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# Modular Drive System

## Installation Manual

400525-02
Revision A1
February 27, 2002
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# Modular Drive System
# Installation Manual




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

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

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|---|---|

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|---|---|

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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
- What you were doing when the problem occurred
- How you tried to solve the problem

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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<br>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<br>example: (Alt,F) | A comma (,) between key names means to press and release the keys one after the other. |

**⚠WARNING**

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

**⚠ CAUTION**

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

**CAUTION**

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

**Note**

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

Throughout this manual, the word "drive" refers to an MDS.

Throughout this manual. the word "FM-3" refers to an FM-3, FM-3DN or FM-3PB.

Throughout thie manual the word "FM-4" refers to an FM-4, FM-4DN or FM-4PB.

# Safety Instructions

## General Warning

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

## Qualified Person

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

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

# Reference Materials

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

- *PowerTools Software User's Guide* (P/N 400503-01)
- *FM-1 Speed Module Reference Manual* (P/N 400506-01)
- *FM-2 Indexing Module Reference Manual* (P/N 400507-01)
- *FM-3 Programming Module Reference Manual* (P/N 400508-01)
- *FM-4 Programming Module Reference Manual* (P/N 400509-01)
- *FM-3 and FM-4 DeviceNet Module Reference Manual* (P/N 400508-03)
- *Function Module Installation Manual* (400506-03)
- *FM-3 and FM-4 Profibus Module Reference Manual* (P/N 400508-04)

# Underwriters Laboratories Listed

LISTED 768R
IND. CONT. EQ.



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

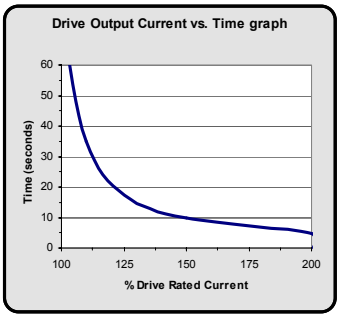
**The "conditions of acceptability" required by UL are:**

- The drive surrounding air ambient temperature must be 40° C (104° F) or less.
- MDS surrounding air ambient temperature can be up to 50°C (122° F) with 3% linear derating for every degree above 40° C (104° F)
- This product is suitable for use on a circuit capable of delivering not more than 10,000 RMS symmetrical amperes, 480 volts maximum.
- Motors must incorporate an overload protection device such as an overtemperature switch.

## Drive Overload Protection

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

| Rated output current (Amps RMS) | | |
|---|---|---|
| **Drive Module Model** | **Continuous** | **Peak** |
| MD-404 | 4 | 8 |
| MD-407 | 7 | 14 |
| MD-410 | 10 | 20 |
| MD-420 | 20 | 40 |
| MD-434 | 34 | 68 |




# CE Declaration of Conformity

CE

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

## Declaration of Conformity

| | |
|---|---|
| **Manufacturer's Name:** | Control Techniques/Emerson Industrial Automation |
| **Manufacturer's Address:** | 12005 Technology Drive<br>Eden Prairie, MN 55344<br>USA |

**Declares that the following products:**

| | |
|---|---|
| **Products Description:** | Modular Drive System (MDS) |
| **Model Number:** | MP-1250/MP-2500/MP-5000<br>MD-407/MD-410/MD-420/MD-434 |

Conforms to the following product specification:

Electomagnetic Compatibility (EMC):

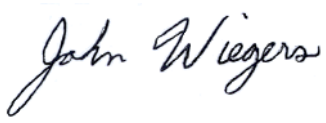
EN 55011/1998 w/Amendment A1:1999 Class A Group 1, CISPR 11/1990 Class A Group 1

| | |
|---|---|
| EN 61800-3, 1996: | IEC 1000-4-2/1995; EN 61000-4-2, 6kV CD<br>IEC 1000-4-3/1995; EN 61000-4-3, ENV 50140/1993, 80% AM, 10V/m @ 3 m<br>IEC 1000-4-4/1995; EN 61000-4-4, 2 kV ALL LINES<br>EN 61000-4-5, 1kV L-L, 2kV L-G |

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 servo drive system is intended to be used with an appropriate motor, electrical protection components, and other equipment to form a complete end product or system. MDS must only be installed by a professional assembler who is familiar with safety and electromagnetic compatibility ("EMC") requirements. 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 information on EMC standards that the MDS complies with, as well ar the product manual for installation guidelines.



**January 31, 2002**

John Wiegers/ Director Enigineering — Date

European Contact:

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

# Safety Considerations

## Safety Precautions

This product is intended for professional incorporation into a complete system. If you install the product incorrectly, it may present a safety hazard. The product and system may use high voltages and currents, 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 Power Module backplane using an approved isolation device or disconnect before any servicing work is performed, removing and/or installing the Power Module and/or Drive Module(s), 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 3 minutes after removing the supply before carrying out any work which may involve contact with electrical connections to the drive.

**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 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.

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# Introduction

## Modular Drive System (MDS)

The Modular Drive System (MDS) is a 480V servo system comprised of a common Power Module and up to eight Drive Modules. The modular approach provides an optimum solution for each application. The Power Module provides the AC rectification and provides DC bus power for up to eight Drive Modules. The common power supply minimizes installation space and cost because there is only one AC Input, one Contactor, one set of AC fuses and one AC line Filter per system. Each Power and Drive Module mounts on an innovative backplane that provides the connection for the DC Bus and Logic Power, this minimzes installation time. A compact installation is possible because the backplanes mount next to each other, removing the need for space between each axis. Fuses (included) are mounted directly on each Drive Module backplane to provide individual protection for each axis.

The Drive Modules can operate as base drives providing Velocity, Torque and Pulse/ Direction operations. For positioning and more advanced applications with more functionality add a FM module to that axis for control. FM modules give the MDS "snap-on" functionality for indexing (FM-2), programming (FM-3) and advanced programming (FM-4). For applications that require fieldbus, the FM-3 and FM-4 modules can be ordered with DeviceNet or Profibus options. Regardless of the control needed commissioning and programming is made easy with our FREE PowerTools FM and PowerTools Pro software.

PowerTools is a Windows® based software that makes extensive use of drag and drop editing, tabbed and hierarchal views, and on-line help to create a "Motion Made Easy" experience. Commissioning time is minimized because the tuning of the drives is completed with system parameters, Inertia mismatch, Friction and Response. The State-Space algorithm uses the system parameters and motor map (DDF files) to make a robust control system that is capable of 10:1 inertia mismatch applications out of the box. For higher mismatches, up to 50:1, a simple adjustment to the Inertia and Response parameters will provide the desired performance. PowerTools has complete diagnostics and status indicators for quick troubleshooting. System problems can be quickly identified with the status indicators and I/O on the Power and Drive Modules, along with fault logging stored in the non-volatile memory, minimizing startup time.

The MDS is able to use Control Techniques motors as well as other manufacturers motors. Setup with a Control Techniques' motor is done by selecting the desired motor in PowerTools. Control Techniques has two lines of motors, MH and Unimotor motors to provide an optimal solution for each application.

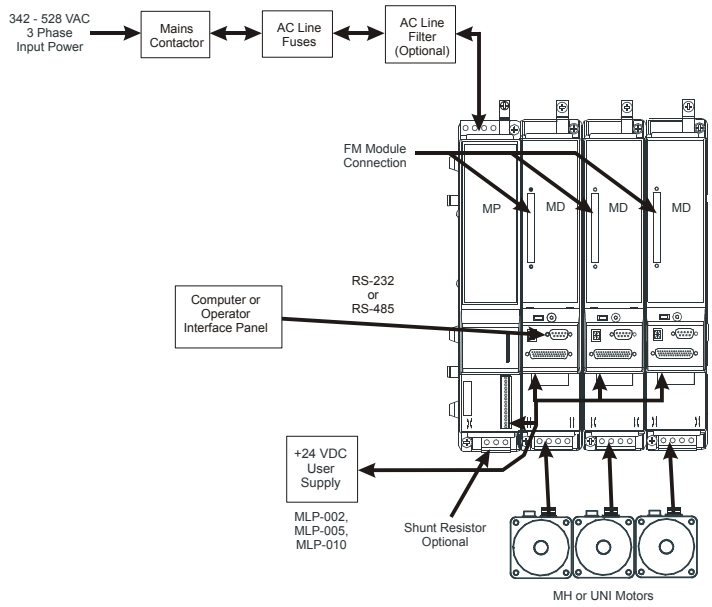



*Figure 1: Module Drive System Overview*

Power Modules are available in three power ratings

| Power Module | Continuous Power | Peak Power |
|---|---|---|
| MP-1250 | 12.5 KW | 25.0 KW |
| MP-2500 | 25.0 KW | 50.0 KW |
| MP-5000 | 50.0 KW | 100.0 KW |

Drive modules are available in five current ratings.

| Drive Module | Power Rating (At 5 KHz) | Switching Frequency | | | |
|---|---|---|---|---|---|
| | | 5 KHz | | 10 KHz | |
| | | Continuous Current | Peak Current | Continuous Current | Peak Current |
| MD-404 | 2.6 KW | 4 A RMS | 8 A RMS | 2.8 A RMS | 5.6 A RMS |
| MD-407 | 4.5 KW | 7 A RMS | 14 A RMS | 5 A RMS | 10 A RMS |
| MD-410 | 6.5 KW | 10 A RMS | 20 A RMS | 6.5 A RMS | 13 A RMS |
| MD-420 | 13.0 KW | 20 A RMS | 40 A RMS | 14 A RMS | 28 A RMS |
| MD-434 | 22.0 KW | 34 A RMS | 68 A RMS | 22 A RMS | 44 A RMS |

## Note

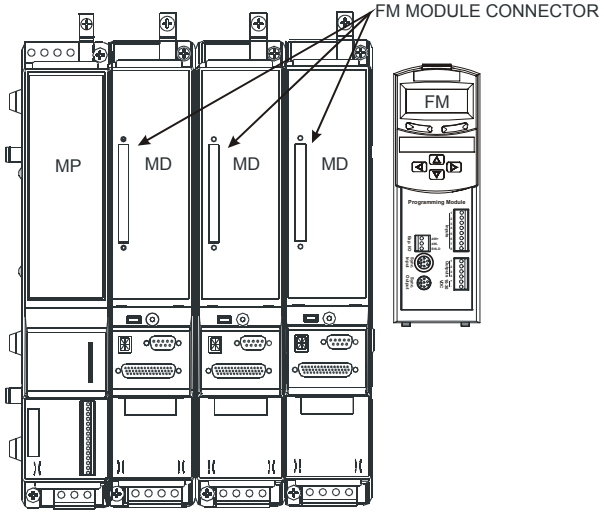
Power ratings in the tables above are for 480 VAC line voltage. For lower input line voltages de-rate output power proportionally.

## FM Modules

The MDS is designed to accept a line of function modules that further enhance its use in various applications.

- FM-2 Indexing Module enables the user to initiate up to 16 different indexes, jogging, and a single home routine.
- FM-3, FM-3DN and FM-3PB Programming Modules offer complex motion profiling. A complex motion profile consists of two or more indexes that are executed in sequence such that the final velocity of each index except the last is non-zero. Logical instructions between index statements can provide a powerful tool for altering motion profiles 'on the fly'. The FM-3 can be order with DeviceNet or Profibus for fieldbus applications.
- FM-4, FM-4DN adn FM-4PB Programming Modules offer complex motion profiling, along with multi-tasking user programs. A complex motion profile consists of two or more indexes that are executed in sequence such that the final velocity of each index except the last is non-zero. Logical instructions between index statements can provide a powerful tool for altering motion profiles 'on the fly'. The FM-4 can be order with DeviceNet or Profibus for fieldbus applications.

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



# Installation

## MDS Installation Overview

Installation of the MDS is completed by following a simple step-by-step process. The MDS installation begins by mounting the backplanes of the modules to a metal mounting panel (Steps 1and 2). Next, the high power connections are made to the backplanes (Steps 3 and 4). Power and Drive Module(s) are mounted to the backplanes (Steps 5, 6, and 7). Once the modules are secured the low power connections are made. After inspection and test, the system is complete and can be powered up for commissioning (Step 8).

**Step 1:** Power Module Backplane Installation, page 19

**Step 2:** Drive Module Backplane Installation, page 20

**Step 3:** Power Module Backplane High Power Connections, page 23

- AC Input Power
- Transformer Sizing ( if required)
- External Shunt Connection (if required)
- Line Fusing and Wire Size

**Step 4:** Drive Module High Power Connections, page 33

- Motor Power Cable

**Step 5:** Power Module Installation, page 34

**Step 6:** Drive Module Installation, page 35

**Step 7:** Power and Drive Module Low Power Connections, page 36

- Logic Power Sizing
- Digital I/O and Logic Power (user supplied)
- AC Interlock
- Digital I/O
- Command Signals
- Motor Brake
- Feedback
- Communications

**Step 8:** Power Up, page 65

Before starting actual Installation it is recommended that mounting location, cable layout, environmental and electromagnetic compatibility be considered to insure a proper installation. Refer to “Basic Installation Notes” on page 6 for Control Techniques recommended installation guidelines and requirements.

# Basic Installation Notes

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

## Electromagnetic Compatibility (EMC)

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

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

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

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

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

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

### Achieving Low Impedance Connections

Noise immunity can be improved and emissions reduced by making sure that all the components have a low impedance connection to the same ground point. A low impedance connection is one that conducts high frequency current with very little resistance. Impedance cannot be accurately measured with a standard ohmmeter, because an ohmmeter measures

DC resistance. For example, a 12 inch long 8 gauge round wire has a significantly higher impedance than a 12 inch long 12 gauge flat braided conductor. A short wire has less impedance than a long one.

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

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

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

- Enclosure and mounting plate
- Each Power and Drive Module PE grounding tab
- 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 to conduit fittings, electrical connectors and grounded machine frame
- 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.

## Cable to Enclosure Shielding

Shielded motor, feedback, serial communications and external encoder cables were used for compliance testing and are necessary to meet the EMC requirements. Each cable shield was grounded at the enclosure wall by the type of grommet shown in the Figure 2.

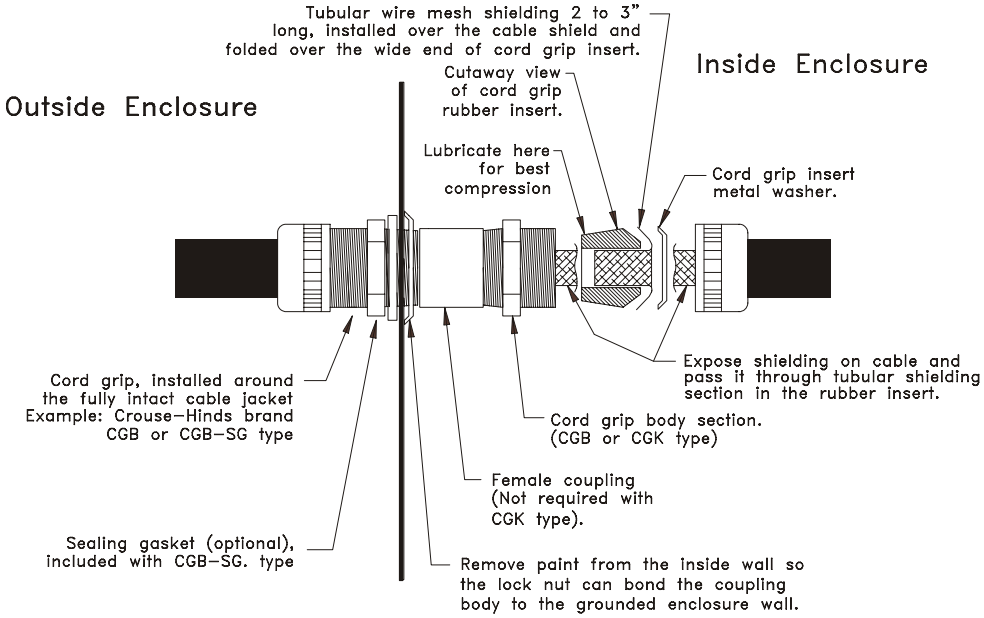



*Figure 2: Through Wall Shield Grommet*

| Cable Type | Cable Model | Shielded Cable Grommet Kit Part # | Conduit Dimension Hole Size | Actual Hole Size |
|---|---|---|---|---|
| Motor Cable, 16 Ga | CMDS | CGS-050 | 1/2" pipe | 7/8" |
| Motor Cable, 12 Ga | CMMS | CGS-050 | 1/2" pipe | 7/8" |
| Motor Cable, 8 Ga | CMLS | CGS-100 | 1" pipe | 1 3/4" |
| Feedback Cable | CFOS | CGS-050 | 1/2" pipe | 7/8" |
| Flex Motor Cable, 16 Ga | CMDF | CGS-050 | 1/2" pipe | 7/8" |
| Flex Motor Cable, 12 Ga | CMMF | CGS-075 | 3/4" pipe | 1 1/16" |
| Flex Feedback Cable | CFCF, CFOF | CGS-063 | 3/4" pipe | 1 1/16" |
| External Encoder | ENCO | CGS-038 | 1/2" pipe | 7/8" |
| AC Power | user supplied | user supplied | user supplied | user supplied |

### AC Line Filters

The AC line filters are necessary to comply with CE emission standards. The MDS was tested with the filters presented in the table below and recommended by Control Techniques*.

| Power Module Model | Schaffner Part # | Control Techniques Model # | Rating |
|---|---|---|---|
| MP-1250 | * | *MFL-020-00 | |
| MP-2500 | * | *MLF-035-00 | |
| MP-5000 | FS6717-65-34 | MLF-065-00 | 65A, 480V, 3 Phase |

* Consult factory for availability of the MLF-020-00 and MLF-035-00. The filter recommended for the MP-5000 can be used for smaller Power Modules.

### Toroids

In applications using long cables additional measures to reduce EMI might be necessary, such as toroids on the motor cable. Based on Control Techniques compliance test results, the following guidelines should be used.

| Total System Current | Switching Frequency | Maximum Motor Cable Length (without toroids) |
|---|---|---|
| < 25A | 5 kHz | 125 Ft |
| | 10 kHz | 50 Ft |
| > 25A | 5 kHz | 75 Ft |
| | 10 kHz | 75 Ft |

Control Techniques recommends using Rasmi toroids in applications with motor cables longer than in table above.

| Motor Cable Model | Rasmi Toroid Part# | CT Model # |
|---|---|---|
| CMDS, CMDF | OC/2 | MPF-OC2-00 |
| CMMS, CMMF | OC/2 | MPF-OC2-00 |
| CMLS | OC/3 | MPF-OC3-00 |

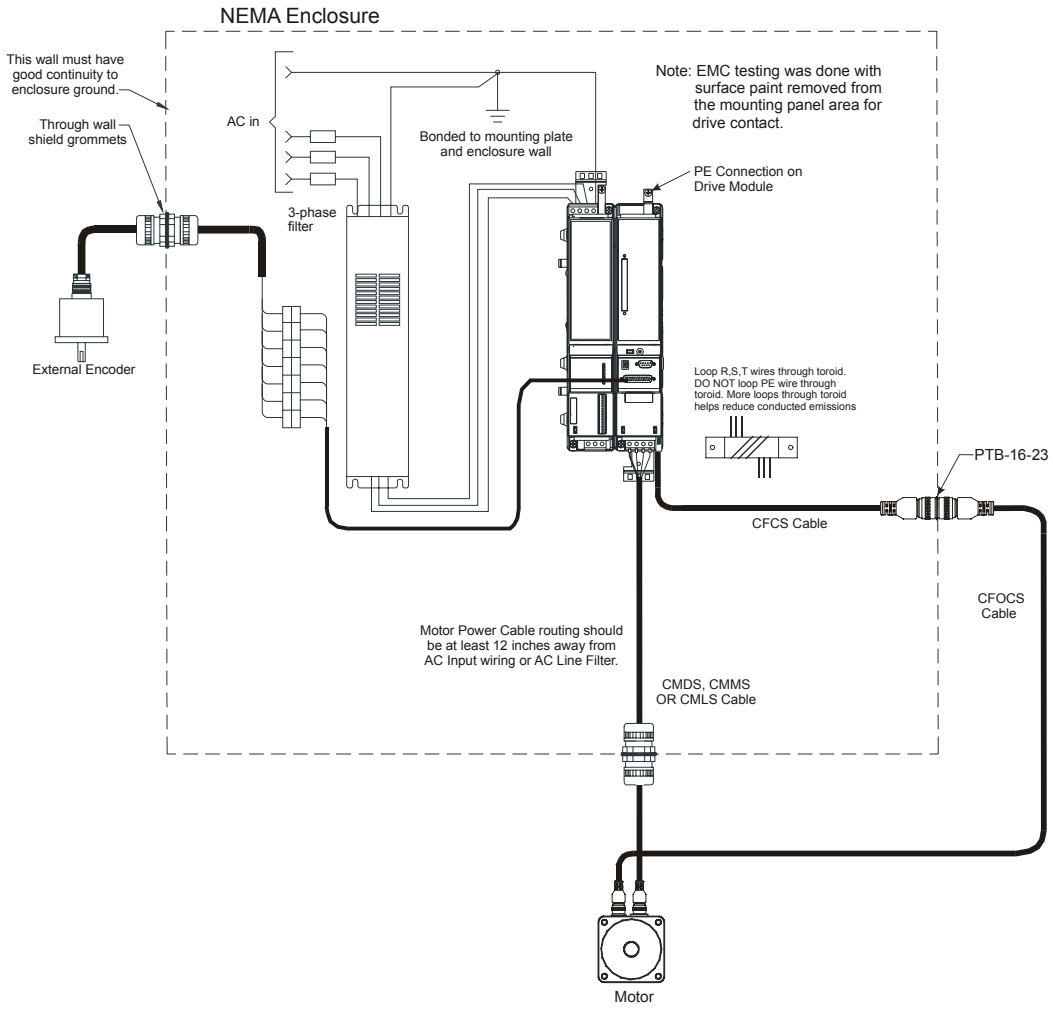



*Figure 3: AC Filter and Cable Connections for MDS Series*

## Environmental Considerations

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

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

**Note**

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

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

## Wiring Notes

- To avoid problems associated with EMI (electromagnetic interference), you should route high power lines (AC input power and motor power) away from low power lines (encoder feedback, serial communications, etc.).
- If a neutral wire (not the same as Earth Ground), is supplied from the building distribution panel it should never be bonded with PE wire in the enclosure.
- You should consider future troubleshooting and repair when installing all wiring. All wiring should be either color coded and/or tagged with industrial wire tabs.
- As a general rule, the minimum cable bend radius is ten times the cable outer diameter.
- All wiring and cables, stationary and moving, must be protected from abrasion.
- Ground wires should not be shared with other equipment.
- Ensure that metal to metal contact is made between the enclosure ground lug and the metal enclosure, not simply through the mounting bolt and threads.
- All inductive coils must be suppressed with appropriate devices, such as diodes or resistor/capacitor (RC) networks.
- All motor and feedback cables must have a continuous shield from the drive to the motor (grounded at both ends).
- Included with every Power and Drive Module is a Cable Strain Relief Bracket. It is a good wiring practice to use the Strain Relief Bracket especially for heavy cables.
- If using Toroids as motor power cable filter, mount them as close to the drive as possible. Best results are obtained when the R, S, T wires are looped through the toroid 4 times.
- Do Not route the motor PE wire through the toroid.
- Keep all motor power cables at least 12 inches away from Incoming AC line on the input side of the filter.

# Panel Layout

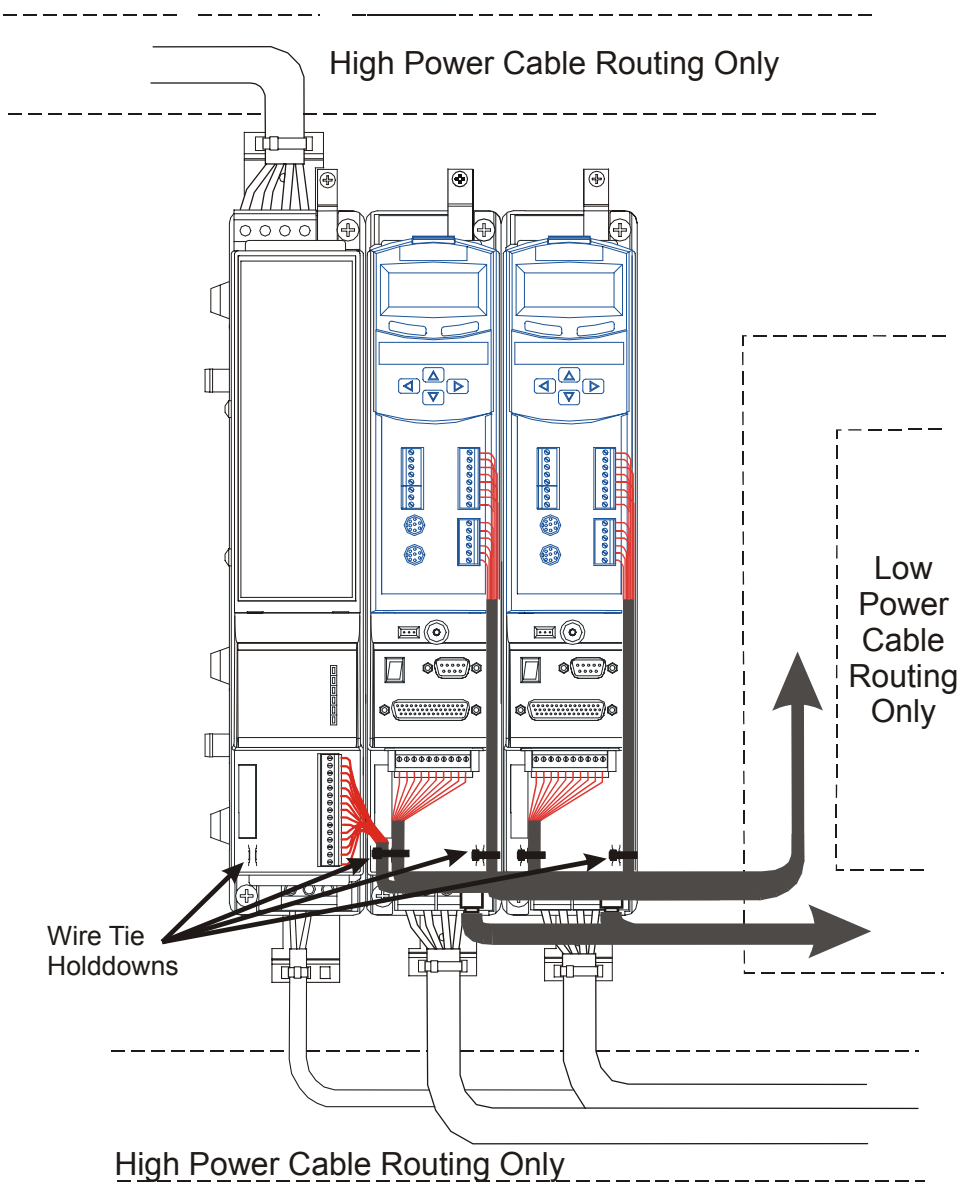



*Figure 4: Recommended Layout*

# MDS Overview

The system must be back mounted vertically on a metal mounting panel such as a NEMA enclosure. Additional space is necessary above and below the system for wiring and cable connections. A MDS system is comprised of one Power Module and up to eight Drive Modules. The Power Module is always the left most mounted module with the Drive Modules mounted to the right. The Drive Modules are to be mounted from largest (highest current rating) next to the Power Module to smallest (lowest current rating). Each module mounts to an associated backplane which is mounted to a metal surface.For mounting dimensions refer to Pages 14 - 18.

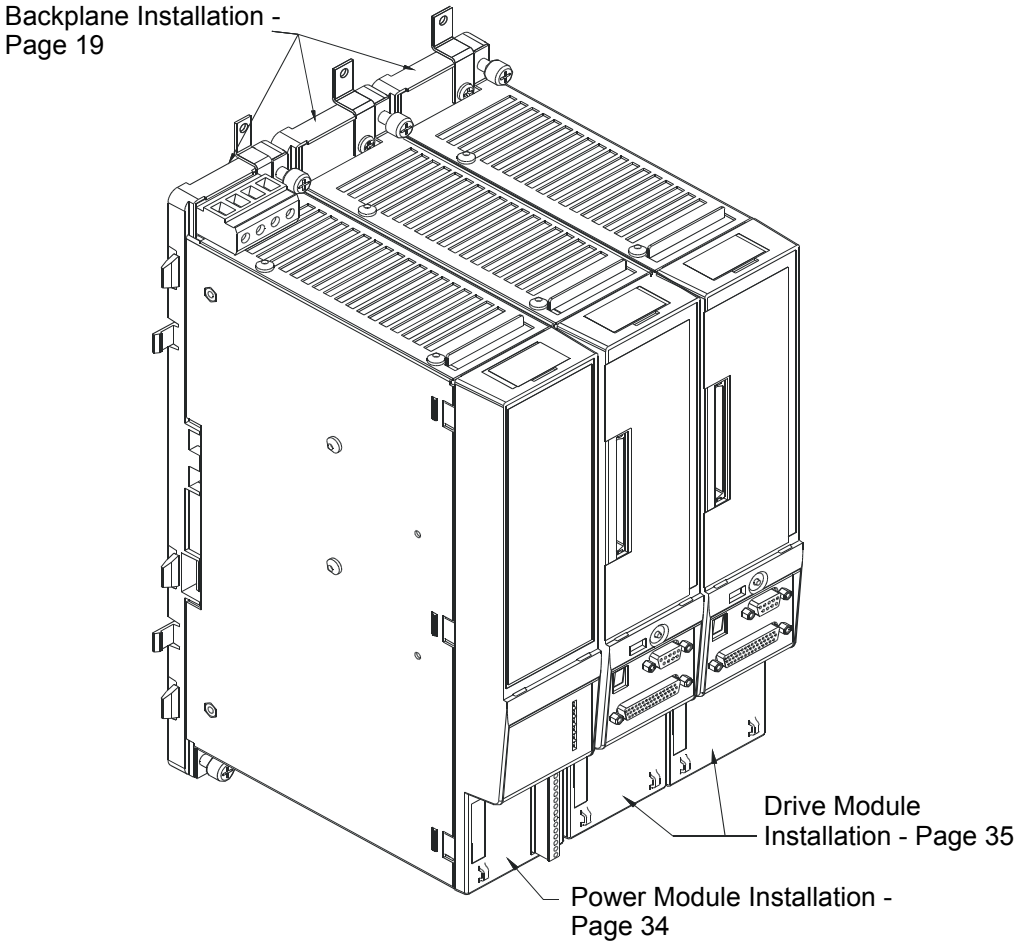



*Figure 5: Modular Drive System*

## Power Module Backplane Dimensions

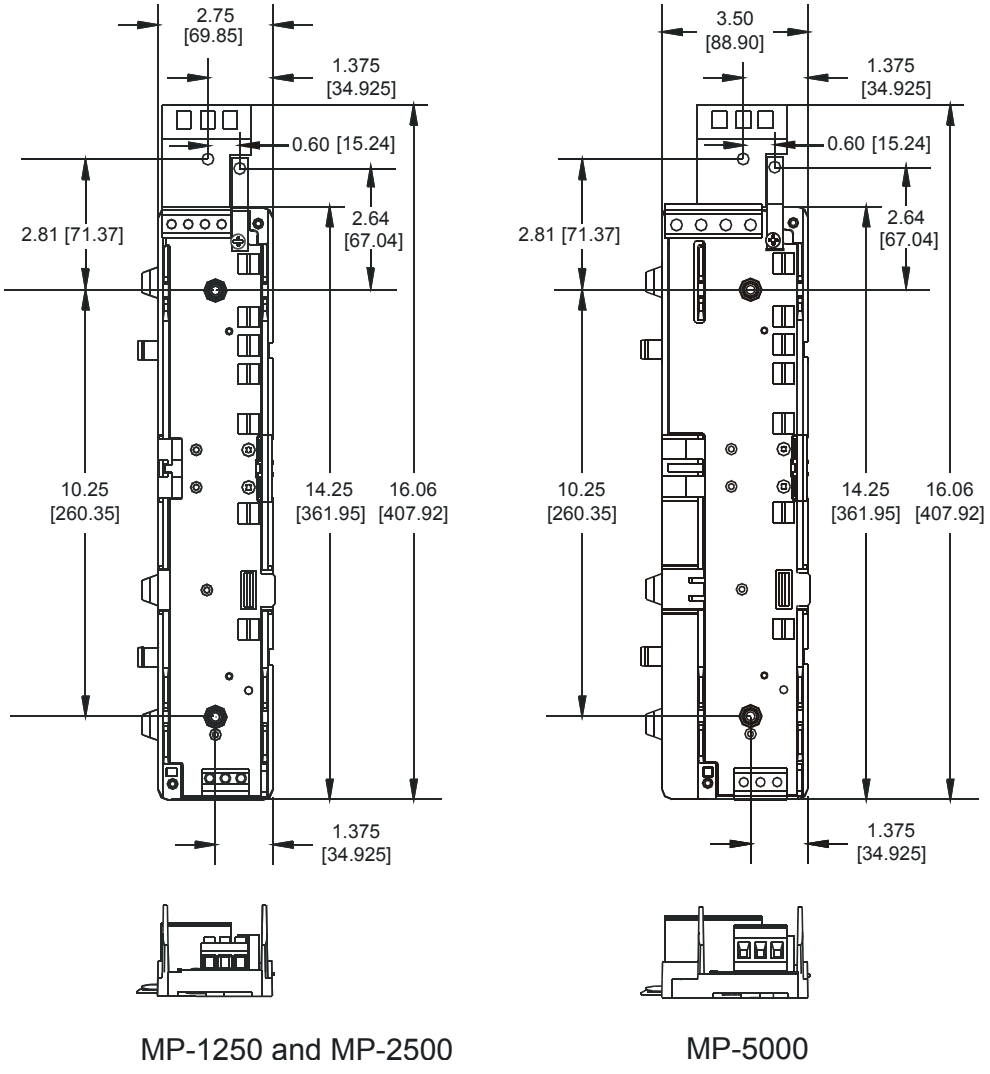



*Figure 6: Power Module Backplane Dimensions*

## Power Module Assembly Dimensions

| Power Module Model | DIM “A” |
|---|---|
| MP-1250 & MP-2500 | 2.75 [69.85] |
| MP-5000 | 3.50 [88.90] |

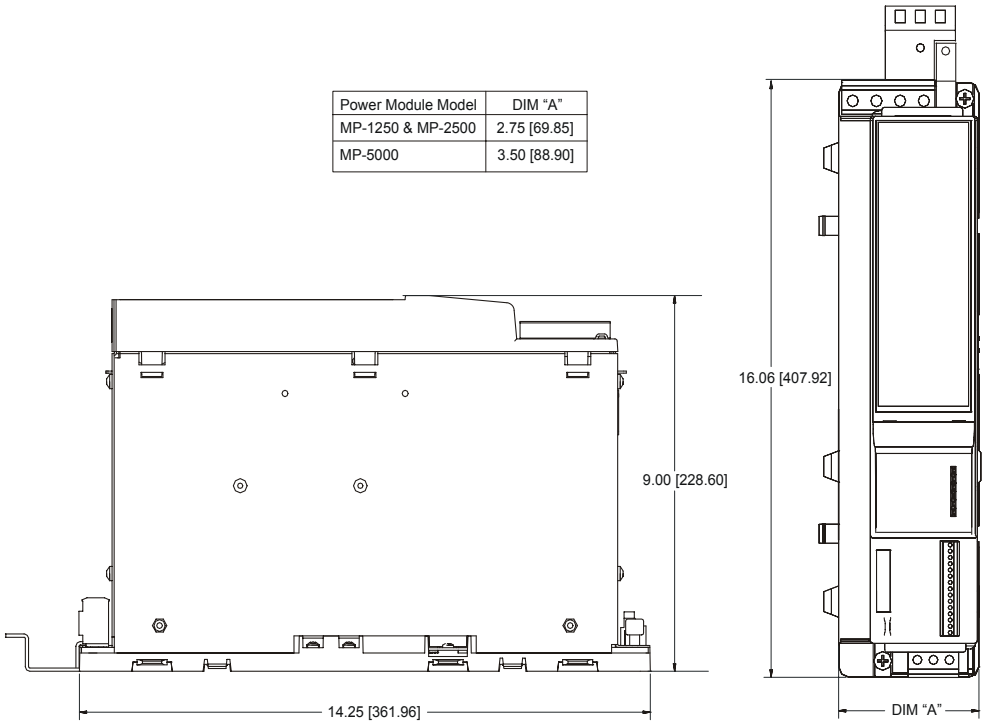
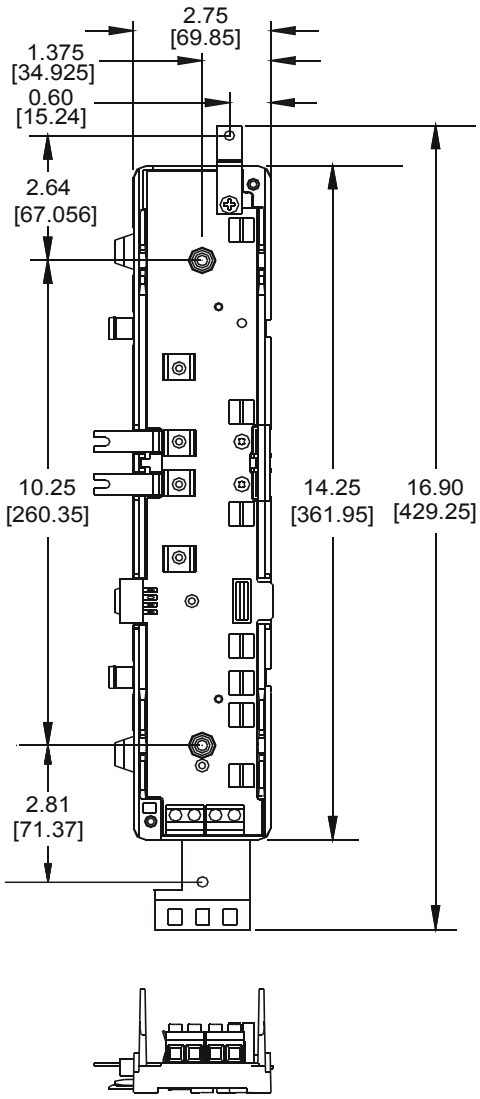



*Figure 7: Power Module Dimensions - MP-5000 Shown*

## Drive Module Backplane Dimensions




MD-404, MD-407 and MD-410

*Figure 8: Drive Module Backplane Dimensions*

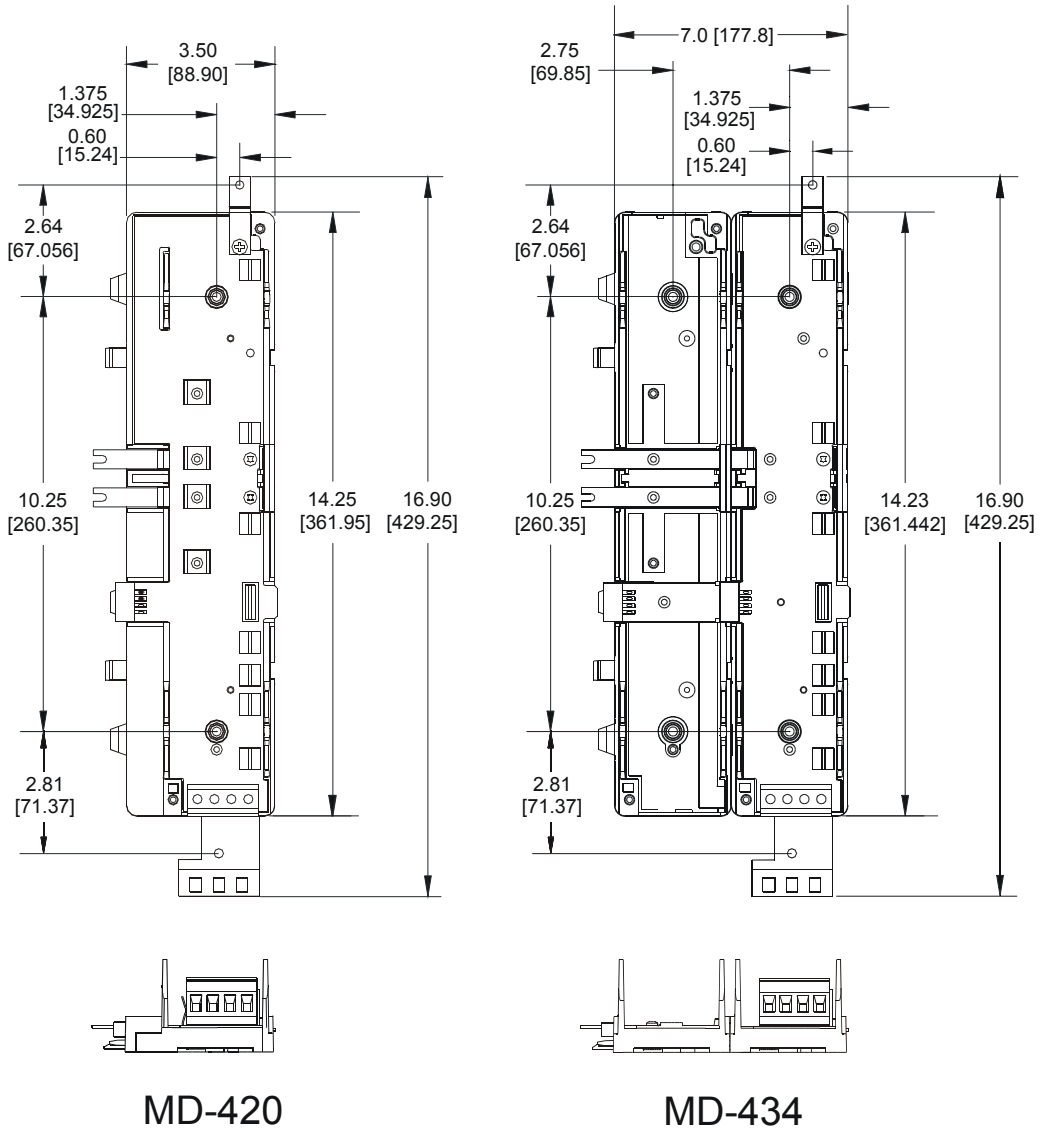



*Figure 9: Drive Module Backplane Dimensions*

## Drive Module Assembly Dimensions

| Drive Module Model | DIM "A" |
|---|---|
| MD-404 | 2.75 [69.85] |
| MD-407 | 2.75 [69.85] |
| MD-410 | 2.75 [69.85] |
| MD-420 | 3.50 [88.90] |
| MD-434 | 5.49 [139.50] |

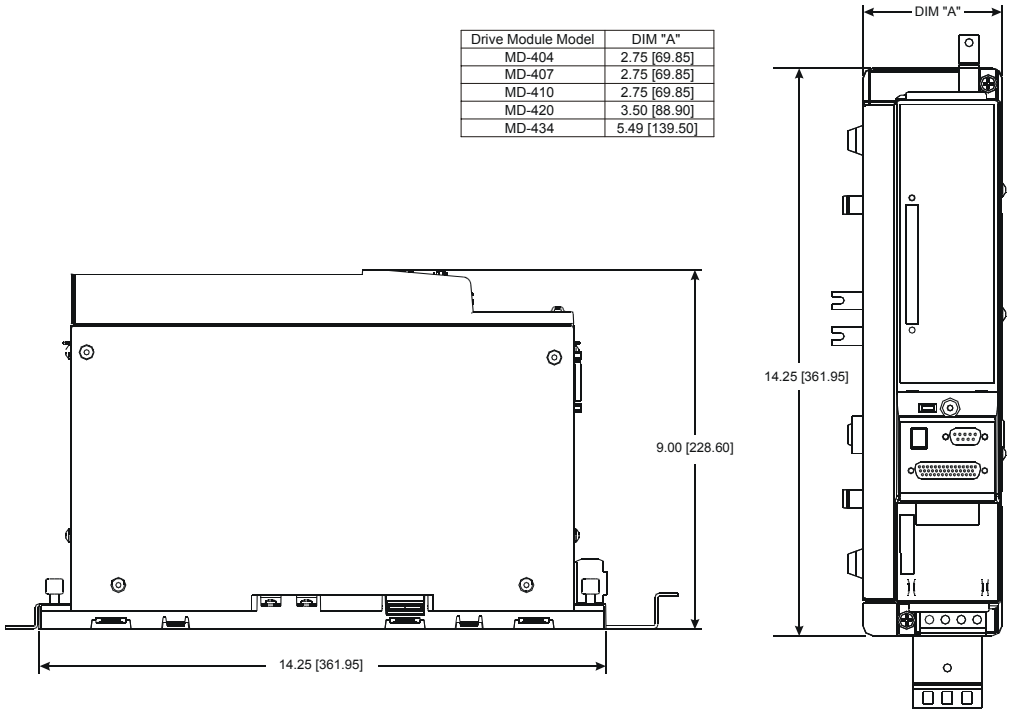



*Figure 10: Drive Module Dimensions - MD-420 Shown*

# Step 1: Power Module Backplane Installation

Mount the Power Module in the left most position using #10 panhead screws. The optional Cable Strain Relief bracket must be installed **before** tightening the screws holding the backplane to the metal mounting panel. To install the Optional Cable Strain Relief bracket simply slide the bracket behind the backplane, aligning the slot of the bracket with the screw holding the backplane to the metal mounting panel. Push on the bracket until it stops. Secure the Optional Cable Strain Relief bracket with a #10 panhead screw and tighten the backplane screws.

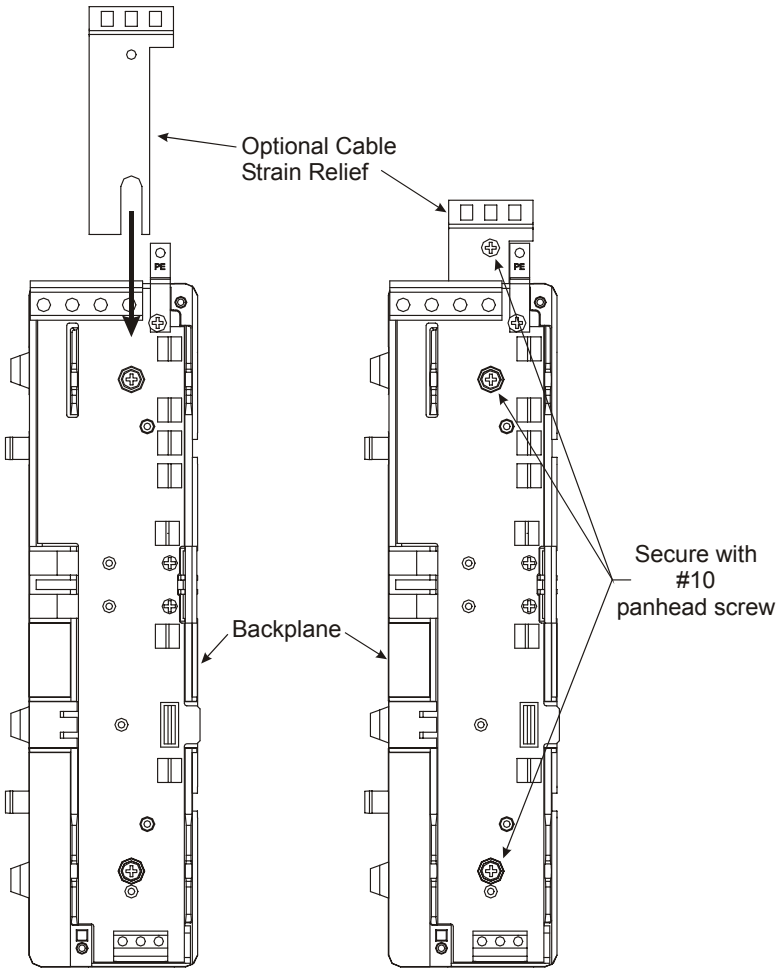



*Figure 11: MP-5000 Power Module Backplane shown with Optional Cable Strain Relief Bracket Mounting*

# Step 2: Drive Module Backplane Installation

**Note**

Starting from the Power Module, the Drive Modules must be installed from largest (highest current rating) to smallest (lowest current rating), with the largest size attached to the Power Module.

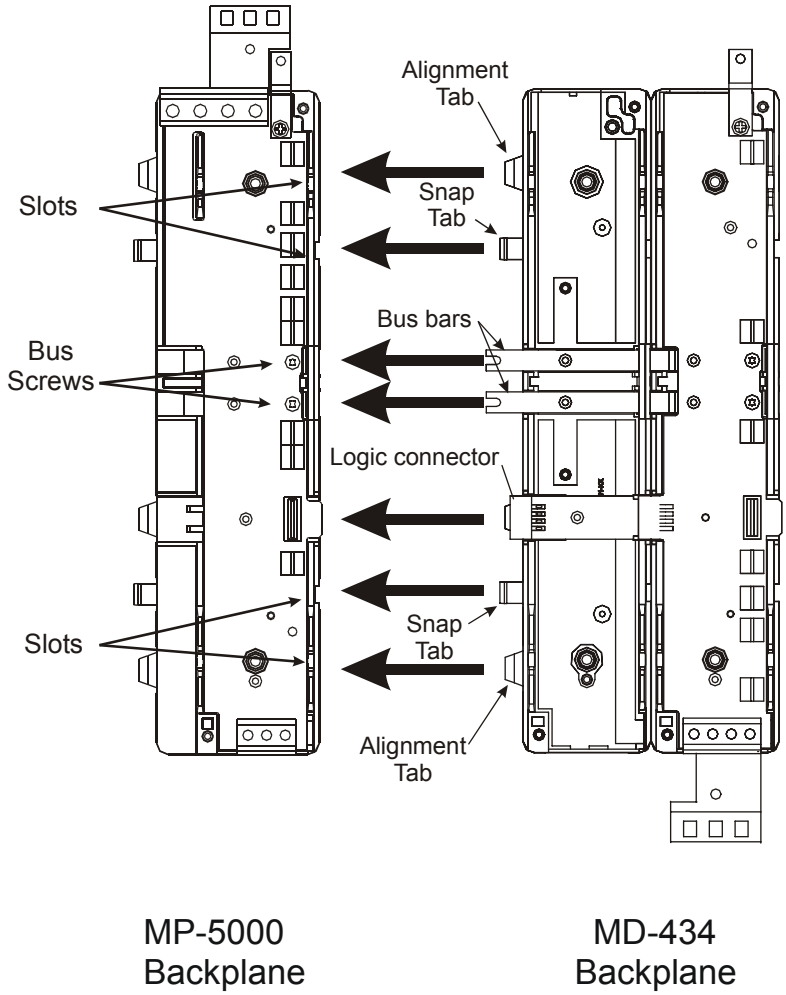



*Figure 12: Assembling the Drive Module Backplane to the Power Module Backplane.*

1. Loosen the DC Bus screws on the Power Module backplane.

2. Align the DC Bus bars with the DC Bus screws, the Logic connector with the Power Module board and all the tabs on the Drive Module backplane with the slots in the Power Module backplane.

3. Push the Drive Module backplane firmly into the Power Module backplane until the Bus bars are under the DC Bus screws and the backplanes snap together. The Power Module backplane board is plugged into the Drive Module backplane Logic connector and the tabs are secure in the slots. Backplane side walls of both modules are in contact with each other.

4. Torque the bus screws to 8-10 in.lbs.

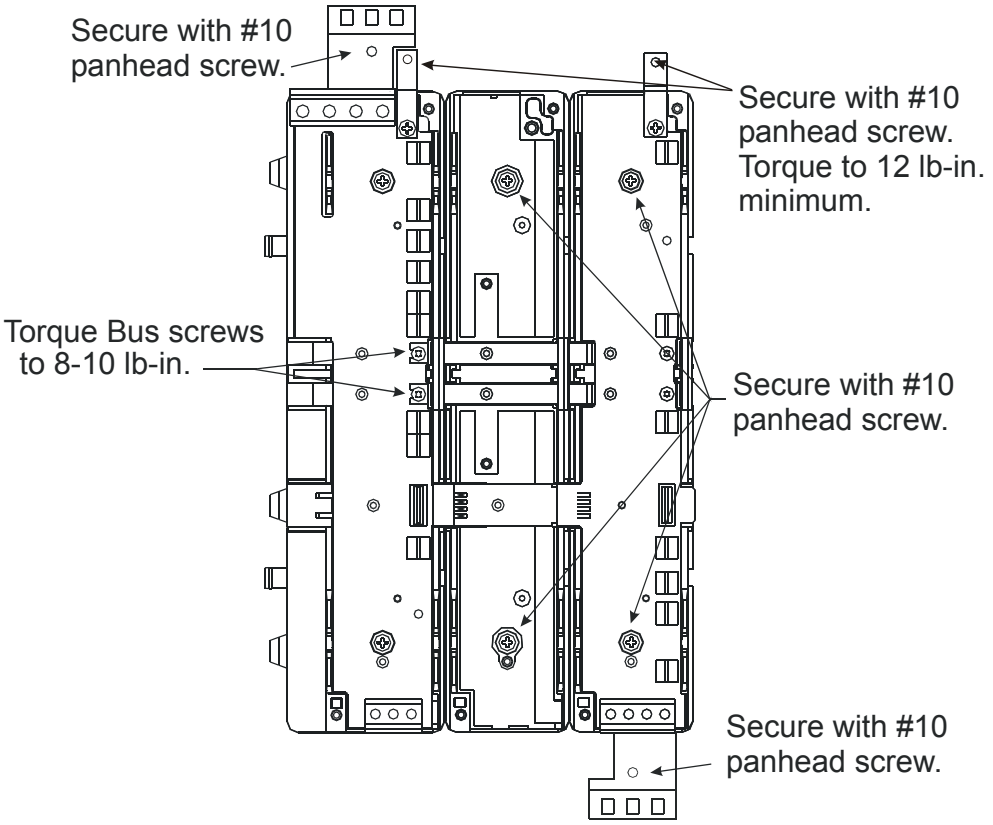



*Figure 13: Securing the Drive Module backplane to the Power Module backplane.*

5. To install the Optional Cable Strain Relief bracket, slide the bracket behind the backplane, aligning the slot with the backplane screw, push until it stops then secure with a #10 panhead screw.

6. Secure the Drive Module backplane to enclosure mounting panel with #10 panhead screws.

**⚠WARNING**

The paint must be removed from behind each PE Ground Tab to ensure proper ground connection.

7. Secure the Power and Drive Module PE ground tabs with #10 panhead screws, torque to 12 in.lb.

8. Continue adding Drive Modules, largest to smallest, by repeating step 1 through step 7.

The Power Module and Drive Module backplanes can be assembled as described above, where one backplane is assembled and secured to the enclosure at a time. Another method is to assemble all the backplanes together (Steps 1-4) and then secure them to the enclosure mounting panel.

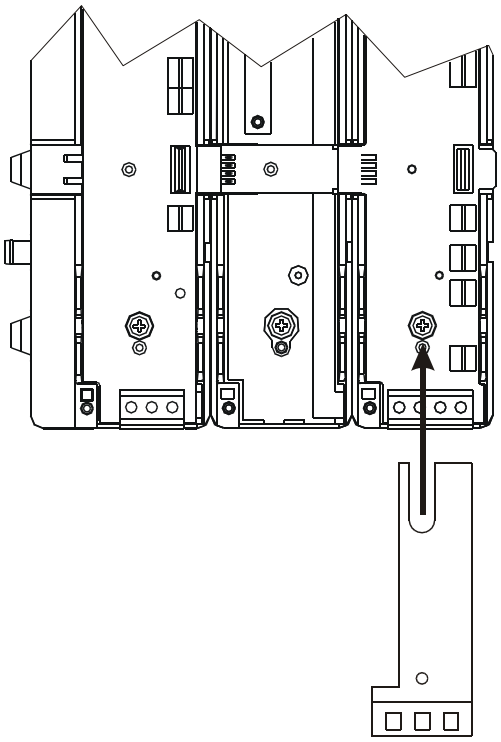


*Figure 14: Installing the Optional Cable Strain Relief Bracket*

# Step 3: Power Module High Power Connections

## System Grounding

To insure a safe and quiet electrical installation, good system grounding is imperative. The figure below is an overview of the recommended system grounding. For more information on achieving an electrically quiet installation refer to "Basic Installation Notes" on page 6.

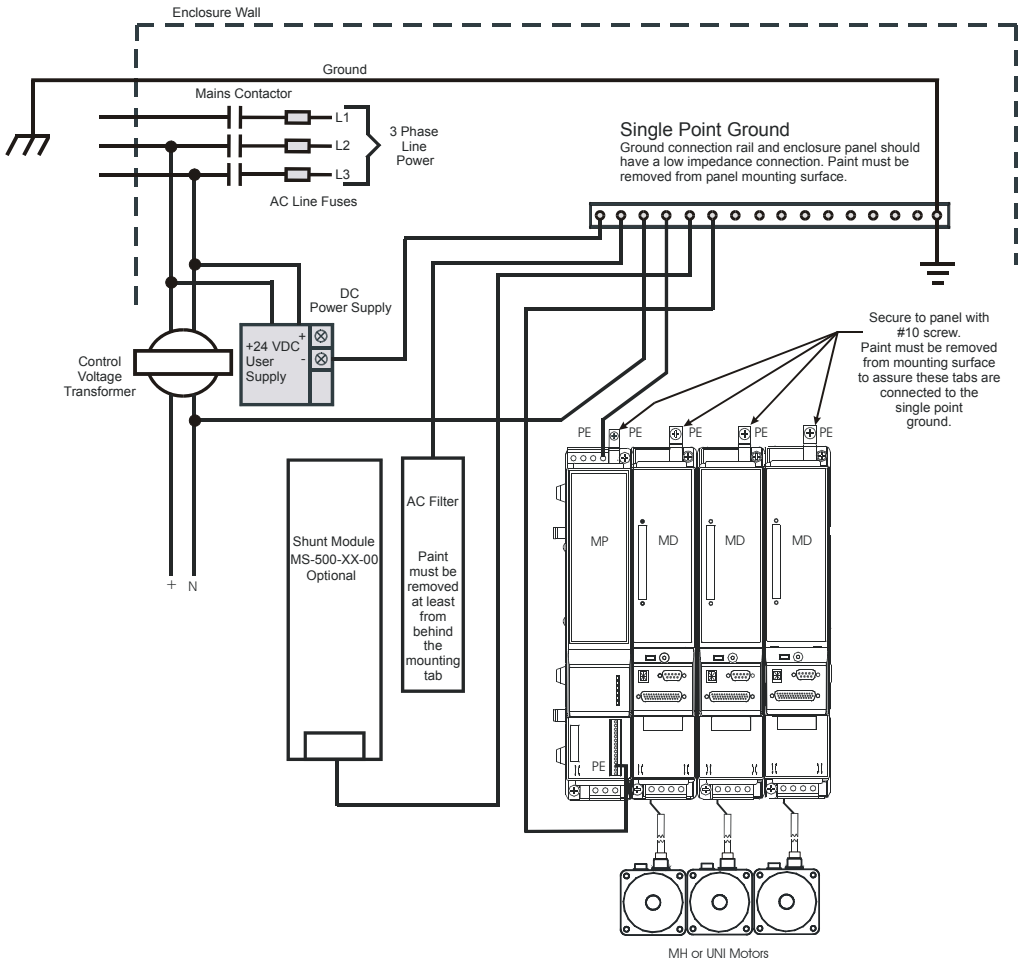



*Figure 15: System Grounding Overview*

**⚠WARNING**

PE is not distributed through the backplanes. A separate PE connection is required for each Power and Drive Module.

Fixed Protective Earth (PE) connections are mandatory for human safety and proper operation. These connections must not be fused or interrupted by any means. Failure to follow proper PE wiring can cause death or serious injury.

## AC Input Power Connection

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

**CAUTION**

If the continuous power required by the system is greater than 35 KW an AC Line Reactor needs to be installed. Minimum requirements for the Line Reactor is 250 mH and 80A continuous. Control Techniques offers a Line Reactor, MLR02580-00. See the CT-MME-POWER-CD for drawings.

**CAUTION**

The maximum voltage applied to the Power Module AC Input terminals must not exceed 528VAC phase to phase and phase to PE ground. This can be accomplished by referencing the AC supply to earth ground.

### 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.

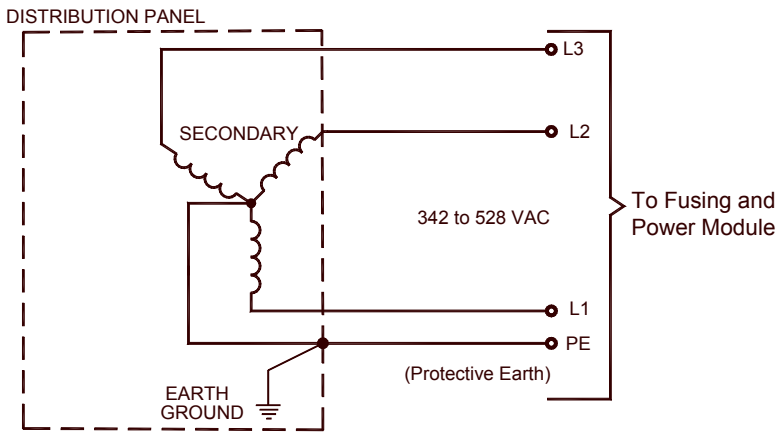



*Figure 16: Earth Grounded WYE Distribution Transformer*

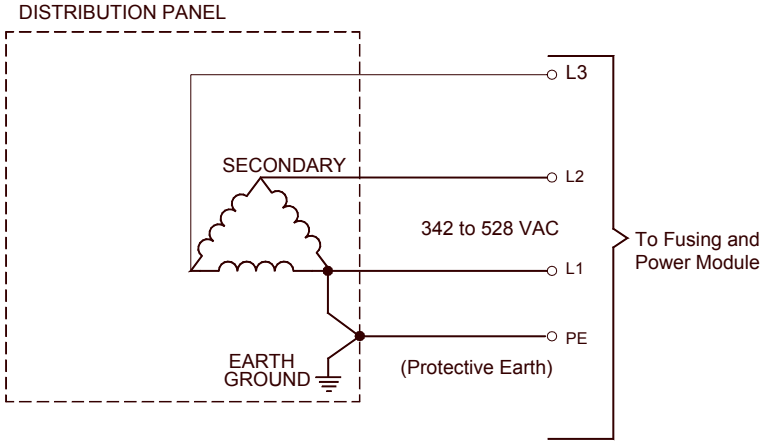



*Figure 17: Earth Grounded Delta Distribution Transformer*

## AC Supplies Requiring Transformers

If the distribution transformer is configured as shown in the figures below, an isolation transformer is required. For sizing of isolation transformer See “Transformer Sizing” on page 27.

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

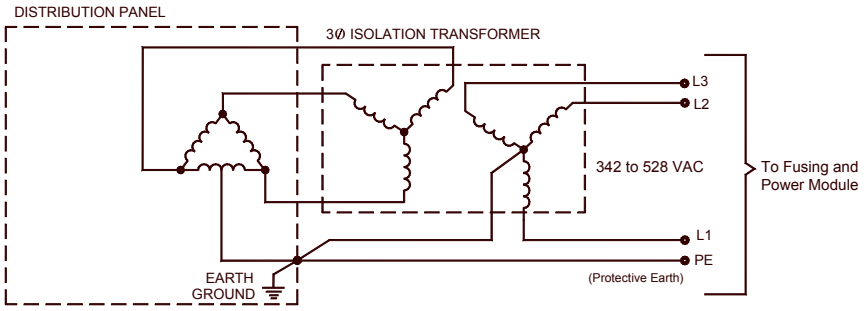



*Figure 18: Three Phase Delta (with mid-phase GND) Distribution to a Three-Phase WYE/WYE Isolation Transformer*

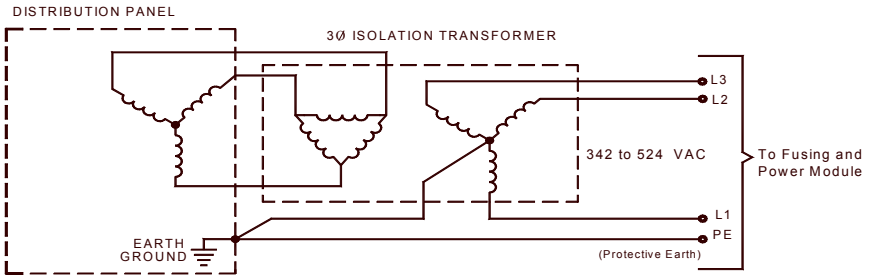



*Figure 19: Three Phase WYE (ungrounded) Distribution to a Three-Phase Delta/WYE Isolation Transformer*

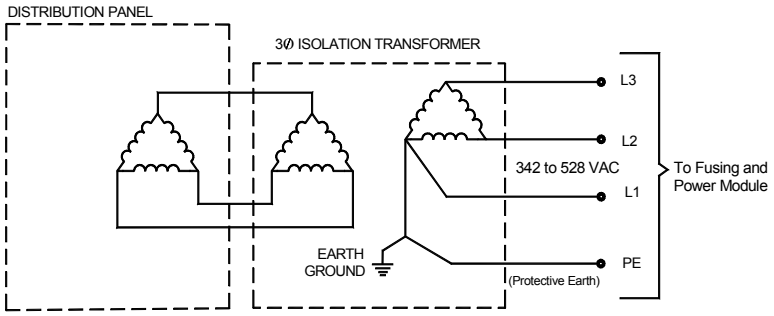



*Figure 20: Three Phase Delta Distribution to a Three Phase Delta/Delta Isolation Transformer*

## Transformer Sizing

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

| Power Module | Suggested KVA Rating |
|---|---|
| MP-1250 | 25 |
| MP-2500 | 50 |
| MP-5000 | 100 |

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

### Line Fusing and Wire Size

You must incorporate over current protection for the AC Input power with the minimum rating shown here. Refer to the table below for recommended fuses and wiring of other uqeivalent fast blow fuses.

| Power Module Model | External AC Line Fuse | Recommended Minimum AC/PE Line Wire Gauge |
|---|---|---|
| MP-1250 | KTK-R 20A, JKS 20A or JJS 20A | 16 GA |
| MP-2500 | JKS 40A or JJS 40 A | 10 GA |
| MP-5000 | JJS 70A | 4 GA |

**⚠WARNING**

The MDS has an internal relay that is required to be wired into the control logic of the installation. The AC Interlock relay contact should be wired in series with the coil of the Mains contactor. The relay contact is rated at +24VDC at 5A. To protect the Modules the AC Interlock will open during a High AC Input or Shunt Fault Condition.

## Electrical AC Input Power Connections

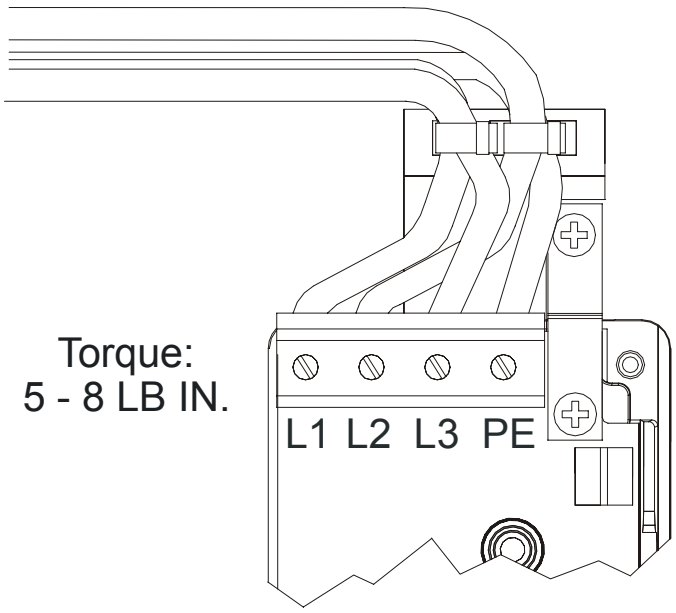



*Figure 21: Power Module AC Power Wiring Diagram*

**⚠WARNING**

Do Not apply power to the backplanes before the modules are attached. The backplanes have exposed high voltage conductors.

## External Shunt Electrical Installation

### Shunt Wire Size

| Power Module Model | Recommended Minimum Shunt Wire Gauge |
|---|---|
| MP-1250 | 16 GA |
| MP-2500 | 16 GA |
| MP-5000 | 16 GA |

### Shunt Resistor Connection

Connect the Shunt Resistor to B+ and Shunt terminals on the Shunt connector.

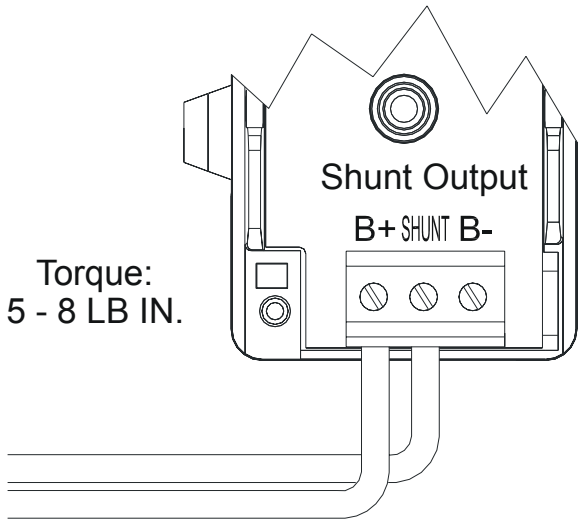



*Figure 22: Power Module Shunt Wiring Diagram*

**CAUTION**

Access to Bus- (B-) is given for measurement purposes only (i.e. oscilloscope or voltage meter). Do Not make any connections to B-.

**⚠WARNING**

Shunt connections are at main voltage potential. Components connected must be rated for the voltage and selected for safety.

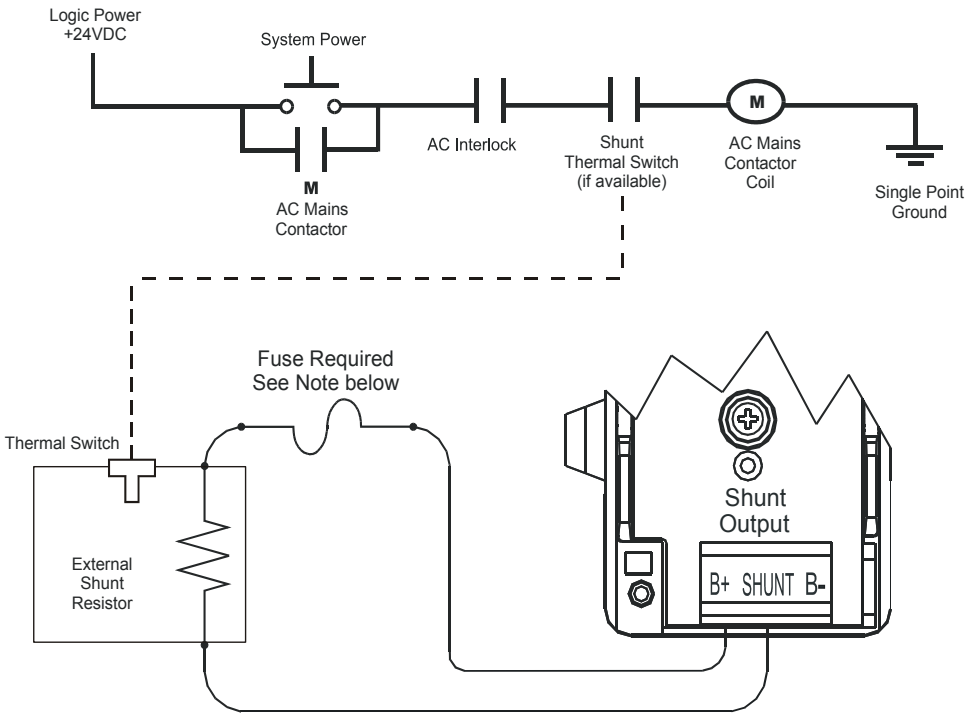



*Figure 23: Power Module Shunt Wiring*

## Note

For proper fuse size refer to table below. Fast blow semiconductor fused rated 700 VDC or higher are recommended (such as Shawmut A70Q). If using Control Techniques' shunt, MS-510-00 or MS-530-00 , refer to Figure 24 for proper connections.

| Power Module | Shunt Output Fuse Size | External Shunt Minimum Resistance (Ohms) |
|---|---|---|
| MP-1250 | 4A | 30 |
| MP-2500 | 8A | 30 |
| MP-5000 | 16A | 9 |

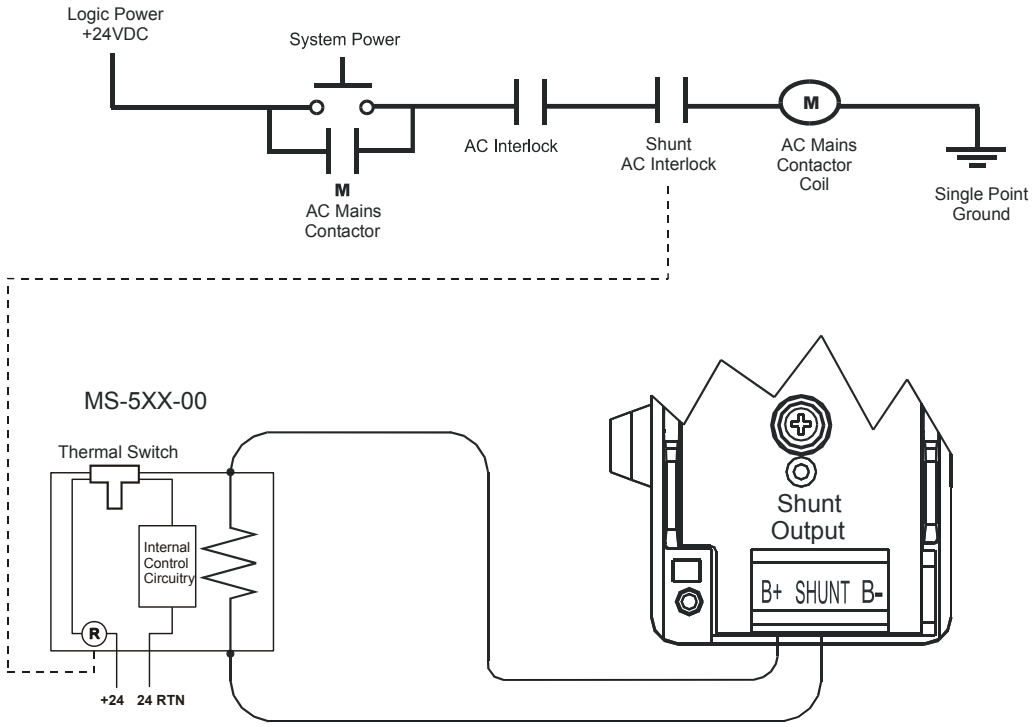



*Figure 24: Power Module Shunt to Control Techniques' MS-5XX-00 Wiring Diagram.*

Figure 24 shows the high power connections only. For a complete wiring diagram to a MS-5XX-00 see the Option and Accessories section in this manual.

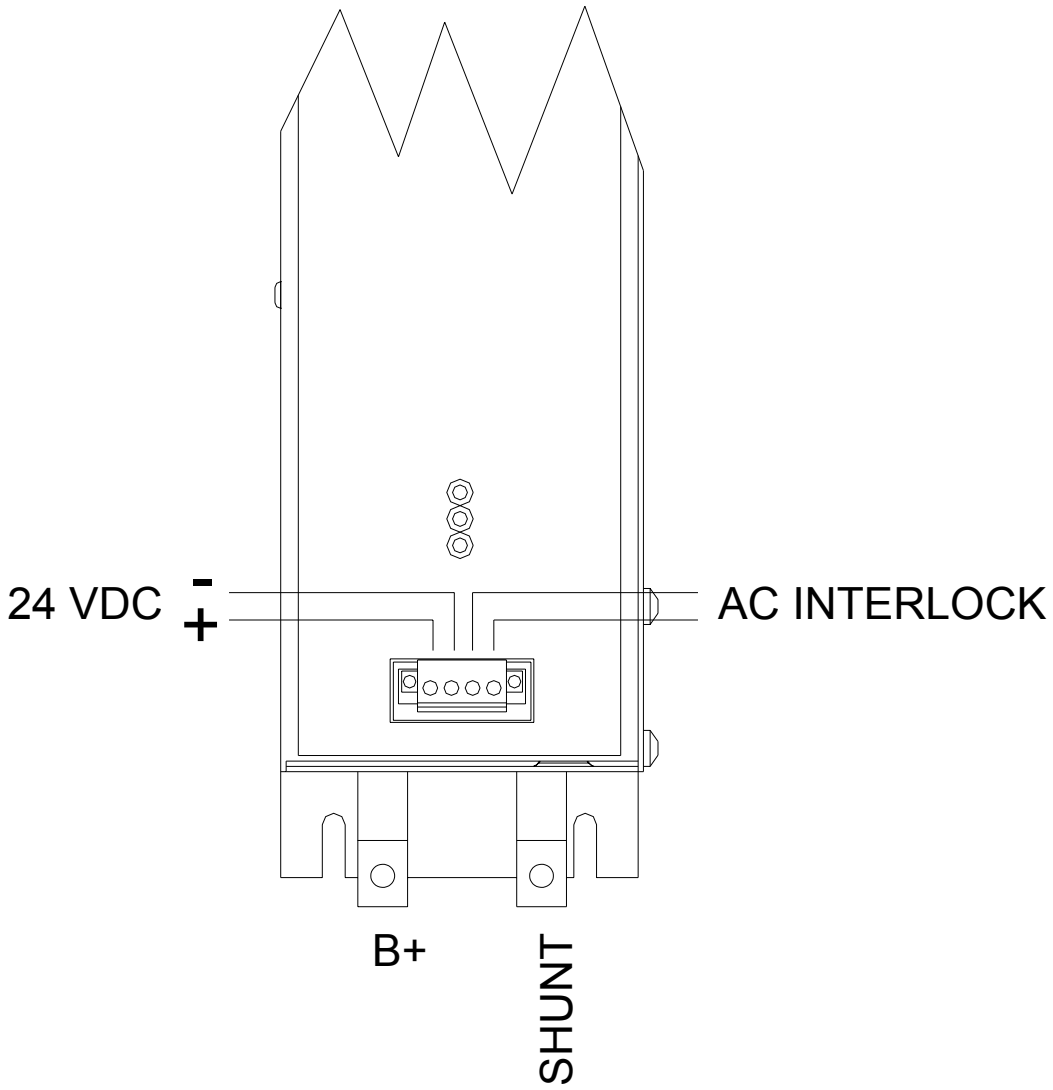



*Figure 25: The MS-5XX-00 Connections*

The MS-5XX-00 has integral control circuitry for protection of the shunt resistor. In order to protect the installation the shunt interlock must be placed in series with the AC Mains Contactor.

# Step 4: Drive Module High Power Connections

## Motor Power Cable Wiring to the Drive Module

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

Motor power connections from the Drive Module to the motor can be made with cables which have a female MS style connector on the motor end and four individual wires and shield that connect to the motor power connector on the bottom of the Drive Module.

| Motor Model | Standard Cable Model# | Flex Cable Model # | Wire Gauge |
|---|---|---|---|
| MH or HT 3" frame | CMDS | CMDF | 16 |
| MH 4" and 6^ frame | CMMS | CMMF | 12 |
| MH 8" frame | CMLS | N/A | 8 |

### 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 of ground.

| Drive Module Motor Connections | Motor Power Cable Model Color Code | |
|---|---|---|
| | CMDS, CMMS,and CMLS | CMDF and CMMF |
| PE | Green/Yellow | Green/Yellow |
| T | Blue | Red 3 |
| S | Black | Red 2 |
| R | Brown | Red 1 |

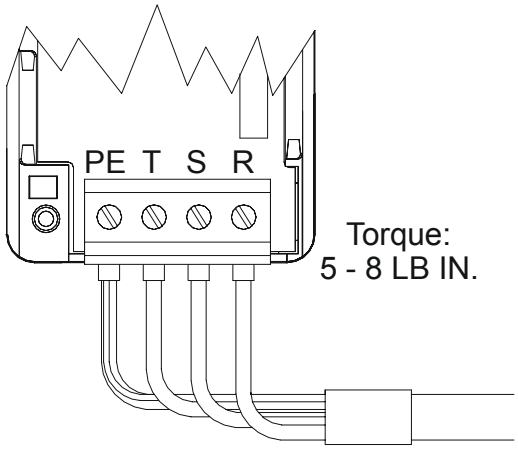



*Figure 26: Drive Module Motor Power Wiring Diagram*

# Step 5: Power Module Installation

After all the backplanes are secured with AC Input Power and Motor Power cable connections made, the Power Module must be installed into the backplane.

**⚠WARNING**

Make sure all power is off before installing any of the modules.

Orient the Power Module so the top of the module is up and the alignment bars in the Module aligns with the alignment tabs in the backplane. The sheet metal of the Power Module will be on the outside of the alignment tabs.

**CAUTION**

Improper alignment of the module can cause damage to the module or the backplane.

Firmly press the Power Module into the backplane to insure good backplane connection. When the Module is completely seated to the backplane, torque the top and bottom retaining screws to 6 - 8 LB IN.

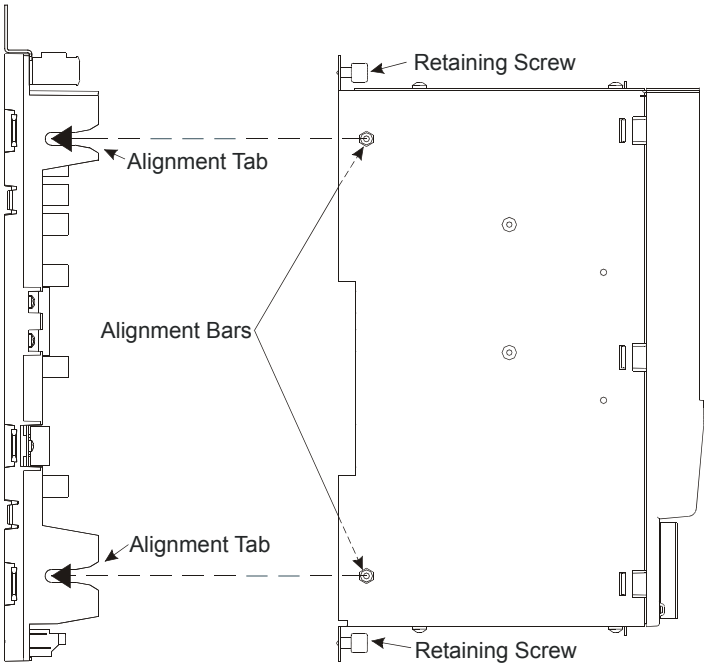



*Figure 27: Power Module Assembly Diagram*

# Step 6: Drive Module Installation

After the Power Module is installed to its backplane the Drive Modules can be installed to their respective backplanes.

**⚠WARNING**

Make sure all power is off before installing any of the modules.

Orient the Drive Module so the top of the module is up and the alignment bars in the Module aligns with the alignment tabs in the backplane. The sheet metal of the Drive Module will be on the outside of the alignment tabs.

**CAUTION**

Improper alignment of the module can cause damage to the module or the backplane.

Firmly press the Drive Module into the backplane to insure good backplane connection. When the Module is completely seated to the backplane, torque the top and bottom retaining screws to 6 - 8 LB IN.

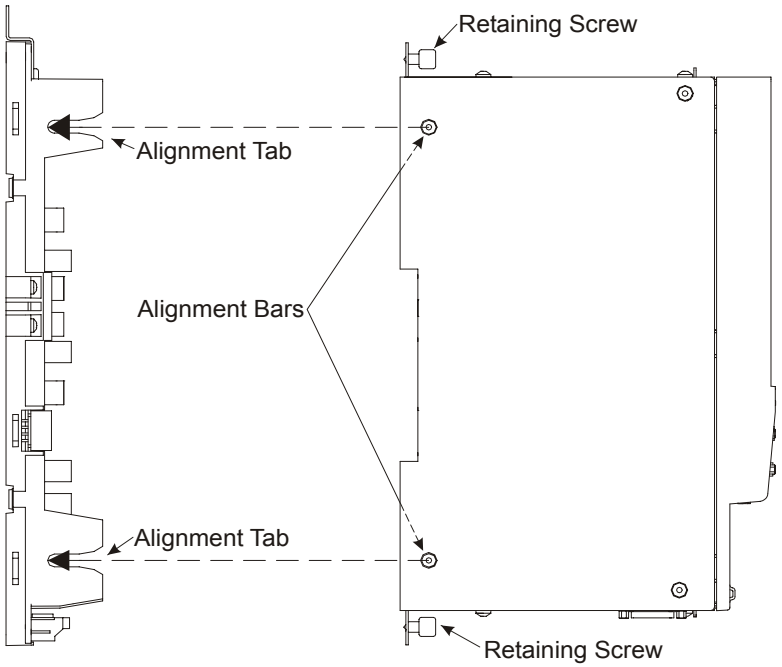



*Figure 28: Drive Module Assembly Diagram*

# Step 7: Power and Drive Module Low Power Connections

## Logic and Digitial I/O Power Sizing

The MDS requires a user supplied logic power supply, 24 VDC +/- 10%, to power the internal logic of the Power Module and Drive Modules. Use the table below to determine the current requirements of the application.

| Module | Model Number | RMS Current (A) |
|---|---|---|
| Power Module | MP-1250 | 0.30 |
| | MP-2500 | |
| | MP-5000 | |
| Drive Module | MD-404 | 0.60/Module |
| | MD-407 | |
| | MD-410 | |
| | MD-420 | |
| | MD-434 | 0.80/Module |
| FM Module | All | 0.40/FM Module |
| Synchronization Feedback Encoder | * | 0.07/Encoder |

* Control Techniques supplies external master synchronization feedback encoders (Model# SCSLD-XXX) or user supplied synchronization feedback encoders can be used. The current required to power the synchronization feedback encoder can not exceed 250 mA @ 5 VDC/ Axis.

The user supply connected to the Power Module provides power for the internal logic of the MDS. The Logic Power is carried through the backplane from the Power Module to the Drive Modules.

A user supply is also required for the Digital I/O power on the Power Module, Drive Modules, and FM Modules. The user supply for Logic Power and Digital I/O Power can be the same supply if desired. However, the input tolerances for Logic Power and Digital I/O are different and may require that the I/O and Logic Power supply be separated. Reference the following Figures for connections.

## Logic and Digitial I/O Power Connections

In Figures 29 and 30 the MDS is being powered by one power supply. The supply needs to be wired into the Power Module Logic Power Input and Digital I/O Input. Each Drive Module and FM module also require Digital I/O power. The Power Module's Logic Power Input range is +24VDC +/-10%. The Digital I/O power for all the modules is +10 to 30 VDC. For applications that require Digital I/O power outside the Logic Power Input range refer to Figure 31 and 32.

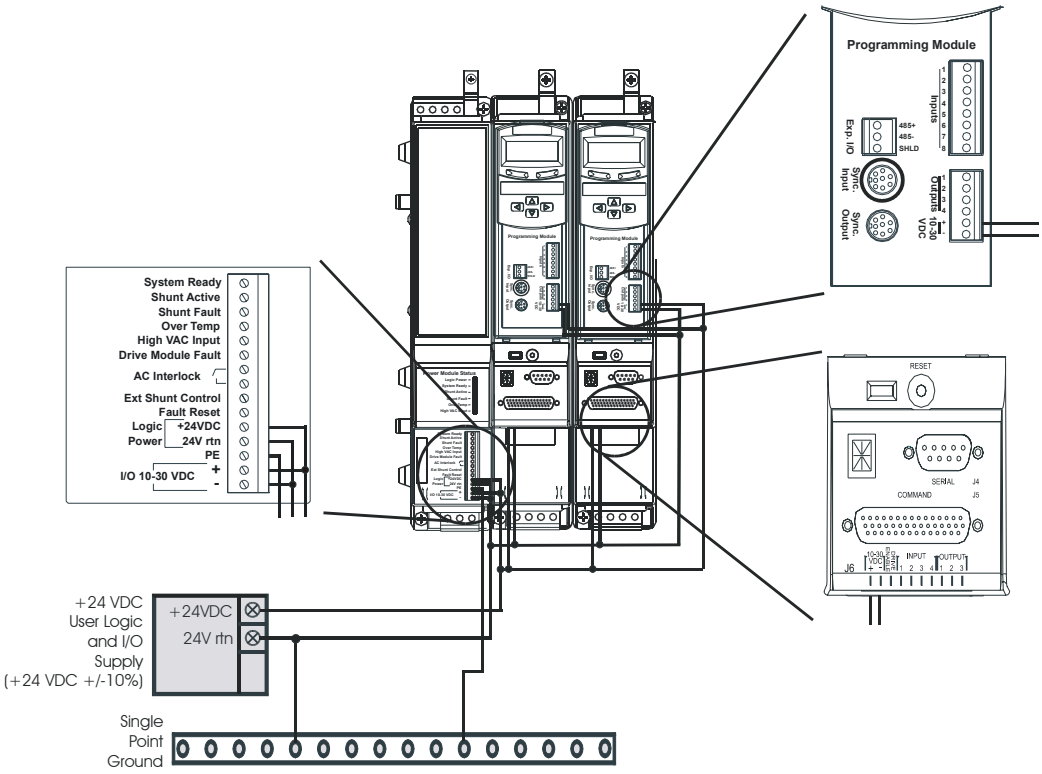



*Figure 29: One Power Supply for the Logic and I/O Power Wiring Diagram.*

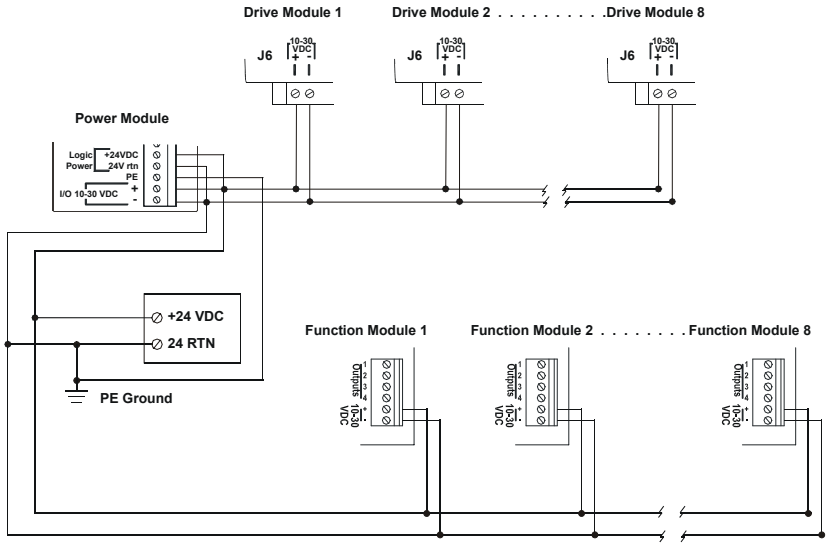



*Figure 30: One Power Supply for the Logic and I/O Power Wiring Diagram.*

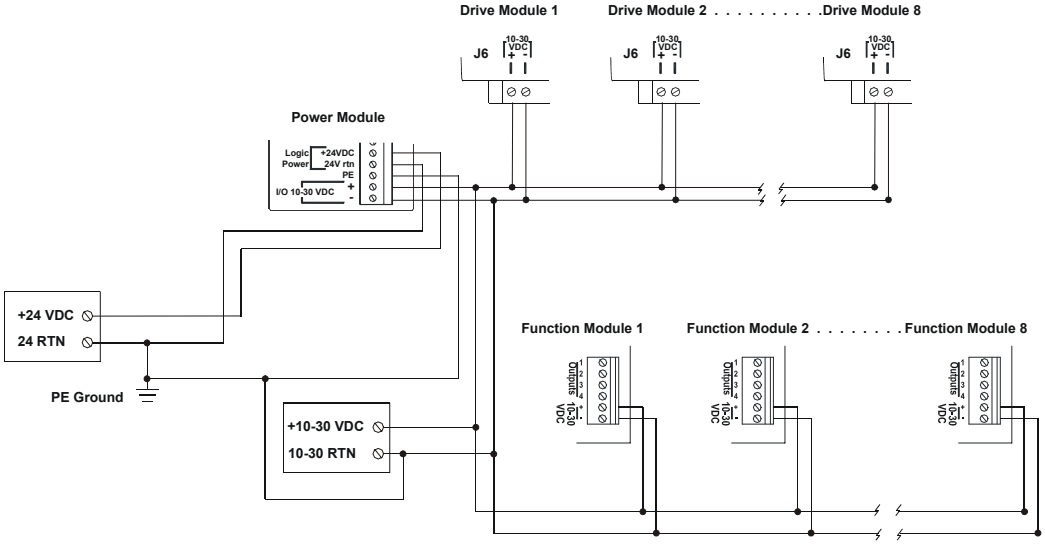



*Figure 31: Separate Power Supplies for the Logic and I/O Power Wiring Diagram*

In Figures 31 and 32 the MDS Logic and I/O power are separated for applications that have Digital I/O power (+10 to 30VDC) that is out of the Logic Power Range (+24VDC +/-10 %).

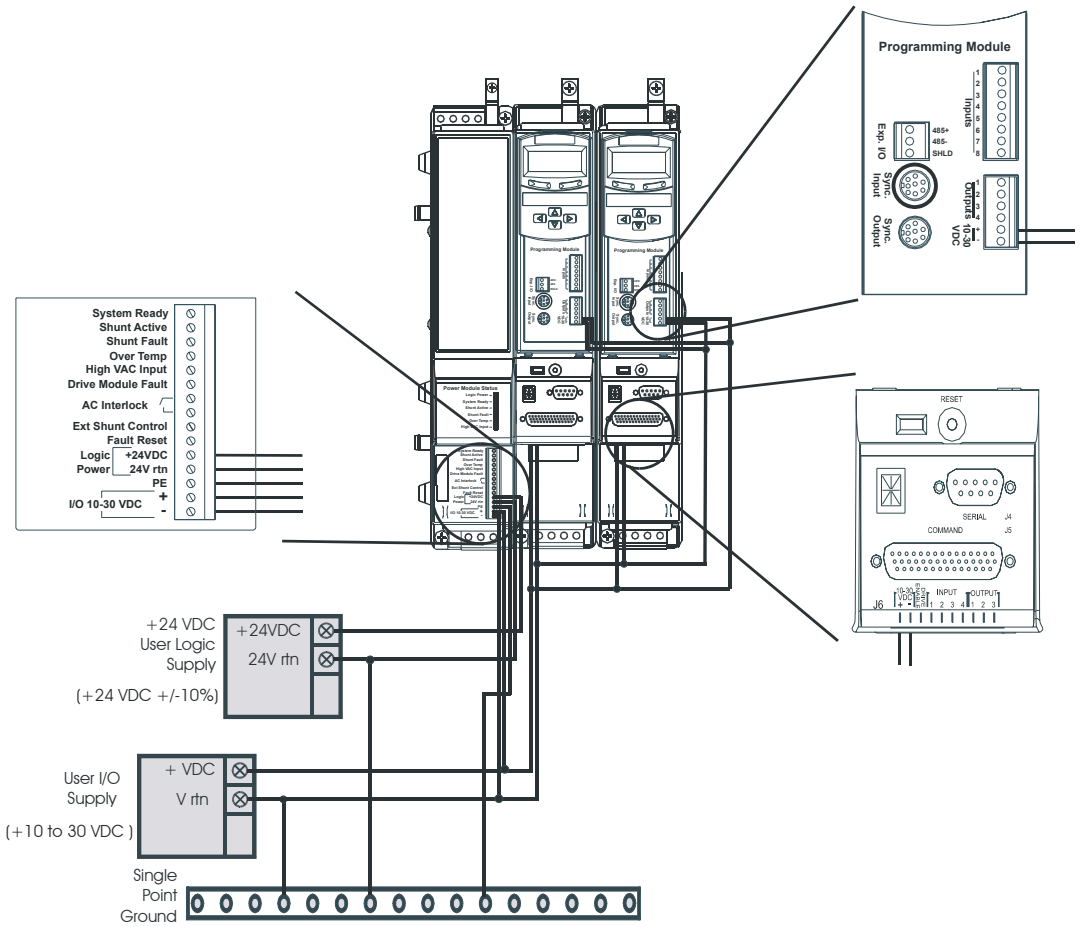



*Figure 32: Separate Power Supplies for the Logic and I/O Power Wiring Diagram.*

## Power Module I/O Connections

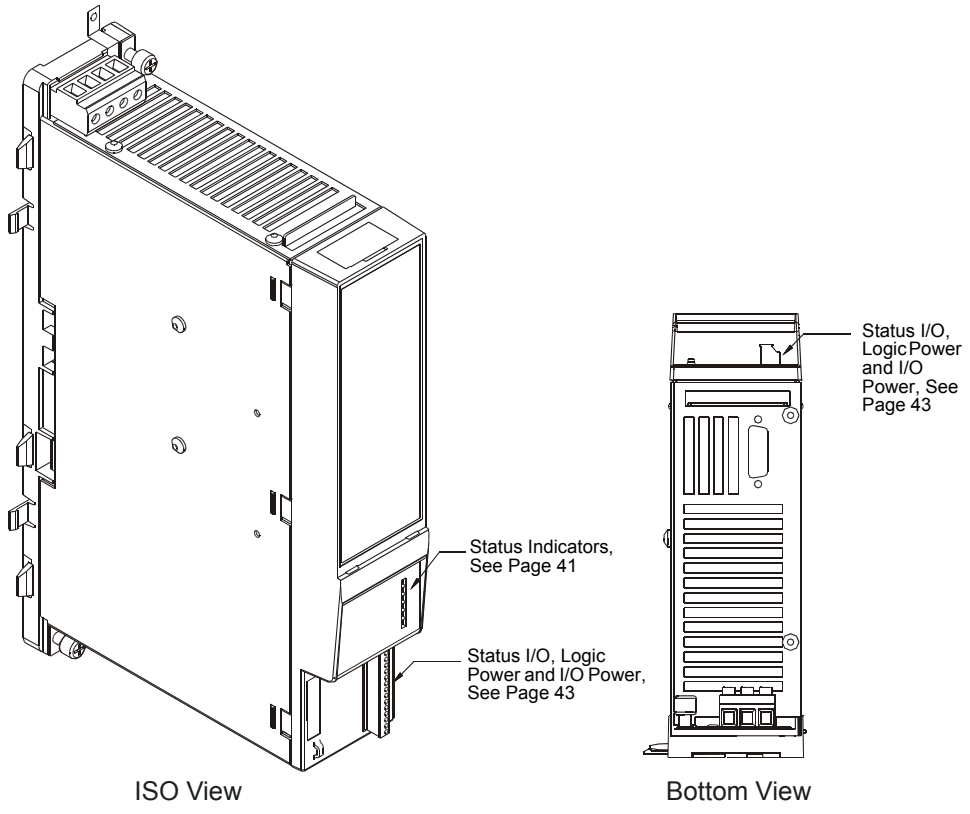



*Figure 33: Power Module Operation and Features*

The function of the Power Module is to rectify the AC input and provide the DC bus for the Drive Modules. The Power Module has an integral soft-start circuit to limit the in-rush current when powering up the system. Once the DC bus is charged the Power Module passes a logic signal (System Ready) to the Drive Modules across the backplane allowing the Drive Modules to draw power from the bus. For deceleration of loads that generate more energy than the DC Bus capacitance can store, the Power Module has an integral shunt transistor that can be connected to an external shunt resistor through the shunt connector on the bottom of the backplane.

The Power Module has a built in processor providing system soft-start control, shunt control and basic self-protection and diagnostic functions such as:

- Excessive AC input voltage

- Loss of AC input voltage phase (single phase operation)
- Over temperature of the rectifier bridge and shunt transistor
- Improper shunt circuit operation or wiring error

Six diagnostic display LEDs controlled by the microprocessor are located on the Power Module front panel as well as the I/O connector with 4 digital outputs, 2 digital inputs, and AC Interlock Relay contacts. The function of these signals can be found on the following pages.

## Power Module Status Indicators (LEDs)

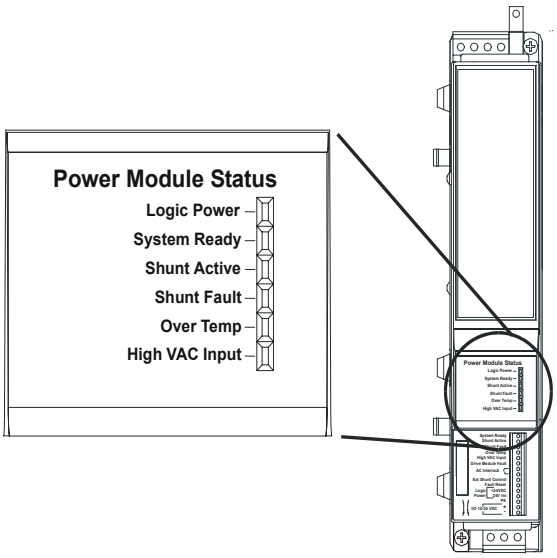



*Figure 34: Power Module Status Indicator location*

### Logic Power

The Logic Power status indicator (green) is illuminated when the +24VDC logic Power is correctly supplied to the Power Module. If the status indicator is not illuminated verify that the user supply is providing between +21.6 VDC and +26.4 VDC.

### System Ready

The System Ready status indicator (green) is illuminated when the system power-up sequence is properly completed. See “Power up Sequence” on page 66.

The System Ready status indicator will blink if one of the AC Input Phases is lost. The system will remain functional in single phase condition. However, it’s strongly undesirable to run the system in single phase mode that can cause severe over heating of the power module components.

If AC power is on and the System Ready status indicator is not illuminated, one of the following has occurred: Shunt fault, Over-temperature or High VAC Input. These faults are described below.

**Shunt Fault**

The Shunt Fault status indicator (red) will be illuminated in the case of shunt resistor wiring error or a short circuit condition.

**Over Temp**

The Over Temp status indicator (red) will be illuminated if continuous RMS power rating of the Power Module is exceeded creating an over temperature condition. The Power Module needs to be shut down to allow for cooling before the Over Temp condition is not present.

This fault may also occur if ambient temperature exceeds 40$^{o}$C.

**High VAC Input**

The High VAC Input status indicator (red) will be illuminated if the AC input Voltage exceeds 528 VAC.

**Shunt Active**

The Shunt Active status indicator (green) will be illuminated when the Shunt Transistor is on. The Shunt Transistor will turn on under two conditions:

- The Bus voltage exceeds 830 VDC due to regenerative energy during motor deceleration. Shunt Transistor turn off level is 780 VDC.
- The External Shunt Control Input is active in case of emergency stop.

## Power Module I/O

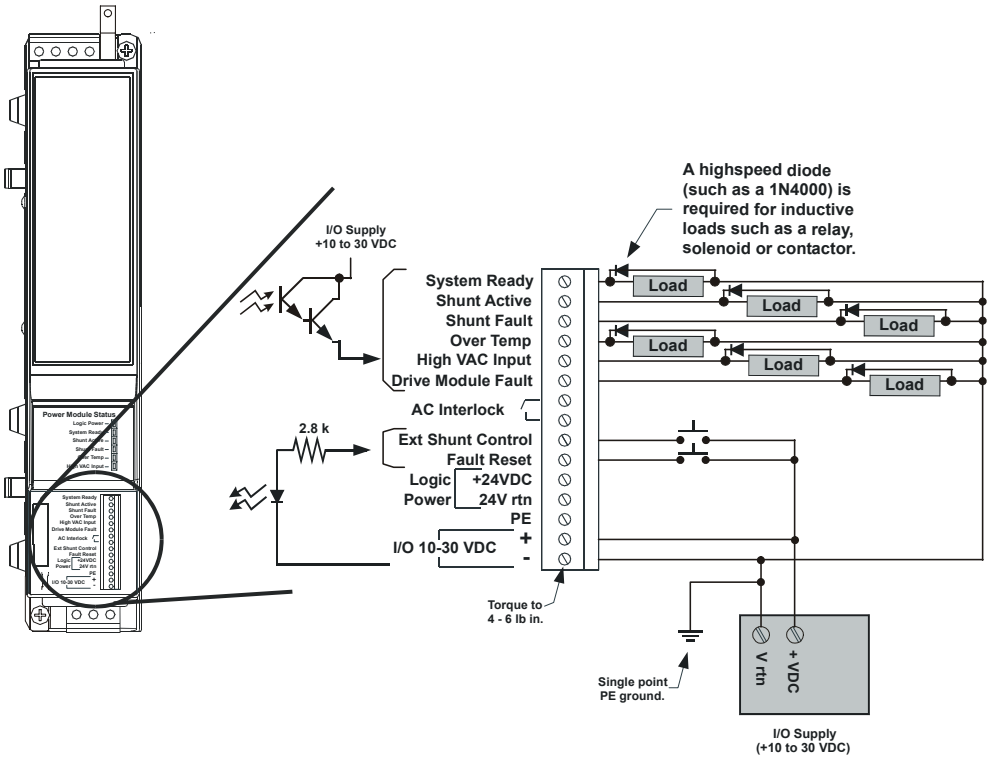



*Figure 35: Power Module I/O Wiring Diagram*

### System Ready

The System Ready output is active (high) when the Power Module has completed the power-up sequence properly. ① (See Figure 38) Once this signal is active the Drive Module can be enabled. The System Ready output remains high during normal system operation and turns low in case of system fault.

If AC power is on and System Ready output is low, one of the following has occurred: ② Shunt fault, ③ Over-temperature fault or ④ High VAC Input. These faults are described below.

### Shunt Fault

The Shunt Fault output ⑤ will be active (high) in the case of shunt resistor wiring error or a short circuit condition.

#### Over Temp

The Over Temp fault will be active (high) if continuous RMS power rating of the Power Module is exceeded creating an over temperature condition. ⑥

#### High VAC Input

The High VAC output will be active (high) if the AC input Voltage exceeds 528 VAC. ⑦

#### Drive Module Fault

The Drive Module Fault output will be active (high) if at least one of the Drive Modules is in over current or short circuit condition. In this case a 'Z' fault will be displayed on the Drive Module display indicator. The System Ready signal will not be affected by the status of this signal.

#### Shunt Active

The Shunt Active Output will be active (high) when the Shunt Transistor is on. The Shunt Transistor will turn on under two conditions:

- The Bus voltage exceeds 830 VDC due to regenerative energy during motor deceleration. Shunt Transistor turn off level is 780 VDC. ⑧
- The External Shunt Control Input is active in case of emergency stop. ⑨

#### AC Interlock

The AC Interlock relay contacts are closed if +24 VDC Logic Power is supplied to the system.⑩ This relay is intended to remove AC power from the system (contacts are open) when one of the faults below occur:

- High VAC Input ⑪ or
- Shunt Fault ⑫

## AC Interlock Connections

**⚠WARNING**

The MDS has an internal relay that is required to be wired into the control logic of the installation. The AC Interlock relay contact should be wired in series with the coil of the Mains contactor. The relay contact is rated at +24VDC at 5A. To protect the Modules the AC Interlock will open during a High AC Input or Shunt Fault Condition.

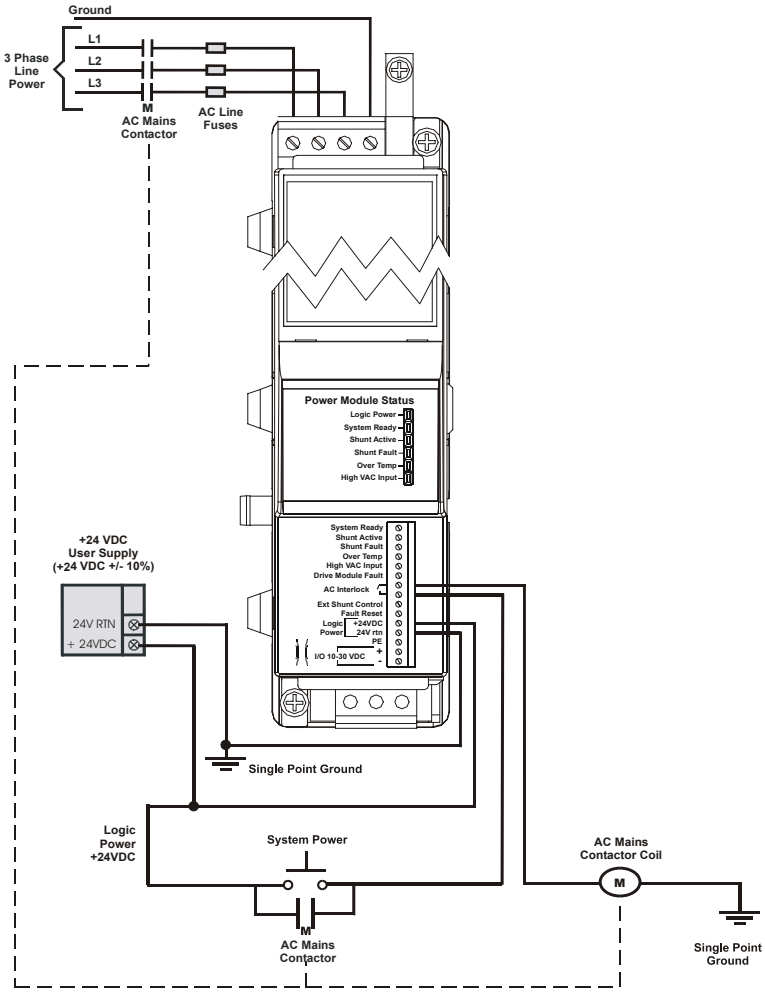



*Figure 36: AC Interlock wiring with +24VDC Mains Contactor Coil*

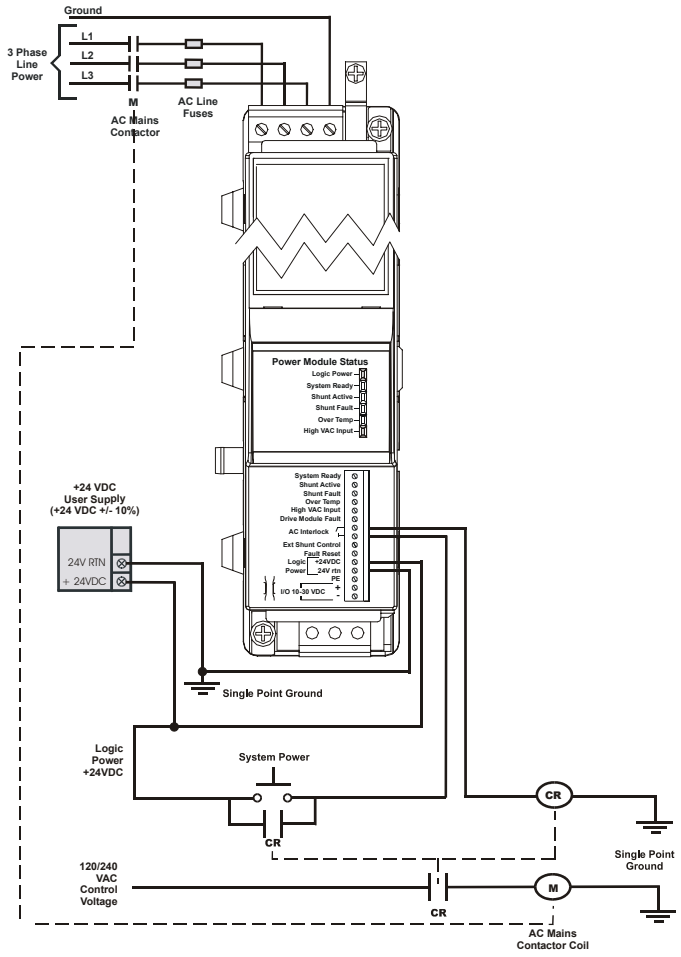



*Figure 37: AC Interlock with 120/240VAC Mains Contactor*

### Ext Shunt Control

The External Shunt Control Input (active high) gives the user control of the shunt transistor in case of an emergency stop. When this input is active the shunt transistor will turn on and bleed the bus down through an external shut resistor. (13)

This Input is disabled when AC Power is supplied to the system. (14)

### Fault Reset

The Faults Reset Input (active high) allows the user to reset any of three faults without removing +24 VDC Logic Power from the system. ⑮⑯⑰

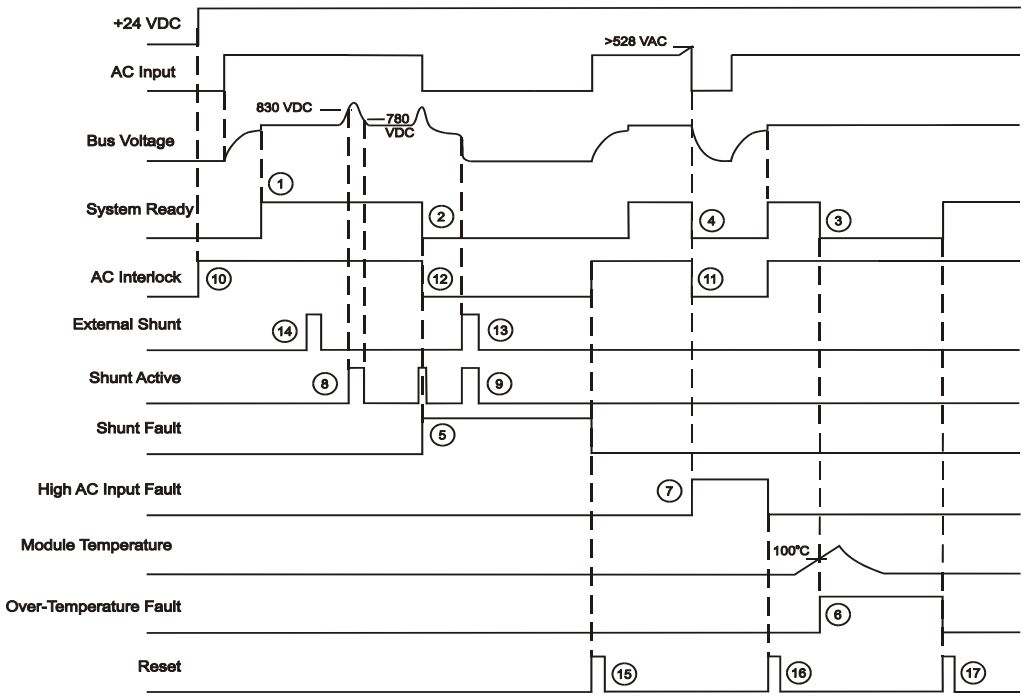



*Figure 38: Power Module Logic Timing Diagram*

### Logic Power

The Logic Power is necessary for all internal logic operation of the Power and Drive Modules. The Logic Power input is +24 VDC +/- 10 %. See “Logic and Digitial I/O Power Connections” on page 37 for wiring diagrams.

### PE (SHIELD)

The PE connection is a convenient place to connect I/O cable shield. It is the same electrical point as all other PE connections of the MDS. See “System Grounding” on page 23.

### I/O

The I/O supply input is used to power the user side of the Power Module I/O. The I/O supply supports +10 to 30 VDC input. See “Logic and Digitial I/O Power Connections” on page 37 for wiring diagrams.

## Drive Module I/O Connections

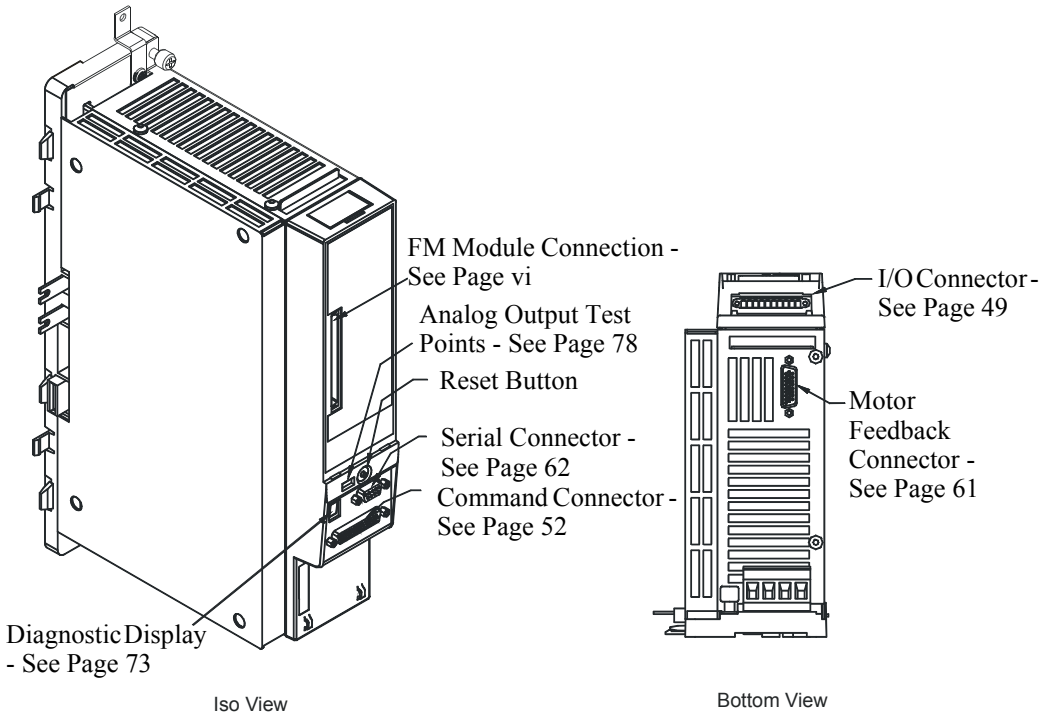



*Figure 39: Drive Module Operations and Features*

The Drive Module draws power from the DC Bus and controls the current flow to the motor. Each Drive Module is configured using PowerTools FM or PowerTools PRO. The Drive Module contains a diagnostic display that provides visible feedback to the current status of the Drive Module. The Drive Module has connections for Digital I/O, Analog I/O, Encoder Feedback, Sync Encoder and the ability to connect FM modules for more functionality.

## Input/Output Connector Wiring

Drive Modules are equipped with five optically isolated input lines (one is dedicated to a drive enable function) and three optically isolated output lines. They are designed to operate from a +10 to 30 VDC source. All inputs and outputs are configured as sourcing.

**CAUTION**

Each output is capable of providing 150mA and must be protected from over current conditions by a user supplied fuse.

**⚠WARNING**

Highly inductive loads such as relays must be suppressed with a diode.

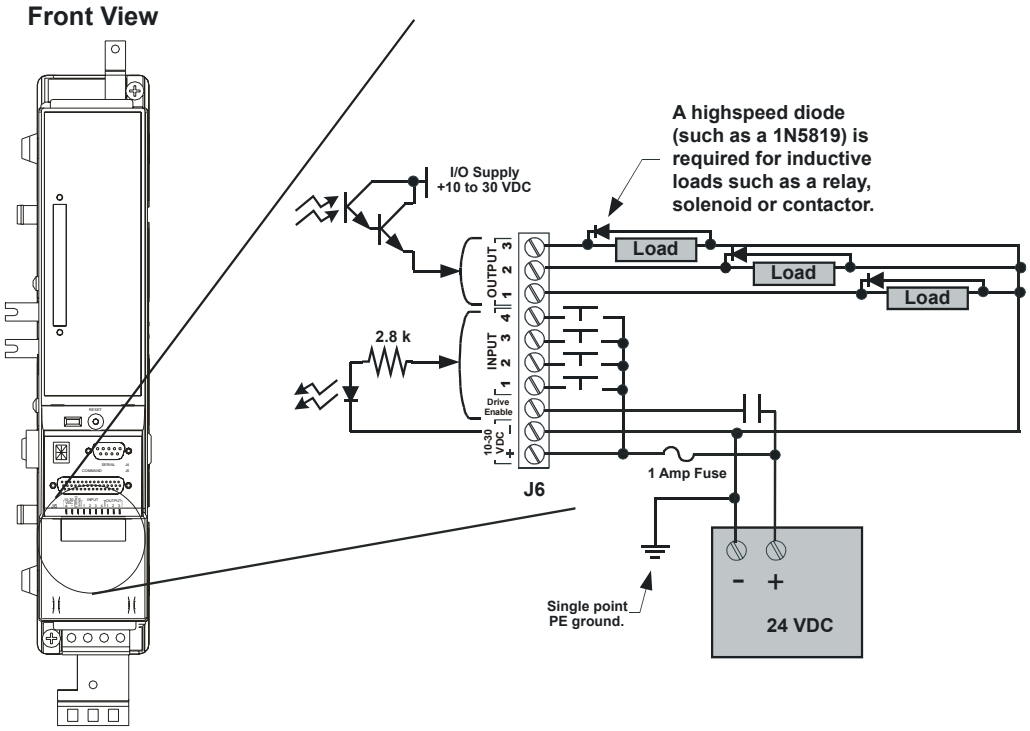



*Figure 40: MDS Drive Module Input/Output Wiring Diagram*

The I/O connector is a 10-pin removable terminal block. It is recommended that #18 to 24 AWG stranded wire be used and torque to 4 - 5 lb.-in.

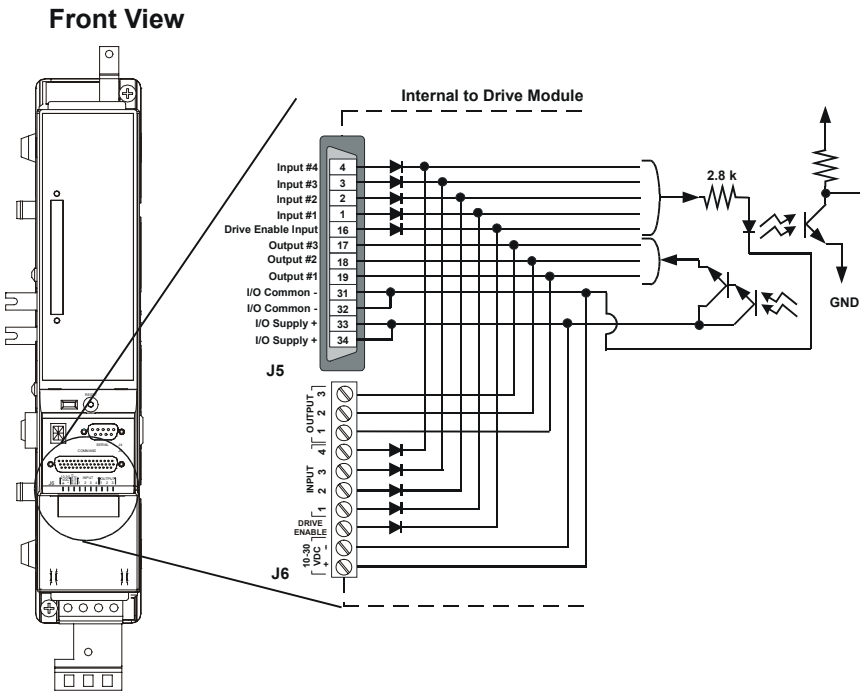



*Figure 41: MDS Drive Module I/O Connector to Command Connector Internal Connections*

**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.

## Motor Brake Wiring

HT and MH motors equipped with brakes have a separate three-pin MS style connector for brake power. The brake power cable (model CBMS-XXX) has an MS style connector on the motor end and three wire leads on the Drive Module end (see Figures 42 and 43). For Unimotors equipped with brakes the brake wiring is contained in the motor power cable.

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.

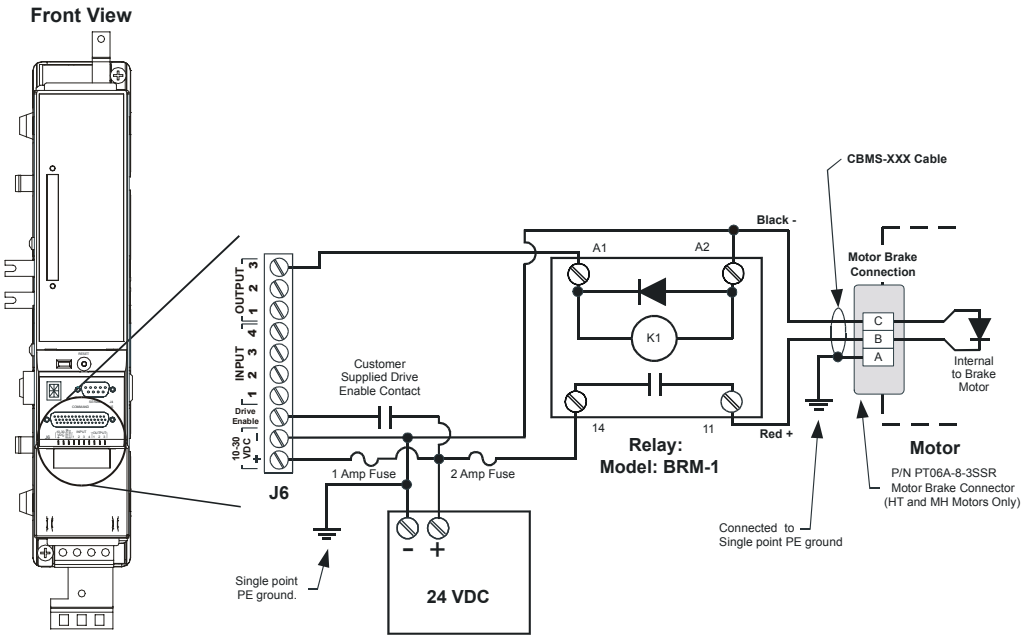



*Figure 42: MDS Drive Module Brake Wiring Diagram using the I/O Connector*

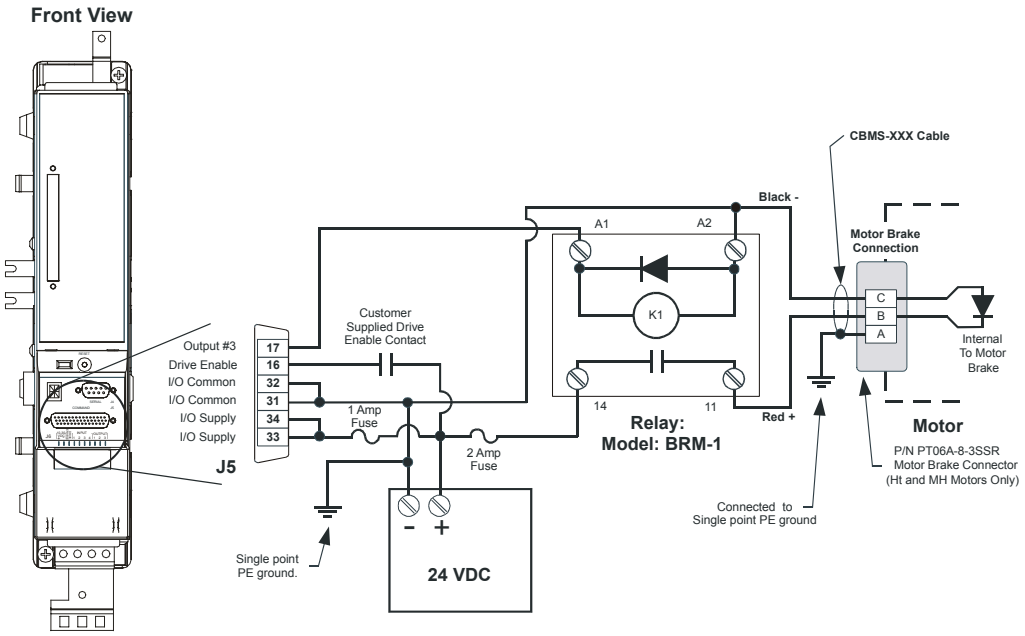



*Figure 43: MDS Drive Module Brake Wiring Diagram using the Command Connector*

## Command Connector Wiring

All command and digital I/O signals are available using the 44-pin Command Connector (J5).

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

If you are interfacing your MDS to an AXIMA Classic or any other motion controller, you may use either the CDRO-XXX or CMDO-XXX cables or the optional External Connection Interface (ECI-44) which provides a convenient screw terminal connection strip. Connect one end of the CMDX command cable to your Drive Module and the other end to the ECI-44.

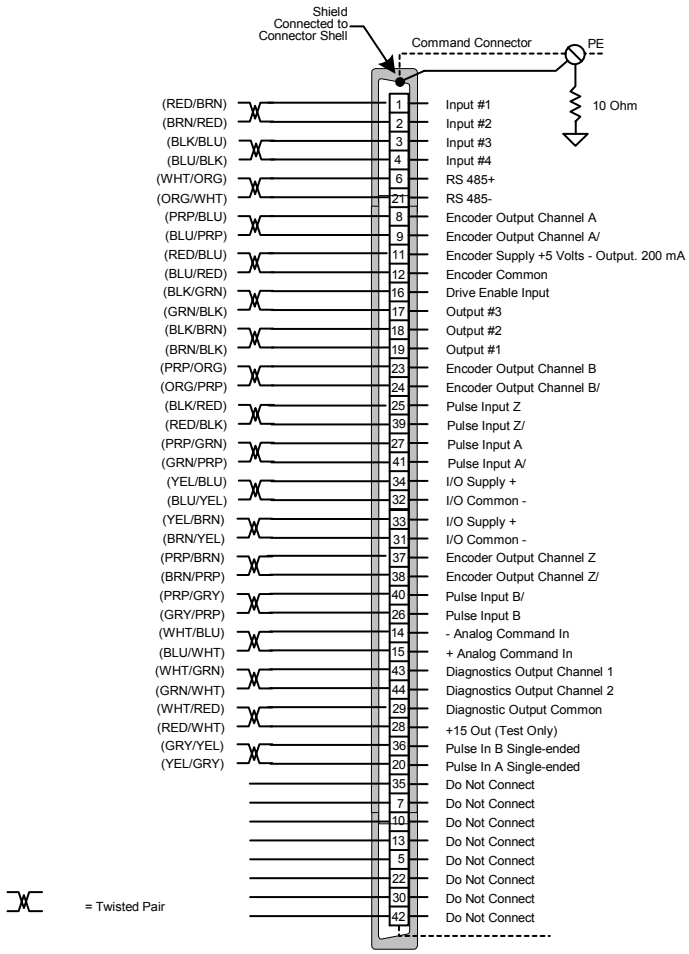



*Figure 44: Command Connector (J5) Pinout and CMDO-XXX Wire Colors*

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

| Function | Pin Numbers | Electrical Characteristics |
|---|---|---|
| Inputs and Drive Enable | 1, 2, 3, 4, 16 | 10-30 V (“On”) 0-3 V (“Off”) optically isolated |
| Outputs | 17, 18, 19 | 10-30 VDC sourcing 150 mA |
| I/O Supply | 33, 34 | 10 - 30 VDC @ 1 Amp maximum |
| I/O Common | 31, 32 | I/O return |
| Pulse Inputs Differential | 25, 26, 27, 39, 40, 41 | 5 V, 200 mV differential, 60 mV hysteresis, RS-422 compatible |

| Function | Pin Numbers | Electrical Characteristics |
|---|---|---|
| Pulse Inputs Single Ended | 20, 36 | TTL, 330 ohm pull-ups to internal 5 V, 1.5 V = low, 3.5 V = high |
| Encoder Supply Output +5 V | 11 | +5 V (200mA) output self-resetting fused internally |
| Encoder Common 0 V | 12 | 0.0 V, 10 ohms away from PE |
| Encoder Out | 8, 9, 23, 24, 37, 38 | Differential line driver output (RS 422) |
| Analog In | 14, 15 | ± 10 VDC differential command |
| Diagnostic Output | 43, 44 | ± 10 VDC 10 mA maximum. Analog diagnostic output, ref. to pin 29 |
| Diagnostic Output Common | 29 | 0.0 V, 10 ohms away from PE<br>0 ohms away from Encoder Common 0V (pin 12) |
| RS 485 ± | 6, 21 | Same signals as the Serial Connector |
| +15 out | 28 | 10 mA supply. ref. pin 29 (for test purposes only.) |

## Command Cables

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

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

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

### Note

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

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

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

## Analog Command Wiring

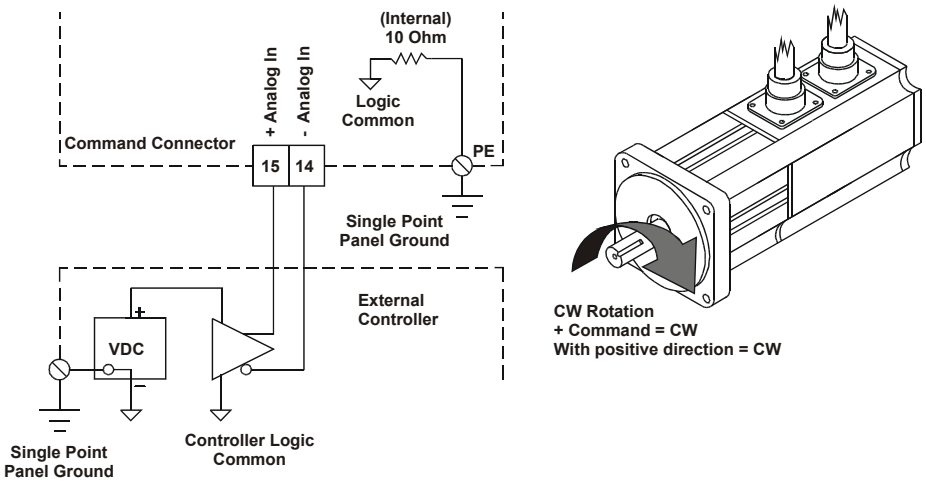



*Figure 45: Analog Command, Differential Wiring Diagram*

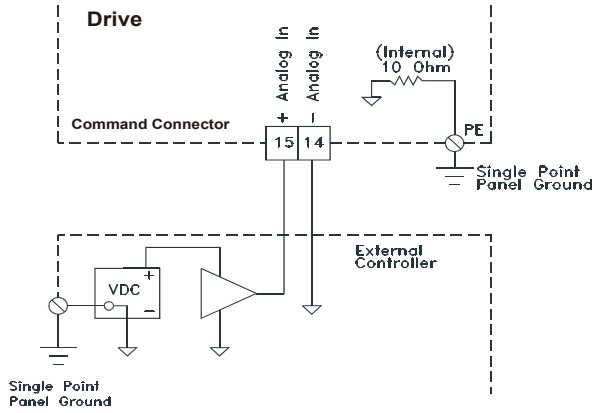



*Figure 46: Analog Command, Single Ended Wiring Diagram*

## Encoder Output Signal Wiring

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

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

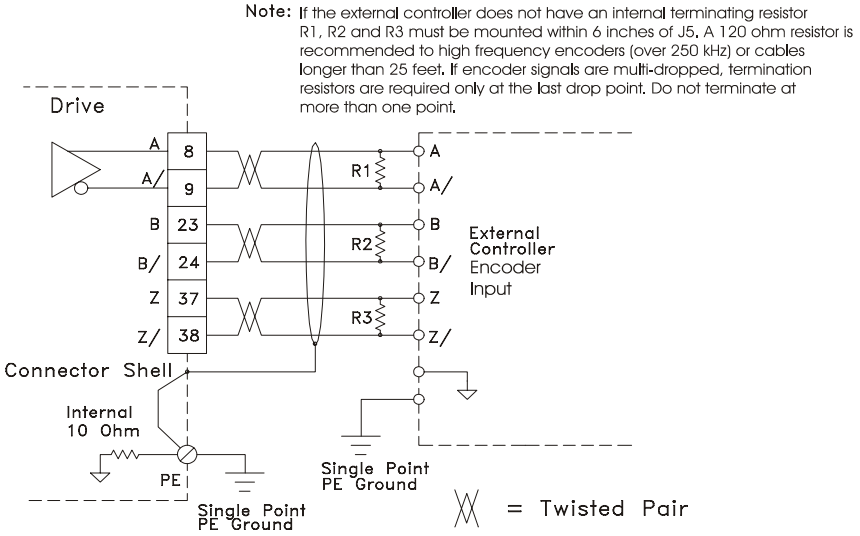



*Figure 47: Command Connector (J5) Encoder Output Wiring*

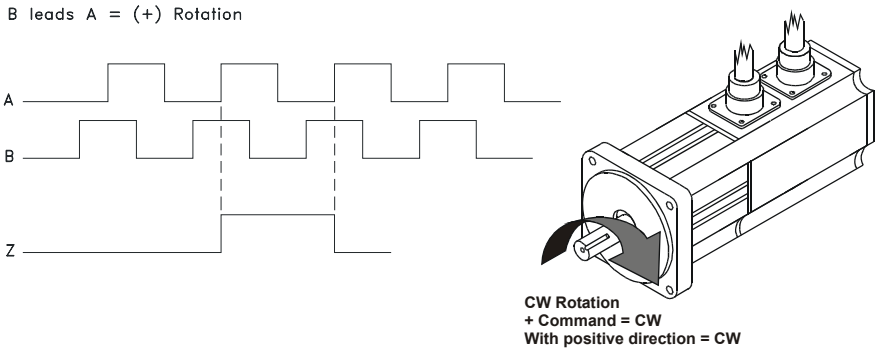



*Figure 48: Direction Convention Diagram*

## Pulse Mode Wiring, Differential Inputs

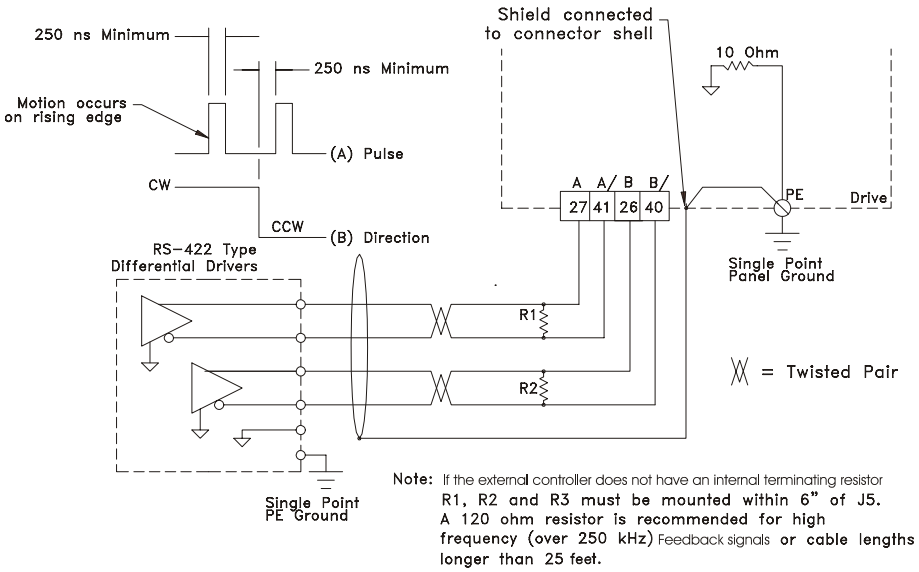



*Figure 49: Pulse Mode, Differential Output to Differential Input*

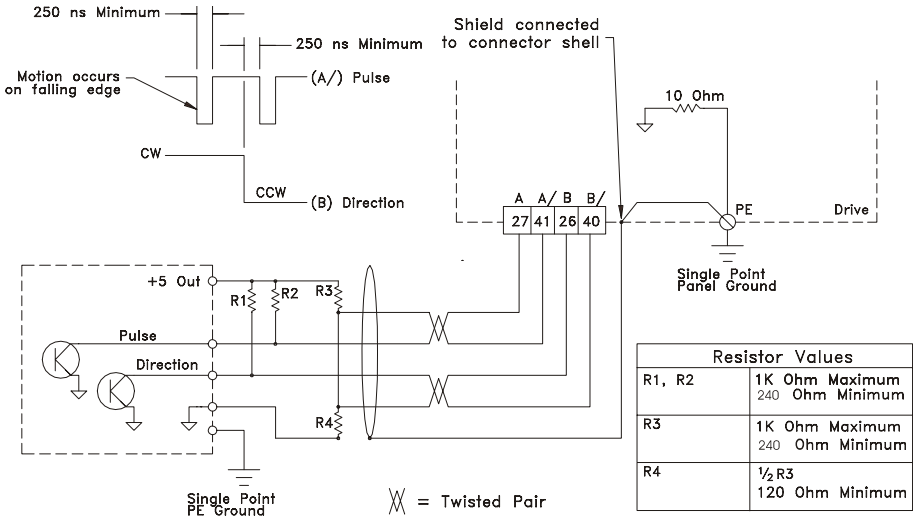



*Figure 50: Pulse Mode, Single Ended Output to Differential Input*

## Pulse Mode Wiring, Single Ended Inputs

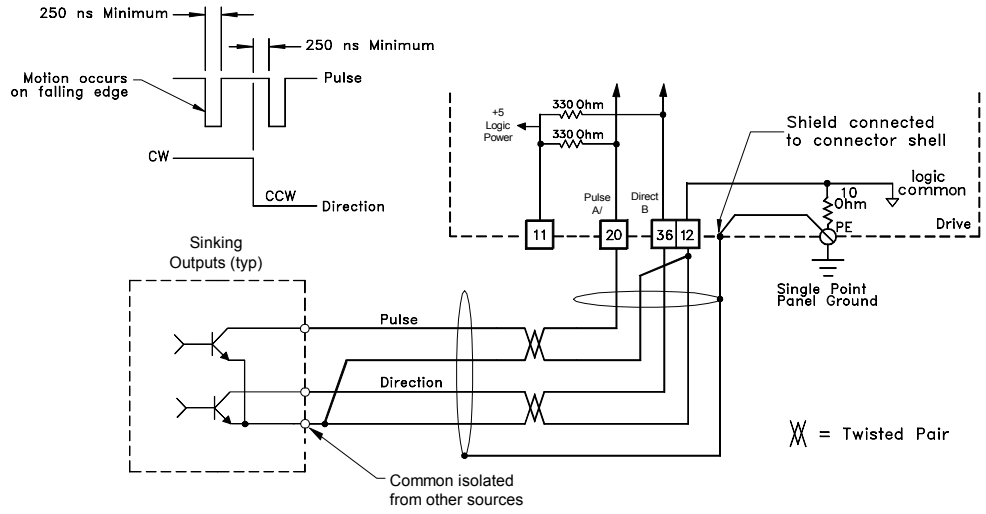



*Figure 51: Pulse Mode, Single Ended Output to Single Ended Input (twisted pair cable)*

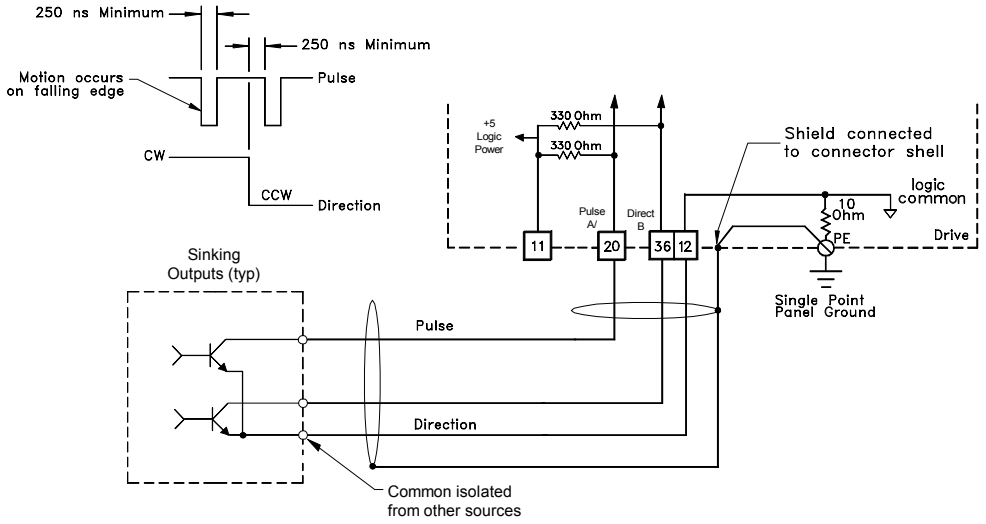



*Figure 52: Pulse Mode, Single Ended Output to Single Ended Input (non-twisted pair cable)*

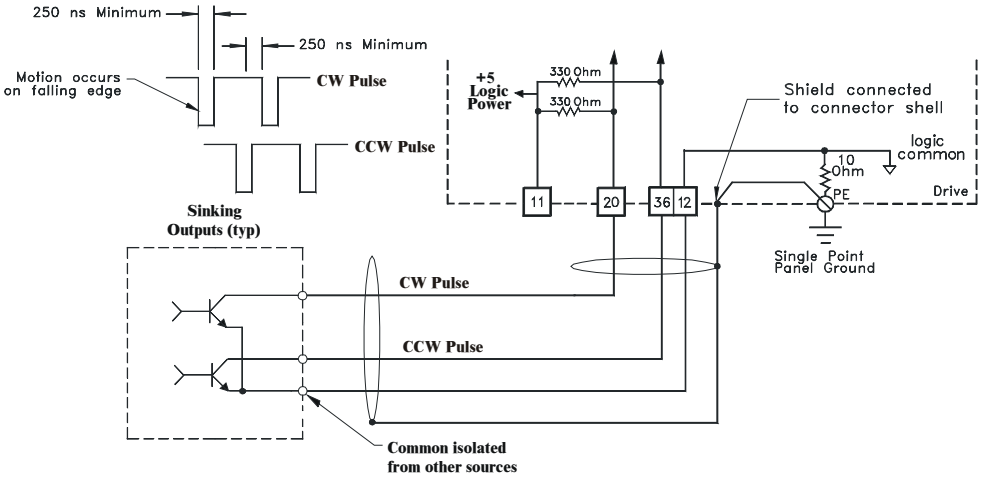



*Figure 53: Pulse/Pulse Mode, Single Ended Output to Single Ended Input (non-twisted pair cable)*

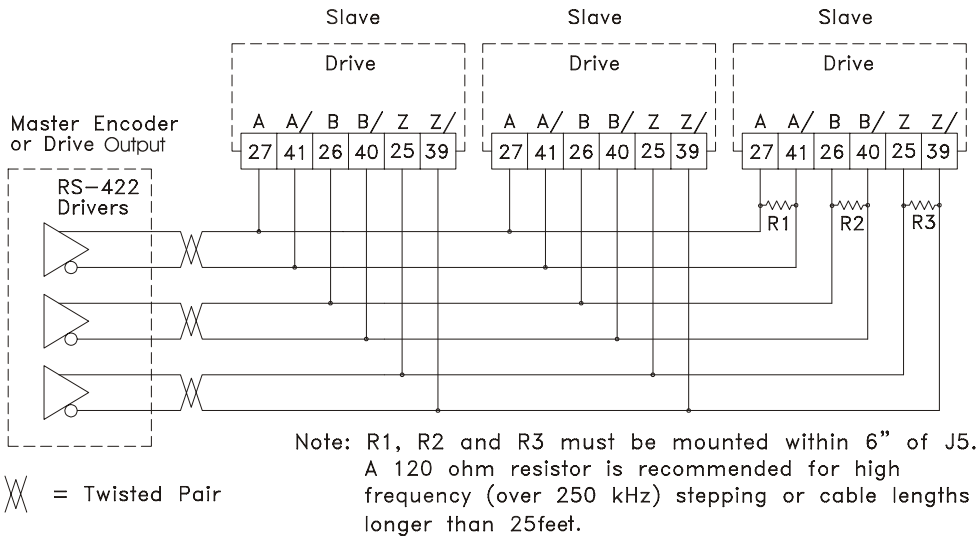



*Figure 54: Master/Slave Encoder Connections*

## Note

Encoder outputs meet RS-422 driver specifications and can drive up to 10 RS-422 signal receivers. Each differential pulse input is an RS-422 line receivers. The default encoder

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

## 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 Module end. For more information about all feedback cables see the "Specifications" section.

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

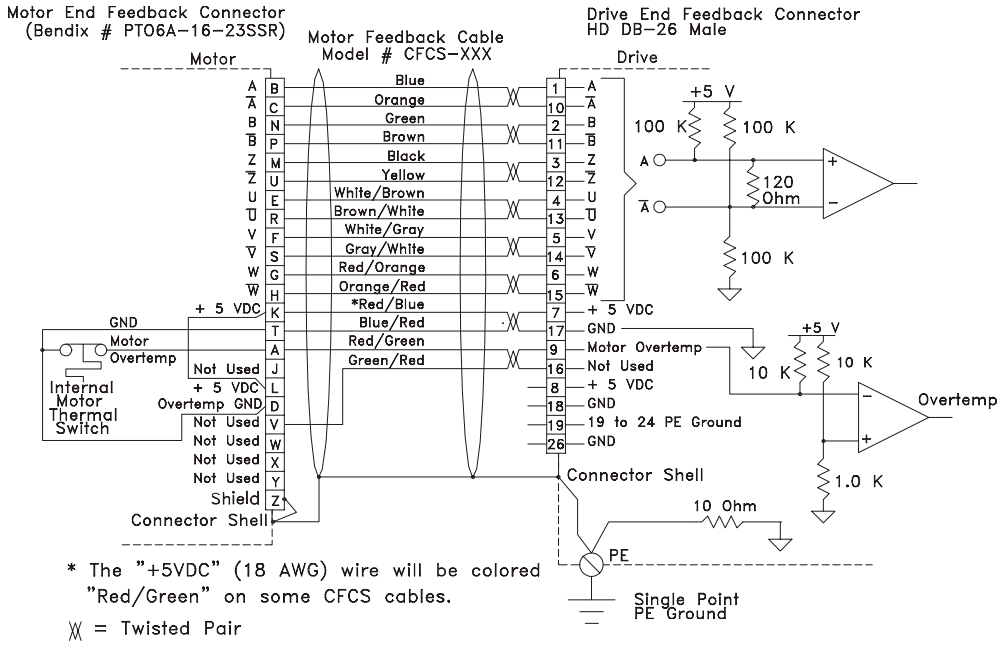



*Figure 55: Motor Feedback Connector Pinout*

The MDS drive can accept differential or single ended commutation signals: U, V, and W. It the commutation signals are single-ended connect the appropriate signals to U, V, and W. The compliment signals U\, V\ and W\ do not need to be grounded for operation. The signals are pulled to ground internally.

## Serial Communications

Serial communications with the MDS is provided through the female DB-9 connector located on the front of the Drive Module. 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.

**⚠ CAUTION**

The MDS serial port on the drive contains connection for RS-232 and RS-485 in the same 9-pin connector. With this dual communications support a 9[pin to 9-pin straight through cable **can not** be used. The Control Techniques' TIA-XXX cable is recommended.

**⚠ CAUTION**

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

**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 MDSs and controllers are using.

This is sometimes beneficial even with battery powered computers.

### Modbus Communications

The Drive Module'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 |

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 Drive Modules. A multi-drop serial cable, is available, which allows you to easily connect two or more MDS Drive Modules.

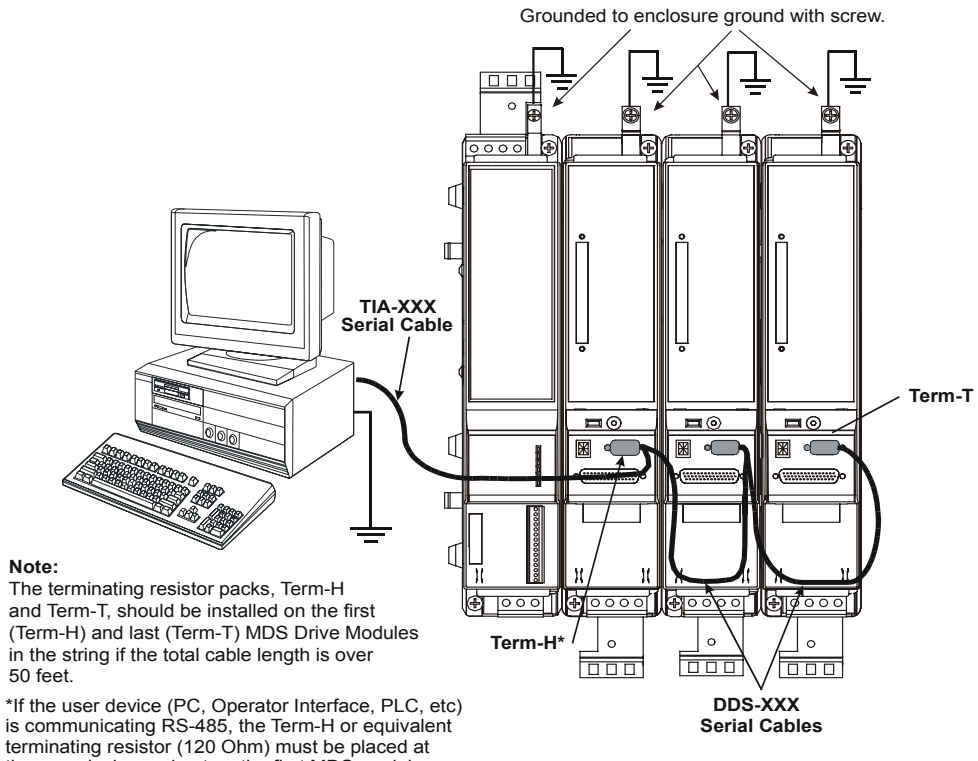



*Figure 56: MDS Multi-Drop Wiring Diagram, RS-232 to RS-485 communications*

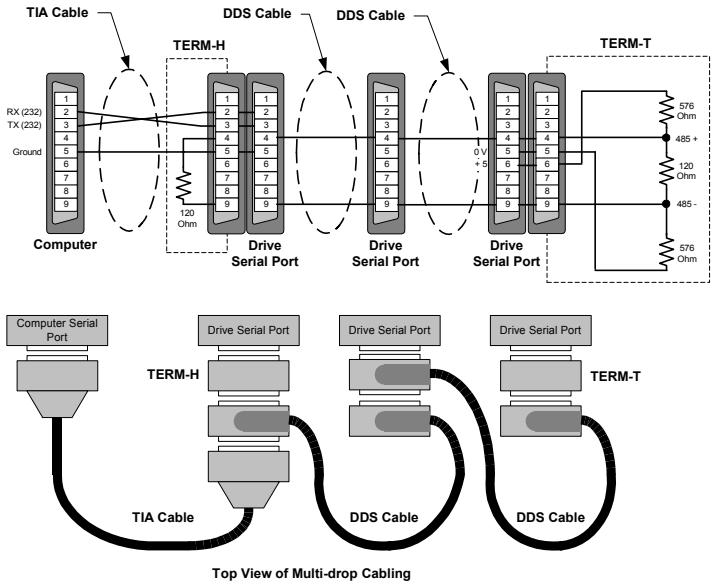



*Figure 57: Multi-Drop Wiring Pinout with RS-232 Communications to PC*

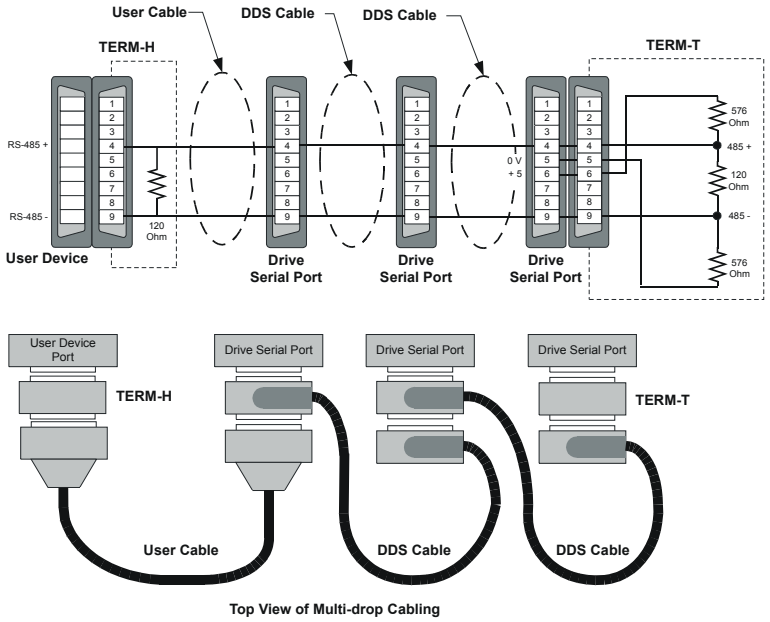



*Figure 58: Multi-Drop Wiring Pinout with RS-485 Communications to User Device*

# Step 9: Power Up Sequence

Verify that all Power and Drive Modules are installed and secured to their respective backplanes.

**⚠WARNING**

Powering up and running the system without all Modules installed to their backplanes in NOT SAFE and could result in serious injury or death.

Verify proper wiring of Incoming VAC and Motor Power. Verify that the AC Interlock Relay is correctly wired to protect the system. Verify that the Logic Power supply and/or I/O Power supply are wired properly. After installation use the following flow chart to verify the correct Power Up sequence.

# Power up Sequence

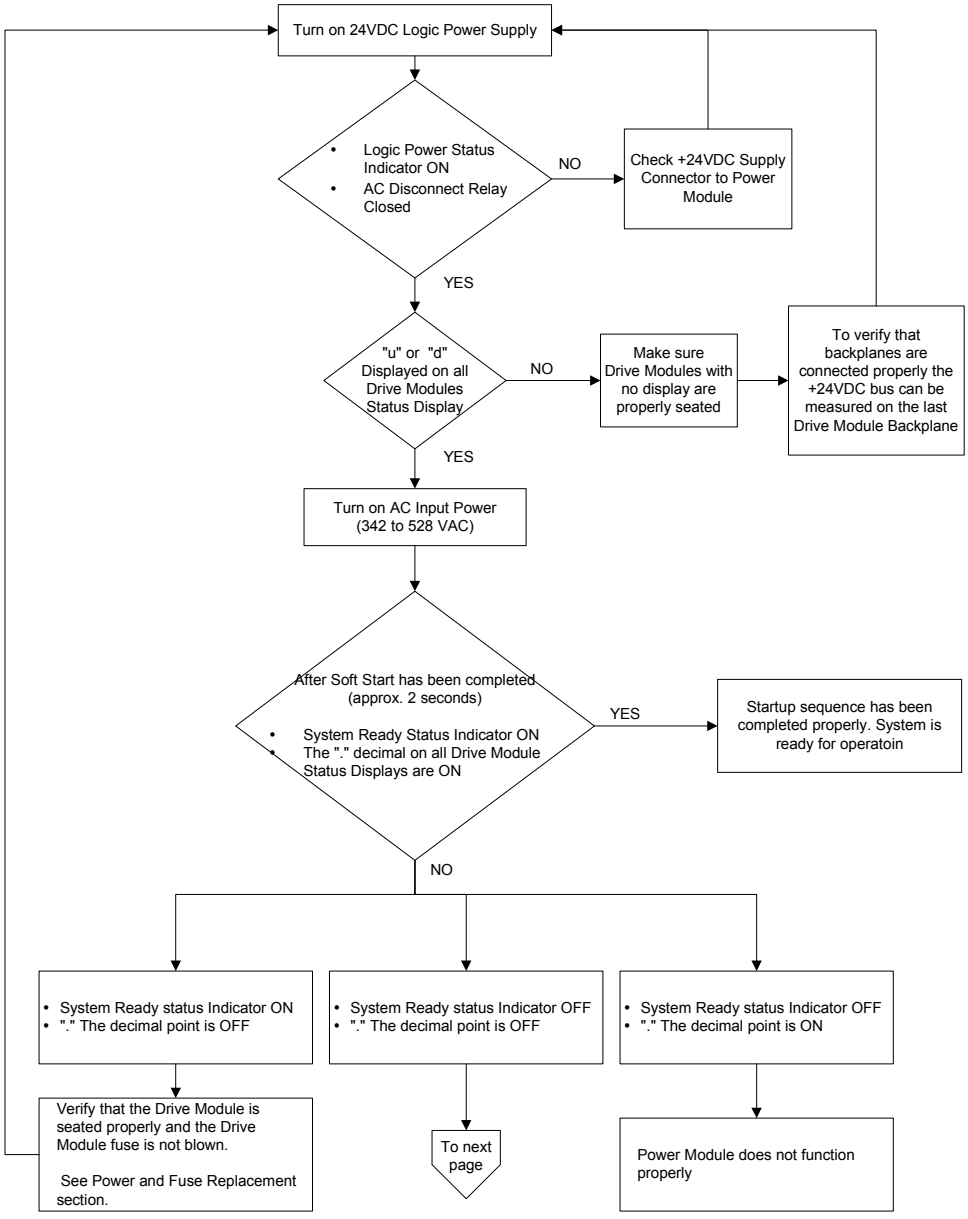



*Figure 59: Power Up Sequence Flow Chart - Part 1*

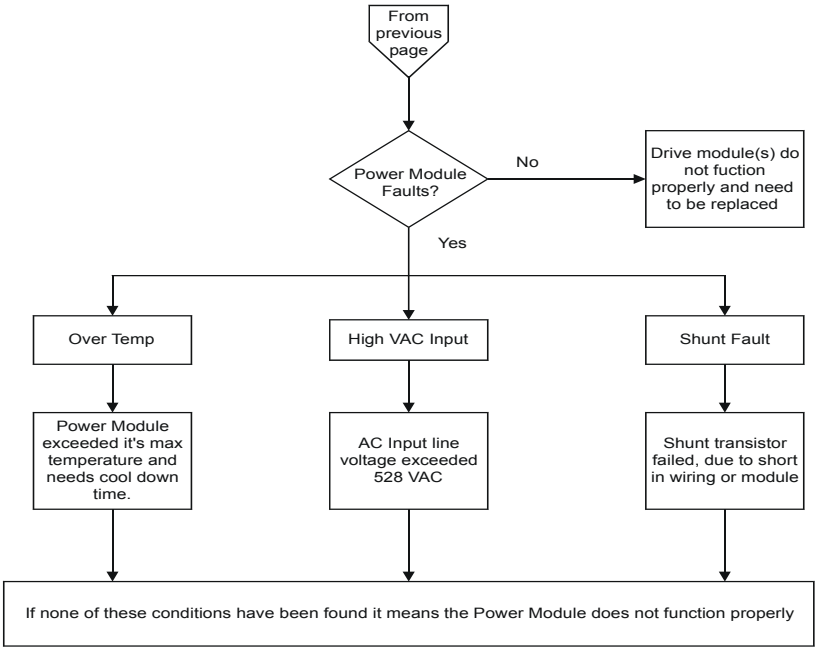



*Figure 60: Power Up Sequence Flow Chart - Part 2*

The MDS is able to handle short drops (glitch) on the AC Input Power without interruption to system operation. If the DC Bus voltage drop is greater than 250 VDC the System Ready Signal will go Low (not Active). If AC Input Power is applied before the DC Bus voltage drops to 60VDC the Power Module will re-enter Soft Start and the Ready Signal will go High (Active) when the Soft Start is complete. If the DC Bus voltage drops below 60VDC the system will need to be reset for the Modules to power-up.

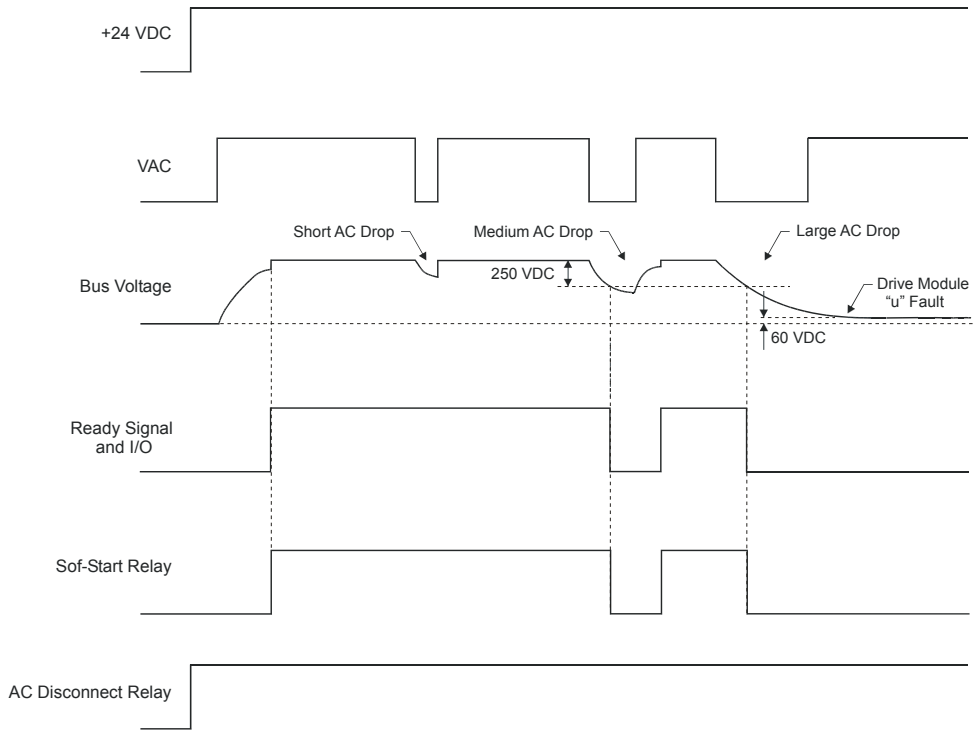



*Figure 61: AC Glitch Handling Diagram*

## Motor Mounting

Motors should be mounted firmly to a metal mounting surface to ensure maximum heat transfer for maximum power output. The mounting surface should be bonded to the single point ground.

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

# Drive and Power Module Removal

**⚠WARNING**

DO NOT remove Power or Drive Modules until at least 3 minutes after AC Power has been removed from the system.

1. Unplug all I/O and/or cable connections to the Power and Drive Modules.
2. Loosen the Retaining Screws of the module being removed
3. Grasp the top and bottom Integrated Removal Tab of the module.
4. Pull the module from the backplane.

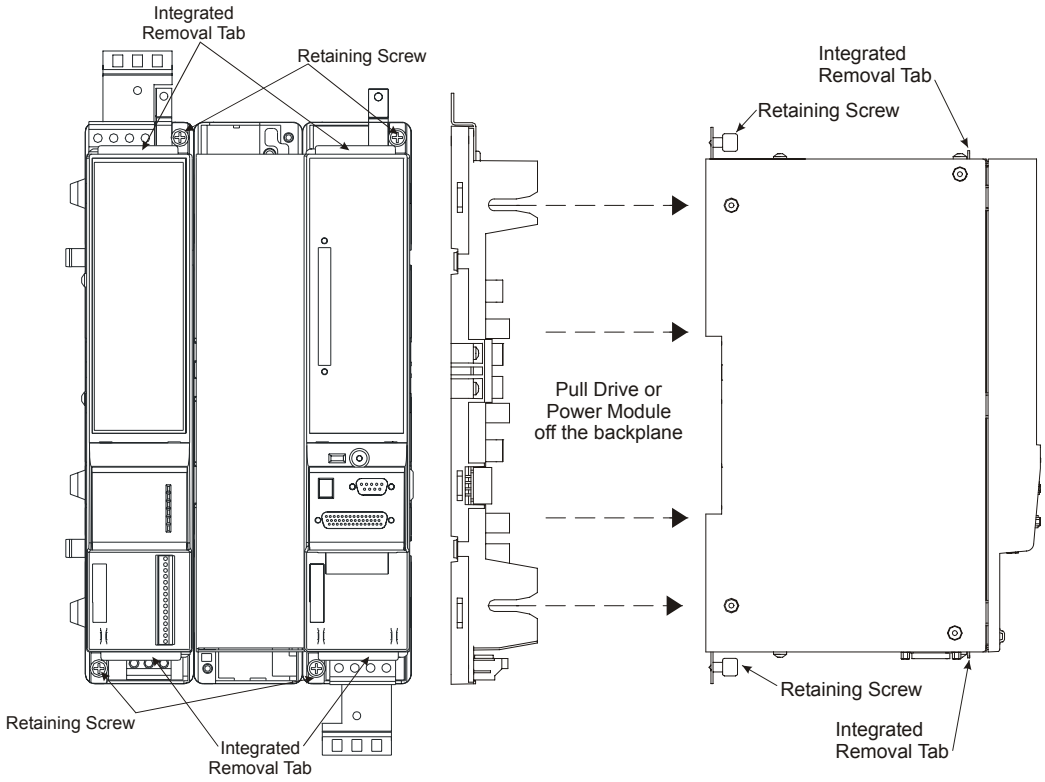



*Figure 62: Power and Drive Module Removal Diagram*

# Drive Module Fuse Replacement

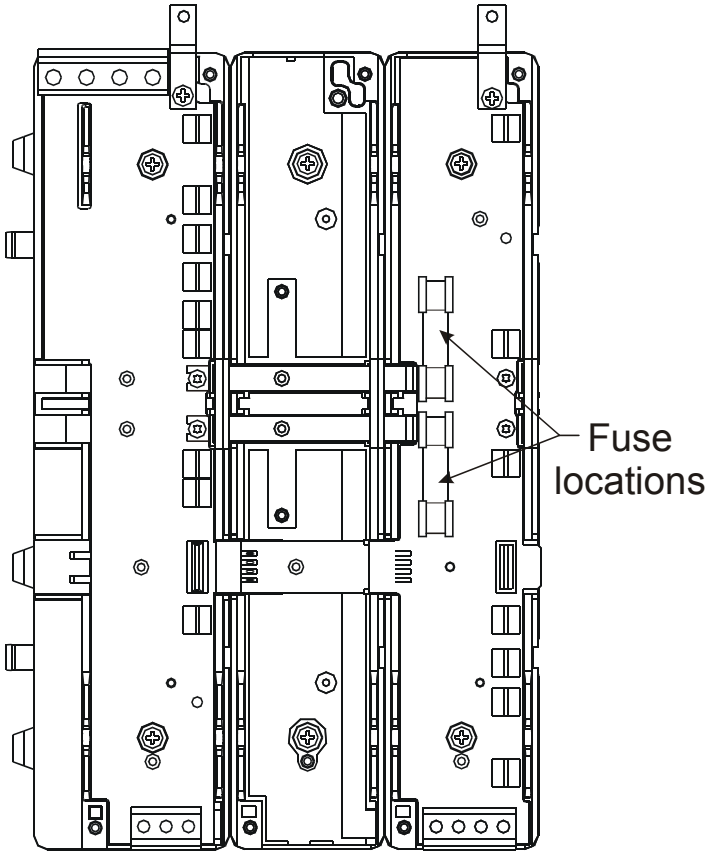



*Figure 63: Fuse Location in a Drive Module Backplane - MP-2500/MD-434 Shown*

The Drive Module backplane is equipped with two over current protection fuses with the ratings shown here. Control Techniques recommends fuse type: SHAWMUT® A70QS.

| Drive Module | Fuse Rating |
|---|---|
| MD-404 | 10 A |
| MD-407 | 16 A |
| MD-410 | 20 A |
| MD-420 | 32 A |
| MD-434 | 50 A |

# Drive Module Backplane Disassembly

These instructions are to remove a Drive Module backplane from another Module backplane. Shown in the figure below is a Power and Drive Module Backplane assembly.

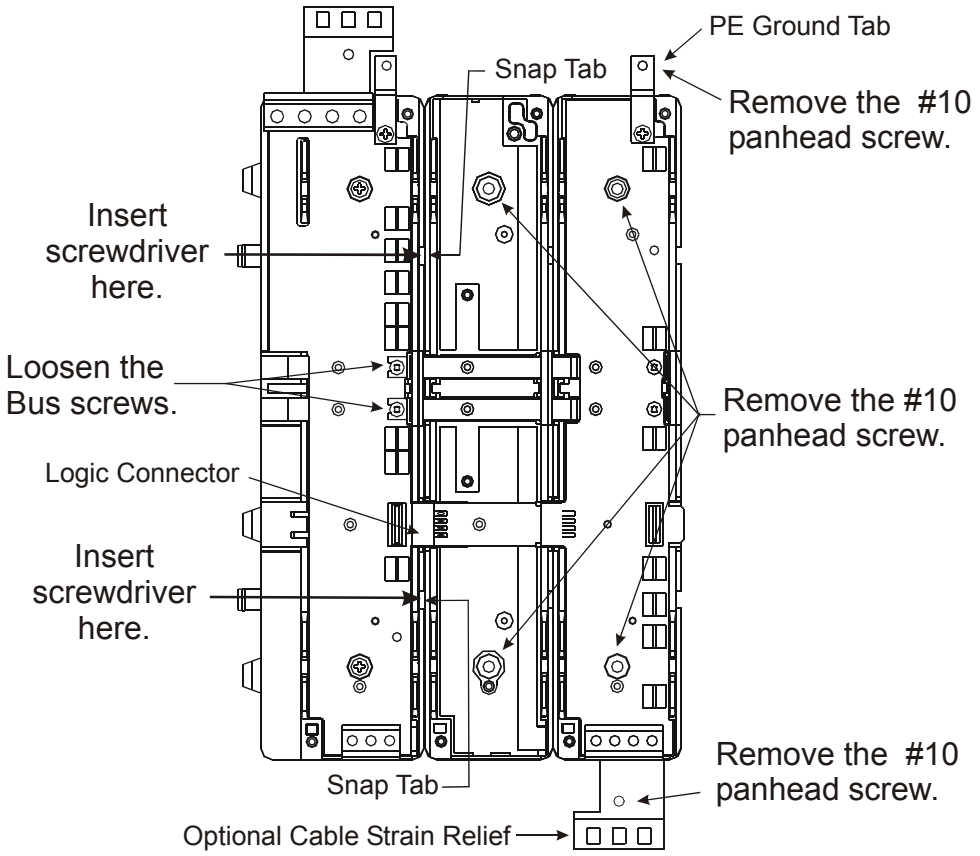



*Figure 64: Drive Module Backplane Disassembly Diagram*

**⚠WARNING**

DO NOT remove Power or Drive Modules until at least 3 minutes after AC Power has been remove from the system.

1. Remove the Drive Module and the Power Module from their backplanes. For details see “Drive and Power Module Removal” on page 69.

2. Remove the PE ground tab screw and if applicable the Optional Cable Strain Relief screw of the backplane being removed.

3. Remove the screws that secure the backplane to the metal mounting panel. If applicable the Optional Cable Strain Relief can be removed now.

4. Loosen the Bus screws.

5. Insert a flat tipped screwdriver into the slot between backplanes as shown in Fig 64. Push on the screwdriver with enough force to depress the snap tab, at the same time carefully pull the backplane away from the other backplane. The backplanes only need to be separated far enough so the snap tab is unlocked from the other backplane.

6. Insert the screwdriver in the slot on the other end of the backplane and depress the snap tab, carefully pull the backplane away, unplugging the Logic connector from the other backplane.

# Status, Diagnostics and Troubleshooting

## Power Module Status Indicators

The Power Module status indicators on the front of the Power Module shows system and Power Module status. When the condition is met the indicators will be illuminated.

| Status Function | Condition |
|---|---|
| Logic Power | The +24VDC Logic Power is correctly supplied to the Power Module. |
| System Ready | Everything in the Power Module is properly connected:<br>• +24VDC Logic Power<br>• AC Input has all three phases<br>• No Power Module Faults<br>and soft start is completed.<br><br>The System Ready indicator will blink in the condition that one of the AC input phases is lost. The system will continue to operate in this condition. |
| Shunt Active | The shunt transistor is on. The shunt transistor will turn on under two conditions;<br>• The Bus voltage exceeds 830 VDC<br>• The External shunt control input is active. |
| **Fault Function** | **Condiltion** |
| Shunt Fault | Shunt resistor is shorted or wired incorrectly, |
| Over Temp | The Power Module RMS power is exceeded creating an over temperature condition in the Power Module or ambient temperature is higher than 40$^{o}$C. |
| High VAC Input | The AC Input voltage exceeds 528 VAC. |

## Drive Module Diagnostic Display

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

| Display Indication | Status | Description |
|---|---|---|
|  | Brake Engaged (Output "Off") | Motor brake is mechanically engaged. This character will only appear if the Brake output function is assigned to an output line.<br>See Brake Operation section for detailed description of Brake Output function. |

| Display Indication | Status | Description |
|---|---|---|
|  | Disabled | Power Stage is disabled. |
|  | Position | Pulse mode operation. |
|  | Velocity | Velocity mode operation. |
|  | Torque | Torque mode operation. |
|  | Summation | Summation mode operation. |
|  | RMS Foldback | Motor torque is limited to 80 percent. |
|  | Stall Foldback | 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 Module. Some faults, like High DC bus and Motor Over Temperature, can be reset with the Reset button on the front of the Drive Module or the Reset input function. Other faults, such as encoder faults, can only be reset by cycling logic power “Off” (wait until the status display turns “Off”), then power “On”.

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

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

| Display | Fault | Action to Reset | Bridge Disabled |
|---|---|---|---|
|  | Power Up Test | Cycle Logic Power | Yes |
|  | NVM Invalid | Reset Button or Input Line | Yes |
|  | Drive Overtemp | Allow Drive to cool down, Cycle Logic Power | Yes |
|  | Invalid Configuration | Reset Button or Input Line | Yes |
|  | Power Module | Cycle Logic Power | Yes |
|  | High DC Bus | Reset Button or Input Line | Yes |
|  | Low DC Bus | Reset Button or Input Line | Yes |
|  | Encoder State | Cycle Logic Power | Yes |
|  | Encoder Hardware | Cycle Logic Power | Yes |
|  | Motor Overtemp | Allow Motor to cool down, Reset Button or Input Line | Yes |

| Display | Fault | Action to Reset | Bridge Disabled |
|---|---|---|---|
|  | Overspeed | Reset Button or Input Line | Yes |
|  | Following Error<br>(Pulse mode only) | Reset Button or Input Line | Yes |
|  | Travel Limit +/- | Auto | No |
|  | All "On" | Normally "On" for one second during power-up | Yes |

## Fault Descriptions

###  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.

###  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.

###  Invalid Configuration

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

###  Drive Overtemp

Indicates the drive IGBT temperature has reached its limit.

###  Power Module

This fault indicates either IGBT module failure or over current/short circuit condition as a result of phase to phase or phase to ground short in the motor or cable.

## H High DC Bus

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

| | High DC Bus Threshold |
|---|---|
| MDS | 880 VDC |

## L Low DC Bus

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

| | Low DC Bus Threshold |
|---|---|
| MDS | 60 VDC |

## EC Encoder State

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

## EE Encoder Hardware

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

## MT Motor Overtemp

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

## O Overspeed

This fault occurs in one of two circumstances:

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

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



**Following Error**

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



**Travel Limit +/-**

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



**All "On"**

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

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

# Diagnostic Analog Output Test Points

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

Each Channel provides a programmable Analog Output Source.

**Analog Output Source options are:**

- Velocity Command
- Velocity Feedback

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

**Default Analog Output Source:**

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

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

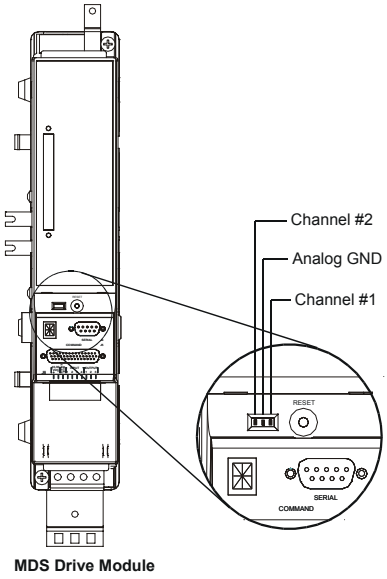



*Figure 65: Diagnostic Analog Output Test Points*

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

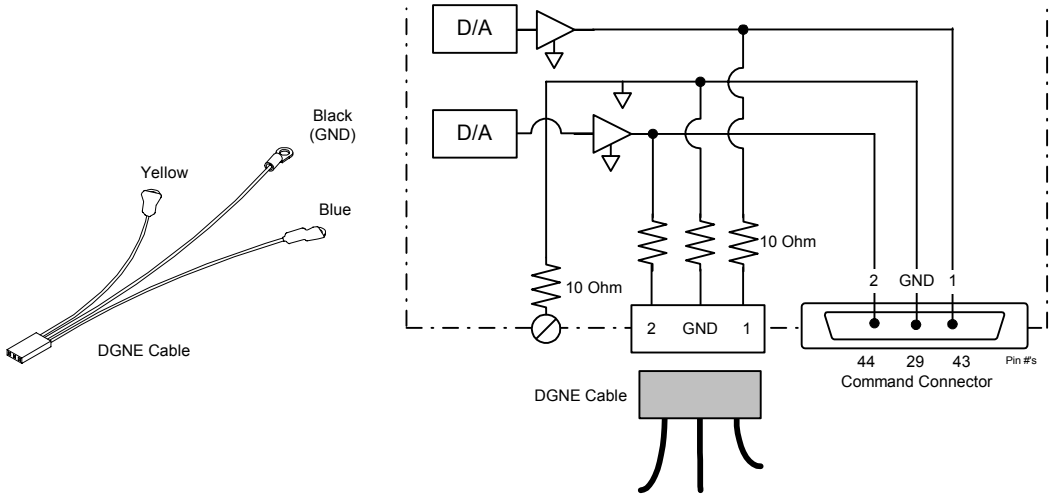



*Figure 66: Diagnostic Cable (DGNE) Diagram*

# Drive Faults

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

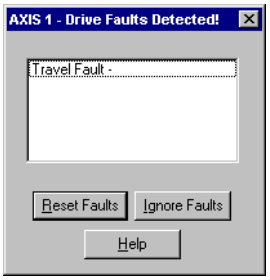



*Figure 67: Active Drive Faults Detected Dialog Box*

## Resetting Faults

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

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

### Viewing Active Drive Faults

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

### Rebooting the Drive

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

## Watch Window

This feature allows you to customize a window to monitor drive parameters which you select from a complete list of drive parameters. From this window you can watch the parameters you selected in real time. This feature is only available when you are online with the drive.

### Note

You cannot change the values of the parameters while they are being displayed in the Watch Window. The parameter in the setup screens will look like they have been changed when they actually have not. To update a parameter, delete it from the Watch Window selection.

### Note

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

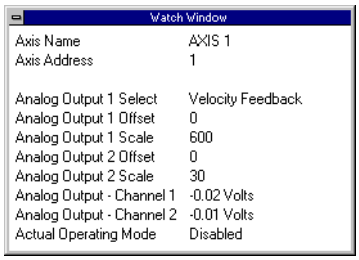



*Figure 68: Watch Window*

The Watch Window is accessed by selecting Watch Drive Parameters from the **Tools** menu or by clicking on the Watch Window icon on the toolbar.

The Watch Window will automatically appear as soon as you select a parameter from the Select Drive Parameters dialog box. After you have selected the parameters you wish to

watch, click the *Close* button. The Select Drive Parameters dialog box will close and the Watch Window will remain open.

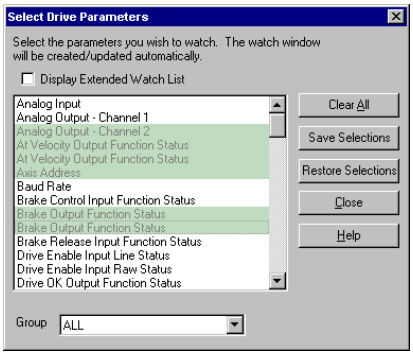



*Figure 69: Select Drive Parameters Dialog Box*

### Group

This list box enables you to view the complete list of parameters or just a group of parameters you are interested in. The groups include: Analog In, Analog Out, Communication, Digital Inputs, Execution, Fault Counts, Fault Log, ID, Input Functions, Motor, Output Functions, Position, Setup, Status, Torque, Tuning, User Defined Motor, and Velocity.

### Clear All Button

This button is used to clear all the parameter selections that were previously selected.

### Save Selections Button

This button saves the parameter selections. This enables you to restore the same list of parameters for use in future online sessions.

### Restore Selections Button

This button restores the parameter selections previously saved. This enables you to restore the list of parameters you created in a previous online session.

# View Motor Parameters

When online with the drive this feature allows you to display a pre-defined Watch Window to monitor three motor parameters. These parameters are normally used when testing the setup of a User Defined Motor for commutation accuracy.

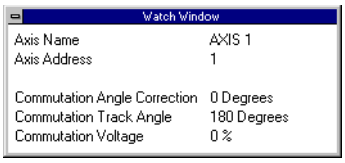



*Figure 70: View Motor Parameters Window*

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

# Error Messages

PowerTools will pop-up an error message box to alert you to any errors it encounters. These message boxes will describe the error and offer a possible solution.

The table below list the of common problems you might encounter when working with PowerTools software along with the error message displayed, the most likely cause and solution.

| Problem/Message | Cause | Solution |
|---|---|---|
| Time-out while waiting for device response. The attempted operation has been cancelled. (see fault: No device selected) | Loss of serial communications. | Check the serial connection to the device and try operation again. |
| The attached device(s) do not have valid revisions, or do not have matching revisions. | Attempting to broadcast to drive without matching firmware revisions. | Program each drive individually. |
| Unable to communicate with device [Address x] | The device that you are attempting to communicate with is no longer available. | Check all connections and verify that you are using the correct baud rate then try again. |
| The specified drive type (name) does not match the actual drive type (name). Please make necessary corrections. | The drive type you selected in the “Drive Type” list box does not match the drive you are downloading to. | Change the drive type selected in the “Drive Type” list box to match the drive you are downloading to. |
| Non-Control Techniques device attached (address). When trying to program more than one drive, only EMC drives of the same type can be attached to the network. | This error is caused When you attempting to perform an upload or download to multiple drives and one or more of the drives are not the same type. | Disconnect the device(s) that has been specified and try the operation again or program each device individually. |
| You have changed a parameter which will not take affect until the drive has been rebooted. Before you reboot the drive, you will need to save your setup to NVM. Do you wish to save your setup to drive NVM now? | See message. | Yes/No. |
| (Operation Name) The attempted operation has been cancelled. | Communication error. | Retry operation. Check connection to drive. |
| Invalid entry. The entry exceeds the precision allowed by this field. The finest resolution this field accepts is (value). | Entered a value out of range. | Enter a value within the range of that field. The status bar displays information on the currently selected object or action. |
| The device was disconnected during the upload. The upload was not complete. | Connection to the device was lost (a time-out occurred). | Check the connection to the device and try again. |
| The device was disconnected during the download. The download was not complete. | Connection to the device was lost (a time-out occurred). | Check the connection to the device and try again. |

| Problem/Message | Cause | Solution |
|---|---|---|
| No device selected. | No device selected during flash upgrade. | Select device(s) from list box. |
| The drive at address is use. | | Close any other windows that are using the same addresses and try again. |

# MDS Specifications

| Specifications | | |
|---|---|---|
| **Power Requirements** | | |
| AC Input Voltage | 3 Ph, 342 to 528 VAC, 47 - 63 Hz (480 VAC for rated performance | |
| | **Model** | **Rating** |
| AC Input Current | MP-1250 | 17 Arms |
| | MP-2500 | 35 Arms |
| | MP-5000 | 70 Arms |
| Output Continuous Current (5 kHz/10 kHz) | MD-404 | 4 Arms / 2.8 Arms |
| | MD-407 | 7 Arms / 5 Arms |
| | MD-410 | 10 Arms / 6.5 Arms |
| | MD-420 | 20 Arms / 14 Arms |
| | MD-434 | 34 Arms / 22 Arms |
| Output Peak Current (5 kHz/10 kHz) | MD-404 | 8 Arms / 5.6 Arms |
| | MD-407 | 14 Arms / 10 Arms |
| | MD-410 | 20 Arms / 13 Arms |
| | MD-420 | 40 Arms / 28 Arms |
| | MD-434 | 68 Arms / 44 Arms |
| Continuous Output Power | MP-1250 | 12.5 kW |
| | MP-2500 | 25 kW |
| | MP-5000 | 50 kW |
| | MD-404 | 3.3 kW |
| | MD-407 | 5.8 kW |
| | MD-410 | 8.3 kW |
| | MD-420 | 16.7 kW |
| | MD-434 | 28.3 kW |
| **Switching Frequency** | 5 or 10 kHz ( Ratings based on 5 kHz performance) | |
| **Logic Power Supply (User Supplied)** | 21.6 to 26.4 VDC ( Current requirements based on system) | |
| **Encoder Supply Output** | +5VDC, 250 mA maximum | |
| **System Efficiency** | >90% | |

| Specifications | | |
|---|---|---|
| **Regeneration** | | |
| Internal Energy Absorption (480V) System Bus Capacitance Drive Module and Power Module | | |
| | **Model** | **Rating** |
| | MP-1250 | 141 Joules |
| | MP-2500 | 235 Joules |
| | MP-5000 | 376 Joules |
| | MD-404 | 10 Joules |
| | MD-407 | 22 Joules |
| | MD-410 | 33 Joules |
| | MD-420 | 47 Joules |
| | MD-434 | 47 Joules |
| Integral Transistor connected to External Resistor, 15 A continuous | | |
| | **Model** | **Rating** |
| | MP-1250 | 30 Ohm minimum, 6 kW max. |
| | MP-2500 | 30 Ohm minimum, 6 kW max. |
| | MP-5000 | 9 Ohm minimum, 12 kW max. |
| **I/O Power Supply (User Supplied)** | + 10 to 30 VDC | |
| **Power Module Control Inputs** | | |
| Digital (2) | +10 to 30 VDC, 2.8 kOhm, Sourcing, Optically Isolated | |
| **Power Module Control Outputs** | | |
| Digital (6) | +10 to 30 VDC, 150 mA, Sourcing, Optically Isolated | |
| Relay Contact (1) | AC Interlock, 24 VDC 5A | |
| **Drive Module Control Inputs** | | |
| Analog (1) | +/- 10 VDC, 14 bit, 100 kOhm, Differential<br>Analog Max Input Rating: Differential +/- 14 VDC<br>Each Input with reference to Analog Ground +/- 14 VDC | |
| Digital (5) | +10-30 VDC, 2.8 kOhm, Sourcing (active high) , Optically Isolated, Max input response time is 500 µs, Input debounce: 0 - 2000 ms, Software selectable | |

| Specifications | | |
|---|---|---|
| Pulse (1) | Software selectable Differential (RS422) or Single Ended (TTL Schmitt Trigger)<br><br>Maximum input frequency:<br>Differential - 2 MHz per channel; 50% duty cycle (8 MHz count in quadrature)<br>Single ended - 1 MHz per channel; 50% duty cycle (4 MHz count in quadrature)<br><br>Ratio Capabilities: 20 to 163,840,000 PPR<br>Input Device = AM26C32<br>Vdiff = 0.1 - 0.2 V<br>V common mode max = +/- 7V<br>Input impedance each input to 0V = 12 - 17 kOhm | |
| **Drive Module Control Outputs** | | |
| Analog (2) | +/- 10 VDC (single ended, 20 mA max) 10 bit software selectable output signals | |
| Digital (3) | +10-30 VDC 150 mA max, Sourcing, Optically Isolated, Input debounce: Programmable range, 0 to 200 ms | |
| Motor Over Temperature (1) | 0 to +5 VDC, Single Ended, 10 kOhm | |
| Pulse (1) | Differential line driver, RS-422 and TTL compatible<br><br>Scalable in one line increment resolution up to 2048 lines/rev of the motor (MG and NT)<br><br>Output Device = AM26C31<br>20 ma per channel, sink and/or source<br>$V_{out\ Hi}$ @ 20 ma = 3.8 - 4.5 V<br>$V_{out\ Lo}$ @ 20 ma = 0.2 - 0.4 V<br>$V_{out\ diff}$ w/100 ohm termination = 2.0 - 3.1 V<br>$V_{out\ common\ mode}$ w/100 ohm termination = 0.0 - 3.0 V<br>$I_{out\ short\ circuit}$ = 30 - 130 mA | |
| **Cooling Method** | | |
| | **Model** | **Rating** |
| | MP-1250 | Convection |
| | MP-2500 | Integral Fan |
| | MP-5000 | Integral Fan |
| | MD-404 | Convection |
| | MD-407 | Integral Fan |
| | MD-410 | Integral Fan |
| | MD-420 | Integral Fan |
| | MD-434 | Integral Fan |
| **Environmental** | | |
| Rated Ambient Temperature | 32 to 104 F (0 to 40 C) | |
| Maximum Ambient Temperature | 32 to 122 F (0 to 50 C) with power derating of 3% / 1.8 F (1 C) above 104 F (40 C) | |
| Rated Altitude | 3280’ (1000 m) | |

| Specifications | | |
|---|---|---|
| Maximum Altitude | For altitudes >3280’ (1000 m) derate output by 1% / 328’ (100m) not to exceed 7560’ (2000 m) | |
| Vibration | 10 to 2000 Hz @ 2g | |
| **Humidity** | 10 to 95% non-condensing | |
| **Storage Temperature** | -13 to 167F (-25 to 75 C) | |
| **Ingress Protection (IP) Rating** | Power and Drive Module: IP20<br>MH motors: IP65<br>Molded motor and feedback cables: IP65 | |
| **Serial Interface** | RS-232 / RS-485<br>Internal RS-232 to RS-485 converter<br>Modbus protocol with 32 bit data extension 9600 or 19.2 k baud | |
| **Serial Communications** | Max baud rate | 19.2k |
| | Start bit | 1 |
| | Stop bit | 2 |
| | Parity | none |
| | Data | 8 |
| **Weight** | | |
| | **Model** | **Rating** |
| Power Module | MP-1250 | 8.35 lbs |
| | MP-2500 | |
| | MP-5000 | 10.25 lbs |
| Drive Module | MD-404 | 8.35 lbs. |
| | MD-407 | |
| | MD-410 | |
| | MD-420 | 10.25 lbs |
| | MD-434 | 12 lbs |
| **High Bus Voltage** | 880 VDC | |
| **Shunt Turn On** | 830 VDC | |
| **Shunt Turn Off (Hysteresis)** | 780 VDC | |
| **Nominal Bus Voltage 480 VAC** | 680 VDC | |
| **Transformer Sizing** | **Model** | **Size** |
| KVA Rating at Max. Power (page 27) | MP-1250 | 25 KVA |
| | MP-2500 | 50 KVA |
| | MP-5000 | 100 KVA |

| Specifications | | |
|---|---|---|
| **AC Input Wire Gauge** | **Model** | **Gauge** |
| | MP-1250 | 16 GA |
| | MP-2500 | 10 GA |
| | MP-5000 | 4 GA |
| **Shunt Size** | All Power Modules | 16 GA |
| **Logic and Digital I/O Power Sizing** | **Model** | **Max. RMS Current (A)** |
| Power Module | MP-1250 | 0.30 |
| | MP-2500 | |
| | MP-5000 | |
| Drive Module | MD-404 | 0.60/Module |
| | MD-407 | |
| | MD-410 | |
| | MD-420 | |
| | MD-434 | 0.80/Module |
| FM Module | All | 0.40/FM Module |
| Synchronization Feedback Encoder | * | 0.07/Encoder |

| Specifications | | | |
|---|---|---|---|
| **Fuses** | **Model** | **Type** | **Size** |
| Power Module (page 27) | MP-1250 | KTK-R, JKS or JJS | 20A |
| | MP-2500 | JKSor JJS | 40A |
| | MP-5000 | JJS | 70A |
| Drive Module (page 70) | MD-404 | Shawmut A70QS | 10 A |
| | MD-407 | | 16 A |
| | MD-410 | | 20 A |
| | MD-420 | | 32 A |
| | MD-434 | | 50 A |

# Drive and Motor Combination Specifications

| Drive | Motor | Cont. Stall Torque lb-in (Nm) | Peak Stall Torque lb-in (Nm) | Power HP @ Rated Speed kWatts | Inertia lb-in-sec$^2$ (kg-cm$^2$) | Max speed RPM | Encoder resolution lines/rev | Motor Ke VRMS/ krpm | Motor Kt lb-in/ ARMS (Nm/ ARMS) |
|---|---|---|---|---|---|---|---|---|---|
| **MD-404** | MH-316 | 21.5 (2.43) | 58 (6.55) | 0.83 | 0.0006725 (0.75987) | 4000 | 2048 | 75 | 10.98 (1.24) |
| | MH-340 | 46 (5.20) | 135 (15.25) | 1.31 | 0.0014275 (1.61296) | 3000 | 2048 | 116 | 16.98 (1.92) |
| | MH-455 | 65 (7.34) | 140.56 (15.88) | 1.8 | 0.003557 (4.01914) | 3000 | 2048 | 120 | 17.57 (1.99) |
| **MD-407** | MH-455 | 72.5 (8.19) | 228.42 (25.81) | 1.8 | 0.003557 (4.01914) | 3000 | 2048 | 120 | 17.57 (1.99) |
| | MH-490 | 105 (11.86) | 225.4 (25.4) | 1.78 | 0.006727 (7.60099) | 3000 | 2048 | 110 | 16.1 (1.82) |
| **MD-410** | MH-455 | 72.5 (8.19) | 268.82 (30.37) | 1.8 | 0.003557 (4.01914) | 3000 | 2048 | 120 | 17.57 (1.99) |
| | MH-490 | 105 (11.86) | 322 (36.38) | 1.78 | 0.006727 (7.60099) | 3000 | 2048 | 110 | 16.1 (1.82) |
| | MH-6120 | 119 (13.45) | 336.8 (38.05) | 3.25 | 0.010657 (12.04159) | 3000 | 2048 | 115 | 16.84 (1.90) |
| **MD-420** | MH-6120 | 119 (13.45) | 353.64 (39.96) | 3.25 | 0.010657 (12.04159) | 3000 | 2048 | 115 | 16.84 (1.90) |
| | MH-6200 | 234 (26.44) | 673.6 (76.11) | 3.41 | 0.018857 (21.30695) | 3000 | 2048 | 115 | 16.84 (1.90) |
| | MH-6300 | 299 (33.78) | 673.6 (76.11) | 3.74 | 0.027187 (30.71921) | 3000 | 2048 | 115 | 16.84 (1.90) |
| **MD-434** | MH-6200 | 234 (26.44) | 729 (82.37) | 3.41 | 0.018857 (21.30695) | 3000 | 2048 | 115 | 16.84 (1.90) |
| | MH-6300 | 299 (33.78) | 932.09 (105.3) | 3.74 | 0.027187 (30.71921) | 3000 | 2048 | 115 | 16.84 (1.90) |
| | MH-8500 | 530 (60.2) | 997 (113.2) | 9.95 | 0.078 (87.837) | 3000 | 2048 | 121.6 | 17.8 (2.011) |
| | MH-8750 | 748 (84.9) | 1500 (170.3) | 15.44 | 0.133 (150.24) | 3000 | 2048 | 162 | 23.7 (2.68) |

# Axial/Radial Loading

| Motor | Max Radial Load (lb.) | Max. Axial Load (lb.) |
|---|---|---|
| MH-316 | 40 | 25 |
| MH-340 | 40 | 25 |
| MH-455 | 100 | 50 |
| MH-490 | 100 | 50 |
| MH-6120 | 150 | 50 |
| MH-6200 | 150 | 50 |
| MH-6300 | 150 | 50 |
| MH-8500 | 250 | 100 |

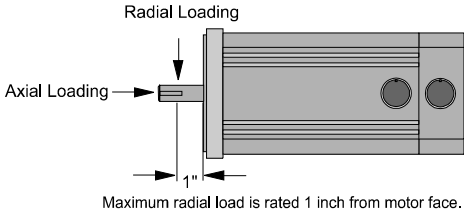



*Figure 71: Axial/Radial Loading*

# IP Ratings

| Motor | Rating |
|---|---|
| MH-316 | IP65 |
| MH-340 | |
| MH-455 | |
| MH-490 | |
| MH-6120 | |
| MH-6200 | |
| MH-6300 | |
| MH-8500 | |

# Encoder Specifications

| Motor | Density | Output Type | Output Frequency | Output Signals | Power Supply |
|---|---|---|---|---|---|
| MH | 2048 lines/rev | RS422 differential driver | 250 kHz per channel | A, B, Z, Comm U, Comm W, Comm V and all complements | 5V, 150 mA ±10% |

# Power Dissipation

In general, the drive power stages are around 90 percent efficient depending on the actual point of the torque speed curve the drive is operating. Logic power losses on the MDS Drive Module is 11 W minimum to 21 W depending on external loading such as FM modules and input voltages.

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) |
|---|---|---|---|
| MD-404 / MH-316 | 20 | 25 | 45 |
| MD-404 / MH-340 | | 36 | 56 |
| MD-404 / MH-455 | | 42 | 62 |
| MD-407 / MH-455 | | 48 | 68 |
| MD-407 / MH-490 | | 72 | 92 |
| MD-410 / MH-455 | | 60 | 80 |
| MD-410 / MH-490 | | 72 | 92 |
| MD-410 / MH-6120 | | 90 | 110 |
| MD-420 / MH-6120 | | 108 | 128 |
| MD-420 / MH-6200 | | 126 | 146 |
| MD-420 / MH-6300 | | 200 | 220 |
| MD-434 / MH-6200 | | 150 | 170 |
| MD-434 / MH-6300 | | 200 | 220 |
| MD-434 / MH-8500 | | 380 | 400 |
| MD-434 / MH-8750 | | 420 | 440 |

## Power Dissipation Calculation

Calculating actual dissipation requirements in an application can help minimize enclosure cooling requirements, especially in multi-axis systems. To calculate dissipation in a specific application, use the following formula for each axis and then total them up. This formula is a generalization and will result in a conservative estimate for power losses.

$$TPL = \frac{TRMS \bullet Vmax}{1500} + Pld + Psr$$

Where:

TPL = Total power losses (Watts)
TRMS = RMS torque for the application (lb-in)
Vmax = Maximum motor speed in application (RPM)
Pld = Logic Power Losses Drive (Watts)

Psr = Shunt Regulation Losses (Watts)-(RSR-2 losses or equivalent)

**Note**

TRMS * Vmax / 1500 = Power Stage Dissipation = Pp

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

# MDS Power Module Dimensions

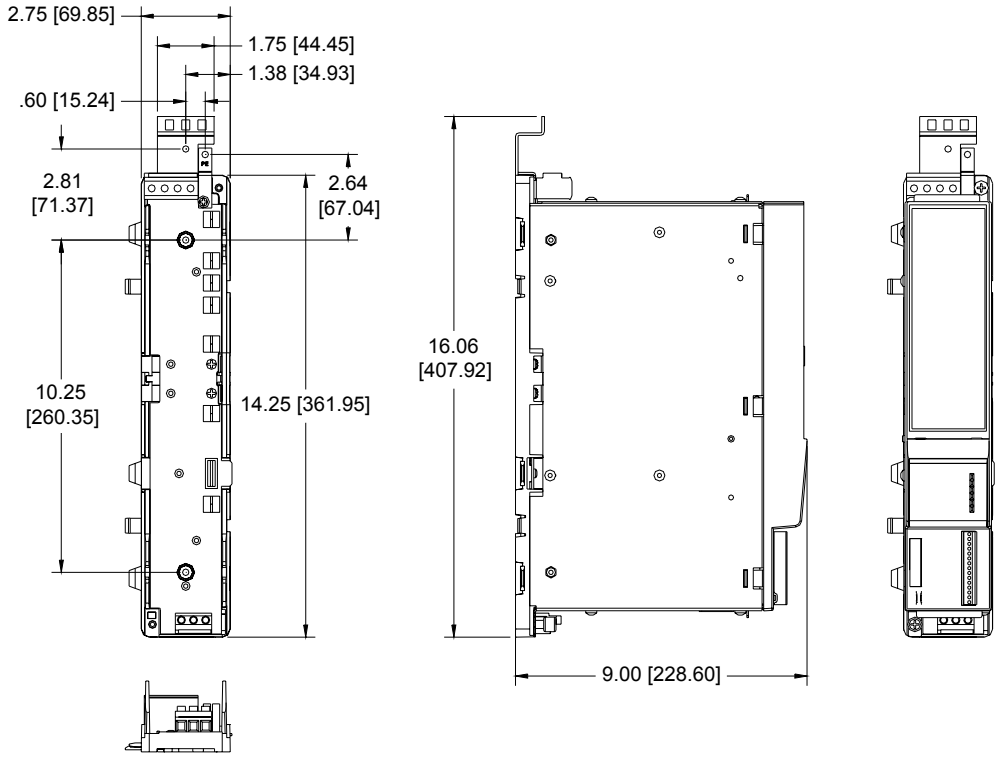



*Figure 72: MP-1250 and MP-2500 Dimensional Drawing*

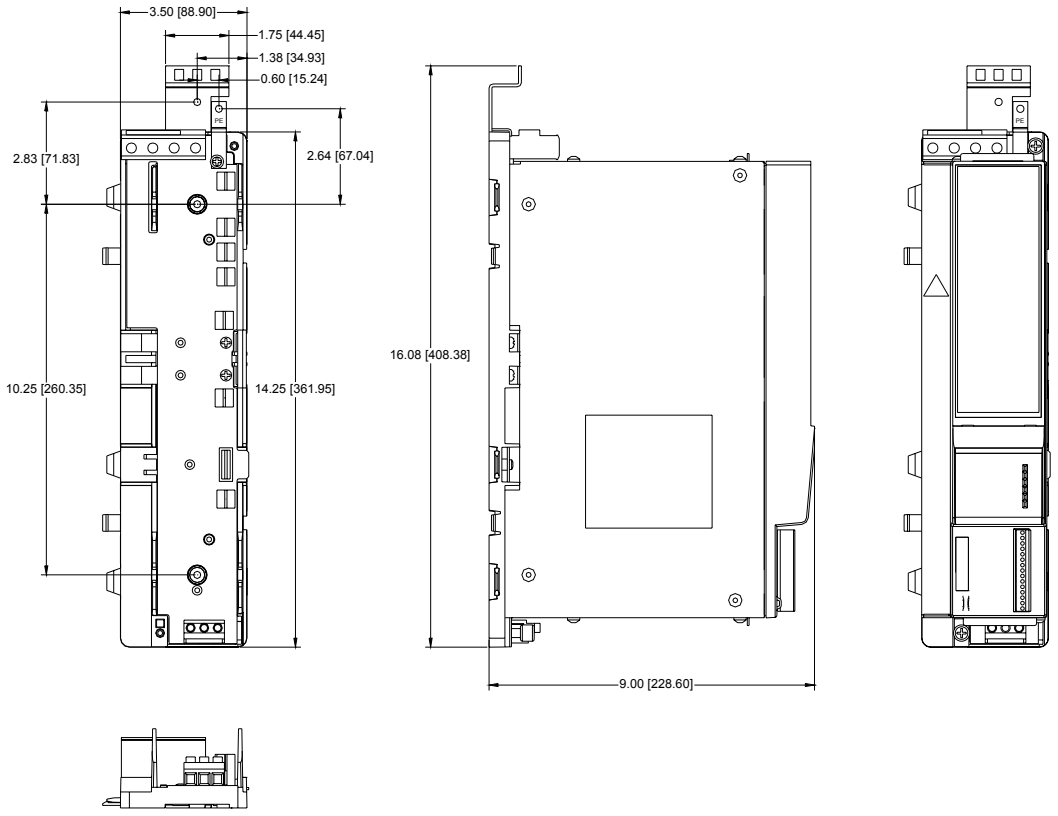



*Figure 73: MP-5000 Dimensional Drawing*

# MDS Drive Module Dimensions

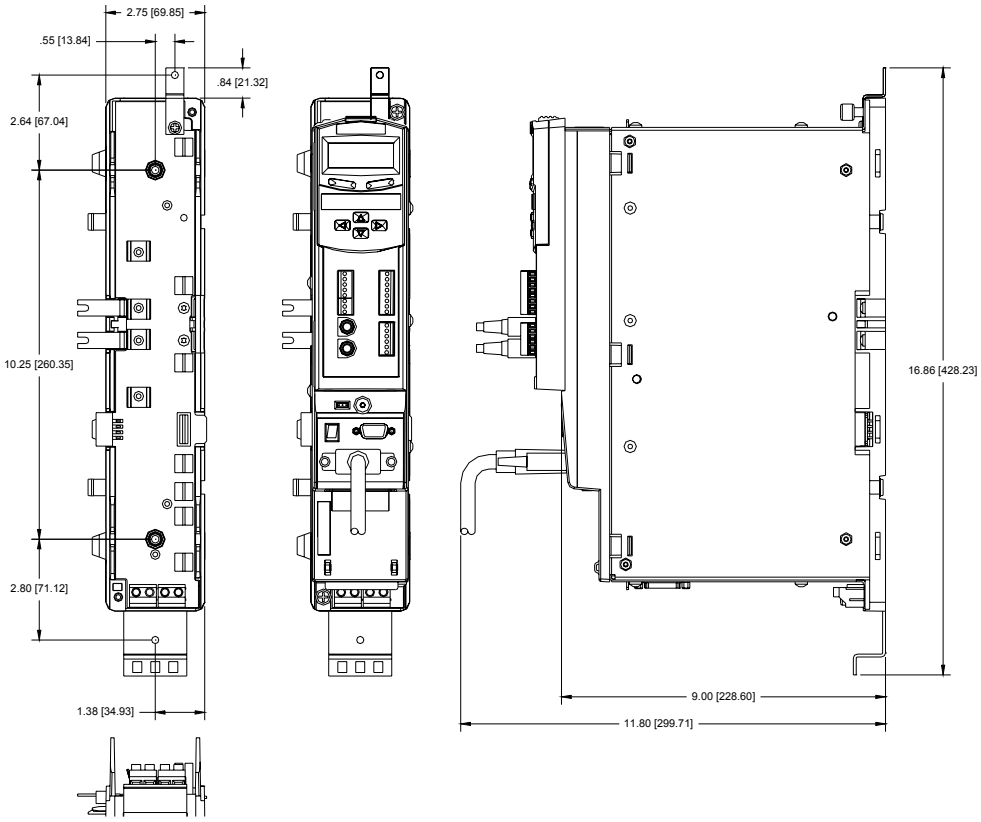



*Figure 74: MD-404, 407 and 410 Dimensional Drawing*

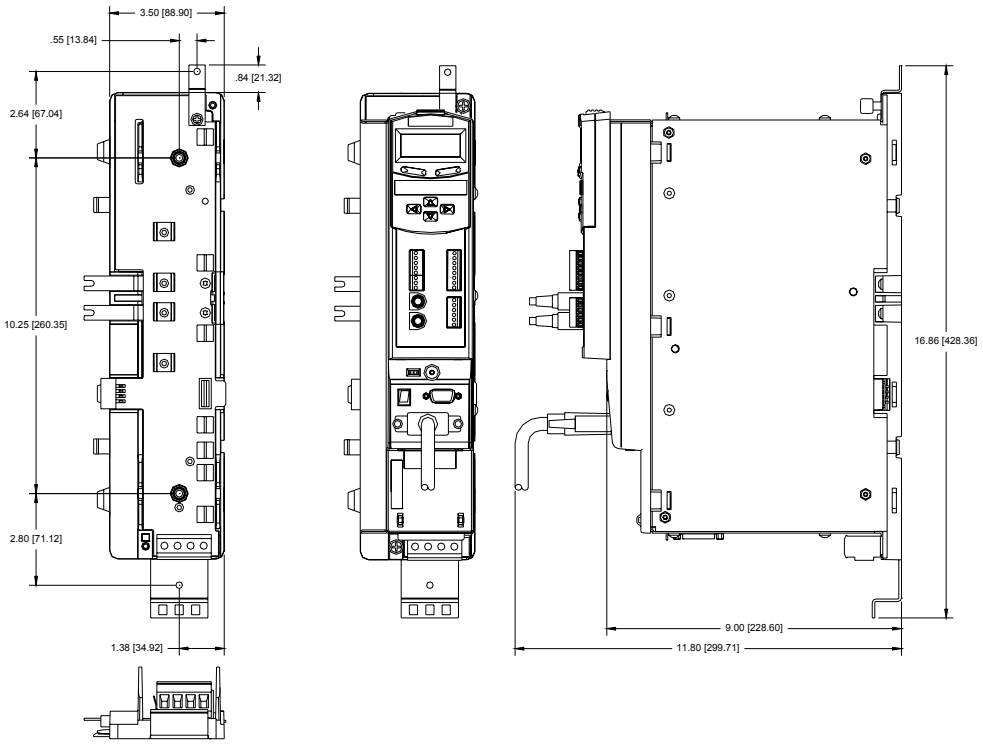



*Figure 75: MD-420 Dimensional Drawing*

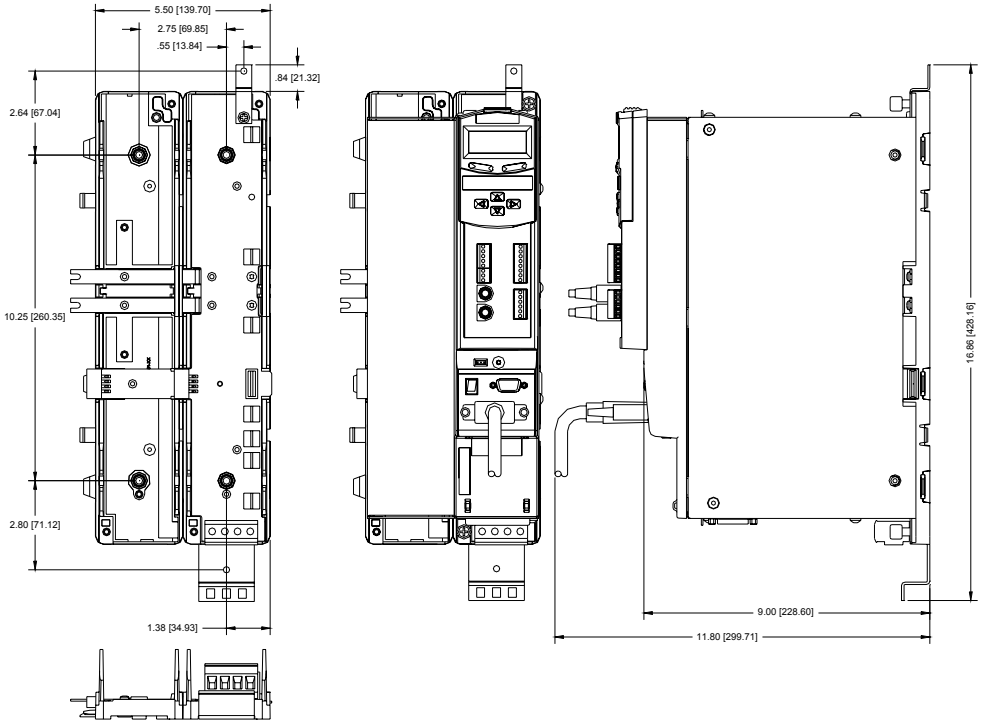
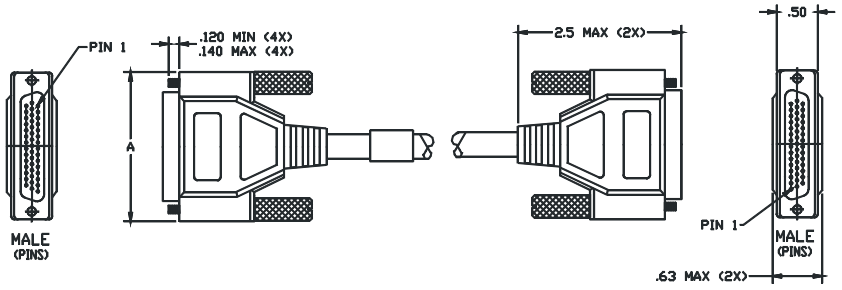


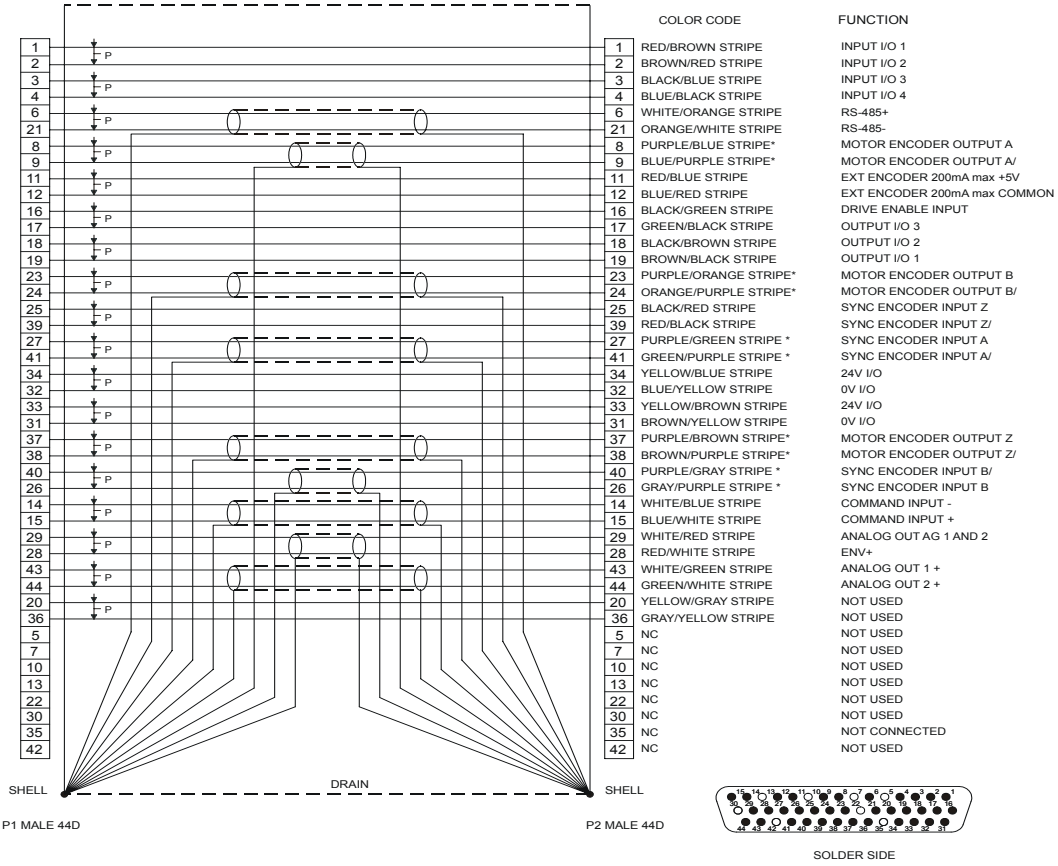

*Figure 76: MD-434 Dimensional Drawing*

# Cable Diagrams

| Drive Signal | CMDX, CMDO, ECI-44 | CDRO | AX4-CEN |
|---|---|---|---|
| Analog Command In + | X | X | X |
| Analog Command In - | X | X | X |
| Encoder Out A | X | X | X |
| Encoder Out A/ | X | X | X |
| Encoder Out B | X | X | X |
| Encoder Out B/ | X | X | X |
| Encoder Out Z | X | X | X |
| Encoder Out Z/ | X | X | X |
| Pulse In A | X | X | |
| Pulse In A/ | X | X | |
| Pulse In B | X | X | |
| Pulse In B/ | X | X | |
| Pulse In Z | X | | |
| Pulse In Z/ | X | | |
| Pulse In A (single ended) | X | | X |
| Pulse In B (single ended) | X | | X |
| I/O Input Drive Enable | X | X | X |
| I/O Input #1 | X | | |
| I/O Input #2 | X | | |
| I/O Input #3 | X | | |
| I/O Input #4 | X | X | X |
| I/O Output #1 | X | X | X |
| I/O Output #2 | X | X | X |
| I/O Output #3 | X | X | X |
| I/O Power + In (1st wire) | X | X | X |
| I/O Power + In (2nd wire) | X | X | X |
| I/O Power 0V In (1st wire) | X | X | X |
| I/O Power 0V In (2nd wire) | X | | |
| Analog Out 0V | X | X | X |
| Analog Out Channel #1 + | X | X | X |
| Analog Out Channel #2 + | X | X | X |
| External Encoder +5 Power Out (200 ma) | X | X | |
| External Encoder Common | X | X | |
| +15V Power Out (10 ma) | X | | |
| RS-485 + | X | | |
| RS-485 - | X | | |

## CMDX-XXX Cable



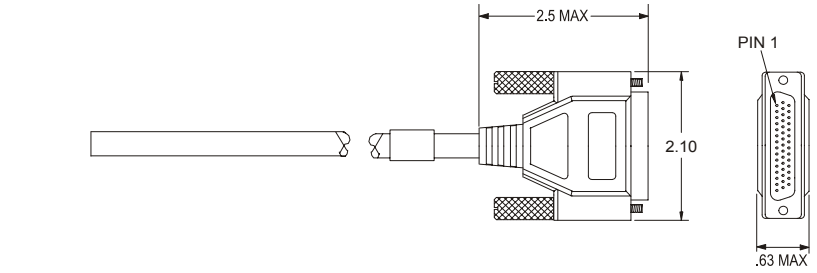



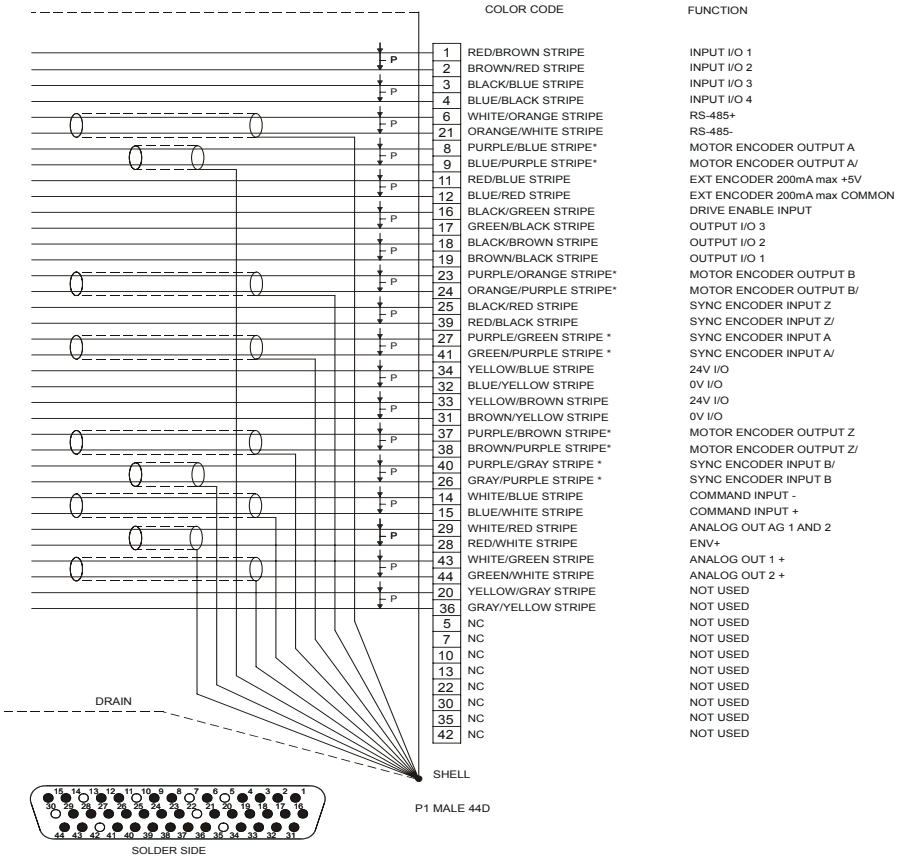

| | COLOR CODE | FUNCTION |
|---|---|---|
| 1 | RED/BROWN STRIPE | INPUT I/O 1 |
| 2 | BROWN/RED STRIPE | INPUT I/O 2 |
| 3 | BLACK/BLUE STRIPE | INPUT I/O 3 |
| 4 | BLUE/BLACK STRIPE | INPUT I/O 4 |
| 6 | WHITE/ORANGE STRIPE | RS-485+ |
| 21 | ORANGE/WHITE STRIPE | RS-485- |
| 8 | PURPLE/BLUE STRIPE* | MOTOR ENCODER OUTPUT A |
| 9 | BLUE/PURPLE STRIPE* | MOTOR ENCODER OUTPUT A/ |
| 11 | RED/BLUE STRIPE | EXT ENCODER 200mA max +5V |
| 12 | BLUE/RED STRIPE | EXT ENCODER 200mA max COMMON |
| 16 | BLACK/GREEN STRIPE | DRIVE ENABLE INPUT |
| 17 | GREEN/BLACK STRIPE | OUTPUT I/O 3 |
| 18 | BLACK/BROWN STRIPE | OUTPUT I/O 2 |
| 19 | BROWN/BLACK STRIPE | OUTPUT I/O 1 |
| 23 | PURPLE/ORANGE STRIPE* | MOTOR ENCODER OUTPUT B |
| 24 | ORANGE/PURPLE STRIPE* | MOTOR ENCODER OUTPUT B/ |
| 25 | BLACK/RED STRIPE | SYNC ENCODER INPUT Z |
| 39 | RED/BLACK STRIPE | SYNC ENCODER INPUT Z/ |
| 27 | PURPLE/GREEN STRIPE * | SYNC ENCODER INPUT A |
| 41 | GREEN/PURPLE STRIPE * | SYNC ENCODER INPUT A/ |
| 34 | YELLOW/BLUE STRIPE | 24V I/O |
| 32 | BLUE/YELLOW STRIPE | 0V I/O |
| 33 | YELLOW/BROWN STRIPE | 24V I/O |
| 31 | BROWN/YELLOW STRIPE | 0V I/O |
| 37 | PURPLE/BROWN STRIPE* | MOTOR ENCODER OUTPUT Z |
| 38 | BROWN/PURPLE STRIPE* | MOTOR ENCODER OUTPUT Z/ |
| 40 | PURPLE/GRAY STRIPE * | SYNC ENCODER INPUT B/ |
| 26 | GRAY/PURPLE STRIPE * | SYNC ENCODER INPUT B |
| 14 | WHITE/BLUE STRIPE | COMMAND INPUT - |
| 15 | BLUE/WHITE STRIPE | COMMAND INPUT + |
| 29 | WHITE/RED STRIPE | ANALOG OUT AG 1 AND 2 |
| 28 | RED/WHITE STRIPE | ENV+ |
| 43 | WHITE/GREEN STRIPE | ANALOG OUT 1 + |
| 44 | GREEN/WHITE STRIPE | ANALOG OUT 2 + |
| 20 | YELLOW/GRAY STRIPE | NOT USED |
| 36 | GRAY/YELLOW STRIPE | NOT USED |
| 5 | NC | NOT USED |
| 7 | NC | NOT USED |
| 10 | NC | NOT USED |
| 13 | NC | NOT USED |
| 22 | NC | NOT USED |
| 30 | NC | NOT USED |
| 35 | NC | NOT CONNECTED |
| 42 | NC | NOT USED |

## Note

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

## CMDO-XXX Cable

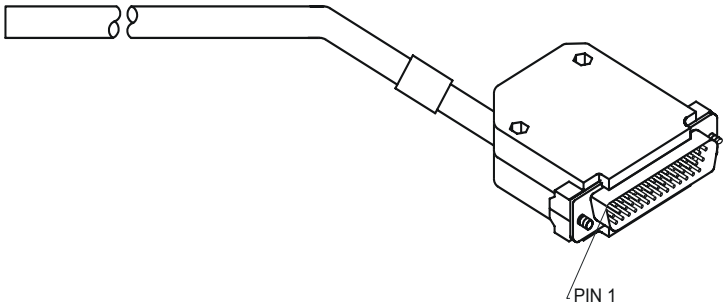


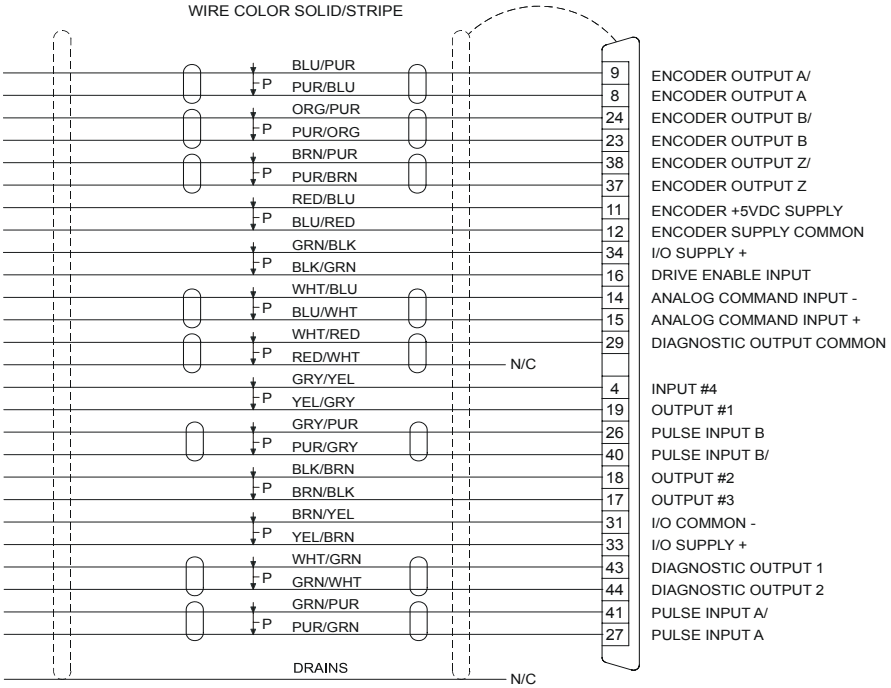



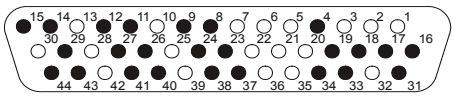

## Note

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

## CDRO-XXX Cable

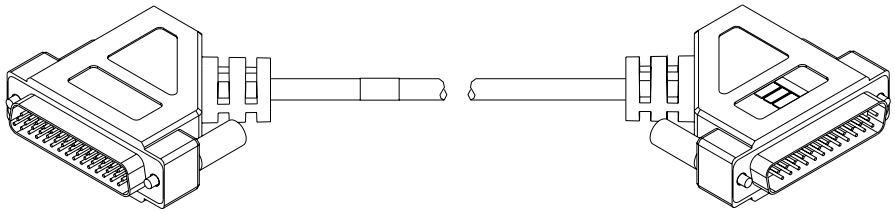


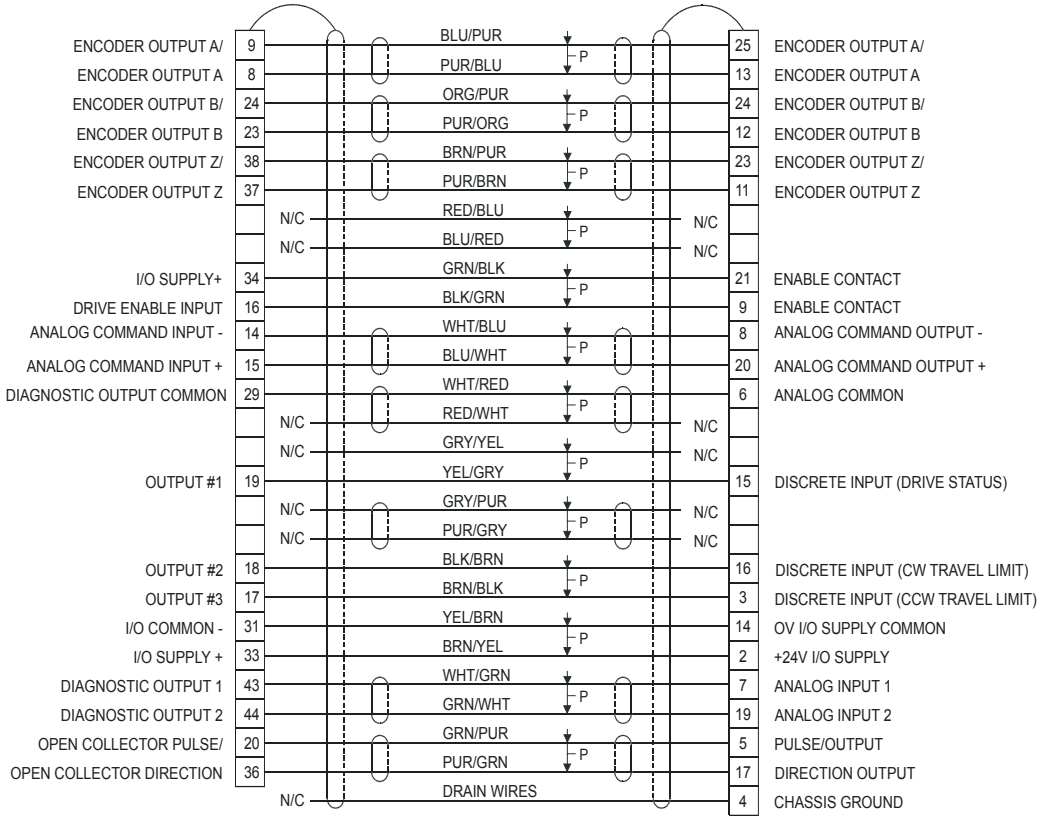



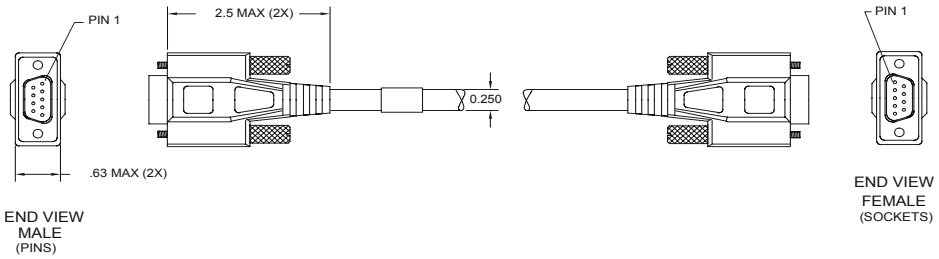

SOLDER SIDE

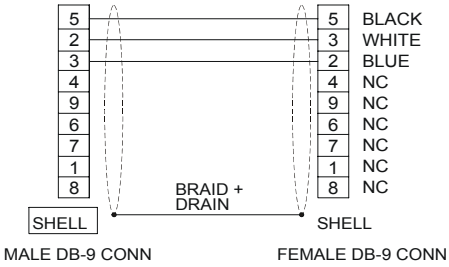
## AX4-CEN-XXX Cable



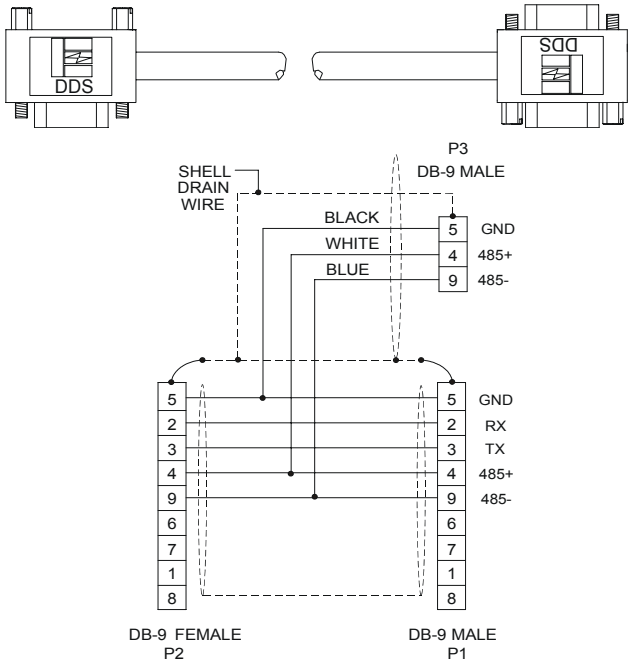


## TIA-XXX Cable

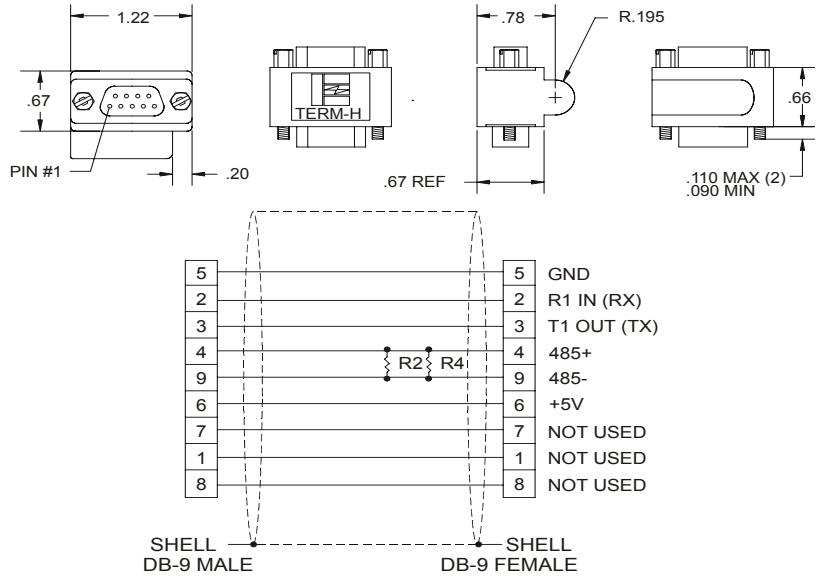


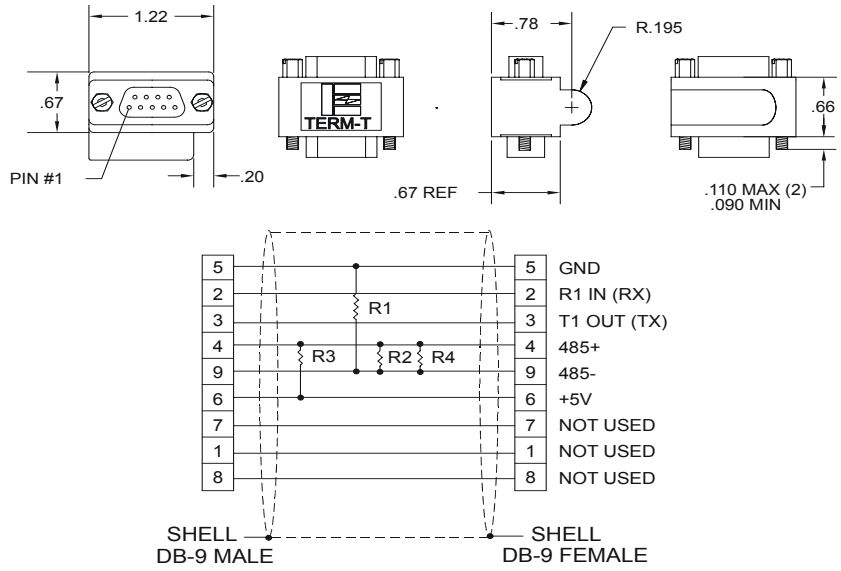

## DDS-XXX Cable



## TERM-H (Head) Terminator



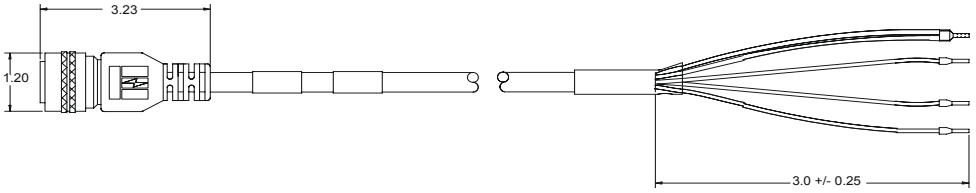

## TERM-T (Tail) Terminator

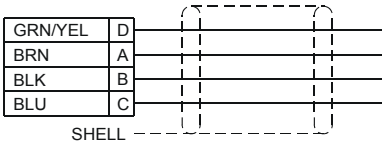


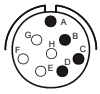

### Note

See the "Multi-drop Communications" section for resistor values.

## CMDS-XXX Cable

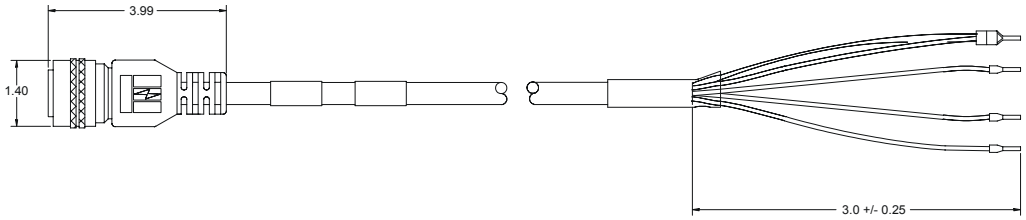


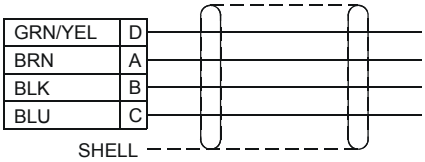



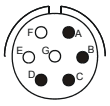




SOLDER SIDE

## CMMS-XXX Cable

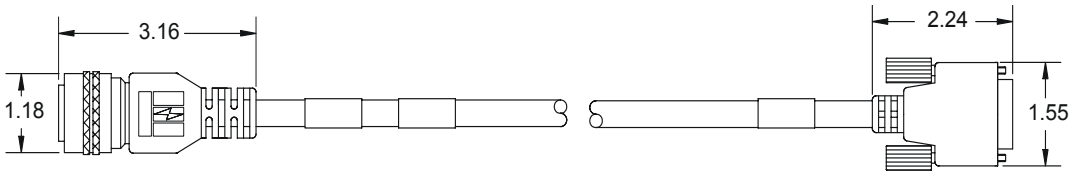


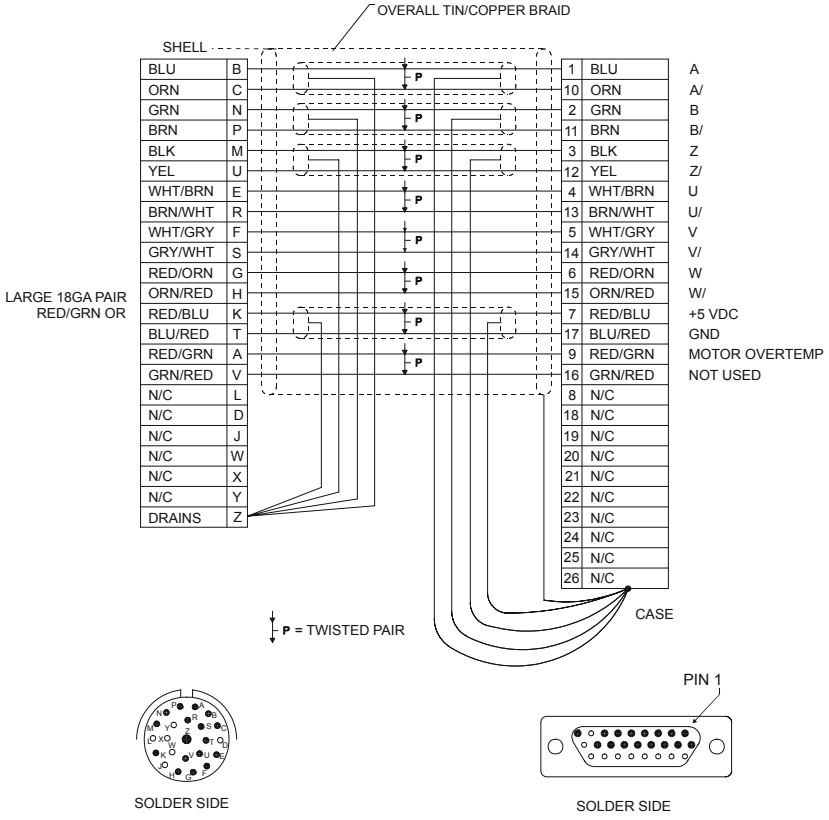



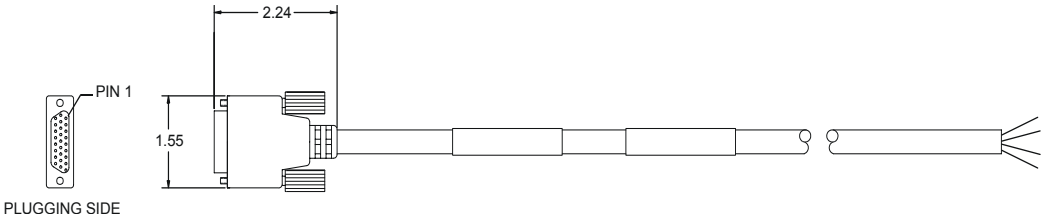

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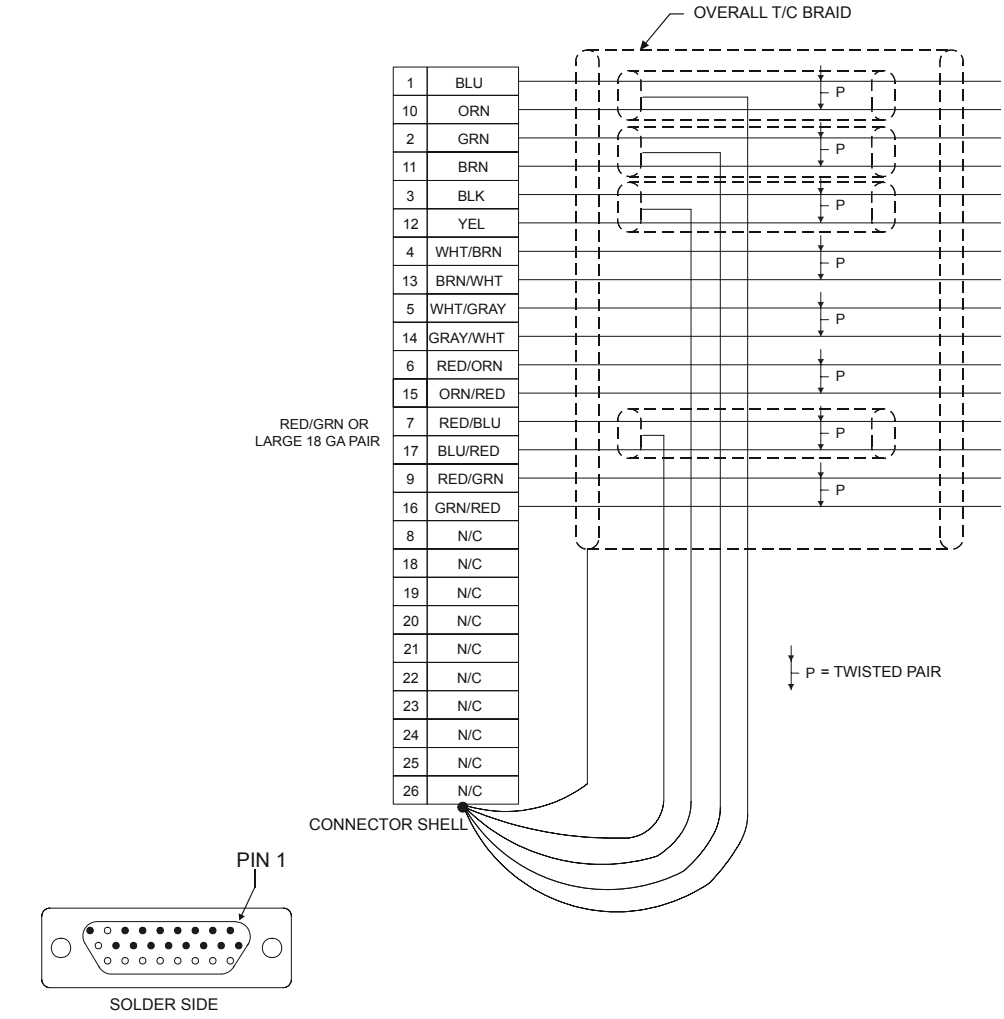
## CFCS-XXX Cable



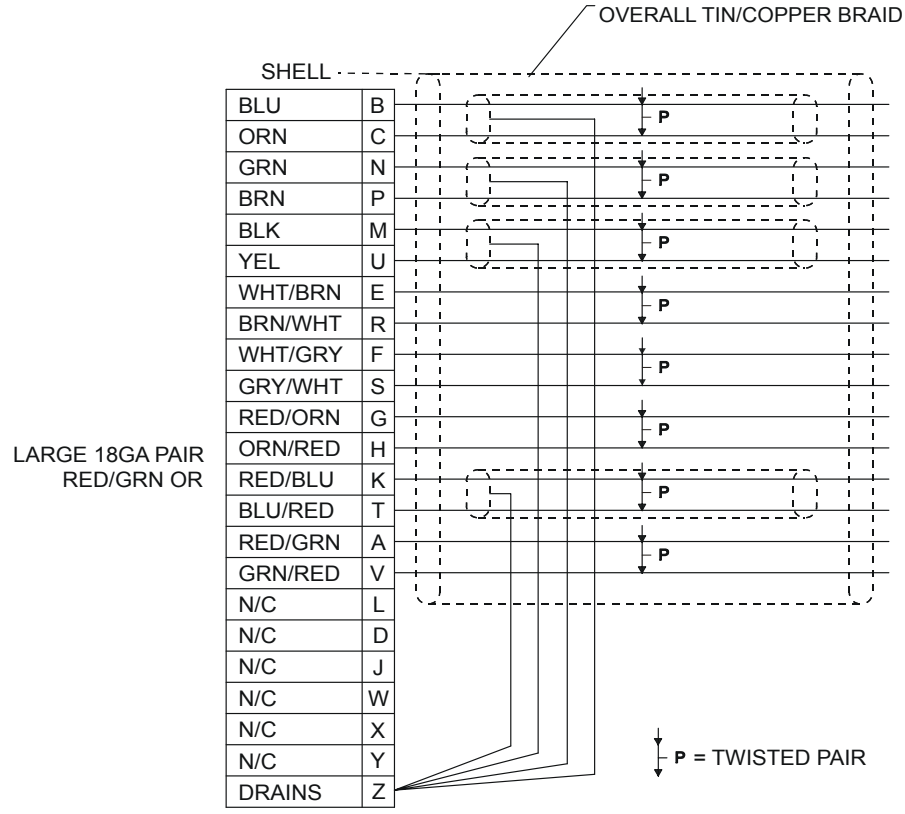
## CFCO-XXX Cable

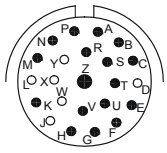


## CFOS-XXX Cable




SOLDER SIDE

# Glossary

### µs

Microsecond, which is 0.000001 second.

### A

Amps.

### ARMS

Amps (RMS).

### AWG

American Wire Gauge.

### Baud Rate

The number of binary bits transmitted per second on a serial communications link such as RS-232. (1 character is usually 10 bits.)

### Check Box

In a dialog box, a check box is a small box that the user can turn “On” or “Off” with the mouse. When “On” it displays an X in a square; when “Off” the square is blank. Unlike option (radio) buttons, check boxes do not affect each other; any check box can be “On” or “Off” independently of all the others.

### CRC

Cyclical Redundancy Check.

### Dialog Box

A dialog box is a window that appears in order to collect information from the user. When the user has filled in the necessary information, the dialog box disappears.

### DIN Rail

Deutsche Industrie Norm Rail

### DLL

In Microsoft Windows, a Dynamic Link Library contains a library of machine-language procedures that can be linked to programs as needed at run time.

### Downloading

The transfer of a complete set of parameters from PowerTools or a Function Module to a drive.

### EEPROM

An EEPROM chip is an Electrically Erasable Programmable Read-Only Memory; that is, its contents can be both recorded and erased by electrical signals, but they do not go blank when power is removed.

### EMC

Electromagnetic Compatibility

### EMI - Electro-Magnetic Interference

EMI is noise which, when coupled into sensitive electronic circuits, may cause problems.

### Firmware

The term firmware refers to software (i.e., computer programs) that are stored in some fixed form, such as read-only memory (ROM).

### FM

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

### Hysteresis

For a system with an analog input, the output tends to maintain it's current value until the input level changes past the point that set the current output value. The difference in response of a system to an increasing input signal versus a decreasing input signal.

### I/O

Input/Output. The reception and transmission of information between control devices. In modern control systems, I/O has two distinct forms: switches, relays, etc., which are in either an on or off state, or analog signals that are continuous in nature generally depicting values for speed, temperature, flow, etc.

### Inertia

The property of an object to resist changes in rotary velocity unless acted upon by an outside force. Higher inertia objects require larger torque to accelerate and decelerate. Inertia is dependent upon the mass and shape of the object.

### Input Function

A function (i.e., Stop, Preset) that may be attached to an input line.

### Input Line

The actual electrical input, a screw terminal.

### Least Significant Bit

The bit in a binary number that is the least important or having the least weight.

### LED

Light Emitting Diode.

### List Box

In a dialog box, a list box is an area in which the user can choose among a list of items, such as files, directories, printers or the like.

### mA

Milliamp, which is 1/1000th of an Ampere.

### MB

Mega-byte.

### MDS

Modular Drive System

### Most Significant Bit

The bit in a binary number that is the most important or that has the most weight.

### ms

Millisecond, which is 1/1000th of a second.

### NVM

Non-Volatile Memory.

### NTC

Negative Temperature Resistor

### Option Button

*See* Radio Button.

### Opto-isolated

A method of sending a signal from one piece of equipment to another without the usual requirement of common ground potentials. The signal is transmitted optically with a light

source (usually a Light Emitting Diode) and a light sensor (usually a photosensitive transistor). These optical components provide electrical isolation.

### Output Function

A function (i.e., Drive OK, Fault) that may be attached to an output line.

### Output Line

The actual transistor or relay controlled output signal.

### Parameters

User read only or read/write parameters that indicate and control the drive operation.

### PE

Protective Earth.

### PID

Proportional-Integral-Derivative. An acronym that describes the compensation structure that can be used in many closed-loop systems.

### PLC

Programmable Logic Controller. Also known as a programmable controller, these devices are used for machine control and sequencing.

### PowerTools-FM and -PRO

Windows®-based software to interface with the Modular Drive System and Function Modules.

### Radio Button

Also known as the Option Button. In a dialog box, radio buttons are small circles only one of which can be chosen at a time. The chosen button is black and the others are white. Choosing any button with the mouse causes all the other buttons in the set to be cleared.

### RAM

RAM is an acronym for Random-Access Memory, which is a memory device whereby any location in memory can be found, on average, as quickly as any other location.

### RMS

Root Mean Squared. For an intermittent duty cycle application, the RMS is equal to the value of 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.

### Uploading

The transfer of a complete set of parameters from PowerTools or an FM-P.

### VAC

Volts, Alternating Current.

### VDC

Volts, Direct Current.

### Windows, Microsoft

Microsoft Windows is an operating system that provides a graphical user interface, extended memory and multi-tasking. The screen is divided into windows and the user uses a mouse to start programs and make menu choices.

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Customer Service
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