Epsilon Ei Indexing Drive and FM-2 Indexing Module

Reference Manual

P/N 400507-01
Revision: A7
Date: July 26, 2004

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

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Eden Prairie, Minnesota 55344-3620
U.S.A.

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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
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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.

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

E Series Only

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

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

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.

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.

- *All Function Modules Installation Manual* (P/N 400506-03)
- *Epsilon Ei Indexing Drive Installation Manual* (P/N 400501-06)
- *PowerTools Software User’s Guide* (P/N 400503-01)
- *Epsilon and EN Drive Parameters Reference Manual* (P/N 400504-01)

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, carries a high level of stored electrical energy, or is used to control mechanical equipment which 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 which prevents access except by trained and authorized personnel, and which 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 the 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.

Underwriters Laboratories Listed

LISTED 51Y8
IND. CONT. EQ.

The Epsilon Series 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 the UL certifies this product to be safe when installed according to the installation guidelines and used within the product specifications.

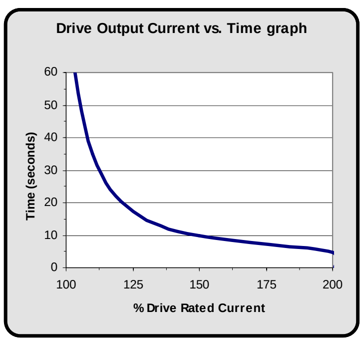
The “conditions of acceptability” required by UL are:

- The Epsilon drive surrounding air ambient temperature must be 40° C (104° F) or less for full rated output and up to 50° C (122° F) with output current derated to 3% for every degree above 40° C (104° F).

Drive overload protection

The Epsilon series drive output current overload protection is provided by the drive and is not adjustable. This overload protection is based on maximum 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**
Ei-202	1.8	3.6
Ei-203	3.0	6.0
Ei-205	5.0	10.0



CE Declaration of Conformity

The Epsilon Series 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.

Note

The FM-2 Indexing Module is not required to carry a CE mark because it operates on low voltages.

Declaration of Conformity

Manufacturer's Name: Control Techniques Drives

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

August 18, 1999

Bradley Schwartz/ VP Engineering

Date

European Contact:

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

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Introduction

Epsilon Ei Indexing Drive

The Epsilon 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 drives can be quickly configured to many applications in less than 5 minutes with Emerson Control Techniques PowerTools FM[1] software on a PC running Windows 95, 98, NT 4.0, 2000 or XP.

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

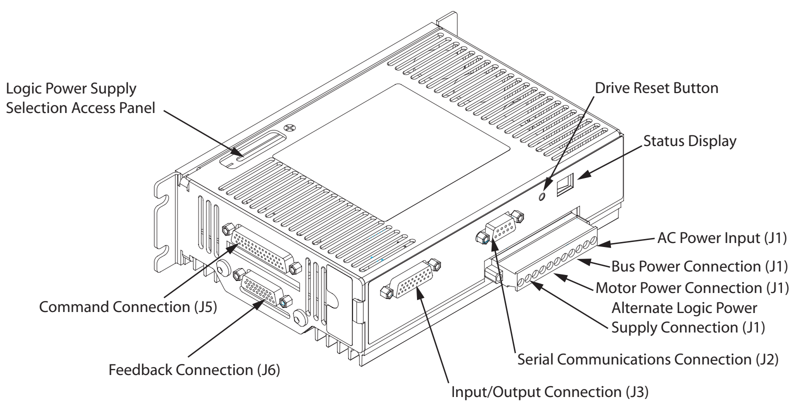


Figure 1: Epsilon Ei Drive Feature Location

Epsilon drives operate at 96 to 264 Vac or the range can be extended to 42 to 264 Vac with an APS (Alternate Power Supply) connected and are available in three power ratings. The drive will fit in a 6 inch deep enclosure with cables connected.

- Epsilon Ei-202 – 650 Watts (1.8 amps cont, 3.6 amps peak)
- Epsilon Ei-203 – 1100 Watts (3.0 amps cont, 6.0 amps peak)
- Epsilon Ei-205 – 1750 Watts (5.0 amps cont, 10.0 amps peak)

1.In this manual, Emerson Motion Control PowerTools® FM software will be referred to as PowerTools FM

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

FM-2 Indexing Module

The FM-2 Module 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 Module is setup using PowerTools FM software. PowerTools FM is an easy-to-use Microsoft® Windows® based setup and diagnostics tool.

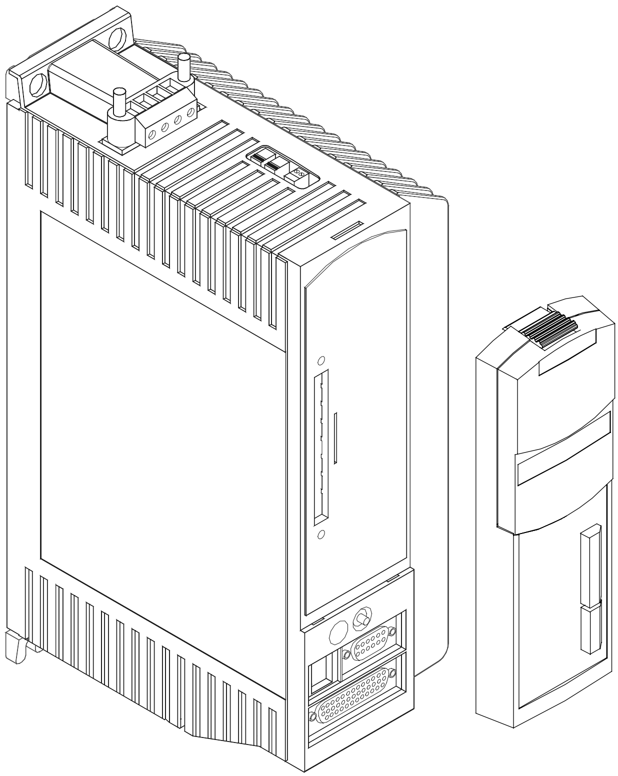


Figure 2: EN Drive and a FM-2 Indexing Module

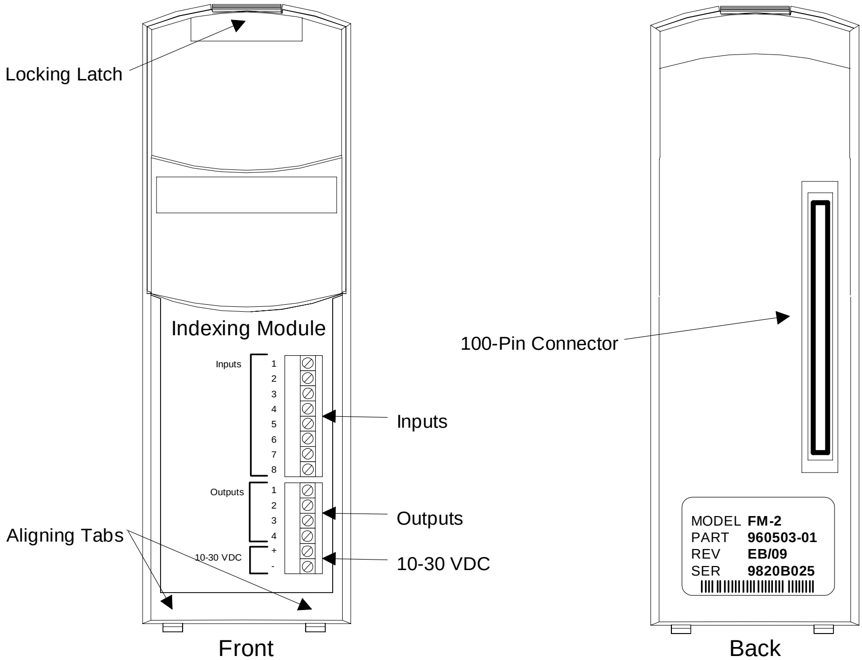


Figure 3: FM-2 Indexing Module Feature Location

Operational Overview

The FM-2 Module augments the EN drive by providing single axis position control. When an FM-2 Module is attached to an EN drive, it overrides the operation and user accessible features of the drive. The drive's basic operating mode, Torque Presets is not available when a FM-2 Module is attached.

The Epsilon Ei drive and FM-2 Module allow you to setup 16 different indexes, Slow and Fast Jog functions and a single Home routine. They also provide eight digital input lines and four digital output lines in addition to the four input and three output lines available on the drive.

User Interface

The Epsilon Ei drive and FM-2 Module are set up using PowerTools FM software. PowerTools FM is an easy-to-use Windows-based setup and diagnostics tool. It 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 device. You can also save it to a file on your PC or print it for review or permanent storage.

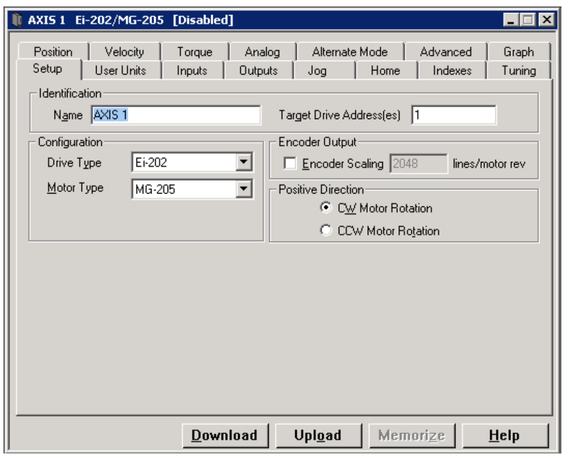


Figure 4: PowerTools FM Setup Tab

How Motion Works

The Epsilon Ei drive and FM-2 Module provides six types of motion: jogging, home, indexing and with alternate mode, analog velocity, analog torque and pulse mode. Only one type of motion may be in process at any given moment. With all Ei drives and the FM-2 modules motion can be initiated by input assignments or thru PowerTools FM or over a network like DeviceNet using an Ei-DN drive. The FM-2 Module can sequentially run various motion routines by use of chained indexes or I/O assignments.

How Jogging Works

The Jog functions produce rotation of the motor at controlled velocities in the positive or negative direction. Jogging is initiated using the Jog + and Jog - input functions.

Assignments to jogs are level sensitive such that when the jog input is turned on, jogging begins and continues jogging until the jog input is removed.

When Jog + goes "On" the axis ramps up to speed and continues at speed. When Jog + goes "Off" the axis decelerates to a stop.

Each jog has its own acceleration and deceleration ramp along with a specified velocity. Jogging has no distance parameter associated with it. If trying to move a specific distance or to a known position, then an index is used.

Jogging in the opposite direction will move off a travel limit (use Jog + to move off a Travel Limit -).

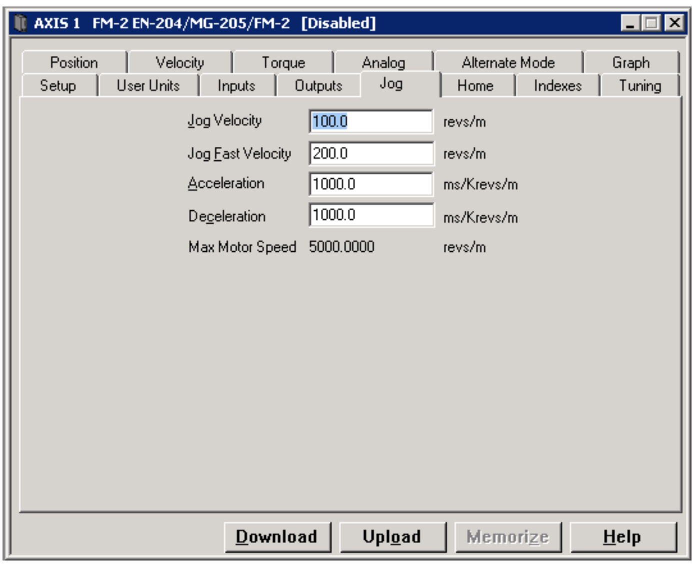


Figure 5: Jog Tab

Jog and Jog Fast Velocity

The Jog Velocity parameter specifies the velocity used for jogging with the Jog + or Jog - input functions.

The Jog Fast Velocity parameter specifies the velocity used for fast jogging with the Jog Fast input function in conjunction with either the Jog + or Jog - input function.

Jog Acceleration and Deceleration

Jog acceleration and deceleration are in units of ms/(k(user unit)/min) or user unit/sec^2, depending on which Time Scale was selected on the User Units Tab. The default value for both is 1000 ms/kRPM. For example, at the default values, if you initiated a Jog with a velocity of 500 RPM, the motor will accelerate to 500 RPM in 0.5 seconds.

Accel Time = 500 RPM x 1000 ms/kRPM x 1 kRPM/1000 RPM
= 500 msec = 0.5 sec

Jog Input Functions

The device has three input functions available which are used to initiate four different jogging operations: Jog+, Jog-, Jog Fast + and Jog Fast -.

Note

In the table below Jog Velocity = 100 RPM and Jog Fast Velocity = 500 RPM.

Jog +	Jog -	Jog Fast	Motion
Off	Off	Off	0 RPM
On	Off	Off	+100 RPM
Off	On	Off	-100 RPM
On	Off	On	+500 RPM
Off	On	On	-500 RPM
On	On	Off	0 RPM
On	On	On	0 RPM

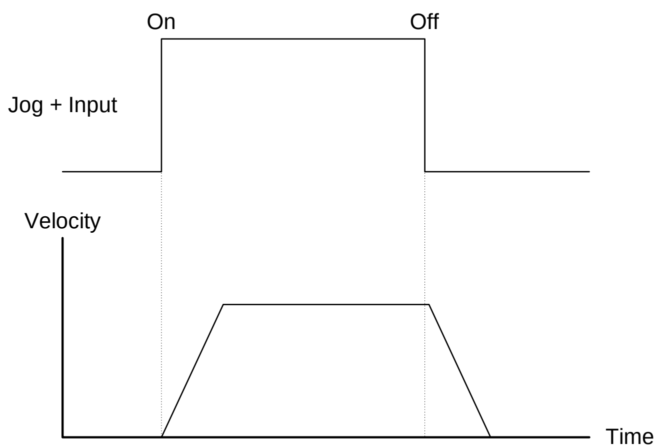


Figure 6: Jog Input

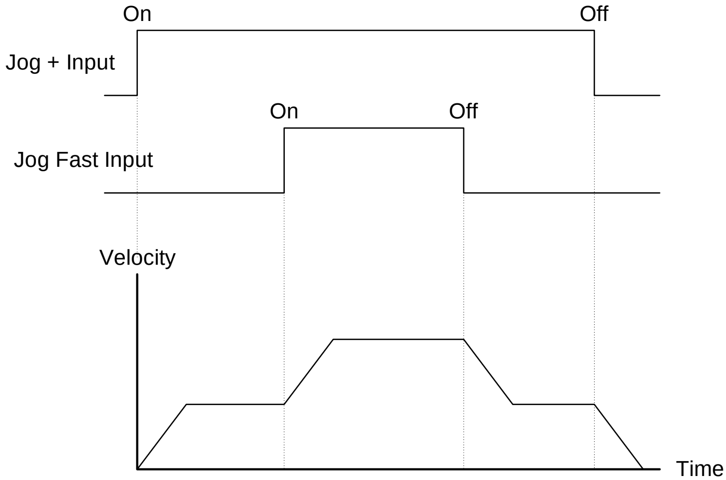


Figure 7: Jog Input and Jog Fast Input

When the Jog Fast input function is not active, the target velocity for the jog is the Jog Velocity. If the Jog Fast input function is active, the target velocity of the jog is the Jog Fast Velocity. Jog Fast can be toggled “On” or “Off” while jogging. Jog acceleration and deceleration ramps are used to ramp between jog velocities.

If the Jog direction is reversed, the Jog deceleration value will be used to decelerate the motor to zero speed and then the Jog acceleration will be used to accelerate to the new (opposite sign) velocity.

Note

The Jog function cannot be initiated when any other motion type (homing, indexing) is in progress.

If both jog input functions are “On” there is no motion after a jog deceleration (they effectively cancel each other). The drive’s display will show “R”, for ready.

If the device is jogging with the Jog + Input function “On” and the Jog - Input function goes active, the device behaves the same as if it would in Jog + just turned “Off”.

The Stop input function will override the Jog operation and decelerate the motor to zero speed.

If the motor reaches a Travel Limit, you can Jog off the Travel Limit in the opposite direction. (Use Jog + to move off a Travel Limit -).

How Home Works

The Home routine is used in applications in which the axis must be precisely aligned with some part of the machine. The Home routine is initiated with the Home Initiate Input Function.

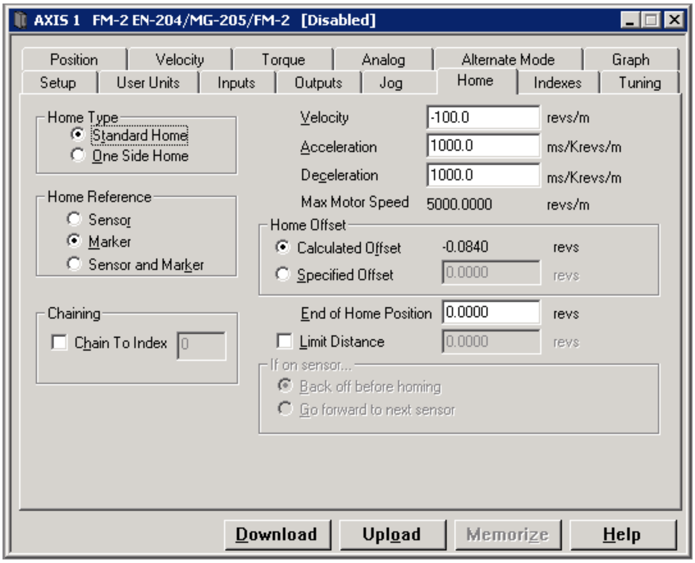


Figure 8: Home Tab

Home Type

Standard Home

The device can home the motor to an external sensor, the motor's encoder marker pulse or to a sensor and then to the encoder marker pulse.

One Side Home

The one side home is designed to add power to simple indexing applications where the machine can be stopped and re-homed from either side of the home sensor.

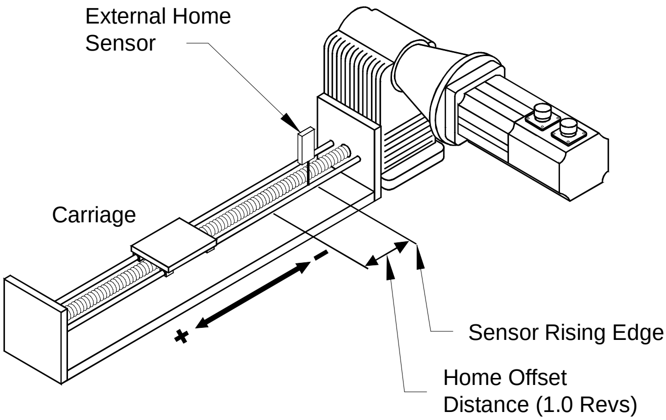


Figure 9: Basic Standard Home Function

The figure above shows a basic standard home function using a ball screw. This example uses most of the setup features in the PowerTools FM Home tab.

Standard Home Sequence

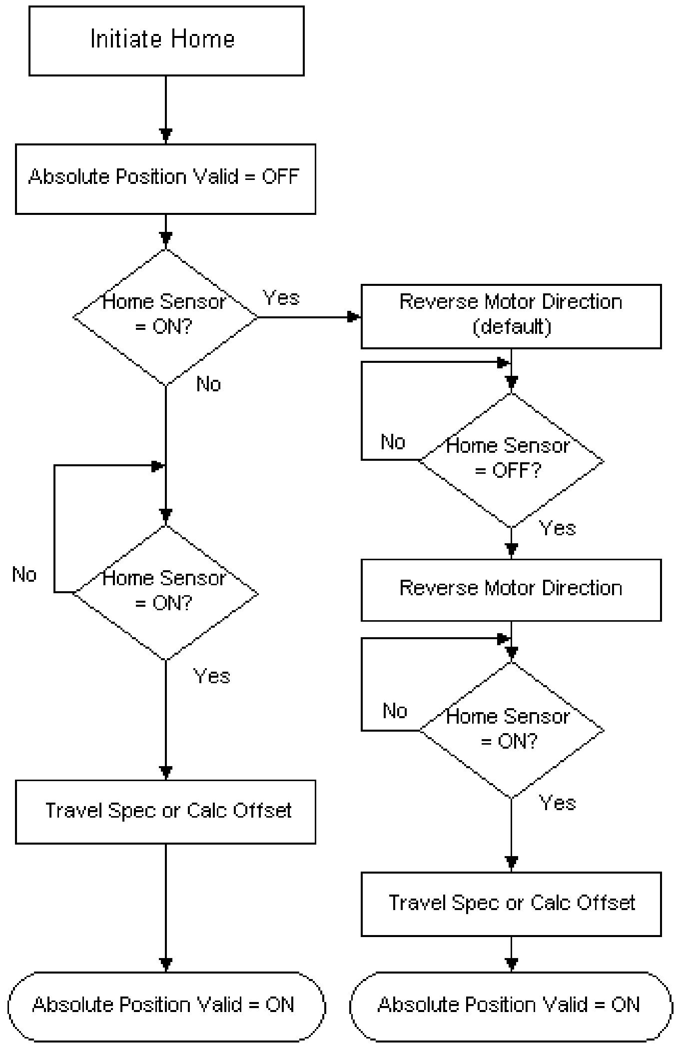


Figure 10: Flow Chart of a Standard Home Routine

Homing to the motor's encoder marker will establish the most accurate and repeatable home position. This method will position the motor relative to the location of the rising edge of the encoder marker pulse. Most applications will use a sensor and marker to find an accurate home position in the vicinity of the home sensor.

One Side Home Sequence

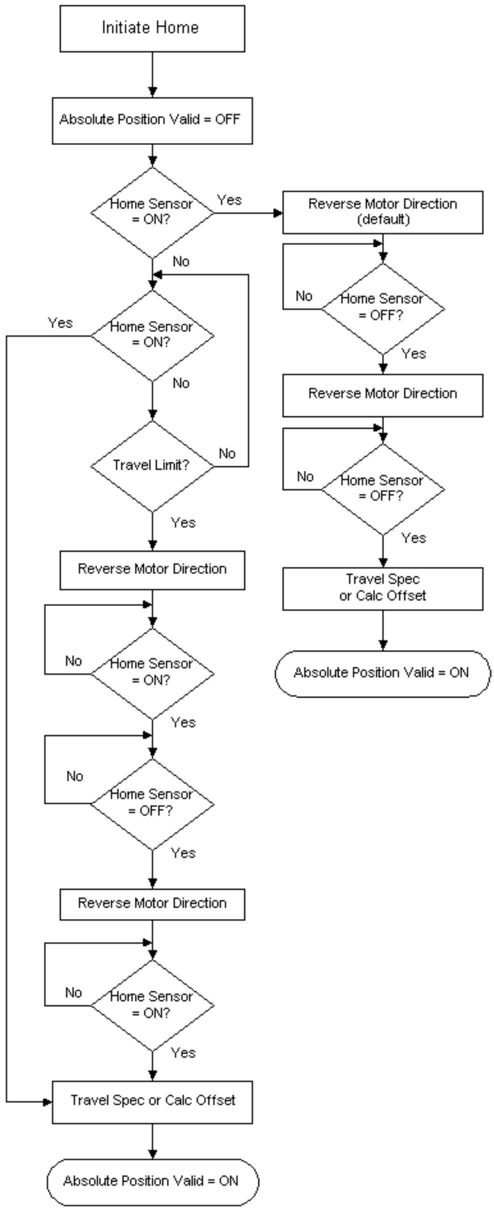


Figure 11: Flow Chart of a One Side Home Routine

Several parameters (including input and output functions) affect how the Home function operates. Each of these parameters are explained in detail on the following pages.

Note

The Home function will NOT be initiated when any other motion command is in progress.

Establishing a Home Reference Position

The second step in setting up a home routine is to select the desired home reference type. The Home Reference parameter selected determines how the Home Reference Position is established. PowerTools FM allows selection of one of three different Home References: Sensor, Marker, or Sensor and Marker for a Standard Home and Sensor for a One Side Home.

Sensor

Selecting Sensor means the rising edge of the Home Sensor input function is used to establish the home reference position.

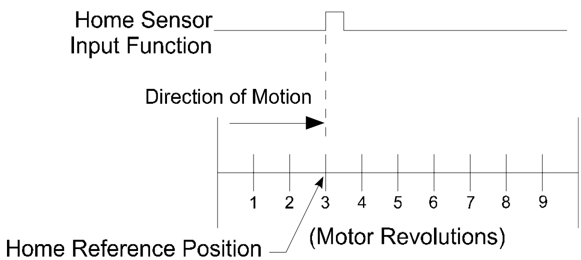


Figure 12: Sensor Home Reference Position

Marker (Standard Home only)

Selecting Marker means the rising edge of the motor's encoder marker channel is used to establish the reference position.

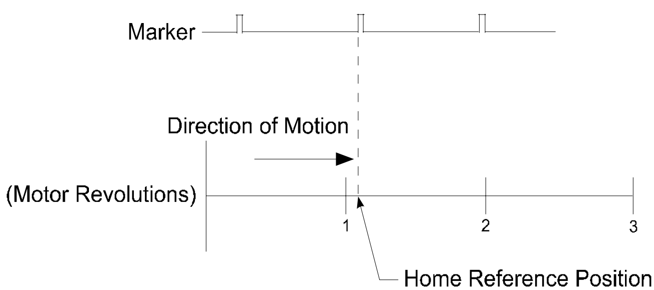


Figure 13: Marker Home Reference Position

Sensor and Marker (Standard Home only)

Selecting Sensor and Marker means the reference position is established using the first marker rising edge after the device sees the rising edge of the Home Sensor input function.

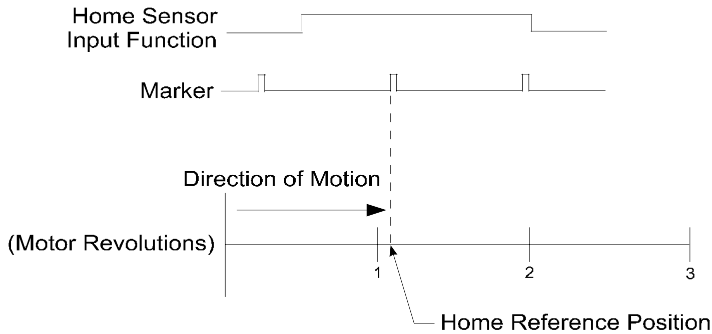


Figure 14: Sensor and Marker Home Reference Position

Accuracy and Repeatability

The amount of accuracy your application requires will determine the Home Reference option you select. Homing to an external sensor only will establish a repeatable home position within 0.0025 revolutions at 3000 RPMs (50 msec sensor capture interval).

Note

The data above assumes the use of a perfectly repeatable home sensor.

Sensor and Marker, and Marker home types will establish a repeatable home position within one encoder count at any motor velocity.

Note

The one encoder count factor assumes the motor is approaching the marker from the same direction. If different directions are used, the final home position will be off by four encoder counts (0.000488 revolutions).

In Sensor and Marker applications, the marker must be at least 800 μs after the rising edge of the sensor input to be considered a valid marker pulse.

Note

At 1000 RPM, the motor will travel 0.0133 revolutions (or 4.8°) in 800 μs.

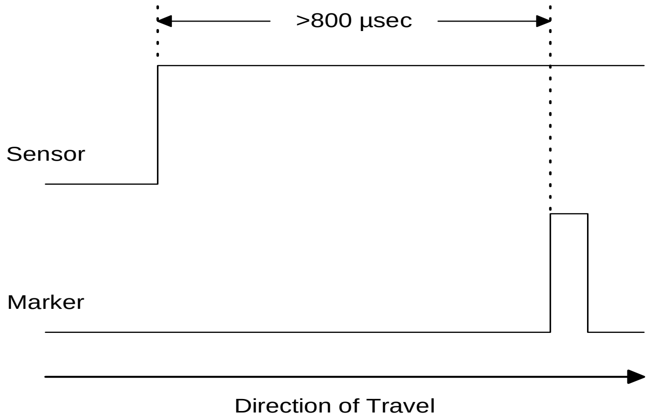


Figure 15: Sensor and Marker Position

The Home Sensor must be “On” for at least 50 µsec to guarantee that it will be recognized.

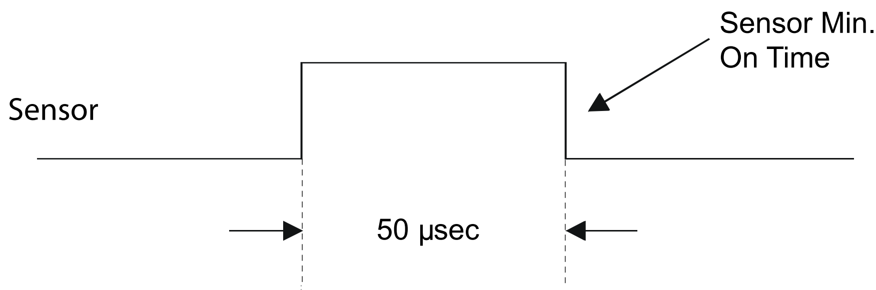


Figure 16: Sensor Position

Home Offset

The Home Offset is the distance from the Reference Position to the final stopping point at the end of the homing sequence. Regardless of the value you enter for the Offset or which Home Reference you choose, an offset is always inherent in the homing process.

The user may either specify a desired offset or allow the drive to calculate an offset automatically. The drive calculates an offset that ensures that the motor will not have to backup to get to the offset position. This is very convenient for unidirectional applications.

The calculated offset is the distance travelled during deceleration ramp from the home velocity to a stop plus the distance travelled at the home velocity for 400µs. This extra distance is used to guarantee that the motor will not need to backup after the deceleration ramp.

The Specified Offset allows the user to choose an exact offset from the Home Reference.

Once the home reference is detected, the device will do whatever is necessary to reach the offset position. This may be as simple as a deceleration to a stop, a continuation at speed followed by a deceleration to a stop, or a deceleration followed by a move in the opposite direction.

To enter a specified home offset, select the Specified Offset option button. PowerTools FM always displays the calculated offset value as a reference.

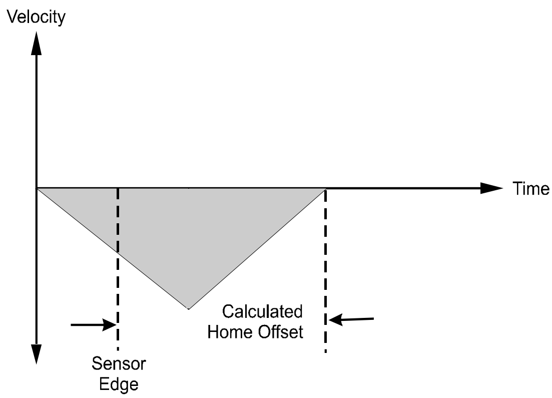


Figure 17: Specified Home Offset

Note

If the home reference is detected before the axis has reached its peak velocity, the axis will still continue to the precise offset position.

Home Offset Examples

The following three home cycle examples each use a different offset method or value.

Example 1: Calculated Offset

In the example below, a calculated offset is used.

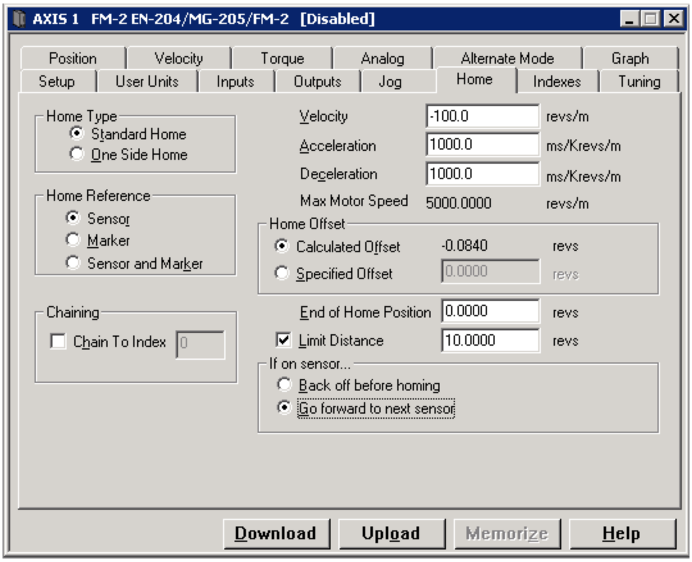


Figure 18: Calculated Offset Screen

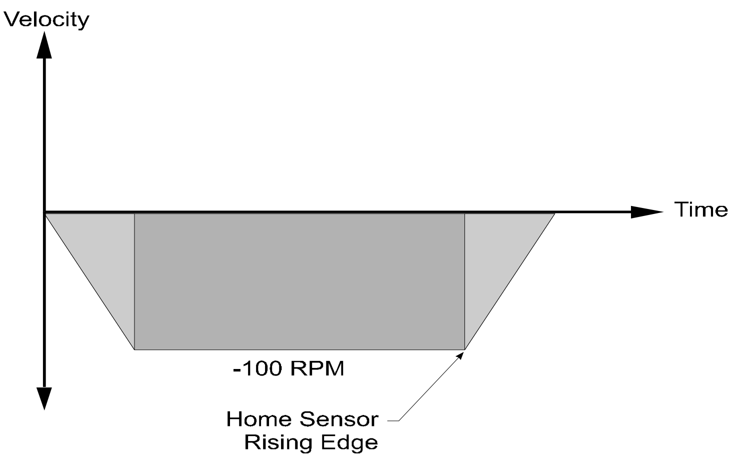


Figure 19: Calculated Offset

Example 2: Specified Offset, Greater than Calculated Offset

In the example below the specified offset is larger than the calculated offset. This causes the axis to continue on at speed before decelerating and stopping at the offset position.

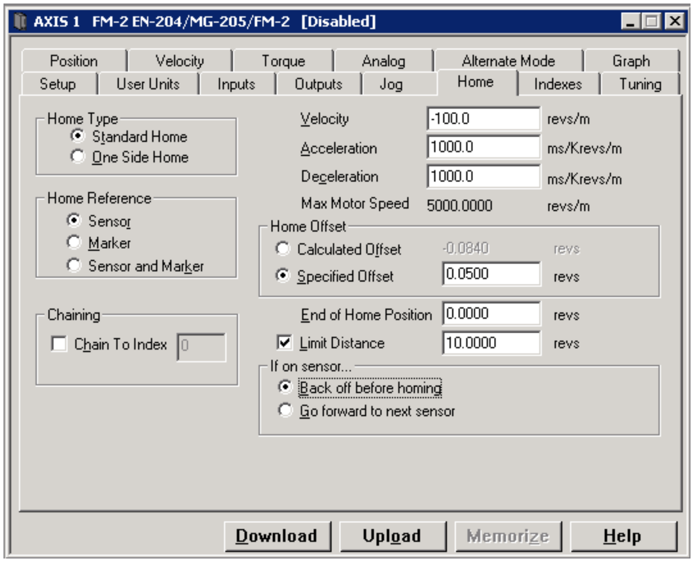


Figure 20: Specified Offset Screen

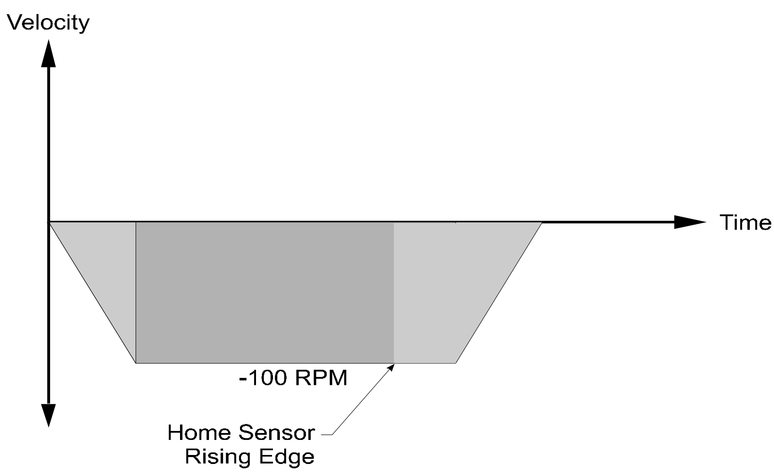


Figure 21: Specified Offset, Greater than Calculated Offset

Example 3: Specified Offset, Back up Required

In the example below the specified offset is located such that the motor must stop and back up to get to the offset position.

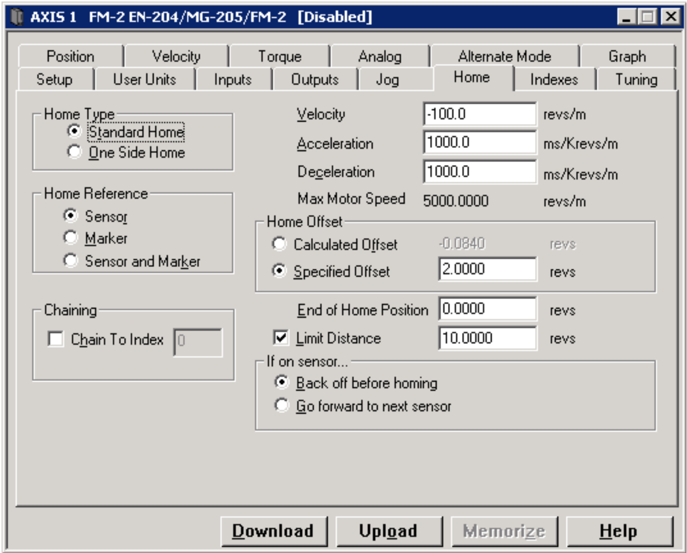


Figure 22: Specified Offset Screen

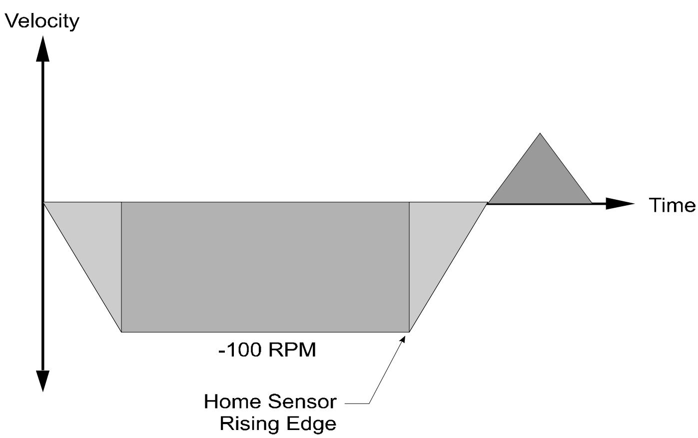


Figure 23: Specified Offset, Backup Required

End of Home Position

The End of Home Position defines the home position in relation to the machine's coordinate system. At the completion of the home routine, the value of the End of Home Position is put into the command and feedback positions.

Home Limit Distance

This parameter places an upper limit on the incremental distance the motor will travel during the home routine.

If no reference is found the system will decelerate and stop at the limit distance. The Home Limit Distance Hit output function will be activated if the home stops at the limit distance without finding the reference. Additionally, the End of Home output will not turn "On" if the limit distance is hit.

Moving Off Sensor Before Homing

In applications that use a sensor (or sensor and marker) to establish a Home Reference Position, there may be situations where the home sensor input is active when the home cycle is initiated. The device can either back off the sensor before homing or go forward to the rising edge of the next sensor.

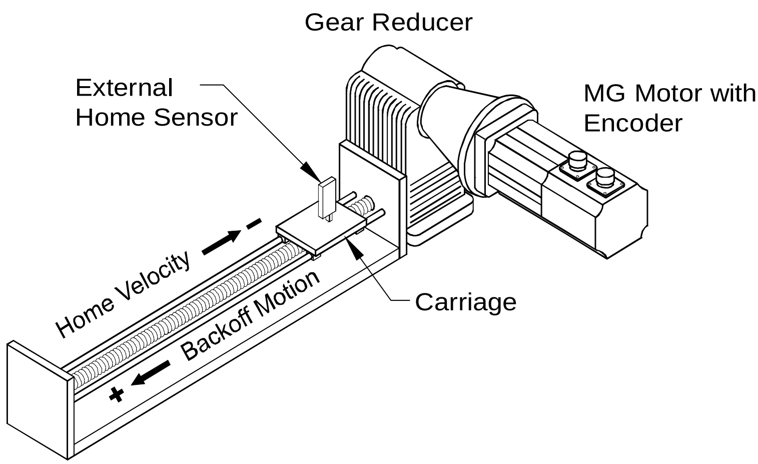


Figure 24: Back Off Sensor Example

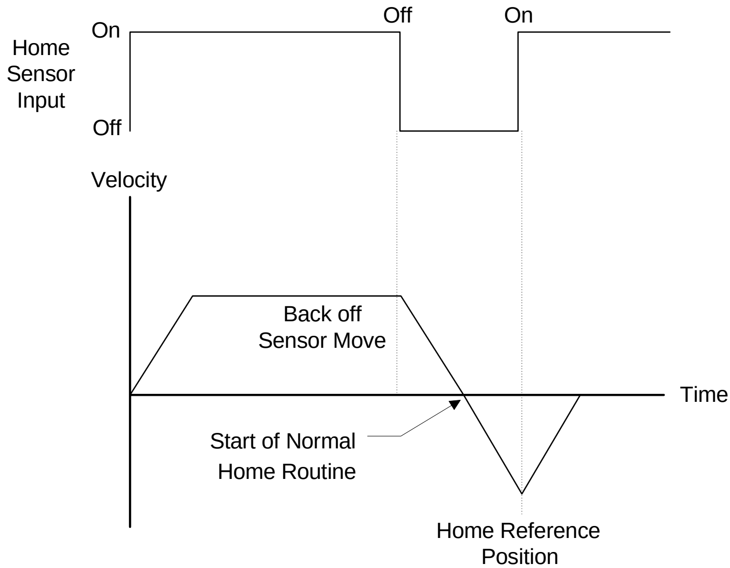


Figure 25: Back Off Sensor

In the figure on the previous page, the motor has restricted travel. In order to find the rising edge of the Home Sensor input, the motor must back away from the sensor until the Home Sensor Input Function deactivates, then move forward looking for the rising edge of the sensor. When backing-off of the sensor, the motor will move in the opposite direction of the Home Velocity.

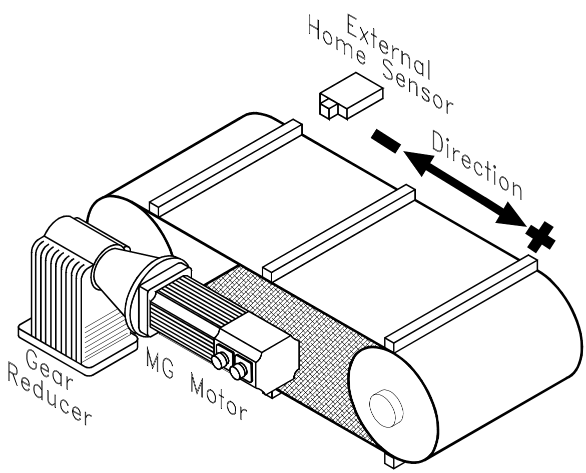


Figure 26: Move Forward Off Sensor Example

In the application shown above we will assume that the motor can only move in the positive (+) direction. The Home Sensor input can be triggered by any one of the spacer lugs on the belt. If the Home Sensor input is active when the device receives a Home Initiate, the motor would move forward off the sensor and continues on until it finds the rising edge of the next Home Sensor input.

Home Input and Output Functions

Input Functions

Home Initiate

The Home Initiate input function is used to initiate the home function. The Home is initiated on the rising edge of this input function. The device will not initiate a Home if there is an Index or Jog in progress or if the Stop input function is active or if a travel limit is active.

Home Sensor

This input function defines the sensor used for homing. It is required if you are homing to a sensor. This function is edge sensitive. The sensor position is determined when the Home Sensor Input Function is activated.

If the device receives a Home Initiate input while the Home Sensor input is active, you can choose to have the motor “back-off” of the home sensor before it initiates the home function.

If debounce is used on the Home Sensor Input Function, the debounce determines the length of time the input must be active to be considered a valid input. The rising edge of the sensor is still used for the reference position. This maintains accuracy while providing the ability to ignore false inputs.

Define Home

This input function is used to manually define the home position using an input function. When this input function is activated, the command and feedback positions will be set to zero. The Absolute Position Valid output function is activated by the Define Home input function.

Output Functions

End of Home

This output function is used to indicate that a home cycle has been successfully completed. This output function is deactivated when any Index, Home, or Jog is initiated.

Home Limit Distance Hit

This output function indicates that no home reference was found while traveling to the Home Limit Distance. The device will decelerate and stop at the Home Limit Distance. This output function is activated when the motor stops. It is deactivated when any index, home or jog is initiated.

Absolute Position Valid

This output function is activated when a Home Routine is successfully completed or the Define Home Input Function is activated. It indicates that the device has been homed. It is cleared by the Home Initiate, an encoder fault and when the device is powered down.

Home Examples

Example 1: Linear Application

In this example, the device uses an external sensor and the motor's encoder marker channel to establish a Home Reference Position. This is the most accurate and most common way to home.

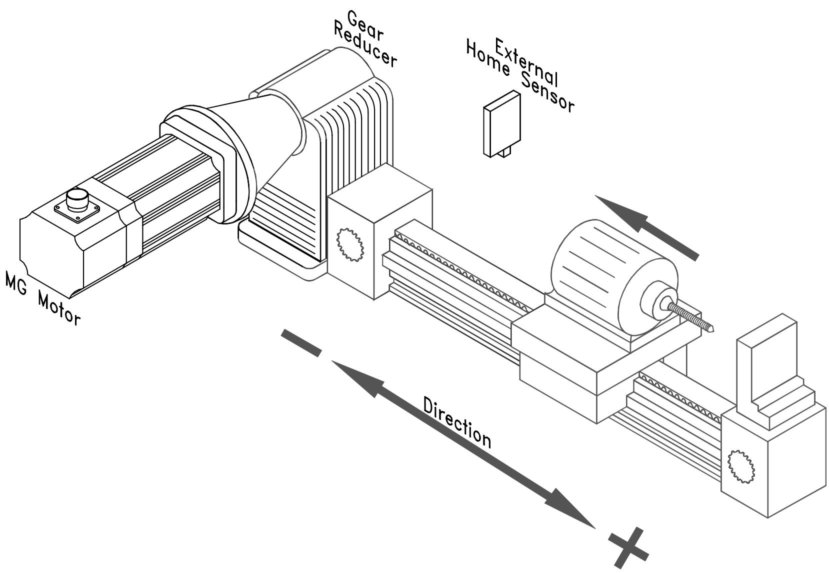


Figure 27: Home to Sensor and Marker

When the device sees the rising edge of the Home Initiate input, it accelerates the motor to the Home Velocity.

The motor continues at that velocity until it first senses the Home Sensor input. It continues at the same velocity until the motor's encoder marker channel is sensed. The rising edge of the motor's encoder marker channel is used to establish the reference position.

Once the home reference (marker) is detected, the motor decelerates to a stop and moves to the offset position.

Home Sequence

1. If on sensor then back off

2. Search for sensor
3. Search for marker
4. Go to offset
5. Set position to End of Home Position

The figure below shows how the PowerTools FM Home tab was setup for this example.

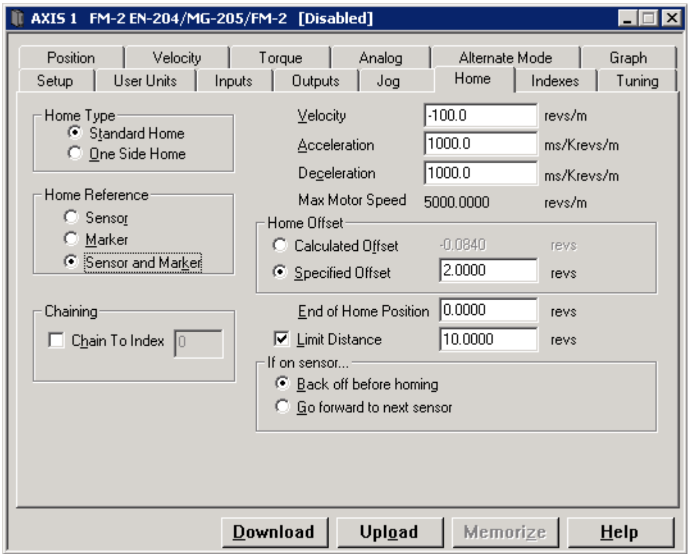


Figure 28: Home Screen, Sensor and Marker Selected

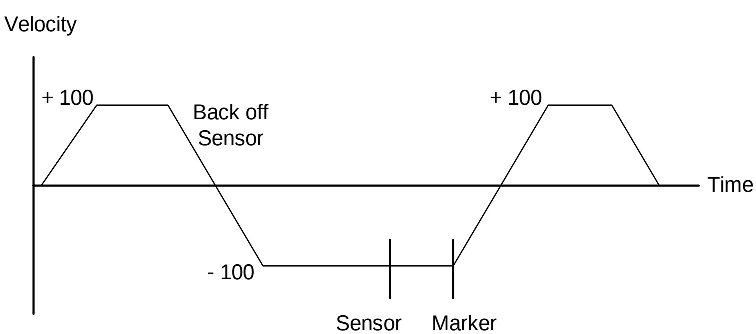


Figure 29: Home Velocity Profile

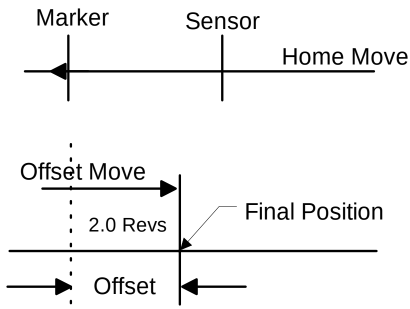


Figure 30: *Home Move Sequence*

Example 2: Rotary Application

This example uses an external sensor and the motor's encoder marker pulse to establish a home reference position.

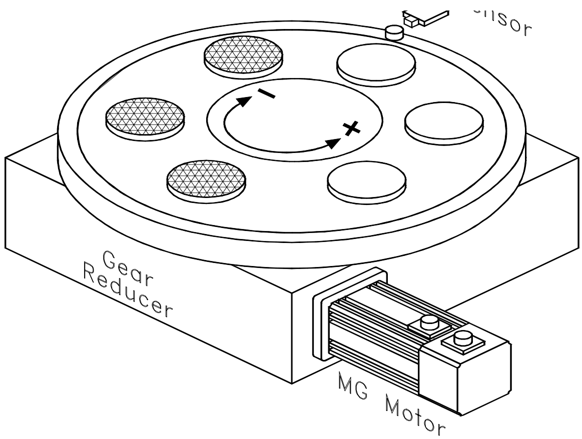


Figure 31: *Sensor and Marker then Offset*

When the device sees the rising edge of the Home Initiate input function, it accelerates the motor to the Home Velocity. The motor continues at that velocity until it first senses the Home Sensor input. The motor continues on at the home velocity until the marker is activated.

The rising edge of the motor's encoder marker channel is used to establish the reference position.

After sensing the rising edge of the motor's marker channel, the device will continue moving and will decelerate to a stop at the specified offset position.

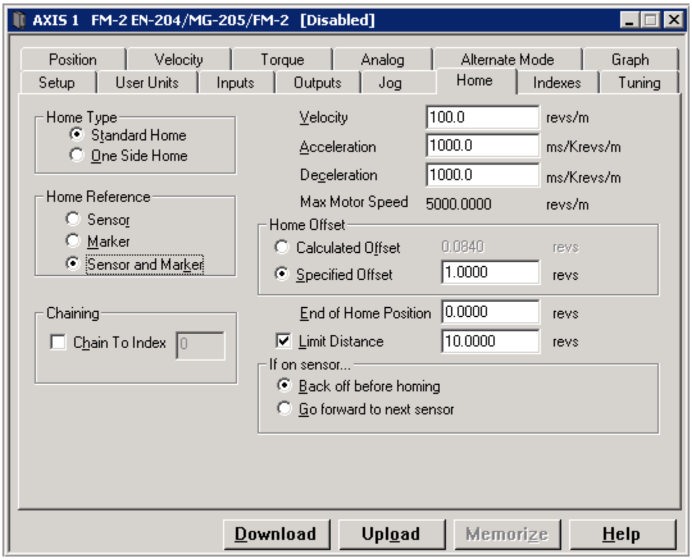


Figure 32: Sensor and Marker then Offset Screen

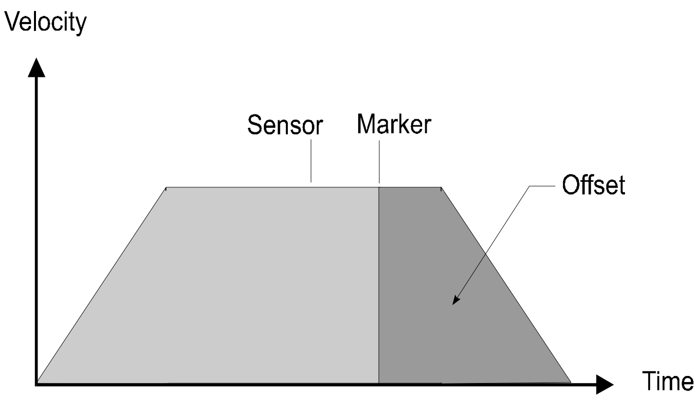


Figure 33: Home Velocity Profile

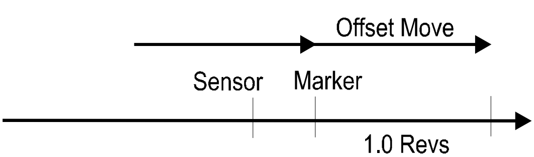


Figure 34: Home Move Sequence

How Indexes Work

An index is a complete motion sequence that moves the motor a specific incremental distance or to an absolute position. This motion sequence includes an acceleration ramp to a programmed velocity, a run at velocity, a deceleration to a stop, and a dwell time.

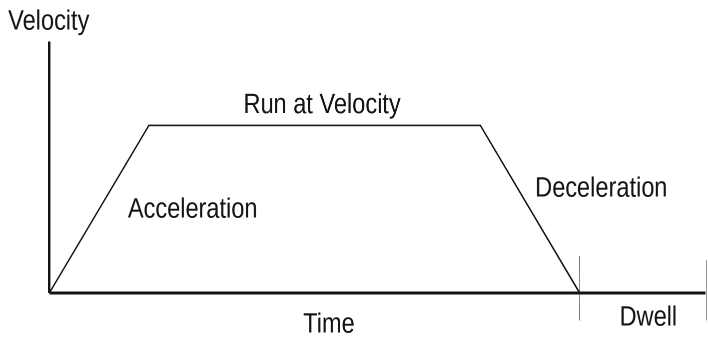


Figure 35: Complete Motion Sequence

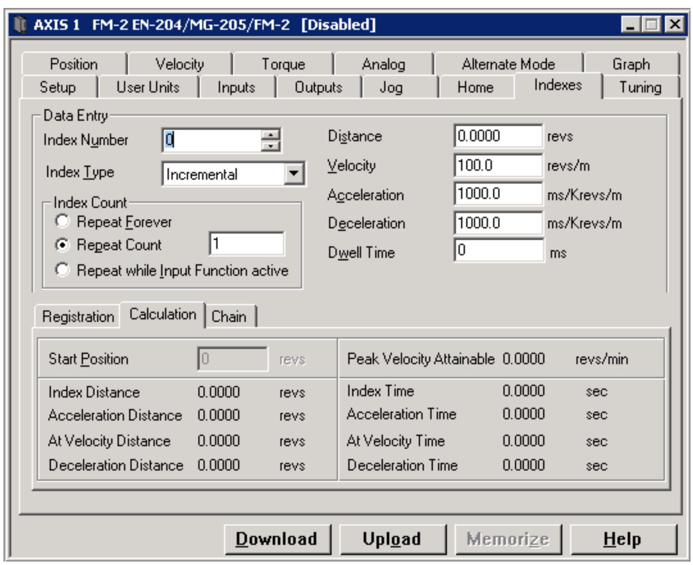


Figure 36: Indexes Tab

All Indexes use linear acceleration and deceleration ramps which may or may not reach the specified velocity depending on the total distance and the ramp values. For example, a short move with long acceleration and deceleration ramps may not reach the peak velocity entered.

Indexes cannot be initiated when any other motion (jogging, homing) is in progress. Indexes can be aborted with the Stop Input function.

Index Type

The device supports five types of indexes: Absolute, Incremental, Registration, Rotary plus, and Rotary minus.

Absolute vs. Incremental

The difference between absolute and incremental indexes is that absolute indexes move to a specific absolute position and incremental indexes move the motor a specific distance. The figures and explanations below demonstrate this concept.

Absolute Indexes

Absolute indexes are used in applications where the motor must travel to a specific position, regardless of where the motor is when the index is initiated.

The device calculates the distance required to move to the specified position from the current position.

Absolute Index

Start position = 6

Absolute index position = 4

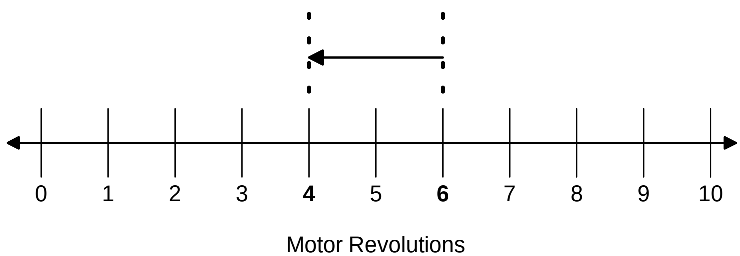


Figure 37: Absolute Index

In the example above, the index position is 4 revs. If this index is initiated the motor will travel to a position of 4 revs no matter where it is sitting before the move. From 6 revs, it will travel -2 revs. If the absolute index to 4 revs is initiated a second time, no motion will occur because the motor will already be at a position of 4 revs.

The direction of an Absolute Index is determined by the starting position and the absolute index position. If the starting position for the above index is 9 revs, then the motor will rotate in the negative direction to end up at 4 revs.

Absolute Indexes with Rotary Rollover enabled will take the shortest path to the position entered in the index position parameter.

Note

Absolute indexes move to positions relative to where the machine was homed using the home routine.

Incremental Indexes

An incremental index will move the motor a specified distance in the + or - direction regardless of the starting position. The direction of the incremental index motion is determined by the sign (+ or -) of the Index Distance parameter.

Incremental Index

Start position = 6

Index distance = 4

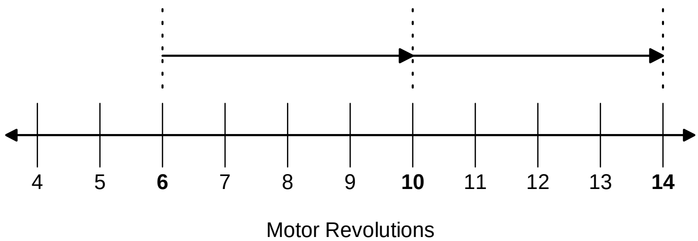


Figure 38: Incremental Index

In the example above the motor starts at 6 revs and travels a distance of 4 revs and stops at 10 revs. If the same index is initiated a second time the FM-2 Module would move the system another 4 revs to a final position of 14 revs.

Registration Indexes

A Registration Index is used in applications where the motor must move until an object is detected and then move a specific distance from the point of detection, such as finding a registration mark and moving a distance beyond.

The Registration Index consists of two parts. The first part accelerates the motor to the target velocity and continues at this velocity until it receives a registration trigger (sensor or torque). Upon receipt of a registration trigger, the registration offset will be executed at the target velocity. The Sensor Limit Distance Hit source can be used to turn on an output, if a sensor input or torque level is not received within the Limit Distance.

Rotary Plus and Rotary Minus Indexes

Rotary Plus and Rotary Minus Indexes provide forced directional control of moves to absolute positions. The position entered for a Rotary Plus or Minus type index must be within the rotary range (i.e. $0 \leq$ Position < Rotary Rollover Point). All other parameters function the same as they do with absolute indexes. An Absolute Index is a direct move to a specific position, regardless of the starting point. A Rotary Plus Index moves to the specified position, but is forced in a positive direction. Similarly, a Rotary Minus Index moves to the specific position, but is forced in a negative direction.

Rotary Plus and Minus Indexes are usually used in rotary applications, therefore the rotary rollover feature on the User Units tab in PowerTools FM software must be enabled to use them.

1. In the following examples the term “D” = (absolute position specified) - (current position). If “D” is negative, motion in the negative direction is implied.

2. In the following examples the Rotary Rollover parameter on the Setup - Position view is set to 360.00°. This means that with each revolution of the motor (or rotary table), feedback will count up to 359.99°, then roll over to Ø°.

Indexes with Rotary Rollover Enabled

Incremental move distances can be outside of the rotary rollover range. See “Setting Up Parameters” on page 67 section for an explanation of Rotary Rollover.

Example 1: If the starting position is at Ø° and 720° is the specified distance, an Incremental index would move 2 revolutions in the positive direction. At the completion of this index the motor position would be Ø°.

Absolute indexes will take the shortest path to the specified position. Absolute index positions must be within the rotary rollover range.

Example 2: If the starting position is at 90° and 80° is the specified position, an Absolute index would travel 10° in the negative direction. At the completion of this index the motor position would be 80°.

Example 3: If the starting position is 45° and 315° is the specified position, an Absolute index would travel 90° in the negative direction because that is the shortest path between 45° and 315°.

Rotary Plus indexes will move to the specified position and are forced in a positive (or plus) direction. Rotary Plus index distances must be within the rotary rollover range.

Example 4: As in example 2 above, the starting position is at 90° and 80° is the specified position. A Rotary Plus index would travel 350° in the positive direction. At the completion of this index the motor position would be 80°.

Example 5: If the starting position is 10° and the specified position is 350°, a Rotary Plus index will travel 340° in the positive direction.

Rotary Minus indexes move to the specified position, but are forced to travel in the negative (or minus) direction. Rotary Minus index positions must be within the rotary rollover range.

Example 6: As in examples 2 and 4 above, the starting position is at 90° and 80° is the specified position. A Rotary Minus index would travel 10° in the negative direction. At the completion of this index the motor position would be 80°.

Example 7: If the starting position is 15° and the specified position is 270°, a Rotary Minus index would travel 105° in the negative direction.

Index Parameters

Distance/Position

The Distance/Position parameter specifies the distance the index will travel (incremental index), the absolute position the index will move to (absolute index), or the limit distance (registration indexes).

Velocity

The Velocity parameter specifies the peak velocity used for the index. The velocity parameter is unsigned and must be greater than zero.

Acceleration

The Acceleration parameter specifies the acceleration value to be used during the index.

Deceleration

The Deceleration parameter specifies the deceleration value to be used during the index.

Dwell Time

The Index Dwell Time parameter specifies the amount of time the system will wait after the index motion before the index is considered complete.

Index Count

The Index Count parameter specifies how many times the index will repeat itself upon being initiated. There are three different parameters to choose from, Repeat Forever, Repeat Count, and Repeat while Input Function active.

Registration Tab

Registration indexes are highly accurate indexes that travel until either a sensor or torque limit is reached, or until a limit distance is achieved. The user may choose to register to one of two sensors labeled "Registration Sensor 1" and "Registration Sensor 2" or to one of two torque levels labeled "Torque Level 1" and "Torque Level 2". All items on the registration tab are unavailable until the Index Type is changed to "Registration".

Registration Sensor 1 option button

If this input function is assigned to an input in the Inputs tab, this sensor will be used for completing the simple registration move.

Registration Sensor 2 option button

If this input function is assigned to an input in the Inputs tab, this sensor will be used for completing the simple registration move.

Torque Level 1 option button

When selected the index will use a torque level as defined under the Torque tab as a registration sensor.

Note

The torque level parameter will not LIMIT the torque produced by the drive.

(insert screen shot of the torque

Torque Level 2 option button

When chosen the index will use a torque level as defined under the "torque" tab as a registration sensor.

Note

The torque level parameter will not LIMIT the torque produced by the drive.

Calculated Offset option button

When selected the drive will calculate the offset based on the deceleration and velocity specified for the index.

Calculated offset

This parameter gives the calculated distance that the motor will travel after the registration index recognizes a sensor or torque level registration input.

Specified Offset option button

When chosen the drive will use an offset value as specified by the user.

Specified Offset

This parameter is the distance that the motor will travel after the registration index recognizes a sensor or torque level registration input. This parameter may be changed by the user.

Registration Window enable

This check box when selected enables the Registration Sensor valid Window. When active, only registration marks that occur inside the registration window are seen as valid.

Registration Window Start

This parameter defines the start of the Registration Sensor Valid Window relative to the start position of this index. This is an unsigned value and is relative only to starting position of this index. Index direction does not affect this parameter. The Registration Window Start position (or distance) should be less than the Registration Window End position. If a registration sensor is seen outside of this window (not between the WindowStart and WindowEnd positions) then it will be ignored.

Registration Window End

This parameter defines the end of the Registration Sensor Valid Window relative to start position of this index. This is an unsigned value and is relative only to starting position of this index. Index direction does not affect this parameter. The Registration Window End position (or distance) should be greater than the Registration Window Start position. If a registration sensor is seen outside of this window (not between the WindowStart and WindowEnd positions) then it will be ignored.

Calculations Tab

This tab is used to display the specific motion parameters based on the distance, velocity, acceleration, and deceleration entered into the parameters above. Calculations are displayed as "Commanded" calculations and do not take into consideration any limitations that the drive and motor selection may introduce into the system.

Start Position

This parameter is used when the index type is selected to be an Absolute index. Given this case PowerTools FM uses the position entered as the starting position of the index in order to display calculations accurately.

Index Distance

This parameter displays the calculated amount of distance that the index will travel throughout the entire motion.

Acceleration Distance

This parameter displays the calculated amount of distance that the motor will travel while the index is accelerating. The Acceleration Distance is based completely on calculated motion and does not include any limitations that might be introduced by the drive, motor, and load variables.

At Velocity Distance

This parameter displays the calculated amount of distance that the index will travel at the velocity specified in the velocity parameter. The At Velocity Distance is based completely on calculated motion and does not include any limitations that might be introduced by the drive, motor, and load variables.

Deceleration Distance

This parameter displays the calculated amount of distance that the motor will travel while the index is decelerating. The deceleration distance is based completely on calculated time and does not include any limitations that might be introduced by the drive, motor, and load variables.

Peak Velocity Attainable

This parameter stores the calculated peak velocity of the index motion. If the acceleration and deceleration parameters are set in a fashion that the maximum velocity is not attainable, the peak velocity could be lower than the velocity specified in the velocity parameter. The Peak Velocity Attainable is based completely on calculated motion and does not include any limitations that might be introduced by the drive, motor, and load variables.

Index Time

This parameter stores the calculated time that the index will take to complete. This index time is based completely on calculated time and does not include any limitations that might be introduced by the drive, motor, and load variables.

Acceleration Time

This parameter displays the calculated time that it will take the index to accelerate. The Acceleration Time is based completely on calculated time and does not include any limitations that might be introduced by the drive, motor, and load variables.

At Velocity Time

This parameter displays the calculated time that the index will be at its specified velocity as entered in the velocity parameter. The At Velocity Time is based completely on calculated time and does not include any limitations that might be introduced by the drive, motor, and load variables.

Deceleration Time

This parameter displays the calculated time that it will take the index to decelerate. The deceleration Tim is based completely on calculated time and does not include any limitations that might be introduced by the drive, motor, and load variables.

How Chaining Works

Chaining is a way to combine two or more indexes into a single sequence. Any index can be chained to another index regardless of index type. By chaining multiple indexes together, the user is only required to perform a single index initiate to execute multiple indexes. Each index in the chain is performed exactly the same as if they were run individually.

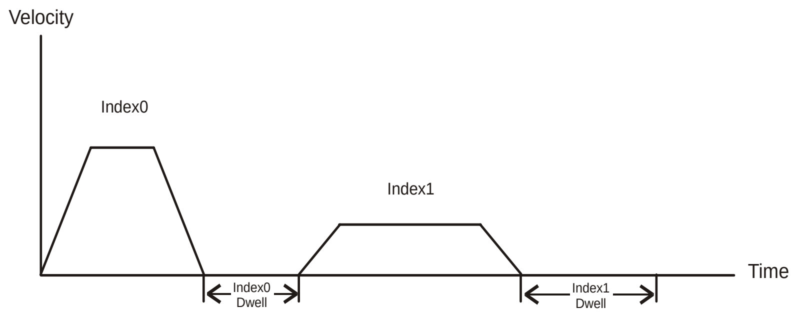


Figure 39: Chaining Example

In the above example, Index0 is chained to Index1. When the user activates the Index Initiate, Index0 starts and, upon completion of Index0 (after Index0 Dwell), Index 1 is automatically initiated. Index1 could then be chained to a third index, or back to Index0 if desired.

All chaining configuration is done on the Chain tab on the Indexes screen. All index parameters are setup on the top portion of the screen. The chaining parameters are found on the Chain tab as shown below.

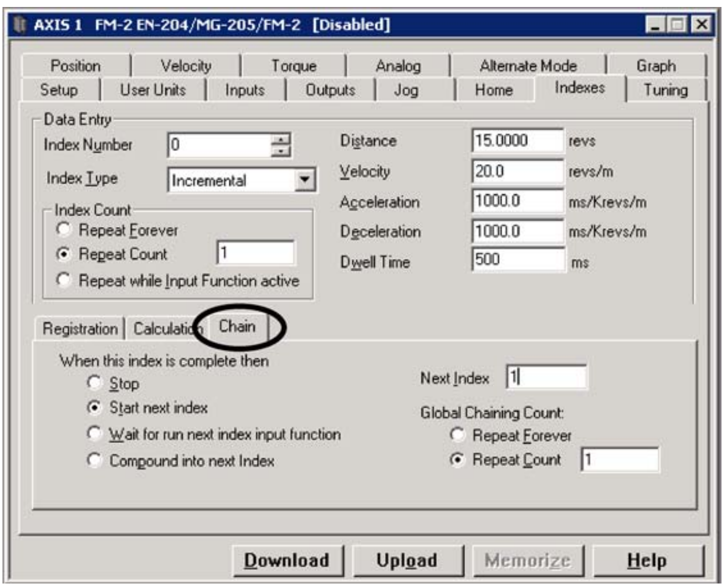


Figure 40: Indexes Tab – Chain Tab

Chaining Parameters

Several parameters must be setup in order to create an index chain. These parameters are as follows:

When this index is complete then

This setting has four different options that define what will happen when the specific index is complete. The available options are Stop, Start Next Index, Wait for Run Next Index input function, or Compound into next Index. Stop is the default selection, so in a default configuration, no indexes are chained together.

Stop

If “Stop” is selected, then the motor will come to a stop at the end of the index and the system will return to a Ready state. If Stop is selected, the Next Index parameter will be unavailable.

Start Next Index

If “Start Next Index” is selected, then the specific index will be chained to the index number shown in the Next Index text box. Therefore, at the end of the specified index (after Dwell is complete), the index shown in the Next Index text box will start automatically.

Wait for Run Next Index input function

If “Wait for Run Next Index input function” is selected, then the specific index will be chained to the index number shown in the Next Index text box. At the end of the specified index (after Dwell is complete), the motor will stop and wait until the “Run Next Index” input function is activated. Once the “Run Next Index” input function is activated, then the index shown in the Next Index text box will start immediately. This function can be used if hand-shaking is required between the FM-2 and a master controller. The FM-2 will wait for the master to activate the Run Next Index input to tell the FM-2 to continue.

Compound into next Index

If "Compound into next Index" is selected, then the specific index will maintain current index velocity until IndexDist is reached then the next index’s accel ramp is used to change velocity.

Next Index

This parameter specifies what index the current index will be chained to. This parameter is only enabled when Start Next Index, Wait for Run Next Index input function, or Compound into next Index is selected. The default index to chain to is 0. If the user wishes to perform a chain of indexes multiple times, the Index in the Next Index text box on the last index of the chain must be set to the first index of the chain. For example if Index0 is chained to Index1 which is chained to Index2, and the user wishes to run the chain multiple times. The Index in the Next Index text box for Index2 must be set to 0 (Index 0).

Global Chaining Count

This setting defines how many times a chain of indexes will be repeated. The available options are Repeat Forever or Repeat Count #. The chain count only applies when the last index of the chain is chained to the first index of the chain. If the "When this index is complete then" setting is set to "Stop", then the chain will not be repeated.

Repeat Forever

If Repeat Forever is selected, then the chain will repeat itself infinitely. The only way to stop the chain is to activate the Stop input function.

Repeat Count

If Repeat Count is selected, then the user must specify the number of times they wish to repeat the chain.

Only one Chain Count can be used at a time. The Global Chaining Count applies to all chains that are setup. If the user wants to run two different chains, then both chains use the same Chain Count.

Index Input and Output Functions

The input and output functions related to indexes can be configured through PowerTools FM software.

Index Initiate

The Index Initiate Input function initiates the selected index. The selected index is specified using Index Select Input functions 0 through 3. If none of the index select functions are assigned, index #0 will be initiated.

No indexes can be initiated when other motion types are in progress (jogging or homing).

Index Select Input 0 through 3

The Index Select Input functions are used to specify the index to be initiated with the Index Initiate input function. That is, the first line, Index Select 0, has the value of 1, the second, Index Select 1, a value of 2, the third, Index Select 2, a value of 4, the fourth, Index Select 3, a value of 8. The index number selected is the sum of the values of the active index select functions. The table below shows this concept. The status of the four Index Select Input functions are combined together to form a 4 bit binary number.

Index Select #0 (value = 1)	Index Select #1 (value = 2)	Index Select #2 (value = 4)	Index Select #3 (value = 8)	Selected Index
Off	Off	Off	Off	0
On	Off	Off	Off	1
Off	On	Off	Off	2
On	On	Off	Off	3
Off	Off	On	Off	4
On	Off	On	Off	5
Off	On	On	Off	6
On	On	On	Off	7

Index Select #0 (value = 1)	Index Select #1 (value = 2)	Index Select #2 (value = 4)	Index Select #3 (value = 8)	Selected Index
Off	Off	Off	On	8
On	Off	Off	On	9
Off	On	Off	On	10
On	On	Off	On	11
Off	Off	On	On	12
On	Off	On	On	13
Off	On	On	On	14
On	On	On	On	15

With all four Index Select input functions inactive, Index number 0 will be initiated when the Index Initiate input function is activated. If you activate Index Select lines 0 and 1, Index number 3 (1 + 2 = 3) will be initiated when the Index Initiate function goes active. If you activate all four Index Select lines simultaneously, the selected Index number is 15 (1 + 2 + 4 + 8 = 15).

It is not necessary to assign all four Index Select input functions to input lines. Unassigned input functions are considered to be inactive. An application that only required four different indexes could assign Index Select 0 and 1 to input lines and leave Index 2 and 3 unassigned. The two input lines could then be used to select indexes 0, 1, 2 and 3.

Registration Sensor 1

This input function is usually used with an external hardware sensor. It is used as the registration reference in a registration index. If the option button on the registration tab on the Indexes Tab is set to Registration Sensor 1, then the registration offset portion of the index will begin when this input function is activated. Two registration sensor input functions have been provided for applications requiring multiple sensors.

Registration Sensor 2

This input function is usually used with an external hardware sensor. It is used as the registration reference in a registration index. If the option button on the registration tab on the Indexes Tab is set to Registration Sensor 2, then the registration offset portion of the index will begin when this input function is activated. Two registration sensor input functions have been provided for applications requiring multiple sensors.

Run Next Index

This input function is used when chaining indexes together, and the user wants to wait for an input to continue the chain, instead of starting the Next Index instantly. If “When this index is complete then” is set to “Wait for run next index input function”, then the current index will complete itself, and wait until this input function is activated to begin the next index in the chain.

Repeat Current Index

When the Repeat while Input Function active option button is selected on the Index tab, an initiated index will continue to function until this input goes low.

End Of Index

This output function is activated when any index is completed. This output function is deactivated when any Home, Jog or Index is initiated.

End of Chaining Count

This output function is activated when the index chain has repeated the chain the number of times as specified in the Global Chain Count parameter. When the last index in the chain has completed the specified Chain Count times (after the Dwell), the End of Chaining Count will activate and remain on until the next index initiate.

End of Index Motion

This output function activates when the motor ceases motion from a given index and becomes inactive when the next index is initiated. When indexes are chained together, the "End of Index Motion" output will turn on in between indexes. If chained indexes are configured such that there is no stop in motion then this output will still become active for 400usec in between indexes. When indexes are compounded together the "End of Index Motion" will not become active between indexes but will at the end of the compounding.

End of Index

This output function Activates when the specified index motion command is completed. If a stop is activated before the index has completed the function will not be activated. This function is inactivated when the specified index command is executed. When indexes are chained together, the "End of Index Motion" output will turn on in between indexes.

Examples

Below is a list of examples that use chaining and show timing diagrams for pertinent input and output functions based on index motion. The indexes for the examples are setup as follows:

Index0
Count = 2
Dwell = 100 msec
When this index is complete then – Stop

Index1
Count = 2
Dwell = 200 msec
When this index is complete then – Start next index
Next Index = 2
Chain Count = 1

Index2
Count = 1
Dwell = 300 msec
When this index is complete then – Stop
Chain Count = 1

Index3
Count = 1
Dwell = 150 msec
When this index is complete then – Start next index
Next Index = 4
Chain Count = 2

Index4
Count = 1
Dwell = 150 msec
When this index is complete then – Start next index
Next Index = 3
Chain Count = 2

Index5
Count = 2
Dwell = 0 msec
When this index is complete then – Wait for run next index input function
Next Index = 6
Chain Count = 1

Index6
Count = 1
Dwell = 150 msec
When this index is complete then – Stop
Chain Count = 1

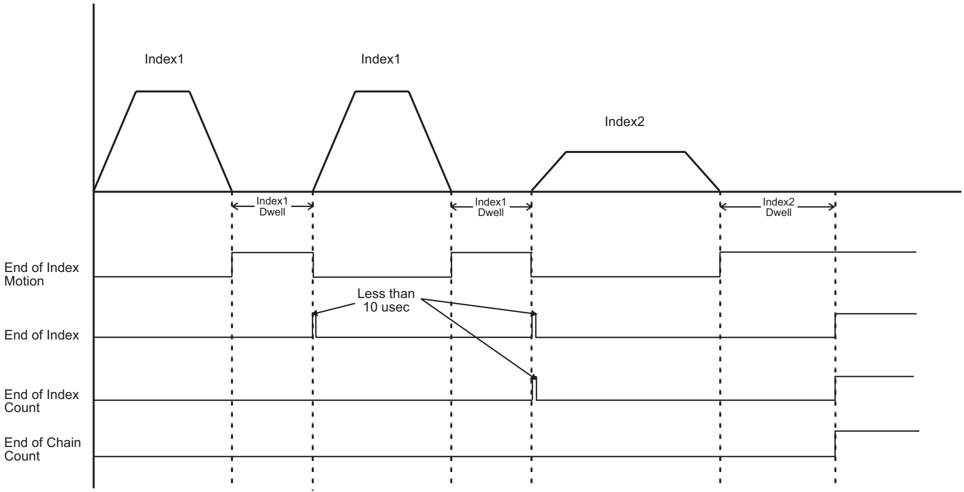


Figure 41: Example 1 – Index1 is chained to Index2 with a Chain Count of 1.

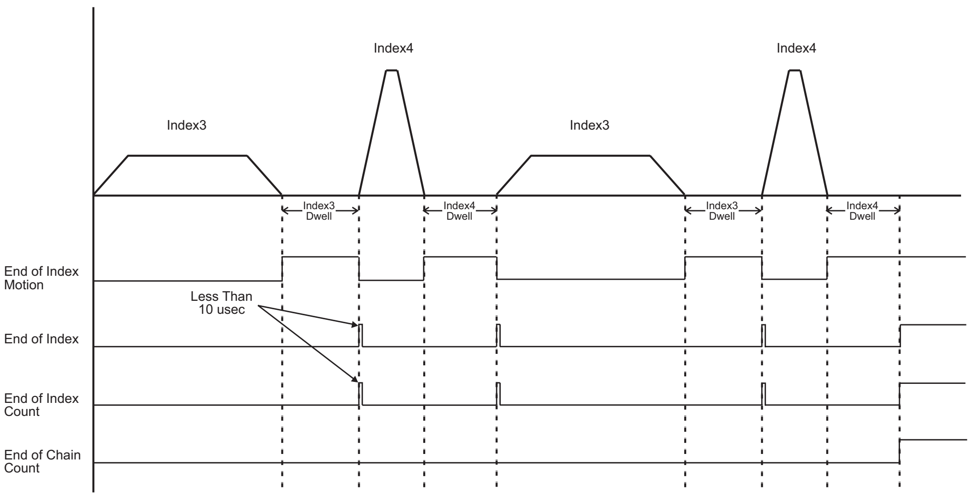


Figure 42: Example 2 – Index3 is chained to Index4 with a Chain Count of 2.

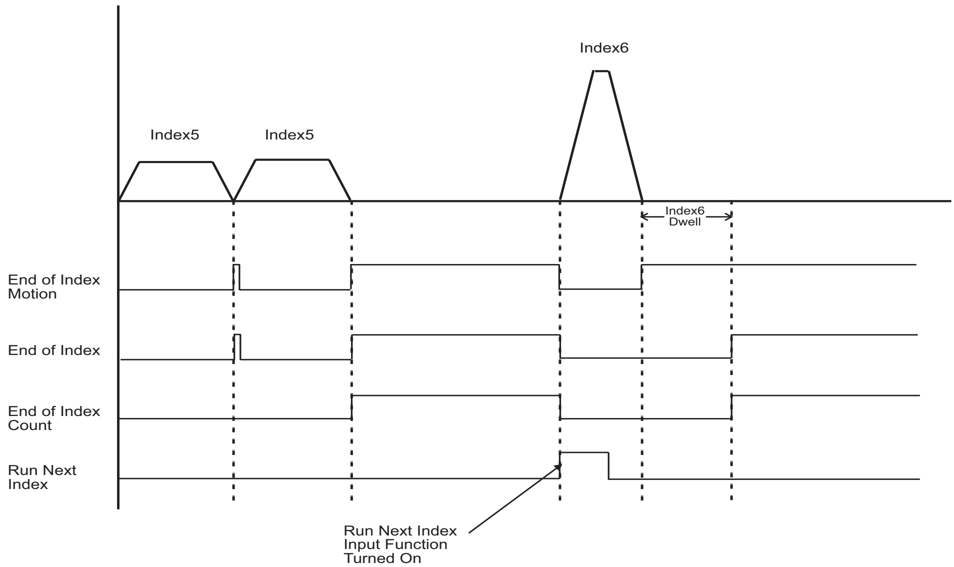


Figure 43: Example 3 – Index5 is chained to Index6 using the Wait for Run Next Index input function.

How Alternate Mode Works

In addition to Jog, Index, and Home functions, the Ei drive provides three basic modes of operation in Alternate Mode: Analog Velocity, Analog Torque, and Pulse Mode.

When in Alternate Mode the drive will ignore all Index, Home, or Jog initiate requests. If the drive is indexing, homing, or jogging when alternate mode is turned on, the drive will initiate a stop command and use the stop decel to ramp down to zero, then it will switch into alternate mode.

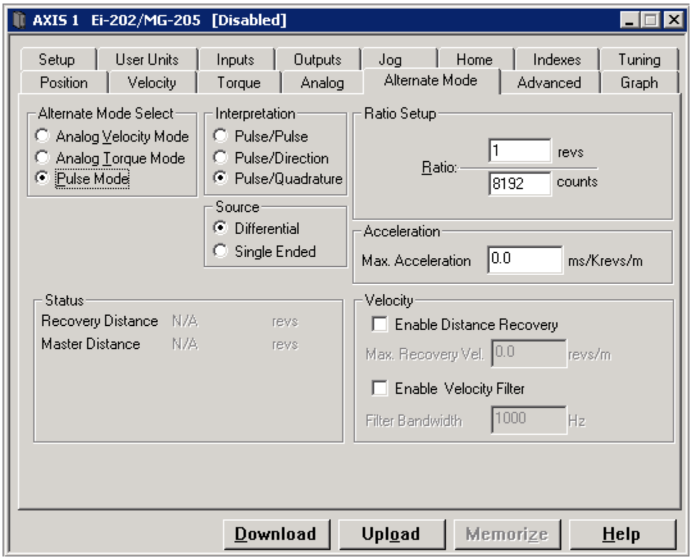


Figure 44: Alternate Mode Screen - Pulse Mode

Alternate Mode Select

Analog Velocity Mode

Analog Inputs

The Analog Inputs 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.

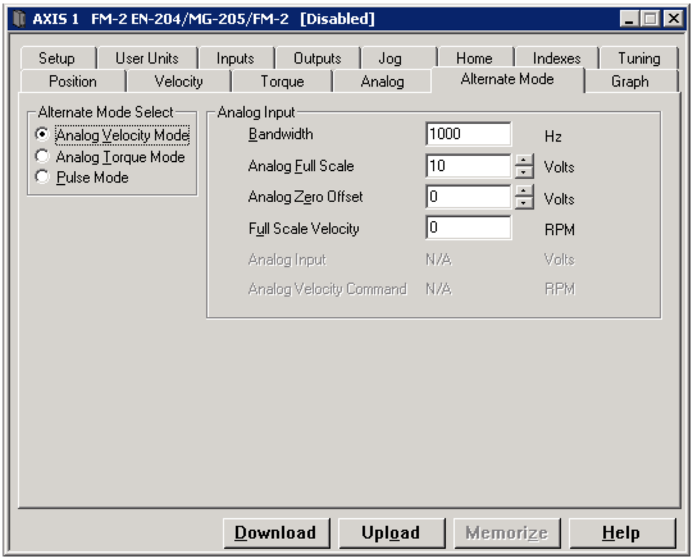


Figure 45: Alternate Mode - Analog Velocity Mode

Analog Input Group

Bandwidth

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

Analog Full Scale

This voltage sets the maximum value that the analog input will reach in normal operation. Valid range for this parameter is -10 to 10 volts.

Analog Zero Offset

This voltage corresponds to zero velocity in the motor and has a range from -10 to 10 volts.

Full Scale Velocity

This parameter displays the maximum velocity attainable given the max analog value detailed in the Analog Full Scale parameter.

Analog Input

This parameter displays the actual value of the analog input in volts.

Analog Velocity Command

When the drive is in Analog Velocity mode this parameter shows the current velocity commanded after the scaling of the Analog input function.

Analog Accel/Decel Limit

Found on the Velocity tab, this feature 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.

Analog 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)

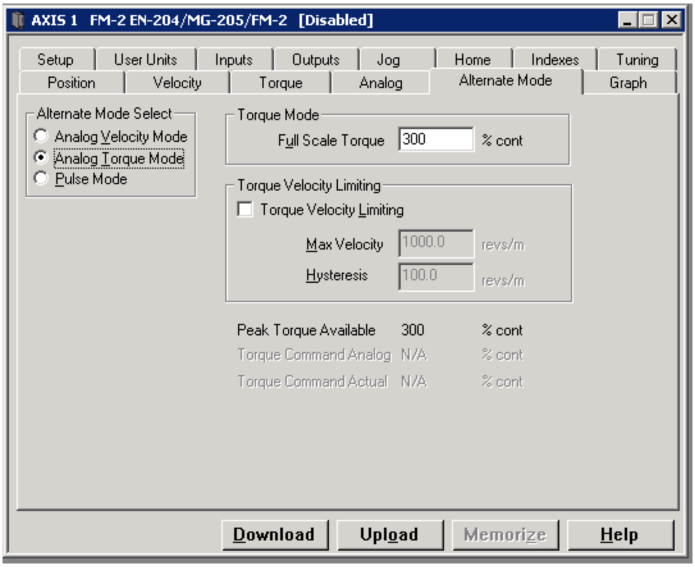


Figure 46: Alternate Mode - Analog Torque Mode

Torque Mode Group

Full Scale Torque

This parameter allows the user to scale torque in the drive to the analog input. Full scale torque = 10 Vdc.

Torque Velocity Limiting Group

Torque Velocity Limiting Check box

When this check box is selected, the Max Velocity and Hysteresis parameters are available in torque mode. This feature will stop the motor from "running away" when the torque is removed from the motor shaft.

Max Velocity

When operating in Torque Mode, this parameter represents the maximum velocity attainable independent of the torque on the motor shaft.

Hysteresis

When the Torque Velocity Limiting check box is selected, the drive will switch between Velocity Mode and Torque Mode depending on the speed of the motor. If the motor reaches the maximum velocity as specified by the Max Velocity parameter, the drive will switch into a constant Velocity Mode until the torque increases on the motor shaft bringing the motor speed down to the Hysteresis point. At this point the drive will switch back into Torque Mode until the Max Velocity point is reached again.

Peak Torque Available

The Peak torque available parameter describes the peak torque available for the system, or the drive and motor combination based on the .ddf file.

Torque Command Analog

This parameter is only available on-line and displays the torque that is being commanded via the analog input.

Torque Command Actual

This parameter is only available on-line and displays the actual torque being required from the drive.

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.

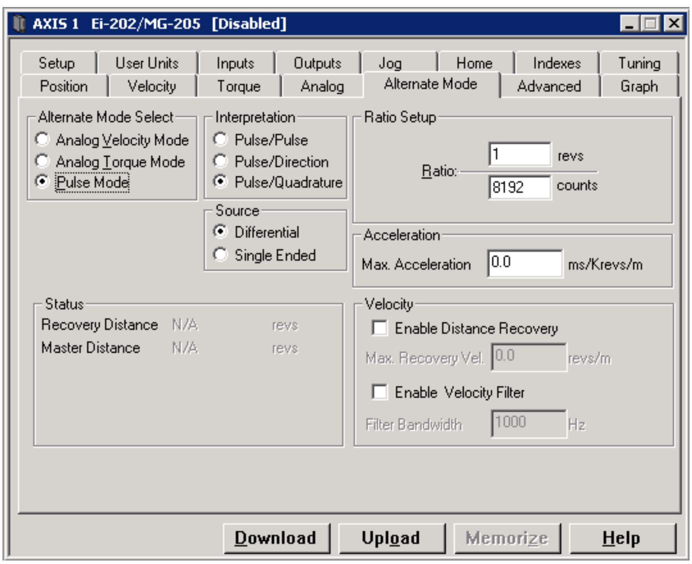


Figure 47: Alternate Mode - Pulse Mode

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 Alternate screen.

Differential Source

The Differential setting (default) is perfect for most encoders or upstream drives. 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.

Single Ended Source

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 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.

The two hardware input circuits are included in the drive and are accessible through the drive command connector. 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):	+/-10 V
Differential (referenced to mating differential input):	+/-10 V

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 input frequency maximum

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

1.5 V low level

3.5 V high level

Output driver requirements:

15 mA sinking (open collector)

5 V 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.

Interpretation Group

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*.

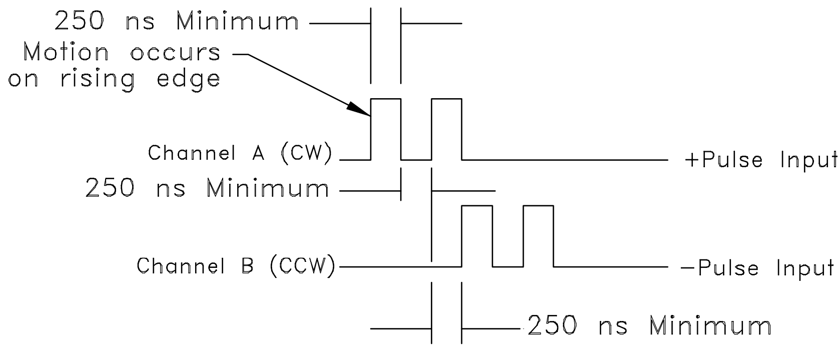


Figure 48: Pulse/Pulse Signals, Differential Inputs

Note

If a travel limit is encountered when in Pulse mode, the user must exit alternate mode and either jog or index off of the travel limit sensor before continuing.

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*.

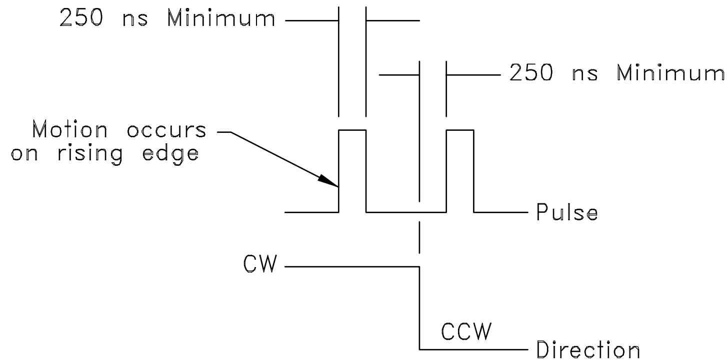


Figure 49: Pulse/Direction Signals, Differential Inputs

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*.

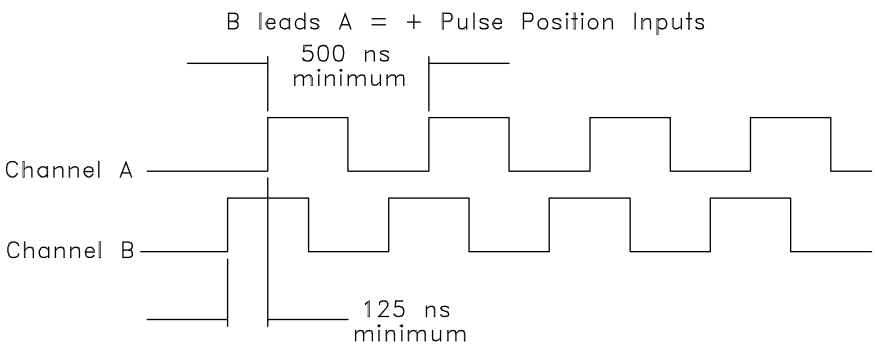


Figure 50: Pulse/Quadrature Signals, + Command

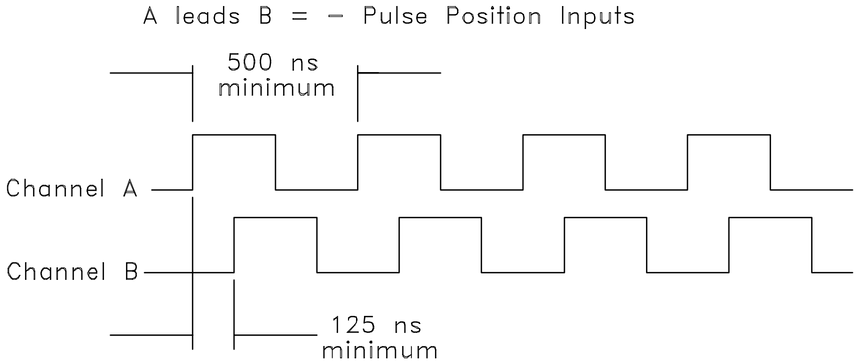


Figure 51: Pulse/Quadrature Signals, – Command

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 preloaded serially with a value after power-up.

Status Group

Recovery Distance

This parameter is only available on-line and stores the number of counts that have been lost during the accel portion of pulse mode. These pulses may be used to recover any distance lost during accel by selecting the Enable Distance Recovery check box.

Master Distance

The Master Distance parameter is only available on-line and displays the master position in the user units specified on the User Units tab.

Ratio Setup

Ratio

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

Acceleration

Max Acceleration

Sometimes when pulse mode is enabled, the Master will already be traveling at a velocity. By default the drive will attempt to ramp up to this velocity in one processor control loop. In most applications this very fast accel is not desirable. The maximum acceleration parameter displays a maximum ramp that the follower will use to ramp up to the specified pulse ratio. Once the follower is at the Master velocity, this accel parameter is disabled and the follower will follow pulse for pulse depending on the specified ratio.

If an acceleration greater then 1000 ms/Krpm is entered into this parameter the drive will set this parameter to 1000 ms.Krpm.

Velocity Group

Enable Distance Recovery Check box

This check box when selected, activates the Distance Recovery feature of the drive. If a master is traveling at a velocity when pulse mode is initiated the follower will travel up to the specified ratio using an acceleration as specified by the user. If using the accel causes the follower to lose any pulses, these pulses will be saved into the Recovery Distance parameter and will be added onto the followers profile after it obtains the specified ratio.

Max Recovery Vel.

This parameter sets the maximum velocity that the motor may obtain as it corrects for pulses lost during the accel portion of pulse mode.

Enable Velocity Filter Check box

The Enable Velocity Filter check box is used to turn on or turn off the Input Pulse Velocity Filter. When the Enable check box is selected, the filter is active and the user may select the bandwidth desired to filter above. If clear, the filter is not used.

Filter Bandwidth

This parameter represents the bandwidth in hertz of the input pulses velocity filter. This filter must be enabled in order for it to function. The valid range of this parameter is 0 to 1200 hertz.

Alternate Mode Input and Output Functions

Alternate Mode Enable

This is a level sensitive function and may be enabled using Input assignments or through Modbus. Alternate Mode Enable allows the drive to run in either Pulse Mode, Analog Velocity Mode, or Analog Torque Mode.

Torque at Max Velocity

While in Torque mode, the output indicates that the motor is velocity limited.

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 **E Series 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.

Encoder Output 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 Output 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. This feature is enabled by checking the Encoder Output Scaling Enable check box in PowerTools FM.

You can setup this feature from the Setup tab in PowerTools FM or using the MODBUS® parameters, Encoder Output Scaling and Encoder Output Scaling Enable.

Current Foldback

Epsilon Only

Current foldback is used to protect the motor and drive from overload. There is one level of current foldback: RMS Foldback.

RMS Foldback is displayed on the diagnostic display as a "C".

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.

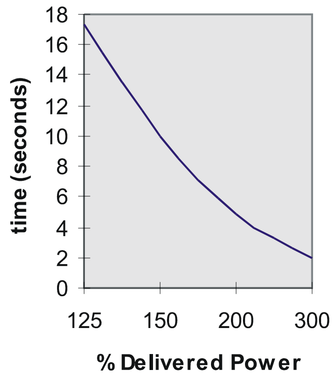


Figure 52: RMS Foldback Trip Point (this graph is accurate to ±5 percent)

Shunt Operation

Shunt Active Output

Epsilon Only

Time indicator of when an external shunt transistor should fire. It can be used to trigger an external shunt transistor. This output is active on Epsilon drives and indicates when the bus voltage reaches 390 Vdc. It shuts off when the bus voltage is reduced below 380 Vdc.

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.

Optionally, the shunt active output can be used to trigger an external shunt transistor.

Brake Operation

Motor brake operation can be 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 (see “Diagnostic Display”).

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	0	1	1	1
	Disabled	0	0	1	1

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

Brake Release

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

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

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 Outputs

The drive has two 10 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.

Each Channel provides a programmable Analog Output Source.

Analog Output Source options are:

- Velocity Command
- Velocity Feedback
- Torque Command

- Torque Feedback
- Following Error

Default Analog Output Source:

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

Output	Source	Offset	Scale
1	Velocity Feedback	0	600 RPM/volt
2	Torque Command	0	30% /volt

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
- Torque Feedback = Percent of continuous torque
- Following Error = Revs

Analog Output Scale units:

- Velocity Command = RPM/volt
- Velocity Feedback = RPM/volt
- Torque Command = Percent of continuous torque/volt
- Torque Feedback = Percent of continuous torque/volt
- 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 ±10V = ±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 to +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 on the drive or the FM-2 Module. After they are assigned to lines, external controllers, such as a PLC or other motion controllers, may be used to affect or monitor the device's operation.

EN **E Series Only**

EN drives are equipped with five optically isolated input lines (one dedicated to a Drive Enable function) and three optically isolated output lines. The FM-2 Module has an additional eight input and four output lines.

The EN drive's input and output lines can be accessed through the removable 10-pin I/O connector (J6), or through the 44-pin command connector (J5).

All inputs and outputs are configured as sourcing and are designed to operate from a +10 to 30 Vdc power source. You are responsible for limiting the output current to less than 150 mA for each digital output.

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 not active 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 not active while 10 to 30 Vdc is being applied.

Note

Input functions which initiate motion (Jog +, Jog -, Index Init and Home Init) cannot be set "Active Off".

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 Lines 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.

Input Line Debounce Time

You can program a “Debounce Time” which means the line will need to be “On” for at least the debounce time before it is recognized. This feature helps prevent false triggering in applications in noisy electrical environments.

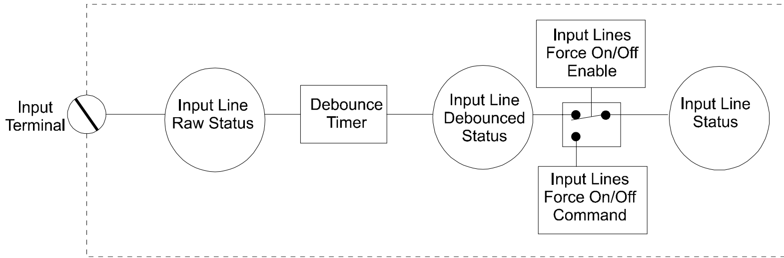


Figure 53: Input Line Diagram

If the Input Line attached to the home sensor is debounced, the actual rising edge of the Home Sensor is used to determine the Home Reference Position (the debounce time ensures a minimum pulse width).

Output Lines 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.

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 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.

Input Functions

Alternate Mode Enable

This input function will enable the Alternate Mode features.

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.

Define Home

This input function is used to set the absolute position to zero. On the rising edge of this input function the absolute position is set to zero and the Absolute Position Valid output function is activated.

Home Initiate

This input function is used to initiate a home routine. The home is initiated on the rising edge of this input function. The drive will not initiate a home routine if there is an Index or Jog in progress or the stop input function is active. The Home Initiate Input function cannot be set “Active Off”.

Home Sensor

This input function defines the sensor used for homing. It is required if you are homing to a sensor or a sensor and marker. This function is edge sensitive. The sensor position is defined when the device senses the rising edge of the sensor.

Index Initiate

This input function initiates the selected index. The index to be initiated is specified using the index select input functions 0 through 3. If none of the index select functions are assigned then index #0 will be initiated. This input function cannot be set “Active Off”.

Index Select 0 through 3

The Index Select Input functions are used to specify the index to be initiated with the Index Initiate input function. The format of the Index Select functions (0 through 3) is binary. That is, the first line, Index Select 0, has the value of 1, the second, Index Select 1, a value of 2, the third, Index Select 2, a value of 4, the fourth, Index Select 3, a value of 8. The index number selected is the sum of the values of the active index select functions. The table below shows this concept.

Index Select #0 (value = 1)	Index Select #1 (value = 2)	Index Select #2 (value = 4)	Index Select #3 (value = 8)	Selected Index
Off	Off	Off	Off	0
On	Off	Off	Off	1
Off	On	Off	Off	2
On	On	Off	Off	3
Off	Off	On	Off	4
On	Off	On	Off	5
Off	On	On	Off	6
On	On	On	Off	7
Off	Off	Off	On	8
On	Off	Off	On	9
Off	On	Off	On	10
On	On	Off	On	11
Off	Off	On	On	12
On	Off	On	On	13
Off	On	On	On	14
On	On	On	On	15

With all four Index Select lines assigned, but none of them active, Index number 0 will be initiated when the Index Initiate input function goes activated. If you activate Index Select lines 0 and 1, Index number 3 (1 + 2 = 3) will be initiated when the Index Initiate function goes active. If you activate all four Index Select lines simultaneously, the selected Index number is 15 (1 + 2 + 4 + 8 = 15).

Jog +

This input function causes the drive to jog in the positive direction. It cannot be set "Active Off". This input function will have no affect if the device is already performing a home or an index, or if the stop input function is active or if the Travel Limit + Input function is active.

Jog -

This input function causes the drive to jog in the negative direction. It cannot be set "Active Off". This input function will have no affect if the device is already performing a home or an index, or if the stop input function is active.

Jog Fast

This input function is used in conjunction with the Jog+ and Jog- functions to specify the desired jog speed. When it is not active and Jog + or Jog - is activated, the drive will jog at the velocity specified by the Jog Velocity parameter. When it is active and Jog + or Jog - is activated, the drive will jog at the velocity specified by the Jog Fast Velocity parameter.

Registration Sensor 1

This input function is usually used with an external hardware sensor. It is used as the registration reference in a registration index. If the option button on the registration tab on the Indexes Tab is set to Registration Sensor 1, then the registration offset portion of the index will begin when this input function is activated. Two registration sensor input functions have been provided for applications requiring multiple sensors.

Registration Sensor 2

This input function is usually used with an external hardware sensor. It is used as the registration reference in a registration index. If the option button on the registration tab on the Indexes Tab is set to Registration Sensor 2, then the registration offset portion of the index will begin when this input function is activated. Two registration sensor input functions have been provided for applications requiring multiple sensors.

Repeat Current Index

When the Repeat while Input Function active option button is selected on the Index tab, an initiated index will continue to function until this input goes low.

Reset

This input function is used to reset fault conditions and is logically OR'ed with the Reset/ Setup button on the front of the drive's. A rising edge is required to reset faults.

Run Next Index

This input function is used with index chaining. If the "When this index is complete then..." setting is set to "Wait for Run Next Index input function", then the current index will stop and wait until this input function is activated before starting the next index in the chain.

Stop

The Stop input function uses the Stop Deceleration Ramp to decelerate the motor to zero velocity and hold position. If the Stop input function is activated when a Jog, Index or Home is in progress, it will be terminated. When this function is active, all Jog, Index and Home input functions will be ignored.

When it is deactivated, all level sensitive and active input functions (Jog +, Jog -, Jog Fast) will become operational. For example, if the Jog + input function is active when the Stop input function is deactivated, the Jog + motion will initiate using the Jog Acceleration parameter.

The decimal point on the EN drive LED goes "Off" when the stop function is activated (or the drive is disabled).

Torque Limit Enable

This input function, when active, causes the Torque Command to be limited to the value of the Torque Limit parameter.

Travel Limit + and -

The + and - Travel Limit input functions will stop motion in the direction indicated by the input function name using the Travel Limit Deceleration rate. These inputs will function regardless of how the motion was initiated (i.e., index, jog or home).

When an axis is stopped by a Travel Limit function, it will maintain position until it receives a motion command (i.e., jog) that moves it in the opposite direction of the active Travel Limit.

For example, the Jog + input could be used to move off the Travel Limit -.

Output Functions

Absolute Position Valid

This output is activated when either the Define Home input function is activated or the End of Home output function is activated. This output is deactivated if the drive is rebooted, an encoder fault occurs, the device is powered down, or a home is reinitiated.

At Velocity

This output function is active whenever the motor is at the peak commanded velocity of a home, jog or index. It activates when the acceleration ramp completes and deactivates when the deceleration ramp begins.

Brake

The Brake output function must be 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”.

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.

End of Home

This output function is activated when a home cycle is completed successfully (Home Limit distance not hit). When this output function is activated, the Absolute Position Valid output function is activated. This output function is deactivated when any Index, Home or Jog is initiated.

End of Chaining Count

This output function will activate when the index chain count is complete or the index chain has repeated itself the specified number of times. This output function will remain active until another chain is started.

End of Index

This output function is activated when any index is completed. This output function is deactivated when any Home, Jog or Index is initiated.

End of Index Motion

This output function will activate when the index motion stops (prior to dwell). It will remain active until another index is initiated or the next index in the chain begins. If two indexes are chained together without a dwell in between (dwell at default of 0 ms), then this output function will be active for 400 µs.

End of Index Count

This output function will activate when an index repeats itself the number of times specified in the index count parameter. It will remain active until the next index is initiated. If "Repeat Forever" is selected for the index count, this function will never activate.

Fault

This output function is active whenever a drive fault condition exists.

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 circuit will limit the current delivered to the motor to 80 percent of the continuous rating.

Home Limit Distance Hit

This output function indicates that no home reference was sensed during the move to the Home Limit Distance.

In + and In - Motion

This output function is activated whenever the velocity is greater than the In Motion Velocity parameter in the positive or negative direction. The default value for the In Motion Velocity parameter is 10 RPM. Hysteresis is used to avoid a high frequency toggling of this output function. This function is deactivated when the motor velocity slows to less than 1/2 of the In Motion Velocity parameter.

Index in Position

At the end of an index this output is activated when the position feedback is within a specified window of distance from the position command for a specific amount of time.

To implement this function the user must set up an "index in position" window and time (found in the Position tab). After the index command is complete, the output will not become active until the position feedback is within the "index in position" window for the amount of time specified by "index in position" time.

Registration Limit Distance Hit

This output function will activate if a registration index travels the full limit distance without seeing a registration sensor or torque level (depending on which was selected).

Shunt Active

This is a real time indicator of the internal shunt activity.

Travel Limit + and -

These output functions are active when the associated Travel Limit input functions are active.

Torque at Max Velocity

This output function is active only when the drive is in Analog Torque Mode. When "Torque Velocity Limiting" is enabled and the velocity feedback reaches the specified "Max Velocity" this output is activated and the motor velocity reaches a ceiling.

Torque Limit Active

This output is active if the Torque Command exceeds the specified Torque Limit value. (The Torque Command Actual is limited to the torque limit).

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.

Torque Level 1 and 2 Active

This output is active if the Torque Command exceeds the specified Torque Level 1 value.

Setting Up Parameters

Setup Tab

The setup tab is displayed as the default each time you open a Configuration Window.

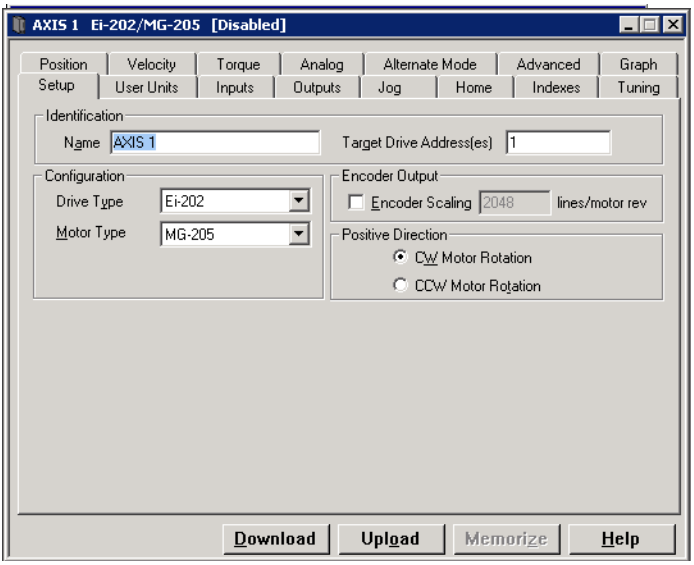


Figure 54: Setup Default Tab

Identification Group

Name

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

Target Drive Address(es)

Enter the “Target Drive Address(es)” to which you wish to download the setup information. Unless you have changed the Modbus address of your device, 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 devices 1, 3, 4, 5, 6, 7 and 9 you could enter the addresses like this: 1,3-7,9.

Configuration Group

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 unless Show All Motors is selected.

Show All Motors

When this is selected all motors that can be used with the drive family are shown. Example, a Ei-202 drive type is used and the Show All Motors is selected, all the motors listed in the Motor Type list box can be used with any Ei drive. If Show All Motors is clear only the motors that can be used with the Ei-202 will be in the Motor Type list box.

⚠ CAUTION

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

Line Voltage

EN **E Series 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.

⚠ CAUTION

The Line voltage must <u>never</u> be set to 115 Vac if the applied voltage is actually 230 Vac. This can cause drive instability and failure.

Encoder Output Group

Encoder Scaling Check Box

This feature allows you to enable the Encoder Scaling parameter.

Encoder Scaling

This feature allows you to change the drive encoder output resolution in increments of 1 line per revolution up to the density of the encoder in the motor. If the Encoder Output 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. The default is to the motor encoder density.

Positive Direction Group

CW Motor Rotation Option Button

Select this option button for applications in which CW motor rotation is considered to be motion in the positive direction (increasing absolute position).

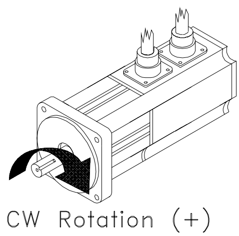


Figure 55: CW Rotation

CCW Motor Rotation Option Button

Select this option button for applications in which CCW motor rotation is considered to be motion in the positive direction (increasing absolute position).

User Units Tab

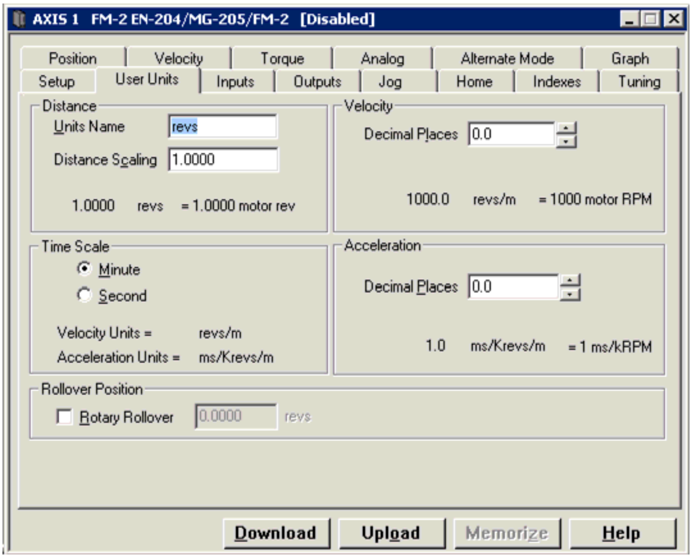


Figure 56: User Units Tab

Units Name

Select the type of units to be used throughout the configuration for all Position/Distance parameters. The default units are revs.

Units Scaling

This will specify the number of user units in 1.0000 motor revolution. This parameter also determines the resolution of distance/position parameters for the entire configuration. The number of decimal places specified here sets the maximum resolution.

For example, If the user has a leadscrew with a 0.5" lead and wishes to perform indexes of 0.025", the Units Scaling must be set to 0.500. By specifying three digits after the decimal place, the user will be able to enter the three digits necessary for the index distance.

Velocity Units

This will specify the number of digits after the decimal place to be used in all Velocity parameters.

Acceleration Units

This will specify the number of digits after the decimal place to be used in all Acceleration/ Deceleration parameters.

Time Scale

Select either minute or second as the time scale for the configuration. The default time scale is minutes. If the selected time scale is seconds, then the velocity units will appear as user units/sec. If the selected time scale is minutes, the velocity units will appear as user units/minute.

If the selected time scale is seconds, then the accel/decel units will appear as user units/sec^2. If the selected time scale is minutes, the accel/decel units will appear as msec/(1000 (user units)/min) or msec/(k (user units)/min). Therefore, for accel/decel units, the default is msec/kRPM (the same as previous versions of the Ei drive and FM-2 module).

Rotary Rollover Position

The check box enables Rotary Rollover and sets the position in User Units for the Rotary Rollover point. If Rotary Rollover is enabled, Position Command and Position Feedback will rollover to zero at the specified Rotary Rollover value.

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 twelve input lines, the debounce value and input function assignments.

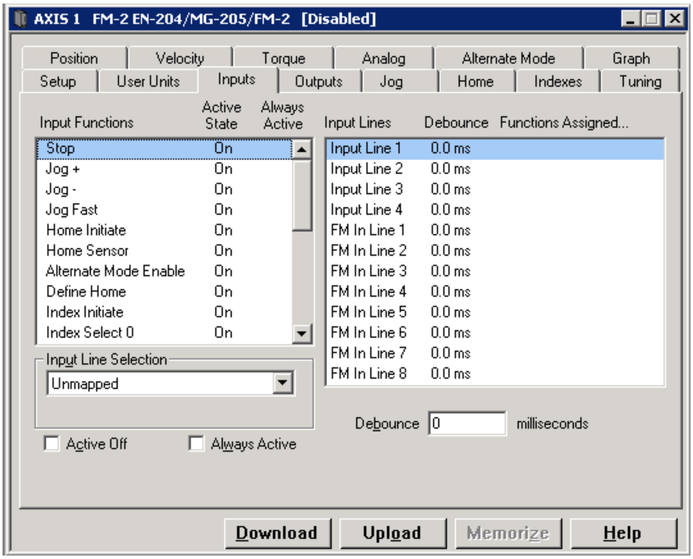


Figure 57: Inputs Tab

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 parameter below.

Always Active

The setting for Always Active is displayed next to each input function. See Always Active below.

Input Line Selection List Box

This list box allows you to assign or unassign the currently highlighted Input Function to an Input 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 Input Function and dropping it onto an Input line.

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 select or clear the “Active Off” check box.

Making an input function “Active On” means that it will be active when 10 Vdc 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 Vdc 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 assigned line.

Input Lines Window

Debounce

The debounce value is displayed next to each input line. 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.

Functions Assigned ...

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

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 seven output lines, the line Active State (“On” or “Off”) and the output function assignments.

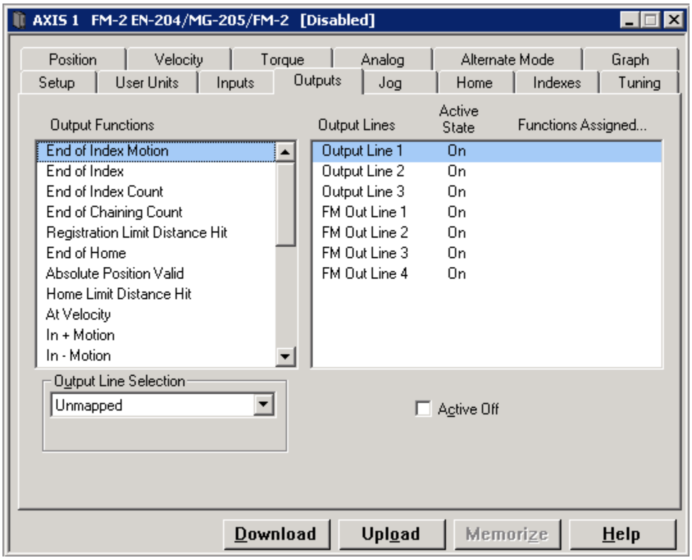


Figure 58: Outputs Tab

Note

For wiring information, refer to the “Installation” section of the *EN Drives Installation Manual* (P/N 400501-02), or the *Epsilon Eb and EN Drives Reference Manual* (P/N 400501-01).

Output Functions Window

This window allows selection of the output function to be assigned to an output line.

Output Line Selection

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.

Output Lines Window

Active State

The setting for “Active State” is displayed next to each output function. See “Active Off” 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.

Jog Tab

This tab allows you to enable and define jog velocity, acceleration and deceleration.

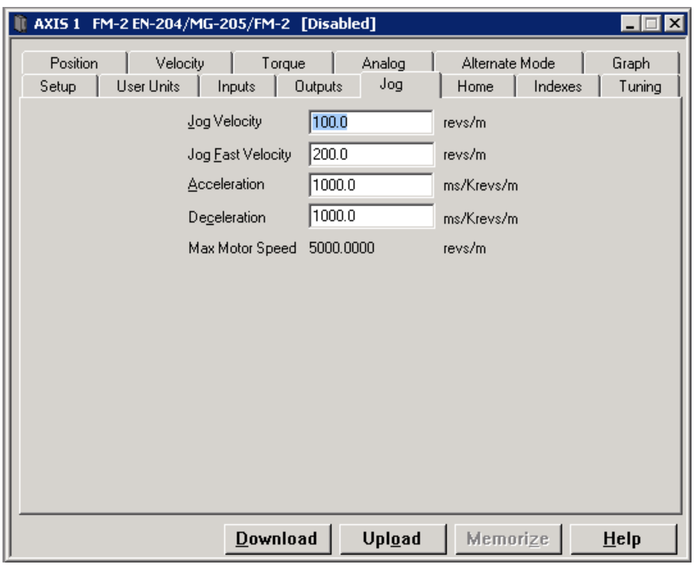


Figure 59: Jog Tab

Jog Velocity

This parameter specifies the velocity used for jogging with the Jog + or Jog - input functions.

Jog Fast Velocity

This parameter specifies the velocity used for fast jogging with the Jog Fast input function in conjunction with either the Jog + or Jog - input functions.

Acceleration

This parameter specifies the acceleration value to be used during the jog. The acceleration units are defined by the Time Scale parameter on the User Units tab.

Deceleration

This parameter specifies the deceleration value to be used during the jog. The deceleration units are defined by the Time Scale parameter on the User Units tab.

Max Motor Speed

This parameter specifies the maximum motor speed for the motor type selected on the Setup tab.

Home Tab

This tab allows you to enable and define the home function.

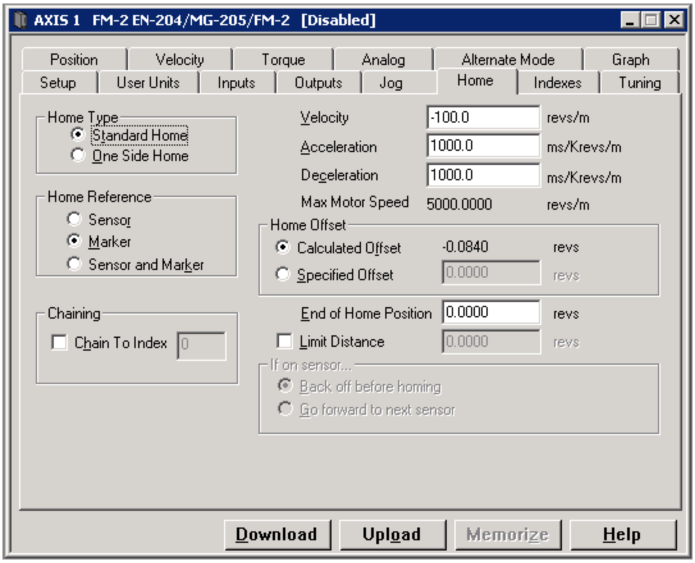


Figure 60: Home Tab

Home Type Group

The Home Type parameter determines the type of home, Standard Home or One Side Home.

Home Reference Group

The Home Reference parameter determines how the reference position is calculated. When Standard Home Type is selected the parameter can have one of three different values: 'Sensor', 'Marker', or 'Sensor and Marker'. When One Side Home Type is selected the parameter value is 'Senor'.

Sensor Option Button

When the Home Reference is 'Sensor' the active going edge of the 'Home Sensor' input function is used to establish the reference position.

Marker Option Button

When the Home Reference is 'Marker' the rising edge of the motor encoder's marker channel is used to establish the reference position.

Sensor and Marker Option Button

When the Home Reference is ‘Sensor and Marker’ the reference position is established using the first marker rising edge after the Home Sensor input function goes active.

Chaining Group

Chain to Index

When the check box is selected, the device will then start the index shown in the text box after the home cycle is complete.

Velocity

This parameter specifies the velocity used for homing. Use a positive value to make the drive home in the positive direction and a negative value to make the drive home in the negative direction.

Acceleration

This parameter specifies the acceleration value to be used during the home. The acceleration units are defined by the Time Scale parameter on the User Units tab.

Deceleration

This parameter specifies the deceleration value to be used during the home. The deceleration units are defined by the Time Scale parameter on the User Units tab.

Max Motor Speed

This parameter specifies the maximum motor speed for the motor type selected on the Setup tab.

Home Offset Group

Calculated Offset Option Button

The calculated offset is defined as the distance travelled during deceleration ramp from the home velocity to a stop plus the distance travelled at the home velocity for 400µs. This extra distance is used to guarantee that the motor will not need to backup after the deceleration ramp.

Specified Offset Option Button

The specified offset allows the user to choose an exact offset from the Home Reference.

End of Home Position

The "End of Home Position" designates the absolute position of the home in the machine coordinate system. At the completion of the home cycle, the End of Home Position value is put into the command and feedback positions. At the completion of the home cycle, the Absolute Position will have the value entered for this parameter. This value is in motor revolutions.

Limit Distance Check Box

The "Limit Distance" check box enables the Home Limit Distance parameter. If this flag is not set, there is no limit to the distance the drive will travel during a home routine.

Limit Distance

This parameter places an upper limit on the distance the motor will travel during the home. In situations where the reference position indicator (sensor or marker) is not seen, this parameter limits the total distance the motor will move.

If on sensor ... Group

Back off before homing Option Button

The Back off before homing flag effects the drive's behavior when the home sensor is active at the time the home is initiated. If the flag is set, the drive will back off the sensor. It does this by moving the opposite direction to that specified by the sign of the home velocity. It continues moving in this direction until the sensor deactivates. It then decelerates to a stop and performs a standard home.

Go forward to next sensor Option Button

The Go forward to next sensor flag effects the drive's behavior when the home sensor is active at the time the home is initiated. If the flag is set, the drive will go forward to the next sensor. It does this by performing a standard home routine looking for the rising edge of the home sensor.

Indexes Tab

This tab allows you to enable, define or assign the various indexes.

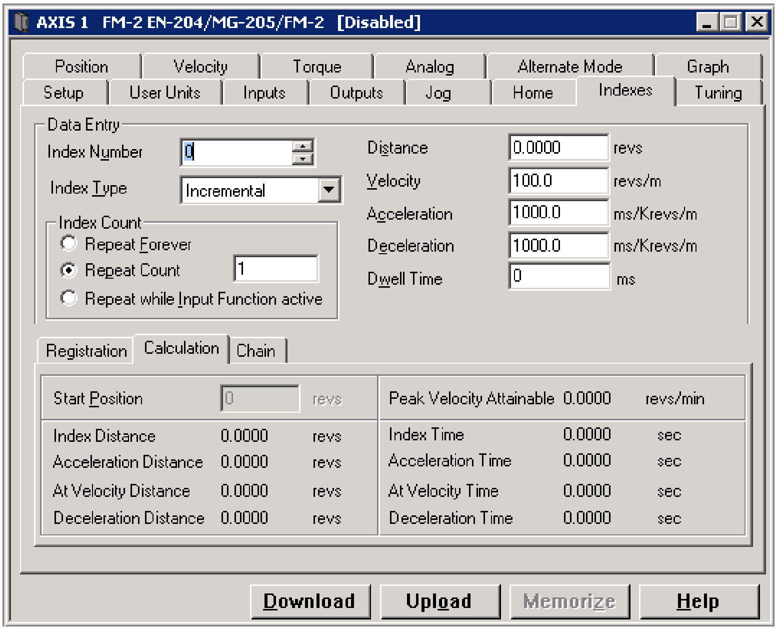


Figure 61: Indexes Tab

Index Number

The device supports up to 16 indexes (0 - 15). Enter the index number you want to modify or assign.

Index Type

Absolute

Absolute indexes are used in applications where the motor must travel to a specific position, regardless of where the motor is when the index is initiated.

Incremental

An incremental index will move the motor a specified distance in the + or - direction regardless of the starting position. The direction of the incremental index motion is determined by the sign (+ or -) of the Index Distance parameter.

Registration

A Registration Index runs at the specified velocity until a registration sensor or torque level is seen or until it reaches the Registration Limit Distance. If a Registration Sensor is seen, then the index runs an additional specified Registration Offset distance. If Registration Indexes are compounded, then Index ends a either Limit Dist or End of Registration offset. It will then start the next index at the ending velocity.

Rotary Plus and Rotary Minus

Rotary Plus and Rotary Minus type indexes are typically used in applications which use rotary rollover. If Rotary Rollover is enabled on the User Units Tab, a Rotary Plus index will always move in the positive direction and a Rotary Minus index will always move in the negative direction. These indexes are forced to run in a specific direction regardless of the starting point. If Rotary Rollover is not enabled, these indexes will function like Absolute indexes.

Distance/Position/Limit Distance

This parameter changes from Distance to Position depending on whether you have chosen Absolute, Incremental or Registration as the Index Type. The maximum distance/position/ limit distance value supported is +/- 214,748.3648 user units.

Velocity

The Velocity parameter specifies the velocity used for the index. The velocity parameter is unsigned and must be greater than zero.

Acceleration

The Acceleration parameter specifies the acceleration value to be used during the index. The acceleration is specified in units of ms/(k(user unit)/min) or user units/sec^2, depending on the time base parameter from the User Units Tab.

Deceleration

The Deceleration parameter specifies the deceleration value to be used during the index. The deceleration is specified in units of ms/(k(user unit)/min) or user units/sec^2, depending on the time base parameter from the User Units Tab.

Dwell Time

Time in ms between indexes. The dwell starts at the end of the commanded motion of the index, and the output line End of Index is turned on at the end of the dwell time. Default is 0 ms. Upper limit is 65,535 seconds.

Index Count

This parameter specifies how many times in a row this index is to run before proceeding on to the next index. If repeat forever is chosen, the index will repeat continuously until a stop command is received. If repeat count is chosen, the user must specify how many times the index is to run. The maximum index count is 65,535.

Registration Tab

The registration index parameters are set on this tab. The signal for the registration mark can come from one of four sources: Registration Sensor 1, Registration Sensor 2, Torque Level 1, or Torque Level 2.

The Offset can either be Calculated by PowerTools FM or Specified by the user in user units. If Calculated is selected, the motor will stop at the specified deceleration ramp. If Specified is selected, the motor will come to a stop the specified offset distance away from the registration mark. If the Specified offset is less than the Calculated offset, the motor will stop at the programmed deceleration ramp and then back up to the specified distance from the registration mark. The Specified offset is a signed parameter; if the index direction is negative, the specified offset parameter should also be negative.

Calculations Tab

This displays various index calculations, such as index distance, index time, acceleration, deceleration and at velocity results.

Start Position

When an “Absolute Index” is selected, the “Start Position” of the index can be set to provide index calculations from a non-zero position. The “Start Position” is defaulted to zero. The “Start Position” parameter is not available using an “Incremental Index”.

Chain Tab

Multiple indexes can be chained together so that they run sequentially. As each index is configured, this tab allows for no chaining or end of the chain (stop), continue to the next index (start next index), or wait for a Run Index Input signal and continue to next index (wait for run ...). Which index is to be run next is specified in the Index Next text box. The default chain setting is Stop.

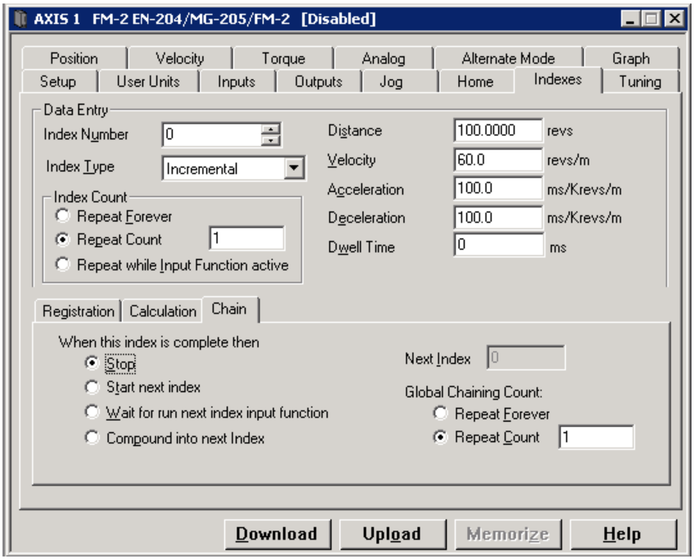


Figure 62: Index Tab - Chain Tab

Compound Indexes

This chaining instruction is used to initiate an index which has no deceleration ramp. The index accelerates up to speed and runs at speed until the specified distance is reached. The program then moves on to the next index. It smoothly transitions into the second index without stopping. The second index then ramps to its pre-configured velocity. Multiple indexes can be “compounded” to create a complex velocity profile. The last index in a complex profile must have a deceleration ramp.

Compound indexes are accomplished by selecting the “Compound into” option button located on the Chaining tab under the corresponding index.

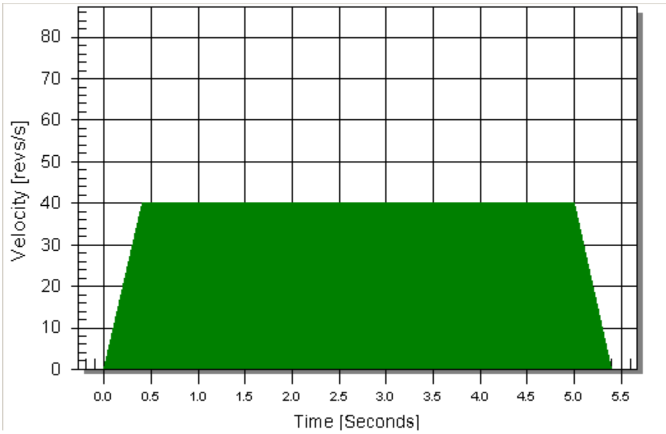


Figure 63: Index 0

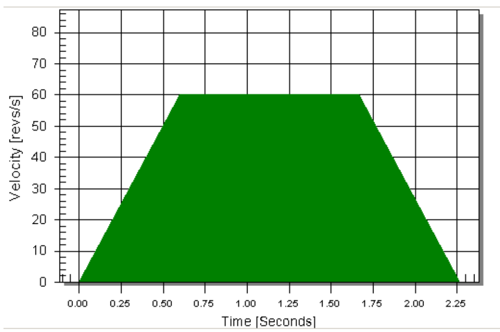


Figure 64: Index 1

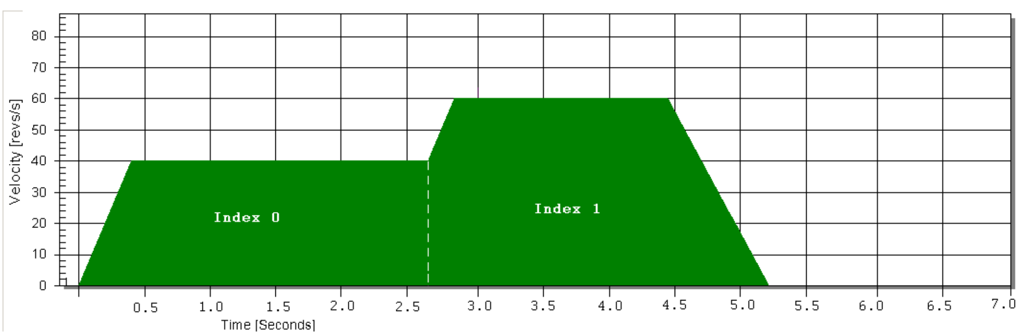


Figure 65: Index 0 Compounded into Index 1

Tuning Tab

All parameters on the Tuning 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. Low Pass Filter is provided to filter machine resonance that are present is some applications.

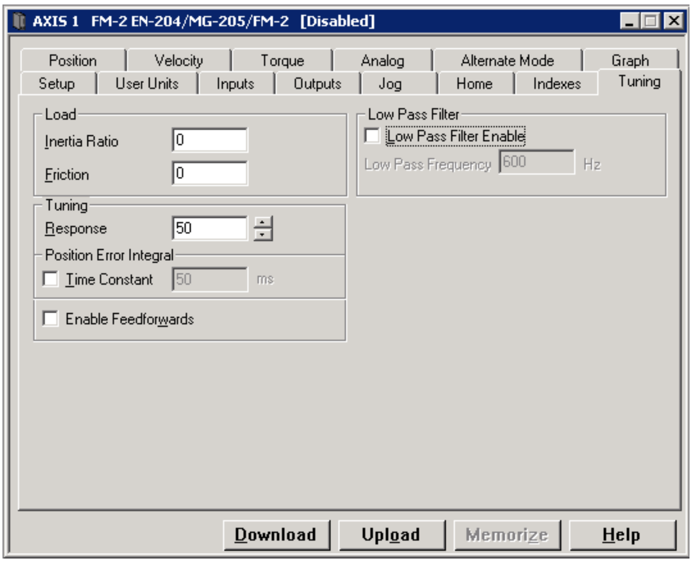


Figure 66: Tuning Tab

Load Group

Inertia Ratio

Inertia Ratio specifies the load to motor 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 Hertz. 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 maximum value recommended is 80 Hz.

Position Error Integral Group

Time Constant Check Box

When selected this enables the Time Constant parameter.

Time Constant

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 applications which have high friction.

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 Tuning Tabs of PowerTools FM. 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 PowerTools FM 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.

Enable Feedforwards Check Box

When selected feedforwards are enabled, the accuracy of the Inertia and Friction parameters is very important. If the Inertia parameter is larger than the actual inertia, the result could be a significant overshoot during ramping. If the Inertia parameter is smaller than the actual inertia, following 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 but not eliminated.

Low Pass Filter Group

Low Pass Filter Enable Check box

This check box when selected 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.

Position Tab

This tab allows you to enable and define the Following Error Limit and view feedback parameters. Feedback values are only enabled if the device is on-line with your PC.

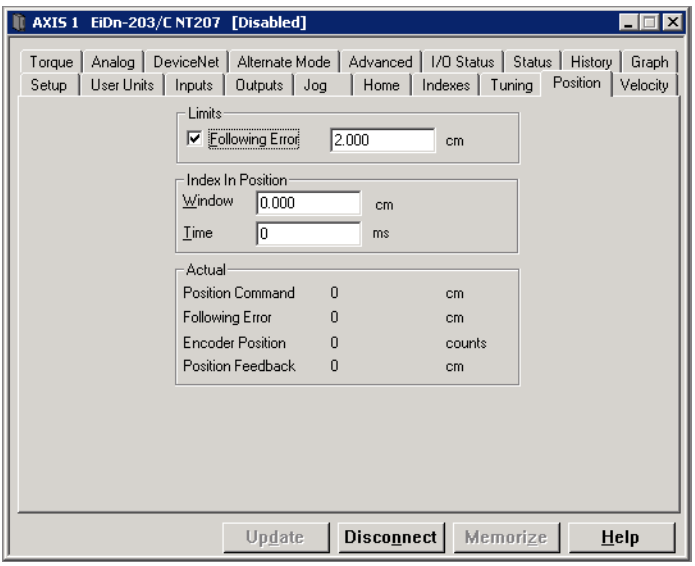


Figure 67: Position Tab - On-line

Limits Group

Following Error Check Box

Select this check box to enable or clear the check box to disable the Following Error Limit.

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. 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 specified in user units.

In Position Time

This is the amount of time in seconds that commanded motion must be complete and the following error must be less than the In Position Window for the In Posn output to activate. If set to zero (default), then InPosn will activate as soon as motion stops and the following error is less than the In Position Window parameter.

In Position Window

The absolute value of the Following Error must be less than or equal to this value at the end of an index in order for the Index InPosn Output to activate. This window is set in units specified in the User Units Tab.

Index in Position Group

In Position Time

This is the amount of time in seconds that commanded motion must be complete and the following error must be less than the In Position Window for the In Posn output to activate. If set to zero (default), then InPosn will activate as soon as motion stops and the following error is less than the In Position Window parameter.

In Position Window

The absolute value of the Following Error must be less than or equal to this value at the end of an index in order for the Index InPosn Output to activate. This window is set in units specified in the User Units Tab.

Examples: The In Position Window is set to 0.0025 revs. At the end of an index, the following error is calculated to be 0.0012 revolutions. Therefore, the InPosn output will activate.

The In Position Window is set to 0.001 inches. If at the end of an index, the following error is calculated to be 0.0015 inches, then the InPosn Output will never turn on.

Actual Group

Position Command

This is the commanded position generated by the device. This is set to zero when the Absolute Position Valid output function is activated. The Position Command is specified in user units.

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. Following Error is specified in user units.

Encoder Position

The motor position in encoder counts since power up when the value was set to zero. This is a signed 32 bit value. This is set to zero when the Absolute Position Valid output function is activated.

Position Feedback

This is the feedback position of the motor. It is set to zero when the Absolute Position Valid output function is activated. Position Feedback is specified in user units.

Velocity Tab

This tab allows you to set the drive limits, and if you are on-line, view the velocity feedback parameters.

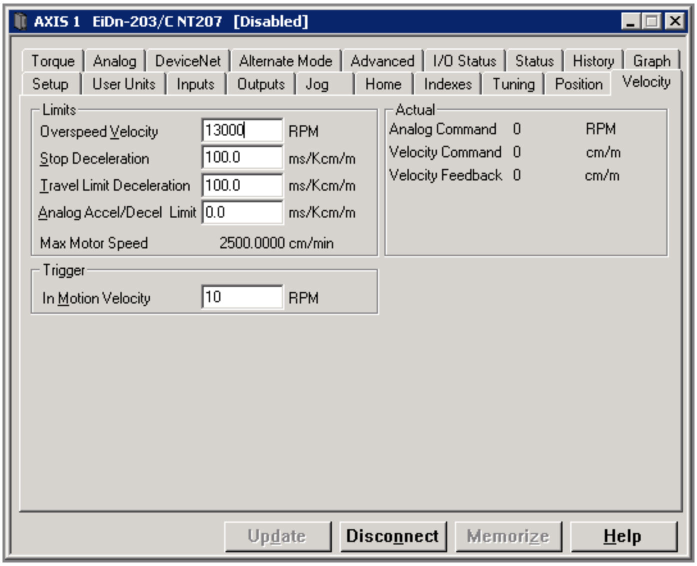


Figure 68: Velocity Tab - On-line

Limits Group

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, an Overspeed Fault will be generated. The internal overspeed fault limit is equal to 150 percent of the Motor Maximum Operating Speed.

Stop Deceleration

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

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.

Analog Accel/Decel Limit

This feature 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.

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.

Actual Group

All parameters in this group are only available when on-line with the drive.

Analog Command

The drive is in Analog Velocity mode this parameter gives the current velocity commanded due to the Analog input function.

Velocity Command

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

Velocity Feedback

This parameter is the actual feedback motor velocity.

Torque Tab

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

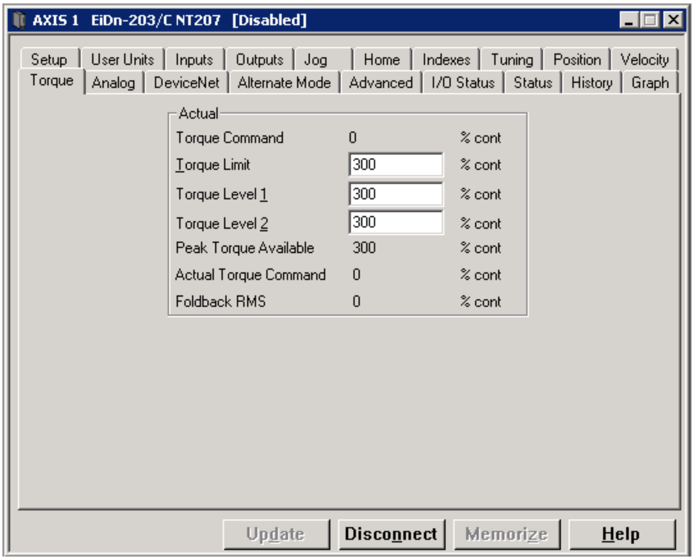


Figure 69: Torque Tab - On-line

Note

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

These parameters are continuously updated while on-line with the drive.

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.

Torque Level 1 and 2

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

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

The torque available from the particular drive and motor combination.

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.

Analog Tab

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

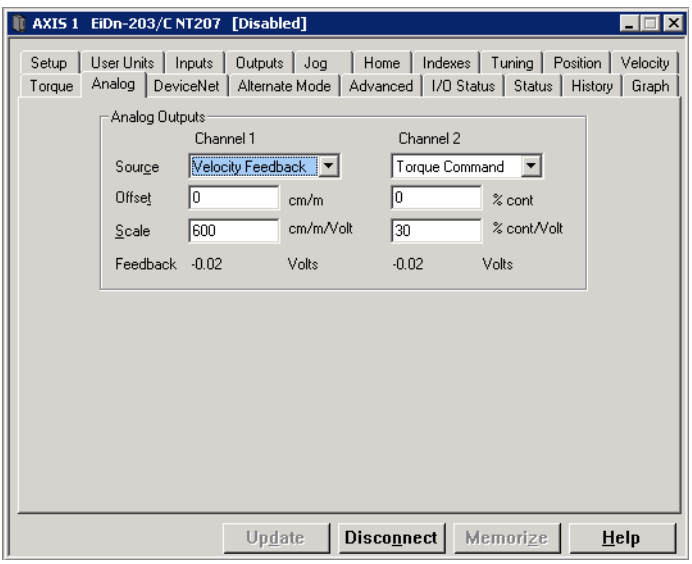


Figure 70: Analog Tab - On-line

Analog Outputs Group

Source

Select the signal that you wish to use as the source for Diagnostic Analog Output #1. 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

Each analog diagnostic output channel includes a programmable Analog Output Offset. This feature allows you to “zoom in” to a desired range effectively increasing the resolution. The units of this parameter is dependent upon the Analog Output Source selection.

Scale

Each analog diagnostic output channel includes a programmable Analog Output Scale. This feature allows you to “zoom in” to a desired range effectively increasing the resolution. The units of this parameter 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 on-line with a device.

I/O Status Tab

This tab displays the status of the input and output functions in real time and is only available while on-line with a device. This tab is divided into two windows, the Inputs window and the Outputs window.

Each window can be sorted by either Function or Line by clicking on the *Sort By Function/ Line* button. The Expand/Collapse button allows you to view the I/O function and the line it’s assigned to simultaneously.

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

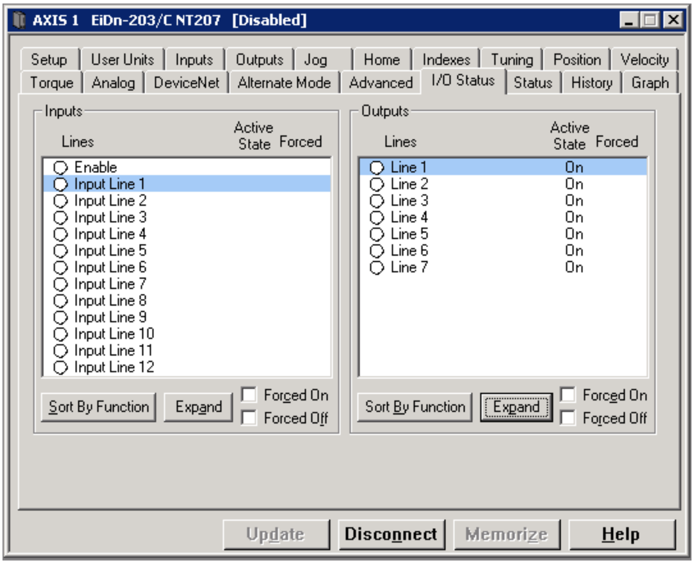


Figure 71: I/O Status Tab - On-line

Inputs Group

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.

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 Check Box

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).

Each window can be sorted by either Function or Line. The functions and lines are arranged in a hierarchy. 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.

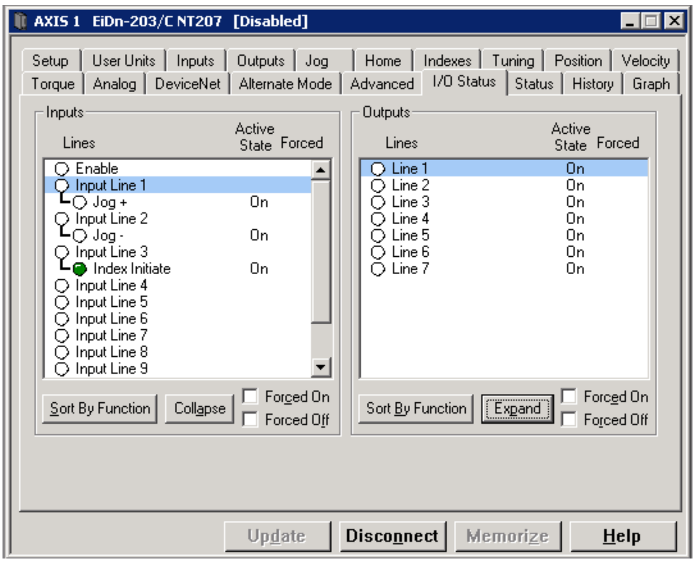


Figure 72: I/O Status Inputs Window Example

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

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 Check Box

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 whether the Outputs window is sorted by functions or lines.

Each window can be sorted by either Function or Line. The functions and lines are arranged in a hierarchy. 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 (see figure 73).

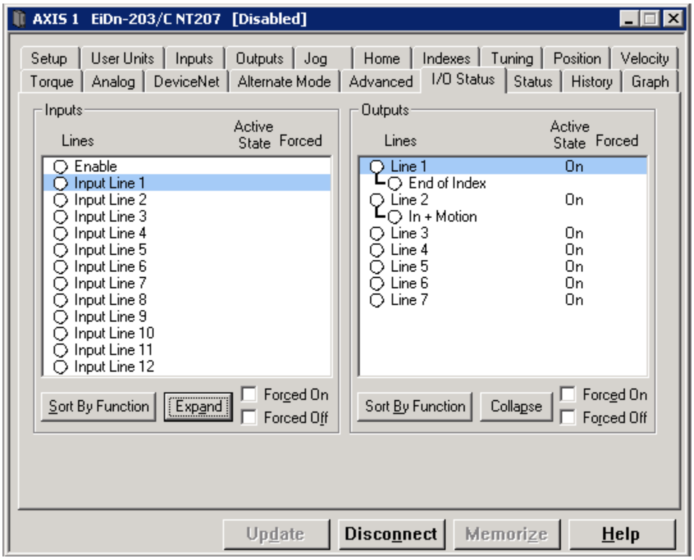


Figure 73: I/O Status Outputs Window Example

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 five categories: Position, Velocity, Torque, Drive Status and Time.

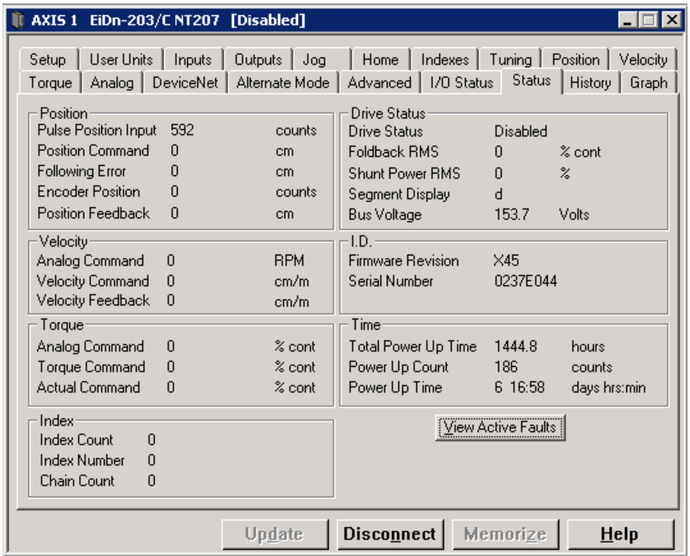


Figure 74: Status Tab - On-line

Note

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

Position Group

Position Command

This is the commanded position generated by the device. 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 Position

The motor position in encoder counts since power up when the value was set to zero. This is a signed 32 bit value. This is set to zero when the Absolute Position Valid output function is activated.

Position Feedback

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

Velocity Group

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

This is the sum of all torque commands applied in summation mode.

Drive Status Group

Drive Status

This reflects the state of the diagnostic LED on the drive. (i.e., Ready, Indexing, Homing, Jogging, etc.).

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.

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. When this value reaches 100 percent the drive will generate an RMS Shunt Power Fault. This parameter does not apply to the EN-204 which does not have an Internal Shunt.

Heatsink RMS

EN

E Series 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 diagnostic display on the front of the drive.

Bus Voltage

Epsilon Only

Displays the actual measured voltage on the DC power bus.

Firmware Revision

Displays the revision of the firmware in the drive you are currently on-line with.

Serial Number

Displays the serial number of the drive with which you are currently on-line.

FM Serial Number

Displays the serial number of the FM-2 Module with which you are currently on-line. This does not apply to Epsilon drives.

Time Group

Total Power Up Time

Total amount of times 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 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 faults by clicking the Reset Faults button.

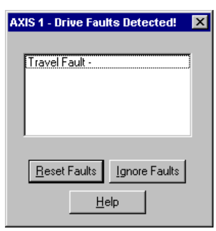


Figure 75: Active Drive Faults Dialog Box

History Tab

This tab displays a complete fault history of your device including a Fault Log window and a Fault Count window.

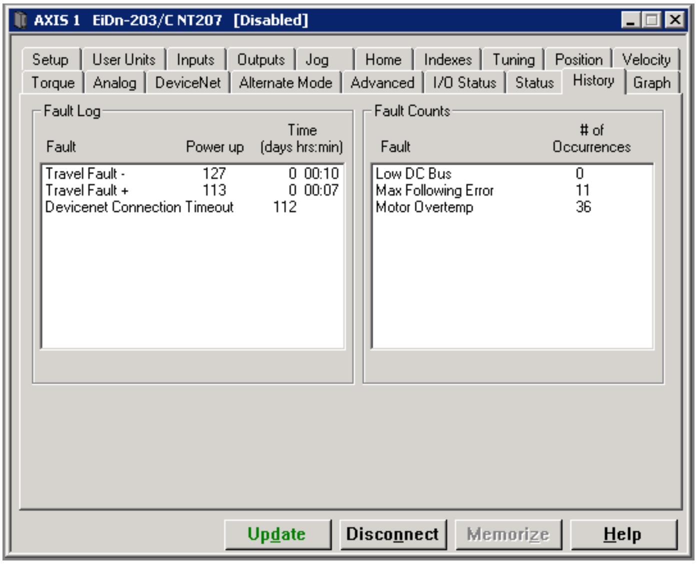


Figure 76: History Tab - On-line

Note

The fault log and fault counts cannot be cleared.

Fault Log Group

Fault Log Window

The Fault Log window displays the last ten faults that have occurred, starting with the most recent fault. The Power Up column indicates the power-up in which the fault occurred. The Time column 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, along with the number of times each fault has occurred.

Note

The fault log and fault counts cannot be cleared.

Advanced Tab

This tab is reserved for very infrequently used parameters that sometimes need to be adjusted to solve tricky 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 the tab will automatically be enabled when starting PowerTools FM.

Drive Ambient Group

Drive Ambient Temperature

Firmware Version B4 and later drives.

E Series Only

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.

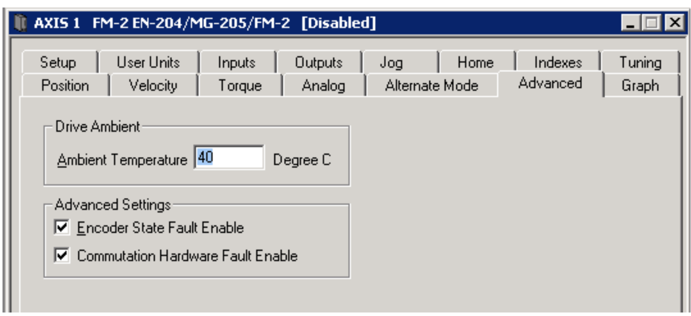


Figure 77: Advanced Tab for an EN Drive

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. Clearing this check box 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 Alternate Power Supply (APS).

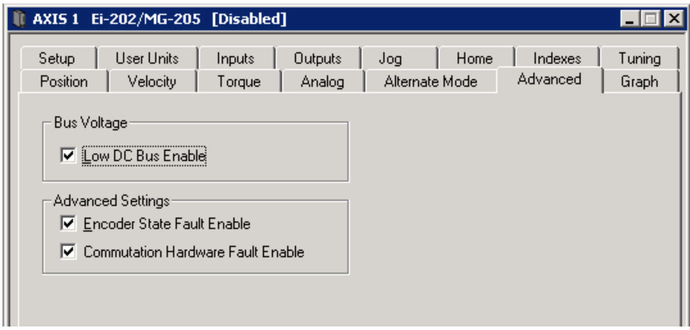


Figure 78: Advanced Tab for Epsilon

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 programmable encoders when the state transitions are not always deterministic.

Commutation Hardware Fault Enalbe

When this checkbox is selected, faults occuring from the commutation tracks U, V, and W will be recognized as "E" faults in the drive. When this checkbox is clear, no fault will occur due to the commutation tracks. This functionality can be useful to diagnose the nature of the E fault. If the checkbox is clear and E faults are still occurring, then the encoder lines (A, A/, B, B/, C, C/) are the most likely source of the E fault.

Graph Tab

The Graph tab is only available when on-line. The Graphing function in the drive makes use of an internal high speed data capture. After this capture is "Arm"ed, the capture will begin to fill a rolling buffer with the data as specified by Channel 1 - Channel 4. Once triggered, the data capture will fill the rest of the allocated memory. After the buffers are completely filled and the trigger activated, the "Upload and Plot" button may be used to upload data which will be displayed in a graphical format.

The User may trigger by entering a trigger level for one of the four channels or using the manual trigger button.

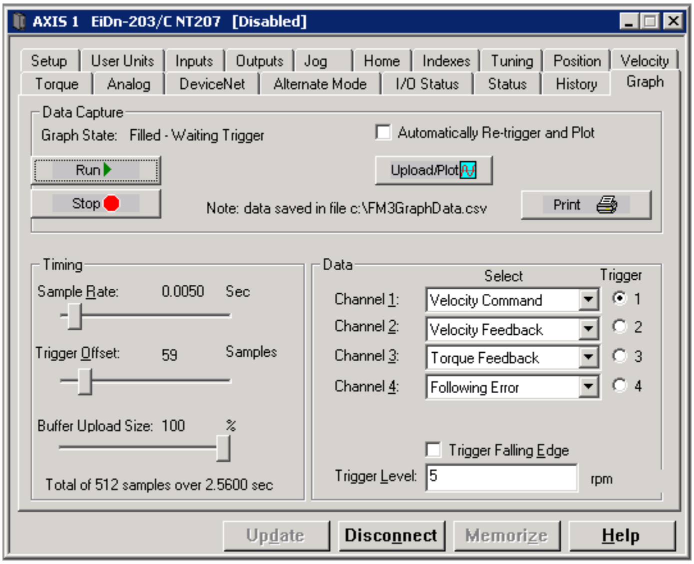


Figure 79: Graph Tab - On-line

Data Capture

The Data Capture group box includes initiate, stop, and graph commands for the graphical monitor.

The “Run” command button commands the drive to begin a high speed data capture of the parameters as selected in each of the four data channels. After the Run command button is activated the buffer will fill up to the trigger offset while the words “Filling Buffer” appear indicating this graph state. Once the trigger offset level is reached the words “Waiting Trigger” will appear next to the Graph State indicating that graphical monitor is now ready to be triggered based on the trigger level selected. The “Run” command button may be activated by the letter “R” on the keyboard.

The “Stop” command button will stop the high speed data log after it has been initiated and clear out the buffer that this data was previously stored in. The “Stop” command button may be activated by the letter “S” on the keyboard.

The “Upload/Plot” command button will upload captured data from the drive and display this data on a graph. The user should wait for the Graph State to read “Triggered” before the data is uploaded

Timing

The Timing Group Box includes parameters which control the size, accuracy, and duration of the capture and upload. These parameters may be changed using the slider bars but the drive must be “updated” or downloaded to in order for these changes to take affect.

Sample Rate

The Sample rate slider gives the user control of time spacing for the captured data. To give the user a better idea of what this number means, the total number of samples and total capture time is displayed on the bottom of the “Timing” group box.

Trigger Offset

This slider corresponds to the number of samples that will be included on the graph display and data capture prior to the actual trigger. If the Trigger offset slider is completely to the left (min samples), the data capture and graphing will start at the trigger location. If the slider is completely to the right (max samples) the graph will capture data until the trigger point.

Buffer Upload Size

In the instance that a user would like to save time in an upload, the buffer upload size slider truncates the drive captured data. If the slider is completely to the right (max) the complete buffer will be uploaded. If the slider is completely to the left, only 1% of the buffer will be uploaded.

Data

The Data Group Box is used to select which parameters will be graphed as well as which parameter will be used as the data trigger. If a change is made to any parameters within the Data Group Box, this change must be sent to the drive via a “download” or “update” command in PowerTools FM.

Channel 1 - 4

Channel 1 through Channel 4 give the user options for parameter display. If parameters with the same units are mapped on adjacent channels then the graphical display will show these two parameters overlapped on the same x/y axis. If it is desirable to have two adjacent Channels mapped to separate axis on the graph then the selection (none) should be used on the channel in between these two parameters.

Trigger

Selecting the trigger option button to the right of the channel will cause the graphical capture to trigger the capture off of that Channel. The “Trigger Level” text box on the bottom of the display will change units to accommodate the selected channels user units. This trigger level may be changed at any time but the change must be sent to the drive via the “update” or “download” button. If a manual trigger is desired, set the channel to “None” and select the corresponding trigger option button. If no trigger is selected the capture will begin when "Run" is clicked and end at the end of the Sample Rate.

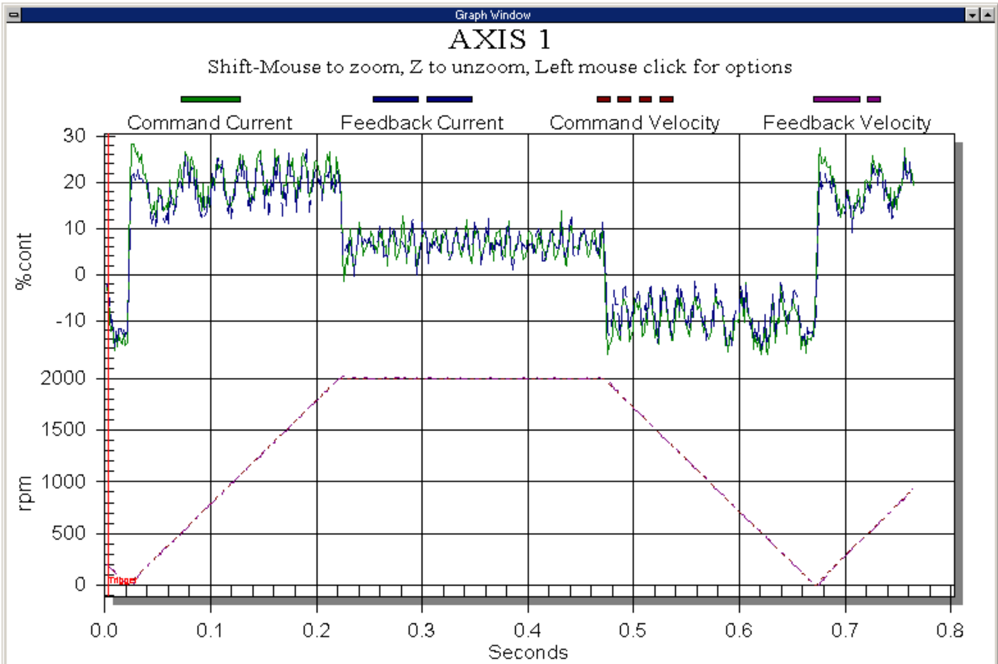


Figure 80: Graphical Plot

Epsilon Ei Indexing Drive 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.

- 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 larger 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 that 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	Schaffner Part #	Control Techniques Part #	Rating
Ei-202, Ei-203	FN2070-10/06	960307-01	10 A, 240 V, 1 Ø
	FS5278-16/08	960305-01	16 A, 240 V, 1 Ø
Ei-205	FS5278-16/08	960305-01	

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

Drive	Part #	Rating
Ei-202, Ei-203, Ei-205	**Corcom** 20EQ1	20 A, 240 V, 1 Ø
Ei-202	Schaffner FN 2070-6-06	6 A, 240 V, 1 Ø

AC Line Filter Installation Notes

- It is critical that you keep the filter inputs routed away from any electrical noise sources or shield them to prevent noise from being induced into them and carried out of the enclosure.
- 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.
- The filter characteristics of most three phase line filters will suffer if the phase to phase loading is unbalanced.

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 below.

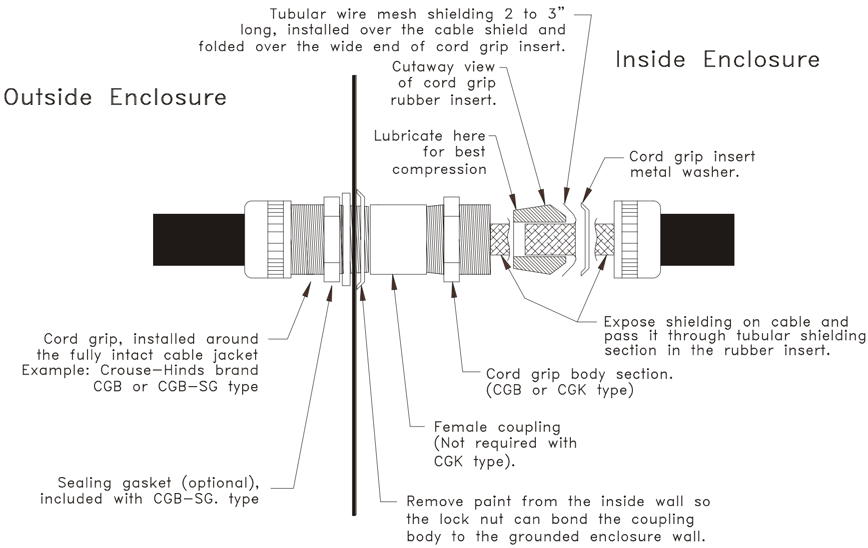
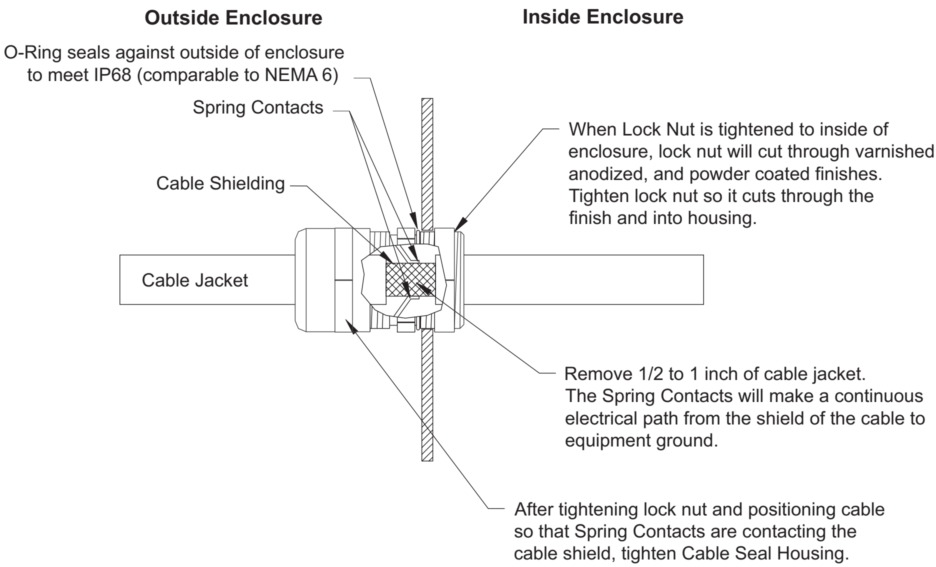


Figure 81: Through Wall Shield Grommet

Cable Type	Control Techniques 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		



Cable Type	Cable Model	Shielded Cable Grommet Kit Model	Actual Hole Size
Motor Cable, 16 Ga	CMDS	CGS-047	0.8125 or 13/16"
Motor Cable, 12 Ga	CMMS	CGS-069	1.125 or 1 1/8"
	4X12SS	CGS-069	1.125 or 1 1/8"
Motor Cable, 8 Ga	CMLS	CGS-098	1.5 or 1 1/2"
Feedback Cable	CFOS	CGS-047	0.8125 or 13/16"
	MGFS	CGS-047	0.8125 or 13/16"
Flex Motor Cable, 16 Ga	CMDF	CGS-047	0.8125 or 13/16"
	4X16SF	CGS-047	0.8125 or 13/16"
Flex Motor Cable, 12 Ga	CMMF	CGS-069	1.125 or 1 1/8"
	4X12SF	CGS-069	1.125 or 1 1/8"
Flex Feedback Cable	CFCF	CGS-069	1.125 or 1 1/8"
	CFOF	CGS-069	1.125 or 1 1/8"
	MGFF	CGS-069	1.125 or 1 1/8"
External Encoder	ENCO	CGS-047	0.8125 or 13/16"

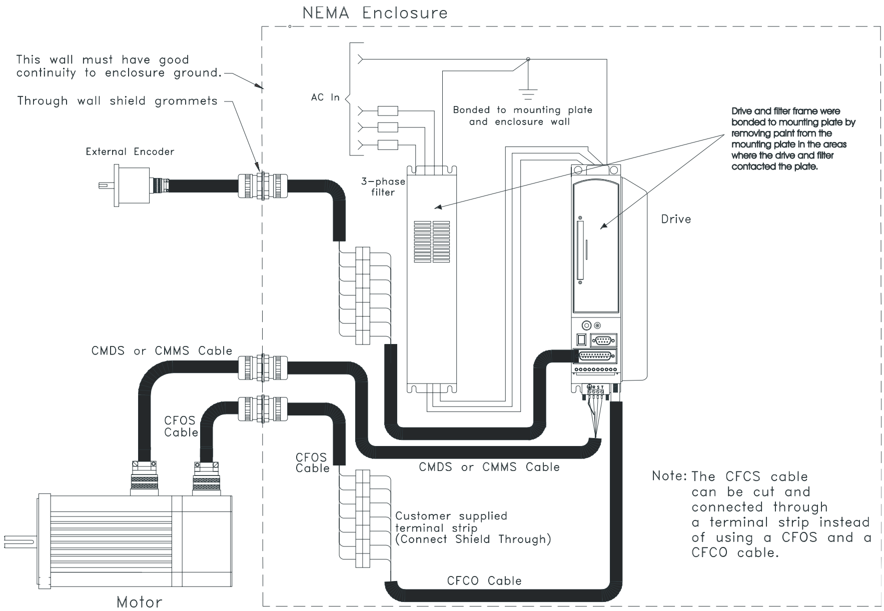


Figure 82: AC Filter and Cable Connections

Environmental Considerations

If the installation environment contains atmospheric contaminants such as moisture, oils, conductive dust, chemical contaminants and metallic particles, you must protect the drive from these by mounting it in a protective enclosure typically rated NEMA 12.

If the ambient temperature inside the enclosure will exceed 40° C (104° F), you may require forced air cooling depending on the RMS loading.

Note

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

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 or "daisy-chained" with other equipment.
- Ensure that full metal to metal surface 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 and one-half inch from the heatsink for ventilation. Additional space may be necessary for wiring and cable connections.

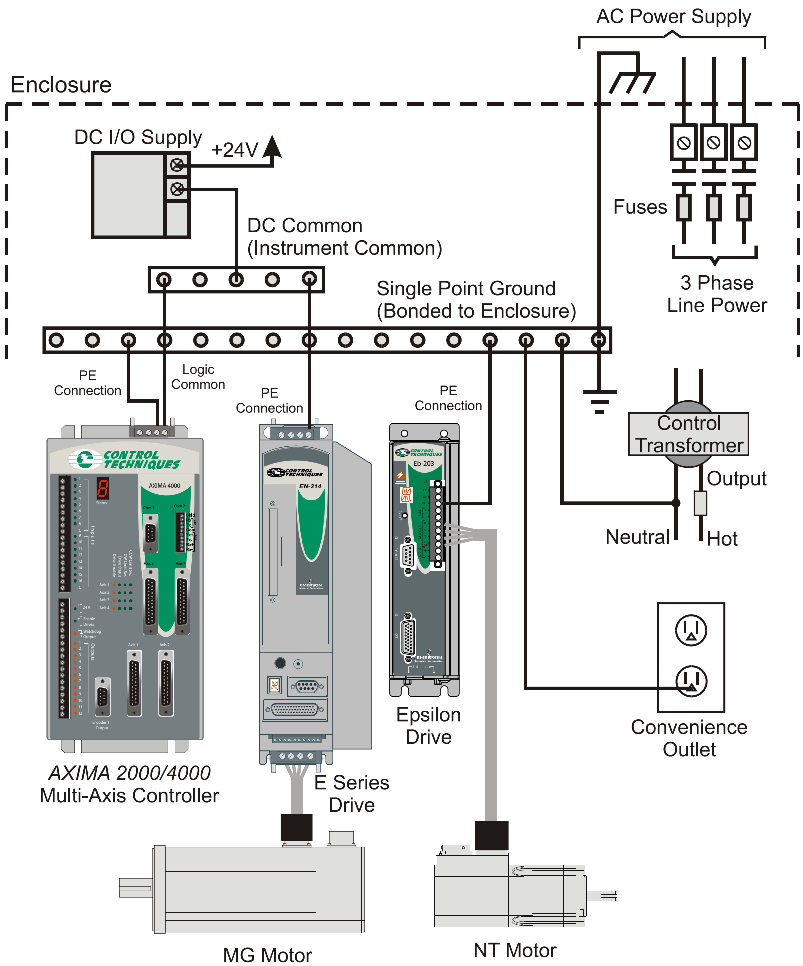
For drive dimensions, weights and mounting specifications, see the "Specifications" section.

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



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

Figure 83: 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 Ei-202, Ei-203 and Ei-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.

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 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.

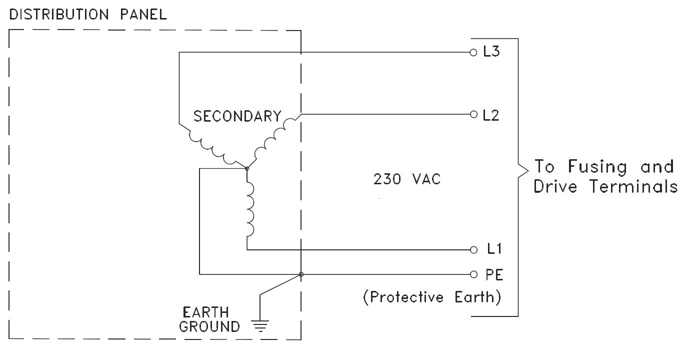


Figure 84: Earth Grounded WYE Distribution Transformer

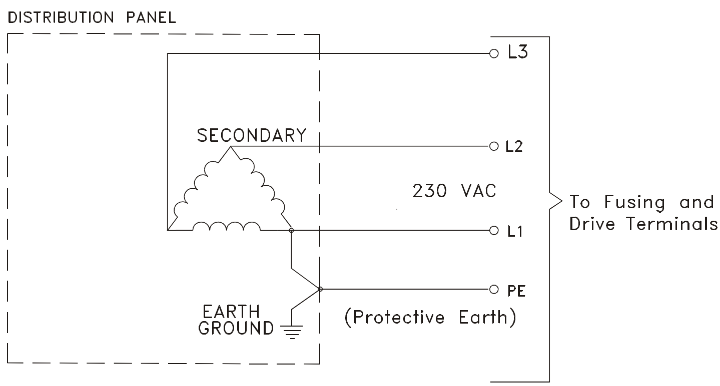


Figure 85: Earth Grounded Delta Distribution Transformer

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.

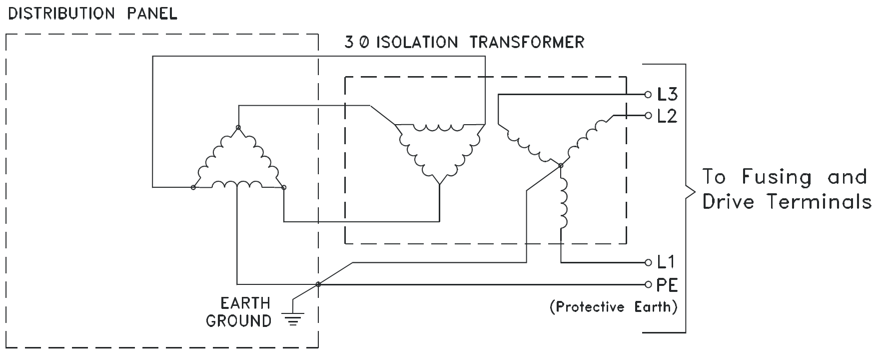


Figure 86: Three Phase Delta (with mid-phase GND) Distribution to a Three-Phase Delta/WYE Isolation Transformer

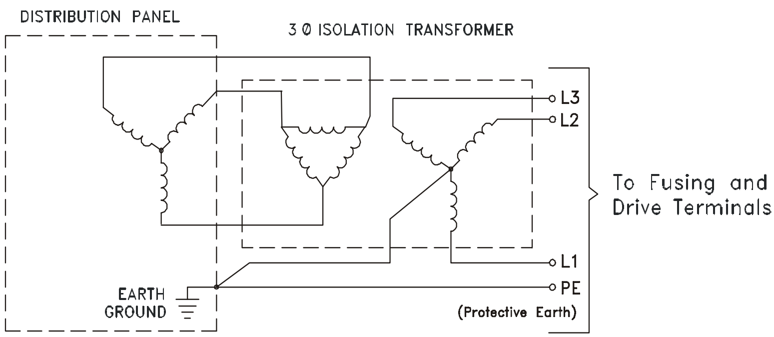


Figure 87: Three Phase WYE (ungrounded) Distribution to a Three-Phase Delta/WYE Isolation Transformer

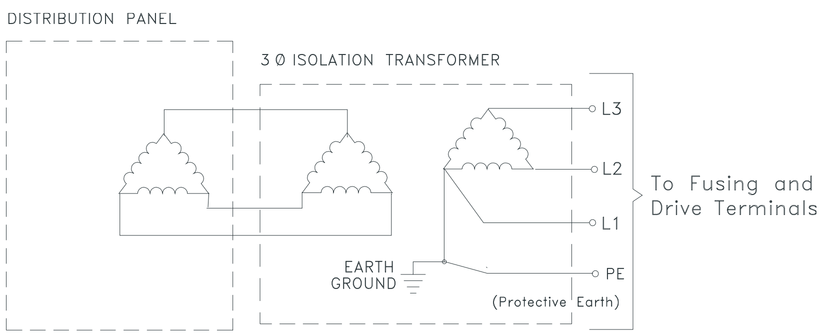


Figure 88: Delta to Delta Isolation Transformer

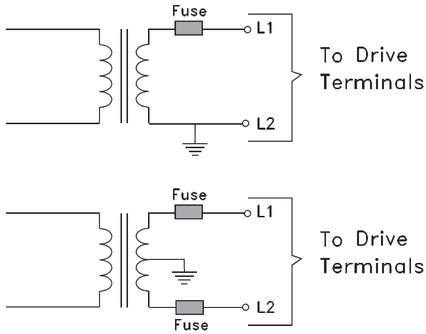


Figure 89: Single Phase Power Supply Connections

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 peak power usage is less than the transformer continuous power rating. Other factors that may influence the required KVA rating are high transformer ambient temperatures [>40º C (>104º F)] and drive operation near the maximum speeds.

Drive/Motor Combination	Suggested KVA Rating
Ei-202 or Ei-203/NT-207	1.0
Ei-202/NT-212	1.2
Ei-203/NT-212	1.7
Ei-203/MG-316	1.7
Ei-205/NT-212	1.7
Ei-205/MG-316	2.3
Ei-205/MG-340	3.0

At speeds near the maximum operating speed, transformer output voltage drop may become a critical issue for proper operation. 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, KTK or LPN or equivalent.

Drive Model	External AC Line Fuse	Recommended Minimum AC/PE Line Wire Gauge
Ei-202	6 LPN Amp	16 AWG
Ei-203	8 LPN Amp	16 AWG
Ei-205	12 LPN Amp	16 AWG

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.

Drive Model	Input Voltage (Vac)	Frequency (Hz)	Input Current (A RMS) at Full Drive Output Current	Inrush Current (A) 1 st Cycle	2nd Cycle
Ei-202	240 / 1 Ø	47 - 63	4.3	140 (2 ms)	20 (2 ms)
Ei-203	240 / 1 Ø	47 - 63	6.5	140 (2 ms)	20 (2 ms)
Ei-205	240 / 1 Ø	47 - 63	10.8	140 (5 ms)	30 (2 ms)

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

Input Power Connections

Note

Power must be “Off” for a minimum of 6 minutes for the Epsilon Ei-205 drive and 3 minutes for the Epsilon Ei-202/203 drives before unplugging the power connection, if the Logic Power Supply jumper is in the 24 Vdc Alternate Power Supply position. If the Logic Power Supply jumper is in the AC power location it is safe to unplug the power connector 30 seconds after removing AC power. This will ensure the bus voltage has bled down to a safe level (below 50 Vdc).

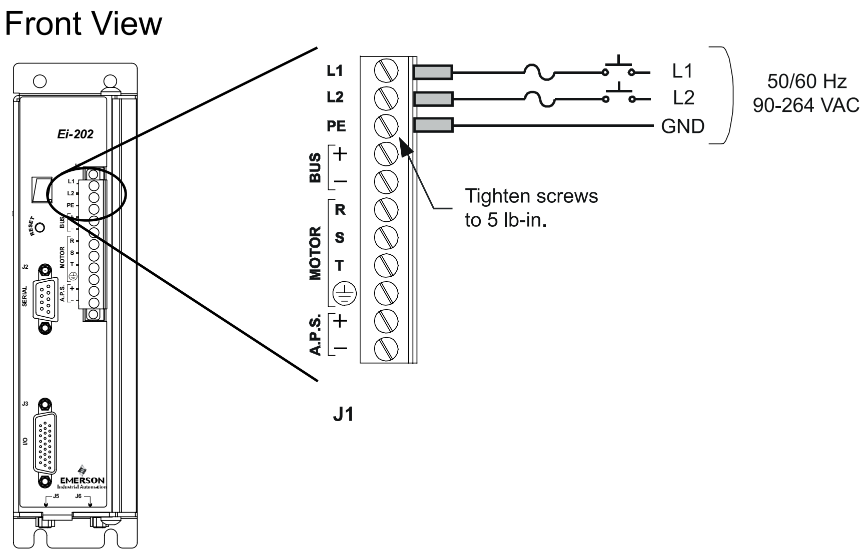


Figure 90: Epsilon AC Power Wiring Diagram

⚠ 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.

Alternate Power Supply Wiring

An Alternate 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.

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 A 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

Using the APS supply input to power the drive logic and motor encoder allows the drive bus to operate at DC voltages below 42 Vac (60 Vdc bus). The drive will operate down to 12 Vdc on the bus (10 Vac on L1 and L2). However the low DC bus monitoring must be disabled to prevent faults at these low DC bus voltage levels. This can be done with PowerTools FM software on the Advanced tab in Detailed Setup mode.

⚠ CAUTION

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

⚠ WARNING

Do not open the APS jumper access panel until at least six minutes after the main AC power has been removed from the L1 and L2 terminals.

Note

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

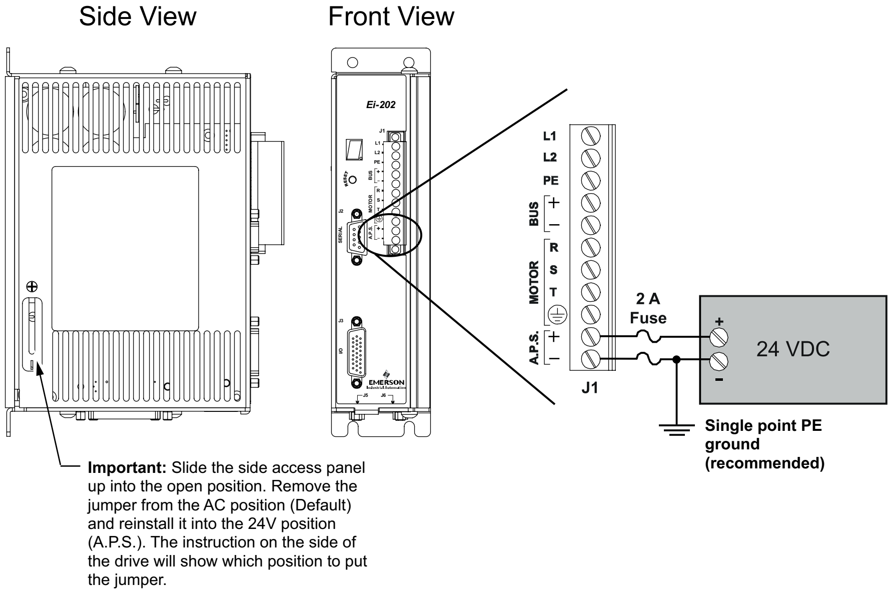


Figure 91: Epsilon Alternate Power Supply Wiring Diagram

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 as shown in the figure above.

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 A at 80 Mhz) on the APS power lines. This may disturb sensitive equipment that shares the same power supply.

WARNING

Do not open the APS jumper access panel until at least six minutes after the main AC power has been removed from the L1 and L2 terminals.

Note

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

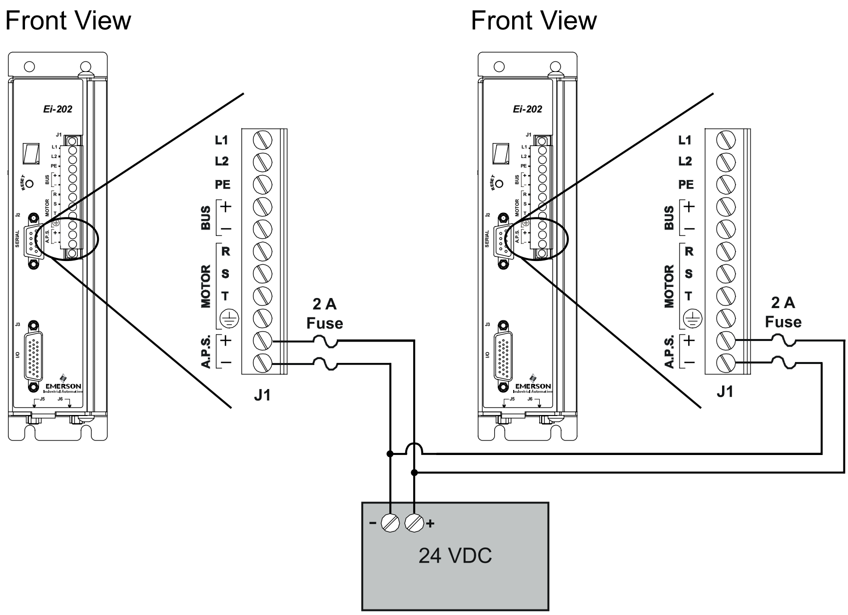


Figure 92: Multiple APS Wiring Diagram

Motor Power Wiring

Motors are equipped with up to three male MS (Military Style) 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 cable. This cable has a female MS style connector on the motor end and four individual wires and shield that connect to the motor power connector on the front of the drive.

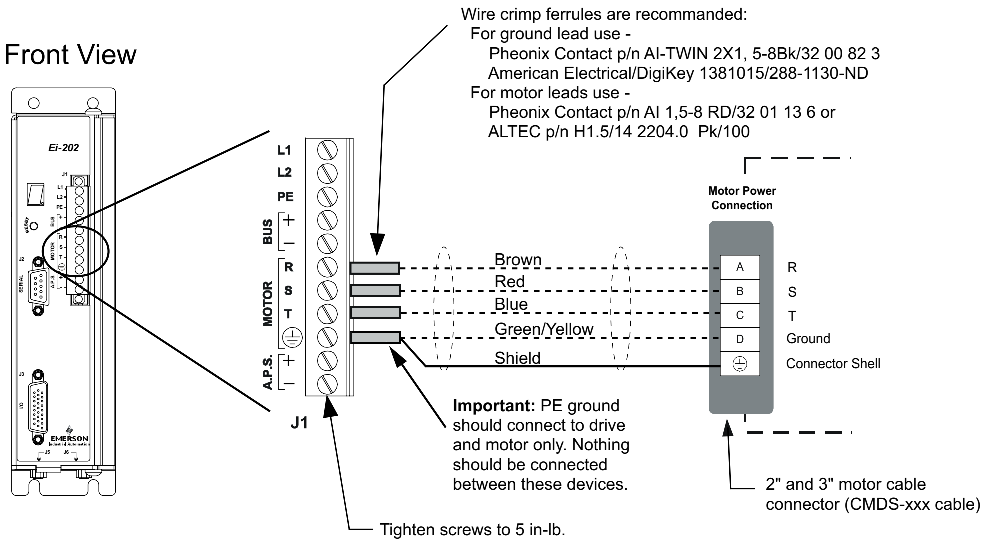


Figure 93: Epsilon Motor Power Wiring Diagram

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.

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, A, B, B and Z, 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.

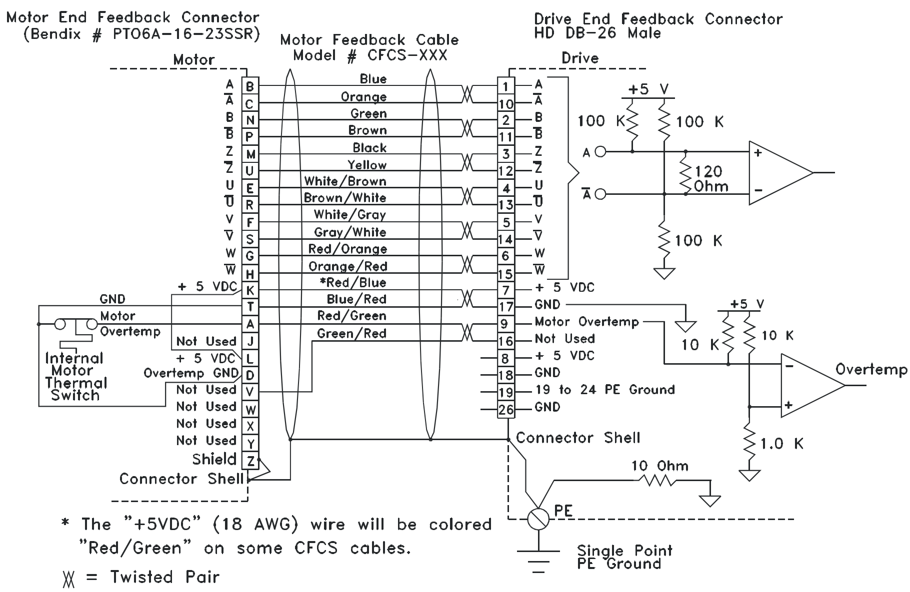


Figure 94: Motor Feedback Connector Pinout

Motor Brake Wiring

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

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.

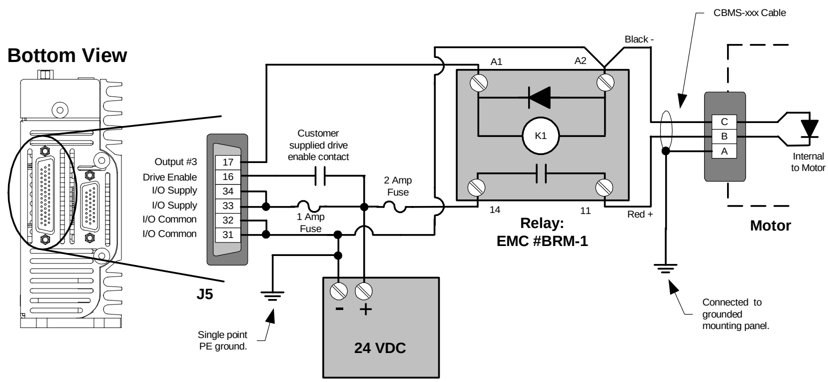


Figure 95: Epsilon Brake Wiring Diagram using the Command Connector

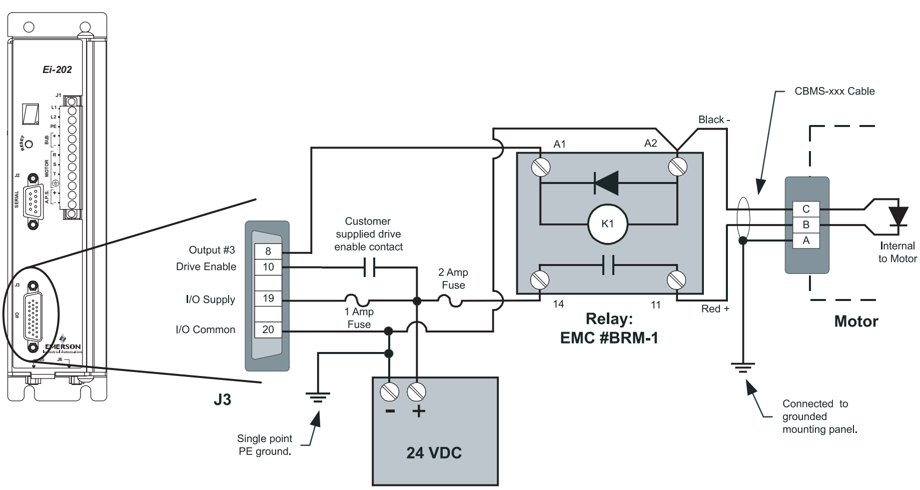


Figure 96: Epsilon Brake Wiring Diagram using the I/O Connector

Input/Output and Drive Enable Wiring

Ei drives are equipped with thirteen optically isolated input lines (one is dedicated to a drive enable function) and seven 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.

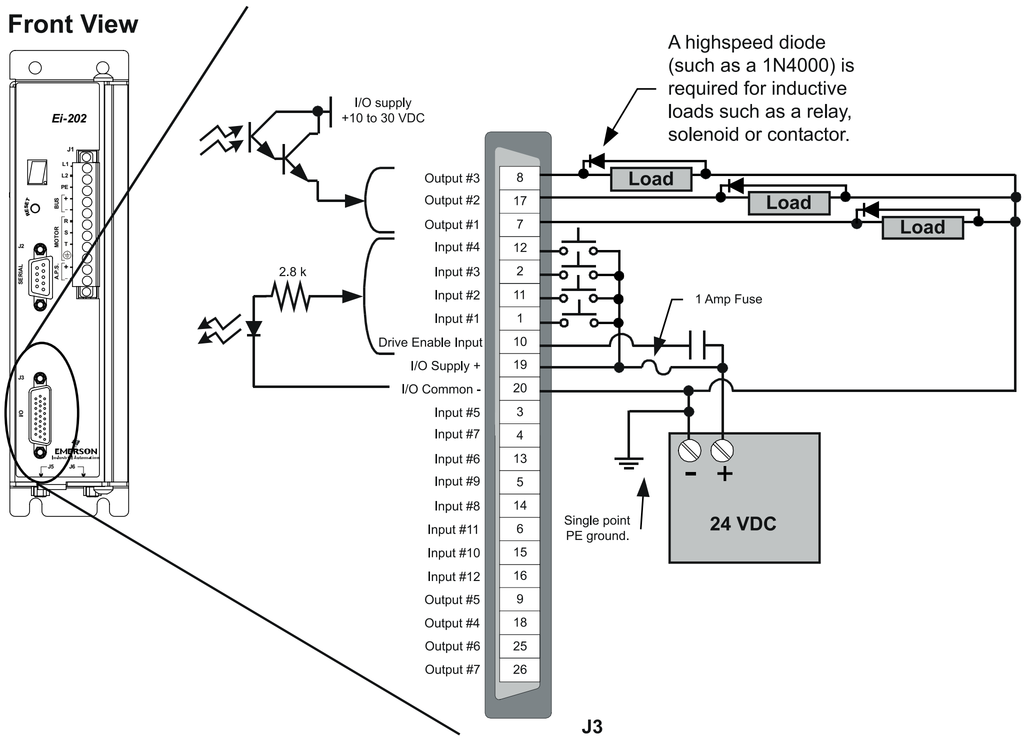


Figure 97: Epsilon Input/Output Wiring Diagram

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

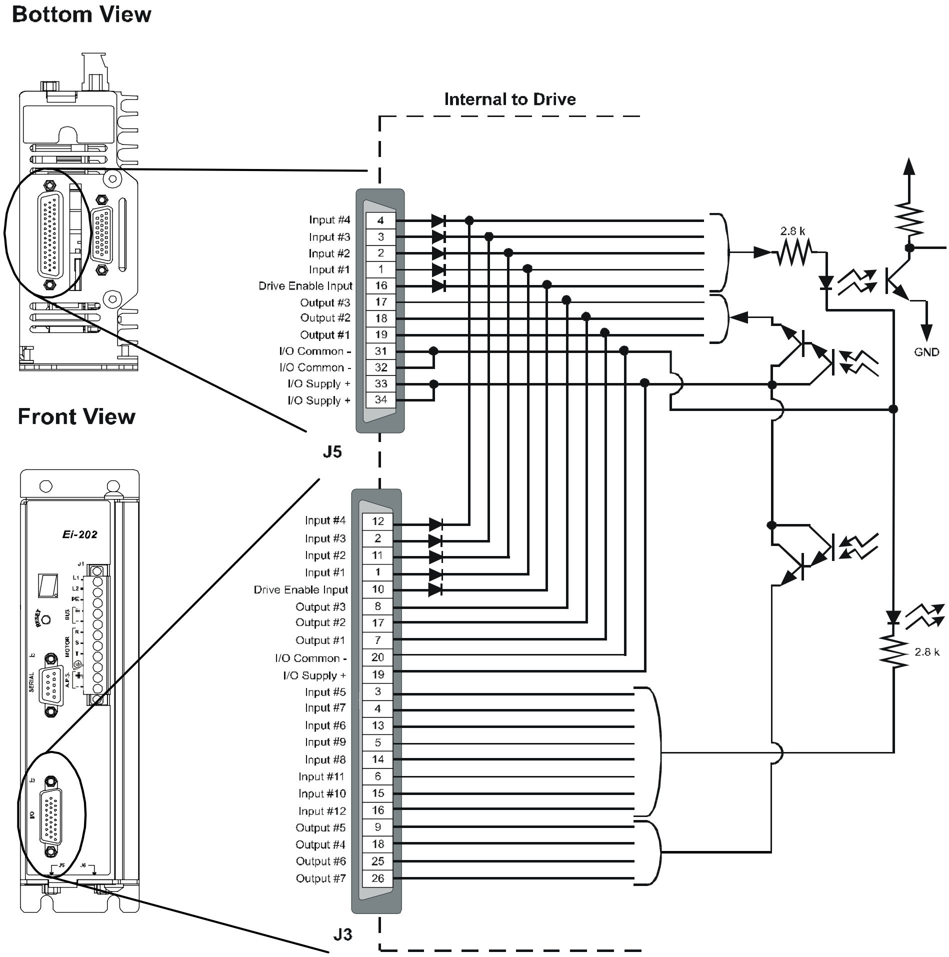


Figure 98: Epsilon I/O Connector to Command Connector Internal Connections

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 Wiring

All command and digital I/O signals are available using the 44-pin Command Connector.

If you are interfacing your drive(s) using field wiring, you may use 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.

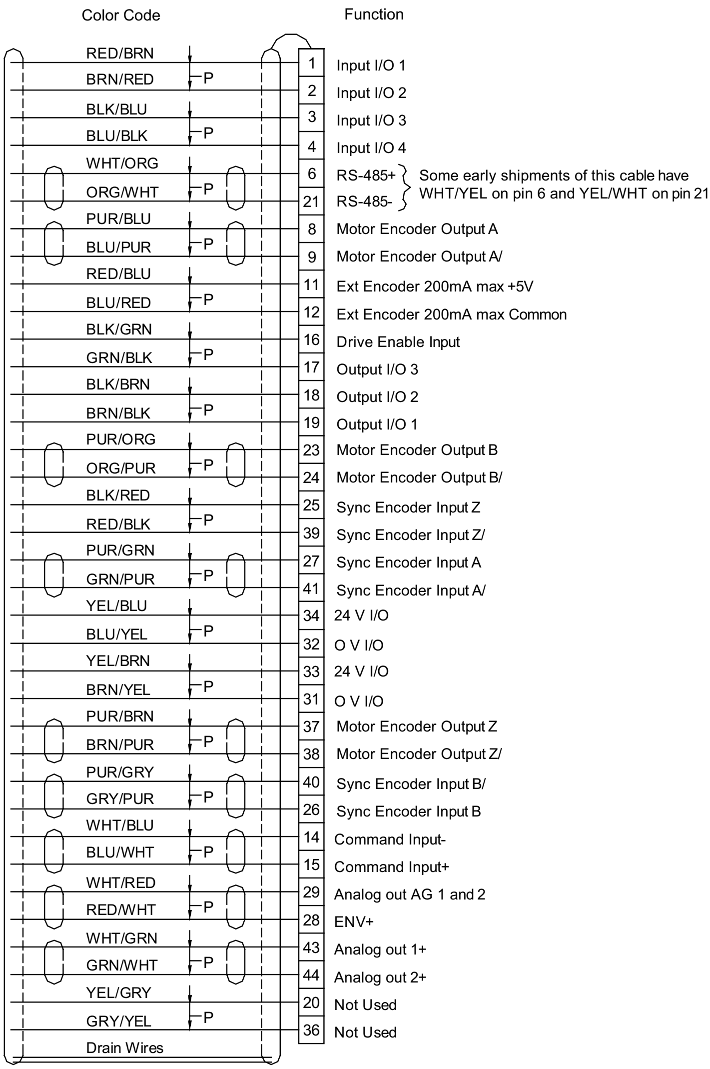


Figure 99: Command Connector Functions and CMDX Cable Wire Colors

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 A maximum
I/O Common	31, 32	I/O return
Encoder Supply Output +5 V	11	+5 V (200mA) output 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)
Diagnostic Output	43, 44	± 10 Vdc 10 mA maximum analog diagnostic, ref. to pin 29
Diagnostic Output Common	29	0.0 V, 10 ohms away from PE. 0 ohms away from Encoder Common 0 V (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 command 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 CMDX cable has the identical signal pinout and wire colors, but has a 44-pin connector on each end.

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 spacing requirement below the drive.

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

Encoder Output Signal Wiring

The default encoder output resolution is 2048 lines per motor revolution. This resolution is adjustable in one line per revolution increments with PowerTools FM software. The range is between 200 and the actual motor encoder density.

Note

Encoder outputs meet RS-422 driver specifications and can drive up to 10 RS-422 signal receivers. The default encoder output resolution is 2048 lines per motor revolution. This resolution is adjustable in one line per revolution increments with PowerTools FM software. The range is between 200 and the actual motor encoder density.

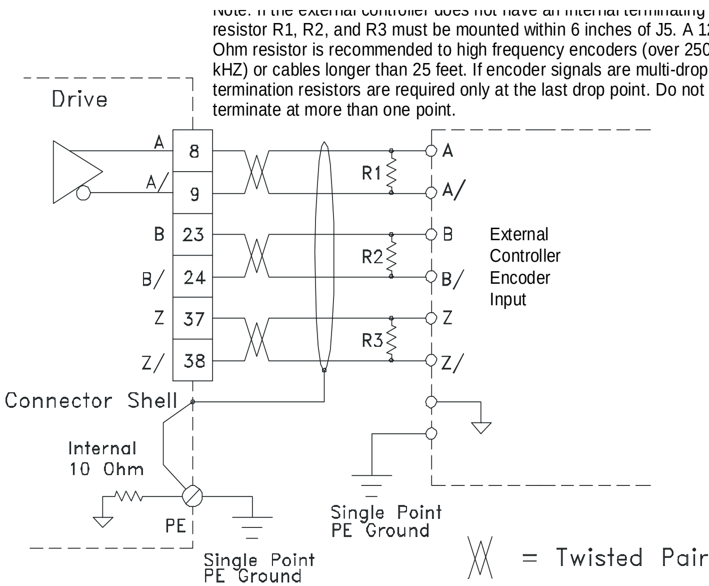


Figure 100: Command Connector Encoder Output Wiring

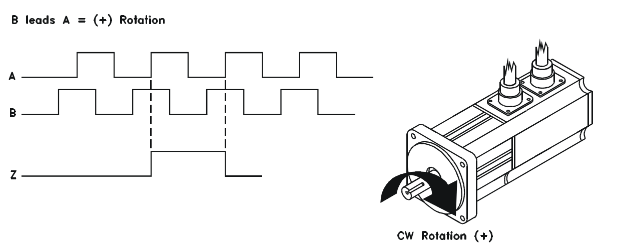


Figure 101: Direction Convention Diagram

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.

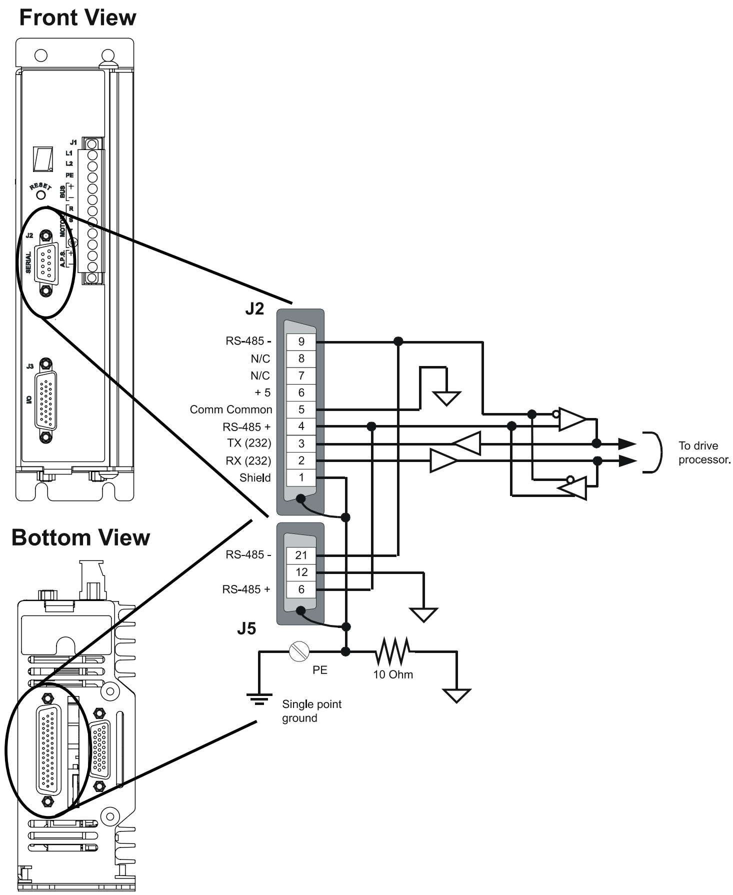


Figure 102: Epsilon RS-232 and RS-485 Internal Connections between the Command Connector and the Serial Communication Connector

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.

Noise pick-up on an unused RS-232 input at J4 pin 2 can in extreme cases interfere with RS-485 communications. When using RS-485 communications it may be necessary to connect J4 pin 2 to J4 pin 5 to avoid communication errors.

⚠ CAUTION

Do Not use a standard 9 pin RS-232 serial cable or null modem cable at J4. Use a TIA or equivalent that connects only pins 2, 3, 5 and the shield at the backshell or pin 1.

MODBUS® Communications

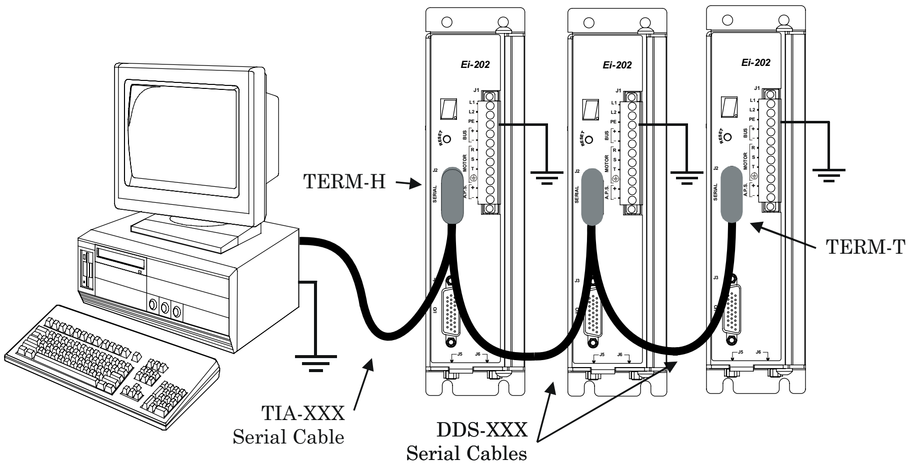
The drive's serial communication protocol is Modbus RTU slave with a 32 bit data extension. The Modbus protocol is available on most operator interface panels and PLC's.

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 103: Multi-Drop Wiring Diagram

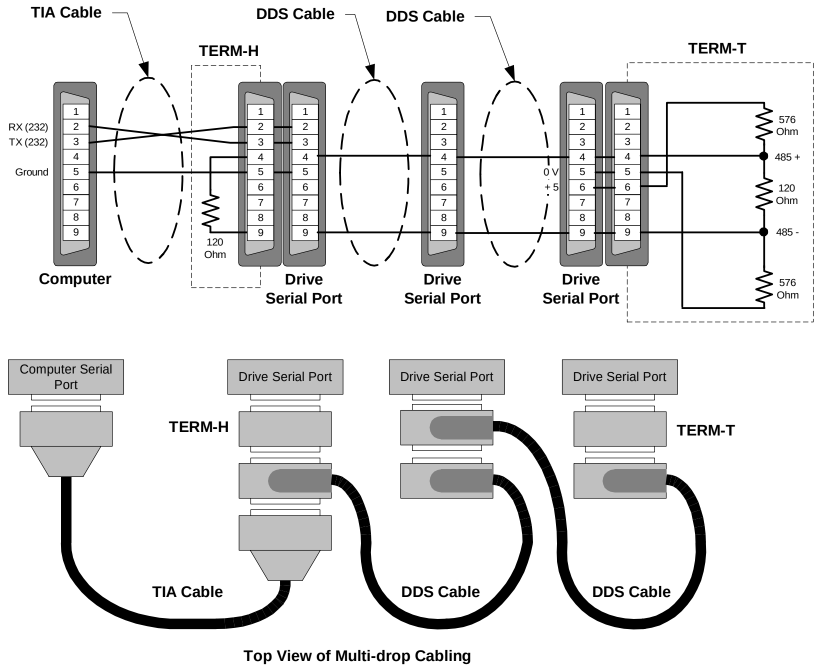


Figure 104: Multi-Drop Wiring Pinout

FM-2 Indexing Module Installation

Mechanical Installation

The FM-2 Module detects and verifies the drive serial number when its attached to an EN drive. If a FM-2 Module is moved from one drive to another, it will detect the difference in serial numbers and generate an Invalid Configuration fault.

Two aligning tabs, a locking latch and a 100-pin connector are used to attach the FM-2 Module to any EN drive. All electrical connections between the FM-2 Module and the EN drive are accomplished with the single connector located on the rear of the FM-2 Module.

CAUTION

Do not attach or detach the FM-2 Module when power is applied to the drive.

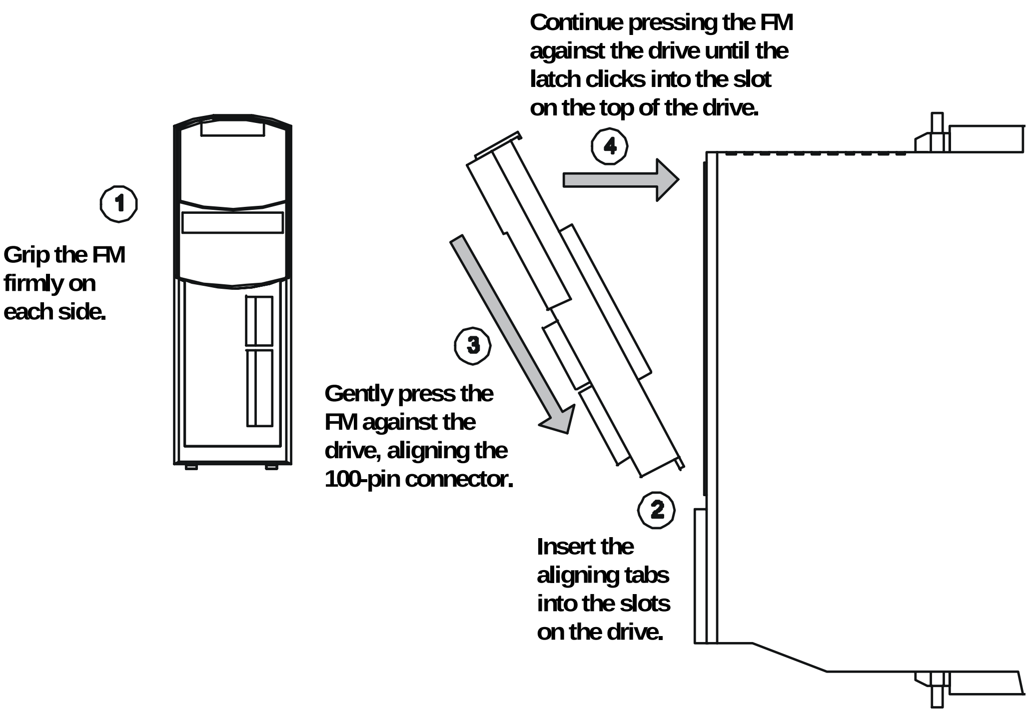


Figure 105: Attaching the FM-2 Module to an EN Drive

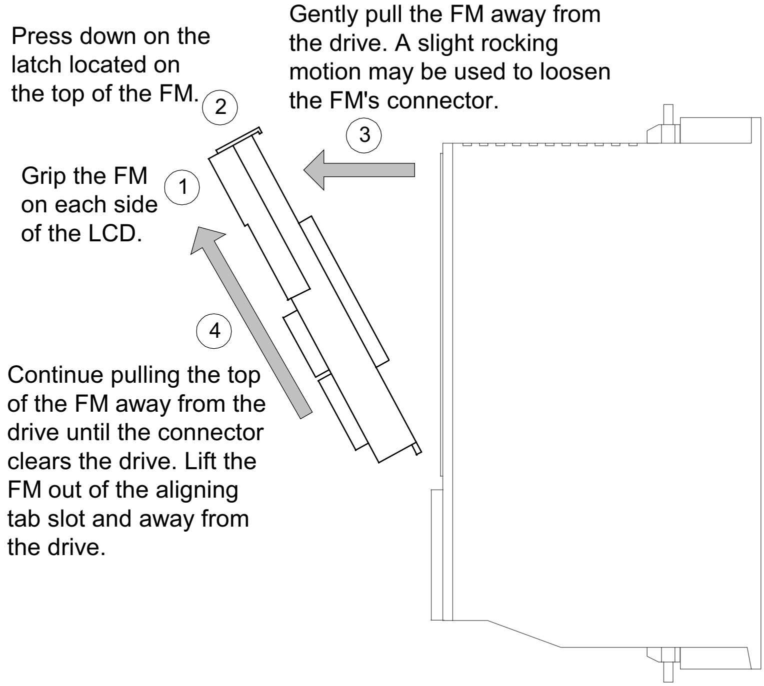


Figure 106: Detaching the FM-2 Module from the Drive Connections

Electrical Installation

Input/Output Wiring

The FM-2 Module is equipped with eight optically isolated input lines and four 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 current to less than 200 mA.

The input lines, output lines and I/O power connectors are on removable terminal blocks. 18 to 24 AWG stranded wire is recommended.

A single power supply can be used to power the I/O on both the EN drive and the FM-2 Module, however, it must be wired to both the drive and the FM-2 Module because I/O power is not passed through the connector on the back of the FM-2 Module. Alternatively, separate power supplies can be used to power the I/O on the drive and the FM-2 Module, as long as they share a common ground.

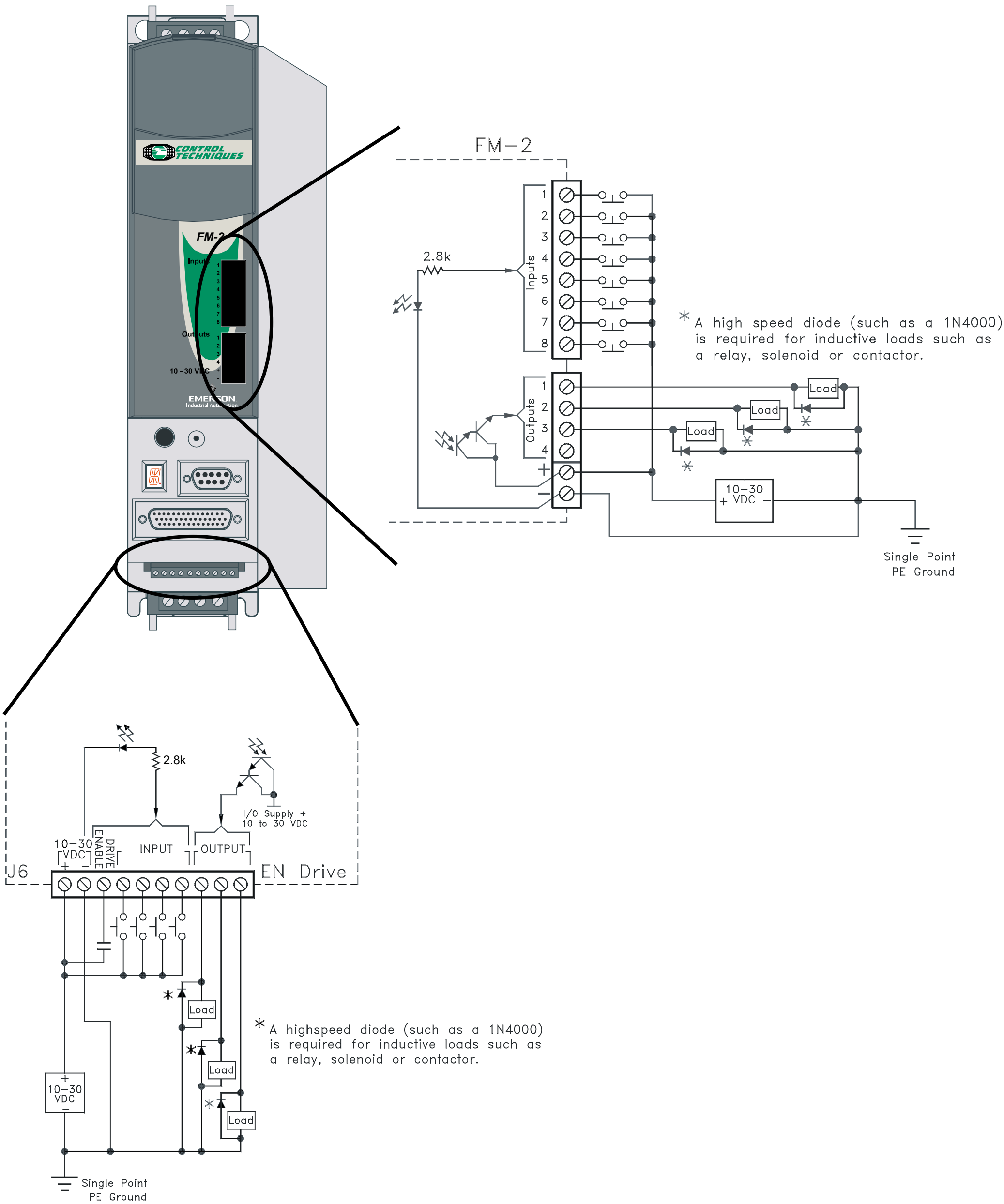


Figure 107: Input/Output Sourcing Wiring Diagram

Command Connector Wiring

All command and I/O signals are accessed using the 44-pin command connector located on the front of the EN drive (see the section on Command Connector Wiring in the Ei Installation chapter).

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).

Function	Pin Numbers	Electrical Characteristics
Inputs and Drive Enable	1, 2, 3, 4, 16	10-30 Volts (“On”) 0-3 Volts (“Off”) optically isolated
Outputs	17, 18, 19	10-30 Volts DC sourcing 200 mA
I/O Supply	33, 34	10 - 30 Vdc @ 1 Amp maximum
I/O Common	31, 32	I/O return
Pulse Inputs	Differential 20, 36 Single-ended 25, 26, 27, 39, 40, 41	Not used with an FM-2
Encoder Supply	11	+5 Volts (200 mA) fused internally
Encoder Common	12	0.0 Volts, 10 ohms away from PE
Encoder Out	8, 9, 23, 24, 37, 38	Differential line driver output (RS 422)
Analog In	14, 15	Not used with an FM-2
Diagnostic Output	43, 44	± 10 Vdc 10 mA maximum analog diagnostic, ref. to pin 29
Diagnostic Output Common	29	0.0 Volts, 10 ohms away from PE
RS 485 ±	6, 21	Same signals as the serial connector J4
+15 out	28	10 mA supply ref. pin 29, for test purposes only

Command Cables

The CMDO, CMDX and CDRO cables are all command cables that plug into the J5 command connector. See the Specifications chapter for cable drawings and diagrams.

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 J5 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.

The CDRO cable includes only the most commonly used signals to reduce the cable O.D. and has a connector at only one end. The 45 degree connector design used on the CDRO cable reduces the enclosure depth requirement from 12 inches to 10 inches.

The CMDX cable has the identical signal pin out and wire colors, but has a 44-pin connector on each end.

Serial Communications

Serial communications with the EN drive and the FM-2 Module is provided through the female DB-9 connector (J4) 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 (J5).

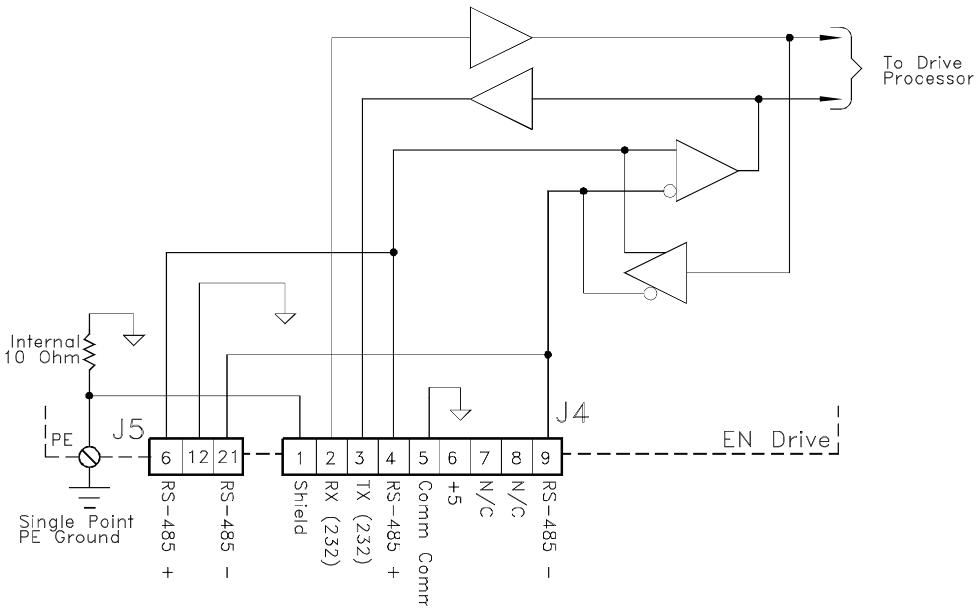


Figure 108: RS-232 and RS-485 Internal Connections

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

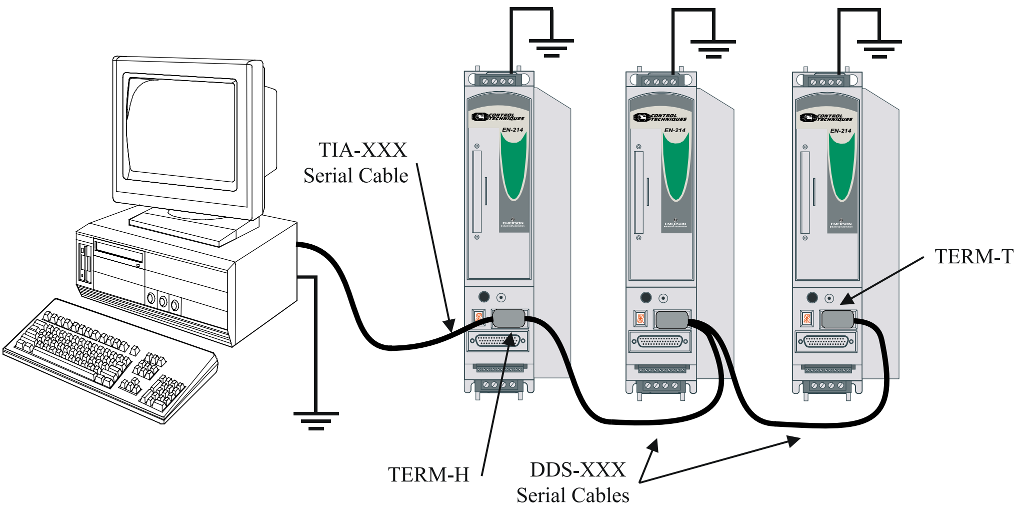
The drive's serial communication protocol is Modbus RTU slave with a 32 bit data extension. The Modbus protocol is available on most operator interface panels and PLC's.

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 109: Multi-Drop Wiring Diagram

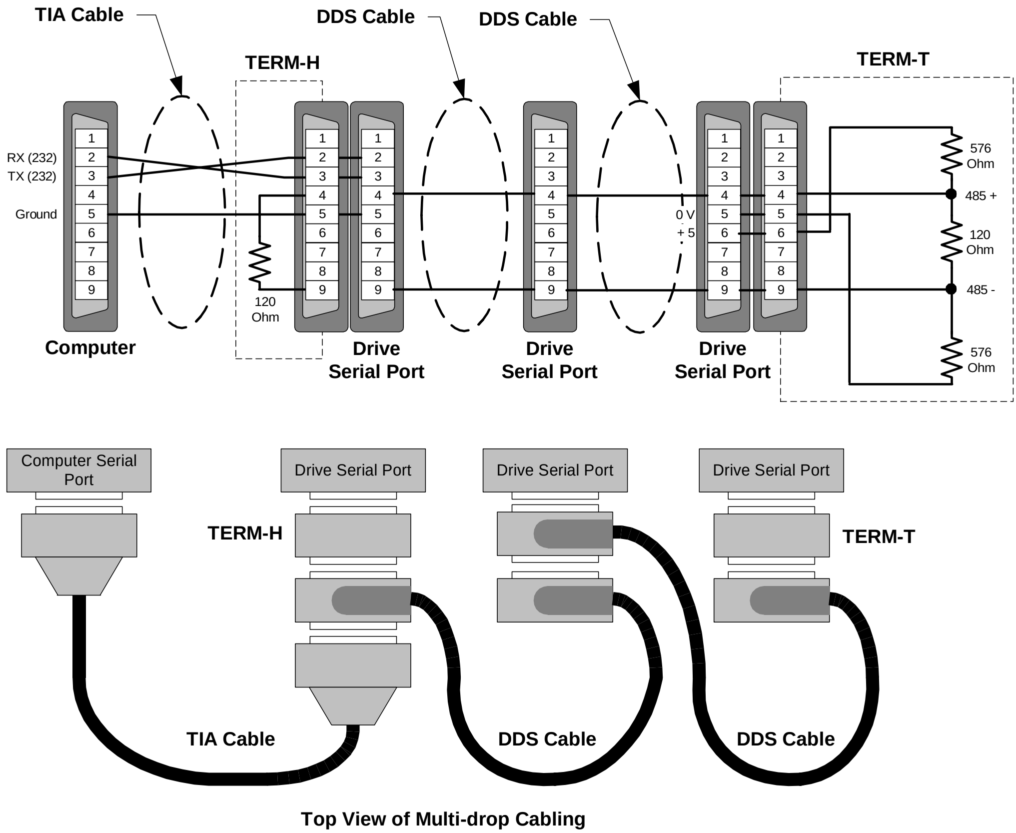


Figure 110: Multi-Drop Wiring Pinout

Off-line Setup

Note

Generally, on-line setup is used when editing parameters in a device. Off-line setup editing is usually only done when not connected to a device.

Step 1: Opening an Off-line Configuration Window

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

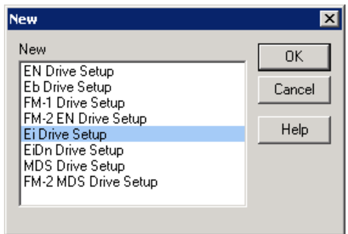


Figure 111: New Dialog Box

When the "New" dialog box appears, select the drive setup selection and press the *OK* button. A new Configuration Window will be displayed.

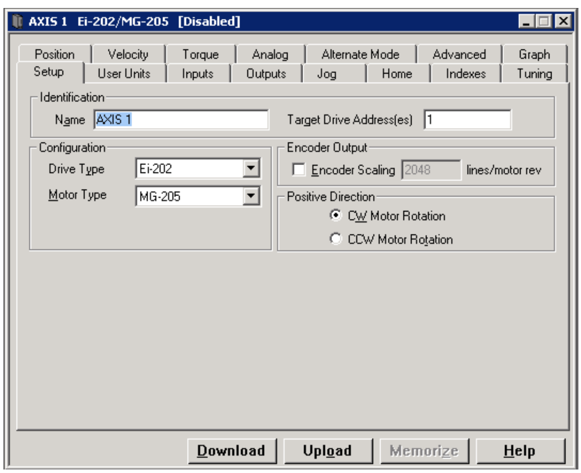


Figure 112: Off-line Configuration Window

All drive setup parameters are accessible in the tabs of the off-line configuration window.

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

Step 2: Entering General Drive Setup Information

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

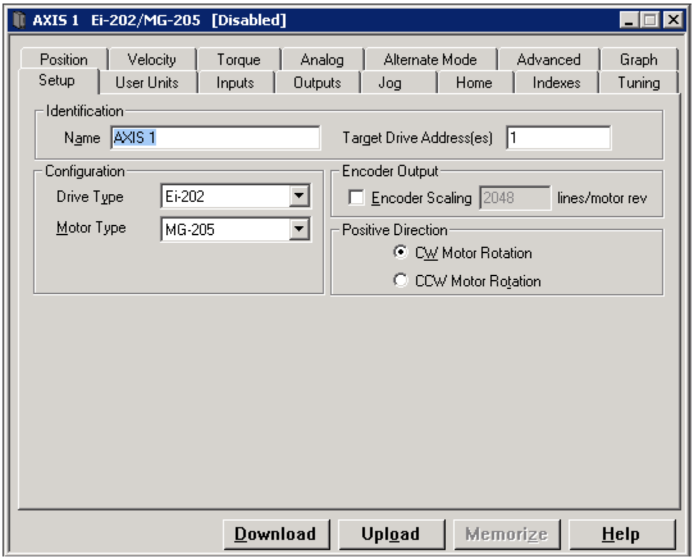


Figure 113: Setup Tab

Entering Identification Parameters:

1. Enter an identifying name 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 device, 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 devices 1, 3, 4, 5, 6, 7 and 9 you could enter the addresses like this: 1,3-7,9.

Entering Configuration Parameters:

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) that will be powering the drive (EN drive only).

Entering Positive Direction Selections:

Click which direction, clockwise (CW) or counterclockwise (CCW), to be considered as motion in the positive direction.

Note

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

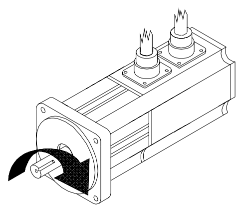


Figure 114: Clockwise Motor Rotation

Step 3: 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 drive enable input, four input lines, the debounce value and input function assignments.

Note

You cannot assign functions or Debounce the Drive Enable input line.

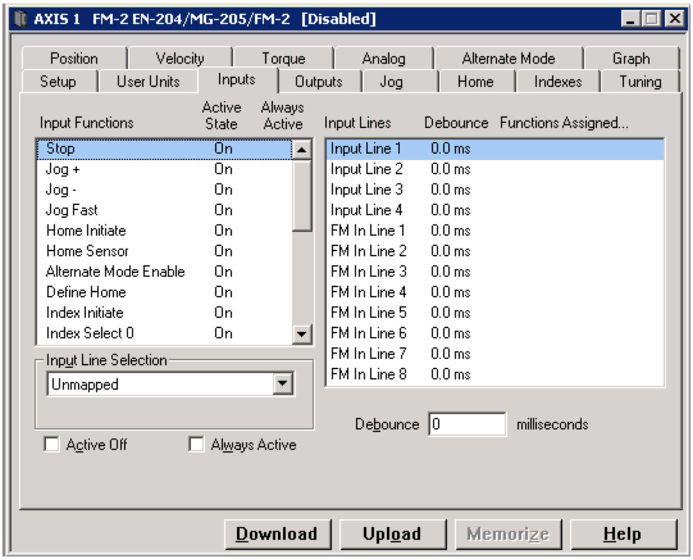


Figure 115: Inputs Tab

To assign an Input Function to an Input line:

1. Assign an input by highlighting an input function in the “Input Functions” window and select the desired input option button or drag 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” option button or drag 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 4: 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.

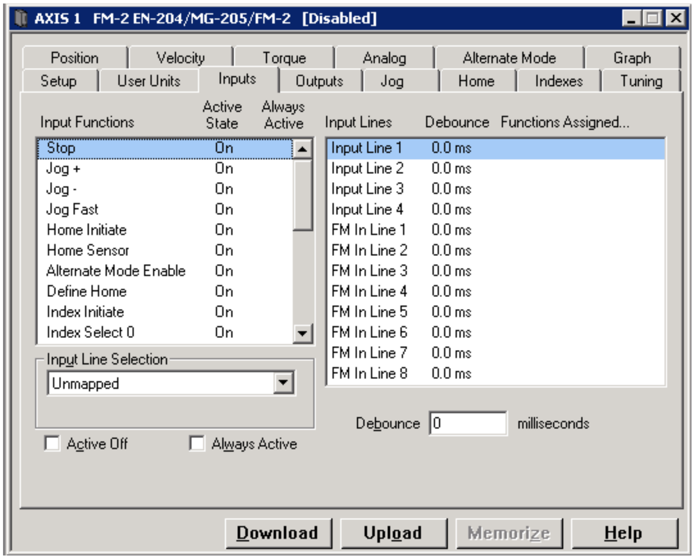


Figure 116: Outputs Tab

To assign an Output Function to an Output Line:

1. Assign an output by highlighting an output function in the "Output Functions" window and select the desired output option button or drag 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" option button or drag 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 Functions window will automatically update to the current setup.

Step 5: Setting Up Jogging

Jogging is controlled with the Jog +, Jog - and Jog Fast input functions. Jogging (like all motion types) is exclusive and will not be initiated when any other motion command is in progress.

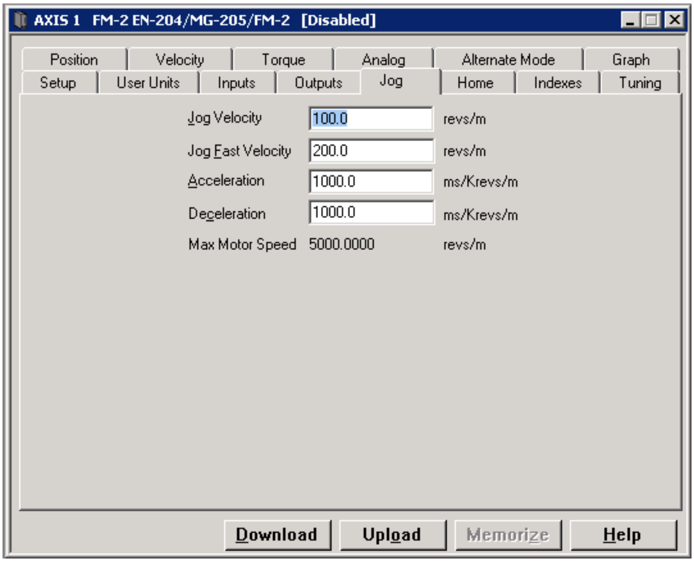


Figure 117: Jogging Parameter Set-up

Before initiating jogging motion, enter the jog related parameters as described below.

1. The Jog Velocity parameter specifies the velocity used for jogging when the Jog Fast input function is not active.

2. The Jog Fast Velocity parameter specifies the velocity used for jogging when the Jog Fast input function is active.

3. The Acceleration parameter specifies the acceleration value to be used during jogging.

4. The Deceleration parameter specifies the deceleration value to be used during jogging.

Step 6: Setting Up the Home Routine

Many applications require that the axis be aligned with some part of the machine before indexes are initiated. The device has a powerful home routine for accomplishing this task. The parameters used by the home are described below.

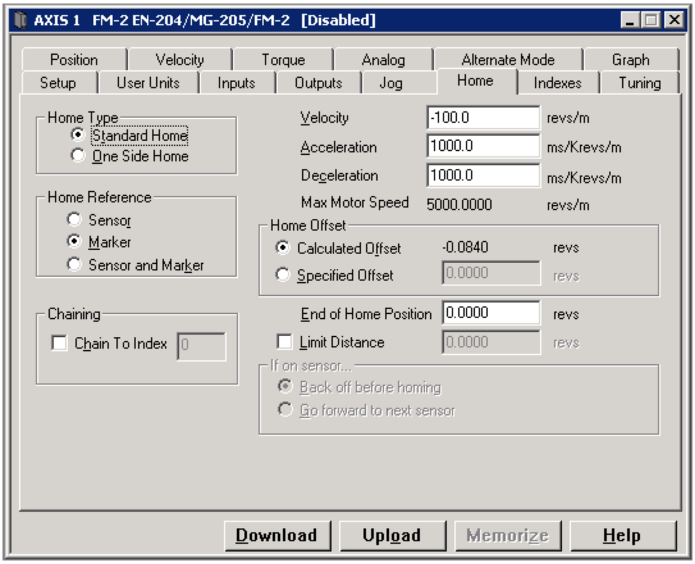


Figure 118: Home Routine Parameter

1. The Home Reference parameter determines how the home reference position is established. The parameter can have one of three different values: 'Sensor', 'Marker', 'Sensor and Marker'.

   - When the Home Reference is 'Sensor' the going active edge of the 'Home Sensor' input function is used to establish the reference position.
   - When the Home Reference is 'Marker' the rising edge of the motor encoder's marker channel is used to establish the reference position.
   - When the Home Reference is 'Sensor and Marker' the reference position is established using the first marker rising edge after the Home Sensor input function goes active.

2. The Velocity parameter specifies the velocity used for homing. Use a positive value to search for home in the positive direction and a negative value to search for home in the negative direction.

3. The Acceleration parameter specifies the acceleration value to be used during the home.

4. The Deceleration parameter specifies the deceleration value to be used during the home.

5. The Home Offset parameter designates the location of the home position in the machine coordinate system relative to the home reference. During the homing routine, after the home reference is detected, the device moves the motor to the home offset position. This

may be a calculated value or a specified value. A calculated offset is the distance required to decelerate to a stop from the home velocity.

6. After the motor reaches the home offset position, the End of Home Position value is put into the command and feedback positions.

7. The Home Limit Distance check box enables the Home Limit Distance parameter. If this flag is not set, there is no limit to the distance the drive will travel during the home routine.

8. The Home Limit Distance parameter places an upper limit on the distance the motor will travel during the home. In situations where the reference position indicator (sensor or marker) is not seen, this parameter limits the total distance the motor will move.

9. Select either the Back off before homing or Go forward to next sensor option button in the "If On Sensor ..." group. This determines the operation of the system if the Home Sensor input function is "On" when the home is initiated.

Step 7: Setting Up Indexes

The device supports 16 indexes. They are configured in the Index tab as described below.

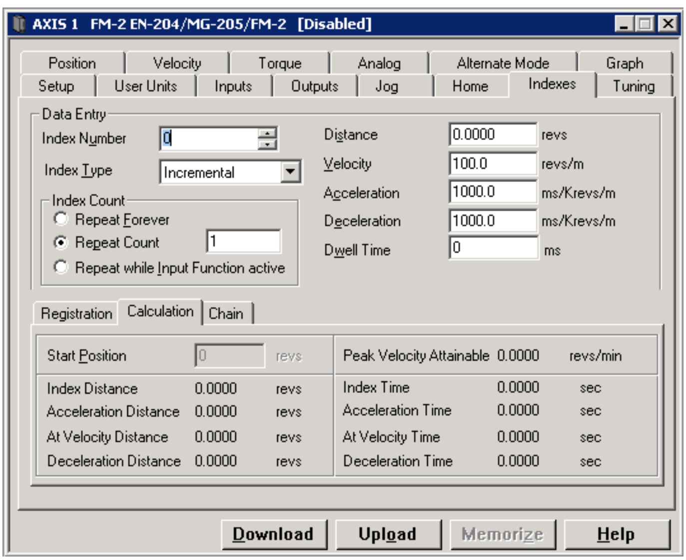


Figure 119: Index Tab Setup

1. Enter the Index Number you want to modify (0 to 15).

2. Select the index type. Absolute indexes travel to specific absolute positions. Incremental indexes move the axis a specific distance from its current position.

3. The Distance/Position parameter specifies the distance the index will travel (incremental index) or the absolute position the index will move to (absolute index).

4. The Velocity parameter specifies the velocity used for the index. The velocity parameter can not be negative.

5. The Acceleration parameter specifies the acceleration value to be used during the index.

6. The Deceleration parameter specifies the deceleration value to be used during the index.

On-line Setup

These steps assume you have already created a configuration file. If you have already downloaded the configuration file, go to Step 3. If you have not yet created the configuration file, go to Off-line Setup Step 1. Do Steps 1 through 7 in the previous section, "Off-line Setup", before establishing communications.

Note

Generally, on-line setup is used when editing parameters in a device. Off-line setup editing is usually only done when not connected to a device.

Step 1: Establishing Communications with Drive

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

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.

3. Select the "Configure Serial Port" option on the Modbus Setup screen. The "Communications Setup" dialog box below will be displayed.

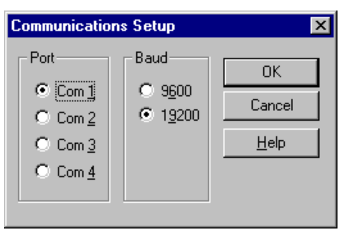


Figure 120: Communications Setup Screen

4. Select the Com port you will be using on your PC and baud rate.

5. Click the *OK* button on the Communications Setup Dialog box and on the Modbus Setup screens.

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 device(s) you wish to download to in the “Target Drive Address(es)” text box.

You may use commas (,) or spaces ( ) to separate individual device addresses or you may use hyphens (-) to include all the device addresses within a range. For example, if you wanted to download to devices 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 device, 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 device(s) you select in the Download window.

Note

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

Step 3: Opening an On-line Configuration Window

If you are not already on-line with the device, use this section to upload a configuration for on-line editing.

To open an on-line 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.

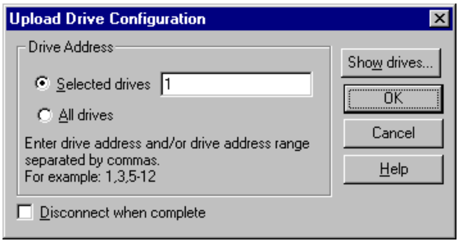


Figure 121: Upload Drive Configuration Dialog Box

Selected Drives Option 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 option button or click the *Show drives* button.

All Drives Option Button

If you select the All drives option 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.

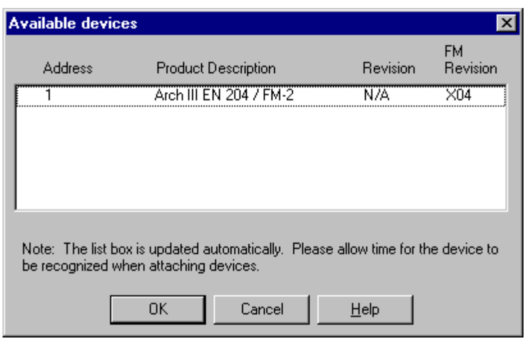


Figure 122: Available Devices Dialog Box

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: Control Panel

The Control Panel allows the user to jog, index or home the device with the click of a button. This tool helps reduce the time required to setup and simplifies diagnostics. The Control Panel can be accessed by selecting Control Panel from **Tools** on the menu or by clicking on the Control Panel icon on the toolbar.

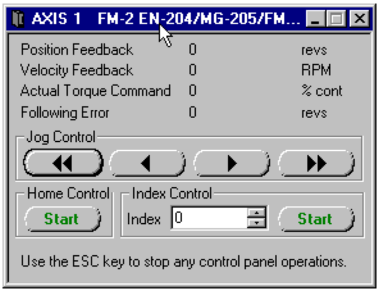


Figure 123: Control Panel

Step 5: Operation Verification

After downloading a configuration file to the FM-2 Module you may want to verify the operation of the system using the checklist below.

1. I/O powered.
2. Connections installed.
3. Enable the drive.
4. Verify “R” on the drive LED display.
5. Jog the axis with the Control Panel or Jog +/Jog - input functions.
6. Initiate a Home.
7. Initiate an Index.

Step 6: Saving the Configuration File

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

Step 7: 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 on-line, the print-out will include several pages of useful on-line diagnostic information.

Step 8: 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 off-line.

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

The drive uses closed loop controllers to control the position and velocity Travel Limit 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.

Many closed loop controllers require tuning using individual user-specified proportional, integral and derivative (PID) gains which require skilled “tweaking” to optimize. The combination of these gains along with the drive gain, motor gain, and motor inertia, define the system bandwidth. The overall system bandwidth is usually unknown at the end of the tweaking process. The drive closes the control loops for the user using a state-space pole placement technique. Using this method, the drive’s position control can be simply and accurately tuned. The overall system’s bandwidth can be defined by a single user-specified value (Response).

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 setup 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. A drive can be tuned basically to four levels.

- 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 FM software or an FM-P.

Initial Settings

Set the drive tuning parameters as follows:

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

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.
4. Set the Line Voltage to the applied voltage (default is 230 Vac).
5. Leave all other tuning parameters at the initial values.
6. Enable the drive and run the system.
7. Adjust Response to obtain the best performance.

Fully Optimized Level

1. Determine the actual system parameters.
2. Disable the drive.
3. Enter the parameters.
4. Line Voltage set to the applied voltage (default is 230 Vac).
5. Enable the drive and run the system.
6. Adjust Response to obtain the best performance.

General Tuning Hints

General Tuning Procedure:

1. Calculate inertia of the system

The inertia of the system up to the motor shaft should be calculated using CT-Size software or some other inertia calculating software. Under perfect mechanical conditions, entering this number into the “Inertia” parameter will produce a well-matched system tuning. Because most systems include mechanics that are less than ideal, a number less than the inertia parameter will need to be used to avoid bandwidth issues or “buzzing” of the motor.

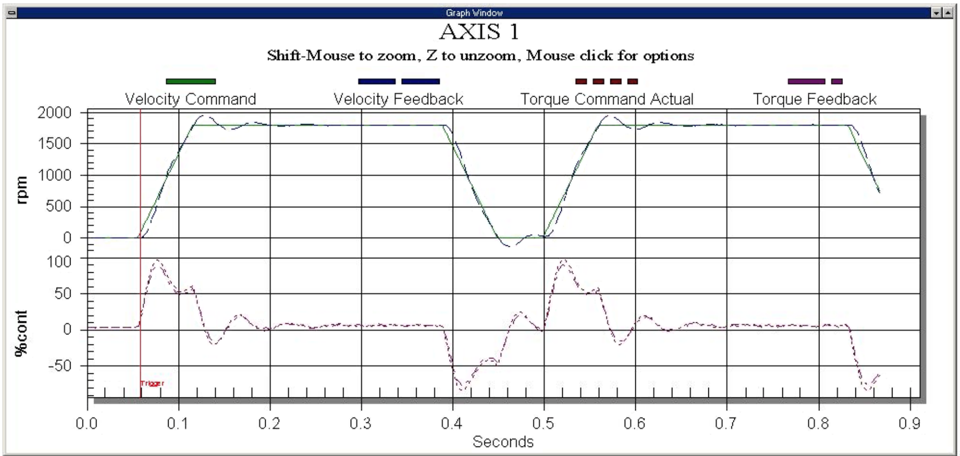


Figure 124: Default Inertia Setting (0)

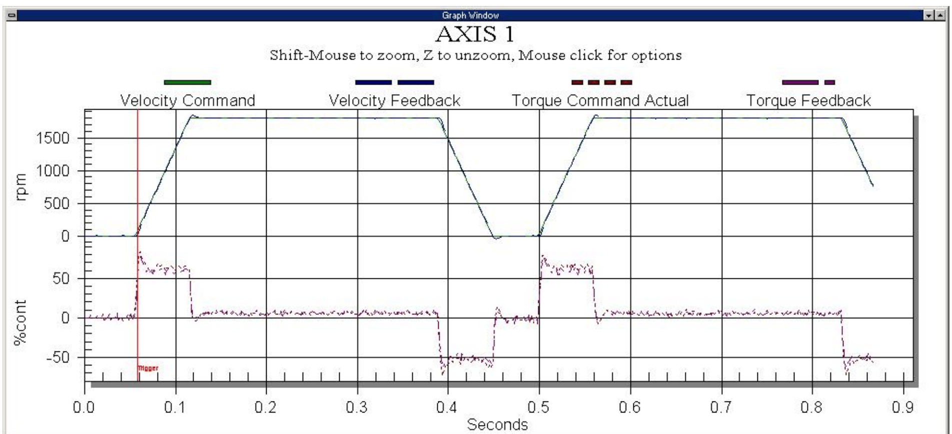


Figure 125: Inertia Setting (5)

2. Increase the response parameter

The Response is normally the next 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.

This is because most higher inertia systems have torsional compliance in the frequency range of interest. Torsional compliance is specially noticed in 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.

The next step in tuning the system to its optimal level is to move the response of the system up to the point of the desired system rigidity. A standard way of accomplishing this is to slowly increase the response of the system until the system becomes unstable (an audible noise will emit from the motor in the form of a buzz or hum). To verify stability at varying loads, this process should be completed with the smallest load on the motor shaft. Once a state of instability is reached back the response off by 20% to insure stable operation for years to come.

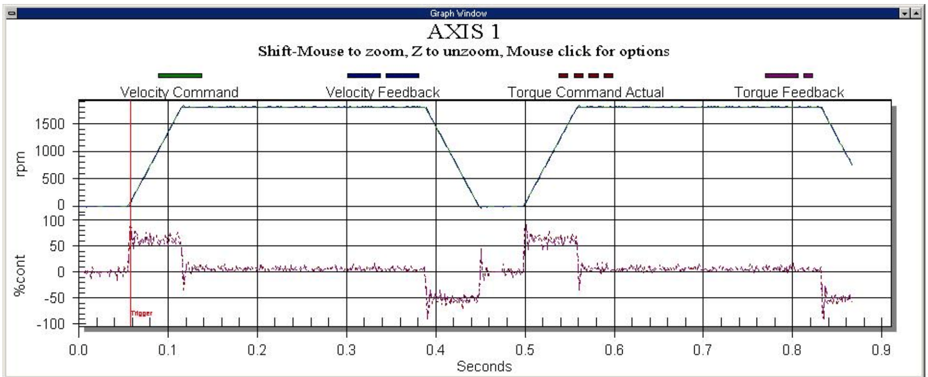


Figure 126: Inertia Setting (5) Response

3. Position Error Integral

The difference in motion when this parameter is disabled and enabled can be observed in the following graphs. The first graph shows motion with the position error integral turned off. The second graph shows motion with the position error integral enabled and the time constant set for 20ms. Note the settling time difference of the two indexes.

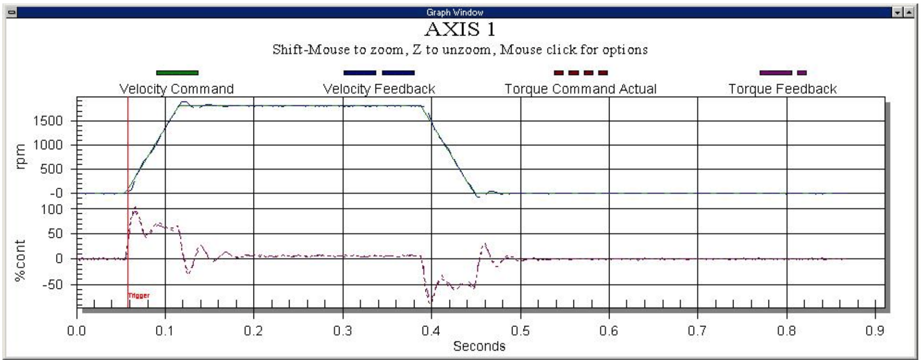


Figure 127: PEI = off

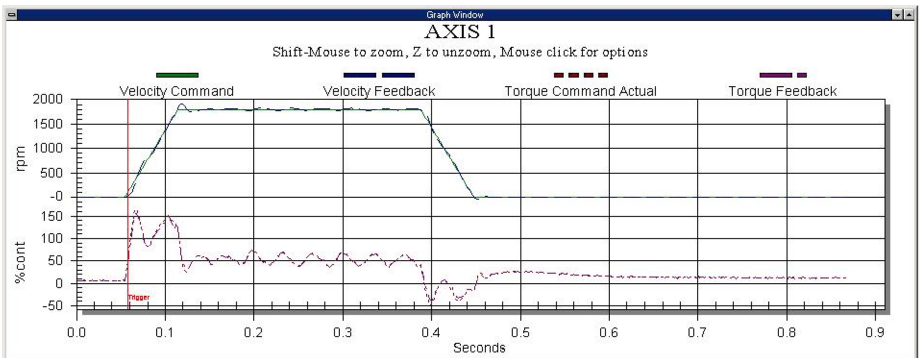


Figure 128: PEI = on

Feedforwards gain 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 can actually be degraded or stability will suffer. Enabling Feedforwards 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.

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

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.

There are three guidelines for defining the inertia ratio:

1. In most applications the default value of 0 (zero) will be used.

2. If the inertia of the machines varies or there is uncertainty in the estimate, use the lowest value for inertia.

3. The machine system bandwidth is reduced if the inertia estimate is low. Consequently a low inertia estimate can sometimes add a level of robustness.

Friction

In the drive, this is a viscous friction parameter, 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. For most servo drives viscous friction is 0.

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.

Note

The drive's position velocity loop is designed to be a second order system with a gain of one, a natural frequency specified in the Response scroll box, and a damping factor of 0.8. If the drive's bandwidth is defined to be the -3dB point of the response, the idealized bandwidth of the system is approximately 2.2 times greater than the natural frequency.

For example: When the Response is set to 50, the idealized bandwidth is 110 Hz.

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, High Performance Gains should not be enabled.

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, in certain modes 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	No
Summation	No	Yes

Low Pass Filter Group

The Low Pass Filter will reduce machine resonance due to mechanical coupling and other flexible drive/load components by filtering the command generated by the velocity loop. A check box on the Tuning tab enables a low pass filter applied to the output of the velocity command before the torque compensator.   The low pass filter frequency parameter defines the low pass filter cut-off frequency. Signals exceeding this frequency will be filtered at a rate of 40 dB per decade. The default value is 600Hz.

Line Voltage

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 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 FM 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, PowerTools FM software or an FM-P.

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 connect 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 (default scaled Torque Command)	RPM /volt (default scaled Actual Velocity)
MG-205	EN-204	4.77	30	600
MG-208		5.11	30	600
MG-316		3.17	30	600
NT-320		4.3	30	600
MG-316	EN-208	3.17	30	600
MG-340		3.14	30	600
MG-455		2.44	30	600
NT-320		5.16	30	600
NT-330		6.87	30	600
NT-345		6.72	30	600
NT-355		5.97	30	600

Motor	Drive	Vm	Percent Continuous/volt (default scaled Torque Command)	RPM /volt (default scaled Actual Velocity)
MG-455	EN-214	2.44	30	600
MG-490		1.85	30	600
MG-4120		1.69	30	600
NT-345		6.72	30	600
NT-355		5.97	30	600
NT-207	Ei-202	7.16	30	600
NT-212		9.22	30	600
MG-205		5.00	30	600
MG-208		6.47	30	600
NT-207	Ei-203	7.16	30	600
NT-212		12.40	30	600
MG-205		5.00	30	600
MG-208		8.25	30	600
MG-316		15.68	30	600

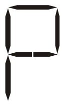
Diagnostics and Troubleshooting

Diagnostic Display

The diagnostic display on the front of the drive shows drive and FM-2 Module 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 any motion command will cause motion. Motion commands will not cause motion unless you are Ready (R) and 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.
	Disabled	Power Stage is disabled.
	Ready	The Epsilon Ei or FM-2 and EN drive system is functioning normally and is ready to execute a motion command.
	Indexing	Index in progress. Other motion commands do not function.
	Jogging	Jog function in progress. Other motion commands do not function.
	Homing	Home cycle in progress. Other motion commands do not function.
	Torque Mode	Analog Torque Mode Operation

Display Indication	Status	Description
	Velocity Mode	Analog Velocity Mode Operation
	Pulse Mode	Pulse Mode Operation
	Stop or Travel Limit Decel	*Stop* or *Travel Limit Decel* in progress.
	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.
	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 diagnostics 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 +/- 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
	Flash Invalid	Reprogram the FM's Flash	Yes
	Drive Overtemp (Epsilon drive only)	Allow Drive to Cool down, Cycle Power	Yes
	Power Up Test	Cycle Power	Yes
	NVM Invalid	Reset Button or Input Line	Yes
	Invalid Configuration	Reset Button or Input Line	Yes
	Power Module	Reset Button or Input Line	Yes
	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

Display	Fault	Action to Reset	Bridge Disabled
	Motor Overtemp	Reset Button or Input Line	Yes
	RMS Shunt Power	Reset Button or Input Line	Yes
	Overspeed	Reset Button or Input Line	Yes
	Max Following Error (Position mode)	Reset Button or Input Line	Yes
	Travel Limit +/-	Auto	No
	All “On”	Normally on for one second during power up	Yes

Fault Descriptions

 Flash Invalid

This fault indicates that the firmware checksum has failed. Use the Tools|Program Flash menu item from PowerTools FM to reprogram/upgrade the firmware stored in flash memory. If this problem persists, call Control Techniques. A common cause would be an interrupted F/W Flash upgrade (cable disconnected in the middle of an upgrade process).

 Drive Overtemp

Indicates the drive IGBT temperature has reached 100ºC (212ºF).

 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

Epsilon Only

If this occurs call Technical Support at Control Techniques.

EN

E Series Only

The FM was not on this drive during its previous power-up and it is not known if the setup data in the FM matches the drive and motor to which the FM is now attached.

This can also happen when a FM is removed from a drive and the drive is powered-up.

To reset the fault, create or open a configuration file with the correct drive and motor selections and download the configuration to the FM or drive. If you are certain that the setup data in the FM or drive matches the system configuration, press and hold the EN drive's Reset button for 10 seconds (until the fault is cleared).

⚠ CAUTION

Damage may occur to the drive, motor or both if the fault is cleared using the Reset button when the setup data in the FM does not match the current drive and motor.

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 440 Vdc. The most likely cause of this fault would be an open shunt fuse, a high AC line condition or an application that requires an external shunt (e.g., a large load with rapid deceleration).

Low DC Bus

This fault will occur whenever the voltage on the DC bus drops below 60 volts. 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. 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.

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.

Encoder Hardware

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

Motor Overtemp

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

RMS Shunt Power

EN **E Series Only**

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

Overspeed

This fault occurs when the actual motor speed exceeds the Overspeed Velocity Limit parameter. This parameter can be accessed with PowerTools FM software.

Max Following Error

This fault is generated when the following error exceeds the following error limit (default following error limit is 0.2 revs). With PowerTools FM you can change the Following Error Limit value or disable it on the Position tab.

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 Technical Service at Control Techniques.

Diagnostic Analog Output Test Points

The DGNE cable was designed to be use 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.

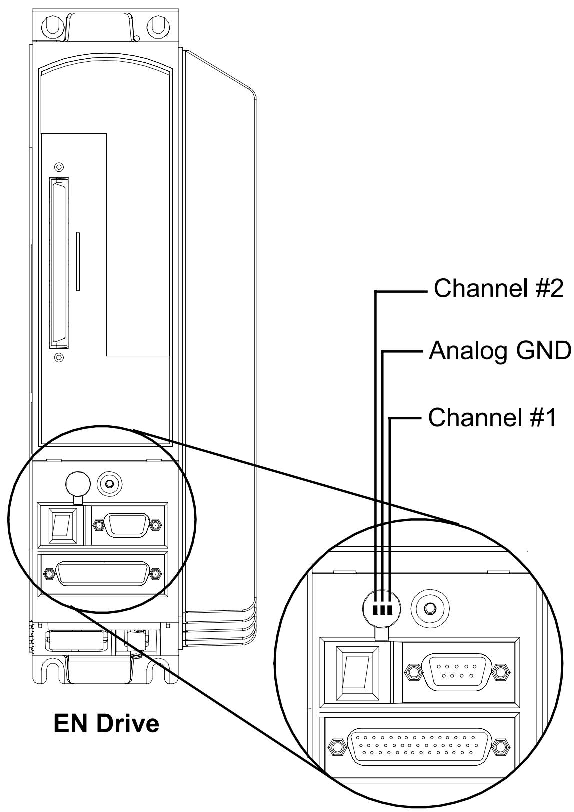


Figure 129: Diagnostic Output Test Points

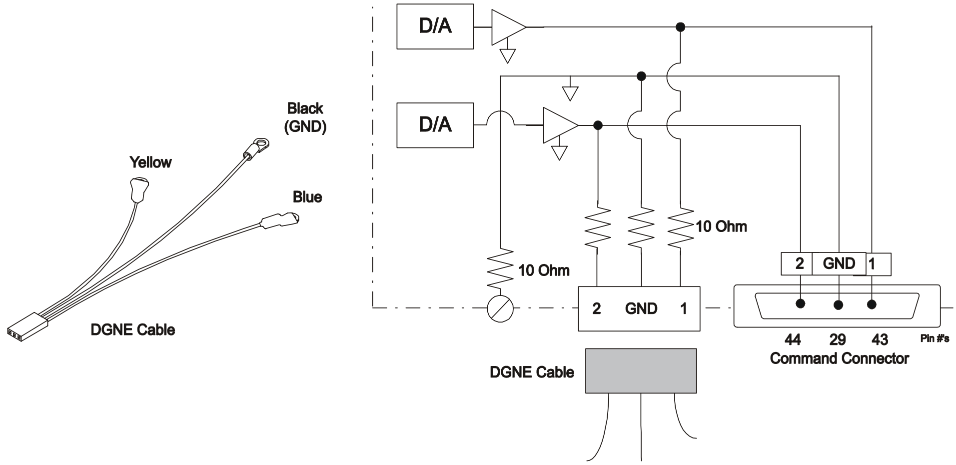


Figure 130: Diagnostic Cable (DGNE) Diagram

Drive Faults

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

Figure 131: Active Drive Faults Dialog Box

Resetting Faults

Some drive faults are automatically reset when the fault condition is cleared. Others require drive power to be cycled or the drive to be “rebooted” to be cleared. 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. The dialog box displayed is the same as Active Drive Faults 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 on-line 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.

Note

It is normal to have the Watch Window show up with the three motor parameters already selected. If you do not need to view them, simply push the *Clear All* button and select the parameters you wish to view.

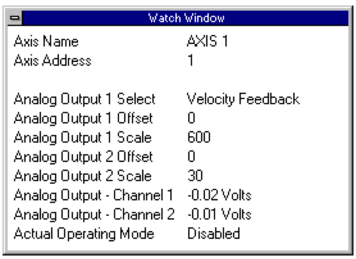


Figure 132: Watch Window

Note

Parameters selected and displayed in the Watch Window cannot be updated from the tabs. To update a parameter, delete it from the Watch Window selection.

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.

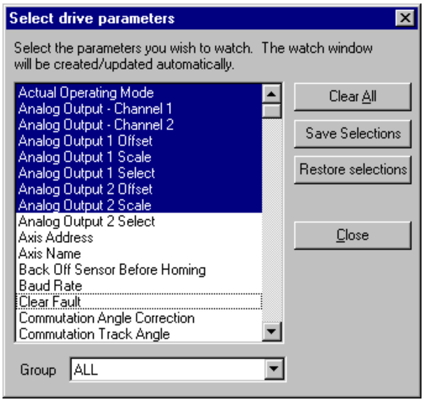


Figure 133: Select Drive Parameters Dialog Box

Select Drive Parameters Dialog Box

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 Out, Communication, Digital Inputs, Digital Outputs, Fault Counts, Fault Log, Home, ID, Input Functions, Jog, Motion Commands, Motor, Output Functions, Position, Setup, Status, Torque, Tuning, User Defined Motor, 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 on-line 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 on-line session.

View Motor Parameters

When on-line 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.

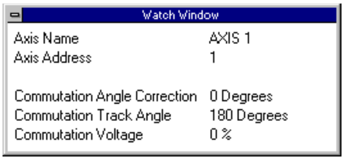


Figure 134: View Motor Parameters Window

The View Motor Parameters window is accessed by selecting View Motor Parameters from the **Tools** menu.

Control Panel

PowerTools FM software is capable of monitoring the performance of the drive. The Control Panel allows the user to jog, index or home the drive with the click of a button. This tool helps reduce the time required to setup and simplifies diagnostics.

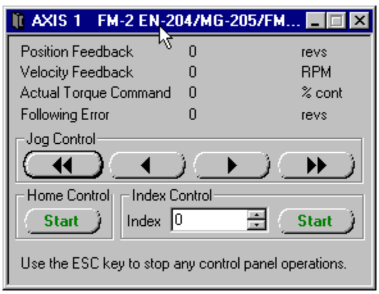


Figure 135: Control Panel Dialog Box

Keyboard Commands

Key	Action
SPACEBAR	Activate the control with the “focus” to allow keyboard-based Jog. Index and Homing control. Jogging stops when the spacebar is released.
ESC	Stops motion started with the control panel.
TAB	Moves focus to next control. The order of movement is generally from left to right and from top to bottom.
SHIFT+TAB	Moves focus to preceding control. The order of movement is generally from right to left and from top to bottom.

Error Messages

PowerTools FM 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 FM 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 effect 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.
No device selected.	The device you are attempting to communicate with is not responding.	Check all connections. Verify the baudrate. Verify that the “Maximum Node Address” value is at least the value of the address of the drive connected.

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 FM 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).

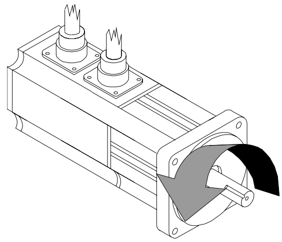


Figure 136: CCW Rotation of the Motor

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 VCA leads VBA, then assign B to T and C to S. These relationships are summarized in the figure below.

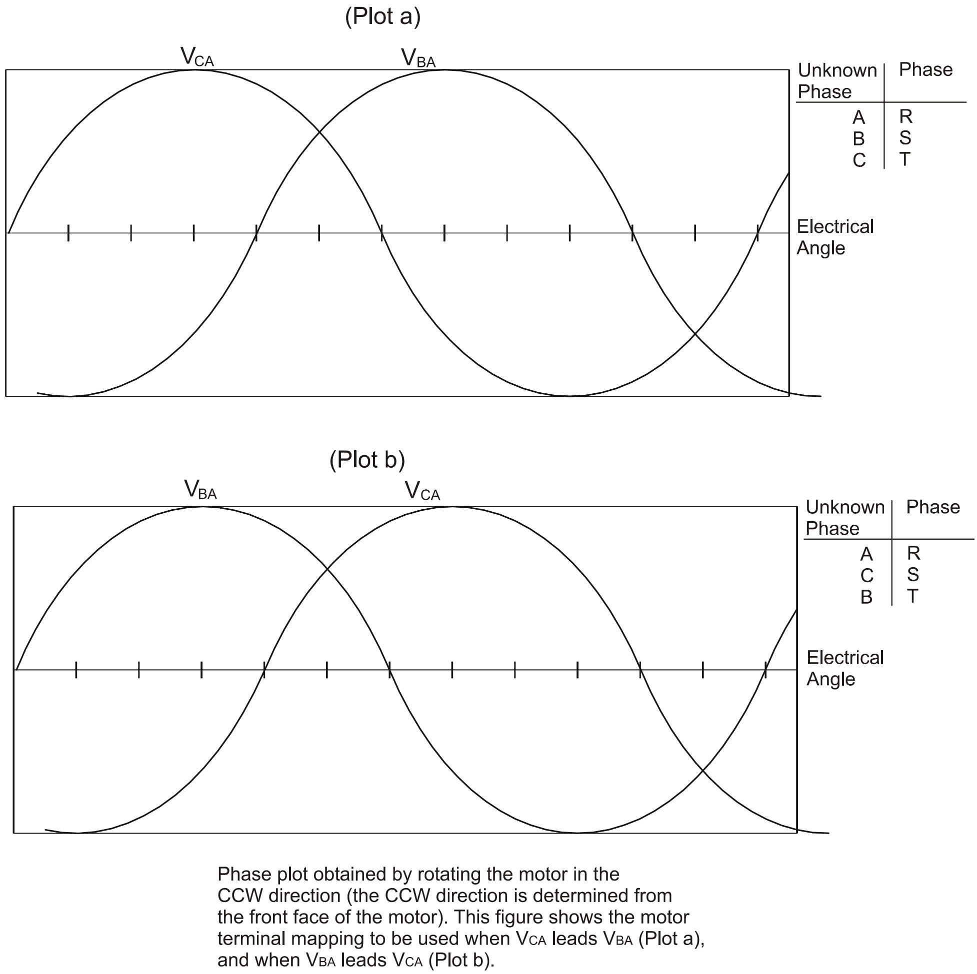


Figure 137: Phase Plot Used to Determining Stator Wiring

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.

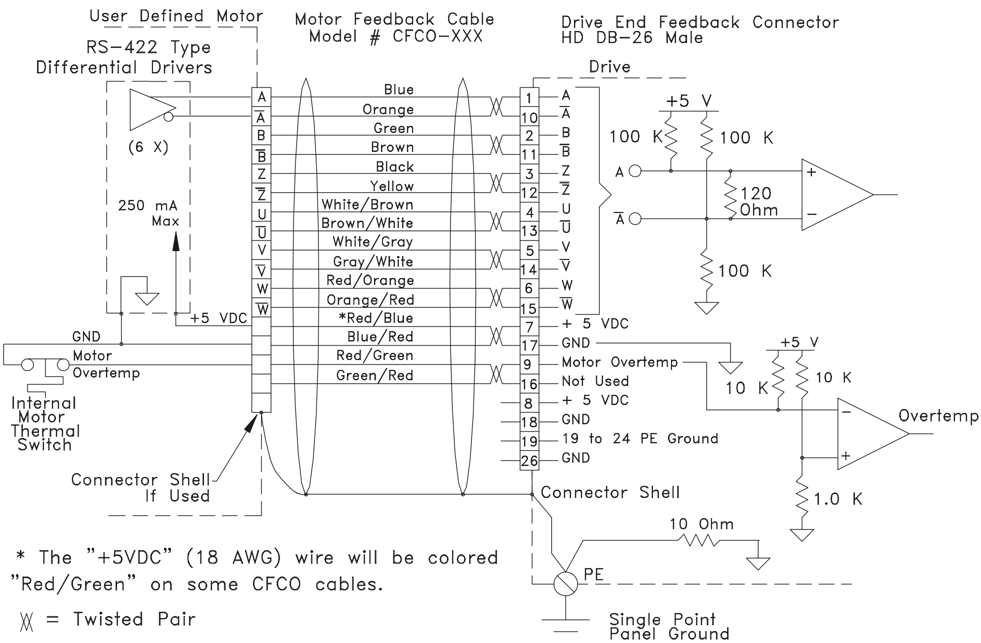


Figure 138: Encoder Connections, User Motor to a Control Techniques Drive

Note

The maximum current available out of the drive encoder +5 volt supply connection is 250 mA.

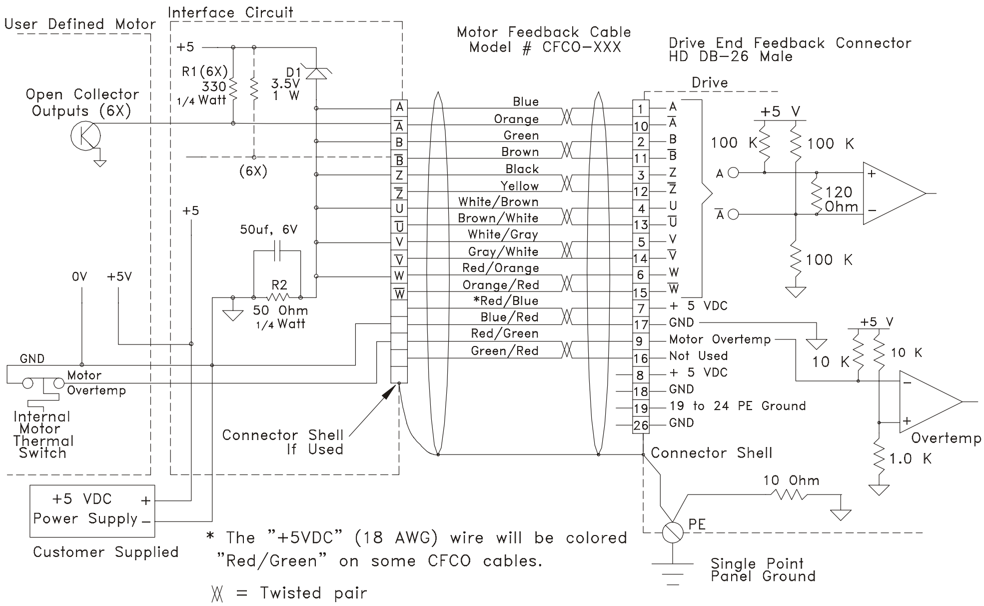


Figure 139: Control Techniques Drive to non-Control-Techniques Motor Feedback Wiring

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 is simply tampered to the encoder common ground (0 volt) pin. The thermal sensor requirements are as follows:

- If a thermistor is used, it must be a PTC (positive temperature coefficient) or increases in resistance as the temperature increases. Its cold resistance should be 500 ohms or less. The 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
- I 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.

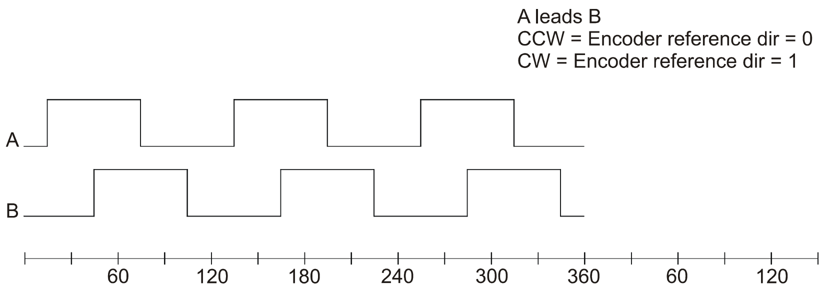


Figure 140: Phase Plot of A and B Encoder Channels

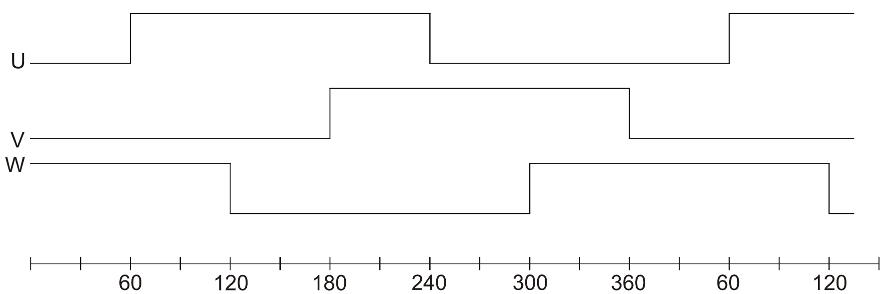


Figure 141: Phase Plot of U, V and W Encoder Signals with CCW Rotation

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 pair 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 5V drives encoder power supply will blow an internal fuse which can only be replaced at the factory.

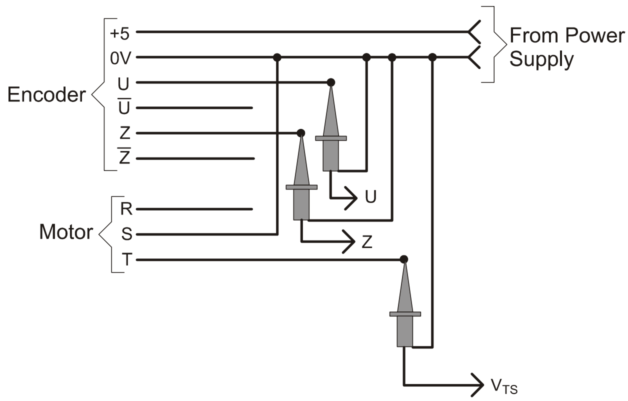


Figure 142: Oscilloscope Connections

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.

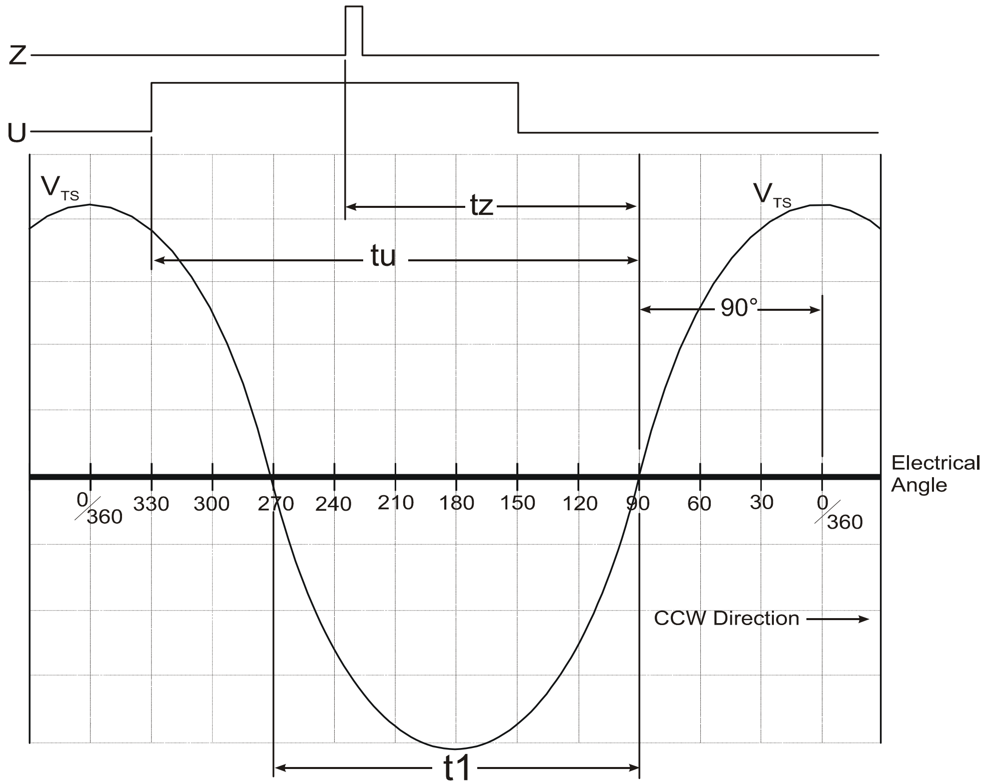


Figure 143: CCW Electrical Angle Plot

$$EUA = 90° + \left(tu \frac{180}{t1} \right)$$

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 76 to determine the electrical angle at the rising edge Z. This is the Encoder Marker Electrical Angle.

$$\text{EMA} = 90^\circ + \left(tz \frac{180}{t1} \right)$$

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.

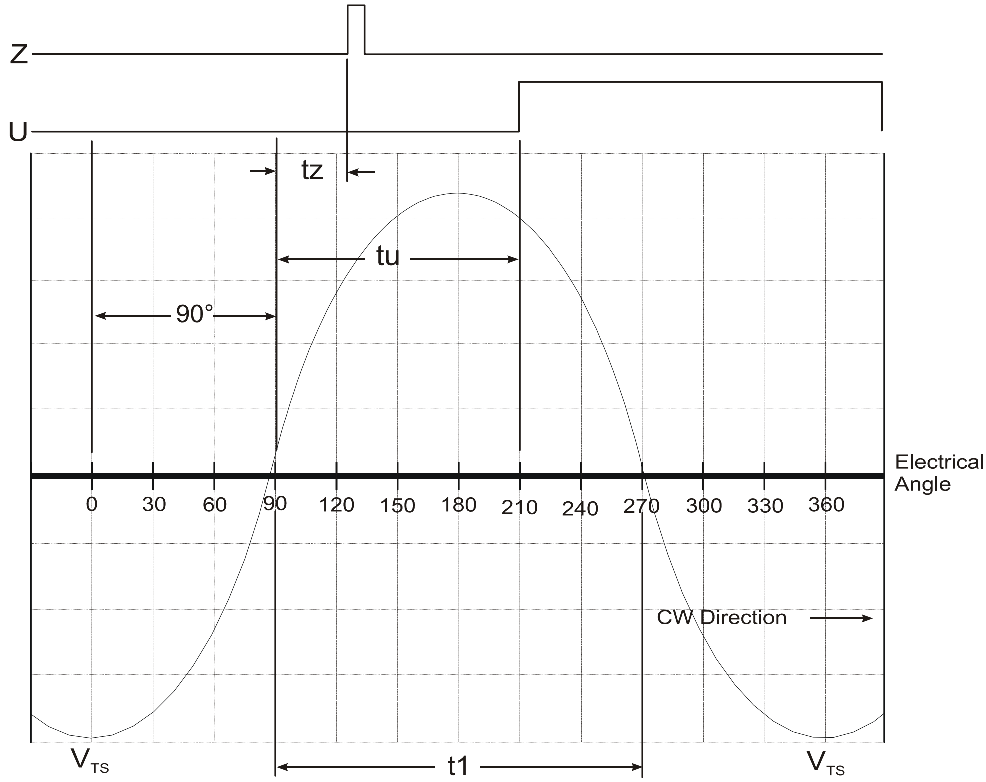


Figure 144: CW Electrical Angle Plot

In Figure 76 the electrical angle decreases from left to right and the positive peak of V_{TS} occurs at zero degrees electrical. In Figure 77 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

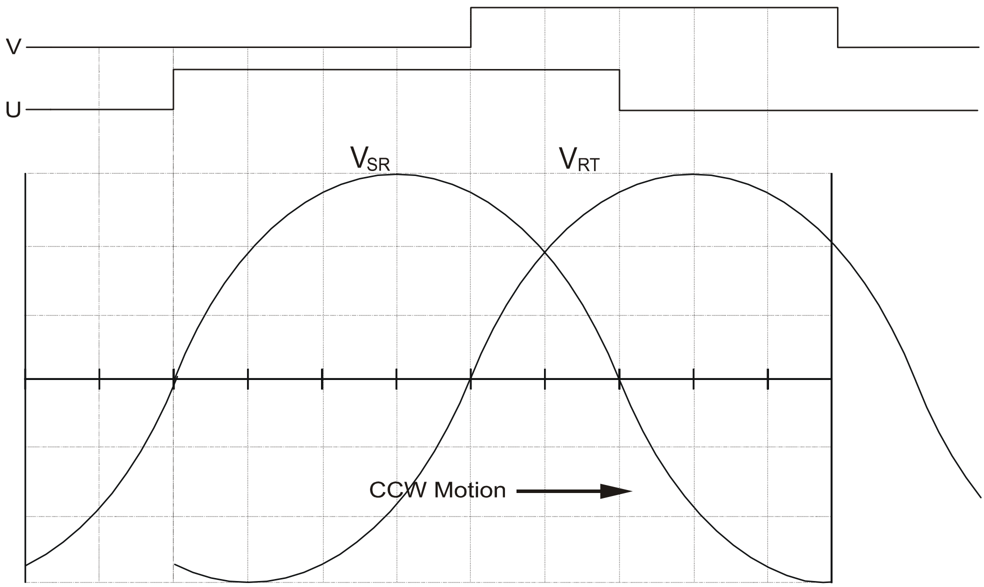
If you cannot obtain a stable angle measurement between U or Z and V_{TS}, check the encoder to verify it has the proper cycles per revolution for your motor's pole count.

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.

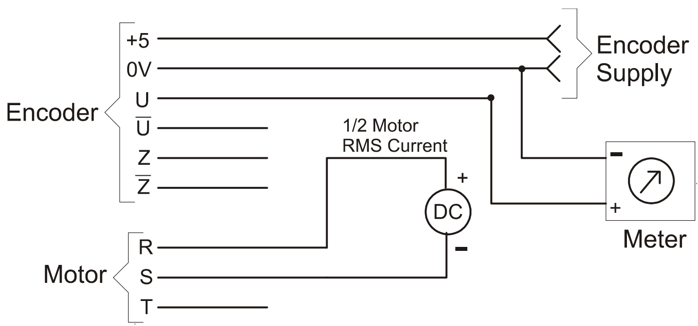
Dynamic Alignment Method

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 its 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.



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 it’s mounting until the rising edge of U is detected with a voltmeter or an oscilloscope. This procedure does not require spinning the motor.



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 its 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.

$$\text{RPM} = \frac{60}{\text{Seconds/Revolutions}}$$

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 FM 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 FM installation and is located in the same directory as the PowerTools FM 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 that uses 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, save it as MOTOR.DDF file. Then copy it back to its original directory, overwriting the existing MOTOR.DDF file. The next time PowerTools FM 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 FM revision during installation.

Serial

This parameter defines the format of the .ddf file. Do not change this parameter.

Beta

This parameter is not used and should be set to 0.

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 FM 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 FM. 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
serial=1000
beta=0
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

[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
```

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 Parameter Descriptions

Note

These parameters are valid and active only when a user defined motor is selected. When a 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 the number of encoder lines per mechanical revolution. The supported values are 1000, 1024, 2000, 2048, 2500, 4096 and 8192. The number of “encoder counts” per revolution is 4 times the value specified here because quadrature decoding is used.

This parameter 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 FM software. Once PowerTools FM 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 FM.

1. Start PowerTools FM and either open an existing file or start a new file off-line.

Note

PowerTools FM will not allow you to select a "Motor Type" or "Drive Type" while on-line 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 FM 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.

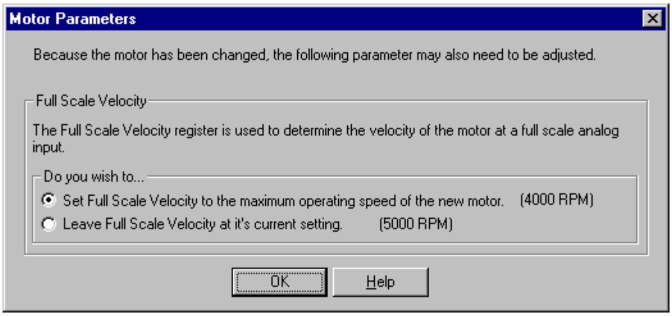


Figure 145: Motor Parameters Dialog Box

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 FM 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.

The four tests are 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 were not able to get the proceeding test to work.

Rotation Test

This test verifies that the encoder has been correctly interfaced to the drive.

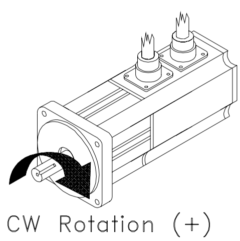


Figure 146: CW Rotation of the Motor

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 on-line 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 FM 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 CCW or no 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.

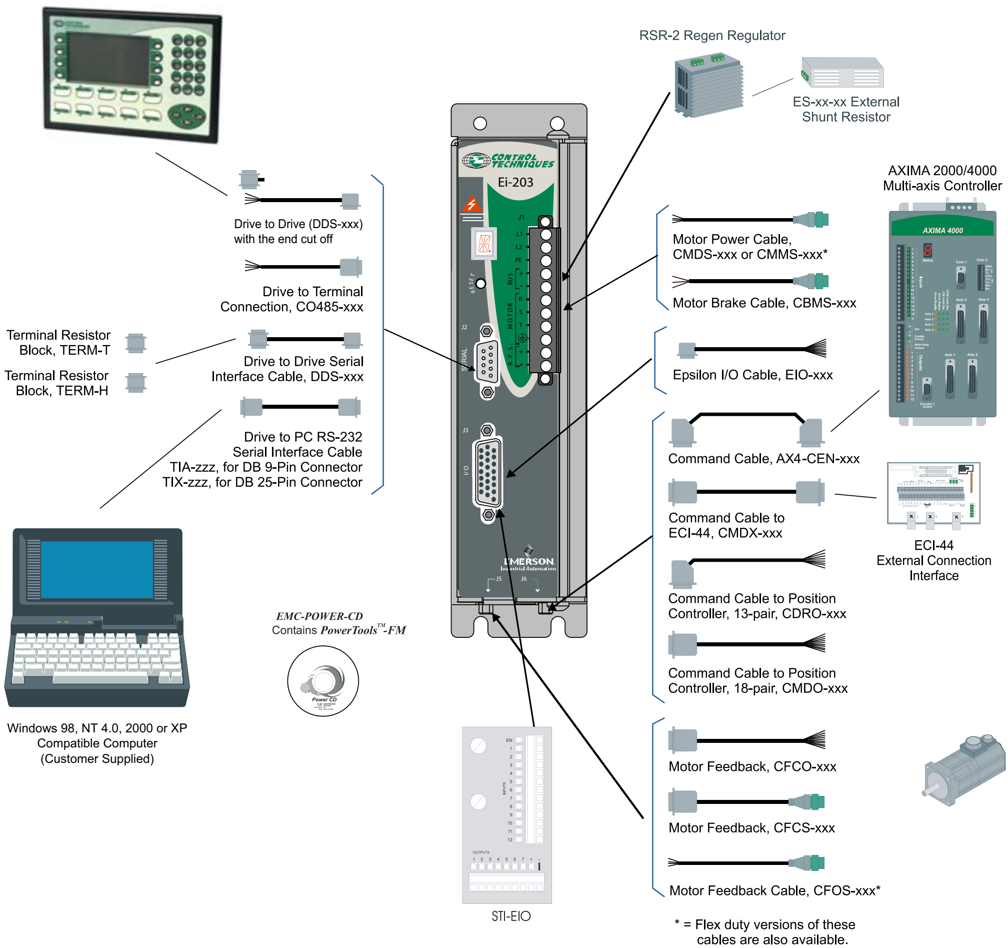
4. Enable the drive. Find the “Velocity Command Analog” parameter on the Status tab. Adjust the analog command until this parameter reads exactly 6 RPM. The motor should be moving at 6 RPM. If the system got through the Torque test, the motor should not run-away at this point. If it does, go back and 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.

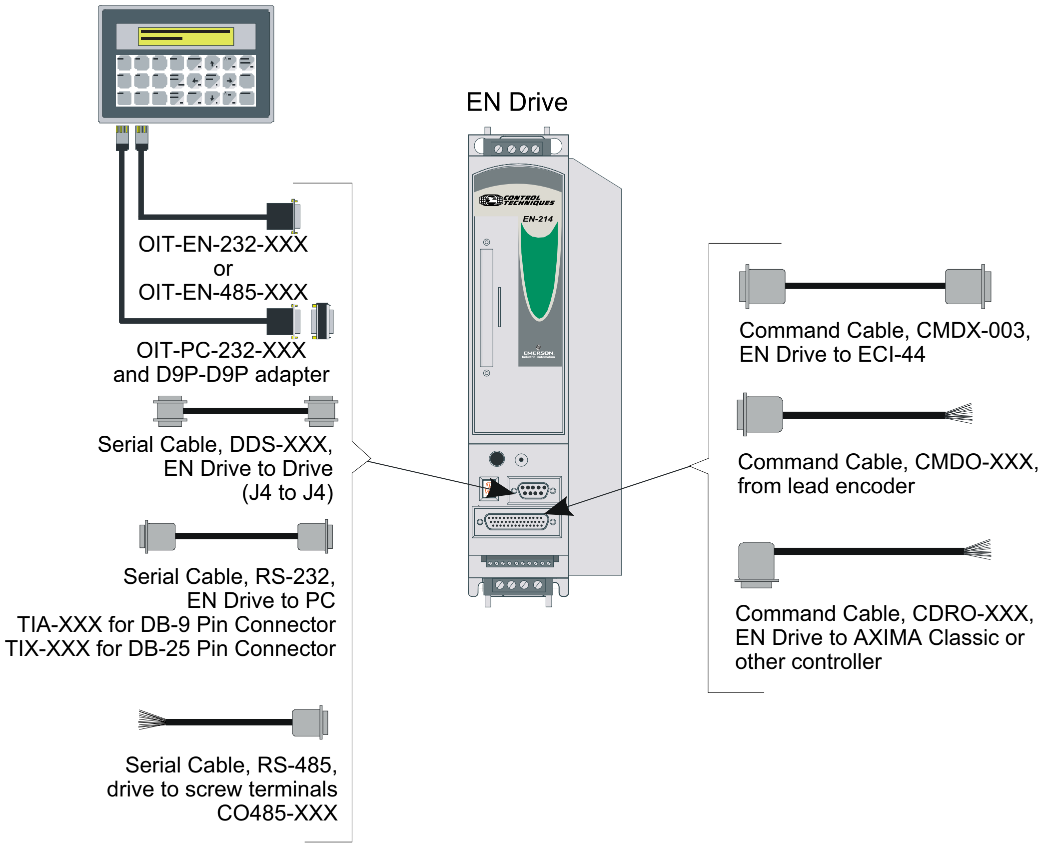
Options and Accessories

Epsilon Ei Indexing Drive Options



FM-2 Indexing Module Options

The following cables are used to connect various components to the EN drive and FM-2.



STI-EIO Interface

The STI-EIO interface, see figure 147, allows access to all digital input and output signals. The STI-EIO board mounts directly to the Epsilon drive's Input/Output Connection (J3) and away from any high voltage wiring.

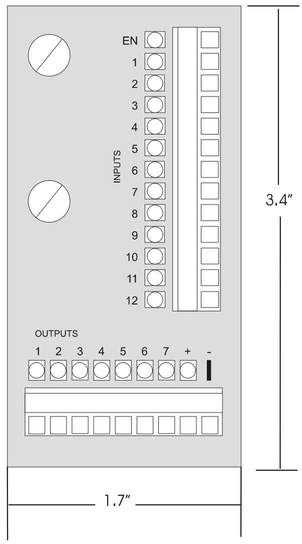


Figure 147: Dimensions of STI-EIO Board

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.

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.

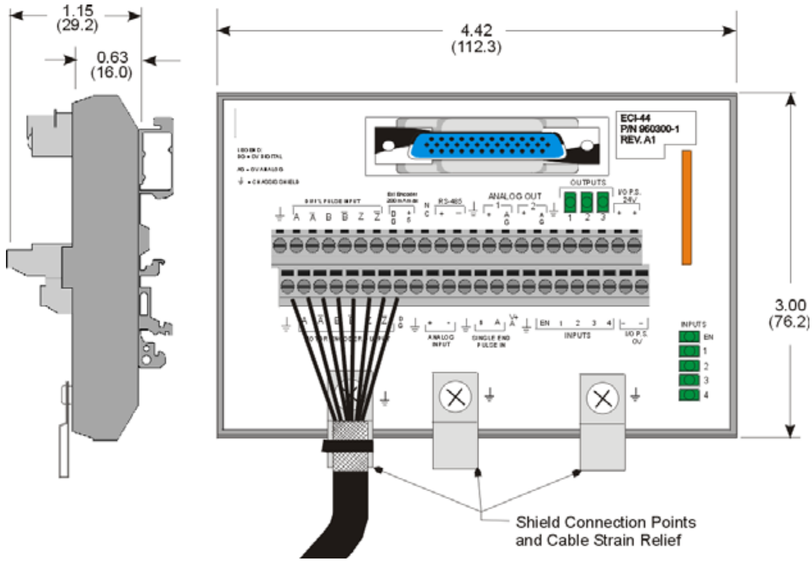


Figure 148: Dimensions of ECI-44

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.

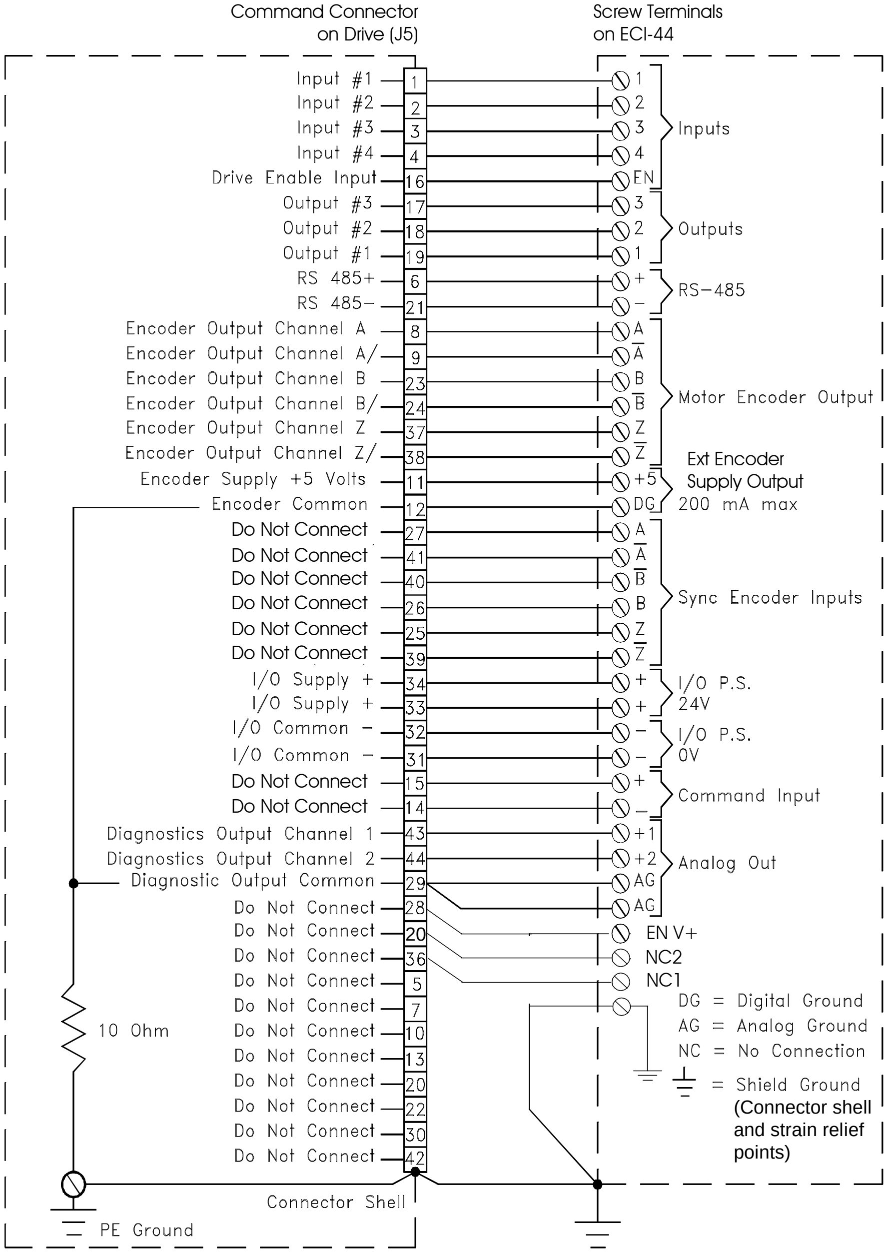


Figure 149: ECI-44 Signal Connections

Epsilon Ei Specifications

	Epsilon Series
Power Requirements	**Standard Range:** 90 - 264 Vac, 1 Ø, 47 - 63 Hz **Extended Range:** (Requires Auxiliary Power Supply (APS) 42-264 Vac, 1 Ø, 47 - 63 Hz
Auxiliary Power Supply/ Auxiliary Logic Power Input	For logic backup, 24 Vdc, 0.5A
Switching Frequency	10 kHz
Power Supply Output	5 Vdc, 250 mA maximum for master encoder usage
Efficiency - Drive	202/203: 93% at full rated output power 205: 95% at full rated output power
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 **Digital inputs:** (12) 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:** (7) 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

	Epsilon Series
Pulse Mode	**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
Encoder Output Signal	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
Shunt Resistor Capacity/ Regeneration Capacity	**Internal:** full speed, full torque decel with NT-212 motor and 5:1 inertial load. Repetition frequency limited only by drive RMS capacity. No internal shunt resistor. **External:** Bus connection provided for external regeneration unit (EMC model RSR-2 with a 20W resistor) 15 ARMS capacity.
Fault Detection Capability	Low DC bus (can be disabled) High DC bus Power Stage fault Logic power Encoder state Encoder line break Drive over temperature Motor over temperature Overspeed Travel limit (+) Travel limit (-) Pulse mode position error Watchdog timer Power-up self test failure Non-volatile memory invalid
Cooling Method	Ei-202, Ei-203 Ei-205: Convection

	Epsilon Series
Environmental	**Ambient temperature range for rated output:** O to 40° C (32 to 104° F) **Maximum ambient operating temperature:** 40 to 50° C (104 to 122° F) with power derating of 3%/° C **Rated altitude:** 1000 m (3,280 feet) **Vibration:** 10 - 2000 Hz at 2g **Humidity requirement:** 10 - 95% non-condensing **Storage temperature:** -25 to 75° C (-13 to 167° F)
Derating	**Temperature:** Operation in ambient temperature over 50° C (122° F) not recommended. Drive output power must be derated by 3%/°C between 40 to 50° C (104 to 122° F) **Derating altitude:** Above 1000 m (3,280.8 ft) reduce output by 1% per 100 m (328.08 ft)
Standards and Agency Approvals	UL listed Canadian UL listed CE Mark: Low voltage directive; EMC directive
Accessory Specifications	
Amplifier Weights	Ei-202 1.5 kg (3.3 lb) Ei-203 1.5 kg (3.3 lb) Ei-205 1.7 kg (3.7 lb) *Add 0.45 kg (1 lb) for shipping.

Drive overload protection.

Rated output current (Amps RMS)		
Drive Model	**Continuous**	**Peak**
Ei-202	1.8	3.6
Ei-203	3.0	6.0
Ei-205	5.0	10.0

FM-2 Specifications

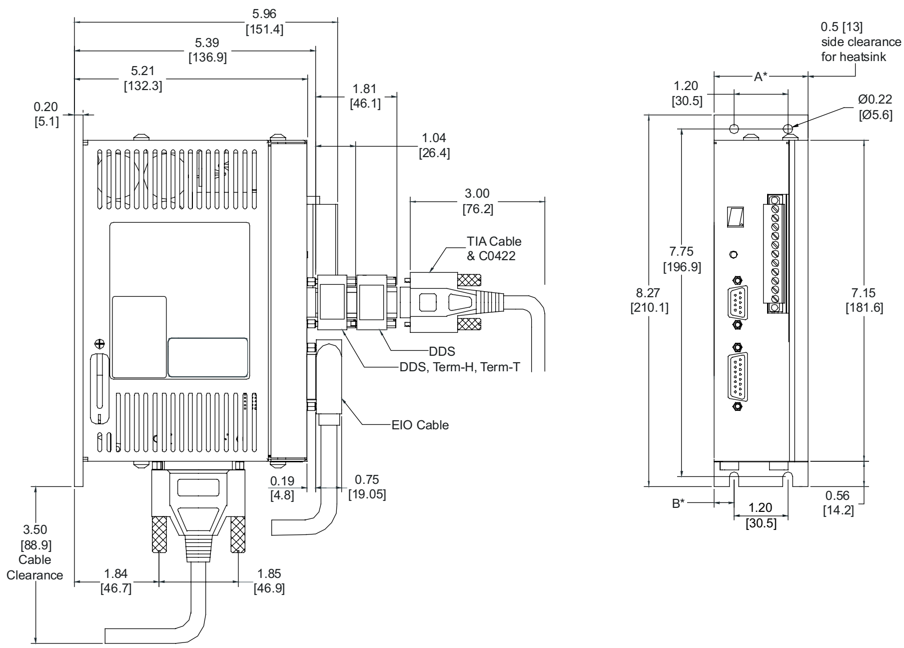
Power consumption: 5 W from EN drive power supply.

Function	Electrical Characteristics
Inputs	10-30 V (“On”), 0-3 V (“Off”), optically isolated
Outputs	10-30 V, DC sourcing, 150 mA, optically isolated

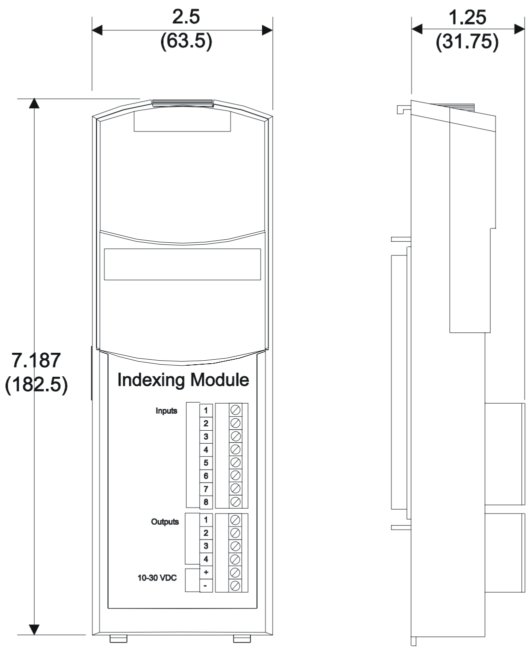
Epsilon Ei Dimensions and Clearances

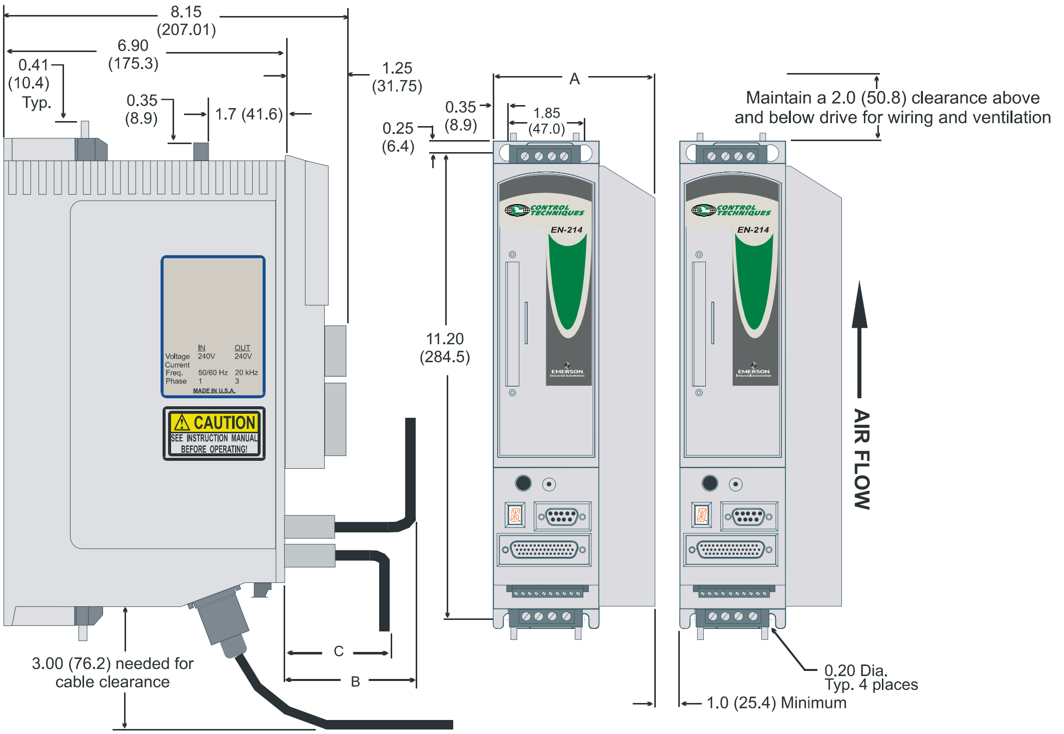
The following table applies to A* and B* as shown in the figure below.

Drive Model	Dimension A* (shown in inches/mm)	Dimension B* (shown in inches/mm)
Ei-202	2.10 [53.3]	.45 [11.4]
Ei-203	2.10 [53.3]	.45 [11.4]
Ei-205	3.56 [90.42]	.7 [17.78]



FM-2 Dimensions and Clearances





Dimensions in ( ) are millimeters

Model	A
EN-204	2.93 (74.4)
EN-208	3.43 (87.1)
EN-214	3.93 (99.8)

Model	B	C	
All Drive Models	TIA Cable CO485-XXX	CMDX CMDO	AX4-CEN CDRO
	2.5 (63.5)	3.5 (88.9)	1.75 (44.5)

Figure 150: FM-2 Module and EN Drive Dimensions and Clearances

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	Max Accel Rate ms/ krpm (no load)	Encoder resolution lines/rev	Motor Ke VRMS/ krpm	Motor Kt lb-in/ ARMS (Nm/ ARMS)
EN-204	MGE-205	5.2 (0.59)	15.6 (1.76)	0.38 (0.28)	0.000084 (0.095)	5000	0.770	2048	28.3	4.1 (0.46)
	MGE-208	9.1 (1.03)	27.3 (3.09)	0.64 (0.48)	0.000144 (0.163)	5000	0.650	2048	28.3	4.1 (0.46)
	MGE-316	18.6 (2.10)	41.9 (4.73)	1.00 (0.75)	0.000498 (0.562)	4000	1.130	2048	37.6	5.5 (0.62)
EN-208	MGE-316	18.6 (2.10)	55.8 (6.31)	1.00 (0.75)	0.000498 (0.562)	4000	0.910	2048	37.6	5.5 (0.62)
	MGM-340	48 (5.65)	133.0 (15.0)	2.00 (1.49)	0.00125 (1.414)	3000	1.090	2048	55.0	8.0 (0.90)
	MGE/M-455	68 (7.68)	139.1 (15.72)	2.46 (1.83)	0.00338 (3.819)	3000	2.680	2048	60.0	8.8 (0.99)
EN-214	MGE/M-455	68 (7.68)	201.0 (22.71)	2.46 (1.83)	0.00338 (3.819)	3000	1.890	2048	60.0	8.8 (0.99)
	MGE/M-490	100 (11.30)	208.0 (23.50)	3.75 (2.79)	0.00648 (7.319)	3000	3.380	2048	58.9	8.6 (0.97)
	MGE/M-4120	132 (14.92)	257.0 (29.03)	5.30 (3.95)	0.00938 (10.593)	3000	4.290	2048	71.8	10.5 (1.19)
Ei-202	MG-205	5 (0.56)	13.5 (1.53)	0.31 (0.23)	0.000084 (0.95)	5000	0.70	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	1.19	2048	28.3	4.1 (0.46)
	NT-207	7.3 (0.82)	15.2 (1.72)	0.45 (0.34)	0.000094 (0.1063)	5000	0.53	2048	35	5.124 (0.58)
	NT-212	9.2 (1.04)	18 (2.03)	0.71 (0.53)	0.000164 (0.185)	5000	0.93	2048	34.7	5.08 (0.57)
Ei-203	MG-205	5 (0.56)	15.0 (1.69)	0.31 (0.23)	0.000084 (0.95)	5000	0.59	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	0.72	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	1.78	2048	37.6	5.5 (0.62)
	NT-212	12.5 (1.41)	27 (3.05)	0.8 (0.6)	0.000164 (0.185)	5000	0.56	2048	34.7	5.08 (0.57)

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 (A)	Mechanical Disengagement Time	Mechanical Engagement Time
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
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)
MGE/M-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)
NT-207	3 (1.36)	N/A
NT-212	4 (1.81)	N/A

Axial/Radial Loading

Motor	Max Radial Load (lb)	Max. Axial Load (lb)
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

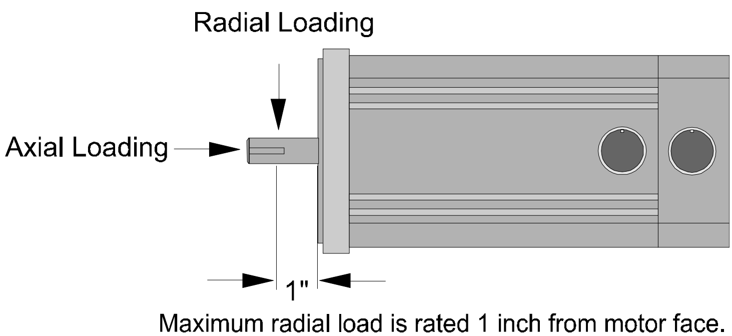


Figure 151 Axial/Radial Loading

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

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 loses on the Epsilon drive with normal loads to 15 W with additional loads such as external encoder and low input voltage (<22 Vdc on APS 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 / MG-205	19	30	52
EN-204 / MG-208		50	72
EN-204 / MG-316		82	104
EN-208 / MG-340		160	182
EN-208 / MG-455		200	222
EN-214 / MG-490		300	322
EN-214 / MG-4120		430	452
Ei-202 / MG-205	11	25	36
Ei-202 / NT-207		25	36
Ei-202 / NT-212		30	41
Ei-203 / NT-207		30	41
Ei-203 / MG-208		30	41
Ei-203 / NT-212		40	51
Ei-203 / MG-316		40	51
Ei-202 / NT-208		30	41

* Includes internal shunt power.

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

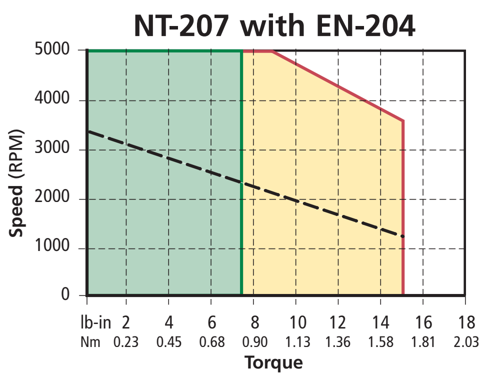
A more accurate calculation would include even more specifics such as actual torque delivered at each speed plus actual shunt regulator usage. For help in calculating these, please contact the Application Department at Control Techniques with your system profiles and loads.

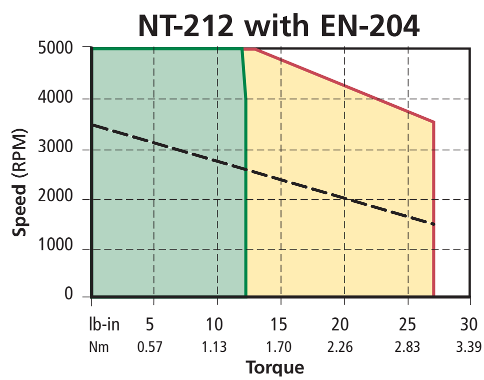
Speed Torque Curves

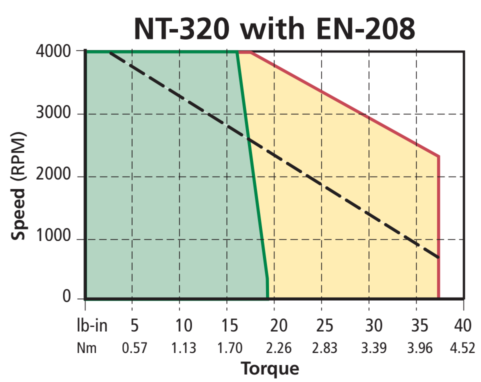
Continuous ratings of the MG motors are based on 100° C (212° F) motor case temperature and 25° C (77° F) ambient temperature with the motor mounted to an aluminum mounting plate as shown in the table below.

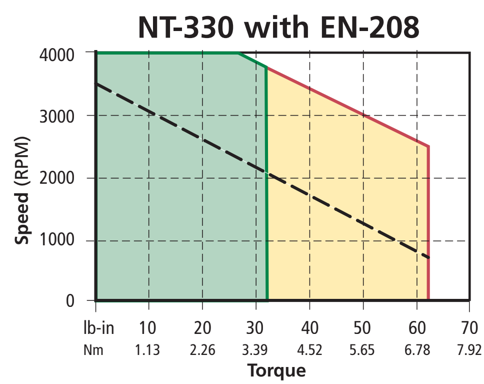
Motor	Mounting Plate Size
MG-205 and 208, NT-207 & NT-212	6” x 6” x .25”
MG-316 through 490	10” x 10” x .375
MG-4120	12” x 16” x .5”

- Speed torque curves are based on 230 Vac (3 Ø on EN-214) drive operation.
- All specifications are ±5 percent due to motor parameter variations.

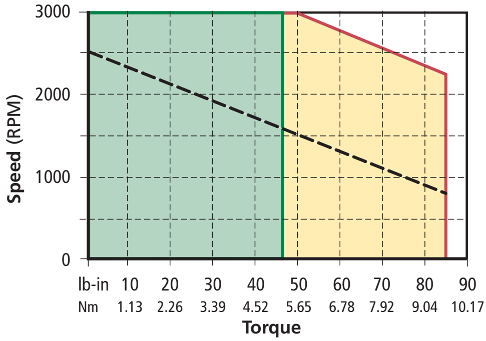




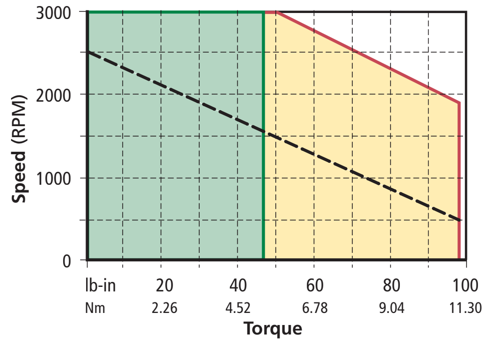




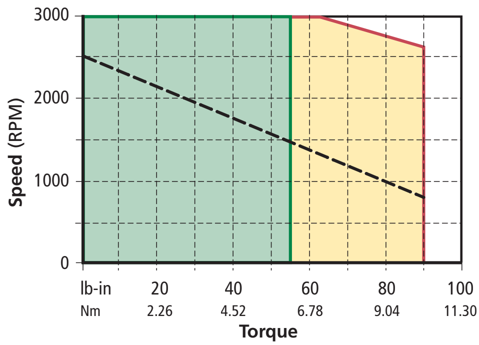
NT-345 with EN-208



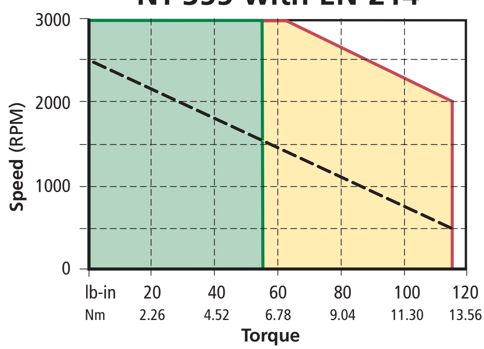
NT-345 with EN-214



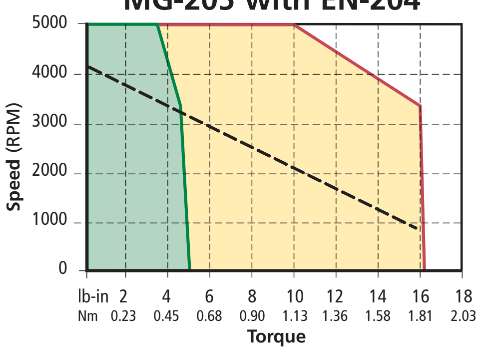
NT-355 with EN-208



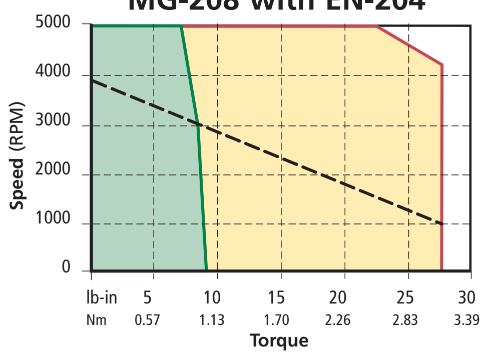
NT-355 with EN-214



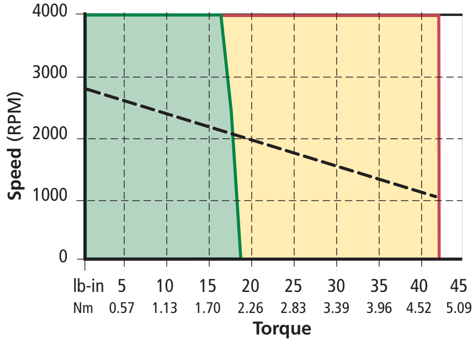
MG-205 with EN-204



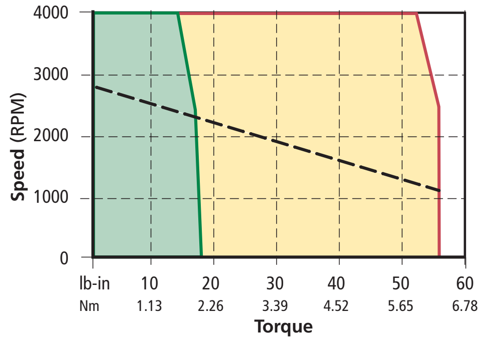
MG-208 with EN-204



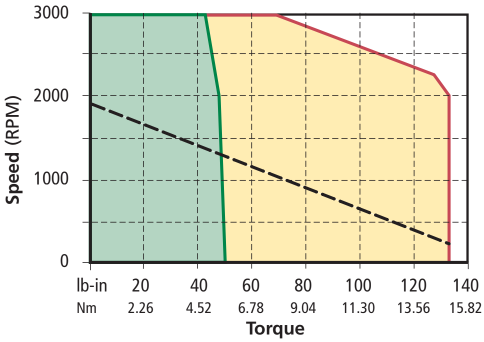
MG-316 with EN-204



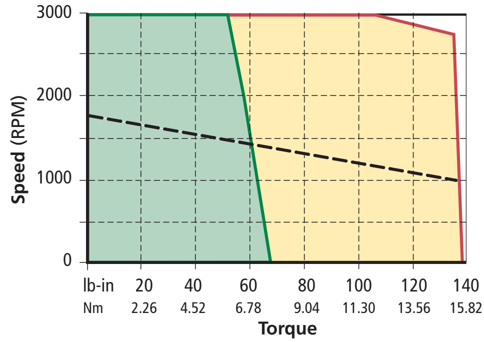
MG-316 with EN-208



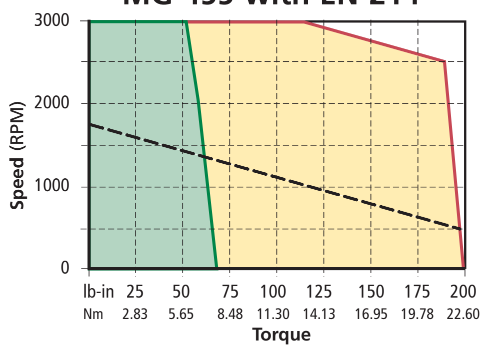
MG-340 with EN-208



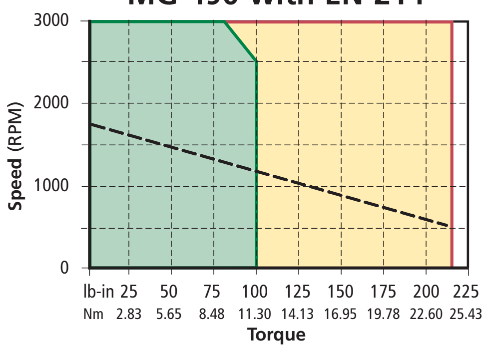
MG-455 with EN-208



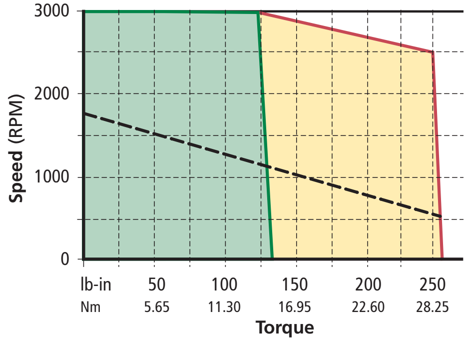
MG-455 with EN-214



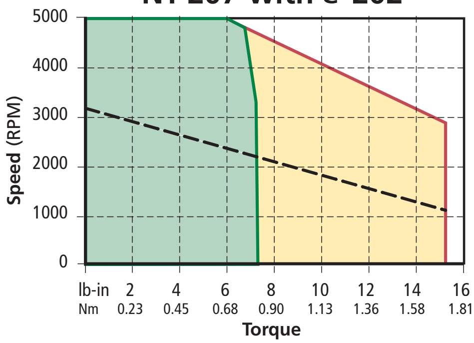
MG-490 with EN-214



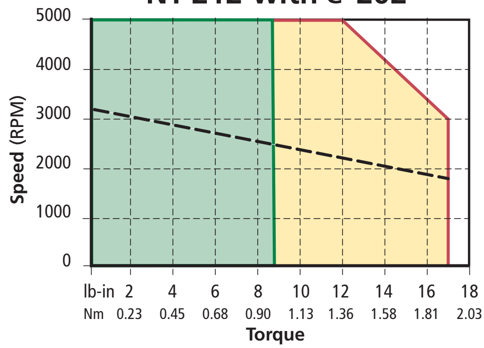
MG-4120 with EN-214



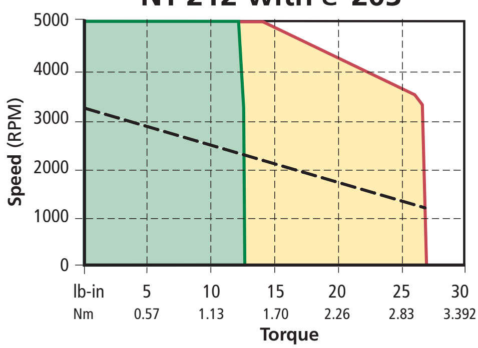
NT-207 with Ɛ-202



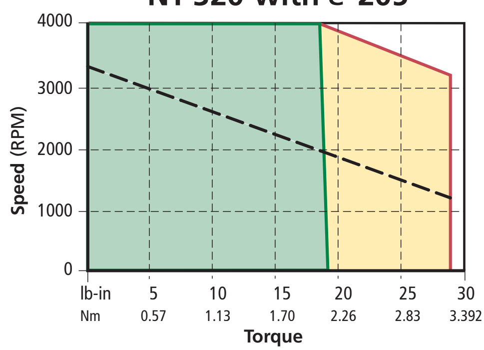
NT-212 with Ɛ-202

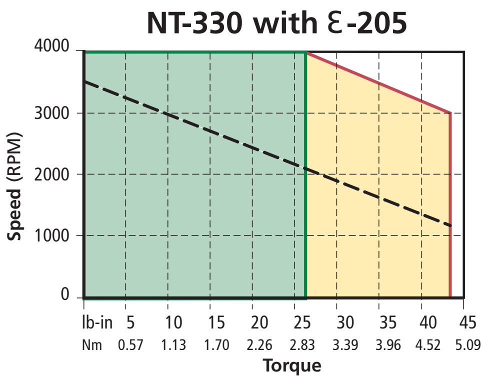


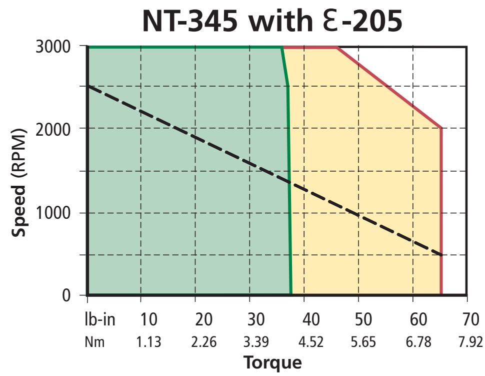
NT-212 with Ɛ-203

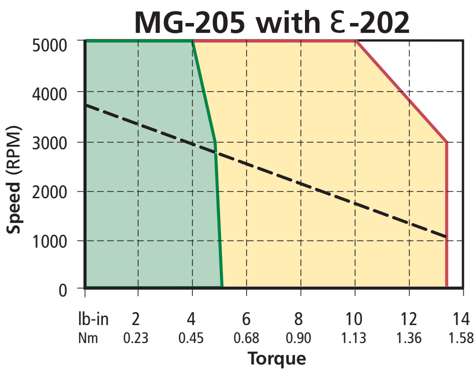


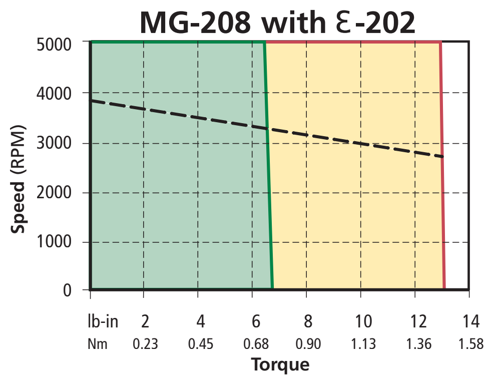
NT-320 with Ɛ-205

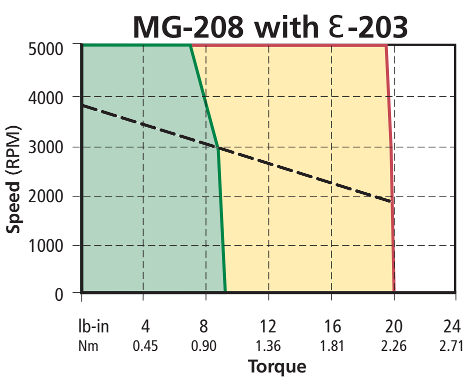


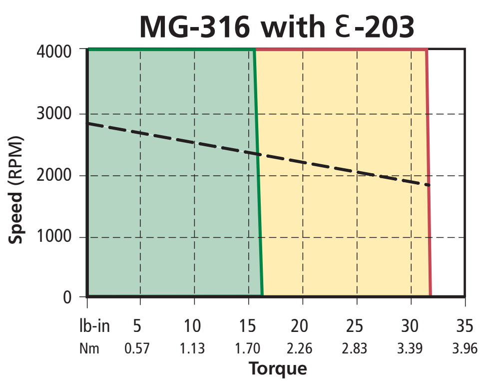

NT-330 with Ɛ-205
Speed (RPM)
4000
3000
2000
1000
0
lb-in 5 10 15 20 25 30 35 40 45
Nm 0.57 1.13 1.70 2.26 2.83 3.39 3.96 4.52 5.09
Torque

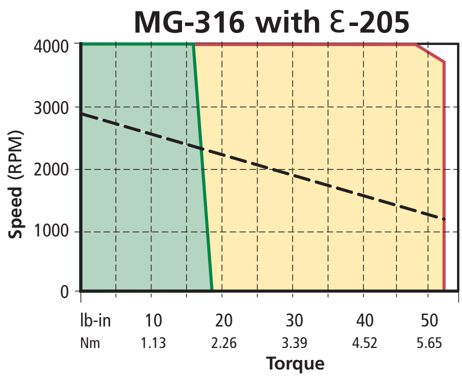

NT-345 with Ɛ-205
Speed (RPM)
3000
2000
1000
0
lb-in 10 20 30 40 50 60 70
Nm 1.13 2.26 3.39 4.52 5.65 6.78 7.92
Torque

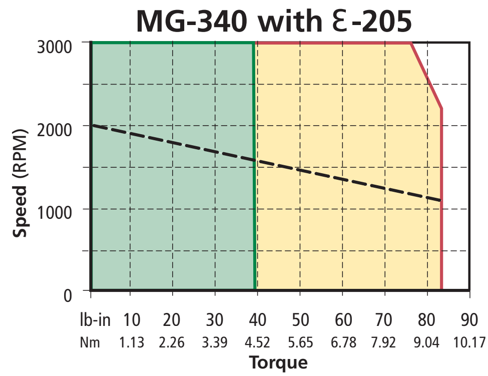

MG-205 with Ɛ-202
Speed (RPM)
5000
4000
3000
2000
1000
0
lb-in 2 4 6 8 10 12 14
Nm 0.23 0.45 0.68 0.90 1.13 1.36 1.58
Torque


MG-208 with Ɛ-202
Speed (RPM)
5000
4000
3000
2000
1000
0
lb-in 2 4 6 8 10 12 14
Nm 0.23 0.45 0.68 0.90 1.13 1.36 1.58
Torque


MG-208 with Ɛ-203
Speed (RPM)
5000
4000
3000
2000
1000
0
lb-in 4 8 12 16 20 24
Nm 0.45 0.90 1.36 1.81 2.26 2.71
Torque

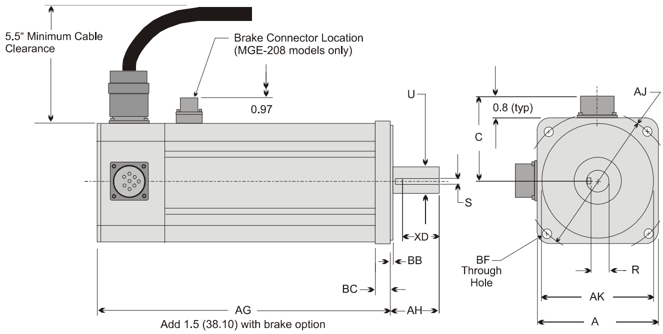

MG-316 with Ɛ-203
Speed (RPM)
4000
3000
2000
1000
0
lb-in 5 10 15 20 25 30 35
Nm 0.57 1.13 1.70 2.26 2.83 3.39 3.96
Torque


MG-316 with Ɛ-205
Speed (RPM)
4000
3000
2000
1000
0
lb-in 10 20 30 40 50
Nm 1.13 2.26 3.39 4.52 5.65
Torque


MG-340 with Ɛ-205
Speed (RPM)
3000
2000
1000
0
lb-in 10 20 30 40 50 60 70 80 90
Nm 1.13 2.26 3.39 4.52 5.65 6.78 7.92 9.04 10.17
Torque

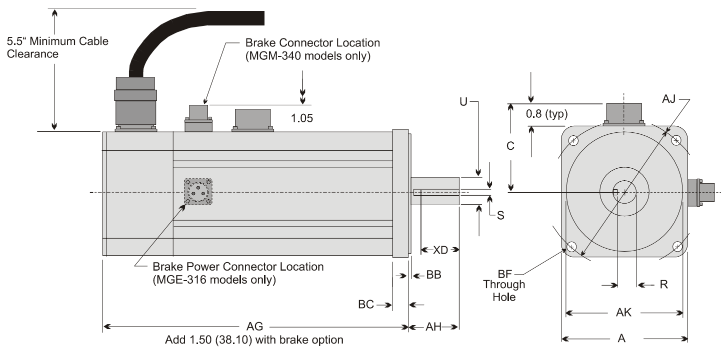
Motor Dimensions

MGE-205 and 208 Motors



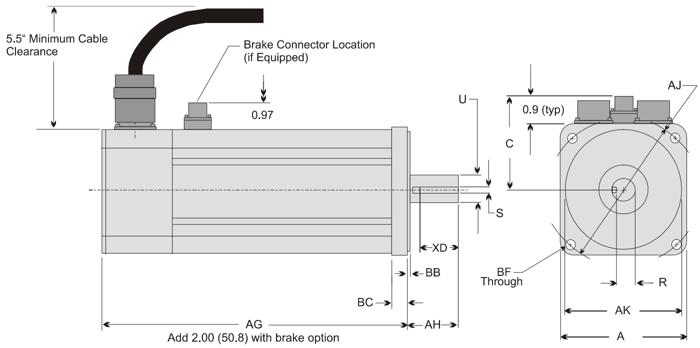
MGE-205 and 208 Mounting Dimensions inches (mm)													
	AG	A	BC	AH	U Max	XD	S Min	R	C Max	AJ	BB	AK	BF
205	5.60 (143.0)	2.25 (57.2)	.46 (11.2)	1.20 (30.5)	.375 (9.525)	.563 (14.3)	.127 (3.23)	0.300 (7.62)	2.0 (51)	2.625 (66.68)	.063 (1.60)	1.502 (38.15)	.205 (5.21)
208	6.75 (171.4)	2.25 (57.2)	.46 (11.2)	1.20 (30.5)	.375 (9.525)	.563 (14.3)	.127 (3.23)	0.300 (7.62)	2.0 (51)	2.625 (66.68)	.063 (1.60)	1.502 (38.15)	.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)	.44 (11.2)	1.21 (30.7)	.4997 (12.69)	.90 (22.9)	.1265 (3.213)	.42 (10.7)	2.50 (64.0)	3.875 (98.43)	.06 (1.600)	2.877 (73.08)	.233 (66.0)
340	10.24 (260.1)	3.50 (89.0)	.44 (11.2)	1.20 (30.6)	.5512 (14.000)	.787 (20.0)	.197 (5.00)	.429 (10.90)	2.50 (64.0)	3.937 (100.00)	.118 (3.00)	3.150 (80.01)	.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)	.53 (13.5)	190 (48.2)	.6245 (15.862)	1.50 (38.1)	.1875 (4.763)	.51 (13.0)	3.20 (81.3)	5.875 (149.23)	.10 (2.50)	4.500 (114.30)	3/8-16 UNC
490	11.11 (282.10)	5.00 (127.0)	.53 (13.5)	190 (48.2)	.8750 (22.225)	1.50 (38.1)	.1875 (4.763)	.77 (19.6)	3.20 (81.3)	5.875 (149.23)	.10 (2.50)	4.500 (114.30)	3/8-16 UNC
4120	13.61 (345.70)	5.00 (127.0)	.53 (13.5)	190 (48.2)	.8750 (22.225)	1.50 (38.1)	.1875 (4.763)	.77 (19.6)	3.20 (81.3)	5.875 (149.23)	.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 (.51)	50.5 (1.99)	19.000 (.7480)	40.0 (1.58)	6.00 (.236)	15.5 (.61)	70.3 (2.77)	145.00 (5.709)	3.00 (.118)	110.10 (4.331)	10.00 (.394)
490	281.7 (11.09)	121.0 (4.764)	13.0 (.51)	50.5 (1.99)	24.000 (9.449)	37.1 (1.46)	7.963 (.3135)	19.9 (.78)	70.3 (2.77)	145.00 (5.709)	3.00 (.118)	110.10 (4.331)	10.00 (.394)
4120	343.1 (13.59)	121.0 (4.764)	13.0 (.51)	50.5 (1.99)	24.000 (9.449)	37.1 (1.46)	7.963 (.3135)	19.9 (.78)	70.3 (2.77)	145.00 (5.709)	3.00 (.118)	110.10 (4.331)	10.00 (.394)

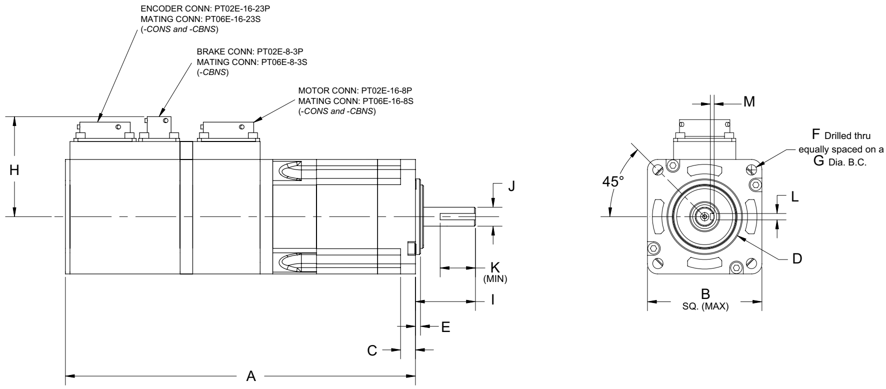
NT Motor Dimensions

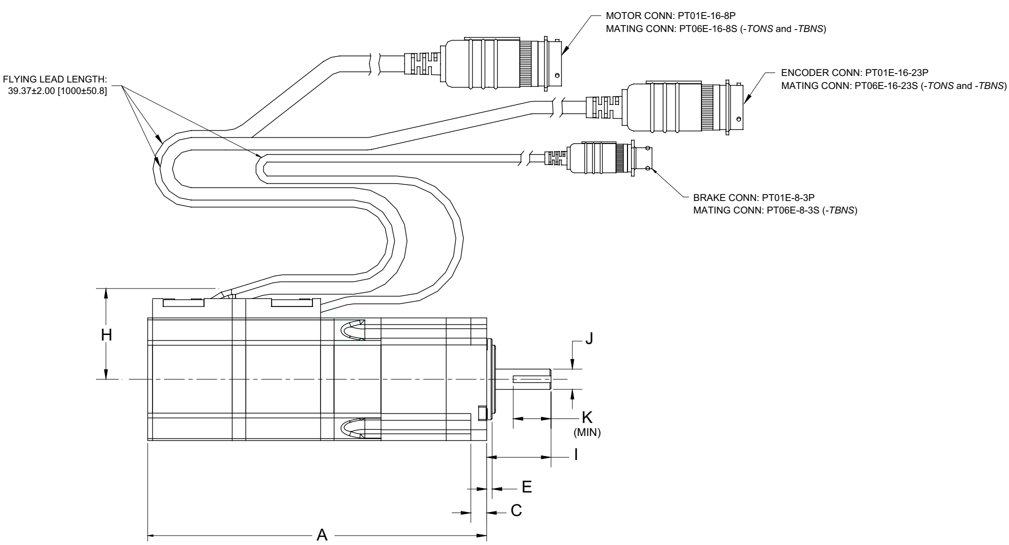
NT Motor Dimensions

English Dimensions		2"		3"			
		NTE-207	NTE-212	NTE-320	NTE-330	NTE-345	NTE-355
A	Length Overall - CONS (Max)	5.55 (141)	6.55 (166.4)	5.218 (132.5)	5.818 (147.8)	7.018 (178.26)	8.218 (208.74)
	Length Overall - TONS/LONS (Max)	4.39 (111.5)	5.39 (136.9)	5.218 (132.5)	5.818 (147.8)	7.018 (178.26)	8.218 (208.74)
A	Length Overall - CBNS (Max)	6.95 (176.4)	7.95 (201.8)	7.24 (184)	7.84 (199.2)	9.043 (229.7)	10.243 (260.17)
	Length Overall - TBNS/LBNS (Max)	6.28 (159.4)	7.95 (201.8)	7.24 (184)	7.84 (199.2)	9.043 (229.7)	10.243 (260.17)
B	Flange Square	2.27 (57.66)	2.27 (57.66)	3.42 (86.87)	3.42 (86.87)	3.42 (86.87)	3.42 (86.87)
C	Flange Thickness	0.3 (7.49)	0.3 (7.49)	0.3 (7.62)	0.3 (7.62)	0.3 (7.62)	0.3 (7.62)
D	Pilot Diameter	1.5 (38.1)	1.5 (38.1)	2.875 (73.03)	2.875 (73.03)	2.875 (73.03)	2.875 (73.03)
E	Pilot thickness	0.1 (2.54)	0.1 (2.54)	0.1 (2.54)	0.1 (2.54)	0.1 (2.54)	0.1 (2.54)
F	Bolt Hole Diameter	0.205 (5.21)	0.205 (5.21)	0.22 (5.59)	0.22 (5.59)	0.22 (5.59)	0.22 (5.59)
G	Bolt Circle Diameter	2.625 (66.68)	2.625 (66.68)	3.875 (98.43)	3.875 (98.43)	3.875 (98.43)	3.875 (98.43)
H	Signal Connector Height - CONS (Max)	1.925 (48.89)	1.925 (48.89)	2.45 (62.24)	2.45 (62.24)	2.45 (62.24)	2.45 (62.24)
H	Signal Connector Height - TONS/LONS (Max)	1.78 (45.2)	1.78 (45.2)	2.35 (59.69)	2.35 (59.69)	2.35 (59.69)	2.35 (59.69)
H	Signal Connector Height - CBNS (Max)	1.98 (50.4)	1.98 (50.4)	2.56 (65)	2.56 (65)	2.56 (65)	2.56 (65)
H	Signal Connector Height - TBNS/LBNS (Max)	1.78 (45.2)	1.78 (45.2)	2.5 (63.5)	2.5 (63.5)	2.5 (63.5)	2.5 (63.5)
I	Shaft Length	1.2 (30.7)	1.2 (30.7)	1.2 (30.7)	1.2 (30.7)	1.2 (30.7)	1.2 (30.7)
J	Shaft Diameter	0.375 (9.525)	0.375 (9.525)	0.5 (12.7)	0.5 (12.7)	0.5 (12.7)	0.5 (12.7)
Shaft key Dimensions							
K	Keyway Length (Min)	0.7 (17.78)	0.7 (17.78)	0.84 (21.34)	0.84 (21.34)	0.84 (21.34)	0.84 (21.34)
L	Keyway Depth	0.079 (2.007)	0.079 (2.007)	0.077 (1.96)	0.077 (1.96)	0.077 (1.96)	0.077 (1.96)
M	Keyway Width	0.126 (3.2)	0.126 (3.2)	0.127 (3.23)	0.127 (3.23)	0.127 (3.23)	0.127 (3.23)

Metric Dimensions		2"		3"			
		NTM-207	NTM-212	NTM-320	NTM-330	NTM-345	NTM-355
A	Length Overall - CONS (Max)	5.55 (141)	6.55 (166.4)	5.218 (132.5)	5.818 (147.8)	7.018 (178.26)	8.218 (208.74)
	Length Overall - TONS/LONS (Max)	4.39 (111.5)	5.39 (136.9)	5.218 (132.5)	5.818 (147.8)	7.018 (178.26)	8.218 (208.74)
A	Length Overall - CBNS (Max)	6.95 (176.4)	7.95 (201.8)	7.24 (184)	7.84 (199.2)	9.043 (229.7)	10.243 (260.17)
	Length Overall - TBNS/LBNS (Max)	6.28 (159.4)	7.28 (184.8)	7.24 (184)	7.84 (199.2)	9.043 (229.7)	10.243 (260.17)
B	Flange Square	2.566 (65.18)	2.566 (65.18)	3.42 (86.87)	3.42 (86.87)	3.42 (86.87)	3.42 (86.87)
C	Flange Thickness	0.3 (7.49)	0.3 (7.49)	0.3 (7.62)	0.3 (7.62)	0.3 (7.62)	0.3 (7.62)
D	Pilot Diameter	2.363 (60)	2.363 (60)	3.15 (80)	3.15 (80)	3.15 (80)	3.15 (80)
E	Pilot thickness	0.1 (2.54)	0.1 (2.54)	0.12 (3)	0.12 (3)	0.12 (3)	0.12 (3)
F	Bolt Hole Diameter	0.228 (5.8)	0.228 (5.8)	0.276 (7.01)	0.276 (7.01)	0.276 (7.01)	0.276 (7.01)
G	Bolt Circle Diameter	2.953 (75)	2.953 (75)	3.937 (100)	3.937 (100)	3.937 (100)	3.937 (100)
H	Signal Connector Height - CONS (Max)	1.925 (48.89)	1.925 (48.89)	2.45 (62.24)	2.45 (62.24)	2.45 (62.24)	2.45 (62.24)
H	Signal Connector Height - TONS/LONS (Max)	1.78 (45.2)	1.78 (45.2)	2.35 (59.69)	2.35 (59.69)	2.35 (59.69)	2.35 (59.69)
H	Signal Connector Height - CBNS (Max)	1.98 (50.4)	1.98 (50.4)	2.56 (65)	2.56 (65)	2.56 (65)	2.56 (65)
H	Signal Connector Height - TBNS/LBNS (Max)	1.78 (45.2)	1.78 (45.2)	2.5 (63.5)	2.5 (63.5)	2.5 (63.5)	2.5 (63.5)
I	Shaft Length	0.926 (23.51)	0.512 (23.51)	1.2 (30.7)	1.2 (30.7)	1.2 (30.7)	1.2 (30.7)
J	Shaft Diameter	0.433 (11)	0.433 (11)	0.5512 (14)	0.5512 (14)	0.5512 (14)	0.5512 (14)
Shaft key Dimensions							
K	Keyway Length (Min)	0.512 (13)	0.512 (13)	0.79 (20)	0.79 (20)	0.79 (20)	0.79 (20)
L	Keyway Depth	0.083 (2.1)	0.083 (2.1)	0.1 (2.55)	0.1 (2.55)	0.1 (2.55)	0.1 (2.55)
M	Keyway Width	0.157 (4)	0.157 (4)	0.2 (5.05)	0.2 (5.05)	0.2 (5.05)	0.2 (5.05)

NT 2" Motor

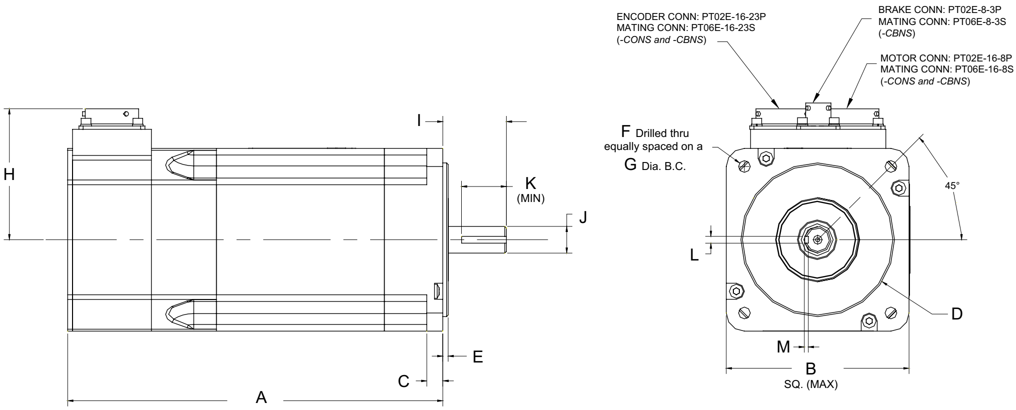


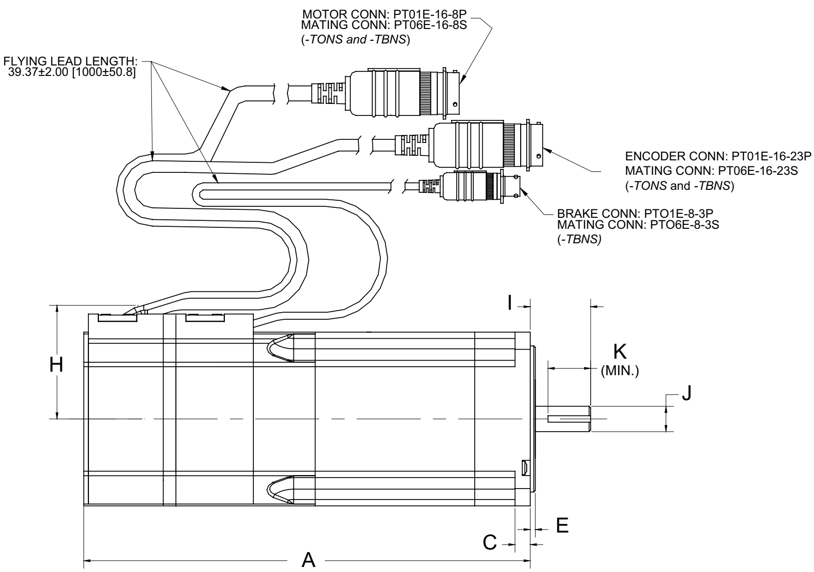


Note

Mounting ears have clearance for #10 or M5 Allen head screw or .3125 inch or 8mm across flats hex nut.

NT 3" Motors





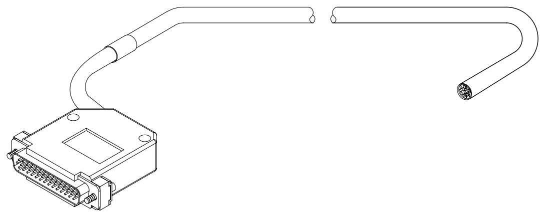
Note

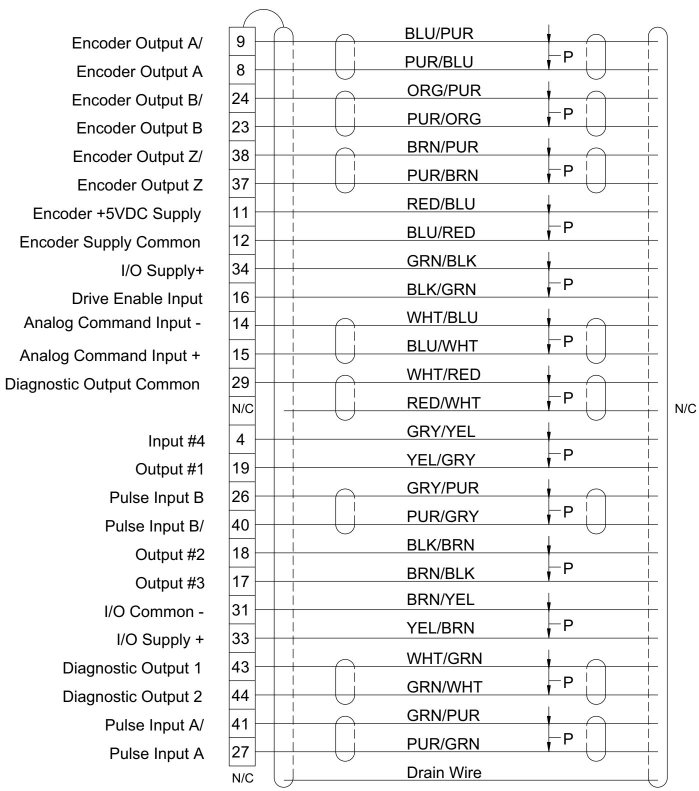
Mounting ears have clearance for 10mm across flats hex nut or 13mm O.D. washer.

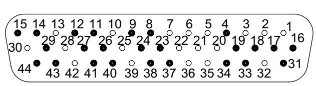
Cable Diagrams

Drive Signal	CMDX, CMDO, ECI-44	CDRO	AX4-CEN
Analog In +	X	X	X
Analog 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
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 #1 +	X	X	X
Analog Out #2 +	X	X	X
External Encoder +5 Power Out (200 ma)	X	X	X
+15V Power Out (10 ma)	X		
RS-485 +	X		
RS-485 -	X		

CDRO-XXX Cable

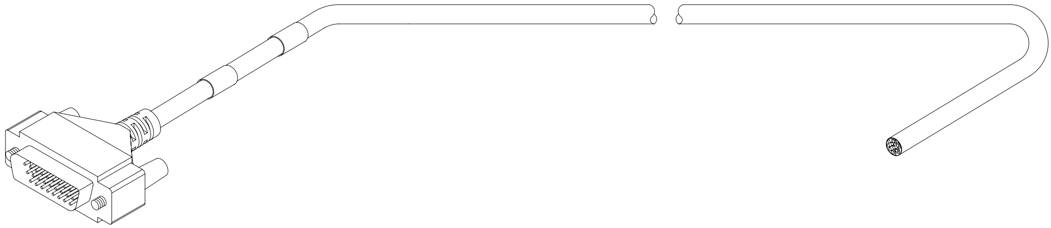


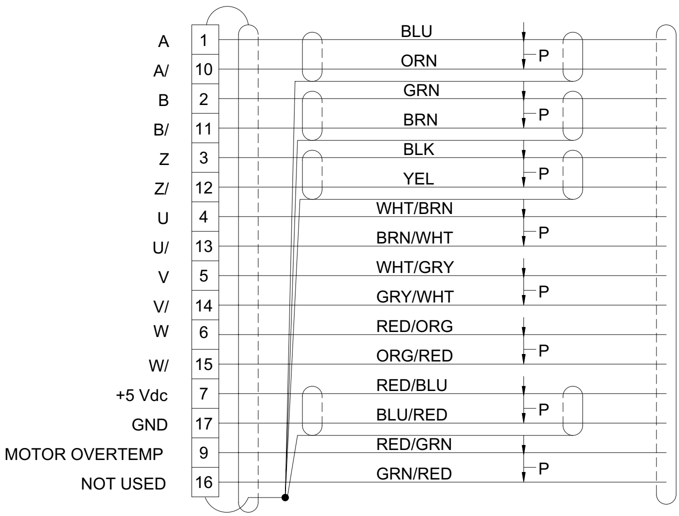


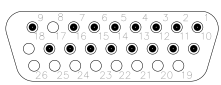


Solder Side Pin

CFCO-XXX Cable

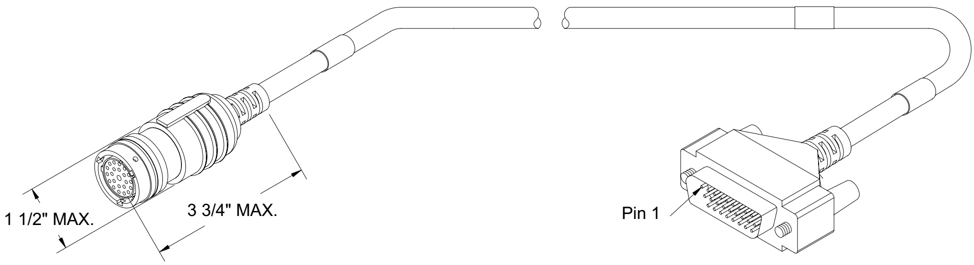


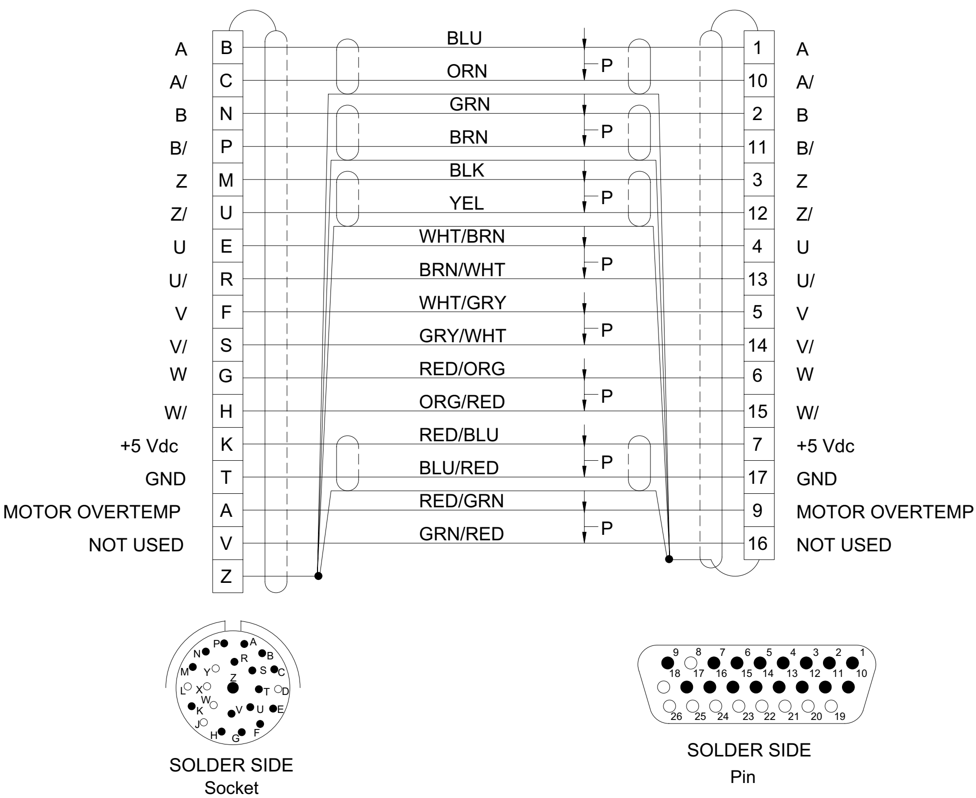




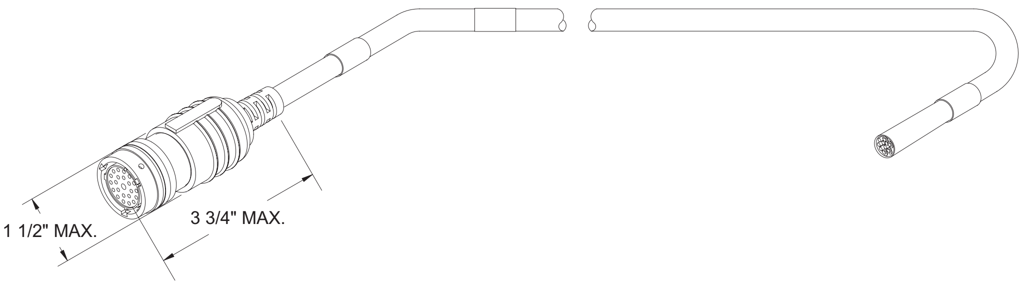
SOLDER SIDE
Pin

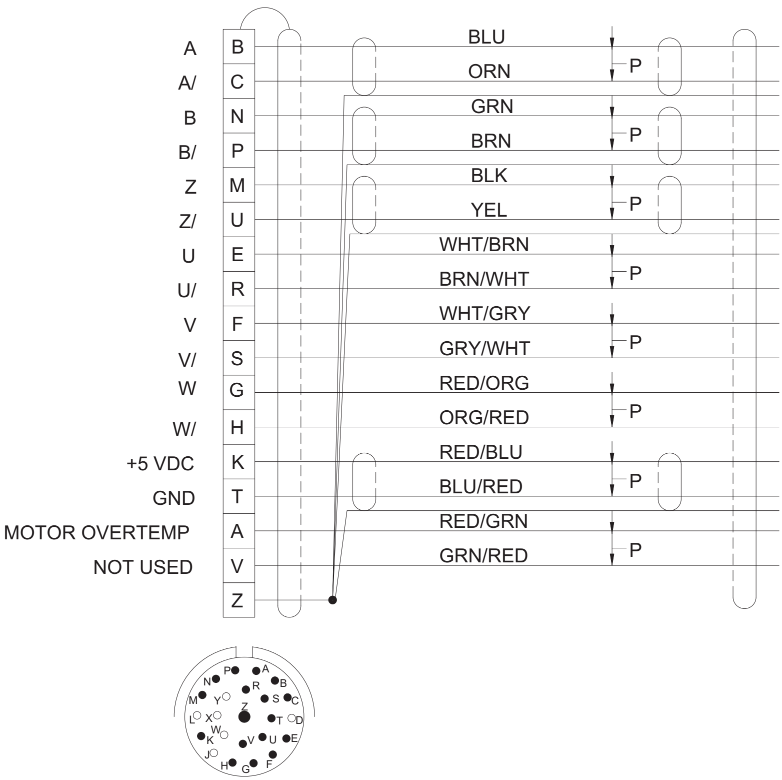
CFCS-XXX Cable





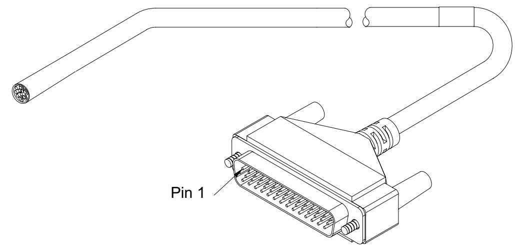
CFOS-XXX Cable

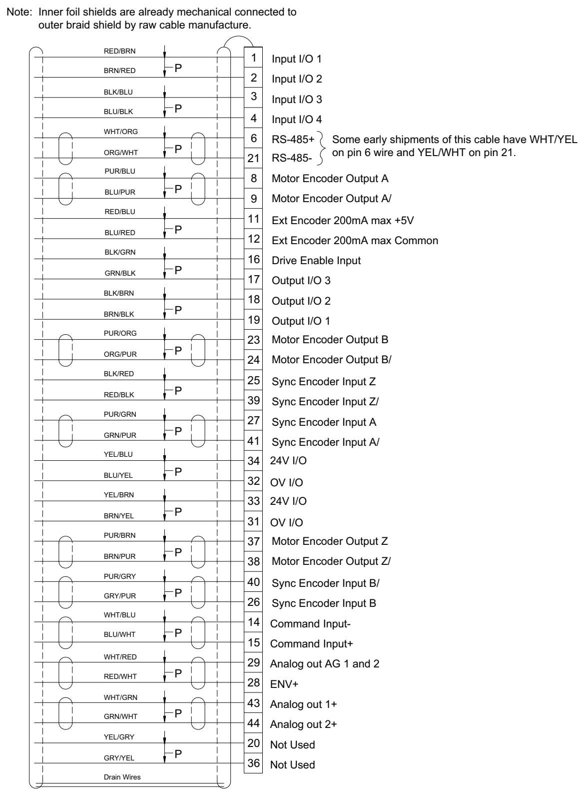


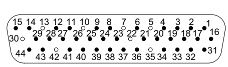


SOLDER SIDE
Socket

CMDO-XXX Cable





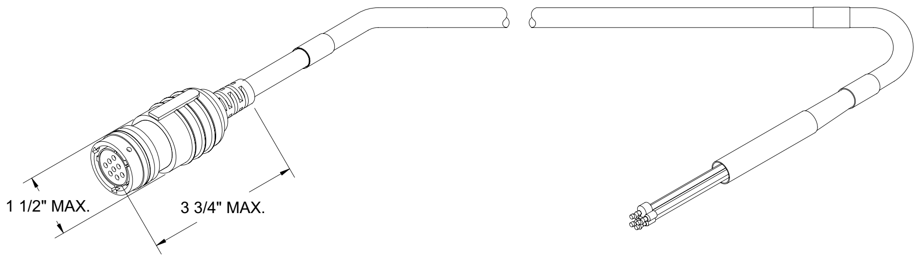


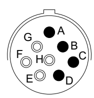
Solder Side Pin

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).

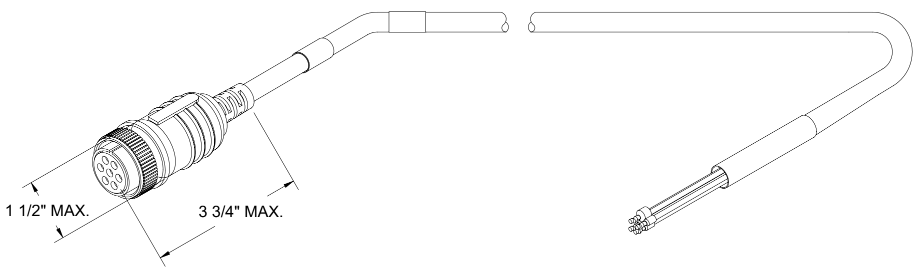
CMDS-XXX Cable

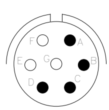




SOLDER SIDE
Socket

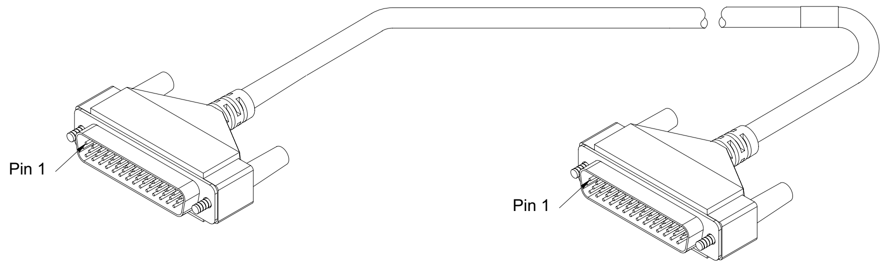
CMMS-XXX Cable

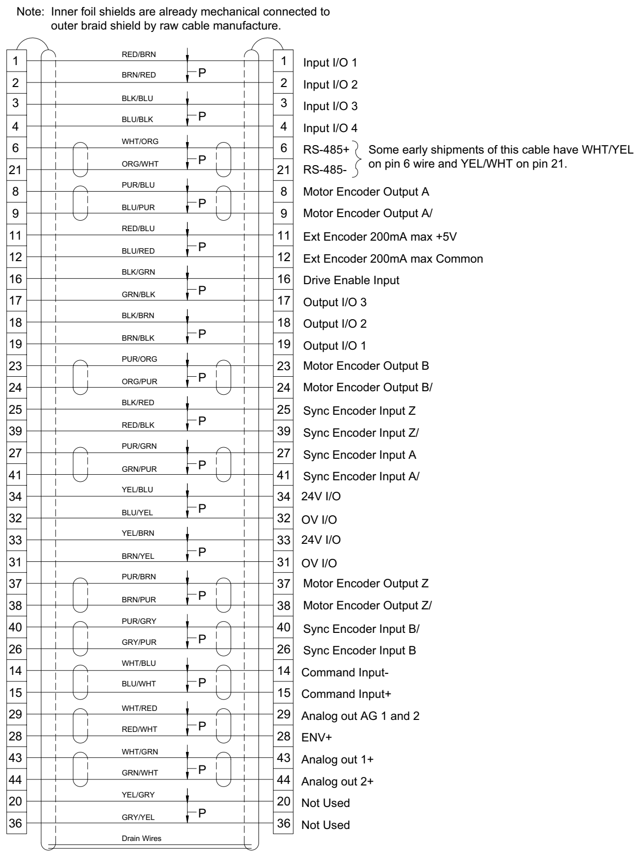




SOLDER SIDE

CMDX-XXX Cable

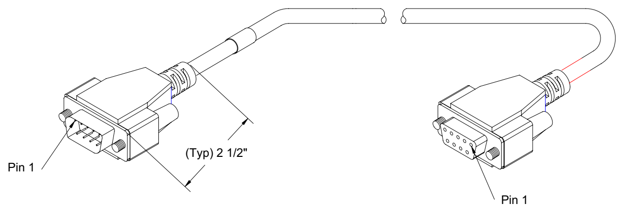


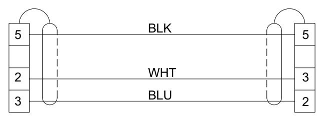


Note

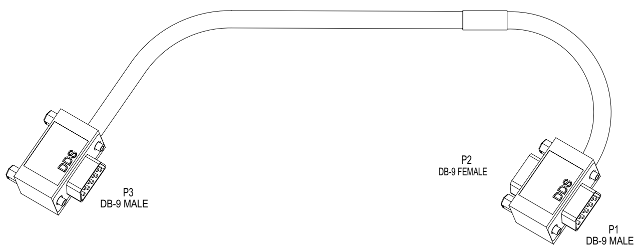
Some CMDX cables may have White/Yellow and Yellow/White wires in place of the White/Orange and Orange/White shown in the figure above (pins 6 and 21).

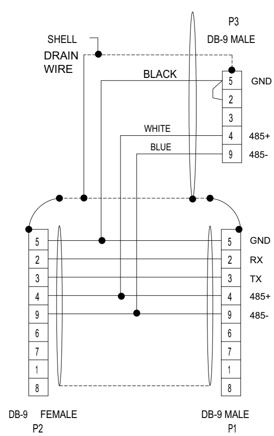
TIA-XXX Cable



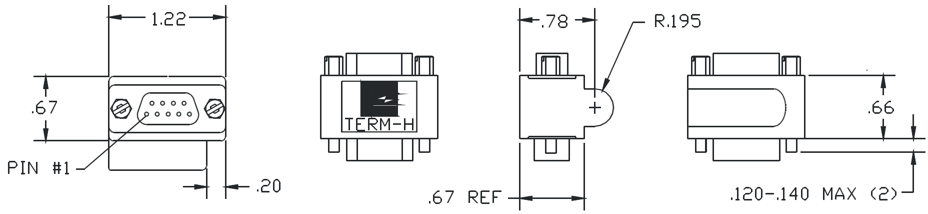


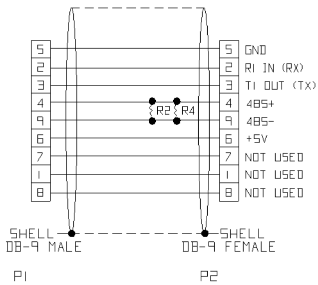
DDS-XXX Cable



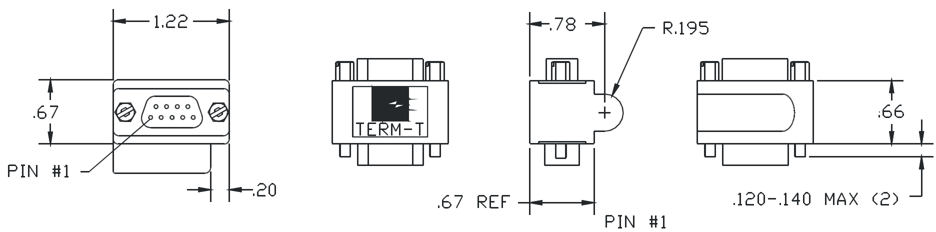


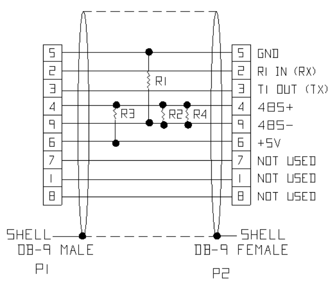
TERM-H (Head) Terminator



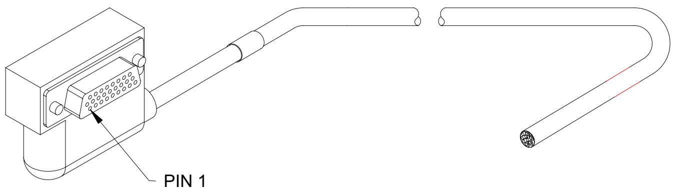


TERM-T (Tail) Terminator





EIO-XXX Cable



Signal	Pin	Wire Color
ENABLE	10	RED/BLK
INPUT LINE 1	1	RED/WHT
INPUT LINE 2	11	ORG/BLK
INPUT LINE 3	2	ORG/WHT
INPUT LINE 4	12	GRN/BLK
INPUT LINE 5	3	GRN/WHT
INPUT LINE 6	13	YEL/BLK
INPUT LINE 7	4	PNK/BLK
OUTPUT LINE 1	7	ORG
OUTPUT LINE 2	17	YEL
OUTPUT LINE 3	8	PNK
OUTPUT LINE 4	18	BLU
I/O +V	19	RED
I/O COM	20	BLK
INPUT LINE 8	14	BLU/WHT
INPUT LINE 9	5	GRY/BLK
INPUT LINE 10	15	PUR/WHT
INPUT LINE 11	6	BRN/WHT
INPUT LINE12	16	BRN
	N/C	GRN
	N/C	LIGHT GRN
OUTPUT LINE 5	9	GRY
OUTPUT LINE 6	25	PUR
OUTPUT LINE 7	26	WHT
		DRAIN WIRES

Glossary

µs

Microsecond, which is 0.000001 seconds.

A

Ampere. The unit of electrical current.

Amplifier

Servo Drive.

ARMS

Ampere (RMS).Root Mean Square.

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 buttons, check boxes do not affect each other; any check box can be “On” or “Off” independently of all the others.

Configuration

The user-created application. It can be saved as a disk file or downloaded to configure the FM-3. It includes all the user-defined setup, assignments and programs.

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 Window, 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 an FM to a drive.

Drive

Servo drive or amplifier.

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).

Flash

Another type of EEPROM.

Flash File

In the FM-3, this file loads the firmware into the drive and function module. Flash files can field upgrade the firmware.

FM

Function Module - device which is attached to the front of the drive to provide additional functionality.

Home Routine

The home provides motion in applications in which the axis must precisely align with some part of a machine.

Hysteresis

For a system with an analog input, the output tends to maintain its 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.

Index

An index is a complete motion sequence (defined motion profile) that moves the motor a specific incremental distance or to an absolute position.

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 terminals of a device or circuit to which energy is applied.

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, which is 1/1000th of an Ampere.

MB

Mega-byte.

MODBUS®

Communication Protocol by Gould, Inc. for industrial communications systems comprised of programmable controller interface units, protocol software and modems. The EN drive follows the Modbus specification outlined in the Modicon Modbus Protocol Reference Manual, PI-MBNS-300 Revision G, November 1994.

Module

Function Module

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. NVM stores specifically defined variables as the variables dynamically change. It is used to store changes through a power loss.

NTC

Negative Temperature Resistor

Option Button

Also known as the Radio Button. Round button used to select one of a group of mutually exclusive options.

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 assigned 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. These variables generally hold numerical data defined in the Setup Views.

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 FM

Windows®-based software to interface with the Epsilon drives, EN drives, MDS system, and FM-1 & FM-2 Function Modules.

Radio Button

See Option Button.

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 steady state 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.

Travel Limit

The distance that is limited by either a travel limit switch or the software.

Torque

The moment of force, a measure of its tendency to produce torsion and rotation about an axis.

Uploading

The transfer of a complete set of parameters from a drive to an FM.

Vac

Volts, Alternating Current.

Variable

A labeled value that encompasses numeric boolean, input function, and output functions.

Vdc

Volts, Direct Current.

Velocity

The rate of change in position in a given direction during a certain time interval.

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.

Index

Since 1979, the “Motion Made Easy” products, designed and manufactured in Minnesota U.S.A., are renowned in the motion control industry for their ease of use, reliability and high performance.

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