# *Applying the Unidrive to Powertec Industrial Motors Powertec and PacTorq™ Motors*

Application Guide

**P/N: PCSIAG0600**
**Date: June 7, 2000**

# Table of Contents

# 1. INTRODUCTION

## 1.1 Purpose of this Application Guide

This manual serves as a supplement to the Unidrive V3 Installation Guide and User Guide. Its purpose is to guide the user in applying a Control Techniques Unidrive to Powertec Industrial Brushless motors in stand-alone applications. There are two types of motors available, the older style known as the **Powertec Brushless DC motor** (which will be the most common in retrofit applications) and the newer style, which is the most common design used today, the AC Synchronous motor or **PacTorq™ Brushless Servomotor**.

In order to achieve this, basic knowledge of how these motors operate and their feedback requirements are essential.

## 1.2 Definition of Brushless DC Motors

Brushless DC Motors are defined as a class of motors that operate using electronic commutation of phase currents rather than electromechanical (brush-type) commutation as it would be for a standard brushed dc motor. These motors are classically referred to as "Trapezoidally" wound motors or "inside out" motors.

The brushless dc drive system is typically composed of a "trapezoidally" wound motor and a "six step" drive. The feedback on this type system has classically been a set of three hall effect devices spaced 120 electrical degrees apart which are used to signal the drive the point at which the stator winding current should be commutated. This keeps the field generated by the stator winding (equivalent to the armature winding in a dc motor) in quadrature (at the time of commutation) with the rotor (equivalent to the dc motor field) in order to produce maximum motor torque (at maximum stator current) which is exactly the function of the mechanical commutator in a dc motor. The "six step" drive basically does this commutation in a "brainless" fashion with combinational logic determining which two power devices should be on based on the Hall effect feedback signals. It is therefore imperative that the alignment of the feedback be correct. The torque produced in the motor is then strictly based on the stator current produced by the difference between the applied "dc" voltage commutated across the stator windings, the dc back emf generated by the rotor and the stator resistance (just like a brushed dc motor). The speed of rotation of the rotor is based on this applied "dc" voltage.
The main difference between the dc motor and the brushless dc machine is that the brushless motor has less stator windings to commutate and therefore has more torque ripple than the equivalent dc motor, especially at low speeds. Other than this subtle difference, the theory of operation of the "brushed" and "brushless" motors is identical.

## 1.3 Definition of Synchronous AC Motors

The Synchronous AC Motor, as its name implies, is classified as an ac motor. It is very similar in construction to the brushless motor with the exception that its stator windings are wound sinusoidally (to produce a sinusoidal back emf) as opposed to trapezoidally wound (to produce a trapezoidal back emf). Ignoring this difference, both motors are identical, they have a three phase stator winding and a permanent magnet rotor.

The synchronous ac drive system is composed of a permanent magnet synchronous ac motor and an ac inverter drive. The big difference between the “six step” drive and the inverter is of course that the inverter produces a sinusoidal voltage across the three phase stator windings which gives rise to a sinusoidal rotating magnetic field in the motor. The permanent magnet rotor, at no load, will align itself to this rotating field. It will generate a sinusoidal back emf directly in phase with the rotating field. At this point, the motor will produce very little torque, but at no load it doesn’t need to. When the motor is loaded, the rotor field will begin to lag behind the rotating field until it reaches a phase shifted angle where the difference in the applied stator voltage and the sinusoidal back emf voltage causes enough current (torque) to balance the load. This angle is referred to the power angle of the machine. When this angle reaches 90 degrees, the motor will achieve maximum (or peak) motor torque. If this angle ever exceeds 90 degrees, the motor will loose torque and collapse in speed. This then demonstrates the importance of the correct alignment of the encoder/resolver since they are the signals that provide the inverter the exact position of the rotor with respect to the rotating field. Therefore, an obvious difference in the torque control of the two systems is that the brushless dc varies the applied stator voltage with respect to the generated dc back emf to control the motor torque (like a standard dc motor) while the synchronous ac varies the phase relationship (power angle) between the applied “rotating“ field of the stator and the sinusoidally generated back emf from the rotor. The dc voltage level applied to the stator windings (minus the IR drop) controls the speed of the brushless dc while the speed of the synchronous ac motor is set by the frequency of the rotating field.

### 1.4 Retrofit Overview

The key to a successful Retrofit is to have the appropriate feedback device.

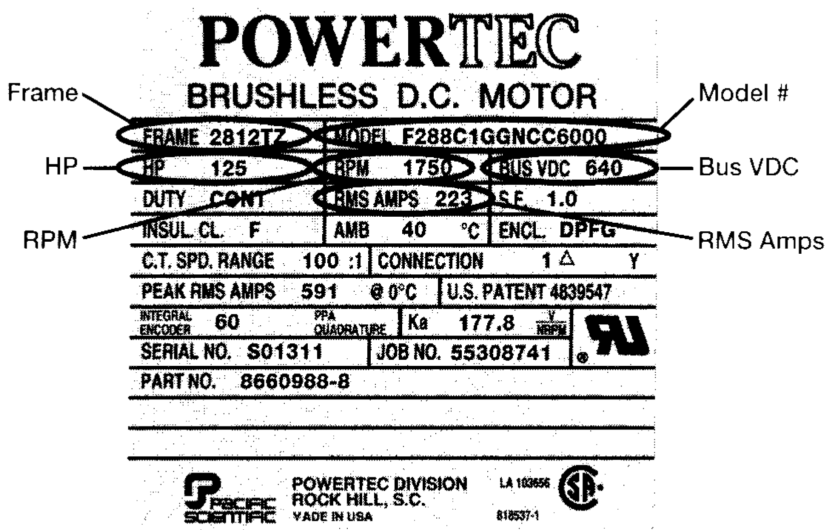
The older Powertec Brushless DC motors were typically supplied with the hall effect grey code (for commutation) and either a 30 or 60 ppr magnetic pickup type speed feedback device depending upon the number of poles the motor has. This device is not useable by the Unidrive and must be replaced by an appropriate feedback. There are two types of retrofit kits available (depending on the motor frame size) for these motors, either a resolver or an encoder with grey code, which include all the required components including the feedback cable (10 meters unless specified otherwise).

The newer style motors (PacTorq™ Brushless Servomotor) were typically supplied with resolvers. **This feedback is acceptable for use with the Unidrive provided the UD53 (Resolver interface) is issue #2 since it accommodates a transformer ratio of 2:1 (CT motor resolver has a 3:1 transformer ratio)** The Unidrive must also have version 3.01.07 software or greater.

## 2. Hardware Requirements

### 2.1 Motor Identification

As mentioned in section 1.1, Powertec Industrial Motors manufactures two types of motors. One method of determining which motor you have is by the type motor controller used to control the motor. The Powertec Brushless DC motors were used in-conjunction with the Genesis Brushless DC Drive. The newer style motors (PacTorq$^{TM}$ Brushless Servomotors) were supplied with Millennium Digital Brushless Drives. The key pieces of information needed from the motor nameplate are: Motor frame size, Rated rpm, Rated rms. Current, Bus voltage, and Model number (see nameplate example below). In addition, the stator winding connection (wye or delta) and the stator voltage constant, Ka, provide useful information for changing motor speed and voltage.




A key piece of information missing from the motor nameplate is the number of poles the motor has. This information is **very important** since it is used in the selection of the proper feedback kit as well as a programming parameter in the Unidrive. The table below shows the motor Model # prefix, frame sizes, the number of motor poles, and the available retrofit feedback kits.

| Model # Prefix | Frame Size | Number of Poles | Encoder Kit # | Resolver Kit # |
|---|---|---|---|---|
| A,B,C,D,F | 182,184, 213, 215, 254, 256, 259 | 4 | Perk1 (1024 PPR) | RUD153 |
| A,B,C,D,F | 287, 288, 328, 2810, 2812, 3210, 3213, 504, 506, 508 | 8 | Perk3 (1024 PPR) | ------ |
| E | E182, ES182, E184, E213, E215, E218 | 6 | **Perk2 (1024 PPR) | ------ |
| E | E254, E256, ES259, EL259, E2810, E2812, E328, E3211, E3213 | 8 | **Perk3 (1024 PPR) | ------ |

**The new designs, PacTorq™ Brushless Servomotors (and Millennium), all have an "E" prefix in the model number. In general, these motors will have Resolver feedback that is useable with the Unidrive. The only requirement with respect to the Unidrive is that **Resolver feedback requires the UD53 option**. The Issue 2 model of the UD53 allows for either a 2:1 transformer ratio (common with PacTorq™ Brushless Servomotors) or a 3:1 transformer ratio (common with CT ServoMotors) which is selectable in the drive software.

All other Model # prefix letters (A,B,C,D & F) are the older style Powertec Brushless DC motors which will be the most common in retrofit applications. These motors **will require** a Feedback Retrofit Kit.

### 2.2 Drive Identification

**The most important information from the drive nameplate is the output voltage and current**. These values are used to select the proper Unidrive size. The drives supplied with the Powertec Industrial Motors (Powertec) motors were either the Genesis Brushless DC Drive or the Millennium Brushless Servo Drive.

The Genesis Brushless DC Drive is an analog / digital controller which has many available option boards. In any retrofit application all option boards and their functions need to be identified to perform a proper retrofit. ***This guide only addresses standard single drive / single motor applications and does not include options***. Consult your local CT Drive Center for additional assistance.  Below is a sample of a Genesis Drive nameplate.

| | | |
|---|---|---|
| MODEL NO: C0753.N4CH000NNNN | | |
| HP: 75 | PHASE: 3 | FREQ: 50/60 |
| INPUT VOLTS: 460V | | AMPS: 135 |
| OUTPUT VOLTS: 460V | | AMPS: 149 |
| DATECODE: 2798 | | |

The Millennium Drive is a microprocessor-based, software programmable digital brushless DC drive. A copy of its nameplate is shown below. The only available option for this drive is the pulse train I/O board. This option can be retrofitted if the reference signal encoder has a differential output.

| | | |
|---|---|---|
| MODEL NO: M7HLON-00007-00 | | |
| HP: 200 | PHASE: 3 | FREQ: 50/60 |
| INPUT VOLTS: 340-505 | | AMPS: 200 |
| OUTPUT VOLTS: 480V | | AMPS: 220 |
| DATECODE: 2798 | | |

### 2.3 Unidrive Sizing

To properly select the Unidrive size, the rated motor current and winding voltage values must be known. The current rating of the Unidrive should be selected to be equal to or the next greater value with respect to the motor rated current. The voltage rating of the drive should be based on the maximum required motor voltage at rated speed. Since the winding voltage is not typically given on the motor nameplate, a second method is used to select the drive voltage rating based on the bus voltage level specified on the motor nameplate. Using the information from the motor nameplate shown in section 2.1 above, the Unidrive is selected as follows:

**Nameplate Information:**

Rated Current: 223 amps
Bus VDC (DC Bus): 640 vdc

Given the bus voltage requirements, the line voltage for the drive can be determined. It is simply the bus voltage divided by 1.414. In this case, the line voltage would be 452 vac. Therefore, a 480 vac Unidrive would be required. With this information and the motor rated current, the correct Unidrive can be selected from the table below. It would be a UNI5401 since it has a continuious output current of 240 amps.

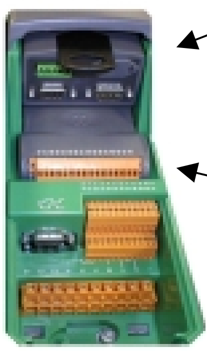
| 480 VAC | Unidrive Models | 240 VAC | Unidrive Models |
|---|---|---|---|
| Model # | Output Amps | Model # | Output Amps |
| UNI1401 | 2.1 | UNI1201LV | 2.1 |
| UNI1402 | 2.8 | UNI1202LV | 2.8 |
| UNI1403 | 3.8 | UNI1203LV | 3.8 |
| UNI1404 | 5.6 | UNI1204LV | 5.6 |
| UNI1405 | 9.5 | UNI1205LV | 9.5 |
| UNI2401 | 12 | UNI2201LV | 12 |
| UNI2402 | 16 | UNI2202LV | 16 |
| UNI2403 | 25 | UNI2203LV | 25 |
| UNI3401 | 34 | UNI3201LV | 34 |
| UNI3402 | 40 | UNI3202LV | 40 |
| UNI3403 | 46 | UNI3203LV | 46 |
| UNI3404 | 60 | UNI3204LV | 60 |
| UNI3405 | 74 | UNI3205LV | 74 |
| UNI4401 | 96 | | |
| UNI4402 | 124 | | |
| UNI4403 | 156 | | |
| UNI4404 | 180 | | |
| UNI4405 | 202 | | |
| UNI5401 | 240 | | |
| UNI5402 | 480 | | |

## 2.4 Feedback Selection

As discussed in previous sections, the older style Powertec Brushless DC Motor had a feedback device that was not useable by the Unidrive, therefore it must be replaced by a suitable device. In the case of a 4 pole machine, two options are available, an encoder (PERK1 Kit) may be used or a Resolver (RUD153 Kit). The 8 pole machines have only one option, the Encoder (PERK3 Kit).

## 2.4A Resolver Retrofit Kit

The Resolver retrofit kit (p/n RUD153) includes the resolver rotor and stator wired to an MS connector, a replacement motor cover plate, a 10 meter resolver cable (Belden type 9990) and a UD53 Resolver small option module for the Unidrive. The UD53 is installed in the Unidrive as shown in the figure below. ( Note: Longer length cables are available by special order)



Large Option Module

Small Option Module (UD 53)

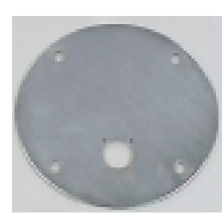
Resolver Components

Stator Assembly

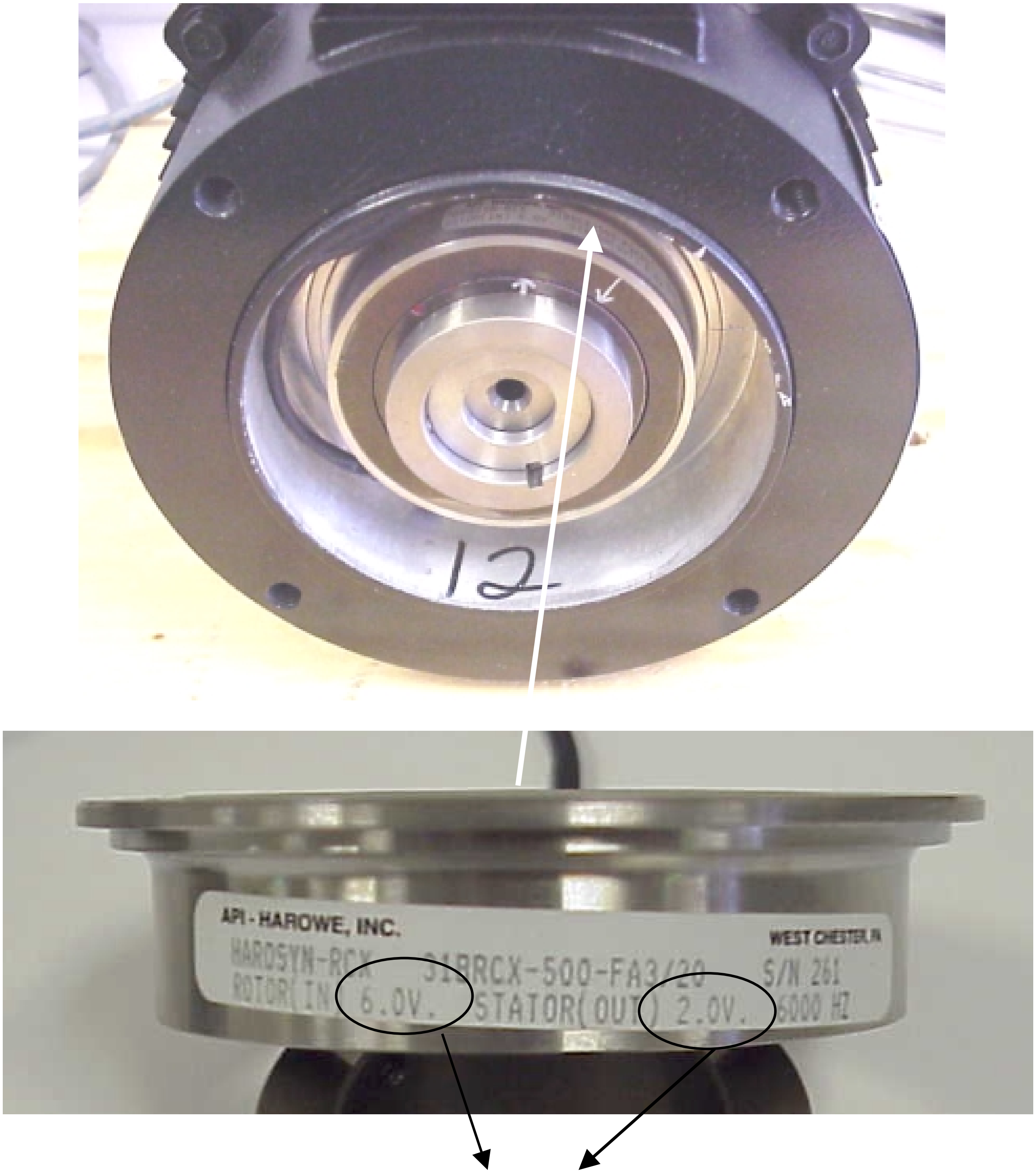
Rotor Assembly

MS Mating Connector

Motor Cover Plate



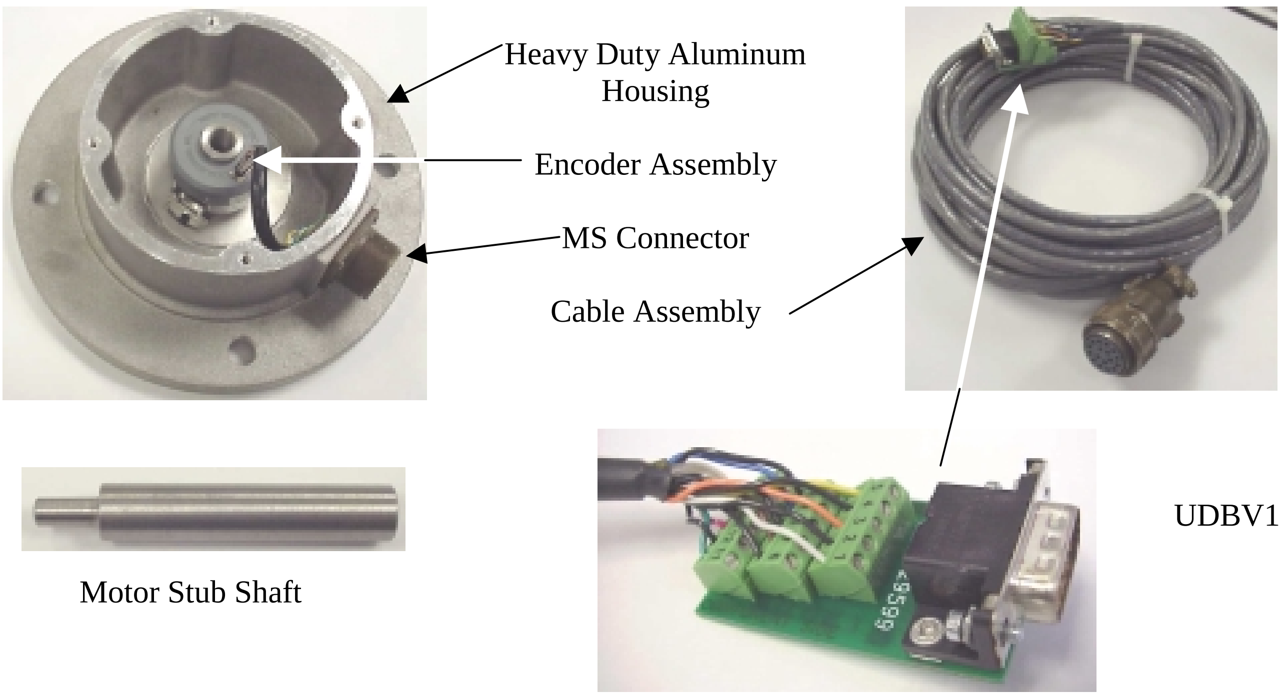
## Back End of Motor (Accessory Face)




Transformer ratio (or turns ratio) = 6.0V : 2.0V ⟶ 3 : 1

## 2.4B Encoder Retrofit Kits

There are two encoder retrofit kits available, PERK1 which is used on all Powertec 4 pole motors (259AT frames and smaller) and PERK3 which is used on all 8 pole Powertec motors (287AT frames and larger). Each kit includes a 1024 PPR quadrature encoder with marker and commutation tracks, a heavy duty cast aluminum adapter housing with an MS connector, Motor stub shaft, 10 Meter encoder cable (with mating MS on one end and a UDBV1 15 pin “D” shell to terminal block adapter pre-wired to the other end), and mounting hardware. ( Note: Longer length cables are available by special order)




## 2.5 Additional Components

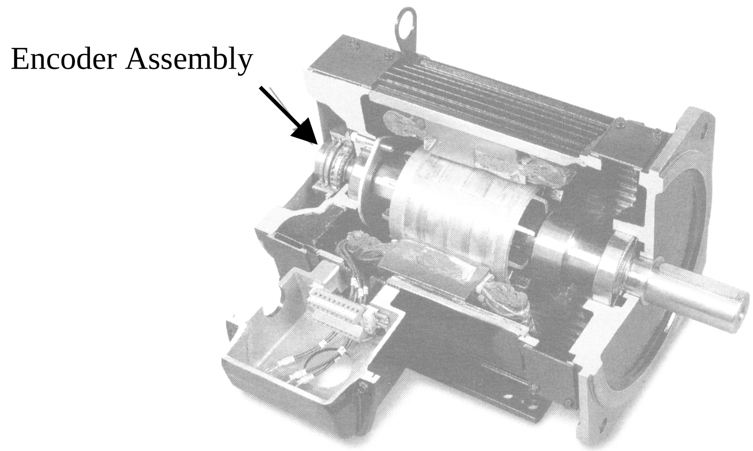
Line Reactors – Input line reactors are highly recommended for retrofits where there is no isolation transformer (which is sized for the drive) supplying the existing drive. These components provide increased drive imunity to nuisance trips caused by line voltage disturbances. Contact your local CT Drive center for proper selection of this component.

Output Reactors – Output reactors are recommended for applications where the distance between the drive and motor exceed the maximum cable length as given in section 2 of the Unidrive Installation Guide or the coupling capacitance to earth ground (in the output wiring) is too large. These conditions can cause nuisance trips of the drive. In general, if the distance between the drive and motor is less than 50 feet, an output reactor in not needed. Contact your local CT Drive center for proper selection of this component.

Drive Fusing – The drive must be fused as dictated in the Unidrive Installation Guide in section #2. The UL listing is dependant upon the use of the correct type UL – listed fuse. Contact your local CT Drive center for assistance in proper selection of this component.

# 3. Installation of the Retrofit Feedback Kits

The picture below shows the location of the existing encoder assembly supplied on the Powertec brushless DC motor. This device will have to be removed inorder to install the Resolver retrofit. If an encoder retrofit kit is used, the existing encoder can be left in place.




### 3.1 Installing the Resolver Retrofit Kit

A. Remove the end-plate cover at the front of the motor (opposite the drive shaft end) to expose the Hall effect encoder assembly.
B. Remove the Hall encoder rotor by loosening two Allen set screws (3/32 hex key) and sliding the rotor off the shaft. A pulling groove on the rotor can be used to apply extra force if required.
C. Remove the Hall encoder stator assembly by removing the two ¼" hex head screws that retain it. Cut the lead wires that run to the motor terminal box.
D. Install the resolver stator assembly in the recess from which the Hall encoder stator was removed and secure it with the two ¼" hex head screws.
E. Install the resolver rotor assembly, sliding it onto the motor shaft until it is flush with the stator. Then secure the rotor by tightening the two Allen set screws. Rotary alignment is not required, as this will be compensated electronically by the Unidrive resolver alignment procedure.
F. Attach the resolver MS connector to the motor cover plate with the hardware provided in the kit. Then attach the cover plate to the motor.

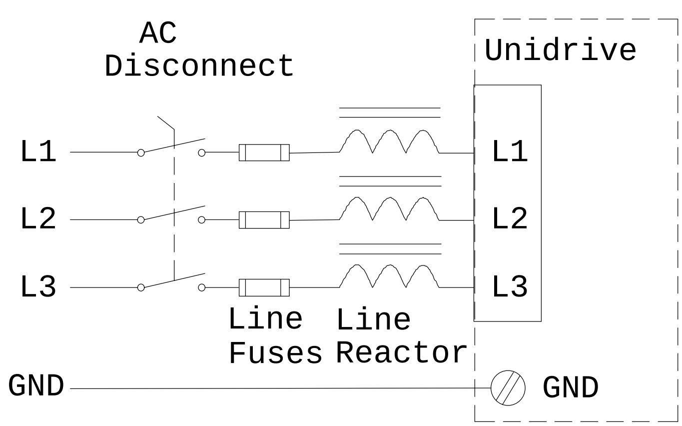
### 3.2 Installing the Encoder Retrofit Kit

A. Remove the end-plate cover at the front of the motor (opposite the drive shaft end) to expose the motor shaft and Hall effect encoder assembly. On motor frames 259AT and smaller, the stamped sheet metal cover can be removed using a flat blade screwdriver. On larger motors, remove the four hex-head screws holding the cover using a ¾" wrench.
B. To install the motor stub shaft, tap the tapered end into the predrilled hole in the motor shaft using a soft mallet. If the motor is old, Locktite™ may be required to hold the stub shaft securely in the motor shaft. It is not necessary to remove the existing Hall effect encoder.
C. Remove the rear cover plate from the adapter housing
D. Secure the adapter to the motor accessory face using the four ½" hex head bolts and lock washers.
E. Install the encoder assembly, sliding it over the stub shaft and securing its torque arms with the two 4-40 screws provided in the kit.
F. Connect the encoder wire assembly from the MS connector to the plug on the encoder.
G. Replace the rear cover plate on the adapter housing.

## 4. Motor and Drive Connections

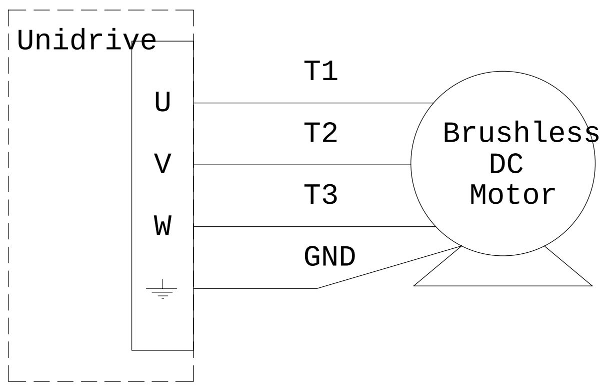
### 4.1 AC Power Wiring

Ensure that the existing input wiring to the drive meets standards established in the Unidrive Installation Guide, section #2, with respect to wire size and fusing requirements. The figure below shows a typical arrangement including a line reactor and disconnect.



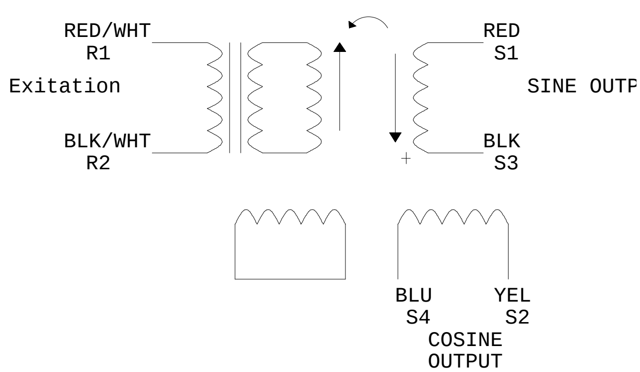
## 4.2 Motor Wiring

Connect motor wires to the Unidrive as shown in the figure below. Ensure that T1 connects to U, T2 to V and T3 to W. This is a standard wiring convention that provides clockwise rotation of the motor (while facing the drive or shaft end of the motor) with forward selected in the drive. A ground connection **MUST** be made between the drive and the motor. The ground connection at the drive should be the ground connection closest to the UVW connections and is typically designated with the ground symbol. This is a very important connection with respect to noise generated in the drive feedback as well as in the user ground system. The physical wire should be run in the same conduit as the motor leads.




## 4.3 Resolver Connections

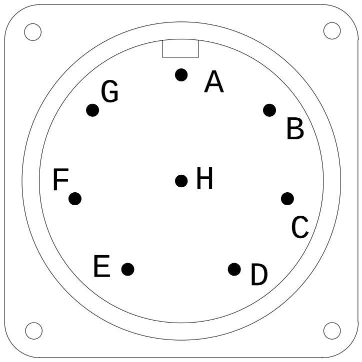
The use of resolver feedback requires the use of a UD53 Resolver Interface small option module. This module is included in the RUD153 retrofit kit. In new applications utilizing either the Millennium or the PacTorq™ Brushless Servomotors, the Resolver connections are made to a terminal block in the motor terminal box. In the retrofit kits (used with the older Powertec motors) the resolver connections are made to an MS connector. The figures and table below show the resolver connections.



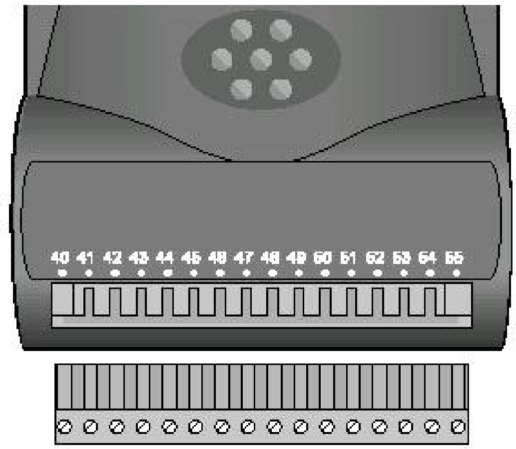

Resolver
Schematic
Drawing

MS Connector P/N MS3102R-20-7P
Mating connector P/N MS3106F-20-7S
Clamp P/N MS3057-12A

UD53 Resolver Interface



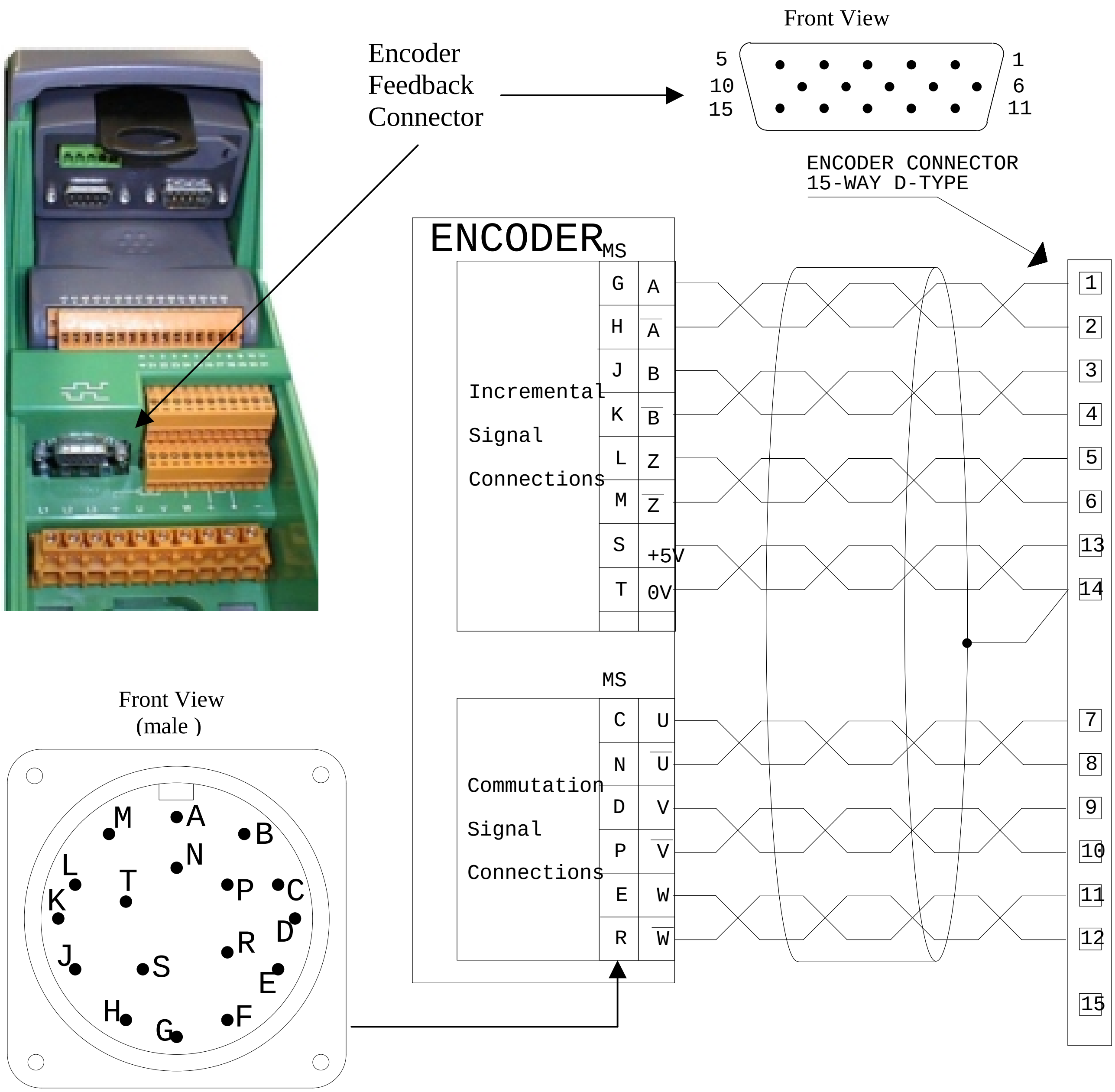

Front View




| Signal Name | Resolver Stator | MS Connector Pin | Cable (Belden 9990) | Unidrive UD53 Module | Motor Terminal Number |
|---|---|---|---|---|---|
| Sine (low) | S3 (blk) | B | Black (in blue shield) | 48 | 2 |
| Sine (high) | S1 (blu) | D | Green (in blue shield) | 49 | 1 |
| Cosine (high) | S2 (yel) | C | White (in green shield) | 50 | 3 |
| Cosine (low) | S4 (red) | A | Black (in green shield) | 51 | 4 |
| Excitation (high) | R1 (red/wht) | E | Red (in red shield) | 52 | 6 |
| Excitation (low) | R2 (blk/wht) | F | Black (in red shield) | 53 | 7 |
| Shields | n/c | n/c | Shields | 55 | - |

## 4.4 Encoder Connections

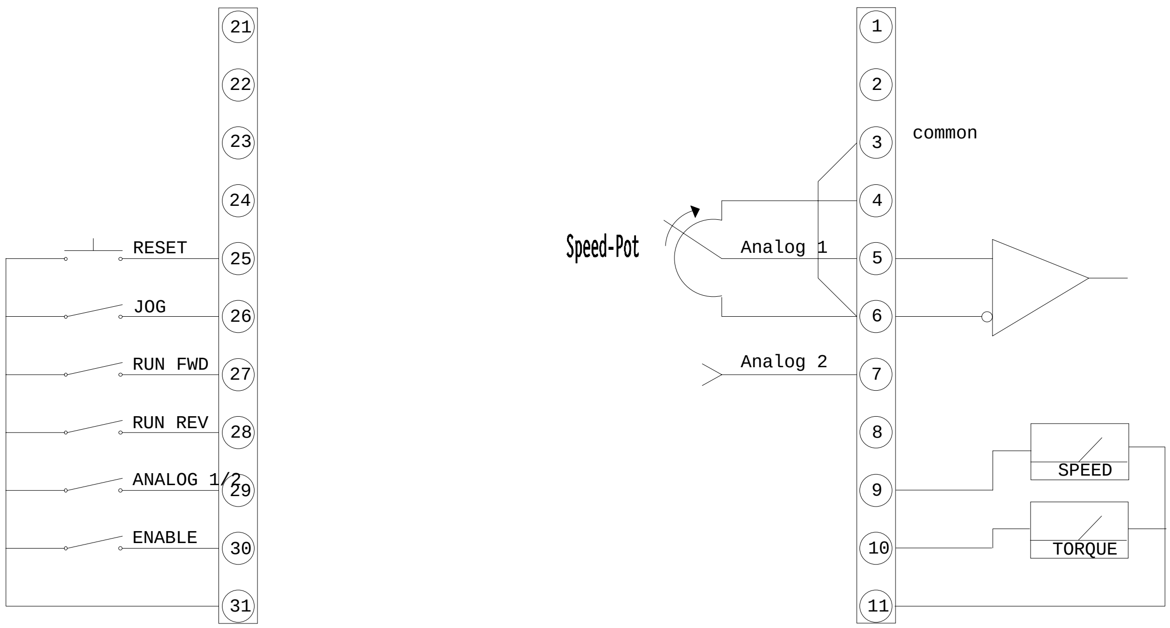
The PERK1 and the PERK3 kits provide a 10-meter cable for connecting the feedback encoder to the Unidrive. This cable has an MS connector on one end and a 15-pin vga d-type shell connector on the other. The cable used is Belden type 9507 ( 7 twisted pairs plus the shield). The 14 wires connecting the encoder to the Unidrive consists of six commutation wires, six speed feedback wires, power supply, common and shield. The figure below shows these connections.




Connector P/N MS3102E20-29P
Mating Connector and Clamp
P/N MS310GF-20-29S

### 4.5 Unidrive Terminal Strip Connections

The logic and analog inputs/outputs on the Unidrive are fully programmable. The controlling inputs (i.e. Run, stop etc.) are programmable as either positive or negative logic (negative, which means the inputs are active when pulled low, is the default). There are five base configurations available via parameter #6.04 (or parameter #00.05) which can be modified to suit the needs of a particular application. The function of the analog inputs and outputs are also fully programmable. The figure below shows the functions of the terminal strip connections, as the drive is defaulted (#6.04 = 4wire proof plc mode). For more information on other selections, refer to the Unidrive User Guide or Unisoft (Windows based program).




### Control Logic Inputs

The basic default logic inputs are shown in the figure above. A brief description for each function will be given below, for other available configurations, consult the Unidrive User Guide, The Advanced User Guide or Unisoft.

1. Reset – A momentary closure of this connection will reset a drive fault.
2. Enable – Closing this connection (maintained) enables the inverter. Opening this connection **immediately disables** the inverter.
3. Run Fwd – Closing this connection will place the drive in the run forward mode. The drive will accelerate to the speed set by the speed potentiometer (or other selected reference). The enable must be closed. Opening this connection will cause the drive to ramp down to zero speed. Note that the drive will still be active at zero speed until the enable is opened.

4. Run Rev - Closing this connection will place the drive in the run reverse mode. The drive will accelerate to the speed set by the speed potentiometer (or other selected reference). The enable must be closed. Opening this connection will cause the drive to ramp down to zero speed. Note that the drive will still be active at zero speed until the enable is opened.
5. Jog – Closing this connection selects the jog mode (and reference). Closing the run forward or the run reverse switch after closing the jog switch will cause the drive to jog in the selected direction. Opening the jog connection while the run forward or the run reverse switch is closed will immediately select the run reference.
6. Analog 1/2 – Closing this switch will select will select analog reference #2 (term #7) as the speed reference.

**Analog Inputs / Outputs**

The figure above shows the default configuration for the analog inputs and outputs. Analog #1 is set up for a speed potentiometer using the +10VDC supply. Analog input #2 is set up for a 0 to 10vdc input. The default configurations for the two analog outputs are Speed (term#9) and Torque/Load (term#10). Both of these signals are 0 to +/- 10vdc, which corresponds to 0 to rated speed and 0 to 175% torque.

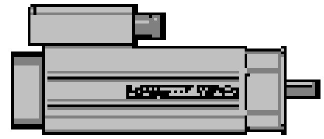
## 5. Unidrive Servo Mode Set-Up Guide

The following is a short Start-Up guide intended to assist one running a Unidrive operating in the SERVO mode (V3.0.0 software or greater).

| WARNING |
| --- |
| This guide is intended to facilitate starting up a Control Techniques Unidrive operating in the SERVO mode. It does not address wiring and associated safety practices. Start-up of this nature can be **hazardous** and should only be performed by qualified technicians familiar with motors and drives of this sort. This guide is meant to supplement the Installation and User's Guide which must be consulted (specifically section 2-1 in the User Guide) prior to this guide being used. Power wiring and keypad operation and other such details are to be found in these manuals. |

The guide assumes that one has connected the Line Voltage, Motor Wiring and Dynamic Braking Resistor to the Unidrive per the Installation Manual. Ensure motor ground is run to the Drive Power Terminal Strip and the Unidrive chassis ground is properly terminated.

## For Servo Motor with Encoder Feedback



Obtain Motor Nameplate and Encoder Data

Motor FLA (Full Load Amps)
Number of Motor Poles (see page 5 for #poles vs. Motor frame size)
Encoder PPR (Pulses/Rev)
Encoder Voltage

| Motor Nameplate Data | Value |
|---|---|
| Motor FLA ( Full Load Amps) | |
| Number of Motor Poles | |

| Encoder Nameplate Data | Value |
|---|---|
| Encoder PPR ( Pulses/Rev ) | |
| Encoder Voltage | |

☐ Keep the encoder cable un-plugged for now. Ensure motor is free to rotate. Remove TB1 and TB2 for now.

☐ Apply Power.

☐ Depress both UP and Down arrows. This will take the display to 0.00.

☐ Set the parameters as follows:

The accel & decel rates selected below are extended to permit running a motor without the need for a DB resistor. However, for faster rates DB will be required.

| Parameter Number | Setting | Comment |
|---|---|---|
| 0.00 | 1254 then the RED button | To enable mode changes |
| 0.48 | Select Servo mode then RED button | |
| 0.00 | 1244 then the RED button | To select USA Defaults |
| 0.02 | Max Motor RPM | Initially set for something less than intended full speed for safety |
| 0.03 | Accel Rate | Initially set for 0.8 |
| 0.04 | Decel Rate | Initially set for 0.8 |
| 0.06 | Symmetrical Current Limit | Initially set for 30-50% |
| 0.42 | Number of motor Poles | From above |
| 0.46 | Motor Full Load Amps | From nameplate |
| 0.00 | 149 to unlock security | To allow general access |
| 3.08 | Max Motor RPM + 100 or 200 | Overspeed Shutdown Point |
| 3.21 | Encoder PPR | From nameplate |
| 3.23 | 0=+5v 1=+10v for Encoder | From nameplate |
| 6.08 | 0 | No Hold at Zero Speed |
| 0.00 | 1000 then the RED button | Store this information thus far |

☐ **Remove main power**

| Caution |
|---|
| After power is removed, the drives fans and display will remain on for several seconds as the +700vdc bus discharges. The Drive contains high voltage capacitors that remain charged to a lethal potential long after the AC supply is disconnected. See Section 2-1 in the User Guide for details- STORED CHARGE |

☐ Plug in the encoder cable. Plug in TB2 with a switch in the off (open) position connected to TB2 pins 30 and 31.

☐ **Re-Apply Power**

Check Encoder for proper operation. Observe parameter #3.27 (Parameter 0.00 will need set to 149 to gain access to menus outside menu 0). It should count up as you rotate the motor shaft CW (and down for CCW rotation) as viewed from the shaft end. The counter should roll over at 16384. Note this shaft position. One revolution should bring the number back to the same point.

☐ If Encoder appears all right with the static checks, you are ready to perform the phasing test. If not, review Initial **Encoder Problems**.

## Encoder Phasing Test

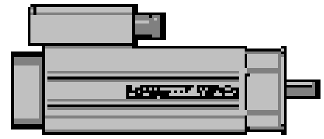
☐ Do the following in the order shown below:

| Parameter Number | Setting | Comment |
|---|---|---|
| 0.40 | 1 | To enable phasing test |
| Close the Enable Switch | Pins 30-31 | |

**Note**: *If the drive is enable prior to the phasing sequence, the motor may lurch and trip with an ENCPH9 error as it has not figured out the commutation information as yet. If one were simply replacing a drive, the originally determined phasing angle could be set manually or by previously recorded file download.*

☐ The Motor should rotate CW (clockwise as view from shaft end) approximately 1 revolution at a low speed and stop. Parameter 0.40 should have returned to a 0 by the drive. If no error messages appear phasing is complete. If the motor rotates CCW, disable the drive, remove power (wait until display goes dark and bus discharges completely) and swap any two motor leads. If an error message appears, consult Phasing **Error Fault Messages**.

## For Servo Motor with Resolver Feedback



Obtain Motor Nameplate Data

Motor FLA (Full Load Amps)
Number of Motor Poles (see page 5 for #poles vs. Motor frame size)

| Motor Nameplate Data | Value |
|---|---|
| Motor FLA ( Full Load Amps) | |
| Number of Motor Poles | |

☐ Determine the resolver turns ratio (primary/secondary)
(see page 9)

☐ Ensure motor is free to rotate. Remove TB1 and TB2 for now.

☐ Apply Power.

☐ Depress both UP and Down arrows. This will take the display to 0.00.

☐ Set the parameters as follows:

The accel & decel rates selected below are extended to permit running a motor without the need for a DB resistor. However, for faster rates DB will be required.

| Parameter Number | Setting | Comment |
|---|---|---|
| 0.00 | 1254 then the RED button | To enable mode changes |
| 0.48 | Select **Servo** mode then RED button | |
| 0.00 | 1244 then the RED button | To select USA Defaults |
| 0.02 | Max Motor RPM | Initially set for something less than intended full speed for safety |
| 0.03 | Accel Rate | Initially set for 0.8 |
| 0.04 | Decel Rate | Initially set for 0.8 |
| 0.06 | Symmetrical Current Limit | Initially set for 30-50% |
| 0.42 | Number of motor Poles | From above |
| 0.46 | Motor Full Load Amps | From nameplate |
| 0.00 | 149 to unlock security | To allow general access |
| 3.08 | Max Motor RPM + 100 or 200 | Overspeed Shutdown Point |
| 16.10 | Resolver turns ratio select | 0 = 3:1, 1 = 2:1 (issue#2 UD53 only) |
| 6.08 | 0 | No Hold at Zero Speed |
| 0.00 | 1000 then the RED button | Store this information thus far |

☐ **Remove main power**

| **Caution** |
|---|
| After power is removed,  the drives fans and display will remain on for several seconds as the +700vdc bus discharges.    The Drive contains high voltage capacitors that remain charged to a lethal potential long after the AC supply is disconnected.  See Section 2-1 in the User Guide for details- STORED CHARGE |

☐ Plug in TB2 with a switch in the off  (open) position connected to TB2 pins 30 and 31.

☐ **Re-Apply Power**

Check Resolver for proper operation.   Observe parameter #16.03 (Parameter 0.00 will need set to 149 to gain access to menus outside menu 0).   It should count up as you rotate the motor shaft CW (and down for CCW rotation) as viewed from the shaft end.  The counter should roll over at 16384.   Note this shaft position.   One revolution should bring the number back to the same point.

☐ If Resolver appears all right with the static checks, you are ready to perform the phasing test.     If not, review Initial **Resolver Problems**.

## Resolver Phasing Test

☐ Do the following in the order shown below:

| Parameter Number | Setting | Comment |
|---|---|---|
| 0.40 | 1 | To enable phasing test |
| Close the Enable Switch | Pins 30-31 | |

**Note**:    *If the drive is enable prior to the phasing sequence, the motor may lurch and trip with an ENCPH9 error as it has not figured out the commutation information as yet.  If one were simply replacing a drive, the originally determined phasing angle could be set manually or by previously recorded file download.*

☐ The Motor should rotate CW (clockwise as view from shaft end) approximately 1 revolution at a low speed and stop.   Parameter 0.40 should have returned to a 0 by the drive.  If no error messages appear phasing is complete.    If the motor rotates CCW, disable the drive, remove power (wait until display goes dark and bus discharges completely) and swap any two motor leads.    If an error message appears, consult **Phasing Error Fault Messages**.

## Running the Motor

If the phasing sequence is successful, one should verify proper drive/motor operation. This can be accomplished without any external devices, just the drive itself. Following the sequence below will allow the **RUN** (Green) and **STOP** (Red) pushbuttons along with the **UP/DOWN** arrows on the front of the drive to control the drive and speed.

| Parameter Number | Setting | Comment |
|---|---|---|
| 6.01 | rP | Set for Ramp Mode |
| 4.12 | 2 | Encoder Filtering |
| 0.05 | 4 | Enable Keypad Operation |
| 0.10 | Depress M ( Mode) | rdY & 0 Should appear |
| Depress the Green (**Run**) button | | |
| Depress **UP** and hold | | Drive should accelerate CW |
| Depress the RED (**Stop**) button | | Drive should decelerate and go off |
| 0.00 | 1000 then the RED button | Store this information thus far |

Parameter 0.10 is the location that one can use the **UP** and **DOWN** arrows to manipulate speed when the display shows run (depress the **M** button)

If the **MOTOR DOES NOT TURN**: Display #0.10 and depress both the UP and DOWN arrows simultaneously. This will bring the reference to zero speed as it is remembered after power down. Remove power (wait for complete discharge) and swap any 2 motor leads and re-try.

| Caution |
|---|
| The drive will remember the last speed it was running should STOP then RUN be depressed later. The last speed is also remembered on a power down as well! It is a good idea to observe #1.17 prior to depressing the GREEN button to see what RPM the drive will go to. If this is not what is desired Display #0.10 and depress both the UP and DOWN arrows simultaneously. This will bring the reference to zero speed as it is remembered after power down. |

## Stability

One may need to adjust #3.10 and #3.11 (Speed Loop Proportional and Integral Gains) to achieve smooth motor stability. See User Guide section 2-20 for details.
If all is well at this point, one could now increase the Current Limit, Max Speed and acceleration/deceleration values as desired.

| Parameter Number | Setting | Comment |
|---|---|---|
| 0.02 | Max Motor RPM | Intended full speed |
| 0.03 | Accel Rate | Per requirements |
| 0.04 | Decel Rate | Per requirements |
| 0.06 | Symmetrical Current Limit | Per requirements |
| 0.00 | 1000 then the RED button | Store this information thus far |

See User Guide section 2-18 for details.

## Basic Setup Options

**Forward/Reverse**

To enable the Forward/Reverse operation from the blue button set #6.13=1

**Zero Speed Hold**

To cause the motor shaft to Hold Locked at Zero Speed after a Stop, you could set #6.08 = 1

## Analog Speed Pot Control

Connect Speed pot as follows:

Clockwise → pin 4
Wiper → pin 7
CCW → pin 11

Enter these parameters

| Parameter Number | Setting | Comment |
|---|---|---|
| 6.04 | 0 | Control Mode |
| 6.11 | 1 | Enable Keypad RUN |
| 6.12 | 1 | Enable Keypad STOP |
| 6.34 | 1 | Run Permit |
| 0.05 | 2 | To select Pot as Reference |

Before running the motor verify that pot reference by observing parameter #1.01 while rotating the pot from full CCW to full CW. Parameter #1.01 should go from 0 to your intended full RPM reference. If it is backwards, re-check your pot wiring. If it is the wrong RPM you desire, adjust #0.02.

**Note:**

If power is turned off after you ran per the above table, one would need to manually reset #6.34=1 (Run Permit).

If one sets #0.29=6.34 (followed by the RED reset button) and place a jumper between pins 29 and 31, the need to reset #6.34 =1 after power-up can be bypassed.

## Simple Shaft Orientation

This will cause the motor shaft to rotate to a specific location upon a STOP command. This location is adjustable.

| Parameter Number | Setting | Comment |
|---|---|---|
| 6.08 | 1 | To Hold shaft a zero after stop |
| 13.08 | 6 | To set for orient mode |
| 13.11 | Your desired shaft position | |

| Caution |
|---|
| When in mode 6 of the position control mode, the motor will orientate (rotate) to the orientation setpoint:<br><br>- Upon Power-Up<br>- Upon Closure of TB2 30-31 Enable<br>- If RUN (Green) then STOP (red) is depressed (if #6.34 Run Permit=1) |

**Initial Encoder Problems**

- If it counts and rolls over but only counts to 8192, re-check the encoder PPR value and parameter #3.21 setting. This would occur is the encoder was actually a 2048PPR but one set in 4096 for instance.

- If it counts but requires 2 revolutions to roll over, re-check the encoder PPR value and parameter #3.21 setting. This would occur is the encoder was actually a 2048PPR but one set in 1024 for instance.

- If #3.27 does not count --- re-check encoder wiring.
- Specifically channels A, /A and B, /B and power supply.
- Measure the supply

- If it counts but counts down rather than up for CW rotation. Swap A and /A. Re-check.

**Initial Resolver Problems**

- If it counts but counts down rather than up for CW rotation. Swap EITHER Sin High and Low OR Cos High and Low.

**Servo Phasing Sequence Errors**

See Appendix E in User Guide and the UD53 Users Guide (if a resolver is used)

## 6. Application Information

### 6.1 Winding Configurations:

The windings in a Pactorq™ Synchronous Servomotor are very similar to what you would find on a standard ac induction motor. In general, you will either have 12 or 9 motor connections available in the motor conduit box. In the US, most induction machines have 9 connections, which allow the motor to have either a 230 or a 460-volt winding (1Y – 460vac, 2Y – 230vac). Motors having 12 connections are the most flexible since the motor can be wired as a 1Y, 2Y, 1D or 2D (y – Wye, D- Delta). The motor tested in this evaluation was provided with 12 connections and the following specifications:

| | |
|---|---|
| Model Number: | E18EHJ1002180000 |
| Frame: | E184TZ |
| Horsepower: | 23.7 |
| Rated RPM: | 1750 |
| Rated Current: | 32 amps |
| Number Poles: | 6 |
| Bus Voltage: | 640 vdc |
| Ke: | 232 V/1000Rpm (motor voltage constant) |
| Winding: | 1D (delta) |

Given the above specifications and the fact that the motor is supplied with 12 connections, how would the motor speed and voltage levels change for the various winding configurations. From the name plate information, the motor winding is set up as a 1D and has a voltage constant of 232 volts per 1000 rpm. Therefore, the motor rated phase to phase voltage at rated speed would be:

$$\frac{1750\text{ (RPM) X }232\text{ (volts/1000 RPM)}}{1000} = \mathbf{406\ vac}$$

Since the motor is a 6-pole design, the required applied frequency to achieve 1750 RPM would be computed as follows:

$$\text{Ns (synchronous speed)} = \frac{120 \text{ X } F}{P} \qquad P = \text{\# Poles}$$

$$1750 = \frac{120 \text{ X } F}{6} \text{ --------- } \quad F = 87.5 \text{ Hz}$$

From the above information, we now know that if 406 vac at 87.5 HZ is applied to motor terminals, the motor will rotate at 1750RPM. Since the motor has a permanent magnet rotor, if the motor is rotated by some external source, it will generate 406 vac at 87.5 Hz at its terminals. The winding connection diagram is shown below.

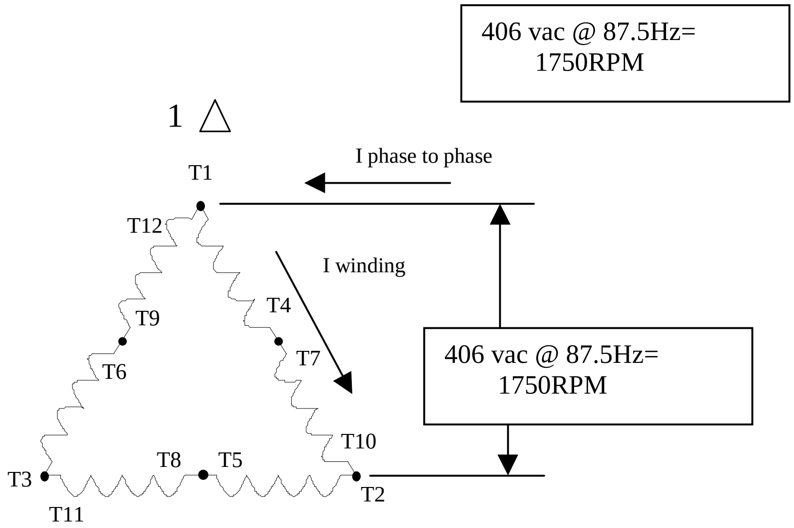
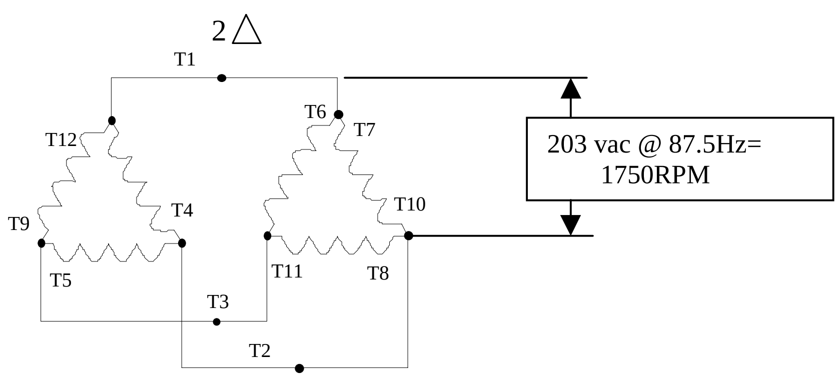



Figure #1

It is readily apparent from figure #1 that 203 vac is applied (or developed) across each winding (T1 – T4 and T7 – T10). Therefore, the basic design of this machine is 203 vac @ 87.5 Hz for each winding and the winding current required to produce rated torque is equal to the phase to phase current divided by the square root of three (32/√3 = 18.475 amps). Knowing this, the rated voltage, rated speed and phase to phase currents (drive output current) for the various windings can be determined.

If the windings were paralleled, as they would be for a 2D winding, the rated voltage for rated speed (1750 RPM) would be 203 vac. This winding configuration is shown in figure #2 below.




Keep in mind that this winding configuration would require two times rated current (64 amps) to supply rated horsepower (23.7).

The next winding configuration is the 2Y shown if figure #3 below. The rated terminal voltage for this winding would be equal to the square root of 3, times the 2D rated voltage. This works out to 351.6 vac.

2⅄

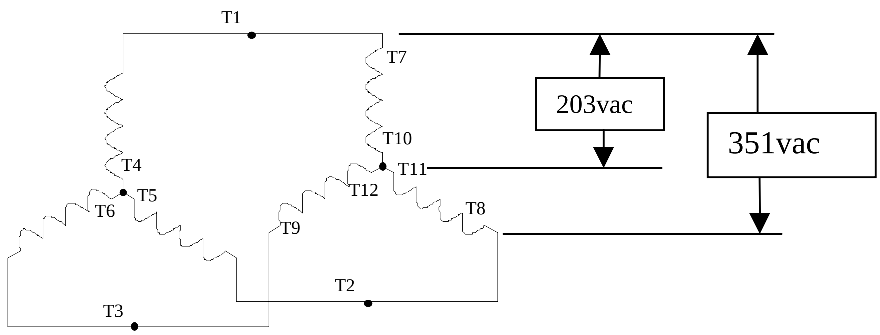



Figure #3

This configuration would also require more than rated motor nameplate current to achieve rated horsepower. The relationship would be the ratio of the 1D phase to phase voltage to the 2Y phase to phase voltage times the 32 amp rating, or 406/351.6 times 32 amps (or 37amps).

The final configuration, the 1Y, would require the highest applied terminal voltage. Figure #4 below shows this configuration. The voltage required to achieve rated speed would be the square root of 3 times the 1D phase to phase voltage.

1⅄

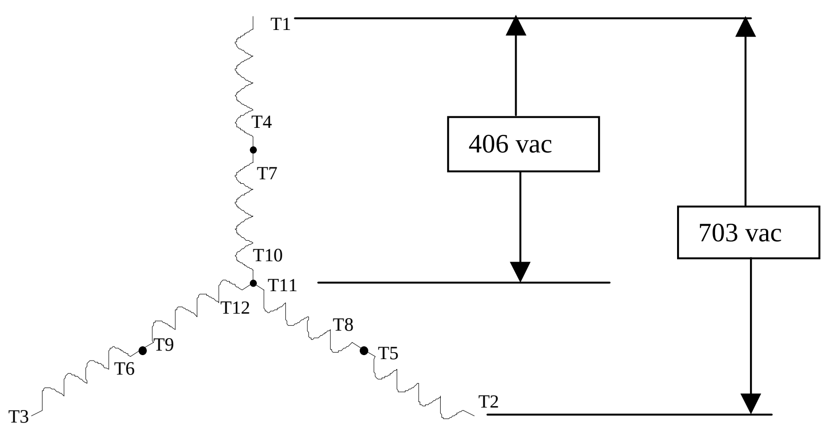



Figure #4

Obviously, the limit in this case is the maximum output of the Unidrive, which would be 460 vac. The rated current would be 18.475 amps (winding current) but the maximum horsepower would be equal to 460/703 times 23.7, which would be 15.5 HP due to the maximum output voltage (max rpm = 460/703 X 1750 =1145).

In summary, the motor ratings for the various winding configurations would be:

| | 1-Δ* | 2-Δ | 1-Y | 2-Y |
|---|---|---|---|---|
| Rated Voltage | 406 vac | 203 vac | 703 vac | 351.6 vac |
| Rated Current | 32 amps | 64 amps | 18.475 amps | 36.9 amps |
| Rated Speed | 1750 | 1750 | 1145** | 1750 |

* Motor nameplate values
** due to max output voltage of Unidrive (460 vac)
Note: Rated Voltage are no load levels

The advantage of the additional windings would be either an increase in motor speed (2-Δ and 2-Y) but an increase in drive size or a decrease in motor speed (1-Y) but a smaller drive. The optimal configuration would be where the winding voltage (phase to phase) is closest to the drive's maximum output voltage.

## 6.2 Motor Phasing Test:

When the Unidrive is run with either a Synchronous AC Servo Motor or a Brushless DC Servo Motor, the drive must know the position of the motor rotor with respect to the position of the generated rotating field. This is critical since torque control (and therefore current control) is based on the phase difference between these two entities. At a no load condition, the rotating field and the rotor pole will be in phase. The magnitude of the applied phase to phase voltage and the generated voltage from the rotor will be virtually equal. In a motoring or regenerating condition, the phase relationship (of the rotating field with respect to the rotor field) will either be leading or lagging.

The Unidrive has a built in routine for finding the null position of a resolver or the point at which the "U" phase hall effect (or Grey code) toggles. This information along with a known position of the permanent magnet rotor allows the drive to always track the position of the rotor with respect to the rotating field. The Unidrive assumes the motor stator winding is "wye" connected, but this is understandable since Control Techniques ServoMotors are always "wye" connected. The following paragraphs and diagrams will show what happens during the phasing tests.

The first step in the test is to apply a dc voltage to phase U with phases V and W tied together. In the "wye connected motor (see figure #5), the permanent magnet rotor will align itself perpendicular to the U (a) phase windings due to the magnetic field generated by passing dc current through all three windings as shown.

The second step is to step the motor in the clockwise direction until the drive sees either the null point of the resolver or the "U" phase of the Hall effect sensor toggle (and the V Phase high and the W phase low). The drive will store the distance traveled.

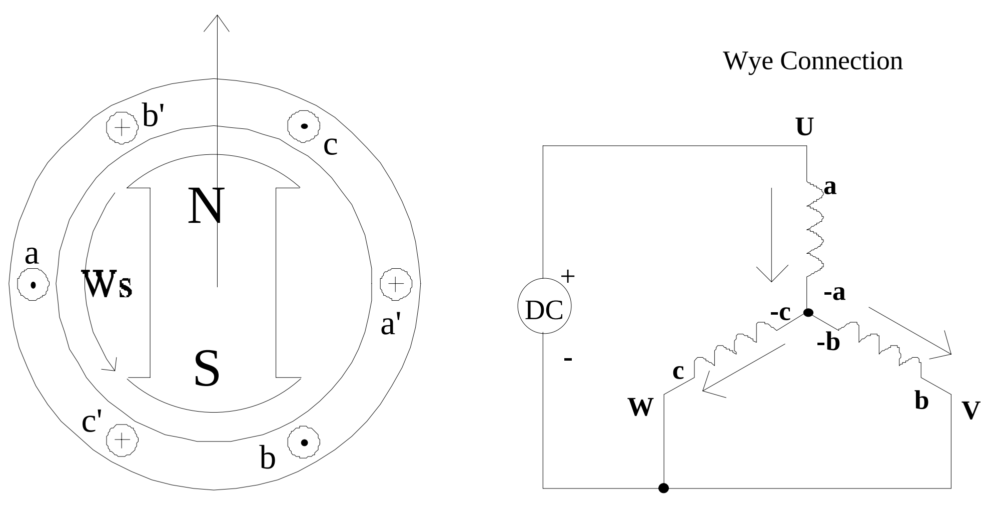



Figure #5

When the phase testing is preformed on the “delta” winding, the results are shown in figure#6.

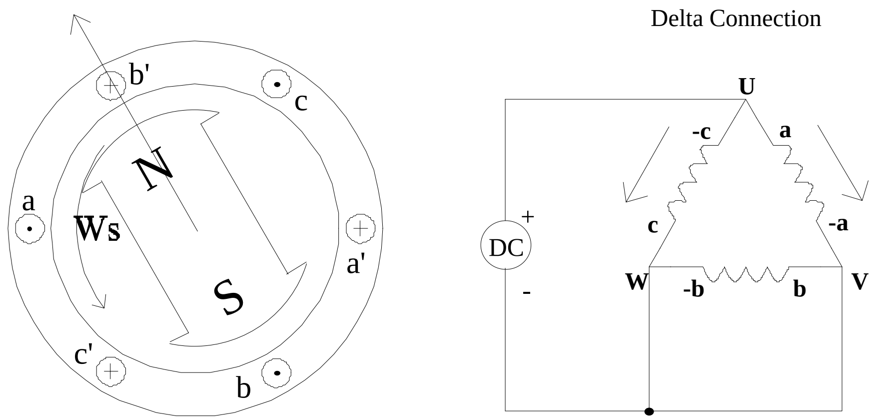
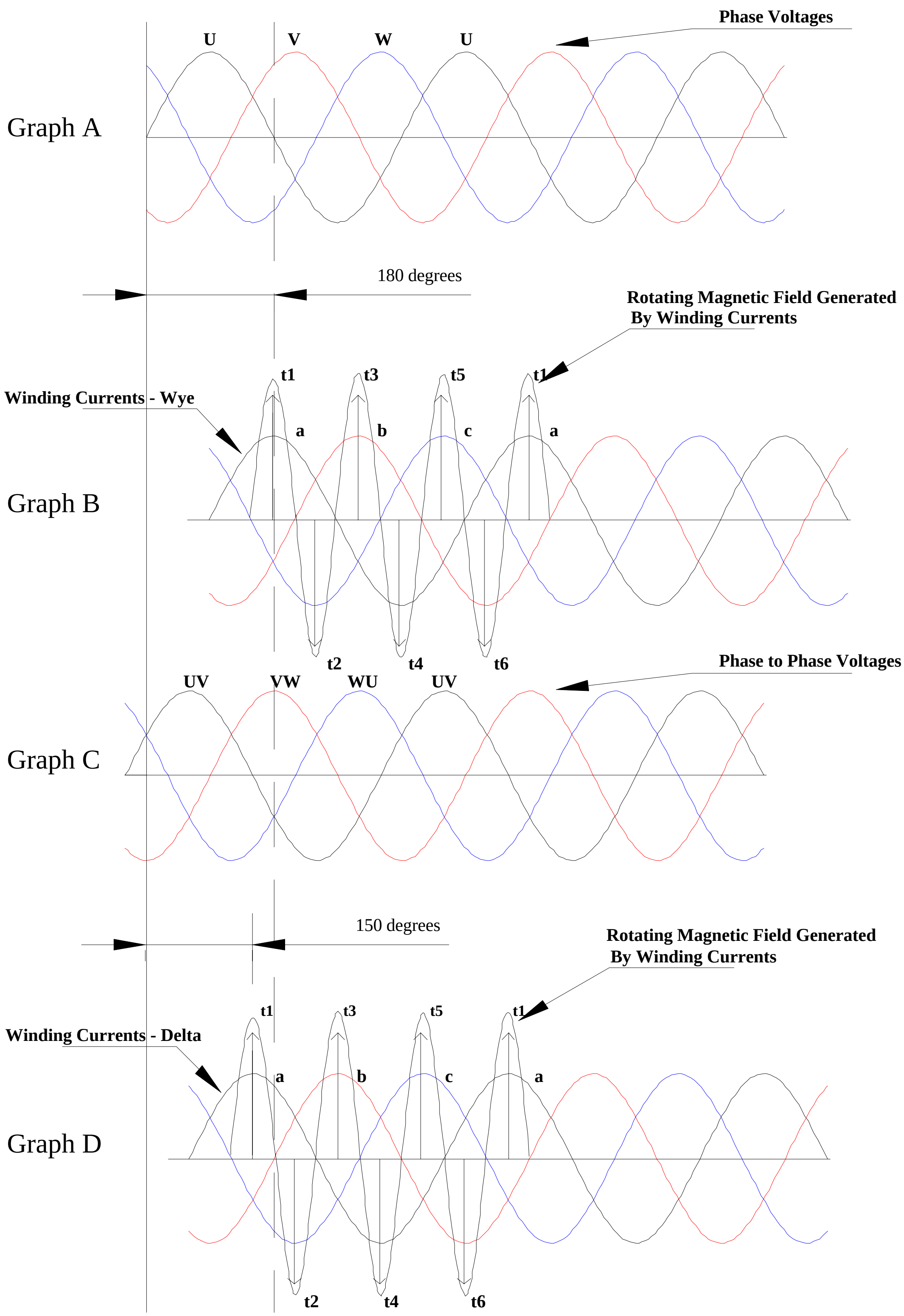



Figure #6

Note that in this case that the initial alignment of the permanent magnet rotor of the “delta” winding motor is 30 degrees off from the “wye” connected motor. When the drive looks for the null point, the distance will be different. This distance is stored in parameter #3.28, Phase Position when the encoder (with grey code signals) is used for feedback and it is stored in parameter #16.09, Resolver phase offset, when a Resolver is used for feedback. The value that is stored is a number from 0 to 6143. This number represents one full revolution of the motor.

The question at hand is whether or not the rotor position as determined by the phase offset test, is correct for a “delta” connected motor. It is assumed that the position is correct for the “wye” connected motor since it was designed for it.

In order to make this determination, two evaluations (test#1 and test#2) were performed. The first was a graphical method where the stator-rotating field was plotted with respect to time for both the “wye” and “delta” connected motors. The second was an analytical test where, after running the phase offset test, the motor was run in the positive and negative directions while the phase offset was increased and decreased by 100 count increments and the motor voltage was recorded. If the phase offset was correctly determined by the test, the motor voltage would be equal in both directions at the same rpm. The results were then plotted.


Phase Voltages
U
V
W
U
Graph A
180 degrees
Rotating Magnetic Field Generated
By Winding Currents
t1
t3
t5
t1
Winding Currents - Wye
a
b
c
a
Graph B
t2
t4
t6
Phase to Phase Voltages
UV
VW
WU
UV
Graph C
150 degrees
Rotating Magnetic Field Generated
By Winding Currents
t1
t3
t5
t1
Winding Currents - Delta
a
b
c
a
Graph D
t2
t4
t6

## Test #1

There are four graphs shown on page #10. Graph A shows the output phase to neutral voltages of the Unidrive while Graph C shows the resultant phase to phase voltages. Graphs B and D show the spatial position in time of the rotating field generated by the "wye" windings and the "delta" windings.

The graphs of the rotating fields clearly shows that the field generated by the "delta" windings leads the field generated by the "wye" windings (reference t1 of graph B verses t1 of graph d). This is exactly where the phase test determines it to be! If one follows the dotted line down from t1 on graph b to the winding currents-delta, you will see that phase b current is zero at that point in time which is the same as is in the phase test.

## Test #2

In case #1, the motor was configured with a "wye" winding arrangement and the feedback device was a resolver. The initial result of the phase-offset test was 2600 in parameter #16.09.

In case #2, the motor was configured with a "delta" winding arrangement and the feedback device was a resolver. The initial result of the phase-offset test was 3208 in parameter #16.09.

In both cases the motor was then run to the same speed in both directions while the offset value was increased and decreased by100 counts while recording the drive output voltage (#5.02).

The graphs and tables clearly show that the Unidrive Phase test correctly determines the proper offset value.

Case #1

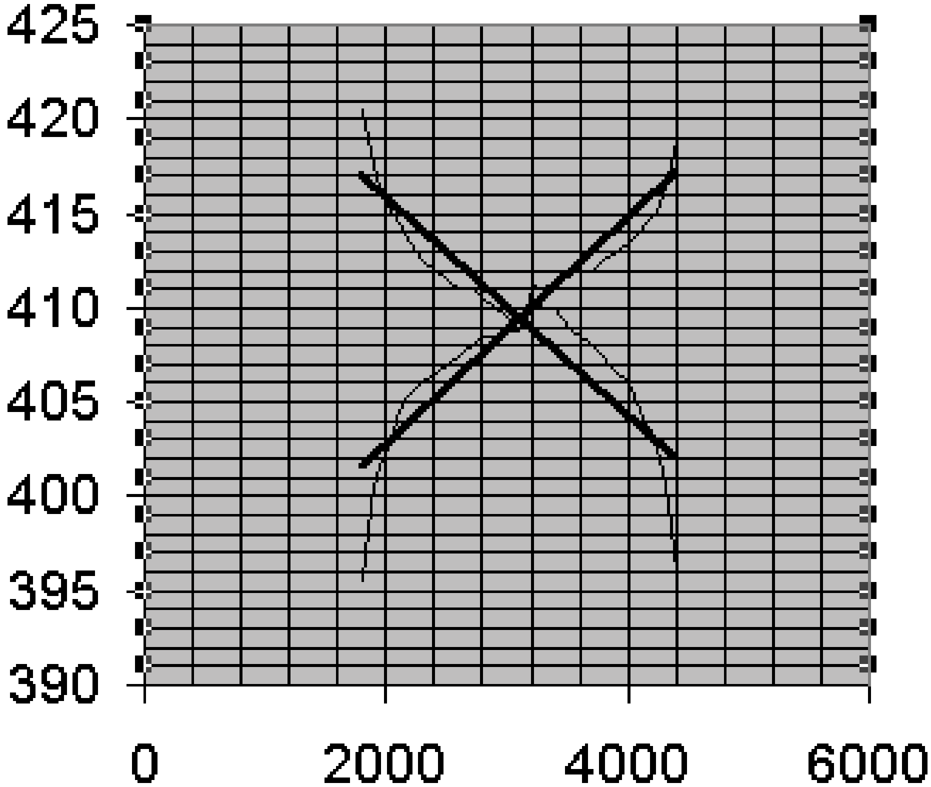
| #16.09 | (+)5.02 | (-)5.02 |
|---|---|---|
| 1808 | 420.5 | 395.5 |
| 1908 | 417.5 | 400.5 |
| 2008 | 415.5 | 402.5 |
| 2108 | 414.5 | 404.5 |
| 2208 | 413.5 | 405.5 |
| 2308 | 412.5 | 406 |
| 2408 | 412 | 406.5 |
| 2508 | 411.5 | 407 |
| 2608 | 411 | 407.5 |
| 2708 | 411 | 408 |
| 2808 | 410.5 | 408.5 |
| 2908 | 410 | 408.5 |
| 3008 | 409.5 | 409 |
| 3108 | 409 | 409 |
| 3208 | 410.5 | 411 |
| 3308 | 410 | 411 |
| 3408 | 410 | 411.5 |
| 3508 | 409 | 412 |
| 3608 | 408.5 | 412 |
| 3708 | 408 | 412 |
| 3808 | 407.5 | 412.5 |
| 3908 | 406.5 | 413 |
| 4008 | 406 | 413.5 |
| 4108 | 404.5 | 414 |
| 4208 | 403 | 415 |
| 4308 | 400.5 | 416.5 |
| 4408 | 396 | 419 |

Phase
Test
Values

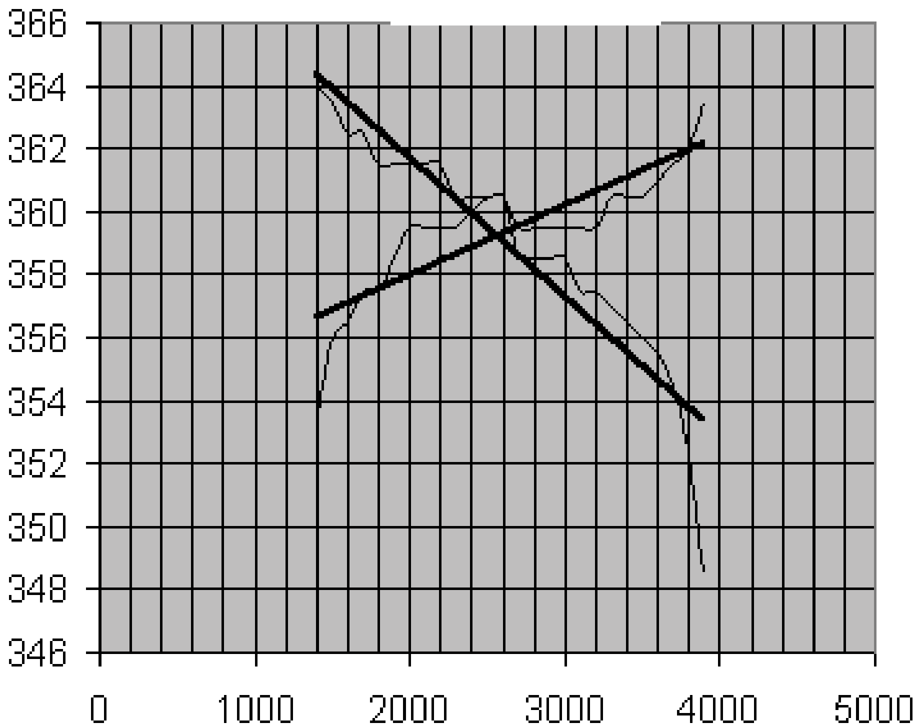
Case #2

| #16.09 | (+)5.02 | (-)5.02 |
|---|---|---|
| 1400 | 364 | 353.5 |
| 1500 | 363.5 | 356 |
| 1600 | 362.5 | 356.5 |
| 1700 | 362.5 | 357.5 |
| 1800 | 361.5 | 357.5 |
| 1900 | 361.5 | 358.5 |
| 2000 | 361.5 | 359.5 |
| 2100 | 361.5 | 359.5 |
| 2200 | 361.5 | 359.5 |
| 2300 | 360.5 | 359.5 |
| 2400 | 360.5 | 360 |
| 2500 | 360.5 | 360.5 |
| 2600 | 360.5 | 360.5 |
| 2700 | 358.5 | 359.5 |
| 2800 | 358.5 | 359.5 |
| 2900 | 358.5 | 359.5 |
| 3000 | 358.5 | 359.5 |
| 3100 | 357.5 | 359.5 |
| 3200 | 357.5 | 359.5 |
| 3300 | 357 | 360.5 |
| 3400 | 356.5 | 360.5 |
| 3500 | 356 | 360.5 |
| 3600 | 355.5 | 361 |
| 3700 | 354.5 | 361.5 |
| 3800 | 352.5 | 362 |
| 3900 | 348.5 | 363.5 |

Case #1


425
420
415
410
405
400
395
390
0
2000
4000
6000

Case #2


366
364
362
360
358
356
354
352
350
348
346
0
1000
2000
3000
4000
5000

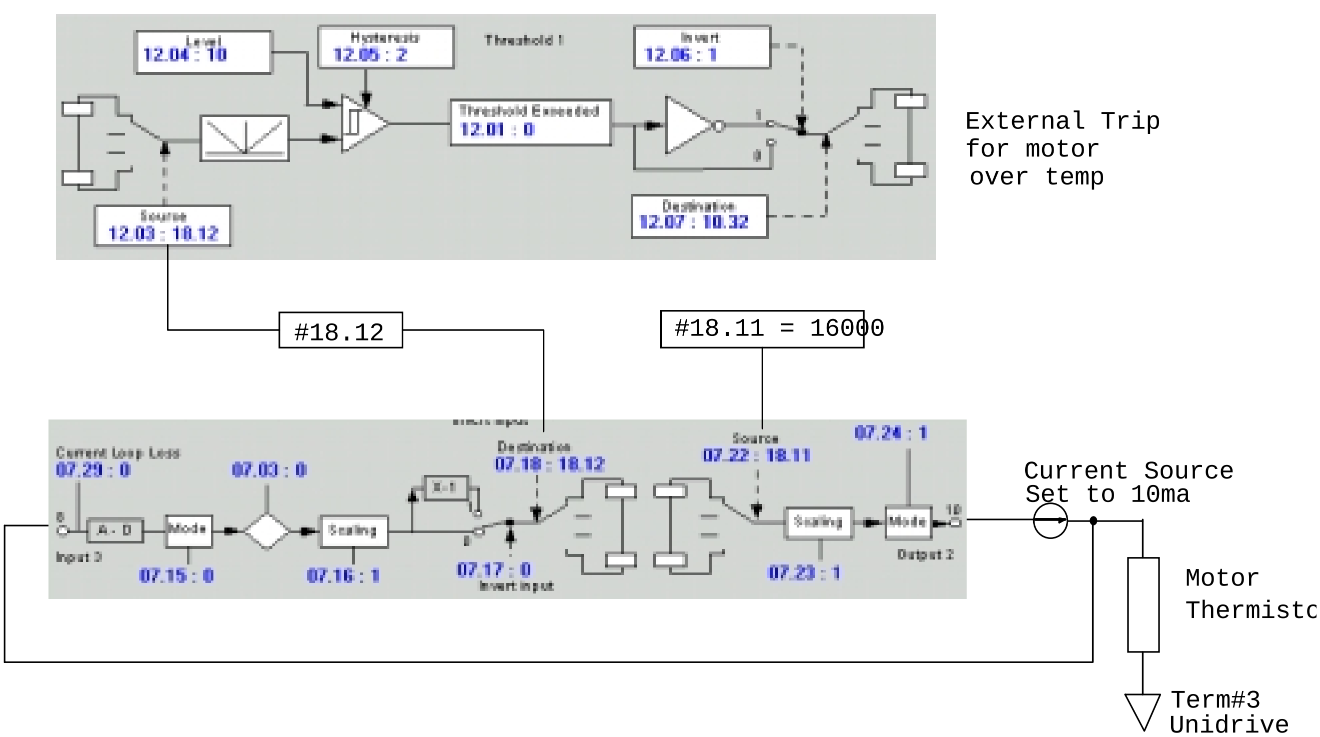
## 6.3 Motor Thermal Protection

There have been two types of thermal protection provided on the brushless servomotors.

If the motor was supplied with the Hall sensor feedback, which was the case for the **Powertec Brushless DC** motors, the thermal protection was based on a thermal switch. This switch can simply be placed in series with the stop or enable circuit.

If the motor was supplied with a resolver, which is typically the case with the **PacTorq™ Brushless Servomotor**, the thermal protection was based on a NTC (negative temperature coefficient) thermistor (some of the newer units may have a thermal switch). The Unidrive thermistor input was designed around a PTC (positive temperature coefficient) and is therefore unusable. A “work around” for this is to use the comparators in Unidrive menu #12 and an analog output (set for 0 to 20ma mode) to create a circuit to sense over-temperature in the motor windings. The trip value for this resistor is 104.2 ohms (for a totally enclosed motor) and 150.5 ohms (for a blower-ventilated motor). This corresponds to 145 degrees and 130 degrees respectively. Below is an example “circuit” demonstrating how the motor thermal protection can be achieved.

**Register #18.11** sets the current source output, 32000 approximately equals 20ma.
**Register #12.04** sets the trip level of the comparator. It is in percent of the maximum from the source register. (100 would equal 10vdc at term # 8)



## 6.4 Dynamic Braking / Regeneration

The majority of Powertec Industrial Motors (Powertec) drives are on non-regenerative applications. In some instances though, the Genesis drives were supplied with a separate braking unit. This unit is not required with Unidrive. The Unidrive has a built in braking transistor. The brake resistor (used with the Genesis braking module or Millennium Drive) may or may not be useable with the Unidrive. This depends upon the ohmic value of the resistor. The table below gives the minimum resistance value allowable for each model of Unidrive. For additional assistance in selecting the appropriate braking resistor, contact your local CT Drive/Application Center.

| MODEL | MINIMUM RESISTANCE |
|---|---|
| UNI 1401 – UNI 1405 | 40 OHMS |
| UNI 2401 | 40 OHMS |
| UNI 2402, UNI2403 | 30 OHMS |
| UNI 3401 – UNI3405 | 10 OHMS |
| UNI 4401 – UNI 4405 | 5 OHMS |
| UNI 5401 | CONSULT FACTORY |

## 6.5 FAQ's

1. Can a Brushless DC or Synchronous AC motor be operated at speeds in excess of the nameplate base speed?

   Yes the motor can be run at speeds in excess of nameplate base speed provided the following constraints are not exceeded.

   a) The mechanical limits of the motor.
   Each particular frame size will have a maximum speed limit typically based on the diameter of the rotor. Refer to Powertec Industrial Motors for these limits.

   b) The maximum output voltage of the drive.
   Since these motors have permanent rotors, the generated voltage will be linearly proportional to the motor speed. In order to produce current (and thus torque), the supply voltage must be slightly greater than the generated voltage. The maximum motor speed is therefore approximately equal to the maximum output voltage divided by the motor voltage constant (Ke) times 1000. This speed must also not exceed the limit in (a) above.
   Using the nameplate data on page 24, the maximum speed using a Unidrive operating on 480vac would be (460/232) x 1000 = 1980 rpm. Since this is an E180 frame, the mechanical limit is 6000 rpm. If the required speed is greater than 1980, the motor winding could be reconfigured for either a 2-Y or 2-D (2280 or 3965 rpm) but a higher current Unidrive would be required.