MITCHELL ELECTRONICS

PO Box 2626 Athens, OH 45701
Voice: 740-594-8532
Fax: 740-594-8533
Email: sales@mitchell-electronics.com
Web: www.mitchell-electronics.com

PM Brushless Servo Motor Feedback Commutation Series – Part 2
Commutation Alignment – How It Is Accomplished

INTRODUCTION

The main difference in servicing permanent magnet brushless motors versus other kinds of motors comes down to correctly aligning the position of the feedback devices relative to the rotor magnet and stator windings. This is necessary so that the drive system is able to correctly commutate the excitation currents to the armature winding. A previous note, "P M Brushless Servo Motor Feedback Commutation Alignment – Why It Is Important" explained what commutation is and why this alignment is necessary for correct commutation. This note picks up from that point and describes how technicians and electricians can check and, if necessary, correctly set the feedback device on the servo motor for proper commutation alignment. The TI-5000EX Encoder Tester from Mitchell Electronics, Inc. is especially designed to support personnel in feedback testing and alignment, so it is used in the examples in this document.

REQUIREMENTS FOR ALIGNMENT

In order to correctly set or check the feedback alignment on a permanent magnet (PM) brushless motor, you must verify each of the following with respect to what the drive system is expecting to see:

1. Correct feedback position for a given position of the rotor magnets relative to the stator windings.

2. Correct forward armature rotation.

3. Correct forward feedback rotation.

Theoretically, only the first item truly has to do with alignment. However, since much motor repair and some in-plant maintenance activities can result in armature leads and feedback leads becoming removed from their connectors, it is important to verify items 2 and 3 as well. If any of these 3 items are incorrect, the drive system will be unable to provide the correct amount of current to the correct armature phase winding in the correct magnet position, and this will result in poor torque, high currents, running in the wrong direction, or not running at all.

The big question is "*What is the correct position of the feedback?*", and the answer is *the position that the drive system wants to see*. How do you know what the drive wants? In some cases the motor or drive manufacturer will provide information. For many motors, that information is available from test equipment manufacturers or companies that provide servo motor repair training. Sometimes the best way to get that information is to test a brand new motor (or motor known to still have the factory alignment). Testing several new or known good motors and comparing results will give you even more confidence. In applying good repair procedures, you will be checking commutation on every motor you encounter and keeping documentation on them. This will build your confidence that you understand the correct factory alignment for a given type of motor.

DETERMINING MAGNET POSITION

Trying to decide how the magnets are aligned with respect to the armature windings at first sounds like a difficult task. However, the laws of physics cut us a big break and provide some accurate and easy to apply techniques. Physics in fact gives us two distinctly different ways to determine magnet position which leads us to two different methods of alignment: static and dynamic. We will briefly discuss the two methods and the pros and cons of each method.

Many readers will realize that if you turn a PM brushless motor mechanically, a voltage will be generated at the armature leads. If you turn the motor at a constant speed, a relatively sinusoidal voltage wave will be generated. You can connect an oscilloscope to the armature leads and see this wave as shown in Figure 1.

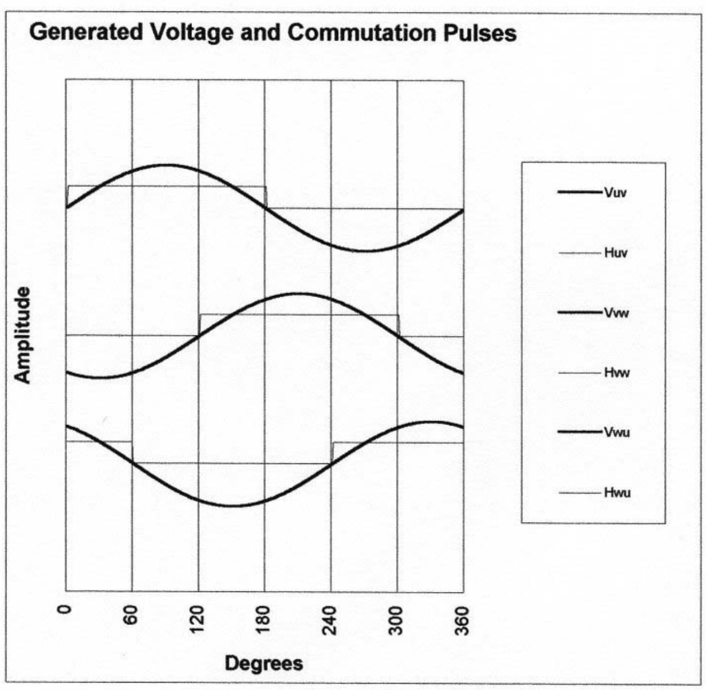

Figure 1 Line-to-Line Generated Voltage and Commutation Pulses

PO Box 2626 Athens, OH 45701
Voice: 740-594-8532
Fax: 740-594-8533
Email: sales@mitchell-electronics.com
Web: www.mitchell-electronics.com

The U-V wave is the Line-to-Line voltage of phase U relative to phase V (scope probe on U and ground clip on phase V – a three channel isolated scope would be required for this display). The voltage peak on a particular phase will represent the position in which the magnets are lined up to link the maximum magnetic flux with that winding. Likewise, the voltage zero crossing will represent the rotor position at which the least amount of flux is linking that winding. This waveform is actually showing you the alignment of the rotor magnets with the winding at a particular instant in time. The square waves: Huv, Hvw, and Hwu, represent Hall effect or encoder commutation pulses. With this display, you can see the time relationship between the feedback signal and the generated voltage. If you move the feedback device, you will see a change in this time relationship. If you know the correct time relationship between the generated voltage and the feedback signal, you can adjust the position of the feedback until the scope shows that correct relationship. The time relationship depicted in Figure 1 is typically correct.

This technique is called dynamic alignment since the motor must be moving and you are looking at dynamic signals from a motor in motion. While dynamic alignment can be useful, the physics of the motors give us yet another method. It turns out that the motor torque wave corresponds to the generated voltage wave. We can generate torque by driving the armature windings with a current. On the bench, this can be accomplished by connecting a small voltage (from a bench power supply or even a 9 volt battery) to the armature leads. For instance, connecting a (+)voltage to phase U and a (–) voltage to phase V, the resulting armature current will produce a torque on the motor shaft to rotate it to a specific position, and this will be a zero torque position. It turns out that the torque will be zero at the same positions where the generated voltage is zero. The position at which the generated voltage was at a positive peak will be the position at which the maximum torque will be generated to move the shaft in the forward direction. Likewise, the position at which the generated voltage was at a negative peak will be the position at which the maximum torque will be generated to move the shaft in the reverse direction. This means that applying the +U –V lockup voltage to the motor will force it to the position of zero torque position. In Figure 1, this would be the center of the Vuv wave where the wave is passing through zero going negative – the 180 degree position.

If we apply this lockup voltage and then read the feedback with a device such as the TI-5000EX, we can determine the position reading of the feedback relative to one of the zero torque positions for the U-V Line-to-Line current. This is an example of a *static alignment* procedure since the motor is not moving. If you find that the feedback reading is incorrect, you can adjust the position of the feedback device relative to the motor shaft and *set* the alignment correctly while it is in this lockup position.

PO Box 2626 Athens, OH 45701
Voice: 740-594-8532
Fax: 740-594-8533
Email: sales@mitchell-electronics.com
Web: www.mitchell-electronics.com

We now have available two methods for alignment: static and dynamic. Which should we choose? In many cases, you could choose either method, but in some cases finding a feedback signal to display on the scope for the dynamic method is not possible. Considering various factors, we feel static alignment is generally the best selection for the following reasons:

1. For many feedback devices including serial encoders, dynamic alignment is difficult or impossible, but static alignment is always possible as long as the feedback tester supports the particular feedback device.

2. Dynamic alignment requires a mechanism for turning the motor shaft at a fair rate of speed, while the static alignment requires only an adjustable bench power supply for providing a lockup voltage.

3. Feedback adjustments can be made while the motor is stationary for static alignment while dynamic alignment requires adjustments to be made while the motor is turning or requires starting and stopping the motor during adjustment.

STATIC ROTOR LOCKUPS

Static alignment requires two main steps: locking the rotor to a known position, and ensuring that the feedback reads correctly at that position. There are 12 different ways to lock up a 3 phase motor by applying lockup voltages to two or three winding leads at a time. There is nothing magical about any of these lockup combinations. Often a particular lockup position will correspond well with the information you have about the feedback reading, so it will be the preferred position to use. In other situations, it may make absolutely no difference which lockup position you select. This will become clearer in the examples later in this document.

If you apply voltage to all three leads, we refer to that as a Line-to-Neutral lockup. If you apply voltage to only two armature leads, we refer to that as a Line-to-Line lockup. Figure 2 shows the 3 phase Line-to-Neutral and 3 phase Line-to-Line generated torque waves and the position on the waves where the rotor will lock up for each of the 12 different lockup voltage combinations. Figure 2 shows one commutation cycle, but remember that in one full rotation there will be as many commutation cycles as there are pole pairs. For instance, for a 6 pole motor, the patterns in Figure 2 would repeat 3 times in one full rotor revolution. For reference we have made the zero angle correspond to the zero crossing (going positive) of the U-N wave. As you would expect, V-N occurs 120 degrees later, and the W-N wave is 120 degrees after V-N. Also notice that the U-V Line-to-Line voltage or torque, occurs 30 degrees before the U-N Line-to-Neutral wave. It is very important to remember that the L-L waves are 30 degrees ahead of the corresponding L-N waves. This means the L-L and L-N lockups will put you at different locations. Notice the +U-V L-L lockup on the bottom occurs at 150 degrees. The +U-V-W (sometimes abbreviated +U-N) L-N lockup occurs at 180 degrees. The 12 lockups will allow you to position the rotor every 30 electrical degrees.

PO Box 2626 Athens, OH 45701
Voice: 740-594-8532
Fax: 740-594-8533
Email: sales@mitchell-electronics.com
Web: www.mitchell-electronics.com

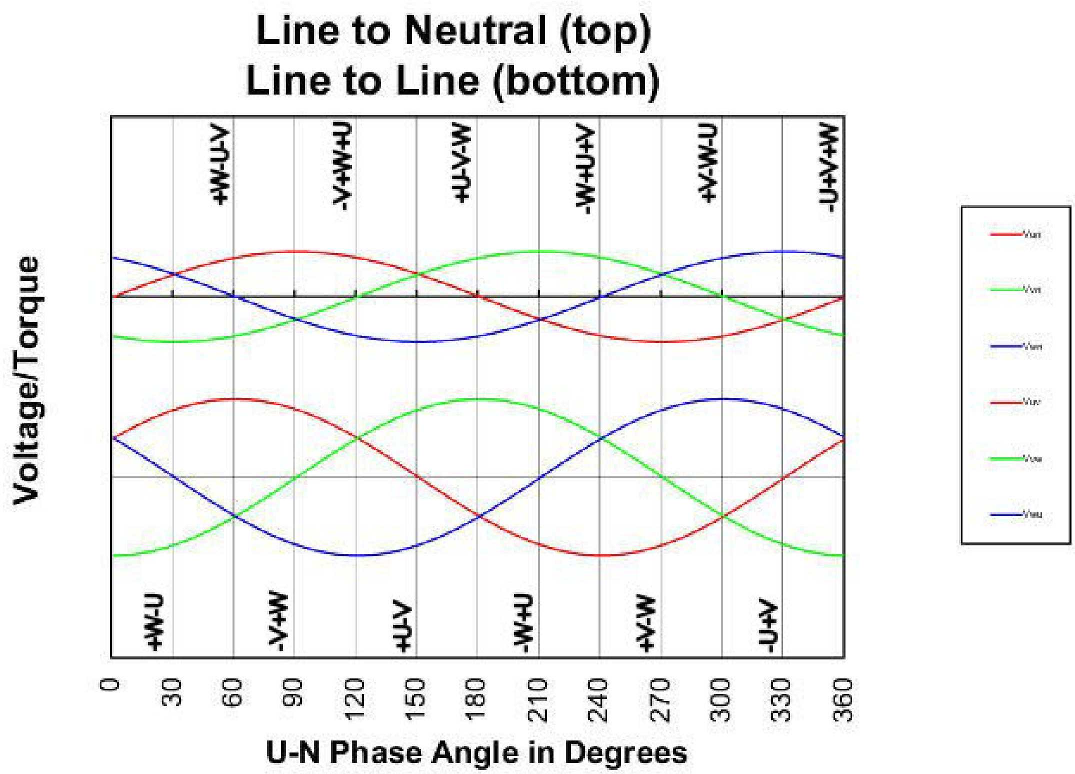

Figure 2 Line-to-Line & Line-to-Neutral Lockups

DETERMINING FEEDBACK POSITION

The TI-5000EX Data Display is normally used to display the feedback position for commutation alignment purposes. The position may be displayed in different ways depending upon the particular device. Hall effect devices and encoder commutation lines will be shown as HI and LO logic states, resolver position will be shown as a resolver angle, and encoder position will usually be shown as a mechanical and electrical angle. The mechanical angle is the rotor position within one revolution, and the electrical angle is the rotor position within one commutation cycle.

For example, moving through 360 mechanical degrees (1 full revolution) for a 2 pole motor would result in one period of the voltage or torque wave, so this would also be 360 electrical degrees. However, for multi pole pair motors, the voltage or torque wave will go through a full period once for each pole pair. For instance, an 8 pole motor will produce 4 wave periods in one revolution since it has 4 pole pairs. This is shown in Figure 3. While the mechanical angle goes through 90 degrees, the electrical angle will go through 360 degrees. We can check alignment using the same position for any of the 4 periods. Referring to Figure 3, a –U+V+W lockup would position the rotor at 0 electrical degrees, but it could be at 0, 90, 180, or 270 mechanical degrees. The TI-

PO Box 2626 Athens, OH 45701
Voice: 740-594-8532
Fax: 740-594-8533
Email: sales@mitchell-electronics.com
Web: www.mitchell-electronics.com

5000EX Data Display allows the operator to set the number of poles for the motor so that the electrical angle is calculated and displayed correctly.

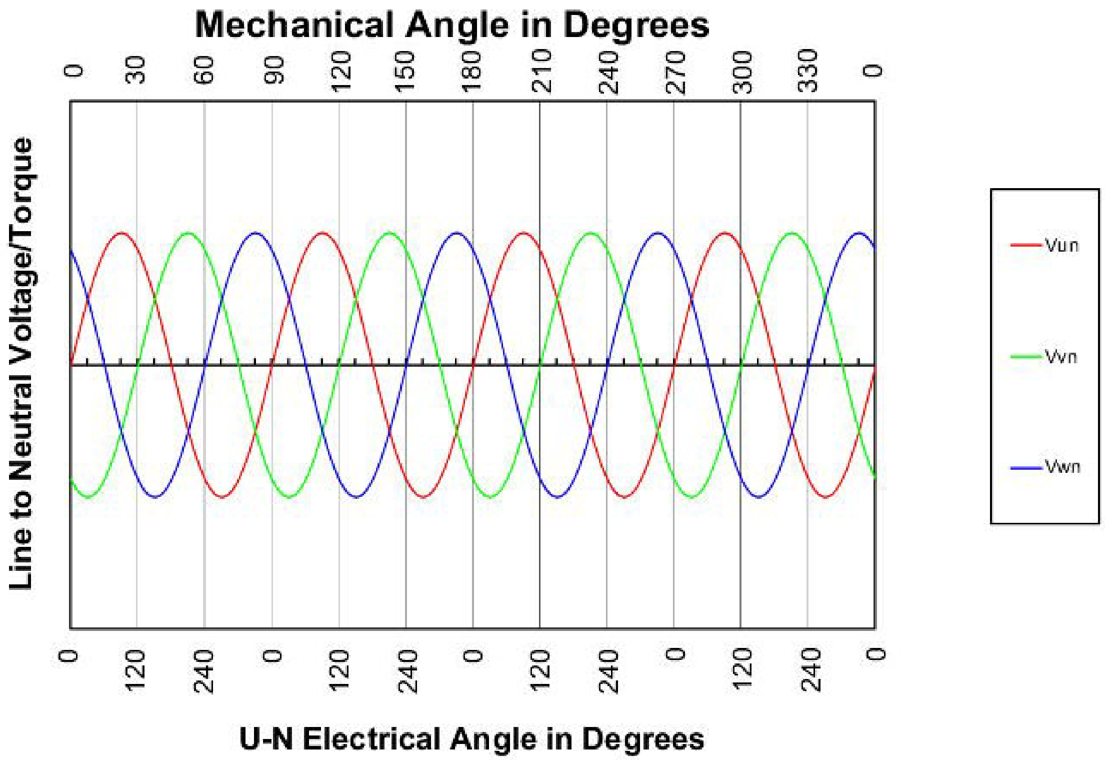

Figure 3 Line-to-Line & Line-to-Neutral Lockups

STATIC ALIGNMENT SETTING PROCESS

Setting and checking the alignment with the TI-5000EX using a static lockup is a very straight forward process. It does vary somewhat depending on the exact type of feedback employed. To familiarize the reader with the differences in various feedback types, we will finish this note with examples of alignment for several different feedback devices.

Keep in mind that the process is the same whether you are checking or setting alignment. The only difference is that when you are setting alignment, you adjust the position of the encoder until the alignment checks properly.

Another important thing to keep in mind is the feedback and armature frames of reference. The armature waves in the preceding figures show electrical and mechanical angles that are referenced to the zero crossing (going positive) position of the U to neutral wave as zero degrees. In the following TI-5000EX Data Display screens, there will be feedback angles shown in electrical and mechanical degrees, but they are for the feedback frame of reference. The process of alignment is to use a lockup voltage to position the rotor at a certain armature angle and adjust the encoder to get the correct corresponding feedback angle as read on the Data Display. The armature and feedback angles will commonly not be the same number.

ENCODER COMMUTATION PULSE ALIGNMENT

Yaskawa motors are typical of AC servo motors with incremental encoder feedback and U, V, and W commutation pulses. Yaskawa motors have both true and complement lines for the U, V, and W, while some may only have the true lines. Normally cables are made so that the U, V, W true lines show up on the Data Display H1, H2, and H3 data boxes. Hall effects are normally connected in that manner as well, and the alignment procedure is basically the same. The major difference is that motors using Hall effects normally use a Line-to-Line alignment while most AC servo motors, such as Yaskawa, will use a Line-to-Neutral alignment.

MITCHELL ELECTRONICS
PO Box 2626 Athens, OH 45701
Voice: 740-594-8532
Fax: 740-594-8533
Email: sales@mitchell-electronics.com
Web: www.mitchell-electronics.com

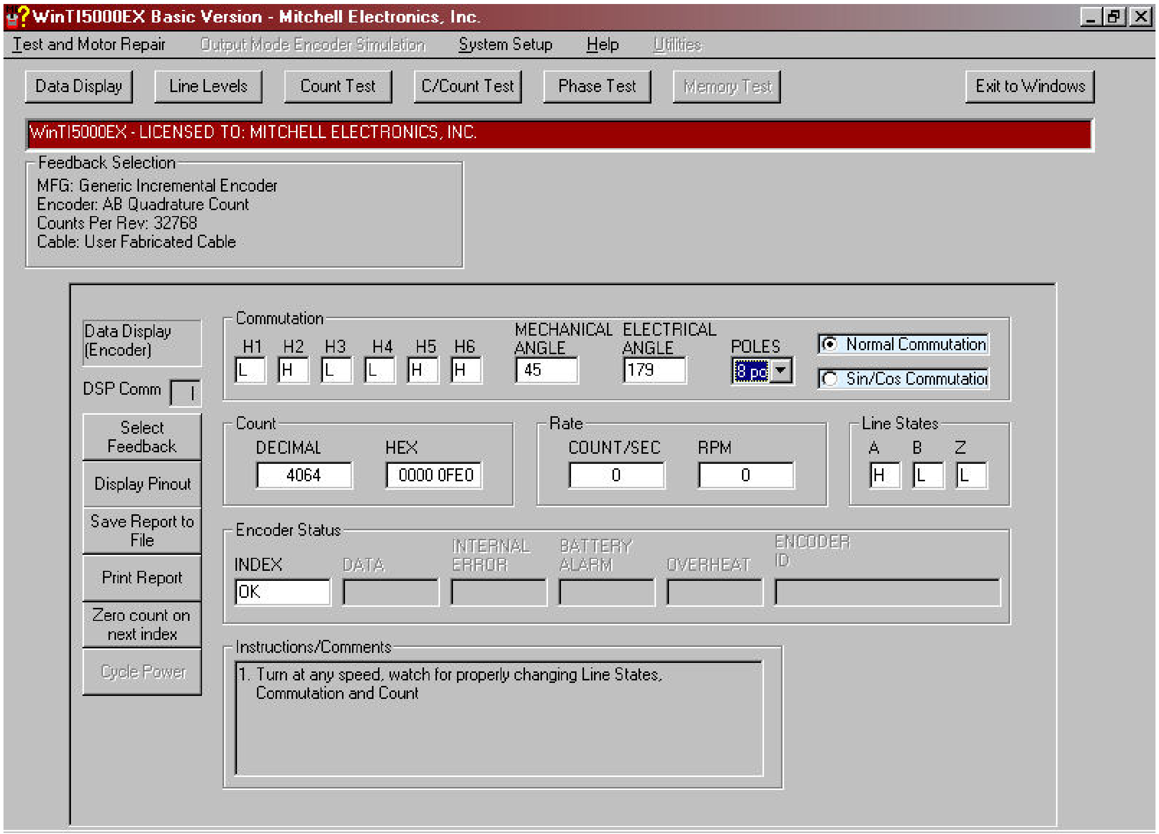

Figure 4 Yaskawa Line-to-Neutral Commutation States Just CCW of Lockup

The alignment for Yaskawa to simply use a +U –V –W lockup (can be referred to as +U –N or plus U to neutral), look for V (H2) to be HI, W (H3) to be LO, and U (H1) to be right at the toggle point. This means that if we apply the voltage to lock the rotor and manually twist the rotor slightly to either side of the lockup position, the indication for U (H1) will toggle (change between HI and LO). Figure 4 shows the display at a position slightly CCW of the lockup position.

If the shaft is forced slightly in the CW direction, we should see the U (H1) indication toggle from L to H as shown in Figure 5. V and W should maintain their states of HI and LO respectively.

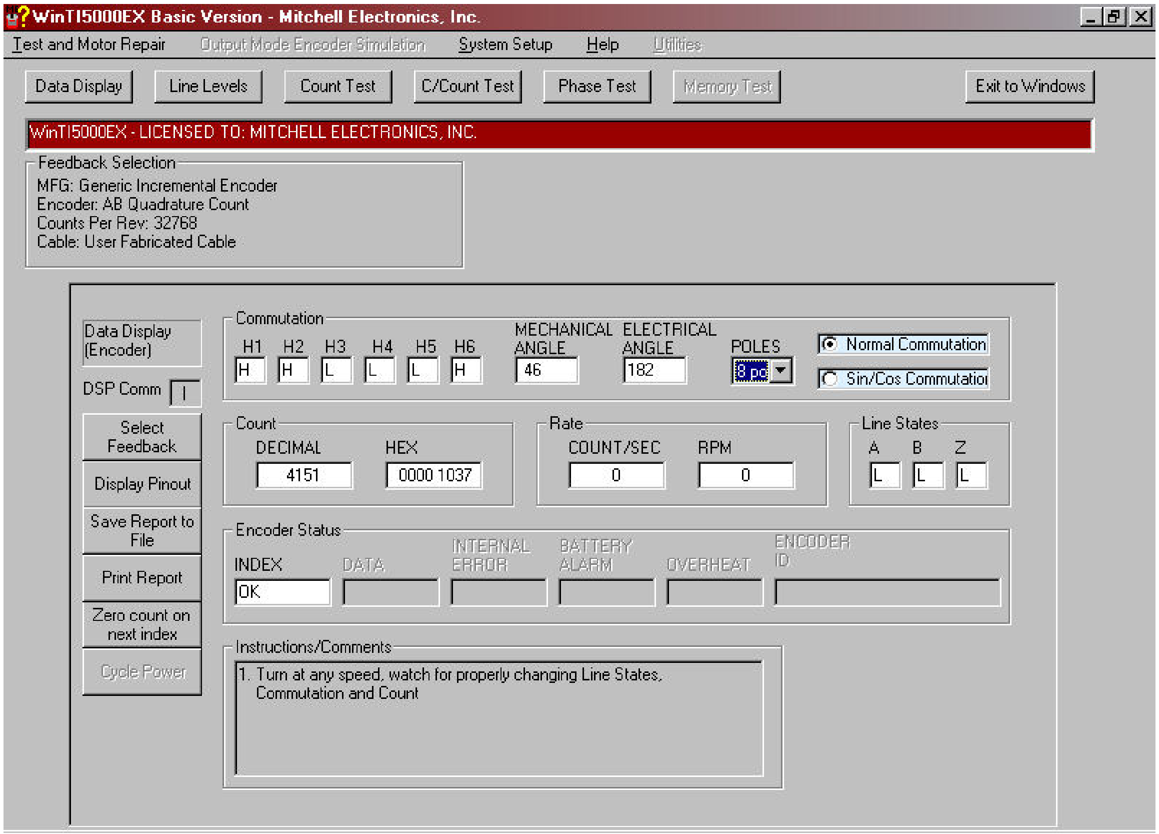

Figure 5 Yaskawa Line-to-Neutral Commutation States Just CW of Lockup

You can see that the electrical angle is very close to 180 degrees at the lockup position. For this particular type of Yaskawa encoder, aligning to that angle would be an alternate method of alignment. It is typical for the encoder index pulse (Z pulse) and the commutation pulses to have some fixed positional relationship. If you know that to be the case, you can optionally use the displayed electrical angle for alignment. For many Yaskawa encoders, the index pulse coincides very closely with the position at which the commutation lines are such that V is LO, W is HI and U is at the toggle point – as is this particular encoder.

However, Yaskawa is an example of the need to verify that fact and not just to assume it. There are some encoders on Yaskawa motors that use magnetic disks rather than optical, and they do not have a consistent positional relationship between the index pulse and the commutation lines. For those encoders, you must align to the commutation line states.

PO Box 2626 Athens, OH 45701
Voice: 740-594-8532
Fax: 740-594-8533
Email: sales@mitchell-electronics.com
Web: www.mitchell-electronics.com

FANUC ALPHA A64 SERIAL ENCODER ALIGNMENT

We will select a Fanuc Alpha A64 serial encoder for the next example since the Fanuc encoders use a 4 bit gray code commutation pattern and this particular encoder is in such common use. The gray code will display 4 commutation states instead of the 3 U, V, and W states that are so common with incremental encoders and Hall effect devices.

The gray code pattern is shown on the Data Display in Figure 6 as C1, C2, C4 and C8. The lockup procedure shown here is to apply +V –W as the lockup voltage. This results in C1 = 0, C2 = 1 and C8 = 0. C4 should be in the position where it will toggle between HI and LO as the shaft is manually forced slightly one way or the other from the lockup position.

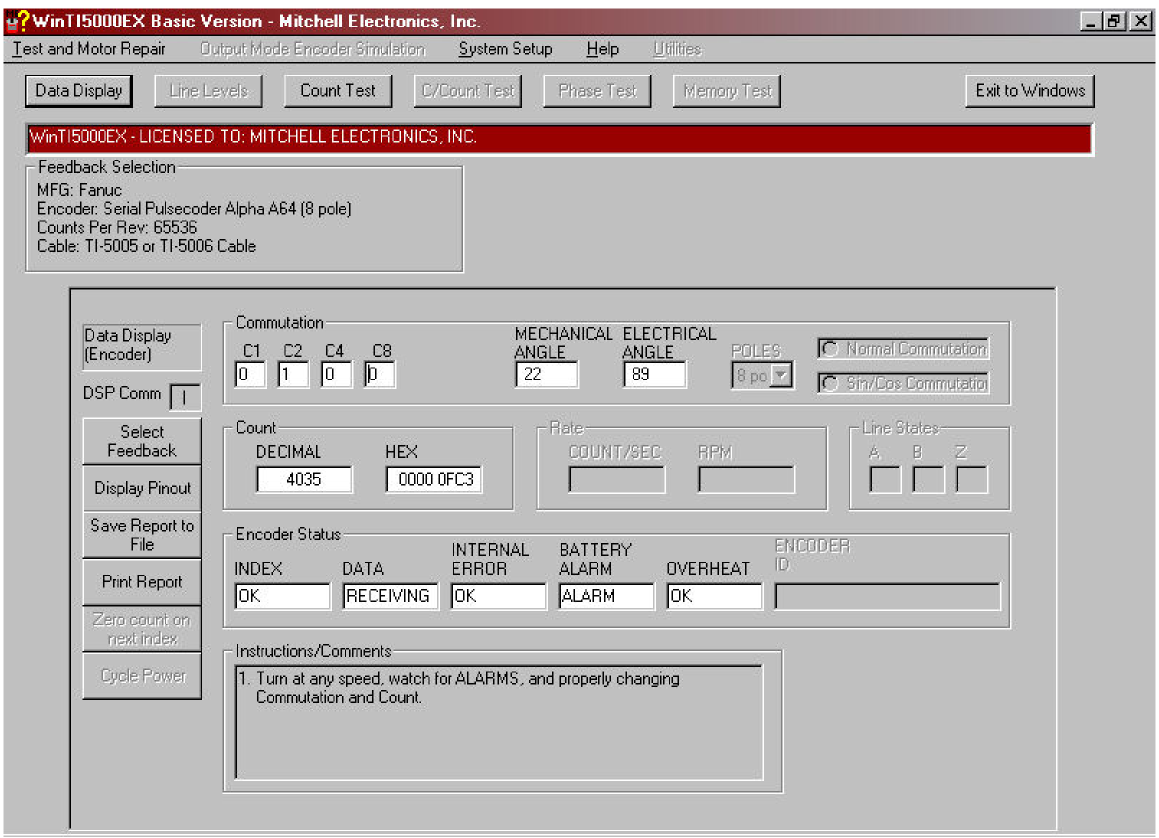

Figure 6 Fanuc Serial +V -W Gray Code States Just CW of Lockup

Again, please note that the electrical angle is near 90 degrees, and 90 degrees could also be used as the alignment target. For these encoders, using either the commutation states or the angle should produce equivalent results. When you actually perform this procedure in a situation in which you must adjust the encoder position, you may notice a difference in the two procedures. You may notice that when using the commutation states it is a little more difficult to put the encoder in the correct position because the commutation states give you no indication of how far off you are from the correct position. The angle, however, gives you a number that not only tells you when you are in the correct position, but gives you guidance as to how far you need to go to get to the correct position.

The example shown in Figure 6 uses the +V – W lockup. However, there is an equivalent procedure which uses a +U –V –W (+U –N or U to neutral) lockup. When this lockup is used, you will be looking for a different pattern: C1 = 0, C2 = 0, C4 = 0 and C8 at the toggle point. Either method works fine and yields equivalent results. The selection is primarily a matter of preference. We favor a 2 wire lockup when there is a choice. The reason is that with a 3 wire lockup, it is possible to have a bad connection on one wire (of the two wires with the same polarity) and not realize it. Energizing 2 wires instead of 3 will lock the rotor, but the position will be 30 electrical degrees away from your target and result in misalignment.

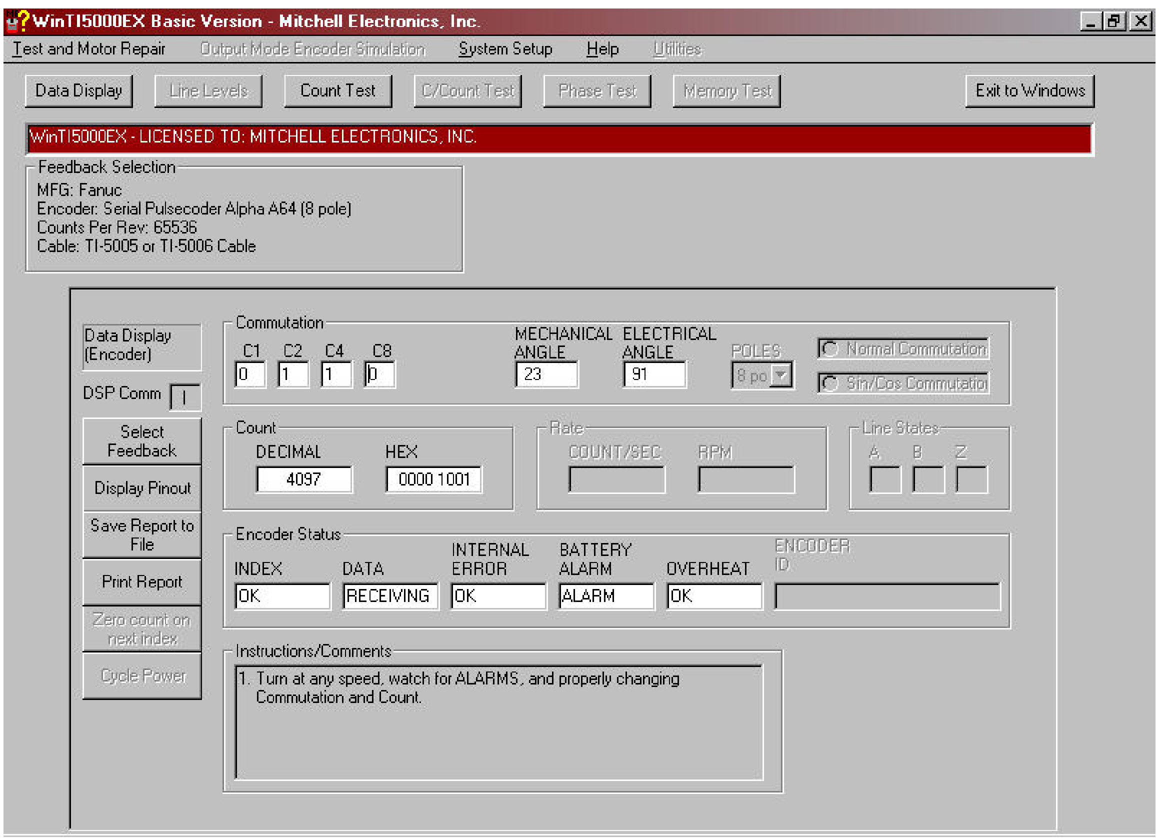

Figure 7 Fanuc Serial +V -W Gray Code States Just CCW of Lockup

PO Box 2626 Athens, OH 45701
Voice: 740-594-8532
Fax: 740-594-8533
Email: sales@mitchell-electronics.com
Web: www.mitchell-electronics.com

MITSUBISHI OBA13 SERIAL ENCODER ALIGNMENT

The Mitsubishi OBA13 serial encoder gives us a chance to focus on alignment based on electrical angle. The Fanuc type gray code display is provided on the Data Display because some technicians prefer it. However, we suggest ignoring the gray codes and using the electrical angle. It is very important to <u>select the correct number of poles</u> in order to display the electrical angle correctly. We will also use this example as an opportunity to provide some other tips that will help set the alignment as accurately as possible and reduce the chances of making a mistake.

Figure 8 shows an electrical angle of 148 degrees for a +U –V lockup. The target in this case is 150 degrees, and 148 degrees is very satisfactory (within ±3 electrical degrees). The OBA13 encoder is built into the motor as opposed to an encoder that can be removed from the motor in one piece. Normally with a removable encoder, you will be adjusting the mounting position of the encoder relative to the motor body. For a built-in encoder, it is more often the case that you had to remove the encoder disk from the motor shaft during repair, and now you have to adjust the disk position on the shaft for proper alignment. In any case, the electrical angle display gives you a number that tells you how far and in which direction to move in order to achieve proper alignment at a nominal 150 degree reading. This makes the procedure much simpler than trying to interpret the gray code reading and make the adjustment.

How close to the target is close enough? Experience in checking new motors has shown that errors up to ±3 electrical degrees are common, so that is a reasonable tolerance. You will notice that there is often a dead zone at the lockup position in which you can easily move the rotor a few electrical degrees. This makes it difficult to get a perfect adjustment. One thing you can do to overcome the dead zone is to average out its effect. For instance if you force the shaft in the CCW direction and let it spring back, you might get a 150 degree reading. If you force it in the CW direction and let it spring back, you might get a 146 degree reading. In that case, you could average these readings and say that you are at 148 degrees. This will reduce the error due to any dead zone. The dead zone is also reduced by increasing lockup current.

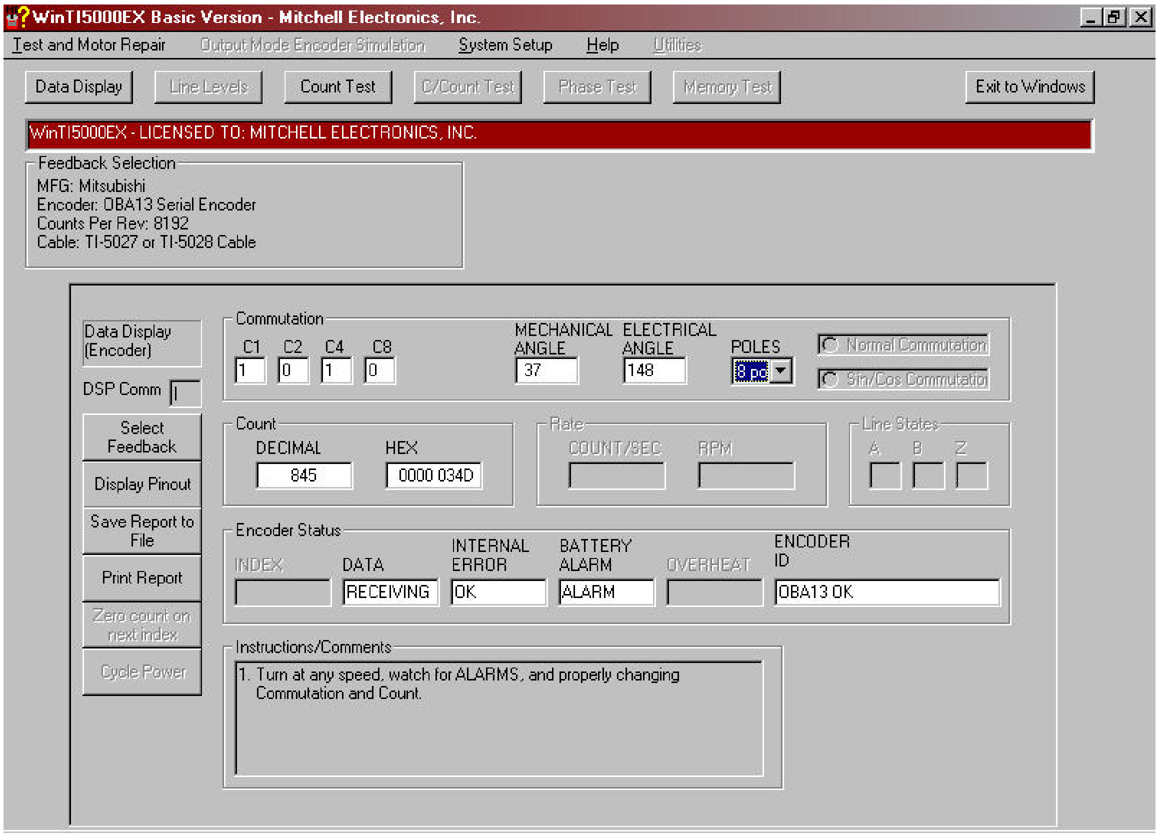

Figure 8 Mitsubishi OBA13 +U –V 150 Electrical Degree Lockup

If you have installed the disk on the motor shaft and set the alignment to get the angle value in Figure 8 (or something tolerably close) for a +U –V lockup, then you should be finished. However, it would be beneficial to go ahead and perform one more lockup using +U –W for the lockup polarities. The reason for this additional lockup is that it provides an opportunity to catch mistakes. Any mistake can potentially keep the motor from running properly when it is installed back on the drive.

When the rotor is locked with a +U –W polarity, you will notice that it moves in the CCW direction from the +U –V lockup. Locking up with a +U –V polarity and then moving the minus lead from V to W will always cause the rotor to jog in the forward armature direction which is CCW for the Mitsubishi motor. Checking this may help you catch a problem in which armature leads were connected back to the wrong pins during reassembly or perhaps mistakes made during rewinding.

In addition for the +U –W lockup, you should see an electrical angle of 210 degrees as shown in Figure 9. If you do not, it could mean that you have entered the wrong number of poles in the Data Display. You would need to enter the correct number, reset the encoder for +U –V and then recheck it at +U –W. Just remember that the +U –W lockup should be 60 electrical degrees higher than the +U –V lockup. If it is not, then something is wrong. This assumes that the forward armature direction and forward encoder direction are the same, and that is typically the case.

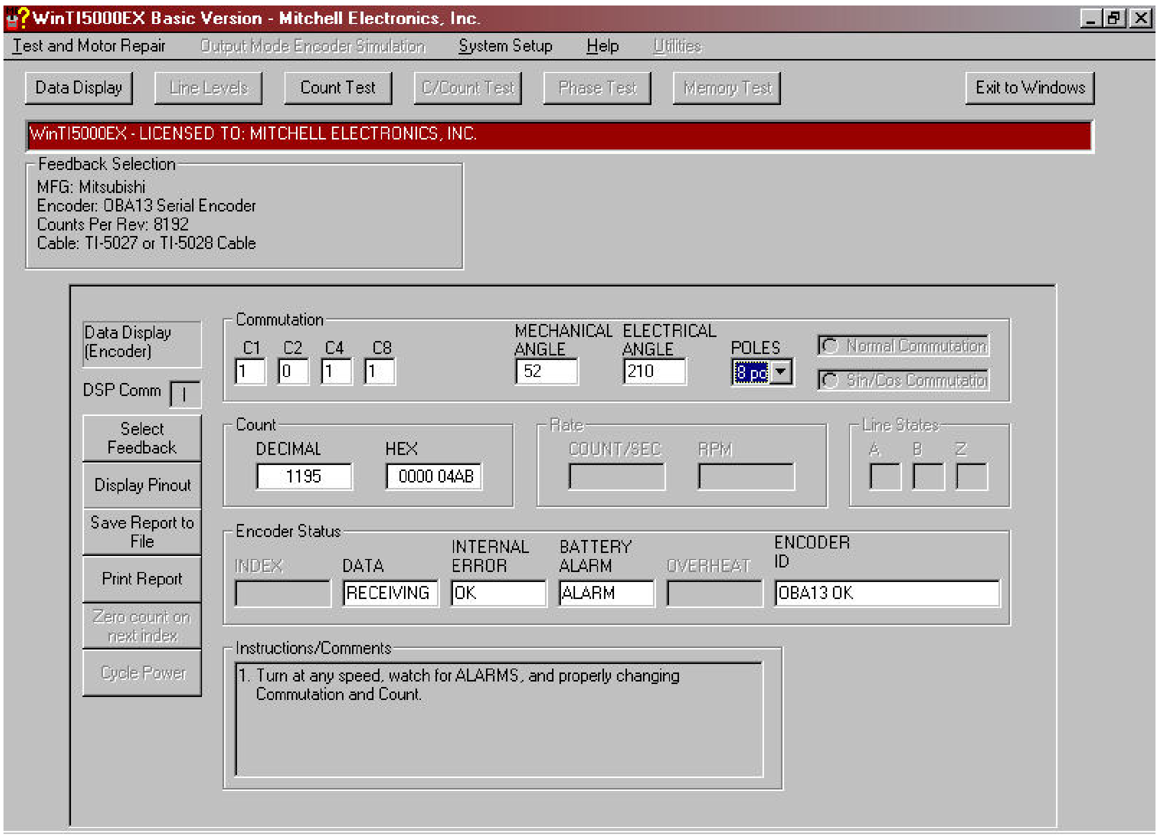

Figure 9 Mitsubishi OBA13 +U –W 210 Electrical Degree Lockup

There are other things that may have been done incorrectly that will cause the second lockup to be incorrect after the first lockup was correct, but suffice to say that the second lockup provides the redundancy necessary to catch some mistakes. Since it can be done quickly, it is worth doing to help ensure success.

RESOLVER ALIGNMENT

The preceding examples have provided a good overview of encoder alignment. A large number of motors use resolvers for commutation feedback, and this section will provide an example of resolver alignment.

Figure 10 shows the Data Display for a Parker Compumotor unit with a rotor lockup of +U –V polarity. The target lockup in this case is 30 degrees, and we are getting 29.0 degrees which is well within tolerance.

Before we go on, we should discuss resolvers and resolver speeds to clarify not only this example, but other situations that could arise. In this case, we have a 4 pole motor and a 1 speed resolver. Since the motor is 4 poles, we will have 2 lockup positions (one for each pole pair). A 1 speed resolver will go through 360 degrees in 1 revolution of the resolver, so it will always show you a mechanical angle. Almost 100% of the time, the resolver will either be 1 speed or the speed will be the same as the number of pole pairs. That means some 4 pole motors like this might use a 2 speed resolver. You could see either a 1 speed or 3 speed resolver on a 6 pole motor, etc.

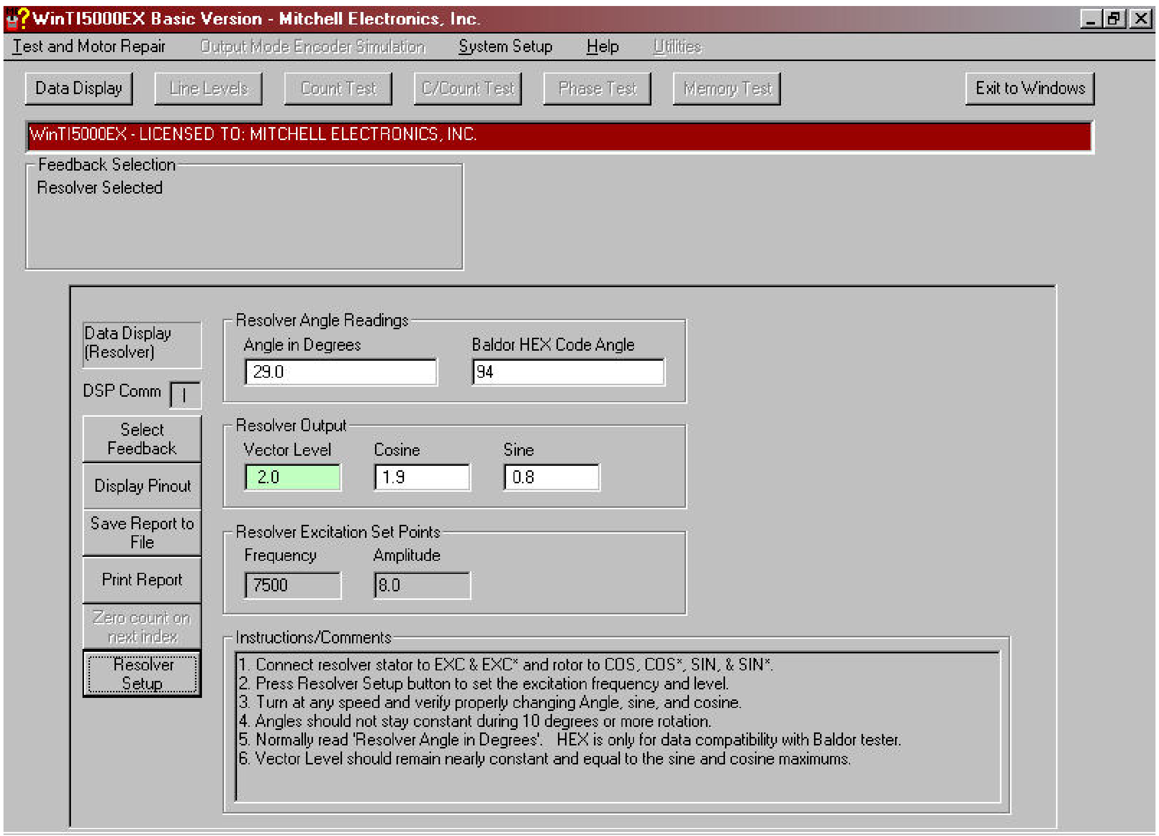

Figure 10 Resolver +U –V 30 Degree Lockup

The important thing to remember is that, if the resolver speed is the same as the number of motor pole pairs, the resolver angle will be the same as the electrical angle, and it will go through 360 degrees multiple times in one revolution. In fact, it will go through 360 degrees the same number of times as the number of resolver speeds, ie: a 4 speed resolver goes through 360 4 times in one revolution. If it is a 1 speed resolver, the resolver angle will be the same as the mechanical angle.

In our example with a 1 speed resolver, we would see that we read a different angle at the two lockup positions. While we read 29.0 degrees in the first position, we will read nominally 210 degrees in the second position. Figure 11 shows 209.0 degrees for the second lockup position. The lockup positions are spread out evenly for multiple pole pairs. That is, for a 4 pole motor with 2 lockup positions, the lockup positions will be 180 mechanical degrees apart. For a 6 pole motor with 3 lockup positions, they will be 120 mechanical degrees apart. For an 8 pole motor the lockups would be 90 mechanical degrees apart, etc.

PO Box 2626 Athens, OH 45701
Voice: 740-594-8532
Fax: 740-594-8533
Email: sales@mitchell-electronics.com
Web: www.mitchell-electronics.com

In our example, we could choose to align to either 30 degrees or 210 degrees. They are both correct. When a motor uses a resolver with the same number of speeds as the number of motor poles, the resolver angle is the same at each lockup position. This can be a minor source of confusion, but if you just keep the difference in mind, the confusion should be minimal.

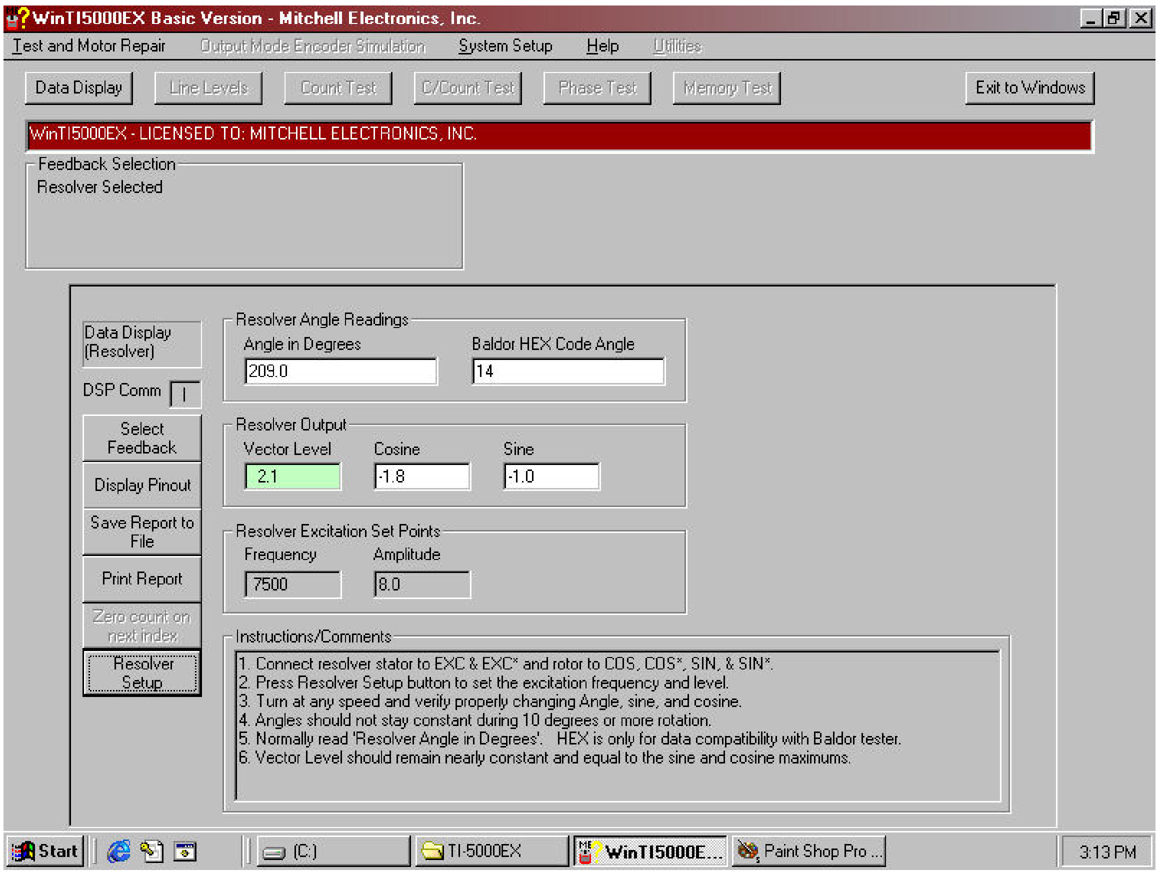

Figure 11 Resolver +U –V 210 Degree Lockup

After the +U –V lockup alignment, we can proceed to a +U –W lockup to see whether we can catch any mistakes (as described in the Mitsubishi alignment section). We will notice when we move the minus lead from V to W that the motor will jog in the CCW direction which is the forward direction for the Parker motor.

If we had been at the 29.0 degree position for the +U –V lockup, we would now be reading 60.4 degrees as shown in Figure 12. However, had we been at the 209.0 degree position, we would be reading something near 240 degree (approximately 180 degrees from 60.4 degrees). Going from the +U –V lockup to the +U –W lockup moves us 30 mechanical degrees. However that is

PO Box 2626 Athens, OH 45701
Voice: 740-594-8532
Fax: 740-594-8533
Email: sales@mitchell-electronics.com
Web: www.mitchell-electronics.com

60 electrical degrees. While this is beyond the scope of this introductory application note, the number of mechanical degrees multiplied by the number of pole pairs (2 in this case) will convert to electrical degrees.

It should also be noted that while the forward direction of serial encoders (the direction in which they count up) is basically fixed by the data, resolvers (and incremental encoders for that matter) may be connected in various ways to reverse the forward direction. Often the resolver pin assignments are not well documented and a repair technician will have to guess and make his own assignments. That can be the case with armature leads as well. As long as the assignments made by the technician are used consistently, there should be no problem. <u>It is very important to document not only the lockup positions, but the pin assignments and other procedural information before removing a feedback device or disassembling a motor</u>. If that rule is followed, then it should be no problem to set the alignment back the way it was before work commenced.

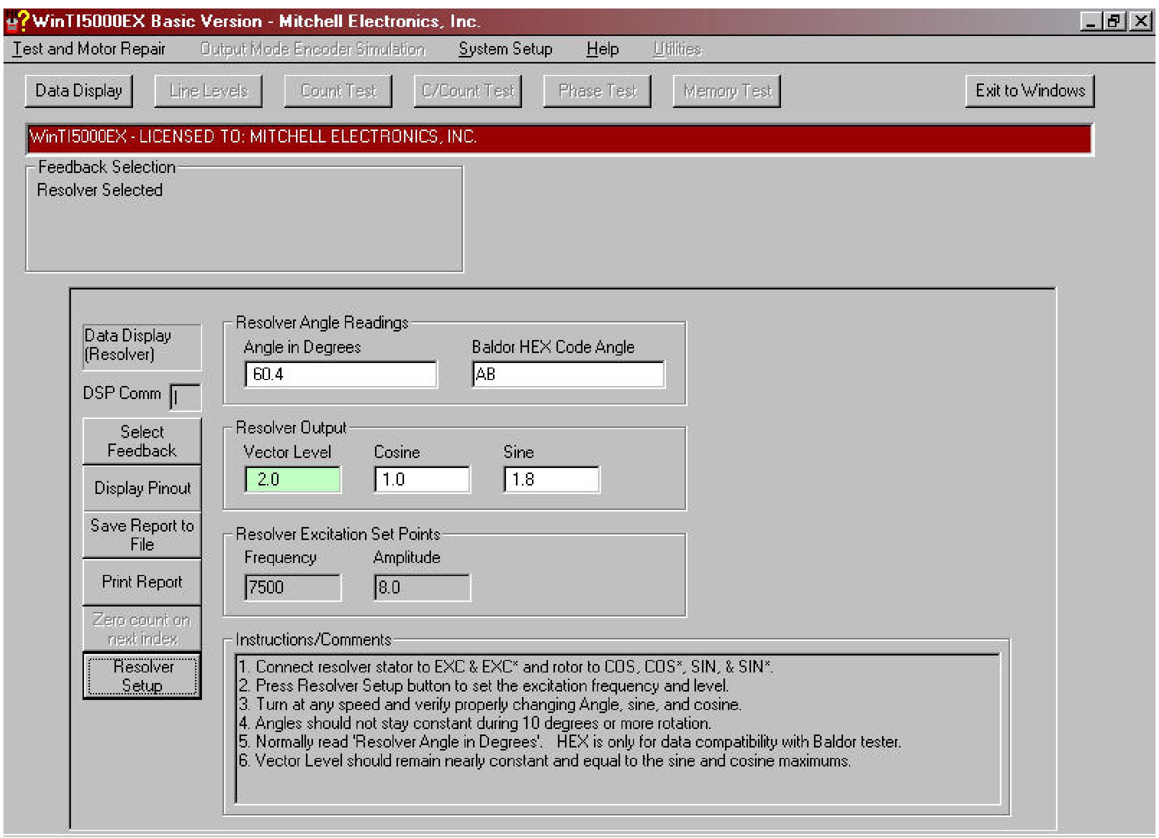

Figure 12 Resolver +U –W 60 Degree Lockup

PO Box 2626 Athens, OH 45701
Voice: 740-594-8532
Fax: 740-594-8533
Email: sales@mitchell-electronics.com
Web: www.mitchell-electronics.com

FEEDBACK MEMORY BASED ALIGNMENT

The last topic to discuss is really a variation in feedback alignment that is being employed by motor manufacturers more and more commonly. The concept discussed so far is that the manufacturer knows the proper position of the feedback with respect to the rotor magnets and windings in order for the intended drive to produce currents of the proper phase and sequence to produce motor torque. Knowing this position for their motor and drive, they use an alignment procedure during manufacturing to ensure proper alignment. Repair technicians or maintenance personnel who remove the feedback device must use a similar alignment procedure to put the feedback in the correct position when it is reinstalled. That is basically what we have been doing in each of the above examples.

It is not hard to imagine that you might be able to misalign a feedback device if you had some way to inform the drive as to the resulting alignment. For instance, if you intentionally move the feedback 60 degrees from the correct alignment and gave the drive a 60 degree offset to apply to the feedback reading, the drive could completely compensate for the misalignment.

This is exactly what is done with Indramat digital motors and certain Allen Bradley motors among others. The feedback devices in these cases contain some type of memory device. The drive is capable of reading data from this memory device just as it reads position information. The memory data will typically contain many motor parameters as well as commutation offset information. By reading this memory, the drive knows exactly what motor is connected to it when it powers up.

The motivation to include commutation information is probably to allow simpler manufacturing techniques. Rather than spend time aligning the feedback during manufacturing, it is simply installed. Then it can be locked up to get the offset for the memory, and it’s ready to go.

While this may be a good innovation for the manufacturer, it definitely adds a degree of complication for a repair technician or plant maintenance person. If a feedback device of this type is simply removed, there is not a good way to realign it unless capability exists to read and decode the offset information from the feedback memory. Having that capability is the best solution. The next best is to be able to check the alignment before anything is disassembled, and then realign to that position upon reassembly. The weak point in that technique is that you cannot always know whether the feedback is aligned properly when it gets to you. If you are a repair technician, how do you know that plant maintenance personnel did not remove the feedback during some troubleshooting attempt? This is a troublesome point to be sure.

The TI-5000EX does in fact provide support for reading the commutation offset and providing lockup angles for some feedback devices of this type. This support will expand as more manufacturers begin to use this technique.

PO Box 2626 Athens, OH 45701
Voice: 740-594-8532
Fax: 740-594-8533
Email: sales@mitchell-electronics.com
Web: www.mitchell-electronics.com

GLOSSARY OF TERMS

Electrical Degrees -

The position angle referenced to one period of the armature generated voltage as 360 degrees. One 360 degree mechanical revolution will result in as many 360 degree electrical cycles as there are pole pairs in the armature. The electrical angle may be calculated by multiplying the mechanical angle by the number of pole pairs.

Forward Direction -

This is the direction of rotation which results in the phase rotation of U followed by V followed by W. It can be tested by locking up with a polarity of +U –V and then noting which direction it jogs when the polarity is switched to +U –W.

Hall Effect Devices -

These are transducers that produce a pulse when a magnetic field passes through them. These devices are often used for commutation feedback when 6-step commutation is used.

Incremental Encoder -

This is an encoder that produces A and B quadrature pulses and often a Z index pulse. Some Japanese manufacturers use this terminology to mean other types of encoders (like serial) that do not have battery backup.

Mechanical Degrees -

Mechanical degrees are the measurement of rotation in which one complete revolution is 360 degrees.

Resolver –

A position transducer feedback device that uses a rotating transformer winding to create voltages that are proportional to the sine and cosine of the position angle.

Reverse Direction -

This is the direction of rotation which results in the phase rotation of U followed by W followed by V. It is the opposite of the rotation that can be tested by locking up +U –V and then +U –W (see forward direction).

Serial Encoder -

This is a position transducer that keeps track of position internally (usually as digital data), and transmits this data to the drive system (or other receiving device) as serial data. This data is somewhat similar to data from a computer’s RS232 COM port. It is very difficult to interpret serial data using an oscilloscope.

Zero Torque Position –

This is a position at which currents applied to motor windings will produce zero torque. With zero torque, the motor will be at rest and will not move to a new location. This corresponds to a zero voltage position.

PO Box 2626 Athens, OH 45701
Voice: 740-594-8532
Fax: 740-594-8533
Email: sales@mitchell-electronics.com
Web: www.mitchell-electronics.com

Zero Voltage Position –

This is a position at which the generated voltage from an armature winding passes through zero as the shaft is rotated. This corresponds to a zero torque position.

DOCUMENT REVISIONS

8/04/06 –

Corrected mistakes in +V -W and –W +U +V lockup labels in Figure 2.