CONTROL TECHNIQUES

Epsilon Eb and EN Drives

Reference Manual

P/N 400501-01
Revision: A4
Date: October 8,2001

EMERSON
Industrial Automation

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Printed in United States of America

This document has been prepared to conform to the current released version of the product. Because of our extensive development efforts and our desire to further improve and enhance the product, inconsistencies may exist between the product and documentation in some instances. Call your customer support representative if you encounter an inconsistency.

Customer Support

Control Techniques
12005 Technology Drive
Eden Prairie, Minnesota 55344-3620
U.S.A.

Telephone: (952) 995-8000 or (800) 397-3786

It is Control Techniques' goal to ensure your greatest possible satisfaction with the operation of our products. We are dedicated to providing fast, friendly, and accurate assistance. That is why we offer you so many ways to get the support you need. Whether it's by phone, fax or modem, you can access Control Techniques support information 24 hours a day, seven days a week. Our wide range of services include:

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Control Techniques' "Motion Made Easy" products are backed by a team of professionals who will service your installation. Our technical support center in Eden Prairie, Minnesota is ready to help you solve those occasional problems over the telephone. Our technical support center is available 24 hours a day for emergency service to help speed any problem solving. Also, all hardware replacement parts, if needed, are available through our customer service organization.

When you call, please be at your computer, with your documentation easily available, and be prepared to provide the following information:

- Product version number, found by choosing About from the **Help** menu
- The type of controller or product you are using

- Exact wording of any messages that appear on your screen
- What you were doing when the problem occurred
- How you tried to solve the problem

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Authorized Control Techniques distributors may place orders directly with our Customer Service department. Contact the Customer Service department at this number for the distributor nearest you.

Document Conventions

Manual conventions have been established to help you learn to use this manual quickly and easily. As much as possible, these conventions correspond to those found in other Microsoft® Windows® compatible software documentation.

Menu names and options are printed in bold type: the **File** menu.

Dialog box names begin with uppercase letters: the Axis Limits dialog box.

Dialog box field names are in quotes: "Field Name."

Button names are in italic: *OK* button.

Source code is printed in Courier font: `Case ERMS`.

In addition, you will find the following typographic conventions throughout this manual.

This	Represents
bold	Characters that you must type exactly as they appear. For example, if you are directed to type **a:setup**, you should type all the bold characters exactly as they are printed.
italic	Placeholders for information you must provide. For example, if you are directed to type *filename*, you should type the actual name for a file instead of the word shown in italic type.
ALL CAPITALS	Directory names, file names, key names, and acronyms.
SMALL CAPS	Non-printable ASCII control characters.
KEY1+KEY2 example: (Alt+F)	A plus sign (+) between key names means to press and hold down the first key while you press the second key.
KEY1,KEY2 example: (Alt,F)	A comma (,) between key names means to press and release the keys one after the other.

⚠WARNING

"Warning" indicates a potentially hazardous situation that, if not avoided, could result in death or serious injury.

⚠CAUTION

"Caution" indicates a potentially hazardous situation that, if not avoided, may result in minor or moderate injury.

CAUTION

"Caution" used without the safety alert symbol indicates a potentially hazardous situation that, if not avoided, may result in property damage.

Note

For the purpose of this manual and product, "Note" indicates essential information about the product or the respective part of the manual.

Epsilon Only

For the purpose of this manual and product, the "Epsilon" symbol indicates information about the Epsilon drive specifically.

EN

EN Only

For the purpose of this manual and product, the "EN" symbol indicates information about the EN drive specifically.

Throughout this manual, the word "drive" refers to an Epsilon or EN drive.

Safety Instructions

General Warning

Failure to follow safe installation guidelines can cause death or serious injury. The voltages used in the product can cause severe electric shock and/or burns and could be lethal. Extreme care is necessary at all times when working with or adjacent to the product. The installation must comply with all relevant safety legislation in the country of use.

Qualified Person

For the purpose of this manual and product, a "qualified person" is one who is familiar with the installation, construction and operation of the equipment and the hazards involved. In addition, this individual has the following qualifications:

- Is trained and authorized to energize, de-energize, clear and ground and tag circuits and equipment in accordance with established safety practices.
- Is trained in the proper care and use of protective equipment in accordance with established safety practices.
- Is trained in rendering first aid.

Reference Materials

The following related reference and installation manuals may be useful with your particular system.

- *PowerTools Software User's Guide* (P/N 400503-01)
- *FM-1 Speed Module Reference Manual* (P/N 400506-01)
- *FM-2 Indexing Module Reference Manual* (P/N 400507-01)
- *FM-3 Programming Module Reference Manual* (P/N 400508-01)
- *FM-4 Programming Module Reference Manual* (P/N 400509-01)
- *FM-3 and FM-4 DeviceNet Module Reference Manual* (P/N 400508-03)
- *RSR-2 Regen Regulator Installation Manual* (400513-01)
- *Flexible Cables Reference Manual* (400512-01)
- *ALP-130 and ALP-430 Installation Manual* (400514-01)
- *Drive Parameters Reference Manual* (400504-01)

Underwriters Laboratories Listed

LISTED 51Y8
IND. CONT. EQ.

The Epsilon and EN Digital Servo Drives are marked with the “UL Listed” label after passing a rigorous set of design and testing criteria developed by UL (UL508C). This label indicates that UL certifies this product to be safe when installed according to the installation guidelines and used within the product specifications.

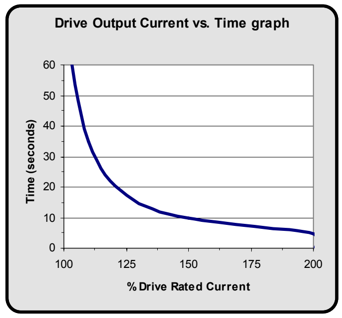
The “conditions of acceptability” required by UL are:

- The drive surrounding air ambient temperature must be 40° C (104° F) or less.
- Epsilon and EN drive surrounding air ambient temperature can be up to 50°C (122° F) with 3% linear derating for every degree above 40° C (104° F)
- This product is suitable for use on a circuit of delivering not more than 5000 RMS symmetrical amperes, 240 volts maximum.
- Motors must incorporate an overload protection device such as an overtemperature switch.

Drive Overload Protection

The drive output current overload protection is provided by the drive and is not adjustable. This overload protection is based on maximum continuous output current capacity. It will allow up to 200 percent of the drive rated current to be delivered for the amount of time determined by the following chart.

Rated output current (Amps RMS)		
Drive Model	**Continuous**	**Peak**
EN-204	4.5	9
EN-208	9	18
EN-214	13	26
Eb-202	1.8	3.6
Eb-203	3	6
Eb-205	5.0	10.0



CE Declaration of Conformity

The Epsilon and EN Digital Servo Drives are marked with the “Conformite Europeenne Mark” (CE mark) after passing a rigorous set of design and testing criteria. This label indicates that this product meets safety and noise immunity and emissions (EMC) standards when installed according to the installation guidelines and used within the product specifications.

Declaration of Conformity	
Manufacturer's Name:	Control Techniques
Manufacturer's Address:	12005 Technology Drive Eden Prairie, MN 55344 USA

Declares that the following products:

Products Description:	Epsilon Series Digital Servo Drive
Model Number:	Eb-202, Ei-202, Eb-203, Ei-203, Eb-205 and Ei-205
System Options:	This declaration covers the above products with the ECI-44 Screw Terminal Interface.

Conforms to the following product specification:

Electomagnetic Compatibility (EMC):

EN 55011/1991 Class A Group 1, CISPR 11/1990 Class A Group 1

EN 61800-3, 1996:	IEC 1000-4-2/1995; EN 61000-4-2, 6kV CD IEC 1000-4-3/1995; EN 61000-4-3, ENV 50140/1993, 80% AM, 10V/m @ 3 m IEC 1000-4-4/1995; EN 61000-4-4, 2 kV ALL LINES EN 61000-4-5, 1kV L-L, 2kV L-G EN 61000-4-11, 300 ms/1000 ms 100% DIP ENV 50204/1995, Pulse, 900 MHz, 50% DTY, 200 Hz

Supplementary information:

The products herewith comply with the requirements of the Low Voltage Directive (LVD) 73/23/EEC and EMC Directive 89/336/EEC

This electronic drive product is intended to be used with an appropriate motor, electrical protection components and other equipment to form a complete end product or system. It must only be installed by a professional assembler who is familiar with requirements for safety and electromagnetic compatibility ("EMC"). The assembler is responsible for ensuring that the end product or system complies with all the relevant laws in the country where it is to be used. Refer to the product manual for installation guidelines.

Bradley Schwartz/ VP Engineering	**September 28, 1999** Date

European Contact:	Sobetra Automation Langeveldpark Lot 10 P. Dasterleusstraat 2 1600 St. Pieters Leeuw, Belgium

Declaration of Conformity

Manufacturer's Name: Control Techniques

Manufacturer's Address: 12005 Technology Drive
Eden Prairie, MN 55344
USA

Declares that the following products:

Products Description: E Series Digital Servo Drive

Model Number: EN-204, EN-208 and EN-214

System Options: This declaration covers the above products with the ALP-130 Backup Logic Power Supply and ECI-44 Screw Terminal Interface.

Conforms to the following product specification:

Electomagnetic Compatibility (EMC):

EN 55011/1991 Class A Group 1, CISPR 11/1990 Class A Group 1

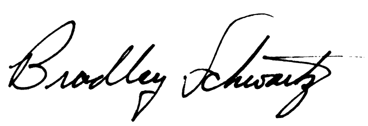
EN 50082-2/1995:

IEC 1000-4-2/1995; EN 61000-4-2, 4kV CD
IEC 1000-4-3/1995; EN 61000-4-3, ENV 50140/1993, 80% AM, 10V/m @ 3 m
IEC 1000-4-4/1995; EN 61000-4-4, 2 kV ALL LINES
IEC 1000-4-8/1993; EN 61000-4-8, 30 A/m
ENV 50141/1993, 80% AM, 10V, .15-80 MHz
ENV 50204/1995, Pulse, 900 MHz, 50% DTY, 200 Hz

Supplementary information:

The products herewith comply with the requirements of the Low Voltage Directive (LVD) 73/23/EEC and EMC Directive 89/336/EEC

This electronic drive product is intended to be used with an appropriate motor, electrical protection components and other equipment to form a complete end product or system. It must only be installed by a professional assembler who is familiar with requirements for safety and electromagnetic compatibility ("EMC"). The assembler is responsible for ensuring that the end product or system complies with all the relevant laws in the country where it is to be used. Refer to the product manual for installation guidelines.



December 2, 1997

Bradley Schwartz/ VP Engineering

Date

European Contact: Sobetra Automation
Langeveldpark Lot 10
P. Dasterleusstraat 2
1600 St. Pieters Leeuw, Belgium

Safety Considerations

Safety Precautions

This product is intended for professional incorporation into a complete system. If you install the product incorrectly, it may present a safety hazard. The product and system may use high voltages and currents, carry a high level of stored electrical energy, or are used to control mechanical equipment that can cause injury.

You should give close attention to the electrical installation and system design to avoid hazards either in normal operation or in the event of equipment malfunction. System design, installation, commissioning and maintenance must be carried out by personnel who have the necessary training and experience. Read and follow this safety information and the instruction manual carefully.

Enclosure

This product is intended to be mounted in an enclosure that prevents access except by trained and authorized personnel and that prevents the ingress of contamination. This product is designed for use in an environment classified as pollution degree 2 in accordance with IEC664-1. This means that only dry, non-conducting contamination is acceptable.

Setup, Commissioning and Maintenance

It is essential that you give careful consideration to changes to drive settings. Depending on the application, a change could have an impact on safety. You must take appropriate precautions against inadvertent changes or tampering. Restoring default parameters in certain applications may cause unpredictable or hazardous operation.

Safety of Machinery

Within the European Union all machinery in which this product is used must comply with Directive 89/392/EEC, Safety of Machinery.

The product has been designed and tested to a high standard, and failures are very unlikely. However the level of integrity offered by the product's control function – for example stop/start, forward/reverse and maximum speed – is not sufficient for use in safety-critical applications without additional independent channels of protection. All applications where malfunction could cause injury or loss of life must be subject to a risk assessment, and further protection provided where needed.

⚠WARNING

General warning

Failure to follow safe installation guidelines can cause death or serious injury. The voltages used in this unit can cause severe electric shock and/or burns, and could be lethal. Extreme care is necessary at all times when working with or adjacent to this equipment. The installation must comply with all relevant safety legislation in the country of use.

AC supply isolation device

The AC supply must be removed from the drive using an approved isolation device or disconnect before any servicing work is performed, other than adjustments to the settings or parameters specified in the manual. The drive contains capacitors which remain charged to a potentially lethal voltage after the supply has been removed. Allow at least 6 minutes for Epsilon 205, 3 minutes for Epsilon 202/203 and 30 seconds for EN drives after removing the supply before carrying out any work which may involve contact with electrical connections to the drive.

Products connected by plug and socket

A special hazard may exist where the drive is incorporated into a product which is connected to the AC supply by a plug and socket. When unplugged, the pins of the plug may be connected to the drive input, which is only separated from the charge stored in the bus capacitor by semiconductor devices. To avoid any possibility of electric shock from the pins, if they are accessible, a means must be provided for automatically disconnecting the plug from the drive (e.g., a latching contactor).

Grounding (Earthing, equipotential bonding)

The drive must be grounded by a conductor sufficient to carry all possible fault current in the event of a fault. The ground connections shown in the manual must be followed.

Fuses

Fuses or over-current protection must be provided at the input in accordance with the instructions in the manual.

Isolation of control circuits

The installer must ensure that the external control circuits are isolated from human contact by at least one layer of insulation rated for use at the applied AC supply voltage.

Table of Contents

Introduction

Epsilon Eb and EN Drives

The Epsilon Eb and EN drives are stand-alone, fully digital brushless servo drives designed and built to reliably provide high performance and flexibility without sacrificing ease of use.

The use of State-Space algorithms make tuning very simple and forgiving. The drives are designed to operate with up to a 10 :1 inertia mismatch right out of the box. Higher (50 :1 and more) inertial mismatches are possible with two simple parameter settings.

The Epsilon Eb and EN base drives can be quickly configured to many applications in less than 5 minutes with PowerTools FM software on a PC running Windows® 95, 98, NT 4.0 and 2000.

Complete diagnostics are provided for quick troubleshooting. A diagnostic display on the front of the drive informs the user of the operational or fault status. The last 10 faults are stored in non-volatile memory along with a time stamp for easy recall.

The EN drives are designed to accept a line of function modules that further enhance its use in various applications.

- FM-1 Speed Module offers the user eight digital Torque presets, two additional Summation modes, and an Alternate Operating mode.
- FM-2 Indexing Module enables the user to initiate up to 16 different indexes, jogging, and a single home routine.
- FM-3 and FM-3DN Programming Modules offer complex motion profiling. A complex motion profile consists of two or more indexes that are executed in sequence such that the final velocity of each index except the last is non-zero. Logical instructions between index statements can provide a powerful tool for altering motion profiles 'on the fly'.
- FM-4 and FM-4DN Programming Modules offer complex motion profiling, along with multi-tasking user programs. A complex motion profile consists of two or more indexes that are executed in sequence such that the final velocity of each index except the last is non-zero. Logical instructions between index statements can provide a powerful tool for altering motion profiles 'on the fly'.

The FM Function modules define complex motion by a configuration file that includes setups and function assignments. For the FM-3 and FM-4 modules, the configuration file also includes programs. The configuration file is created using PowerTools FM or PowerTools Pro. The FM-1 and FM-2 modules use PowerTools FM software, and the FM-3, FM-3DN, FM-4, and FM-4DN modules use PowerTools Pro software. Setup views have the same look and feel as dialog boxes. The wiring of input and output functions is done through assignments in the software. PowerTools software is an easy-to-use Microsoft® Windows® based setup and diagnostics tool.

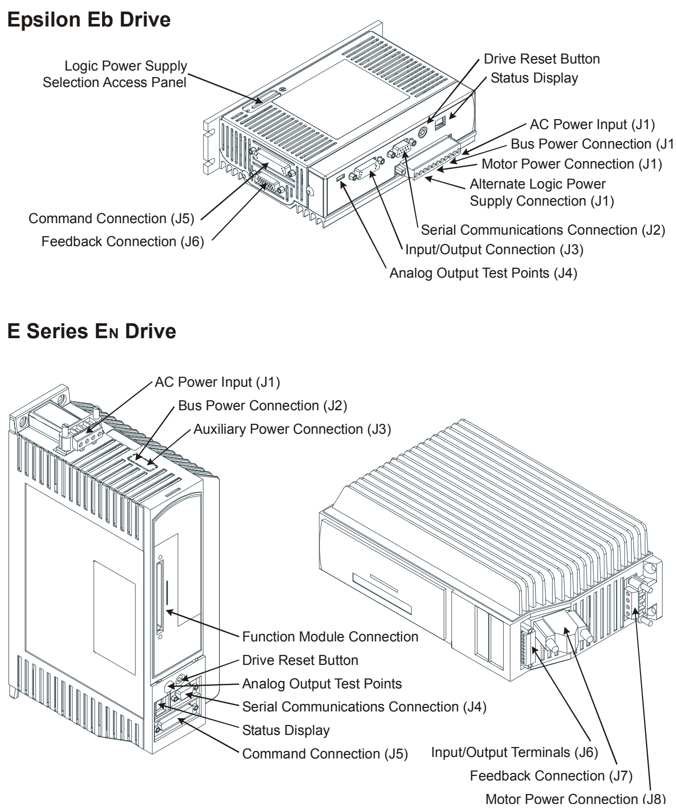


Figure 1: Epsilon Eb and EN Drives Feature Location

Epsilon and EN Drives are rated at 90 to 264 VAC input voltage. With an Alternate Power Supply (APS) applied, the Epsilon Drive input range can be extended from 42 to 264 VAC.

EN drives are available in three power ratings

Drive Model	Power Rating	Continuous Current	Peak Current
EN-204	1750 W	4.5 A RMS	9.0 A RMS
EN-208	2750 W	9.0 A RMS	18.0 A RMS
EN-214	4340 W	13 A RMS	26 A RMS

Epsilon drives are available in three power ratings.

Drive Model	Power Rating	Continuous Current	Peak Current
Epsilon Eb-202	650 W	1.8 A RMS	3.6 A RMS
Epsilon Eb-203	1100 W	3.0 A RMS	6.0 A RMS
Epsilon Eb-205	1750 W	5.0 A RMS	10.0 A RMS

The Epsilon Eb drive will fit in a 6 inch deep enclosure with cables connected.

The MG and NT motors that are matched to the Epsilon and EN drives provide low inertia, high power to size ratios, and encoder feedback for accurate positioning.

Operational Overview

User Interface

The EN drive and the Epsilon drive are set up using PowerTools FM software.

PowerTools FM Software

PowerTools FM software is an easy to use Windows®-based setup and diagnostics tool. PowerTools FM software provides you with the ability to create, edit and maintain your drive's setup. You can download or upload your setup data to or from a drive and save it to a file on your PC or print it for review or permanent storage.

PowerTools FM software provides two setup views of the drive, EZ Setup and Detailed Setup. EZ Setup view is intended to be used by most PowerTools FM software users and provides access to all commonly used drive parameters. Detailed Setup view is available for more advanced drive users who need access to all setup options and diagnostic information.

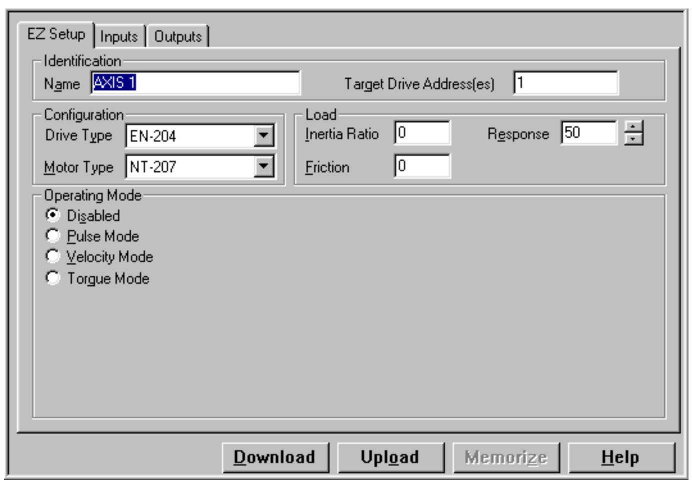


Figure 2: PowerTools FM Window, EZ Setup View

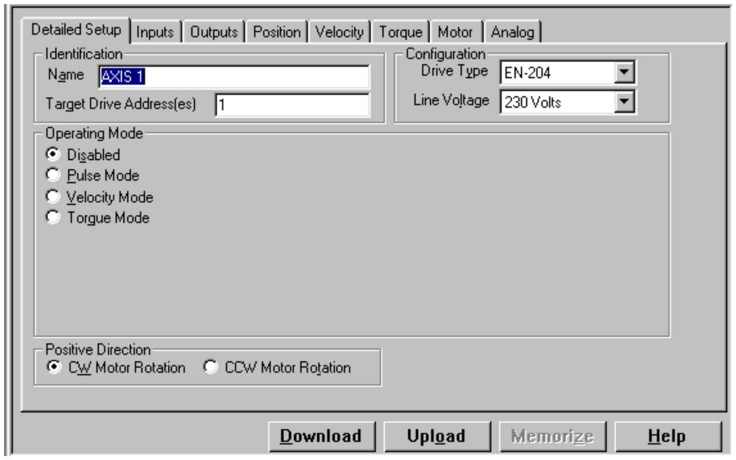


Figure 3: PowerTools FM Window, Detailed Setup View

How Motion Works

Below is a list of details related to motion in a drive.

- The Stop input function overrides motion in all operating modes including Pulse and Torque mode. It shifts the mode to Velocity mode and decelerates the axis according to the Stop deceleration ramp.
- The Travel Limits work in all operating modes including; Pulse, Velocity and Torque modes.
- When a Travel Limit has been activated in a particular direction, uninhibited motion is allowed in the opposite direction.
- The Positive Direction parameter affects all motion by specifying which direction the motor shaft will rotate (CW or CCW) when the command position is increasing.
- When changing modes with Torque Mode Enable input function, no ramping occurs between the two different commands.
- When using Summation mode, the properties of both summed modes are honored.

Functional Overview

The drive is a digital servo drive which provides three basic modes of operation: Pulse, Velocity and Torque. The Operating Mode selection defines the basic operation of the drive.

External control capability is provided through the use of input and output functions. These functions may be assigned to any input or output line which may be controlled by external devices, such as a PLC or multi-axis controller, to affect the drive operation.

Drive parameters can be modified using PowerTools FM software or an FM-P. All drive parameters have a pre-assigned Modbus address which allows you to access them using a Modbus interface.

Pulse Mode

In Pulse mode, the drive will receive pulses which are used to control the position and velocity of the motor.

There are three pulse interpretations associated with Pulse mode: Pulse/Pulse, Pulse/Direction and Pulse/Quadrature. These selections determine how the input pulses are interpreted by the drive.

Note

High Performance Gains check box in PowerTools FM software is typically enabled when Pulse mode is used (the default is enabled).

Pulse Source Selection

The drive provides two types of pulse input circuits which allows you to choose the appropriate input type to match the device generating the position pulses. The selection is done by wiring to the desired input pins of the Command Connector and setting the Pulse Source selection in the Setup tab. The Differential setting (default) is perfect for most encoders or upstream drives. The Single Ended setting is a good match for any open collector driver that requires an external pull up resistor making it ideal for most stepper controllers, PLC stepper cards and PC computer parallel printer ports.

The two hardware input circuits are included in the drive and are accessible through the drive command connector. The differential input circuit is RS-422 compatible making it inherently noise immune while being able to accept pulse rates of up to 2 Mhz per channel. The single ended inputs use high noise immunity circuitry and have internal pull-up resistors to the drive’s 5 Volt logic supply so external pull-ups and biasing circuitry is not required. When proper installation techniques are followed as shown below, the differential input setup will provide a more robust and noise immune system than a single ended input setup.

Differential input is recommended under any of the following conditions:

- Pulse width < 2 µs

- Pulse frequency > 250 kHz
- Pulse command cable length > 25 feet
- Noisy electrical environments

Differential input circuit specifications:

Input frequency maximum	2 Mhz
Input device:	AM26C32
Input impedance	12 Kohms each input
Maximum voltage applied to input pins (A, A/) or (B, B/)	
Single Ended (referenced to 0V drive logic)	+/-10V
Differential (referenced to mating differential input)	+/-10V
Maximum common mode voltage	+/-7 V
Minimum differential voltage required	200 mV
Input voltage hysteresis	60 mV

ECI-44 Terminal	Command Connector Pin #	Pulse-Direction Signal	Pulse-Pulse Signal	Pulse Quadrature Signal
Sync Enc In “A”	27	Pulse	Pulse +	A
Sync Enc In “A/”	41	Pulse/	Pulse +/	A/
Sync Enc In “B”	26	Direction	Pulse -	B
Sync Enc In “B/”	40	Direction/	Pulse -/	B/

Single ended input circuit specifications:

Single ended input specifications:

1 MHz maximum input frequency

Internal 330 ohm pull-up to 5 Volt (non-isolated)

1.5 Volt low level

3.5 Volt high level

Output driver requirements:

15 mA sinking (open collector)

5 Volt capacity

Signal common connected to Drive Logic 0V (Sync Encoder Common 0V)

ECI-44 terminal	Command Connector Pin #	Pulse-Direction Signal	Pulse-Pulse Signal	Pulse Quadrature Signal
NC2	20	Pulse /	Pulse CW /	A
NC1	36	Direction	Pulse CCW /	B

Pulse / : Commands motion on the falling edge (active edge).

Direction: Positive (+) motion when high (inactive) and Negative (-) motion when low (active).

Pulse CW / : Commands positive (+) motion on the falling edge (active edge) of a pulse.

Pulse CCW /: Commands negative (-) motion on the falling edge (active edge) of a pulse.

A and B : Encoder Quadrature signal interpretation. When B leads A Positive (+) motion commands will be generated, When A leads B, negative (-) motion commands will be generated.

Note

Actual motor rotation direction will depend on pulse ratio polarity and setting of the Positive Direction bit.

Pulse/Direction Interpretation

In Pulse/Direction interpretation, pulses are received on the A channel and the direction is received on the B channel. If the B is high, pulses received on the A are interpreted as positive changes to the *Pulse Position Input*. If the B is low, pulses received on the A are interpreted as negative changes to the *Pulse Position Input*.

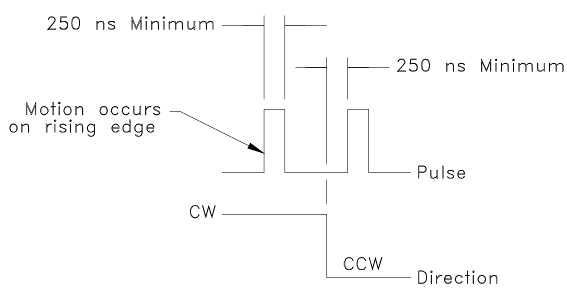


Figure 4: Pulse/Direction Signals, Differential Inputs

Pulse/Quadrature Interpretation

In Pulse/Quadrature interpretation, a full quadrature encoder signal is used as the command. When B leads A encoder counts are received they are interpreted as positive changes to the *Pulse Position Input*. When A leads B encoder counts are received they are interpreted as negative changes to the *Pulse Position Input*. All edges of A and B are counted, therefore one revolution of a 2048 line encoder will produce an 8192 count change on the *Pulse Position Input*.

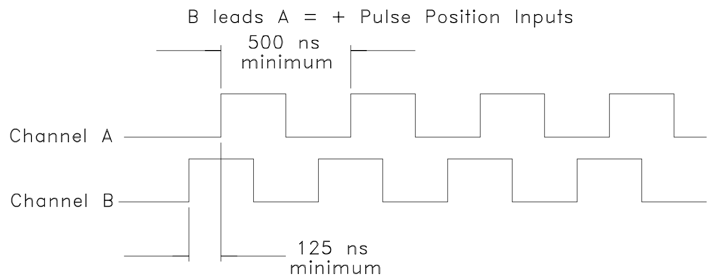


Figure 5: Pulse/Quadrature Signals, + Command

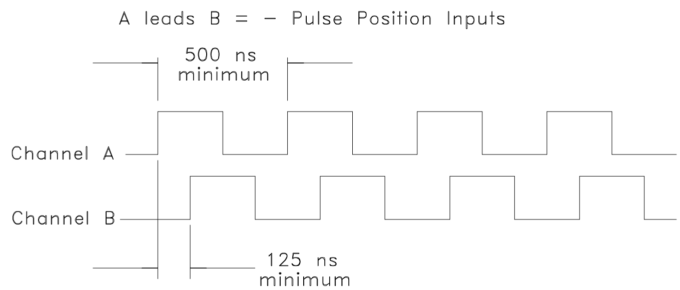


Figure 6: Pulse/Quadrature Signals, – Command

Pulse/Pulse Interpretation

In Pulse/Pulse interpretation, pulses received on the A channel are interpreted as positive changes to the *Pulse Position Input*. Pulses received on the B channel are interpreted as negative changes to the *Pulse Position Input*.

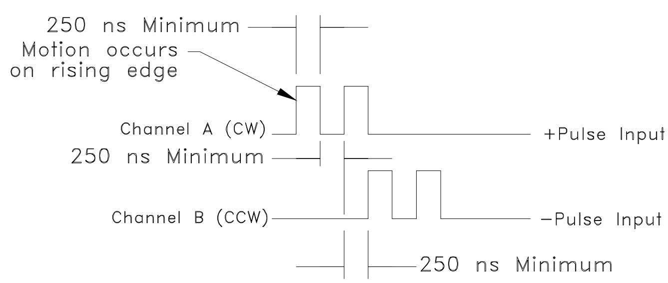


Figure 7: Pulse/Pulse Signals, Differential Inputs

Pulse Mode Parameters

The *Pulse Position Input* parameter shows the total pulse count received by the drive since the last power-up.

The *Pulse Position Input*, *Position Command*, *Position Feedback Encoder* and *Position Feedback* are initialized to zero on power-up. Only *Position Feedback Encoder* can be pre-loaded serially with a value after power-up.

The *Pulse Mode Ratio* parameter includes a numerator which represents motor revolutions, and a denominator which represents master pulses. The Pulse Ratio Revolutions is allowed to be negative which reverses all Pulse mode motion.

The *Pulse Position Input* is multiplied by the Pulse Mode Ratio to produce the *Position Command*.

Following Error/Following Error Limit

The Following Error is the algebraic difference between the Position Command and the Position Feedback. It is positive when the Position Command is greater than the Position Feedback. All accumulated Following Error will be cleared when the drive is disabled.

The Following Error Limit is functional in Pulse mode only. A Following Error Limit can be set using PowerTools FM or a FM-P. This limit is in motor revolutions and has a range of .001 to 10.000 revolutions. The Following Error Limit can be enabled or disabled.

Pulse Mode Following Error

In Pulse Mode, the range of the Following Error is ±2863.3 revolutions. If the Following Error Limit is not enabled and the Following Error exceeds 2863.3 revolutions, the displayed value is limited to this maximum value and will not rollover.

If the Following Error Limit Enable is enabled, the absolute value of the Following Error will be compared to the Following Error Limit. If the limit is exceeded, a fault will be generated. If the Following Error Limit Enable is disabled, the Following Error Limit is not used.

Velocity Mode Following Error

In Velocity mode, the maximum Following Error possible varies based on the gain and torque limit settings. When the Actual Torque Command reaches the maximum possible level, the following error will stop increasing and any additional position error will be dropped. In Velocity mode, when the following error exceeds the Following Error Limit parameter there is no action.

Encoder Feedback and Position Feedback

Encoder Feedback (Position Feedback Encoder) and Position Feedback are two separate parameters which indicate the same physical motor position. Encoder Feedback is the position change since power up in motor encoder counts and Position Feedback is the total position change since power up in motor revolutions. The Position Direction parameter setting will change which direction the motor rotates when the position feedback and position command are counting up. In the default setting the position counts up when the motor shaft rotates clockwise (when viewed from the shaft end).

The Encoder Feedback (Position Feedback Encoder) parameter can be pre-loaded serially by setting the Position Feedback Encoder Modbus parameter.

Velocity Mode

Three submodes are associated with Velocity mode: Analog, Presets and Summation.

Analog Submode

The Analog Input receives an analog voltage which is converted to the Velocity Command Analog parameter using the Full Scale Velocity, Analog Input Full Scale, and Analog Input Zero Offset parameters. The equation for this conversion is:

$$VCA = \frac{((AI - AZO)\,FSV)}{AFS}$$

Where:

VCA = Velocity Command Analog (RPM)

AI = Analog Input (volts)
AZO = Analog Input Zero Offset (volts)
FSV = Full Scale Velocity (RPM)
AFS = Analog Input Full Scale (volts)

The Velocity Command is always equal to the Velocity Command Analog in Analog Velocity mode. The Velocity Command is the command received by the velocity closed loop control.

Analog Accel/Decel Limit

This feature in the Analog submode allows you to limit the accel and decel rate when using the analog input for velocity control. This makes it very simple to use the drive in high performance, variable speed, start-stop applications such as Clutch-Brake replacements without requiring a sophisticated controller to control the acceleration ramps. In applications which do not require the drive to limit the ramps such as when using an external position controller, the parameter can be set to “0” (its default value). If the Analog Accel/Decel Limit parameter value is changed during a ramp, the new ramp limit is imposed within the next servo loop update.

The Analog Accel/Decel Limit parameter is accessed on the Velocity tab. Its range is 0.0 to 32700.0 ms/kRPM.

Presets Submode

Presets submode provides up to eight digital Velocity Presets and associated Accel/Decel Presets. At any time only one Velocity Preset can be selected. They are selected using the Velocity Preset Line #1, Line #2 and Line #3 input functions (see table below).

Velocity Preset Line #3	Velocity Preset Line #2	Velocity Preset Line #1	Selected Velocity and Accel / Decel Preset #
0	0	0	0
0	0	1	1
0	1	0	2
0	1	1	3
1	0	0	4
1	0	1	5
1	1	0	6
1	1	1	7

* (0) = Inactive input function, (1) = Active input function

When one of the Velocity Presets is selected, the Target Velocity is set equal to the Velocity Preset value and the accel/decel ramp rate is set to the Accel/Decel value associated with that velocity.

If the Velocity Command Preset is not equal to the Target Velocity, an acceleration (or deceleration) ramp is in progress. In this state, the Velocity Command Preset will be increased (or decreased) based upon the acceleration (or deceleration) ramp rate of the selected velocity preset. During the acceleration/deceleration ramp, the At Velocity output function is inactive.

If the Velocity Command Preset is equal to the Target Velocity, all ramping is complete, the Velocity Command Preset is constant and the At Velocity output function is active.

The Velocity Command is always equal to the Velocity Command Preset in Presets submode.

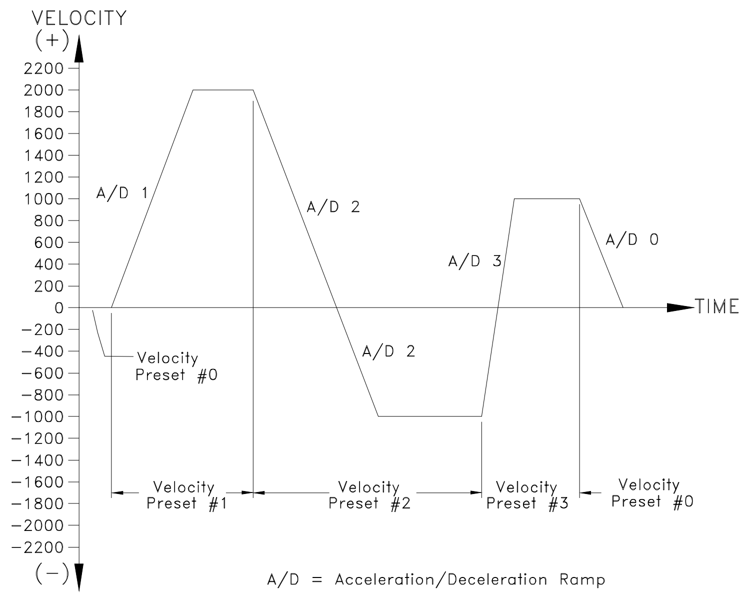


Figure 8: Velocity vs. Time Diagram using Preset Velocities

Summation Submode

In Summation submode the Velocity Command is the result of the sum of the Velocity Command Analog and the Velocity Command Preset values.:

$$VC = AC + PC$$

Where:

VC = Velocity Command
AC = Velocity Command Analog
PC = Velocity Command Preset

Example 1:

Use of Velocity Presets in a phase advance/retard application. Velocity Preset #0 is set to 0 RPM, Velocity Preset #1 is set to +5 RPM, and Velocity Preset #2 is set to -5 RPM. The Analog Input is the command source for a web application where a phase adjustment may be useful. Without interrupting the operation, you may select either Velocity Preset #1 or #2 to speed up or slow down the motor thereby advancing or retarding the phase between the motor and the web material.

Example 2:

Use the Velocity Command Analog as a trim adjustment to the digital Velocity Presets. Velocity Preset #2 is selected with Analog Input at 0, so the Velocity Command Preset and Velocity Command are equal (set to match a conveyor speed). You can use the Analog Input (Velocity Command Analog) as a fine adjust for the Velocity Command to exactly match the conveyor speed.

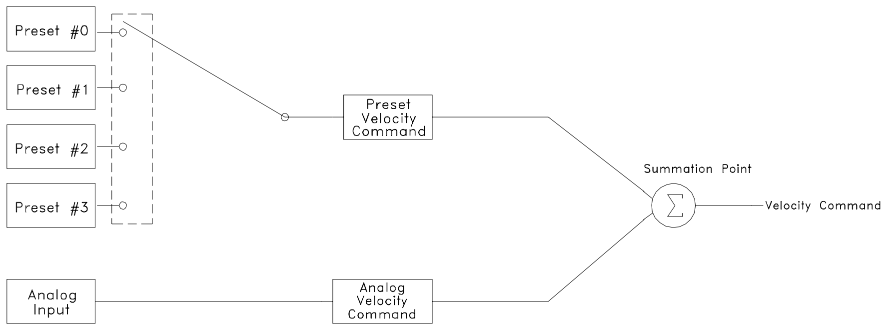


Figure 9: Summation Mode Block Diagram

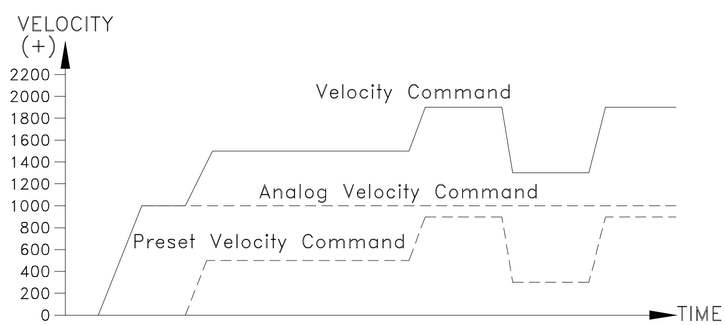


Figure 10: Velocity vs. Time Diagram, Summation Mode

Torque Mode

In Torque mode both the position and velocity loops are disabled and only the torque loop is enabled.

Note

Velocity related faults and velocity related input and output functions are still enabled (including Stop and Travel Limits).

In Torque mode the drive receives an Analog Input which is scaled to the Analog Torque Command by the Full Scale Torque, Analog Input Full Scale, and Analog Input Zero Offset parameters. The equation is:

$$TC = \frac{((AI - AZO)\,FST)}{AFS}$$

Where:

TC = Torque Command
AI = Analog Input (volts)
AZO = Analog Input Zero Offset (volts)
FST = Full Scale Torque (%)
AFS = Analog Full Scale (volts)

Drive Modifiers

This section describes functions that can modify the operation of the drive.

Stop

The Stop input function, when activated, will cause motion to stop regardless of motor direction or the operating mode. The Stop Deceleration Ramp defines the rate of velocity change to zero speed.

Activating the Stop input function causes the drive to change to Velocity mode. Therefore, if you are operating in Torque mode, the drive must be tuned to the load to prevent instability when activating the Stop input function.

For example, if an application is operating in Torque mode at 1000 RPM, and the Stop input function is activated with a Stop Deceleration Ramp of 500 ms/kRPM, the motor will decelerate to a stop in 500 ms.

⚠WARNING

When the Stop input function is deactivated, the previous operating mode is restored within 400 µs and the drive and motor will respond immediately with no ramping unless ramping is part of the selected mode.

+/- Travel Limits

The + and - Travel Limit input functions will stop motion in the direction indicated by the input function using the Travel Limit Deceleration rate. This feature is active in all modes. When an axis is stopped by a Travel Limit function, it will maintain position until it receives a command that moves it in the opposite direction of the active Travel Limit.

For example, the + Travel Limit will stop motion only if the motor is moving + but allows - motion to move off the limit switch. Conversely, the - Travel Limit will stop motion only if the motor is moving - but allows + motion to move off the limit switch.

If both input functions are active at the same time, no motion in either direction will be possible until at least one of the inputs is released.

When either + or - Travel Limit input function is activated, a fault will be logged into the Fault Log, and the drive will display an “L” on the LED diagnostics display on the front of the drive. Once the axis is driven off the limit switch, the fault will be cleared and the “L” will disappear.

If both Travel Limit input functions are activated simultaneously, the drive will respond as if the Stop input function has been activated and will use the Stop Deceleration ramp.

EN **EN Only**

The function of the Travel Limits will be effected by the installation of an Function Module (FM) to the EN drive. Please refer to the particular FM’s reference manual for complete description.

Travel Limit Application Notes

Torque Mode

If you are operating in Torque mode, the drive must be tuned to the load to prevent instability when activating the Travel Limit input functions.

Host Controller Travel Limits

If the host controller decelerates the drive faster than the Travel Limit Deceleration ramp, the drive allows the controller to maintain full control of the axis during the deceleration. This results in no following error build up in the controller and easier recovery.

Vertical Loads in Velocity Mode

In applications with horizontal, counterbalanced or un-counterbalanced vertical loads, the load will held in position when motion is stopped due to a + or - Travel Limit. The position will be held until the controller commands motion in the opposite direction of the activated Travel Limit.

Vertical Loads in Torque Mode

In applications with horizontal or counterbalanced vertical loads, the load will held in position when motion is stopped due to a + or - Travel Limit. The position will be held until the controller commands motion in the opposite direction of the activated Travel Limit.

⚠WARNING

When an axis is stopped by the upper Travel Limit with a vertical load, the controller must maintain a torque command at a minimum level to hold the load or the load may drop.

In applications with un-counterbalanced vertical loads, you must be careful not to set the controller's torque command to zero when the upper Travel limit is activated. Setting the controllers analog torque command to zero in this situation will command the axis to move off the limit switch causing the load to drop.

If your controller removes the torque command (zeroes the analog command output) when a Travel Limit is activated, you have a number of choices to prevent the load from dropping. All of which require some external logic to determine when the controller can actually take control again.

- Activate the opposite Travel Limit input function, then release it when the controller is operational again.
- Activate the Stop input function, then release it when the controller is operational again.
- Apply the axis brake, then release it when the controller is operational again

Pulse Mode

In applications with horizontal, counterbalanced or un-counterbalanced vertical loads, the load will be held in position when motion is stopped due to a + or - Travel Limit. The position will be held until the controller commands motion in the opposite direction of the activated Travel Limit.

When the travel limits are activated, the drive will decelerate at the Travel Limit Deceleration Ramp and will continue to store all the command pulses received up to $\pm 2^{32}$ counts. The stored pulses need to be cleared out before the axis will move off the Travel Limit. This can be done if the controller generates command pulses in the direction opposite the activated Travel limit. The stored command pulses can also be cleared by activating both Travel Limit input functions at the same time, activating the Stop input function or disabling the drive for as little as 5 msec (plus any debounce time).

Torque Limiting

The Torque Command is calculated as shown previously, but its value is limited by the Torque Limit parameter and the current foldback function (see "Torque Limit" and "Current Foldback"). The result of this limiting function is Torque Command Actual. This is the command that drives the Power Stage to generate current in the motor. The Torque Limit Active output function is active whenever the Torque Command Actual is less than from the Torque Command. This will be true when motion is stopped due to a Travel Limit input function.

Torque Limit Function

The Torque Limit Enable input function allows an external controller to limit the Actual Torque Command to a lower value. The Torque Limit parameter is active only when the Torque Limit Enable input function is active.

$$T_{TL} = P_{MT}, P_{DT}, R_{FL}, S_{FL} \text{ or } P_{TL} \text{ (whichever is lower)}$$

Where:

T_{TL} = Total Torque Limit
P_{MT} = Peak motor torque
P_{DT} = Peak drive torque
R_{FL} = RMS foldback limit (80 percent of continuous system torque rating)
S_{FL} = Stall foldback limit (80 percent of drive stall current rating)
P_{TL} = Programmable *Torque Limit*

Note

The Torque Limit Enable input must be active to use P_{TL}.

If the application requires that the Torque Limit be enabled at all times, the Torque Limit Enable input function may be setup to be Always Active to avoid the use of an input line.

Velocity Limiting

The drive commanded velocity is limited to 112.5% of the motor's maximum operating speed. This limiting has nothing to do with the Line Voltage setting. Depending on AC supply voltage, it may or may not be possible to get to motor maximum operating speed.

Note

See the "Drive/Motor Specifications" section for maximum motor speeds.

Example 1:

If the Motor Type is an MG-316, the maximum motor speed of the MG-316 is 4000 RPM. If the Line Voltage parameter is set to 230 VAC and the Velocity Limit is equal to 112.5 percent of 4000 RPM or 4500 RPM.

Example 2:

If the Motor Type is an MG-316, the maximum motor speed of the MG-316 is 4000 RPM. If the Line Voltage parameter is set to 115 VAC, the Velocity Limiting Active output will never come on.

Overspeed Velocity Parameter

Motor speed is continuously monitored against the Overspeed Velocity parameter whether the drive is enabled or not and when the motor speed exceeds the limit, or Overspeed Velocity Limit, a fault is issued. The default value for Overspeed Velocity Limit is 13000 RPM.

The drive has an internal overspeed velocity limit. This limit is the maximum of the Overspeed Velocity parameter and 150% of the motor maximum operating speed. For example, an MG-316 with 4000 RPM maximum speed the internal limit is 6000 RPM.

The Overspeed fault will be activated when either one of these two conditions are met:

1. When the actual motor speed exceeds the Overspeed Velocity Limit parameter.

2. If the combination of command pulse frequency and Pulse Ratio can generate a motor command speed in excess of the fixed limit of 13000 RPM. In Pulse mode operation and any Summation mode which uses Pulse mode, the input pulse command frequency is monitored and this calculation is made. For example: with a Pulse Ratio of 10 pulses per motor revolution, the first pulse received will cause an Overspeed fault even before there is any motor motion.

In Motion Velocity

The In Motion Velocity parameter defaults to a value of 10 RPM. If the motor Velocity Feedback is above the In Motion Velocity value, the In + Motion or In - Motion output function is active. When the motor velocity falls below one half of the In Motion Velocity, the In + Motion or In - Motion output function is inactive.

The maximum value for In Motion Velocity is 100 RPM and is intended to be used to indicate “in motion” not “at speed”.

Note

The In Motion Velocity detect is monitored every 400 µs so machine jitter and torque ripple could cause flicker in this signal if the commanded velocity is near the In Motion Velocity parameter value.

Motor Direction Polarity

The direction that the motor turns with a positive command can be changed with the Positive Direction parameter. This can be accessed with PowerTools FM in the EZ Setup tab or Detailed Setup tab. The positive direction by default causes the motor to turn CW as viewed looking at the shaft.

Note

CW and CCW rotation is determined by viewing the motor from the shaft end.

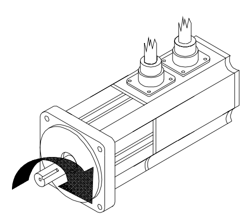


Figure 11: Clockwise Motor Rotation

Positive direction is defined as the command which causes the internal position counter to count "Up". They are:

- A positive analog velocity or torque command (i.e., a higher voltage on the (+) differential input than on the (-) input).
- A positive direction (+) pulse command.
- A positive preset velocity or torque command.

Current Foldback

Current foldback is used to protect the motor and drive from overload. There are two levels of current foldback: RMS Foldback and Stall Foldback.

RMS and Stall Foldback are displayed on the diagnostic display as a "C" and "c" respectively.

RMS Foldback

RMS foldback protects the motor from overheating. The RMS Foldback parameter models the thermal heating and cooling of the drive and motor based on the commanded current and the motor velocity. On power-up, the RMS Foldback level is zero and is continually updated. When the RMS Foldback level reaches 100 percent, current foldback is activated and the Foldback Active output function is active.

Each drive is designed to deliver up to 300 percent of the motor’s continuous torque for no less the two seconds when running at 100 RPM or more. If only 150 percent of continuous torque is required, several seconds of operation before RMS foldback is typical.

During current foldback the Torque Command Actual will be limited to 80 percent continuous motor torque. Current foldback is cancelled when the RMS Foldback level falls below 70 percent. This could take several seconds or several minutes depending on the load.

The RMS Foldback value is dependent on both torque and velocity. At low speeds (<20 percent of maximum motor speed) the RMS Foldback will closely follow the Torque Command Actual. At high speeds (>50 percent of maximum motor speed) the RMS Foldback will read higher than the Torque Command Actual.

The time constant for RMS Foldback is 10 seconds. This means that if the load is 150 percent of continuous, it will take about 10 seconds to reach the foldback trip point.

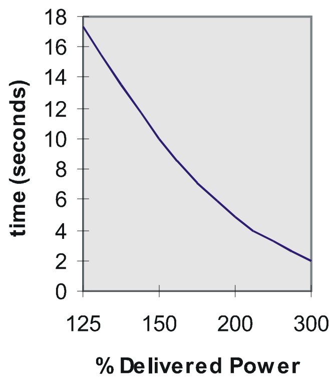


Figure 12: RMS Foldback Trip Point (this graph is accurate to ±5 percent)

Stall Foldback

EN

EN Only

Stall Foldback prevents overheating of the Power Stage. It activates in any mode when the motor velocity is 100 RPM or less and the Torque Command causes the current to exceed the stall current threshold for 100 ms or more.

Note

The stall current threshold is not the same as the drives continuous current rating. For example, the EN-204 has a continuous rating of 4.5 Amps but a stall current threshold of 7 Amps.

Stall Foldback will also be triggered when the drive sees repeated high currents in one of the three motor phases. This can occur when a motor is indexed back and forth between two of its electrical poles.

- For 4 pole motors such as MG-205 or MG-208 this distance is 90° mechanical.
- For 6 pole motors such as MG-316 through the MG-4120 this distance is 60° mechanical.
- For 8 pole motors this distance is 45° mechanical.

Once Stall Foldback is activated, the drive current is reduced to 80 percent of the stall current threshold until the Torque Command Actual is reduced to less than 70 percent of the stall current threshold for about 200 ms or until the motor velocity exceeds 100 RPM.

Shunt Operation

The EN-208 and EN-214 drive models have internal shunt control. The Epsilon and EN-204 have an output function to control an external shunt transistor, but no internal shunt transistor or resistor.

The EN-208 has a 50 ohm, 50 watt internal resistor and the EN-214 has a 33 ohm, 50 watt internal shunt resistor to dissipate regenerative energy generated when braking a motor. The Epsilon and EN-204 drives rely on the bus capacitors to absorb normal levels of regeneration energy.

Shunt RMS Fault

This fault activates when the RMS power dissipated in the internal shunt resistor is greater than allowed based on the heatsink utilization and ambient temperature.

Shunt Power RMS

EN Only

This parameter models the thermal heating and cooling of the drive internal shunt. This parameter indicates the percent of shunt capacity utilization. When this value reaches 100 percent the drive will generate an RMS Shunt Power Fault. In drives with firmware Rev. A4 or later. The maximum safe level of shunt power is based on Drive Ambient Temperature parameter and the power being delivered by the drive as shown in Heatsink Power RMS. It is also possible to get a Shunt Fault at a value exceeding 100 percent.

Epsilon Only

This parameter displays the shunt output duty cycle in percent. No value of duty cycle will trigger a shunt fault in an Epsilon drive. When using the Shunt Active output function to trigger an external shunt switch this can be used to verify actual Regenerative Power dissipation.

Shunt Active Output

This is a real time indicator of the internal shunt control in the EN drive. On the Epsilon, this output can be used to connect to an external shunt transistor to dissipate bus energy. This output is active on all drives and indicates when the bus voltage reaches 415 VDC (393 for Epsilon). It will shut off when the bus voltage is reduced below 385 VDC.

Shunt Monitoring Algorithm

EN Only

The algorithm used for monitoring shunt utilization accurately determines the shunt resistor capacity available under various operating conditions. The drive monitors the amount of power being dissipated by the shunt and if the power dissipation exceeds the allowable limit a Shunt Fault is generated. The allowable shunt capacity varies based on the actual drive loading and ambient temperature.

The heat sink is designed with a certain amount of dissipation capability and the sum of the heat generated by the drive bridge rectifier, power module and shunt resistor must be less than this total capacity. For example, if the drive is operating near its continuous current limit with a 40 ° C ambient, most of the heatsink capacity will be used to dissipate the heat generated by the output power module and bridge rectifier. In this case the allowable shunt power will be very low because the capacity is limited by the design.

Conversely, if the drive loading is very low and/or the ambient temperature is reduced, the capacity to dissipate shunt power is increased. The relationship between the Shunt dissipation capacity, Heatsink RMS loading and Ambient Temperature is shown in the following charts.

Heatsink RMS

EN **EN Only**

This parameter is available using the PowerTools FM Watch Window as a diagnostic tool. It displays the effective Heatsink utilization based on the power dissipated by the input bridge rectifier and the output power stage. The value of 100 percent is the maximum continuous power dissipation available at 40 ° C ambient temperature with zero shunt activity. The relationship between the Shunt dissipation capacity, Heatsink RMS loading and Ambient Temperature is shown in the following charts.

Drive Ambient Temperature

EN **EN Only**

The Drive Ambient Temperature parameter is located on the PowerTools FM "Advanced" tab in the Detailed Setup View. This tab is not normally visible and it is only rarely necessary.

The Drive Ambient Temperature is a parameter which will let the drive know the air temperature around the drive heat sink while the system is under normal operating conditions. If the actual ambient temperature is higher than 40 ° C, setting the Drive Ambient Temperature parameter to the actual temperature will help to protect the drive by activating the Shunt Fault at an appropriate time.

The Drive Ambient Temperature parameter determines the total amount of heat the heat sink can dissipate. Each Watt of power dissipated will produce an incremental rise in temperature. So, if the ambient temperature is lower, more wattage can be dissipated before reaching the temperature limit of the components mounted to the heatsink.

By default, we assume an ambient temperature of 40 ° C which is the design ambient temperature for the nominal maximum drive current. If the actual ambient is lower than this, extra capacity is available for additional shunt power dissipation. Setting the Drive

Ambient Temperature parameter to the actual ambient temperature allows you to take advantage of a lower temperature and could eliminate the need for an external shunt resistor and controller.

The charts below indicate the operating range for a given ambient temperature.

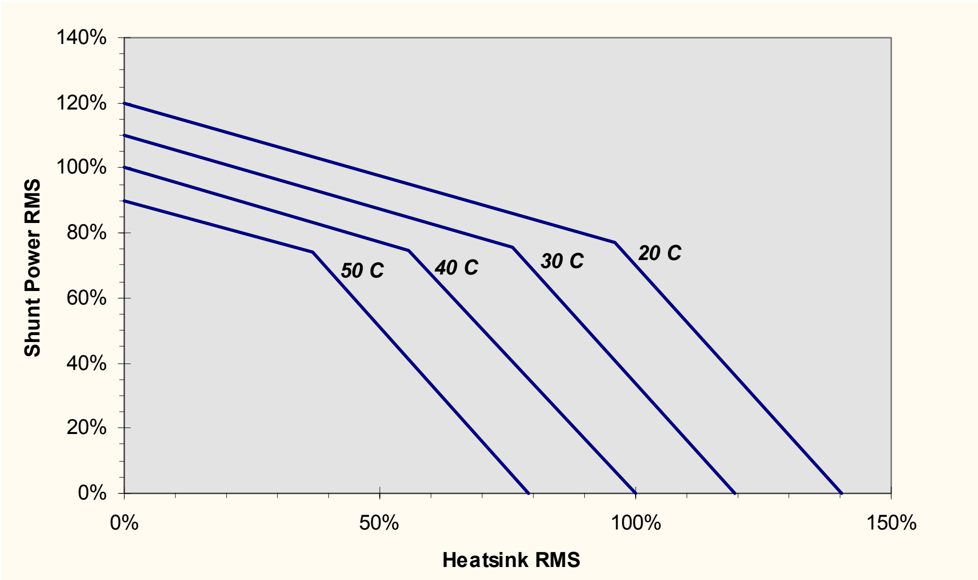


Figure 13: EN-208 Shunt Power RMS vs. Heatsink RMS

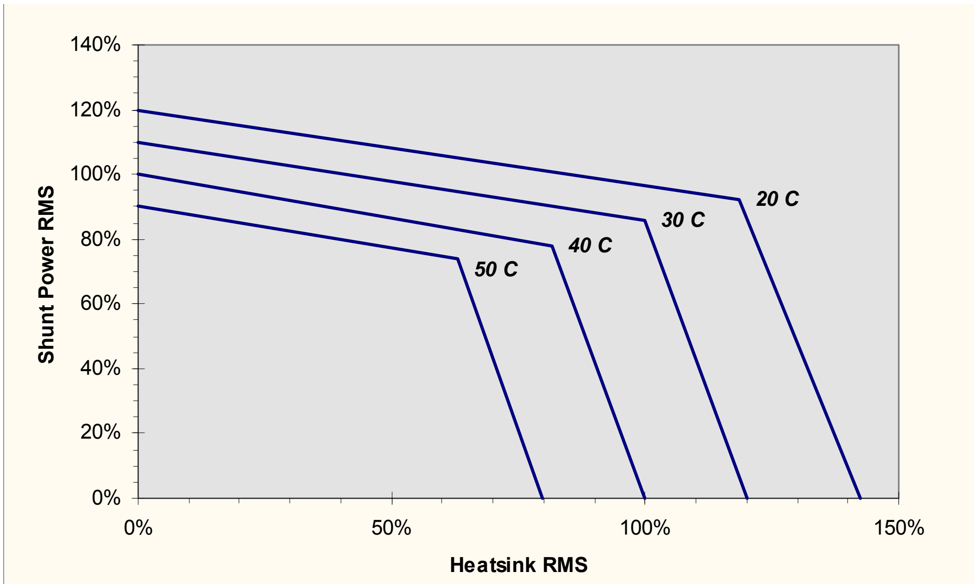


Figure 14: EN-214 Shunt Power RMS vs. Heatsink RMS

External Shunt Operation

The DC bus is accessible for applications requiring an external shunt regulator. Control Techniques offers an external shunt regulator (model RSR-2) which can provide additional regenerative power dissipation.

Note

The external shunt regulator must be able to sense the DC bus voltage and switch the shunt resistor in and out of the circuit as needed to maintain acceptable bus voltage.

The shunt power rating required is determined by the application.

The connection for an external shunt regulator is between Bus - and Bus +.

External Shunt Regulator Requirements:

- Shunt trip "On" voltage: 415 to 435 VDC (390 to 395 VDC for Epsilon)
- Shunt trip "Off" voltage: 385 to 405 VDC (380 to 385 for Epsilon)
- Minimum resistance: 20 ohms (20 ARMS)
- Power Requirements: Application dependent

You should mount the external shunt control and resistor so that the heat it generates does not affect the drive.

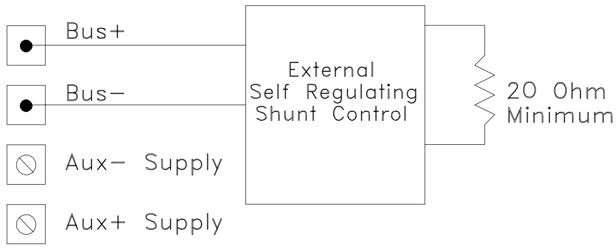


Figure 15: *External Shunt Wiring Diagram*

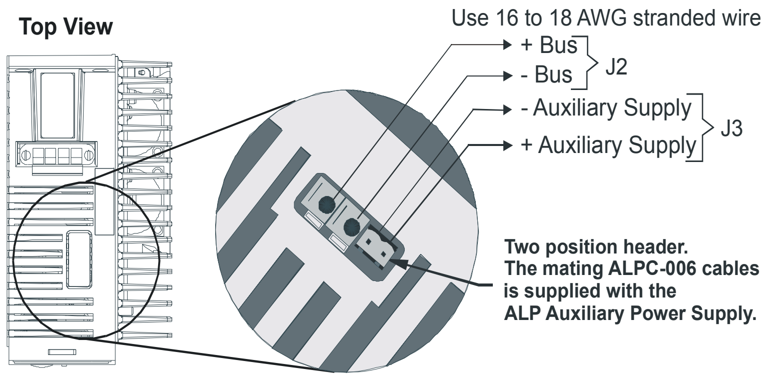


Figure 16: *EN Bus Connections*

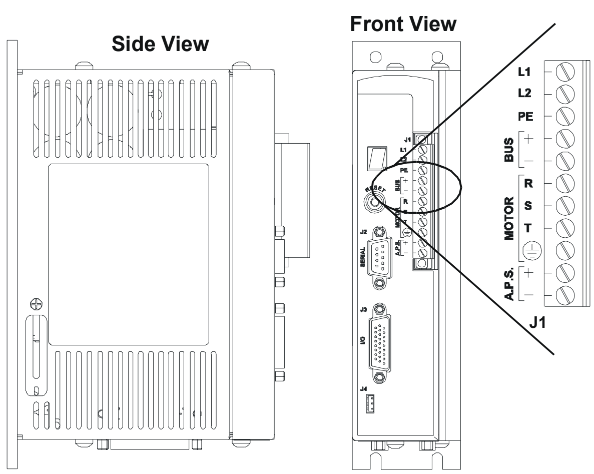


Figure 17: *Epsilon Bus Connections*

Brake Operation

Motor brake operation is controlled by the Brake Release and Brake Control input functions. These input functions can be used together to control the state of the Brake output function. The table below shows the relationship between the Brake input and Brake output functions.

Note

No motion should be commanded while the brake is engaged.

Brake Release Input	Off				On			
Brake Control Input	On		Off		On		Off	
Drive Power Stage	Enabled	Disabled	Enabled	Disabled	Enabled	Disabled	Enabled	Disabled
Brake Output	Off	Off	On	Off	On	On	On	On
Brake*	Eng	Eng	Diseng	Eng	Diseng	Diseng	Diseng	Diseng

* Eng=Mechanically Engaged
Diseng=Mechanically Disengaged

Brake Release Input Function

The Brake Release input function will release the brake under all conditions. When this input function is "On", the Brake output function will be "On" (i.e., release brake). This input function overrides all other brake control, thus allowing the brake to be released while a fault is active or the power stage is disabled. See also Brake output function.

Brake Control Input Function

This input function, when active, will engage the brake unless overridden by the Brake Release input function. This input lets you externally engage the brake while allowing the drive to also control the brake during fault and disabled conditions.

Brake Output Function

The Brake output function is used to control the motor holding brake. If the Brake output function is "Off", the brake is mechanically engaged. When the brake is engaged, the diagnostic display on the front of the drive will display a “b”.

The drive outputs are limited to 150 mA capacity, therefore, a suppressed relay is required to control motor coil. Control Techniques offers a relay, model BRM-1.

Analog Command Input

The Analog Command Input can be used as a velocity or torque command. The drive accepts a ±10 VDC differential analog command on pins 14 and 15 of the Command Connector and has 14 bits of resolution.

The Analog Inputs Bandwidth, Analog Full Scale and Analog Input Zero Offset parameters are applied to the Analog Input to generate either an analog velocity or torque command. These three parameters can be edited using PowerTools FM, a FM-P or serially using Modbus.

Bandwidth

The value of the parameters sets the Low Pass Filter cutoff frequency applied to the analog command input. Signals that exceed this frequency are filtered at a rate of 20 dB/decade.

Analog Full Scale

This parameter specifies the full scale voltage for the analog input. When the drive receives an analog command input equal to the Analog Input Full Scale parameter, the drive will command either Full Scale Velocity or Full Scale Torque depending on the operating mode.

Analog Zero Offset

Analog Input Zero Offset is used to null any input voltage that may be present at the drive when a zero velocity or torque is commanded by a controller. The amount of offset can be read with PowerTools FM software using the following procedure:

1. Provide the zero velocity command to the analog command input on the command connector.
2. Read the Analog Input Value.
3. Enter the Analog Input Value in the Analog Input Zero Offset.

Analog Command Wiring

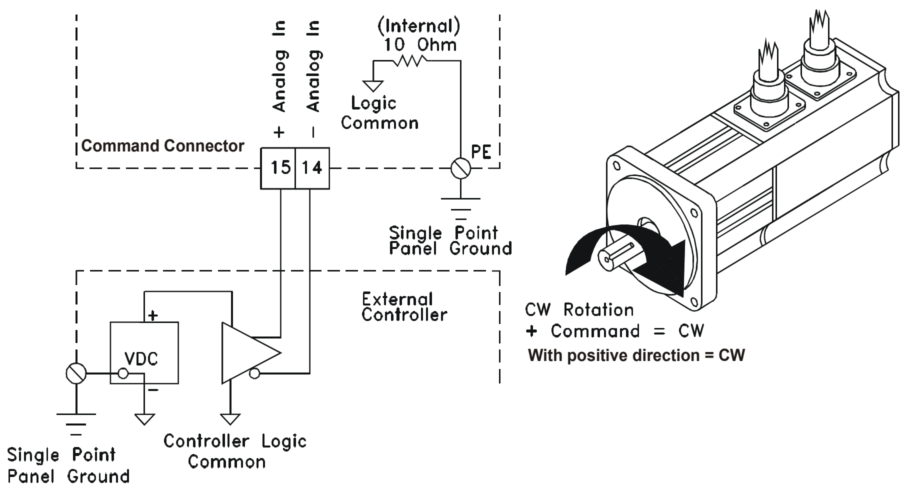


Figure 18: Analog Command, Differential Wiring Diagram

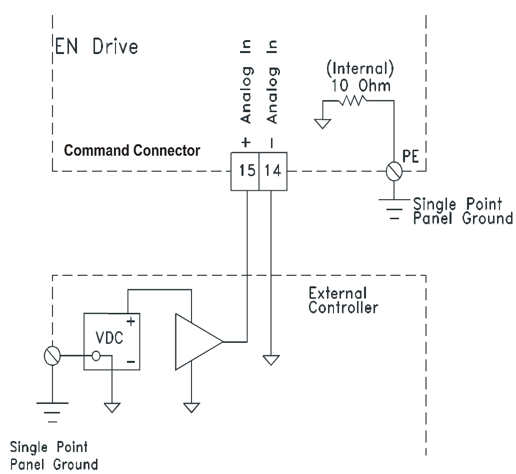


Figure 19: Analog Command, Single-ended Wiring Diagram

Analog Outputs

The drive has two 8 bit Analog Outputs which may be used for diagnostics, monitoring or control purposes. These outputs are referred to as Channel 1 and Channel 2. They can be accessed from the Command Connector on the drive or from the diagnostics output pins located on the front of the drive.

Each Channel provides a programmable Analog Output Source.

Analog Output Source options are:

- Velocity Command
- Velocity Feedback
- Torque Command (equates to Torque Command Actual parameter)
- Torque Feedback
- Following Error

Default Analog Output Source:

Channel	Output Source	Offset	Scale
1	Velocity Feedback	0	600 RPM/volt
2	Torque Command	0	30 percent/volt for selected motor

Each channel includes a programmable Analog Output Offset and an Analog Output Scale. This feature allows you to “zoom in” to a desired range effectively increasing the resolution. The units for both of these parameters is dependent upon the Analog Output Source selection.

Analog Output Offset units:

- Velocity Command = RPM
- Velocity Feedback = RPM
- Torque Command = Percent of continuous torque for selected motor
- Torque Feedback = Percent of continuous torque for selected motor
- Following Error = Revs

Analog Output Scale units:

- Velocity Command = RPM/volt
- Velocity Feedback = RPM/volt
- Torque Command = Percent of continuous torque/volt for selected motor
- Torque Feedback = Percent of continuous torque/volt for selected motor
- Following Error = Revs/volts

Example:

You could use the Analog Outputs to accurately measure velocity overshoot. For example, to measure a target velocity of 2000 RPM at a resolution of ±10 V = ±200 RPM do the following.

1. Selected Velocity Feedback for the Analog Output Source
2. Set the Analog Output Offset to 2000 RPM
3. Set the Analog Output Scale to 20 RPM/VOLT

This will provide an active range from ±10 Volts to represent 1800 to 2200 RPM. Therefore, the measured resolution has been increased.

Digital Inputs and Outputs

External control capability is provided through the use of input and output functions. These functions may be assigned to any input or output line. After they are assigned to lines, external controllers such as a PLC or multi-axis controllers, may be used to affect or monitor the drive operation.

Drives are equipped with five optically isolated input lines (one dedicated to a Drive Enable function) and three optically isolated output lines. All inputs and outputs are compatible with sourcing signals (active = + voltage) and are designed to operate from a +10 to 30 VDC. You are responsible for limiting the output current to less than 150 mA for each digital output.

These input and output lines can be accessed through the removable 10-pin I/O Connector, and through the 44-pin Command Connector.

Note

See “Input/Output and Drive Enable Wiring”.

Input Function Active State

The active state of an input function can be programmed to be “Active Off” or “Active On” using PowerTools FM. Making an input function “Active On” means that it will be active when +10 to 30 VDC is applied to the input line it is assigned to and is inactive when no voltage is applied to the line. Making an input function "Active Off" means that it will be active when no voltage is applied to the input line and inactive while +10 to 30 VDC is being applied.

You can also make an input function "Always Active", which means that it is active regardless of whether or not it is assigned to an input line and, if you assign it to an input line, it will be active whether or not voltage is applied to that line. This is useful for testing the drive operation before I/O wiring is complete.

Input Line Debounce Time

You can program a "Debounce Time" which means the line will need to be active for at least the debounce time before it is recognized. This feature helps prevent false triggering in applications with high ambient noise.

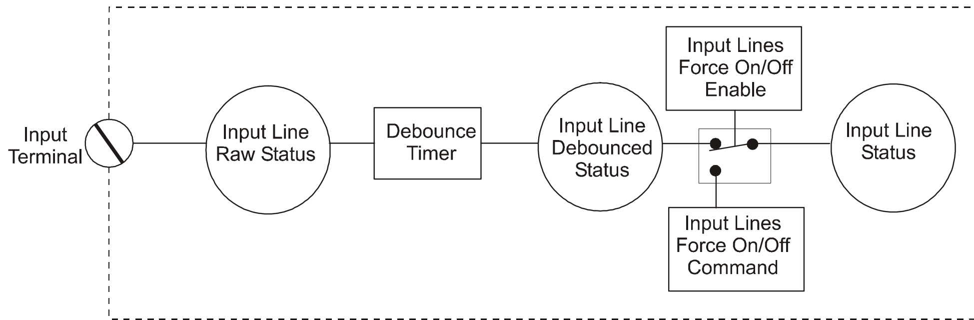


Figure 20: Input Line Diagram

Output Line Active State

The default active state of an output line is "Active On". This means that the output line will supply a voltage when the result of the OR'ed output function(s) assigned to that output line is activated by the drive.

Making an output line "Active Off" means that the line will be "Off" (not conducting) when the result of the OR'ed output function(s) assigned to that output line is active, and will supply a voltage when the output function is inactive.

Input Functions

Travel Limit + or -

The + and - Travel Limit input functions will stop motion in the direction indicated by the input function using the Travel Limit Deceleration rate. This feature is active in all modes. When an axis is stopped by a Travel Limit function, it will maintain position until it receives a command that moves it in the opposite direction of the active Travel Limit.

For example, the + Travel Limit will stop motion only if the motor is moving + but allows - motion to move off the limit switch. Conversely, the - Travel Limit will stop motion only if the motor is moving - but allows + motion to move off the limit switch.

If both input functions are active at the same time, no motion in either direction will be possible until at least one of the inputs is released.

When either + or - Travel Limit input function is activated, a fault will be logged into the Fault Log, and the drive will display an "L" on the LED diagnostics display on the front of the drive. Once the axis is driven off the limit switch, the fault will be cleared and the “L” will disappear.

If both Travel Limit input functions are activated simultaneously, the drive will respond as if the Stop input function has been activated and will use the Stop Deceleration ramp.

Stop

The Stop input function, when activated, will cause motion to stop regardless of motor direction or the operating mode. The Stop Deceleration Ramp defines the rate of velocity change to zero speed.

Activating the Stop input function causes the drive to change to Velocity mode. Therefore, if you are operating in Torque mode, the drive must be tuned to the load to prevent instability when activating the Stop input function.

For example, if an application is operating in Torque mode at 1000 RPM, and the Stop input function is activated with a Stop Deceleration Ramp of 500 ms/kRPM, the motor will decelerate to a stop in 500 ms.

⚠WARNING

When the Stop input function is deactivated, the previous operating mode is restored within 400 µs and the drive and motor will respond immediately with no ramping unless ramping is part of the selected mode.

Reset

This input is used to reset fault conditions and is logically OR’ed with the Reset button. A rising edge pulse is required to reset faults.

Velocity Preset Lines 1, 2 and 3

The Velocity Preset Lines are used to select one of the eight pre-defined velocities using the binary selection patterns shown below.

If you select a different Preset Velocity, the drive will immediately ramp to the new velocity using the new acceleration ramp without stopping.

Velocity Preset #3	Velocity Preset Line #2	Velocity Preset Line #1	Selected Velocity and Accel/ Decel Preset #
0	0	0	0
0	0	1	1
0	1	0	2
0	1	1	3
1	0	0	4

Velocity Preset #3	Velocity Preset Line #2	Velocity Preset Line #1	Selected Velocity and Accel/ Decel Preset #
1	0	1	5
1	1	0	6
1	1	1	7

* (0) = Inactive input function
(1) = Active input function

Torque Limit Enable

This input function, when active, causes the Torque Command to be limited to the value of the Torque Limit parameter. The Torque Limit can be made "Always Active" by checking the Always Active checkbox on the Inputs tab.

Brake Release

This input function will release the brake under all conditions. If this input function is active, the Brake output function is switched to active (i.e., release brake). This overrides all other brake control, thus allowing the brake to be released while a fault is active or the power stage is disabled.

Brake Control

This input function, when active, will engage the brake unless overridden by the Brake Release input function. This input function lets you externally engage the brake, while allowing the drive to also control the brake during fault and disabled conditions.

Torque Mode Enable

This input function, when active, causes the drive to change operating mode to torque mode. When this input function is deactivated the default operating mode is enabled with no transitional ramping.

Output Functions

Travel Limit + or -

These outputs are active when the associated Travel Limit input function are active.

Brake

This output function is used to control the motor holding brake. If the Brake output is “Off”, the brake is mechanically engaged.

Foldback Active

This output function is active when the drive is limiting motor current. If the RMS Foldback value exceeds 100 percent of the continuous rating, the current foldback algorithm will limit the current delivered to the motor to 80 percent of the continuous rating.

Drive OK

This output function is active whenever no fault condition exists. Travel Limits and the Drive Enable have no effect on this output function.

In Motion + or -

These output function is active whenever the motor is turning at a velocity greater than the In Motion Velocity parameter in the + or - direction respectively. Default value of In Motion Velocity is 10 RPM. Hysteresis is used to avoid a high frequency toggling of this output function. This function is deactivated when the motor velocity is less than 1/2 of the In Motion Velocity parameter.

Power Stage Enabled

This output is active when the drive is OK and enabled. It will go inactive when anything happens to disable the output power stage.

Fault

This output function is active whenever a drive fault condition exists. The Travel Limits will also cause this output function to be active.

At Velocity

This output function is active whenever the motor is at the desired velocity (i.e., acceleration or deceleration is complete). This output is only associated with Velocity Preset Velocities.

Torque Limit Active

This output is active if the Torque Command exceeds the specified Torque Limit value. Refer to Torque Limiting in the Operating Overview section of this manual.

Velocity Limiting Active

This output function is active when the Actual Velocity Command is being limited. The velocity limit is dependent upon the maximum motor speed for the Motor Type selected.

If the Actual Velocity Command exceeds the velocity limit, the command will be limited and the Velocity Limiting Active output function will be active.

Shunt Active

This is a real time indicator of the internal shunt activity. For EN-204 and Epsilon drives this output can be used to control all external shunt control switches.

Torque Level 1 and 2 Active

These outputs are active if the Torque Command exceeds the respective Torque level value.

Setting Up Parameters

EZ Setup/Detailed Setup Tab

This is the default tab that is displayed each time you open a Configuration Window.

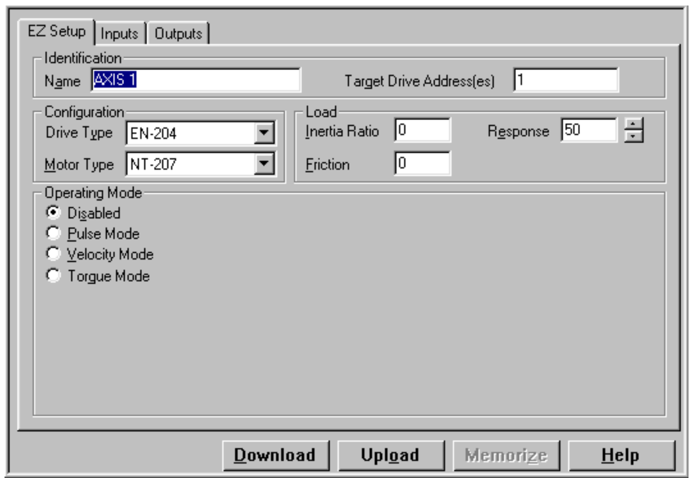


Figure 21: Default Offline EZ Setup Tab

Identification Group

Name

Enter a 24 character alpha-numeric name for the drive you are currently setting up. Assigning a unique name for each drive in your system allows you to quickly identify a drive when downloading, editing and troubleshooting. All keyboard characters are valid.

Target Drive Address(es)

Enter the “Target Drive Address(es)” you wish to download the setup information to (or upload from).

To download to more than one drive simultaneously, separate the device addresses with commas, spaces or hyphens. Commas and spaces separate individual addresses. Hyphens indicate to include all address, between the indicated addresses, (i.e., 1, 3, 7) means download to addresses 1 and 3 and 7 only. (1 - 7) indicates, download to addresses 1, 2, 3, 4, 5, 6, 7. If you download to more than one device simultaneously, they must all be the same drive and any FM modules attached to EN drives must all be of the same model and firmware revision.

Configuration Group (EZ Setup view only)

Drive Type

Select the drive model for the system you are currently setting up. PowerTools FM software will only display the motor models that are compatible with the drive you selected and any user defined motors.

Motor Type

Select the motor you wish to use. PowerTools FM software will only display the motor models that are compatible with the drive you selected and any user defined motors.

⚠ CAUTION

Selecting the wrong motor type can cause poor performance and may even damage the motor and/or drive.

Configuration Group (Detailed Setup view only)

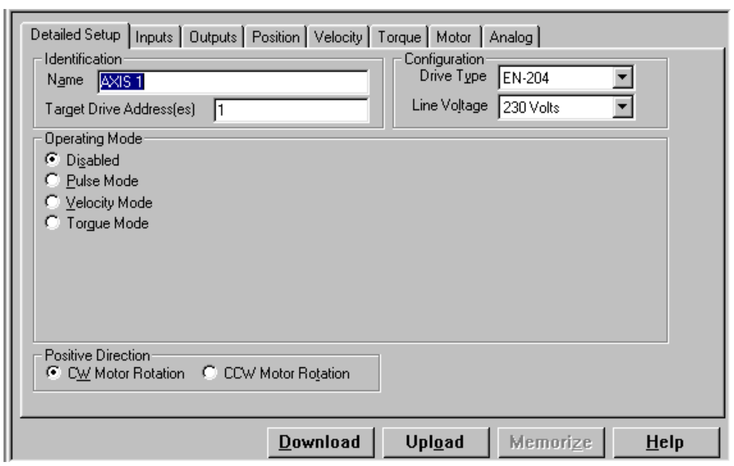


Figure 22: Detailed Setup Window for an EN Drive.

Drive Type

Select the drive model for the system you are currently setting up. PowerTools FM software will only display the motor models that are compatible with the drive you selected and any user defined motors.

Line Voltage - EN Only

Line Voltage specifies the applied power and adjusts the internal gains to compensate for it. This parameter has two choices 115 VAC and 230VAC. If the line Voltage is set to 230VAC when the actual applied voltage is 115 VAC, the motor will be slightly less responsive to commands and load disturbances.

⚠ CAUTION

The Line Voltage must never be set to 115 VAC if the applied voltage is actually 230 VAC. This can cause drive instability and failure.

Load Group

This is found on the EZ Setup tab in EZ Setup view or on the Motor tab in Detailed Setup view.

Inertia Ratio

Inertia Ratio specifies the load to rotor inertia ratio and has a range of 0.0 to 50.0. If the exact inertia is unknown, a conservative approximate value should be used. If you enter an inertia value higher than the actual inertia, the resultant motor response will tend to be more oscillatory.

Friction

This parameter is characterized in terms of the rate of friction increase per 100 motor RPM. If estimated, always use a conservative (less than or equal to actual) estimate. If the friction is completely unknown, a value of zero should be used. A typical value used here is less than one percent.

Response

The Response adjusts the velocity loop bandwidth with a range of 1 to 500 Hz. In general, it affects how quickly the drive will respond to commands, load disturbances and velocity corrections. A good value to start with (the default) is 50 Hz. The effect of Response in greatly influenced by High Performance Gain settings. With High performance Gains enabled, the maximum value recommended is 100 Hz.

Operating Mode Group

Disabled Radio Button

Selecting this radio button to put the drive in the disabled mode. This is equivalent to removing the Drive Enable input.

Figure 23: Operating Mode, Disabled Mode Selected

Pulse Mode Radio Button

Selecting this radio button puts your drive into Pulse mode and displays three Interpretations: Pulse/Pulse, Pulse/Direction and Pulse/Quadrature. In Pulse mode the drive will receive pulses which are used to control the position and velocity of a move.

Velocity Mode Radio Button

Selecting this radio button puts your drive into Velocity mode which includes three Submodes: Analog, Presets and Summation.

Torque Mode Radio Button

Selecting this radio button will put your drive in Torque mode and activates the Full Scale Torque and the Torque Limit data entry boxes. In Torque mode the drive develops torque in proportion to the voltage received on the Analog Input. The Analog Input is scaled to the Analog Torque Command by the Full Scale Torque, Analog Input Full Scale and Analog Input Zero Offset parameters.

Pulse Mode Interpretation Group

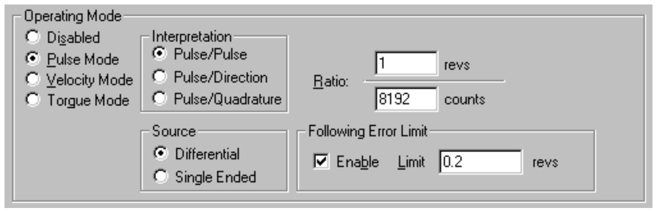


Figure 24: Operating Mode, Pulse Mode Selected

Pulse/Pulse Radio Button

Selecting this radio button puts your drive in Pulse/Pulse interpretation. In Pulse/Pulse mode, pulses received on the A channel are interpreted as positive changes to the Pulse Position Input, and pulses received on the B channel are interpreted as negative changes to the Pulse Position Input.

Pulse/Direction Radio Button

Selecting this radio button puts your drive in Pulse/Direction interpretation. In Pulse Direction mode, pulses are received on the A channel, and the direction is received on the B channel. If the B is high, pulses received on the A are interpreted as positive changes to the Pulse Position Input. If the B is low, pulses received on the A are interpreted as negative changes to the Pulse Position Input.

Pulse/Quadrature Radio Button

Selecting this radio button puts your drive in Pulse/Quadrature interpretation. If Pulse Quadrature is selected, a full quadrature encoder signal is used as the command. When B leads A encoder counts received are interpreted positive changes to the Pulse Position Input. When A leads B encoder counts received are interpreted as negative changes to the Pulse Position Input. All edges of A and B are counted, therefore one revolution of a 2048 line encoder will produce a 8192 count change on the Pulse Position Input.

Source Group

Differential Radio Button

Selects the differential hardware input of the drive to receive pulses (default) these pulse inputs are as follows:

ECI-44 Terminal	Command Connector Pin #	Pulse-Direction Signal	Pulse-Pulse Signal	Pulse Quadrature Signal
Sync Enc In "A"	27	Pulse	Pulse +	A

ECI-44 Terminal	Command Connector Pin #	Pulse-Direction Signal	Pulse-Pulse Signal	Pulse Quadrature Signal
Sync Enc In "A/"	41	Pulse/	Pulse +/	A/
Sync Enc In "B"	26	Direction	Pulse -	B
Sync Enc In "B/"	40	Direction/	Pulse -/	B/

Differential Inputs are typically needed for pulse rate 7250 kHz or high ambient noise environments.

Single Ended Radio Button

Selects the single ended hardware input of the drive to receive pulses (default) these pulse inputs are as follows:

ECI-44 Terminal	Command Connector Pin #	Pulse-Direction Signal	Pulse-Pulse Signal	Pulse Quadrature Signal
NC2	20	Pulse /	Pulse + /	A
NC1	36	Direction	Pulse - /	B

Ratio Formula

Defines the number of command pulses it will take to move the motor the distance specified in the Pulse Mode Ratio Revolutions. The default value is 1 motor revolution per 8192 counts.

The coarsest ratio possible is 10 input counts per motor revolution. Setting a ratio to fewer than 10 input counts per motor revolution will cause an Overspeed fault without generating motion.

Following Error Limit Group

Enable Check Box

Check this box to enable or disable the Following Error Limit. The Following Error is the algebraic difference between the Position Command and the Position Feedback. It is positive when the Position Command is greater than the Position Feedback. If the absolute value of the following error exceeds the value you enter here, the drive will generate a Following Error fault. All accumulated Following Error will be cleared when the drive is disabled.

Following Error Limit

The Following Error Limit is functional in Pulse mode only. This limit is in motor revolutions and has a range of .001 to 10.000 revolutions.

Velocity Mode Submode Group

Analog Radio Button

Selecting this radio button puts the drive into Analog submode. In Velocity mode the drive develops velocity in proportion to the voltage received on the Analog Input. The Analog Input is scaled to the Analog Velocity Command by the Full Scale Velocity, Analog Input Full Scale, and Analog Input Zero Offset parameters.

For example:

+5V = 2000 RPM CW
-5V = 2000 RPM CCW
Analog Input Full Scale = 10V
Full Scale Velocity = 4000 RPM

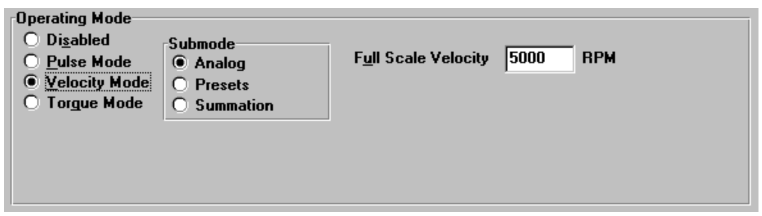


Figure 25: Operating Mode, Velocity Mode Selected

Full Scale Velocity

This parameter is the maximum motor velocity (in RPM) desired when the drive receives an analog voltage equal to the Analog Input Full Scale parameter setting.

Note

Full Scale Velocity and Analog Input Full Scale do not set limits. They only set the proportion of motor speed to Analog Input Voltage.

The Full Scale Velocity and Analog Input Full Scale parameters are used in the Analog or Summation operating modes.

Default values:

Motor Selection	Full Scale Velocity @ Analog Input Full Scale
MG-205 and MG-208, NT 207, NT 212	5000 RPM @ 10V
MG-316	4000 RPM @ 10V
MG-340, MG-455, MG490 and MG-4120	3000 RPM @ 10V

Presets Radio Button

Selecting this radio button puts the drive into Presets submode. Presets submode provides up to eight digital Velocity Presets and associated Accel/Decel Presets. At any time, only one Velocity Preset can be selected. They are selected using the Velocity Preset 1, the Velocity Preset 2 and the Velocity Preset 3 input functions.

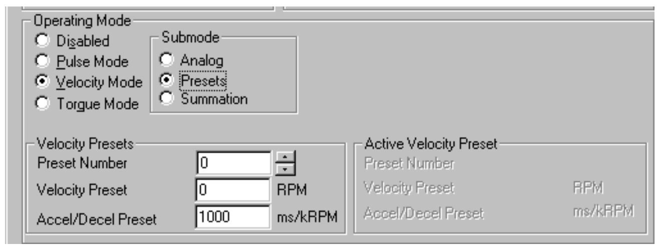


Figure 26: Velocity Presets

Velocity Presets

Enter a value for each of the Velocity Presets you wish to use. The units are RPM and the range is from ± maximum motor velocity. A positive value will cause CW motion and a negative value will cause CCW motion. (Motor direction is determined as you face the shaft end of the motor).

Accel/Decel Presets

Enter an Accel/Decel Presets value for each of the velocity presets you are using. The units are milliseconds per 1000 RPM and the range is from 0 to 32700.0. Default is 1000 ms/kRPM.

Summation Radio Button

Selecting this radio button puts the drive into Summation submode. Summation Velocity operating mode is defined as the summation of the Velocity Command Analog and the Velocity Command Preset to produce the Velocity Command.

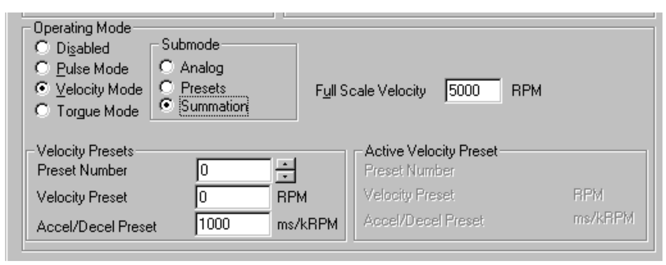


Figure 27: Full Scale Velocity

Velocity Presets

Enter a value for each of the Velocity Presets you wish to use. The units are RPM and the range is from ± maximum motor velocity. A positive value will cause CW motion and a negative value will cause CCW motion. (Motor direction is determined as you face the shaft end of the motor).

Accel/Decel Presets

Enter an Accel/Decel Presets value for each of the Velocity Presets you are using. The units are milliseconds per 1000 RPM and the range is from 0 to 32700.0. Default is 1000 ms/kRPM.

Full Scale Velocity

This parameter is the motor velocity (in RPM) desired when the drive receives an analog voltage equal to the Analog Input Full Scale parameter setting.

Note

Full Scale Velocity and Analog Input Full Scale do not set limits. They only set the proportion of motor speed to Analog Input Voltage.

The Full Scale Velocity and Analog Input Full Scale parameters are used in the Analog or Summation operating modes.

Default values:

Motor Selection	Full Scale Velocity @ Analog Input Full Scale
MG-205 and MG-208, NT 207, NT 212	5000 RPM @ 10V
MG-316	4000 RPM @ 10V
MG-340, MG-455, MG490 and MG-4120	3000 RPM @ 10V

Torque Mode Group

Selecting this radio button will put your drive in Torque mode and activates the Full Scale Torque and the Torque Limit data entry boxes. In Torque mode the drive develops torque in proportion to the voltage received on the Analog Input. The Analog Input is scaled to the Analog Torque Command by the Full Scale Torque, Analog Input Full Scale and Analog Input Zero Offset parameters.

For example:

5V = Motor continuous torque
10V = Motor peak torque (2 times continuous)
+10V = Peak motor torque CW
-10V = Peak motor torque CCW

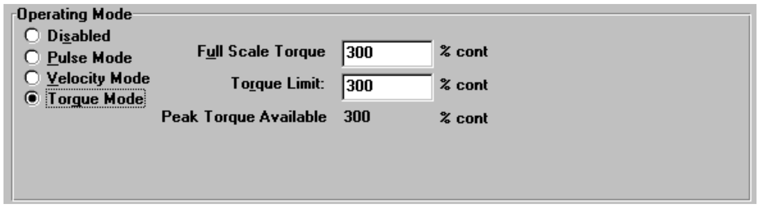


Figure 28: Operating Mode, Torque Mode Selected

Full Scale Torque

This parameter specifies the Torque Command when the Analog Input voltage is equal to the Analog Full Scale parameter.

Torque Limit

This value is the level which the Torque Command will be limited to when the Torque Limit input function is active. To make the Torque Limit always active, set the Torque Limit Input Function to be Always Active.

Peak Torque Available

This displays the maximum torque available from the selected drive and motor combination. This is calculated by PowerTools FM and is not a drive parameter.

Positive Direction Group (Detailed Setup view only)

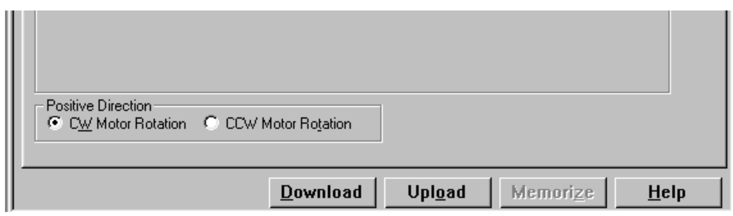


Figure 29: Positive Direction in Detailed Setup View

CW Motor Rotation Radio Button

This defines that the motor will rotate clockwise when given a positive velocity, torque or position command. CW/CCW is defined when facing the motor output shaft.

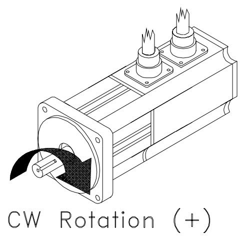


Figure 30: CW Motor Rotation

CCW Motor Rotation Radio Button

This defines that the motor will rotate counterclockwise when given a positive velocity, torque or position command. CW/CCW is defined when facing the motor output shaft.

Inputs Tab

This tab is divided into two windows: The “Input Functions” window, on the left side, displays the input functions available, the function polarity and the always active state. The “Input Lines” window, on the right side, displays the four input lines, the debounce value and input function assignments.

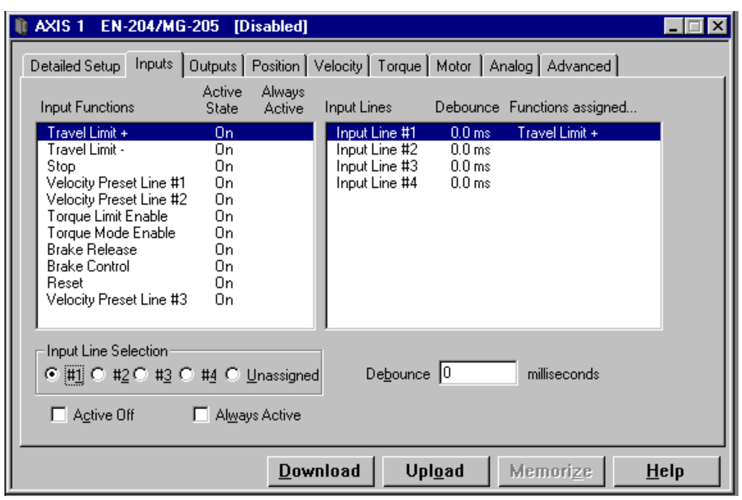


Figure 31: Inputs Tab for EN Drive

Input Functions Window

This window allows you to select the input function you wish to assign to an input line.

Active State

The active state of each input function is displayed next to the output function. See the "Active Off" check box section on the following page.

Always Active

The setting for Always Active is displayed next to each input function. See "Always Active" check box section on the following page.

Input Line Selection Radio Buttons - EN Only

This selection box is used to assign an input function to an input line. Highlight the function you wish to assign, then select the appropriate input line radio button. To unassign an input function, highlight the function in the Input Functions window, then select the "Unassigned" radio button.

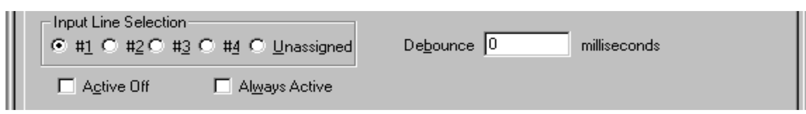


Figure 32: EN Input Line Selection View

Input Line Selection List Box - Epsilon Only

This list box allows you to assign or unassign a highlighted Input Function to an Input Line. Click on the list box arrow to see the Input lines. Then click on the line numbers to assign the function. Assigning the input functions can also be accomplished by dragging the Input Function over and dropping it onto an Input line. To unassign an input function, highlight the function in the Input Lines window and press the delete key or drag the input function from the Input Lines window back to the Input Functions window .

Figure 33: Epsilon Input Line Selection View

Active Off Check Box

This check box allows you to change the "Active On/Off" state. Select the desired function in the input functions window, then check or uncheck the "Active Off" checkbox.

Making an input function “Active On” means that it will be active when +10 to 30 VDC is applied to the input line it’s assigned to and is inactive when no voltage is applied to the line. Making an input function "Active Off" means that it will be active when no voltage is applied to the input line and inactive while +10 to 30 VDC is being applied.

Always Active Check Box

This check box is used to make an input function “Always Active”. When you make an input function always active, it’s active whether assigned to an input line or not. If you make an input function “Always Active” then assign it to an input line, that function will be active whether or not voltage is applied to the line it is assigned to.

Input Lines Window

Debounce

The debounce value is displayed next to each input line. See “Debounce” below.

Functions assigned ...

This feature displays the Input Function assigned to each particular Input Line.

Debounce

This feature helps prevent false input triggering in noisy electrical environments. Enter a “Debounce Time” in milliseconds. The value entered here is the minimum amount of time the input line will need to be active before it is recognized as a valid input.

Outputs Tab

This tab is divided into two windows: The “Output Functions” window, on the left side, displays the available output functions. The “Output Lines” window, on the right side, displays the output lines, the line active state and the output function assignments.

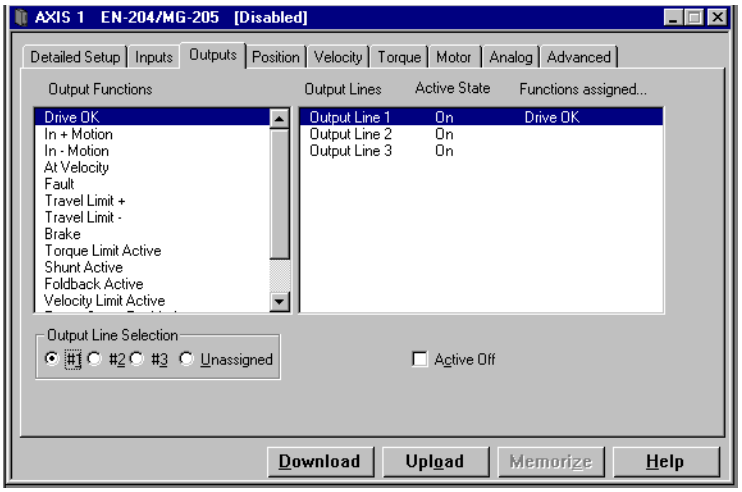


Figure 34: Outputs Tab

Output Functions Window

This window allows you to select the output function you wish to assign to an output line.

Output Line Selection Radio Button - EN Only

This selection box is used to assign an output function to an output line. Highlight the function you wish to assign, then select the appropriate output line. To unassign an output function, highlight the function in the Output Functions window, then select the “unassigned” option.

Figure 35: EN Output Line Selection View

Output Line Selection List Box - Epsilon Only

This list box allows you to assign or unassign the currently highlighted Output Function to an Output Line. Click on the list box arrow to see the possible assignment lines. Then click on one of the line numbers to assign the function. This list box would normally be used when a mouse is not available to navigate the software. Assigning the input functions can also be accomplished by dragging the Output Function and dropping it onto an Output line. To unassign an output function, highlight the function in the Output Lines window and press the delete key or drag the output function from the Output Lines window back to the Output Functions Window.

Figure 36: Epsilon Output Line Selection View

Output Lines Window

Active State

The setting for "Active State" is displayed next to each output function. See "Active Off" check box below.

Functions assigned ...

This feature displays the Output Function assigned to each particular Output Line.

Active Off Check Box

The default active state of an output line is "Active On". This means that the output line will supply a voltage when the result of the logical OR of the output function(s) assigned to that output line is active.

Making an output line "Active Off" means that the line will be "Off" (not conducting) when the result of the logical OR of the output function(s) assigned to that output line is active, and will supply a voltage when the logical OR of the output function(s) is not active.

Position Tab (Detailed Setup view only)

This tab is only definable in Pulse mode and allows you to enable and define the Following Error Limit and if you are on line, view actual operating parameters.

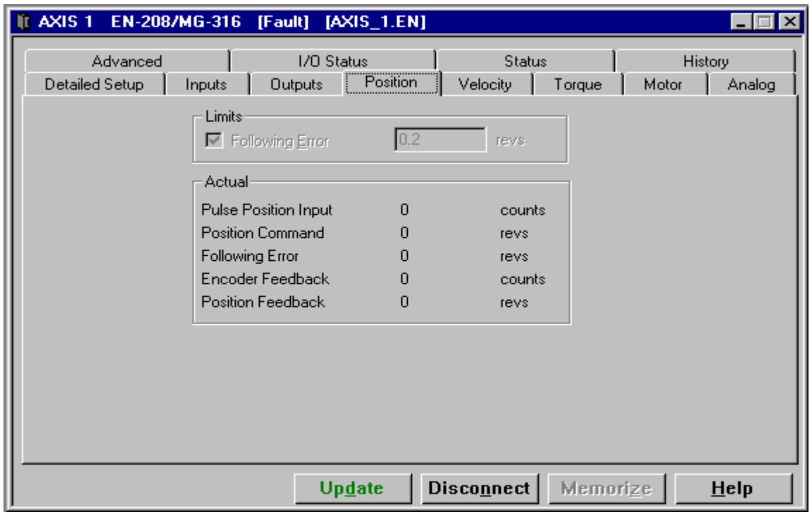


Figure 37: Position Tab

Limits Group

Enable Following Error Limit Check Box

Check this box to enable or disable the Following Error Limit.

Following Error Limit

This parameter only has an effect in Pulse mode. The Following Error is the difference between the Position Command and the Position Feedback. It is positive when the Position Command is greater than the Position Feedback. If the absolute value of the following error exceeds the value you enter here, the drive will generate a Following Error Fault (F). All accumulated Following Error will be cleared when the drive is disabled.

The Following Error Limit is in motor revolutions and has a range of .001 to 10.000 revolutions.

Actual Group

Pulse Position Input

This parameter returns the total number of actual pulses received on the pulse input hardware. This value is active in all operating modes.

Position Command

This is the commanded position generated by either the pulse command or velocity command. In Pulse Summation mode, it is the sum total position command by both pulse and velocity commands.

Following Error

The Following Error is the difference between the Position Command and the Position Feedback. It is positive when the Position Command is greater than the Position Feedback.

Encoder Feedback

The motor position in encoder counts since power-up when the value was set to zero. This is a signed 32 bit value. The motor position in encoder counts since power-up when the value was set to zero. This parameter can be rewritten anytime after power-up.

Position Feedback

This is the feedback position of the motor. This parameter displays the motor position in revolutions and fractions since this parameter was set to zero since power-up.

Velocity Tab (Detailed Setup view only)

This tab allows you to set the drive limits, and if you are online, view the actual operating velocity feedback parameters.

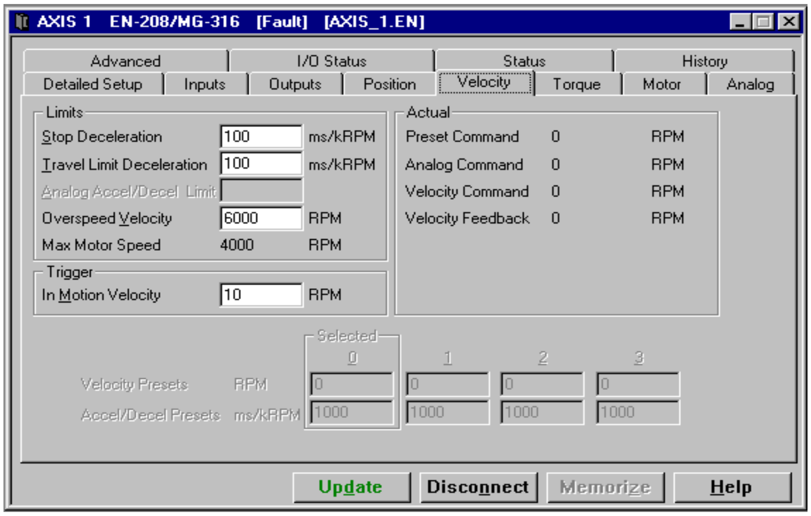


Figure 38: Velocity Tab

Limits Group

Stop Deceleration

The value you enter here defines the rate of velocity change to zero speed when a Stop input function is activated.

The units are ms/kRPM and the range is from 0 to 32700.0. The default is 100 ms/kRPM.

Travel Limit Deceleration

The value you enter here defines the rate of velocity change to zero speed when a Travel Limit input function is activated.

The units are ms/kRPM and the range is from 1.0 to 5000.0. Default is 100 ms/kRPM.

Analog Accel/Decel Limit

This parameter determines the maximum accel and decel rate that will be allowed when using the Analog input in Analog Velocity mode. It does not affect the Stop decel or Travel limit decel rates.

Overspeed Velocity

This parameter specifies the maximum allowable speed. If the Velocity Feedback exceeds either the drive's internal overspeed fault limit or the value of the Overspeed Velocity which is lower, an Overspeed fault will be generated. The internal overspeed fault limit is equal to 150 percent of the Motor Maximum Operating Speed.

Max Motor Speed

Displays the maximum rated motor speed for the selected motor as defined by the motor specification file. For the User Defined Motors this is defined in the MOTOR.DDF file.

Trigger Group

In Motion Velocity

This parameter sets the activation point for both the In + Motion and In - Motion output functions. The output function will deactivate when the motor velocity slows to half of this value. The default is 10 RPMs.

Actual Group

Preset Command

Preset Velocity Command is based on the velocity preset selected. Units are in RPMs.

Analog Command

Analog command voltage currently being applied to the analog command input on the command connector. Units are in RPMs.

Velocity Command

The Velocity Command is the actual command received by the velocity loop. Units are in RPMs.

Velocity Feedback

This parameter is the actual motor velocity feedback in RPMs.

Velocity Presets

Enter a value for each of the Velocity Presets you wish to use. The units are RPM and the range is from ± maximum motor velocity. A positive value will cause CW motion and a negative value will cause CCW motion. (Motor direction is determined as you face the shaft end of the motor).

Accel/Decel Presets

Enter an Accel/Decel Presets value for each of the velocity presets you are using. The units are milliseconds per 1000 RPM and the range is from 0 to 32700.0. Default is 1000 ms/kRPM.

Torque Tab (Detailed Setup view only)

This tab allows you to edit the Torque Limit and view the following torque parameters.

These parameters are continuously updated when you are online with the drive.

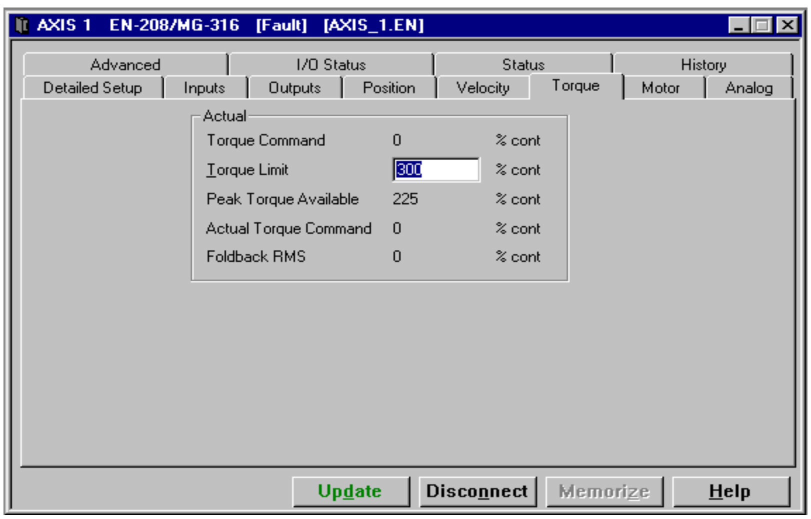


Figure 39: Torque Tab

Note

The Torque Limit value takes effect only when the Torque Limit Enable input function is active.

Actual Group

Torque Command

This parameter returns the torque command value before it is limited. The Torque Command may be limited by either the Torque Limit (if the Torque Limit Enable input function is active) or current foldback.

Torque Limit

This value is the level which the Torque Command will be limited to when the Torque Limit input function is active. To make the Torque Limit always active, set the Torque Limit Input Function to be "Always Active".

Peak Torque Available

This displays the maximum torque available from the selected drive and motor combination. This is calculated by PowerTools FM and is not a drive parameter.

Actual Torque Command

Displays the Torque command after all limiting. This command is used by the current loop to generate motor torque.

Foldback RMS

This parameter accurately models the thermal heating and cooling of the drive and motor. When it reaches 100 percent, current foldback will be activated.

Torque Level 1 and 2

This parameter sets the activation level for the appropriate Torque Level output function.

Motor Tab (Detailed Setup view only)

This tab allows you to select the motor to be used with the current drive (only when offline with the drive). Standard or user-defined motors (available in the MOTOR.DDF file) are allowed selections. The drive selected will affect the standard motor options but the user-defined motors are always available. All other parameters on the Motor tab are related to the load on the motor and application requirements.

Note

If you are online with the drive, the Motor Type will be grayed.

All parameters on the Motor tab are related to the load on the motor and application requirements.

The load on the motor is specified by two parameters: Inertia Ratio and Friction. Typical application requirements are specified by the response adjustment and Feedforward Gains. Position Error Integral is provided to compensate for systems with high friction or vertical loads. A Low Pass Filter is provided to filter machine resonance that are present is some applications.

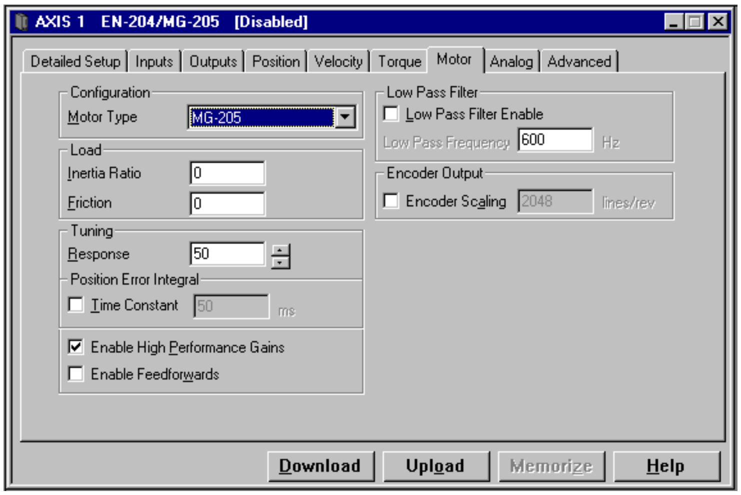


Figure 40: Motor Tab

Configuration Group

Motor Type

Select the motor you wish to use. PowerTools FM software will only display the motor models that are compatible with the drive you selected and any user defined motors.

⚠ CAUTION

Selecting the wrong motor type can cause poor performance and may even damage the motor and/or drive.

Low Pass Filter Group

Low Pass Filter Enable Checkbox

This enables a low pass filter applied to the output of the velocity command before the torque compensator. The low pass filter is only active in Pulse and Velocity modes, not Torque Modes.

Low Pass Frequency

This parameter defines the low pass filter cut-off frequency signals exceeding this frequency will be filtered at a rate of 40 db. per decade.

Encoder Output Group

Encoder Scaling Check Box

This check box enables the Encoder Scaling feature. When not enabled, the encoder output density is the same as the motor encoder density.

Encoder Scaling

This feature allows you to change the drive encoder output resolution in increments of one line per revolution up to the density of the encoder in the motor. If the Encoder Scaling parameter is set to a value higher than the motor encoder density, the drive encoder output density will equal that of the motor encoder.

Load Group

Inertia Ratio

Inertia Ratio specifies the load to rotor inertia ratio and has a range of 0.0 to 50.0. If the exact inertia is unknown, a conservative approximate value should be used. If you enter an inertia value higher than the actual inertia, the resultant motor response will tend to be more oscillatory.

Friction

This parameter is characterized in terms of the rate of friction increase per 100 motor RPM. If estimated, always use a conservative (less than or equal to actual) estimate. If the friction is completely unknown, a value of zero should be used. A typical value used here is less than one percent.

Tuning Group

Response

The Response adjusts the velocity loop bandwidth with a range of 1 to 500 Hz. In general, it affects how quickly the drive will respond to commands, load disturbances and velocity corrections. A good value to start with (the default) is 50 Hz. The affect of response is greatly affected by High Performance Gains. With High Performance Gains the maximum value recommended is 100 Hz.

Position Error Integral Group

Position Error Integral Check Box

The Position Error Integral is a control term, which can be used to compensate for the continuous torque required to hold a vertical load against gravity. It is also useful in Pulse mode applications to minimize following error.

Time Constant

The user configures this control term using the "Position Error Integral Time Constant" parameter. This parameter determines how quickly the drive will correct for in-position following error. The time constant is in milliseconds and defines how long it will take to decrease the following error to 37 percent of the original value. In certain circumstances the value actually used by the drive will be greater than the value specified here.

Min Time Constant = 1000/Response

For example, with "Response" set to 50, the minimum time constant value is 1000/50 = 20 msec.

Enable High Performance Gains Check Box

Enabling the High Performance Gains increases closed loop stiffness which can be beneficial in open loop velocity applications and Pulse mode. When enabled, they make the system less forgiving in applications where the actual inertia varies or the coupling between the motor and the load has excessive windup or backlash.

Note

When using an external position controller in Velocity mode, High Performance Gains should not be enabled.

Enable Feedforwards Check Box

When feedforwards are enabled, the accuracy of the Inertia and Friction are very important. If the Inertia is larger than the actual inertia, the result could be a significant overshoot during ramping. If the Inertia is smaller than the actual inertia, following error during ramping will be reduced but not eliminated. If the Friction is greater than the actual friction, it may result in velocity error or instability. If the Friction is less than the actual friction, velocity error will be reduced by not eliminated.

Analog Tab (Detailed Setup view only)

This tab displays the setup and feedback data for the Analog Input and the two diagnostic Analog Outputs.

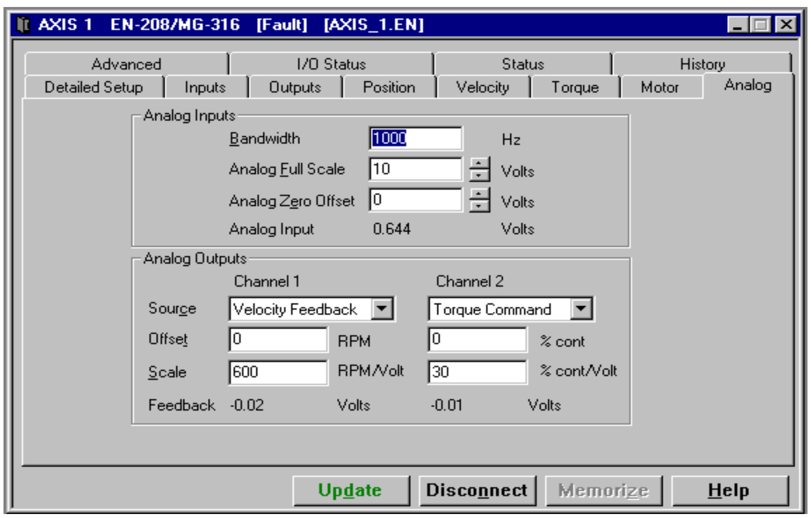


Figure 41: Analog Tab

Analog Inputs Group

Bandwidth

This sets the low-pass filter cut off frequency applied to the analog command input. Signals exceeding this frequency will be filtered at a rate 20 db. per decade.

Analog Full Scale

This parameter specifies the voltage required to command Full Scale Velocity or Full Scale Torque. It is used in Velocity Analog and Torque Analog operating modes.

Analog Zero Offset

This parameter is used to null any voltage present at the drive when a zero velocity or torque command is provided by a controller. The amount of offset can be measured by the Analog Input parameter when a zero velocity or torque command is supplied.

Analog Input

The analog voltage signal that is received on pins 14 and 15 of the Command Connector and is used to generate the Analog Velocity Command or the Analog Torque Command depending on the Actual Operating Mode.

For example:

+10 VDC = Maximum motor CW velocity or maximum CW torque.

-10 VDC = Maximum motor CCW velocity or maximum CCW torque.

Analog Outputs Group

Source

Select the signal that you wish to use as the source for Analog Output Channel #1 and Channel #2. There are five options: Velocity Feedback, Velocity Command, Torque Feedback, Torque Command and Following Error. The scaling and offset are affected by the source parameter selected. The units of the scaling and offset are adjusted according to the source parameter.

Offset and Scale

Each analog diagnostic output channel includes a programmable Analog Output Offset and an Analog Output Scale. These features allows you to “zoom in” to a desired range effectively increasing the resolution. The units for both of these parameters is dependent upon the Analog Output Source selection.

Feedback

This is a display of the real time status of the two analog outputs in volts. It is only available when you are online.

I/O Status Tab

This tab displays the status of the input and output functions in real time and is only available when you are online with a drive. This tab is divided into two windows, the "Inputs" window and the "Outputs" window.

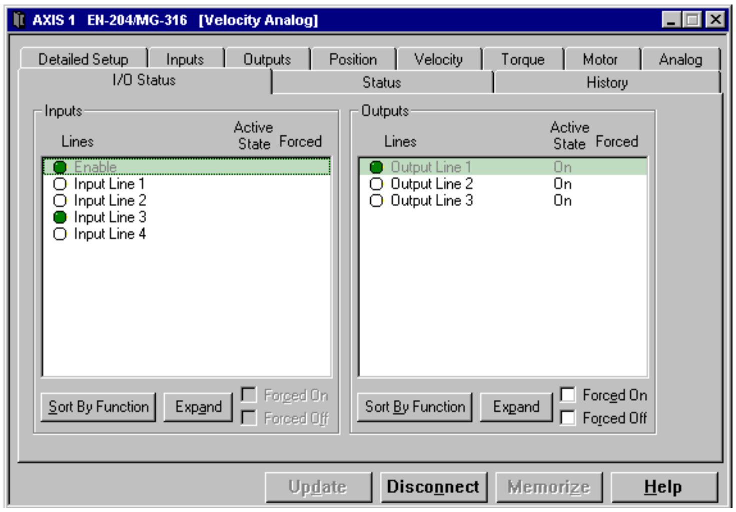


Figure 42: I/O Status Tab

Inputs Group

Inputs Lines Window

This feature shows the various input lines and whether they are active. The line is active if the circle next to the line is green or lit-up.

Active State

The active state is shown for each input line.

Forced

The forced state is shown for each input line.

Forced On and Forced Off

You can force an input line to a level by using the "Forced On" and "Forced Off" check boxes. When you force an input line “On” or “Off”, all the functions assigned to that line will be affected.

Note

The forced state of input and output lines are not saved to NVM and will be lost when the drive is powered down.

Sort By Function/Line Button

Click on this button to change how the "Inputs" window is sorted (i.e., by functions or lines).

The window can be sorted by either function or line. The functions and lines are arranged in a hierarchy. If the window is sorted by lines, then each line is displayed and any functions assigned to a particular line are grouped below the line.

Expand/Collapse Button

This button expands or collapses the hierarchy of the "Inputs" window. An expanded view shows the relationship between functions and lines. A collapsed view shows only lines or functions.

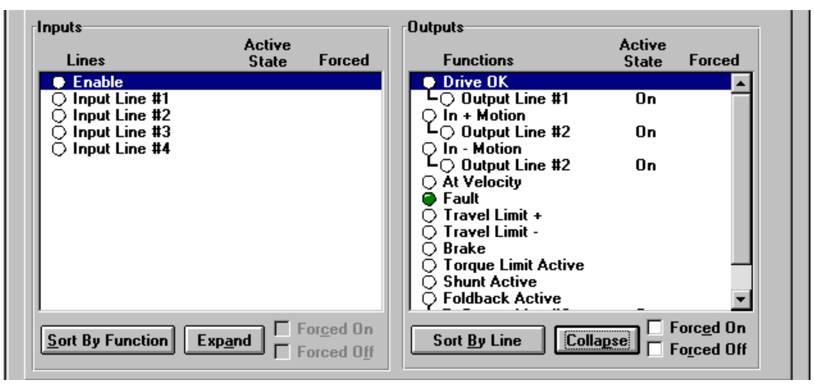


Figure 43: Collapsed and Expanded Views

If the function or line is currently active, the "LED" to the left of the function or line name will be green.

Note

When a function or line is active, the state of the "LED" associated with the function or line is dependent on how the "Always Active", "Forced On or Off" and "Active Off" controls are used.

Outputs Group

Outputs Lines Window

This feature shows the various output lines and whether they are active. The line is active if the circle next to the line is green or lit-up.

Active State

The active state is displayed for each output line.

Forced

The forced state is displayed for each output line.

Forced On and Forced Off

You can force an output line to a level by using the "Forced On" and "Forced Off" check boxes. When you force an output line “On” or “Off”, the output functions are not affected.

Note

The forced state of input and output lines are not saved to NVM and will be lost when the drive is powered down.

Sort By Function/Line Button

Click on this button to change how the "Outputs" window is sorted (i.e., by functions or lines).

Each window can be sorted by either function or line. The functions and lines are arranged in a hierarchy. If the window is sorted by lines, then each line is displayed and any functions assigned to a particular line are grouped below the line.

Expand/Collapse Button

This button expands or collapses the hierarchy of the "Outputs" window. An expanded view shows the relationship between functions and lines. A collapsed view shows only lines or functions.

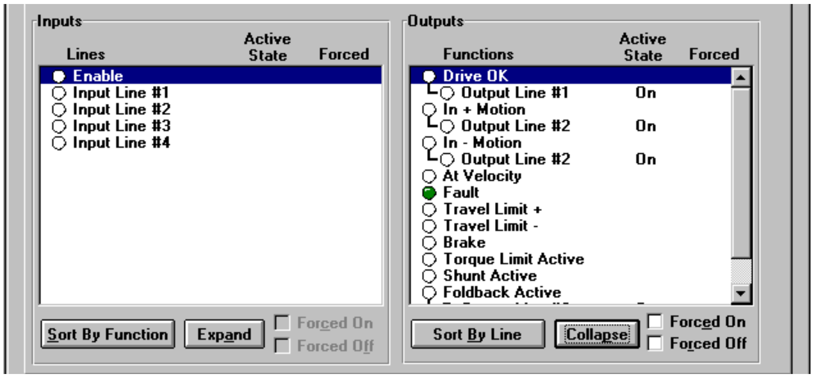


Figure 44: Collapsed and Expanded Views

If the function or line is currently active, the "LED" to the left of the function or line name will be green.

Note

When a function or line is active, the state of the "LED" associated with the function or line is dependent on how the "Always Active", "Forced On or Off" and "Active Off" controls are used.

Status Tab

This tab displays the drive status in real time and is only available when you are on-line with a drive. The information in this tab is divided into six categories: Position, Velocity, Torque, Drive Status, I.D. and Drive Run Time.

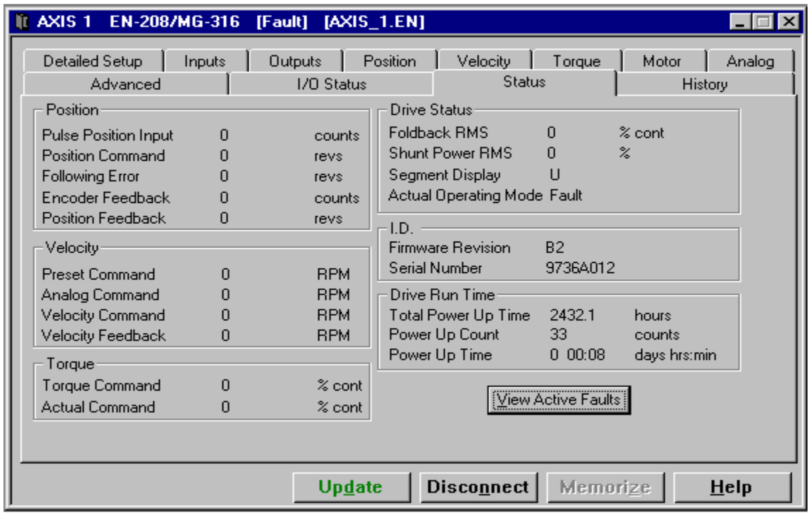


Figure 45: Status Tab

Note

The information in this tab is for diagnostics purposes only and cannot be changed from within this tab.

Position Group

Pulse Position Input

This parameter returns the total number of actual pulses received on the pulse input hardware. This value is active in all operating modes.

Position Command

This is set to zero when the Absolute Position Valid output function is activated.

Following Error

The Following Error is the difference between the Position Command and the Position Feedback. It is positive when the Position Command is greater than the Position Feedback.

Encoder Feedback

The motor position in encoder counts since power up when the value was set to zero. This is a signed 32 bit value. This parameter can be preloaded using the serial interface.

Position Feedback

This parameter is the motor position since power-up. This value is automatically reset to zero at power-up.

Velocity Group

Preset Command

Preset Velocity command based on the velocity preset selected.

Analog Command

Analog command voltage currently being applied to the analog command input on the command connector.

Velocity Command

The Velocity Command is the actual command received by the velocity loop.

Velocity Feedback

This parameter is the actual feedback motor velocity in RPMs.

Torque Group

Torque Command

This parameter returns the torque command value before it is limited. The torque command may be limited by either the Torque Limit (if the Torque Limit Enable input function is active) or current foldback.

Actual Command

Displays the Torque command after all limiting. This command is used by the current loop to generate Motor Torque.

Drive Status Group

Foldback RMS

This parameter accurately models the RMS loading of the drive and motor. When it reaches 100 percent, current foldback will be activated.

Shunt Power RMS

This parameter models the thermal heating and cooling of the drive internal shunt. This parameter indicates the percent of shunt capacity utilization and is based on the Heat Sink RMS value. When this value reaches 100 percent the drive will generate an RMS Shunt Power Fault.

Heatsink RMS - EN Only

This parameter models the thermal utilization of the heatsink by the power stage. It determines the amount of thermal capacity available for the Regen Shunt Resistor. A display of 10 percent heatsink capacity remaining for use by the shunt resistor. When this value reaches 100 percent or higher, no capacity is left for the shunt resistor and a shunt resistor and a shunt fault will occur as soon as the shunt is activated.

Segment Display

Character currently being displayed by the status display on the front of the drive.

Actual Operating Mode

This parameter returns the actual (or current) operating mode or state of the drive. This is determined by the Operating Mode Default, Alternate Operating Mode, Input Functions which override the operating mode, fault conditions, function modules or disabling the drive.

Bus Voltage - Epsilon Only

Displays the actual measured voltage on the DC power bus.

ID Group (Detailed Setup view only)

Firmware Revision

Displays the revision of the firmware in the drive you are currently online with.

Serial Number

Displays the serial number of the drive with which you are currently online.

Drive Run Time Group (Detailed Setup view only)

Total Power Up Time

Total amount of time displayed in hours the drive has been powered-up since leaving the factory.

Power Up Count

Number of times the drive has been powered-up since leaving the factory.

Power Up Time

Amount of time displayed in hours the drive has been powered-up since last power up.

View Active Faults Button

Pushing this button displays the Active Drive Faults dialog box. From this dialog box you can reset any resettable active fault by clicking the *Reset* button.

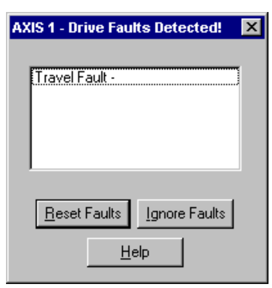


Figure 46: Active Drive Faults Dialog Box

Fault Log Group (EZ Setup view only)

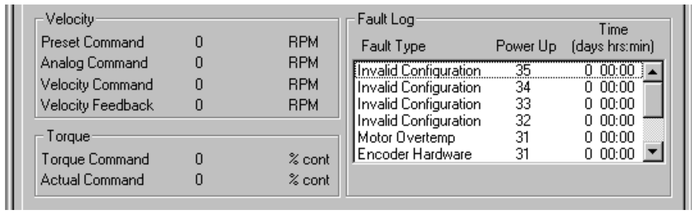


Figure 47: Fault Log View

Fault Log Window

This window displays the last ten drive faults with time stamps. The first fault is the most recent fault. The information in this window is read only and cannot be edited or cleared.

Power up

This feature indicates during which power-up that the fault occurred.

Time (days hrs:min)

This feature indicates the time into the power-up that the fault occurred. The time is displayed in days, hours and minutes).

History Tab (Detailed Setup view only)

This tab displays a complete fault history including a "Fault Log" window and a "Fault Count" window.

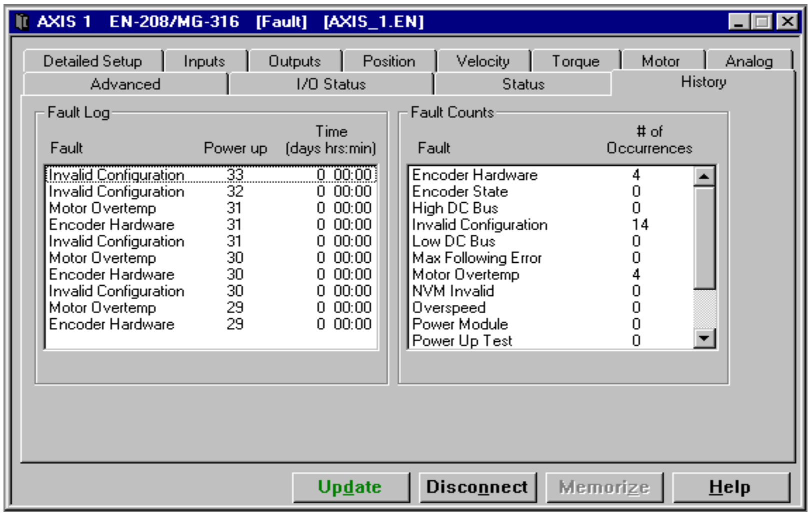


Figure 48: History Tab

Note

The "Fault Log" and "Fault Counts" cannot be cleared.

Fault Log Group

Fault Log Window

This window displays the last ten drive faults with time stamps. The first fault is the most recent fault. The information in this window is read only and cannot be edited or cleared.

Power up

This feature indicates during which power-up that the fault occurred.

Time (days hrs:min)

This feature indicates the time into the power-up that the fault occurred. The time is displayed in days, hours and minutes).

Fault Counts Group

Fault Counts Window

The "Fault Counts" window displays all the faults that can occur and the number of times those faults happened since the drive was originally powered-up. The information in this window cannot be edited or cleared.

of Occurrences

The "# of Occurrences" column displays the number of times each fault has occurred since the drive was originally powered up.

Advanced Tab

This tab is reserved for very infrequently used parameters that sometimes need to be adjusted to solve certain application problems. This tab is not normally visible and it is only rarely necessary. If any parameter in this tab is not at default, then it will automatically be enabled when starting PowerTools FM.

All the setups here are effective for all modes used and for both the (Main) Default Operating Mode and the Alternate Operating Mode.

Drive Ambient Group

Drive Ambient Temperature - EN Only

Firmware Version B4 and later drives.

Drive Ambient Temperature is a parameter which will let the drive know the air temperature around the drive heat sink while the system is under normal operating conditions. If the actual ambient temperature is higher than 40°C (104°F), setting the Drive Ambient Temperature parameter to the actual temperature will help to protect the drive by activating the Shunt Fault at an appropriate time.

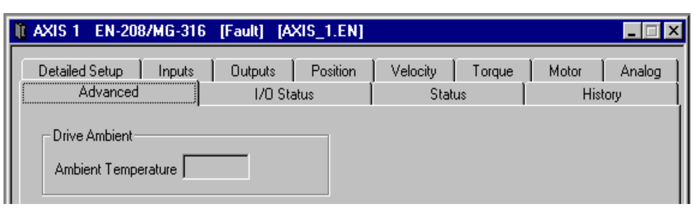


Figure 49: EN Drive Ambient View

Bus Voltage Group

Low DC Bus Enable - Epsilon Only

This parameter's default setting is enabled. When enabled, the drive will detect a low DC bus at 60 VDC and will log a Low DC Bus Fault if a power down is not completed after the low DC bus is detected. Setting this to disabled will disable the Low DC Bus Voltage Fault. This will allow the drive to operate at a DC bus voltage below 60 VDC as long as the logic power is supplied by the A.P.S. (Alternate Power Supply).

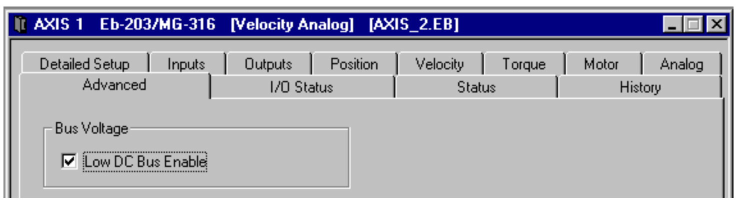


Figure 50: Epsilon Bus Voltage View

Encoder State Fault Enable

This parameter's default setting is enabled. When enabled, the drive will detect encoder state faults. Refer to Fault Codes in the Diagnostic and Troubleshooting section of this manual. The drive will not detect Encoder State faults when the fault is disabled. Disabling encoder faults is necessary for some types of programable encoders where the state transitions are not always deterministic.

Installation

Basic Installation Notes

You are required to follow all safety precautions during start-up such as providing proper equipment grounding, correctly fused power and an effective Emergency Stop circuit which can immediately remove power in the case of a malfunction. See the "Safety Considerations" section for more information.

Electromagnetic Compatibility (EMC)

Drives are designed to meet the requirements of EMC. Under extreme conditions a drive might cause or suffer from disturbances due to electromagnetic interaction with other equipment. It is the responsibility of the installer to ensure that the equipment or system into which the drive is incorporated complies with the relevant EMC legislation in the country of use.

The following instructions provide you with installation guidance designed to help you meet the requirements of the EMC Directive 89/336/EEC.

Adhering to the following guidelines will greatly improve the electromagnetic compatibility of your system, however, final responsibility for EMC compliance rests with the machine builder, and Control Techniques cannot guarantee your system will meet tested emission or immunity requirements.

If you need to meet EMC compliance requirements, EMI/RFI line filters must be used to control conducted and radiated emissions as well as improve conducted immunity.

Physical location of these filters is very important in achieving these benefits. The filter output wires should be kept as short as possible (12 inches is suggested) and routed away from the filter input wires. In addition:

- Choose an enclosure made of a conductive material such as steel, aluminum or stainless steel.
- Devices mounted to the enclosure mounting plate, which depend on their mounting surfaces for grounding, must have the paint removed from their mounting surfaces and the mating area on the mounting plate to ensure a good ground. See the, "Achieving Low Impedance Connections" section for more information.
- If grounding is required for cable grommets, connectors and/or conduit fittings at locations where cables are mounted through the enclosure wall, paint must be removed from the enclosure surface at the contact points.
- AC line filter input and output wires and cables should be shielded, and all shields must be grounded to the enclosure.

Achieving Low Impedance Connections

Noise immunity can be improved and emissions reduced by making sure that all the components have a low impedance connection to the same ground point. A low impedance connection is one that conducts high frequency current with very little resistance. Impedance cannot be accurately measured with a standard ohmmeter, because an ohmmeter measures DC resistance. For example, a 12 inch long 8 gauge round wire has a significantly higher impedance than a 12 inch long 12 gauge flat braided conductor. A short wire has less impedance than a long one.

Low impedance connections can be achieved by bringing large areas of conductive surfaces into direct contact with each other. In most cases this requires paint removal because a ground connection through bolt threads is not sufficient. However, component materials should be conductive, compatible and exhibit good atmospheric corrosion resistance to prevent loss through corrosion which will hinder the low impedance connection. Enclosure manufacturers offer corrosion resistant, unpainted mounting plates to help.

Bringing components into direct contact cannot always be achieved. In these situations a conductor must be relied upon to provide a low impedance path between components. Remember a flat braided wire has lower impedance than a round wire of a large gauge rating.

A low impedance connection should exist between the following components, but not limited to:

- Enclosure and mounting plate
- Servo amplifier chassis and mounting plate
- EMI/RFI AC line filter chassis and mounting plate
- Other interface equipment chassis and mounting plate
- Other interface equipment chassis and electrical connectors
- Enclosure and conduit fittings or electrical connectors
- Enclosure mounting plate and earth ground
- Motor frame and conduit fittings or electrical connectors
- Encoder chassis and electrical connector

A good rule to follow when specifying conductors for high frequency applications is to use a metal strap with a length to width ratio that is less than 3:1.

AC Line Filters

The AC line filters used during Control Techniques' compliance testing are listed below. These filters are capable of supplying the drive input power to the specified drive under maximum output power conditions.

Epsilon	EN Model	Schaffner Part #	Control Techniques Part #	Rating
Eb-202, Eb-203		FN2070-10/06	960307-01	10A, 240V, 1 Ø
	EN-204	FS5278-16/08	960305-01	16A, 240V, 1 Ø
Eb-205	EN-208	FS5278-16/08	960305-01	
	EN-214	FN-258/16	960304-01	16A, 480V, 3 Ø

Alternately, Control Techniques has also seen good results with the following line filters:

Epsilon	EN Model	Part #	Rating
	EN-204	**Schaffner** FN 2070M-16/8 **Corcom** 20EQ1	20A, 240V, 1 Ø
Eb-205	EN-208	**Schaffner** FN 2070M-16/8 **Corcom** 20EQ1	
Eb-202, Eb-203, Eb-205		**Corcom** 20EQ1	
Eb-202		**Schaffner** FN 2070-6-06	6A, 240V, 1 Ø

AC Line Filter Installation Notes

- EMC criteria can be met in installations where multiple drives are supplied through a single filter, however, it is the installers responsibility to verify EMC compliance. Questions on this subject should be directed to the filter manufacturer.
- It is critical that you keep the filter inputs routed away from any electrical noise sources to prevent noise from being induced into them and carried out of the enclosure.

Cable to Enclosure Shielding

Shielded motor, feedback, serial communications and external encoder cables were used for Control Techniques' compliance testing and are necessary to meet the EMC requirements. Each cable shield was grounded at the enclosure wall by the type of grommet described earlier and shown in the figure 51.

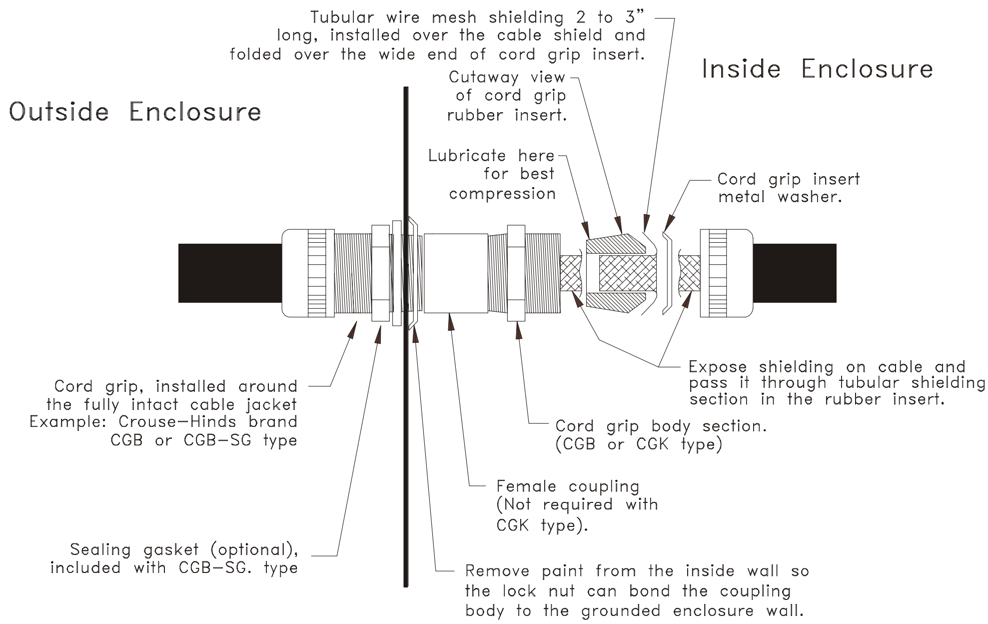


Figure 51: Through Wall Shield Grommet

Cable Type	Cable Model	Shielded Cable Grommet Kit Part #	Conduit Dimension Hole Size	Actual Hole Size
Motor Cable, 16 Ga	CMDS	CGS-050	1/2" pipe	7/8"
Motor Cable, 12 Ga	CMMS	CGS-050	1/2" pipe	7/8"
Feedback Cable	CFOS	CGS-050	1/2" pipe	7/8"
Flex Motor Cable, 16 Ga	CMDF	CGS-050	1/2" pipe	7/8"
Flex Motor Cable, 12 Ga	CMMF	CGS-075	3/4" pipe	1 1/16"
Flex Feedback Cable	CFCF, CFOF	CGS-063	3/4" pipe	1 1/16"
External Encoder	ENCO	CGS-038	1/2" pipe	7/8"
AC Power	user supplied	user supplied	user supplied	user supplied

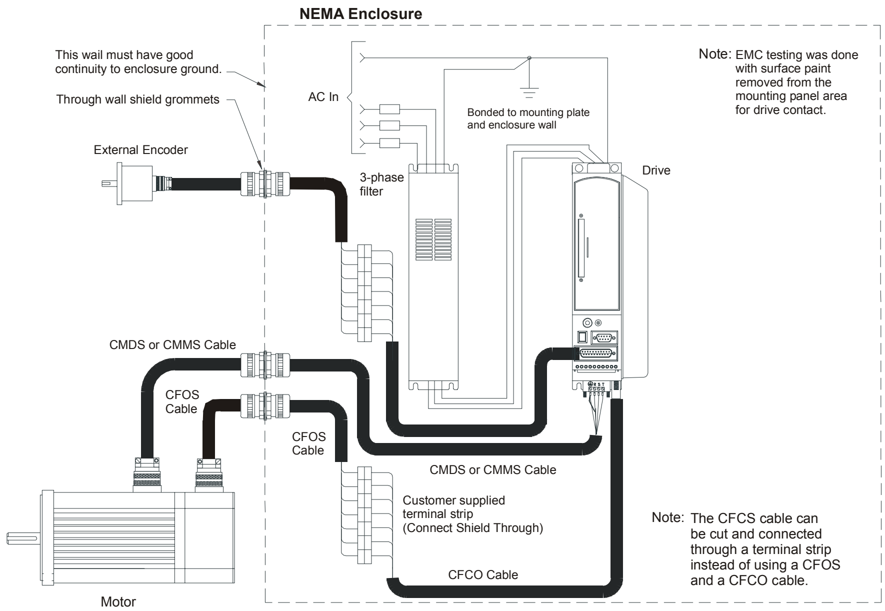


Figure 52: AC Filter and Cable Connections for EN Drives

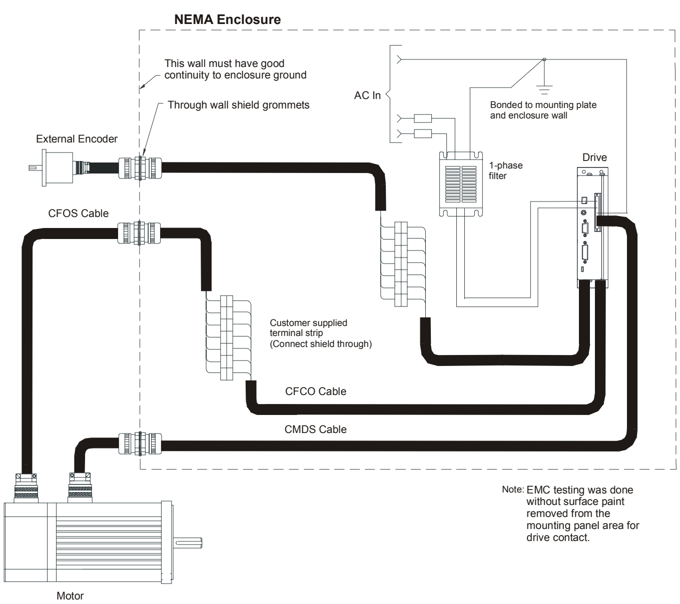


Figure 53: AC Filter and Cable Connections for Epsilon Drives

Environmental Considerations

If the product will be subjected to atmospheric contaminants such as moisture, oils, conductive dust, chemical contaminants and metallic particles, you must mount it vertically in a metal NEMA type 12 enclosure.

If the ambient temperature inside the enclosure will exceed 40° C (104° F), you must consider forced air cooling.

Note

It is necessary to maintain the drive surround air ambient temperature at 40° C (104° F) [50°C (122ºF) with derating of 3% per degree above 40° C].

The amount of cooling depends on the size of the enclosure, the thermal transfer of the enclosure to the ambient air and the amount of power being dissipated inside the enclosure. Consult your enclosure manufacturer for assistance with determining cooling requirements.

Wiring Notes

- To avoid problems associated with EMI (electromagnetic interference), you should route high power lines (AC input power and motor power) away from low power lines (encoder feedback, serial communications, etc.).
- If a neutral wire (not the same as Earth Ground), is supplied from the building distribution panel it should never be bonded with PE wire in the enclosure.
- You should consider future troubleshooting and repair when installing all wiring. All wiring should be either color coded and/or tagged with industrial wire tabs.
- As a general rule, the minimum cable bend radius is ten times the cable outer diameter.
- All wiring and cables, stationary and moving, must be protected from abrasion.
- Ground wires should not be shared with other equipment.
- Ensure that metal to metal contact is made between the enclosure ground lug and the metal enclosure, not simply through the mounting bolt and threads.
- All inductive coils must be suppressed with appropriate devices, such as diodes or resistor/capacitor (RC) networks.

Mechanical Installation

Drive Mounting

Drives must be back mounted vertically on a metal surface such as a NEMA enclosure. A minimum spacing of two inches must be maintained above and below the drive for ventilation. Additional space may be necessary for wiring and cable connections.

For drive dimensions, weights and mounting specifications, see the "Specifications" section.

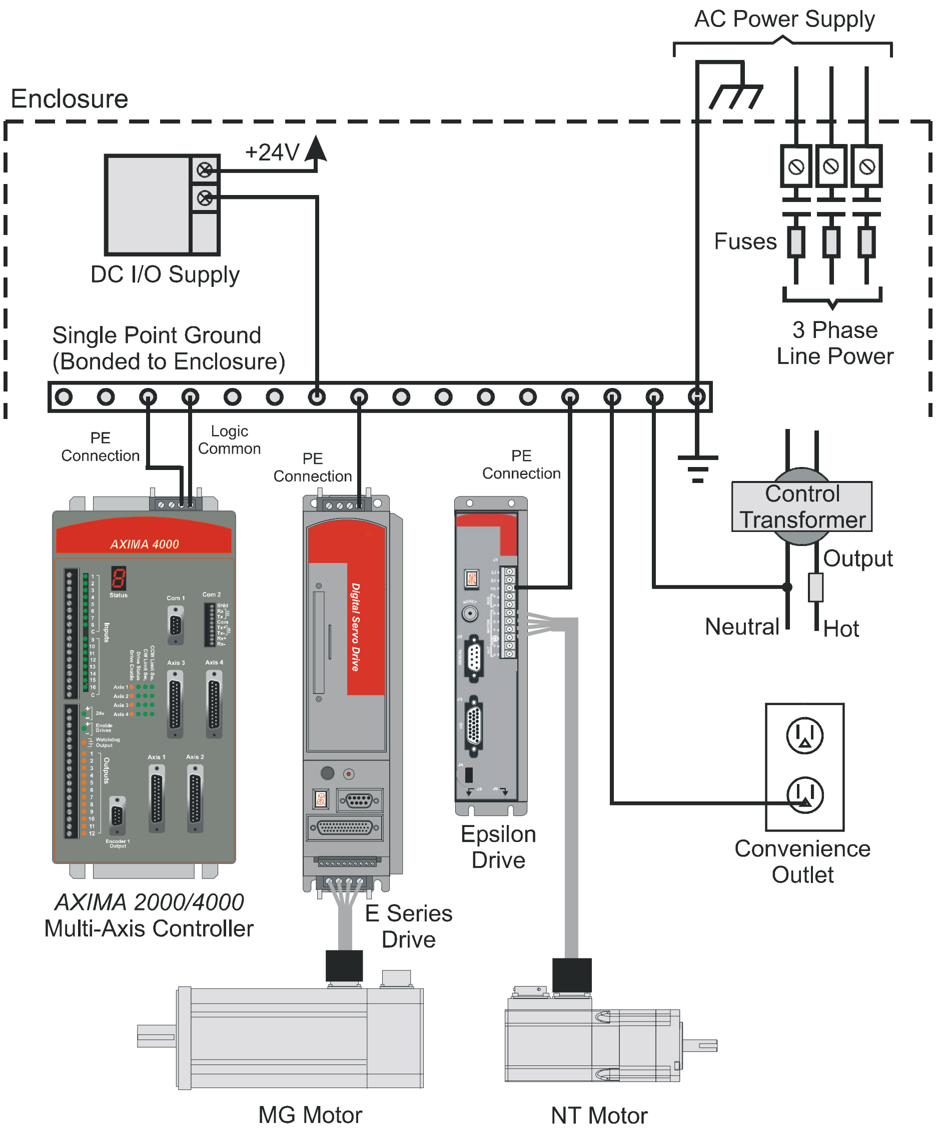
Motor Mounting

Motors should be mounted firmly to a metal mounting surface to ensure maximum heat transfer for maximum power output and to provide a good ground.

For motor dimensions, weights and mounting specifications, see the "Specifications" section.

Electrical Installation

System Grounding



Note: The aluminum heatsink is electrically connected to the PE terminal.

Figure 54: Typical System Grounding Diagram

Power Supply Requirements

The examples below show AC power connections for single phase and three phase drives. These examples are shown for reference only. Local electrical codes should be consulted before installation.

⚠WARNING

The Protective Earth (PE) wire connection is mandatory for human safety and proper operation. This connection must not be fused or interrupted by any means. Failure to follow proper PE wiring can cause death or serious injury.

Epsilon Only

The Eb-202, Eb-203 and Eb-205 drives require 90 to 264 VAC single-phase power. An Epsilon drive can be connected to any pair of power phases on a 1 Ø or 3 Ø power source that is grounded as shown in the following diagrams.

The input power range of the Epsilon drives can be extended to 42 to 264 VAC with the Low DC Bus fault disabled.

EN Only

The EN-204 and EN-208 drives require 90 to 264 VAC single phase power. The EN-214 can operate with single or three phase 90 to 264 VAC. If single phase power is used with the EN-214, you must de-rate the output power available by 20 percent.

Note

The maximum voltage applied to the drive terminals must not exceed 264 VAC phase to phase and phase to PE ground. This can be accomplished by referencing the AC supply to earth ground.

⚠CAUTION

Do not connect or disconnect the AC power by inserting or removing the AC power connector. Using the connector in this manner, even once, will damage the connector, making it unusable.

AC Supplies NOT Requiring Transformers

If the distribution transformer is configured as shown in the figures below, the AC power supply can be connected directly to the amplifier terminals.

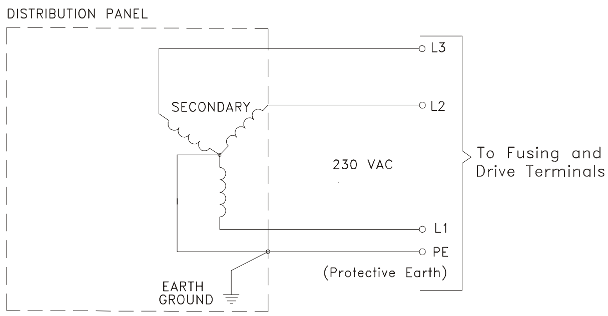


Figure 55: Earth Grounded WYE Distribution Transformer

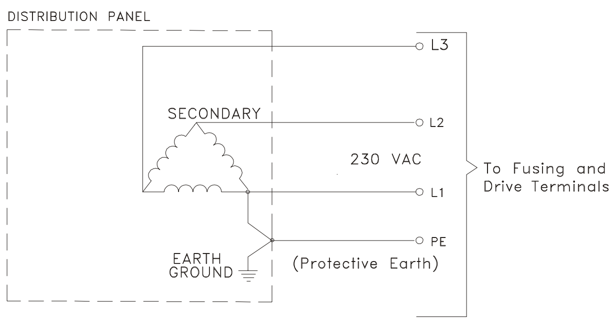


Figure 56: Earth Grounded Delta Distribution Transformer

AC Supplies Requiring Transformers

If the distribution transformer is configured as shown in the figures below, an isolation transformer is required.

If an isolation transformer is used between the power distribution point and the drives, the transformer secondary must be grounded for safety reasons as shown in the figures below.

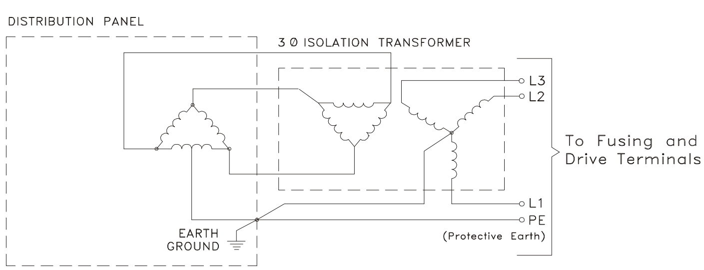


Figure 57: Three Phase Delta (with mid-phase GND) Distribution to a Three-Phase Delta/WYE Isolation Transformer

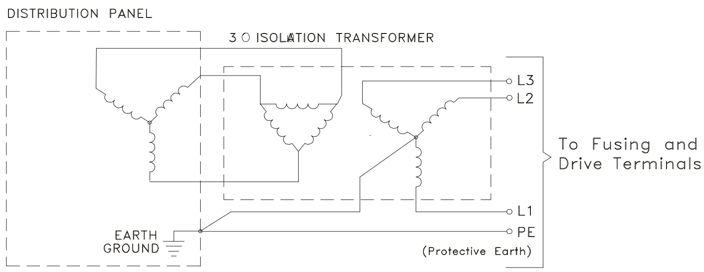


Figure 58: *Three Phase WYE (ungrounded) Distribution to a Three-Phase Delta/WYE Isolation Transformer*

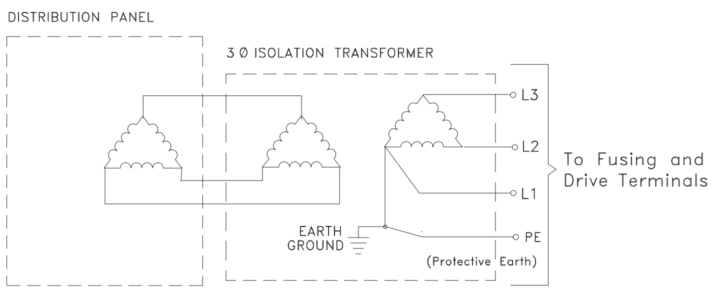


Figure 59: *Delta to Delta Isolation Transformer*

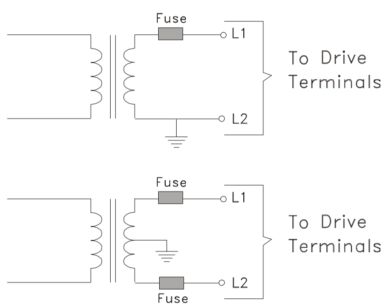


Figure 60: *Single Phase Power Supply Connections*

Transformer Sizing

If your application requires a transformer, use the following table for sizing the KVA rating. The values in the table are based on “worst case” power usage and can be considered a conservative recommendation. You can down-size the values only if the maximum power usage is less than the transformer continuous power rating. Other factors that may influence the required KVA rating are high transformer ambient temperatures (>40° C or >104° F) and drive operation near the maximum speeds.

Drive/Motor Combination	Suggested KVA Rating
EN-204/NT-320	3.0
EN-204/MG-205	0.8
EN-204/MG-208	1.5
EN-204/MG-316	2.3
EN-208/NT-320	3.0
EN-208/NT-330	3.9
EN-208/NT-345	4.3
EN-208/NT-355	4.9
EN-208/MG-316	2.3
EN-208/MG-340	3.9
EN-208/MG-455	4.9
EN-214/NT-345	4.3
EN-214/NT-355	4.3
EN-214/MG-455	4.3
EN-214/MG-490	6.0
EN-214/MG-4120	6.5
Eb-202/NT-207	1.0
Eb-202/NT-212	1.2
Eb-203/NT-207	1.0
Eb-203/NT-212	1.7
Eb-203/MG-316	2.3
Eb-205/NT-212	1.7
Eb-205/NT-320	3.0
Eb-205/NT-330	3.0
Eb-205/NT-345	3.0
Eb-205/MG-340	3.0
Eb-205/MG-316	2.3

Transformer output voltage drop may become a limiting factor at motor speeds and loads near maximum ratings. Typically, higher KVA transformers have lower voltage drop due to lower impedance.

Line Fusing and Wire Size

You must incorporate over current protection for the incoming AC power with the minimum rating shown here. Control Techniques recommends Bussman type: KTK-R, RK1or equivalent.

Drive Model	External AC Line Fuse	Recommended Minimum AC/PE Line Wire Gauge
EN-204	KTK-R 15 Amp 1Ø	14 AWG
EN-208	RK1 20 Amp 1Ø	12 AWG
EN-214	RK1 20 Amp 3Ø	12 AWG
Eb-202	KTK-R 6 Amp	16 AWG
Eb-203	KTK-R 8 Amp	16 AWG
Eb-205	KTK-R 12 Amp	16 AWG

Drive Model	Input Voltage (VAC)	Frequency (Hz)	Input Current (Amps RMS) at full drive output current		Inrush Current (Amps) 1st Cycle	2nd Cycle
			1 Ø	3 Ø		
EN-204	90 - 264 / 1 Ø	47 - 63	9.5 A	-	140 (8ms)	50 (8 ms)
EN-208	90 - 264 / 1 Ø		19 A	-	140 (8ms)	50 (8 ms)
EN-214	90 - 264 / 1 - 3 Ø		20 A*	14 A	100 (5 ms) 3 Ø	40 (5 ms) 3 Ø
Eb-202	90 - 264 / 1 Ø	47 - 63	4.3		140 (5 ms)	20 (2 ms)
Eb-203			6.5			
Eb-205			10.8			30 (2ms)

* This is at 20% derated drive output only current as required when using single-phase AC power.

Epsilon Only

This inrush current specification assumes the drive has been powered off for at least eight minutes at 40ºC (104ºF) ambient or five minutes at 25ºC (77ºF) ambient. If this amount of time has not elapsed since power off, the inrush current will be higher.

Input Power Connections

Epsilon Only

Power must be "Off" for a minimum of 6 minutes for the Epsilon 205 and 3 minutes for the Epsilon 202/203 drives before unplugging the power connection, to ensure the bus voltage has decreased to a safe level (below 50 VDC).

EN

EN Only

According to UL requirements, the EN drive is suitable for use on a circuit capable of delivering not more than 5000 RMS symmetrical amperes, 240 volts maximum.

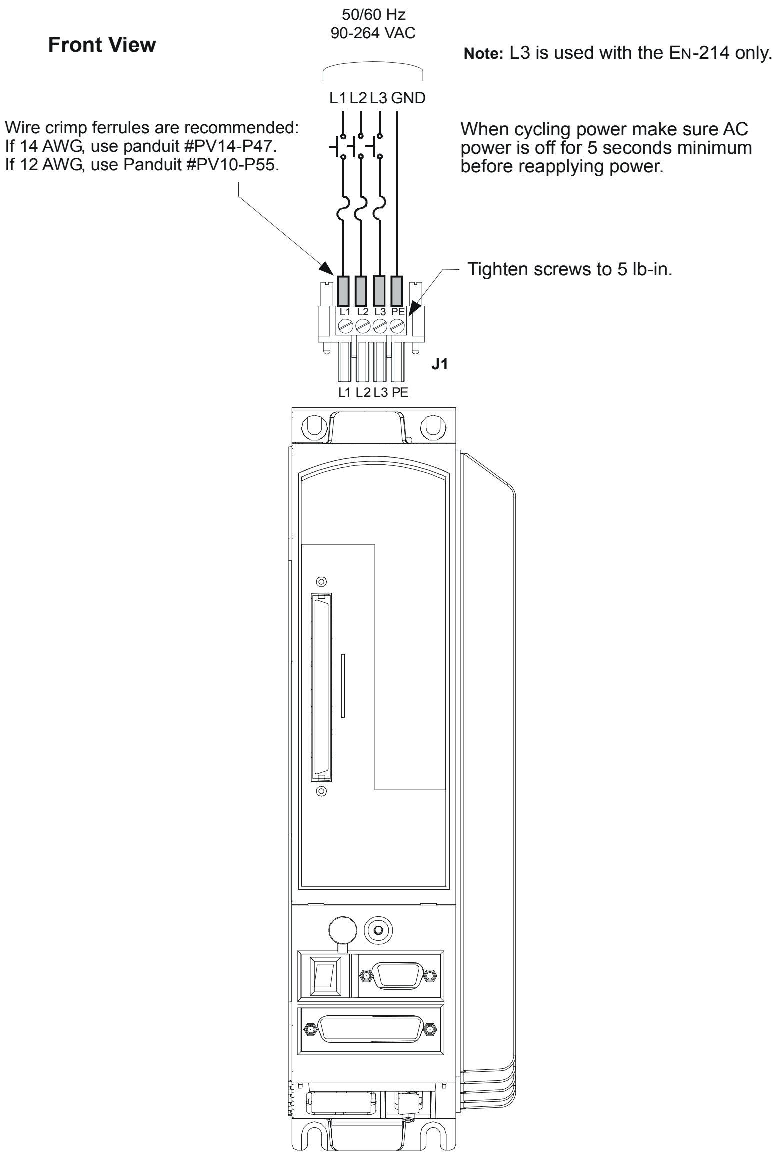


Figure 61: EN AC Power Wiring Diagram

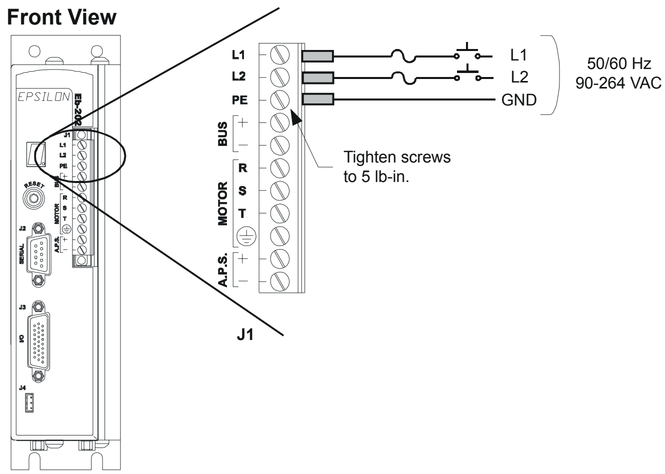


Figure 62: Epsilon AC Power Wiring Diagram

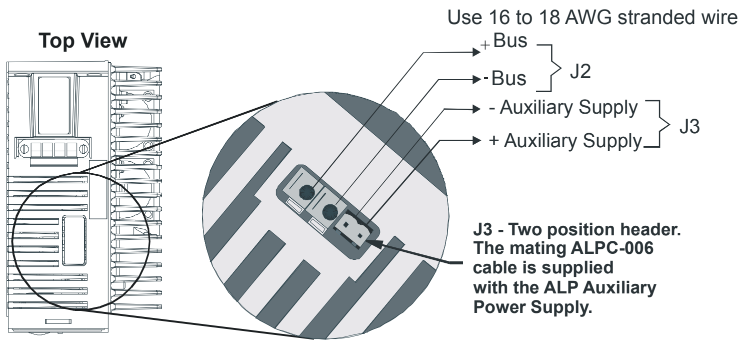
⚠ CAUTION

Do not connect or disconnect AC power by inserting or removing the AC power connector. Using the connector in this manner, even once, will damage the connector making it unusable.

Auxiliary Logic/Alternate Power Wiring Supply

Auxiliary Power Supply (APS) allows the drive to retain motor position information and serial communications when the main AC power supply is disconnected. You must reset the drive, either using the reset button or a reset input, after AC power is re-applied if the backup supplies have been active.

Auxiliary Logic Power Usage (EN Only)



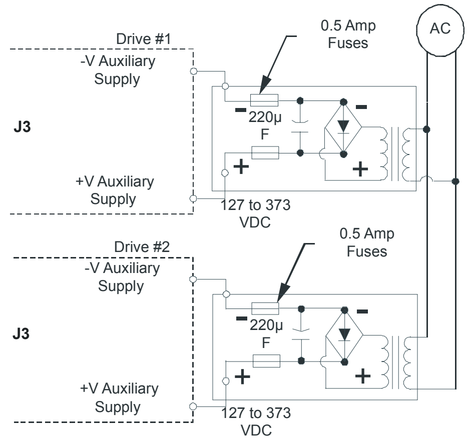


Figure 63: EN Auxiliary Power Supply Wiring Diagram

As shown in Figure 63, the auxiliary logic power connector is accessed through a plastic punch-out tab located on top of the drive that reads "BUS/AUX". The auxiliary logic power for each EN drive must be individually transformer isolated from the AC supply. The voltage range is 127 to 373 VDC, at 21 Watts. This can be accomplished by isolating, rectifying and filtering 90 to 264 VAC.

System	Power	Voltage
EN Drive Only	15 watts	127 to 373 VDC (Transformer isolated, rectified and filtered 90 to 264 VAC)
EN Drive with FM Module	21 watts	

Control Techniques offers Auxiliary Logic Power Supplies (models ALP-130 and -430) that supply enough power for one EN drive with an FM module and four EN drives with FM module's respectively. See the "Options and Accessories" section for more information.

Model	Input	Output	IP	Rated Ambient Temperature	Weight
ALP-130	115/230 VAC 60 Watts	140 VDC 30 Watts	20	50° C (122° F)	6.4 lbs (2.9 kg)
ALP-430	115/230 VAC 40-60 Watts	140 VDC (4) x 20 Watts	20	50° C (122° F)	7.7 lbs (3.5 kg)

⚠WARNING

Do not connect AC power directly into the auxiliary logic connector. You must wire this connection correctly with transformer isolated 127 to 373 VDC power. Failure to do so can cause death, serious injury or equipment damage. Also, use caution when removing the plastic punch-out tab. AC power must be disconnected for at least 30 seconds before removing the tab.

Alternate Power Supply Wiring (Epsilon Only)

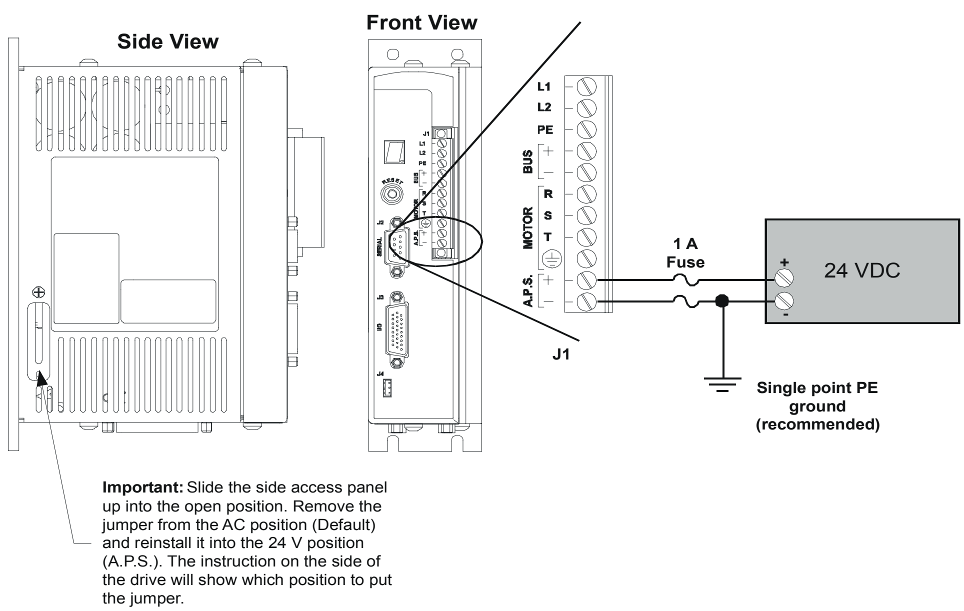


Figure 64: Epsilon Alternate Power Supply Wiring Diagram

Epsilon Only

If the low DC bus fault is disabled with PowerTools software on the Advanced tab, resetting the drive is not necessary

WARNING

Do not move the APS jumper with the main AC power applied to the drive. Wait at least 6 minutes after the main AC power has been removed from the L1 and L2 terminals.

CAUTION

Do not wire AC line power into the APS input. Doing so will damage the drive.

As shown in Figure 64, enabling APS power is done by sliding open the access panel on the side of the drive. Then move the jumper into the APS position using needle nose pliers.

Use static control procedures when handling the jumper inside the drive case.

The APS input is isolated from all other circuits on the Epsilon drive including the DC bus, logic and I/O. This permits you to use one common 24 VDC power supply for multiple drives without concern for ground loops and noise coupling between drives. The APS connection will generate some high frequency ripple (.25 Amps at 80 khz) on the APS power lines. This may disturb sensitive equipment that shares the same power supply.

APS Input Specification

Voltage Range	Current	Inrush Current
18-30 VDC	0.5 A maximum 0.7 A peak (0.4 A maximum 0.6 A peak if external encoder is not used)	80 A for 1 ms if not limited by power supply

	Drive Logic with Motor Encoder Only			Add for Master Encoder		Other Dependencies
APS Applied Voltage	18	24	28	18	24-28	Add 10% per axis for fewer than 4 axis on same A.P.S. power supply.
Current Draw per drive (mA RMS)	550	400	360	110	75	

Note

Connecting 24V common on the APS to chassis ground reduces offset voltage in the Analog Diagnostics Outputs.

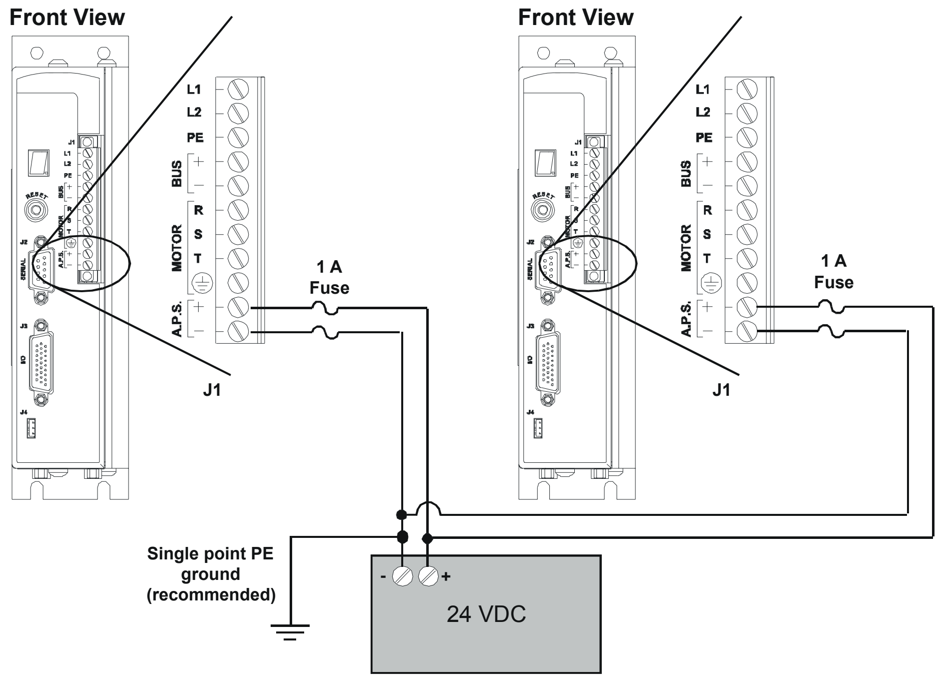


Figure 65: Multiple APS Wiring Diagram

Motor Power Wiring

MG and NT Motors are equipped with up to three male MS (Military Standard) connectors, one for stator connections, one for encoder connections and one for the brake (if so equipped).

Stator connections from the drive to the motor are made with the CMDS or CMMS cable have a female MS style connector on the motor end and four individual wires and shield that connect to the motor power connector on the bottom of the drive.

Note

The motor ground wire and shields must be run all the way back to the amplifier terminal and must not be connected to any other conductor, shield or ground.

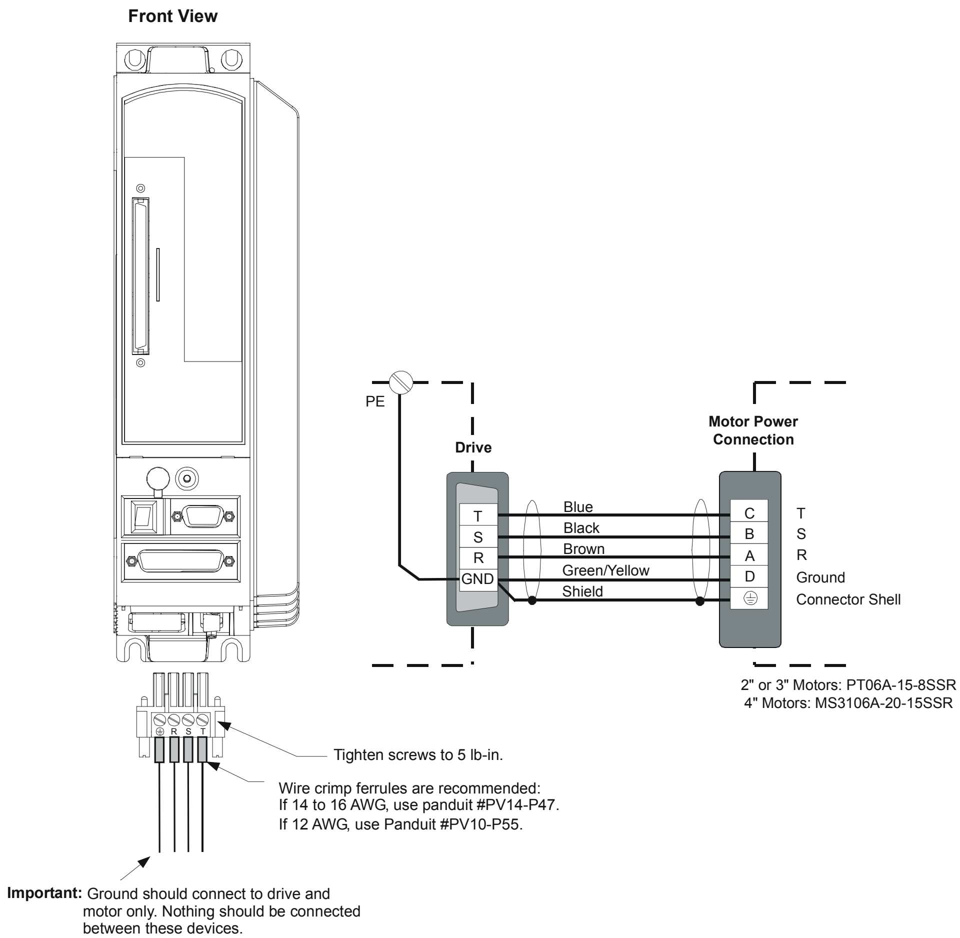


Figure 66: EN Motor Power Wiring Diagram

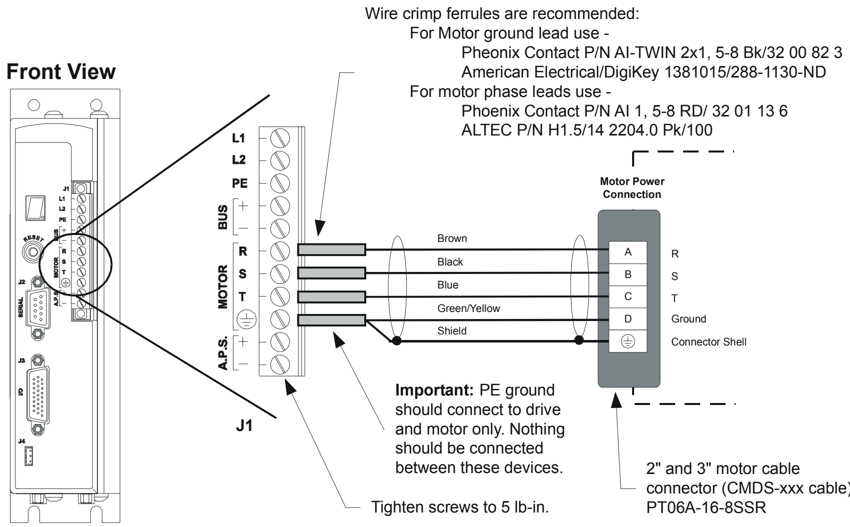


Figure 67: Epsilon Motor Power Wiring Diagram

Motor Feedback Wiring

Encoder feedback connections are made with the CFCS cable. This cable has an MS style connector on the motor end and a 26-pin high density “D” connector on the drive end.

For A, $\overline{A}$, B, $\overline{B}$ and Z, $\overline{Z}$ pairs, the CFCS cable uses low capacitance (~10 pf/ft) wire to get a characteristic impedance of 120 ohms. This impedance match is important to minimize signal loss and ringing.

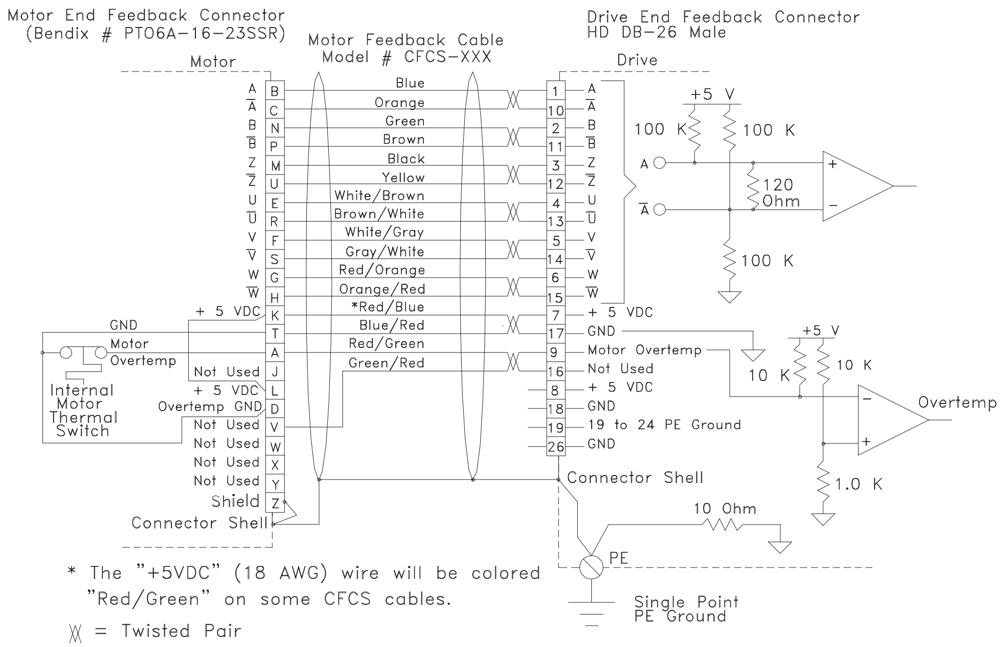


Figure 68: Motor Feedback Connector Pinout

Motor Brake Wiring

Motors equipped with brakes have a three-pin MS style connector. The brake power cable (model CBMS-XXX) has an MS style connector on the motor end and three wire leads on the amplifier end (see the following wiring diagrams).

You must provide a DC power supply rated at +24 VDC with a 2 amp minimum current capacity for the brake. If you use this voltage source to power other accessories such as I/O or more than one brake, you must increase its current capability.

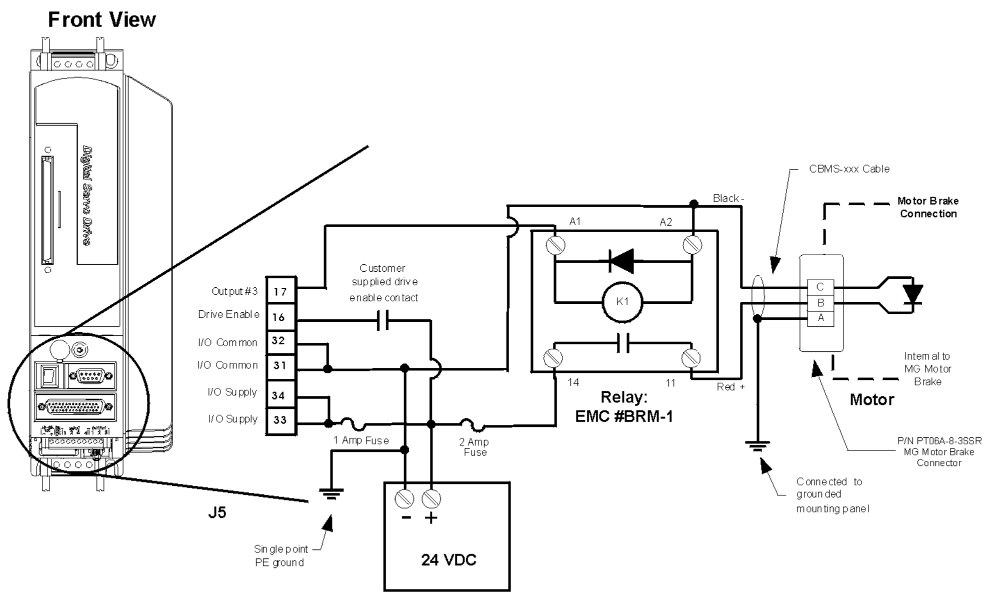


Figure 69: EN Brake Wiring Diagram using the Command Connector

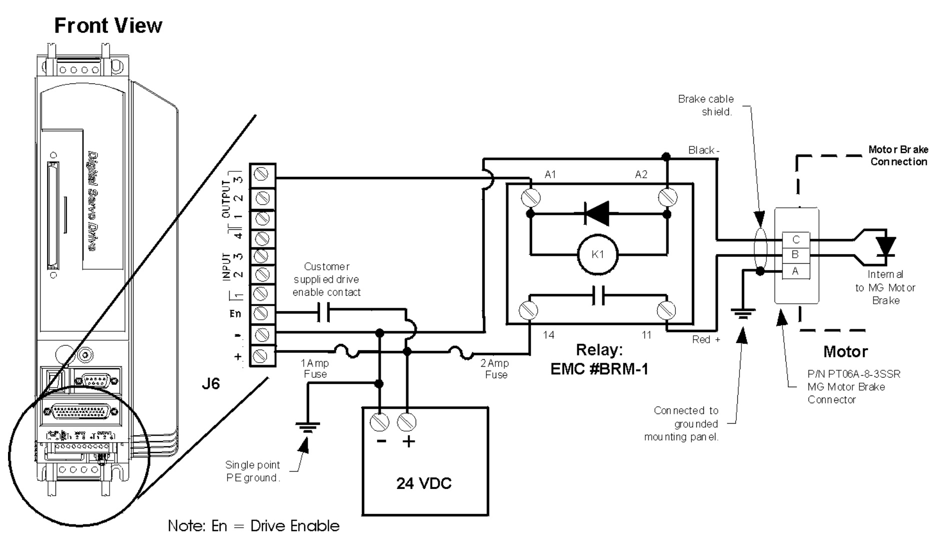


Figure 70: EN Brake Wiring Diagram using the I/O Connector

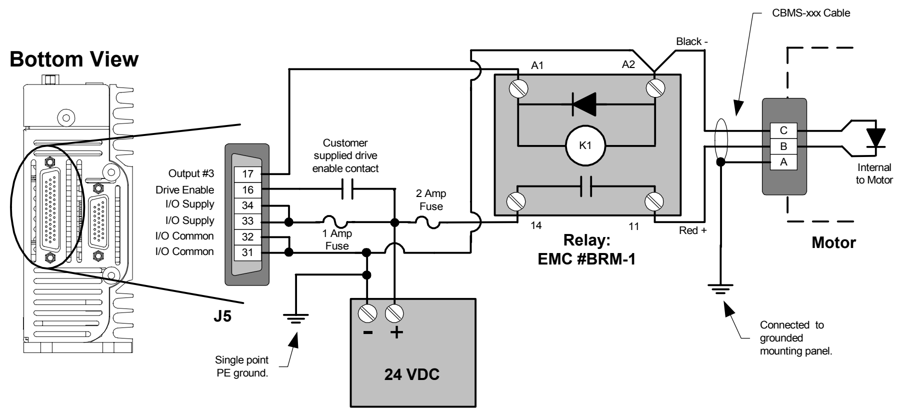


Figure 71: Epsilon Brake Wiring Diagram using the Command Connector

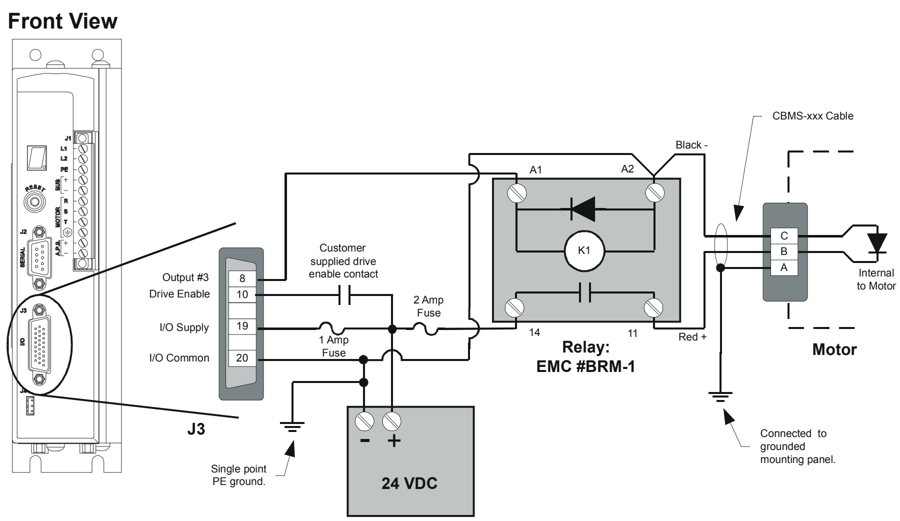


Figure 72: Epsilon Brake Wiring Diagram using the I/O Connector

Input/Output and Drive Enable Wiring

Drives are equipped with five optically isolated input lines (one is dedicated to a drive enable function) and three optically isolated output lines. They are designed to operate from a +10 to 30 VDC source. All inputs and outputs are configured as sourcing. You are responsible for choosing a load that will limit each output's current to less than 150 mA.

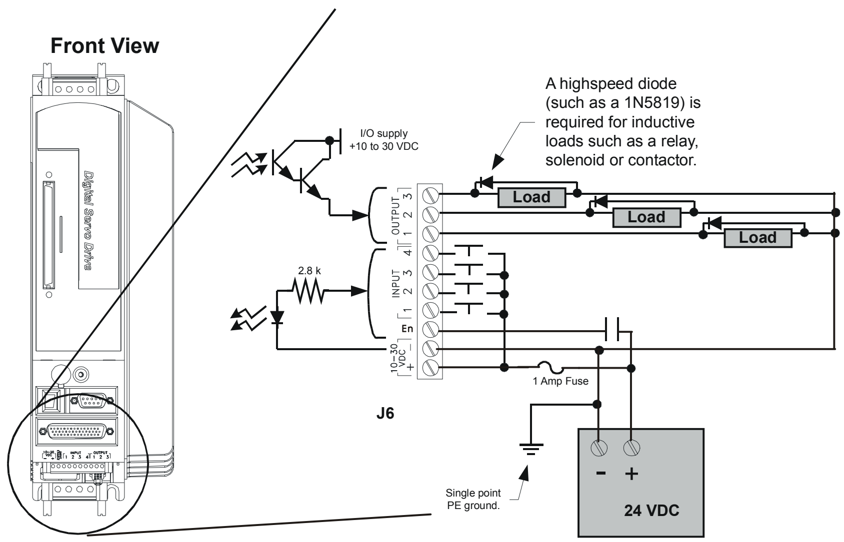


Figure 73: EN Input/Output Wiring Diagram

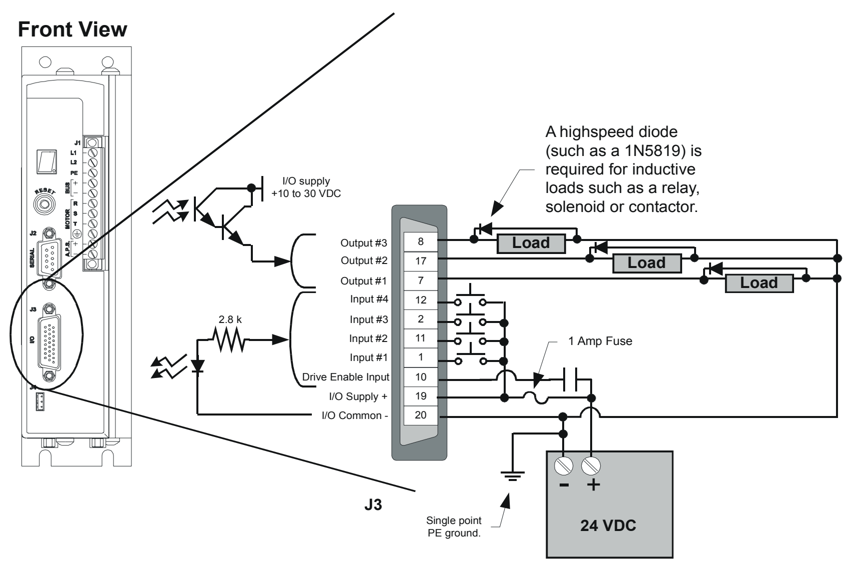


Figure 74: Epsilon Input/Output Wiring Diagram

EN Only

The I/O connector is a 10-pin removable terminal block. It is recommended that #18 to 24 AWG stranded wire be used.

Epsilon Only

The I/O connector is a 26-pin male connector on the front of the drive. Control Techniques offers a low profile interface plug (STI-EIO) and cable (EIO-xxx) for connections.

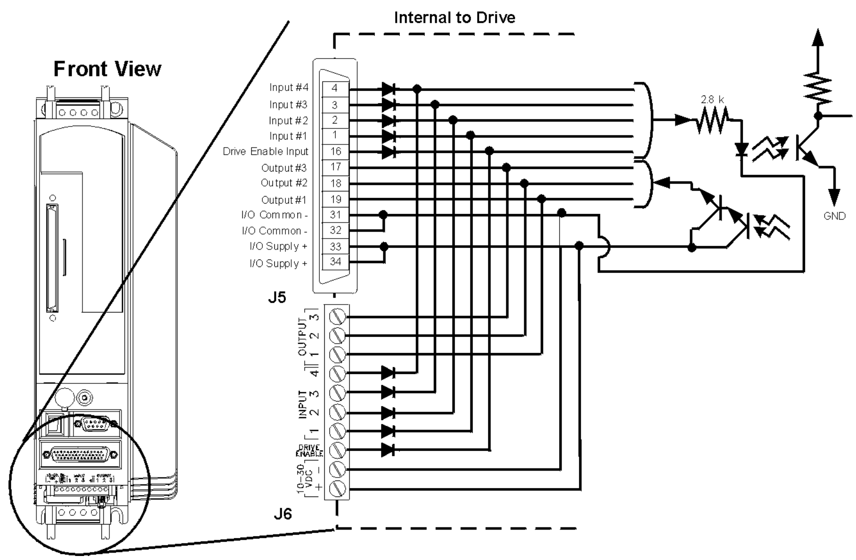


Figure 75: EN I/O Connector to Command Connector Internal Connections

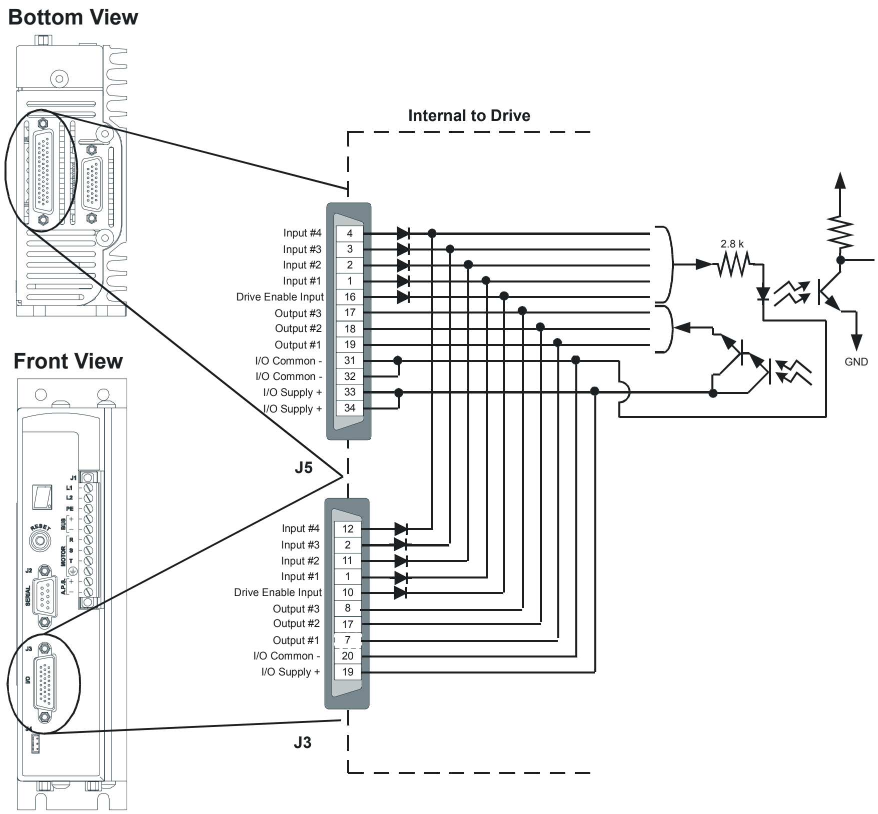


Figure 76: Epsilon I/O Connector to Command Connector Internal Connections

Note

If loads are applied to the same output signal on both Command Connector and I/O Connector, the sum total current loading must be limited to 150 mA per output signal.

Command Connector (J5) Wiring

All command, 3 output and 4 input signals are available using the 44-pin Command Connector.

If you are interfacing your drive(s) to an AXIMA 2000 or 4000 multi-axis controller, simply connect the 44-pin connector of your AX4-CEN-XXX cable to the drive and the 25-pin connector to the AXIMA multi-axis controller.

If you are interfacing your drive(s) to an AXIMA or any other motion controller, you may use either the CDRO-XXX or CMDO-XXX cables or the optional External Connection Interface

(ECI-44) which provides a convenient screw terminal connection strip. Connect one end of the CMDX command cable to your drive and the other end to the ECI-44.

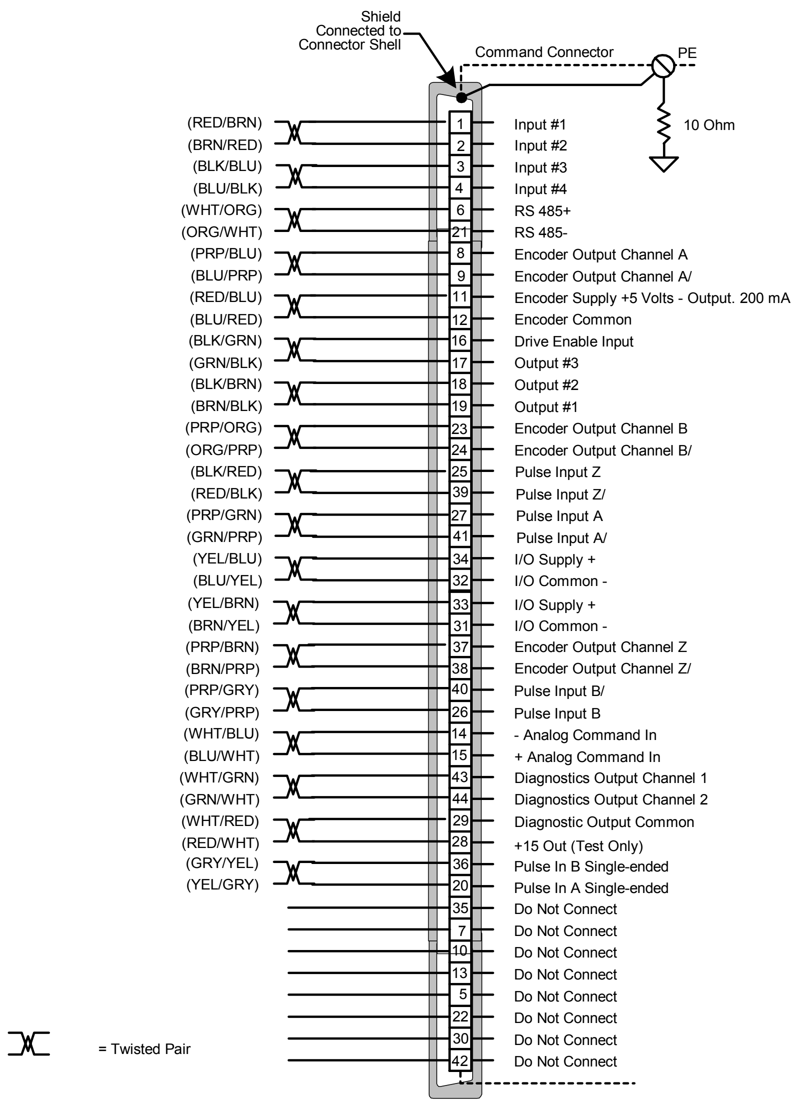


Figure 77: Command Connector (J5) Pinout and CMDO-XXX Wire Colors

For information about Command Connector pinout and CMDO-XXX cable wire colors, see the "Specifications" section.

Function	Pin Numbers	Electrical Characteristics
Inputs and Drive Enable	1, 2, 3, 4, 16	10-30 V (“On”) 0-3 V (“Off”) optically isolated
Outputs	17, 18, 19	10-30 VDC sourcing 150 mA
I/O Supply	33, 34	10 - 30 VDC @ 1 Amp maximum
I/O Common	31, 32	I/O return
Pulse Inputs Differential	25, 26, 27, 39, 40, 41	5 V, 200 mV differential, 60 mV hysteresis, RS-422 compatible
Pulse Inputs Single Ended	20, 36	TTL, 330 ohm pull-ups to internal 5 V, 1.5 V = low, 3.5 V = high
Encoder Supply Output +5 V	11	+5 V (200mA) output self-resetting fused internally
Encoder Common 0 V	12	0.0 V, 10 ohms away from PE
Encoder Out	8, 9, 23, 24, 37, 38	Differential line driver output (RS 422)
Analog In	14, 15	± 10 VDC differential command
Diagnostic Output	43, 44	± 10 VDC 10 mA maximum. Analog diagnostic output, ref. to pin 29
Diagnostic Output Common	29	0.0 V, 10 ohms away from PE 0 ohms away from Encoder Common 0V (pin 12)
RS 485 ±	6, 21	Same signals as the Serial Connector
+15 out	28	10 mA supply. ref. pin 29 (for test purposes only.)

Command Cables

The CMDO, CMDX and CDRO cables are all cables that plug into the Command Connector.

The CMDO and CMDX cables both use the same straight connector style, same color code and carry the full complement of signals available from the Command Connector. The difference is the CMDO cable has a male connector on one end with open wires on the other while the CMDX cable has male connectors on both ends.

For information about CMDO-XXX and CMDX-XXX (18 pair cable) cable wire colors see the "Specifications" section.

Note

Some CMDO and CMDX cables may have White/Yellow and Yellow/White wires in place of the White/Orange and Orange/White shown in the figure above (pins 6 and 21).

The CDRO cable includes only the most commonly used signals to reduce the cable outer dimension and has a connector at only one end. The 45 degree connector design used on the CDRO cable also reduces the enclosure spacing requirement below the drive.

For information about the CDRO-XXX (13 pair) cable wire colors, see the "Specifications" section.

Analog Command Wiring

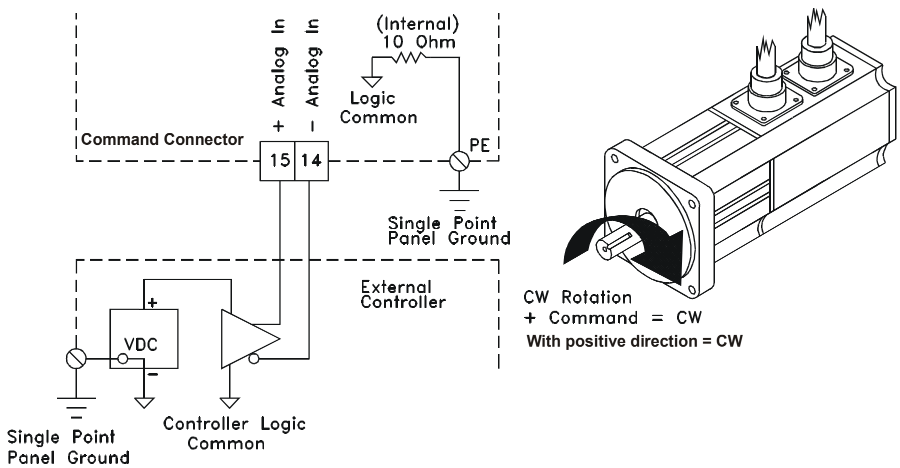


Figure 78: Analog Command, Differential Wiring Diagram

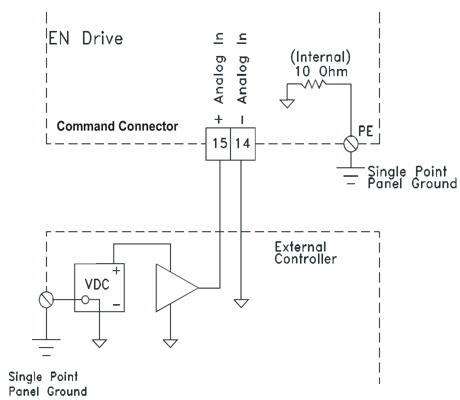


Figure 79: Analog Command, Single Ended Wiring Diagram

Encoder Output Signal Wiring

The encoder outputs meet RS-422 line driver specifications and can drive up to ten RS-422 signal receivers.

The default encoder output scaling is set to output the actual motor encoder resolutions. The standard MG and NT motors have 2048 lines per revolution. With PowerTools this resolution is adjustable in one line per revolution increments up to the density of the encoder in the motor.

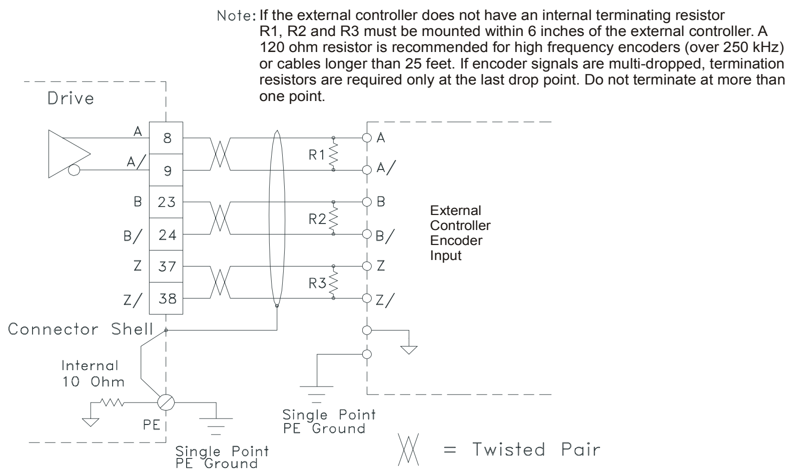


Figure 80: Command Connector Encoder Output Wiring

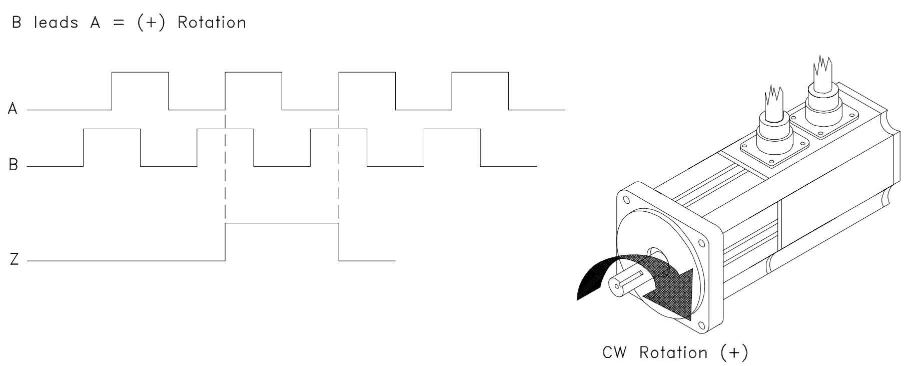


Figure 81: Direction Convention Diagram

Pulse Mode Wiring, Differential Inputs

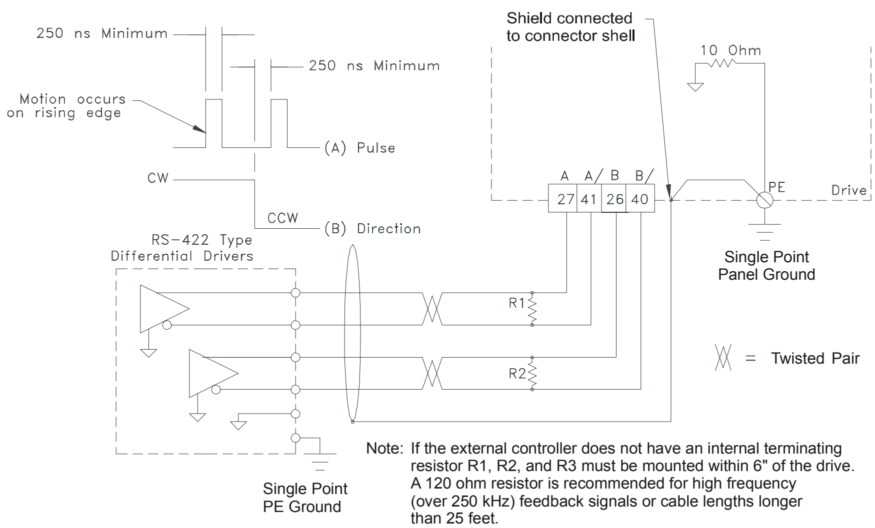


Figure 82: Pulse Mode, Differential Output to Differential Input

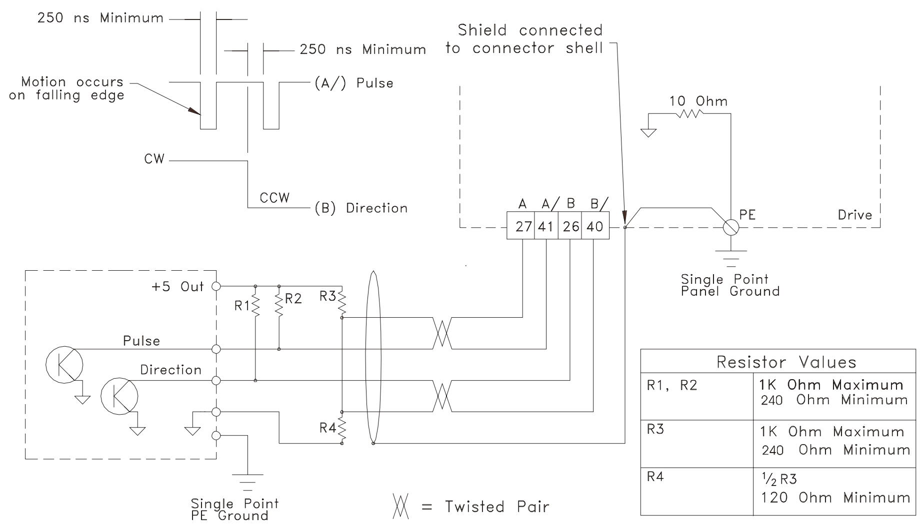


Figure 83: Pulse Mode, Single Ended Output to Differential Input

Pulse Mode Wiring, Single Ended Inputs

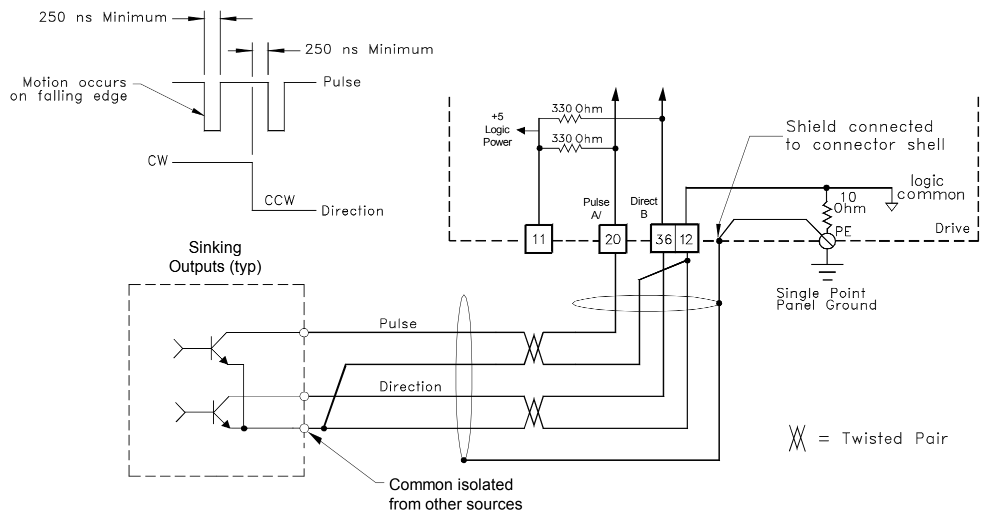


Figure 84: Pulse Mode, Single Ended Output to Single Ended Input (twisted pair cable)

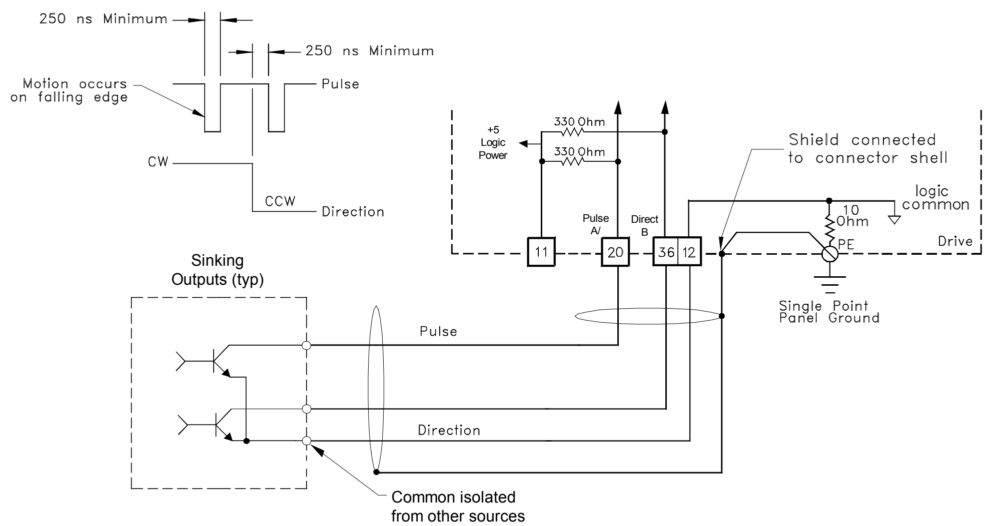


Figure 85: Pulse Mode, Single Ended Output to Single Ended Input (non-twisted pair cable)

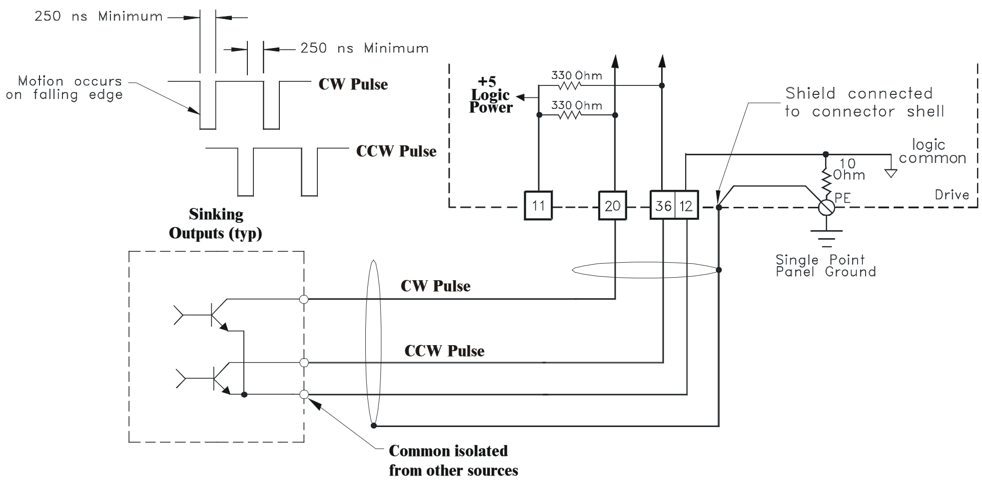


Figure 86: Pulse/Pulse Mode, Single Ended Output to Single Ended Input (non-twisted pair cable)

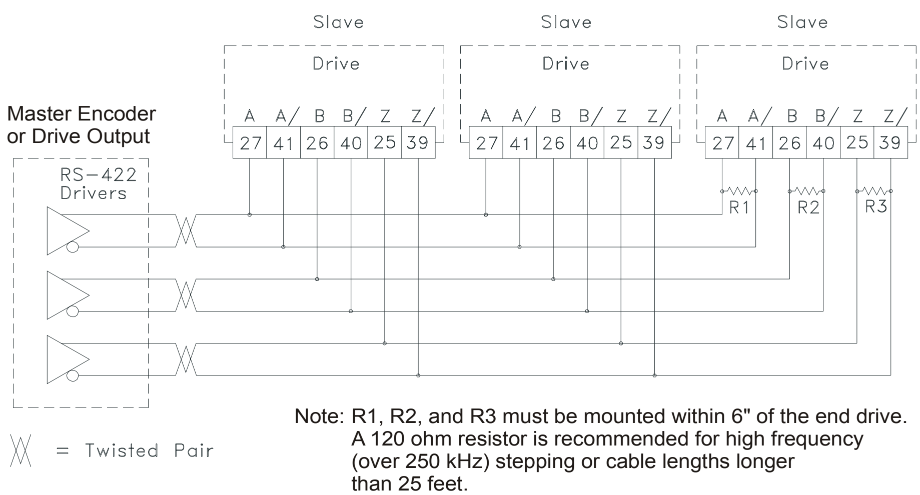


Figure 87: Master/Slave Encoder Connections

Note

Encoder outputs meet RS-422 driver specifications and can drive up to 10 RS-422 signal receivers. Each differential pulse input is an RS-422 line receivers. The default encoder output resolution is 2048 lines per motor revolution. This resolution is adjustable in one line per revolution increments with PowerTools software. The range is between 1 and the actual motor encoder density.

Serial Communications

Serial communications with the drive is provided through the female DB-9 connector located on the front of the drive. The serial interface is either three wire non-isolated RS-232C or two wire non-isolated RS-485. RS-485 is also available through the 44-pin Command Connector.

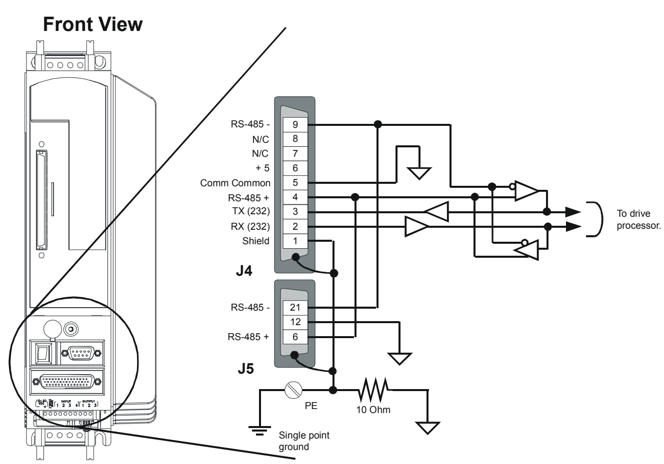


Figure 88: EN Drive RS-232 and RS-485 Internal Connections between the Command Connector and the Serial Communication Connector

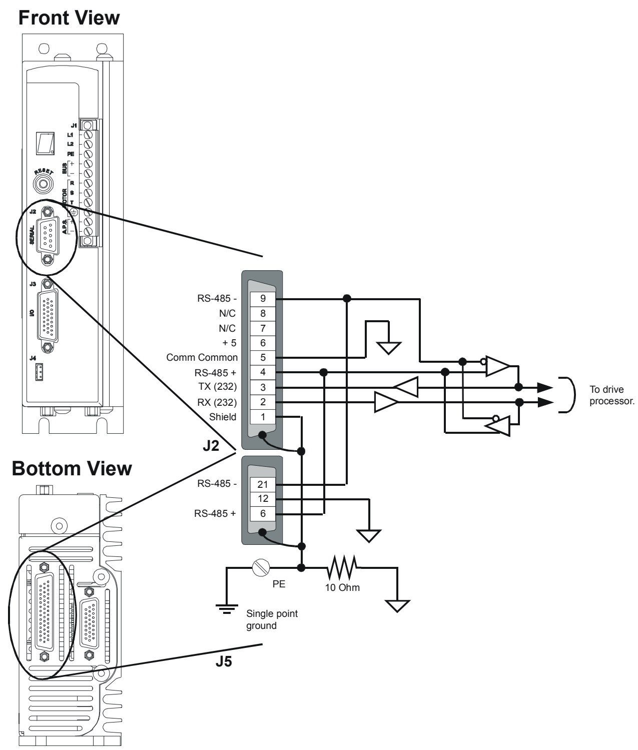


Figure 89: Epsilon RS-232 and RS-485 Internal Connections between the Command Connector and the Serial Communication Connector

⚠ CAUTION

When connecting the serial port of your PC to the serial port of the drive, verify that your PC's ground is the same as the drive PE ground. Failure to do so can result in damage to your PC and/or your drive.

Note

Communication errors can usually be avoided by powering the computer or host device off of a convenience outlet that is mounted in the enclosure and whose neutral and ground are wired to the same single ended point ground that the drives and controllers are using.

This is sometimes beneficial even with battery powered computers.

Modbus Communications

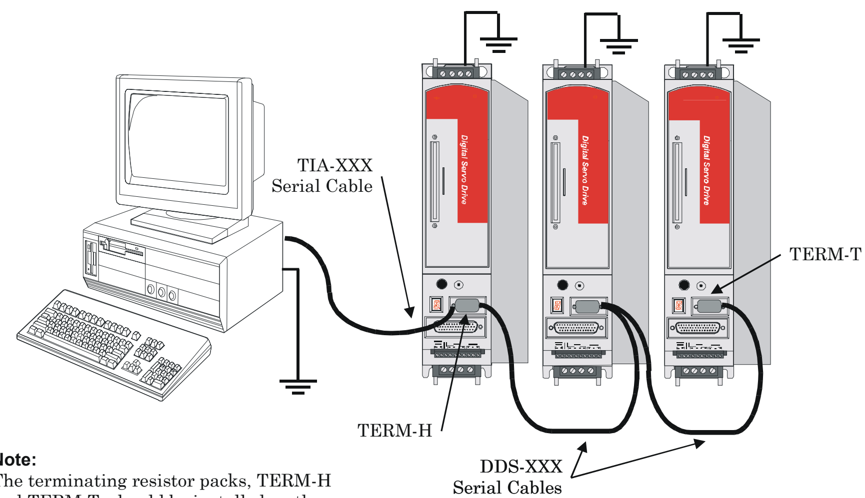
The drive's serial communication protocol is Modbus RTU slave with a 32 bit data extension. The Modbus protocol is available on most operator interface panels and PLC's.

Serial Communications Specifications	
Max baud rate	19.2k
Start bit	1
Stop bit	2
Parity	none
Data	8

Control Techniques' Motion Interface panels are supplied with a Modbus master communications driver.

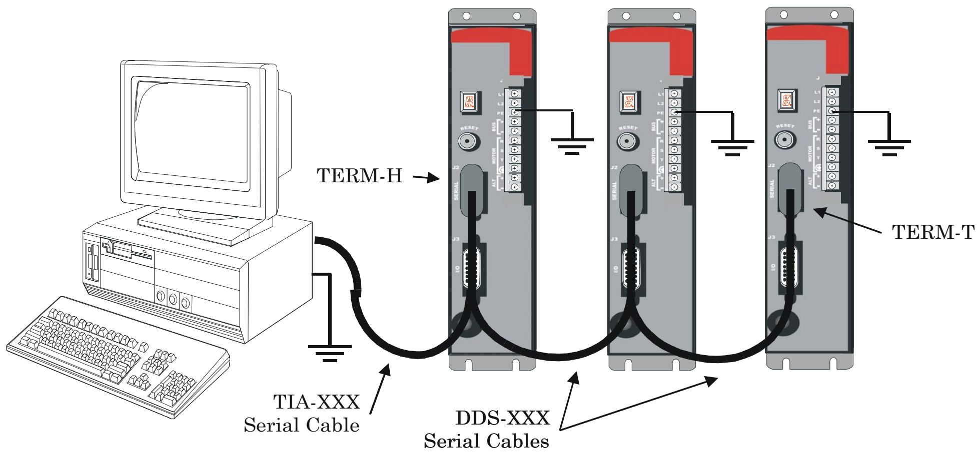
Multi-Drop Communications

The RS-485 option (pins 4 and 9) is provided for multi-drop configurations of up to 32 drives. Control Techniques provides a special multi-drop serial cable which allows you to easily connect two or more drives.



Note:
The terminating resistor packs, TERM-H and TERM-T, should be installed on the first (TERM-H) and last (TERM-T) drive in the string if the total cable length is over 50 feet.

Figure 90: EN Multi-Drop Wiring Diagram



Note:
The terminating resistor packs, TERM-H and TERM-T, should be installed on the first (TERM-H) and last (TERM-T) drive in the string if the total cable length is over 50 feet.

Figure 91: Epsilon Eb Multi-Drop Wiring Diagram

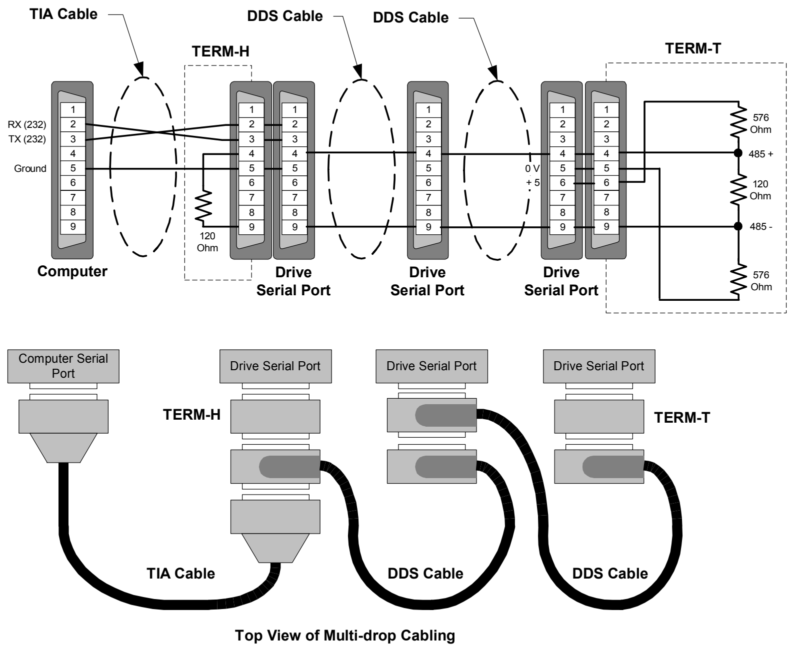


Figure 92: Multi-Drop Wiring Pinout

Quick Start

Offline Setup

Note

Generally, online setup is used when editing parameters in a drive. Offline setup editing is usually only done when not connected to a drive.

EZ Setup View

The EZ Setup view is the default tab that is displayed each time you open the PowerTools software. This tab allows you to set most of the parameters needed to configure your drive, with the exception of the digital input and output functions.

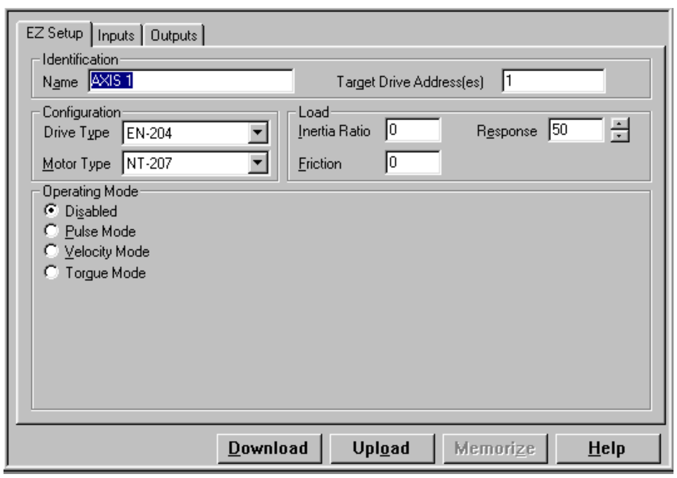


Figure 93: PowerTools Window, EZ Setup View, Offline

You can change the software so that the Detailed Setup tab becomes the default view.

Step 1: Changing the Default View

To select the default setup screen view (EZ Setup or Detailed Setup):

1. Select “Preferences” from the **Options** menu.
2. Select the “General” option from the menu.
3. Click the “Default to Detailed View” check box to change view to Detailed Setup or deselect to change view to EZ Setup.
4. Click the *OK* button.

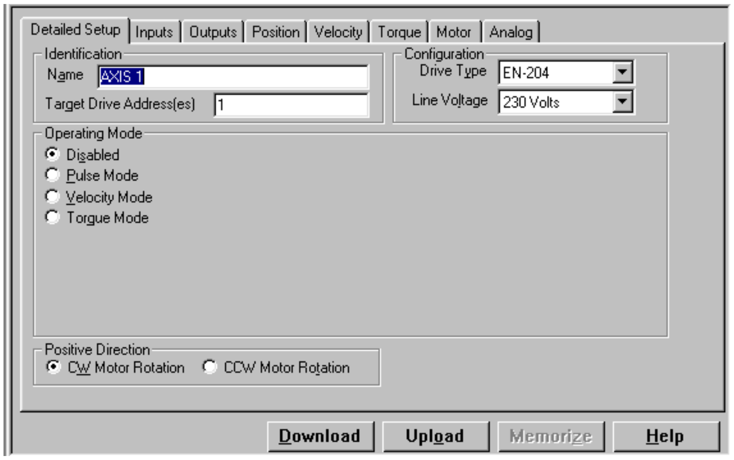


Figure 94: *PowerTools FM Window, Detailed Setup View, Offline*

Detailed Setup View

The Detailed Setup view allows you to access many additional parameters and details about your drive. When you are online with a drive, PowerTools FM will display twelve tabs if you have selected to view the Advanced tab in the Options/Preferences/General dialog box.

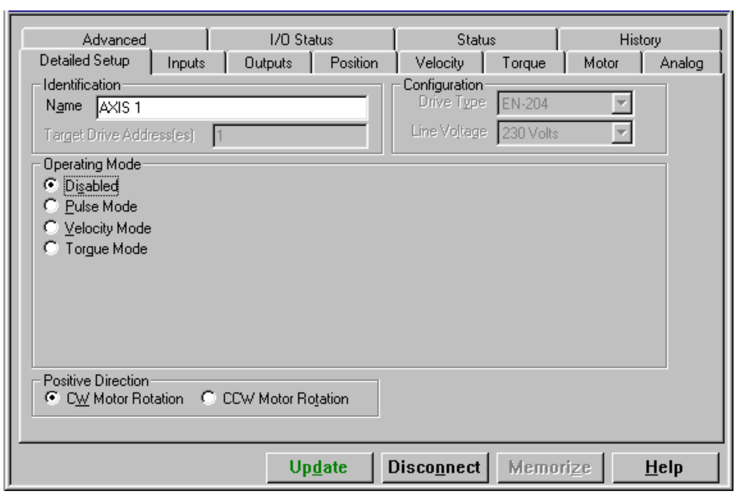


Figure 95: *PowerTools FM Window, Detailed Setup View,Online*

Step 2: Opening an Offline Configuration Window

To open an offline Configuration Window, click the New icon from the toolbar or select New from the **File** menu.

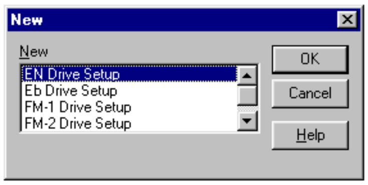


Figure 96: New Dialog Box

When the Predefined Setup Selection dialog box appears, select the desired predefined setup and press the *OK* button. A new Configuration Window will be displayed.

All drive setup parameters are accessible in the tabs of the offline configuration window.

You can now proceed to setup the drive parameters as desired.

Step 3: Entering General Drive Setup Information

The EZ Setup tab contains system data such as drive type, motor type and axis name.

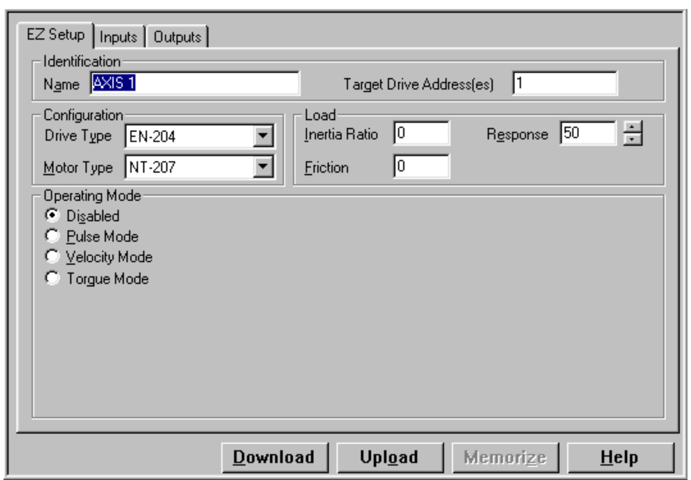


Figure 97: Offline EZ Setup Tab

Identification Group:

1. Enter an identifying name in the “Name” box for the drive you are setting up. You can use up to 24 alpha-numeric characters.

2. Enter the “Target Drive Address(es)” to which you wish to download the setup information. Unless you have changed the Modbus address of your drive, leave this parameter set to the default value of 1.

   You may use commas (,) or spaces ( ) to separate individual drive addresses or you may use hyphens (-) to include all the drive addresses within a range. For example, if you wanted to download to drives 1, 3, 4, 5, 6, 7 and 9 you could enter the addresses like this: 1,3-7,9.

Configuration Group:

EZ Setup view, drive type and motor type are available. Detail Setup view, drive type and line voltage are available. Motor type is selected using the Motor tab.

1. Click the down arrow of the “Drive Type” list box, then select the drive model for the drive you are currently setting up.

2. Click the down arrow of the “Motor Type” list box, then select the motor connected to the drive you are setting up. PowerTools FM will only display the motor models that are compatible with the “Drive Type” you selected.

3. Click the down arrow of the “Line Voltage” list box and select the voltage (115 or 230) which will be powering the drive (EN drive only).

Positive Direction Selections:

In Detail Setup view, click which direction, clockwise (CW) or counterclockwise (CCW), is to be considered as motion in the positive direction.

Note

CW and CCW rotation is determined by viewing the motor from the shaft end.

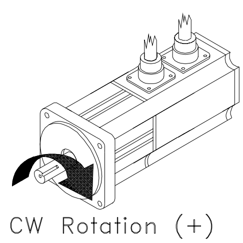


Figure 98: Clockwise Motor Rotation

Step 4: Selecting an Operating Mode

Depending on the mode you select, PowerTools FM software will display related submodes and/or additional parameters that pertain to the main operating mode you selected.

Pulse Mode Setup

This procedure assumes that you have connected the proper pulse mode wiring as described in the "Installation" section of this manual.

1. Select the “Pulse Mode” radio button from the Operating Mode group.

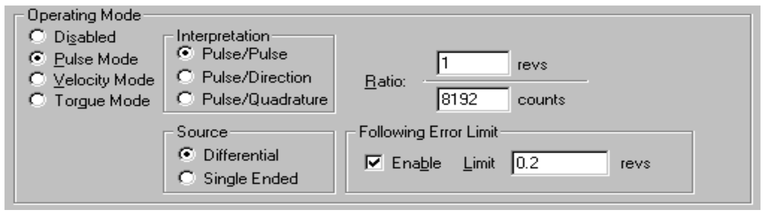


Figure 99: Operating Mode View

2. Select one of the Interpretation group radio buttons; “Pulse/Pulse”, “Pulse/Direction” or “Pulse/Quadrature”.

3. Select Differential or Single Ended from the Source group.

4. Enter a “Ratio”. The default is 1 output motor revolution to 8192 input pulse counts. This can be a signed (+/-) number.

Note

The coarsest ratio possible is 10 input counts per motor revolution. Settings below this will cause an overspeed fault.

---

5. If needed, enable the “Following Error Limit” by checking the “Enable” check box.

6. Enter a value between 0.0010 and 10.000 revolutions of the motor.

Velocity Mode Setup

The following Velocity mode setup procedures assume that you have connected the proper analog command wiring as described in the “ Installation” section of this manual.

Velocity Analog Submode Setup

1. Select the “Velocity Mode” radio button from the Operating Mode group.

2. Select the “Analog” submode radio button from the Submode group.

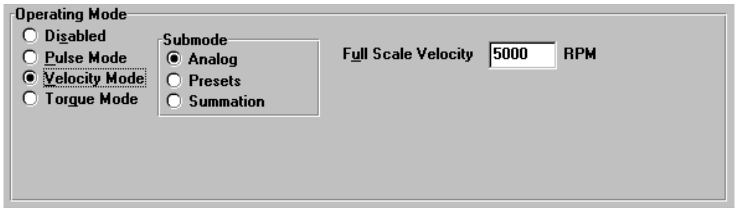


Figure 100: Operating Mode, Velocity Mode Selected

3. Enter a “Full Scale Velocity” value. The velocity is equal to the Analog Full Scale parameter which is defaulted to a 10V analog command.

Velocity Presets Submode Setup

1. Select the “Velocity Mode” radio button from the Operating Mode group.
2. Select the “Presets” submode radio button from the Submode group.

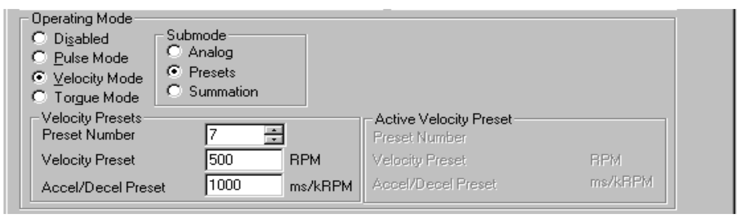


Figure 101: Velocity Submode, Velocity Presets

3. Select the desired “Velocity Preset” number.
4. Enter a "Velocity Preset" for each "Preset Number" being used.
5. Enter an “Accel/Decel Presets” value for each "Preset Number" being used.
6. Click on the Inputs tab. Assign the “Velocity Preset Line #1” and “Velocity Preset Line #2” functions to input lines by highlighting the function then selecting one of the “Input Line Selection” radio buttons or by dragging the highlighted preset to the desired input lines.
7. The Velocity Preset Input functions can be made Always Active or Active Off by using the respective check box.

Velocity Summation Submode Setup

1. Select the “Velocity Mode” radio button from the Operating Mode group.
2. Select the “Summation” submode radio button from the Submode group.

3. Select the desired “Velocity Preset” number.

4. Enter a "Velocity Preset" for each "Preset Number" being used.

5. Enter an “Accel/Decel Presets” value for each "Preset Number" being used

.

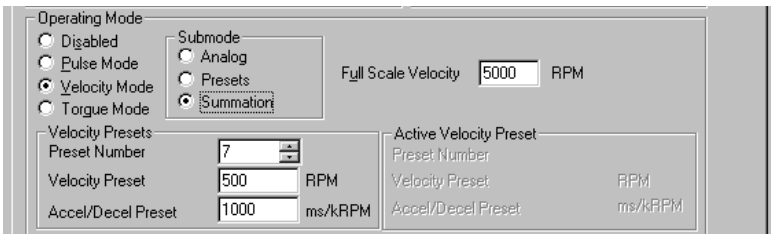


Figure 102: Velocity Summation Submode

Torque Mode Setup

This procedure assumes that you have connected the proper analog command wiring as described in the "Installation" section of this manual.

1. Select the “Torque Mode” radio button from the Operating Mode group.

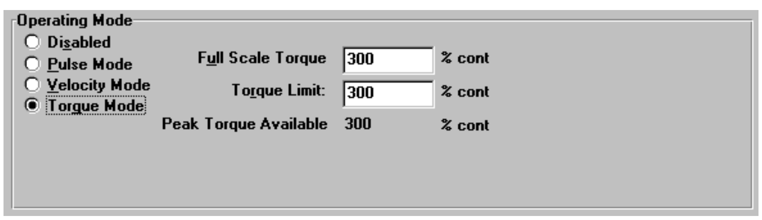


Figure 103: Operating Mode, Torque Mode Selected

2. Enter a “Full Scale Torque” value. This "Full Scale Torque" value corresponds to an Analog Full Scale parameter, which is defaulted to a 10V analog command.

Torque Limit Setup

This function can be active in any Operating Mode.

1. Enter a "Torque Limit" value. The "Torque Limit" is the value at which the Torque Command will be limited when the "Torque Limit Enable" input function is active.

2. Click on the Inputs tab. Assign the "Torque Limit Enable" input function to an input line by highlighting the function, then selecting one of the "Input Line Selection" radio buttons or by dragging the highlighted input function to the desired input line.

Torque Level 1 and 2 Setup

This function can be active in any Operating Mode.

1. Click on the Outputs tab.
2. Highlight the "Torque Level 1 Active or Torque Level 2 Active" output function in the "Output Functions" window.
3. Select an Output Line radio button that corresponds to the output line you wish to assign this function.
4. In Detailed Setup view, click on the Torque tab.
5. Enter a value into the Torque Level 1 and/or Torque Level 2. The Torque Levels correspond to the Analog Full Scale parameter, which is defaulted to a 10V analog command.

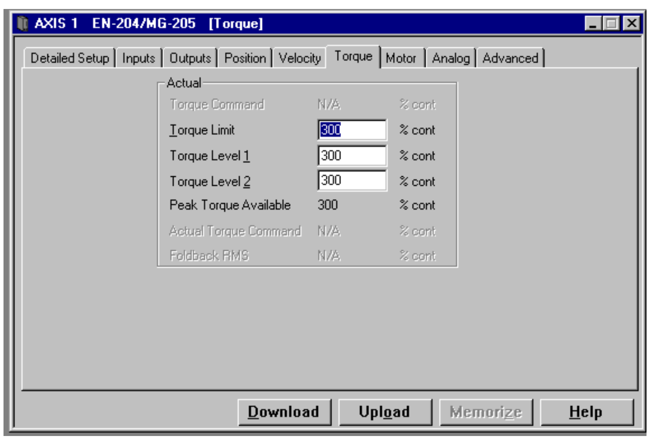


Figure 104: Torque Tab

Step 5: Entering Load Parameters

In Detailed Setup view select the Motor tab otherwise the EZ Setup tab can be used. The load on the motor is specified by the Inertia Ratio and Friction parameters. Application requirements are specified by the Response adjustment. If more accurate tuning is required, see the "Tuning Procedures" section.

Note

Also, refer to the Enable High Performance Gains and Feedforward Gains features.

Inertia Ratio

Inertia Ratio specifies the load to rotor inertia ratio and has a range of 0.0 to 50.0. A value of 1.0 specifies that load inertia equals the rotor inertia (1:1 load to motor inertia). The drives can control up to a 10:1 inertia mismatch with the default Inertia value of 0.0. Inertial Ratio mismatches of over 50:1 are possible with some minimal additional adjustments.

Note

If the exact inertia value is unknown, the value that is entered should be conservative, because values higher than the actual can cause the motor to oscillate.

Friction

This parameter specifies the viscous friction component of the load and has a range of 0.0 to 100.0. The units are percent continuous torque increase per 100 RPM. This value is used to tune the velocity and position loops, including feedforward compensation (if enabled). A typical value would be between 0.0 and 1.0.

Note

If the value is unknown, use a conservative value or a zero value.

Response

The Response adjusts the velocity loop bandwidth with a range of 1 to 500 Hertz. In general, it affects how quickly the drive will respond to commands, load disturbances and velocity corrections. The effect of Response is greatly influenced by the status of the High Performance Gains. With High Performance Gains enabled, the maximum value recommended is 100 Hz.

Step 6: Assigning Inputs

Inputs are assigned in the Inputs tab which is divided into two windows. The "Input Functions" window, on the left side, displays the input functions available, the function polarity and the always active state. The "Input Lines" window, on the right side, displays the four input lines, the debounce value and input function assignments.

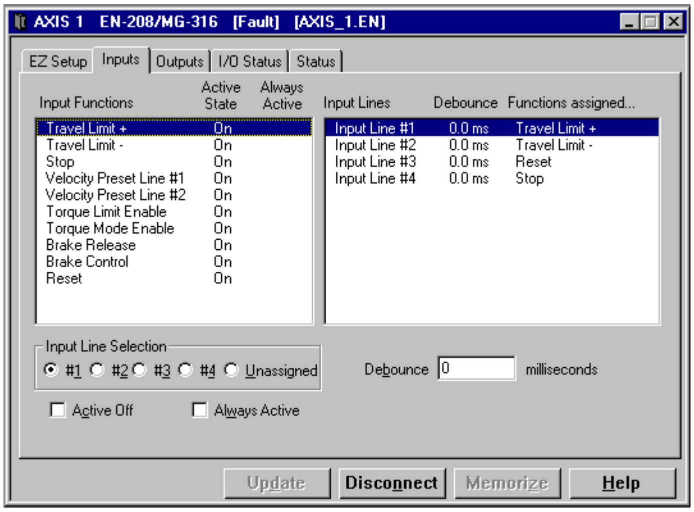


Figure 105: Inputs Tab

To assign an Input Function to an Input line:

1. Assign an input by highlighting an input function in the "Input Functions" window and selecting the desired input radio button or by dragging the highlighted input function to the desired input in the "Input Lines" window.

2. To unassign an input function from an input line, select the desired input function from the “Input Functions” window, then select the “Unassigned” radio button or by dragging the highlighted input assignment back to the "Input Functions" window.

To make an Input Function “Active Off”:

1. Select the desired input function in the “Input Functions” window

2. Click the “Active Off” check box. The Active State column in the "Input Functions" window will automatically update to the current setup.

To make an Input Function “Always Active”:

1. Select the desired input function in the “Input Functions” window.

2. Click the “Always Active” check box. The Active State column in the "Input Functions" window will automatically update to the current setup.

Step 7: Assigning Outputs

Output functions are assigned in the Outputs tab which is divided into two windows. The “Output Functions” window, on the left side, displays the output functions available. The

“Output Lines” window, on the right side, displays the three output lines, the line active state and the output function assignments.

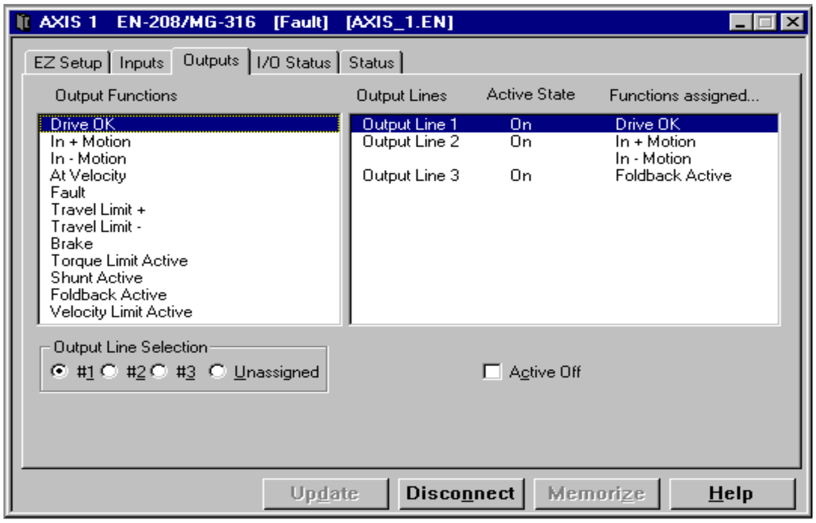


Figure 106: Outputs Tab

To assign an Output Function to an Output Line:

1. Assign an output by highlighting an output function in the "Output Functions" window and selecting the desired output radio button or by dragging the highlighted output function to the desired output in the "Output Lines" window.

2. To unassign an output function from an output line, select the desired output function from the “Output Functions” window, then select the “Unassigned” radio button or by dragging the highlighted output assignment back to the "Output Functions" window.

To make an Output Function “Active Off”:

1. Select the desired output function in the “Output Lines” window.

2. Click the “Active Off” check box. The Active State column in the "Output Lines" window will automatically update to the current setup.

Online Setup

If you have previously created a configuration file, go to Step 3. If you do not have one done, go to Offline Setup Step 1. Do Steps 1 through 9 in the previous section, "Offline Setup", before establishing communications.

Note

Generally, online setup is used when editing parameters in a drive. Offline setup editing is usually only done when not connected to a drive.

Step 1: Establishing Communications with Drive

Now that the basic EN drive setup parameters are entered, it is time to establish communications with the drive and download the configuration data. Before proceeding, be sure to connect the serial communication cable between your PC and the drive.

The first step in establishing serial communications is to select the Com port and the baud rate using the procedure below:

1. Clicking on the **Options** menu.
2. Select the "Preferences\Communications" option. The Modbus Setup dialog box will be displayed.
3. Select the “Configure Serial Port” button. The Communications Setup dialog box below will be displayed.

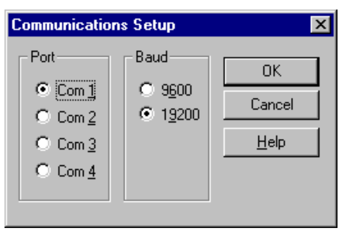


Figure 107: Communications Setup Dialog Box

4. Select the Com port you will be using on your PC and baud rate.
5. Click the *OK* button.
6. Click the OK button in the Modbus Setup dialog box.

Note

The default baud rate for all drives is 19200.

Step 2: Downloading the Configuration File

When you are ready to download the information in the current Configuration Window, go to the Setup tab and enter the address(es) of the drive(s) you wish to download to in the "Target Drive Address(es)" text box.

You may use commas (,) or spaces ( ) to separate individual drive addresses or you may use hyphens (-) to include all the drive addresses within a range. For example, if you wanted to download to drives 1, 3, 4, 5, 6, 7 and 9 you could enter the addresses like this: 1,3-7,9.

Note

To download to more than one drive, all drive models and motor models must be the same and any FM modules attached to the EN drives must all be of the same model and firmware revision.

Click the *Download* button at the bottom of the Configuration Window (or click the Download icon in the toolbar).

PowerTools FM will establish communications and transfer all the information in the current Configuration Window to the drive(s) you select in the Download window.

Note

Downloading will automatically clear an Invalid Configuration fault ("U" fault).

Step 3: Opening an Online Configuration Window

If you are not already online with the drive, use this section to upload a configuration for online editing.

To open an online Configuration Window, click the Upload icon on the toolbar. PowerTools FM will display the Scanning dialog box while it scans your PC's serial ports for any compatible devices.

Next, the Upload Drive Configuration dialog box is displayed. This dialog box allows you to select the device(s) you wish to upload into a Configuration Window.

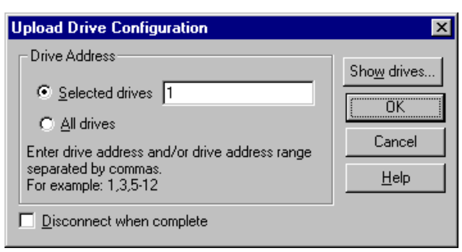


Figure 108: Upload Configuration Dialog Box

Selected Drives Radio Button

If you have only one device connected, that device's address will be displayed in the Selected drives data box. If you have more than one device connected in a multi-drop configuration, the Selected drives data box will be empty. You can then select either the *All drives* radio button or the *Show drives* button.

All Drives Radio Button

If you select the All drives radio button, PowerTools FM will open a Configuration Window for each device connected to your PC.

Show drives . . . Button

The *Show drives* button will display the Available Devices dialog box. This dialog box displays a list of the devices that are attached to your system (or network). This includes both Control Techniques and non-Control Techniques devices. Devices which are not serviceable by PowerTools FM software will be grayed.

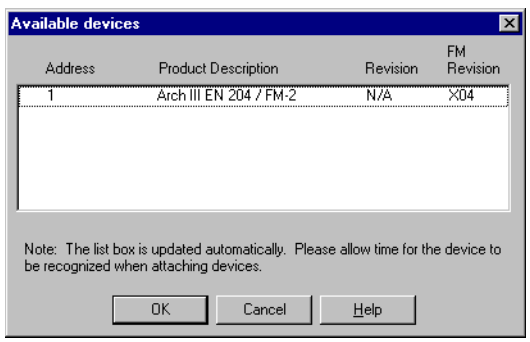


Figure 109: Available Devices Dialog Box

From this dialog box select the device(s) you wish to upload into a Configuration Window. You can only select non-grayed items. The list box is updated at regular intervals. Please allow time when connecting and disconnecting devices to the system. Click the *OK* button to begin the upload.

Step 4: Operation Verification

After downloading a configuration file to the drive, you may want to verify the operation of the system using the checklist below.

1. I/O powered.

2. Connections installed.

3. The drive enabled.

4. The characters “V, T, P or +” displays verified on the drive "LED" status display with the decimal point "On".

Step 5: Saving the Configuration File

To save the drive setup information, select Save from the **File** menu. Follow the dialog box instructions.

Step 6: Printing the Configuration File

To generate a printed copy of all the data in the drive configuration, select Print from the **File** menu. If you print while online, the print-out will include several pages of useful online diagnostic information.

Step 7: Disconnecting Communications

After you successfully download to the drive, you may want to disconnect the serial communications link between the drive and your PC to clear the serial port or to access some PowerTools FM options only available when offline.

To disconnect serial communications, click the *Disconnect* button at the bottom of the Configuration Window (or select the Disconnect command from the **Device** menu).

Tuning Procedures

Overview

The drive uses closed loop controllers to control the position and velocity of the attached motor. These position and velocity controllers and the associated tuning parameters are in effect when the drive is in velocity or pulse mode and have no effect when the drive is in Torque mode.

Classic closed loop controllers are tuned using proportional, integral and derivative (PID) gains which require skilled “tweaking” to optimize. The drive uses a revolutionary tuning approach utilizing state-space algorithms. Using this method a drive can control the motor more accurately and with more robustness than the older PID algorithms.

The drive’s default settings are designed to work in applications with up to a 10:1 load to motor inertia mismatch. Most applications can operate with this default setting.

Some applications may have performance requirements which are not attainable with the factory settings. For these applications a set of measurable parameters can be specified which will set up the internal control functions to optimize the drive performance. The parameters include Inertia Ratio, Friction, Response and Line Voltage. All the values needed for optimization are “real world” values that can be determined by calculation or some method of dynamic measurement.

PID vs. State-Space

The power of the state-space control algorithm is that there is no guessing and no “fine tuning” as needed with PID methods. PID methods work well in controlled situations but tend to be difficult to setup in applications where all the effects of the system are not compensated for in the PID loop. The results are that the system response is compromised to avoid instability.

The drive state-space control algorithm uses a number of internally calculated gains that represent the wide variety of effects present in a servo system. This method gives a more accurate representation of the system and maximizes the performance by minimizing the compromises.

You need only to setup the system and enter three parameters to describe the load and the application needs. Once the entries are made the tuning is complete - no guessing and no “tweaking”. The drive uses these entries plus motor and amplifier information to set up the internal digital gain values. These values are used in the control loops to accurately set up a stable, repeatable and highly responsive system.

Tuning Procedure

Once the initial setup has been completed, you can run the system to determine if the level of tuning is adequate for the application. There are basically four levels of tuning for a drive.

- No Tuning
- Basic Level
- Intermediate Level
- Fully Optimized Level

Each level is slightly more involved than the previous one requiring you to enter more information. If your system needs optimization, we recommend that you start with the Basic Level, then determine if further tuning is needed based on axis performance.

The setup procedures explained here assume that you are using PowerTools software or an FM-P.

Initial settings

Pulse Mode (with or without a position controller)
Velocity Mode (without a position controller)

If you are using the drive in Pulse mode with or without a position controller or as an open loop velocity drive only, set the drive tuning parameters as follows:

- Inertia Ratio = 0
- Friction = 0
- Response = 50
- High Performance Gains = Enabled
- Feedforwards = Disabled

Velocity Mode (with a position controller)

If you are using the drive in Velocity mode with a position controller, set the drive tuning parameters as follows:

- Inertia Ratio = 0
- Friction = 0
- Response = 100
- High Performance Gains = Enabled
- Feedforwards = Disabled

Torque Mode (with or without a closed loop position controller)

If you are using the drive in Torque mode, without Stop inputs or Travel Limit inputs, no tuning is required.

If you are operating in Torque mode and you are using the Stop or Travel Limit inputs, you must setup the drive as if it were running in Velocity mode without a position controller. This is because the drive will automatically shift into Velocity mode when either of these functions is activated and will use the gain setups when decelerating and holding position.

This unique feature offers an extra level of safety because the drive can override the position controller and bring the axis to a safe stop if the controller loses the ability to control the axis.

Tuning steps

If your Inertia Ratio is greater than 10 times the motor inertia go directly to the Intermediate Level tuning.

No Tuning

No tuning will be required in most applications where the load inertia is 10 times the motor inertia or less.

Basic Level

Adjust Response to obtain the best performance.

Intermediate Level

1. Calculate or estimate the load inertia. It is always better to estimate low.
2. Disable the drive.
3. Enter the inertia value calculated into the Inertia Ratio parameter.

EN **EN Only**

Set the Line Voltage to the applied voltage (default is 230 VAC).

4. Leave all other tuning parameters at the initial values.
5. Enable the drive and run the system.
6. Adjust Response to obtain the best performance.

Fully Optimized Level

1. Determine the actual system parameters.
2. Disable the drive.
3. Enter the parameters.

EN **EN Only**

Line Voltage set to the applied voltage (default is 230 VAC).

4. Enable the drive and run the system.

5. Adjust Response to obtain the best performance.

General Tuning Hints

The Response is normally the final adjustment when tuning. For best performance the Response should be lower with a higher inertia mismatch (>10:1) and higher with a lower inertia mismatch.

If your system has some torsional compliance, such as with a jaw type coupling with a rubber spider, or if there is a long drive shaft, the Response should be decreased. The highest recommended Response with High Performance Gains enabled is 100 Hz.

Feedforwards can be enabled if the performance requirements are very demanding. However when using them, make sure the Inertia Ratio and Friction values are an accurate representation of the load. Otherwise, the system performance will actually be degraded or stability will suffer. Enabling the Feedforward makes the system less tolerant of inertia or friction variations during operation.

Tuning Parameters

Inertia Ratio

Inertia Ratio specifies the load to motor inertia ratio and has a range of 0.0 to 50.0. A value of 1.0 specifies that load inertia equals the motor inertia (1:1 load to motor inertia). The drives can control up to a 10:1 inertia mismatch with the default Inertia Ratio value of 0.0. Inertial mismatches of over 50:1 are possible if response is reduced.

The Inertia Ratio value is used to set the internal gains in the velocity and position loops, including feedforward compensation if enabled.

To calculate the Inertia Ratio value, divide the load inertia reflected to the motor by the motor inertia of the motor. Include the motor brake as a load where applicable. The resulting value should be entered as the Inertia Ratio parameter.

$$IR = \frac{RLI}{MRI}$$

Where:

IR = Inertia Ratio
RLI = Reflected Load Inertia (lb-in-sec^2)
MI = Motor Inertia (lb-in- sec^2)

If the exact inertia is unknown, a conservative approximate value should be used. If you enter an inertia value higher than the actual inertia, the resultant motor response will tend to be more oscillatory.

If you enter an inertia value lower than the actual inertia, but is between 10 and 90 percent of the actual, the drive will tend to be more sluggish than optimum but will usually operate satisfactorily. If the value you enter is less than 10 percent of the actual inertia, the drive will have a low frequency oscillation at speed.

Friction

This parameter is characterized in terms of the rate of friction increase per 100 motor RPM. The range is 0.00 to 100.00 in units of percent continuous torque of the specified motor/drive combination. The Friction value can either be estimated or measured.

If estimated, always use a conservative (less than or equal to actual) estimate. If the friction is completely unknown, a value of zero should be used. A typical value used here would be less than one percent.

If the value entered is higher than the actual, system oscillation is likely. If the value entered is lower than the actual a more sluggish response is likely but generally results in good operation.

Response

The Response adjusts the velocity loop bandwidth with a range of 1 to 500 Hz. In general, it affects how quickly the drive will respond to commands, load disturbances and velocity corrections. The effect of Response is greatly influenced by the status of the High Performance Gains.

With High Performance Gains disabled, the actual command bandwidth of the drive system will be equal to the Response value. In this case the load disturbance correction bandwidth is fixed at approximately 5 Hz. Increasing the Response value will reduce the drive's response time to velocity command changes but will not affect the response to load or speed disturbances.

When High Performance Gains are enabled, the actual response bandwidth is three to four times the Response value. In this case, it affects both the velocity command and the load disturbance correction bandwidth. Increasing the Response when the High Performance Gains are enabled will increase loop stiffness. With High Performance gains enabled, the maximum Response level recommended is approximately 100 Hz.

If the Inertia Ratio and Friction values are exactly correct and the High Performance Gains are enabled, changing the Response will not affect the damping (percent of overshoot and number of ringout cycles) to velocity command changes or load disturbance corrections but will affect their cycle frequency. The response level should be decreased as the load to motor inertia ratio increases or if High Performance Gains are enabled.

High Performance Gains

Enabling High Performance Gains fundamentally affects the closed loop operation of the drive and greatly modifies the effect of the Response parameter. High Performance Gains are most beneficial when the Inertia Ratio and Friction parameters are accurate.

High Performance Gains, when enabled, make the system less forgiving in applications where the actual inertia varies or the coupling between the motor and the load has excessive windup or backlash.

Note

When using an external position controller, some applications will benefit in rare instances by disabling High Performance Gains.

Position Error Integral

Position Error Integral is a control term that is effective only in Pulse mode which serves to minimize following error especially at constant speed. This minimizes phase error between master and slave when running in a line shaft or gearing application. It also helps maintain accurate command execution during steady state or low frequency torque disturbances (typically less than 10 Hz) or when holding a non-counterbalanced vertical load in position.

The adjustment parameter is Position Error Integral Time Constant which is available in the Motor and Tuning Tabs of PowerTools. This parameter determines how quickly the drive will attempt to eliminate the following error. The time constant is in milliseconds and defines how long it will take to decrease the following error by 63%. (3 time constants will reduce the following error by 96 %). The range for this parameter is 5 to 500 milliseconds. In certain circumstances the value actually used by the drive will be greater than the value specified in the Power Tools because the minimum allowed time constant value is a function of the 'Response' parameter. The formula is Min. Time Constant = 1000/Response. For example with 'Response' set to 50, the minimum time constant value is 1000/50 = 20 msec. A higher time constant value will minimize instability with more compliant loads such as long drive shafts, or spring loads. A lower time constant setting will increase the response and will stiffen the system.

Feedforwards

Feedforward gains are essentially open loop gains that generate torque commands based on the commanded velocity, accel/decel and the known load parameters (Inertia Ratio and Friction). Using the feedforwards reduces velocity error during steady state and reduces overshoot during ramping. This is because the Feedforwards do not wait for error to build up to generate current commands.

Feedforwards should be disabled unless the absolute maximum performance is required from the system. Using them reduces the forgiveness of the servo loop and can create instability if the actual inertia and/or friction of the machine varies greatly during operation or if the Inertia Ratio or Friction parameters are not correct.

The internal feedforward velocity and acceleration gains are calculated by using the Inertia Ratio and Friction parameters. The feedforward acceleration gain is calculated from the Inertia Ratio parameter and the feedforward velocity gain is calculated from the Friction parameter.

When Feedforwards are enabled, the accuracy of the Inertia Ratio and Friction parameters is very important. If the Inertia Ratio parameter is larger than the actual inertia, the result would be a significant velocity overshoot during ramping. If the Inertia parameter is smaller than the actual inertia, velocity error during ramping will be reduced but not eliminated. If the Friction parameter is greater than the actual friction, it may result in velocity error or instability. If the Friction parameter is less than the actual friction, velocity error will be reduced by not eliminated.

Feedforwards can be enabled in any operating mode, however, there are certain modes in which they do not function. These modes are described in table below.

Operating Mode	Feedforward Parameters Active	
	Accel FF	Vel FF
Analog Velocity	No	Yes
Preset Velocity	Yes	Yes
Pulse/Position	No	Yes
Summation	Yes	Yes

* EN revision B6 or later.

Low Pass Filter Enable and Frequency

The drive provides a low pass filter which may be used to reduce machine resonance due to mechanical coupling or other flexible load components. The low pass filter filters the torque command generated by the velocity loop. It is not active in Torque mode.

The low pass filter's frequency must be at least 2.5 times greater than the actual velocity loop bandwidth. If there is no noticeable mechanical resonance effecting the system, the system is better off without the low pass filter. If the system has a mechanical resonance effecting the performance, the low pass filter can diminish the effects of the resonance and allow the tuning response parameter to be increased.

The low pass filter may improve system performance when there is an inertia mismatch between the load and the motor inertia causing compliance in the effective load shaft. For example, if an EN-214/MG-490 drive motor combination is driving a 16-inch long ne-inch steel shaft with a 40:1 inertia mismatch, the highest the tuning can be set to is 1 hertz. If the low pass filter is enabled at a frequency of 70 hertz, the system's tuning response may be set to 15 hertz.

Line Voltage (EN Only)

Line Voltage specifies the applied power and adjusts the internal gains to compensate for it. This parameter has two choices 115 VAC and 230 VAC. If the Line Voltage is set to 230 VAC when the actual applied voltage is 115 VAC, the motor will be slightly less responsive to commands and load disturbances.

⚠WARNING

The Line Voltage must never be set to 115 VAC if the applied voltage is actually 230 VAC. This can cause drive instability and failure.

Determining Tuning Parameter Values

For optimum performance you will need to enter the actual system parameters into the drive. This section discusses the methods which will most accurately determine those parameters.

Note

If you have an application which exerts a constant unidirectional loading throughout the travel such as in a vertical axis, the inertia tests must be performed in both directions to cancel out the unidirectional loading effect.

Initial Test Settings

When running the tests outlined in this section, the motor and drive must be operational so you will need to enter starting values.

If your application has less than a 10:1 inertia mismatch, the default parameter settings will be acceptable. If the inertial mismatch is greater than 10:1, use the following table for initial parameter settings.

Parameter	Setting
Friction	0.00
Inertia Ratio	1/3 to 1/2 Actual
Response	500/Inertia Ratio
High Performance Gains	Disabled
Feedforwards	Disabled
Line voltage	Actual Applied

Determining Friction

This parameter represents friction that increases proportionally as motor velocity increases. The viscous friction of your system can be determined by reading the percent of continuous torque required to operate the loaded motor at two different speeds.

Consider the following before determining the Friction:

- The most consistent readings can usually be obtained at motor speeds higher than 500 RPM but lower test speeds can be used if necessary.

- If your application has travel limits, it may be helpful to use an external position controller to prevent the axis from exceeding the machine limits. Set up a trapezoidal profile as shown.
- In the procedure below, the Torque Command and Velocity Feedback parameters can be measured using the drive's analog outputs, PowerTools software.
- With vertical loads the test readings must be taken while traveling in the same direction.
- An oscilloscope may be needed for systems with limited travel moves to measure the rapidly changing torque and velocity signals.
- If your system's friction changes with operating temperature, perform this procedure at normal operating temperature.

Procedure for Determining Friction:

1. Run the motor at the low test speed (at least 500 RPM).
2. While at speed, note the Torque Command Actual value (T_{CL}).

Note

If the friction loading of your system varies when operating at constant speed, due to a load or spring load that changes as the motor rotates, use the lowest value measured.

3. Repeat Step 1 using a velocity at least two times the low speed.
4. While at speed, note the Torque Command Actual value (T_{CH}).
5. Use the following formula to calculate the friction:

$$FV = (100)\frac{(T_{CH} - T_{CL})}{RPM_H - RPM_L}$$

Where:

T_{CH} = Torque Command Limited value at higher speed
T_{CL} = Torque Command Limited at lower speed
RPM_H = Higher RPM (velocity)
RPM_L = Lower RPM (velocity)
FV = Friction value

The figure below shows the relationship of Torque Command to the Velocity Feedback. There is increased torque during the Accel ramp (Ta), constant torque (Tc) during the constant velocity portion of the ramp and decreased torque (Td) during the decel ramp.

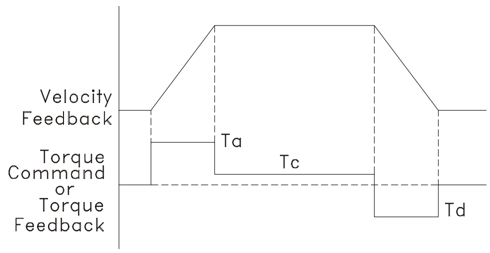


Figure 110: Trapezoidal Velocity Waveform with Torque Waveform

Determining Inertia Ratio

Actual system Inertia Ratio is determined by accelerating and decelerating the load with a known ramp while measuring the torque required.

Consider the following before determining the inertia:

- If your application allows a great deal of motor motion without interference, it is recommended that you use a Preset Velocity to produce accurate acceleration ramps.
- If your application has a very limited range of motion, it is recommended that you use a position controller to produce the acceleration ramps and to prevent exceeding the axis range of motion.
- The accel and decel ramp should be aggressive enough to require at least 20 percent of continuous motor torque. The higher the torque used during the ramp, the more accurate the final result will be.
- With ramps that take less than 1/2 second to accelerate, read the Diagnostic Analog Outputs with an oscilloscope to measure the Torque Feedback.
- With ramps that take 1/2 second or longer to accelerate, read the Torque Command parameter on the Motor tab of PowerTools or with the Watch Window.
- To best determine the inertia, use both acceleration and deceleration torque values. The difference allows you to drop the constant friction out of the final calculation.
- If your application exerts a constant “unidirectional loading” throughout the travel such as in a vertical axis, the inertia test profiles must be performed in both directions to cancel out the unidirectional loading effect.
- The Torque Command Limited and Velocity Feedback parameters can be measured using the drive’s Analog Outputs, or PowerTools software.

An oscilloscope will be needed for systems with limited travel moves and rapidly changing signals of torque and velocity.

Inertia Measurement Procedure:

Note

The test profile will need to be run a number of times in order to get a good sample of data.

1. Enable the drives and run the test profiles.

2. Note the Torque Command Limited value during acceleration and deceleration.

3. Use the appropriate formula below to calculate the inertia.

For horizontal loads or counterbalanced vertical loads use the following formula:

$$IR = \frac{(R \bullet Vm\,(Ta + Td))}{2000} - 1$$

Where:

IR = Inertia Ratio
R = ramp in ms/kRPM
Ta = (unsigned) percent continuous torque required during acceleration ramping (0 - 300)
Td = (unsigned) percent continuous torque required during deceleration ramping (0 - 300)
Vm = motor constant value from Table 18 below

For un-counter balanced vertical loads use the following formula:

$$IR = \frac{(R \bullet Vm\,(Tau + Tud + Tad + Tdd))}{4000} - 1$$

Where:

IR = Inertia Ratio
R = ramp in ms/kRPM
Vm = motor constant value from the table below
Tau = (unsigned) percent continuous torque required during acceleration ramping while moving up (against the constant force)
Tdu = (unsigned) percent continuous torque required during deceleration ramping while moving up (against the constant force)
Tad = (unsigned) percent continuous torque required during acceleration ramping while moving down (aided by the constant force)
Tdd = (unsigned) percent continuous torque required during deceleration ramping while moving down (aided by the constant force)

Ramp Units Conversion

If you are using an external position controller to generate motion you may need to convert the ramp units as desired below.

Many position controllers define acceleration in units per sec^2. The formulas above use ms/kRPM. Make sure you make this conversion when entering the information into the formula.

Conversion Formula:

$$MPK = \frac{10^6}{(RPSS \bullet 60)}$$

Where:

MPK = accel ramp in ms/kRPM

RPSS = accel ramp in revolutions per second^2

Motor	Drive	Vm	Percent Continuous/volt Scaled Torque Command Output (default))	RPM /volt Scaled Velocity Command Output (default))
NT-320	EN-204	4.30	30	600
MG-205		4.77	30	600
MG-208		5.11	30	600
MG-316		3.17	30	600
NT-320	EN-208	5.16	30	600
NT-330		6.87	30	600
NT-345		6.72	30	600
NT-355		5.97	30	600
MG-316		3.17	30	600
MG-340		3.14	30	600
MG-455		2.44	30	600
NT-345	EN-214	6.72	30	600
NT-355		5.97	30	600
MG-455		2.44	30	600
MG-490		1.85	30	600
MG-4120		1.69	30	600
NT-207	Eb-202	7.27	30	600
NT-212		5.37	30	600
MG-205		4.77	30	600
MG-208		3.63	30	600
NT-207	Eb-203	7.27	30	600
NT-212		7.22	30	600
MG-205		4.77	30	600
MG-208		4.63	30	600
MG-316		2.67	30	600

Motor	Drive	Vm	Percent Continuous/volt Scaled Torque Command Output (default))	RPM /volt Scaled Velocity Command Output (default))
NT-320	Eb-205	4.77	30	600
NT-330		5.50	30	600
NT-345		5.10	30	600

Diagnostics and Troubleshooting

Diagnostic Display

The diagnostic display on the front of the drive shows drive status and fault codes. When a fault condition occurs, the drive will display the fault code, overriding the status code. The decimal point is “On” when the drive is enabled and the Stop input is not active. This indicates that the drive is ready to run and will respond to motion commands. Commands will not cause motion unless the decimal point is “On”.

Display Indication	Status	Description
	Brake Engaged (Output "Off")	Motor brake is mechanically engaged. This character will only appear if the Brake output function is assigned to an output line. See Brake Operation section for detailed description of Brake Output function.
	Disabled	Power Stage is disabled.
	Position	Pulse mode operation.
	Velocity	Velocity mode operation.
	Torque	Torque mode operation.
	Summation	Summation mode operation.
	RMS Foldback	Motor torque is limited to 80 percent.
	Stall Foldback (EN drive only)	Drive output current is limited to 80 percent of drive stall current.

Display Indication	Status	Description
◆	Ready to Run	Drive enabled, no Stop input.

Fault Codes

A number of diagnostic and fault detection circuits are incorporated to protect the drive. Some faults, like high DC bus and amplifier or motor over temperature, can be reset with the Reset button on the front of the drive or the Reset input function. Other faults, such as encoder faults, can only be reset by cycling power "Off" (wait until the status display turns "Off"), then power "On".

The drive accurately tracks motor position during fault conditions. For example, if there is a "Low DC Bus" fault where the power stage is disabled, the drive will continue to track the motor's position provided the logic power is not interrupted.

The +/- Travel Limit faults are automatically cleared when the fault condition is removed. The table below lists all the fault codes in priority order from highest to lowest. This means that if two faults are active, only the higher priority fault will be displayed.

Display	Fault	Action to Reset	Bridge Disabled
I	Power Up Test	Cycle Power	Yes
N	NVM Invalid	Reset Button or Input Line	Yes
A	Drive Overtemp (Epsilon drive only)	Allow Drive to cool down, Cycle Power	Yes
U	Invalid Configuration (EN drive only)	Reset Button or Input Line	Yes
Z	Power Module	Reset Button or Input Line (for EN) Cycle Power (for Epsilon)	Yes

Display	Fault	Action to Reset	Bridge Disabled
	High DC Bus	Reset Button or Input Line	Yes
	Low DC Bus	Reset Button or Input Line	Yes
	Encoder State	Cycle Power	Yes
	Encoder Hardware	Cycle Power	Yes
	Motor Overtemp	Allow Motor to cool down, Reset Button or Input Line	Yes
	RMS Shunt Power (EN drives only)	Reset Button or Input Line	Yes
	Overspeed	Reset Button or Input Line	Yes
	Following Error (Pulse mode only)	Reset Button or Input Line	Yes
	Travel Limit +/-	Auto	No
	All "On"	Normally "On" for one second during power-up	Yes

Fault Descriptions

I	**Power Up Test**

This fault indicates that the power-up self-test has failed. This fault cannot be reset with the reset command or reset button.

N	**NVM Invalid**

At power-up the drive tests the integrity of the non-volatile memory. This fault is generated if the contents of the non-volatile memory are invalid.

U	**Invalid Configuration**

EN

EN Only

A function module was attached to the drive on its previous power-up. To clear, press and hold the Reset button for 10 seconds.

Epsilon Only

This fault will occur if the digital board in the drive does not match the power board settings. It is only useful during manufacturing. A drive with this fault should be returned for service.

A	**Drive Overtemp**

Epsilon Only

Indicates the drive IGBT temperature has reached 100°C (212°F).

Z	**Power Module**

This fault is generated when a power stage over-temperature, over-current or loss of power stage logic supply occurs. This can be the result of a motor short to ground, a short in the motor windings, a motor cable short or the failure of a switching transistor.

It can also occur if the drive enable input is cycled "Off" and "On" rapidly (>10 Hz).

H	**High DC Bus**

This fault will occur whenever the voltage on the DC bus exceeds the High DC Bus threshold. The most likely cause of this fault would be an open external shunt fuse, a high AC line condition or an application that requires an external shunt (e.g., a large load with rapid deceleration).

	High DC Bus Threshold	Low DC Bus Threshold
EN	440	96
Epsilon	415	60

u Low DC Bus

This fault will occur whenever the voltage on the DC bus drops below the Low DC Bus threshold. The most likely cause of this fault is a reduction (or loss) of AC power. A 50 ms debounce time is used with this fault to avoid faults caused by intermittent power disruption. With and Epsilon drive, the low DC bus monitoring can be disabled with PowerTools software in the Advanced tab.

	High DC Bus Threshold	Low DC Bus Threshold
EN	440	96
Epsilon	415	60

P Encoder State

Certain encoder states and state transitions are invalid and will cause the drive to report an encoder state fault. This is usually the result of noisy encoder feedback caused by poor shielding. For some types of custom motors it may be necessary to disable this fault. Refer to the Advanced Tab section of Setting Up Parameters for more information.

E Encoder Hardware

If any pair of complementary encoder lines are in the same state, an encoder line fault is generated. The most likely cause is a missing or bad encoder connection.

M Motor Overtemp

This fault is generated when the motor thermal switch is open due to motor over-temperature or incorrect wiring.

S RMS Shunt Power

EN **EN Only**

This fault is generated when RMS shunt power dissipation is greater than the design rating of the internal shunt.

Overspeed

This fault occurs in one of two circumstances:

1. When the actual motor speed exceeds the Overspeed Velocity Limit parameter or 150% of motor maximum operating speed. This parameter can be accessed with PowerTools software.

2. If the combination of command pulse frequency and Pulse Ratio can generate a motor command speed in excess of the fixed limit of 13000 RPM, an Overspeed Fault will be activated. In Pulse mode operation and any Summation mode which uses Pulse mode, the input pulse command frequency is monitored and this calculation is made. For example, with a Pulse Ratio of 10 pulses per motor revolution, the first pulse received will cause an Overspeed fault even before there is any motor motion.

Following Error

This fault is generated when the following error exceeds the following error limit (default following error limit is .2 revs). With PowerTools you can change the Following Error Limit value or disable in the Position tab. The Following Error Limit is functional in Pulse mode only.

Travel Limit +/-

This fault is caused when either the + or - Travel Limit input function is active.

All "On"

This is a normal condition during power up of the drive. It will last for less than 1 second. If this display persists, call Control Techniques for service advice.

Normally, "All On" for less than one second during power-up. All segments dimly lit when power is "Off" is normal when an external signal is applied to the encoder inputs (motor or master) or serial port from an externally powered device. The signals applied to the inputs cannot exceed 5.5V level required to drive logic common or drive damage will occur.

Diagnostic Analog Output Test Points

The drive has two 8-bit real-time Analog Outputs which may be used for diagnostics, monitoring or control purposes. These outputs are referred to as Channel 1 and Channel 2. They can be accessed from the Command Connector on the drive or from the Diagnostics Analog Output Pins located on the front of the drive.

Each Channel provides a programmable Analog Output Source.

Analog Output Source options are:

- Velocity Command
- Velocity Feedback
- Torque Command (equates to Torque Command Actual parameter)
- Torque Feedback
- Following Error

Default Analog Output Source:

- Channel 1 = Velocity Feedback
- Channel 2 = Torque Command

Channel	Output Source	Offset	Scale
1	Velocity Feedback	0	600 RPM/volt
2	Torque Command	0	30 percent/volt for selected motor

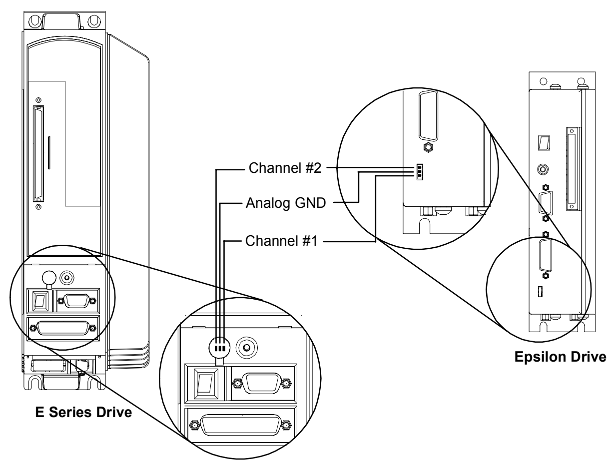


Figure 111: Diagnostic Analog Output Test Points

The DGNE cable was designed to be used with either an oscilloscope or a meter. The wires are different lengths to avoid shorting to each other. However, if signals do get shorted to GND, the drive will not be damaged because the circuitry is protected.

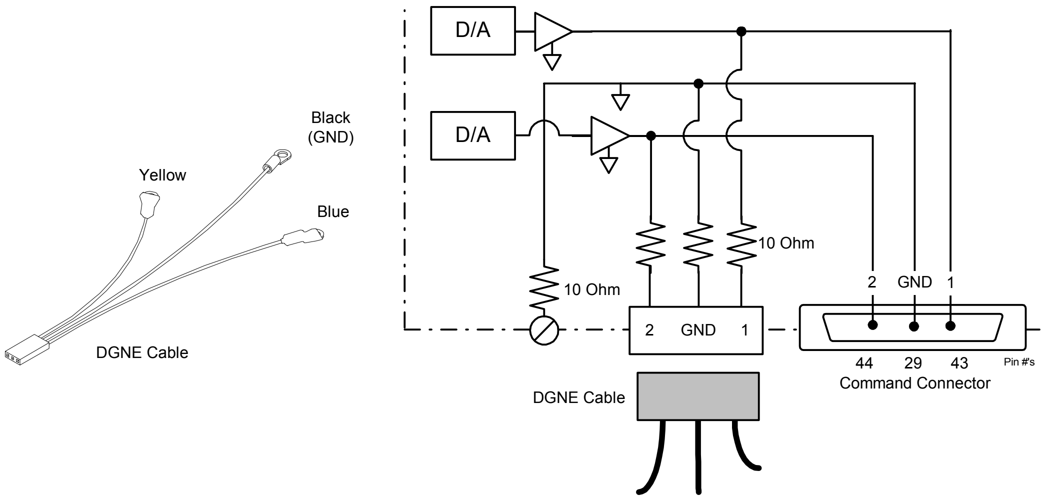


Figure 112: Diagnostic Cable (DGNE) Diagram

Drive Faults

The Active Drive Faults dialog box is automatically displayed whenever a fault occurs. There are two options in this dialog box: Reset Faults and Ignore Faults.

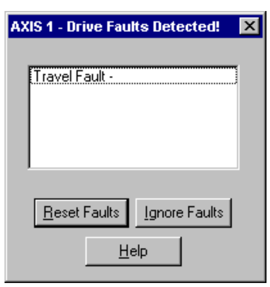


Figure 113: Active Drive Faults Detected Dialog Box

Resetting Faults

Some drive faults are automatically reset when the fault condition is cleared. Other faults require drive power to be cycled or the drive to be “rebooted”. If you wish to continue working in the PowerTools FM software without resetting the fault, click the *Ignore Fault* button.

To reset faults that can be reset with the *Reset Faults* button, simply click the *Reset Faults* button in the Drive Faults Detected dialog box or push the Reset button on the front of the drive where the fault occurred.

Viewing Active Drive Faults

To view all active drive faults, select the View Faults command from the **Device** menu or by clicking on the View Faults icon on the toolbar. The dialog box displayed is the same as Active Drive Faults Detected dialog box described above.

Rebooting the Drive

To reboot the drive, cycle power or select the Reboot Drive command from the **Device** menu. This command reboots the drive attached to the active Configuration Window.

Watch Window

This feature allows you to customize a window to monitor drive parameters which you select from a complete list of drive parameters. From this window you can watch the parameters you selected in real time. This feature is only available when you are online with the drive.

Note

You cannot change the values of the parameters while they are being displayed in the Watch Window. The parameter in the setup screens will look like they have been changed when they actually have not. To update a parameter, delete it from the Watch Window selection.

Note

It is normal to have the Watch Window show up with the three motor parameters already selected if the motor parameters window has been accessed previously. If you do not need to view them, simply push the *Clear All* button and select the parameters you wish to view.

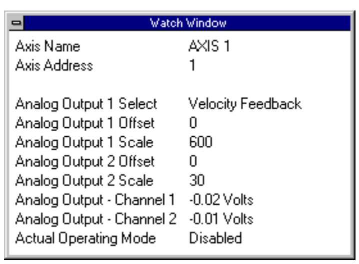


Figure 114: Watch Window

The Watch Window is accessed by selecting Watch Drive Parameters from the **Tools** menu or by clicking on the Watch Window icon on the toolbar.

The Watch Window will automatically appear as soon as you select a parameter from the Select Drive Parameters dialog box. After you have selected the parameters you wish to watch, click the *Close* button. The Select Drive Parameters dialog box will close and the Watch Window will remain open.

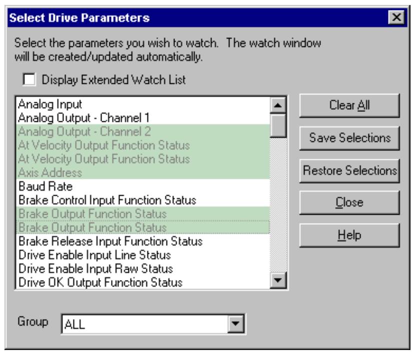


Figure 115: Select Drive Parameters Dialog Box

Group

This list box enables you to view the complete list of parameters or just a group of parameters you are interested in. The groups include: Analog In, Analog Out, Communication, Digital Inputs, Execution, Fault Counts, Fault Log, ID, Input Functions, Motor, Output Functions, Position, Setup, Status, Torque, Tuning, User Defined Motor, and Velocity.

Clear All Button

This button is used to clear all the parameter selections that were previously selected.

Save Selections Button

This button saves the parameter selections. This enables you to restore the same list of parameters for use in future online sessions.

Restore Selections Button

This button restores the parameter selections previously saved. This enables you to restore the list of parameters you created in a previous online session.

View Motor Parameters

When online with the drive this feature allows you to display a pre-defined Watch Window to monitor three motor parameters. These parameters are normally used when testing the setup of a User Defined Motor for commutation accuracy.

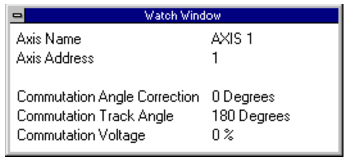


Figure 116: View Motor Parameters Window

The View Motor Parameters window is accessed by selecting View Motor Parameters from the **Tools** menu.

Error Messages

PowerTools will pop-up an error message box to alert you to any errors it encounters. These message boxes will describe the error and offer a possible solution.

The table below list the of common problems you might encounter when working with PowerTools software along with the error message displayed, the most likely cause and solution.

Problem/Message	Cause	Solution
Time-out while waiting for device response. The attempted operation has been cancelled. (see fault: No device selected)	Loss of serial communications.	Check the serial connection to the device and try operation again.
The attached device(s) do not have valid revisions, or do not have matching revisions.	Attempting to broadcast to drive without matching firmware revisions.	Program each drive individually.
Unable to communicate with device [Address x]	The device that you are attempting to communicate with is no longer available.	Check all connections and verify that you are using the correct baud rate then try again.
The specified drive type (name) does not match the actual drive type (name). Please make necessary corrections.	The drive type you selected in the "Drive Type" list box does not match the drive you are downloading to.	Change the drive type selected in the "Drive Type" list box to match the drive you are downloading to.
Non-Control Techniques device attached (address). When trying to program more than one drive, only EMC drives of the same type can be attached to the network.	This error is caused When you attempting to perform an upload or download to multiple drives and one or more of the drives are not the same type.	Disconnect the device(s) that has been specified and try the operation again or program each device individually.
You have changed a parameter which will not take affect until the drive has been rebooted. Before you reboot the drive, you will need to save your setup to NVM. Do you wish to save your setup to drive NVM now?	See message.	Yes/No.
(Operation Name) The attempted operation has been cancelled.	Communication error.	Retry operation. Check connection to drive.
Invalid entry. The entry exceeds the precision allowed by this field. The finest resolution this field accepts is (value).	Entered a value out of range.	Enter a value within the range of that field. The status bar displays information on the currently selected object or action.
The device was disconnected during the upload. The upload was not complete.	Connection to the device was lost (a time-out occurred).	Check the connection to the device and try again.
The device was disconnected during the download. The download was not complete.	Connection to the device was lost (a time-out occurred).	Check the connection to the device and try again.

Problem/Message	Cause	Solution
No device selected.	No device selected during flash upgrade.	Select device(s) from list box.
The drive at address is use.		Close any other windows that are using the same addresses and try again.

User Defined Motors

Drives can be configured to operate with brushless DC (synchronous permanent magnet) motors not manufactured by Control Techniques. This feature is very useful for users who are retrofitting drives on existing systems or who have special motor requirements.

Commutation Basics

To properly commutate the motor, the drive must know the electrical angle (the angle between the motor magnetic field and stator coils; R, S and T). At power-up, the drive determines the starting electrical angle from the U, V and W commutation tracks. After this is determined, the U, V and W commutation tracks are ignored and the commutation is entirely based on the A and B incremental channels. The number of U, V and W cycles must match the number of poles in the motor but they do not have to be aligned with the motor poles in any particular way.

The U, V and W tracks have a fairly coarse resolution, therefore, on power-up, the commutation accuracy is limited to ±30 electrical degrees from optimum. When the Z channel is seen by the drive, the commutation angle is gradually shifted to the optimum position as defined by the Motor Encoder Marker Angle parameter. This shift is accomplished in about one second whether the motor is rotating or not.

Tools Required:

- Oscilloscope dual trace 5 Mhz bandwidth minimum.
- AC/DC voltmeter, 20 VDC and 200 VAC minimum.
- Drill motor (reversible) or some means of spinning the motor.
- Coupling method between the drill motor and the test motor.
- 5 VDC power supply to power the motor encoder.
- Motor power cable (CMDS or CMMS).
- Motor feedback cable (CFCO).
- Terminal strip (18 position suggested) to conveniently connect the motor power and encoder wires during testing.
- Method to securely hold the motor during operation (a vise or large C-clamp).

Procedure

The steps required to assemble a servo system consisting of a drive, and a non-Control Techniques motor are listed below:

1. Determine if your motor is compatible with the drive by verifying its characteristics. There are a number of restrictions such as encoder line density and motor pole count that must be considered. Most of these parameters are commonly found on a motor data sheet and some may have to be determined by testing.

   It is important that the encoder used have a repeatable Z channel angle with reference to one of the commutation channels. This is especially the case if you will be using the same encoder on several motors and you wish to use the same setup file on them all. Otherwise you will need to generate a motor file for each individual motor/encoder.

2. Design and assemble the cabling and interface circuitry required to connect the motor and drive. Motor and feedback cables must be properly shielded and grounded.

3. Determine the encoder alignment. In order to commutate a motor correctly the angular relationship of the encoder commutation tracks and the marker pulse with respect to the R, S and T windings in the stator must be known.

4. Enter the motor/encoder data into the MOTOR.DDF file. This data is then read by the PowerTools software when setting up the drive.

5. Test your system to verify that the servo system is working correctly.

Step 1: Motor Wiring

The first step is to wire the motor terminals to the drive. Control Techniques designates the motor terminals as R, S and T.

Use the following procedure to establish the R, S and T mapping:

1. Assume the motor terminals of the non-Control Techniques motor are designated A, B and C. If they are not marked, name the terminals randomly. The next steps will determine their working designations.

2. You can select any of the three motor terminals and call it R. In this procedure we will choose terminal A.

⚠WARNING

The rotation of the motor will generate dangerous voltages and currents on the motor phase leads. Make sure the wires and connections are properly insulated.

---

3. Connect the scope to read VCA and VBA. VCA and VBA are measured by putting the probe ground clips on A and the scope probes on C and B.

4. Rotate the motor CCW (i.e., rotate the shaft counter-clockwise as you face the shaft end of the motor).

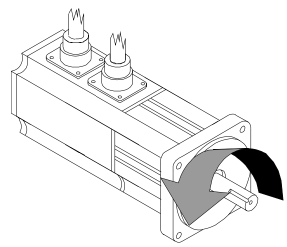
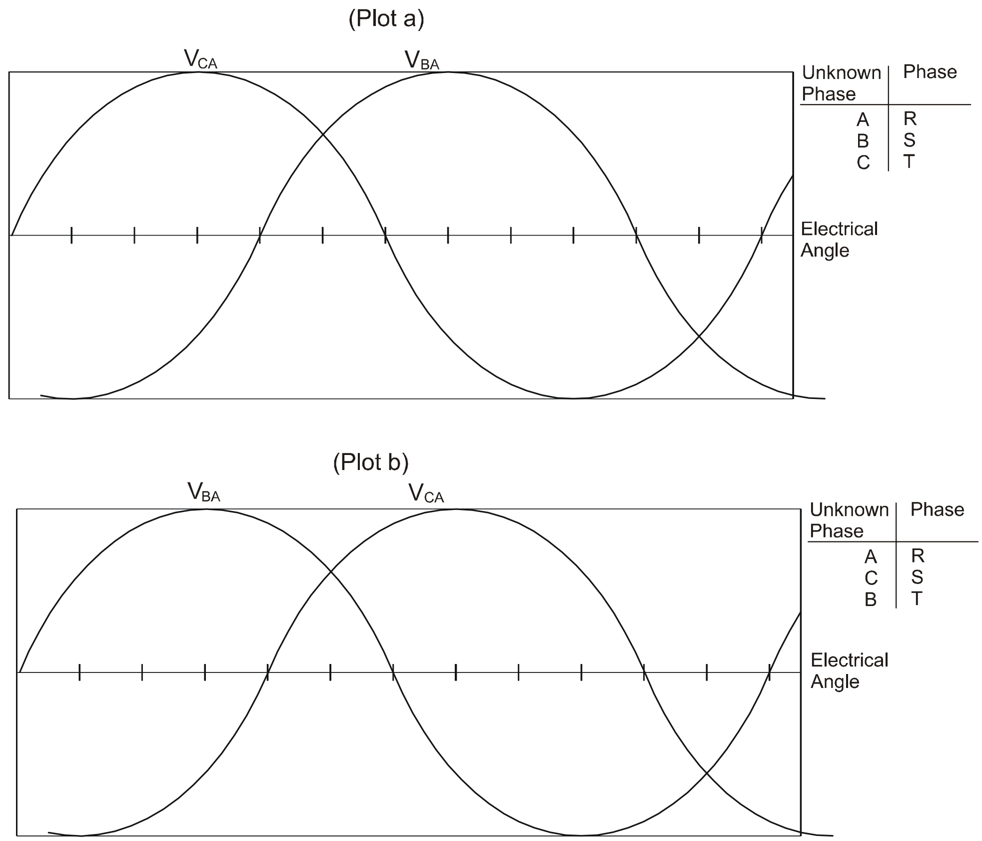


Figure 117: CCW Rotation of the Motor

5. Look at the phase-to-phase voltages VCA and VBA. There are two possibilities. If VCA leads VBA, then assign B to S and C to T. If VBA leads VCA, then assign B to T and C to S. These relationships are summarized in the figure below.



Phase plot obtained by rotating the motor in the CCW direction (the CCW direction is determined from the front face of the motor). This figure shows the motor terminal mapping to be used when V_{CA} leads V_{BA} (Plot a), and when V_{BA} leads V_{CA} (Plot b).

Figure 118: Phase Plot Used to Determining Stator Wiring

Note

For the remainder of this procedure we will refer to the motor terminals using the Control Techniques designations R, S and T.

Step 2: Motor Feedback Wiring

This step describes how to wire the feedback signals to the drive. There are two parts to this step: electrical interfacing and logical interfacing.

Encoder Electrical Interfacing

Each of the encoder signals is received by a differential receiver to minimize the noise susceptibility and to increase frequency bandwidth. This requires two wires for each logical signal. (i.e., signal A requires channel A and A/, etc.).

For optimum performance these signals should be generated by an encoder with a line driver output. Encoders which supply only single ended output signals will require some interfacing circuitry.

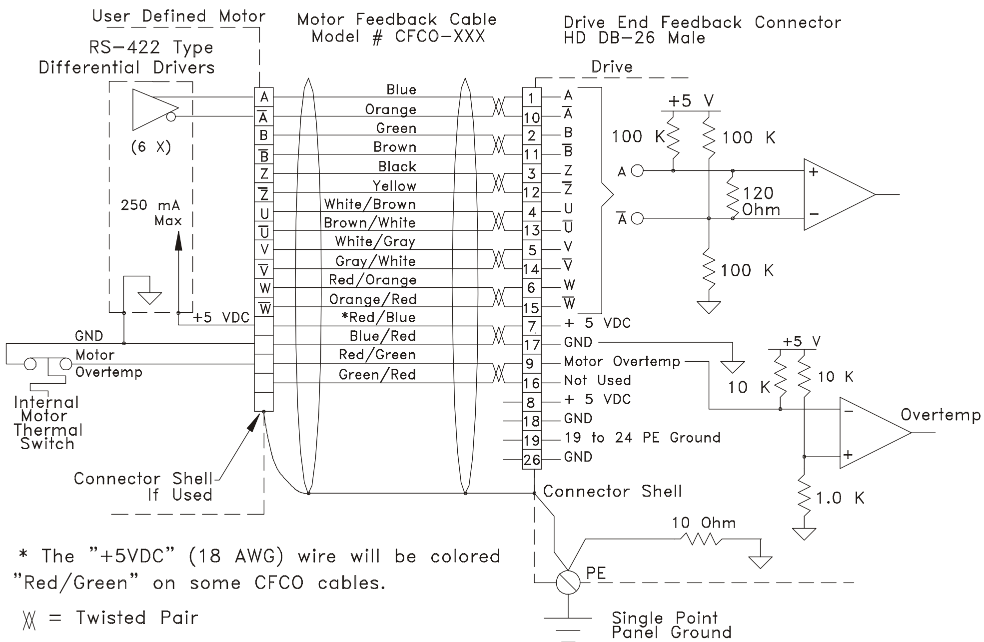


Figure 119: User Defined Motor Differential Feedback Connections

Note

The maximum current available out of the drive encoder +5 volt supply connection is 250 mA.

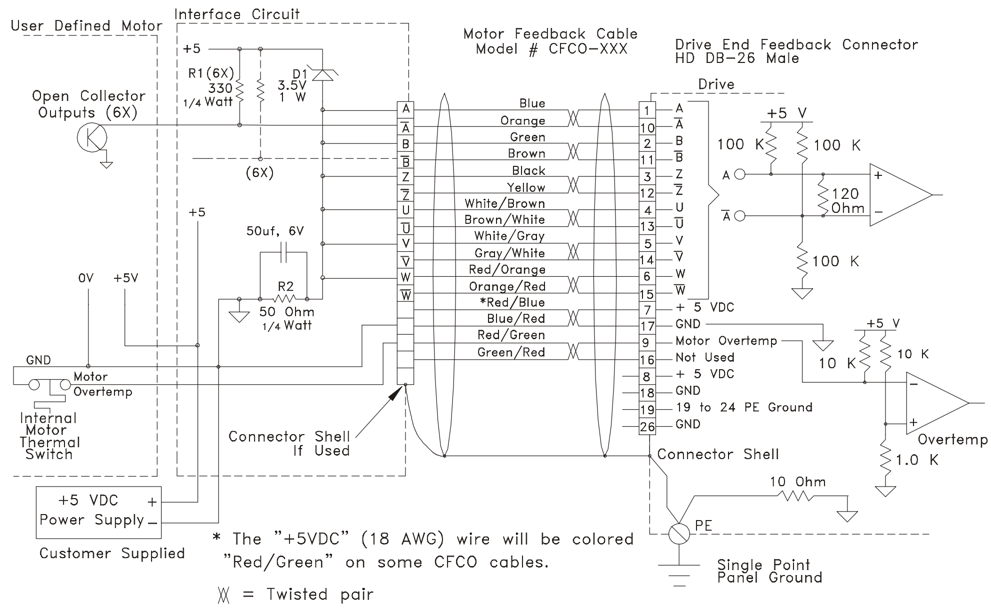


Figure 120: User Defined Motor Single Ended Feedback Connections

Thermal Switch Interfacing

The drive provides a facility to monitor the motor thermal sensor and shut the drive down in the event of a motor overtemp condition. This must be connected properly in order to enable the protection. If your motor does not have a thermal sensor, the sensor input pin needs to be connected to GND (connect pin 9 to pin 18). The thermal sensor requirements are as follows:

- If a thermistor is used, it must be a PTC (positive temperature coefficient) or it must increase in resistance as the temperature increases. The cold resistance should be 500 ohms or less. A motor fault will occur when the thermistor resistance reaches approximately 1.0 kohm.
- Switch Operation: open circuit on temperature rise
- Voltage rating min: 10 VDC
- Current capacity min: 1 mA

Encoder Logical Interfacing

The encoder is expected to provide six logical signals: A, B, Z, U, V and W. Each of these signals is received at the drive by a differential receiver circuit. For example, the A logical signal is received as channels A and /A.

Signals A and B provide incremental motor position in quadrature format. Z is a once per revolution marker pulse. U, V and W are commutation tracks.

There are two steps in interfacing the encoder signals:

1. Determine whether your encoder has all the required signals to operate with a drive. Some encoders, for example, do not provide a marker pulse or the marker pulse may not have a fixed phase relationship to the commutation tracks.

2. Determine the mapping from the motor encoder signals to the drive. To help with this second step we have provided a description of the required characteristics of the A, B, Z, U, V and W encoder signals.

The signal relationships of A, B, U, V and W required by the drive are shown in the phase plots below. For clarity the time scale against which A and B are plotted is different from that which U, V and W are plotted. Note that A leads B and U leads V and V leads W.

Plots like these are obtained by powering the encoder then rotating the motor while observing the signals on an oscilloscope. It is important to note which direction of motor rotation (CW or CCW) generates the phasing shown in the figures below.

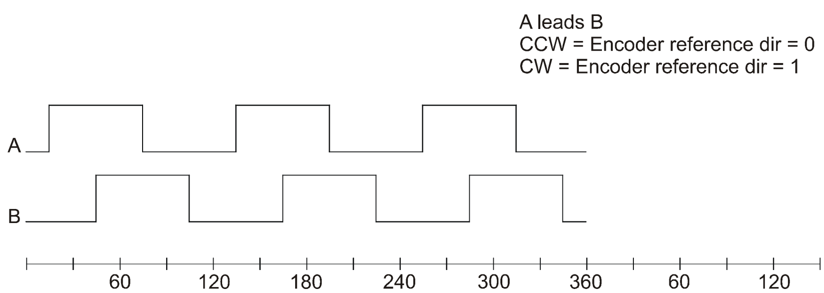


Figure 121: Phase Plot of A and B Encoder Channels

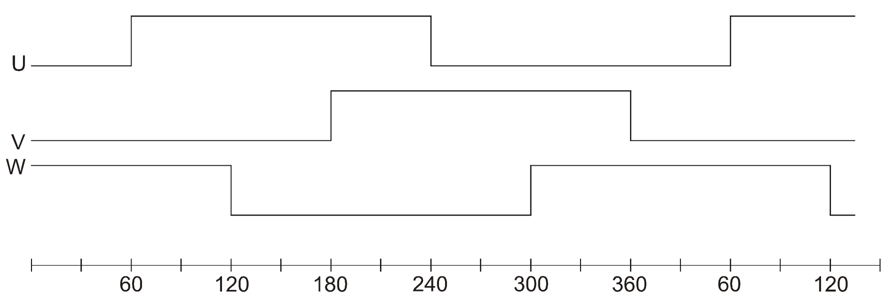


Figure 122: Phase Plot of U, V and W Encoder Signals with CCW Rotation

If the signal phasing in the figure above is obtained by rotating the motor -, the Motor Encoder Reference Motion is defined as - and the Motor Encoder Reference Motion parameter is set to 0. If the signal phasing in the figure above is obtained by rotating the motor +, then the Motor Encoder Reference Motion is defined as + and the Motor Encoder Reference Motion is set to 1.

Note

It is important that all the encoder phases match the phase plot in the figure above. (i.e., A leads B, U leads V and V leads W. No particular phase relationship is required between the A and B pari and the U, V, W signals.

Drive signal names are relatively standard. Your encoder signals may be named differently or they may have the same names but the signals may be functionally different. You must determine the proper encoder signal mapping to correctly wire your encoder to a drive.

⚠ CAUTION

Encoder signals are used for commutation. Incorrectly wired encoder signals can cause damage to the drive.

Step 3: Determine Encoder Alignment

In order for the drive to commutate with a motor correctly, it must know how the encoder commutation tracks and how the marker pulses are aligned with respect to the R, S and T windings in the stator. The drive does not require any particular alignment position but instead allows the alignment to be specified using the Motor Encoder U Angle and Motor Encoder Marker Angle parameters.

If the motor under test has a defined encoder alignment which is repeated on all similar motors, simply determine the proper angles then use the same settings on all similar motors.

If the motor under test does not have a specific encoder alignment, you should establish some standard mechanical alignment before determining and setting the encoder electrical angles. This will allow you to replace the motor with another one in the same alignment without going through this procedure each time.

Reading Encoder Alignment

The reference motion for this test can be either CW or CCW. We will first use CCW. An oscilloscope will be used to monitor the signals. This procedure must be performed with the motor disconnected from the drive with the exception of the encoder power supply.

⚠ CAUTION

Be careful when using the drive encoder power supply for testing a motor. Shorting the 5 V drives encoder power supply will blow an internal fuse which can only be replaced at the factory.

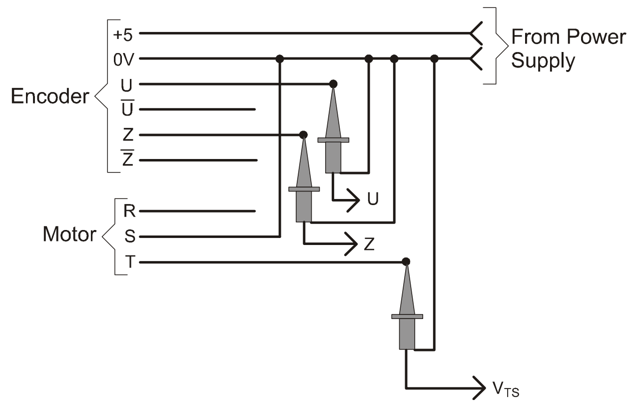


Figure 123: Oscilloscope Connections

CCW Reference Rotation

Before reading the motor signals, zero the V_{TS} oscilloscope channel on a horizontal graduation marker to allow more accurate readings.

Couple the drill motor to the motor shaft. While spinning the motor counter-clockwise, use an oscilloscope to examine the phase relationship between encoder channel U and positive peak of V_{TS} (the voltage at motor power terminal T with reference to S).

Use the figure below to determine the electrical angle at which the rising edge of U occurs. This is the Motor Encoder U Angle. Note that with a CCW reference rotation the positive peak of V_{TS} is at zero electrical degrees and the electrical angle decreases from left to right.

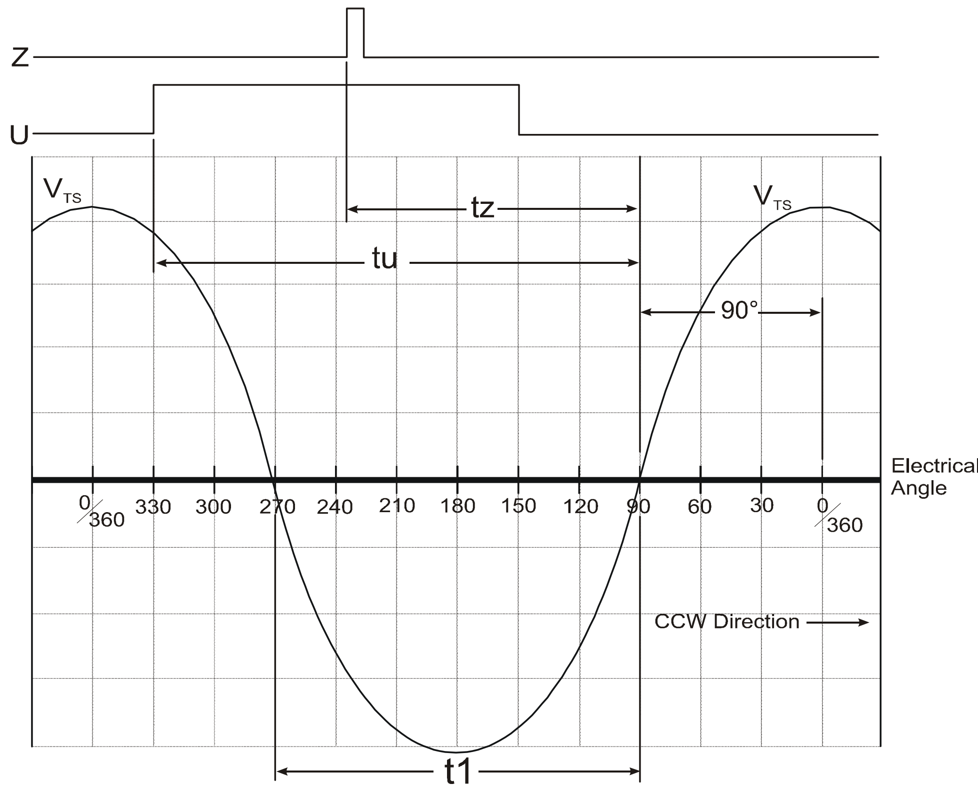


Figure 124: CCW Electrical Angle Plot

$$EUA = 90° + \left(tu \frac{180}{t1} \right)$$

Where:

EUA = Motor Encoder “U” Angle

If EUA is >360° subtract 360°.

Next, use the oscilloscope to examine the phase relationship between Z and V_{TS}. Use Figure 124 to determine the electrical angle at the rising edge Z. This is the Encoder Marker Electrical Angle.

$$EMA = 90° + \left(tz \frac{180}{t1} \right)$$

Where:

EMA = Motor Encoder Marker Angle

If EMA is >360° subtract 360°.

Many encoders are designed so that the encoder marker pulse occurs a specified number of electrical degrees from the rising edge of U. You could obtain this value from the encoder specification sheet however, to minimize errors in conversion, you should make this measurement.

If you cannot obtain a stable angle measurement between U or Z and V_{TS}, check the encoder to verify it has the proper cycles per revolution for your motors pole count.

CW Reference Rotation

If the reference motion for the encoder is CW (i.e., Encoder Reference Motion parameter will be set to 1), rotate the motor in the CW direction. Using an oscilloscope, look at the phase relationship between the rising edge of U and negative peak of V_{TS}. Use the figure below to determine the electrical angle at the rising edge of U. Determine the marker electrical angle in a similar manner.

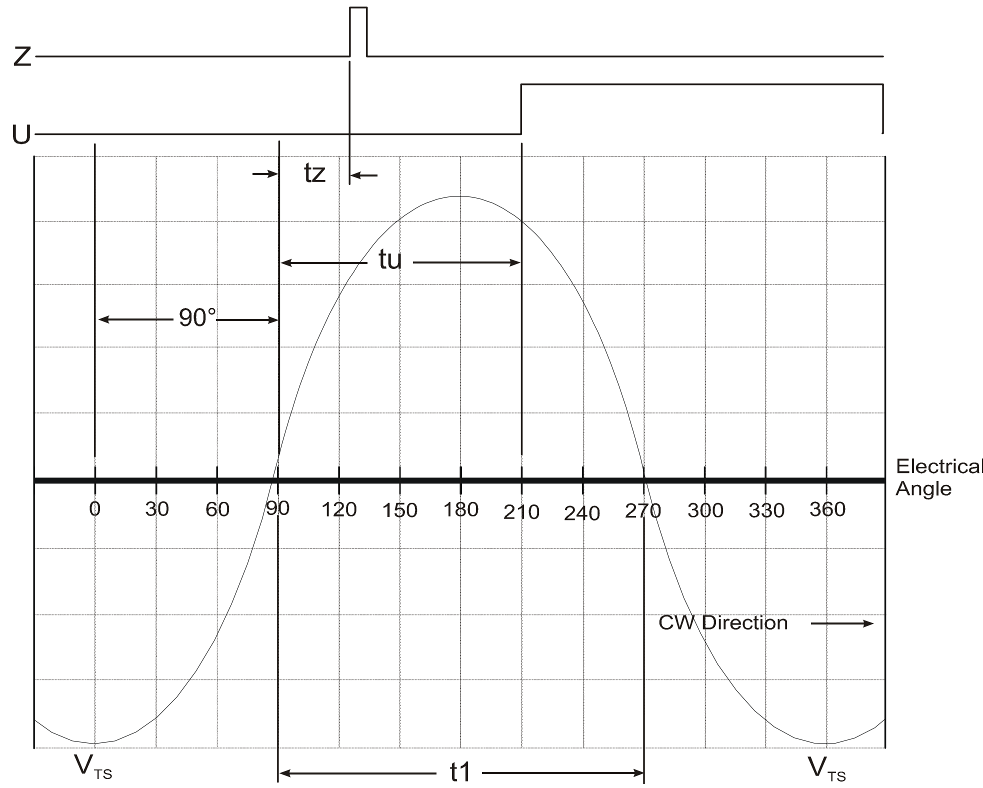


Figure 125: CW Electrical Angle Plot

In Figure 124 the electrical angle decreases from left to right and the positive peak of V_{TS} occurs at zero degrees electrical. In Figure 125 the electrical angle increases from left to right and the negative peak of V_{TS} occurs at zero degrees electrical. Note that with a CW reference rotation the negative peak of V_{TS} is at zero electrical degrees and the electrical angle decreases from left to right.

Note

If you cannot obtain a stable angle measurement between U or Z and V_{TS}, check the encoder to verify it has the proper cycles per revolution for your motors pole count.

Establishing a Standard Alignment

A typical encoder alignment practice is to set the rising edge of U to zero crossing of the rising wave of V_{SR} with the motor rotating CCW.

Dynamic Alignment Method

This method is used at Control Techniques to establish the alignment on motors. It is accomplished by spinning the motor CCW with another device while monitoring U and V_{SR}. Then while the motor is spinning CCW, the encoder body is rotated on it's mounting until the desired alignment is established. The encoder is then locked down. This will cause the rising edge of V to line up with the rising edge zero crossing of V_{RT} when the encoder reference rotation is CCW.

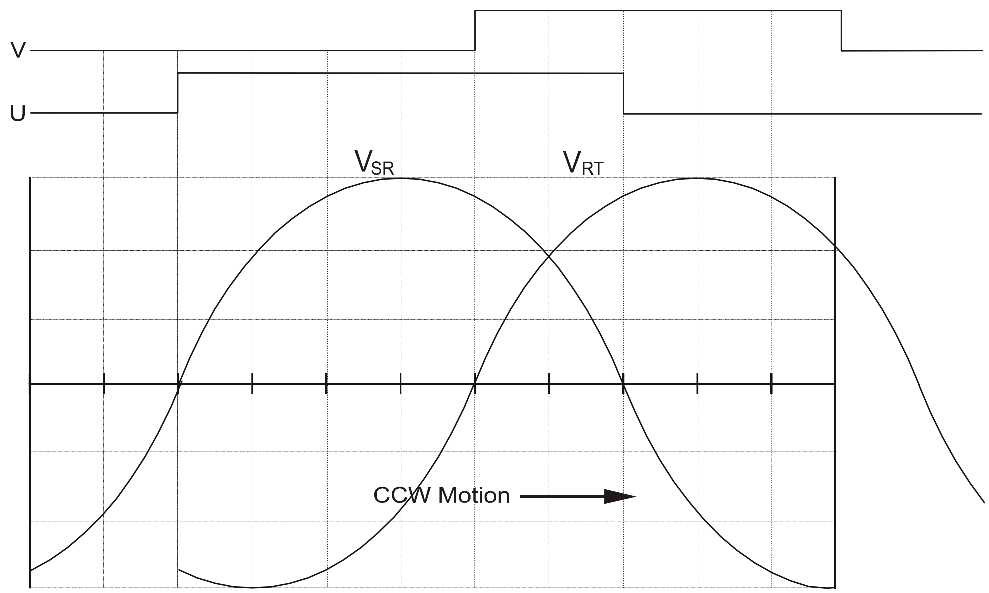


Figure 126: CCW Alignment Plot

Static Alignment Method

Another method to align the encoder is to apply DC current through the motor power phases R to S and rotate the encoder on its mounting until the rising edge of U is detected with a voltmeter or an oscilloscope. This procedure does not require spinning the motor.

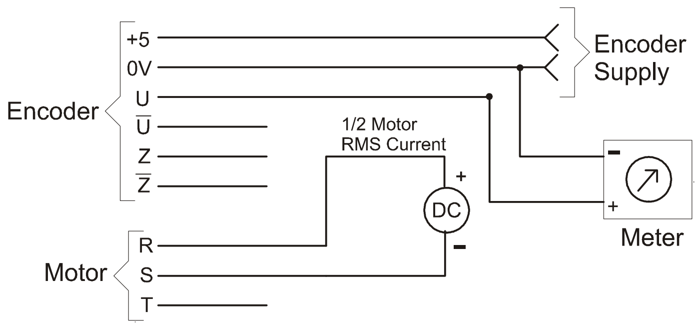


Figure 127: Static Alignment Schematic

The current applied through R to S should be the same polarity each time (i.e., + on R) and the current must be controlled to no more than 50 percent of the RMS stall current rating of the motor.

Note

Verify that you are seeing the rising edge of the U channel in the encoder reference direction by twisting the motor shaft CCW by hand while the DC current is applied and verifying that U goes high when the shaft is rotated in the encoder reference direction.

Step 4: Determine Motor Parameters

Measuring the actual motor Ke is recommended because not all motor manufacturers use the same measurement techniques. Normally the number of motor poles and the Ke is specified on the motor data sheet. If it not, or you wish to verify it, use the following tests.

Motor Ke

In this test you will be measuring the AC voltage generated by the motor or the CEMF (Counter Electro-Motive Force). This measurement requires an AC voltmeter that can accurately read sine waves of any frequency and some way to determine the motor speed at the time of the measurement such as a photo tachometer or an oscilloscope.

1. Connect the volt meter across any two of the motor power leads.

2. Set the volt meter to read VAC at it’s highest range. You can usually expect to read about 20 to 300 VAC.

3. Spin the motor in either direction at least 500 RPM.

4. Determine the actual RPM using a photo-tachometer or by monitoring the frequency of the Z channel with an ocsilloscope.

Note

When using an oscilloscope, use the following formula to determine the motor velocity in RPM.

$$RPM = \frac{60}{Seconds/Revolutions}$$

Use the following formula to determine the Ke of the motor after the voltage and speed measurements.

$$Ke = 1000\frac{VRMS}{RPM}$$

Motor Pole Count

To determine the number motor poles, measure the number of electrical revolutions per mechanical motor revolution. The number of poles in the motor is two times the number of electrical cycles (360 degrees) per mechanical revolution. Use the following procedure:

1. Attach a scope probe to the R winding referenced to the S winding and one to the encoder Z channel referenced to the encoder power supply 0 volt.

2. Connect S winding to the encoder power supply 0 volt wire thereby connecting the scope ground clips together.

3. Set the scope up to trigger on the Z channel.

4. Rotate the motor in either direction at any speed.

Note

If you are using an electric drill to rotate the motor, the drill's name plate should specify the maximum RPM.

5. Adjust the horizontal time base until at least two Z channel pulses are visible.

6. Count the number of full cycles of the Motor waveform you see between the rising edges of the Z pulses.

7. Calculate the number of motor poles:

$$\text{Number of Cycles} \bullet 2 = \text{Number of Motor Poles}$$

Step 5: Editing the MOTOR.DDF File

The PowerTools software obtains the names and parameters of user defined motors from the Motor Data Definition File (MOTOR.DDF). This file is automatically loaded during the PowerTools installation and is located in the same directory as the PowerTools software. This file contains two sections: the Header and the Motor data. An example MOTOR.DDF file is shown on page 282.

The MOTOR.DDF file is a text file setup with carriage returns as parameter separators. It can be accessed and edited with any general purpose text editor such as Windows Notepad. In order for some text editors to read the file and recognize it as a text file, you will need to copy it over to another directory and change the file name suffix from .ddf to .txt.

Most text editors allow you to save the modified file as a text file if it was read originally as a .txt file. You must be careful that the edited file is saved as a text file otherwise it will be unusable as a .ddf file.

After you have completed editing the file, saved it as MOTOR.DDF file. Then copy it back to its original directory, overwriting the existing MOTOR.DDF file. The next time PowerTools is started it will automatically recognize the new MOTOR.DDF file.

Header

The header includes the revision and serial number information along with a count of how many special motor definitions are included in the particular file. Standard Control Techniques motors will not appear in this file because their data is hard coded into the drive's memory.

Revision

This parameter is fixed and is set by the PowerTools revision during installation.

NameCount

The nameCount parameter defines the number of motor sections contained in the .ddf file. If four motor sections exist, this parameter should be set equal to 4 which will cause PowerTools to recognize only the first four (4) motor definitions in the file.

Motor Data

The motor data section contains the names and parameters of one or more user defined motors.

MotorID is used for each motor to mark the beginning of a new user defined motor definition. The format is [MotorXX] where XX is the ID number starting with zero and incrementing by one.

You must use both ID numbers. For example, an ID of 1 would be entered as 01. There is no practical limit to the number of user defined motors allowed in the .ddf file. Only one set of user defined motor data can be stored in a single drive at any one time.

The motor name is limited to 12 characters and must immediately follow the MotorID marker. This is the motor name that shows up in the “Motor Type” combo box in PowerTools. The motor parameters do not define with which drive they may be used. Therefore, any user defined motor may be used with any drive.

```
[Definition]
revision=0x4132
nameCount=2

[Motor0]
name=User1
motorPoles=4
encoderLines=2048
encoderMarker=330
encoderU=330
encoderRef=0
rotorInertia=0.00010
motorKE=28.3
phaseResistance=20.80
phaseInductance=27.1
peakCurrent=4.29
continuousCurrent=1.43
maxOperatingSpeed=5000
encoderExponent=0

[Motor1]
name=User2
motorPoles=4
encoderLines=2048
encoderMarker=330
encoderU=330
encoderRef=0
rotorInertia=0.00017
motorKE=28.3
phaseResistance=7.30
phaseInductance=12.5
peakCurrent=7.80
continuousCurrent=2.60
maxOperatingSpeed=5000
encoderExponent=0
```

In this example, the parameters of two user defined motors are named “User1” and “User2”. Abbreviated parameter identifiers are used in the .ddf file. The table below shows the abbreviated identifier for each parameter followed by a description of each.

Motor Parameter	DDF Identifier
Motor Poles	motorPoles
Motor Encoder Lines Per Revolution	encoderLines
Motor Encoder Marker Angle	encoderMarker
Motor Encoder U Angle	encoderU
Motor Encoder Reference Motion	encoderRef
Motor Inertia	rotorInertia
Motor KE	motorKE
Motor Resistance	phaseResistance
Motor Inductance	phaseInductance
Motor Peak Current	peakCurrent
Motor Continuous Current	continuousCurrent
Motor Maximum Operating Speed	maxOperatingSpeed
Motor Encoder Exponent	encoderExponent

Motor Parameter Descriptions

Note

These parameters are valid and active only when a user defined motor is selected. When an Control Techniques motor is selected, the data in these registers remain at the last value set and do not update to reflect the data of the Control Techniques motor selected.

Motor Poles

Specifies the number of magnetic pole pairs (N-S) on the motor. The supported values are 2, 4, 6, 8, 10, 12, 14 and 16 poles.

Motor Encoder Lines Per Revolution

Specifies a coefficient for determining the number of encoder lines per mechanical revolution. The supported values are 1 to 16383. The equation for determining the total number of encoder lines per revolution is:

$$nLines = n*10^x$$

where

nLines = Total number of Encoder Lines
n = Motor Encoder Lines per Rev Coefficient
x = Motor Encoder Exponent

The total number of encoder lines is used both for commutation and for position/ velocity control. To properly commutate the motor, the drive must know the electrical angle (the angle between the motor magnetic field and stator coils).

Motor Encoder Lines Per Revolution Coefficient

Specifies a coefficient for determining the number of encoder lines per mechanical revolution. The supported values are 1 to 16383. The equation for determining the total number of encoder lines per revolution is:

nLines = n * 10x

where:

nLines = Total Nnumber of encoder lines
n = Motor encoder lines per rev coefficient
x = Motor encoder exponent

The total number of encoder lines is used both for commutation and for position/velocity control. To properly commutate the motor, the drive must know the electrical angle (the angle between the motor magnetic field and stator coils).

Motor Encoder Exponent

Specifies the exponent for determining the number of encoder lines per mechanical revolution. The supported values are: 0, 1, 2, 3, 4. The equation for determining the total number of encoder lines per revolution is:

$nLines = n*10^x$

where:

nLines = Total Number of Encoder Lines
n = Motor Encoder Lines per Rev Coefficient
x = Motor Encoder Exponent

The total number of encoder lines is used both for commutation and for position/velocity control. To properly commutate the motor, the drive must know the electrical angle (the angle between the motor magnetic field and stator coils).

Motor Encoder Marker Angle

Specifies the electrical angle at which the marker (Z) pulse occurs with reference to V_{TS} when the motor is spun in the encoder reference direction. At power-up the drive obtains an initial estimate of the electrical angle from the status of the U, V and W commutation tracks. This estimate can be off by as much as 30 °.

When the drive receives the marker pulse, the drive will, within one second, gradually shift the commutation to the more accurate electrical angle specified by this parameter. The system will then operate more efficiently. See “Step 3: Determine Encoder Alignment” for a detailed procedure on how to determine this parameter.

Motor Encoder U Angle

Specifies the electrical angle at which the rising edge of the U commutation track will occur with reference to V_{TS} when the motor is spun in the encoder reference direction.

At power-up the drive looks at the status of the U, V and W commutation tracks and, using this parameter, obtains a crude (± 30 °) estimate of the electrical angle. See “Step 3: Determine Encoder Alignment” for a detailed procedure on how to determine this parameter.

Motor Encoder Reference Motion

Specifies the direction of motion assumed in phase plots of the encoder’s quadrature and summation signals. The supported values are CW(1) and CCW(0). Your encoder may have the same phase plot but is generated from a different direction of rotation. This parameter affects the way the drive interprets the quadrature and commutation signals.

Motor Inertia

This parameter specifies the inertia of the motor. The range is .00001 to .5 lb-in-sec^2. The drive uses this parameter to interpret the “Inertia Ratio” parameter. “Inertia Ratio” is specified as a ratio of load to motor inertia.

Motor KE

Specifies the Ke of the motor. The units are VRMS/ kRPM. The line-to-line voltage will have this RMS value when the motor is rotated at 1000 RPM. The range is 5 to 500.

Motor Resistance

Specifies the phase-to-phase resistance of the motor. You can determine this value by measuring the resistance between any two motor stator terminals with an ohm meter. The range is .1 to 50 ohms.

Motor Inductance

Specifies the phase-to-phase inductance of the motor. The range is 1.0 to 100.0 mH.

Motor Peak Current

Specifies the peak current allowed by the motor. The range is 1 to 100 ARMS. If the peak current of the motor is greater than 30 ARMS, specify the peak as 30 ARMS. The drive will limit the peak current to the drive's capacity.

Motor Continuous Current

Specifies the continuous current allowed by the motor. It is used to determine the current foldback point and the amount of current allowed during foldback. The drive can also limit the continuous current to the motor based on the drive capacity. This means that the operational "continuous current" may be different than the value specified here. The range is 1 to 100 ARMS.

Motor Maximum Operating Speed

Specifies the maximum operating speed of the motor. It is used by the drive to set the default motor overspeed trip point and to limit the Velocity Command. The Velocity Command is limited to 9/8ths (112.5 percent) of the Motor Maximum Operating Speed. If the actual velocity exceeds 150 percent of this value, the drive will fault on Overspeed. Typically this parameter is determined by the encoder bandwidth and/or other mechanical or electrical parameters of the motor. The maximum value is 11,000 RPM.

Step 6: Configuring the Drive

Once you have determined the motor parameters and entered them into the MOTOR.DDF file, you can configured the drive to the user defined motor using PowerTools software. Once PowerTools is started it will read the MOTOR.DDF file and you will be able to select the non-Control Techniques motor.

Selecting a User Defined Motor

Use the following procedure to select the user defined motor with PowerTools:

1. Start PowerTools and either open an existing file or start a new file offline.

Note

PowerTools will not allow you to select a "Motor Type" or "Drive Type" while online with a drive.

2. From the "Motor Type" list box on the EZ Setup tab (or from the Motor tab if you are in Detailed Setup view) select your motor from the list of motors.

   When you select a new motor, PowerTools will display the Motor Parameters dialog box. In most cases you will want to select the default option which sets the Full Scale Velocity parameter to the value you entered into the MOTOR.DDF file.

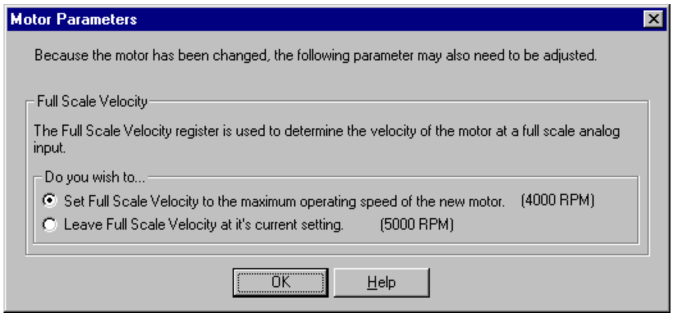


Figure 128: Motor Parameters Dialog Box

3. Select the correct drive type.

4. Download the configuration to the drive.

5. Select the *OK* button.

The drive will now be configured for the non-Control Techniques motor.

Step 7: Verification and Checkout

Once the cabling and interface circuitry have been assembled and the drive has been correctly configured, you are ready to power-up the drive. Use the procedure below to power-up the servo system and verify that it is operating correctly.

Note

For safety reasons, it is a good idea to double check that the key motor parameters below have been specified correctly.

- Motor Ke
- Motor Resistance
- Motor Inductance
- Motor Peak Current
- Motor Continuous Current

This procedure requires the use of PowerTools and some kind of I/O simulator. The simulator is needed to generate a variable analog command voltage and to allow the drive to be enabled and disabled. It is possible that the motor will "run-away" during the course of the test.

⚠WARNING

The motor may run away during this test. Make sure it is securely fastened and that there is nothing connected to the motor shaft.

At a certain point in the test it will be necessary to manually rotate the motor through an integral number of revolutions. This can only be done if the motor shaft and housing are marked in some way so that the motor can be aligned to a specific position. A disk or pulley can be installed during that portion of the test to make this alignment more precise.

There are four tests: Rotation test, Torque test, Commutation test and Velocity test. Each test builds on the last. It is important to perform the tests in the order given.

Note

Do not attempt to perform a test if you have not been able to get the proceeding test to work.

Rotation Test

This test verifies that the encoder has been correctly interfaced to the drive.

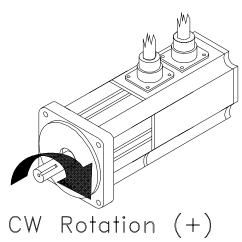


Figure 129: CW Rotation of the Motor

Note

This test assumes that you have completed “Step 6: Configuring the Drive” on page 287.

1. Power-up the drive but leave it disabled.

2. While online with the drive, select the Status tab. Find the Position Feedback parameter and note its value.

3. Mark the motor shaft and the motor face. This is your reference starting point.

4. Manually rotate the motor CW one revolution as accurately as you can. Verify that the Position Feedback increased by one revolution. This verifies that the A and B encoder

signals are wired correctly and the Motor Encoder Reference Motion parameter is correct.

5. Manually rotate the motor as accurately as you can, CW 20 revolutions. The Position Feedback should increase by exactly 20 revs. If the change has some significant fractional part (20.5 for example) the Motor Encoder Lines Per Revolution parameter is probably wrong.

6. Select "View Motor Parameters" from the **Tools** menu. Note the value of the Commutation Track Angle parameter. This parameter is obtained directly from the state of the U, V and W commutation tracks.

7. Slowly rotate the motor clockwise. The Commutation Track Angle should increase in 60 degree steps and will roll over to 0 at 360. If it does not change, there is a fundamental problem with the U, V and W encoder signals. If it decreases or changes erratically there is either a problem with the Motor Encoder Reference Motion parameter or the phasing of U, V and W.

8. Disconnect serial communications by clicking on the *Disconnect* button.

9. Power-down the drive and wait for the status display to go blank and then power the drive up again.

10. Re-establish communications with the drive by selecting the *Upload* button.

11. Select "View Motor Parameters" from the **Tools** menu. Note the value of the Commutation Angle Correction parameter. Its value should be zero until the motor encoder Z channel is detected. Rotate the motor through one or more complete revolutions until the Z channel is detected.

12. The value should now have a non-zero value between ±40 degrees. If the parameter is still zero, the drive is probably not seeing the marker pulse.

    To confirm this repeat Steps 7-9 several times with different motor shaft starting locations. If the absolute value of the parameter is greater than 40, there is either a problem with the phasing of U, V and W or an inconsistency in the encoder alignment parameters.

Torque Test

The purpose of this test is to enable the drive in Torque mode and verify that a positive command produces CW torque.

1. Use PowerTools to select Torque mode and set Full Scale Torque to 5 percent. Then click the *Update* button to download the changes to the drive.

    With Full Scale Torque set to 5 percent, a maximum analog command of 10 volts will generate 5 percent of continuous torque in the motor which should be enough to spin the motor but not to damage it.

2. Move to the Analog tab and find the "Analog Input" parameter.

3. Using your simulator adjust the analog command until the value of this parameter is approximately 0 volts.

4. Enable the drive. It should not move. If the drive faults at this point you most likely have a wiring problem (see “Step 1: Motor Wiring”).

5. Gradually increase the analog command voltage. The motor should start moving with a voltage level somewhere between 2 and 5 volts. Verify that the direction of motion is CW.

6. If there is no motion or CCW motion, there is a problem with encoder alignment parameters. If the motor moves 30 to 90 ° and then stops, there could be one of several problems:

   - The number of Motor Poles has been specified incorrectly.
   - The Encoder Lines Per Revolution parameter has been specified incorrectly
   - The motor terminals have been mis-identified (see “Step 1: Motor Wiring”).

Commutation Accuracy Test

This test will determine how accurately the encoder Z channel has been specified. It requires that the motor be connected and ready to run but it will be spun by the drill motor while in Torque mode with a zero torque command.

1. Disable the drive.

2. Set the Torque Limit to 0.

3. Make the Torque Limit input function always active.

4. Enable the drive.

5. Select “View Motor Parameters” from the **Tools** menu so you can monitor the Commutation Voltage.

6. Spin the motor clockwise 500 to 1000 RPM, then counter-clockwise at the same speed.

   The Commutation Voltage should be <10 percent. If the Commutation Voltage is higher than 10 percent, the Motor Encoder Marker Angle was incorrectly specified and should be re-tested.

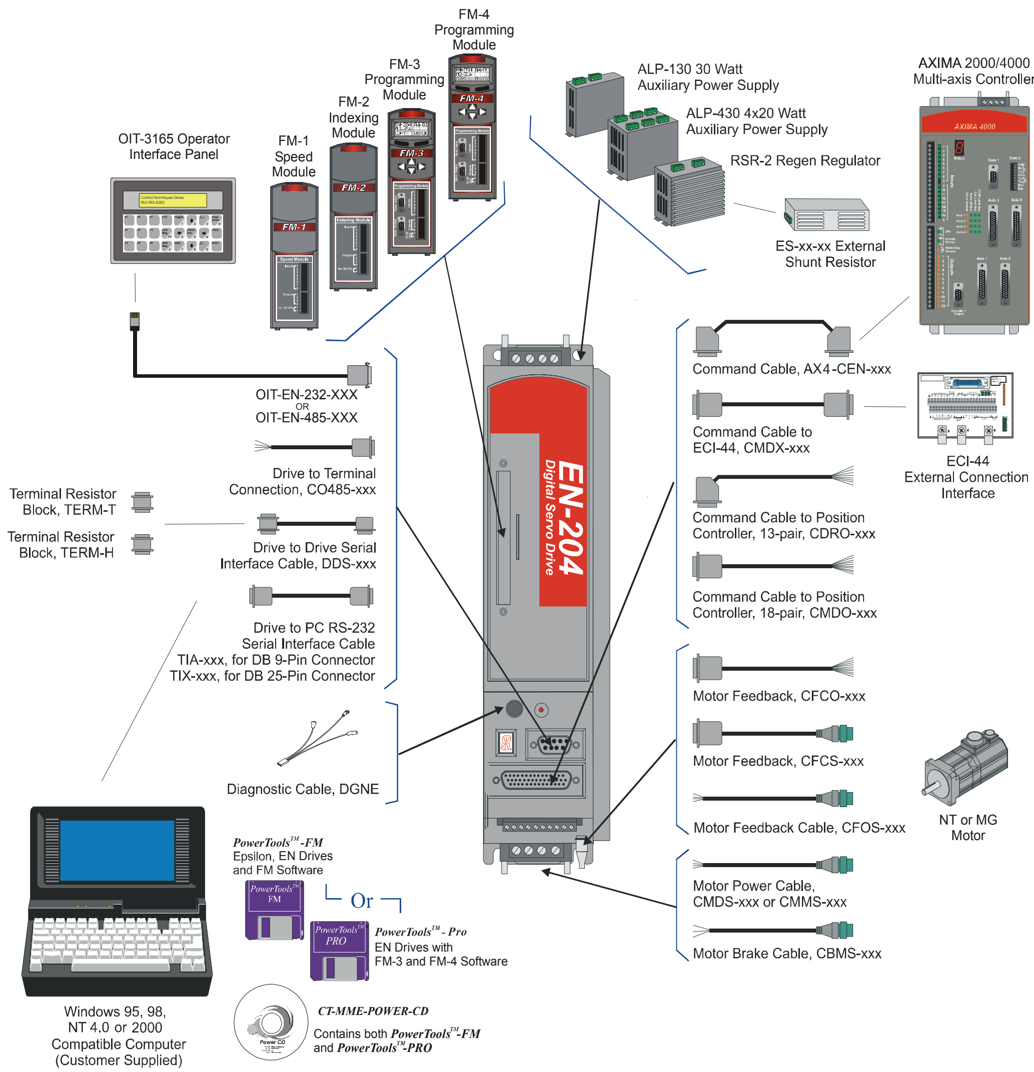
7. Reset the Torque Limit and the Torque Limit Enable input function to their previous settings.

Velocity Test

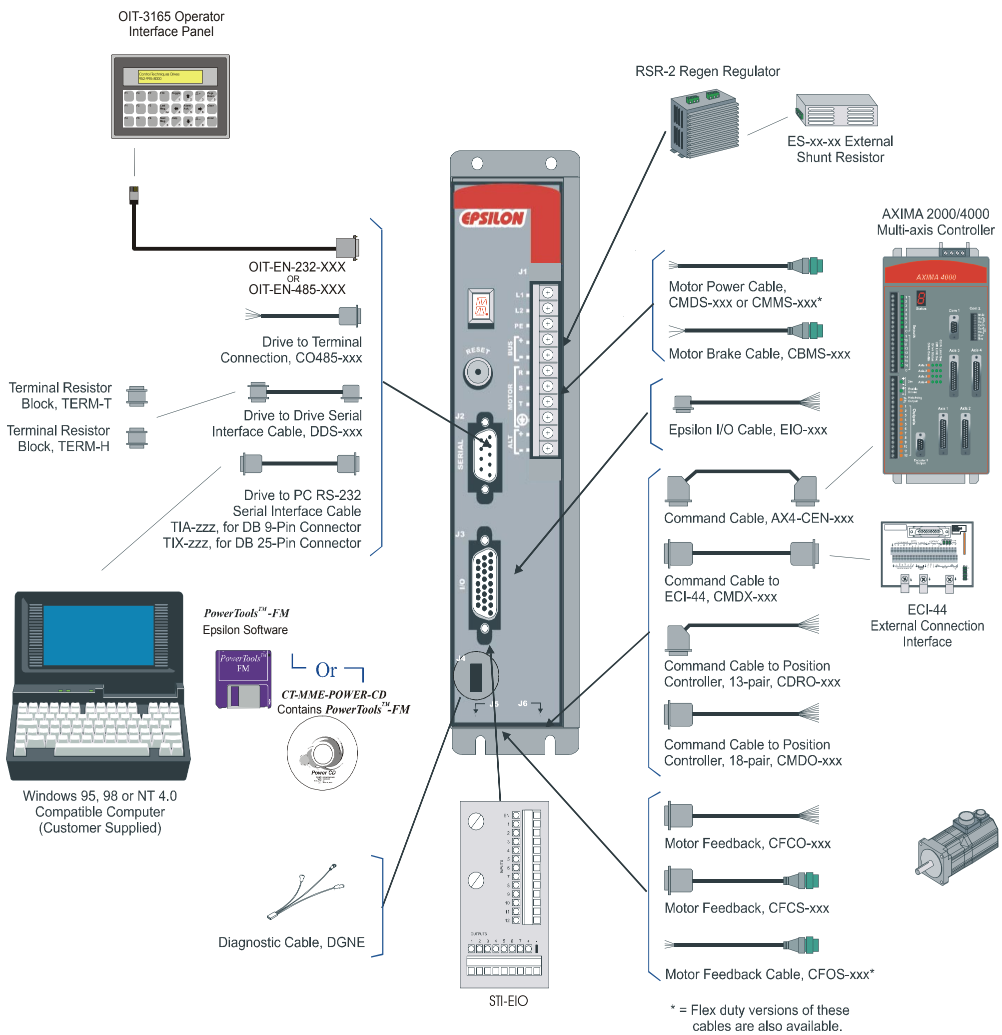
1. Disable the drive.
2. Select Velocity Analog mode and set "Full Scale Velocity" parameter to 12 RPM.
3. Use the simulator to adjust the analog command voltage to 5 volts.
4. Enable the drive. Find the "Velocity Command Analog" parameter on the Status tab. Adjust the analog command until this parameter reads exactly 6 RPM. The motor should be moving at 6 RPM. If the system got through the Torque test, the motor should not run-away at this point. If it does, go back and repeat the Torque test.
5. Confirm that the motor velocity is really 6 RPM by confirming that it takes 10 seconds to make one revolution. If this is not the case, the problem may be that both the motor poles and the encoder line density are off by the same factor.
6. Reduce the analog command voltage to zero volts and disable the drive.

Options and Accessories

EN Drive Options



Epsilon Eb Drive Options



STI-EIO Standard Terminal Interface

The STI-EIO interface allows access to all digital input and output signals. The STI-EIO mounts directly to the J3 connector on the drive. See the figure below.

Note

Shield connection points are connected to the shell of the 44-pin "D" connector on the STI EIO.

The STI-EIO wire range is #18 to 24 AWG stranded insulated wire.

Note

Wiring should be done with consideration for future troubleshooting and repair. All wiring should be either color coded and/or tagged with industrial wire tabs. Low voltage wiring should be routed away from high voltage wiring.

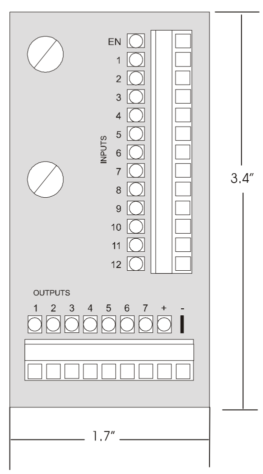


Figure 130: Dimensions of STI-EIO Board

ECI-44 External Connector Interface

The ECI-44 allows access to all command and input and output signals. The ECI-44 should be mounted close to the drive and away from any high voltage wiring. The ECI-44 comes complete with the hardware necessary for mounting to most DIN rail mounting tracks.

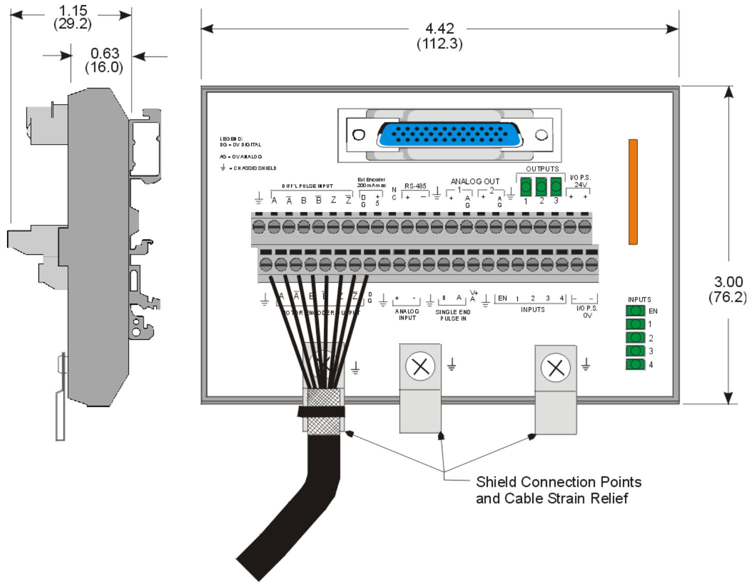


Figure 131: Dimensions of ECI-44

Note

Shield connection points are connected to the shell of the 44-pin "D" connector on the ECI-44.

Use tie wraps to provide a strain relief and a ground connection at the shield connection points.

If you do not wish to use the DIN rail mounting hardware, the ECI-44 can be disassembled and the mounting clips removed.

The ECI-44 wire range is #18 to 24 AWG stranded insulated wire.

Note

Wiring should be done with consideration for future troubleshooting and repair. All wiring should be either color coded and/or tagged with industrial wire tabs. Low voltage wiring should be routed away from high voltage wiring.

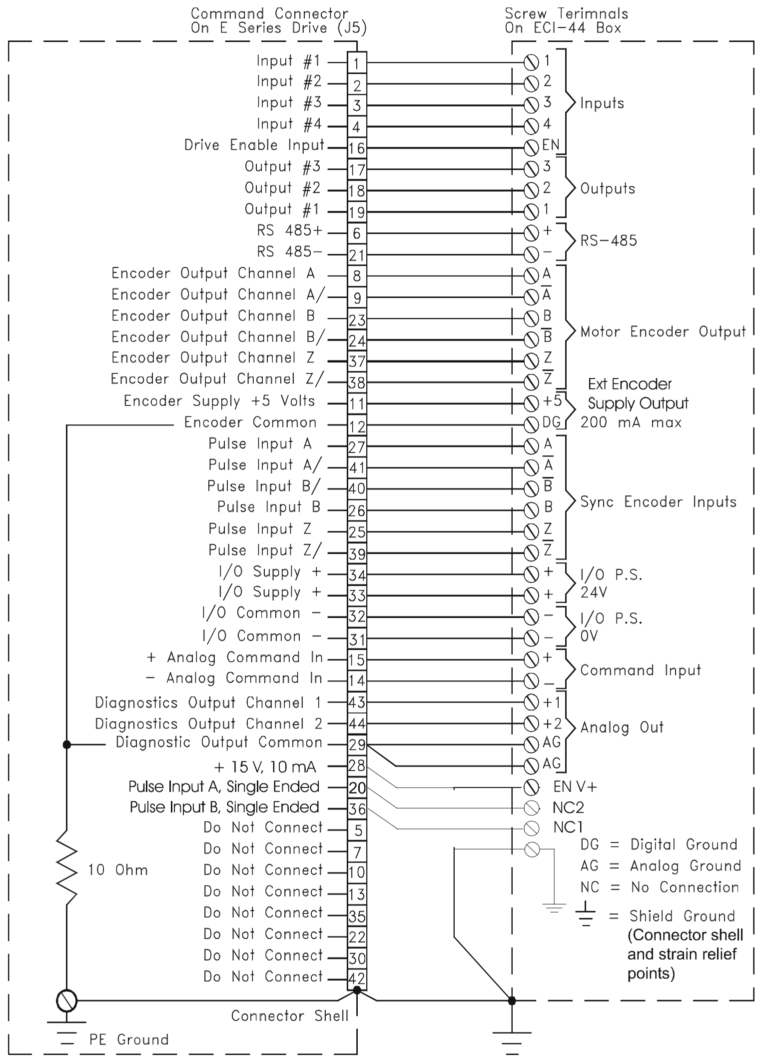


Figure 132: ECI-44 Signal Connections

FM-1 Speed Module

The FM-1 is a compact and rugged module that attaches to the front of the EN drive. It provides eight digital input lines and four digital output lines in addition to the four input and three output lines available on the EN drive. The FM-1 is setup using PowerTools FM software. PowerTools FM is an easy-to-use Microsoft® Windows®-based setup and diagnostics tool.

With the FM-1 installed, the base drive functions normally, with some additional features, including eight more inputs and four more outputs. The additional major features include; four additional Velocity presets, eight digital Torque presets, two additional Summation modes, plus an Alternate Operating mode function.

Note

See the *FM-1 Speed Module Reference Manual*, P/N 400506-01, for more information.

FM-2 Indexing Module

The FM-2 is a compact and rugged indexing module that attaches to the front of the EN drive. It enables you to initiate up to 16 different indexes, jogging and a single home routine. It also provides eight digital input lines and four digital output lines in addition to the four input and three output lines available on the EN drive. The FM-2 is setup using PowerTools FM software. PowerTools FM is an easy-to-use Microsoft® Windows®-based setup and diagnostics tool.

Note

See the *FM-2 Indexing Module Reference Manual*, P/N 400506-01, for more information.

FM-3 and FM-3DN Programming Module

The FM-3 and FM-3DN are compact and rugged programming modules that attach to the front of the EN drive. They provide eight digital input lines and four digital output lines in addition to the four input and three output lines available on the EN drive. TheFM-3 and FM-3DN offer complex motion profiling, along with multi-tasking user programs. A compex motion profile consists of two or more indexes that are executed in sequence such that the final velosity of each index except the last is non-zero. Logical instructions between index statements can provide a powerful tool for altering motion profiles ’on the fly". The FM-3 is setup using PowerTools PRO software. PowerTools PRO is an easy-to-use Microsoft® Windows®-based setup and diagnostics tool.

Note

See the *FM-3 Programming Module Reference Manual,* P/N 400508-01, and the *FM-3/4DN Programming Module Reference Manual*, P/N 400508-03, for more information.

FM-4 and FM-4DN Programming Module

The FM-4 and FM-4DN are compact and rugged programming modules that attach to the front of the EN drive. They provide eight digital input lines and four digital output lines in addition to the four input and three output lines available on the EN drive. The FM-4 and FM-4DN Programming Modules offer complex motion profiling, along with multi-tasking user programs. A compex motion profile consists of two or more indexes that are executed in sequence such that the final velosity of each index except the last is non-zero. Logical instructions between index statements can provide a powerful tool for altering motion profiles ’on the fly".

Note

See the *FM-4 Programming Module Reference Manual,* P/N 400509-01, and the *FM-3/4DN Programming Module Reference Manual,* P/N 400508-03, for more information.

Specifications

Drive Specifications

	EN	Epsilon Series
Power Requirements	90 - 264 VAC, 47-63 Hz (240 VAC for rated performance) EN-204: 1 Ø EN-208: 1 Ø EN-214: 3 Ø (for 1 Ø operation, drive output power must be derated by 20%)	**Standard Range**: 90-264 VAC, 1 Ø, 47-63 Hz **Extended Range**: (requires APS) 42-264 VAC,1 Ø, 47-63 Hz
Auxiliary Power Supply/ Auxiliary Logic Power Input	130 - 370 VDC, 18 W load (including FM's attached to the drive)	For logic backup, 24 VDC, 0.5 A loading
Switching Frequency	20 kHz	
Power Supply Output	5 VDC, 250 mA maximum for master encoder usage	
Efficiency - Drive	90-93% at full rated output power	Eb 202/203 93% Eb 205 95%
Ingress Protection (IP) Rating	Drive: IP20 MG motors: IP65 NT motors: IP65/IP54 Molded motor and feedback cables: IP65	
Serial Interface	RS-232 / RS-485 Internal RS-232 to RS-485 converter Modbus protocol with 32 bit data extension 9600 or 19.2 k baud	
Control Inputs	**Analog command:** ±10 VDC 14 bit, 100 kOhm impedance, differential **Maximum Voltage Input Rating:** Differential = +/- 14VDC, each input to 0V = +/- 14 VDC **Digital inputs:** (5) 10-30 VDC, 2.8 kohm impedance; current sourcing signal compatible (active high); max input response time is 500 µs; optically isolated **Input debounce:** 0-2000 ms	
Control Outputs	**Diagnostic analog outputs:** (2) ±10 VDC (single ended, 20 mA max) 10 bit software selectable output signals **Digital outputs:** (3) 10-30 VDC 150 mA max, current sourcing, (active high) optically isolated: Input debounce: Programmable range, 0 to 200 ms **Motor temp sensor (analog):** 0 to +5 VDC (single ended), 10 kOhm impedance	

<table>
<tr><th></th><th>EN</th><th>Epsilon Series</th></tr>
<tr><td>Pulse Mode</td><td colspan="2">Interface: Software selectable differential (RS422) or single ended (TTL Schmitt Trigger)

Maximum input frequency: Differential - 2 MHz per channel; 50% duty cycle (8 MHz count in quadrature)

Single ended - 1 MHz per channel; 50% duty cycle (4 MHz count in quadrature)

Ratio Capabilities: 20 to 163,840,000 PPR

Input Device = AM26C32
V_{diff} = 0.1 - 0.2 V
$V_{common\ mode}$ max = +/- 7 V
Input impedance each input to 0 V = 12 - 17 kOhm</td></tr>
<tr><td>Encoder Output Signal</td><td colspan="2">Differential line driver, RS-422 and TTL compatible

Scalable in one line increment resolution up to 2048 lines/rev of the motor (MG and NT)

Output Device = AM26C31
20 ma per channel, sink and/or source
$V_{out\ Hi}$ @ 20 ma = 3.8 - 4.5 V
$V_{out\ Lo}$ @ 20 ma = 0.2 - 0.4 V
$V_{out\ diff}$ w/100 ohm termination = 2.0 - 3.1 V
$V_{out\ common\ mode}$ w/100 ohm termination = 0.0 - 3.0 V
$I_{out\ short\ circuit}$ = 30 - 130 ma</td></tr>
<tr><td>Shunt Resistor Capacity/ Regeneration Capacity</td><td>Internal: The internal shunting capacity for the drive/motor combinations listed below is based on full speed and peak torque reversal.
EN-204/MG-316: 10:1 Mismatch, Bus Capacitance
EN-208/MG-455: 5:1 Mismatch, 50W, 50 Ohm
EN-214/MG-4120: 10:1 Mismatch, 50 W, 33 Ohm

External: Bus connections are provided for connection to external shunt controller. The EMC model RSR-2 is recommended. The shunt resistor connected to the RSR-2 must be 20 Ohms or greater and be limited to 5 ARMS. Multiple RSR-2s can be paralleled to give additional shunting capacity, but the current draw through the bus connections on the drive must be limited to 15 ARMS.</td><td>Internal: The internal shunting capacity for the drive/motor combinations listed below is based on full speed and peak torque reversal.
Eb-202/NT-212: 5:1 Mismatch, Bus Capacitance
Eb-203/NT-212: 5:1 Mismatch, Bus Capacitance
Eb-205/MG-340: 5:1 Mismatch, Bus Capacitance

External: Bus connections are provided for connection to external shunt controller. The EMC model RSR-2 is recommended. The shunt resistor connected to the RSR-2 must be 20 Ohms or greater and be limited to 5 ARMS. Multiple RSR-2s can be paralleled to give additional shunting capacity, but the current draw through the bus connections on the drive must be limited to 15 ARMS.</td></tr>
<tr><td>Fault Detection Capability</td><td>Low DC bus
High DC bus
Power Stage fault
Logic power
Encoder state
Encoder line break
Motor over temperature
Overspeed
Travel limit (+)
Travel limit (-)
Pulse mode position error
RMS shunt power fault
Function module error
Power-up self test failure
Non-volatile memory invalid</td><td>Low DC bus (can be disabled)
High DC bus
Power Stage fault
Logic power
Encoder state
Encoder line break
Drive overtemperature
Motor over temperature
Overspeed
Travel limit (+)
Travel limit (-)
Pulse mode position error
Watchdog timer
Power-up self test failure
Non-volatile memory invalid</td></tr>
</table>

	EN	Epsilon Series
Cooling Method	EN-204, EN-208: Natural Convection EN-214: Integral thermally controlled fan (60°)	Eb-202, Eb-203, Eb-205: Natural Convection
Environmental	**Ambient temperature range for rated output:** 32° F to 104° F (O° C to 40° C) **Maximum ambient operating temperature:** 104° F to 122° F (40° C to 50° C) with power derating of 3%/°C **Rated altitude:** 3,280 feet (1000 m) **Vibration:** 10 - 2000 Hz at 2g **Humidity requirement:** 10 - 95% non-condensing **Storage temperature:** -13 °F to 167 °F (-25 °C to 75 °C)	
Derating	Temperature: Operation in ambient temperature over 50° C (122° F) not recommended. Drive output power must be derated by 3 %/°C between 104° F to 122° F (40° C to 50° C) Single phase operation: EN-214 drive output power rating is reduced by 20% **Derating altitude:** Above 3,280.8 ft (1000 m) reduce output by 1% per 328.08 ft (100 m)	
Standards and Agency Approvals	UL Listed Canadian UL Listed CE Mark: Low voltage directive; EMC directive	UL listed Canadian UL listed CE Mark: Low voltage directive; EMC directive
Accessory Specifications	**ALP-130:** Input 115/230 VAC; Output 140 VDC, 30 W **ALP-430:** Input 115/230 VAC; Output 140 VDC, (4)x20 W	
Amplifier Weights	EN-204 6.4 lb (2.9 kg) EN-208 7.7 lb (3.5 kg) EN-214 8.9 lb (4.0 kg)	Eb-202 3.3 lb (1.5 kg) Eb-203 3.3 lb (1.5 kg) Eb-205 3.7 lb (1.7 kg)

Drive and Motor Combination Specifications

Drive	Motor	Cont. Torque lb-in (Nm)	Peak Torque lb-in (Nm)	Power HP @ Rated Speed (kWatts)	Inertia lb-in-sec^2 (kg-cm^2)	Max speed RPM	Encoder resolution lines/rev	Motor Ke VRMS/ krpm	Motor Kt lb-in/ ARMS (Nm/ ARMS)
EN-204	NT-320	18 (2.03)	29 (3.28)	1.02 (0.76)	0.000328 (0.3703)	4000	2048	29	3.5 (0.3955)
	MG-205	5.2 (0.59)	15.6 (1.76)	0.38 (0.28)	0.000084 (0.095)	5000	2048	28.3	4.1 (0.46)
	MG-208	9.1 (1.03)	27.3 (3.09)	0.64 (0.48)	0.000144 (0.163)	5000	2048	28.3	4.1 (0.46)
	MG-316	18.6 (2.10)	41.9 (4.73)	1.00 (0.75)	0.000498 (0.562)	4000	2048	37.6	5.5 (0.62)
EN-208	NT-320	19.65 (2.22)	37.5 (4.24)	1.02 (0.76)	0.000328 (0.3703)	4000	2048	29	3.5 (0.3955)
	NT-330	31.5 (3.56)	62 (7.01)	2.00 (1.49)	0.000438 (0.4945)	4000	2048	36	5.04 (0.5695)
	NT-345	47 (5.31)	85 (9.60)	2.24 (1.67)	0.000668 (0.7542)	3000	2048	50	7.13 (0.8056)
	NT-355	55.5 (6.27)	105 (11.86)	2.64 (1.97)	0.000888 (1.0026)	3000	2048	50	7.3 (0.8249)
	MG-316	18.6 (2.10)	55.8 (6.31)	1.00 (0.75)	0.000498 (0.562)	4000	2048	37.6	5.5 (0.62)
	MG-340	48 (5.65)	133.0 (15.0)	2.00 (1.49)	0.00125 (1.414)	3000	2048	55.0	8.0 (0.90)
	MG-455	68 (7.68)	139.1 (15.72)	2.46 (1.83)	0.00338 (3.819)	3000	2048	60.0	8.8 (0.99)
EN-214	NT-345	47 (5.31)	99 (11.19)	2.24 (1.67)	0.000668 (0.7542)	3000	2048	50	7.13 (0.8056)
	NT-355	55.5 (6.27)	116 (13.11)	2.64 (1.97)	0.000888 (1.0026)	3000	2048	50	7.3 (0.8249)
	MG-455	68 (7.68)	201.0 (22.71)	2.46 (1.83)	0.00338 (3.819)	3000	2048	60.0	8.8 (0.99)
	MG-490	100 (11.30)	208.0 (23.50)	3.75 (2.79)	0.00648 (7.319)	3000	2048	58.9	8.6 (0.97)
	MG-4120	132 (14.92)	257.0 (29.03)	5.30 (3.95)	0.00938 (10.593)	3000	2048	71.8	10.5 (1.19)
Eb-202	NT-207	7.3 (0.82)	15.2 (1.72)	0.45 (0.34)	0.000094 (0.1063)	5000	2048	35	5.124 (0.58)
	NT-212	9.2 (1.04)	18 (2.03)	0.71 (0.53)	0.000164 (0.185)	5000	2048	34.7	5.08 (0.57)
	MG-205	5 (0.56)	13.5 (1.53)	0.31 (0.23)	0.000084 (0.95)	5000	2048	28.3	4.1 (0.46)
	MG-208	6.7 (0.76)	13.2 (1.49)	0.53 (0.4)	0.000144 (0.163)	5000	2048	28.3	4.1 (0.46)

Drive	Motor	Cont. Torque lb-in (Nm)	Peak Torque lb-in (Nm)	Power HP @ Rated Speed (kWatts)	Inertia lb-in-sec^2 (kg-cm^2)	Max speed RPM	Encoder resolution lines/rev	Motor Ke VRMS/ krpm	Motor Kt lb-in/ ARMS (Nm/ ARMS)
Eb-203	NT-212	12.5 (1.41)	27 (3.05)	0.8 (0.6)	0.000164 (0.185)	5000	2048	34.7	5.08 (0.57)
	MG-205	5 (0.56)	15.0 (1.69)	0.31 (0.23)	0.000084 (0.95)	5000	2048	28.3	4.1 (0.46)
	MG-208	9.1 (1.03)	20 (2.26)	0.58 (0.43)	0.000144 (0.163)	5000	2048	28.3	4.1 (0.46)
	MG-316	15.8 (1.79)	31.8 (3.59)	1.0 (0.75)	0.000498 (0.562)	4000	2048	37.6	5.5 (0.62)
Eb-205	NT-212	12.5 (1.41)	27 (3.05)	0.8 (0.6)	0.000164 (0.185)	5000	2048	34.7	5.08 (0.57)
	NT-320	19 (2.15)	30 (3.39)	1.02 (0.76)	0.000328 (0.3703)	4000	2048	29	3.5 (0.3955)
	NT-330	26 (2.94)	44 (4.97)	1.43 (1.07)	0.000438 (0.4975)	4000	2048	36	5.04 (0.5695)
	NT-345	38 (4.29)	66 (7.46)	1.71 (1.28)	0.000668 (0.7542)	3000	2048	50	7.13 (0.8056)
	MG-205	5 (0.56)	15.0 (1.69)	0.31 (0.23)	0.000084 (0.95)	5000	2048	28.3	4.1 (0.46)
	MG-208	9.1 (1.03)	20 (2.26)	0.58 (0.43)	0.000144 (0.163)	5000	2048	28.3	4.1 (0.46)
	MG-316	15.8 (1.79)	31.8 (3.59)	1.0 (0.75)	0.000498 (0.562)	4000	2048	37.6	5.5 (0.62)

Motor Brake Specifications

Motor	Holding Torque lb-in (Nm)	Added Inertia lb-in-sec2 (kg-cm2)	Added Weight lb (kg)	Coil Voltage (VDC)	Coil Current (Amps)	Mechanical Disengagement Time	Mechanical Engagement Time
NTE/M-2XX-CBNS	20 (2.26)	0.000106 (0.12)	1 (0.46)	24 (±10%)	0.33 (±10%)	28 ms	14 ms
MGE-2XXCB	10 (1.13)	0.000025 (0.0282)	1.8 (0.55)	24 (±10%)	0.48 (±10%)	25 ms	40 ms
MGE-316CB MGM-340CB	50 (5.6)	0.00015 (0.1693)	2.4 (1.1)	24 (±10%)	0.52 (±10%)	100 ms	250 ms
MGE/M-455CB MG-490CB MG-4120CB	220 (24.9)	0.000412 (0.4652)	5.8 (2.6)	24 (±10%)	0.88 (±10%)	100 ms	250 ms

Motor Weights

Motor	Weight lb (kg) without Brake	Weight lb (kg) with Brake
NT-207	3 (1.36)	4 (1.81)
NT-212	4 (1.81)	5 (2.27)
NT-320	6 (2.72)	8.55 (3.88)
NT-330	7.3 (3.31)	9.85 (4.47)
NT-345	10 (4.54)	12.55 (5.70)
NT-355	12.3 (5.58)	14.85 (6.74)
MGE-205	3.0 (1.36)	N/A
MGE-208	4.0 (1.8)	5.8 (2.6)
MGE-316	8.3 (3.8)	10.7 (4.9)
MGM-340	14.6 (6.6)	17.0 (7.7)
MGE/M-455	18.5 (8.4)	24.3 (11.0)
MGE/M-490	27.0 (12.3)	32.8 (14.9)
MGE/M-4120	38.0 (17.3)	43.8 (19.9)

Axial/Radial Loading

Motor	Max Radial Load (lb.)	Max. Axial Load (lb.)
NTE/M-207	20	15
NTE/M-212	20	15
NTE/M-320	40	25
NTE/M-330	40	25
NTE/M-345	40	25
NTE/M-355	40	25
MGE-205	20	15
MGE-208	20	15
MGE-316	40	25
MGM-340	40	25
MGE/M-455	100	50
MGE/M-490	100	50
MGE/M-4120	100	50

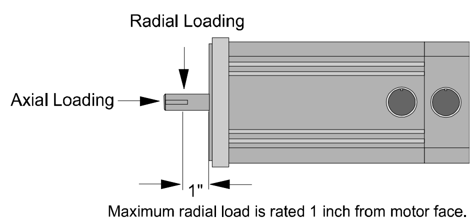


Figure 133 Axial/Radial Loading

IP Ratings

Motor	Rating
MG (all)	IP65
NT-207	IP65
NT-207 (w/o seals)	IP54
NT-212	IP65
NT-212 (w/o seals)	IP54
NT-3XX (all)	IP65

Encoder Specifications

Motor	Density	Output Type	Output Frequency	Output Signals	Power Supply
MG and NT	2048 lines/rev	RS422 differential driver	250 kHz per channel	A, B, Z, Comm U, Comm W, Comm V and all complements	5V, 200 mA ±10%

Power Dissipation

In general, the drive power stages are 90 to 95 percent efficient depending on the actual point of the torque speed curve the drive is operating. Logic power losses on the EN drive is 11 W minimum to 21 W depending on external loading such as FM modules and input voltages. Logic power losses on the Epsilon drive are 11 W with normal loads to 15 W with additional loads such as external encoder and low input voltage (<22 VDC on A.P.S. or 120 VAC on AC input).

The values shown in the table below represent the typical dissipation that could occur with the drive/motor combination specified at maximum output power.

Drive Model	Logic Power Losses (typ) Drive (Pld) (Watts)	Maximum Power Stage Losses (Pp) (Watts)	Total Power Losses (Watts)
EN-204/NT-320	19	105	124
EN-204/MG-205		30	52
EN-204/MG-208		50	72
EN-204/MG-316		82	104
EN-208/NT-320		135	154
EN-208/NT-330		175	194
EN-208/NT-345		185	204
EN-208/NT-355		211	230
EN-208/MG-340		160	182
EN-208/MG-455		200	222
EN-214/NT-345		192	211
EN-214/NT-355		221	240
EN-214/MG-490		300	322
EN-214/MG-4120		430	452
Eb-202/NT-207	11	25	36
Eb-202/NT-212		30	41
Eb-202/MG-205		25	36
Eb-203/NT-207		30	41
Eb-203/NT-212		55	66
Eb-203/MG-208		55	66
Eb-203/MG-316		60	71
Eb-205/MG-316		72	83
Eb-205/MG-340		88	99
Eb-205/NT-212		55	66
Eb-205/NT-320		88	99
Eb-205/NT-330		88	99
Eb-205/NT-345		88	99

Power Dissipation Calculation

Calculating actual dissipation requirements in an application can help minimize enclosure cooling requirements, especially in multi-axis systems. To calculate dissipation in a specific application, use the following formula for each axis and then total them up. This formula is a generalization and will result in a conservative estimate for power losses.

$$TPL = \frac{TRMS \bullet Vmax}{1500} + Pld + Psr$$

Where:

TPL = Total power losses (Watts)
TRMS = RMS torque for the application (lb-in)
Vmax = Maximum motor speed in application (RPM)
Pld = Logic Power Losses Drive (Watts)
Psr = Shunt Regulation Losses (Watts)-(RSR-2 losses or equivalent)

Note

TRMS * Vmax / 1500 = Power Stage Dissipation = Pp

A more accurate calculation would include even more specifics such as actual torque delivered at each speed plus actual shunt regulator usage. For help in calculating these please contact our Application Department with your system profiles and loads.

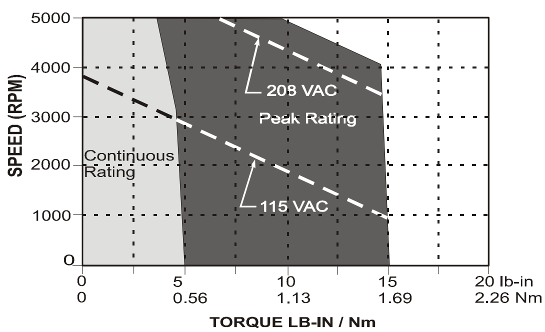
Speed Torque Curves

Continuous ratings of the MG and NT motors are based on 100°C (212°F) motor case temperature and 25°C (77°F) ambient temperature with the motor mounted to an aluminum mounting plate as shown in the table below

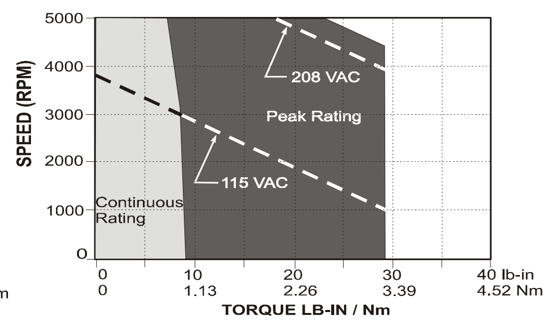
Motor	Mounting Plate Size
MG-205 and 208, NT-207 and 212	6” x 6” x .25”
MG-316 through 490 and NT-320 through NT-355	10” x 10” x .375
MG-4120	12” x 16” x .5”

- Speed torque curves are based on 240 VAC drive operation.
- All specifications are ±5 percent due to motor parameter variations.

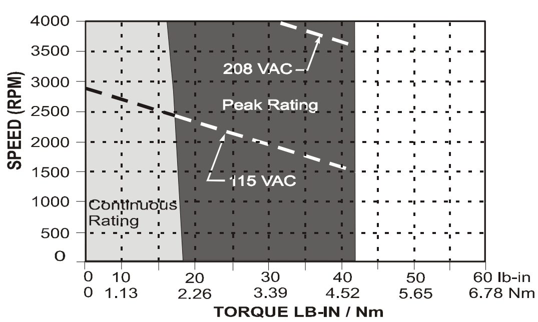
MG-205 with EN-204



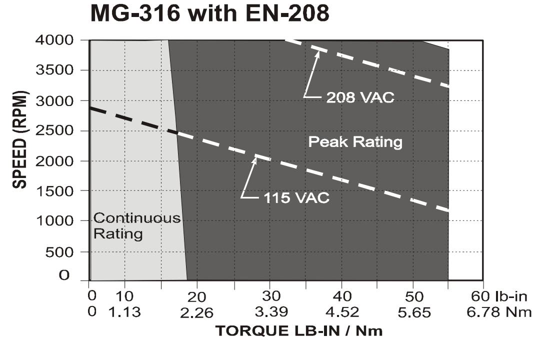
MG-208 With EN-204



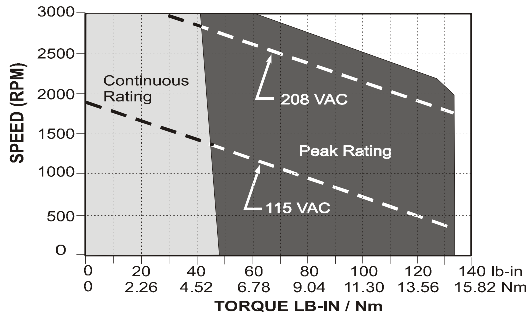
MG-316 with EN-204



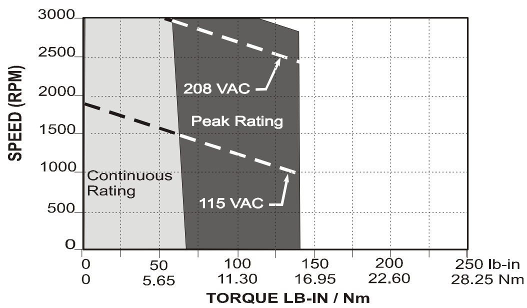
MG-316 with EN-208



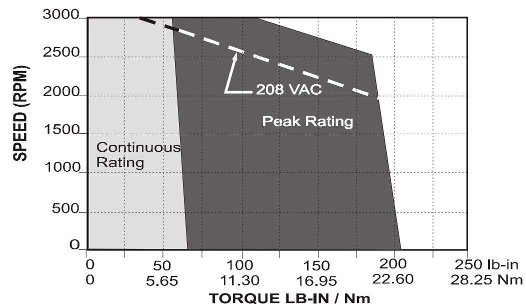
MG-340 with EN-208



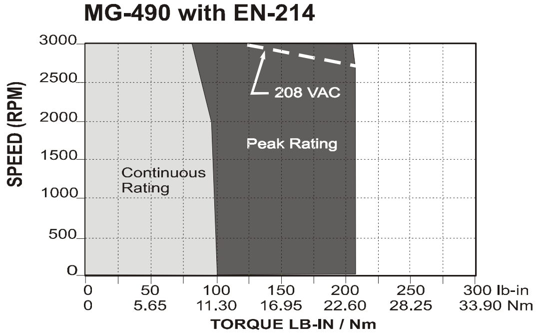
MG-455 with EN-208



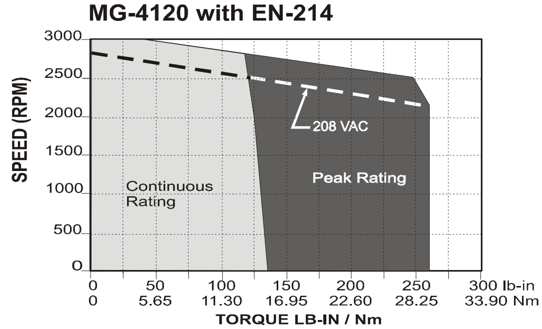
MG-455 with EN-214

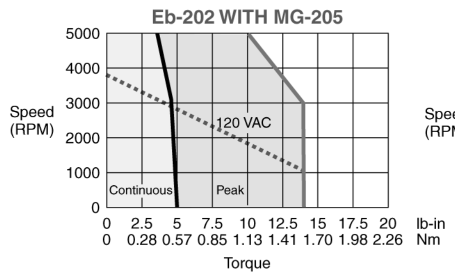


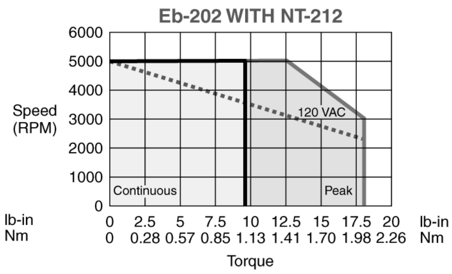
MG-490 with EN-214

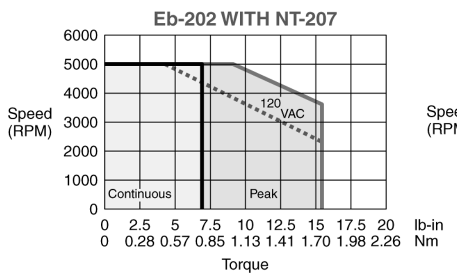


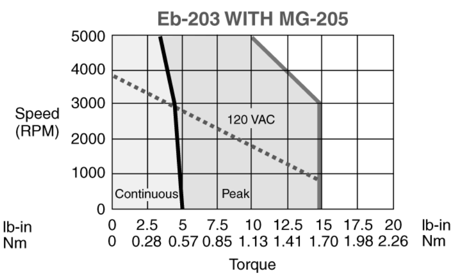
MG-4120 with EN-214

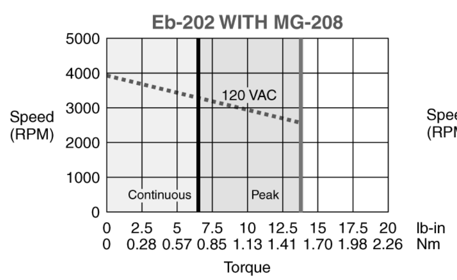


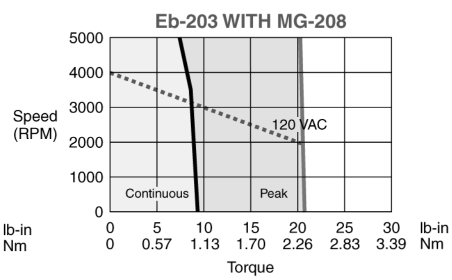

Eb-202 WITH MG-205
Speed (RPM)
5000
4000
3000
2000
1000
0
120 VAC
Continuous
Peak
0 2.5 5 7.5 10 12.5 15 17.5 20 lb-in
0 0.28 0.57 0.85 1.13 1.41 1.70 1.98 2.26 Nm
Torque

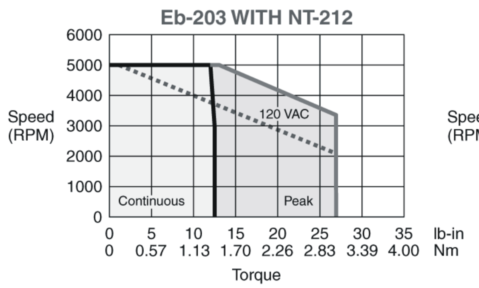

Eb-202 WITH NT-212
Speed (RPM)
6000
5000
4000
3000
2000
1000
0
120 VAC
Continuous
Peak
0 2.5 5 7.5 10 12.5 15 17.5 20 lb-in
0 0.28 0.57 0.85 1.13 1.41 1.70 1.98 2.26 Nm
Torque

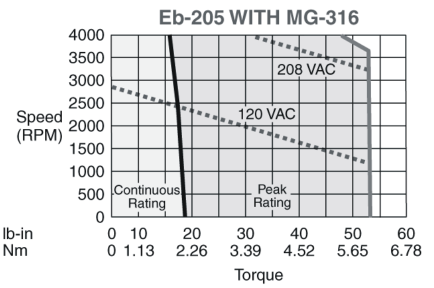

Eb-202 WITH NT-207
Speed (RPM)
6000
5000
4000
3000
2000
1000
0
120 VAC
Continuous
Peak
0 2.5 5 7.5 10 12.5 15 17.5 20 lb-in
0 0.28 0.57 0.85 1.13 1.41 1.70 1.98 2.26 Nm
Torque

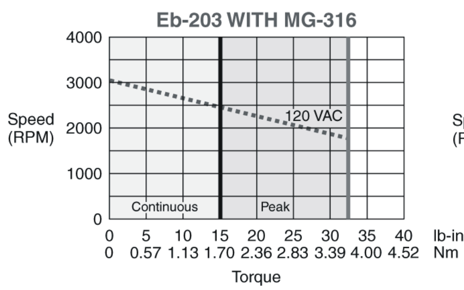

Eb-203 WITH MG-205
Speed (RPM)
5000
4000
3000
2000
1000
0
120 VAC
Continuous
Peak
0 2.5 5 7.5 10 12.5 15 17.5 20 lb-in
0 0.28 0.57 0.85 1.13 1.41 1.70 1.98 2.26 Nm
Torque

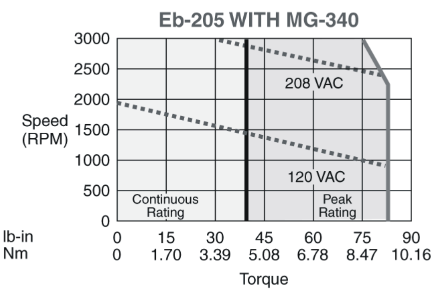

Eb-202 WITH MG-208
Speed (RPM)
5000
4000
3000
2000
1000
0
120 VAC
Continuous
Peak
0 2.5 5 7.5 10 12.5 15 17.5 20 lb-in
0 0.28 0.57 0.85 1.13 1.41 1.70 1.98 2.26 Nm
Torque

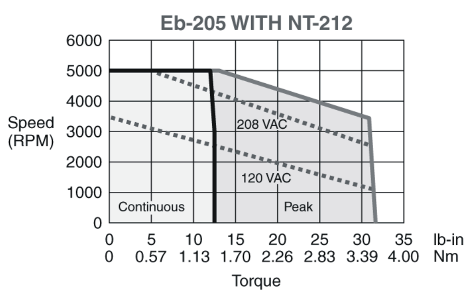

Eb-203 WITH MG-208
Speed (RPM)
5000
4000
3000
2000
1000
0
120 VAC
Continuous
Peak
0 5 10 15 20 25 30 lb-in
0 0.57 1.13 1.70 2.26 2.83 3.39 Nm
Torque


Eb-203 WITH NT-212
6000
5000
4000
3000
2000
1000
0
Speed (RPM)
120 VAC
Continuous
Peak
0 5 10 15 20 25 30 35 lb-in
0 0.57 1.13 1.70 2.26 2.83 3.39 4.00 Nm
Torque

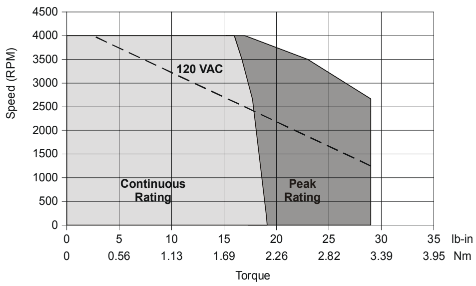

Eb-205 WITH MG-316
4000
3500
3000
2500
2000
1500
1000
500
0
Speed (RPM)
208 VAC
120 VAC
Continuous Rating
Peak Rating
0 10 20 30 40 50 60
0 1.13 2.26 3.39 4.52 5.65 6.78
Torque


Eb-203 WITH MG-316
4000
3000
2000
1000
0
Speed (RPM)
120 VAC
Continuous
Peak
0 5 10 15 20 25 30 35 40 lb-in
0 0.57 1.13 1.70 2.36 2.83 3.39 4.00 4.52 Nm
Torque

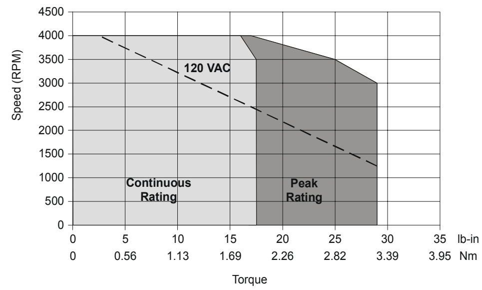

Eb-205 WITH MG-340
3000
2500
2000
1500
1000
500
0
Speed (RPM)
208 VAC
120 VAC
Continuous Rating
Peak Rating
0 15 30 45 60 75 90
0 1.70 3.39 5.08 6.78 8.47 10.16
Torque


Eb-205 WITH NT-212
6000
5000
4000
3000
2000
1000
0
Speed (RPM)
208 VAC
120 VAC
Continuous
Peak
0 5 10 15 20 25 30 35 lb-in
0 0.57 1.13 1.70 2.26 2.83 3.39 4.00 Nm
Torque

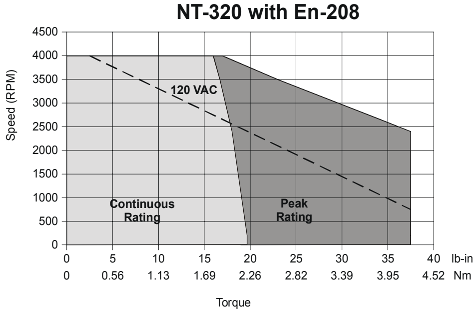
NT-320 with Eb/i-205



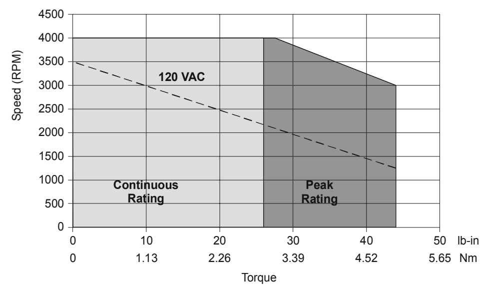
NT-320 with En-204



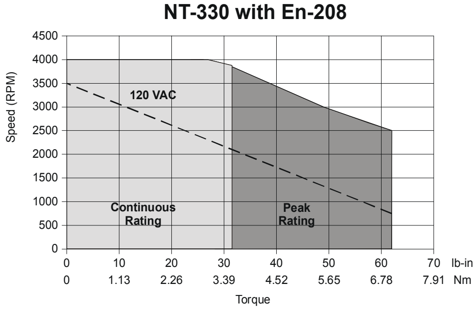
NT-320 with En-208



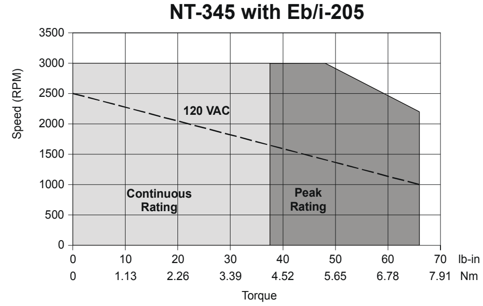
NT-330 with Eb/i-205

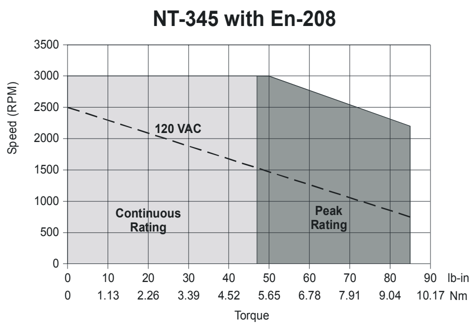


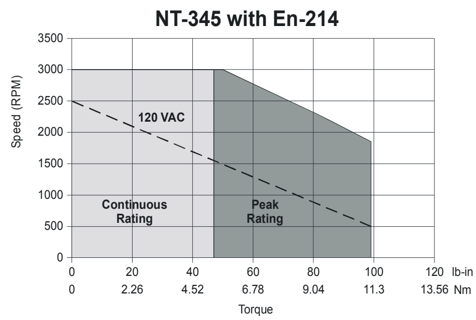
NT-330 with En-208

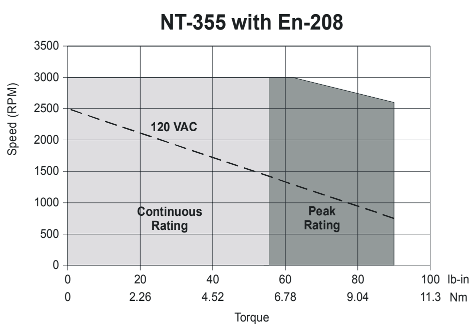


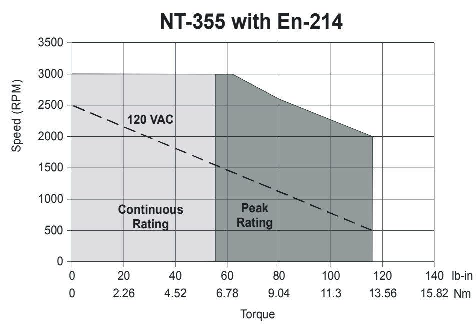
NT-345 with Eb/i-205



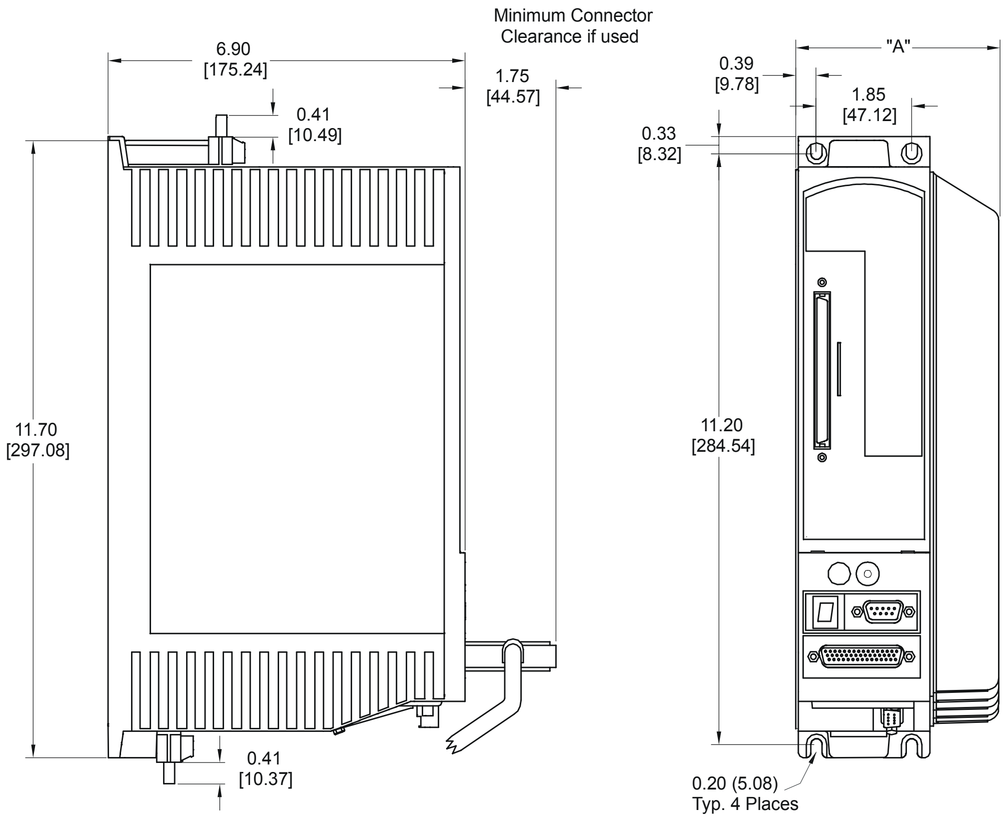

NT-345 with En-208
Speed (RPM)
3500
3000
2500
2000
1500
1000
500
0
120 VAC
Continuous Rating
Peak Rating
0 10 20 30 40 50 60 70 80 90 lb-in
0 1.13 2.26 3.39 4.52 5.65 6.78 7.91 9.04 10.17 Nm
Torque


NT-345 with En-214
Speed (RPM)
3500
3000
2500
2000
1500
1000
500
0
120 VAC
Continuous Rating
Peak Rating
0 20 40 60 80 100 120 lb-in
0 2.26 4.52 6.78 9.04 11.3 13.56 Nm
Torque


NT-355 with En-208
Speed (RPM)
3500
3000
2500
2000
1500
1000
500
0
120 VAC
Continuous Rating
Peak Rating
0 20 40 60 80 100 lb-in
0 2.26 4.52 6.78 9.04 11.3 Nm
Torque


NT-355 with En-214
Speed (RPM)
3500
3000
2500
2000
1500
1000
500
0
120 VAC
Continuous Rating
Peak Rating
0 20 40 60 80 100 120 140 lb-in
0 2.26 4.52 6.78 9.04 11.3 13.56 15.82 Nm
Torque

EN Drive Dimensions

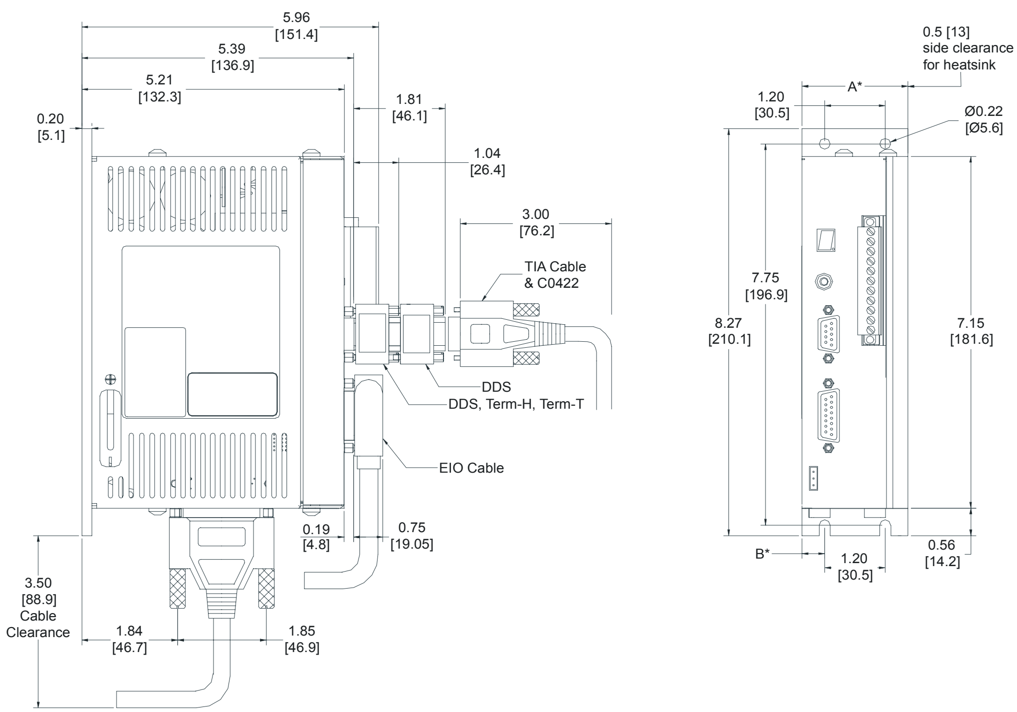


Model	Dim "A"
EN-204	2.93 [74.4]
EN-208	3.43 [87.1]
EN-214	3.93 [99.8]

Epsilon Drive Dimensions

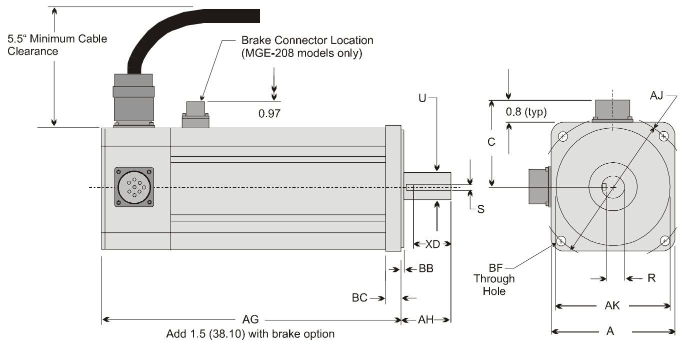
The following table applies to A* and B* as shown in the figure below.

Drive Model	Dimension A* (shown in inches/mm)	Dimension B* (shown in inches/mm)
Eb-202	2.10 [53.3]	.45 [11.4]
Eb-203	2.10 [53.3]	.45 [11.4]
Eb-205	3.56 [90.42]	.7 [17.78]



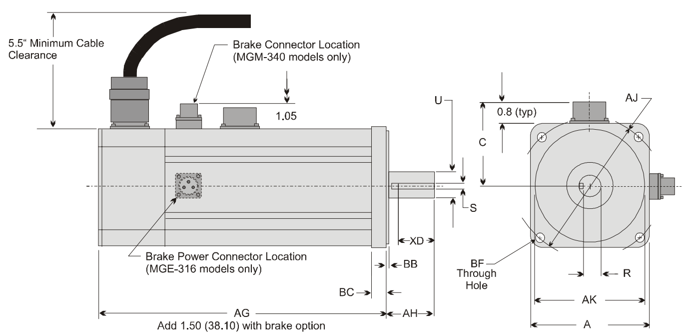
MG Motor Dimensions

MGE-205 and 208 Motors



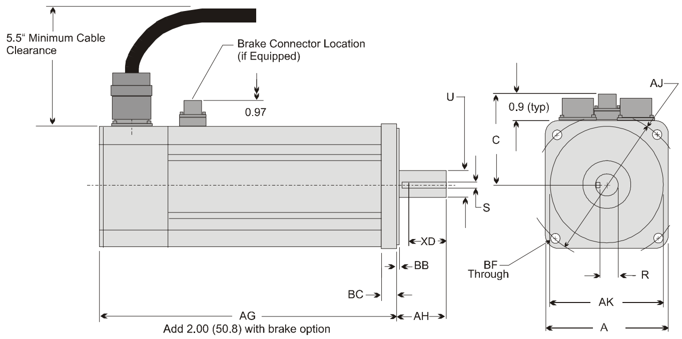
MGE-205 and 208 Mounting Dimensions inches (mm)													
	AG	A	BC	AH	U Max	XD	S Min	R	C Max	AJ	BB	AK	BF
205	5.60 (143.0)	2.25 (57.2)	0.46 (11.2)	1.20 (30.5)	0.375 (9.525)	0.563 (14.3)	0.127 (3.23)	0.300 (7.62)	2.0 (51)	2.625 (66.68)	0.063 (1.60)	1.502 (38.15)	0.205 (5.21)
208	6.75 (171.4)	2.25 (57.2)	0.46 (11.2)	1.20 (30.5)	0.375 (9.525)	0.563 (14.3)	0.127 (3.23)	0.300 (7.62)	2.0 (51)	2.625 (66.68)	0.063 (1.60)	1.502 (38.15)	0.205 (5.21)

MGE-316 and 340 Motors



MGE-316 and MGM-340 Mounting Dimensions inches (mm)													
	AG	A	BC	AH	U Max	XD	S Min	R	C Max	AJ	BB	AK	BF
316	7.24 (184.0)	3.31 (84.0)	0.44 (11.2)	1.21 (30.7)	0.4997 (12.69)	0.90 (22.9)	.1265 (3.213)	0.42 (10.7)	2.50 (64.0)	3.875 (98.43)	0.06 (1.600)	2.877 (73.08)	0.233 (66.0)
340	10.24 (260.1)	3.50 (89.0)	0.44 (11.2)	1.20 (30.6)	0.5512 (14.000)	0.787 (20.0)	.197 (5.00)	0.429 (10.90)	2.50 (64.0)	3.937 (100.00)	0.118 (3.00)	3.150 (80.01)	0.276 (7.01)

MGE-455, 490 and 4120 Motors



MGE-455, 490 and 4120 Mounting Dimensions inches (mm)

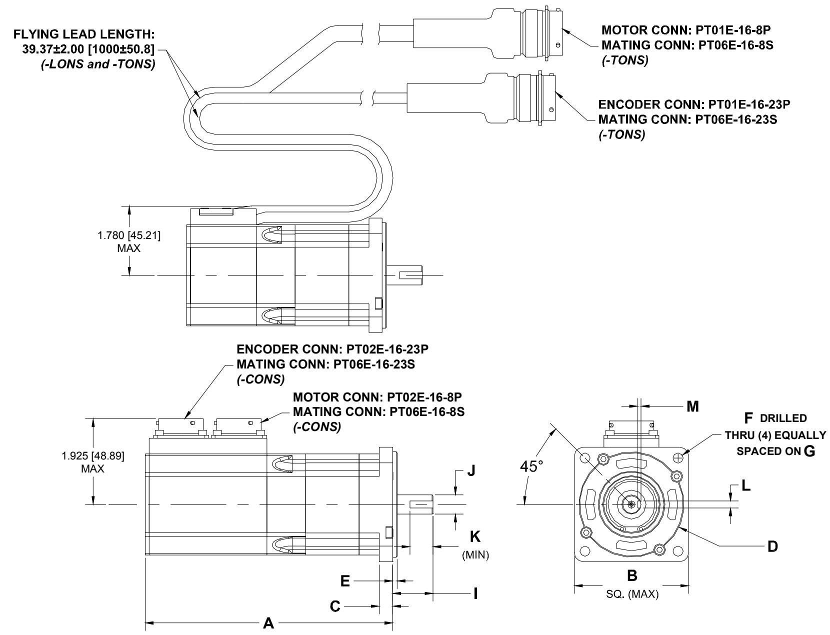
	AG	A	BC	AH	U Max	XD	S Min	R	C Max	AJ	BB	AK	BF
455	8.61 (218.7)	5.00 (127.0)	0.53 (13.5)	190 (48.2)	0.6245 (15.862)	1.50 (38.1)	0.1875 (4.763)	0.51 (13.0)	3.20 (81.3)	5.875 (149.23)	0.10 (2.50)	4.500 (114.30)	3/8-16 UNC
490	11.11 (282.10)	5.00 (127.0)	0.53 (13.5)	190 (48.2)	0.8750 (22.225)	1.50 (38.1)	0.1875 (4.763)	0.77 (19.6)	3.20 (81.3)	5.875 (149.23)	0.10 (2.50)	4.500 (114.30)	3/8-16 UNC
4120	13.61 (345.70)	5.00 (127.0)	0.53 (13.5)	190 (48.2)	0.8750 (22.225)	1.50 (38.1)	0.1875 (4.763)	0.77 (19.6)	3.20 (81.3)	5.875 (149.23)	0.10 (2.50)	4.500 (114.30)	3/8-16 UNC

MGM-455, 490 and 4120 Mounting Dimensions mm (inches)

	AG	A	BC	AH	U Max	XD	S Min	R	C Max	AJ	BB	AK	BF
455	216.0 (8.59)	121.0 (4.764)	13.0 (0.51)	50.5 (1.99)	19.000 (0.7480)	40.0 (1.58)	6.00 (.236)	15.5 (0.61)	70.3 (2.77)	145.00 (5.709)	3.00 (0.118)	110.10 (4.331)	10.00 (0.394)
490	281.7 (11.09)	121.0 (4.764)	13.0 (0.51)	50.5 (1.99)	24.000 (0.9449)	37.1 (1.46)	7.963 (.3135)	19.9 (0.78)	70.3 (2.77)	145.00 (5.709)	3.00 (0.118)	110.10 (4.331)	10.00 (0.394)
4120	343.1 (13.59)	121.0 (4.764)	13.0 (0.51)	50.5 (1.99)	24.000 (0.9449)	37.1 (1.46)	7.963 (.3135)	19.9 (0.78)	70.3 (2.77)	145.00 (5.709)	3.00 (0.118)	110.10 (4.331)	10.00 (0.394)

NT Motor Dimensions

NTE-207 and 212 Motors; English Face (NEMA 23 with 3/8 inch shaft)

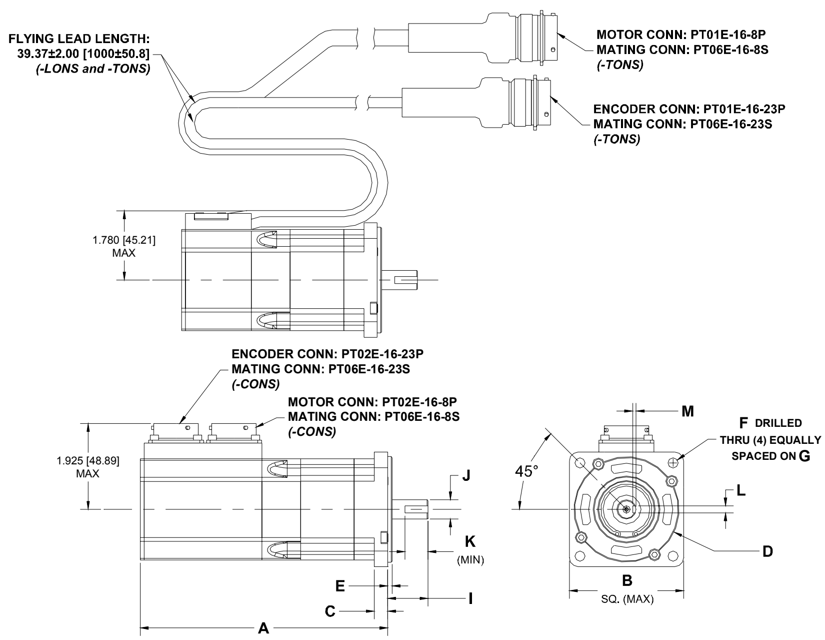


NTE-207, 212 -CONS,TONS and LONS Mounting Dimensions inches (mm)												
	A	B	C	D Max	E	F	G	I Max	J Max	K Min	L Min	M Min
207-CONS	5.55 (140.96)	2.27 (57.66)	0.295 (7.49)	1.50 (38.10)	0.10 (2.54)	0.205 (5.21)	2.625 (66.68)	1.21 (30.73)	0.375 (9.525)	0.70 (17.78)	0.1248 (3.17)	0.075 (1.905)
207-TONS/ LONS	4.390 (111.51)	2.27 (57.66)	0.295 (7.49)	1.50 (38.10)	0.10 (2.54)	0.205 (5.21)	2.625 (66.68)	1.21 (30.73)	0.375 (9.525)	0.70 (17.78)	0.1248 (3.17)	0.075 (1.905)
212-CONS	6.555 (166.36)	2.27 (57.66)	0.295 (7.49)	1.50 (38.10)	0.10 (2.54)	0.205 (5.21)	2.625 (66.68)	1.21 (30.73)	0.375 (9.525)	0.70 (17.78)	0.1248 (3.17)	0.075 (1.905)
212-TONS/ LONS	5.39 (136.91)	2.27 (57.66)	0.295 (7.49)	1.50 (38.10)	0.10 (2.54)	0.205 (5.21)	2.625 (66.68)	1.21 (30.73)	0.375 (9.525)	0.70 (17.78)	0.1248 (3.17)	0.075 (1.905)

Note

Mounting ears have clearance for #10 or M5 Allen head screw or .3125" or 8mm across flats hex nut.

NTM-207 and 212 Motors; Metric Face

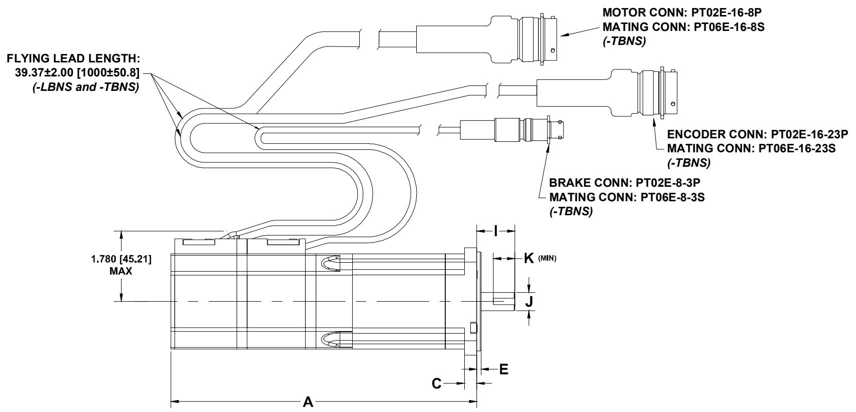


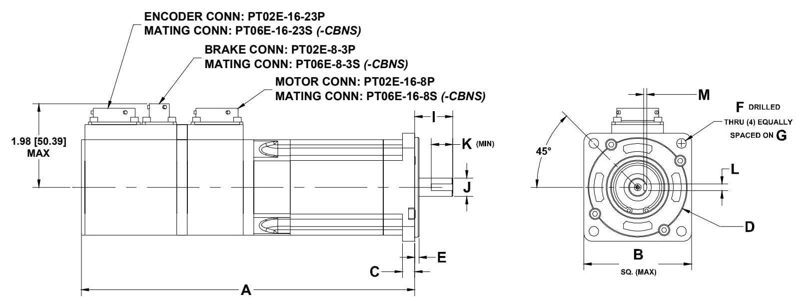
NTM-207, 212 -CONS,TONS and LONS Mounting Dimensions mm (inches)												
	A	B	C	D Max	E	F	G	I Max	J Max	K Min	L Min	M Min
207-CONS	140.96 (5.55)	65.18 (2.566)	7.49 (0.295)	60.012 (2.363)	2.54 (0.10)	5.80 (0.228)	75.0 (2.953)	23.51 (0.926)	10.999 (0.433)	13.0 (0.512)	3.97 (0.156)	2.0 (0.079)
207-TONS/ LONS	111.51 (4.39)	65.18 (2.566)	7.49 (0.295)	60.012 (2.363)	2.54 (0.10)	5.80 (0.228)	75.0 (2.953)	23.51 (0.926)	10.999 (0.433)	13.0 (0.512)	3.97 (0.156)	2.0 (0.079)
212-CONS	166.36 (6.55)	65.18 (2.566)	7.49 (0.295)	60.012 (2.363)	2.54 (0.10)	5.80 (0.228)	75.0 (2.953)	23.51 (0.926)	10.999 (0.433)	13.0 (0.512)	3.97 (0.156)	2.0 (0.079)
212-TONS/ LONS	136.91 (5.39)	65.18 (2.566)	7.49 (0.295)	60.012 (2.363)	2.54 (0.10)	5.80 (0.228)	75.0 (2.953)	23.51 (0.926)	10.999 (0.433)	13.0 (0.512)	3.97 (0.156)	2.0 (0.079)

Note

Mounting ears have clearance for 10mm across flats hex nut or 13mm O.D. washer.

NTE-207 and 212 Brake Motors; English Face (NEMA 23 with 3/8 inch shaft)



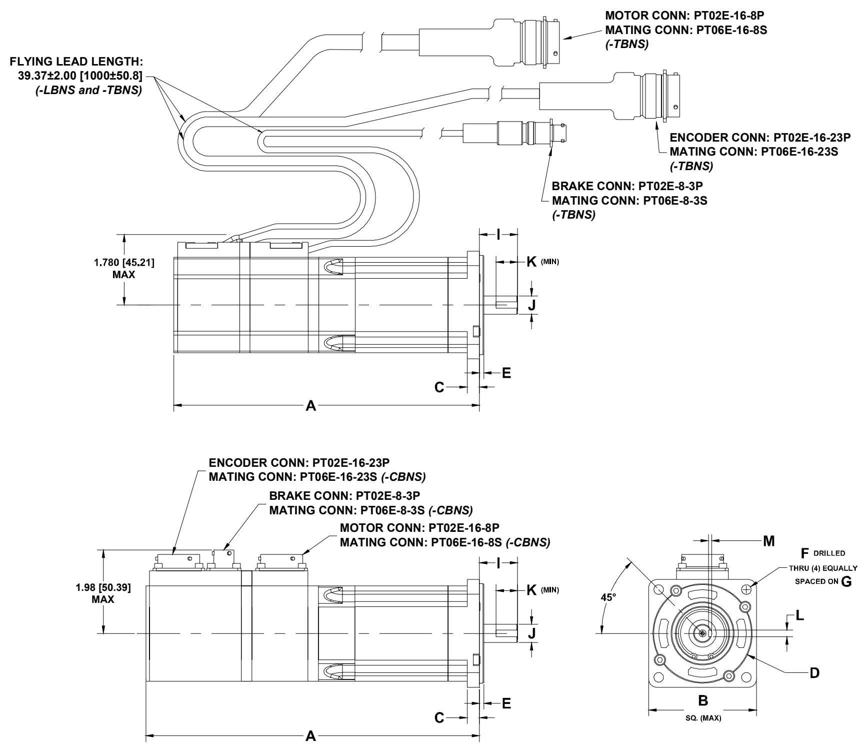


NTE-207, 212 -CBNS, TBNS and LBNS Mounting Dimensions inches (mm))												
	A	B	C	D Max	E	F	G	I Max	J Max	K Min	L Min	M Min
207-CBNS	6.945 (176.40)	2.27 (57.66)	0.295 (7.49)	1.50 (38.100)	0.10 (2.54)	0.205 (5.21)	2.625 (5.21)	1.21 (30.73)	0.375 (9.525)	0.70 (17.78)	0.1248 (3.17)	0.075 (1.905)
207-TBNS/LBNS	6.277 (159.44)	2.27 (57.66)	0.295 (7.49)	1.50 (38.100)	0.10 (2.54)	2.05 (5.21)	2.625 (66.68)	1.210 (30.73)	0.375 (9.525)	0.70 (17.78)	1.498 (38.049)	0.075 (1.905)
212-CBNS	7.945 (201.80)	2.27 (57.66)	0.295 (7.49)	1.50 (38.100)	0.10 (2.54)	0.205 (5.21)	2.625 (66.68)	1.21 (30.73)	0.375 (9.525)	0.70 (17.78)	0.1248 (3.17)	0.075 (1.905)
212-TBNS/LBNS	7.277 (184.84)	2.27 (57.66)	0.295 (57.66)	1.50 (38.100)	0.10 (2.54)	0.205 (5.21)	2.625 (66.68)	1.210 (30.73)	0.375 (9.525)	0.70 (17.78)	0.1248 (3.17)	0.075 (1.905)

Note

Mounting ears have clearance for #10 or M5 Allen head screw or .3125" or 8mm across flats hex nut.

NTE-207 and 212 Brake Motors; Metric Face

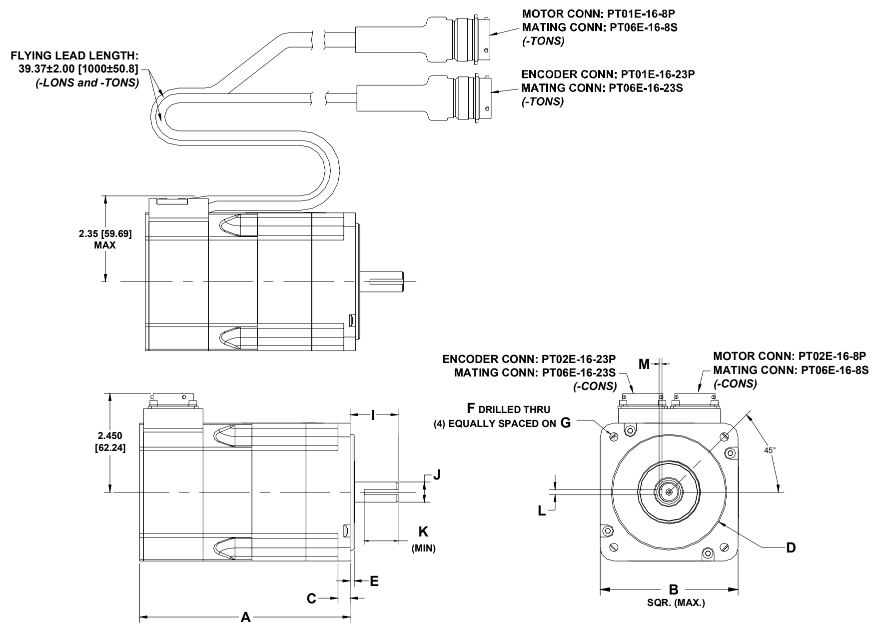


NTM-207, 212 -CBNS, TBNS and LBNS Mounting Dimensions mm (inches)												
	A	B	C	D Max	E	F	G	I Max	J Max	K Min	L Min	M Min
207-CBNS	176.40 (6.945)	65.18 (2.566)	7.49 (0.295)	60.012 (2.363)	2.54 (0.10)	5.80 (0.228)	75.00 (2.953)	23.51 (0.926)	10.999 (0.433)	13.0 (0.512)	3.97 (0.156)	2.0 (0.079)
207-TBNS/ LBNS	159.44 (6.277)	65.18 (2.566)	7.49 (0.295)	60.012 (2.363)	2.54 (0.10)	5.80 (0.228)	75.00 (2.953)	23.51 (0.926)	10.999 (0.433)	13.0 (0.512)	3.97 (0.156)	2.0 (0.079)
212-CBNS	201.80 (7.945)	65.18 (2.566)	7.49 (0.295)	60.012 (2.363)	2.54 (0.10)	5.8 (0.228)	75.00 (2.953)	23.51 (0.926)	10.999 (0.433)	13.0 (0.512)	3.97 (0.156)	2.0 (0.079)
212-TBNS/ LBNS	184.84 (7.277)	65.18 (2.566)	7.49 (0.295)	60.012 (2.363)	2.54 (0.10)	5.8 (0.228)	75.00 (2.953)	23.51 (0.926)	10.999 (0.433)	13.0 (0.512)	3.97 (0.156)	2.0 (0.079)

Note

Mounting ears have clearance for 10mm across flats hex nut or 13mm O.D. washer.

NTE/M-320, 330, 345 and 355 Motors



NTE-320, 330, 345, 355 -CONS, TONS and LONS Mounting Dimensions (inches (mm)) NTM-320, 330, 345, 355-CONS, TONS, and LONS Mounting Dimensions (mm (inches))												
	A	B	C	D Max	E	F	G	I Max	J Max	K Min	L Min	M Min
NTE-320	5.218 (132.53)	3.42 (86.87)	0.30 (7.62)	2.875 (73.03)	0.10 (2.54)	0.22 (5.59)	3.875 (5.59)	1.21 (30.73)	0.50 (12.7)	0.84 (21.34)	0.125 (3.18)	0.073 (1.85)
NTE-330	5.818 (147.78)	3.42 (86.87)	0.30 (7.62)	2.875 (73.03)	0.10 (2.54)	0.22 (5.59)	3.875 (5.59)	1.21 (30.73)	0.50 (12.7)	0.84 (21.34)	0.125 (3.18)	0.073 (1.85)
NTE-345	7.018 (178.26)	3.42 (86.87)	0.30 (7.62)	2.875 (73.03)	0.10 (2.54)	0.22 (5.59)	3.875 (5.59)	1.21 (30.73)	0.50 (12.7)	0.84 (21.34)	0.125 (3.18)	0.073 (1.85)
NTE-355	8.218 (208.74)	3.42 (86.87)	0.30 (7.62)	2.875 (73.03)	0.10 (2.54)	0.22 (5.59)	3.875 (5.59)	1.21 (30.73)	0.50 (12.7)	0.84 (21.34)	0.125 (3.18)	0.073 (1.85)
NTM-320	132.53 (5.218)	86.87 (3.42)	7.62 (0.3)	80.0 (3.15)	3.0 (0.118)	7.01 (0.276)	100.0 (3.937)	30.73 (1.21)	14.0 (0.5512)	20.0 (0.787)	5.0 (0.1969)	2.45 (0.096)
NTM-330	147.78 (5.818)	86.87 (3.42)	7.62 (0.3)	80.0 (3.15)	3.0 (0.118)	7.01 (0.276)	100.0 (3.937)	30.73 (1.21)	14.0 (0.5512)	20.0 (0.787)	5.0 (0.1969)	2.45 (0.096)
NTM-345	178.26 (7.018)	86.87 (3.42)	7.62 (0.3)	80.0 (3.15)	3.0 (0.118)	7.01 (0.276)	100.0 (3.937)	30.73 (1.21)	14.0 (0.5512)	20.0 (0.787)	5.0 (0.1969)	2.45 (0.096)
NTM-355	208.74 (8.218)	86.87 (3.42)	7.62 (0.3)	80.0 (3.15)	3.0 (0.118)	7.01 (0.276)	100.0 (3.937)	30.73 (1.21)	14.0 (0.5512)	20.0 (0.787)	5.0 (0.1969)	2.45 (0.096)

Motor Wiring Color Cable

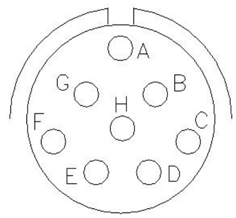
Motor Encoder Cable	Motor Encoder Connector Pin # (CONS/TONS)	Signal Name	Motor Cable Colors (Current)	Motor Cable Colors (Previous)	CFCO Cable Colors
(8 Pair Shielded Cable)	B	A	Blue	Blue	Blue
	C	A/	Orange	Blue/White	Orange
	N	B	Green	Green	Green
	P	B/	Brown	Green/White	Brown
	M	Z	Black	Yellow	Black
	U	Z/	Yellow	Yellow/Black	Yellow
	E	U	White/Brown	Brown	White/Brown
	R	U/	Brown/White	Brown/White	Brown/White
	F	V	White/Gray	Orange	White/Gray
	S	V/	Gray/White	Orange/Black	Gray/White
	G	W	Red/Orange	Violet	Red/Orange
	H	W/	Orange/Red	Violet/White	Orange/Red
	K,L	+5VDC	Red/Blue	Red	Red/Blue
Jumper Installed CONS and TONS	T	0V COMMON	Blue/Red	Red/White	Blue/Red
	D	THERM Ground	Green/Red	Black	Green/Red
***LONS ONLY	A	THERM Signal	Red/Green	White	Red/Green
	Z	*ENCODER SHIELD	N/C	N/C	*Shield

Motor Power Cable	Motor Power Connector PIN #	Power Connections	Motor Power Cable Colors (CONS)	Motor Power Cable Colors (TONS/LONS)	4X16SS Cable Colors (EMC Cables)
(4 Wire Shielded Cable)	A	R	Red	Brown	Brown
	B	S	Black	Black	Black
	C	T	Blue	Blue	Blue
	D, E	**PE (Ground)	**Green/Yellow	**Green/Yellow	**Green/Yellow
Motor Power Connections	Shell	*Power Shield	*Shield	*Shield	*Shield

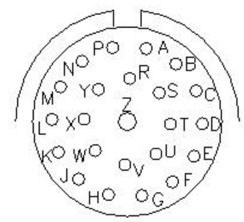
*Encoder Shield and Power Shield must be separated from each other all the way back to the amplifier. They can be connected to the same enclosure walls via individual shielded grommets (i.e., CGS-xxx).

**Protected Earth Ground can be connected at the motor and the amplifier only with no connections to anything else in between, including frame ground.

***For proper thermal switch operation in a LONS motor, jumper THERM Ground (Green/Red) to OV Common (Blue/Red).



Motor Power Connector: PT02E-16-8P
Mating Connector: PT06E-16-8S



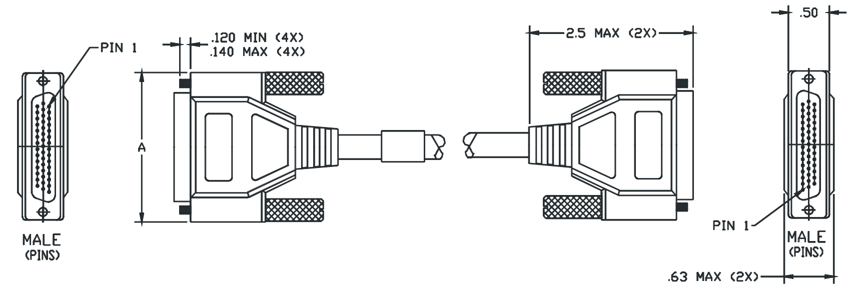
Encoder Connector: PT02E-16-23P
Mating Connector: PT06E-16-23S

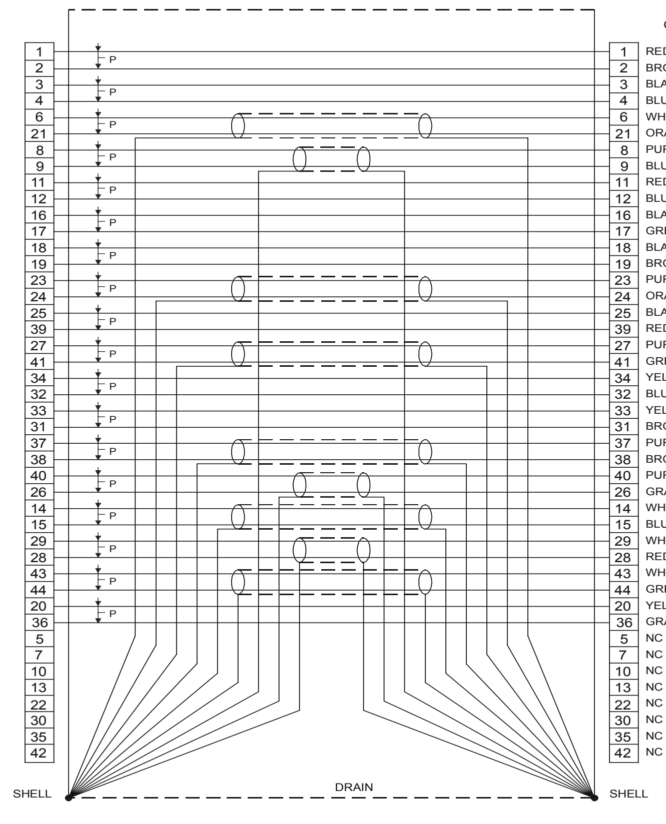
Cable Diagrams

Drive Signal	CMDX, CMDO, ECI-44	CDRO	AX4-CEN
Analog Command In +	X	X	X
Analog Command In -	X	X	X
Encoder Out A	X	X	X
Encoder Out A/	X	X	X
Encoder Out B	X	X	X
Encoder Out B/	X	X	X
Encoder Out Z	X	X	X
Encoder Out Z/	X	X	X
Pulse In A	X	X	
Pulse In A/	X	X	
Pulse In B	X	X	
Pulse In B/	X	X	
Pulse In Z	X		
Pulse In Z/	X		
Pulse In A (single ended)	X		X
Pulse In B (single ended)	X		X
I/O Input Drive Enable	X	X	X
I/O Input #1	X		
I/O Input #2	X		
I/O Input #3	X		
I/O Input #4	X	X	X
I/O Output #1	X	X	X
I/O Output #2	X	X	X
I/O Output #3	X	X	X

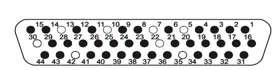
Drive Signal	CMDX, CMDO, ECI-44	CDRO	AX4-CEN
I/O Power + In (1st wire)	X	X	X
I/O Power + In (2nd wire)	X	X	X
I/O Power 0V In (1st wire)	X	X	X
I/O Power 0V In (2nd wire)	X		
Analog Out 0V	X	X	X
Analog Out Channel #1 +	X	X	X
Analog Out Channel #2 +	X	X	X
External Encoder +5 Power Out (200 ma)	X	X	
External Encoder Common	X	X	
+15V Power Out (10 ma)	X		
RS-485 +	X		
RS-485 -	X		

CMDX-XXX Cable





Pin	COLOR CODE	FUNCTION
1	RED/BROWN STRIPE	INPUT I/O 1
2	BROWN/RED STRIPE	INPUT I/O 2
3	BLACK/BLUE STRIPE	INPUT I/O 3
4	BLUE/BLACK STRIPE	INPUT I/O 4
6	WHITE/ORANGE STRIPE	RS-485+
21	ORANGE/WHITE STRIPE	RS-485-
8	PURPLE/BLUE STRIPE*	MOTOR ENCODER OUTPUT A
9	BLUE/PURPLE STRIPE*	MOTOR ENCODER OUTPUT A/
11	RED/BLUE STRIPE	EXT ENCODER 200mA max +5V
12	BLUE/RED STRIPE	EXT ENCODER 200mA max COMMON
16	BLACK/GREEN STRIPE	DRIVE ENABLE INPUT
17	GREEN/BLACK STRIPE	OUTPUT I/O 3
18	BLACK/BROWN STRIPE	OUTPUT I/O 2
19	BROWN/BLACK STRIPE	OUTPUT I/O 1
23	PURPLE/ORANGE STRIPE*	MOTOR ENCODER OUTPUT B
24	ORANGE/PURPLE STRIPE*	MOTOR ENCODER OUTPUT B/
25	BLACK/RED STRIPE	SYNC ENCODER INPUT Z
39	RED/BLACK STRIPE	SYNC ENCODER INPUT Z/
27	PURPLE/GREEN STRIPE *	SYNC ENCODER INPUT A
41	GREEN/PURPLE STRIPE *	SYNC ENCODER INPUT A/
34	YELLOW/BLUE STRIPE	24V I/O
32	BLUE/YELLOW STRIPE	0V I/O
33	YELLOW/BROWN STRIPE	24V I/O
31	BROWN/YELLOW STRIPE	0V I/O
37	PURPLE/BROWN STRIPE*	MOTOR ENCODER OUTPUT Z
38	BROWN/PURPLE STRIPE*	MOTOR ENCODER OUTPUT Z/
40	PURPLE/GRAY STRIPE *	SYNC ENCODER INPUT B/
26	GRAY/PURPLE STRIPE *	SYNC ENCODER INPUT B
14	WHITE/BLUE STRIPE	COMMAND INPUT -
15	BLUE/WHITE STRIPE	COMMAND INPUT +
29	WHITE/RED STRIPE	ANALOG OUT AG 1 AND 2
28	RED/WHITE STRIPE	ENV+
43	WHITE/GREEN STRIPE	ANALOG OUT 1 +
44	GREEN/WHITE STRIPE	ANALOG OUT 2 +
20	YELLOW/GRAY STRIPE	NOT USED
36	GRAY/YELLOW STRIPE	NOT USED
5	NC	NOT USED
7	NC	NOT USED
10	NC	NOT USED
13	NC	NOT USED
22	NC	NOT USED
30	NC	NOT USED
35	NC	NOT CONNECTED
42	NC	NOT USED

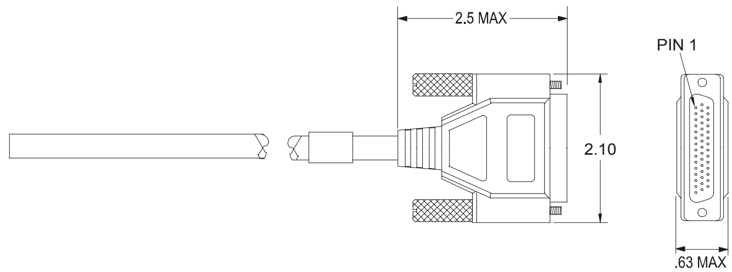


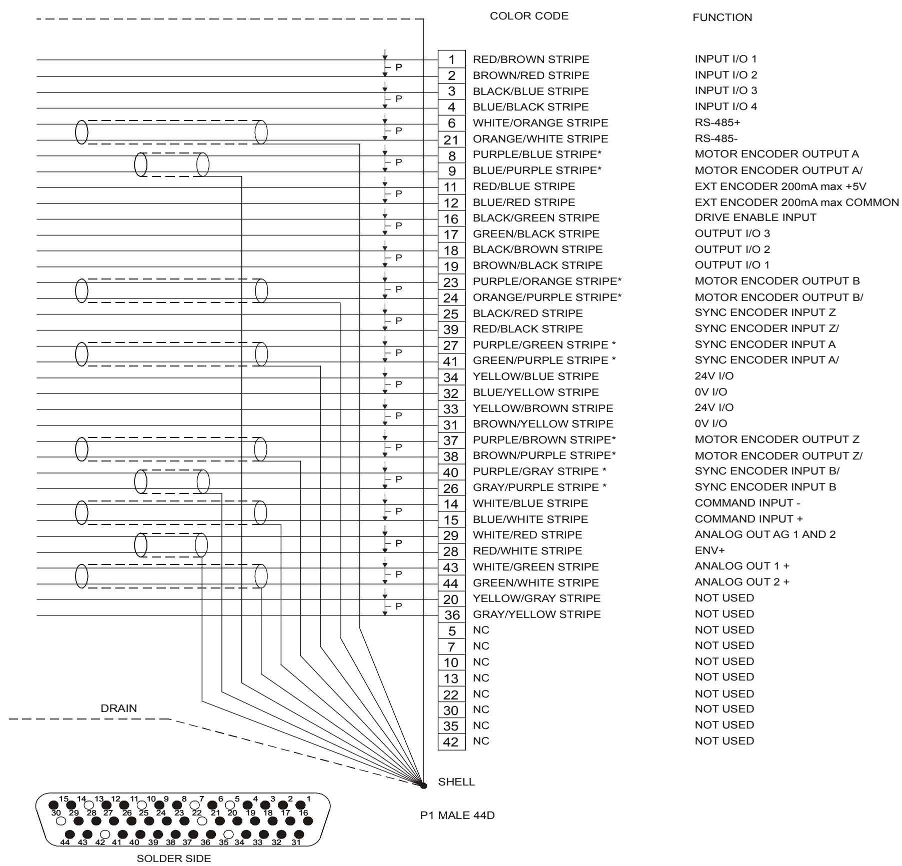
SOLDER SIDE

Note

Some CMDX cables may have White/Yellow and Yellow/White wires in place of the White/Orange and Orange/White shown in the figure above (pins 6 and 21).

CMDO-XXX Cable

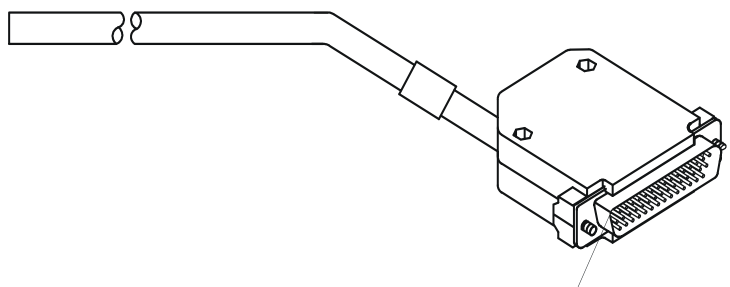


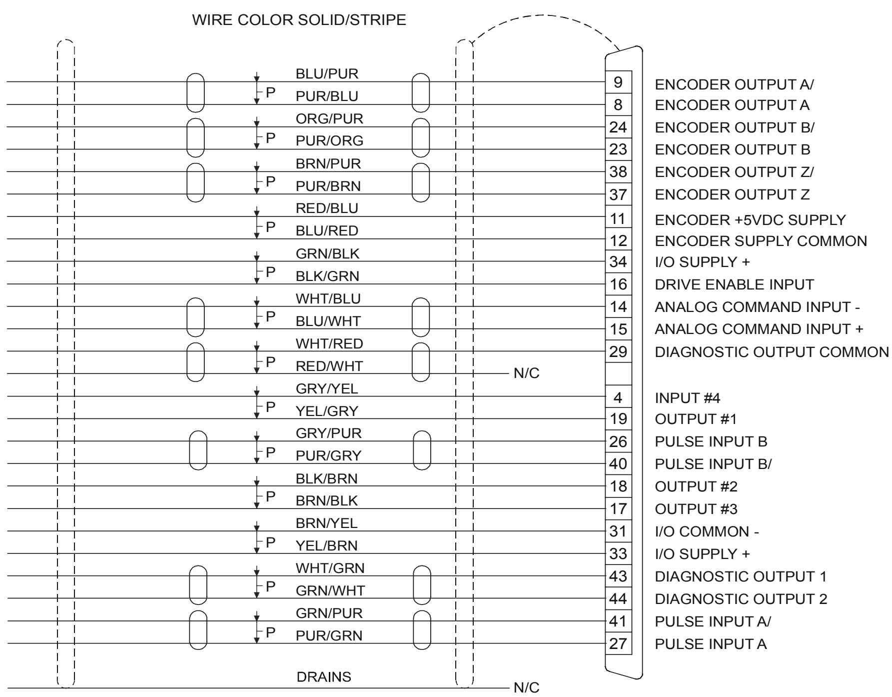


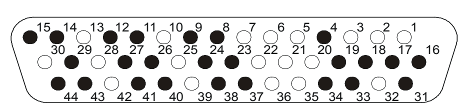
Note

Some CMDO cables may have White/Yellow and Yellow/White wires in place of the White/Orange and Orange/White shown in the figure above (pins 6 and 21).

CDRO-XXX Cable

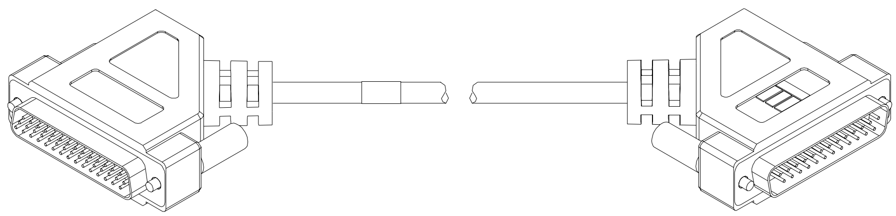


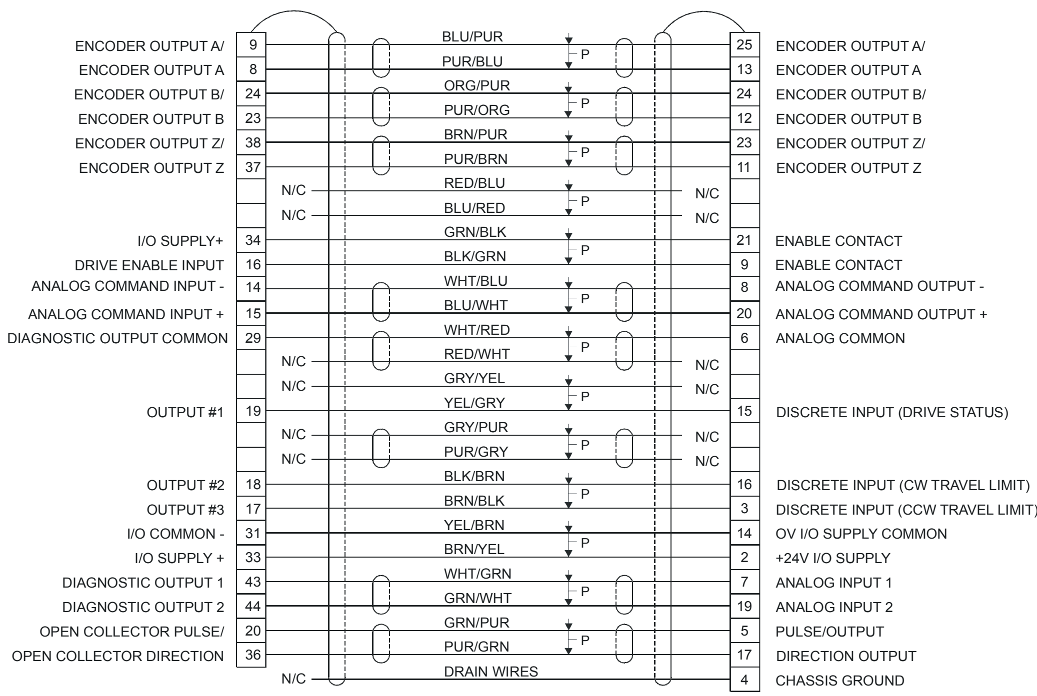




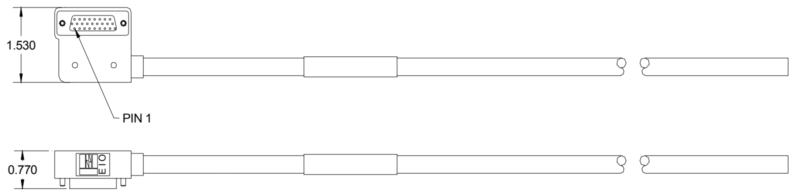
SOLDER SIDE

AX4-CEN-XXX Cable





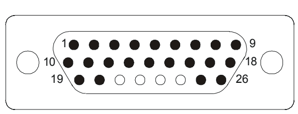
EIO-XXX Cable



OVERALL T/C BRAID

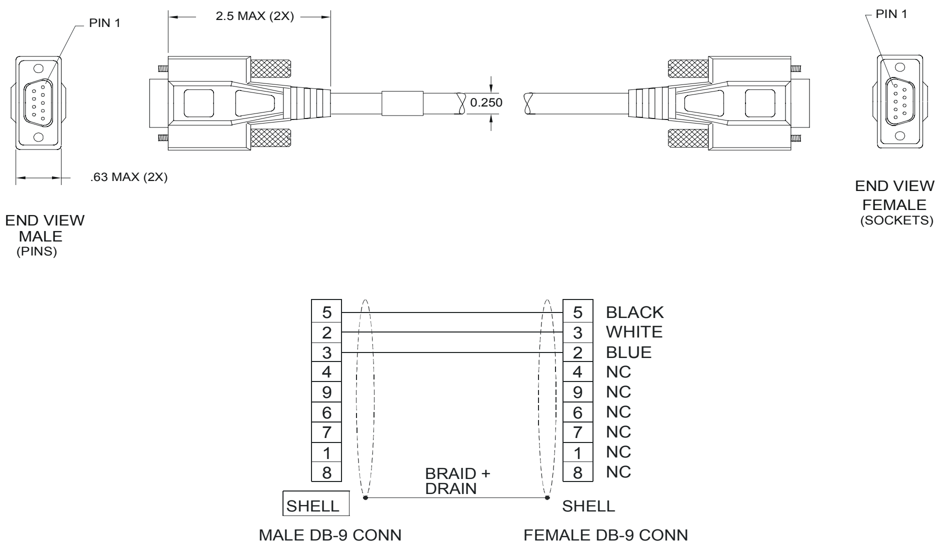
FUNCTION	PIN	COLOR		
INPUT LINE 1	1	RED/WHT		
ENABLE	10	RED/BLK		
INPUT LINE 3	2	ORG/WHT		
INPUT LINE 2	11	ORG/BLK		
INPUT LINE 5	3	GRN/WHT		
INPUT LINE 4	12	GRN/BLK		
INPUT LINE 7	4	PNK/BLK		
INPUT LINE 6	13	YEL/BLK		
INPUT LINE 9	5	GRY/BLK		
INPUT LINE 8	14	BLU/WHT		
INPUT LINE 11	6	BRN/WHT		
INPUT LINE 10	15	PUR/WHT		
OUTPUT LINE 1	7	ORG		
OUTPUT LINE 2	17	YEL		
OUTPUT LINE 5	9	GRY		
INPUT LINE 12	16	BRN		
OUTPUT LINE 3	8	PNK		
OUTPUT LINE 4	18	BLU		
I/O +V	19	RED		
I/O COM	20	BLK		
N/C	21	N/C		
N/C	22	N/C	N/C	GRN
N/C	23	N/C	N/C	LIGHT GRN
N/C	24	N/C		
OUTPUT LINE 6	25	PUR		
OUTPUT LINE 7	26	WHT		

TERMINATE OVERALL SHIELD TO CONNECTOR SHELL ONLY

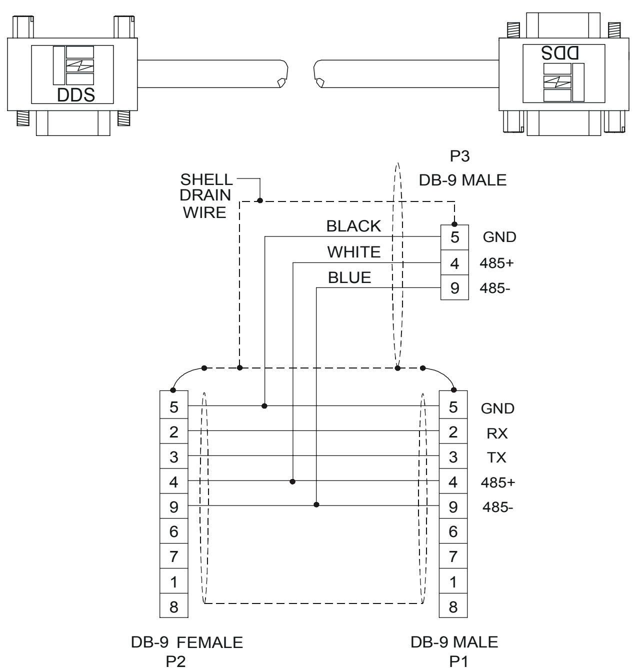


WIRING SIDE SUB "D"

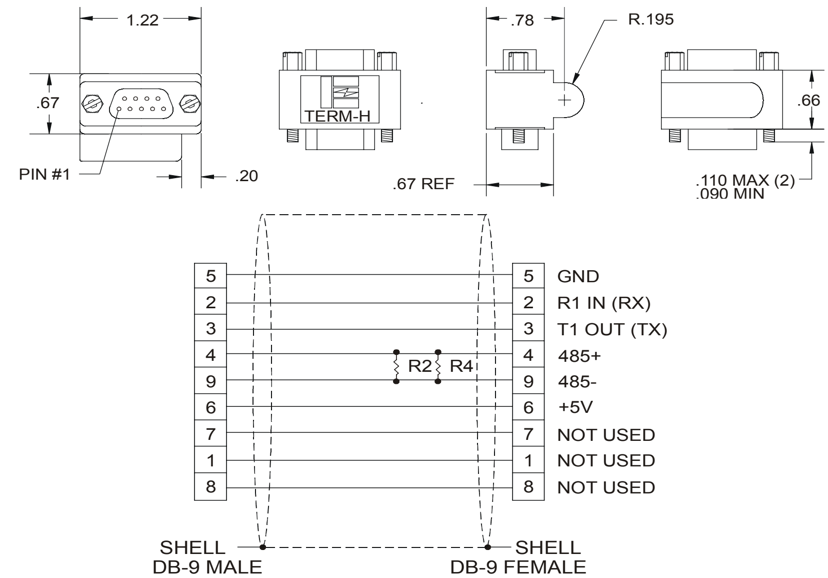
TIA-XXX Cable



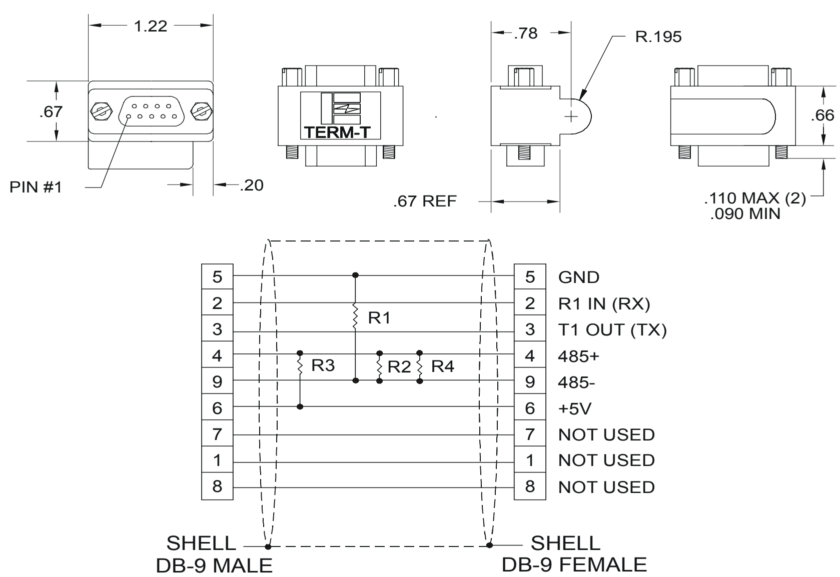
DDS-XXX Cable



TERM-H (Head) Terminator



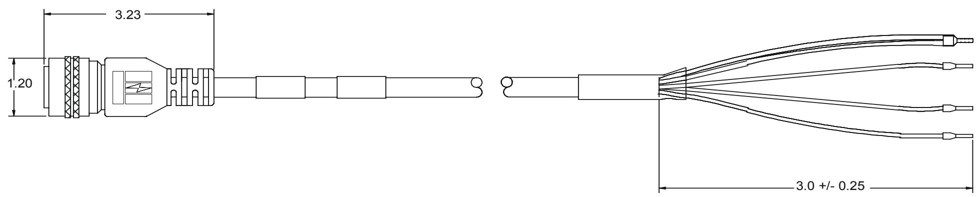
TERM-T (Tail) Terminator

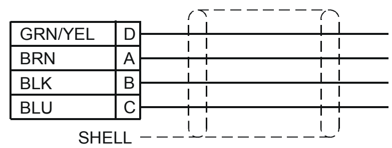


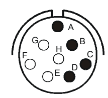
Note

See the "Multi-drop Communications" section for resistor values.

CMDS-XXX Cable

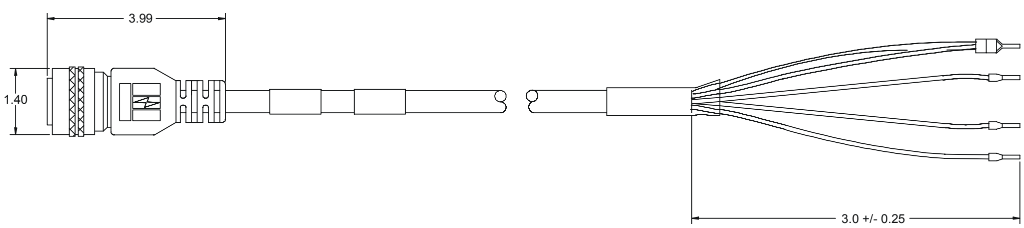


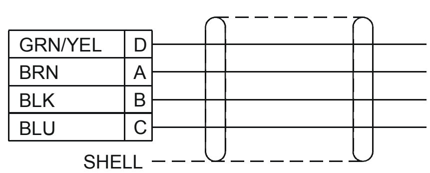


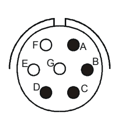


SOLDER SIDE

CMMS-XXX Cable

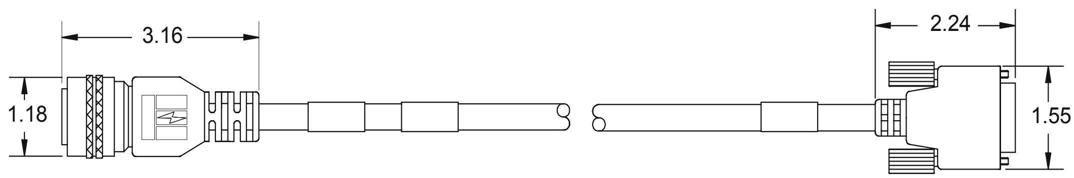


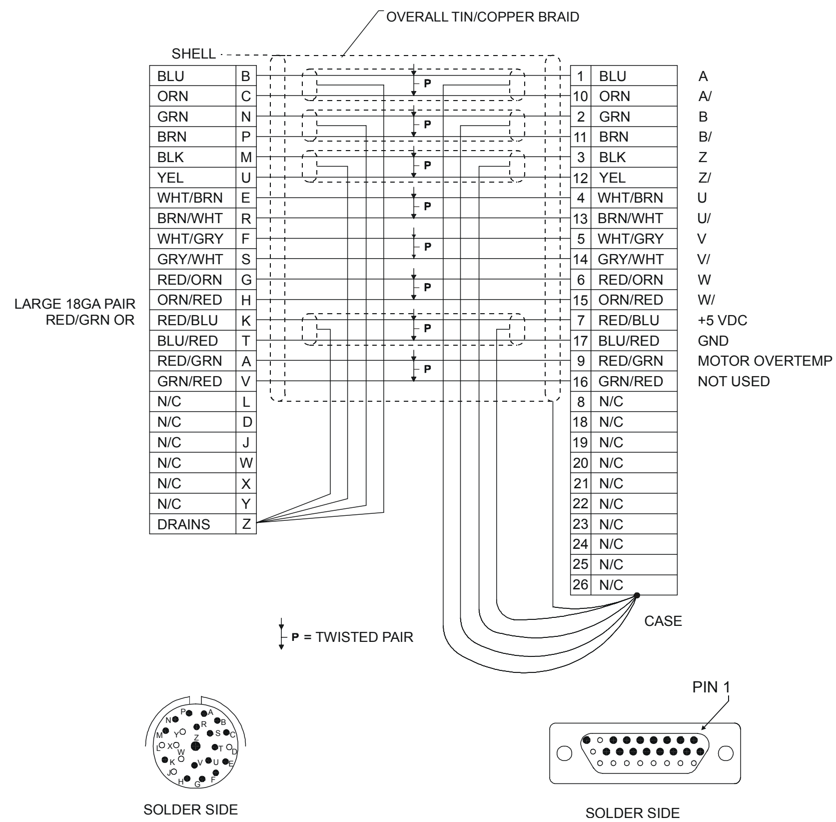




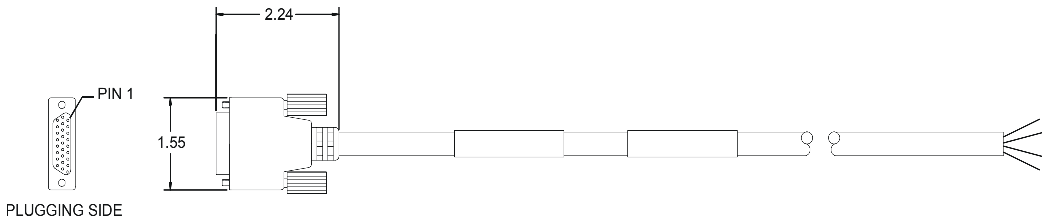
SOLDER SIDE

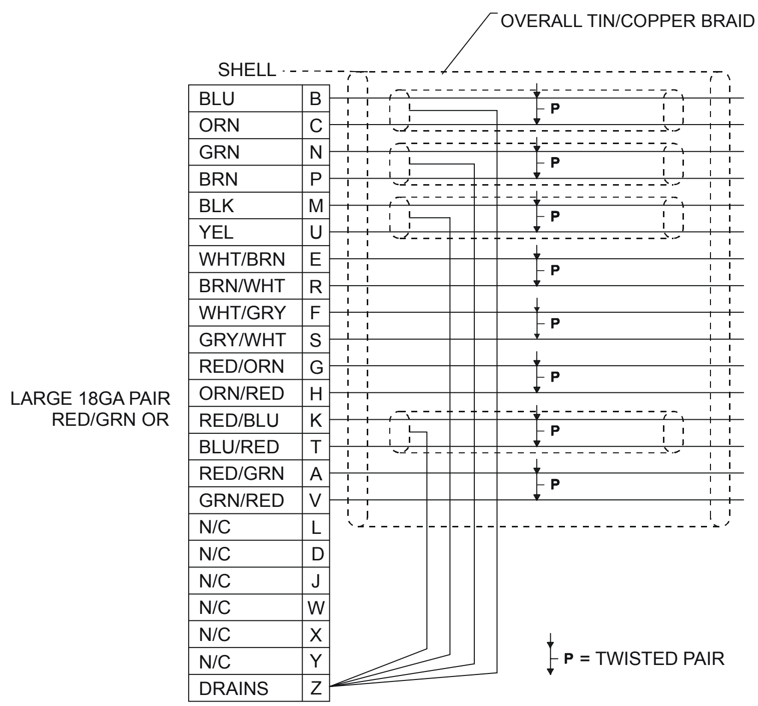
CFCS-XXX Cable

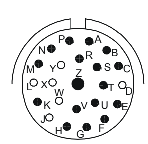




CFCO-XXX Cable

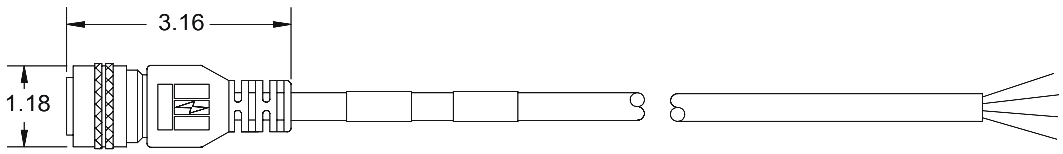


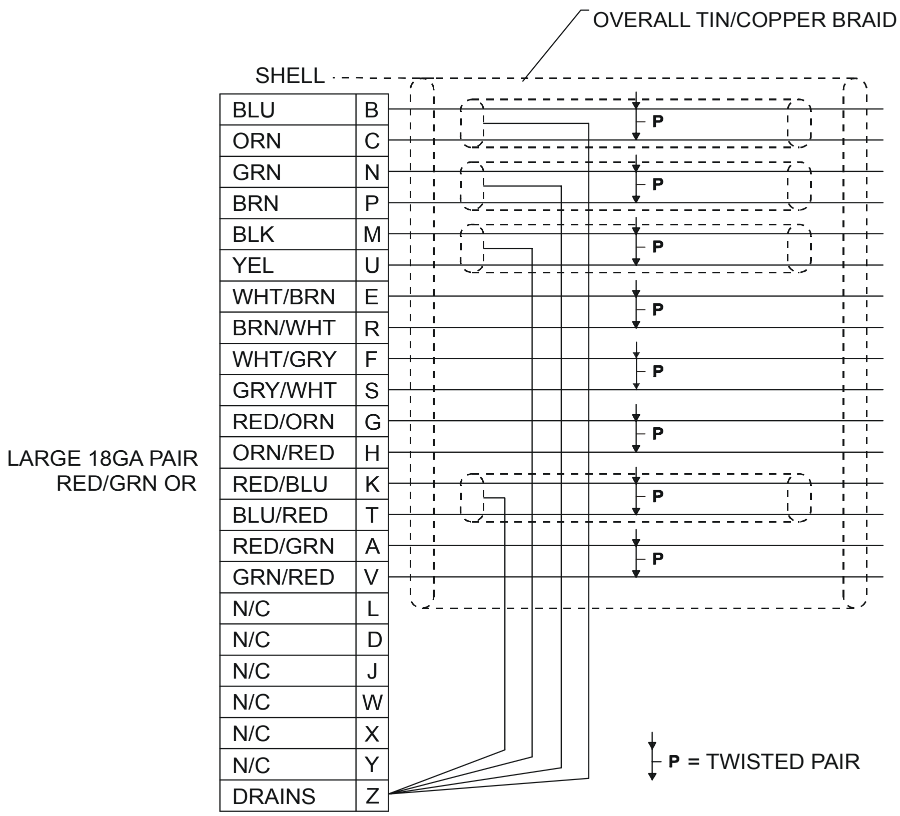


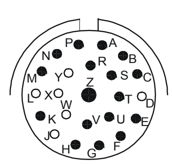


SOLDER SIDE

CFOS-XXX Cable







SOLDER SIDE

Glossary

µs

Microsecond.

A

Amps.

ARMS

Amps (RMS).

AWG

American Wire Gauge.

Baud Rate

The number of binary bits transmitted per second on a serial communications link such as RS-232. (1 character is usually 10 bits.)

Check Box

In a dialog box, a check box is a small box that the user can turn "On" or "Off" with the mouse. When "On" it displays an X in a square; when "Off" the square is blank. Unlike option (radio) buttons, check boxes do not affect each other; any check box can be "On" or "Off" independently of all the others.

CRC

Cyclical Redundancy Check.

Dialog Box

A dialog box is a window that appears in order to collect information from the user. When the user has filled in the necessary information, the dialog box disappears.

DIN Rail

Deutsche Industrie Norm Rail

DLL

In Microsoft Windows, a Dynamic Link Library contains a library of machine-language procedures that can be linked to programs as needed at run time.

Downloading

The transfer of a complete set of parameters from PowerTools or an FM-P.

EEPROM

An EEPROM chip is an Electrically Erasable Programmable Read-Only Memory; that is, its contents can be both recorded and erased by electrical signals, but they do not go blank when power is removed.

EMC

Electromagnetic Compatibility

EMI - Electro-Magnetic Interference

EMI is noise which, when coupled into sensitive electronic circuits, may cause problems.

Firmware

The term firmware refers to software (i.e., computer programs) that are stored in some fixed form, such as read-only memory (ROM).

FM

Function Module - device which is attached to the front of the drive to provide additional functionality.

Hysteresis

For a system with an analog input, the output tends to maintain it's current value until the input level changes past the point that set the current output value. The difference in response of a system to an increasing input signal versus a decreasing input signal.

I/O

Input/Output. The reception and transmission of information between control devices. In modern control systems, I/O has two distinct forms: switches, relays, etc., which are in either an on or off state, or analog signals that are continuous in nature generally depicting values for speed, temperature, flow, etc.

Inertia

The property of an object to resist changes in rotary velocity unless acted upon by an outside force. Higher inertia objects require larger torque to accelerate and decelerate. Inertia is dependent upon the mass and shape of the object.

Input Function

A function (i.e., Stop, Preset) that may be attached to an input line.

Input Line

The actual electrical input, a screw terminal.

Least Significant Bit

The bit in a binary number that is the least important or having the least weight.

LED

Light Emitting Diode.

List Box

In a dialog box, a list box is an area in which the user can choose among a list of items, such as files, directories, printers or the like.

mA

Milliamp.

MB

Mega-byte.

Most Significant Bit

The bit in a binary number that is the most important or that has the most weight.

ms

Millisecond.

NVM

Non-Volatile Memory.

NTC

Negative Temperature Coefficient Resistor

Option Button

See Radio Button.

Opto-isolated

A method of sending a signal from one piece of equipment to another without the usual requirement of common ground potentials. The signal is transmitted optically with a light source (usually a Light Emitting Diode) and a light sensor (usually a photosensitive transistor). These optical components provide electrical isolation.

Output Function

A function (i.e., Drive OK, Fault) that may be attached to an output line.

Output Line

The actual transistor or relay controlled output signal.

Parameters

User read only or read/write parameters that indicate and control the drive operation.

PE

Protective Earth.

PID

Proportional-Integral-Derivative. An acronym that describes the compensation structure that can be used in many closed-loop systems.

PLC

Programmable Logic Controller. Also known as a programmable controller, these devices are used for machine control and sequencing.

PowerTools-Base and -FM

Windows®-based software to interface with the Epsilon drives, EN drives and Function Modules.

Radio Button

Also known as the Option Button. In a dialog box, radio buttons are small circles only one of which can be chosen at a time. The chosen button is black and the others are white. Choosing any button with the mouse causes all the other buttons in the set to be cleared.

RAM

RAM is an acronym for Random-Access Memory, which is a memory device whereby any location in memory can be found, on average, as quickly as any other location.

RMS

Root Mean Squared. For an intermittent duty cycle application, the RMS is equal to the value of direct current which would produce the equivalent heating over a long period of time.

ROM

ROM is an acronym for Read-Only Memory. A ROM contains computer instructions that do not need to be changed, such as permanent parts of the operating system.

RPM

Revolutions Per Minute.

Serial Port

A digital data communications port configured with a minimum number of signal lines. This is achieved by passing binary information signals as a time series of 1's and Ø's on a single line.

Uploading

The transfer of a complete set of parameters from PowerTools or an FM-P.

VAC

Volts, Alternating Current.

VDC

Volts, Direct Current.

Windows, Microsoft

Microsoft Windows is an operating system that provides a graphical user interface, extended memory and multi-tasking. The screen is divided into windows and the user uses a mouse to start programs and make menu choices.

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Eden Prairie, Minnesota 55344
U.S.A.

Customer Service
Phone: (952) 995-8000 or (800) 397-3786
Fax: (952) 995-8129
Technical Support
Phone: (952) 995-8033 or (800) 397-3786
Fax (952) 9995-8020

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