SECTION 3

MENTOR II
Applications Software

SPINDLE ORIENTATION

COVERING SOFTWARE VERSION
2.1.x

As more and more machine tools become computer controlled, the ability for them to change tools automatically becomes essential. For this operation to be carried out successfully, the spindle must be held in a fixed position.

Spindle orientation option allows the Mentor II drive to achieve this with a single command from a CNC controller. It is an option which is implemented in the form of a software package.

PRINCIPLES

Spindle orientation option gives the drive positional control over the spindle as well as velocity control. Positional feedback is achieved by attaching an encoder to the spindle. The position reference can also be provided by an encoder, or alternatively, the reference can be programmed into the drive in a read/write parameter.

On receiving an orientate command, the drive will decelerate the spindle to zero speed, and then rotate it via the shortest route to the position required. A position loop is implemented on the error signal between the position reference and the actual spindle position, the gain of which is programmable for optimum response. The output of the position loop is limited to a programmable maximum and then fed into the standard speed loop of the drive, Fig. 1. A different speed loop gain is used during orientation to further improve the response. Once the final position has been found, a second position loop gain is implemented to improve the rigidity of the system, and an orientation complete signal is given for an external controller.

A finer zero speed indication is also provided within the orientation package. The standard zero speed relay becomes active whenever the speed is less than 1.5% of maximum, while the finer indication does not become active until the speed has droped to less than 0.3% of maximum.

HARDWARE CONNECTIONS

The encoder fitted to the spindle must be an incremental type with a marker pulse and quadrature outputs. Encoders with complementary outputs are recommended, especially if the motor is a distance from the drive.

The electronics senses the direction of rotation of the encoders by the relative phase of the A and B channels. For a forward direction the A channel must lead the B channel, and for reverse direction the B channel must lead the A channel. The required forward direction of the motor and the way in which the encoder is driven by the motor, may require that the A and B channels are swapped for correct direction sensing.

For encoders which have unbalanced (single wire) connections, the complimentary inputs are biased to 1.25V by 3.3K resistors mounted on solder posts on the cards. If the encoders used have signals greater than 8V, better noise immunity can be achieved by removing the resistors, which shifts the threshold level to 5V. Each encoder input can handle input signals up to a maximum of ±15V relative to the ground potential of the control circuit. No modifications are required if the encoder has complementary outputs.

IMPLEMENTATION

The control software resides in the system Eprom of the MD21. For detailed information on enabling the programme refer to section 1.3 of leaflet 'Mentor II Supplementary Information'. When the software is first enabled a processor 2 reset must be carried out before the programme will run.

Eight parameters have to be set up to produce the correct position error, and a further 5 parameters are used to control the orientation sequence. Below is a table of these parameters with suggested starting values, followed by a brief description of them.

#15.06	=	100	Orientate angle
#15.07	=	20	Position error limit
#15.11	=	128	Scale for 1024 line encoder
#15.12	=	128	Scale for 1024 line encoder
#15.13	=	20	Angular position scale MSB
#15.14	=	97	Angular position scale LSB
#15.15	=	15	Position loop gain
#15.16	=	170	Delay before orientation complete
#15.18	=	255	Speed loop proportional gain in orientation
#15.19	=	25	Position loop gain once orientation found
#15.21	=	1	Orientation enable
#15.22	=	0	Orientation angle select
#15.23	=	0	Multiplier 1 pre-scaler
#15.24	=	1	Position error display
# 7.11	=	0	GP1 destination (must not equal default of 318)

The value in *#15.06* now has a range of 0 - 1000 representing 1 revolution. For *#15.06* to represent degrees rotation (0-360), put 58 in *#15.13* and 25 in *#15.14*).

This setup assumes the use of a 1024 line encoder.

Position error limit *#15.17*

The value set in *#15.17* limits the orientation correction signal so that high position loop gains can be used without the risk of instability. Parameter *#15.07* is also used as a speed reference during first time orientation, more information regarding this can be found in the section 'Orientation sequence'.

Orientate angle ***#15.06***

If *#15.22* is 0 then *#15.06* is the angular position of orientation from the marker pulse. This can be scaled to indicate degrees or any other unit that is convenient. With *#15.13* & *#15.14* set to 2097 as above, 1 unit in *#15.06* represents 1/1000 of a revolution of the spindle.

Orientation angle select ***#15.22***

This selects either an encoder or a parameter to select the orientation position. With *#15.22* = 0, parameter *#15.06* will be used as the orientation angle, if *#15.22* = 1 then the master encoder will become the orientation reference.

Orientate command ***#15.25***

Parameter *#15.25* is the orientate command bit. When it is set to 1 the software starts the orientation process. One of the programmable logic inputs can be used to control this bit from an external source.

Encoder scale factor ***#15.11 & #15.12***

These parameters should always be equal and should be set to fixed values depending on the type of encoder used. The following equation should be used to calculate the scale value required:-

$$\text{SCALE} = \frac{131072}{\text{No. of Encoder Lines}}$$

Position loop gain ***#15.15***

This parameter defines the gain applied to the position error to derive the position correction. It should be set so that the orientation position is found as quickly as possible without instability.

Speed loop proportional gain during orientation ***#15.18***

To give good damping during orientation, a different speed loop gain is used. This gain is selected when the motor reaches zero speed.

Position loop gain once orientation found *#15.19*

Once the orientation position has been found the system can stand a higher position loop gain so that it is much stiffer. This gain is selected when the orientation complete indication is set.

Angular position scale *#15.13* & *#15.14*

The orientation position reference in *#15.06* can be scaled to a convenient unit of angular measurement. The following equation should be used to find the scale value required for a particular application.

$$\text{SCALE} = \frac{2097152}{\text{units / revolution}}$$

Example 1:-

For 1 revolution to be split into 1000 parts.

$$\text{SCALE} = \frac{2097152}{1000} = 2097$$

(20 in *#15.13* & 97 in *#15.14*)

Example 2:-

For 1 revolution to be split into 360 degrees.

$$\text{SCALE} = \frac{2097152}{360} = 5825$$

(58 in *#15.13* & 25 in *#15.14*)

Delay before orientation complete *#15.16*

The value set in here determines the time within which the shaft must remain within 1/256 of a revolution of the angular position required, before the orientation complete signal is given. Each unit of this parameter represents 2.5mS, giving a maximum delay of 637mS.

Orientation complete *#15.26*

This bit indicates that the orientation process is complete. It is set when the shaft has been within 1/256 of a revolution of the angle required for a period set by *#15.16.*

Zero speed bit *#15.27*

This is the finer zero speed indication provided in the package. The bit is set whenever the spindle speed is less than 0.3% of maximum.

ORIENTATION SEQUENCE

The orientation package relies upon the marker pulse reseting the counter to measure absolute position. If orientation is commanded before the spindle has been turned, the position indicated by the counter is invalid because it will not have been reset by the marker pulse. For this reason the orientation sequence is different on the first command for orientation from all subsequent commands for orientation.

The first time orientation sequence is as follows:-

(a) Bit parameter *#1.14*is set to 1 and internal reference *#1.18* is made equal to *#15.07* (position error limit). This causes the spindle to rotate at a slow speed.

(b) The counter is monitored until a reset occurs, indicating the presence of the marker pulse.

(c) Parameter *#1.18* is made equal to 0 causing the spindle to stop.

(d) When zero speed is detected, parameter *#3.09* is made equal to *#15.18*, parameter *#5.18* is reset to 0, and parameter *#3.19* is set to 1.

These changes set up the position loop for orientation.

(e) When the spindle has been within 1/256 of a revolution of its final positon for a time period set in *#15.16*, the orientation complete signal is given. Also, parameter *#15.15* is made equal to *#15.19*, giving a rigid system during a tool change.

If the position error is ever found to be greater than 1/256 of a revolution, the orientation complete is reset and will not be set again until the error is less than 1/256 for the period set in *#15.16*.

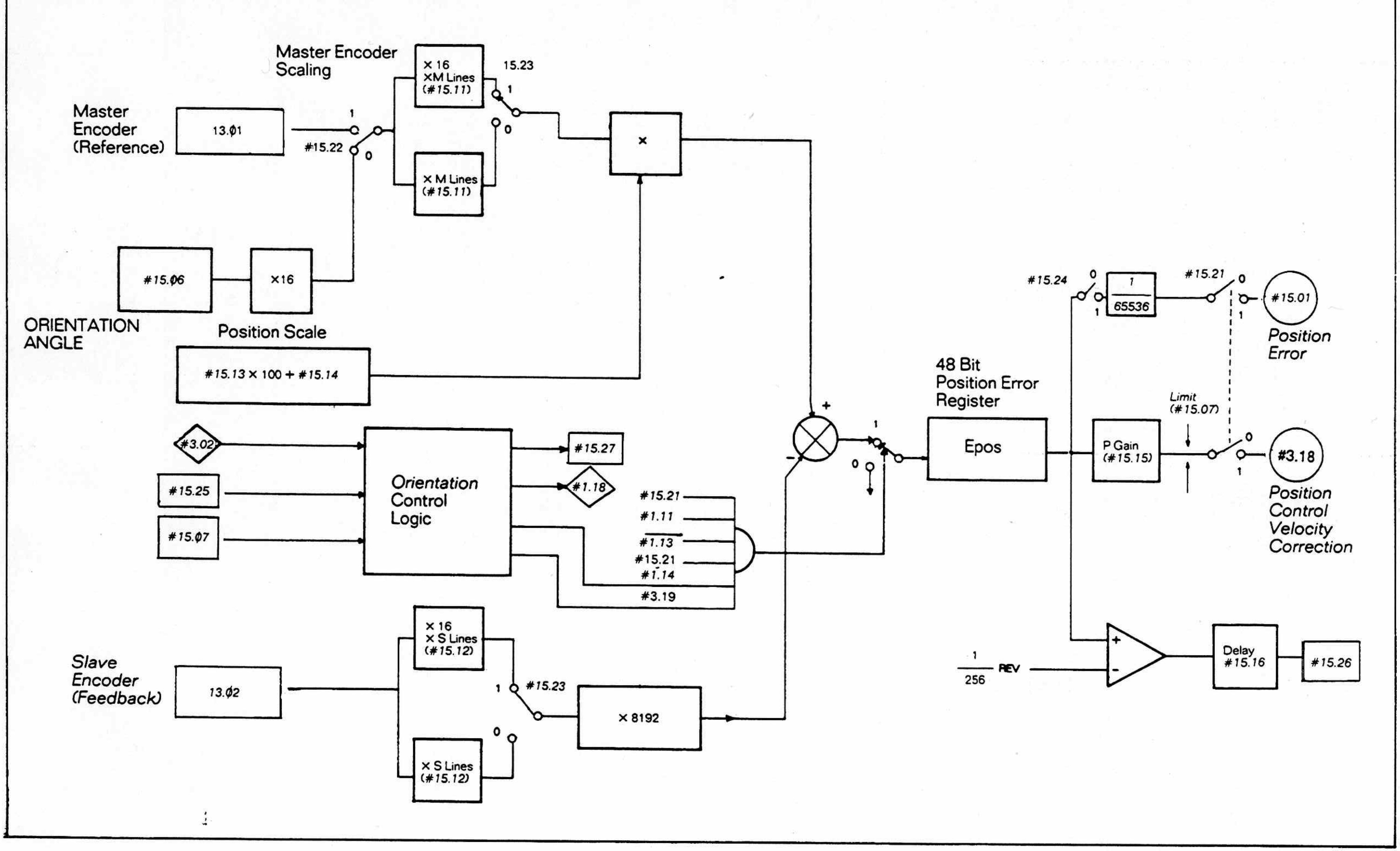
Any subsequent commands for orientation will instigate the above sequence from (c) onwards.

If the orientation command is cleared anywhere in the above sequence, parameters *#1.14* and *#3.19* are reset to 0, and parameters *#5.18*, *#3.09*, and *#15.15* are set back to their original values.

During the orientation sequence, parameter *#15.17* contains a value indicating which part the orientation process is in. The sequence is as follows:-

0 = No orientation command present.
1 = Approaching zero speed from a running condition (a, b and c).
2 = Position loop closed and seeking final position (d).
3 = Position loop closed and orientation complete (e).

Fig. 1 Spindle Orientation Block Diagram



Parameter Table

Name	*No.*	*Range*	*Scale*
Internal ref.	#01.18	-1000 to 1000	
Speed feedback	#03.02	-1000 to 1000	
Position Correction	#03.19	-1000 to 1000	
Master encoder count	#13.01	0 to 1023	
Slave encoder count	#13.02	0 to 1023	
Position error	#15.01	-1000 to 1000	
Orientation angle	#15.06	-1999 to 1999	
Limit	#15.07	-1000 to 1000	
Scale factor master	#15.11	0 to 255	
Scale factor slave	#15.12	0 to 255	
Angular position scale MSB	#15.13	0 to 255	
Angular position scale LSB	#15.14	0 to 255	
Position loop gain	#15.15	0 to 255	
Delay before orientation complete	#15.16	0 to 255	
Orientation phase	#15.17	0 to 255	
Speed loop gain during orientation	#15.18	0 to 255	
Position loop gain once orientation found	#15.19	0 to 255	
Ref. on	#01.11	1=Run	0=Stop
Inch	#01.13	1=Inch	0=Not inch
Internal ref. select	#01.14	1=#1.18	0=#1.17
Hard ref.	#03.19	1=Included	0=Excluded
Ramped ref.	#03.21	1=Included	0=Excluded
Orientation enable	#15.21	1=Enable	0=Disable
Orientation angle select	#15.22	1=Ref.	0=Angle
Mult. factor	#15.23	1=*16	0=*1
Position error display	#15.24	1=#15.01 Set	0=#15.01 Not Set
Orientate command	#15.25	1=Orientate	0=Normal
Orientation complete	#15.26	1=Complete	0=Not complete
Fine zero speed bit	#15.27	1=Zero speed	0=>0.3% speed