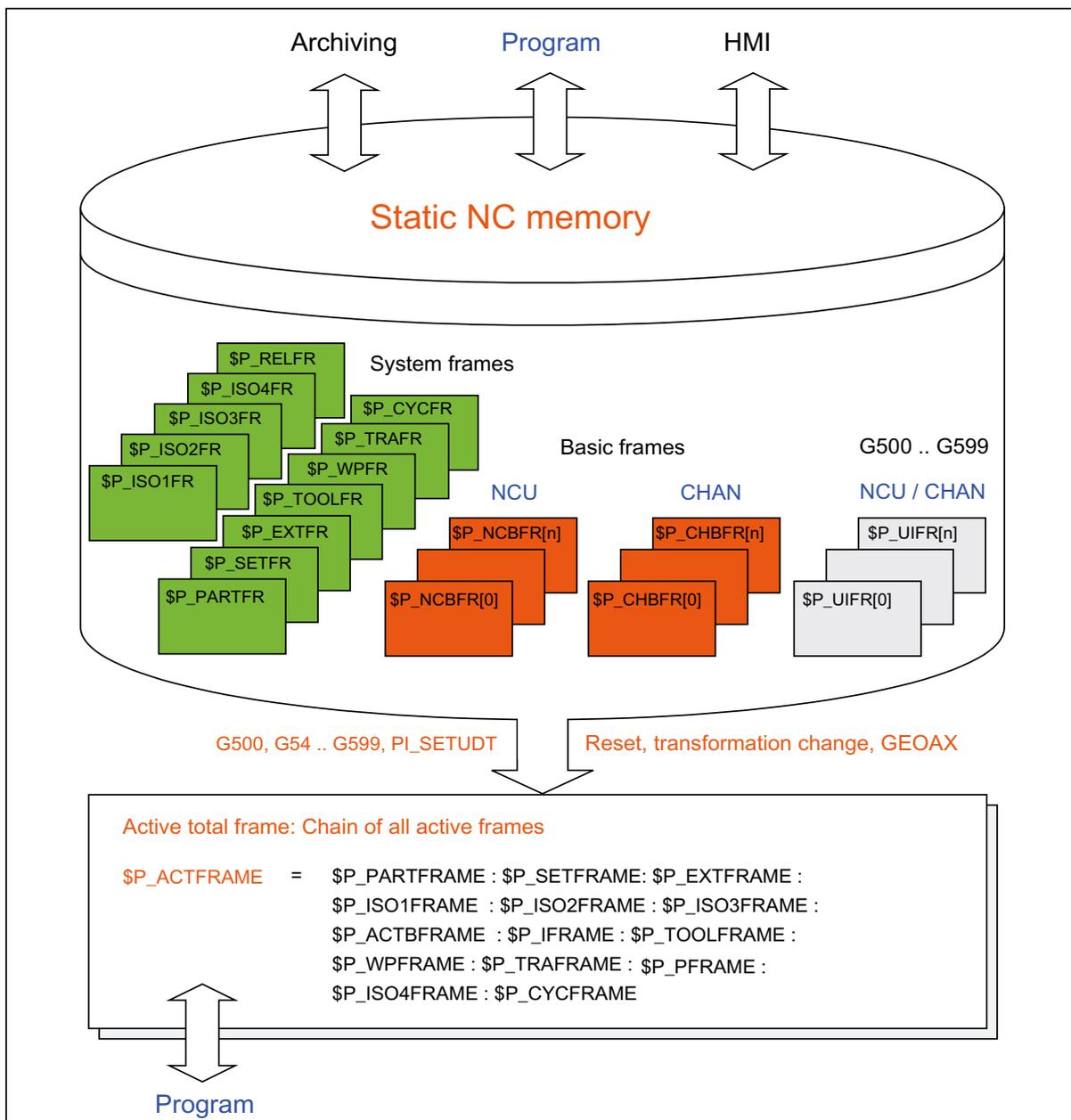
WKS → BKS	$\vec{v} = R * \underline{S} * \underline{M} * \vec{v}' + t$
BKS → WKS	$\vec{v}' = \text{inv}(\underline{M}) * \text{inv}(\underline{S}) * \text{inv}(\underline{R}) + (\vec{v} - t)$

- V: Position vector in BCS
- V': Position vector in WCS

### 10.5.3 Frames in data management and active frames

#### 10.5.3.1 Overview

There are various types of frame: system frames, basic frames, settable frames and the programmable frame. Apart from the programmable frame, all types have a frame in the data management and an active frame. The programmable frame is only active. Frames in the data management are stored in the static NC memory and can be archived. The program can describe both data management frames and active frames. HMI can only describe data management frames.



### 10.5.3.2 Activating data management frames

Data management frames become active frames on executing G500, G54...G599, or on resetting with the appropriate machine data setting, transformation change, GEOAX. HMI writes to the data management frame and activates the frames through a PI service during RESET.

Changing a frame via HMI with the aid of the \_N\_SETUDT PIs is effective only after a restart of the program or in the reset state, provided the following HMI machine data is set:

MD9440 ACTIVATE\_SEL\_USER\_DATA (Set active offset effective immediately)

WCS position specifications do not change immediately when a change is made to a frame via HMI, but after restart.

System frames are activated during the preprocessing stage by executing the appropriate system functions, either from the part program or using the HMI.

System frames, which are saved in the data management, are also activated by means of a G500, G54 to G599 instruction. The cycle programmer has the option to modify the system frames and activate them by means of a G500, G54 to G599 instruction. However, this option should only be used with reservation.

The activation of all data management frames can be changed through the following machine data:

MD24050 \$MC\_FRAME\_SAA\_MODE (save and activate data management frames)

Bit	Significance
0	Data management frames are activated only by programming the \$P_CHBFRMASK, \$P_NCBFRMASK and \$P_CHSFRMASK bitmasks. G500...G599 activate only the corresponding settable frame. The reset response is independent of this.
1	Data management frames are not implicitly described by system functions, such as TOROT, PAROT, zero offset external and transformations.

The \$P\_CHSFRMASK variable is used to activate system frames from the data management.

The value of the variables is specified as bitcoded according to the machine data:  
MD28082 \$MC\_MM\_SYSTEM\_FRAME\_MASK (SRAM system frames)

If the corresponding bit is set to one, the data management frame is activated. If the bit is equal to zero, the data management frame is not active and the currently active system frame remains active.

All the system frames whose bits are set in the following machine data are activated for actual value setting and external zero offset after the RESET:

MD24006 \$MC\_CHSFRAME\_RESET\_MASK (active system frames after Reset)

The system frames for TCARR, PAROT and TOROT, TOFRAME are activated according to the setting in the following machine data:

MD20150 \$MC\_GCODE\_RESET\_VALUES (RESET position of G groups)

As when selecting and deselecting transformations and GEOAX ( ), when switching geometry axes the current complete frame is either deleted or recalculated on the basis of the new geometry axis configuration, and activated. The system frames and all other frames are conditioned again in relation to the geometry axes.

### 10.5.3.3 NCU global frames

All settable frames G54 to G599 and all basic frames can be configured NCU globally or channel-specifically. A combination of these is also possible with basic frames. Global frames affect all channels on an NCU. All channels have read and write access to the NCU. Global frames only have axial frame components, such as translations, scales and mirrors of individual axes. Each channel can read or modify global frames for any machine axis.

A characteristic of global frames is that they are calculated in all channels of an NCU. As the assignment of machine axes to channel axes and, in particular, to geometry axes, can be different in all channels, there is no geometric relationship. Global frames describe offsets, scales and mirrors of machine axes. Rotations cannot be used on global frames.

All settable frames can be reconfigured to global frames with the following machine data:

MD18601 \$MN\_MM\_NUM\_GLOBAL\_USER\_FRAMES (number of global, pre-defined user frames (SRAM))

If the value of this machine data is greater than zero, there are no channel-specific settable frames.

The following machine data becomes irrelevant then, and is not evaluated:

MD28080 \$MC\_MM\_NUM\_USER\_FRAMES (number of settable frames (SRAM))

The number of global basic frames is parameterized through the following machine data:

MD18602 \$MN\_MM\_NUM\_GLOBAL\_BASE\_FRAMES (number of global, basic frames (SRAM))

Channel-specific basic frames can also exist simultaneously through the following machine data:

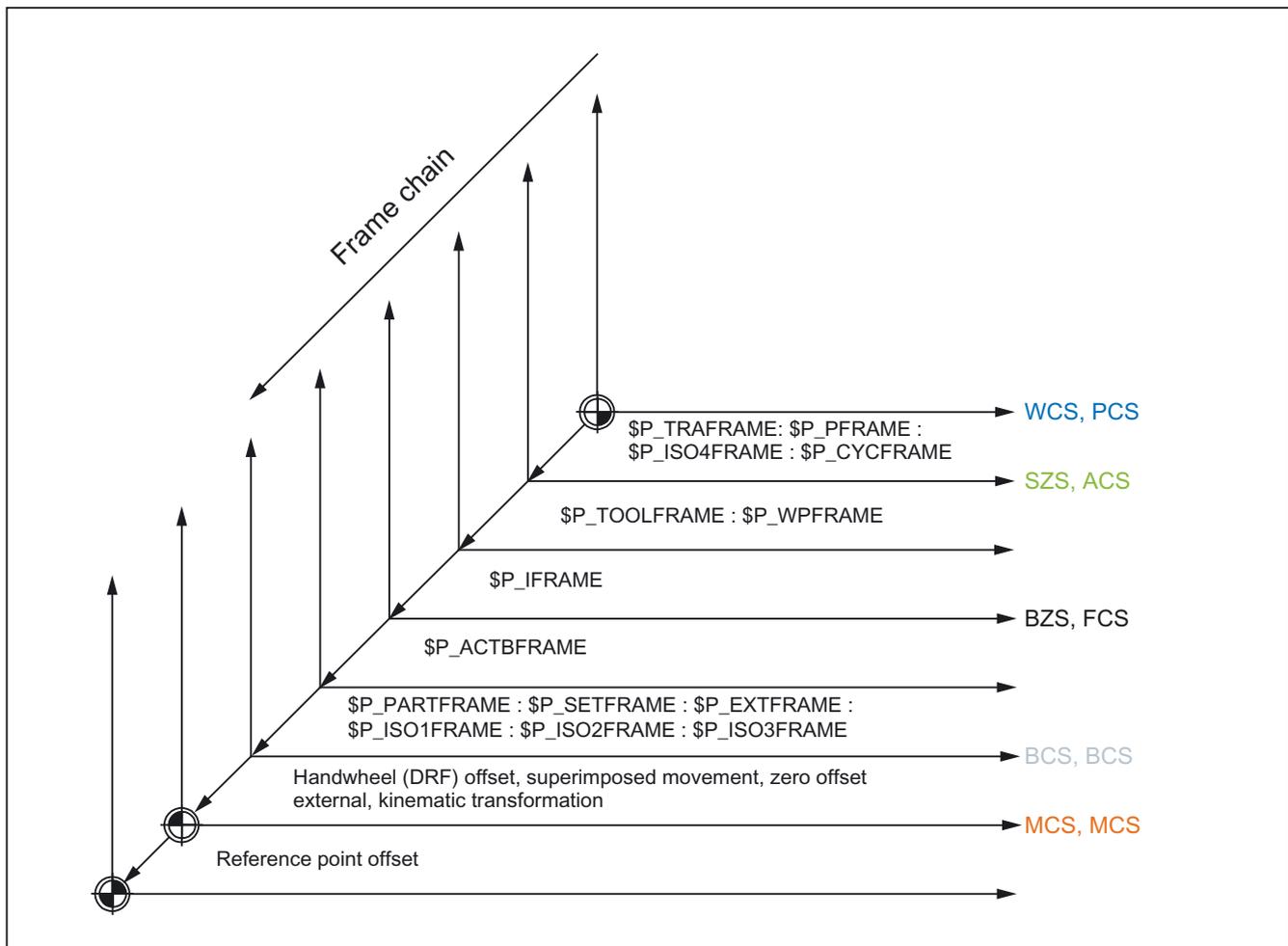
MD28081 \$MC\_MM\_NUM\_BASE\_FRAMES (number of basic frames (SRAM))

Global frames can be read and written from all channels of an NCU. When writing global frames, the user must ensure channel coordination. This can be achieved through e.g. wait markers.

### 10.5.4 Frame chain and coordinate systems

#### 10.5.4.1 Overview

The figure below shows the frame chain for the current complete frame. The frame chain is stored between the BCS and WCS. The SZS (**S**ettable **Z**ero **S**ystem) corresponds to the WCS, transformed by the programmable frame. The BZS (**B**asic **Z**ero **S**ystem) still includes the current settable frame. The system frame for the zero offset external is only available if it has been configured, otherwise the zero offset external is interpolated as a superimposed motion of the axis, as it has been up to this point.



- WCS: **W**orkpiece **C**oordinate **S**ystem
- SZS: **S**ettable **Z**ero **S**ystem
- BZS: **B**asic **Z**ero **S**ystem
- BCS: **B**asic **C**oordinate **S**ystem
- MCS: **M**achine **C**oordinate **S**ystem
- PCS: **P**art **C**oordinate **S**ystem

- ACS: Adjustable Coordinate System
- FCS: Foot Coordinate System
- BCS: Basic Coordinate System
- MCS: Machine Coordinate System

The current complete frame is calculated according to the formula below:

$$\begin{aligned}
 \$P\_ACTFRAME = & \quad \$P\_PARTFRAME : \$P\_SETFRAME : \$P\_EXTFRAME : \\
 & \quad \$P\_ISO1FRAME : \$P\_ISO2FRAME : \$P\_ISO3FRAME : \\
 & \quad \$P\_ACTBFRAME : \$P\_IFRAME : \\
 & \quad \$P\_TOOLFRAME : \$P\_WPFRAME : \$P\_TRAFRAME : \\
 & \quad \$P\_PFRAME : \$P\_ISO4FRAME : \$P\_CYCFRAME
 \end{aligned}$$

### 10.5.4.2 Relative coordinate systems

Relative coordinate systems display the current setpoint positions of the axes, which lie relative to a specified reference point in the active displayed coordinate system. No programming can be done regarding the relative coordinate systems. Only the axis positions in these systems can be read via the system variables.

The new display coordinate systems lie relative to WCS and ENS coordinate system and result through transformation of the WCS or ENS axis positions with the active system frame  $\$P\_RELF$ FRAME. The relative coordinate systems can not only be displaced linearly, but also rotated, mirrored, compressed or expanded.

The position indicator for axis setpoints is done in WCS or in ENS. The configuring is done via HMI machine data. Always only one display-coordinate system is active in the channel. For this reason only one relative frame is provided, which generates both the relative coordinate systems in the same ratio. The HMI displays the relative coordinates according to the configuring.

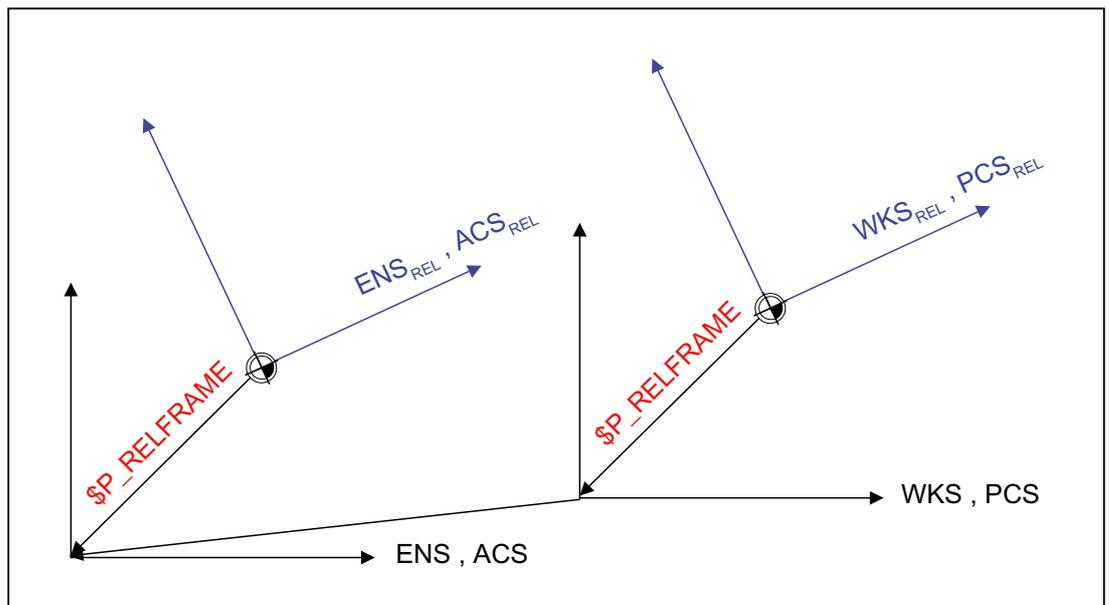


Figure 10-23 Relative coordinate systems

The data maintenance frame \$P\_RELFR can be written in the part program and via BTSS. All the frame components can be modified.

The active system frame \$P\_RELFRAME can be written in the part program and via BTSS.

The configuring of the system frame \$P\_RELFR is done via the following machine data:

Machine data	Bit	Description
MD28082 \$MC_MM_SYSTEM_FRAME_MASK	11	Creation of \$P_RELFR; with this, relative coordinate systems become existent.
MD28083 \$MC_MM_SYSTEM_DATAFRAME_MASK	11	Data maintenance frame \$P_RELFR
MD24006 \$MC_CHSFRAME_RESET_MASK.	11	\$P_RELFR becomes active at Reset
MD24007 \$MC_CHSFRAME_RESET_CLEAR_MASK	11	\$P_RELFR is deleted at Reset
MD24008 \$MC_CHSFRAME_POWERON_MASK	11	\$P_RELFR is deleted at PowerOn

The axis position in the relative coordinate system  $WCS_{Rel}$  can be read via the variable \$AA\_PCS\_REL[ax]. The variable can be read in part program, BTSS and via synchronous actions.

The axis position in the relative coordinate system  $ENS_{Rel}$  can be read via the variable \$AA\_ACS\_REL[ax]. The variable can be read in part program, BTSS and via synchronous actions.

The setting of a relative reference point via the operator panel is done via the general command interface for the workpiece and tool measuring. The system frame \$P\_RELFR for relative coordinate systems is calculated and activated as follows:

- \$AC\_MEAS\_TYPE = 14
- PI services \_N\_SETUDT(6, 7)

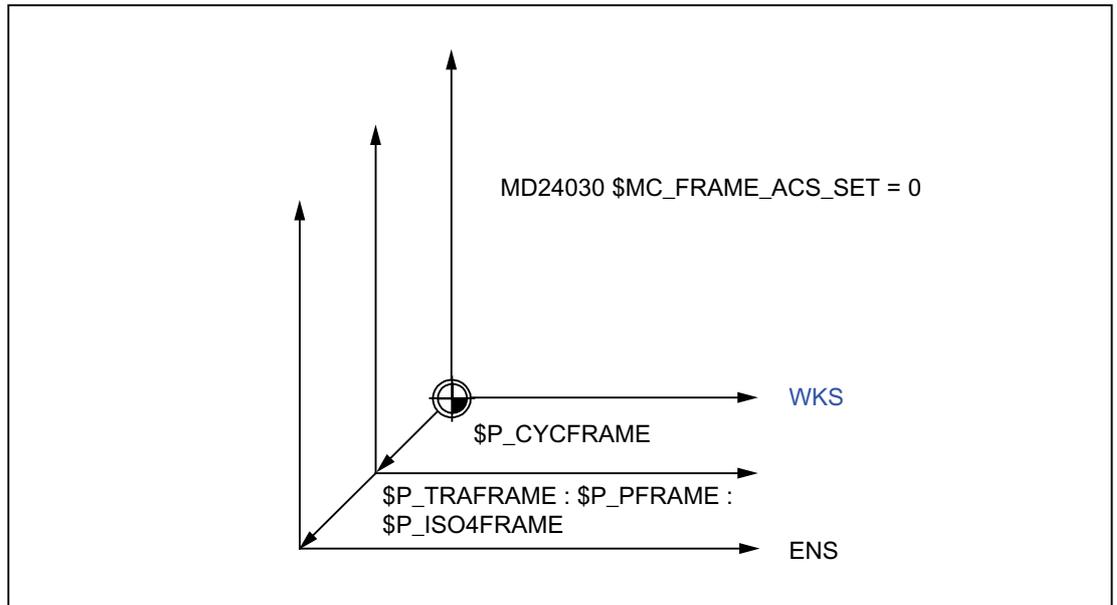
An example for setting the relative axis positions is given in:

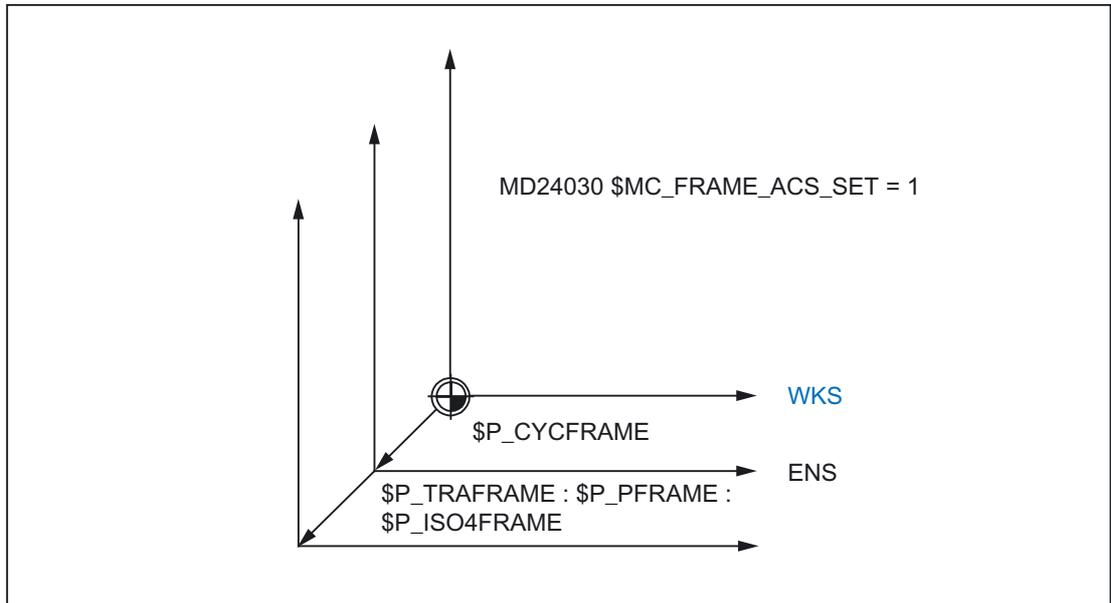
**References:**

/FB2/ Function Manual, Extended Functions; Measurement (M5), Chapter "Measurement of Geo- and special axes (Meas Type 14, 15)"

### 10.5.4.3 Configurable SZS

The function of the SZS coordinate system is to display actual values and move the axes during a cycle interruption. Cycles utilize frames in the frame chain to perform their functions. They input translations or rotations into either the programmable frame or the cycle system frame. The WCS is, therefore, modified by cycles. A user who uses Stop to interrupt a cycle, however, does not wish to traverse in the "cycle coordinate system", but in the programmed WCS. This is why the SZS is used for the display. For reasons of compatibility, the SZS is made configurable.





The following machine data can be used to set whether the ENS is with or without the programmable frame, the transformation frame and \$P\_ISO4FRAME:

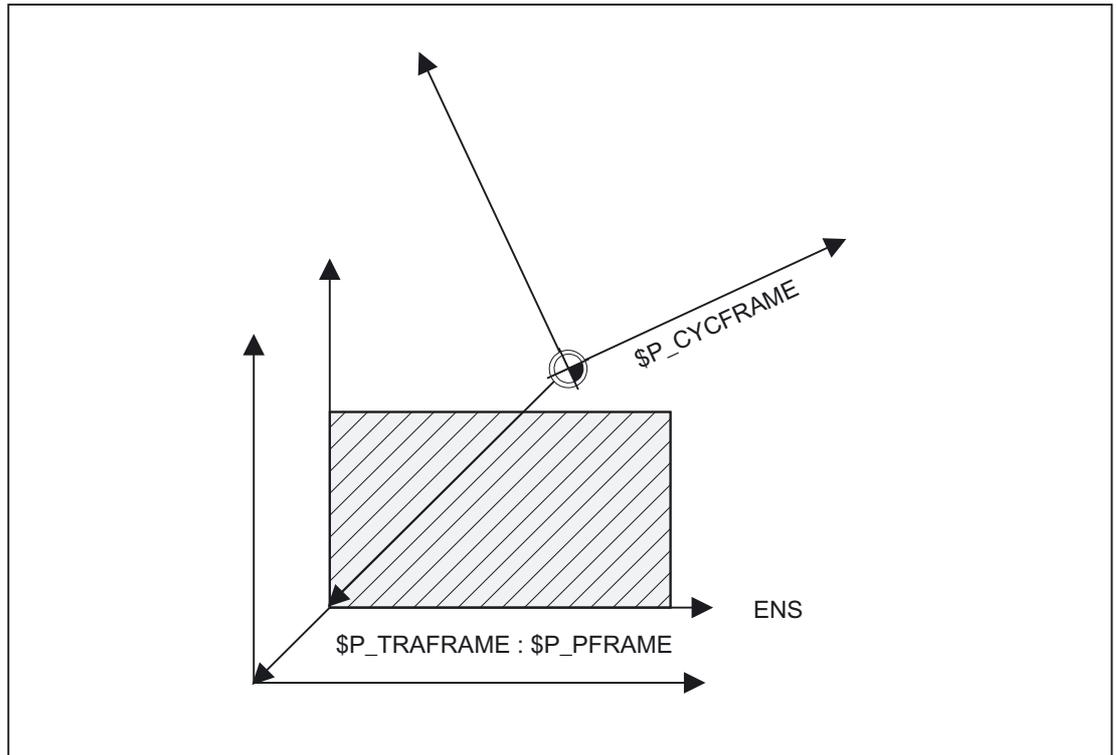
MD24030 \$MC\_FRAME\_ACS\_SET (setting of the ENS coordinate system)

As default, the value 1 is set.

Reconfiguring the SZS affects all SZS actual-value displays and the \$AA\_IEN[axis] system variables. Traversing geometry axes in JOG mode in the SZS also depends on the configuration.

#### 10.5.4.4 Manual traverse in the SZS coordinate system

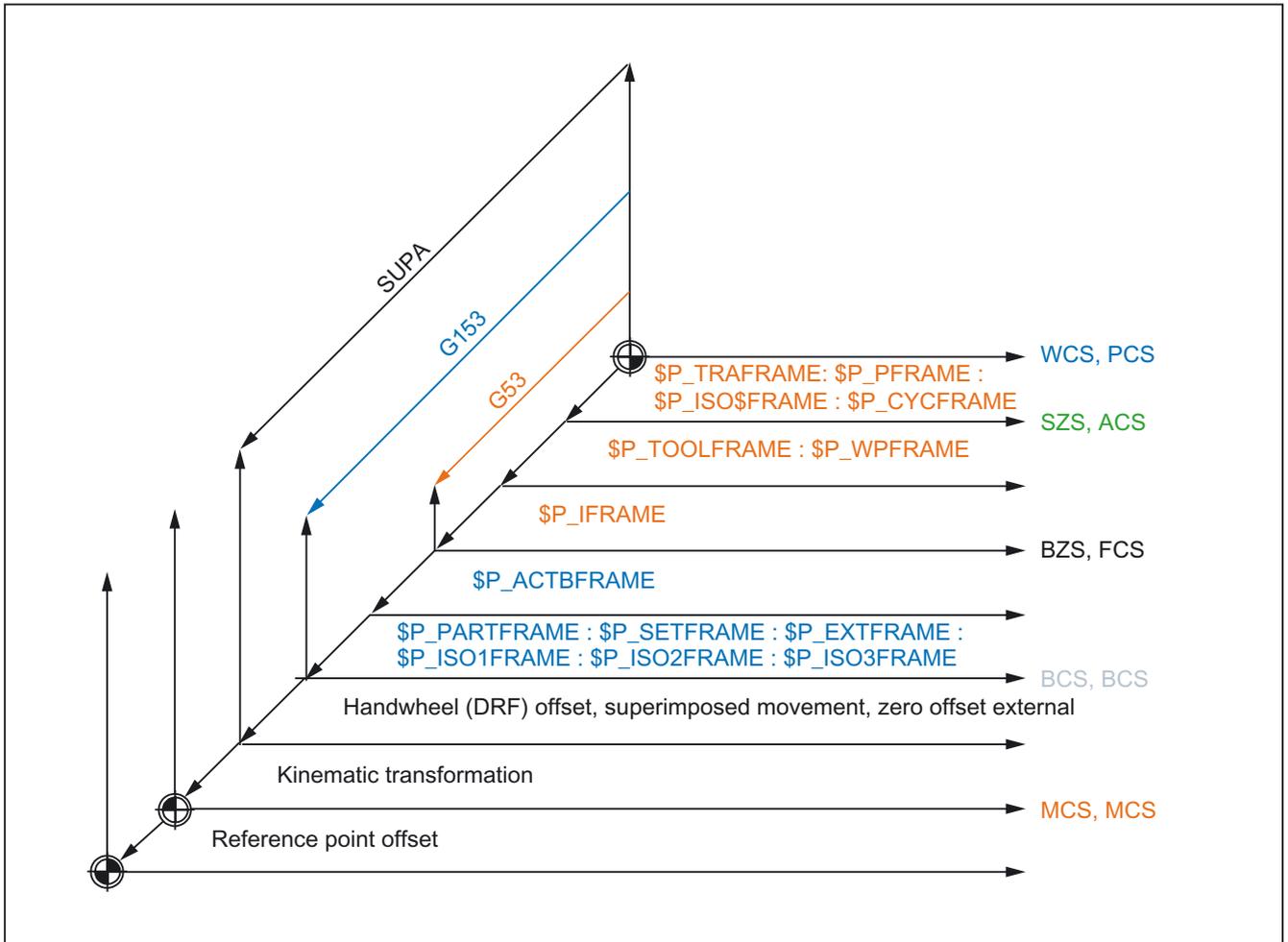
Previously, geometry axes have been traversed manually in JOG mode in the WCS. In addition, there is also the option to carry out this manual operation in the SZS coordinate system. The `$AC_JOG_COORD` variable enables the user to switch between manual traversing in the WCS and SZS. The user can now select if he wants to traverse in the SZS or the WCS.



### 10.5.4.5 Suppression of frames

#### Programming

Command	Significance
G53	Non-modal suppression of the following frames: <ul style="list-style-type: none"> <li>• System frame for cycles</li> <li>• Programmable frame</li> <li>• System frame for transformations, workpieces, TOROT and TOFRAME</li> <li>• Active settable frame</li> </ul>
G153	Non-modal suppression of the following frames: <ul style="list-style-type: none"> <li>• System frame for cycles</li> <li>• Programmable frame</li> <li>• System frame for TOROT and TOFRAME, workpieces</li> <li>• Active settable frame</li> <li>• All channel-specific and NCU global basic frames</li> <li>• System frames for PAROT, PRESET, scratching, ext. ZO</li> </ul>
SUPA	Implicit preprocessing stop and non-modal suppression of frames analog G153 and additional <ul style="list-style-type: none"> <li>• Handwheel offsets (DRF)</li> <li>• [Ext. zero offset]</li> <li>• Overlaid motion</li> </ul>
G500	Modal activation of the G500 frame. The G500 frame should be a zero frame.
DRFOF	Deactivate (clear) the handwheel offsets (DRF)



### Parameterization

Frame suppressions `SUPA`, `G153` and `G53` lead to the `WCS`, `SZS` and possibly the `BZS` jumping when frame suppression is active. This characteristic for position display and pre-defined position variables can be changed through the following machine data:

MD24020 `$MC_FRAME_SUPPRESS_MODE` (Positions during frame suppression)

Bit	Significance
0	Positions for display (BTSS) are without frame suppression.
1	Position variables are without frame suppression.

When the bit is set, the position for the display or the variables is calculated without frame suppression so that no further jumps in the position occur.

## 10.5.5 Frame chain frames

### 10.5.5.1 Overview

There are up to four frame variants:

- Settable frames (G500, G54 to G599)
- Basic frames
- Programmable frame
- System frames

### 10.5.5.2 Settable frames \$P\_UIFR[n]

The number of NCU global settable frames is set through the following machine data:

MD18601 \$MN\_MM\_NUM\_GLOBAL\_USER\_FRAMES (number of global, pre-defined user frames (SRAM))

The number can be between 0 and 100. If the MD has a value greater than zero, there are only NCU global settable frames, otherwise the following machine data specifies the number of channel-specific settable frames:

MD28080 \$MC\_MM\_NUM\_USER\_FRAMES (number of settable frames (SRAM))

System variable \$P\_UIFR[n] can be used to read and write the frame field elements. The frame is not activated simultaneously when writing a field element, but rather activation only takes place on execution of a G500, G54, to G599 instruction. For NCU global frames, the changed frame only becomes active in those channels of the NCU, which execute a G500, G54 to G599 instruction. The variable is used primarily for storing write operations from HMI or PLC. These frame variables are saved by the data backup.

### Current settable frame \$P\_IFRAME

The predefined frame variable \$P\_IFRAME can be used to read and write the current settable frame, which is valid in the channel, in the part program. The written settable frame is immediately included in the calculation. In the case of NCU global settable frames, the modified frame acts only in the channel in which the frame was programmed. If the frame is to be modified for all channels of an NCU, \$P\_UIFR[n] and \$P\_IFRAME must be written simultaneously. The other channels must then activate the corresponding frame, e.g. with G54.

### Programming of settable frames

Settable frames can be read and written via the part program and via the OPI by operator actions and by the PLC. However, only data management frames can be written by the OPI. The index of the active settable frame can be ascertained via the \$P\_UIFRNUM system variable.

### 10.5.5.3 Channel basic frames \$P\_CHBFR[n]

The number of basic frames in the channel can be configured via the machine data:

MD28081 \$MC\_MM\_NUM\_BASE\_FRAMES (number of basic frames (SRAM))

The minimum configuration is designed for at least one basic frame per channel. A maximum of 16 basic frames per channel is possible. In addition to the 16 basic frames, there can also be 16 NCU-global basic frames in the channel.

System variable \$P\_CHBFR[n] can be used to read and write the basic frame field elements. While writing a basic frame field element, the chained total frame is not activated. Instead, the activation takes place only after a G500, G54..G599 instruction is executed. The variable is used primarily for storing write operations to the basic frame on HMI or PLC. These frame variables are saved by the data backup.

### Current channel basic frames \$P\_CHBFRAME[n]

System variable \$P\_CHBFRAME[n] can be used to read and write the current channel basic frame field elements. The resulting total basic frame is calculated by means of the write process in the channel. Whenever a basic frame is written, the complete basic frame is calculated again.

### Basic frame in channel \$P\_UBFR

The system variable is retained for reasons of compatibility, although it is redundant for the \$P\_CHBFR[0] variables.

The basic frame with field device 0 is not activated simultaneously when writing to the predefined \$P\_UBFR variable, but rather activation only takes place on execution of a G500, G54, .G599 instruction. For NCU global frames, the changed frame only becomes active in those channels of the NCU, which execute a G500, G54..G599 instruction. The variable is used primarily for storing write operations to the basic frame on HMI or PLC. The variable can also be read and written in the program.

\$P\_UBFR is identical to \$P\_CHBFR[0]. One basic frame always exists in the channel by default, so that the system variable is compatible with older versions. If there is no channel-specific basic frame, an alarm is issued at read/write: "Frame: Instruction not allowed" is output on a read or write access.

### Current first basic frame in the channel \$P\_BFRAME

The system variable is retained for reasons of compatibility, although it is redundant for the \$P\_CHBFRAME[0] variables.

The predefined frame variable \$P\_BFRAME can be used to read and write the current basic frame with the field device of 0, which is valid in the channel, in the part program. The written basic frame is immediately included in the calculation. In the case of NCU global settable frames, the modified frame acts only in the channel in which the frame was programmed. If the frame is to be modified for all channels of an NCU, \$P\_UBFR and \$P\_BFRAME must be written simultaneously. The other channels must then activate the corresponding frame, e.g. with G54.

\$P\_BFRAME is identical to \$P\_CHBFRAME[0]. The system variable always has a valid default value. If there is no channel-specific basic frame, an alarm is issued at read/write: "Frame: Instruction not allowed" is output on a read or write access.

### Programming basic frames

Basic frames can be read and written via the part program and via the OPI by operator actions and by the PLC. However, only data management frames can be written by the OPI.

#### 10.5.5.4 NCU global basic frames \$P\_NCBFR[n]

The number of global basic frames can be configured via the machine data:

MD18602 \$MN\_MM\_NUM\_GLOBAL\_BASE\_FRAMES (number of global, basic frames (SRAM))

There are a maximum of 16 global basic frames. All basic frames are stored as fields.

System variable \$P\_NCBFR[n] can be used to read and write the basic frame field elements. While writing a basic frame field element, the chained total frame is not activated. Instead, the activation takes place only after a G500, G54..G599 instruction is executed. If the modified frame is to be active in every channel of the NCU, every channel must execute a G500, G54..G599 instruction. The variable is used primarily for storing write operations to the basic frame on HMI or PLC. These frame variables are saved by the data backup.

### Current NCU global basic frames \$P\_NCBFRAME[n]

System variable \$P\_NCBFRAME[n] can be used to read and write the current global basic frame field elements. The resulting total basic frame is calculated by means of the write process in the channel. The modified frame is activated only in the channel in which the frame was programmed. If the frame is to be modified for all channels of an NCU, \$P\_NCBFR[n] and \$P\_NCBFRAME[n] must be written simultaneously. The other channels must then activate the frame, e.g. with G54. Whenever a basic frame is written, the complete basic frame is calculated again.

## Programming global frames

Global frames are programmed analogously, as are channel-specific frames, i.e. global basic frames are programmed with `$P_NCBFR[n]` and global settable frames with `$P_UIFR[n]`.

Geometry axis, channel axis and machine axis identifiers can be used as axis identifiers for frame program commands. If there is no machine axis for the channel axis on the NCU, programming with channel axis identifiers is rejected with the alarm 18314 "Frame: Type conflict". Channel-specific frames can be programmed with geometry axis, channel axis and machine axis identifiers. If there is no corresponding channel axis for the machine axis on the NCU, programming with machine axis identifiers is rejected with the alarm 18314 "Frame: Type conflict". If frame components are applied to a machine axis or a channel axis, which is also a geometry axis, the corresponding geometry axis components will also be simultaneously modified.

Example:

```
$P_NCBFR[0] = CTRANS( ax1, 10 )
$P_NCBFR[0] = CTRANS(x, 10)
$P_NCBFR[0, ax1, FI ] = 0.1
$P_NCBFR[0, x, FI] = 0.1
```

Rotations cannot be used on global frames. The programming of a rotation is denied with alarm: "18310 Channel %1 Block %2 Frame: rotation not allowed" is displayed.

It is not possible to program chaining of global frames and channel-specific frames, and any attempt at this is rejected with the alarm 18314 "Frame: Type conflict". All global frames and channel-specific frames are internally chained to the complete frame. This takes place in the channel and only with all channel axes known in the channel. The assignment of a frame with rotation components to a global frame is denied with alarm "Frame: Rotation not allowed".

Example:

```
$P_NCBFR[0] = CTRANS( x, 10 ):CROT( y, 45 ) ; Faulty assignment on the global basic
frame
```

The following frames are channel-specific:

`$P_UBFR`, `$P_BFRAME`, `$P_CHBFR[n]`,

`$P_CHBFRAME[n]`, `$P_NCBFRAME[n]`,

`$P_ACTBFRAME` and `$P_ACTFRAME`

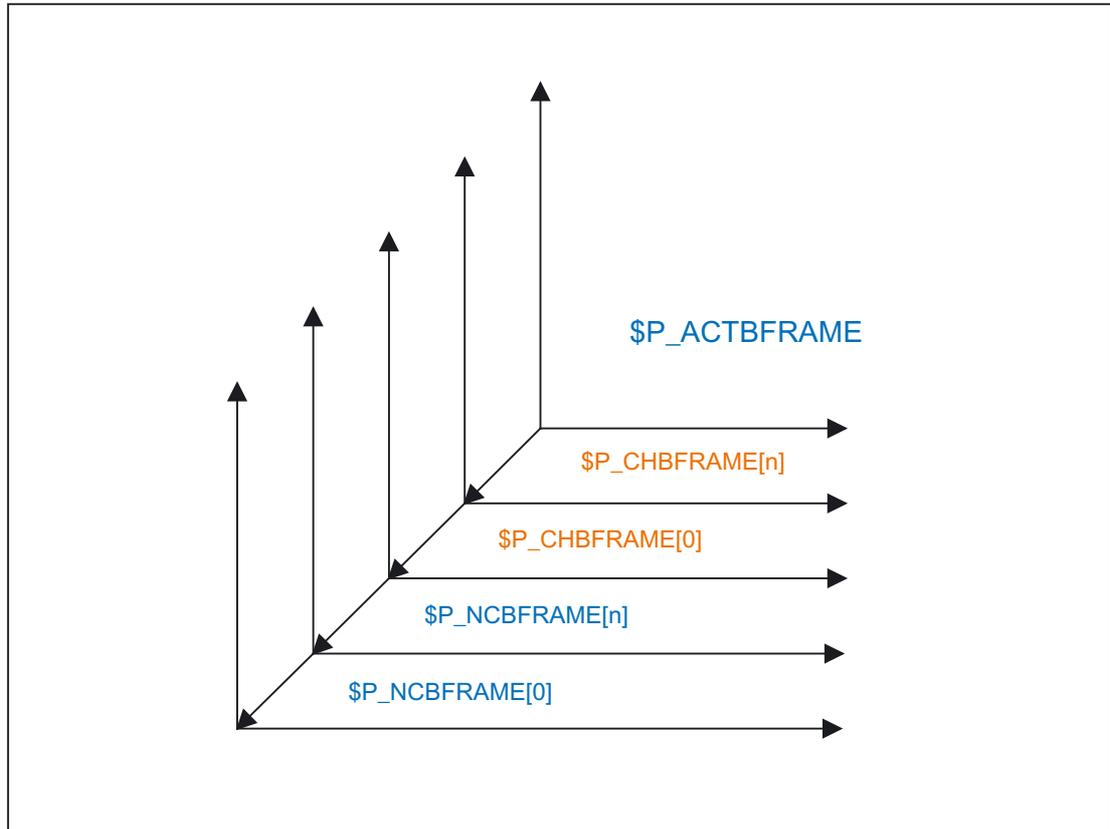
These frames can contain rotation components.

These frames only affect the channel that has been set.

With SW 5.1, attempts to program a channel axis, which is also a link axis, is rejected with alarm "14092 Channel %1 block %2 axis %3 is wrong axis type". An axis can be programmed only if it physically exists on the NCU.

### 10.5.5.5 Complete basic frame \$P\_ACTBFRAME

The chained complete basic frame is determined by the variable. The variable is read-only.



\$P\_ACTBFRAME  
corresponds to  
\$P\_NCBFRAME[0] : ... : \$P\_NCBFRAME[n] : \$P\_CHBFRAME[0] : ... : \$P\_CHBFRAME[n].

### Programmability of the complete basic frame

System variables \$P\_CHBFRMASK and \$P\_NCBFRMASK can be used to select, which basic frames to include in the calculation of the "complete" basic frame. The variables can only be programmed in the program and read via the operator panel interface. The value of the variables is interpreted as a bit mask and specifies, which basic frame array element of \$P\_ACTBFRAME is included in the calculation. \$P\_CHBFRMASK can be used to define, which channel-specific basic frames are included, and \$P\_NCBFRMASK can be used to define, which NCU global basic frames are included in the calculation. When the variables are programmed, the complete basic frame and the complete frame are calculated again. After RESET and in the default setting, the value of \$P\_CHBFRMASK equals \$MC\_CHBFRAME\_RESET\_MASK and the value of \$P\_NCBFRMASK equals \$MN\_NCBFRAME\_RESET\_MASK.

\$P\_NCBFRMASK = 'H81' ; \$P\_NCBFRAME[0] : \$P\_NCBFRAME[7]  
\$P\_CHBFRMASK = 'H11' ; \$P\_CHBFRAME[0] : \$P\_CHBFRAME[4]

### 10.5.5.6 Programmable frame \$P\_PFRAME

Programmable frames are available only as active frames.  
This frame is reserved for the programmer.

The programmable frame can be maintained with the machine data:  
MD24010 \$MC\_PFRAME\_RESET\_MODE = 1 ("Reset mode for programmable frame")  
during RESET.

This functionality is important, most of all if after a RESET one still wants to retract out of an oblique hole.

## MIRROR

Mirrorings of a geometry axis were thus far (up to SW-P4) related to a defined reference axis only using the machine data:

MD10610 \$MN\_MIRROR\_REF\_AX ("reference axis for the mirroring")

From the user's point of view, this definition is hard to follow. When mirroring the z axis, the display showed that the x axis was mirrored and the y axis had been rotated about 180 degrees. When mirroring two axes this became even more complex and it was no longer easy to understand, which axes had been mirrored and, which had not.

With SW P5 and higher, there is the option to clearly display the mirroring of an axis. A mirroring is then not mapped to the mirroring of a reference axis and rotation of other axes. This setting can be configured through the machine data setting:

MD10610 \$MN\_MIRROR\_REF\_AX = 0.

MIRROR and AMIRROR are used to expand the programming of the programmable frame. Previously, the specified value of the coordinate axis, e.g. the value 0 for MIRROR X0, is not evaluated, but the AMIRROR has a toggle function, i.e. MIRROR X0 activates the mirror and a further AMIRROR X0 deactivates it. MIRROR always has an absolute effect and AMIRROR an additive effect.

The

MD10612 \$MN\_MIRROR\_TOGGLE = 0 ("Mirror Toggle")

machine data setting can be used to define that the programmed values are evaluated.

A value of 0, as in AMIRROR X0, deactivates the mirroring of the axis, and values not equal to 0 cause the axis to be mirrored if it is not already mirrored.

It is possible to read or write mirrors component by component independent of machine data MD10612 \$MN\_MIRROR\_TOGGLE.

A value = 0 means that the axis is not mirrored and a value = 1 means that the axis will always be mirrored, irrespective of whether it has already been mirrored or not.

\$P_NCBFR[0,x,mi] = 1	; x axis is always mirrored.
\$P_NCBFR[0,x,mi] = 0	; x axis mirror is OFF.

### Axial replacement G58, G59

The translation component of the programmable frame is split into an absolute component and a component for the total of all additively programmed translations. The absolute component can be changed using TRANS, CTRANS or by writing the translation components, in which the additive component is set to zero. G58 changes only the absolute translation component for the specified axis; the total of additively programmed translations is retained.

G58 X... Y... Z... A... ..

G59 is used for axial overwriting of the additively programmed translations for the specified axes, which were programmed with ATRANS.

G59 X... Y... Z... A... ..

Example:

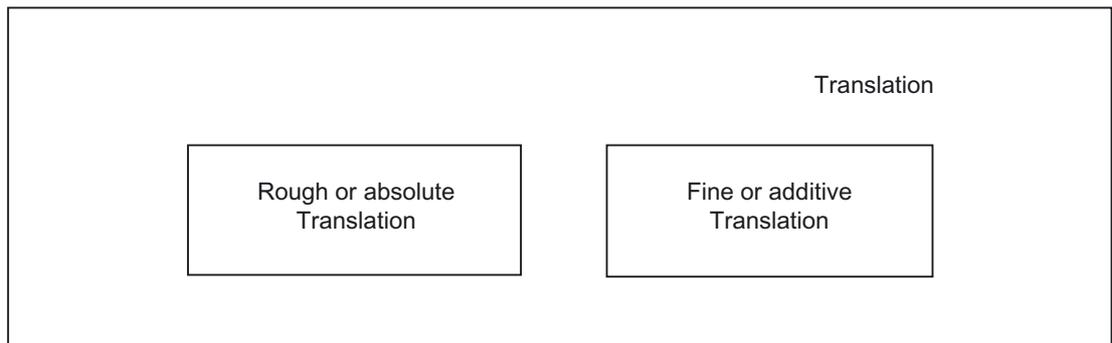
```

TRANS X10 Y10 Z10
ATrans X5 Y5 ; Total translations X15 Y15 Z10
G58 X20 ; Total translations X25 Y15 Z10
G59 X10 Y10 ; Total translations X30 Y20 Z10
    
```

G58 and G59 can be used only if machine data: MD24000 \$MC\_FRAME\_ADD\_COMPONENTS ("Frame components for G58/G59") is TRUE, otherwise Alarm "18311 Channel %1 Block %2 Frame: instruction not permissible" is output.

The function can also only be used in conjunction with a configured fine offset for the programmable frame. If G58 or G59 is used without a configured fine offset, alarm "18312 channel %1 block %2 frame: Fine offset not configured" is output.

The absolute component of the translation is stored in the rough offset component and the additive translation component is stored in the fine offset component. To this end, the programmable frame or the fine offset is expanded.



The fine component is transferred on saving the programmable frame in a local frame variable (LUD or GUD) and on rewriting.

The table below shows the effect of various program commands on the absolute and additive translation.

	Coarse or absolute translation	Fine or additive translation
TRANS X10	10	0
ATRANS X10	Unchanged	alt_fine + 10
CTRANS (X, 10)	10	0
CTRANS ()	0	0
CFINE (X, 10)	0	10
\$P_PFRAME [X, TR] = 10	10	Unchanged
\$P_PFRAME [X, FI] = 10	Unchanged	10
G58 X10	10	Unchanged
G59 X10	Unchanged	10

### 10.5.5.7 Channel-specific system frames

#### Channel-specific system frames

System frames are only described by system functions, such as PRESET, scratching, zero offset external and oblique processing. There are up to seven system frames per channel.

The valid system frames in the channel can be defined via machine data:

MD28082 \$MC\_MM\_SYSTEM\_FRAME\_MASK (System frames SRAM)

Only system frames required for system functions should be configured, in the interests of memory space. Per channel, each system frame occupies approx. 1 KB SRAM und approx. 6 KB DRAM. The system frame for PRESET and scratching and the system frame for cycles are the default. Channel-specific system frames are configured as bit codes, in accordance with the table below:

Bit	Default	System frame
0	1	PRESET and scratching
1	0	Zero offset external via system frames
2	0	TCARR and PAROT with an orientational toolholder
3	0	TOROT and TOFRAME
4	0	Frame for workpiece reference points
5	1	Frame for cycles
6	0	Frame for selection and deselection of transformations
7	0	\$P_ISO1FRAME : Frame for G51.1 mirroring (ISO)
8	0	\$P_ISO2FRAME : Frame for G68 2DROT (ISO)
9	0	\$P_ISO3FRAME : Frame for G68 3DROT (ISO)
10	0	\$P_ISO4FRAME: Frame for G51 scale (ISO)
11	0	\$P_RELFR: Frame for relative coordinate systems

Example:

\$MC\_MM\_SYSTEM\_FRAME\_MASK = 'B001101' means that there are three system frames; one for PRESET, one for PAROT and one for TOROT and TOFRAME.

The system frame mask is used to define if the corresponding function has a system frame. With non-configured frames, in certain circumstances the function will be rejected with an alarm.

### System frames in data management

The system frames are stored in the static NC memory and can, therefore, be archived and reloaded. System frames in data management can be read and written in the program using the following variables:

System variables	Significance
\$P_SETFR	System frame for PRESET and scratching ( <b>SetFrame</b> )
\$P_EXTFR	System frame for zero offset external ( <b>ExtFrame</b> )
\$P_PARTFR	System frame for TCARR and PAROT ( <b>PartFrame</b> )
\$P_TOOLFR	System frame for TOROT and TOFRAME ( <b>ToolFrame</b> )
\$P_WPFR	System frame for workpiece reference points ( <b>Work-Piece-Frame</b> )
\$P_CYCFR	System frame for cycles ( <b>Cycle-Frame</b> )
\$P_TRAFRAME	System frame for transformations ( <b>Transformation Frame</b> )
\$P_ISO1FR	Frame for G51 .1 mirroring (ISO)
\$P_ISO2FR	Frame for G68 2DROT (ISO)
\$P_ISO3FR	Frame for G68 3DROT (ISO)
\$P_ISO4FR	System frame for G51 scale (ISO)
\$P_RELFR	System frame for relative coordinate systems

All write operations to these frames must be executed using system functions. For cycle programmers, it has been made possible to write the frames using the above variables. Attempts to write to a non-configured system frame are rejected with the alarm "Channel %1 block %2 name %3 not defined or option not available".

System frames in the data management are either activated directly with the system function (TOROT, PAROT, etc.), or with a G500, G54 to G599 instruction.

## Active system frames

The active system frames are the frames, which are active in the main run. An appropriate current system frame exists for each current system frame in the data management. Only with the activation of the data management frame are the values taken into account with regard to the preprocessing.

The following current system frames exist:

- **\$P\_SETFRAME**

In the part program, the variable `$P_SETFRAME` can be used to read and write the current system frame for PRESET and scratching. The variable returns a zero frame if the system frame is not configured through MD28082.

- **\$P\_EXTFRAME**

In the part program, the variable `$P_EXTFRAME` can be used to read and write the current system frame for the zero offset external. The variable returns a zero frame if the system frame is not configured through MD28082.

- **\$P\_PARTFRAME**

In the part program, the variable `$P_PARTFRAME` can be used to read and write the current system frame for `TCARR` and `PAROT` for toolholders with orientation capability. The variable returns a zero frame if the system frame is not configured through MD28082.

- **\$P\_TOOLFRAME**

In the part program, the variable `$P_TOOLFRAME` can be used to read and write the current system frame for `TOROT` and `TOFRAME`. The variable returns a zero frame if the system frame is not configured through MD28082.

- **\$P\_WPFRAME**

In the part program, the variable `$P_WPFRAME` can be used to read and write the current system frame for setting workpiece reference points. The variable returns a zero frame if the system frame is not configured through MD28082.

- **\$P\_CYCFRAME**

In the part program, the variable `$P_CYCFRAME` can be used to read and write the current system frame for cycles. The variable returns a zero frame if the system frame is not configured through MD28082.

- **\$P\_TRAFRAME**

In the part program, the variable `$P_TRAFRAME` can be used to read and write the current system frame for transformations. The variable returns a zero frame if the system frame is not configured through MD28082.

- **\$P\_ISO1FRAME, \$P\_ISO2FRAME, \$P\_ISO3FRAME, \$P\_ISO4FRAME**

One can read and write the current system frames for special ISO language commands in the parts program through the variables. The variable returns a zero frame if the system frame is not configured through MD28082.

- **\$P\_RELFRAME**

In the part program, the variable `$P_RELFRAME` can be used to read and write the current system frame for relative coordinate systems. The variable returns a zero frame if the system frame is not configured through MD28082.

- **\$P\_ACSFRAME**

The currently resulting frame that is defined by the ENS-(ACS) coordinate system, can be read and written through the \$P\_ACSFRAME variable.

For MD24030 \$MC\_FRAME\_ACS\_SET = 0, the frame is calculated as follows:

\$P\_ACSFRAME = \$P\_PARTFRAME : \$P\_SETFRAME : \$P\_EXTFRAME :  
\$P\_ISO1FRAME : \$P\_ISO2FRAME : \$P\_ISO3FRAME :  
\$P\_ACTBFRAME : \$P\_IFRAME :  
\$P\_TOOLFRAME : \$P\_WPFRAME

For MD24030 \$MC\_FRAME\_ACS\_SET = 1, the frame is calculated as follows:

\$P\_ACSFRAME = \$P\_PARTFRAME : \$P\_SETFRAME : \$P\_EXTFRAME :  
\$P\_ISO1FRAME : \$P\_ISO2FRAME : \$P\_ISO3FRAME :  
\$P\_ACTBFRAME : \$P\_IFRAME :  
\$P\_TOOLFRAME : \$P\_WPFRAME : \$P\_TRAFRAME:  
\$P\_PFRAME : \$P\_ISO4FRAME

- **\$P\_ACTFRAME**

The resulting current complete frame \$P\_ACTFRAME is now a chain of all system frames, basic frames, the current settable frame and the programmable frame. The current frame is always updated whenever a frame component is changed.

The current complete frame is calculated according to the formula below:

\$P\_ACTFRAME = \$P\_PARTFRAME : \$P\_SETFRAME : \$P\_EXTFRAME :  
\$P\_ISO1FRAME : \$P\_ISO2FRAME : \$P\_ISO3FRAME :  
\$P\_ACTBFRAME : \$P\_IFRAME :  
\$P\_TOOLFRAME : \$P\_WPFRAME : \$P\_TRAFRAME:  
\$P\_PFRAME : \$P\_ISO4FRAME : \$P\_CYCFRAME

## 10.5.6 Implicit frame changes

### 10.5.6.1 Frames and switchover of geometry axes

In the channel, the geometry axis configuration can be changed by switching a transformation on and off and with the `GEOAX ( )` command (R3).

Machine data

MD10602 \$MN\_FRAME\_GEOAX\_CHANGE\_MODE

can be used to configure, for all channels of the system, whether the current complete frame is calculated again on the basis of the new geometry axes or whether the complete frame is deleted.

Four modes can be set via machine data:

- MD10602 \$MN\_FRAME\_GEOAX\_CHANGE\_MODE = 0

The current complete frame is deleted when geometry axes are switched over, when transformations are selected and deselected, and on `GEOAX ( )`.

The modified geometry axis configuration is not used until a new frame is activated.

- MD10602 \$MN\_FRAME\_GEOAX\_CHANGE\_MODE = 1

The current complete frame is calculated again when the geometry axes are switched over, and the translations, scales and mirrors of the new geometry axes are effective.

The rotations of the geometry axes, which were programmed before the switchover, remain effective for the new geometry axes.

The aspects described in the chapter "Frames for selection and deselection of transformations" are relevant to `TRANSMIT`, `TRACYL` and `TRAANG`.

**References:**

/FB1/ Function Manual, Basic Functions; Axes, Coordinate System, Frames (K2);  
Chapter: Frame for selection and deselection of transformations

- MD10602 \$MN\_FRAME\_GEOAX\_CHANGE\_MODE = 2

The current complete frame is calculated again when the geometry axes are switched over, and the translations, scales and mirrors of the new geometry axes are effective. If rotations are active in the current basic frames, the current settable frame or the programmable frame before the switchover, it is aborted with the alarm "Frame: Geometry axis switchover not allowed".

The aspects described in the chapter "Frames for selection and deselection of transformations" are relevant to `TRANSMIT`, `TRACYL` and `TRAANG`.

**References:**

/FB1/ Function Manual, Basic Functions; Axes, Coordinate System, Frames (K2);  
Chapter: Frame for selection and deselection of transformations

- MD10602 \$MN\_FRAME\_GEOAX\_CHANGE\_MODE = 3

The current frame is deleted when selecting and deselecting transformations.

With `GEOAX ( )`, the current complete frame is calculated again and the translations, scales and mirrors of the new geometry axes come into effect.

The rotations of the geometry axes, which were programmed before the switchover, remain effective for the new geometry axes.

The workpiece geometry is described by a coordinate system that is formed by the geometry axes. A channel axis is assigned to each geometry axis and a machine axis is assigned to each channel axis. An axial frame exists for each machine axis and for each frame (system frame, basic frame, settable frame, programmable frame). When a new machine axis is assigned to a geometry axis, the axial frame components of the machine axis, such as translations (coarse and fine), scales and mirrors of the appropriate frame, are also applied. The new geometry in the channel is then generated by the new contour frames resulting from the new geometry axes (up to three in number).

The current valid frames are calculated again on the geometry axis switchover and a resulting complete frame is generated. The data management frames are not included unless they are activated.

Example:

The channel axis is to become a geometry axis x through `geo axis` substitution. The substitution is to give the programmable frame a translation component of 10 in the x axis. The current settable frame is to be retained.

MD10602 \$MN\_FRAME\_GEOAX\_CHANGE\_MODE = 1

```

$P_UIFR[1] = CROT(x,10,y,20,z,30)      ; Frame is retained after geo axis
                                       substitution.
G54                                    ; Settable frame becomes active.
TRANS a10                              ; Axial offset of a is also substituted.
GEOAX(1, a)                             ; a becomes x axis;
                                       $P_ACTFRAME=CROT(x,10,
                                       y,20,z,30):CTTRANS(x10).
    
```

Several channel axes can become geometry axes on a transformation change.

Example:

Channel axes 4, 5 and 6 become the geometry axes of a 5-axis transformation. The geometry axes are thus all substituted before the transformation. The current frames are changed when the transformation is activated. The axial frame components of the channel axes, which become geometry axes, are taken into account when calculating the new WCS. Rotations programmed before the transformation are retained. The old WCS is restored when the transformation is deactivated. The most common application will be that the geometry axes do not change before and after the transformation and that the frames are to stay as they were before the transformation.

Machine data:

```

$MN_FRAME_GEOAX_CHANGE_MODE = 1

$MC_AXCONF_CHANAX_NAME_TAB[0] = "CAX"
$MC_AXCONF_CHANAX_NAME_TAB[1] = "CAY"
$MC_AXCONF_CHANAX_NAME_TAB[2] = "CAZ"
$MC_AXCONF_CHANAX_NAME_TAB[3] = "A"
$MC_AXCONF_CHANAX_NAME_TAB[4] = "B"
$MC_AXCONF_CHANAX_NAME_TAB[5] = "C"
    
```

```
$MC_AXCONF_GEOAX_ASSIGN_TAB[0] = 1
$MC_AXCONF_GEOAX_ASSIGN_TAB[1] = 2
$MC_AXCONF_GEOAX_ASSIGN_TAB[2] = 3
```

```
$MC_AXCONF_GEOAX_NAME_TAB[0] = "X"
$MC_AXCONF_GEOAX_NAME_TAB[1] = "Y"
$MC_AXCONF_GEOAX_NAME_TAB[2] = "Z"
```

```
$MC_TRAFO_GEOAX_ASSIGN_TAB_1[0]=4
$MC_TRAFO_GEOAX_ASSIGN_TAB_1[1]=5
$MC_TRAFO_GEOAX_ASSIGN_TAB_1[2]=6
```

```
$MC_TRAFO_AXES_IN_1[0] = 4
$MC_TRAFO_AXES_IN_1[1] = 5
$MC_TRAFO_AXES_IN_1[2] = 6
$MC_TRAFO_AXES_IN_1[3] = 1
$MC_TRAFO_AXES_IN_1[4] = 2
```

Program:

```
$P_NCBFRAME[0] = ctrans(x,1,y,2,z,3,a,4,b,5,c,6)
$P_CHBFRAME[0] = ctrans(x,1,y,2,z,3,a,4,b,5,c,6)
$P_IFRAME = ctrans(x,1,y,2,z,3,a,4,b,5,c,6):crot(z,45)
$P_PFRAME = ctrans(x,1,y,2,z,3,a,4,b,5,c,6):crot(x,10,y,20,z,30)
```

```
TRAORI      ; Geo axis (4,5,6) sets transformer
            ; $P_NCBFRAME[0] = ctrans(x,4,y,5,z,6,cax,1,cay,2,caz,3)
            ; $P_ACTBFRAME =ctrans(x,8,y,10,z,12,cax,2,cay,4,caz,6)
            ; $P_PFRAME =
            ctrans(x,4,y,5,z,6,cax,1,cay,2,caz,3):crot(x,10,y,20,z,30)
            ; $P_IFRAME = ctrans(x,4,y,5,z,6,cax,1,cay,2,caz,3):crot(z,45)
TRAFOOF     ; Geo axis (1,2,3) sets transformation deactivation
            ; $P_NCBFRAME[0] = ctrans(x,1,y,2,z,3,a,4,b,5,c,6)
            ; $P_CHBFRAME[0] = ctrans(x,1,y,2,z,3,a,4,b,5,c,6)
            ; $P_IFRAME = ctrans(x,1,y,2,z,3,a,4,b,5,c,6):crot(z,45)
            ; $P_PFRAME = ctrans(x,1,y,2,z,3,a,4,b,5,c,6):crot(x,10,y,20,z,30)
```

### 10.5.6.2 Frame for selection and deselection of transformations

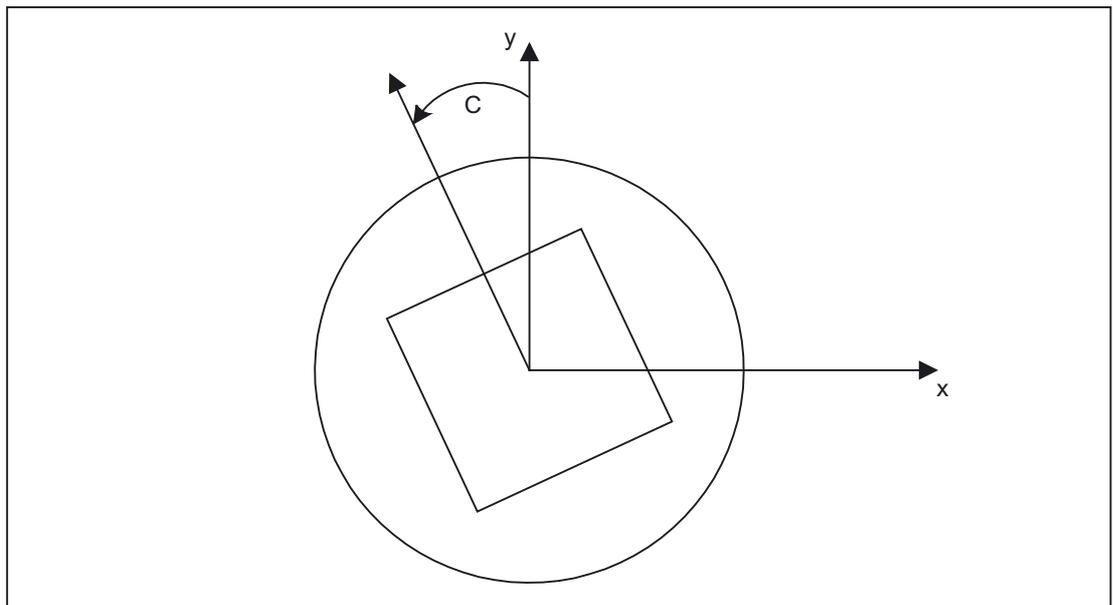
This function is available with NCK 51.00.00 and higher. Transformations `TRANSMIT`, `TRACYL` and `TRAANG` are supported.

As a rule, the assignment of geometry axes to channel axes changes when selecting and deselecting transformations. It is not possible to uniquely assign axial frame components to geometric contour frame components when carrying out transformations, in which rotary axes become linear axes and vice versa. The contour frame must be conditioned using special treatment for such non-linear transformations.

The mode, set with machine data  
`MD10602 $MN_FRAME_GEOAX_CHANGE_MODE = 1` and `2`,  
is expanded in such a way as to take the above transformations into account.

When selecting transformations, the contour frame is connected to the axial frames. With transformations `TRANSMIT`, `TRACYL` and `TRAANG`, the virtual geometry axis is subject to special treatment.

#### TRANSMIT



**Transmit expansions:**

The machine data

```
MD24905 $MC_TRANSMIT_ROT_AX_FRAME_1 = 1
```

```
MD24905 $MC_TRANSMIT_ROT_AX_FRAME_2 = 1
```

can be used to take the axial complete frame of the transmit rotary axis, i.e. the translation, fine offset, mirroring and scaling, into account in the transformation.

A rotary axis offset can, for example, be entered by compensating the oblique position of a workpiece in a frame within a frame chain. As a rule, this offset can also be included in the transformation as an offset in the rotary axis. A c axis offset, as in the figure above, then leads to corresponding x and y values.

```
MD24905 $MC_TRANSMIT_ROT_AX_FRAME_1 = 2
```

```
MD24905 $MC_TRANSMIT_ROT_AX_FRAME_2 = 2
```

With this setting, the axial offset of the rotary axis is taken account of in the transformation up to the SZS. The axial offsets of the rotary axis included in the SZS frames are entered into the transformation frame as rotations. This setting is only effective if the transformation frame has been configured.

**Frame expansions:**

The expansions described below are only valid for the machine data

```
$MN_FRAME_GEOAX_CHANGE_MODE = 1
```

```
$MN_FRAME_GEOAX_CHANGE_MODE = 2
```

The selection of transformation `TRANSMIT` produces a virtual geometry axis, coupled by way of the rotary axis, which is merely included in the contour frame but does not have a reference to an axial frame. The geometric value results from the rotation of a rotary axis. All other geometry axes accept their axial components when the transformation is selected.

**Translations:**

On selecting transmit, translations of the virtual axis are deleted. Translations of the rotary axis can be taken into account in the transformation.

**Rotations:**

Rotations before the transformation are taken over.

**Mirrorings:**

Mirrorings of the virtual axis are deleted. Mirrorings of the rotary axis can be taken into account in the transformation.

**Scalings:**

Scalings of the virtual axis are deleted. Scalings of the rotary axis can be taken into account in the transformation.

**Example:**

**Machine data for TRANSMIT**

**; FRAME configurations**

\$MC\_MM\_SYSTEM\_FRAME\_MASK = 'H41' ; TRAFRAME, SETFRAME  
 \$MC\_CHSFRAME\_RESET\_MASK = 'H41' ; Frames are active after Reset.  
 \$MC\_CHSFRAME\_POWERON\_MASK = 'H41' ; Frames are deleted on POWER ON.

\$MN\_FRAME\_GEOAX\_CHANGE\_MODE = 1 ; Frames are calculated after  
 switchover of the geo axis.

\$MC\_RESET\_MODE\_MASK = 'H4041' ; Basic frame is not deselected after  
 RESET.

;\$MC\_RESET\_MODE\_MASK = 'H41' ; Basic frame is deselected after  
 RESET.

;\$MC\_GCODE\_RESET\_VALUES[7] = 2 ; G54 is the default setting.  
 \$MC\_GCODE\_RESET\_VALUES[7] = 1 ; G500 is the default setting.

\$MN\_MM\_NUM\_GLOBAL\_USER\_FRAMES = 0  
 \$MN\_MM\_NUM\_GLOBAL\_BASE\_FRAMES = 3

\$MC\_MM\_NUM\_USER\_FRAMES = 10 ; from 5 to 100  
 \$MC\_MM\_NUM\_BASE\_FRAMES = 3 ; from 0 to 8

\$MN\_NCBFRAME\_RESET\_MASK = 'HFF'  
 \$MC\_CHBFRAME\_RESET\_MASK = 'HFF'

\$MN\_MIRROR\_REF\_AX = 0 ; No scaling when mirroring

\$MN\_MIRROR\_TOGGLE = 0

\$MN\_MM\_FRAME\_FINE\_TRANS = 1 ; Fine offset

\$MC\_FRAME\_ADD\_COMPONENTS = TRUE ; G58, G59 is possible

**; TRANSMIT is 1st transformer**

\$MC\_TRAFO\_TYPE\_1 = 256

\$MC\_TRAFO\_AXES\_IN\_1[0] = 1

\$MC\_TRAFO\_AXES\_IN\_1[1] = 6

\$MC\_TRAFO\_AXES\_IN\_1[2] = 3

```

$MC_TRAFO_AXES_IN_1[3] = 0
$MC_TRAFO_AXES_IN_1[4] = 0

$MA_ROT_IS_MODULO[AX6] = TRUE;

$MC_TRAFO_GEOAX_ASSIGN_TAB_1[0]=1
$MC_TRAFO_GEOAX_ASSIGN_TAB_1[1]=6
$MC_TRAFO_GEOAX_ASSIGN_TAB_1[2]=3

$MC_TRANSMIT_BASE_TOOL_1[0]=0.0
$MC_TRANSMIT_BASE_TOOL_1[1]=0.0
$MC_TRANSMIT_BASE_TOOL_1[2]=0.0

$MC_TRANSMIT_ROT_AX_OFFSET_1 = 0.0
$MC_TRANSMIT_ROT_SIGN_IS_PLUS_1 = TRUE

$MC_TRANSMIT_ROT_AX_FRAME_1 = 1

; TRANSMIT is 2nd transformer

$MC_TRAFO_TYPE_2 = 256

$MC_TRAFO_AXES_IN_2[0] = 1
$MC_TRAFO_AXES_IN_2[1] = 6
$MC_TRAFO_AXES_IN_2[2] = 2
$MC_TRAFO_AXES_IN_2[3] = 0
$MC_TRAFO_AXES_IN_2[4] = 0

$MC_TRAFO_GEOAX_ASSIGN_TAB_2[0] = 1
$MC_TRAFO_GEOAX_ASSIGN_TAB_2[1] = 6
$MC_TRAFO_GEOAX_ASSIGN_TAB_2[2] = 2

$MC_TRANSMIT_BASE_TOOL_2[0] = 4.0
$MC_TRANSMIT_BASE_TOOL_2[1] = 0.0
$MC_TRANSMIT_BASE_TOOL_2[2] = 0.0

$MC_TRANSMIT_ROT_AX_OFFSET_2 = 19.0
$MC_TRANSMIT_ROT_SIGN_IS_PLUS_2 = TRUE

$MC_TRANSMIT_ROT_AX_FRAME_2 = 1

```

**Part program:**

```

; Frame settings
N820 $P_UIFR[1] = ctrans(x,1,y,2,z,3,c,4)
N830 $P_UIFR[1] = $P_UIFR[1] : crot(x,10,y,20,z,30)
N840 $P_UIFR[1] = $P_UIFR[1] : cmirror(x,c)
N850
N860 $P_CHBFR[0] = ctrans(x,10,y,20,z,30,c,15)
N870

; Tool selection, clamping compensation, plane selection
N890 T2 D1 G54 G17 G90 F5000 G64 SOFT
N900

;Approach start position
N920 G0 X20 Z10
N930
N940 if $P_BFRAME <> CTRANS(X,10,Y,20,Z,30,C,15)
N950 setal(61000)
N960 endif
N970 if $P_BFRAME <> $P_CHBFR[0]
N980 setal(61000)
N990 endif
N1000 if $P_IFRAME <>
CTRANS(X,1,Y,2,Z,3,C,4):CROT(X,10,Y,20,Z,30):CMIRROR(X,C)
N1010 setal(61000)
N1020 endif
N1030 if $P_IFRAME <> $P_UIFR[1]
N1040 setal(61000)
N1050 endif
N1060 if $P_ACTFRAME <>
CTRANS(X,11,Y,22,Z,33,C,19):CROT(X,10,Y,20,Z,30):CMIRROR(X,C)
N1070 setal(61000)
N1080 endif
N1090
N1100 TRANSMIT(2)
N1110
N1120 if $P_BFRAME <> CTRANS(X,10,Y,0,Z,20,CAZ,30,C,15)
N1130 setal(61000)
N1140 endif
N1180 if $P_IFRAME <>
CTRANS(X,1,Y,0,Z,2,CAZ,3,C,4):CROT(X,10,Y,20,Z,30):CMIRROR(X,C)

```

```

N1190 setal(61000)
N1200 endif
N1240 if $P_ACTFRAME <>
CTRANS(X,11,Y,0,Z,22,CAZ,33,C,19):CROT(X,10,Y,20,Z,30):CMIRROR(X,C)
N1250 setal(61001)
N1260 endif
N1270
N1280
N1290 $P_UIFR[1,x,tr] = 11
N1300 $P_UIFR[1,y,tr] = 14
N1310
N1320 g54
N1330

```

```

;Set frame
N1350 ROT RPL=-45
N1360 ATRANS X-2 Y10
N1370

```

```

;Four-edge roughing
N1390 G1 X10 Y-10 G41 OFFN=1; allowance 1 mm
N1400 X-10
N1410 Y10
N1420 X10
N1430 Y-10
N1440

```

```

;Change tool
N1460 G0 Z20 G40 OFFN=0
N1470 T3 D1 X15 Y-15
N1480 Z10 G41
N1490

```

```

; Square finishing
N1510 G1 X10 Y-10
N1520 X-10
N1530 Y10
N1540 X10
N1550 Y-10
N1560

```

```

; Deselect frame
N2950 m30 N1580 Z20 G40
N1590 TRANS
N1600
N1610 if $P_BFRAME <> CTRANS(X,10,Y,0,Z,20,CAZ,30,C,15)
N1620 setal(61000)
N1630 endif
N1640 if $P_BFRAME <> $P_CHBFR[0]
N1650 setal(61000)
N1660 endif
N1670 if $P_IFRAME <>
TRANS(X,11,Y,0,Z,2,CAZ,3,C,4):CROT(X,10,Y,20,Z,30):CMIRROR(X,C)
N1680 setal(61000)
N1690 endif
N1730 if $P_ACTFRAME <>
TRANS(X,21,Y,0,Z,22,CAZ,33,C,19):CROT(X,10,Y,20,Z,30):CMIRROR(X,C)
N1740 setal(61001)
N1750 endif
N1760
N1770 TRAF00F
N1780
N1790 if $P_BFRAME <> CTRANS(X,10,Y,20,Z,30,C,15)
N1800 setal(61000)
N1810 endif
N1820 if $P_BFRAME <> $P_CHBFR[0]
N1830 setal(61000)
N1840 endif
N1850 if $P_IFRAME <>
TRANS(X,11,Y,2,Z,3,C,4):CROT(X,10,Y,20,Z,30):CMIRROR(X,C)
N1860 setal(61000)
N1870 endif
N1880 if $P_IFRAME <> $P_UIFR[1]
N1890 setal(61000)
N1900 endif
N1910 if $P_ACTFRAME <>
TRANS(X,21,Y,22,Z,33,C,19):CROT(X,10,Y,20,Z,30):CMIRROR(X,C)
N1920 setal(61002)
N1930 endif
N1940
N2010 $P_UIFR[1] = ctrans()
N2011 $P_CHBFR[0] = ctrans()
N2020 $P_UIFR[1] = ctrans(x,1,y,2,z,3,c,0)
N2021 G54

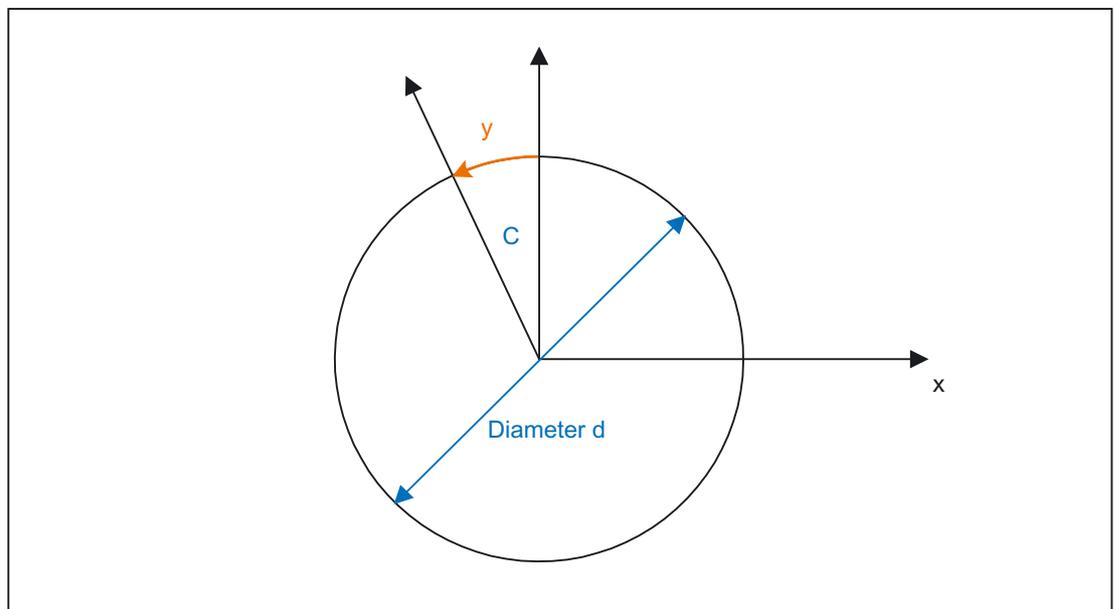
```

```

N2021 G0 X20 Y0 Z10 C0
N2030 TRANSMIT(1)
N2040 TRANS x10 y20 z30
N2041 ATRANS y200
N2050 G0 X20 Y0 Z10
N2051 if $P_IFRAME <> CTRANS (X,1,Y,0,Z,3,CAY,2)
N2052 setal(61000)
N2053 endif
N2054 if $P_ACTFRAME <> CTRANS (X,11,Y,20,Z,33,CAY,2):CFINE (Y,200)
N2055 setal(61002)
N2056 endif
N2060 TRAFOOF
N2061 if $P_IFRAME <> $P_UIFR[1]
N2062 setal(61000)
N2063 endif
N2064 if $P_ACTFRAME <> CTRANS (X,11,Y,2,Z,33):CFINE (Y,0)
N2065 setal(61002)
N2066 endif

```

## TRACYL



**Tracyl expansions:**

The machine data below can be used to take the axial complete frame of the tracyl rotary axis, i.e. the translation, fine offset, mirroring and scaling, into account in the transformation:

MD24805 \$MC\_TRACYL\_ROT\_AX\_FRAME\_1 = 1

MD24855 \$MC\_TRACYL\_ROT\_AX\_FRAME\_2 = 1

A rotary axis offset can, for example, be entered by compensating the oblique position of a workpiece in a frame within a frame chain. As a rule, this offset can also be included in the transformation as an offset in the rotary axis or as a y offset. A c axis offset, as in the figure above, then leads to corresponding x and y values.

MD24805 \$MC\_TRACYL\_ROT\_AX\_FRAME\_1 = 2

MD24855 \$MC\_TRACYL\_ROT\_AX\_FRAME\_2 = 2

With this setting, the axial offset of the rotary axis is taken account of in the transformation up to the SZS. The axial offsets of the rotary axis included in the SZS frames are entered into the transformation frame as offsets on the sheath surface. This setting is only effective if the transformation frame has been configured.

**Frame expansions:**

The expansions described below are only valid for the machine data

MD10602 \$MN\_FRAME\_GEOAX\_CHANGE\_MODE = 1

MD10602 \$MN\_FRAME\_GEOAX\_CHANGE\_MODE = 2

The selection of transformation `TRANSMIT` produces a virtual geometry axis on the sheath surface, coupled by way of the rotary axis, which is merely included in the contour frame but does not have a reference to an axial frame. All components of the virtual geometry axis are deleted. All other geometry axes accept their axial components when the transformation is selected.

**Translations:**

On selecting tracyl, translations of the virtual axis are deleted. Translations of the rotary axis can be taken into account in the transformation.

**Rotations:**

Rotations before the transformation are taken over.

**Mirrorings:**

Mirrorings of the virtual axis are deleted. Mirrorings of the rotary axis can be taken into account in the transformation.

**Scalings:**

Scalings of the virtual axis are deleted. Scalings of the rotary axis can be taken into account in the transformation.

**Example:**

**Machine data for TRACYL:**

**; FRAME configurations**

```

$MC_MM_SYSTEM_FRAME_MASK = 'H41' ; TRAFRAME, SETFRAME
$MC_CHSFRAME_RESET_MASK = 'H41' ; Frames are active after Reset.
$MC_CHSFRAME_POWERON_MASK = ; Frames are deleted on POWER ON.
'H41'

$MN_FRAME_GEOAX_CHANGE_MODE = ; Frames are calculated after switchover of
1 the geo axis.

$MC_RESET_MODE_MASK = 'H4041' ; Basic frame is not deselected after RESET.
;$MC_RESET_MODE_MASK = 'H41' ; Basic frame is deselected after RESET.

;$MC_GCODE_RESET_VALUES[7] = 2 ; G54 is the default setting.
$MC_GCODE_RESET_VALUES[7] = 1 ; G500 is the default setting.

$MN_MM_NUM_GLOBAL_USER_FRAMES = 0
$MN_MM_NUM_GLOBAL_BASE_FRAMES = 3

$MC_MM_NUM_USER_FRAMES = 10 ; from 5 to 100
$MC_MM_NUM_BASE_FRAMES = 3 ; from 0 to 8

$MN_NCBFRAME_RESET_MASK = 'HFF'
$MC_CHBFRAME_RESET_MASK = 'HFF'

$MN_MIRROR_REF_AX = 0 ; No scaling when mirroring
$MN_MIRROR_TOGGLE = 0
$MN_MM_FRAME_FINE_TRANS = 1 ; Fine offset
$MC_FRAME_ADD_COMPONENTS = ; G58, G59 is possible
TRUE
    
```

**; TRACYL with groove side offset is 3rd transformer**

\$MC\_TRAFO\_TYPE\_3 = 513; TRACYL

\$MC\_TRAFO\_AXES\_IN\_3[0] = 1

\$MC\_TRAFO\_AXES\_IN\_3[1] = 5

\$MC\_TRAFO\_AXES\_IN\_3[2] = 3

\$MC\_TRAFO\_AXES\_IN\_3[3] = 2

\$MC\_TRAFO\_GEOAX\_ASSIGN\_TAB\_3[0] = 1

\$MC\_TRAFO\_GEOAX\_ASSIGN\_TAB\_3[1] = 5

\$MC\_TRAFO\_GEOAX\_ASSIGN\_TAB\_3[2] = 3

\$MC\_TRACYL\_BASE\_TOOL\_1[0] = 0.0

\$MC\_TRACYL\_BASE\_TOOL\_1[1] = 0.0

\$MC\_TRACYL\_BASE\_TOOL\_1[2] = 0.0

\$MC\_TRACYL\_ROT\_AX\_OFFSET\_1 = 0.0

\$MC\_TRACYL\_ROT\_SIGN\_IS\_PLUS\_1 = TRUE

\$MC\_TRACYL\_ROT\_AX\_FRAME\_1 = 1

**Part program:**

```

; Simple traversing test with groove side offset
N450 G603
N460

; Frame settings
N500 $P_UIFR[1] = ctrans(x,1,y,2,z,3,b,4)
N510 $P_UIFR[1] = $P_UIFR[1] : crot(x,10,y,20,z,30)
N520 $P_UIFR[1] = $P_UIFR[1] : cmirror(x,b)
N530
N540 $P_CHBFR[0] = ctrans(x,10,y,20,z,30,b,15)
N550
N560 G54
N570

; Continuous-path mode, resurface by grinding selected
N590 G0 x0 y0 z-10 b0 G90 F50000 T1 D1 G19 G641 ADIS=1 ADISPOS=5
N600
N610 if $P_BFRAME <> CTRANS(X,10,Y,20,Z,30,B,15)
N620 setal(61000)
N630 endif
N640 if $P_BFRAME <> $P_CHBFR[0]
N650 setal(61000)
N660 endif
N670 if $P_IFRAME <>
TRANS(X,1,Y,2,Z,3,B,4):CROT(X,10,Y,20,Z,30):CMIRROR(X,B)
N680 setal(61000)
N690 endif
N700 if $P_IFRAME <> $P_UIFR[1]
N710 setal(61000)
N720 endif
N730 if $P_ACTFRAME <>
TRANS(X,11,Y,22,Z,33,B,19):CROT(X,10,Y,20,Z,30):CMIRROR(X,B)
N740 setal(61000)
N750 endif
N760

; Transformation ON
N780 TRACYL(40.)
N790
N800 if $P_BFRAME <> CTRANS(X,10,Y,0,Z,30,CAY,20,B,15)
N810 setal(61000)
N820 endif
N830 if $P_CHBFR[0] <> CTRANS(X,10,Y,0,Z,30,CAY,20,B,15)

```

```

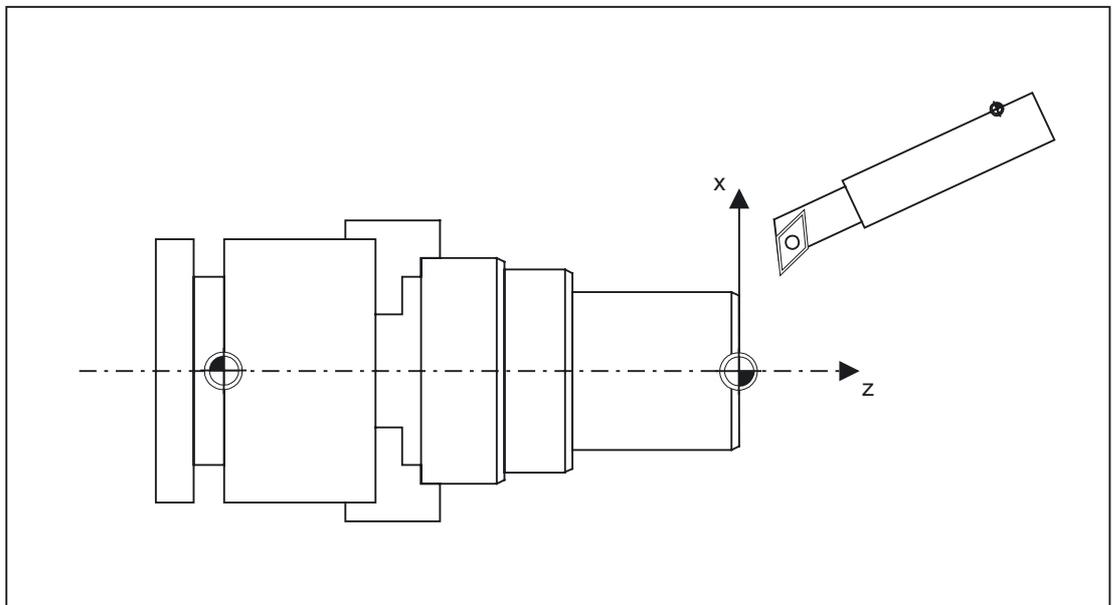
N840 setal(61000)
N850 endif
N860 if $P_IFRAME <>
TRANS(X,1,Y,0,Z,3,CAY,2,B,4):CROT(X,10,Y,20,Z,30):CMIRROR(X,B)
N870 setal(61000)
N880 endif
N890 if $P_UIFR[1] <>
TRANS(X,1,Y,0,Z,3,CAY,2,B,4):CROT(X,10,Y,20,Z,30):CMIRROR(X,B)
N900 setal(61000)
N910 endif
N920 if $P_ACTFRAME <>
TRANS(X,11,Y,0,Z,33,CAY,22,B,19):CROT(X,10,Y,20,Z,30):CMIRROR(X,B)
N930 setal(61001)
N940 endif
N950
N960 $P_UIFR[1,x,tr] = 11
N970 $P_UIFR[1,y,tr] = 14
N980
N990 g54
N1000
N1010 if $P_BFRAME <> CTRANS(X,10,Y,0,Z,30,CAY,20,B,15)
N1020 setal(61000)
N1030 endif
N1040 if $P_BFRAME <> $P_CHBFR[0]
N1050 setal(61000)
N1060 endif
N1070 if $P_IFRAME <>
TRANS(X,11,Y,0,Z,3,CAY,2,B,4):CROT(X,10,Y,20,Z,30):CMIRROR(X,B)
N1080 setal(61000)
N1090 endif
N1100 if $P_IFRAME <> $P_UIFR[1]
N1110 setal(61000)
N1120 endif
N1130 if $P_ACTFRAME <>
TRANS(X,21,Y,0,Z,33,CAY,22,B,19):CROT(X,10,Y,20,Z,30):CMIRROR(X,B)
N1140 setal(61001)
N1150 endif
N1160

; Transformation off
N1180 TRAF00F
N1190
N1200 if $P_BFRAME <> CTRANS(X,10,Y,20,Z,30,B,15)
N1210 setal(61000)
N1220 endif

```

```
N1230 if $P_BFRAME <> $P_CHBFR[0]
N1240 setal(61000)
N1250 endif
N1260 if $P_IFRAME <>
TRANS(X,11,Y,2,Z,3,B,4):CROT(X,10,Y,20,Z,30):CMIRROR(X,B)
N1270 setal(61000)
N1280 endif
N1290 if $P_IFRAME <> $P_UIFR[1]
N1300 setal(61000)
N1310 endif
N1320 if $P_ACTFRAME <>
TRANS(X,21,Y,22,Z,33,B,19):CROT(X,10,Y,20,Z,30):CMIRROR(X,B)
N1330 setal(61002)
N1340 endif
N1350
N1360 G00 x0 y0 z0 G90
N1370
N1380 m30
```

## TRAANG



**Frame expansions:**

The expansions described below are only valid for the machine data

MD10602 \$MN\_FRAME\_GEOAX\_CHANGE\_MODE = 1

MD10602 \$MN\_FRAME\_GEOAX\_CHANGE\_MODE = 2

**Translations:**

On selecting traang, translations of the virtual axis are retained.

**Rotations:**

Rotations before the transformation are taken over.

**Mirrorings:**

Mirrorings of the virtual axis are taken over.

**Scalings:**

Scalings of the virtual axis are taken over.

**Example:**

**Machine data for TRAANG:**

**; FRAME configurations**

\$MC\_MM\_SYSTEM\_FRAME\_MASK = 'H1' ; SETFRAME

\$MC\_CHSFRAME\_RESET\_MASK = 'H41' ; Frames are active after RESET.

\$MC\_CHSFRAME\_POWERON\_MASK = 'H41' ; Frames are deleted on POWER ON.

\$MN\_FRAME\_GEOAX\_CHANGE\_MODE = 1 ; Frames are calculated after switchover of the geo axis.

\$MC\_RESET\_MODE\_MASK = 'H4041' ; Basic frame is not deselected after RESET.

;\$MC\_RESET\_MODE\_MASK = 'H41' ; Basic frame is deselected after RESET.

;\$MC\_GCODE\_RESET\_VALUES[7] = 2 ; G54 is the default setting.

\$MC\_GCODE\_RESET\_VALUES[7] = 1 ; G500 is the default setting.

\$MN\_MM\_NUM\_GLOBAL\_USER\_FRAMES = 0

\$MN\_MM\_NUM\_GLOBAL\_BASE\_FRAMES = 3

\$MC\_MM\_NUM\_USER\_FRAMES = 10 ; from 5 to 100

\$MC\_MM\_NUM\_BASE\_FRAMES = 3 ; from 0 to 8

\$MN\_NCBFRAME\_RESET\_MASK = 'HFF'

\$MC\_CHBFRAME\_RESET\_MASK = 'HFF'

`$MN_MIRROR_REF_AX = 0` ; No scaling when mirroring  
`$MN_MIRROR_TOGGLE = 0`  
`$MN_MM_FRAME_FINE_TRANS = 1` ; Fine offset  
`$MC_FRAME_ADD_COMPONENTS = TRUE` ; G58, G59 is possible

**; TRAANG is 1st transformer**

`$MC_TRAFO_TYPE_1 = 1024`

`$MC_TRAFO_AXES_IN_1[0] = 4` ; Oblique axis  
`$MC_TRAFO_AXES_IN_1[1] = 3` ; Axis is parallel to z  
`$MC_TRAFO_AXES_IN_1[2] = 2`  
`$MC_TRAFO_AXES_IN_1[3] = 0`  
`$MC_TRAFO_AXES_IN_1[4] = 0`

`$MC_TRAFO_GEOAX_ASSIGN_TAB_1[0]=4`  
`$MC_TRAFO_GEOAX_ASSIGN_TAB_1[1]=2`  
`$MC_TRAFO_GEOAX_ASSIGN_TAB_1[2]=3`

`$MC_TRAANG_ANGLE_1 = 85.`  
`$MC_TRAANG_PARALLEL_VELO_RES_1 = 0.`  
`$MC_TRAANG_PARALLEL_ACCEL_RES_1 = 0.`

`$MC_TRAANG_BASE_TOOL_1[0] = 0.0`  
`$MC_TRAANG_BASE_TOOL_1[1] = 0.0`  
`$MC_TRAANG_BASE_TOOL_1[2] = 0.0`

**; TRAANG is 2nd transformer**

`$MC_TRAFO_TYPE_2 = 1024`

`$MC_TRAFO_AXES_IN_2[0] = 4`  
`$MC_TRAFO_AXES_IN_2[1] = 3`  
`$MC_TRAFO_AXES_IN_2[2] = 0`  
`$MC_TRAFO_AXES_IN_2[3] = 0`  
`$MC_TRAFO_AXES_IN_2[4] = 0`

```
$MC_TRAFO_GEOAX_ASSIGN_TAB_2[0] = 4  
$MC_TRAFO_GEOAX_ASSIGN_TAB_2[1] = 0  
$MC_TRAFO_GEOAX_ASSIGN_TAB_2[2] = 3
```

```
$MC_TRAANG_ANGLE_2 = -85.  
$MC_TRAANG_PARALLEL_VELO_RES_2 = 0.2  
$MC_TRAANG_PARALLEL_ACCEL_RES_2 = 0.2
```

```
$MC_TRAANG_BASE_TOOL_2[0] = 0.0  
$MC_TRAANG_BASE_TOOL_2[1] = 0.0  
$MC_TRAANG_BASE_TOOL_2[2] = 0.0
```

**Part program:**

```
; Frame settings  
N820 $P_UIFR[1] = ctrans(x,1,y,2,z,3,b,4,c,5)  
N830 $P_UIFR[1] = $P_UIFR[1] : crot(x,10,y,20,z,30)  
N840 $P_UIFR[1] = $P_UIFR[1] : cmirror(x,c)  
N850  
N860 $P_CHBFR[0] = ctrans(x,10,y,20,z,30,b,40,c,15)  
N870  
  
; Tool selection, clamping compensation, plane selection  
N890 T2 D1 G54 G17 G90 F5000 G64 SOFT  
N900  
  
;Approach start position  
N920 G0 X20 Z10  
N930  
N940 if $P_BFRAME <> CTRANS(X,10,Y,20,Z,30,B,40,C,15)  
N950 setal(61000)  
N960 endif  
N970 if $P_BFRAME <> $P_CHBFR[0]  
N980 setal(61000)  
N990 endif  
N1000 if $P_IFRAME <>  
TRANS(X,1,Y,2,Z,3,B,4,C,5):CROT(X,10,Y,20,Z,30):CMIRROR(X,C)  
N1010 setal(61000)  
N1020 endif  
N1030 if $P_IFRAME <> $P_UIFR[1]  
N1040 setal(61000)  
N1050 endif
```

```

N1060 if $P_ACTFRAME <>
TRANS (X,11,Y,22,Z,33,B,44,C,20):CROT(X,10,Y,20,Z,30):CMIRROR(X,C)
N1070 setal(61000)
N1080 endif
N1090
N1100 TRAANG(,1)
N1110
N1120 if $P_BFRAME <> CTRANS(X,10,Y,20,Z,30,CAX,10,B,40,C,15)
N1130 setal(61000)
N1140 endif
N1150 if $P_BFRAME <> $P_CHBFR[0]
N1160 setal(61000)
N1170 endif
N1180 if $P_IFRAME <>
CTRANS(X,1,Y,2,Z,3,CAX,1,B,4,C,5):CROT(X,10,Y,20,Z,30):CMIRROR(X,CAX,C)
N1190 setal(61000)
N1200 endif
N1210 if $P_IFRAME <> $P_UIFR[1]
N1220 setal(61000)
N1230 endif
N1240 if $P_ACTFRAME <>
TRANS(X,11,Y,22,Z,33,CAX,11,B,44,C,20):CROT(X,10,Y,20,Z,30):CMIRROR(X,CAX,C)
N1250 setal(61001)
N1260 endif
N1270
N1280
N1290 $P_UIFR[1,x,tr] = 11
N1300 $P_UIFR[1,y,tr] = 14
N1310
N1320 g54
N1330

```

```

;Set frame
N1350 ROT RPL=-45
N1360 ATRANS X-2 Y10
N1370

```

```

;Four-edge roughing
N1390 G1 X10 Y-10 G41 OFFN=1; allowance 1 mm
N1400 X-10
N1410 Y10
N1420 X10

```

```
N1430 Y-10  
N1440
```

```
;Change tool  
N1460 G0 Z20 G40 OFFN=0  
N1470 T3 D1 X15 Y-15  
N1480 Z10 G41  
N1490
```

```
; Square finishing  
N1510 G1 X10 Y-10  
N1520 X-10  
N1530 Y10  
N1540 X10  
N1550 Y-10  
N1560
```

```
; Deselect frame  
N1580 Z20 G40  
N1590 TRANS  
N1600  
N1610 if $P_BFRAME <> CTRANS(X,10,Y,20,Z,30,CAX,10,B,40,C,15)  
N1620 setal(61000)  
N1630 endif  
N1640 if $P_BFRAME <> $P_CHBFR[0]  
N1650 setal(61000)  
N1660 endif  
N1670 if $P_IFRAME <>  
TRANS(X,11,Y,14,Z,3,CAX,1,B,4,C,5):CROT(X,10,Y,20,Z,30):CMIRROR(X,CAX,C)  
N1680 setal(61000)  
N1690 endif  
N1700 if $P_IFRAME <> $P_UIFR[1]  
N1710 setal(61000)  
N1720 endif  
N1730 if $P_ACTFRAME <>  
TRANS(X,21,Y,34,Z,33,CAX,11,B,44,C,20):CROT(X,10,Y,20,Z,30):CMIRROR(X,CAX,C)  
N1740 setal(61001)  
N1750 endif  
N1760  
N1770 TRAFOOF  
N1780
```

```

N1790 if $P_BFRAME <> CTRANS(X,10,Y,20,Z,30,B,40,C,15)
N1800 setal(61000)
N1810 endif
N1820 if $P_BFRAME <> $P_CHBFR[0]
N1830 setal(61000)
N1840 endif
N1850 if $P_IFRAME <>
TRANS(X,1,Y,14,Z,3,B,4,C,5):CROT(X,10,Y,20,Z,30):CMIRROR(X,C)
N1860 setal(61000)
N1870 endif
N1880 if $P_IFRAME <> $P_UIFR[1]
N1890 setal(61000)
N1900 endif
N1910 if $P_ACTFRAME <>
TRANS(X,11,Y,34,Z,33,B,44,C,20):CROT(X,10,Y,20,Z,30):CMIRROR(X,C)
N1920 setal(61002)
N1930 endif
N1940
N1950 m30

```

### 10.5.6.3 Adapting active frames

The geometry axis configuration can change during program execution or on `RESET`. The number of available geometry axes can vary from zero to three. With unavailable geometry axes, components in the active frames (e.g. rotations) can lead to the active frames for this axis configuration becoming invalid. This is indicated by the alarms below:

Channel %1 block %2 rotation programmed for non-existent geometry axis

This alarm remains present until the frames have been changed accordingly.

The machine data below can be used to switch on the automatic adaptation of active frames, thus preventing alarm 16440:

MD24040 \$MC\_FRAME\_ADAPT\_MODE

Bitmask for adapting the active frames with reference to the axis constellation.

The following settings apply:

- Bit 0: Rotations in active frames, which rotate coordinate axes with no geometry axes, are deleted from the active frames.
- Bit 1: Shear angles in the active frames are orthogonalized.
- Bit 2: Scalings of all geometry axes in the active frames are set to value 1.

With machine data setting

MD24040 \$MC\_FRAME\_ADAPT\_MODE = 1,

all rotations in the active frames, which could produce coordinate axis movements for non-existent geometry axes, are deleted.

The data management frames are not changed. Only the possible rotations are applied when the data management frames are activated.

Example:

No y axis exists:

MD20050 \$MC\_AXCONF\_GEOAX\_ASSIGN\_TAB[0] = 1

MD20050 \$MC\_AXCONF\_GEOAX\_ASSIGN\_TAB[1] = 0

MD20050 \$MC\_AXCONF\_GEOAX\_ASSIGN\_TAB[2] = 3

\$P\_UIFR[1] = crot(x,45,y,45,z,45)

```
N390 G54 G0 X10 z10 f10000
```

```
if $P_IFRAME <> crot(y,45)
```

```
; Only the rotation about y is taken  
over.
```

```
setal(61000)
```

```
endif
```

## 10.5.7 Predefined frame functions

### 10.5.7.1 Inverse frame

To round off the frame arithmetic, the part program provides a function which calculates the inverse frame from another frame. The chaining between a frame and its inverse frame always produces a zero frame.

FRAME INVFRAME( FRAME )

Frame inversion is an aid for coordinate transformations. Measuring frames are usually calculated in the WCS. If you should wish to transform this calculated frame into another coordinate system, i.e. the calculated frame should be entered into any desired frame within the frame chain, the calculations below should be used.

The new complete frame is a chain of the old complete frame and the calculated frame.

\$P\_ACTFRAME = \$P\_ACTFRAME : \$AC\_MEAS\_FRAME

The new frame in the frame chain is therefore:

Target frame is \$P\_SETFRAME:

\$P\_SETFRAME = \$P\_ACTFRAME : \$AC\_MEAS\_FRAME : INVFRAME(\$P\_ACTFRAME) :  
\$P\_SETFRAME

Target frame is nth channel basic frame \$P\_CHBFRAME[n]:

```
n = 0: TMP = $P_PARTFRAME : $P_SETFRAME : $P_EXTFRAME : $P_NCBFRAME[0..k]
n <> 0: TMP = $P_PARTFRAME : $P_SETFRAME : $P_EXTFRAME :
$P_NCBFRAME[0..k] : $P_CHBFRAME[0..n-1]
k = $MN_MM_NUM_GLOBAL_BASE_FRAMES
$P_CHBFRAME[n] = INVFRAME(TMP) : $P_ACTFRAME : $AC_MEAS_FRAME :
INVFRAME($P_ACTFRAME) : TMP : $P_CHBFRAME[n]
```

Target frame is \$P\_IFRAME:

```
TMP = $P_PARTFRAME : $P_SETFRAME : $P_EXTFRAME : $P_BFRAME
$P_IFRAME = INVFRAME(TMP) : $P_ACTFRAME : $AC_MEAS_FRAME :
INVFRAME($P_ACTFRAME) : TMP : $P_IFRAME
```

Application example:

A frame calculated, for example, via a measuring function, must be entered in the current SETFRAME such that the new complete frame is a chain of the old complete frame and the measurement frame. The SETFRAME is calculated accordingly by means of frame inversions.

```
DEF INT RETVAL
DEF FRAME TMP
```

```
$TC_DP1[1,1]=120 ; Type
$TC_DP2[1,1]=20.;0
$TC_DP3[1,1]= 10. ; (z) length compensation vector
$TC_DP4[1,1]= 0. ; (y)
$TC_DP5[1,1]= 0. ; (x)
$TC_DP6[1,1]= 2. ; Radius
```

```
T1 D1
```

```
g0 x0 y0 z0 f10000
```

```
G54
```

```
$P_CHBFRAME[0] = crot(z,45)
```

```
$P_IFRAME[x,tr] = -sin(45)
```

```
$P_IFRAME[y,tr] = -sin(45)
```

```
$P_PFRAME[z,rt] = -45
```

```
; Measure corner with four measuring points
```

```
$AC_MEAS_VALID = 0

; Approach measuring point 1
g1 x-1 y-3

; Store measuring point 1
$AC_MEAS_LATCH[0] = 1

; Approach measuring point 2
g1 x5 y-3

; Store measuring point 2
$AC_MEAS_LATCH[1] = 1

; Approach measuring point 3
g1 x-4 y4

; Store measuring point 3
$AC_MEAS_LATCH[2] = 1

; Approach measuring point 4
g1 x-4 y1

; Store measuring point 4
$AC_MEAS_LATCH[3] = 1

; Set position setpoint of the corner
$AA_MEAS_SETPOINT[x] = 0
$AA_MEAS_SETPOINT[y] = 0
$AA_MEAS_SETPOINT[z] = 0

; Define setpoint angle of intersection
$AC_MEAS_CORNER_SETANGLE = 90
$AC_MEAS_WP_SETANGLE = 30

; Measuring plane is G17
$AC_MEAS_ACT_PLANE = 0

; Select tool
$AC_MEAS_T_NUMBER = 1
$AC_MEAS_D_NUMBER = 1
```

```

; Set measuring type on corner 1
$AC_MEAS_TYPE = 4

; Start measuring process
RETVAl = MEASURE()

if RETVAL <> 0
setal(61000 + RETVAL)
endif

if $AC_MEAS_WP_ANGLE <> 30
setal(61000 + $AC_MEAS_WP_ANGLE)
endif

if $AC_MEAS_CORNER_ANGLE <> 90
setal(61000 + $AC_MEAS_CORNER_ANGLE)
endif

; Transform measured frame and write in accordance with $P_SETFRAME in such a way
; that a complete frame is produced, as a result of the old complete frame
; being chained with the measuring frame.

$P_SETFRAME = $P_ACTFRAME : $AC_MEAS_FRAME : INVFRAME($P_ACTFRAME) :
$P_SETFRAME

; Describe system frames in data management
$P_SETFR = $P_SETFRAME

; Approach the corner
g1 x0 y0

; Retract the rectangle rotated about 30 degrees
g1 x10
y10
x0
y0

m30

```

### 10.5.7.2 Additive frame in frame chain

Measurements on the workpiece or calculations in the part program and cycles generally produce a frame that is applied additively to the current complete frame. The WCS and thus the programming zero must, therefore, be displaced and possibly rotated. This measured frame is available as a temporary frame and not yet actively included in the frame chain. This function is used to calculate and possible activate this frame:

```
INT ADDFRAME (FRAME, STRING)
```

#### Programming

Parameter 1:      Type: FRAME      Additively measured or calculated frame

Parameter 2:      Type: STRING      Strings for current frames:  
 "\$P\_CYCFRAME", "\$P\_ISO4FRAME",  
 "\$P\_PFRAME", "\$P\_WPFRAME",  
 "\$P\_TOOLFRAME", "\$P\_IFRAME",  
 "\$P\_CHBFRAME[0..16]", "\$P\_NCBFRAME[0..16]",  
 "\$P\_ISO1FRAME", "\$P\_ISO2FRAME",  
 "\$P\_ISO3FRAME",  
 "\$P\_EXTFRAME", "\$P\_SETFRAME"  
 "\$P\_PARTFRAME"

Strings for data management frames:  
 "\$P\_CYCFR", "\$P\_ISO4FR, "\$P\_TRAFR",  
 "\$P\_WPFR",  
 "\$P\_TOOLFR", "\$P\_UIFR[0..99]",  
 "\$P\_CHBFR[0..16]", "\$P\_NCBFR[0..16]",  
 "\$P\_ISO1FR, "\$P\_ISO2FR, "\$P\_ISO3FR,  
 "\$P\_EXTFR", "\$P\_SETFR", "\$P\_PARTFR"

Function value:	Type: INT	Value:	Significance:
		0	OK
		1	Specified target (string) is wrong
		2	Target frame is not configured
		3	Rotation in frame is not permitted

The `ADDFRAME()` function calculates the target frame, which is specified by the `STRING`. The target frame is calculated in such a way that the new complete frame appears as a chain of the old complete frame and the transferred frame, e.g.:

```
ERG = ADDFRAME (TMPFRAME, "$P_SETFRAME")
```

The new complete frame is calculated to be:

$$\$P\_ACTFRAME_{new} = \$P\_ACTFRAME_{old} : TMPFRAME$$

If a current frame has been specified as a target frame, then the new complete frame becomes active at the preprocessing stage. If the target frame is a data management frame, then the frame is not operative until it is explicitly activated in the part program.

The function does not set any alarms, but returns the error codes via the return value. The cycle can react according to the error codes.

## 10.5.8 Functions

### 10.5.8.1 Setting zeros, workpiece measuring and tool measuring

PRESET is achieved using HMI operator actions or measuring cycles. The calculated frame can be written to system frame `SETFRAME`. The position setpoint of an axis in the WCS can be altered when the actual-value memory is preset.

"Scratching" means workpiece and tool measuring. The position of the workpiece in relation to an edge, a corner or a hole can be measured. To determine the zero position of the workpiece or the hole, position setpoints can be added to the measured positions in the WCS. The resultant offsets can be entered in a selected frame. In tool measuring, the length or radius of a tool can be measured using a measured reference part.

Measurements can be taken via operator actions or measuring cycles. Communication with the NCK takes place via predefined system variables. In the NCK, the calculation is made by using a HMI operator action to activate a PI service, or by using a part-program command from the measuring cycles. A tool and a plane can be selected as a basis for the calculation. The calculated frame is entered in the result frame.

### 10.5.8.2 Zero offset external via system frames

#### Zero offset via PLC or part program

The amount of the external zero offset can be specified through HMI and PLC via BTSS or programmed in the part program via the axis-specific system variable `$AA_ETRANS`  
[<Axis>] = <Value>.

##### Activation

The activation of the external zero offset takes place through the interface signal: DB31, ... DBX3.0 (accept external zero offset)

##### Behavior

After the activation the respective specified axis-specific amount of the external zero offset is traversed outside for each axis with the next possible traversing block.

Next possible means that enough dynamic reserves must be available for the respective axis for traversing the zero offset. If the axis is traversed in the next traversing block after activation owing to its programming with the maximum speed, dynamic reserve is no longer available for traversing the external zero offset.

Together with the continuous path mode G64 the traversing of the offset can stretch over several part program blocks.

### Zero offset via system frame

The external zero offset can then also be managed and activated by the functionality described above via the system frame \$P\_EXTFRAME .

#### Configuring

The configuring of the external zero offset is done via the system frame \$P\_EXTFRAME via bit1 = 1 in the machine data: MD28082 \$MC\_MM\_SYSTEM\_FRAME\_MASK = 'B0010'  
The amount for the external zero offset can be specified manually via the HMI user interface and the PLC user program via BTSS or programmed in the part program via the axial system variable \$AA\_ETRANS[<Axis>].

#### Activation

The activation of the external zero offset takes place through the interface signal: DB31, ... DBX3.0 (accept external zero offset)

#### Behavior

Upon activation of the external zero offset the traversing movements of all axes, except command and PLC axes, are stopped immediately and the advance is reorganized. The rough offset of the current system frame and of the system frame in data management is set to the value of the axial system variable \$AA\_ETRANS[<axis>]. Thereafter, the offset is traversed first and then the interrupted movement is continued.

#### Behavior for incremental dimension

In case of active incremental dimension G91 and machine data: MD42440 \$MC\_FRAME\_OFFSET\_INCR\_PROG (zero offset in frames) = 0  
traversing the offset is done in the scope of the external zero offset via system frame, despite opposite configuring of the machine data, with the approach block, although it is specified by a frame.

---

#### Note

The external zero offset always acts absolutely.

---

### 10.5.8.3 Toolholder

#### Translations

With kinematics of type P and M the selection of a toolholder activates an additive frame (table offset of the orientational toolholder), which takes into account the zero point offset as a result of the rotation of the table. The zero offset is entered in a system frame ( $\$P\_PARTFR$ ). In this case the translatory component of this frame is overwritten. Other contents of this frame remain intact.

To be able to use this system frame, the bit 2 must be set in the machine data:  
MD28082  $\$MC\_MM\_SYSTEM\_FRAME\_MASK$ .

Alternatively, there is the option to enter this offset into the basic frame identified by machine data

MD20184  $\$MC\_TOCARR\_BASE\_FRAME\_NUMBER$ .

This option is available in the interests of compatibility with older software versions. It is not recommended for use with new systems.

A frame offset as a result of a toolholder change becomes effective immediately on selection of  $TCARR=$  . . . . A change in the tool length, on the other hand, only becomes effective immediately if a tool is active.

A frame rotation does not take place on activation and a rotation which is already active is not changed. As in case T (only the tool can be rotated), the position of the rotary axes used for the calculation is dependent on the G code  $TCOFR/TCOABS$  and determined from the rotation component of an active frame or from the entries  $\$TC\_CARRn$ . Activation of a frame changes the position in the workpiece coordinate system accordingly, without compensating movement by the machine itself.

The ratios are shown in the figure below:

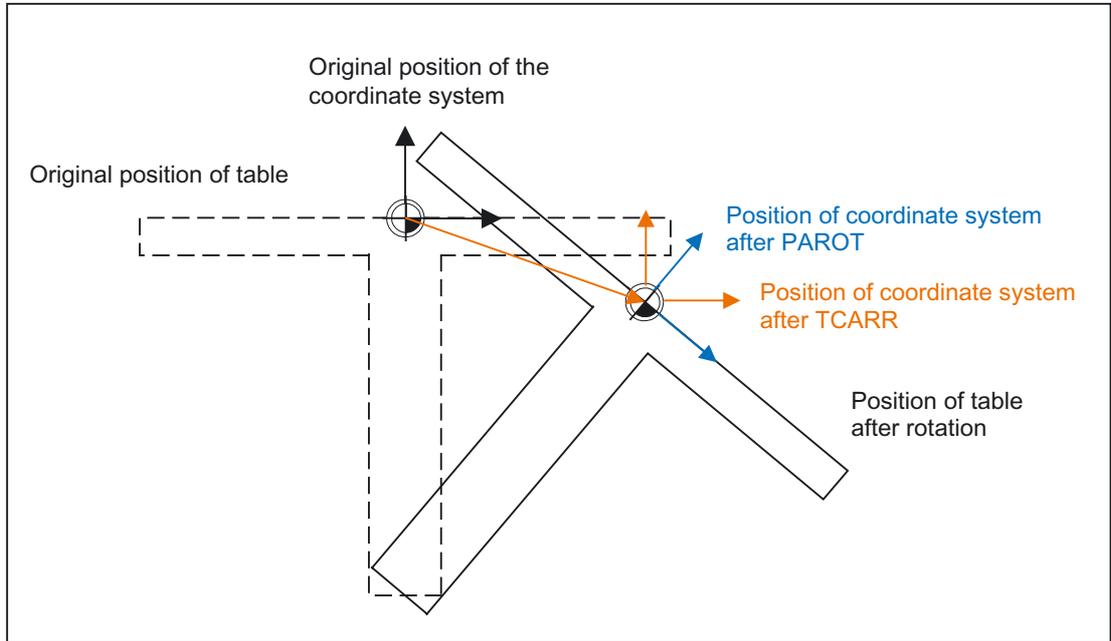


Figure 10-24 Frame on activation of a rotary table with TCARR

With kinematics of type M (tool and table are each rotary around one axis), the activation of a toolholder with `TCARR` simultaneously produces a corresponding change in the effective tool length (if a tool is active) and the zero offset.

## Rotations

Depending on the machining task, it is necessary to take into account not only a zero offset (whether as frame or as tool length) when using a rotary toolholder or table, but also a rotation. However, the activation of an orientational toolholder never leads directly to a rotation of the coordinate system.

If only the tool can be rotated, a frame can be defined for it using `TOFRAME` or `TOROT`.

With rotary tables (kinematics types P and M), activation with `TCARR` similarly does not lead to an immediate rotation of the coordinate system, i.e. even though the zero point of the coordinate system is offset relative to the machine, while remaining fixed relative to the zero point of the workpiece, the orientation remains unchanged in space.

If the coordinate system needs to be fixed relative to the workpiece, i.e. not only offset relative to the original position but also rotated according to the rotation of the table, then `PAROT` can be used to activate such a rotation in a similar manner to the situation with a rotary tool.

With `PAROT`, the translations, scalings and mirroring in the active frame are retained, but the rotation component is rotated by the rotation component of an orientational toolholder corresponding to the table.

Up to and including SW P6.1, the rotation activated by `PAROT` is calculated in the programmable frame (`$P_PFRAME`), thus changing its rotation component.

With SW P6.2 and higher, the entire programmable frame remains unchanged, including its rotation component.

The rotation component, which describes the rotation of the tool table, is then entered into system frame `$PARTFR`, if bit 2 of machine data `MD28082 $MC_MM_SYSTEM_FRAME_MASK` is set.

Alternatively, the basic frame described in machine data `MD20184 $MC_TOCARR_BASE_FRAME_NUMBER` can also be used.

As with the note made in the description of the table offset, the second alternative here is not recommended for use with new systems.

The rotation component of the part frame can be deleted with `PAROTOF`, independently of whether this frame is found in a basic or a system frame.

The translation component is deleted when a toolholder, which does not produce an offset, is activated or a possibly active orientational toolholder is deselected with `TCARR=0`.

`PAROT` or `TOROT` take into account the overall orientation change in cases where the table or the tool are oriented with two rotary axes. With mixed kinematics only the corresponding component caused by a rotary axis is considered. It is thus possible, for example, when using `TOROT`, to rotate a workpiece such that an oblique plane lies parallel to the X-Y plane fixed in space, whereby rotation of the tool must be taken into account in machining where any holes to be drilled, for example, are not perpendicular to this plane.

Example:

On a machine, the rotary axis of the table points in the positive Y direction. The table is rotated by +45 degrees. `PAROT` defines a frame, which similarly describes a rotation of 45 degrees about the Y axis. The coordinate system is not rotated relative to the actual environment (marked in the figure with "Position of the coordinate system after `TCARR`"), but is rotated by -45 degrees relative to the defined coordinate system (position after `PAROT`). If this coordinate system is defined with `ROT Y-45`, for example, and if the toolholder is then selected with active `TCOFR`, an angle of +45 degrees will be determined for the rotary axis of the toolholder.

Language command `PAROT` is not rejected if no orientational toolholder is active. However, such a call then produces no frame changes.

### Machining in direction of tool orientation

Particularly on machines with tools that can be oriented, traversing should take place in the tool direction (typically, when drilling) without activating a frame (e.g. using `TOFRAME` or `TOROT`), on which one of the axes points in the direction of the tool. This is also a problem if, when carrying out oblique machining operations, a frame defining the oblique plane is active, but the tool cannot be set exactly perpendicularly because an indexed toolholder (Hirth tooth system) prevents free setting of the tool orientation. In these cases it is then necessary - contrary to the actually requested motion perpendicular to the plane - to drill in tool direction, as the drill would otherwise not be guided in the direction of its longitudinal axis, which among other things would lead to breaking of the drill.

The end point of such a motion is programmed with `MOV T= . . .`

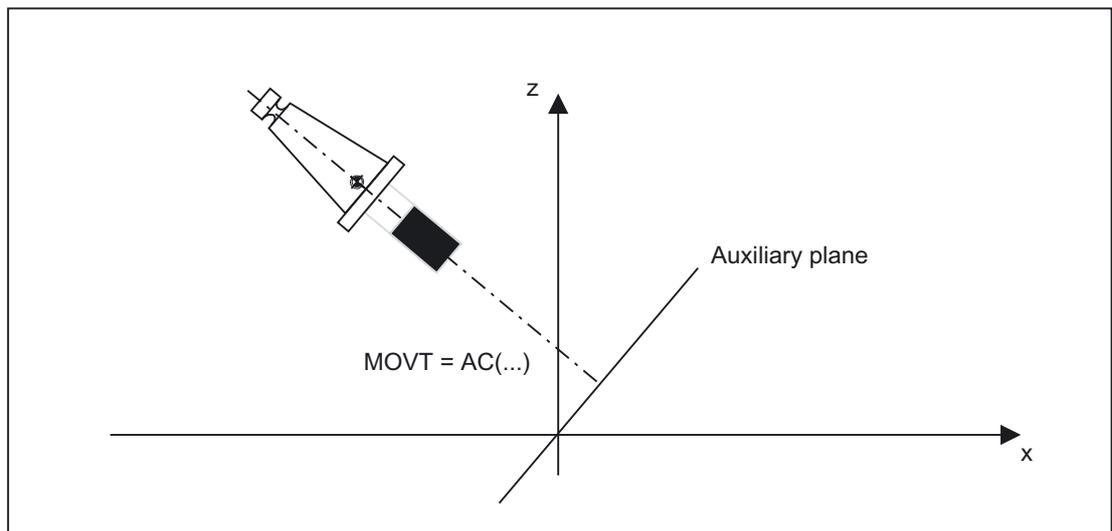
The programmed value is effective incrementally in the tool direction as standard.

The positive direction is defined from the tool tip to the tool adapter. The content of `MOV T` is thus generally negative for the infeed motion (when drilling), and positive for the retraction motion. This corresponds to the situation with normal paraxial machining, e.g. with `G91 Z . . .`

Instead of `MOV T= . . .` it is also possible to write `MOV T=IC ( . . . )` if it is to be plainly visible that `MOV T` is to function incrementally. There is no functional difference between the two forms.

If the motion is programmed in the form `MOV T=AC ( . . . )`, `MOV T` functions absolutely.

In this case a plane is defined, which runs through the current zero point, and whose surface normal vector is parallel to the tool orientation. `MOV T` then gives the position relative to this plane (see figure). The reference plane is only used to calculate the end position. Active frames are not affected by this internal calculation.



Programming with `MOV T` is independent of the existence of a toolholder that can be oriented. The direction of the motion is dependent on the active plane.

It runs in the directions of the vertical axes, i.e. with `G17` in Z direction, with `G18` in Y direction and with `G19` in X direction. This applies both where no orientational toolholder is active and for the case of an orientational toolholder without rotary tool or with a rotary tool in its basic setting.

MOV<sub>T</sub> acts similarly for active orientation transformation (3-4-5-axis transformation).

If in a block with MOV<sub>T</sub> the tool orientation is changed simultaneously (e.g. active 5-axis transformation by means of simultaneous interpolation of the rotary axes), the orientation at the start of the block is decisive for the direction of movement of MOV<sub>T</sub>.

With an active 5-axis transformation, the path of the tool center point (TCP) is not affected by the change of orientation, i.e. the path remains a straight line and its direction is determined by the tool orientation at the start of the block.

If MOV<sub>T</sub> is programmed, linear or spline interpolation must be active (G0, G1, ASPLINE, BSPLINE, CSPLINE). Otherwise, an alarm is produced.

If a spline interpolation is active, the resultant path is generally not a straight line, since the end point calculated by MOV<sub>T</sub> is treated as if it had been programmed explicitly with X, Y, Z.

A block with MOV<sub>T</sub> must not contain any programming of geometry axes (alarm 14157).

### Definition of frame rotations with solid angles

Where a frame is to be defined to describe a rotation around more than one axis, this is achieved through chaining individual rotations. A new rotation is hereby always performed in the already rotated coordinate system.

This also applies to programming in a block e.g. with ROT X... Y... Z...,

(the sequence of rotations is defined by machine data:

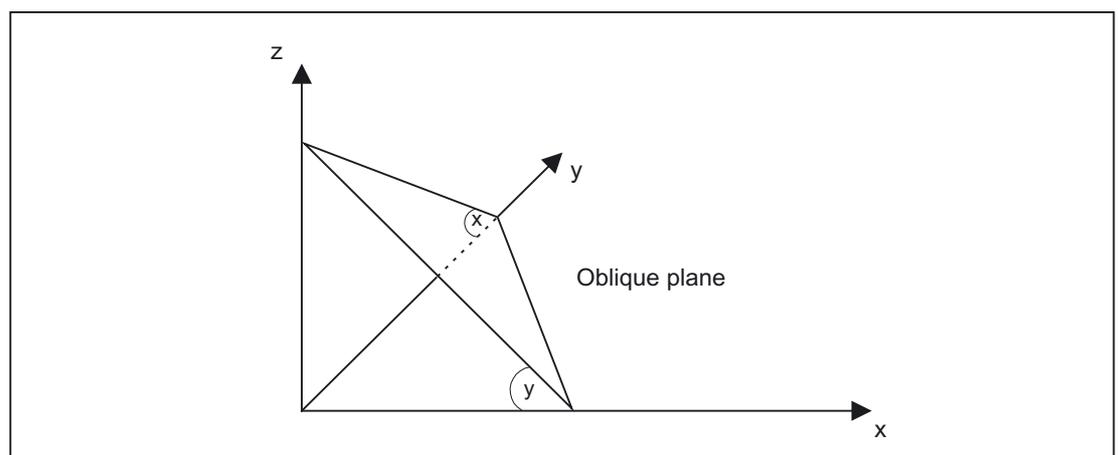
MD10600 \$MN\_FRAME\_ANGLE\_INPUT\_MODE

and is independent of the sequence of the axis letters in the block)

and when constructing a frame in multiple blocks, e.g. in the format:

```
N10 ROT Y...
N20 AROT X...
N30 AROT Z...
```

In workpiece drawings, oblique surfaces are frequently described by way of solid angles, i.e. the angles, which the intersection lines of the oblique plane form with the main planes (X-Y, Y-Z, Z-X planes) (see figure). The machine operator is not expected to convert these solid angles into the angles of rotation of a chaining of individual rotations.



For this reason, the language commands `ROTS`, `AROTS` and `CROTS` are used, with which the rotations can be immediately described as solid angles.

The orientation of a plane in space is defined unambiguously by specifying two solid angles. The third solid angle is derived from the first two. Therefore, a maximum of 2 solid angles may be programmed, e.g. in the form `ROTS X10 Y15`. If a third solid angle is specified, an alarm will be triggered.

It is permissible to specify a single solid angle. The rotations which are performed with `ROTS` or `AROTS` in this case are identical to those for `ROT` and `AROT`.

An expansion of the existing functionality arises only in cases where exactly two solid angles are programmed.

The two programmed axes define a plane, the non-programmed axis defines the related third axis of a right-hand coordinate system. Which axis is first and which second is then unambiguously defined for both programmed axes (the definition corresponds to those found in the plane definition of `G17/G18/G19`). The angle programmed with the axis letter of an axis of the plane then specifies the axis, around which the other axis of the plane must be rotated in order to move this into the line of intersection, which the rotated plane forms with the plane surrounded by the other and the third axis. This definition ensures that, in the case that one of the two programmed angles is towards zero, the defined plane enters the plane, which is created if only one axis is programmed (e.g. with `ROT` or `AROT`).

The diagram shows an example where `X` and `Y` are programmed. `Y` here gives the angle, by which the `X` axis must rotate around the `Y` axis to bring the `X` axis to the line of intersection formed by the oblique plane and the `X-Z` plane. The same principle applies for the programmed value of `X`.

---

#### Note

In the shown position of the oblique plane the value of `Y` is positive, that of `X` on the other hand negative.

---

The specification of the solid angle does not define the orientation of the two-dimensional coordinate system within the plane (i.e. the angle of rotation around the surface normal vector). The position of the coordinate system is thus determined so that the rotated first axis lies in the plane, which is surrounded by the first and third axes of the non-rotated coordinate system.

This means that

- When programming `X` and `Y` the new `X`-axis lies in the old `Z-X` plane.
- When programming `Z` and `X` the new `Z`-axis lies in the old `Y-Z` plane.
- When programming `Y` and `Z` the new `Y`-axis lies in the old `X-Y` plane.

If the required coordinate system does not correspond to this basic setting, then an additional rotation must be performed with `AROT` . . .

On programming the solid angles, they are converted into the equivalent RPY or Euler angles, depending on machine data:

`MD10600 $MN_FRAME_ANGLE_INPUT_MODE`.

These then appear also in the display.

## Frame rotation in tool direction

With the language command `TOFRAME`, which also existed in older software versions, it is possible to define a frame whose Z axis points in the tool direction.

An already programmed frame is then overwritten by a frame, which describes a pure rotation. Any zero offsets, mirrorings or scalings existing in the previously active frame are deleted.

This response is sometimes interfering. It is often particularly practical to retain a zero offset, with which the reference point in the workpiece is defined.

The language command `TOROT` is then also used. This command overwrites only the rotation component in the programmed frame and leaves the remaining components unchanged. The rotation defined with `TOROT` is the same as that defined with `TOFRAME`. `TOROT` is, like `TOFRAME`, independent of the availability of an orientational toolholder. This language command is also especially useful for 5-axis transformations.

The new language command `TOROT` ensures consistent programming with active orientational toolholders for each kinematics type.

`TOFRAME` or `TOROT` defines frames whose Z direction points in the tool direction. This definition is suitable for milling, where `G17` is usually active. However, particularly with turning or, more generally, when `G18` or `G19` is active, it is desirable that frames, which will be aligned on the X or Y axis, can be defined. As a result of this, the G codes below are newly introduced into G code group 53:

```
TOFRAMEX
TOFRMAEY
TOFRAMEZ
TOROTX
TOROTY
TOROTZ
```

These G codes enable corresponding frames to be defined. The functions of `TOFRAME` and `TOFRAMEZ` or of `TOROT` and `TOROTZ` are identical to one another.

With software version P6 and higher, there is the option to write frames produced by `TOROT` or `TOFRAME` into their own system frame (`$P_TOOLFR`).

For this, bit 3 must be set in machine data:

```
MD28082 $MC_MM_SYSTEM_FRAME_MASK.
```

The programmable frame is then retained unchanged.

When programming `TOROT` or `TOFRAME`, etc. response is identical, with or without a system frame. Differences occur when the programmable frame is processed further elsewhere.

In new systems, it is recommended that only the intended system frame is used for frames produced by G codes in group 53.

Example:

`TRANS` is programmed after `TOROT`. `TRANS` without specified parameters deletes the programmable frame. In the variant without a system frame, this also deletes the frame component of the programmable frame produced by `TOROT`, but if the `TOROT` component is in the system frame, it is retained.

TOROT or TOFRAME, etc. are disabled with language command TOROTOF. TOROTOF deletes the entire system frame \$P\_TOOLFR. If the programmable frame (old variant) and not the system frame is described by commands TOFRAME, etc. TOROT only deletes the rotation component and leaves the remaining frame components unchanged.

If a rotating frame is already active before language command TOFRAME or TOROT is activated, a request is often made that the newly defined frame should deviate as little as possible from the old frame. This is the case, for example, if a frame definition needs to be modified slightly because the tool orientation cannot be set freely on account of Hirth-toothed rotary axes. The language commands uniquely define the Z direction of the new frame.

In previous software versions, machine data:

MD21110 \$MC\_X\_AXIS\_IN\_OLD\_X\_Z\_PLANE

can be used to choose between two variants for the position of the X-axis and Y-axis.

However, in both cases there is no reference to the previously active frame.

Setting data

SD42980 \$SC\_TOFRAME\_MODE

is, therefore, introduced, which can be used to control the response of TOFRAME and TOROT. It can accept values of 0 (inactive) to 3. If the value of the setting data is not zero, the effect of machine data:

MD21110 \$MC\_X\_AXIS\_IN\_OLD\_X\_Z\_PLANE is overwritten.

The values 1 to 3 have the following meanings:

- 1: The new X direction is chosen to lie in the X-Z plane of the old coordinate system. In this setting the angle difference between the old and new Y axis will be minimal.
- 2: The new Y direction is chosen to lie in the Y-Z plane of the old coordinate system. In this setting the angle difference between the old and new Y axis will be minimal.
- 3: The value chosen is the mean value of the two settings, which would have been chosen with 1 and 2.

**Characteristics and expansions:**

Settings 1 and 2 are reached by rotating the coordinate system around the Z axis, starting from any position on the X and Y axis, until the desired setting is reached. Setting 3 is achieved by executing a rotation whose value is the exact mean of these two angles. However, this only applies for the case that the old and new Z direction enclose an angle of less than 90 degrees. With variant 1, both the old and new X axes form an angle of under 90 degrees, with variant 2 the same is true of the Y axis (the relevant axes point in "approximately" the same direction). If the two Z directions form an angle of more than 90 degrees, however, the conditions of an angle < 90 degrees between the old and new axes can no longer be met simultaneously for both X and Y. In this case, priority is given to the X direction, i.e. a mean value is taken from the direction for 1 and the negative direction for 2.

If one of the G codes TOFRAMEX, TOFRAMEY, TOROTX, TOROTY is programmed in place of TOFRAME (Z) or TOROT (Z), the descriptions for adapting the axis directions perpendicular to the main direction are also valid for the cyclically exchanged axes. The assignments in the table below are then valid:

	TOFRAME, TOFRAMEZ TOROT, TOROTZ	TOFRAMEY TOROTY	TOFRAMEX TOROTX
Tool direction (vertical axis)	Z	Y	X
Secondary axis (horizontal axis)	X	Z	Y
Secondary axis (ordinate)	Y	X	Z

**Example**

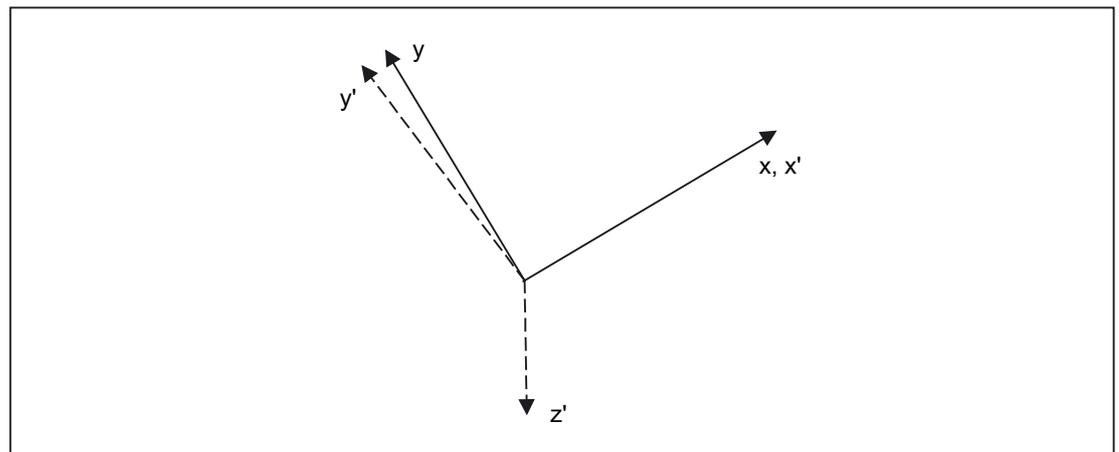
```

...
...
N90 $SC_TOFRAME_MODE=1
N100 ROT Z45
N110 TCARR=1 TCOABS T1 D1
N120 TOROT
...
...

```

N100 describes a rotation by 45 degrees in the X-Y plane. It is assumed that the toolholder activated in N110 rotates the tool by 30 degrees around the X axis, i.e. the tool lies in the Y-Z plane and is rotated by 30 degrees relative to the Z axis. As a result the Z axis of the frame newly defined in N120 also points in this direction (independently of the value in setting data SD42980 \$SC\_TOFRAME\_MODE in N90).

In the figure below, the situation for setting data setting: SD42980 \$SC\_TOFRAME\_MODE=1 is shown:



The old and new X axes X and X' coincide in the projection in the direction of the old Z axis. The old and new Y axes Y and Y' form an angle of 8.13 degrees (right angles are generally not retained in the projection).

For setting data setting:

SD42980 \$SC\_TOFRAME\_MODE=2,

Y and Y' would coincide accordingly and X and X' would form an angle of 8.13 degrees.

For setting data setting:

SD42980 \$SC\_TOFRAME\_MODE=3,

X and X', as well as Y and Y', would each form an angle of 4.11 degrees.

---

**Note**

The named angles (8.13 and 4.11 degrees) are the angles, which the projections of the axes form in the X-Y plane. They are not the spatial angles of these axes.

---

## TCARR and PAROT

Previously, TCARR has used the basic frame identified by machine data:

MD20184 \$MC\_TOCARR\_BASE\_FRAME\_NUMBER.

A system frame can be created for TCARR and PAROT alone, in order to avoid conflicts with systems, which already use all the basic frames.

PAROT, TOROT and TOFRAME have previously changed the rotation component of the programmable frame. In this case, it is not possible to shut down PAROT or TOROT separately. On RESET, the programmable frame is deleted, which means the after changing the operating mode to JOG, the rotation component of PAROT and TOROT is no longer available. The user must also have unrestricted access to the programmable frame. Frames produced by PAROT and TOROT must be able to be archived and reloaded via data backup.

The system frame for TCARR and PAROT is configured with bit 2 in machine data:

MD28082 \$MC\_MM\_SYSTEM\_FRAME\_MASK.

Machine data:

MD20184 \$MC\_TOCARR\_BASE\_FRAME\_NUMBER

is then no longer evaluated.

If the system frame for TCARR is configured, TCARR and PAROT describe that system frame; otherwise the basic frame identified by machine data:

MD20184 \$MC\_TOCARR\_BASE\_FRAME\_NUMBER

is described.

With kinematics systems of the types P and M, TCARR will enter the table offset of the orientational toolholder (zero offset resulting from the rotation of the table) as a translation into the system frame. PAROT converts the system frame such, that a part-oriented WCS results.

The system frames are stored in the SRAM and, therefore, remain stored after Reset. The system frames also remain active in the case of a mode change.

For the display, the G codes PAROT and TOROT, TOFRAME are each assigned to a separate G code group.

## PAROTOF

PAROTOF is the switch off command for PAROT. This command deletes the rotations in the system frame for PAROT. In so doing, the rotations in the current \$P\_PARTFRAME and in the data management frame \$P\_PARTFR are deleted. The position of the coordinate system is then recreated according to TCARR. PAROTOF is in the same G code group as PAROT and appears, therefore, in the G code display.

## TOROT and TOFRAME

The system frame for TOROT and TOFRAME is configured with bit 3 in machine data: MD28082 \$MC\_MM\_SYSTEM\_FRAME\_MASK.  
This system frame is located before the programmable frame in the frame chain.  
The SZS coordinate system is located before the programmable frame.

## TOROTOF

TOROTOF is the switch off command for TOROT and TOFRAME. This command deletes the system frame for TOROT and TOFRAME. The current \$P\_TOOLFRAME and the data management frame \$P\_TOOLFR are also deleted. TOROTOF is in the same G code group as TOROT and TOFRAME and appears, therefore, in the G code display.

## Example

Example of using an orientational toolholder with deactivated kinematics:

```

N10          $TC_DP1[1,1]= 120
N20          $TC_DP3[1,1]=13           ; Tool length 13 mm
; Definition of toolholder 1:
N30          $TC_CARR1[1] = 0          ; X components of 1st offset vector
N40          $TC_CARR2[1] = 0          ; Y components of 1st offset vector
N50          $TC_CARR3[1] = 0          ; Z components of 1st offset vector
N60          $TC_CARR4[1] = 0          ; X components of 2nd offset vector
N70          $TC_CARR5[1] = 0.         ; Y components of 2nd offset vector
N80          $TC_CARR6[1] = -15.       ; Z components of 2nd offset vector
N90          $TC_CARR7[1] = 1          ; X components of 1st axis
N100         $TC_CARR8[1] = 0          ; Y components of 1st axis
N110         $TC_CARR9[1] = 0          ; Z components of 1st axis
N120         $TC_CARR10[1] = 0         ; X components of 2nd axis
N130         $TC_CARR11[1] = 1         ; Y components of 2nd axis
N140         $TC_CARR12[1] = 0         ; Z components of 2nd axis
N150         $TC_CARR13[1] = 30.       ; Angle of rotation of 1st axis
N160         $TC_CARR14[1] = -30.     ; Angle of rotation of 2nd axis
N170         $TC_CARR15[1] = 0         ; X components of 3rd offset vector
N180         $TC_CARR16[1] = 0         ; Y components of 3rd offset vector
N190         $TC_CARR17[1] = 0         ; Z components of 3rd offset vector
    
```

```

N200      $TC_CARR18[1] = 0           ; X components of 4th offset vector
N210      $TC_CARR19[1] = 0           ; Y component of 4th offset vector
N220      $TC_CARR20[1] = 15.         ; Z components of 4th offset vector
N230      $TC_CARR21[1] = A           ; Reference for 1st axis
N240      $TC_CARR22[1] = B           ; Reference for 2nd axis
N250      $TC_CARR23[1] = "M"         ; Toolholder type
N260      X0 Y0 Z0 A0 B45 F2000
N270      TCARR=1 X0 Y10 Z0 T1 TCOABS ; Selection of orient. toolholder
N280      PAROT                       ; Rotation of table
N290      TOROT                       ; Rotation of z axis in tool orient.
N290      X0 Y0 Z0
N300      G18 MOVT=AC(20)             ; Processing in G18 plane
N310      G17 X10 Y0 Z0              ; Processing in G17 plane
N320      MOVT=-10
N330      PAROTOF                     ; Deactivate rotation of table
N340      TOROTOF                     ; No longer align WCS with tool
N400M30
    
```

### 10.5.9 Subprograms with SAVE attribute (SAVE)

#### Settable frames G54 to G599

In case of adjustable frames the behavior depends on the setting of:  
MD10617 \$MN\_FRAME\_SAVE\_MASK.BIT0

- BIT0 = 0  
If the subprogram uses only the active adjustable frame, but which retains the G function, the change is then also retained after the end of the subprogram.
- BIT0 = 1  
With the end of the subprogram the adjustable frame which is active before the subroutine call or the corresponding G function is reactivated.

#### Basic frames \$P\_CHBFR[ ] and \$P\_NCBFR[ ]

In case of basic frames the behavior depends on the setting of:  
MD10617 \$MN\_FRAME\_SAVE\_MASK.BIT1

- BIT1 = 0  
If the active basic frame is changed by the subprogram, the change remains effective even after the end of the subprogram.
- BIT1 = 1  
With the end of the subprogram the basic frame which is active before the subroutine call is reactivated.

## Programmable frame

With the end of the subprogram the programmable frame active before the subroutine call is reactivated.

## System frames

If the system frames are changed by the subprogram, the change remains effective even after the end of the subprogram.

### 10.5.10 Data backup

Data block `_N_CHANx_UFR` is used to archive the system frames.

Machine data

`MD28082 $MC_MM_SYSTEM_FRAME_MASK`

should not have changed between saving and reintroducing the saved system frames. If it has changed then it is possible that saved system frames could no longer be loaded. In this case, the loading process triggers an alarm.

Data backup always takes place in accordance with the currently valid geometry axis assignment, not in accordance with the axis configurations set in the machine data.

The machine data

`$MC_MM_SYSTEM_DATAFRAME_MASK`

can be used to configure data management frames for the system frames.

If you do not want a data management frame for a system frame, the frame does not have to be saved. With `G500`, `G54` to `G599`, the active frame is retained.

A separate data block `_N_NC_UFR` is used to archive global frames.

The block requested by the HMI is created if the machine data

`MD18601 $MN_MM_NUM_GLOBAL_USER_FRAMES`

or

`MD18602 $MN_MM_NUM_GLOBAL_BASE_FRAMES`

has a value greater than zero.

Channel-specific frames are saved in data block `_N_CHANx_UFR`.

In certain circumstances, alarms could be triggered when reintroducing saved data, if the frame affiliates, be they NCU global or channel-specific, have been changed using machine data.

Data backup always takes place in accordance with the axis configuration set in the machine data, not in accordance with the currently valid geometry axis assignment.

### 10.5.11 Positions in the coordinate system

The setpoint positions in the coordinate system can be read via the following system variables. The actual values can be displayed in the WCS, SZS, BZS or MCS via the PLC. There is a softkey for actual-value display in MCS/WCS. Machine manufacturers can define on the PLC side, which coordinate system corresponds to the workpiece coordinate system on their machines. The HMI requests the appropriate actual values from the NCK.

#### **\$AA\_IM[axis]**

The setpoints in the machine coordinate system can be read for each axis using the variables \$AA\_IM[axis].

#### **\$AA\_IEN[axis]**

The setpoints in the settable zero system (SZS) can be read for each axis using the variables \$AA\_IEN[axis].

#### **\$AA\_IBN[axis]**

The setpoints in the basic zero system (BZS) can be read using the variable \$AA\_IBN[axis].

#### **\$AA\_IW[axis]**

The setpoints in the workpiece coordinate system (WCS) can be read using the variable \$AA\_IW[axis].

## 10.5.12 Control system response

### 10.5.12.1 POWER ON

#### Frame conditions after POWER ON

Frame	Frame conditions after POWER ON
Programmable frame	Deleted.
Settable frames	Are retained, depending on: MD24080 \$MC_USER_FRAME_POWERON_MASK Bit 0 = 1 MD20152 \$MC_GCODE_RESET_MODE[7] = 1
Complete basic frame	Retained, depending on MD20110 \$MC_RESET_MODE_MASK bit 0 and bit 14 Individual basic frames can be deleted with MD10615 \$MN_NCBFRAME_POWERON_MASK and MD24004 \$MC_CHBFRAME_POWERON_MASK.
System frames	Retained Depending on: MD24008 \$MC_CHSFRAME_POWERON_MASK, individual system frames can be deleted on POWER ON. Deletion of system frame is executed in the data management on first priority.
Zero offset external	Permanent, but has to be activated again. The system frame is retained.
DRF offset	Deleted.

### 10.5.12.2 Mode change

#### System frames

System frames are retained and remain active when the operating mode is changed.

#### JOG mode

In JOG mode, the frame components of the current frame are only taken into account for the geometry axes if a rotation is active. No other axial frames are taken into account.

#### PLC and command axes

The response for PLC and command axes can be set via machine data:

MD32074 \$MA\_FRAME\_OR\_CORRPOS\_NOTALLOWED (Frame or HL correction is not permissible)

### 10.5.12.3 RESET, end of part program

#### RESET responses of basic frames

The RESET response of basic frames is set via the machine data:

MD20110 \$MC\_RESET\_MODE\_MASK (definition of initial control settings after RESET/TP end)

#### RESET responses of system frames

The system frames are retained in the data management after a Reset.

The machine data below can be used to configure the activation of individual system frames:

MD24006 \$MC\_CHSFRAME\_RESET\_MASK (active system frames after Reset)

Bit	Significance
0	System frame for actual value setting and scratching is active after RESET.
1	System frame for zero offset external is active after RESET.
2	Is not evaluated.
3	Is not evaluated.
4	System frame for workpiece reference point is active after RESET.
5	System frame for cycles is active after RESET.
6	Reserved, RESET response depends on MD20110 \$MC_RESET_MODE_MASK.
7	System frame \$P_ISO1FR is active after RESET.
8	System frame \$P_ISO2FR is active after RESET.
9	System frame \$P_ISO3FR is active after RESET.
10	System frame \$P_ISO4FR is active after RESET.
11	System frame \$P_RELFR is active after RESET.

#### RESET response of the system frames of TCARR, PAROT, TOROT and TOFRAME

The RESET response of the system frames of TCARR, PAROT, TOROT and TOFRAME depends on the G-Code RESET setting.

The setting is made with machine data:

MD20110 \$MC\_RESET\_MODE\_MASK (definition of initial control settings after RESET/TP end)

MD20152 \$MC\_GCODE\_RESET\_MODE[ ] (RESET response of G groups)

MD20150 \$MC\_GCODE\_RESET\_VALUES (RESET position of G groups)

MD20110	Significance	
Bit 0 = 0	TCARR and PAROT system frames are retained as before the RESET.	
Bit 0 = 1	MD20152 \$MC_GCODE_RESET_MODE[51] = 0	
	MD20150 \$MC_GCODE_RESET_VALUES[51] = 1	PAROTOF
	MD20150 \$MC_GCODE_RESET_VALUES[51] = 2	PAROT
	MD20152 \$MC_GCODE_RESET_MODE[51] = 1	
	TCARR and PAROT system frames are retained as before the RESET.	
	MD20152 \$MC_GCODE_RESET_MODE[52] = 0	
	MD20150 \$MC_GCODE_RESET_VALUES[52] = 1	TOROTOF
	MD20150 \$MC_GCODE_RESET_VALUES[52] = 2	TOROT
	MD20150 \$MC_GCODE_RESET_VALUES[52] = 3	TOFRAME
	MD20152 \$MC_GCODE_RESET_MODE[52] = 1	
TOROT and TOFRAME system frames are retained as before the RESET.		

TCARR and PAROT are two independent functions, which describe the same frame. With PAROTOF, the component of TCARR is not activated on RESET.

MD20110	Significance	
Bit 0 = 1 and bit 14 = 0	Chained complete basic frame is deleted.	
Bit 0 = 1 and bit 14 = 1	The complete basic frame is derived on the basis of: MD24002 \$MC_CHBFRAME_RESET_MASK (active channel-specific basic frame after RESET) and MD10613 \$MN_NCBFRAME_RESET_MASK (active NCU global basic frame after RESET)	
	MD24002 \$MC_CHBFRAME_RESET_MASK	
	Bit 0 = 1	1st channel basic frame is calculated into the chained complete basic frame.
	Bit 7 = 1	8th channel basic frame is calculated into the chained complete basic frame.
	MD10613 \$MN_NCBFRAME_RESET_MASK	
	Bit 0 = 1	1st NCU global basic frame is calculated into the chained complete basic frame.
	Bit 7 = 1	8th NCU global basic frame is calculated into the chained complete basic frame.

**Frame conditions after RESET/parts program end**

Frame	Condition after RESET/part program end
Programmable frame	Deleted.
Settable frames	Retained, depending on MD20110 \$MC_RESET_MODE_MASK and MD20152 \$MC_GCODE_RESET_MODE.
Complete basic frame	Retained, depending on: MD20110 \$MC_RESET_MODE_MASK Bit 0 and Bit 14, MD10613 \$MN_NCBFRAME_RESET_MASK and MD24002 \$MC_CHBFRAME_RESET_MASK.
System frames	Retained, depending on MD24006 \$MC_CHSFRAME_RESET_MASK and MD20150 \$MC_GCODE_RESET_VALUES[ ].
External zero offset	Retained
DRF offset	Retained

**Deletion of system frames**

The system frames in the data management can be deleted during RESET using machine data:

MD24007 \$MC\_CHSFRAME\_RESET\_CLEAR\_MASK (deletion of system frames during RESET)

Bit	Significance
0	System frame for actual value setting and scratching is deleted during RESET.
1	System frame for zero offset external is deleted during RESET.
2	Reserved, for TCARR and PAROT see MD20150 \$MC_GCODE_RESET_VALUES[ ].
3	Reserved, for TOROT and TOFRAME see MD20150 \$MC_GCODE_RESET_VALUES[ ].
4	System frame for workpiece reference points is deleted during RESET.
5	System frame for cycles is deleted during RESET.
6	Reserved, RESET response depends on MD20110 \$MC_RESET_MODE_MASK.
7	System frame for \$P_ISO1FR is deleted during RESET.
8	System frame for \$P_ISO2FR is deleted during RESET.
9	System frame for \$P_ISO3FR is deleted during RESET.
10	System frame for \$P_ISO4FR is deleted during RESET.
11	System frame \$P_RELFR is deleted during RESET.

### 10.5.12.4 Part program start

#### Frame conditions after part program start

Frame	Condition after parts program start
Programmable frame	Deleted.
Settable frames	Retained, depending on: MD20112 \$MC_START_MODE_MASK
Complete basic frame	Retained
System frames	Retained
External zero offset	Retained
DRF offset	Retained

### 10.5.12.5 Block search

#### Block search

Data management frames are also modified when carrying out a block search with calculation.

#### Cancellation of block search

If the block search is aborted with RESET, then the machine data:  
MD28560 \$MC\_MM\_SEARCH\_RUN\_RESTORE\_MODE  
can be used to configure that all data management frames are set to the value they had before the block search:

Bit	Significance
0	All frames in the data management are restored.

In case of cascaded block searches, the frames are set to the status of the previous block search.

#### SERUPRO

The "SERUPRO" function is not supported.

### 10.5.12.6 REPOS

There is no special treatment for frames. If a frame is modified in an ASUB, it is retained in the program. On repositioning with REPOS, a modified frame is included, provided the modification was activated in the ASUB.

## 10.6 Workpiece-related actual-value system

### 10.6.1 Overview

#### Definition

The term "workpiece-related actual-value system" designates a series of functions that permit the user:

- To use a workpiece coordinate system defined in machine data after power-up.  
Features:
  - No additional operations are necessary.
  - Effective in JOG and AUTOMATIC modes
- To retain the valid settings for the following after end of program for the next part program:
  - Active plane
  - Settable frame (G54-G57)
  - Kinematic transformation
  - Active tool offset
- To change between work coordinate system and machine coordinate system via the user interface.
- To change the work coordinate system by operator action (e.g. changing the settable frame or the tool offset).

### 10.6.2 Use of workpiece-related actual-value system

#### Requirements, basic settings

The settings described in the previous Section have been made for the system.  
The predefined setting after power-up of the HMI software is MCS.

#### Switchover to WCS

The change to the WCS via the user interface causes the axis positions relative to the origin of the WCS to be displayed.

#### Switchover to MCS

The change to the MCS via the user interface causes the axis positions relative to the origin of the MCS to be displayed.

### Interrelationships between coordinate systems

The figure below shows the interrelationships between the machine coordinate system (MCS) and the workpiece coordinate system (WCS).

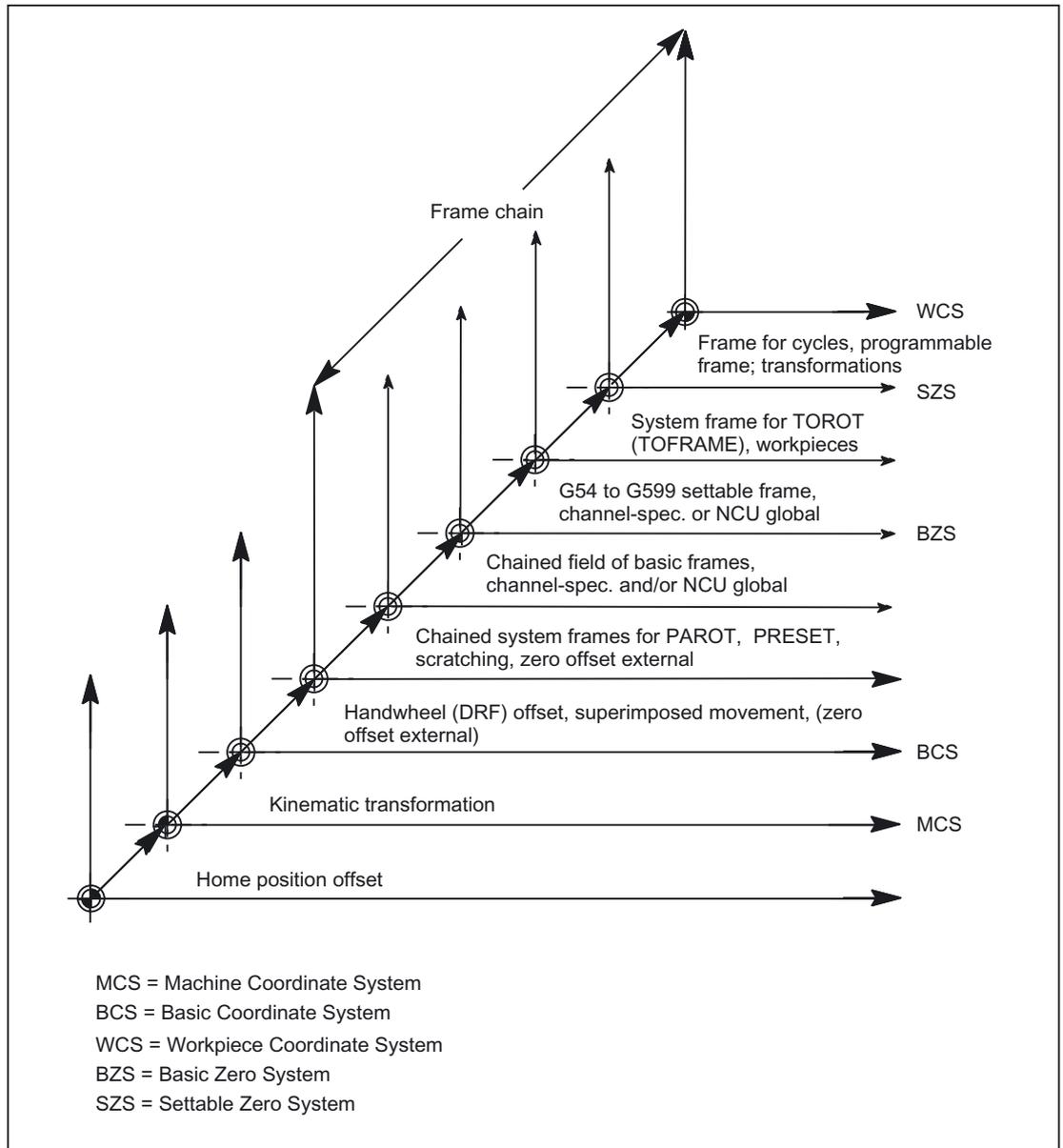


Figure 10-25 Interrelationship between coordinate systems

#### References:

- /PG/ Programming Guide, Fundamentals
- /FB1/ Function Manual, Basic Functions; Tool Offset (W1)
- /FB1/ Function Manual, Basic Functions; Auxiliary Function Outputs to PLC (H2)
- /FB2/ Function Manual, Extended Functions; Kinematic Transformation (M1)
- /FB3/ Function Manual, Special Functions; Axis Couplings and ESR (M3);  
 Section: Coupled Motion, Chapter: Master Value Coupling
- /FB3/ Function Manual, Special Functions; Tangential Control (T3)

### 10.6.3 Special reactions

#### Overstore

Overstoring in `RESET` state of:

- Frames (zero offsets)
- Active plane
- Activated transformation
- Tool offset

immediately affects the actual-value display of all axes in the channel.

#### Entry via operator panel front

If operations on the operator panel are used to change the values for "Active frame" (zero offsets, "Parameters" operating area) and "Active tool length compensation" ("Parameters" operating area), one of the following actions is used to activate these changes in the display:

- Press the `RESET` key.
- Reselect:
  - Zero offset by the part program
  - Tool offset by the part program
- Reset:
  - Zero offset by overstoreing
  - Tool offset by overstoreing
- Part-program start

#### MD9440

If the HMI machine data `MD9440 ACTIVATE_SEL_USER_DATA` for the operator panel front is set, the entered values become active immediately in `RESET` state.

When values are entered in the part-program execution stop state, they become effective when program execution continues.

#### Actual-value reading

If the actual value of `$AA_IW` is read in the WCS after activation of a frame (zero offset) or a tool offset, the activated changes are already contained in the result read even if the axes have not yet been traversed with the activated changes.

The actual values in the settable zero system (SZS) can be read from the part program for each axis using the variable `$AA_IEN[axis]`.

The actual values in the basic zero system (BZS) can be read from the part program for each axis using the variable \$AA\_IBN[axis].

### **Actual-value display**

The programmed contour is always displayed in the WCS.

The following offsets are added to the MCS:

- Kinematic transformation
- DRF offset/zero offset external
- Active frame
- Active tool offset of the current tool

### **Switchover by PLC**

The actual values can be displayed in the WCS, SZS, BZS or MCS via the PLC. The PLC can define, which coordinate system corresponds to the workpiece coordinate system on a machine.

On MMC power-on the MCS is preset.

With the signal DB19 DBB0.7 "MCS/WCS switchover", it is also possible to switch from the PLC to the WCS.

### **Transfer to PLC**

Depending on machine data

MD20110/MD20112, bit 1,

the auxiliary functions (D, T, M) are output to the PLC (or not) on selection of the tool length compensation.

---

#### **Note**

If the WCS is selected from the PLC, an operator action can still be used to switch between the WCS and MCS for the relevant mode.

However, when the mode and or area is changed, the WCS selected by the PLC is evaluated and activated.

#### **References:**

/FB1/ Function Manual, Basic Functions; Mode Group, Channel, Program Operation, Reset Response (K1)

---

## **10.7 Restrictions**

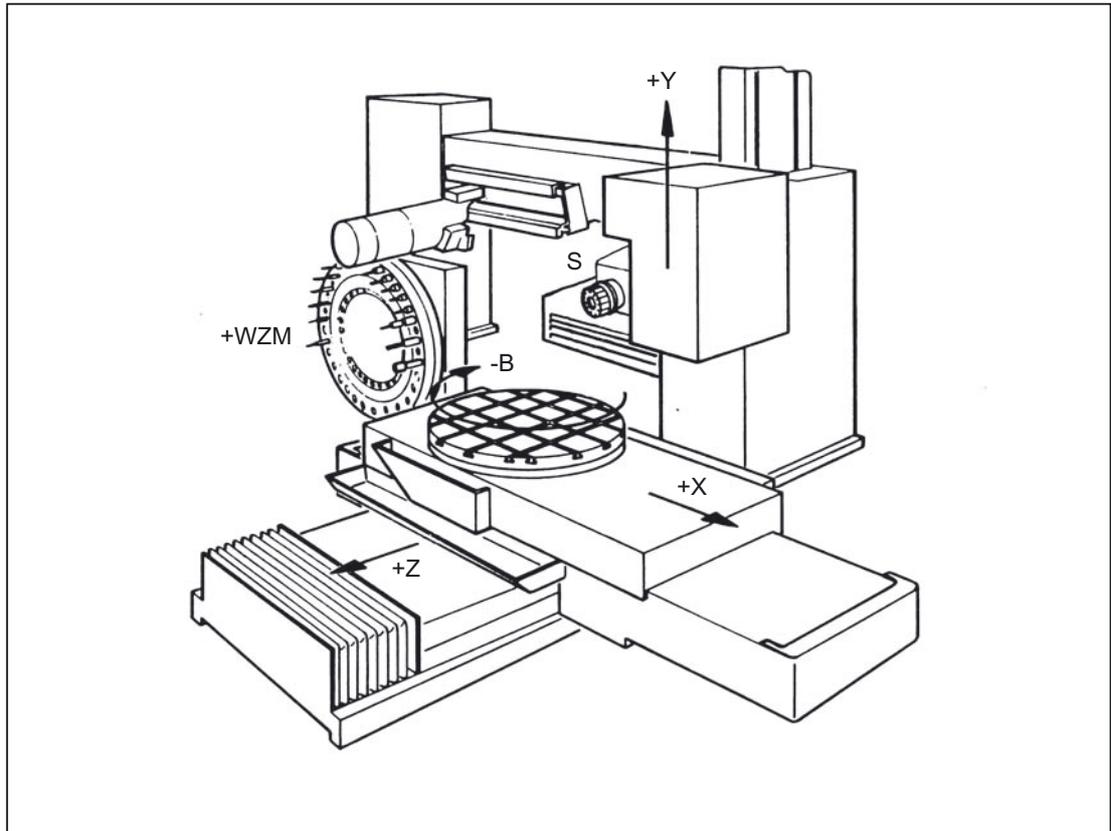
There are no supplementary conditions to note.

## 10.8 Examples

### 10.8.1 Axes

#### Axis configuration for a 3-axis milling machine with rotary table

1st machine axis: X1	Linear axis
2nd machine axis: Y1	Linear axis
3rd machine axis: Z1	Linear axis
4th machine axis: B1	Rotary table (for turning for multiface machining)
5th machine axis: W1	Rotary axis for tool magazine (tool revolver)
6th machine axis: C1	(Spindle)
1st geometry axis: X	(1st channel)
2nd geometry axis: Y	(1st channel)
3rd geometry axis: Z	(1st channel)
1st special axis: B	(1st channel)
2nd special axis: WZM	(1st channel)
1st spindle: S1/C	(1st channel)



Parameterization of the machine data

Machine data	Value
MD10000 AXCONF_MACHAX_NAME_TAB[0]	= X1
MD10000 AXCONF_MACHAX_NAME_TAB[1]	= Y1
MD10000 AXCONF_MACHAX_NAME_TAB[2]	= Z1
MD10000 AXCONF_MACHAX_NAME_TAB[3]	= B1
MD10000 AXCONF_MACHAX_NAME_TAB[4]	= W1
MD10000 AXCONF_MACHAX_NAME_TAB[5]	= C1
MD20050 AXCONF_GEOAX_ASSIGN_TAB[0]	= 1
MD20050 AXCONF_GEOAX_ASSIGN_TAB[1]	= 2
MD20050 AXCONF_GEOAX_ASSIGN_TAB[2]	= 3
MD20060 AXCONF_GEOAX_NAME_TAB[0]	=X
MD20060 AXCONF_GEOAX_NAME_TAB[1]	=Y
MD20060 AXCONF_GEOAX_NAME_TAB[2]	=Z
MD20070 AXCONF_MACHAX_USED[0]	= 1

Machine data	Value
MD20070 AXCONF_MACHAX_USED[1]	= 2
MD20070 AXCONF_MACHAX_USED[2]	= 3
MD20070 AXCONF_MACHAX_USED[3]	= 4
MD20070 AXCONF_MACHAX_USED[4]	= 5
MD20070 AXCONF_MACHAX_USED[5]	= 6
MD20080 AXCONF_CHANAX_NAME_TAB[0]	=X
MD20080 AXCONF_CHANAX_NAME_TAB[1]	=Y
MD20080 AXCONF_CHANAX_NAME_TAB[2]	=Z
MD20080 AXCONF_CHANAX_NAME_TAB[3]	= B
MD20080 AXCONF_CHANAX_NAME_TAB[4]	= WZM
MD20080 AXCONF_CHANAX_NAME_TAB[5]	= S1
MD30300 IS_ROT_AX[3]	= 1
MD30300 IS_ROT_AX[4]	= 1
MD30300 IS_ROT_AX[5]	= 1
MD30310 ROT_IS_MODULO[3]	= 1
MD30310 ROT_IS_MODULO[4]	= 1
MD30310 ROT_IS_MODULO[5]	= 1
MD30320 DISPLAY_IS_MODULO[3]	= 1
MD30320 DISPLAY_IS_MODULO[4]	= 1
MD20090 SPIND_DEF_MASTER_SPIND	= 1
MD35000 SPIND_ASSIGN_TO_MACHAX[AX1]	= 0
MD35000 SPIND_ASSIGN_TO_MACHAX[AX2]	= 0
MD35000 SPIND_ASSIGN_TO_MACHAX[AX3]	= 0
MD35000 SPIND_ASSIGN_TO_MACHAX[AX4]	= 0
MD35000 SPIND_ASSIGN_TO_MACHAX[AX5]	= 0
MD35000 SPIND_ASSIGN_TO_MACHAX[AX6]	= 1

### 10.8.2 Coordinate systems

#### Configuring a global basic frame

An NC with 2 channels is required. The following applies:

- The global basic frame can then be written by either channel.
- The other channel recognizes this change when the global basic frame is reactivated.
- The global basic frame can be read by either channel.
- Either channel can activate the global basic frame for that channel.

#### Machine data

Machine data	Value
MD10000 \$MN_AXCONF_MACHAX_NAME_TAB[0]	= X1
MD10000 \$MN_AXCONF_MACHAX_NAME_TAB[1]	= X2
MD10000 \$MN_AXCONF_MACHAX_NAME_TAB[2]	= X3
MD10000 \$MN_AXCONF_MACHAX_NAME_TAB[3]	= X4
MD10000 \$MN_AXCONF_MACHAX_NAME_TAB[4]	= X5
MD10000 \$MN_AXCONF_MACHAX_NAME_TAB[5]	= X6
MD18602 \$MN_MM_NUM_GLOBAL_BASE_FRAMES	= 1
MD28081 \$MC_MM_NUM_BASE_FRAMES	= 1

Machine data for channel 1	Value	Machine data for channel 1	Value
\$MC_AXCONF_CHANAX_NAME_TAB[0]	=X	\$MC_AXCONF_CHANAX_NAME_TAB[0]	=X
\$MC_AXCONF_CHANAX_NAME_TAB[1]	=Y	\$MC_AXCONF_CHANAX_NAME_TAB[1]	=Y
\$MC_AXCONF_CHANAX_NAME_TAB[2]	=Z	\$MC_AXCONF_CHANAX_NAME_TAB[2]	=Z
\$MC_AXCONF_MACHAX_USED[0]	= 1	\$MC_AXCONF_MACHAX_USED[0]	= 4
\$MC_AXCONF_MACHAX_USED[1]	= 2	\$MC_AXCONF_MACHAX_USED[1]	= 5
\$MC_AXCONF_MACHAX_USED[2]	= 3	\$MC_AXCONF_MACHAX_USED[2]	= 6
\$MC_AXCONF_GEOAX_NAME_TAB[0]	=X	\$MC_AXCONF_GEOAX_NAME_TAB[0]	=X
\$MC_AXCONF_GEOAX_NAME_TAB[1]	=Y	\$MC_AXCONF_GEOAX_NAME_TAB[1]	=Y
\$MC_AXCONF_GEOAX_NAME_TAB[2]	=Z	\$MC_AXCONF_GEOAX_NAME_TAB[2]	=Z
\$MC_AXCONF_GEOAX_ASSIGN_TAB[0]	= 1	\$MC_AXCONF_GEOAX_ASSIGN_TAB[0]	= 4
\$MC_AXCONF_GEOAX_ASSIGN_TAB[1]	= 2	\$MC_AXCONF_GEOAX_ASSIGN_TAB[1]	= 5
\$MC_AXCONF_GEOAX_ASSIGN_TAB[2]	= 3	\$MC_AXCONF_GEOAX_ASSIGN_TAB[2]	= 6

### Part program in first channel

Code (excerpt)	Comment
. . .	
N100 \$P_NCBFR[0] = CTRANS( x, 10 )	; Activation of the NC global basic frame
. . .	
N130 \$P_NCBFRAME[0] = CROT(X, 45)	; Activation of the NC global basic frame with rotation => alarm 18310, since rotations of NC global frames are not permitted
. . .	

### Part program in second channel

Code (excerpt)	Comment
. . .	
N100 \$P_NCBFR[0] = CTRANS( x, 10 )	; The NCU global basic frame is also active in second channel.
. . .	
N510 G500 X10	; Activate basic frame
N520 \$P_CHBFRAME[0] = CTRANS( x, 10 )	; Current frame of second channel is activated with an offset.
. . .	

## 10.8.3 Frames

### Example 1

The channel axis is to become a geometry axis through geometry axis substitution.

The substitution is to give the programmable frame a translation component of 10 in the X axis.

The current settable frame is to be retained:

FRAME\_GEOX\_CHANGE\_MODE = 1

```

$P_UIFR[1] = ; Frame is retained after geo axis substitution.
CROT(x,10,y,20,z,30)
G54 ; Settable frame becomes active.
TRANS a10 ; Axial offset of a is also substituted.
GEOAX(1, a) ; a becomes x axis.
; $P_ACTFRAME= CROT(x,10,y,20,z,30):CTTRANS(x10)
    
```

Several channel axes can become geometry axes on a transformation change.

### Example 2

Channel axes 4, 5 and 6 become the geometry axes of a 5-axis orientation transformation. The geometry axes are thus all substituted before the transformation.

The current frames are changed when the transformation is activated.

The axial frame components of the channel axes, which become geometry axes, are taken into account when calculating the new WCS. Rotations programmed before the transformation are retained. The old WCS is restored when the transformation is deactivated.

The most common application will be that the geometry axes do not change before and after the transformation and that the frames are to stay as they were before the transformation.

**Machine data:**

```
$MN_FRAME_GEOAX_CHANGE_MODE = 1
```

```
$MC_AXCONF_CHANAX_NAME_TAB[0] = "CAX"  
$MC_AXCONF_CHANAX_NAME_TAB[1] = "CAY"  
$MC_AXCONF_CHANAX_NAME_TAB[2] = "CAZ"  
$MC_AXCONF_CHANAX_NAME_TAB[3] = "A"  
$MC_AXCONF_CHANAX_NAME_TAB[4] = "B"  
$MC_AXCONF_CHANAX_NAME_TAB[5] = "C"
```

```
$MC_AXCONF_GEOAX_ASSIGN_TAB[0] = 1  
$MC_AXCONF_GEOAX_ASSIGN_TAB[1] = 2  
$MC_AXCONF_GEOAX_ASSIGN_TAB[2] = 3
```

```
$MC_AXCONF_GEOAX_NAME_TAB[0] = "X"  
$MC_AXCONF_GEOAX_NAME_TAB[1] = "Y"  
$MC_AXCONF_GEOAX_NAME_TAB[2] = "Z"
```

```
$MC_TRAFO_GEOAX_ASSIGN_TAB_1[0]=4  
$MC_TRAFO_GEOAX_ASSIGN_TAB_1[1]=5  
$MC_TRAFO_GEOAX_ASSIGN_TAB_1[2]=6
```

```
$MC_TRAFO_AXES_IN_1[0] = 4  
$MC_TRAFO_AXES_IN_1[1] = 5  
$MC_TRAFO_AXES_IN_1[2] = 6  
$MC_TRAFO_AXES_IN_1[3] = 1  
$MC_TRAFO_AXES_IN_1[4] = 2
```

**Program:**

```

$P_NCBFRAME[0] = ctrans(x,1,y,2,z,3,a,4,b,5,c,6)
$P_CHBFRAME[0] = ctrans(x,1,y,2,z,3,a,4,b,5,c,6)
$P_IFRAME = ctrans(x,1,y,2,z,3,a,4,b,5,c,6):crot(z,45)
$P_PFRAME = ctrans(x,1,y,2,z,3,a,4,b,5,c,6):crot(x,10,y,20,z,30)

TRAORI ; Geo axis (4,5,6) sets transformer
; $P_NCBFRAME[0] =
;   ctrans(x,4,y,5,z,6,cax,1,cay,2,caz,3)
; $P_ACTBFRAME =
;   ctrans(x,8,y,10,z,12,cax,2,cay,4,caz,6)
; $P_PFRAME = ctrans(x,4,y,5,z,6,cax,1,cay,2,caz,3) :
; crot(x,10,y,20,z,30)
; $P_IFRAME =
;   ctrans(x,4,y,5,z,6,cax,1,cay,2,caz,3):crot(z,45)

TRAFOOF; ; Geo axis (1,2,3) sets transformation deactivation
; $P_NCBFRAME[0] = ctrans(x,1,y,2,z,3,a,4,b,5,c,6)
; $P_CHBFRAME[0] = ctrans(x,1,y,2,z,3,a,4,b,5,c,6)
; $P_IFRAME =
;   ctrans(x,1,y,2,z,3,a,4,b,5,c,6):crot(z,45)
; $P_PFRAME =
;   ctrans(x,1,y,2,z,3,a,4,b,5,c,6):crot(x,10,y,20,z,30)

```

## 10.9 Data lists

### 10.9.1 Machine data

#### 10.9.1.1 Memory specific machine data

Number		Identifier: \$MM_	Description
HMI Advanced	HMI Embedded		
9242		MA_STAT_DISPLAY_BASE	Numerical basis for display of moving joint <i>STAT</i>
9243		MA_TU_DISPLAY_BASE	Numerical basis for display of rotary axis position <i>TU</i>
9244		MA_ORIAXES_EULER_ANGLE_NAME	Display of orientation axes as Euler angle
9245		MA_PRESET_FRAMEIDX	Value storage scratching and PRESET
9247	9247	USER_CLASS_BASE_ZERO_OFF_PA	Availability of basic offset in "Parameters" operating area
9248	9248	USER_CLASS_BASE_ZERO_OFF_MA	Availability of basic offset in Machine operating area
	9249	USER_CLASS_VERT_MODE_SK	Provide protection for vertical area soft keys
	9400	TOOL_REF_GEO_AXIS1	Absolute dimension tool length compensation geometry axis 1
	9401	TOOL_REF_GEO_AXIS2	Absolute dimension tool length compensation geometry axis 2
	9402	TOOL_REF_GEO_AXIS3	Absolute dimension tool length compensation geometry axis 3
9424	9424	MA_COORDINATE_SYSTEM	Coordinate system for actual-value display
	9425	MA_SCRATCH_DEFAULT_MODE	Tool offset computation for geometry axes with scratching
9440	9440	ACTIVE_SEL_USER_DATA	Active data (frames) are immediately operative after editing
9449		WRITE_TOA_LIMIT_MASK	Applicability of MD9203 to edge data and location-dependent offsets
9450	9450	MM_WRITE_TOA_FINE_LIMIT	Limit value for wear fine
9451	9451	MM_WRITE_ZOA_FINE_LIMIT	Limit value for offset fine
	9459	PA_ZOA_MODE	Display mode of zero offset

### 10.9.1.2 NC-specific machine data

Number	Identifier: \$MN_	Description
10000	AXCONF_MACHAX_NAME_TAB	Machine axis name
10600	FRAME_ANGLE_INPUT_MODE	Input type for rotation with frame
10602	FRAME_GEOAX_CHANGE_MODE	Frames and switchover of geometry axes
10610	MIRROR_REF_AX	Reference axis for FRAME element mirroring
10612	MIRROR_TOGGLE	Toggle mirroring
10613	NCBFRAME_RESET_MASK	RESET response of global basic frame
10615	NCBFRAME_POWERON_MASK	POWER ON response of global basic frames
10617	FRAME_SAVE_MASK	Response of frames to subroutine return jump with SAVE
10650	IPO_PARAM_NAME_TAB	Name of interpolation parameters
10660	INTERMEDIATE_POINT_NAME_TAB	Name of intermediate point coordinates for G2/G3
11640	ENABLE_CHAN_AX_GAP	Channel axis gaps allowed
18600	MM_FRAME_FINE_TRANS	Fine offset for all settable FRAMES and the basic frame
18601	MM_NUM_GLOBAL_USER_FRAMES	Number of globally predefined user frames
18602	MM_NUM_GLOBAL_BASE_FRAMES	Number of global basic frames

### 10.9.1.3 Channel-specific machine data

Number	Identifier: \$MC_	Description
20050	AXCONF_GEOAX_ASSIGN_TAB	Assignment geometry axis to channel axis
20060	AXCONF_GEOAX_NAME_TAB	Geometry axis name in channel
20070	AXCONF_MACHAX_USED	Machine axis number valid in channel
20080	AXCONF_CHANAX_NAME_TAB	Channel axis name/special axis name in channel
20110	RESET_MODE_MASK	Definition of basic control settings after RESET/TP end)
20118	GEOAX_CHANGE_RESET	Allow automatic geometry axis change
20126	TOOL_CARRIER_RESET_VALUE	Active toolholder on RESET
20140	TRAFO_RESET_VALUE	Transformation record on power-up (RESET/TP end)
20150	GCODE_RESET_VALUES	Reset G groups
20152	GCODE_RESET_MODE	RESET response of the G Groups
20184	TOCARR_BASE_FRAME_NUMBER	Number of the basic frame for pickup of the table offset
21015	INVOLUTE_RADIUS_DELTA	NC start disable without reference point
22532	GEOAX_CHANGE_M_CODE	M code for replacement of geometry axes
22534	TRAFO_CHANGE_M_CODE	M code for transformation changeover

10.9 Data lists

Number	Identifier: \$MC_	Description
24000	FRAME_ADD_COMPONENTS	Separate programming/modification of additively programmable frame components
24002	CHBFRAME_RESET_MASK	RESET response of channel-specific basic frames
24004	CHBFRAME_POWERON_MASK	POWER ON response of channel-specific basic frames
24006	CHSFRAME_RESET_MASK	RESET response of channel-specific system frames
24007	CHSFRAME_RESET_CLEAR_MASK	Clear system frames on RESET
24008	CHSFRAME_POWERON_MASK	Delete system frames on POWER ON
24010	PFRAME_RESET_MODE	RESET mode for programmable frame
24020	FRAME_SUPPRESS_MODE	Positions for frame suppression
24030	FRAME_ACT_SET	SZS coordinate system setting
24040	FRAME_ADAPT_MODE	Adapting active frames
24050	FRAME_SAA_MODE	Save and activate data management frames
24805	TRACYL_ROT_AX_FRAME_1	Rotary axis offset TRACYL 1
24855	TRACYL_ROT_AX_FRAME_2	Rotary axis offset TRACYL 2
24905	TRANSMIT_ROT_AX_FRAME_1	Rotary axis offset TRANSMIT1
24955	TRANSMIT_ROT_AX_FRAME_2	Rotary axis offset TRANSMIT2
28080	MM_NUM_USER_FRAMES	Number of settable Frames (SRAM)
28081	MM_NUM_BASE_FRAMES	Number of channel-specific base frames
28082	MM_SYSTEM_FRAME_FRAMES	Configuration screen form for channel-specific system frames
28560	MM_SEARCH_RUN_RESTORE_MODE	Restore data after a simulation

10.9.1.4 Axis/spindle-specific machine data

Number	Identifier: \$MA_	Description
32074	FRAME_OR_CORRPOS_NOTALLOWED	FRAME or HL offset is not permitted
35000	SPIND_ASSIGN_TO_MACHAX	Assignment spindle to machine axis

## 10.9.2 Setting data

### 10.9.2.1 Channel-specific setting data

Number	Identifier: \$SC_	Description
42440	FRAME_OFFSET_INCR_PROG	Zero offsets are traversed on incremental programming
42980	TOFRAME_MODE	Determination of the direction of X and Y axes for frame definition

### 10.9.3 System variables

Names	Description
\$AA_ETRANS[axis]	Offset value zero offset external
\$AA_IBN[axis]	Actual value in basic zero coordinate system (BZS)
\$AA_IEN[axis]	Actual value in settable zero point coordinate system (ENS)
\$AA_OFF[axis]	Overlaid motion for programmed axis
\$AC_DRF[axis]	DRF offset (differential resolver function)
\$AC_JOG_COORD	Changeover of the manual operation coordinate system
\$P_ACSFRAME	Current frame for defining the ENS (ACS)
\$P_ACTBFRAME	Current chained total basic frame
\$P_ACTFRAME	Current total frame
\$P_BFRAME	Current first basic frame in the channel. Corresponds to \$P_CHBFRAME
\$P_CHBFR[n]	Channel basic frames, activated via G500, G54 to G599
\$P_CHBFRAME[n]	Current basic frame in channel 0 to 15 NCU basic frames can be set through: MD28081 MM_NUM_BASE_FRAMES
\$P_CHBFMASK	Bit mask for definition of channel-specific basic frames
\$P_CHSFRMASK	Bit mask for activating system frames in data management
\$P_CYCFR	System frame for cycles
\$P_CYCFRAME	Current system frame for cycles
\$P_EXTFR	System frame for zero offset external in data management
\$P_EXTFRAME	Current system frame for zero offset external
\$P_IFRAME	Current settable frame
\$P_ISO1FR	System frame for ISO G51.1 mirroring
\$P_ISO2FR	System frame for G68 2DROT (ISO)
\$P_ISO3FR	System frame for G68 3DROT (ISO)
\$P_ISO4FR	System frame for G51 scale (ISO)
\$P_ISO1FRAME	Current system frame for ISO G51.1 mirroring

Names	Description
\$P_ISO2FRAME	Current system frame for G68 2DROT (ISO)
\$P_ISO3FRAME	Current system frame for G683DROT (ISO)
\$P_ISO4FRAME	Current system frame for G51 scale (ISO)
\$P_NCBFR[n]	NCU basic frames, activated via G500, G54 to G599
\$P_NCBFRAME[n]	Current NCU basic frame 0 to 15 NCU basic frames can be set through: MD18602 MM_NUM_GLOBAL_BASE_FRAMES
\$P_NCBFRMASK	Bit mask for definition of NCU global basic frames
\$P_PARTFR	System frame for TCARR and PAROT in data management
\$P_PARTFRAME	Current system frame for TCARR and PAROT with an orientational toolholder
\$P_PFRAME	Current programmable frame
\$P_SETFR	System frame for PRESET and scratching in data management
\$P_SETFRAME	Current system frame for PRESET and scratching
\$P_TOOLFR	System frame for TOROT and TOFRAME in data management
\$P_TOOLFRAME	Current system frame for TOROT and TOFRAME
\$P_TRAFRAME	System frame for transformations
\$P_TRAFRAME	Current system frame for transformations
\$P_UBFR	Basic frame in channel activated after G500, G54 to G599 Corresponds to \$P_CHBFR[0].
\$P_UIFR[n]	Settable frames, activated via G500, G54 to G599
\$P_UIFRNUM	Number of active frame \$P_UIFR
\$P_WPFR	System frame for workpiece reference points
\$P_WPFRAME	Current system frame for workpiece reference points

### \$AA\_ETRANS[X]

\$AA\_ETRANS[X] is an axis-specific system variable of the DOUBLE type. The default setting in the system for this variable is zero.

Values set by the user are activated through the NC/PLC interface signal:

DB31, ... DBX3.0 (external zero offset)

## 10.9.4 Signals

### 10.9.4.1 Signals from channel

DB number	Byte.Bit	Description
21, ...	61.0	T function modification
21, ...	62.0	D function modification
21, ...	118-119	T function
21, ...	129	D function
21, ...	208	Number of active function G group 1
21, ...	209	Number of active function G group 2
...	...	...
21, ...	230	Number of active function G group 29

### 10.9.4.2 Signals to axis/spindle

DB number	Byte.Bit	Description
31, ...	3.0	Accept zero offset external

### 10.9.4.3 Signals from axis/spindle

DB number	Byte.Bit	Description
31, ...	60.0	Spindle/no axis



## Emergency Stop (N2)

### 11.1 Brief description

#### Function

The control system supports the machine manufacturer in implementing an emergency stop function on the basis of the following functions:

- An emergency stop button is installed in a location easily accessible to the machine operator on all SINUMERIK machine control panels. The functionality of the emergency stop button includes the positive opening of electrical switching contacts and a mechanical self-activating latching/locking.
- The emergency stop request to the NC is transmitted via the NC/PLC interface on the PLC.
- In response to an emergency stop command, the NC decelerates all axes and spindles as quickly as possible (with setpoint value 0), i.e. braking at the current limit of the drives.
- In the case of an emergency stop, all machine functions controlled by the PLC can be brought to a safe state that can be set by the machine manufacturer.
- Unlatching the emergency stop button does not cancel the emergency stop state nor does it initiate a restart.
- After the emergency stop state has been canceled, it is not necessary to reference the machine axes or synchronize the spindles. The actual positions of the machine axes are continuously tracked during the emergency stop sequence.

### 11.2 Relevant standards

#### Relevant standards

Compliance with the following standards is essential for the emergency stop function:

- EN ISO 12000-1
- EN ISO 12000-2
- EN 418
- EN 60204

## EMERGENCY STOP

In accordance with EN 418, an emergency stop is a function that:

- Is intended to prevent or diminish developing or existing risks to operating personnel, and damage to the machine or machined materials.
- is triggered by a single action of a person, if the normal stop function is not suitable for it.

## Hazards

In the terms of EN 418, risks may arise from:

- Functional irregularities (machine malfunctions, unacceptable properties of the material to be machined, human error, etc.).
- Normal operation.

## Standard EN ISO 12000-2

In accordance with the basic safety requirement of the EC Machinery Directive regarding emergency stop, machines must be equipped with an emergency stop device.

### Exceptions

No emergency stop device is required on machines:

- Where an emergency stop device would not reduce the risk, either because the shutdown time would not be reduced or because the measures to be taken would not be suitable for controlling the risk.
- that are held and operated manually.

NOTICE
The machine manufacturer is expressly directed to comply with the national and international standards. The SINUMERIK controllers support the machine manufacturer in the implementation of the emergency stop function according to the specifications in the following function description. But the responsibility for the emergency stop function (its triggering, sequence, and acknowledgment) rests exclusively with the machine manufacturer.

## 11.3 Emergency stop control elements

### Emergency stop control elements

In accordance with EN 418, emergency stop control elements must be designed so that they latch mechanically on their own and are easy for the operator and others to actuate in the event of an emergency.

The following list includes some possible types of control elements:

- Mushroom-head pushbutton switches
- Wires/cables, cords, rods
- Puller grips
- In special cases: Foot-operated switches without protective covers

### Emergency stop button and control

Actuation of the emergency stop button or a signal derived directly from the button must be routed to the controller (PLC) as a PLC input. In the PLC user program, this PLC input must be forwarded to the NC on the interface signal:

DB10 DBX56.1 (Emergency stop)

Resetting of the emergency stop button or a signal derived directly from the button must be routed to the controller (PLC) as a PLC input. In the PLC user program, this PLC input must be forwarded to the NC on the interface signal:

DB10 DBX56.2 (Acknowledge emergency stop)

### Connection Conditions

For connecting the emergency stop button see:

**References:**

/BH/ Operator Components Manual

## 11.4 Emergency stop sequence

After actuation of the emergency stop control element, the emergency stop device must operate in the best possible way to prevent or minimize the danger.

"In the best possible way" means that the most favorable delay rate can be selected and the correct stop category (defined in EN 60204) can be determined according to a risk assessment.

### Emergency stop sequence in the NC

The predefined (in EN 418) sequence of internal functions implemented to obtain the emergency stop state is as follows in the control system:

1. Part program execution is interrupted.

All machine axes are braked in the relevant axis-specific parameterized time:

MD36610 \$MA\_AX\_EMERGENCY\_STOP\_TIME (time of braking ramp in event of errors)

The maximum braking ramp that can be achieved thereby, is defined by the maximum brake current of the respective drive. The maximum brake current is achieved by setting a setpoint = 0 (fast braking).

2. Reset interface signal:

DB11 DBX6.3 (Mode group ready)

3. Set the interface signal:

DB10 DBX106.1 (Emergency stop active)

4. Alarm 3000 "emergency off" is shown.

5. After the expiry of a parameterized delay time, the servo enables of machine axes are reset.

The setting of the delay time is programmed in machine data:

MD36620 \$MA\_SERVO\_DISABLE\_DELAY\_TIME (switch-off delay servo enable)

The following setting rule must be observed: MD36620  $\geq$  MD36610

6. All machine axes are switched in the follow-up mode within the controller.

The machine axes are no longer in position control during this.

### Emergency stop sequence at the machine

The emergency stop sequence on the machine is determined solely by the machine manufacturer.

Attention should be paid to the following points in connection to the sequence on the NC:

- The process in the NC is started using the interface signal:

DB10 DBX56.1 (Emergency stop)

After the machine axes have come to a standstill, the power supply must be interrupted, in compliance with EN 418.

**Note**

The responsibility for interrupting the power supply rests with the machine manufacturer.

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- The digital and analog outputs of the PLC I/O are not influenced by the emergency stop sequence in the NC.

If individual outputs are required to attain a particular state or voltage level in the event of an emergency stop, the machine manufacturer must implement this in the PLC user program.

- The fast digital outputs of the NCK I/O system are not influenced by the emergency stop sequence in the NC.

If individual outputs must assume a specific state in the case of emergency stop, the machine manufacturer must transmit the desired state to the NC in the PLC user program via interface signals:

DB10 DBB4-7

---

**Note**

If the sequence in the NC is not to be executed as described above, then the interface signal DB10 DBX56.1 (emergency stop) must not be set until an emergency stop state defined by the machine manufacturer in the PLC user program is reached.

As long as the interface signal is not set and no other alarm is pending, all interface signals are operative in the NC. Any emergency stop state defined by the manufacturer (including axis-, spindle-, and channel-specific emergency stop states) can therefore be assumed.

---

## 11.5 Emergency stop acknowledgement

The emergency stop control element may only be reset as a result of manual manipulation of the emergency stop control element according to EN 418.

Resetting of the emergency stop control element alone must not trigger a restart command.

A machine restart must be impossible until all of the actuated emergency stop control elements have been deliberately reset by hand.

### Emergency stop acknowledgement

The EMERGENCY STOP state is only reset if the interface signal:DB10 DBX56.2 (acknowledge EMERGENCY STOP) is set followed by the interface signal:DB11, ... DBX0.7 (mode group reset).

Hence it can be noted that the interface signal DB10 DBX56.2 (acknowledge emergency stop) and the interface signal DB21, ... DBX7.7 (Reset) together are set at least for so long, till the interface signal DB10 DBX106.1(emergency stop active) is reset.

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**Note**

The emergency stop state cannot be reset with the interface signal DB21, ... DBX7.7 (Reset) alone.

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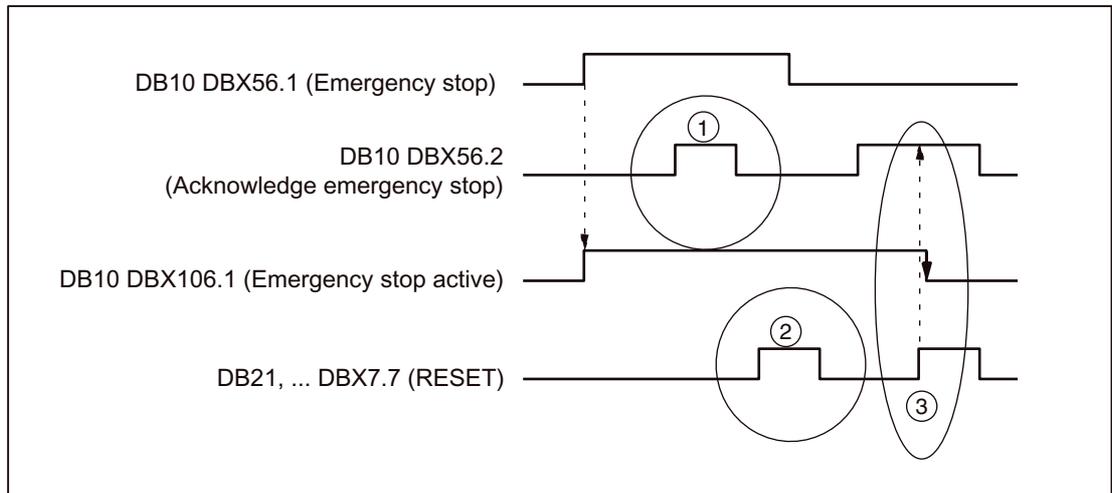


Figure 11-1 Resetting the emergency stop state

- (1) DB10 DBX56.2 (acknowledge emergency stop) is inoperative
- (2) DB21, ... DBX7.7 (Reset) is inoperative
- (3) DB10 DBX56.2 and DB21, ... DBX7.7 reset DB10 DBX106.1(emergency stop active)

## Effects

Resetting the emergency stop state has the following effects:

- within the controller for all machine axes:
  - the servo enables are set.
  - the follow-up mode is cancelled.
  - the position control is activated.
- the following interface signals are set:
  - DB31, ... DBX60.5 (position control active)
  - DB11 DBX6.3 (Mode group ready).
- the following interface signal is reset:
  - DB10 DBX106.1 (Emergency stop active)
- the alarm 3000 "emergency off" is deleted.
- Part program processing is interrupted in all channels of the NC.

## PLC and NCK I/Os

The PLC user program must switch the PLC and NCK I/Os back to the state for operation of the machine.

**POWER OFF/ON (supply off/on)**

The emergency stop state can also be reset by switching the controller off and back on (POWER OFF/ON).

**Requirement:**

During power-up of the control the interface signal DB10 DBX56.1 (emergency stop) may not be set.

## 11.6 Data lists

### 11.6.1 Machine data

#### 11.6.1.1 Drive-specific machine data

Number	Identifier: \$MD_	Description
1404	PULSE_SUPPRESSION_DELAY	Time for pulse suppression

#### 11.6.1.2 Axis/spindle-specific machine data

Number	Identifier: \$MA_	Description
36610	AX_EMERGENCY_STOP_TIME	Length of the braking ramp for error states
36620	SERVO_DISABLE_DELAY_TIME	Cutout delay servo enable

### 11.6.2 Signals

#### 11.6.2.1 Signals to NC

DB number	Byte.Bit	Description
10	56.1	Emergency stop
10	56.2	Acknowledge Emergency Stop

#### 11.6.2.2 Signals from NC

DB number	Byte.Bit	Description
10	106.1	Emergency stop active

#### 11.6.2.3 Signals to BAG

DB number	Byte.Bit	Description
11	0.7	Mode group RESET

## Transverse Axes (P1)

### 12.1 Brief description

#### Transverse axis

Within the framework of "turning" technology, the transverse axis refers to the machine axis that travels perpendicular to the axis of symmetry of the spindle, in other words, to longitudinal axis Z.

#### Properties

- Every geometry axis of a channel can be defined as a transverse axis.
- Only one transverse axis can be defined per channel.
- A transverse axis is a linear axis for the following functions, which can be permitted and activated at the same time or separately:
  - Programming and display in the diameter
  - Reference axis for constant cutting speed G96/G961/G962

#### Several transverse axes in the channel

Diameter programming and reference axis for G96/G961/G962 can be active for different transverse axes.

#### Transverse axis functions (overview)

	Programming and display in the diameter			Reference axis for G96/G961/G962	
	Geometry axis		Linear channel axes	Geometry axis	
<b>Permissible axis type:</b>	Geometry axis		Linear channel axes	Geometry axis	
<b>Selection in the channel</b>	one	m of 3	m of n	one	one of 3
<b>Specific effect:</b>	Channel	Axis		Channel	
<b>Machine data:</b>	MD20100 \$MC_DIAMETER_AX_DEF	MD30460 \$MA_BASE_FUNCTION_MASK		MD20100 \$MC_DIAMETER_AX_DEF	
<b>Programming:</b>	DIAM* channel-specific modal G group 29			SCC [AX] channel-specific modal Reference axis for G96/G961/G962	
<b>Acceptance during axis replacement:</b>	DIAM*A [AX] axis-specific modal				

	Programming and display in the diameter	Reference axis for G96/G961/G962
Axis-specific non-modal diametral/radius programming	DAC, DIC; RAC, RIC blockwise axis-specific only programming	

DIAM\*: DIAMOF, DIAMON, DIAM90, DIAMCYCOF  
 DIAM\*A[AX]: DIAMOF A[AX], DIAMON A[AX], DIAM90 A[AX], DIAMCYCOF A[AX], DIAMCHANA[AX]  
 AX: Axis identifier for geometry/channel or machine axis identifier

---

**Note**

Rotary axes are not permitted to serve as transverse axes.

---

**Programming the transversing paths**

The traverse paths of a transverse axis programmed in the part program may be either radius- or diameter-based. It is possible to switch between the two reference types with the part program commands DIAMON (DIAMeter ON = diameter) and DIAMOF (DIAMeter OF = radius). In this way, dimensional information can be taken directly from the technical drawing without conversion.

**Active parts program**

When the part program DIAMON (dimensional information as diameter) is active, the following is true for the transverse axis:

- The setpoint and actual values that refer to the workpiece coordinate system are displayed as diameter values.
- System variables for setpoints and actual values that refer to the workpiece coordinate system contain diameter values.
- Offsets are entered, programmed and displayed in radius format.
- Programmed end positions are converted to radius values internally.
- The absolute interpolation parameters (e.g. I, J, K) for circular interpolation (G2 and G3) are converted to radius values internally.
- Measurement results that were determined by touch trigger probe in the workpiece coordinate system are stored as diameter measurements.
- Setpoints and actual values can be read in diameter format in the WCS with the aid of system variables.

When the part program command DIAMOF (dimensional information as radius) is active, the above-mentioned data is always entered, programmed, internally stored, read or displayed as radius data.

## 12.2 Defining a geometry axis as transverse axis

### Transverse axis

Within the framework of "turning" technology, the transverse axis refers to the machine axis that travels perpendicular to the axis of symmetry of the spindle, in other words, to longitudinal axis Z.

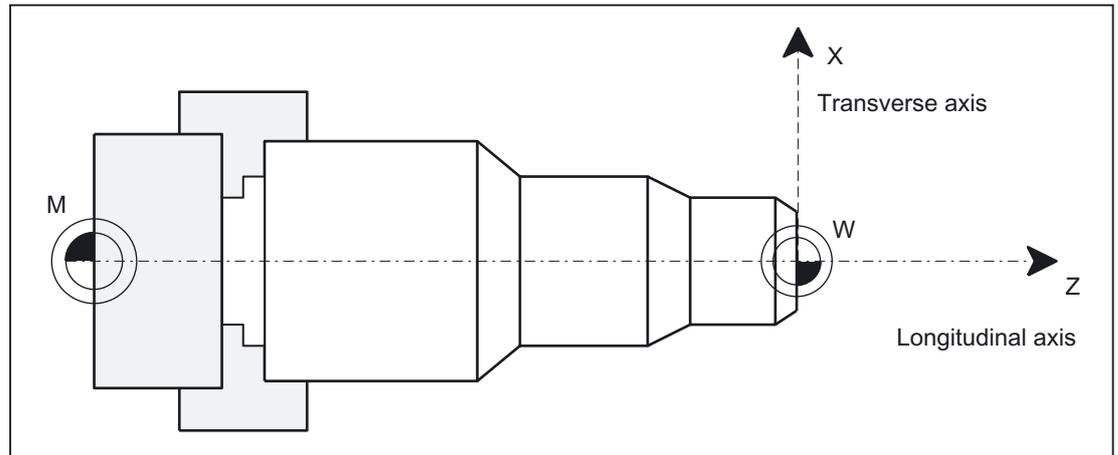


Figure 12-1 Position of the transverse axis in the machine coordinate system

### Definition

#### Definition of a transversing axis in the channel

The definition of a geometry axis as a transverse axis is done using machine data:  
MD20100 \$MC\_DIAMETER\_AX\_DEF (geometry axis with transverse axis function).

For this axis, diameter programming and assigning a constant cutting speed with G96/G961/G962 are both permitted.

#### Definition of several transversing axes in the channel

The machine data MD30460 \$MA\_BASE\_FUNCTION\_MASK allows the definition of additional transverse axes, for which axis-specific diameter programming with bit2=1 is possible.

An axis can be simultaneously defined in MD20100 and in MD30460 with bit2. For this, the channel-specific MD20100 has a higher priority than the axis-specific MD30460.

With:

- MD20100, the function G96/G961/G962 is assigned to the transverse axis during power up.
- MD20100, the channel-specific diameter programming DIAMON, DIAMOF, DIAM90, DIAMCYCOF is assigned to the transverse axis during power up. This axis occupies the axis-specific basic position DIAMCHANA[AX] after power up.
- MD30460 bit2 the additional enabling of the axis-specific statements DIAMONA[AX], DIAMOF A[AX], DIAM90A[AX], DIACYCOFA[AX], DIMCHANA[AX].

### Example for defining a transverse axis in the channel

```
MD20100 $MC_DIAMETER_AX_DEF="X" ;the geometry axis X is the transverse axis  
in the channel
```

### Restrictions

However, only exactly one geometry axis can be defined as transverse axis per channel.  
With MD30460 \$MA\_BASE\_FUNCTION\_MASK bit2=1 is only permitted for linear axes.

### Channel-specific basic position after power up, RESET

The channel-specific basic position after power up or RESET or end of parts program of the G group 29: DIAMON, DIAM90, DIAMOF, DIAMCYCOF define the

MD20150 \$MC\_GCODE\_RESET\_VALUE  
and independently of  
MD20110 \$MC\_RESET\_MODE\_MASK/bit0 the MD20152 \$MC\_GCODE\_RESET\_MODE.

The user can set the respective desired status via an event-controlled program call (program event).

If G96/G961/G962 is the basic position after power up, a transverse axis must be defined using MD20100 \$MC\_DIAMETER\_AX\_DEF, otherwise the alarm message 10870 is output.

Reference axis for G96/G961/G962 retained:

MD20110 \$MC\_RESET\_MODE\_MASK, bit 18=1 for RESET or end of parts program

MD20112 \$MC\_START\_MODE\_MASK, bit 18=1 for start of parts program

A reference axis for G96/G961/G962 can also be assigned without application of a transverse axis in MD20100 via SCC[AX]. For this scenario, the constant cutting speed cannot be activated with G96. For further information refer to

#### References:

/PG/ Programming Manual Fundamentals, Feedrate Control and Spindle Motion  
"Constant Cutting Speed (G96, G961, G962, G97, G971, LIMS, ACC[AX])"

## 12.3 Dimensional information for transverse axes

Transverse axes can be programmed with respect to both diameter and radius. Generally, they are diameter-related, i.e. programmed with doubled path dimension so that the corresponding dimensional information can be transferred to the part program directly from the technical drawings.

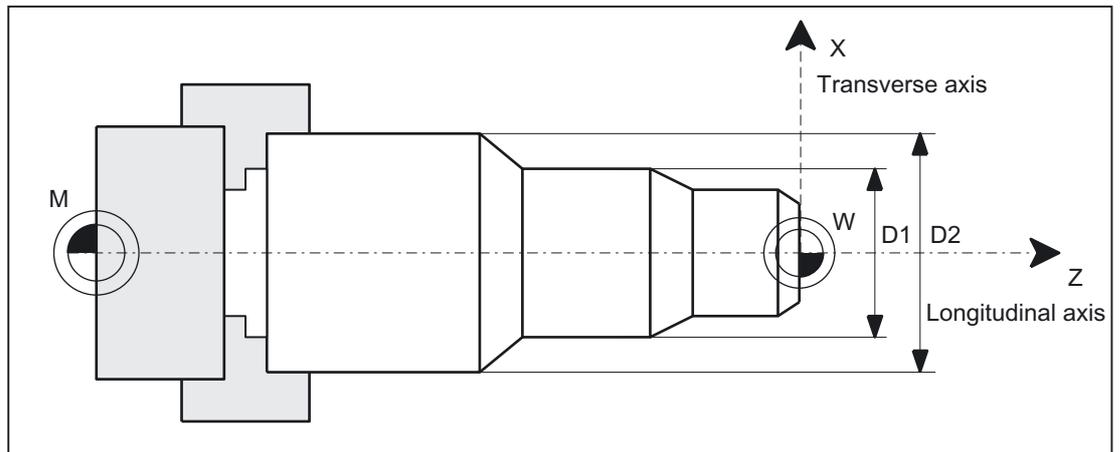


Figure 12-2 Transverse axis with diameter information (D1, D2)

### Switching the diameter programming on/off

#### Channel-specific diameter programming

The activating or deactivating of the diameter programming is done via the modally active parts program statements of the G group 29:

- DIAMON: Diameter programming ON
- DIAMOF: Diameter programming OFF, in other words, radius programming ON
- DIAM90: Diameter or radius programming depending on the reference mode:
  - Diameter programming ON in connection with absolute dimensioning G90
  - Radius programming ON in connection with incremental dimensioning G91
- DIAMCYCOF: Radius programming for G90 and G91 ON, for the HMI, the last active G code of this group remains active

Reference is made exclusively to the transverse axis of the channel.

#### Axis-specific diameter programming for several transverse axes in one channel

##### Note

The additionally specified axis must be activated via MD30460 \$MA\_BASE\_FUNCTION\_MASK with bit2=1.

The axis specified must be a known axis in the channel. Geometry, channel or machine axes are permitted.

Programming is not permitted in synchronized actions.

The following axis-specific modal statements can be programmed several times in a parts program block:

- DIAMONA[Axis]: Diameter programming for G90, G91 AC and IC ON
- DIAMOFA[Axis]: Diameter programming OFF, in other words, radius programming ON
- DIAM90A[axis]: Diametral or radius programming depending upon the reference mode:
  - Diameter programming ON in connection with absolute dimensioning G90 and AC
  - Radius programming ON in connection with incremental dimensioning G91 and IC
- DIACYCOFA[axis]: Radius programming for G90 and G91 ON, for the HMI, the last active G code of this group remains active
- DIAMCHANA[axis]: Acceptance of diameter programming channel status
- DIAMCHAN: all axes with MD30460, bit2=1 accept the diameter programming channel status

Axis-specific modal statements have priority over the channel setting.

### Acceptance of the additional transverse axis in the channel

Due to a GET request from the parts program, the diameter programming status for an additional transverse axis is accepted in the new channel during axis replacement using RELEASE[axis].

#### Axis replacement in synchronized actions

For axis replacement in synchronized actions, a transverse axis takes the status of the axis-specific diameter programming with it into the new channel if the following applies to the transverse axis:

- with MD30460, bit2=1 axis-specific diameter programming is permitted.
- it is not subordinated to the channel-specific diameter programming in the releasing channel.

The active dimension can be queried via the system variable \$AA\_DIAM\_STAT[AX].

#### Axis replacement via axis container rotation

By rotating the axis container, the assignment of a channel axis can change to assignment of a machine axis. The current diameter programming status is retained however for the channel axis after the rotation. This also applies to the current channel status and axis status, because the status is the same for all axes of the axis container at the time of the machine data "putting into effect" the status from MD30460 \$MA\_BASE\_FUNCTION\_MASK.

### Initial setting

The following machine data is used to parameterize the initial setting:

MD20150 \$MC\_GCODE\_RESET\_VALUES [28] (initial setting of the G groups)  
and independently of MD20110 \$MC\_RESET\_MODE\_MASK for bit0 the  
MD20152 \$MC\_GCODE\_RESET\_MODE

## Diameter-related data

After activation of the diameter programming, the following data refer to diameter dimensions:

### DIAMON/DIAMONA[AX]

- Display data of transverse axis in the workpiece coordinate system:
  - Setpoint and actual position
  - Distance-to-go
  - REPOS Offset
- "JOG" mode:
  - Increments for incremental dimension (INC) and handwheel travel (dependent upon active MD)
- Part program programming:
  - End positions, independent of reference mode (G90/G91)
  - Interpolation parameters of circular-path programming (G2/G3) if these are programmed with part program instruction: AC absolute.
- Actual values read with reference to the workpiece coordinate system (WCS):
  - \$AA\_MW[*Transverse axis*]  
System variable of the measuring functions MEAS (measuring with delete distance-to-go) and MEAW (measuring without delete distance-to-go)
  - \$P\_EP[*Transverse axis*]
  - \$AA\_IW[*Transverse axis*]

### DIAM90/DIAM90A[AX]

After activation of the reference-mode-dependent diameter programming, the following data are always displayed in relation to diameter regardless of the operating mode (G90/G91):

- Actual value
- Actual values read with reference to the workpiece coordinate system (WCS):
  - \$AA\_MW[*Transverse axis*]  
System variable of the measuring functions MEAS (measuring with delete distance-to-go) and MEAW (measuring without delete distance-to-go)
  - \$P\_EP[*Transverse axis*]
  - \$AA\_IW[*Transverse axis*]

### DIAMCYCOF/DIACYCOFA[AX]

Just as for DIAMCYCOF, a changeover to radius programming takes place within the controller for DIACYCOFA [AX]. The diameter programming status that was active before DIAMCYCOF or DIACYCOFA [AX] continues to be displayed to the HMI.

### Permanently radius-related data

For transverse axes, the following data is **always** entered, programmed and displayed in relation to radius:

- Offsets:
  - Tool offsets
  - Programmable and configurable frames
  - External work offset
  - DRF and preset offset
  - etc.
- Working area limitation
- Software limit switch
- Feed
- Display data with reference to the machine coordinate system
- Display data of the service images for axis, FSD and MSD

#### Extended functions for data that is always radius-related:

- PLC axes, via FC18 or axes controlled exclusively by the PLC.
  - The dimension for PLC axes in the radius also applies to several transverse axes with diameter function and is independent of channel-specific or axis-specific diameter programming.
  - In JOG mode (Inc) a PLC axis is subordinate to the channel status. If diameter programming is active and MD20624 \$MC\_HANDWH\_CHAN\_STOP\_COND bit15=0, only half the path of the specified increment is transversed.

**Radius programming** from MD20100 \$MC\_DIAMETER\_AX\_DEF and MD30460 \$MA\_BASE\_FUNCTION\_MASK, bit2 is dependent upon MD20360 \$MC\_TOOL\_PARAMETER\_DEF\_MASK taken into consideration as follows:

Bit3=0: Work offset \$P\_EXTFRAME and frames

For transverse axes, work offsets in frames are always calculated as radius values.

Bit5=0: external work offset (axis superimposition)

For transverse axes, the external work offset is always calculated as radius values.

Bit8=1: Display of remaining path in WCS always as a radius

#### DRF-traveling with handwheel

For all transverse axes, MD11346 \$MN\_HANDWH\_TRUE\_DISTANCE == 1 for

Bit9=0:

causes the half path of the specified handwheel increment to be traveled, if channel-specific or axis-specific diameter programming is active for this axis.

Bit 9=1:

the half path of the specified handwheel increment is always traveled.

### Displaying position values in the diameter

Position values of the transverse axis are always displayed as a diameter value, if the bit0=1 is set by MD27100 \$MC\_ABSBLOCK\_FUNCTION\_MASK.

### Dimension on several transverse axes permanent diameter-related data

Several transverse axes permitted by MD30460 \$MA\_BASE\_FUNCTION\_MASK, bit2=1 do not behave differently in comparison to a transverse axis defined using MD20100 \$MC\_DIAMETER\_AX\_DEF. Diameter values continue to be converted into radius values.

For all of the transverse axes defined in the channel, the following functions can be activated as a diameter per MD20360 \$MC\_TOOL\_PARAMETER\_DEF\_MASK for a **set** bit:

- 1: Transverse axis tool length as a diameter
- 2: Alarm for wear or tool length as a diameter and level change
- 3: Work offset in frames of the transverse axis as a diameter
- 4: Preset value as a diameter
- 5: External work offset of transverse as a diameter
- 6: Actual values of the transverse axis as a diameter
- 7: Display of actual values of the transverse axis as a diameter value.
- 10: Tool portion of an active tool carrier that can be oriented if no tool is active
- 11: Evaluation of \$TC\_DP6 as a diameter
- 12: Evaluation of \$TC\_DP15 as wear of the tool diameter

#### Work offset \$P\_EXTFRAME and frames

Bit3=1: For all transverse axes, work offsets in frames are always calculated as diameter values. The frame stores the work offsets internally as a radius value. There is no conversion during a change of diameter, to radius programming or vice versa.

#### Work offset external

Bit 5=1: For all transverse axes, external work offsets are always calculated as diameter values. There is no conversion during a change of diameter, to radius programming or vice versa.

### Settable response of geometry axes for traveling with handwheel

If the geometry axis is traveled as a transverse axis in the channel for handwheel traveling MD11346 \$MN\_HANDWH\_TRUE\_DISTANCE == 1, the response of the handwheel traveling can be changed via MD20624 \$MC\_HANDWH\_CHAN\_STOP\_COND, bit15:

Bit15=0: Only the half path of the specified increment is traveled.

Bit15=1: The specified increment is traveled completely.

### Application examples

X is a transverse axis defined via MD20100 \$MC\_DIAMETER\_AX\_DEF.  
 Y is a geometry axis and U is an additional axis. These two axes are transverse axes with specified diameter further defined in MD30460 \$MA\_BASE\_FUNCTION\_MASK with bit2=1.  
 DIAMON is not active after power up.

```
N10 G0 G90 X100 Y50      ;no diameter programming is active
N20 DIAMON              ;Channel-specific diameter programming, in effect for X
N30 Y200 X200          ;Dimension: X in the diameter, Y in the radius
N40 DIAMONA[Y]         ;axis-specific modal diameter programming,
                       ;in effect for Y
N50 Y250 X300          ;Dimension: X and Y in diameter
N60 DIAM90             ;dimension: X G90/AC in the diameter, G91/IC in the radius
N70 Y200               ;Y: continuing, axis-specific modal diameter programming
N75 G91 Y20 U=DIC(40)  ;dimension: Y in the diameter, U non-modally IC in the
                       diameter
N80 X50 Y100           ;dimension: X in the radius (G91), Y in the diameter
N85 G90 X100 U200      ;dimension: X in the diameter, U in the radius
N90 DIAMCHANA[Y]       ;Y accepts the channel status DIAM90
N95 G91 X100 Y100      ;Dimension: X and Y in the radius(G91)
N100 G90 X200 Y200     ;Dimension: X and Y in diameter
```

### Example with axle replacement

Transverse axes with diameter specification applied as in the previous example.  
 X and Y are located in channel 1 and are also known in channel 2, i.e. permitted for axis replacement.

```
Channel 1
N10 G0 G90 X100 Y50      ;no diameter programming is active
N20 DIAMON              ;Channel-specific diameter programming for X
N30 Y200 X200          ;Dimension: X in the diameter, Y in the radius
N40 DIAMONA[Y]         ;Y axis-specific modal diameter programming
N50 Y250 X300          ;Dimension: X and Y in diameter
N60 SETM(1)            ;Synchronous marker 1
N70 WAIT(1,2)          ;wait for synchronous marker 1 in channel 2
Channel 2
...
N50 DIAMOF              ;channel 2 no diameter programming active
...
N100 WAIT(1,1)         ;wait for synchronous marker 1 in channel 1
N110 GETD(Y)           ;Axis replacement direct Y
N120 Y100              ;Y the channel-specific diameter programming
                       ;subordinated in channel 2, i.e. dimension in the radius
```

## 12.4 Data lists

### 12.4.1 Machine data

#### 12.4.1.1 Channel-specific machine data

Number	Identifier: \$MC_	Description
20050	AXCONF_GEOAX_ASSIGN_TAB[n]	Assignment of geometry axis to channel axis
20060	AXCONF_GEOAX_NAME_TAB[n]	Geometry axis name in channel
20100	DIAMETER_AX_DEF	Geometry axis with transverse axis function
20110	RESET_MODE_MASK	Definition of control basic setting after power-up and RESET/part program end
20112	START_MODE_MASK	Definition of the control basic settings for NC start
20150	GCODE_RESET_VALUES[n]	Reset G groups
20152	GCODE_RESET_MODE[n]	G code basic setting at RESET/end of parts program
20360	TOOL_PARAMETER_DEF_MASK	Definition of tool parameters
20624	HANDWH_CHAN_STOP_COND	Definition of the behavior of traveling with handwheel
27100	ABSBLOCK_FUNCTION_MASK	Parameterize block display with absolute values

#### 12.4.1.2 Axis/spindle-specific machine data

Number	Identifier: \$MA_	Description
30460	BASE_FUNCTION_MASK	Axis functions



## Basic PLC Program (P3)

### 13.1 Brief description

#### General

The PLC basic program organizes the exchange of signals and data between the PLC user program and the NCK (Numerical Control Kernel), HMI (Human Machine Interface) and MCP (Machine Control Panel). A distinction is made between the following groups for signals and data:

- Cyclic signal exchange
- Event-driven signal exchange
- Messages

#### Cyclic signal exchange

The cyclically-exchanged signals consist primarily of bit arrays.

- They contain **commands** transmitted from the PLC to the NCK (such as start or stop) and **status information** from the NCK (such as program running, interrupted, etc.).
- The bit fields are organized into signals for:
  - BAG
  - Channels
  - Axes/spindles
  - General NCK signals

The cyclic exchange of data is performed by the basic program at the start of the PLC cycle (OB1). This ensures, for example, that the signals from the NCK remain constant throughout a cycle.

### Event-driven signal exchange NCK → PLC

PLC functions that have to be executed as a function of the workpiece program are triggered by auxiliary functions in the workpiece program. If a block with auxiliary functions is executed, the type of auxiliary function determines whether the NCK has to wait for this function to execute (e.g. tool change) or whether the function will be executed together with the workpiece machining process (e.g. tool loading on milling machines with chain magazine).

Data transfer must be as fast and yet as reliable as possible, in order to minimize the effect on the NCK machining process. Data transfer is, therefore, interrupt- and acknowledgment-driven. The basic program evaluates the signals and data, acknowledges this to the NCK and transfers the data to the application interface at the start of the cycle. If the data do not require user acknowledgment, this does not affect NC processing.

### Event-driven signal exchange PLC → NCK

An "event-driven signal exchange PLC → NCK" takes place whenever the PLC passes a request to the NCK (e.g. traversal of an auxiliary axis). In this case, data transfer is also acknowledgment-driven. When performed from the user program, this type of signal exchange is triggered using a function block (FB) or function call (FC).

The associated FBs (Function Blocks) and FCs (Function Calls) are supplied together with the basic program.

### Messages

User messages are acquired and conditioned by the basic program. A defined bit field is used to transfer the message signals to the basic program, where they are evaluated and, if message events occur, entered in the PLC's interrupt buffer by means of the ALARM S/SQ function. Where an HMI (e.g. HMI embedded) is provided, the messages are transferred to and displayed on the HMI.

### PLC/HMI data exchange

In this type of data exchange, the HMI takes the initiative, being referred to as the "client" on the bus system. The HMI polls or writes data. The PLC processes these requests at the cycle control point via the operating system. The PLC basic program is not involved in these exchanges.

---

#### Note

The function of the machine is largely determined by the PLC program. Every PLC program in the RAM can be edited with the programming device.

---

## 13.2 Key data of the PLC-CPU's for 840D sl and 840Di sl

### Scope of performance

The table given below shows the performance range of the PLC CPUs and the scope of the basic PLC program with reference to various types of control.

	Type of control		
	840Di sl	840D sl	
PLC-CPU:	Integrated PLC CPU317-2DP master/slave	Integrated PLC CPU317-2DP master/slave	
<b>Key CPU data</b>			
Memory for user and basic program	128 to 768 KB	128 to 768 KB	
Data block memory	Max. 256 KB	Max. 256 KB	
Memory submodule	no	No	
Bit memories	32768	32768	
Timers	512	512	
Meters	512	512	
Clock memories	8	8	
Program/data blocks:			
OB	1, 10, 20-21, 32-35, 40, 55-57, 80-82, 85-87, 90, 100, 121-122	1, 10, 20-21, 32-35, 40, 55-57, 80-82, 85-87, 90, 100, 121-122	
FB	0-2048	0-2048	
FC	0-2048	0-2048	
DB	1-2048	1-2048	
Max. data block length	64 KB	64 KB	
Max. block length FC, FB	64 KB	64 KB	
Inputs/outputs (addressing capacity in bytes)			
digital + analog	4096/4096	4096/4096	
Incl. reserved area	(8192/8192)	(8192/8192)	
Process image	256/256	256/256	
Note: The inputs/outputs above 4096 are reserved for integrated drives.			
Inputs/outputs <sup>1)</sup> (addressing)			
	Row 0 is integrated in the NCU.	Through optional configuring of I/O devices:	Through optional configuring of I/O devices:
digital		From I/O byte 0	From I/O byte 0
analog		From PI/PO byte 288	From PI/PO byte 288
		PROFIBUS only	PROFIBUS only
Processing time			
Bit instructions (I/O)	0.03 ms/kA	0.03 ms/kA	
Word instructions	0.1 ms/kA	0.1 ms/kA	

13.2 Key data of the PLC-CPU's for 840D sl and 840Di sl

		Type of control	
PDIAG (Alarm S,SQ)	Yes	yes	
PROFIBUS	Master/Slave	Master/Slave	
Number of PROFIBUS slaves	Max. 125	max. 125	
Number of PROFIBUS slots	max. 512	max. 512	
DP master system no. DP	1	1	
DP master system no. MPI/DP	2	2	
DP master system No. internal PROFIBUS (PCI)	-	3	
Programmable block communication PBK	yes	yes	
Consistent data to standard slave via SFC 14, 15	128	128	
<b>I/O expansion</b>			
I/O modules, central	none	none	
PROFIBUS DP interfaces	1 (2)	1 (2)	
Interfaces (MPI)	1 (0)	1 (0)	

1) Row 0 is integrated in the NC. Rows 1 to 3 are available for I/O devices

	PLC filter	
	840Di sl (MC13)	840D sl (NCU 730.2 PN)
<b>PLC-CPU:</b>	Integrated PLC CPU319-3PN/DP Master/Slave	Integrated PLC CPU319-3PN/DP Master/Slave
<b>Key CPU data</b>		
Memory for user and basic program	512 to 1536 KB	512 to 1536 KB
Data block memory	Max. of 256KB	Max. of 256KB
Memory submodule	No	No
Bit memories	65536	65536
Timers	2048	2048
Counter	2048	2048
Clock memory	8	8
Program/data blocks:		
OB	1, 10, 20-21, 32-35, 40, 55-57, 80-82, 85-87, 90, 100, 121-122	1, 10, 20-21, 32-35, 40, 55-57, 80-82, 85-87, 90, 100, 121-122
FB	0-2048	0-2048
FC	0-2048	0-2048
DB	1-4096	1-4096
Max. data block length	64 KB	64 KB
Max. block length FC, FB	64 KB	64 KB
Inputs/outputs (addressing capacity in bytes)		

## 13.2 Key data of the PLC-CPUs for 840D sl and 840Di sl

		PLC filter	
digital + analog	4096/4096	4096/4096	
Incl. reserved area	(8192/8192)	(8192/8192)	
Process image	256/256	256/256	
Note: The inputs/outputs above 4096 are reserved for integrated drives.			
Inputs/outputs <sup>1)</sup> (addressing)			
	Row 0 is integrated in the NCU.	Through optional configuring of I/O devices:	Through optional configuring of I/O devices:
digital		From I/O byte 0	From I/O byte 0
analog		From PI/PO byte 288	From PI/PO byte 288
		PROFIBUS, PROFINET	PROFIBUS, PROFINET
Processing time			
Bit instructions (I/O)	0.01 ms/kA	0.01 ms/kA	
Word instructions	0.02 ms/kA	0.02 ms/kA	
PDIAG (Alarm S,SQ)	yes	yes	
PROFIBUS	Master/Slave	Master/Slave	
Number of PROFIBUS slaves	max. 125	max. 125	
Number of PROFIBUS slaves	max. 256	max. 256	
Number of PROFIBUS slots	max. 512	max. 512	
DP master system no. DP	1	1	
DP master system no. MPI/DP	2	2	
Master system No. PROFINET	100	100	
DP master system No. internal PROFIBUS (PCI)	-	3	
PBK programmable block communication	yes	yes	
Consistent Data to standard slave via SFC 14, 15	128	128	
<b>I/O expansion</b>			
I/O modules, central	none	none	
PROFIBUS DP interfaces	1 (2)	1 (2)	
Interfaces (MPI)	1 (0)	1 (0)	
PROFINET interfaces	1	1	

<sup>1)</sup> Row 0 is integrated in the NC. Rows 1 to 3 are available for I/O devices

---

**Note**

**Number of PROFIBUS slaves**

The content of the SDB2000 and related further SDBs is stored by the PLC operating system in internal data structures, which the PROFIBUS ASIC can also access. Furthermore, information from SDB2000 is also conditioned (CPI interface) and transmitted to the NCK and the PLC basic program. This is necessary in order to control drives and PROFIsafe modules on the PROFIBUS. A memory area defined by the PLC is available for these data structures. Its size is limited by the maximum number of slots. This means that during loading, SDBs with fewer slaves than listed above may be refused. A slot is usually a slave module or the slave itself. Only on a module with both I and Q areas does one module count as 2 slots. It is, therefore, not possible to specify the size of SDB 2000 exactly. It cannot be determined whether the configuration is legal until the SDB container has been loaded to the CPU. The values shown above must be taken as guide values only. If the configuration is not permissible, the alarm 410160 is set. If the configuration does not fit in the internal data range, no PROFIsafe and no SFC 15 functions work.

---

**PLC versions**

- PLC 317-2DP with SIMATIC version 2.1.8 (version ID 20.70.31) or higher version is implemented
- PLC 319-2DP with SIMATIC version 2.4 (version ID 24.90.xx) or higher version is implemented.

These versions are compatible with the corresponding SIMATIC CPU 300, which means that all modules and software packages that are approved for these versions and CPUs on SIMATIC are, therefore, suitable. Exceptions are modules, which in general may only be put in line 0.

Version identification in the version screen is made up of:

- SIMATIC CPU PLC primary version identifier
- Firmware transfer increment
- Internal increment

## Version screen on HMI

In the version screen the currently used PLC and the related version of the PLC operating system is displayed under PLC (e.g. PLC\_317-2DP 20.70.31).

In the column after that the module code of the PLC module used can be read. The following PLC module codes are currently in use:

Module code	PLC module	Firmware version	Operating system SW version ID
201x	PLC 317-2DP with IBC32	FW 2.1	20.70.31
MCI 2 (840Di) 211x	PLC 317-2DP with IBC32	FW 2.1	20.70.31
2308	PLC 319-3PN/DP	FW 2.4	24.90.10
MCI 3 (840Di)	PLC 319-3PN/DP	FW 2.4	24.90.10

## PLC basic program functions

	PLC filter	
	840Di	840D sl
<b>Scope</b>		
Axes/spindles	See catalog	31
Channels	6	10
Mode groups	6	10
<b>Functions</b>		
Status/control signals	+	+
M decoders (M00-99)	+	+
G group decoders	+	+
Aux. function distributors	+	+
Aux. function transfer, interrupt-driven	+	+
M decoding acc. to list	+	+
Move axes/spindles from PLC	+	+
Async. subprogram interface	+	+
Error/operating messages	+	+
Transfer MCP and HHU signals	+	+
Display control handheld unit	+	+
Read/write NCK variables and GUD	+	+
PI services	+	+
Tool management	+	+
Star/delta switchover	+	+
<b>m:n</b>	+	+
<b>Safety Integrated</b>		+
<b>Program diagnostics</b>	+	+

### Mode selector on PLC CPUs for 840D

On the NCU component, the right-hand twist button labeled "PLC" is used to set the PLC operating mode.

The switch settings are listed in the following table.

Switch setting	Significance	Remark
0	RUN-P	
1	RUN	Cannot load program
2	STOP	
3	MRES	

## 13.3 Reserve resources (timers, counters, FC, FB, DB, I/O)

### Reserve resources (timers, counters, FC, FB, DB, I/O)

The components below are reserved for the basic program:

- **Timers**

No reservation

- **Counter**

No reservation

- **FC, FB, DB**

FC 0 to FC 29 and FB 0 to FB 29 are reserved for the basic program. The number range between 1000 and 1023 is also reserved for FCs and FBs. Data blocks DB 1 to DB 62 and DB 71 to DB 80 are reserved. The number range 1000 to 1099 is also reserved in addition for DB. The data blocks of channels, axes/spindles and tool management functions that are not activated may be assigned as desired by the user.

- **I/O range**

The PLC has an I/O address volume of 8192 bytes each for inputs and outputs. The address ranges starting at 4096/4096 are reserved for/occupied by integrated drives. However, diagnostic addresses for modules can be assigned to the highest address range as proposed by STEP 7. Furthermore, the address range between 256 and 287 is assigned for the NCK, CP and HMI in rack 0 on the SIMATIC 300 station.

## 13.4 Startup hardware configuration of the PLC-CPUs

### General procedure

The hardware configuration for the PLC CPUs used in the NCU7x0, including other components of the NCU (NCK, CP, HMI, drive), must be defined via STEP 7. Proceed as follows in STEP7:

1. Create a new project (File, New, Project)
2. Insert, Hardware, SIMATIC 300 station
3. Select the SIMATIC 300 station with the mouse
4. right mouse button, open object

The HW-Config is now started.

5. A suitable SINUMERIK component is selected from the hardware catalog "SIMATIC 300 \ SINUMERIK \ 840D sl".
6. I/Os are to be extended from the hardware catalog of STEP 7

The addresses for the I/O modules can be changed, if needed.

### Prerequisites

In order to be able to select SINUMERIK components from the hardware catalog, you must run the Toolbox setup program first ("Hardware expansions for STEP7" and "Starter"). The current version of hardware expansions for STEP 7 can also be found under eSupport.

### Example of current hardware allocations PLC to NCU

Table 13-1 Hardware expansions

NCU	MLFB	Comparable SIMATIC CPU MLFB included	Selecting from STEP 7 hardware catalog
SINUMERIK 840D NCU 710.1	6FC5 371-0AA00-0AA0	6ES7 317-2AJ00-0AB0	NCU710.1 STEP 7 V5.3 SP2 and higher and Toolbox 840D sl 01.01.00)
SINUMERIK 840D NCU 720.1	6FC5 372-0AA00-0AA0	6ES7 317-2AJ00-0AB0	NCU720.1 STEP 7 V5.3 SP2 and higher and Toolbox 840D sl 01.01.00)
SINUMERIK 840D NCU 730.1	6FC5 373-0AA00-0AA0	6ES7 317-2AJ00-0AB0	NCU730.1 STEP 7 V5.3 SP2 and higher and Toolbox 840D sl 01.01.00)
SINUMERIK 840D NCU 740.1	6FC5 374-0AA01-?AA0	6ES7 318-3EL00-0AB0	NCU740.1 STEP 7 V5.4 or later and Toolbox 840D sl 01.04.02)

NCU	MLFB	Comparable SIMATIC CPU MLFB included	Selecting from STEP 7 hardware catalog
SINUMERIK 840Di sl with MCI2	6FC5 222-0AA02-1AA0	6ES7 317-2AJ00-0AB0	840Di with PLC317-2 DP STEP 7 V5.3 SP2 and higher and Toolbox 840D sl 01.02.00)
SINUMERIK 840Di sl with MCI3	6FC5222-0AA02-3AA0	6ES7 318-3EL00-0AB0	840Di with MCI3 STEP 7 V5.4 or later and Toolbox 840D sl 01.04.02)

**Note**

On SINUMERIK 840D, SIMATIC line 0 is allocated for the SINUMERIK components.

In this line stretches to:

- **Slot 2:** the integrated PLC with the different bus systems
- **Slot 3,** empty
- **Slot 4:** the NCK 840D sl. The properties (I/O address 256, process alarm) of the NCK must not be changed, as process interrupts (e.g. auxiliary functions) of the NCK to PLC may, in this case, no longer function.
- **Slot 5:** the integrated Ethernet CP 840D sl
- **Slot 6:** the integrated HMI 840D sl

The integrated drive is linked on the internal PCI bus (PROFIBUS protocol).

Currently, this bus does not support I/O access, and SFCs are not supported for this bus.

If you are using a different NCU, you can change the NCU using "drag & drop". The settings remain unaffected. When using the program "Starter" the icon "SINAMICS\_in\_NCUxyz" is also to be deleted and created again after the exchange of the NCU in the SIMATIC Manager.

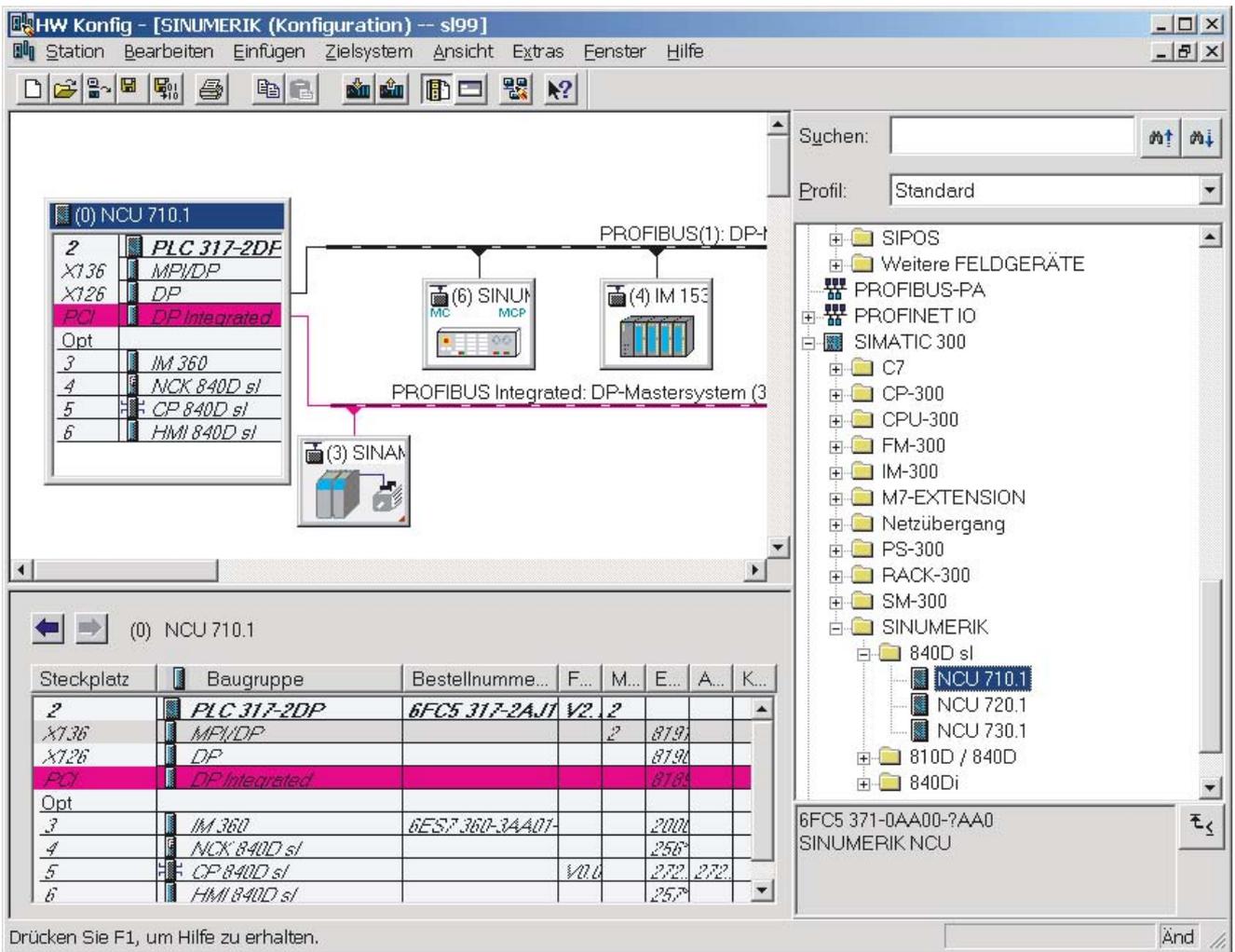


Figure 13-1 Hardware configuration on the SINUMERIK 840D sl and SINAMICS Properties dialog box

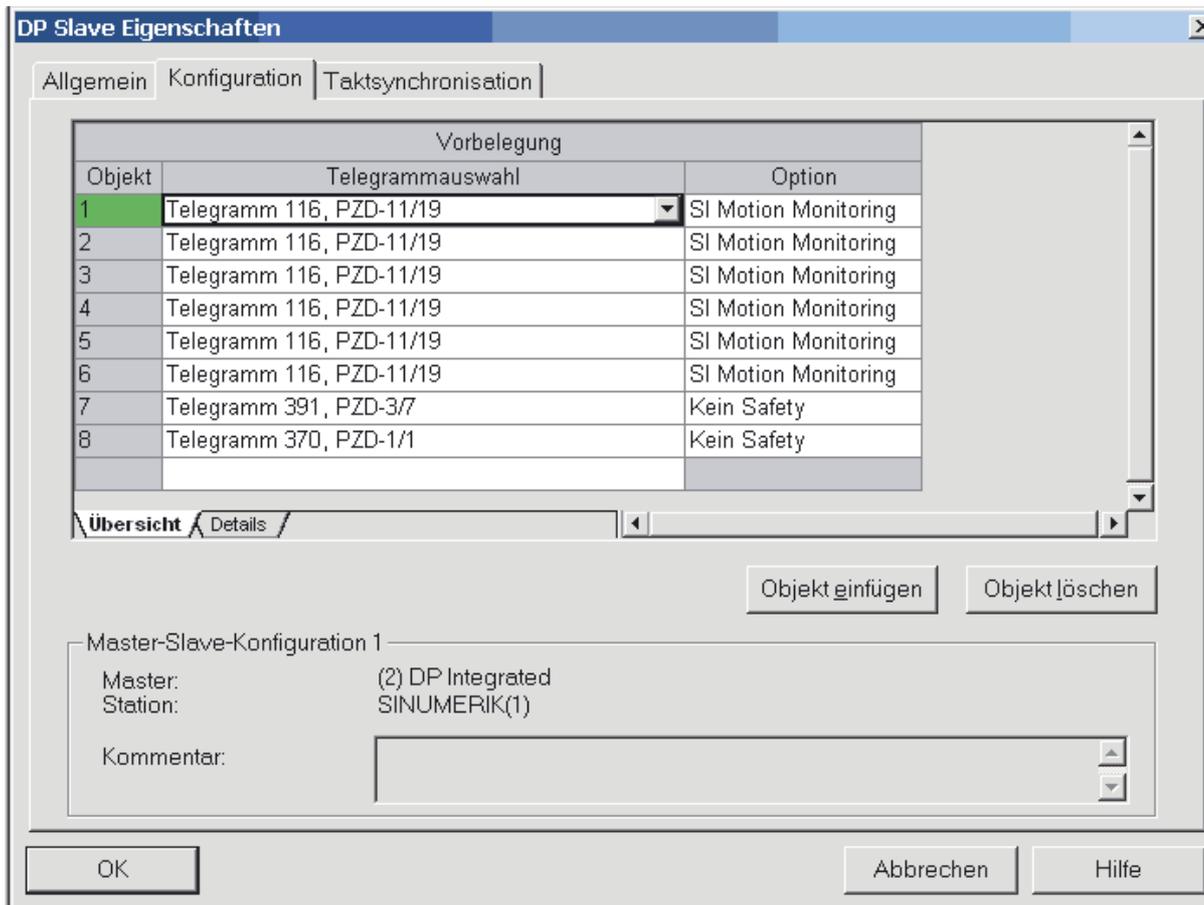


Figure 13-2 DP slave properties

In the Properties dialog box for the integrated SINAMICS drive, object codes 1 to 6 are used to identify axes 1 to 6. The axes are set for message frame type 106 and Safety Motion Monitoring as standard. This is the default setting. Telegram type 106 features the longest possible user data length of an NC axis. The message frame type in the NC machine data may not tally at all with this setting. In the context of an NC axis, message frame type 106 means: 2 encoders + DSC

Object 7 contains the ALM via which, for example, enables have to be activated by the PLC user program. Object 8 contains the Dev0 (Device 0).

Axis expansions with the NX10 and NX15 modules are possible for NCU720 and NCU730. You will find NX10 and NX15 in the PROFIBUS-DP\SINAMICS module catalog.

You will find the clock settings for the drives in the dialog box under the tab. In case the transmission cycles of the drives have to be changed, a change must be made under this tab.

### **Ethernet communication**

In case of CP 840D the Ethernet address is assigned by default for the port X127. As such, the PLC can be reached via this port from a STEP 7 project. If needed, the Ethernet address on the CP 840D can be changed to the Ethernet address of the port X120 or X130. Then a cable connection to the PG of this port is also necessary.

### **Connection of central I/O devices**

The physical connection for a connection to an IM361 does not exist. No central I/O is possible.

## 13.5 Starting up the PLC program

### 13.5.1 Installing the basic program for 840D

A complete general reset of the NCK and the PLC is necessary before starting up the NCU component for the first time. Turn the "SIM/NCK" switch on the left-hand side to position 1 and the "PLC" switch on the right-hand side to position 3. Then restart the controller. This action generates a "hard reset request" on the PLC. The memories of the PLC and NC are then initialized.

#### Installation

The basic program is installed by the Toolbox by means of the execution of a setup program for the basic program, hardware expansion for STEP7 (option package for SINUMERIK 840D sl) and NC-Var selector components, as well as for other tools. To start the installation, run setup.exe in the main CD directory. You can then choose which components to install. After the installation you can select the basic program library directly from STEP7 (bp7x0\_14, 14 is the main basic program version 1.4). The concrete version of the basic program can be scanned for the object properties of the library or the program folder in the comment field.

#### General

The OB source programs, including standard parameterization, interface symbols and data-block templates for the handheld unit and M decoding functions are included in the SIMATIC project or SIMATIC library of the basic program.

STEP 7 must be installed before installing the basic program Toolbox. After an update of STEP 7, it is generally recommended to reinstall the hardware expansion for STEP 7 from the toolbox.

## 13.5.2 Application of basic program

A new CPU program (e.g. "Turnma1") must be set up in a project by means of the STEP 7 software for each installation (machine).

### Comment

The catalog structures of a project and the procedure for creating projects and user programs are described in the relevant SIMATIC documentation.

### Procedure

The basic-program blocks are copied using the SIMATIC Manager and "File" > "Open" > "Library".

The following components must be copied from the library:

- From the block container: FCs, FBs, DBs, OBs, SFC, SFB, UDT
- Source\_files (from the source container): GPOB840D
- Possibly MDECLIST, HHU\_DB and others
- The symbols table (from the symbols container)

### Compatibility with STEP 7

There are no dependencies between the basic program and current STEP7 versions.

### 13.5.3 Version codes

#### Basic Program

The version of the basic program is displayed on the HMI version screen along with the controller type.

The controller type is encoded as follows:

Left-justified decade of DB 17 DBD 0 (byte 0)	Controller type
03	SINUMERIK 840D (561,571, 572, 573)
04	SINUMERIK 840Di
03	SINUMERIK 840D sl (NCU 7x0) SINUMERIK 840Di sl

#### User Program

Users can also display their own PLC version codes on the HMI version screen. For this purpose, a data of type STRING containing a maximum of 54 characters must be defined in any data block. The data can contain a text of the user's choice. Parameter assignments for this string are made via a pointer in FB 1. Parameterization requires symbolic definition of the data block.

See also section "block descriptions" > "FB 1: RUN\_UP Basic program, start-up section (Page 974)".

### 13.5.4 Machine program

The machine manufacturer creates the machine program using the library routines supplied with the basic program. The machine program contains the logic operations and sequences on the machine. The interface signals to the NC are also controlled in this program. More complex communication functions with the NCK, e.g. read/write NC data, tool-management acknowledgments, etc., are activated and executed via blocks FCs and FBs of the basic-program).

The machine program can be created in various STEP 7 creation languages, e.g. AWL, KOP, FUP, S7-HIGRAPH, S7GRAPH, SCL. The complete machine program must be generated and compiled in the correct sequence.

This means that blocks that are called by other blocks must generally be compiled **before these** blocks.

If blocks that are called by other blocks are subsequently modified in the interface (VAR\_INPUT, VAR\_OUTPUT, VAR\_IN\_OUT, VAR) as the program is developed, then the call block and all blocks associated with it must be compiled again. This general procedure applies analogously to instance data blocks for FBs. If these sequence of operations is not maintained, time-stamp conflicts occur when the data retranslated into STEP 7. As such, the recompilability of the blocks is not ensured and with the function "Status of block" unnecessary conflicts can also appear. It is, moreover, advisable to generate blocks in ASCII-STL by means of the STEP 7 editor when they have been created in Ladder Diagram or in single statements (incremental mode).

### 13.5.5 Data backup

The PLC-CPU does not save any symbolic names, but instead only the datatype descriptions of the block parameters VAR\_INPUT, VAR\_OUTPUT, VAR\_IN\_OUT, VAR and the datatypes of the global data blocks.

---

#### Note

No sensible recompilation is possible without the related project for this machine. This especially affects, for instance the function status of the block or the necessary changes done in the PLC-CPU programs later. It is, therefore, necessary to keep a backup copy of the STEP 7 project located in the PLC CPU on the machine. This is a great help for the service case and saves unnecessary consumption of time in restoring the original project.

---

If the STEP 7 project exists and has been created according to the instructions given above, then symbols can be processed in the PLC-CPU on this machine. It may also be advisable to store the machine source programs as ".awl" files in case they are required for any future upgrade.

The source programs of all organization blocks and all instance data blocks should always be available.

### 13.5.6 PLC-series startup, PLC archive

Once the blocks have been loaded to the PLC CPU, a series archive can be generated via the HMI operator interface to back up data on the machine. To ensure data consistency, this backup must be created immediately after block loading when the PLC is in the Stop state. It does not replace the SIMATIC project backup as the series archive saves binary data only, For instance, no symbolic information is present here. In addition, no CPU DBs (SFC 22 DBs) or SDBs generated in the CPU are saved.

The PLC series archive can be generated directly from the relevant SIMATIC project as an alternative. To do this, in STEP 7 select the "Archive" tab available under the "Options" > "Settings" menu item. This contains an entry "SINUMERIK (\*.arc)", which must be selected to create a series commissioning file. After selection of the archive, select the "File" > "Archive" menu item. The relevant series archive will then be generated. If the project contains several programs, the program path can be selected. A series archive is set up for the selected program path. All blocks contained in the program path are incorporated into the archive, except for CPU-DBs (SFC 22 DBs). In addition, the "SDB archive" can be activated or deactivated in the function. With this selection the SDB present in the STEP 7 project can be added to the archive or left outside.

### Automation

The process of generating a series archive can be automated (comparable to the command interface in STEP7). In generating this series archive, the command interface is expanded.

The following functions are available for this expansion:

The functions (shown here in VB script) are not available until server instantiations and Magic have been called:

```
Const S7BlockContainer = 1138689, S7PlanContainer = 17829889
```

```
Const S7SourceContainer = 1122308
```

```
set S7 = CreateObject("Simatic.Simatic.1")
```

```
instantiate rem command interface of STEP 7
```

```
Set S7Ext = CreateObject("SimaticExt.S7ContainerExt")
```

```
Call S7Ext.Magic("")
```

Functions:

```
Function Magic(bstrVal As String) As Long
```

```
Function MakeSeriesstart-up (FileName As String, Option As Long, Container As S7Container) As Long
```

## Description

Function **Magic**(bstrVal As String) As Long

Call gives access to certain functions. The function must be called once after server instantiation. The value of bstrVal can be empty. This initiates a check of the correct STEP 7 version and path name in Autoexec. The functions are enabled with a return parameter of 0.

Return parameter (-1) = incorrect STEP 7 version

Return parameter (-2) = no entry in Autoexec.bat

Function **MakeSeriesstart-up**(FileName As String, Option As Long, Container As S7Container) As Long

**"Option" parameter:**

0:	Normal series IBN file with general reset.
Bit 0 = 1:	Series IBN file without general reset. When project contains SDBs, this option is inoperative. A general reset is then always executed.
Bit 1 = 1:	Series IBN file with PLC restart

Return parameter value:

0	= OK
-1	= Function unavailable, call Magic function beforehand
-2	= File name cannot be generated
-4	= Container parameter invalid or container block empty
-5	= Internal error (memory request rejected by Windows)
-6	= Internal error (problem in STEP 7 project)
-7	= Write error when generating series startup files (e.g. diskette full)

## Use in script

```

If S7Ext.Magic("") < 0 Then
    Wscript.Quit(1)
End If

Set Proj1 = s7.Projects("new")
set S7Prog = Nothing
Set s7prog = Proj1.Programs.Item(1) 'if there is only one program'
For Each cont In s7prog.Next
    If (Cont.ConcreteType = S7BlockContainer) Then
        ' Check block container
    Exit For
    End if
    Cont = Nothing
Next
Error = S7Ext.MakeSerienIB("f:\dh\arc.dir\PLC.arc", 0, Cont)
' Now error analysis
    
```

The For Each ... Next Block programmed above can be programmed in the Delphi programming language as follows (the programming for C, C++ programming languages is similar):

```

Var
  EnumVar: IEnumVariant;
  rgvar: OleVariant;
  fetched: Cardinal;

//For Each Next
EnumVar := (S7Prog.Next._NewEnum) as IEnumVariant;
While (EnumVar.Next(1,rgvar,fetched) = S_OK) Do Begin
  Cont := IS7Container(IDispatch(rgvar)); // block container
  Check sources
  If (Cont.ConcreteType = S7BlockContainer) Then Break;
  Cont := NIL;
End;

```

## 13.5.7 Software upgrade

### Software upgrade

Whenever you update the PLC or NCK software, always reset the PLC to its initial state first. This initial clear state can be achieved by means of a general PLC reset. In case of this resetting all the available blocks are deleted.

In normal cases, the new basic program is to be linked for a new NCU software version. The basic programs blocks must be loaded into the user project for this purpose. In this case no OB 1, OB 40, OB 82, OB 86, OB 100, the FC 12 and also the DB 4 may not be transmitted, if these blocks are already present in the user project. These blocks may have been modified by the user. The new basic program must be linked with the user program.

To do this, proceed as follows:

1. Generate the text or source file of all user blocks before copying the basic program.
2. Then copy the new basic program blocks to this machine project (for a description, see Subsection "Application of basic program")
3. All user programs "\*.awl" must then be recompiled in the correct order! (see also: "Machine program (Page 899)":
4. This newly compiled machine program must then be loaded to the PLC CPU with STEP 7.

However, it is normally sufficient to recompile the organization blocks (OB) and the instance data blocks of the machine program. This means you only need to generate sources for the organization blocks and the instance data blocks (before upgrading).

## Overall reset

A description of how to perform a general PLC reset appears in the Installation and Start-Up Guide. However, a general reset does not delete the contents of the diagnostic buffer nor the node address on the MPI bus. Another possible general reset method is described below. This method must be used when the normal general reset process does not work.

Proceed as follows:

No.	Action	Effect
1	Control system is switched off	
2	PLC switch setting 3 (MRES) and switch control on again or perform hardware RESET.	LED labeled PS flashes slowly.
3	Set PLC start-up switch to position 2 (STOP) and back to position 3 (MRES).	The LED labeled PS starts to flash faster.
4	Set PLC start-up switch to setting 2 or 0.	

## NC tags

The latest NC VAR selector can be used for each NC software version (even earlier versions). For older NC software versions the variables can also be selected from the latest complete list. The data content in DB 120 (default DB for variables) does not depend on the software status. That is, variables selected in an older software version need not be reselected when the software is upgraded.

### 13.5.8 I/O modules (FM, CP modules)

Special packages for STEP 7 are generally required for more complex I/O modules. Some of these special packages include support blocks (FCs, FBs) stored in a STEP7 library. The blocks contain functions for operating the relevant module which are parameterized and called by the user program. In many cases, the FC numbers for the CP and FM module handling blocks are also included in the number range of the basic program for the 840D.

What can one do in these conflicts?

The block number of the basic program must remain unchanged. The block numbers of required handling blocks can be assigned to free numbers using STEP 7. These new blocks (with new FC numbers) are then called in the user program with the parameter assignments required by the function.

### 13.5.9 Troubleshooting

This section describes problems which may occur, their causes and remedies and should be read carefully before hardware is replaced.

Errors, cause/description and remedy			
Serial no. error information	Errors	Cause/description	To correct or avoid errors
1	No connection via MPI to PLC.	The MPI cable is not plugged in or is defective. Possibly, the STEP 7 software is also not correctly configured for the MPI card.	Test: Create a link with the programmer in the STEP 7 editor by means of connection "Direct_PLC". A number of node addresses must be displayed here. If they do not appear, the MPI cable is defective/not plugged in.
2	PLC cannot be accessed in spite of PLC general reset.	A system data block SDB 0 has been loaded with a modified MPI address. This has caused an MPI bus conflict due to dual assignment of addresses.	Disconnect all MPI cables to other components. Create the link "Direct_PLC" with the programmer. Correct the MPI address.
3	All four LEDs on the PLC flash (DI disaster)	A system error has occurred in the PLC. <b>Measures:</b> The diagnostic buffer on the PLC must be read to analyze the system error in detail. To access the buffer, the PLC must be stopped (e.g. set "PLC" switch to position 2). A hardware reset must then be performed. The diagnostic buffer can then be read out with STEP 7. Relay the information from the diagnostic buffer to the Hotline/Development Service. A general reset must be carried out if requested after the hardware RESET. The diagnostic buffer can then be read with the PLC in the Stop state.	Once the PLC program has been RESET or reloaded, the system may return to normal operation. Even in this case, the content of the diagnostic buffer should be sent to the Development Office.

## 13.6 Linking PLC CPUs to 840D

### 13.6.1 General

The AS 300 family is used as the PLC for all systems. On the SINUMERIK 840 D, the PLC CPU is integrated into the NCU component as a sub-module. The relevant performance data for PLC CPUs can be found in the above table or in the SIMATIC catalog.

### 13.6.2 Features of PLC CPUs

SINUMERIK 840D sl/840Di sl PLC CPUs are based on standard SIMATIC CPUs in the S7-300 family. As a result, they generally possess the same functions. Functional deviations are shown in the table above. Owing to differences in their memory system as compared to the SIMATIC CPU, certain functions are not available (e.g. save blocks on memory card, save project on memory card).

---

#### **Note**

With the current SIMATIC CPUs, the PLC is not automatically started after voltage failure and recovery when a PLC Stop is initiated via software operation. In this instance, the PLC remains in the Stop state with an appropriate diagnostic entry for safety reasons. You can start the PLC only via software operation "Execute a restart" or by setting the switch to "Stop" and then "Run". This behavior is also integrated in the current versions of the SINUMERIK PLC.

---

### 13.6.3 Interface on 840D with integrated PLC

#### **Physical interfaces**

As the SINUMERIK 840D system has an integrated PLC, signals can be exchanged between the NCK and PLC directly via a dual-port RAM.

#### **Data exchange with the control panel**

Data exchange with the operator panel (HMI, OP) usually takes place via the internal software-based C bus. Alternatively, external HMI or OP systems can also be connected on Ethernet or the MPI bus. In the event of connection to the Ethernet bus, the integrated CP provides the link to the PLC.

On the SINUMERIK 840D, data exchange with the machine control panel (MCP) and handheld unit (HHU) is determined by the interface setup of the MCP/HHU. Possible connection paths include: MPI, PROFIBUS, Ethernet.

Programming devices should preferably be connected directly to the PLC on the Ethernet bus via the internal CP or via the MPI (Multi-Point-Interface).

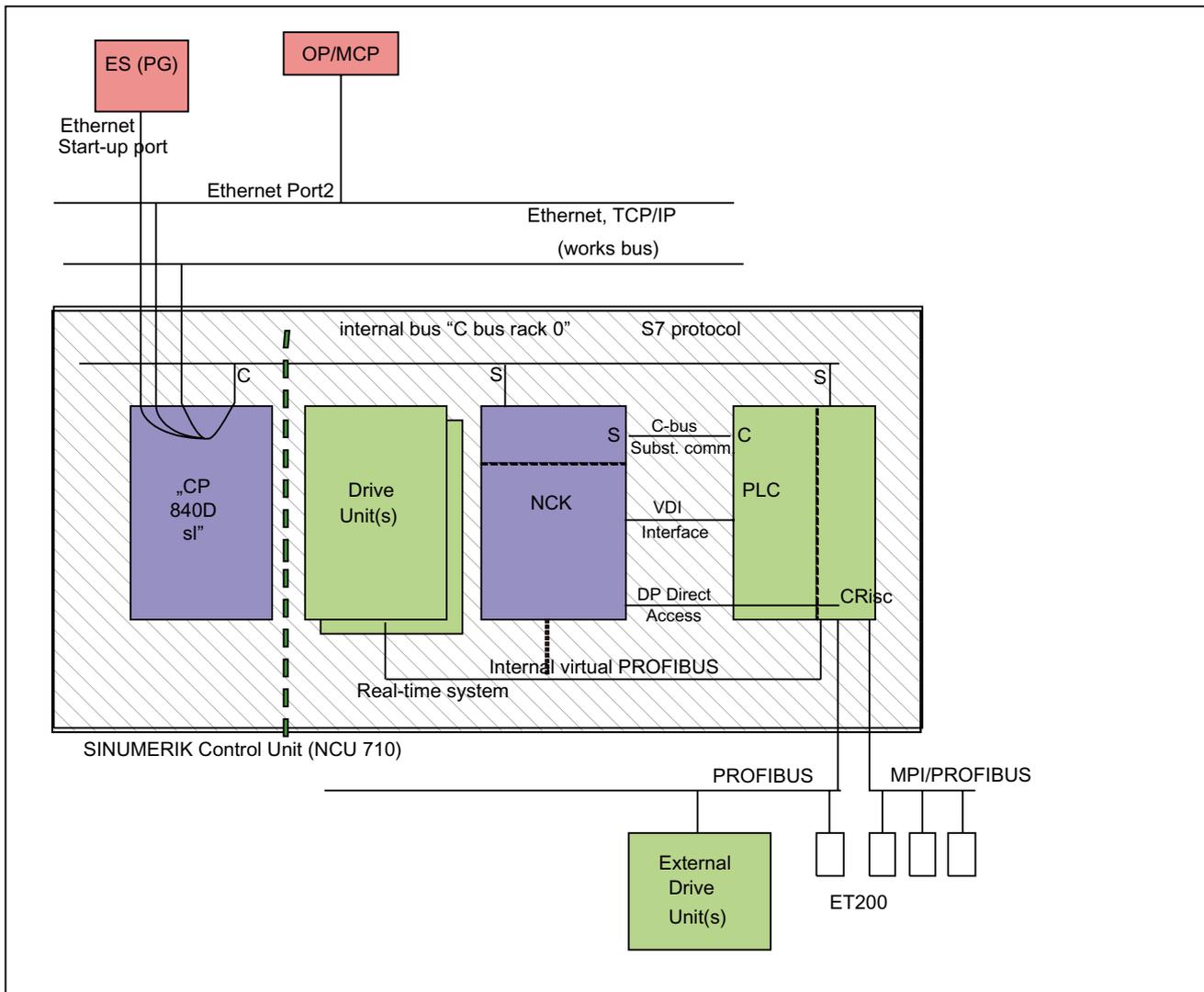


Figure 13-3 NCK/PLC coupling on SINUMERIK 840D (integrated PLC)

### NCK/PLC interface

As illustrated in the figure, NCK/PLC data exchange is organized by the basic program in the PLC. At the beginning of the cycle (OB1), the **status information** (e.g. "Program running") written to the internal DPR (DPR = Dual Port RAM) by the NCK is copied to data blocks by the basic program, which the user can then access (user interface). The **control signals** for the NCK (e.g. NC start) entered in the interface data blocks by the user are also written to the internal DPR and transmitted to the NCK at the start of the cycle.

Workpiece-program-specific **auxiliary functions** transferred to the PLC are first evaluated by the basic program (interrupt-driven) and then transferred to the user interface at the start of OB 1. If the relevant NC block contains auxiliary functions that require the interruption of the NCK machining process (e.g. M06 for tool change), the basic program halts the decoding of the NCK block initially for one PLC cycle. The user can then use the "read disable" interface signal to halt the block execution until the tool change has been completed. If, on the other hand, the relevant NC block does not contain auxiliary functions requiring the interruption of the NC machining process (e.g. M08 for "Cooling on"), the transfer of these "rapid" auxiliary functions is enabled directly in OB 40, so that block execution is only marginally influenced by the transfer to the PLC.

The evaluation and enabling of the **G functions** transferred from the NCK are also alarm-driven, however they are transferred directly to the user interface. Where a G function is evaluated at several points in the PLC program, differences in the information of the G function within one PLC cycle may arise.

In the case of **NC actions** triggered and assigned with parameters by the PLC (e.g. traverse concurrent axes), triggering and parameter assignment is performed using FCs and FBs, not interface data blocks. The FCs and FBs belonging to the actions are supplied together with the basic program. The FCs and FBs required must be loaded by the user and called in the PLC program of the machine manufacturer (machine program). For an overview of FC, FB and data blocks, sorted according to basic and extended functions, please refer to the chapter "Start-up of PLC programs".

## Interface HMI/PLC

HMI/PLC data exchange takes place via the software C bus or via the Ethernet, internal CP, control-internal C bus link. The CP transfers the data intact from one bus segment to another. The HMI is always the active partner (client) and the PLC is always the passive partner (server). Data transmitted or requested by the HMI are read from and written to the HMI/PLC interface area by the PLC operating system (timing: cycle control point). From the viewpoint of the PLC application, the data are identical to I/O signals.

## Interface MCP/PLC, interface HHU/PLC (Ethernet link)

MCP/PLC and HHU (HT2) /PLC data exchange takes place via the integrated CP's Ethernet bus. The CP transfers the MCP/HHU signals to and fetches them from the PLC's internal DPR (Dual-Port RAM). On the PLC side, the basic program handles communication with the user interface. The basic program parameters define the operand areas (e.g. I/O) and the start addresses via the parameters of the basic programs (FB 1, DB 7).

### Interface MCP/PLC (PROFIBUS link)

MCP/PLC data exchange takes place via the PLC's PROFIBUS. The MCP's I/O addresses are to be set in the PLC's process image area and via HW configuration in STEP 7. The MCP\*In, MCP\*Out pointer variables must be set to the same addresses. The selected DP slave number must be entered in MCP\*BusAdr.

### Interface MCP/PLC, interface HHU/PLC (MPI link)

is no longer supported

#### **13.6.4 Diagnostic buffer on PLC**

The diagnostic buffer of the PLC (readable using STEP 7) will enter diagnostic information on the PLC operating system.

## 13.7 Interface structure

### Interface DBs

Mapping in interface data blocks is necessary due to the large number of signals exchanged between the NCK and PLC. These are global data blocks from the viewpoint of the PLC program. During system start-up, the basic program creates these data blocks from current NCK machine data (no. of channels, axes, etc.). The advantage of this approach is that the minimum amount of PLC RAM required for the current machine configuration is used.

### 13.7.1 PLC/NCK interface

#### General

The PLC/NCK interface comprises a data interface on one side and a function interface on the other. The data interface contains status and control signals, auxiliary functions and G functions, while the function interface is used to transfer jobs from the PLC to the NCK.

#### Data interface

The data interface is subdivided into the following groups:

- NCK-specific signals
- Mode-group-specific signals
- Channel-specific signals
- Axis/spindle/drive-specific signals

#### Function interface

The function interface is formed by FBs and FCs. The figure below illustrates the general structure of the interface between the PLC and the NCK.

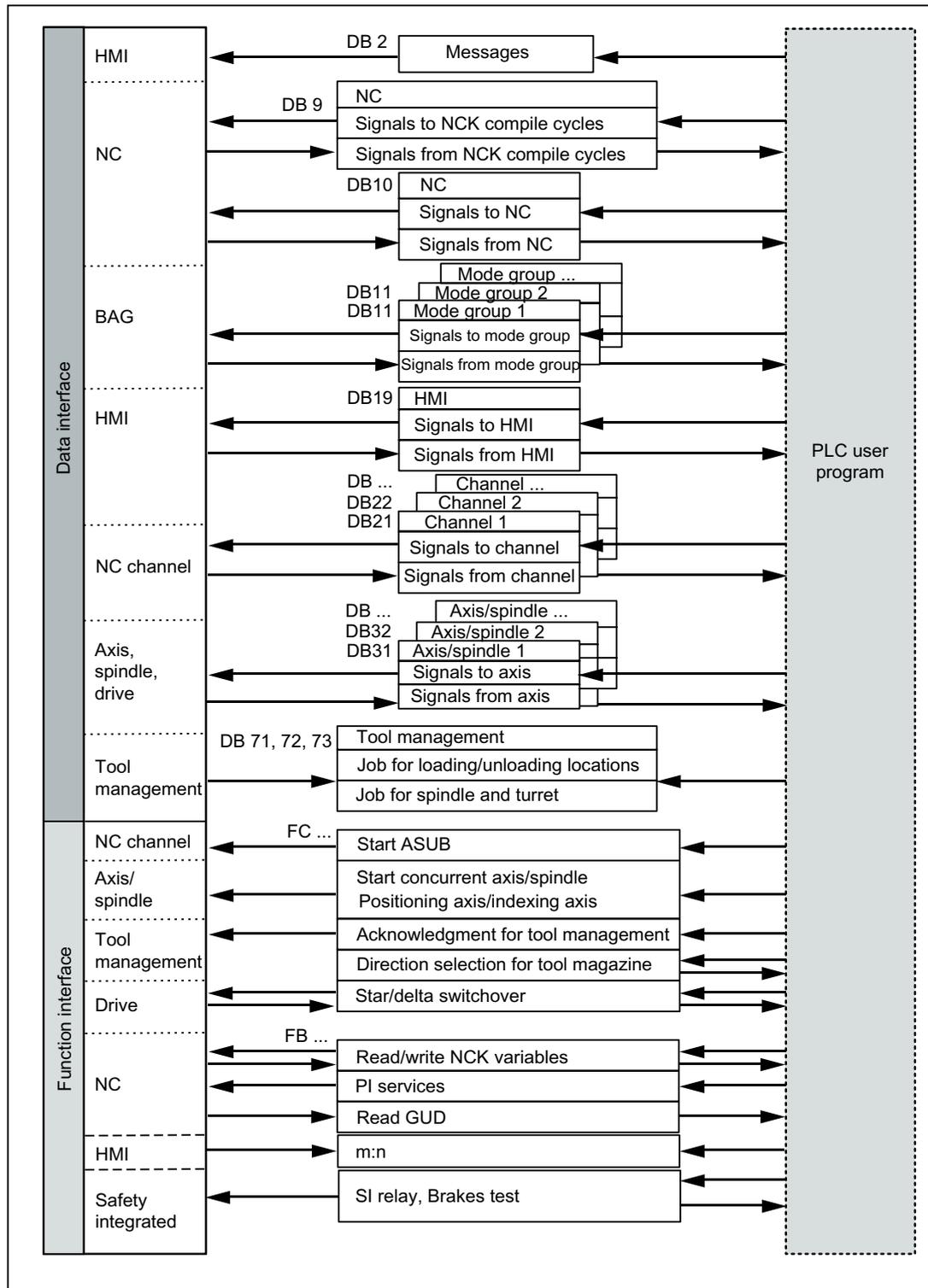


Figure 13-4 PLC/NCK user interface

## Compile-cycle signals

In addition to the standard signals exchanged between the PLC and NCK, an interface data block for compile cycles is also generated if required (DB 9). The associated signals, which are dependent on the compile cycles, are transmitted cyclically at the start of OB 1. The basic program starts transmission at the lowest address and works up to the highest. First, signals are transferred from the PLC to the NCK, then from the NCK to the PLC. The user must synchronize the NCK and PLC as necessary (e.g. using the semaphore technique). Signal transmission is asynchronous between NCK and PLC. This means, for example, that active NCK data transmission can be interrupted by the PLC. This can mean that data is not always consistent.

## PLC/NCK signals

The group of signals from the PLC to NCK includes:

- Signals for modifying the digital and analog I/O signals of the NCK
- Keyswitch and emergency stop signals

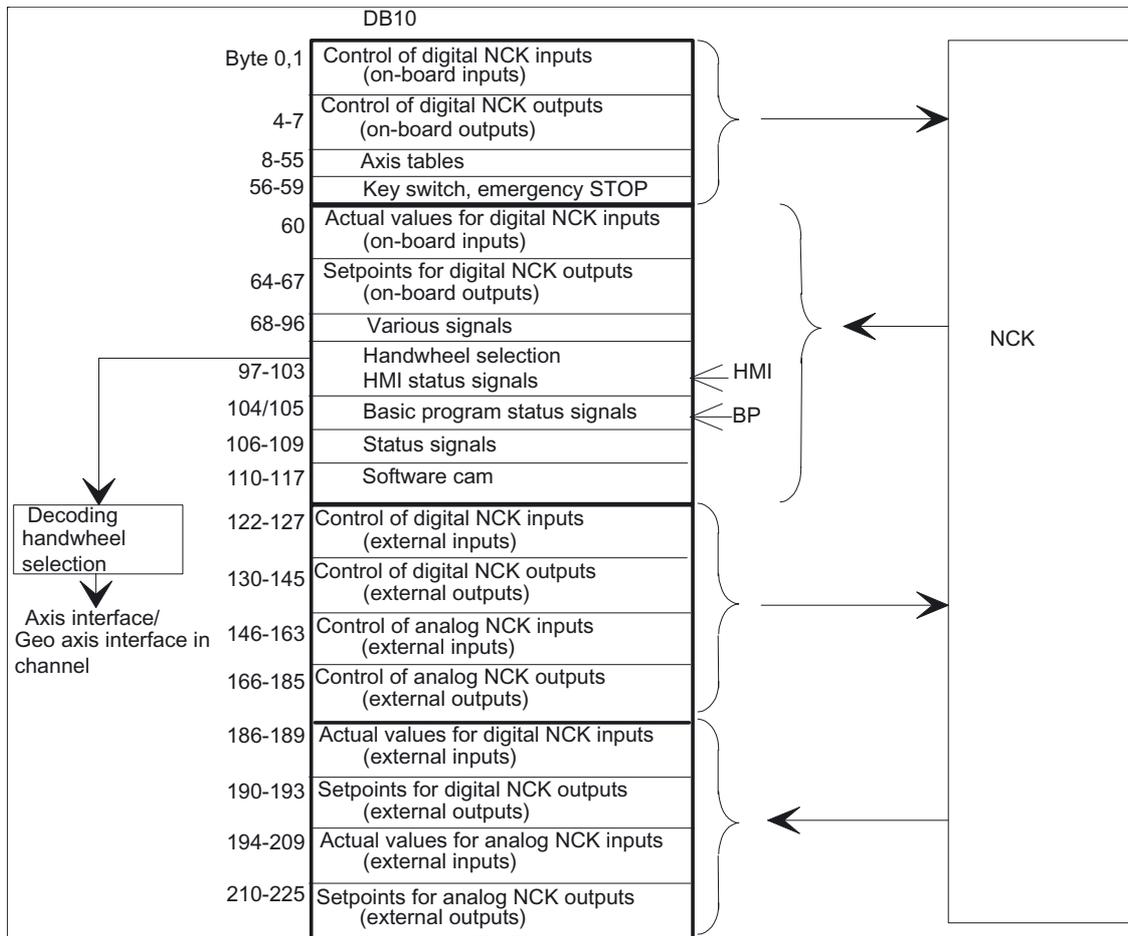


Figure 13-5 PLC/NCK interface

### NCK/PLC signals

The group of signals from the NCK to PLC includes:

- Actual values of the digital and analog I/O signals of the NCK
- Ready and status signals of the NCK

Also output in this group are the HMI handwheel selection signals and the status signals.

The signals for handwheel selection are decoded by the basic program and entered in the machine-/axis-specific interface.

### Digital/analog inputs/outputs of the NCK

The following must be noted with respect to the digital and analog inputs and outputs of the NCK:

#### Inputs:

- All input signals or input values of the NCK are also transferred to the PLC.
- The transfer of signals to the NC parts program can be suppressed by the PLC. Instead, a signal or value can be specified by the PLC.
- The PLC can also transfer a signal or value to the NCK even if there is no hardware for this channel on the NCK side.

#### Outputs:

- All signals or values to be output are also transferred to the PLC.
- The NCK can also transfer signals or values to the PLC even if there is no hardware for this channel on the NCK side.
- The values transferred by the NCK can be overwritten by the PLC.
- Signals and values from the PLC can also be output directly via the NCK I/O devices.

---

#### Note

While realizing the digital and analog NCK I/Os the information contained in the following documentation must be taken into account:

#### References:

Function Manual Extended Functions; Digital and analog NCK I/Os (A4)

---

### Signals PLC/Mode group

The operating mode signals set by the machine control panel or the HMI are transferred to the operating mode group (BAG) of the NCK. On the 840D, these are valid for all NCK channels. On 840D systems, several mode groups can optionally be defined in the NCK.

The mode group reports its current status to the PLC.

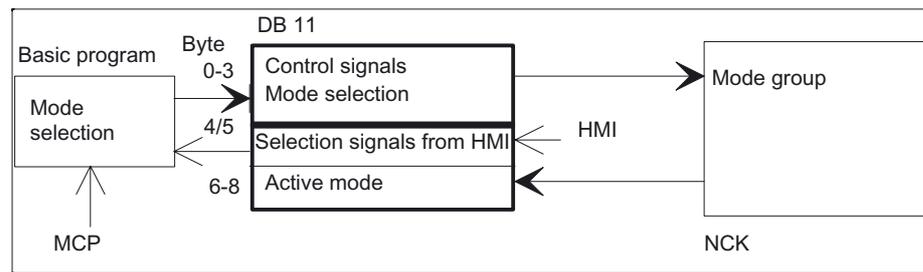


Figure 13-6 PLC/Mode group interface

## Signals PLC/NCK channels

The signal groups below must be considered on the interface:

- Control/status signals
- Auxiliary/G functions
- Tool management signals
- NCK functions

The **control/status functions** are transmitted cyclically at the start of OB1. The signals entered in the channel-specific interface by the HMI (HMI signals are entered by the PLC operating system) are also transferred at this time if they have been defined on the HMI operator panel, not on the MCP.

**Auxiliary functions and G functions** are entered in the interface data blocks in two ways. First, they are entered with the change signals.

- The **M signals** M00 - M99 (they are transferred from the NCK with extended address 0) are also decoded and the associated interface bits set for the duration of one cycle.
- For **G functions**, only the groups selected via machine data are entered in the interface data block.
- The **S values** are also entered together with the related M signals (M03, M04, M05) in the spindle-specific interface. The axis-specific feedrates are also entered in the appropriate axis-specific interface.

When the **tool management (magazine management)** function is activated in the NCK, the assignment of spindle or revolver and the loading/unloading points are entered in separate interface DBs (DB71 - 73)

The triggering and parameter assignment of **NCK functions** is performed by means of PLC function calls.

The following function calls are available:

- Position a linear axis or rotary axis
- Position an indexing axis
- Start a prepared asynchronous subprogram (ASUB)
- Reading/writing of NC variables
- Update magazine and tool movement

Some of the above functions are described in their own function documentation.

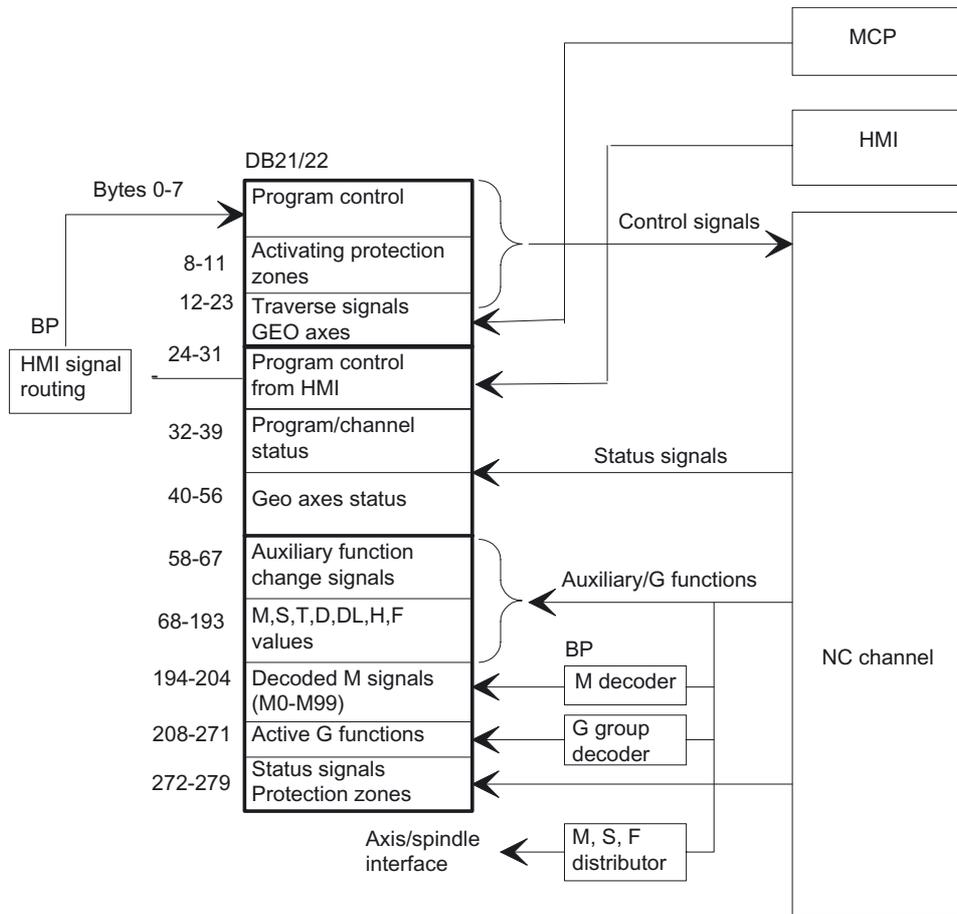


Figure 13-7 PLC/NCK channel interface

### PLC/axis, spindle, drive signals

The axis-specific and spindle-specific signals are divided into the following groups:

- Shared axis/spindle signals
- Axis signals
- Spindle signals
- Drive signals

The signals are transmitted cyclically at the start of OB 1 with the following exceptions:

Exceptions include:

- Axial F value
- M value
- S value

An **axial F value** is entered via the M, S, F distributor of the basic program if it is transferred to the PLC during the NC machining process.

The **M and S value** are also entered via the M, S, F distributor of the basic program if one or both values require processing.

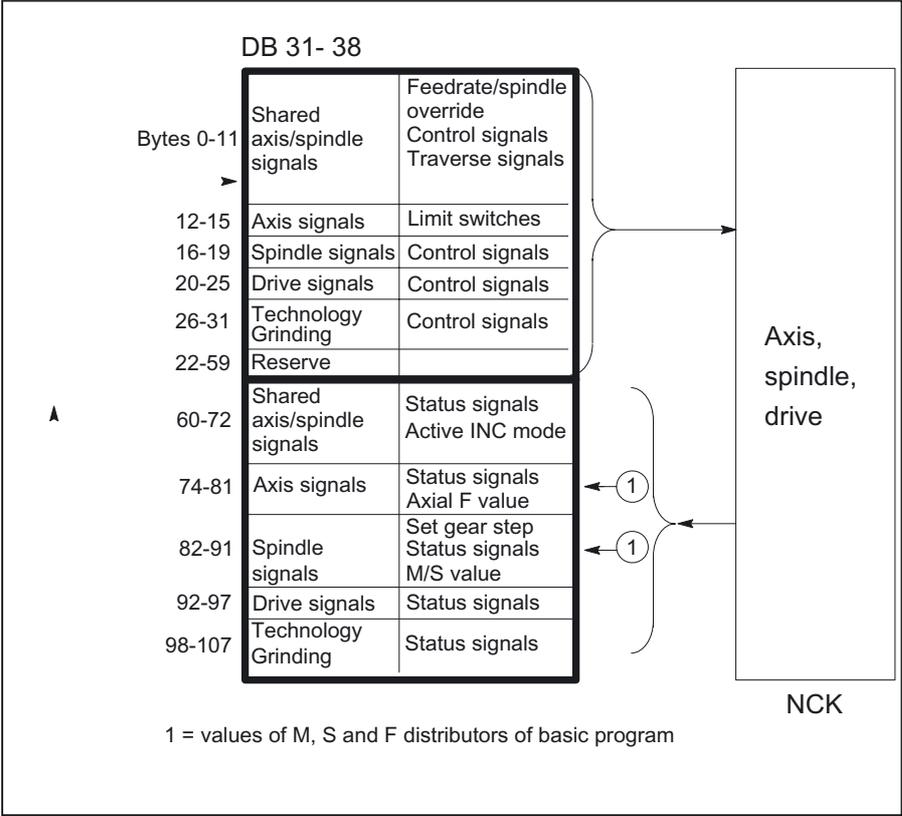


Figure 13-8 Interface between PLC and axes/spindles/drives

## 13.7.2 Interface PLC/HMI

### General

The following groups of functions are required for the PLC/HMI interface:

- Control signals
- Machine operation
- PLC messages
- PLC status display

### Control signals

Some control signals are signal inputs, for example, via the machine control panel, which have to be taken into account by the HMI. This group of signals includes, for example, display actual values in MCS or WCS, key disable, etc. These are exchanged with the HMI via a separate interface data block (DB19).

### Machine operation

All operator inputs, which lead to response actions on the machine, are monitored by the PLC. Operator actions are usually performed on the machine control panel (MCP). However, it is also possible to perform some operator actions on the HMI e.g. mode selection.

The PLC operating system enters the operating signals sent by the HMI directly into the interface data blocks. As standard, the basic program routes these operating signals in such a way that, provided equivalent operator actions are available, these can be performed either on the HMI **or** on the MCP. If required, the user can switch off the operation via HMI through a parameter "MMCToIF" of FB1.

### PLC messages

The signaling functions are based on the system diagnostic functions integrated in the operating system of the AS 300. These have the following characteristics:

- The PLC operating system enters all important system states and state transitions in a **diagnostics status list**. Communication events and I/O module diagnostics data (for modules with diagnostic functions) are also entered.
- Diagnostics events, which lead to a system stop, are also entered with a time stamp in a **diagnostic buffer** (circular buffer) in the chronological order of their occurrence.
- The events entered in the diagnostic buffer are automatically transmitted to human machine interface systems (OP or HMI) via the bus systems once these have issued a ready signal (message service). Transfer to the node ready is a function of the PLC operating system. Receipt and interpretation of the messages are executed by the HMI software.

- The PLC user program can also use SFCs (System Function Calls) to enter messages in the diagnostic buffer or ALARM S/ALARM SQ buffer.
- The events are entered in the interrupt buffer.

The associated message texts must be stored on the OP or HMI.

An FC (FC 10) for message acquisition is prepared in conjunction with the basic program. This FC records events, subdivides them into signal groups and reports them to the HMI via the interrupt buffer.

The message acquisition structure is shown in the figure "Acquisition and signaling of PLC events". The features include:

- Bit fields for events related to the VDI interface are combined in a single data block (DB2) with bit fields for user messages.
- Bit fields are evaluated at several levels by FC10.
  - **Evaluation 1; Acquisition of group signals**  
A group signal is generated for each group of signals if at least one bit signal is set to "1". This signal is generally linked to the disable signal of the VDI interface (on modules with diagnostic functions). The group signals are acquired completely in cycles.
  - **Evaluation 2; Acquisition of interrupt messages**  
A fixed specification exists to define which signals in a group generate an interrupt message when they change from "0" to "1".
  - **Evaluation 3; Acquisition of operating signals**  
A fixed specification exists to define which signals in a group generate an operational message.
- The scope of the user bit fields (user area) is set by default to 10 areas with 8 bytes each, but the number of areas can also be adjusted to suit the requirements of the machine manufacturer via basic program parameters in FB 1.

## Acknowledgment concept

The following acknowledgment procedures are implemented for error and operational messages:

**Operating messages** are intended for the display of normal operating states as information for the user. Acknowledgment signals are, therefore, not required for this type of message. An entry is made in the diagnostic status list for incoming and outgoing messages. The HMI maintains an up-to-date log of existing operating messages using the identifiers "operating message arrived" and "operating message gone".

**Interrupt messages** are used to display error states on the machine, which will usually lead to the machine being stopped. Where several errors occur in rapid succession, it is important to be able to distinguish their order of occurrence for troubleshooting purposes. This is indicated, on the one hand, by the order in which they are entered in the diagnostic buffer and on the other, by the time stamp, which is assigned to every entry.

If the cause of the error disappears, the associated interrupt message is only deleted if the user has acknowledged it (e.g. by pressing a key on the MCP). In response to this signal, the "Message acquisition" FC examines which of the reported errors have disappeared and enters these in the diagnostic buffer with the entry "Interrupt gone". This enables the HMI to also maintain an up-to-date log of pending interrupt messages. The time of day indicating the time at which the error occurred is maintained for messages, which are still pending (in contrast to a received interrogation).

### STEP 7

A tool can be started in the SIMATIC Manager via menu item "Target system" > "CPU messages". Alarms and messages can be displayed by number using this tool. To do this, activate the "Alarm" tab and enter a check mark under "A" in the upper half of the screen.

### User program

The user PLC program merely needs to call the basic program block FC 10 with appropriate parameter settings in the cyclic program section and set or reset the bit fields in DB2. All further necessary measures are implemented by the basic program and HMI.

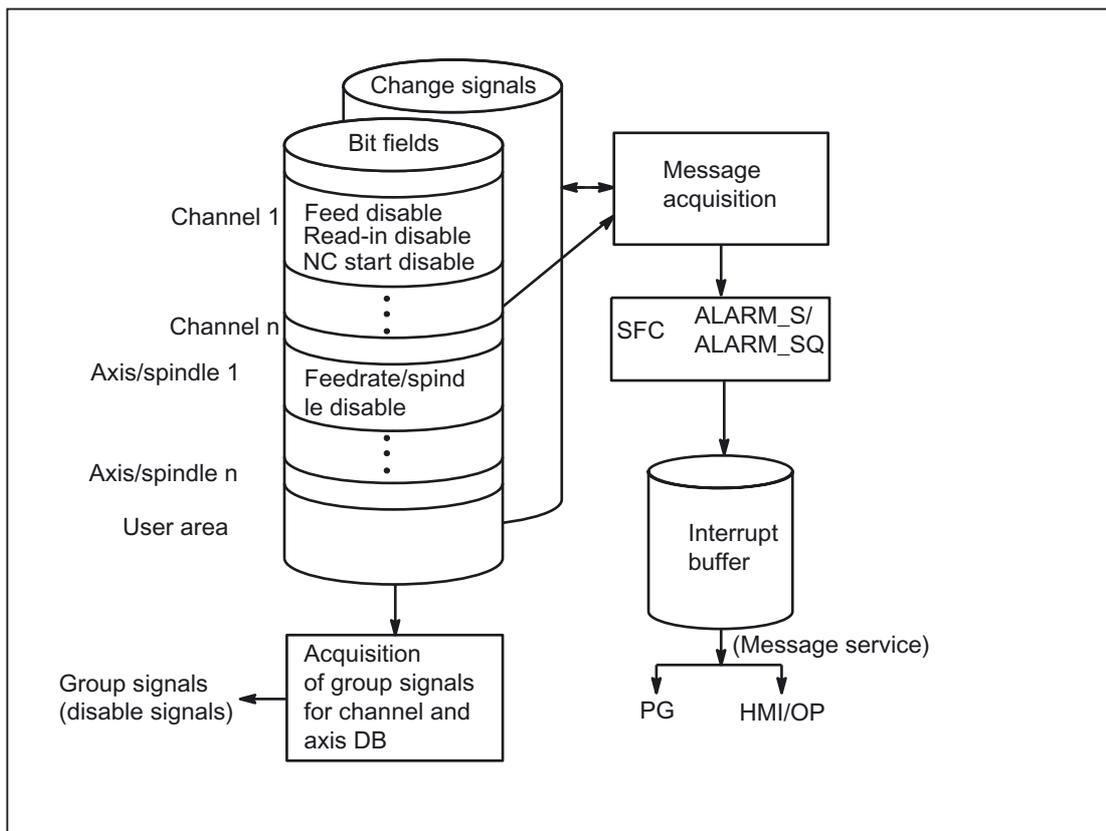


Figure 13-9 Acquisition and signaling of PLC events

## Extensions of the PLC alarms via the block FC 10

The FB 1-parameter "ExtendAIMsg" helps in making a selection of the PLC alarm mechanism.

If "ExtendAIMsg:= FALSE" the earlier process of the FC 10 with the DB 2 is active as bit-field data block. The known restrictions regarding the number of channels and axes are applicable.

On the other hand, in case of "ExtendAIMsg:= TRUE" the extension of the FC 10 becomes active. The DB 2 and DB 3 are created as usual. The user must set or reset the bits in DB 2. The parameter setting via message and alarm and a parameter setting of the numeric value of the 2nd decade of the user alarms are contained in DB 5.

The extensions are:

- Support for 10 channels, 31 axes.
- Areas for feed stop, read-in disable, etc. are available without messages. The information from this area is stored on the interface in DB21, DB31 depending upon the FC 10-parameter "ToUserIF" together with the related message bits as group signals. As such, the previous cumbersome handling of the signals is omitted.
- The alarms/messages also get the 16-bit integer additional value (%Z parameter in the alarm text) in addition to the alarm number for the user area 0. The user must write the 16-bit integer values in the DB 2 in the Array variable ZInfo0 parallel to setting an alarm bit. An integer value is available for each bit in the user area 0, see UDT1002 in the basic program.
- The user messages can be parameterized in the second decade of the message number in the numerical range 0 to 9. The display value of the second decade must be written by the user in the DB5 in the array variable UserDek2No. A number can be defined for each user area, see DB 5 in the basic program.

The value 0 is set by default for second decade.

The structuring of the DB 2 in UDT1002 can be recognized (basic program). In case of new alarm functions, the UDT1002 must be assigned symbolically to the DB2.

At the start of DB 2 there are bit fields for signals without alarm generation. This is followed by an array of size 64 integer for additional info of the user area 0.

Thereafter follow the areas, which also trigger alarms/messages (see List Manual) These areas are extended to 10 channels, 31 axes.

## Simple implementation of a user program on the new alarms

The source container of the basic program contains the file "udt2\_for\_Convert.awl", which has the following structural element from UDT1002:

- ChanA as array of 1 ... 8
- AxisA as array of 1 ... 18
- UserA as array of 1 ... 31

This UDT2 is to be compiled via the KOP/FUP/AWL - Editor. The UDT2 must be assigned to the DB 2 in the symbol table.

Sources must be generated for components, which have assignments on DB 2. Alternatively, sources can naturally be created for all blocks too. The UDT1002 must now be assigned to the DB 2 in the symbol table. Thereafter, the sources must be recompiled.

Now all the alarm allocations are assigned to the new data areas in the DB 2 and now only the parameter "ExtendAIMsg" at FB 1 must be set to True .

After a Power On RESET the alarm behavior is the same as earlier.

### 13.7.3 PLC/MCP/HHU interface

#### General

There are three different connection options for the machine control panel (MCP) and the handheld unit (HHU). This is in part due to the history of the MCP and HHU. This description focuses primarily on the connection of the Ethernet components.

On SINUMERIK 840 D sl, the machine control panel (MCP) or HT8 (MCP) and handheld unit HT1, HT2 (HHU) are connected via the Ethernet bus, which also links the TCU to the NCU. The advantage of this is that only one bus cable is required to connect the operator unit.

#### Topology SINUMERIK 840D sl

On the 840 D, the machine control panel and the handheld unit are connected to the CP 840D sl Ethernet bus (see Figure below). Where the connection of further keys and displays is required for customized operator panels, an additional keyboard interface (machine control panel without operating unit) can be used. For each keyboard interface, 64 pushbuttons, switches, etc. and 64 display elements can be connected via ribbon cable.

The signals sent from the MCP are copied to the PLC's DPR (Dual Port RAM) by the integrated Ethernet CP-840D sl. The basic program of the PLC enters the incoming signals in the input image configured on FB1. The NC-related signals are generally distributed by the basic program to the VDI interface. If required, the signals can be modified by the user.

The signals from the PLC to the MCP (displays) are transferred in the opposite direction.

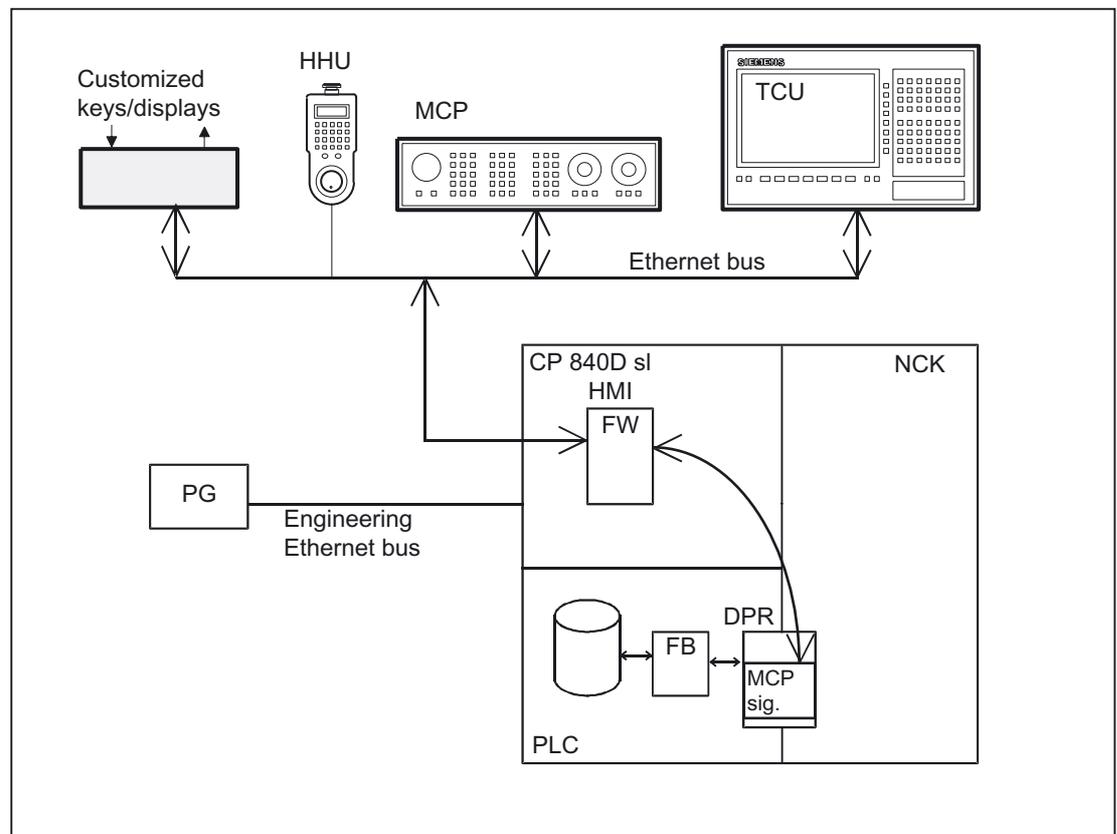


Figure 13-10 Connection of the machine control panel on 840D sl

### Topology SINUMERIK 840Di sl

In case of 840Di sl the machine control panel, the handheld unit are connected via Ethernet or PROFIBUS. The PLC operating system copies the incoming signals straight to the user interface (e.g. input image) at the cycle control point. As on the SINUMERIK 840 D sl, transfer to the VDI interface is performed by the user program or by standard blocks of the basic program (e.g. FC19).

### Bus addresses

On Ethernet components, MAC and IP addresses or logic names are determining factors in respect of communication. The control system's system programs convert logic names into MAC or IP addresses. On the PLC, the numeric component of the logic name is used for communication. This numeric part is specified by the user to the FB 1 via the parameter "MCPxBusAdr".

The logical name of an MCP or HHU always begins with "DIP". This is followed by a number corresponding to the switch position of the MCP component (e.g. DIP 192, DIP 17).

### MCP interface in the PLC

The signals from the machine control panel are routed by default via the I/O interface to the PLC area. A distinction must be made between NC and machine-specific signals. NC-specific key signals are distributed to the relevant mode-group-, NCK-, axis- and spindle-specific interface by FC19 (or FC24, FC25, FC26, depending on the type of MCP) by default. The reverse applies to the associated status signals, which are routed to the MCP interface. For this purpose, FC 19 or the other blocks mentioned above must be called in the **user program**.

Customized keys, which can be used to trigger a wide range of machine functions, must be evaluated directly by the user program. The user program also routes the status signals to the output area for the LEDs.

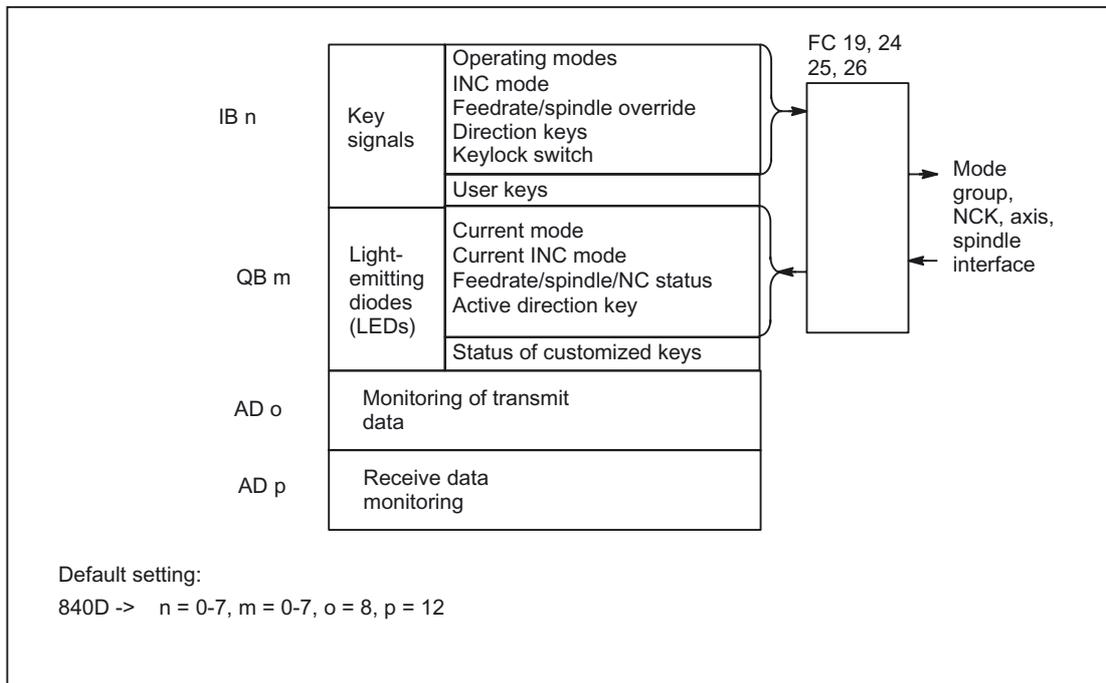


Figure 13-11 Interface to and from machine control panel

## 13.8 Structure and functions of the basic program

### General

The program is modular in design, i.e. it is structured according to NCK functions.

In the operating system, a distinction is made between the following levels of execution:

- Start-up and synchronization (OB 100)
- Cyclic mode (OB 1)
- Process interrupt handling (OB 40)
- Diagnostic interrupt, module failure processing (OB 82, OB 86)

Each section of the basic program - as illustrated in the figure below - must be called by the user in OBs 1, 40 and 100.

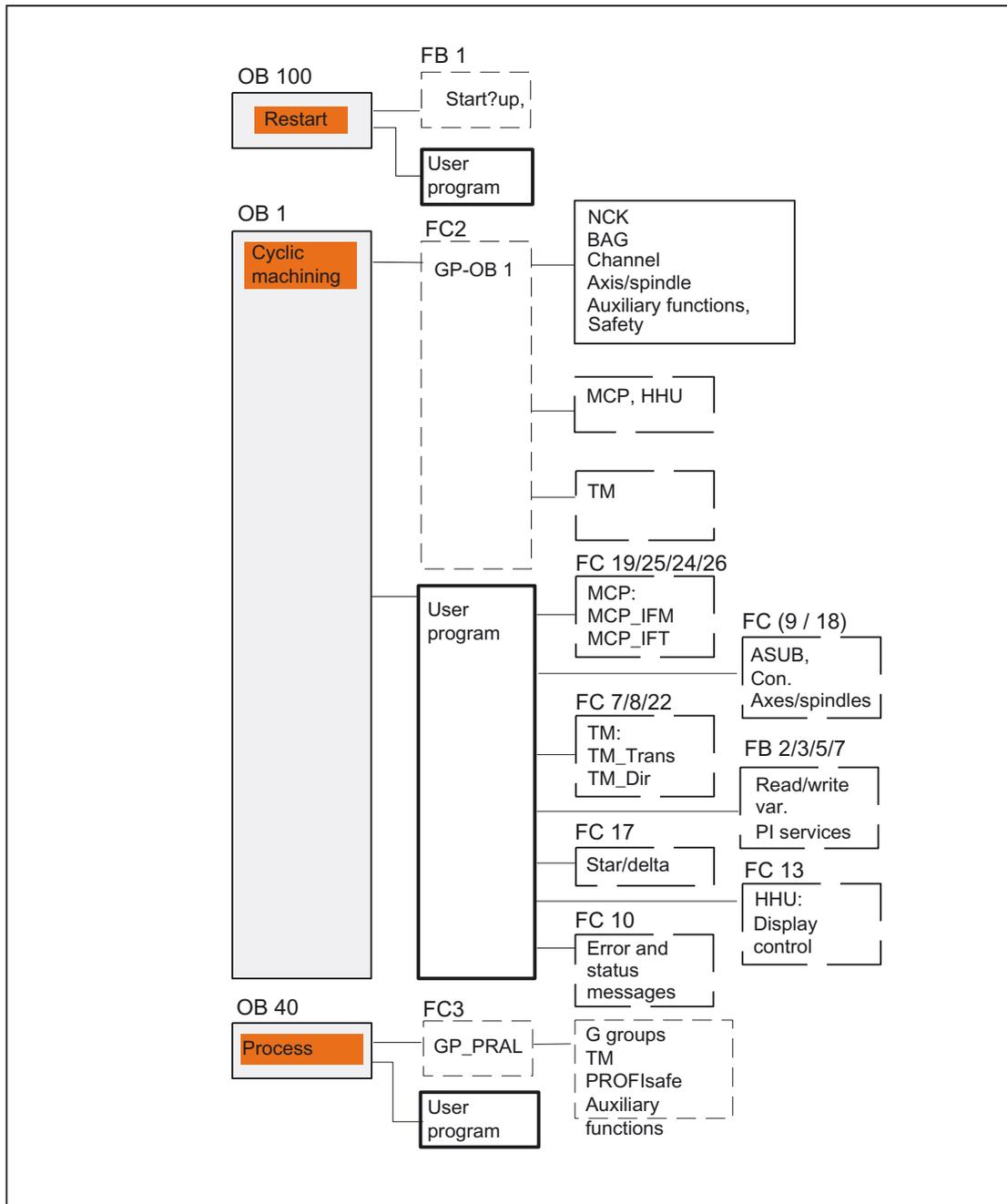


Figure 13-12 Structure of the basic program

## 13.8.1 Start-up and synchronization of NCK PLC

### Loading the basic program

The basic program must be loaded with the S7 tool when the PLC is in the Stop state. This ensures that all blocks in the basic program will be initiated correctly the next time they are called. Otherwise, undefined states can occur in the PLC (e.g. blinking of all PLC LEDs).

### Start-up

The synchronization of NCK and PLC is performed during startup. The system and user data blocks are checked for integrity and the most important basic program parameters are verified for plausibility. In cases of errors, the basic program produces an alarm (visible on HMI) and switches the PLC to the Stop state.

A warm restart is not provided, i.e. following system initialization, the operating system runs organization block OB 100 and always commences cyclic execution at the start of OB 1.

### Synchronization

The PLC is synchronized with the HMI and NCK and CP during power-up.

### Sign-of-life

After a correct initial start and the first complete OB1 cycle (initial setting cycle) the PLC and NCK continuously exchange sign of life signals. If the sign-of-life signal from the NCK fails to arrive, the PLC/NCK interface is neutralized and the signal "NCK CPU ready" in DB 10 is set to zero.

### 13.8.2 Cyclical mode (OB 1)

#### General

The NCK PLC interface is processed completely in cyclic mode. From a chronological viewpoint, the basic program runs ahead of the user program. In order to minimize the execution time of the basic program, only the control/status signals are transmitted cyclically; transfer of the auxiliary functions and G functions only takes place on request.

The following functions are performed in the cyclic part of the basic program:

- Transmission of the control/status signals
- Distribution of the auxiliary functions
- M decoding (M00 - M99),
- M, S, F distribution
- Transmission of the MCP signals via the NCK (on the SINUMERIK 840D only)
- Acquisition and conditioning of the user errors and operating messages.

#### Control/Status signals

A shared feature of the control and status signals is that they are bit fields. The basic program updates them at the start of OB1.

The signals can be subdivided into the following groups:

- General signals
- Mode group-specific signals (such as mode types)
- Channel-specific signals (such as program and feed modifications)
- Axis- and spindle-specific signals (such as feed disable)

#### Auxiliary and G functions

The auxiliary and G functions have the following characteristics:

- Transfer to the PLC is block-synchronous (referred to a parts program block)
- Transfer is acknowledge-driven.
- The acknowledgment times have an immediate effect on the execution time of NC blocks containing auxiliary functions requiring acknowledgment.

The value range is presented in the table below:

Function	Structure		Range of values		Data type	
	1st value	2nd value	1st value	2nd value	1st value	2nd value
G function		G function		255 <sup>1)</sup>		Byte
M word	M group	M word	99	99.999.999	Word	DWord
S word	Spindle no.	S word	6	Floating point <sup>2)</sup>	Word	DWord

Function	Structure		Range of values		Data type	
T word	Magazine no.	T word	99	65535	Word	Word
D word	-	D word	99	255	Byte	Byte
H word	H group	H word	99	Floating point	Word	DWord
F word	Axis No.	F word	18	Floating point	Word	DWord

<sup>1)</sup> relative number, transferred for each G group

<sup>2)</sup> corresponding STEP 7 format (24-bit mantissa, 8-bit exponent)

The M, S, T, H, D and F values sent by the NCK are output together with the accompanying change signals to the **CHANNEL DB** interface via the auxiliary/G functions (see List Manual). The function value and the extended address are transferred to the appropriate data word. The accompanying modification signal is activated to 1 for one PLC cycle. When the modification signal is reset, the acknowledgment is passed to the NCK. The acknowledgment of high-speed auxiliary functions is given by the basic program immediately the basic program detects the auxiliary function.

In addition to distribution of the auxiliary and G functions, selected signals are processed as described below.

## M decoder

M functions can be used to transfer both switching commands and fixed point values. Decoded dynamic signals are output to the **CHANNEL DB** interface for standard M functions (range M00 - M99) signal length = 1 cycle time).

## G group decoders

In the case of G functions sent by the NCK, the related groups are decoded and the current G number is entered in the corresponding interface byte of the CHANNEL DB, i.e. all active G functions are entered in the channel DBs. The entered G functions are retained even after the NC program has terminated or aborted.

---

### Note

During system startup, all G group bytes are initialized with the value "0".

---

## M, S, F distributor

The M, S, F, distributor is used to enter spindle-specific M words M(1...6)=[3,4,5], S words and F words for axial feeds in the appropriate **spindle and axis data blocks**. The criterion for distribution is the extended address, which is passed to the PLC for M words, S words and axial F words.

### MCP signal transmission

On the SINUMERIK 840 D, depending on the bus connection, MCP signals are transmitted to the parameterized I/O areas either directly to the PLC or indirectly via an internal procedure using the basic program.

### User messages

The acquisition and processing of the user error and operational messages is performed by an FC in the basic program.

### 13.8.3 Time-interrupt processing (OB 35)

The user must program **OB 35** for time-alarm processing. The default time base setting of OB 35 is 100 ms. A different time base can be selected using the STEP7 "HW Config" tools. However, the OB 35 time setting must be at least 3 ms in order to avoid a PLC CPU stop. The stop is caused by reading of the HMI system state list during power-up of the HMI. This reading process blocks priority class control for approx. 2 ms. The OB 35 with a time base set to a rather lower value is then no longer processed correctly.

### 13.8.4 Process interrupt processing (OB 40)

A process interrupt **OB 40** (interrupt) can, for example, be triggered by appropriately configured I/Os or by certain NC functions. Due to the different origin of the interrupt, the PLC user program must first interpret the cause of the interrupt in OB 40. The cause of the interrupt is contained in the local data of OB 40.

**References:**

SIMATIC STEP 7 Description or Online Help of STEP 7

### 13.8.5 Diagnostic interrupt, module failure processing (OB 82, OB 86)

#### General

A module diagnosis or module failure on an I/O module triggers OB 82/OB 86. These blocks are supplied by the basic program. The basic program block FC5 is called in these OBs. This is wired by default to trigger a PLC stop in the event of an error being detected.

A PLC Stop

- If the cause of the error is removed, a PLC stop will not be triggered.
- does not occur in case of the Profibus-MCPs specified as the FB 1 parameters.

The response can be changed by modifying the FC5 parameter setting.

## PROFIBUS Diagnosis

The slaves of both the PROFIBUS connections MPI/DP or DP1 are registered by the basic program as group message in the form of a ready signal in the interface signal

DB10 DBX92.0 (MPI/DP Bus Slaves OK) and

DB10 DBX92.1 (DP1 Bus Slaves OK)

The group message is derived from the LED status of the respective PROFIBUS (System state list SZL 0x174).

If an error or a failure of a slave is detected, the alarm 400551 or 400552 is also reported. The alarm is automatically deleted when the error is removed. Detailed information about the error or the failure will be displayed in the alarm messages as exact cause of error in a future HMI software version in the diagnostics. No FC 125, FB 125 is necessary for this diagnostic display, because the information is called directly from the HMI via the corresponding SZL functions of the PLC operating system via the communication channels to the PLC. This saves the relatively large block in the PLC and reduces also the PLC cycle time. Since the FB 125 works under interrupt disable during its processing, OBs with a higher priority can be executed more quickly.

---

### Note

Till the HMI software version with the diagnostic display for the PROFIBUS becomes available, it is recommended to use FC 125 for PROFIBUS diagnostics. This block has relatively less cycle time and the slave states can be updated via the DB 10 interface signal mentioned earlier by activating the FC 125 block.

---

## 13.8.6 Response to NCK failure

### General

During cyclic operation, the PLC basic program continuously monitors NCK availability by polling the sign-of-life character. If the NCK is no longer reacting, then the NCK PLC interface is neutralized and the NST **NCK CPU ready** in **signals from NC group (DB 10.DBX 104.7)** is reset. The signals sent by the NCK to the PLC are initialized with default settings.

The PLC itself remains active so that it can continue to control machine functions. However, it remains the responsibility of the user program to set the machine to a safe state.

### NCK → PLC signals

The signals sent by the NCK to the PLC are divided into the following groups:

- Status signals from the NCK, channels, axes and spindles
- Modification signals of the auxiliary functions
- Values of the auxiliary functions
- Values of the G functions

#### **Status signals:**

The status signals from the NCK, channels, axes, and spindles are reset.

#### **Auxiliary-function modification signals:**

Auxiliary-function modification signals are also reset.

#### **Auxiliary-function values:**

Auxiliary-function values are retained so that it is possible to trace the last functions triggered by the NCK.

#### **G-function values:**

G function values are reset (i.e. initialized with the value 0 respectively).

### PLC → NCK signals

The signals sent by the PLC to the NCK are divided into control signals and tasks that are transferred by FCs to the NCK.

#### **Control signals:**

The control signals from the PLC to the NCK are frozen; cyclic updating by the basic program is suspended.

#### **Jobs from PLC to NCK:**

The FCs and FBs, which are used to pass jobs to the NCK, must no longer be processed by the PLC user program, as this could lead to incorrect checkback signals. During power-up of the control, a job (e.g. read NCK data) must not be activated in the user program until the **NCK CPU ready** signal is set.

## 13.8.7 Functions of the basic program called from the user program

### General

In addition to the modules of the basic program, which are called at the start of OBs 1, 40 and 100, functions are also provided, which have to be called and supplied with parameters at a suitable point in the user program.

These functions can be used, for example, to pass the following jobs from the PLC to the NCK:

- Traversing concurrent axes (FC 18)
- Start asynchronous subprograms (ASUBs) (FC 9),
- Selecting NC programs (FB 4)
- Control of spindle (FC 18),
- Read/write variables (FB 2, FB 3).

---

#### Note

The following note will later help you to check and diagnose a function call (FCs, FBs of basic program). These are FCs and FBs, which are controlled by a trigger signal (e.g. via parameter Req, Start, etc.), and which supply an execution acknowledgment as an output parameter (e.g. via parameter Done, NDR, Error, etc.). A variable compiled of other signals, which produce the trigger for the function call should be set. Start conditions may be reset only as a function of the states of parameters Done, NDR and Error.

This control mechanism may be positioned in front of or behind the function call. If the mechanism is placed after the call, the output variables can be defined as local variables (advantage: Reduction of global variables, flags, data variables and time-related advantages over data variables).

The trigger parameter must be a global variable (e.g. flag, data variable).

In OB 100, jobs still activated by the user program (Parameter Req, Start, etc. := TRUE) must be set to zero at the named parameters. A POWER OFF/ON could result in a state in which jobs are still active.

---

### Concurrent axes

The distinguishing features of concurrent axes are as follows:

- They must be defined as such via the NC machine data.
- They can be traversed either from the PLC or from the NC by means of the JOG keys,
- Starting from the PLC is possible in the NC operating modes MDA and AUTOMATIC via FC,
- The start is independent of NC block boundaries.

Function calls are available for positioning axes, indexing axes and spindles (FC 18).

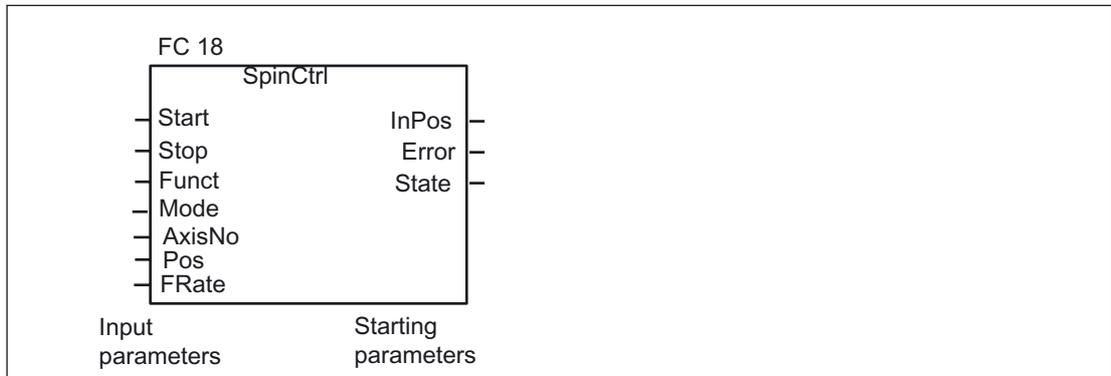
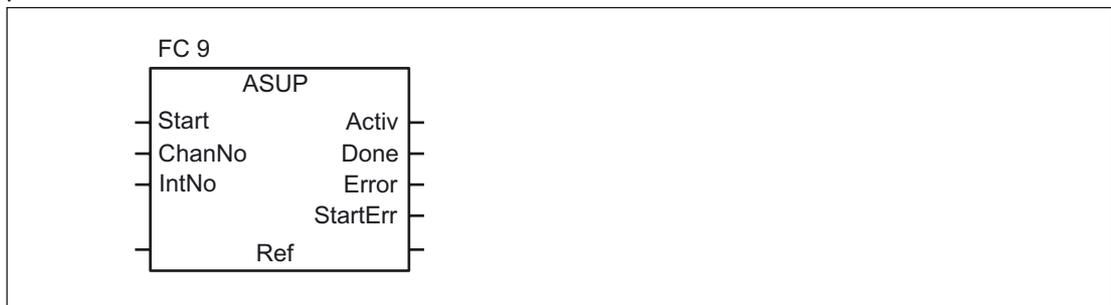


Figure 13-13 FC 18 input/output parameters

### ASUBs

Asynchronous subprograms (ASUBs) can be used to activate any function in the NCK. Before an asynchronous subprogram can be started from the PLC, it must be ensured that it is available and prepared by the NC program or by FB 4 PI services (ASUB).

Once prepared in this way, it can be started at any time from the PLC. The NC program running in one of the parameterized channels of FC 9 is interrupted by the asynchronous subprogram. An ASUB is started by calling FC 9 from the user program by setting the start parameter to 1.



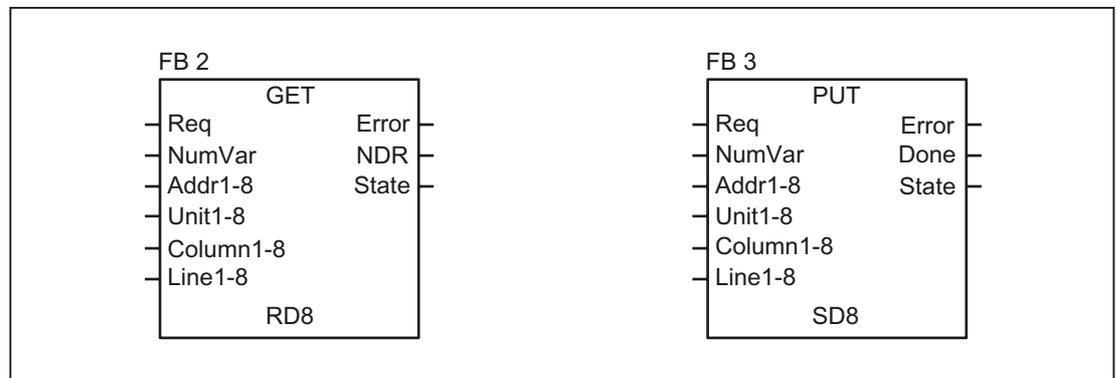
#### Note

If an asynchronous subprogram has not been prepared by an NC program or by FB 4 (ASUB) (e.g. if no interrupt no. has been assigned), a start error is output (StartErr = TRUE).

## Read/Write NC variables

NCK variables can be read with FB GET while values can be entered in NCK variables with FB PUT. The NCK variables are addressed via identifiers at inputs Addr1 to Addr8. The identifiers (symbols) point to address data, which must be stored in a global DB. To allow generation of this DB, PC software is supplied with the basic program with which the required variables can be selected from a table, which is also supplied. The selected variables are first collected in a second, project-related list. Command **Generate DB** creates a "\*.AWL" file, which must be linked to the program file for the machine concerned and compiled together with the machine program.

1 to 8 values can be read or written with a read or write job. If necessary, the values are converted [e.g. NCK floating point values (64 bits) are converted to PLC format (32 bits with 24-bit mantissa and 8-bit exponent) and vice versa]. A loss of accuracy results from the conversion from 64-bit to 32-bit REAL. The maximum precision of 32-bit REAL numbers is approximately 10 to the power of 7.



## Functions AG\_SEND, AG\_RECV

The named functions correspond to the functions of the library "SIMATIC\_NET\_CP" of the S7-300 CPU in STEP 7. In general, these functions are valid for the online help of these functions. The functions AG\_SEND, AG\_RECV can be used for data exchange with another station via the integrated "CP 840D sl".

There are a total of 5 functions for the "AG Functions"

1. AG\_SEND (SINUMERIK 840D sl)
2. AG\_RECV (SINUMERIK 840D sl)
3. AG\_LOCK (currently not implemented)
4. AG\_UNLOCK (currently not implemented)
5. AG\_CNTRL (currently not implemented)

The 3 functions mentioned last are currently not available for SINUMERIK 840D.

---

**Note**

For the function AG\_SEND the signal sequence for the parameter ACT is currently displayed wrongly. ACT must be TRUE as long as an event is reported in DONE or ERROR.

---

When using the functions AG\_SEND, AG\_RECV a data transport to the other point takes place via the Ethernet Bus of the CP. The other point is configured normally in STEP 7 in NetPro. The special feature in the call of the functions lies in the specification of the parameter "LADDR" to the named blocks.

In case of SINUMERIK 840D sl the parameter "LADDR" must be filled with the value W#16#8110. In the basic program, these functions are available under the FC numbers 1005, 1006, 1007, 1008, 1010.

Table 13-2 Allocation of the FC numbers to the corresponding FC in the library "SIMATIC\_NET\_CP"

FC number	FC Blocks
1005	FC 5
1006	FC 6
1007	FC 7
1008	FC 8
1010	FC 10

These blocks can also be used in a SIMATIC-CPU 3xx with CP343-1.

The protocols TCP and UDP are supported. TCP is to be preferred.

---

**Note**

Other communication blocks, such as BSEND, USEND, which possess a CP343-1, are not supported in SINUMERIK 840D sl.

---

### 13.8.8 Symbolic programming of user program with interface DB

#### General

##### Note

The basic program library on the CD supplied with the Toolbox for the 840D contains files NST\_UDTB.AWL and TM\_UDTB.AWL.

The compiled UDT blocks from these two files are stored in the CPU program of the basic program.

A UDT is a data type defined by the user that can, for example, be assigned to a data block generated in the CPU.

Symbolic names of virtually all the interface signals are defined in these UDT blocks.

The UDT numbers 2, 10, 11, 19, 21, 31, 71, 72, 73 are used.

The assignments have been made as follows:

UDT assignments		
UDT number	Assignment to interface DB	Significance
UDT 2	DB 2	Interrupts/Messages
UDT 10	DB 10	NCK signals
UDT 11	DB 11	Mode group signals
UDT 19	DB 19	HMI signals
UDT 21	DB 21 to DB 30	Channel signal
UDT 31	DB 31 to DB 61	Axis/spindle signals
UDT 71	DB71	Tool management: Load/unload locations
UDT 72	DB 72	Tool management: Change in spindle
UDT 73	DB 73	Tool management: Change in revolver
UDT 77	DB 77	MCP and HHU signals with standard SDB 210
UDT 1002	DB 2	extended alarms/messages (FB 1-Parameter "ExtendAIMsg:=TRUE"

To symbolically program the interface signals, the interface data blocks must first be symbolically assigned using the symbol editor.

For example, symbol "AxisX" is assigned to operand DB31 with data type UDT 31 in the symbol file.

After this input, the STEP 7 program can be programmed in symbols for this interface.

---

**Note**

Programs generated with an earlier software version that utilize the interface DBs described above can also be converted into symbol programs. A fully qualified instruction for data access e.g. "U DB31.DBX60.0" is then necessary here for (spindle/ no axis) in the program created till now. This command is converted upon activation of the symbolics in the editor "AxisX.E\_SpKA".

---

**Description**

Abbreviated symbolic names of the interface signals are defined in the two STL files NST\_UDTB.AWL and TM\_UDTB.AWL.

In order to create the reference to the names of the interface signals, the name is included in the comment after each signal.

The names are based on the English language. The comments are in English.

The symbolic names, commands and absolute addresses can be viewed by means of a STEP 7 editor command when the UDT block is opened.

---

**Note**

Unused bits and bytes are listed, for example, with the designation "f56\_3".

- "56": Byte address of the relevant data block
  - "3": Bit number in this byte
- 

### 13.8.9 M decoding according to list

**Description of functions**

When the **M decoding according to list** function is activated via the GP parameter of FB1 "ListMDecGrp" (number of M groups for decoding), up to 256 M functions with extended address can be decoded by the basic program.

The assignment of the M function with extended address and the bit to be set in the signal list is defined in the decoding list. The signals are grouped for this purpose.

The signal list contains 16 groups with 16 bits each as decoded signals.

There is only one decoding list and one signal list i.e. this is a cross-channel function.

The M functions are decoded. Once they are entered in the decoding list, then the associated bit in the signal list is set.

When the bit is set in the signal list, the read-in disable in the associated NCK channel is set simultaneously by the basic program.

The read-in disable in the channel is reset once the user has reset all the bits output by this channel and thus acknowledged them.

The output of an M function decoded in the list as a high-speed auxiliary function does not result in a read-in disable.

The figure below shows the structure of the **M decoding according to list**:

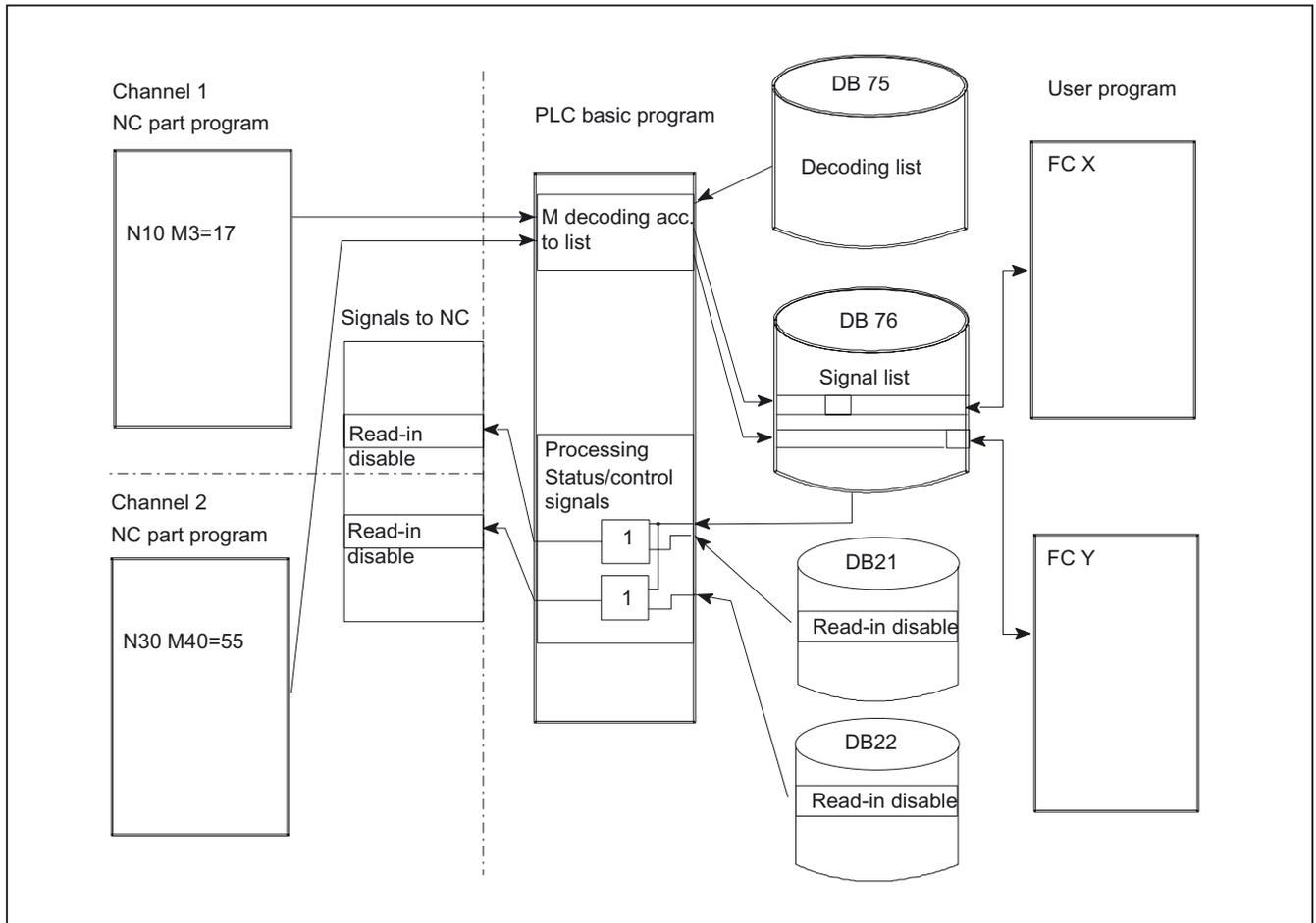


Figure 13-14 M decoding acc. to list

### Activation of the function

The number of groups to be evaluated/decoded is indicated in the basic program parameter "ListMDecGrp" when FB 1 is called in OB 100 (see also "FB 1: RUN\_UP Basic program, start-up section (Page 974)"). M decoding is activated if this value is between 1 and 16. Before the function is activated, the decoding list DB75 must be transferred to the PLC followed by a restart.

### Structure of decoding list

The source file for the decoding list (MDECLIST.AWL) is supplied with the basic program. DB 75 is created when the STL source is compiled.

There must be an entry in decoding list DB 75 for every group of M functions to be decoded.

A maximum of 16 groups can be created.

16 bits are available in each group in the list of decoded signals.

The assignment between the M function with extended address and the bit to be set in the signal list is specified via the first and last M functions in the decoding list.

The bit address is generated correspondingly from the first M function ("MFirstAdr") to the last M function ("MLastAdr") from bit 0 up to maximum bit 15 for each group.

Each entry in the decoding lists consists of 3 parameters, each of which is assigned to a group.

Assignment of groups			
Group	Extended M address	First M address in group	Last M address in group
1	MSigGrp[1].MExtAdr	MSigGrp[1].MFirstAdr	MSigGrp[1].MLastAdr
2	MSigGrp[2].MExtAdr	MSigGrp[2].MFirstAdr	MSigGrp[2].MLastAdr
...	...	...	...
16	MSigGrp[16].MExtAdr	MSigGrp[16].MFirstAdr	MSigGrp[16].MLastAdr

Type and value range for signals			
Signal	Type	Value range	Remark
MExtAdr	Int	0 ... 99	Extended M address
MFirstAdr	DInt	0 to 99.999.999	First M address in group
MLastAdr	Dint	0 to 99.999.999	Last M address in group

### Signal list

Data block DB 76 is set up when the function is activated.

A bit is set in the appropriate group in DB 76 for an M signal decoded in the list.

At the same time, a read-in disable is set in the channel in which the M function has been output.

### Example

Three groups of M commands are to be decoded in the following example:

- M2 = 1 to M2 = 5
- M3 = 12 to M3 = 23
- M40 = 55

Structure of the decoding list in DB 75:

Example parameters				
Group	Decoding list (DB 75)			Signal list
	Extended M address	First M address in group	Last M address in group	DB 76
1	2	1	5	DBX 0.0 ... DBX 0.4
2	3	12	23	DBX 2.0 ... DBX 3.3
3	40	55	55	DBX 4.0

```

DATA_BLOCK DB 75
TITLE =
VERSION : 0.0
STRUCT
    MSigGrp : ARRAY [1 .. 16 ] OF STRUCT
        MExtAdr : INT ;
        MFirstAdr : DINT;
        MLastAdr : DINT;
    END_STRUCT;
END_STRUCT;
BEGIN
    MSigGrp[1].MExtAdr := 2;
    MSigGrp[1].MFirstAdr := L#1;
    MSigGrp[1].MLastAdr := L#5;
    MSigGrp[2].MExtAdr := 3;
    MSigGrp[2].MFirstAdr := L#12;
    MSigGrp[2].MLastAdr := L#23;
    MSigGrp[3].MExtAdr := 40;
    MSigGrp[3].MFirstAdr := L#55;
    MSigGrp[3].MLastAdr := L#55;
END_DATA_BLOCK

```

### Structure of FB 1 in the OB 100

(enter the number of M groups to be decoded in order to activate the function):

```

Call FB 1, DB 7(
...
ListMDecGrp := 3, //M decoding of three groups
...
);

```

The appending of the entry in OB 100 and transfer of DB 75 (decoding list) to the AG must be followed by a restart. During the restart, the basic program sets up DB76 (signal list).

If the NC program is started at this point and the expanded M function (e.g. M3=17) is processed by the NCK, this M function will be decoded and bit 2.5 set in DB 76 (see decoding list DB 75). At the same time, the basic program sets the read-in disable and the processing of the NC program is halted (in the corresponding NC-channel DB the entry "expanded address M function" and "M function no." is made).

The read-in disable in the channel is reset once the user has reset and, therefore, acknowledged, all the bits output by this channel in the signal list (DB 76).

### 13.8.10 PLC machine data

#### General

The user has the option of storing PLC-specific machine data in the NCK. The user can then process these machine data after the power-up of the PLC (OB 100). This enables, for example, user options, machine expansion levels, machine configurations, etc., to be implemented.

The interface for reading these data lies in the DB 20. However, DB20 is set up by the basic program during power-up only when user machine data are used i.e. sum of GP parameters "UDInt", "UDHex" and "UDReal" is greater than zero.

The sizes of the individual areas, and hence the total length of the DB 20, is set by the following PLC machine data:

MD14504 \$MN\_MAXNUM\_USER\_DATA\_INT

MD14506 \$MN\_MAXNUM\_USER\_DATA\_HEX

MD14508 \$MN\_MAXNUM\_USER\_DATA\_FLOAT

These settings are specified to the user in the GP parameters "UDInt", "UDHex" and "UDReal".

The data is stored in the DB 20 by the BP in the sequence:

1. Integer MD
2. Hexa-fields MD
3. Real MD

The integer and real values are stored in DB 20 in S7 format.

Hexadecimal data are stored in DB20 in the order in which they are input (use as bit fields).

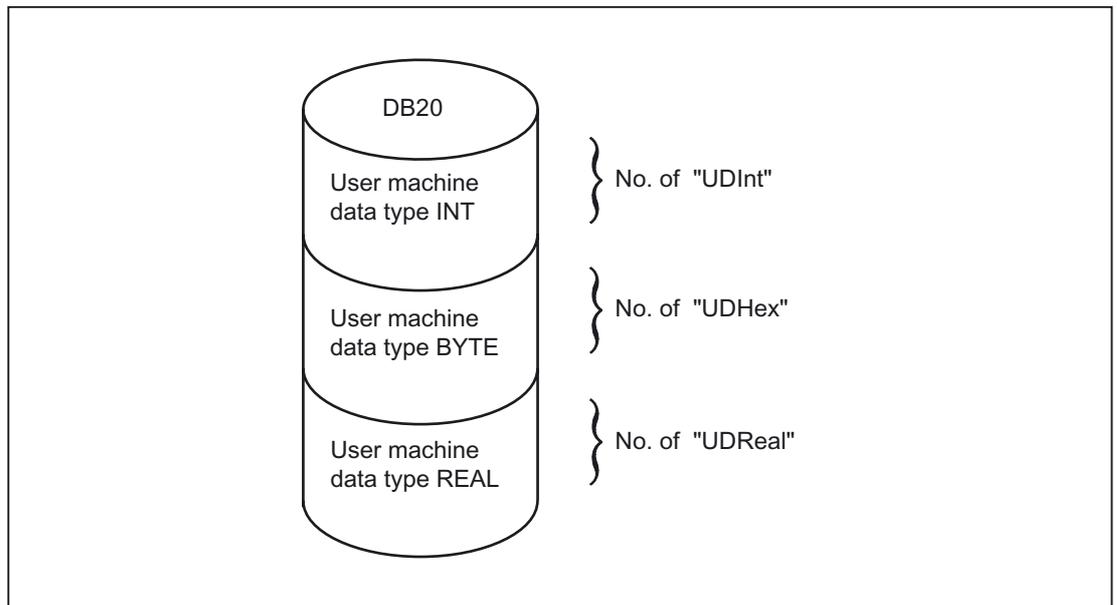


Figure 13-15 DB 20

**Note**

If the number of PLC machine data used is increased later, then DB20 must be deleted beforehand. To prevent such extensions in use having any effect on the existing user program, the data in DB20 should be accessed in symbolic form wherever possible, e.g. by means of a structure definition in the UDT.

<b>Interrupts</b>	
<b>400120</b>	<b>Delete DB 20 in PLC and restart</b>
Explanation	DB length is not the same as the required DB length
Response	Interrupt display and PLC Stop
To correct or avoid errors	Delete DB 20 followed by RESET
Continuation	After cold restart

**Example**

The project in the example requires 4 integer values, 2 hexadecimal fields with bit information and 1 real value.

Machine data:

MD14510 \$MN_USER_DATA_INT[0]	123
MD14510 \$MN_USER_DATA_INT[1]	456
MD14510 \$MN_USER_DATA_INT[2]	789
MD14510 \$MN_USER_DATA_INT[3]	1011
...	
MD14512 \$MN_USER_DATA_HEX[0]	12
MD14512 \$MN_USER_DATA_HEX[1]	AC
...	
MD14514 \$MN_USER_DATA_FLOAT[0]	123.456

GP Parameter (OB 100):

```
CALL FB 1, DB 7 (
    MCPNum := 1,
    MCP1In := P#E0.0,
    MCP1Out := P#A0.0,
    MCP1StatSend := P#A8.0,
    MCP1StatRec := P#A12.0,
    MCP1BusAdr := 6,
    MCP1Timeout := S5T#700MS,
    MCP1Cycl := S5T#200MS,
    NCCyclTimeout := S5T#200MS,
    NCRunupTimeout := S5T#50S;
```

BP parameters (to scan runtime):

```
1 gp_par.UDInt; //4,
1 gp_par.UDHex; //2,
1 gp_par.UDReal; //1 )
```

During PLC power-up, DB20 was generated with a length of 28 bytes:

DB 20	
address	data
0.0	123
2.0	456
4.0	789
6.0	1011
8.0	b#16#12
9.0	b#16#AC
10.0	1.234560e+02

The structure of the machine data used is specified in a UDT:

```

TYPE UDT 20
  STRUCT
    UDInt :   ARRAY [0 .. 3 ] OF INT ;
    UDHex0 :  ARRAY [0 .. 15 ] OF BOOL ;
    UDReal :  ARRAY [0 .. 0 ] OF REAL ;      //Description as field, for
                                              // later expansions
  END_STRUCT;
END_TYPE

```

### Note

ARRAY OF BOOL are always sent to even-numbered addresses. For this reason, an array range of 0 to 15 must generally be selected in the UDT definition or all Boolean variables specified individually.

Although only a REAL value is used initially in the example, a field (with one element) has been created for the variable. This ensures that extensions can be made easily in the future without the symbolic address being modified.

### Symbolic accesses

An entry is made in the symbol table to allow data access in symbolic form:

Symbol	Operand	Data type
UData	DB 20	UDT 20

Access operations in user program (list includes only symbolic read access):

```

...
L      "UData".UDInt[0];
L      "UData".UDInt[1];
L      "UData".UDInt[2];
L      "UData".UDInt[3];

U      "UData".UDHex0[0];
U      "UData".UDHex0[1];
U      "UData".UDHex0[2];
U      "UData".UDHex0[3];
U      "UData".UDHex0[4];
U      "UData".UDHex0[5];
U      "UData".UDHex0[6];
U      "UData".UDHex0[7];
...
U      "UData".UDHex0[15];

L      "UData".UDReal[0];
...

```

## 13.8.11 Configuration machine control panel, handheld unit, direct keys

### General

Up to two machine control panels and one handheld unit can be in operation at the same time. For the machine control panel or HT8 (MCP) and hand-held unit HT2, HT1 (BHG) there are various connection options (Ethernet, PROFIBUS). It is possible to connect two MCPs to different bus systems (mixed operation is only possible on Ethernet and PROFIBUS). This can be achieved using FB1 parameter "MCPBusType". In this parameter, the right-hand decade is responsible for the first MCP and the left-hand decade for the second MCP.

The components are parameterized by calling basic-program block FB 1 in OB 100. FB 1 stores its parameters in the associated instance DB (DB 7, symbolic name "gp\_par"). Separate parameter sets are provided for each machine control panel and the handheld unit. The input/output addresses of the user must be defined in these parameter sets. These input and output addresses are also used in FC 19, FC 24, FC 25, FC 26 and FC 13. Further, the addresses for status information, Profibus or Ethernet are also to be defined. The default time settings for timeout and cyclic forced retriggering should not be changed. Please refer to the Operator Components Manual for further information on MCPs and HHU(HT2) components.

### Activation

Each component is activated either via the number of machine control panels (MCPNum parameter) or, in the case of the handheld unit, via the HHU parameter. The MCP and HHU connection settings are entered in FB1 parameters "MCPMPPI", "MCPBusType" or "BHG", "BHGMPPI".

### Handheld unit (HT2)

In the handheld unit the addressing is done via a parameter of the GD parameter set. This was necessary for reasons of compatibility of the parameter names.

### Configuration

Essentially, there are various communication mechanisms for transferring data between the MCP/HHU and PLC. These mechanisms are characterized by the bus connection of the MCP and HHU. In one case (Ethernet), data is transported via the "CP 840D sl".

The mechanism is parameterized completely via the MCP/HHU parameters in FB1.

In the other case the transmission is done through the PLC-operating system through the Profibus configuration

The parameter setting is done via STEP 7 in HW-Config. To enable the basic program to access these data and failure monitoring of MCP/HHU, the addresses set in FB 1-parameters must be made available to the basic program.

An overview of the various coupling mechanisms appears below. Mixed operation can also be configured.

If an error is detected due to a timeout monitor, an entry is made in the alarm buffer of the PLC CPU (interrupts 400260 to 400262). In this case, the input signals from the MCP or from the handheld unit (MCP1In/MCP2In or BHGIn) are reset to 0. If it is possible to resynchronize the PLC and MCP/HHU, communication is resumed automatically and the error message reset by the GP.

**Note**

In the following tables, "(n.r.)" indicates "not relevant".

**840D: Ethernet connection**

Without further configuration settings being made, communication takes place directly from the PLC GP via the CP 840D sl. The FB 1 parameters listed below are used for parameterization.

The numeric part of the logical name of the component must be entered in "MCP1 BusAdr", "MCP2 BusAdr" or "BHGRecGDNo" (corresponds to the bus address of node). The logical name is defined via switches on the MCP or terminal box.

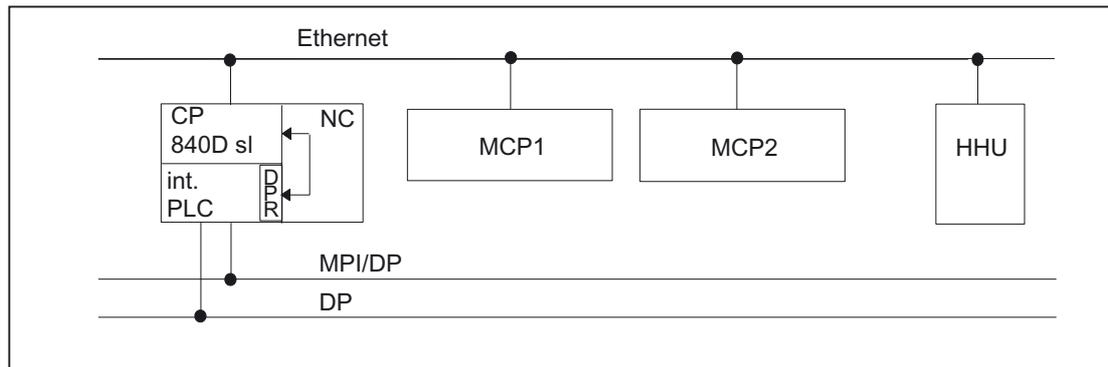


Figure 13-16 840D sl: Ethernet connection

Relevant parameters (FB 1)		
MCP		HHU
MCPNum=1 or 2 (number of MCPs)		HHU = 5 (via CP 840D sl)
MCP1In	MCP2In	BHGIn
MCP1Out	MCP2Out	BHGOut
MCP1StatSend	MCP2StatSend	BHGStatSend
MCP1StatRec	MCP2StatRec	BHGStatRec
MCP1BusAdr	MCP2BusAdr	BHGInLen (n.r.)
MCP1Timeout (n.r.)	MCP2Timeout (n.r.)	BHGOutLen (n.r.)
MCP1Cycl (n.r.)	MCP2Cycl (n.r.)	BHGTimeout (n.r.)
<b>MCPMPI = FALSE</b>		BHGCycl (n.r.)
MCP1Stop	MCP2Stop	BHGRecGDNo

Relevant parameters (FB 1)		
MCP		HHU
MCP1 NotSend	MCP2 NotSend	BHGRecGBZNo (n.r.)
		BHGRecObjNo (n.r.)
MCPBusType = b#16#55 (via CP 840D sl)		BHGSendGDNo (n.r.)
		BHGSendGBZNo (n.r.)
MCPsDB210= FALSE		BHGSendObjNo (n.r.)
MCPCopyDB77 = FALSE		<b>BHGMPI = FALSE</b>
		BHGStop
		BHG NotSend

An error entry is also made in the PLC alarm buffer for timeouts, resulting in the following error messages on the HMI:

- 400260: MCP 1 failure
- or
- 400261: MCP 2 failure
- 400262: HHU failure

An MCP or HHU failure is detected immediately after a cold restart even if no data have yet been exchanged between the MCP/HHU and PLC.

The monitoring function is activated as soon as all components have signaled "Ready" after power-up.

### Example OPs: Direct control key

The direct control keys of the OPs at the Ethernet Bus should be transferred to the PLC. Till now, the direct control keys have been transferred to the PLC via the PROFIBUS or via a special cable connection between OP and MCP.

For connecting the direct control keys via the Ethernet, this concerns e.g. the "OP08T", there is a parameterization in the basic program for activating the data transport. The related parameters lie in the instance DB of the FB 1 (OpKeyNum to OpKeyBusType, see data table). The parameters are provided by the user in the start OB 100 through the switching of the parameter at the FB 1 call. The bus address and Op1/2KeyStop can also be modified in the cyclic operation by writing the FB 1-Instance-DB DB 7.

The transport of the user data of the direct control keys runs in the same way as in the case of Ethernet MCP. The data transport can also be stopped and restarted via writing the DB 7-parameter "Op1/2KeyStop". During the Stop-phase the address of the direct control key module (TCU-index or the MCP-address) can also be changed.

After resetting the Stop-signal a connection to the new address is established.

The status of the respective direct-key interfaces can be read in the interface signal:

DB10.DBX104.3 (OP1Key ready)

or

DB10.DBX104.4 (OP2Key ready)

**Address Direct Control Keys**

For the parameter Op1/2KeyBusAdr the TCU-index is normally to be used. This affects the OPs, such as OP08T, OP12T, which for the direct control keys **do not** have special cable connection to an Ethernet MCP.

If OPs with direct control keys have a special cable connection and these are connected to an Ethernet-MCP, then for the parameter Op1/2KeyBusAdr the address of the MCP (DIP-switch setting of the MCP) is to be used. Only the data stream of the direct control keys (2 bytes) is transferred via the direct control key interface.

**Alarm direct control keys**

An error entry is also made in the PLC alarm buffer for timeouts. resulting in the following error messages on the HMI:

- 400274: Direct control key 1 failed  
or
- 400275: Direct control key 2 failed

**Control unit switching for direct control keys**

The user switches Op1/2KeyBusAdr with 0xFF and Stop = TRUE in the startup block OB 100. Via the M to N block FB 9 the direct control key address of the M to N-interface is stored to the parameter "Op1KeyBusAdr".

Relevant parameters (FB 1)		
Direct control key		e.g. direct keys OP08T
OpKeyNum = 1 or 2 (Number of OP's with direct control keys)		
Op1KeyIn	Op2KeyIn	
Op1KeyOut	Op2KeyOut	
OpKey1BusAdr	Op2KeyBusAdr	Address: TCU Index:
Op1KeyStop	Op2KeyStop	
Op1KeyNotSend	Op2KeyNotSend	
OpKeyBusType = b#16#55 (via CP 840D sl)		

**MCP-Identification**

Via the Identify interface in the DB 7 it is possible to query the type of the ethernet component (MCP, HT2, HT8 or direct keys) with the relevant parameters at the input/output in cyclic operation:

- Relevant parameters at the input:  
"IdentMcpBusAdr", "IdentMcpProfilNo", "IdentMcpBusType", "IdentMcpStrobe"
- Relevant parameters at the output:  
"IdentMcpType", "IdentMcpLengthIn", "IdentMcpLengthOut",

Here the DIP device address or the TCU index at the parameter "IdentMcpBusAdr" is activated by the user program together with setting of the Strobe signal.

The input parameter "IdentMcpProfilNo" is normally to be set to the value 0. This parameter is to be set to the value 1 only in the identification of the direct control keys. The parameter "IdentMcpBusType" currently has no significance for a user program and is to be left in its default value.

After resetting the Strobe signal by the basic program, valid output information becomes available to the user. The resetting of the Strobe signals by the basic program can last for several PLC cycles (up to 2 seconds).

The output parameters should show the user the size of the data areas for the addressed device. Furthermore, it can be defined here, whether an HT2 or an HT8 or no device is connected to the connection box. With this information the MCP channel or the HHU-channel can be activated. In the cyclic operation the parameters can be written symbolically by the user program and read via the symbol names of the DB 7 (gp\_par).

Relevant parameters (FB 1)		
MCP-device identification		Input parameters e.g. OP08T
Input	Output	Values in direct control keys
IdentMcpBusAdr	IdentMcpType	IdentMcpBusAdr = TCU-Index
IdentMcpBusProfilNo	IdentMcpLengthIn	IdentMcpBusProfilNo = Value 1
IdentMcpBusType	IdentMcpLengthOut	IdentMcpBusType = Default value
IdentMcpStrobe		
<b>IdentMcpBusProfilNo</b>		<b>Value</b>
MCP, BHG, HT8, HT2		B#16#0
Direct control keys, such as OP08T, OP12T		B#16#1
<b>IdentMcpType (Mcp-Type)</b>		
no device connected		0
MCP 483C IE (Compact)		B#16#80
MCP 483C IE		B#16#81
MCP 310		B#16#82
MCP OEM		B#16#83
MCP DMG		B#16#84
HT8		B#16#85
TCU_DT (Direct control keys)		B#16#86
MCP_MPP		B#16#87
HT2		B#16#88
OP08T (direct control keys)		B#16#89

**840D: PROFIBUS connection**

In case of PROFIBUS connection of the MCP, this component must be considered in the hardware configuration setting of STEP 7. The MCP may only be interfaced with the standard DP bus on the PLC (**not on MPI/DP**). The addresses must be stored in the input and output log range. These start addresses must also be stored in the pointer parameters of the FB1. The FB1 parameters listed below are used for further parameterization.

There is no PROFIBUS variant of the HHU. For this reason, an Ethernet connection is shown for the HHU in this figure. The Profibus slave address must be stored in the parameter "MCP1BusAdr" and "MCP2BusAdr". Enter the pointer to the configured diagnostic address (e.g. P#A8190.0) in "MCPxStatRec".

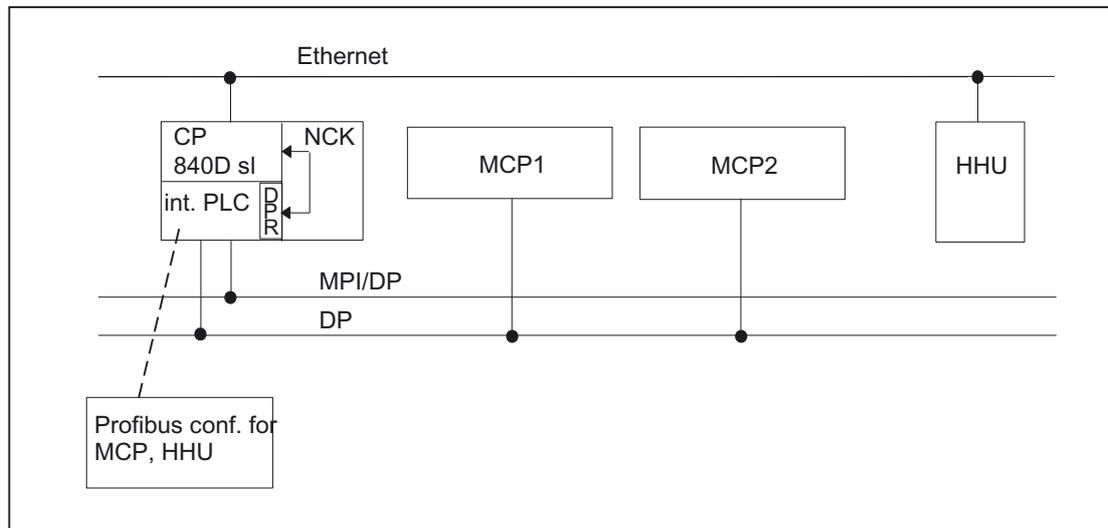


Figure 13-17 840D sl: PROFIBUS connection

Relevant parameters (FB 1)		
MCP		HHU
MCPNum = 1 or 2 (number of MCPs)		HHU = 5 (via CP 840D sl)
MCP1In	MCP2In	BHGIn
MCP1Out	MCP2Out	BHGOut
MCP1StatSend (n.r.)	MCP2StatSend (n.r.)	BHGStatSend
MCP1StatRec	MCP2StatRec	BHGStatRec
MCP1BusAdr	MCP2BusAdr	BHGInLen
MCP1Timeout	MCP2Timeout	BHGOutLen
MCP1Cycl (n.r.)	MCP2Cycl	BHGTTimeout (n.r.)
<b>MCPMPI = FALSE</b>		BHGCycl (n.r.)
MCP1Stop	MCP2Stop	BHGRecGDNo
MCPBusType = b#16#33		BHGRecGBZNo (n.r.)
		BHGRecObjNo (n.r.)
MCPsDB210= FALSE		BHGSendGDNo (n.r.)
MCPCopyDB77 = FALSE		BHGSendGBZNo (n.r.)
		BHGSendObjNo (n.r.)

Relevant parameters (FB 1)	
MCP	HHU
	BHGMPI = FALSE
	BHGStop

MCP failure normally switches the PLC to the STOP state. If this is undesirable, OB 82, OB 86 can be used to avoid a stop. The basic program has by default the OB 82 and OB 86 call. FC5 is called in these OBs. This FC5 checks whether the failed slave is an MCP. If this is the case, no PLC stop is triggered. Setting "MCPxStop" := TRUE causes the basic program to deactivate the MCP as a slave via SFC 12. If the PLC does not switch to the stop state following the failure of or a fault on the MCP, an interrupt message will be generated via the basic program. The interrupt is deleted when the station recovers.

### 13.8.12 Switchover of handheld device

Only Ethernet variants support switchover/deactivation of the machine control panel (MCP) or handheld unit (HHU) as standard. On MPI and PROFIBUS variants, this function is either not supported at all or can only be implemented in restricted format requiring additional effort on the part of the user. For example, with the PROFIBUS variant of the MCP, the DB77 data area specified for MCP1, MCP2 or HHU can be used for the MCP pointer on FB1. The MCP slave bus address must be set correctly under MCPxBusAdr as this is used as the basis for monitoring. A user program copy routine to copy the signals of the active MCP from the I/O area configured in HW Config to DB77. This enables a number of MCPs on the PROFIBUS to be switched via signals. Set the MCPxStop parameter to True for the switchover phase from one MCP to another.

One method will be outlined now with the Ethernet variants of MCP and HHU.

#### Control signals

Parameters MCP1Stop, MCP2Stop and BHGStop can be used to stop communication with individual components (parameter setting = 1). This function is available only on Ethernet variants. This stop or activation of communication can be applied in the current cycle. However, the change in value must be implemented through the symbolic notation of the parameters and not by means of another FB 1 call.

Example of stopping transfer from the first machine control panel:

```
SET;
S gp_par.MCP1Stop;
```

Setting parameters MCP1Stop, MCP2Stop, BHGStop also results in a suppression or deletion of interrupts 400260 to 400262.

#### Switchover of Bus address

An existing connection with a machine control panel (MCPI) or handheld unit (HHU) can be aborted. Another MCP or HHU component already connected to the bus (different address) can then be activated. Proceed as follows to switch addresses:

1. Stop communication with component to be decoupled via parameter MCP1Stop or MCP2Stop or BHGStop = 1.
2. Following checkback in DB10 byte 104 (relevant bits 0, 1 and 2 are set to 0), the bus address (with MCP, this is the FB1 parameter "MCP1BusAdr" or "MCP2BusAdr") is changed; With HHU Ethernet variant, the bus address is set at FB1 parameter "BHGRcGDNo") of this unit is changed to the new component.
3. In this PLC cycle, communication with the new component can now be activated again by means of parameter MCP1Stop or MCP2Stop or BHGStop = 0.
4. Communication with the new component is taking place when the checkback is in DB 10 byte 104 (relevant bits 0, 1, 2 are set to 1).

## 13.9 SPL for Safety Integrated

Rather than being a function of the basic program, SPL is a user function. The basic program makes a data block (DB 18) available for Safety SPL signals and runs a data comparison to ensure the consistency of SPL program data in the NCK.

**References:**

/FBSI/ Description of Functions Safety Integrated

## 13.10 Assignment overview

### 13.10.1 Assignment: NCK/PLC interface

The values of the NC/PLC interface for SINUMERK 840D sl are described in detail in:

**References:**

Lists sl (Book2)

### 13.10.2 Assignment: FB/FC

Number	Significance
FB 15	Basic program
FB 1, FC 2, FC 3, FC 5	Basic program
FC 0 ... 29	Reserved for Siemens
FB 0 ... 29	Reserved for Siemens
FC 30 ... 999 <sup>1)</sup>	Free for user assignment
FB 30 ... 999 <sup>1)</sup>	Free for user assignment
FC 1000 ... 1023	Reserved for Siemens
FB 1000 ... 1023	Reserved for Siemens
FC 1024 ... upper limit	Free for user assignment
FB 1024 ... upper limit	Free for user assignment

<sup>1)</sup> The actual upper limit of the block number (FB/FC) depends on the PLC CPU on which the selected NCU is located.

---

#### Note

Values of FC, FB see " Memory requirements of basic PLC program for SINUMERIK 840D (Page 956)".

---

## 13.10.3 Assignment: DB

**Note**

Only as many data blocks as are required according to the NC machine data configuration are set up.

Overview of data blocks			
DB no.	Name	Name	Package
1		Reserved for Siemens	BP
2 ... 5	PLC-MELD	PLC messages	BP
6 ... 8		Basic program	
9	NC-COMPILE	Interface for NC compile cycles	BP
10	NC INTERFACE	Central NCK interface	BP
11	Mode group 1	Interface mode group	BP
12		Computer link and transport system interface	
13 ... 14		Reserved for basic program	
15		Basic program	
16		PI Service definition	
17		Version identifier	
18		Reserved for basic program	
19		HMI interface	
20		PLC machine data	
21 ... 30	CHANNEL 1 ... n	Interface NC channels	BP
31 ... 61	AXIS 1 ... m	Interfaces for axes/spindles or free for user assignment	BP
62 ... 70		Free for user assignment	
71 ... 74		Tool management	BP
75 ... 76		M group decoding	
77		Data block for MCP signals	
78 ... 80		Reserved for Siemens	
81 ... 999 <sup>1)</sup>		see below: ShopMill, ManualTurn	
1000 ... 1099		Reserved for Siemens	
1100 ... High limit		Free for user assignment	

<sup>1)</sup> The actual upper limit of the block number (DB) depends on the PLC CPU on which the selected NCU is located. The data blocks of channels, axes/spindles and tool management functions that are not activated may be assigned as desired by the user.

---

**Note**

The data blocks of channels, axes/spindles and tool management functions that are not activated may be assigned as required by the user.

---

#### 13.10.4 Assignment: Timers

Timer No.	Significance
T 0 ... T 512 <sup>1)</sup>	User area

<sup>1)</sup> The actual upper limit of the timer number (DB) depends on the PLC CPU on which the selected NCU is located.

## 13.11 Memory requirements of basic PLC program for SINUMERIK 840D

The basic program consists of basic and optional functions. The **basic functions** include cyclic signal exchange between the NC and PLC. The **Options** include e.g. the FCs, which can be used, if needed.

The table below lists the memory requirements for the basic functions and the options. The data quoted represent guide values, the actual values depend on the current software version.

Memory requirements of blocks with SINUMERIK 840D			
Block type no.	Function	Remark	Block size (bytes)
			Working memory
<b>Basic functions in basic program</b>			
FB 1, FB 15		Must be loaded / on CF card	52182
FC 2, 3, 5, 12		Must be loaded	470
DB 4, 5, 7, 8		Must be loaded	1006
DB 2, 3, 17		Are generated by the BP	632
OB 1, 40, 100, 82, 86		Must be loaded	398
		Total	55698
<b>PLC/NCK, PLC/HMI interface</b>			
DB 10	PLC/NCK signals	Must be loaded	262
DB 11	Signals PLC/Mode group	Is generated by BP	56
DB 19	PLC/HMI signals	Is generated by BP	434
DB 21 to DB 30	PLC/channel signals	Are generated by BP as a function of NC-MD: for each DB	416
DB 31 to DB 61	PLC/axis or spindle signals	Are generated by BP as a function of NC-MD: for each DB	148
<b>Basic program options</b>			
Machine control panel			
FC 19	Transfer of MCP signals, M variant	Must be loaded when M variant of MCP is installed	92
FC 25	Transfer of MCP signals, T variant	Must be loaded when T variant of MCP is installed	92
FC 24	Transfer of MCP signals, slim variant	Must be loaded when slim variant of MCP is installed	100
FC 26	Transfer of MCP signals, HT8 variant	Must be loaded for HT8	68

## 13.11 Memory requirements of basic PLC program for SINUMERIK 840D

<b>Basic program options</b>			
Handheld unit			
FC 13	Display control HHU	Can be loaded for handheld units	144
Error/operating messages			
FC 10	Acquisition FM/BM	Load when FM/BM is used	66
ASUB			
FC 9	ASUB start	Load when PLC ASUBs are used	128
<b>Basic program options</b>			
Star/delta changeover			
FC 17	Star/delta switchover of MSD	Load for star/delta switchover	114
Spindle control			
FC 18	Spindle control	Load for spindle control from PLC	132
PLC/NC communication			
FB 2	Read NC variable	Load for Read NC variable	76
DB n	Read NC variable	One instance DB per FB 2 call	270
FB 3	Write NC variable	Load for Write NC variable	76
DB m	Write NC variable	One instance DB per FB3 call	270
FB 4	PI services	Load for PI services	76
DB o	PI services	One instance DB per FB 4 call	130
DB 16	PI services description	Load for PI services	618
FB 5	Read GUD variables	Load for PI services	76
DB p	Read GUD variables	One instance DB per FB 5 call	166
DB 15	General communication	Global data block for communication	146
FB 7	PI services 2	Load for PI services	76
DB o	PI services 2	One instance DB per FB4 call: every	144
FC 21	Transfer	Load with dual-port RAM, ...	164
m:n			
FB 9	Switchover M to N	Load with M to N	58
Safety Integrated			
FB 10	Safety relay	Load with Safety option	74
FB 11	Brake test	Load with Safety option	76
DB 18	Safety data	DB for Safety	226
Tool management			
FC 7	Transfer function turret	Load for tool management option	84
FC 8	Transfer function	Load for tool management option	132
FC 22	Direction selection	Load, when direction selection is needed	138

13.11 Memory requirements of basic PLC program for SINUMERIK 840D

<b>Basic program options</b>			
DB 71	Loading locations	Generated by BP as a function of NC MD	40+30*B
DB 72	Spindles	Generated by BP as a function of NC MD	40+48*Sp
DB 73	Revolver	Generated by BP as a function of NC MD	40+44*R
DB 74	Basic function	Generated by BP as a function of NC MD	100+(B+Sp+R)*22
Compile cycles			
DB 9	Interface PLC compile cycles	Is generated by BP as a function of NC option	436

**Example**

Based on the memory requirements in the table above, the memory requirements have been determined for two sample configurations (see table below).

Block type no.	Function	Remark	Block size (bytes)	
				Working memory
Minimum configuration (1 spindle, 2 axes and T MCP)				
see above	Basic program, base			54688
	Interface DBs			1612
	MCP			92
		Total		56392

Block type no.	Function	Remark	Block size (bytes)	
				Working memory
Maximum configuration (2 channels, 4 spindles, 4 axes, T MCP)				
see above	Basic program, base			54688
see above	Interface DBs			2768
see above	MCP			92
see above	Error/operating messages			66
see above	ASUBs	1 ASUB initiation		128
see above	Concurrent axis	For 2 turrets		132
see above	PLC/NC communication	1 x read variable and 1 x write variable		838
see above	Tool management	2 turrets with one loading point each		674
see above	Compile cycles			436
		Total		59822

## 13.12 Basic conditions and NC VAR selector

### 13.12.1 Supplementary conditions

#### 13.12.1.1 Programming and parameterizing tools

#### Hardware

For the PLCs used in SINUMERIK 840D sl, the following equipment is required for the programming devices or PCs:

	Minimum	Recommendation
Processor	Pentium	Pentium
RAM (MB)	256	512 or more
Hard disk, free capacity (MB)	500	> 500
interfaces	MPI, Ethernet incl. cable Memory card	
Graphic	SVGA (1024*768)	
Mouse	Yes	
Operating system	Windows 2000 /XP Professional, STEP7 version 5.3 SP2 or higher	

The required version of **STEP7** can be installed on equipment meeting the above requirements in cases where the package has not already been supplied with the programming device.

The following functions are possible with this package:

- Programming
  - Editors and compilers for STL (complete scope of the language incl. SFB/SFC calls), LAD, FBD
  - Creation and editing of assignment lists (symbol editor)
  - Data block editor
  - Input and output of blocks ON/OFF line
  - Insertion of modifications and additions ON and OFF line
  - Transfer of blocks from programming device to the PLC and vice versa
- Configuring
  - Parameterizing tool **HW Config** for CPU and I/O device parameterization
  - **NetPro** parameterizing tool for setting the CPU communication parameters
  - Output of system data such as hardware and software version, memory capacity, I/O expansion/assignment

- Testing and diagnostics (ONLINE)
  - Variable status/forcing (I/Os, flags, data block contents, etc.)
  - Status of individual blocks
  - Display of system states (ISTACK, BSTACK, system status list)
  - Display of system messages
  - PLC STOP/complete restart/overall reset triggering from the programming device
  - Compress PLC
- Documentation
  - Printout of individual or all blocks
  - Allocation of symbolic names (also for variables in data blocks)
  - Input and output of comments within each block
  - Printout of test and diagnostics displays
  - Hardcopy function
  - Cross-reference list
  - Program overview
  - Assignment plan I/O/M/T/Z/D
- Archiving of utility routines
  - Allocation of the output statuses of individual blocks
  - Comparison of blocks
  - Rewiring
  - STEP 5 → STEP 7 converter
- Option packages
  - Programming in S7-HIGRAPH, S7-GRAPH, SCL.  
These packages can be ordered from the SIMATIC sales department.
  - Additional packages for configuration modules (e.g. CP3425 → NCM package)

---

**Note**

More information about possible functions can be found in SIMATIC catalogs and STEP 7 documentation.

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### 13.12.1.2 SIMATIC documentation required

**References:**

- System description SIMATIC S7
- S7-300 instruction list
- Programming with STEP 7
- User Manual STEP 7
- Programming Manual STEP 7; designing of user programs
- Reference Manual STEP 7; Instructions list AWL
- Reference Manual STEP 7; Ladder Diagram KOP
- Reference Manual STEP 7; Default and system functions
- Manual STEP 7; Conversion of STEP 5 programs
- STEP 7 overall index
- Manual CPU 317-2DP

### 13.12.1.3 Relevant SINUMERIK documents

**References:**

- Start-up Manual SINUMERIK 840D sl
- Device Manual Operator Components SINUMERIK 840D sl/840Di sl
- Function Manual, Basic Functions
- Function Manual, Extended Functions
- Function Manual, Special Functions
- Lists sl (Book1)
- Lists sl (Book2)

## 13.12.2 NC VAR selector

### 13.12.2.1 Overview

#### General

The PC application "NC VAR selector" fetches the addresses of required NC variables and processes them for access in the PLC program (FB 2/FB 3). This enables the programmer to select NC variables from the entire range of NC variables, to store this selection of variables, to edit them by means of a code generator for the STEP7 compiler and finally to store them as an ASCII file (\*.AWL) in the machine CPU program. This process is shown in the figure "NC VAR selector".

For storing the files created by NC-VAR-selector a catalog is to be implemented via the Windows Explorer with any catalog name. The selected data of the NC-VAR selector (data.VAR and data.AWL files) must be stored in this catalog. Thereafter, the AWL file is to be transferred and compiled via the menu option "Code" → "in STEP7 Project" The "Daten.AWL" (STL data) file must then be inserted into the STEP 7 machine project via "Insert", "External Source" in the STEP 7 Manager. The source container must be selected in the manager for this purpose. This action stores this file in the project structure. Once the file has been transferred, these AWL (STL) files must be compiled with STEP 7.

---

#### Note

The latest NC VAR selector can be used for each NC software version (even earlier versions). For older NC software versions the variables can also be selected from the latest complete list. The data content in DB 120 (default DB for variables) does not depend on the software status. That is, variables selected in an older software version need not be reselected when the software is upgraded.

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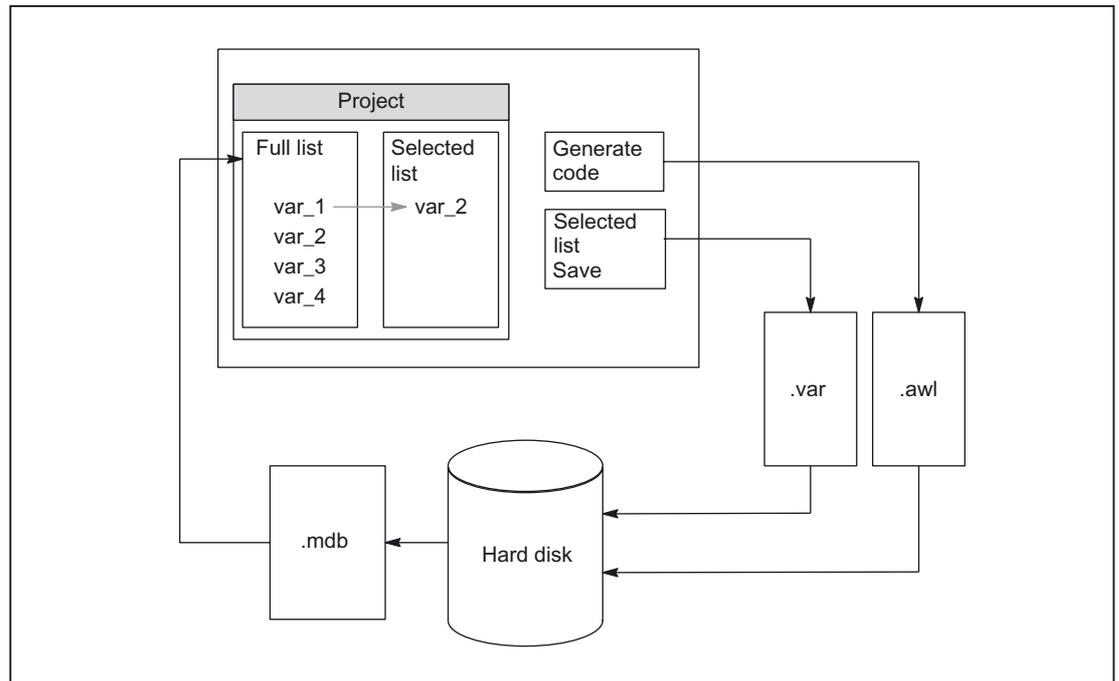


Figure 13-18 NC VAR selector

After the "NC VAR selector" application has been started, select a list of variables of an NC variant (hard disk → file Ncv.mdb) to display all the variables contained in this list in a window.

The variable list ncv\*.mdb is separated on:

<b>SINUMERIK 840D</b>	
NC variables including machine and setting data:	ncv_NcData.mdb
Machine data for 611D drive:	ncv_611d.mdb
Machine data for 611D linear drive:	ncv_611dLinear.mdb
Machine data of the 611D drive, Performance 2:	ncv_611d_P2.mdb
Machine data of the 611D linear drive, Performance 2:	ncv_611d_P2Linear.mdb
Machine data of the hydraulic drive:	ncv_Hydraulics.mdb

<b>SINUMERIK 840D sl</b>	
NC variables including machine and setting data:	ncv_NcData.mdb
Parameters of the Drive:	ncv_SinamicsServo.mdb

The user can also transfer variables to a second list (separate window). This latter selection of variables can then be stored in an ASCII file or edited as a STEP 7 source file (.awl) and stored.

Once he has generated a PLC data block by means of the STEP 7 compiler, the programmer is able to read or write NCK variables via the basic program function blocks "PUT" and "GET" using the STEP 7 file.

The list of selected variables is also stored as an ASCII file (file extension .var).

The variable list supplied with the "NC VAR selector" tool is adapted to the current NC software version. This list does not contain any variables (GUD variables) defined by the user. These variables are processed by the function block FB 5 in the basic program.

---

**Note**

The latest version of the "NC VAR selector" is capable of processing all previous NC software versions. It is, therefore, not necessary to install different versions of the "NC VAR selector" in parallel.

---

**System features, supplementary conditions**

The PC application "NC VAR selector" requires Windows 95 (or later operating system).

The assignment of names to variables is described in:

**References:**

/LIS1/ Lists (Book 1); Chapter: Variables,  
or in the Variables Help file (integrated in NC VAR selector).

### 13.12.2.2 Description of functions

#### Overview

The figure below illustrates how the NC VAR selector is used within the STEP 7 environment.

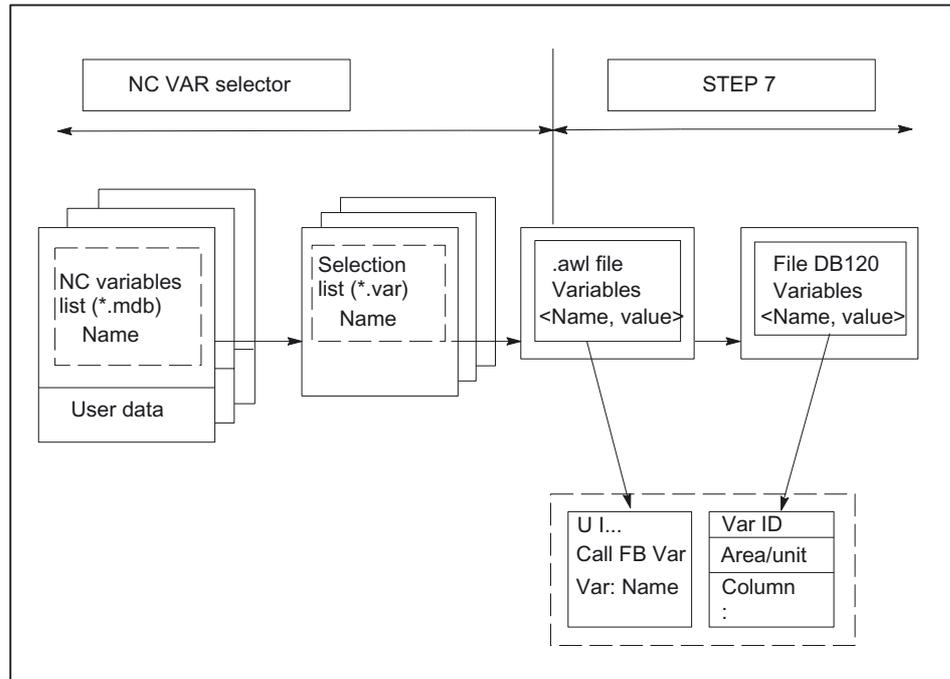


Figure 13-19 Application of NC VAR selector in the STEP 7 environment

The NC VAR selector is used to generate a list of selected variables from a list of variables and then to generate an **.awl** file that can be compiled by the STEP 7 compiler.

- A \*.awl file contains the names and alias names of the NC variables, as well as information about their address parameters. Any data block generated from this file will only contain the address parameters (10 bytes per parameter).
- The generated data blocks must always be stored in the machine-specific file storage according to STEP 7 specifications.
- To ensure that the parameterization of the GET/PUT (FB 2/3) blocks with respect to NC addresses can be implemented with symbols, the freely assignable, symbolic name of the generated data block must be included in the STEP 7 symbol table.

### Basic display/Basic menu

After the NC VAR selector has been selected (started), the basic display with all input options (upper menu bar) appears on the screen. All other displayed windows are placed within the general window.

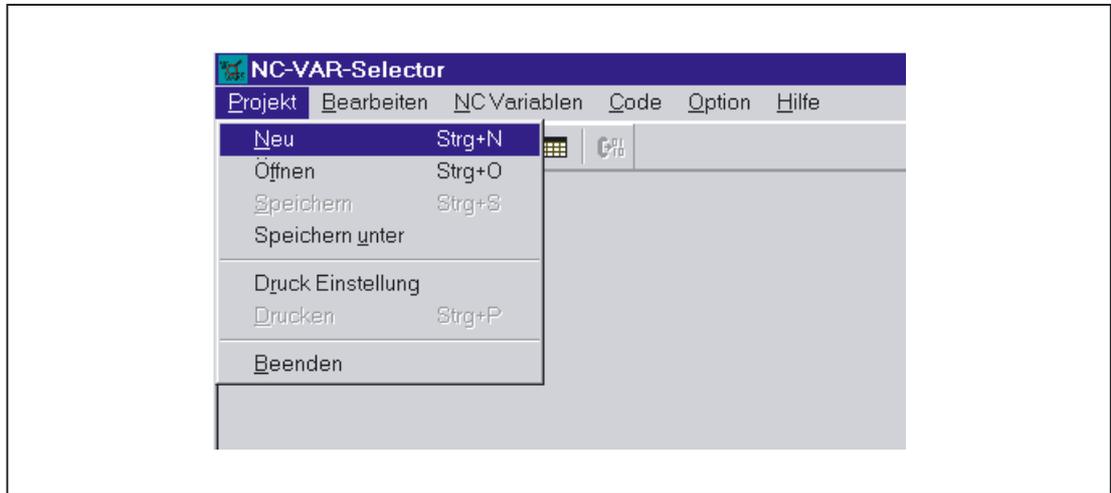


Figure 13-20 Basic display with basic menu

### Project menu item

All operator actions associated with the project file (file of selected variables) are performed under this menu item.

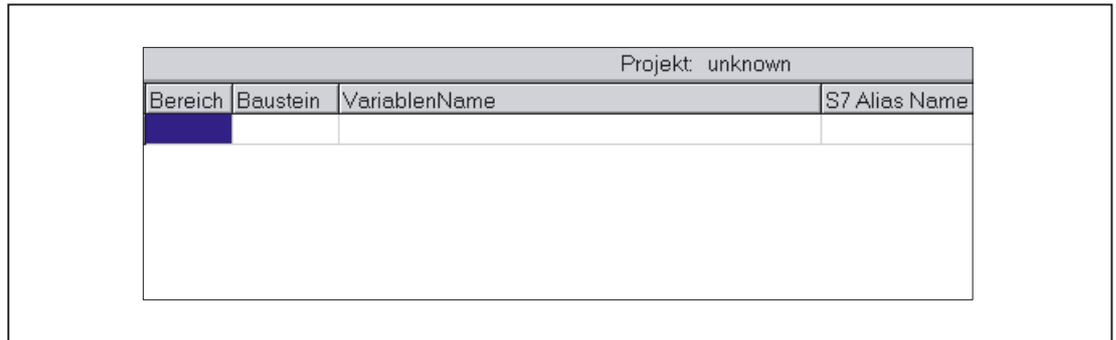
### Terminating the application

The application can be terminated by selecting the "End" option under the "Project" menu item.

### Creating a new project

A new project (new file for selected variables) can be set up under the "Project" menu item.

A window is displayed for the selected variables when "NEW" is selected. The file selection for the NC variable list is then displayed after a prompt (applies only if the NC variable list is not already open).



Projekt: unknown			
Bereich	Baustein	VariablenName	S7 Alias Name

Figure 13-21 Window with selected variables for new project

The selected variables are displayed in a window.

### Open an already existing project

Select "Open" under the "Project" menu item to open an existing project (variables already selected). A file selection window is displayed allowing the appropriate project with extension ".var" to be selected.

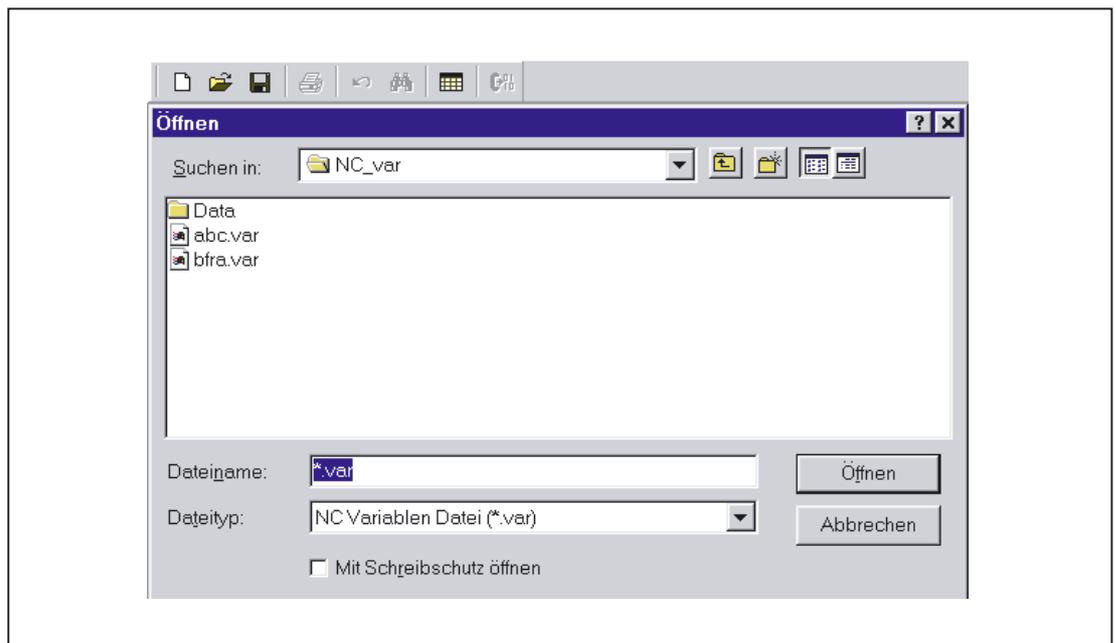


Figure 13-22 Selection window for existing projects

If, after selection of the project, new variables are to be added, a complete list of NC variables must be selected. No complete list need be called if the user only wishes to delete variables from the project.

### Storing a project

The variable list is stored using the "Project" > "Save" or "Save As...." menu items.

"Save" stores the variable list under a path, which is already specified. If the project path is not known, then the procedure is as for "Save As....".

"Save As...." displays a window in which the path for the project to be stored can be specified.

### Printing a project

The "Print" command under the "Project" menu item can be selected to print a project file. The number of lines per page is selected under the "Print Setting" menu item. The default setting is 77 lines.

### Edit menu item

The following operator actions are examples of those, which can be carried out directly with this menu item:

- Transfer variables
- Delete variables
- Change alias names
- Find variables

These actions can also be canceled again under Edit.

### Undoing actions

Operator actions relating to the creation of the project file (transfer variables, delete variables, change alias names) can be undone in this menu.

### NC variables menu item

The basic list of all variables is saved in NC Var Selector path Data\Swxy (xy stands for software version no., e.g. SW 5.3:=xy=53). This list can be selected as an NC variables list. In case of SINUMERIK 840D sl the basic lists are present in the path Data\Swxy\_sl.

### Selecting an NC variable list

A list of all the NC variables for an NC version can now be selected and displayed via the "NC Variable List", "Select" menu item.

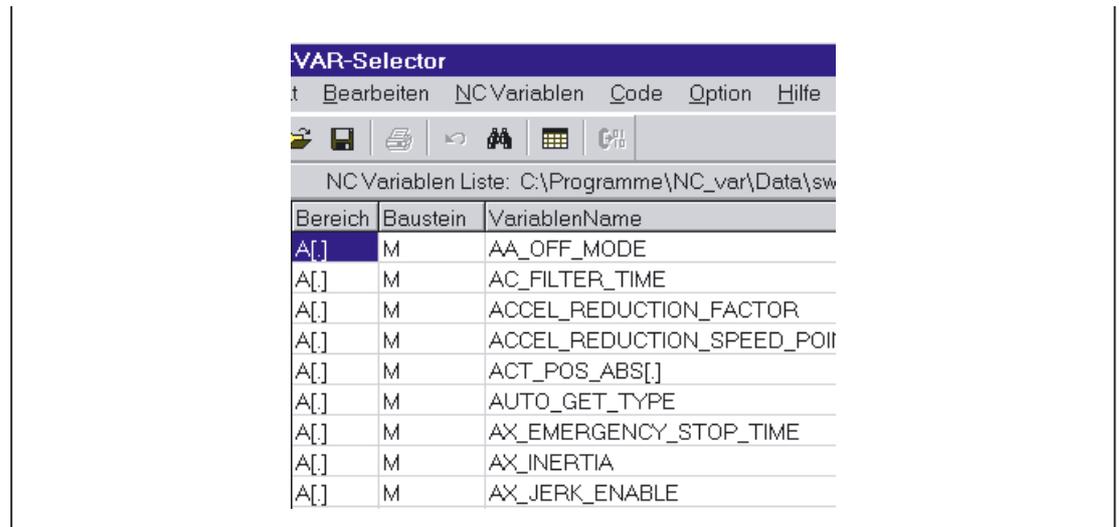


Figure 13-23 Window with selected Complete List

The field variables (e.g. axis area, T area data, etc.) are indicated by means of brackets ([.]). Additional information must be specified here. When the variables are transferred to the project list, the additional information required is requested.

### Displaying subsets

Double-click on any table field (with the exception of variable fields) to display a window in which filter criteria can be preset.

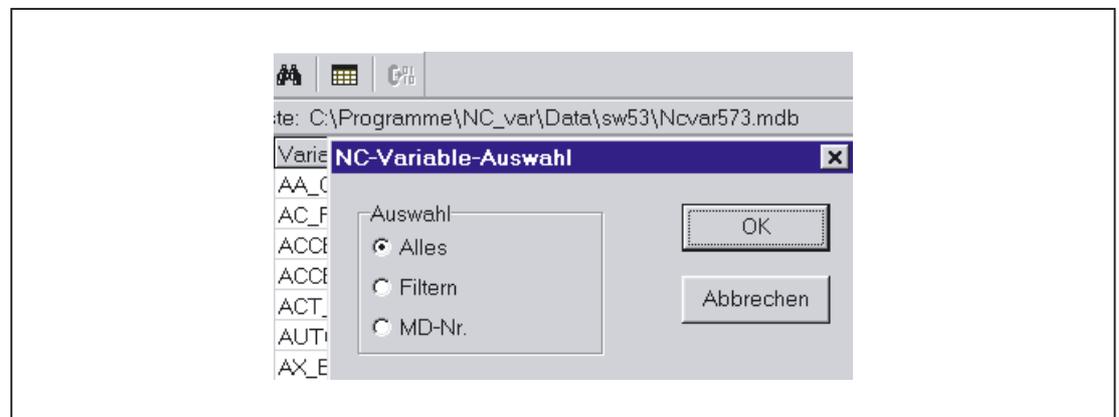


Figure 13-24 Window with filter criteria for displaying list of variables

There are three options:

- Display all data
- Input area, block and name (incl. combinations)
- Display MD/SE data number

The following wildcards can also be used:

*	To extend the search criterion as required
---	--



## Variables in multi-dimensional structures

If variables are selected from multi-dimensional structures, then the column and/or line number as well as the area number must be entered so that the variables can be addressed. The required numbers can be found in the NC variables documentation.

### References:

Lists sl (Book1); Variables

By entering a zero (0) as the block number or the line or column index, it is possible to use the variable in the S7 PLC as a pointer to these data. When reading or writing these data via the functions "PUT" and "GET", the optional parameters "UnitX", "ColumnX" and "LineX" must be filled with the necessary information.

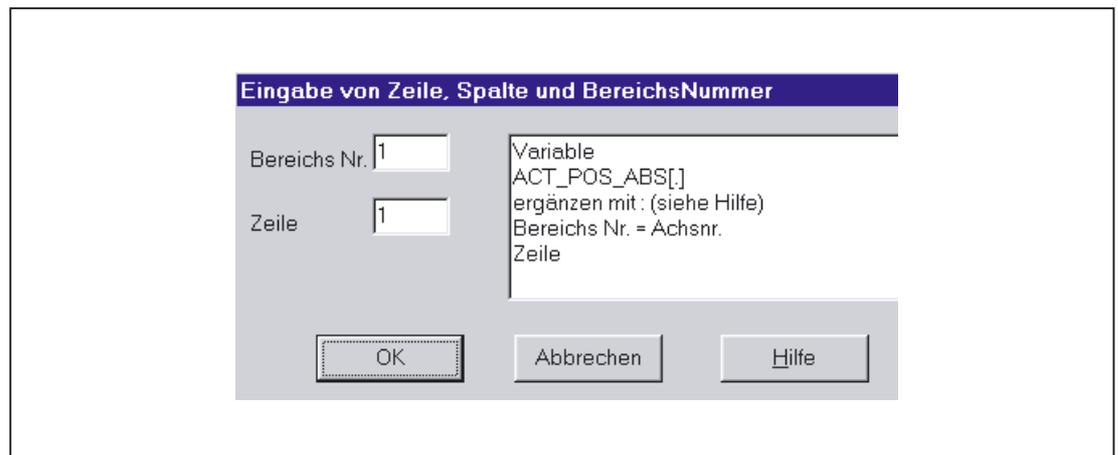


Figure 13-26 Entry field for line, column and block no.

## Delete variables

Variables are deleted in the window of selected variables by selecting the appropriate variables (single mouse click) and pressing the "Delete" key. No deletion action is taken with the double-click function. It is possible to select several variables for deletion (see "Selecting variables").

This action can also be undone under the "Edit" menu item.

### Note

Deleting of variables results in a change of the absolute addresses of the pointer structures to the variables. When changing the variable selection, it is, therefore, absolutely necessary to **generate** one or several **text files of all user blocks prior to the change**. This is the only way to ensure that the assignment of the variables in FB "GET" or FB "PUT" remains correct, even after recompilation.

### Storing a selected list

Once variables have been selected, they can be stored under a project name. The files are stored on a project-specific basis.

A window is displayed for the file to be stored. The project path and name for the file must be selected in the window.

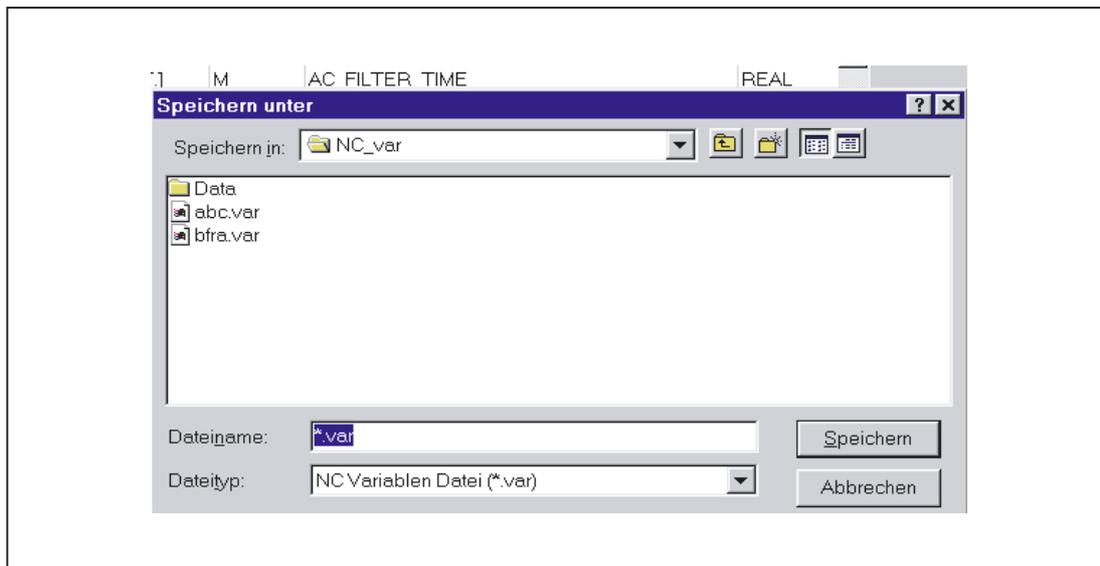


Figure 13-27 Window for project path and name of file to be stored

### Code generation

This menu item contains three selection options:

1. Settings (input of data block number to be generated) and other settings
2. Generate (create data block)
3. In the STEP7 project (transferring the data block to a STEP7 project)

### Settings

Under this menu item, the DB number and the symbol for this DB number for which the code is created is entered.

Under the "Mass System" tab, a selection is made to determine how the unit system variables are calculated in the PLC.

Under the "Generate" tab, the project creation is defined for the relevant target system.

## Generate

Under this menu item, the STEP 7 file from the selected variable list with extension ".awl" is set.

A file is generated when "Select" is clicked:

An **.awl** file that can be used as an input for the STEP 7 compiler.

A window opens, in which path and name for the .awl file to be generated must be specified for the file to be saved.

## In STEP 7 project

The generated AWL file is transferred to a selectable SIMATIC project (program path) and compiled. Furthermore, the symbol can also be transferred. This function is available from STEP 7 version 5.1 onwards. This process takes a longer time owing to the call of STEP 7. Before transferring a new AWL file the file window of the AWL file is to be closed in the KOP/FUP/AWL Editor.

## Option menu item

The following can be selected under the "Option" menu item:

- The current language
- The mode for alias input (always >24 characters)

## Help menu item

The information below can be viewed by selecting the corresponding submenu item:

- The Operator's Guide
- The Description of Variables

The copyright and the version number can also be displayed.

### 13.12.2.3 Start-up, installation

The Windows application "NC Var selector" is installed using the SETUP program supplied with the package.

## 13.13 Block descriptions

### 13.13.1 FB 1: RUN\_UP Basic program, start-up section

#### Function

The synchronization of NCK and PLC is performed during startup. The data blocks for the NC/PLC user interface are created with reference to the NC configuration defined in the machine data and the most important parameters verified for plausibility. In the event of an error, FB 1 passes an error identifier to the diagnostics buffer and switches the PLC to the STOP state.

To enable an orderly start-up of the control, it is vital to synchronize the NCK and PLC, as these systems have their own types of power-up procedure. During startup routine, therefore, the CPUs perform "subsidiary startup functions" and exchange ID information to ensure that the procedure is functioning correctly.

Since the startup procedure is asynchronous, it is unavoidable that one CPU may have to "wait" until the other has "caught up". This is automatically managed by the basic program.

The integrated PLC only supports cold starts. A warm restart is not provided, i.e. following system initialization, the operating system runs organization block OB 100 and always commences cyclic execution at the start of OB 1.

Users need only supply the FB 1 parameters that are relevant to their applications. The preset values in the associated instance DB 7 do not need to be assigned. The block can only be called in OB 100.

#### Output parameters

The output parameters in FB 1 provide the PLC user with information about the control system configuration. These data can also be accessed in the cyclic program section.

There are two access options:

1. Direct access to the DB 7 data block (instance of the FB 1) in symbolic format (e.g. L gp\_par.MaxChan; in this case, gp\_par is the symbolic name of the DB 7)
2. Assignment of a flag; during parameterization of the FB 1, the data element is assigned to the relevant parameter (e.g. MaxChan:=MW 20) Information about the maximum number of channels can then be polled in memory word 20 in the rest of the user program.

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#### Note

For the values of the parameters of MCP and HHU see "Configuration machine control panel, handheld unit, direct keys (Page 945)".

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## Declaration SINUMERIK 840D

Code	Comment
FUNCTION_BLOCK FB 1	
VAR_INPUT	
MCPNum:	INT:=1; //0: No MCP //1: 1 MCP (default) //2: 2 MCPs
MCP1In:	POINTER; //Start addr. input signals MCP 1
MCP1Out:	POINTER; //Start addr. output signals MCP 1
MCP1StatSend:	POINTER; //Status DW for sending MCP 1
MCP1StatRec:	POINTER; //Status DW for receiving MCP 1
MCP1BusAdr:	INT:=6; //Default
MCP1Timeout:	S5TIME:= S5T#700MS;
MCP1Cycl:	S5TIME:= S5T#200MS;
MCP2In:	POINTER; //Start addr. input signals MCP 2
MCP2Out:	POINTER; //Start addr. output signals MCP 2
MCP2StatSend:	POINTER; //Status DW for sending MCP 2
MCP2StatRec:	POINTER; //Status DW for receiving MCP 2
MCP2BusAdr:	INT ;
MCP2Timeout:	S5TIME:= S5T#700MS;
MCP2Cycl:	S5TIME:= S5T#200MS;
MCPMPI:	BOOL:= FALSE;
MCP1Stop:	BOOL:= FALSE;
MCP2Stop:	BOOL:= FALSE;
MCP1NotSend:	BOOL:= FALSE;
MCP2NotSend:	BOOL:= FALSE;
MCPsDB210:	BOOL:= FALSE;
MCPCopyDB77:	BOOL:= FALSE;
MCPBusType:	BYTE=B#16#0;
HHU:	INT:=0; //Handheld unit interface //0: No HHU //1: HHU on MPI //2: HHU on OPI
BHGIn:	POINTER; //Transmit data of the HHU
BHGOut:	POINTER; //Receive data of the HHU
BHGStatSend:	POINTER; //Status DW for sending HHU
BHGStatRec:	POINTER; //Status DW for receiving HHU
BHGInLen:	BYTE:= B#16#6; //Input 6 bytes
BHGOutLen:	BYTE:= B#16#14; //Output 20 bytes
BHGTimeout:	S5TIME:= S5T#700MS;
BHGCycl:	S5TIME:= S5T#100MS;
BHGRecGDNo:	INT:=2;
BHGRecGBZNo:	INT:= 2;
BHGRecObjNo:	INT:= 1;

Code	Comment
BHGSendGDNo:	INT:= 2;
BHGSendGBZNo:	INT:= 1;
BHGSendObjNo:	INT:= 1;
BHGMPI:	BOOL:= FALSE;
BHGStop:	BOOL:= FALSE;
BHGNotSend:	BOOL:= FALSE;
NCCyclTimeout:	S5TIME:= S5T#200MS;
NCRunupTimeout:	S5TIME:= S5T#50S;
ListMDecGrp:	INT:= 0;
NCKomm:	BOOL:= FALSE;
MMCToIF:	BOOL:= TRUE;
HWheelMMC:	BOOL:= TRUE; //Handwheel selection via HMI
ExtendAlMsg :	BOOL ;
MsgUser:	INT:= 10; //Number of user areas in DB 2
UserIR:	BOOL:= FALSE; //User programs in OB 40, //Observe local data expansion!
IRAuxfuT:	BOOL:= FALSE; //Evaluate T function in OB 40
IRAuxfuH:	BOOL:= FALSE; //Evaluate H function in OB 40
IRAuxfuE:	BOOL:= FALSE; //Evaluate DL function in OB 40
UserVersion:	POINTER; //Pointer to string variable indicated in //version screen display
OpKeyNum :	INT;
Op1KeyIn	POINTER;
Op1KeyOut :	POINTER;
Op1KeyBusAdr :	INT;
Op2KeyIn :	POINTER;
Op2KeyOut :	POINTER;
Op2KeyBusAdr :	INT;
Op1KeyStop :	BOOL ;
Op2KeyStop :	BOOL ;
Op1KeyNotSend :	BOOL ;
Op2KeyNotSend :	BOOL ;
OpKeyBusType :	BYTE ;
IdentMcpBusAdr :	INT;
IdentMcpProfilNo :	BYTE ;
IdentMcpBusType :	BYTE ;
IdentMcpStrobe :	BOOL ;
END_VAR	
VAR_OUTPUT	
MaxBAG:	INT;
MaxChan:	INT;
MaxAxis:	INT;
ActivChan:	ARRAY[1..10] OF BOOL;

Code	Comment
ActivAxis:	ARRAY[1..31] OF BOOL;
UDInt :	INT;
UDHex:	INT;
UDReal :	INT;
IdentMcpType :	BYTE ;
IdentMcpLengthIn :	BYTE ;
IdentMcpLengthOut :	BYTE ;
END_VAR	

### Description of formal parameters of SINUMERIK 840D

The table below lists all formal parameters of the RUN\_UP function for the 840D:

Signal	Type	Type	Range of values	Remark
MCPNum	I	INT	Up to 2	Number of active MCP 0: No MCPs available
MCP1In MCP2In	I	POINTER	E0.0 to E120.0 or M0.0 to M248.0 or DBn DBX0.0 to DBXm.0	Start address for input signals of relevant machine control panel
MCP1Out MCP2Out	I	POINTER	A0.0 to A120.0 or M0.0 to M248.0 or DBn DBX0.0 to DBXm.0	Start address for output signals of relevant machine control panel
MCP1StatSend MCP2StatSend	I	POINTER	A0.0 to A124.0 or M0.0 to M252.0 or DBn DBX0.0 to DBXm.0	Currently no significance
MCP1StatRec MCP2StatRec	I	POINTER	A0.0 to A124.0 or M0.0 to M252.0 or DBn DBX0.0 to DBXm.0	Currently no significance
MCP1BusAdr MCP2BusAdr	I	INT	1 ... 126 192 .. 223	DP slave: PROFIBUS address Ethernet MCP: DIP-Setting
MCP1Timeout MCP2Timeout	I	S5time	Recommendation: 700 ms	Cyclic sign-of-life monitoring for machine control panel
MCP1Cycl MCP2Cycl	I	S5time	Recommendation: 200 ms	Relevant only for PROFIBUS
MCPMPI	I	BOOL	false	Available owing to compatibility
MCP1Stop MCP2Stop	I	BOOL		0: Start transfer of machine control panel signals 1: Stop transfer of machine control panel signals DP slave: Slave deactivated

Signal	Type	Type	Range of values	Remark
MCP1NotSend MCP2NotSend	I	BOOL		0: Send and receive operation activated 1: Receive machine control panel signals only
MCPSDB210	I	BOOL	false	Available owing to compatibility
MCPCopyDB77	I	BOOL	false	Available owing to compatibility
MCPBusType	I	BYTE		b#16#33: PROFIBUS b#16#55: Ethernet Mixed mode possible, see Chapter "Configuration machine control panel, handheld unit, direct keys (Page 945) "
HHU	I	INT	0, 5	Handheld unit interface 0: No HHU 5: HHU on Ethernet
BHGIn	I	POINTER	E0.0 to E124.0 or M0.0 to M252.0 or DBn DBX0.0 to DBXm.0	Start address PLC receive data from HHU
BHGOut	I	POINTER	A0.0 to A124.0 or M0.0 to M252.0 or DBn DBX0.0 to DBXm.0	Start address PLC transmit data to HHU
BHGStatSend	I	POINTER	A0.0 to A124.0 or M0.0 to M252.0 or DBn DBX0.0 to DBXm.0	Available owing to compatibility
BHGStatRec	I	POINTER	A0.0 to A124.0 or M0.0 to M252.0 or DBn DBX0.0 to DBXm.0	Available owing to compatibility
BHGInLen	I	BYTE	HHU default: B#16#6 (6 Byte)	Available owing to compatibility
BHGOutLen	I	BYTE	HHU default: B#16#14 (20 Byte)	Available owing to compatibility
BHGTimeout	I	S5time	Recommendation: 700 ms	Available owing to compatibility
BHGCycl	I	S5time	Recommendation: 100 ms	Available owing to compatibility
BHGRecGDNo	I	INT	HHU default: 2	Ethernet DIP switch
BHGRecGBZNo	I	INT	HHU default: 2	Available owing to compatibility
BHGRecObjNo	I	INT	HHU default: 1	Available owing to compatibility

Signal	Type	Type	Range of values	Remark
BHGSendGDNo	I	INT	HHU default: 2	Available owing to compatibility
BHGSendGBZNo	I	Int	HHU default: 1	Available owing to compatibility
BHGSendObjNo	I	INT	HHU default: 1	Available owing to compatibility
BHGMPI	I	BOOL	false	Available owing to compatibility
BHGStop	I	BOOL		0: Start transmission of handheld unit signals
				1: Stop transmission of handheld unit signals
BHGNotSend	I	BOOL		0: Send and receive operation activated
				1: Receive handheld unit signals only
NCCyclTimeout	I	S5time	Recommendation: 200 ms	Cyclic sign-of-life monitoring NCK
NCRunupTimeout	I	S5time	Recommendation: 50 s	Power-up monitoring NCK
ListMDecGrp	I	INT	0 ... 16	Activation of expanded M group decoding
				0: Not active
				1...16: Number of M groups
NCKomm	I	BOOL		PLC NC communications services (FB 2/3/4/5/7: Put/Get/PL_SERV/GETGUD)
				TRUE: active
MMCToIF	I	BOOL		Transmission of HMI signals to interface (modes, program control etc.)
				TRUE: Active
HWheelMMC	I	BOOL		TRUE: Handwheel selection via HMI
				FALSE: Handwheel selection via user program
ExtendAIMsg	I	BOOL		Activation extension of the FC10 (see Section "Structure and Functions of the basic program")
MsgUser	I	INT	0 ... 32	Number of user areas for messages (DB 2)
UserIR	I	BOOL		Local data expansion OB40 required for processing of signals from user
IRAuxfuT	I	BOOL		Evaluate T function in OB 40
IRAuxfuH	I	BOOL		Evaluate H function in OB 40
IRAuxfuE	I	BOOL		Evaluate DL function in OB 40
UserVersion	I	POINTER	DBxx	Pointer to string variable. The associated string variable is indicated in the version display (max. 41 characters).
OpKeyNum	I	INT	0 ... 2	Number of active Direct control key modules
				0: no Ethernet direct control keys available.

Signal	Type	Type	Range of values	Remark
Op1KeyIn Op2KeyIn	I	POINTER	P#Ex.0 or P#Mx.0 or P#DBn.DBXx.0.	Start address for the input signals of the affected direct control key modules
Op1KeyOut Op2KeyOut	I	POINTER	P#Ax.0 or P#Mx.0 or P#DBn.DBXx.0.	Start address for the output signals of the affected direct control key modules
Op1KeyBusAdr Op2KeyBusAdr	I	INT	1 ... 191	Direct control keys via Ethernet: TCU Index:
Op1KeyStop Op2KeyStop	I	BOOL		0: Start transmission of direct control key signals
				1: Stop transmission of direct control key signals
Op1KeyNotSend Op2KeyNotSend	I	BOOL		0: Send and receive operation activated
				1: Receive direct control key signals only
OpKeyBusType	I	BYTE	b#16#55	b#16#55: Ethernet
IdentMcpBusAdr	I	INT	1 ... 254	only IE devices
IdentMcpProfilNo	I	BYTE	0, 1	Profile of a device
				0: complete device
				1: only direct control keys
IdentMcpBusType	I	BYTE	b#16#5	only IE devices
IdentMcpStrobe	I	BOOL		Activate query
MaxBAG	Q	INT	1 ... 10	Number of mode groups
MaxChan	Q	INT	1 ... 10	Number of channels
MaxAxis	Q	INT	1 ... 31	Number of axes
ActivChan	Q	ARRAY[1...10] OF BOOL		Bit string for active channels
ActivAxis	Q	ARRAY[1..31] OF BOOL		Bit string for active axes
UDInt	Q	INT		Quantity of INTEGER machine data in DB20
UDHex	Q	INT		Quantity of hexadecimal machine data in DB20
UDReal	Q	INT		Quantity of REAL machine data in DB 20
IdentMcpType	Q	BYTE		Type (HT2, HT8, ...)
IdentMcpLengthIn	Q	BYTE		Length info input data in PLC
IdentMcpLengthOut	Q	BYTE		Length info output data in PLC

## MCP/HHU monitoring (840D)

The following alarms are displayed at HMI in cases of errors for the communication with the machine control panel (MCP):

- 400260: MCP 1 failure or
- 400261: MCP 2 failure
- 400262: HHU failure

In this case, the input signals from the MCP or from the handheld unit (MCP1In/MCP2In or BHGIn) are reset to 0. If it is possible to resynchronize the PLC and MCP/HHU, communication is resumed automatically and the error message reset by the GP.

## 840D example call

An example call for the FB 1 in OB 100 appears below. This example is part of the diskette with basic program for 840D.

```
ORGANIZATION_BLOCK OB 100
VAR_TEMP
    OB100_EV_CLASS :          BYTE ;
    OB100_STRTUP :          BYTE ;
    OB100_PRIORITY :        BYTE ;
    OB100_OB_NUMBR :        BYTE ;
    OB100_RESERVED_1 :      BYTE ;
    OB100_RESERVED_2 :      BYTE ;
    OB100_STOP :            WORD ;
    OB100_RESERVED_3 :      WORD ;
    OB100_RESERVED_4 :      WORD ;
    OB100_DATE_TIME :       DATE_AND_TIME;
END_VAR
BEGIN
    CALL FB 1, DB 7 (
        MCPNum :=          1,
        MCP1In :=          P#E0.0,
        MCP1Out :=         P#A0.0,
        MCP1StatSend :=    P#A8.0,
        MCP1StatRec :=     P#A12.0,
        MCP1BusAdr :=      6,
        MCP1Timeout :=     S5T#700MS,
        MCP1Cycl :=        S5T#200MS,
        NC-CyclTimeout :=  S5T#200MS,
        NC-RunupTimeout := S5T#50S);
    //INSERT USER PROGRAM HERE
END_ORGANIZATION_BLOCK
```

### 13.13.2 FB 2: Read GET NC variable

#### Function

The PLC user program can read variables from the NCK area using FB GET. The FB is multi-instance-capable.

FB 2 also includes an Instance DB from the user area.

When FB 2 is called with a positive signal edge change at control input "Req", a job is started, which reads the NCK variables referenced by ADDR1-ADDR8 and then copies them to the PLC operand areas referenced by RD1 to RD8. Successful completion of the read process is indicated by a logical "1" in status parameter "NDR".

The **read process** lasts for several PLC cycles (normally 1 ... 2). The block can be called up in cyclic mode only.

Any errors are indicated by Error and State.

In order to reference the NC variables, all required variables are first selected with the "NC VAR selector" tool and generated as STL source in a data block. A name must then be assigned to this DB in the symbol table.

"DB name.S7 name" is transferred as the actual parameter of the NCK variable address (Addr1 to Addr8) when FB 2 is called.

#### Variable addressing

For some NC variables, it is necessary to select area no. and/or line or column from the NC-VAR selector. For these variables it is possible to select a basic type, i. e. area/column/row is filled with "0" by default.

The contents of the area number, line and column specified by the NC VAR selector are checked for a "0" in the FB. If a "0" is present, the value is transferred to the input parameter. The user must supply the required parameters (UnitX/ColumnX/LineX) before calling FB GET. FB PUT.

#### NOTICE

FB 2 can read NC variables only if basic program parameter NCKomm ="1" has been set (in OB 100: FB 1, DB 7). The call is permitted only in cyclic program OB1. An assignment for all parameters with Req = 0 is also permitted in OB 100.

When **channel-specific** variables are read, only variables from **one** and the same channel may be addressed via Addr1 to Addr8 in a job (FB 2 call).

In areas V and H, different logic axis numbers must not be assigned in one job. (Failure to observe this rule results in Error:= TRUE, State:= W#16#02).

NCK variables within **one** group can be combined in a job:

	Area				
Group 1	C[1]	N	B	A	T
Group 2	C[2]	N	B	A	T
Group 3	V[.]	H[.]			

The same rules apply to channels 3 to 10 as illustrated as examples in the above table in groups 1 and 2.

**Note**

Especially when reading several long strings, the number of usable variables can be less than 8.

**Declaration of the function**

```

FUNCTION_BLOCK FB 2
VAR_INPUT
    Req :                BOOL ;
    NumVar :             INT ;
    Addr1 :              ANY ;
    Unit1 :              BYTE ;
    Column1 :            WORD ;
    Line1 :              WORD ;
    Addr2 :              ANY ;
    Unit2 :              BYTE ;
    Column2 :            WORD ;
    Line2 :              WORD ;
    Addr3 :              ANY ;
    Unit3 :              BYTE ;
    Column3 :            WORD ;
    Line3 :              WORD ;
    Addr4 :              ANY ;
    Unit4 :              BYTE ;
    Column4 :            WORD ;
    Line4 :              WORD ;
    Addr5 :              ANY ;
    Unit5 :              BYTE ;
    Column5 :            WORD ;
    Line5 :              WORD ;
    Addr6 :              ANY ;
    Unit6 :              BYTE ;
    Column6 :            WORD ;
    Line6 :              WORD ;

```

13.13 Block descriptions

```

    Addr7 :          ANY ;
    Unit7 :          BYTE ;
    Column7 :        WORD ;
    Line7 :          WORD ;
    Addr8 :          ANY ;
    Unit8 :          BYTE ;
    Column8 :        WORD ;
    Line8 :          WORD ;
END_VAR
VAR_OUTPUT
Error :            BOOL ;
NDR :             BOOL ;
State :           WORD ;
END_VAR

```

```

VAR_IN_OUT
    RD1 :          ANY ;
    RD2 :          ANY ;
    RD3 :          ANY ;
    RD4 :          ANY ;
    RD5 :          ANY ;
    RD6 :          ANY ;
    RD7 :          ANY ;
    RD8 :          ANY ;
END_VAR

```

**Description of formal parameters**

The table below list all formal parameters of the GET function.

Signal	Type	Type	Range of values	Remark
Req	I	BOOL		Job start with positive signal edge
NumVar	I	INT	1 ... 8 (corresponds to use of Addr1 to Addr8)	Number of variables to be read
Addr1 to Addr8	I	ANY	[DBName].[VarName]	Variable identifiers from <b>NC Var selector</b>
Unit1 to Unit8	I	BYTE		Area address, optional for variable addressing
Column1 to Column8	I	WORD		Column address, optional for variable addressing
Line1 to Line8	I	WORD		Line address, optional for variable addressing

Signal	Type	Type	Range of values	Remark
Error	Q	BOOL		Negative acknowledgment of job or execution of job impossible
NDR	Q	BOOL		Job successfully executed Data are available
State	Q	WORD		See error identifiers
RD1 to RD8	I/O	ANY	P#Mm.n BYTE x... P#DBnr.dbxm.n BYTE x	Target area for read data

## Error identifiers

If it was not possible to execute a job, the failure is indicated by "logic 1" on status parameter error. The error cause is coded at the block output State:

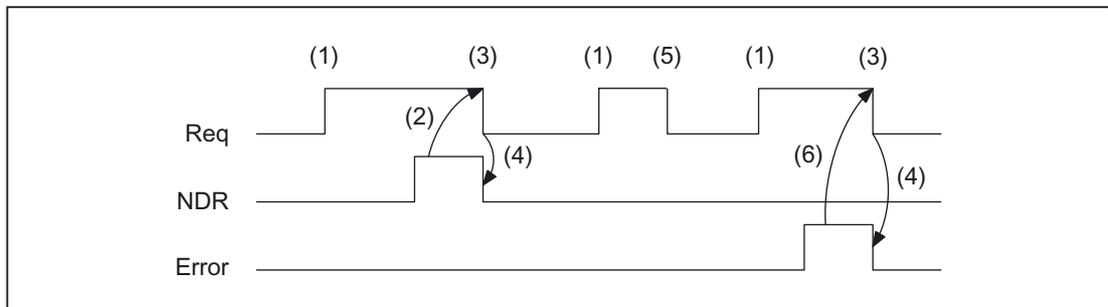
State		Significance	Note
WORD H	WORD L		
1 ... 8	1	Access error	In high byte number of Var in which error occurred
0	2	Error in job	Incorrect compilation of Var. in a job
0	3	Negative acknowledgment, job not executable	Internal error, try: NC RESET
1 ... 8	4	Insufficient local user memory available	Read var. is longer than specified in RD1 to RD8; in high byte number of var, in which error occurred
0	5	Format conversion error	Error on conversion of var. type double: Var. is not within S7 REAL area
0	6	FIFO full	Job must be repeated since queue is full
0	7	Option not set	BP parameter "NCKomm" is not set
1 ... 8	8	Incorrect target area (RD)	RD1 to RD8 may not be local data
0	9	Transmission occupied	Job must be repeated
1 ... 8	10	Error in variable addressing	Unit or column/line contains value 0
0	11	Address of variable invalid	Check Addr (or variable name), area, unit
0	12	NumVar = 0	Check parameter NumVar
1 ... 8	13 (0x0d)	ANY data reference incorrect	NcVar date required has not been parameterized

### Configuration steps

Proceed as follows to read NC variables:

- Select variables with the NC VAR selector.
- Save selected variables in a \*.VAR file
- Generate a STEP 7 \*.STL source file.
- Generate a DB with the associated address data.
- Enter the symbol for the generated DB in the symbol table so that it is possible to access the address parameters symbolically in the user program.
- Set FB2 parameters

### Pulse diagram



- (1) Activation of function
- (2) Positive acknowledgment: Receive new data
- (3) Reset function activation after receipt of acknowledgment
- (4) Signal change by means of FB
- (5) Not permissible
- (6) Negative acknowledgment: Error has occurred, error code in the output parameter State

**Call example**

Reading of three channel-specific machine data from channel 1, whose address specifications are stored in DB120.

**Select data with NC VAR selector** and store in file DB120.VAR; then create file DB120.AWL:

Area	Block	Name	Type	No.	Byte	S7 Name
C[1]	M	MD20070 \$MC_AXCONF_MACHAX_USED[1]	char	20070	1	C1AxConfMachAx Used1
C[1]	M	MD20070 \$MC_AXCONF_MACHAX_USED[2]	char	20070	1	C1AxConfMachAx Used2
C[1]	M	MD20090 \$MC_SPIND_DEF_MASTER_SPIND	int	20090	1	C1SpindDefMaster Spind

S7 (ALIAS) names have been selected in order to:

- Incorporate the channel designation into the name  
and
- Remove the characters [ ], which are not legal in a STEP 7 symbol.

**Entry of the name in the S7 SYMBOL table** (e.g. NCVAR for DB120):

Symbol	Operand	Data type
NCVAR	DB 120	DB 120

File DB120.AWL must be compiled and transferred to the PLC.

**Parameterization of FB 2 with instance DB 110:**

```

DATA_BLOCK DB 110           //Unassigned user DB, as instance for FB 2
FB 2
BEGIN
END_DATA_BLOCK
Function FC "VariablenCall" : VOID
    U    I 7.7;                //Unassigned machine control panel key
    S    M 100.0;              //Activate req.
    U    M 100.1;              //NDR completed message
    R    M 100.0;              //Terminate job
    U    I 7.6;                //Manual error acknowledgment
    U    M 102.0;              //Error pending
    R    M 100.0;              //Terminate job
    CALL FB 2, DB 110 (
        Req :=      M 100.0,
        NumVar :=   3,          //Read 3 variables
        Addr1 :=    NCVAR.C1AxConfMachAxUsed1,
        Addr2 :=    NCVAR.C1AxConfMachAxUsed2,
        Addr3 :=    NCVAR.C1SpindDefMasterSpind,
        Error :=    M102.0,
        NDR :=      M100.1,
        State :=    MW104,
        RD1 :=      P#DB99.DBX0.0 BYTE 1,

```

```

RD2 := P#DB99.DBX1.0 BYTE 1,
RD3 := P#M110.0 INT 1);

```

**Example: Variable addressing**

Reading of two R parameters of channel 1, whose address specifications are stored in DB 120 as the basic type. The R parameter number is parameterized via parameter LineX.

```

DATA_BLOCK DB 120
VERSION : 0.0
STRUCT
  C1_RP_rpa0_0:
  STRUCT
    SYNTAX_ID :          BYTE := B#16#82;
    area_and_unit :      BYTE := B#16#41;
    column :           WORD := W#16#1;
    line :             WORD := W#16#0;
    block type :       BYTE := B#16#15;
    NO. OF LINES :     BYTE := B#16#1;
    type :             BYTE := B#16#F;
    length :           BYTE := B#16#8;
  END_STRUCT;
END_STRUCT;
BEGIN
END_DATA_BLOCK
  CALL FB 2, DB 110 (
    Req := M 0.0,
    NumVar := 2,
    Addr1 := "NCVAR".C1_RP_rpa0_0,
    Line1 := W#16#1,
    Addr2 := "NCVAR".C1_RP_rpa0_0,
    Line2 := W#16#2,
    Error := M 1.0,
    NDR := M 1.1,
    State := MW 2,
    RD1 := P#M 4.0 REAL 1,
    RD2 := P#M 24.0 REAL 1);

```

## Data types

The data types of the NCK are listed in the NC-VAR selector with the variables. The tables below give the assignments to the S7 data types.

Classification of data types	
NCK data type	S7 data type
double	REAL
float	REAL
long	DINT
integer	DINT
uint_32	DWORD
int_16	INT
uint_16	WORD
unsigned	WORD
char	CHAR or BYTE
string	STRING
bool	BOOL
datetime	DATE_AND_TIME

### 13.13.3 FB 3: PUT write NC variables

#### Function

The PLC user program can write variables in the NCK area using FB PUT. The FB is multi-instance-capable.

Every FB 3 call must be assigned a separate instance DB from the user area.

When FB 3 is called with a positive signal edge change at control input Req, a job is started to overwrite the NC variables referenced by Addr1 to Addr8 with the data of the PLC operand areas locally referenced by SD1 to SD8. Successful completion of the write process is indicated by a logical "1" in status parameter "Done".

The **write process** lasts for several PLC cycles (normally 1-2). The block can be called up in cyclic mode only.

Any errors are indicated by Error and State.

In order to reference the NC variables, all required variables are first selected with the "NC VAR selector" tool and generated as STL source in a data block. A name must then be assigned to this DB in the symbol table.

"DB name.S7 name" is transferred as the actual parameter of the NCK variable address (Addr1 to Addr8) when FB 3 is called.

### Variable addressing

For some NC variables, it is necessary to select area no. and/or line or column in the NC VAR selector. For these variables it is possible to select a basic type, i.e. area/column/row is filled with "0" by default.

The contents of the area number, line and column specified by the NC VAR selector are checked for a "0" in the FB. If a "0" is present, the value is transferred to the input parameter. The user must supply the required parameters (UnitX/ColumnX/LineX) before calling Here unit corresponds to area no., column to column and line to row.

### Machine data, GUD

In order to define machine data and GUDs without a password, the protection levels of the data you want to access must be redefined to the lowest level.

**References:**

- Commissioning Manual; Chapter: "Protection levels concept"
- Programming Manual, Job Planning; Chapter: "Define protection levels for user data"

<b>NOTICE</b>
<p>FB 3 can only write NC variables if basic program parameter "NCKomm" has been set to "1" (in OB 100: FB 1, DB 7). The call is permitted only in cyclic program OB1. An assignment for all parameters with Req = 0 is also permitted in OB 100.</p> <p>When <b>channel-specific</b> variables are written, only variables from <b>one</b> and the same channel may be addressed via Addr1 to Addr8 in a job (FB 3 call).</p> <p>In areas V and H, different logic axis numbers must not be assigned in a single job. (Failure to observe this rule results in Error:= TRUE, State:= W#16#02).</p>

NCK variables within **one** group can be combined in a job:

	Area				
Group 1	C[1]	N	B	A	T
Group 2	C[2]	N	B	A	T
Group 3	V[.]	H[.]			

The same rules apply to channels 3 to 10 as illustrated as examples in the above table in groups 1 and 2.

**Note**

Especially when reading several long strings, the number of usable variables can be less than 8.

## Declaration of the function

```
FUNCTION_BLOCK FB 3
VAR_INPUT
    Req :          BOOL ;
    NumVar :       INT ;
    Addr1 :        ANY ;
    Unit1 :        BYTE ;
    Column1 :      WORD ;
    Line1 :        WORD ;
    Addr2 :        ANY ;
    Unit2 :        BYTE ;
    Column2 :      WORD ;
    Line2 :        WORD ;
    Addr3 :        ANY ;
    Unit3 :        BYTE ;
    Column3 :      WORD ;
    Line3 :        WORD ;
    Addr4 :        ANY ;
    Unit4 :        BYTE ;
    Column4 :      WORD ;
    Line4 :        WORD ;
    Addr5 :        ANY ;
    Unit5 :        BYTE ;
    Column5 :      WORD ;
    Line5 :        WORD ;
    Addr6 :        ANY ;
    Unit6 :        BYTE ;
    Column6 :      WORD ;
    Line6 :        WORD ;
    Addr7 :        ANY ;
    Unit7 :        BYTE ;
    Column7 :      WORD ;
    Line7 :        WORD ;
    Addr8 :        ANY ;
    Unit8 :        BYTE ;
    Column8 :      WORD ;
    Line8 :        WORD ;
END_VAR
VAR_OUTPUT
    Error :        BOOL ;
    Done :         BOOL ;
    State :        WORD ;
END_VAR
VAR_IN_OUT
```

```

SD1 :          ANY ;
SD2 :          ANY ;
SD3 :          ANY ;
SD4 :          ANY ;
SD5 :          ANY ;
SD6 :          ANY ;
SD7 :          ANY ;
SD8 :          ANY ;
END_VAR
    
```

### Description of formal parameters

The table below lists all formal parameters of the PUT function.

Signal	Type	Type	Range of values	Remark
Req	I	BOOL		Job start with positive signal edge
NumVar	I	INT	1 to 8 (corresponds to use of Addr1 to Addr8)	Number of variables to be written
Addr1 to Addr8	I	ANY	[DBName].[VarName]	Variable identifiers from <b>NC Var selector</b>
Unit 1 to Unit 8	I	BYTE		Area address, optional for variable addressing
Column 1 to Column 8	I	WORD		Column address, optional for variable addressing
Line 1 to Line 8	I	WORD		Line address, optional for variable addressing
Error	Q	BOOL		Negative acknowledgment of job or execution of job impossible
Done	Q	BOOL		Job successfully executed
State	Q	WORD		See error identifiers
SD1 to SD8	I/O	ANY	P#Mm.n BYTE x... P#DBnr.dbxm.n BYTE x	Data to be written

## Error identifiers

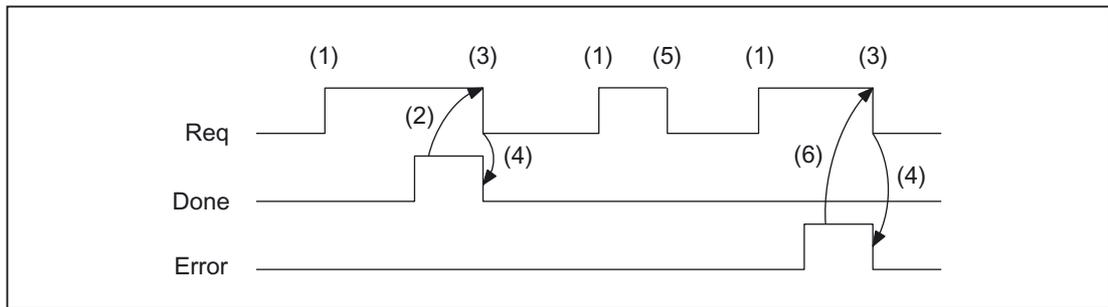
If it was not possible to execute a job, the failure is indicated by "logic 1" on status parameter error. The error cause is coded at the block output State:

State		Significance	Note
WORD H	WORD L		
1 to 8	1	Access error	In high byte number of Var in which error occurred
0	2	Error in job	Incorrect compilation of Var in a job
0	3	Negative acknowledgment, job not executable	Internal error, try: Check job, NC RESET
1 ... 8	4	Data areas or data types do not match or string is empty	Check data to be written in SD1 to SD8; in high byte number of the Var in which error occurred
0	6	FIFO full	Job must be repeated since queue is full
0	7	Option not set	BP parameter "NCKomm" is not set
1 ... 8	8	Incorrect target area (SD)	SD1 to SD8 may not be local data
0	9	Transmission occupied	Job must be repeated
1 ... 8	10	Error in variable addressing	Unit or column/line contains value 0
0	11	Variable addr. invalid or var. is read-only	Check Addr (or variable name), area, unit
0	12	NumVar = 0	Check parameter NumVar
1 to 8	13 (0x0d)	ANY data reference incorrect	NcVar date required has not been parameterized
1 to 8	15 (0x0f)	User data too long	Remedy: Pack fewer variables in the job or use shorter string variables

## Configuration steps

To write NC variables, the same configuration steps are required as for reading NC variables. It is useful to store the address data of all NC variables to be read or written in a DB.

**Pulse diagram**



- (1) Activation of function
- (2) Positive acknowledgment: variables have been written
- (3) Reset function activation after receipt of acknowledgment
- (4) Signal change by means of FB
- (5) Not permissible
- (6) Negative acknowledgment: Error has occurred, error code in output parameter state

**Call example**

Writing of three channel-specific machine data of channel 1:

Select the three data with NC VAR selector and store in the file DB120.VAR:

Area	Block	Name	Type	Byte	S7 Name
C[1]	RP	rpa[5]	DOUBLE	4	rpa_5C1RP
C[1]	RP	rpa[11]	DOUBLE	4	rpa_11C1RP
C[1]	RP	rpa[14]	DOUBLE	4	rpa_14C1RP

Entry NCVAR for DB 120 with the S7 SYMBOL Editor:

Symbol	Operand	Data type
NCVAR	DB 120	DB 120

File DB120.AWL must be compiled and transferred to the PLC.

Call and parameterization of FB 3 with instance DB 111:

```

DATA_BLOCK DB 111          //Unassigned user DB, as instance for FB 3
FB 3
BEGIN
Function FC "VariablenCall": VOID
END_DATA_BLOCK
    U    I 7.7;           //Unassigned machine control panel key
    I    M 100.0;        //Activate req.
    U    M 100.1;        //Done completed message
    R    M 100.0;        //Terminate job
    
```

```

U   I 7.6;           //Manual error acknowledgment
U   M 102.0;        //Error pending
R   M 100.0;        //Terminate job
CALL FB 3, DB 111 (
    Req :=           M 100.0,
    NumVar :=        3,                               //Write 3 variables
    Addr1 :=         NCVAR.rpa_5C1RP,
    Addr2 :=         NCVAR.rpa_11C1RP,
    Addr3 :=         NCVAR.rpa_14C1RP,
    Error :=         M102.0,
    Done :=          M100.1,
    State :=         MW104,
    SD1 :=           P#DB99.DBX0.0 REAL 1,
    SD2 :=           P#DB99.DBX4.0 REAL 1,
    SD3 :=           P#M110.0 REAL 1);

```

### Example Variable addressing

Writing of two R parameters of channel 1, whose address specifications are stored in DB 120 as the basic type. The R parameter number is parameterized via parameter LineX.

```

DATA_BLOCK DB 120
VERSION : 0.0
STRUCT
    C1_RP_rpa0_0:
    STRUCT
        SYNTAX_ID :           BYTE := B#16#82;
        area_and_unit :       BYTE := B#16#41;
        column :             WORD := W#16#1;
        line :               WORD := W#16#0;
        block type :         BYTE := B#16#15;
        NO. OF LINES :       BYTE := B#16#1;
        type :               BYTE := B#16#F;
        length :             BYTE := B#16#8;
    END_STRUCT;
END_STRUCT;
BEGIN
END_DATA_BLOCK
CALL FB 3, DB 122 (
    Req :=           M 10.0,
    NumVar :=        2,
    Addr1 :=         "NCVAR".C1_RP_rpa0_0,
    Line1 :=         W#16#1,
    Addr2 :=         "NCVAR".C1_RP_rpa0_0,

```

```
Line3 :=      W#16#2
Error :=      M 11.0,
Done :=       M 11.1,
State :=      MW 12,
SD1 :=        P#M 4.0 REAL 1,
SD2 :=        P#M 24.0 REAL 1);
```

### 13.13.4 FB 4: PI\_SERV PI services

#### Function

FB PI\_SERV can be used to start program-instance services in the NCK area.

---

#### Note

Recommendation: Use the extended FB 7 in place of FB 4.

---

A program section, which carries out a particular function (e.g. with tool management, search for empty location in a magazine), is executed in the NCK by making a request via the PI service.

Every FB 4 call must be assigned an instance DB from the user area.

The specified service is referenced via the "PIService" parameter. The selected PI service is supplied via the freely assignable additional input variables with varying data types (Addr1 to Addr4 for strings, WVar1 to WVar 10 for INTEGER or WORD variables).

A job is started when **FB 4 is called** by means of a positive edge change at control input Req. Successful execution of the job is displayed by means of a logical "1" in status parameter "Done". Any errors are indicated by Error and State.

The "PI" data block (DB16) contains internal descriptions of the possible PI services. A name must then be assigned to this DB in the signal list. On calling the FB 4, "DB-Name.PI-Name" is transferred as the actual parameter for "PIService".

The execution of the PI service extends over several PLC cycles (generally 1 to 2). The block can be called up in cyclic mode only.

---

#### Note

FB 4 can start PI services only if the basic program parameter "NCKomm" has been set to "1" (in OB 100: FB 1, DB 7). The call is permitted only in cyclic program OB1. An assignment for all parameters with Req = 0 is also permitted in OB 100.

---

## Declaration of the function

```

FUNCTION_BLOCK FB 4
VAR_INPUT
    Req :                BOOL ;
    PIService :          ANY ;
    Unit :               INT ;
    Addr1 :              ANY ;
    Addr2 :              ANY ;
    Addr3 :              ANY ;
    Addr4 :              ANY ;
    WVar1 :              WORD ;
    WVar2 :              WORD ;
    WVar3 :              WORD ;
    WVar4 :              WORD ;
    WVar5 :              WORD ;
    WVar6 :              WORD ;
    WVar7 :              WORD ;
    WVar8 :              WORD ;
    WVar9 :              WORD ;
    WVar10 :             WORD ;
END_VAR
VAR_OUTPUT
    Error :              BOOL ;
    Done :               BOOL ;
    State :              WORD ;
END_VAR

```

## Description of formal parameters

The following table shows all formal parameters of the function PI\_SERV.

Signal	Type	Type	Range of values	Remark
Req	I	BOOL		Job request
PIService	I	ANY	[DBName].[VarName] Standard is: "PI".[VarName]	PI service description <sup>1)</sup>
Unit	I	INT	1...	Area number
Addr1 to Addr4	I	ANY	[DBName].[VarName]	Reference to strings specification according to selected PI service
WVar1 to WVar10	I	WORD	1...	INTEGER or WORD variables. Specification according to selected PI service,
Error	Q	BOOL		Negative acknowledgment of job or execution of job impossible
Done	Q	BOOL		Job successfully executed

Signal	Type	Type	Range of values	Remark
State	Q	WORD		See error identifiers

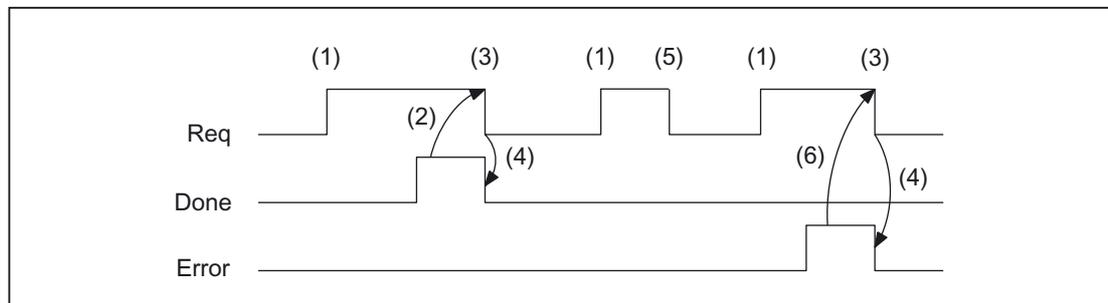
1) See README file on basic program diskette supplied

### Error identifiers

If it was not possible to execute a job, the failure is indicated by "logic 1" on status parameter error. The error cause is coded at the block output State:

State	Significance	Note
3	Negative acknowledgment, job not executable	Internal error, try: NC RESET
6	FIFO full	Job must be repeated since queue is full
7	Option not set	BP parameter "NCKomm" is not set
9	Transmission occupied	Job must be repeated
13 (0x0d)	ANY data reference incorrect	String date required has not been parameterized
14 (0x0e)	PIService parameter reference incorrect	No valid PI description
15 (0x0f)	String too long	Addr1.. Check Addr4 strings

### Timing diagram



- (1) Activation of function
- (2) Positive acknowledgment: PI service has been executed
- (3) Reset function activation after receipt of acknowledgment
- (4) Signal change by means of FB
- (5) Not permissible
- (6) Negative acknowledgment: Error has occurred, error code in the output parameter State

### 13.13.4.1 Overview of available PI services

The following section provides an overview of the PI services that can be started from the PLC.

The significance and application of the general FB 4 input variables (Unit, Addr ..., WVar ...) depend on the individual PI service concerned.

Table 13-3 General PI services

PI service	Function
ASUB	Assign interrupt
CANCEL	Execute cancel
CONFIG	Reconfiguration of tagged machine data
DIGION	Digitizing on
DIGIOF	Digitizing off
FINDBL	Activate block search
LOGIN	Activate password
LOGOUT	Reset password
NCRES	Trigger NC-RESET
SELECT	Select program for processing for one channel
SETUDT	Sets the current user data to active
SETUFR	Activate user frame

Table 13-4 PI services of tool management

PI service	Function
CRCEDN	Create new cutting edge
CREACE	Create cutting edge
CREATO	Generate tool
DELECE	Delete a cutting edge
DELETO	Delete tool
MMCSEM	Semaphores for various PI services
TMCRT0	Create tool
TMFDPL	Empty location search for loading
TMFPBP	Empty location search
TMGETT	T-number for the specified tool identifier with duplo number
TMMVTL	Prepare magazine location for loading, unload tool
TMPOSM	Position magazine location or tool
TMPCIT	Set increment value for workpiece counter
TMRASS	Reset active status
TRESMO	Reset monitoring values
TSEARC	Complex search using search screen forms

### 13.13.4.2 General PI services

#### PI service: ASUB

##### Function: Assign interrupt

A program stored on the NCK is assigned an interrupt signal for a channel. This is possible only when the program file may be executed. The path names and the program names are to be written in correct notation.

For the correct notation of the path and the program names see:

##### References:

Programming Manual Job Planning; Chapter: "File and Program Management" > "Program Memory".

Parameterization			
Signal	Type	Value range	Meaning
PIService	ANY	PI.ASUP	Assign interrupt
Unit	INT	1 ... 10	Channel
WVar1	WORD	1 ... 8	Interrupt number
WVar2	WORD	1 ... 8	Priority
WVar3	WORD	0/1	LIFTFAST
WVar4	WORD	0/1	BLSYNC
Addr1	STRING		Path name
Addr2	STRING		Program name

##### Note

The SETINT instruction is also used to make the assignment.

The ASUP PI service may only be executed when the channel to be activated is in RESET state.

##### References:

Programming Manual, Job Planning; Chapter: "Flexible NC-Programming" > "Interrupt routine (ASUB)"

#### PI service: CANCEL

##### Function: Execute Cancel

Has the effect that the function "Cancel" (corresponding to the key on HMI) is executed.

Parameterization			
Signal	Type	Value range	Meaning
PIService	ANY	PI.CANCEL	Cancel

**PI service: CONFIG****Function: Reconfiguration**

The reconfiguration command activates machine data, which have been entered sequentially by the operator or the PLC, almost in parallel.

The command can only be activated when the control is in RESET state or the program is interrupted (NC stop at block limit). An FB 4 error checkback message is output if these conditions are not fulfilled (state = 3).

Parameterization			
Signal	Type	Value range	Meaning
PIService	ANY	PI.CONFIG	Reconfiguration
Unit	INT	1	
WVar1	INT	1	Classification

**PI service: DIGION****Function: Digitizing on**

Selecting digitizing in the specified channel.

Parameterization			
Signal	Type	Value range	Meaning
PIService	ANY	PI.DIGION	Digitizing on
Unit	INT	1 to 10	Channel

**PI service: DIGIOF****Function: Digitizing off**

Deactivating digitizing in the specified channel.

Parameterization			
Signal	Type	Value range	Meaning
PIService	ANY	PI.DIGIOF	Digitizing off
Unit	INT	1 to 10	Channel

**PI service: FINDBL****Function: Activate block search**

A channel is switched to block search mode and the appropriate acknowledgment then transmitted. The block search is then executed immediately by the NCK. The search pointer must already be in the NCK at this point in time. The search can be interrupted at any time by an NC RESET. Once the search is successfully completed, the normal processing mode is reactivated automatically. NC Start then takes effect from the located search target. The operator is responsible for providing a collision-free approach path.

Parameterization			
Signal	Type	Value range	Meaning
PIService	ANY	PI.FINDBL	Block search
Unit	INT	1 to 10	Channel
WVar1	WORD	x	Preprocessing mode

- x Writes the preprocessing mode
- Value:    Meaning:
- = 1       Without calculation
- = 2       With calculation
- = 3       with main block consideration

**PI service: LOGIN**

**Function: Create password**

Transfers the parameterized password to the NCK. The passwords generally consist of 8 characters. If required, blanks must be added to the string of the password.

**Example:**

Password: STRING[8] := 'SUNRISE';

Parameterization			
Signal	Type	Value range	Meaning
PIService	ANY	PI.LOGIN	Create password
Unit	INT	1	NCK
Addr1	STRING	8 characters	Password

**PI service: LOGOUT**

**Function: Reset password**

The password last transferred to the NCK is reset.

Parameterization			
Signal	Type	Value range	Meaning
PIService	ANY	PI.LOGOUT	Reset password
Unit	INT	1	NCK

**PI service: NCRES**

**Function: Trigger NC-RESET**

Initiates an NCK RESET. The Unit and WVar1 parameters must be assigned 0.

Parameterization			
Signal	Type	Value range	Meaning
PIService	ANY	PI.NCRES	Trigger NC-RESET
Unit	INT	0	0
WVar1	WORD	0	0

**PI service: SELECT**

**Function: Select processing for a channel**

A program stored on the NCK is selected for processing for one channel. This is possible only if the file may be executed. The path name and program name must be entered as described in the Programming Manual Job Planning, File and Program Management, Section "Program Memory". Please also refer to example of FB 4 for notation of path and program names.

**Possible block types**

Block types	
Workpiece directory	WPD
Main program	MPF
Subroutine	SPF
cycles	CYC
Asynchronous subprograms	ASP
Binary files	BIN

Parameterization			
Signal	Type	Value range	Meaning
PIService	ANY	PI.SELECT	Program selection
Unit	INT	1 ... 10	Channel
Addr1	STRING		Path name
Addr2	STRING		Program name

**PI service: SETUdT**

**Function: Set function current user data active**

The current user data, such as tool offsets, basic frames and settable frames are set to active in the next NC block (only in STOP state).

Parameterization			
Signal	Type	Range of values	Meaning
PIService	ANY	PI.SETUdT	Activate user data
Unit	INT	1 to 10	Channel
WVar1	WORD	1 to 5	User Data Type
			1 = active tool offset
			2 = active Basic frame
			3 = active settable frame
			4 = active global Basic frame
5 = active global settable frame			
WVar2	WORD	0	Standby
WVar3	WORD	0	Standby

**PI service: SETUFR**

**Function: Activate user frames**

User frames are loaded to the NCK. All necessary frame values must be transferred to the NCK beforehand by writing variables with FB 3.

Parameterization			
Signal	Type	Value range	Meaning
PIService	ANY	PI.SETUFR	Activate user frames
Unit	INT	1 to 10	Channel

### 13.13.4.3 PI services of tool management

#### PI service: CRCEDN

##### Function: Create new cutting edge

If the T number of an existing tool is specified in parameter "T number" in the PI service, then a cutting edge is set up for this particular tool (in this case, parameter "D number" (number of cutting edge to be created) has a value range of 00001–00009). If a positive T number is specified as a parameter and the tool for the T number entered does not exist, then the PI service is aborted. If a value of 00000 is entered as the T number (model of absolute D numbers), then the D number values can range from 00001-31999. The new cutting edge is set up with the specified D number. If the specified cutting edge already exists, then the PI service is aborted in both cases.

Parameterization			
Signal	Type	Range of values	Significance
PIService	ANY	PI.CRCEDN	Create new cutting edge
Unit	INT	1 ... 10	TOA
WVar1	INT		T number of tool for which cutting edge must be created. A setting of 00000 states that the cutting edge should not refer to any particular tool (absolute D number).
WVar2	INT	1 ... 9 or 01 - 31999	Edge number of tool cutting edge

#### PI service: CREAM

##### Function: Create cutting edge

Creation of the cutting edge with the next higher/next unassigned D number for the tool with the transferred T number in TO, TS (if present). The cutting edge for the OEM cutting edge data is set up simultaneously in the TUE block - if one is present.

Parameterization			
Signal	Type	Range of values	Significance
PIService	ANY	PI.CREAM	Create cutting edge
Unit	INT	1 ... 10	TOA
WVar1	INT		T number

**PI service: CREATO****Function: Create tool**

Creation of a tool with specification of a T number. The tool is entered as existing in the tool directory area (TV). The first "cutting edge" D1 (with zero contents) is created for tool offsets in the TO block. D1 (with zero contents) is also created for the OEM "cutting edge" data in the TUE block - if one is present. If a TU block exists, it will contain the data set for the tool.

Parameterization			
Signal	Type	Range of values	Significance
PIService	ANY	PI.CREATO	Create tool
Unit	INT	1 ... 10	TOA
WVar1	INT		T number

**PI service: DELECE****Function: Delete a tool cutting edge**

If the T number of an existing tool is specified in parameter "T number" in the PI service, then a cutting edge is deleted for this particular tool (in this case, parameter "D number" (number of cutting edge to be created) has a value range of 00001–00009). If a positive T number is specified as a parameter and the tool for the T number entered does not exist, then the PI service is aborted. If a value of 00000 is entered as the T number (model of absolute D numbers), then the D number values can range from 00001-31999. If the specified cutting edge does not exist, then the PI service is aborted in both cases.

Parameterization			
Signal	Type	Range of values	Significance
PIService	ANY	PI.DELETE	Delete cutting edge
Unit	INT	1 ... 10	TOA
WVar1	INT		T number of tool for which cutting edge must be created. A setting of 00000 states that the cutting edge should not refer to any particular tool (absolute D number).
WVar2	INT	1 ... 9 or 01 ... 31999	Edge number of cutting edge that must be deleted

**PI service: DELETO****Function: Deleting a tool**

Deletes the tool assigned to the transferred T number with all cutting edges (in TO, in some cases TU, TUE and TG (type 4xx), TD and TS blocks).

Parameterization			
Signal	Type	Range of values	Significance
PIService	ANY	PI.DELETO	Delete tool
Unit	INT	1 ... 10	TOA
WVar1	INT		T number

**PI service: MMCSEM**

Semaphores for various PI services

**For use by HMI and PLC**

10 semaphores are provided for each channel. These protect critical functions for the HMI/PLC. By setting the semaphore for the corresponding function number, several HMI/PLC units can be synchronized with it in cases where a function contains a critical section with respect to data to be fetched by the NCK. Semaphores are managed by the HMI/PLC. A semaphore value of 1 stipulates a Test & Set operation for the semaphore of the specified function number. The return value of the PI service represents the result of this operation:

- Checkback value Done := TRUE: Semaphore has been set, critical function can be called
- Checkback value Error := TRUE with state = 3: Semaphore was already set, critical function cannot be called at the present time. The operation must be repeated later.

**Note**

On completion of the operation (reading data of this PI service) it is **essential** that the **semaphore is enabled again**.

**Parameter:**

WVar1 = FunctionNumber

This function number represents a PI service:

Function number	PI service
1	TMCRT0 (create tool)
2	TMGDPL (search for empty location for loading):
3	TMMVTL (prepare magazine location for loading, unload tool)
4	TMFPBP (search for location)
5	TMGETT (search for tool number)
6	TSEARC (search for tool)
7 ... 10	Reserved

WVar2=SemaphorValue

Value	Description
0:	Reset semaphore
1:	Test and set semaphore

Parameterization			
Signal	Type	Range of values	Significance
PIService	ANY	PI.MMCSEM	Set semaphore
Unit	INT	1, 2 to 10	Channel
WVar1	INT	1 ... 10	FunctionNumber
WVar2	WORD	0, 1	SemaphoreValue

### PI service: TMCRTO

#### Function Create tool:

Creating a tool with specification:

- of an identifier, a duplo number, e.g. with:  
 $\$TC\_TP1[y] = \text{duplo number};$   
 $\$TC\_TP2[y] = \text{"tool identifier"};$
- optionally a T number, e.g. with:  
 $y = \text{T number}$

The tool is entered as existing in the tool directory area (TV). The first cutting edge "D1" (with zero contents) is created for tool offsets in the TO block. "D1" (with zero contents) is also set up for the monitoring data in the TS block, and simultaneously with zero contents for the OEM cutting edge data in the TUE block - if one is present. The TD block contains the identifier, duplo number and number of cutting edges (=1) for the T number that is entered optionally or allocated by the NCK.

If a TU block exists, it will contain the data set for the tool. After execution of the PI, the T number of the tool created is available in the TV block under **TnumWZV**.

---

#### Note

Before and after this PI service, the MMCSEM PI service must be called up with the associated parameter WVar1 for this PI service. See PI service MMCSEM for more information.

---

Parameterization			
Signal	Type	Range of values	Significance
PIService	ANY	PI.TMCRT0	Create tool
Unit	INT	1 - 10	TOA
WVar1	INT		T number
WVar2	INT		Duplo number
Addr1	STRING	max. 32 characters	Tool identifier
T number > 0 means a T number must be specified T number = -1 means that the NCK should allocate a T number The example shows T number = -1 ⇒ T number assigned by NCK			

## PI service: TMFDPL

### Function: Empty location search for loading

(dependent on parameter assignment):

#### Location\_number\_to = -1, Magazine\_number\_to = -1:

Searches all magazines in the specified area (= channel) for an empty location for the tool specified with a T number. After execution of the PI, the magazine and locations numbers found during the search are listed in the configuration block of the channel (component **magCMCmdPar1** (magazine number) and **magCMCmdPar2** (location number)). Location\_number\_ID and magazine\_number\_ID can be set as search criteria or not (= -1). The PI is acknowledged positively or negatively depending on the search result.

#### Location\_number\_to = -1, Magazine\_number\_to = Magazine\_number:

An empty location for the tool specified with a T number is searched for in the specified magazine. Location\_number\_ID and magazine\_number\_ID can be set as search criteria or not (= -1). The PI is acknowledged positively or negatively depending on the search result.

#### Location\_number\_to = Location\_number, Magazine\_number\_to = Magazine\_number:

The specified location is checked, to confirm that it is free to be loaded with the specified tool. Location\_number\_ID and magazine\_number\_ID can be set as search criteria or not (= -1). The PI is acknowledged positively or negatively depending on the search result.

Command parameters 1 and 2 are located at source.

Loading: If source is an internal loading magazine, then the command parameters are located at the target (a real magazine).

Unloading: Source is always a real magazine.

---

### Note

Before and after this PI service, the MMCSEM PI service must be called up with the associated parameter WVar1 for this PI service. See PI service MMCSEM for more information.

---

Parameterization			
Signal	Type	Range of values	Significance
PIService	ANY	PI.TMFDPL	Empty location for loading
Unit	INT	1 - 10	TOA
WVar1	INT		T number
WVar2	INT		Location_number_to
WVar3	INT		Magazine_number_to
WVar4	INT		Location_number_ID
WVar5	INT		Magazine_number_ID

**PI service: TMFPBP**

**Function: Empty location search**

(dependent on parameter assignment):

For this see the description of FB 7: PI\_SERV2 General PI services

**PI service: TMGETT**

**Function: Determine T-number for the specified tool identifier with duplo number**

Determining the T number for a specified tool identifier with duplo number. The PI services stores the T number determined for the tool as result in the variable TnumWZV in the block TV. If the specified tool does not exist, then the T number "-0001" is returned. Since the PI service returns a result in the variable TnumWZV, the service is to be stored with the semaphore mechanism (PI service \_N\_MMCSSEM) with the function number for \_N\_TMGETT.

**Note**

Before and after this PI service, the MMCSSEM PI service must be called up with the associated parameter WVar1 for this PI service. See PI service MMCSSEM for more information.

Parameterization			
Signal	Type	Range of values	Significance
PIService	ANY	PI.TMGETT	Determining the T number
Unit	INT	1 ... 10	TOA
Addr1	STRING	max. 32 characters	Name of the tool, for which the T number is searched
WVar2	INT		Duplo number of the tool, for which the T number is searched

## PI service: TMMVTL

### Function: Prepare magazine location for loading, unload tool

This PI service is used both to load and unload tools. Whether the PI initiates a loading or unloading operation depends on the assignment between the real locations and the "from" parameters and "to" parameters: Loading  $\Rightarrow$  'From' = Loading point/station, unloading  $\Rightarrow$  'To' = loading point/station

The TMMVTL PI service is used for all movements.

1. Loading and unloading (loading point  $\leftrightarrow$  magazine)
2. Loading and unloading (loading point  $\leftrightarrow$  buffer storage, e.g. spindle)
3. Relocation within a magazine
4. Relocation between different magazines
5. Relocation between magazine and buffer storage
6. Relocation within buffer storage

The following variables from the TM block are used to monitor case 1, 3, 4, 5:

magCmd (area no. = TO unit, line = magazine number)

magCmdState  $\leftarrow$  "acknowledgment"

The following variables from the TMC block are used to monitor case 2, 6):

magCBCmd (area no. = TO unit)

magCBCmdState  $\leftarrow$  "acknowledgment"

### Load function

Prepares the specified real magazine for the specified channel for loading, i.e. traverses the magazine to the selected location for loading at the specified loading point/station (location\_number\_from, magazine\_number\_from) and inserts the tool.

When location\_number\_to = -1, an empty location for the tool specified by a T number is first sought in the specified magazine and the magazine then traversed. After execution of the PI, the number of the location found is listed in the TM area in component **magCMCmdPar2** for the **real** magazine of the channel.

With location\_number\_to = -2 and a valid magazine number, loading takes place into the currently queued magazine position of the specified magazine. After execution of the PI, the number of the location for tool loading is listed in the TM area in component **magCMCmdPar2** for the real magazine of the channel.

### Unload function

The tool specified by the tool number is unloaded at the specified loading point/station (location\_number\_to, magazine\_number\_to), i.e. the magazine is traversed to the position for unloading and the tool is then removed. The magazine location for the tool is marked as being free in the TP block. The tool can be specified either via a T number or by means of the location and magazine numbers. The value -1 is entered at unused specification points.

**Note**

Before and after this PI service, the MMCSEM PI service must be called up with the associated parameter WVar1 for this PI service. See PI service MMCSEM for more information.

Parameterization			
Signal	Type	Range of values	Significance
PIService	ANY	PI.TMMVTL	Make magazine location ready for loading, unload tool
Unit	INT	1 ... 10	TOA
WVar1	INT		T number
WVar2	INT		Location_number_from
WVar3	INT		Magazine_number_from
WVar4	INT		Location_number_to
WVar5	INT		Magazine_number_to

**PI service: TMPOSM****Function: Position magazine location or tool**

(dependent on parameter assignment):

A magazine location, which has either been specified directly or qualified via a tool located on it, is traversed to a specified position (e.g. in front of a load location) via the PI service.

The PI service makes a magazine location, which can be qualified in various ways, traverse in front of a specified load location. The load location must be specified in the PI parameters "location\_number\_from" and "magazine number\_from" (compulsory!).

The magazine location to be traversed can be qualified by the following:

- T number of the tool

The location where the tool is positioned traverses; the "tool identifier", "duplo number", "location\_number\_from" and "magazine number\_from" parameters are irrelevant (i.e. values "", "-0001", "-0001", "-0001").

or

- Tool identifier and duplo number

The location where the tool is positioned traverses; the "T number", "location\_number\_from" and "magazine number\_from" parameters are irrelevant (i.e. value "-0001" each).

or

- Direct specification of the location in the "location\_number\_from" and "magazine\_number\_from" parameters

The tool-qualifying parameters T number, "tool identifier" and "duplo number" are irrelevant (i.e. values "-0001", "", "-0001").

Parameterization			
Signal	Type	Range of values	Significance
PIService	ANY	PI.TMPOSM	Position magazine location or tool
Unit	INT	1 ... 10	TOA
Addr1	STRING	max. 32 characters	Tool identifier
WVar1	INT		T number
WVar2	INT		Duplo number
WVar3	INT		Location_number_from
WVar4	INT		Magazine_number_from
WVar5	INT		Location number_ref
WVar6	INT		Magazine number_ref

### PI service: TMPCIT

**Function: Set increment value for the workpiece counter**

Incrementing the workpiece counter of the spindle tool

Parameterization			
Signal	Type	Range of values	Significance
PIService	ANY	PI.TMPCIT	Set increment value for workpiece counter
Unit	INT	1 ... 10	TOA
WVar1	WORD	0 ... max.	Spindle number; corresponds to the type index in the location data with spindle location type of the buffer magazine in channel.000 = main spindle
WVar2	WORD	0 ... max.	Increment value; indicates the number of spindle revolutions after which the workpiece counter is incremented

### PI service: TMRASS

**Function: Reset the active status**

Resetting the active status on worn tools

This PI service is used to search for all tools with the tool status active and disabled. The active status is then canceled for these tools. Potentially appropriate times for this PI service are the negative edge of VDI signal "tool disable ineffective", an end of program, or a channel RESET. This PI service is intended mainly for the PLC, since it knows when the disabled tool is finally no longer to be used.

Parameterization			
Signal	Type	Range of values	Significance
PIService	ANY	PI. TMRASS	Reset active status
Unit	INT	1 ... 10	TO area

**PI service: TRESMO**

**Function: Reset monitoring values**

This PI service resets the monitoring values of the designated edges of the designated tools to their setpoint (initial) values.

This only relates to tools with active monitoring.

Compare the NC-Speech Command `RESETMON`.

Parameter assignment			
Signal	Type	Value range	Significance
PIService	ANY	PI. TRESMO	Reset monitoring values
Unit	INT	1 ... 10	TO area
WVar1	WORD	- max ... max	ToolNumber
			0: Applies to all tools
			> 0: Applies only to this tool
			< 0: Applies to all sister tools of the specified T No.
WVar2	WORD	0 ... max.	D number
			< 0: Monitoring of specified edge of specified tools is reset.
			0: Monitoring of all edges of specified tools is reset.
WVar3	WORD	0 ...15	Monitoring types
			Type of monitoring to be reset.
			This parameter is binary-coded.
			1: Tool-life monitoring is reset.
			2: Count monitoring is reset.
			4: Wear monitoring is reset.
8: Sum-offset monitoring is reset. Combinations of monitoring types can be reset by adding the values above.			
0: All active tool-monitoring functions (\$TC_TP9) are reset.			

**PI service: TSEARCH**

**Function: Complex search using search screen forms**

(dependent on parameter assignment):

The PI service allows you to search for tools with specified properties within a search domain (in one or more magazines starting and ending at a specific location). The specified properties refer only to data of the tools and their cutting edges.

The PI service is only available if tool management is activated.

You can define a search direction and the number of hits for the PI service (e.g. one tool for the next tool with matching properties or all tools with the specified properties).

As a result of this service, the user who made the call receives a list of the internal T numbers of the tools found.

The search criteria can only be specified as AND operation. If an application needs to define an OR operation for the search criteria, it must first execute a series of queries with AND criteria and then combine/evaluate the results of the individual queries.

To assign the parameters of the PI service, the properties of the required tools are first defined via variable service in the TF block. For this in the block TF in the operand masks (parMaskT..) the relevant

- comparison criteria (which tool data is to be compared?) are highlighted,
- comparison operator-data (parDataT..) filled with the corresponding comparison types (=, <, >, <=, >=, &&) to be executed
- and the comparison values are entered in the operand data.

The PI service is then initiated and, after its successful return, the variable service from the TF block is used to read out the number of hits in the variable resultNrOfTools and the result list in the variable resultToolNr (i.e. the list of internal T numbers of the tools found in the search - resultNrOfTools quantity).

The PI service must be encapsulated with a semaphore from its preparation until the successful return of the result. This is the only way to ensure exclusive access and the exclusive use of the TF block in conjunction with the TSEARCH PI service. The function number provided for the semaphore feature (PI service MMCSEM) is the function number for TSEARCH.

If the service is configured incorrectly, a malfunction occurs. In all other cases, it will return a result, even if no tools are found (resultNrOfTools = 0).

The search domain can be defined as follows in the parameters "MagNrFrom", "PlaceNrFrom", "MagNrTo", "PlaceNrTo":

MagNr From	PlaceNr From	MagNr To	PlaceNr To	Search area
WVar1	WVar2	WVar3	WVar4	
#M1	#P1	#M2	#P2	Locations starting at magazine #M1, location #P1 up to magazine #M2, location #P2 are searched
#M1	-1	#M1	-1	All locations in magazine #M1 - and no others - are searched
#M1	-1	-1	-1	All locations starting at magazine #M1 are searched
#M1	#P1	-1	-1	All locations starting at magazine #M1 and location #P1 are searched
#M1	#P1	#M1	-1	Locations in magazine #M1 starting at magazine #M1 and location #P1 in this magazine are searched
#M1	#P1	#M2	-1	Locations starting at magazine #M1, location #P1 up to magazine #M2, location #P2 are searched
#M1	-1	#M2	#P2	Locations starting at magazine #M1 up to magazine #M2, location #P2 are searched
#M1	-1	#M2	-1	Locations starting at magazine #M1 up to and including magazine #M2 are searched
-1	-1	-1	-1	All magazine locations are searched

For a symmetric search (see parameter "SearchDirection")

- the search area may stretch over only a single magazine (cases 2 and 5 from the above table). If another search domain is specified, the service will malfunction.
- a reference location must be entered in the parameters "MagNrRef" and "PlaceNrRef", with respect to which the symmetric search is done.

The reference location is a buffer location (a location from the magazine buffer, i.e. change position, gripper, etc.) or a load point (a location from the internal loading magazine). The search is executed symmetrically with reference to the magazine location in front of the specified reference location. A multiple assignment to the magazine being searched must be configured in the TPM block for the reference location. If this is not the case, a malfunction occurs. If the magazine location in front of the reference location is outside the search domain, the service responds as if it has not found a matching location.

**Note**

Before and after this PI service, the MMCSEM PI service must be called up with the associated parameter WVar1 for this PI service. See PI service MMCSEM for more information.

Parameter assignment			
Signal	Type	Value range	Significance
PIService	ANY	PI.TSEARC	Complex search using search screen forms
Unit	INT	1 - 10	TOA
WVar1	INT		MagNrFrom Magazine number of magazine from which search must begin
WVar2	INT		PlaceNrFrom Location number of location in magazine MagNrFrom, at which search must begin
WVar3	INT		MagNrTo Magazine number of magazine at which search must end
WVar4	INT		PlaceNrTo Location number of location in magazine MagNrTo, at which search must end
WVar5	INT		MagNrRef Magazine number of (internal) magazine, with reference to which the symmetrical search is to be performed. (this parameter is only relevant with a "symmetrical" search direction)
WVar6	INT		PlaceNrRef Location number of location in magazine MagNrRef, with reference to which the symmetrical search is to be performed. This parameter is only relevant with a "symmetrical" search direction
WVar7	INT	1, 2, 3	SearchDirection specifies the required search direction.
			1: Forwards from the first location of the search domain
			2: Backwards from the last location of the search domain
			3: symmetric to the real magazine location, which is before the location specified with Magazin-Number_ID and Location-Number_ID

Parameter assignment				
Signal	Type	Value range	Significance	
WVVar8	INT	0, 1, 2, 3	KindofSearch	
			0:	Find all tool with this property cutting edge specifically
			1:	Search for the first tool found with this property (cutting edge specifically)
			2:	Browse all cutting edges to find all tool with this property
			3:	Browse all tools to search for the first tool found with this property

### Call example

#### Program selection in channel 1 (main program and workpiece program)

Entry of PI for DB 16 and STR for DB 124 with the S7 SYMBOL editor:

Parameterization		
Symbol	Operand	Data type
PI	DB 16	DB 16
STR	DB 124	DB 124

```

DATA_BLOCK DB 126           //Unassigned user DB, as instance for FB 4
FB 4
BEGIN
END_DATA_BLOCK

DATA_BLOCK DB 124
  struct
    PName:      string[32]:= '_N_TEST_MPF ';
    Path:       string[32]:= '/_N_MPF_DIR/'; //Main program
    PName_WST:  string[32]:= '_N_ABC_MPF';
    Path_WST:   string[32]:= //Workpiece program
                '/_N_WCS_DIR/_N_ZYL_WPD';

  end_struct
BEGIN
END_DATA_BLOCK
Function FC "PICall" : VOID
  U  I 7.7; //Unassigned machine control panel key
  S  M 0.0; //Activate req.
  U  M 1.1; //Done completed message

```

```

R  M 0.0;          //Terminate job
U  I 7.6;          //Manual error acknowledgment
U  M 1.0;          //Error pending
R  M 0.0;          //Terminate job

CALL FB 4, DB 126 (
  Req :=           M0.0,
  PIService :=     PI.SELECT,
  Unit :=          1,                               // CHAN 1
  Addr1 :=         STR.Path,
  Addr2 :=         STR.PName,                       //Main-program selection
  //Addr1:=STR.Path_WST,
  //Addr2:=STR.PName_WST,                           //Workpiece-program selection
  Error :=         M1.0,
  Done :=          M1.1,
  State :=         MW2);

```

### 13.13.5 FB 5: GETGUD read GUD variable

#### Function

The PLC user program can read a GUD variable (GUD = Global User Data) from the NCK or channel area using the FB GETGUD.

The FB has multi-instance capability. The call is permitted only in cyclic program OB1. An assignment for all parameters with Req = 0 is also permitted in OB 100. Capital letters must be used for the names of GUD variables.

Every FB 5 call must be assigned a separate instance DB from the user area.

A job is started when **FB 5 is called** by means of a positive edge change at control input Req. This job includes the name of the GUD variable to be read in parameter "Addr" with data type "STRING". The pointer to the name of the GUD variables is assigned symbolically to the "Addr" parameter with <DataBlockName>.<VariableName>. Additional information about this variable is specified in parameters "Area", "Unit", "Index1" and "Index2" (see table of block parameters).

When parameter "CnvtToken" is activated, a variable pointer (token) can be generated for this GUD variable as an option. This pointer is generated via the NC-VAR selector for system variables of the NC. Only this method of generating pointers is available for GUD variables. Once a pointer has been generated for the GUD variable, then it is possible to read and write via FB 2 and FB 3 (GET, PUT) with reference to this variable pointer. This is the only method by which GUD variables can be read. When FB 2 or FB 3 is parameterized, only parameter Addr1 ... Addr8 need to be parameterized for this GUD variable pointer. GUD variable fields are an exception. Bei diesen Feldern ist zusätzlich Line1 ... Line8 mit dem Feldindex dieser Variablen zu parametrieren. The successful completion of the read process is displayed by the status parameter "Done"=TRUE.

The read process extends over several PLC cycles (generally 1 to 2).  
Any errors are displayed via the output parameters "Error" and "State".

---

**Note**

FB 5 can only write GUD variables if basic program parameter "NCKomm" has been set to "TRUE" (in OB 100: FB 1, DB 7; see "FB 1: RUN\_UP Basic program, start-up section (Page 974)").

---

### Declaration of the function

```
FUNCTION_BLOCK FB 5           //Server name
    KNOW_HOW_PROTECT
    VERSION: 3.0
VAR_INPUT
    Req :          BOOL ;
    Addr:          ANY ;    //Variables name string
    Area:          BYTE ;   //Area: NCK = 0, channel = 2
    Unit :         BYTE ;
    Index1:        INT ;    //Field index 1
    Index2:        INT ;    //Field index 2
    CnvtToken:     BOOL ;   //Conversion into 10-byte token
    VarToken:      ANY ;    //Struct with 10 bytes for the variable token
END_VAR

VAR_OUTPUT
    Error :        BOOL ;
    Done :         BOOL ;
    State :        WORD ;
END_VAR

VAR_IN_OUT
    RD:           ANY ;
END_VAR

BEGIN
END_FUNCTION_BLOCK
```

## Description of formal parameters

The table below lists all formal parameters of the GETGUD function.

Signal	Type	Type	Range of values	Remark	
Req	I	BOOL		Job start with positive signal edge	
Addr	I	ANY	[DBName].[VarName]	GUD variable name in a variable of data type STRING	
Area	I	BYTE		Area address:	
				0:	NCK variables
				2:	Channel variables
Unit	I	BYTE		NCK area: Unit:=1 Channel area: Channel no.	
Index1	I	INT		Field index 1 of variable Variable has the value 0 if no field index is used.	
Index2	I	INT		Field index 2 of variable Variable has the value 0 if no field index is used.	
CnvtToken	I	BOOL		Activate generation of a 10 byte variable token	
VarToken	I	ANY	[DBName].[VarName]	Address to a 10-byte token (see example)	
Error	Q	BOOL		Negative acknowledgment of job or execution of job impossible	
Done	Q	BOOL		Job successfully executed	
State	Q	WORD		See error identifiers	
RD	I/O	ANY	P#Mm.n BYTE x... P#DBnr.dbxm.n BYTE x	data to be read	

## Error identifiers

If it was not possible to execute a job, the failure is indicated by "logic 1" on status parameter error. The error cause is coded at the block output State:

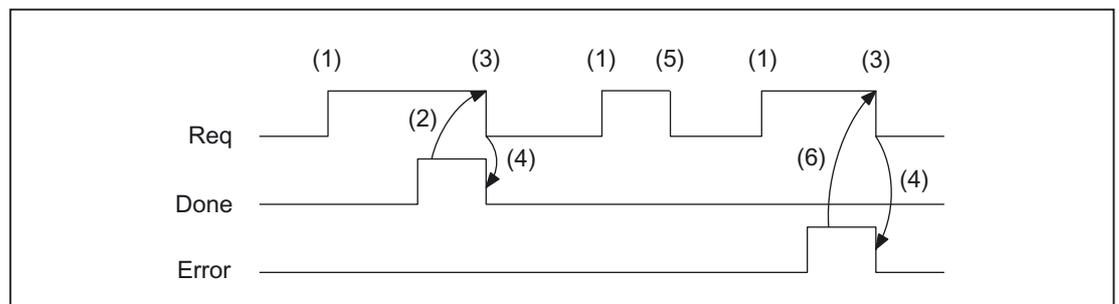
State		Significance	Note
WORD H	WORD L		
0	1	Access error	
0	2	Error in job	Incorrect compilation of Var. in a job
0	3	Negative acknowledgment, job not executable	Internal error, try: NC RESET
0	4	Data areas or datatypes do not tally	Check data to be read in RD
1	4	Insufficient local user memory available	read variable is longer than specified in RD

State		Significance	Note
WORD H	WORD L		
0	6	FIFO full	Job must be repeated, since queue is full
0	7	Option not set	BP parameter "NCKomm" is not set
0	8	Incorrect target area (SD)	RD may not be local data
0	9	Transmission occupied	Job must be repeated
0	10	Error in addressing	Unit contains value 0
0	11	Address of variable invalid	Address check (or variable name), area, unit
1 ... 8	13 (0x0d)	ANY data reference incorrect	String/NcVar data required has not been parameterized
0	15 (0x0f)	String more than 32 characters	GUD variable name too long

### Configuration steps

To be able to read a GUD variable, its name must be stored in a string variable. The data block with this string variable must be defined in the symbol table so that the "Addr" parameter can be assigned symbolically for FB GETGUD. A structure variable can be defined optionally in any data area of the PLC to receive the variable pointer (see specification in following example).

### Pulse diagram



- (1) Activation of function
- (2) Positive acknowledgment: variables have been written
- (3) Reset function activation after receipt of acknowledgment
- (4) Signal change by means of FB
- (5) Not permissible
- (6) Negative acknowledgment: Error has occurred, error code in the output parameter "State"

**Call example 1**

Read a GUD variable from channel 1 with the name "GUDVAR1" (type definition of the variables: INTEGER). The user-defined variable should be converted in a 10-byte variable pointer for the subsequent writing with the F3 (see also the table "Assignment of the datatypes" in "FB 2: Read GET NC variable (Page 982)").

**Call and parameterization of FB 5 with instance DB 111:**

```
// Data block for GUD variable
DATA_BLOCK DB_GUDVAR      //Assignment to symbol table

STRUCT
  GUDVar1 : STRING[32] := 'GUDVAR1';      //Name is defined by user
  GUDVar1Token :
  STRUCT
    SYNTAX_ID : BYTE ;
    area_and_unit : BYTE ;
    column : WORD ;
    line : WORD ;
    block type : BYTE ;
    NO. OF LINES : BYTE ;
    type : BYTE ;
    length : BYTE ;
  END_STRUCT;
END_STRUCT;

BEGIN
END_DATA_BLOCK

//Unassigned user DB, as instance for FB 5
DATA_BLOCK DB 111

      FB 5
BEGIN
END_DATA_BLOCK

//Unassigned user DB, as instance for FB 3
DATA_BLOCK DB 112

      FB 3
BEGIN
END_DATA_BLOCK

//A user-defined channel variable from channel 1 must be read
//with conversion into a variable pointer to allow subsequent
//writing of this variable.
```

```
Function FC "VariablenCall" : VOID
U   I 7.7;           //Unassigned machine control panel key
S   M 100.0;        //Activate req.
U   M 100.1;        //Done completed message
R   M 100.0;        //Terminate job
U   I 7.6;           //Manual error acknowledgment
U   M 102.0;        //Error pending
R   M 100.0;        //Terminate job

CALL FB 5, DB 111 (
    Req      := M 100.0,      //Starting edge for reading
    Addr     := DB_GUDVAR.GUDVar1,
    Area     := B#16#2,      //Channel variable
    Unit     := B#16#1,      //Channel 1
    Index1   := 0,           //No field index
    Index2   := 0,           //No field index
    CnvtToken := TRUE,       //Conversion into 10-byte token
    VarToken  := DB_GUDVAR.GUDVar1Token,
    Error     := M 102.0,
    Done      := M 100.1,
    State     := MW 104
    RD       := P#DB99.DBX0.0 DINT 1 // free memory area
);
```

After a successful FB-5 call the writing can be done via the returned address of the FB 5 parameter ("VarToken") with the help of FB3.

```
CALL FB 3, DB 112 (
    Req      := M 200.0,
    NumVar   := 1,           //Write 1 GUD variable
    Addr1    := DB_GUDVAR.GUDVar1Token,
    Error     := M 102.0,
    Done      := M 100.1,
    State     := MW 104
    SD1     := P#DB99.DBX0.0 DINT 1);
```

## Call example 2

Read a GUD variable from channel 1 with the name "GUD\_STRING" (type definition of the variables: STRING with length 30 bytes). The user-defined variable should be converted in a 10-byte variable pointer for subsequent writing with the FB 3.

## Call and parameterization of FB 5 with instance DB 111:

```
// Data block for GUD variable
DATA_BLOCK DB_GUDVAR      //Assignment to symbol table

STRUCT
  GUDVarS : STRING[32] := 'GUD_STRING';          //Name is defined by user
  GUDVarSToken :
  STRUCT
    SYNTAX_ID : BYTE ;
    area_and_unit : BYTE ;
    column : WORD ;
    line : WORD ;
    block type : BYTE ;
    NO. OF LINES : BYTE ;
    type : BYTE ;
    length : BYTE ;
  END_STRUCT;

  string_of_GUD : STRING[30];          // must at least be so long as
                                       // the definition of 'GUD_STRING'!
  new_name : STRING[30] := 'GUD_123';
END_STRUCT;

BEGIN
END_DATA_BLOCK

//Unassigned user DB, as instance for FB 5
DATA_BLOCK DB 111

      FB 5
BEGIN
END_DATA_BLOCK

//Unassigned user DB, as instance for FB 3
DATA_BLOCK DB 112

      FB 3
BEGIN
END_DATA_BLOCK
```

```
//A user-defined channel variable from channel 1 must be read
//with conversion into a variable pointer to allow subsequent
//writing of this variable.

Function FC "VariablenCall" : VOID
U   I 7.7;           //Unassigned machine control panel key
S   M 100.0;        //Activate req.
U   M 100.1;        //Done completed message
R   M 100.0;        //Terminate job
U   I 7.6;          //Manual error acknowledgment
U   M 102.0;        //Error pending
R   M 100.0;        //Terminate job

CALL FB 5, DB 111 (
    Req       := M 100.0,      //Starting edge for reading
    Addr      := DB_GUDVAR.GUDVarS,
    Area      := B#16#2,      //Channel variable
    Unit      := B#16#1,      //Channel 1
    Index1    := 0,           //No field index
    Index2    := 0,           //No field index
    CnvtToken := TRUE,        //Conversion into 10-byte token
    VarToken  := DB_GUDVAR.GUDVar1Token,
    Error     := M 102.0,
    Done      := M 100.1,
    State     := MW 104
    RD       := DB_GUDVAR.string_of_GUD);
```

After a successful FB-5 call the writing can be done via the returned address of the FB 5 parameter ("VarToken") with the help of FB3.

```
CALL FB 3, DB 112 (
    Req       := M 200.0,
    NumVar    := 1,           //Write 1 GUD variable
    Addr1     := DB_GUDVAR.GUDVar1Token,
    Error     := M 102.0,
    Done      := M 100.1,
    State     := MW 104
    SD1      := DB_GUDVAR.new_name);
```

### 13.13.6 FB 7: PI\_SERV2 PI services

#### Function

A detailed description of the FB 7 is contained in the description of FB 4.

The FB is multi-instance-capable. The call is permitted only in cyclic program OB1. An assignment for all parameters with Req = 0 is also permitted in OB 100.

The only difference to FB 4 is the number of WVar1 and subsequent parameters. These are defined in FB 7 from WVar1 to WVar16 (FB 4 in the VAR\_INPUT from WVar1 to WVar10). All the other parameters are identical to FB 4.

This PI server can be used for all PI services that have been implemented with FB 4. In addition, the PI services listed below can only be executed with FB 7.

#### Declaration of the function

```
FUNCTION_BLOCK FB 7
Var_INPUT
  Req :          BOOL ;
  PIService :   ANY ;
  Unit :        INT ;
  Addr1 :       ANY ;
  Addr2 :       ANY ;
  Addr3 :       ANY ;
  Addr4 :       ANY ;
  WVar1 :       WORD ;
  WVar2 :       WORD ;
  WVar3 :       WORD ;
  WVar4 :       WORD ;
  WVar5 :       WORD ;
  WVar6 :       WORD ;
  WVar7 :       WORD ;
  WVar8 :       WORD ;
  WVar9 :       WORD ;
  WVar10 :      WORD ;
  WVar11 :      WORD ;
  WVar12 :      WORD ;
  WVar13 :      WORD ;
  WVar14 :      WORD ;
  WVar15 :      WORD ;
  WVar16 :      WORD ;
END_VAR
VAR_OUTPUT
  Error :       BOOL ;
  Done :        BOOL ;
```

```

State :          WORD ;
END_VAR

```

### Description of formal parameters

The following table shows all formal parameters of the function PI\_SERV2.

Signal	Type	Type	Range of values	Remark
Req	I	BOOL		Job request
PIService	I	ANY	[DBName].[VarName] Standard is: "PI".[VarName]	PI service description
Unit	I	INT	1...	Area number
Addr1 to Addr4	I	ANY	[DBName].[VarName]	Reference to strings specification according to selected PI service
WVar1 to WVar16	I	WORD	1...	Integer or word variables. Specification according to selected PI service,
Error	Q	BOOL		Negative acknowledgment of job or execution of job impossible
Done	Q	BOOL		Job successfully executed
State	Q	WORD		See error identifiers

### Overview: Additional PI services supplementary to the FB 4 PI services

The following section provides an overview of the PI services that can be started from the PLC. The significance and application of the general FB 7 input variables (Unit, Addr ..., WVar ...) depend on the individual PI service concerned.

PI service	Function	Available in
TMFPBP	Empty location search	SINUMERIK 840D

**PI service:TMFPBP**

**Function: Empty location search**

(dependent on parameter assignment)

This service searches the magazine(s) named in the relevant parameters for an empty location, which meets the specified criteria such as tool size and location type. The result of the empty location search can be fetched from variables magCMCmdPar1 (magazine number) and magCMCmdPar2 (location number) in block TMC when the service has functioned correctly. As the PI service stores a result in variables magCMCmdPar1 and magCMCmdPar2, the service must be protected by the semaphore mechanism (PI service MMCSEM) with the function number for \_N\_TMFDP in cases where several control units or PLCs are operating on one NC. The search area can be predefined in the following way by setting parameters "MagazineNumber\_From", "LocationNumber\_From", "MagazineNumber\_To", "LocationNumber\_To":

Magazine Number _From	Location Number _From	Magazine Number _To	Location Number _To	Search area
WVar1	WVar2	WVar3	WVar4	
#M1	#P1	#M1	#P1	Only location #P1 in magazine #M1 is checked
#M1	#P1	#M2	#P2	Locations starting at magazine #M1, location #P1 up to magazine #M2, location #P2 are searched
#M1	-1	#M1	-1	All locations in magazine #M1 - and no others - are searched
#M1	-1	-1	-1	All locations starting at magazine #M1 are searched
#M1	#P1	-1	-1	All locations starting at magazine #M1 and location #P1 are searched
#M1	#P1	#M1	-1	Locations in magazine #M1 starting at magazine #M1 and location #P1 in this magazine are searched
#M1	#P1	#M2	-1	Locations starting at magazine #M1, location #P1 up to magazine #M2, location #P2 are searched
#M1	-1	#M2	#P2	Locations starting at magazine #M1 up to magazine #M2, location #P2 are searched
#M1	-1	#M2	-1	Locations starting at magazine #M1 up to and including magazine #M2 are searched
-1	-1	-1	-1	All magazine locations are searched

**Note**

Before and after this PI service, the MMCSEM PI service must be called up with the associated parameter WVar1 for this PI service. See PI service MMCSEM for more information.

Parameterization			
Signal	Type	Range of values	Significance
PIService	ANY	PI.TMFPBP	Empty location search
Unit	INT	1 ... 10	TOA
WVar1	INT		MagazinNumber_From Magazine number of magazine, from which search must begin
WVar2	INT		LocationNumber_From: Location number of location in magazine MagazineNumber_From, at which search must begin
WVar3	INT		MagazineNumber_To: Magazine number of magazine, at which search must end
WVar4	INT		LocationNumber_To: Location number of location in magazine MagazineNumber_To, at which search must end
WVar5	INT		MagazineNumber_Ref:
WVar6	INT		LocationNumber_Ref:
WVar7	INT	0, 1 ... 7	Number of required half locations to left
WVar8	INT	0, 1 ... 7	Number of required half locations to right
WVar9	INT	0, 1 ... 7	Number of required half locations in upward direction
WVar10	INT	0, 1 ... 7	Number of required half locations in downward direction
WVar11	INT		Number of required location type
WVar12	INT	0 ... 4	Specifies the required search direction
			0: Empty location search strategy is set in \$TC_MAMP2
			1: Upwards
			2: Down
			3: Symmetrical

### 13.13.7 FB 9: MtoN Control unit switchover

#### Function

This block allows switchover between several **control units** (HMI operator panel fronts and/or MCP machine control panels), which are connected to one or more NCU control modules via a bus system.

#### References:

Function Manual, Extended Functions; Several Control Panels on Multiple NCUs, Decentralized Systems (B3)

The **Interface** between the individual control units and the NCU (PLC) is the M : N interface in the data block DB 19. The FB 9 works with the signals of these interfaces.

Apart from initialization, sign-of-life monitoring and error routines, the following **basic functions** are also performed by the block for control unit switchover:

Tabulated overview of functions:	
Basic function	Significance
HMI queuing	HMI wants to go online with an NCU
HMI coming	HMI is connecting to an NCU
HMI going	HMI is disconnecting from an NCU
Forced break	HMI must break connection with an NCU
Operating focus changeover to server mode	Change operating focus from one NCU to the other
Active/passive operating mode:	Operator control and monitoring/monitoring only
MCP switchover	As an option, MCP can be switched over with the HMI

#### Brief description of a few important functions

Active/passive operating mode:

An online HMI can operate in two different modes:

Active mode: Operator can control and monitor

Passive mode: Operator can monitor (HMI header only)

After switchover to an NCU, this initially requests active operating mode in the PLC of the online NCU. If two control units are linked online simultaneously to an NCU, one of the two is always in active mode and the other in passive mode. The operator can request active mode on the passive HMI at the press of a button.

#### MCP switchover

As an option, an MCP assigned to the HMI can be switched over at the same time. To achieve this, the MCP address must be entered in the "mstt\_adress" parameter of the NETNAMES.INI configuration file on the HMI and "MCPEnable" must be set to TRUE. The MCP of the passive HMI is deactivated so that there is only ever one active MCP on an NCU at one time.

## Boot condition

To prevent the previously selected MCP being reactivated when the NCU is restarted, input parameters MCP1BusAdr = **255** (address of 1st MCP) and "MCP1STOP" =**TRUE** (deactivate 1st MCP) must be set when FB1 is called in OB100.

## Approvals

When one MCP is switched over to another, any active feed or axis enables will be retained.

---

### Note

Keys actuated at the moment of switchover remain operative until the new MCP is activated (by the HMI, which is subsequently activated). The override settings for feedrate and spindle also remain valid. To deactivate actuated keys, the input image of the machine control signals must be switched to non-actuated signal level on a falling edge of DB10.DBX104.0. The override settings should remain unchanged. Measures for deactivating keys must be implemented in the PLC user program (see example "Override Changeover").

The call is permitted only in cyclic program OB1.

---

## Declaration of the function

```

FUNCTION_BLOCK FB 9
VAR_INPUT
    Ack :          BOOL ;           //Acknowledge interrupts
    OPMixedMode:  BOOL:= FALSE;    //Mixed operation with non-M-to-N-enabled
                                         OP //deactivated
    ActivEnable:  BOOL:= TRUE;     // Not supported
    MCPEnable :   BOOL:= TRUE;     // Activate MCP switchover
END_VAR
VAR_OUTPUT
    Alarm1 :      BOOL ;           // Interrupt: Error in HMI bus address, bus
                                         type!
    Alarm2 :      BOOL ;           // Interrupt: No confirmation HMI 1
                                         offline!
    Alarm3 :      BOOL ;           // Interrupt: HMI 1 is not going offline!
    Alarm4 :      BOOL ;           // Interrupt: No confirmation HMI 2
                                         offline!
    Alarm5 :      BOOL ;           // Interrupt: HMI 2 is not going offline!
    Alarm6 :      BOOL ;           // Interrupt: Queuing HMI is not going
                                         online!
    Report :      BOOL ;           // Message: Sign-of-life monitoring
    ErrorMMC :    BOOL ;           // Error detection HMI
END_VAR

```

## Description of formal parameters

The table below lists all formal parameters of the M:N function.

Formal parameters of M:N function				
Signal	Type	Type	Remark	
Ack	I	BOOL	Acknowledge interrupts	
OPMixedMode	I	BOOL	Mixed operation deactivated for OP without M:N capability	
ActivEnable	I	BOOL	Function is not supported. Control panel switchover Interlocking via MMCx_SHIFT_LOCK in DB 19	
MCPEnable	I	BOOL	Activate MCP switchover:	
			<b>TRUE:</b>	MCP is switched over with operator panel.
			<b>FALSE:</b>	MCP is not switched over with operator panel. This can be used to permanently link an MCP. See also MMCx_MSTT_SHIFT_LOCK in DB 19.
Alarm1	Q	BOOL	Interrupt: Error in HMI bus address, bus type!	
Alarm2	Q	BOOL	Interrupt: No confirmation HMI 1 offline!	
Alarm3	Q	BOOL	Interrupt: HMI 1 is not going offline!	
Alarm4	Q	BOOL	Interrupt: No confirmation HMI 2 offline!	
Alarm5	Q	BOOL	Interrupt: HMI 2 is not going offline!	
Alarm6	Q	BOOL	Interrupt: Queuing HMI is not going online!	
Report	Q	BOOL	Message: Sign-of-life monitoring HMI	
ErrorMMC	Q	BOOL	Error detection HMI	

### Note

The block must be called by the user program. The user must provide an instance DB with any number for this purpose. The call is multi-instance-capable.

## Example of a call for FB 9

```
CALL FB 9, DB 109 (
  Ack           := Error_ack,           //e.g. MCP RESET
  OPMixedMode   := FALSE,
  ActivEnable   := TRUE,
  MCPEnable     := TRUE);              // Enable for MCP switchover
```

### Note

Input parameter "MCPEnable" must be set to TRUE to enable the MCP switchover. The default value of these parameters is set in this way and need not be specially assigned when the function is called.

## Interrupts, errors

The output parameters "Alarm1" to "Alarm6" and "Report" exist as information in the PLC and are output in the event of M:N errors visualized on the HMI by the appearance of alarms 410900 - 410906.

If execution of an HMI function has failed (and an appropriate error message cannot be displayed), status parameter "ErrorMMC" is set to 'logical 1' (e.g. booting error, when no connection is made).

## Call example for FB 1 (Call in OB 100)

```
CALL "RUN_UP", "gp_par" (
    MCPNum           := 1,
    MCP1In           := P#I 0.0,
    MCP1Out          := P#Q 0.0,
    MCP1StatSend     := P#Q 8.0,
    MCP1StatRec      := P#Q 12.0,
    MCP1BusAdr       := 255,           // Address of 1st MCP
    MCP1Timeout      := S5T#700MS,
    MCP1Cycl         := S5T#200MS,
    MCP1Stop         := TRUE,         // MCP switched off
    NCCyclTimeout    := S5T#200MS,
    NCRunupTimeout   := S5T#50S);
```

## Example Override switchover

```
// Auxiliary flags used M100.0, M100.1, M100.2, M100.3
//Edge positive of MCP1Ready must check the override
//and measures for activation
// Initiate MCP block
//This example applies to the feedrate override.
//The interface and input bytes must be exchanged for spindle override.
U   DB10.DBX 104.0;           //MCP1Ready
EN  M   100.0;               //Edge trigger flag 1
JCN smth1;
S   M   100.2;               //Set auxiliary flag 1
R   M   100.3;               //Reset auxiliary flag 2
```

```

// Save override
    L DB21.DBB 4;           //Feed override interface
    T EB 28;               //Buffer storage (freely input
                          // or flag byte)

wei1:
U   M   100.2;           //Switchover takes place
O   DB10.DBX 104.0;     //MCP1Ready
JCN smth2;
U   DB10.DBX 104.0;     //MCP1Ready
FP  M   100.1;         //Edge trigger flag 2
JC  smth2;
U   M   100.2;           //Switchover takes place
R   M   100.2;         //Reset auxiliary flag 1
JC  smth2;
U   M   100.3;         //Comparison has taken place
SPB MCP;                //Call MCP program
// Route the stored override to the interface of the switched MCP
// until the override values match
    L EB 28;               //Buffer storage open
    T DB21.DBB 4;         //Route override interface
    L EB 3;               //Override input byte for feed
    <>i;                   //Match?
JC  smth2;               //No, jump
S   M   100.3;         //Yes, set auxiliary flag 2
// When override values match, call the MCP program again
MCP: CALL "MCP_IFM" (    //FC 19
    BAGNo      := B#16#1,
    ChanNo     := B#16#1,
    SpindleIFNo := B#16#0,
    FeedHold   := M 101.0,
    SpindleHold := M 101.1);
wei2: NOP                0;

```

### 13.13.8 FB 10: Safety relay (SI relay)

#### Function

The SPL block "Safety relay" for "Safety Integrated" is the PLC equivalent of the NC function of the same name. The standard SPL "Safety relay" block is designed to support the implementation of an emergency stop function with safe programmable logic. However, it can also be used to implement other similar safety functions, e.g. control of a protective door. The function contains 3 input parameters (In1, In2, In3). On switchover of one of these parameters to the value 0, the output Out0 is deactivated without delay and outputs Out1, Out2 and Out3 deactivated via the parameterized timer values (parameters TimeValue1, TimeValue2, TimeValue3). The outputs are activated again without delay, if inputs In1 to In3 take the value 1 and a positive edge change is detected at one of the acknowledgement inputs Ack1, Ack2. To bring the outputs to their basic setting (values = 0) after booting, the parameter "FirstRun" must be configured as follows. The parameter "FirstRun" must be switched to the value TRUE via a retentive data (memory bit, bit in data block) on the first run after control booting. This data can be preset, e.g. in OB 100. The parameter is reset to FALSE when FB 10 is executed for the first time. Separate data must be used for parameter "FirstRun" for each call with its own instance.

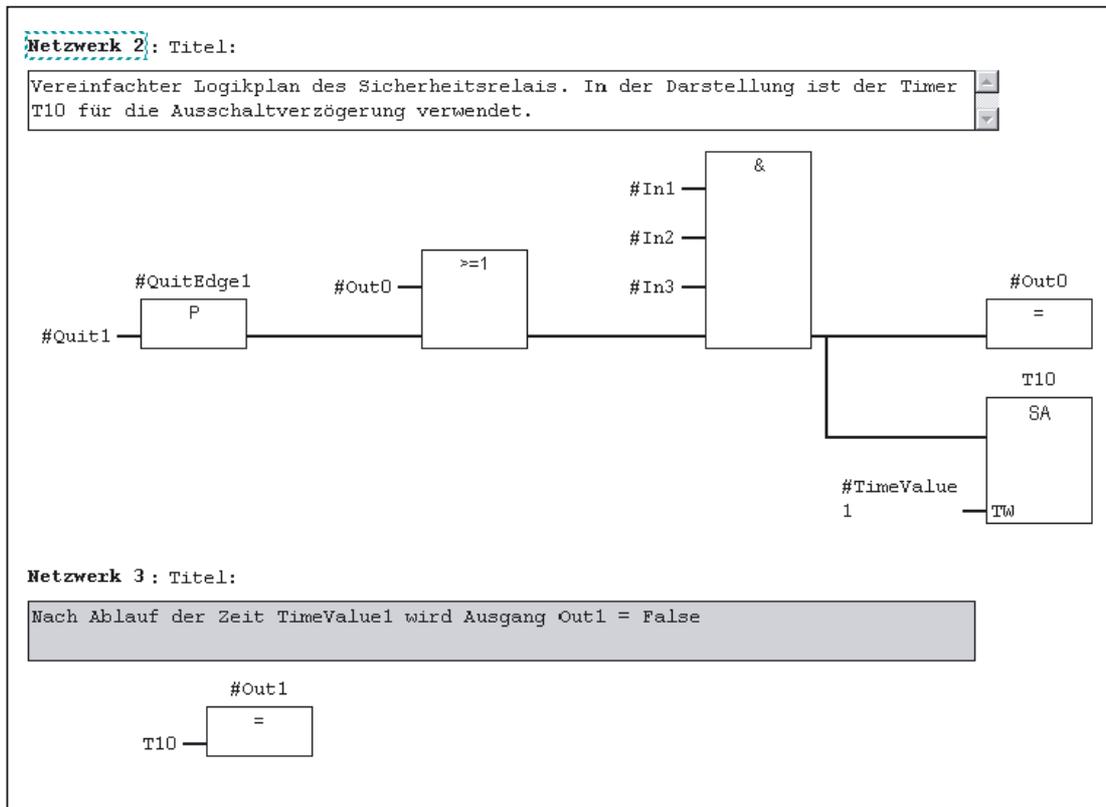
The corresponding NCK-SPL-component is described in:

**References:**

Function Manual Safety Integrated

#### Simplified block diagram in CSF

The figure below shows only one acknowledgment input Ack1 and one delayed deactivation output Out1. The circuit for Ack2 and the other delayed outputs are identical. The parameter FirstRun is also missing in the function diagram. The mode of operation is described above.



### Declaration of the function

```

FUNCTION_BLOCK FB 10
VAR_INPUT
    In1 : BOOL      := TRUE;           //Input 1
    In2 : BOOL      := TRUE;           //Input 2
    In3 : BOOL      := TRUE;           //Input 3
    Ackn1 :         : BOOL ;           //Ack 1 signal
    Ackn2 :         : BOOL;            //Ack 2 signal
    TimeValue1 :    TIME := T#0ms ;     //TimeValue for output 1
    TimeValue2 :    TIME := T#0ms ;     //TimeValue for output 2
    TimeValue3 :    TIME := T#0ms ;     //TimeValue for output 3
END_VAR
VAR_OUTPUT
    Out0 : BOOL ;                       //Output without delay
    Out1 : BOOL ;                       //Delayed output to false by timer 1
    Out2 : BOOL ;                       //Delayed output to false by timer 2
    Out3 : BOOL ;                       //Delayed output to false by timer 3
END_VAR
VAR_INOUT
    FirstRun : BOOL ;                  //TRUE by user after initial start of SPL
END_VAR
    
```

## Description of formal parameters

The following table shows all formal parameters of the SI relay function:

Formal parameters of SI relay function			
Signal	Type	Type	Remark
In1	I	BOOL	Input 1
In2	I	BOOL	Input 2
In3	I	BOOL	Input 3
Ackn1	I	BOOL	Acknowledge input 1
Ackn2	I	BOOL	Acknowledge input 2
TimeValue1	I	TIME	Time value 1 for OFF delay
TimeValue2	I	TIME	Time value 2 for OFF delay
TimeValue3	I	TIME	Time value 3 for OFF delay
Out0	Q	BOOL	Output, instantaneous (no delay)
Out1	Q	BOOL	Output, delayed by TimeValue1
Out2	Q	BOOL	Output, delayed by TimeValue2
Out3	Q	BOOL	Output, delayed by TimeValue3
FirstRun	I/O	BOOL	Activation of initial state

### Note

The block must be called cyclically by the user program once following SPL program startup. The user must provide an instance DB with any number for this purpose. The call is multi-instance-capable.

## 13.13.9 FB 11: Brake test

### Function

The braking operation check should be used for all axes, which must be prevented from moving in an uncontrolled manner by a holding brake. This check function is primarily intended for the so-called "vertical axes".

The machine manufacturer can use his PLC user program to close the brake at a suitable moment in time (guide value every 8 hours, similar to the SI test stop) and allow the drive to produce an additional torque/additional force equivalent to the weight of the axis. In error-free operation, the brake can produce the necessary braking torque/braking force and keep the axis at a virtual standstill. When an error occurs, the actual position value exits the parameterizable monitoring window. In this instance, the position controller prevents the axis from sagging and negatively acknowledges the mechanical brake test.

The necessary parameterization of NC and Drive is described in:

**References:**

Function Manual Safety Integrated

The brake test must always be started when the axis is at a standstill. For the entire duration of the brake test, the enable signals of the parameterized axis must be set to enable (e.g. the controller inhibit, feed enable signals). Furthermore, the signal at the axis/spindle DB31, ... .DBX28.7 (PLC-controlled axis) is to be set to status 1 by the user program for the complete duration of the test.

Before activating the signal DB31, ... .DBX28.7 (PLC-controlled axis) the axis is to be switched as "neutral axis", e.g. DB31, ... .DBX8.0 - 8.3 (assign NC axis to channel) is to be set to channel 0 as well as DB31, ... .DBX8.4 (activation signal when using this byte) is to be set.

The return message:

- about the current status can be queried in DB31, ... DBB68.
- the Nc via the signal DB31, ... .DBX63.1 (PLC controls axis) is to be awaited before the block is started. The direction in which the drive must produce its torque/force is specified by the PLC in the form of a "traversing motion" (e.g. via FC 18).

The axis must be able to reach the destination of this movement without risk of collision if the brake is unable to produce the necessary torque/force.

**Note**

**Instructions for FC 18**

If FC18 is called for the same axis in the remainder of the user program, the calls must be mutually interlocked. For example, this can be achieved via a common call of this function with an interlocked common data interface for the FC 18 parameters. A second option is to call the FC18 repeatedly, in which case the inactive FC18 will not be processed by the program. A multiple-use interlock must be provided.

The brake test is divided into the following steps:

Brake test sequence		
Step	Expected feedback	Monitoring time value
Start brake test	DBX 71.0 = 1	TV_BTactiv
Close brake	Bclosed = 1	TV_Bclose
Output traversing command	DBX 64.6 Or DBX 64.7	TV_FeedCommand
Issue test travel command	DBX 62.5 = 1	TV_FXSreached
Wait for the holding time	DBX 62.5 = 1	TV_FXShold
Deselect brake test/ open brake	DBX 71.0 = 0	TV_BTactiv
Output test ok		

## Declaration of the function

```

Function_BLOCK FB 11
VAR_INPUT
    Start          : BOOL ;           //Start of brake test
    Ackn           : BOOL ;           //Acknowledge error
    Bclosed        : BOOL ;           //Brake closed input (single channel - PLC)
    Axis           : INT;             //Testing axis no.
    TimerNo        : TIMER ;          //Timer from user
    TV_BTactiv     : S5TIME ;         //TimeValue -> brake test active
    TV_Bclose      : S5TIM;           //TimeValue -> close brake
    TV_FeedCommand : S5TIME ;         //TimeValue -> force FeedCommand
    TV_FXSreached  : S5TIME ;         //TimeValue -> fixed stop reached
    TV_FXShold     : S5TIME ;         //TimeValue -> test brake
END_VAR
VAR_OUTPUT
    CloseBrake     : BOOL ;           //Signal close brake
    MoveAxis       : BOOL ;           //Do move axis
    Done           : BOOL ;
    Error          : BOOL ;
    State          : BYTE ;           //Error byte
END_VAR

```

## Description of formal parameters

The following table lists all of the formal parameters of the brake test function

Formal parameters of brake test function			
Signal	Type	Type	Remark
Start	I	BOOL	Starts the brake test
Ack	I	BOOL	Acknowledge fault
Bclosed	I	BOOL	Checkback input whether Close Brake is activated (single-channel - PLC)
Axis	I	INT	<b>Axis number of axis to be tested</b>
TimerNo	I	TIMER	Timer from user program
TV_BTactiv	I	S5TIME	Monitoring time value → brake test active, checking of axis signal DBX 71.0
TV_Bclose	I	S5TIME	Monitoring time value → close brake Check of input signal Bclosed after output CloseBrake has been set.
TV_FeedCommand	I	S5TIME	Monitoring time value → Travel command given Check travel command after MoveAxis has been set
TV_FXSreched	I	S5TIME	Monitoring time value → fixed stop reached
TV_FXShold	I	S5TIME	Monitoring time value → test brake
CloseBrake	Q	BOOL	Request, close brake

Formal parameters of brake test function			
Signal	Type	Type	Remark
MoveAxis	Q	BOOL	Request, initiate traversing motion
Done	Q	BOOL	Test successfully completed
Error	Q	BOOL	Error has occurred
State	Q	BYTE	Error status

### Fault IDs

State	Significance
0	No error
1	Start conditions not fulfilled, e.g. the axis is not in closed-loop control/brake closed/axis inhibited
2	No NC checkback in "Brake test active" signal on selection of brake test
3	No "Brake applied" checkback by input signal Bclosed
4	No travel command output (e.g. axis motion has not been started)
5	Fixed end stop will not be reached → axis RESET was initiated.
6	Traversing inhibit/Approach too slow → fixed stop cannot be reached. TV FXSreached monitoring timeout
7	Brake is not holding at all (the end position is reached)/approach speed is too high
8	Brake opens during the holding time
9	Error when deselecting the brake test
10	Internal error
11	"PLC-controlled axis" signal not enabled in the user program

### Note

The block must be called by the user program. The user must provide an instance DB with any number for this purpose. The call is multi-instance-capable.

### Example of a call for FB 11

```

AN      M      111.1;      //Request to close brake, Z axis of FB
=       A      85.0;      //Brake control, Z axis
OPEN   Axis3";      //Brake test, Z axis
O      I      73.0;      //Brake test trigger, Z axis
O      M      110.7;      //Brake test running
FP     M      110.0;
UN     M      111.4;      //Error has occurred
S      M      110.7;      //Brake test running
S      M      110.6;      //Next step
JCN    m001
L      DBB     68;
AW     W#16#F;
T      MB     115;      //flag channel state
L      B#16#10
T      DBB     8;      //Request neutral axis
m001:  U      DBX     68.6;      //Checkback signal, axis is neutral
        U      M      110.6;
        FP     M      110.1;
        R      M      110.6;
        S      M      110.5;      //Next step
        S      DBX     28.7;      //Request PLC-monitored axis

        U      DBX     63.1;      //Checkback signal, axis monitored by PLC
        U      M      110.5;
        FP     M      110.2;
        R      M      110.5;
        S      M      111.0;      //Start brake test for FB

CALL FB 11, DB 211 (//Brake test block
      Start      :=M      111.0,      //Start brake test
      Ackn       := I      3.7,      //Acknowledge error with RESET key
      Bclosed    := I      54.0,      //Return message close brakes
                                          //controlled
      Axis       := 3,      //Axis number of axis to be tested
                                          //Z axis
      TimerNo    := T      110,      //Timer number
      TV_BTactiv := S5T#200MS,      //Monitoring time value:
                                          //Brake test active DBX71.0
      TV_Bclose  := S5T#1S,      //Monitoring time value:
                                          //Brake closed
      TV_FeedCommand := S5T#1S,      //Monitoring time value:
                                          //Traversing command output

```

```

TV_FXSreache      := S5T#1S,          //Monitoring time value:
                                     //Fixed stop reached
TV_FXShold        := S5T#2S,          //Monitoring time value:
                                     //Brake test time
CloseBrake        :=M   111.1,        //Request to close brake
MoveAxis          :=M   111.2,        Initiate //Request traversing motion //
Done              :=M   111.3,        //Test successfully completed
Error             :=M   111.4,        //Error has occurred
State             := MB  112);        //Error status

OPEN              "Axis3";           //Brake test, Z axis

U   M   111.2;           //Moveaxis
FP  M   111.5;           //FC18 Start
S   M   111.7;           //Start FC18

O   M   111.3;           //Test successfully completed
O   M   111.4;           //Error has occurred
FP  M   110.3;
R   DBX 28.7;           //Request, PLC-monitored axis

UN  DBX 63.1;           //Checkback signal, axis monitored by PLC
U   M   111.0;           //Start brake test for FB
U   M   110.7;           //Brake test running
FP  M   110.4;
R   M   111.0;           //Start brake test for FB
R   M   110.7;           //Brake test running

//optional begin
JCN  m002:
L   MB  115;           //old channel status
OW   W#16#10;
T   DBB 8;           //Request channel axis
m002:  NOP  0;
//optional end

CALL "SpinCtrl" (//Traverse Z axis
Start      :=M   111.2,          //Start traversing motion
Stop       := FALSE,
Funct      := B#16#5,           //Mode: Axis mode
Mode       := B#16#1,           //Procedure: Incremental
AxisNo     := 3,                //Axis number of axis to be traversed
                                     //axis Z-axis
Pos        := -5.000000e+000,    //Traversing distance: Minus 5 mm
FRate      := 1.000000e+003,     //Feedrate: 1000 mm/min

```

```

        InPos      :=M      113.0,      //Position reached
        Error      :=M      113.1,      //Error has occurred
        State      := MB    114);      //Error status

OPEN          "Axis3"; //Brake test, Z axis
U      M      113.0; //Position reached
O      M      113.1; //Error has occurred
FP     M      113.2;
R      M      111.7; //Start FC18

```

### 13.13.10 FB 29: Signal recorder and data trigger diagnostics

#### Function

##### Signal recorder

The diagnostics FB allows various diagnostic routines to be performed on the PLC user program. A diagnostic routine logs signal states and signal changes. In this diagnostic routine, function number 1 is assigned to the "Func" parameter. Up to 8 signals of the parameters "Signal\_1" to "Signal\_8" are recorded in a ring buffer each time one of the signals changes. The current information of parameters "Var1" as BYTE value, and "Var2" and "Var3" as INTEGER values are also stored in the ring buffer.

The number of past OB 1 cycles is also stored in the buffer as additional information. This information enables the graphical evaluation of signals and values in OB 1 cycle grid. The first time the diagnostics FB is called in a new PLC cycle, the "NewCycle" parameter must be set to TRUE. If the diagnostics FB is called several times in the same OB 1 cycle, the "NewCycle" parameter must be set to FALSE for the second and subsequent calls. This prevents a new number of OB 1 cycles from being calculated.

The ring buffer, specified by the user, must have an ARRAY structure specified as in the source code. The array can have any number of elements. A size of 250 elements is recommended. The "ClearBuf" parameter is used to clear the ring buffer and set the BufAddr pointer (I/O parameter) to the start. The instance DB related to the FB is a DB from the user area and is to be transferred to the FB Diagnostics with the parameter "BufDB".

##### Data trigger

The data trigger function is intended to allow triggering on specific values (or bits) at any permissible memory cell. The cell to be triggered is "rounded" with a bit mask ("AndMask" parameter) before the "TestVal" parameter is compared in the diagnostic block.

**Note**

The source code for the function is available in the source container of the basic-program library under the name "Diagnose.awl". The instance DB and the ring buffer DB are also defined in this source block. The function call is also described in the function. The DB numbers and the call must be modified.

---

**Declaration of the function**

```
FUNCTION_BLOCK FB 29
VAR_INPUT
Func          : INT ;           //Function number: 0 = No function,
                                   //1 = Signal recorder, 2 = Data trigger
Signal_1      : BOOL ;         //Start of brake test
Signal_2      : BOOL ;
Signal_3      : BOOL ;
Signal_4      : BOOL ;
Signal_5      : BOOL ;
Signal_6      : BOOL ;
Signal_7      : BOOL ;
Signal_8      : BOOL ;
NewCycle      : BOOL ;
Var1          : BYTE ;
Var2          : INT;
Var3          : INT;
BufDB         : INT;
ClearBuf      : BOOL ;
DataAdr       : POINTER;       //Area pointer to testing word
TestVal       : WORD ;         //Value for triggering
AndMask       : WORD ;         //AND mask to the testing word
END_VAR
VAR_OUTPUT
TestIsTrue    : BOOL ;
END_VAR
VAR_IN_OUT
BufAddr       : INT;
END_VAR
```

## Structure for ring buffer

```

TITLE =
//Ring buffer DB for FB 29

VERSION : 1.0

STRUCT
  Field: ARRAY [0 .. 249 ] OF STRUCT //can be any size of this struct

  Cycle : INT ; //Delta cycle to last storage in buffer
  Signal_1 : BOOL ; //Signal names same as FB 29
  Signal_2 : BOOL ;
  Signal_3 : BOOL ;
  Signal_4 : BOOL ;
  Signal_5 : BOOL ;
  Signal_6 : BOOL ;
  Signal_7 : BOOL ;
  Signal_8 : BOOL ;
  Var1 : BYTE ;
  Var2 : WORD ;
  Var3 : WORD ;
END_STRUCT;
END_STRUCT;
BEGIN
END_DATA_BLOCK

```

## Description of formal parameters

The table below lists all formal parameters of the Diagnostics function:

Formal parameters of diagnostics function				
Signal	Type	Type	Value range	Remark
Func	I	INT	0, 1, 2	Function
				0: Switch off
				1: Signal recorder
				2: Data trigger
Parameters for function 1				
Signal_1 to Signal_8	I	BOOL		Bit signals checked for change
NewCycle	I	BOOL		See the "Signal recorder" description above
Var1	I	BYTE		Additional value
Var2	I	INT		Additional value
Var3	I	INT		Additional value
BufDB	I	INT		Ring buffer DB no.

Formal parameters of diagnostics function				
Signal	Type	Type	Value range	Remark
ClearBuf	I	BOOL		Delete ring buffer DB and reset pointer BufAddr
BufAddr	I/O	INT		Target area for read data
Parameters for function 2				
DataAdr	I	POINTER		Pointer to word to be tested
TestVal	I	WORD		Comparison value
AndMask	I	WORD		See description
TestIsTrue	Q	BOOL		Result of comparison

### Configuration steps

- Select function of diagnostics block.
- Define suitable data for the recording as signal recorder or data triggering.
- Find a suitable point or points in the user program for calling the diagnostics FB.
- Create a data block for the ring buffer, see call example.
- Call the diagnostics FB with parameters in the user program.

In function 1, it is advisable to clear the ring buffer with the "ClearBuf" parameter. When the recording phase with function 1 is completed, read out the ring buffer DB in STEP7 with the function "opening the data block in the data view". The content of the ring buffer DB can now be analyzed.

### Call example

```

FUNCTION FC 99: VOID
TITLE =
VERSION : 0.0

BEGIN
NETWORK
TITLE = NETWORK

CALL FB 29, DB 80 (
Func          := 1,
Signal_1     :=M      100.0,
Signal_2     :=M      100.1,
Signal_3     :=M      100.2,
Signal_4     :=M      100.3,
Signal_5     :=M      10.4,
Signal_6     :=M      100.5,
Signal_7     :=M      100.6,
Signal_8     :=M      100.7,

```

```
NewCycle      := TRUE,  
Var1          := MB          100,  
BufDB        := 81,  
ClearBuf     :=M           50.0);  
END_FUNCTION
```

### 13.13.11 FC 2: GP\_HP Basic program, cyclic section

#### Function

The complete processing of the NCK-PLC interface is carried out in cyclic mode. In order to minimize the execution time of the basic program, only the control/status signals are transmitted cyclically; transfer of the auxiliary functions and G functions only takes place when requested by the NCK.

#### Declaration

```
FUNCTION FC 2: VOID  
// no parameters
```

#### Call example

As far as the time is concerned, the basic program must be executed **before** the user program. It is, therefore, called first in OB 1.

The following example contains the standard declarations for OB 1 and the calls for the basic program (FC2), the transfer of the MCP signals (FC19), and the acquisition of error and operating messages (FC10).

```
ORGANIZATION_BLOCK OB 1  
VAR_TEMP  
  OB1_EV_CLASS :      BYTE ;  
  OB1_SCAN_1   :      BYTE ;  
  OB1_PRIORITY :      BYTE ;  
  OB1_OB_NUMBR :      BYTE ;  
  OB1_RESERVED_1 :     BYTE ;  
  OB1_RESERVED_2 :     BYTE ;  
  OB1_PREV_CYCLE :     INT ;  
  OB1_MIN_CYCLE :     INT ;  
  OB1_MAX_CYCLE :     INT ;  
  OB1_DATE_TIME :     DATE_AND_TIME ;  
END_VAR  
BEGIN  
CALL FC 2;           //Call basic program as first FC
```

```

//INSERT USER PROGRAM HERE
CALL FC 19 (                               //MCP signals to interface
BAGNo := B#16#1,                          //Mode group no. 1
ChanNo := B#16#1,                        //Channel no. 1
SpindleIFNo := B#16#4,                  //Spindle interface number = 4
FeedHold := m22.0,                      //Feed stop signal
                                           //modal
SpindleHold := db2.dbx151.0);           //Spindle stop modal
                                           //in message DB
CALL FC 10 (                               //Error and operational messages
                                           ToUserIF := TRUE,      //Signals transferred from DB2 to interface
                                           //to interface
                                           Ack := I6.1);        //Acknowledgment of error messages
                                           //via I 6.1
END_ORGANIZATION_BLOCK

```

### 13.13.12 FC 3: GP\_PRAL Basic program, interrupt-driven section

#### Function

Block-synchronized transfers from the NCK to the PLC (auxiliary and G functions) are carried out in the interrupt-driven part of the basic program. **Auxiliary functions** are subdivided into normal and high-speed auxiliary functions.

The high-speed functions of an NC block are buffered and the transfer acknowledged to the NC. These are passed to the application interface at the start of the next OB1 cycle.

High-speed auxiliary functions programmed immediately one after the other, are not lost for the user program. This is ensured by a mechanism in the basic program.

Normal auxiliary functions are acknowledged to the NC only after one completed cycle duration. This allows the application to issue a read disable to the NC.

The **G Functions** are evaluated immediately and passed to the application interface.

## NC process interrupts

If the interrupt is triggered by the NC (possible in each I/O cycle), a bit in the local data of OB 40 ("GP\_IRFromNCK") is set by the basic program, when the FB 1 parameter "UserIR": = TRUE". This data is not set on other events (process interrupts through I/Os). This information makes it possible to branch into the associated interrupt routine in the user program in order to initiate the necessary action.

To be able to implement high-speed, job-driven processing of the user program for the machine, the following NC functions are available in the interrupt processing routine (OB 40 program section) for the PLC user program:

- Selected **auxiliary functions**
- **Tool-change function** for tool-management option
- **Position reached** for positioning axes, indexing axes and spindles with activation via PLC

The functions listed above can or must be evaluated by the user program in OB 40 in order to initiate reactions on the machine. As an example, the revolver switching mechanism can be activated when a T command is programmed on a turning machine.

For further details on programming hardware interrupts (time delay, interruptibility, etc.) refer to the corresponding SIMATIC documentation.

## Auxiliary functions

Generally, high-speed or acknowledging auxiliary functions are processed with or without interrupt control independently of any assignment.

Basic-program parameters in FB 1 can be set to define which auxiliary functions (T, H, DL) must be processed solely on an interrupt-driven basis by the user program.

Functions which are not assigned via interrupts are only made available by the cyclic basic program as in earlier versions. The change signals of these functions are available in a PLC cycle.

Even if the selection for the auxiliary function groups (T, H, DL) is made using interrupt control, only one interrupt can be processed by the user program for the selected functions.

A bit is set channel-specifically in the local data "GP\_AuxFunction" for the user program (if "GP\_AuxFunction[1]" is set, then an auxiliary function is available for the 1st channel).

In the related channel-DB the change signal and the function value are available for the user. Das Änderungssignal dieser interrupt driven function is reset to zero in the cyclic basic program section after the execution of at least one full OB1 cycle (max. approx. two OB1 cycles).

## Tool change

With the tool-management option, the tool-change command for revolver and the tool change in the spindle is supported by an interrupt. The local data bit "GP\_TM" in OB 40 is set for this purpose. The PLC user program can thus check the tool management DB (DB 72 or DB 73) for the tool change function and initiate the tool change operation.

## Position reached

In the bit structure, "GP\_InPosition" of the local data of OB 40 is specific to the machine axis (each bit corresponds to an axis/spindle, e.g. GP\_InPosition[5] corresponds to axis 5).

If a function has been activated via FC 18 (spindle control, positioning axis, indexing axis) for an axis or spindle, the associated "GP\_InPosition" bit can be used to implement instantaneous evaluation of the "InPos" signal of the FCs listed above. This feature can be used, for example, to obtain immediate activation of clamps for an indexing axis.

## Declaration

```
FUNCTION FC 3 : VOID
// no parameters
```

## Call example

As far as the time is concerned, the basic program must be executed **before** other interrupt-driven user programs. It is, therefore, called first in OB 40.

The following example contains the standard declarations for OB 40 and the call for the basic program.

```
ORGANIZATION_BLOCK OB 40
VAR_TEMP
    OB40_EV_CLASS :          BYTE ;
    OB40_STRT_INF :          BYTE ;
    OB40_PRIORITY :          BYTE ;
    OB40_OB_NUMBR :          BYTE ;
    OB40_RESERVED_1 :        BYTE ;
    OB40_MDL_ID :            BYTE ;
    OB40_MDL_ADDR :          INT;
    OB40_POINT_ADDR :        DWORD;
    OB40_DATE_TIME :         DATE_AND_TIME;

//Assigned to basic program
GP_IRFromNCK : BOOL ;           //Interrupt by NCK for user
GP_TM : BOOL ;                 //Tool management
GP_InPosition : ARRAY [1..3] OF BOOL; //Axis-oriented for positioning,
//Indexing axes, spindles
GP_AuxFunction : ARRAY [1..10] OF BOOL; //Channel-oriented for auxiliary functions
GP_FMBlock : ARRAY [1..10] OF BOOL; //Currently not used
//Further local user data may be defined from this point onwards
END_VAR
BEGIN
    CALL FC 3;
    //INSERT USER PROGRAM HERE
END_ORGANIZATION_BLOCK
```

### 13.13.13 FC 5: GP\_DIAG Basic program, diagnostic alarm, and module failure

#### Function

Module defects and module failures are detected in this section of the basic program.

The FC5 block parameter can be used to define whether the PLC is to be placed in Stop mode. The PLC is placed in STOP mode only for incoming events. Exceptions of the parameter "PLC-Stop" are the Profibus-MCPs parameterized at FB 1 (must be connected to the DP1 Bus).

#### Declaration

```
FUNCTION FC 5: VOID
  VAR_INPUT
    PlcStop: BOOL:= TRUE;
  END_VAR
```

#### Call example

As far as timing is concerned, the basic program can be executed after other user programs. This is advisable since the FC5 circuitry will place the PLC in Stop mode.

This example contains the standard declarations for OB 82 and OB 86 and the call of the basic program block.

```
ORGANIZATION_BLOCK OB 82
VAR_TEMP
  OB82_EV_CLASS : BYTE ;
  OB82_FLT_ID : BYTE ;
  OB82_PRIORITY : BYTE ;
  OB82_OB_NUMBR : BYTE ;
  OB82_RESERVED_1 : BYTE ;
  OB82_IO_FLAG : BYTE ;
  OB82_MDL_ADDR : INT ;
  OB82_MDL_DEFECT : BOOL ;
  OB82_INT_FAULT : BOOL ;
  OB82_EXT_FAULT : BOOL ;
  OB82_PNT_INFO : BOOL ;
  OB82_EXT_VOLTAGE : BOOL ;
  OB82_FLD_CONNCTR : BOOL ;
  OB82_NO_CONFIG : BOOL ;
  OB82_CONFIG_ERR : BOOL ;
  OB82_MDL_TYPE : BYTE ;
  OB82_SUB_NDL_ERR : BOOL ;
  OB82_COMM_FAULT : BOOL ;
  OB82_MDL_STOP : BOOL ;
  OB82_WTCH_DOG_FLT : BOOL ;
  OB82_INT_PS_FLT : BOOL ;
  OB82_PRIM_BATT_FLT : BOOL ;
  OB82_BCKUP_BATT_FLT : BOOL ;
  OB82_RESERVED_2 : BOOL ;
  OB82_RACK_FLT : BOOL ;
```

```

    OB82_PROC_FLT : BOOL ;
    OB82_EPROM_FLT : BOOL ;
    OB82_RAM_FLT : BOOL ;
    OB82_ADU_FLT : BOOL ;
    OB82_FUSE_FLT : BOOL ;
    OB82_HW_INTR_FLT : BOOL ;
    OB82_RESERVED_3 : BOOL ;
    OB82_DATE_TIME : DATE_AND_TIME;
END_VAR
BEGIN
    CALL FC 5
        (PlcStop := FALSE) ;
END_ORGANIZATION_BLOCK

ORGANIZATION_BLOCK OB 86
VAR_TEMP
    OB86_EV_CLASS : BYTE ;
    OB86_FLT_ID : BYTE ;
    OB86_PRIORITY : BYTE ;
    OB86_OB_NUMBR : BYTE ;
    OB86_RESERVED_1 : BYTE ;
    OB86_RESERVED_2 : BYTE ;
    OB86_MDL_ADDR : WORD ;
    OB86_RACKS_FLTD : ARRAY [0 .. 31] OF BOOL;
    OB86_DATE_TIME : DATE_AND_TIME;
END_VAR
BEGIN
    CALL FC 5
        (PlcStop := TRUE) ;
END_ORGANIZATION_BLOCK

```

### 13.13.14 FC 7: TM\_REV Transfer block for tool change with revolver

#### Function

After a revolver has been changed, the user will call this block FC TM\_REV. The revolver number (corresponding to interface number in DB 73) must be specified in parameter "ChgdRevNo" for this purpose. As this block is called, the associated "Interface active" bit in data block DB 73, word 0 of FC 7 is reset after parameter "Ready" := TRUE is returned.

Block FC TM\_REV may be started (with "Start" parameter = "TRUE") only if an activation signal for the appropriate interface (DB 73, word 0) for this transfer has been supplied by the tool management function.

When this job is executed correctly, the output parameter "Ready" contains the value TRUE. The user must then set the "Start" parameter to FALSE or not call the block again.

If the "Ready" parameter is set to FALSE, the error code in the "Error" parameter must be interpreted.

If the error code = 0, then this job must be repeated in the next PLC cycle (e.g. "Start" remains set to "TRUE"). This means that the transfer job has not yet been completed (see example FC 7 call and timing diagram).

The "Start" parameter does not need a signal edge for a subsequent job.

 **WARNING**

A cancellation of a transfer (e.g. through an external signal RESET) is not permitted. The "Start" parameter must always retain the 1 signal until the "Ready" and/or "Error" parameters  $\neq 0$ .

An error code  $\neq 0$  indicates incorrect parameterization.

**Note**

For further details on tool management (also with regard to PLC) refer to the Description of Functions Tool Management. In addition, PI services for tool management via FB 4, FC 8 and FC 22 are available.

## Manual revolver switching

If a manual action is used to rotate the revolver, this information must be forwarded to the tool management. The asynchronous transfer function of FC 8 must be used to transfer the modified positions of the revolver. This must only occur once on the first manual rotation in the sequence. In this case, the following parameterization of the asynchronous transfer is needed via FC 8:

```
TaskIdent = 4
TaskIdentNo = channel
NewToolMag = Magazine number of the revolver
NewToolLoc = Original location of the tool
OldToolMag = Magazine no. buffer storage (spindle) = 9998
OldToolLoc = Buffer storage number of the spindle
Status = 1
```

This action also causes the same T command to be resent to the tool-management interface if the previous T is programmed again.

**Declaration of the function**

**STL representation**

```

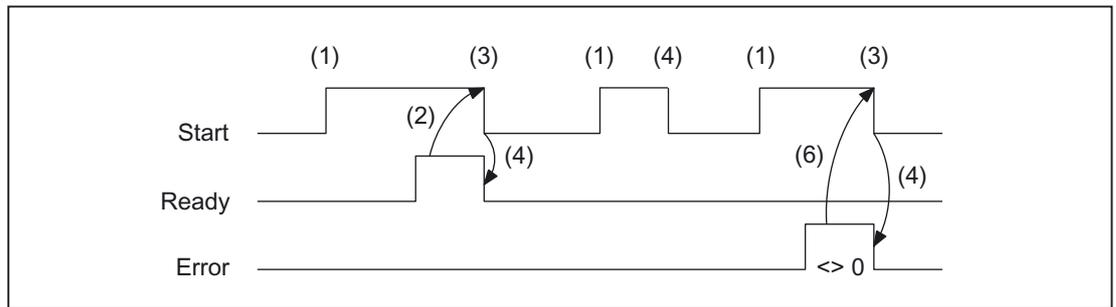
FUNCTION FC 7 :      VOID
//NAME :TM_REV
VAR_INPUT
    Start:           BOOL ;
    ChgdRevNo:       BYTE ;
END_VAR
VAR_OUTPUT
    Ready:           BOOL ;
    Error :          INT;
END_VAR
BEGIN
END_FUNCTION
    
```

**Description of formal parameters**

The table below lists all formal parameters of the TM\_REV function.

Signal	Type	Type	Value range	Comment
Start	I	BOOL		1 = Start of transfer
ChgdRevNo	I	BYTE	1...	Number of revolver interface
Ready	Q	BOOL		1 = Transfer complete
Error	Q	INT	0 ... 3	Error checkback
				0: No error has occurred
				1: No revolver present
				2: Illegal revolver number in parameter "ChgdRevNo"
3: Illegal job ("interface active" signal for selected revolver = "FALSE")				

## Pulse diagram



- (1) Activation of function by means of a positive edge
- (2) Positive acknowledgment: Tool management has been transferred
- (3) Reset function activation after receipt of acknowledgment
- (4) Signal change using FC
- (5) This signal chart is not permissible. The job must generally be terminated since the new tool positions must be conveyed to the tool management in the NCK.
- (6) Negative acknowledgment: Error has occurred, error code in the output parameter Error

## Call example

```

CALL FC 7 (                                     //Tool-management transfer block
                                                //for Revolver
Start :=          m 20.5,                       //Start := "1 " => transfer trigger
ChgdRevNo :=      DB61.DBB 1,
Ready :=         m 20.6,
Error :=         DB61.DBW 12);
u m 20.6;                                       //Poll ready
r m 20.5;                                       //Reset start
spb m001;                                       //Jumps, if everything OK
l db61.dbw 12;                                 //Error information
ow w#16#0;                                     //Evaluate error
JC error;                                     //Jumps to troubleshooting, if <> 0
m001:                                          // Start of another program
error:
r m 20.5;                                     //Reset start, if an error has occurred

```

### 13.13.15 FC 8: TM\_TRANS transfer block for tool management

#### Function

The user calls this block FC TM-TRANS when the position of the tool or the status of the transfer operation changes. The parameter "TaskIdent" specifies the transfer job for the block FC 8 at the tool management interface:

- For loading/unloading positions,
- For spindle change positions,
- For revolver change positions as transfer identifier
- Asynchronous transfer
- Asynchronous transfer with location reservation

The interface number is indicated in parameter "TaskIdentNo".

Example for loading point 5:

Parameter "TaskIdent":= 1 and "TaskIdentNo":= 5.

Furthermore, the **current** tool positions and status data (list of "Status" parameter in the following text) are also transmitted for this transfer function.

---

#### Note

FC8 informs the NCK of the current positions of the old tool.

The NCK knows where the old and the new tool have been located until the position change.

---

In the case of a transfer without a so-called "old tool" (e.g. on loading), the value 0 is assigned to parameters "OldToolMag", "OldToolLoc".

Block FC TM\_TRANS may be started only with "Start" parameter = "TRUE" if an activation signal for the appropriate interface (DB 71, DB 72, DB 73 in word 0) for this transfer has been supplied by the tool management function.

When this job is executed correctly, the output parameter "Ready" contains the value TRUE.

The user must then set the "Start" parameter to FALSE or not call the block again.

If the "Ready" parameter = FALSE, the error code in the "Error" parameter must be interpreted (see Call example FC 8 and timing diagram).

If the error code = 0, then this job must be repeated in the next PLC cycle (e.g. "Start" remains set to "TRUE"). This means that the transfer operation has not yet been completed.

If the user assigns a value of less than 100 to the Parameter "Status", then the associated interface in data block DB 71 or DB 72 or DB 73, word 0 is deactivated (process completed). The appropriate bit for the interface is set to 0 by FC 8.

The "Start" parameter does not need a signal edge for a subsequent job. This means that new parameters can be assigned with "Start = TRUE" immediately when "Ready = TRUE" is received.

### **Asynchronous transfer**

To ensure that changes in the position of a tool are automatically signaled from PLC to tool management (e.g. power failure during an active command or independent changes in the position by the PLC), block FC 8 TM\_TRANS with "TaskIdent": = 4 or 5 is called. This call does not require interface activation by tool management.

If parameter "TaskIdent" = 5 the tool management reserves the location in addition to changing the position. The location is only reserved if the tool has been transported from a real magazine to a buffer storage.

A relevant NC channel must be parameterized in the "TaskIdentNo" parameter.

The previous position of the tool is specified in parameters "OldToolMag", "OldToolLoc"; the current position of the tool is specified in parameters "NewToolMag", "NewToolLoc". Status = 1 must be specified.

With status 5, the specified tool remains at location "OldToolMag", "OldToolLoc". This location must be a buffer (e.g. spindle). The real magazine and location must be specified in the parameters "NewToolMag", "NewToolLoc"; the location is at the position of the buffer. This procedure must always be used if the tool management is to be informed of the position of a specific magazine location. This procedure is used for alignment in search strategies.

---

#### **Note**

A cancellation of a transfer (e.g. through an external signal RESET) is not permitted. The "Start" parameter must always retain the 1 signal until the "Ready" and/or "Error" parameters <> 0.

---

An error code <> 0 indicates incorrect parameterization.

---

#### **Note**

For further details on tool management (also with regard to PLC) refer to the Description of Functions Tool Management. In addition, PI services for tool management via FB 4, FC 7 and FC 22 are available.

---

**Declaration of the function**

**STL Representation**

```

FUNCTION FC 8 : VOID
//NAME :TM_TRANS
VAR_INPUT
    Start:                BOOL ;
    TaskIdent:            BYTE ;
    TaskIdentNo:         BYTE ;
    NewToolMag:          INT;
    NewToolLoc:          INT;
    OldToolMag:          INT;
    OldToolLoc:          INT;
    Status:              INT;
END_VAR
VAR_OUTPUT
    Ready                BOOL ;
    Error :              INT;
END_VAR
BEGIN
END_FUNCTION
    
```

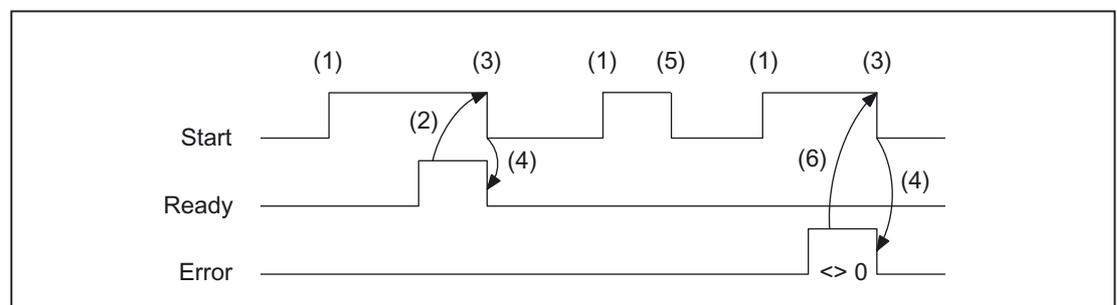
**Description of formal parameters**

The table below lists all formal parameters of the TM\_TRANS function:

Signal	Type	Type	Value range	Comment
Start	I	BOOL		1 = Start of transfer
TaskIdent	I	BYTE	1 ... 5	Interface or tank identifier
				1: Loading/unloading location
				2: Spindle change position
				3: Revolver change position
				4: Asynchronous transfer
5: Asynchronous transfer with location reservation				
TaskIdentNo	I	BYTE	1 ...	Number of associated interface or channel number. The upper nibble can specify the interface number for asynchronous transfer (e.g. B#16#12, 1st interface, 2nd channel).
NewToolMag	I	INT	1, 0 ...	Current magazine number of tool to be replaced
				-1: Tool remains at its location NewToolLoc = any value Only permissible if TaskIdent = 2
NewToolLoc	I	INT	0 ... max. location number	Current location number of new tool

Signal	Type	Type	Value range	Comment
OldToolMag	I	INT	-1, 0 ...	Current magazine number of tool to be replaced
				-1: Tool remains at its location OldToolLoc = any value. Only permissible if TaskIdent = 2
OldToolLoc	I	INT	Max. location number	Current location number of tool to be replaced
Status	I	INT	1 ... 7, 103 ... 105	Status information about transfer operation
Ready	Q	BOOL		1= transfer completed
Error	Q	INT	0 ... 65535	Error checkback
				0: No error has occurred
				1: Unknown "TaskIdent"
				2: Unknown "TaskIdentNo"
				3: Illegal task ("signal "Interface (SS) active" of selected revolver = "FALSE")
Other values:	The number corresponds to the error message of the tool management function in the NCK caused by this transfer.			

### Timing diagram



- (1) Activation of function by means of a positive edge
- (2) Positive acknowledgment: Tool management has been transferred
- (3) Reset function activation after receipt of acknowledgment
- (4) Signal change using FC
- (5) This signal chart is not permissible. The job must generally be terminated since the new tool positions must be conveyed to the tool management in the NCK.
- (6) Negative acknowledgment: Error occurred, error code in the output parameter Error

## Status list

### Status = 1:

**The WZV operation is completed** (loading/unloading/reloading, prepare change, change).

The parameters "NewToolMag", "NewToolLoc", "OldToolMag", "OldToolLoc" of the FC 8 block are to be parameterized to the actual positions of the tools involved. Except in the case of preparing change these are normally the specified target position of the tools of the associated WZV interface, see also "Explanations of the formal parameters".

1. In the case of loading/unloading/reloading, the tool has arrived at the required target address. If the bit in the interface in DB 71.DBX (n+0).3 "position at loading point" is enabled, status 1 cannot be used for the function termination. Status 5 must be used for correct termination.
2. In the case of "Prepare change", the new tool is now available. The tool may, for example, be positioned in a buffer (gripper). In some cases, the target (magazine, location) of the old tool has been moved to the tool-change position after placement of the new tool in a buffer. However, the old tool still remains in the spindle. The preparations for a tool change are thus complete. After this acknowledgment, the "Change" command can be received. The positions in parameters "NewToolMag", "NewToolLoc", "OldToolMag" and "OldToolLoc" correspond to the current tool positions.
3. In the case of "Change" (spindle or revolver), the tools addressed in the interface have now reached the required target addresses. The tool-change operation is thus completed.

### Status = 2: The "new" tool cannot be made available.

This status is only admissible in conjunction with the "Prepare Change" command. When this status is applied, the PLC must be prevented from making a change with the proposed tool. The proposed (new) tool is disabled by the tool management function in the NCK. A new command is then output by the tool management with a duplo tool. The positions in parameters "NewToolMag", "NewToolLoc", "OldToolMag", and "OldToolLoc" correspond to the original tool positions.

### Status = 3: An error occurred.

The tool positions must not have been changed. Any changes to the magazine positions which have taken place in the meantime must be notified beforehand, for example, with status = 105 via FC 8 transfer block. Only then will the tool positions be taken into account by the tool management function.

### Status = 4: It would be better to position the "old" tool in the magazine position specified in parameters "OldToolMag" and "OldToolLoc".

This status is permissible only in conjunction with preparation for tool change (change into spindle). After this status has been transferred to the tool management in the NCK, the tool management tries to consider the specified magazine position in the next command. But this is done only when this position is free. Parameters "NewToolMag" and "NewToolLoc" are not taken into account.

**Status = 5: The operation is complete.**

The "new" tool is in the position specified in parameters "NewToolMag", "NewToolLoc". In this case, the specified tool is not really in this position, but is still in the same magazine location. However, this magazine location has been moved to the position set in the parameters (e.g. tool change position). This status may be used only for revolvers, chain-type magazines and disk magazines. Status 5 enables the tool management function to adjust the current position of a magazine and to improve the search strategy for subsequent commands. This status is permissible only in conjunction with loading, unloading, and reloading operations and with preparations for a tool change.

The "OldToolMag" and "OldToolLoc" parameters must be parameterized with the data of a buffer.

- **Loading, reloading:**

On loading or reloading, a location for the tool is already reserved in the NCK. The machine operator must then insert the tool at the target location. Note: The location reservation is canceled when the control system is switched on again.

- **Tool-change preparation:**

Tool motions still to be executed are not carried out until after the tool has been changed.

- **Positioning to load point:**

If the bit in the interface in DB 71.DBX (n+0).3 "position at loading point" is enabled, status 1 cannot be used for the function termination.

**Status = 6: The WZV job has been completed.**

This status has the same function as status 1, but, in addition, a reservation of the source location is carried out. This status is only permitted when reloading. The command is ended and the source location of the tool is reserved if the target location is in a buffer magazine.

**Status = 7: Initiate repetition of the command "Prepare Tool".**

This status is only admissible in conjunction with the "Change tool" command. This status is intended for use when the "new" tool has changed its position (e.g. via an asynchronous command of the "new" tool). After "Ready = 1" has been provided by FC 8, the "Prepare Change" command is repeated automatically with the same tool. For the automatic repetition, a new tool search is carried out. The positions in parameters "NewToolMag", "NewToolLoc", "OldToolMag", and "OldToolLoc" correspond to the original tool positions.

**Status = 103: The "new" tool can be inserted.**

This status is permitted only in the tool change preparation, when the PLC may reject the new tool (e.g. in case of MD20310 \$MC\_TOOL\_MANAGEMENT\_MASK, bit 4=1 for the possibility, request changed parameter from PLC once again). The tool positions have remained unchanged. This status is thus necessary, when the processing is to be continued in the NCK without an unnecessary stop.

**References:**

Function Manual Tool Management

**Status = 104: The "new" tool is in the position specified in parameters "NewToolMag", "NewToolLoc".**

This status is only permissible if the tool is still in the magazine in the same location. The "old" tool is in the position (buffer) specified in parameters "OldToolMag", "OldToolLoc". In this case, however, the new tool is not really in this position, but is still in the same magazine location. However, this magazine location has been moved to the position set in the parameters (e.g. tool change position). This status may be used only in conjunction with revolvers, chain-type magazines and disk magazines for the "Tool change preparation" phase. Status enables the tool management to adjust the current position of a magazine and to improve the search strategy for subsequent commands.

**Status = 105: The specified buffer has been reached by all tools involved**  
(standard case if the operation has not yet been completed).

The tools are in the specified tool positions (parameters "NewToolMag", "NewToolLoc", "OldToolMag", "OldToolLoc").

### Status definition

A general rule for the acknowledgment status is that the state information 1 to 7 leads to the termination of the command. If FC 8 receives one of the statuses, the "Interface active bit" of the interface specified in FC 8 is reset to "0" (see also interface lists DB 71 to DB 73), thus completing the operation. The response is different in the case of status information 103 to 105. When the FC 8 receives one of these items of status information, the "Interface active bit" of this interface remains at "1". Further processing is required by the user program in the PLC (e.g. continuation of magazine positioning). This item of status information is generally used to transfer changes in position of one or both tools while the operation is still in progress.

### Call example

```
CALL FC 8 (           //Tool-management transfer block
  Start :=           m 20.5,           //Start := "1 " => transfer trigger
  TaskIdent :=       DB61.DBB 0,
  TaskIdentNo :=     DB61.DBB 1,
  NewToolMag :=      DB61.DBW 2,       //Current position of new tool
  NewToolLoc :=      DB61.DBW 4,
  OldToolMag :=      DB61.DBW 6,       //Current position of old tool
  OldToolLoc :=      DB61.DBW 8,
  Status :=          DB61.DBW 10,     //Status
  Ready :=           m 20.6,
  Error :=           DB61.DBW 12);

u m 20.6;           //Poll ready
r m 20.5;           //Reset start
spb m001;          //Jumps, if everything OK
l DB61.dbw 12;     //Error information
ow w#16#0;         //Evaluate error
JC error;          //Jumps to troubleshooting
```

```
m001:                //Normal branch  
  
error:              //Troubleshooting  
r m 20.5:          //Reset start
```

### 13.13.16 FC 9: ASUB startup of asynchronous subprograms

#### Function

The FC ASUB can be used to trigger any functions in the NC. Before an ASUB can be started from the PLC, it must have been selected and parameterized by an NC program or by FB 4 (PI service ASUB). The channel and the interrupt numbers for the parameters in FC 9 must match here.

Once prepared in this way, it can be started at any time from the PLC. The NC program running on the channel in question is interrupted by the asynchronous subprogram. Only one ASUB can be started in the same channel at a time. If the start parameter is set to logical 1 for two FC 9s within **one** PLC cycle, the ASUBs are started in the sequence in which they are called.

The start parameter must be set to logic 0 by the user once the ASUB has been terminated (Done) or if an error has occurred.

For the purpose of job processing, every FC ASUB requires its own WORD parameter "Ref" from the global user memory area. This parameter is for internal use only and must not be changed by the user. The parameter "Ref" is initialized with the value 0 in the first OB 1 cycle and, for this reason, **every FC 9 must be called absolutely**. Alternatively, the user can initialize parameter "Ref" with a value of 0 during startup. This option makes conditional calls possible. When a conditional call is activated by parameter "Start" = 1, it must remain active until parameter "Done" has made the transition from 1 to 0.

---

#### Note

The FB 4 call must be terminated before the FC 9 can be started. FC 9 cannot be started if "Emergency off" is set. Neither can FC 9 be started if the channel reset is active.

---

### Declaration of the function

```

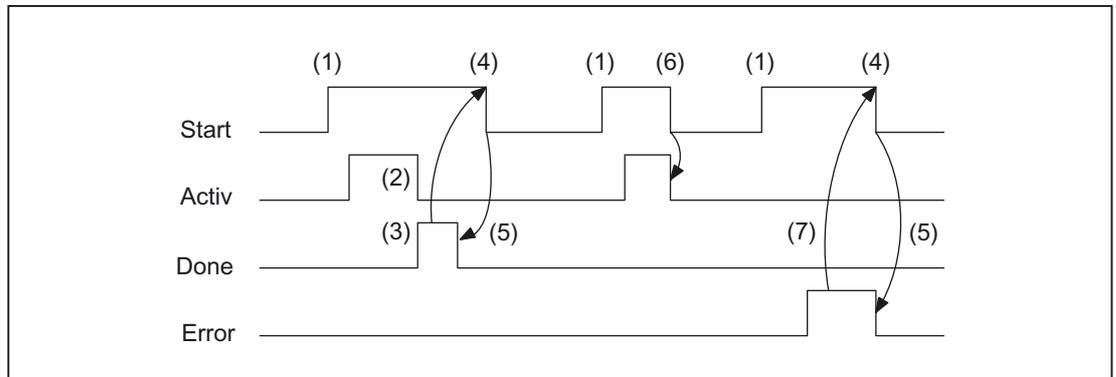
FUNCTION FC 9 : VOID
//NAME :ASUP
VAR_INPUT
    Start:        BOOL ;
    ChanNo:       INT;
    IntNo:        INT;
END_VAR
VAR_OUTPUT
    Active:       BOOL ;
    Done :        BOOL ;
    Error :       BOOL ;
    StartErr:    BOOL ;
END_VAR
VAR_IN_OUT
    Ref:          WORD ;
END_VAR
    
```

### Description of formal parameters

The table below lists all formal parameters of the ASUB function.

Signal	Type	Type	Value range	Remark
Start	I	BOOL		
ChanNo	I	INT	1 ... 10	No. of the NC channel
IntNo	I	INT	1 ... 8	Interrupt No.
Active	Q	BOOL		1 = Active
Done	Q	BOOL		1 = ASUB completed
Error	Q	BOOL		1 = Interrupt switched off
StartErr	Q	BOOL		1 = Interrupt number not assigned or deleted
Ref	I/O	WORD	Global variable (MW, DBW,..)	1 word per FC 9 (for internal use)

## Timing diagram



- (1) Activation of function
- (2) ASUP active
- (3) Positive acknowledgment: ASUB ended
- (4) Reset function activation after receipt of acknowledgment
- (5) Signal change using FC
- (6) Not permitted If function activation is reset prior to receipt of acknowledgment, the output signals are not updated without the operational sequence of the activated function being affected.
- (7) Negative acknowledgment: Error has occurred

## Call example

```
CALL FC 9 (                                     //Start an asynchronous subprogram
                                                //in channel 1 interrupt number 1

    Start :=      I 45.7,
    ChanNo :=     1,
    IntNo  :=     1,
    Active :=     M 204.0,
    Done   :=     M204.1,
    Error  :=     M 204.4,
    StartErr :=   M 204.5,
    Ref    :=     MW 200);
```

### 13.13.17 FC 10: AL\_MSG error and operating messages

#### Function

FC AL\_MSG evaluates the signals entered in DB 2 and displays them as incoming and outgoing error and operational messages on the HMI.

The incoming signals (positive edge) are displayed immediately in the case of both error and operational messages.

Outgoing signals (negative edge) are only canceled immediately in the case of operating messages. Error messages remain stored on the HMI - even if the signals no longer exist - until the "acknowledge" parameter is issued, WCS.e. until the user acknowledges the messages.

The "ToUserIF" parameter can be used to transfer the group signals for the feed, read and NC start disabling signals and feed stop signal to the existing axis, spindle and channel interfaces. The group signals are transferred to the user interface directly from the status information in DB 2 irrespective of an interrupt acknowledgment.

1. If parameter "ToUserIF": is set to FALSE, signals are not transferred to the user interface. In this case, the user must take measures in his PLC program to ensure that these signals are influenced in the interface.
2. If parameter "ToUserIF": is set to TRUE, all signals listed above are sent to the user interface as a group signal in each case. The user PLC program can, therefore, influence these signals only via DB 2 in connection with a message or interrupt output. The appropriate information is overwritten in the user interface.

As an alternative to the procedure described under paragraph 2, the user can influence the disable and stop signals without a message output by applying a disable or stop signal state to the interface signals after FC AL\_MSG has been called.

The following program illustrates this method:

```
CALL FC 10 (
  ToUserIF :=      TRUE,
  Ack :=          I 6.1);

u m 50.0;          //Feed disable for channel 1
to DB 21;
s dbx 6.0;        //Setting the blocking condition,
                  //Resetting is done via FC AL_MSG,
                  //if M 50.0 outputs the signal "0".
```

**FB 1 Parameter "ExtendAlMsg"**

With the activation of the parameter a new structuring of the DB 2 becomes effective (see "Interface PLC/HMI (Page 916)"). Upon activation the bit fields are available to the user for the disable and halt signals, which do not generate any alarms, messages. As a result, the user need not implement the aforesaid measures. The desired functionality is given automatically by a simple setting, resetting of signals in the new DB 2 areas.

The error and the operating messages are stored by the user in the data block DB 2.

**References:**

Lists/ (Book2), "Data blocks DB of the PLC user interface".

**Note**

In DB 2, a "1" signal must be present for several OB1 cycles to ensure that a message can also be displayed on the HMI. There is an upper limit for the number of interrupts and messages that can be pending at the same time. This upper limit is dependent on the PLC CPU. On PLC 317-2DP, the upper limit for messages pending simultaneously is 60.

**Declaration of the function****STL Representation**

```

FUNCTION FC 10 :      VOID
    // NAME:          AL_MSG
VAR_INPUT
    ToUserIF :        BOOL ;
    Ack :             BOOL ;
END_VAR
END_FUNCTION

```

**Description of formal parameters**

The table below lists all formal parameters of the AL-MSG function.

Signal	Type	Type	Range of values	Remark
ToUserIF	I	BOOL		1 = Transfer the signals to user interface every cycle
Ack	I	BOOL		1 = Acknowledge error messages.

**Call example**

```

CALL FC 10 (
    ToUserIF := TRUE, //Error and operational messages
                    //Signals from DB 2 are transferred to
                    //interface
    Ack := I6.1);    //Acknowledgement of the error message done via
                    //Input E6.1.

```

### 13.13.18 FC 12: AUXFU call interface for user with auxiliary functions

#### Function

FC AUXFU is generally called on an event-driven basis in the basic program if the channel transferred in the input parameter contains new auxiliary functions. The PLC user can extend FC AUXFU with program instructions for processing his auxiliary function to avoid cyclic polling of the channel DBs. This mechanism permits auxiliary functions to be processed on a job-driven basis. FC AUXFU is supplied as a compiled empty block in the basic program. In this case, the basic program supplies parameter "Chan" with the channel number. The PLC user knows which channel has new auxiliary functions available. The new auxiliary functions can be determined by the auxiliary-function change signals in the channel concerned.

#### Declaration of the function

```
FUNCTION FC 12: VOID           //Event control of auxiliary functions
VAR_INPUT
  Chan:      BYTE ;
END_VAR
BEGIN
  BE;
END_FUNCTION
```

#### Explanation of formal parameters

The table below lists all formal parameters of the AUXFU function:

Signal	Type	Type	Value range	Remark
Chan	I	BYTE	0 ... 9	No. of NC channel -1

#### Example

```
FUNCTION FC 12: VOID           //Event control of auxiliary functions
VAR_INPUT
  Chan:      BYTE ;           //Parameter is supplied by basic program
END_VAR
VAR_TEMP
  ChanDB:    INT;
END_VAR
BEGIN
  L Chan;                       //Channel index no., (0,1,2,..)
  + 21;                          //Channel DB offset
```

```

T ChanDB;                //Save channel DB no.
TO DB[ChanDB];          //Channel DB is opened indirectly
// Auxiliary-function change signals are now scanned, etc.
    BE;
END_FUNCTION

```

### 13.13.19 FC 13: BHGDisp Display control for handheld unit

#### Function

This block carries out the display control of the handheld unit (HHU). The information to be output on the display is stored as 32 characters in string data ChrArray (these are 64 characters when using an HT2). A fixed text assignment of 32 or 64 characters is, therefore, required for this string when the data block is created.

16 characters are sent to BHG/HT2 for each job, which lasts for several OB 1-cycle. The assignment of the characters in ChrArray to each line is unique. For line 1 the characters 1 to 16 and for the line 2 the characters 17 to 32 of the string data ChrArray are transferred. In addition, for HT2 the line 3 with the characters 33 to 48 and line 4 made of characters 49 to 64 are shown.

The block checks, whether the minimum length of the ChrArray is available for operating the BHG or the HT2. If less characters are present in the string data than are to be displayed, then the line is filled with blanks.

By setting parameter Row to 0, it is possible to suppress the display (e.g. if several variables in one or several PLC cycles need to be entered in the string without any display output). If several lines are to be updated "simultaneously" (transfer of the characters to the lines lasts for several OB 1 cycles) (Parameter Row > 1), then the lines are updated one by one each with 16 characters per line.

Variable portions within the string can be inserted by means of the numerical converter functionality (optional). For the numeric converter the parameter "Convert" must be set to TRUE. The variable to be displayed is referenced via the pointer Addr. Parameter "DataType" contains the format description of this parameter (see parameter table). The number of bytes of the variable is linked to the format description. The address justified to the right within the string is specified by parameter "StringAddr". The number of written characters is shown in the parameter table.

#### Signals

Byte 1 is supplied by the output signals of the HHU and the character specifications are supplied by the block. These may not be written by the PLC user program.

**Additional parameters****HHU**

The pointer parameters for the input and output data of the handheld unit must be parameterized in the start OB 100 in FB 1, DB 7. Parameter "BHGIIn" corresponds to the input data of the PLC from the handheld unit (data received by PLC). Parameter "BHGOOut" corresponds to the output data of the PLC to the handheld unit (data transmitted by PLC). These two pointers must be set to the starting point of the relevant data area (which is also parameterized in SDB 210 with an MPI link).

For operating a BHG a "2" is to be entered at FB 1 parameter BHG.

**HT2**

For using a HT2 a "5" is to be entered at FB 1 parameter BHG. The pointer parameter of the input and output data are also to be supplied, as described above.

In the parameters BHGRecGDNo and BHGRecGBZNo the value is to be entered, which is configured at the S2 of the DIP-Fix-switch (rotary coding switch) of the connection module of the HT2.

**Note**

If the numerical converter is used to display information, then it is better to avoid performing a conversion in every PLC cycle for the sake of reducing the PLC cycle time. In this case, it is advisable to use the input signal from the HHU to the PLC "Acknowledgment digital display" (DB m+5.7) for parameter "Convert".

In this way it can be ensured that the most recent numerical information is displayed.

Only the string is processed if the value 0 is entered in the "Row" parameter. The function is therefore not linked to the display control function for BHG, HT2 and can be used as a conversion routine in a string. If "Row" = 0, the pointers for the BHG are not evaluated.

**Declaration of the function****STL representation**

```

DATA_BLOCK "strdat"                // DB-Number defined in the symbol file

STRUCT                             //32 characters are defined
  disp:    STRING [32]:= 'character_line1 character_line2';
END_STRUCT;
BEGIN
END_DATA_BLOCK

FUNCTION FC 13 : VOID
  VAR INPUT
    Row :    BYTE ;                //Display line (see table)
    ChrArray :    STRING ;        //Transfer at least string[32/64]
    Convert :    BOOL ;           //Activate numerical conversion
    Addr:    POINTER;            //Points to the variable being converted
  
```

```

    DataType :    BYTE ;           //Data type of the variables
    StringAddr :  INT ;           //right-justified string address (1...32/64)
    Digits :     BYTE ;           //Number of decimal places (1 to 3)
END VAR
VAR OUTPUT
    Error :      BOOL ;           //Conversion or string error
END VAR

```

## Description of formal parameters

The table below lists all formal parameters of the BHGDisp function:

Signal	Type	Type	Value range	Remark	
Row	I	BYTE	0 ... B#16#F	Display-line "binary" evaluation:	
				0:	no display output
				1:	Line 1
				2:	Line 2
				3:	Line 1 and line 2 to be changed
				4:	Line 3
				5:	Line 1 and line 3 to be changed
				8:	Line 4
			B#16#F	automatic change of all 4 lines	
ChrArray	I	STRING	>= string[32] [DBName].[VarName]	This string contains the entire display content For HT2 the string with 64 characters must be created.	
Convert	I	BOOL		Activation of numerical conversion	
Addr	I	Pointer		Points to the variable to be converted	
DataType	I	BYTE	1 ... 8, B#16#13	Data type of the tag	
				1:	BOOL, 1 character
				2:	BYTE, 3 characters
				3:	CHAR, 1 character
				4:	WORD, 5 characters
				5:	INT, 6 characters
				6:	DWORD, 7 characters
				7:	DINT, 8 characters
				8:	REAL, 9 characters
				(refer Parameter Digits)	

Signal	Type	Type	Value range	Remark
				B#16#13: String, up to 32/64 characters, Addr must be a pointer to a STRING.
StringAddr	I	INT	1 ... 32/64	Right-justified address within variable ChrArray
Digits	I	BYTE	1 ... 4	Relevant only for data type REAL with sign(VZ)
				1: 6.1 digits unsigned
				2: 5.2 digits unsigned
				3: 4.3 digits unsigned
				4: 3.4 digits unsigned
				Specification of digits indicated as unsigned.
Error	Q	BOOL		created ChrArray too small, conversion error, numerical overflow or StringAddr faulty

Ranges of values

Ranges of values of data types	
Data type	Representable numerical range
BOOL	0, 1
BYTE	0 ... 255
WORD	0 ... 65535
INT	- 32768 to + 32767
DWORD	0 ... 9999999
DINT	- 9999999 to + 9999999
REAL (Digits := 1)	- 999999.9 to + 999999.9
REAL (Digits := 2)	- 99999.99 to + 99999.99
REAL (Digits := 3)	- 9999.999 to + 9999.999
REAL (Digits := 4)	- 999.9999 to + 999.9999

## Call example

```
CALL FC 13 (
  Row :=          MB 26,
  ChrArray :=     "strdat".disp,      //DB with name strdat in the symbol table,
                                          //Data element disp is as string[32]
                                          //(HT2: String[64] declared
                                          //and assigned in full with characters

  Convert :=      M 90.1,
  Addr :=        P#M 20.0,           //Number to be converted
  DataType :=    MB 28,              //Data type of the variables
  StringAddr :=  MW 30,
  Digits :=      B#16#3,            //3 decimal places
  Error :=       M 90.2);
```

### 13.13.20 FC 17: YDelta star/delta changeover

#### Function

The block for star/delta changeover controls the timing of the defined switching logic such that the changeover can be performed in either direction even when the spindle is running. This block may be used only for digital main spindle drives and must be called separately for each spindle.

The changeover operation is implemented via 2 separate contactors in a sequence involving 4 steps:

Step 1:	Deleting the interface signal DB31, ... .DBX21.5 (motor selection done) in the related axis-DB and registering the changeover process via A with DB31, ... .DBX21.3 (motor selection).
Step 2:	As soon as the checkback message NST DB31, ... DBX93.7 (Pulse enabled) and the acknowledgment of the announced motor selection from the drive have appeared, the currently energized contactor drops out.
Step 3:	The other contactor is energized after the time period set by the user in parameter "TimeVal" has elapsed.
Step 4:	After a further delay, the changeover is signaled to the drive with NST DB31, ... .DBX21.5 (motor selection done):

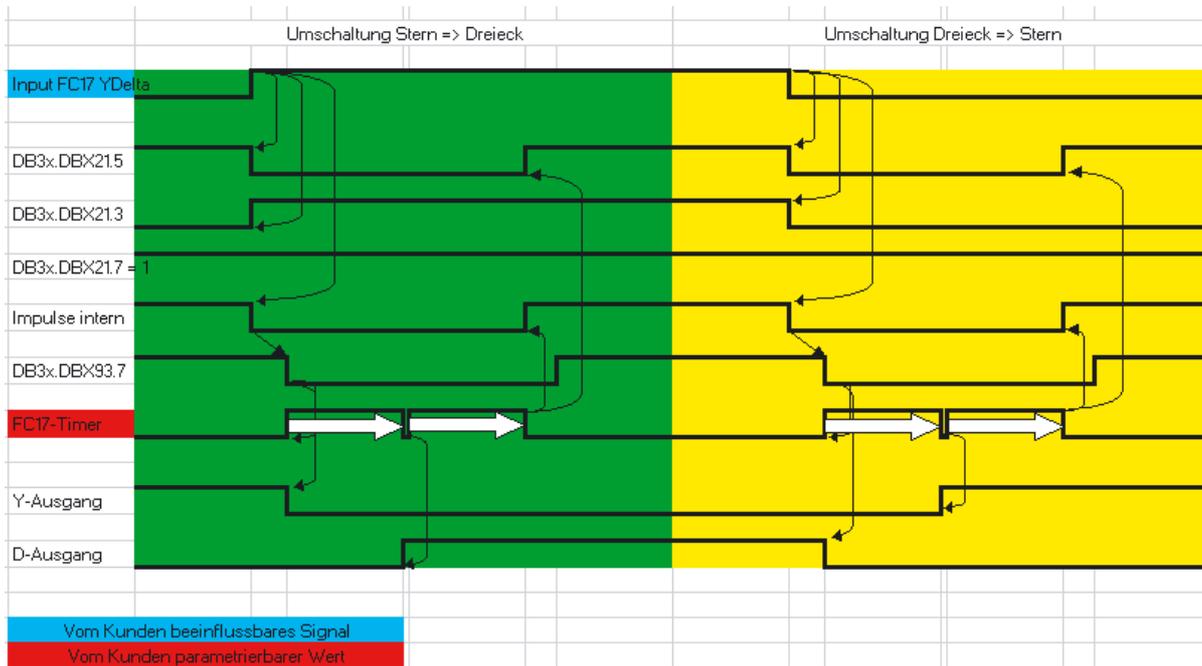


Figure 13-28 Star/delta changeover

For more information on motor speed adjustments see:

**References:**

Function Manual, Basic Functions; Spindles (S1); Chapter "Configurable gear adjustments"  
 Function Manual, Basic Functions; Speeds, Reference/Actual value syst., Regulation (G2)

**Error message**

If the parameter "SpindleIFNo" is not in the permissible range, the PLC is stopped with output of interrupt message number 401702.

**Special features**

When parameterizing "TimeVal" with the value 0, a default value of 100 ms is used. With a value of less than 50 ms, the minimum setting of 50 ms is applied.

The block must be called unconditionally.

**Note**

Switchover does not take place if the spindle is in an axis mode such as M70, SPOS.

## Restrictions

Star/delta changeover on digital main spindle drives initiates a process, which contains closed-loop control sequences. Since the closed-loop control system supports automatic star/delta changeover, certain restrictions should be noted:

- Due to the automatic deactivation of the pulse on the drive, the NST DB31, ... .DBX93.7 (Pulse enabled) deactivates simultaneously the IS DB31, ... .DBX61.7 (current controller active) and DB31, ... .DBX61.6 (speed controller active).
- If a changeover from star to delta takes place while the spindle is rotating and the spindle position controller is switched on, IS "Position controller active" (DB31, ... DBX61.5), this triggers alarm 25050 "Contour monitoring".
- Once the star/delta changeover has been initiated with FC17, it cannot be delayed by the user, e.g. by waiting until the star/delta contactors change over during the course of operation. The user can implement this signal interaction with PLC logic.

## Declaration of the function

### STL Representation

```

VAR_INPUT
  YDelta:          BOOL ;           //Star = 0, delta = 1
  SpindleIFNo:    INT;             //Machine axis number
  TimeVal:         S5TIME ;        //Time value
  TimerNo :       INT;             //User timer for changeover time
END_VAR
VAR_OUTPUT
  Y:               BOOL ;           //Star contactor
  Delta:           BOOL ;           //Delta contactor
END_VAR
VAR_IN_OUT
  Ref:             WORD ;           //Block status word (instance)
END_VAR

```

## Description of formal parameters

The table below lists all formal parameters of the YDelta function:

Signal	Type	Type	Value range	Remark
YDelta	I	BOOL		= Star = Triangle The changeover edge of the signal initiates the changeover operation.
SpindleIFNo	I	INT	1 ...	Number of the axis interface declared as a spindle
TimeVal	I	S5time	0 ...	Switchover time
TimerNo	I	INT	10 ...	Timer for programming the wait time
Y	Q	BOOL		Energizing of star contactor
Delta	Q	BOOL		Energizing of delta contactor
Ref	I/O	WORD		Instance for status information Internal use

## Call example

```
CALL FC 17 (
  YDelta :=          I 45.7,          //Star delta
  SpindleIFNo :=    4,
  TimeVal :=        S5T#150ms,
  TimerNo :=        10,              //Timer 10
  Y :=              Q 52.3,          //Star contactor
  Delta :=          Q 52.4,          //Delta contactor
  Ref :=            mw 50);          //Instance
```

### 13.13.21 FC 18: SpinCtrl spindle control

#### Function

FC SpinCtrl can be used to control spindles and axes from the PLC.

**References:**

/FB1/ Function Manual, Basic Functions; Spindles (S1)  
Function Manual, Extended Functions; Positioning Axes (P2)  
Function Manual, Extended Functions; Indexing Axes (T1)

This block supports the following functions:

- Position spindle
- Rotate spindle
- Oscillate spindle
- Indexing axes
- Positioning axes

Each function is activated by the positive edge of the appropriate initiation signal (start, stop). This signal must remain in the logic "1" state until the function has been acknowledged positively or negatively by InPos="1" or Error = "1". The output parameters are deleted when the relevant trigger signal is reset and the function terminated.

To be able to control an axis or spindle via the PLC, it must be activated for the PLC. This can, for example, be achieved by calling the FC "SpinCtrl" with activation of the "Start" or "Stop" parameter. In this case, the FC "SpinCtrl" requests control over the spindle/axis from the NC.

The NC feeds back the status of this spindle/axis in byte 68 in the associated spindle/axis interface (DB31, ...) (see interface lists). Once the axis/spindle is operating under PLC control, the travel command for the active state can be evaluated via the relevant axis interface.

On completion ("InPos" is TRUE, "Start" changes to zero), the axis/spindle check function is switched to a neutral status by FC "SpinCtrl".

Alternatively, the PLC user program can also request the check for the PLC prior to calling FC "SpinCtrl".

By calling this function several times in succession, a better response reaction by the spindle/axis can be obtained as the changeover process in the FC can be omitted.

Activation through the PLC user program is executed in the corresponding spindle interface in byte 8.

After return of the check, the spindle can again be programmed by the NC program.

---

**Note**

**Please note:**

FC 18 must be called cyclically until signal "InPos" or, in the case of an error "Error", produces an edge transition of 1 to 0. Only when the "InPos"/"Error" signal has a 0 state can the axis/spindle concerned be "started" or "stopped" again (the next "start" must be delayed by at least one PLC cycle). This also applies when the assignment in data byte 8 on the axial interface has been changed.

**Abort:**

The function cannot be aborted by means of parameter "Start" or "Stop", but only by means of the axial interface signals (e.g. delete distance-to-go). The axial interface also returns status signals of the axis that may need to be evaluated (e.g. exact stop, traverse command).

**InPos on spindle - rotation/oscillation:**

For the function "Rotate spindle" and also for "Oscillate spindle" the significance of the parameter "InPos" is defined as follows:

Setpoint speed is output → unction started without errors.

Reaching the desired spindle speed must be evaluated via the spindle interface.

**Simultaneity:**

Several axes can be traversed simultaneously or subject to a delay by FC 18 blocks. The upper limit is defined by the maximum number of axes. The NCK handles the PLC function request (FC 18) via independent interfaces for each axis/spindle.

**Axis disable:**

With the axis disabled, an axis controlled via FC 18 will not move. Only a simulated actual value is generated. (Behavior as with NC programming).

---

 **WARNING**

If several block calls (FC 18) have been programmed for the same axis/spindle in the PLC user program, then the functions concerned must be interlocked by conditional calls in the user program. The conditional call of a started block (parameter Start or Stop = TRUE) must be called cyclically until the signal state of output parameter "Active" or "InPos" changes from 1 to 0.

## Functions

### 1. Position spindle:

The following signals are relevant:

Start:	Initiation signal
Funct:	"1" = Position spindle
Mode:	Positioning mode 1, 2, 3, 4
AxisNo:	Number of machine axis
Pos:	Position
FRate:	Positioning speed, if FRate = 0, the value from MD35300 \$MA_SPIND_POSCTRL_VELO (position control activation speed) is taken
InPos:	Is set to "1" when position is reached with "Exact stop fine".
Error:	With positioning error = "1"
State:	Error code

### 2. Rotate spindle:

The following signals are relevant:

Start:	Initiation signal for start rotation
Stop:	Initiation signal for stop rotation
Funct:	"2" = Rotate spindle
Mode:	Positioning mode 5 (direction of rotation M4) Positioning mode < >5 (direction of rotation M3)
AxisNo:	Number of machine axis
FRate:	Spindle speed
InPos:	Function has started without an error
Error:	With positioning error = "1"
State:	Error code

### 3. Oscillate spindle:

The following signals are relevant:

Start:	Initiation signal for start oscillation
Stop:	Initiation signal for stop oscillation
Funct:	"3" = Oscillate spindle
AxisNo:	Number of machine axis
Pos:	Set gear step
InPos:	Setpoint speed is output
Error:	With positioning error = "1"
State:	Error code

The oscillation speed is taken from machine data:

MD35400 \$MA\_SPIND\_OSCILL\_DES\_VELO

MD35010 \$MA_GEAR_STEP_CHANGE_ENABLE = 0	Function	MD35010 \$MA_GEAR_STEP_CHANGE_ENABLE = 1	Function
Pos = 0	Oscillation	Pos = 0	
Pos = 1	Oscillation	Pos = 1	Oscillation with gear stage change M41

MD35010 \$MA_GEAR_STEP_ CHANGE_ENABLE = 0	Function	MD35010 \$MA_GEAR_STEP_ CHANGE_ENABLE = 1	Function
Pos = 2	Oscillation	Pos = 2	Oscillation with gear stage change M42
Pos = 3	Oscillation	Pos = 3	Oscillation with gear stage change M43
Pos = 4	Oscillation	Pos = 4	Oscillation with gear stage change M44
Pos = 5	Oscillation	Pos = 5	Oscillation with gear stage change M45

#### 4. Traverse indexing axis:

The following signals are relevant:

Start:           Initiation signal  
 Funct:           "4" = Indexing axis

---

#### Note

With Funct: "4" = Indexing axis

The modulo conversion can be compared with approaching the indexing position via  
 POS[AX] = CIC (value) in the part program.

---

Mode:	Positioning mode 0, 1, 2, 3, 4
AxisNo:	Number of machine axis
Pos:	Indexing position
FRate:	Positioning speed; if FRate = 0, the value is taken from machine data POS_AX_VELO (unit as set in machine data).
InPos:	Is set to "1" when position is reached with "Exact stop fine".
Error:	With positioning error = "1"
State:	Error code

**5 to 8. Position axes:**

The following signals are relevant:

Start:	Initiation signal
Funct:	"5 to 8" = Position axes
Mode:	Positioning mode 0, 1, 2, 3, 4
AxisNo:	Number of machine axis
Pos:	Position
FRate:	Positioning speed; if FRate = 0, the value is taken from machine data POS_AX_VELO (unit as set in machine data).
InPos:	Is set to "1" when position is reached with "Exact stop fine".
Error:	With positioning error = "1"
State:	Error code

**9. Rotate spindle with automatic gear stage selection:**

The following signals are relevant:

Start:	Initiation signal for start rotation
Stop:	Initiation signal for stop rotation
Funct:	"9" = Rotate spindle with gear stage selection
Mode:	Positioning mode 5 (direction of rotation M4)
	Positioning mode < >5 (direction of rotation M3)
AxisNo:	Number of machine axis
FRate:	Spindle speed
InPos:	Setpoint speed is output
Error:	With positioning error = "1"
State:	Error code

**10/11. Rotate spindle with constant cutting rate:**

The "Constant cutting rate" function must be activated by the NC program in order for this to be executed.

The following signals are relevant:

Start:	Initiation signal for start rotation
Stop:	Initiation signal for stop rotation
Funct:	"B#16#0A = Rotate spindle with constant cutting rate (m/min)
Funct:	"B#16#0B = Rotate spindle with constant cutting rate (feet/min)
Mode:	Positioning mode 5 (direction of rotation M4)
	Positioning mode < >5 (direction of rotation M3)
AxisNo:	Number of machine axis
FRate:	cutting rate
InPos:	Setpoint speed is output
Error:	With position error = "1"
State:	Error code

**Declaration of the function**

```

FUNCTION FC 18: VOID                                //SpinCtrl
VAR_INPUT
    Start:          BOOL ;
    Stop:           BOOL ;
    Funct:          BYTE ;
    Mode:           BYTE ;
    AxisNo:         INT;
    Pos:            REAL;
    FRate:          REAL;
END_VAR
VAR_OUTPUT
    InPos:          BOOL ;
    Error:          BOOL ;
    State:          BYTE ;
END_VAR
    
```

**Description of formal parameters**

The table below lists all formal parameters of the SpinCtrl function.

Signal	Type	Type	Range of values	Remark
Start	I	BOOL		Start spindle control from PLC
Stop	I	BOOL		Stop spindle control from PLC
Funct	I	BYTE	1 to B#16#0B	1: Position spindle 2: Rotate spindle 3: Oscillate spindle 4: Indexing axis 5: Positioning axis metric 6: Positioning axis inch 7: PosAxis metric with handwheel override 8: PosAxis inch with handwheel override 9: Rotate spindle with automatic gear stage selection A: Rotate spindle with constant cutting rate (m/min) B: Rotate spindle with constant cutting rate (feet/min)
Mode	I	BYTE	0 to 5	0: Pos to absolute pos 1: Pos incrementally 2: Pos shortest path 3: Pos absolute, positive approach direction 4: Pos absolute, negative approach direction 5: Rotational direction as for M4

Signal	Type	Type	Range of values	Remark
AxisNo	I	INT	1 - 31	No. of axis/spindle to be traversed
Pos	I	REAL	± 0.1469368 I -38 to ± 0.1701412 I +39	Rotary axis: Degrees Indexing axis: Indexing position Linear axis: mm or inches
FRate	I	REAL	± 0.1469368 I -38 to ± 0.1701412 I +39	Rotary axis and spindle: rev/min See under table containing info about FRate
InPos	Q	BOOL		1 = Position reached, or function executed
Error	Q	BOOL		1 = error
State	Q	BYTE	0 to 255	Error code

## FRate

The feed rate in FC 18 can also be specified as:

- Cutting rate with unit m/min or feet/min
- Constant grinding wheel surface speed in m/s or feet/s

These alternative velocity settings can be used only if this function is activated by the NC program. Checkback signals for successful activation can be found in byte 84 on the axis interface.

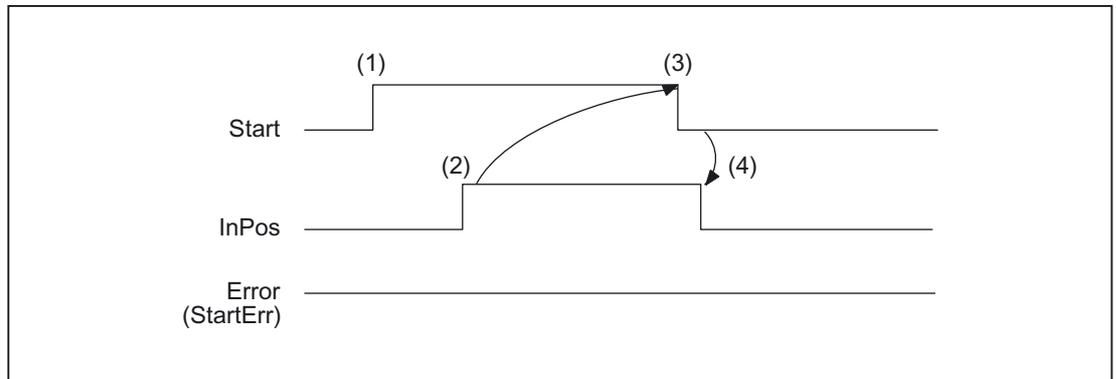
## Error identifiers

If a function could not be executed, this is indicated by the "Error" status parameter being set to 'logic 1'. The error cause is coded at block output "State":

State	Significance
Errors caused by PLC handling:	
1 B#16#1	Several axis/spindle functions have been activated simultaneously
20 B#16#14	A function has been started without the position being reached
30 B#16#1e	The axis/spindle has been transferred to the NC while still in motion
40 B#16#28	The axis is programmed by the NC program, NCK internal error
50 B#16#32	permanently assigned PLC axis traverses (JOG) or refers
60 B#16#3C	permanently assigned PLC axis Channel status does not permit a start
Errors that occur due to handling of the NCK.	
The alarm numbers are described in the Diagnostics Manual SINUMERIK 840D s1/ 840Di s1:	
100 B#16#64	False position programmed for axis/spindle (corresponds to alarm number 16830)
101 B#16#65	Programmed speed is too high
102 B#16#66	False value range constant cutting speed (corresponds to \MMC-Alarm 14840)

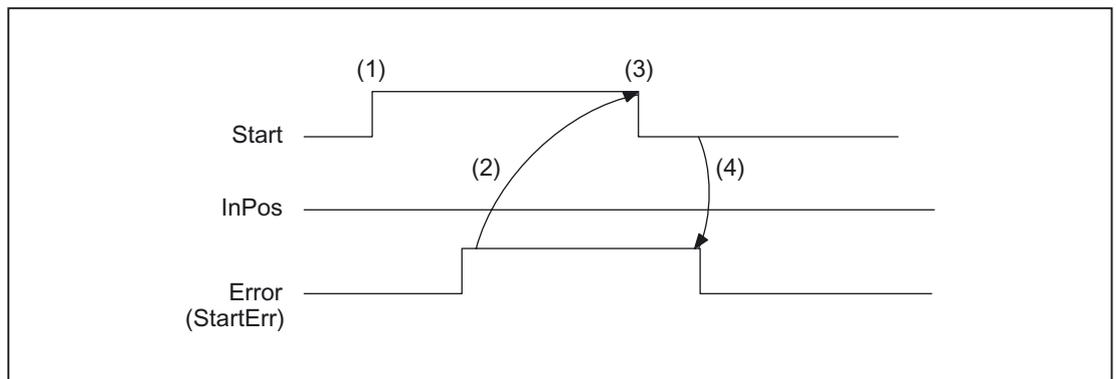
State	Significance
104 B#16#68	Following spindle: illegal programming (corresponds to alarm number 22030)
105 B#16#69	No measuring system available (corresponds to alarm number 16770)
106 B#16#6a	Positioning process of the axis still active (corresponds to alarm number 22052)
107 B#16#6b	Reference mark not found (corresponds to alarm number 22051)
108 B#16#6c	No transition from speed control to position control (corresponds to alarm number 22050)
109 B#16#6d	Reference mark not found (corresponds to alarm number 22051)
110 B#16#6e	Velocity/speed is negative
111 B#16#6f	Setpoint speed is zero
112 B#16#70	Invalid gear stage
115 B#16#73	Programmed position has not been reached
117 B#16#75	G96/G961 is <b>not active</b> in the NC
118 B#16#76	G96/G961 is <b>still active</b> in the NC
120 B#16#78	Axis is indexing axis (corresponds to MMC-alarm 20072)
121 B#16#79	Indexing position error (corresponds to MMC-alarm 17510)
125 B#16#7d	DC (shortest path) not possible (corresponds to MMC-alarm 16800)
126 B#16#7e	Abs. value Minus not possible (corresponds to MMC-alarm 16820)
127 B#16#7f	Abs. value Plus not possible (corresponds to MMC-alarm 16810)
128 B#16#80	No transverse axis available for diameter programming (corresponds to MMC-alarm 16510)
130 B#16#82	Software end switch Plus (corresponds to MMC-alarm 20070)
131 B#16#83	Software end switch Minus (corresponds to MMC-alarm 20070)
132 B#16#84	Working area limit Plus (corresponds to MMC-alarm 20071)
133 B#16#85	Working area limit Minus (corresponds to MMC-alarm 20071)
134 B#16#85	Frame not permitted for indexing axis
135 B#16#87	Indexing axis with "Hirth-tooththing" is active (corresponds to MMC-alarm 17501)
136 B#16#88	Indexing axis with "Hirth-tooththing" is active and axis not referenced (corresponds to MMC-alarm 17503)
137 B#16#89	Spindle operation not possible for transformed spindle/axis (corresponds to MMC-alarm 22290)
138 B#16#8A	for the axis the corresponding effective coordinate-system-specific working area limit Plus violated (corresponds to MMC-alarm 20082)
139 B#16#8B	for the axis the corresponding effective coordinate-system-specific working area limit Minus violated (corresponds to MMC-alarm 20082)
System or other serious interrupts:	
200 B#16#c8	Corresponds to system interrupt number 450007

### Pulse diagram



- (1) Activation of function by means of a positive signal edge with start or stop
- (2) Positive acknowledgment: Function executed/Position reached
- (3) Reset function activation after receipt of acknowledgment
- (4) Signal change using FC

### Timing diagram (fault scenario)



- (1) Activation of function by means of a positive signal edge with start or stop
- (2) Negative acknowledgment: Error has occurred
- (3) Reset function activation after receipt of acknowledgment
- (4) Signal change using FC

## Call examples

## 1. Position spindle:

```

//Positive acknowledgment resets Start:
U M112.0;           //InPos
R M 100.0;         //Start
//Negative acknowledgment, after error evaluation (state: MB114) reset with T12
start
U M113.0;         // Error
U I 6.4;          //Key T12
R M 100.0;         //Start
//Start with T13
U I 6.3;          //Key T13
AN F 112.0;       //Restart only when InPos or Error = 0
AN F 113.0;
S M 100..0;

CALL FC 18 (
    Start :=      M100.0,
    Stop :=       FALSE,
    Funct :=      B#16#1,           //Position spindle
    Mode :=       B#16#2,           //Shortest path
    AxisNo :=     5,
    Pos :=        MD104,
    FRate :=      MD108,
    InPos :=      M112.0,
    Error :=      M113.0,
    State :=      MB114);

```

## 2. Start spindle rotation:

```

CALL FC 18 (
    Start :=      M100.0,
    Stop :=       FALSE,
    Funct :=      B#16q#,           //Rotate spindle
    Mode :=       B#16#5,           //Rotational direction as for M4
    AxisNo :=     5,
    Pos :=        0.0,
    FRate :=      MD108,
    InPos :=      M112.0,
    Error :=      M113.0,
    State :=      MB114);

```

### 3. Start spindle oscillation

```
CALL FC 18 (  
    Start :=      M100.0,  
    Stop :=       FALSE,           //Oscillate spindle  
    Funct :=      B#16#3,  
    Mode :=       B#16#0,  
    AxisNo :=     5,  
    Pos :=        0.0,  
    FRate :=      MD108,  
    InPos :=      M112.0,  
    Error :=      M113.0,  
    State :=      MB114);
```

### 4. Traverse indexing axis

```
CALL FC 18 (  
    Start :=      M100.0,  
    Stop :=       FALSE,           //Not used  
    Funct :=      B#16#4,         //Traverse indexing axis  
    Mode :=       B#16#0,         //Position absolutely  
    AxisNo :=     4,  
    Pos :=        MD104,          //Default setting in REAL: 1.0;2.0;..  
    FRate :=      MD108,  
    InPos :=      M112.0,  
    Error :=      M113.0,  
    State :=      MB114);
```

### 5. Position axes

```
CALL FC 18 (  
    Start :=      M100.0,  
    Stop :=       FALSE,           //Not used  
    Funct :=      B#16#5,         //Position axes  
    Mode :=       B#16#1,         //Position incrementally  
    AxisNo :=     6,  
    Pos :=        MD104,  
    FRate :=      MD108,  
    InPos :=      M112.0,  
    Error :=      M113.0,  
    State :=      MB114);
```

### 13.13.22 FC 19: MCP\_IFM transmission of MCP signals to interface

#### Function

With the FC MCP\_IFM (M-variant) from the machine control panel a range of 19 inch e.g. MCP 483 are transferred to the corresponding signals of the NCK-/PLC-interface:

- Mode Groups
- Axis selections
- WCS/MCS switchover commands
- Traversing keys
- Overrides
- Key-operated switch

In the basic program (FC 2) handwheel selections, modes and other operating signals are transferred from the operator panel front (HMI) to the NCK/PLC interface so that the modes support selection from the MCP or HMI.

Transfer of MMC signals to the interface can be deactivated by setting the value of the parameter "MMCToIF" to "FALSE" in FB 1 (DB 7).

The following specifications apply to the **feed override**, **axis travel keys** and **INC keys** depending on the active mode or on the coordinate system selected:

- **Feed override:**
  - The feed override is transferred to the interface of the selected channel and to the interface of the axes.
  - The feed override signals are transferred to the NC channel in addition to the "Rapid traverse override" (DBB 5) interface byte if the "Feed override for rapid traverse effective" HMI signal is set (exception: Switch setting "Zero"). "Rapid traverse override effective" is also set with this HMI signal.
- **Machine functions for INC and axis travel keys:**
  - When the MCS is selected, the signals are transferred to the interface of the selected machine axis.
  - When the WCS is selected, the signals are transferred to the geo-axis interface of the parameterized channel.
  - When the system is switched between MCS and WCS, the active axes are generally deselected.

The **handwheel selection signals from the HMI** are decoded and activated in the machine-axis or the Geo-axis interface of the handwheel selected (only if parameter "HWheelMMC := TRUE" in FB 1).

The LEDs on the machine control panel derived from the selections in the acknowledgment.

Feedrate and spindle Start/Stop are not transferred to the interface, but output modally as a "FeedHold" or "SpindleHold" signal. The user can link these signals to other signals leading to a feed or spindle stop (this can be implemented, e.g. using the appropriate input signals in FC 10: AL\_MSG). The associated LEDs are activated at the same time.

If the machine control panel fails, the signals it outputs are preset to zero; this also applies to "FeedHold" and "SpindleHold" output signals.

Multiple calls of FC 19 or FC 24, FC 25, FC 26 are permitted in a single PLC cycle. In this case, the first call in the cycle drives the LED displays. Furthermore, all actions of the parameterized block are carried out in the first call. In the following calls, only a reduced level of processing of the channel and mode group interface takes place. The geometry axes are supplied with directional data only in the first block call in the cycle.

Single block processing can be selected/deselected only in the first call in the cycle.

The second machine control panel can be processed if parameter "ModeGroupNo" has been increased by B#16#10. When parameterizing, the HHU number is contained in the lower nibble (lower 4 bits).

"BAGNo" = 0 or B#16#10 means that the mode group signals are not processed.

"ChanNo" = 0 means that the channel signals are not processed.

The INC selections are transferred to the mode group interface. The activation for this specification is done via the DB10.DBX57.0 (INC-inputs in BAG-area active) through this block once after power up.

Machine control panels can still be handled in parallel by this module. The module 2 call for the 2nd machine control panel in OB1 cycle must come after the call of the 1st MCP Support for two MCPs is provided in the control panel blocks up to certain limits (support is not provided as standard for mutual interlocking of axis selections with identical assignments on two MCPs).

## Flexible axis configuration

It is possible to be flexible in the assignment of axis selections or direction keys for machine axis numbers.

Better support is now provided by the MCP blocks for the use of two MCPs, which are to run in parallel, in particular for an application using two channels and two mode groups. Note that the axis-numbers are also specified in the parameterized mode group number of the MCP block in the axis tables of the relevant MCP.

To afford this flexibility, tables for axis numbers are stored in DB 10.

For the **first** machine control panel (MCP) the table starts from the byte 8 (symbolic name: MCP1AxisTbl[1..22]) and for the **second** Machine control panel (MCP) starting from the byte 32 (symbolic name: MCP2AxisTbl[1..22]) for the second MCP. Here the machine axis numbers are to be entered byte-wise.

It is permissible to enter a value of 0 in the axis table. Checks are not made to find illegal axis numbers, meaning that false entries can lead to a PLC Stop.

For **FC 19**, the **maximum possible number of axis selections** can also be restricted. This upper limit is set for the first Machine control panel in DB10.DBW30 (symbolic name: MCP1MaxAxis) or for the second Machine control panel in DB10.DBW54 (symbolic name: MCP2MaxAxis) set.

The default setting is 0, corresponding to the maximum number of configured axes. The axis numbers and the limit can also be adapted dynamically. Afterwards, a new axis must be selected on FC 19. Axis numbers may not be switched over while the axes are traversing the relevant direction keys.

The compatibility mode is preset with axis numbers **1 to 9** for both MCPs and restricted to the configured number of axes.

## Example

More than nine axes are to be controlled with FC19 using a special application. We recommend that you proceed as follows:

- Reserve free key on MCP
- Evaluate this key as a flipflop
- Evaluate the flipflop output as pos. and neg. edge
- For pos. edge write one set of axis numbers in the axis table (DB10) and switch on LED via this key.
- For neg. edge write one set of axis numbers in the axis table (DB10) and switch on LED via this key.

## Declaration of the function

```

FUNCTION FC 19 : VOID                                //symbolic name: MCP_IFM

  VAR_INPUT
    BAGNo :          BYTE ;
    ChanNo:          BYTE ;
    SpindleIFNo:     BYTE ;
  END_VAR

  VAR_OUTPUT
    FeedHold :       BOOL ;
    SpindleHold :   BOOL ;
  END_VAR

BEGIN
END_FUNCTION

```

### Description of formal parameters

The table below shows all formal parameters of the "MCP\_IFM" function:

Signal	Type	Type	Range of values	Remark
BAGNo	I	BYTE	0 - b#16#0A and b#16#10 - b#16#1A	No. of mode group to which the mode signals are transferred. BAGNo >= b#16#10 means access to the second machine control panel.
ChanNo	I	BYTE	0 - B#16#0A	Channel no. for the channel signals
SpindleIFNo	I	BYTE	0 - 31 (B#16#1F)	Number of the axis interface declared as a spindle
FeedHold	Q	BOOL		Feed stop from MCP, modal
SpindleHold	Q	BOOL		Spindle stop from MCP, modal

### MCP selection signals to the user interface

#### Key-operated switch

Source: MCP - Switch	Destination: Interface DB
Position 0	DB10.DBX56.4
Position 1	DB10.DBX56.5
Position 2	DB10.DBX56.6
Position 3	DB10.DBX56.7

### Operating modes and machine functions

Source: MCP - Key	Destination: Interface DB (parameter BAGNo) Display for BAG 1
AUTOMATIC	DB11.DBX0.0
MDI	DB11.DBX0.1
JOG	DB11.DBX0.2
REPOS	DB11.DBX1.1
REF	DB11.DBX1.2
TEACH IN	DB11.DBX1.0
INC 1 ... 10 000, INC Var.	DB11.DBX2.0 - 2.5

### Direction keys rapid traverse override

The transfer is dependent upon the selected axis. The associated interface bits are deleted for axes, which are not selected.

Source: MCP - Key	Destination: Interface DB (parameter ChanNo)
Direction key +	DB21, ... .DBX12.7
Direction key -	DB21, ... .DBX12.6
Rapid traverse override	DB21, ... .DBX12.5
Direction key +	DB21, ... .DBX16.7
Direction key -	DB21, ... .DBX16.6
Rapid traverse override	DB21, ... .DBX16.5
Direction key +	DB21, ... .DBX20.7
Direction key -	DB21, ... .DBX20.6
Rapid traverse override	DB21, ... .DBX20.5

Source: MCP - Key	Destination: Interface DB (all axis DBs)
Direction key +	DB31, ... .DBX4.7
Direction key -	DB31, ... .DBX4.6
Rapid traverse override	DB31, ... .DBX4.5

### Override

Source: MCP - Switch	Destination: Interface DB (parameter ChanNo)
Feedrate override	DB21, ... .DBB4

Source: MCP - Switch	Destination: Interface DB (all axis DBs)
Feedrate override	DB31, ... .DBB0 (selected axis number) The feed override of the 1st MCP is applied to all axes.
Spindle override	DB31, ... .DBB19 (parameter SpindleIFNo)

## Channel signals

Source: MCP - Keys	Destination: Interface DB (parameter ChanNo)
NC start	DB21, ... .DBX7.1
NC stop	DB21, ... .DBX7.3
RESET	DB21, ... .DBX7.7
Single BLock	DB21, ... .DBX0.4

## Feedrate, spindle signals

Source: MCP - Keys	Destination: FC output parameters
Feed stop Feed enable	Parameter: "FeedHold" linked with memory, LED are controlled
Spindle stop Spindle enable	Parameter: "SpindleHold" linked with memory, LED are controlled

## Checkback signals from user interface for controlling displays

## Operating modes and machine functions

Destination: MCP - LED	Source: Interface DB (parameter BAGNo) Display for BAG 1
AUTOMATIC	DB11.DBX6.0
MDA	DB11.DBX6.1
JOG	DB11.DBX6.2
REPOS	DB11.DBX7.1
REF	DB11.DBX7.2
TEACH IN	DB11.DBX7.0

Aim: MCP - LED	Source: Interface DB (parameter BAGNo) Display for BAG 1
INC 1 ... 10 000, INC Var.	DB11.DBX2.0 - 8.5

## Channel signals

Destination: MCP - LED	Source: Interface DB (parameter ChanNo)
NC start	DB21, ... .DBX35.0
NC stop	DB21, ... .DBX35.2 or DB21, ... .DBX35.3
Single Block	DB21, ... .DBX0.4

### Note

Direction key LEDs are controlled by operating the direction keys.

Axis selection and WCS/MCS LEDs are controlled by operating the relevant pushbutton switch.

## Call example

```
CALL FC 19 ( //Machine control panel M variants Signals to interface
  BAGNo := B#16#1, //Mode group no. 1
  ChanNo := B#16#1, //Channel no. 1
  SpindleIFNo := B#16#4, //Spindle interface number = 4
  FeedHold := m22.0, //Feed stop signal modal
  SpindleHold := db2.dbx151.0); //Spindle stop modal in
//message DB
```

With these parameter settings, the signals are sent to the 1st mode group, the 1st channel and all axes. In addition, the spindle override is transferred in the 4th axis/spindle interface. The feed hold signal is passed to bit memory 22.0 and the spindle stop signal to data block DB2, data bit 151.0.

## Reconnecting the axis selections

To ensure a flexible assignment of the axis selection keys to the appropriate axis or spindle, FC 19 **needs not be modified or reprogrammed**. The axis number simply has to be entered in axis table DB10.DBB8 and followed as required: The axis number simply has to be entered in axis table DB10.DBB8 and followed as required:

### Example:

The spindle is defined as the 4th axis and must be selected via axis key 9.

```
Solution:
The value 4 must be entered in DB10 byte (8+(9-1)) for the 4th axis.

CALL FC 19 ( //signals to interface
  BAGNo := B#16#1, //Mode group no. 1
  ChanNo := B#16#1, //Channel no. 1
```

```

SpindleIFNo :=      B#16#4,      //Spindle interface number = 4

FeedHold :=        m30.0,        //Feed stop signal modal
SpindleHold :=     m30.1);       //Spindle stop modal

```

### 13.13.23 FC 21: transfer PLC NCK data exchange

#### Function

When the Transfer block is called, data are exchanged between the PLC and NCK according to the selected function code. Data are transferred as soon as FC 21 is called, not only at the start of the cycle.

The "Enable" signal activates the block.  
FC 21 is processed only when "Enable" = "1".

The following functions for the data exchange between PLC and NCK are supported:

1. Signal synchronized actions at the NCK - channel
2. Signals synchronized actions from NCK - channel
3. Fast data exchange PLC-NCK (Read function in NCK)
4. Fast data exchange PLC-NCK (Write function in NCK)
5. Update control signals to NCK - channel
6. Update control signals to axes (data byte 2 of the user interface)
7. Update control signals to axes (data byte 4 of the user interface)

#### Declaration of the function

##### STL Representation

```

VAR_INPUT
  Enable :      BOOL ;
  Funct:      BYTE ;
  S7Var :      ANY ;
  IVar1 :      INT;
  IVar2 :      INT;
END_VAR

VAR_OUTPUT
  Error :      BOOL ;
  ErrCode :    INT;
END_VAR

```

### Explanation of formal parameters

The table below shows all formal parameters of the "Transfer" function.

Signal	Type	Type	Value range	Comment	
Enable	I	BOOL		1 = FC 21 active	
Funct	I	BYTE	1 ... 7	1:	Synchronized actions at channel
				2:	Synchronized actions from channel
				3:	Read data
				4:	Write data
				5:	Control signals to channel
				6, 7:	Control signals to axis
S7Var	I	ANY	S7 data storage area	Depends on "Funct"	
IVAR1	I	INT	0 ...	Depends on "Funct"	
IVAR2	I	INT	1 ...	Depends on "Funct"	
Error	Q	BOOL			
ErrCode	Q	INT		Depends on "Funct"	

### Function 1, 2: Signals synchronized actions to/from Channel

Synchronized actions can be disabled or enabled by the PLC.

The data area is stored on the user interface in DB21, ... .DBB 300..307 (to channel) and DB 21, ... .DBB 308 ...315 (from channel). The parameter "S7Var" is not evaluated for this function, but must be assigned an actual parameter (see call example). The data are transferred to/from the NC as soon as FC 21 is processed.

The following signals are relevant:

Signal	Type	Type	Value range	Comment	
Enable	I	BOOL		1 = FC 21 active	
Funct	I	BYTE	1, 2	1:	Synchronized actions at channel
				2:	Synchronized actions from channel
S7Var	I	ANY	S7 data storage area	Not used	
IVAR1	I	INT	1..MaxChannel	Channel number	
Error	Q	BOOL			
ErrCode	Q	INT		1:	"Funct" invalid
				10:	Channel no. invalid

#### Call example:

```

FUNCTION FC 100 : VOID
VAR_TEMP
    myAny:          ANY ;
END_VAR
BEGIN
NETWORK
...

```

```
// Deactivate synchronized actions with ID3, ID10 and ID31 in NC channel 1 :
SYAK:          TO DB21;
SET;
S DBX300.2;    //ID3
S DBX301.1;    //ID10
S DBX303.6;    //ID31
L B#16#1;
T MB11;
SPA TRAN;

// Synchronized actions from NCK channel:
SYVK:          L B#16#2;
               T MB11;
TRAN: CALL FC 21 (
               Enable :=      M 10.0,          // if TRUE, FC 21 active
               Funct :=      MB 11,
               S7Var :=      #myAny,          //Not used
               IVAR1 :=      1,              //Channel no.
               IVAR2 :=      0,
               Error :=      M 10.1,
               ErrCode :=     MW 12);
...
END_FUNCTION
```

### Function 3, 4: Rapid data exchange PLC-NCK

#### General

A separate, internal data area is provided to allow the high-speed exchange of data between the PLC and NCK. The size of the internal data field is preset to 1024 bytes. The accesses (read/write) from PLC take place via the FC 21. The occupation of this range (structure) must be defined identically in the NC part program and the PLC user program.

These data can be accessed from the NC parts program by commands \$A\_DBB[x], \$A\_DBW[x], \$A\_DBD[x], \$A\_DBR[x] (see Parameter Manual System variables).

The concrete address in the data field is specified by a byte offset (0 to 1023) in parameter IVAR1. In this case, the alignment must be selected according to the data format, i.e. a Dword starts at a 4-byte limit and a word at a 2-byte limit. Bytes can be positioned on any chosen offset within the data field, single-bit access operations are not supported and converted to a byte access operation by FC 21. Data type information and quantity of data are taken from the ANY parameter, transferred via S7Var.

Without additional programming actions, data consistency is only ensured for 1 and 2 byte access in the NCK and in the PLC. For the 2-byte consistency this is true only for the data type WORD or INT, but not for the data type BYTE.

In the case of longer data types or transfer of fields, which should be transferred consistently, a semaphore byte must be programmed in parameter IVAR2 that can be used by FC 21 to determine the validity or consistency of a block. This handling must be supported by the NC, i.e. in the part program, by writing or deleting the semaphore byte. The semaphore byte is stored in the same data field as the actual user data.

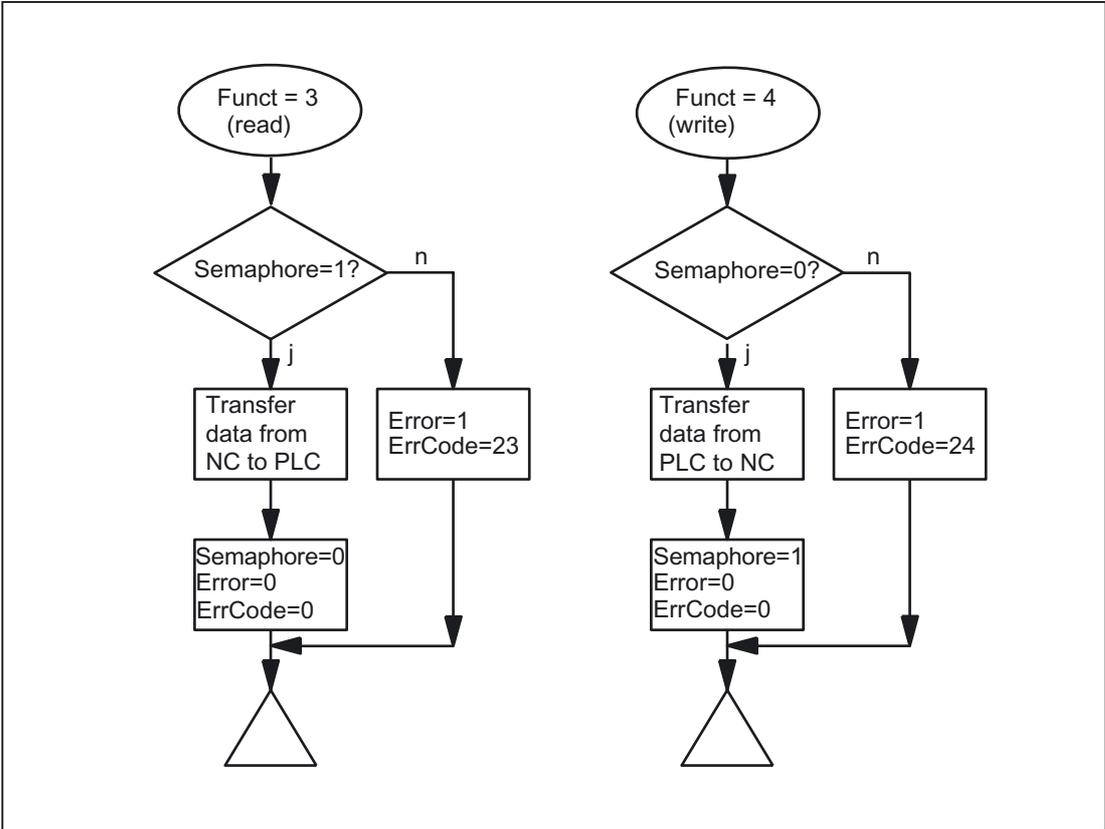
The semaphore byte is identified by a value between 0 and 1023 in IVAR2.

The PLC reads and describes the semaphore byte via FC 21 in the same call, which should transfer the user data. The PLC programmer only needs to set up a semaphore variable. For access from the NC via the parts program, the semaphore feature must be programmed using individual instructions according to the flow chart shown below. The sequence is different for reading and writing variables.

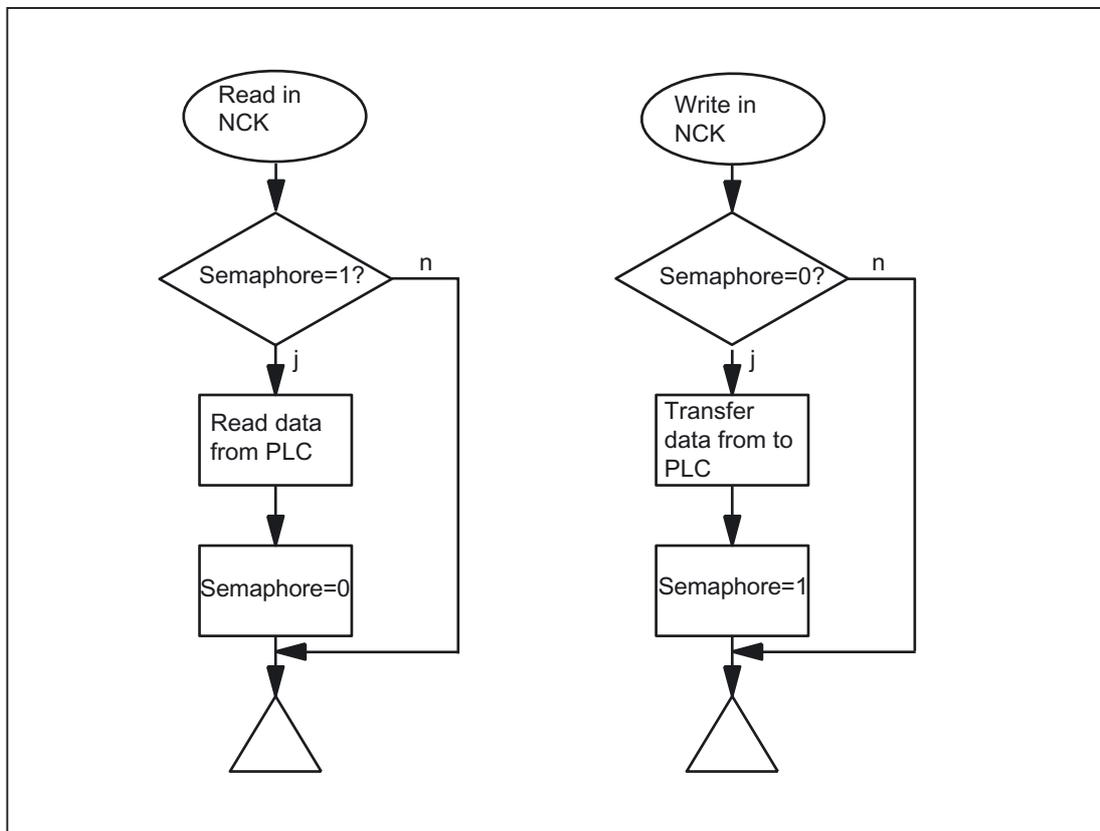
Only individual variables or ARRAYS can be supported directly by the semaphore technique. Structure transfers must be subdivided into individual jobs. The user must ensure data consistency of this structure by programming a semaphore system.

If IVAR2 is set to -1, data are transferred without a semaphore.

Data exchange with semaphore in PLC (schematic of FC 21)



Basic structure in NCK:



**Variable value ranges**

The following signals are relevant:

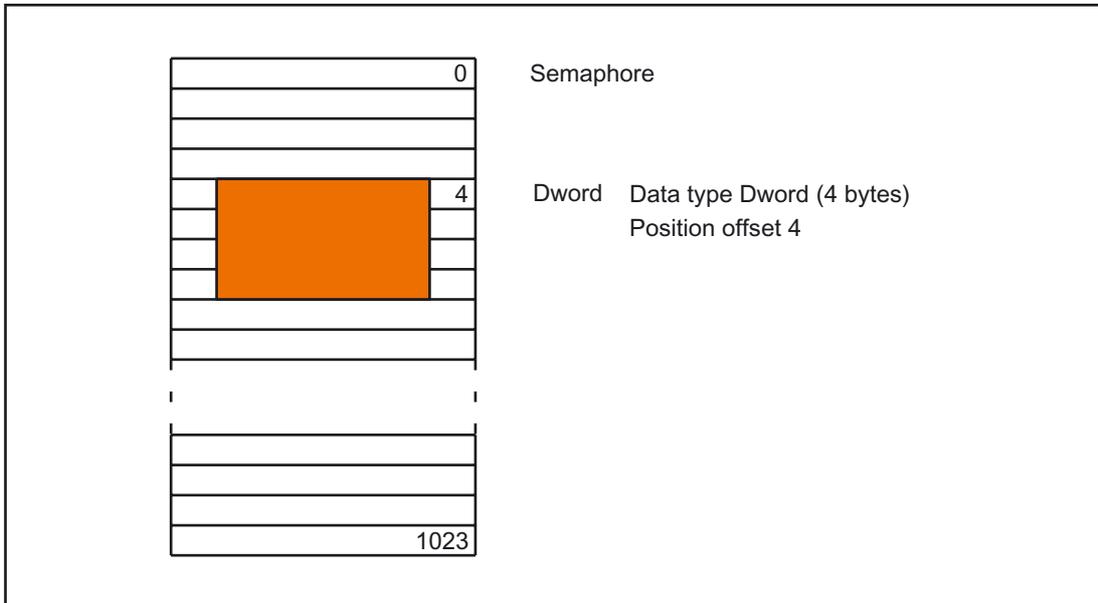
Signal	Type	Type	Value range	Comment
Enable	I	BOOL		= FC 21 active
Funct	I	BYTE	3, 4	3: Read data
				4: Write data
S7Var	I	ANY	S7 data area, except local data	Source/destination data storage area
IVAR1	I	INT	0 ... 1023	Position offset
IVAR2	I	INT	-1 ... 1023	Semaphore byte Transfer without semaphore: -1
Error	Q	BOOL		
ErrCode	Q	INT		20: Alignment error
				21: Illegal position offset
				22: Illegal semaphore byte
				23: No new data to be read
				24: Cannot write data
				25: Local data parameterized for S7Var

**Call example:**

**1. Read double word of position offset 4 with semaphore in byte 0 and store in MD 100:**

Data type Dword (4 bytes)

Position offset 4



```

CALL FC 21 (
  Enable :=      M 10.0,           // if TRUE, FC 21 active
  Funct  :=      B#16#3,          //Read data
  S7Var  :=      P#M 100.0 DWORD 1,
  IVAR1  :=      4,
  IVAR2  :=      0,
  Error  :=      M 10.1,
  ErrCode :=     MW12);
UN M10.1;           //Enable as long as 1,
                   //till value is read
R F10.0;

```

**Examples: Examples of NCK programming from synchronized actions:**

**Data transfer from NC to PLC, with data written via synchronized actions;**

**Byte 0 serves as the semaphore**

```
ID=1 WHENEVER $A_DBB[0] == 0 DO $A_DBR[4] = $AA_IM[X] $A_DBB[0] = 1
```

**Data transfer from PLC to NC, with data read via synchronized actions;**

**Byte 1 serves as the Semaphore:**

```
ID=2 WHENEVER $A_DBB[1] == 1 DO $R1 = $A_DBR[12] $A_DBB[1] = 0
```

**2. Read word of position offset 8 without semaphore and store in MW 104:**

```

CALL FC 21 (
  Enable :=      M 10.0,           // if TRUE, FC 21 active
  Funct  :=      B#16#3,           //Read data
  S7Var  :=      P#M 104.0 WORD 1,
  IVAR1  :=      8,
  IVAR2  :=      -1,
  Error  :=      M 10.1,
  ErrCode :=      MW12);

```

**Function 5: Update control signals to channel**

The purpose of function 5 is to transmit important control signals at high speed in between cyclic data transfers. Data bytes 6 and 7 of user interfaces DB21, ... are transferred to the NC. The channel is specified in parameter "IVAR1". This enable, for example, the feed disable, read-in disable to be transferred outside of the PLC cycle.

The following signals are relevant:

Signal	Type	Type	Value range	Comment
Enable	I	BOOL		1= FC 21 active
Funct	I	BYTE	5	5: Control signals to channel
S7Var	I	ANY	S7 data storage area	Not used
IVAR1	I	INT	1st max. channel	Channel number
Error	Q	BOOL		
ErrCode	Q	INT		1: "Funct" invalid
				10: Channel no. invalid

**Function 6: Update control signals to axes**

The purpose of function 6 is to transmit important control signals at high speed in between cyclic data transfers. The **data byte 2** of application interface DB31, ... is transferred to the NC. The transfer is performed for all activated axes. This allows the servo enable to be transferred outside the PLC cycle, for example.

The following signals are relevant:

Signal	Type	Type	Value range	Comment
Enable	I	BOOL		1= FC 21 active
Funct	I	BYTE	6	6: Control signals to axes
S7Var	I	ANY	S7 data storage area	Not used
IVAR1	I	INT	0	
Error	Q	BOOL		
ErrCode	Q	INT		1: "Funct" invalid

### Function 7: Update control signals to axes

The purpose of function 7 is to transmit important control signals at high speed in between cyclic data transfers. The **data byte 4** of application interface DB31, ... is transferred to the NC. The transfer is performed for all activated axes. This enables, for example, the feed stop to be transferred outside the PLC cycle.

The following signals are relevant:

Signal	Type	Type	Value range	Comment
Enable	I	BOOL		1= FC 21 active
Funct	I	BYTE	7	7: Control signals to axes
S7Var	I	ANY	S7 data storage area	Not used
IVAR1	I	INT	0	
Error	Q	BOOL		
ErrCode	Q	INT		1: "Funct" invalid

### 13.13.24 FC 22: TM\_DIR Direction selection for tool management

#### Function

The block TM\_DIR provides the shortest path for positioning a magazine or a revolver based on the actual and setpoint position.

As long as a 1 signal is applied to the **Start** input, all output parameters are updated cyclically. Changes can be made to input parameters (e.g. position values) in subsequent PLC cycles. The output signals are undefined when the start signal is at 0 level.

In the case of direction selection with special positioning input "Offset" > 0, a new setpoint position is calculated from the setpoint and special positions and the number of magazine locations according to the following formula:

New setpoint position = (setpoint pos. - (special pos. -1)) neg. modulo # locations

The new setpoint position corresponds to the location number at which the magazine must be positioned so that the setpoint position requested by the user corresponds to the location number of the special position. The directional optimization is active both with and without special positioning.

The block must be called once with the appropriate parameter settings for each magazine.

#### WARNING

The block may only be called in conjunction with the tool management.

#### Note

For further details on tool management (also with regard to PLC) refer to the Description of Functions Tool Management. Furthermore, PI services are provided for tool management via the FB 4, FC 7 and FC 8 (see also the corresponding Sections in this documentation).

**Declaration of the function**

**STL representation**

```

FUNCTION FC 22 : VOID
// NAME:          TM_DIR
VAR_INPUT
    MagNo:        INT ;
    ReqPos:       INT;
    ActPos:       INT;
    Offset:       BYTE ;
    Start:        BOOL ;
END_VAR

VAR_OUTPUT
    Cw:           BOOL ;
    Ccw:          BOOL ;
    InPos:        BOOL ;
    Diff:         INT;
    Error :       BOOL ;
END_VAR

BEGIN
END_FUNCTION
    
```

**Description of formal parameters**

The table below shows all formal parameters of the "TM\_DIR" function.

Signal	Type	Type	Range of values	Remark
MagNo	I	INT	1 ...	Magazine number
ReqPos	I	INT	1 ...	Setpoint location
ActPos	I	INT	1 ...	Actual location
Offset	I	BYTE	0 ...	Offset for special positioning
Start	I	BOOL		Start of calculation
Cw	Q	BOOL		1 = Move magazine clockwise
Ccw	Q	BOOL		1 = Move magazine counterclockwise
InPos	Q	BOOL		1 = In position
Diff	Q	INT	0 ...	Differential path (shortest path)
Error	Q	BOOL		1 = error

## Call example

```
CALL FC 22 (                               //Tool management direction selection
  MagNo :=      2,                          //Magazine number
  ReqPos :=    mw 20,                        //Target position
  ActPos :=    mw 22,                        //Current position
  Offset :=    b#16#0,                       //Offset for special positioning
  Start :=    m 30.4,                        //Start trigger
                                          //Return parameters
  Cw :=        m 30.0,                        //Move magazine
                                          //in anticlockwise direction
  Ccw :=       m 30.1,                        //Move magazine
                                          //in anticlockwise direction
  InPos :=    m 30.2,                        //Magazine in position
  Diff :=    mw 32,                          //Differential path
  Error :=    m30.3                          //Error has occurred
);
```

### 13.13.25 FC 24: MCP\_IFM2 transmission of MCP signals to interface

#### Function

With FC MCP\_IFM2 (M variant slim machine control panel e.g. MCP 310), the following are transferred from the machine control panel (MCP) to the corresponding signals of the NCK/PLC interface:

- Mode groups
- Axis selections
- WCS/MCS switchover
- Traversing keys
- Overrides or override simulation signals

In the basic program (FC 2), handwheel selections, modes and other operating signals continue to be transferred from the operator panel front or HMI to the NCK/PLC interface so that the modes support selection from the MCP or HMI.

Transfer of HMI signals to the interface can be deactivated by setting the value of the parameter "MMCToIF" to "FALSE" in FB 1 (DB 7). "MMCToIF" can also be activated/deactivated in the cyclic program by setting and resetting (e.g. R gp\_par.MMCToIF).

The following specifications apply to the **feed override**, **axis travel keys** and **INC keys** depending on the active mode or on the coordinate system selected:

- **Feed override:**
  - The feed override is transferred to the interface of the selected channel and to the interface of the axes.
  - The feed override signals are transferred to the NC channel in addition to the "Rapid traverse override" (DBB 5) interface byte if the "Feed override for rapid traverse effective" HMI signal is set (exception: Switch setting "Zero"). "Rapid traverse override effective" is also set with this HMI signal.
- **Machine functions for INC and axis travel keys:**
  - When the MCS is selected, the signals are transferred to the interface of the selected machine axis.
  - When the WCS is selected, the signals are transferred to the geo-axis interface of the parameterized channel.
  - When the system is switched between MCS and WCS, the active axes are generally deselected.

The **handwheel selection signals from HMI** are decoded and activated in the machine-axis or the Geo-axis interface of the handwheel selected (only if parameter "HWheelMMC := TRUE" in FB 1).

The associated LEDs of the machine control panel are derived from the acknowledgments from the relevant selections.

Feedrate and spindle Start/Stop are not transferred to the interface, but output modally as a "FeedHold" or "SpindleHold" signal. The user can link these signals to other signals leading to a feed or spindle stop (this can be implemented, e.g. using the appropriate input signals in FC 10: AL\_MSG). The associated LEDs are activated at the same time.

The **spindle direction** (+, -) is not switched directly either, but made available as output parameter "SpindleDir". permitting, for example, FC 18 to be parameterized. A spindle enable signal is also switched via parameter "SpindleHold". One possible method of moving a spindle directly is to preselect it as an axis so that it can be traversed via (axis) direction keys.

If the machine control panel fails, the signals it outputs are preset to zero; this also applies to "FeedHold" and "SpindleHold" output signals.

Multiple calls of FC 24 or FC 19, FC 25, FC 26 are permitted in a single PLC cycle. In this case, the first call in the cycle drives the LED displays. Furthermore, all actions of the parameterized block are carried out in the first call. In the following calls, only a reduced level of processing of the channel and mode group interface takes place. The geometry axes are supplied with directional data only in the first block call in the cycle.

Single block processing can be selected/deselected only in the first call in the cycle.

The second machine control panel can be processed if parameter "ModeGroupNo" has been increased by B#16#10. When parameterizing, the HHU number is contained in the lower nibble (lower 4 bits).

"BAGNo" = 0 or B#16#10 means that the mode group signals are not processed.

ChanNo = 0 means that the channel signals are not processed.

The INC selections are transferred to the mode group interface. The activation for this specification is done via the DB10.DBX57.0 (INC-inputs in BAG-area active) through this block once after power up.

Furthermore, two machine control panels can be handled in parallel by this block. The module call for the 2nd machine control panel in OB1 cycle must come after the call of the 1st MCP. Support for two MCPs is provided in the control panel blocks up to certain limits (support is not provided as standard for mutual interlocking of axis selections with identical assignments on two MCPs).

## Flexible axis configuration

It is possible to be flexible in the assignment of axis selections or direction keys for machine axis numbers.

Better support is now provided by the MCP blocks for the use of two MCPs, which are to run in parallel, in particular for an application using two channels and two mode groups. Note that the axis-numbers are also specified in the parameterized mode group number of the MCP block in the axis tables of the relevant MCP.

To afford this flexibility, tables for axis numbers are stored in DB 10.

For the **first** machine control panel (MCP), the table starts at byte 8 (symbolic name: MCP1AxisTbl[1..22]) and for the **second** Machine control panel (MCP) starting from the byte 32 (symbolic name: MCP2AxisTbl[1..22]) for the second MCP. The machine axis numbers must be entered byte by byte here. It is permissible to enter a value of 0 in the axis table. Checks are not made to find impermissible axis numbers, meaning that false entries can lead to a PLC Stop.

For **FC 24**, the **maximum possible number of axis selections** can also be restricted.

This upper limit is set for the 1st machine control panel in DB10.DBW30 (symbolic name: MCP1MaxAxis) or for the 2nd machine control panel in DB10.DBW54 (symbolic name: MCP2MaxAxis) for the respective MCP.

The default setting is 0, corresponding to the maximum number of configured axes. The axis numbers and the limit can also be adapted dynamically. Afterwards, a new axis must be selected on FC 24. Axis numbers may not be switched over while the axes are traversing the relevant direction keys. The compatibility mode is preset with axis numbers **1 to 6** for both MCPs and restricted to the configured number of axes.

## Declaration of the function

```

FUNCTION FC 24 : VOID
// NAME:                MCP_IFM2

VAR_INPUT
    BAGNo :                BYTE ;
    ChanNo:                BYTE ;
    SpindleIFNo:          BYTE ;
END_VAR

VAR_OUTPUT
    FeedHold :            BOOL ;
    SpindleHold :        BOOL ;
    SpindleDir:          BOOL ;
END_VAR

BEGIN
END_FUNCTION

```

## Description of formal parameters

The table below shows all formal parameters of the "MCP\_IFM2" function:

Signal	Type	Type	Range of values	Remark
BAGNo	I	BYTE	0 - b#16#0A and b#16#10 - b#16#1A	No. of mode group to which the mode signals are transferred. BAGNo >= b#16#10 means access to the second machine control panel.
ChanNo	I	BYTE	0 - B#16#0A	Channel no. for the channel signals
SpindleIFNo	I	BYTE	0 - 31 (B#16#1F)	Number of the axis interface declared as a spindle
FeedHold	Q	BOOL		Feed stop from MCP, modal
SpindleHold	Q	BOOL		Spindle stop from MCP, modal
SpindleDir	Q	BOOL		Direction of spindle rotation
				0: corresponds to + (left)
				1: corresponds to - (right)

## Call example

```
CALL FC 24 (                                     //Slim machine control panel M variants
                                     //signals to interface
    BAGNo :=          B#16#1,                //Mode group no. 1
    ChanNo :=         B#16#1,                //Channel no. 1
    SpindleIFNo :=   B#16#4,                //Spindle interface number = 4
    FeedHold :=      m22.0,                 //Feed stop signal modal
    SpindleHold :=   db2.dbx151.0);         //Spindle stop modal in message data block
    SpindleDir:=     m22.1);               //Spindle direction return
```

With these parameter settings, the signals are sent to the 1st mode group, the 1st channel and all axes. In addition, the spindle override is transferred in the 4th axis/spindle interface. The feed hold signal is passed to bit memory 22.0 and the spindle stop signal to data block DB2, data bit 151.0. The spindle direction feedback signal supplied via parameter "SpindleDir" can be used as a direction input for an additional FC 18 call.

### 13.13.26 FC 25: MCP\_IFT transfer of MCP/OP signals to interface

#### Function

With the FC MCP\_IFM (M-variant) from the machine control panel a range of 19 inch e.g. MCP 483 are transferred to the corresponding signals of the NCK-/PLC interface:

- Mode groups
- Direction keys of four axes
- WCS/MCS switchover commands
- Overrides
- Key-operated switch

In the basic program (FC 2), handwheel selections, modes and other operating signals continue to be transferred from the operator panel front or HMI to the NCK/PLC interface so that the modes support selection from the MCP or BT.

Transfer of HMI signals to the interface can be deactivated by setting the value of the parameter "MMCToIF" to "FALSE" in FB 1 (DB 7).

The following specifications apply to the **feed override**, **axis travel keys** and **INC keys** depending on the active mode or on the coordinate system selected:

- **Feed override:**
  - The feed override is transferred to the interface of the selected channel and to the interface of the axes.
  - The feed override signals are transferred to the NC channel in addition to the "Rapid traverse override" (DBB 5) interface byte if the "Feed override for rapid traverse effective" HMI signal is set (exception: Switch setting "Zero"). "Rapid traverse override effective" is also set with this HMI signal.
- **Machine functions for INC and axis travel keys:**
  - When the MCS is selected, the signals are transferred to the interface of the selected machine axis.
  - When the WCS is selected, the signals are transferred to the geo-axis interface of the parameterized channel.

The **handwheel selection signals from the MMC** are decoded and activated in the machine-axis or the Geo-axis interface of the handwheel selected (only if parameter "HWheelMMC := TRUE" in FB 1). = TRUE").

The LEDs on the machine control panel derived from the selections in the acknowledgment.

Feedrate and spindle Start/Stop are not transferred to the interface, but output modally as a "FeedHold" or "SpindleHold" signal. The user can link these signals to other signals leading to a feed or spindle stop (this can be implemented, e.g. using the appropriate input signals in FC 10: AL\_MSG). The associated LEDs are activated at the same time.

If the machine control panel fails, the signals it outputs are preset to zero; this also applies to "FeedHold" and "SpindleHold" output signals.

Multiple calls of FC 25 or FC 19, FC 24, FC 26 are permitted in a single PLC cycle. In this case, the first call in the cycle drives the LED displays. Furthermore, all actions of the parameterized block are carried out in the first call. In the following calls, only a reduced level of processing of the channel and mode group interface takes place. The geometry axes are supplied with directional data only in the first block call in the cycle.

Single block processing can be selected/deselected only in the first cycle.

The second machine control panel can be processed if parameter "ModeGroupNo" has been increased by B#16#10. When parameterizing, the HHU number is contained in the lower nibble (lower 4 bits).

"BAGNo" = 0 or B#16#10 means that the mode group signals are not processed.

ChanNo = 0 means that the channel signals are not processed.

### Flexible axis configuration

It is possible to be flexible in the assignment of axis selections or direction keys for machine axis numbers.

Better support is now provided by the MCP blocks for the use of two MCPs, which are to run in parallel, in particular for an application using two channels and two mode groups. The module 2 call for the 2nd machine control panel in OB1 cycle must come after the call of the 1st MCP. Note that the axis-numbers are also specified in the parameterized mode group number of the MCP block in the axis tables of the relevant MCP.

To afford this flexibility, tables for axis numbers are stored in DB 10.

For the **first** machine control panel (MCP), the table starts at byte 8 (symbolic name: MCP1AxisTb[1..22]) and for the **second** Machine control panel (MCP) starting from the byte 32 (symbolic name: MCP2AxisTb[1..22]) for the second MCP. The machine axis numbers are entered here bitwise. It is permissible to enter a value of 0 in the axis table. Checks are not made to find impermissible axis numbers, meaning that false entries can lead to a PLC Stop.

The restriction of the **possible number of axes at FC 25** is done via the 0-values in the axis table. The axis numbers can also be adapted dynamically. Axis numbers may not be switched over while the axes are being traversed via the relevant direction keys. The compatibility mode is preset with axis numbers **1 to 4** for both MCPs and restricted to the configured number of axes.

---

#### Note

For further information see "FC 19: MCP\_IFM transmission of MCP signals to interface (Page 1088)".

---

### Declaration of the function

```

FUNCTION FC 25 : VOID
// NAME:                MCP_IFT

VAR_INPUT
    BAGNo :                BYTE ;
    ChanNo:                BYTE ;
    SpindleIFNo:          BYTE ;
END_VAR

VAR_OUTPUT
    FeedHold :            BOOL ;
    SpindleHold :         BOOL ;
END_VAR

BEGIN
END_FUNCTION
    
```

### Description of formal parameters

The table below shows all formal parameters of the "MCP\_IFT" function:

Signal	Type	Type	Value range	Comment
BAGNo	I	BYTE	0 - b#16#0A and b#16#10 - b#16#1A	No. of mode group to which the mode signals are transferred. BAGNo >= b#16#10 means access to the second machine control panel.
ChanNo	I	BYTE	0 - B#16#0A	Channel no. for the channel signals
SpindleIFNo	I	BYTE	0 - 31 (B#16#1F)	Number of the axis interface declared as a spindle
FeedHold	Q	BOOL		Feed stop from MCP, modal
SpindleHold	Q	BOOL		Spindle stop from MCP, modal

## Call example

```
CALL FC 25 (                                     //Machine control panel T variants
                                     //signals to interface
    BAGNo :=          B#16#1,                //Mode group no. 1
    ChanNo :=         B#16#1,                //Channel no. 1
    SpindleIFNo :=    B#16#4,                //Spindle interface number = 4
    FeedHold :=       m22.0,                 //Feed stop signal modal
    SpindleHold :=    db2.dbx151.0);         //Spindle stop modal in message data block
```

With these parameter settings, the signals are sent to the 1st mode group, the 1st channel and all axes. In addition, the spindle override is transferred in the 4th axis/spindle interface. The feed hold signal is passed to bit memory 22.0 and the spindle stop signal to data block DB2, data bit 151.0.

### 13.13.27 FC 26: HPU\_MCP transmission of HT8 signals to interface

#### Function declaration

```
FUNCTION FC 26 : VOID
// NAME:          HPU_MCP

VAR_INPUT
    BAGNo :      BYTE ;
    ChanNo:      BYTE ;
END_VAR

BEGIN
END_FUNCTION
```

#### Parameter

Parameter	Type	Type	Value range	Comment
BAGNo	I	BYTE	1st MCP: B#16#00 - B#16#0A	Upper nibble: Number of the MCP whose signals are to be transferred. 0 = 1st MCP, 1 = 2nd MCP
			2nd MCP: B#16#10 - B#16#1A	Lower nibble: Number of the mode group, in which the mode group-specific interface signals are to be transferred. The mode group-specific signals are not processed, if the mode-group number is 0.
ChanNo	I	BYTE	B#16#00 - B#16#0A	Number of the channel, in which the channel-specific interface signals are to be transferred. The channel-specific signals are not processed, if the channel number is 0.
Type: I = input parameter, O = output parameter				

**Call examples**

Call of the FC 26 for the first MCP, the first mode group and the first channel of the NC.

```
CALL FC 26 (                                     //Machine control panel of HT8
           BAGNo :=      B#16#01,                //1.MCP, 1.BAG
           ChanNo :=     B#16#01);               //Channel 1
```

Call of the FC 26 for the second MCP, the second mode group and the third channel of the NC.

```
CALL FC 26 (                                     //Machine control panel of HT8
           BAGNo :=      B#16#12,                //2.MCP, 2.BAG
           ChanNo :=     B#16#03 );              //Channel 3
```

**General function description**

The function FC 26 "HPU\_MCP (machine control panel-signals of the hand-held unit HT8)" transfers the HT8-specific signals of the following functions between the HT8-input/output data areas parameterized in the function block FB 1 (Parameter: MCPxIn and MCPxOut) and the NC/PLC-interface:

- Mode groups
- Machine function INC
- Coordinate system WCS or MCS
- Axial traverse key
- Axis selection
- Feed override
- Rapid traverse override
- Keyswitch information

---

**Note****Mode switchover through HT 8 and/or HMI**

The function FC 2 "GP\_HP Basic program, cyclic part" transfers the signals of the block-switchover in such a way that an alternative selection of MCP of HT 8 and of the HMI is possible. The transfer of the HMI signals to the NC/PLC interface can also be switched off in the function block FB 1 with the parameter "MMCToIF" = FALSE .

**Active axes:**

Using HT 8 a maximum of 6 axes can be addressed at the same time. The selection of the axes is to be realized by the user/machine manufacturer in the PLC user program.

---

## Flexible axis configuration

The function FC 26 enables a flexible assignment of the machine axes to the traversing keys or to the axis selection. 2 tables are available in DB 10 for this purpose:

- Machine axis table 1st MCP: DB10.DBB8 to DBB13 (Table of the machine axis number)  
Symbolic name: MCP1AxisTbl[1..22]
- Machine axis table 2nd MCP: DB10.DBB32 to DBB37 (Table of the machine axis number)  
symbolic name: MCP2AxisTbl[1..22]

In the tables the axis numbers  $n$  (with  $n = 1, 2, \dots$ ) of the active machine axis are to be entered byte-wise. The value 0 must be entered in the unused table locations.

The table length can be specified to the FC 26:

- 1st MCP: DB10.DBB30 (upper limit of the machine axis table)
- 2nd MCP: DB10.DBB54 (upper limit of the machine axis table)

A value of 4, for example, means that FC 26 takes into account only the first 4 table entries or machine axes. The maximum value for the FC 26 is 6. For value 0 or values greater than 6 the maximum value is taken implicitly.

---

### Note

Please note the following constraints:

- A check of the permissible machine axis numbers is not done. Invalid machine axis numbers can lead to a PLC Stop.
  - The machine axis numbers can be changed dynamically. The table may not be written, if currently a machine axis is being moved via a traversing key.
- 

## Transfer of the traversing key signals depending upon the active coordinate system

The traversing key signals for 6 axes lie in the HT 8 input data area below:

- EB  $n + 2$ , Bit 0 - Bit 5 (positive traversing direction)
- EB  $n + 3$ , Bit 0 - Bit 5 (negative traversing direction)

The switchover of the coordinate system is done via the input signal:

- EB  $n + 0$ , Bit 0 (MCS/WCS)

The input signal is evaluated in FC 26 with the help of the edge trigger flag. The active coordinate system is shown in the following output signal:

- AB  $n + 0$ , Bit 0 (MCS/WCKS) with 0 = MCS, 1 = WCS

In case of active MCS the traversing key signals of the axes 1 - 6 are transferred in the axis-specific interfaces (DB31, ... .DBX4.6 and DBX4.7 (traversing key +/-)) of the axes specified in the machine axis tables (DB10.DBB8 to DBB13 or DBB32 to DBB37).

In case of active WCS it is assumed that the axes 1 - 3 of the machine axis table are geometric axes. For this reason the traversing key signals:

- of the axes **1 - 3** (EB n + 2 / 3, Bit 0 - Bit 2) are transferred in the interface of the geometric axes in DB21, ... .DBB 12 + (n \* 4), with n = 0, 1, 2), Bit 6 and Bit 7 (traversing keys +/-) of the channel specified with the parameter "ChanNo".  
The assignment of the traversing key signals of the axes 1, 2 and 3 to the geometric axes 1, 2 and 3 of the channel is permanent and may not be changed.
- of the axes **4 - 6** (EB n + 2 / 3, Bit 3 - Bit 5) are transferred in the axis-specific interface (DB31, ... .DBX4.6 and DBX4.7 (traversing keys +/-) of the axes 4 - 6 entered in the machine axis table (DB10.DBB11 to DBB13 or DBB35 to DBB37).

### No traversing of machine axes in WCS

In case of active WCS (AB n + 0, Bit 0 = 1) the traversing of the machine axes can be locked. For this, the following output signals are to be set in the PLC user program:

- AB n + 3, Bit 7 = 1 (For WCS: no machine axes)

Requirement to the FC 26, not to transfer any traversing key signals for the machine axes. The traversing key signals for the axes 1 - 3 of the machine axis table are transferred to the geometric axes 1 - 3 of the specified channel. The traversing key signals for the axes 4 - 6 of the machine axis table are not transferred.

- AB n + 2, Bit 6 (axes 7 - n selected)

Requirement at the FC 26 not to transfer any traversing key signals, since the axes 1 - 6 of the machine axis table are switched over. The axes 1 - 3 are thus not geometric axes, but instead also machine axes.

### Feed override

The value of the HT8 override switch is transferred as feed override in the channel-specific interface DB 21, ... .DBB4 (feedrate override) of the programmed channel (parameter: "ChanNo") and in the axis-specific interfaces DB31, ... .DBB0 (feedrate override) of the axes programmed in the table DB10.DBB8 to DBB13 (machine axis number).

### Rapid traverse override

Is for the programmed channel (parameter: "ChanNo") the signal DB21, ... .DBX25.3 = 1 (feedrate override for rapid traverse) set, the value of the HT8 override switch is set as rapid traverse override in this channel-specific. Interface in DB 21, ... .DBB5 (rapid traverse override) and in addition the signal DB21, ... .DBX6.6 = 1 (rapid traverse override active) is set.

## Machine function INC

The HT8 signals of the machine functions INC are transferred differently depending upon the active coordinate system MCS or WCS:

- Active coordinate system: MCS

The selected machine function INC is transferred for all 6 axes in the axis-specific interfaces in DB31, ... .DBX5.0 to DBX5.5 (machine function) of the axes programmed in the table in DB10.DBB8 to DBB13 (machine axis numbers) .

- Active coordinate system: WCS

For the axes 1 to 3 the signals of the machine function INC are transferred in the channel-specific. Interface in DB21, ... .DBX13.0 to DBX13.5 (machine function) of the programmed channel (Parameter: "ChanNo").

For the axes 4 to 6 the signals of the machine function INC are transferred in the channel-specific. interfaces in DB31, ... .DBX5.0 to DBX5.5 (machine function) of the axes programmed in the table in DB10.DBB11 to DBB13 (machine axis numbers).

The selection signals of the INC machine functions are transferred in the mode group-specific interface DB11 DBB 2 + (n \* 20), Bit 0 to Bit 5 (with n = 0, 1, 2, ...). The FC 26 informs the NCK about the activation of the mode group-interface for the INC machine function once after the power-up with DB10.DBX57.0 (INC inputs active in the mode group area).

## Handwheel selection

The hand-wheel selection signals are evaluated by HMI and transferred to the corresponding NC/PLC interface signals of the machine or geometric axes:

- Geometry axes: DB21, ... DBB 12 + (n \* 4), Bit 0 to Bit 2 (with n = 0, 1, 2)
- Machine axes: DB31, ... .DBX4.0 to DBX4.2

Requirement: FB 1-Parameter: "HWheelMMC" = TRUE

## Multiple call in one PLC cycle

Multiple calls of FC 26 are permitted in a single PLC cycle. Upon the first call in the PLC cycle:

- all actions of the parameterized blocks are executed
- the LED signals are written in the output area
- in case of selected WCS, the traversing key signals of the geometric axes are written
- the signals for the selection and deselection of the individual block are processed

Upon further calls of the FC 26 only a reduced processing of the channel and mode group-interface is done.

### Processing of two MCP

If the function FC 26 is called twice for two MCP in the cyclic sequence of the PLC program (organization block OB 1), the call for the second MCP must be made after the call for the first MCP.

---

#### Note

If an axis can be traversed from two MCP, then the implementation of a mutual interlocking is the responsibility of the user (machine manufacturer).

---

### Failure of the MCP of HT8

In case of failure of the MCP of HT8 all the input signals are set to the value 0.

#### 13.13.27.1 Overview of the NC/PLC interface signals of HT 8

#### Operating modes and machine functions

Source: MCP	Destination: Programmed mode group (Parameter BAGNo) Display for BAG 1
AUTOMATIC	DB11.DBX0.0
MDI	DB11.DBX0.1
JOG	DB11.DBX0.2
REPOS	DB11.DBX1.1
REF	DB11.DBX1.2
TEACH IN	DB11.DBX1.0
INC 1 ... 10 000, INC Var.	DB11.DBX2.0 - DBX 2.5

#### Traversing keys and rapid traverse override

Source: MCP	Aim: Geometry axis of the prog. channel (Parameter: ChanNo)
Traversing key +	DB21, ... .DBX12.7
Traversing key -	DB21, ... .DBX12.6
Rapid traverse override	DB21, ... .DBX12.5
Traversing key +	DB21, ... .DBX16.7
Traversing key -	DB21, ... .DBX16.6
Rapid traverse override	DB21, ... .DBX16.5
Traversing key +	DB21, ... .DBX20.7
Traversing key -	DB21, ... .DBX20.6
Rapid traverse override	DB21, ... .DBX20.5

<b>Source: MCP</b>	<b>Aim: Prog. axes corresponding to the table in DB 10, DBB 8 - 13 (1st MCP) or DBB 32 - 37 (2nd MCP)</b>
Traversing key +	DB31, ... .DBX4.7
Traversing key -	DB31, ... .DBX4.6
Rapid traverse override	DB31, ... .DBX4.5

## Override

<b>Source: MCP</b>	<b>Aim: Programmed channel (Parameter: ChanNo)</b>
Feed override	DB21, ... .DBB4

<b>Source: MCP</b>	<b>Aim: Prog. axes corresponding to the table in DB 10, DBB 8 - 13 (1st MCP) or DBB 32 - 37 (2nd MCP)</b>
Feed override	DB31, ... .DBB0

## Channel signals

<b>Source: MCP</b>	<b>Aim: Programmed channel (Parameter: ChanNo)</b>
NC start	DB21, ... .DBX7.1
NC stop	DB21, ... .DBX7.3
RESET	DB21, ... .DBX7.7
Single BLock	DB21, ... .DBX0.4

### 13.13.27.2 Overview of the NC/PLC interface signals of HT 8

#### Operating modes and machine functions

Destination: MCP	Source: Interface-DB (Parameter BAGNo) Display for BAG 1
AUTOMATIC	DB11.DBX6.0
MDA	DB11.DBX6.1
JOG	DB11.DBX6.2
REPOS	DB11.DBX7.1
REF	DB11.DBX7.2
TEACH IN	DB11.DBX7.0

### 13.13.28 FC 19, FC 24, FC 25, FC 26 source code description

#### Task

Machine control panel to application interface (FC 19 M variant, FC 24 slim variant, FC 25 T variant, FC 26 HT8 variant)

#### Associated blocks

- DB 7, no. of MOGs, channels, axes
- DB 7, pointer of machine control panel
- DB 8, storage for the next cycle

#### Resources used

None.

#### General

The blocks FC 19 (M version), FC 24 (slim-line version), FC 25 (T version) and FC 26 (HT8 version) transfer the signals of the machine control panel to and from the application interface. In the input parameters, "ModeGroupNo" selects the mode group to be processed by the block. The "ModeGroupNo" parameter also selects the number of the machine control panel (Bit 4). "ChanNo" selects the channel to be processed.

Not FC 26:

The "SpindleIFNo" parameter defines the axis interface of the spindle. The spindle override is transferred to this spindle interface. The parameters are checked for incorrect parameterization.

Not FC 26:

Output parameters "FeedHold" and "SpindleHold" are generated from the 4 feed/spindle disable and feed/spindle enable keys and are returned with "logical 1" for disable.

Information for the next cycle is stored in DB8, bytes 0 to 3 or bytes 62 to 65, depending on the machine control panel number. This information is the edge trigger flag, feed value and selected axis number. The blocks are provided with user data via the pointer parameters in DB 7 "MCP1In" and "MCP1Out" ("MCP2In" and "MCP2Out"). The pointers are addressed indirectly via a further pointer from the VAR section of DB7 in order to avoid absolute addressing. This additional pointer is determined symbolically in FB1.

## Block description

All 4 components have a similar structure and are classified for the individual subtasks:

**In the Input network**, various parameters are copied to local variables. The machine control signals (user data for input/output area) are also copied between locations using the various pointers in DB 7 (gp\_par). These local variables are handled in the block for reasons of efficiency. Some values are initialized for the start-up.

MCS/WCS switchover with edge evaluation, axis selections, direction keys and rapid traverse overlay is determined in the **Global\_IN network** for further processing in the block. User-specific changes must take place in this part of the program, which are mainly oriented at the axis selection.

Only the keyswitch information is copied in **Network NC** .

The **mode group network** transfers the modes of the keys as dynamic signals to the NCK. The INC checkback signals from the NC are stored temporarily for the corresponding LEDs. If the mode group number is 0, this network is not processed. A too large number generates the message 401901 or 402501 and changes over after stop.

In the **Channel network** the NC Start, Stop, Reset and Single Block functions are activated by corresponding checkback signals. The direction keys of the geometry axes are supplied if a corresponding preselection is made, otherwise they are cleared. If the channel number is 0, this network is not processed. A too large number generates the message 401902 or 402502 and changes over after stop.

The **Spindle network** transfers the spindle override to the interface configured via "SpindleIFNo".

The **Network Axes** transfers the feed override to the selected axis interface. The direction keys are assigned to the selected axis/spindle. If an axis has been selected previously, the direction information is set to 0.

The output parameters are prepared and the LED signals of the INC machine function are generated in the **Global\_OUT network** .

The **Output network** transfers the output signals of the machine control panel from the VAR\_TEMP image to the logical address. The data for the next cycle are also saved.

### Axis selection extension

The Global\_IN network must be modified if more than nine axes are selected. If other keys and LEDs are to be used on the machine control panel here, proceed as follows:

1. The command UD DW#16#Value (comment: Clear all axis LEDs for display) deletes all defined LEDs for axis selections. The bit mask is currently processing the nine axis selection LEDs.
2. The command UW W#16# (comment: "Masking all the axis selection buttons" ) checks whether the direction has changed. The bit string must be adjusted here.
3. The branch destination list (SPL) must be expanded with new jump labels. The new jump labels should be inserted in descending order before label m009. The selection information should be extended for the new jump labels, as described for labels m009 and m008.

---

#### Note

The blocks are made available as STL sources if required. But they do not match the current status of the block. Some details of the actual implementation in C have been developed further. For this reason we recommend that you specify your additional requirements for the blocks and that you pass these onto project management via the sales department.

---

## 13.14 Signal/data descriptions

### 13.14.1 Interface signals NCK/PLC, HMI/PLC, MCP/PLC

#### References

The NCK/PLC, HMI/PLC and MCP/PLC interface signals are contained in the Lists document.  
Lists sl (Book2)

The reference code contained therein (according to the signal names) refer to the respective function description, in which the signal is described.

The NCK signals that are evaluated by the basic program and transferred in conditioned form to the user interface are presented in the following sections.

### 13.14.2 Decoded M signals

The M functions programmed in the part program, ASUB or synchronized actions are channel specifically transferred from the NC to the PLC:

- M functions from channel 1: DB 21
- M functions from channel 2: DB 22
- etc.

The signal length is one PLC cycle.

---

#### **Note**

The spindle-specific M functions below are not decoded: M3, M4, M5, and M70.

---

---

Address in DB 21, ...	Variable	Type	Comment
DBX 194.0 ... 7	M_Fkt_M0 ... M7	BOOL	M signals M0 ... M7
DBX 195.0 ... 7	M_Fkt_M8 ... M15	BOOL	M signals M8 ... M15
DBX 196.0 ... 7	M_Fkt_M16 ... M23	BOOL	M signals M16 ... M23
DBX 197.0 ... 7	M_Fkt_M24 ... M31	BOOL	M signals M24 ... M31
DBX 198.0 ... 7	M_Fkt_M32 ... M39	BOOL	M signals M32 ... M39
DBX 199.0 ... 7	M_Fkt_M40 ... M47	BOOL	M signals M40 ... M47
DBX 200.0 ... 7	M_Fkt_M48 ... M55	BOOL	M signals M48 ... M55
DBX 201.0 ... 7	M_Fkt_M56 ... M63	BOOL	M signals M56 ... M63
DBX 202.0 ... 7	M_Fkt_M64 ... M71	BOOL	M signals M64 ... M71
DBX 203.0 ... 7	M_Fkt_M72 ... M79	BOOL	M signals M72 ... M79
DBX 204.0 ... 7	M_Fkt_M80 ... M87	BOOL	M signals M80 ... M87
DBX 205.0 ... 7	M_Fkt_M88 ... M95	BOOL	M signals M88 ... M95
DBX 206.0 ... 3	M_Fkt_M96 ... M99	BOOL	M signals M96 ... M99

---

**Note**

The M02/M30 auxiliary function output to the PLC does not state that the part program has been terminated. To determine definitely the end of a part program in the channel, the following interface signal must be evaluated:

DB21, ... .DBX33.5 (M02/M30 active)

The channel status must be RESET. The auxiliary function output could arise from an asynchronous subroutine (ASUB) or a synchronized action and has nothing to do with the real end of the parts program in this case.

---

### 13.14.3 G Functions

The M functions programmed in the part program, ASUB or synchronized actions are channel specifically transferred from the NC to the PLC:

- G functions from channel 1: DB 21
- G functions from channel 2: DB 22
- etc.

The signal length is one PLC cycle.

#### **POWER ON**

After POWER ON, the value zero, i.e. active G groups undefined, is specified in the NC/PLC interface for all G groups.

#### **Part program end or abort**

After part program end or abort, the last state of the G group is retained.

#### **NC START**

After NC-START the values of the 8 G-groups specified in the machine data: MD22510 \$NC\_ GCODE\_GROUPS\_TO\_PLC are overwritten according to the default setting set via the machine data as well as the values programmed in the part program.

Address in DB 21, ...	Variables	Type	Basic position	Comment
DBB 208	G_FKT_GR_1	BYTE	0	Active G function of group 1
DBB 209	G_FKT_GR_2	BYTE	0	Active G function of group 2
DBB 210	G_FKT_GR_3	BYTE	0	Active G function of group 3
DBB 211	G_FKT_GR_4	BYTE	0	Active G function of group 4
DBB 212	G_FKT_GR_5	BYTE	0	Active G function of group 5
DBB 213	G_FKT_GR_6	BYTE	0	Active G function of group 6
DBB 214	G_FKT_GR_7	BYTE	0	Active G function of group 7
DBB 215	G_FKT_GR_8	BYTE	0	Active G function of group 8
DBB 216	G_FKT_GR_9	BYTE	0	Active G function of group 9
DBB 217	G_FKT_GR_10	BYTE	0	Active G function of group 10
DBB 218	G_FKT_GR_11	BYTE	0	Active G function of group 11
DBB 219	G_FKT_GR_12	BYTE	0	Active G function of group 12
DBB 220	G_FKT_GR_13	BYTE	0	Active G function of group 13
DBB 221	G_FKT_GR_14	BYTE	0	Active G function of group 14
DBB 222	G_FKT_GR_15	BYTE	0	Active G function of group 15
DBB 223	G_FKT_GR_16	BYTE	0	Active G function of group 16
DBB 224	G_FKT_GR_17	BYTE	0	Active G function of group 17
DBB 225	G_FKT_GR_18	BYTE	0	Active G function of group 18
DBB 226	G_FKT_GR_19	BYTE	0	Active G function of group 19
DBB 227	G_FKT_GR_20	BYTE	0	Active G function of group 20
DBB 228	G_FKT_GR_21	BYTE	0	Active G function of group 21
DBB 229	G_FKT_GR_22	BYTE	0	Active G function of group 22

Address in DB 21, ...	Variables	Type	Basic position	Comment
DBB 230	G_FKT_GR_23	BYTE	0	Active G function of group 23
DBB 231	G_FKT_GR_24	BYTE	0	Active G function of group 24
DBB 232	G_FKT_GR_25	BYTE	0	Active G function of group 25
DBB 233	G_FKT_GR_26	BYTE	0	Active G function of group 26
DBB 234	G_FKT_GR_27	BYTE	0	Active G function of group 27
DBB 235	G_FKT_GR_28	BYTE	0	Active G function of group 28
DBB 236	G_FKT_GR_29	BYTE	0	Active G function of group 29
DBB 237	G_FKT_GR_30	BYTE	0	Active G function of group 30
DBB 238	G_FKT_GR_31	BYTE	0	Active G function of group 31
DBB 239	G_FKT_GR_32	BYTE	0	Active G function of group 32
DBB 240	G_FKT_GR_33	BYTE	0	Active G function of group 33
DBB 241	G_FKT_GR_34	BYTE	0	Active G function of group 34
DBB 242	G_FKT_GR_35	BYTE	0	Active G function of group 35
DBB 243	G_FKT_GR_36	BYTE	0	Active G function of group 36
DBB 244	G_FKT_GR_37	BYTE	0	Active G function of group 37
DBB 245	G_FKT_GR_38	BYTE	0	Active G function of group 38
DBB 246	G_FKT_GR_39	BYTE	0	Active G function of group 39
...	...	...	...	...
DBB 271	G_FKT_GR_64	BYTE	0	Active G function of group 64

A complete listing of all the G functions is given in:

**References:**

Programming Manual Fundamentals; Chapter: "List of G-Functions/Preparatory functions"

### 13.14.4 Message signals in DB 2

DB 2 allows the user to display the messages for individual signals on the operator panel. As the lists of interface signals show, signals are divided into predefined groups. When a message occurs, disappears or is acknowledged, the number entered in the message number column is transferred to the HMI. Text can be stored in the HMI for each message number.

**References:**

- Lists sl (Book2), see Section "PLC Messages (DB 2)".
- Startup Manual; Chapter "Alarm and message texts"

---

**Note**

The number of user areas can be parameterized via FB 1.

After the configuration has been modified (FB 1: MsgUser), DB 2/3 must be deleted.

---

## 13.15 Programming tips with STEP 7

Some useful tips on programming complex machining sequences in STEP7 are given below. This is essentially handling of the data type POINTER or ANY.

Fundamental tips on the structure of the data type POINTER and ANY see:

**References:**

STEP 7-Manual; Chapter: "Designing user programs" > "Register of CPU and saving of data"

### 13.15.1 Copying data

#### Copying variants

For the high-speed copying of data from one DB into another it is recommended

- **for larger data quantities** to use the system function SFC BLKMOV or SFC FILL, because here a high-speed copying takes place.
- the routine given below is **for smaller data quantities**, because the supply of ANY parameter to the SFCs consumes additional time.

#### Example

Code		Comment
		// DB xx.[AR1] is the source
		// DI yy.[AR2] is the destination
OPEN	DB 100;	//Source DB
LAR1	P#20.0;	//Source start address on data byte 20
OPEN	DI 101;	//Destination DB
LAR2	P#50.0;	//Destination start address on data byte 50
		//AR1, AR2, DB, DI loaded beforehand
L	4;	//Transfer 8 bytes
M001:		
L	DBW [AR1,P#0.0];	//Copy word-oriented
T	DIW [AR2,P#0.0];	
+AR1	P#2.0;	
+AR2	P#2.0;	
TAK;		
LOOP	M001;	

## 13.15.2 ANY and POINTER

The following programming examples show the programming mechanism. They demonstrate how input/output and transit variables (VAR\_INPUT, VAR\_OUTPUT, VAR\_IN\_OUT) are accessed by data types "POINTER" or "ANY" within an FC or FB. The access operations are described in such a way that a part symbolic method of programming can be used.

### 13.15.2.1 Use of POINTER and ANY in FC

#### Function

FC 99 has inputs parameters that are defined as POINTER or ANY.

The example shows a body program via which the subcomponents of the POINTER or ANY can be accessed. In this case, the DB parameterized with POINTER or ANY is opened and the address offset stored as a cross-area pointer in address register AR1, Thus allowing access to data elements of variables (generally structures and arrays) that are addressed via the POINTER, ANY.

This access operation is described at the end of the relevant program sequence in the example. With data type ANY, it is also possible to execute a check or branch when the variable is accessed based on the data type and the number of elements involved.

#### Example

Code	Comment
FUNCTION FC 99: VOID	
VAR_INPUT	
Row : BYTE ;	
Convert : BOOL ;	//Activate numerical conversion
Addr: POINTER;	//Points to variable
Addr1 : ANY ;	
END_VAR	
VAR_TEMP	
dbchr : WORD ;	
Number: WORD ;	
type : BYTE ;	
END_VAR	
BEGIN	
NETWORK	
TITLE =	
	//POINTER
L                P##Addr;	
LAR1 ;	//Retrieve pointer
L                W [AR1,P#0.0];	//Retrieve DB number
T                #dbchr;	
L                D [AR1,P#2.0];	//Offset part of pointer

Code		Comment
LAR1 ;		
AUF DB [#dbchr];		//Open DB of variables
L B [AR1,P#40.0];		//Retrieve byte value using pointer with //address offset 40 //ANY
L	P##Addr1;	
LAR1 ;		//Retrieve ANY
L	B [AR1,P#1.0];	//Retrieve type
T	#typ;	
L	W [AR1,P#2.0];	//Retrieve amount
T	#Amount;	
L	W [AR1,P#4.0];	//Retrieve DB number
T	#dbchr;	
L	D [AR1,P#6.0];	//Offset part of pointer
LAR1 ;		
OPEN	DB [#dbchr];	//Open DB of variables
L	B [AR1,P#0.0];	//Retrieve byte value using ANY

### 13.15.2.2 Use of POINTER and ANY in FB

#### Function

FB 99 has inputs parameters that are defined as POINTER or ANY.

The example shows a body program via which the subcomponents of the POINTER or ANY can be accessed. In this case, the DB parameterized with POINTER or ANY is opened and the address offset stored as a cross-area pointer in address register AR1, thus allowing access to data elements of variables (generally structures and arrays) that are addressed via the POINTER, ANY.

This access operation is described at the end of the relevant program sequence in the example. With data type ANY, it is also possible to execute a check or branch when the variable is accessed based on the data type and the number of elements involved.

#### Example

Code	Comment
FUNCTIONBLOCK FB 99	
VAR_INPUT	
Row : BYTE ;	
Convert : BOOL ;	//Activate numerical conversion
Addr: POINTER;	//Points to variable
Addr1 : ANY ;	
END_VAR	
VAR_TEMP	
dbchr : WORD ;	
Number: WORD ;	
type : BYTE ;	
END_VAR	
BEGIN	
NETWORK	
TITLE =	
	//POINTER
L                    P##Addr;	
LAR1 ;	//Retrieve pointer from instance DB
L                    DIW [AR1,P#0.0];	//Retrieve DB number
T                    #dbchr;	
L                    DID [AR1,P#2.0];	//Offset part of pointer
LAR1 ;	
OPEN                  DB [#dbchr];	//Open DB of variables
L                    B [AR1,P#40.0];	//Retrieve byte value using pointer with
	//address offset 40
	//ANY
L                    P##Addr1;	
LAR1 ;	//Retrieve ANY from instance DB

Code		Comment
L	DIB [AR1,P#1.0];	//Retrieve type
T	#typ;	
L	DIW [AR1,P#2.0];	//Retrieve amount
T	#Amount;	
L	DIW [AR1,P#4.0];	//Retrieve DB number
T	#dbchr;	
L	DID [AR1,P#6.0];	//Offset part of pointer
LAR1 ;		
OPEN	DB [#dbchr];	//Open DB of variables
L	B [AR1,P#0.0];	//Retrieve byte value using ANY

### 13.15.2.3 POINTER or ANY variable for transfer to FC or FB

#### POINTER or ANY variable

With version 1 or later of STEP 7 it is possible to define a pointer or ANY in VAR\_TEMP.

The following two examples show how an ANY can be supplied.

#### Example 1: Transfer ANY parameter via a selection list to another FB (FC)

**Several** ANY parameters are defined in an FB (FC). A specific ANY parameter must now be chosen from a selection list for transfer to another FB (FC). This can only be done by means of an ANY in VAR\_TEMP. 1 to 4 can be set in parameter "WhichAny" in order to select Addr1 to Addr4.

#### Note

Address register AR2 is used in the block. However, this address register AR2 is also used for multi-instance DBs. For this reason, this FB should **not** be declared as multi-instance DB.

Code	Comment
FUNCTIONBLOCK FB 100	
CODE_VERSION1	//starting from STEP 7 Version 2 for deactivating the //multi-instance DB
VAR_INPUT	
WhichAny : INT ;	
Addr1 : ANY ;	//Observe predetermined order
Addr2 : ANY ;	
Addr3 : ANY ;	
Addr4 : ANY ;	

Code	Comment
END_VAR	
VAR_TEMP	
dbchr : WORD ;	
Number: WORD ;	
type : BYTE ;	
Temp_addr : ANY ;	
END_VAR	
BEGIN	
NETWORK	
TITLE =	
L           WhichAny;	
DEC 1;	
L           P#10.0;	//10 bytes per ANY
*I;	
LAR2;	
L           P##Addr1;	
+AR2;	//Add ANY start addresses
L           P##Temp_addr;	
LAR1 ;	//Retrieve pointer from VAR_TEMP
L           DID [AR2,P#0.0];	//Transfer pointer value to VAR_TEM
T           LD [AR1,P#0.0];	
L           DID [AR2,P#4.0];	
T           LD [AR1,P#4.0];	
L           DIW [AR2,P#8.0];	
T           LW [AR1,P#8.0];	
CALL FB 101, DB 100	
(ANYPAR := #Temp_addr);	//ANYPAR is data type ANY

**Example 2: Transfer an ANY parameter constructed earlier to another FB (FC)**

**One ANY parameter that has already been compiled must be transferred to another FB (FC). This can be done only by means of an ANY stored in VAR\_TEMP.**

Code	Comment
FUNCTIONBLOCK FB 100	
VAR_INPUT	
DBNumber: INT ;	
DBOffset : INT ;	
Data type: INT ;	
Number: INT ;	
END_VAR	
VAR_TEMP	
dbchr : WORD ;	
Temp_addr : ANY ;	
END_VAR	
BEGIN	
NETWORK	
TITLE =	
L        P##Temp_addr;	
LAR1 ;	//Retrieve pointer from VAR_TEMP
L        B#16#10;	//ANY identifier
T        LB [AR1,P#0.0];	
L        Data type;	
T        LB [AR1,P#1.0];	
L        Amount;	
T        LW [AR1,P#2.0];	
L        DBNumber;	
T        LW [AR1,P#4.0];	
L        DBOffset;	
SLD 3;	//Offset is a bit offset
T        LD [AR1,P#6.0];	
CALL FB 101, DB 100	
(ANYPAR := #Temp_addr);	//ANYPAR is data type ANY

### 13.15.3 Multi-instance DB

#### Function

From Version 2 in STEP 7, you can provide multi-instance enabled FBs, i.e. with multi-instance DBs. The primary characteristic of multi-instance DBs is that a data module can be used for various instances of FBs (see STEP 7 documentation). The quantity structure of the DBs can be optimized this way.

Multi-instance DBs should be activated only when they are actually going to be used since they increase the runtime and code size of the FBs.

---

#### Note

When complex programs are implemented in multi-instance enabled FBs that use a pointer and address register, it is important for the programmer to observe certain rules.

With multi-instance DBs, the start address of the variable (VAR\_INPUT, VAR\_OUTPUT, VAR\_IN\_OUT, VAR) is transferred with the DI data block register and address register AR2. When variables are accessed within the multi-instance enabled FB, the compiler independently controls the access operation via address register AR2. However, when complex program sections also have to work with address registers in the same FB (e.g. to copy data), then the old contents of AR2 must be saved before the register is changed. The contents of AR2 must be restored to their original state before an instance variable (VAR\_INPUT, VAR\_OUTPUT, VAR\_IN\_OUT, VAR) is accessed. The AR2 register of the instance is to be saved most usefully in a local variable (VAR\_TEMP).

The command "Load pointer to an instance variable" returns a pointer value from the start of the instance data. To be able to access this variable via a pointer, the offset stored in AR2 must be added.

---

#### Example

Code	Comment
FUNCTION_BLOCK FB 99	
VAR_INPUT	
varin: INT ;	
END_VAR	
VAR	
variable1: ARRAY[[0..9] of INT;	
variable2: INT ;	
END_VAR	
BEGIN	
L        P##variable1;	//Pointer at start of ARRAY
	//The value 8500 0010 is now in the accumulator
	//and a cross-area pointer is in the AR2
	//Pointer. If one is to work across areas
	//then, during the addition of these
	//two pointers, an area is to be disabled.

Code		Comment
AD	DW#16#00FF_FFFF,	//Skipping of an area
LAR1		//Load into AR1
TAR2;		
+AR1 AR2;		//AR2 instance offset to be added
		//You can now indirectly access the ARRAY
		//of variable 1 via AR1.
L	DIW [AR1, P#0.0];	//E.g. access to the first element
END_FUNCTION_BLOCK		

### 13.15.4 Strings

The STRING data type is required by certain services of the basic program. For this reason, some additional facts about the string structure and general handling procedures for parameter assignments are given below.

#### Structure of strings

A data of type STRING is generally stored (defined) in a data block. There are two methods of defining a string:

1. Only the data type STRING is assigned to a variable. The STEP7 compiler automatically generates a length of 254 characters.
2. Data type STRING is assigned to a variable together with a string length in square parenthesis (e.g. [32]). With this method, the STEP7 compiler generates a string length corresponding to the input.

Two bytes more than prescribed by the definition are always stored for variables of the STRING data type. The STEP 7 compiler stores the maximum possible number of characters in the 1st byte. The 2nd byte contains the number of characters actually used. Normally, the useful length of the assigned strings is stored by the STEP 7 compiler. The characters (1 byte per character) are then stored from the 3rd byte onwards.

String parameters are generally assigned to blocks of the basic program by means of a POINTER or ANY. Such assignments must generally be made using symbolic programming methods. The data block, which contains the parameterizing string, must be stored in the symbol list. The assignment to the basic program block is then made by means of the symbolic data block name followed by a full stop and the symbolic name of the string variable.

### 13.15.5 Determining offset addresses for data block structures

#### Function

Another task, which occurs frequently, is symbolic determination of an offset address within a structured DB, e.g. an ARRAY or STRUCTURE is stored somewhere within the DB. After loading the address register symbolically with the start address, you might like to access the individual elements of the ARRAY or STRUCTURE via an address register. One way of loading the address register symbolically is to use an FC whose input parameter is a pointer. The address of the ARRAY or STRUCTURE is then assigned symbolically to the input parameter of this FC in the program. The program code in the FC now determines the offset address from the input parameter, and passes the offset address in the address register (AR1) to the calling function. Symbolic addressing is thus possible even with indirect access.

#### Example

Code	Comment
FUNCTION FC 99: VOID	
VAR_INPUT	
Addr: POINTER;	//Points to variable
END_VAR	
BEGIN	
NETWORK	
TITLE =	
L        P##Addr;	
LAR1 ;	//Retrieve pointer from Addr
L        D [AR1,P#2.0];	//Offset part of pointer of variable
LAR1 ;	
END_FUNCTION	

## 13.15.6 FB calls

### Function

For optimizing the flow speeds, it is useful to call all function block calls with many static parameters, such as the blocks FB 2, 3, 4, 5, and 7 provided by the basic program in start-up with the related instance parameters. In the start-up (OB 100), the preassignment of the parameters must be done, which can then no longer be changed in the cyclic part (OB 1). These fixed parameter values are no longer parameterized in the cyclic call, because they have already been written in the Instance DB.

### Example Parameterization of FB 2 with instance DB 110

The following example shows how a useful distribution in OB 100 and OB 1 portion is to be implemented.

First, the usual call in the cyclic program is displayed.

```
CALL FB 2, DB 110 (
    Req :=          M 100.0,
    NumVar :=       2,                               //Read 2 variables
    Addr1 :=        NCVAR.C1_RP_rpa0_0
    Line1 :         W#16#1
    Addr2 :=        NCVAR.C1_RP_rpa0_0
    Line2 .         W#16#2
    Error :=        M1.0,
    NDR :=          M1.1,
    State :=        MW 2,
    RD1 :=          P#M 4.0 REAL 1,
    RD2 :=          P#M 24.0 REAL 1,
```

The modified version of the program call starts from here.  
Here the call in OB 100 is displayed:

```
CALL FB 2, DB 110 (
    Req :=          FALSE,
    NumVar :=       2,                               //Read 2 variables
    Addr1 :=        NCVAR.C1_RP_rpa0_0
    Line1 :         W#16#1
    Addr2 :=        NCVAR.C1_RP_rpa0_0
    Line2 .         W#16#2
    RD1 :=          P#M 4.0 REAL 1,
    RD2 :=          P#M 24.0 REAL 1,
```

Here the call still remaining in OB 1 is displayed:

```
CALL FB 2, DB 110 (
    Req :=          M0.0,
```

```
Error :=      M1.0,  
NDR :=       M1.1,  
State :=     MW 2,
```

---

**Note**

Owing to this measure, a shorter cycle time is achieved in OB 1, because the static parameter values need not be copied in the instance DB in each OB-1 cycle.

---

**The savings of this variant:**

The cyclic copying effort of 3 integer values and 4 ANY parameters with respect to the instance DB, which results from 3 time loading of a constant in the instance data block. In case of each ANY transfer, constants are loaded in the data block 4 times with subsequent transfer.

## 13.16 Data lists

### 13.16.1 Machine data

#### 13.16.1.1 NC-specific machine data

Number	Identifier: \$MN_	Description
10100	PLC_CYCLIC_TIMEOUT	Cyclic PLC monitoring time
14504	MAXNUM_USER_DATA_INT	Number of user data (INT)
14506	MAXNUM_USER_DATA_HEX	Number of user data (HEX)
14508	MAXNUM_USER_DATA_FLOAT	Number of user data (FLOAT)
14510	USER_DATA_INT	User data (INT)
14512	USER_DATA_HEX	User data (HEX)
14514	USER_DATA_FLOAT[n]	User data (FLOAT)

#### Note

Machine data in integer/hex format is operated in the NC as DWORD. A machine data in floating point format is managed in the NC as FLOAT (8-Byte IEEE) They are stored only in the NC/PLC interface and can be read by the PLC user program from DB 20 even during PLC booting.

#### 13.16.1.2 Channel-specific machine data

Number	Identifier: \$MC_	Description
28150	MM_NUM_VDIVAR_ELEMENTS	Number of elements for writing PLC variables



## Reference Point Approach (R1)

### 14.1 Brief description

#### Function

The "Reference Point Approach" function is used to synchronize the measuring system of a machine axis with machine zero. The machine axis is traversed to machine zero and the measuring system set to zero.

If it is not possible to approach machine zero directly, a reference point within the traversing range of the machine axis is used whose position with reference to machine zero precisely known.

After the reference point approach, the measuring system of the machine axis is not set to zero but to the corresponding reference point value.

#### Measuring systems and referencing methods

The "Reference point approach" function enables machine axes to be referenced using the following measuring systems and referencing methods:

- Measuring systems
  - Incremental rotary measuring system with at least one zero mark
  - Incremental linear measuring system
  - Rotary measuring system with distance-coded reference marks (supplied by Heidenhain)
  - Linear measuring system with distance-coded reference marks (supplied by Heidenhain)
  - Absolute rotary measuring system
  - Absolute linear measuring system

- Referencing methods
  - Referencing with incremental measuring systems with BERO and one-edge and two-edge detection
  - Referencing with incremental measuring systems with replacement of homing cam with BERO
  - Referencing with incremental measuring systems with BERO with configured approach velocity for spindle applications
  - Referencing with measuring systems with distance-coded reference marks by overtravelling 2 or 4 zero marks
  - Referencing of passive measuring systems using measuring system adjustment
  - Referencing in follow-up mode
  - Referencing with cam switch at the drive

## Start

The reference point approach of a machine axis can be started manually or via the part program:

- Manual: Operation mode JOG and MDA, machine function REF
- Part program: Part program command G74

## 14.2 Axis-specific referencing

In axis-specific reference point approach, reference point approach must be initiated individually for each machine axis that is to be referenced.

### Selecting mode and machine function

Before starting reference point approach of the machine axes, you must first place the relevant mode group in JOG or MDA mode:

DB11, ... DBX0.2 (active JOG mode)

DB11, ... DBX0.1 (active JOG mode)

Then machine function REF (reference point approach) must be selected:

DB11, ... DBX1.2 (REF machine function)

### Start of reference point approach

In axis-specific reference point approach, each machine axis must be started individually.

Reference point approach is started with the axis-specific traversing keys:

DB31, ... DBX4.6 (Traversing key minus)

DB31, ... DBX4.7 (Traversing key minus)

### Direction enable

To avoid faulty operation, the direction release must be parameterized:

MD34010 \$MA\_REFP\_CAM\_DIR\_IS\_MINUS (approach reference point in minus direction)

The direction enable specifies which traversing key starts the reference point approach:

Value	Description
0	Reference point approach in plus direction
1	Reference point approach in minus direction

### Jog mode

The following machine data element can be used to specify whether reference point approach is completed when the direction key is pressed once or whether the operator is required to keep the direction key pressed (jogging) for safety reasons:

MD11300 \$MN\_JOG\_INC\_MODE\_LEVELTRIGGRD (INC and REF in jog mode)

If the machine operator releases the direction key, the machine axis is decelerated to zero speed. Reference point approach is not aborted. Reference point approach is continued the next time the direction key is pressed.

### Referencing status

The referencing status of the machine axis is reset with the start of the reference point approach:

DB31, ... DBX60.4 (referenced/synchronized 1)

DB31, ... DBX60.5 (referenced/synchronized 2)

DB21, ... DBX36.2 (all axes with obligatory reference point are referenced)

### Distance-coded measuring systems

In distance-coded measuring systems, reference point approach can be started with any traversing key.

### Sequence

The machine operator or machine manufacturer (via the PLC user program) is responsible for ensuring that the machine axes are referenced in the proper order.

- Machine operator

The machine axes must be started by the machine operator in the specified order.

- Machine manufacturer

The PLC user program of the machine manufacturer allows machine axes to be started only in the proper order.

### Simultaneous reference point approach of several machine axes

Several machine axes can be referenced simultaneously, depending on the control:

SINUMERIK 840D:	max. 8 machine axes
-----------------	---------------------

### Completion of reference point approach

Acknowledgment that reference point approach of a machine axis has been successfully completed is given by setting the referencing status:

DB31, ... DBX60.4 (referenced/synchronized 1)

DB31, ... DBX60.5 (referenced/synchronized 2)

### **Cancellation of reference point approach**

In axis-specific reference point approach, the machine axis is traversed in the channel that was assigned as the master channel of the machine axis.

MD30550 \$MA\_AXCONF\_ASSIGN\_MASTER\_CHAN

For aborting the reference point approach, either mode group reset or channel reset for the master channel of the machine axis must be activated:

DB11, ... DBX0.7 (mode group reset)

DB21, ... DBX7.7 (channel reset)

All machine axes that have not yet successfully completed reference point approach when the action is cancelled remain in status "Not referenced":

DB31, ... DBX60.4 (referenced/synchronized 1)

DB31, ... DBX60.5 (referenced/synchronized 2)

## 14.3 Channel-specific referencing

In channel-specific reference point approach, all machine axes of the channel are referenced in the parameterized sequence when reference point approach is initiated.

### Selecting mode and machine function

Before starting reference point approach of the machine axes, you must first set the mode group to JOG or MDA mode:

DB11, ... DBX0.2 (active JOG mode)

DB11, ... DBX0.1 (active MDA mode)

Then machine function REF (reference point approach) must be selected:

DB11, ... DBX1.2 (REF machine function)

### Parameterizing the axis sequence

The following machine data element is used to specify the sequence in which the machine axes of the channel are referenced:

MD34110 \$MA\_REFP\_CYCLE\_NR = *Number*

Number	Description
-1	The machine axis does not have to be referenced for NC START in the channel.
0	The machine axis does not participate in channel-specific reference point approach.
1 - 15	Sequence number in channel-specific reference point approach.

The machine axes are referenced in ascending order of numbers.

Machine axes with the same number will be referenced simultaneously.

### Simultaneous reference point approach of several machine axes

Several machine axes can be referenced simultaneously, depending on the control:

SINUMERIK 840D:	Max. 8 machine axes
SINUMERIK 810D:	Max. 5 machine axes

### Start of reference point approach

Channel-specific reference point approach is started with:

DB21, ... DBX1.0 (activate referencing)

The status of channel-specific reference point approach is indicated by the channel with:

DB21, ... DBX33.0 (activate referencing)

### **Referencing status**

The referencing status of the machine axis is reset with the start of the reference point approach:

DB31, ... DBX60.4 (referenced/synchronized 1)

DB31, ... DBX60.5 (referenced/synchronized 2)

### **Completion of reference point approach**

As soon as channel-specific reference approach has been successfully completed for all machine axes involved, this is acknowledged with:

DB21, ... DBX36.2 (all axes with obligatory reference point are referenced)

### **Cancellation of reference point approach**

In channel-specific reference point approach the machine axis is traversed in the channel to which that axis is currently assigned as channel axis.

For aborting the reference point approach either mode group reset or channel reset for the corresponding channel must be activated:

DB11, ... DBX0.7 (mode group reset)

DB21, ... DBX7.7 (channel reset)

All machine axes for which the reference point approach is not yet successfully completed when the action is cancelled remain in status "Not referenced":

DB31, ... DBX60.4 (referenced/synchronized 1)

DB31, ... DBX60.5 (referenced/synchronized 2)

## 14.4 Reference point approach from part program (G74)

Referencing of machine axes can be activated for the first time or repeated from the part program

Referencing must be repeated, for example, after:

- converting the actual value of the machine axis: PRESETON function
- Machine axis is parked:  
DB31, ... DBX1.5 (position measuring system 1) = 0  
DB31, ... DBX1.6 (position measuring system 2) = 0
- DB31, ... DBX2.1 (servo enable) = 0
- Exceeding the encoder limit frequency of the position measuring system

### Programming

#### Syntax

G74 *Machine axis* { *Machine axis* }

#### Function

Machine axes can be referenced from a part program with part program instruction G74

Parameter: *Machine axes*

The name of the machine axis must be specified. The machine axis must be a channel axis of the channel in which the part program is processed.

Effective:

G74 is non-modal.

#### Special features

G74 must be programmed in a separate part program block.

### Reset response

Mode group reset or channel reset aborts the reference point approach for all programmed machine axes:

DB11, ... DBX0.7 (mode group reset)

DB21, ... DBX7.7 (channel reset)

All machine axes for which the reference point approach is not yet successfully completed when the action is cancelled remain in status "Not referenced":

DB31, ... DBX60.4 (referenced/synchronized 1)

DB31, ... DBX60.5 (referenced/synchronized 2)

## 14.5 Referencing with incremental measurement systems

### 14.5.1 Zero mark selection with BERO

#### Function

Referencing of incremental measuring systems is based on the unique position of the encoder zero mark relative to the overall traversing range of the machine axis. If several encoder zero marks are detected in the traversing range of the machine axis due to machine-specific factors, e.g. reduction gear between encoder and load, a BERO must be mounted on the machine and connected to the relevant drive module (SIMODRIVE 611D) via a BERO input in order to uniquely specify the reference point. The position of the reference point is then derived from the combination of BERO signal and encoder zero mark.

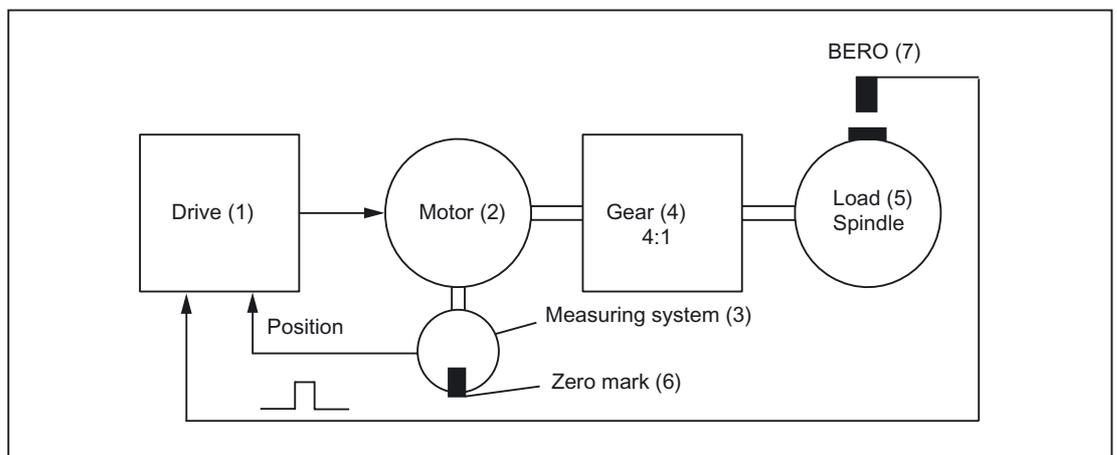


Figure 14-1 Zero mark selection with BERO

Zero mark evaluation with BERO must be parameterized as the referencing mode:

MD34200 \$MA\_ENC\_REFP\_MODE = 5

#### Negative edge evaluation

In the case of a referencing operation with a negative edge evaluation of the BERO signal:

MD34120 \$MA\_REFP\_BERO\_LOW\_ACTIVE = FALSE

synchronization is with the next encoder zero mark encountered after the BERO is exited.

#### Positive edge evaluation

In the case of a referencing operation with a positive edge evaluation of the BERO signal:

MD34120 \$MA\_REFP\_BERO\_LOW\_ACTIVE = TRUE

synchronization is with the next encoder zero mark encountered after the BERO is approached.

If, mechanically, the BERO is sized in such a way that the positive BERO signal covers the entire width of the encoder zero mark, the encoder zero mark will be reliably detected in both traversing directions.

### 14.5.2 Chronological sequence

Reference point approach with incremental measuring systems can be divided into three phases:

- Phase 1: Traversing to the reference cam
- Phase 2: Synchronization with the zero mark of the position measuring system (encoder zero mark)
- Phase 3: Traversing to the reference point

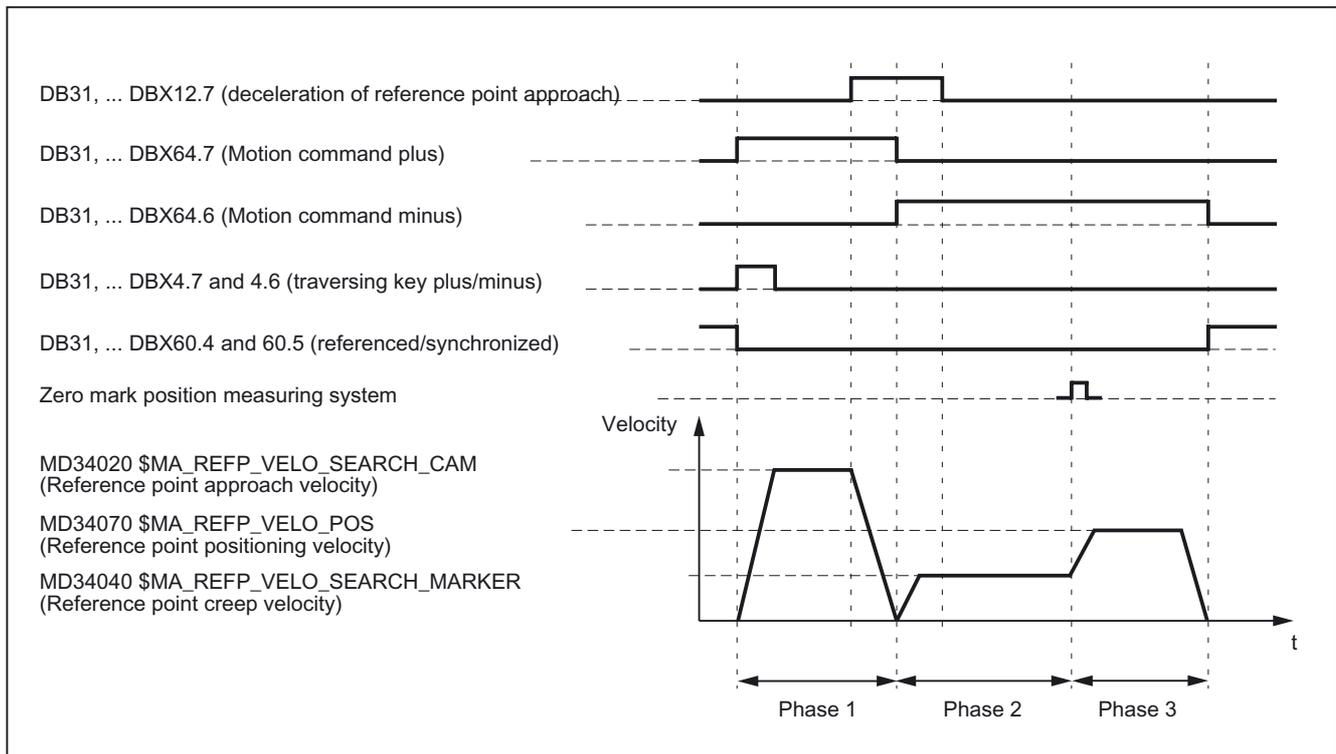


Figure 14-2 Time sequence when referencing with incremental measuring systems (example)

### 14.5.3 Phase 1: Traversing to the reference cam

#### Phase 1: Graphic representation

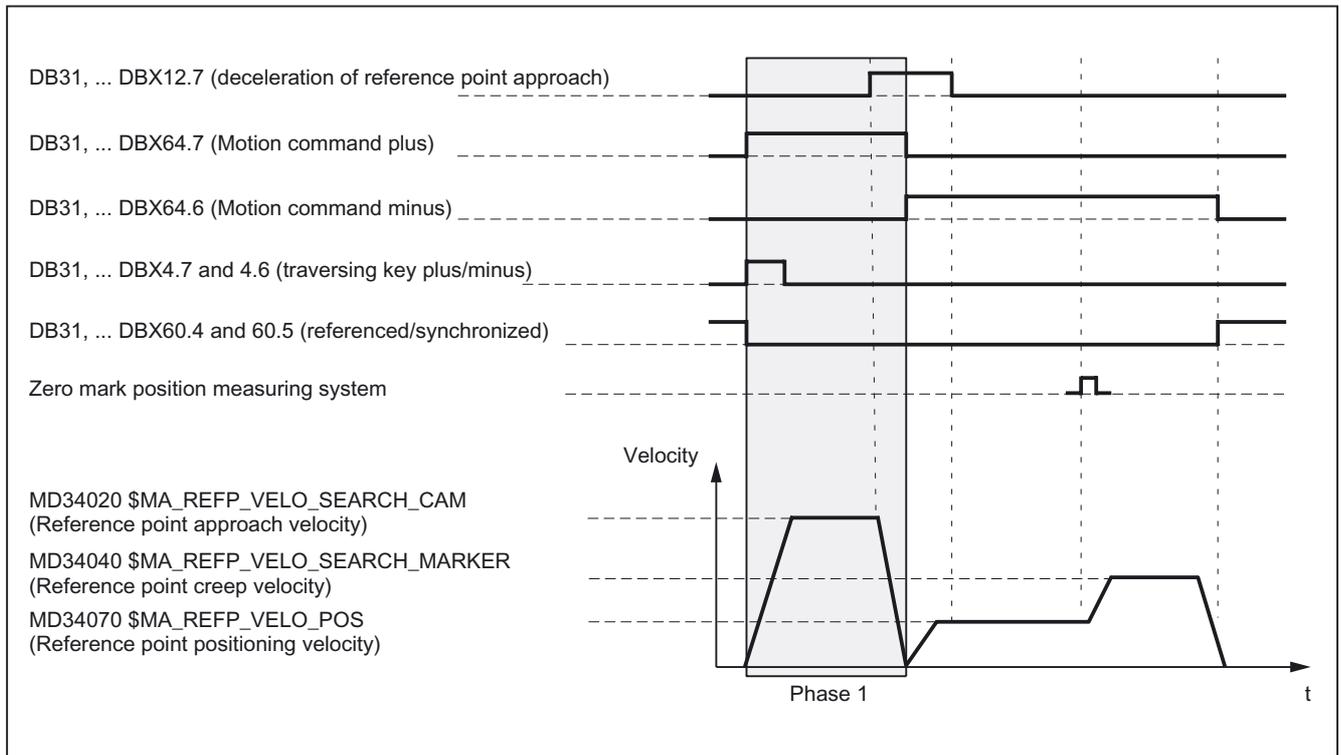


Figure 14-3 Phase 1: Traversing to the reference cam

#### Phase 1: Start

For information on starting reference point approach, refer to "Axis-specific referencing" and "Channel-specific referencing."

### Phase 1: Sequence

In phase 1, depending on the position of the machine axis with reference to the homing cam, we distinguish between three cases:

1. The machine axis is positioned before the reference cam
2. The machine axis is positioned on the reference cam
3. The machine axis has no reference cam

#### Case 1: The machine axis is positioned before the reference cam

After the start of reference point approach, the machine axis is accelerated in the parameterized direction and to the parameterized reference point approach velocity :

MD34010 \$MA\_REFP\_CAM\_DIR\_IS\_MINUS (Reference point approach in minus direction)

MD34020 \$MA\_REFP\_VELO\_SEARCH\_CAM (Reference point approach velocity)

The PLC user program communicates to the NC that the reference cam has been reached via the following interface signal:

DB31, ... DBX12.7 (reference point approach deceleration)

As a result the NC decelerates to zero speed. The following distance  $s_{min}$  is still minimally back tracked:

$$S_{MIN} = \frac{(MD34040 \$MA\_REFP\_VELO\_SEARCH\_MARKER)^2}{2 * MD32300 \$MA\_MAX\_AX\_ACCEL}$$

This minimum distance is required to ensure that the machine axis exits the reference cam in Phase 2 at the parameterized reference point creep velocity.

Phase 1 is now complete. Reference point approach is continued with Phase 2.

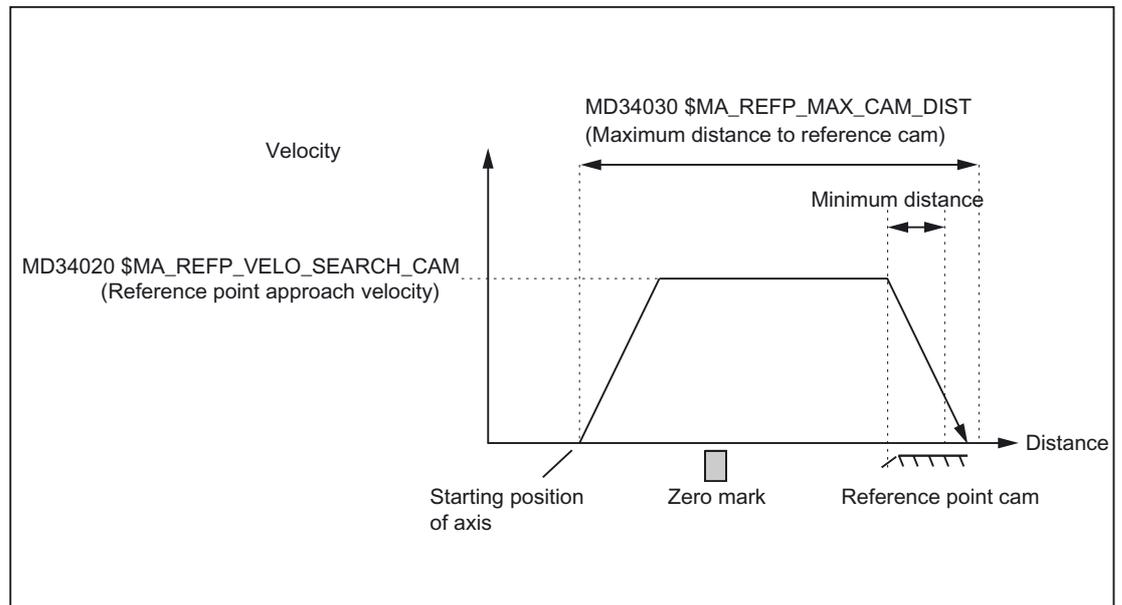


Figure 14-4 Minimum distance for deceleration

**Case 2: The machine axis is positioned on the reference cam**

The machine axis remains at its starting position.

Phase 1 is now complete. Reference point approach is continued with Phase 2.

**Case 3: The machine axis has no reference cam**

Machine axes without reference point cams remain at their starting position.

These include, for example:

- Machine axes that only have one zero mark along their entire traversing range
- Rotary axes that only have one zero mark per revolution

Zero must be entered in the following machine data for machine axes without a reference point cam:

MD34000 \$MA\_REFP\_CAM\_IS\_ACTIVE (Axis with reference cam) = 0

Phase 1 is now complete. Reference point approach is continued with Phase 2.

**Phase 1: Features**

- Feed override active.
- Feed stop (channel-specific and axis-specific) is active.
- NC-STOP and NC-START are active.
- The machine axis is stopped if the reference cam does not arrive within the parameterized distance:

MD34030 \$MA\_REFP\_MAX\_CAM\_DIST (max. distance to reference cam)

DB31, ... DBX12.7 (reference point approach delay) = 1

### 14.5.4 Phase 2: Synchronization with the zero mark

#### Phase 2: Graphic representation

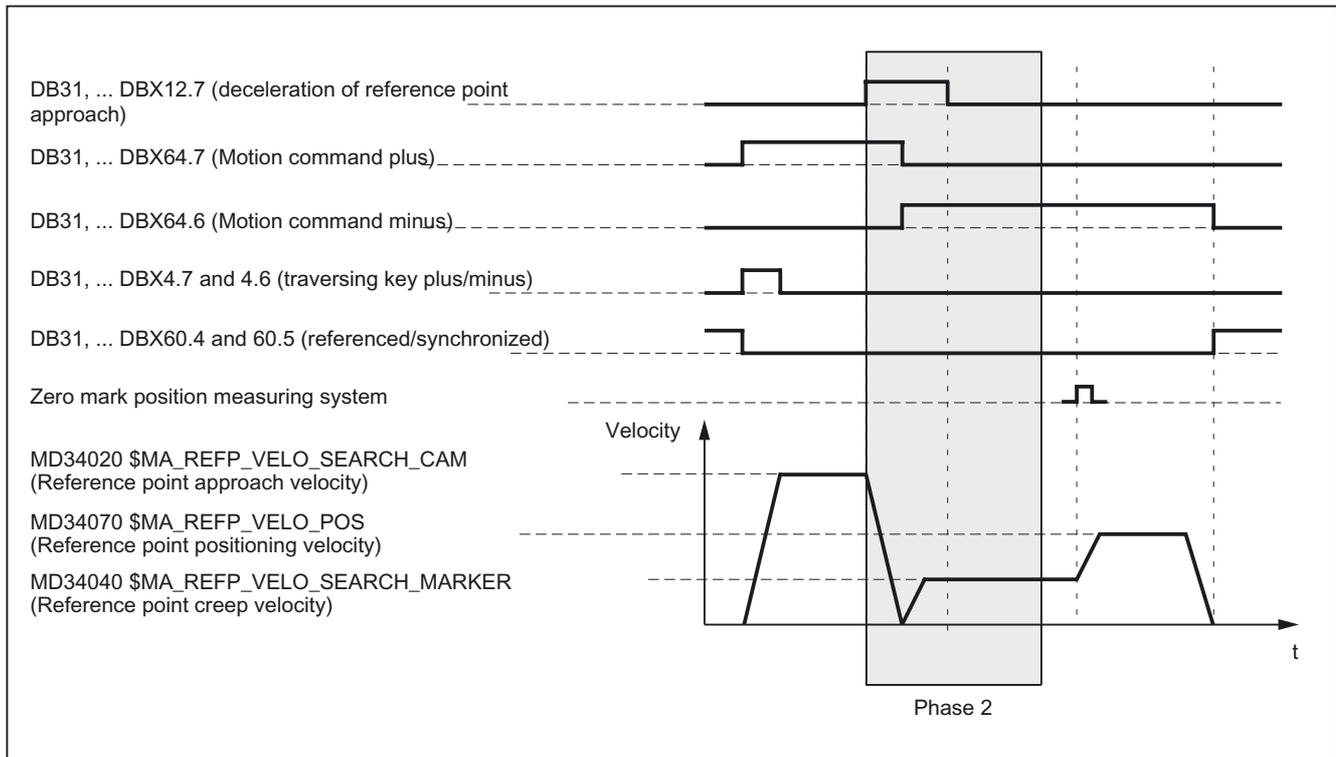


Figure 14-5 Phase 2: Synchronization with the zero mark

#### Phase 2: Start

Phase 2 is automatically started when phase 1 has been completed without an alarm.

##### Initial situation:

The machine axis is positioned on the reference cam.

##### Zero mark search direction:

The zero mark is searched for in the parameterized direction and approached:

MD34050 \$MA\_REFP\_SEARCH\_MARKER\_REVERSE (direction reversal on reference cam)

## Phase 2: Sequence

Synchronization in Phase 2 can occur in two ways:

- Synchronization with falling reference cam signal edge
- Synchronization with rising reference cam signal edge

The type of synchronization is determined with the machine data:

MD34050 \$MA\_REFP\_SEARCH\_MARKER\_REVERSE (direction reversal on reference cam)

Value	Meaning
0	Synchronization with falling reference cam signal edge
1	Synchronization with rising reference cam signal edge

---

### Note

If the actual velocity of the machine axis at approach of the reference cam has not yet reached the target velocity of Phase 2 within the parameterized tolerance limits, Phase 1 will be re-started:

MD35150 \$MA\_SPIND\_DES\_VELO\_TOL (spindle speed tolerance)

This will be the case, for example, if the machine axes are positioned at the reference cam when reference point approach starts.

---

### Case 1: Synchronization with falling reference cam signal edge

During synchronization with falling reference cam signal edge, the machine axis accelerates to the parameterized reference point creep velocity against the parameterized reference point approach direction (traversing direction of Phase 1):

MD34040 \$MA\_REFP\_VELO\_SEARCH\_MARKER (reference point creep velocity)

MD34010 \$MA\_REFP\_CAM\_DIR\_IS\_MINUS (Reference point approach in minus direction)

After the reference cam is exited (DB31, ... DBX12.7 = 0), the next encoder zero mark is awaited.

As soon as the encoder zero mark is detected, Phase 2 comes to an end. The machine axis continues at constant velocity and reference point approach is continued with phase 3.

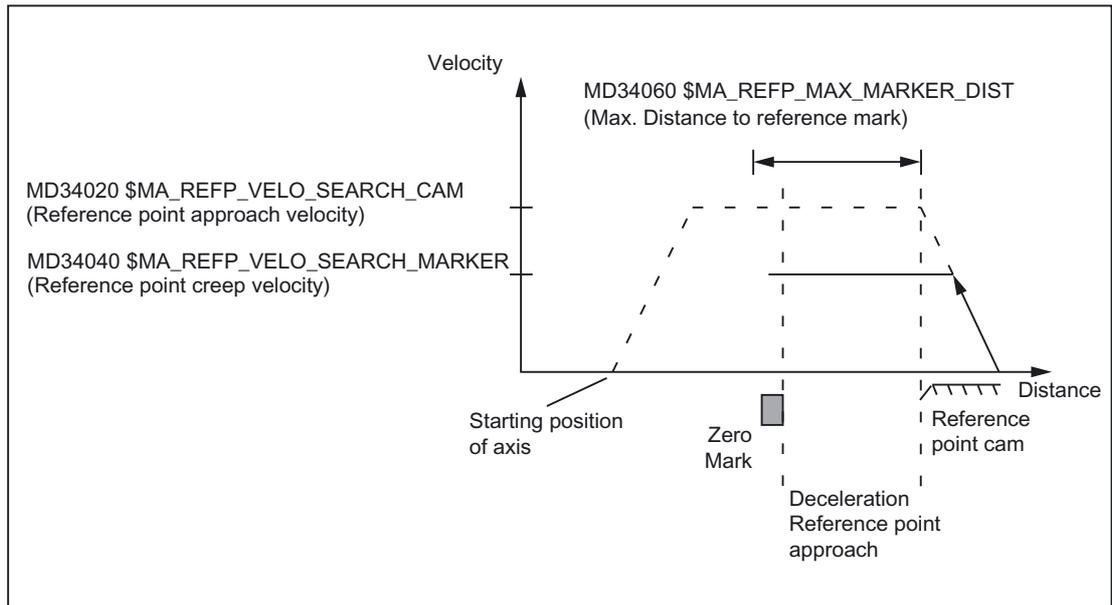


Figure 14-6 Synchronization with falling reference cam signal edge

**Case 2: Synchronization with rising reference cam edge**

During synchronization with rising reference cam signal edge, the machine axis accelerates to the parameterized reference point approach velocity against the parameterized reference point approach direction (traversing direction of the phase 1):

MD34020 \$MA\_REFP\_VELO\_SEARCH\_CAM (Reference point approach velocity)

MD34010 \$MA\_REFP\_CAM\_DIR\_IS\_MINUS (Reference point approach in minus direction)

After the reference cam is exited (DB31, ... DBX12.7 = 0), the machine axis is decelerated to stillstand.

The machine axis then travels back to the reference cam at the parameterized reference point creep velocity:

MD34040 \$MA\_REFP\_VELO\_SEARCH\_MARKER (reference point creep velocity)

After the reference cam is reached (DB31, ... DBX12.7 = 1), the next encoder zero mark is awaited.

As soon as the encoder zero mark is detected, Phase 2 comes to an end. The machine axis continues at constant velocity and reference point approach is continued with phase 3.

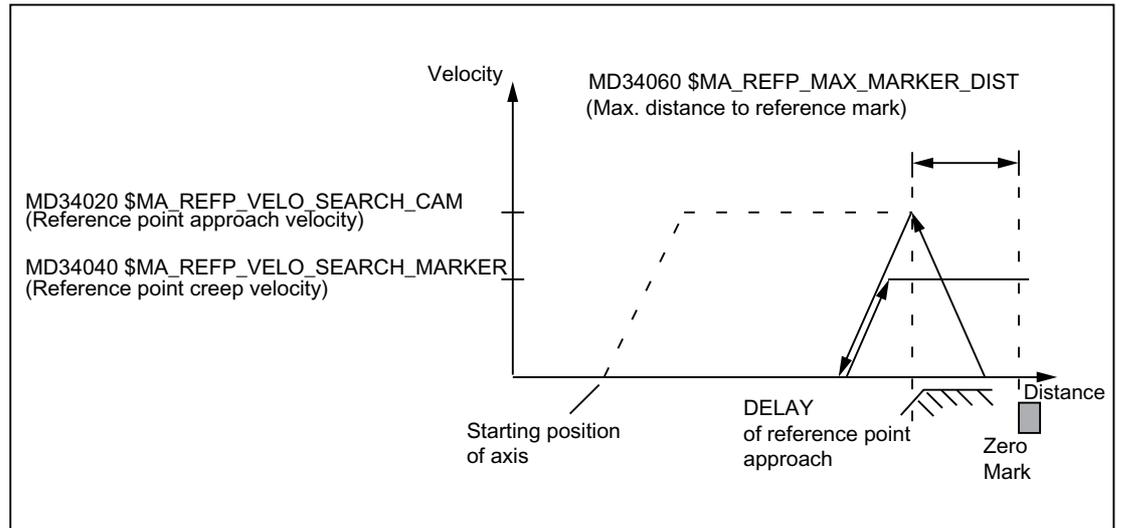


Figure 14-7 Synchronization with rising reference cam signal edge

### Electronic reference cam offset

Electronic reference cam offset is used for compensating reference cam length increases caused by temperature:

MD34092 \$MA\_REFP\_CAM\_SHIFT (electronic reference cam offset for incremental measuring systems with equidistant zero marks)

After a rising or falling reference cam edge is detected the axis is synchronized for the next encoder zero mark only after the cyclically calculated offset path has been covered.

Because the offset path  $s_{\text{shift}}$  is calculated by the NC in IPO cycles, the following minimum and maximum offset paths  $s_{\text{shift\_min}}$  and  $s_{\text{shift\_max}}$  will result:

$$s_{\text{shift\_min}} = \text{MD34092 } \$MA\_REFP\_CAM\_SHIFT$$

$$s_{\text{shift\_max}} = \text{MD34092 } \$MA\_REFP\_CAM\_SHIFT + \text{MD34040 } \$MA\_REFP\_VELO\_SEARCH\_MARKER * \text{interpolation cycle}$$

The reference cam offset acts in the direction of zero mark search.

#### Prerequisite

The reference cam offset is only active for machine axes for which a reference cam has been parameterized:

$$\text{MD34000 } \$MA\_REFP\_CAM\_IS\_ACTIVE = 1$$

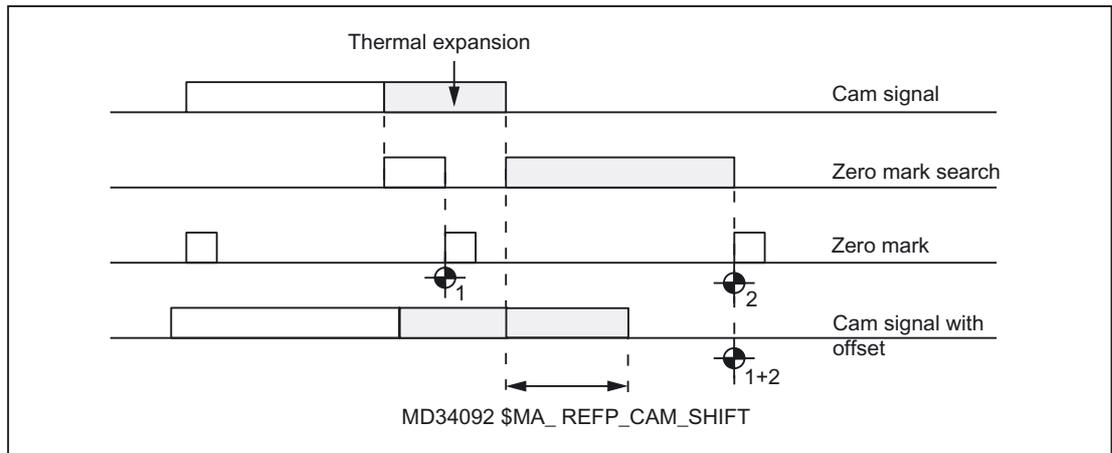


Figure 14-8 Electronic reference cam offset

## Reference cam adjustment

### Encoder with equidistant zero marks

Always ensure that the reference cam of encoders that supply zero marks at equidistances is accurately adjusted so that the correct zero mark is always detected during reference point approach.

### Dynamic response

The following factors influence the dynamic response from the arrival of the reference cam to the machine up to the detection of reference cam signals transferred from the PLC user program to the NC:

- Switching accuracy of the reference cam switch
- Delay of the reference cam switch (NC contact)
- Delay at the PLC input
- PLC cycle time
- Cycle time for updating the VDI interface
- Interpolation cycle
- Position control cycle

**Setting notes**

- reference cam

Aligning the signal edge of the reference cam directly between two zero marks has proven to be the most practical method.

- Electronic reference cam offset

Information needed for parameterizing the electronic reference cam offset is to be found in the read-only machine data:

MD34093 \$MA\_REFP\_CAM\_MARKER\_DIST (distance between reference cam/reference mark)

The indicated value is equivalent to the distance between departure from the reference cam and detection of the reference mark. If the values are too small, there is a risk that the determination of the reference point will be non-deterministic, due to temperature effects or fluctuations in the operating time of the cam signal.

 **WARNING**

If the reference cam adjustment is faulty or inaccurate, an incorrect zero mark can be evaluated. The control then calculates an incorrect machine zero. As a result, the machine axis will approach the wrong positions. Software limit switches, protected areas and working area limitations act on incorrect positions and are therefore incapable of protecting the machine. The path difference is +/- of the path covered by the machine axis between 2 zero marks.

**Phase 2: Features**

- Feedrate override is **not** active.

Internal motion with feedrate override = 100%.

If a feedrate override of 0% is specified, motion is aborted.

- Feed stop (channel-specific and axis-specific) is active.
- NC-STOP and NC-START are **not** active.
- If the machine axis does not arrive at Phase 2 within the parameterized distance of the reference mark (encoder zero mark), the machine axis will be stopped:

MD34060 \$MA\_REFP\_MAX\_MARKER\_DIST (max. distance to the reference mark)

### 14.5.5 Phase 3: Traversing to the reference point

#### Phase 3: Graphic representation

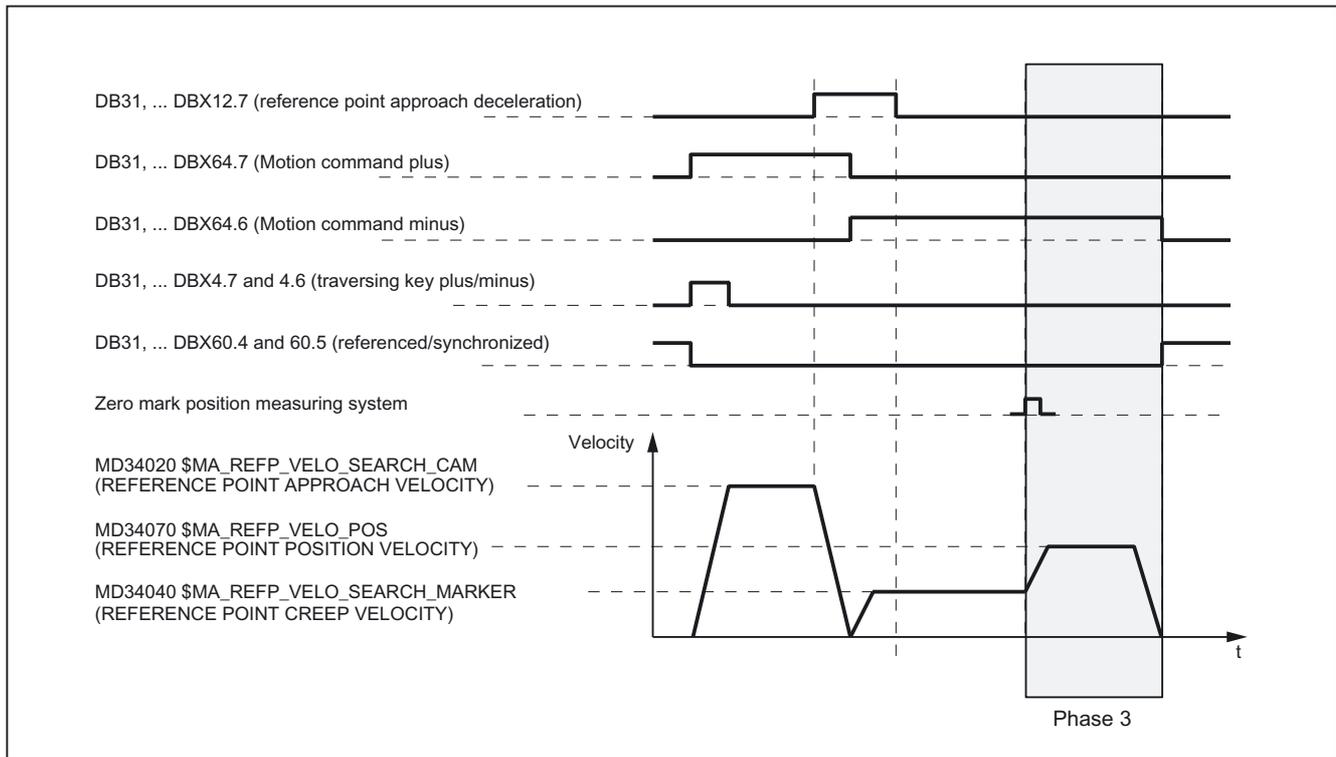


Figure 14-9 Phase 3: Traversing to the reference point

#### Phase 3: Start

At the end of phase 2 the machine axis travels at reference point creep velocity. Therefore, as soon as phase 2 is completed successfully without an alarm, phase 3 is started without interruption.

#### Initial situation

The encoder zero mark has been detected.

#### Phase 3: Sequence

The machine axis moves at the assigned reference point positioning velocity: MD34070 \$MA\_REFP\_VELO\_POS (reference point positioning velocity) from the encoder zero mark detected in Phase 2 to the reference point.

The path  $s_{ref}$  to be covered is calculated from the sum of the reference point distance plus reference point offset:

MD34080 \$MA\_REFP\_MOVE\_DIST (reference point distance)

MD34090 \$MA\_REFP\_MOVE\_DIST\_CORR (reference point offset)

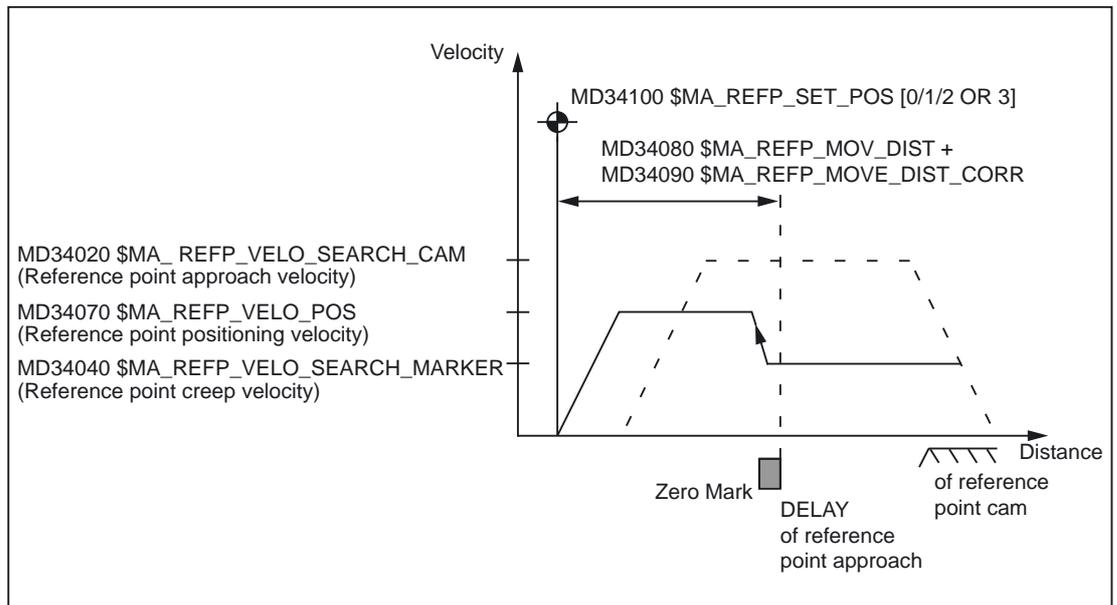


Figure 14-10 Reference point position

When the reference point is reached the machine axis is stopped and the actual value system of the machine axis is synchronized with the reference point value specified by the PLC user program.

MD34100 \$MA\_REFP\_SET\_POS [ n ] (Reference point value)

The reference point value is specified by the PLC user program via:

DB31, ... DBX2.4/5/6/7 (reference point value 1/2/3/4)

The reference point value, which was selected by the PLC user program at the time of the arrival of the reference cam in Phase 1 (DB31, ... DBX12.7 = 1), is taken over by the NC.

The machine axis is now referenced. As identification, the NC sets the appropriate interface signal depending on the active measuring system:

DB31, ... DBX60.4/5 (Referenced/Synchronized 1/2) = 1

### Features of phase 3

- Feed override active.
- Feed stop (channel-specific and axis-specific) is active.
- NC STOP and NC START are active.

### Special feature of phase 3

If the parameterized distance from the encoder zero mark to the reference point, i.e. the sum of reference point distance and reference point offset (MD34080 + MD34090) is smaller than the required braking distance for stopping from the reference point positioning velocity (MD34070), the machine axis initially stops "behind" the reference point and then travels back to it.

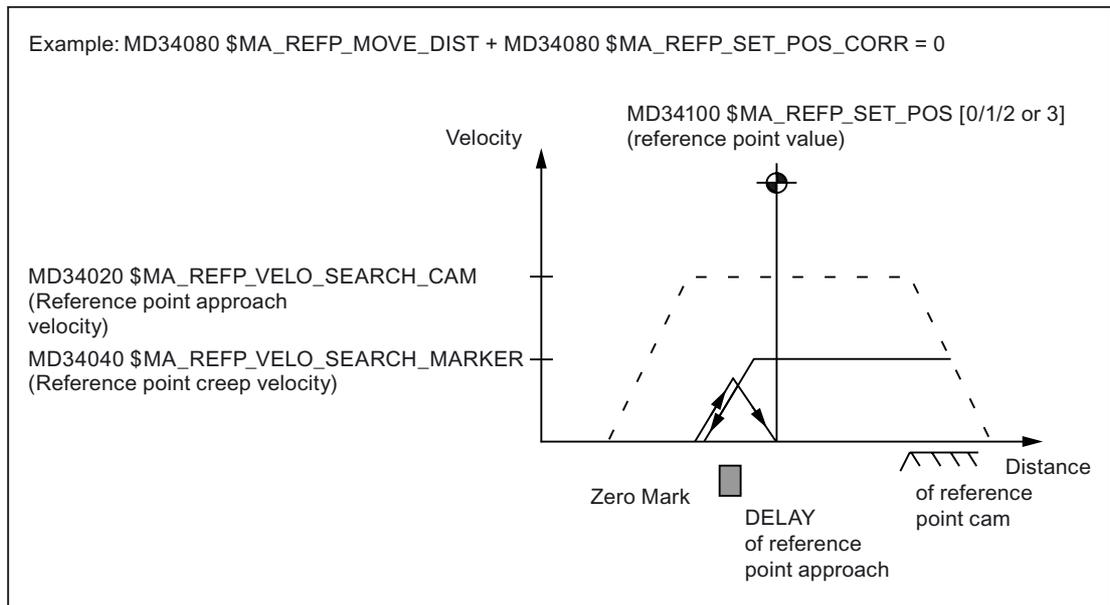


Figure 14-11 Reference point distance plus reference point offset smaller than braking distance

## 14.5.6 Buffered actual value

### Automatic referencing

By buffering the actual value, "automatic referencing" is enabled, which does not require machine axes with incremental measuring systems, after situations in which they are in the "Not referenced" condition, to traverse back to the reference point for referencing of the measuring system. For example, this is the case after:

- POWER OFF/ON
- "Parking" selected:

DB31, ... DBX1.5/1.6 (Position measuring system 1/2) = 0

DB31, ... DBX2.1 (servo enable) = 0

If the function is active, referencing is performed without axis motion by synchronizing the actual value system of the machine axis to the last valid actual value. The actual value is buffered in a retentive memory area of the control even after POWER OFF.

### WARNING

During the time in which the measuring system (encoder) of the machine axis is switched off ((POWER OFF, "Parking" the axis, etc.), the machine axis may not be further mechanically moved. This must be supported by the machine manufacturer with such measures as holding brakes, etc., and ensured by the user. Otherwise the actual value system of the machine axis will no longer be synchronized resulting in danger to personnel and machine.

### Precondition for automatic referencing

At the time of automatic referencing (e.g. after POWER ON, "Parking" of the machine axis is again deselected, etc.), the encoder status of the active measuring system of the machine axis must have the value 2.

MD34210 \$MA\_ENC\_REFP\_STATE = 2

That is, the encoder is referenced, an exact stop is reached, and automatic referencing is active the next time the encoder is activated.

The following conditions must be fulfilled:

- "Automatic referencing" is assigned for the measuring system (encoder):

MD34210 \$MA\_ENC\_REFP\_STATE = 1

Encoder status = 1: Automatic referencing enabled, but encoder not yet referenced or exact stop not reached.

- The measuring system has already been successfully referenced with reference point approach.

This is identified by the NC by changing the encoder status from 1 to 2.

Encoder status = 2: Encoder is referenced, an exact stop is reached, and automatic referencing is active the next time the encoder is activated.

- The machine axis was disabled in "Exact stop fine" status.

---

### Note

Within the scope of actual value buffering, the following axis specific interface signal is evaluated:

DB31, ... DBX60.7 (Position reached with fine exact stop)

The actual values of machine axes that do not use the signal cannot be buffered.

---

## Functional sequence

Two different cases apply for automatic referencing, which depend on the encoder status:

- **Case 1: Encoder status = 2**

Automatic referencing in parameterized, the measuring system has been referenced and the machine axis was switched off in status "exact stop fine".

As a result:

- The actual value system of the machine axis is synchronized with the buffered actual value.
- The status of the machine axis is set to "Referenced".

DB31, ... DBX60.4/60.5 (Referenced/Synchronized 1/2) = 1

- **Case 2: Encoder status = 1**

Automatic referencing in parameterized but the measuring system has either not yet been referenced or the machine axis was not switched off in status "exact stop fine".

As a result:

- The actual value system of the machine axis is synchronized with zero.
- The status of the machine axis is set to "Not referenced":

DB31, ... DBX60.4/60.5 (Referenced/Synchronized 1/2) = 0

## 14.6 Referencing with distance-coded reference marks

### 14.6.1 General overview

#### Distance-coded reference marks

Measuring systems with distance-coded reference marks consist of two parallel scale tracks:

- Incremental grating
- Reference mark track

The distance between any two consecutive reference marks is defined in different ways. This makes it possible to determine the absolute position of the machine axis when two consecutive reference marks are crossed. For example, if the distance between the reference marks is approx. 10 mm, a traverse path of approx. 20 mm is all that is required to reference the machine axis.

Referencing can be performed from any axis position in the positive or negative direction (exception: end of travel range).

### 14.6.2 Basic parameter assignment

#### Linear measuring systems.

The following data must be set to parameterize linear measuring systems:

- The absolute offset between the machine zero point and the position of the first reference mark of the linear measuring system:

MD34090 \$MA\_REFP\_MOVE\_DIST\_CORR (reference point/absolute offset)

See also below: Determining the absolute offset

- Orientation of the length measuring system (equidirectional or inverse) relative to the machine system coordinate system:

MD34320 \$MA\_ENC\_INVERS (length measuring system inverse to the machine system)

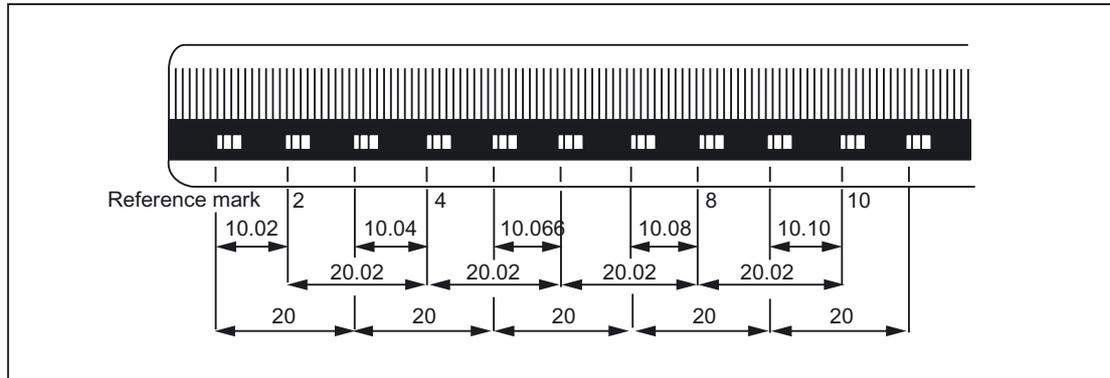


Figure 14-12 DIADUR graduated glass scale with distance-coded reference marks (dimensions in mm for 20 mm scale division)

### Rotary measuring system

For rotary measuring systems, the same applies as for linear measuring systems (see above).

### Determining the absolute offset

The following procedure is recommended for the determination of the absolute offset between the machine zero point and the position of the first reference mark of a machine axis:

1. Enter the value zero for the absolute offset:

MD34090 \$MA\_REFP\_MOVE\_DIST\_CORR = 0

2. Perform reference point approach.

**Note:** Reference point approach should be performed at a point in the machine where the exact position of the machine axis relative to machine zero can be determined easily with a laser interferometer, for example.

3. Determine the actual position of the machine axis via the operator interface screen.
4. Measure the current position of the machine axis with reference to the machine zero point.
5. Calculate absolute offset and enter in MD34090.

The absolute offset is calculated with respect to the machine coordinate system and depending on the orientation of the measuring system (equidirectional or inverse) as:

Orientation of the measuring system	Absolute offset
Equidirectional	Measured position + displayed actual position
Opposite direction	Measured position - displayed actual position

### WARNING

After determining the absolute offset and the entry in MD34090, the reference point traversing for the machine axis must be carried out once more.

## Referencing methods

Referencing with distance-coded reference marks can be performed in one of two ways:

- Evaluation of **two** consecutive reference marks:

MD34200 \$MA\_ENC\_REFP\_MODE (referencing mode) = 3

Advantage:

- Short travel path

- Evaluation of **four** consecutive reference marks:

MD34200 \$MA\_ENC\_REFP\_MODE = 8

Advantage:

- Plausibility check by NC is possible
- Increase in reliability of referencing result

### 14.6.3 Chronological sequence

#### Chronological sequence

Referencing with distance-coded reference marks can be divided into two phases:

- Phase 1: Travel across the reference marks with synchronization
- Phase 2: Traveling to a fixed destination point

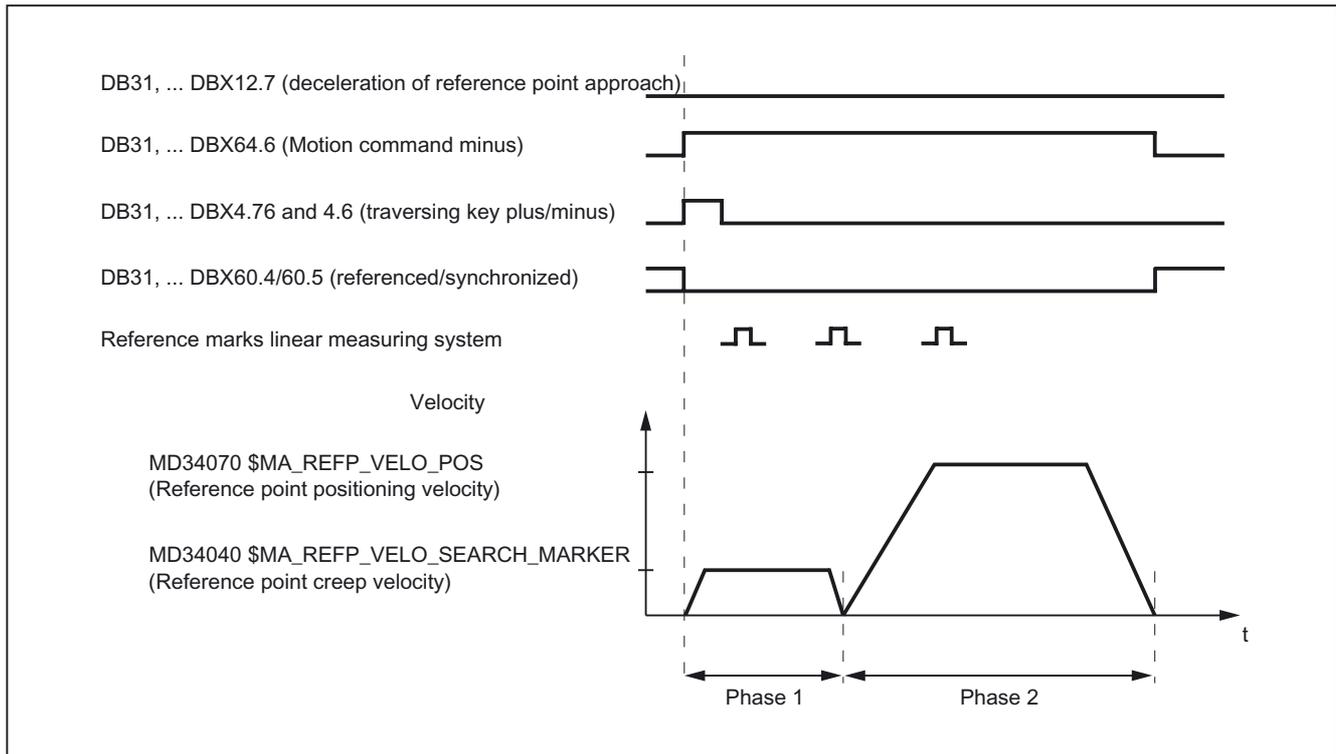


Figure 14-13 Distance-coded reference marks

## 14.6.4 Phase 1: Travel across the reference marks with synchronization

### Phase 1: Start

For information on starting reference point approach, refer to "Axis-specific referencing" and "Channel-specific referencing."

### reference cam

In measuring systems with distance-coded reference marks, reference cams are not required for the actual referencing action. For functional reasons, however, a reference cam is required for channel-specific reference point approach and reference point approach from the part program (*G74*) before the traversing range end of the machine axis.

### Phase 1: Sequence

#### Sequence without touching a reference cam

Once reference point approach is started, the machine axis accelerates to the assigned reference point creep velocity:

MD34040 \$MA\_REFP\_VELO\_SEARCH\_MARKER (reference point creep velocity)

Once the parameterized number of reference marks has been crossed, the machine axis is stopped again and the actual value system of the machine axis is synchronized to the absolute position calculated by the NC.

#### Sequence when starting from the reference cam

If the machine axis is at the reference cam at the start of the reference point traversing, it accelerates to the parameterized reference point creep velocity against the parameterized reference point approach direction:

MD34040 \$MA\_REFP\_VELO\_SEARCH\_MARKER (reference point creep velocity)

MD34010 \$MA\_CAM\_DIR\_IS\_MINUS (Reference point approach in minus direction)

That ensures that the machine axis does not reach the travel range limit before it has crossed the parameterized number of reference marks.

Once the parameterized number of reference marks has been crossed, the machine axis is stopped again and the actual value system of the machine axis is synchronized to the absolute position calculated by the NC.

#### **Sequence when contact is made with reference cam during referencing**

Once reference point approach is started, the machine axis accelerates to the assigned reference point creep velocity:

MD34040 \$MA\_REFP\_VELO\_SEARCH\_MARKER (reference point creep velocity)

Before the machine axis travels over the parameterized number of reference marks, it touches the reference cam. It is then reversed and reference mark search is restarted in the opposite direction.

Once the parameterized number of reference marks has been crossed, the machine axis is stopped again and the actual value system of the machine axis is synchronized to the absolute position calculated by the NC.

#### **Plausibility check of the reference mark distance**

An error occurs if, during reference point traversing for two subsequent reference marks, the NC determines a distance greater than twice the parameterized reference mark distance.

MD34300 \$MA\_ENC\_REFP\_MARKER\_DIST (Reference mark distance)

The machine axis will then traverse in opposite direction at half the parameterized reference point creep velocity (MD34040) and the search for reference mark is restarted.

If a faulty reference mark distance is detected again, the machine axis is stopped and the reference point traversing is aborted (alarm 20003 "fault in the measuring system").

#### **Abort criterion**

If the parameterized number of reference marks is not detected within the parameterized distance, the machine axis is stopped and reference point traversing is aborted.

MD34060 \$MA\_REFP\_MAX\_MARKER\_DIST (max. distance to the reference mark)

#### **Features of phase 1**

After phase 1 is successfully completed, the actual value system of the machine axis is synchronized.

## 14.6.5 Phase 2: Travel to fixed stop

### Phase 2: Start

Phase 2 is automatically started when phase 1 has been completed without an alarm.

#### Initial situation:

- The machine axis is positioned directly behind the last of the parameterized number of reference marks.
- The actual value system of the machine axis is synchronized.

### Phase 2: Sequence

In Phase 2, the machine axis completes reference point approach by traversing to a defined target position (reference point). This action can be suppressed in order to shorten the reference point approach:

MD34330 \$MA\_STOP\_AT\_ABS\_MARKER

Value	Meaning
0	Travel to target position
1	No travel to target position

#### Travel to target position (normal case)

The machine axis accelerates to the parameterized reference point position velocity and travels to the parameterized target point (reference point):

MD34070 \$MA\_REFP\_VELO\_POS (Reference point positioning velocity)

MD34100 \$MA\_REFP\_SET\_POS (reference point value)

The machine axis is referenced. To identify this, the NC sets an interface signal for the measuring system that is currently active:

DB31, ... DBX60.4/60.5 (Referenced/Synchronized 1/2) = 1

#### No travel to target position

The machine axis is now referenced. To identify this, the NC sets an interface signal for the measuring system that is currently active:

DB31, ... DBX60.4/60.5 (Referenced/Synchronized 1/2) = 1

## Features of phase 2

Phase 2 will display different characteristics, depending on whether a reference point cam is parameterized for the machine axis.

### Machine axis without reference point cam

MD34000 \$MA\_REFP\_CAM\_IS\_ACTIVE (Axis with reference point cam) = 0

Properties:

- Feed override active.
- The feed stop (channel-specific and axis-specific) is active.
- NC STOP and NC START are active.

### Machine axis with reference point cam

MD34000 \$MA\_REFP\_CAM\_IS\_ACTIVE (Axis with reference point cam) = 1

Properties:

- Feedrate override is **not** active.

Machine axis moves internally when feedrate override = 100%.

If a feedrate override of 0% is specified, an abort occurs.

- The feed stop (channel-specific and axis-specific) is active.
- NC-STOP and NC-START are **not** active.
- If the parameterized number of reference marks is not detected within the parameterized distance after the exit of the reference cam, the machine axis will be stopped.

MD34060 \$MA\_REFP\_MAX\_MARKER\_DIST (max. distance to the reference mark)

## Special features of rotary measuring systems

On rotary distance-coded measuring systems, the absolute position can only be determined uniquely within one revolution. Depending on the mechanical mounting of the encoder, the overtravel of the absolute position in the hardware does not always coincide with the traversing range of the rotary axis.

## Special features of modulo rotary axes

With modulo rotary axes, the reference point position is mapped on the parameterized modulo range:

MD30330 \$MA\_MODULO\_RANGE (extent of modulo range)

MD30340 \$MA\_MODULO\_RANGE\_START (starting position of modulo range)

---

**Note**

The reference point position is mapped onto the assigned (ghost) modulo range even with axis function "Determination of reference point position rotary, distance-coded encoder within the configured modulo range":

MD30455 \$MA\_MISC\_FUNCTION\_MASK (axis functions), BIT1 = 1

---

## 14.7 Referencing by means of actual value adjustment

### 14.7.1 Actual value adjustment to the referencing measurement system

#### Function

When actual value adjustment to the referencing measuring system is performed, the resulting absolute actual position after successful referencing of the measuring system of a machine axis is transferred directly to all other measuring systems of the machine axis, and the machine axis is designated as referenced:

DB31, ... DBB60.4/60.5 (referenced/synchronized 1/2) = 1

#### Advantage

When the machine axis switches from an explicitly referenced measuring system to the measuring system referenced by actual value adjustment, continuous servo control is assured (servo enable active) because the matched actual position prevents a sudden change in actual value.

---

#### Note

In order to improve positioning precision by determining the measuring-system-specific encoder fine information, we recommend explicitly re-referencing the measuring system previously referenced by actual value adjustment after switching over.

---

#### Activation

The activation of the actual value adjustment to the referencing measuring system is machine-specifically carried out via:

MD34102 \$MA\_REFP\_SYNC\_ENCS = 1

### 14.7.2 Actual value adjustment to the referenced measurement system

#### Function

If a machine axis has several measuring systems and one of them is referenced, the remaining measuring systems can be referenced by actual value adjustment to the measuring system already referenced.

#### Advantage

Referencing does not take as long because the path to be traversed only has to be sufficiently long to allow elimination of the backlash in both measuring systems.

If the distance to the traversing range limits is large enough, referencing can be started at any point along the traversing range of the machine axis in any direction because no zero mark, reference point cam, etc., is required.

### Parameter assignment

The following machine data must be parameterized for actual value adjustment to a referenced measuring system:

- Homing mode: Actual value adjustment to a referenced measuring system  
MD34200 \$MA\_ENC\_REFP\_MODE[*measuring system*] = 6
- Traverse path for backlash recovery:  
MD34080 \$MA\_REFP\_MOVE\_DIST[*measuring system*] (reference point distance)

---

#### Note

##### Reference point distance greater than zero

To ensure reliable backlash recovery, the assigned value for the reference point distance must be greater than the maximum backlash of both measuring systems.

##### Reference point distance equal to zero

The reference point distance can also equal zero. In this case, actual value adjustment is performed without a traversing movement as soon as reference point approach starts. In this case, the active backlash should be less than half the increment of the measuring system whose actual value is taken.

---

### 14.7.3 Actual value adjustment for measuring systems with distance-coded reference marks

#### Function

In order to improve positioning precision by determining the measuring-system-specific encoder fine information, we recommend explicitly re-referencing the measuring system previously referenced by actual value adjustment after switching over the measuring system.

If an encoder with distance-coded reference marks is used for the passive measuring system, referencing can be avoided if the following conditions are met:

1. Active measuring system: indirect measuring system (motor measuring system) with absolute encoder, for example
2. Passive measuring system: Direct measuring system with distance-coded reference marks
3. Travel movement of the machine axis with the referenced indirect measuring system before measuring system switchover in which the number of reference marks required for referencing are crossed. This automatically references the passive direct measuring system.

## Parameterization

In addition to the specific machine data required to reference the individual measuring systems, the following machine data must be set:

- Enable actual value adjustment:  
MD34102 \$MA\_REFP\_SYNC\_ENCS = 1
- Direct measuring system with distance-coded reference marks:
  - MD34200 \$MA\_ENC\_REFP\_MODE[*measuring system*] = 3  
Distance-coded reference marks
  - MD30242 \$MA\_ENC\_IS\_INDEPENDENT[*measuring system*] = 2

During actual value adjustment, the passive direct measuring system is adjusted to the actual position of the active indirect measuring system, but is not marked as referenced. After the parameterized number of reference marks have been crossed, the passive direct measuring system is automatically referenced. Referencing is performed in every operating mode.

## Sequence

1. Initial situation: Neither of the measuring systems are referenced:  
DB31, ... DBX60.4 = 0 (referenced/synchronized 1)  
DB31, ... DBX60.5 = 0 (referenced/synchronized 2)
2. Reference the indirect measuring system according to the measuring system type:  
DB31, ... DBX60.4 = 1 (referenced/synchronized 1)  
DB31, ... DBX60.5 = 0 (referenced/synchronized 2)
3. Traverse the machine axis across the parameterized number of reference marks.  
This automatically references the direct measuring system:  
DB31, ... DBX60.4 = 1 (referenced/synchronized 1)  
DB31, ... DBX60.5 = 1 (referenced/synchronized 2)

## 14.8 Referencing in follow-up mode

### Function

Incremental measuring systems and measuring systems with distance-coded reference marks can be referenced even when the machine axis is in follow-up mode. This requires that reference point approach be properly parameterized according to the measuring system in use (see "Referencing with incremental measuring systems" and "Referencing with distance-coded reference marks").

When referencing in follow-up mode the machine axis is moved not by the NC but by means of an external travel movement over the encoder zero mark and the parameterized number of distance-coded reference marks. The measuring system is referenced when the encoder zero mark or parameterized number of distance-coded reference marks are detected.

---

### Note

#### Reproducibility of the referencing result

In NC-guided reference point approach, reproducibility of the referencing result is ensured through adherence to the assigned traverse velocities during the referencing operation. During referencing in follow-up mode, responsibility for achieving reproducibility of the referencing results lies with the machine manufacturer/user.

---

### Unique zero mark

Referencing of an incremental measuring system is based on the explicit position of the encoder zero mark relative to the overall traversing range of the machine axis.

Because the reference cam signal is not evaluated by the NC during referencing in follow-up mode, unique identification of the reference point when referencing in follow-up mode will only result with:

- Only one encoder zero mark in the traversing range of the machine axis
- Linear measuring systems with distance-coded reference marks
- Modulo rotary axes (absolute position within one revolution)

### Zero mark selection when several zero marker signals occur

If several encoder zero marks are detected in the traversing range of the machine axis due to machine-specific factors, e.g. reduction gear between encoder and load, a BERO must be mounted on the machine and connected to the relevant drive module (SIMODRIVE 611D) via a BERO input in order to uniquely specify the reference point. The position of the reference point is then derived from the combination of BERO signal and encoder zero mark.

Zero mark evaluation with BERO must be parameterized as the referencing mode:

MD34200 \$MA\_ENC\_REFP\_MODE = 5

#### Negative edge evaluation

In the case of a referencing operation with a negative edge evaluation of the BERO signal:

MD34120 \$MA\_REFP\_BERO\_LOW\_ACTIVE = FALSE

synchronization is with the next encoder zero mark encountered after the BERO is exited.

#### Positive edge evaluation

In the case of a referencing operation with a positive edge evaluation of the BERO signal:

MD34120 \$MA\_REFP\_BERO\_LOW\_ACTIVE = TRUE

synchronization is with the next encoder zero mark encountered after the BERO is approached.

Mechanically, the BERO must be sized in such a way that the positive BERO signal covers the entire width of the encoder zero mark.

### Enable

The "Referencing in follow-up mode" function is enabled with:

MD34104 \$MA\_REFP\_PERMITTED\_IN\_FOLLOWUP = TRUE

### Starting the referencing operation

If the machine axis is operating in the follow-up mode at the start of reference point traversing, (DB31,... DBX61.3 == TRUE) the measuring system will be referenced in the follow-up mode.

If the machine axis is not operating in the follow-up mode at the start of reference point traversing, the "normal" from the NC controlled reference point travels is carried out.

Referencing in follow-up mode can be started in the following modes:

- JOG-REF: Traversing keys
- AUTOMATIC: Part program command G74

### Sequence of referencing operation (JOG-REF mode)

1. Activate follow-up mode of machine axis:  
DB31, ... DBX1.4 (follow-up mode) = 0  
DB31, ... DBX2.1 (servo enable) = 0
2. Take into account activation of follow-up mode:  
DB31, ... DBX61.3 (follow-up mode active) = 1
3. Switch to JOG-REF mode.
4. External movement of machine axis across encoder zero mark or parameterized number of distance-coded reference marks. The referencing operation is started internally in the NC as soon as the machine axis is moved:  
DB31, ... DBX61.4 (axis/spindle stationary) = 0
5. The measuring system is referenced after the encoder zero mark or the assigned number of distance-coded reference marks have been successfully detected:  
DB31, ... DBX60.4/60.5 (referenced/synchronized 1/2) = 1

### Aborting the reference operation

An active referencing operation can be aborted by:

- Deselecting follow-up mode
- NCK Reset

### Response when measuring systems are already referenced

A measuring system that has already been referenced can only be re-referenced in AUTOMATIC mode using part program instruction *G74*.

### Sequence of referencing operation (AUTOMATIC mode)

1. Switch to AUTOMATIC mode.
2. Start the part program.
3. Activate follow-up mode of machine axis:  
DB31, ... DBX1.4 (follow-up mode) = 0  
DB31, ... DBX2.1 (servo enable) = 0
4. Take into account activation of follow-up mode:  
DB31, ... DBX61.3 (follow-up mode active) = 1
5. The referencing operation is started internally in the NC as soon as part program instruction *G74* is processed.
6. External movement of machine axis across encoder zero mark or parameterized number of distance-coded reference marks.

7. The measuring system is referenced after the encoder zero mark or the assigned number of distance-coded reference marks have been successfully detected:

DB31, ... DBX60.4/60.5 (referenced/synchronized 1/2) = 1

8. The block change occurs after the referencing operation has been successfully completed.

#### **Aborting the reference operation**

An active referencing operation can be aborted by:

- Deselecting follow-up mode
- NCK Reset

#### **Response when measuring systems are already referenced**

A measuring system that you have already referenced can be referenced again.

## 14.9 Referencing with absolute value encoders

### 14.9.1 Information about calibration

#### Machine axes with absolute encoder

The advantage of machine axes with absolute value encoder is that after a one time adjustment procedure, the necessary reference point traversing with incremental measuring systems (e.g. build-up of control, de-selection of "Parking" of machine axes etc.) can be skipped and the actual value system of the machine axis can be immediately synchronized to the determined absolute position.

#### Adjustment

Adjustment of an absolute encoder involves matching the actual value of the encoder with the machine zero once and then setting it to valid.

The current adjustment status of an absolute value encoder is displayed in the following axis specific machine data of the machine axis, to which it is connected:

MD34210 \$MA\_ENC\_REFP\_STATE (status of absolute encoder)

Value	Meaning
0	Encoder not calibrated
1	Encoder adjustment enabled
2	Encoder is calibrated

#### Adjustment methods

The following adjustment methods are supported:

- Adjustment by entering a reference point offset
- Adjustment by entering a reference point value
- Automatic adjustment with probe
- Adjustment with BERO

#### Readjustment

Readjustment of the absolute encoder is required after:

- Gear change between load and absolute encoder
- Removal/installation of the absolute value encoder
- Removal/installation of the motor with the absolute value encoder
- Data loss in the static NC memory
- Battery failure
- Setting actual value (PRESETON)

**NOTICE**

The NCK can only detect a required readjustment during the following events:

- Gear change with change of gear ratio
- Addressing the zero-mark monitoring
- New encoder serial number after change of the absolute value encoder

Thereupon, the status of the absolute encoder is automatically reset by NCK to 0 (encoder not calibrated) (MD34210 = 0) and the following alarm is displayed:

Alarm 25022 "Axis <Axis identifier> Encoder <Number> Warning 0"

or when addressing the zero-mark monitoring (only systems with SIMODRIVE 611D):

Alarm 25020 "Axis <Axis identifier> Zero-mark monitoring of the active encoder"

In all other cases (e.g. PRESETON) it is the sole responsibility of the user, by resetting the status to 0 (encoder not adjusted), to show the misalignment of the absolute value encoder and to carry out a readjustment.



**WARNING**

**Data backup**

During the back-up of machine data of a machine A, the encoder status of the machine axis (MD34210) is also backed up.

During loading of this data record into a machine B of the same type, e.g. in the context of a serial start-up or after a case of maintenance, the referenced machine axes will be automatically regarded as adjusted/referenced by the NC. It is the special responsibility of the machine manufacturer/user to undertake a readjustment in such cases.

See also explanations regarding machine data:

MD30250 \$MA\_ACT\_POS\_ABS (Absolute encoder position at the time of switch-off)

## 14.9.2 Calibration by entering a reference point offset

### Function

During adjustment by entering the reference point offset, the difference between the position displayed on the operator interface and the true actual position in the machine is determined and made known to the NC as reference point offset.

### Procedure

1. Determining the position of the machine axis with reference to the machine zero point via e.g.:
  - Position measurement (e.g. laser interferometer)
  - Moving the machine axis to a known position (e.g. fixed stop)
2. Reading the displayed actual position of the machine axis on the operator interface.
3. Calculating the reference point offset (difference between the actual positions determined under point 1 and 2) and entering in machine data:

MD34090 \$MA\_REFP\_MOVE\_DIST\_CORR (reference point offset)

4. Marking the absolute value encoder as adjusted:

MD34210 \$MA\_ENC\_REFP\_STATE = 2

---

#### Note

The encoder adjustment does not become active until the next time the encoder is activated (e.g. when the controller is powered up).

---

1. Initiate POWER ON reset.
2. Controlling the position of the machine axis displayed on the operator interface.

---

#### Note

##### Backlash compensation

If backlash compensation is parameterized for a measuring system with absolute value encoder, the following must be observed:

No backlash is permitted during machine axis travel to the adjusted machine position.

##### Activate reference point offset permanently

The entered reference point offset (MD34090) will be permanently active only after initial POWER ON - Reset. If the machine axis is moved after the absolute encoder adjustment without an interim POWER ON - Reset, the reference point offset entered in the machine data can be overwritten, for example, as part of internal overrun offset.

##### Checking the actual position

Following adjustment of the absolute encoder, we recommend that you verify the actual position of the machine axis the next time you power up the controller (POWER ON).

---

### 14.9.3 Adjustment by entering a reference point value

#### Function

During adjustment by entering the reference point value, the absolute position of the machine axis with reference to the machine zero point is determined by e.g.:

- Position measurement (e.g. laser interferometer)
- Moving the machine axis to a known position (e.g. fixed stop)

This determined position value will be made known to the NC as the reference point value. The NC then calculates the reference point offset from the difference between the encoder absolute value and the reference point value.

#### Procedure

1. Set reference mode to "Take over of the reference point value"  
MD34200 \$MA\_ENC\_REFP\_MODE = 0
2. Traversing machine axis in the JOG mode to the (e.g. Laser interferometer) position to be measured or already known (e.g. fixed stop).

---

#### Note

The machine axis can only be traversed in the direction enabled for referencing with the travel keys:

MD34010 \$MA\_REFP\_CAM\_DIR\_IS\_MINUS (approach reference point in minus direction)

To avoid an invalid position because of backlash in the drive train, the known position must be approached at low velocity.

---

1. Communicate the position of the machine axis relative to machine zero to the NC as the reference point value:  
MD34100 \$MA\_REFP\_SET\_POS = *Position*
2. Releasing encoder adjustment:  
MD34210 \$MA\_ENC\_REFP\_STATE = 1
3. Activate NCK-Reset for acceptance of the entered machine data values.
4. Switch to JOG-REF mode.
5. Operate the travel key used for referencing in step 2.

The machine axis does not move when the traversing key is actuated!

The NC calculates the reference point offset from the entered reference point value and that given by the absolute value encoder. The result is entered into the machine data:

MD34090 \$MA\_REFP\_MOVE\_DIST\_CORR (reference point offset)

The status of the absolute value encoder is set to "Encoder is adjusted":

MD34210 \$MA\_ENC\_REFP\_STATE = 2

The actual value system of the machine axis is synchronized.

The machine axis is now referenced. As identification, the NC sets the appropriate interface signal based on which measuring system is currently active:  
DB31, ... DBB60.4/60.5 (referenced/synchronized 1/2) = 1

6. Initiate POWER ON reset.

---

#### Note

##### Activate reference point offset permanently

The entered reference point offset (MD34090) will only be permanently active after POWER ON - Reset.

If the machine axis is moved after the absolute encoder adjustment without an interim POWER ON - Reset, the reference point offset entered in the machine data can be overwritten, for example, within internal overrun corrections.

##### Checking the actual position

Following adjustment of the absolute encoder, we recommend that you verify the actual position of the machine axis the next time you power up the controller (POWER ON).

---

## 14.9.4 Automatic calibration with probe

### Function

In automatic adjustment with a probe, a known position in the machine is approached with the machine axis from a part program. The position value is stored in the NC as a reference point value. The position is reached when the probe switches, and the NC then calculates the reference point offset from the difference between the encoder value and reference point value.

---

#### Note

##### Part program for automatic adjustment

The part program for automatic adjustment using a probe must be created by the machine manufacturer/user for the specific requirements of the machine.

##### Freedom from collision

Because actual-value-related monitoring is not active for the machine axes being referenced, the machine operator must take special care to ensure that collisions do not occur in the machine while the machine axes are being moved!

---

### Part program

The part program for automatic adjustment of absolute encoders with probe must perform the points listed below for each axis in the order indicated:

1. Approach the adjustment position of machine axis, which is detected from the probe response.

The position must be approached several times from the same direction, but at a velocity which is gradually reduced on each approach, to ensure that the measured value obtained is as accurate as possible. The measured value is stored in system variable \$AA\_IM.

2. Calculating and writing the reference point offset:

```
MD34090 $MA_REFP_MOVE_DIST_CORR = MD34100 $MA_REFP_SET_POS - $AA_IM
```

1. Set the absolute encoder status to "Encoder is adjusted":

```
MD34210 $MA_ENC_REFP_STATE = 2
```

### Sequence

Proceed as follows for automatic adjustment with probe:

1. Enable part program start even for non-referenced machine axes:

```
MD20700 $MC_REFP_NC_START_LOCK = 0
```

2. Enter the machine axis position relative to machine zero when probe is switched as the reference point value for all relevant machine axes:

```
MD34100 $MA_REFP_SET_POS = reference point value
```

3. Activate NCK-Reset for the acceptance of the entered machine data values.
4. Start part program.

5. After completion of the part program, re-secure the partial program start for machine axes which are not referenced:

```
MD20700 $MC_REFP_NC_START_LOCK = 1
```

6. Initiate POWER ON - Reset so that the reference point offset written by the part program is permanently active:

```
MD34090 $MA_REFP_MOVE_DIST_CORR (reference point offset)
```

---

#### Note

##### Activate reference point offset permanently

The entered reference point offset (MD34090) will only be permanently active after POWER ON - Reset.

If the machine axis is moved after the absolute encoder adjustment without an interim POWER ON - Reset, the reference point offset entered in the machine data can be overwritten, for example, as part of internal overrun offset.

##### Checking the actual position

Following adjustment of the absolute encoder, we recommend that you verify the actual position of the machine axis the next time you power up the controller (POWER ON).

---

## 14.9.5 Calibration with BERO

### Function

For adjustment using BERO, a reference point approach to a defined machine position is performed the same as for incremental measuring systems. In this case the BERO replaces the encoder zero mark that the absolute encoder does not have. After successful completion of reference point approach, the NC automatically calculates the reference point offset from the difference between the encoder absolute value and the parameterized reference point value.

### Procedure

Proceed as follows for adjustment with BERO:

1. Set referencing mode to "Referencing with BERO":

```
MD34200 $MA_ENC_REFP_MODE = 2
```

2. Assign reference point value:

```
MD34100 $MA_REFP_SET_POS = Reference point value
```

3. Start reference point approach.

Reference point approach can be started manually in JOG-REF mode or in AUTOMATIC or MDA mode from a part program (G74).

After a successful reference point approach, the absolute encoder is calibrated, the actual value system of the machine axis is synchronized, and the machine axis is referenced.

To identify this, the NC sets an interface signal for the measuring system that is currently active:

```
DB31, ... DBB60.4/60.5 (referenced/synchronized 1/2) = 1
```

---

#### Note

If the BERO is removed after adjustment of the absolute encoder, the referencing mode must be assigned to "Referencing with absolute encoder".

```
MD34200 $MA_ENC_REFP_MODE = 0
```

---

### Signal propagation delay compensation

The signal propagation time can cause corruption of the absolute position detected by the NC. The signal propagation time can be compensated for in any direction:

```
MD31122 $MA_BERO_DELAY_TIME_PLUS (BERO delay time plus)
```

```
MD31123 $MA_BERO_DELAY_TIME_MINUS (BERO delay time minus)
```

---

#### Note

Prerequisite for a correct compensation of signal propagation time is drives of type SIMODRIVE 611 digital. The compensation times are pre-set in delivery condition in such a way that changes are usually not required.

---

### **Creep velocity**

If with the approach of BERO, it is to be proceeded with the parameterized reference point creep velocity (MD34040 \$MA\_REFP\_VELO\_SEARCH\_MARKER) then "BERO with projected start velocity with spindles" must be parameterized as reference mode:

MD34200 \$MA\_ENC\_REFP\_MODE = 7

## 14.9.6 Reference point approach with absolute encoders

### Traversing movement release

If for a machine axis with adjusted absolute value encoder as active measuring system, reference point traversing is activated (manual in the mode JOG-REF or automatic according to part program instruction G74), the machine axis travels depending on the parameterized release traversing movement.

MD34330 \$MA\_REFP\_STOP\_AT\_ABS\_MARKER = <Value>

Value	Meaning
0	Traversing is enabled. When reference point approach is initiated, the machine axis moves to the reference point position. Reference point approach is completed when the reference point position is reached.
1	Traversing is <b>not</b> enabled. After the activation of the reference point travel, the machine axis does not travel and the reference point travel is immediately completed.

### 14.9.7 Reference point approach in rotary absolute encoders with external zero mark

#### Function

To be able to use the reference point approach with a zero mark, as is usual in incremental encoders (refer to Chapter "Referencing in incremental measuring systems") even with absolute encoders, the missing HW zero marks are created in software form once every encoder revolution, always at the same position within the rotation.

#### Difference compared to referencing with incremental encoders

An absolute encoder with replacement zero mark should not be considered as a complete equivalent of an incremental encoder. All the properties of the absolute encoder are retained. The following table lists the different properties of incremental and absolute encoders:

Table 14-1 Properties of incremental and absolute encoders

Feature	Incremental encoder	Absolute encoders
Encoder type	MD30240 \$MA_ENC_TYPE	
	= 1	= 4
Internal encoder position	MD30250 \$MA_ACT_POS_ABS	
	Value is updated only in MD34210 ≥ 1	Value is updated only in MD30270 = 0
Traversing range extension	MD30270 \$MA_ENC_ABS_BUFFERING	
	No effect	= 0 (default): Active
Reference point offset	MD34090 \$MA_REFP_MOVE_DIST_CORR	
	Value input allowed	Value is updated exclusively via control
Supported referencing types	MD34200 \$MA_ENC_REFP_MODE	
	= 1, 2, 3, 4, 5, 6, 7	= 0, 1, 2
Adjustment status	MD34210 \$MA_ENC_REFP_STATE = 0, 1, 2	
	Automatic encoder misalignment during shut down while in motion.	Automatic encoder misalignment during parameter set change with position jump or during serial number change.
Absolute position modulo range	MD34220 \$MA_ENC_ABS_TURNS_MODULO	
	= 0	= 1 - 4096
Encoder Serial No.	MD34230 \$MA_ENC_SERIAL_NUMBER	
	= 0	The value must be updated from the PLC during each encoder change, otherwise loss of adjustment plus alarm.
Transfer of series startup files	Without any restrictions.	Due to encoder properties MD30250, MD30270, MD34090, MD34210, MD34220, MD34230 only possible with limitations.
Cam activation time	0 seconds	several seconds
Zero mark	1 per encoder revolution	none

Feature	Incremental encoder	Absolute encoders
Zero mark monitoring	Hardware	Software
Position after POWER ON without actual value buffering	0.0	Last position within MD34220.
	MD34210 = 0	MD30270 = 1
Position after POWER ON with actual value buffering	Last standstill position before deactivation.	Last position including small movements during POWER OFF.
	MD34210 = 1	MD30270 = 0
Referenced after POWER ON	depends on adjustment status	

## Requirement

The function can be used only with rotary absolute encoders:

- MD31000 \$MA\_ENC\_IS\_LINEAR = 0
- MD30240 \$MA\_ENC\_TYPE = 4

## Parameter assignment

- Reference point approach with zero marks:  
MD34200 \$MA\_ENC\_REFP\_MODE = 1
- A reference point offset should not be input in the following MD:  
MD34090 \$MA\_REFP\_MOVE\_DIST\_CORR  
This MD describes, in connection with absolute encoders, the offset between machine and absolute encoder zero, and it therefore has a different meaning.
- The load-side zero mark search rate MD34040 \$MA\_REFP\_VELO\_SEARCH\_MARKER should not exceed the limiting frequency of the absolute trace of the encoder MD36302 \$MA\_ENC\_FREQ\_LIMIT\_LOW.  
If the speed is too high, absolute information cannot be read any more, and thus, no equivalent zero marks are generated.
- If no zero marks are found within:  
MD34060 \$MA\_REFP\_MAX\_MARKER\_DIST  
otherwise, an alarm will be triggered.
- A start of the zero mark search with the override of a BERO (MD34200 = 5) is not supported. MD34200 = 0 is to be used as a equivalent.
- The following MD must be set if the absolute encoder retains even the referenced status through POWER OFF, besides the last position:  
MD34210 \$MA\_ENC\_REFP\_STATE = 2

### Data backup and standard commissioning

Some properties of an absolute encoder restrict the transfer of series startup files to other machines. The following machine data must be checked and corrected if necessary after loading the series startup:

- MD30250 \$MA\_ACT\_POS\_ABS (internal encoder position)
- MD30270 \$MA\_ENC\_ABS\_BUFFERING (traversing range extension)
- MD34090 \$MA\_REFP\_MOVE\_DIST\_CORR (absolute offset)
- MD34210 \$MA\_ENC\_REFP\_STATE (adjustment status)
- MD34220 \$MA\_ENC\_ABS\_TURNS\_MODULO (Modulo range)
- MD34230 \$MA\_ENC\_SERIAL\_NUMBER (encoder serial number)

### 14.9.8 Automatic encoder replacement detection

#### Function

Automatic encoder replacement detection is required for absolute encoders in order to detect if the encoder has been replaced and therefore needs to be readjusted.

The NC reads the encoder-specific serial number of the encoder from the drive every time the control is powered up. If the serial number has changed the NC resets the encoder status to "Encoder not calibrated".

MD34210 \$MA\_ENC\_REFP\_STATE = 0

The status of the measuring system is indicated as "Not referenced":

DB31, ... DBB60.4/60.5 (referenced/synchronized 1/2) = 0

#### Serial number display

The NC stores the serial numbers read in the build-up specific to the machine in the machine data:

MD34230 \$MA\_ENC\_SERIAL\_NUMBER (encoder serial number)

---

#### Note

Currently, only the serial numbers of absolute encoders with an EnDat interface can be read. For all other encoders the display shows that no serial number has been read.

Automatic encoder replacement detection can therefore only be used with the specified encoder types.

---

## Avoiding readjustments

In some special cases, for example, when a machine axis (built-on rotary axes) is removed and then mounted again, readjustment is not necessary/desirable.

To avoid readjustment, zero must be parameterized as a serial number to be ignored for the measuring system of the machine axis in question.

MD34232 \$MA EVERY\_ENC\_SERIAL\_NUMBER = 0

If the NC now reads zero as the serial number, the encoder status is not reset and the serial number indicated in the machine data is kept.

### Example sequence of operation:

1. The NC reads the serial number of the absolute encoder for the measuring system of the machine axis in question and the serial number is not equal to zero.
2. The absolute encoder is calibrated in the correct manner.
3. When the controller is powered up subsequently, the NC reads "zero" as the serial number of the absolute encoder.

Serial number "zero" is ignored and the encoder status remains the same, that is "calibrated".

4. When the controller is powered up, the NC again reads the serial number it read under Item 1 and that is still indicated in the machine data. The encoder status continues to be "Adjusted".

---

### Note

#### PROFIBUS drives

As not every drive connected via PROFIBUS-DP is able to deliver the encoder serial number in time for build-up of control or at all, the range of the encoder serial number with PROFIBUS drives is pre-set with zero to avoid unnecessary new NC internal adjustments:

MD34232 \$MA EVERY\_ENC\_SERIAL\_NUMBER = 0

A manual parameterizing to 1 is ineffective.

---

### 14.9.9 Enabling the measurement system

The measuring system of a machine axis is activated in the following cases:

- Power up of the control (POWER ON)
- Activation of the measuring system via interface signal (deselection of "parking"):  
DB31, ... DBB1.5/1.6 (position measuring system 1/2)  
DB31, ... DBB2.1 (servo enable)
- Violation of the assigned encoder limit frequency (spindles):  
MD36300 \$MA\_ENC\_FREQ\_LIMIT

When the measuring system is activated, the NC synchronizes the actual value system of the machine axis with the current absolute value. Traversing is disabled during synchronization for axes but not for spindles.

### Parameterizing the encoder limit frequency (spindles)

The EQN 1325 absolute encoder made by Heidenhain has an incremental track and an absolute track.

If a spindle is driven at a speed above the encoder limit frequency of the incremental track, the substantially lower limit frequency of absolute track must be parameterized as the encoder limit frequency.

MD36300 \$MA\_ENC\_FREQ\_LIMIT

Otherwise an incorrect absolute position would be read because the parameterized encoder limit frequency is not reached when the measuring system is activated. This would cause a position offset in the actual value system of the machine axis.

### Determining the encoder limit frequency

The encoder limit frequency to be parameterized is derived from the smaller of the two following limit speeds:

- Encoder  
The limit speed or encoder limit frequency is listed in the data sheet of the encoder (e.g. limit speed = 2000 [rpm])
- NC

Due to the NC-internal evaluation process, the maximum limit speed for which error-free calculation of the absolute value by the NC is possible is 4 encoder revolutions per interpolation cycle.

For an interpolation cycle of, for example, 12 ms: Limit speed = 4 / 12 ms = 20,000 rpm

The limiting frequency corresponding to the limiting speed is calculated to be:

$$MD36300 = \frac{4 * MD31020}{MD10050 * MD10070}$$

MD31020 \$MA\_ENC\_RESOL (Encoder lines per revolution)

MD10050 \$MN\_SYSCLOCK\_CYCLE\_TIME (System clock cycle)

MD10070 \$MN\_IPO\_SYSCLOCK\_TIME\_RATIO (Factor for interpolator cycle)

---

**Note**

The position control switching speed relevant for spindles is set according to the encoder limiting frequency of the absolute value encoder of the spindle:

MD35300 \$MA\_SPIND\_POSCTRL\_VELO (position control switching speed)

MD36300 \$MA\_ENC\_FREQ\_LIMIT (Encoder limit frequency)

---

### 14.9.10 Referencing variants that are not supported

The following referencing variants are not supported when used with absolute encoders:

- Referencing/calibrating with encoder zero mark
- Distance-coded reference marks
- BERO with two-edge evaluation

## 14.10 Supplementary conditions

### 14.10.1 Large traverse range

#### Notes on uniqueness of encoder position

##### Linear absolute encoder

The absolute value of linear position encoders, e.g. Heidenhain LC181, is always unique for the scale lengths available.

##### Rotary absolute encoder

The absolute value of rotary absolute encoders is only unique within the range of the specific maximum encoder revolutions.

For example, the EQN 1325 rotary absolute encoder by Heidenhain supplies a unique absolute value in the range of 0 to 4,096 encoder revolutions.

Depending on how the encoder is connected that will result in:

- Rotary axis with encoder on load: 4096 load revolutions
- Rotary axis with encoder on motor: 4096 motor revolutions
- Linear axis with encoder on motor: 4096 motor revolutions

Example:

An EQN 1325 rotary absolute encoder is connected to the motor of a linear axis. For an effective leadscrew pitch of 10 mm this will result in a unique absolute value within the travel range -20.48 to +20.48 m.

#### Supplementary conditions

- Linear axes with a traversing range > 4096 encoder revolutions, rotatory absolute value encoder EQN 1325 and a parameterized absolute value encoder range of MD34220 \$MA\_ENC\_ABS\_TURNS\_MODULO = 4096:
  - The maximum possible travel range corresponds to that of incremental encoders.
- Endlessly turning rotary axes with absolute encoders:
  - Any number of integer transmission ratios are permitted.
  - We recommend that you parameterize endlessly turning rotary axes with absolute encoders as modulo rotary axes (traversing range 0...360 degrees).

MD34220 \$MA\_ENC\_ABS\_TURNS\_MODULO

Otherwise, the machine axis may require a very long traverse path to reach absolute zero when the measuring system is activated.

- Machine axes with absolute encoders:
  - To ensure that the NC correctly determines the current actual position when the measuring system is reactivated, the machine manufacturer/user must ensure that the machine axis is moved less than half the assigned traversing range when the measuring system is deactivated (POWER OFF, "parking" selected).

MD34220 \$MA\_ENC\_ABS\_TURNS\_MODULO

## 14.11 Data lists

### 14.11.1 Machine data

#### 14.11.1.1 NC-specific machine data

Number	Identifier: \$MN_	Description
11300	JOG_INC_MODE_LEVELTRIGGRD	INC/REF in jog/continuous mode

#### 14.11.1.2 Channel-specific machine data

Number	Identifier: \$MC_	Description
20700	REFP_NC_START_LOCK	NC start disable without reference point

#### 14.11.1.3 Axis/spindle-specific machine data

Number	Identifier: \$MA_	Description
30200	NUM_ENCS	Number of encoders
30240	ENC_TYP	Actual value encoder type
30242	ENC_IS_INDEPENDENT	Encoder is independent
30250	ACT_POS_ABS	Absolute encoder position at time of deactivation.
30270	ENC_ABS_BUFFERING	Absolute encoder: Traversing range extension
30300	IS_ROT_AX	Rotary axis/spindle
30310	ROT_IS_MODULO	Modulo conversion for rotary axis/spindle
30330	MODULO_RANGE	Magnitude of the modulo range
30340	MODULO_RANGE_START	Starting position of modulo range
30355	MISC_FUNCTION_MASK	Axis functions
31122	BERO_DELAY_TIME_PLUS	BERO delay time in plus direction
31123	BERO_DELAY_TIME_MINUS	BERO delay time in minus direction
34000	REFP_CAM_IS_ACTIVE	Axis with reference cam
34010	REFP_CAM_DIR_IS_MINUS	Reference point approach in minus direction
34020	REFP_VELO_SEARCH_CAM	Homing approach velocity
34030	REFP_MAX_CAM_DIST	Maximum distance to reference cam
34040	REFP_VELO_SEARCH_MARKER	Reference point creep velocity
34050	REFP_SEARCH_MARKER_REVERSE	Direction reversal to reference cam

Number	Identifier: \$MA_	Description
34060	REFP_MAX_MARKER_DIST	Maximum distance to reference mark; Max. distance to 2 reference mark for distance-coded scales
34070	REFP_VELO_POS	Reference point positioning velocity
34080	REFP_MOVE_DIST	Reference point distance/destination point for distance-coded system
34090	REFP_MOVE_DIST_CORR	Reference point/absolute offset, distance-coded
34092	REFP_CAM_SHIFT	Electronic reference cam shift for incremental measurement systems with equidistant zero marks.
34093	REFP_CAM_MARKER_DIST	Reference cam/reference mark distance
34100	REFP_SET_POS	Reference point value
34102	REFP_SYNC_ENCS	Actual value adjustment to the referencing measurement system
34104	REFP_PERMITTED_IN_FOLLOWUP	Enable referencing in follow-up mode
34110	REFP_CYCLE_NR	Axis sequence for channel-specific Homing
34120	REFP_BERO_LOW_ACTIVE	Polarity change of the BERO cam
34200	ENC_REFP_MODE	Referencing mode
34210	ENC_REFP_STATE	Status of absolute encoder
34220	ENC_ABS_TURNS_MODULO	Absolute encoder range for rotary encoders
34230	ENC_SERIAL_NUMBER	Encoder serial number
34232	EVERY_ENC_SERIAL_NUMBER	Expansion of encoder serial number
34300	ENC_REFP_MARKER_DIST	Basic distance of reference marks for distance-coded encoders
34310	ENC_MARKER_INC	Interval between two reference marks with distance-coded scales
34320	ENC_INVERS	Linear measuring system inverse to machine system:
34330	REFP_STOP_AT_ABS_MARKER	Distance-coded linear measuring system without destination point
35150	SPIND_DES_VELO_TOL	Spindle speed tolerance
36302	ENC_FREQ_LIMIT_LOW	Encoder limit frequency re-synchronization
36310	ENC_ZERO_MONITORING	Zero mark monitoring

## 14.11.2 Signals

### 14.11.2.1 Signals to BAG

DB number	Byte.Bit	Name
11	0.7	Mode group RESET
11	1.2	Machine function REF

### 14.11.2.2 Signals from BAG

DB number	Byte.Bit	Name
11	5.2	Active machine function REF

### 14.11.2.3 Signals to channel

DB number	Byte.Bit	Name
21, ...	1.0	Activate referencing
21, ...	28.7	OEM channel signal (HMI → PLC) REF

### 14.11.2.4 Signals from channel

DB number	Byte.Bit	Name
21, ...	33.0	Referencing active
21, ...	35.7	Reset
21, ...	36.2	All axes referenced

### 14.11.2.5 Signals to axis/spindle

DB number	Byte.Bit	Name
31, ...	1.4	Follow-up mode (request)
31, ...	1.5/1.6	Position measuring system 1/position measuring system 2
31, ...	2.4 - 2.7	Reference point value 1 to 4

---

DB number	Byte.Bit	Name
31, ...	4.6/4.7	Traversing keys minus/plus
31, ...	12.7	Deceleration of reference point approach

---

#### 14.11.2.6 Signals from axis/spindle

---

DB number	Byte.Bit	Name
31, ...	60.4/60.5	Referenced, synchronized 1/Referenced, synchronized 2
31, ...	61.3	Follow-up mode active
31, ...	64.6/64.7	Traverse command minus/plus

---



## Spindles (S1)

### 15.1 Brief description

#### Spindle functions

The primary function of a spindle is to set a tool or workpiece in rotary motion in order to facilitate machining.

Depending on the type of machine, the spindle must support the following functions in order to achieve this:

- Input of a direction of rotation for the spindle (M3, M4)
- Input of a spindle speed (S....)
- Spindle stop without orientation (M5)
- Spindle stop with Orientation/Spindle positioning (SPOS, M19 and SPOSA)
- Gear change (M40 to M45)
- Spindle-axis functionality (spindle becomes rotary axis and vice versa)
- Thread cutting (G33, G34, G35)
- Tapping with and without compensating chuck (G331, G332)
- Revolutional feedrate (G95)
- Constant cutting rate (G96, G961, G97, G971)
- Programmable spindle speed limits (G25, G26, LIMS)
- Position encoder assembly on the spindle or on the spindle motor
- Spindle monitoring for min. and max. speed as well as max. encoder limit frequency and end point monitoring of spindle
- Switching the position control (SPCON, SPCOF, M70) on/off
- Programming of spindle functions:
  - From the part program
  - Via synchronized actions
  - Via PLC with FC18 or via special spindle interfaces for simple spindle activation

## 15.2 Spindle modes

### 15.2.1 Overview

#### Spindle modes

The spindle can have the following modes:

- Control mode
- Oscillation mode
- Positioning mode
- Synchronous mode, synchronous spindle
- Rigid tapping

**References:**

/FB2/ Function Manual Extended Functions; Synchronous Spindle (S3)

/PG/ Programming Manual, Fundamentals

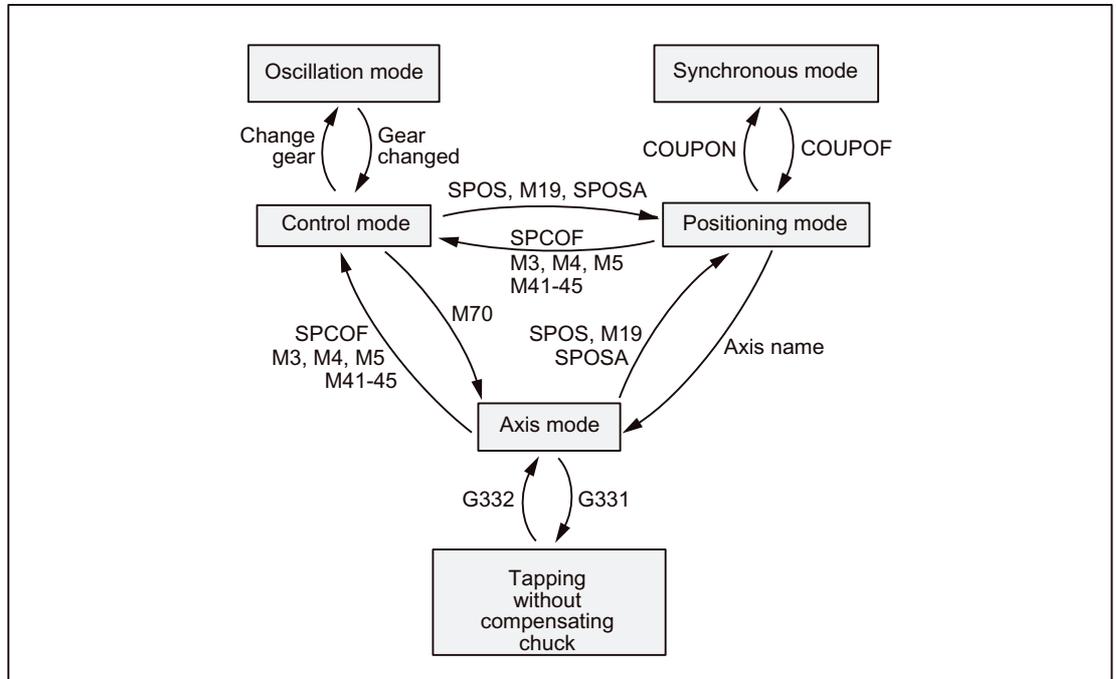
/PGZ/ Programming Manual, Cycles

#### Axis mode

The spindle can be switched from spindle mode to axis mode (rotary axis) if the same motor is used for spindle and axis operation.

## 15.2.2 Switching between spindle modes

Switching between spindle and axis operation can be done as follows:



- Control mode → Oscillation mode

The spindle changes to oscillation mode if a new gear step has been specified using automatic gear step selection (M40) in conjunction with a new S-value or by M41 to M45. The spindle only changes to oscillation mode if the new gear stage is not equal to the current actual gear stage.

- Oscillation mode → Control mode

When the new gear is engaged, the interface signal: DB31, ... DBX84.6 (Oscillation mode) is reset and the interface signal: DB31, ... DBX16.3 (Gear changed) is used to go to control mode. The last programmed spindle speed (S-value) is activated.

- Control mode → Positioning mode

If the spindle is to be stopped from direction of rotation (M3 or M4) with orientation, or is to be re-oriented from standstill (M5), then the positioning mode is selected with SPOS, SPOSA or M19.

- Positioning mode → Control mode

If spindle orientation is to be terminated, M3, M4 or M5 is used to change to control mode. The last programmed spindle speed (S-value) is activated.

- Positioning mode → Oscillation mode  
 If the orientation of the spindle is to be terminated, M41 to M45 can be used to switch to oscillation mode. When the gear change is complete, the last programmed spindle speed (S-value) and M5 (Control mode) are reactivated.
- Positioning mode → Axis mode  
 If a spindle was stopped with orientation, the assigned axis name is used to program a change to axis mode. The gear step is retained.
- Control mode → Axis mode  
 Switching from open-loop control mode to axis mode can be also achieved by programming of M70. In this case, a rotating spindle is decelerated in the same way as for M5, position control activated and the zero parameter set selected.
- Axis mode → Control mode  
 To terminate axis mode, M3, M4 or M5 can be used to change to control mode. The last programmed spindle speed (S-value) is activated.
- Axis mode → Oscillation mode  
 To terminate axis mode, M41 to M45 can be used to change to oscillation mode (only if the programmed gear step is not the same as the actual gear step). When the gear change is complete, the last programmed spindle speed (S-value) and M5 (Control mode) are reactivated.

### 15.2.3 Control mode

#### When open-loop control mode?

The spindle is in control mode with the following functions:

Constant spindle speed	S.... M3/M4/M5 and G93, G94, G95, G97, G971
	S.... M3/M4/M5 and G33, G34, G35
	S.... M3/M4/M5 and G63
Constant cutting rate	G96/G961 S.... M3/M4/M5

## Preconditions

- The spindle need not be synchronized.
- No spindle position actual-value sensor required for M3/M4/M5 in connection with:
  - Inverse-time feedrate coding (G93)
  - Feedrate in mm/min or inch/min (G94)
  - Tapping with compensating chuck (G63)
- A spindle position actual-value sensor is an essential requirement for M3/M4/M5 in connection with:
  - Revolutional feedrate (G95)
  - Constant cutting rate (G96, G961, G97, G971)
  - Thread cutting (G33, G34, G35)
  - Tapping (G331, G332)
  - Activate position control (SPCON, M70)

## Speed control mode

Speed control mode is particularly suitable if a constant spindle speed is required, but the position of the spindle is not important (e.g. constant milling speed for even appearance of the workpiece surface).

- Speed control mode is activated in the part program with M3, M4, M5 or with SPCOF.
- NC/PLC IS:  
DB31, ... DBX84.7 (open-loop control mode)  
is set.
- NC/PLC IS:  
DB31, ... DBX61.5 (Position controller active)  
is reset if position control is not used.
- Acceleration in speed control mode is defined independent of the gear step in machine data:  
MD35200 \$MA\_GEAR\_STEP\_SPEEDCTRL\_ACCEL  
and should, whenever possible, correspond to the physical properties.

## Position control mode

Position control is particularly suitable if the position of the spindle needs to be tracked over a longer period or if synchronous spindle setpoint value linkage is to be activated.

- The position control mode is activated in the part program with SPCON (<spindle number>).
- NC/PLC IS:  
DB31, ... DBX61.5 (Position controller active)  
is set.
- Acceleration in position control mode is defined independent of the gear step in machine data:  
MD35210 \$MA\_GEAR\_STEP\_POSCTRL\_ACCEL.

### Independent spindle reset

Machine data:

MD35040 \$MA\_SPIND\_ACTIVE\_AFTER\_RESET (Independent spindle reset)

defines how the spindle behaves after a reset or program end (M2, M30):

Value	Description
0	When the spindle is reset or at the end of the program, the spindle immediately decelerates to a stop at the active acceleration rate. The last programmed spindle speed and direction of rotation are deleted.
1	On a reset or at the end of the program, the last programmed spindle speed (S-value) and the last programmed direction of spindle rotation (M3, M4, M5) are retained. The spindle is not braked.

If prior to a reset or end of program the constant cutting speed (G96, G961) is active, the current spindle speed (in relation to 100% spindle override) is applied internally as the last programmed spindle speed.

The spindle can only be stopped with NC/PLC IS:

DB31, ... DBX2.2 (Delete distance-to-go/Spindle reset).

The direction of rotation is deleted in the event of all alarms generating a spindle quick stop. The last programmed spindle speed (S value) is retained.

Once the source of the alarm has been eliminated, the spindle must be restarted.

### Spindle actual speed display and spindle behavior with G96, G961

#### DB31, ... DBX61.4 (axis/spindle stationary)

Machine data:

MD36060 \$MA\_STANDSTILL\_VELO\_TOL

defines the speed at which the spindle is considered "stationary".

The speed set in the machine data should be dimensioned so that NC/PLC IS:

DB31, ... DBX61.4 (Axis/Spindle stationary) is sure to be pending on standstill.

If the NC/PLC interface signal:

DB31,...DBX61.4 (Axis/Spindle stationary)

registers and no position control is active for the spindle then the actual speed is shown as zero on the operator interface and is read as zero by the system variables \$AA\_S[n].

#### References:

FB1/ Function Manual, Basic Functions; Various Interface Signals and Functions (A2)

### Spindle response at constant cutting speed G96, G961

- At the start of machining (transition from G0 to Gx) and after NC stop, G60 (exact stop, modal) and G09 (exact stop, non-modal) the system waits until the actual speed has reached the speed setpoint tolerance range before starting the path.

NC/PLC IS:

DB31, ... DBX83.5 (nAct = nSet)  
is then set.

- NC PLC IS:  
DB31, ... DBX83.5 (nAct = nSet)  
and  
DB31, ... DBX83.1 (Setpoint speed limited)  
are also set to defined values even if severe speed changes are specified (transverse axis travels towards position 0).
- If the speed drops below the minimum speed  
or when NC/PLC IS:  
DB31, ... DBX61.4 (Axle/Spindle stationary)  
is detected, NC/PLC IS:  
DB31, ... DBX83.5 (nAct = nSet)  
is reset (e.g. for an emergency machine strategy).
- A path operation, which has started (G64, rounding), is not interrupted.

Machine data:

MD35500 \$MA\_SPIND\_ON\_SPEED\_AT\_IPO\_START  
can also influence spindle behavior significantly.

### Spindle behavior at the end of gear step change

- NC/PLC IS:  
DB31, ... DBX16.3 (Gear changed)  
tells the NC that the new gear step  
(NC/PLC IS DB31, ... DBX16.0-16.2 (Actual gear step A to C))  
applies and oscillation mode is terminated.

In this case, it does not matter whether NC/PLC IS:

DB31, ... DBX18.5 (oscillation mode)  
is still set.

The actual gear step should correspond to the set gear step.

The actual gear step signaled is relevant for selection of the parameter set.

- Once the gear step change (GSW) has been acknowledged via the PLC (DB31, ... DBX16.3), the spindle is in speed control mode (DB31, ... DBX84.7 = 1).  
  
If a direction of rotation (M3, M4, M5 or FC18: "Start spindle rotation") or a spindle speed (S value) was programmed before the gear step change, then the last speed and direction of rotation will be reactivated after the gear step change.

## 15.2.4 Oscillation mode

### Operating principle

Oscillation mode is activated for the spindle during the gear step change.

A detailed description of the working of "Oscillation mode spindle mode type" is available under the topic Gear step change with oscillation mode (Page 1250).

## 15.2.5 Positioning mode

### When is positioning mode used?

The spindle positioning mode stops the spindle at the defined position and activates the position control, which remains active until it is de-activated.

The spindle is in positioning mode with the following functions in which the parameter [n] is not required for the main spindle, where n = spindle number:

- SPOS [n] = . . . . .
- SPOS [n] = ACP ( . . . . . )
- SPOS [n] = ACN ( . . . . . )
- SPOS [n] = AC ( . . . . . )
- SPOS [n] = IC ( . . . . . )
- SPOS [n] = DC ( . . . . . )
- SPOSA [n] = ACP ( . . . . . )
- SPOSA [n] = ACN ( . . . . . )
- SPOSA [n] = AC ( . . . . . )
- SPOSA [n] = IC ( . . . . . )
- SPOSA [n] = DC ( . . . . . ) identical to SPOSA [n] = . . . . .
- M19 or M [n] = 19

### SPOS [n]=AC(.....)

Spindle positioning to an absolute position (0 to 359.999 degrees). The positioning direction is determined either by the current direction of spindle rotation (spindle rotating) or the distance-to-go.

### SPOS [n]=IC(.....)

Spindle positioning to an incremental position (+/- 999999.99 degrees) in relation to the last programmed position. The positioning direction is defined by the sign of the path to be traversed.

### **SPOS [n]=DC(.....)**

Spindle positioning across the shortest path to an absolute position (0 to 359.999 degrees). The positioning direction is determined either by the current direction of spindle rotation (spindle rotating) or automatically by the control (spindle stationary).

### **SPOS[n]=.....**

Identical functional sequence as `SPOS [n]=DC(.....)`.

### **SPOS [n]=ACP(.....)**

Approaches the position from the positive direction.

When positioning from a negative direction of rotation, the speed is decelerated to zero and accelerated in the opposite direction to execute the positive approach.

### **SPOS [n]=ACN(.....)**

Approaches the position from the negative direction.

When positioning from a positive direction of rotation, the speed is decelerated to zero and accelerated in the opposite direction to execute the negative approach.

## **MD20850**

In order to reach a constancy of `M19` and `SPOS` or `SPOSA` regarding the behavior at VDI-interface, in case of `SPOS` and `SPOSA` the auxiliary function `M19` is output to the VDI interface and activated through setting of the following machine data:

`MD20850 SPOS_TO_VDI = 1`

After activation, the minimum duration of an `SPOS/SPOSA` block is increased to the time for output and acknowledgment of the auxiliary functions by the PLC.

## **M19 (DIN 66025)**

`M19` can be used to position the spindle.

The position and the position approach mode are read here from the following setting data:

`SD43240 M19_SPOS` (spindle position for spindle positioning with `M19`)

`SD43240 M19_SPOSMODE` (spindle position approaching mode for spindle positioning with `M19`)

The positioning options of `M19` are identical to those of:

`SPOS = <Approach mode> <position/path>`

`M19` is output as an auxiliary function to the VDI interface as an alternative to `M3`, `M4`, `M5`, and `M70`. The `M19` block remains active in the interpolator for the duration of the positioning motion (like `SPOS`).

Part programs using M19 as a macro (e.g. DEFINE M19 AS SPOS = 0) or as a subroutine, continue to remain executable. For the sake of compatibility with previous controls, the internal processing of M19 (NCK positions the spindle) can be disabled as shown in the following example:

```
MD22000 $MC_AUXFU_ASSIGN_GROUP[0] = 4 ; Auxiliary functions group: 4
MD22010 $MC_AUXFU_ASSIGN_TYPE[0] = "M" ; Auxiliary functions type: "M"
MD22020 $MC_AUXFU_ASSIGN_EXTENSION[0] = 0 ; Auxiliary functions expansion: 0
MD22030 $MC_AUXFU_ASSIGN_VALUE[0] = 19 ; Auxiliary function value: 19
```

### SD43240 and SD43250

The positioning data for M19 are stored in the following axis-specific setting data:

SD43240 \$SA\_M19\_SPOS[n] (spindle position for spindle positioning with M19)

SD43240 \$SA\_M19\_SPOSMODE[n] (spindle position approaching mode for spindle positioning with M19)

### End of positioning

The positioning can be programmed with:

Command	Description
FINEA [Sn]	End of motion on reaching "Exact stop fine" (DB31, ... DBX60.7)
COARSEA [Sn]	End of motion on reaching "Exact stop coarse" (DB31, ... DBX60.6)
IPOENDA [Sn]	End of motion when "IPO stop" is reached

### Block change

#### Settable block change time

In addition to the existing programmable end-of-motion criterion with FINEA, COARSEA, IPOENDA, for single-axis interpolation, a new end-of-motion criterion can be programmed for block change with IPOBRKA in the braking ramp (100-0%).

The program advances to the next block if the end-of-motion criteria for all spindles or axes programmed in the current block, plus the block change criterion for path interpolation, are fulfilled. This applies to both part-program and technology-cycle blocks.

Further explanations regarding configurable set change time of "configurable positioning axes" for single axis interpolation can be found under:

#### References:

/FB2/ Function Manual, Extended Functions; Positioning axes (P2)

SPOS, M19 and SPOSA have the same functionality, but differ in their block change behavior:

- **Programming with SPOS and M19**

The block change is carried out if all functions programmed in the block have reached their end-of-block criterion (e.g. all auxiliary functions acknowledged by the PLC, all axes have reached their end points) and the spindle has completed its positioning motion.

- **Programming with SPOSA**

The program moves to the next block if all the functions (except for spindle) programmed in the current block have reached their end-of-block criterion. If SPOSA is the only entry in the block, block change is performed immediately. The spindle positioning operation may be programmed over several blocks (see WAITS).

## Coordination

A coordination of the sequence of motions can be achieved with:

- **PLC:**

NC/PLC interface signal:

DB31, ... DBX83.5 (spindle in setpoint range)

is not approached, then the channel-specific signal:

DB21, ... DBX6.1 ("Read-in disable")

can be set to expect a certain position of a spindle.

- **MD configuration:**

Setting:

MD35500 \$MA\_SPIND\_ON\_SPEED\_AT\_IPO\_START = 1

is used to perform path interpolation taking the tolerance:

MD35150 \$MA\_SPIND\_DES\_VELO\_TOL

into account only if the spindle has rotated up to the preselected speed.

Setting:

MD35500 \$MA\_SPIND\_ON\_SPEED\_AT\_IPO\_START = 2

stops traveling path axes before the start of machining at the last G0.

Machining continues:

- On the next traversing command
- If the spindle speed is reached
- When MD35510 \$MA\_SPIND\_STOPPED\_AT\_IPO\_START = 1 (path feed enable, if spindle stationary)

- **In the part program:**

Coordination actions in the part program have the following advantages:

- The part programmer can decide at what point in the program the spindle needs to be up to speed, e.g. in order to start machining a workpiece.
- This avoids unnecessary delays.

 <b>CAUTION</b>
<p>The part programmer must ensure that one of the following maintenance conditions occurs for <code>WAITS</code>.</p> <ul style="list-style-type: none"> <li>- Position reached</li> <li>- Spindle stationary</li> <li>- Spindle up to programmed speed</li> </ul> <p>In cases where one spindle is used in several channels, the part programmer must ensure that <code>WAITS</code> starts at the earliest in the phase in which the spindle of another channel has already started to accelerate or decelerate towards the new speed or direction of rotation.</p>

- `WAITS` instructions are used for coordination in the part program:

<code>WAITS</code>	for main spindle (master spindle)
<code>WAITS [n]</code>	for main and other spindles
<code>WAITS [n, m, . . . , q]</code>	for several spindles up to the maximum number of spindles

	<b>The control waits before executing subsequent blocks until:</b>
position(s) programmed with <code>SPOSA</code>	are reached.
M5	<p>The spindle is stationary.</p> <p>NC/PLC interface signal: DB31, ... DBX61.4 (Spindle stationary), taking the tolerance: MD36060 \$MA_STANDSTILL_VELO_TOL into account.</p> <p><code>WAITS</code> is terminated and the next block loaded when the first occurrence of the signal is detected.</p>
M3, M4 (speed control mode)	<p>The speed is in the setpoint range.</p> <p>NC/PLC interface signal: DB31, ... DBX83.5 (spindle in setpoint range)</p> <p>Tolerance: MD35150 \$MA_SPIND_DES_VELO_TOL</p> <p><code>WAITS</code> is terminated and the next block loaded when the first occurrence of the signal is detected.</p> <p>This function of <code>WAITS</code> applies in the programmed channel.</p> <p><code>WAITS</code> can be used to wait for all spindles known to this channel, although spindles may also have been started in other channels.</p>

## Special cases

- **Tolerance for spindle speed:**

If the machine data setting is:  
MD35150 \$MA\_SPIND\_DES\_VELO\_TOL = 0  
the NC/PLC interface signal:  
DB31...;DBX83.5 (spindle in setpoint range)  
is always set to 1.

WAITS is terminated as soon as the spindle has reached the setpoint-side target after a change in speed or direction (M3/M4).

- **Missing enable signals:**

If WAITS waits for the "Spindle in setpoint range" signal in speed control mode and the spindle stops or fails to rotate because an enable signal (axial feed enable, controller, pulse enable, etc.) is missing, the block is not terminated until the "Spindle in setpoint range" signal is active, once enable signals are being received again.

- **Response to NC and mode-group stop:**

If an NC or mode-group stop is triggered during WAITS, the wait operation is resumed after the NC start with all the above conditions.

---

### Note

In particular when using spindles across different channels, care should be taken when programming not to start WAITS too early in one channel, i.e. at a time when the spindle in the other channel is still rotating at its "old" speed.

In such cases, the "Spindle in setpoint range" signal is activated and WAITS is \*stopped too soon.

To prevent this happening, it is strongly recommended to set a WAITM before WAITS.

---

## M function output

Auxiliary function M19 is output to the VDI interface by:

M[n]=19	always output to the IS
SPOS [n]	Output of M19 to the IS with MD setting: MD20850 \$MC_SPOS_TO_VDI = 1
SPOSA[n]	Output of M19 to the IS with MD setting: MD20850 \$MC_SPOS_TO_VDI = 1

If M19 is programmed, auxiliary function M [n]=19 is always output to the interface.

For SPOS and SPOSA M19 is output depending on machine data:  
MD20850 \$MC\_SPOS\_TO\_VDI  
to the IS.

### Feed

The positioning speed is configured by the machine data:

MD35300 \$MA\_SPIND\_POSCTRL\_VELO (position control switching speed)

The value can be changed through programming or via synchronized actions:

FA[S <sub>n</sub> ]	where n = spindle number
FA[S <sub>n</sub> ]=0	the configured speed is active

The speed is specified in [degrees/min].

### Acceleration

The dynamic response during positioning can be modified by programming or by synchronized actions:

ACC[S <sub>n</sub> ]	Programming or synchronized action
ACC[S <sub>n</sub> ]=0	the configured acceleration is active

n: Spindle number, 0 ... max. spindle number

### Positioning from rotation

The spindle can be in speed control mode or in position control mode when positioning starts (SPOS, M19 or SPOSA command in the program).

The following sequence is obtained:

Case 1:	Spindle in speed control mode, encoder limit frequency exceeded
Case 2:	Spindle in speed control mode, encoder limit frequency not exceeded
Case 3:	Spindle in position control mode
Case 4:	Spindle speed < Position-control activation speed

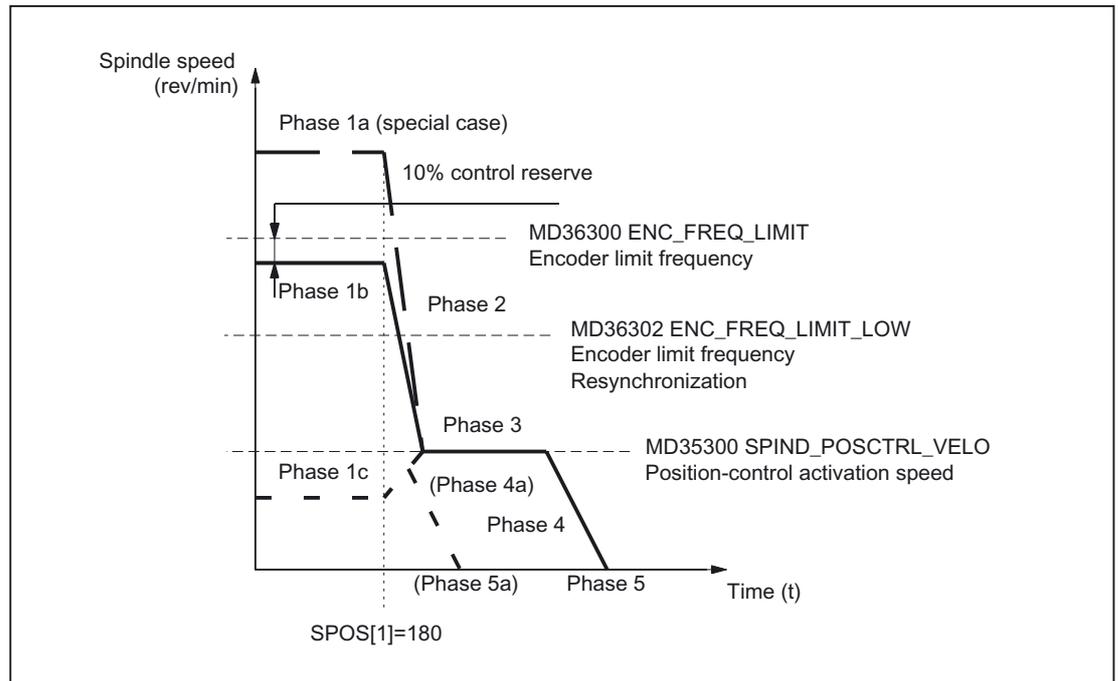


Figure 15-1 Positioning from rotation

**Note**

The speed from machine data: MD36302 \$MA\_ENC\_FREQ\_LOW must be greater than the position-control activation speed (MD35300 \$MA\_SPIND\_POSCTRL\_VELO).

**Phase 1**

**Possible positioning from Phase 1a:**

The spindle is rotating at a higher speed than the encoder limit frequency. The spindle is not synchronized.

**Possible positioning from Phase 1b:**

The spindle is rotating at a lower speed than the encoder limit frequency. The spindle is synchronized.

**Note**

If position control is active, the speed can only amount to 90% of the maximum speed of the spindle or the encoder limit frequency (10% control reserve required).

**Possible positioning from Phase 1c:**

The spindle rotates at the programmed spindle speed, whereby the speed is less than that given in the machine data: MD35300 \$MA\_SPIND\_POSCTRL\_VELO (Position control activation speed). The spindle is synchronized.

## Phase 2

### Spindle speed > Position-control activation speed

With the activation of the command `SPOS`, `M19` or `SPOSA` the deceleration of the spindle begins with the acceleration given in the machine data:

MD35200 `$MA_GEAR_STEP_SPEEDCTL_ACCEL`

up to the position control activation speed.

The spindle is synchronized once the encoder limit frequency is undercrossed.

### Spindle speed < Position-control activation speed

With the programming of `SPOS`, `M19` or `SPOSA` the spindle is switched to the position control mode (if it is not already in the position control mode).

MD35210 `$MA_GEAR_STEP_POSCTRL_ACCEL` (Acceleration in the position control mode)

will be active. The travel path to the end point is calculated.

The spindle travels to the programmed end point optimally in terms of time. This means that the end point is approached at the highest possible speed (maximum MD35300 `$MA_SPIND_POSCTRL_VELO`). Depending on the appropriate secondary conditions, the phases 2 - 3 - 4 - 5 or 4a - 5a are executed.

## Phase 3

### Spindle speed > Position-control activation speed

When the position-control activation speed stored in machine data:

MD35300 `$MA_SPIND_POSCTRL_VELO`

is reached:

- Position control is activated (if not already active)
- The distance-to-go (to end point) is calculated
- Acceleration in machine data:  
MD35210 `$MA_GEAR_STEP_POSCTRL_ACCEL` (Acceleration in position control mode) is activated (or this level of acceleration is maintained)

### Spindle speed < Position-control activation speed

To reach the end point, the spindle is accelerated up to the speed defined in machine data:

MD35300 `$MA_SPIND_POSCTRL_VELO` (position-control activation speed).

This is not exceeded.

The braking start point calculation identifies when the programmed spindle position can be approached accurately at the acceleration defined in machine data:

MD35210 `$MA_GEAR_STEP_POSCTRL_ACCEL`.

## Phase 4

### **Spindle speed > Position-control activation speed**

The spindle brakes from the calculated "braking point" with machine data:  
MD35210 \$MA\_GEAR\_STEP\_POSCTRL\_ACCEL  
to the end point.

### **Spindle speed < Position-control activation speed**

At the point, which is determined by the braking start point calculation in Phase 3,  
the spindle decelerates to stillstand with the acceleration given in the following machine data:

MD35210 \$MA\_GEAR\_STEP\_POSCTRL\_ACCEL

### **Phase 4a:**

When the SPOS command is activated the proximity of the end point is such  
that the spindle can no longer be accelerated up to machine data:  
MD35300 \$MA\_SPIND\_POSCTRL\_VELO.

The spindle is braked to stillstand with the acceleration given in the following machine data:

MD35210 \$MA\_GEAR\_STEP\_POSCTRL\_ACCEL

## Phase 5

### **Spindle speed > Position-control activation speed**

Position control remains active and holds the spindle in the programmed position.

---

### **Note**

The maximum encoder limit frequency of the spindle position actual-value encoder is monitored by the control (it may be exceeded); in position control mode, the setpoint speed is reduced to 90% of the measurement system limit speed.

NC/PLC IS:  
DB31, ... DBX83.1 (Programmed speed too high)  
is set.

If  
"MS limit frequency exceeded"  
is still pending following a reduction in the setpoint speed, an alarm is output.

---

### **Spindle speed < Position-control activation speed (Phase 5, 5a)**

The spindle is stationary and it has reached the position. The position control is active and stops the spindle in the programmed position.

NC/PLC IS:  
DB31, ... DBX60.6 (Position reached with exact stop coarse)  
and  
DB31, ... DBX60.7 (Position reached with exact stop fine)  
are set if the distance between the spindle actual position and the programmed position  
(spindle setpoint position) is less than the settings for the exact stop fine and coarse limits.

This is defined in machine data:  
MD36010 \$MA\_STOP\_LIMIT\_FINE  
and  
MD36000 \$MA\_STOP\_LIMIT\_COARSE.

---

#### Note

The positioning procedure is considered complete when the end-of-positioning criterion is reached and signaled.

The condition is "Exact stop fine". This applies to *SPOS*, *M19* or *SPOSA* from the part program, synchronized actions and spindle positioning by the PLC using FC 18.

---

### Positioning from standstill

A distinction is made between two cases with regard to positioning from standstill:

- Case 1: The spindle is not synchronized.

This is the case if the spindle is to be positioned after switching on the control and drive or after a gear step change (e.g. for a tool change).

MD31040 \$MA\_ENC\_IS\_DIRECT = 0

- Case 2: The spindle is synchronized.

This is the case if, after switching on the control and drive, the spindle is to be rotated through a minimum of one revolution with *M3* or *M4* and then stopped with *M5* (synchronization with the zero mark) before the first positioning action.

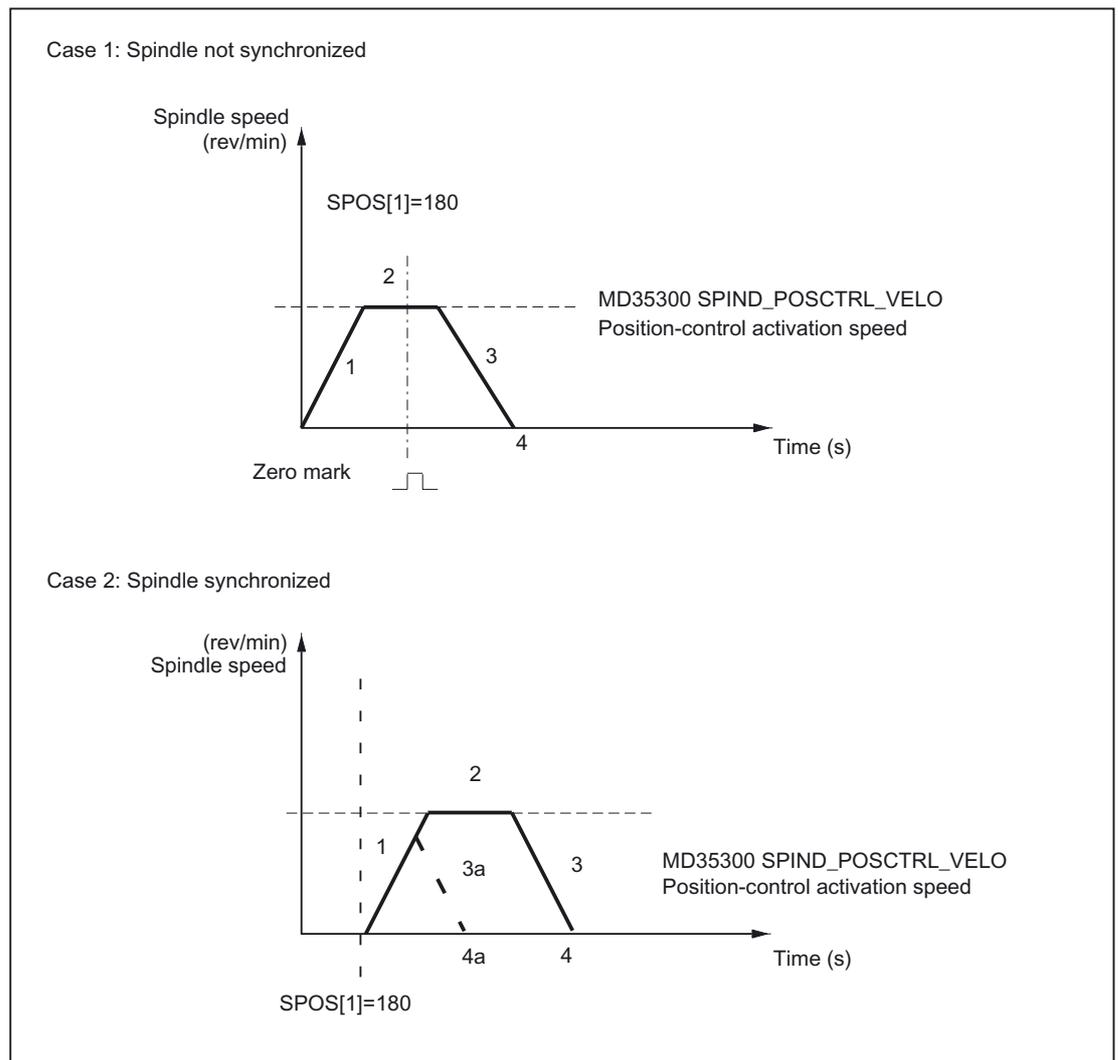


Figure 15-2 Positioning with stationary spindle

## Phase 1

### Case 1: Spindle not synchronized

With the programming of `SPOS`, `M19` or `SPOSA` the spindle accelerates with the acceleration from the machine data:

`MD35200 $MA_GEAR_STEP_SPEEDCTRL_ACCEL`(Acceleration in the speed control mode)

This direction of rotation is defined by the machine data:

`MD35350 $MA_SPIND_POSITIONING_DIR` (Direction of rotation while positioning to standstill)

**Exception:**

If ACN, ACP, IC is used for positioning, the programmed direction of travel is activated.

The spindle is synchronized at the next zero mark of the spindle position actual-value encoder, and switches to the position control mode.

Whether the zero mark is found in the traversed path (except for IC), is monitored:

MD34060 \$MA\_REFP\_MAX\_MARKER\_DIST (maximum distance to the reference mark)

If the speed defined in machine data:

MD35300 \$MA\_SPIND\_POSCTRL\_VELO (Positioning speed)

is reached before the spindle is synchronized, the spindle will continue to rotate at the positioning creep speed (the spindle is not accelerated further).

**Case 2: Spindle synchronized**

SPOS, M19 or SPOSA will switch the spindle to position control mode.

The acceleration from the following machine data is active:

MD35210 \$MA\_GEAR\_STEP\_POSCTRL\_ACCEL(acceleration in position control mode)

The direction of rotation is defined by the programmed motion (ACP, ACN, IC, DC) or via the queued remaining distance.

The speed entered in

MD35300 \$MA\_SPIND\_POSCTRL\_VELO (position control activation speed)

is not exceeded in the machine data.

The travel path to the end point is calculated.

The spindle travels to the programmed end point optimally in terms of time. This means that the end point is approached at the highest possible speed (maximum MD35300 \$MA\_SPIND\_POSCTRL\_VELO). Depending on the appropriate secondary conditions, the phases 1 - 2 - 3 - 4 or 1- 3a - 4a are executed.

## Phase 2

**Case 1: Spindle not synchronized**

When the spindle is synchronized, position control is activated.

The spindle rotates at the maximum speed stored in machine data:

MD35300 \$MA\_SPIND\_POSCTRL\_VELO

until the braking start point calculation identifies the point at which the programmed spindle position can be approached accurately with the defined acceleration.

### **Case 2: Spindle synchronized**

To reach the end point, the spindle is accelerated up to the speed defined in machine data:  
MD35300 \$MA\_SPIND\_POSCTRL\_VELO.  
This is not exceeded.

The braking start point calculation identifies when the programmed spindle position can be approached accurately at the acceleration defined in machine data:  
MD35210 \$MA\_GEAR\_STEP\_POSCTRL\_ACCEL.

At the point, which is determined by the braking start point calculation in Phase 1, the spindle decelerates to stillstand with the acceleration given in the following machine data:

MD35210 \$MA\_GEAR\_STEP\_POSCTRL\_ACCEL

### **Phase 3**

At the point, which is determined by the braking start point calculation in Phase 2, the spindle decelerates to stillstand with the acceleration given in the following machine data:

MD35210 \$MA\_GEAR\_STEP\_POSCTRL\_ACCEL

#### **Phase 3a:**

When the `SPOS` command is activated the proximity of the end point is such that the spindle can no longer be accelerated up to machine data:  
MD35300 \$MA\_SPIND\_POSCTRL\_VELO.

The spindle is braked to stillstand with the acceleration given in the following machine data:

MD35210 \$MA\_GEAR\_STEP\_POSCTRL\_ACCEL

### **Phase 4, 4a**

The spindle is stationary and it has reached the position. The position control is active and stops the spindle in the programmed position.

NC/PLC IS:

DB31, ... DBX60.6 (Position reached with exact stop coarse)

and

DB31, ... DBX60.7 (Position reached with exact stop fine)

are set if the distance between the spindle actual position and the programmed position (spindle setpoint position) is less than the settings for the exact stop fine and coarse limits.

This is defined in the machine data:

MD36010 \$MA\_STOP\_LIMIT\_FINE

MD36000 \$MA\_STOP\_LIMIT\_COARSE

#### **Phase 3:**

At the point, which is determined by the braking start point calculation in Phase 2, the spindle decelerates to stillstand with the acceleration given in the following machine data:

MD35210 \$MA\_GEAR\_STEP\_POSCTRL\_ACCEL

**Phase 4:**

The spindle is stationary and it has reached the position. The position control is active and stops the spindle in the programmed position.

NC/PLC IS:

DB31, ... DBX60.6 (Position reached with exact stop coarse)

and

DB31, ... DBX60.7 (Position reached with exact stop fine)

are set if the distance between the spindle actual position and the programmed position (spindle setpoint position) is less than the settings for the exact stop fine and coarse limits.

This is defined in the machine data:

MD36010 \$MA\_STOP\_LIMIT\_FINE

MD36000 \$MA\_STOP\_LIMIT\_COARSE

**Aborting the positioning process**

The positioning action can only be aborted with NC/PLC IS:

DB31, ... DBX2.2 (Delete distance-to-go/Spindle reset).

The positioning action is aborted with each reset (Operator panel front reset/NC/PLC IS DB31, ... DBX2.2 (Delete distance-to-go/Spindle reset)), independent of machine data:

MD35040 \$MA\_SPIND\_ACTIVE\_AFTER\_RESET (individual spindle reset)

**Special features**

- The accelerations are defined in the following machine data:
  - MD35210 \$MA\_GEAR\_STEP\_POSCTRL\_ACCEL (acceleration in position control mode)
  - MD35200 \$MA\_GEAR\_STEP\_SPEEDCTRL\_ACCEL (Acceleration in the speed control mode)
- The spindle override switch is active.
- The positioning action (SPOS, M19 and SPOSA) is canceled with each reset.
- The positioning action is canceled with NC STOP.
- The positioning velocity can also be programmed with FA[Sn].

## 15.2.6 Axis mode

### Why axis mode?

For certain machining tasks (e.g. on lathes with end-face machining), the spindle not only has to be rotated with M3, M4 and M5 and positioned with SPOS, M19 and SPOSA, but also addressed as an axis with its axis identifier (e.g. "C").

### Prerequisites

- The same spindle motor is used for spindle mode and axis mode.
- The same position measurement system or separate position measurement systems can be used for spindle mode and axis mode.
- A position actual-value encoder is a mandatory requirement for axis mode.
- If the axis is not synchronized, e.g. M70 is programmed after POWER ON, the axis must first be referenced with G74. Only then does the mechanical position match the programmed one.

#### Example:

```
M70  
G74 C1=0 Z100  
G0 C180 X50
```

### Configurable M function

The M function used to switch the spindle to axis mode can be configured in the machine data:

MD20094 \$MC\_SPIND\_RIGID\_TAPPING\_M\_NR

The value on delivery is 70.

### Functionality

If the axis mode is active and the rotary axis homed, all axis functions can be used.

#### References:

/FB2/ Function Manual, Extended Functions; Rotary Axes (R2)

The most important functions are:

- Programming with axis name
- Use of zero offsets (G54, G55, TRANS, etc.)
- G90, G91, IC, AC, DC, ACP, ACN
- Use of kinematic transformations (e.g. TRANSMIT)
- Interpolation with other axes (path interpolation)
- Programming as a positioning axis

**Special points to be noted**

- The feed override switch is active.
- NC/PLC IS:  
DB21, ... DBX7.7 (Reset)  
does not terminate axis mode as standard.
- The NC/PLC interface signals:  
DB31, ... DBB16 to DBB19 and DBB82 to DBB91  
are not important if:  
DB31, ... DBX60.0 (axis/no spindle) = 0
- Axis mode can be activated in all gear steps.  
If the position actual-value encoder is installed on the motor (indirect measurement system), the positioning and contouring accuracy may vary for the different gear steps.
- The gear step cannot be changed when the axis mode is active.  
The spindle must be switched to control mode.  
This is done with M41 ... M45 and M5, SPCOF.
- In axis mode, the machine data of the parameter set with index zero are effective in order to carry out adaptation in this mode.

**Transition to axis mode**

The transition to axis mode is performed by programming:

- the spindle with axis name
- from M70 (or with the M function configured with MD20094 \$MC\_SPIND\_RIGID\_TAPPING\_M\_NR)

The relevant machine data when changing the servo parameter set are:

Machine data	Meaning
MD31050 \$MA_DRIVE_AX_RATIO_DENOM	Measuring gear denominator
MD31060 \$MA_DRIVE_AX_RATIO_NUMERA	Numerator load gearbox
MD32200 \$MA_POSCTRL_GAIN	K <sub>v</sub> factor
MD32452 \$MA_BACKLASH_FACTOR	Weighting factor for backlash
MD32610 \$MA_VELO_FFW_WEIGHT	Weighting factor for feedforward control
MD32800 \$MA_EQUIV_CURRCTRL_TIME	Equivalent time constant current control loop for feedforward control
MD32810 \$MA_EQUIV_SPEEDCTRL_TIME	Equivalent time constant speed control loop for feedforward control
MD32910 \$MA_DYN_MATCH_TIME	Time constant for dynamic matching
MD36012 \$MA_STOP_LIMIT_FACTOR	Factor for exact stop coarse/fine and zero speed control
MD36200 \$MA_AX_VELO_LIMIT	Velocity monitoring threshold value

The dynamic limits of the axis stored in the machine data are applicable in axis operation.

The axis switches to the current feedforward control mode as designated by the MD and the commands `FFWON` and `FFWOF`.

Other notes on the servo parameter set:

**References:**

/FB1/ Function Manual, Basic Functions; Velocities, Setpoint/Actual-Value System, Closed-Loop Control (G2)

When using resolution changes in (analog) drive actuators, the following NC program steps are required:

1. Changeover to axis mode

Programming	Comment
SPOS=...	
M5	; Controller enable off (by PLC) → is output on PLC
M70	; Switch actuator (by PLC on account of M70) Controller enable on (by PLC)
C=...	; NC traverses with axis parameter set

2. Switch back to spindle mode

Programming	Comment
C=...	
M71	; → Output to PLC  Closed-loop controller enable off (by PLC) Switch actuator (by PLC) Switched to spindle parameter set (1-5) internally in the NC, controller enable on (by PLC)
M3/4/5 or SPOS=...	; NC traverses with spindle parameter set

**Change to spindle mode**

The interpolation parameter (set 1 ... 5) is selected according to the currently valid gear step.

The feedforward control function is always activated, except for tapping with compensating chuck.

Machine data:

MD32620 \$MA\_FFW\_MODE (feedforward control type)  
must always be not equal to 0.

Feedforward control should always be operated with the value 100% to avoid alarms being output during positioning.

Parameter set	Axis mode	Spindle mode
0	Valid	
1		Valid
2		Valid
3		Valid
4		Valid
5		Valid

Depending on gear step

Figure 15-3 Validity of parameter sets for axis and spindle modes

### 15.2.7 Initial spindle state

#### Initial spindle state

The following machine data is used to specify a spindle mode as initial state:

MD35020 \$MA\_SPIND\_DEFAULT\_MODE

Value	Initial spindle state
0	Speed control mode, position control deselected
1	Speed control mode, position control activated
2	Positioning mode
3	Axis mode

#### Time when the initial spindle state takes effect

The time when the initial spindle state takes effect is set in the machine data:

MD35030 \$MA\_SPIND\_DEFAULT\_ACT\_MASK

Value	Effective time
0	POWER ON
1	POWER ON and program start
2	POWER ON and RESET (M2/M30)

## 15.3 Reference/synchronize

### Why synchronize?

In order to ensure that the control detects the exact position when it is switched on, the control must be synchronized with the position measurement system of the spindle.

The following functions are possible only with a synchronized spindle:

- Thread cutting
- Rigid tapping
- Axis programming

Further explanations regarding synchronization of the spindle can be found under:

**References:**

/FB1/ Function Manual, Basic Functions; Reference Point Travel (R1)

### Why reference?

In order to ensure that the control detects the exact machine zero when it is switched on, the control must be synchronized with the position measurement system of the rotary axis. This process is known as referencing. The sequence of operations required to home an axis is known as homing.

Only a homed axis can approach a programmed position accurately on the machine.

Further explanations regarding referencing of round axis can be found under:

**References:**

/FB1/ Function Manual, Basic Functions; Reference Point Travel (R1)

### Installation position of the position measurement system

The position measurement systems can be installed as follows:

- Direct on the motor in combination with a Bero proximity switch on the spindle as a zero-mark encoder
- On the motor via a measuring gearbox in combination with a Bero proximity switch on the spindle as a zero-mark encoder
- Directly on the spindle
- On the spindle via a measuring gearbox in combination with a Bero proximity switch on the spindle as a zero-mark encoder (only with ratios not equal to 1:1)

Where two position measurement systems are provided, they can be installed either in the same location or separately.

### Synchronization procedure

When the spindle is switched on, the spindle can be synchronized as follows:

- The spindle is started with a spindle speed (S value) and a spindle rotation (M3 or M4) and synchronized with the next zero mark of the position measurement system or with the next Bero signal.
- The spindle is to be positioned from standstill using SPOS, M19 or SPOSA. The spindle synchronizes with the next zero mark of the position measurement system or with the next Bero signal. It is then positioned to the programmed position.
- The spindle can be synchronized from the movement (after M3 or M4) using SPOS, M19 or SPOSA.

The responses are as follows:

- With  $SPOS = Pos$ ,  $SPOS = DC(Pos)$  and  $SPOS = AC(Pos)$ , the direction of motion is retained and the position is approached.
- With  $SPOS = ACN(Pos)$  or  $SPOS = ACP(Pos)$ , the position is always approached with negative or positive direction of motion. If necessary, the direction of motion is inverted prior to positioning.
- If does not make any difference whether the procedure is initiated from the part program, FC 18 or synchronized actions.
- Crossing the zero mark in JOG mode by means of direction keys in speed control mode.

---

#### Note

During synchronization of the spindle, all four possible reference point values and reference point offsets are effective as appropriate to the measurement system selected. The measurement system offset has the same effect.

The following machine data must be observed:

MD34080 \$MA\_REFP\_MOVE\_DIST  
(Reference point distance/end point for distance-coded system)

MD34090 \$MA\_REFP\_MOVE\_DIST\_CORR  
(Reference point offset/absolute offset, distance-coded)

MD34100 \$MA\_REFP\_SET\_POS  
(reference point value, of no relevance in the case of distance-coded system).

If a non-homed spindle with  $SPOS=IC(...)$  and a path  $< 360$  degrees is positioned, it may be the case that the zero mark is not crossed and the spindle position is still not synchronized with the zero mark.

This can happen:

- After POWER ON
  - By setting the axial NC/PLC interface signals:  
DBX17.5 (resynchronize spindle during positioning 2)  
and  
DB31, ... DBX17.4 (resynchronize spindle during positioning 1)
-

## Special features for synchronization with BERO

The position falsification caused by the signal delay with BERO can be corrected internally in the NC by entering a signal runtime compensation.

In machine data:

MD31122 \$MA\_BERO\_DELAY\_TIME\_PLUS

or

MD31123 \$MA\_BERO\_DELAY\_TIME\_MINUS

a signal runtime compensation (dead time) for positive or negative movement direction is entered in connection with the following machine data setting:

MD34200 \$MA\_ENC\_REFP\_MODE = 2 or 7.

- Setting:  
MD34200 \$MA\_ENC\_REFP\_MODE = 7  
executes position synchronization only at a fixed velocity/speed defined in machine data:  
MD34040 \$MA\_REFP\_VELO\_SEARCH\_MARKER.

The velocity defined in machine data:

MD34040 \$MA\_REFP\_VELO\_SEARCH\_MARKER

is also effective when homing in operating mode JOG-REF and through the part program with G74.

- Setting:  
MD34200 \$MA\_ENC\_REFP\_MODE = 2  
executes position synchronization without specifying a specific velocity/speed.

---

### Note

The overriding of the signal propagation delay by the NC requires the use of type 611-D drives.

Signal propagation delays are preset on delivery so that the content generally does not have to be changed.

---

## Homing sequence

If the spindle is to be programmed in axis mode directly after control power up, it must be ensured that the axis is homed.

When the control is switched on, the spindle can be homed (condition is one zero mark per revolution).

For information on operation of referencing see:

### References:

/FB1/ Function Manual, Basic Functions; Reference Point Approach (R1)

The rotary axis is homed at the same time as the spindle is synchronized (see Synchronization procedure) if the position measurement system used for the spindle is also used for the rotary axis.

### Position measurement systems, spindle

The spindle can be switched from spindle mode to axis mode (rotary axis) if a single motor is used for spindle mode and axis mode.

The spindle (spindle mode and axis mode) can be equipped with one or two position measurement systems. With two position measurement systems, it is possible to assign one position measurement system to the spindle and the other to the rotary axis, or to assign two position measurement systems to the spindle. Where two position measurement systems are provided, both are updated by the control, but only one can be active.

NC/PLC IS:

DB31, ... DBX1.5 (Position measurement system 1)

and

DB31, ... DBX1.6 (Position measurement system 2)

are used to select the active position measurement system.

The active position measurement system is required for the following functions:

- Position control of the spindle (SPCON)
- Spindle positioning (SPOS, M19 and SPOSA)
- Thread cutting (G33, G34, G35)
- Tapping without compensating chuck (G331, G332)
- Revolutional feedrate (G95)
- Constant cutting rate (G96, G961, G97, G971)
- Spindle actual speed display
- Axis mode
- Synchronous spindle setpoint value linkage.

### NC/PLC IS DB31, ... DBX16.4 (Resynchronize spindle)

In the following cases, the spindle position measurement system must be resynchronized:

- The position encoder is on the motor, a Bero proximity switch is mounted on the spindle and a gear step change is performed. Synchronization is triggered internally once the spindle is rotating in the new gear step (see Synchronization procedure).
- The machine has a selector switch for a vertical and horizontal spindle. Two different position encoders are used (one for the vertical spindle and one for the horizontal spindle), but only one actual-value input is used on the control. When the system switches from the vertical to the horizontal spindle, the spindle must be resynchronized.

This synchronization action is triggered with NC/PLC IS:

DB31, ... DBX16.4 (Resynchronize spindle 1)

or

DB31, ... DBX16.5 (Resynchronize spindle 2).

The spindle must be in open-loop control mode.

## 15.4 Configurable gear adaptation

### 15.4.1 Gear steps for spindles and gear step change

#### Why do we need gear steps?

Gear steps are used on spindles to step down the speed of revolution of the motor in order to generate a high torque at low spindle speeds or to step up in order to maintain a high speed.

#### No. of gear steps

5 gear steps can be configured for each spindle.

The number of used gear steps is defined in machine data:

MD35090 \$MA\_NUM\_GEAR\_STEPS

#### Parameterization of the gear steps

The gear steps 1 to 5 can be parameterized via the following machine data:

Machine data	Description
MD35110 \$MA_GEAR_STEP_MAX_VELO[n]	Maximum speed for automatic gear stage change
MD35120 \$MA_GEAR_STEP_MIN_VELO[n]	Minimum speed for automatic gear stage change
MD35130 \$MA_GEAR_STEP_MAX_VELO_LIMIT[n]	Maximum speed of gear step
MD35135 \$MA_GEAR_STEP_PC_MAX_VELO_LIMIT[n]	Maximum speed of gear step in position control
MD35140 \$MA_GEAR_STEP_MIN_VELO_LIMIT[n]	Minimum speed of gear step
MD35200 \$MA_GEAR_STEP_SPEEDCTRL_ACCEL[n]	Acceleration in speed control mode
MD35210 \$MA_GEAR_STEP_POSCTRL_ACCEL[n]	Acceleration in position control mode
MD35012 \$MA_GEAR_STEP_CHANGE_POSITION[n]	Gear step change position

### Type of gear step change

The type of gear step change is set in machine data:

MD35010 \$MA\_GEAR\_STEP\_CHANGE\_ENABLE

Bit	Value	Description
0	0	The spindle motor is attached to the spindle directly (1:) or with a non-variable transmission ratio (basic setting). The machine data of the first gear step are effective.
	1	Spindle motor with up to 5 gear steps. The gear step change takes place: <ul style="list-style-type: none"> <li>• in oscillation mode</li> <li>• at indefinite change position</li> </ul>
1	0	Meaning as in Bit 0 = 0.
	1	Meaning as in Bit 0 = 1, however, the gear step change takes place at the configured spindle position. The change position is set in machine data: MD35012 \$MA_GEAR_STEP_CHANGE_POSITION The position is approached in the current gear step before the gear step change. If Bit 1 is set, the Bit 0 is ignored!
3	1	The gear step change dialog between NCK and PLC is simulated.
5	1	The second gear step data set is used while tapping with G331/G332 (see the following paragraph "Second gear step data set"). The bit must be set for the master spindle used during the tapping.

### Requirement for a gear step change

In principle, the gear step change is only performed if the requested gear step is not the same as the active gear step.

### Parameter set selection during gear step change

The servo parameter set is also changed over with the gear step if:

MD35590 \$MA\_PARAMSET\_CHANGE\_ENABLE = 0 or 1

For further information, please refer to Chapter "Parameter set selection during gear step change (Page 1245)".

### Request gear step change

A gear step change can be requested:

- in the part program:
  - automatically through the programmed spindle speed in M40
  - or
  - through direct programming with M41 to M45
- through the PLC using the FC18 function block
- through synchronized actions with M40 and S or M41 to M45
- in the reset state through description of NC/PLC interface:

DB31, ... DBX16.0-16.2 (actual gear stage A to C)

The mechanically active gear step can be communicated to the NC especially after a POWER ON.

---

#### Note

If the spindle motor is attached to the spindle directly (1:1) or with a non-variable transmission ratio (MD35010 = 0), then the M40 and M41...M45 auxiliary functions are not relevant to this spindle.

---

### Gear step change

Gear step selection between two gear steps with specification of a maximum spindle speed is shown in the example below:

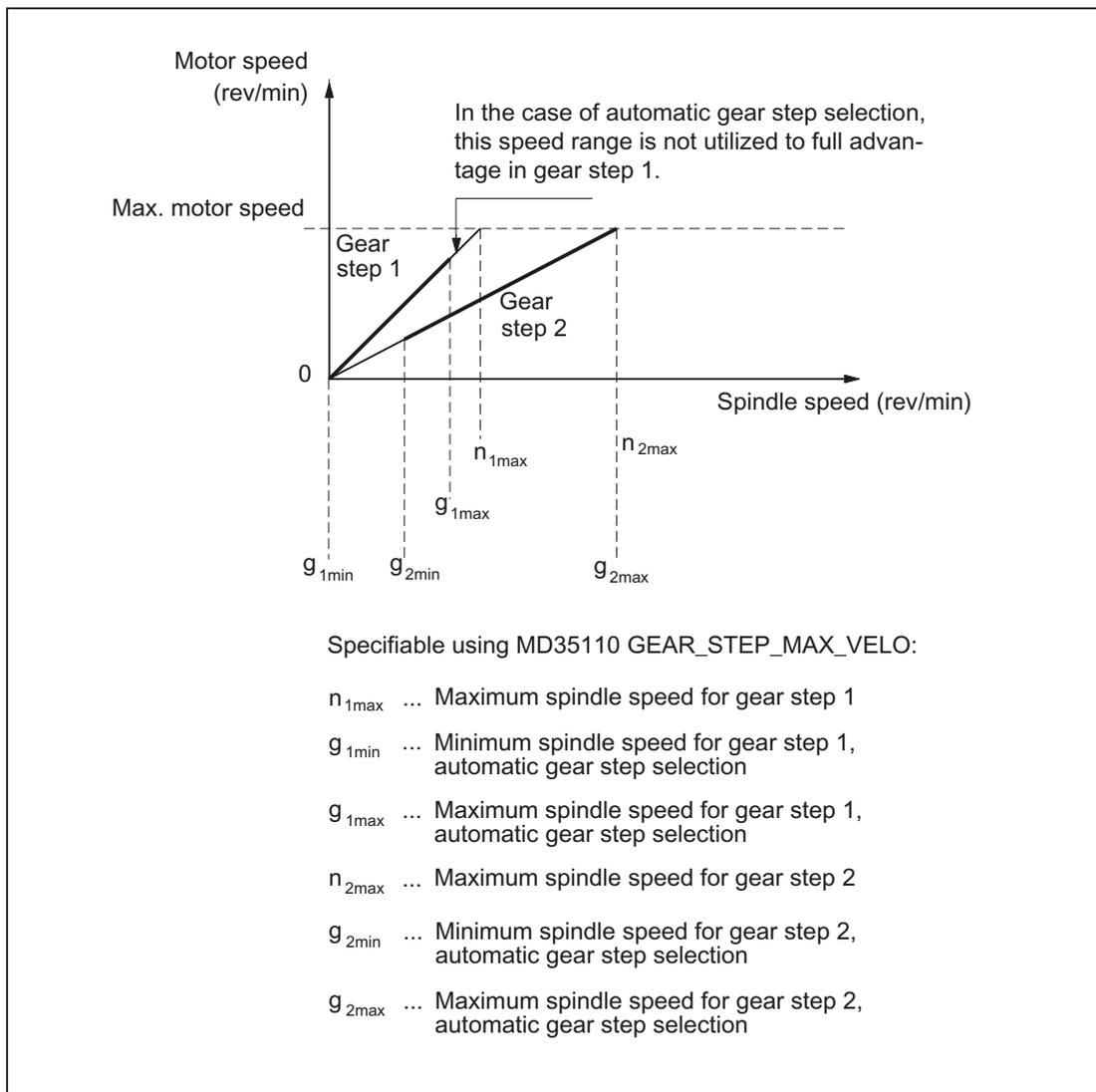


Figure 15-4 Gear step change with selection between two gear steps

## Process sequence of the gear step change

If the new gear step is preselected, the following sequence is implemented:

### 1. Changeover sequence

The two following NC/PLC interface signals are set:

DB31, ... DBX82.0-82.2 (actual gear stage A to C)

DB31, ... DBX82.3 (change over gear stage)

In accordance with the point at which NC/PLC IS:

DB31, ... DBX18.5 (Oscillation speed)

is set, the spindle decelerates to a standstill at the acceleration for oscillation or at the acceleration for speed control/position control.

Oscillation can be activated at the latest when the spindle reaches a standstill:

DB31, ... DBX61.4 (Axis/Spindle stationary)

with NC/PLC IS:

DB31, ... DBX18.5 (Oscillation speed).

In principle, the new gear step can also be engaged without oscillation

When the new gear step is engaged, the following NC/PLC interface signals are set by the PLC program:

DB31, ... DBX16.0-16.2 (actual gear stage A to C)

DB31, ... DBX16.3 (gear is changed)

### 2. End of gear step change

The gear step change is treated as completed (spindle operation type "oscillation mode" is deselected), if the NC/PLC interface signal:

DB31, ... DBX16.3 (gear is changed)

is set.

The new actual gear step is changed to the servo and interpolation parameter set when the motor is stationary.

With NC/PLC interface signal:

DB31, ... DBX16.3 (gear is changed)

is used to communicate to the NC that the new gear step is valid and the oscillation mode can be completed.

NC/PLC IS:

DB31, ... DBX82.3 (Change gear)

is reset by the NCK,

which causes the PLC program to reset NC/PLC IS:

DB31, ... DBX16.3 (Gear changed).

In this case, it does not matter whether NC/PLC IS:

DB31, ... DBX18.5 (oscillation mode)

is still set.

The actual gear step, which should correspond to the set gear step, is relevant for selecting the parameter set.

If this is not the case, then Alarm 22010 :

MD11410 \$MN\_SUPPRESS\_ALARM\_MASK, Bit 3 = 0

is output.

Following acknowledgment of gear step change via the PLC with NC/PLC IS: DB31, ... DBX16.3 (Gear changed) the spindle is in speed control mode (DB31, ... DBX84.7).

For further instructions on signal exchange between PLC and NC, see:

**References:**

/FB1/ Function Manual - Basic Functions; Diverse NC/PLC Interface Signals and Functions (A2)

**Second Gear Step Data Set**

The automatic gear step change M40 can be extended by a second configurable gear step data set.

The second gear step data set is used **exclusively** in connection with tapping without compensation chuck (G331, G332) so that an effective adjustment of spindle speed and motor torque can be achieved.

The activation is undertaken by setting the following bit for the master spindle:

MD35010 \$MA\_GEAR\_STEP\_CHANGE\_ENABLE, Bit 5 = 1

The number of used gear steps of the two gear step datasets is defined with the machine data:

MD35092 \$MA\_NUM\_GEAR\_STEPS2

The second gear step block dataset is deactivated if:

MD35092 \$MA\_NUM\_GEAR\_STEPS2 = 0 (basic setting)

The first gear step dataset then selects the gear step when M40 is active.

**Note**

The number of gear steps in the second data set can vary from the first. If no appropriate gear step is found for a programmed speed for M40, then - as before - no gear step change is carried out.

For more information about a typical program sequence in thread cutting without compensating chuck G331/G332 refer to:

**References:**

/PG/ Programming Manual Fundamentals; Chapter: Programming motion commands

The gear steps 1 to 5 of the second gear step dataset can be parameterized via the following machine data:

Machine data	Description
MD35112 \$MA_GEAR_STEP_MAX_VELO2[n]	Maximum speed for automatic gear stage change
MD35122 \$MA_GEAR_STEP_MIN_VELO2[n]	Minimum speed for automatic gear stage change
MD35212 \$MA_GEAR_STEP_POSCTRL_ACCEL2[n]	Acceleration in position control mode

**Note**

The number of servo parameter sets concerning the mechanical factors remain unchanged. Furthermore, five mechanical gear steps for the spindle and one for the axis operation can be configured.

The speed limitations are configured only once for each gear step with the following machine data, independently of the different switching thresholds:

Machine data	Description
MD35130 \$MA_GEAR_STEP_MAX_VELO_LIMIT[n]	Maximum speed of gear step
MD35140 \$MA_GEAR_STEP_MIN_VELO_LIMIT[n]	Minimum speed of gear step

For tapping without compensating chuck (G331, G332) the speed can be limited to the linear acceleration range of the motor additionally. For this, the maximum speed of the linear motor characteristics range is specified in the following machine data as a function of the gear step:

MD35550 \$MA\_DRILL\_VELO\_LIMIT[n]

**Specify gear step in the part program****Automatic selection with active M40**

The gear step is automatically selected by the control. The gear step in which the programmed spindle speed (S value) is possible is checked in this context. If a gear step results from this that is not equal to the current (actual) gear step, then the following NC/PLC interface signals are set:

DB31, ... DBX82.3 (change over gear stage)

DB31, ... DBX82.0-82.2 (actual gear stage A to C)

While the appropriate gear step is being determined, a gear step change is only requested if the new speed is not within the permissible speed range of the active gear step.

The speed is limited to the maximum speed of the current gear step or raised to the minimum speed of the current gear step and the appropriate NC/PLC interface signal is set:

DB31, ... DBX83.1 (Setpoint speed restricted)

DB31, ... DBX83.2 (Setpoint speed restricted)

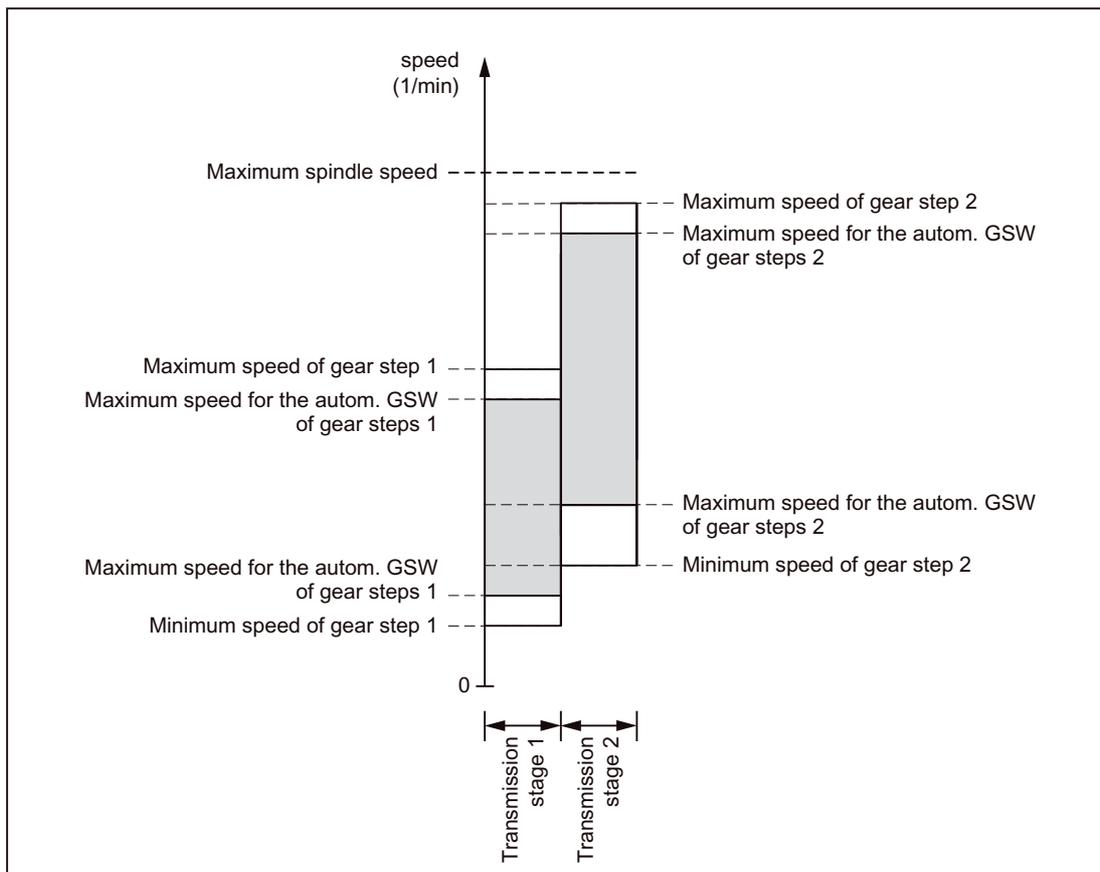


Figure 15-5 Example for two gear steps with overlapping speed ranges for automatic gear step change (M40)

**Note**

In the case of M40, the spindle must be in open-loop control mode for automatic gear step selection with an S value. Otherwise the gear step change is rejected and the following alarm is set:

Alarm 22000 "Gear step change is not possible"

**Note**

An active reduction gear is not considered in the selection for the automatic gear stage change.

### Permanently defining the gear step with M41 to M45

The gear step can be permanently defined in the part program with M41 to M45.

If a gear step is specified via M41 to M45 that is not equal to the current (actual) gear step, then the following NC/PLC interface signals are set:

DB31, ... DBX82.3 (change over gear stage)

DB31, ... DBX82.0-82.2 (actual gear stage A to C)

The programmed spindle speed (S value) then refers to this permanently defined gear step:

- If a spindle speed is programmed and it is more than the maximum speed of the permanently defined gear step (MD35130 \$MA\_GEAR\_STEP\_MAX\_VELO\_LIMIT), then the speed is decreased to this limit and the following NC/PLC interface signal is set:

DB31, ... DBX83.1 (Setpoint speed restricted)

- If a spindle speed is programmed and it is less than the minimum speed of the permanently defined gear step (MD35140 \$MA\_GEAR\_STEP\_MIN\_VELO\_LIMIT), then the speed is increased to this minimum and the following NC/PLC interface signal is set:

DB31, ... DBX83.2 (Setpoint speed restricted)

### Block change

When programming the gear step change in the part program, the gear step change set remains active until the gear step change is aborted by PLC.

This corresponds to the effect as if the following NC/PLC interface signal were set:

DB21, ... DBX6.1 (read-in disable)

## Specification of gear step via PLC with FC18

The gear step change can also be performed by function block FC18 during a part program, in the reset state or in all operating modes.

If the speed and direction of rotation is specified with FC18, the NC can be requested to select the gear step as appropriate for the speed. This corresponds to an automatic gear step change with M40.

The gear step is not changed if:

- the spindle is positioned via FC18.
- the spindle is traversed in the axis mode.

Further instructions on function block FC18 can be found under:

### References:

/FB1/ Function Manual, Basic Functions; PLC Basic Program (P3)

### Specification of a gear step in synchronized actions

The gear step change can be requested by synchronized actions:

- through the automatic gear step change for M40 with S.
- or
- through specification of gear steps 1 to 5 with M41 to M45.

The gear step is not changed if:

- the spindle is positioned via synchronized actions.
- the spindle is traversed in the axis mode.

---

#### Note

For further details, please refer to the section "Specification of a gear step in part program".

Exception:

The block change is not affected by the specification of a gear step in synchronized actions.

---

### Manual specification of a gear step

Outside a part program that is running, the gear step can also be changed without a request from the NC or the machine. This is the case, for example, when a gear step is changed directly by hand.

To select the appropriate parameter set, the NC must be informed of the current gear step. For this to work, the control or the part program must be in the reset state.

#### Constraints

Transfer of the gear step to the NC is initiated when  
NC/PLC IS:  
DB31, ... DBX16.0-16.2 (Actual gear step A to C) changes.

These three bits must be set continuously during operation.

Successful transfer is acknowledged with NC/PLC IS:  
DB31, ... DBX82.0-82.2 (Set gear step A to C)  
to the PLC.

NC/PLC IS:  
DB31, ... DBX16.3 (Gear changed)  
must not be set.

If position control is active when a new gear step is specified by PLC with  
DB31, ... DBX16.0-16.2, then it is switched off for the duration of this changeover sequence.

### NC stop during gear step change

The spindle cannot be stopped with NC/PLC IS:

DB21, ... DBX7.4 (NC stop)

if:

- the spindle is not yet in oscillation mode for the gear step change.
- NC/PLC IS:  
DB31, ... DBX16.3 (Gear changed)  
is not set.

---

#### Note

Options for aborting:

DB31, ... DBX2.2 (Delete distance-to-go/Spindle reset)

or

DB31, ... DBX16.3 (Gear changed)

with corresponding acknowledgment from actual gear step:

DB31, ... DBX16.0-16.2 (Actual gear step).

---

### Spindle response after a gear step change

How the spindle behaves once the gear step has been changed depends on the following initial conditions:

- If the spindle was in the stop state before the gear step change ( $M5$ , FC18: "Stop rotate spindle"), in positioning or axis mode,  $M5$  (spindle stop) is active after completion of the gear step change.
- If a direction of rotation ( $M3$ ,  $M4$ , or FC18: "Start spindle rotation"), then the last speed and direction of rotation will become active again after the gear step change. In the new gear step, the spindle accelerates to the last spindle speed programmed ( $S$  value).
- If position control was active before the gear step change ( $SPCON$ ), then it is reactivated after the gear step change.

The next block in the part program can be executed.

### Special points to be noted

The following points must be observed on gear step change:

- The gear step change is not terminated by selecting NC/PLC IS:  
DB31, ... DBX20.1 (Ramp-up switchover to V/f mode).  
Setpoint 0 is output.

The gear step change is acknowledged as usual  
via the NC/PLC interface signal:

DB31, ... DBX16.3 (gear is changed)

- The "Ramp-function generator rapid stop" signal must be reset by the PLC before the gear step change is completed by the PLC.
- The process sequence of the gear step change is ended during NC reset without any alarm output.

The gear step output with NC/PLC IS:  
DB31, ... DBX16.0-16.2 (Actual gear step A to C)  
is applied by the NC.

### Star/Delta switchover with FC17

Digital main spindle drives can be switched in both directions between star and delta using FC17, even when the spindle is running. This automatic switchover is controlled by a defined logic circuit in FC17, which provides the user with a configurable switchover time for the relevant spindle.

Further instructions on function block FC17 can be found under:

**References:**

/FB1/ Function Manual, Basic Functions; PLC Basic Program (P3)

## 15.4.2 Parameter set selection during gear step change

### Servo parameter sets

The servo parameter sets 1 to 6 adapt the position controller to the changed properties of the machine during a gear change of the spindle.

### Parameter set selection during gear step change

The gear step parameter set (interpolation parameters) and, depending on the setting in the following machine data, the servo parameter set are also modified during gear step change.

MD35590 \$MA\_PARAMSET\_CHANGE\_ENABLE (parameter set change possible)

Value	Description
0	<p>In-system parameter set selection</p> <p>The parameter sets of the servo are assigned permanently.</p> <p>The following applies:</p> <ul style="list-style-type: none"> <li>For axes and spindles in the axis mode, the first parameter set is active in principle.</li> </ul> <p>Exception:</p> <p>In G33, G34, G35, G331 and G332 the parameter set for the involved axes is activated with the following number:</p> <p>Master spindle gear step + 1 (corresponds to parameter set No. 2 ... 6)</p> <ul style="list-style-type: none"> <li>For spindles in the spindle mode, the parameter set is set matching the gear step.</li> </ul>
1	<p>Besides the in-system parameter set selection, there is also the option of an "external" parameter set selection.</p> <ul style="list-style-type: none"> <li>by the PLC (DB31, ... DBX 9.0 - 9.2)</li> <li>via programming of <code>SCPARA</code> in the part program or in synchronized actions</li> </ul> <p>However, the in-system parameter set selection has priority.</p> <p>Note: Value 1 is relevant only to axes.</p>
2	<p>The servo parameter set is specified <b>exclusively</b> by the PLC (DB31, ... DBX 9.0 - 9.2) or through the programming of <code>SCPARA</code> in the part program or in synchronized actions (for axes and spindles).</p> <p>The 1st parameter set is selected after POWER ON.</p>

### Spindle mode

MD35590 \$MA\_PARAMSET\_CHANGE\_ENABLE = 0 or 1

The parameter set is selected according to the gear step + 1.

The active gear step is located in:

DB31, ... DBX16.0-16.2 (actual gear stage A to C)

The active parameter set is output in:

DB31, ... DBX69.0-69.2 (controller parameter set A to C)

One set of parameters, with the following assignment, is provided by the NC for each of the 5 gear steps:

Dataset for ...	NC/PLC interface DBX 69.2/69.1/69.0	Parameter set Number	Parameter set Index [n]
Axis mode	last active gear step	1	0
Gear stage 1	001	2	1
Gear stage 2	010	3	2
Gear stage 3	011	4	3
Gear stage 4	100	5	4
Gear stage 5	101 110 111	6	5

### Spindle in axis mode

If the spindle is in the axis mode, then the active gear stage is stored internally first, and the parameter set index 0 is selected in the servo. The last gear stage and the associated parameter set are reactivated with the **next** spindle programming.

### Load gearbox transmission ratio

It is possible to configure positive or **negative load gearbox factors** for each gear step and in axis mode.

The setting is undertaken separately for numerator and denominator via the machine data:

MD31050 \$MA\_DRIVE\_AX\_RATIO\_DENOM[n] (load gearbox denominator)

MD31050 \$MA\_DRIVE\_AX\_RATIO\_DENOM[n] (load gearbox numerator)

The setting range is the same size for positive and negative load gearbox factors.

It is not possible to enter the value 0.

---

#### Note

If an indirect encoder is configured, and the load gearbox transmission ratio changes, then the reference is lost and the NC/PLC interface signal: DB31, ... DBX60.4/60.5 (referenced/synchronized 1 or 2) is reset for the relevant measuring system.

---

### References

For further information about control and servo parameter set, please refer to:

Function Manual - Basic Functions; Velocities, Setpoint-Actual Value Systems, Closed-Loop Control (G2)

Programming Manual, Job Planning; Chapter: Programmable servo parameter set

### 15.4.3 Intermediate gear

#### Application and functions

A configured intermediate gear can be used to adapt a variety of rotating tools. The intermediate gear on the tool side has a multiplicative effect on the motor/load gearbox.

It is set via machine data:

MD31066 \$MA\_DRIVE\_AX\_RATIO2\_NUMERA (Intermediate gear numerator)

MD31064 \$MA\_DRIVE\_AX\_RATIO2\_DENOM (Intermediate gear denominator)

An encoder on the tool for the intermediate gear

is configured with machine data:

MD31044 \$MA\_ENC\_IS\_DIRECT2 (Encoder on intermediate gear).

Change parameters for these machine data can be activated with "NewConfig" either using the SinuCOM-NC commissioning software or via a softkey on the operator panel (HMI). The existing motor/load gearboxes, on the other hand, are active after POWER ON.

#### Tool change

If the intermediate gear is changed at the same time as the tool, the user must also reconfigure the transmission ratio of the numerator and denominator via the machine data of the intermediate gear.

#### Example:

In the case of an installed tool with a transmission ratio of 2:1, a suitable intermediate gear is configured and is activated immediately in the part program with the command `NEWCONF`.

```
N05 $MA_DRIVE_AX_RATIO2-NUMERA[AX5] = 2  
M10 $MA_DRIVE_AX_RATIO2-DENOM[AX5] = 1  
N15 NEWCONF
```

#### CAUTION

It remains the task of the user to stop within the appropriate period in order to make changes to the machine data when required and then activate a "NewConfig".

## Switchover

Switchover to a new transmission ratio is performed immediately by means of NewConfig. From a technological viewpoint, the associated mechanical switchover process takes some time, since, in mechanical terms, a different intermediate gear with rotating tool is being installed.

---

### Note

At zero speed, switchover is jerk-free. The user is therefore responsible for taking appropriate precautions.

Applications in which switchover takes place during motion and which require smoothed or soft speed transition can be handled using existing setpoint speed filters.

---

For further instructions for control technical dependencies see:

### References:

/FB1/ Function Manual, Basic Functions; Speeds, Setpoint/Actual Value System, Control (G2)

## 15.4.4 Non-acknowledged gear step change

### Mode change

A gear step change that has not been acknowledged cannot be interrupted by a change in operating mode (e.g. switchover to JOG).

The switchover is delayed by the maximum period entered in machine data:  
MD10192 \$MN\_GEAR\_CHANGE\_WAIT\_TIME

If the gear step change is not acknowledged within this time, the NC will output an alarm:

### Further events

Events that initiate reorganization will also wait until a gear step change is completed.

The time entered in machine data:

MD10192 \$MN\_GEAR\_CHANGE\_WAIT\_TIME

determines how long the control waits before executing the gear step change.

If this time elapses without the gear step change being completed, the NC responds with an alarm.

The following events have an analog response:

- User ASUB
- Mode change
- Delete distance-to-go
- Axis replacement

- Activate PI user data
- Enable PI service machine data
- Switch over skip block, switch over Dry Run
- Editing in the modes
- Compensation block alarms
- Overstore
- Rapid retraction with G33, G34, G35
- Subroutine level abort, subroutine abort

### **Response after POWER ON**

The active gear step on the machine can be specified by the PLC control after POWER ON and in the RESET state.

The NCK will then select the appropriate parameter set and check back the NC/PLC interface signals:  
DB31, ... DBX82.0-82.2 (Set gear step A to C)  
to the PLC.

## 15.4.5 Gear step change with oscillation mode

### What is oscillation?

Oscillation in this context means that the spindle motor rotates alternately in the clockwise and counterclockwise directions. This oscillation movement makes it easy to engage a new gear step.

### Oscillation mode

NC/PLC IS:  
DB31, ... DBX82.3 (Change gear)  
displays that a gear step change is required.

In principle, the new gear step can also be engaged without oscillation

1. Machine data:  
MD35010 \$MA\_GEAR\_STEP\_CHANGE\_ENABLE  
must be set to 1.
2. NC/PLC IS:  
DB31, ... DBX84.6 (oscillation mode)  
is set.
3. The acceleration is determined in the following machine data:  
MD35410 \$MA\_SPIND\_OSCILL\_ACCEL

### DB31, ... DBX18.5 (oscillation speed)

The spindle is in oscillation mode if a new gear step was defined using automatic gear step selection (M40) or M41 to M45 (DB31, ... DBX82.3 (Change gear) is set).

NC/PLC IS:  
DB31, ... DBX82.3 (Change gear)  
is only enabled when a new gear step is defined  
that is not the same as the current actual gear step.

If NC/PLC IS:  
DB31, ... DBX18.5 (Oscillation speed)  
is simply set by the PLC without a new gear step being defined by the NC,  
the spindle does not change to oscillation mode.

Oscillation mode is activated with NC/PLC IS:  
DB31, ... DBX18.5 (Oscillation speed).

Depending on NC/PLC IS:  
DB31, ... DBX18.4 (Oscillation via PLC)  
while the function is in operation, a distinction is made between:

- Oscillation via NCK
- Oscillation via PLC
- Oscillation with FC 18

#### References:

/FB1/ Function Manual, Basic Function; PLC Basic Program (P3)

## Oscillation time

The oscillation time for oscillation mode can be defined in a machine data for each direction of rotation:

Oscillation time in M3 direction (referred to as t1 in the following):	MD35440 \$MA_SPIND_OSCILL_TIME_CW
Oscillation time in M4 direction (referred to as t2 in the following):	MD35450 \$MA_SPIND_OSCILL_TIME_CCW

## Oscillation via NCK

### Phase 1:

NC/PLC IS:

DB31, ... DBX18.5 (Oscillation speed)

accelerates the spindle motor to the speed (with oscillation acceleration) defined in machine data:

MD35400 \$MA\_SPIND\_OSCILL\_DES\_VELO (oscillation speed).

Start direction is defined through the following machine data:

MD35430 \$MA\_SPIND\_OSCILL\_START\_DIR (Start direction with oscillation)

The time t1 (or t2) is started,

according to which start direction is given in the machine data:

MD35430 \$MA\_SPIND\_OSCILL\_START\_DIR

The time - and not the fact that the oscillation speed is reached - is always decisive.

### Phase 2:

If time t1 (t2) has passed, the spindle motor

accelerates in the opposite direction to the speed defined in machine data:

MD35400 \$MA\_SPIND\_OSCILL\_DES\_VELO.

Time t2 (t1) starts.

### Phase 3:

If time t2 (t1) has passed, the spindle motor accelerates in the opposite direction (same direction as in Phase 1) to the speed defined in machine data:

MD35400 \$MA\_SPIND\_OSCILL\_DES\_VELO.

Time t1 (t2) starts. The process continues with Phase 2.

### Oscillation via PLC

NC/PLC IS:

DB31, ... DBX18.4 (Oscillation via PLC)

and

DB31, ... DBX18.5 (oscillation speed)

accelerates the spindle motor to the speed (with oscillation acceleration) defined in machine data:

MD35400 \$MA\_SPIND\_OSCILL\_DES\_VELO (oscillation speed).

The direction of rotation is defined by NC/PLC IS:

DB31, ... DBX18.7 (Set direction of rotation CCW)

and

DB31, ... DBX18.6 (Set direction of rotation CW).

The oscillation movement and the two times t1 and t2 (for clockwise and counterclockwise rotation) must be simulated on the PLC.

### Special points to be noted

Setting/Resetting the NC/PLC IS and machine data in oscillation mode:

- To decelerate the spindle, the PLC user need not set NC/PLC IS: DB31, ... DBX4.3 (Spindle stop).

The spindle is brought to a standstill internally by the control when a gear step change is requested.

- The gear step change should always be terminated with NC/PLC IS: DB31, ... DBX16.3 (Gear changed).

- NC/PLC IS:

DB31, ... DBX18.5 (Oscillation speed)

should be used to support mechanical engagement of the gear.

It has no effect on the internal control mechanism for the gear step change procedure and should therefore only be set as necessary.

- If NC/PLC IS: DB31, ... DBX18.5 (Oscillation speed) is reset, oscillation mode stops.

However, the spindle remains in "oscillation mode".

- The acceleration is defined in the following machine data: MD35410 \$MA\_SPIND\_OSCILL\_ACCEL

- The spindle will cease to be synchronized if an indirect measuring system (motor encoder) is used.

If the machine data is set to:

MD31050 \$MA\_ENC\_IS\_DIRECT = 0,

NC/PLC IS:

DB31, ... DBX60.4/5 = 0 (Homed/Synchronized)

is automatically deleted.

The zero mark is synchronized the next time it is crossed.

## End of oscillation mode

On termination of oscillation mode, the spindle returns to open-loop control mode and automatically changes to the mode defined by `SPCON` or `SPCOF`.

All gear-specific limit values (min./max. speed, etc.) correspond to the set values of the actual gear step.

## Functionality

Machine tools of conventional design require a gear step change of the spindle in oscillation mode.

If the machine data configuration is:

**MD35010 \$MA\_GEAR\_STEP\_CHANGE\_ENABLE = 1**

the following sequence is implemented:

- Deceleration of the spindle.

The braking action corresponds to an M5 movement.

- Output of VDI interface signals:  
DB31, ... DBX84.6 (Oscillation mode)  
DB31, ... DBX82.3 (Change gear)  
DB31, ... DBX82.0-82.2 (Set gear step A to C).

If position control has been enabled, it is disabled:

DB31, ... DBX61.5 = 0.

- The load gearbox can now "disengage".
- NC/PLC IS:  
DB31, ... DBX18.5 (Oscillation enable)  
can be set by the PLC.

The spindle motor then performs an oscillation motion with preset values.

The oscillation motion is designed to facilitate and accelerate the re-engaging of the gear wheels.

- Writing of NC/PLC IS:  
DB31, ... DBX16.0-16.2 (Actual gear step A to C)  
by the PLC.

- Once the PLC has sent:  
DB31, ... DBX16.3 (Gear changed)  
to the NCK, the last movement to be active is continued, if available.

For indirect encoders (motor encoders), the homing status is cleared:

DB31, ... DBX60.4/5 = 0.

### Block change

If the spindle is switched to oscillation mode with NC/PLC IS: DB31, ... DBX82.3 (Change gear), the processing of the part program remains suspended. A new block is not executed.

If oscillation mode is terminated with NC/PLC IS: DB31, ... DBX16.3 (Gear changed), the processing of the part program is resumed. A new block is executed.

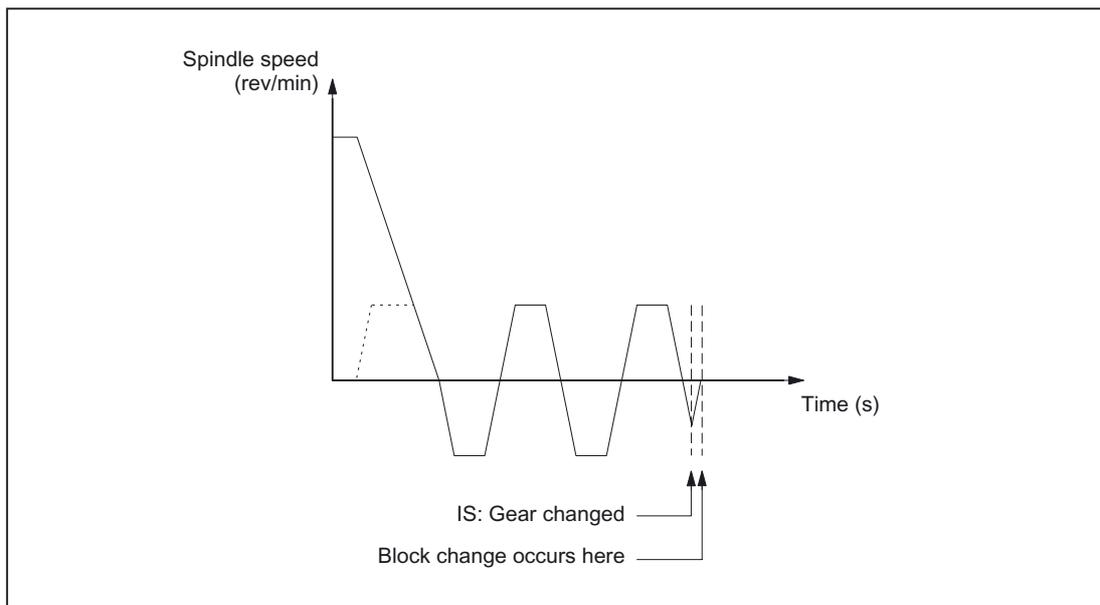


Figure 15-6 Block change following oscillation mode

### Oscillation mode

Typical time sequence for the gear step change with a spindle:



## 15.4.6 Gear step change at fixed position

### Application and advantages

Machine tools increasingly use standardized spindle drives, firstly to save technological dead time on a gear step change and secondly to gain the cost benefits of using standardized components.

The Gear step change at fixed position function supports the "directed gear step change" of load gearboxes that need to be activated in a different way than the NC. The gear step change can in this case only be performed at a defined spindle position. An oscillation motion as required by conventional load gearboxes is thus no longer necessary.

### Sequence for gear step change at fixed position

Gear step change at fixed position

Machine data configuration:

**MD35010 \$MA\_GEAR\_STEP\_CHANGE\_ENABLE = 2**

runs the following sequence:

- Positioning of the spindle from standstill or movement across the position configured in machine data:  
MD35012 \$MA\_GEAR\_STEP\_CHANGE\_POSITION.

If the gear step change is performed out of a movement, then the current direction of rotation is maintained. The spindle is in positioning mode during the positioning action.

NC/PLC IS:

DB31, ... DBX84.5 (positioning mode)  
is output.

If no reference is available:

DB31, ... DBX60.4/5 = 0

or NC/PLC IS:

DB 31, ... DBX17.4/5 (Resynchronize on positioning MS 1/2)

is set, the positioning action is extended by the time it takes to find the zero mark.

- After reaching the gear step change position configured in machine data:  
MD35012 \$MA\_GEAR\_STEP\_CHANGE\_POSITION  
the machine waits for the time in machine data:  
MD35310 \$MA\_SPIND\_POSIT\_DELAY\_TIME  
before switching to oscillation mode,  
and the known gear step change dialog starts.
- Output of VDI interface signals:  
DB31, ... DBX84.6 (Oscillation mode)  
DB31, ... DBX82.3 (Change gear)  
DB31, ... DBX82.0-82.2 (Set gear step A to C).

- Position control is not disabled when an active measuring system with indirect encoder (motor encoder) is used:  
MD31040 \$MA\_ENC\_IS\_DIRECT = 0  
If a measuring system with a direct encoder (load encoder) is active, position control is deactivated:  
DB31, ... DBX61.5 = 0,  
because the induction flux to the load is interrupted and closed-loop position control is no longer possible.
- If position-controlled operation is not possible, it can be disabled by resetting "Servo enable":  
DB31, ... DBX2.1 = 0.
- Mechanical switchover of the gear step on the machine.  
No oscillation motion is required from the drive.  
NC/PLC IS:  
DB31, ... DBX18.5 (Oscillation enable)  
and  
DB31, ... DBX18.4 (Oscillation via PLC)  
should **not** be set.  
In principle, oscillation movement is still possible at this point.
- Writing of NC/PLC IS:  
DB31, ... DBX16.0-16.2 (Actual gear step A to C)  
by the PLC.
- After signal:  
DB31, ... DBX16.3 (Gear step changed),  
the last movement to be active is continued, if available.  
For indirect encoders (motor encoders), the homing status is cleared:  
DB31, ... DBX60.4/5 = 0.  
The spindle is in speed control mode and NC/PLC IS:  
DB311, ... DBX84.7 (Open-loop control mode)  
is output.

### Gear step change at fixed position

Typical time sequence for the gear step change at fixed position:

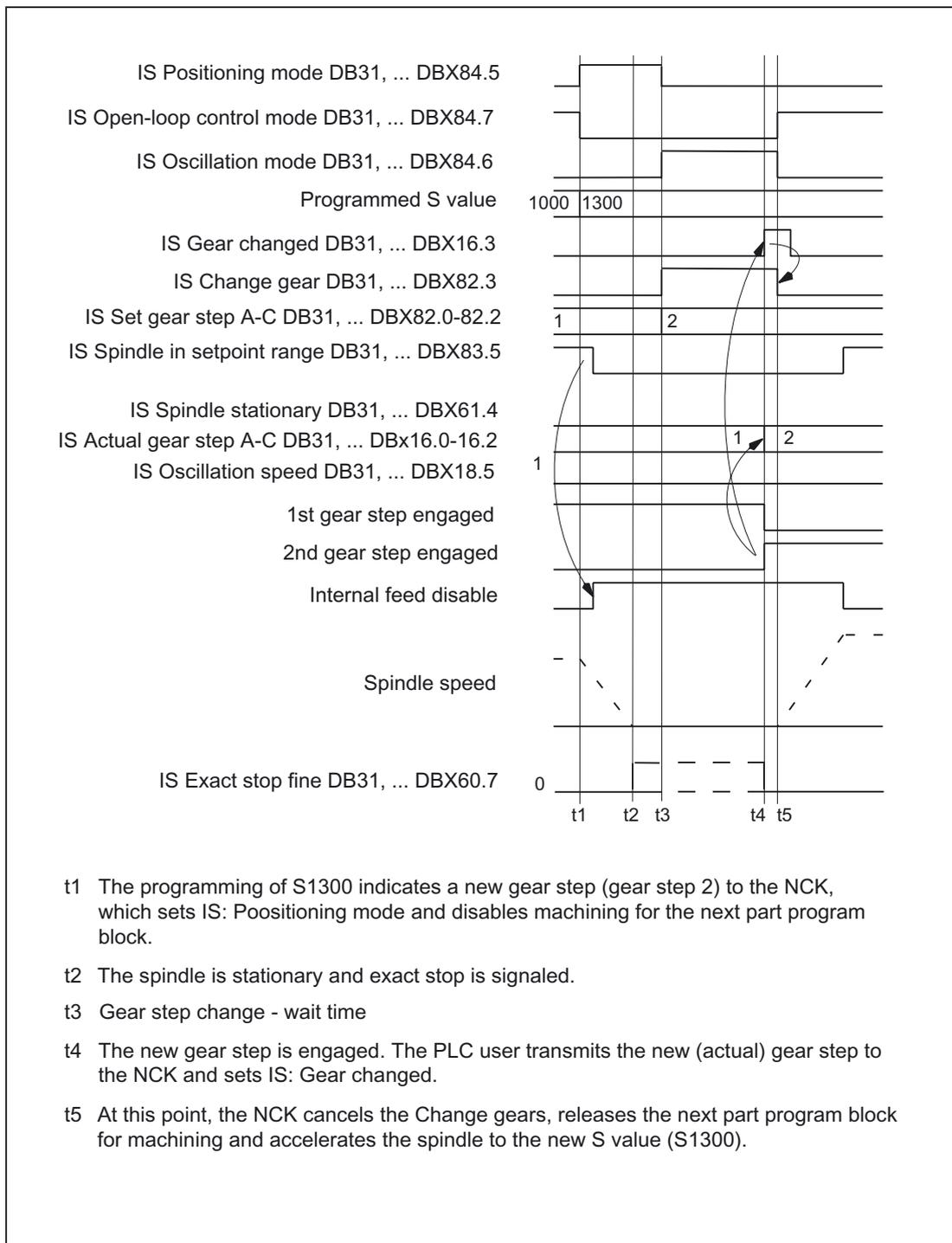


Figure 15-8 Gear step change with stationary spindle

### Gear step change position MD35012

The gear step change position is defined in machine data:  
MD35012 \$MA\_GEAR\_STEP\_CHANGE\_POSITION  
for each gear step.

### Gear step change wait time MD35310

After the positioning action the machine waits for the time configured in machine data:  
MD35310 \$MA\_SPIND\_POSIT\_DELAY\_TIME  
until gear change request:  
DB31, ... DBX84.6 (Oscillation mode)  
DB31, ... DBX82.3 (Change gear)  
and  
DB31, ... DBX82.0-82.2 (Set gear step A to C)  
are output.

### Position identifiers/position

The position is always approached via the shortest path (corresponds to DC).

If no reference is available and the spindle is in stillstand  
(e.g. after Power On), then the direction of travel is determined by the following machine  
data:

MD35350 \$MA\_SPIND\_POSITIONING\_DIR

If an adjustable gear step change position is required, then this can be achieved by writing  
the machine data and by a subsequent NewConfig.

The change of the MD value can be achieved by the part program or HMI.

If the system is unable to reach the preset position, then alarm 22020 is signaled and the  
gear step change dialog between NCK and PLC does not take place in order not to destroy  
the gears. As this alarm is serious, the part program cannot continue and the cause must be  
eliminated under all circumstances Experience has shown that the abortion of positioning is  
usually due to incorrect MD settings or incompatible PLC signals.

## Velocity

The positioning velocity is taken from the machine data:  
MD35300 \$MA\_SPIND\_POSCTRL\_VELO  
NC/PLC IS "Spindle speed override"/"Feedrate override" at  
DB31, ... DBX17.0=0: DB31, ... DBB19)  
as well as:  
DB31, ... DBX17.0=1: DB31, ... DBB0  
are effective as normal for positioning.  
The positioning speed can be changed proportionally through the program instruction  
OVRA [Sn].

---

### Note

OVRA [Sn] is valid modally. After the gear step change, a value appropriate for the machining should be reset.

---

The part-program instruction FA [Sn] does not change the positioning speed during gear step change.

## Acceleration

The acceleration values are determined through the gear step dependent machine data:  
MD35200 \$MA\_GEAR\_STEP\_SPEEDCTRL\_ACCEL  
and  
MD35210 \$MA\_GEAR\_STEP\_POSCTRL\_ACCEL.

The acceleration can be changed proportionally by programming ACC [Sn].

---

### Note

ACC [Sn] is valid modally. After the gear step change, a value appropriate for the machining should be reset.

---

**Speed-dependent acceleration**

The "knee-shaped acceleration characteristic" is effective as in positioning with *SPOS* or *FC18*.

**Jerk**

It is currently not possible to limit the change in acceleration.

**End of positioning**

The transition between the end of the positioning action (*DB31*, ... *DBX84.5*) and the start of oscillation mode (*DB31*, ... *DBX84.6*) is defined on reaching "Exact stop fine" (*DB31*, ... *DB60.7*) and the time value entered in machine data: *MD3510 \$MA\_SPIND\_POSIT\_DELAY\_TIME*.

The determination of the transition condition has an effect firstly on the gear step change time and secondly on the accuracy of the approach to the preset gear step change position.

**Block change**

The block change is stopped and the machining blocks are not started until the gear step has been changed by the PLC (*DB31*, ... *DBX16.3*).

**End of gear step change**

Once the gear step change has been completed, the spindle returns to open-loop control mode and will automatically change to the controller mode defined by *SPCON* or *SPCOF*.

All gear-specific limit values (min./max. speed of gear step, etc.) correspond to the check-back values of the actual gear step.

### Constraints

- The spindle must have at least one measuring system.
- Position-controlled operation must be possible and must have been activated.
- Generally, it must be possible to execute `SPOS` from the part program, from a synchronized action or via FC18: "Start spindle positioning" without errors.

Unless all requirements can be met, the function described cannot be used successfully.

### Activation

The function of gear step change at fixed position is activated by the configuration:  
MD35010 `$MA_GEAR_STEP_CHANGE_ENABLE = 2`

## 15.5 Selectable spindles

### Application

The "selectable spindles" function allows you to write part programs with reference to the spindles used ("channel spindle, logical spindle") regardless of the actual assignment of configured spindles ("physical spindles") to a channel.

The physical spindles loaded or unloaded by "axis replacement" no longer have to be specified explicitly in the part program.

### Functionality

Each spindle is clearly mapped to a machine axis through a configurable number with the machine data:

MD35000 \$MA\_SPIND\_ASSIGN\_TO\_MACHAX[AX...].

This number is always valid for a spindle whereby it is irrespective in which channel the spindle is actively handled.

The channel spindles can be switched over because an intermediate level is introduced between the logical spindle numbers used in the part program and the physical spindles existing in the channel.

The setting data table

(SD42800 \$SC\_SPIND\_ASSIGN\_TAB[...]; Spindle number converter)

assigns each logical spindle used in the part program a physical spindle.

The spindle number converter is effective in spindle programming by means of:

- The part program
- Synchronized actions

The spindle number converter has no effect with PLC commands, which use function block FC18. The physical spindle must always be addressed there within the context of the axis.

The logical spindles can be switched by changing the setting data:

SD42800 \$SC\_SPIND\_ASSIGN\_TAB[...]

The change can be achieved by the part program, by the PLC and/or HMI.

---

### Note

In setting data:

SD42800 \$SC\_SPIND\_ASSIGN\_TAB[0]

contains the logical master spindle.

It is only used for display purposes.

This setting data is defined in the part program by `SETMS` (logical spindle).

Unused spindles are assigned the value 0 in SD42800.

System variables affected by the spindle mapping table are:

`$P_S`, `$P_SDIR`, `$P_SMODE`, `$P_GWPS`, `$AC_SDIR`, `$AC_SMODE`, `$AC_MSNUM`, `$AA_S`.

---

**References:**

/PGA/ Programming Manual, Job Planning

The converted, physical spindle number is always output as the address extension in the auxiliary function output.

**Constraints**

- Switchable channel spindles are **not** a substitute for the Axis replacement function.
- You can only switch spindles, which have been assigned to the channel by means of configuration.
- If spindles, which are presently active in another channel, are designated for switchover, either the "Auto-Get" function is triggered for the physical spindle or alarm 16105 "Assigned spindles do not exist" is output, depending on the configuration variant.
- If the setting data:  
SD42800 \$SC\_SPIND\_ASSIGN\_TAB[...]  
is specified by the PLC or from HMI, then the channel whose table is changed should be in Reset status or the spindle to be changed should not be used in the running part program respectively.

A synchronized response can be achieved by means of a STOPRE preprocessor stop.

- The multiple mapping of logical to physical spindles is not prevented in the NC. However, with the display of logical spindle in the operator interface, there are ambiguities corresponding to the change table.
- Spindle conversion operates on spindles via FC 18.

**Activation**

Setting data:

SD42800 \$SC\_SPIND\_ASSIGN\_TAB[...]

is enabled by activating machine data:

MD20092 \$MC\_SPIND\_ASSIGN\_TAB\_ENABLE=1.

**Basic position SD42800**

After switching on the NC in installation switch position 1 (Delete SRAM) the setting data:

SD42800 \$SC\_SPIND\_ASSIGN\_TAB[...]

is in the basic position.

The numbers of the logical and physical spindles are identical.

SD42800 \$SC\_SPIND\_ASSIGN\_TAB[1] = 1

SD42800 \$SC\_SPIND\_ASSIGN\_TAB[2] = 2

SD42800 \$SC\_SPIND\_ASSIGN\_TAB[3] = 3

SD42800 \$SC\_SPIND\_ASSIGN\_TAB[4] = 4

SD42800 \$SC\_SPIND\_ASSIGN\_TAB[5] = 5

...

**Example**

Assumptions: Spindle configurations:

Specifying the spindle number and machine axis

```
MD35000 $MA_SPIND_ASSIGN_TO_MACHAX [AX4] = 1
MD35000 $MA_SPIND_ASSIGN_TO_MACHAX [AX5] = 2
MD35000 $MA_SPIND_ASSIGN_TO_MACHAX [AX6] = 3
MD35000 $MA_SPIND_ASSIGN_TO_MACHAX [AX7] = 5
```

Applying a machine axis in the channel

```
MD20070 $MC_AXCONF_MACHAX_USED[0] = 4
MD20070 $MC_AXCONF_MACHAX_USED[1] = 5
MD20070 $MC_AXCONF_MACHAX_USED[2] = 6
MD20070 $MC_AXCONF_MACHAX_USED[3] = 7
```

Specifying the master spindle

```
MD20090 $MC_SPIND_DEF_MASTER_SPIND = 1
```

Spindle number converter

```
MD20092 $MC_SPIND_ASSIGN_TAB_ENABLE = 1           Activate spindle number converter
SD42800 $SC_SPIND_ASSIGN_TAB[0] = 1             Master spindle as configured
SD42800 $SC_SPIND_ASSIGN_TAB[1] = 1             Basic table setting
SD42800 $SC_SPIND_ASSIGN_TAB[2] = 2
SD42800 $SC_SPIND_ASSIGN_TAB[3] = 3
SD42800 $SC_SPIND_ASSIGN_TAB[4] = 0             Logical spindle not assigned
M3 S1000      Address extension = 1, M1=3 S1=1000 is output. The spindle with the
              configured No. "1" (No. of physical master spindle) rotates.
...
...
SD42800 $SC_SPIND_ASSIGN_TAB[1] = 5             Assignment of logical spindle 1 to
                                                physical spindle 5
SD42800 $SC_SPIND_ASSIGN_TAB[2] = 3             Assignment of logical spindle 2 to
                                                physical spindle 3.
Caution: physical spindle 3 has now been
assigned twice. When programming logical
spindles 2 and 3, physical spindle 3 is
always addressed. In the basic machine
displays, both spindles rotate.
SETMS (2)      SD42800 $SC_SPIND_ASSIGN_TAB[0] = 2 defined internally by NCK.
...

```

M5	Master spindle = address extension = 2, spindle number M3=5 The physical spindle configured with number "3" stops.
...	
GET (S4)	Alarm 16105, as logical spindle "4" cannot be switched.
...	
RELEASE (S1)	Channel spindle "1" = physical. Spindle "5" is enabled.
...	
M30	

## 15.6 Programming

### 15.6.1 Programming from the part program

#### Programming statements

Statement	Description
SETMS	The master spindle is the spindle stored in machine data: MD20090 \$MC_SPIND_DEF_MASTER_SPIND (Initial setting for master spindle on channel).
SETMS(n)	The spindle with the number (n) is the master spindle (can differ from the initial setting in machine data: MD20090 \$MC_SPIND_DEF_MASTER_SPIND). The master spindle must be defined for the following functions:
G95	Rev. feedrate
G96 S../G961 S...	constant cutting speed in m/min or ft/min
G97/G971	Cancel G96/G961 and freeze last spindle speed
G63	Tapping with compensating chuck
G33/G34/G35	Thread cutting
G331/G332	Rigid tapping
G4 S...	Dwell time in spindle revolutions
	Programming M3, M4, M5, S, SPOS, M19, SPOSA, M40, M41 to M45 and WAITS without entering the spindle number.
	The current master spindle setting can be retained via RESET and START. The setting is made in machine data: MD20110 \$MC_RESET_MODE_MASK and MD20112 \$MC_START_MODE_MASK. <b>References:</b> /FB1/ Function Manual, Basic Functions; Mode Group, Channel, Program Operation (K1)
M3 M1=3	Direction of spindle rotation clockwise for master spindle. Direction of spindle rotation clockwise for spindle number 1
M4 M2=4	Direction of spindle rotation counterclockwise for master spindle. Direction of spindle rotation counterclockwise for spindle number 2
M5 M1=5	Spindle stop without orientation for master spindle. Spindle stop without orientation for spindle number 1
S .... S2= ....	Spindle speed in rpm for master spindle. Spindle speed in rpm for spindle number 2
SPOS =270 SPOS[n] =270	Spindle positioning for the master spindle or the spindle with number n to the position 270 degrees. The block change is only performed when the spindle is in position.

Statement	Description
SPOSA=90 SOSSA[n]=90	Spindle positioning for the master spindle or the spindle with number n to the position 90 degrees. The block change is executed immediately. Spindle positioning continues, regardless of further part program processing, until the spindle has reached its position.
SPOS=DC(Pos), SPOS[n]=DC(Pos), SPOSA=DC(Pos), SPOSA[n]=DC(Pos)	The direction of motion is retained for positioning while in motion and the position approached. When positioning from standstill, the position is approached via the shortest path.
SPOS=ACN(Pos), SPOS[n]=ACN(Pos), SPOSA=ACN(Pos), SPOSA[n]=ACN(Pos)	The position is always approached with negative direction of motion. If necessary, the direction of motion is inverted prior to positioning.
SPOS=ACP(Pos), SPOS[n]=ACP(Pos), SPOSA=ACP(Pos), SPOSA[n]=ACP(Pos)	The position is always approached with positive direction of motion. If necessary, the direction of motion is inverted prior to positioning.
SPOS=IC(Pos), SPOS[n]=IC(Pos), SPOSA=IC(Pos), SPOSA[n]=IC(Pos)	The travel path is specified. The direction of travel is obtained from the sign in front of the travel path. If the spindle is in motion, the direction of travel is inverted as necessary to allow traversing in the programmed direction.  If the zero mark is crossed during traversing, the spindle is automatically synchronized with the zero mark if no reference is available or if a new one has been requested via an interface signal.
M19 M[n]=19	Spindle positioning for the master spindle or the spindle with number n to the position entered in setting data: SD43240 \$SA_M19_SPOS. The block change is only performed when the spindle is in position.
M70 M1=70	Bring spindle to standstill and activate position control, select zero parameter set, activate axis mode for the master spindle or for the spindle with number 1.
SPCON, SPCON(n), SPCON(n,m)	Spindle position control for the master spindle ON Spindle position control mode for the spindle number n ON Spindle position control mode for the spindle number n and m ON
PCOF, SPCOF(n), SPCOF(n,m)	Spindle position control for the master spindle OFF, activate speed control mode. Spindle position control for the master spindle OFF, activate speed control mode for the spindle number n as well as for the spindle number n and m.
FPRAON (S2)	Revolutional feedrate for spindle S2 ON, derived from the master spindle
FPRAON (S2, A)	Revolutional feedrate for spindle S2 ON, derived from axis A. The revolutional feedrate value must be specified with FA[Sn].
FPRAOF (S2)	Revolutional feedrate for spindle S2 OFF.
C30 G90 G1 F3600	Rotary axis C (spindle in axis mode) travels to the position 30 degrees at a speed of 3600 degrees/min = 10 rpm.
G25 S...., G25 S2...	Programmable minimum spindle speed limitation. Programmable minimum spindle speed limitation for spindle number 2.
G26 S...., G26 Sn...	Programmable maximum spindle speed limitation. Programmable maximum spindle speed limitation for spindle number n.
LIMS=	Programmable maximum spindle speed limitation with G96, G961, G97.

Statement	Description
WAITS	Part program, synchronization command for master spindle. Execution of the following blocks is suspended until the spindle(s) programmed with <i>SPOSA</i> has/have reached their position(s) with exact stop fine. Waits until the spindle is at standstill after <i>M5</i> . Waits until the spindle has reached its setpoint speed after <i>M3/M4</i> .
WAITS(n) WAITS(n,m)	Synchronization command for spindle n. Synchronization command for spindles n and m.
FA[Sn]	Programming of positioning speed (axial feed) for spindles in [deg/min]. The value configured in machine data: MD35300 \$MA_SPIND_POSCTRL_VELO is reactivated with FA[Sn]=0.
OVRA[Sn]	Programming of axial override value for spindle n in [%].
ACC[Sn]	Programming of the axial acceleration capacity of spindle n in [%].
SPI(n)	Axis functions for a spindle with <i>SPI</i> (n) (spino) are converted into the data type AXIS according to machine data: MD35000 \$MA_SPIND_ASSIGN_TO_MACHAX[ ] . <i>SPI</i> is used if axis functions are programmed using the spindle number. The following instructions are possible with <i>SPI</i> : <ul style="list-style-type: none"> <li>• Frame instructions with <i>SPI</i>: <ul style="list-style-type: none"> <li>– CTRANS()</li> <li>– CFINE()</li> <li>– CMIRROR()</li> <li>– CSCALE()</li> </ul> </li> <li>• Velocity and acceleration values for following spindles with <i>SPI</i>: <ul style="list-style-type: none"> <li>– FA[SPI(n)]</li> <li>– ACC[SPI(n)]</li> <li>– OVRA[SPI(n)]</li> </ul> </li> <li>• System variable with <i>SPI</i>: <ul style="list-style-type: none"> <li>– \$P_PFRAME[SPI(1),TR] = 2.22 frames can be written, for example.</li> <li>– \$P_PFRAME = CTRANS (X, axis value, Y, axis value, SPI(1), axis value)</li> <li>– \$P_PFRAME = CSCALE (X, scale, Y, scale, SPI(1), scale)</li> <li>– \$P_PFRAME = CMIRROR (S1, Y, Z)</li> <li>– \$P_UBFR = CTRANS (A, 10) : CFINE (19, 0.1)</li> </ul> </li> </ul> Detailed information about programming of <i>SPI</i> can be found in <b>References:</b> /PGA/ Programming Guide Advanced
M40, M1=40	Automatic gear step selection for master spindle. Automatic gear step selection for spindle number 1.
M41 to M45 M1=41 to M1=45	Select gear step 1 to 5 for master spindle. Select gear step 1 to 5 for spindle number 1.

---

**Note**

M functions M3, M4, M5, and M70 are not output in DB21, ... DBB194 and DBB202 if a spindle is configured in a channel. These M functions are offered as extended M functions in DB21, ... DBB68 ff. and in the relevant axis DBs, DB31, ... DBB86 ff.

---

Detailed explanations for programming the spindle can be found under:

**References:**

/PG/ Programming Manual, Fundamentals

## 15.6.2 Programming via synchronized actions

### M40 to M45

M functions M40 to M45 can also be programmed in synchronized actions.

Please note:

- Programming of M40...M45 in the part program has no effect on the current status of the automatic gear step change of synchronized actions, and vice versa.
- When programming S values with M40, automatic gear step change is effective separately for synchronized actions and the part program.

For synchronized actions:

- M40 is deactivated after POWER ON.

The gear step is not adjusted if an S value is specified from a synchronized action.

- An M40 command programmed using synchronized actions always remains active for synchronized actions (modal) and is not reset on RESET.

M41...M45 selects the first to fifth gear step according to the programming instructions in the part program.

Please note:

- An axis replacement is necessary in order to run the function.
- Once the gear step change has been performed, the spindle status is neutral (same response as M3, M4, M5 instructions).

Further explanations regarding the programming of spindle as well as spindle movements from synchronized actions can be found under:

**References:**

/PGA/ Programming Manual Job Planning

/FBSY/ Function Description Synchronized Actions

### 15.6.3 Programming spindle controls via the PLC with FC18

#### Automatic gear step change with FC18

When the PLC specifies the direction of rotation and speed using FC18, the NCK can determine and select a gear step to match the speed. This is equivalent to the M40 functionality when programming via the part program.

The correct start code must be set when FC18 is called in a PLC user program, in order to activate gear step selection.

More detailed explanations regarding the programming of spindle controls by PLC with FC18 can be found under:

**References:**

/FB1/ Function Manual, Basic Functions; PLC Basic Program (P3)

### 15.6.4 Special spindle movements via PLC interface

#### Why use a special spindle interface?

This function can be used to program the spindle via an axial PLC interface as an alternative to the FC18. The simplicity of the settings results in slightly restricted functionality. This functionality can be used preferably for simple control applications.

#### Functionality

Special VDI interface signals are provided to start and stop spindles outside a running part program. In this regard, the channel status and the program status need not be in the active mode. These states are assumed e.g. during RESET and in the JOG mode.

The spindle concerned must have the state "Channel axis" or "Neutral axis" and must not be moved using the JOG keys or positioned by FC18 or synchronized actions. The spindle jobs are accepted via the internal DBB30 spindle interface, if these conditions are fulfilled.

The spindle settings are retained after a change in mode (e.g. from JOG mode to AUTOMATIC). The spindle settings (direction of rotation, speed or cutting rate) are applied to the part program at the start of the program and can be modified again using part program instructions. In JOG mode, the spindle can be moved at the speed last programmed.

#### Multi-channel operation

In the case of multi-channel operation, the spindle started by the PLC becomes active in the channel that handles the spindle at the appropriate moment.

This channel can be determined on the PLC by reading NC/PLC IS: DB31, ... DBX68.0-68.3 (NC axis/spindle in channels A to D).

## Spindle job

In order to start a job, the channel handling the spindle must be in the acceptance status. A spindle job is always started on the Low-High edge of an internal DBB30 signal.

Generally, the internal DBB30 start signals do not have any meaning in the static status and do not prevent the spindle being programmed by FC18, synchronized actions, the part program or JOG traversing movements (e.g. when the STOP signal is statically at "1").

## Conditions for the acceptance status

Outside a running part program, spindles can be started and stopped using the special VDI interface signals NCK → PLC.

To do this, the **Channel status** must be in the "Interrupted" or "Reset" mode:

DB21, ... DBX35.6 = 1 (channel status "interrupted")

DB21, ... DBX35.7 = 1 (channel status "reset")

The **program status** must be in the "interrupted" or "cancelled" mode:

DB21, ... DBX35.3 = 1 (program status "interrupted")

DB21, ... DBX35.4 = 1 (program status "interrupted")

These states will occur on RESET and in JOG mode.

At the start time, the spindle concerned must meet the following requirements:

- It must be in the status "Channel axis" or "Neutral axis" and must not be moved by means of the JOG keys.
- When the spindle is specified, no positioning movement may be carried out by FC18 or synchronized actions.

## Spindle job outside the acceptance range

Low-High edges outside the acceptance range will be ignored. No alarm message is output by the NCK. It can be assumed that the acceptance range will be indicated to the operator by the PLC program.

Spindle jobs outside the acceptance range can also be carried out using FC18 or ASUB.

## SD43200 Overwrite

Setting data:  
SD43200 \$SA\_SPIND\_S  
can be overwritten as follows:

- Through speed programming
- Through direct programming in the part program
- Through HMI software

---

### Note

The setting data is written immediately and asynchronously to part-program execution.

---

## Conditions for writing

When overwriting the setting data:  
SD43200 \$SA\_SPIND\_S  
the following conditions apply:

Programming through:	Conditions for programming:
Speed programming	MD35035 \$MA_SPIND_FUNCTION_MASK Bit 4 = 1 must be set. Constant cutting rate G96, G961 must not be active.
	NC/PLC IS: DB31, ... DBX84.0 = 0 (constant cutting speed) must be set.
Direct programming in the part program	A programmed S-value and the value of the directly written SD can be outdated with respect to time. If this is the case, after programming the SD, the statement <code>STOPRE</code> should be executed.
HMI	Only positive values including zero can be accepted. Otherwise, a corresponding message is generated.

## Spindle commands

The following basic logic functions can be specified for the spindle:

Basic logic functions:	Spindle commands:
Motion specification: Spindle stop Spindle start clockwise rotation Spindle start counterclockwise rotation Select gear step Spindle positioning	Independently of a running part program: Input from the PLC via internal VDI interface signals DB31, ... DBB30

Basic logic functions:	Spindle commands:
Speed MD35035 \$MA_SPIND_FUNCTION_MASK Bit 4 = 1 When movement starts the speed is read from setting data: SD43200 \$SA_SPIND_S.	Speed specifications from part program or FC18 are programmed in setting data: SD43200 \$SA_SPIND_S.
Setpoint speed: MD35035 \$MA_SPIND_FUNCTION_MASK Bit 5 = 1 The content from setting data: SD43200 \$SA_SPIND_S is used as the setpoint speed.	You can use the JOG keys to operate the spindle at the speed defined in setting data: SD43200 \$SA_SPIND_S.
Constant cutting speed: MD35035 \$MA_SPIND_FUNCTION_MASK Bit 8 = 1 Read from setting data: SD43202 \$SA_SPIND_CONSTCUT_S.	Specifications for the constant cutting speed from part program, FC18 and synchronized actions are programmed in setting data: SD43200 \$SA_SPIND_S.

Notes on machine data MD35035 \$MA\_SPIND\_FUNCTION\_MASK:

For bit 4 and bit 8, the following also applies:

- Programmed S values that are not programmed speed values are **not** written to the corresponding setting data.  
This includes S values in the case of a rotation-related dwell time (G4).
- The spindle jobs are accepted via the internal DBB30 interface, if these conditions are fulfilled (acceptance status).

### Speed default

Speed defaults from part program, FC18 or synchronized actions are written to the following setting data from all the usual sources:

SD43200 \$SA\_SPIND\_S (speed for spindle start via VDI)

#### Gear step change and effect on speed

In the current version, no gear step change is triggered if the setpoint speed is out of the speed range of the gear step. The usual speed limitations and the speed increase to the setpoint speed are active.

### Constant cutting rate setting

Defaults for constant cutting speed from part program, FC18 or synchronized actions are written to the following setting data from all the usual sources:

SD43202 \$SA\_SPIND\_CONSTCUT\_S (cutting speed for spindle start via VDI)

#### Supplementary condition

To ensure that constant cutting rate settings are active, the spindle concerned must be a master spindle in the channel handling the spindle.

This condition is fulfilled if the following NC/PLC interface signal is set:

DB31, ... DBX84.0 = 1 (constant cutting speed is active)

### Writing from the part program

When writing from the part program, the value for the constant cutting rate is interpreted as follows:

if G710 is active in the 12th G Group:	Metric
if G700 is set in the 12th G Group:	inch as [feet/min]

Regarding G70, G71 and the specification of external (HMI), the setting in the machine data: MD10240 \$MN\_SCALING\_SYSTEM\_IS\_METRIC determines the interpretation of the specified values.

Further explanations regarding measuring system (metric/inch) can be found under:

#### References:

/FB1/ Function Manual, Basic Functions; Speeds, Setpoint-/Actual Value System, Control (G2)

### Setting via FC18 synchronized actions

If the constant cutting rate is set via FC18, the setting of bit 6 in byte to in the "Signals to concurring positioning axes" area determines how the speed value (bytes 8...11) is interpreted.

In the case of setting via synchronized actions, the feedrate type will determine how the S value is interpreted, analogously to the part program.

### Reading from part program and synchronized actions

The programmed cutting rate value can be determined both in the part program and in synchronized actions by reading system variables:

\$P\_CONSTCUT\_S

and

\$AC\_CONSTCUT\_S.

The programmed cutting rate value can also be read via the OPI interface.

### System variable

**RV:** Defined range of values of the two new system variables.

Description	NCK variable
Last constant cutting rate programmed RV = {0, DBL_Max}	\$P_CONSTCUT_S[n]
Current constant cutting rate RV = {0, DBL_Max}	\$AC_CONSTCUT_S[n]

**Spindle-specific functions**

**MD35035**

Machine data:

MD35035 \$MA\_SPIND\_FUNCTION\_MASK

defines spindle-specific functions from the part programs, FC18 and synchronized actions as follows:

No gear step change with DryRun, program testing and SERUPRO.	
Bit 0 = 1	Gear step change for blocks with M40, M41 to M45 or via FC18 and synchronized actions are suppressed with DryRun.
Bit 1 = 1	Gear step change for blocks with M40, M41 to M45 or via FC18 and synchronized actions are suppressed with Program Test and SERUPRO.
Bit 2 = 1	Gear step change for programmed gear step is performed after deselection of functions DryRun and SERUPRO.
Acceptance of programmed speed and cutting rate including settings.	
Bit 4 = 1	The programmed speed including speed specifications are accepted in setting data: SD43200 \$SA_SPIND_S. through FC18 and synchronized actions.
Bit 5 = 1	The content of setting data: SD43200 \$SA_SPIND_S serves as the setpoint speed in JOG mode. You can use the JOG keys to operate the spindle at the speed defined in SD43200. If the content is zero, other JOG speed specifications are active (see setting data SD41200 \$SN_JOGSPIND_SET_VELO).
Bit 8 = 1	The programmed cutting speed including specifications for FC18 and synchronized actions are accepted in SD43202 \$SA_SPIND_S.
Spindle override is also actively influenced during zero marker search with M19, SPOS, or SPOSA.	
Bit 12 = 1	Spindle override is effective during zero marker search with M19, SPOS or SPOSA.
For additional information about machine data: MD35035 \$MA_SPIND_FUNCTION_MASK please refer to: <b>References:</b> /FB1/ Function Manual, Basic Function; Acceleration (B2)	

## 15.6.5 Gear step change with DryRun, program testing and SERUPRO

### Part program, synchronized actions and FC18

The behavior of the gear stage change from the part program, FC18 and synchronized actions for the functions DryRun, Programmtest and SERUPRO (SearchRunByProgrammtest) can be configured with the following, already available machine data:

MD35035 \$MA\_SPIND\_FUNCTION\_MASK.

These functions do not generally require a gear step change and can therefore be suppressed in machine data:

MD35035 \$MA\_SPIND\_FUNCTION\_MASK

with bits 0 to 2 as follows:

Dry run feedrate (DryRun)	
Bit 0 = 0	Gear steps are activated even with the DryRun function active for part program blocks with M40, M41 to M45 or via FC18 and synchronized action programming. response).
Bit 0 = 1	Gear step change for blocks with M40, M41 to M45 or via FC18 and synchronized actions are suppressed with DryRun.
Program test and SERUPRO	
Bit 1 = 0	Gear steps are activated even with the Program Test function active for part program blocks with M40, M41 to M45 or via FC18 and synchronized action programming. response).
Bit 1 = 1	Gear step change for blocks with M40, M41 to M45 or via FC18 and synchronized actions are suppressed with Program Test and SERUPRO.
DryRun, program testing and SERUPRO	
Bit 2 = 0	Gear step change for programmed gear step is <b>not</b> performed subsequently on REPOS after deselection of functions DryRun, Program Test and SERUPRO.
Bit 2 = 1	Gear step change for programmed gear step is performed after deselection of functions DryRun and SERUPRO if possible.

### Gear step change suppression

If a gear step change is suppressed, if necessary, the interpolator will limit the programmed spindle speed to the permissible speed range of the active gear step.

NC/PLC IS:

DB31,... DBX83.2 (Setpoint speed increased)

and

DB31,...DBX83.1 (Setpoint speed limited) generated as a result of this limit are suppressed.

Monitoring by the PLC program is not necessary during DryRun and in dry run feedrate.

When the gear step change is suppressed, no new gear step setpoint is output to the PLC with NC/PLC IS:

DB31,...DBX82.0-82.2 (Gear step setpoint).

The gear step change request:  
DB31,...DBX82.3 (Change gear)  
is also suppressed.

This ensures that no gear step change information has to be processed by the PLC program.

### Determining the last active gear step

System variable:

\$P\_GEAR

returns the gear step programmed in the part program (which may not have been output to the PLC).

System variable:

\$AC\_SGEAR

can be used to read the last active gear step from the part program, synchronized actions and operator panel interface.

The DryRun function can be deselected within a running part program. Once it has been deselected, the correct gear step requested by the part program must be identified and selected.

It cannot be assured that the remainder of the part program will run without errors until the correct gear step has been activated. Any necessary gear step change is performed in the system REPOS started on deselection if the spindle is in speed control mode. A complete gear step change dialog takes place with the PLC and the last programmed gear step is activated.

If there is a mismatch between the gear step programmed in the part program and the actual gear step returned via the VDI interface with REPOS, no gear step change takes place.

The same applies to the SERUPRO function.

Further explanations regarding set search execution SERUPRO can be found under:

**References:**

/FB1/ Function Manual, Basic Functions; Mode group, Channel, Program Mode (K1)

### Boundary conditions

If the gear step change is suppressed, the output spindle speed moves within the speed range specified by the current gear step.

The following restrictions apply to the subsequent activation of a gear step change with REPOS:

- The gear step change is not activated subsequently if the spindle in the deselection or target block is a command spindle (synchronized action) or PLC spindle (FC18).
- If the gear step cannot be activated because the spindle is in position or axis mode or a link is active, alarm 22011"Channel%1 block%3 spindle% Change to programmed gear step not possible" is signaled.

## Example

### Gear step change in DryRun

```

1. Activate 1st gear step (GS) for output state;
N00 M3 S1000 M41          ; 1st GS is selected
M0                        ; Part program stops

PI service: Activate dry run feedrate (DryRun);
                        ; (Configuring)
N10 M42                  ; 2nd GS requested, no gear step change takes
                        ; place
N11 G0 X0 Y0 Z0         ; Positioning axes
N12 M0                  ; Part program stops

PI service: Deactivate dry run feedrate (DryRun);
                        ; REORG and REPOS are performed
                        ; now the gear step change to the 2nd gear step
                        ; takes place
N20 G1 Z100 F1000      ;
...                      ;
N99 M30                ; Part program end

```

## 15.6.6 External programming (PLC, HMI)

### SD43300 and SD42600

The revolutionary feedrate behaviour can be selected externally via the axial setting data: SD43300 \$SA\_ASSIGN\_FEED\_PER\_REV\_SOURCE (Rotational feedrate for spindles) in JOG operating mode using the channel-specific setting data SD42600 \$SC\_JOG\_FEED\_PER\_REV\_SOURCE (Revolutional feedrate control in JOG mode).

The following settings can be made via the setting data:

>0:	The machine axis number of the rotary axis/spindle from which the revolutionary feedrate shall be derived.
-1:	The revolutionary feedrate is derived from the master spindle of the channel in which the axis/spindle is active in each case.
0:	Function is deselected.

## FPRAON (S2)

Revolutional feedrate for spindle S2 ON, derived from the master spindle

**FPRAON (S2, A)**

Revolutional feedrate for spindle S2 ON, derived from axis A.  
The revolutional feedrate value must be specified with `FA [Sn]`.

**FPRAOF (S2)**

Revolutional feedrate for spindle S2 OFF.

**SPI(n)**

It is also possible to program `SPI (n)` instead of `SPI (Sn)`.

## 15.7 Spindle monitoring

### 15.7.1 Speed ranges

#### Permissible speed ranges for the spindle

The spindle monitoring functions and the currently active functions (G94, G95, G96, G961, G97, G971, G33, G34, G35, G331, G332, etc.) define the permissible speed ranges of the spindle.

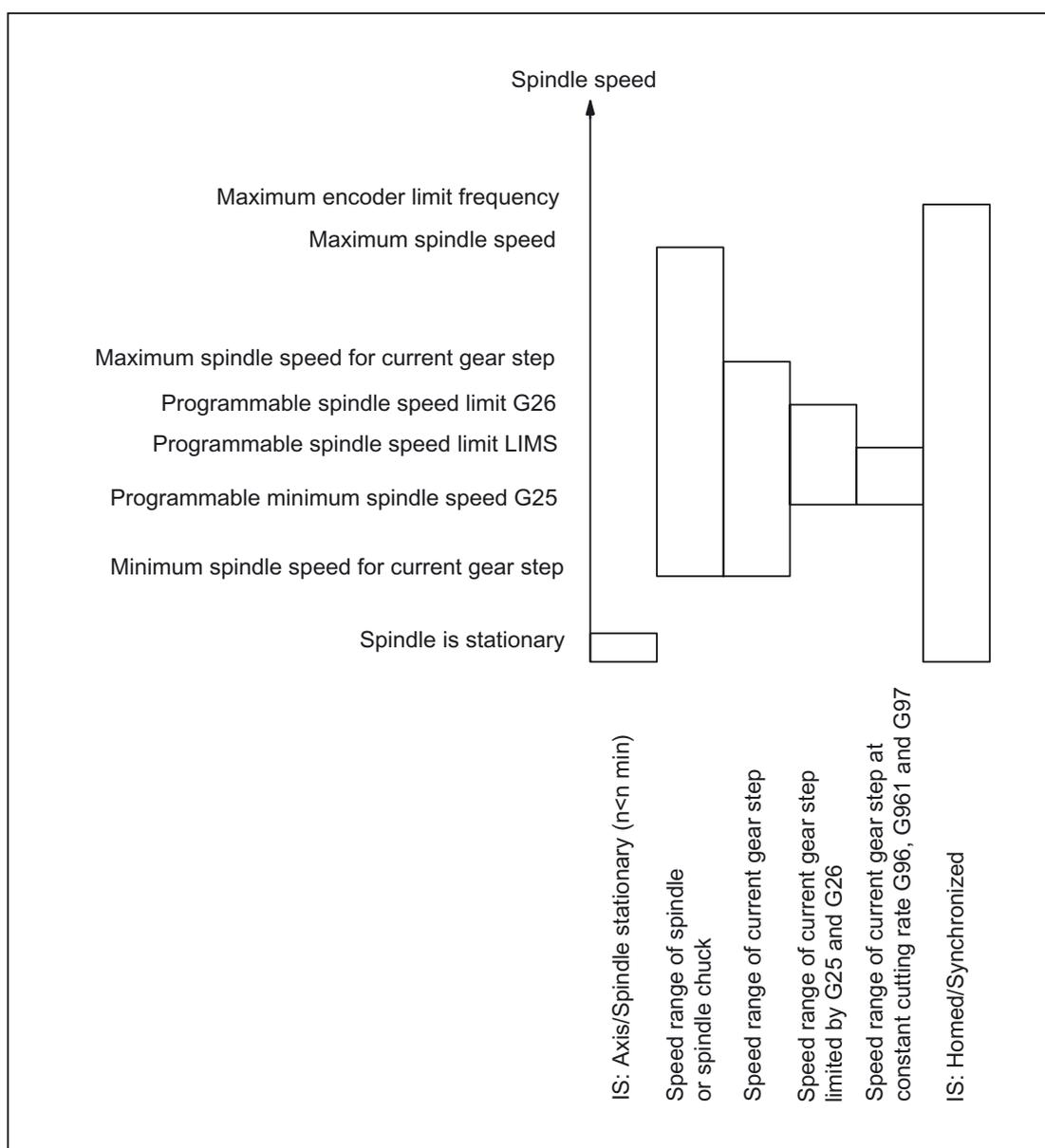


Figure 15-9 Ranges of spindle monitoring functions/speeds

## 15.7.2 Axis/spindle stationary ( $n < n_{min}$ )

### Spindle monitoring with stationary axis/spindle

Only if the axis/spindle is stationary, i.e. the actual spindle speed falls below a specifiable value in machine data:

MD36060 \$MA\_STANDSTILL\_VELO\_TOL (maximum velocity/speed "Axis/spindle stationary")

and no longer generates any setpoints, is it possible to perform certain functions on the machine, such as tool change, open machine doors, path feed enable, etc.

If the spindle is stationary,

- NC/PLC IS:  
DB31, ... DBX61.4 axis/spindle stationary)  
is set to 1.
- The next machining block is released  
and machine data:  
MD35510 \$MA\_SPIND\_STOPPED\_AT\_IPO\_START  
is set to 0.

Exception:

MD35510 \$MA\_SPIND\_STOPPED\_AT\_IPO\_START =1

Path interpolation is not influenced, the traveled path axis is not stopped.

Monitoring is effective in all spindle modes and in axis mode.

## 15.7.3 Spindle in setpoint range

### Function

"Spindle in setpoint range" spindle monitoring checks whether:

- The programmed spindle speed is reached.
- The spindle is stationary (NC/PLC IS:  
DB31, ... DBX61.4 (axis/spindle stationary)).
- The spindle is still in the acceleration or deceleration phase.

In spindle control mode, the setpoint speed (programmed speed \* spindle offset including active limitations) is compared with the actual speed.

If the actual speed deviates from machine data:

MD35150 \$MA\_SPIND\_DES\_VELO\_TOL  
by more than the spindle speed tolerance:

- Axial NC/PLC IS:  
DB31, ... DBX83.5 (Spindle in setpoint range)  
is set to 0.

- The next machining block is not enabled.
- Machine data:  
MD35500 \$MA\_SPIND\_ON\_SPEED\_AT\_IPO\_START  
is set to 1.

Exception:

MD35500 \$MA\_SPIND\_ON\_SPEED\_AT\_IPO\_START = 0

Path interpolation is not influenced, the traveled path axis is not stopped.

### Tolerance range for setpoint speed

MD35150 \$MA\_SPIND\_DES\_VELO\_TOL = 0.1

The spindle actual speed may deviate +/- 10% from the setpoint speed.

The spindle setpoint speed is derived from the programmed speed taking the current limits into account.

Any limitation or increase of the programmed speed is indicated either by axial NC/PLC IS:

DB31, ... DBX83.1 (Set speed limited)

or

DB31, ... DBX83.2 S (Set speed increased)

and does **not** prevent the axis reaching the speed tolerance range.

If the spindle lies inside the tolerance range, axial NC/PLC IS:

DB31, ... DBX83.5 (Spindle in setpoint range)

is set to 1 at the VDI interface.

Special case:

If the speed tolerance is set to 0, axial NC/PLC IS:

DB31, ... DBX83.5 (Spindle in setpoint range)

is permanently set to 1 and no path control is performed.

### Speed change

Path control only takes place at the start of the traverse block and only if a speed change has been programmed. If the speed tolerance range is violated, e.g. due to an overload, the path movement is not automatically brought to a standstill.

### 15.7.4 Diagnosis of spindle speed limitation

The restriction of increase of spindle speed is reported via the output of the following NC/PLC interface signals (refer to Chapter "Spindle in setpoint range (Page 1282)"):

- DB31, ... DBX83.1 (Setpoint speed restricted)
- DB31, ... DBX83.2 (Setpoint speed restricted)

To diagnose the effective/limiting spindle parameters, one can have read access to the most important parameters of spindle motion via system variables. The system variables are indexed with the spindle number and they return only values that are relevant to the speed control and spindle position modes.

#### Function

The following system variables are available in the spindle mode:

System variable	Description
\$AC_SMAXVELO[n]	Maximum possible spindle speed [rpm] resulting from the active limiting data.
\$AC_SMAXVELO_INFO[n]	Specification of the speed limiting data as numerical value. *)
\$AC_SMINVELO[n]	Minimum possible spindle speed [rpm], corresponds to the minimum speed in the speed control mode.
\$AC_SMINVELO_INFO[n]	Specification of the speed increasing data as numerical value. *)
\$AC_SMAXACC[n]	Acceleration value of spindle [r/s <sup>2</sup> ].
\$AC_SMAXACC_INFO[n]	Acceleration limiting cause in the form of a numerical value. *)
\$AC_SPIND_STATE[n]	Status bits of the spindle.
n : Spindle no. (n= 0: the variables are related to the current master spindle)	

\*) The text of the numerical value is to be taken from the description of the system variables.

Evaluation of diagnosis data:

The system variables for each spindle can be read via synchronized actions and in the part program, giving due consideration to the preprocessing stop in the **NCK** .

#### Boundary conditions

The values delivered by the system variables depend on the spindle mode:

- Speed control mode:

All system variables deliver current values.

- Positioning mode:

The system variables \$AC\_SMAXVELO, \$AC\_SMAXACC and \$AC\_SPIND\_STATE deliver valid values. The system variables \$AC\_SMINVELO and \$AC\_SMINVELO\_INFO deliver the data that becomes effective on changing to the speed control mode.

- Axis mode (e.g. if the spindle is used by a transformation TRANSMIT, TRACYL,... or follows a path motion as a special axis):

The system variable \$AC\_SPIND\_STATE can also be used in the axis mode. Separate system variables are available in the axis mode for dynamic data:

\$AA\_VMAXM, \$AA\_VMAXB and \$AA\_VLFCT.

The following control system response results in block-search response, type SERUPRO:

- The system variable \$AC\_SMAXVELO/\$AC\_SMAXACC delivers the maximum representable speed/acceleration.
- \$AC\_SMAXVELO\_INFO and \$AC\_SMAXACC\_INFO deliver the VALUE "0" (no limitation is active).
- \$AC\_SMINVELO and \$AC\_SMINVELO\_INFO deliver data as in case of normal part program processing.
- \$AC\_SPIND\_STATE returns the states as they are set for SERUPRO.

### Sample programming

Example of the visualization of the content of the system variables for Spindle 1. The variables are written to the R parameters cyclically. These can be displayed on HMI in the R Parameters area.

#### Program code

```
N05 IDS=1 WHENEVER TRUE DO $R10=$AC_SMAXVELO[1]
N10 IDS=2 WHENEVER TRUE DO $R11=$AC_SMAXVELO_INFO[1]
N15 IDS=3 WHENEVER TRUE DO $R12=$AC_SMINVELO[1]
N20 IDS=4 WHENEVER TRUE DO $R13=$AC_SMINVELO_INFO[1]
N25 IDS=5 WHENEVER TRUE DO $R14=$AC_SPIND_STATE[1]
```

## 15.7.5 Minimum/maximum Speed of gear step

### Minimum speed

The minimum gear step speed is entered in machine data:  
MD35140 \$MA\_GEAR\_STEP\_MIN\_VELO\_LIMIT.

This setpoint speed cannot be undershot by programming an S value, which is too small.

NC/PLC IS:

DB31, ... DBX83.2 (Setpoint speed increased) (Programmed speed too low) is set.

The minimum gear step speed is effective only in speed mode and can only be undershot by:

- Spindle override 0%
- M5
- S0
- NC/PLC IS DB31, ... DBX4.3 (Spindle stop)

- Withdraw NC/PLC IS: DB31, ... DBX2.1 (Controller enable).
- NC/PLC IS DB21, ... DBX7.7 (Reset)
- NC/PLC IS DB31, ... DBX2.2 (Delete distance-to-go/Spindle reset)
- NC/PLC IS DB31, ... DBX18.5 (Oscillation speed)
- NC/PLC IS DB21, ... DBX7.4 (NC STOP axes plus spindles)
- NC/PLC IS DB31, ... DBX1.3 (Axis/Spindle disable)
- NC/PLC IS DB31, ... DBX16.7 (Delete S value)

### Maximum speed

The maximum gear step speed is entered in machine data:  
MD35130 \$MA\_GEAR\_STEP\_MAX\_VELO\_LIMIT.

When the gear step is engaged, this setpoint speed cannot be exceeded.

When the programmed spindle speed is limited, NC/PLC IS:  
DB31, ... DBX83.1 (Setpoint speed limited) (programmed speed too high)  
is set.

### 15.7.6 Maximum encoder limit frequency

 <b>CAUTION</b>
--

<p>The maximum encoder frequency limit of the actual spindle position encoder is monitored by the control (the limit can be exceeded). It is the responsibility of the machine tool manufacturer to ensure that the configuration of the spindle motor, gearbox, measuring gearbox, encoder and machine data prevents the maximum speed of the actual spindle position encoder being exceeded.</p>
--

### Maximum encoder frequency exceeded

If the spindle speed reaches a speed (large S value programmed), which exceeds the maximum encoder limit frequency (the maximum mechanical speed limit of the encoder must not be exceeded), the synchronization is lost. The spindle continues to rotate, but with reduced functionality.

With the following functions, the spindle speed is reduced until the active measurement system is operating below the encoder limit frequency again:

- Thread cutting (G33, G34, G35)
- Tapping without compensating chuck (G331, G332)
- Revolutional feedrate (G95)
- Constant cutting rate (G96, G961, G97, G971)
- SPCON (position-controlled spindle operation)

When the encoder limit frequency is exceeded

NC/PLC IS:

DB31, ... DBX60.4 (Homed/Synchronized 1)

or

DB31, ... DBX60.5 (Homed/Synchronized 2)

are reset for the measurement system in question and NC/PLC IS:

DB31, ... DBX60.2 (encoder limit frequency 1 exceeded)

or

DB31, ... DBX60.3 (encoder limit frequency 2 exceeded)

are set.

If the spindle is in axis mode, the maximum encoder limit frequency must not be exceeded. The maximum velocity (MD32000 \$MA\_MAX\_AX\_VELO) must lie below the maximum encoder limit frequency; otherwise, alarm 21610 is output and the axis is brought to a standstill.

### Maximum encoder limit frequency undershot

If the maximum encoder frequency limit has been exceeded and the speed subsequently falls below the maximum encoder limit frequency (smaller S value programmed, spindle offset switch changed, etc.), the spindle is automatically synchronized with the next zero mark or the next Bero signal. The new synchronization will always be carried out for the active position measuring system that has lost its synchronization and whose max. encoder limit frequency is currently undershot.

### Special points to be noted

If the following functions are active, the maximum encoder frequency cannot be exceeded:

- Spindle positioning mode, axis mode
- Thread cutting (G33, G34, G35)
- Tapping without compensating chuck G331, G332 (does not apply to G63)
- Revolutional feedrate (G95)
- Constant cutting rate (G96, G961, G97, G971)
- SPCON

### 15.7.7 End point monitoring

#### End point monitoring

During positioning (the spindle is in positioning mode), the system monitors the distance from the spindle (with reference to the actual position) to the programmed spindle position setpoint (end point).

For this to work, in machine data:

MD36000 \$MA\_STOP\_LIMIT\_COARSE (Exact stop limit coarse)

and

MD36010 \$MA\_STOP\_LIMIT\_FINE (Exact stop limit fine)

two limit values can be defined as an incremental path starting from the spindle position setpoint.

Regardless of the two limit values, the positioning of the spindle is always as accurate as defined by the connected spindle measurement encoder, the backlash, the transmission ratio, etc.

#### Exact stop window dependent on parameter set

Various parameter-set-dependent exact stop windows can be configured.

This makes it possible to work to different levels of accuracy in axis mode and spindle positioning. The exact stop window can be configured separately for each gear step for spindle positioning.

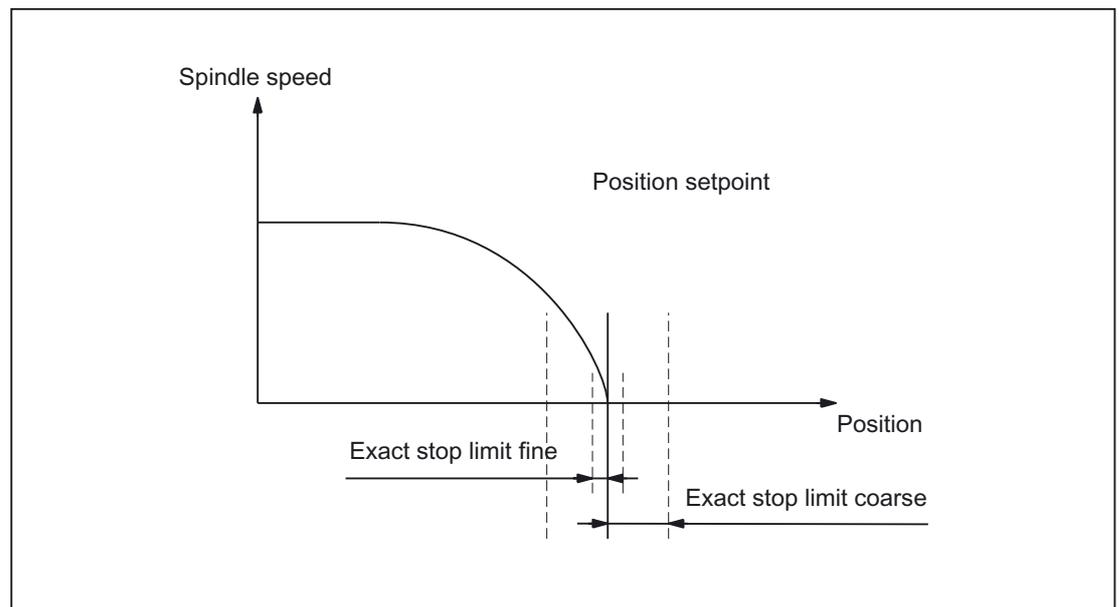


Figure 15-10 Exact stop zones of a spindle

### DB31, ... DBX60.7 and DB31, ... DBX60.6 (position reached with exact stop coarse/fine)

The two limit values defined by machine data:  
 MD36000 \$MA\_STOP\_LIMIT\_COARSE (Exact stop limit coarse)  
 and  
 MD36010 \$MA\_STOP\_LIMIT\_FINE (Exact stop limit fine)  
 are output to the PLC using NC/PLC IS:  
 DB31, ... DBX60.7 (Position reached with exact stop coarse)  
 and  
 DB31, ... DBX60.6 (Position reached with exact stop fine).

### Block change for SPOS and M19

When positioning the spindle with `SPOS` or `M19` the block is changed dependent on end point monitoring with NC/PLC IS:  
 DB31, ... DBX60.6 (Position reached with exact stop fine).

All other functions programmed in the block must have achieved their end criterion (e.g. all auxiliary functions acknowledged by the PLC).

With `SPOSA`, the block change does not depend on the monitoring of the end point.

## 15.8 Examples

### 15.8.1 Automatic gear step selection (M40)

#### Example

To illustrate the contents of the new block search variables:  
Assumptions about automatic gear step selection (M40):

S0...500	1st gear step
S501..1000	2nd gear step
S1001..2000	3rd gear step

Content of system variables:

\$P_SEARCH_S	; Collected S value
\$P_SEARCH_DIR	; Collected direction of rotation
\$P_SEARCH_GEAR	; Collected gear step

Collected	S value:	Direction of rotation:	Gear step:
	; 0/last speed	-5	40/last GS
N05 G94 M40 M3 S1000	; 1000	3	40
N10 G96 S222	: 222	3	40
N20 G97	; f (PlanAxPosPCS)*	3	40
N30 S1500	; 1500	3	40
N40 SPOS=0**	; 1500	-19	40
N50 M19**	; 1500	-19	40
N60 G94 G331 Z10 S300	; 300	-19	40
N70 M42	; 300	-19	42
N80 M4	; 300	4	42
N90 M70	; 300	70	42
N100 M3 M40	; 300	3	40
N999 M30			

\* f (PlanAxPosPCS): The speed depends on the current position of the transverse axis in the workpiece coordinate system.

\*\* (\$P\_SEARCH\_SPOS and \$P\_SEARCH\_SPOSMODE are programmed)

## 15.9 Data lists

### 15.9.1 Machine data

#### 15.9.1.1 NC-specific machine data

Number	Identifier: \$MN_	Description
10192	GEAR_CHANGE_WAIT_TIME	Wait time for acknowledgment of a gear stage change during reorganization
10714	M_NO_FCT_EOP	M function for spindle active after <code>RESET</code>
12060	OVR_SPIND_IS_GRAY_CODE	Spindle override with Gray coding
12070	OVR_FACTOR_SPIND_SPEED	Evaluation of spindle speed override switch
12080	OVR_REFERENCE_IS_PROG_FEED	Override reference velocity
12082	OVR_REFERENCE_IS_MIN_FEED	Defining the reference of the path override
12090	OVR_FUNCTION_MASK	Selection of override specifications

#### 15.9.1.2 Channel-specific machine data

Number	Identifier: \$MC_	Description
20090	SPIND_DEF_MASTER_SPIND	Initial setting for master spindle on channel
20092	SPIND_ASSIGN_TAB_ENABLE	Enabling/disabling of spindle converter
20850	SPOS_TO_VDI	Output of auxiliary function "M19" to the VDI interface
22400	S_VALUES_ACTIVE_AFTER_RESET	S function active after <code>RESET</code>

#### 15.9.1.3 Axis/spindle-specific machine data

Number	Identifier: \$MA_	Description
30300	IS_ROT_AX	Rotary axis
30310	ROT_IS_MODULO	Modulo conversion
31044	ENC_IS_DIRECT2	Encoder on intermediate gear
31050	DRIVE_AX_RATIO_DENOM	Denominator load gearbox
31060	DRIVE_AX_RATIO_NUMERA	Numerator load gearbox
31064	DRIVE_AX_RATIO2_DENOM	Intermediate gear denominator
31066	DRIVE_AX_RATIO2_NUMERA	Intermediate gear numerator

Spindles (S1)

15.9 Data lists

Number	Identifier: \$MA_	Description
31070	DRIVE_ENC_RATIO_DENOM	Measuring gear denominator
31080	DRIVE_ENC_RATIO_NUMERA	Measuring gear numerator
31122	BERO_DELAY_TIME_PLUS	BERO delay time in plus direction
31123	BERO_DELAY_TIME_MINUS	BERO delay time in minus direction
32200	POSCTRL_GAIN	K <sub>v</sub> factor
32800	EQUIV_CURRCTRL_TIME	Equivalent time constant current control circuit for feedforward control
32810	EQUIV_SPEEDCTRL_TIME	Equivalent time constant speed control circuit for feedforward control
32910	DYN_MATCH_TIME	Time constant for dynamic matching
34040	REFP_VELO_SEARCH_MARKER	Reference point creep speed
34060	REFP_MAX_MARKER_DIST	Monitoring of zero mark distance
34080	REFP_MOVE_DIST	Reference point distance/destination point for distance-coded system
34090	REFP_MOVE_DIST_CORR	Reference point offset/absolute offset, distance-coded
34100	REFP_SET_POS	Reference point value
34200	ENC_REFP_MODE	Homing mode
35000	SPIND_ASSIGN_TO_MACHAX	Assignment of spindle to machine axis
35010	GEAR_STEP_CHANGE_ENABLE	Type of gear step change
35012	GEAR_STEP_CHANGE_POSITION	Gear step change position
35020	SPIND_DEFAULT_MODE	Basic spindle setting
35030	SPIND_DEFAULT_ACT_MASK	Activate initial spindle setting
35035	SPIND_FUNCTION_MASK	Setting of spindle-specific functions
35040	SPIND_ACTIVE_AFTER_RESET	Spindle active after reset
35090	NUM_GEAR_STEPS	Number of installed gear steps
35092	NUM_GEAR_STEPS2	2nd gear step data set: Number of installed gear steps
35100	SPIND_VELO_LIMIT	Maximum spindle speed
35110	GEAR_STEP_MAX_VELO[n]	Maximum speed for automatic gear stage change
35112	GEAR_STEP_MAX_VELO2[n]	2nd gear step data set: Maximum speed for automatic gear stage change
35120	GEAR_STEP_MIN_VELO[n]	Minimum speed for automatic gear stage change
35122	GEAR_STEP_MIN_VELO2[n]	2nd gear step data set: Minimum speed for automatic gear stage change
35130	GEAR_STEP_MAX_VELO_LIMIT[n]	Maximum speed of gear step
35135	GEAR_STEP_PC_MAX_VELO_LIMIT[n]	Maximum speed of gear step in position control
35140	GEAR_STEP_MIN_VELO_LIMIT[n]	Minimum speed of gear step
35150	SPIND_DES_VELO_TOL	Spindle speed tolerance
35160	SPIND_EXTERN_VELO_LIMIT	Spindle speed limitation via PLC
35200	GEAR_STEP_SPEEDCTRL_ACCEL[n]	Acceleration in speed control mode

Number	Identifier: \$MA_	Description
35210	GEAR_STEP_POSCTRL_ACCEL[n]	Acceleration in position control mode
35212	GEAR_STEP_POSCTRL_ACCEL2[n]	2nd gear step data set: Acceleration in position control mode
35220	ACCEL_REDUCTION_SPEED_POINT	Speed limit for reduced acceleration
35230	ACCEL_REDUCTION_FACTOR	Reduced acceleration
35300	SPIND_POSCTRL_VELO	position control activation speed
35350	SPIND_POSITIONING_DIR	Positioning direction of rotation for a non-synchronized spindle
35400	SPIND_OSCILL_DES_VELO	Oscillation speed
35410	SPIND_OSCILL_ACCEL	Oscillation acceleration
35430	SPIND_OSCILL_START_DIR	Oscillation start direction
35440	SPIND_OSCILL_TIME_CW	Oscillation time for M3 direction
35450	SPIND_OSCILL_TIME_CCW	Oscillation time for M4 direction
35500	SPIND_ON_SPEED_AT_IPO_START	Feed enable with spindle in setpoint range
35510	SPIND_STOPPED_AT_IPO_START	Feed enable with stationary spindle
35550	DRILL_VELO_LIMIT[n]	Maximum speeds for tapping
35590	PARAMSET_CHANGE_ENABLE	Parameter set definition possible from PLC
36060	STANDSTILL_VELO_TOL	Threshold velocity "Axis/spindle stationary"
36200	AX_VELO_LIMIT	Threshold value for velocity monitoring.

## 15.9.2 Setting data

### 15.9.2.1 Channel-specific setting data

Number	Identifier: \$SC_	Description
42600	JOG_FEED_PER_REF_SOURCE	Revolutional feedrate control in JOG mode
42800	SPIND_ASSIGN_TAB	Spindle number converter
42900	MIRROR_TOOL_LENGTH	Mirror tool length offset
42910	MIRROR_TOOL_WEAR	Mirror wear values of tool length compensation
42920	WEAR_SIGN_CUTPOS	Mirror wear values of machining plane
42930	WEAR_SIGN	Invert sign of all wear values
42940	TOOL_LENGTH_CONST	Retain the assignment of tool length components when changing the machining plane (G17 to G19)

### 15.9.2.2 Axis/spindle-specific setting data

Number	Identifier: \$SA_	Description
43200	SPIND_S	Specification of the spindle speed
43202	SPIND_CONSTCUT_S	Specification of the constant cutting rate for the master spindle
43210	SPIND_MIN_VELO_G25	Progr. Spindle speed limitation G25
43220	SPIND_MAX_VELO_G26	Progr. Spindle speed limitation G26
43230	SPIND_MAX_VELO_LIMS	Progr. spindle speed limitation G96/G96.1
43240	M19_SPOS	Spindle position for spindle positioning with M19
43250	M19_SPOSMODE	Spindle positioning approach mode for spindle positioning with M19
43300	ASSIGN_FEED_PER_REF_SOURCE	Rotational feedrate for positioning axes/spindles

### 15.9.3 Signals

#### 15.9.3.1 Signals to axis/spindle

DB number	Byte.bit	Description
31, ...	0.7 - 0.0	Feedrate override H to A
31, ...	1.3	Axis/spindle disable
31, ...	1.4	Follow-up mode
31, ...	1.5	Position measuring system 1
31, ...	1.6	Position measuring system 2
31, ...	1.7	Override active
31, ...	2.1	Servo enable
31, ...	2.2	Spindle reset/delete distance-to-go
31, ...	3.6	Velocity/spindle speed limitation
31, ...	3.7	Program test Axis/Spindle Enable
31, ...	16.2-16.0	Actual gear step A to C
31, ...	16.3	Gear changed
31, ...	16.4	Resynchronize spindle 1
31, ...	16.5	Resynchronize spindle 2
31, ...	16.6	no n-monitoring with gear change
31, ...	16.7	Delete S value
31, ...	17.0	Feedrate override for spindle valid
31, ...	17.4	Resynchronize spindle during positioning 1
31, ...	17.5	Resynchronize spindle during positioning 2

DB number	Byte.bit	Description
31, ...	17.6	Invert M3/M4
31, ...	18.4	Oscillation via PLC
31, ...	18.5	Oscillation enable (oscillation speed)
31, ...	18.6	Oscillation rotation direction clockwise (Set rotation direction clockwise)
31, ...	18.7	Oscillation rotation direction counterclockwise (Set rotation direction counterclockwise)
31, ...	19.7 - 19.0	Spindle offset H to A
31, ...	30.0	Spindle stop
31, ...	30.1	Spindle start CW
31, ...	30.2	Spindle start CCW
31, ...	30.3	Automatic gear step change
31, ...	30.4	Spindle positioning
31, ...	60.0	Spindle/No Axis
31, ...	60.2	Encoder limit frequency exceeded 1
31, ...	60.3	Encoder limit frequency exceeded 2
31, ...	60.4	Homed/synchronized 1
31, ...	60.5	Homed/synchronized 2
31, ...	60.6	Position reached with exact stop coarse
31, ...	60.7	Position reached with exact stop fine
31, ...	61.4	Axis/spindle stationary ( $n < n_{min}$ )
31, ...	61.5	Position controller active
31, ...	61.6	Speed control loop active
31, ...	61.7	Current controller active
31, ...	82.2-82.0	Set gear step A to C
31, ...	82.3	Change gear
31, ...	83.0	Speed limit exceeded
31, ...	83.1	Setpoint speed limited
31, ...	83.2	Setpoint speed increased
31, ...	83.5	Spindle in setpoint range
31, ...	83.7	Actual direction of rotation clockwise

### 15.9.3.2 Signals from axis/spindle

DB number	Byte.bit	Description
31, ...	84.3	Rigid tapping active
31, ...	84.4	active spindle mode synchronous mode
31, ...	84.5	Active spindle positioning mode
31, ...	84.6	Active spindle mode oscillation mode
31, ...	84.7	Active spindle control mode
31, ...	85.5	Spindle actually reached in position
31, ...	86 and 87	M function for spindle
31, ...	88-91	S function for spindle

## Feeds (V1)

### 16.1 Brief description

#### Types of feedrate

The feedrate determines the machining speed (axis or path velocity) and is observed in every type of interpolation, even where allowance is made for tool offsets on the contour or on the tool center point path (depending on G commands).

The following types of feedrate allow optimum adaptation to the various technological applications (turning, milling, drilling, etc.):

- Rapid traverse feedrate (G0)
- Inverse-time feedrate (G93)
- Linear feedrate (G94)
- Revolutional feedrate (G95)
- Constant cutting rate (G96, G961)
- Constant speed (G97, G971)
- Feed rate for thread cutting (G33, G34, G35)
- Feedrate for tapping with compensating chuck (G63)
- Feedrate for tapping without compensating chuck (G331, G332)
- Feedrate for chamfer/rounding FRC, FRCM
- Non-modal feedrate FB

#### Programmable run-in, run-out path for G33

The thread run-in and run-out path can be programmed. The thread axis is accelerated or braked inside the specified path.

---

**Note**

The axis can be overloaded if the specified path is too short.

---

### Axis assignment of the feedrates

Feedrates can be assigned to the axes variably to adjust to the different technological requirements.

The following versions are possible:

- Separate feedrates for the working plane and the infeed axis
- Variable axis assignment for path feedrate
- Feedrate for positioning axes

### Feedrate control

The programmed feedrate can be changed during the machining or for test purposes to enable adjustment to the changed technological conditions.

- via the machine control panel
- via the operator panel front
- via the PLC
- per program command

### Feedrate interpolation

To permit flexible definition of the feed characteristic, the feed programming according to DIN 66205 has been extended by linear and cubic characteristics.

The cubic profiles can be programmed directly or as an interpolating spline.

You can program the following feedrate profiles:

- FNORM

Response as per DIN 66025 (default setting).

An F-value programmed in the block is applied over the entire path of the block, and is subsequently regarded as a fixed modal value.

- FLIN

An Fvalue programmed in the block is traversed linearly over the path from the current value at the beginning of the block to the end of the block, and is subsequently regarded as modal value.

- FCUB

The blockwise programmed Fvalues are - relative to the end of the block - connected by a spline. The spline starts and ends tangentially to the previous or following feedrate setting. If the F address is missing in one block, then the last programmed F value is used for it.

- FPO

The F address [Syntax: F=FPO (...,...)] designates the course of the feedrate via a polynomial from the current value to the end of the block in which it was programmed. The end value is treated as modal from there onwards.

The machine data:

MD20172 \$MC\_COMPRESS\_VELO\_TOL

allows a tolerance to be defined for the path feedrate if FLIN and FCUB are used in connection with compression COMPON.

Explanations on programmable course of the feedrate are available in:

**References:**

/PGA/ Programming Guide Job Planning

### Feedrate for chamfer/rounding FRC, FRCM

The machining conditions can change significantly during surface transitions to chamfer/rounding. The chamfer/rounding contour elements therefore need their own optimized feedrate values in order to achieve the required surface finish.

You can program the feedrate for the chamfer/rounding with FRC (non-modal) or FRCM (modal).

### Non-modal feedrate FB

A separate feedrate can be specified for an individual block with the FB command. The earlier active path feedrate is overwritten for this block; the earlier effective modal path feedrate is active again after this block.

### Programmable single-axis dynamic response

The dynamic response of individual axes can be changed in a targeted manner via programming.

- Percentage acceleration override (ACC) in part program and synchronized actions
- Programmable end of motion criterion: FINEA (exact stop fine), COARSEA (exact stop coarse), IPOENDA (Interpolator stop) in the part program and in synchronized actions
- Programmable servo parameter set (SCPARA) in the part program and in synchronized actions

## 16.2 Path feedrate F

### 16.2.1 General

#### Path feedrate F

The path feedrate represents the geometrical total of the velocity components in the participating axes. It is therefore generated from the individual motions of the interpolating axes.

The default uses the axial velocities of the geometry axes which have been programmed. The `FGROUP` command can be used to include other geometry and/or synchronized axes in the calculation of the path feedrate.

The path feedrate F determines the machining speed and is observed in every type of interpolation even where allowance is made for tool offsets. The value programmed under the address F remains in the program until a new F value or a new type of feedrate is programmed.

#### Value range for path feedrate F

**References:**

/PG/ Programming Manual Fundamentals

/FB1/ Function Manual, Basic Functions; Velocities, Setpoint/ Actual Value Systems, Closed-Loop Control (G2)

#### F value at PLC interface

The F value of the current path feedrate is always entered in the channel-specific PLC interface for auxiliary functions (DB21, ... DBB158 bis 193).

The related interface signals (modification signal, F value) are described in:

**References:**

/FB1/ Function Manual, Basic Functions; Auxiliary Function Output to PLC (H2)

#### Feedrate with transition circle

For further information, see:

**References:**

PG/ Programming Manual Fundamentals

## Feedrate for internal radius and external radius path sections

For circular blocks or spline blocks with curvature in the same direction and tool radius offset activated (G41/G42), the programmed feedrate can act on the center point path or on the contour (depending on the internal radius or external radius path sections).

A group of G commands is provided for this purpose:

- CFTCP  
Programmed feedrate acting on the center point path.
- CFC  
Programmed feedrate acting on the contour.
- CFCIN  
Programmed feedrate acting only on the contour with a concave spline.

### References:

/PG/ Programming Manual Fundamentals

## Maximum tool path velocity

The maximum path velocity results from the maximum velocities of the linear or rotary axes involved (MD32000 \$MA\_MAX\_AX\_VELO), i.e. the axis with the lowest maximum velocity determines the maximum path velocity. This cannot be exceeded.

If G0 is programmed, traversing is at the path velocity resulting from the MD32000 \$MA\_MAX\_AX\_VELO limitation.

## Limit velocity for path axes

In addition, the FL[x]=... command can be used to program a limit velocity for path axes (geometry and synchronized axes).

### References:

/PG/ Programming Manual Fundamentals

This enables separate feedrates to be programmed for the working plane and infeed axis. This means that a feedrate is specified for both path-related interpolation and for the infeed axis. The axis perpendicular to the selected machining plane is designated as the infeed axis. The infeed axis-specific feedrate can be programmed to limit the axis velocity and therefore the path velocity. No coordinate rotations through frames should be included, i.e. the infeed axis must be an axis of the standard coordinate system. This function can be used to compensate for the fact that a cutter has a lower cutting performance on the face side than across the cutter circumference.

Programming example:

. . . . G94 . . . .	Selection of feedrate type (mm/min)
X30 Y20 F200	Path feedrate = 200 mm/s
FL[Z]=50 Z-30	Max. feedrate for Z axis: 50 mm/s

## 16.2.2 Type of feedrate G93, G94, G95

### Effectivity

The feedrate types G93, G94, G95 are active for the G functions of group 1 (except G0) in the automatic modes.

G94 or G95 can be used for traversing in JOG mode.

#### References:

/FB2/ Function Manual, Extended Functions; Jog With/Without Handwheel (H1)

### Inverse-time feedrate (G93) (valid for 840D only)

The inverse-time feedrate is used when it is easier to program the duration, rather than the feedrate, for retraction of a block.

The inverse-time feedrate is calculated from the following formula:

$$F = \frac{v}{s} ; F [1/min]$$

Where    F:    Inverse-time feedrate  
          v:    Required path velocity in mm/min or inch/min  
          s:    Path length in mm/inch

Programming example:

```
N10 G1 G93X100 Y200 F2 ; The programmed path is traversed in 0.5 min.
```

---

#### Note

G93 may not be used when G41/G42 is active. If the block length varies greatly from block to block, a new F value should be programmed in each block for G93.

---

### Linear feedrate (G94)

The linear feedrate is programmed in the following units relative to a linear or rotary axis:

- [mm/min, degrees/min] on standard metric systems
- [inch/min, degrees/min] on standard imperial systems

## Revolutional feedrate (G95)

The revolutional feedrate is programmed in the following units relative to a master spindle:

- [mm/rev] on standard metric systems
- [inch/rev] on standard imperial systems
- [degrees/rev] on a rotary axis

The path velocity is calculated from the actual speed of the spindle according to the following formula:

$$V = n * F$$

and

V:	Path velocity
n:	Master spindle speed
F:	Programmed revolutional feedrate

---

### Note

The programmed F value is deleted when the system switches between the feedrate types G93, G94 and G95.

---

In JOG mode, the response of the axis/spindle also depends on the setting data:  
SD41100 \$SN\_JOG\_REV\_IS\_ACTIVE (revolutional feed rate for JOG active)

- If this setting data is active, an axis/spindle is always moved with revolutional feedrate machine data:  
MD32050 \$MA\_JOG\_REV\_VELO (revolutional feedrate with JOG)  
or  
MD32040 \$MA\_JOG\_REV\_VELO\_RAPID  
(revolutional feedrate with JOG with rapid traverse overlay)  
depending on the master spindle.
- If the setting data is not active, then the axis/spindle responds as a function of the setting data:  
SD43300 \$SA\_ASSIGN\_FEED\_PER\_REV\_SOURCE  
(revolutional feedrate for position axes/ spindles).
- If the setting data is not active, the response of a geometry axis on which a frame with rotation acts depends on the channel-specific setting data:  
SD42600 \$SC\_JOG\_FEED\_PER\_REV\_SOURCE  
(in JOG mode revolutional feedrate for geometry axes, on which the frame with rotation acts).

**"Revolutional feedrate active" DB31, ... DBX62.2**

A programmed, active revolutional feedrate (G95) is displayed using this interface signal.

**Alarms**

- If no F value is programmed, alarm 10860 "No feedrate programmed" is issued. The alarm is not generated with G0 blocks.
- If a negative path velocity is programmed, alarm 14800 "Programmed path velocity smaller than or equal to zero" is output.
- If a revolutional feedrate (G95) is programmed but no master spindle has been defined, alarm 10810 "No master spindle defined" is output.

**16.2.3 Type of feedrate G96, G961, G962, G97, G971****Constant cutting rate (G96, G961)**

The constant cutting rate is used on turning machines to keep the cutting conditions constant, independently of the work diameter of the workpiece. This allows the tool to be operated in the optimum cutting performance range and therefore increases its service life.

**Selection of G96, G961:**

When programming G96, G961, the corresponding S value is interpreted as the cutting rate in m/min or ft/min along the transverse axis. If the workpiece diameter decreases during machining, the speed is increased until the constant cutting speed is reached.

When G96, G961 is first selected in the part program, a constant cutting rate must be entered in mm/min or ft/min. When the command is reselected, a constant cutting rate may be entered.

With G96, the control system will automatically switch to revolutional feedrate (as with G95), i.e. the programmed feedrate F is interpreted in mm/rev or inch/rev.

When programming G961, linear feedrate is selected automatically (as with G94). A programmed feedrate F is interpreted in mm/min or inch/min.

Based on the programmed cutting rate  $S_{\text{Speed}}$ , either ( $S_{\text{G96}}$ ) or ( $S_{\text{G961}}$ ) and the part-oriented actual value of the transverse axis (radius  $r$ ), the control system uses the following formula to determine the spindle speed:

$$n = \frac{S_{\text{Speed}}}{2 * \pi * r}$$

$\pi$  = Circle constant

### Diameter programming and reference axis for several transverse axes in one channel:

One or more transverse axes are permitted and can be activated simultaneously or separately:

- Programming and displaying in the HMI operator interface in the diameter
- Assignment of the specified reference axis with `SCC[AX]` for a constant cutting rate `G96`, `G961`, `G962`

#### References:

/FB1/ Function Manual, Basic Functions; Transverse Axes (P1)

Example

### Example

$S_{G96} = 230 \text{ m/min}$

- where  $r = 0.2 \text{ m} \rightarrow n = 183.12 \text{ rpm}$
- where  $r = 0.1 \text{ m} \rightarrow n = 366.24 \text{ rpm}$

⇒ The smaller the workpiece diameter, the higher the speed.

For `G96`, `G961` or `G962` a geometry axis must be defined as the transverse axis.

The transverse axis, whose position affects the speed of the mater spindle, is defined using channel-specific machine data:

`MD20100 $MC_DIAMETER_AX_DEF` (geometry axis with transverse axis function)

The function `G96`, `G961` or `G962` requires that the machine zero and the workpiece zero of the transverse axis are in the turning center of the spindle.

### Constant speed (G97, G971)

`G97`, `G971` deactivates the "Constant cutting rate function" (`G96`, `G961`) and saves the last calculated spindle speed. With `G97`, the feedrate is interpreted as a revolutionary feedrate (as with `G95`).

When programming `G971`, linear feedrate is selected (as with `G94`). The feedrate `F` is interpreted in mm/min or inch/min.

When `G97`, `G971` is active, an `S` value can be reprogrammed to define a new spindle speed. This will not modify the cutting rate programmed in `G96`, `G961`.

`G97`, `G971` can be used to avoid speed variations in movements along the transverse axis without machining (e.g. cutting tool).

**Note**

G96, G961 is only active during workpiece machining (G1, G2, G3, spline interpolation, etc., where feedrate F is active).

The response of the spindle speed for active G96, G961 and G0blocks can be defined in the channel-specific machine data:

MD20750 ALLOW\_G0\_IN\_G96 (G0 logic for G96, G961)

When constant cutting rate G96, G961 is selected, no gear stage change can take place.

The spindle speed override switch acts on the spindle speed calculated.

A DRF offset in the transverse axis does not affect the spindle speed setpoint calculation.

At the start of machining (after G0) and after NC Stop, G60, G09, ... the path start waits for "nAct= nSet".

The interface signals "nAct = nSet" and "Set speed limited" are not modified by internal speed settings.

When the speed falls below the minimum speed or if the signal "Axis/spindle stationary" is recognized, "nAct =nSet" is reset.

A path operation, which has started (G64, rounding), is not interrupted.

---

**Spindle speed limitation with G96, G961**

For the function "Constant cutting rate", in setting data:

SD43230 \$SA\_SPIND\_MAX\_VELO\_LIMS

(spindle speed limitation with G96/G961)

and in the part program (for the master spindle) with the programming command LIMS, a maximum spindle speed can be set.

The most recently changed value (LIMS or SD) is active.

LIMS is effective with G96, G961, G97 and can be specified on up to four speed limitations in the part program in one block. Spindle number Sn=1, 2, 3, or 4 of the master spindle that is possible in the particular instance can be programmed in part program instruction LM[Sn].

---

**Note**

When the block is loaded in the main run, all programmed values are transferred to to setting data SD43230 \$SA\_SPIND\_MAX\_VELO\_LIMS.

---

The speed limit set with LIMS remains stored after the control is switched off, depending on the machine data:

MD10710 PROG\_SD\_RESET\_SAVE\_TAB[n] (setting data to be updated).

When G96, G961, G97 are reactivated, this spindle speed limitation is also activated.

The maximum permissible spindle speed defined by means of G26 or setting data: SD43220 \$SA\_SPIND\_MAX\_VELO\_G26 (maximum spindle speed) , cannot be exceeded.

In the event of incorrect programming that would cause one of the speed limits (G26 or SD43220 \$SA\_SPIND\_MAX\_VELO\_G26) to be exceeded, the "Programmed speed too high" interface signal (DB31, ... DBX83.1) is set.

In order to ensure smooth rotation with large part diameters, the spindle speed is not permitted to fall below a minimum level.

This speed is defined using setting data:

SD43210 \$SA\_SPIND\_MIN\_VELO\_G25 (minimum spindle speed)

and can be set for each gear step with the machine data:

MD35140 \$MA\_GEAR\_STEP\_MIN\_VELO\_LIMIT (minimum velocity of the gear step) .

The minimum spindle speed can be changed in the part program with G25. In the event of programming that would mean one of the spindle limits (G25 or SD43220 \$SA\_SPIND\_MAX\_VELO\_G26) is not reached, the "Set speed too low" interface signal (DB31, ... DBX83.2) is set.

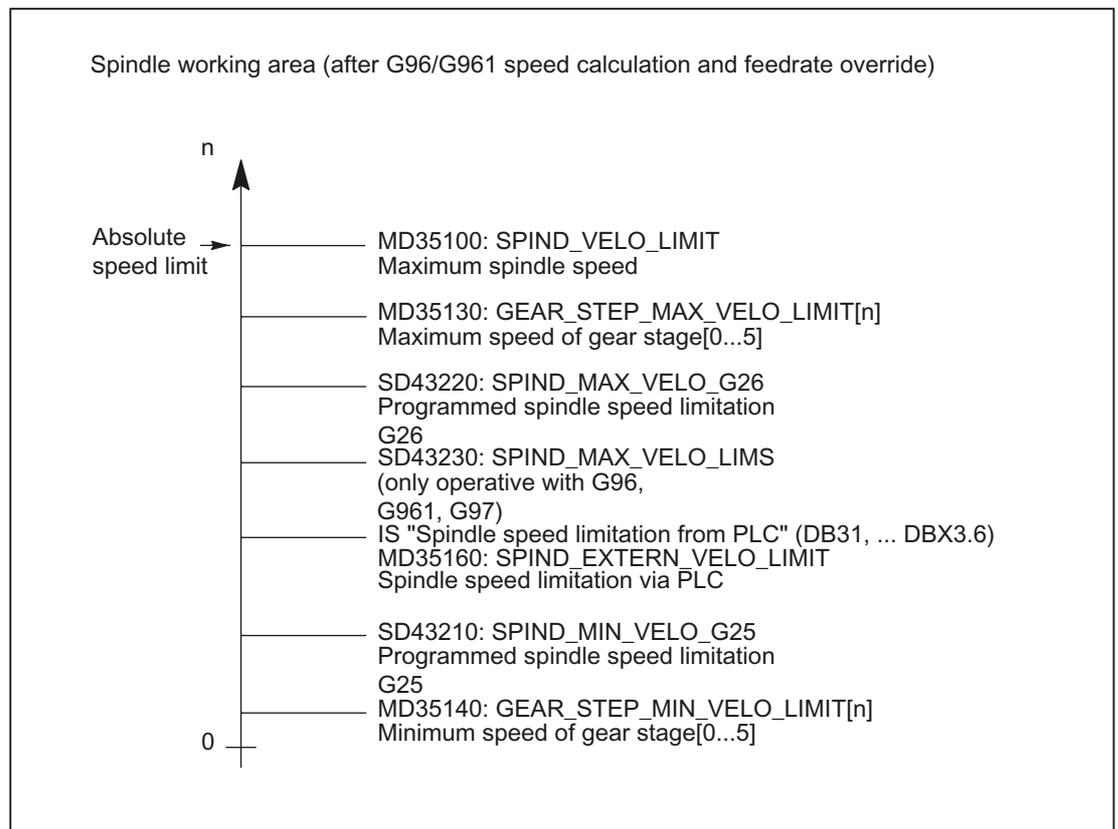


Figure 16-1 Spindle speed limitations

The various spindle speed limits are illustrated in the figure above. For more information and for information on the effect of the setting data see:

**References:**

/FB1/ Function Manual, Basic Functions; Spindles (S1);

Section: Spindle Monitoring Functions, Setting Data

### Master spindle switchover with G96, G961

If the master spindle is switched over when G96, G961 are active, the speed of the former master spindle is retained. This corresponds to a transition from G96 to G97. The master spindle newly defined with SETMS executes the "Constant cutting rate" function generated in this way.

### Interrupts

#### Constant cutting rate G96, G961, G962

- If no F value is programmed, alarm 10860 "No feedrate programmed" is output. The alarm is not generated with G0 blocks.
- Alarm 14800 "Programmed path velocity smaller than or equal to zero" is output while programming a negative path velocity.
- If, with an active G96, G961 or G962, no transverse axis is defined in the machine data: MD20100 \$MC\_DIAMETER\_AX\_DEF (geometry axis with transverse axis function) , alarm 10870 "No transverse axis defined" is issued.
- If a negative maximum spindle speed is programmed with the LIMS program command when G96, G961 are active, alarm 14820 "Negative maximum spindle speed programmed for G96, G961" is output.
- If no constant cutting rate is programmed when G96, G961 is selected for the first time, alarm 10900 "No S value programmed for constant cutting rate" is output.

## 16.2.4 Feedrate with G33, G34, G35 (thread cutting)

### 16.2.4.1 General

#### Application of G33

The function G33 can be used to machine threads with constant lead of the following type:

##### References:

/PA/ Programming Guide, Fundamentals

/PAZ/ Programming Guide, Cycles

#### Speed S, feedrate F, thread lead

A revolutional feedrate [mm/revolution] is used for G33 threads. The revolutional feedrate is defined by programming the thread lead increase [mm/revolution].

The speed of the axes for the thread length is calculated from the programmed spindle speed S and the thread lead.

Feedrate F [mm/min] = speed S [rev/min] \* thread lead [mm/rev]

At the end of the acceleration ramp, the position coupling between the spindle actual value (spindle setpoint with SPCON on master spindle) and the axis setpoint is established. At this moment, the position of the axis in relation to the zero mark of the spindle (including zero mark offsets) is as if the axis had accelerated abruptly at the start of the block when the thread start position (zero mark plus SF) was crossed. Compensation is made for the following error of the axis.

#### Minimum spindle speed

In order to ensure smooth rotation at low speeds, the spindle speed is not permitted to fall below a minimum level.

This speed is defined using setting data:

SD43210 \$SA\_SPIND\_MIN\_VELO\_G25 (minimum spindle speed)

and can be set for each gear step with the machine data:

MD35140 \$MA\_GEAR\_STEP\_MIN\_VELO\_LIMIT (minimum velocity for gear step change) .

The minimum spindle speed can be changed in the part program with G25.

#### NC STOP, single block

NC STOP and single block (even at the block boundary) are only active after completion of thread chaining. All subsequent G33 blocks and the first subsequent non-G33 block are traversed like a single block.

#### Premature abortion without destruction

Thread cutting can be aborted without destruction before the end point is reached. This can be done by activating a retraction motion.

### Thread cutting with ROT frame

With ROT frame and G33, G34, G35, alarm 10607 "Thread with frame not executable" is activated if the rotation causes a change in the thread length and thus the lead. Rotation around the thread axis is permissible.

Alarm 10607 "Thread with frame not executable" can be suppressed by setting bit 12 in machine data:

MD11410 \$MN\_SUPPRESS\_ALARM\_MASK ,  
if the ROT statement is used intentionally in the application.

All other frames are accepted by the NC without alarm. Attention is drawn to the lead-changing effect of SCALE.

#### 16.2.4.2 Programmable run-in and run-out path for G33, G34 and G35

##### Application

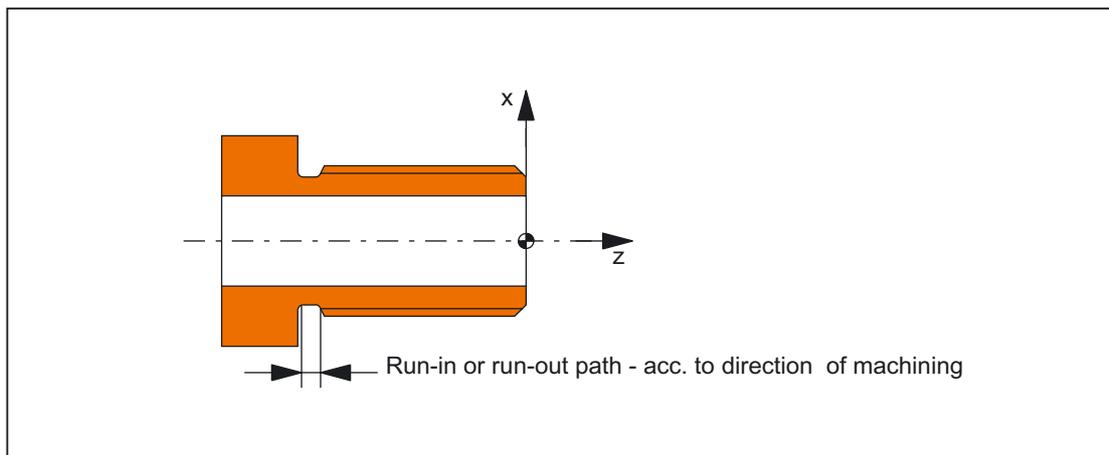


Figure 16-2 Run-in or run-out path too short

- **Short run-in path**

Due to the collar on the thread run-in, little room is left for the tool (T) start ramp. This must therefore be set shorter via DITS.

- **Short run-out path**

Due to the collar on the thread run-out, little room is left for the tool deceleration ramp, leading to the risk of collision between the workpiece and the tool edge. The tool braking ramp can be set shorter via DITE. Due to the inertia of the mechanical system, however, a collision can nevertheless occur.

Remedy: Program a shorter thread, reduce the spindle speed.

The programmed run-in and run-out path only increases the rate of acceleration on the path. If one of the two paths is set larger than the thread axis needs with active acceleration, the thread axis is accelerated or decelerated with maximum acceleration.

## Activation

The `DITS` and `DITE` functions are always active during thread cutting.

### Example:

```
N...
N59 G90 G0 Z100 X10 SOFT M3 S500
N60 G33 Z50 K5 SF=180 DITS=1 DITE=3           ; Start of corner rounding with Z=53
N61 G0 X20
```

## SD42010

Only paths, and not positions, are programmed with `DITS` and `DITE`.

The part program instructions are related to the setting data:

`SD42010 $SC_THREAD_RAMP_DISP[0,1], ,`

which defines the following acceleration response of the axis on thread cutting:

- **SD42010 ≤ 0 to -1**

Identical with previous response.

Starting/braking of the feedrate axis at configured acceleration rate.

Jerk according to current `BRISK/SOFT` programming.

- **SD42010 = 0**

Abrupt starting/braking of the feedrate axis on thread cutting.

- **SD42010 ≥ 0**

The thread run-up/deceleration distance is specified.

To avoid technology alarm 22280, the acceleration limits of the axis must be observed in case of very small run-in and run-out paths.

---

### Note

`DITE` acts at the end of the thread as a rounding clearance. This achieves a smooth change in the axis movement.

---

## Compatibility

Machine data:

`MD20650 $MC_THREAD_START_IS_HARD`

is dispensed with and is replaced by:

`SD42010 $SC_THREAD_RAMP_DISP[0]`

or

`SD42010 $SC_THREAD_RAMP_DISP[1]` .

The response of the new setting data with:

`SD42010 $SC_THREAD_RAMP_DISP[0] = 0`

or

`SD42010 $SC_THREAD_RAMP_DISP[1] = 0`

is identical to the previous machine data setting:

`MD20650 $MC_THREAD_START_IS_HARD = 1`.

The response with:

SD42010 \$SC\_THREAD\_RAMP\_DISP[0] = -1

or

SD42010 \$SC\_THREAD\_RAMP\_DISP[1] = -1

is identical to the previous machine data setting:

MD20650 \$MC\_THREAD\_START\_IS\_HARD = 0 (default).

## Constraints

When a block containing command `DITS` and/ or `DITE` is loaded in the interpolator, the path programmed in `DITS` is transferred to setting data:

SD42010 \$SC\_THREAD\_RAMP\_DISP[0]

and the path programmed in `DITE` is transferred to setting data:

SD42010 \$SC\_THREAD\_RAMP\_DISP[1] .

The programmed run-in path is handled according to the current setting (inches, metric).

If no run-in/deceleration path is programmed before or in the first thread block, the value is determined by the current value in setting data:

SD42010 \$SC\_THREAD\_RAMP\_DISP[0,1] .

In the event of `RESET`, the setting data:

SD42010 \$SC\_THREAD\_RAMP\_DISP[0,1]

is set to "-1".

### 16.2.4.3 Linear progressive/degressive thread-lead change with G34 and G35

#### Application G34, G35

The functions can be used to produce self-shearing threads.

#### Functionality

The thread lead increase (G34) defines the numerical increase in the lead value. A larger pitch results in a larger distance between the threads on the workpieces. The velocity of the thread axis thus increases assuming that the spindle speed is constant. The opposite naturally applies to decreasing thread lead (G35).

The following definitions have been made for the thread-lead changes with respect to the new G codes:

- G34: Increase in thread lead corresponds to progressive change.
- G35: Decrease in thread lead corresponds to degressive change.

Both functions G34 and G35 imply the functionality of G33 and additionally provide the option of programming an absolute lead change value for the thread under F. If the start and end lead of a thread is known, the thread-lead change can be determined using the following equation:

$$F = \frac{|k_e^2 - k_a^2|}{2 * l_G}$$

The identifiers have the following meanings:

- F: The thread-lead change to be programmed [mm/rev<sup>2</sup>]
- k<sub>e</sub>: Thread lead of axis target point coordinate, thread axis [mm/rev]
- k<sub>a</sub>: Initial thread lead (programmed under I, J or K) [mm/rev]
- l<sub>G</sub>: Thread length [mm]

The absolute value of F must be applied to G34 or G35 according to the desired lead increase or lead decrease.

When the thread length l<sub>G</sub>, lead change F and initial lead k<sub>a</sub> are known, the lead increase at the end of block k<sub>e</sub> can be determined as follows by modifying the formula:

- G34 (progressive lead):

$$k_e = \sqrt{k_a^2 + F * 2 * l_G}$$

- G35 (degressive lead):

$$k_e = \sqrt{k_a^2 - F * 2 * l_G}$$

---

### Note

If the formula results in a negative root expression, the thread cannot be machined!

In this case, the NC signals alarm 10605 or alarm 22275.

---

### Sample program

Thread cutting G33 with degressive thread lead G35

```

N1608 M3 S10 ; Spindle speed
N1609 G0 G64 Z40 X216 ; Approach starting point
N1610 G33 Z0 K100 SF=R14 ; Thread with constant pitch 100 mm/rev
N1611 G35 Z-220 K100 F17.045455 ; Thread lead decrease 17.045455 mm/rev2
; Thread lead at end of block 50 mm/rev
N1612 G33 Z-240 K50 ; Traverse thread block without jerk
N1613 G0 X218 ;
N1614 G0 Z40 ;
N1616 M17 ;

```

### Suppress special alarms

Any lead changes that would overload the thread axis when G34 is active or would result in an axis standstill when G35 is active are detected in advance during block preparation.

Alarm 10604 "Thread lead increase too high" or alarm 10605 "Thread lead decrease too high" are output if bit 10 in machine data:

MD11410 SUPPRESS\_ALARM\_MASK  
is not set.

During thread cutting, certain practical applications require a correction of the spindle speed. In this case, the operator will base his correction on the permissible velocity of the thread axis.

The output of the alarm generated during monitoring (10604 or 10605) can be suppressed by setting bit 10 in machine data:

MD11410 SUPPRESS\_ALARM\_MASK.

Block preparation continues as normal when alarms are suppressed.

The following situations are monitored cyclically when the thread is machined (interpolation):

- Exceeding of maximum velocity of thread axis
- Reaching of axis standstill with G35.

In these cases,  
alarm 22270 "Maximum velocity of thread axis reached"  
or  
alarm 22275 "Zero velocity of thread axis reached"  
is output.

## Alarms

Thread cutting G33, G34, G35

- The following alarms are output when programming is incorrect:

Alarm	10604	"Thread lead increase too high"
Alarm	10605	"Thread lead decrease too high"
Alarm	10607	"Thread with frame (ROT) cannot be executed"
Alarm	16005	"Illegal lift-off path"
Alarm	16710	"Master spindle not programmed"
Alarm	16720	"Thread lead is zero"
Alarm	16730	"Incorrect parameters"
Alarm	16740	"No geometry axis programmed"

- If the spindle speed is too high when G33, G34, G35 are active, e.g. spindle override set to 200%, alarm 22270 "Spindle speed for thread cutting too high" is output.

Alarm 22270 is output when the rapid traverse speed of the thread axis is exceeded. It is possible to reduce the spindle speed using the spindle override switch to prevent serious alarms.

### References:

/FB1/ Function Manual, Basic Functions; Diagnostic Tools (D1);  
Chapter: General Machine Data  
/DA/ Diagnostics Guide

#### 16.2.4.4 Stop for thread cutting

##### Stop for thread cutting

---

**Note**

The non-destructive interrupt function should only be used for thread cutting, not for tapping with G33.

---

##### Retraction movement

The retraction motion (`liftfast`) for thread cutting is controlled by the following keywords:

- LFON  
⇒ Enable `liftfast` for thread cutting.
- LFOF  
⇒ Disable `liftfast` for thread cutting.

These G functions can always be programmed.

The default setting for NC Reset and/or NC Start is specified in machine data: MD20150 GCODE\_RESET\_VALUES.

The following sources can initiate a retraction motion during thread cutting:

- Fast inputs (programming with `SETINTLIFTFAST` for "LIFTFAST" option)
- NC Stop
- Alarms that implicitly initiate the NC stop.

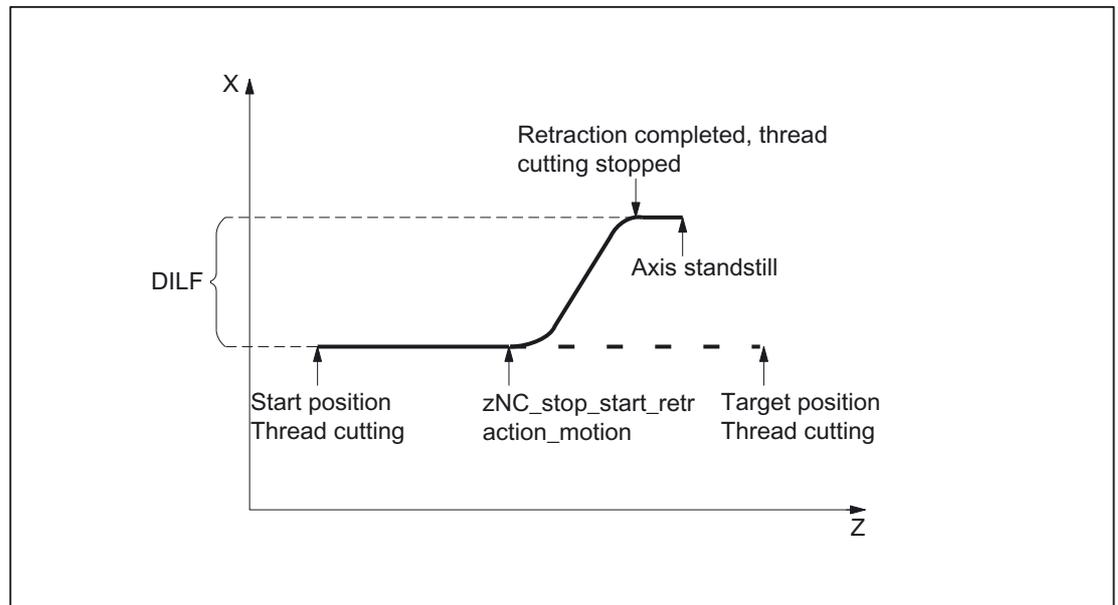


Figure 16-3 Interruption of G33 through retraction motion

## Retraction path

The retraction path can be configured in machine data:  
MD21200 LIFTFAST\_DIST.

If required, this path in the part program can be changed by writing `DILF` at any point.

Following an NC reset, the value entered in machine data:  
MD21200 LIFTFAST\_DIST  
(default value) is always active.

## Retraction direction

The method for defining the retraction direction is controlled in conjunction with the variable `ALF` using the following keywords:

- `LFTXT`

The plane of the retraction movement is determined by the path tangent and the tool direction. This G code (default setting) is used to program the response on a fast lift.

For information about `ALF` programming, refer to:

### References:

/PGA/ Programming Guide, Operations Planning

/FB1/ Function Manual, Basic Function; Mode Group, Channel, Program Operation (K1);  
Chapter: Asynchronous Subroutines (ASUBs), Interrupt Routines

- LFWP

The plane of the retraction movement is the active working plane selected with G codes G17, G18 or G19. The direction of the retraction plane is independent of the path tangent. This allows a fast lift to be programmed parallel to the axis.

These G functions can always be programmed.

The default setting for NC Reset and/or NC Start is specified in machine data::  
MD20150 GCODE\_RESET\_VALUES.

In the plane of the retraction movement, ALF is used, as before, to program the direction in discrete steps of 45 degrees. With LFTXT, retraction in the tool direction was defined for ALF=1.

With LFWP the direction in the working plane is derived from the following assignment:

G17:	X/Y plane	ALF=1	Retraction in X direction
		ALF=3	Retraction in Y direction
G18:	Z/X plane	ALF=1	Retraction in Z direction
		ALF=3	Retraction in X direction
G19:	Y/Z plane	ALF=1	Retraction in Y direction
		ALF=3	Retraction in Z direction

---

#### Note

The extension for programming the plane of the retraction movement can be used independently of thread cutting.

---

#### Retraction speed

Retraction is performed at maximum axis velocity.  
This can be configured in machine data:  
MD32000 MAX\_AX\_VELO.

#### Retraction acceleration, jerk

Acceleration is performed at maximum possible values.  
This can be configured in machine data:  
MD32300 MAX\_AX\_ACCEL.

**Example**

```

N55 M3 S500 G90 G18 ; Set active machining plane
...
N65 MSG ("thread cutting")
MM_THREAD:
N67 $AC_LIFTFAST=0 ; Reset before beginning of
thread
N68 G0 Z5
N69 X10
N70 G33 Z30 K5 LFON DILF=10 LFWP ALF=7 ; Enable fast retraction for
thread cutting
; Retraction path = 10 mm
; Retraction plane Z/X
(due to G18)
; Retraction direction -X
(with ALF=3; retraction
direction +X)
N71 G33 Z55 X15
N72 G1 ; Deactivate thread cutting
N69 IF $AC_LIFTFAST GOTOB MM_THREAD ; If thread cutting
; was aborted
N90 MSG ("")
...
N70 M30
N55 M3 S500 G90 G0 X0 Z0
...
N87 MSG ("tapping")
N88 LFOF ; Deactivate fast retraction
before tapping
N89 CYCLE... ; Thread drilling cycle with G33
N90 MSG ("")
...
N99 M3012.97

```

**Control system response**

At POWER ON and RESET, the retraction path is set as configured (MD), as is the state of LFON or LFOF and LFTXT or LFWP using machine data:  
MD20150 GCODE\_RESET\_VALUES  
from the corresponding G group.

### Smoothed actual values

If low-resolution encoders are being used, smoothed actual values can be applied for constant coupled path and axis motions.

Machine data:

MD34990 ENC\_ACTVAL\_SMOOTH\_TIME

can be used to change the time constant for more effectively smoothed actual values for:

- Thread cutting with feedrate for G33, G34, G35
- Revolutonal feedrate for G95, G96, G97, FRAPON
- Display of actual positions and actual speed/velocity

The larger the time constant, the better the smoothing of the actual values and the longer the overtravel.

### 16.2.5 Feedrate for G331/G332, rigid tapping

G331 (tapping) and G332 (tapping retraction) can be used to tap a thread without a compensating chuck (rigid tapping) if the spindle is technically capable of operating in position control mode.

### Speed S, feedrate F, thread lead

A revolutonal feedrate [mm/rev.] is used for G331 and G332. The revolutonal feedrate is defined by programming the thread lead increase [mm/rev.].

The speed of the axes for the thread length is calculated from the programmed spindle speed S and the thread lead.

Feedrate F [mm/min] = speed S [rev/min] \* thread lead [mm/rev]

---

#### Note

For further information about programming G63/G331/G332, please see:

#### References:

Programming Guide, Fundamentals

Programming Guide, Cycles

---

### Override

The revolutonal feedrate in G331 and G332 can be influenced by an override.

Depending on the configuration, the override affects either the spindle speed or the path feedrate:

MD12090 \$MN\_OVR\_FUNCTION\_MASK

Bit	Value	Significance
0	0	The override influences the spindle speed (initial setting). Depending on the setting in the machine data: MD12080 \$MN_OVR_REFERENCE_IS_PROG_FEED the override is related either to the programmed spindle speed or to the configured spindle speed limitation.
	1	The override influences the path feedrate Depending on the setting in machine data: MD12082 \$MN_OVR_REFERENCE_IS_MIN_FEED the override is related either to the programmed path feedrate or to the configured path feedrate limitation.

**Note**

The following overrides are not effective in G331 and G332:

- Programmable path feedrate override `OVR`
- Rapid traverse override

**Inhibiting stop events for G331/G332**

During tapping, a stop can be prevented if the block contains a path movement or a G4.

For this purpose, bit 0 must be set to 0 in machine data:

MD11550 \$MN\_STOP\_MODE\_MASK.

The stop, which was activated previously, is possible again after G331/G332 has been executed.

**16.2.6 Feedrate for G63, tapping with compensation chuck****Application**

G63 is a subfunction for tapping threads using a tap with compensating chuck. An encoder (position encoder) is not required.

**Speed S, feedrate F, thread lead**

With G63, a speed  $S$  must be programmed for the spindle and a feedrate  $F$  for the infeed axis (axis for thread length).

The feedrate  $F$  must be calculated by the programmer on the basis of the speed  $S$  and the thread lead.

Feedrate  $F$  [mm/min] = speed  $S$  [rev/min] \* thread lead [mm/rev]

## 16.3 Feedrate FA for positioning axes

### Syntax

```
FA[<positioning axis>] = <feedrate value>
```

### Functionality

The velocity of a positioning axis is programmed with axis-specific feedrate FA.

- Effectiveness: Modal
- Special points to be noted
  - No more than 5 axis-specific feedrates can be programmed in each part program block.
  - The feedrate is always G94.
  - If no axial feedrate FA is programmed, the axial default: MD32060 \$MA\_POS\_AX\_VELO (initial setting for positioning axis velocity) takes effect.

#### Parameter: Positioning axis

- Value range: Identifier of channel axes  
MD20080 \$MC\_AXCONF\_CHANAX\_NAME\_TAB

#### Parameter: Feed value

- Value range  
0.001...999,999.999 mm/min, degrees/min or 0.001, ...39,999.9999 inch/min

For more information about the value range of the axial feedrate see:

#### References:

/PG/ Programming Manual Fundamentals  
/FB1/ Function Manual, Basic Functions; Velocities, Setpoint/ Actual Value Systems, Closed-Loop Control (G2)

- NC/PLC interface (channel-specific)  
The feedrate is output at the channel-specific NC/PLC interface:  
DB21, ... DBB158 - DBB193  
For a description of the channel-specific NC/PLC interface signals (modification signal, machine axis number of positioning axis, etc.) see:

#### References:

/FB1/ Function Manual, Basic Functions; Various Interface Signals and Functions (A2)

- NC/PLC interface (axis-specific)  
The feed value is output at the axis-specific NC/PLC interface:  
DB31, ... DBB78 - DBB81

**Note****Maximum axis velocity**

The maximum axis velocity is not exceeded:  
MD32000 \$MA\_MAX\_AX\_VELO (maximum axis velocity)

**F function output to the NC/PLC interface**

Output of the F functions to the NC/PLC interface is not recommended. Activating the output of F functions to the NC/PLC interface can cause a drop in velocity in continuous-path mode. The output of F functions to the NC/PLC interface can be suppressed:  
MD22240 \$MC\_AUXFU\_F\_SYNC\_TYPE (output time of the F functions)

For a detailed description please refer to:

**References:**

/FB1/ Function Manual, Basic Functions; Auxiliary Functions (H2)

**RESET response**

After end of program or NC-RESET, the feedrate value takes effect depending on machine data:

MD22410 \$MC\_F\_VALUES\_ACTIVE\_AFTER\_RESET = <value>

Value	Meaning
0	After NC RESET the default values are effective.
1	After NC RESET the last FA values to be programmed are effective.

## 16.4 Feedrate control

### 16.4.1 General

#### Programming and controlling the feedrate

The figure below shows the options for feedrate programming and control.

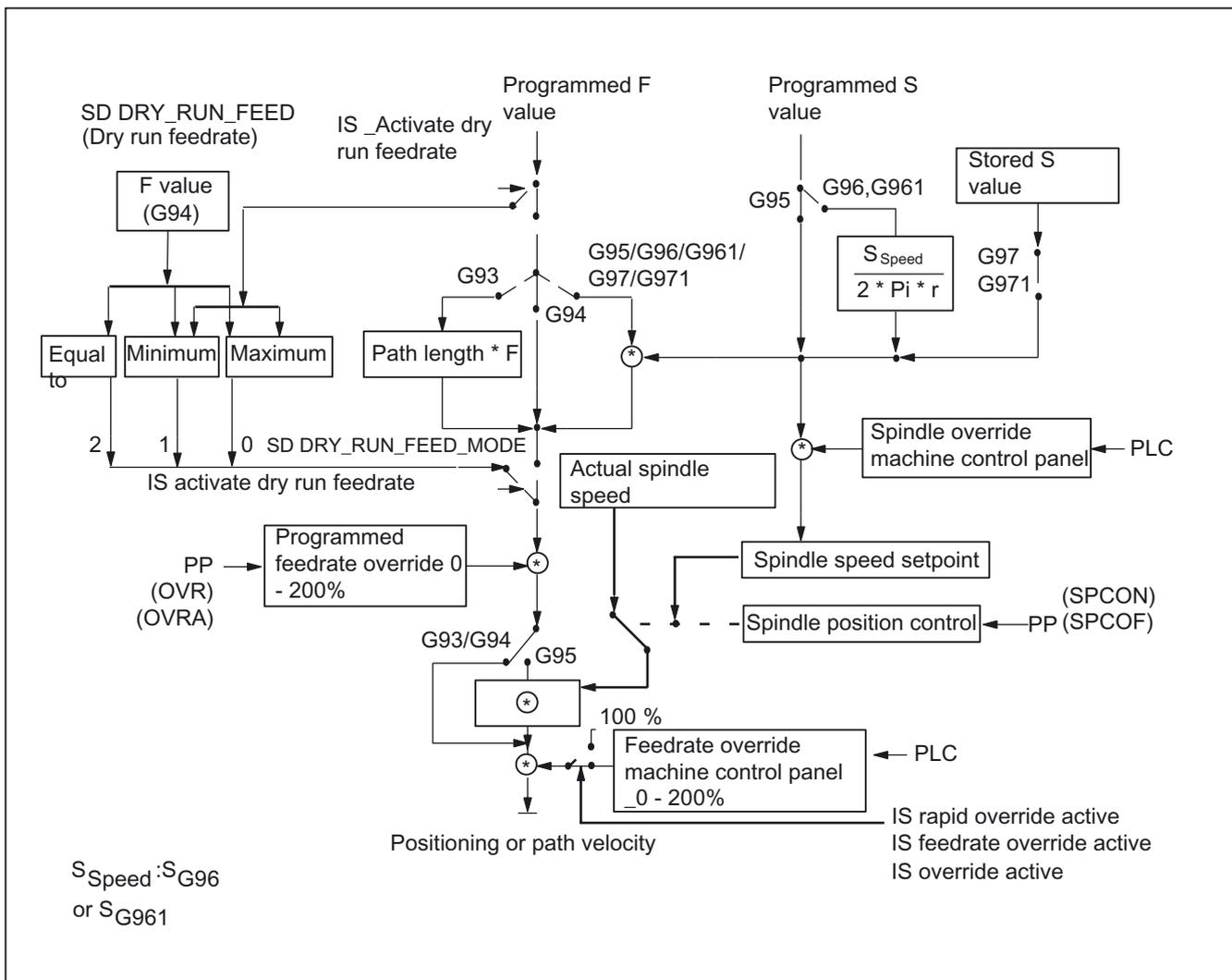


Figure 16-4 Programming and controlling the feedrate

## 16.4.2 Feedrate disable and feedrate/spindle stop

### General

The feedrate disable or feedrate/spindle stop brings the axes to a standstill with adherence to the braking characteristics and the path contour (exception: G33 block).

#### References:

/FB1/ Function Manual, Basic Functions; Continuous-Path Mode, Exact Stop and Look Ahead (B1)

### "Feedrate disable" DB21, ... DBX6.0

Interface signal "Feedrate disable" (DB21, ... DBX6.0) shuts down all axes (geometry and auxiliary axes) of a channel in all modes.

Activation of channel-specific feedrate disable	
If G33, G34, G35 active:	Not effective
If G63 active:	Effective
If G331, G332 active:	Effective

### "Feed stop" DB21, ...DBX12.3 geometry axes

Interface signals "Feed stop" (DB21, ... DBX12.3 and the following signals) for geometry axes 1, 2, and 3 stop the geometry axes of a channel in JOG mode.

### "Feed stop" DB31, ...DBX4.3 axis-specific

The axis-specific "Feed stop" interface signal (DB31, ... DBX4.3) is used to stop the relevant machine axis.

In automatic mode:

- If the "Feed stop" is performed for a path axis, all the axes traversed in the current block and all axes participating in the axis group are stopped.
- If the "Feed stop" is performed for a positioning axis, only this axis is stopped.

Only the current axis is stopped in JOG mode.

Activation of axis-specific function "Feed stop"	
Active in G33, G34, G35	Effective (causes contour deviations)
For active G63	Effective
In active G331, G332	Effective

**Axis/spindle disable" DB31, ... DBX1.3**

Activating "Axis/spindle disable" (DB31, ...DBX1.3) disables the axial PLC interlocks "No controller enable" and "Feed stop".

The axial and channel-specific override, however, is active.

**"Spindle stop" DB31, ... DBX4.3**

IS "Spindle stop" (DB31, ... DBX4.3) is used to stop the relevant spindle.

Activation of the "Spindle stop" function	
Active in G33, G34, G35	Effective (may cause contour deviations depending on dynamic characteristics)
For active G63	Effective
In active G331, G332	<b>not</b> functional

**16.4.3 Feedrate override on machine control panel****General**

The operator can use the feedrate override switch to increase or decrease the path feedrate relative to the programmed percentage with immediate effect. The feedrates are multiplied by the override values.

An override between 0 and 200% can be programmed for the path feedrate.

The rapid traverse override switch is used to reduce the traversing velocity when testing a part program.

An override between 0 and 100% can be programmed for the rapid traverse.

The feedrate can be changed axis-specifically for positioning axes. The override can be between 0 and 200%.

The spindle override can be used to modify the spindle speed and the cutting rate (with G96, G961). The override can be between 0 and 200%.

The override is not permitted to exceed the machine-specific acceleration and speed limits or generate a contour error.

The feedrate override can be changed separately for path and position axes.

The overrides influence the programmed values or the limiting (e.g. G26, LIMS in spindle speed).

A sequence of G63 blocks is traversed regardless of the feedrate override. A sequence of G63 blocks consists of directly following blocks having the G code G63. It starts with the first G63 block and ends with the first path motion block that does not have G63.

**Channel-specific "Feedrate override" DB21, ...DBB4/"rapid traverse override" DB21, ...DBB5**

One enable signal and one byte are provided on the PLC interface for the override factor, for the two feedrate types.

IS "Feed override" (DB21, ... DBB4)

IS "Feed override active" (DB21, ... .. DBB4)

IS "Rapid traverse override" (DB21, ... DBB5)

IS "Rapid traverse override active" (DB21, ... DBX6.6)

The interface for the override can be provided by the PLC in binary-coded or gray-coded form.

Whether binary or gray-coded is valid is defined via machine data:

MD12020 OVR\_FEED\_IS\_GRAY\_CODE (path feedrate override switch, gray-coded)

and

MD12040 OVR\_RAPID\_IS\_GRAY\_CODE (rapid traverse override switch, gray coded).

The following permanent assignment applies to binary code:

Code	Override factor
00000000	0.00 $\triangleq$ 0%
00000001	0.01 $\triangleq$ 1%
00000010	0.02 $\triangleq$ 2%
00000011	0.03 $\triangleq$ 3%
00000100	0.04 $\triangleq$ 4%
.	.
.	.
.	.
01100100	1.00 $\triangleq$ 100%
.	.
.	.
.	.
11001000	2.00 $\triangleq$ 200%

In gray coding, the override factors corresponding to the switch position is entered in machine data:

MD12030 OVR\_FACTOR\_FEEDRATE [n]

(evaluation of path feedrate override switch)

or

MD12050 OVR\_FACTOR\_RAPID\_TRA [n] (evaluation of rapid traverse override switch).

An active feedrate override has an effect on all path axes that are assigned to the current channel.

An active rapid traverse override has an effect on all the axes that are traversed with rapid traverse and that are assigned to the current channel.

If there is no dedicated rapid traverse override switch, you can switch between effective rapid traverse override and feedrate override. In this case, feedrate overrides above 100% are limited to 100% for rapid traverse override.

The override to be active can be selected via the PLC or operator panel front. On activating the rapid traverse override via the operator panel front, the "feedrate override for rapid traverse" is selected (DB21, ... DBX25.3) is transferred via the PLC basic program to the "rapid traverse override effective" interface signal (DB21, ... DBX6.6) and the IS "feedrate override" (DB21, ... DBB4) is copied to the IS "Rapid traverse override" (DB21, ... DBB5).

On selecting via PLC, the "rapid traverse override active" interface signal (DB21, ... DBX6.6) is to be set by the PLC user program and the interface signal of the feedrate override (DB21, ... DBB4) is to be copied to the Rapid traverse override (DB21, ... DBB5).

Effectiveness of the channel-specific feedrate and rapid traverse override	
Active in G33, G34, G35	<b>not</b> functional
For active G63	<b>not</b> functional
In active G331, G332	<b>not</b> functional

### Reference speed for path feedrate override

The reference speed for the path feedrate override specified via machine control panel can be set as different from the standard or default.

The machine data:

MD12082 OVR\_REFERENCE\_IS\_MIN\_FEED  
enables the corresponding selection.

### Axis-specific "Feedrate override" DB31, ...DBB0

One enable signal and one byte for the feedrate override are available on the PLC interface for each positioning axis:

IS "Feed override" (DB21, ... DBB0)

IS "Override active" (DB31, ... DBX1.7)

The interface for the feedrate override can be provided by the PLC in binary-coded or gray-coded form.

Machine data:

MD12000 OVR\_AX\_IS\_GRAY\_CODE (gray-coded axis feedrate override switch)  
is used to define whether binary or gray code is valid.

The following permanent assignment applies to binary code:

Code	Override factor
00000000	0.00 $\pm$ 0%
00000001	0.01 $\pm$ 1%
00000010	0.02 $\pm$ 2%
00000011	0.03 $\pm$ 3%
00000100	0.04 $\pm$ 4%
.	.
.	.
.	.
01100100	1.00 $\pm$ 100%
.	.
.	.
.	.
11001000	2.00 $\pm$ 200%

In gray coding, the override factors corresponding to the switch position are entered in machine data:

MD12010 OVR\_FACTOR\_AX\_SPEED [n] (evaluation of axis feedrate override switch).

Effectiveness of the axis-specific feedrate override	
Active in G33, G34, G35	<b>not functional</b>
For active G63	<b>not active</b> (the override is set in the NC permanently to 100%)
In active G331, G332	<b>not active</b> (the override is set in the NC permanently to 100%)

**Spindle override" DB31, ... DBB0"**

One enable signal and one byte for the spindle override factor are available on the PLC interface for each spindle.

IS "Spindle override" (DB31, ... DBB19)

IS "Override active" (DB31, ... DBX1.7)

The interface for the spindle override can be provided from the PLC in binary-coded or gray-coded form.

Machine data:

MD12060 OVR\_SPIND\_IS\_GRAY\_CODE (spindle override switch is gray-coded)

is used to define whether binary or gray code is valid.

The following permanent assignment applies to binary code:

Code	Override factor
00000000	0.00 $\pm$ 0%
00000001	0.01 $\pm$ 1%
00000010	0.02 $\pm$ 2%
00000011	0.03 $\pm$ 3%
00000100	0.04 $\pm$ 4%
.	.
.	.
.	.
01100100	1.00 $\pm$ 100%
.	.
.	.
.	.
11001000	2.00 $\pm$ 200%

In gray coding, the override factors corresponding to the switch position are entered in machine data:

MD12070 OVR\_FACTOR\_SPIND\_SPEED [n] (evaluation of spindle override switch).

Effectiveness of the spindle override	
Active in G33, G34, G35	active (if the spindle is in position control, then the override switch can be actuated)
For active G63	<b>not</b> active (the override is set in the NC permanently to 100%)
In active G331, G332	Effective

**Limiting the override factor**

In a binary-coded interface, the maximum possible override factors for path, axis feedrate and spindle speed can be limited further with machine data:

MD12100 OVR\_FACTOR\_LIMIT\_BIN (limiting in binary-coded override switch).

**Override active DB21, ...DBX6.6/DB21, ... DBX6.7/DB31, ... DBX1.7**

The override values set with the selector switch on the machine control panel are immediately active for all modes and machine functions, provided that IS "Rapid traverse override active", (DB21, ... DBX6.6) "Feedrate override active" (DB21, ... DBX6.7) or "Override active" (DB31, ... DBX1.7) are set.

An override factor of 0% acts as a feedrate disable.

**Override inactive**

If override is inactive (above IS signals are set to 0), the override factor 1 is used internally in the NC, i.e. the override is 100%. The value that is entered in the PLC interface is not relevant.

An exception is the zero setting for a binary interface and the 1st switch setting for a gray-coded interface. In these cases, the override factors entered at the PLC interface are used. With a binary interface, the override factor = 0. With a Gray-coded interface, the value entered in the machine data for the 1st switch setting is output as the override value. It should be populated with 0.

An override factor of 0% acts as a feedrate disable.

**Reference to spindle override**

Whether the spindle override is related to the speed limited by MD or SD, or to the programmed speed is specified in machine data:

MD12080 OVR\_REFERENCE\_IS\_PROG\_FEED (override reference speed).

## 16.4.4 Programmable feedrate override

### Function

The programmable feedrate override can be used to change the velocity level of path and positioning axes by means of a command in the part program.

A separate feedrate override can be programmed for positioning axes.

### Programming

The feedrate override can be changed with the following commands:

OVR= . . . .	Feedrate change for path feedrate $F$
OVRA [X1] = . . .	Feedrate change for positioning feedrate $F_A$

The programmable range is between 0 and 200%.

The default setting is 100%.

### Effectivity

Interface signals "Rapid traverse and feedrate override" (DB21, ... DBB6) and "Axis-specific override active" (DB31, ... DBX1.7) do not apply to the programmable feedrate override. The programmable feedrate override remains active when these signals are deactivated.

The active override is calculated from the product of the programmable feedrate override and the feedrate override from the machine control panel.

The default setting is 100%. It is active if no feedrate override has been programmed or following a `RESET`, if machine data:

`MD22410 F_VALUES_ACTIVE_AFTER_RESET` (F function active via `RESET`)  
is not set.

OVR is not active with G33, G34, G35.

## 16.4.5 Dry run feedrate

### Application

The dry run feedrate is used when testing part programs without machining the workpiece in order to allow the program or program sections to execute with an increased path feedrate, for example.

### "Dry run feedrate selected" DB21, .... DBX24.6

The dry run feedrate can be activated from the PLC or the operator panel.

When activated from the operator panel, interface signal "Dry run feedrate selected" (DB21, ... DBX24.6) is set and transferred by the PLC basic program to interface signal "Activate dry run feedrate" (DB21, ... DBX0.6).

When selected on the PLC, the "Activate dry run feedrate" interface signal is required to be set by the PLC user program.

The execution of the program is triggered with G94.

The dry run feedrate also takes precedence over the feedrates for G93, G95 and G33, G34, G35.

In this case, the programmed feedrate is compared to the dry run feedrate in: SD42100 DRY\_RUN\_FEED and the axis is then traversed at the higher of the two feedrates.

### Dry run feedrate change "Dry run feedrate active" DB21, .... DBX318.6.

The dry run feedrate (SD42100 DRY\_RUN\_FEED = 1) can be changed via the operator panel in the operating area "Parameters".

The interface signal "Dry run feedrate active" (DB21, ... DBX318.6) is set if the selection has been accepted by the NCK. DRY is displayed in the operator panel status bar to indicate an active dry run feedrate if

- selection takes place when the program stops at the end of a block or if the machine data
- MD10704 DRY\_RUN\_MASK = 1 has been set during execution of the program.

If MD10704 DRYRUN\_MASK = 0 has been set a dry run feedrate may only be activated/deactivated at the end of a block.

If the dry run feedrate is no longer selected, the interface signal "Dry run feedrate active" (DB21, ... DBX318.6) is reset.

### Evaluation

The effect of:  
SD42100 DRY\_RUN\_FEED  
can be controlled via another setting data:  
SD42101 DRY\_RUN\_FEED\_MODE.

SD42101 DRY_RUN_FEED_MODE	Effectivity
	As long as the "Activate dry run feedrate" interface signal is set, instead of the programmed feedrates, the feedrate value set in SD42100 DRY_RUN_FEED is effective as follows:
0	The maximum value from SD42100 DRY_RUN_FEED and the programmed velocity is effective. This is the same as the default setting.
1	The minimum value from SD42100 DRY_RUN_FEED and the programmed velocity is effective.
2	Setting data SD42100 DRY_RUN_FEED is effective directly, regardless of the programmed velocity.
3 -9	reserved
10	As for configured value 0 except for thread cutting (G33, G34, G35) and tapping (G33, G34, G35). These functions are executed as programmed.
11	As for configured value 1 except for thread cutting (G33, G34, G35) and tapping (G33, G34, G35). These functions are executed as programmed.
12	As for configured value 2 except for thread cutting (G33, G34, G35) and tapping (G33, G34, G35). These functions are executed as programmed.

A dry run feedrate can be selected in the automatic modes and activated on interruption of an automatic mode or end of a block. Using machine data MD10704 DRYRUN\_MASK = 1, the dry run feedrate can also be activated during execution of the program (in the part program block).

#### Note

Activation during machining triggers an internal reorganization task on the control which causes the axes to be stopped for a short time. This can affect the surface finish of the workpiece being machined.

With MD10704 DRYRUN\_MASK = 2, the dry run feedrate can be activated/ deactivated at any time without the axes stopping. The function only becomes effective with a block which comes later in the program run.

## 16.4.6 Multiple feedrate values in one block

### Application

The functionality described in the following is used primarily for grinding, but is not restricted to it.

#### References:

/FB2/ Function Manual, Extended Functions; Grinding (W4)

/FB2/ Function Manual, Extended Functions; Oscillation (P5)

### Functionality

The function "Multiple feedrates in one block" can be used to activate 6 different feedrate values of an NC block, a dwell time or a retraction motion synchronously, depending on the external digital and/or analog inputs.

### Retraction

Retraction by the programmed amount is initiated in the IPO cycle.

### Signals

The HW input signals are combined in one input byte for the function "Multiple feedrate in one block". A permanent functional assignment applies within the byte:

Table 16-1 Input byte for "Multiple feedrates in one block"

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Input no.	I7	I6	I5	I4	I3	I2	I1	I0
Feedrate address	F7	F6	F5	F4	F3	F2	ST	SR

I7 to I2      Activation of feedrates F7 to F2  
 E1            Activation of dwell time ST (in seconds)  
 I0            Activation of retraction motion SR

## Priorities

The signals are scanned in ascending order starting at I0.

Therefore, the retraction motion (SR) has the highest priority and the feedrate F7 the lowest priority.

SR and ST end the feedrate motions that were activated with F2 - F7.  
SR also ends ST, i.e. the complete function.

The highest-priority signal determines the current feedrate.

Machine data:

MD21230 MULTFEED\_STORE\_MASK

(store input signals for the "Multiple feedrates in one block" function)

can be used to define the response on loss of the highest-priority input in each case (F2 - F7).

The end-of-block criterion is satisfied when:

- The programmed end position is reached
- The retraction motion ends (SR)
- The dwell time elapses (ST)

## Delete distance-to-go

A retraction motion or dwell time causes the distance-to-go to be deleted.

## Hardware assignment

The channel-specific machine data:

MD21220 MULTFEED\_ASSIGN\_FASTIN

(assignment of the input byte of the NCK I/Os for "Multiple feedrates in one block")

can be used to assign up to two digital input bytes or comparator input bytes to the NCK I/O.

Machine data:

MD21220 MULTFEED\_ASSIGN\_FASTIN

can also be used to invert the input bits.

If a 2nd byte is entered, the contents of the 1st and 2nd byte are ORed before being used.

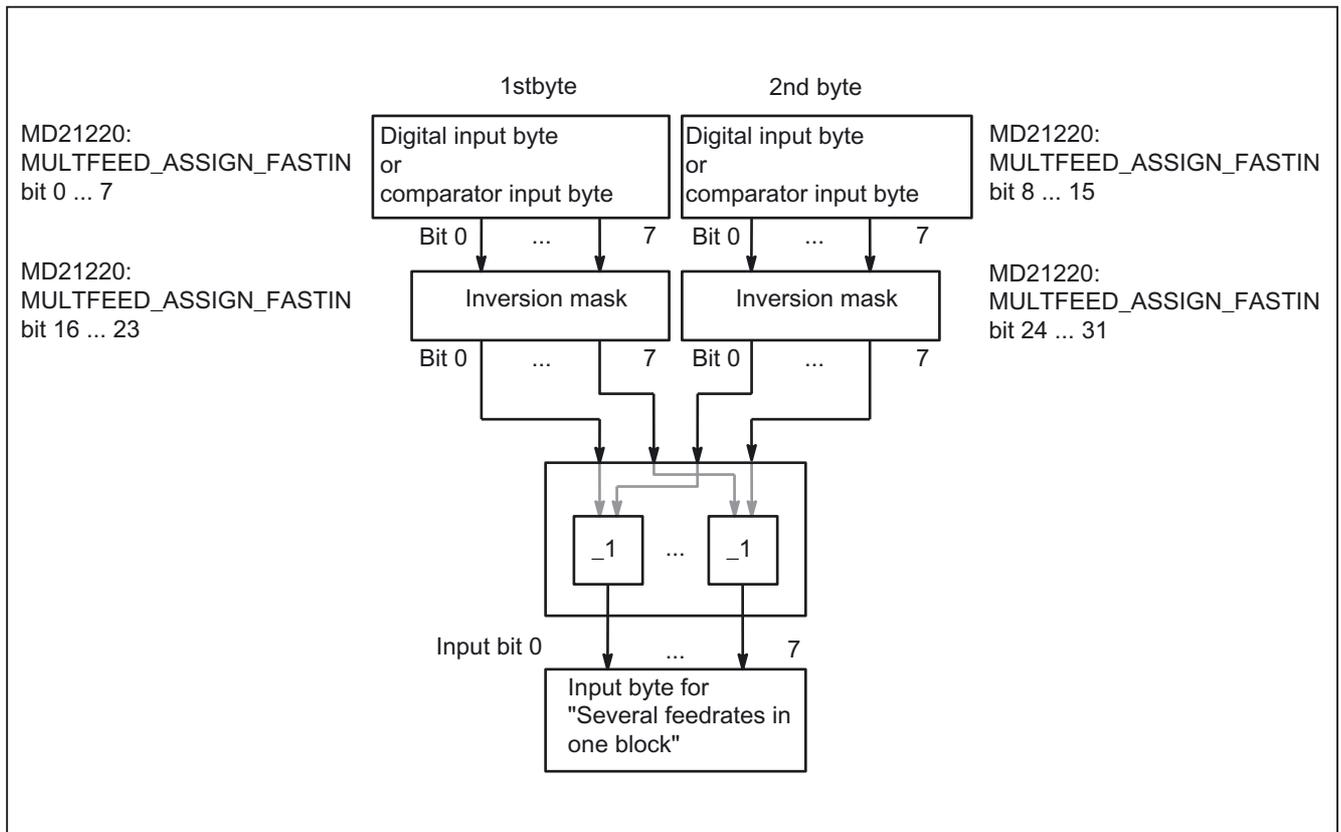


Figure 16-5 Signal routing for "Multiple feeds in one block"

The assignment of the digital input bytes and parameterization of the comparators are described in:

**References:**

/FB1/ Function Manual, Basic Functions; Various Interface Signals (A2)

### Programming path motion

The path feedrate is programmed under the address  $F$  and remains valid until an input signal is present. This value acts modally.

$F2 = \dots$  to  $F7 = \dots$  can be used in addition to the path feedrate to program up to 6 further feedrates in the block.

The numerical expansion indicates the bit number of the input that activates the feedrate when changed:

e.g.  $F7 = 1000$  ; 7 corresponds to input bit 7.

Bits 2 to 7 are permissible for numerical expansion of the feedrate. The programmed values act non-modally. The path feedrate programmed under  $F$  applies in the next block.

Dwell (sparking out time) and retraction path are programmed under separate addresses in the block:

ST=...	dwell (for grinding sparking out time)
SR=...	Retraction path

These addresses apply non-modally.

### Programming axial motion

The axial feedrates are programmed under address FA and remain valid until an input signal is present. They act modally.

FMA[2, x] = ... to FMA[7, x] = ... can be used to program up to 6 further feedrates per axis in the block.

The first expression in square brackets indicates the bit number of the input that activates the feedrate when changed. The second expression indicates the axis to which the feedrate applies.

Example:

```
FMA[3,Y]=1000           ;axial feedrate for Y axis,
                        ;corresponds to input bit 3
```

Bits 2 to 7 are permissible for the numerical expansion of the axial feedrate. The values programmed under FMA are active non-modally. The feedrate programmed under FA applies to the next block.

Dwell (sparking out time) and retraction path can also be defined for a single axis:

STA[x]=...	;dwell (sparking out time), axis-specific
SRA[x]=...	;retraction path, axis-specific

The expression in square brackets indicates the axis for which the sparking out time and retraction path apply.

```
STA[X]=2.5             ;sparking out time 2.5 seconds
SRA[X]=3.5             ;retraction path 3.5 (unit e.g.: mm)
```

These addresses apply non-modally.

If feedrates, a sparking out time (dwell) or retraction path are programmed for an axis on account of an external input, this axis must not be programmed as a POSA axis in this block (positioning axis beyond end of block).

When the input for the sparking out time or retraction path is activated, the distance-to-go for the path axes or the particular single axis is deleted and the dwell or retraction is started.

---

**Note**

The unit for the retraction path refers to the current valid unit of measurement (mm or inch).

The reverse stroke is always made in the opposite direction to the current motion. *SR/SRA* always programs the value for the reverse stroke. No sign is programmed.

It is also possible to poll the status of an input for synchronous commands of various axes.

Look Ahead is also active for multiple feedrates in one block. In this way, the current feedrate is restricted by the Look Ahead value.

---

**Application**

Typical applications include:

- Analog or digital calipers

Depending on whether the external inputs are analog or digital, various feedrate values, a dwell and a retraction path can be activated. The limit values are defined via the setting data.

- Switching from infeed to working feedrate via proximity switch

**Example**

Internal grinding of a conical ring, where the actual diameter is determined using calipers and, depending on the limits, the feedrate value required for roughing, finishing or fine finishing is activated. The position of the calipers also provides the end position. Thus, the block end criterion is determined not only by the programmed axis position of the infeed axis but also by the calipers.

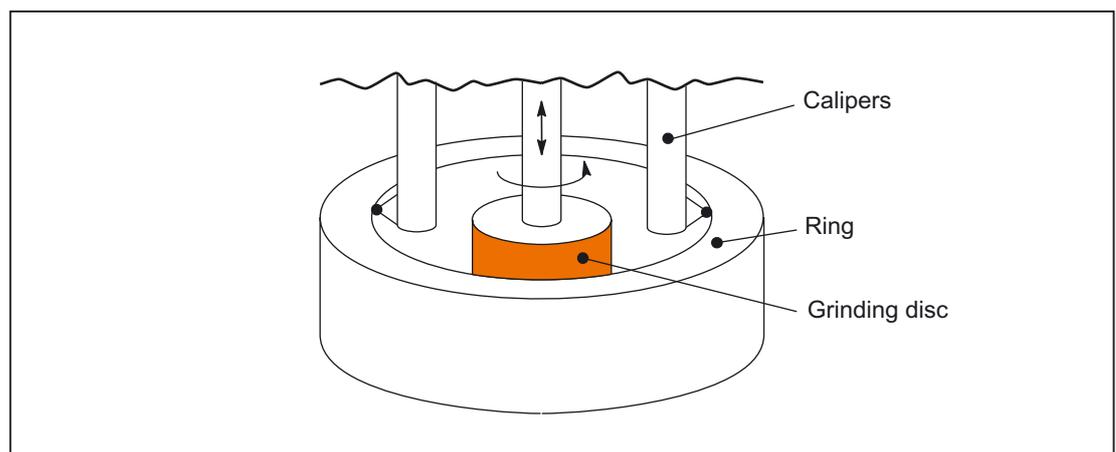
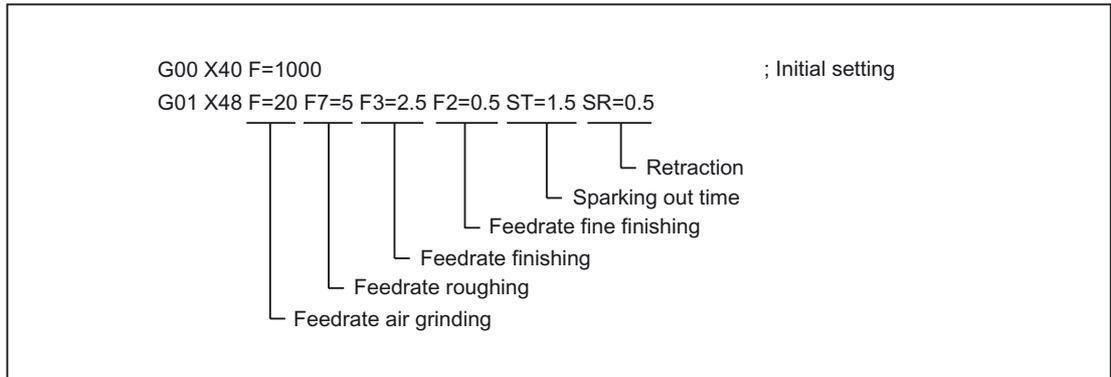


Figure 16-6 Calipers

Part program



**Note**

The axial feedrate/path feedrate (F value) is the 100% feedrate.

Feedrates smaller than or equal to the axial feedrate/path feedrate can be implemented with "Multiple feedrate values in one block" (F2 to F7 values).

The "Multiple feedrate values in one block" functionality is only available in conjunction with the "Synchronized actions" function.

**References:**

/FB1/ Function Manual, Basic Functions; Various Interface Signals and Functions (A2)

## 16.4.7 Fixed feedrate values

### Function

The machine data can be used to define 4 fixed feedrate values, which can be activated via the interface signal. The function is possible in AUTOMATIC and JOG modes.

### Behavior in AUTOMATIC mode

The fixed feedrate, which has been selected, is used instead of the programmed feedrate. The following MDs and interface signals can be used to select fixed feedrates for path/geometry axes:

- MD12202 \$MN\_PERMANENT\_FEED[n] (fixed feedrates for linear axes)
- MD12204 \$MN\_PERMANENT\_ROT\_AX\_FEED[n] (fixed feedrates for rotary axes)
- IS "Activate fixed feedrate x for path/geometry axes" (DB21, ... DBX29.0- 29.3)

The contour travels at the activated fixed feedrate, instead of using the programmed feedrate.

### Behavior in JOG mode

The fixed feedrate selected via the interface signal is applied during travel instead of the JOG velocities set.

The travel direction is specified via the interface signal.

The following MDs and interface signals can be used to select fixed feedrates for path/geometry axes and for machine data:

- MD12202 \$MN\_PERMANENT\_FEED[n] (fixed feedrates for linear axes)
- MD12202 \$MN\_PERMANENT\_ROT\_AX\_FEED[n] (fixed feedrates for rotary axes)
- IS "Activate fixed feedrate x for machine axes" (DB31, ... DBX3.2-3.5)

The axis travels at the activated fixed feedrate, instead of at the JOG velocity/JOG-rapid traverse velocity set in MD.

### Constraints

- Fixed feedrate does not influence spindles, positioning axes and tapping.
- While traversing with fixed feedrate, the override depends on machine data:  
MD12200 \$MN\_RUN\_OVERRIDE\_0 (traveling with override 0)
- The DRF offset cannot be activated for a selected fixed feedrate.
- The fixed feedrates are always linear feedrate values. Switchover to linear feedrate is conducted internally even in case of revolutional feedrate.

## Interface signals

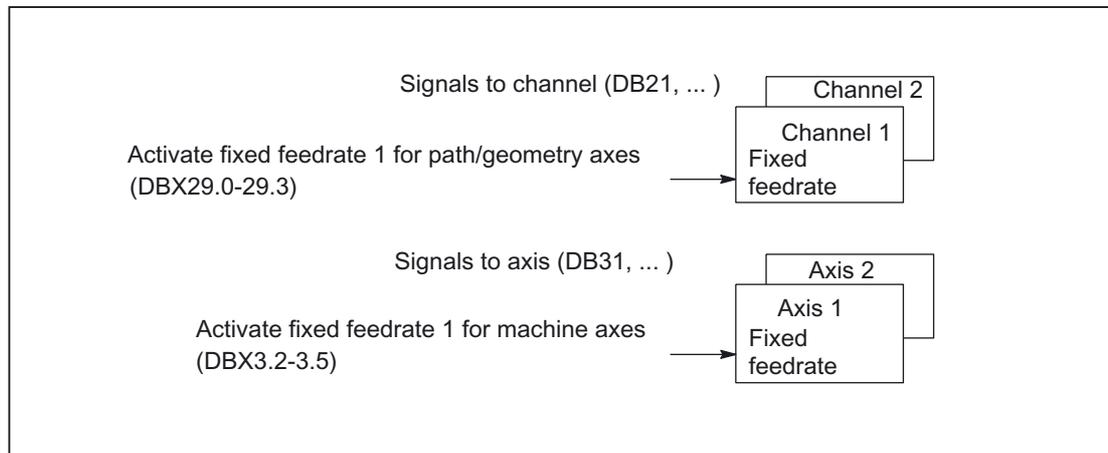


Figure 16-7 Overview of interface signals for fixed feedrate

## 16.4.8 Feedrate for chamfer/rounding FRC, FRCM

## General

The machining conditions can change significantly during surface transitions to chamfer/rounding. Hence, the chamfer/rounding contour elements require dedicated, optimized feedrate values to achieve the desired surface quality.

## Function

You can program the feedrate for the chamfer/rounding with `FRC` (non-modal) or `FRCM` (modal).

The feedrate value is interpreted according to the type of feedrate active:

G94, G961, G971:	Feedrate in mm/min, inch/min or %/min
G95, G96, G97:	Revolutional feedrate in mm/rev or inch/rev

The `FRC/FRCM` value is applied depending upon the machine data:  
MD20201 CHFRND\_MODE\_MASK

Bit 0 = 0:	FRC/FRCM from following block (default setting)
Bit 1 = 0:	FRC/FRCM from preceding block (recommended setting)

Reason: The feedrate type (G94, G95, G96, G961 etc.) and thus the conversion to the internal format must be consistent within the block for `F` and `FRC/FRCM`.

## Empty blocks

When chamfer or rounding is active, the possible number of blocks containing no traversing information is limited.

The maximum number is defined in machine data:  
MD20200 CHFRND\_MAXNUM\_DUMMY\_BLOCKS.

The possible blocks without traversing information in the compensation plane are pure dummy commands and are called empty blocks. For this reason, they may only be written between two blocks with traversing information.

## Boundary conditions

- Feedrate interpolation `FLIN` and `FCUB` is not possible for chamfer/rounding.
- `FRC/FRCM` has no effect if a chamfer is being machined with `G0`; the command can be programmed according to the `F` value without error message.
- `FRC` is only effective if a chamfer/rounding is programmed in the same block or if `RNDM` has been activated.
- `FRC` overwrites the `F` or `FRCM` value for chamfer/rounding in the current block.
- `FRC/FRCM` must be set to a value greater than zero.
- `FRCM=0` activates the feedrate programmed in `F` for the chamfer/rounding.
- If `FRCM` is programmed, the `FRCM` value must be reprogrammed, equivalent to `F`, on a `G94` ↔ `G95` change, etc. If only `F` is reprogrammed and `FRCM > 0` before the feedrate type is changed, error message 10860 (no feedrate programmed) appears.

## 16.4.9 Non-modal feedrate FB

### General

A separate feedrate can be specified for a single block with the command `FB` (Feed Block). The previously active path feedrate is overwritten for this block. After this block, the previous modal path feedrate is active again.

### Function

The non-modal feedrate is programmed with `FB=<value>`.

The feedrate is interpreted according to the active feedrate type:

G94, G961, G971:	Feedrate in mm/min or inches/min or %/min
G95, G96, G97:	Revolutional feedrate in mm/rev or inch/rev

### Boundary conditions

- The programmed value of `FB=<value>` must be greater than zero.
- If no traversing motion is programmed in the block (e.g.: Computational block), the `FB` has no effect.
- If no explicit feed for chamfering/rounding is programmed, then the value of `FB` also applies for any contour element chamfering/rounding in this block.
- The path speed profile programmed with `FLIN` or `FCUB` is not active together with revolutional feedrate for `G95` as well as with constant cutting speed for `G96/G961` and `G97/G971`.
- Feedrate interpolations `FLIN`, `FCUB`, .. are also possible without restriction.
- Simultaneous programming of `FB` and `FD` (handwheel travel with feed overlay) or `F` (modal path feedrate) is not possible.

## 16.4.10 Programmable single-axis dynamic response

### Single axes

Single axes can be programmed:

In the part program	POS[Axis]=...
	POSA[Axis]=...
	SPOS[Axis]=...
	SPOSA[Axis]=...
	OS[Axis]=...
	OSCILL[Axis]=...
In synchronized actions (command axes)	EVERY ... DO
	POS[Axis]=...
	SPOS [Spindle] = .....
	MOV[Axis]=...
In the PLC	FC15/FC16 and FC18

### Dynamic response of an axis/spindle

The dynamic response of an axis is dependent on:

- the preset feed value (MD32060 POS\_AX\_VELO)

Can be programmed in the part program with `FA[axis]= ...`, or a feed override `OVRA[axis]= ...` in percent.

Programmable in synchronized actions using `FA[Axis]= ....`

Modifiable from the PLC by entering `FRate`, or overwriting the axial override.

- The acceleration value (MD32300 MAX\_AX\_ACCEL)

Programmable indirectly in the part program by overwriting the machine data with subsequent `NewConfig`, or directly using a percentage acceleration override `ACC[Axis]= ....`

Modifiable indirectly in synchronized actions by overwriting the MD (no `NewConfig` possible) or by executing an `ASUB`, or programmable directly using a percentage acceleration override `ACC[Axis]= ...` (cannot be preset by the PLC).

The PLC has the same options as synchronized actions.

- The acceleration characteristics

Programmable in the part program using `BRISKA(axis)`, `SOFTA(axis)`, `DRIVEA(axis)` and `JERKA(axis)`.

Not programmable in synchronized actions (only directly using an `ASUB`).

Cannot be preset by the PLC (only indirectly using an `ASUB`).

- The selected servo parameter set

A parameter set describes the most important setting options for control purpose in the servo.

It comprises, e.g. the following axis-specific/spindle-specific machine data:

31050 DRIVE_AX_RATIO_DENOM[n]	Parameter set n for 0 to 5
31060 DRIVE_AX_RATIO_NUMERA[n]	Parameter set n for 0 to 5
32200 POSCTRL_GAIN[n]	Parameter set n for 0 to 5
32452 BACKLASH_FACTOR[n]	Parameter set n for 0 to 5
32610 VELO_FFW_WEIGHT[n]	Parameter set n for 0 to 5
32800 EQUIV_CURRCTRL_TIME[n]	Parameter set n for 0 to 5
32810 EQUIV_SPEEDCTRL_TIME[n]	Parameter set n for 0 to 5
32910 DYN_MATCH_TIME[n]	Parameter set n for 0 to 5
36012 STOP_LIMIT_FACTOR[n]	Parameter set n for 0 to 5
36200 AX_VELO_LIMIT[n]	Parameter set n for 0 to 5

For more information about parameter sets and programming, please refer to:

**References:**

/FB1/ Function Manual, Basic Functions; Velocities, Setpoint/Actual Value Systems, Closed-Loop Control (G2)

/PG/ Programming Guide, Fundamentals; Path Response and Feedrate Control

### Dynamic criteria and feedforward control

With dynamic response criteria, it must be distinguished from where they were set:

- In the part program
- or
- From a main-run interpolation (synchronized action or PLC default)

---

**Note**

Changes in the dynamic response made in a part program do not affect command axis or PLC axis movements.

Changes from synchronized actions do not affect the movements from a part program.

---

### Travel with feedforward control ON/OFF

The type of feedforward control and the path axes to which feedforward is to be applied are determined:

- Programmable in the part program with `FFWON/ FFWOF` for axes selected using machine data.
- Only indirectly programmable in synchronized actions (`ASUB`).
- Only indirectly programmable from the PLC (`ASUB`).

## Percentage acceleration override

### ACC[Axis]

ACC[Axis]= 0 .. 200 can be used to modify the acceleration set in machine data:  
MD32300 MAX\_AX\_ACCEL  
in a range between 0% and 200% in part programs and synchronized actions.

ACC[Axis]= <value>	Where	Axis =	Channel axis name (X, Y ...), spindle (S1, ...)
		Value =	Percent of MD32300 MAX_AX_ACCEL (0 <= value <= 200)

The current acceleration value can be called with the system variables \$AA\_ACC[Axis]. It is determined by:

$$\$AA\_ACC[Axis] = \text{Content}(\text{MD32300 MAX\_AX\_ACCEL}[Axis]) * \text{ACC}[Axis] / 100$$

MD 32320 DYN\_LIMIT\_RESET\_MASK can be used to control maintaining the ACC value in the event of channel RESET/M30.

### Note

The acceleration offset programmed with ACC[ . . . ] is always considered as specified above for the output in \$AA\_ACC. However, \$AA\_ACC is not output in the part program at the same time as in a synchronized action.

The value described in the part program is only considered in the system variable \$AA\_ACC as described in the part program, if ACC has not been changed in the meantime by a synchronized action.

The value described in the synchronized action is only considered in the system variable \$AA\_ACC as described in the synchronized action, if ACC has not been changed in the meantime by a part program.

## Main run axes

Main run axes (MR axes) are axes that are interpolated by the main run and can be:

- Command axes (activated by synchronized actions)
- PLC axes (started by PLC via function block)
- Asynchronous oscillating axes (setting data or from part program)
- Neutral axes

### Note

Depending on whether \$AA\_ACC is programmed in a part program or in a synchronized action, the ACC value is output for the NC axes or the main run axes.

Variable \$AA\_ACC must always be queried in the mode in which the acceleration was written (either part program or synchronized action).

## Examples

### In the part program

---

```
...  
N80 G01 POS[X]=100 FA[X]=1000 ACC[X]=90 IPOENDA[X]  
...
```

### Or via a synchronized action

---

```
...  
N100 EVERY $A_IN[1] DO POS[X]=50 FA[X]=2000 ACC[X]=140 IPOENDA[X]  
...
```

### Acceleration factor written in part program:

---

```
...  
ACC[X]=50  
RO $AA_ACC[X]  
  
IF (RO <> $MA_MAX_AX_ACCEL[X] * 0,5  
SETAL(61000)  
ENDIF
```

### Acceleration factor is set by the synchronized action:

---

```
WHEN TRUE DO ACC[X]=25 $R1 = $AA_ACC[X]  
G4 F1  
  
IF (RO <> $MA_MAX_AX_ACCEL[X] * 0.25  
SETAL(61001)  
ENDIF  
  
M30
```

## End-of-motion criterion for single axes

Similar to the block change criterion for path interpolation (G601, G602 and G603) it is also possible to program the movement end criterion for single-axis interpolation in a part program or in synchronized actions for main run axes: command/PLC axes.

Programmable criterion	end-of-motion on reaching
FINEA[Axis]	"Exact stop fine"
COARSEA[Axis]	"Exact stop coarse"
IPOENDA[Axis]	"Interpolator stop" (IPO stop)

Axis: Channel axis name (X, Y ...), spindle (S1, ...)

The end-of-motion criterion set will affect how quickly or slowly part program blocks and technology cycle blocks with single-axis movements are completed.

The same applies for PLC positioning instructions via FC15/16/18.

The set end-of-motion criterion can be scanned with system variable \$AA\_MOTEND[Axis].

\$AA_MOTEND[Axis] = 1	end-of-motion with "Exact stop fine"
\$AA_MOTEND[Axis] = 2	end-of-motion with "Exact stop coarse"
\$AA_MOTEND[Axis] = 3	end-of-motion with "IPO stop"

### Note

Depending on whether \$AA\_MOTEND is programmed in a part program or a synchronized action, the MOTEND value is output for the NC axes or the main-run axes.

The last programmed value is retained following a RESET.

### Example:

...
N80 G01 POS[X]=100 FA[X]=1000 ACC[X]=90 IPOENDA[X]
...

Or via a synchronized action
...
N100 EVERY \$A_IN[1] DO POS[X]=50 FA[X]=2000 ACC[X]=140 IPOENDA[X]

For more information about block changes and end-of-motion criteria for FINEA, COARSEA and IPOENDA, please refer to:

### References:

/FB2/ Function Manual, Extended Functions; Positioning Axes (P2);  
Chapter: Block change

## Programmable servo parameter set

**SCPARA[Axis] = ...**

SCPARA[axis]= ... can be used to program the parameter set (consisting of MDs) in the part program and in synchronized actions (previously, this could only be done via the PLC).

SCPARA[Axis]= <value>	Where	Axis =	Channel axis name (X, Y ...), spindle (S1, ...)
		Value =	Desired parameter set (1 ≤ value ≤ 6)

### DB3n DBB9 bit3

To prevent conflicts between the PLC user request and NC user request, a further bit is defined on the PLC→NCK interface:

DB3n DBB9 bit3 "Parameter set selection by SCPARA disabled".

The PLC user is thereby able to set up a structured sequence when using PLC parameter switchover and entries from synchronized actions or part programs simultaneously.

On a change of bit 3 (0 ⇒ 1 or 1 ⇒ 0), the entry is written to bits 0 - 2.

### Note

If parameter set selection via SCPARA is disabled, there is no error message if the latter is programmed nevertheless.

The current parameter set can be scanned by system variable \$AA\_SCPAR[Axis].

### Example:

```

...
N100 SCPARA[X]=3          ; The 3rd parameter set is selected for axis X.
...

```

## Constraints

- Different end-of-motion criteria will affect how quickly or slowly part program blocks are completed. This can have side effects for technology cycles and PLC user parts.
- The PLC user program must be expanded if the servo parameter set is to be changed both inside a part program or synchronous action and the PLC.
- After POWER ON, the following initial settings are made:

Percentage acceleration override for all single-axis interpolations	100%
End-of-motion criterion for all single-axis interpolations	FINEA
Servo parameter set defined by the NC	1

- When the operating mode is changed from AUTO  $\Rightarrow$  JOG, the programmed dynamic response changes remain valid.
- In the event of a `RESET`, the last programmed value remains for the part program specifications. The settings for main-run interpolations do not change.
- Block search:

The last end-of-motion criterion programmed for an axis is collected and output in an action block. The last block with a programmed end-of-motion criterion that was processed in the search run serves as a container for all programmed end-of-motion criteria for all axes.

**Example:**

```
N01 G01 POS[X]=20 POS[Y]=30 IPOENDA[X] IPOENDA[Y]
N02 POS[Z]=55 FINEA[Z]
N03 $A_OUT[1]=1
N04 POS[X]=100 COARSEA[X]
N05 .....
TARGET:                                ; Block search target
```

- In this example, `N04` serves as a container for all programmed end-of-motion criteria. Two action blocks are saved. The digital output (`N03`) is issued in the first action block and in the second, `COARSEA` is set for the X axis, `IPOENDA` for the Y axis and `FINEA` for the Z axis.

The same applies to the programmed servo parameter set. The last programmed acceleration override is effective from the first approach block.

## 16.5 Supplementary conditions

### 16.5.1 General boundary conditions

#### Several feeds in one block

The "Several feeds in one block" function is only available in conjunction with the: "Synchronized Actions" function.

**References:**

/FBSY/ Description of Functions Synchronized Actions

### 16.5.2 Supplementary conditions for feedrate programming

#### Unit of measurement

The applicable unit of measurement for feedrates is based on the value entered in machine data:

MD12240 SCALING\_SYSTEM\_IS\_METRIC  
(standard control system metric/imperial)

and the type of axis entered in machine data:

MD30300 IS\_ROT\_AX  
(rotary or linear axis).

#### Standard setting for feedrate type

G94 is displayed on the screen as the standard setting.

The initial setting (standard programming setting) for the feedrate type is only displayed when the part program starts up.

The initial setting is set in machine data:

MD20150 GCODE\_RESET\_VALUES (initial setting for G groups).

### Activation of the F values

Machine data:

MD22140 F\_VALUES\_ACTIVE\_AFTER\_RESET (F function active via RESET)

can be used to define whether the following most recently programmed F values are to remain active following a RESET.

- Programmed path feedrate: F= . . .
- Programmed feedrate change for path feedrate: OVR= . . .
- Programmed positioning feedrate: FA= . . .
- Programmed feedrate change for positioning feedrate: OVRA[U]= . . .

For more detailed information about syntax, please see:

**References:**

/PG/ Programming Guide, Fundamentals

### Position spindle

If G95, G96, G961, G97, G971, G33, G34, G35 is active, spindle positioning should not be performed, because the derived path feedrate following spindle positioning = 0.

⇒ If the programmed axis position has not yet been reached, the block cannot be completed.

## 16.6 Examples

### 16.6.1 Feedrate programming for chamfer/rounding FRC, FRCM

#### Example 1: Following block feedrate

MD20201 CHFRND\_MODE\_MASK Bit0 = 0  
(apply feedrate from following block; default setting)

```

N10 G0 X0 Y0 G17 F100 G94
N20 G1 X10 CHF=2 ; Chamfer N20-N30 with F=100 mm/min
N30 Y10 CHF=4 ; Chamfer N30-N40 with FRC=200 mm/min
N40 X20 CHF=3 FRC=200 ; Chamfer N40-N60 with FRCM=50 mm/min
N50 RNDM=2 FRCM=50
N60 Y20 ; Modal rounding N60-N70 with
FRCM=50 mm/min
N70 X30 ; Modal rounding N70-N80 with
FRC=100 mm/min
N80 Y30 CHF=3 FRC=100 ; Chamfer N80-N90 with
FRCM=50 mm/min (modal)
N90 X40 ; Modal rounding N90-N100 with
F=100 mm/min (deselection of FRCM)
N100 Y40 FRCM=0 ; Modal rounding N100-N120 with G95
FRC=1 mm/rev
N110 S1000 M3
N120 X50 G95 F3 FRC=1
...
M02

```

## Example 2: Feedrate of previous block

MD20201 CHFRND\_MODE\_MASK Bit0 = 1  
(accept feedrate of previous block; recommended setting)

```
N10 G0 X0 Y0 G17 F100 G94
N20 G1 X10 CHF=2 ; Chamfer N20-N30 with F=100 mm/min
N30 Y10 CHF=4 FRC=120 ; Chamfer N30-N40 with FRC=120 mm/min
N40 X20 CHF=3 FRC=200 ; Chamfer N40-N60 with FRC=200 mm/min
N50 RNDM=2 FRCM=50
N60 Y20 ; Modal rounding N60-N70 with
FRCM=50 mm/min
N70 X30 ; Modal rounding N70-N80 with
FRCM=50 mm/min
N80 Y30 CHF=3 FRC=100 ; Chamfer N80-N90 with
FRC=100 mm/min (modal)
N90 X40 ; Modal rounding N90-N100 with
FRCM=50 mm/min
N100 Y40 FRCM=0 ; Modal rounding N100-N120 with
F=100 mm/min
N110 S1000 M3
N120 X50 CHF=4 G95 F3 FRC=1 Chamfer N120-N130 with G95
FRC=1 mm/rev
N130 Y50 Modal rounding N130-N140
with F=3 mm/rev
N140 X60
...
M02
```

## 16.7 Data lists

### 16.7.1 Machine data

#### 16.7.1.1 NC-specific machine data

Number	Identifier: \$MN_	Description
10704	DRYRUN_MASK	Activation of dry run feedrate
10710	PROG_SD_RESET_SAVE_TAB	Setting data to be updated
11410	SUPPRESS_ALARM_MASK	Mask for suppressing special alarms
11550	STOP_MODE_MASK	Preventing stop events in the program section
12000	OVR_AX_IS_GRAY_CODE	Axis feedrate override switch Gray-coded
12010	OVR_FACTOR_AX_SPEED	Evaluation of the axis feed override switch
12020	OVR_FEED_IS_GRAY_CODE	Path feed override switch Gray-coded
12030	OVR_FACTOR_FEEDRATE	Evaluation of the path feed override switch
12040	OVR_RAPID_IS_GRAY_CODE	Rapid traverse override switch Gray-coded
12050	OVR_FACTOR_RAPID_TRA	Evaluation of the rapid traverse override switch
12060	OVR_SPIND_IS_GRAY_CODE	Spindle override switch Gray-coded
12070	OVR_FACTOR_SPIND_SPEED	Evaluation of the spindle override switch
12080	OVR_REFERENCE_IS_PROG_FEED	Override reference velocity
12082	OVR_REFERENCE_IS_MIN_FEED	Defining the reference of the path override
12090	OVR_FUNCTION_MASK	Selection of override specifications
12100	OVR_FACTOR_LIMIT_BIN	Limit for binary-coded override switch
12200	RUN_OVERRIDE_0	Traversing with override 0
12202	PERMANENT_FEED	Fixed feedrates for linear axes
12204	PERMANENT_ROT_AX_FEED	Fixed feedrates for rotary axes
12240	SCALING_SYSTEM_IS_METRIC	Basic system metric

#### 16.7.1.2 Channel-specific machine data

Number	Identifier: \$MC_	Description
20100	DIAMETER_AX_DEF	Geometry axes with transverse axis functions
20172	COMPRESS_VELO_TOL	Maximum permissible deviation from path feed for compression
20150	GCODE_RESET_VALUES	Reset G groups
20200	CHFRND_MAXNUM_DUMMY_BLOCKS	Maximal number of dummy blocks for chamfer/radii
20201	CHFRND_MODE_MASK	Feed for chamfer/rounding

Number	Identifier: \$MC_	Description
20660	THREAD_AUTO_LIFTFASTANGLE	Determination of retraction angle (thread cutting)
20750	ALLOW_GO_IN_G96	G0 logic in G96
21200	LIFTFAST_DIST	Traversing path for fast retraction from the contour
21220	MULTFEED_ASSIGN_FASTIN	Assignment of input bytes of NCK I/Os for "Multiple feeds in one block"
21230	MULTFEED_STORE_MASK	Store input signals for the "Multiple feeds in one block" function
22240	AUXFU_F_SYNC_TYPE	Output timing of F functions
22410	F_VALUES_ACTIVE_AFTER_RESET	F function active after RESET

### 16.7.1.3 Axis/spindle-specific machine data

Number	Identifier: \$MA_	Description
30300	IS_ROT_AX	Rotary axis
32000	MAX_AX_VELO	Maximum axis velocity
32060	POS_AX_VELO	Initial setting for positioning-axis velocity
32300	MAX_AX_ACCEL	Axis acceleration
32320	DYN_LIMIT_RESET_MASK	Reset behavior of dynamic limits
34990	ENC_ACTIVAL_SMOOTH_TIME	Smoothing time constant for actual values
35100	SPIND_VELO_LIMIT	Maximum spindle speed
35130	GEAR_STEP_MAX_VELO_LIMIT	Maximum speed of gear step
35140	GEAR_STEP_MIN_VELO_LIMIT	Minimum speed of gear step
35160	SPIND_EXTERN_VELO_LIMIT	Spindle-speed limitation via PLC

## 16.7.2 Setting data

### 16.7.2.1 Channel-specific setting data

Number	Identifier: \$SC_	Description
42000	THREAD_START_ANGLE	Start angle for thread
42010	THREAD_RAMP_DISP	Run-in and run-out path of feed axis with thread cutting
42100	DRY_RUN_FEED	Dry run feed
42101	DRY_RUN_FEED_MODE	Dry run feed mode
42110	DEFAULT_FEED	Default value for path feed
42600	JOG_FEED_PER_REV_SOURCE	In the JOG mode, revolutional feedrate for geometry axes on which a frame with rotation acts
43300	ASSIGN_FEED_PER_RES_SOURCE	Revolutional feedrate for positioning axes

### 16.7.2.2 Axis/spindle-specific setting data

Number	Identifier: \$SA_	Description
43210	SPIND_MIN_VELO_G25	Minimum spindle speed
43220	SPIND_MAX_VELO_G26	Maximum spindle speed
43230	SPIND_MAX_VELO_LIMS	Spindle-speed limitation with G96

## 16.7.3 Signals

### 16.7.3.1 Signals to channel

DB number	Byte.Bit	Description
21, ...	0.6	Activate dry run feed
21, ...	4	Feed override
21, ...	5	Rapid traverse override
21, ...	6.0	Feed disable
21, ...	6.6	Rapid traverse override active
21, ...	6.7	Feed override active
21, ...	12.3	Feed stop, geometry axis 1
21, ...	16.3	Feed stop, geometry axis 2
21, ...	20.3	Feed stop, geometry axis 3

### 16.7.3.2 Signals from channel

DB number	Byte.Bit	Description
21, ...	24.6	Dry run feed selected
21, ...	25.3	Feed override for rapid traverse selected
21, ...	29.0	Activate fixed feedrate 1 for path/geometry axes
	29.1	Activate fixed feedrate 2 for path/geometry axes
	29.2	Activate fixed feedrate 3 for path/geometry axes
	29.3	Activate fixed feedrate 4 for path/geometry axes
21, ...	318.6	Dry run feedrate active

### 16.7.3.3 Signals to axis/spindle

DB number	Byte.Bit	Description
31, ...	0	Feed/spindle override
31, ...	1.7	Override active
31, ...	3.2	Activate fixed feedrate 1 for machine axis
	3.3	Activate fixed feedrate 2 for machine axis
	3.4	Activate fixed feedrate 3 for machine axis
	3.5	Activate fixed feedrate 4 for machine axis
31, ...	4.3	Feed stop/spindle stop
31, ...	62.2	Revolutional feedrate active
31, ...	81	F function for positioning axis
31, ...	83.1	Programmed speed too high



## Tool Offset (W1)

### 17.1 Short description

#### Calculating tool compensation data

The SINUMERIK 840D control can be used to calculate the following tool compensation data:

- Length compensation
- Radius compensation
- Storage of tool data in a flexible tool offset memory:
  - Tool identification with T numbers from 0 to 32000
  - Definition of a tool with a maximum of 9 cutting edges
  - Cutting edge described by up to 25 tool parameters
- Tool selection selectable: Immediate or via selectable M function
- Tool radius compensation:
  - Selection and deselection strategy configurable: Normal or contour-related
  - Compensation active for all interpolation types:
    - Linear
    - Circle
    - Helical
    - Spline
    - Polynomial
    - Involute
  - Compensation at outer corners selectable:
    - Transition circle/ellipse (G450) or equidistant intersection (G451)
  - Parameter-driven adaptation of G450/G451 functions to the contour
  - Free traversing on outer corners with G450 and DISC parameter
  - Number of dummy blocks without axis motion selectable in the compensation plane

- Collision detection selectable:  
Possible contour violations are detected predictively, if:
  - Path is shorter than tool radius
  - Width of an inside corner is shorter than the tool diameter
- Keep tool radius compensation constant
- Intersection procedure for polynomials

### Toolholder with orientation capability

This function permits the machining of inclined surfaces with allowance for tool length compensation, provided that the kinematics of the toolholder (without NC axes) permits a static orientation of the tool. The more complex 5-Axis transformation is not required for this case.

**References:**

/FB3/ Function Manual, Special Functions; 3- to 5-Axis Transformation (F2)

Appropriate selection of the tool data and toolholder data describes the kinematics for the control such that it can make allowance for the tool length compensation. The control can take some of the description data direct from the current frame.

---

**Note**

Please refer to the following documentation for further information on tools and tool compensations and a full technical description of the general and specific programming features for tool compensation (TLC and TRC):

**References:**

/PG/ Programming Manual Fundamentals

---

### Flat/Unique D number structure

Compensations can be selected via unique D numbers with management function.

### Special handling of tool compensations

The evaluation of signs can be controlled for tool length and wear by the setting data:

SD42900 \$SC\_MIRROR\_TOOL\_LENGTH (Sign change tool length when mirroring)

SD42960 \$SC\_TOOL\_TEMP\_COMP (Temperature compens. regarding tool).

The same applies to the response of the wear components when mirroring geometry axes or changing the machining plane via setting data.

**References:**

/PG/ Programming Manual Fundamentals; Tool compensations

## **G461/G462**

In order to enable the solid machining of inside corners in certain situations with the activation and deactivation of tool radius compensation, commands G461 und G462 have been introduced and the approach/retraction strategy has thus been extended for tool radius compensation.

- G461

If no intersection is possible between the last TRC block and a previous block, the control calculates an intersection by extending the offset curve of this block with a circle whose center point coincides with the end point of the non-corrected block, and whose radius is equal to the tool radius.

- G462

If no intersection is possible between the last TRC block and a previous block, the control calculates an intersection by inserting a straight line at the end point of the last block with tool radius compensation (the block is extended by its end tangent).

## **Changing from G40 to G41/G42**

The change from G40 to G41/G42 and vice versa is no longer treated as a tool change for tools with relevant tool point direction (turning and grinding tools).

## **Tool compensation environments**

Functions, which enable the following actions in relation to the current states of tool data, are available in SW 7.1:

- Save
- Deletion
- Read
- Modify

Some of the functions were previously implemented in measuring cycles. They are now universally available.

A further function can be used to determine information about the assignment of the tool lengths of the active tool to the abscissa, ordinate and applicate.

## 17.2 Tool

### 17.2.1 General

#### Select tool

A tool is selected in the program with the T function.

Whether the new tool will be loaded immediately by means of the T function depends on the setting in the machine data:

\$MC\_TOOL\_CHANGE\_MODE (new tool compensation with M function) determines whether the new tool is loaded immediately on execution of the T function.

#### Change tool immediately

MD22550 \$MC\_TOOL\_CHANGE\_MODE = 0 (new tool compensation with M function).

The new tool is changed immediately with the T function.

This setting is used mainly for turning machines with tool revolver.

#### Change tool with M06

MD22550 \$MC\_TOOL\_CHANGE\_MODE = 1 (new tool compensation with M function).

The new tool is prepared for changing with the T function.

This setting is used mainly on milling machines with a tool magazine, in order to bring the new tool into the tool change position without interrupting the machining process.

The old tool is removed from the spindle and the new tool is loaded into the spindle with the entered M function in the machine data:

MD22560 \$MC\_TOOL\_CHANGE\_M\_CODE (M function for tool change)

This tool change must be programmed with the M function M06, in accordance with DIN 66025.

The next tool is preselected with the machine data:

MD20121 \$MC\_TOOL\_PRESEL\_RESET\_VALUE (Preselected tool at RESET)

Its tool length compensation values must be considered at RESET and powerup according to machine data:

MD20110 \$MC\_RESET\_MODE\_MASK (Determination of control default settings after RESET/TP end).

#### Value range of T

The T function accepts the following whole numbers:

- From T0 (no tool)
- To T32000 (tool number 32000).

## Tool cutting edge

Each tool can have up to 9 cutting edges. The 9 tool cutting edges are assigned to the D functions D1 to D9.

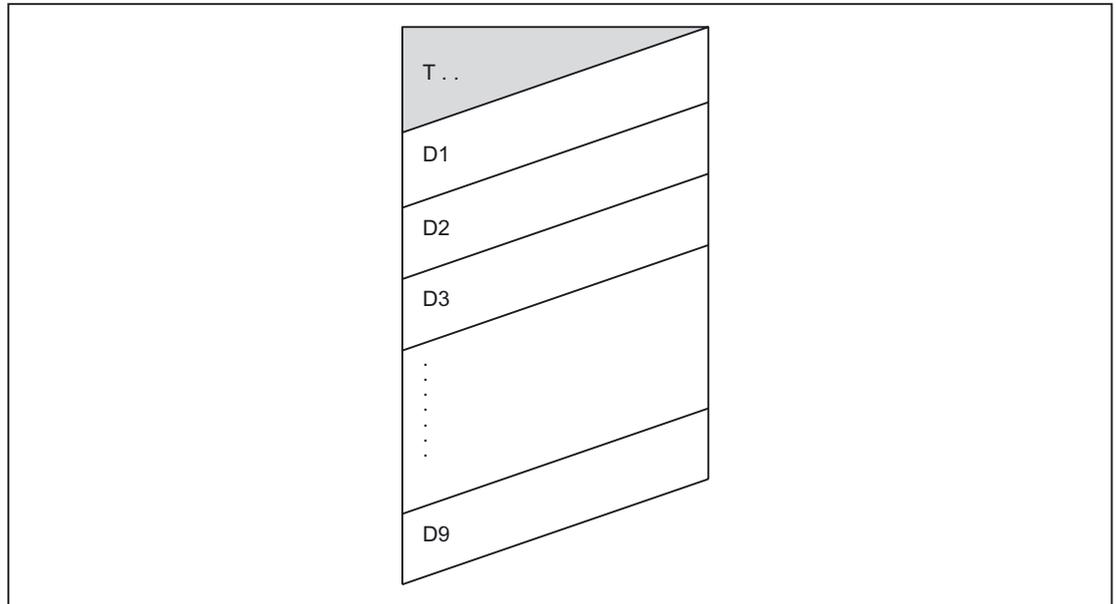


Figure 17-1 Example of a tool T... with 9 cutting edges (D1 to D9)

## D function

The tool cutting edge is programmed with D1 (edge 1) to D9 (edge 9). The tool cutting edge always refers to the currently active tool. An active tool cutting edge (D1 to D9) without an active tool (T0) is inactive. Tool cutting edge D0 deselects all tool compensations of the active tool.

## Selection of the cutting edge when changing tool

When a new tool (new T number) has been programmed and the old one replaced, the following options are available for selecting the cutting edge:

- The cutting edge number is programmed.
- The cutting edge number is defined by the machine data:  
MD20270 \$MC\_CUTTING\_EDGE\_DEFAULT (Basic setting of tool cutting edge without programming)

Value	Significance
= 0	No automatic cutting edge selection in accordance with M06
< > 0	Number of the cutting edge, which is selected in accordance with M06
= -1	The cutting edge number of the old tool is retained and is also selected for the new tool, in accordance with M06.

### Activating the tool compensations

D1 to D9 activate the tool compensation for a cutting edge on the active tool. Tool length compensation and tool radius compensation can be activated at different times:

- **Tool length compensation (TLC)** is performed on the first traversing motion of the axis, on which the TLC is to act.

This traversing motion must be a linear interpolation (G0, G1, POS, POSA) or polynomial interpolation (POLY). If the POS/POSA axis is one of the active geometry axes, the tool length compensation is applied with the first axis motion in which the WLK is supposed to act.

- **Tool radius compensation (TRC)** becomes active when G41/G42 is programmed in the active plane (G17, G18 or G19).

The selection of tool radius compensation with G41/G42 is only permitted in a program block with G0 (rapid traverse) or G1 (linear interpolation).

## 17.2.2 Compensation memory structure

### Tool compensation memory size

Each channel can have a dedicated tool compensation memory (TO unit).

Which tool compensation memory exists for the relevant channel is set with the machine data:

MD28085 \$MC\_MM\_LINK\_TOA\_UNIT (Assignment of TO unit to a channel).

The maximum number of tool cutting edges for all tools managed by the NCK is set with the machine data:

MD18100 \$MN\_MM\_NUM\_CUTTING\_EDGES\_IN\_TOA (number of tool cutting edges in NCK).

### Tools

The TO memory consists of tools numbered T1 to T32000.

Each tool can be set up via TOA files or individually, using the "New tool" soft key. Compensation values not required must be assigned the value zero. (this is the default setting when the offset memory is created): The individual values in the offset memory (tool parameters) can be read and written from the program using system variables.

---

#### Note

The tools (T1 to T32000) do not have to be stored in ascending order or contiguously in the tool compensation memory, and the first tool does not have to be assigned number T1.

---

### Tool cutting edges

Each tool can have up to 9 cutting edges (D1 to D9). The first cutting edge (D1) is set up automatically when a new tool is loaded in the tool compensation memory. Other cutting edges (up to 8) are set up consecutively and contiguously using the "New cutting edge" soft key. A different number of tool cutting edges can be assigned to each tool in this way.

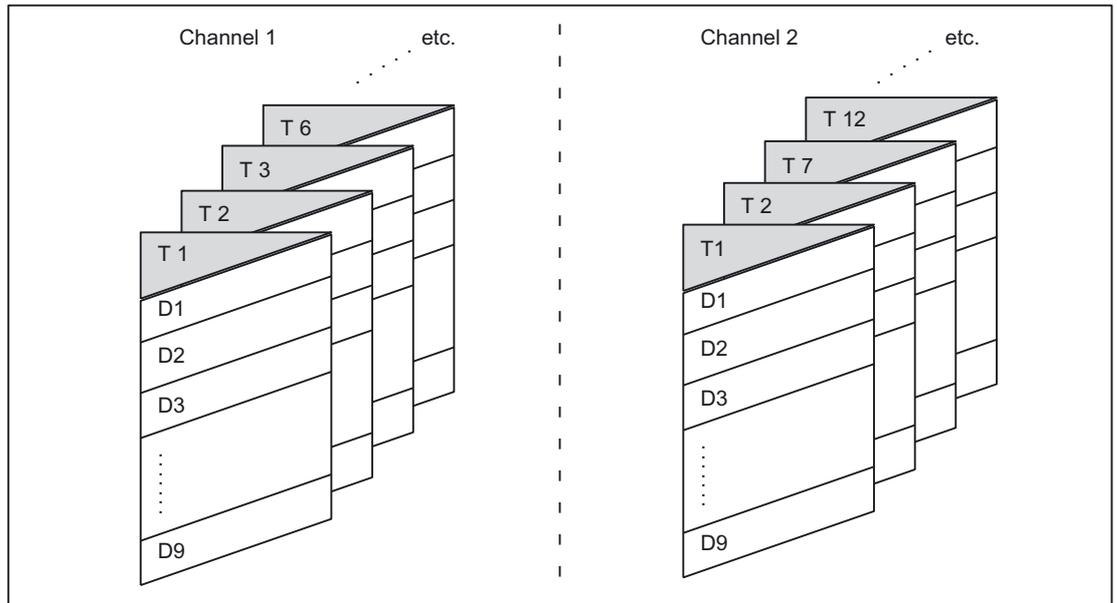
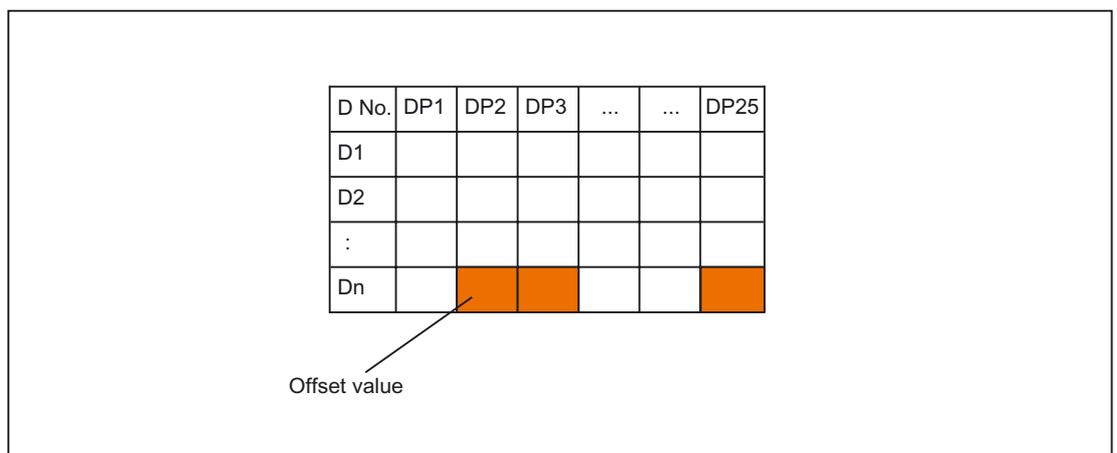


Figure 17-2 Example of a tool compensation memory structure for 2 channels

### 17.2.3 Calculating the tool compensation

#### D No.

The D no. is sufficient for calculating the tool compensations (can be set via MD).



## Programming

The above compensation block is to be calculated in the NC.

Part program call:

```
| ...  
| Dn
```

### 17.2.4 Address extension for NC addresses T and M

#### MD20096

Whether also with tool management **not** activated, the address extension of T and M is to be interpreted as spindle number, can be set through the machine data:

MD20096 \$MC\_T\_M\_ADDRESS\_EXT\_IS\_SPINO (spindle number as address extension).

The same rules then apply to the reference between the D number and T number as when the "Tool management" function is active.

#### Effect on the D number

A compensation data set is determined by the D number.

The D address cannot be programmed with an address extension.

The evaluation of the D address always refers to the currently active tool.

The programmed D address refers to the active tool in relation to the master spindle (same as for tool management function), when machine data is set:

MD20096 \$MC\_T\_M\_ADDRESS\_EXT\_IS\_SPINO = TRUE (spindle number as address extension).

#### Effect on the T number

If the "Tool management" function is active, the values programmed with reference to the master spindle (or master toolholder) are displayed as programmed/active T numbers.

If tool management is not active, **all** programmed T values are displayed as programmed/active, regardless of the programmed address extension.

Only the T value programmed in relation to the master spindle is shown as programmed/active, when:

MD20096 \$MC\_T\_M\_ADDRESS\_EXT\_IS\_SPINO = TRUE (spindle number as address extension).

## Example

The example below shows the effect of MD20096.

Two spindles are considered. Spindle 1 is the master spindle. M6 was defined as the tool change signal.

```
T1 = 5
M1 = 6
T2 = 50
M2 = 6
D4
```

- If tool management is active, D4 refers to tool "5".  
T2=50 defines the tool for the secondary spindle, whose tool does not influence the path compensation. The path is determined exclusively by the tool programmed for the master spindle.
- D4 relates to tool "50" without active tool management and with the machine data:  
MD20096 \$MC\_T\_M\_ADDRESS\_EXT\_IS\_SPINO = **FALSE** (significance of address extension on T, M tool change).  
The address extensions of neither T nor M are evaluated in the NCK.  
Each tool change command defines a new path compensation.
- D4 relates to tool "5" (as when tool management is active) without active tool management and with the machine data:  
MD20096 \$MC\_T\_M\_ADDRESS\_EXT\_IS\_SPINO = **TRUE**.  
Address extension 1 (T1= ..., M1= ...) addresses the master spindle.

---

### Note

Previously, when tool management was not activated, each tool change command (programmed with T or M) caused the tool compensation to be recalculated in the path. The address extension is not defined further by this operation. The significance of the extension is defined by the user (in the PLC user program).

---

## 17.2.5 Free assignment of D numbers

### "Relative" D numbers

In the NCK, it is possible to manage the D numbers as "relative" D numbers for the tool compensation data sets. The corresponding D numbers are assigned to each T number. The maximum number of D numbers was previously limited to 9.

### Functions

Expansions to functions when assigning D numbers:

- The maximum permitted D numbers are defined via the machine data:  
MD18105 \$MN\_MM\_MAX\_CUTTING\_EDGE\_NO (Max. value of the D-numbers (DRAM))  
The default value is 9, in order to maintain compatibility with existing applications.
- The number of cuts (or the offset data sets) **for each tool** can be defined via the machine data:  
MD18106 \$MN\_MM\_MAX\_CUTTING\_EDGE\_PERTOOL (Max. number of the D numbers per tool (DRAM))  
This allows you to customize the number of cutting edges to be configured for each tool to the actual number of real cutting edges for monitoring purposes.
- It is also possible to rename D numbers in the NCK and thus to allocate any D numbers to the cutting edges.

---

#### Note

In addition to relative D number allocation, the D numbers can also be assigned as "flat" or "absolute" D numbers (1-32000) without a reference to a T number (within the "Flat D number structure" function).

---

### Cutting edge number CE

When you rename D numbers, the information in the tool Catalog detailing the numbers defined for these cutting edges is lost. It is, therefore, impossible to determine, following renaming, which cutting edge of the Catalog is being referenced.

Since this information is required for retooling procedures, a **cutting edge number CE** has been introduced for each cutting edge. This number remains stored when the D number is renamed.

The D number identifies the cutting edge compensation in the part program. This **compensation number D** is administered separately from the **cutting edge number CE** (the number in the tool Catalog). Any number can be used. The number is used to identify a compensation in the part program and on the display.

The CE number identifies the actual physical cutting edge during retooling. The cutting edge number CE is not evaluated by the NCK on compensation selection during a tool change (only available via the OPI).

The cutting edge number CE is defined with system variable  $\$TC\_DPCE[t,d]$ :

- **t** stands for the internal T number.
- **d** stands for the D number.

Write accesses are monitored for collisions, i.e. all cutting edge numbers of a tool must be different. The variable  $\$TC\_DPCE$  is a component of the cutting edge parameter data set  $\$TC\_DP1$  to  $\$TC\_DP25$ .

It is only practical to parameterize  $\$TC\_DPCE$  if the maximum cutting edge number (MD18105) is greater than the maximum number of cutting edges per tool (MD18106).

In this case, the default cutting edge number is the same as the classification number of the cutting edge. Compensations of a tool are created starting at number 1 and are incremented up to the maximum number of cutting edges per tool (MD18106).

The cutting edge number CE is the same as the D number (in compatibility with the behavior till now) if:

$$MD18105 \leq MD18106.$$

A read operation returns  $CE=D$ . A write operation is ignored without an alarm message.

---

#### Note

The compensation values  $\$TC\_DP1$  to  $\$TC\_DP25$  of the active tool compensation can be read with system variable  $\$P\_AD[n]$ , where  $n=1$  to 25. The CE cutting edge number of the active compensation is returned with  $n=26$ .

---

## Commands

When the maximum cutting edge number:

MD18105  $\$MN\_MM\_MAX\_CUTTING\_EDGE\_NO$  (Max. value of the D numbers (DRAM)) is greater than the maximum number of cutting edges per tool:

MD18106  $\$MN\_MM\_MAX\_CUTTING\_EDGE\_PERTOOL$  (Max. number of D numbers per tool (DRAM))

the following commands are available:

Command	Significance
CHKDNO	Checks the uniqueness of the available D numbers. The D numbers of all tools defined within a TO unit may not occur more than once. No allowance is made for replacement tools.
GETDNO	Determines the D number for the cutting edge of a tool. If no D number matching the input parameters exists, $d=0$ . If the D number is invalid, a value greater than 32000 is returned.
SETDNO	Sets or changes the D number of the CE cutting edge of tool T. If there is no data block for the specified parameter, the value <code>FALSE</code> is returned. Syntax errors generate an alarm. The D number cannot be set explicitly to 0.

Command	Significance
GETACTTD	<p>Determines the associated T number for an absolute D number.</p> <p>There is not check for uniqueness. If several D numbers within a TO unit are the same, the T number of the first tool found in the search is returned.</p> <p>This command is not suitable for use with "flat" D numbers, because the value 1 is always returned in this case (no T numbers in database).</p>
DZERO	<p>Marks all D numbers of the TO unit as invalid.</p> <p>This command is used for support during retooling.</p> <p>Compensation data sets tagged with this command are no longer verified by the CHKDNO language command. These data sets can be accessed again by setting the D number once more with SETDNO.</p>

**Note**

If the maximum cutting edge number is smaller than the maximum number of cutting edges per tool (**MD18105 < MD18106**), the language commands described do not affect the system.

This relation is preset in the NCK as standard, in order to maintain compatibility with existing applications.

The individual commands are described in detail in:

**References:**

/PG/ Programming Manual Fundamentals

**Activation**

In order to work with unique D numbers and, therefore, with the defined language commands, it must be possible to name D numbers freely for the tools.

The following conditions must be fulfilled for this purpose:

- MD18105 > MD18106
- The 'flat D number' function is not activated.

MD18102 \$MN\_MM\_TYPE\_OF\_CUTTING\_EDGE (type of D number programming (SRAM)).

## Examples

**MD18105 \$MN\_MM\_MAX\_CUTTING\_EDGE\_NO** (Max. value of the D numbers (DRAM))

A maximum of one compensation can be defined per tool (with D number = 1).

---

### Note

When the "Flat D numbers" function is active, only one D compensation can be defined in the TO unit.

---

**MD18105 \$MN\_MM\_MAX\_CUTTING\_EDGE\_NO = 9999**

Tools can be assigned unique D numbers.

For example:

- D numbers 1, 2, 3 are assigned to T number 1
- D numbers 10, 20, 30, 40, 50 are assigned to T number 2
- D numbers 100, 200 are assigned to T number 3
- etc.

CHKDNO; **MD18105 \$MN\_MM\_MAX\_CUTTING\_EDGE\_NO = 9999**

The following data are to be checked for unique D numbers:

- T number 1 with D numbers 1, 2, 3
- T number 2 with D numbers 10, 20, 30, 40, 50
- T number 3 with D numbers 100, 200, 30  
(typing error during definition: 30 was entered instead of 300)

CHKDNO	The FALSE state is returned when the above constellation is checked because D=30 has been entered twice.
CHKDNO (2, 3, 30)	The FALSE state is returned when the specified D number 30 is checked because D=30 has been entered twice.
CHKDNO (2, 3, 100)	The TRUE state indicates that D=100 has been entered just once.
CHKDNO (1, 3)	The TRUE state is returned although there is a conflict between the D=30 of the third tool and D=30 of the second tool.

**MD18106 \$MN\_MM\_MAX\_CUTTING\_EDGE\_PERTOOL = 1** (Max. number of the D numbers per tool (DRAM))

Only tools with just one cutting edge are used. The value 1 of the machine data inhibits the definition of a second cutting edge for a tool.

**MD18106 \$MN\_MM\_MAX\_CUTTING\_EDGE\_PERTOOL = 12**

A maximum of 12 cutting edges can be defined per tool.

## Programming examples

### Renaming a D number

The D number of cutting edge CE = 3 is to be renamed from 2 to 17. The following specifications apply:

- Internal T number T = 1
- D number = 2
- Tool with one cutting edge with:

```
$TC_DP2[ 1, 2 ] = 120
$TC_DP3[ 1, 2 ] = 5.5
$TC_DPCE[ 1, 2 ] = 3 ;Cutting edge number CE
```

- MD18105 \$MN\_MM\_MAX\_CUTTING\_EDGE\_NO = 20 (Max. value of the D numbers (DRAM))

Within the part program, this compensation is programmed as standard with T1, . . . .D2.

You assign the current D number of cutting edge 3 to a variable (DNoOld) and define the variable DNoNew for the new D number:

```
def int DNoOld, DNoNew = 17
DNoOld = GETDNO( 1, 3 )
SETDNO( 1, 3, DNoNew )
```

The new D value 17 is then assigned to cutting edge CE=3.

Now the data for the cutting edge are addressed via D number 17, both via the system variable and in programming with the NC address D.

This compensation is now programmed in the part program with T1, . . . .D17 and the data are addressed as follows:

```
$TC_DP2[ 1, 17 ] = 120
$TC_DP3[ 1, 17 ] = 5.5
$TC_DPCE[ 1, 17 ] = 3 ;Cutting edge number CE
```

---

### Note

If a further cutting edge has been defined for the tool, e.g. \$TC\_DPCE[ 1, 2 ] = 1 ; = CE, the D-number 2 of the cutting edge 1 cannot have the same name as the D-number of the cutting edge 3 i.e.: SETDNO( 1, 1, 17) returns the status = FALSE as return value.

---

**DZERO - Invalidate D numbers**

The activation of this command invalidates all D numbers of the tools in the TO unit. It is no longer possible to activate a compensation until valid D numbers are again available in the NCK. The D numbers must be reassigned using the `SETDNO` command.

The following tools must be defined (all with cutting edge number 1):

T1, D1	D no. of cutting edge CE=1
T2, D10	D no. of cutting edge CE=1
T3, D100	D no. of cutting edge CE=1

The following command is then programmed:

```
DZERO
```

If one of the compensations is now activated (e.g. with T3 D100), an alarm is generated, because D100 is not currently defined.

The D numbers are redefined with:

```
SETDNO( 1, 1, 100 )      ;T=1, cutting edge 1 receives the (new) D number 100
SETDNO( 2, 1, 10 )      ;T=2, cutting edge 1 receives the (old) D number 10
SETDNO( 3, 1, 1 )       ;T=3, cutting edge 1 receives the (new) D number 1
```

**Note**

In the event of a power failure, the `DZERO` command can leave the NCK in an undefined state with reference to the D numbers. If this happens, repeat the `DZERO` command when the power is restored.

### Operating principle of a retooling program

Let us assume you want to ensure that the required tools and cutting edges are available. The status of the tool-holding magazine of the NCK is arbitrary. The D numbers in the part programs for the new machining operation generally do not match the D numbers of the actual cutting edges. The retooling program can have the following appearance:

```

DZERO                ; All D numbers of the TO unit are tagged as invalid.
....                ; One or more loops over the locations of the magazine(s)
                    ; to check the tools and their cutting edge numbers.
                    ; If a tool is found, which is still enabled ($TC_TP8) and
                    ; has the required cutting edge number CE (GETDNO), the new
                    ; D number is allocated to the cutting edge (SETDNO).
....                ; Loading and unloading operations are performed.
                    ; It is possible to work with the tool status "to be
                    ; unloaded" and "to be loaded".
CHKDNO               ; Loading/unloading and the operation for renaming D
                    ; numbers are complete.
                    ; Individual tools and/or D numbers can be checked, and
                    ; collisions can be handled automatically according to the
                    ; return value.

```

### 17.2.6 Compensation block in case of error during tool change

#### MD22550

If a tool preparation has been programmed in the part program and the NCK detects an error (e.g. the data set for the programmed T number does not exist in the NCK), the user can assess the error situation and perform appropriate tasks, in order to subsequently resume machining.

The tool change may be programmed independently, depending on the machine data:

MD22550 \$MC\_TOOL\_CHANGE\_MODE (new tool compensation with M function).

**MD22550 \$MC\_TOOL\_CHANGE\_MODE = 0**

```

T= "T no."          ; Tool preparation + tool change in one NC block,
                    ; i.e. when T is programmed a new D compensation becomes
                    ; active in the NCK (see
                    ; machine data MD20270 $MC_CUTTING_EDGE_DEFAULT)

```

**MD22550 \$MC\_TOOL\_CHANGE\_MODE = 1**

```

T= "T no."      ; Tool preparation
M06             ; Change tool
                ; (the number of the tool-change M code can be changed),
                ; i.e. when M06 is programmed a new D compensation becomes
                ; active in the NCK (see
                ; machine data MD20270 $MC_CUTTING_EDGE_DEFAULT)

```

The following problems can occur if tool management is not active:

- D compensation data set missing
- Error in part program

**Note**

The "tool not in magazine" problem cannot be detected since the NCK did not have access to any magazine information during tool compensation.

**D compensation data set missing**

Program execution is interrupted at the block containing the invalid D value (regardless of the value of machine data MD22550). The operator must either correct the program or reload the missing data set.

To do this, he needs the D number for the flat D number function, or otherwise the T number as well. These parameters are transferred when the alarm is triggered.

**Error in part program**

The options for intervention in the event of an error depend on how the tool change was programmed, defined via the machine data:

MD22550 \$MC\_TOOL\_CHANGE\_MODE (new tool compensation with M function).

**Tool change with T programming (MD22550 = 0)**

In this case, the "Compensation block" function available in the NCK is used. The NC program stops at the NC block in which a programmed T value error was detected. The "Compensation block" is executed again when the program is resumed.

The operator can intervene as follows:

- Correct the part program.
- Reload the missing cutting edge compensation data from the HMI.
- Include the missing cutting edge compensation data in the NCK using "Overstore".

Following operator intervention, the START key is pressed and the block, which caused the error, is executed again. If the error was corrected, the program is continued. Otherwise, an alarm is output again.

**Tool change with T and M06 programming (MD22550 = 1)**

In this case, an error is detected in the NC block containing the tool preparation (T programming), however this error is to be ignored initially. Processing continues until the tool change request (usually M06) is executed. The program is to stop at this point.

The programmed T address can contain any number of program lines ahead of the M06 command, or the two instructions can appear in different (sub)programs. For this reason, it is not usually possible to modify a block or a compensation block, which has already been executed.

The operator has the same options for intervention as with = 0.

Reloading of missing data is possible. In this case, however, T must be programmed with "Overstore".

If a program error has occurred, the line with the error cannot be corrected (Txx); only the line at which the program stopped and which generated the alarm can be edited. Only when machine data:

MD22562 \$MC\_TOOL\_CHANGE\_ERROR\_MODE Bit0 = 1 (response on errors in tool change).

The sequence is as follows:

```
Txx          ; Error! Data set with xx does not exist.
              ; Detect state; detect xx;
              ; continue in program
.....
M06          ; Detect bit memory "xx missing" → output alarm,
              ; stop program
              ; Correct block with, e.g. Tyy M06, start,
              ; block Tyy M06 interpreted and OK.
              ; Machining continues.
```

The following occurs when this part of the program is executed again:

```
Txx          ; Error! Data set with xx does not exist,
              ; Detect state; detect xx;
              ; continue in program
.....
Tyy M06     ; Detect bit memory "xx missing" → cancel without further
              response,
              ; as Tyy M06 is correct → program does not stop (correct).
```

If necessary, the original point of the T call can be corrected after the end of the program. If the tool change logic on the machine cannot process this, the program must be aborted and the point of the error corrected.

If only one data set is missing, it is transferred to the NCK, Txx is programmed in "Overstore" and the program is subsequently resumed.

---

As in the case of "missing D number", the required parameter (T number) can be accessed by the user for "missing T number" via the appropriate alarm (17191).

---

**Note**

In order to enable program correction, it stops immediately at the faulty Txx block.

The program text operation is also stopped when machine data:

MD22562 \$MC\_TOOL\_CHANGE\_ERROR\_MODE Bit0=1 (response on errors in tool change).

---

## 17.2.7 Definition of the effect of the tool parameters

### MD20360

The effect of the tool parameters on the transverse axis in connection with diameter programming can be controlled selectively with the machine data:

MD20360 \$MC\_TOOL\_PARAMETER\_DEF\_MASK (definition of tool parameters).

Details are described with the mentioned MD

### DRF handwheel traversal with half distance

During DRF handwheel traversal, it is possible to move a transverse axis through only half the distance of the specified increment as follows:

Specify the distance with handwheel via the machine data:

MD11346 \$MN\_HANDWHEEL\_TRUE\_DISTANCE = 1 (handwheel path or speed specification).

Define the DRF offset in the transverse axis as a diameter offset with the machine data:

MD20360 \$MC\_TOOL\_PARAMETER\_DEF\_MASK Bit 9 = 1 (definition of tool parameters).

Deselecting an axial DRF compensation ( $DRFOF$ ) also deletes an existing tool compensation (handwheel override in tool direction).

---

**Note**

For further information about superimposed movements with the handwheel, please refer to:

**References:**

/FB2/ Function Manual, Extended Functions; Jog With/Without Handwheel (H1)

/PG/ Programming Manual Fundamentals (The Programming Guide describes the complete technical descriptions in order to deselect the DRF offset by axis.)

---

## 17.3 Flat D number structure

### 17.3.1 General

#### Simple tool management

Simple tool management (no replacement tools, no magazines) using D numbers is possible for turning machines.

The function is available in the basic level of tool management (without tool management function activated). Grinding tools cannot be defined using this function.

#### Activation

Which type of D number management is valid may be set via the machine data:

MD18102 \$MN\_MM\_TYPE\_OF\_CUTTING\_EDGE (type of D number programming).

Value	Significance
0	As previously = default setting
1	Flat D number structure with absolute <b>direct D programming</b>

Cutting edges can be deleted individually via PI command or NC programming command. Cutting edges with a specific number can also be created selectively using HMI.

### 17.3.2 Creating a new D number (compensation block)

#### Programming

Tool compensations can be programmed with system variables \$TC\_DP1 to \$TC\_DP25. The contents have the same meaning as before.

The syntax changes: no T number is specified.

- "Flat D number" function **active**:

**\$TC\_DPx[d]** = value ;where x=parameter no., d=D number

i.e. data with this syntax can only be loaded to the NCK if the "Flat D number" function is activated.

- "Flat D number" function **inactive**:

**\$TC\_DPx[t][d]** = value ;where t=T number, d=D number

A D number can only be assigned once for each tool, i.e. each D number stands for exactly one compensation data block.

A new data block is stored in the NCK memory when a D number that does not exist is created for the first time.

The maximum number of D or offset data blocks (max. 600) is set via the machine data:  
MD18100 \$MN\_MM\_NUM\_CUTTING\_EDGES\_IN\_TOA (tool compensations in TO area).

### **Data backup**

Data backup is carried out in the same format, i.e. a backup file created with the "Flat D number" function cannot be loaded on the NCK of a control that has not activated the function.

This also applies in reverse for transfer.

### **D range**

1 - 99 999 999

## **17.3.3 D number programming**

### **MD18102**

How the D number is programmed can be set via the machine data:

MD18102 \$MN\_MM\_TYPE\_OF\_CUTTING\_EDGE (type of D number programming).

**D0** still contains the previous significance, "Deselection of active compensation in NCK".

### **Address extension of D**

It is not possible to extend the address of D. Only one active compensation data block is possible for the tool path at a given time.

### **Direct, absolute programming**

Programming in the part program is carried out as before. Only the value range of the programmed D number is increased.

#### **Example 1**

MD22550 \$MC\_TOOL\_CHANGE\_MODE = 0 (new tool compensation with M function).

MD18102 \$MN\_MM\_TYPE\_OF\_CUTTING\_EDGE = 1 (type of D number programming).

MD20270 \$MC\_CUTTING\_EDGE\_DEFAULT = -1 (Basic setting of tool cutting edge without programming).

Program code	Comment
...	
D92	
X0	; Traverse with compensations from D92.
T17	; Outputs T=17 to the PLC
X1	; Traverse with compensations from D92.
D16	
X2	; Traverse with compensations from D16.
D32000	
X3	; Traverse with compensations from D32000.
T29000	; Outputs T=29000 to the PLC.
X4	; Traverse with compensations from D32000.
D1	
X5	; Traverse with compensations from D1.
...	

**Example 2**

MD22550 = 0

Program code	Comment
T1	
T2	
T3	
D777	; No waiting, D777 is activated, T3= programmed and active tool in the display, D777= programmed and active compensation.

**Note**

The tool change and the assignment of a D compensation to an actual tool are not the responsibility of NCK.

### Delete D no. via part program

- **With** flat D number  
\$TC\_DP1[d] = 0  
Compensation data set is deleted from NCK with number d.  
The memory is then free for the definition of another D number.
- **Without** flat D number  
\$TC\_DP1[t][d] = 0=  
Cutting edge d of tool t is deleted.
- \$TC\_DP1[0] = 0  
Delete all D compensations from NCK.

Active compensation data blocks (D numbers) cannot be deleted. It may, therefore, be necessary to program D0 before deleting.

### Tool MDs

The following machine data affect the way tools and cutting edges (D numbers) work in the NCK:

- MD20270 \$MC\_CUTTING\_EDGE\_DEFAULT (Basic setting of tool cutting edge without programming)
- MD20130 \$MC\_CUTTING\_EDGE\_RESET\_VALUE (tool cutting edge length compens. During ramp-up)
- MD20120 \$MC\_TOOL\_RESET\_VALUE (tool cutting edge length compens. During ramp-up)
- MD20121 \$MC\_TOOL\_PRESEL\_RESET\_VALUE (Preselected tool at RESET)
- MD22550 \$MC\_TOOL\_CHANGE\_MODE (new tool compensation with M function)
- MD22560 \$MC\_TOOL\_CHANGE\_M\_CODE (M function for tool change)
- MD20110 \$MC\_RESET\_MODE\_MASK (Determination of control default settings after RESET/TP end)
- MD20112 \$MC\_START\_MODE\_MASK (Definition of the control default settings in case of NC START)

## 17.3.4 Programming the T number

When the "Flat D number structure" function is active, NC address T continues to be evaluated, i.e. the programmed T number and the active T number are displayed. However, the NC determines the D number without reference to the programmed T value.

The NC detects 1 master spindle per channel (via the spindle number, which can be set using MD). Compensations and the M6 command (tool change) are only calculated in reference to the master spindle.

An address extension T is interpreted as a spindle number (e.g. T2 = 1; tool 1 to be selected on spindle 2); a tool change is only detected if spindle 2 is the master spindle.

### 17.3.5 Programming M6

#### MD22550 and MD22560

The NC detects 1 master spindle per channel (via the spindle number, which can be set using MD). Compensations and the M6 command (tool change) are only calculated in reference to the master spindle.

Whether the tool change command is performed with an M function is defined via the machine data:

MD22550 \$MC\_TOOL\_CHANGE\_MODE (new tool compensation with M function).

T is used as the tool preparation command.

The name of the M function for the tool change is defined via the machine data:

MD22560 \$MC\_TOOL\_CHANGE\_M\_CODE (M function for tool change).

The default is M6. An address extension of M6 is interpreted as a spindle number.

#### Example

Two spindles are defined, spindle 1 and spindle 2, and the following applies:

```
MD20090 = 2      ; Spindle no. 2 is the master spindle.
M6             ; Tool change desired, command refers implicitly to the master
               spindle
M1 = 6         ; No tool change, since spindle no. 2 is the master spindle
M2 = 6         ; Tool is changed, since spindle no. 2 is the master spindle
```

### 17.3.6 Program test

#### MD20110

To have the active tool and the tool compensation included as follows, can be defined via the machine data:

MD20110 \$MC\_RESET\_MODE\_MASK, Bit 3 (Definition of control default settings after RESET/TP end).

Value		Significance
Bit 3	= 1	From the last test program to finish in test mode
	= 0	From the last program to finish before activation of the program test

#### Prerequisite

The bits 0 and 6 must be set by the machine data:

MD20110 \$MC\_RESET\_MODE\_MASK, Bit 3 (Definition of control default settings after RESET/TP end).

## 17.3.7 Tool management or "Flat D numbers"

### Tool management

NCK active tool management works on the basis of the following assumptions:

1. Tools are managed in magazines.
2. Cutting edges are monitored; limits reached cause the tool to be disabled.
3. Idea behind replacement tools: Tools are programmed for selection only the on the basis of their identifier. NCK then selects the concrete tool according to the strategy.

This means that it only makes sense to employ tool management when specific tools have been defined and these are to be utilized by the NCK.

### Flat D number

Flat D number means that tool management is carried out outside the NCK and there is no reference made to T numbers.

### No mixture of tool management and flat D no.

It does not make sense to mix or distribute the tool management functions over the NCK and PLC, since the main reason for tool management on the NCK is **to save time**.

This only works if the tasks that are time-critical are carried out on the NCK. This is not the case for "Flat D number", however.

---

#### **Note**

Activation of both of the functions "Flat D number structure" and "Tool management" is monitored. If both are activated at the same time, "Tool management" takes priority.

---

## 17.4 Tool cutting edge

### 17.4.1 General

#### Tool cutting edge

The following data are used to describe a tool cutting edge uniquely:

- Tool type (end mill, drill, etc.)
- Geometrical description
- Technological description

#### Tool parameter

The geometrical description, the technological description and the tool type are mapped to tool parameters for each tool cutting edge.

The following tool parameters are available for the relevant tool types:

Tool parameter	Significance	Note
1	Tool type	
2	Cutting edge position	for turning tools or for milling/grinding tools with 2D TRC contour tool
Geometry - tool lengths		
3	Length 1	
4	Length 2	
5	Length 3	
Geometry - tool shape		
6	Radius 1/Length 1	for 3D face milling
7	Length 2	for 3D face milling
8	Radius 1	for 3D face milling
9	Radius 2	for 3D face milling
10	Angle 1/minimum threshold angle	for 3D face milling with 2D TRC contour tool
11	Angle 2/minimum threshold angle	for 3D face milling with 2D TRC contour tool
Wear - tool length		
12	Length 1	
13	Length 2	
14	Length 3	
Wear - tool shape		

Tool parameter	Significance	Note
15	Radius 1/Length 1	for 3D face milling
16	Length 2	for 3D face milling
17	Radius 1	for 3D face milling
18	Radius 2	for 3D face milling
19	Angle 1 / minimum limit angle	for 3D face milling with 2D TRC contour tool.
20	Angle 2 / maximum limit angle	for 3D face milling with 2D TRC contour tool.
Tool base dimension/adaptor dimension		
21	Basic length 1	
22	Basic length 2	
23	Basic length 3	
Technology		
24	Undercut angle	only for turning tools
25	Reserved*	

\* "Reserved" means that this tool parameter is not used and is reserved for expansions.

### 3D-face milling

Milling cutter types 111, 120, 121, 130, 155, 156 and 157 are given special treatment for 3D-face milling by evaluating tool parameters (1 -23).

### References

For more information about various tool types, see:

- Function Manual - Basic Functions; Tool Offset (W1), Chapter "Tool type (tool parameters)"
- Programming Manual Fundamentals; Chapter: "Tool compensations" > "List of tool types"
- Function Manual - Special Functions; 3D-tool radius compensation (W5)

## 17.4.2 Tool parameter 1: Tool type

### Description

The tool type (3-digit number) defines the tool in question. The selection of this tool type determines further components such as geometry, wear and tool base dimensions in advance.

### Conditions

The following is applicable to the "Tool type" parameter:

- The tool type must be specified for each tool cutting edge.
- Only the values specified can be used for the tool type.
- Tool type "0" (zero) means that no valid tool has been defined.

### Tool types and tool parameters

Different tool types and the most important tool parameters are listed in the following table. The tool parameters available for a certain tool type are designated with "x".

Table of the most important available tool parameters (only tool type necessary)																		
1	tool parameter \$TC_DP	2	3	4	5	6	7	8/9	12/13/14	15/16	21/22/23	24	TPG 3	TPG 4/5	TPG 6	TPG 7	TPG 8	
tool type	compensation by NCK	cutting edge position	geometry - length 1	- length 2	- length 3	geometry - radius 1	slot width / - radius 2	projection / - length 4/5	wear - length 1/2/3	wear - radius 1/2	adap/base measure. - length 1/2/3	tool clearance angle	- disc radius min	- disc width min/fact.	- speed max	- peripheral speed max	- angle gradient disc	
<b>Milling tools and drilling tools (all others)</b>																		
100	Milling tools according to CLDATA <sup>*1</sup>		x	x	x	x			x	x	x							
110	ball end mill		x	x	x	x			x	x	x							
120	end mill		x	x	x	x			x	x	x							
121	end mill with corner rounding		x	x	x	x	x		x	x	x							
130	angle head cutter		x	x	x	x			x	x	x							
131	angle head cutter with corner rounding		x	x	x	x	x		x	x	x							
140	face mill		x	x	x	x			x	x	x							
145	thread mill		x	x	x	x			x	x	x							
150	side mill		x	x	x	x			x	x	x							
155	truncated cone mill		x	x	x	x			x	x	x							
200	twist drill		x	x	x	x			x		x							
205	solid bit		x	x	x	x			x		x							
210	drilling rod		x	x	x	x			x		x							
220	center drill		x	x	x	x			x		x							
230	countersink		x	x	x	x			x		x							
231	piloted counterbore		x	x	x	x			x		x							
240	tap drill regular thread		x	x	x	x			x		x							
241	tap drill fine thread		x	x	x	x			x		x							
242	tap drill Whitworth thread		x	x	x	x			x		x							
250	reamer		x	x	x	x			x		x							
<b>grinding tools and turning tools (400 - 599)</b>																		
400	peripheral grinding wheel	x	x	x	x	x			x	x	x						x	x
401	peripheral grinding wheel with monitoring	x	x	x	x	x			x	x	x		x	x	x	x	x	x
403	wie 401 aber ohne Basismaß für SUG <sup>+2</sup>	x	x	x	x	x			x	x	x		x	x	x		x	
410	Planschleibe	x	x	x	x	x			x	x	x							x
411	Planschleibe mit Überwachung	x	x	x	x	x			x	x	x		x	x	x	x		x
413	as 401 but without base measurement for SUG <sup>+2</sup>	x	x	x	x	x			x	x	x		x	x	x			
490	dresser	x	x	x	x	x			x	x	x							
500	roughing tool	x	x	x	x	x			x	x	x	x						
510	smoothing tool	x	x	x	x	x			x	x	x	x						
520	recessing tool	x	x	x	x	x			x	x	x	x						
530	cutting-off tool	x	x	x	x	x			x	x	x	x						
540	threading tool	x	x	x	x	x			x	x	x	x						
<b>special tools (700)</b>																		
700	slotting saw		x	x	x	x	x	x	x	x	x							

CLDATA<sup>\*1</sup> "cutter Location Data" — tool position data according to DIN 66215,  
BI 1SUG<sup>+2</sup> — grinding wheel peripheral speed

**Note**

The tool type has no significance in the turning tool groups.  
 Non-listed numbers are also permitted, in particular with grinding tools (400-499).

---

**Tool offset data**

Tool offset data (TOA data) is stored in the system variables.

Example: Slotting saw tool type (Type 700)

	Geometry	Wear	Base	Unit
<b>Length compensation</b>				
Length 1	\$TC_DP3	\$TC_DP12	\$TC_DP21	mm
Length 2	\$TC_DP4	\$TC_DP13	\$TC_DP22	mm
Length 3	\$TC_DP5	\$TC_DP14	\$TC_DP23	mm
<b>Saw blade compensation</b>				
Diameter d	\$TC_DP6	\$TC_DP15		mm
Slot width b	\$TC_DP7	\$TC_DP16		mm
Projection k	\$TC_DP8	\$TC_DP17		mm

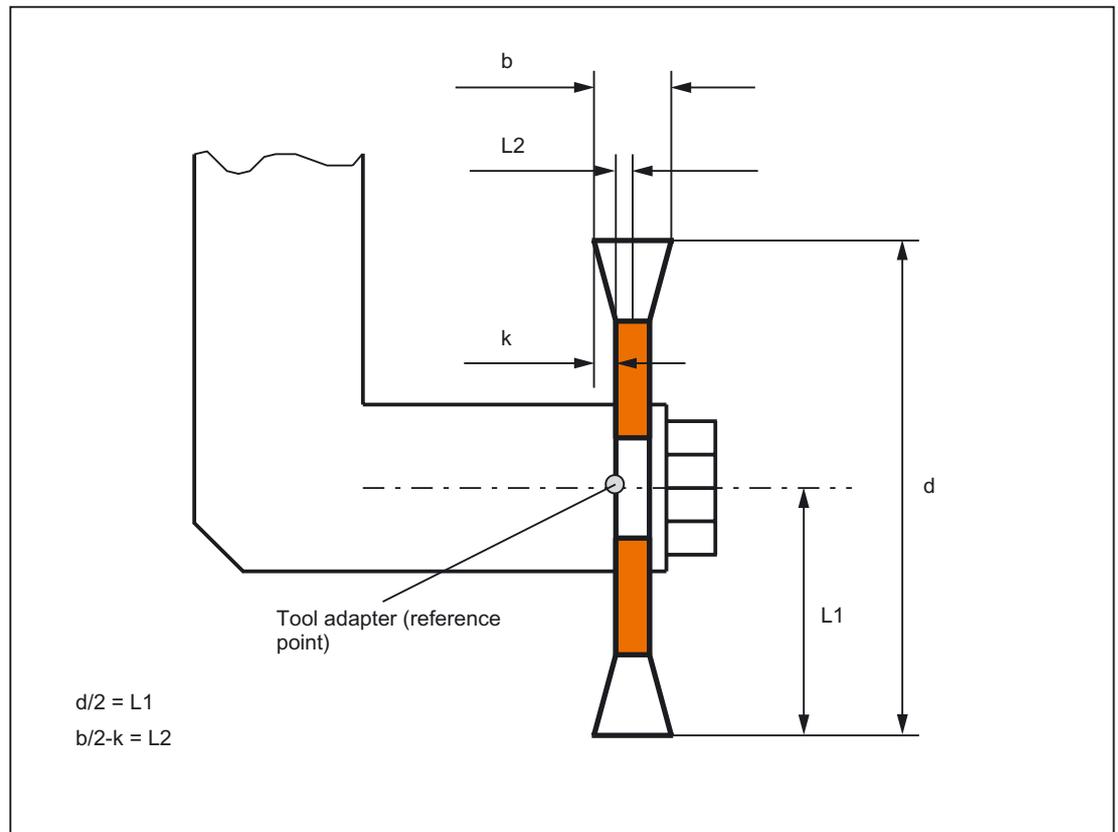


Figure 17-3 Geometry of slotting saw (analogous to angle head cutter)

The width of the saw blade is accounted for with tool radius compensation (G40 to G42 as follows:

Command	Significance
G40	No saw blade compensation
G41	Saw blade compensation left
G42	Saw blade compensation right

### 17.4.3 Tool parameter 2: Cutting edge position

#### Description

The cutting edge position describes the position of the tool tip P in relation to the cutting edge center point S. It is entered in tool parameter 2.

The cutting edge position is required together with the cutting edge radius (tool parameter 8) for the calculation of the tool radius compensation for turning tools (tool type 5xx).

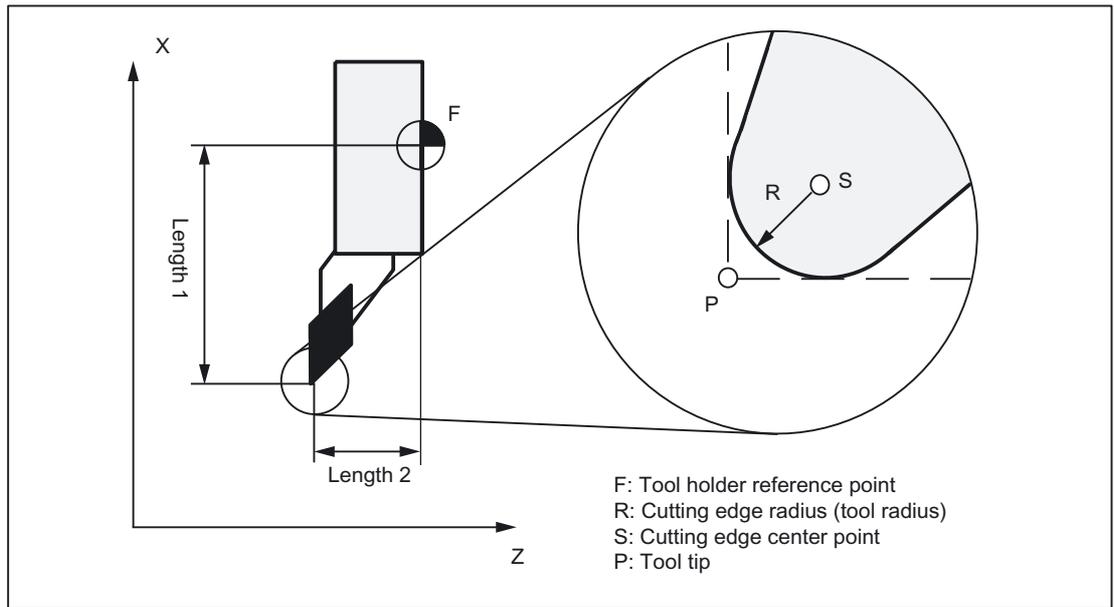


Figure 17-4 Dimensions for turning tools: Turning tool

#### Cutting edge position parameter values

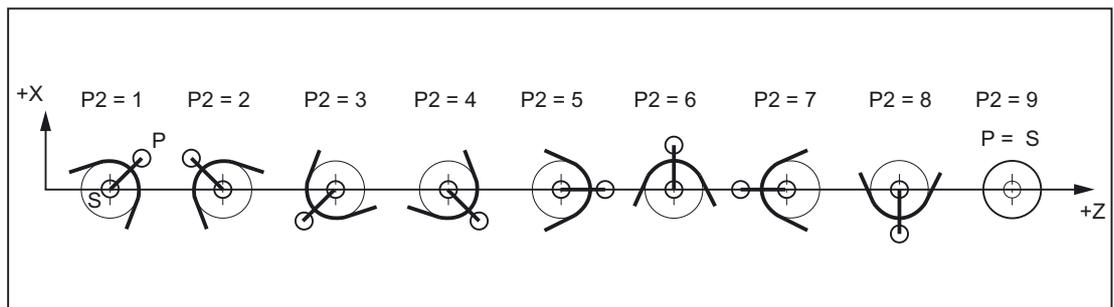


Figure 17-5 Tool parameter 2 (P2): Machining behind the turning center

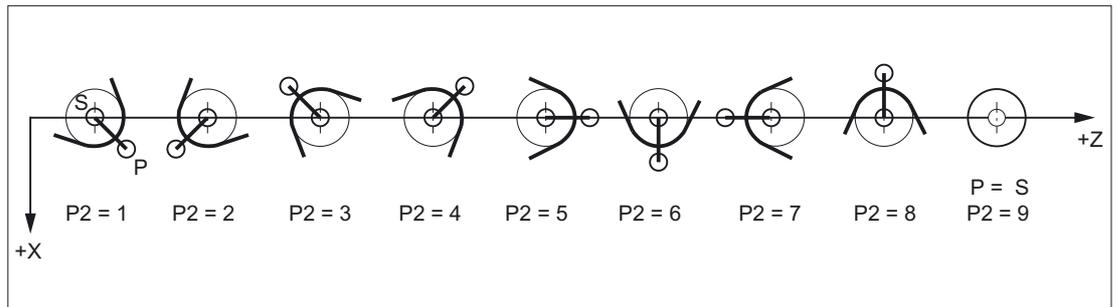


Figure 17-6 Tool parameter 2 (P2): Machining in front of the turning center

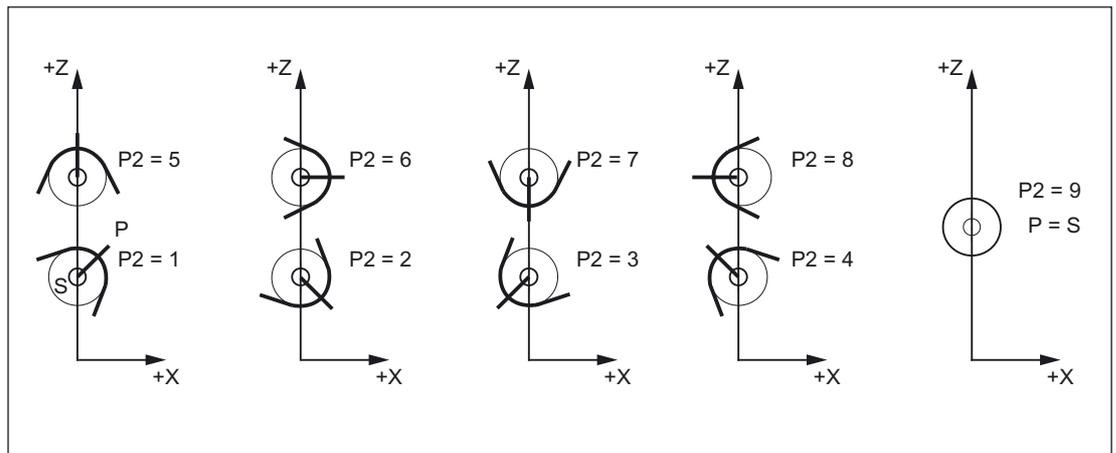


Figure 17-7 Tool parameter 2 (P2): Cutting edge position for vertical boring and turning mills

### Special points to be noted

- If the cutting edge center point S is used instead of point P as a reference point to calculate the tool length compensation, the identifier 9 must be entered for the cutting edge position.
- The identifier 0 (zero) is not permitted as a cutting edge position.

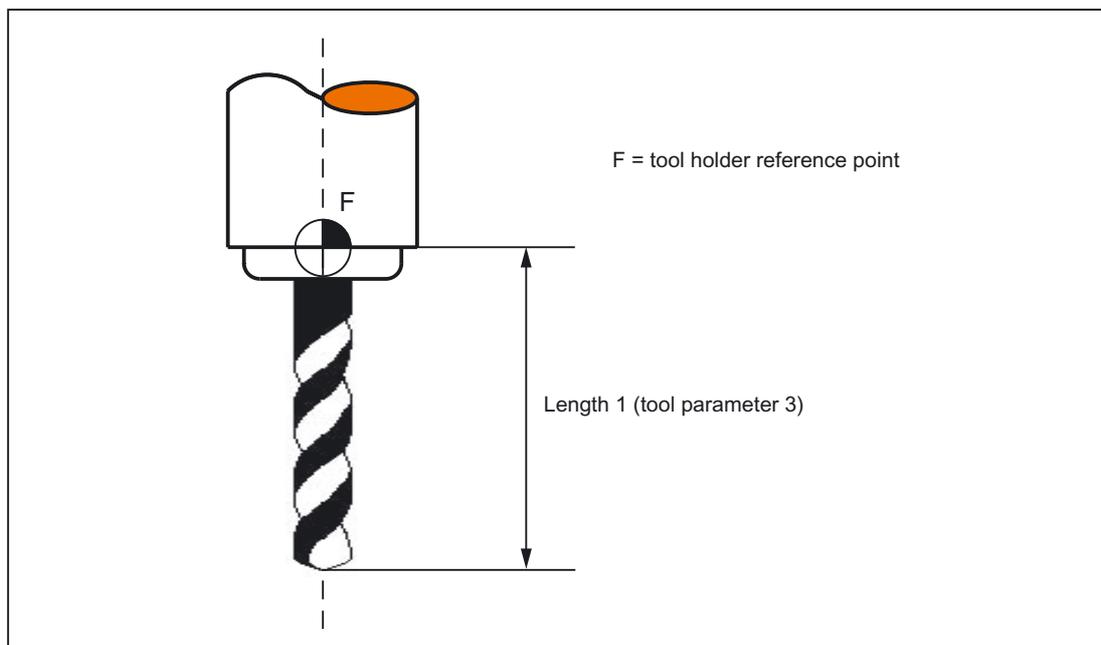
### 17.4.4 Tool parameters 3 - 5: Geometry - tool lengths

#### Description

The lengths of the tools are required for the geometry tool length compensation. They are input as tool lengths 1 to 3 in the tool parameters 3 to 5. The following length specifications must be entered as a minimum for each tool type:

Tool type	Required tool lengths
Tool type 12x, 140, 145, 150:	Tool length 1
Tool type 13x:	Tool length 1 to 3 (depending on plane G17-G19)
Tool type 2xx:	Tool length 1
Tool type 5xx:	Tool length 1 to 3

Example Twist drill (tool type 200) with tool length (tool parameter 3)



#### Note

All three tool parameters 3 to 5 (tool length 1 to 3) are always calculated in the three geometry axes, irrespective of the tool type.

If more tool lengths are input in the tool parameters 3 to 5 for a tool type than is required as the minimum, then these extra tool lengths are settled in the geometry axes without any alarm.

### Special points to be noted

The active size of the tool is only defined when the geometry tool length compensation (tool parameters 3 to 5) and the wear tool length compensation (tool parameters 12 to 14) are added together. The base-dimension/adapter-dimension tool length compensation is also added in order to calculate the total tool length compensation in the geometry axes.

### References

For information about entering tool dimensions (lengths) in tool parameters 3 to 5 (tool lengths 1 to 3) and how these are calculated in the three geometry axes, please refer to → Operating Manual.

## 17.4.5 Tool parameters 6 - 11: Geometry - tool shape

### Description

The shape of the tool is defined with the help of tool parameters 6 to 11. The data is required for the geometry tool radius compensation.

In most cases, only tool parameter 6 (tool radius 1) is used.

Tool parameter	Description	Application	
6	Tool length 1	Not used	
7	Tool length 2	Not used	
8	Tool radius 1	The tool radius must be entered for the following tool types in tool parameter 6 (tool radius 1):	
		Tool type 1xx	Milling tools
		Tool type 5xx	Turning tools
		A tool radius does not have to be entered for drilling tools (tool type 2xx). The cutting edge position (tool parameter 2) also has to be entered for turning tools (tool type 5xx).	
9	Tool radius 2	Not used	
10	Tool angle 1	Not used	
11	Tool angle 2	Not used	

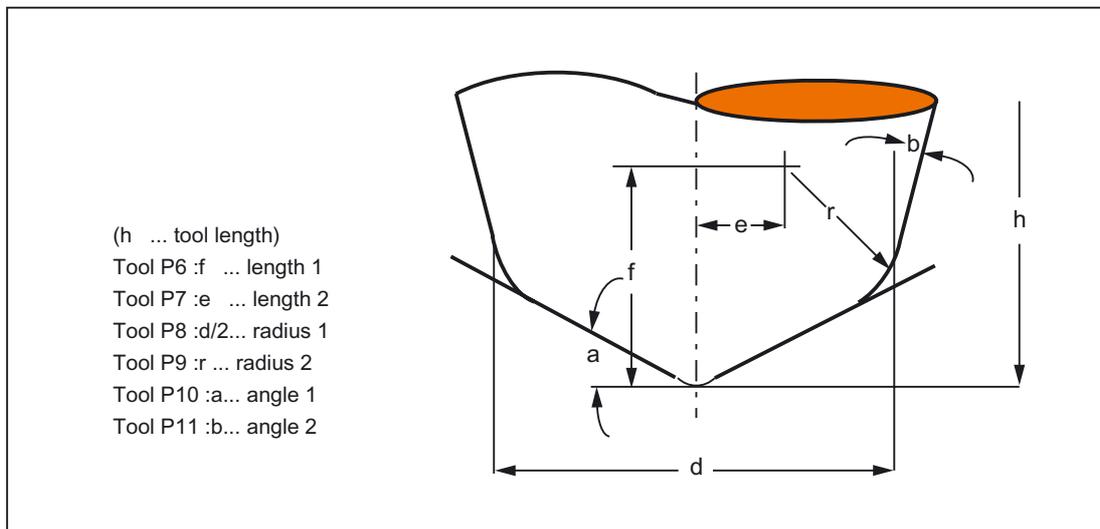
### 2D TRC with contour tools

For the definition of contour tools with multiple tool cutting edges, the minimum and maximum limit angle can be entered. Both limit angles each relate to the vector of the cutting edge center point to the cutting edge reference point and are counted clockwise.

Tool angle 1	Minimum limit angle per tool cutting edge
Tool angle 2	Maximum limit angle per tool cutting edge

### 3D-face milling

All the tool parameters 6 to 11 are required for tool description of 3D-face milling.



### References

Please refer to the following documentation for information about entering tool shapes (radius for tool radius compensation) in tool parameters 6 to 11 and how these are calculated by geometry tool radius compensation in the three geometry axes:

- Programming Manual Fundamentals; Chapter: "Tool compensations" > "2½ D-tool compensation"
- Function Manual - Special Functions; 3D-tool radius compensation (W5)

For 3D-face milling, please refer to:

- Programming Manual, Job Planning; Chapter: "Transformations" > "Three, Four and Five axis Transformation (TRAORI)"

## 17.4.6 Tool parameters 12 - 14: Wear - tool lengths

### Description

While geometry tool length compensation (tool parameters 3 to 5) is used to define the size of the tool, wear tool length compensation can be used to correct the change in the active tool size.

The active tool dimensions can change due to:

- Differences between the tool fixture on the tool measurement machine and the tool fixture on the machine tool
- Tool wear caused during service life by machining
- Definition of the finishing allowances

### Active tool size

The geometry tool compensation (tool parameters 3 to 5) and the wear tool length compensation (tool parameters 12 to 14) are added together (geometry tool length 1 is added to wear tool length 1, etc.) to arrive at the size of the active tool.

## 17.4.7 Tool parameters 15 - 20: Wear - tool shape

### Description

While geometry tool radius compensation (tool parameters 6 to 11) is used to define the shape of the tool, wear tool radius compensation can be used to correct the change in the active tool shape.

The active tool dimensions can change due to:

- Tool wear caused during service life by machining
- Definition of the finishing allowances

### Active tool shape

The geometry tool radius compensation (tool parameters 6 to 11) and the wear tool radius compensation (tool parameters 15 to 20) are added together (geometry tool radius 1 is added to wear tool radius 1, etc.) to arrive at the shape of the active tool.

### 17.4.8 Tool parameters 21 - 23: Tool base dimension/adapter dimension

#### Description

Tool base dimension/adapter dimension can be used when the reference point of the toolholder (tool size) differs from the reference point of the toolholder.

This is the case when:

- The tool and the tool adapter are measured separately but are installed on the machine in one unit (the tool size and adapter size are entered separately in a cutting edge).
- The tool is used in a second tool fixture located in another position (e.g. vertical and horizontal spindle).
- The tool fixtures of a tool turret are located at different positions.

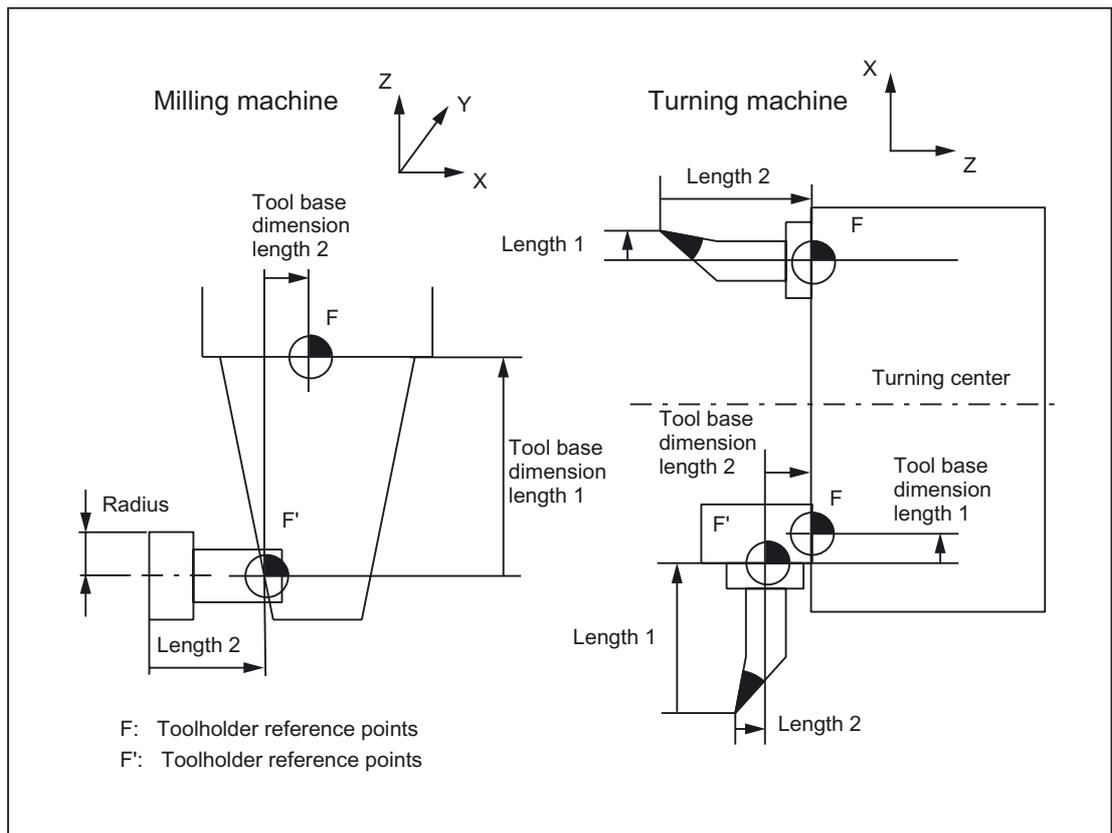


Figure 17-8 Application examples for base-dimension/adapter-dimension TLC

### Tool basic length 1 to 3 (tool parameters 21 to 23)

In order that the discrepancy between the toolholder reference point F and the toolholder reference point F' can be corrected on the three geometry axes (three dimensional), all 3 basic lengths are active irrespective of the tool type. In other words, a twist drill (tool type 200) with a tool length compensation (length 1) can also have a tool base dimension/adapter dimension in 3 axes.

### References

Please refer to the following documentation for more information about base-dimension/adapter-dimension tool length compensation:

- Programming Manual, Fundamentals

### 17.4.9 Tool parameter 24: Undercut angle

#### Meaning

Certain turning cycles, in which traversing motions with tool clearance are generated, monitor the tool clearance angle of the active tool for possible contour violations.

#### Value range

The angle (0 to 90° with no leading sign) is entered in tool parameter 24 as the tool clearance angle.

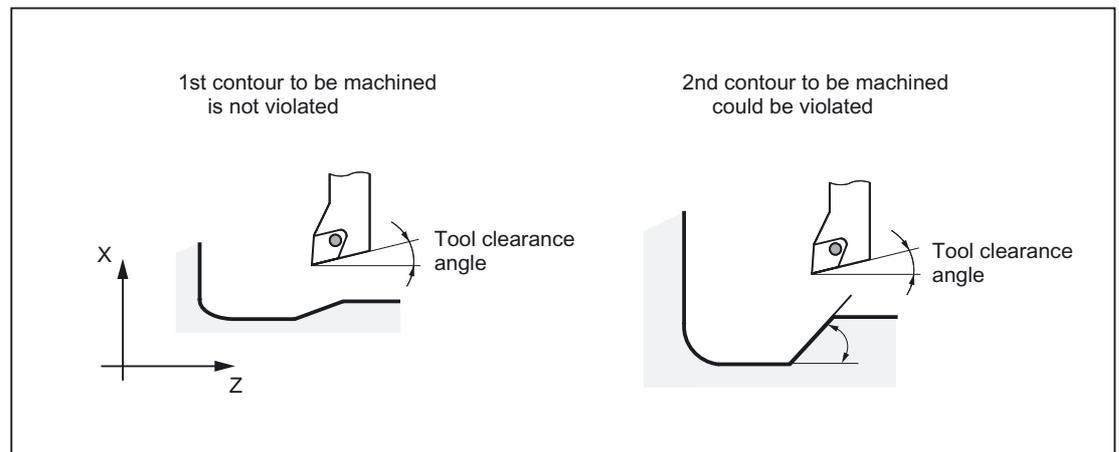


Figure 17-9 Tool clearance angle of the turning tool during relief cutting

#### Machining type, longitudinal or transverse

The tool clearance angle is entered in different ways according to the type of machining (longitudinal or face). If a tool is to be used for both longitudinal and face machining, two cutting edges must be entered for different tool clearance angles.

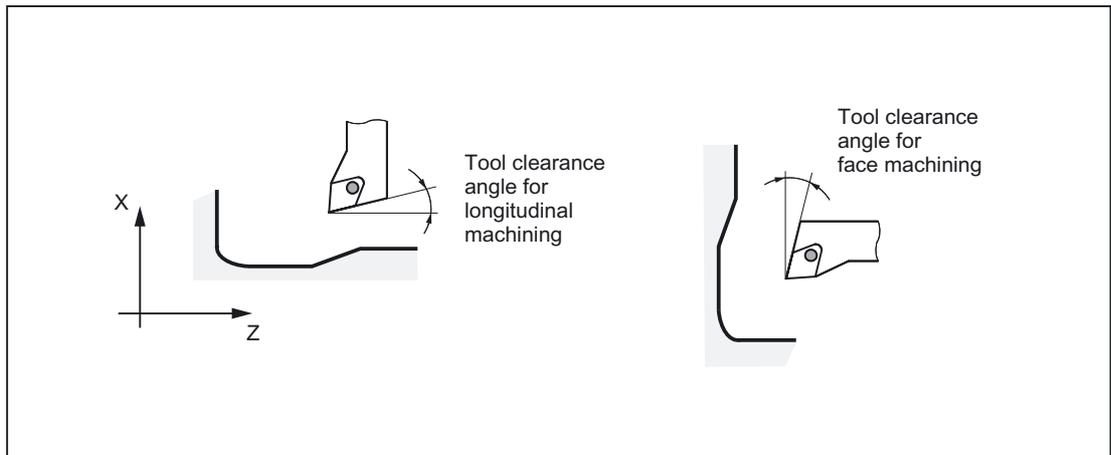


Figure 17-10 Tool clearance angle for longitudinal and face machining

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**Note**

If a tool clearance angle (tool parameter 24) of zero is entered, relief cutting is not monitored in the turning cycles.

---

**References**

Please refer to the following documentation for a detailed description of the tool clearance angle:

- Programming Manual Cycles

### 17.4.10 Tools with a relevant tool point direction

The following must be observed for tools with relevant cutting edge position:

- The straight line between the tool edge center points at the block start and block end is used to calculate intersection points with the approach and retraction block. The difference between the tool edge reference point and the tool edge center point is superimposed on this movement.

For approach and/or retraction with `KONT`, the movement is superimposed in the linear subblock of the approach or retraction movement. Therefore, the geometric conditions for tools with or without relevant cutting edge position are identical.

- In circle blocks and in motion blocks containing rational polynomials with a denominator degree  $> 4$ , it is not permitted to change a tool with active tool radius compensation in cases where the distance between the tool edge center point and the tool edge reference point changes. With other types of interpolation, it is now possible to change when a transformation is active (e.g. `TRANSMIT`).
- For tool radius compensation with variable tool orientation, the transformation from the tool edge reference point to the tool edge center point can no longer be performed by means of a simple zero offset. Tools with a relevant cutting edge position are therefore not permitted for 3D peripheral milling (an alarm is output).

---

#### Note

The subject is irrelevant with respect to face milling as only defined tool types without relevant cutting edge position are permitted for this operation anyway. (A tool with a type, which has not been explicitly approved, is treated as a ball end mill with the specified radius. A cutting edge position parameter is ignored).

---

## 17.5 Tool radius compensation 2D (TRC)

### 17.5.1 General

**Note**

For tool radius compensation (WRK) see:

**References:**

/PG/ Programming Manual Fundamentals

Only the Programming Guide contains a complete technical description of the tool radius compensation (TRC) and its special aspects.

#### Why TRC?

The contour (geometry) of the workpiece programmed in the part program should be independent of the tools used in production. This makes it necessary to draw the values for the tool length and tool radius from a current offset memory. Tool radius compensation can be used to calculate the equidistant path to the programmed contour from the current tool radius.

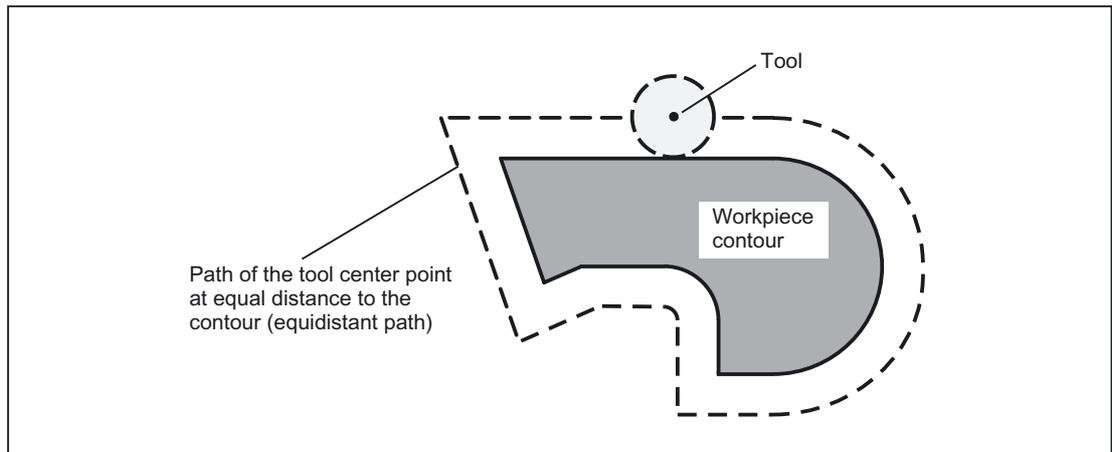


Figure 17-11 Workpiece contour (geometry) with equidistant path

#### TRC on the plane

TRC is active on the current plane (G17 to G19) for the following types of interpolation:

• Linear interpolation	...	G0, G1
• Circular interpolation	...	G2, G3, CIP
• Helical interpolation	...	G2, G3
• Spline interpolation	...	ASPLINE, BSPLINE, CSPLINE
• Polynomial interpolation	...	POLY

## 17.5.2 Selecting the TRC (G41/G42)

### Direction of compensation

TRC calculates a path, which is equidistant to the programmed contour. Compensation can be performed on the left- or right-hand side of the programmed contour in the direction of motion.

Command	Significance
G41	TRC on the left-hand side of the contour in the direction of motion
G42	TRC on the right-hand side of the contour in the direction of motion
G40	Deselection of TRC

### Intermediate blocks

In general, only program blocks with positions on geometry axes in the current plane are programmed when TRC is active. However, dummy blocks can still also be programmed with active TRC. Dummy blocks are program blocks, which do not contain any positions on a geometry axis in the current plane:

- Positions on the infeed axis
- Auxiliary functions
- etc.

The maximum number of dummy blocks can be defined in the machine data:

MD20250 \$MC\_CUTCOM\_MAXNUM\_DUMMY\_BLOCKS (Max no. of dummy blocks with no traversing movements for TRC).

### Special points to be noted

- TRC can only be selected in a program block with G0 (rapid traverse) or G1 (linear interpolation).
- A tool must be loaded (T function) and the tool cutting edge (tool compensation) (D1 to D9) activated no later than in the program block with the tool radius compensation selection.
- Tool radius compensation is not selected with a tool cutting edge/tool compensation of D0.
- If only one geometry axis is programmed on the plane when tool radius compensation is selected, the second axis is automatically added on the plane (last programmed position).
- If no geometry axis is programmed for the current plane in the block with the tool radius compensation selection, no selection takes place.
- If tool radius compensation is deselected (G40) in the block following tool radius compensation selection, no selection takes place.
- If tool radius compensation is selected, the approach behavior is determined by the NORM/KONT instructions.

### 17.5.3 Approach and retraction behavior (NORM/KONT/KONTC/KONTT)

#### NORM and KONT

The `NORM` and `KONT` instructions can be used to control approach behavior (selection of tool radius compensation with `G41/42`) and retraction behavior (deselection of tool radius compensation with `G40`):

Command	Significance
<code>NORM</code>	Normal setting at start point/end point (initial setting)
<code>KONT</code>	Follow contour at start point/end point
<code>KONTC</code>	Approach/retraction with constant curvature
<code>KONTT</code>	Approach/retraction with constant tangent

#### Special points to be noted

- `KONT` only differs from `NORM` when the tool start position is behind the contour.

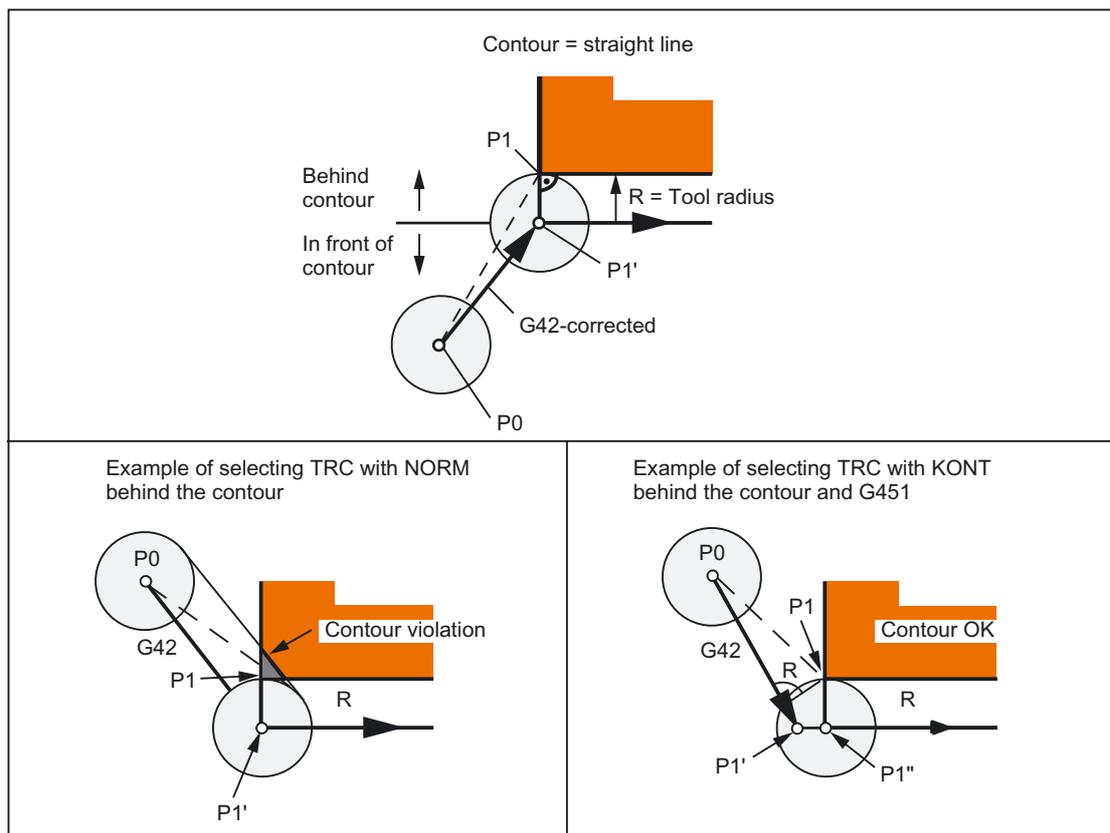


Figure 17-12 Example for selecting TRC with `KONT` or `NORM` in front of and behind the contour

- **KONT** and **G450/G451** (corner behavior at outer corners) has a general effect and determines the approach and retraction behavior with TRC.
- When tool radius compensation is deselected, the retraction behavior is determined by the **NORM/KONT** instructions.

### Supplementary conditions

The approach and retraction blocks are polynomials in the following two variants. Therefore, they are only available for control variants, which support polynomial interpolation.

- **KONTT**  
With **KONTT**, approach and retraction to/from the contour is with a constant tangent. The curvature at the block transition is not usually constant.
- **KONTC**  
With **KONTC**, not only the tangent but also the curvature is constant at the transition, with the result that a **jump in acceleration** can no longer occur on activation/deactivation.

Although **KONTC** includes the **KONTT** property, the constant tangent version **KONTT** is available on its own, because the constant curvature required by **KONTC** can produce undesired contours.

### Axes

The continuity condition is observed in all **three** axes. It is thus possible to program a simultaneous path component perpendicular to the compensation plane for approach/retraction.

Only **linear blocks** are permitted for the original approach and retraction blocks with **KONTT/KONTC**. These programmed linear blocks are replaced in the control by the corresponding polynomial curves.

### Exception

**KONTT** and **KONTC** are not available in 3D variants of tool radius compensation (**CUT3DC**, **CUT3DCC**, **CUT3DF**).

If they are programmed, the control switches internally to **NORM** without an error message.

### Example for KONTC

The two figures below show a typical application for approach and retraction with constant curvature:

The full circle is approached beginning at the circle center point. The direction and curvature radius of the approach circle at the block end point are identical to the values of the next circle. Infeed takes place in the Z direction in both approach/retraction blocks simultaneously.

The associated NC program segment is as follows:

```
$TC_DP1[1,1]=121 ; Milling tool
$TC_DP6 [1,1]=10 ; Radius 10 mm
N10 G1 X0 Y0 Z60 G64 T1 D1 F10000
N20 G41 KONTC X70 Y0 Z0
N30 G2 I-70 ; Full circle
N40 G40 G1 X0 Y0 Z60
N50 M30
```

#### Explanation:

In this example, a full circle with a radius of 70 mm is machined in the X/Y plane. Since the tool has a radius of 10 mm, the resulting tool center point path describes a circle with a radius of 60 mm. The start/end points are at X0 Y0 Z60, with the result that a movement takes place in the Z direction at the same time as the approach/retraction movement in the compensation plane.

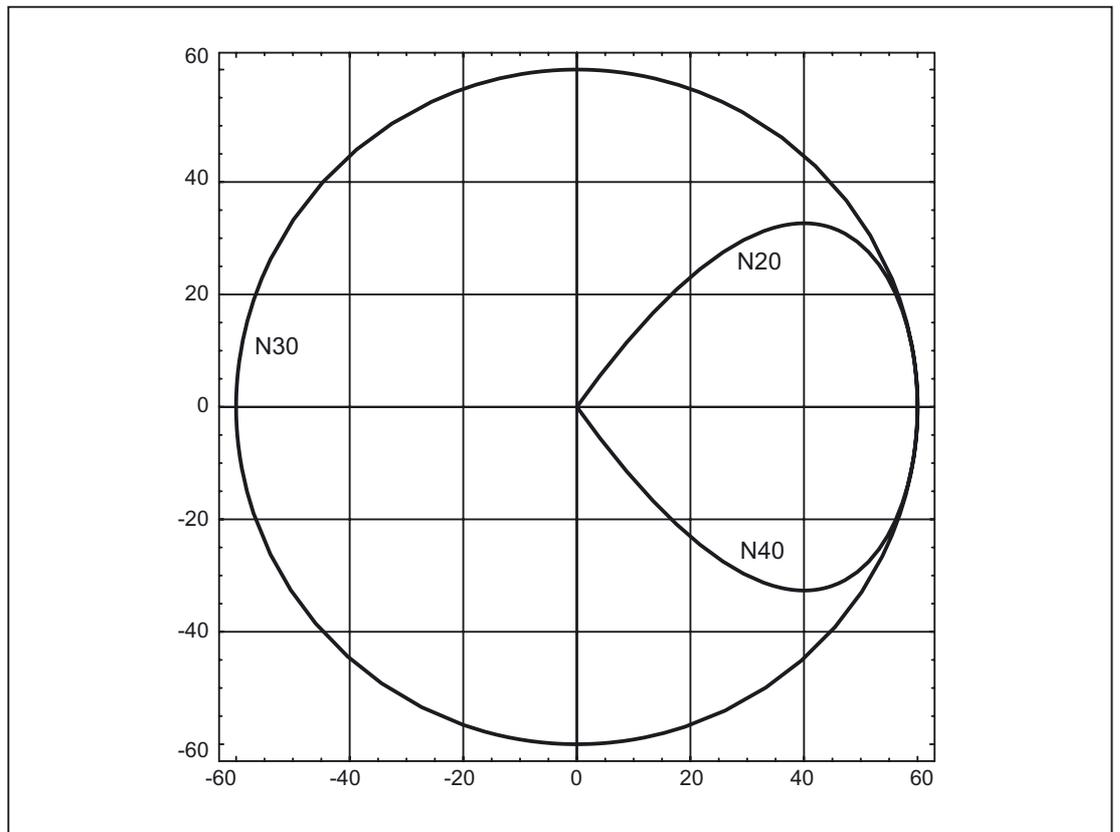


Figure 17-13 Approach and retraction with constant curvature during inside machining of a full circle:  
Projection in the X-Y plane.

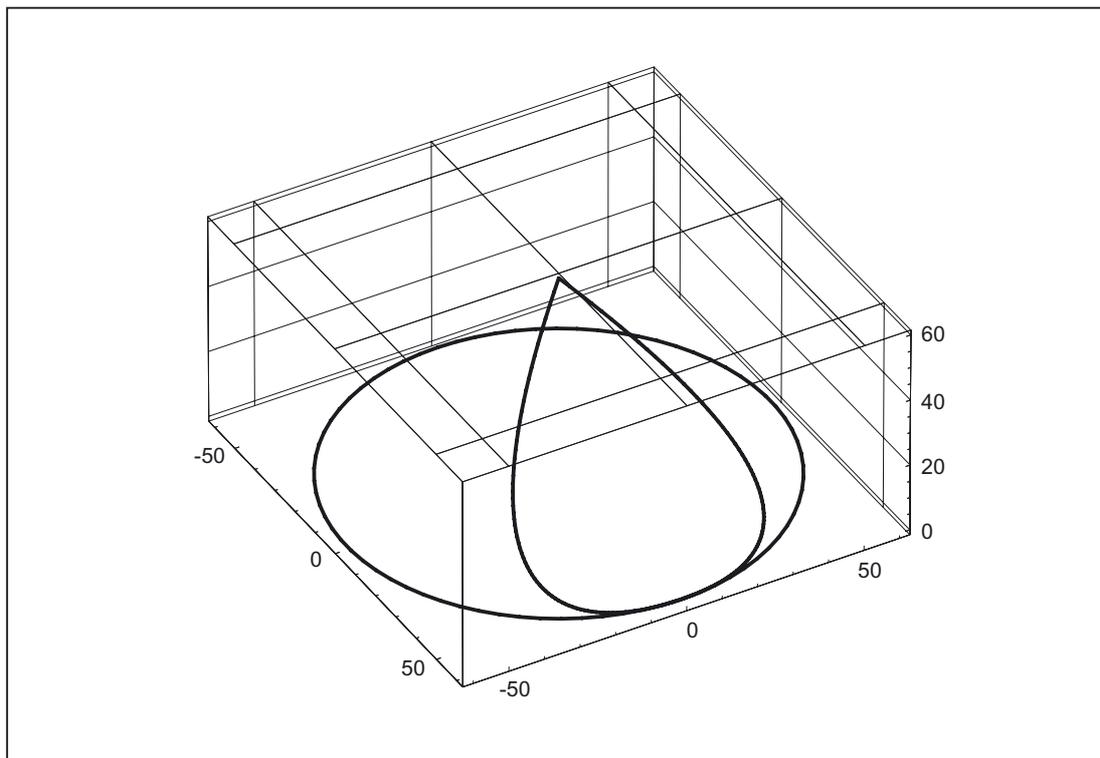


Figure 17-14 Approach and retraction with constant curvature during inside machining of a full circle: 3D representation.

### KONTT and KONTC compared

The figure below shows the differences in approach/retraction behavior between `KONTT` and `KONTC`. A circle with a radius of 20 mm about the center point at X0 Y-40 is compensated with a tool with an external radius of 20 mm. The tool center point therefore moves along a circular path with radius 40 mm. The end point of the approach blocks is at X40 Y30. The transition between the circular block and the retraction block is at the zero point. Due to the extended continuity of curvature associated with `KONTC`, the retraction block first executes a movement with a negative Y component. This will often be undesired. This response does not occur with the `KONTT` retraction block. However, with this block, an acceleration step change occurs at the block transition.

If the `KONTT` or `KONTC` block is the approach block rather than the retraction block, the contour is exactly the same, but is simply machined in the opposite direction, i.e. the **approach and retraction behavior are symmetrical.**

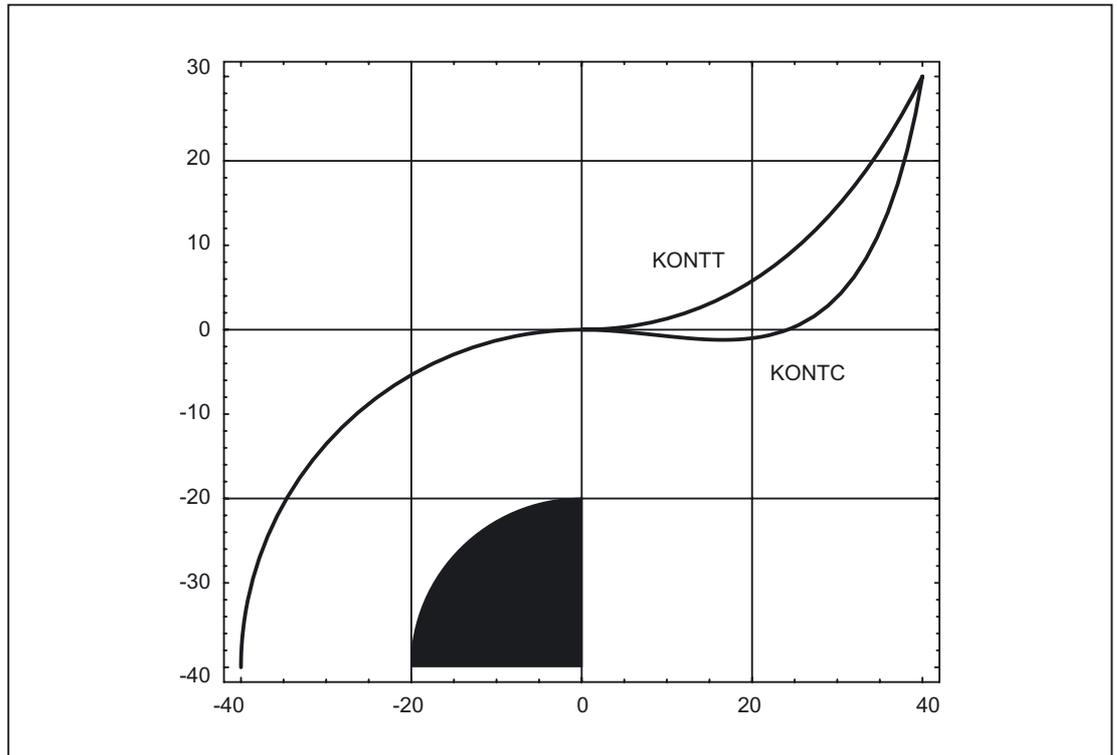


Figure 17-15 Differences between KONTT and KONTC

#### Note

The figure shows that a straight line bordering on the contour quadrant, e.g. to X20 Y-20, would be violated with KONTC on retraction/approach to X0, Y0.

## 17.5.4 Smooth approach and retraction

### 17.5.4.1 Function

#### Description

The SAR (Smooth Approach and Retraction) function is used to achieve a tangential approach to the start point of a contour, regardless of the position of the start point.

The approach behavior can be varied and adapted to special needs using a range of additional parameters.

The two functions, smooth approach and smooth retraction, are largely symmetrical. The following section is, therefore, restricted to a detailed description of approach; special reference is made to differences affecting retraction.

### Sub-movements

There are maximum 4 sub-movements in case of soft retraction and approach with the following positions:

- Start point of the movement P<sub>0</sub>
- Intermediate points P<sub>1</sub>, P<sub>2</sub> and P<sub>3</sub>
- End point P<sub>4</sub>

Points P<sub>0</sub>, P<sub>3</sub> and P<sub>4</sub> are always defined. Intermediate points P<sub>1</sub> and P<sub>2</sub> can be omitted, according to the parameters defined and the geometrical conditions.

On retraction, the points are traversed in the reverse direction, i.e. starting at P<sub>4</sub> and ending at P<sub>0</sub>.

#### 17.5.4.2 Parameters

The response of the smooth approach and retraction function is determined by up to 9 parameters:

#### Non-modal G code for defining the approach and retraction contour

This G code cannot be omitted.

- G147: Approach with a straight line
- G148: Retraction with a straight line
- G247: Approach with a quadrant
- G248: Retraction with a quadrant
- G347: Approach with a semicircle
- G348: Retraction with a semicircle

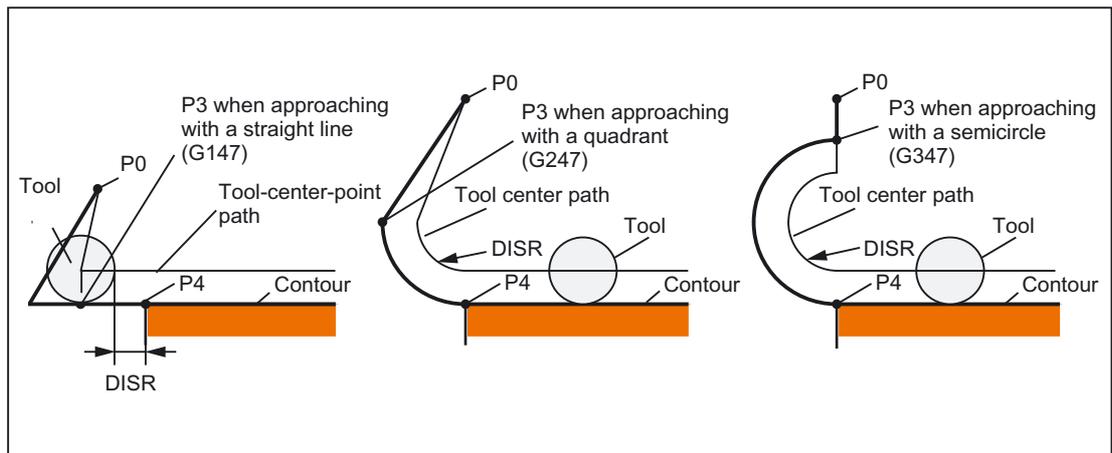


Figure 17-16 Approach behavior depending on G147 to G347 and DISR (with simultaneous activation of tool radius compensation)

### Modal G code for defining the approach and retraction contour

This G code is only relevant if the approach contour is a quadrant or semicircle. The approach and retraction direction can be determined as follows:

- G140:

Defining the approach and retraction direction using active tool radius compensation. ((G140 is the initial setting.)

With positive tool radius:

- G41 active → approach from left
- G42 active → approach from right

If no tool radius compensation is active (G40), the response is identical to G143. In this case, an alarm is not output. If the radius of the active tool is 0, the approach and retraction side is determined as if the tool radius were positive.

- G141:

Approach contour from left, or retract to the left.

- G142:

Approach contour from right, or retract to the right.

- G143:

Automatic determination of the approach direction, i.e. the contour is approached from the side where the start point is located, relative to the tangent at the start point of the following block (P<sub>4</sub>).

---

#### Note

The tangent at the end point of the preceding block is used accordingly on **retraction**. If the end point is not programmed explicitly on retraction, i.e. if it is to be determined implicitly, G143 is not permitted on retraction, since there is a mutual dependency between the approach side and the position of the end point. If G143 is programmed in this case, an alarm is output. The same applies if, when G140 is active, an automatic switchover to G143 takes place as a result of an inactive tool radius compensation.

---

Modal G code (G340, G341), which defines the subdivision of the movement into individual blocks from the start point to the end point

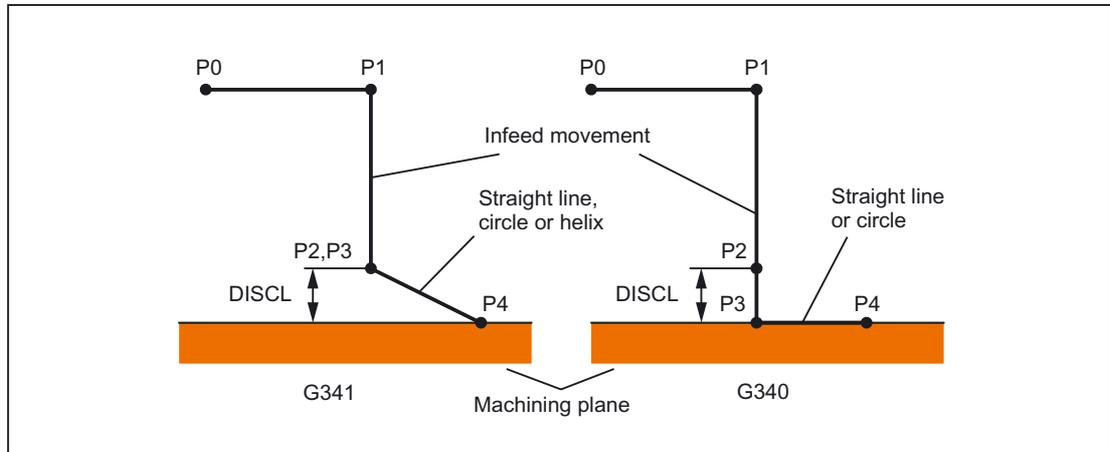


Figure 17-17 Sequence of the approach movement depending on G340/G341

G340: The approach characteristic from P<sub>0</sub> to P<sub>4</sub> is shown in the figure.

If G247 or G347 is active (quadrant or semicircle) and start point P<sub>3</sub> is outside the machining plane defined by the end point P<sub>4</sub>, a helix is inserted instead of a circle. Point P<sub>2</sub> is not defined or coincides with P<sub>3</sub>.

The circle plane or the helix axis is determined by the plane, which is active in the SAR block (G17 - G19), i.e. the projection of the start tangent is used by the following block, instead of the tangent itself, to define the circle.

The movement from point P<sub>0</sub> to point P<sub>3</sub> takes place along two straight lines at the velocity valid before the SAR block.

G341: The approach characteristic from P<sub>0</sub> to P<sub>4</sub> is shown in the figure.

P<sub>3</sub> and P<sub>4</sub> are located within the machining plane, with the result that a circle is always inserted instead of a helix with G247 or G347.

#### Note

Active, rotating frames are included in all cases where the position of the active plane G17 - G19 (circle plane, helix axis, infeed movements perpendicular to the active plane) is relevant.

## DISR

**DISR** Specifies the length of a straight approach line or the radius of an approach arc.

### Retraction/approach with straight lines

On approach/retraction along a straight line, **DISR** specifies the distance from the cutter edge to the start point of the contour, i.e. the length of the straight line with active TRC is calculated as the total of the tool radius and the programmed value of **DISR**.

An alarm is displayed:

- If **DISR** is negative and the amount is greater than the tool radius (the length of the resulting approach line is less than or equal to zero).

### Retraction/approach with circles

Approach/retraction with circles  $\square$  **DISR** indicates always the radius of the tool center point path. If tool radius compensation is activated, a circle is generated internally, the radius of which is dimensioned such that the tool center path is derived, in this case also, from the programmed radius.

An alarm is output on approach and retraction with circles:

- If the radius of the circle generated internally is zero or negative
- If **DISR** is not programmed
- If the radius value  $\leq 0$ .

## DISCL

**DISCL** specifies the distance from point P<sub>2</sub> from the machining plane.

If the position of point P<sub>2</sub> is to be specified by an absolute reference on the axis perpendicular to the circle plane, the value must be programmed in the form

**DISCL** = AC ( .... ).

If **DISCL** is not programmed, points P<sub>1</sub>, P<sub>2</sub> and P<sub>3</sub> are identical with G340 and the approach contour is mapped from P<sub>1</sub> to P<sub>4</sub>.

The system checks that the point defined by **DISCL** lies between P<sub>1</sub> and P<sub>3</sub>, i.e. in all movements, which have a component perpendicular to the machining plane (e.g. infeed movements, approach movements from P<sub>3</sub> to P<sub>4</sub>), this component must have the same leading sign. It is not permitted to change direction. An alarm is output if this condition is violated.

On detection of a direction reversal, a tolerance is permitted that is defined by the machine data:

MD20204 \$MC\_WAB\_CLEARANCE\_TOLERANCE (direction reversal on SAR).

However, if P<sub>2</sub> is outside the range defined by P<sub>1</sub> and P<sub>3</sub> and the deviation is less than or equal to this tolerance, it is assumed that P<sub>2</sub> is in the plane defined by P<sub>1</sub> and/or P<sub>3</sub>.

### Example:

An approach is made with G17 starting at position Z=20 of point P<sub>1</sub>. The SAR plane defined by P<sub>3</sub> is at Z=0. The point defined by **DISCL** must, therefore, lie between these two points. MD20204=0.010. If P<sub>2</sub> is between 20.000 and 20.010 or between 0 and -0.010, it is assumed that the value 20.0 or 0.0 is programmed. The alarm is output if the Z position of P<sub>2</sub> is greater than 20.010 or less than -0.010.

Depending on the relative position of start point  $P_0$  and end point  $P_4$  with reference to the machining plane, the infeed movements are performed in the negative (normal for approach) or positive (normal for retraction) direction, i.e. with G17 it is possible for the Z component of end point  $P_4$  to be greater than that of start point  $P_0$ .

**Programming the end point  $P_4$  (or  $P_0$  for retraction) generally with X... Y... Z...**

**Possible ways of programming the end point  $P_4$  for approach**

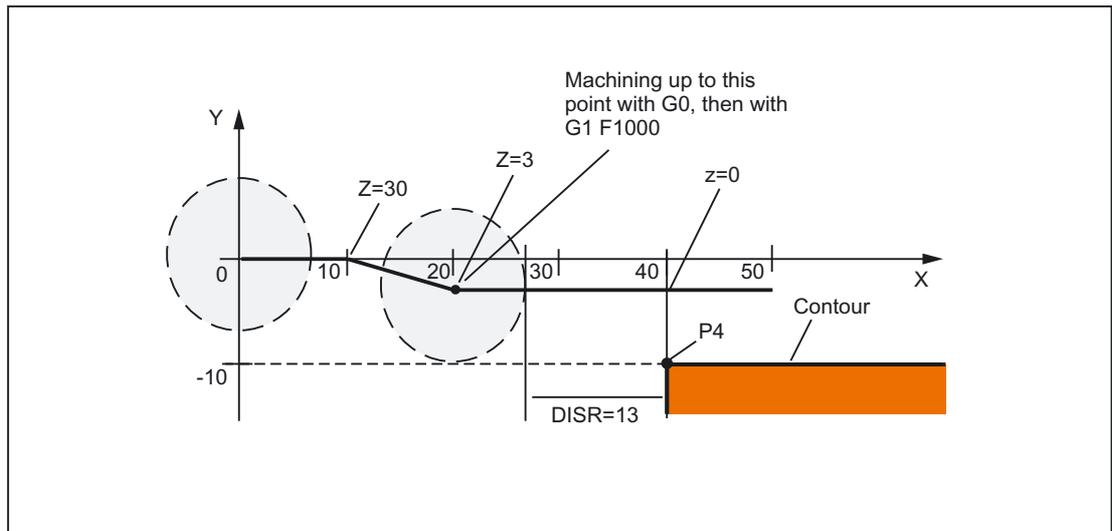
End point  $P_4$  can be programmed in the actual SAR block.

$P_4$  can be determined by the end point of the next traversing block.

Further blocks (dummy blocks) can be inserted between the SAR block and the next traversing block without moving the geometry axes.

The end point is deemed to have been programmed in the actual SAR block for approach if at least one geometry axis is programmed on the machining plane (X or Y with G17). If only the position of the axis perpendicular to the machining plane (Z with G17) is programmed in the SAR block, this component is taken from the SAR block, but the position in the plane is taken from the following block. In this case, an alarm is output if the axis perpendicular to the machining plane is also programmed in the following block.

**Example:**



```

$TC_DP1[1,1]=120 ; Milling tool T1/D1
$TC_DP6 [1,1] = 7 ; Tool with 7 mm radius

N10 G90 G0 X0 Y0 Z30 D1 T1
N20 X10
N30 G41 G147 DISCL=3 DISR=13 Z=0 F1000
N40 G1 X40 Y-10
N50 G1 X50
...
...
    
```

N30/N40 can be replaced by:

```
N30 G41 G147 DISCL=3 DISR=13 X40 Y-10 Z0 F1000
```

or:

```
N30 G41 G147 DISCL=3 DISR=13 F1000
```

```
N40 G1 X40 Y-10 Z0
```

### Possible ways of programming the end point P<sub>0</sub> for retraction

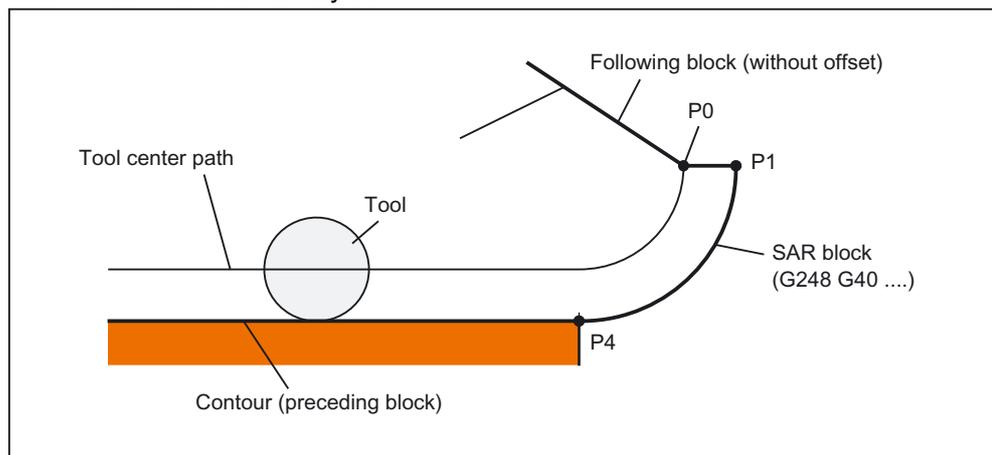
The end position is always taken from the SAR block, no matter how many axes have been programmed. We distinguish between the following situations:

1. No geometry axis is programmed in the SAR block.

In this case, the contour ends at point P<sub>2</sub> (or at point P<sub>1</sub>, if P<sub>1</sub> and P<sub>2</sub> coincide). The position in the axes, which describe the machining plane, is determined by the retraction contour (end point of the straight line or arc). The axis component perpendicular to this is defined by DISCL. If, in this case, DISCL = 0, the movement takes place completely within the plane.

2. Only the axis perpendicular to the machining plane is programmed in the SAR block.

In this case, the contour ends at point P<sub>1</sub>. The position of the two other axes is determined in the same way as in 1.



#### Retraction with SAR with simultaneous deactivation of TRC

If the SAR retraction block is also used to deactivate tool radius compensation, in the case of 1. and 2., an additional path from P<sub>1</sub> to P<sub>0</sub> is inserted such that no movement is produced when tool radius compensation is deactivated at the end of the retraction contour, i.e. this point defines the tool center point and not a position on a contour to be corrected.

3. At least one axis of the machining plane is programmed.

The second axis of the machining plane can be determined modally from its last position in the preceding block. The position of the axis perpendicular to the machining plane is generated as described in 1. or 2., depending on whether this axis is programmed or not. The position generated in this way defines the end point P<sub>0</sub>.

No special measures are required for deselection of tool radius compensation, because the programmed point P<sub>0</sub> already directly defines the position of the tool center point at the end of the complete contour.

The start and end points of the SAR contour ( $P_0$  and  $P_4$ ) can coincide on approach and retraction.

**Velocity of the preceding block (typically G0).**

All movements from point  $P_0$  to point  $P_2$  are performed at this velocity, i.e. the movement parallel to the machining plane and the part of the infeed movement up to the safety clearance.

**Programming the feedrate with FAD**

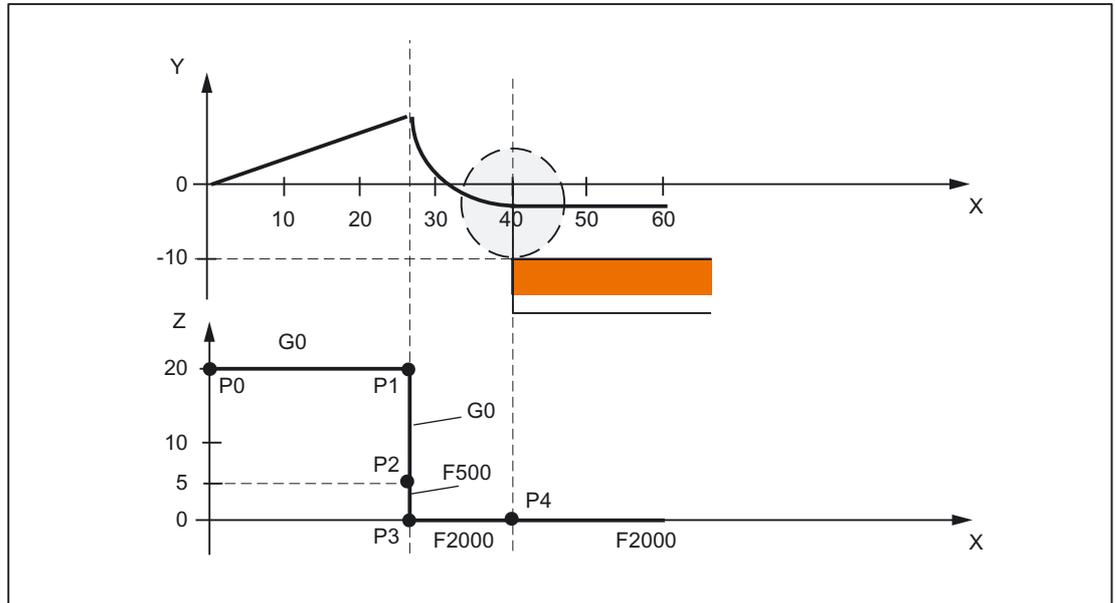
FAD programmed with ...	
G340	Feedrate from $P_2$ or $P_3$ to $P_4$ .
G341	Feedrate of the infeed movement perpendicular to the machining plane from $P_2$ to $P_3$ .

If FAD is not programmed, this part of the contour is traversed at the velocity, which is active modally from the preceding block, in the event that no F command defining the velocity is programmed in the SAR block.

**Programmed response:**

- FAD=0 or negative → Alarm Output
- FAD= . . . → Programmed value acts in accordance with the active G code of group 15 (feed type; G93, G94, etc.)
- FAD=PM ( . . . ) → Programmed value is interpreted as linear feed (like G94), irrespective of the active G code of group 15
- FAD=PR ( . . . ) → Programmed value is interpreted as revolutionary feed (like G95), irrespective of the active G code of group 15

**Example:**



```

$TC_DP1[1,1]=120 ;Milling tool T1/D1
$TC_DP6 [1,1] = 7 ;Tool with 7mm radius

N10 G90 G0 X0 Y0 Z20 D1 T1
N20 G41 G341 G247 DISCL=AC(5) DISR=13FAD 500 X40 Y-10 Z=0 F2000
N30 X50
N40 X60
...

```

**Programming feed F**

This feed value is effective from point P<sub>3</sub> (or from point P<sub>2</sub>, if FAD is not programmed). If no F command is programmed in the SAR block, the speed of the preceding block is valid. The velocity defined by FAD is not used for following blocks.

17.5.4.3 Velocities

Velocities at approach

In both approach diagrams below, it is assumed that no new velocity is programmed in the block following the SAR block. If this is not the case, the new velocity comes into effect after point P4.

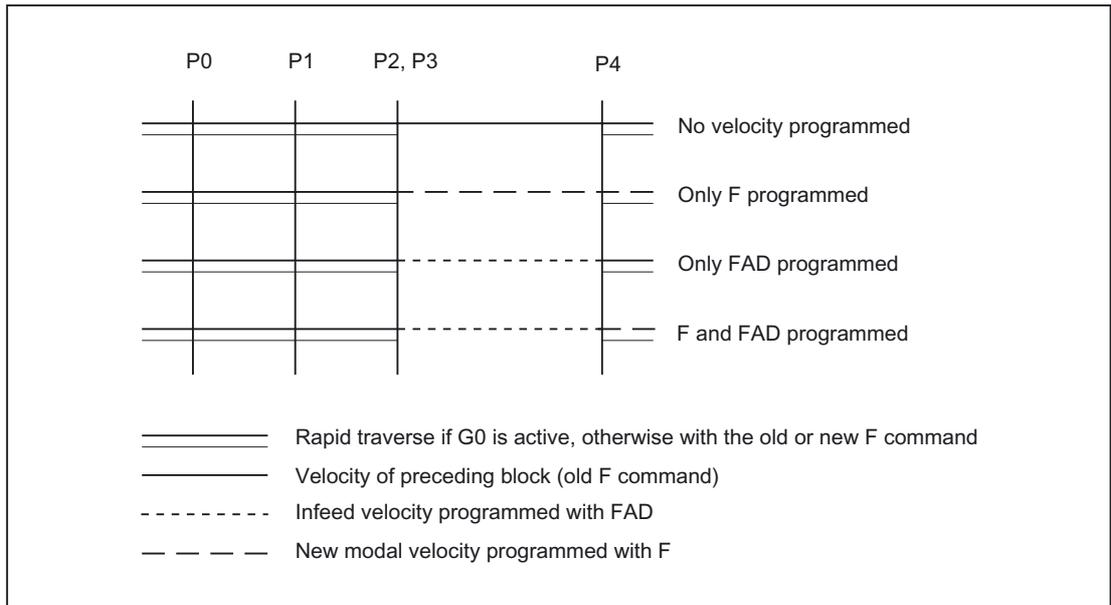


Figure 17-18 Velocities in the SAR subblocks on approach with G340

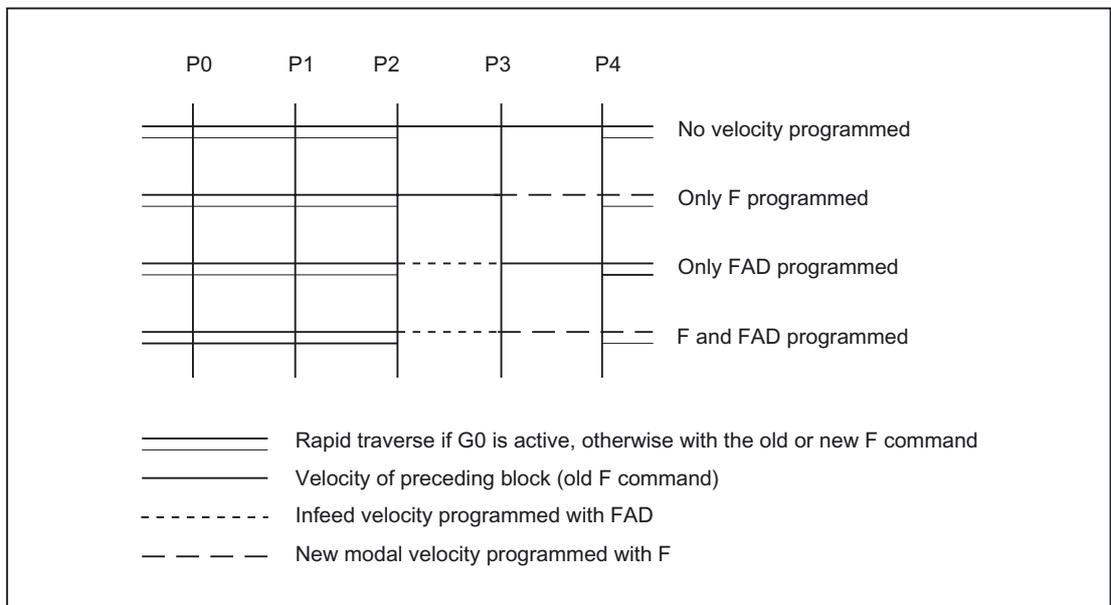


Figure 17-19 Velocities in the SAR subblocks on approach with G341

## Velocities at retraction

During retraction, the rolls of the modally active feedrate from the previous block and the programmed feedrate value in the SAR block are interchanged, i.e. the actual retraction contour (straight line, circle, helix) is traversed with the old feedrate value and a new velocity programmed with the F word applies from point P<sub>2</sub> up to P<sub>0</sub>.

If even retraction is active and FAD is programmed, the path from P<sub>3</sub> to P<sub>2</sub> is traversed with FAD, otherwise it is traversed with the old velocity. The last F command programmed in a preceding block always applies for the path from P<sub>4</sub> to P<sub>2</sub>. G0 has no effect in these blocks.

Traversing from P<sub>2</sub> to P<sub>0</sub> takes place with the F command programmed in the SAR block or, if no F command is programmed, with the modal F command from a preceding block. This applies on the condition that G0 is not active.

If rapid traverse is to be used on retraction in the blocks from P<sub>2</sub> to P<sub>0</sub>, G0 must be activated before the SAR block or in the SAR block itself. If an additional F command is programmed in the actual SAR blocks, it is then ineffective. However, it remains modally active for following blocks.

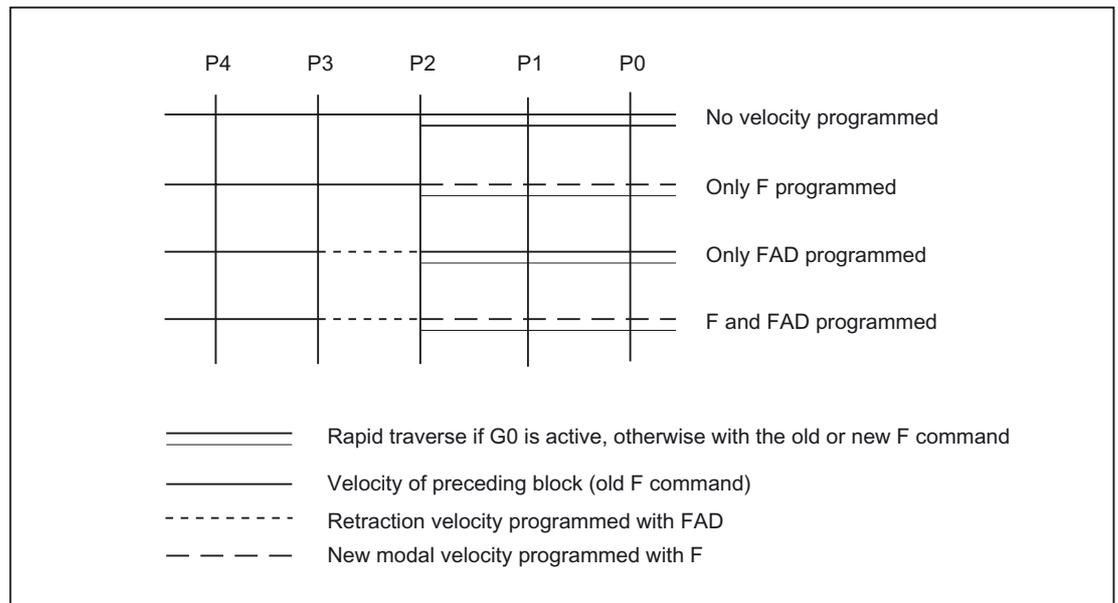


Figure 17-20 Velocities in the SAR subblocks on retraction

#### 17.5.4.4 System variables

Points P<sub>3</sub> and P<sub>4</sub> can be read in the WCS as system variables during approach.

\$P_APR:	Read P <sub>3</sub> (start point) in WCS	
\$P_AEP:	Read P <sub>4</sub> (contour start point) in WCS	
\$P_APDV	=1	If the content of \$P_APR and \$P_AEP is valid, i.e. if these contain the position values belonging to the last SAR approach block programmed.
	=0	The positions of an older SAR approach block are read.

Changing the WCS between the SAR block and the read operation has no effect on the position values.

#### 17.5.4.5 Supplementary conditions

##### Supplementary conditions

- Any further NC commands (e.g. auxiliary function outputs, synchronous axis movements, positioning axis movements, etc.) can be programmed in a SAR block.

These are executed in the first subblock on approach and in the last subblock on retraction.

- If the end point P<sub>4</sub> is taken not from the SAR block but from a subsequent traversing block, the actual SAR contour (straight line, quadrant or semicircle) is traversed in this block.

The last subblock of the original SAR block does not then contain traversing information for geometry axes. It is always output, however, because further actions (e.g. single axes) may have to be executed in this block.

- At least two blocks must always be taken into consideration:
  - The SAR block itself
  - The block, which defines the approach or retraction direction

Further blocks can be programmed between these two blocks.

The number of possible dummy blocks is limited with the machine data:

MD20202 \$MC\_WAB\_MAXNUM\_DUMMY\_BLOCKS (Maximum number of blocks with no traversing motions with SAR).

- If tool radius compensation is activated simultaneously in an approach block, the first linear block of the SAR contour is the block, in which activation takes place.

The complete contour generated by the SAR function is treated by tool radius compensation as if it has been programmed explicitly (collision detection, calculation of intersection, approach behavior *NORM/KONT*).

- The direction of the infeed movement and the position of the circle plane or the helix axis are defined exclusively by the active plane (G17 - G19) - rotated with an active frame where appropriate.

- On approach, a preprocessor stop must not be inserted between the SAR block and the following block, which defines the direction of the tangent.

Whether programmed explicitly or inserted automatically by the controller, a preprocessor stop results, in this case, in an alarm.

### Response with REPOS

If an SAR cycle is interrupted and repositioned, it resumes at the point of interruption on  $RMI$ . With  $RME$ , the contact point is the end point of the last SAR block; with  $RMB$ , it is the start point of the first SAR block.

If  $RMI$  is programmed together with  $DISPR$  (reapproach at distance  $DISPR$  in front of interruption point), the reapproach point can appear in a subblock of the SAR cycle before the interruption subblock.

### 17.5.4.6 Examples

#### Example 1

The following conditions must be true:

- Smooth approach is activated in block N20
- $X=40$  (end point);  $Y=0$ ;  $Z=0$
- Approach movement performed with quadrant ( $G247$ )
- Approach direction not programmed,  $G140$  is valid, i.e. because TRC is active ( $G42$ ) and compensation value is positive (10), the contour is approached from the right
- Approach circle generated internally (SAR contour) has radius 20, so that the radius of the tool center path is equal to the programmed value  $DISR=10$
- Because of  $G341$ , the approach movement takes place with a circle in the plane, resulting in a start point at (20, -20, 0)
- Because  $DISCL=5$ , point P2 is at position (20, -20, 5) and, because of  $Z30$ , point P1 is in N10 at (20, -20, 30)

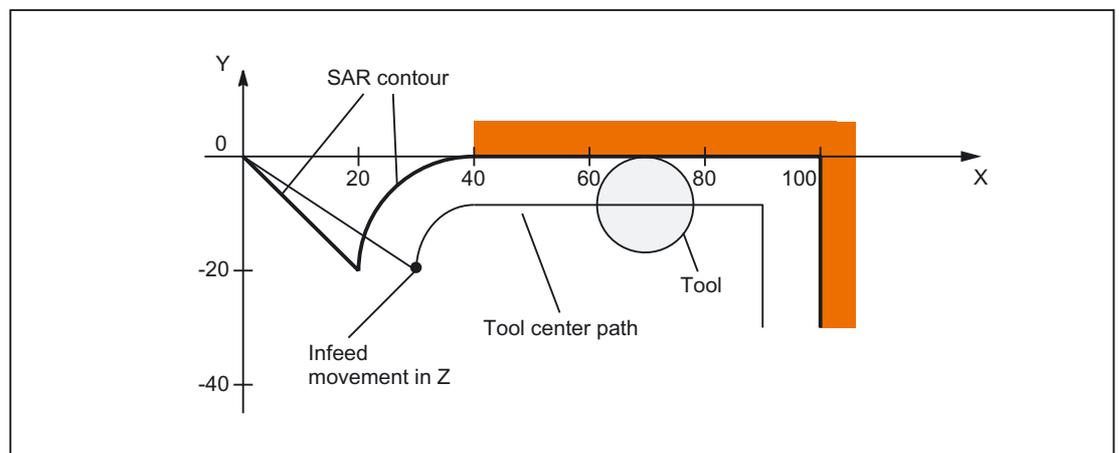


Figure 17-21 Contour example 1

**Part program:**

```

$TC_DP1[1,1]=120 ; Tool definition T1/D1
$TC_DP6[1,1]=10 ; Radius
N10 G0 X0 Y0 Z30
N20 G247 G341 G42 NORM D1 T1 Z0 FAD=1000 F=2000 DISCL=5 DISR=10
N30 X40
N40 X100
N50 Y-30
...

```

**Example 2**

The following conditions must be true for approach:

- Smooth approach is activated in block N20
- Approach movement performed with quadrant (G247)
- Approach direction not programmed, G140 is valid, i.e. because TRC is active (G41), the contour is approached from the left
- Contour offset OFFN=5 (N10)
- Current tool radius=10, and so the effective compensation radius for TRC=15; the radius of the SAR contour is thus equal to 25, with the result that the radius of the tool center path is equal to DISR=10
- The end point of the circle is obtained from N30, since only the Z position is programmed in N20
- Infeed movement
  - From Z20 to Z7 (DISCL=AC(7)) with rapid traverse
  - Then on to Z0 with FAD=200
  - Approach circle in X-Y-plane and following blocks with F1500  
(In order that this velocity becomes effective in the following blocks, the active G-code G0 in N30 must be overwritten with G1. Otherwise, the contour would continue to be machined with G0.)

The following conditions must be true for retraction:

- Smooth retraction is activated in block N60
- Retraction movement performed with quadrant (G248) and helix (G340)
- FAD not programmed, since irrelevant for G340
- Z=2 in the start point; Z=8 in the end point, since DISCL=6
- When DISR=5, the radius of SAR contour=20; that of the tool center point path=5
- After the circle block, the retraction movement leads from Z8 to Z20 and the movement is parallel to the X-Y plane up to the end point at X70 Y0.

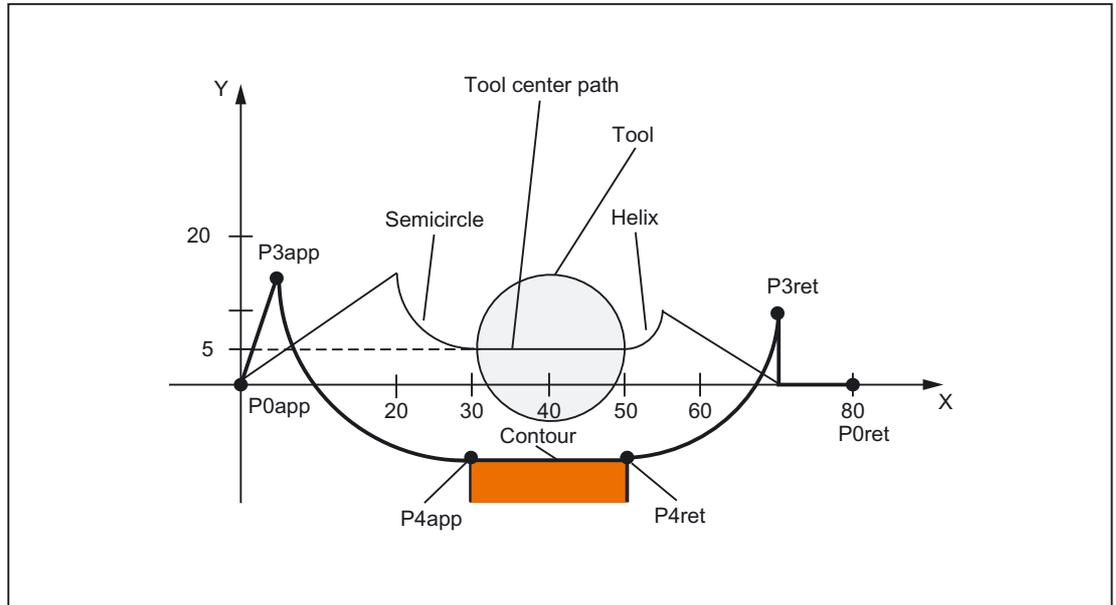


Figure 17-22 Contour example 2

**Part program:**

```

$TC_DP1[1,1]=120                ;Tool definition T1/D1
$TC_DP6[1,1]=10                 ; Radius
N10 G0 X0 Y0 Z20 G64 D1 T1 OFFN = 5                                (P0app)
N20 G41 G247 G341 Z0 DISCL = AC(7) DISR = 10 F1500 FAD=200        (P3app)
N30 G1 X30 Y-10                                                    (P4app)
N40 X40 Z2
N50 X50                                                            (P4ret)
N60 G248 G340 X70 Y0 Z20 DISCL = 6 DISR = 5 G40 F10000           (P3ret)
N70 X80 Y0                                                        (P0ret)
N80 M 30

```

**Note**

The contour generated in this way is modified by tool radius compensation, which is activated in the SAR approach block and deactivated in the SAR retraction block.

The tool radius compensation allows for an effective radius of 15, which is the sum of the tool radius (10) and the contour offset (5). The resulting radius of the tool center path in the approach block is therefore 10, and 5 in the retraction block.

### 17.5.5 Deselecting the TRC (G40)

#### G40 instruction

TRC is deselected with the G40 instruction.

#### Special points to be noted

- TRC can only be deselected in a program block with G0 (rapid traverse) or G1 (linear interpolation).
- If D0 is programmed when tool radius compensation is active, compensation is not deselected and error message 10750 is output.
- If a geometry axis is programmed in the block with the tool radius compensation deselection, then the compensation is deselected even if it is not on the current plane.

### 17.5.6 Compensation at outside corners

#### G450/G451

The G functions G450/G451 can be used to control the response with discontinuous block transitions at outside corners:

Command	Significance
G450	Discontinuous block transitions with transition circle
G451	Discontinuous block transitions with intersection of equidistant paths

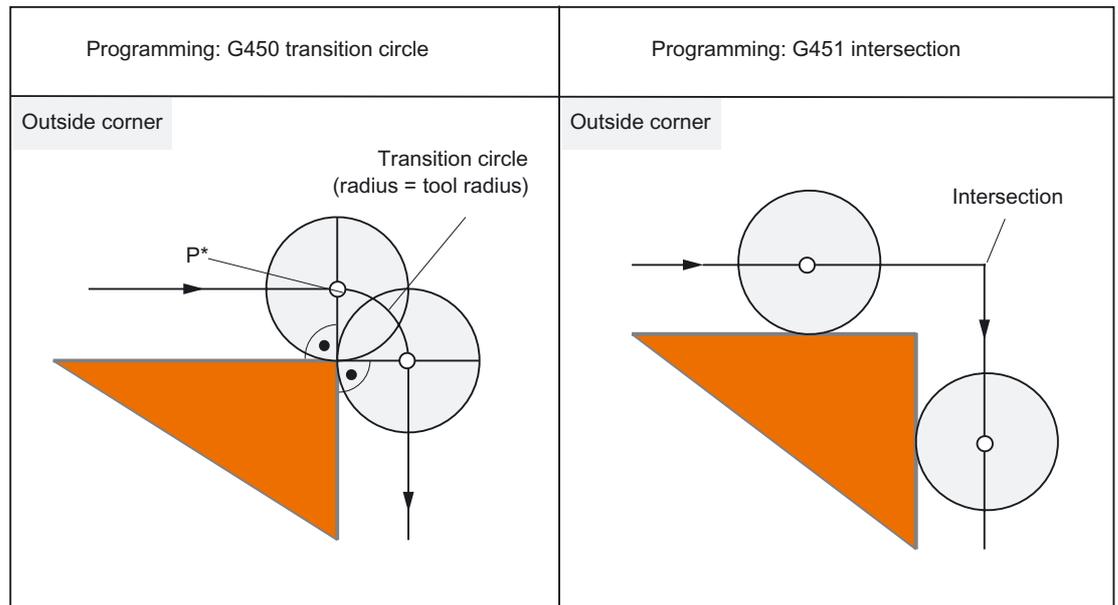


Figure 17-23 Example of a 90 degree outside corner with G450 and G451

### G450 (transition circle)

With the G function G450 active, on outside corners, the center point of the tool travels a circular path along the tool radius. The circular path starts with the normal position (perpendicular to the path tangent) at the end point of the previous path section (program block) and ends in normal position at the start point of the new path section (program block).

Where outside corners are very flat, the response with G450 (transition circle) and G451 (intersection) becomes increasingly similar → refer to very flat outside corners.

If pointed outside corners are desired, the tool must be retracted from the contour (→ see "DISC").

### DISC

The G450 transition circle does not produce sharp outside contour corners because the path of the tool center point through the transition circle is controlled so that the cutting edge stops at the outside corner (programmed position). When sharp outside corners are to be machined with G450, the DISC instruction can be used to program an overshoot. Thus, the transition circle becomes a conic and the tool cutting edge retracts from the outside corner.

The range of values of the DISC instruction is 0 to 100, in increments of 1.

Value	Significance
DISC = 0	Overshoot disabled, transition circle active
DISC = 100	Overshoot large enough to theoretically produce a response similar to intersection (G451).

The programmable maximum value for DISC can be set via the machine data:

MD20220 \$MC\_CUTCOM\_MAX\_DISC (max. value for DISC).

Values greater than 50 are generally not advisable with DISC.

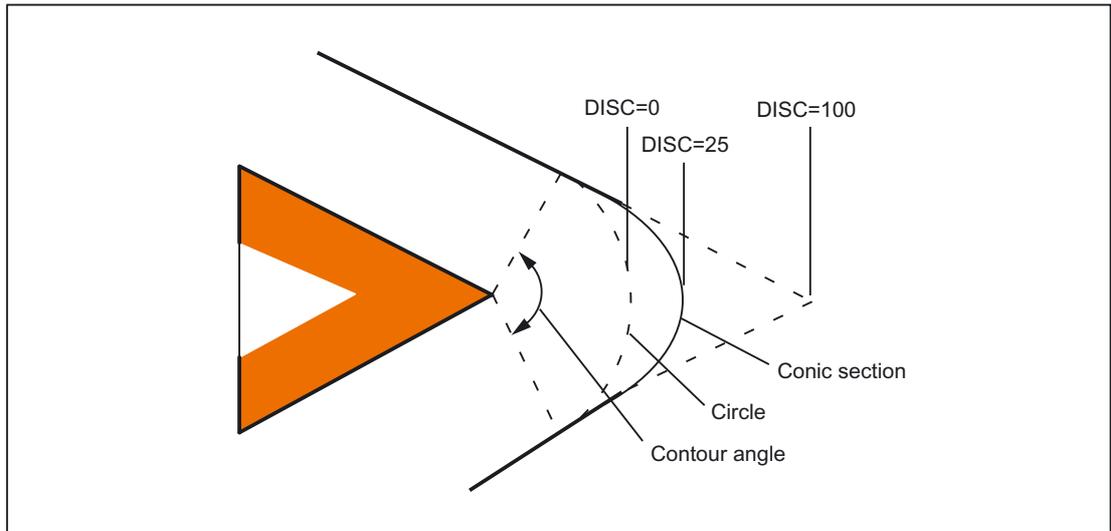


Figure 17-24 Example: Overshoot with DISC= 25

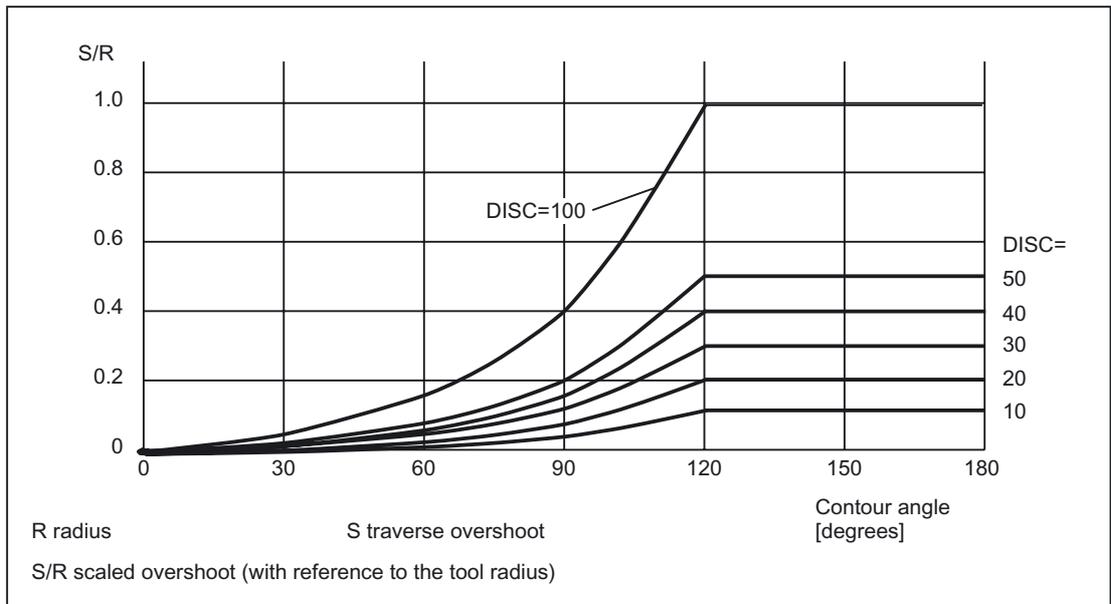


Figure 17-25 Overshoot with DISC depending on contour angle

### G451 (intersection)

If G function G451 is active, the position (intersection) resulting from the path lines (straight line, circle or helix only) located at a distance of the tool radius to the programmed contour (center-point path of the tool), is approached. Spines and polynomials are never extended.

### Very pointed outside corners

Where outside corners are very pointed, G451 can result in excessive idle paths. Therefore, the system switches automatically from G451 (intersection) to G450 (transition circle, with DISC where appropriate) when outside corners are very pointed.

The threshold angle (contour angle) for this automatic switchover (intersection point → transition circle) can be specified in the machine data:

MD20210 \$MC\_CUTCOM\_CORNER\_LIMIT (Max. angle for compensation blocks with tool radius compensation).

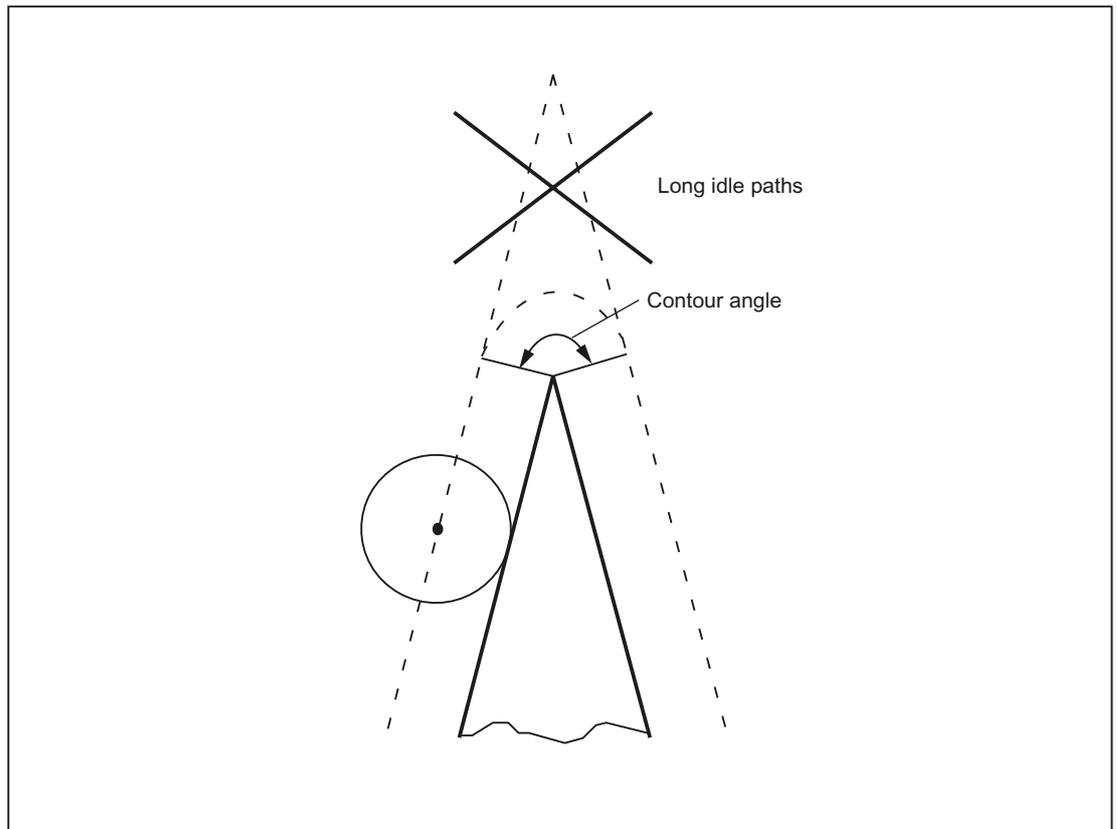


Figure 17-26 Example of automatic switchover to transition circle

### Very flat outside corners

Where outside corners are very flat, the response with G450 (transition circle) and G451 (intersection) becomes increasingly similar. In this case, it is no longer advisable to insert a transition circle. One reason why it is not permitted to insert a transition circle at these outside corners with 5-axis machining is that this would impose restrictions on speed in contouring mode (G64). Therefore, the system switches automatically from G450 (transition circle, with DISC where appropriate) to G451 (intersection) when outside corners are very flat.

The threshold angle (contour angle) for this automatic switchover (transition circle → intersection point) can be specified in the machine data:

MD20230 \$MC\_CUTCOM\_CURVE\_INSERT\_LIMIT (Max. angle for intersection calculation with tool radius compensation).

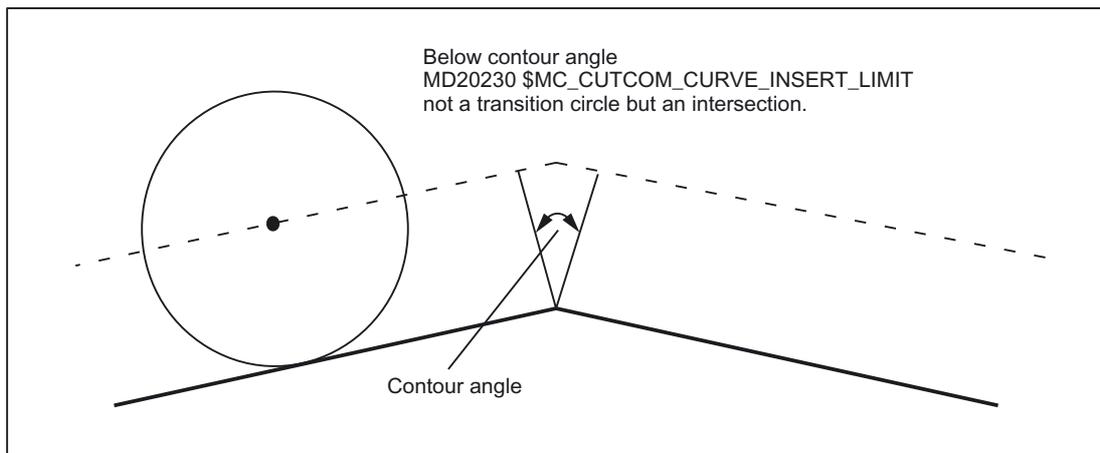


Figure 17-27 Example of automatic switchover to intersection

### 17.5.7 Compensation at inside corners

#### Intersection

If two consecutive blocks form an inside corner, an attempt is made to find a point at which the two equidistant paths intersect. If an intersection is found, the programmed contour is shortened to the intersection (first block shortened at end, second block shortened at beginning).

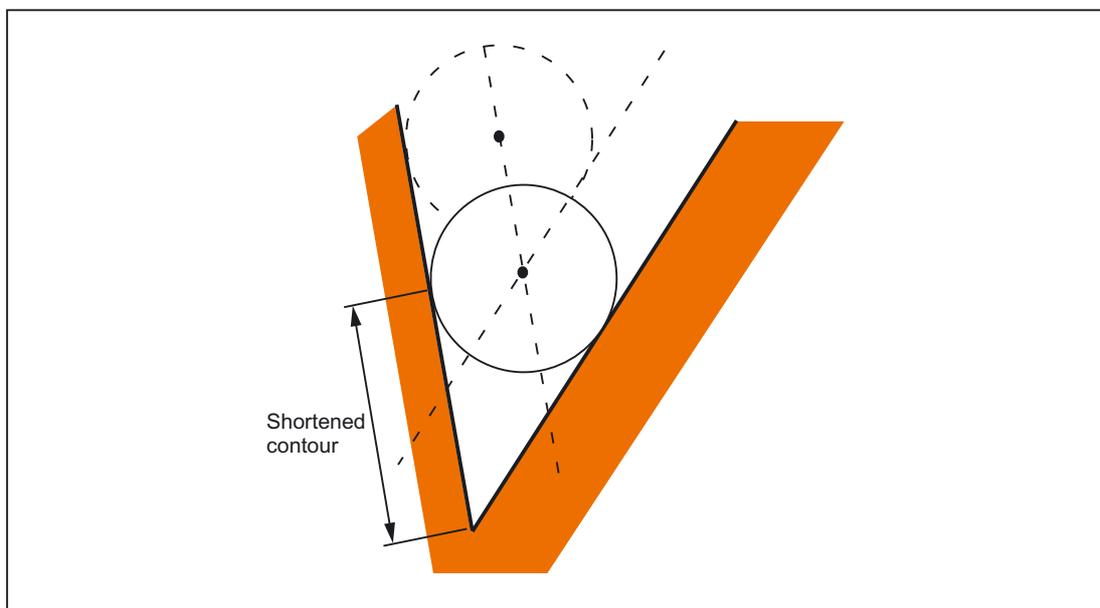


Figure 17-28 Example of a shortened contour

## No intersection

In certain cases, no intersection is found between two consecutive blocks for inside corners (see figure below).

## Predictive contour calculation

If no intersection is found between two consecutive blocks, the control automatically checks the next block and attempts to find an intersection with the equidistant paths of this block (see figure below: intersection S). This automatic check of the next block (predictive contour calculation) is always performed until a number of blocks defined via machine data has been reached.

MD20240 \$MC\_CUTCOM\_MAXNUM\_CHECK\_BLOCKS (blocks for predictive contour calculation for TRC).

If no intersection is found within the number of blocks defined for the check, program execution is interrupted and an alarm is output.

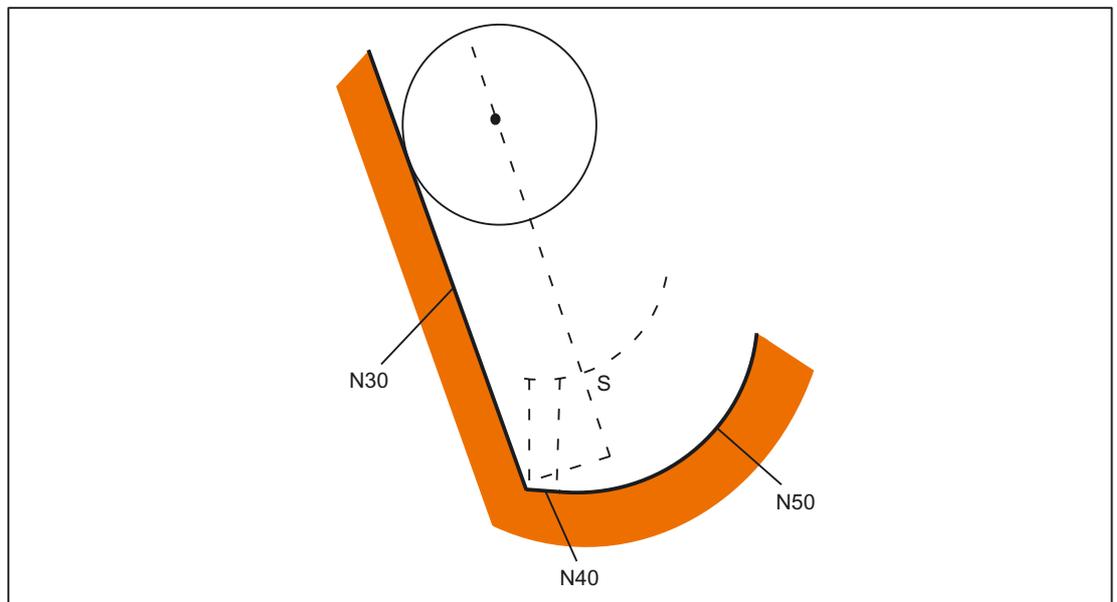


Figure 17-29 If there is no intersection between N30 and block N40, the intersection between block N30 and block N50 is calculated.

## Multiple intersections

→ see also "Collision detection"

It can be the case with inside corners that predictive contour calculation finds multiple intersections of the equidistant paths in several consecutive blocks. In these cases, the last intersection is always used as the valid intersection:

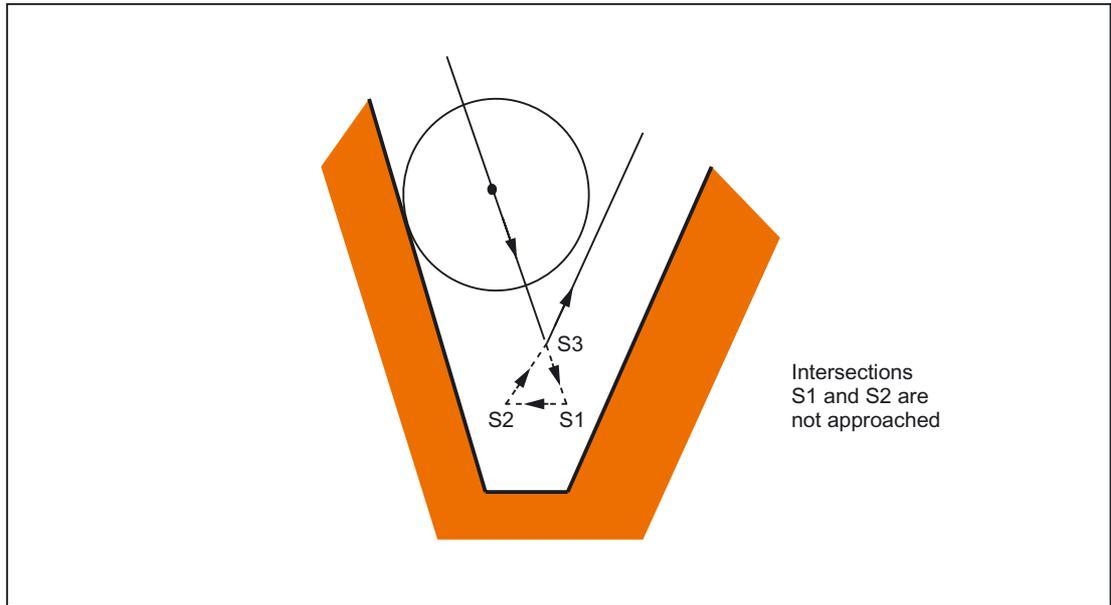


Figure 17-30 Example: Inside corner with TRC without contour violation (predicting 3 blocks)

**Special points to be noted**

Where multiple intersections with the next block are found, the intersection nearest the start of the next block applies.

**17.5.8 Collision detection and bottleneck detection**

**Collision detection**

Collision detection (bottleneck detection) examines whether the equidistant paths of non-consecutive blocks intersect. If an intersection is found, the response is the same as for inside corners with multiple intersections: The last intersection to be found is valid:

The maximum number of blocks used for the predictive check can be entered in the machine data:

MD20240 \$MC\_CUTCOM\_MAXNUM\_CHECK\_BLOCKS (blocks for predictive contour calculation for TRC).

**Programming**

Collision detection can be activated or deactivated in the program:

Command	Significance
CDON	Collision detection ON
CDOF	Collision detection OFF
CDOF2	Collision detection OFF

With `CDOF`, the search for an intersection initially examines two consecutive blocks. Other blocks are not included in the search. If an intersection is found between adjacent blocks, no further blocks are examined. With outside corners, an intersection can always be found between two consecutive blocks.

Predictive examination of more than two adjacent blocks is thus possible with `CDON` and `CDOF`.

---

**Note**

`CDOF2` is only effective for 3D peripheral milling and has the same significance as `CDOF` for all other types of machining (e.g. 3D face milling).

---

**Omission of block**

If an intersection is detected between two blocks, which are not consecutive, none of the motions programmed between these blocks on the compensation plane are executed. All other motions and executable instructions (M commands, traversal of positioning axes, etc.) contained in the omitted blocks are executed at the intersection position in the sequence, in which they are programmed in the NC program.

**Warning 10763**

If a block has been omitted as a result of the collision or bottleneck detection functions, warning 10763 is output. The program is not interrupted.

This warning is suppressed if bit 1 is enabled in machine data:

MD11410 \$MN\_SUPPRES\_ALARM\_MASK (Mask for suppressing special alarm outputs).

**Special points to be noted**

When the intersections of non-consecutive blocks are checked, it is not the programmed original contours that are examined, but the associated calculated equidistant paths. This can result in a "bottleneck" being falsely detected at outside corners. The reason for this is that the calculated tool path does not run equidistant to the programmed original contour when `DISC>0`.

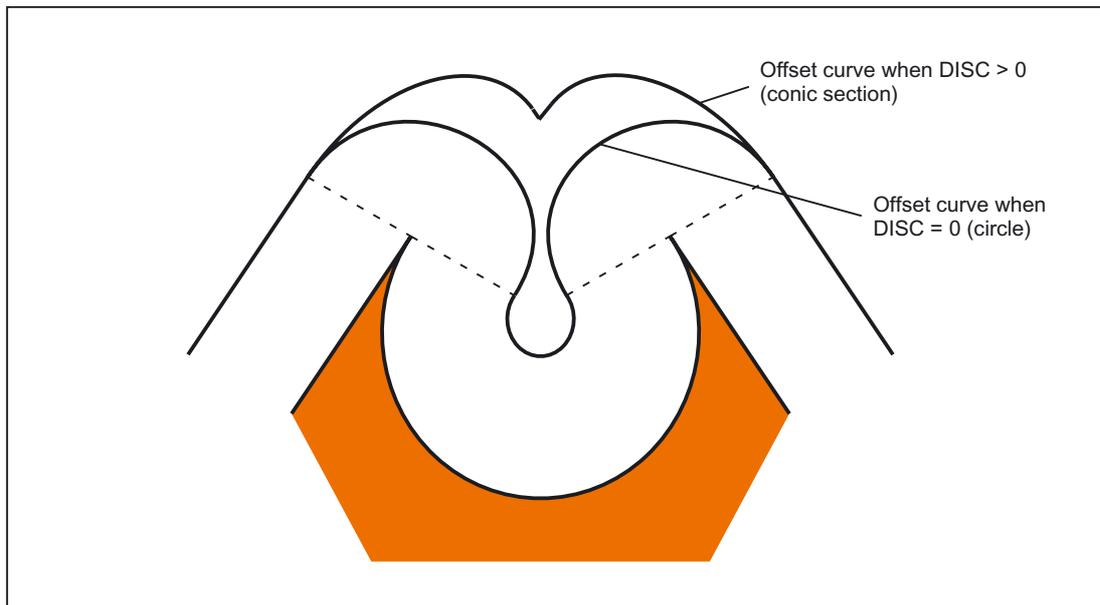


Figure 17-31 Bottleneck detection and outside corners

### 17.5.9 Blocks with variable compensation value

#### Supplementary conditions

A variable compensation value is permissible for all types of interpolation (including circular and spine interpolation).

It is also permitted to change the sign (and, therefore, the compensation side).

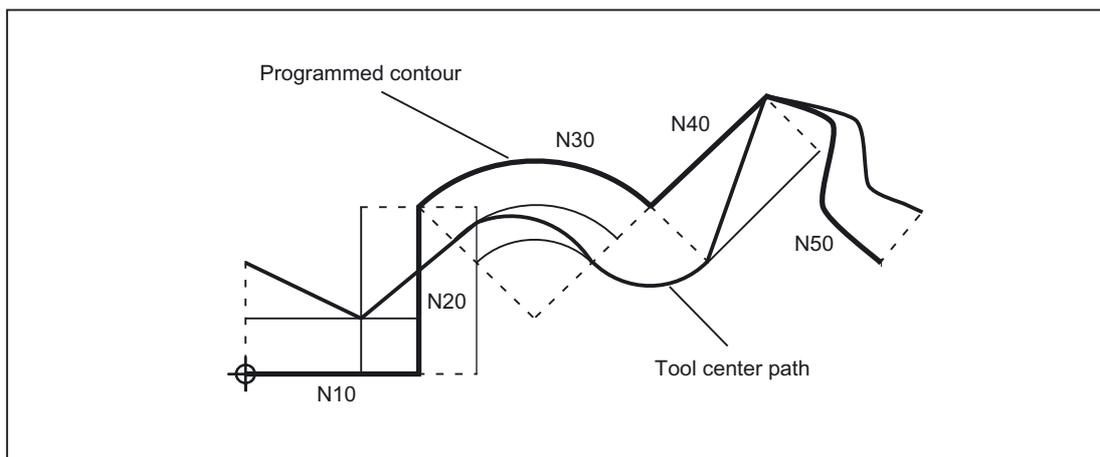


Figure 17-32 Tool radius compensation with variable compensation value

## Calculation of intersection

When the intersections in blocks with variable compensation value are calculated, the intersection of the offset curves (tool paths) is always calculated based on the assumption that the compensation value is constant.

If the block with the variable compensation value is the first of the two blocks to be examined in the direction of travel, then the compensation value at the block end is used for the calculation; the compensation value at the block start is used otherwise.

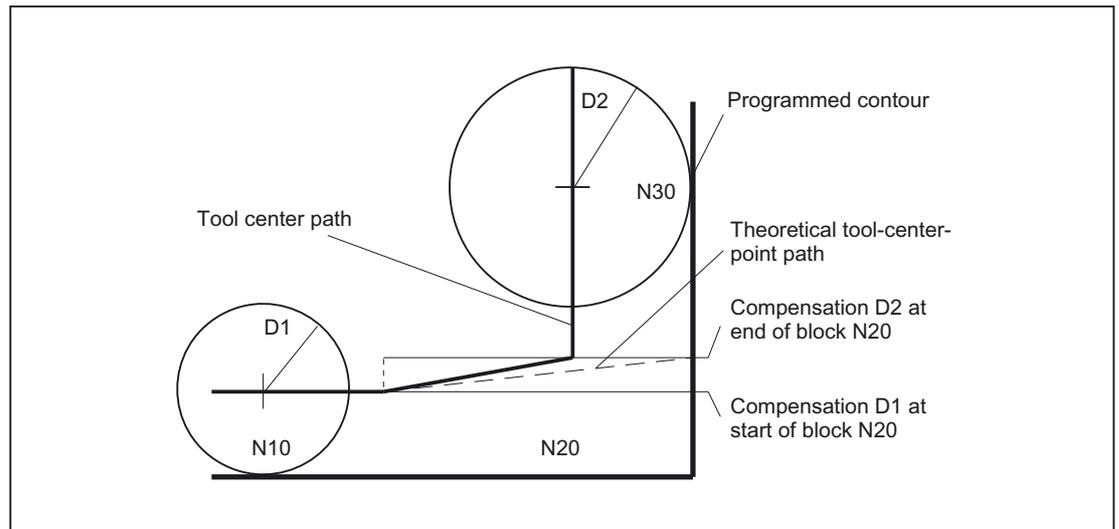


Figure 17-33 Intersection calculation with variable compensation value

## Restrictions

If during machining on the inside of the circle the compensation radius becomes greater than the programmed circle radius, then the machining is rejected with the following alarm:

Alarm 10758 "Curvature radius with variable compensation value too small"

## Maintain stability of closed contour

If a radius of two circles is increased slightly, a third block may be necessary in order to maintain the stability of the closed contour. This is the case if two adjacent blocks, which represent two possible intersection points for a closed contour, are skipped due to the compensation.

A stable closed contour can be achieved by choosing the first intersection point instead of the second.

SD42496 \$SC\_CUTCOM\_CLSD\_CONT  $\neq$  0 (response of TRC for closed contour).

In that case, the second intersection point is always reached, even if the block is skipped. A third block is then not required.

## 17.5.10 Keep tool radius compensation constant

### Description

The "Keep tool radius compensation constant" function is used to suppress tool radius compensation for a number of blocks, whereby a difference between the programmed and the actual tool center path traveled set up by tool radius compensation in the previous blocks is retained as the compensation.

It can be an advantage to use this method when several traversing blocks are required during line milling in the reversal points, but the contours produced by the tool radius compensation (follow strategies) are not wanted.

### Activation

The "Keep tool radius compensation constant" function is activated with the G code `CUTCONON` (CUTter compensation CONstant ON) and deactivated with the G code `CUTCONOF` (CUTter compensation CONstant OFF).

`CUTCONON` and `CUTCONOF` form a modal G-code group.

The initial setting is `CUTCONOF`.

The function can be used independently of the type of tool radius compensation (2½D, 3D face milling, 3D circumferential milling).

### Normal case

Tool radius compensation is normally active before the compensation suppression and is still active when the compensation suppression is deactivated again.

In the last traversing block before `CUTCONON`, the offset point in the block end point is approached. All following blocks, in which compensation suppression is active, are traversed without compensation. However, they are offset by the vector from the end point of the last offset block to its offset point. These blocks can have any type of interpolation (linear, circular, polynomial).

The deactivation block of the compensation suppression, i.e. the block that contains `CUTCONOF`, is compensated normally. It starts in the offset point of the start point. One linear block is inserted between the end point of the previous block, i.e. the last programmed traversing block with active `CUTCONON`, and this point.

Circular blocks, for which the circle plane is perpendicular to the compensation plane (vertical circles), are treated as though they had `CUTCONON` programmed. This implicit activation of compensation suppression is automatically canceled in the first traversing block that contains a traversing motion in the compensation plane and is not such a circle. Vertical circle in this sense can only occur during circumferential milling.

**Example:**

```

N10                                ; Definition of tool d1
N20 $TC_DP1[1,1] = 110             ; Type
N30 $TC_DP6[1,1]=                  ; Radius
N40
N50 X0 Y0 Z0 G1 G17 T1 D1 F10000
N60
N70 X20 G42 NORM
N80 X30
N90 Y20
N100 X10 CUTCONON                  ; Activate compensation suppression
N110 Y30 KONT                       ; On deactivation of contour suppression,
                                     insert bypass circle, if necessary
N120 X-10 CUTCONOF                 ; No bypass circle on deactivation of TRC
N130 Y20 NORM
N140 X0 Y0 G40
N150 M30

```

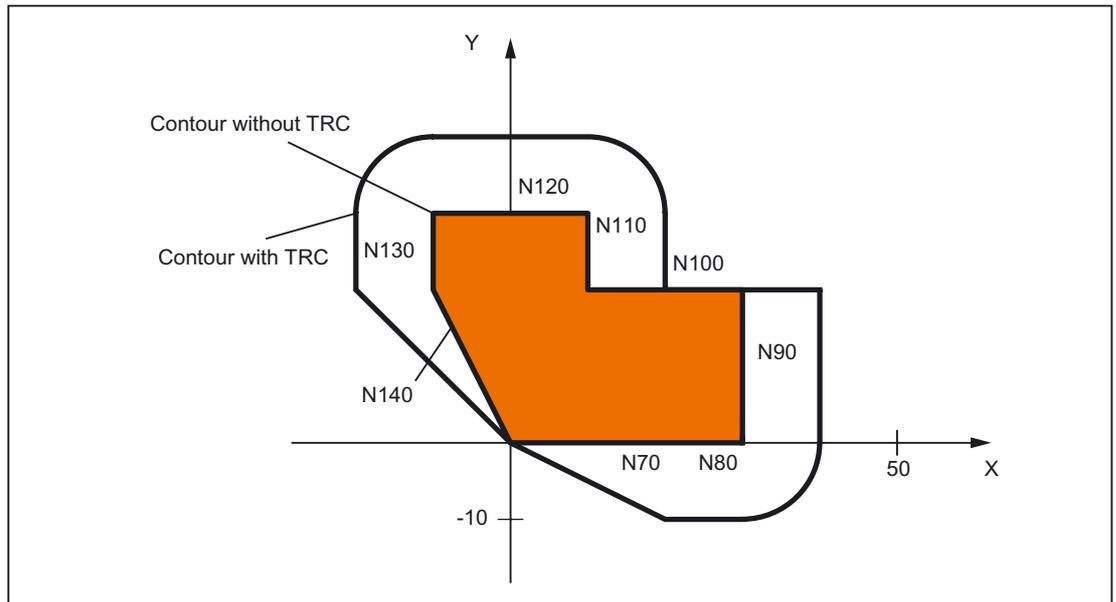


Figure 17-34 Sample program for contour suppression

### Special cases

- If tool radius compensation is not active (G40), CUTCONON has no effect. No alarm is produced. The G code remains active, however.  
This is significant if tool radius compensation is to be activated in a later block with G41 or G42.
- It is permissible to change the G code in the 7th G-code group (tool radius compensation; G40/G41/G42) with CUTCONON active. A change to G40 is active immediately.  
The offset used for traversing the previous blocks is traveled.
- If CUTCONON or CUTCONOF is programmed in a block without traversing in the active compensation plane, activation is delayed until the next block that has such a traversing motion.
- If CUTCONON is programmed with active tool radius compensation and not canceled before the end of the program, the traversing blocks are traversed with the last valid compensation.  
The same applies for reprogramming of G41 or G42 in the last traversing block of a program.
- If tool radius compensation is activated with G41 or G42 and CUTCONON is also already active, activation of compensation is delayed until the next traversing block with CUTCONOF.
- When reapproaching the contour with CUTCONOF, the 17th G-code group (approach and retraction behavior with tool compensation; NORM/KONT) is evaluated, i.e. a bypass circle is inserted if necessary for KONT. A bypass circle is inserted under the same conditions as for activation of tool radius compensation with G41 or G42.
- The number of blocks with suppressed tool radius compensation is restricted:  
MD20252 \$MC\_CUTCOM\_MAXNUM\_SUPPR\_BLOCKS (Maximum number of blocks with compensation suppression).  
If it is exceeded, machining is aborted and an error message issued.  
The restriction is necessary because the internal block processing in the last block before CUTCONON must be resumed when repositioning.
- The response after reprogramming G41 or G42 when tool radius compensation is already active is similar to compensation suppression.  
The following deviations apply:
  - Only linear blocks are permissible
  - A single traversing block that contains G41 or G42 is modified so that it ends at the offset point of the start point in the following block. Thus it is not necessary to insert a dummy block. The same applies to the last block in a sequence of traversing blocks where each contains G41 or G42.
  - The contour is always reapproached with NORM, independent of the G code of the 17th group (approach and retraction behavior with tool compensation; NORM/KONT).
- If G41/G42 is programmed several times in consecutive traversing blocks, all blocks are machined as for CUTCONON, except for the last one.

- The type of contour suppression is evaluated only in the first traversing block of a sequence of consecutive traversing blocks.

If both `CUTCONON` and `G41` or `G42` are programmed in the first block, the response to deactivating contour suppression is determined by `CUTCONON`.

Changing from `G41` to `G42` or vice versa makes sense in this case as a means of changing the compensation side (left or right of the contour) when restarting.

A change of compensation side (`G41/G42`) can also be programmed in a later block, even if contour suppression is active.

- Collision detection and bottleneck detection is deactivated for all blocks with active contour suppression.

## 17.5.11 Alarm behavior

### Alarm during preprocessing

If a tool radius compensation alarm is output during preprocessing, main-run machining stops at the next block end reached, i.e. usually at the end of the block currently being interpolated (if Look Ahead is active, once the axes have come to a stop).

### Alarms for preprocessing stop and active tool radius compensation

Tool radius compensation generally requires at least one of the following traversing blocks (even more for bottlenecks) to determine the end point of a block. Since the preprocessing stop of such a block is not available, traversing continues to the offset point in the last block. Correspondingly, the offset point in the start point is approached in the first block after a preprocessing stop.

The contour obtained may deviate considerably from the one that would result without preprocessing stop. Contour violations in particular are possible. Therefore the following setting data was introduced:

`SD42480 $MC_STOP_CUTCOM_STOPRE` (alarm response for TRC and preprocessing stop).

The response of the tool radius compensation remains unchanged compared to the previous status, and/or an alarm is output for preprocessing stop during active tool radius compensation and the program is halted, depending on the value.

The user can acknowledge this alarm and continue the NC program with NC start or abort it with `RESET`.

### 17.5.12 Intersection procedure for polynomials

#### Function

If two curves with active tool radius compensation form an outside corner, depending on the G code of the 18th group (corner behavior with tool compensation; G450/G451) and regardless of the type of curves involved (straight lines, circles, polynomials):

- Either a conic is inserted to bypass the corner  
or
- The curves involved are extrapolated to form an intersection.

If no intersection is found with G451 activated, or if the angle formed by the two curves is too steep, switchover to insert mode is automatic.

The intersection procedure for polynomials is released with the machine data:

MD20256 \$MC\_CUTCOM\_INTERS\_POLY\_ENABLE (Intersection process possible for polynomials)

---

#### Note

If this machine data is set to inactive, a block (can be very short) is always inserted (even if transitions are almost tangential). These short blocks always produce unwanted drops in speed during G64 operation.

---

### 17.5.13 G461/G462 Approach/retract strategy expansion

#### Function

In certain special geometrical situations, extended approach and retraction strategies, compared with the previous implementation, are required in order to activate or deactivate tool radius compensation (see figure below).

---

#### Note

The following example describes only the situation for deactivation of tool radius compensation. The response for approach is virtually identical.

---

#### Example

```
G42 D1 T1 ; Tool radius 20 mm
...
G1 X110 Y0
N10 X0
N20 Y10
N30 G40 X50 Y50
```

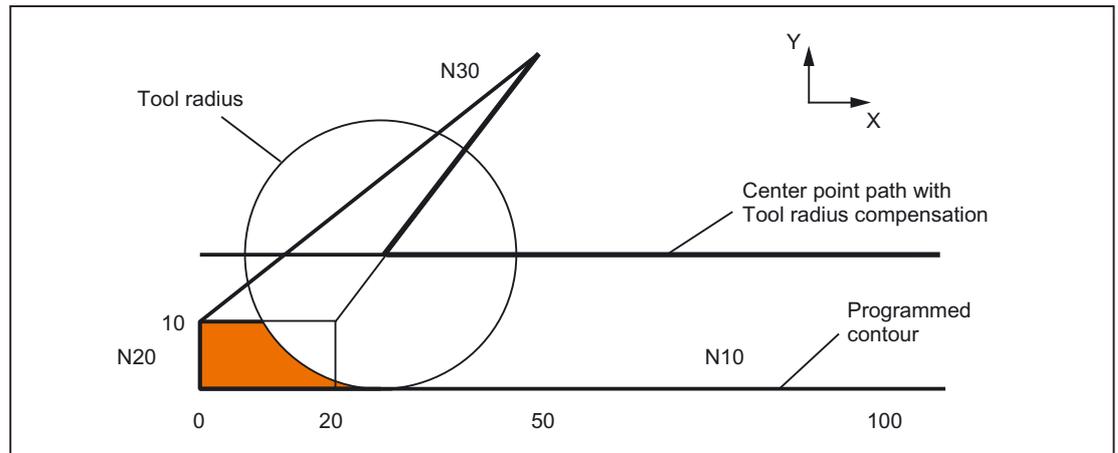


Figure 17-35 Retraction behavior with G460

The last block with active tool radius compensation (N20) is so short that an intersection no longer exists between the offset curve and the preceding block (or a previous block) for the current tool radius. An intersection between the offset curves of the following and preceding blocks is therefore sought, i.e. between N10 and N30 in this example. The curve used for the retraction block is not a real offset curve, but a straight line from the offset point at the end of block N20 to the programmed end point of N30. The intersection is approached if one is found. The colored area in the figure is not machined, although the tool used would be capable of this.

## G460

With G460, the approach/retraction strategy is the same as before.

## G461

If no intersection is possible between the last TRC block and a preceding block, the offset curve of this block is extended with a circle whose center point lies at the end point of the uncorrected block and whose radius is equal to the tool radius.

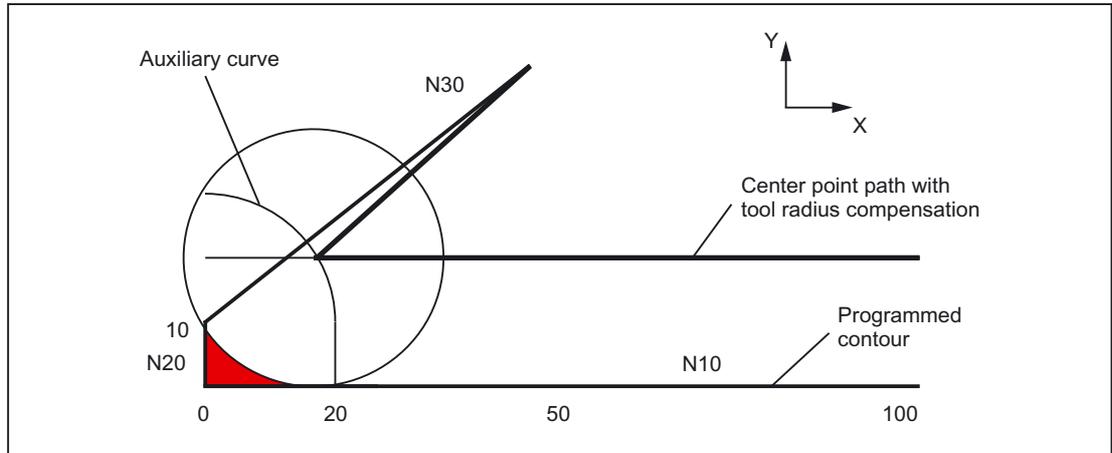


Figure 17-36 Retraction behavior with G461

The control attempts to cut this circle with one of the preceding blocks. If `CDOF` is active, the search is terminated when an intersection is found, i.e. the system does not check for more intersections with even earlier blocks.

If `CDON` is active, the search for more intersections continues after the first intersection is found.

An intersection point, which is found in this way, is the new end point of a preceding block and the start point of the deactivation block. The inserted circle is used exclusively to calculate the intersection and does not produce a traversing movement.

---

**Note**

If no intersection is found, the following alarm is output:

Alarm "10751 Collision danger"

---

**G462**

If no intersection is possible between the last TRC block and a preceding block, a straight line is inserted, on retraction with `G462` (initial setting), at the end point of the last block with tool radius compensation (the block is extended by its end tangent).

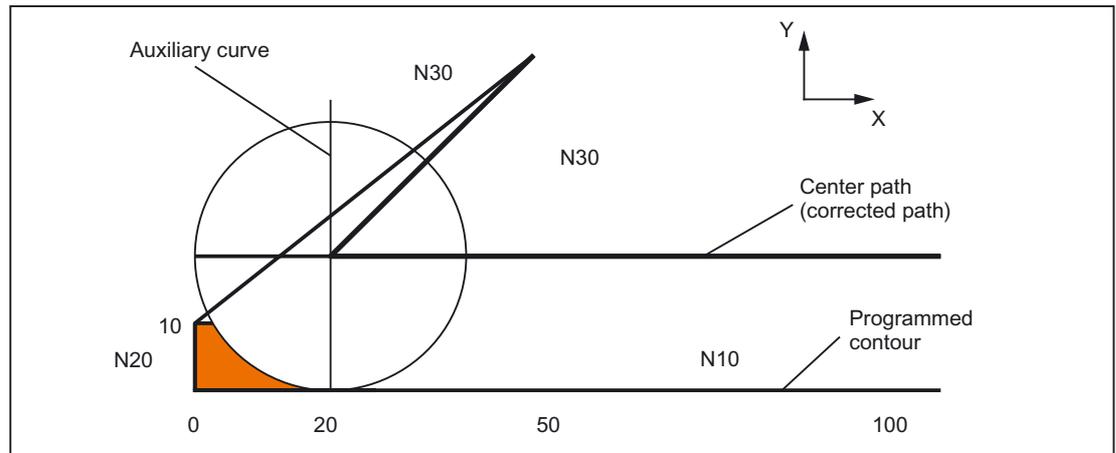


Figure 17-37 Retraction behavior with G462

The search for the intersection is then identical to the procedure for G461.

With G462, the corner generated by N10 and N20 in the sample program is not machined to the full extent actually possible with the tool used. However, this behavior may be necessary if the part contour (as distinct from the programmed contour), to the left of N20 in the example, is not permitted to be violated even with y values greater than 10 mm.

If KONT is active (travel round contour at start or end point), behavior will differ according to whether the end point is in front of or behind the contour.

### End point in front of contour

If the end point is located in front of the contour, the retraction behavior is the same as for NORM. This feature does not change, even if the last contour block with G451 is extended with a straight line or a circle. Additional circumnavigation strategies to avoid a contour violation in the vicinity of the contour end point are therefore not required.

### End point behind contour

If the end point is behind the contour, a circle or straight line is always inserted depending on G450/G451. In this case, G460-G462 has no effect.

If, in this situation, the last traversing block has no intersection with a preceding block, an intersection with the inserted contour element or with the linear section from the end point of the circumnavigation circle to the programmed end point can result.

If the inserted contour element is a circle (G450), and it intersects with the preceding block, this is the same as the intersection, which would be produced with NORM and G461. In general, however, a remaining section of the circle still has to be traversed. An intersection calculation is no longer required for the linear section of the retraction block.

In the second case (if no intersection is found between the inserted contour element and the preceding blocks), the intersection between the retraction straight line and a preceding block is approached.

Therefore, when G461 or G462 is active, behavior deviating from G460 can only arise if NORM is active or if behavior with KONT is identical to NORM due to the geometrical conditions.

---

**Note**

The approach behavior is symmetrical to the retraction behavior.

The approach/retraction behavior is determined by the state of the G command in the approach/retraction block. The approach behavior can therefore be set independently of the retraction behavior.

---

**Example:**

Program for using G461 during approach:

```
N10 $TC_DP1[1,1]=120           ; Tool type mill
N20 $TC_DP6[1,1]=10           ; Radius
N30 X0 Y0 F10000 T1 D1
N40 Y20
N50 G42 X50 Y5 G461
N60 Y0 F600
N70 X30
N80 X20 Y-5
N90 X0 Y0 G40
N100 M30
```

## 17.6 Toolholder with orientation capability

### 17.6.1 General

#### Introduction

The orientation of the tool can vary (e.g. **due to retooling**) for a single class of machine tools. When the machine is operating, the orientation that has been set is **permanent**, however, and cannot be changed during traversing. For this reason, kinematic orientation transformation (3-, 4- or 5-axis transformations, TRAORI) is neither necessary nor does it make sense for such machines. However, it is necessary to take account of the changes in the tool length components caused by changing the orientation, without having to trouble the user with mathematics involved. The control performs these calculations.

#### Required data

The following requirements must be met if the control is to take tool compensations into account for toolholders with orientation capability:

- Tool data (geometry, wear, etc.)
- Toolholder data (data for the geometry of the toolholder with orientation capability)

#### Toolholder selection

A toolholder defined in the control must be specified for the "Toolholder with orientation capability" function. The NC program command below is used for this purpose:

```
TCARR = m
```

m: Number of the toolholder

The toolholder has an associated toolholder data block, which describes its geometry.

Activating the toolholder and its block has an immediate effect, i.e. from the next traversing block onwards.

#### Assignment tool/toolholder

The tool that was active previously is assigned to the new toolholder.

From the point of view of the control, toolholder number m and tool numbers T can be combined freely. In the real application, however, certain combinations can be ruled out for machining or mechanical reasons. The control does not check whether the combinations make sense.

### Description of the kinematics of the toolholder

The kinematics of the toolholder with orientation capability is described with a total of 33 parameter sets.

The data of the data block can be edited by the user.

### Toolholder with orientation capability

Example: Cardan toolholder with two axes for the tool orientation

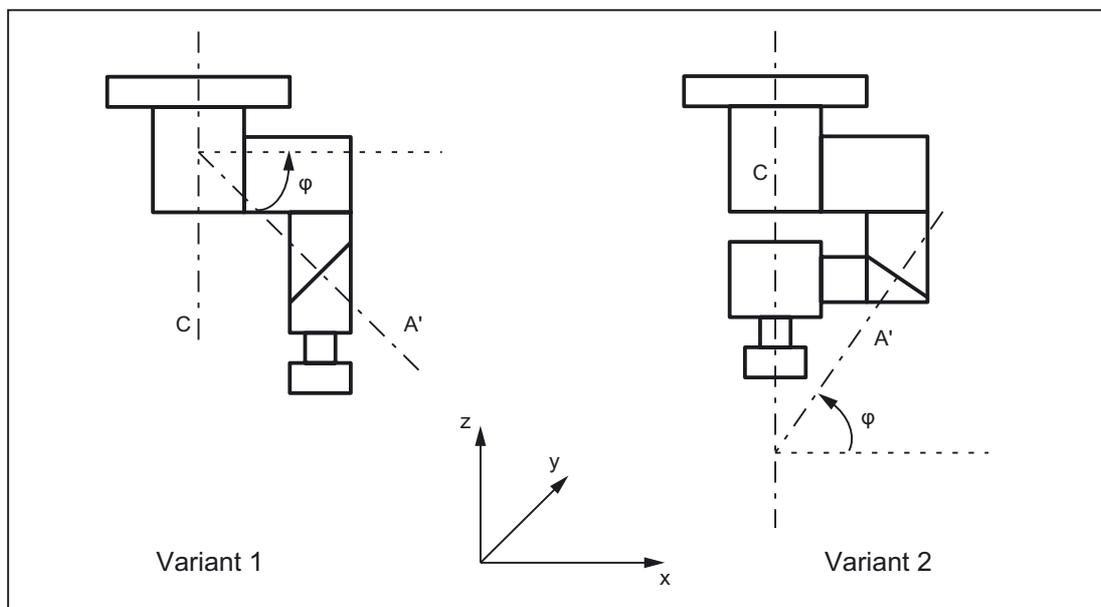


Figure 17-38 Cardan toolholder with two axes

### Processing toolholder data blocks

Two options are available:

- Explicit entry in the toolholder data block from the part program
- Automatic acceptance of certain values (angles) from a frame

A requirement for this is that  $TCOFR$  (Tool Carrier Orientation FRame) is also specified when the toolholder is selected.

The tool orientation used to calculate the tool length is determined again from the frame active at this time when a toolholder is changed.

## Orientation in Z direction

The G function `TOFRAME` defines a frame such that the Z direction in this frame is the same as the current tool orientation.

If no tool carrier or a tool carrier without change in orientation is active, then the Z direction is in the new frame:

- The same as the old Z direction with `G17`
- The same as the old Y direction with `G18`
- The same as the old X direction with `G19`.

## TCOABS for active frame

The absolute toolholder orientation is set using:

`TCOABS` (Tool Carrier Orientation ABSolute)

The orientation taken into account for the tool length compensation is **independent** of the orientation of the active frame.

Only one of the instructions `TCOABS` or `TCOFR` can be valid.

## Frame change

The user can change the frame following selection of the tool. This does not have any effect on the tool length compensation components.

### Angles in the toolholder data:

The programmed angles of rotation stored in the toolholder data are not affected by the angle of rotation defined by the frames. When changing from `TCOFR` to `TCOABS`, the original (programmed) angles of rotation in the toolholder data are reactivated.

## Tool compensation types

TRC takes account of the current tool orientation when `CUT2D` or `CUT3DFS` is active.

### All other tool compensation types

These are all the compensation types of G-code group 22, with the exception of `CUT3DC` and `CUT3DF`. The response remains the same with respect to the plane used for compensation. This is determined independent of the tool orientation from the active frame.

For `CUT2DF` and `CUT3DF`, the compensation plane used for TRC is determined from the frame **independently** of the current tool orientation. The active plane (`G17/G18/G19`) is considered.

### CUT3DC and CUT3DF

3D tool compensation for circumferential milling

3D tool compensations for face milling with active 5-axis transformation are not affected by the "Toolholder with orientation capability" function.

The orientation information is determined by the active kinematic 5-axis transformation.

### Limited toolholder orientation

An alarm is output if an orientation that cannot be reached with the defined toolholder kinematic is specified by the frame.

The following kinematics cannot achieve any orientation:

- If the two rotary axes, which are necessary to define the kinematic, are not perpendicular to each other and if the tool axis, which defines the tool direction, does not stand perpendicular to the second rotary axis  
or
- Fewer than two axes have been defined.

### Non-rotary toolholders

The tool orientation used internally is dependent only on the basic orientation of the tool and the active plane (G17 - G19).

### Ambiguities

With two axes, a particular tool orientation defined by the frame can generally be set with **two** different rotary angle pairs. Of these two, the control selects the setting with which the rotary angle is as close as possible to the programmed rotary angle.

### Storing angles in the toolholder data

In virtually any case where ambiguities may arise, it is necessary to store the approximate angle expected from the frame in the toolholder data.

### Parameter sets

A complete set of parameters for a toolholder with orientation capability consists of 33 values.

The following system variables are available:

- \$TC\_CARR1 to \$TC\_CARR33
- In addition, \$TC\_CARR34 to \$TC\_CARR65 are freely available for the user and for fine offsets.

The significance of the individual parameters is distinguished as follows:

#### Machine kinematics:

\$TC\_CARR1 to \$TC\_CARR20 and \$TC\_CARR23

\$TC\_CARR18 to \$TC\_CARR20 define a further vector  $I_4$ , which is needed to describe the machine with extended kinematics (both tool and workpiece can be rotated).

\$TC\_CARR21 and \$TC\_CARR22 contain the channel-axis identifiers of the rotary axes, the positions of which can be used to determine the orientation of the toolholder with orientation capability, if necessary.

#### Kinematic type:

\$TC\_CARR23 using letter T, P or M

The following three options are available for the kinematic type, for which both upper and lower case text are permissible:

T:	Only the ( <b>T</b> ool) can be rotated (basic value).
P:	Only the workpiece ( <b>P</b> art) can be rotated.
M:	Both tool and workpiece can be rotated ( <b>M</b> ixed mode).

Any character other than the three mentioned here will result in the alarm if it is tried to activate the toolholder with orientation capability:

Alarm "14153 Channel %1 block %2 unknown tool carrier type: %3"

#### Rotary axis parameters:

\$TC\_CARR24 to \$TC\_CARR33

The system variables in \$TC\_CARR24 to \$TC\_CARR33 can be used to define offsets, angle compensations, Hirth tooth system, and axis limits.

---

#### Note

The system variables are available with and without active tool management.

---

### Components and presetting of the chain/data block

The values \$TC\_CARR1 to \$TC\_CARR20 and \$TC\_CARR24 to \$TC\_CARR33 in the toolholder data block are of NC language format type `REAL`.

The values \$TC\_CARR21 and \$TC\_CARR22 for the axis identifier of the first rotary axis ( $v_1$ ) and the second rotary axis ( $v_2$ ) are of NC language format type `AXIS`. They are all preset to zero.

The value \$TC\_CARR23 is initialized with the uppercase letter "T" (only tool can be rotated).

\$TC\_CARRn[m]

\$TC\_CARR[0]= 0 has a special significance

### System variables for toolholders with orientation capability

\$TC\_CARRn[m]

n: Parameters 1 to 33

m: Number of the tool carrier 1 that can be oriented...Value of the machine data:

MD18088 \$MN\_MM\_NUM\_TOOL\_CARRIER (Maximum number of definable tool carriers)

Description	NCK variables	Language format	Preassignment
x component of offset vector $l_1$	\$TC_CARR1	REAL	0
y component of offset vector $l_1$	\$TC_CARR2	REAL	0
z component of offset vector $l_1$	\$TC_CARR3	REAL	0
x component of offset vector $l_2$	\$TC_CARR4	REAL	0
y component of offset vector $l_2$	\$TC_CARR5	REAL	0
z component of offset vector $l_2$	\$TC_CARR6	REAL	0
x component of rotary axis $v_1$	\$TC_CARR7	REAL	0
y component of rotary axis $v_1$	\$TC_CARR8	REAL	0
z component of rotary axis $v_1$	\$TC_CARR9	REAL	0
x component of rotary axis $v_2$	\$TC_CARR10	REAL	0
y component of rotary axis $v_2$	\$TC_CARR11	REAL	0
z component of rotary axis $v_2$	\$TC_CARR12	REAL	0
Angle of rotation $\alpha_1$ (in degrees)	\$TC_CARR13	REAL	0
Angle of rotation $\alpha_2$ (in degrees)	\$TC_CARR14	REAL	0
x component of offset vector $l_3$	\$TC_CARR15	REAL	0
y component of offset vector $l_3$	\$TC_CARR16	REAL	0
z component of offset vector $l_3$	\$TC_CARR17	REAL	0
x component of offset vector $l_4$	\$TC_CARR18	REAL	0
y component of offset vector $l_4$	\$TC_CARR19	REAL	0
z component of offset vector $l_4$	\$TC_CARR20	REAL	0
Axis identifier of the rotary axis $v_1$	\$TC_CARR21	AXIS	0
Axis identifier of the rotary axis $v_2$	\$TC_CARR22	AXIS	0
Kinematic type	\$TC_CARR23	CHAR	T
Offset of rotary axis $v_1$	\$TC_CARR24	REAL	0
Offset of rotary axis $v_2$	\$TC_CARR25	REAL	0
Angle offset of rotary axis $v_1$ (Hirth tooth)	\$TC_CARR26	REAL	0
Angle offset of rotary axis $v_2$ (Hirth tooth)	\$TC_CARR27	REAL	0
Angle increment of rotary axis $v_1$ (Hirth tooth)	\$TC_CARR28	REAL	0
Angle increment of rotary axis $v_2$ (Hirth tooth)	\$TC_CARR29	REAL	0
Minimum position of rotary axis $v_1$ (SW limit)	\$TC_CARR30	REAL	0
Minimum position of rotary axis $v_2$ (SW limit)	\$TC_CARR31	REAL	0
Maximum position of rotary axis $v_1$ (SW limit)	\$TC_CARR32	REAL	0
Maximum position of rotary axis $v_2$ (SW limit)	\$TC_CARR33	REAL	0

#### System variables for the user and for fine offsets

- \$TC\_CARR34 to \$TC\_CARR40

Contain parameters, which are freely available to the user.

- \$TC\_CARR41 to \$TC\_CARR65

Contain fine offset parameters that can be added to the values in the basic parameters. The fine offset value assigned to a basic parameter is obtained when the value 40 is added to the parameter number.

- \$TC\_CARR47 to \$TC\_CARR54 and \$TC\_CARR61 to \$TC\_CARR63

Not defined and produce an alarm if read or write access is attempted.

Description	NCK variables	Language format	Preassignment
Toolholder name *	\$TC_CARR34	String[32]	""
Axis name 1 **	\$TC_CARR35	String[32]	""
Axis name 2 **	\$TC_CARR36	String[32]	""
Identifier **	\$TC_CARR37	INT	0
Position component X **	\$TC_CARR38	REAL	0
Position component Y **	\$TC_CARR39	REAL	0
Position component Z **	\$TC_CARR40	REAL	0
x comp. fine offset of offset vector l <sub>1</sub>	\$TC_CARR41	REAL	0
y comp. fine offset of offset vector l <sub>1</sub>	\$TC_CARR42	REAL	0
z comp. fine offset of offset vector l <sub>1</sub>	\$TC_CARR43	REAL	0
x comp. fine offset of offset vector l <sub>2</sub>	\$TC_CARR44	REAL	0
y comp. fine offset of offset vector l <sub>2</sub>	\$TC_CARR45	REAL	0
z comp. fine offset of offset vector l <sub>2</sub>	\$TC_CARR46	REAL	0
x comp. fine offset of offset vector l <sub>3</sub>	\$TC_CARR55	REAL	0
y comp. fine offset of offset vector l <sub>3</sub>	\$TC_CARR56	REAL	0
z comp. fine offset of offset vector l <sub>3</sub>	\$TC_CARR57	REAL	0
x comp. fine offset of offset vector l <sub>4</sub>	\$TC_CARR58	REAL	0
y comp. fine offset of offset vector l <sub>4</sub>	\$TC_CARR59	REAL	0
z comp. fine offset of offset vector l <sub>4</sub>	\$TC_CARR60	REAL	0
Offset of fine offset of rotary axis v <sub>1</sub>	\$TC_CARR64	REAL	0
Offset of fine offset of rotary axis v <sub>2</sub>	\$TC_CARR65	REAL	0
<b>Remarks:</b>			
*	A toolholder with orientation capability cannot subsequently be assigned a number with system variable \$TC_CARR34, only a name.		
**	System variables \$TC_CARR35 to \$TC_CARR40 refer to the intended use of the toolholder with orientation capability within the measuring cycles and can also be used for other purposes.		

## 17.6.2 Kinematic interaction and machine design

### Representation of the kinematic chain

The concept of the kinematic chain is used to describe the kinematic interaction between a reference point and the tool tip.

The chain specifies all the data required for the toolholder data block in a schematic. To describe the concrete case with a particular kinematic, the relevant components of the chain must be assigned real vectors, lengths and angles. The chain represents the maximum constellation. In simpler applications, individual components can be zero (e.g. kinematics with one or no rotary axis).

The machine does not have to have axes that rotate the tool and/or workpiece table. The function can be used even if the orientations are set manually by handwheels or reconfiguration.

The machine design is described by the following parameters:

- Two rotary axes ( $v_1$  and  $v_2$ ), each with one angle of rotation ( $\alpha_1$  or  $\alpha_2$ ), which counts positively for clockwise rotation facing the direction of the rotation vector.
- Up to four offset vectors ( $l_1$  to  $l_4$ ) for relevant machine dimensions (axis distances, distances to machine or tool reference points).

### Zero vectors

Vectors  $v_1$  and  $v_2$  can be zero. The associated angle of rotation (explicitly programmed or calculated from the active frame) must then also be zero, since the direction of the rotating axis is not defined. If this condition is not satisfied, an alarm is produced when the toolholder is activated.

### Less than two rotating axes

The option not to define a rotating axis makes sense when the toolholder to be described can only rotate the tool in one plane. A sensible minimum data block may, therefore, contain only one single entry not equal to 0 in the toolholder data; namely, a value in one of the components of  $v_1$  or  $v_2$  for describing a rotating axis parallel to the axis where the angle of rotation  $\alpha_1$  or  $\alpha_2$  is determined from one frame.

### Further special cases

Vectors  $v_1$  and  $v_2$  can be colinear. However, the degree of freedom for orientation is lost, i.e. this type of kinematic is the same as one where only one rotary axis is defined. All possible orientations lie on one cone sheath. The conical sheath deforms to a straight line if tool orientation  $t$  and  $v_1$  or  $v_2$  become colinear. Change of orientation is, therefore, not possible in this special case. The cone sheath deforms to a circular surface (i.e. all orientations are possible in one plane), if tool orientation  $t$  and  $v_1$  or  $v_2$  are perpendicular to each other.

It is permissible for the two vectors  $v_1$  and  $v_2$  to be zero. A change in orientation is then no longer possible. In this special case, any lengths  $l_1$  and  $l_2$ , which are not equal to zero, act as additional tool length compensations, in which the components in the individual axes are not affected by changing the plane (G17 - G19).

### Kinematics data expansions

- Possibility of direct access to existing machine axes in order to define the toolholder setting via the rotary axis positions.
- Extension of the kinematics with rotary workpiece and on kinematics with rotary tool and rotary workpiece.
- Possibility to permit only discrete values in a grid for the rotary axis positions (Hirth tooth system).

The extensions are compatible with earlier software versions and encompass the kinematic data blocks from \$TC\_CARR18 to \$TC\_CARR23.

### Machine with rotary tool

On machines with rotary tool there is no change in the definition of the kinematics compared to older software versions. The newly introduced vector  $l_4$ , in particular, has no significance. Should the contents of  $l_4$  not be zero, this is ignored.

The term "Toolholder with orientation capability" is actually no longer really appropriate for the new kinematic types, with which the table can also be rotated, either alone or additionally to the tool. However, it has been kept for reasons of compatibility.

The kinematic chains used to describe the machine with rotary tool (general case) are shown in the figure below:

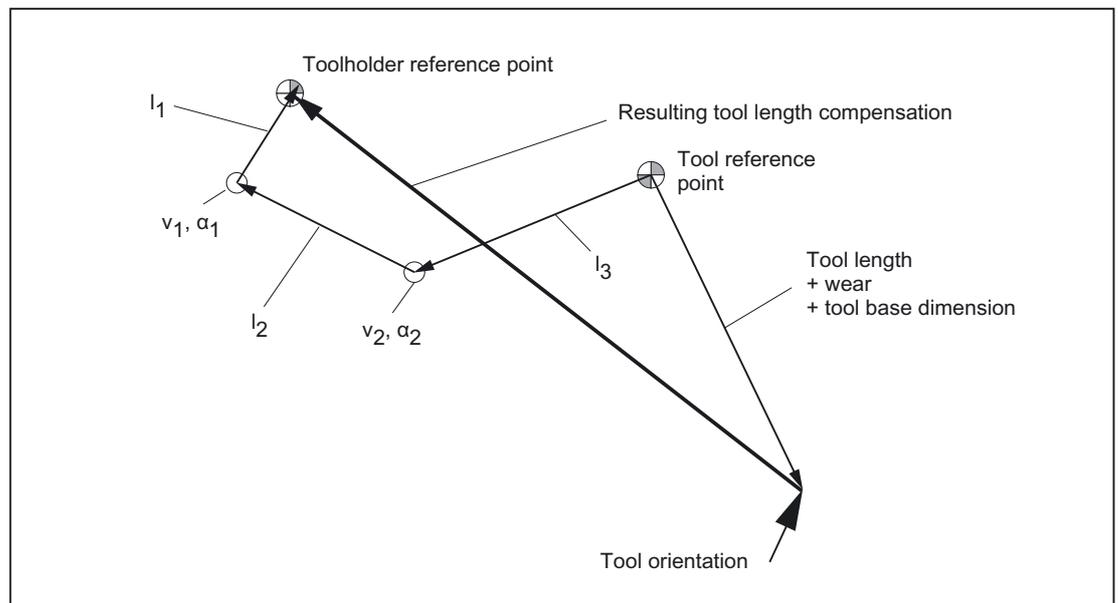


Figure 17-39 Kinematic chain to describe a tool with orientation

Vectors, which describe offsets in the rotary head, are positive in the direction from the tool tip to the reference point of the toolholder.

The following kinematic type is defined for machines with a rotary tool:

\$TC\_CARR23 using letter T

### Machine with rotary workpiece

On machines with rotary workpiece, the vector  $l_1$  has no significance. If it contains a value other than zero, this is ignored.

The kinematic chain for machines with rotary workpiece is shown in the figure below.

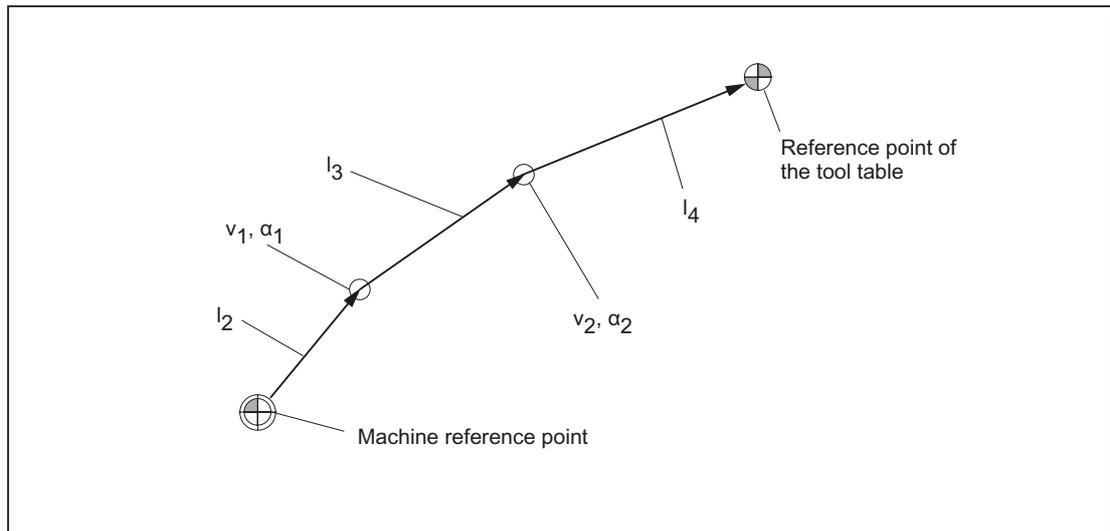


Figure 17-40 Kinematic chain to describe a rotary table

Vectors, which describe offsets in the rotary table, are positive in the direction from the machine reference point to the table.

The following kinematic type is defined for machines with a rotary workpiece:

\$TC\_CARR23 using letter P

#### Note

On machines with rotary workpiece it is generally useful if the selected machine reference point and the reference point of the table are identical. Selecting the reference points in this way has the advantage that the position of the workpiece zero in the initial state (i.e. with rotary axes not turned) does not change when the rotary table is activated. The (open) kinematic chain (see figure) is then closed.

In this special case, therefore, the following formula applies:  $l_2 = - (l_3 + l_4)$

## Machines with extended kinematics

On machines with extended kinematics (both tool and workpiece are rotary), it is only possible to turn each of the components with one axis.

The kinematic of the rotary tool is described with the first rotary axis ( $v_1$ ) and the two vectors  $l_1$  and  $l_2$ , that of the rotary table with the second rotary axis ( $v_2$ ) and the two vectors  $l_3$  and  $l_4$ . The two kinematic chain components for machines with rotary tool and rotary workpiece are shown in the figure below.

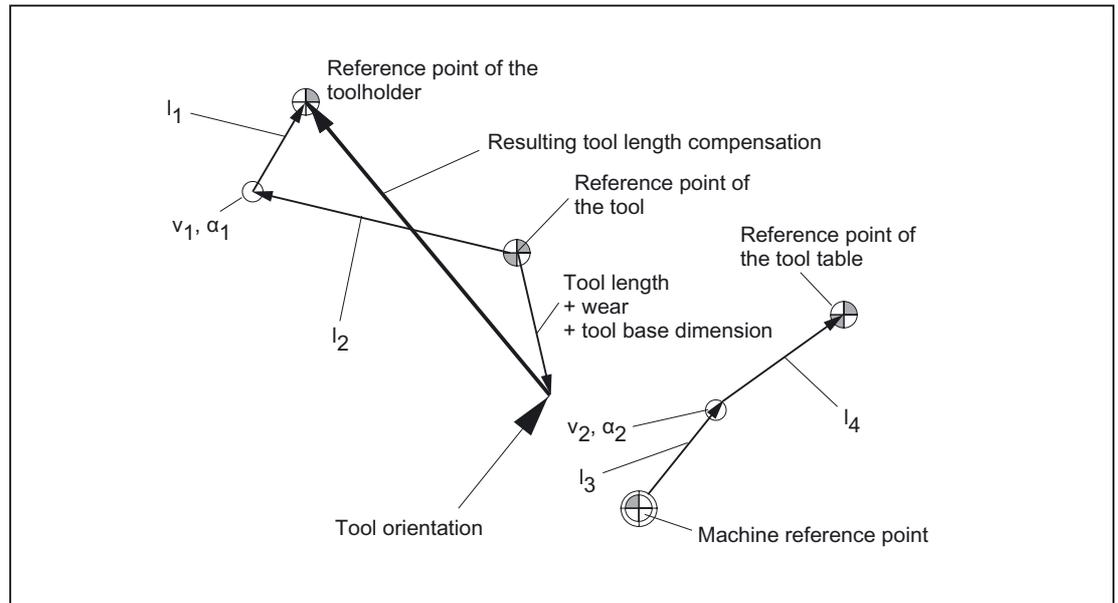


Figure 17-41 Kinematic sequence with extended kinematics

The following kinematic type is defined for machines with a rotary tool and rotary workpiece: \$TC\_CARR23 using letter M (extended kinematics)

### Note

On machines with extended kinematics it is generally useful, as with machines where only the table can be rotated, for the machine reference point and the reference point of the table to be identical. The (open) chain component to describe the table (see figure) is then closed.

In this special case, the following formula applies:  $l_3 = -l_4$

## Rotary tool types T and M

For machine kinematics with a rotary tool (types T and M), the toolholder component with orientation capability, which describes the tool or head component (as opposed to the table component), acts, in conjunction with the active tool, as a new overall tool.

### Fine offset

The offset vectors  $l_1$  to  $l_4$  and the offsets of the rotary axes  $v_1$  and  $v_2$  can be represented as the sum of a basic value and a fine offset. The fine offset parameters assigned to the basic values are achieved by **adding a value of 40 to the index of the basic value**.

**Example:**

The parameter \$TC\_CARR5 is assigned to the fine offset \$TC\_CARR45.

---

**Note**

For the significance of the system variables \$TC\_CARR41 to \$TC\_CARR65 available for the fine offset see:

**References:**

/PGA/ Programming Manual Job Planning; Tool Compensations

---

**Activation**

The following setting adds the fine offset values to the basic values:

SD42974 \$SC\_TOCARR\_FINE\_CORRECTION = 1 (fine offset TCARR on/off)

**Supplementary conditions**

The amount is limited to the permissible fine offset.

The maximum permissible value is defined:

For:	With machine data:
• The components of vectors $l_1$ to $l_4$ :	MD20188 \$MC_TOCARR_FINE_LIM_LIN
• The offsets of the two rotary axes $v_1$ and $v_2$ :	MD20190 \$MC_TOCARR_FINE_LIM_ROT

An illegal fine offset value is only detected when:

- A toolholder with orientation capability, which contains such a value, is activated and
- at the same time the following setting data is set:  
SD42974 \$SC\_TOCARR\_FINE\_CORRECTION

## Description of a rotation

A data block for describing a rotation comprises one vector  $v_1/v_2$  to describe the direction of rotation of the rotary axis in its initial state and an angle  $\alpha_1/\alpha_2$ . The angle of rotation is counted positively for clockwise rotation facing the direction of the rotation vector.

The two toolholder angles  $\alpha_1$  and  $\alpha_2$  are determined using a frame, independent of the active plane currently selected (G17 - G19).

The tool orientation in the initial state (both angles  $\alpha_1$  and  $\alpha_2$  are zero) is (as in the default case):

- G17: Parallel to Z
- G18: Parallel to Y
- for G19: Parallel to X

## Assigning data to the toolholder

### Example of a machine with rotary toolholder

The following settings are obtained at the mill head shown for a machine with toolholder with orientation capability of kinematic type T:

Component of the offset vector $l_1 =$	(-200, 0, 0)
Component of the offset vector $l_2 =$	(0, 0, 0)
Component of offset vector $l_3 =$	(-100, 0, 0)
Component of rotary axis $v_1 =$	(1, 0, 0)
Component of rotary axis $v_2 =$	(-1, 0, 1)
Tool base dimension of tool reference point	(0, 0, 250)

### Note

The tool reference point for the tool base dimension is defined by the reference point at the machine.

For more information about the reference points in the working area, please refer to:

### References:

/FB1/ Function Manual, Basic Functions; Axes, Coordinate Systems, Frames (K2).

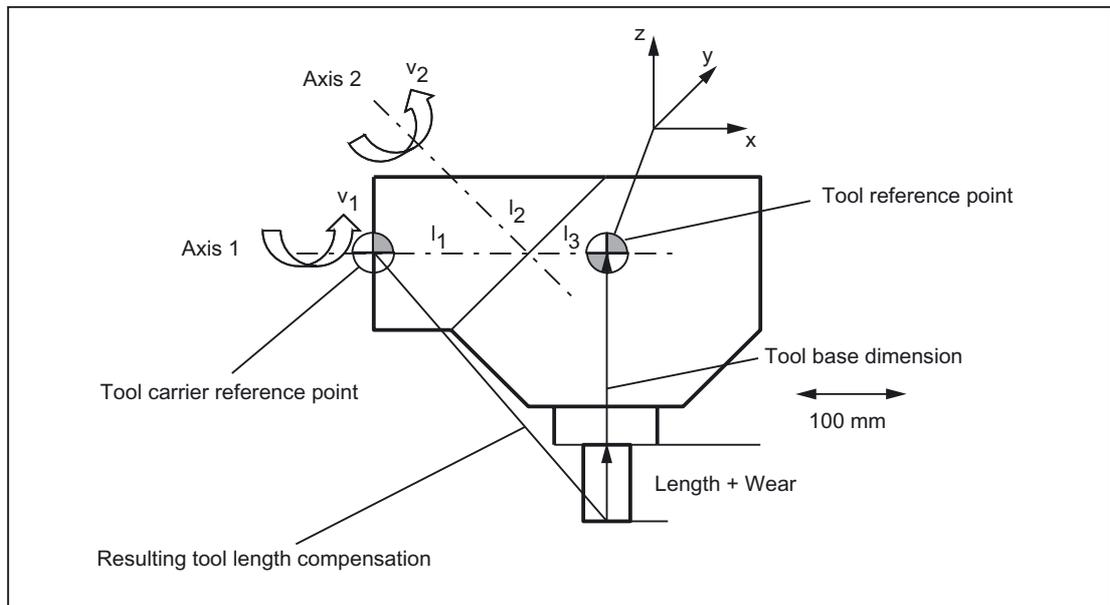


Figure 17-42 Assignment of the toolholder data

Suitable assumptions were made for the following values in the data block:

- The two rotary axes intersect at one point.  
All components of  $l_2$  are therefore zero.
- The first rotary axis lies in the x/z plane, the second rotary axis is parallel to the x axis.  
These conditions define the directions of  $v_1$  and  $v_2$  (the lengths are irrelevant, provided that they are not equal to zero).
- The reference point of the toolholder lies 200 mm in the negative x direction viewed from the intersection of the two rotary axes.  
This condition defines  $l_1$ .

### Specify associated data block values

The following associated data block values are specified for the toolholder shown on a machine with rotary toolholder:

Description	NCK variables	Value
x component of offset vector $l_1$	\$TC_CARR1	- 200
y component of offset vector $l_1$	\$TC_CARR2	0
z component of offset vector $l_1$	\$TC_CARR3	0
x component of offset vector $l_2$	\$TC_CARR4	0
y component of offset vector $l_2$	\$TC_CARR5	0
z component of offset vector $l_2$	\$TC_CARR6	0
x component of rotary axis $v_1$	\$TC_CARR7	1
y component of rotary axis $v_1$	\$TC_CARR8	0
z component of rotary axis $v_1$	\$TC_CARR9	0
x component of rotary axis $v_2$	\$TC_CARR10	-1

Description	NCK variables	Value
y component of rotary axis $v_2$	\$TC_CARR11	0
z component of rotary axis $v_2$	\$TC_CARR12	1
Angle of rotation $\alpha_1$ (in degrees)	\$TC_CARR13	0
Angle of rotation $\alpha_2$ (in degrees)	\$TC_CARR14	0
x component of offset vector $l_3$	\$TC_CARR15	-100
y component of offset vector $l_3$	\$TC_CARR16	0
z component of offset vector $l_3$	\$TC_CARR17	0

## Explanation

The toolholder kinematic chosen in the example is such that the two rotary axes form an angle of 45 degrees, which means that the orientation cannot take just any value. In concrete terms, this example does not permit the display of orientations with negative X components.

x component of the tool base dimension: 0  
y component of the tool base dimension: 0  
z component of the tool base dimension: 250

---

## Note

The required data cannot be determined unequivocally from the geometry of the toolholder, i.e. the user is free to a certain extent to decide the data to be stored. Thus, for the example, it is possible to specify only one z component for the tool base dimension up to the second axis. In this case,  $l_2$  would no longer be zero, but would contain the components of the distance between this point on the second axis and a further point on the first axis. The point on the first axis can also be selected freely. Depending on the point selected,  $l_1$  must be selected such that the reference point (which can also be selected freely) is reached.

**In general:** vector components that are not changed by rotation of an axis can be distributed over any vectors "before" and "after" rotation.

---

### 17.6.3 Oblique machining with 3 + 2 axes

#### Description of function

Inclined machining with 3 + 2 axes describes an extension of the concept of toolholders with orientation capability and applies this concept to machines with a rotary table, on which the orientation of tool and table can be changed simultaneously.

The "Inclined machining with 3 + 2 axes" function is used to machine surfaces with any rotation with reference to the main planes X/Y (G17), Z/X (G18) and Y/Z (G19).

It is possible to produce any orientation of the tool relative to the workpiece by rotating either the tool, the workpiece or both the tool and the workpiece.

The software automatically calculates the necessary compensating movements resulting from the tool lengths, lever arms and the angle of the rotary axis. It is always assumed that the required orientation is set first and not modified during a machining process such as pocket milling on an inclined plane.

Furthermore, the following 3 functions are described, which are required for oblique machining:

- **Position programming** in the direction of the tool orientation independent of an active frame
- Definition of a **frame rotation** by specifying the solid angle
- Definition of the **component of rotation in tool direction** in the programmed frame while maintaining the remaining frame components

#### Demarcation to 5-axis transformation

If the required functionality specifies that the TCP (Tool Center Point) does not vary in the event of reorientation with reference to the workpiece, even during interpolation, the 5-axis software is required.

For more explanations on 5-axis transformations, see:

**References:**

/FB3/ Function Manual, Special Functions; 3- to 5-Axis Transformation (F2)

#### Specification of the toolholder with orientation capability

The toolholder with orientation capability is represented by a general 5-axis kinematic sequence described by a data block in the tool compensation memory with a total of 33 REAL values. For toolholders that have two rotary axes for setting the orientation (e.g. a millhead), 31 of these values are constant.

In the current SW version, a data block in the tool compensation memory is described with a total of 47 REAL values. For toolholders that have two rotary axes for setting the orientation, 45 of these values are constant.

The remaining two values are variable and are used to specify the orientation. The constant values describe offsets and directions and setting options for the rotary axes; the variable values describe the angles of the rotary axes.

## 17.6.4 Machine with rotary work table

### System variables

To date, the angles stored in \$TC\_CARR13 and \$TC\_CARR14 were used for the calculation of the active tool length with TCOABS. This still applies if \$TC\_CARR21 and \$TC\_CARR22 do not refer to rotary axes. If \$TC\_CARR21 or \$TC\_CARR22 contains a reference to a rotary axis in the channel, the axis position of the relevant axis at the start of the current block is used as the angle, rather than the entry in \$TC\_CARR13 or \$TC\_CARR14.

A mixed operating mode is permissible, i.e. the angles can be determined from the entry in the system variables \$TC\_CARR13 or \$TC\_CARR14 for one axis, and from the position of a channel axis for the other.

This makes it possible for machines, on which the axes used to set the toolholder with orientation capability are known within the NC, to access their position directly, whereas it was previously necessary, for example, to read system variable \$AA\_IM[axis] and write the result of the read operation to \$TC\_CARR13/14. In particular, this removes the implicit preprocessing stop when reading the axis positions.

### MD20180

The rotary axis position is used with its programmed or calculated value, when the machine data:

MD20180 \$MC\_TOCARR\_ROT\_ANGLE\_INCR[i] = 0 (Rotary axis increment of the tool carrier that can be oriented)

If the machine data is not zero however, the position used is the nearest grid point obtained for a suitable integer value n from the equation:

$$\varphi = \$MC\_TOCARR\_ROT\_ANGLE\_OFFSET[i] + n * \$MC\_TOCARR\_ROT\_ANGLE\_INCR[i]$$

This functionality is required if the rotary axes need to be indexed and cannot, therefore, assume freely-defined positions (e.g. with Hirth tooth systems). System variable \$P\_TCANG[i] delivers the approximated value and system variable \$P\_TCDIFF[i] the difference between the exact and the approximated value.

### Frame orientation TCOFR

With TCOFR (determination of the angle from the orientation defined by an active frame), the increments are scaled after determination of the angle from the active frame rotation. If the requested orientation is not possible due to the machine kinematic, the machining is aborted with an alarm. This also applies if the target orientation is very close to an achievable orientation. In particular the alarm in such situations cannot be prevented through the angle approximation.

### TCARR frame offset

A frame offset as a result of a toolholder change becomes effective immediately on selection of `TCARR=...` A change in the tool length, on the other hand, only becomes effective immediately if a tool is active.

### TCOFR/TCOABS frame rotation

A frame rotation does not take place on activation and a rotation, which is already active, is not changed. As in case T (only the tool can be rotated), the position of the rotary axes used for the calculation is dependent on the G code `TCOFR/TCOABS` and determined from the rotation component of an active frame or from the entries `$TC_CARRn`.

Activation of a frame changes the position in the workpiece coordinate system accordingly, without compensating movement by the machine itself. The ratios are shown in the figure below:

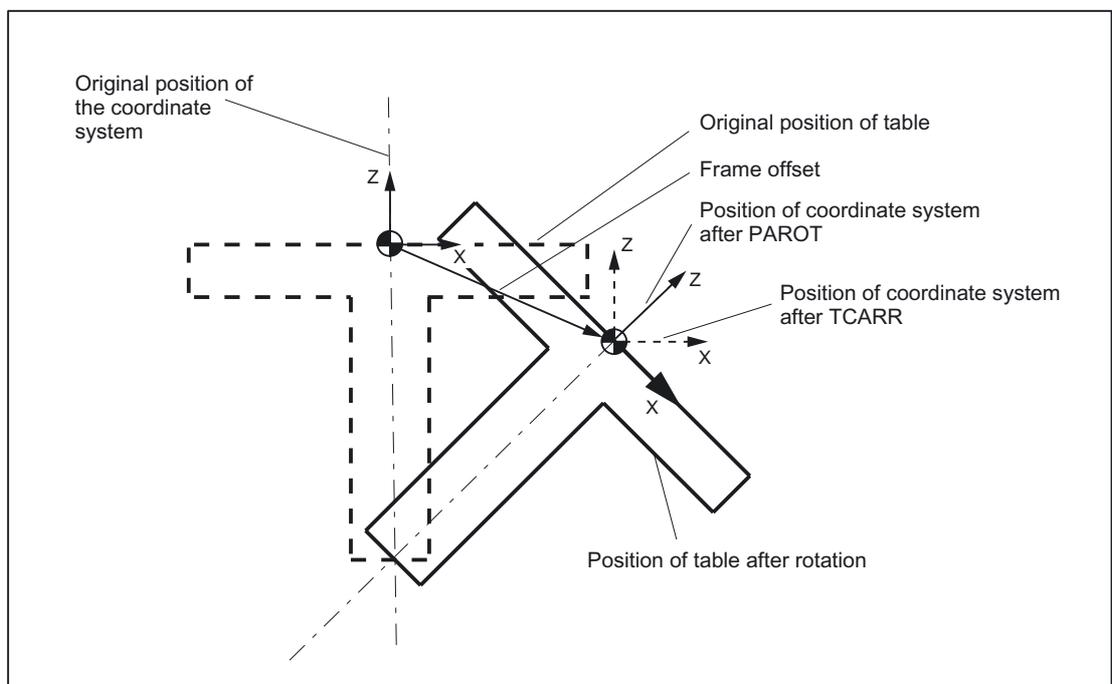


Figure 17-43 Zero offset on activation of a rotary table with `TCARR`

### Example

On the machine in the figure, the rotary axis of the table is pointing in the positive Y direction. The table is rotated by +45 degrees. `PAROT` defines a frame, which similarly describes a rotation of 45 degrees about the Y axis. The coordinate system is not rotated relative to the actual environment (marked in the figure with "Position of the coordinate system after `TCARR`"), but is rotated by -45 degrees relative to the defined coordinate system (position after `PAROT`). If this coordinate system is defined with `ROT Y-45`, for example, and if the toolholder is then selected with active `TCOFR`, an angle of +45 degrees will be determined for the rotary axis of the toolholder.

## Rotary table

With rotary tables (kinematic types P and M), activation with `TCARR` similarly does not lead to an immediate rotation of the coordinate system (see figure), i.e. even though the zero point of the coordinate system is offset relative to the machine, while remaining fixed relative to the zero point of the workpiece, the orientation remains unchanged in space.

## Activation of kinematic types P and M

With kinematics of type P and M the selection of a toolholder activates an additive frame (table offset of the toolholder with orientation capability), which takes into account the zero point offset as a result of the rotation of the table.

The zero offset can be written to a dedicated system frame `$P_PARTFR`. For this, the bit 2 must be set in the machine data:

MD28082 `$MC_MM_SYSTEM_FRAME_MASK` (System frames (SRAM))

The basic frame identified by following machine data is then no longer required for the zero offset:

MD20184 `$MC_TOCARR_BASE_FRAME_NUMBER` (Number of the basic frames for taking the table offset)

## Activation of kinematic type M

With kinematics of type M (tool and table are each rotary around one axis), the activation of a toolholder with `TCARR` simultaneously produces a corresponding change in the effective tool length (if a tool is active) and the zero offset.

## Rotations

Depending on the machining task, it is necessary to take into account not only a zero offset (whether as frame or as tool length) when using a rotary toolholder or table, but also a rotation. However, the activation of a toolholder with orientation capability never leads directly to a rotation of the coordinate system.

## TOROT

If only the tool can be rotated, a frame whose Z axis points in the direction of the tool can be defined with `TOFRAME` or `TOROT`.

## PAROT

If the coordinate system needs to be fixed relative to the workpiece, i.e. not only offset relative to the original position but also rotated according to the rotation of the table, then `PAROT` can be used to activate such a rotation in a similar manner to the situation with a rotary tool.

With `PAROT`, the translations, scalings and mirrorings in the active frame are retained, but the rotation component is rotated by the rotation component of a toolholder with orientation capability corresponding to the table.

`PAROT` and `TOROT` take into account the overall change in orientation in cases where the table or the tool are oriented with two rotary axes. With mixed kinematics only the corresponding component caused by a rotary axis is considered. It is thus possible, for example, when using `TOROT`, to rotate a workpiece such that an oblique plane lies parallel to the X-Y plane fixed in space, whereby rotation of the tool must be taken into account in machining where any holes to be drilled, for example, are not perpendicular to this plane.

Language command `PAROT` is not rejected if no toolholder with orientation capability is active. This causes no changes in the programmed frame.

---

### Note

For more information about the `TCARR` and `TOROT` functions, as well as `PAROT` in relation to channel-specific system frames, please refer to:

#### References:

/FB1/ Function Manual, Basic Functions; Axes, Coordinate systems, Frames (K2).

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## 17.6.5 Procedure when using toolholders with orientation capability

### Creating a toolholder

The number of available toolholder data sets in the NCK is defined with machine data:

MD18088 \$MN\_MM\_NUM\_TOOL\_CARRIER (Maximum number of definable tool carriers)

1. The value is calculated as follows:

**MD18088 = "Number of TO units" \* "Number of tool holder data sets of a TO unit"**

**MD18088/"number of TO units"** is permanently allocated to each TO unit.

---

#### Note

For further explanations on the definition and assignment of a TO unit by machine data:

MD28085 \$MC\_MM\_LINK\_TOA\_UNIT (Assignment of a TO unit to a channel (SRAM))

#### References:

/FB/ Function Manual for Extended Functions; Memory Configurations (S7)

---

1. Zero setting of toolholder data:

You can use the command `$TC_CARR1[0] = 0` to zero all values of all data sets.

Individual toolholder data sets can be deleted selectively with the NC command `DELTC` or the PI service `_N_DELTCAR`.

2. Accessing the data of a toolholder:

- Part program

→ `$TC_CARRn[m] = value`

This describes the previous value of the system variables `n` for toolholder `m` with the new value "value".

→ `value = $TC_CARRn[m]`

With "def real value" - the parameters of a toolholder `m` can be read if they have already been defined (e.g. set MD18088). Otherwise, an alarm is signaled.

- OPI interface

The parameters of a toolholder with orientation capability can be read and written with the NCK-HMI (OPI) variable services using system variable `$P_TCANG[<n>]`.

3. Data backup:

The system variables specified above are saved as part of the general NCK data backup.

### Selecting the toolholder

A tool holder with number  $m$  is selected with the  $TCARR = m$  NC program command (TCARR**T**ool **C**arrier).

$TCARR = 0$  deselects an active toolholder.

#### New tool or new toolholder

When a new tool is activated, it is always treated as if it was mounted on the active toolholder.

A new toolholder is activated immediately when it is programmed. It is not necessary to change tools or reprogram the active tool. The toolholder (number) and tool (number) are independent and can be used in any combination.

### Toolholder from G code of group 42

Absolute tool orientation  $TCOABS$  (**T**ool **C**arrier **O**rientation **ABS**olute):

Tool orientation is determined explicitly if the corresponding values are entered in system variable  $\$TC\_CARR13$  or  $\$TC\_CARR14$  and G code  $TCOABS$  is activated in G-code group 42.

Frame tool orientation  $TCOFR$  (**T**ool **C**arrier **O**rientation **FR**ame):

Tool orientation can also be determined automatically from the current orientation of an active frame when selecting a tool, if one of the following G codes is active in G-code group 42 when the toolholder is selected:

- $TCOFR$  or  $TCOFRZ$

The toolholder with orientation capability is set so that the tool points in the Z direction.

- $TCOFRX$

The toolholder with orientation capability is set so that the tool points in the X direction.

- $TCOFRY$

The toolholder with orientation capability is set so that the tool points in the Y direction.

The effect of  $TCOFR$  is such that, when machining on an inclined surface, tool compensations are considered implicitly as if the tool were standing vertically on the surface.

**Note**

The tool orientation is not bound strictly to the frame orientation. When a frame is active and G code `TCOABS` is active, you can select a tool, whereby the orientation of the tool is independent of the orientation of the active frame.

Following tool selection, you can change the frame, which does not affect the components of tool length compensation. It is then no longer certain that the tool is positioned perpendicular to the machining plane. You should therefore first check that the intended tool orientation is maintained on an inclined surface.

When `TCOFR`, etc., is active, the tool orientation used in the tool length calculation is always determined from the active frame each time the toolholder is changed.

---

**Toolholder from G code of group 53**

The G codes of group 53 (`TOFRAME`, `TOROT`, etc.) can be used to define a frame such that an axis direction (Z, Y or X) in this frame is equal to the current tool orientation.

The G code of group 6 (`G17` - `G19`), which is active at the time `TOFRAME` is called, determines the tool orientation.

If no toolholder is active, or if a toolholder is active but does not cause the tool orientation to change, the Z direction in the new frame is:

- The same as the old Z direction with `G17`
- The same as the old Y direction with `G18`
- The same as the old X direction with `G19`.

These directions are modified accordingly for rotating toolholders. The same applies to the new X and Y directions.

Instead of `TOFRAME` or `TOROT`, one of the G codes `TOFRAMEX`, `TOFRAMEY`, `TOROTX`, or `TOROTY` can be used. The meanings of the axes are interchanged accordingly.

## Group change

Changing the G code from group 42 (TCOABS, TCOFR, etc.) causes recalculation of the tool length components.

The (programmed) angles of rotation stored in the toolholder data are not affected, with the result that the angles originally stored in the toolholder data are reactivated on a change from TCOFR to TCOABS.

### Read rotary angle ( $\alpha_1$ or $\alpha_2$ ):

The angles currently used to calculate the orientation can be read via system variable \$P\_TCANG[n] where  $n = 1$  or  $n = 2$ .

If two permissible solutions (i.e. a second valid pair of angles) are available for a particular orientation, the values can be accessed with \$P\_TCANG[3] or \$P\_TCANG[4]. The number of valid solutions 0 to 2 can be read with \$P\_TCSOL.

### Tool radius compensation with CUT2D or CUT3DFS:

The current tool orientation is included in the tool radius compensation if either CUT2D or CUT3DFS is active in G-code group 22 (tool compensation type).

For non-rotating toolholders, the behavior depends solely on the active plane of G code group 6 (G17 - G19) and is, therefore, identical to the previous behavior.

### All other tool compensation types:

The behavior for all other tool compensation types is unchanged.

For CUT2DF and CUT3DF in particular, the compensation plane used for TRC is determined from the active frame, independent of the current tool orientation. Allowance is made for the active plane (G17 - G19) and the behavior is, therefore, the same as before.

The two remaining G codes of group 22, CUT3DC and CUT3DE, are not affected by the toolholder functionality because the tool orientation information in these cases is made available by the active kinematic transformation.

## Two rotary axes

Two general solutions exist for two rotary axes. The control itself chooses these two solution pairs such that the orientation angles resulting from the frame are as close as possible to the specified angles.

The two following options are available for specifying the angles:

1. If \$TC\_CARR21 or \$TC\_CARR22 contains a reference to a rotary axis, the position of this axis at the start of the block in which the toolholder is activated is used to specify the angle.
2. If \$TC\_CARR21 or \$TC\_CARR22 does not contain a reference to a rotary axis, the values contained in \$TC\_CARR13 or \$TC\_CARR14 are used.

## Example

The control first calculates an angle of 10 degrees for one axis. The specified angle is 750 degrees. 720 degrees (= 2 \* 360 degrees) are then added to the initial angle, yielding a final angle of 730 degrees.

## Rotary axis offset

Rotary axis offsets can be specified with system variables \$TC\_CARR24 and \$TC\_CARR25. A value not equal to zero in one of these parameters means that the initial state of the associated rotary axis is the position specified by the parameter (and not position zero). All angle specifications then refer to the coordinate system displaced by this value.

When the machining plane is changed (G17 - G19), only the tool length components of the active tool are interchanged. The components of the toolholder are not interchanged. The resulting tool length vector is then rotated in accordance with the current toolholder and, if necessary, modified by the offsets belonging to the toolholder.

The two toolholder angles  $\alpha_1$  and  $\alpha_2$  are determined using a frame, independent of the active plane currently selected (G17 - G19).

## Limit values

Limit angles (software limits) can be specified for each rotary axis in the system variable set (\$TC\_CARR30 to \$TC\_CARR33) used to describe the toolholder with orientation capability. These limits are not evaluated if both the minimum and maximum value is zero.

If at least one of the two limits is not equal to zero, the system checks whether the previously calculated solution is within the permissible limits. If this is not the case, an initial attempt is made to reach a valid setting by adding or subtracting multiples of 360 degrees to or from the invalid axis position. If this is impossible and two different solutions exist, the first solution is discarded and the second solution is used. The second solution is treated the same as the first with reference to the axis limits.

If the first solution is discarded and the second used instead, the contents of \$P\_TCANG[1/2] and \$P\_TCANG[3/4] are swapped, hence the solution actually used is also stored in \$P\_TCANG[1/2] in this case.

The axis limits are monitored even if the axis angle is specified instead of being calculated. This is the case if TCOABS is active when a toolholder with orientation capability is activated.

## 17.6.6 Programming

### Tool holder selection

A toolholder is selected with the number **m** of the toolholder with:

`TCARR = m`

### Access to toolholder data blocks

The following access is possible from the part program:

The current value of the parameter **n** for the tool holder **m** is **written** with the new "value" with::

`$TC_CARRn[m] = value`

The parameters of a tool holder **m** can, as far as the toolholder data set is already defined, **read** with:

`value = $TC_CARRn[m]` (Value must be a REAL variable)

The toolholder dataset number must lie in the range, which is defined by the machine data:

MD18088 \$MN\_MM\_NUM\_TOOL\_CARRIER (Total number of toolholder datasets that can be defined)

This number of toolholder data sets, divided by the number of active channels, can be defined for a channel.

#### Exception:

If settings, which deviate from the standard, are selected via the machine data:

MD28085 \$MC\_MM\_LINK\_TOA\_UNIT (Assignment of TO unit to a channel).

### Canceling all toolholder data blocks

All values of all toolholder data sets can be deleted from within the part program using one command.

`$TC_CARR1[0] = 0`

Values not set by the user are preset to 0.

### Activation

A toolholder becomes active when both a **toolholder** and a **tool** have been activated. The selection of the toolholder alone has no effect. The effect of selecting a toolholder depends on the G code `TCOABS/TCOFR` (modal G-code group for toolholders).

Changing the G code in the `TCOABS/TCOFR` group causes recalculation of the tool length components when the toolholder is active. With `TCOABS`, the values stored in the toolholder data for both angles of rotation  $\alpha_1$  and  $\alpha_2$  are used to determine the tool orientation.

With `TCOFR`, the two angles are determined from the current frame. The values stored in the toolholder data are not changed, however. These are also used to resolve the ambiguity that can result when the angle of rotation is calculated from one frame. Here, the angle that deviates least from the programmed angle is selected from the various possible angles.

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**Note**

For more explanations on the programming of tool compensations with toolholder kinematic and for the system variables see:

**References:**

/PGA/ Programming Manual Job Planning

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## 17.6.7 Supplementary conditions and control system response for orientation

### Full orientation

For a given data set that describes a certain kinematic, all the conceivable special orientations can only be displayed when the following conditions are satisfied:

- The two vectors  $v_1$  and  $v_2$ , that describe the rotary axes, must be defined (i.e. must not be equal to zero).
- The two vectors  $v_1$  and  $v_2$  must be perpendicular to each other.
- The tool orientation must be perpendicular to the second rotary axis.

### Non-defined orientation

If these conditions are not satisfied and an orientation that cannot be achieved by an active frame is requested with `TCOFR`, an alarm is output.

**Vector/angle of rotation dependencies**

If vector  $v_1$  or  $v_2$ , which describes the direction of a rotary axis, is set to zero, the associated angle of rotation  $\alpha_1$  or  $\alpha_2$  must also be set to zero. Otherwise, an alarm is produced. The alarm is not output until the toolholder is activated, i.e. when the toolholder is changed.

**Tool fine compensation combined with orientation**

Tool fine compensations and toolholders **cannot** be combined. The activation of tool fine compensation when a toolholder is active, and vice versa the activation of the toolholder when tool fine compensation is active, produces an alarm.

### Automatic toolholder selection, RESET

For `RESET` or at program start, a toolholder can be selected automatically via the machine data:

MD20126 `$MC_TOOL_CARRIER_RESET_VALUE` (Active toolholder at RESET)

It is handled similar to the controlled selection of a tool via the machine data:

MD20120 `$MC_TOOL_RESET_VALUE` (Tool length compensation Power up (RESET/TP end))

The behavior at `RESET` or at program start is controlled as in the case of tool selection via the same bit 6 in the machine data:

MD20110 `$MC_RESET_MODE_MASK` (definition of initial control settings after RESET/TP end)

or:

MD20112 `$MC_START_MODE_MASK` (definition of initial control system settings at NC-START)

#### References:

/FB1/ Function Manual, Basic Functions; Mode Group, Channel, Program Operation, Reset Response (K1)

#### SW 6.3 and higher

If `TCOABS` was active for the last selection before reset, the behavior is unchanged compared to previous versions. A different active G code causes the toolholder with orientation capability to be activated with the frame that was active before the last reset. Modified toolholder data (`$TC_CARR...`) are also considered. If these data are unchanged, the toolholder is activated in exactly the same state as before reset. If the toolholder data were changed after the toolholder selection before reset, selection corresponding to the last frame is not always possible. In this case, the toolholder with orientation capability is selected according to the G-Code (group 42) values valid at this time and the active frame.

### MD22530 output of auxiliary functions to PLC

That, optionally, a constant or an M code is output when the toolholder is selected, whose number of the code is derived from the toolholder number. Can be set with the machine data:

MD22530 `$MC_TOCARR_CHANGE_M_CODE` (M-Code at toolholder change)

#### References:

/FB1/ Function Manual, Basic Functions; Output of Auxiliary Functions to PLC (H2)

## Toolholder kinematics

The following supplementary conditions must be met for toolholder kinematics:

- Tool orientation in initial state, both angles  $\alpha_1$  and  $\alpha_2$  zero, as per default setting, even if:
  - G17 parallel to Z
  - G18 Parallel to Y
  - G19 parallel to Z
- A permissible position in terms of the axis limits must be achievable.
- For any possible orientation to be set, the two rotary axes must be perpendicular to each other.

For machines, on which the table is rotated by both axes, the tool orientation must also be perpendicular to the first rotary axis.

For machines with mixed kinematics, the tool orientation must be perpendicular to the axis, which rotates the tool, i.e. also the first rotary axis.

The following applies to orientations specified **in a frame**:

- The orientation specified in a frame must be achievable with the defined toolholder kinematics, otherwise an alarm is output.

This situation can occur if the two rotary axes required to define the kinematics are not perpendicular to each other.

This applies if fewer than two rotary axes are defined and is the case:

  - With **kinematic type T with rotary tool**, if the tool axis, which defines the tool direction, is not perpendicular to the **second** axis.
  - With **kinematic types M and P with rotary workpiece**, if the tool axis, which defines the tool direction, is not perpendicular to the **first** axis.
- Rotary axes, which require a frame with a defined tool orientation in order to reach a specific position, are only determined unambiguously in the case of one rotary axis. Two general solutions exist for two rotary axes.
- In all cases where ambiguities may arise, it is particularly important that the approximate angles expected from the frame are stored in the tool data, and that the rotary axes are in the vicinity of the expected positions.

## Response with ASUP, REPOS

The toolholder can be changed in an asynchronous subprogram (ASUB). When the interrupted program is resumed with REPOS, the approach motion of the new toolholder is taken into account and the program continues with this motion. The treatment here is analogous to tool change in an ASUB.

### References:

/FB1/ Function Manual, Basic Functions; Mode Group, Channel, Program Operation, Reset Response (K1)

## 17.7 Cutting data modification for tools that can be rotated

### Function

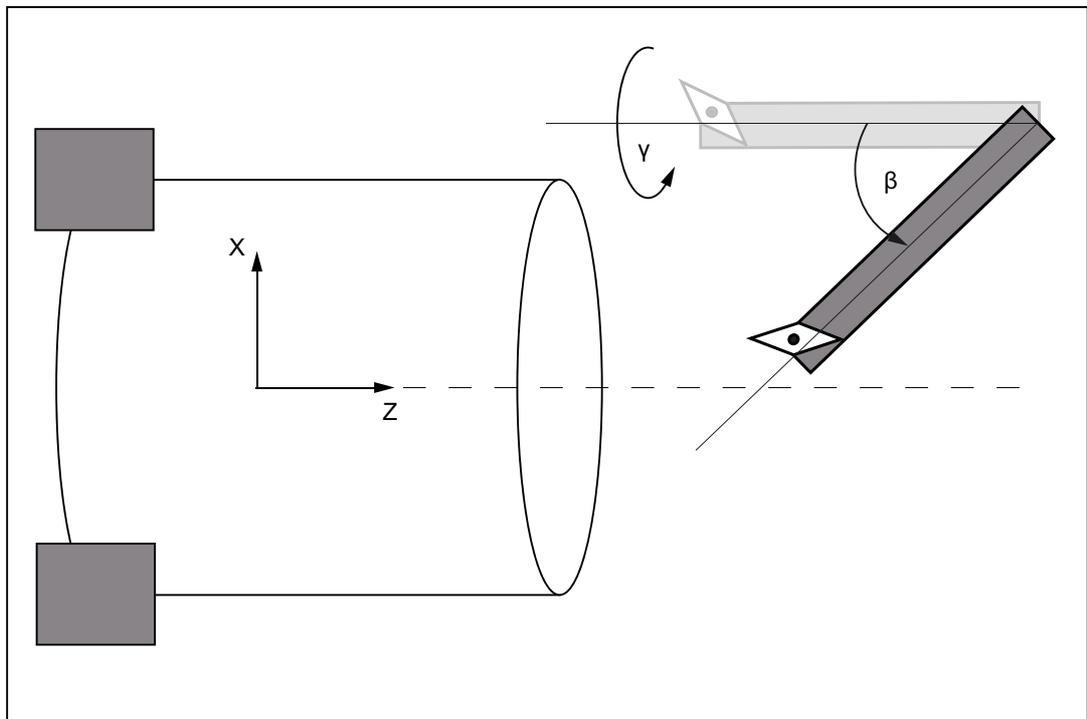
Using the function "cutting data modification for rotatable tools", the changed geometrical relationships, that are obtained relative to the workpiece being machined when rotating tools (predominantly turning tools, but also drilling and milling tools) can be taken into account.

### 17.7.1 Determination of angle of rotation

The actual rotation of the tool is always determined from a currently active, orientable toolholder (refer to Chapter "Tool Holder with Orientation Capacity").

The angle of rotation of the tool holder with orientation capacity is normally (but not necessarily) defined with the `TCOFR` command from an active frame. This method can be used to define the tool orientation independently of the actual kinematics with which the tool is rotated, identically in each case with the help of two angles.

The two machine-independent orientation angles  $\beta$  (Beta) and  $\gamma$  (Gamma) are used to define the tool rotation.  $\beta$  is the angle of rotation and the applicator (typically a B axis in `G18`) and  $\gamma$  a rotation around the ordinate (Typically a C axis in `G18`). The rotation is first executed around Y, finally around  $\beta$ , i.e. the y axis is rotated by the  $\beta$  axis:



## 17.7.2 Cutting edge position, cut direction and angle for rotary tools

### Turning tools

Turning tools means the following tools whose tool type (\$TC\_DP1) has values in the range of 500 to 599. Grinding tools (tool types 400 to 499) are equivalent to turning tools.

Tools are treated independently of tool type such as turning tools if:

SD42950 \$SC\_TOOL\_LENGTH\_TYPE = 2

### Cutting edge position and cut direction

Turning tools are limited by their main and secondary cutting edges. The tool parameter "Cutting edge position" is defined via the position of these two cutting edges relative to the coordinate axes. The ratios are displayed with diagram in the following figure:

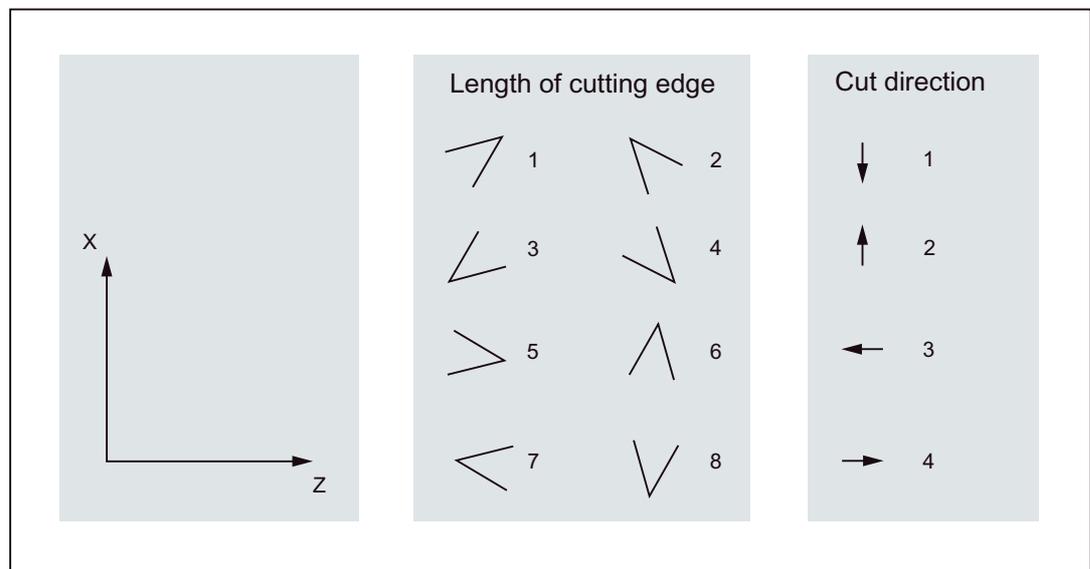


Figure 17-44 Cutting edge position and cut direction for turning tools

The values 1 to 4 characterize the cases in which both cutting edges lie in the same quadrant; the values 5 to 8 characterize the cases in which both cutting edges lie in neighboring quadrants or there is a coordinate axis between the two cutting edges. The cutting edge position is stored in the tool parameter \$TC\_DP2.

A cut direction can be defined for each turning tool. It is stored in the tool parameter \$TC\_DP11. It has values between 1 and 4, and it characterizes a positive or negative direction of the coordinate axes:

<b>Value:</b>	<b>Meaning:</b>
1	Ordinate -
2	Ordinate +
3	Abscissa -
4	Abscissa +

Two different cut directions can be assigned to each cutting edge position:

Cutting edge position:	1	2	3	4	5	6	7	8
Cut direction:	2, 4	2, 3	1, 3	1, 4	1, 2	3, 4	1, 2	3, 4

### Holder angle and clearance angle

The following figure depicts the two angles (holder angle and clearance angle) of a turning tool with cutting edge position 3, that are necessary for describing the geometry of the tool cutting edge. The cut direction in this example is 3, i.e. it denotes the negative Z direction (abscissa direction for G18).

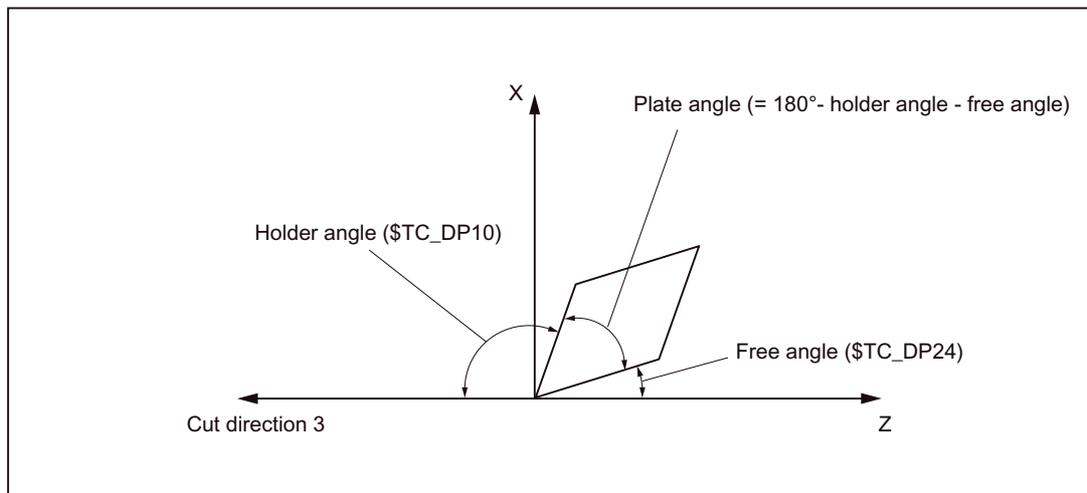


Figure 17-45 Angle and cut direction for a turning tool with cutting edge position 3

The cut direction specifies the reference direction of the holder angle. The clearance angle is the angle measured between the inverse cut direction and the adjacent cutting edge (positive). Holder angle and clearance angle are stored in the tool parameters \$TC\_DP10 or \$TC\_DP24.

### Note

Cut direction and tool angle are relevant only in the cutting edge positions 1 to 8.

### 17.7.3 Modifications during the rotation of turning tools

#### Tool orientation

Unlike milling tools, turning tools are not rotation-symmetric. This means that normally 3 degrees of freedom or three rotary axes are required to describe the tool orientation. The concrete kinematics therefore, is independent of the machine only to the extent the desired orientation can be set. If necessary, the third degree of freedom can be substituted by a rotation of the tool coordinate system.

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#### Note

The division of the orientation into one portion created by the tool holder with orientation capacity, and a second portion achieved via a rotation of the coordinate system is the responsibility of the application. The control does not provide any further functionality in this regard.

---

#### Shape of cutting edge

If a turning tool turns by an angle against the machining plane (i.e. around an axis in the machining plane, typically a C axis) that is not a multiple of  $180^\circ$ , then the configuration of the (circular) tool cutting edge in the machining plane becomes an ellipse. It is assumed that the deviations from the circular form arising on account of such rotations is so insignificant that they can be ignored (tilt angle  $< 5^\circ$ ), i.e. the control always ignores the tool orientation and assumes a circular cutting edge.

This also means that with reference to the active plane, the control accepts only a rotation by  $180^\circ$  as a setting deviating from the initial position. This limitation is valid for the shape of cutting edge only. The tool lengths are always considered correctly in random spatial rotations.

#### Cutting edge position, cut direction and angle

A rotation by  $180^\circ$  around an axis in the machining plane means that while using the tool at the same position, the spindle rotation direction with reference to the use of the unturned tool must be inverted.

Cut direction and cutting edge position are also not modified like the cutting edge reference point (see below) if the tool is rotated from the plane by  $\pm 90^\circ$  (with a tolerance of app.  $1^\circ$ ) because then the configuration of the cutting edge is not defined in the current plane.

If the tool rotates in the plane (rotation around an axis vertical to the machining plane or around the Y axis for G18), the cutting edge position is determined from the resulting angle for the clearance and holder angles. If these two angles are not specified for the tool (i.e. \$TC\_DP10 and \$TC\_DP24 are both zero), then the new cutting edge position is determined from the turning angle alone. The cutting edge position changes only in 90° steps, i.e. the cutting edge position remains independent of the initial state either in the value range 1 to 4 or 5 to 8. The new cutting edge position is then determined exclusively from the angle of rotation if the specified values for holder angle and clearance angle are not allowed (negative values, resulting plate angle negative or more than 90°). Clearance angle and holder angle are not modified in all these cases.

Depending on the rotation, the cut direction is modified in such a way that the resulting clearance angle remains less than 90°. If the original cut direction and the original cutting edge position do not fit together (refer to "Cutting edge position, cut direction and angle for turning tools"), then the cut direction is not modified during rotation of the tool.

The angle of rotation in the plane, as it was determined from the tool holder with orientation capacity, is available in the system variable \$P\_CUTMOD\_ANG or \$AC\_CUTMOD\_ANG. This angle is the original angle without any final rounding to multiples of 45° or 90°.

#### Limit cases

If, for a turning tool, the cutting edge position, cut direction, clearance and holder angles have valid values so that all cutting edge positions (1 to 8) are possible through suitable rotations in the plane, then the cutting edge positions 1 to 4 are preferred to cutting edge positions 5 to 8 in the cases in which one of the cutting edges (main or secondary cutting edge) is away from the coordinate axis by less than half the input increment ((0.0005° for an input specification of 3 decimal digits).

The following is applicable in all other cases (milling tools or turning tools without valid cutting edge parameters) in which rotation is possible only in 90° steps: If the amount of the rotation angle is smaller than 45° + 0.5 input increments (corresponds to 45.0005° for an input specification of 3 decimal points), the cutting edge position and cut direction are not changed, i.e. these cases are treated as rotations that are smaller than 45°. Rotations, the amount of which deviates from 180° by less than 45° + 0.5 input increments are treated identically as rotations in the range of 135° to 225°.

## Cutting edge reference point

The cutting edge center point and the cutting edge reference point are defined for turning tools. The position of these two points relative to each other is defined by the cutting edge position.

The distance of the two points for cutting edge positions 1 to 4 is equal to  $\sqrt{2}$  times the cutting edge radius; for cutting edge positions 5 to 8 it is equal to 1 times the cutting edge radius. In the first case, the cutting edge reference point relative to the cutting edge center point lies in the machining plane on a bisecting line, while in the second case it lies on a coordinate axis.

If you rotate the tool by a random angle around an axis vertical to the machining plane, the cutting edge reference point would also rotate if it had a fixed position relative to the tool. The above-mentioned condition (position on an axis or a bisecting axis) is not fulfilled in most cases. This is not desirable. Instead, the cutting edge reference point should always be modified in such a way that the distance vector between cutting edge reference point and cutting edge center point has one of the mentioned 8 directions. The cutting edge position must be modified for this if necessary.

The ratios are shown with examples in the figure below:

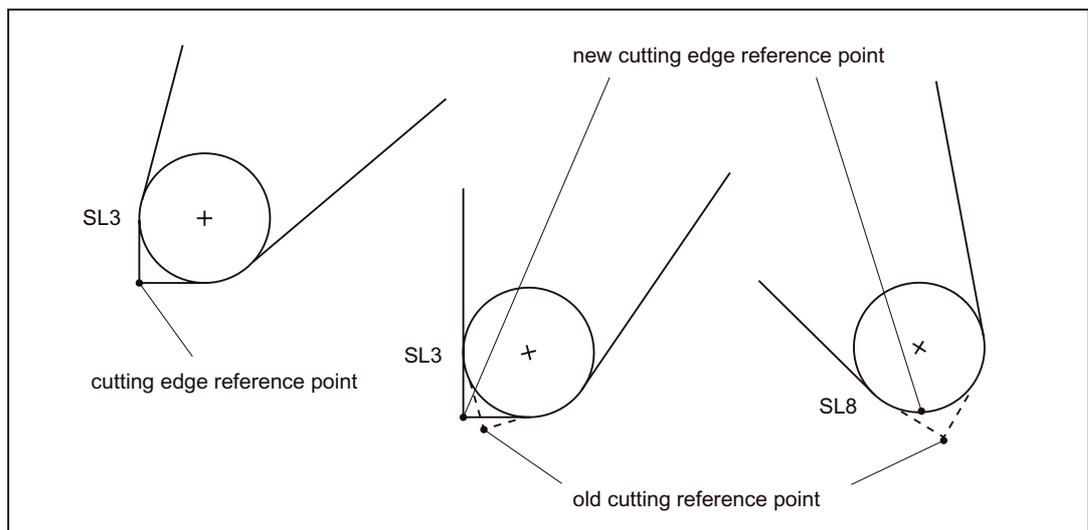


Figure 17-46 Cutting edge reference point and cutting edge position (SL) for tool rotation

A tool with the cutting edge position 3, the clearance angle  $22.5^\circ$  and holder angle  $112.5^\circ$  is rotated. For rotations up to  $22.5^\circ$ , the cutting edge position is maintained, the position of the cutting edge reference point relative to the tool however, is compensated in such a way that the relative position of both points are maintained in the machining plane. For bigger rotations (up to  $67.5^\circ$ ), the cutting edge position changes to value 8.

### Note

As the cutting edge reference point is defined by the tool length vector, modifying the cutting edge reference point changes the effective tool length.

### 17.7.4 Cutting edge position for milling and tapping tools

#### Milling and tapping tools

Milling and tapping tools means the following tools whose tool type (\$TC\_DP1) has values in the range of 100 to 299.

Tools are treated independently of tool type such as milling and tapping tools if:

SD42950 \$SC\_TOOL\_LENGTH\_TYPE = 1

#### Length of cutting edge

A cutting edge position is also introduced for the so defined milling and tapping tools which is modified according to the following description, in case of rotations.

Any specified cutting edge position for tools that are not milling and tapping tools or turning tools according to the mentioned definitions, is not evaluated.

The cutting edge position of the tapping and milling tools is stored in tool parameter \$TC\_DP2 as in the case of turning tools. Based on the definition of the cutting edge position for turning tools, this parameter can assume the values 5 to 8. Here, the cutting edge position specifies the orientation (the direction of the rotation axis) of the tool:

Length of cutting edge	Direction of rotation axis of tool
5	Abcissa +
6	Ordinate +
7	Abcissa -
8	Ordinate -

Example:

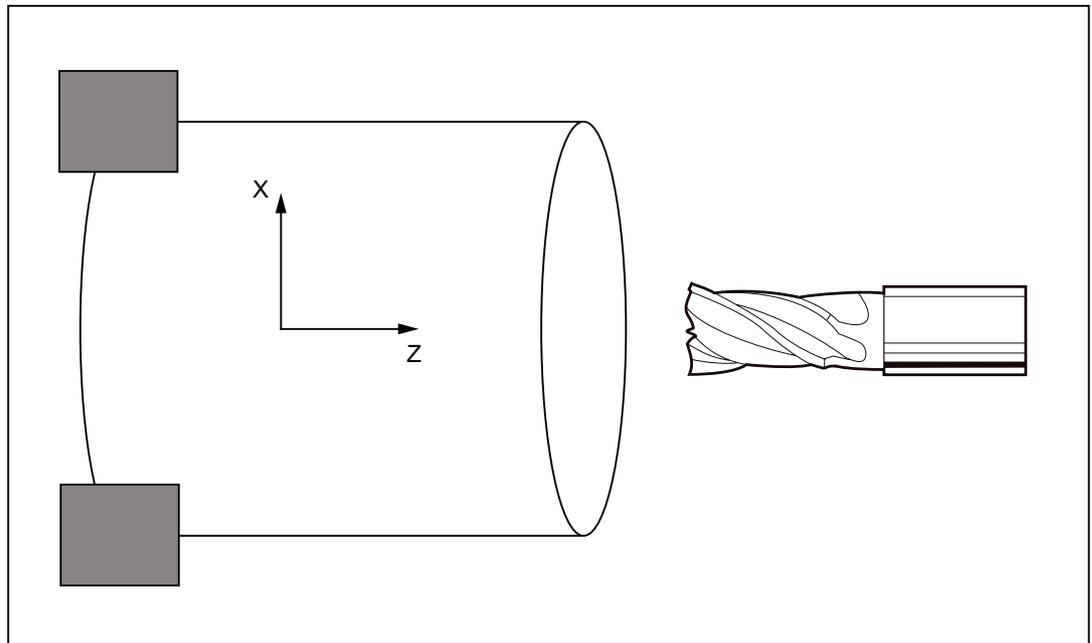


Figure 17-47 Milling tool with cutting edge position 7

### 17.7.5 Modifications during rotation of milling and tapping tools

The cutting edge position is recalculated appropriately during a rotation of a milling or tapping tool. Cut direction and tool angle (clearance angle or holder angle) are not defined for milling and tapping tools so that the change in cutting edge position is derived exclusively from the rotation. Thus, for milling and tapping tools, the cutting edge position always changes when the amount of rotation with reference to the zero setting is more than  $45^\circ$ .

## 17.7.6 Parameter assignment

### Reaction to errors

Different fault conditions can occur during the activation of the "Cutting edge data modification for rotary tools" function (via explicit call with `CUTMOD` or through a tool selection).

For each of these possible fault conditions, one can define whether the error is to trigger an alarm output, whether such an alarm is only to be displayed (warning), or whether additionally the interpretation of the part program must be cancelled. The setting is done via the following machine data:

MD20125 \$MC\_CUTMOD\_ERR

Two bits of the machine data are assigned to each fault condition:

Fault condition	Bit	Description
No valid cut direction is defined for the active tool.	0	Alarm output for error "Invalid cut direction"
	1	Program stop for error "Invalid cut direction"
The cutting edge angle (clearance angle and holder angle) of the active tool are both zero.	2	Alarm output for error "Not defined cutting edge angle"
	3	Program stop for error "Not defined cutting edge angle"
The clearance angle of the active tool has an impermissible value ( $< 0^\circ$ or $> 180^\circ$ ).	4	Alarm output for error "Invalid clearance angle"
	5	Program stop for error "Invalid clearance angle"
The holder angle of the active tool has an impermissible value ( $< 0^\circ$ or $> 90^\circ$ ).	6	Alarm output for error "Invalid holder angle"
	7	Program stop for error "Invalid holder angle"
The plate angle of the active tool has an impermissible value ( $< 0^\circ$ or $> 90^\circ$ ).	8	Alarm output for error "Invalid plate angle"
	9	Program stop for error "Invalid plate angle"
The cutting edge position - holder angle combination of the active tool is not permitted (the holder angle must be $\leq 90^\circ$ for cutting edge position 1 to 4; for cutting edge positions 5 to 8 it must be $\geq 90^\circ$ ).	10	Alarm output for error "Invalid cutting edge position - holder angle combination"
	11	Program stop for error "Invalid cutting edge position - holder angle combination"
Inadmissible rotation of the active tool (the tool was rotated from the active machining plane by $\pm 90^\circ$ (with a tolerance of about $1^\circ$ ). Hence the cutting edge position is no longer defined in the machining plane.	12	Alarm output for error "Invalid rotation"
	13	Program stop for error "Invalid rotation"

## Response to POWER ON

The "cutting edge data modification for rotary tools" function (CUTMOD) is initialized automatically during POWER ON with the value stored in machine data:

MD20127 \$MC\_CUTMOD\_INIT

If the value of this machine data is "-2", CUTMOD is set to the value that is set in machine data:

MD20126 \$MC\_TOOL\_CARRIER\_RESET\_VALUE (Active toolholder at RESET)

## 17.7.7 Programming

The "Cutting edge data modification for rotary tools" function is activated with the CUTMOD command.

### Syntax

CUTMOD=<value>

### Description

CUTMOD	Command to switch-in the function "cutting data modification for tools that can be rotated"
<value>	The following values can be assigned to the CUTMOD command:
0	The function is deactivated. The values supplied from system variables \$P_AD... are the same as the corresponding tool parameters.
> 0	The function is activated if a toolholder that can be orientated with the specified number is active, i.e. the activation is linked to a specific toolholder that can be orientated. The values supplied from system variables \$P_AD... may be modified with respect to the corresponding tool parameters depending on the active rotation. The deactivation of the designated toolholder that can be orientated temporarily deactivates the function; the activation of another toolholder that can be orientated permanently deactivates it. This is the reason that in the first case, the function is re-activated when again selecting the same toolholder that can be orientated; in the second case, a new selection is required - even if at a subsequent time, the toolholder that can be orientated is re-activated with the specified number. The function is not influenced by a reset.
-1	The function is always activated if a toolholder that can be orientated is active. When changing the toolholder or when de-selecting it and a subsequent new selection, CUTMOD does not have to be set again.

- 2 The function is always activated if a toolholder that can be orientated is active whose number is the same as the currently active toolholder that can be orientated.  
If a toolholder that can be orientated is not active, then this has the same significance as `CUTMOD=0`.  
If a toolholder that can be orientated is active, then this has the same significance as when directly specifying the actual toolholder number.
- < -2 Values less than 2 are ignored, i.e. this case is treated as if `CUTMOD` was not programmed.  
**Note:**  
This value range should not be used as it is reserved for possible subsequent expansions.

---

**Note**

**SD42984 \$SC\_CUTDIRMOD**

The function can be activated using the `CUTMOD` command replaces the function that can be activated using the setting data `SD42984 $SC_CUTDIRMOD`. However, this function remains available unchanged. However, as it doesn't make sense to use both functions in parallel, it can only be activated if `CUTMOD` is equal to zero.

---

### Effectiveness of the modified cutting data

The modified tool nose position and the modified tool nose reference point are immediately effective when programming, even for a tool that is already active. A tool does not have to be re-selected for this purpose.

### Influence of the active machining plane

To determine modified tool nose position, cutting direction and holder or clearance angle, the evaluation of the cutting edge in the active plane (`G17 - G19`) is decisive.

However, if setting data `SD42940 $SC_TOOL_LENGTH_CONST` (change of the tool length component when selecting the plane), a valid value not equal to zero (plus or minus 17, 18 or 19), then its contents define the plane in which the relevant quantities are evaluated.

## System variables

The following system variables are available:

System variables	Description
\$P_CUTMOD_ANG/ \$AC_CUTMOD_ANG	Supplies the (non-rounded) angle in the active machining plane, that was used as basis for the modification of the cutting data (tool nose position, cut direction, clearance angle and holder angle) for the functions activated using <code>CUTMOD</code> and/or <code>\$SC_CUTDIRMOD</code> .  \$P_CUTMOD_ANG refers to the actual state in the preprocessing, \$AC_CUTMOD_ANG to the actual main run block.
\$P_CUTMOD/ \$AC_CUTMOD	Reads the currently valid value that was last programmed using the command <code>CUTMOD</code> (number of the toolholder that should be activated for the cutting data modification).  If the last programmed <code>CUTMOD</code> value = -2 (activation with the currently active toolholder that can be orientated), then the value -2 is not returned in <code>\$P_CUTMOD</code> , but the number of the active toolholder that can be orientated at the time of programming.  \$P_CUTMOD refers to the actual state in the preprocessing, \$AC_CUTMOD to the actual main run block.
\$P_CUT_INV/ \$AC_CUT_INV	Supplies the value <code>TRUE</code> if the tool is rotated so that the spindle direction of rotation must be inverted. To do this, the following four conditions must be fulfilled in the block to which the read operations refer: <ol style="list-style-type: none"> <li>1. If a turning or grinding tool is active (tool types 400 to 599 and/or SD42950 <code>\$SC_TOOL_LENGTH_TYPE = 2</code>).</li> <li>2. The cutting influence was activated using the language command <code>CUTMOD</code>.</li> <li>3. A toolholder that can be orientated is active, which was designated using the numerical value of <code>CUTMOD</code>. Check - I reformulated.</li> <li>4. The toolholder that can be orientated rotates the tool around an axis in the machining plane (this is typically the C axis) so that the resulting perpendicular of the tool cutting edge is rotated with respect to the initial position by more than 90° (typically 180°).</li> </ol> <p>The contents of the variable is <code>FALSE</code> if at least one of the specified four conditions is not fulfilled. For tools whose tool nose position is not defined, the value of the variable is always <code>FALSE</code>.</p> <p>\$P_CUT_INV refers to the actual state in the preprocessing and \$AC_CUT_INV to the actual main run block.</p>

All main run variables (`$AC_CUTMOD_ANG`, `$AC_CUTMOD` and `$AC_CUT_INV`) can be read in synchronized actions. A read access operation from the preprocessing generates a preprocessing stop.

**Modified cutting data**

If a tool rotation is active, the modified data are made available in the following system variables:

System variable	Description
\$P_AD[2]	Length of cutting edge
\$P_AD[10]	Holder angle
\$P_AD[11]	Cut direction
\$P_AD[24]	Clearance angle

**Note**

The data are always modified with respect to the corresponding tool parameters (\$TC\_DP2[... , ...] etc.) if the function "cutting data modification for rotatable tools" was activated using the command CUTMOD and a toolholder that can be orientated, which causes a rotation, is activated.

**17.7.8 Example**

The following example refers to a tool with tool nose position 3 and a toolholder that can be orientated, which can rotate the tool around the B axis.

The numerical values in the comments specify the end of block positions in the machine coordinates (MCS) in the sequence X, Y, Z.

Program code	Comment
N10 \$TC_DP1[1,1]=500	
N20 \$TC_DP2[1,1]=3	; Length of cutting edge
N30 \$TC_DP3[1,1]=12	
N40 \$TC_DP4[1,1]=1	
N50 \$TC_DP6[1,1]=6	
N60 \$TC_DP10[1,1]=110	; Holder angle
N70 \$TC_DP11[1,1]=3	; Cut direction
N80 \$TC_DP24[1,1]=25	; Clearance angle
N90 \$TC_CARR7[2]=0 \$TC_CARR8[2]=1 \$TC_CARR9[2]=0	; B axis
N100 \$TC_CARR10[2]=0 \$TC_CARR11[2]=0 \$TC_CARR12[2]=1	; C axis
N110 \$TC_CARR13[2]=0	
N120 \$TC_CARR14[2]=0	
N130 \$TC_CARR21[2]=X	
N140 \$TC_CARR22[2]=X	
N150 \$TC_CARR23[2]="M"	
N160 TCOABS CUTMOD=0	
N170 G18 T1 D1 TCARR=2	X Y Z

## 17.7 Cutting data modification for tools that can be rotated

Program code	Comment
N180 X0 Y0 Z0 F10000	; 12.000 0.000 1.000
N190 \$TC_CARR13[2]=30	
N200 TCARR=2	
N210 X0 Y0 Z0	; 10.892 0.000 -5.134
N220 G42 Z-10	; 8.696 0.000 -17.330
N230 Z-20	; 8.696 0.000 -21.330
N240 X10	; 12.696 0.000 -21.330
N250 G40 X20 Z0	; 30.892 0.000 -5.134
N260 CUTMOD=2 X0 Y0 Z0	; 8.696 0.000 -7.330
N270 G42 Z-10	; 8.696 0.000 -17.330
N280 Z-20	; 8.696 0.000 -21.330
N290 X10	; 12.696 0.000 -21.330
N300 G40 X20 Z0	; 28.696 0.000 -7.330
N310 M30	

## Explanations:

In block N180, initially the tool is selected for CUTMOD=0 and non-rotated toolholders that can be orientated. As all offset vectors of the toolholder that can be orientated are 0, the position that corresponds to the tool lengths specified in \$TC\_DP3[1,1] and \$TC\_DP4[1,1] is approached.

The toolholder that can be orientated with a rotation of 30° around the B axis is activated in block N200. As the tool nose position is not modified due to CUTMOD=0, the old tool nose reference point is decisive just as before. This is the reason that in block N210 the position is approached, which keeps the old tool nose reference point at the zero (i.e. the vector (1, 12) is rotated through 30° in the Z/X plane).

In block N260, contrary to block N200 CUTMOD=2 is effective. As a result of the rotation of the toolholder that can be orientated, the modified tool nose position becomes 8. The consequence of this is also the different axis positions.

The tool radius compensation (TRC) is activated in blocks N220 and/or N270. The different tool nose positions in both program sections has no effect on the end positions of the blocks in which the TRC is active; the corresponding positions are therefore identical. The different tool nose positions only become effective again in the deselect blocks N260 and/or N300.

## 17.8 Incrementally programmed compensation values

### 17.8.1 G91 extension

#### Prerequisites

Incremental programming with G91 is defined such that the compensation value is traversed additively to the incrementally programmed value when a tool compensation is selected.

#### Applications

For applications such as scratching, it is necessary only to traverse the path programmed in the incremental coordinates. The activated tool compensation is not traversed.

#### Sequence

Selection of a tool compensation with incremental programming

- Scratch workpiece with tool tip.
- Save the actual position in the basic frame (set actual value) after reducing it by the tool compensation.
- Traverse incrementally from the zero position.

#### Activation

With setting data:

SD42442 \$SC\_TOOL\_OFFSET\_INCR\_PROG,

it is possible to define whether a changed tool length is traversed with FRAME and incremental programming of an axis, or whether only the programmed path is traversed.

#### Zero offset/frames G91

With setting data:

SD42440 \$SC\_FRAME\_OFFSET\_INCR\_PROG,

it is possible to define whether a zero offset is traversed as standard with value = 1 with FRAME and incremental programming of an axis, or whether only the programmed path is traversed with value = 0.

#### References:

/FB1/ Function Manual, Basic Functions; Axes, Coordinate Systems, Frames (K2), Chapter: "Frames"

**Supplementary condition**

If the behavior is set such that the offset remains active even after the end of the program and RESET (MD20110 \$MC\_RESET\_MODE\_MASK, bit6=1), and if an incremental path is programmed in the first part program block, the compensation is always traversed additively to the programmed path.

**Note**

With this configuration, part programs must always begin with absolute programming.

**17.8.2 Machining in direction of tool orientation****Typical application**

On machines with toolholders with orientation capability, traversing should take place in the tool direction (typically, when drilling) without activating a frame (e.g. using TOFRAME or TOROT), on which one of the axes points in the direction of the tool.

This is also true of machines on which a frame defining the oblique plane is active during oblique machining operations, but the tool cannot be set exactly perpendicular because an indexed toolholder (Hirth tooth system) is restricting the setting of the tool orientation.

In these cases it is then necessary - contrary to the motion actually requested perpendicular to the plane - to drill in the tool direction, as the drill would otherwise not be guided in the direction of its longitudinal axis, which, among other things, would lead to breaking of the drill.

**MOVT**

The end point of such a motion is programmed with `MOVT= . . .`. The programmed value is effective incrementally in the tool direction as standard. The positive direction is defined from the tool tip to the toolholder. The content of `MOVT` is thus generally negative for the infeed motion (when drilling), and positive for the retraction motion. This corresponds to the situation with normal paraxial machining, e.g. with `G91Z . . .`

If the motion is programmed in the form `MOVT=AC ( . . . )`, `MOVT` functions absolutely. In this case a plane is defined, which runs through the current zero point, and whose surface normal vector is parallel to the tool orientation. `MOVT` then gives the position relative to this plane:

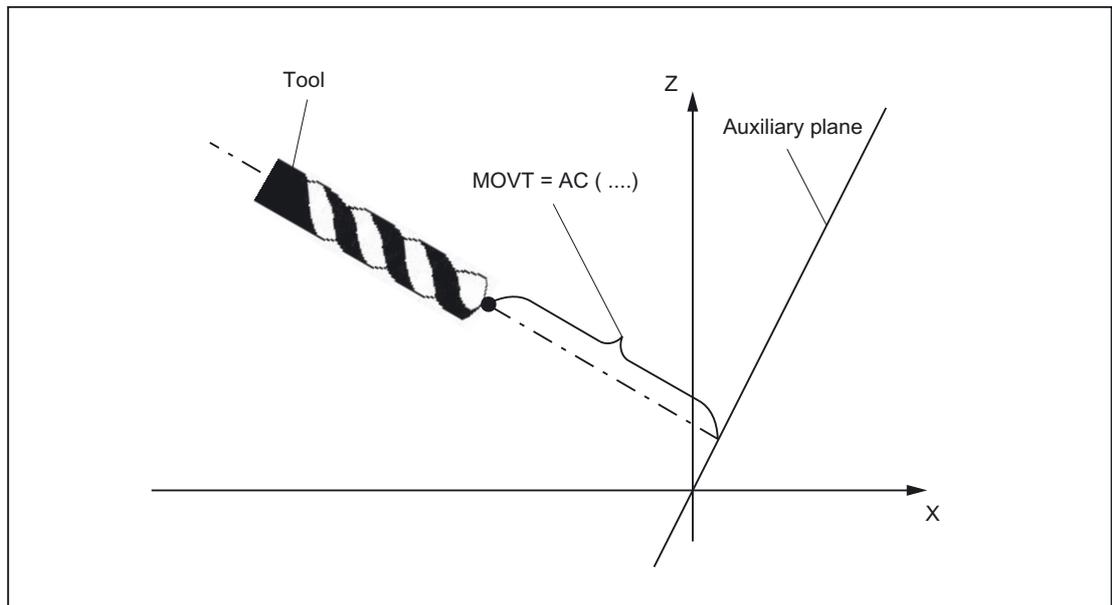


Figure 17-48 Definition of the position for absolute programming of a motion in tool direction

The reference to this auxiliary plane serves only to calculate the end position. Active frames are not affected by this internal calculation.

Instead of `MOVT= . . .` it is also possible to write `MOVT=IC ( . . . )` if it is to be plainly visible that `MOVT` is to function incrementally. There is no functional difference between the two forms.

### Supplementary conditions

The following supplementary conditions apply to programming with `MOVT`:

- It is independent of the existence of a toolholder with orientation capability. The direction of the motion is dependent on the active plane. It runs in the direction of the vertical axes, i.e. with `G17` in Z direction, with `G18` in Y direction and with `G19` in X direction. This applies both where no toolholder with orientation capability is active and for the case of a toolholder with orientation capability without rotary tool or with a rotary tool in its basic setting.
- `MOVT` acts similarly for active orientation transformation (3-4-5-axis transformation).
- If in a block with `MOVT` the tool orientation is changed simultaneously (e.g. active 5-axis transformation by means of simultaneous interpolation of the rotary axes), the orientation at the start of the block is decisive for the direction of movement of `MOVT`. The path of the tool tip (TCP - Tool Center Point) is not affected by the change in orientation.
- Linear or spline interpolation (`G0`, `G1`, `ASPLINE`, `BSPLINE`, `CSPLINE`) must be active. Otherwise, an alarm is produced. If a spline interpolation is active, the resultant path is generally not a straight line, since the end point determined by `MOVT` is treated as if it had been programmed explicitly with X, Y, Z.
- A block with `MOVT` must not contain any programming of geometry axes (alarm 14157).

## 17.9 Basic tool orientation

### Application

Normally, the orientation assigned to the tool itself depends exclusively on the active machining plane. For example, the tool orientation is parallel to Z with G17, parallel to Y with G18 and parallel to X with G19.

Different tool orientations can only be programmed by activating a 5-axis transformation. The following system variables have been introduced in order to assign a separate orientation to each tool cutting edge:

System variable	Description of tool orientation	Format	Preassignment
\$TC_DPV[t, d]	Tool cutting edge orientation	INT	0
\$TC_DPV3[t, d]	L1 component of tool orientation	REAL	0
\$TC_DPV4[t, d]	L2 component of tool orientation	REAL	0
\$TC_DPV5[t, d]	L3 component of tool orientation	REAL	0

Indexing: Same as tool system variable \$TC\_DPx[t, d]  
t: T number of cutting edge  
d: D number of cutting edge

Identifiers \$TC\_DPV3 to \$TC\_DPV5 are analogous to identifiers \$TC\_DP3 to \$TC\_DP5 of the tool length components.

### MD18114

The system variables for describing the tool orientation are only available if machine data is not equal to zero:

MD18114 \$MN\_MM\_ENABLE\_TOOL\_ORIENT (assign orientation to tool cutting)

MD18114 \$MN_MM_ENABLE_TOOL_ORIENT	
Value = 1	Only system variable \$TC_DPV[t, d] is available.
Value = 2	All four system variables are available.

### Define direction vector

If all four system variables contain 0, the orientation is defined only by the active plane (as before).

If system variable \$TC\_DPV[t, d] is equal to zero, the other three parameters - if available - define a direction vector. The amount of the vector is insignificant.

**Example:**

```
$TC_DPV[1, 1] = 0
$TC_DPV3[1, 1] = 1.0
$TC_DPV4[1, 1] = 0.0
$TC_DPV5[1, 1] = 1.0
```

In this example, the basic orientation points in the direction of the bisector in the L1-L3 plane, i.e. the basic orientation in the bisector for a milling tool and active plane G17 lies in the Z/X plane.

### Basic orientation of tools

Basic orientation of:	With :
Turning and grinding tools	G18
Milling tools	G17

The active tool orientation is unchanged in these cases and is equivalent to the original settings in \$TC\_DPVx[t, d].

The basic orientation is always the direction perpendicular to the plane in which tool radius compensation is performed. With turning tools, in particular, the tool orientation generally coincides with the longitudinal tool axis.

The setting data specified below are effective only if the basic orientation of the tool is defined by an entry in at least one of the system variables \$TC\_DPVx[t, d].

They have no effect if the tool orientation is only determined by the plane selection G17 - G19 and is compatible with previous behavior.

The plane of the basic orientation for a cutting edge is treated either like a milling tool or like a turning tool, irrespective of the entry in \$TC\_DP1, if the following setting data is not equal to zero:

SD42950 \$SC\_TOOL\_LENGTH\_TYPE (allocation of the tool length components independent of tool type)

## Plane change

A change of plane causes a change in orientation.

The following rotations are initiated:

When changing from:	Rotations
G17 ⇒ G18: G18 ⇒ G19: G19 ⇒ G17:	Rotation through -90 degrees about the Z axis followed by rotation through -90 degrees about the X axis
G17 ⇒ G19: G18 ⇒ G17: G19 ⇒ G18:	Rotation through 90 degrees about the X axis followed by rotation through 90 degrees about the Z axis

These rotations are the same as those that have to be performed in order to interchange the components of the tool length vector on a change of plane.

The basic orientation is also rotated when an adapter transformation is active.

If the following setting data is not equal to zero, the tool orientation is not rotated on a change of plane:

SD42940 \$SC\_TOOL\_LENGTH\_CONST (change of tool length components on change of planes).

## Tool length components

The components of the tool orientation are treated the same as the components of the tool length, with respect to setting data:

SD42910 \$SC\_MIRROR\_TOOL\_LENGTH (Sign change tool wear when mirroring).

SD42950 \$SC\_TOOL\_LENGTH\_TYPE (allocation of the tool length components independent of tool type)

Therefore the components are changed respectively and assigned to the geometry axis.

**System variable \$TC\_DPV[t, d]**

The purpose of system variable \$TC\_DPV[t, d] is to allow the simple specification of certain basic orientations (parallel to coordinate axes) that are required frequently. The permissible values are shown in the table below. The values in the first and second/third columns are equivalent.

\$TC_DPV[t, d]	Basic orientation	
	Milling tools *	Turning tools *
≤ 0 or > 6	(\$TC_DPV5[t, d], \$TC_DPV4[t, d], \$TC_DPV3[t, d],) **	(\$TC_DPV3[t, d], \$TC_DPV5[t, d], \$TC_DPV4[t, d],) **
1	(0, 0, V)	(0, V, 0)
2	(0, V, 0)	(0, 0, V)
3	(V, 0, 0)	(V, 0, 0)
4	(0, 0, -V)	(0, -V, 0)
5	(0, -V, 0)	(0, 0, -V)
6	(-V, 0, 0)	(-V, 0, 0)

\* Turning tools in this context are any tools whose tool type (\$TC\_DP1[t, d]) is between 400 and 599. All other tool types refer to milling tools.

\*\* If all three values \$TC\_DPV3[t, d], \$TC\_DPV4[t, d], \$TC\_DPV5[t, d] are equal to zero in this case, the tool orientation is determined by the active machining plane (default).

V Stands for a positive value in the corresponding system variables.

**Example:**

For milling tools:

\$TC\_DPV[t, d] = 2 is equal to:

\$TC\_DPV3[t, d] = 0, \$TC\_DPV4[t, d] = 0, \$TC\_DPV5[t, d] = V.

### Supplementary conditions

If the "Scratch" function is used in the `RESET` state, the following must be noted with respect to the initial setting:

- The wear components are evaluated depending on the initial settings of the G-code groups `TOWSTD`, `TOWMCS` and `TOWWCS`.
- If a value other than the initial setting is needed to ensure correct calculation, scratching may be performed only in the `STOP` state.

---

#### **Note**

"Special handling of tool compensations" pays particular attention to tool compensations with evaluation of sign for tool length with wear and temperature fluctuations.

The following are taken into account:

- Tool type
  - Transformations for tool components
  - Assignment of tool length components to geometry axes independently of tool type
-

## 17.10 Special handling of tool compensations

### 17.10.1 Relevant setting data

#### SD42900- 42960

Setting data SD42900 - SD42940 can be used to make the following settings with reference to tool compensation:

- Sign of the tool length
- Sign of the wear
- Behavior of the wear components when mirroring geometry axes
- Behavior of the wear components when changing the machining plane via setting data
- Allocation of the tool length components independent of actual tool type
- Transformation of wear components into a suitable coordinate system for controlling the effective tool length

---

#### Note

In the following description, the wear includes the total values of the following components:

- Wear values: \$TC\_DP12 to \$TC\_DP20
  - Sum offset, consisting of:
    - Wear values: \$SCPX3 to \$SCPX11
    - Setup values: \$ECPX3 to \$ECPX11
- 

You will find detailed information about sum and tool offsets in:

#### References:

/FBW/ Function Manual Tool Management

/PG/ Programming Manual Fundamentals; Tool Compensations

### Required setting data

- SD42900 \$SC\_MIRROR\_TOOL\_LENGTH (mirroring of tool length components and components of the tool base dimension)
- SD42910 \$SC\_MIRROR\_TOOL\_WEAR (mirroring of wear values of tool length components)
- SD42920 \$SC\_WEAR\_SIGN\_CUTPOS (sign evaluation of the wear components)
- SD42930 \$SC\_WEAR\_SIGN (inverts the sign of the wear dimensions)
- SD42940 \$SC\_TOOL\_LENGTH\_CONST (allocation of the tool length components to the geometry axes)
- SD42950 \$SC\_TOOL\_LENGTH\_TYPE (allocation of the tool length components independent of tool type)
- SD42935 \$SC\_WEAR\_TRANSFORM (transformation of wear values)
- SD42960 \$SC\_TOOL\_TEMP\_COMP (tool length offsets)

### 17.10.2 Mirror tool lengths (SD42900 \$SC\_MIRROR\_TOOL\_LENGTH)

#### Activation

Tool length mirroring is activated via the setting data:

SD42900 \$SC\_MIRROR\_TOOL\_LENGTH <> 0 (TRUE) (Sign change tool length when mirroring)

#### Function

The following components are mirrored by inverting the sign:

- Tool lengths: \$TC\_DP3, \$TC\_DP4, \$TC\_DP5
- Tool base dimensions: \$TC\_DP21, \$TC\_DP22, \$TC\_DP23

Mirroring is performed for all tool base dimensions whose associated axes are mirrored. Wear values are **not** mirrored.

### Mirror wear values

The following setting data should be set in order to mirror the wear values:

SD42910 \$SC\_MIRROR\_TOOL\_WEAR <> 0 (Sign change tool wear when mirroring)

Inverting the sign mirrors the wear values of the tool length components whose associated axes are mirrored.

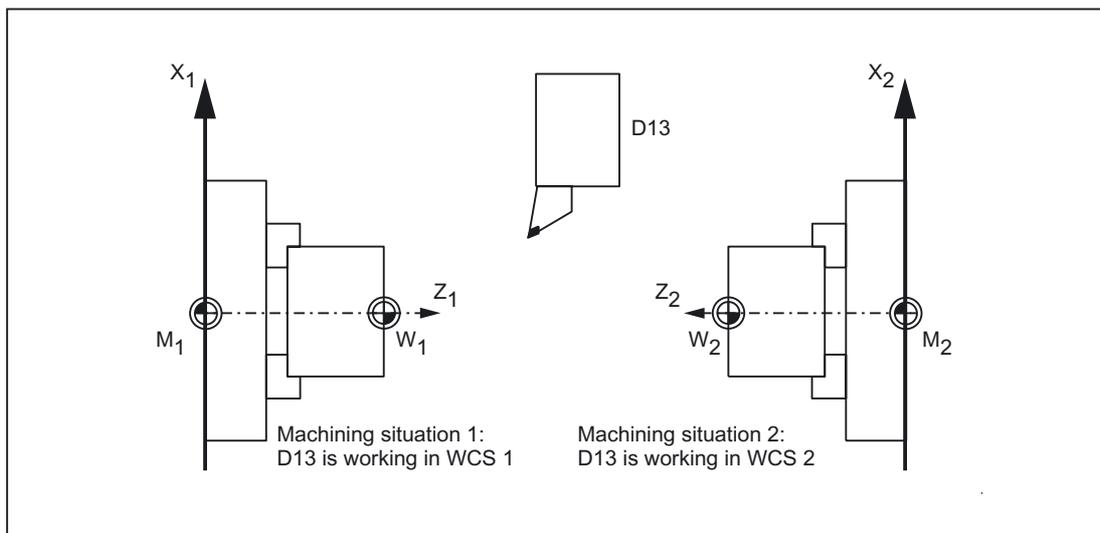


Figure 17-49 Application example: Double-spindle turning machine

### 17.10.3 Mirror wear lengths (SD42920 \$SC\_WEAR\_SIGN\_CUTPOS)

#### Activation

Wear length mirroring is activated by:

SD42920 \$SC\_WEAR\_SIGN\_CUTPOS <> 0 (TRUE) (Sign of wear for tools with cutting edge systems)

#### Function

Length of cutting edge	Length 1	Length 2
1	---	---
2	---	Inverted
3	Inverted	Inverted
4	Inverted	---
5	---	---
6	---	---
7	---	Inverted
8	Inverted	---
9	---	---

In the case of tool types without a relevant cutting edge position, the wear length is not mirrored.

#### Note

The mirroring (sign inversion) in one or more components can cancel itself through a simultaneous activation of the functions:

Tool length-mirroring (SD42900 <> 0)

And:

Tool length-mirroring (SD42920 <> 0)

### SD42930 \$SC\_WEAR\_SIGN

Setting data not equal to zero:

Inverts the sign of all wear dimensions. This affects both the tool length and other variables such as tool radius, rounding radius, etc.

Entering a positive wear dimension makes the tool "shorter" and "thinner".

### Activation of modified setting data

When the setting data described above are modified, the tool components are not reevaluated until the next time a tool edge is selected. If a tool is already active and the data of this tool are to be reevaluated, the tool must be selected again.

#### Example:

```

N10 $SC_WEAR_SIGN = 0                ; No sign inversion of the wear values
N20 $TC_DP1[1,1] = 120              ; End mill
N30 $TC_DP6[1,1] = 100              ; Tool radius 100 mm
N40 $TC_DP15[1,1] = 1               ; Wear dimension of tool radius 1 mm, resulting
                                     tool radius 101 mm

N100 T1 D1 G41 X150 Y20
....
N150 G40 X300N10
....
N200 $SC_WEAR_SIGN = 1              ; Sign inversion for all wear values; the new
                                     radius of 99 mm is activated on a new
                                     selection (D1). Without D1, the radius would
                                     continue to be 101 mm.

N300 D1 G41 X350 Y-20
N310 ....

```

The same applies in the event that the resulting tool length is modified due to a change in the mirroring status of an axis. The tool must be selected again after the mirror command, in order to activate the modified tool-length components.

## 17.10.4 Tool length and plane change (SD42940 \$SC\_TOOL\_LENGTH\_CONST)

### Plane change

The assignment of tool length components (length, wear and tool base dimension) to geometry axes does not change when the machining plane is changed (G17-G19).

### Assignment of tools

The assignment of tool length components to geometry axes for turning and grinding tools (tool types 400 to 599) is generated from the value of the following setting data in accordance with the following table:

SD42940 \$SC\_TOOL\_LENGTH\_CONST (change of tool length components on change of planes).

Layer	Length 1	Length 2	Length 3
17	Y	X	Z
*)	X	Z	Y
19	Z	Y	X
-17	X	Y	Z
-18	Z	X	Y
-19	Y	Z	X
*) Each value not equal to 0, which is not equal to one of the six listed values, is evaluated as value 18.			

The following table shows the assignment of tool length components to geometry axes for **all other tools** (tool types < 400 or > 599):

Layer	Length 1	Length 2	Length 3
*)	Z	Y	X
18	Y	X	Z
19	X	Z	Y
-17	Z	X	Y
-18	Y	Z	X
-19	X	Y	Z
*) Each value not equal to 0, which is not equal to one of the six listed values, is evaluated as value 17.			

### Note

For representation in tables, it is assumed that geometry axes 1 to 3 are named X, Y, Z. The axis order and not the axis identifier determines the assignment between a compensation and an axis.

Three tool length components can be arranged on the 6 different types above.

### 17.10.5 Tool type (SD42950 \$SC\_TOOL\_LENGTH\_TYPE)

Definition of the assignment between tool length components (length, wear and tool base dimension) and geometry axes independent of tool type.

Setting data **not equal to zero**: (the default definition is applied)

A distinction is made between turning and grinding tools (tool types 400 to 599) and other tools (milling tools).

The value range is from 0 to 2. Any other value is interpreted as 0.

The assignment of tool length components is always independent of the actual tool type.

- Value = 1: Always as for milling tools
- Value = 2: Always as for turning tools

#### Toolholder with orientation capability

##### Setting data SD42900 - SD42950

Setting data SD42900 - SD42950 have no effect on the components of an active toolholder with orientation capability. The calculation with a toolholder with orientation capability always allows for a tool with its total resulting length (tool length + wear + tool base dimension). The calculation of the resulting total length allows for all modifications caused by the setting data.

---

##### Note

When toolholders with orientation capability are used, it is common to define all tools for a non-mirrored basic system, even those, which are only used for mirrored machining. When machining with mirrored axes, the toolholder is then rotated such that the actual position of the tool is described correctly. All tool-length components then automatically act in the correct direction, dispensing with the need for control of individual component evaluation via setting data, depending on the mirroring status of individual axes.

The use of toolholders with orientation capability is also practical if the physical characteristics of the machine type prevents tools, which are permanently installed with different orientations, from being rotated. Tool dimensioning can then be performed uniformly in a basic orientation, where the dimensions relevant for machining are calculated according to the rotations of a virtual toolholder.

---

### 17.10.6 Temperature offsets in tool direction (SD42960 \$SC\_TOOL\_TEMP\_COMP)

---

**Note**

Temperature offset in the tool direction is operative only as an option with generic 5-axis transformation, types 24 and 56.

---

### 17.10.7 Tool lengths in the WCS, allowing for the orientation

#### Change tool or working plane

The values displayed for the tool correspond to the expansion in the WCS. If a toolholder with an inclined clamping position is to be used, you should make sure that the transformation used supports the toolholder. If this is not the case, incorrect tool dimensions will be displayed. When changing the working plane from G17 to G18 or G19, you should ensure that the transformation can also be used for these working planes. If the transformation is only available for G17 machining, the dimensions continue to be displayed for a tool in the Z direction after the plane change.

When transformation is deactivated, the basic tool is displayed in the x, y or z direction, according to the working plane. Allowance is made for a programmed toolholder. These tool dimensions are not altered when traversing without a transformation.

### 17.10.8 Tool length offsets in tool direction

#### Temperature compensation in real time

On 5-axis machines with a moving tool, temperature fluctuations can occur in the machining heads. These can result directly in expansion fluctuations, which are transmitted to the tool spindle in the form of linear expansion. A typical case on 5-axis heads, for example, is thermal expansion in the direction of the longitudinal spindle axis.

It is possible to compensate this thermal expansion even when the tool is orientated by assigning the temperature compensation values to the tool rather than to the machine axes. In this way, linear expansion fluctuations can be compensated even when the tool orientation changes.

Using the orientation transformation whose direction is determined by the current tool orientation, it is possible to overlay motions in real time and rotate them simultaneously. At the same time, the compensation values are adjusted continuously in the tool coordinate system.

Compensation applies to the "Temperature compensation" option and is active only when the axis to be compensated is really referenced.

## Activation

Temperature compensation in the tool direction is an option, which must be enabled beforehand.

It is activated by setting the following machine data to a value **other than zero**.

MD20390 \$MC\_TOOL\_TEMP\_COMP\_ON (Activation of temperature compensation for tool length)

In addition, the bit 2 must be set for each affected channel axis in the machine data:

MD32750 \$MA\_TEMP\_COMP\_TYPE [<axis index>] (temperature compensation type)

This can be more than three axes in cases where more than three channel axes in succession can be temporarily assigned to geometry axes as a result of geometry axis replacement of transformation switchover. If this bit is not set for a particular channel axis, the compensation value cannot be applied in the axis. This does not have any effect on other axes. In this case, an alarm is not output.

## Applicability

Temperature compensation in the tool direction is operative only with generic 5-axis transformations with:

- Transformation type 24

Two axes rotate the tool

- Transformation type 56

One axis rotates the tool, the other axis rotates the workpiece without temperature compensation

In generic 5-axis transformation with:

- Transformation type 40

The tool orientation is constant with a rotary workpiece, which means that the movement of the rotary axes on the machine does not affect the temperature compensation direction.

Temperature compensation in the tool direction also works in conjunction with orientation transformations (not generic 5-axis transformations) with:

- Transformation type 64 to 69

Rotating linear axis

---

### Note

Temperature compensation can be activated with all other types of transformation. It is not affected by a change in tool orientation. The axis move as if no orientation transformation with temperature compensation were active.

---

### Supplementary conditions

Temperature compensation in the tool direction is an option, which must be enabled in advance and is available:

- For generic 5-axis transformation
- For transformation with rotated linear axis for transformation types 64 to 69

### Limit values

The compensation values are restricted to the maximum values by the machine data:

MD20392 \$MC\_TOOL\_TEMP\_COMP\_LIMIT[0] (Maximum temperature compensation for tool length)

To:

MD20392 \$MC\_TOOL\_TEMP\_COMP\_LIMIT[2]

The limit value default setting is 1 mm. If a temperature compensation value higher than this limit is specified, it will be limited without an alarm.

### SD42960

The three temperature compensation values together form a compensation vector and are contained in setting data:

SD42960 \$SC\_TOOL\_TEMP\_COMP[0] (Temperature compensation with reference to tools)

To:

SD42960 \$SC\_TOOL\_TEMP\_COMP[2]

The setting data are user-defined, e.g. using synchronized actions or from the PLC. The compensation values can, therefore, also be used for other compensation purposes.

In the initial state or when orientation transformation is deactivated, all three compensation values apply in the direction of the three geometry axes (in the typical order X, Y, Z). The assignment of components to geometry axes is independent of the tool type (turning, milling or grinding tools) and the selected machining plane G17 to G19. Changes to the setting data values take effect immediately.

### Toolholder with orientation capability

If a toolholder with orientation capability is active, the temperature compensation vector is rotated simultaneously to any change in orientation. This applies independently of any active orientation transformation.

If a toolholder with orientation capability is active in conjunction with a generic 5-axis transformation or a transformation with rotating linear axis, the temperature compensation vector is subjected to both rotations.

**Note**

While transformations with rotating linear axes take changes in the tool vector (length) into account, they **ignore** its change in orientation, which can be effected by a toolholder with orientation capability.

Temperature compensation values immediately follow any applied change in orientation. This applies in particular when an orientation transformation is activated or deactivated.

The same is true when the assignment between geometry axes and channel axes is changed. The temperature compensation value for an axis is reduced to zero (interpolatively), for example, when it ceases to be a geometry axis after a transformation change. Conversely, any temperature compensation value for an axis, which changes over to geometry axis status, is applied immediately.

**Examples**

**Temperature compensation in tool direction**

Example of a 5-axis machine with rotating tool, on which the tool can be rotated about the C and B axes.

In its initial state, the tool is parallel to the Z axis. If the B axis is rotated through 90 degrees, the tool points in the X direction.

Therefore, a temperature compensation value in the following setting data is also effective in the direction of the machine X axis if transformation is active:

SD42960 \$SC\_TOOL\_TEMP\_COMP[2] (Temperature compensation with reference to tools)

If the transformation is deactivated with the tool in this direction, the tool orientation is, by definition, parallel again to the Z axis and thus different to its actual orientation. The temperature offset in the X axis direction is therefore reduced to zero and reapplied simultaneously in the Z direction.

Example of a 5-axis machine with rotating tool (transformation type 24). The relevant machine data are listed below:

- The first rotary axis rotates about Z.C-axis
- The second rotary axis rotates about Y B-axis

The essential machine data are shown in the table below:

MD20390 TOOL_TEMP_COMP_ON = TRUE	; Temperature compensation active
Option	; Activate option
MD32750 TEMP_COMP_TYPE[ AX1 ] = 4	; Compensation in tool direction
MD32750 TEMP_COMP_TYPE[ AX2 ] = 4	; Compensation in tool direction
MD32750 TEMP_COMP_TYPE[ AX3 ] = 4	; Compensation in tool direction
	; Assignment of transformation type 24:
MD24100 TRAFO_TYPE_1 = 24	; Transformer type 24 in first channel
MD24110 TRAFO_AXES_IN_1[0] = 1	; First axis of the transformation
MD24110 TRAFO_AXES_IN_1[1] = 2	; Second axis of the transformation
MD24110 TRAFO_AXES_IN_1[2] = 3	; Third axis of the transformation

MD24110 TRAFO_AXES_IN_1[3] = 5	; Fifth axis of the transformation
MD24110 TRAFO_AXES_IN_1[4] = 4	; Fourth axis of the transformation
MD24120 TRAFO_GEOAX_ASSIGN_TAB_1[0] = 1	; Geo axis for channel axis 1
MD24120 TRAFO_GEOAX_ASSIGN_TAB_1[1] = 2	; Geo axis for channel axis 2
MD24120 TRAFO_GEOAX_ASSIGN_TAB_1[2] = 3	; Geo axis for channel axis 3
MD24570 TRAFO5_AXIS1_1[0] = 0.0	;
MD24570 TRAFO5_AXIS1_1[1] = 0.0	; Direction
MD24570 TRAFO5_AXIS1_1[2] = 1.0	; First rotary axis is parallel to Z
MD24572 TRAFO5_AXIS1_2[0] = 0.0	; Direction
MD24572 TRAFO5_AXIS1_2[1] = 1.0	; Second rotary axis is parallel to Y
MD24572 TRAFO5_AXIS1_2[2] = 0.0	;
MD25574 TRAFO5_BASE_ORIENT_1[0] = 0.0	;
MD25574 TRAFO5_BASE_ORIENT_1[1] = 0.0	; Basic tool orientation
MD25574 TRAFO5_BASE_ORIENT_1[2] = 1.0	; In Z direction

## NC program

### Temperature compensation values in the NC program

The compensation values assigned to axes X and Z are not zero and are applied for temperature compensation with respect to tool length. The machine axis positions reached in each case are specified as comments in the program lines.

```

SD42960 TOOL_TEMP_COMP[0] = -0.3           ; First compensation value
SD42960 TOOL_TEMP_COMP[1] = 0.0           ;
SD42960 TOOL_TEMP_COMP[2] = -1.0         ; Second compensation value

                                           ; Position setpoints of the
                                           ; machine axes

N10 g74 x0 y0 z0 a0 b0                     ; X Y Z
N20 x20 y20 z20 f10000                     ; 20.30 20.00 21.00
N30 traori()                               ; 20.30 20.00 21.00
N40 x10 y10 z10 b90                       ; 11.00 10.00 9.70
N50 trafoof                                ; 10.30 10.00 11.00
N60 x0 y0 z0 b0 c0                       ; 0.30 0.00 1.00
N70 m30

```

With the exception of block N40, temperature compensation always acts in the original directions, as the tool is pointing in the basic orientation direction. This applies particularly in block N50. The tool is actually still pointing in the direction of the X axis because the B axis is still at 90 degrees. However, because the transformation is already deactivated, the applied orientation is parallel to the Z axis again.

MD20390 TOOL_TEMP_COMP_ON = TRUE	; Temperature compensation active
Option	; Activate option
MD32750 TEMP_COMP_TYPE[ AX1 ] = 4	; Compensation in tool direction
MD32750 TEMP_COMP_TYPE[ AX2 ] = 4	; Compensation in tool direction
MD32750 TEMP_COMP_TYPE[ AX3 ] = 4	; Compensation in tool direction

For more details on "Temperature compensation" see:

**References:**

/FB2/ Function Manual, Extended Functions; Compensations (K3)

For information on "Generic 5-axis transformations" see:

**References:**

/FB3/ Function Manual, Special Functions; 3- to 5-Axis Transformation (F2)

## 17.11 Sum offsets and setup offsets

### 17.11.1 General

#### Sum offsets

Sum offsets can be treated as **programmable process compensations** during machining and are composed of all the error sizes (including the wear), which cause the workpiece to deviate from the specified dimensions.

Sum offsets are a generalized type of wear. They are part of the cutting edge data. The parameters of the sum offset refer to the geometrical data of a cutting edge.

The compensation data of a sum offset are addressed by a **DL number (DL: location-dependent; compensations with reference to the location of use)**.

In contrast, the wear values of a D number describe the physical wear of the cutting edge, i.e. in special situations, the sum offset can match the wear of the cutting edge.

Sum offsets are intended for general use, i.e. with active or inactive tool management or with the flat D number function.

Machine data are used to classify the sum offsets into:

- Sum offset fine
- Sum offset coarse (setup offset)

#### Setup offset

The setup offset is the compensation to be entered by the setup engineer before machining. These values are stored separately in the NCK. The operator subsequently only has access to the "sum offset fine" via HMI.

The "sum offset fine" and "sum offset coarse" are added internally in the NCK. This value is referred to below as the sum offset.

---

#### Note

The function is enabled via the machine data setting:

MD18080 \$MN\_MM\_TOOL\_MANAGEMENT\_MASK, Bit 8=1 (Gradual memory reservation for tool management).

---

If kinematic transformations (e.g. 5-axis transformations) are active, the tool length is calculated first after allowing for the various wear components. The total tool length is then used in the transformation. Unlike the case of a toolholder with orientation capability, the wear values are thus always included in the transformation irrespective of the G code of group 56.

## 17.11.2 Description of function

### Sum offsets

Several sum offsets (DL numbers) can be defined per D number. This allows you to determine, for example, **workpiece-location-dependent** compensation values and assign them to a cutting edge. Sum offsets have the same effect as wear, i.e. they are added to the compensation values of the D number. The data are permanently assigned to a D number.

### Attitudes

You can define the following settings in machine data:

- Activate sum offset
- Define maximum quantity of DL data sets to be created in NCK memory
- Define maximum quantity of DL numbers to be assigned to a D number
- Define whether the sum offsets (fine/coarse) are to be saved during data backup
- Define the sum offset to be activated, if:
  - A new cutting edge compensation is activated
  - An operator panel front **RESET** is performed
  - An operator panel front **START** is performed
  - The end of the program has been reached

The name is oriented to the logic of the corresponding machine data for tools and cutting edges.

The "setup offset" and "sum offset fine" can be read and written via system variables and corresponding OPI services.

---

#### Note

When tool management is active, a machine data can be used to define whether the sum offset of a tool activated during a programmed tool change remains unchanged or is set to zero.

---

#### Summary of compensation parameters \$TC\_DPx

The following general system variables were previously defined for describing a cutting edge:

\$TC_DP1	Tool type
\$TC_DP2	Length of cutting edge

### Parameters for geometry and wear

Tool geometry compensations are assigned to system variables \$TC\_DP3 to \$TC\_DP11. System variables \$TC\_DP12 to \$TC\_DP20 allow you to name a wear for each of these parameters.

Geometry	Wear	Length compensations
\$TC_DP3	\$TC_DP12	Length 1
\$TC_DP4	\$TC_DP13	Length 2
\$TC_DP5	\$TC_DP14	Length 3
Geometry	Wear	Radius compensation
\$TC_DP6	\$TC_DP15	Radius
\$TC_DP7	\$TC_DP16	Corner radius (tool type 700; slotting saw)
Geometry	Wear	Further compensations
\$TC_DP8	\$TC_DP17	Length 4 (tool type 700; slotting saw)
\$TC_DP9	\$TC_DP18	Length 5
\$TC_DP10	\$TC_DP19	Angle 1 (angle between face of tool and torus surface)
\$TC_DP11	\$TC_DP20	Angle 2 (angle between tool longitudinal axis and upper end of torus surface)

### Tool base dimension/adaptor dimension

\$TC_DP21	Adapter length 1
\$TC_DP22	Adapter length 2
\$TC_DP23	Adapter length 3

### Technology

System variable	Clearance angle
\$TC_DP24	<ul style="list-style-type: none"> <li>The clearance angle is stored here for ManualTurn; tool type 5xx. Same significance as in standard cycles for turning tools.</li> <li>The tip angle of the drill is stored here for ShopMill; tool type 2xx.</li> <li>Used in standard cycles for turning tools; tool type 5xx. This is the angle at the secondary cutting edge for these tools.</li> </ul>
\$TC_DP25	<ul style="list-style-type: none"> <li>The value for the cutting rate is stored here for ManualTurn.</li> <li>A bit-coded value for various states of tool types 1xx and 2xx is stored here for ShopMill.</li> </ul>

**Parameters of the sum and setup offsets (\$TC\_SCPxy-, \$TC\_ECPxy)**

The numbering of the parameters is oriented to the numbering of system variables \$TC\_DP3 to \$TC\_DP11.

The effect of the parameters is similar to the wear (additive to the tool geometry). Up to six sum/setup parameters can be defined per cutting edge parameter.

Tool geometry parameter, to which the compensation is added.	Sum/setup parameters, length compensations	Tool wear parameters
\$TC_DP3	Length 1 \$TC_SCP13, \$TC_SCP23,\$TC_SCP33, \$TC_SCP43,\$TC_SCP53,\$TC_SCP63 \$TC_ECP13, \$TC_ECP23,\$TC_ECP33, \$TC_ECP43,\$TC_ECP53,\$TC_ECP63 The numbers in bold, 1, 2, ... 6, designate the parameters of a maximum of six (location-dependent or similar) compensations that can be programmed with DL =1 to 6 for the parameter specified in column one.	\$TC_DP12
\$TC_DP4	Length 2 \$TC_SCP14, \$TC_SCP24,\$TC_SCP34, \$TC_SCP44,\$TC_SCP54,\$TC_SCP64 \$TC_ECP14, \$TC_ECP24,\$TC_ECP34, \$TC_ECP44,\$TC_ECP54,\$TC_ECP64	\$TC_DP13
\$TC_DP5	Length 3 etc.	\$TC_DP14
	<b>Radius compensation</b>	
\$TC_DP6	Radius	\$TC_DP15
\$TC_DP7	Corner radius	\$TC_DP16
	<b>Further compensations</b>	
\$TC_DP8	Length 4	\$TC_DP17
\$TC_DP9	Length 5	\$TC_DP18
\$TC_DP10	Angle 1, etc.	\$TC_DP19
\$TC_DP11	Angle 2 \$TC_SCP21, \$TC_SCP31,\$TC_SCP41, \$TC_SCP51,\$TC_SCP61,\$TC_SCP71 \$TC_ECP21, \$TC_ECP31,\$TC_ECP41, \$TC_ECP51,\$TC_ECP61,\$TC_ECP71 The numbers in bold, 2, 3, ... 7, designate the parameters of a maximum of six (location-dependent or similar) compensations that can be programmed with DL =1 to 6 for the parameter specified in column one.	\$TC_DP20

## Supplementary conditions

The maximum number of DL data sets of a cutting edge and the total number of sum offsets in the NCK are defined by machine data. The default value is zero, i.e. no sum offsets can be programmed.

Activate the "monitoring function" to monitor a tool for wear or for "sum offset".

The additional sum/setup data sets use additional buffered memory. 8 bytes are required per parameter.

A sum-offset data set requires: 8 bytes \* 9 parameters = 72 bytes

A setup data set requires an equal amount of memory. A certain number of bytes is also required for internal administration data.

### 17.11.3 Activation

#### Function

The function must be activated via the machine data:

MD18108 \$MN\_MM\_NUM\_SUMCORR (sum offsets in TO area).

System variables \$TC\_ECPx and \$TC\_SCPx and setup and sum offsets ("fine") defined via the OPI interface can be activated in the part program.

This is done by programming the language command `DL="number"`.

When a new D number is activated, either a new DL number is programmed, or the DL number defined via the following machine data becomes active:

MD20272 \$MC\_SUMCORR\_DEFAULT (basic setting of the additive offset without a program)

## DL programming

The sum offset is always programmed relative to the active D number with the command:

DL = "n"

The sum offset "n" is added to the wear of the active D number.

---

### Note

If you use "setup offset" and "sum offset fine", both compensations are combined and added to the tool wear.

---

The sum offset is deselected with the command:

DL = 0

---

### Note

DL0 is not allowed. If compensation is deselected (D0 and T0), the sum offset also becomes ineffective.

Programming a sum offset that does not exist triggers an alarm, similar to programming a D compensation that does not exist.

Thus, only the defined wear remains part of the compensation (defined in system variables \$TC\_DP12 to \$TC\_DP20).

Programming a sum offset when a D compensation is active (also applies to deselection) has the same effect on the path as programming a D command. An active radius compensation will, therefore, lose its reference to adjacent blocks.

---

## Configuration

**MD18112 \$MN\_MM\_KIND\_OF\_SUMCORR, bit 4=0: (Properties of sum offset in the TO area) default setting:**

Only **one** set of sum offsets exists per DL number.

We refer in general to the sum offset.

This describes the data represented by \$TC\_SCPx.

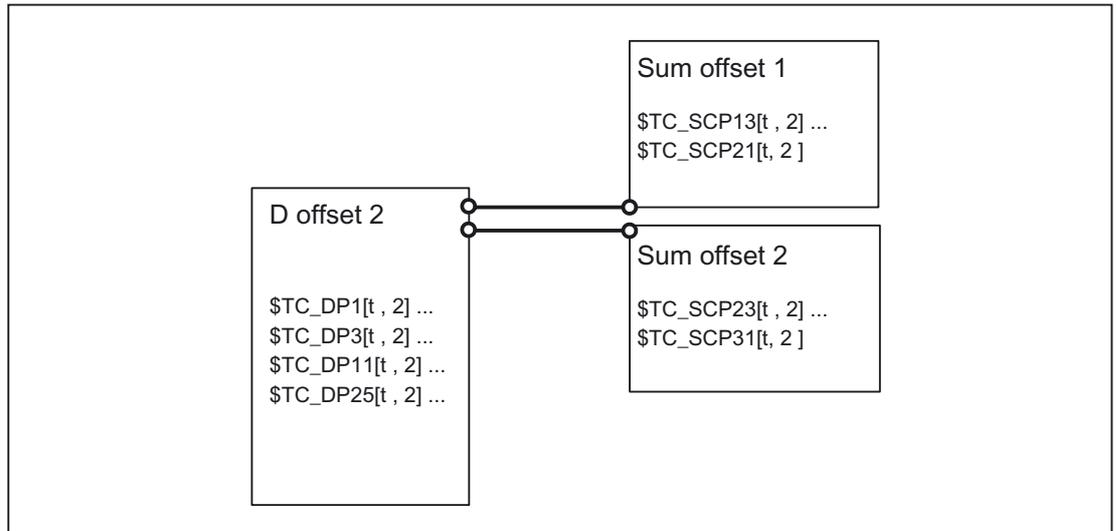


Figure 17-50 MD18112 \$MN\_MM\_KIND\_OF\_SUMCORR, bit 4 = 0

Tool T = t is active. With the data in the figure, the following is programmed:

```

D2                ; Cutting edge offsets, i.e. $TC_DP3 to $TC_DP11 + wear
                  ; ($TC_DP12 to $TC_DP20) + adapter dimension
...
DL=1              ; Sum offset 1 is added to the previous D2 compensations, i.e.
                  ; $TC_SCP13 to $TC_SCP21.
...
DL=2              ; Sum offset 2 is added to the D2 compensation instead of sum
                  ; offset 1, i.e. $TC_SCP23 to $TC_SCP31.
...
DL=0              ; Deselection of sum offset;
                  ; only the data of D2 remain active.
    
```

**MD18112 \$MN\_MM\_KIND\_OF\_SUMCORR, bit 4=1: Setup offsets are available**

The sum offset is now composed of the "sum offset fine" (represented by \$TC\_SCPx) and the setup offset (represented by \$TC\_ECPx). Two data sets therefore exist for one DL number. The sum offset is calculated by adding the corresponding components (\$TC\_ECPx + \$TC\_SCPx).

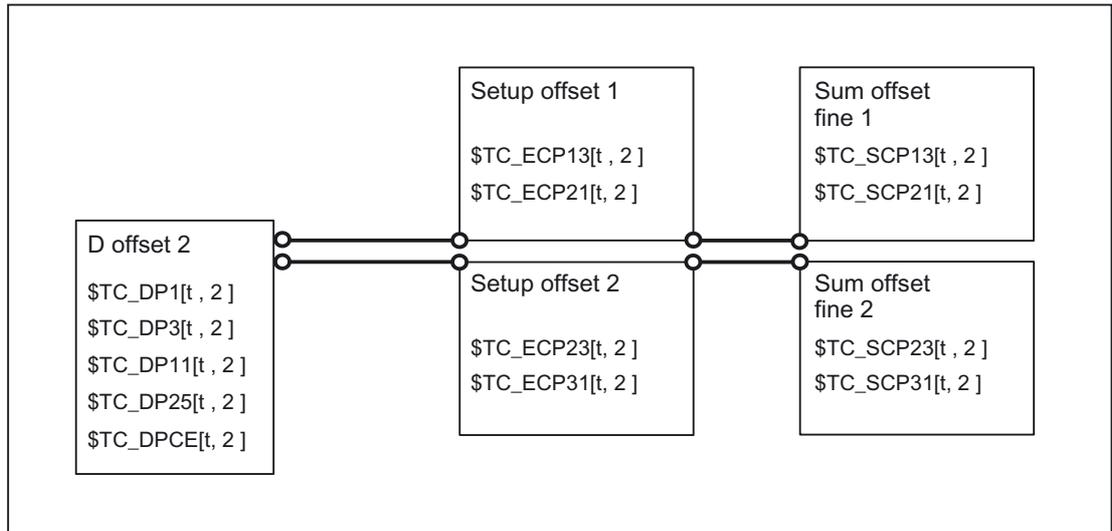


Figure 17-51 MD18112 \$MN\_MM\_KIND\_OF\_SUMCORR, bit 4 = 1 "setup offsets" + "sum offsets fine"

Tool T = t is active. With the data in the figure, the following is programmed:

```

D2           ; Cutting edge compensations, i.e. $TC_DP3 to $TC_DP11 + wear
              ($TC_DP12 to $TC_DP20) + adapter dimension
...
DL=1        ; Sum offset 1 is added to the previous D2 compensations, i.e.
              $TC_ECP13 + $TC_SCP13 to $TC_ECP21 + $TC_SCP21.
...
DL=2        ; Sum offset 2 is added to the D2 compensation instead of sum
              offset 1; i.e. $TC_ECP23 + $TC_SCP23,...$TC_ECP31 + $TC_SCP31
...
DL=0        ; Deselection of sum offset. Only the data of D2 remain active.
    
```

### Reading/writing in the part program

The individual sets of sum offset parameters are differentiated according to the number ranges of system variable \$TC\_SCP.

The significance of the individual variables is similar to geometry variables \$TC\_DP3 to \$TC\_DP11. Only length 1, length 2 and length 3 are enabled for the basic functionality (variables \$TC\_SCP13 to \$TC\_SCP15 for the first sum offset of the cutting edge).

```

R5 = $TC_SCP13[ t, d ]           ; Sets the value of the R parameter to the value
                                  of the first component of sum offset 1 for
                                  cutting edge (d)
                                  on tool (t).
R6 = $TC_SCP21[ t, d ]           ; Sets the value of the R parameter to the value
                                  of the last component of sum offset 1 for
                                  cutting edge (d) on tool (t).
    
```

```

R50 = $TC_SCP23[ t, d ]           ; Sets the value of the R parameter to the value
                                   of the first component of sum offset 2 for
                                   cutting edge (d) on tool (t).
$TC_SCP43[ t, d ] = 1.234         ; Sets the value of the first component of sum
                                   offset 4 for cutting edge (d) on tool (t) to the
                                   value 1.234.

```

The above statements also apply to the setup offsets (if the NCK is configured with this option), i.e.

```

R5 = $TC_ECP13[ t, d ]           ; Sets the value of the R parameter to the value
                                   of the first component of setup offset 1 for
                                   cutting edge (d) on tool (t).
R6 = $TC_ECP21[ t, d ]           ; Sets the value of the R parameter to the value
                                   of the last component of setup offset 1 for
                                   cutting edge (d) on tool (t).
Etc.

```

When working with setup offsets, "sum offsets fine" are written with the \$TC\_SCPx system variables.

### Creating a new sum offset

If the compensation data set (x) does not yet exist, it is created on the first write operation to one of its parameters (y).

```

$TC_SCPxy[ t, d ] = r.r          ; Parameter y of sum offset x is assigned the
                                   value "r.r.". The other parameters of x have a
                                   value of zero.

```

When working with setup offsets, "sum offsets fine" are written with the \$TC\_SCPx system variables.

---

#### Note

When working with setup offsets, the data set for the setup offset is created when a data set is created for "sum offset fine", if a data set did not already exist for [t, d].

---

### Creating a new setup offset

If the compensation data set (x) does not yet exist, it is created on the first write operation to one of its parameters (y).

```
$TC_ECPxy[ t, d ] = r.r           ; The value "r.r" is assigned to the parameter y
                                   of setup offset x. The other parameters of x
                                   have the value zero.
```

#### Note

When working with setup offsets, the data set for the "sum offset fine" is created when a data set is created for setup offsets, if a data set did not already exist for [t, d].

### DELDL - Delete sum offset

Sum offsets are generally only relevant when machining with a cutting edge at a certain time at a certain location of the workpiece. You can use the NC language command `DELDL` to delete sum offsets from cutting edges (in order to release memory).

```
status = DELDL( t, d )           ; Deletes all sum offsets for cutting edge d on tool
                                   t.
                                   ; t, d are optional parameters.
```

If d is not specified, all sum offsets of all cutting edges of tool t are deleted.

If d and t are not specified, all sum offsets for the cutting edges on all tools of the TO unit are deleted (for the channel, in which the command is programmed).

When working with setup offsets, the `DELDL` command deletes both the setup offset and the "sum offsets fine" of the specified cutting edge(s).

#### Note

The memory used for the data sets is released after deletion.

The deleted sum offsets can subsequently no longer be activated or programmed.

Sum offsets and setup offsets on active tools cannot be deleted (similar to the deletion of D compensations or tool data).

The "status" return value indicates the result of the deletion command:

0:	Deletion was successful
-1:	Deletion was not (one cutting edge) or not completely (several cutting edges) successful

## Data backup

The data are saved during a general tool-data backup (as a component of the D number data sets).

It is advisable to save the sum offsets, in order to allow the current status to be restored in the event of an acute problem. Machine data settings can be made to exclude sum offsets from a data backup (settings can be made separately for "setup offsets" and "sum offsets fine").

---

### Note

Sum offsets behave in the same way as D compensations with reference to block search and REPOS. The behavior on Reset and PowerOn can be defined by machine data.

If the setting of the following machine data indicates that the last active tool compensation number (D) is to be activated after PowerOn, the last active DL number is then no longer active:

MD20110 \$MC\_RESET\_MODE\_MASK (definition of initial control system settings after RESET/TP end)

---

## 17.11.4 Examples

### Example 1

That no compensation and no sum offset will come into effect must be defined during tool change via the machine data:

- MD20270 \$MC\_CUTTING\_EDGE\_DEFAULT=0 (Basic setting of tool cutting edge without programming)
- MD20272 \$MC\_SUMCORR\_DEFAULT=0 (default setting sum offset without program).

```
T5 M06           ; Tool number 5 is loaded - no compensation active.
D1 DL=3         ; Compensation D1 + sum offset 3 of D1 are activated.
X10
DL=2           ; Compensation D1 + sum offset 2 are activated.
X20
DL=0           ; Sum offset deselection, only compensation D1 is now active.
D2            ; Compensation D2 is activated - the sum offset is not included
              ; in the compensation.
X1
DL=1           ; Compensation D2 + sum offset 1 are activated.
X2
D0            ; Compensation deselection
X3
DL=2           ; No effect - DL2 of D0 is zero (same as programming T0 D2).
```

**Example 2**

During tool change it has to be defined that offset D2 and sum offset DL=1 are activated via the machine data:

MD20270 \$MC\_CUTTING\_EDGE\_DEFAULT=2 (Basic setting of tool cutting edge without programming)

MD20272 \$MC\_SUMCORR\_DEFAULT=1 (default setting sum offset without program)

```
T5 M06           ; Tool number 5 is loaded - D2 + DL=1 are active (= values of
                  ; machine data)
D1 DL=3         ; Compensation D1 + sum offset 3 of D1 are activated.
X10
DL=2           ; Compensation D1 + sum offset 2 are activated.
X20
DL=0           ; Sum offset deselection, only compensation D1 is now active.
D2             ; Compensation D2 is activated - sum offset DL=1 is activated.
X1
DL=2           ; Compensation D2 + sum offset 2 are activated.
D1             ; Compensation D1 + sum offset 1 are activated.
```

**17.11.5 Upgrades for Tool Length Determination****17.11.5.1 Taking the compensation values into account location-specifically and workpiece-specifically****Composition of the effective tool length**

For a tool compensation without active kinematic transformation, the effective tool length consists of up to 8 vectors:

- Tool length (geometry) (\$TC\_DP3 - \$TC\_DP5)
- Wear (\$TC\_DP12 - \$TC\_DP14)
- Tool base dimension (see note) (\$TC\_DP21 - \$TC\_DP23)
- Adapter dimension (see note) (\$TC\_ADPT1 - \$TC\_ADPT3)
- Total offsets fine (\$TC\_SCPx3 - \$TC\_SCPx5)
- Sum offsets coarse or setup offsets (\$TC\_ECPx3 - \$TC\_ECPx5)
- Offset vector I<sub>1</sub> of toolholder with orientation capability (\$TC\_CARR1 - \$TC\_CARR3)
- Offset vector I<sub>2</sub> of toolholder with orientation capability (\$TC\_CARR4 - \$TC\_CARR6)
- Offset vector I<sub>3</sub> of toolholder with orientation capability (\$TC\_CARR15 - \$TC\_CARR17)

**Note**

The tool base dimension and adapter dimension can only be applied as alternatives.

**Type of action of the individual vectors**

The type of action of the individual vectors or groups of vectors depends on the following further quantities:

Influencing quantity	Operating principle
G codes	Active processing level
Tool type	Milling tool or turning/grinding tools
Machine data	Tool management active/not active, toolholder with orientation capability available/not available
Setting data	Behavior of tool length components when mirroring or when changing the plane
Toolholder with orientation capability	Set values of toolholder with orientation capability
Adapter transformations	Transformed tool compensation values

**Distribution over the geometry-axis components**

How the three vector components of partial totals of the vectors involved are distributed over the three geometry-axis components is determined by the following quantities:

Influencing quantity	dependencies
Active processing level: G17 X/Y direction G18 Z/X direction G19 Y/Z direction	Infeed plane: Z Y X
Tool type: Milling tools, drilling tools, grinding tools, turning tools	See: Section "Tool type", Table "Minimum number of required tool parameters"
SD42900 \$SC_MIRROR_TOOL_LENGTH SD42910 \$SC_MIRROR_TOOL_WEAR SD42920 \$SC_WEAR_SIGN_CUTPOS SD42930 \$SC_WEAR_SIGN SD42940 \$SC_TOOL_LENGTH_CONST SD42950 \$SC_TOOL_LENGTH_TYPE	See: Sections "Special handling of tool compensations" and "Setting data".
Adapter transformations	See: "FB Tool management"

The resulting tool orientation always remains parallel to one of the three axis directions X, Y or Z and exclusively depends on the active machining plane G17-G19, since it has not yet been possible to assign the tool an orientation.

**Stepless variation of the tool orientation**

The toolholder with orientation capability also enables the tool orientation to be varied steplessly, in addition to providing further offsets or linear expansion fluctuations with the aid of offset vectors  $I_1 - I_3$ .

For more information, see:

**References:**

/FB1/ Function Manual, Basic Functions; Tool Offset (W1),  
Section: Toolholder with orientation capability

**Minor operator compensations**

Minor compensations, however, must also be modified during the normal production mode.

The reasons for this are e.g.:

- Tool wear
- Clamping errors
- Temperature sensitivity of the machine:

These compensations are defined as follows:

Definition	Wear components
Wear	\$TC_DP12 - \$TC_DP14,
Total offsets fine	\$TC_SCPx3 - \$TC_SCPx5,
Sum offsets coarse or setup offsets	\$TC_ECPx3 - \$TC_ECPx5

In particular, compensations, which affect the tool length calculation, should be entered in the coordinates used for measurement.

These workpiece-specific compensations can be achieved more simply using the G-code group 56 with the three values `TOWSTD`, `TOWMCS` and `TOWWCS` and the setting data:

SD42935 \$SC\_WEAR\_TRANSFORM (transformation of tool components)

## SD42935

Which of the wear components:

- Wear (\$TC\_DP12 - \$TC\_DP14)
- Setup offsets or sum offsets coarse (\$TC\_ECPx3 - \$TC\_ECPx5)
- Sum offsets fine (\$TC\_SCPx3 - \$TC\_SCPx5)

are to be transformed in the transformations:

- Adapter transformation
- Toolholder with orientation capability

are to be or not to be transformed, can be defined via the setting data:

SD42935 \$SC\_WEAR\_TRANSFORM (transformation of wear values)

With the setting data in its initial state, all wear values are transformed.

The setting data is considered in the following functions:

- Wear values in the machine coordinate system  
Part program instruction: TOWMCS
- Wear values in the workpiece coordinate system  
Part program instruction: TOWWCS

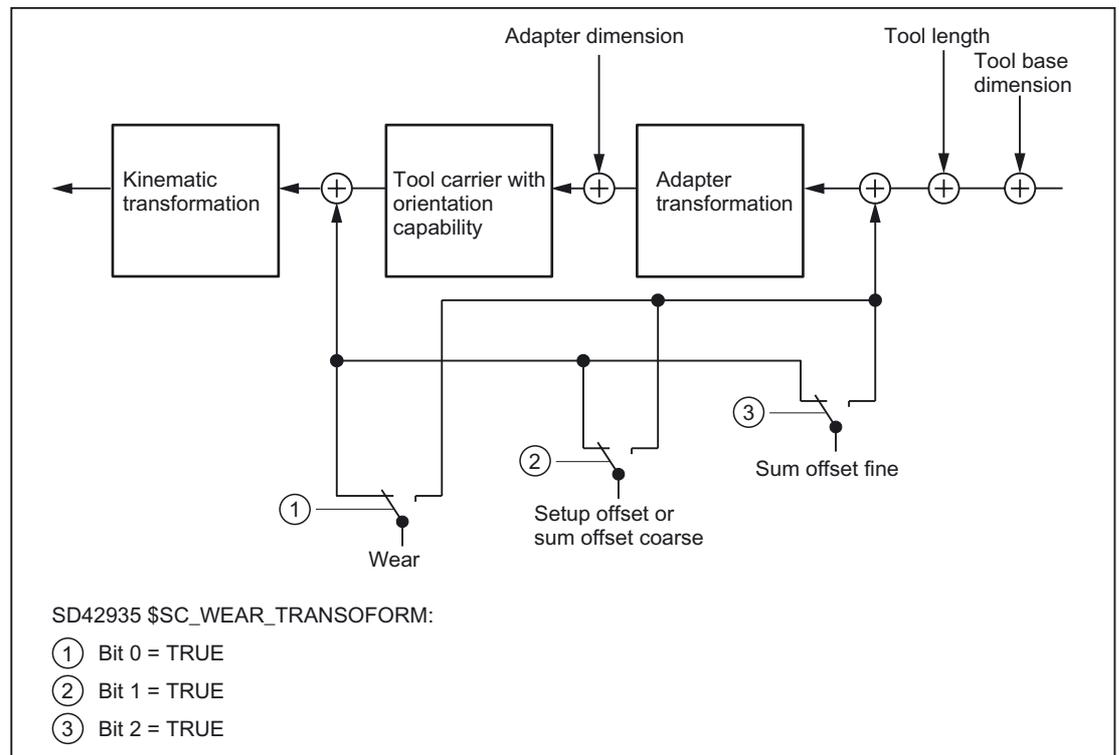


Figure 17-52 Transformation of wear data dependent on SD42935

**Programming**

G-code group 56 can be used to define the following values:

Syntax	Corrections
TOWSTD	Initial setting value for offsets in tool length
TOWMCS	Wear data in the machine coordinate system (MCS)
TOWWCS	Wear values in workpiece coordinate system (WCS)
TOWBCS	Wear values in basic coordinate system (BCS)
TOWTCS	Wear values in the TCS (Tool Coordinate System) at the toolholder (tool carrier reference point T)
TOWKCS	Wear values in tool coordinate system for kinematic transformation (KCS) of tool head

**Coordinate systems for offsets in tool length**

G codes TOWMCS, TOWWCS, TOWBCS, TOWTCS and TOWKCS can be used, e.g. to measure the wear tool length component in five different coordinate systems.

- |   |     |
|---|-----|
| 1. Machine coordinate system                          | MCS |
| 1. Basic Coordinate System                            | BCS |
| 1. Workpiece coordinate system                        | WCS |
| 1. Tool coordinate system of kinematic transformation | KCS |
| 1. Tool coordinate system                             | TCS |

The calculated tool length or a tool length component can be represented and read out in one of these coordinate systems using the GETTCOR function (predefined subprogram).

**References:**

/FB1/ Function Manual, Basic Functions; Tool Offset (W1),  
Section: Read tool lengths, tool length components



This would be the case when:

- no kinematic transformation is active
- or orientation transformations (3-axis, 4-axis and 5-axis transformations) are active.

## TOWWCS

Wear values in WCS (workpiece coordinate system):

- If a toolholder with orientation capability is active, the tool vector is calculated as for `TOWMCS`, without taking the wear into account.
- The wear data are interpreted in the workpiece coordinate system.

The wear vector in the workpiece coordinate system is converted to the machine coordinate system and added to the tool vector.

## TOWBCS

Wear values in BCS (basic coordinate system):

- If a toolholder with orientation capability is active, the tool vector is calculated as for `TOWMCS`, without taking the wear into account.
- The wear data are interpreted in the workpiece coordinate system.

The wear vector in the basic coordinate system is converted to the workpiece coordinate system and added to the tool vector.

### Nonlinear transformation

If a nonlinear transformation is active, e.g. with `TRANSMIT`, and the MCS is specified as the desired coordinate system, the BCS is automatically used instead of the MCS.

### Toolholder with orientation capability

A table component of the toolholder with orientation capability, if available, is not applied directly to the coordinate systems, unlike a table (or part) component of the kinematic transformation. A rotation described by such a component is represented in a basic frame or system frame and is thus included in the transition from WCS to BCS.

### Kinematic transformation

The table (or part) component of the kinematic transformation is described by the transition from BCS to MCS.

## TOWTCS

Wear values in TCS (tool coordinate system):

- If a toolholder with orientation capability is active, the tool vector is calculated as for TOWMCS, without taking the wear into account.
- The wear data are interpreted in the tool coordinate system.

The wear vector in the TCS (Tool Coordinate System) is converted to the machine coordinate system by way of the tool coordinate system of the kinematic transformation (KCS) and added to the tool vector.

## TOWKCS

The wear value specifications for the kinematic transformation are interpreted in the associated TCS (Tool Coordinate System).

The wear vector is converted to the machine coordinate system by way of the tool coordinate system of the kinematic transformation and added to the tool vector.

## G code change when a tool is active

Changing the G code in the group TOWSTD, TOWMCS, TOWWCS, TOWBCS, TOWTCS, and TOWKCS does not affect an already active tool, and does not become effective until the next tool is selected.

A new G code of this group will also come into effect if it is programmed in the same block, in which a tool is selected.

## Evaluation of individual wear components

Evaluation of individual wear components (assignment to geometry axes, sign evaluation) is influenced by:

- The active plane
- The adapter transformation
- The five setting data shown in the table below:

Setting Data	Wear components		
	TOWSTD	TOWMCS	TOWWCS
SD42910 \$SC_MIRROR_TOOL_WEAR			
SD42920 \$SC_WEAR_SIGN_CUTPOS	X	X	—
SD42930 \$SC_WEAR_SIGN	X	—	—
SD42940 \$SC_TOOL_LENGTH_CONST	X	X	X
SD42950 \$SC_TOOL_LENGTH_TYPE	X	X	X

### Note

Wear components, which are subjected to an active rotation by an adapter transformation or a toolholder with orientation capability, are referred to as non-transformed wear components.

### Special points to be noted

If `TOWMCS` or `TOWWCS` is active, the following setting data does not affect the non-transformed wear components:

SD42920 `$SC_WEAR_SIGN_CUTPOS` (Sign of wear for tools with cutting edge systems)

The following setting data also does not affect the non-transformed wear components in case of `TOWWCS`:

SD42910 `$SC_MIRROR_TOOL_WEAR` (Sign change tool wear when mirroring)

In this case, a possibly active mirroring is already contained in the frame, which is referred to for evaluating the wear components.

On a plane change, the assignment between the non-transformed wear components and the geometry axes is retained, i.e. these are not interchanged as with other length components. The assignment of components depends on the active plane for tool selection.

### Example

Let's assume a milling tool is used where only the wear value `$TC_DP12` assigned to length L1 is not equal to zero.

If `G17` is active, this length is effective in the direction of the Z axis.

This measure always acts in the Z-direction also upon a plane change after the tool selection, when `TOWMCS` or `TOWWCS` are active and the bit 1 is set in the setting data:

SD42935 `$SC_WEAR_TRANSFORM` (transformations for tool components)

If, for example, `G18` is active on tool selection, the component is always effective in the Y direction instead.

## 17.12 Working with tool environments

### 17.12.1 General

#### Functions

The current states of tool data can be processed using the functions below, which are generally available:

- Save
- Deletion
- Read
- Modify

A further function can be used to determine information about the assignment of the tool lengths of the active tool to the abscissa, ordinate and applicate.

### 17.12.2 Saving with TOOLENV

#### Scope of a tool environment

The `TOOLENV` memory function is used to save any current states needed for the evaluation of tool data stored in the memory.

The individual data are as follows:

- The active G code of group 6 (`G17`, `G18`, `G19`)
- The active G code of group 56 (`TOWSTD`, `TOWMCS`, `TOWWCS`, `TOWBCS`, `TOWTCS`, `TOWKCS`)
- The active transverse axis
- Machine data:  
MD18112 `$MN_MM_KIND_OF_SUMCORR` (Properties of sum offsets in the TO area)
- Machine data:  
MD20360 `$MC_TOOL_PARAMETER_DEF_MASK` (definition of tool parameters).
- Setting data:  
SD42900 `$SC_MIRROR_TOOL_LENGTH` (Sign change tool length when mirroring)
- Setting data:  
SD42910 `$SC_MIRROR_TOOL_WEAR` (Sign change tool wear when mirroring)

- Setting data:  
SD42920 \$SC\_WEAR\_SIGN\_CUTPOS (Sign of wear for tools with cutting edge systems)
- Setting data:  
SD42930 \$SC\_WEAR\_SIGN (sign of wear)
- Setting data:  
SD42935 \$SC\_WEAR\_TRANSFORM (transformations for tool components)
- Setting data:  
SD42940 \$SC\_LENGTH\_CONST (change of tool components on change of planes)
- Setting data:  
SD42950 \$SC\_TOOL\_LENGTH\_TYPE (allocation of the tool length components independent of tool type)
- The orientation component of the current complete frame (rotation and mirroring, no work offsets or scales)
- The orientation component and the resulting length of the active toolholder with orientation capability
- The orientation component and the resulting length of an active transformation
- In addition to the data describing the environment of the tool, the T number, D number and DL number of the active tool are also stored, so that the tool can be accessed later in the same environment as the `TOOLENV` call, without having to name the tool again.

### Not in the tool environment

The value of the machine data determines whether the adapter length or the tool base dimension is included in the tool length calculation:

MD18104 \$MN\_MM\_NUM\_TOOL\_ADAPTER (tool adapter in TO area).

Since a change to this machine data only takes effect after Power On, it is not saved in the tool environment.

---

### Note

Resulting length of **toolholders with orientation capability** and **transformations**:

Both toolholders with orientation capability and transformations can use system variables or machine data, which act as additional tool length components, and which can be subjected partially or completely to the rotations performed. The resulting additional tool length components must also be stored when `TOOLENV` is called, because they represent part of the environment, in which the tool is used.

---

**Adapter transformation:**

The adapter transformation is a property of the tool adapter and thus of the complete tool. It is, therefore, not part of a tool environment, which can be applied to another tool.

By saving the complete data necessary to determine the overall tool length, it is possible to calculate the effective length of the tool at a later point in time, even if the tool is no longer active or if the conditions of the environment (e.g. G codes or setting data) have changed. Similarly, the effective length of different tool can be calculated assuming that it would be used under the same conditions as the tool, for which the status was saved.

**TOOLENV function**

Saving a tool environment

The `TOOLENV` function is a predefined subprogram. It must, therefore, be programmed in a separate block.

*Syntax:*

**Status = TOOLENV(\_NAME)**

*Value/parameter:*

**Status**                    INT

- 0:**    Function OK
- 1:**    No memory reserved for tool environments:  
MD18116 \$MN\_MM\_NUM\_TOOL\_ENV = 0 (number of tool environments in TO area).  
i.e. the "tool environments" functionality is not available.
- 2:**    No more free memory locations for tool environments available.
- 3:**    Null string illegal as name of a tool environment.
- 4:**    No parameter (name) specified.

**\_NAME**                    STRING

Name, under which the current data set is stored.

If a data set of the same name already exists, it is overwritten. In this case, the status is 0.

### 17.12.3 Delete tool environment

#### DELTOOLENV function

This function can be used to delete sets of data used to describe tool environments. Deletion means that the set of data stored under a particular name can no longer be accessed (an access attempt triggers an alarm).

The DELTOOLENV function is a predefined subprogram.

It must, therefore, be programmed in a separate block.

*Syntax:*

There are two call formats:

**Status = DELTOOLENV()**

**Status = DELTOOLENV(\_NAME)**

*Value/parameter:*

**Status** INT

0: Function OK

-1: No memory reserved for tool environments:

MD18116 \$MN\_MM\_NUM\_TOOL\_ENV = 0 (number of tool environments in TO area).

i.e. the "tool environments" functionality is not available.

-2: A tool environment with the specified name does not exist.

**\_NAME** STRING

Name of data set to be deleted

The first call format deletes all data sets.

The second call format deletes the data set with the specified name.

Data sets can only be deleted using the DELTOOLENV command, by an INITIAL.INI download or by a cold start (NCK powerup with default machine data). There are no further automatic deletion operations (e.g. on RESET).



## 17.12.5 Read T, D, DL from a tool environment

### GETTENV function

The `GETTENV` function is used to read the T, D and DL numbers stored in a tool environment.

The `GETTENV` function is a predefined subprogram. It must, therefore, be programmed in a separate block.

*Syntax:*

**Status** = `GETTENV`(**\_NAME**, **\_TDDL**)

*Value/parameter:*

**Status**                    `INT`

- 0:    Function OK
- 1:    No memory reserved for tool environments:  
      MD18116 \$MN\_MM\_NUM\_TOOL\_ENV = 0 (number of tool environments in TO area).  
      i.e. the "tool environments" functionality is not available.
- 2:    A tool environment with the name specified in **\_NAME** does not exist.

**\_NAME**                    `STRING`

Name of the tool environment, from which the T, D and DL numbers can be read

**\_TDDL[3]**                `INT`

This integer array contains:

- in "**\_TDDL[0]**" the T number of the tool,
- in "**\_TDDL[1]**" the D number of the tool,
- in "**\_TDDL[2]**" the DL number of the tool,

whose tool environment in the data set is stored with the name "**\_NAME**".

It is possible to omit the first parameter in the `GETTENV` function call (e.g. `GETTENV`(, **\_TDDL**)) or to pass a null string as the first parameter (e.g. `GETTENV`("", **\_TDDL**)). In both of these two special cases, the T, D and DL numbers of the **active** tool are returned in **\_TDDL**.

## 17.12.6 Read tool lengths, tool length components

### GETTCOR function

The `GETTCOR` function is used to read out tool lengths or tool length components.

The parameters can be used to specify, which components are considered, and the conditions, under which the tool is used.

The `GETTCOR` function is a predefined subprogram. It must, therefore, be programmed in a separate block.

#### Syntax:

**Status = GETTCOR(\_LEN, \_COMP, \_STAT, \_T, \_D, \_DL)**

All parameters can be omitted with the exception of the first parameter (`_LEN`).

#### Value/parameter:

**Status**                    INT

- 0:    Function OK
- 1:    No memory reserved for tool environments:  
MD18116 \$MN\_MM\_NUM\_TOOL\_ENV = 0 (number of tool environments in TO area).  
i.e. the "tool environments" functionality is not available.
- 2:    A tool environment with the name specified in `_STAT` does not exist.
- 3:    Invalid string in parameter `_COMP`.  
Causes of this error can be invalid characters or characters programmed twice.
- 4:    Invalid T number
- 5:    Invalid D number
- 6:    Invalid DL number
- 7:    Attempt to access non-existent memory module
- 8:    Attempt to access a non-existent option (programmable tool orientation, tool management).
- 9:    The `_COMP` string contains a colon (identifier for the specification of a coordinate system), but it is not followed by a valid character denoting the coordinate system.

**\_LEN[11]**                    REAL

Result vector

The vector components are arranged in the following order:

Tool type	(LEN[0])
Length of cutting edge	(LEN[1])

Abscissa	(LEN[2])
Ordinate	(LEN[3])
Applicate	(LEN[4])
Tool radius	(LEN[5])

The coordinate system defined in **\_COMP** and **\_STAT** is used as the reference coordinate system for the length components. If no coordinate system is defined in **\_COMP**, the tool lengths are represented in the machine coordinate system.

The assignment of the abscissa, ordinate and applicate to the geometry axes depends on the active plane in the tool environment, i.e. with G17, the abscissa is parallel to X, with G18 it is parallel to Z, etc.

Components **LEN[6]** to **LEN[10]** contain the additional parameters, which can be used to specify the geometry description of a tool (e.g. \$TC\_DP7 to \$TC\_DP11 for the geometry and the corresponding components for wear or sum and setup offsets).

These 5 additional elements and the tool radius are only defined for components E, G, S, and W. Their evaluation does not depend on **\_STAT**. The corresponding values in **LEN[5]** to **LEN[10]** can thus only be not equal to zero if at least one of the four specified components is involved in the tool length calculation. The remaining components do not influence the result. The dimensions refer to the control's basic system (inch or metric).

#### **\_COMP**                      STRING

This string consists of two substrings, which are separated from one another by a **colon**.

The individual characters (letters) of the **first substring** identify the tool length components to be taken into account when calculating the tool length.

The **second substring** identifies the coordinate system, in which the tool length is to be output. It consists of only one single relevant character.

The order of the characters in the strings, and their notation (upper or lower case), is arbitrary. Any number of blanks or white spaces can be inserted between the characters.

The letters in the substrings **cannot** be programmed twice. The meanings in the **first substring** are as follows:

- : (Minus symbol, only allowed as first character): The complete tool length is calculated, minus the components specified in the next string.
- C: Adapter or tool base dimension (whichever of the two alternative components is active for the tool in use)
- E: Setup offsets
- G: Geometry
- K: Kinematic transformation (is only evaluated for generic 3, 4 and 5-axis transformation)
- S: Sum offsets

**T:** Toolholder with orientation capability

**W:** Wear

If the first substring is empty (except for white spaces), the complete tool length is calculated allowing for all components. This applies even if the **\_COMP** parameter is not specified.

An optional programmable colon must be followed by a single character specifying the coordinate system, in which the tool length components are to be evaluated. If no coordinate system is specified, the evaluation is performed in the MCS (machine coordinate system). If any rotations are to be taken into account, they are specified in the tool environment defined in **\_STAT**.

The characters have the following significance:

**B:** Basic coordinate system (BCS)

**K:** Tool coordinate system of kinematic transformation (KCS)

**M:** Machine coordinate system (MCS)

**T:** Tool coordinate system (TCS)

**W:** Workpiece coordinate system (WCS)

**\_STAT**                    STRING

Name of the data set for describing a tool environment.

If the value of this parameter is the null string ("") or is not specified, the current status is used.

**\_T**                        INT

Internal T number of tool

If this parameter is not specified, or if its value is 0, the tool stored in **\_STAT** is used.

If the value of this parameter is -1, the T number of the active tool is used. It is also possible to specify the number of the active tool explicitly.

---

### Note

If **\_STAT** is not specified, the current status is used as the tool environment. Since **\_T = 0** refers to the T number saved in the tool environment, the active tool is used in that environment, i.e. parameters **\_T = 0** and **\_T = -1** have the same meaning in this special case.

---

**\_D** INT

Cutting edge of the tool. If this parameter is not specified, or if its value is 0, the D number used is based on the source of the T number. If the T number from the tool environment is used, the D number of the tool environment is also read, otherwise the D number of the currently active tool is read.

**\_DL** INT

Number of the local compensation. If this parameter is not specified, the DL number used is based on the source of the T number. If the T number from the tool environment is used, the D number of the tool environment is also read, otherwise the D number of the currently active tool is read.

Any rotations and component exchanges initiated by the adapter transformation, toolholder with orientation capability and kinematic transformation, are part of the tool environment. They are thus always performed, even if the corresponding length component is not supposed to be included. If this is undesirable, tool environments must be defined, in which the corresponding transformations are not active. In many cases (i.e. any time a transformation or toolholder with orientation capability is not used on a machine), the data sets stored for the tool environments automatically fulfill these conditions, with the result that the user does not need to make special provision.

### MD20360 \$MC\_TOOL\_PARAMETER\_DEF\_MASK

The two least significant bits of this machine data specify how the wear (bit 0) and tool length (bit 1) are to be evaluated if a diameter axis is used for turning and grinding tools.

If the bits are set, the associated entry is weighted with the factor 0.5. This weighting is reflected in the tool length returned by `GETTCOR`.

**Example:**

MD20360 \$MC\_TOOL\_PARAMETER\_DEF\_MASK = 3 (definition of tool parameters).

MD20100 \$MC\_DIAMETER\_AX\_DEF="X" (Geometry axis with face axis function)

X is diameter axis (standard turning machine configuration):

```

N30      $TC_DP1[1.1] =      500
N40      $TC_DP2[1.1] =        2
N50      $TC_DP3[1.1] =      3.0      ; Geometry L1
N60      $TC_DP4[1,1]=      4.0
N70      $TC_DP5[1,1]=      5.0
N80      $TC_DP12[1,1]=     12.0      ; Wear L1
N90      $TC_DP13[1,1]=     13.0
N100     $TC_DP14[1,1]=     14.0
N110     t1 d1 g18
N120     r1 = GETTCOR(_LEN, "GW")
    
```

```

N130      r3 = _LEN[2]                ; 17.0 (= 4.0 + 13.0)
N140      r4 = _LEN[3]                ; 7.5 (= 0.5 * 3.0 + 0.5 * 12.0)
N150      r5 = _LEN[4]                ; 19.0 (= 5.0 + 14.0)
N160      m30

```

### Kinematic transformation, toolholder with orientation capability

If a toolholder with orientation capability is taken account of during the tool length calculation, the following vectors are included in that calculation:

Type	Vectors
<b>M</b>	$l_1$ and $l_2$
<b>T</b>	$l_1$ , $l_2$ and $l_3$
<b>P</b>	Tool length is not influenced by the toolholder with orientation capability.

In generic **5-axis transformation**, the following machine data are included in the tool length calculation for transformer types 24 and 56:

Transformer type	Machine data
<b>24</b>	MD24550/24650 \$MC_TRAFO5_BASE_TOOL_1/2 MD24560/24660 \$MC_TRAFO5_JOINT_OFFSET_1/2 MD24558/24658 \$MC_TRAFO5_PART_OFFSET_1/2
<b>56</b>	MD24550/24650 \$MC_TRAFO5_BASE_TOOL_1/2 MD24560/24660 \$MC_TRAFO5_JOINT_OFFSET_1/2

Transformation type 56 corresponds to type M for a toolholder with orientation capability.

With this 5-axis transformation in the software versions used up to now, the following vector is equivalent to the sum of the two vectors  $l_1$  and  $l_3$  for a toolholder with orientation capability type M.

MD24560/24660 \$MC\_TRAFO5\_JOINT\_OFFSET\_1/2 (vector of kinematic offset of the first/second 5-axis transformation in the channel)

Only the sum is relevant for the transformation in both cases. The way, in which the two individual components are composed, is insignificant. When calculating the tool length, however, it is relevant which component is assigned to the tool and which is assigned to the tool table.

This explains the introduction of new machine data:

MD24558/24658 \$MC\_TRAFO5\_JOINT\_OFFSET\_PART\_1/2 (vector kinematic offset in table).

It is equivalent to the vector  $l_3$ .

The following machine data no longer corresponds to the sum of  $l_1$  and  $l_3$ , but only to vector  $l_1$ .

MD24560/24660 \$MC\_TRAFO5\_JOINT\_OFFSET\_1/2 (vector of kinematic offset of the first 5-axis transf. in the channel).

The new response is identical to the current response, if the following machine data equals zero:

MD24558/24658 \$MC\_TRAFO5\_JOINT\_OFFSET\_PART\_1/2 (vector kinematic offset in table).

### GETTCOR examples

GETTCOR(_LEN):	Calculates the tool length of the currently active tool in the machine coordinate system allowing for all components.
GETTCOR(_LEN; "CGW : W" ):	Calculates the tool length for the active tool, consisting of the adapter or tool base dimension, geometry and wear. Further components, such as toolholder with orientation capability or kinematic transformation, are not considered. The workpiece coordinate system is used for the output.
GETTCOR(_LEN, "-K :B" ):	Calculates the complete tool length of the active tool without allowing for the length components of an active kinematic transformation. Output in the basic coordinate system.
GETTCOR(_LEN, ":M", "Testenv1",,3):	Calculates the complete tool length in the machine coordinate system for the tool stored in the tool environment named "Testenv1". The calculation is performed for cutting edge number D3, regardless of the cutting edge number stored.

### Compatibility

The GETTCOR function is used in conjunction with the TOOLENV and SETTCOR functions to replace parts of the functionality, which were previously implemented externally in the measuring cycles.

Only some of the parameters, which actually determine the effective tool length, were implemented in the measuring cycles. The above functions can be configured to reproduce the behavior of the measuring cycles in relation to the tool length calculation.

## 17.13 Tool lengths L1, L2, L3 assignment: LENTOAX

### LENTOAX function

The "LENTOAX" function provides information about the assignment of tool lengths  $L_1$ ,  $L_2$  and  $L_3$  of the **active** tool to the abscissa, ordinate and applicate. The assignment of abscissa, ordinate and applicate to the geometry axes is affected by frames and the active plane (G17 - G19).

Only the geometry component of a tool (\$TC\_DP3[x,y] to \$TC\_DP5[x,y]) is considered, i.e. a different axis assignment for other components (e.g. wear) has no effect on the result.

The "LENTOAX" function is a predefined subprogram. It must, therefore, be programmed in a separate block.

#### Syntax:

**Status = LENTOAX(\_AXIND, \_MATRIX, \_COORD)**

The first two parameters must always be programmed; the last parameter can be omitted.

#### Value/parameter:

<b>Status</b>	INT
0:	Function OK, information in <b>_AXIND</b> sufficient for description (all tool length components are parallel to the geometry axes).
1:	Function is OK, however, the content of <b>_MATRIX</b> must be evaluated for a correct description (the tool length components are not parallel to the geometry axes).
-1:	Invalid string in parameter <b>_COORD</b> .
-2:	No tool active.

<b>_AXIND[3]</b>	INT	array
------------------	-----	-------

Indices 0 to 2 are assigned to the abscissa (0), ordinate (1) and applicate (2) (e.g. **\_AXIND[0]** contains the number of the tool length components, which are effective in the direction of the abscissa).

The content has the following significance:

0:	Assignment exists (axis does not exist)
1 to 3:	Number of the length effective in the corresponding coordinate axis. The sign is negative if the tool length component is pointing in the negative coordinate direction.
or	
-1 to -3:	

**\_MATRIX[3][3]**      REAL      array

Matrix, which represents the vector of the tool lengths ( $L_1=1$ ,  $L_2=1$ ,  $L_3=1$ ) to the vector of the coordinate axes (abscissa, ordinate, applicate), i.e. the tool length components are assigned to the **columns** in the order  $L_1$ ,  $L_2$ ,  $L_3$  and the axes are assigned to the **lines** in the order abscissa, ordinate, applicate.

All elements are always valid in the matrix, even if the geometry axis belonging to the coordinate axis is not available, i.e. if the corresponding entry in **\_AXIND** is 0.

**\_COORD**      STRING

Specifies the coordinate system used for the assignment.

**MCS** or **M**:      The tool length is represented in the machine coordinate system.

**BCS** or **B**:      The tool length is represented in the basic coordinate system.

**WCS** or **W**:      The tool length is represented in the workpiece coordinate system (default).

**KCS** or **K**:      The tool length is represented in the tool coordinate system of the **kinematic transformation**.

**TCS** or **T**:      The tool length is represented in the tool coordinate system.

The notation of the characters in the string (upper or lower case) is arbitrary.

## Further explanations

If the tool length components are parallel to the geometry axes, the axis indices assigned to length components  $L_1$  to  $L_3$  are returned in the **\_AXIND** array.

If a tool length component points in the negative axis direction, the associated axis index contains a minus sign. In this case, the return value (**status**) is 0. If an axis does not exist, the associated return value is 0. The assignment can also be read from the **\_MATRIX** parameter. Six of the nine matrix elements are then zero, and three elements contain the value +1 or -1.

---

### Note

In the TCS, all tool length components are always parallel or antiparallel to the axes.

The components can only be antiparallel when mirroring is active and the following setting data is activated:

SD42900 \$SC\_MIRROR\_TOOL\_LENGTH (Sign change tool length when mirroring)

---

If not all length components are parallel or antiparallel to the geometry axes, the index of the axis, which contains the largest part of a tool length component, is returned in `_AXIND`. In this case (if the function does not return an error for a different reason), the return value is 1. The mapping of tool length components `L1` to `L3` onto geometry axes 1 to 3 is then described completely by the contents of the 3rd parameter `_MATRIX`.

The `_COORD` parameter can be used to specify, which coordinate system is to be used for the geometry axes. If the `_COORD` parameter is not specified (notation `LENTOAX(_AXIND, _MATRIX)`), the WCS is used (default).

**Example:**

Standard situation: milling tool with G17

`L1` applies in Z (applicator), `L2` applies in Y (ordinate), `L3` applies in X (abscissa).

Function call in the form:

**Status = LENTOAX(\_AXIND, \_MATRIX, "WCS")**

The result parameter `_AXIND` contains the values:

`_AXIND[0] = 3`

`_AXIND[1] = 2`

`_AXIND[2] = 1`

Or, in short: ( 3, 2, 1)

In this case, the associated matrix `_MATRIX` is:

$$\_MATRIX = \begin{pmatrix} & & 1 \\ & 1 & \\ 1 & & \end{pmatrix}$$

A change from G17 to G18 or G19 does not alter the result, because the assignment of the length components to the geometry axes changes in the same way as the assignment of the abscissa, ordinate and applicator.

A frame rotation of Z through 60 degrees is now programmed with G17 active, e.g. `rot Z60`. The direction of the applicator (Z direction) remains unchanged; the main component of `L2` now lies in the direction of the new X axis; the main component of `L1` now lies in the direction of the negative Y axis. The return axis is thus 1, and `_AXIND` contains the values (2, -3, 1).

In this case, the associated matrix `_MATRIX` is:

$$\_MATRIX = \begin{pmatrix} \text{sn}(\ ) & \text{s}(\ ) \\ \text{s}(\ ) & \text{sn}(\ ) \\ 1 & & \end{pmatrix}$$

---

**Note**

For further information to the above mentioned coordinate systems, please refer to:

**References:**

/PGA/ Programming Manual Job Planning; Tool Compensations

---

## 17.14 Supplementary conditions

### 17.14.1 Flat D number structure

#### Grinding tools

Grinding tools (tool types 400-499) cannot be defined using the simple tool management structure (flat D numbers).

#### Block search

T number output to PLC triggers a synchronization process in the NCK: with absolute, indirect D programming, the PLC returns the D values via VDI. The NCK waits until the output of a T number is followed by a response from the PLC: "I have written the D number". With block search without calculation, this process of synchronization must be deactivated until the first valid T number has been output again. That means that the NCK must not wait on D programming.

---

**Note**

At what point the auxiliary functions can be output to PLC after block search is complete, can be controlled with the machine data:

\$MC\_AUXFU\_AT\_BLOCK\_SEARCH\_END (auxiliary function output after block search)

Automatic on end or on NC start.

---

#### REORG

The (only) writable variable \$A\_MONIFACT, which is defined here, is stored by main-run data. Since the write process takes place synchronously to the main run, no special measures are required for Reorg.

### 17.14.2 SD42935 expansions

#### SD42935

Which of the wear components are to be transformed and which are not to be transformed in conjunction with the functions `TOWMCS` and `TOWWCS` can be defined via the setting data:

SD42935 \$SC\_WEAR\_TRANSFORM (transformation of wear values)

## 17.15 Examples

### 17.15.1 Toolholder with orientation capability

#### 17.15.1.1 Example: Toolholder with orientation capability

##### Requirement

The following example uses a toolholder, which is described fully by a rotation about the Y axis. It is therefore sufficient to enter only one value to define the rotary axis (block N20).

Blocks N50 to N70 describe an end mill with radius 5 mm and length 20 mm.

Block N90 defines a rotation of 37 degrees about the Y axis.

Block N120 activates the tool radius compensation and all settings are made to describe the compensation in the following blocks with a rotation of 37 degrees about the Y axis.

```

N10                                ; Definition of toolholder 1
N20 $TC_CARR8[1] = 1                ; Component of the first rotary axis in
                                   ; the Y direction
N30
N40                                ; Definition of tool-compensation memory
                                   ; T1/D1
N50 $TC_DP1[1,1] = 120              ; End mill
N60 $TC_DP3[1,1] = 20               ; Length 1
N70 $TC_DP6[1,1] = 5               ; Radius
N80
N90 ROT Y37                         ; 37-degree rotation about y axis
N100
N110 X0 Y0 Z0 F10000
N120 G42 CUT2DF TCOFR TCARR = 1 T1 D1 X10
N130 X40
N140 Y40
N150 X0
N160 Y0
N170 M30

```

### 17.15.1.2 Example of toolholder with orientation capability with rotary table

#### Use of the MOV command

For use of the MOV<sub>T</sub> command it is assumed that the program is running on a 5-axis machine, on which the tool rotates about the Y axis in case of a rotation of the B axis:

```
N10 TRAORI ()
N20 X0 X0 Z0 B45 F2000 ; Setting the tool orientation
N30 MOVT=-10 ; Infeed movement 10 mm in tool
; direction
; (under 45 degrees in the Y-Z plane)
N40 MOVT=AC(20) ; Retraction in tool direction at
; distance of
; 20 mm from the zero point
```

#### Machine with rotary table

Complete definition for the use of a toolholder with orientation capability with rotary table:

```
N10 $TC_DP1[1,1]=120
N20 $TC_DP3[1,1]= 13 ; Tool length 13 mm

; Definition of toolholder 1:

N30 $TC_CARR1[1] = 0 ; X component of 1st offset vector
N40 $TC_CARR2[1] = 0 ; Y component of 1st offset vector
N50 $TC_CARR3[1] = 0 ; Z component of 1st offset vector

N60 $TC_CARR4[1] = 0 ; X component of 2nd offset vector
N70 $TC_CARR5[1] = 0 ; Y component of 2nd offset vector
N80 $TC_CARR6[1] = -15 ; Z component of 2nd offset vector

N90 $TC_CARR7[1] = 1 ; X component of 1st axis
N100 $TC_CARR8[1] = 0 ; Y component of 1st axis
N110 $TC_CARR9[1] = 0 ; Z component of 1st axis

N120 $TC_CARR10[1] = 0 ; X component of 2nd axis
N130 $TC_CARR11[1] = 1 ; Y component of 2nd axis
N140 $TC_CARR12[1] = 0 ; Z component of 2nd axis

N150 $TC_CARR13[1] = 30 ; Angle of rotation of 1st axis
N160 $TC_CARR14[1] = -30 ; Angle of rotation of 2nd axis
```

```

N170 $TC_CARR15[1] = 0 ; X components of 3rd offset vector
N180 $TC_CARR16[1] = 0 ; Y component of 3rd offset vector
N190 $TC_CARR17[1] = 0 ; Z component of 3rd offset vector

N200 $TC_CARR18[1] = 0 ; X component of 4th offset vector
N210 $TC_CARR19[1] = 0 ; Y component of 4th offset vector
N220 $TC_CARR20[1] = 15 ; Z component of 4th offset vector

N230 $TC_CARR21[1] = A ; Reference for 1st axis
N240 $TC_CARR22[1] = B ; Reference for 2nd axis
N250 $TC_CARR23[1] = "P" ; Toolholder type

N260 X0 Y0 Z0 A0 B45 F2000
N270 TCARR=1 X0 Y10 Z0 T1 TCOABS
N280 PAROT
N290 X0 Y0 Z0
N300 G18 MOVT=AC(20)
N310 G17 X10 Y0 Z0
N320 MOVT=-10
N330 PAROTOF
N340 TCOFR
N350 X10 Y10 Z-13 A0 B0
N360 ROTS X-45 Y45
N370 X20 Y0 Z0 D0
N380 Y20
N390 X0 Y0 Z20
N400 M30

```

The definition of the toolholder with orientation capability is given in full. The components which contain the value 0 need not actually be given, as they are preset to zero in any case.

The toolholder is activated in N270.

As *\$TC\_CARR21* and *\$TC\_CARR22* refer to the machine axes A and B and TCOABS is active, the values in *\$TC\_CARR13* and *\$TC\_CARR14* are ignored, i.e. the axis position A0 B45 is used for the rotation.

The rotation of the 4th offset vector (length 15 mm in Z direction) around the B axis causes an offsetting of the zero point by X10.607 [= 15 \* sin(45)] and Z-4.393 [= -15 \* (1. - cos(45))]. This zero offset is taken into account by an automatically written basic or system frame so that the position X10.607 Y10.000 Z8.607 is approached. In the Z direction the tool selection leads to an additional offset of 13 mm; the Y component is not affected by the table rotation.

N280 defines a rotation in accordance with the rotation of the table of the toolholder with orientation capability. The new X direction thus points in the direction of the bisecting line in the 4th quadrant, the new Z axis in the direction of the bisecting line in the 1st quadrant.

The zero point is approached in N290, i.e. the machine position X10.607 Y0 Z-4.393, since the position of the zero point is not changed by the rotation.

N300 traverses in Y to the position Y33.000, since G18 is active and the Y component is not affected by the active frame. The X and Z positions remain unchanged.

The position X17.678 Y0 Z1.536 is approached in N310.

N320 changes only the Z position to the value -8.464 as a result of the MOVZ command. As only the table can be rotated, the tool orientation remains unchanged parallel to the machine Z direction, even if the Z direction of the active frame is rotated by 45 degrees.

N330 deletes the basic or system frame; thus the frame definition from N280 is undone.

In N340, TCOFR specifies that the toolholder with orientation capability is to be aligned according to the active frame. Since a rotation is no longer active in N330 due to the PAROTOF command, the initial state is applied. The frame offset becomes zero.

N350 thus approaches the position X10 X10 Z0 (= Z-13 + tool length). Note: Through the simultaneous programming of both rotary axes A and B the actual position of the toolholder with orientation capability is made to match that used in N340. The position approached by the three linear axes is dependent on this position, however.

In N360, solid angles are used to define a plane whose intersecting lines in the X-Z and in the Y-Z plane each form an angle of +45 degrees or -45 degrees with the X or Y axis. The plane defined in such a way therefore has the following position: the surface normal points towards the solid diagonals.

N370 traverses to the position X20 Y0 Z0 in the new coordinate system. Since the tool is deselected with D0 at the same time, there is no longer an additional offset in Z. Since the new X axis lies in the old X-Z plane, this block reaches the machine position X14.142 Y0 Z-14.142.

N380 only traverses on the Y axis in the rotated coordinate system. This leads to a motion of all three machine axes. The machine position is X5.977 Y16.330 Z-22.307.

N390 approaches a point on the new Z axis. Relative to the machine axes this is thus on the solid diagonal. All three axes thus reach the position 11.547.

### 17.15.1.3 Basic tool orientation example

#### Basic orientation in the bisector

A milling tool is defined with length  $L1=10$  whose basic orientation is in the bisector of the X-Z plane.

```
N10   $TC_DP1[1,1]=120
N20   $TC_DP3[1,1]=10
N30   $TC_DPV [1,1] = 0
N40   $TC_DPV3[1,1] = 1
N50   $TC_DPV4[1,1] = 0
N60   $TC_DPV5[1,1] = 1
N70   g17 f1000 x0 y0 z0 t1 d1
N80   movt=10
N80   m30
```

#### Description of example:

In N10 to N60, a milling tool is defined with length  $L1=10$  (N20). The basic orientation is in the bisector of the X-Z plane N40 to N60.

In N70, the tool is activated and the zero position is approached. As a result of the tool length the machine positions X0 Y0 Z10 are thus obtained in this block.

In N80 an incremental traversing motion is performed from 10 into tool direction. The resulting axis positions are thus X7.071 Y0 Z17.071.

### 17.15.1.4 Calculation of compensation values on a location-specific and workpiece-specific basis

#### Tool with adapter

A tool with adapter and toolholder with orientation capability is defined in the following program example. In order to simplify the overview, only length  $L1$  is different to zero for the additive and insert offsets and for the adapter in case of the tool itself. The offset vectors of the toolholder with orientation capability are all zero.

```
N10   $TC_TP2[1] = "MillingTool"           ; Name of identifier
N20   $TC_TP7[1]=9                         ; Location types
N30   $TC_TP8[1]=2                         ; Status: enabled and not blocked

; D corr. D=1

N40   $TC_DP1[1,1]=120                     ; Tool type - milling
N50   $TC_DP3[1,1]=; tool length compensation
      vector
N60   $TC_DP12[1,1]= ; wear
```

```

N70     $TC_SCP13[1,1]=0.1           ; Sum offset DL=1
N80     $TC_ECP13[1,1]=0.01        ; Insert offset DL=1
N90     $TC_ADPTT[1]=5             ; Adapter transformation
N100    $TC_ADPT1[1]=0.001         ; Adapter dimension

                                           ; Magazine data
N110    $TC_MAP1[1]=3              ; Magazine type: Revolver
N120    $TC_MAP2[1]="Revolver"     ; Magazine identifier
N130    $TC_MAP3[1]=17             ; Status of magazine
N140    $TC_MAP6[1]=1              ; Dimension - line
N150    $TC_MAP7[1]=2              ; Dimension - column -> 2 positions
N160    $TC_MPP1[1,1]=1            ; Location type
N170    $TC_MPP2[1,1]=9            ; Location types
N180    $TC_MPP4[1,1]=2            ; Location state
N190    $TC_MPP7[1,1]=1            ; Bring adapter into position
N200    $TC_MPP6[1,1]=1            ; T number "MillingTool"
N210    $TC_MAP1[9999]=7           ; Magazine type: buffer
N220    $TC_MAP2[9999]="buffer"    ; Magazine identifier
N230    $TC_MAP3[9999]=17          ; Status of magazine
N240    $TC_MAP6[9999]=1           ; Dimension - line
N250    $TC_MAP7[9999]=1           ; Dimension - column -> 1 position
N260    $TC_MPP1[9999.1]=2         ; Location type
N270    $TC_MPP2[9999.1]=9         ; Location types
N280    $TC_MPP4[9999.1]=2         ; Location state
N290    $TC_MPP5[9999,1]=1         ; Spindle no. 1
N300    $TC_MDP2[1,1]=0            ; Distance from spindle to mag. 1

                                           ; Definition of toolholder 1
N310    $TC_CARR10[1] = 1           ; Component of 2nd rotary axis in X
                                           direction
N320    $TC_CARR14[1] = 45          ; Angle of rotation of 2nd axis
N330    $TC_CARR23[1] = "T"        ; Tool mode
N340    Stopre
N350    $SC_WEAR_TRANSFORM = 'B101'
N360    T0 D0 DL=0
N370    ROT X30
N380    G90 G1 G17 F10000 X0 Y0 Z0
N390    T="MillingTool" X0 Y0 Z0 TOWSTD ; X 0.000 Y11.110 Z 0.001
N400    T="MillingTool" X0 Y0 Z0 TOWMCS ; X 0.000 Y10.100 Z 1.011
N410    T="MillingTool" X0 Y0 Z0 TOWWCS ; X 0.000 Y 9.595 Z 0.876
N420    TCARR=1 X0 Y0 Z0           ; X 0.000 Y 6.636 Z 8.017
N430    G18 X0 Y0 Z0               ; X10.100 Y-0.504 Z 0.876
N440    m30

```

**Explanations regarding the example above**

Starting at block N390, various methods are used to approach position X0 Y0 Z0. The machine positions reached are specified in the blocks in comments. After the program a description is given of how the positions were reached.

N390: The adapter transformation 5 (block N90) transforms length L1 into length L2. Only the actual adapter dimension is not subject to this transformation. The Y value (L2 with G17) results from the sum of the tool length (10), tool wear (1), sum offset (0.1), and insert offset (0.01). The adapter dimension (0.001) is in Z (L1).

N400: In block N350, bits 0 and 2 are enabled in setting data:

SD42935 \$SC\_WEAR\_TRANSFORM (transformations for tool components)

This means that the tool wear and the insert offset are not subject to the adapter transformation because of TOWMCS in block N400. The sum of these two compensations is 1.01. The Z position is, therefore, increased by this amount and the Y position is reduced by this amount compared with block N390.

TOWWCS is active in N410. The sum of the tool wear and the insert offset is thus effective in the active workpiece coordinate system. In block N370, a rotation through 30 degrees is activated about the X axis. The original compensation value of 1.01 in the Z direction thus yields a new Z component of 0.875 ( $= 1.01 * \cos(30)$ ) and a new Y component of -0.505 ( $= 1.01 * \sin(30)$ ). This yields the dimension specified in the program comment when added to the sum of the tool length, sum offset and adapter dimension produced in block N390.

In addition, a toolholder with orientation capability is activated in block N420. This executes a rotation through 45 degrees about the X axis (see N310 - N330). Since all offset vectors of the toolholder are zero, there is no additional zero offset. The toolholder with orientation capability acts on the sum of the tool length, sum offset and adapter dimension. The resulting vector component is X0 Y7.141 Z7.142. To this, as in block N410, the sum of tool wear and insert offset evaluated in WCS is added.

G18 is activated in N430. The components of the sum of the tool length, sum offset and adapter dimension are interchanged accordingly. The toolholder with orientation capability continues to act on this new vector (rotation through 45 degrees about X axis). The resulting vector component thereby is X10.100 Y0.0071 Z0.0071. The vector formed from tool wear and insert offset (X0 Y-0.505 Z0.875) is not affected by the change of plane. The sum of the two vectors yields the dimension specified in the comment in N430.

## 17.15.2 Examples 3-6: SETTCOR function for tool environments

### Example 3

```

N10    def real _CORVAL[3]
N20    $TC_DP1[1,1] = 120                ; Milling tool
N30    $TC_DP3[1,1] = 10.0              ; Geometry L1
N40    $TC_DP12[1,1] = 1.0              ; Wear L1
N50    _CORVAL[0] = 0.333
N60    t1 d1 g17 g0
N70    r1 = settcor(_CORVAL, "GW", 0, 2, 2)
N80    t1 d1 x0 y0 z0                    ; ==> MCS position X0.000 Y0.000
                                           Z0.333
N90    M30

```

\_CORCOMP is 2, therefore, the compensation effective in the Z direction is entered in the geometry component (the old value is overwritten) and the wear value is deleted. The resulting total tool length is thus:

$$L1 = 0.333 + 0.0 = 0.333.$$

### Example 4

```

N10    def real _CORVAL[3]
N20    $TC_DP1[1,1] = 120                ; Milling tool
N30    $TC_DP3[1,1] = 10.0              ; Geometry L1
N40    $TC_DP12[1,1] = 1.0              ; Wear L1
N50    _CORVAL[0] = 0.333
N60    t1 d1 g17 g0
N70    r1 = settcor(_CORVAL, "GW", 0, 3, 2)
N80    t1 d1 x0 y0 z0                    ; ==> MCS position X0.000 Y0.000
                                           Z11.333
N90    M30

```

\_CORCOMP is 3, therefore, the wear value and compensation value are added to the geometry component and the wear component is deleted. The resulting total tool length is thus  $L1 = 11.333 + 0.0 = 11.333$ .

## Example 5

```

N10    def real _CORVAL[3]
N20    $TC_DP1[1,1] = 120                ; Milling tool
N30    $TC_DP3[1,1] = 10.0              ; Geometry L1
N40    $TC_DP12[1,1] = 1.0              ; Wear L1
N50    _CORVAL[0] = 0.333
N60    t1 d1 g17 g0
N70    r1 = settcor(_CORVAL, "GW", 0, 3, 0)
N80    t1 d1 x0 y0 z0                    ;==> MCS position X0.333 Y0.000
                                           Z11.000
N90    M30

```

`_CORCOMP` is 3, as in the previous example, but the compensation is now effective on the geometry axis with index 0 (X axis). The tool components `L3` are assigned to this geometry axis due to `G17` with a milling tool. Calling `SETTCOR` thus does not affect tool parameters `$TC_DP3` and `$TC_DP12`. Instead, the compensation value is entered in `$TC_DP5`.

## Example 6

```

N10    def real _CORVAL[3]
N20    $TC_DP1[1,1] = 500                ; Turning tool
N30    $TC_DP3[1,1] = 10.0              ; Geometry L1
N40    $TC_DP4[1,1] = 15.0              ; Geometry L2
N50    $TC_DP12[1,1] = 10.0             ; Wear L1
N60    $TC_DP13[1,1] = 0.0              ; Wear L2
N70    _CORVAL[0] = 5.0
N80    rot y 30
N90    t1 d1 g18 g0
N100   r1 = settcor(_CORVAL, "GW", 0, 3, 1)
N110   t1 d1 x0 y0 z0                    ; ==> MCS position X24.330
                                           Y0.000 Z17.500
N120   M30

```

The tool is a turning tool. A frame rotation is activated in `N80`, causing the basic coordinate system (BCS) to be rotated in relation to the workpiece coordinate system (WCS). In the WCS, the compensation value (`N70`) acts on the geometry axis with index 1, i.e. on the X axis because `G18` is active. Since `"_CORRMODE = 3"`, the tool wear in the direction of the X axis of the WCS must become zero once `N100` has been executed. The contents of the relevant tool parameters at the end of the program are thus:

```

$TC_DP3[1,1]          : 21.830          ; Geometry L1
$TC_DP4[1,1]          : 21.830          ; Geometry L2
$TC_DP12[1,1]         : 2.500           ; Wear L1
$TC_DP13[1,1]         : -4.330         ; Wear L2

```

The total wear including `_CORVAL` is mapped onto the  $X'$  direction in the WCS. This produces point  $P_2$ . The coordinates of this point (measured in  $X/Y$  coordinates) are entered in the geometry component of the tool. The difference vector  $P_2 - P_1$  remains in the wear. The wear thus no longer has a component in the direction of `_CORVAL`.

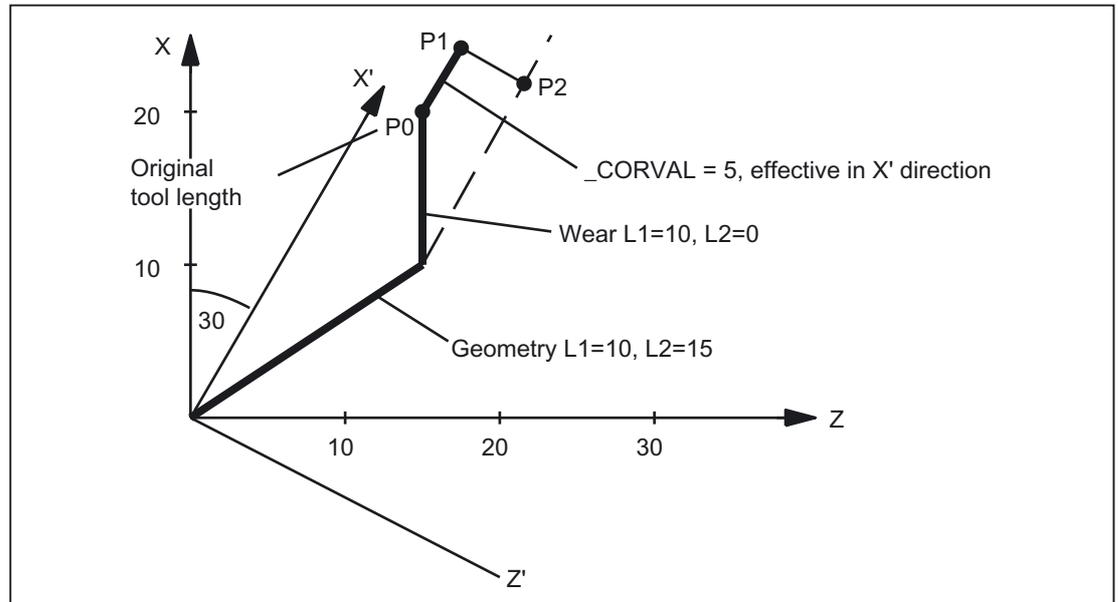


Figure 17-54 Tool length compensation, example 6

If the sample program is continued after `N110` with the following instructions:

```
N120  _CORVAL[0] = 0.0
N130  r1 = settcor(_CORVAL, "GW", 0, 3, 0)
N140  t1 d1 x0 y0 z0 ; ==> MCS position X24.330 Y0.000
                                Z17.500
```

The remaining wear is included completely in the geometry because the compensation is now effective in the  $Z'$  axis (parameter `_GEOAX` is 0). Since the new compensation value is 0, the total tool length and thus the position approached in `N140` may not change. If `_CORVAL` were not equal to 0 in `N120`, a new total tool length and thus a new position in `N140` would result, however, the wear component of the tool length would always be zero, i.e. the total tool length is subsequently always contained in the geometry component of the tool.

The same result as that achieved by calling the SETTCOR function with the `_CORCOMP = 0` parameter twice can also be reached by calling `_CORCOMP = 1` (vectorial compensation) just once:

```

N10    def real _CORVAL[3]
N20    $TC_DP1[1,1] = 500                ; Turning tool
N30    $TC_DP3[1,1] = 10.0              ; Geometry L1
N40    $TC_DP4[1,1] = 15.0              ; Geometry L2
N50    $TC_DP12[1,1]= 10.0              ; Wear L1
N60    $TC_DP13[1,1] =0.0               ; Wear L2
N70    _CORVAL[0] = 0.0
N71    _CORVAL[1] = 5.0
N72    _CORVAL[2] = 0.0
N80    rot y 30
N90    t1 d1 g18 g0
N100   r1 = settcor(_CORVAL, "GW", 1, 3, 1)
N110   t1 d1 x0 y0 z0                    ; ==> MCS position X24.330 Y0.000
                                           Z17.500
N120   M30

```

In this case, all wear components of the tool are set to zero immediately after the first call of SETTCOR in N100.

### Example 7

```

N10    def real _CORVAL[3]
N20    $TC_DP1[1,1] = 500                ; Turning tool
N30    $TC_DP3[1,1] = 10.0              ; Geometry L1
N40    $TC_DP4[1,1] = 15.0              ; Geometry L2
N50    $TC_DP12[1,1]= 10.0              ; Wear L1
N60    $TC_DP13[1,1] =0.0               ; Wear L2
N70    _CORVAL[0] = 5.0
N80    rot y 30
N90    t1 d1 g18 g0
N100   r1 = settcor(_CORVAL, "GW", 3, 3)
N110   t1 d1 x0 y0 z0                    ; ==> MCS position X25.000 Y0.000
                                           Z15.000

```

As opposed to example 6, parameter `_CORCOMP = 3`, and so the `_GEOAX` parameter can be omitted. The value contained in `_CORVAL[0]` now acts immediately on the tool length component L1, the rotation in N80 has no effect on the result, the wear components in `$TC_DP12` are included in the geometry component together with `_CORVAL[0]`, with the result that the total tool length is stored in the geometry component of the tool, due to `$TC_DP13`, after the first SETTCOR call in N100.

### Example 8

```

N10    def real _CORVAL[3]
N20    $TC_DP1[1,1] = 500                ; Turning tool
N30    $TC_DP3[1,1] = 10.0              ; Geometry L1
N40    $TC_DP4[1,1] = 15.0              ; Geometry L2
N50    $TC_DP5[1,1] = 20.0              ; Geometry L3
N60    $TC_DP12[1,1]= 10.0              ; Wear L1
N70    $TC_DP13[1,1] = 0.0              ; Wear L2
N80    $TC_DP14[1,1] = 0.0              ; Wear L3
N90    $$SC_WEAR_SIGN = TRUE
N100   _CORVAL[0] = 10.0
N110   _CORVAL[1] = 15.0
N120   _CORVAL[2] = 5.0
N130   rot y 30
N140   t1 d1 g18 g0
N150   r1 = settcor(_CORVAL, "W", 1, 1)
N160   t1 d1 x0 y0 z0                    ; ==> MCS position X7.990 Y25.000
                                           Z31.160

```

In N90 the setting data is enabled:

SD42930 \$\$SC\_WEAR\_SIGN (sign of wear)

i.e. the wear must be valued with a negative sign.

The compensation is vectorial ( $\_CORCOMP = 1$ ), and the compensation vector must be added to the wear ( $\_CORMODE = 1$ ). The geometric conditions in the Z/X plane are shown in the figure below:

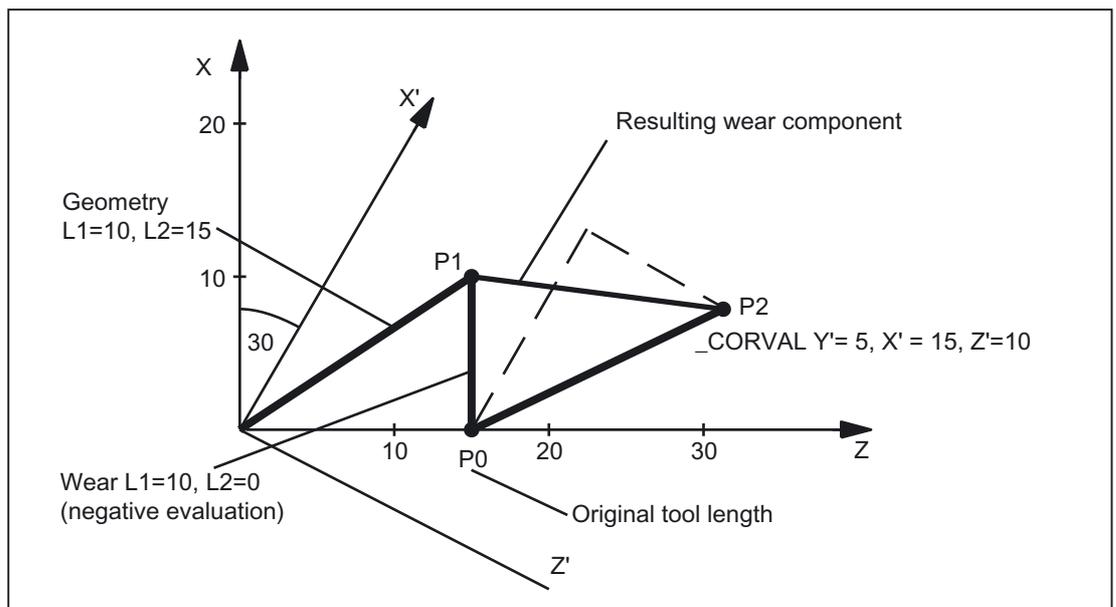


Figure 17-55 Tool length compensation, example 8

The geometry component of the tool remains unchanged due to `_CORMODE = 1`. The compensation vector defined in the WCS (rotation about y axis) must be included in the wear component such that the total tool length in the figure refers to point P<sub>2</sub>. Therefore, the resulting wear component of the tool is given in relation to the distance between points P<sub>1</sub> and P<sub>2</sub>.

However, since the wear is evaluated negatively, due to setting data SD42930, the compensation determined in this way has to be entered in the compensation memory with a negative sign. The contents of the relevant tool parameters at the end of the program are thus:

```

$TC_DP3[1,1]      : 10.000      ; Geometry L1 (unchanged)
$TC_DP4[1,1]      : 15.000      ; Geometry L2 (unchanged)
$TC_DP5[1,1]      : 10.000      ; Geometry L3 (unchanged)

$TC_DP12[1,1]     : 2.010       ; Wear L1
                    ; (= 10 -15*cos(30) + 10*sin(30))
$TC_DP13[1,1]     : -16.160     ; Wear L2
                    ; (= -15*sin(30) - 10*cos(30))
$TC_DP14[1,1]     : -5.000      ; Wear L3

```

The effect of setting data SD42930 on the L3 component in the Y direction can be recognized without the additional complication caused by the frame rotation.

### Example 9

2 (tool length must be valued in the diameter axis with the factor 0.5) is the value of machine data:

MD20360 \$MC\_TOOL\_PARAMETER\_DEF\_MASK (definition of tool parameters).

X is diameter axis:

```

N10  def real _LEN[11]
N20  def real _CORVAL[3]
N30  $TC_DP1[1,1]= 500
N40  $TC_DP2[1,1]= 2
N50  $TC_DP3[1,1]= 3.
N60  $TC_DP4[1,1]= 4.
N70  $TC_DP5[1,1]= 5.
N80  _CORVAL[0] = 1.
N90  _CORVAL[1] = 1.
N100 _CORVAL[2] = 1.
N110 t1 d1 g18 g0 x0 y0 z0      ; ==> MCS position X1.5 Y5 Z4
N120 r1 = settcor(_CORVAL, "g", 1, 1)
N130 t1 d1 x0 y0 z0            ; ==> MCS position X2.5 Y6 Z5
N140 r3 = $TC_DP3[1,1]         ; = 5. = (3.000 + 2. * 1.000)
N150 r4 = $TC_DP4[1,1]         ; = 5. = (4.000 + 1.000)
N160 r5 = $TC_DP5[1,1]         ; = 6. = (5.000 + 1.000)
N170 m30

```

The compensation of the tool length is to be 1 mm in each axis (N80 to N100).

1 mm is thus added to the original length in lengths L2 and L3.

Twice the compensation value (2 mm) is added to the original tool length in L1, in order to change the total length by 1 mm as required. If the positions approached in blocks N110 and N130 are compared, it can be seen that each axis position has changed by 1 mm.

## 17.16 Data lists

### 17.16.1 Machine data

#### 17.16.1.1 NC-specific machine data

Number	Identifier: \$MN_	Description
18082	MM_NUM_TOOL	Number of tools that the NCK can manage (SRAM)
18088	MM_NUM_TOOL_CARRIER	Number of toolholders
18094	MM_NUM_CC_TDA_PARAM	Number of TOA data
18096	MM_NUM_CC_TOA_PARAM	Number of TOA data, which can be set up per tool and evaluated by the CC
18100	MM_NUM_CUTTING_EDGES_IN_TOA	Tool compensations per TOA module
18102	MM_TYPE_OF_CUTTING_EDGE	Activate flat D number management
18105	MM_MAX_CUTTING_EDGE_NO	Address extension interpreted as spindle number
18106	MM_MAX_CUTTING_EDGE_PERTOOL	Maximum number of cutting edges per tool
18108	MM_NUM_SUMCORR	Number of all sum offsets in NCK
18110	MM_MAX_SUMCORR_PER_CUTTEDGE	Maximum number of sum offsets per cutting edge
18112	MM_KIND_OF_SUMCORR	Properties of sum offsets in the NCK
18114	MM_ENABLE_TOOL_ORIENT	Assign orientation to cutting edges
18116	MM_NUM_TOOL_ENV	Tool environments in TO area

#### 17.16.1.2 Channel-specific machine data

Number	Identifier: \$MC_	Description
20096	T_M_ADDRESS_EXT_IS_SPINO	Spindle number as address extension
20110	RESET_MODE_MASK	Definition of control basic setting after power-up and RESET parts program end
20120	TOOL_RESET_VALUE	Definition of tool, for which tool length compensation is selected during powerup or on reset or parts program end as a function of machine data: MD20110 RESET_MODE-MASK.
20121	TOOL_PRESEL_RESET_VALUE	Definition of the preselected tool, for which the tool length compensation is selected during powerup and on reset or parts program end as a function of MD20110.

Number	Identifier: \$MC_	Description
20125	CUTMOD_ERR	Troubleshooting for the CUTMOD function
20126	TOOL_CARRIER_RESET_VALUE	Active toolholder on RESET
20127	CUTMOD_INIT	Initialize CUTMOD for POWER ON
20130	CUTTING_EDGE_RESET_VALUE	Definition of tool cutting edge, for which tool length compensation is selected during powerup or on reset or parts program end as a function of machine data: MD20110 RESET_MODE-MASK.
20132	SUMCORR_RESET_VALUE	Number for selecting sum offset
20140	TRAFO_RESET_VALUE	Definition of transformation set, which is selected during powerup or on reset or parts program end as a function of machine data: MD20110 RESET_MODE-MASK.
20180	TOCARR_ROT_ANGLE_INCR[i]	Value of the minimum incremental step with toolholder with orientation capability
20182	TOCARR_ROT_ANGLE_OFFSET[i]	Offset of the rotary axis with toolholder with orientation capability
20184	TOCARR_BASE_FRAME_NUMBER	Base frame of the table offset for toolholder with orientation capability with rotary table
20188	TOCARR_FINE_LIM_LIN	Limit linear fine offset TCARR
20190	TOCARR_FINE_LIM_ROT	Limit rotary fine offset TCARR
20202	WAB_MAXNUM_DUMMY_BLOCKS	Maximum number of blocks with no traversing motions with SAR
20204	WAB_CLEARANCE_TOLERANCE	
20210	CUTCOM_CORNER_LIMIT	Max. angle for intersection calculation with tool radius compensation
20220	CUTCOM_MAX_DISC	Maximum value for tool radius compensation
20230	CUTCOM_CURVE_INSERT_LIMIT	Minimum value for intersection calculation with tool radius compensation
20240	CUTCOM_MAXNUM_CHECK_BLOCKS	Blocks for predictive contour calculation with tool radius compensation
20250	CUTCOM_MAXNUM_DUMMY_BLOCKS	Max. no. of dummy blocks with no traversing movements
20252	CUTCOM_MAXNUM_SUPPR_BLOCKS	Maximum number of blocks with compensation suppression
20256	CUTCOM_INTERS_POLY_ENABLE	Intersection process possible for polynomials
20270	CUTTING_EDGE_DEFAULT	Selected cutting edge after tool change
20272	SUMCORR_DEFAULT	Number for activating a new cutting edge compensation
20360	TOOL_PARAMETER_DEF_MASK	Defines the effect of tool parameters
20390	TOOL_TEMP_COMP_ON	Activation of temperature compensation for tool length
20392	TOOL_TEMP_COMP_LIMIT	Maximum temperature compensation for tool length
20610	ADD_MOVE_ACCEL_RESERVE	Acceleration reserve for overlaid movements
21080	CUTCOM_PARALLEL_ORI_LIMIT	Limit angle between path tangent and tool orientation with 3D tool radius compensation
22530	TOCARR_CHANGE_M_CODE	M code for change of toolholder

## Tool Offset (W1)

### 17.16 Data lists

Number	Identifier: \$MC_	Description
22550	TOOL_CHANGE_MODE	New tool compensations with M function
22560	TOOL_CHANGE_M_CODE	M function for tool change
22562	TOOL_CHANGE_ERROR_MODE	Error response on programmed tool change
24558	TRAF05_JOINT_OFFSET_PART_1	Vector of kinematic offset in table, transformation 1
24658	TRAF05_JOINT_OFFSET_PART_2	Vector of kinematic offset in table, transformation 2
28085	MM_LINK_TOA_UNIT	Assignment of TO unit to a channel

#### 17.16.1.3 Axis/spindle-specific machine data

Number	Identifier: \$MA_	Description
32750	TEMP_COMP_TYPE	Temperature compensation type

#### 17.16.2 Setting data

##### 17.16.2.1 Channel-specific setting data

Number	Identifier: \$SC_	Description
42442	TOOL_OFFSET_INCR_PROG	Retraction of tool compensations on incremental programming
42470	CRIT_SPLINE_ANGLE	Corner limit angle for the compressor with COMPCAD (changed in SW 7.1 and higher)
42480	STOP_CUTCOM_STOPRE	Alarm response for tool radius compensation and preprocessing stop
42494	CUTCOM_ACT_DEACT_CTRL	Approach/retraction behavior for tool radius compensation in blocks without travel information
42496	CUTCOM_CLSDT_CONT	Maintain stability of approach/retraction behavior for tool radius compensation in blocks
42900	MIRROR_TOOL_LENGTH	Mirror tool length compensation
42910	MIRROR_TOOL_WEAR	Mirror wear values of tool length compensation
42920	WEAR_SIGN_CUTPOS	Mirror wear values of machining plane
42930	WEAR_SIGN	Invert sign of all wear values
42935	WEAR_TRANSFORM	Transformation of wear values
42940	TOOL_LENGTH_CONST	Retain the assignment of the tool length compensation dwhen changing the machining plane (G17 - G19)
42950	TOOL_LENGTH_TYPE	Assignment of the tool length offset independent of tool type

Number	Identifier: \$SC_	Description
42960	TOOL_TEMP_COMP	Temperature compensation value in relation to tool
42974	TCARR_FINE_CORRECTION	Fine offset TCARR on/off
42984	CUTDIRMOD	Modification of \$P_AD[2] or \$P_AD[11]

### 17.16.3 Signals

#### 17.16.3.1 Signals from channel

DB number	Byte.Bit	Name
21, ...	61.0	T function 1 change
21, ...	62.0	D function 1 change
21, ...	116-119	T function 1
21, ...	128-129	D function 1
21, ...	214	Active G function of group 7
21, ...	223	Active G function of group 16
21, ...	224	Active G function of group 17
21, ...	225	Active G function of group 18
21, ...	230	Active G function of group 23



## NC/PLC Interface Signals (Z1)

### 18.1 Brief description

The section entitled "NC/PLC interface signals" includes a detailed description of NC/PLC interface signals relevant to function:

- PLC messages (DB2)
- NC (DB10)
- Mode group (DB11)
- OP (DB19)
- NCK channel (DB21-DB30)
- Axis/spindle (DB31-DB61)
- Loading/unloading a magazine (DB71)
- Spindle as change point (DB72)
- Tool turret (DB73)

## 18.2 Various interface signals and functions (A2)

### 18.2.1 Signals from PLC to NC (DB10)

<b>DB10</b> <b>DBX56.4 - DBX56.7</b>	<b>Key-operated switch positions 0 to 3</b>																																			
Edge evaluation: no	Signal(s) updated: cyclic																																			
Significance of signal	<p>Access to certain data types can be disabled depending on the key-operated switch position. Input, changing, deleting data as well as certain operations on the operator panel can be disabled for certain user groups in this way.</p> <p>Key-operated switch position 0 offers the fewest access rights and position 3 the most access rights.</p> <p>The signals "key-operated switch positions 1 to 3" can either be entered directly from the key-operated switch on the machine control panel or from the PLC user program.</p> <p>Only one interface signal may be set in each case. If several positions are set simultaneously (interface signals), then they are no longer valid and key-operated switch position 3 is automatically set by the control.</p> <p>The allocation between the lockable data areas and the key operated switch positions is made by HMI machine data for protection stages.</p> <p>The following signal combinations apply:</p> <table border="1" data-bbox="373 1093 1434 1357"> <tr> <td colspan="5" style="text-align: center;">The following signal combinations apply:</td> </tr> <tr> <td></td> <td colspan="4" style="text-align: center;">DB10, DBB56</td> </tr> <tr> <td style="text-align: center;">Key-operated switch position</td> <td style="text-align: center;">Bit 7</td> <td style="text-align: center;">Bit 6</td> <td style="text-align: center;">Bit 5</td> <td style="text-align: center;">Bit 4</td> </tr> <tr> <td style="text-align: center;">0</td> <td style="text-align: center;">0</td> <td style="text-align: center;">0</td> <td style="text-align: center;">0</td> <td style="text-align: center;">1</td> </tr> <tr> <td style="text-align: center;">1</td> <td style="text-align: center;">0</td> <td style="text-align: center;">0</td> <td style="text-align: center;">1</td> <td style="text-align: center;">0</td> </tr> <tr> <td style="text-align: center;">2</td> <td style="text-align: center;">0</td> <td style="text-align: center;">1</td> <td style="text-align: center;">0</td> <td style="text-align: center;">0</td> </tr> <tr> <td style="text-align: center;">3</td> <td style="text-align: center;">1</td> <td style="text-align: center;">0</td> <td style="text-align: center;">0</td> <td style="text-align: center;">0</td> </tr> </table>	The following signal combinations apply:						DB10, DBB56				Key-operated switch position	Bit 7	Bit 6	Bit 5	Bit 4	0	0	0	0	1	1	0	0	1	0	2	0	1	0	0	3	1	0	0	0
The following signal combinations apply:																																				
	DB10, DBB56																																			
Key-operated switch position	Bit 7	Bit 6	Bit 5	Bit 4																																
0	0	0	0	1																																
1	0	0	1	0																																
2	0	1	0	0																																
3	1	0	0	0																																
Application example(s)	Depending on the rights assigned to the operator, programmer or installation engineer, certain functions will be disabled by the key-operated switch. Unintentional changes to data (e.g. zero offsets) or activation of program conditions (e.g. selecting dry run feed rate) by the operator can therefore be prevented.																																			
Corresponding to ....	Disabling using a password																																			

## 18.2.2 Selection/Status signals from HMI to PLC (DB10)

<b>DB10 DBX103.0</b>	<b>Remote diagnosis active</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	Remote diagnosis (optional) is active, i.e. the control is operated via an external PC.	
Signal state 0 or edge change 1 → 0	Remote diagnosis is not active.	

<b>DB10 DBX103.5</b>	<b>AT box ready</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	The AT box for expansion modules is ready.	
Signal state 0 or edge change 1 → 0	The AT box is not ready. An expansion module conforming to the AT specification has either no functionality or restricted functionality.	
Additional references	/BH/ Operator Components Manual; PCU 50, Chapter: Spare parts	

<b>DB10 DBX103.6</b>	<b>PCU Temperature limit</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	The environment conditions of the limit value are in the permitted tolerance range of 5 to 55 degree C.	
Signal state 0 or edge change 1 → 0	The temperature range was either exceeded, or the temperature fell below the limit. The temperature monitor has responded and the PCU is disabled.	

<b>DB10 DBX103.7</b>	<b>PCU Battery alarm</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	The battery monitor has responded. Power failure can cause the loss of recently changed data and a correct device configuration. A corresponding HMI alarm is reported. The PCU buffer battery is to be tested. An insufficient battery voltage also affects the current time on the operator interface.	
Signal state 0 or edge change 1 → 0	No PCU battery alarm is active.	
Signal irrelevant for ...	SINUMERIK 840/840Di with PCU 50, PCU 20 or PCU 70	
Additional references	/BH/ Operator Components Manual; PCU 50, Chapter: Replacing the battery	

18.2.3 Signals from the NC to the PLC (DB10)

<b>DB10 DBX104.7</b>	<b>NCK-CPU-Ready</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	<p>The NCK CPU is ready and registers itself cyclically with the PLC.</p> <p>After a correct initial start and the first complete OB1 cycle (initial setting cycle) the PLC and NCK continuously exchange sign of life signals.</p> <p>The PLC basic program sets the interface signal "NCK CPU Ready" to 1.</p>	
Signal state 0 or edge change 1 → 0	<p>The NCK CPU is not ready.</p> <p>If a sign of life is not received from the NCK, the PLC/NCK interface is neutralized by the PLC basic program and the interface signal "NCK CPU Ready" is set to 0.</p> <p>The following measures are introduced by the PLC basic program:</p> <ul style="list-style-type: none"> <li>• Status signals from NCK to PLC (user interface) are deleted (cleared)</li> <li>• Change signals for help functions are deleted</li> <li>• Cyclic processing of the user interface PLC to NCK is terminated.</li> </ul>	
Application example(s)	Individual PLC outputs can, for example, be set to a defined state from the PLC user program.	
Additional references	/DA/ Diagnosis Manual /FB1/ Function Manual basic Functions, PLC Basic Program (P3)	

<b>DB10 DBX108.1</b>	<b>HMI-CPU2-Ready (to BTSS or to MPI)</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	The CPU is ready and registers itself cyclically with the NCK.	
Signal state 0 or edge change 1 → 0	The CPU is not ready.	

<b>DB10 DBX108.2 - DBX108.3</b>	<b>HMI CPU1 Ready (HMI to MPI)/ HMI CPU1 Ready (HMI to BTSS, standard connection)</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	The CPU is ready and registers itself cyclically with the NCK.	
Signal state 0 or edge change 1 → 0	The CPU is not ready.	
Application example(s)	Appropriate measures can be introduced by the PLC user program, if "HMI-CPU1-Ready" = 0.	
Additional references	/DA/ Diagnostics Manual	

<b>DB10 DBX108.6</b>	<b>611D Ready</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	All existing drives signal the status drive ready (summary of axial interface signals "DRIVE ready").	
Signal state 0 or edge change 1 → 0	As soon as the drive not ready status is signaled from a drive (i.e. IS "DRIVE ready" = 0).	
Signal irrelevant for ...	SINUMERIK 840Di	
Corresponding to ....	DB31, ... DBX93.5 (DRIVE ready)	

<b>DB10 DBX108.7</b>	<b>NC Ready</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	The control system is ready. This interface signal is an image of the relay contact "NC Ready". This signal is set if: <ul style="list-style-type: none"> <li>• Relay contact "NC Ready" is closed</li> <li>• All the voltages in the control have been established</li> <li>• The control is in the cyclic mode</li> </ul>	

<b>DB10 DBX108.7</b>	<b>NC Ready</b>
Signal state 0 or edge change 1 → 0	<p>The control is not ready. The relay contact "NC Ready" is open.</p> <p>The following faults will cause NC Ready to be canceled:</p> <ul style="list-style-type: none"> <li>• Undervoltage and overvoltage monitoring function has responded</li> <li>• Individual components are not ready (NCK CPU Ready)</li> <li>• NC CPU watchdog</li> </ul> <p>If the signal "NC Ready" goes to 0 the following measures are introduced by the control if they are still possible:</p> <ul style="list-style-type: none"> <li>• The controller enable signals are withdrawn (this stops the drives)</li> <li>• The following measures are introduced by the PLC basic program: <ul style="list-style-type: none"> <li>– Status signals from NCK to PLC (user interface) are deleted (cleared)</li> <li>– Change signals for help functions are deleted</li> <li>– Cyclic processing of the PLC to NCK user interface is terminated</li> </ul> </li> </ul> <p>For further information see References!</p> <p>The control is not ready again until after POWER ON.</p>
Corresponding to ....	Relay contact "NC Ready"
Additional references	/DA/ Diagnosis Manual /FB1/ Function Manual Basic Functions, PLC Basic Program (P3)

<b>DB10 DBX109.0</b>	<b>NCK alarm is active</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	<p>At least one NCK alarm is present.</p> <p>This is a group signal for the interface signals of all existing channels: DB21, ... DBX36.6 (channel-specific NCK alarm is active).</p>
Signal state 0 or edge change 1 → 0	No NCK alarm is active.
Corresponding to ....	DB21, ... DBX36.6 (channel-specific NCK alarm is active) DB21, ... DBX36.7 (NCK alarm with processing stop present)
Additional references	/DA/ Diagnostics Manual

<b>DB10 DBX109.5</b>	<b>Heatsink temperature alarm, NCU 573</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	<p>In NCU 573, the limit values of the heat sink temperature was exceeded.</p> <p>The heat sink temperature got activated and a steady operation of the operator panel is no longer guaranteed.</p>
Signal state 0 or edge change 1 → 0	The heatsink monitoring function of the NCU 573 has not responded.

<b>DB10 DBX109.6</b>	<b>Air temperature alarm</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	<p>The ambient temperature or fan monitoring function has responded.</p> <p>This may be due to the following causes:</p> <ul style="list-style-type: none"> <li>• The temperature monitoring has identified an ambient temperature that is too high (approx. 60 °C). Alarm 2110 "NCK temperature alarm" is output.</li> <li>• The speed monitoring of the 24 V DC fan used to cool the module has responded. Alarm 2120 "NCK fan alarm" is output.</li> </ul> <p>Measures: Replace the fan and/or ensure that additional ventilation is provided.</p> <p>When a temperature or fan error responds, a relay contact (terminal 5.1, 5.2 or 5.1, 5.3) in the infeed/regenerative feedback unit is activated which can be evaluated by the customer.</p>
Signal state 0 or edge change 1 → 0	Neither the temperature monitoring nor the fan monitoring has responded.
Application example(s)	Appropriate measures can be initiated by the PLC user program if the temperature or fan monitoring is activated.
Corresponding to ....	When a temperature or fan error responds, a relay contact (terminal 5.1, 5.2 or 5.1, 5.3) in the infeed/regenerative feedback unit is activated. This can be evaluated.
Additional references	/DA/ Diagnostics Manual

<b>DB10 DBX109.7</b>	<b>NCK battery alarm</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	<p>The NCK battery voltage monitoring function has responded.</p> <p>This may be due to the following causes:</p> <ul style="list-style-type: none"> <li>• The battery voltage is within the pre-warning limit range (approx. 2.7 to 2.9 V). Alarm 2100 "NCK battery warning threshold reached" has been triggered. Refer to References for effects and measure.</li> <li>• The battery voltage is below the pre-warning limit range (<math>\leq 2.6</math> V). Alarm 2101 "NCK battery alarm" is signaled in cyclic operation. Effects: A supply voltage failure - e.g. when the control is switched off - would result in the loss of battery-buffered data (e.g. part program memory, variables, machine data ...). Measure: Refer to additional References.</li> <li>• When the control ran-up, it was identified that the battery voltage was below the pre-warning limit range (<math>\leq 2.6</math> V). Alarm 2102 "NCK battery alarm" is output; NC ready and mode group ready are not issued. Effects: Some of the battery-buffered data may already have been lost! Measure: Refer to additional References.</li> </ul>
Signal state 0 or edge change 1 → 0	The battery voltage is above the lower limit value (normal condition).
Special cases, errors, ...	The NCK batteries should only be replaced while the NC is switched on to avoid data loss because of no memory backup.
Additional references	/DA/ Diagnostics Manual /IAD/ SINUMERIK 840D/611D, Installation and Startup Guide

18.2.4 Signals to operator panel (DB19)

<b>DB19 DBX0.0</b>	<b>Screen bright</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	The screen blanking is disabled.	
Signal state 0 or edge change 1 → 0	The screen blanking remains in effect.	
Corresponding to ....	DB19 DBX0.1 (darken screen)	

<b>DB19 DBX0.1</b>	<b>Darken screen</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	The screen is darkened by the PLC user program. The automatic screen brightening/darkening is therefore ineffective: i.e. the screen does not brighten up automatically on actuating the keyboard.	
Signal state 0 or edge change 1 → 0	The screen is controlled by the PLC user program "bright". In this signal state, the screen brightening/darkening setting can be derived by the control via the keyboard automatically. The screen is darkened if no key is pressed for a period defined via the following machine data on the keyboard: MD9006 \$MM_DISPLAY_BLACK_TIME (time to darken the screen) The screen is brightened the next time a key on the operator panel front is pressed.	
Application example(s)	Screen saver	
Special cases, errors, ....	Notice: The keyboard of the operator panel front continues to be effective if the interface signal: DB19 DBX0.1 (darken screen) = 1 We therefore recommend that this is disabled using the interface signal: DB19 DBX0.2 (key disable)	
Corresponding to ....	DB19 DBX0.2 (key disable) MD9006 \$MM_DISPLAY_BLACK_TIME (time to darken the screen)	

<b>DB19 DBX0.2</b>	<b>Key disable</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	The keyboard is disabled for the user.
Signal state 0 or edge change 1 → 0	The keyboard is enabled for the user.
Application example(s)	If the screen is darkened with the interface signal: DB19 DBX0.1 (darken screen), the keyboard should be actuated simultaneously with the interface signal: DB19 DBX0.2 (key disable) to avoid an unintended operation.
Corresponding to ....	DB19 DBX0.1 (darken screen)

<b>DB19 DBX0.3</b>	<b>Clear cancel alarms</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	Clear error key on the machine control panel is pressed. All cancel alarms of the NCKs and the control panel are then acknowledged. The PLC application acknowledges the PLC alarms itself. PowerOn and Reset alarms remain active on the NCK until the cause of the error has been removed.
Signal state 0 or edge change 1 → 0	Clear error key on the machine control panel is not pressed.
Functionality	Only applicable to HMI Advanced or PCU 50.
Corresponding to ....	DB19 DBX20.3 (Cancel alarm cleared)

<b>DB19 DBX0.4</b>	<b>Clear recall alarms</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	Clear error key on the machine control panel is pressed. All cancel alarms of the NCKs and the control panel are then acknowledged. The PLC application acknowledges the PLC alarms itself. POWER On and Reset alarms remain active on the NCK until the cause of the error has been removed.
Signal state 0 or edge change 1 → 0	Clear error key on the machine control panel is not pressed.
Application example(s)	Applies to HMI Advanced only
Corresponding to ....	DB19 DBX20.4 (Recall alarm cleared)

18.2 Various interface signals and functions (A2)

<b>DB19 DBX0.7</b>	<b>Actual value in WCS</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	The PLC selects the display of actual values in the workpiece coordinate system (WCS). This means that when the machine area is selected, the WCS display is activated; i.e. the machine and the supplementary axes as well as their actual positions and distances to go are displayed in the WCS in the "Position" window.  The interface signal is only evaluated when it enters the basic machine screen; this means that the operator, within the machine area, can toggle as required between the particular coordinate systems using the softkeys "actual values MCS" and "actual values WCS".
Signal state 0 or edge change 1 → 0	This means that when the machine area is selected the coordinate system previously selected (WCS or MCS) is reactivated and displayed.
Application example(s)	Using the interface signal:DB19, DBX0.7 (actual value in WCS) = 1 each time that the machine area is re-selected, the workpiece coordinate system display frequently required by the operator (WCS), is selected.
Corresponding to ....	DB19 DBX20.7 (changeover MCS/WCS)
Additional references	Operation Guide HMI (corresponding to the used software)

<b>DB19 DBB2</b>	<b>Higraph first error display</b>
Edge evaluation: No	Signal(s) updated: Cyclically

<b>DB19 DBB4</b>	<b>Higraph first error display</b>
Edge evaluation: No	Signal(s) updated: Cyclically

<b>DB19 DBX6.0 - 6.7</b>	<b>Analog spindle 1, utilization in percent</b>
Edge evaluation: No	Signal(s) updated: Cyclically

<b>DB19 DBX7.0 - DBX7.7</b>	<b>Analog spindle 2, utilization in percent</b>
Edge evaluation: No	Signal(s) updated: Cyclically

<b>DB19 DBX8.0 - DBX8.7</b>	<b>Channel number of the machine control panel to HMI</b>
Edge evaluation: No	Signal(s) updated: Cyclically

<b>DB19 DBX10.0</b>	<b>Programming area selection</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	Program area selection active	
Signal state 0 or edge change 1 → 0	Program area selection inactive	

<b>DB19 DBX10.1</b>	<b>Alarm area selection</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	Alarm area selection active	
Signal state 0 or edge change 1 → 0	Alarm area selection inactive	

<b>DB19 DBX10.2</b>	<b>Tool offset selection</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	Tool offset selection active	
Signal state 0 or edge change 1 → 0	Tool offset selection inactive	

<b>DB19 DBX10.7</b>	<b>ShopMill control signal</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	

<b>DB19 DBX12.2</b>	<b>COM2</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	COM2 active	
Signal state 0 or edge change 1 → 0	COM2 inactive	
Application example(s)	Valid for HMI Embedded; a file transfer can be initiated via RS-232-C.	

18.2 Various interface signals and functions (A2)

<b>DB19 DBX12.3</b>	<b>COM1</b>	
Edge evaluation: No		Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	COM1 active	
Signal state 0 or edge change 1 → 0	COM1 inactive	
Application example(s)	Valid for HMI Embedded; a file transfer can be initiated via RS-232-C.	

<b>DB19 DBX12.4</b>	<b>RS-232-C Stop</b>	
Edge evaluation: No		Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	RS-232-C stop active	
Signal state 0 or edge change 1 → 0	RS-232-C stop inactive	
Application example(s)	Valid for HMI Embedded; a file transfer can be initiated via RS-232-C.	

<b>DB19 DBX12.5</b>	<b>RS-232-C external</b>	
Edge evaluation: No		Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	RS-232-C externally active	
Signal state 0 or edge change 1 → 0	RS-232-C externally inactive	
Application example(s)	Valid for HMI Embedded; a file transfer can be initiated via RS-232-C.	

<b>DB19 DBX12.6</b>	<b>RS-232-C off</b>	
Edge evaluation: No		Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	RS-232-C off active	
Signal state 0 or edge change 1 → 0	RS-232-C off inactive	
Application example(s)	Valid for HMI Embedded; a file transfer can be initiated via RS-232-C.	

<b>DB19 DBX12.7</b>	<b>RS-232-C on</b>	
Edge evaluation: No		Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	RS-232-C on active	
Signal state 0 or edge change 1 → 0	RS-232-C on inactive	
Application example(s)	Valid for HMI Embedded; a file transfer can be initiated via RS-232-C.	

<b>DB19 DBX13.5</b>	<b>Unload</b>	
Edge evaluation: No		Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	Unload active	
Signal state 0 or edge change 1 → 0	Unload inactive	
Application example(s)	Valid for HMI Embedded; a file transfer can be initiated using the hard disk.	

<b>DB19 DBX13.6</b>	<b>Load part program</b>	
Edge evaluation: No		Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	Loading active	
Signal state 0 or edge change 1 → 0	Loading inactive	
Application example(s)	Valid for HMI Embedded; a file transfer can be initiated using the hard disk.	

18.2 Various interface signals and functions (A2)

<b>DB19 DBX13.7</b>	<b>Selection</b>	
Edge evaluation: No		Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	Selection active	
Signal state 0 or edge change 1 → 0	Selection inactive	
Application example(s)	Valid for HMI Embedded; a file transfer can be initiated using the hard disk.	

<b>DB19 DBX14.0 - DBX14.6</b>	<b>PLC index</b>	
Edge evaluation: No		Signal(s) updated: Cyclically
Description	This byte for control of the V24 interface describes the PLC index for the standard control file, which specifies the axis, channel or TO number. This file is handled according to the contract from the PLC → HMI in the interface signal: DB19 DBB12	
Application example(s)	Valid for HMI Embedded, with reference to DB19 DBB12 Dependent on: DB19 DBX14.7=0 → Akt. FS: PLC index that specifies axis, channel or TO No. DB19 DBX14.7=1 → Pas.FS: PLC index for the user control file	

<b>DB19 DBX14.7</b>	<b>Active or passive file system</b>	
Edge evaluation: No		Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	Passive file system	
Signal state 0 or edge change 1 → 0	Active file system	
Application example(s)	Valid for HMI Embedded, with reference to DB19 DBB12	

<b>DB19 DBX15.0 - DBX15.7</b>	<b>PLC line offset</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Description	This byte to control the RS-232-C interface defines the line of the standard or user control file in which the control file to be transferred is specified.
Application example(s)	Valid for HMI Embedded, with reference to DB19 DBB12 Dependent on: DB19 DBX14.7=0 → Akt. FS: PLC line offset in a standard control file DB19 DBX14.7=1 → Pas. FS: PLC line offset in a user control file

<b>DB19 DBX16.0 - DBX16.6</b>	<b>PLC index for the user control file</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Description	This byte for controlling file transfer via hard disk defines the index for the control file (job list). This file is handled from the PLC → HMI corresponding to the contract which is in DB19 DBB13.
Application example(s)	Valid for HMI advanced, with reference to the interface signal: DB19 DBB13 Dependent on: DB19 DBX14.7=0 → Akt. FS: PLC index for the standard control file DB19 DBX14.7=1 → Pas.FS: PLC index for the user control file

<b>DB19 DBX16.7</b>	<b>Active or passive file system</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	Passive file system
Signal state 0 or edge change 1 → 0	Active file system
Application example(s)	with HMI Advanced always 1

<b>DB19 DBX17.0 - DBX17.7</b>	<b>PLC line offset in the user control file</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Description	This byte for controlling file transfer via the hard disk defines the line of the user control file in which the control file to be transferred is located.
Application example(s)	Valid for HMI Advanced, with reference to DB19 DBB13 Dependent on: DB19 DBX14.7=0 → Akt. FS: PLC line offset in a standard control file DB19 DBX14.7=1 → Pas. FS: PLC line offset in a user control file

18.2 Various interface signals and functions (A2)

<b>DB19 DBX44.0</b>	<b>Mode change disable</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	Mode change disable active	
Signal state 0 or edge change 1 → 0	Mode change disable active	

<b>DB19 DBX45.0</b>	<b>FC9 Out: Active</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	

<b>DB19 DBX45.1</b>	<b>FC9 Out: Done</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	

<b>DB19 DBX45.2</b>	<b>FC9 Out: Error</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	

<b>DB19 DBX45.3</b>	<b>FC9 Out: StartError</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	

18.2.5 Signals from operator control panel (DB19)

<b>DB19 DBX20.1</b>	<b>Screen is dark</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	The screen is darkened.	
Signal state 0 or edge change 1 → 0	The screen is not darkened.	
Application example(s)	Using this IS, the PLC can identify whether the screen was switched dark using the interface signal: DB19, DBX0.1 (darken screen) or using the machine data: MD9006 \$MM_DISPLAY_BLACK_TIME (screen blanking time).	
Corresponding to ....	MD9006 \$MM_DISPLAY_BLACK_TIME (screen blanking time)	

<b>DB19 DBX20.3</b>	<b>Cancel alarm cleared</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	Cancel alarm deleted active
Signal state 0 or edge change 1 → 0	Cancel alarm deleted inactive Note: The signal is not reset automatically, it must be set by the user via the PLC user program.

<b>DB19 DBX20.4</b>	<b>Recall alarm cleared</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	Recall alarm deleted inactive
Signal state 0 or edge change 1 → 0	Recall alarm deleted inactive Note: The signal is not reset automatically, it must be set by the user via the PLC user program.

<b>DB19 DBX20.6</b>	<b>Simulation selected</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	On entry to simulation = 1
Signal state 0 or edge change 1 → 0	On exit from simulation = 0
Application example(s)	Can be evaluated by machine manufacturer in order to activate the test on NC start. The following must be set in the drive machine data: MD1012 \$MD_FUNC_SWITCH, bit 2 = 0.  Status "Ext. pulse disable active, terminal 663 open" is then not transmitted to the NC.
Corresponding to ....	MD1012 \$MD_FUNC_SWITCH, bit 2

18.2 Various interface signals and functions (A2)

<b>DB19 DBX20.7</b>	<b>Switch over MCS/WCS</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	The coordinate system is switched over from workpiece coordinate system (WCS) to machine coordinate system (MCS) or from MCS to WCS. After it has been set, the signal is active for 1 PLC cycle.	
Signal state 0 or edge change 1 → 0	No effect	
Application example(s)	The interface signal: DB19, DBX20.7 (change over MCS/WCS) must be transferred to the interface signal: DB19, DBX0.7 (actual value in WCS) in order that the changeover becomes effective.	
Corresponding to ....	DB19, DBX0.7 (actual value in WCS)	

<b>DB19 DBX22.0 - DBX22.7</b>	<b>Displayed channel number from HMI</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	

<b>DB19 DBX24.0</b>	<b>Error (status RS-232-C from PLC)</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	Error status active	
Signal state 0 or edge change 1 → 0	Error status inactive	
Application example(s)	The actual status of the RS 232C is sent to the PLC in acknowledgment byte DB19.DBB24.	
Corresponding to ....	Applies to HMI Embedded	

<b>DB19 DBX24.1</b>	<b>O.K. (status RS-232-C from PLC)</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	O.K. status active	
Signal state 0 or edge change 1 → 0	O.K. status inactive	
Application example(s)	The actual status of the RS 232C is sent to the PLC in acknowledgment byte DB19.DBB24.	
Corresponding to ....	Applies to HMI Embedded	

<b>DB19 DBX24.2</b>	<b>COM2 (status RS-232-C from PLC)</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	COM2 active	
Signal state 0 or edge change 1 → 0	COM2 inactive	
Application example(s)	The actual status of the RS 232C is sent to the PLC in acknowledgment byte DB19.DBB24.	
Corresponding to ....	Applies to HMI Embedded	

<b>DB19 DBX24.3</b>	<b>COM1 (status RS-232-C from PLC)</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	COM1 active	
Signal state 0 or edge change 1 → 0	COM1 inactive	
Application example(s)	The actual status of the RS 232C is sent to the PLC in acknowledgment byte DB19.DBB24.	
Corresponding to ....	Applies to HMI Embedded	

<b>DB19 DBX24.4</b>	<b>RS-232-C stop (status RS-232-C from PLC)</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	RS-232-C stop active	
Signal state 0 or edge change 1 → 0	RS-232-C stop inactive	
Application example(s)	The actual status of the RS 232C is sent to the PLC in acknowledgment byte DB19.DBB24.	
Corresponding to ....	Applies to HMI Embedded	

<b>DB19 DBX24.5</b>	<b>RS-232-C external (status RS-232-C from PLC)</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	RS-232-C externally active	
Signal state 0 or edge change 1 → 0	RS-232-C externally inactive	
Application example(s)	The actual status of the RS 232C is sent to the PLC in acknowledgment byte DB19.DBB24. The bit "RS-232-C external" is delayed until the transfer of the part program to be externally executed has been started and the selection has been made. Only then is an "NC Start" possible.	
Corresponding to ....	Applies to HMI Embedded	

<b>DB19 DBX24.6</b>	<b>RS-232-C off (status RS-232-C from PLC)</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	RS-232-C off active	
Signal state 0 or edge change 1 → 0	RS-232-C off inactive	
Application example(s)	The actual status of the RS 232C is sent to the PLC in acknowledgment byte DB19.DBB24.	
Corresponding to ....	Applies to HMI Embedded	

<b>DB19 DBX24.7</b>	<b>RS-232-C on (status RS-232-C from PLC)</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	RS-232-C on active
Signal state 0 or edge change 1 → 0	RS-232-C on inactive
Application example(s)	The actual status of the RS 232C is sent to the PLC in acknowledgment byte DB19.DBB24.
Corresponding to ....	Applies to HMI Embedded

<b>DB19 DBX25.0 - DBX25.7</b>	<b>Error RS-232-C</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Description	<p>0 = no error</p> <p>1 = invalid number for the control file (value in DB19.DBB14&lt;127 or invalid)</p> <p>2 = DB19.DBB15 could not be read</p> <p>3 = control file /BD.DIR/PLC_IN_OUT_xxx.TEA not found (value in DB19.DBB14 invalid)</p> <p>4 = invalid index in control file. (value in DB19.DBB15 incorrect)</p> <p>5 = selected job list in the control file could not be opened (only HMI Advanced)</p> <p>6 = error in the job list (job list interpreter returns error) (only HMI Advanced)</p> <p>7 = job list interpreter signals empty job list (only HMI Advanced)</p> <p>8 = error during the RS-232-C transmission. The error text is entered into the DIENSTE PROTOKOLL [SERVICES REPORT].</p> <p>9 = error when executing job list (only HMI Advanced)</p>
Corresponding to ....	Applies to HMI Embedded

<b>DB19 DBX26.1</b>	<b>OK (job list selection from PLC, status)</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	Transfer correctly completed
Signal state 0 or edge change 1 → 0	Transfer completed with error
Corresponding to ....	Valid for HMI Advanced

18.2 Various interface signals and functions (A2)

<b>DB19 DBX26.2</b>	<b>Error (job list selection from PLC, status) (previously bit 0)</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	Transfer completed with error
Signal state 0 or edge change 1 → 0	Transfer correctly completed
Corresponding to ....	Valid for HMI Advanced

<b>DB19 DBX26.3</b>	<b>Active (job list selection from PLC, status)</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	Job in progress
Signal state 0 or edge change 1 → 0	No task in progress
Corresponding to ....	Valid for HMI Advanced

<b>DB19 DBX26.5</b>	<b>Unload (job list selection from PLC, status)</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	Unload active
Signal state 0 or edge change 1 → 0	Unload inactive
Corresponding to ....	Valid for HMI Advanced

<b>DB19 DBX26.6</b>	<b>Load (job list selection from PLC, status)</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	Loading active
Signal state 0 or edge change 1 → 0	Loading inactive
Corresponding to ....	Valid for HMI Advanced

<b>DB19 DBX26.7</b>	<b>Selection (job list selection from PLC, status)</b>	
Edge evaluation: No		Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	Selection active	
Signal state 0 or edge change 1 → 0	Selection inactive	
Corresponding to ....	Valid for HMI Advanced	

<b>DB19 DBX27.0 - DBX27.7</b>	<b>Data transfer error</b>	
Edge evaluation: No		Signal(s) updated: Cyclically
Description	<ul style="list-style-type: none"> <li>• 0 = no error</li> <li>• 1 = invalid number for control file (value in DB19.DBB16&lt;127 or invalid)</li> <li>• 2 = DB19.DBB17 could not be read</li> <li>• 3 = control file /BD.DIR/PLC_IN_OUT_xxx.TEA not found (value in DB19.DBB16 invalid)</li> <li>• 4 = invalid index in control file (value in DB19.DBB17 incorrect)</li> <li>• 5 = selected job list in control file could not be opened</li> <li>• 6 = error in the job list (job list interpreter signals an error)</li> <li>• 7 = job list interpreter signals an empty job list</li> <li>• 8 = data transfer error The error text is entered into the DIENSTE PROTOKOLL [SERVICES REPORT].</li> <li>• 9 = error while executing the job list</li> </ul>	
Corresponding to ....	Valid for HMI Advanced	

<b>DB19 DBX40.0 - DBX40.7</b>	<b>Mode group number</b>	
Edge evaluation: No		Signal(s) updated: Cyclically
Description	This byte contains the mode group number.	

18.2 Various interface signals and functions (A2)

<b>DB19 DBX41.0 - DBX41.7</b>	<b>Channel number (FC9: ChanNo)</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Description	This byte contains the channel number (FC9: ChanNo).

<b>DB19 DBX42.0</b>	<b>FC9: Start (measuring in Jog mode)</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	Start active
Signal state 0 or edge change 1 → 0	Start inactive

18.2.6 Signals to channel (DB21, ...)

<b>DB21, ... DBX6.2</b>	<b>Delete distance-to-go (channel-specific)</b>
Edge evaluation: no	Signal(s) updated: cyclic
Signal state 1 or edge change 0 → 1	<p>Delete distance-to-go (channel-specific):</p> <p>IS "Delete distance-to-go (channel-specific)" for path axes is only active in AUTOMATIC mode. The rising edge of the interface signal is only effective for the axes involved in the geometry grouping. These are also stopped with a ramp stop and their distance-to-go deleted (setpoint - actual value difference). Any remaining following error is not removed. The next program block is then started.</p> <p>IS "Delete distance-to-go (channel-specific)" is therefore ignored by positioning axes.</p> <p>Note:</p> <p>IS "Delete distance-to-go" does not influence the running dwell time in a program block with dwell time.</p>
Signal state 0 or edge change 1 → 0	No effect
Signal irrelevant for ...	Positioning axes
Application example(s)	To terminate motion because of an external signal (e.g. measuring probe)
Special cases, errors, ....	<p>Delete distance-to-go (channel-specific)</p> <p>When the axes have been stopped with IS "Delete distance-to-go" the next program block is prepared with the new positions. After a "Delete distance-to-go", geometry axes thus follow a different contour to the one originally defined in the part program.</p> <p>If G90 is programmed in the block after "Delete distance-to-go" it is at least possible to approach the programmed absolute position. On the other hand, with G91, the position originally defined in the part program is no longer reached in the following block.</p>
Corresponding to ....	DB21, ... DBX6.2 (delete distance-to-go (axis-specific))

## 18.2.7 Signals from channel (DB21, ...)

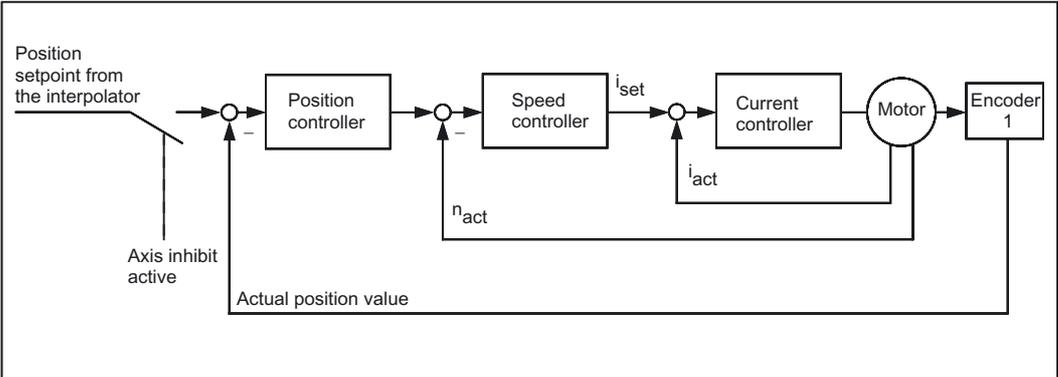
<b>DB21, ... DBX36.6</b>	<b>Channel-specific NCK alarm is active</b>	
Edge evaluation: no	Signal(s) updated: cyclic	
Signal state 1 or edge change 0 → 1	At least one NCK alarm is present for this channel. Thus the following group interface signal is also set: DB10 DBX109.0 (NCK alarm is present) The PLC user program can interrogate whether processing for the channel in question has been interrupted because of an NCK channel: DB21, ... DBX36.7 (NCK alarm with processing stop present).	
Signal state 0 or edge change 1 → 0	No NCK alarm is active for this channel.	
Corresponding to ....	DB21, ... DBX36.6 (NCK alarm with processing stop present) DB10 DBX109.0 (NCK alarm pending)	
Additional references	/DA/ Diagnostics Guide	

<b>DB21, ... DBX36.7</b>	<b>NCK alarm with processing stop present</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	At least one NCK alarm - which is causing a processing stop of the part program running in this channel - is active.	
Signal state 0 or edge change 1 → 0	There is no alarm active in this channel that is causing a processing stop.	
Application example(s)	With this alarm a program interruption because of an NCK alarm can be recognized immediately by the PLC user program and the necessary steps introduced.	
Corresponding to ....	DB21, ... DBX36.6 (channel-specific NCK alarm pending)	
Additional references	/DA/ Diagnostics Guide	

<b>DB21, ... DBX318.7</b>	<b>Overstore active</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	The overstore function is enabled (with the channel-specific PI service "_N_OST_ON"). If the PI service is denied, the signal will not change.
Signal state 0 or edge change 1 → 0	The overstore function is disabled (with the channel-specific PI service "_N_OST_OFF"). If the PI service is denied, the signal will not change.

### 18.2.8 Signals to axis/spindle (DB31, ...)

<b>DB31, ... DBX1.0</b>	<b>Drive test travel enable</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	<p>Safety handshake when the function generator is started by the NC.</p> <p>If an axis is to be traversed without further operator intervention, using: DB31, ... DBX61.0 (drive test travel request) = 1 signal, the NC requests a travel enable signal (permissive signal) from the PLC control.</p> <p>If all axis travel conditions are fulfilled, PLC acknowledges this with: DB31, ... DBX1.0 (drive test travel enable) = 1 signal</p> <p>The PLC always has the master authority in deciding whether an axis can be traversed.</p>
Signal state 0 or edge change 1 → 0	The NC does not request permission to move axis from the PLC with: DB31, ... DBX1.0 (drive test travel enable) = 0 signal
Additional references	/IAD/ SINUMERIK 840D Startup Guide; Chapter: SIMODRIVE 611D

<b>DB31, ... DBX1.3</b>	<b>Axis/spindle disable</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1 - Axis disable - Spindle disable	<p>(Test status)</p> <p>If the interface signal "Axis disable" is output - for this axis - no more position partial setpoints are output to the position controller; the axis travel is therefore disabled. The position control loop remains closed and the remaining following error is reduced to zero.</p> <p>If an axis is moved with axis disable the actual value position display shows the setpoint position and the actual velocity value display shows the setpoint velocity even though the machine axis is not actually moving.</p> <p>With a RESET the position actual value display is set to the real actual value of the machine.</p> <p>Travel commands continue to be output to the PLC for this axis.</p> <p>If the interface signal is canceled again the associated axis can again traverse normally.</p> <p>If the interface signal "Axis disable" is set for a traversing axis, the axis is stopped with a ramp stop.</p> <p>If the interface signal "Spindle disable" is set, as for axis disable, for this spindle no more speed setpoints are output to the speed controller in the open-loop control mode and no more position partial setpoints are output to the position controller in positioning mode. The movement of the spindle is thus disabled. The speed actual value display displays the speed setpoint value.</p> <p>Spindle disable can only be canceled per "Reset" or with M2 followed by a program restart.</p> <p>If interface signal "Spindle disable" is set while a spindle is turning, the spindle is stopped according to its acceleration characteristic.</p>
Signal state 0 or edge change 1 → 0	<p>(Normal conditions).</p> <p>The position setpoint values are transferred to the position controller cyclically.</p> <p>The speed setpoint values are transferred to the speed controller cyclically.</p> <p>Cancellation of the "Axis/spindle disable" (edge change 1 → 0) does not take effect until the axis/spindle is stationary (i.e. an interpolation setpoint is no longer present).</p>
	 <p>The diagram illustrates the control loop for an axis. It starts with a 'Position setpoint from the interpolator' which goes to a summing junction. An 'Axis inhibit active' signal also goes to this junction with a minus sign. The output goes to a 'Position controller'. The output of the position controller goes to another summing junction. The 'Actual position value' (labeled <math>n_{act}</math>) is fed back to this junction with a minus sign. The output goes to a 'Speed controller'. The output of the speed controller goes to a third summing junction. The 'Actual current' (labeled <math>i_{act}</math>) is fed back to this junction with a minus sign. The output goes to a 'Current controller', which drives a 'Motor'. The 'Motor' is connected to 'Encoder 1', which provides the 'Actual position value' feedback.</p>
Application example(s)	<p>The interface signal "Axis disable" and "Spindle disable" is used when running-in and testing a new NC part program. In so doing, the machine axes and spindles should not execute any traversing or rotational movement.</p>

<p><b>DB31, ... DBX1.3</b></p>	<p><b>Axis/spindle disable</b></p>																																													
<p>Special cases, errors, ....</p>	<p>If, for an axis/spindle "axis/spindle disable" is present, then the interface signals: DB31, ... DBX2.1 (controller enable), DB2 ... (feed/spindle stop) and where relevant DB31, ... DBX12.0-12.1 (hardware limit switch) are not effective regarding braking the axis/spindle.</p> <p>The axis/spindle can however be brought into the "follow up" or "hold" state (refer to DB31, ... DBX1.4 (follow-up mode)).</p> <p>Notes:</p> <p>This signal inhibits setpoint output to the drive.</p> <p>A brief pulse can bring a traversing axis to a standstill. The axis will not move again in this block, but only when the next block is reached.</p> <p>Re-synchronization takes place automatically on the next traversing command for this axis, i.e. the axis traverses the remaining distance-to-go.</p> <div style="border: 1px solid black; padding: 10px; margin: 10px 0;"> <p style="text-align: center;">Example:</p> <pre>G0 X0 Y0 G1 F1000 X100 ; for X20 the signal "axis inhibit" briefly comes,                 ; X-axis remains stationary, the NC continues to interpolate Y100 X200 ; X travels from approx. 20 to 200 ...</pre> </div> <p>For response together with synchronized operation, see:</p> <p><b>References:</b> /FB2/ Function Manual, Extended Functions; Synchronized Spindle (S3)</p> <p>This signal is no longer effective when the coupling for FS/FA is activated. → No. 6</p> <p>If the signal for the LS/LA is set, it also applies to the FS/FA(s) → No. 7</p> <p>A workpiece clamped between two spindles (workpiece transfer from front to rear-side machining) cannot be destroyed.</p> <div style="border: 1px solid black; padding: 10px; margin: 10px 0;"> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>No.</th> <th>set: 1 LS/LA</th> <th>not set: 0 FS/FA</th> <th>Coupling</th> <th>Procedure</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>0</td> <td>0</td> <td>Off</td> <td>Setpoints of axes are output</td> </tr> <tr> <td>2</td> <td>0</td> <td>1</td> <td>Off</td> <td>No setpoint output for FS/FA</td> </tr> <tr> <td>3</td> <td>1</td> <td>0</td> <td>Off</td> <td>No setpoint output for LS/LA</td> </tr> <tr> <td>4</td> <td>1</td> <td>1</td> <td>Off</td> <td>No setpoint output for LS/LA and FS/FA</td> </tr> <tr> <td>5</td> <td>0</td> <td>0</td> <td>ON</td> <td>Setpoints of axes are output</td> </tr> <tr> <td>6</td> <td>0</td> <td>1</td> <td>ON</td> <td>Disable not effective for FS/FA</td> </tr> <tr> <td>7</td> <td>1</td> <td>0</td> <td>ON</td> <td>Disable also effective for FS/FA</td> </tr> <tr> <td>8</td> <td>1</td> <td>1</td> <td>ON</td> <td>No setpoint output for LS/LA and FS/FA</td> </tr> </tbody> </table> </div>	No.	set: 1 LS/LA	not set: 0 FS/FA	Coupling	Procedure	1	0	0	Off	Setpoints of axes are output	2	0	1	Off	No setpoint output for FS/FA	3	1	0	Off	No setpoint output for LS/LA	4	1	1	Off	No setpoint output for LS/LA and FS/FA	5	0	0	ON	Setpoints of axes are output	6	0	1	ON	Disable not effective for FS/FA	7	1	0	ON	Disable also effective for FS/FA	8	1	1	ON	No setpoint output for LS/LA and FS/FA
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<p>Corresponding to ....</p>	<p>DB21, ... DBX33.7 (program test active)</p>																																													

DB31, ... DBX1.4	Follow-up mode
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1	<p>Follow-up mode is selected for the axis/spindle by the PLC.</p> <p>The means that the position setpoint continually tracks the actual value if the controller enable for the drive is withdrawn.</p> <p>As soon as the follow-up mode is effective, the interface signal: DB31, ... DBX61.3 (follow-up mode active) is set to a 1 signal.</p> <p>The actual value continues to be acquired and updated. If the axis/spindle is moved from its current position by an external effect the zero speed and clamping monitoring do not issue an alarm.</p> <p>When the closed-loop control system is reactivated, a control-internal repositioning operation is performed (REPOSA: linear approach with all axes) to the last programmed position if a part program is active.</p>
Signal state 0	<p>Follow-up mode is not selected (hold).</p> <p>When "controller enable" is removed the previous position setpoint is kept in the control. If the axis/spindle is moved out of position during this time a following error occurs between the position setpoint and the position actual value. This position difference is reduced to zero immediately by issuing "controller enable" so that the previous setpoint position is restored. Then, all the other axis movements start from the setpoint position valid before "controller enable" was removed.</p> <p>When the position control is switched in again the axis may make a speed setpoint jump. Zero speed monitoring or clamping monitoring is still active.</p> <p>In order to disable (switch-out) the zero speed monitoring, when clamping an axis, the interface signal: DB31, ... DBX2.3 (clamping operation running) should be set.</p> <p>In the "holding state", the interface signal: DB31, ... DBX61.3 (follow-up mode active) is set to a 0 signal.</p>
Special cases, errors, ....	<p>If the drive controller enable is withdrawn inside the control due to faults, then the following should be carefully observed:</p> <p>Before an NC start, after the queued alarms have been successfully deleted (i.e. inside the control, the controller enable is re-issued), then "holding" should be activated: DB31, ... DBX1.4 (follow-up mode) = 0</p> <p>Otherwise, for an NC start and selected follow-up mode, the traversing distance of the previous NC block would not be executed due to the internal delete distance to go.</p> <p>Notice:</p> <p>When changing over from the "follow-up" state to the "hold" state and in the control mode (a controller enable is issued), a delete distance-to-go command is activated in the control. As a consequence, for example, an NC block - in which only this axis is traversed - is ended directly.</p>
Corresponding to ....	<p>DB31, ... DBX2.1 (controller enable)</p> <p>DB31, ... DBX2.3 (clamping in progress)</p> <p>DB31, ... DBX61.3 (follow-up mode active)</p>

<b>DB31, ... DBX1.5 - DBX1.6</b>	<b>Position measuring system 1 (PMS1)/Position measuring system 2 (PMS2)</b>
Edge evaluation: No	Signal(s) updated: Cyclically
PMS1: Signal state 1 PMS2: Signal state 0	Position measuring system 1 is used for the axis/spindle (e.g. for position control, absolute value calculation, display). If a position measuring system 2 also exists (MD30200 \$MA_NUM_ENC = 2), this actual value is also acquired.
PMS1: Signal state 0 PMS2: Signal state 1	Position measuring system 2 is used for the axis/spindle (e.g. for position control, absolute value calculation, display). If a position measuring system 1 also exists, this actual value is also acquired.
PMS1: Signal state 1 PMS2: Signal state 1	As it is not possible to use both position measuring systems simultaneously for the position control of an axis/spindle, the control automatically selects position measuring system 1. If a position measuring system 2 also exists, this actual value is also acquired.
PMS1: Signal state 0 PMS2: Signal state 0	<ol style="list-style-type: none"> <li>1. The axis is in the park position.            This means that the following features are valid:           <ul style="list-style-type: none"> <li>– Both position measuring systems are inactive.</li> <li>– There is no actual value acquisition.</li> <li>– The position measuring system monitoring functions are disabled (among others, cable connection of a measured value encoder).</li> </ul>           The reference point has no effect:            DB31, ... DBX60.4/5 (referenced/synchronized) has the signal condition 0            As soon as an axis is parked, the interface signals:            DB31, ... DBX61.5 (position controller active),            DB31, ... DBX61.6 (speed controller active)            and            DB31, ... DBX61.7 (current controller active)            are set to a 0.            After parking has been completed the axis must be re-referenced (reference point approach).            If interface signals PMS1 and PMS2 are set to 0 while the axis is moving, the axis is stopped with a ramp stop without the controller enable being internally withdrawn.            This is appropriate for the following situations:           <ul style="list-style-type: none"> <li>– Spindle encoder no longer outputs a signal above a certain speed (no longer supplies any pulses).</li> <li>– Spindle encoder is decoupled mechanically because it would not be able to cope with the speed.</li> <li>– The spindle can then continue to run in speed-controlled mode. In order to really bring the axis/spindle to a stop, the controller enable must always be removed additionally by the PLC.</li> </ul> </li> <li>2. The spindle does not have a position measuring system and is only speed controlled.            In this case, the interface signal:            DB31, ... DBX2.1 (controller enable)            should be set to a 1 signal.</li> </ol>

DB31, ... DBX1.5 - DBX1.6	Position measuring system 1 (PMS1)/Position measuring system 2 (PMS2)
Application example(s)	<p>1. Changing over from position measuring system 1 to positioning measuring system 2 (and vice versa).</p> <p>If the axis in both position measuring systems was referenced and the limit frequency of the measured value encoder has not been exceeded in the meantime (i.e. DB31, ... DBX60.4 and 60.5 (referenced/synchronized 1 and 2) has signal state 1, then after the changeover, a reference point approach does not have to be repeated.</p> <p>On switchover, the current difference between position measuring system 1 and 2 is traversed immediately.</p> <p>With the machine data: MD36500 \$MA_ENC_CHANGE_TOL (maximum tolerance on position actual value changeover) a tolerance bandwidth can be entered - the deviation between the two actual values may lie within this bandwidth when changing over.</p> <p>If the actual value difference is greater than the tolerance, a switchover between the two systems does not take place and alarm 25100 "Measuring system switchover" not possible is triggered.</p> <p>2. Parking axis (i.e. no PMS is active):</p> <p>If the encoder has to be removed - e.g. if a rotary table has to be removed from the machine - the position measuring system monitoring is switched off in the parking position.</p> <p>The mounted axis/spindle encoder turns so quickly in certain applications that it can no longer maintain its electrical characteristics (edge rate-of-rise, etc.).</p> <p>3. Switch-off measuring system:</p> <p>When measuring system 1 or 2 is switched off the associated interface signal: DB31, ... DBX60.4/60.5 (referenced/synchronized 1/2) is reset.</p> <p>4. Reference point approach:</p> <p>Reference point approach of the axis is executed with the selected position measuring system. Every PMS must be separately referenced.</p>
Special cases, errors, ....	<p>If the state "parking axis" is active, the interface signal: DB31, ... DBX60.4/60.5 (referenced/synchronized 1/2) is ignored at NC start for this axis.</p>
Corresponding to ....	<p>DB31, ... DBX60.4 (referenced/synchronized 1) DB31, ... DBX60.5 (referenced/synchronized 2) DB31, ... DBX61.6 (speed controller active) DB31, ... DBX2.1 (controller enable) MD36500 \$MA_ENC_CHANGE_TOL (Max. tolerance on position actual value switchover) MD30200 \$MA_NUM_ENC_S (number of encoders)</p>
Additional references	/FB1/ Function Manual, Basic Functions; Speeds, Set-Actual Value System, Control (G2)

DB31, ... DBX2.1	<b>Controller enable</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1	The position control loop of the axis/spindle is closed; the axis/spindle is in closed-loop control.
Signal state 1 or edge change 0 → 1	<p>When "controller enable" is set by the PLC user program:</p> <ul style="list-style-type: none"> <li>• Position control loop of axis is closed.</li> <li>• Position actual value is no longer switched to the position setpoint.</li> <li>• The controller enable of the drive is output.</li> <li>• The interface signal: DB31, ... DBX61.5 (position controller active) is set to 1.</li> </ul> <p>When "controller enable" has been signaled no new actual value synchronization of the axis (reference point approach) of the axis is necessary if the maximum permissible limit frequency of the axis measuring system has not been exceeded during follow-up mode.</p> <p>As a function of the interface signal: DB31, ... DBX1.4 ( follow-up mode) it is possible to select whether or not the axis first traverses back to the earlier setpoint position (i.e. the positional deviation caused by the clamping process is moved through to eliminate the deviation).</p>
Edge change 1 → 0 or signal state 0	<p>"Controller enable" will be/is removed:</p> <p>The procedure for removing "controller enable" depends on whether the axis/spindle or an axis of the geometry grouping is stationary or traversing at this point in time.</p> <ul style="list-style-type: none"> <li>• Axis/spindle stationary: <ul style="list-style-type: none"> <li>– Position control loop of axis is opened.</li> <li>– When IS "Follow-up mode" = 1 the position actual value is switched to the position setpoint (i.e. the setpoint position is corrected to the actual value position). The position actual value of the axis/spindle continues to be acquired by the control.</li> <li>– The controller enable of the drive is removed.</li> <li>– The interface signals: DB31, ... DBX61.5 (position controller active) DB31, ... DBX61.6 (speed controller active) DB31, ... DBX61.7 (current controller active) are set to 0.</li> </ul> </li> <li>• Axis/spindle traverses: <ul style="list-style-type: none"> <li>– The axis is stopped with rapid stop.</li> <li>– Alarm 21612 "VDI signal controller enable reset during movement" is triggered.</li> <li>– The position control loop of the axis/spindle is opened.</li> <li>– Independent of the interface signal: DB31, ... DBX1.4 (follow-up mode) At the end of braking the position actual value is switched to the position setpoint (i.e. the setpoint position is corrected to track the actual value position). The position actual value of the axis/spindle continues to be acquired by the control. IS "Follow-up mode" is set.</li> <li>– The interface signals: DB31, ... DBX61.5 (position controller active) DB31, ... DBX61.6 (speed controller active) DB31, ... DBX61.7 (current controller active) are set to 0.</li> </ul> </li> </ul> <p>The axis status cannot be changed again until after RESET.</p>

<b>DB31, ... DBX2.1</b>	<b>Controller enable</b>
Application example(s)	<p>Using controller enable when clamping the axis:</p> <p>The axis is positioned to the clamping position. As soon as it has stopped it is clamped and then controller enable is removed. Controller enable is removed because the axis could be mechanically pressed out of position slightly by clamping and the position controller would continuously have to work against the clamping.</p> <p>When clamping is to be stopped, a controller enable signal is first set again and then the axis is freed from clamping.</p>
Special cases, errors, ....	<p>If an attempt is made to traverse the axis/spindle without controller enable, the axis/spindle remains stationary but sends a traversing/move command to the PLC (axis only). The traversing/move command is kept and is executed when the controller enable is re-activated.</p> <p>If the controller enable of a traversing geometry axis is removed the programmed contour cannot be maintained.</p> <p>Controller enable is automatically cancelled by the control when certain faults occur at the machine, the position measuring system or the control.</p>
Corresponding to ....	<p>DB31, ... DBX61.3 (follow-up mode active)</p> <p>DB31, ... DBX1.4 (follow-up mode)</p> <p>DB31, ... DBX61.5 (position controller active)</p> <p>DB31, ... DBX61.6 (speed controller active)</p> <p>DB31, ... DBX61.7 (current controller active)</p> <p>MD36620 \$MA_SERVO_DISABLE_DELAY_TIME (switch-off delay controller enable)</p> <p>MD36610 \$MA_AX_EMERGENCY_STOP_TIME (braking ramp time when errors occur)</p>

<b>DB31, ... DBX2.2</b>	<b>Delete distance-to-go (axis-specific)/spindle reset</b>
Edge evaluation: yes	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	<p>Delete distance-to-go (axis-specific):</p> <p>Depending on the operating mode, the following occurs for IS "delete distance-to-go axial":</p> <ul style="list-style-type: none"> <li>In the JOG mode:                     <p>If the interface signal is set for one axis (edge change 0 → 1), this axis is stopped with ramp stop and its distance-to-go deleted (setpoint-actual value difference). Any remaining following error is removed.</p> </li> <li>for AUTOMATIC and MDA:                     <p>The rising edge of the interface signals only influences the axes which are not in the geometry grouping. They are stopped with ramp stop and their distance-to-go deleted (setpoint-actual value difference). The next program block can then be started. IS "delete distance-to-go axial" is therefore ignored by geometry axes.</p> </li> </ul> <p>Note: IS "Delete distance-to-go" does not influence the running dwell time in a program block with dwell time.</p>
Signal state 0 or edge change 1 → 0	No effect
Application example(s)	To terminate motion because of an external signal (e.g. measuring probe)

18.2 Various interface signals and functions (A2)

<b>DB31, ... DBX2.2</b>	<b>Delete distance-to-go (axis-specific)/spindle reset</b>
Special cases, errors, ....	"Delete distance-to-go (axial)" After the axes have been stopped with "Delete distance-to-go" the next program block is prepared with the new positions. The axes thus follow a different contour to the one originally defined in the part program after a "Delete distance-to-go". If G90 is programmed in the block after "Delete distance-to-go" it is at least possible to approach the programmed absolute position. On the other hand, with G91, the position originally defined in the part program is not reached in the following block.
Corresponding to ....	DB21, ... DBX6.2 (delete distance-to-go, channel-specific)
Additional references	/FB1/ Function Manual, Basic Functions; Spindles (S1)

<b>DB31, ... DBX9.0 - DBX9.2</b>	<b>Controller parameter set switchover (request) requested parameter set</b>
Edge evaluation: No	Signal(s) updated: On request
Signal state 1 or edge change 0 → 1	-
Signal state 0 or edge change 1 → 0	-
Signal irrelevant for ...	MD35590 \$MA_PARAMSET_CHANGE_ENABLE = 0
Application example(s)	The binary-coded index of the parameter set to be activated is located in the 3 bits: <ul style="list-style-type: none"> <li>• 0 corresponds to the 1st parameter set</li> <li>• 1 corresponds to the 2nd parameter set</li> <li>• etc. (max. 6 parameter sets are possible)</li> </ul>
Special cases, errors, ....	Indices 6-7 are mapped onto parameter set 6.
Corresponding to ....	DB31, ...DBX69.0-69.2

<b>DB 31, ... DBX9.3</b>	<b>Disable parameter set switchover commands from NC Locks</b>
Signal state 1 or edge change 0 → 1	NC should not initiate any parameter set switchovers.
Signal state 0 or edge change 1 → 0	Parameter set switchover by the NC is enabled.
Corresponding to ....	DB31, ... DBX9.0 - DBX9.2

<b>DB31, ... DBX20.0</b>	<b>Ramp-up times</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	V/f operation operation is activated using machine data: MD1014 \$MD_U/F_MODE_ENABLE. The time entered in the machine data: MD1126 \$MD_U/F_MODE_RAMP_TIME_2 is effective.	
Signal state 0 or edge change 1 → 0	V/f operation operation is activated using machine data: MD1014 \$MD_U/F_MODE_ENABLE. The time entered in the machine data: MD1125 \$MD_U/F_MODE_RAMP_TIME_1 is effective.	
Signal irrelevant for ...	SINUMERIK 840Di	
Corresponding to ....	MD1014 \$MD_U/F_MODE_ENABLE (activate V/f operation) MD1125 \$MD_UF_MODE_RAMP_TIME_1 (ramp-up time 1 for V/f mode) MD1126 \$MD_UF_MODE_RAMP_TIME_2 (ramp-up time 2 for V/f mode)	
Additional references	/FBA/ SIMODRIVE 611D Function Manual Drive Functions	

<b>DB31, ... DBX20.1</b>	<b>Ramp-function generator fast stop</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	A fast stop is triggered by the PLC for the drive (611D). Speed setpoint 0 is therefore entered. The drive is stopped without a ramp function (regenerative braking). As soon as the fast stop is recognized by the drive module, the interface signal: DB31, ... DBX92.1 (Ramp-function generator fast stop active) is returned to the PLC.	
Signal state 0 or edge change 1 → 0	No rapid stop is requested by the PLC for the drive.	
Signal irrelevant for ...	SINUMERIK 840Di	
Corresponding to ....	DB31, ... DBX92.1 (ramp-function generator fast stop active)	
Additional references	/IAD/ SINUMERIK 840D Installation and Startup Guide; Chapter: SIMODRIVE 611D	

DB31, ... DBX20.2	Torque limit 2
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	<p>Torque limit 2 is requested by the PLC for the axis/spindle.</p> <p>For 611D two torque limit values can be set for each axis/spindle, whereby torque limit 2 refers to torque limit 1 (reduction factor). Torque limit 2 is selected via the interface. The limit value is defined using the drive parameters.</p> <p>As soon as torque limit 2 is active for the drive, the drive signals this using the interface signal: DB31, ... DBX92.2 (torque limit 2 active)</p>
Signal state 0 or edge change 1 → 0	Only torque limit 1 has been selected by the PLC.
Signal irrelevant for ...	SINUMERIKI 840Di
Application example(s)	In order to reduce the stress on the mechanics and workpiece, the actual torque limit can be reduced using torque limit 2 for certain machining operations.
Corresponding to ....	DB31, ... DBX92.2 (torque limit 2 active)
Additional references	/IAD/ SINUMERIK 840D Installation and Startup Guide; Chapter: SIMODRIVE 611D

DB31, ... DBX20.3	Speed setpoint smoothing
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	<p>The PLC requests a filter to smooth the speed setpoint value.</p> <p>In the drive module the interface signal is only effective under the following conditions:</p> <ul style="list-style-type: none"> <li>• Speed setpoint filter 1 is active in the drive</li> <li>• speed setpoint filter 1 has been configured as a low-pass filter (i.e. not as a band-stop filter)</li> </ul> <p>As soon as these conditions exist whereby the smoothing of the speed setpoint is active, the 611D or 611U signals this to the PLC using the interface signal: DB31, ... DBX92.3 (speed setpoint smoothing active).</p>
Signal state 0 or edge change 1 → 0	No smoothing of the speed setpoint value is requested by the PLC.
Application example(s)	With this interface signal, speed setpoint smoothing can - for example - be activated from the PLC user program for a spindle during speed control to achieve smooth torque output. Speed setpoint smoothing can therefore be deactivated when the spindle is in positioning mode.
Special cases, errors, ....	
Corresponding to ....	DB31, ... DBX92.3 (speed setpoint smoothing active)
Additional references	/IAD/ SINUMERIK 840D Installation and Startup Guide; Chapter: SIMODRIVE 611D

<b>DB31, ... DBX21.0 - DBX21.2</b>	<b>Drive parameter set selection A, B, C</b>																																				
Edge evaluation: No	Signal(s) updated: Cyclically																																				
Meaning	<p>With bit combinations A, B and C it is possible to select 8 different drive parameter sets for the digital drives SIMODRIVE 611D/611U.</p> <p>The following assignment applies:</p> <table border="1" data-bbox="406 519 1465 898"> <thead> <tr> <th>Drive parameter set</th> <th>C</th> <th>B</th> <th>A</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>2</td> <td>0</td> <td>0</td> <td>1</td> </tr> <tr> <td>3</td> <td>0</td> <td>1</td> <td>0</td> </tr> <tr> <td>4</td> <td>0</td> <td>1</td> <td>1</td> </tr> <tr> <td>5</td> <td>1</td> <td>0</td> <td>0</td> </tr> <tr> <td>6</td> <td>1</td> <td>0</td> <td>1</td> </tr> <tr> <td>7</td> <td>1</td> <td>1</td> <td>0</td> </tr> <tr> <td>8</td> <td>1</td> <td>1</td> <td>1</td> </tr> </tbody> </table> <p>The switchable drive parameters are as follows:</p> <ul style="list-style-type: none"> <li>• Current setpoint filters (low-pass, band-stop); for adaptation to the mechanics</li> <li>• Motor speed normalization</li> <li>• Speed controller parameters</li> <li>• Speed setpoint filter</li> <li>• Speed monitoring data</li> </ul> <p>As soon as the new drive parameter becomes effective, the drive signals this to the PLC using the interface signals: DB31, ... DBX93.0, 1 and 2 (active parameter set).</p>	Drive parameter set	C	B	A	1	0	0	0	2	0	0	1	3	0	1	0	4	0	1	1	5	1	0	0	6	1	0	1	7	1	1	0	8	1	1	1
Drive parameter set	C	B	A																																		
1	0	0	0																																		
2	0	0	1																																		
3	0	1	0																																		
4	0	1	1																																		
5	1	0	0																																		
6	1	0	1																																		
7	1	1	0																																		
8	1	1	1																																		
Application example(s)	Drive parameter switchover can be used for the following: <ul style="list-style-type: none"> <li>• Changing the gear stage</li> <li>• Changing-over the measuring circuit</li> </ul>																																				
Special cases, errors, ....	In principle it is possible to switch over drive parameter sets at any time. However, as torque jumps can occur when switching over speed controller parameters and motor speed normalization, parameters should only be switched over when in the zero speed state (especially when the axis is stationary).																																				
Corresponding to ....	DB31, ... DBX93.0, 1 and 2 (active drive parameter set)																																				
Additional references	/IAD/ SINUMERIK 840D Installation and Startup Guide; Chapter: SIMODRIVE 611D																																				

<b>DB31, ... DBX21.3 - DBX21.4</b>	<b>Motor selection A, B</b>																			
Edge evaluation: No	Signal(s) updated: Cyclically																			
Description	<p>The PLC can switch between 4 different motors or motor mode types using the motor selection function.</p> <p>The following assignment applies:</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Motor selection</th> <th>Application</th> <th>B</th> <th>A</th> </tr> </thead> <tbody> <tr> <td>Motor 1</td> <td>Operating mode 1</td> <td>0</td> <td>0</td> </tr> <tr> <td>Motor 2</td> <td>Operating mode 2</td> <td>0</td> <td>1</td> </tr> <tr> <td>Motor 3</td> <td rowspan="2">res. up to SW6.3, then for 611D Performance 2 or 611U can be used for operating mode 3 or 4</td> <td>1</td> <td>0</td> </tr> <tr> <td>Motor 4</td> <td>1</td> <td>1</td> </tr> </tbody> </table> <p>As soon as a new motor selection is detected, the drive cancels the pulse enable (feedback signal using the interface signal DB31, ... DBX93.3 and 4 (active motor)).</p> <p>Using the motor selection, it is possible, for example, to choose mode 1 as star-connected operation and mode 2 as delta-connection operation for the main spindle drive (MSD).</p> <p>The drive signals the currently selected motor back to the PLC using the interface signals: DB31, ... DBX93.3 and 4 (active motor).</p>	Motor selection	Application	B	A	Motor 1	Operating mode 1	0	0	Motor 2	Operating mode 2	0	1	Motor 3	res. up to SW6.3, then for 611D Performance 2 or 611U can be used for operating mode 3 or 4	1	0	Motor 4	1	1
Motor selection	Application	B	A																	
Motor 1	Operating mode 1	0	0																	
Motor 2	Operating mode 2	0	1																	
Motor 3	res. up to SW6.3, then for 611D Performance 2 or 611U can be used for operating mode 3 or 4	1	0																	
Motor 4		1	1																	
Application example(s)	Timing for star-delta switchover																			
Special cases, errors, ....	<b>Caution:</b> Before a new motor is selected, the interface signal: DB31, ... DBX21.5 (motor selection carried out) must be set to 0!																			
Corresponding to ....	DB31, ... DBX93.3 and 4 (active motor) DB31, ... DBX21.5 (motor selected)																			
Additional references	/IAD/ SINUMERIK 840D Installation and Startup Guide; Chapter: SIMODRIVE 611D																			

<b>DB31, ... DBX21.5</b>	<b>Motor selection in progress</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	The PLC outputs the interface signal: DB31, ... DBX21.5 (motor selected) to the 611D to confirm that the external contactor has been switched over to the new motor (e.g. that motor contactor 2 has been energized as part of the star/delta switchover process). The pulses are then enabled by the drive.
Signal state 0 or edge change 1 → 0	The interface signal: DB31, ... DBX21.5 (motor selected) must be reset to 0 by the PLC user program before a new motor is selected! Otherwise the pulses from the drive might be enabled too early.
Corresponding to ....	DB31, ... DBX93.3 and 4 (active motor) DB31, ... DBX21.3 and 4 (motor selection A, B)
Additional references	/IAD/ SINUMERIK 840D Installation and Startup Guide; Chapter: SIMODRIVE 611D

<b>DB31, ... DBX21.6</b>	<b>Speed controller integrator disable</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	<p>The interface signal is used by the 611D/611U to disable the integrator of the speed controller. The speed controller is thus changed over from a PI to a P controller.</p> <p><b>Note:</b> If the speed controller integrator disable is activated, equalization processed might take place in certain applications (e.g. if the integrator was already holding a load while stationary).</p> <p>The 611D/611U acknowledges the integrator disable to the PLC using the interface signal: DB31, ... DBX93.6 (speed controller integrator disabled).</p>	
Signal state 0 or edge change 1 → 0	The integrator of the speed controller is enabled.	
Corresponding to ....	DB31, ... DBX93.6 (integrator n-controller disabled)	
Additional references	/IAD/ SINUMERIK 840D Installation and Startup Guide; Chapter: SIMODRIVE 611D	

<b>DB31, ... DBX21.7</b>	<b>Pulse enable</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	<p>Pulse enable is signaled by the PLC for this drive (axis/spindle).</p> <p>The pulses for the drive modules are only enabled if all enable signals (hardware and software) are available (see figure for DB31, ... DBX93.5).</p> <p>In this case, the interface signal: DB31, ... DBX93.7 (pulses enabled) is signaled to the PLC with a signal.</p> <p>For additional information refer to DB31, ... DBX93.7 and references.</p>	
Signal state 0 or edge change 1 → 0	<p>The pulses are disabled by the PLC for this drive.</p> <p>If pulse enable is canceled for a moving axis/spindle the axis/spindle is not longer braked in a controlled fashion. The axis coasts to rest.</p>	
Application example(s)	Signal relevant to safety	
Special cases, errors, ....	If pulse enable is canceled for a moving axis/spindle as a result of an Emergency Stop, the axis/spindle only coasts to rest.	
Corresponding to ....	DB31, ... DBX93.7 (pulses enabled)	
Additional references	/IAD/ SINUMERIK 840D Installation and Startup Guide; Chapter: SIMODRIVE 611D	

18.2.9 Signals from axis/spindle (DB31, ...)

<b>DB31, ... DBX61.0</b>	<b>Drive test travel request</b>
Edge evaluation: no	Signal(s) updated: cyclic
Signal state 1 or edge change 0 → 1	<p>The control signals that all of the traversing conditions for the drives are fulfilled.</p> <p>Prerequisites for this are:</p> <ul style="list-style-type: none"> <li>The mechanical brake of the axis involved was previously released and all other axis traversing conditions are fulfilled.</li> </ul> <p>With: DB31, ... DBX61.0 (drive test, travel request) = 1 signal the appropriate axes can be moved.</p> <ul style="list-style-type: none"> <li>The axis disable: DB31, ... DBX1.3 (axis/spindle disable) = 1 signal is not active.</li> </ul>
Signal state 0 or edge change 1 → 0	<p>The control signals that the axes cannot be moved.</p> <p>Axes cannot be moved for:</p> <ul style="list-style-type: none"> <li>DB31, ... DBX61.0 (drive test, travel request) = 0 signal</li> <li>in the control when faults are present</li> </ul> <p>This means that the prerequisites specified above are not fulfilled.</p>
Additional references	/IAD/ SINUMERIK 840D Installation and Startup Guide; Chapter: SIMODRIVE 611D

<b>DB31, ... DBX61.3</b>	<b>Follow-up mode active</b>
Edge evaluation: no	Signal(s) updated: cyclic
Signal state 1 or edge change 0 → 1	<p>The control signals that the follow-up mode for the axis/spindle is not active.</p> <p>Prerequisites for this are:</p> <ul style="list-style-type: none"> <li>The controller enable for the drive has been withdrawn (either by the PLC with "controller enable" = 0 signal or inside the control for faults; refer to the references)</li> <li>Follow-up operation is selected (either by the PLC with IS "follow-up operation" = 1 signal or in the control, e.g. when withdrawing the controller enable from an axis that is moving)</li> </ul> <p>The position setpoint continually tracks the actual value while the follow-up mode is active. Zero speed and clamping monitoring are not active.</p>
Signal state 0 or edge change 1 → 0	<p>The control signals that follow-up mode for the axis/spindle is not active. Zero speed and clamping monitoring are active.</p> <p>This means that the above specified prerequisites are not fulfilled.</p> <p>In the "hold" state, the interface signal: DB31, ... DBX61.3 (follow-up mode active) is 0.</p>
Special cases, errors, ....	<p>Notice:</p> <p>A delete distance-to-go is triggered internally in the control on transition from "Follow up" to "Hold" (IS "Follow-up mode" = 0) or in the closed-loop control mode (IS "Controller enable" = 1).</p>
Corresponding to ....	<p>DB31, ... DBX2.1 (controller enable)</p> <p>DB31, ... DBX1.4 (follow-up mode!)</p>
Additional references	/DA/ Diagnostics Guide

<b>DB31, ... DBX61.4</b>	<b>Axis/spindle stops</b>	
Edge evaluation: no	Signal(s) updated: cyclic	
Signal state 1 or edge change 0 → 1	The current speed of the axis or the actual number of rotations of the spindle lies under the limit given by the machine data: MD36060 \$MA_STANDSTILL_VELO_TOL (Maximum speed/number of rotations for signal "Axis/Spindle stationary").	
Signal state 0 or edge change 1 → 0	The actual velocity of the axis or the actual spindle speed is greater than the value specified in the MD (standstill/zero speed range). If a travel command is present, e.g. for a spindle, then the signal is always = 0 - even if the actual speed lies below that specified in MD36060. If the interface signal: DB31, ... DBX61.4 (axis/ spindle stationary) is signaled and there is no closed-loop position control active for the spindle, then at the MMC, an actual speed of zero is displayed and with the system variable \$AA_S[n] zero is read.	
Application example(s)	Enable signal for opening a protective device (e.g. open door). The workpiece chuck or the tool clamping device is only opened when the spindle is stationary. The oscillation mode can be switched-in during gear stage change after the spindle has been braked down to standstill. The tool clamping device must have been closed before the spindle can be accelerated.	
Corresponding to ....	MD36060 \$MA_STANDSTILL_VELO_TOL (maximum velocity/speed for signal "Axis/spindle stationary")	

18.2 Various interface signals and functions (A2)

<b>DB31, ... DBX61.5</b>	<b>Position controller active</b>
Edge evaluation: no	Signal(s) updated: cyclic
Signal state 1 or edge change 0 → 1	The control signals that the position controller for the axis or spindle is closed.
Signal state 0 or edge change 1 → 0	The control signals that the position controller for the axis or spindle is open. If "controller enable" is canceled because of a fault or from the PLC user program the position controller is opened and therefore the interface signal DB31, ... DBX61.5 (position controller active) is set to 0. Spindle without position control: Signal "Position controller active" is always "0". See References for other effects.
Application example(s)	If the position control is active the axis/spindle is kept in position by the position controller. Any brakes or clamps can thus be opened. The interface signal: DB31, ... DBX61.5 (position controller active) can be used as feedback signal for the interface signal: DB31, ... DBX2.1 (controller enable). The holding brake of a vertical axis must be activated as soon as the position control is no longer active. If a spindle has been technically designed/dimensioned for the purpose, in the part program, it can be changed-over into the closed-loop position controlled mode as spindle or as axis (with <i>SPCON</i> or <i>M70</i> ). In these cases, the interface signal "position controller active" is set.
Special cases, errors, ....	Special case for simulation axes (MD30350 \$MA_SIMU_AX_VDI_OUTPUT = "1"): The IS "position controller active" is also set for simulation axes as soon as MD = "1".
Corresponding to ....	DB31, ... DBX2.1 (controller enable) DB31, ... DBX1.4 (follow-up mode) DB31, ... DBX1.5 and 1.6 (position measuring system 1 and 2)
Additional references	/DA/ Diagnostics Guide

<b>DB31, ... DBX61.6</b>	<b>Speed controller active</b>
Edge evaluation: no	Signal(s) updated: cyclic
Signal state 1 or edge change 0 → 1	The control signals that the speed controller is closed for the axis or spindle.
Signal state 0 or edge change 1 → 0	The control signals that the speed controller is open for the axis or spindle. The speed controller output is cleared.
Application example(s)	If the spindle is not under position control, the interface signal can be used as a feedback for the interface signal: DB31, ... DBX2.1 (controller enable).

<b>DB31, ... DBX61.6</b>	<b>Speed controller active</b>
Special cases, errors, ....	Special case for simulation axes (MD30350 = "1"): The interface signal: DB31, ... DBX61.6 (speed controller active) is also set for simulation axes as soon as: MD30350 \$MA_SIMU_AX_VDI_OUTPUT (output of the axis signals for simulation axes) = "1".
Corresponding to ....	DB31, ... DBX61.5 (position controller active)

<b>DB31, ... DBX61.7</b>	<b>Current controller active</b>
Edge evaluation: no	Signal(s) updated: cyclic
Signal state 1 or edge change 0 → 1	The control signals that the current controller is closed for the axis or spindle.
Signal state 0 or edge change 1 → 0	The control signals that the current controller for the axis or spindle is open. The current controller output (including the feedforward quantities on the manipulated variable for the voltage) is cleared.
Corresponding to ....	DB31, ... DBX61.5 (position controller active) DB31, ... DBX61.6 (speed controller active)

<b>DB31, ... DBX69.0 - DBX69.2</b>	<b>Controller parameter set switchover (A (checkback signal)) Active parameter set</b>
Edge evaluation: no	Signal(s) updated: After switchover
Signal state 1 or edge change 0 → 1	-
Signal state 0 or edge change 1 → 0	-
Signal irrelevant for ...	MD35590 \$MA_PARAMSET_CHANGE_ENABLE = 0
Application example(s)	The binary-coded index of the activated parameter set is located in the 3 bits: <ul style="list-style-type: none"> <li>• 0 corresponds to the 1st parameter set</li> <li>• 1 corresponds to the 2nd parameter set</li> <li>• etc. (max. 6 parameter sets are possible)</li> </ul>
Special cases, errors, ....	Index 0 is returned if the switchover function is disabled with: MD35590 \$MA_PARAMSET_CHANGE_ENABLE = 0. In this case, the 1st parameter set is always active.
Corresponding to ....	DB31, ...DBX9.0 - DBX9.2 (controller parameter set switchover (request))

<b>DB31, ... DBX76.0</b>	<b>Lubrication pulse</b>	
Edge evaluation: yes	Signal(s) updated: cyclic	
Edge change 0 → 1 or 1 → 0	As soon as the axis/spindle has covered the traversing distance set in the machine data: MD33050 \$MA_LUBRICATION_DIST (travel distance for lubrication from the PLC), the interface signal: DB31, ...DBX76.0 (lubrication pulse) is inverted and the lubrication is started. The position measurement is restarted after each Power On.	
Application example(s)	The lubrication pump for the axis/spindle can be activated with IS "Lubrication pulse". Machine bed lubrication therefore depends on the distance traveled.	
Corresponding to ....	MD33050 \$MA_LUBRICATION_DIST (lubrication pulse distance)	

<b>DB31, ... DBX92.0</b>	<b>Setting-up mode active</b>	
Edge evaluation: no	Signal(s) updated: cyclic	
Signal state 1 or edge change 0 → 1	Setting-up mode is active for the drive (611D). The setting-up mode is selected using the terminals on the infeed/regenerative feedback module. The setting-up mode is required for optimizing the machining process. The following adaptations and additional functions are possible: <ul style="list-style-type: none"> <li>• Drive: <ul style="list-style-type: none"> <li>- Reducing the speed setpoint limits</li> <li>- Reducing the current setpoint limits</li> </ul> </li> <li>• I/RF: <ul style="list-style-type: none"> <li>- Disabling the closed-loop DC link voltage control</li> </ul> </li> </ul>	
Signal state 0 or edge change 1 → 0	Normal operation is active for the drive. The following thus applies: <ul style="list-style-type: none"> <li>• The maximum limit values for speed and current setpoint are active</li> <li>• DC link voltage control is active</li> </ul>	
Signal irrelevant for ...	SINUMERIK 840Di	
Additional references	/IAD/ SINUMERIK 840D Installation and Startup Guide; Chapter: SIMODRIVE 611D	

<b>DB31, ... DBX92.1</b>	<b>Ramp-function generator fast stop active</b>	
Edge evaluation: no	Signal(s) updated: cyclic	
Signal state 1 or edge change 0 → 1	<p>PLC receives the signal that the ramp function generator fast stop is active. The function has been activated by the interface signal: DB31, ... DBX20.1 (ramp-function generator fast stop)</p> <p>The drive is stopped without a ramp function with speed setpoint = 0 and without pulse suppression.</p>	
Signal state 0 or edge change 1 → 0	Ramp function generator fast stop is not active for the drive.	
Application example(s)	Bypassing the ramp function generator on the servo side	
Corresponding to ....	DB31, ... DBX20.1 (ramp-function generator fast stop)	
Additional references	/IAD/ SINUMERIK 840D Installation and Startup Guide; Chapter: SIMODRIVE 611D	

<b>DB31, ... DBX92.2</b>	<b>Torque limit 2 active</b>	
Edge evaluation: no	Signal(s) updated: cyclic	
Signal state 1 or edge change 0 → 1	Drive (611D) sends an acknowledgment to the PLC that torque limit 2 is active in addition to torque limit 1. The particular limit value is defined using the drive parameters.	
Signal state 0 or edge change 1 → 0	Only torque limit 1 is active.	
Signal irrelevant for ...	SINUMERIK 840Di	
Corresponding to ....	DB31, ... DBX20.2 (torque limit 2)	
Additional references	/IAD/ SINUMERIK 840D Installation and Startup Guide; Chapter: SIMODRIVE 611D	

<b>DB31, ... DBX92.3</b>	<b>Speed setpoint smoothing active</b>
Edge evaluation: no	Signal(s) updated: cyclic
Signal state 1 or edge change 0 → 1	The speed setpoint smoothing requested by the PLC with the interface signal: DB31, ... DBX20.3 (speed setpoint smoothing) is active.
Signal state 0 or edge change 1 → 0	No speed setpoint smoothing is active.
Corresponding to ....	DB31, ... DBX20.3 (speed setpoint smoothing)
Additional references	/IAD/ SINUMERIK 840D Installation and Startup Guide; Chapter: SIMODRIVE 611D

<b>DB31, ... DBX93.0 - DBX93.2</b>	<b>Active drive parameter set A, B, C</b>																																				
Edge evaluation: no	Signal(s) updated: cyclic																																				
Meaning	<p>The drive module (611D/611U) signals back to the PLC which drive parameter set is currently active.</p> <p>With bit combinations A, B and C, 8 different drive parameter sets can be selected for the 611D.</p> <p>The following assignment applies:</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th style="text-align: center;">active drive parameter set</th> <th style="text-align: center;">C</th> <th style="text-align: center;">B</th> <th style="text-align: center;">A</th> </tr> </thead> <tbody> <tr><td style="text-align: center;">1</td><td style="text-align: center;">0</td><td style="text-align: center;">0</td><td style="text-align: center;">0</td></tr> <tr><td style="text-align: center;">2</td><td style="text-align: center;">0</td><td style="text-align: center;">0</td><td style="text-align: center;">1</td></tr> <tr><td style="text-align: center;">3</td><td style="text-align: center;">0</td><td style="text-align: center;">1</td><td style="text-align: center;">0</td></tr> <tr><td style="text-align: center;">4</td><td style="text-align: center;">0</td><td style="text-align: center;">1</td><td style="text-align: center;">1</td></tr> <tr><td style="text-align: center;">5</td><td style="text-align: center;">1</td><td style="text-align: center;">0</td><td style="text-align: center;">0</td></tr> <tr><td style="text-align: center;">6</td><td style="text-align: center;">1</td><td style="text-align: center;">0</td><td style="text-align: center;">1</td></tr> <tr><td style="text-align: center;">7</td><td style="text-align: center;">1</td><td style="text-align: center;">1</td><td style="text-align: center;">0</td></tr> <tr><td style="text-align: center;">8</td><td style="text-align: center;">1</td><td style="text-align: center;">1</td><td style="text-align: center;">1</td></tr> </tbody> </table>	active drive parameter set	C	B	A	1	0	0	0	2	0	0	1	3	0	1	0	4	0	1	1	5	1	0	0	6	1	0	1	7	1	1	0	8	1	1	1
active drive parameter set	C	B	A																																		
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Application example(s)	<p>Drive parameter switchover can be used for the following:</p> <ul style="list-style-type: none"> <li>• To change the gear stage</li> <li>• To change over the measuring circuit</li> </ul>																																				
Corresponding to ....	DB31, ... DBX21.0 - DBX21.2 (drive parameter set selection)																																				
Additional references	/IAD/ SINUMERIK 840D Installation and Startup Guide; Chapter: SIMODRIVE 611D																																				

<b>DB31, ... DBX93.3 - DBX93.4</b>	<b>Active motor A, B</b>																						
Edge evaluation: no	Signal(s) updated: cyclic																						
Meaning	<p>The drive module (611D) returns signals to PLC stating which motor selection is currently active. Motor selection can be used with a main spindle drive (MSD) to switch between star and delta operation and so reduce the starting current. The following assignment applies:</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Active motor</th> <th>Application</th> <th>B</th> <th>A</th> </tr> </thead> <tbody> <tr> <td>Motor 1</td> <td>MSD: Star mode</td> <td>0</td> <td>0</td> </tr> <tr> <td>Motor 2</td> <td>MSD: Delta mode</td> <td>0</td> <td>1</td> </tr> <tr> <td>Motor 3</td> <td>Reserved</td> <td>1</td> <td>0</td> </tr> <tr> <td>Motor 4</td> <td>Reserved</td> <td>1</td> <td>1</td> </tr> </tbody> </table>			Active motor	Application	B	A	Motor 1	MSD: Star mode	0	0	Motor 2	MSD: Delta mode	0	1	Motor 3	Reserved	1	0	Motor 4	Reserved	1	1
Active motor	Application	B	A																				
Motor 1	MSD: Star mode	0	0																				
Motor 2	MSD: Delta mode	0	1																				
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Corresponding to ....	DB31, ... DBX21.3 and DBX21.4 (motor selection) DB31, ... DBX21.5 (motor selected)																						
Additional references	/IAD/ SINUMERIK 840D Installation and Startup Guide; Chapter: SIMODRIVE 611D																						

<b>DB31, ... DBX93.5</b>	<b>Drive Ready</b>		
Edge evaluation: no	Signal(s) updated: cyclic		
Signal state 1 or edge change 0 → 1	Feedback signal from the drive to the PLC that the drive is ready.		

<p><b>DB31, ... DBX93.5</b></p>	<p><b>Drive Ready</b></p>
<p>Signal state 0 or edge change 1 → 0</p>	<p>The drive is not ready. The drive might be disabled for the following reasons (refer to Fig.):</p> <ul style="list-style-type: none"> <li>• Enable terminals not energized (e.g. terminal 63 "Controller and pulse enable"; terminal 663 "Safe operating stop", terminal 64 "Setpoint enable")</li> <li>• Drive alarm active (e.g. motor temperature has reached switch-off threshold)</li> <li>• DC link voltage is too low</li> <li>• Drive has not yet reached cyclic operation</li> <li>• Hardware fault</li> <li>• No position measuring system is active ("parking axis" state)</li> <li>• I/R is not switched on</li> </ul> <p>As soon as the drive is ready for operation it is stopped (depending on the fault state either with pulse disable or fast stop) or pulse disable is maintained during ramp up.</p> <p>The interface signals: DB10 DBX108.6 (611D ready) DB31, ... DBX61.7 (current controller active) DB31, ... DBX61.6 (speed controller active) are also withdrawn.</p> <p>IS "611D Ready" is not available for the 840Di when used in conjunction with the drive 611U.</p>
<p>Corresponding to ....</p>	<p>DB10 DBX108.6 (611D-Ready) DB31, ... DBX61.7 (current controller active) DB31, ... DBX61.6 (speed controller active)</p>
<p>Additional references</p>	<p>/IAD/ SINUMERIK 840D Installation and Startup Guide; Chapter: SIMODRIVE 611D</p>

<b>DB31, ... DBX93.6</b>	<b>Speed controller integrator disabled</b>	
Edge evaluation: no	Signal(s) updated: cyclic	
Signal state 1 or edge change 0 → 1	The request from the PLC to disable the integrator of the speed controller using interface signal: DB31, ... DBX21.6 (integrator inhibit, speed controller) is active for the drive module. The speed controller has therefore switched from a PI to a P controller.	
Signal state 0 or edge change 1 → 0	The integrator of the speed controller is enabled. The speed controller functions as a PI controller.	
Corresponding to ....	DB31, ... DBX21.6 (integrator disable, n-controller)	
Additional references	/IAD/ SINUMERIK 840D Installation and Startup Guide; Chapter: SIMODRIVE 611D	

<b>DB31, ... DBX93.7</b>	<b>Pulses enabled</b>	
Edge evaluation: no	Signal(s) updated: cyclic	
Signal state 1 or edge change 0 → 1	The pulse enable for the drive module is available. The axis/spindle can now be traversed.	
Signal state 0 or edge change 1 → 0	<p>The drive module pulses are suppressed. Therefore, the axis/spindle cannot be traversed. The pulses are suppressed as soon as there is no enable signal (refer to Fig.). Also, if the "controller enable of drive" is withdrawn, the drive is stopped with setpoint 0 (regenerative braking). A timer is started in the drive module and after the configured time has expired: MD1404 \$MD_PULSE_SUPPRESSION_DELAY (timer stage, pulse suppression), the pulses are inhibited.</p> <p>If, within this time, the actual speed reaches the shutdown speed: MD1403 \$MD_PULSE_SUPPRESSION_SPEED (pulse suppression), then at this time, the pulses are inhibited.</p> <p>If the speed is less than/equal to the speed threshold (MD1403), and if the controller enable of the drive is withdrawn, then the pulses are immediately suppressed.</p> <p>Pulse suppression is also triggered if there is no position measuring system ("parking axis" state). As soon as the pulses are suppressed, then also the interface signals: DB31, ... DBX61.7 (current controller active) and DB31, ... DBX61.6 (speed controller active) are reset.</p>	

<p>DB31, ... DBX93.7</p>	<p><b>Pulses enabled</b></p>
	<p>PE = Pulse enable I/R = Infeed/regenerative feedback module</p>
	<p>Pulse enable for 611D drive module</p>
<p>Corresponding to ....</p>	<p>DB31, ... DBX21.7 (pulse enable) MD1404 \$MD_PULSE_SUPPRESSION_DELAY MD1403 \$MD_PULSE_SUPPRESSION_SPEED</p>
<p>Additional references</p>	<p>/IAD/ SINUMERIK 840D Installation and Startup Guide; Chapter: SIMODRIVE 611D</p>

DB31, ... DBX94.0	Motor temperature prewarning	
Edge evaluation: no	Signal(s) updated: cyclic	
Signal state 1 or edge change 0 → 1	<p>The drive module signals a "Motor temperature prewarning" to the PLC. In this case, the motor temperature has exceeded the defined warning threshold: MD1602 \$MD_MOTOR_TEMP_WARN_LIMIT (maximum motor temperature; standard value 120 °C) (Ⓜ in the diagram).</p> <p>If the motor temperature remains too high, after a defined time: MD1603 \$MD_MOTOR_TEMP_ALARM_TIME (timer state, motor temperature alarm, standard value 240 s) the drive is regeneratively braked and then the pulses are inhibited (Ⓜ in the diagram). Alarm 300614 is output and the interface signal: DB10 DBX108.6 (611D ready) is withdrawn.</p> <p>If the motor temperature rises still further and the shutdown threshold defined in: MD1607 \$MD_MOTOR_TEMP_SHUTDOWN_LIMIT (motor temperature shutdown limit, default value 155 °C) is reached, the drive is stopped immediately (refer to Ⓜ in the diagram). An alarm is also output and IS "Drive Ready" canceled.</p> <p>However, if the motor temperature drops back down to below the warning threshold, the IS is reset to 0 (refer to Ⓜ in the diagram).</p> <p><b>Special case:</b> If no temperature sensor signal is measured, this is interpreted as a fault in the motor PTC thermistor In this case, the interface signal: DB31, ... DBX94.0 (motor temperature prewarning) is also set. The procedure continues as described above.</p>	
Signal state 0 or edge change 1 → 0	<p>The motor temperature is below the warning threshold. The actual motor temperature is displayed in the axis/spindle service display in the operating area "diagnostics". This display corresponds to the machine data: MD1702 \$MD_MOTOR_TEMPERATURE (motor temperature)</p>	

<p>DB31, ... DBX94.0</p>	<p><b>Motor temperature prewarning</b></p>
<p>Application example(s)</p>	<p>As soon as "Motor temperature prewarning" has been signaled, the PLC can, for example, initiate controlled shutdown of the drives.</p>
<p>Corresponding to ....</p>	<p>DB31, ... DBX93.5 (drive ready) MD1602 \$MD_MOTOR_TEMP_WARN_LIMIT MD1603 \$MD_MOTOR_TEMP_ALARM_TIME MD1607 \$MD_MOTOR_TEMP_SHUTDOWN_LIMIT</p>
<p>Additional references</p>	<p>/DA/ Diagnostics Guide /IAD/ SINUMERIK 840D Installation and Startup Guide; Chapter: SIMODRIVE 611D</p>

<b>DB31, ... DBX94.1</b>	<b>Heatsink temperature prewarning</b>	
Edge evaluation: no	Signal(s) updated: cyclic	
Signal state 1 or edge change 0 → 1	<p>The drive module sends the warning "heatsink temperature prewarning" to the PLC. This triggers the following:</p> <ul style="list-style-type: none"> <li>Terminal 5 on the infeed/regenerative feedback module is simultaneously activated.</li> <li>The drive module is switched off after 20 seconds. The drives are stopped when the impulse enable is removed. Then alarm 300515 is triggered.</li> </ul>	
Signal state 0 or edge change 1 → 0	The drive module heatsink temperature pre-warning has not responded.	
Application example(s)	As soon as "heatsink temperature prewarning" has been signaled, the PLC can, for example, initiate controlled shutdown of the drives.	
Additional references	/DA/ Diagnostics Guide	

<b>DB31, ... DBX94.2</b>	<b>Ramp-up completed</b>	
Edge evaluation: no	Signal(s) updated: cyclic	
Signal state 1 or edge change 0 → 1	<p>The PLC is signaled, that after a new speed setpoint has entered, the speed actual value has reached the speed tolerance bandwidth:  MD1426 \$MD_SPEED_DES_EQ_ACT_TOL (tolerance bandwidth for <math>n_{set} = n_{act} - signal</math>)  and has remained within this tolerance bandwidth for at least the time defined using machine data:  MD1427 \$MD_SPEED_DES_EQ_ACT_DELAY (delay time <math>n_{set} = n_{act} - signal</math>)  refer to the diagram).</p> <p>Even if the speed actual value leaves the tolerance band (because of speed fluctuations resulting from changes in load) the "ramp-up completed" signal remains (1 signal).</p>	
Signal state 0 or edge change 1 → 0	The conditions described above have not yet been fulfilled. The ramp-up has therefore not yet been completed.	

<p>DB31, ... DBX94.2</p>	<p style="text-align: center;"><b>Ramp-up completed</b></p> <p>The diagram illustrates the timing of the 'Ramp-up completed' signal. It consists of four vertically aligned plots sharing a common time axis:</p> <ul style="list-style-type: none"> <li><b>Top Plot:</b> Shows the 'Ramp-function generator active (control word servo)' signal, which is a pulse that becomes active when the speed setpoint is initiated.</li> <li><b>Second Plot:</b> Shows 'Speed n' (actual speed) and 'Speed setpoint n<sub>set</sub>'. The actual speed ramps up to meet the setpoint, then exhibits a tolerance band. The tolerance is defined by MD2426 \$MD_SPEED_DES_EQ_ACT_TOL. A 'Speed tolerance bandwidth' is also indicated.</li> <li><b>Third Plot:</b> Shows the 'IS "Ramp-up completed"' signal. It is active (1) during the ramp-up phase and becomes inactive (0) once the speed tolerance is reached.</li> <li><b>Bottom Plot:</b> Shows the 'IS "n<sub>act</sub> = n<sub>set</sub>"' signal. It is active (1) during the ramp-up phase and becomes inactive (0) once the speed tolerance is reached. It also shows a pulse when the speed tolerance is reached.</li> </ul> <p>Time intervals are marked with <math>T &lt; TD</math> (no signal) and <math>T &gt; TD</math> (signal that is interlocked). The delay time <math>TD</math> is defined as <math>TD = MD1427 \\$MD\_SPEED\_DES\_EQ\_ACT\_DELAY</math>.</p>
<p>Corresponding to ....</p>	<p>DB31, ... DBX94.6 ("n<sub>act</sub> = n<sub>set</sub>")          DB31, ... DBX94.3 (" M<sub>D</sub>  = M<sub>dx</sub>")          MD1426 \$MD_SPEED_DES_EQ_ACT_TOL          MD1427 \$MD_SPEED_DES_EQ_ACT_DELAY</p>
<p>Additional references</p>	<p>/IAD/ SINUMERIK 840D Installation and Startup Guide; Chapter: SIMODRIVE 611D</p>

<b>DB31, ... DBX94.3</b>	<b><math> M_d  &lt; M_{dx}</math></b>	
Edge evaluation: no	Signal(s) updated: cyclic	
Signal state 1 or edge change 0 → 1	<p>611D signals to the PLC that the torque setpoint <math> M_d </math> does not exceed the threshold torque <math>M_{dx}</math> in the steady-state condition (i.e. ramp-up completed) (refer to the diagram).</p> <p>The threshold torque is set using the machine data: MD1428 \$MD_TORQUE_THRESHOLD_X (threshold torque) as a % of the actual torque limit value. The torque threshold characteristic is speed-dependent.</p> <p>While ramping-up, the interface signal: DB31, ... DBX94.2 (<math> M_d  &lt; M_{dx}</math>) remains at 1.</p> <p>The signal <math> M_d  &lt; M_{dx}</math> only becomes active after ramp-up has been completed: DB31, ... DBX94.2 (ramp-up completed) = 1 and the signal interlocking time for the threshold torque: MD1429 \$MD_TORQUE_THRESHOLD_X_DELAY (delay time <math>n_d &lt; n_{dx} - \text{signal}</math>) has expired</p>	
Signal state 0 or edge change 1 → 0	<p>The torque setpoint <math> M_d </math> is larger than the threshold torque <math>M_{dx}</math>.</p> <p>If necessary, the PLC user program can initiate a response.</p>	



<b>DB31, ... DBX94.3</b>	$ M_d  < M_{dx}$
Corresponding to ....	DB31, ... DBX94.2 (ramp-up completed) MD1428 \$MD_TORQUE_THRESHOLD_X MD1429 \$MD_TORQUE_THRESHOLD_X_DELAY MD1427 \$MD_SPEED_DES_EQ_ACT_DELAY
Additional references	/IAD/ SINUMERIK 840D Installation and Startup Guide; Chapter: SIMODRIVE 611D

<b>DB31, ... DBX94.4</b>	$ n_{act}  < n_{min}$
Edge evaluation: no	Signal(s) updated: cyclic
Signal state 1 or edge change 0 → 1	The SIMODRIVE 611 D/ 611D signals the PLC that the speed actual value $n_{act}$ is less than the minimum speed ( $n_{min}$ ). The minimum speed is defined using the machine data: MD1418 \$MD_SPEED_THRESHOLD_MIN.
Signal state 0 or edge change 1 → 0	The speed actual value is higher than the minimum speed.
Corresponding to ....	MD1418 \$MD_SPEED_THRESHOLD_MIN (minimum speed ( $n_{min}$ for $n_{act} < n_{min}$ ))
Additional references	/IAD/ SINUMERIK 840D Installation and Startup Guide; Chapter: SIMODRIVE 611D

<b>DB31, ... DBX94.5</b>	$ n_{act}  < n_x$
Edge evaluation: no	Signal(s) updated: cyclic
Signal state 1 or edge change 0 → 1	The 611D/ 611U signals the PLC that the speed actual value $n_{act}$ is less than the threshold speed ( $n_x$ ). The threshold speed is defined using the machine data: MD1417 \$MD_SPEED_THRESHOLD_X.
Signal state 0 or edge change 1 → 0	The speed actual value is higher than the threshold speed.
Corresponding to ....	MD1417 \$MD_SPEED_THRESHOLD_X (threshold speed ( $n_x$ for $n_{act} < n_x$ ))
Additional references	/IAD/ SINUMERIK 840D Installation and Startup Guide; Chapter: SIMODRIVE 611D

18.2 Various interface signals and functions (A2)

<b>DB31, ... DBX94.6</b>	<b>n<sub>act</sub> = n<sub>set</sub></b>
Edge evaluation: no	Signal(s) updated: cyclic
Signal state 1 or edge change 0 → 1	<p>SIMODRIVE 611D/611U signals the PLC that after a new speed setpoint has been entered, the speed actual value n<sub>act</sub> has reached the speed tolerance bandwidth:  MD1426 \$MD_SPEED_DES_EQ_ACT_TOL (tolerance bandwidth for n<sub>set</sub> = n<sub>act</sub> signal)  and has remained within this tolerance bandwidth for at least the time defined using machine data:  MD1427 \$MD_SPEED_DES_EQ_ACT_DELAY (delay time for n<sub>set</sub> = n<sub>act</sub> signal)  (refer to the diagram).</p> <p>If the speed actual value then leaves the tolerance bandwidth, then contrary to the signal "ramp-up completed", the interface signal:  DB31, ... DBX94.6 (n<sub>act</sub> = n<sub>set</sub>)  is set to 0.</p>
Signal state 0 or edge change 1 → 0	The conditions described above have not yet been fulfilled. The speed actual value is outside the speed tolerance bandwidth.
Corresponding to ....	DB31, ... DBX94.2 (ramp-up completed) MD1426 \$MD_SPEED_DES_EQ_ACT_TOL MD1427 \$MD_SPEED_DES_EQ_ACT_DELAY
Additional references	/IAD/ SINUMERIK 840D Installation and Startup Guide; Chapter: SIMODRIVE 611D

<b>DB31, ... DBX94.7</b>	<b>Variable signaling function</b>
Edge evaluation: no	Signal(s) updated: cyclic

DB31, ... DBX94.7	Variable signaling function
Signal state 1	<p>The SIMODRIVE 611D/611U signals the PLC that the threshold value has exceeded the value being monitored.</p> <p>With the variable signaling function it is possible to monitor for each axis whether a defined threshold - that can be entered - is exceeded for any programmable value of SIMODRIVE 611D/611U. A corresponding interface signal is then sent to the PLC.</p> <p>The parameters for the variables being monitored are set in the following 611D machine data:</p> <ul style="list-style-type: none"> <li>• MD1620 \$MD_PROG_SIGNAL_FLAGS (bits variable signal function)</li> <li>• MD1621 \$MD_PROG_SIGNAL_NR (signal number variable signal function)</li> <li>• MD1622 \$MD_PROG_SIGNAL_ADDRESS (address variable signal function)</li> <li>• MD1623 \$MD_PROG_SIGNAL_THRESHOLD (threshold variable signal function)</li> <li>• MD1624 \$MD_PROG_SIGNAL_HYSTERESIS (hysteresis variable signal function)</li> <li>• MD1625 \$MD_PROG_SIGNAL_ON_DELAY (on delay variable signal function)</li> <li>• MD1626 \$MD_PROG_SIGNAL_OFF_DELAY (off delay variable signal function)</li> </ul> <p><b>Monitoring:</b></p> <p>The parameterized variable is monitored to check whether it exceeds a defined threshold. In addition, a tolerance band (hysteresis) can be defined which is considered when scanning for violation of the threshold value. Further, the "threshold exceeded" signal can be also be logically combined with an on delay and off delay time (refer to the diagram).</p> <p><b>Selection:</b></p> <p>The variable to be monitored can be selected by entering a signal number or by entering a symbolic address.</p> <p>The machine data: MD1620 \$MD_PROG_SIGNAL_FLAGS (bits, variable signaling function) can be used to enable and disable the variable signaling function on an axis-for-axis basis. This machine data can also be used to determined whether the threshold value comparison is to be signed or unsigned.</p> <p>For further information see References.</p>
Signal state 0	<p>SIMODRIVE 611D signals the PLC that the threshold value of the variable being monitored has not been exceeded or that the conditions defined in the above 611D-MD are not fulfilled.</p> <p>If the variable signaling function is disabled (MD1620), signal state "0" is output to the PLC.</p>

<p>DB31, ... DBX94.7</p>	<p><b>Variable signaling function</b></p>
<p>Application example(s)</p>	<p>With the variable signal function the machine tool manufacturer can monitor one additional threshold value for specific applications for each axis/spindle and evaluate the result in the PLC user program.</p> <p><b>Example:</b> The interface signal: DB31, ... DBX94.7 (variable signaling function) should be set to a 1 if the motor torque exceeds 50 % of the rated torque.</p>
<p>Corresponding to ....</p>	<p>MD1620 \$MD_PROG_SIGNAL_FLAGS (bits variable signal function) MD1621 \$MD_PROG_SIGNAL_NR (signal number variable signal function) MD1622 \$MD_PROG_SIGNAL_ADDRESS (address variable signal function) MD1623 \$MD_PROG_SIGNAL_THRESHOLD (threshold variable signal function) MD1624 \$MD_PROG_SIGNAL_HYSTERESIS (hysteresis variable signal function) MD1625 \$MD_PROG_SIGNAL_ON_DELAY (on delay variable signal function) MD1626 \$MD_PROG_SIGNAL_OFF_DELAY (off delay variable signal function)</p>
<p>Additional references</p>	<p>/IAD/ SINUMERIK 840D Installation and Startup Guide; Chapter: SIMODRIVE 611D</p>

<b>DB31, ... DBX95.0</b>	<b>VDC link &lt; warning threshold</b>	
Edge evaluation: no	Signal(s) updated: cyclic	
Signal state 1 or edge change 0 → 1	The drive signals the PLC that the DC link voltage VDC link has dropped below the DC link undervoltage warning threshold. The DC link undervoltage warning threshold is defined using: MD1604 \$MD_LINK_VOLTAGE_WARN_LIMIT. The DC link undervoltage warning threshold should be defined to be greater than 400 V, depending on the application case. If the DC link voltage drops below 280 V, the unit is powered-down by the hardware.	
Signal state 0 or edge change 1 → 0	The DC link voltage VDClink is greater than the DC link undervoltage warning threshold.	
Application example(s)	If a warning signal is given, measures can be taken by the PLC user program, for example, to stop machining (e.g. start tool retraction) or to buffer the DC link voltage.	
Corresponding to ....	MD1604 \$MD_LINK_VOLTAGE_WARN_LIMIT (DC link undervoltage warning threshold)	
Additional references	/IAD/ SINUMERIK 840D Installation and Startup Guide; Chapter: SIMODRIVE 611 digital	

<b>DB31, ... DBX95.7</b>	<b>i<sup>2</sup>t monitoring</b>	
Edge evaluation: no	Signal(s) updated: cyclic	
Signal state 1 or edge change 0 → 1	The drive signals the PLC that the power unit monitoring has responded. The rated current limit of this i <sup>2</sup> t monitoring function is defined in drive machine data MD1261 \$MD_I2T_NOMINAL_REDUCTION. It is also possible to set the time for which the power unit may be at its limit in machine data: MD1262 \$MD_DIAGNOSIS_I2T The i <sup>2</sup> t monitoring function can be used to protect the power unit of digital drives against continuous overloads.	
Signal state 0 or edge change 1 → 0	The i <sup>2</sup> t monitoring function has not responded.	
Application example(s)	Further measures can be initiated by the PLC user program, if necessary, when the warning signal is activated.	
Corresponding to ....	MD1261 \$MD_I2T_NOMINAL_REDUCTION (i <sup>2</sup> t limiting, rated power unit current) MD1262 \$MD_DIAGNOSIS_I2T (i <sup>2</sup> t time at the limit) MD1263 \$MD_LIMIT_I2T (i <sup>2</sup> t actual limit factor) MD1264 \$MD_LOAD_I2T (i <sup>2</sup> t actual utilization factor)	
Additional references	/IAD/ SINUMERIK 840D Installation and Startup Guide; Chapter: SIMODRIVE 611digital	

## 18.3 Axis monitoring, protection zones (A3)

### 18.3.1 Signals to channel (DB21, ...)

<b>DB21, ... DBX1.1</b>	<b>Enable protection zones</b>	
Edge evaluation: yes	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	When a positive edge of this signal appears, a protection zone is enabled and the active alarm cleared. Then, motion can start in the same protection zone. As a result of the start of motion, the protection zone is enabled, the IS "machine or channel-specific protection zone violated" is set, and the axis starts to move. The enabling signal is canceled if motion is started that does not lead into the enabled protection zone.	
Signal state 0 or edge change 1 → 0	No effect	
Application example(s)	This allows protection zones to be released: <ul style="list-style-type: none"> <li>• if the current position is within a protection zone (alarm 2 present)</li> <li>• if motion is to be started towards the protection zone limit (alarm 1 or 2 present)</li> </ul>	

<b>DB21, ... DBX8.0 - DBX9.1</b>	<b>Activate machine-specific protection zone 1 ( ...10)</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	The pre-activated, machine-related protection zone 1 ( ...10) is activated by the PLC user program. The protection zone is immediately activated. Only protection zones that have been pre-activated in the part program can be activated.	
Signal state 0 or edge change 1 → 0	The pre-activated, machine-related protection zone 1 ( ...10) is de-activated by the PLC user program. The protection zone is immediately de-activated. Only protection zones that have been activated via the PLC and have been pre-activated in the NC part program can be de-activated.	
Application example(s)	Before a sensor, for example, is moved into the working range, the relevant machine-related protection zone can be activated.	

<b>DB21, ... DBX10.0 - DBX11.1</b>	<b>Activate channel-specific protection zone 1 ( ...10)</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	The preactivated, channel-specific protection zone 1 ( ...10) is activated by the PLC user program. The protection zone is immediately activated. Only protection zones that have been pre-activated in the part program can be activated.
Signal state 0 or edge change 1 → 0	The pre-activated, channel-specific protection zone 1 ( ...10) is de-activated by the PLC user program. The protection zone is immediately de-activated. Only protection zones that have been activated via the PLC and have been pre-activated in the NC part program can be de-activated.
Application example(s)	Before a synchronous spindle, for example, is moved into the working range, the relevant machine-related protection zone can be activated.

### 18.3.2 Signals from channel (DB21, ...)

<b>DB21, ... DBX272.0 – DBX273.1</b>	<b>Machine-related protection zone 1 ( ...10) pre-activated</b>
Edge evaluation: no	Signal(s) updated: cyclic
Signal state 1 or edge change 0 → 1	The machine-related protection zone 1 ( ...10) is preactivated in the current block. (Pre-activated in the part program). The protection zone can therefore be activated or de-activated in the PLC user program using the interface signal: DB21, ... DBX8.0 - DBX9.1 (machine-related protection zone 1 ( ...10))
Signal state 0 or edge change 1 → 0	The machine-related protection zone 1 ( ...10) is deactivated in the current block. (De-activated in the part program). The protection zone can therefore not be activated or de-activated in the PLC user program using the interface signal: DB21, ... DBX8.0 to DBX9.1 (activate machine-related protection zone 1 ( ...10))
Corresponding to ....	DB21, ... DBX8.0 - DBX9.1 (activate machine-related protection zone 1 ( ...10))

<b>DB21, ... DBX274.0 – DBX275.1</b>	<b>Channel-specific protection zone 1 ( ...10) pre-activated</b>
Edge evaluation: no	Signal(s) updated: cyclic
Signal state 1 or edge change 0 → 1	The channel-specific protection zone 1 ( ...10) is preactivated in the current block. (Pre-activated in the part program). The protection zone can therefore be activated or de-activated in the PLC user program using the interface signal: DB21, ... DBX10.0 - DBX11.1 channel-specific protection zone 1 ( ...10))

18.3 Axis monitoring, protection zones (A3)

<b>DB21, ... DBX274.0 – DBX275.1</b>	<b>Channel-specific protection zone 1 (...10) pre-activated</b>
Signal state 0 or edge change 1 → 0	The channel-specific protection zone 1 ( ...10) is deactivated in the current block. (De-activated in the part program.)  The protection zone can therefore not be activated or de-activated in the PLC user program using the interface signal: DB21, ... DBX10.0 - DBX11.1 (channel-specific protection zone 1 (...10))
Corresponding to ....	DB21, ... DBX10.0 - DBX11.1 (activate channel-specific protection zone 1 (...10))

<b>DB21, ... DBX276.0 – DBX277.1</b>	<b>Machine-related protection zone 1 (...10) violated</b>
Edge evaluation: no	Signal(s) updated: cyclic
Signal state 1 or edge change 0 → 1	The activated, machine-related protection zone 1 ( ...10) is violated in the current block or in the current JOG movement.  The pre-activated, machine-related protection zone 1 ( ...10) would be violated in the current block if it would be activated by the PLC.
Signal state 0 or edge change 1 → 0	The activated, machine-related protection zone 1 (...10) is not violated in the current block.  The pre-activated, machine-related protection zone 1 (...10) would not be violated in the current block if it would be activated by the PLC.
Application example(s)	Before parts are moved into the working zone - this IS can be used to check as to whether the tool or workpiece is located in the machine-related protection zone of the part to be moved in.

<b>DB21, ... DBX278.0 - DBX279.1</b>	<b>Channel-specific protection zone 1 (...10) violated</b>
Edge evaluation: no	Signal(s) updated: cyclic
Signal state 1 or edge change 0 → 1	The activated, channel-specific protection zone 1 ( ...10) is violated in the current block.  The pre-activated, channel-specific protection zone 1 ( ...10) would be violated in the current block if it would be activated by the PLC.
Signal state 0 or edge change 1 → 0	The activated, channel-specific protection zone 1 ( ...10) is not violated in the current block.  The pre-activated, channel-specific protection zone 1 (...10) would not be violated in the current block if it would be activated by the PLC.
Application example(s)	Before parts are moved into the working zone - this IS can be used to check whether the tool or workpiece is located in the channel-specific protection zone of the part to be moved-in.

## 18.3.3 Signals to axis/spindle (DB31, ...)

<b>DB31, ... DBX2.3</b>	<b>Clamping in progress</b>
Edge evaluation: no	Signal(s) updated: cyclic
Signal state 1 or edge change 0 → 1	Clamping in progress. The clamping monitoring function is activated.
Signal state 0 or edge change 1 → 0	Clamping completed. The clamping monitoring function is replaced by the standstill (zero speed) monitoring.
Corresponding to ....	MD36050 \$MA_CLAMP_POS_TOL (Clamping tolerance)

<b>DB31, ... DBX3.6</b>	<b>Velocity/spindle speed limitation</b>
Edge evaluation: no	Signal(s) updated: cyclic
Signal state 1 or edge change 0 → 1	The NCK limits the velocity/spindle speed to the limit value set in the machine data: MD35160 \$MA_SPIND_EXTERN_VELO_LIMIT
Signal state 0 or edge change 1 → 0	No limitation active.
Corresponding to ....	MD35100 \$MA_SPIND_VELO_LIMIT (max. spindle speed) SD43220 \$SA_SPIND_MAX_VELO_G26 (prog. spindle speed limiting G26) MD43230 \$SA_SPIND_MAX_VELO_LIMIT (prog. spindle speed limiting G96/G961)

<b>DB31, ... DBX12.0 - DBX12.1</b>	<b>Hardware limit switches plus and minus</b>
Edge evaluation: no	Signal(s) updated: cyclic
Signal state 1 or edge change 0 → 1	A switch can be mounted at each end of the travel range of a machine axis which will cause a signal "hardware limit switch plus or minus" to be signaled to the NC via the PLC if it is actuated. If the signal is recognized as set, alarm 021614 "hardware limit switch + or -" is output and the axis is decelerated immediately. The braking/deceleration type is defined using the machine data: MD36600 \$MA_BRAKE_MODE_CHOICE (braking behavior at the hardware limit switch)  If the controller enable is withdrawn at the same time as the "hardware limit switch" signal, then the axis responds as described in Chapter A2 ("various interface signals").
Signal state 0 or edge change 1 → 0	Normal condition - a hardware limit switch has not been actuated.
Corresponding to ....	MD36600 \$MA_BRAKE_MODE_CHOICE (deceleration behavior when the hardware limit switch responds)

<b>DB31, ... DBX12.2 - DBX12.3</b>	<b>2nd software limit switch plus or minus</b>
Edge evaluation: no	Signal(s) updated: cyclic
Signal state 1 or edge change 0 → 1	2nd software limit switch for the plus and minus directions is effective. 1st software limit switch for the plus and minus directions is not effective. In addition to the 1st software limit switches (plus and minus), the 2nd software limit switches (plus and minus) can be activated using these interface signals. The position is defined using machine data: MD36130 \$MA_POS_LIMIT_PLUS2 (2nd software limit switch plus) and MD36120 \$MA_POS_LIMIT_MINUS2 (2nd software limit switch minus).
Signal state 0 or edge change 1 → 0	1st software limit switch for the plus and minus directions is effective. 2nd software limit switch for the plus and minus directions is not effective.
Corresponding to ....	MD36110 \$MA_POS_LIMIT_PLUS (1st software limit switch plus) MD36130 \$MA_POS_LIMIT_PLUS2 (2nd software limit switch plus) MD36100 \$MA_POS_LIMIT_MINUS (1st software limit switch minus) MD36120 \$MA_POS_LIMIT_MINUS2 (2nd software limit switch minus)

## 18.3.4 Signals from axis/spindle (DB31, ...)

DB31, ... DBX60.2 - DBX60.3	Encoder limit frequency exceeded 1 Encoder limit frequency exceeded 2
Edge evaluation: no	Signal(s) updated: cyclic
Signal state 1 or edge change 0 → 1	The limit frequency set in the machine data: MD36300 \$MA_ENC_FREQ_LIMIT (encoder limit frequency) has been exceeded.  The reference point for the position measuring system involved has been lost (IS: Referenced/synchronized has a signal state 0). Closed loop position control is no longer possible. Spindles continue to run with closed-loop speed control. Axes are stopped with a fast stop (with open-circuit position control loop) along a speed setpoint ramp.
Signal state 0 or edge change 1 → 0	The limit frequency set in machine data: MD36300 \$MA_ENC_FREQ_LIMIT is no longer exceeded (encoder frequency < ENC_FREQ_LIMIT_LOW).  For the edge change 1 → 0, the encoder frequency must have fallen below the value of machine data: MD36302 \$MA_ENC_FREQ_LIMIT_LOW

## 18.4 Continuous-path mode, exact stop and LookAhead (B1)

### 18.4.1 Signals from channel (DB21, ...)

<b>DB21, ... DBX36.3</b>	<b>All axes stationary</b>
Edge evaluation: no	Signal(s) updated: cyclic
Signal state 1 or edge change 0 → 1	All axes assigned to the channel are stationary with interpolator end. No other traversing movements are active.

### 18.4.2 Signals from axis/spindle (DB31, ...)

<b>DB31, ... DBX60.6</b>	<b>Position reached with exact stop coarse</b>
Edge evaluation: no	Signal(s) updated: cyclic
Signal state 1 or edge change 0 → 1	The axis is in the appropriate exact stop and no interpolator is active for the axis and: <ul style="list-style-type: none"> <li>the control is in the reset mode (reset key or end of program)</li> <li>the axis was last programmed as a positioning axis or positioning spindle (initial setting of supplementary axis: Positioning axis)</li> <li>the path movement was stopped with NC Stop</li> <li>the spindle is in the closed-loop position-controlled mode (SPCON/SPOS instruction) and is stationary</li> <li>the axis is switched from closed-loop speed-controlled to closed-loop position-controlled mode with IS "position measuring system"</li> </ul>
Signal state 0 or edge change 1 → 0	The axis is not in the appropriate exact stop or the interpolator is active for the axis or: <ul style="list-style-type: none"> <li>the path movement was stopped with NC Stop</li> <li>the spindle is in the closed-loop speed-controlled mode (SPCOF/SPOSA instruction)</li> <li>the "follow-up" mode is active for the axis</li> <li>the "parking" mode is active for the axis</li> <li>the axis is switched from closed-loop position-controlled to closed-loop speed-controlled mode with IS "position measuring system"</li> </ul>
Signal irrelevant for ...	Rotary axes that are programmed as rounding axes.
Corresponding to ....	MD36000 \$MA_STOP_LIMIT_COARSE (exact stop coarse)

<b>DB31, ... DBX60.7</b>	<b>Position reached with exact stop fine</b>	
Edge evaluation: no	Signal(s) updated: cyclic	
Signal state 1 or edge change 0 → 1	Refer to DB31, ... DBX60.6 (position reached with exact stop coarse).	
Signal state 0 or edge change 1 → 0	Refer to DB31, ... DBX60.6 (position reached with exact stop coarse).	
Signal irrelevant for ...	Rotary axes that are programmed as rounding axes.	
Corresponding to ....	MD36010 \$MA_STOP_LIMIT_FINE (exact stop fine)	

## 18.5 Travel to fixed stop (F1)

### 18.5.1 Signals to axis/spindle (DB31, ...)

<b>DB31, ... DBX1.1</b>	<b>Acknowledge fixed stop reached</b>
Edge evaluation: no	Signal(s) updated: cyclic
Signal state 1 or edge change 0 → 1	Significance after the fixed stop has been reached: DB31, ... DBX62.5 (fixed stop reached) = 1 → The axis presses against the fixed stop with the clamping torque: → The fixed stop monitoring window is activated. → A block change is executed.
Signal state 0  Edge change 1 → 0	Significance after the fixed stop has been reached: DB31, ... DBX62.5 (fixed stop reached) = 1 → The axis presses against the fixed stop with the clamping torque. → The fixed stop monitoring window is activated. → A block change is not executed and the channel message "Wait: Auxiliary function acknowledgment missing" is displayed. Meaning after the fixed stop has been reached: IS "Fixed stop reached" DB31, ... DBX62.5 = 1 → The function is aborted, the alarm "20094 axis %1 Function aborted" is output. Significance when de-selecting the function $FXS=0$ via the part program: → The torque limiting and the monitoring of the fixed stop monitoring window are canceled.
IS irrelevant for ...	MD37060 \$MA_FIXED_STOP_ACKN_MASK (monitoring PLC acknowledgments for travel to fixed stop) = 0 or 1
Corresponding to ....	MD37060 \$MA_FIXED_STOP_ACKN_MASK (monitoring PLC acknowledgments for travel to fixed stop) DB31, ... DBX62.5 (fixed stop reached)

<b>DB31, ... DBX1.2</b>	<b>Sensor for fixed stop</b>
Edge evaluation: no	Signal(s) updated: cyclic
Signal state 1 or edge change 0 → 1	Fixed stop is reached.
Signal state 0 or edge change 1 → 0	Fixed stop is not reached.
Corresponding to ....	The signal is only active if: MD37040 \$MA_FIXED_STOP_BY_SENSOR = 1

<b>DB31, ... DBX3.1</b>	<b>Enable travel to fixed stop</b>	
Edge evaluation: no	Signal(s) updated: cyclic	
Signal state 1 or edge change 0 → 1	<p>Meaning when <code>FXS</code> function is selected using the part program (IS "Activate travel to fixed stop" = 1):</p> <p>→ Travel to fixed stop is enabled and the axis traverses from the start position at the programmed velocity to the programmed target position.</p>	
Signal state 0	<p>Meaning when <code>FXS</code> function is selected using the part program (IS "Activate travel to fixed stop" = 1):</p> <p>→ Travel to fixed stop is inhibited.</p> <p>→ The axis is stationary at the start position with reduced torque.</p> <p>→ The channel message "wait": Auxiliary function acknowledgment missing" is displayed.</p>	
Edge change 1 → 0	<p>Meaning before the fixed stop has been reached (IS "fixed stop reached" = 0):</p> <p>→ Travel to fixed stop is aborted.</p> <p>→ The alarm "20094: Axis%1 Function aborted" is displayed.</p> <p>Meaning after the fixed stop has been reached (IS "fixed stop reached" = 1):</p> <p>→ The torque limiting and monitoring of the fixed stop monitoring window are canceled.</p> <p>Deselection: DB31, ...DBX1.1 (acknowledge fixed stop reached)</p>	
IS irrelevant for ...	MD37060 \$MA_FIXED_STOP_ACKN_MASK (monitoring PLC acknowledgments for travel to fixed stop) = 0 or 2	
Corresponding to ....	MD37060 \$MA_FIXED_STOP_ACKN_MASK (monitoring PLC acknowledgments for travel to fixed stop) DB31, ... DBX62.4 (activate travel to fixed stop)	

## 18.5.2 Signals from axis/spindle (DB31, ...)

<b>DB31, ... DBX62.4</b>	<b>Activate travel to fixed stop</b>	
Edge evaluation: no	Signal(s) updated: cyclic	
Signal state 1 or edge change 0 → 1	<p>The "Travel to fixed stop" function is active.</p> <p>This signal is used for analog drives in order, for example, to activate the current or torque limitation parameterized in the actuator.</p>	
Signal state 0 or edge change 1 → 0	<p>The "Travel to fixed stop function" is not active.</p>	

<b>DB31, ... DBX62.5</b>	<b>Fixed stop reached</b>	
Edge evaluation: no	Signal(s) updated: cyclic	
Signal state 1 or edge change 0 → 1	The fixed stop was reached after selecting the <code>FXS</code> function. This signal is used by analog drives, e.g. to switch the actuator from speed-controlled to current or torque-controlled mode so that a programmable clamping torque can be set.	
Signal state 0 or edge change 1 → 0	The fixed stop has still not been reached after selecting the <code>FXS</code> function.	

## 18.6 Help function output to PLC (H2)

### 18.6.1 Signals to channel (DB21, ...)

<b>DB21, ... DBX30.5</b>	<b>Activate associated M01</b>	
Edge evaluation: no	Signal(s) updated:	
Signal state 1 or edge change 0 → 1	PLC signals the NCK that the associated M01 (help function) should be activated.	
Signal state 0 or edge change 1 → 0	De-activate the associated M01 (help function).	
Corresponding to ....	DB21, ... DBX 318.5 (associated M01 active)	

### 18.6.2 Signals from channel (DB21, ...)

<b>DB21, ... DBB58, DBB60 - DBB65</b>	<b>M, S, T, D, H, F functions Modification</b>	
Edge evaluation: No	Signal(s) updated: job-controlled by NCK	
Signal state 1 or edge change 0 → 1	One M, S, T, An D, H, or F function has been output to the interface with a new value together with the associated change signal at the beginning of an OB1 cycle. In this case, the change signal indicates that the appropriate value is valid.	
Signal state 0 or edge change 1 → 0	The change signals are reset by the PLC basic program at the start of the next OB1 cycle. The value of the data involved is not valid.	

<b>DB21, ... DBX59.0 - DBX59.4</b>	<b>M function 1-5 not included in list</b>	
Edge evaluation: No	Signal(s) updated: job-controlled by NCK	
Signal state 1 or edge change 0 → 1	<p>M function is greater than 99 (for extended address = 0) or for extended address &gt; 0, not included in the decoding list.</p> <p>This signal is available - together with the associated M change signal - for one OB1 cycle.</p> <p>Cause:</p> <ul style="list-style-type: none"> <li>• Incorrect M function programmed</li> <li>• M function not configured in the decoding list of the PLC</li> </ul> <p>Remedy, e.g.:</p> <ul style="list-style-type: none"> <li>• PLC sets read-in disable</li> <li>• Output of a PLC alarm</li> </ul>	
Signal state 0 or edge change 1 → 0	M function less than 99 (for extended address = 0) or for extended address > 0 included in the decoding list.	

<b>DB21, ... DBB60 - DBB64, DBB66 - DBB67</b>	<b>M, S, T, D, H, F functions Additional info "Quick" (fast acknowledgment)</b>	
Edge evaluation: No	Signal(s) updated: job-controlled by NCK	
Signal state 1 or edge change 0 → 1	<p>One M, S, T, An D, H, or F function has been output to the interface with a new value together with the associated change signal at the beginning of an OB1 cycle.</p> <p>In this case, the additional info "Quick" indicates the quick help function.</p>	
Signal state 0 or edge change 1 → 0	<p>The change signals are reset by the PLC basic program at the start of the next OB1 cycle.</p> <p>The value of the data involved is not valid.</p>	

<b>DB21, ... DBB68 - DBB97</b>	<b>M functions 1 to 5 Extended address M functions 1 to 5</b>	
Edge evaluation: No	Signal(s) updated: job-controlled by NCK	
Signal state 1 or edge change 0 → 1	<p>Up to 5 M functions programmed in an NC block are simultaneously made available here as soon as the M change signals are available.</p> <p>Value range of M functions: 0 to 9999 9999; integer number</p> <p>Value range of the extended address: 0 to 99; integer number</p> <p>The M functions remain valid until they are overwritten by new M functions.</p>	
Signal state 0 or edge change 1 → 0	<ul style="list-style-type: none"> <li>• After the PLC has ramped-up.</li> <li>• All help functions are deleted before a new function is entered.</li> </ul>	
Application example(s)	<p>Decoding and evaluation of M functions that are not decoded as standard or via a list.</p> <p>Using the extended address, the M function can be assigned to another channel that does not correspond to that channel in which the program is running.</p>	
Special cases, errors, .....	For M00 to M99 the extended address = 0.	

<b>DB21, ... DBB98 - DBB115</b>	<b>S functions 1 to 3 Extended address S functions 1 to 3</b>	
Edge evaluation: No	Signal(s) updated: job-controlled by NCK	
Signal state 1 or edge change 0 → 1	Up to 3 S functions programmed in an NC block are simultaneously made available here as soon as the S change signals are available. Value range of the spindle speed: 0 to 999 999; integer number Value range of the extended address: 0 to 6; integer number The S functions remain valid until they are overwritten by new S functions.	
Signal state 0 or edge change 1 → 0	<ul style="list-style-type: none"> <li>• After the PLC has ramped-up.</li> <li>• All help functions are deleted before a new function is entered.</li> </ul>	
Application example(s)	Spindle speed control by the PLC. The extended address is used to program for which spindle the S word is valid. E.g.: S2=500	

<b>DB21, ... DBB118, DBB119</b>	<b>T function 1</b>	
Edge evaluation: No	Signal(s) updated: job-controlled by NCK	
Signal state 1 or edge change 0 → 1	The T function programmed in an NC block is made available here as soon as the T change signal is available. Value range of T functions: 0 to 99 999 999; integer number The T function remains valid until it is overwritten by a new T function.	
Signal state 0 or edge change 1 → 0	<ul style="list-style-type: none"> <li>• After the PLC has ramped-up.</li> <li>• All help functions are deleted before a new function is entered.</li> </ul>	
Application example(s)	Control of automatic tool selection.	
Special cases, errors, .....	With T0, the current tool is removed from the tool holder but not replaced by a new tool (default configuration of the machine manufacturer).	

18.6 Help function output to PLC (H2)

<b>DB21, ... DBB129</b>	<b>D function 1</b>	
Edge evaluation: No	Signal(s) updated: job-controlled by NCK	
Signal state 1 or edge change 0 → 1	<p>The D function programmed in an NC block is made available here as soon as the D change signal is available.</p> <p>Value range of D functions: 0 to 999; integer number</p> <p>The D function remains valid until it is overwritten by a new D function.</p>	
Signal state 0 or edge change 1 → 0	<ul style="list-style-type: none"> <li>• After the PLC has ramped-up.</li> <li>• All help functions are deleted before a new function is entered.</li> </ul>	
Application example(s)	Implementation of protective functions.	
Special cases, errors, .....	D0 is reserved for deselecting the current tool offset.	

<b>DB21, ... DBB140 - DBB157</b>	<b>H functions 1 to 3 Extended address H functions 1 to 3</b>	
Edge evaluation: No	Signal(s) updated: job-controlled by NCK	
Signal state 1 or edge change 0 → 1	<p>Up to 3 H functions programmed in an NC block are made available here simultaneously as soon as the H change signals are available.</p> <p>Value range of the H function: Floating point (corresponding to the MC5+format)</p> <p>Value range of the extended address: 0 to 99; integer number</p> <p>The H functions remain valid until they are overwritten by new H functions.</p>	
Signal state 0 or edge change 1 → 0	<ul style="list-style-type: none"> <li>• After the PLC has ramped-up.</li> <li>• All help functions are deleted before a new function is entered.</li> </ul>	
Application example(s)	Switching functions on the machine.	

<b>DB21, ... DBB158 - DBB193</b>	<b>F functions 1 to 6 Extended address F functions 1 to 6</b>							
Edge evaluation: No	Signal(s) updated: job-controlled by NCK							
Signal state 1 or edge change 0 → 1	<p>Up to 6 F functions (one path feed and up to 5 axis-specific feeds for positioning axes) are made available here simultaneously as soon as the F change signals are available.</p> <p>Value range of F function: Floating point (corresponding to the MC5+format)</p> <p>Value range of the extended address: 0 to 18; integer number</p> <p>The extended address of the F function is generated from the feed type (path feed or axis-specific feed) and the axis names.</p> <p>It is coded as follows:</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td style="text-align: center;">0:</td> <td style="text-align: center;">Path feed; e.g.: F=1000</td> <td style="text-align: center;">e.g.: F=1000</td> </tr> <tr> <td style="text-align: center;">1 to 18:</td> <td style="text-align: center;">Machine axis number of the positioning axis for an axis-specific feed</td> <td style="text-align: center;">e.g.: FA[X1]=500</td> </tr> </table> <p>The F functions remain until they are overwritten by new F functions.</p>		0:	Path feed; e.g.: F=1000	e.g.: F=1000	1 to 18:	Machine axis number of the positioning axis for an axis-specific feed	e.g.: FA[X1]=500
0:	Path feed; e.g.: F=1000	e.g.: F=1000						
1 to 18:	Machine axis number of the positioning axis for an axis-specific feed	e.g.: FA[X1]=500						
Signal state 0 or edge change 1 → 0	<ul style="list-style-type: none"> <li>• After the PLC has ramped-up.</li> <li>• All help functions are deleted before a new function is entered.</li> </ul>							
Application example(s)	Control of programmed F word by the PLC, e.g. through overwriting of the set feed rate override.							
Corresponding to ....	MD22240 \$MC_AUXFU_F_SYNC_TYPE (output time of F functions)							

<b>DB21, ... DBB194 - DBB206</b>	<b>Dynamic M functions: M0 - M99</b>	
Edge evaluation: No	Signal(s) updated: job-controlled by NCK	
Signal state 1 or edge change 0 → 1	The dynamic M signal bits are set by decoded M functions.	
Signal state 0 or edge change 1 → 0	<p>For a general help function output, the dynamic M signal bits are acknowledged by the PLC basic program after the OB1 has been completely run-through (executed once).</p> <p>For a fast help function output, after the PLC identifies the help functions, they are acknowledged in the same OB40 cycle.</p>	
Application example(s)	Spindle clockwise/counterclockwise rotation, switch coolant ON/OFF	

18.6 Help function output to PLC (H2)

<b>DB21, ... DBX318.5</b>	<b>Associated M01/M00 active</b>
Edge evaluation: No	Signal(s) updated:
Signal state 1 or edge change 0 → 1	This bit indicates that an M00 or M01 help function is active if the appropriate associated M00 and M01 (help functions) were enabled/activated beforehand.
Signal state 0 or edge change 1 → 0	No associated M00/M01 help functions active.
Corresponding to ....	DB21, ... DBX30.5 (activate associated M01)

18.6.3 Signals from axis/spindle (DB31, ...)

<b>DB31, ... DBD78</b>	<b>Value of F help function</b>
Edge evaluation: no	Signal(s) updated: Job-controlled
	The values of the F help functions for positioning axes are stored here. The axis to which each value applies is determined by the extended address.

<b>DB31, ... DBD86</b>	<b>Value of M help function</b>
Edge evaluation: no	Signal(s) updated: Job-controlled
	The values for the M3, M4, M5 help functions are sent to the associated interface for the addressed spindle.

<b>DB31, ... DBD88</b>	<b>Value of S help function</b>
Edge evaluation: no	Signal(s) updated: Job-controlled
	The values for the S help functions are sent to the associated interface for the addressed spindle.

## 18.7 Mode group, channel, program operation, reset response (K1)

### 18.7.1 Signals to mode group (DB11)

<b>DB11 DBX0.0</b>	<b>AUTOMATIC mode</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	AUTOMATIC mode is selected by the PLC program.	
Signal state 0 or edge change 1 → 0	AUTOMATIC mode is not selected by the PLC program.	
Signal irrelevant for ...	DB11 DBX0.4 (operating mode, changeover inhibit) = 1	
Corresponding to ....	DB11 DBX6.0 (active AUTOMATIC mode)	

<b>DB11 DBX0.1</b>	<b>MDA mode</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	MDA mode is selected by the PLC program.	
Signal state 0 or edge change 1 → 0	MDA mode is not selected by the PLC program.	
Signal irrelevant for ...	DB11 DBX0.4 (operating mode, changeover inhibit) = 1	
Corresponding to ....	DB11 DBX6.1 (active MDA mode)	

18.7 Mode group, channel, program operation, reset response (K1)

<b>DB11 DBX0.2</b>	<b>JOG mode</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	JOG mode is selected by the PLC program.
Signal state 0 or edge change 1 → 0	JOG mode is not selected by the PLC program.
Signal irrelevant for ...	DB11 DBX0.4 (operating mode, changeover inhibit) = 1
Corresponding to ....	DB11 DBX6.2 (active JOG mode)

<b>DB11 DBX0.4</b>	<b>Mode changeover inhibit</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	The currently active mode (JOG, MDA or AUTOMATIC) of the mode group cannot be changed. The machine functions that can be selected within a mode group can be changed.
Signal state 0 or edge change 1 → 0	The mode of the mode group can be changed.
	<p>The diagram shows three mode selection boxes: 'AUTOMATIC mode', 'MDA operating mode', and 'JOG mode'. These are connected to a central junction. A line from this junction leads to a switch labeled 'Mode switchover disable'. Below the switch, the text 'DBX0.4 = 0' is present. The switch is currently open, and a line connects it to a box labeled 'NC'.</p>

## 18.7 Mode group, channel, program operation, reset response (K1)

<b>DB11 DBX0.5</b>	<b>Mode group stop</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	An NC stop is activated for all the channels of the mode group. The channel status of all the active channels changes to the channel status "interrupted". All of the channels in channel status "reset" remain in the channel status "reset". Programs that are running at this point are immediately interrupted (at the earliest possible point, even within a block) and the program status changes to "stopped". All the moving axes of the mode group are decelerated according to their acceleration characteristics without contour violation. The program can be restarted with NC start. None of the spindles of that mode group are affected.	
Signal state 0 or edge change 1 → 0	Channel status and program execution are not influenced.	
Special cases, errors, ... ..	All the axes of a mode group that are not triggered by a program or a program block (e.g. axes traverse because traverse keys are being pressed on the machine control panel) decelerate to rest with mode group stop.	

<b>DB11 DBX0.6</b>	<b>Mode group stop axes plus spindles</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	An NC stop is activated for all the channels of the mode group. The channel status of all of the active channels changes to the channel status "interrupted". All of the channels in channel status "reset" remain in the channel status "reset". Programs that are running at this point are immediately interrupted (at the earliest possible point, even within a block) and the program status changes to "stopped". All the moving axes and spindles of the mode group are decelerated according to their acceleration characteristics without contour violation. The program can be restarted with NC start.	
Signal state 0 or edge change 1 → 0	Channel status and program execution are not influenced.	
Special cases, errors, .....	All the axes and spindles of a mode group that are not triggered by a program or a program block (e.g. axes traverse because traverse keys are pressed on the machine control panel, spindles are controlled by the PLC) decelerate to rest with "mode group stop plus spindles".	

<b>DB11 DBX0.7</b>	<b>Mode group reset</b>	
Edge evaluation: yes	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	A reset is activated for all the channels of the mode group. All of the channels are then in the channel status "reset". All of the current programs are then in the program status "aborted". All moving axes and spindles are decelerated to zero speed according to their acceleration ramp without contour violation. The initial settings are set (e.g. for G functions). The alarms for the mode group are cleared if they are not POWER ON alarms.	
Signal state 0 or edge change 1 → 0	Channel status and program execution are not influenced by this signal.	
Corresponding to ....	DB21, ... DBX7.7 (channel reset) DB11 DBX6.7 (all channels in the reset state)	

18.7 Mode group, channel, program operation, reset response (K1)

<b>DB11 DBX0.7</b>	<b>Mode group reset</b>
Special cases, errors, .....	An alarm that withdraws the interface signal DB11 DBX6.3 (mode group ready) ensures that all channels of the mode group are no longer in the reset state. In order to switch to another operating mode, a mode group reset (DB11 DBX0.7) must then be initiated.

<b>DB11 DBX1.0</b>	<b>Machine function TEACH IN</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	Machine function TEACH IN is activated in JOG mode for the mode group.
Signal state 0 or edge change 1 → 0	Machine function TEACH IN is not activated.
Signal irrelevant for ...	If JOG mode is not active.
Additional references	/BA/ Operations Guide HMI (corresponding to the used software)

<b>DB11 DBX1.1</b>	<b>Machine function REPOS</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	Machine function REPOS is activated in JOG mode for the mode group.
Signal state 0 or edge change 1 → 0	Machine function REPOS is not activated.
Signal irrelevant for ...	JOG mode is not active.
Application example(s)	When a fault occurs when executing a part program (e.g. tool breakage), the axis is manually moved away from the fault location in the JOG mode in order to be able to replace the tool. The axis can then be manually returned to the exact previous position using the REPOS machine function so that the program can be continued in the automatic mode.
Additional references	/BA/ Operations Guide HMI (corresponding to the used software)

<b>DB11 DBX1.2</b>	<b>Machine function REF</b>	
Edge evaluation: No		Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	Machine function REF is activated in the JOG mode for the mode group.	
Signal state 0 or edge change 1 → 0	Machine function REF is not activated.	
Signal irrelevant for ...	If JOG mode is not active.	
Additional references	/FB1/ Function Manual, Basic Functions; Reference Point Travel (R1)	

<b>DB11 DBX1.6</b>	<b>Single block type B</b>	
Edge evaluation: No		Signal(s) updated:
Signal state 1 or edge change 0 → 1	<p>Bit set and DB11 DBX1.7 not set: Response across modes</p> <ul style="list-style-type: none"> <li>• All channels are stopped.</li> <li>• All channels receive a start command.</li> <li>• Channel KS stops at the end of the block.</li> <li>• The channels KA receive a STOPATEND. (comparable with DB21, ... DBX7.2 (NC stop at the block limit).)</li> <li>• All channels are stopped at a block limit (at some point in time).</li> </ul> <p>(If DB11 DBX1.6 and DB11 DBX1.7 are set simultaneously, it is impossible to determine which single block type is required. In this case, the control assumes: No single block across mode groups).</p>	
Signal state 0 or edge change 1 → 0	<p>If Bit DB11 DBX1.6 is not set and Bit DB11 DBX1.7 is set, then it is single block type A. (If DB11 DBX1.6 and DB11 DBX1.7 are not set, it is impossible to determine which single block type is required. The control then assumes: No single block across mode groups).</p>	
Corresponding to ....	Single block type A	

18.7 Mode group, channel, program operation, reset response (K1)

<b>DB11 DBX1.7</b>	<b>Single block type A</b>	
Edge evaluation: No	Signal(s) updated:	
Signal state 1 or edge change 0 → 1	DB11 DBX1.7 set and DB11 DBX1.6 not set: Response across modes <ul style="list-style-type: none"> <li>• All channels are stopped.</li> <li>• All channels receive a start (start key).</li> <li>• Channel KS stops at the end of the block (due to single-block)</li> <li>• Channels KA receive a STOP command. (comparable to the STOP KEY).</li> <li>• All channels are stopped. (deceleration phase of all KAs)</li> </ul> (If DB11 DBX1.6 and DB11 DBX1.7 are set simultaneously, it is impossible to determine which single block type is required. The control then assumes: No single block across mode groups).	
Signal state 0 or edge change 1 → 0	If DB11 DBX1.7 is not set and DB11 DBX1.6 is set, then it is single block type B. (If DB11 DBX1.6 and DB11 DBX1.7 are not set, it is impossible to determine which single block type is required. The control then assumes: No single block across mode groups).	
Corresponding to ....	Single block type B	

18.7.2 Signals from the mode group (DB11)

<b>DB11 DBX4.0</b>	<b>Selected mode AUTOMATIC</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	AUTOMATIC mode is selected by HMI.	
Signal state 0 or edge change 1 → 0	AUTOMATIC mode is not selected by HMI.	

<b>DB11 DBX4.1</b>	<b>Selected mode MDA</b>	
Edge evaluation:	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	MDA mode is selected by HMI.	
Signal state 0 or edge change 1 → 0	MDA mode is not selected by HMI.	

<b>DB11 DBX4.2 Data block</b>	<b>Selected JOG mode Signal(s) from BAG (HMI → PLC)</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	JOG mode is selected by HMI.	
Signal state 0 or edge change 1 → 0	JOG mode is not selected by HMI.	

<b>DB11 DBX5.0</b>	<b>Selected machine function TEACH IN</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	The machine function TEACH IN is selected by HMI within BAG.	
Signal state 0 or edge change 1 → 0	The machine function TEACH IN is not selected by HMI.	
Additional references	/BA/ Operations Guide HMI (corresponding to the used software)	

<b>DB11 DBX5.1</b>	<b>Selected REPOS machine function</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	The machine function REPOS is selected by HMI within BAG.	
Signal state 0 or edge change 1 → 0	The machine function REPOS is not selected by HMI.	
Application example(s)	When a fault occurs when executing a part program (e.g. tool breakage), the axis is manually moved away from the fault location in the JOG mode in order to be able to replace the tool. The axis can then be manually returned to the exact previous position using the REPOS machine function so that the program can be continued in the automatic mode.	
Additional references	/BA/ Operations Guide HMI (corresponding to the used software)	

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<b>DB11 DBX5.2</b>	<b>Selected machine function REF</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	The machine function REF is selected by HMI within BAG.	
Signal state 0 or edge change 1 → 0	The machine function REF is not selected by HMI.	
Additional references	/FB1/ Function Manual, Basic Functions; Reference Point Travel (R1)	

<b>DB11 DBX6.0 Data block</b>	<b>Active mode AUTOMATIC Signal(s) from the mode group (NCK → PLC)</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	AUTOMATIC mode is active.	
Signal state 0 or edge change 1 → 0	AUTOMATIC mode is not active.	

<b>DB11 DBX6.1</b>	<b>Active mode MDA</b>	
Edge evaluation:	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	MDA mode is active.	
Signal state 0 or edge change 1 → 0	MDA mode is not active.	

## 18.7 Mode group, channel, program operation, reset response (K1)

<b>DB11 DBX6.2</b>	<b>Active JOG mode</b>	
Edge evaluation: No		Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	JOG mode is active.	
Signal state 0 or edge change 1 → 0	JOG mode is not active.	

<b>DB11 DBX6.3</b>	<b>Mode group ready</b>	
Edge evaluation: No		Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	This signal is set after power on and all of the voltage have been established. The mode group is now ready and parts programs can be executed and axes traversed in the individual channels.	
Signal state 0 or edge change 1 → 0	<p>The mode group is not ready. Possible causes for this are:</p> <ul style="list-style-type: none"> <li>• A critical axis or spindle alarm is present</li> <li>• Hardware faults</li> <li>• The mode group has been incorrectly configured (machine data)</li> </ul> <p>If the mode group ready changes to signal state "0", then:</p> <ul style="list-style-type: none"> <li>• the axis and spindle drives are braked down to standstill with the max. braking current.</li> <li>• the signals from the PLC to the NCK are brought into an inactive state (cleared state).</li> </ul>	
Special cases, errors, .....	<p>An alarm that withdraws the interface signal DB11 DBX6.3 (mode group ready) ensures that all channels of the mode group are no longer in the reset state. In order to switch to another operating mode, a mode group reset (DB11 DBX0.7) must be made.</p>	

<b>DB11 DBX6.7</b>	<b>All channels in the reset state</b>	
Edge evaluation: No		Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	All the channels that belong to this mode group are in the "channel status reset" state (DB21, ... DBX7.7).	
Signal state 0 or edge change 1 → 0	At least one of the channels in the mode group is not in "channel status reset" (DB21, ... DBX7.7).	
Corresponding to ....	DB21, ... DBX7.7 (channel state, reset)	

18.7 Mode group, channel, program operation, reset response (K1)

<b>DB11 DBX7.0</b>	<b>Active machine function TEACH IN</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	Machine function TEACH IN is active in the mode group.
Signal state 0 or edge change 1 → 0	Machine function TEACH IN is not active.
Additional references	/BA/ Operations Guide HMI (corresponding to the used software)

<b>DB11 DBX7.1</b>	<b>Active REPOS machine function</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	Machine function REPOS is active in the mode group.
Signal state 0 or edge change 1 → 0	Machine function REPOS is not active.
Application example(s)	When a fault occurs when executing a part program (e.g. tool breakage), the axis is manually moved away from the fault location in the JOG mode in order to be able to replace the tool. The axis can then be manually returned to the exact previous position using the REPOS machine function so that the program can be continued in the automatic mode.
Further references	/BA/ Operations Guide HMI (corresponding to the used software)

<b>DB11 DBX7.2</b>	<b>Active machine function REF</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	Machine function REF is active in the mode group.
Signal state 0 or edge change 1 → 0	Machine function REF is not active.
Further references	/FB1/ Function Manual, Basic Functions; Reference Point Travel (R1)

## 18.7.3 Signals to channel (DB21, ...)

<b>DB21, ... DBX0.4</b>	<b>Activate single block</b>	
Edge evaluation: no	Signal(s) updated: cyclic	
Signal state 1 or edge change 0 → 1	In AUTOMATIC and MDA modes, the operator must enable processing of each individual part program block of the part program selected in the channel by reactivating NC START.	
Signal state 0 or edge change 1 → 0	No effect.	
Special cases, errors, .....	<ul style="list-style-type: none"> <li>• In the case of active tool offset, intermediate blocks are inserted, when necessary. These blocks must also be enabled using NC START.</li> <li>• In a series of G33 blocks, a single block is only operative if "dry run feed" is selected.</li> <li>• In the case of a decoding single block, calculation blocks are not processed in the single step.</li> </ul>	
Corresponds to ....	DB21, ... DBX35.3 (program status interrupted)	

<b>DB21, ... DBX0.5</b>	<b>Activate M01</b>	
Edge evaluation: no	Signal(s) updated: cyclic	
Signal state 1 or edge change 0 → 1	Activation of program control "Conditional stop" M01 is requested.	
Signal state 0 or edge change 1 → 0	Activation of program control "Conditional stop" M01 is not requested.	
Corresponds to ....	DB21, ... DBX24.5 (M01 selected) DB21, ... DBX32.5 (M0/M01 active)	

DB21, ... DBX1.6	PLC action completed
Edge evaluation: no	Signal(s) updated: cyclic
	<p>At the end of the block search, concluding action blocks are executed:                      DB21, ... DBX32.3 (action block active) == 1 AND                      DB21, ... DBX32.6 (last action block active) == 1</p> <p>Alarm "10208 Channel &lt;Channel Number&gt; Issue NC START to continue program" notifies the user that he must reactivate NC START to resume the part program starting from the target block.</p> <p>If other actions are to be executed by the PLC user program prior to the NC START (e.g. tool change), Search mode can be parameterized as follows:                      MD11450 \$MN_SEARCH_RUN_MODE = 1</p> <p>Output of alarm delayed until the existing signal is reset.</p>
Signal state 1 or edge change 0 → 1	PLC action is completed.
Signal state 0 or edge change 1 → 0	PLC action is not yet completed.
Corresponds to ....	DB21, ... DBX32.3 (action block active) DB21, ... DBX32.6 (last action block active) DB21, ... DBX33.4 (block search active)

DB21, ... DBX1.7	Activate program test
Edge evaluation: no	Signal(s) updated: cyclic
Signal state 1 or edge change 0 → 1	<p>Activation of the program test is requested.</p> <p>During the program test, all motion commands of axes (not spindles) take place under "Axis disable."</p> <p><b>Notice!</b>                      Due to the axis disable, the assignment of a tool magazine is not changed for the program test. The user/machine manufacturer must utilize a suitable PLC user program to ensure that the NCK-internal tool management and the actual assignment of the tool magazine remain consistent. Refer to the program example included in the PLC Toolbox.</p>
Signal state 0 or edge change 1 → 0	Activation of the program test is not requested.
Corresponds to ....	DB21, ... DBX25.7 (program test selected) DB21, ...DBX33.7 (program test active)

<b>DB21, ... DBX2.0</b>	<b>Skip block</b>	
Edge evaluation: no	Signal(s) updated: cyclic	
Signal state 1 or edge change 0 → 1	Skip blocks marked in the part program with a slash (/) are not processed. If there is a series of skip blocks, the signal is only active if it is present before the first skip block of the series is decoded.  Note The signal should be available prior to the start of the part program.	
Signal state 0 or edge change 1 → 0	Skip blocks marked in the part program with a slash (/) are processed.	
Corresponds to ....	DB21, ... DBX26.0 (Skip block selected) DB21, ... DBX35.2 (Program status stopped)	

<b>DB21, ... DBX6.1</b>	<b>Read-in disable</b>	
Edge evaluation: no	Signal(s) updated: cyclic	
Signal state 1 or edge change 0 → 1	The main run reads in no more preprocessed part program blocks.  Note The signal is only active in AUTOMATIC and MDA modes.	
Signal state 0 or edge change 1 → 0	The main run reads in preprocessed part program blocks.	
Corresponds to ....	DB21, ... DBX35.0 (program status running)	

<b>DB21, ... DBX6.4</b>	<b>Program level abort</b>	
Edge evaluation: yes	Signal(s) updated: cyclic	
Signal state 1 or edge change 0 → 1	At each edge change 0 → 1 the current program level being processed (subroutine level, ASUB level, save routine) is immediately aborted. Processing of the part program continues at the next higher program level from the exit point.	
Signal state 0 or edge change 1 → 0	No effect.	
Special cases, errors, .....	The main program level cannot be aborted with this IS, only with IS "Reset".	

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<b>DB21, ... DBX7.0</b>	<b>NC START disable</b>	
Edge evaluation: no	Signal(s) updated: cyclic	
Signal state 1 or edge change 0 → 1	The NC START disable prevents a part program from being started with NC START signal DB21, ... DBX7.1 (NC START) == 1.	
Signal state 0 or edge change 1 → 0	NC START disable is not active.	
Special cases, errors, .....	The start of a part program selected in the channel by part program command <code>START</code> in another channel (program coordination) is not prevented by the interface signal: DB21, ... DBX7.0 (NC start disable) == 1.	
Corresponds to ....	DB21, ... DBX7.1 (NC START)	

<b>DB21, ... DBX7.1</b>	<b>NC START</b>	
Edge evaluation: yes	Signal(s) updated: cyclic	
Signal state 1 or edge change 0 → 1	<p>AUTOMATIC mode: The selected NC program is started or continued, or the auxiliary functions that were saved during the program interruption are output.</p> <p>If data are transferred from the PLC to the NC during program status "Program interrupted," then these data are immediately cleared at NC start.</p> <p>Operating mode MDA: The entered block information or part program blocks are released for execution.</p>	
Signal state 0 or edge change 1 → 0	No effect.	
Corresponds to ....	DB21, ... DBX7.0 (NC start disable)	

<b>DB21, ... DBX7.2</b>	<b>NC STOP at block limit</b>	
Edge evaluation: no	Signal(s) updated: cyclic	
Signal state 1 or edge change 0 → 1	The current NC program is stopped after the current part program block has been completely processed. Otherwise, as for DB21, ... DBX7.3 (NC stop).	
Signal state 0 or edge change 1 → 0	No effect.	
Corresponds to ....	<p>DB21, ... DBX7.3 (NC stop)</p> <p>DB21, ... DBX7.4 (NC stop, axes plus spindles)</p> <p>DB21, ... DBX35.2 (program status stopped)</p> <p>DB21, ... DBX35.6 (channel status interrupted)</p>	

DB21, ... DBX7.3	NC STOP	
Edge evaluation: no	Signal(s) updated: cyclic	
Signal state 1 or edge change 0 → 1	<p>AUTOMATIC or MDA mode: Processing of the part program active in the channel is stopped. The axes (not spindles) are brought to a standstill within the assigned acceleration parameters.</p> <ul style="list-style-type: none"> <li>• Program status: stopped</li> <li>• Channel status: interrupted</li> </ul> <p>JOG mode: In JOG mode, incompletely traversed incremental paths (INC...) are retracted at the next NC START.</p> <p>Note The signal must be present for at least one PLC cycle (OB1).</p>	
Signal state 0 or edge change 1 → 0	No effect.	
Signal irrelevant for ...	<ul style="list-style-type: none"> <li>• Program status: aborted</li> <li>• Channel status: Reset</li> </ul>	
Special cases, errors, .....	<ul style="list-style-type: none"> <li>• If data are transferred to the NCK after NC STOP (e.g. tool offset), the data are cleared at the next NC START.</li> </ul>	
Corresponds to ....	DB21, ... DBX7.2 (NC STOP at block limit) DB21, ... DBX7.4 (NC STOP axes plus spindles) DB21, ... DBX35.2 (program status stopped) DB21, ... DBX35.6 (channel status interrupted)	

DB21, ... DBX7.4	NC STOP axes plus spindles	
Edge evaluation: no	Signal(s) updated: cyclic	
	See DB21, ... DBX7.3 (NC STOP). In addition, the spindles of the channel are stopped.	

18.7 Mode group, channel, program operation, reset response (K1)

<b>DB21, ... DBX7.7</b>	<b>Reset</b>
Edge evaluation: no	Signal(s) updated: cyclic
Signal state 1 or edge change 0 → 1	The channel is reset. The initial settings are set (e.g. G functions). The alarms for the channel are cleared if they are not POWER ON alarms. The reset signal must be issued by the PLC (e.g. using a logic operation with the reset key on the MCP). The signal is only evaluated by the selected channel. The program status changes to "Aborted", and the channel status changes to "Channel status reset".
Signal state 0 or edge change 1 → 0	No effect.
Corresponds to ....	DB11, ... DBX0.7 (mode group reset) DB21, ... DBX35.7 (channel status reset)

<b>DB21, ... DBX31.0 - DBX31.2</b>	<b>REPOS mode (REPOSPATHMODE)</b>
Edge evaluation: no	Signal(s) updated: cyclic
	REPOS mode specified by HMI: Bit: 2 1 0 0 0 0 = 0: no REPOS mode active 0 0 1 = 1: Re-approach to block start <i>RMB</i> 0 1 0 = 2: Re-approach to interruption point <i>RMI</i> 0 1 1 = 3: Re-approach to block end point <i>RME</i> 1 0 0 = 4: Re-approach to nearest path point <i>RMN</i>
Corresponds to ....	DB21, ...DBX25.0 - DBX25.2 (REPOS mode (REPOSPATHMODE)) DB31, ... DBX10.0 (REPOSDELAY)

<b>DB21, ... DBX31.4</b>	<b>REPOS mode change (REPOSMODEEDGE)</b>
Edge evaluation: yes	Signal(s) updated: cyclic
Signal state 1 or edge change 0 → 1	The REPOS mode has changed: DB21, ... DBX31.0 - DBX31.2 (REPOS mode (REPOSPATHMODE))
Signal state 0 or edge change 1 → 0	REPOS mode has not changed.
Corresponds to ....	DB21, ... DBX31.0 - DBX31.2 (REPOS mode (REPOSPATHMODE)) DB21, ... DBX319.0 (REPOSMODEEDGEACKN) DB21, ...DBX31.0 - DBX31.2 (REPOS mode (REPOSPATHMODE))

## 18.7.4 Signals from channel (DB21, ...)

<b>DB21, ... DBX32.3</b>	<b>Action block active</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	The action block is being executed.	
Signal state 0 or edge change 1 → 0	No action block active.	
Additional references	/BA/ Operations Guide HMI (corresponding to the used software)	

<b>DB21, ... DBX32.4</b>	<b>Approach block active</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	The approach block for the progress of the program with "Block search with computation on contour" is active, as with "Block search with computation on block end point" no approach block is created of its own. The axes are automatically positioned on the collected search position if ASUP exits with REPOSA during "Block search with computation on contour".	
Signal state 0 or edge change 1 → 0	The search target is found during "Block search with computation on contour".	
Further references	/PGA/ Programming Manual Advanced	

<b>DB21, ... DBX32.5</b>	<b>M00/M01 active</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	The part program block is processed, the auxiliary functions are output, and: <ul style="list-style-type: none"> <li>• M00 is in the RAM</li> <li>• M01 is in the RAM and IS "Activate M01" is active</li> </ul> The program status changes to "Stopped".	
Signal state 0 or edge change 1 → 0	<ul style="list-style-type: none"> <li>• With DB21, ... DBX7.1 (NC start)</li> <li>• For a program abort as a result of a reset</li> </ul>	

<b>DB21, ... DBX32.5</b>	<b>M00/M01 active</b>
Screen	<p>                 ① Data transfer to working memory      ④ M change signal (1 PLC cycle time)                  ② Block processed                              ⑤ IS "M00/M01 active"                  ③ NC block with M00                            ⑥ IS "Channel state active" (even when axes are moved in JOG mode)             </p>
Corresponding to ....	DB21, ... DBX0.5 (activate M01) DB21, ... DBX24.5 (M01 selected)

<b>DB21, ... DBX32.6</b>	<b>Last action block active</b>
Edge evaluation: No      Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	The last action block is being executed. This means, that all the action blocks on the side of NC have been processed and the actions on the side of PLC (ASUP, FC) or the operator such as overstore, mode change according to JOG/REPOS are possible. In this way the PLC for example can still perform a tool change before the start of movement.
Signal state 0 or edge change 1 → 0	The last action block is not being executed. Action blocks contain the actions collected during "block search with computation" such as <ul style="list-style-type: none"> <li>• Outputting help function H, M00, M01, M..</li> <li>• Tool programming T, D, DL</li> <li>• Spindle programming S-Value, M3/M4/M5/M19, SPOS</li> <li>• Feed programming, F</li> </ul>
Further references	/FB1/ Function Manual, Basic Functions; K1 Channel, Program Operation, Reset Response

<b>DB21, ... DBX33.4</b>	<b>Block search active</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	The block search function is active. It was selected from the operator interface screen and started using the interface signal: DB21, ... DBX7.1 (NC start)	
Signal state 0 or edge change 1 → 0	Search target found.	
Application example(s)	The block search function makes it possible to jump to a certain block within a part program and to start processing the part program from this block.	
Additional references	/FB1/ Function Manual, Basic Functions; K1 Channel, Program Operation, Reset Response	

<b>DB21, ... DBX33.5</b>	<b>M02/M30 active</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	<ul style="list-style-type: none"> <li>• NC block with M02 or M30 (or M17 if a subroutine was started) is completely processed; if traversing motions are also programmed in this block, the signal is only output when the target position is reached.</li> <li>• The program was interrupted as a result of a reset, and the program status changes to "Aborted".</li> <li>• When MDA mode or machine functions REF or PRESET are selected</li> <li>• After DB10 DBX56.2 (acknowledge EMERGENCY STOP)</li> </ul>	
Signal state 0 or edge change 1 → 0	<ul style="list-style-type: none"> <li>• No program end or program abort</li> <li>• Status after activation of control</li> <li>• Start of an NC Program</li> </ul>	

<b>DB21, ... DBX33.5</b>	<b>M02/M30 active</b>
Screen	<p>                     ① Data transfer to working memory      ④ M change signal (1 PLC cycle time)                      ② Block processed                              ⑤ IS "M02/M30 active"                      ③ NC block with M02                 </p>
Application example(s)	The PLC can detect the end of program processing with this signal and react appropriately.
Special cases, errors, .....	<ul style="list-style-type: none"> <li>• The M02 and M30 functions have equal priority.</li> <li>• The interface signal: DB21, ... DBX33.5 (M02/M30 active) is available as steady-state signal after the end of the program.</li> <li>• Not suitable for automatic follow-on functions such as workpiece counting, bar feed, etc. M02/M30 must be written in a separate block and the word M02/M30 or the decoded M signal used for these functions.</li> <li>• Auxiliary functions that could result in a read-in operation being stopped and any S values that are to be operative beyond M02/M30 must not be written in the last block of a program.</li> </ul>

<b>DB21, ... DBX33.6</b>	<b>Transformation active</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	The NC command TRAORI (activate transformation) is programmed in the NC part program. This block has been processed by the NC and the transformation is now activated.	
Signal state 0 or edge change 1 → 0	No transformation active.	
Additional references	/PGA/ Programming Manual Job Planning	

<b>DB21, ... DBX33.7</b>	<b>Program test active</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	Program control program test is active. Axis disable is set internally for all axes (not spindles). Therefore the machine axes do not move when a part program block or a part program is being processed. The axis movements are simulated on the operator interface with changing axis position values. The axis position values for the display are generated from the calculated setpoints. The part program is processed in the normal way.
Signal state 0 or edge change 1 → 0	Program control "Program test" is not active.
Corresponding to ....	DB21, ... DBX1.7 (activate program test) DB21, ... DBX25.7 (program test selected)

<b>DB21, ... DBX35.0</b>	<b>Program status running</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	The part program was started with the interface signal: DB21, ... DBX7.1 (NC start) and is running. The running program was stopped with the interface signal: DB21, ... DBX6.1 (read-in disable)
Signal state 0 or edge change 1 → 0	<ul style="list-style-type: none"> <li>• Program stopped by M00/M01 or NC stop or operating mode change.</li> <li>• If single block mode, the block is processed.</li> <li>• End of program reached (M02/M30).</li> <li>• Program aborted due to a reset.</li> <li>• No actual block in the memory (e.g. for MDA).</li> <li>• The actual block cannot be executed.</li> </ul>
Signal irrelevant for ...	The part program was started with the interface signal: DB21, ... DBX7.1 (NC start) and is running.
Special cases, errors, .....	The interface signal: DB21, ... DBX35.0 (program status running) does not change to 0 if workpiece machining is stopped due to the following events: <ul style="list-style-type: none"> <li>• A feed disable or spindle disable was output</li> <li>• DB21, ... DBX6.1 (read-in disable)</li> <li>• Feed correction to 0%</li> <li>• The spindle and axis monitoring functions respond</li> <li>• Position setpoints are entered in the NC program for axes in "follow-up mode," for axes without "servo enable," or for "parking axes"</li> </ul>
Corresponding to ....	DB21, ... DBX6.1 (read-in disable)

18.7 Mode group, channel, program operation, reset response (K1)

<b>DB21, ... DBX35.1</b>	<b>Program status wait</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	The running program is waiting for the program command <code>WAIT_M</code> or <code>WAIT_E</code> in an NC block. The wait condition specified in the <code>WAIT</code> command for the channel or channels has not yet been fulfilled.
Signal state 0 or edge change 1 → 0	Program status wait is not active.
Further references	/PG/ Programming Manual Fundamentals

<b>DB21, ... DBX35.2</b>	<b>Program status stopped</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	The NC part program has been stopped by: <ul style="list-style-type: none"> <li>• DB21, ... DBX7.3 (NC stop)</li> <li>• DB21, ... DBX7.4 (NC stop, axes plus spindles)</li> <li>• DB21, ... DBX7.2 (NC stop at the block limit)</li> <li>• Programmed <code>M00</code> or <code>M01</code></li> <li>or</li> <li>• Single block mode</li> </ul>
Signal state 0 or edge change 1 → 0	"Program status stopped" is not present.
Corresponding to ....	DB21, ... DBX7.3 (NC stop) DB21, ... DBX7.4 (NC stop, axes plus spindles) DB21, ... DBX7.2 (NC stop at the block limit)

<b>DB21, ... DBX35.3</b>	<b>Program status interrupted</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	When the operating mode changes from AUTOMATIC or MDA (in stopped program status) to JOG, the program status changes to "Interrupted". The program can be continued at the point of interruption in AUTOMATIC or MDA mode when NC start is issued.
Signal state 0 or edge change 1 → 0	"Program status interrupted" not available.
Special cases, errors, .....	The interface signal: DB21, ... DBX35.3 (program status interrupted) indicates that the part program can continue to be processed by restarting it.

<b>DB21, ... DBX35.4</b>	<b>Program status aborted</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	The program has been selected but not started, or the current program was aborted with a reset.	
Signal state 0 or edge change 1 → 0	Program status interrupted is not active.	
Corresponding to ....	DB21, ... DBX7.7 (reset)	

<b>DB21, ... DBX35.5</b>	<b>Channel status active</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	In this channel: <ul style="list-style-type: none"> <li>• A part program is presently being executed in Automatic or MDA mode</li> <li>or</li> <li>• At least one axis is being traversed in JOG mode.</li> </ul>	
Signal state 0 or edge change 1 → 0	DB21, ... DBX35.3 (channel status interrupted) or DB21, ... DBX35.7 (channel status reset) is present.	

<b>DB21, ... DBX35.6</b>	<b>Channel status interrupted</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	The NC part program in AUTOMATIC or MDA mode or a traversing motion in JOG mode can be interrupted by: <ul style="list-style-type: none"> <li>• DB21, ... DBX7.3 (NC stop)</li> <li>• DB21, ... DBX7.4 (NC stop, axes plus spindles)</li> <li>• DB21, ... DBX7.2 (NC stop at the block limit)</li> <li>• Programmed M00 or M01</li> <li>or</li> <li>• Single block mode</li> </ul> After an NC start the part program or the interrupted traversing movement can be continued.	
Signal state 0 or edge change 1 → 0	DB21, ... DBX35.5 (channel status active) or DB21, ... DBX35.7 (channel status reset) is present.	

18.7 Mode group, channel, program operation, reset response (K1)

<b>DB21, ... DBX35.7</b>	<b>Channel status reset</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	The signal changes to 1 as soon as the channel goes into the reset state, i.e. no processing taking place.	
Signal state 0 or edge change 1 → 0	The signal is set to 0 as soon as processing takes place in the channel, e.g.: <ul style="list-style-type: none"> <li>• Execution of a part program</li> <li>• Block search</li> <li>• TEACH IN active</li> <li>• Overstore active</li> </ul>	

<b>DB21, ... DBX36.4</b>	<b>Interrupt processing active</b>	
Edge evaluation:	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	One or several channels in the mode group are not in the required operating state as the result of an active interrupt routine. The signal is not set if an interrupt routine is running in a program mode.	
Signal state 0 or edge change 1 → 0	All channels are operating in the required mode.	
Corresponding to ....	MD11600 \$MN_BAG_MASK	

<b>DB21, ... DBX36.5</b>	<b>Channel is ready</b>	
Edge evaluation:	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	A channel is ready for a part program processing of machine axes, geometry axes and positioning axes. These are already allocated corresponding to machine configuration and the current program status of the concerned channels.	
Signal state 0 or edge change 1 → 0	The concerned channel is not ready for a part program processing of machine axes, geometry axes and positioning axes.	
Corresponding to ....	MD11600 \$MN_BAG_MASK	

<b>DB21, ... DBX37.6</b>	<b>Read-in disable is ignored</b>	
Edge evaluation:	Signal(s) updated:	
	<p>The following machine data are used to specify that the read-in disable (DB21, ... DBX6.1) is to be ignored:</p> <ul style="list-style-type: none"> <li>• MD11602 \$MN_ASUP_START_MASK, Bit 2 = 1 (start also permitted if read-in disable is active)</li> <li>• MD20116 \$MC_IGNORE_INHIBIT_ASUP (execute interrupt program in spite of read-in disable)</li> <li>• MD20107 \$MC_PROG_EVENT_IGN_INHIBIT (Prog events ignore read-in disable)</li> </ul> <p>Part program blocks for which read-in disable is ignored are designated as read-in disable-inoperative.</p>	
Signal state 1	Read-in disable is active (DB21, ... DBX6.1==1) AND part program block is read-in disable-inoperative.	
Signal state 0	Read-in disable is not active (DB21, ... DBX6.1 == 0) OR (read-in disable is active (DB21, ... DBX6.1 == 1) AND part program block is read-in disable-inoperative)	
Corresponding to ....	DB21, ... DBX37.7 (Stop at block end is ignored during single block (SBL))	

<b>DB21, ... DBX37.7</b>	<b>Stop at block end is ignored during single block (SBL)</b>	
Edge evaluation:	Signal(s) updated:	
	<p>The following machine data and part program commands are used to specify that the stop at block end during single block (DB21, ... DBX0.4 == 1) is to be ignored:</p> <ul style="list-style-type: none"> <li>• MD10702 \$MN_IGNORE_SINGLEBLOCK_MASK (Prevent single block stop)</li> <li>• MD20117 \$MC_IGNORE_SINGLEBLOCK_ASUP (Execute interrupt program completely in spite of single block)</li> <li>• MD20106 \$MC_PROG_EVENT_IGN_SINGLEBLOCK (Prog events ignore single block)</li> <li>• SBLOF (suppress single block), SBLON (cancel single block suppression)</li> </ul> <p>Part program blocks for which stop at block end during single block is ignored are designated as single block-inoperative.</p>	
Signal state 1	Single block is active (DB21, ... DBX0.4==1) AND part program block is single block-inoperative.	
Signal state 0	Single block is not active (DB21, ... DBX0.4 == 0) OR (single block is active (DB21, ... DBX0.4 == 1) AND part program block is single block-operative)	
Corresponding to ....	Read-in disable is ignored. DB21, ... DBX37.6 (read-in disable is ignored)	

<b>DB21, ... DBB208 - DBB271</b>	<b>Active G function of groups 1 to 60</b>																												
Edge evaluation: No	Signal(s) updated: Cyclically																												
Signal state <> 0	<p>A G function or mnemonic identifier of the G group is active.                      The active G function can be determined from the value (starting with 1):                      1 = First G function of the G group                      2 = Second G function of the G group                      3 = Third G function of the G group</p> <p>Please refer to a listing of the possible G-groups with the relevant functions in the Programming Fundamentals Guide.</p>																												
Signal state = 0	No G function or G group mnemonic identifier is active.																												
Application example(s)	<p>The active G group is stored in binary code in the relevant byte.                      The following evaluation applies:</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td style="padding-right: 20px;">Bit</td> <td style="padding-right: 10px;">7</td> <td style="padding-right: 10px;">6</td> <td style="padding-right: 10px;">5</td> <td style="padding-right: 10px;">4</td> <td style="padding-right: 10px;">3</td> <td style="padding-right: 10px;">2</td> <td style="padding-right: 10px;">1</td> <td style="padding-right: 10px;">0</td> </tr> <tr> <td>Evaluation</td> <td>128</td> <td>64</td> <td>32</td> <td>16</td> <td>8</td> <td>4</td> <td>2</td> <td>1</td> </tr> <tr> <td>Example: G90</td> <td>0</td> <td>1</td> <td>0</td> <td>1</td> <td>1</td> <td>0</td> <td>1</td> <td>0</td> </tr> </table>		Bit	7	6	5	4	3	2	1	0	Evaluation	128	64	32	16	8	4	2	1	Example: G90	0	1	0	1	1	0	1	0
Bit	7	6	5	4	3	2	1	0																					
Evaluation	128	64	32	16	8	4	2	1																					
Example: G90	0	1	0	1	1	0	1	0																					
Special cases, errors, .....	In contrast to auxiliary functions, G functions are not output to the PLC subject to acknowledgement, i.e. processing of the part program is continued immediately after the G function output.																												
Additional references	Programming Manual, Fundamentals																												

<b>DB21, ... DBX318.0</b>	<b>ASUB is stopped</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	The signal is set to 1 if the control stops automatically prior to the end of the ASUB. The IS DB21, ... DBX318.0 (ASUB is stopped) is only supplied in the case "Interrupt in a program mode and channel status stopped".	
Signal state 0 or edge change 1 → 0	The IS DB21, ... DBX318.0 (ASUB is stopped) is set to 0 with start and reset.	

18.7 Mode group, channel, program operation, reset response (K1)

<b>DB21, ... DBX318.0</b>	<b>ASUB is stopped</b>
	<p>Typical sequence of an ASUB with REPOSA:</p>
ASUB with REPOSA is triggered in the status AUTOMATIC mode stopped	<p>If the interrupt routine is ended with REPOSA, then the following sequence is typical:</p> <ul style="list-style-type: none"> <li>• The part program is stopped using the stop key, stop-all key or as a result of an alarm.</li> <li>• The controller assumes program status "Stopped".</li> <li>• The PLC initiates an ASUB via block FC9.</li> <li>• Before the re-approach to the contour, the controller stops and goes to program status "Stopped". IS DB21, ... DBX318.0 (ASUB is stopped) is set.</li> <li>• The user presses Start. The IS DB21, ... DBX318.0 (ASUB is stopped) is reset, the re-approach motion is started.</li> <li>• At the end of the re-approach motion, the FC9 signal "ASUB done" is set and the path of the interrupted part program is continued.</li> </ul>

<b>DB21, ... DBX318.1</b>	<b>Block search via program test is active</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	During the processing of the part program block in context of block search (internal channel status: "Program test"), up to the change of the target block in the main execution (Program status: "Stopped").	
Signal state 0 or edge change 1 → 0	With the change of the target block in the main execution (internal channel status: "Program test" is de-selected; Stop condition: "Search target found" is displayed).	
Special cases, errors, .....	The block search (SERUPRO) can only be activated in AUTOMATIC mode in program status "Aborted".	

<b>DB21, ... DBX319.0</b>	<b>REPOS MODE EDGE ACKN</b>
Edge evaluation: yes	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	The interface signal detected by the NCK: DB21, ... DBX31.4 (REPOS MODE EDGE) is with the interface signal: DB21, ... DBX319.0 (REPOS MODE EDGE ACKN) acknowledged, if level signals from: DB21, ... DBX31.0 - DBX31.2 (REPOS MODE 0-2) and from: DB31, ... DBX10.0 (REPOS DELAY) are taken over in the NC. The levels relate to the current block in the main run.
Signal state 0 or edge change 1 → 0	SERUPRO-ASUB stops automatically before REPOS and IS DB21, ... DBX319 (REPOS MODE EDGE) does not influence the SERUPRO approach.
Corresponding to ....	DB21, ... DBX31.4 (REPOS MODE EDGE)

<b>DB21, ... DBX319.1 - DBX319.3</b>	<b>Repos Path Mode Ackn 0 - 2</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1	Using the interface signal: DB21, ... DBX319.1 - DBX319.3 (Repos Path Mode Ackn 0-2) with the 3 bits, one of the functions for the re-approach point RMB, RMI, RME or RMN can be acknowledged according to the following coding to the PLC: DB21, ... DBX319.1 - DBX319.3 = 1 → RMB: Re-approach at the start of the block DB21, ... DBX319.1 - DBX319.3 = 2 → RMI: Re-approach at the point of interruption DB21, ... DBX319.1 - DBX319.3 = 3 → RME: Re-approach at the end of the block DB21, ... DBX319.1 - DBX319.3 = 4 → RMN: Re-approach at the nearest path point
Signal state 0	DB21, ... DBX319.1 - DBX319.3 = 0 → RMNOTDEF: The ReposMode that is not re-defined is acknowledged to the PLC.

<p>DB21, ... DBX319.1 - DBX319.3</p>	<p>Repos Path Mode Ackn 0 - 2</p>
	<p>Example of the sequence of REPOS acknowledgments in the part program and signal timing of the acknowledgement process from the NCK:</p> <p>① Start part program ② Stop part program ③ Preselect RMN ④ Output ASUB ⑤ Command is started with ASUP ⑥ Re-approach from REPOS has been completed. The remaining block starts. ⑦ The remaining block is finished</p>
<p>Corresponding to ....</p>	<p>DB21, ... DBX31.0 - DBX31.2 (REPOSPATHMODE0-2) DB21, ... DBX31.4 (REPOSMODEEGGE) DB21, ... DBX319.0 (REPOSMODEEGGEACKN) DB31, ... DBX70.2 (Repos Delay Ackn)</p>
<p>Additional references</p>	<p>/FB1/ Function Manual, Basic Functions; BAG, Channel, Program Operation, Reset Response (K1), Section: " Block search, type 5 SERUPRO for block search"</p>

<b>DB21, ... DBX319.5</b>	<b>Repos DEFERAL Chan</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	All axes currently controlled by this channel have either no REPOS offset or their REPOS offsets are invalid.	
Signal state 0 or edge change 1 → 0	Miscellaneous.	
Corresponding to ....	DB31, ... DBX70.0 (Repos offset)	

<b>DB21, ... DBB376</b>	<b>PROG-EVENT-DISPLAY</b>	
Edge evaluation: No	Signal(s) updated: Event-driven	
Signal state 1 or edge change 0 → 1	The event assigned to the bit has activated the "Event-driven program call" function.	
Signal state 0 or edge change 1 → 0	<ul style="list-style-type: none"> <li>• The event assigned to the bit has not activated the "Event-driven program call" function.</li> <li>or</li> <li>• The event-driven user program has expired or was cancelled with RESET.</li> </ul>	
Bit assignments	Bit 0 → part program start from channel status RESET Bit 1 → end of part program Bit 2 → operator panel reset Bit 3 → run-up Bit 4 → 1st start after the search run Bit 5 - 7 → reserved, currently always 0 All bits 0 → No event-driven program call is active Signal duration: at least one complete PLC cycle	

<b>DB21, ... DBX378.0</b>	<b>ASUB is active</b>	
Edge evaluation: No	Signal(s) updated: Event-driven	
Signal state 1 or edge change 0 → 1	One ASUB is active. <b>Note:</b> The user gets a feedback on a running ASUB through DB21, ... DBX378.0 even outside FC9 block.	
Signal state 0 or edge change 1 → 0	No ASUB is active.	

<b>DB21, ... DBX378.1</b>	<b>Still ASUB is active</b>	
Edge evaluation: No	Signal(s) updated: Event-driven	
Signal state 1 or edge change 0 → 1	An ASUB with suppressed display updating (refer to MD20191 \$MC_IGN_PROG_STATE_ASUP) is active.	
Signal state 0 or edge change 1 → 0	No ASUB with suppressed display updating is active.	

<b>DB21, ... DBX384.0</b>	<b>Control program branching</b>	
Edge evaluation: No	Signal(s) updated:	
Signal state 1 or edge change 0 → 1	GOTOS in the part program initiates a return to the program start. The program is then processed again.	
Signal state 0 or edge change 1 → 0	GOTOS initiates no return. Program execution is continued with the next part program block after GOTOS.	
Corresponding to ....	MD27860 \$MC_PROCESSTIMER_MODE (Activation of the program runtime measurement) MD27880 \$MC_PART_COUNTER (activation of workpiece counters)	

**18.7.5 Signals to axis/spindle (DB31, ...)**

<b>DB31, ... DBX10.0</b>	<b>REPOSDELAY</b>	
Edge evaluation: no	Signal(s) updated: cyclic	
Signal state 1 or edge change 0 → 1	The REPOS offset of the axis is first applied with its next programming.	
Signal state 0 or edge change 1 → 0	There is no REPOS offset.	
Special cases, errors, .....	The signal is not relevant for path axes.	
Corresponds to ....	DB21, ... DBX31.0 - DBX31.2 (REPOSPATHMODE0-2) DB31, ... DBX70.2 (REPOS Delay Ackn) DB31, ... DBX72.0 (REPOSDELAY)	

**18.7.6 Signals from axis/spindle (DB31, ...)**

<b>DB31, ... DBX70.0</b>	<b>REPOS offset</b>	
Edge evaluation: no	Signal(s) updated: cyclic	
Signal state 1 or edge change 0 → 1	A REPOS offset must be applied for the appropriate axis.	
Signal state 0 or edge change 1 → 0	No REPOS offset need be applied for the appropriate axis.	
Corresponds to ....	DB31, ... DBX70.1 (REPOS offset valid)	

## 18.7 Mode group, channel, program operation, reset response (K1)

<b>DB31, ... DBX70.1</b>	<b>REPOS offset valid</b>
Edge evaluation: no	Signal(s) updated: cyclic
Signal state 1 or edge change 0 → 1	The range of validity of the REPOS offset is indicated with the value 1. The REPOS offset was calculated to be valid.
Signal state 0 or edge change 1 → 0	A value of zero indicates that the REPOS offset was calculated to be invalid.
Application example(s)	Updating the REPOS offset in the range of validity: Between SERUPRO end and start, the axis can be moved in JOG mode with a mode change. The user moves the REPOS offset to the zero value.
Corresponds to ....	DB31, ... DBX70.0 (REPOS offset)

<b>DB31, ... DBX70.2</b>	<b>REPOS Delay Ackn</b>
Edge evaluation: no	Signal(s) updated: cyclic
Signal state 1 or edge change 0 → 1	The axis was programmed within a traversing block, and the REPOS offset was applied. Note A REPOS offset was available for the axis, and REPOSDELAY was active: DB31, ... DBX10.0 (REPOSDELAY) == 1 This signal behaves the same as: DB21, ... DBX319.1 - DBX319.3 (Repos Path Mode Ackn)
Signal state 0 or edge change 1 → 0	The value zero is used to acknowledge that the REPOS offset is not active for this axis. This signal is cancelled on activation of the remaining block.
Corresponds to ....	DB31, ... DBX10.0 (REPOSDELAY) DB31, ... DBX72.0 (REPOSDELAY)

<b>DB31, ... DBX72.0</b>	<b>REPOSDELAY</b>
Edge evaluation: no	Signal(s) updated: cyclic
Signal state 1 or edge change 0 → 1	After a block search, a REPOS offset is applied for this axis. However it is not applied using the approach block, but rather using the next traversing block in which the axis is programmed.
Signal state 0 or edge change 1 → 0	The REPOS offset for this axis is not active.
Special cases, errors, .....	The signal is not relevant for path axes.
Corresponds to ....	DB21, ... DBX31.0 - DBX31.2 (REPOSPATHMODE) DB31, ... DBX10.0 (REPOSDELAY) DB31, ... DBX70.2 (REPOS Delay Ackn)

<b>DB31, ... DBX76.4</b>	<b>Path axis</b>	
Edge evaluation: no	Signal(s) updated: cyclic	
Signal state 1 or edge change 0 → 1	The axis is involved in the path (path axis). Note In conjunction with SERUPRO in status "Target block found", the signal refers to the status of the axis in the target block.	
Signal state 0 or edge change 1 → 0	The axis is not involved in the path.	

## 18.8 Axis types, coordinate systems, frames (K2)

### 18.8.1 Signals to axis/spindle (DB31, ...)

<b>DB 31, ... DBX3.0</b>	<b>External Zero Offset</b>	
Edge evaluation: no	Signal(s) updated:	
Signal state 1 or edge change 0 → 1	The preselected value of the external work offset of an axis is used as the new value for calculating the total work offset between the basic and the workpiece coordinate systems.	
Signal state 0 or edge change 1 → 0	The preselected value of the external work offset of an axis is not used as the new value for calculating the total work offset between the basic and workpiece coordinate systems. The previous value is still valid.	
Signal irrelevant for ...	\$AA_ETRANS[axis] equals zero for all axes.	
Special cases, errors, .....	Signal zero after ramp-up (power ON).	
Corresponding to ....	\$AA_ETRANS[axis]	

## 18.9 Emergency Stop (N2)

### 18.9.1 Signals to NC (DB10)

<b>DB10 DBX56.1</b>	<b>EMERGENCY STOP</b>
Edge evaluation: no	Signal(s) updated: cyclic
Signal state 1 or edge change 0 → 1	The NC is switched to the EMERGENCY STOP state and the EMERGENCY STOP procedure is started on the NC.
Signal state 0 or edge change 1 → 0	The NC is not in the EMERGENCY STOP state. The EMERGENCY STOP status is (still) active but can be reset using the interface signals: DB10 DBX56.2 (acknowledge EMERGENCY STOP) and DB11 DBX0.7 (mode group reset)
Corresponding to ....	DB10 DBX56.2 (acknowledge EMERGENCY STOP) DB10 DBX106.1 (acknowledge EMERGENCY STOP)

<b>DB10 DBX56.2</b>	<b>Acknowledge EMERGENCY STOP</b>
Edge evaluation: no	Signal(s) updated: cyclic
Signal state 1 or edge change 0 → 1	The EMERGENCY STOP state is only reset if the interface signal: DB10 DBX56.2 (acknowledge EMERGENCY STOP) is set followed by the interface signal: DB11, ... DBX0.7 (mode group reset).  It must be noted that IS "Acknowledge EMERGENCY STOP" and IS "Reset" must be set (together) for a long enough period so that the interface signal: DB10 DBX106.1 (EMERGENCY STOP active) was reset.  Resetting the EMERGENCY STOP state has the following effects: <ul style="list-style-type: none"> <li>• the controller enable is switched in</li> <li>• Follow-up mode is canceled for all axes and position control mode resumed</li> <li>• DB31, ... DBX61.5 set (position controller active)</li> <li>• DB11, ... DBX6.3 set (mode group ready)</li> <li>• DB10 DBX106.1 reset (EMERGENCY STOP active)</li> <li>• Alarm 3000 is canceled</li> <li>• Part program processing is interrupted for all channels</li> </ul>

<b>DB10 DBX56.2</b>	<b>Acknowledge EMERGENCY STOP</b>
	<p>             IS "EMERGENCY STOP"              IS acknowledge "EMERGENCY STOP"              IS "EMERGENCY STOP active?"              IS "RESET"         </p> <p>             ① IS "Acknowledge EMERGENCY STOP" has no effect              ② IS "Reset" has no effect              ③ IS "Acknowledge EMERGENCY STOP" and "RESET" reset "EMERGENCY STOP" active         </p>
Special cases, errors, .....	The EMERGENCY STOP state cannot be reset using the interface signal: DB21, ... DBX7.7 (reset).
Corresponding to ....	DB10 DBX56.1 (EMERGENCY STOP) DB10 DBX106.1 (acknowledge EMERGENCY STOP) DB11 DBX0.7 (mode group reset)

### 18.9.2 Signals from NC (DB10)

<b>DB10 DBX106.1</b>	<b>EMERGENCY STOP active</b>	
Edge evaluation: no	Signal(s) updated: cyclic	
Signal state 1 or edge change 0 → 1	The NC is in the EMERGENCY STOP state.	
Corresponding to ....	DB10 DBX56.1 (EMERGENCY STOP) DB10 DBX56.2 (acknowledge EMERGENCY STOP)	

## **18.10 PLC basic program (P3)**

To describe the NC/PLC interface signals, refer to:

**References:**

Function Manual, Basic Functions; PLC Basic Program (P3)

Chapter: "Signal/Data Specifications"

## 18.11 Reference point approach (R1)

### 18.11.1 Signals to channel (DB21, ...)

<b>DB21, ... DBX1.0</b>	<b>Activate referencing</b>	
Edge evaluation: yes	Signal(s) updated: cyclic	
Signal state 1 or edge change 0 → 1	<p>The channel specific referencing is started with the interface signal: DB21, ... DBX1.0 (Activate referencing).</p> <p>The control acknowledges the successful start with the interface signal: DB21, ... DBX33.0 (Referencing active)</p> <p>With the channel specific referencing each machine axis, which is allocated to a channel, can be referenced (control internals are simulated by traversing keys plus/minus).</p> <p>Using the axis-specific machine data: MD34110 \$MA_REFP_CYCLE_NR (axis sequence for channel-specific Referencing) can determine in which sequence the machine axes are referenced.</p> <p>If all the axes entered in REFP_CYCLE_NR have reached their reference point, the interface signal: DB21, ... DBX36.3 (all axes present) is set.</p>	
Application example(s)	<p>If the machine axes are to be referenced in a particular sequence, there are the following possibilities:</p> <ul style="list-style-type: none"> <li>• The operator must observe the correct sequence when starting.</li> <li>• The PLC must check the sequence when starting or define it itself.</li> <li>• The function channel specific referencing will be used.</li> </ul>	
Corresponding to ....	<p>DB21, ... DBX33.0 (Referencing active)</p> <p>DB21, ... DBX36.2 (all reference point required axes are referenced)</p>	

<b>DB21, ... DBX33.0</b>	<b>Referencing active</b>	
Edge evaluation: yes	Signal(s) updated: cyclic	
Signal state 1 or edge change 0 → 1	<p>The channel specific referencing was started with the interface signal: DB21, ... DBX1.0 (activate referencing) and the successful start was acknowledged with the interface signal: DB21, ... DBX33.0 (referencing active). The channel specific referencing is operational.</p>	
Signal state 0 or edge change 1 → 0	<ul style="list-style-type: none"> <li>• channel specific referencing is completed.</li> <li>• axis specific referencing is operational</li> <li>• no referencing active</li> </ul>	
Signal irrelevant for ...	Spindles	
Corresponding to ....	DB21, ... DBX1.0 (activate referencing)	

18.11.2 Signals from channel (DB21, ...)

<b>DB21, ... DBX36.2</b>	<b>All axes that have to be referenced are referenced</b>	
Edge evaluation: no	Signal(s) updated: cyclic	
Signal state 1 or edge change 0 → 1	<p>All axes that must be referenced (linear axes and rotary axes) of the channel are referenced.</p> <p>The machine data: MD20700 \$MC_REFP_NC_START_LOCK (NC start inhibit without reference point) is zero.</p> <p>If two position measuring systems are connected to an axis, that would prevent an NC start, then the active one must be referenced so that the axis is considered to have been referenced.</p> <p>An NC Start command for parts program processing is only accepted when this signal is present.</p> <p>Axes that have to be referenced are axes, if: MD34110 \$MA_REFP_CYCLE_NR_ = -1 and the axis is not in the parked position (position measuring system inactive and the controller enable withdrawn).</p>	
Signal state 0 or edge change 1 → 0	One or more axes of the channel have not been referenced.	
Special cases, errors, .....	The spindles of the channel have no effect on this interface signal.	
Corresponding to ....	DB31, ... DBX60.4 (referenced/synchronized 1) DB31, ... DBX60.5 (referenced/synchronized 2)	

### 18.11.3 Signals to axis/spindle (DB31, ...)

DB31, ... DBX2.4 - DBX2.7	Reference point value 1 to 4
Edge evaluation: no	Signal(s) updated: cyclic
Signal state 1 or edge change 0 → 1	<p>When the reference cam is reached, the NCK is signaled which coded reference cam is actuated.</p> <p>The interface signal: DB31, ... DBX2.4 - DBX2.7 (reference point values 1 to 4) must remain set until the reference point is reached, or until a new coded reference cam is actuated.</p> <p>If the machine axis has reached the reference point (axis stationary) then using the reference point value pre-selected using IS "reference point values 1 to 4" from the machine data: MD34100 \$MA_REFP_SET_POS (reference point value) is transferred into the control as the new reference position.</p>
Signal state 0 or edge change 1 → 0	No effect.
Signal irrelevant for ...	Linear measurement systems with distance-coded reference marks
Application example(s)	On a machine tool with large traversing distances, four coded reference cams can be distributed over the entire distance traveled by the axis, four different reference points approached and the time required to reach a valid referenced point reduced.
Special cases, errors, .....	If the machine axis has arrived at the reference point and none of the four "reference point value 1 to 4" interface signals has been set, the value of the reference point is automatically set to 1.
Corresponding to ....	MD34100 \$MA_REFP_SET_POS (reference point value)

DB31, ... DBX12.7	Reference point approach delay
Edge evaluation: no	Signal(s) updated: cyclic
Signal state 1 or edge change 0 → 1	The machine axis is positioned on the reference cam.
Signal state 0 or edge change 1 → 0	The machine axis is positioned in front of the reference cam. An appropriately long reference cam (up to the end of the traversing range) should be used to prevent the machine axis from being located behind (after) the referencing cam.
Corresponding to ....	DB31, ... DBX2.4 - DBX2.7 (reference point values 1 to 4)

18.11.4 Signals from axis/spindle (DB31, ...)

<b>DB31, ... DBX60.4</b>	<b>Referenced/synchronized 1</b>	
Edge evaluation:	Signal(s) updated:	
Signal state 1 or edge change 0 → 1	<p><b>Axes:</b> When being referenced, if the machine axis has reached the reference point (incremental measuring systems) or the target point (for length measuring system with distance-coded reference marks), then the machine axis is referenced and the following interface signal is set: DB31, ... DBX60.4 (referenced/synchronized 1) (depending on which position measuring system is active when referencing).</p> <p><b>Spindles:</b> After power-on, a spindle is synchronized the latest after one spindle revolution (260 degrees) (the zero mark passed or the Bero responded).</p>	
Signal state 0 or edge change 1 → 0	The machine axis/spindle with position measuring system 1 is not referenced/synchronized.	
Corresponding to ....	DB31, ... DBX1.5 (position measuring system 1)	
Additional references	/FB1/ Function Manual, Basic Functions; Spindles (S1)	

<b>DB31, ... DBX60.5</b>	<b>Referenced/synchronized 2</b>	
Edge evaluation:	Signal(s) updated:	
Signal state 1 or edge change 0 → 1	<p><b>Axes:</b> When being referenced, if the machine axis has reached the reference point (incremental measuring systems) or the target point (for length measuring system with distance-coded reference marks), then the machine axis is referenced and the following interface signal is set: DB31, ... DBX60.5 (referenced/synchronized 2) (depending on which position measuring system is active when referencing).</p> <p><b>Spindles:</b> After power-on, a spindle is synchronized the latest after one spindle revolution (260 degrees) (the zero mark passed or the Bero responded).</p>	
Signal state 0 or edge change 1 → 0	<p>The machine axis/spindle with position measuring system 2 is not referenced/synchronized.</p> <p><b>Axes:</b> Alarm 21610 was output.</p> <p><b>Spindles:</b> Encoder limit frequency exceeded.</p>	
Corresponding to ....	<p>DB31, ... DBX1.6 (position measuring system 2)</p> <p>MD34102 \$MA_REFP_SYNC_ENCS (measuring system calibration) = 0</p>	
Additional references	/FB1/ Function Manual, Basic Functions; Spindles (S1)	

## 18.12 Spindles (S1)

### 18.12.1 Signals to axis/spindle (DB31, ...)

DB31, ... DBX2.2	Spindle reset/delete distance-to-go
Edge evaluation: yes	Signal(s) updated: cyclic
Edge change 0 → 1	Independent of the machine data: MD35040 \$MA_SPIND_ACTIVE_AFTER_RESET selects a spindle reset for the various spindle operating modes in the following fashion: <ul style="list-style-type: none"> <li>• Control mode:               <ul style="list-style-type: none"> <li>– Spindle stops</li> <li>– Program continues to run</li> <li>– Spindle continues to run with subsequent M and S program commands</li> </ul> </li> <li>• Oscillating mode:               <ul style="list-style-type: none"> <li>– Oscillation is interrupted</li> <li>– Axes continue to run</li> <li>– Program continues with the actual gearbox stage</li> <li>– With the following M value and higher S value, it is possible that the IS: DB31, ... DBX83.1 (programmed speed high) is set.</li> </ul> </li> <li>• Positioning mode:               <ul style="list-style-type: none"> <li>– Is stopped</li> </ul> </li> <li>• Axis operation:               <ul style="list-style-type: none"> <li>– Is stopped</li> </ul> </li> </ul>
Signal state 0 or edge change 1 → 0	No effect.
Corresponding to ....	MD35040 \$MA_SPIND_ACTIVE_AFTER_RESET (own spindle reset) DB21, ... DBX7.7 (reset) DB31, ... DBX2.2 (delete distance to go): is a different name for the same signal

<b>DB31, ... DBX16.0 - DBX16.2</b>	<b>Actual gear stage A to C</b>																					
Edge evaluation: yes	Signal(s) updated: Cyclically																					
Signal state 1 (status-controlled)	<p>If the new gear stage is engaged, the PLC user program sets the interface signals:          DB31, ... DBX16.2 - DBX16.0 (actual gear stage A to C)          and          DB31, ... DBX16.3 (gear is changed over).</p> <p>This signals the NCK that the correct gear stage has been successfully engaged.          The gear change is considered to have been completed (spindle oscillation mode is deselected),          the spindle accelerates in the new gear stage to the last programmed spindle speed and the next          block in the parts program can be executed.</p> <p>The actual gear stage is output in coded format.          For each of the 5 gear stages, there is one set of parameters assigned as follows:</p> <table border="1" data-bbox="368 763 1425 1176"> <thead> <tr> <th>Parameter set No.</th> <th>NC/PLC interface</th> <th>Meaning</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>–</td> <td>Data for axis mode</td> </tr> <tr> <td>1</td> <td>000 001</td> <td>Data for 1st gear stage</td> </tr> <tr> <td>2</td> <td>010</td> <td>Data for 2nd gear stage</td> </tr> <tr> <td>3</td> <td>011</td> <td>Data for 3rd gear stage</td> </tr> <tr> <td>4</td> <td>100</td> <td>Data for 4th gear stage</td> </tr> <tr> <td>5</td> <td>101 110 111</td> <td>Data for 5th gear stage</td> </tr> </tbody> </table>	Parameter set No.	NC/PLC interface	Meaning	0	–	Data for axis mode	1	000 001	Data for 1st gear stage	2	010	Data for 2nd gear stage	3	011	Data for 3rd gear stage	4	100	Data for 4th gear stage	5	101 110 111	Data for 5th gear stage
Parameter set No.	NC/PLC interface	Meaning																				
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3	011	Data for 3rd gear stage																				
4	100	Data for 4th gear stage																				
5	101 110 111	Data for 5th gear stage																				
Special cases, errors, .....	If the PLC user reports back to the NCK with a different actual gear stage than issued by the NCK as the setpoint gear stage, the gear change is still considered to have been successfully completed and the actual gear stage A to C is activated.																					
Corresponding to ....	DB31, ... DBX82.0 - DBX82.2 (setpoint gear stage A to C) DB31, ... DBX82.3 (change over gear stage) DB31, ... DBX16.3 (gear is changed) DB31, ... DBX18.5 (oscillation speed) Parameter sets for gear stages																					

<b>DB31, ... DBX16.3</b>	<b>Gear is changed over</b>
Edge evaluation: yes	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	<p>When the new gear stage is engaged, the PLC user sets the interface signals: DB31, ... DBX16.0 - DBX16.2 (actual gear stages A to C) and DB31, ... DBX16.3 (gear is changed over).</p> <p>This signals the NCK that the correct gear stage has been successfully engaged. The gear stage change is complete (spindle oscillation mode is deselected), the spindle accelerates in the new gear stage to the last programmed spindle speed and the next block in the parts program can be executed. The interface signal: DB31, ... DBX82.3 (change over gear) is reset by the NCK - the PLC user then resets the interface signal: (gear is changed over).</p>
Signal state 0 or edge change 1 → 0	No effect.
Signal irrelevant for ...	... spindle modes other than the oscillation mode
Special cases, errors, .....	If the PLC user reports back to the NCK with a different actual gear stage than issued by the NCK as the setpoint gear stage, the gear change is still considered to have been successfully completed and the actual gear stage A to C is activated.
Corresponding to ....	DB31, ... DBX16.2 - DBX16.0 (actual gear stage A to C) DB31, ... DBX82.2 - DBX82.0 (setpoint gear stage A to C) DB31, ... DBX82.3 (change over gear stage) DB31, ... DBX18.5 (oscillation speed)

<b>DB31, ... DBX16.4 - DBX16.5</b>	<b>Resynchronizing spindles 2 and 1</b>
Edge evaluation: yes	Signal(s) updated: Cyclically
Edge change 0 → 1	The spindle should be resynchronized, as the synchronization between the position measuring system of the spindle and the 0 degree position has been lost.
Signal state 0 or edge change 1 → 0	No effect.
Signal irrelevant for ...	... spindle modes other than the control mode.
Application example(s)	The machine has a selector switch to changeover between a vertical and a horizontal spindle. Two different position encoders are used (one for the vertical spindle and one for the horizontal spindle), but only one actual value input is used on the control. When the system switches from the vertical to the horizontal spindle, the spindle must be resynchronized. This synchronization is triggered by the IS "re-synchronize spindle 1 or 2".
Corresponding to ....	DB31, ... DBX60.4 (referenced/synchronized 1) DB31, ... DBX60.5 (referenced/synchronized 2)

18.12 Spindles (S1)

<b>DB31, ... DBX16.7</b>	<b>Delete S value</b>	
Edge evaluation: yes	Signal(s) updated: Cyclically	
Edge change 0 → 1	<b>Control mode:</b> <ul style="list-style-type: none"> <li>• Spindle stops</li> <li>• Program continues to run</li> <li>• Spindle continues to run with the following S value, if M3 or M4 were active</li> </ul> <b>Oscillation mode, axis mode, positioning mode:</b> <ul style="list-style-type: none"> <li>• Signal has no effect for the corresponding function. However, if the open-loop control mode is selected again, a new S value must be programmed.</li> </ul>	
Signal state 0 or edge change 1 → 0	No effect.	
Application example(s)	Terminating traversing motion on account of an external signal (e.g. sensing probe).	

<b>DB31, ... DBX17.4 - DBX17.5</b>	<b>Re-synchronize spindle when positioning 2 and 1</b>	
Edge evaluation: yes	Signal(s) updated: Cyclically	
Signal state 1	When positioning, the spindle must be re-synchronized.	
Signal state 0 or edge change 1 → 0	No effect.	
Signal irrelevant for ...	... spindle modes other than the positioning mode.	
Application example(s)	The spindle has an indirect measuring system and slippage may occur between the motor and the clamp. If the signal=1 - when positioning is started, the old reference is deleted and the zero mark is searched for again before the end position is approached.	
Corresponding to ....	DB31, ... DBX60.4 (referenced/synchronized 1) DB31, ... DBX60.5 (referenced/synchronized 2)	

<b>DB31, ... DBX17.6</b>	<b>Invert M3/M4</b>	
Edge evaluation: yes	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	The direction of rotation of the spindle motor changes for the following functions: <ul style="list-style-type: none"> <li>• M3</li> <li>• M4</li> <li>• M5</li> <li>• SPOS/M19/SPOSA from the motion; not effective for SPOS/M19/SPOSA from zero speed (stationary).</li> </ul>	
Application example(s)	The machine has a selector switch to changeover between a vertical and a horizontal spindle. The mechanical design is implemented so that for the horizontal spindle, one more gearwheel is engaged than for the vertical spindle. The direction of rotation must therefore be changed for the vertical spindle if the spindle is always to rotate clockwise with M3.	

<b>DB31, ... DBX18.4</b>	<b>Oscillation controlled by the PLC</b>	
Edge evaluation: yes	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	<p>If the interface signal: DB31, ... DBX18.4 (oscillation controlled by the PLC) is not set, then automatic oscillation in the NCK is carried-out using the interface signal: DB31, ... DBX18.5 (oscillation speed).</p> <p>The two times for the directions of rotation are entered in the machine data: MD35440 \$MA_SPIND_OSCILL_TIME_CW (oscillation time for the M3 direction) and MD35450 \$MA_SPIND_OSCILL_TIME_CCW (oscillation time for the M4 direction).</p> <p>If the IS "oscillation via PLC" is set, then with the IS "oscillation speed" a speed is only output in conjunction with the interface signals: DB31, ... DBX18.6 - DBX18.7 (setpoint direction of rotation, counter-clockwise and clockwise). The oscillation, i.e. the continuous change of the direction of rotation, is performed by the PLC user program using the interface signal "setpoint direction of rotation, counter-clockwise and clockwise" (oscillation via the PLC).</p>	
Application example(s)	If the new gear stage cannot be engaged in spite of several attempts by the NCK, the system can be switched to oscillation via PLC. Both of the times for the directions of rotation can then be altered by the PLC user program as required. This ensures that the gear satge is reliably changed - even with unfavorable gear wheel positions.	
Corresponding to ....	MD35440 \$MA_SPIND_OSCILL_TIME_CW (oscillation time for the M3 direction) MD35450 \$MA_SPIND_OSCILL_TIME_CCW (oscillation time for the M4 direction) DB31, ... DBX18.5 (oscillation speed) DB31, ... DBX18.7 (setpoint direction of rotation, counter-clockwise) DB31, ... DBX18.6 (setpoint direction of rotation, clockwise)	

DB31, ... DBX18.5	Oscillation speed
Edge evaluation: no	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	<p>If the gear stage is to be changed (DB31, ... DBX82.3 (change over gear) is set), then the spindle operating mode changes to the oscillation mode.</p> <p>Depending on the instant in time that the interface signal: DB31, ... DBX18.5 (oscillation speed) is set, the spindle decelerates down to standstill with different deceleration levels:</p> <p>The IS "Oscillation speed" is set before the interface signal: DB31, ... DBX82.3 (change over gear) is set by the NCK.</p> <p>When oscillating, the spindle is decelerated down to standstill with the deceleration: MD35410 \$MA_SPIND_OSCILL_ACCEL.</p> <p>Once the spindle is stationary, oscillation is immediately initiated.</p> <p>The IS "Oscillation speed" is enabled after the IS "Change gear" is set by the NCK and when the spindle is stationary. The position controller is disabled. The spindle decelerates with the specified deceleration rate in the speed controlled mode.</p> <p>After the IS "oscillation speed" is set, the spindle starts to oscillate with the oscillation acceleration (MD35410).</p> <p>If the interface signal: DB31, ... DBX18.4 (oscillation via the PLC) is not set, then automatic oscillation is executed in the NCK using the IS "Oscillation speed".</p> <p>The two times for the directions of rotation are entered in the machine data: MD35440 \$MA_SPIND_OSCILL_TIME_CW (oscillation time for the M3 direction) and MD35450 \$MA_SPIND_OSCILL_TIME_CCW (oscillation time for the M4 direction).</p> <p>If the IS "oscillation via PLC" is set, then with the IS "oscillation speed" a speed is only output in conjunction with the interface signals: DB31, ... DBX18.6 - DBX18.7 (setpoint direction of rotation, counter-clockwise and clockwise).</p> <p>The oscillation, i.e. the continuous change of the direction of rotation, is performed by the PLC user program using the interface signal "setpoint direction of rotation, counter-clockwise and clockwise" (oscillation via the PLC).</p>
Signal state 0 or edge change 1 → 0	The spindle does not oscillate.
Signal irrelevant for ...	... all spindle modes except the oscillation mode.
Application example(s)	The oscillation speed is used to make it easier to engage a new gear stage.
Corresponding to ....	DB31, ... DBX18.4 (oscillation controlled by the PLC) DB31, ... DBX18.7 (setpoint direction of rotation, counter-clockwise) DB31, ... DBX18.6 (setpoint direction of rotation, clockwise)

<b>DB31, ... DBX18.6 - DBX18.7</b>	<b>Setpoint direction of rotation, counter-clockwise/setpoint direction of rotation, clockwise</b>	
Edge evaluation: yes	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	If the interface signal: DB31, ... DBX18.4 (oscillation by the PLC) is set, then the direction of rotation for the oscillation speed can be entered using the two interface signals: DB31, ... DBX18.6 - DBX18.7 (setpoint direction of rotation counter-clockwise and clockwise). The times for the oscillation movement of the spindle motor are defined by setting the interface signals "direction of rotation setpoint counter-clockwise and clockwise" for a corresponding length of time.	
Signal irrelevant for ...	... spindle modes other than the oscillation mode	
Application example(s)	Refer to DB31, ... DBX18.4 (oscillation controlled by the PLC)	
Special cases, errors, .....	If both of the interface signals are set simultaneously enabled, no oscillation speed is output. If an interface signal is not set, then an oscillation speed is not output.	
Corresponding to ....	DB31, ... DBX18.4 (oscillation controlled by the PLC) DB31, ... DBX18.5 (oscillation speed)	

<b>DB31, ... DBX30.0</b>	<b>Spindle stop</b>	
Edge evaluation: yes	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	Corresponds to M5 (spindle stop for master spindle).	
Application example(s)	A spindle stop is executed if the following interface signal is output: DB31, ... DBX61.4 (axis/spindle stationary) = 1	
Corresponding to ....	DB31, ... DBX17.6 (axis/spindle stationary)	

<b>DB31, ... DBX30.1</b>	<b>Spindle start, clockwise rotation</b>	
Edge evaluation: yes	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	Corresponds to M3 (Direction of spindle rotation clockwise for master spindle).	
Application example(s)	The content of the following setting data is read and it becomes effective with the positive edge of the "Spindle start clockwise" starting signal. SD43200 \$SA_SPIND_S (speed for spindle start via VDI)	
Corresponding to ....	DB31, ... DBX18.7 (setpoint direction of rotation, counter-clockwise) DB31, ... DBX18.6 (setpoint direction of rotation, clockwise) DB31, ... DBX17.6 (invert M3/M4)	

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<b>DB31, ... DBX30.2</b>	<b>Spindle start, counter-clockwise rotation</b>
Edge evaluation: yes	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	Corresponds to M4 (Direction of spindle rotation counterclockwise for master spindle).
Application example(s)	The content of the following setting data is read and it becomes effective with the positive edge of the "Spindle start counterclockwise" starting signal: SD43200 \$SA_SPIND_S (speed for spindle start via VDI)
Corresponding to ....	DB31, ... DBX18.7 (setpoint direction of rotation, counter-clockwise) DB31, ... DBX18.6 (setpoint direction of rotation, clockwise) DB31, ... DBX17.6 (invert M3/M4)

<b>DB31, ... DBX30.3</b>	<b>Select gear step</b>
Edge evaluation: yes	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	This function is presently being prepared. This is the reason that interface signal is temporarily reserved.
Application example(s)	One parameter set each is provided for each of the 5 gear stages. When changing over to the spindle mode, the corresponding parameter set 1 to 5 is selected according to the gear stage engaged. A gear stage can be preselected as follows: <ul style="list-style-type: none"> <li>• M40 ⇒ automatically by the programmed spindle speed</li> <li>• M41 to M45 ⇒ permanently by the part program</li> <li>• By the PLC, using function block FC 18</li> <li>• In the RESET state by writing to the VDI interface</li> </ul>
Corresponding to ....	MD35010 \$MA_GEAR_STEP_CHANGE_ENABLE (the gear stage can be changed) MD35590 \$MA_PARAMSET_CHANGE_ENABLE (a parameter set can be specified by the PLC) DB31, ... DBX82.3 (change over gear stage)

<b>DB31, ... DBX30.4</b>	<b>Spindle positioning</b>
Edge evaluation: yes	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	Corresponds to M19 (Position for spindle positioning)
Application example(s)	If the spindle is to be stopped from direction of rotation (M3 or M4) with orientation, or is to be re-oriented from standstill (M5), then the positioning mode is selected with SPOS, SPOSA or M19.
Corresponding to ....	MD20850 \$MC_SPOS_TO_VDI (for SPOS/SPOSA, "M19" is output to the VSI interface) SD43240 \$SA_M19_SPOS (position for spindle positioning with M19) DB31, ... DBX84.5 (active spindle operating mode, positioning mode)

## 18.12.2 Signals from axis/spindle (DB31, ...)

<b>DB31, ... DBX60.0</b>	<b>Spindle/no axis</b>	
Edge evaluation: yes	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	<p>The machine axis is operated in one of the following spindle modes:</p> <ul style="list-style-type: none"> <li>• Control mode</li> <li>• Oscillation mode</li> <li>• Positioning mode</li> <li>• Rigid tapping</li> <li>• Synchronous mode</li> </ul> <p>The interface signals to the axis (DB31, ... DBB12 - DBB15) and from the axis (DB31, ... DBB74 - DBB81) are <b>invalid</b>.</p> <p>The interface signals to the spindle (DB31, ... DBB16 - DBB19) and from the spindle (DB31, ... DBB82 - DBB91) are <b>valid</b>.</p>	
Signal state 0 or edge change 1 → 0	<p>The machine axis is operated as an axis</p> <p>The interface signals to the axis (DB31, ... DBB12 - DBB15) and from the axis (DB31, ... DBB74 - DBB81) are <b>valid</b>.</p> <p>The interface signals to the spindle (DB31, ... DBB16 - DBB19) and from the spindle (DB31, ... DBB82 - DBB91) are <b>invalid</b>.</p>	
Application example(s)	<p>If a machine axis operates alternatively as a spindle or rotary axis:</p> <ul style="list-style-type: none"> <li>• Turning machine: Spindle/C axis</li> <li>• Milling machine: Spindle/rotary axis for rigid tapping</li> </ul> <p>The currently active operating mode can be identified from interface signal: DB31, ... DBX60.0 (spindle/no axis).</p>	

<b>DB31, ... DBX82.0 - 82.2</b>	<b>Setpoint gear stage A to C</b>																									
Edge evaluation: yes	Signal(s) updated: Cyclically																									
	See DB31, ... DB82.3 (change gear).																									
Signal state 1 or edge change 0 → 1	<p>The set gear stage is output in coded format:</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td>1. Gear stage</td> <td>0 0 0</td> <td>(C B A)</td> </tr> <tr> <td>1. Gear stage</td> <td>0 0 1</td> <td></td> </tr> <tr> <td>2. Gear stage</td> <td>0 1 0</td> <td></td> </tr> <tr> <td>3. Gear stage</td> <td>0 1 1</td> <td></td> </tr> <tr> <td>4. Gear stage</td> <td>1 0 0</td> <td></td> </tr> <tr> <td>5. Gear stage</td> <td>1 0 1</td> <td></td> </tr> <tr> <td>invalid value</td> <td>1 1 0</td> <td></td> </tr> <tr> <td>invalid value</td> <td>1 1 1</td> <td></td> </tr> </table>		1. Gear stage	0 0 0	(C B A)	1. Gear stage	0 0 1		2. Gear stage	0 1 0		3. Gear stage	0 1 1		4. Gear stage	1 0 0		5. Gear stage	1 0 1		invalid value	1 1 0		invalid value	1 1 1	
1. Gear stage	0 0 0	(C B A)																								
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4. Gear stage	1 0 0																									
5. Gear stage	1 0 1																									
invalid value	1 1 0																									
invalid value	1 1 1																									
Signal irrelevant for ...	... Other spindle modes except oscillation mode																									

18.12 Spindles (S1)

<b>DB31, ... DBX82.0 - 82.2</b>	<b>Setpoint gear stage A to C</b>
Corresponding to ....	DB31, ... DBX82.3 (Change gear) DB31, ... DBX16.0 - DBX16.2 (Actual gear stage A to C) DB31, ... DBX16.3 (gear is changed)

<b>DB31, ... DBX82.3</b>	<b>Change gear stage</b>
Edge evaluation: yes	Signal(s) updated: Cyclically
	<p>Specification of gear stage:</p> <ul style="list-style-type: none"> <li>Manual specification using M function M41 - M45 corresponding to gear stage 1 - 5 If set gear stage &lt;&gt; actual gear stage =&gt; DB31, ... DBX82.3 (change gear) = 1 DB31, ... DBX82.0 - DBX82.2 (set gear stage) = set gear stage</li> <li>Automatic gear step selection depending on the progr. Spindle speed via M-function M40 at specified setpoint speed requires gear stage change =&gt; DB31, ... DBX82.3 (change gear) = 1 DB31, ... DBX82.0 - DBX82.2 (setpoint gear stage) = setpoint gear stage</li> </ul>
Signal state 1 or edge change 0 → 1	New set gear stage was specified AND set gear stage <> actual gear stage
Special cases, errors, .....	Signal is not output if: Set gear stage == actual gear stage
Corresponding to ....	DB31, ... DBX82.0 - DBX82.2 (Set gear stage A to C) DB31, ... DBX16.0 - 16.2 (Actual gear stage A to C) DB31, ... DBX16.3 (gear is changed)

<b>DB31, ... DBX83.0</b>	<b>Speed limit exceeded</b>
Edge evaluation: yes	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	The actual speed exceeds the maximum spindle speed: MD35100 \$MA_SPIND_VELO_LIMIT by more than the spindle speed tolerance: MD35150 \$MA_SPIND_DES_VELO_TOL
Corresponding to ....	MD35150 \$MA_SPIND_DES_VELO_TOL (spindle speed tolerance) MD35100 \$MA_SPIND_VELO_LIMIT (maximum spindle speed)

<b>DB31, ... DBX83.1</b>	<b>Set speed limited (programmed speed too high)</b>	
Edge evaluation: yes	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	<p>The set speed of the spindle that is specified directly (programmed spindle speed) or indirectly (constant cutting speed) would violate the current maximum limit value. The set speed is therefore defined at the maximum limit value.</p> <p>Limit values:</p> <ul style="list-style-type: none"> <li>• Maximum speed of specified gear stage</li> <li>• Maximum spindle speed</li> <li>• Speed limited by VDI</li> <li>• Programmed spindle speed limit G26</li> <li>• Programmed spindle speed limitation for G96</li> </ul>	
Signal state 0 or edge change 1 → 0	The set speed of the spindle is outside the maximum limit value.	
Application example(s)	<p>The interface signal: DB31, ... DBX83.1 (set speed limited) can be used to determine if the programmed speed is unattainable.</p> <p>The PLC user can accept this state as permissible and enable the path feed, or he can disable the path feed or the complete channel, IS: DB31, ... DBX83.5 (spindle in set range) is processed.</p>	

<b>DB31, ... DBX83.2</b>	<b>Setpoint speed increased (programmed speed too low)</b>	
Edge evaluation: yes	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	<p>The set speed of the spindle that is specified directly (programmed spindle speed) or indirectly (constant cutting speed) would violate the current minimum limit value. The set speed is therefore defined at the minimum limit value.</p> <p>Limit values:</p> <ul style="list-style-type: none"> <li>• Minimum speed of the specified gear stage</li> <li>• Minimum spindle speed</li> <li>• Speed limiting by means of NC/PLC interface</li> <li>• Programmed spindle speed limitation G25</li> <li>• Programmed spindle speed limitation for G96</li> </ul>	
Signal state 0 or edge change 1 → 0	The set speed of the spindle is outside the minimum limit value.	
Application example(s)	<p>The interface signal indicates if the programmed set speed is unattainable. The feed can be enabled nonetheless by means of the PLC user program.</p> <p>The PLC user can accept this state as permissible and enable the path feed, or he can disable the path feed or the complete channel, IS: DB31, ... DBX83.5 (spindle in set range) is processed.</p>	
Corresponding to ....	<p>DB21, ... DBX6.0 (feed disable)</p> <p>DB31, ... DBX4.3 (feed/spindle stop)</p> <p>DB31, ... DBX83.5 (spindle in set range)</p>	

<b>DB31, ... DBX83.5</b>	<b>Spindle in the set range</b>
Edge evaluation: yes	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	The actual speed of the spindle deviates from the set speed by less than the spindle speed tolerance: MD35150 \$MA_SPIND_DES_VELO_TOL.
Signal state 0 or edge change 1 → 0	The actual speed of the spindle deviates from the set speed by more than the spindle speed tolerance: MD35150 \$MA_SPIND_DES_VELO_TOL.  Normal status during the acceleration/deceleration phase of the spindle.
Signal irrelevant for ...	... All spindle modes except for control mode (speed mode).
Application example(s)	Feed enable in the channel only at the end of the acceleration phase of the spindle: IF ( DB31, ... DBX83.5 (spindle in set range) == 1 ) THEN ( DB21, ... DBX6.0 (feed disable) = 0 ) ELSE ( DB21, ... DBX6.0 (feed disable) = 1 ) Note: Axes positioning will also be stopped.
Corresponding to ....	MD35500 \$MA_SPIND_ON_SPEED_AT_IPO_START MD35500 \$MA_SPIND_DES_VELO_TOL (spindle speed tolerance)

<b>DB31, ... DBX83.7</b>	<b>Actual direction of rotation clockwise</b>
Edge evaluation: yes	Signal(s) updated: Cyclically
	Interface signal is only valid if the spindle is rotating: DB31, ... DBX61.4 (axis/spindle stationary) == 0 The actual direction of rotation is derived from the position measuring encoder.
Signal state 1 or edge change 0 → 1	Actual direction of rotation: Right
Signal state 0 or edge change 1 → 0	Actual direction of rotation: Left
Signal irrelevant for ...	<ul style="list-style-type: none"> <li>• Spindle is stationary: DB31, ... DBX61.4 (axis/spindle stationary) == 1</li> <li>• Spindles without position measuring encoder</li> </ul>
Corresponding to ....	DB31, ... DBX61.4 (axis/spindle stationary)

<b>DB31, ... DBX84.3</b>	<b>Rigid tapping active</b>
Edge evaluation: yes	Signal(s) updated: Cyclically
	<p>The spindle is internally switched to axis mode by the "Rigid tapping" function (G331/G332). This results in a reaction to or updating of the spindle-specific interface signals:</p> <ul style="list-style-type: none"> <li>• DB31, ... DBX2.2 (spindle reset)</li> <li>• DB31, ... DBX16.4 - DBX16.5 (synchronize spindle)</li> <li>• DB31, ... DBX17.6 (invert M3/M4)</li> <li>• DB31, ... DBX83.5 (spindle in set range)</li> <li>• DB31, ... DBX83.1 (programmable speed too high)</li> </ul>
Signal state 1 or edge change 0 → 1	<ul style="list-style-type: none"> <li>• Rigid tapping is active.</li> </ul>
Application example(s)	<p>Notice!</p> <p>If the following signals are set during rigid tapping, the thread will be destroyed:</p> <ul style="list-style-type: none"> <li>• DB11, ... DBX0.7 (mode group reset) = 1</li> <li>• DB21, ... DBX7.7 (channel reset) = 1</li> <li>• DB31, ... DBX2.1 (servo enable) = 0</li> <li>• DB31, ... DBX8.3 (feed stop) = 1</li> </ul>

<b>DB31, ... DBX84.5</b>	<b>Active spindle mode: Positioning mode</b>
Edge evaluation: yes	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	Positioning mode (SPOS or SPOSA) is active.
Corresponding to ....	DB31, ... DBX84.7 (spindle mode control mode) DB31, ... DBX84.6 (spindle mode oscillation mode)

<b>DB31, ... DBX84.6</b>	<b>Active spindle mode: Oscillation mode</b>
Edge evaluation: yes	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	<p>Oscillation mode is active.</p> <p>Note: The spindle changes automatically to oscillation mode if there is a gear change.</p>
Corresponding to ....	DB31, ... DBX84.7 (spindle mode control mode) DB31, ... DBX84.5 (spindle mode positioning mode) DB31, ... DBX82.3 (change gear)

18.12 Spindles (S1)

<b>DB31, ... DBX84.7</b>	<b>Active spindle mode: Control mode</b>
Edge evaluation: yes	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	The spindle is in control mode with the following functions: <ul style="list-style-type: none"> <li>• Spindle direction of rotation specification M3/M4 or spindle stop M5</li> <li>• M41...M45, or automatic gear stage change M40</li> </ul>
Corresponding to ....	DB31, ... DBX84.6 (spindle mode oscillation mode) DB31, ... DBX84.5 (spindle mode positioning mode)

<b>DB31, ... DBX85.5</b>	<b>Spindle in position</b>
Edge evaluation: yes	Signal(s) updated: Cyclically
	The interface signal is processed exclusively with the function spindle positioning. This includes: <ul style="list-style-type: none"> <li>• SPOS, SPOSA and M19 in the part program</li> <li>• SPOS and M19 in synchronized actions</li> <li>• Start positioning during use of the functions block FC18</li> </ul> <p>If the spindle is traversed after a positioning for already set signal DB31, ... DBX85.5 (Spindle in position), e.g. in the JOG mode, then this signal is deleted. If the spindle returns to its original position in JOG mode, then the signal DB31, ... DBX85.5 (spindle in position) is set again. The last position selection is maintained.</p>
Signal state 1 or edge change 0 → 1	Precondition for the output of the NST DB31, ... DBX85.5 (spindle in position) is reaching the NST DB31, ... DBX60.7 (exact stop fine). Additionally the last programmed spindle position must have arrived at the desired value.  If the spindle is already at the programmed position after a positioning, then signal DB31,... DBX85.5 (spindle in position) is set.
Signal state 0 or edge change 1 → 0	On the cancellation of the NC/PLC interface signal: DB31, ... DBX60.7 (Exact stop fine), DB31, ... DBX85.5 is <b>always</b> reset.
Application example(s)	Spindle in position for the tool change  If the tool change cycle is interrupted by the machine operator e.g. with NC stop, NC stop axis plus spindle, mode group stop etc., then the correct position to which the spindle is to travel in the tool changer can be queried via DB31, ... DBX85.5.
Corresponding to ....	DB31, ... DBX60.7 (Exact stop fine)

<b>DB31, ... DBB86 - DBB87</b>	<b>M function for spindle</b>
Edge evaluation: yes	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	From the NCK one of the following M Functions: M3, M4, M5, M70 is output to the PLC. The output occurs by means of: See "Corresponds to ...." below
Corresponding to ....	DB31, ... DBB86 - DBB87 (M function for spindle), axis-specific DB21, ... DBB58, DBB68 - DBB97 (M function for spindle), channel-specific

DB31, ... DBB88 - DBB91	S function for spindle	
Edge evaluation: yes	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	<p>An S function was output from the NCK to the PLC. The output occurs by means of: See "Corresponds to ...." below</p> <p>The following S functions are output here:</p> <ul style="list-style-type: none"> <li>• S.... as spindle speed in rpm (programmed value)</li> <li>• S .... as constant cutting speed in m/min or ft/min</li> </ul> <p>The following S functions are <b>not</b> output here:</p> <ul style="list-style-type: none"> <li>• S.... as the programmed Spindle speed limiting G25</li> <li>• S.... as the programmed Spindle speed limiting G26</li> <li>• S .... as spindle speed in rpm if a spindle was not defined in the controller</li> <li>• S.... as the dwell time in spindle revolutions</li> </ul>	
Corresponding to ....	DB31, ... DBB88 - DBB91 (S function for spindle), axis-specific DB21, ... DBB60, DBB98 - DBB115 (S function for spindle), channel-specific	

## 18.13 Feeds (V1)

### 18.13.1 Signals to channel (DB21, ...)

<b>DB21, ... DBX0.6</b>	<b>Activate dry run feed</b>
Edge evaluation: yes	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	<p>The dry run feed rate defined using the setting data: SD42100 \$SC_DRY_RUN_FEED is used instead of the programmed feed (for G01, G02, G03) if the dry run feed rate is greater than that programmed.</p> <p>The dry run feed rate is effective after the reset state. This interface signal is evaluated at NC start when the channel is in the "reset" state.</p> <p>The dry run feed can be activated from the PLC or operator panel.</p> <p>When selected from the operator panel front, the PLC interface signal: DB21, ... DBX24.6 (dry run feed selected) is set and transferred from the PLC basic program to the interface signal: DB21, ... DBX0.6 (activate dry run feed).</p> <p>When selected using the PLC, the IS "activate dry run feed" should be set from the PLC user program.</p>
Signal state 0 or edge change 1 → 0	<p>The programmed feed is used. Effective after the reset state.</p>
Application example(s)	Testing a workpiece program with an increased feed rate.
Special cases, errors, .....	If the signal changes to "0" within a G33 block, the programmed feed is not activated until the end of the block is reached, since an NC stop was not triggered.
Corresponding to ....	DB21, ... DBX24.6 (dry run feed rate selected) SD42100 \$SC_DRY_RUN_FEED (dry run feed rate)

<b>DB21, ... DBB4</b>	<b>Feedrate override</b>
Edge evaluation: No	Signal(s) updated: Cyclically

<p><b>DB21, ... DBB4</b></p>	<p><b>Feedrate override</b></p>																																																																																																												
<p>Signal state 1 or edge change 0 → 1</p>	<p>The feedrate override can be defined via the PLC in binary or Gray coding. With binary coding, the feed value is interpreted in %. 0% to 200% feed changes are possible, in accordance with the binary value in the byte. The following permanent assignment applies:</p> <table border="1" data-bbox="406 526 1465 828"> <thead> <tr> <th>Code</th> <th>Feed rate override factor</th> </tr> </thead> <tbody> <tr> <td>00000000</td> <td>0.00 ± 0%</td> </tr> <tr> <td>00000001</td> <td>0.01 ± 1%</td> </tr> <tr> <td>00000010</td> <td>0.02 ± 2%</td> </tr> <tr> <td>00000011</td> <td>0.03 ± 3%</td> </tr> <tr> <td>11001000</td> <td>2.00 ± 200%</td> </tr> </tbody> </table> <p>Binary values &gt; 200 are limited to 200%. The machine data: MD12100 \$MN_OVR_FACTOR_LIMIT_BIN (limit for binary-coded override switch) can be used to additionally limit the maximum feedrate override. With Gray coding, the individual switch settings are assigned to the following codes:</p> <table border="1" data-bbox="406 1115 1225 1904"> <caption>Table: Gray coding for feed rate override</caption> <thead> <tr> <th>Switch position</th> <th>Code</th> <th>Feed rate override factor (standard values)</th> </tr> </thead> <tbody> <tr><td>1</td><td>00001</td><td>0.0</td></tr> <tr><td>2</td><td>00011</td><td>0.01</td></tr> <tr><td>3</td><td>00010</td><td>0.02</td></tr> <tr><td>4</td><td>00110</td><td>0.04</td></tr> <tr><td>5</td><td>00111</td><td>0.06</td></tr> <tr><td>6</td><td>00101</td><td>0.08</td></tr> <tr><td>7</td><td>00100</td><td>0.10</td></tr> <tr><td>8</td><td>01100</td><td>0.20</td></tr> <tr><td>9</td><td>01101</td><td>0.30</td></tr> <tr><td>10</td><td>01111</td><td>0.40</td></tr> <tr><td>11</td><td>01110</td><td>0.50</td></tr> <tr><td>12</td><td>01010</td><td>0.60</td></tr> <tr><td>13</td><td>01011</td><td>0.70</td></tr> <tr><td>14</td><td>01001</td><td>0.75</td></tr> <tr><td>15</td><td>01000</td><td>0.80</td></tr> <tr><td>16</td><td>11000</td><td>0.85</td></tr> <tr><td>17</td><td>11001</td><td>0.90</td></tr> <tr><td>18</td><td>11011</td><td>0.95</td></tr> <tr><td>19</td><td>11010</td><td>1.00</td></tr> <tr><td>20</td><td>11110</td><td>1.05</td></tr> <tr><td>21</td><td>11111</td><td>1.10</td></tr> <tr><td>22</td><td>11101</td><td>1.15</td></tr> <tr><td>23</td><td>11100</td><td>1.20</td></tr> <tr><td>24</td><td>10100</td><td>1.20</td></tr> <tr><td>25</td><td>10101</td><td>1.20</td></tr> <tr><td>26</td><td>10111</td><td>1.20</td></tr> <tr><td>27</td><td>10110</td><td>1.20</td></tr> <tr><td>28</td><td>10010</td><td>1.20</td></tr> <tr><td>29</td><td>10011</td><td>1.20</td></tr> <tr><td>30</td><td>10001</td><td>1.20</td></tr> <tr><td>31</td><td>10000</td><td>1.20</td></tr> </tbody> </table> <p>The factors listed in the table for the feedrate override are stored in the machine data: MD12030 \$MN_OVR_FACTOR_FEEDRATE [n]. 6FC5397-0BP10-3BA0</p> <p>The table contains the default settings. The number of possible switch settings for standard machine panels is described in the Configuration Guides for SINUMERIK 840D.</p>	Code	Feed rate override factor	00000000	0.00 ± 0%	00000001	0.01 ± 1%	00000010	0.02 ± 2%	00000011	0.03 ± 3%	11001000	2.00 ± 200%	Switch position	Code	Feed rate override factor (standard values)	1	00001	0.0	2	00011	0.01	3	00010	0.02	4	00110	0.04	5	00111	0.06	6	00101	0.08	7	00100	0.10	8	01100	0.20	9	01101	0.30	10	01111	0.40	11	01110	0.50	12	01010	0.60	13	01011	0.70	14	01001	0.75	15	01000	0.80	16	11000	0.85	17	11001	0.90	18	11011	0.95	19	11010	1.00	20	11110	1.05	21	11111	1.10	22	11101	1.15	23	11100	1.20	24	10100	1.20	25	10101	1.20	26	10111	1.20	27	10110	1.20	28	10010	1.20	29	10011	1.20	30	10001	1.20	31	10000	1.20
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<p>Basic Functions Function Manual, 01/2008</p>	<p>1699</p>																																																																																																												

18.13 Feeds (V1)

<b>DB21, ... DBB4</b>	<b>Feedrate override</b>
Corresponding to ....	DB21, ... DBX6.7 (feed rateoverride active) MD12030 \$MN_OVR_FACTOR_FEEDRATE [n] (evaluation of the path feed rate override switch) MD12100 \$MN_OVR_FACTOR_LIMIT_BIN (limit for binary coded override switch)

<b>DB21, ... DBB5</b>	<b>Rapid traverse override</b>
Edge evaluation: No	Signal(s) updated: Cyclically

<p><b>DB21, ... DBB5</b></p>	<p><b>Rapid traverse override</b></p>																																																																																																												
<p>Signal state 1 or edge change 0 → 1</p>	<p>The rapid traverse override can be entered via the PLC in either the binary or Gray code. For binary coding, the rapid traverse override is interpreted as a %. 0% to 100% feed changes are possible, in accordance with the binary value in the byte. The following permanent assignment applies:</p> <table border="1" data-bbox="406 510 1385 792"> <thead> <tr> <th>Code</th> <th>Rapid traverse override factor</th> </tr> </thead> <tbody> <tr> <td>00000000</td> <td>0.00 ± 0%</td> </tr> <tr> <td>00000001</td> <td>0.01 ± 1%</td> </tr> <tr> <td>00000010</td> <td>0.02 ± 2%</td> </tr> <tr> <td>00000011</td> <td>0.03 ± 3%</td> </tr> <tr> <td>11001000</td> <td>1.00 ± 100%</td> </tr> </tbody> </table> <p>Binary values &gt; 100 are limited to 100%. Using the machine data: MD12100 \$MN_OVR_FACTOR_LIMIT_BIN (limit for binary-coded override switch), the maximum rapid traverse override can be additionally limited. In gray coding, the following codes are assigned to the individual switch settings:</p> <table border="1" data-bbox="406 981 1283 1827"> <caption>Table: Gray coding for rapid traverse override</caption> <thead> <tr> <th>Switch position</th> <th>Code</th> <th>Rapid traverse override factor (standard values)</th> </tr> </thead> <tbody> <tr><td>1</td><td>00001</td><td>0.0</td></tr> <tr><td>2</td><td>00011</td><td>0.01</td></tr> <tr><td>3</td><td>00010</td><td>0.02</td></tr> <tr><td>4</td><td>00110</td><td>0.04</td></tr> <tr><td>5</td><td>00111</td><td>0.06</td></tr> <tr><td>6</td><td>00101</td><td>0.08</td></tr> <tr><td>7</td><td>00100</td><td>0.10</td></tr> <tr><td>8</td><td>01100</td><td>0.20</td></tr> <tr><td>9</td><td>01101</td><td>0.30</td></tr> <tr><td>10</td><td>01111</td><td>0.40</td></tr> <tr><td>11</td><td>01110</td><td>0.50</td></tr> <tr><td>12</td><td>01010</td><td>0.60</td></tr> <tr><td>13</td><td>01011</td><td>0.70</td></tr> <tr><td>14</td><td>01001</td><td>0.75</td></tr> <tr><td>15</td><td>01000</td><td>0.80</td></tr> <tr><td>16</td><td>11000</td><td>0.85</td></tr> <tr><td>17</td><td>11001</td><td>0.90</td></tr> <tr><td>18</td><td>11011</td><td>0.95</td></tr> <tr><td>19</td><td>11010</td><td>1.00</td></tr> <tr><td>20</td><td>11110</td><td>1.00</td></tr> <tr><td>21</td><td>11111</td><td>1.00</td></tr> <tr><td>22</td><td>11101</td><td>1.00</td></tr> <tr><td>23</td><td>11100</td><td>1.00</td></tr> <tr><td>24</td><td>10100</td><td>1.00</td></tr> <tr><td>25</td><td>10101</td><td>1.00</td></tr> <tr><td>26</td><td>10111</td><td>1.00</td></tr> <tr><td>27</td><td>10110</td><td>1.00</td></tr> <tr><td>28</td><td>10010</td><td>1.00</td></tr> <tr><td>29</td><td>10011</td><td>1.00</td></tr> <tr><td>30</td><td>10001</td><td>1.00</td></tr> <tr><td>31</td><td>10000</td><td>1.00</td></tr> </tbody> </table> <p>The factors listed in the table for the rapid traverse override are stored in the machine data: MD12050 \$MN_OVR_FACTOR_RAPID_TRA[n]. The table contains the default settings. The number of possible switch settings for standard machine panels is described in the Configuration Guides for SINUMERIK 840D.</p>	Code	Rapid traverse override factor	00000000	0.00 ± 0%	00000001	0.01 ± 1%	00000010	0.02 ± 2%	00000011	0.03 ± 3%	11001000	1.00 ± 100%	Switch position	Code	Rapid traverse override factor (standard values)	1	00001	0.0	2	00011	0.01	3	00010	0.02	4	00110	0.04	5	00111	0.06	6	00101	0.08	7	00100	0.10	8	01100	0.20	9	01101	0.30	10	01111	0.40	11	01110	0.50	12	01010	0.60	13	01011	0.70	14	01001	0.75	15	01000	0.80	16	11000	0.85	17	11001	0.90	18	11011	0.95	19	11010	1.00	20	11110	1.00	21	11111	1.00	22	11101	1.00	23	11100	1.00	24	10100	1.00	25	10101	1.00	26	10111	1.00	27	10110	1.00	28	10010	1.00	29	10011	1.00	30	10001	1.00	31	10000	1.00
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18.13 Feeds (V1)

<b>DB21, ... DBB5</b>	<b>Rapid traverse override</b>
Corresponding to ....	DB21, ... DBX6.6 (rapid traverse override active) MD12050 \$MN_OVR_FACTOR_RAPID_TRA[n] (evaluation of the path feed rate override switch) MD12100 \$MN_OVR_FACTOR_LIMIT_BIN (limit for binary coded override switch)

<b>DB21, ... DBX6.0</b>	<b>Feed disable</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	<p>The signal is active in one channel in all operating modes.</p> <p>The signal disables the feed for all of the axes (geometry and synchronized) that interpolate relative to one another as long as G33 (thread) is not active.</p> <p>All axes are brought to a standstill but still maintaining the path contour. When the feed disable is canceled (0 signal), the interrupted part program is continued.</p> <p>The signal triggers a feed disable for all positioning axes. This signal brings all traversing axes to a standstill with controlled braking (ramp stop). No alarm is output.</p> <p>The position control is retained, i.e. the following error is eliminated.</p> <p>If a travel request is issued for an axis with an active "Feed disable", then this is kept. The queued travel request is executed immediately when the "Feed disable" is canceled.</p> <p>If the axis is interpolating in relation to others, this also applies to these axes.</p>
Signal state 0 or edge change 1 → 0	<p>The feed rate is enabled for all axes of the channel.</p> <p>If a travel request ("travel command") exists for an axis or group of axes when the "feed disable" is canceled, then this is executed immediately.</p>
Application example(s)	Stopping machining by selecting FEED OFF on the machine control panel.
Special cases, errors, .....	The feed disable is inactive when G33 is active.

<b>DB21, ... DBX6.6</b>	<b>Rapid traverse override active</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	<p>The rapid traverse override between 0 and a maximum of 100% entered in the PLC interface is channel-specific. The override factor is defined using the machine data: MD12040 \$MN_OVR_RAPID_IS_GRAY_CODE (rapid traverse override switch gray coded) and MD12050 \$MN_OVR_FACTOR_RAPID_TRA [n] (evaluation of the rapid traverse override switch).</p>
Signal state 0 or edge change 1 → 0	<p>The rapid traverse override entered at the PLC interface is ignored.</p> <p>When the rapid traverse override is inactive, the NC always uses 100% as the internal override factor.</p> <p>Exceptions are the zero setting for a binary interface and the 1st switch setting for a Gray-coded interface. In these cases, the override factors entered at the PLC interface are used. With a binary interface, the override factor = 0. With a Gray-coded interface, the value entered in the machine data for the 1st switch setting is output as the override value.</p>

<b>DB21, ... DBX6.6</b>	<b>Rapid traverse override active</b>
Application example(s)	The override value is generally selected using the rapid traverse override switch on the machine control panel. Using the interface signal: DB21, ... DBX6.6 (rapid traverse override active), the rapid traverse override switch can be enabled from the PLC user program while commissioning a new NC program, e.g. using the key-operated switch.
Special cases, errors, .....	The rapid traverse override is inactive when G33, G63, G331, G332 are active.
Corresponding to ....	DB21, ... DBB5 (rapid traverse override)

<b>DB21, ... DBX6.7</b>	<b>Feedrate override active</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	The feed rate override between 0 and a maximum of 200% entered at the PLC interface is active for the path feed rate and therefore automatically for the related axes. In JOG mode, the feed rate override acts directly on the axes. The override factor is entered using the machine data: MD12020 \$MN_OVR_FEED_IS_GRAY_CODE (path feed rate override factor, gray-coded) and MD12030 \$MN_OVR_FACTOR_FEEDRATE [n] (evaluation of the path feed rate override switch)
Signal state 0 or edge change 1 → 0	The feed rate override entered at the PLC interface is ignored. When the feed rate override is inactive, the NC always uses 100% as the internal override factor. Exceptions are the zero setting for a binary interface and the 1st switch setting for a Gray-coded interface. In these cases, the override factors entered in the PLC interface are used. With a binary interface, the override factor = 0. With a Gray-coded interface, the value entered in the machine data for the 1st switch setting is output as the override value.
Application example(s)	The override value is generally selected using the feed rate override switch on the machine control panel. Using the interface signal: DB21, ... DBX6.7 (feed rate override active), the feed rate override switch can be enabled from the PLC user program while commissioning a new NC program, e.g. using the key-operated switch.
Special cases, errors, .....	The feed rate override is inactive when G33, G63, G331, G332 are active.
Corresponding to ....	DB21, ... DBB4 (feed rate override)

18.13 Feeds (V1)

<b>DB21, ... DBX12.3, DBX16.3, DBX20.3</b>	<b>Feed stop (Geometry axis 1 to 3)</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	<p>The signal is only active in JOG mode.</p> <p>The signal stops the feed of the geometry axis. This signal brings all traversing axes to a standstill with controlled braking (ramp stop). No alarm is output.</p> <p>The position control is retained, i.e. the following error is eliminated.</p> <p>If - for a geometry axis - a travel request is issued with an active "feed stop", the request is kept. This queued travel request is executed immediately after the "feed stop" is canceled.</p>	
Signal state 0 or edge change 1 → 0	<p>The feed is enabled for the geometry axis.</p> <p>If, for the geometry axis, a travel request ("travel command") is active when the "feed stop" is cancelled, this is executed immediately.</p>	

<b>DB21, ... DBX24.6</b>	<b>Dry run feed rate selected</b>	
Edge evaluation: No	Signal(s) updated: Cyclically	
Signal state 1 or edge change 0 → 1	<p>Dry run feed rate is selected.</p> <p>Instead of the programmed feed rate, the dry run feed rate entered in setting data: SD42100 \$SC_DRY_RUN_FEED is active.</p> <p>When activated from the operator panel, the dry run feed signal is automatically entered in the PLC interface and transmitted by the PLC basic program to the PLC interface signal: DB21, ... DBX0.6 (active dry run feed).</p>	
Signal state 0 or edge change 1 → 0	<p>Dry run feed rate is not selected.</p> <p>The programmed feed rate is active.</p>	
Corresponding to ....	<p>DB21, ... DBX0.6 (activate dry run feed)</p> <p>SD42100 \$SC_DRY_RUN_FEED (dry run feed rate)</p>	

<b>DB21, ... DBX25.3</b>	<b>Feed rate override selected for rapid traverse</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	<p>The feed rate override switch should also be active as rapid traverse override switch. Override values above 100% are limited to the maximum value for 100% rapid traverse override.</p> <p>The interface signal: DB21, ... DBX25.3 (feed rate override for rapid traverse selected) is automatically entered into the PLC interface from the operator panel and transferred from the PLC basic program to the PLC interface signal: DB21, ... DBX6.6 (rapid traverse override active).</p> <p>Further, the interface signal: DB21, ... DBB4 (feed rate override) is copied from the PLC basic program to the interface signal: DB21, ... DBB5 (rapid traverse override).</p>
Signal state 0 or edge change 1 → 0	The feed rate override switch should not be activated as rapid traverse override switch.
Application example(s)	The signal is used when no separate rapid traverse override switch is available.

<b>DB 21, ... DBX29.0 - DBX29.3</b>	<b>Activate fixed feed rate 1 - 4 for path/geometry axes</b>																														
Edge evaluation: No	Signal(s) updated: Cyclically																														
Description	<p>These signals are used to select/de-select the function "fixed feed" and define which fixed feed should be effective for path/geometry axes.</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Bit 3</th> <th>Bit 2</th> <th>Bit 1</th> <th>Bit 0</th> <th>Meaning</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>0</td> <td>0</td> <td>Fixed feed is de-selected</td> </tr> <tr> <td>0</td> <td>0</td> <td>0</td> <td>1</td> <td>Fixed feed 1 is selected</td> </tr> <tr> <td>0</td> <td>0</td> <td>1</td> <td>0</td> <td>Fixed feed 2 is selected</td> </tr> <tr> <td>0</td> <td>1</td> <td>0</td> <td>0</td> <td>Fixed feed 3 is selected</td> </tr> <tr> <td>1</td> <td>0</td> <td>0</td> <td>0</td> <td>Fixed feed 4 is selected</td> </tr> </tbody> </table>	Bit 3	Bit 2	Bit 1	Bit 0	Meaning	0	0	0	0	Fixed feed is de-selected	0	0	0	1	Fixed feed 1 is selected	0	0	1	0	Fixed feed 2 is selected	0	1	0	0	Fixed feed 3 is selected	1	0	0	0	Fixed feed 4 is selected
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Corresponding to ....	MD12202 \$MN_PERMANENT_FEED[n] MD12200 \$MN_RUN_OVERRIDE_0																														

### 18.13.2 Signals to axis/spindle (DB31, ...)

<b>DB31, ... DBB0</b>	<b>Feed rate override (axis-specific)</b>
Edge evaluation: No	Signal(s) updated: Cyclically

18.13 Feeds (V1)

<p><b>DB31, ... DBB0</b></p>	<p><b>Feed rate override (axis-specific)</b></p>																																																																																																																						
<p>Signal state 1 or edge change 0 → 1</p>	<p>The axis-specific feed rate override can be defined via the PLC in binary or Gray coding. With binary coding, the feed value is interpreted in %. 0% to 200% feed changes are possible, in accordance with the binary value in the byte.</p> <p>The following permanent assignment applies:</p> <table border="1" data-bbox="368 510 1425 958"> <thead> <tr> <th>Code</th> <th>Axis-specific feed rate override factor</th> </tr> </thead> <tbody> <tr><td>00000000</td><td>0.00 ± 0%</td></tr> <tr><td>00000001</td><td>0.01 ± 1%</td></tr> <tr><td>00000010</td><td>0.02 ± 2%</td></tr> <tr><td>00000011</td><td>0.03 ± 3%</td></tr> <tr><td>⋮</td><td>⋮</td></tr> <tr><td>⋮</td><td>⋮</td></tr> <tr><td>01100100</td><td>1.00 ± 100%</td></tr> <tr><td>⋮</td><td>⋮</td></tr> <tr><td>⋮</td><td>⋮</td></tr> <tr><td>11001000</td><td>2.00 ± 200%</td></tr> </tbody> </table> <p>Binary values &gt; 200 are limited to 200%.</p> <p>Using the machine data: MD12100 \$MN_OVR_FACTOR_LIMIT_BIN (limit for binary-coded override switch) the maximum axis-specific feed rate override can be additionally limited.</p> <p>In gray coding, the following codes are assigned to the individual switch settings:</p> <table border="1" data-bbox="368 1160 1161 1742"> <caption>Table: Gray coding for axis-specific feed rate override</caption> <thead> <tr> <th>Switch position</th> <th>Code</th> <th>Axial feed rate override factor (standard values)</th> </tr> </thead> <tbody> <tr><td>1</td><td>00001</td><td>0.0</td></tr> <tr><td>2</td><td>00011</td><td>0.01</td></tr> <tr><td>3</td><td>00010</td><td>0.02</td></tr> <tr><td>4</td><td>00110</td><td>0.04</td></tr> <tr><td>5</td><td>00111</td><td>0.06</td></tr> <tr><td>6</td><td>00101</td><td>0.08</td></tr> <tr><td>7</td><td>00100</td><td>0.10</td></tr> <tr><td>8</td><td>01100</td><td>0.20</td></tr> <tr><td>9</td><td>01101</td><td>0.30</td></tr> <tr><td>10</td><td>01111</td><td>0.40</td></tr> <tr><td>11</td><td>01110</td><td>0.50</td></tr> <tr><td>12</td><td>01010</td><td>0.60</td></tr> <tr><td>13</td><td>01011</td><td>0.70</td></tr> <tr><td>14</td><td>01001</td><td>0.75</td></tr> <tr><td>15</td><td>01000</td><td>0.80</td></tr> <tr><td>16</td><td>11000</td><td>0.85</td></tr> <tr><td>17</td><td>11001</td><td>0.90</td></tr> <tr><td>18</td><td>11011</td><td>0.95</td></tr> <tr><td>19</td><td>11010</td><td>1.00</td></tr> <tr><td>20</td><td>11110</td><td>1.05</td></tr> <tr><td>21</td><td>11111</td><td>1.10</td></tr> <tr><td>22</td><td>11101</td><td>1.15</td></tr> <tr><td>23</td><td>11100</td><td>1.20</td></tr> <tr><td>24</td><td>10100</td><td>1.20</td></tr> <tr><td>25</td><td>10101</td><td>1.20</td></tr> <tr><td>26</td><td>10111</td><td>1.20</td></tr> <tr><td>27</td><td>10110</td><td>1.20</td></tr> <tr><td>28</td><td>10010</td><td>1.20</td></tr> <tr><td>29</td><td>10011</td><td>1.20</td></tr> <tr><td>30</td><td>10001</td><td>1.20</td></tr> <tr><td>31</td><td>10000</td><td>1.20</td></tr> </tbody> </table> <p>The factors listed in the table for the axial feed rate override are stored in the NC-specific machine data: MD12010 \$MN_OVR_FACTOR_AX_SPEED [n]</p> <p>The table contains the default settings.</p> <p>The number of possible switch settings for standard machine panels is described in the Configuration Guides for SINUMERIK 840D.</p>	Code	Axis-specific feed rate override factor	00000000	0.00 ± 0%	00000001	0.01 ± 1%	00000010	0.02 ± 2%	00000011	0.03 ± 3%	⋮	⋮	⋮	⋮	01100100	1.00 ± 100%	⋮	⋮	⋮	⋮	11001000	2.00 ± 200%	Switch position	Code	Axial feed rate override factor (standard values)	1	00001	0.0	2	00011	0.01	3	00010	0.02	4	00110	0.04	5	00111	0.06	6	00101	0.08	7	00100	0.10	8	01100	0.20	9	01101	0.30	10	01111	0.40	11	01110	0.50	12	01010	0.60	13	01011	0.70	14	01001	0.75	15	01000	0.80	16	11000	0.85	17	11001	0.90	18	11011	0.95	19	11010	1.00	20	11110	1.05	21	11111	1.10	22	11101	1.15	23	11100	1.20	24	10100	1.20	25	10101	1.20	26	10111	1.20	27	10110	1.20	28	10010	1.20	29	10011	1.20	30	10001	1.20	31	10000	1.20
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21	11111	1.10																																																																																																																					
22	11101	1.15																																																																																																																					
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24	10100	1.20																																																																																																																					
25	10101	1.20																																																																																																																					
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29	10011	1.20																																																																																																																					
30	10001	1.20																																																																																																																					
31	10000	1.20																																																																																																																					

<b>DB31, ... DBB0</b>	<b>Feed rate override (axis-specific)</b>
Corresponding to ....	DB31, ... DBX1.7 (override effective) MD12010 \$MN_OVR_FACTOR_AX_SPEED [n] (evaluation of the axis feed rate override switch) MD12100 \$MN_OVR_FACTOR_LIMIT_BIN (limit for binary coded override switch)

<b>DB31, ... DBX1.7</b>	<b>Override active</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	<p><b>Feed rate override active:</b> The axis-specific feed rate override between 0 and a maximum of 200% entered in the PLC interface is used.</p> <p>The override factor is defined using the machine data: MD12000 \$MN_OVR_AX_IS_GRAY_CODE (axis feed rate override switch gray coded) and MD12010 \$MN_OVR_FACTOR_AX_SPEED [n] (evaluation of the axis feed rate override switch).</p> <p><b>Spindle override active:</b> The spindle override - input at the PLC interface - of 0 to a maximum of 200% is taken into account. The override factor is entered using the machine data: MD12060 \$MN_OVR_SPIND_IS_GRAY_CODE (spindle override switch, Gray coded) and MD12070 \$MN_OVR_FACTOR_SPIND_SPEED [n] (evaluation of the spindle override switch).</p>
Signal state 0 or edge change 1 → 0	<p>The existing axis-specific feed rate override or spindle override is not active. If the feed rate override is inactive, "100%" is used as the internal override factor. Exceptions are the zero setting for a binary interface and the 1st switch setting for a Gray-coded interface. In these cases, the override factors entered at the PLC interface are used. For a binary interface, the override factor = 0. For a gray-coded interface, the value entered in the machine data for the 1st switch setting is output as the override value.</p>
Application example(s)	<p>The override value is generally specified using the axis-specific feed rate override switch or the spindle override switch on the machine control panel.</p> <p>The "feed rate override active" signal can be used to enable the feed rate override switch from the PLC user program, e.g. using the key-operated switch when commissioning a new NC program.</p>
Special cases, errors, .....	<p>The spindle override is always accepted with 100% in the spindle "Oscillation mode". The spindle override acts on the programmed values before the limits (e.g. G26, LIMS...) intervene. The feed rate override is ineffective for:</p> <ul style="list-style-type: none"> <li>• active G33</li> <li>• active G63 (the override is defined in the NC at 100%)</li> <li>• active G331, G332 (the override is defined in the NC at 100%)</li> </ul> <p>The spindle override is inactive for:</p> <ul style="list-style-type: none"> <li>• active G63 (the override is defined in the NC at 100%)</li> </ul>
Corresponding to ....	DB31, ... DBB0 (feed/spindle override)

18.13 Feeds (V1)

<b>DB31, ... DBX3.2 - DBX3.5</b>	<b>Activate fixed feed rate 1 - 4 for machine axes</b>																														
Edge evaluation: No	Signal(s) updated: Cyclically																														
Description	<p>These signals are used to select/de-select the function "fixed feed" and define which fixed feed should be effective for machine axes.</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Bit 5</th> <th>Bit 4</th> <th>Bit 3</th> <th>Bit 2</th> <th>Meaning</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>0</td> <td>0</td> <td>Fixed feed is de-selected</td> </tr> <tr> <td>0</td> <td>0</td> <td>0</td> <td>1</td> <td>Fixed feed 1 is selected</td> </tr> <tr> <td>0</td> <td>0</td> <td>1</td> <td>0</td> <td>Fixed feed 2 is selected</td> </tr> <tr> <td>0</td> <td>1</td> <td>0</td> <td>0</td> <td>Fixed feed 3 is selected</td> </tr> <tr> <td>1</td> <td>0</td> <td>0</td> <td>0</td> <td>Fixed feed 4 is selected</td> </tr> </tbody> </table>	Bit 5	Bit 4	Bit 3	Bit 2	Meaning	0	0	0	0	Fixed feed is de-selected	0	0	0	1	Fixed feed 1 is selected	0	0	1	0	Fixed feed 2 is selected	0	1	0	0	Fixed feed 3 is selected	1	0	0	0	Fixed feed 4 is selected
Bit 5	Bit 4	Bit 3	Bit 2	Meaning																											
0	0	0	0	Fixed feed is de-selected																											
0	0	0	1	Fixed feed 1 is selected																											
0	0	1	0	Fixed feed 2 is selected																											
0	1	0	0	Fixed feed 3 is selected																											
1	0	0	0	Fixed feed 4 is selected																											
Corresponding to ....	MD12202 \$MN_PERMANENT_FEED[n] MD12200 \$MN_RUN_OVERRIDE_0																														

<b>DB31, ... DBX4.3</b>	<b>Feed stop/spindle stop (axis-specific)</b>
Edge evaluation: No	Signal(s) updated: Cyclically
Signal state 1 or edge change 0 → 1	<p>The signal is active in all modes.</p> <p><b>Feed stop:</b> The signal triggers a "feed stop" for the axis. This signal brings all traversing axes to a standstill with controlled braking (ramp stop). No alarm is output. The signal triggers a "feed stop" for all path axes interpolating relative to each other when the "feed stop" is activated for any one of these path axes. In this case, all the axes are brought to a stop with adherence to the path contour. When the "feed stop" signal is canceled, execution of the interrupted parts program is resumed. The position control is retained, i.e. the following error is eliminated. If a travel request is issued for an axis with an active "feed stop", this is kept. This queued travel request is executed immediately after the "feed stop" is canceled. If the axis is interpolating in relation to others, this also applies to these axes.</p> <p><b>Spindle stop:</b> The spindle is brought to a standstill along the acceleration characteristic. In the positioning mode, when the "Spindle stop" signal is set positioning is interrupted. The above response applies with respect to individual axes.</p>

<b>DB31, ... DBX4.3</b>	<b>Feed stop/spindle stop (axis-specific)</b>
Signal state 0 or edge change 1 → 0	<p><b>Feed stop:</b> The feed rate is enabled for the axis. If a travel request ("travel command") is active when the "feed stop" is canceled, this is executed immediately.</p> <p><b>Spindle stop:</b> The speed is enabled for the spindle. The spindle is accelerated to the previous speed setpoint with the acceleration characteristic or, in positioning mode, positioning is resumed.</p>
Application example(s)	<p><b>Feed stop:</b> The traversing motion of the machine axes is not started with "feed stop", if, for example, certain operating states exist at the machine that do not permit the axes to be moved (e.g. a door is not closed).</p> <p><b>Spindle stop:</b> In order to change a tool To enter help functions (M, S, H, T, D and F functions) during setup.</p>
Special cases, errors, .....	Spindle stop is inactive when G331, G332 are active.

<b>DB31, ... DBB19</b>	<b>Spindle override</b>																						
Edge evaluation: No	Signal(s) updated: Cyclically																						
Signal state 1 or edge change 0 → 1	<p>The spindle override can be defined via the PLC in binary or Gray coding.</p> <p>The override value determines the percentage of the programmed speed setpoint that is issued to the spindle.</p> <p>With binary coding, the override is interpreted in %. 0% to 200% feed changes are possible, in accordance with the binary value in the byte.</p> <p>The following permanent assignment applies:</p> <table border="1" data-bbox="368 622 1425 1072"> <thead> <tr> <th style="text-align: center;">Code</th> <th style="text-align: center;">Spindle override factor</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">00000000</td> <td style="text-align: center;">0.00 ± 0%</td> </tr> <tr> <td style="text-align: center;">00000001</td> <td style="text-align: center;">0.01 ± 1%</td> </tr> <tr> <td style="text-align: center;">00000010</td> <td style="text-align: center;">0.02 ± 2%</td> </tr> <tr> <td style="text-align: center;">00000011</td> <td style="text-align: center;">0.03 ± 3%</td> </tr> <tr> <td style="text-align: center;">⋮</td> <td style="text-align: center;">⋮</td> </tr> <tr> <td style="text-align: center;">⋮</td> <td style="text-align: center;">⋮</td> </tr> <tr> <td style="text-align: center;">01100100</td> <td style="text-align: center;">1.00 ± 100%</td> </tr> <tr> <td style="text-align: center;">⋮</td> <td style="text-align: center;">⋮</td> </tr> <tr> <td style="text-align: center;">⋮</td> <td style="text-align: center;">⋮</td> </tr> <tr> <td style="text-align: center;">11001000</td> <td style="text-align: center;">2.00 ± 200%</td> </tr> </tbody> </table> <p>Binary values &gt; 200 are limited to 200%.</p> <p>The machine data: MD12100 \$MN_OVR_FACTOR_LIMIT_BIN (limit for binary-coded override switch) can be used to additionally limit the maximum spindle override.</p>	Code	Spindle override factor	00000000	0.00 ± 0%	00000001	0.01 ± 1%	00000010	0.02 ± 2%	00000011	0.03 ± 3%	⋮	⋮	⋮	⋮	01100100	1.00 ± 100%	⋮	⋮	⋮	⋮	11001000	2.00 ± 200%
Code	Spindle override factor																						
00000000	0.00 ± 0%																						
00000001	0.01 ± 1%																						
00000010	0.02 ± 2%																						
00000011	0.03 ± 3%																						
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⋮	⋮																						
01100100	1.00 ± 100%																						
⋮	⋮																						
⋮	⋮																						
11001000	2.00 ± 200%																						

DB31, ... DBB19	Spindle override																																																																																																
Signal state 1 or edge change 0 → 1	<p>In gray coding, the following codes are assigned to the individual switch settings:</p> <div style="border: 1px solid black; padding: 10px; margin: 10px auto; width: fit-content;"> <p style="text-align: center;">Table: Gray coding for spindle override</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: center;">Switch position</th> <th style="text-align: center;">Code</th> <th style="text-align: center;">Spindle override factor (standard values)</th> </tr> </thead> <tbody> <tr><td style="text-align: center;">1</td><td style="text-align: center;">00001</td><td style="text-align: center;">0.5</td></tr> <tr><td style="text-align: center;">2</td><td style="text-align: center;">00011</td><td style="text-align: center;">0.55</td></tr> <tr><td style="text-align: center;">3</td><td style="text-align: center;">00010</td><td style="text-align: center;">0.60</td></tr> <tr><td style="text-align: center;">4</td><td style="text-align: center;">00110</td><td style="text-align: center;">0.65</td></tr> <tr><td style="text-align: center;">5</td><td style="text-align: center;">00111</td><td style="text-align: center;">0.70</td></tr> <tr><td style="text-align: center;">6</td><td style="text-align: center;">00101</td><td style="text-align: center;">0.75</td></tr> <tr><td style="text-align: center;">7</td><td style="text-align: center;">00100</td><td style="text-align: center;">0.80</td></tr> <tr><td style="text-align: center;">8</td><td style="text-align: center;">01100</td><td style="text-align: center;">0.85</td></tr> <tr><td style="text-align: center;">9</td><td style="text-align: center;">01101</td><td style="text-align: center;">0.90</td></tr> <tr><td style="text-align: center;">10</td><td style="text-align: center;">01111</td><td style="text-align: center;">0.95</td></tr> <tr><td style="text-align: center;">11</td><td style="text-align: center;">01110</td><td style="text-align: center;">1.00</td></tr> <tr><td style="text-align: center;">12</td><td style="text-align: center;">01010</td><td style="text-align: center;">1.05</td></tr> <tr><td style="text-align: center;">13</td><td style="text-align: center;">01011</td><td style="text-align: center;">1.10</td></tr> <tr><td style="text-align: center;">14</td><td style="text-align: center;">01001</td><td style="text-align: center;">1.15</td></tr> <tr><td style="text-align: center;">15</td><td style="text-align: center;">01000</td><td style="text-align: center;">1.20</td></tr> <tr><td style="text-align: center;">16</td><td style="text-align: center;">11000</td><td style="text-align: center;">1.20</td></tr> <tr><td style="text-align: center;">17</td><td style="text-align: center;">11001</td><td style="text-align: center;">1.20</td></tr> <tr><td style="text-align: center;">18</td><td style="text-align: center;">11011</td><td style="text-align: center;">1.20</td></tr> <tr><td style="text-align: center;">19</td><td 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for SINUMERIK 840D.</p>	Switch position	Code	Spindle override factor (standard values)	1	00001	0.5	2	00011	0.55	3	00010	0.60	4	00110	0.65	5	00111	0.70	6	00101	0.75	7	00100	0.80	8	01100	0.85	9	01101	0.90	10	01111	0.95	11	01110	1.00	12	01010	1.05	13	01011	1.10	14	01001	1.15	15	01000	1.20	16	11000	1.20	17	11001	1.20	18	11011	1.20	19	11010	1.20	20	11110	1.20	21	11111	1.20	22	11101	1.20	23	11100	1.20	24	10100	1.20	25	10101	1.20	26	10111	1.20	27	10110	1.20	28	10010	1.20	29	10011	1.20	30	10001	1.20	31	10000	1.20
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Corresponding to ....	DB31, ... DBX1.7 (override active) MD12070 \$MN_OVR_FACTOR_SPIND_SPEED [n] (evaluation of the spindle override switch) MD12100 \$MN_FACTOR_LIMIT_BIN (limit for binary-coded override switch)																																																																																																

**18.13.3 Signals from axis/spindle (DB31, ...)**

<b>DB31, ... DBX62.2</b>	<b>Revolutional feed rate active</b>	
Edge evaluation: no	Signal(s) updated: cyclic	
Signal state 1 or edge change 0 → 1	For programming of G95 (revolutional feed rate) in JOG mode or automatic mode.	
Corresponding to ....	SD41100 \$SN_JOG_REV_IS_ACTIVE (revolutional feed rate for JOG active) SD42600 \$SC_JOG_FEED_PER_REV_SOURCE (in the JOG mode revolutional feed rate for geometry axes, on which the frame with rotation acts) SD43300 \$SA_ASSIGN_FEED_PER_REV_SOURCE (revolutional feed rate for position axes/spindles) MD32040 \$MA_JOG_REV_VELO_RAPID (revolutional feed rate for JOG with rapid traverse override) MD32050 \$MA_JOG_REV_VELO (revolutional feed rate for JOG mode)	

<b>DB31, ... DBB78 - DBB81</b>	<b>F function for positioning axis</b>	
Edge evaluation: no	Signal(s) updated: cyclic	
Signal state 1 or edge change 0 → 1	The F value of a positioning axis programmed in the current block is entered in the axis-specific PLC interface signal. The assignment between the DB number and machine axis number is established using the axis name. The value is retained until it is overwritten by another. Format: Binary number in real format.	
Application example(s)	Modification of the programmed F value by the PLC, e.g. by overwriting the selected axis-specific feed rate override.	
Corresponding to ....	MD22240 \$MC_AUXFU_F_SYNC_TYPE (output time F functions)	

# A

## Appendix

### A.1 List of abbreviations

<b>A</b>	
AC	Adaptive Control
ADI4	Analog Drive Interface for 4 Axes
ALM	Active Line Module
ARM	Rotating induction motor
AS	Automation System
ASCII	American Standard Code for Information Interchange
ASUB	Asynchronous subprogram
AuxF	Auxiliary function
AUXFU	Auxiliary function

<b>B</b>	
BA	Mode
BAG	Mode group
BCD	Binary Coded Decimals: Decimal numbers encoded in binary code
BCS	Basic Coordinate System
BERO	Proximity limit switch
BI	Binector Input
BICO	Binector Connector
BIN	BINary files Binary files
BO	Binector Output
BOT	Boot file (SIMODRIVE 611D)
BP	Basic Program (PLC)

<b>C</b>	
CAD	Computer-Aided Design
CAM	Computer-Aided Manufacturing
CC	Compile Cycle
CF card	Compact Flash Card
CI	Connector Input

Appendix

A.1 List of abbreviations

CNC	Computerized Numerical Control
CO	Connector Output
CoL	Certificate of License
COM	Communication
Compact I/O module	Compact I/O module (PLC I/O module)
CP	Communication Processor
CPA	Compiler Projecting dAta: Compiler configuring data
CPU	Central Processing Unit:
CR	Carriage Return
CRC	Cutter Radius Compensation
CTS	Clear To Send: Signal from serial data interfaces
CU	Control Unit
CUTCOM	CUTter radius COMpensation: Tool radius compensation

<b>D</b>	
DAU	Digital-to-Analog Converter
DB	Data block (PLC)
DBB	Data block byte (PLC)
DBD	Data block double word (PLC)
DBW	Data block word (PLC)
DBX	Data block bit (PLC)
DIN	Deutsche Industrie Norm (German Industry Standard)
DIO	Data Input/Output: Data transfer display
DIR	DIRectory
DO	Drive Object
DPM	Dual-Port Memory
DPR	Dual-Port RAM
DRAM	Dynamic memory (non-buffered)
DRF	Differential Resolver Function (handwheel)
DRIVE-CliQ	Drive Component Link with IQ
DRY	DRY run: Dry run feedrate
DSB	Decoding Single Block
DSC	Dynamic Servo Control/Dynamic Stiffness Control
DW	Data word
DWORD	Double word (currently 32 bits)

<b>E</b>	
EMC	Electro-Magnetic Compatibility
EN	European Standard
ENC	Encoder: Actual value encoder
EnDat	Encoder interface

EPROM	Erasable Programmable Read Only Memory
EQN	Designation for an absolute encoder with 2048 sine signals per revolution
ES	Engineering System
ESD	Electrostatic Sensitive Devices
ESR	Extended stop and retract
ETC	ETC key ">": Softkey bar extension in the same menu

<b>F</b>	
FB	Function block (PLC)
FC	Function Call: Function block (PLC)
FD	Feed Drive
FEPROM	Flash EPROM: Read and write memory
FIFO	First In First Out: memory which works without address specification and whose data are read in the order in which they were stored.
FIPO	Fine InterPOLator
FRAME	Coordinate transformation
FST	Feed STop
FW	Firmware

<b>G</b>	
GC	Global Control (Profibus: Broadcast telegram)
GEO	Geometrie, e.g. geometry axis
GIA	Gear Interpolation dAta
GND	Signal GrouND
GS	Gearbox stage
GSD	Device master file for describing a Profibus slave
GSDML	Generic Station Description Markup Language: XML-based description language for creating a GSD file
GUD	Global User Data
GWPS	Grinding Wheel Peripheral Speed

<b>H</b>	
HEX	Abbreviation for hexadecimal number
HHU	Handheld unit
HMI	Human Machine Interface, SINUMERIK operator interface
HW	Hardware
HW Config	SIMATIC S7 tool for configuration and parameterization of hardware components within an S7 project
HW limit switch	Hardware limit switch

Appendix

A.1 List of abbreviations

<b>I</b>	
I/R	Infeed/regenerative feedback unit of SIMODRIVE 611(D)
IBN	Commissioning
ICA	Interpolatory compensation
INC	Increment
IPO	Interpolator
IS	Interface signal

<b>J</b>	
JOG	JOGging: Setup mode

<b>K</b>	
$K_p$	Proportional gain
$K_{\dot{u}}$	Transmission ratio
KV	Gain factor of control loop

<b>L</b>	
LAN	Local Area Network
LEC	Leadscrew error compensation
LED	Light-Emitting Diode
LF	Line Feed
LR	Position controller
LSB	Least Significant Bit
LUD	Local User Data

<b>M</b>	
MAC	Media Access Control
MB	Megabyte
MCI	Motion Control Interface
MCIS	Motion Control Information System
MCP	Machine control panel
MD	Machine Data
MDA	Manual Data Automatic: Manual input
MCS	Machine coordinate system
MLFB	Machine-readable product designation
MM	Motor module
MMC	Man-Machine Communication

MPF	Main Program File: NC part program (main program)
MPI	Multi-Point Interface: Multiport Interface
MSD	Main Spindle Drive
MSGW	Message word
MSTT	Machine Control Panel

<b>N</b>	
NC	Numerical Control
NCK	Numerical Control Kernel
NCU	Numerical Control Unit
NRK	Name of operating system of the NCK
NX	Numerical eXtension (axis extension module)

<b>O</b>	
OB	Organization block in the PLC
OEM	Original Equipment Manufacturer
OLP	Optical Link Plug: Fiber-optic bus connector
OP	Operator Panel: Operating equipment
OPI	Operator Panel Interface: Interface for connection to the operator panel
OPT	Options

<b>P</b>	
PC	Personal Computer
PCMCIA	Personal Computer Memory Card International Association
PCU	PC Unit
PCW	Program control word
PG	Programming device
PID	Parameter identification: Part of a PIV
PII	Process image of inputs
PIO	Process image of outputs
PIV	Parameter identification: Value: Parameterizing part of a PPO
PLC	Programmable Logic Control: Adaptive controller
PMS	Position Measuring System
PNO	PROFIBUS User Organization
PO	Power On
POS	Positioning: e.g. POS axis = positioning axis = channel axis which traverses non-interpolatory channel axes to their programmed positions, i.e. independently of other channel axes
POSMO A	Positioning Motor Actuator: positioning motor

Appendix

A.1 List of abbreviations

POSMO CA	Positioning Motor Compact AC: Complete drive unit with integrated power and control module as well as positioning unit and program memory; AC infeed
POSMO DC	Positioning Motor Compact DC: Like CA but with DC infeed
POSMO SI	Positioning Motor Servo Integrated: Positioning motor, DC infeed
PPO	Parameter Process data Object; Cyclic data message frame for Profibus DP transmission and "Variable speed drives" profile
PROFIBUS	Process Field Bus: Serial data bus
PRT	Program test
PTP	Point-To-Point Point-to-point
PUD	Program global User Data: Global program variable
PZD	Process Data: Process data part of a PPO

<b>Q</b>	
QEC	Quadrant error compensation

<b>R</b>	
RAM	Random Access Memory: Read/write memory
REF	REfERENCE point approach function
REPOS	REPOSition function
RISC	Reduced Instruction Set Computer: Type of processor with small instruction set and ability to process instructions at high speed
ROV	Rapid Override: Input correction
RPY	Roll Pitch Yaw: Rotation type of a coordinate system
RP	R parameter, arithmetic parameter, predefined user variable
RTCP	Real Time Control Protocol
RTL	Rapid Traverse Linear Interpolation: Linear interpolation during rapid traverse motion

<b>S</b>	
SBC	Safe Brake Control
SBL	Single Block
SD	Setting Data
SEA	Setting Data Active: Identifier (file type) for setting data
SERUPRO	SEArch RUn by PROgram test Search run by program test
SGA	Safety-related output
SGE	Safety-related input
SH	Safe stop
SIM	Single Inline Module
SK	Softkey
SKP	SKiP: Function for skipping a part program block
SLM	Synchronous Linear Motor

SM	Stepper Motor
SMC	Cabinet-mounted sensor module
SME	Sensor Module Externally-mounted
SPF	SubProgram File
SRAM	Static RAM (non-volatile)
SRM	Synchronous Rotary Motor
SSI	Synchronous Serial Interface (interface type)
SSL	Block search
STW	Control word
SW	Software
SW limit switch	Software limit switch
SYF	SYstem Files System files
SYNACT	SYNchronized ACTion

<b>T</b>	
T	Tool
TB	Terminal Board (SINAMICS)
TC	Tool change
TCP	Tool Center Point: Tool tip
TCP/IP	Transport Control Protocol/Internet Protocol
TCU	Thin Client Unit
TEA	Testing Data Active: Identifier for machine data
TIA	Totally Integrated Automation
TLC	Tool Length Compensation
TM	Terminal Module (SINAMICS)
TM	Tool management
TNRC	Tool Nose Radius Compensation
TO	Tool Offset
TOA	Tool Offset Active: Identifier (file type) for tool offsets
TRANSMIT	TRANSform Milling Into Turning: Coordination transformation for milling operations on a lathe
TRC	Tool Radius Compensation
TTL	Transistor-Transistor Logic (interface type)

<b>U</b>	
UPS	Uninterruptible power supply (UPS)
USB	Universal Serial Bus

<b>V</b>	
VDE	Verband Deutscher Elektrotechniker [Association of German Electrical Engineers]

## Appendix

### A.1 List of abbreviations

---

VDI	Verein Deutscher Ingenieure [Association of German Engineers]
VDI	Internal communication interface between NCK and PLC
VI	Voltage Input
VO	Voltage Output

<b>W</b>	
WCS	Workpiece Coordinate System
WOP	Workshop-Oriented Programming
WPD	Workpiece Directory
WZ	Tool

<b>X</b>	
XML	Extensible Markup Language

<b>Z</b>	
ZO	Zero offset
ZOA	Zero Offset Active: Identifier for zero offsets
ZSW	Status word (of drive)

## **A.2 Feedback on the documentation**

This document will be continuously improved with regard to its quality and ease of use. Please help us with this task by sending your comments and suggestions for improvement via e-mail or fax to:

E-mail: <mailto:docu.motioncontrol@siemens.com>

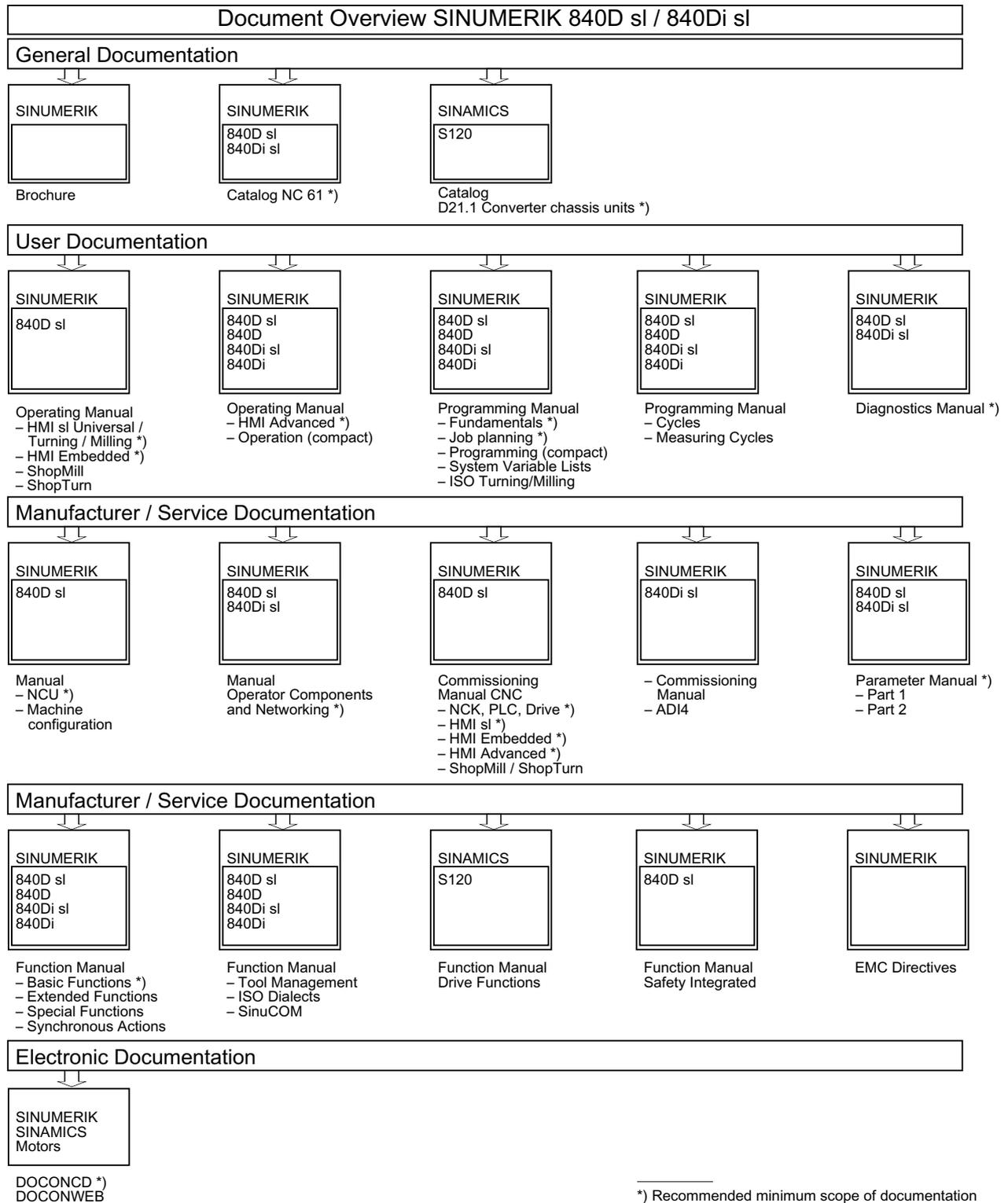
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Suggestions and/or corrections

## A.3 Overview





# Glossary

## Absolute dimensions

A destination for an axis movement is defined by a dimension that refers to the origin of the currently active coordinate system. See → Chain measure

## Acceleration with jerk limitation

In order to optimize the acceleration response of the machine whilst simultaneously protecting the mechanical components, it is possible to switch over in the machining program between abrupt acceleration and continuous (jerk-free) acceleration.

## Address

An address is the identifier for a certain operand or operand range, e.g. input, output, etc.

## Alarms

All → messages and alarms are displayed on the operator panel in plain text with date and time and the corresponding symbol for the cancel criterion. Alarms and messages are displayed separately.

1. Alarms and messages in the part program:

Alarms and messages can be displayed in plain text directly from the part program.

2. Alarms and messages from PLC

Alarms and messages for the machine can be displayed in plain text from the PLC program. No additional function block packages are required for this purpose.

## Archive

Reading out of files and/or directories on an **external** memory device.

## Asynchronous subroutine

Part program that can be started asynchronously to (independently of) the current program status using an interrupt signal (e.g. "Rapid NC input" signal).

### **Automatic**

Operating mode of the control (block sequence operation according to DIN): Operating mode for NC systems in which a → subprogram is selected and executed continuously.

### **Auxiliary functions**

Auxiliary functions enable part programs to transfer → parameters to the → PLC, which then trigger reactions defined by the machine manufacturer.

### **Axes**

In accordance with their functional scope, the CNC axes are subdivided into:

- Axes: interpolating path axes
- Auxiliary axes: non-interpolating feed and positioning axes with an axis-specific feed rate. Auxiliary axes are not involved in actual machining, e.g. tool feeder, tool magazine.

### **Axis address**

See → Axis identifier

### **Axis identifier**

Axes are identified using X, Y, and Z as defined in DIN 66217 for a right-handed, right-angled → coordinate system.

Rotary axes rotating around X, Y, and Z are identified using A, B, and C. Additional axes situated parallel to the specified axes can be designated using other letters.

### **Axis name**

See → Axis identifier

### **Backlash compensation**

Compensation for a mechanical machine backlash, e.g. backlash on reversal for ball screws. Backlash compensation can be entered separately for each axis.

### **Backup battery**

The backup battery ensures that the → user program in the → CPU is stored so that it is safe from power failure and so that specified data areas and bit memory, timers and counters are stored retentively.

**Base axis**

Axis whose setpoint or actual value position forms the basis of the calculation of a compensation value.

**Basic Coordinate System**

Cartesian coordinate system which is mapped by transformation onto the machine coordinate system.

The programmer uses axis names of the basic coordinate system in the → part program. The basic coordinate system exists parallel to the → machine coordinate system if no → transformation is active. The difference between the two coordinate systems lies in the → axis identifiers.

**Baud rate**

Rate of data transfer (Bit/s).

**Blank**

Workpiece as it is before it is machined.

**Block search**

For debugging purposes or following a program abort, the "Block search" function can be used to select any location in the part program at which the program is to be started or resumed.

**Booting**

Loading the system program after power on.

**C axis**

Axis around which the tool spindle describes a controlled rotational and positioning movement.

**Channel**

A channel is characterized by the fact that it can process a → part program independently of other channels. A channel exclusively controls the axes and spindles assigned to it. Part program runs of different channels can be coordinated through → synchronization.

### Chip

"Block" is the term given to any files required for creating and processing programs.

### Circular interpolation

The → tool moves on a circle between specified points on the contour at a given feed rate, and the workpiece is thereby machined.

### CNC

See → NC

### COM

Component of the NC for the implementation and coordination of communication.

### Compensation axis

Axis with a setpoint or actual value modified by the compensation value

### Compensation memory

Data range in the control, in which the tool offset data are stored.

### Compensation table

Table containing interpolation points. It provides the compensation values of the compensation axis for selected positions on the basic axis.

### Compensation value

Difference between the axis position measured by the encoder and the desired, programmed axis position.

### Connecting cables

Connecting cables are pre-assembled or user-assembled 2-wire cables with a connector at each end. This connecting cable connects the → CPU to a → programming device or to other CPUs by means of a → multi-point interface (MPI).

### Continuous-path mode

The objective of continuous-path mode is to avoid substantial deceleration of the → path axes at the part program block boundaries and to change to the next block at as close to the same path velocity as possible.

**Contour**

Contour of the → workpiece

**Contour monitoring**

The following error is monitored within a definable tolerance band as a measure of contour accuracy. An unacceptably high following error can cause the drive to become overloaded, for example. In such cases, an alarm is output and the axes are stopped.

**Coordinate system**

See → Machine coordinate system, → Workpiece coordinate system

**CPU**

Central processing unit, see → Memory-programmable control

**C-Spline**

The C-Spline is the most well-known and widely used spline. The transitions at the interpolation points are continuous, both tangentially and in terms of curvature. 3rd order polynomials are used.

**Cycles**

Protected subroutines for execution of repetitive machining operations on the → workpiece.

**Data block**

1. Data unit of the → PLC that → HIGHSTEP programs can access.
2. Data unit of the → NC: Data modules contain data definitions for global user data. These data can be initialized directly when they are defined.

**Data word**

Two-byte data unit within a → data block.

**Diagnostics**

1. Operating area of the control.
2. The control has both a self-diagnostics program as well as test functions for servicing purposes: status, alarm, and service displays

### **Dimensions specification, metric and inches**

Position and lead values can be programmed in inches in the machining program. Irrespective of the programmable dimensions (G70/G71), the controller is set to a basic system.

### **DRF**

Differential Resolver Function: NC function which generates an incremental zero offset in Automatic mode in conjunction with an electronic handwheel.

### **Drive**

The drive is the unit of the CNC that performs the speed and torque control based on the settings of the NC.

### **Dynamic feedforward control**

Inaccuracies in the → contour due to following errors can be practically eliminated using dynamic, acceleration-dependent feedforward control. This results in excellent machining accuracy even at high → path velocities. Feedforward control can be selected and deselected on an axis-specific basis via the → part program.

### **Editor**

The editor makes it possible to create, edit, extend, join, and import programs/texts/program blocks.

### **Exact stop**

When an exact stop statement is programmed, the position specified in a block is approached exactly and, if necessary, very slowly. To reduce the approach time, exact stop limits are defined for rapid traverse and → feed.

### **Exact stop limit**

When all path axes reach their exact stop limits, the control responds as if it had reached its precise destination point. A block advance of the → part program occurs.

### **External zero offset**

Zero-point offset specified by the → PLC.

**Fast retraction from contour**

When an interrupt occurs, a motion can be initiated via the CNC machining program, enabling the tool to be quickly retracted from the workpiece contour that is currently being machined. The retraction angle and the distance retracted can also be parameterized. After fast retraction, an interrupt routine can also be executed (SINUMERIK 840D).

**Feed override**

The programmed velocity is overridden by the current velocity setting made via the → machine control panel or from the → PLC (0 to 200%). The feedrate can also be corrected by a programmable percentage factor (1-200%) in the machining program.

**Finished-part contour**

Contour of the finished workpiece. See → Raw part.

**Fixed machine point**

Point that is uniquely defined by the machine tool, e.g. machine reference point.

**Fixed-point approach**

Machine tools can approach fixed points such as a tool change point, loading point, pallet change point, etc. in a defined way. The coordinates of these points are stored in the control. The control moves the relevant axes in → rapid traverse, whenever possible.

**Frame**

A frame is an arithmetic rule that transforms one Cartesian coordinate system into another Cartesian coordinate system. A frame contains the following components: → zero offset, → rotation, → scaling, → mirroring.

**Functionality**

The path-jerk limitation can be activated/deactivated by programming the setting data.

Parameter: *Value*

- Value range: TRUE, FALSE

Application:

- Part program
- Static synchronized action

## Geometry

Description of a → workpiece in the → workpiece coordinate system.

## Geometry axis

Geometry axes are used to describe a 2- or 3-dimensional area in the workpiece coordinate system.

## Ground

Ground is taken as the total of all linked inactive parts of a device which will not become live with a dangerous contact voltage even in the event of a malfunction.

## Helical interpolation

The helical interpolation function is ideal for machining internal and external threads using form milling cutters and for milling lubrication grooves.

The helix comprises two movements:

- Circular movement in one plane
- A linear movement perpendicular to this plane

## High-level CNC language

The high-level language offers: → user-defined variables, → system variables, → macro techniques.

## High-speed digital inputs/outputs

The digital inputs can be used for example to start fast CNC program routines (interrupt routines). The digital CNC outputs can be used to trigger fast, program-controlled switching functions (SINUMERIK 840D).

## HIGHSTEP

Summary of programming options for → PLCs of the AS300/AS400 system.

## Identifier

In accordance with DIN 66025, words are supplemented using identifiers (names) for variables (arithmetic variables, system variables, user variables), subroutines, key words, and words with multiple address letters. These supplements have the same meaning as the words with respect to block format. Identifiers must be unique. It is not permissible to use the same identifier for different objects.

**Inch measuring system**

Measuring system, which defines distances in inches and fractions of inches.

**Inclined surface machining**

Drilling and milling operations on workpiece surfaces that do not lie in the coordinate planes of the machine can be performed easily using the function "inclined-surface machining".

**Increment**

Travel path length specification based on number of increments. The number of increments can be stored as → setting data or be selected by means of a suitably labeled key (i.e. 10, 100, 1000, 10000).

**Incremental dimension**

Also incremental dimension: A destination for axis traversal is defined by a distance to be covered and a direction referenced to a point already reached. See → Absolute dimension.

**Intermediate blocks**

Motions with selected → tool offset (*G41/G42*) may be interrupted by a limited number of intermediate blocks (blocks without axis motions in the offset plane), whereby the tool offset can still be correctly compensated for. The permissible number of intermediate blocks which the control reads ahead can be set in system parameters.

**Interpolator**

Logic unit of the → NCK that defines intermediate values for the motions to be carried out in individual axes based on information on the end positions specified in the part program.

**Interpolatory compensation**

Interpolatory compensation is a tool that enables manufacturing-related leadscrew error and measuring system error compensations.

**Interrupt routine**

Interrupt routines are special → subroutines that can be started by events (external signals) in the machining process. A part program block which is currently being worked through is interrupted and the position of the axes at the point of interruption is automatically saved.

### **Inverse-time feedrate**

With SINUMERIK 840D, the time required for the path of a block to be traversed can be programmed for the axis motion instead of the feed velocity (G93).

### **JOG**

Control operating mode (setup mode): In JOG mode, the machine can be set up. Individual axes and spindles can be traversed in JOG mode by means of the direction keys. Additional functions in JOG mode include: → Reference point approach, → Repos, and → Preset (set actual value).

### **Key switch**

The key switch on the → machine control panel has four positions that are assigned functions by the operating system of the control. The key switch has three different colored keys that can be removed in the specified positions.

### **Keywords**

Words with specified notation that have a defined meaning in the programming language for → part programs.

### **KV**

Servo gain factor, a control variable in a control loop.

### **Leading axis**

The leading axis is the → gantry axis that exists from the point of view of the operator and programmer and, thus, can be influenced like a standard NC axis.

### **Leadscrew error compensation**

Compensation for the mechanical inaccuracies of a leadscrew participating in the feed. The control uses stored deviation values for the compensation.

### **Limit speed**

Maximum/minimum (spindle) speed: The maximum speed of a spindle can be limited by specifying machine data, the → PLC or → setting data.

### **Linear axis**

In contrast to a rotary axis, a linear axis describes a straight line.

**Linear interpolation**

The tool travels along a straight line to the destination point while machining the workpiece.

**Load memory**

The load memory is the same as → RAM for the CPU 314 of the → PLC.

**Look Ahead**

The **Look Ahead** function is used to achieve an optimal machining speed by looking ahead over an assignable number of traversing blocks.

**Machine axes**

Physically existent axes on the machine tool.

**Machine control panel**

An operator panel on a machine tool with operating elements such as keys, rotary switches, etc., and simple indicators such as LEDs. It is used to directly influence the machine tool via the PLC.

**Machine coordinate system**

A coordinate system, which is related to the axes of the machine tool.

**Machine zero**

Fixed point of the machine tool to which all (derived) measuring systems can be traced back.

**Machining channel**

A channel structure can be used to shorten idle times by means of parallel motion sequences, e.g. moving a loading gantry simultaneously with machining. Here, a CNC channel must be regarded as a separate CNC control system with decoding, block preparation and interpolation.

**Macro techniques**

Grouping of a set of statements under a single identifier. The identifier represents the set of consolidated statements in the program.

### **Main block**

A block prefixed by ":" introductory block, containing all the parameters required to start execution of a → part program.

### **Main program**

The → part program designated by a number or an identifier in which additional main programs, subroutines, or → cycles can be called.

### **MDA**

Control operating mode: Manual Data Automatic. In the MDA mode, individual program blocks or block sequences with no reference to a main program or subroutine can be input and executed immediately afterwards through actuation of the NC start key.

### **Messages**

All messages programmed in the part program and → alarms detected by the system are displayed on the operator panel in plain text with date and time and the corresponding symbol for the cancel criterion. Alarms and messages are displayed separately.

### **Metric measuring system**

Standardized system of units: For length, e.g. mm (millimeters), m (meters).

### **Mirroring**

Mirroring reverses the signs of the coordinate values of a contour, with respect to an axis. It is possible to mirror with respect to more than one axis at a time.

### **Mode group**

Axes and spindles that are technologically related can be combined into one mode group. Axes/spindles of a BAG can be controlled by one or more → channels. The same → mode type is always assigned to the channels of the mode group.

### **Mode of operation**

An operating concept on a SINUMERIK control. The following modes are defined: → Jog, → MDA, → Automatic.

**NC**

Numerical Control: Numerical control (NC) includes all components of machine tool control: → NCK, → PLC, HMI, → COM.

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**Note**

A more correct term for SINUMERIK 840D controls would be: Computerized Numerical Control.

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**NCK**

Numerical Control Kernel: Component of NC that executes the → part programs and basically coordinates the motion operations for the machine tool.

**NRK**

Numeric robotic kernel (operating system of → NCK)

**NURBS**

The motion control and path interpolation that occurs within the control is performed based on NURBS (**N**on **U**niform **R**ational **B**-**S**plines). As a result, a uniform process is available within the control for all interpolations for SINUMERIK 840D.

**OEM**

The scope for implementing individual solutions (OEM applications) for the SINUMERIK 840D has been provided for machine manufacturers, who wish to create their own operator interface or integrate process-oriented functions in the control.

**Operator Interface**

The user interface (UI) is the display medium for a CNC in the form of a screen. It features horizontal and vertical softkeys.

**Oriented spindle stop**

Stops the workpiece spindle in a specified angular position, e.g. in order to perform additional machining at a particular location.

**Oriented tool retraction**

**RETT**TOOL: If machining is interrupted (e.g. when a tool breaks), a program command can be used to retract the tool in a user-specified orientation by a defined distance.

### Overall reset

In the event of an overall reset, the following memories of the → CPU are deleted:

- → Work memory
- Read/write area of → load memory
- → System memory
- → Backup memory

### Override

Manual or programmable control feature, which enables the user to override programmed feedrates or speeds in order to adapt them to a specific workpiece or material.

### Part program block

Part of a → part program that is demarcated by a line feed. There are two types: → main blocks and → subblocks.

### Part program management

Part program management can be organized by → workpieces. The size of the user memory determines the number of programs and the amount of data that can be managed. Each file (programs and data) can be given a name consisting of a maximum of 24 alphanumeric characters.

### Path axis

Path axes include all machining axes of the → channel that are controlled by the → interpolator in such a way that they start, accelerate, stop, and reach their end point simultaneously.

### Path feedrate

Path feed affects → path axes. It represents the geometric sum of the feed rates of the → geometry axes involved.

### Path velocity

The maximum programmable path velocity depends on the input resolution. For example, with a resolution of 0.1 mm the maximum programmable path velocity is 1000 m/min.

### PCIN data transfer program

PCIN is an auxiliary program for sending and receiving CNC user data (e.g. part programs, tool offsets, etc.) via a serial interface. The PCIN program can run in MS-DOS on standard industrial PCs.

## Peripheral module

I/O modules represent the link between the CPU and the process.

I/O modules are:

- → Digital input/output modules
- → Analog input/output modules
- → Simulator modules

## PLC

**Programmable Logic Control:** → Programmable logic controller. Component of → NC: Programmable controller for processing the control logic of the machine tool.

## PLC program memory

SINUMERIK 840D: The PLC user program, the user data and the basic PLC program are stored together in the PLC user memory.

## PLC Programming

The PLC is programmed using the **STEP 7** software. The STEP 7 programming software is based on the **WINDOWS** standard operating system and contains the STEP 5 programming functions with innovative enhancements.

## Polar coordinates

A coordinate system, which defines the position of a point on a plane in terms of its distance from the origin and the angle formed by the radius vector with a defined axis.

## Polynomial interpolation

Polynomial interpolation enables a wide variety of curve characteristics to be generated, such as **straight line, parabolic, exponential functions** (SINUMERIK 840D).

## Positioning axis

Axis that performs an auxiliary movement on a machine tool (e.g. tool magazine, pallet transport). Positioning axes are axes that do not interpolate with → path axes.

## Pre-coincidence

Block change occurs already when the path distance approaches an amount equal to a specifiable delta of the end position.

### **Program block**

Program blocks contain the main program and subroutines of → part programs.

### **Programmable frames**

Programmable → frames enable dynamic definition of new coordinate system output points while the part program is being executed. A distinction is made between absolute definition using a new frame and additive definition with reference to an existing starting point.

### **Programmable Logic Control**

Programmable logic controllers (PLC) are electronic controls, the function of which is stored as a program in the control unit. This means that the layout and wiring of the device do not depend on the function of the control. The programmable logic controller has the same structure as a computer; it consists of a CPU (central module) with memory, input/output modules and an internal bus system. The peripherals and the programming language are matched to the requirements of the control technology.

### **Programmable working area limitation**

Limitation of the motion space of the tool to a space defined by programmed limitations.

### **Programming key**

Character and character strings that have a defined meaning in the programming language for → part programs.

### **Protection zone**

Three-dimensional zone within the → working area into which the tool tip must not pass.

### **Quadrant error compensation**

Contour errors at quadrant transitions, which arise as a result of changing friction conditions on the guideways, can be virtually entirely eliminated with the quadrant error compensation. Parameterization of the quadrant error compensation is performed by means of a circuit test.

### **R parameters**

Arithmetic parameter that can be set or queried by the programmer of the → part program for any purpose in the program.

**Rapid traverse**

The highest traverse rate of an axis. For example, rapid traverse is used when the tool approaches the → workpiece contour from a resting position or when the tool is retracted from the workpiece contour. The rapid traverse velocity is set on a machine-specific basis using a machine data element.

**Reference point**

Machine tool position that the measuring system of the → machine axes references.

**Rotary axis**

Rotary axes apply a workpiece or tool rotation to a defined angular position.

**Rotation**

Component of a → frame that defines a rotation of the coordinate system around a particular angle.

**Rounding axis**

Rounding axes rotate a workpiece or tool to an angular position corresponding to an indexing grid. When a grid index is reached, the rounding axis is "in position".

**Safety Functions**

The control is equipped with permanently active monitoring functions that detect faults in the → CNC, the → PLC, and the machine in a timely manner so that damage to the workpiece, tool, or machine is largely prevented. In the event of a fault, the machining operation is interrupted and the drives stopped. The cause of the malfunction is logged and output as an alarm. At the same time, the PLC is notified that a CNC alarm has been triggered.

**Scaling**

Component of a → frame that implements axis-specific scale modifications.

**Selecting**

Series of statements to the NC that act in concert to produce a particular → workpiece. Likewise, this term applies to execution of a particular machining operation on a given → raw part.

### Serial RS-232-C interface

For data input/output, the PCU 20 has one serial V.24 interface (RS232) while the PCU 50/70 has two V.24 interfaces. Machining programs and manufacturer and user data can be loaded and saved via these interfaces.

### Setting data

Data, which communicates the properties of the machine tool to the NC, as defined by the system software.

### Softkey

A key, whose name appears on an area of the screen. The choice of soft keys displayed is dynamically adapted to the operating situation. The freely assignable function keys (soft keys) are assigned defined functions in the software.

### Software limit switch

Software limit switches limit the traversing range of an axis and prevent an abrupt stop of the slide at the hardware limit switch. Two value pairs can be specified for each axis and activated separately by means of the → PLC.

### Spline interpolation

With spline interpolation, the controller can generate a smooth curve characteristic from only a few specified interpolation points of a set contour.

### SRT

Transformation ratio

### Standard cycles

Standard cycles are provided for machining operations, which are frequently repeated:

- Cycles for drilling/milling applications
- for turning technology

The available cycles are listed in the "Cycle support" menu in the "Program" operating area. Once the desired machining cycle has been selected, the parameters required for assigning values are displayed in plain text.

### Subblock

Block preceded by "N" containing information for a sequence, e.g. positional data.

## Subroutine

Sequence of statements of a → part program that can be called repeatedly with different defining parameters. The subroutine is called from a main program. Every subroutine can be protected against unauthorized read-out and display. → Cycles are a form of subroutines.

## Supply System

A network is the connection of multiple S7-300 and other end devices, e.g. a programming device via a → connecting cable. A data exchange takes place over the network between the connected devices.

## Synchronization

Statements in → part programs for coordination of sequences in different → channels at certain machining points.

## Synchronized Actions

### 1. Auxiliary function output

During workpiece machining, technological functions (→ auxiliary functions) can be output from the CNC program to the PLC. For example, these auxiliary functions are used to control additional equipment for the machine tool, such as quills, grabbers, clamping chucks, etc.

### 2. Fast auxiliary function output

For time-critical switching functions, the acknowledgement times for the → auxiliary functions can be minimized and unnecessary hold points in the machining process can be avoided.

## Synchronized axes

Synchronized axes take the same time to traverse their path as the geometry axes take for their path.

## Synchronized axis

A synchronized axis is the → gantry axis whose set position is continuously derived from the motion of the → leading axis and is, thus, moved synchronously with the leading axis. From the point of view of the programmer and operator, the synchronized axis "does not exist".

## Syntax

```
$SC_IS_SD_MAX_PATH_JERK = value
```

### System memory

The system memory is a memory in the CPU in which the following data is stored:

- Data required by the operating system
- The operands times, counters, markers

### System variables

A variable that exists without any input from the programmer of a → part program. It is defined by a data type and the variable name preceded by the character \$. See → User-defined variable.

### Tapping without compensating chuck

This function allows threads to be tapped without a compensating chuck. By using the interpolating method of the spindle as a rotary axis and the drilling axis, threads can be cut to a precise final drilling depth, e.g. for blind hole threads (requirement: spindles in axis operation).

### Text editor

See → Editor

### TOA area

The TOA area includes all tool and magazine data. By default, this area coincides with the → channel area with regard to the reach of the data. However, machine data can be used to specify that multiple channels share one → TOA unit so that common tool management data is then available to these channels.

### TOA unit

Each → TOA area can have more than one TOA unit. The number of possible TOA units is limited by the maximum number of active → channels. A TOA unit includes exactly one tool data block and one magazine data block. In addition, a TOA unit can also contain a toolholder data block (optional).

### Tool

Active part on the machine tool that implements machining (e.g. turning tool, milling tool, drill, LASER beam, etc.).

**Tool nose radius compensation**

Contour programming assumes that the tool is pointed. Because this is not actually the case in practice, the curvature radius of the tool used must be communicated to the control which then takes it into account. The curvature center is maintained equidistantly around the contour, offset by the curvature radius.

**Tool offset**

Consideration of the tool dimensions in calculating the path.

**Tool radius compensation**

To directly program a desired → workpiece contour, the control must traverse an equidistant path to the programmed contour taking into account the radius of the tool that is being used (G41/G42).

**Transformation**

Additive or absolute zero offset of an axis.

**Traversing range**

The maximum permissible travel range for linear axes is ± 9 decades. The absolute value depends on the selected input and position control resolution and the unit of measurement (inch or metric).

**User-defined variable**

Users can declare their own variables for any purpose in the → part program or data block (global user data). A definition contains a data type specification and the variable name. See → System variable.

**User memory**

All programs and data, such as part programs, subroutines, comments, tool offsets, and zero offsets/frames, as well as channel and program user data, can be stored in the shared CNC user memory.

**User Program**

User programs for the S7-300 automation systems are created using the programming language STEP 7. The user program has a modular layout and consists of individual blocks.

The basic block types are:

- Code blocks  
These blocks contain the STEP 7 commands.
- Data blocks  
These blocks contain constants and variables for the STEP 7 program.

### **Variable definition**

A variable definition includes the specification of a data type and a variable name. The variable names can be used to access the value of the variables.

### **Velocity control**

In order to achieve an acceptable traverse rate in the case of very slight motions per block, an anticipatory evaluation over several blocks (→ Look Ahead) can be specified.

### **WinSCP**

WinSCP is a freely available open source program for Windows for the transfer of files.

### **Working area**

Three-dimensional zone into which the tool tip can be moved on account of the physical design of the machine tool. See → Protection zone.

### **Working area limitation**

With the aid of the working area limitation, the traversing range of the axes can be further restricted in addition to the limit switches. One value pair per axis may be used to describe the protected working area.

### **Working memory**

RAM is a work memory in the → CPU that the processor accesses when processing the application program.

### **Workpiece**

Part to be made/machined by the machine tool.

### **Workpiece contour**

Set contour of the → workpiece to be created or machined.

### **Workpiece coordinate system**

The workpiece coordinate system has its starting point in the → workpiece zero-point. In machining operations programmed in the workpiece coordinate system, the dimensions and directions refer to this system.

### **Workpiece zero**

The workpiece zero is the starting point for the → workpiece coordinate system. It is defined in terms of distances to the → machine zero.

## Zero offset

Specifies a new reference point for a coordinate system through reference to an existing zero point and a  $\rightarrow$  frame.

1. Settable

SINUMERIK 840D: A configurable number of settable zero offsets are available for each CNC axis. The offsets - which are selected by means of G functions - take effect alternately.

2. External

In addition to all the offsets which define the position of the workpiece zero, an external zero offset can be overridden by means of the handwheel (DRF offset) or from the PLC.

3. Programmable

Zero offsets can be programmed for all path and positioning axes using the `TRANS` statement.



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