

MDrive 17 & 23 Plus

Motion Control

Integrated Motor and Driver



**IMS™ INTELLIGENT MOTION
SYSTEMS, INC.**

by Schneider Electric

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Important information

The drive systems described here are products for general use that conform to the state of the art in technology and are designed to prevent any dangers. However, drives and drive controllers that are not specifically designed for safety functions are not approved for applications where the functioning of the drive could endanger persons. The possibility of unexpected or un-braked movements can never be totally excluded without additional safety equipment. For this reason personnel must never be in the danger zone of the drives unless additional suitable safety equipment prevents any personal danger. This applies to operation of the machine during production and also to all service and maintenance work on drives and the machine. The machine design must ensure personal safety. Suitable measures for prevention of property damage are also required.

Qualification of personnel

Only technicians who are familiar with and understand the contents of this manual and the other relevant documentation are authorized to work on and with this drive system. The technicians must be able to detect potential dangers that may be caused by setting parameters, changing parameter values and generally by the operation of mechanical, electrical and electronic equipment.

The technicians must have sufficient technical training, knowledge and experience to recognise and avoid dangers.

The technicians must be familiar with the relevant standards, regulations and safety regulations that must be observed when working on the drive system.

Intended Use

The drive systems described here are products for general use that conform to the state of the art in technology and are designed to prevent any dangers. However, drives and drive controllers that are not specifically designed for safety functions are not approved for applications where the functioning of the drive could endanger persons. The possibility of unexpected or unbraked movements can never be totally excluded without additional safety equipment.

For this reason personnel must never be in the danger zone of the drives unless additional suitable safety equipment prevents any personal danger. This applies to operation of the machine during production and also to all service and maintenance work on drives and the machine. The machine design must ensure personal safety. Suitable measures for prevention of property damage are also required.

In all cases the applicable safety regulations and the specified operating conditions, such as environmental conditions and specified technical data, must be observed.

The drive system must not be commissioned and operated until completion of installation in accordance with the EMC regulations and the specifications in this manual. To prevent personal injury and damage to property damaged drive systems must not be installed or operated.

Changes and modifications of the drive systems are not permitted and if made all no warranty and liability will be accepted.

The drive system must be operated only with the specified wiring and approved accessories. In general, use only original accessories and spare parts.

The drive systems must not be operated in an environment subject to explosion hazard (ex area).

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GETTING STARTED

Getting Started - MDrivePlus Motion Control

Before You Begin

The Quick Start guide is designed to help get you connected and communicating with the MDrivePlus Motion Control. The following examples will help you get the motor turning for the first time and introduce you to Immediate and Program modes of operation.



WARNING! Please

ensure that you

read the sections of

the product manual

pertaining to the MDrivePlus model you purchased in their entirety prior to placing the unit into full operation.

Tools and Equipment Required

- MDrivePlus Motion Control Unit
- Communications Converter Cable or equivalent (USB or Serial to RS-422)
- Product CD or Internet access to www.imshome.com
- An Unregulated Power Supply (See specifications for your exact MDrivePlus Motion Control and required voltage.)
- Basic Tools: Wire Cutters / Strippers / Screwdriver
- Wire for Power Supply (See specifications for your exact MDrivePlus Motion Control.)
- Windows XP Service Pack 2
- A free USB or serial communications port

Connecting the Power Supply

Using the recommended wire (see the specifications for your MDrivePlus Motion Control), connect the DC output of the power supply to the +V input of the connector appropriate for your MDrivePlus model.

Connect the power supply ground to the Power Ground pin appropriate for your MDrivePlus.

Connecting Communications

Connect the Host PC to the MDrivePlus Motion Control using the IMS Communications Converter Cable or equivalent.

Install IMS Terminal Software

1. Download IMS Terminal from http://www.imshome.com/software_interfaces.html.
2. Install the software.
3. Once IMS Terminal is installed, the Communications Settings can be checked and/or set.



WARNING:
Do not connect or disconnect DC input to the

MDrivePlus with power applied! Disconnect the AC power side to power down the DC Supply.

For battery operated systems, conditioning measures should be taken to prevent device damage caused by in-rush current draws, transient arcs and high voltage spikes.

Establishing Communications

1. Open IMS Terminal by clicking Start>Programs>IMS Terminal>IMS Term. The Program Edit Window (left) and Terminal Window (right) will be displayed.

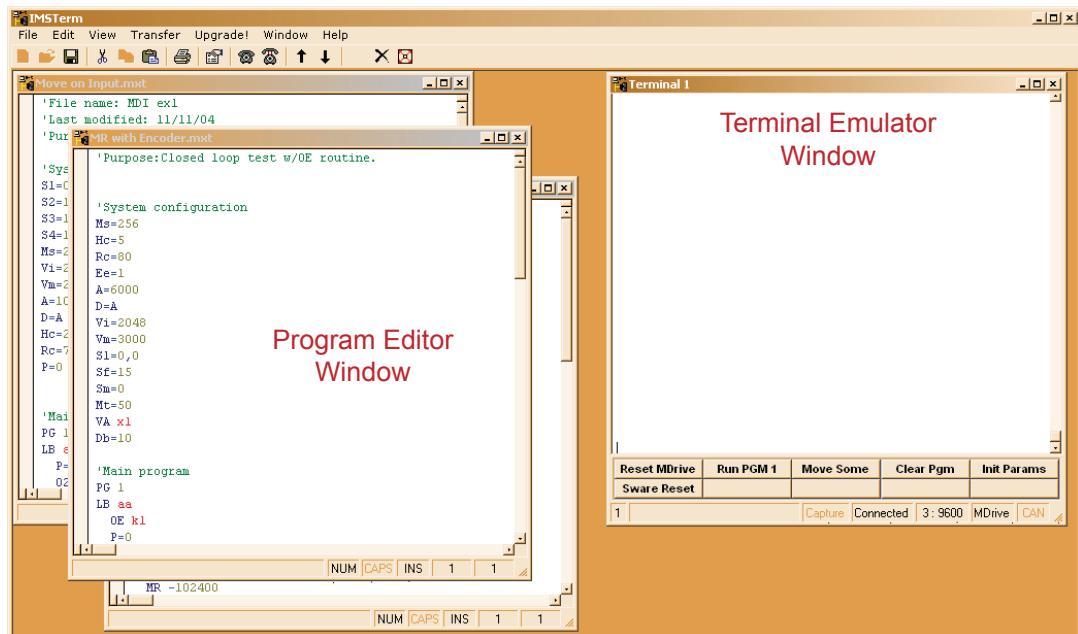


Figure GS.2: IMS Terminal Main Screen

2. On the Menu Bar click Edit / Preferences to open the Preferences dialog box.
3. Click on the Comm Settings tab to open the Comm Settings page.
 - a. Set Scroll Back to desired range of text lines to be displayed.
 - b. Under Device, verify that MDrive has been selected, and also verify the Comm Port being used. Do not change any other settings. Click "OK".

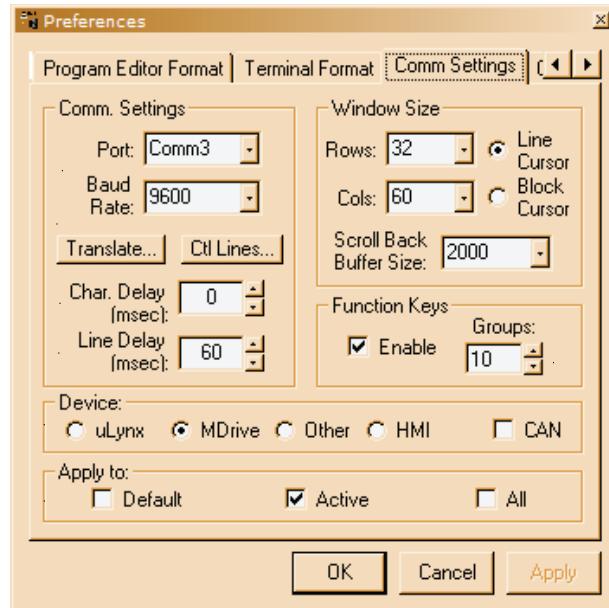


Figure GS.3: IMS Terminal Preferences Dialog

Apply Power to the MDrivePlus Motion Control

1. Verify that all connections have been made, then apply power to the MDrivePlus Motion Control. Click on the Phone icon or the Disconnect status box to establish communications between IMS Terminal and the MDrivePlus. The following sign-on message should appear in the Terminal Window:

"Copyright 2001-2006 by Intelligent Motion Systems, Inc."

2. If you can see the sign-on message, then the MDrivePlus is properly powered-up and communicating.
 - a. If the sign-on message does not appear, try using a software reset. Hold down the "Ctrl" key and press "C". If the sign-on message still does not appear, check all connections, as well as all hardware and software configurations, then start IMS Terminal again.
3. You are now connected and communicating to the MDrivePlus Motion Control.
Note: There are indicators at the bottom of the Terminal Window that show whether you are connected or disconnected, the current Baud Rate, and the type of device (MDrive) for which the IMS Terminal is configured. These three items may be changed directly from this screen by double clicking on each of them.

Testing the MDrivePlus Motion Control

1. Click in the Terminal Window, and type (followed by ENTER):
PR VM
2. The MDrivePlus Motion Control will return a value of 768000
3. Type the following in the Terminal Window (followed by ENTER):
VM=360000
PR VM
4. The MDrivePlus Motion Control will return a value of 360000
5. Type FD and press ENTER. (FD = Factory Defaults)

"Copyright 2001-2007 by Intelligent Motion Systems, Inc."

should appear in the Terminal Window within a few seconds.

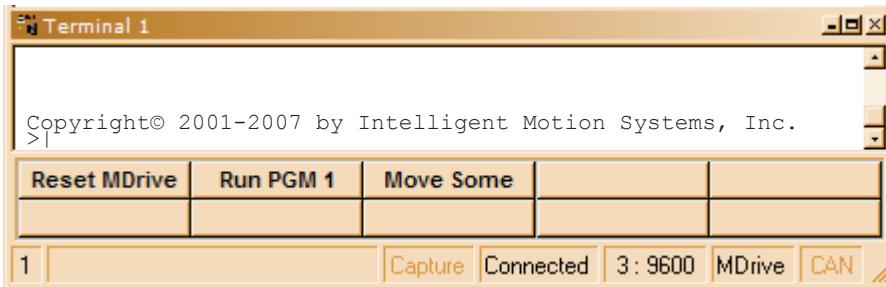


Figure GS.4: MDrivePlus Motion Control Sign-On Message

Make the MDrivePlus Motion Control Move

1. Type MR 51200 into the Terminal Window and press ENTER. (MR = Move Relative)
 - a. With the default settings, the MDrive Motion Control should move one revolution in approximately 0.066 seconds, or at a velocity of 15 revolutions per second.
2. Type SL 102400 and press ENTER. (SL = Slew)
 - a. With the default settings, the MDrivePlus Motion Control should run constantly at a speed of approximately 2 revolutions per second or 120 revolutions per minute.
3. Type SL 0 and press ENTER. The MDrivePlus Motion Control should decelerate to a full stop.



Note: Entering MDrivePlus commands directly into the Terminal Window is called "Immediate Mode".

The MDrivePlus Motion Control command set is not case sensitive except for command DN = <>



Warning: If you have installed the MDrivePlus to a load, be sure the load can safely be moved before testing.

Tip: A small piece of tape on the motor shaft is a visual aid to help see the shaft turning.

N NOTE: Entering MDrivePlus commands into the Program Edit Window, to be edited and saved, is called "Program Mode".

N NOTE: The program can be stopped by pressing the Escape Button or by pressing Ctrl+C.

Motion Control Example Using Program Mode

1. Click on drop-down menu View > New Edit Window to open the Program Edit Window.
2. Type "XYZ Test" into the "Open a New file for editing" dialog box, and click "OK".
3. Click anywhere within the Program Edit Window, and type (followed by ENTER):

```

VA LP=0      'user variable name LP = start count 0
A=100000     'set acceleration to 100000 steps/sec2
D=100000     'set deceleration to 100000 steps/sec2
PG 1         'enter program mode, start program at address 1
LB AA        'label program AA
MR 250000    'move motor 250000 steps in the positive direction
H            'hold program execution until motion completes
H 1000       'hold 1000 milliseconds
MR -250000   'move motor 250000 steps in the negative direction
H            'hold program execution until motion completes
H 1000       'hold 1000 milliseconds
IC LP        'increment user variable LP
PR " LP=",LP; 'print axis position, 4 characters used, the
               'terminal will display LP=1 LP=2 LP=3
BR AA, LP<3  'branch to process label AA, if user variable LP< 3
E             'end program execution
PG           'exit program, return to immediate mode

```

4. Type FD in the Terminal Window and press ENTER to clear the MDrive buffer to factory defaults before downloading any program.
5. Click on drop-down menu Transfer > Download to transfer the program from the Program Edit Window to the Terminal Window. (Under "Source Type" choose "Edit Window".)
6. Type EX 1 in the Terminal Window and press ENTER to execute the program. (EX = Execute at address 1.)
7. The MDrivePlus Motion Control will turn 250,000 microsteps in a clockwise direction, accelerating at 100,000 microsteps per sec², then decelerating at 100,000 microsteps per sec², pausing for 1000 milliseconds, then reversing the sequence in a counterclockwise direction, repeating the motion cycle 3 times until the program ends.

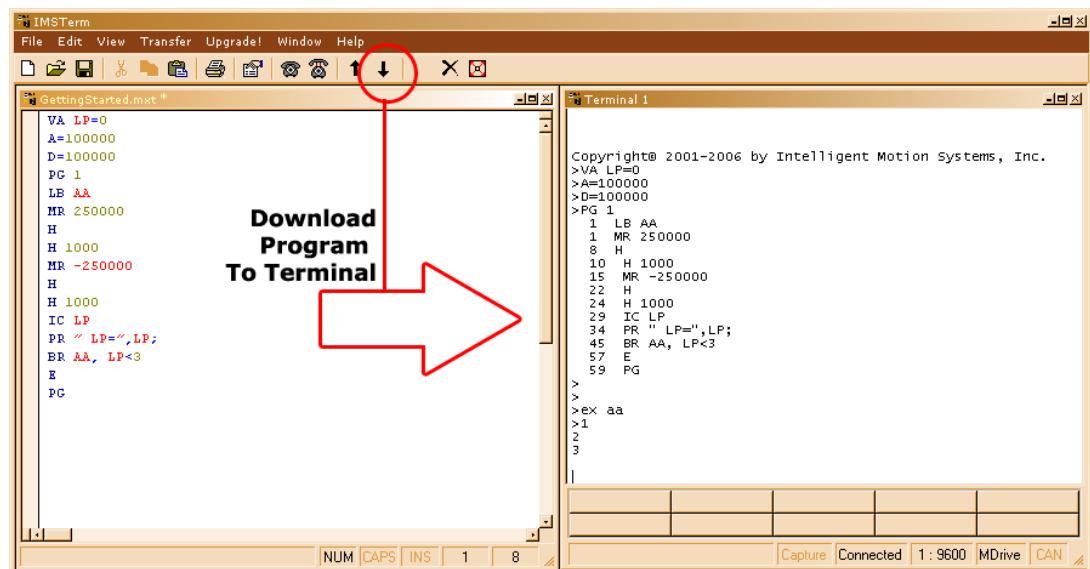


Figure GS.5: Download the Program

Programming Notes

The example above demonstrates basic commands that verify that your MDrivePlus Motion Control is communicating with your PC. More complex commands and movement may require that your I/O and/or Analog Input be interfaced and configured. Refer to MDrivePlus Motions Control Software Reference for details.

For more information on MDrivePlus Motion Control Programming and Command Control Sets, refer to the Software Section of this manual.

INTELLIGENT MOTION SYSTEMS, INC.

Excellence in Motion™



PART 1: HARDWARE SPECIFICATIONS

Section 1.1: MDrive17Plus Motion Control Product Introduction

Section 1.2: MDrive17Plus Motion Control Detailed Specifications

Section 1.3: MDrive17Plus² Motion Control Detailed Specifications

Section 1.4: MDrive17Plus²-65 Motion Control Detailed Specifications

Section 1.5: MDrive23Plus Motion Control Product Introduction

Section 1.6: MDrive23Plus Motion Control Detailed Specifications

Section 1.7: MDrive23Plus² Motion Control Detailed Specifications

Section 1.8: MDrive23Plus²-65 Motion Control Detailed Specifications

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SECTION 1.1

MDrive17Plus Motion Control Product Introduction

Introduction to the MDrive17Plus Motion Control System

The MDrive17Plus Motion Control offers system designers a low cost, intelligent motion controller integrated with a NEMA 17 high torque brushless motor and a +12 to +48 volt microstepping driver.

The unsurpassed smoothness and performance delivered by the MDrive17Plus Motion Control are achieved through IMS's advanced 2nd generation current control. By applying innovative techniques to control current flow through the motor, resonance is significantly damped over the entire speed range and audible noise is reduced.

The MDrive17Plus accepts a broad input voltage range from +12 to +48 VDC, delivering enhanced performance and speed. Oversized input capacitors are used to minimize power line surges, reducing problems that can occur with long runs and multiple drive systems. An extended operating temperature range of -40° to +85°C provides long life, trouble free service in demanding environments.

Standard features available in the MDrive17Plus Motion Control include four +5 to +24 volt general purpose I/O lines, one 10 bit analog input, 0 to 5MHz step clock rate, 20 microstep resolutions up to 51,200 steps per revolution, and full featured easy-to-program instruction set.

Expanded features in the MDrive17Plus² version include up to eight +5 to +24 volt general purpose I/O lines and the capability of electronic gearing by following a rotary or linear axis at an electronically controlled ratio, or an output clock can be generated fixed to the internal step clock.

For use in environments where exposure to chemical, dust and liquids may occur, a sealed assembly MDrive-17Plus²-65 version is designed to meet IP65 specifications.

All MDrive17Plus Motion Control are available with optional closed loop control. This increases functionality by adding stall detection, position maintenance and find index mark.

The closed loop configuration is added via a 512 line (2048 edge) magnetic encoder with index mark, internal to the unit so there is no increase in length. Or, for an expanded choice of line counts and resolutions with MDrive17Plus² versions only, closed loop control is available with an interface to a remotely mounted user-supplied external encoder.

The MDrive communicates over RS-422/485 which allows for point-to-point or multiple unit configurations utilizing one communication port. Addressing and hardware support up to 62 uniquely addressed units communicating over a single line. Baud rate is selectable from 4.8 to 115.2kbps.

Available motor configurations are available in three motor lengths. Interface connections are accomplished using 12.0" (30.5cm) flying leads or a 7 position terminal strip. Plus² versions come with pluggable locking wire crimp connectors. Plus²-65 sealed versions come with M12/M23 circular connectors.

The MDrive17Plus is a compact, powerful and inexpensive solution that will reduce system cost, design and assembly time for a large range of brushless motor applications



Note: The MDrivePlus Motion Control is available in a CAN communications configuration. For more information and Hardware Specifications see the IMS Web site for the MDrivePlus CANopen manual.

For detailed descriptions of supported CANopen objects please refer to the MDrive CANpen Software Reference.



Figure 1.1.1: MDrive17Plus



Figure 1.1.2: MDrive17Plus²-65

Standard Feature Summary

- Highly Integrated Microstepping Driver, Motion Controller and NEMA 17 High Torque Brushless Motor
- Advanced 2nd Generation Current Control for Exceptional Performance and Smoothness
- Single Supply: +12 to +48 VDC
- Low Cost
- Extremely Compact

- Available Options:
 - Internal Magnetic Encoder for Closed Loop Control
 - Integrated Planetary Gearbox
 - Control Knob for Manual Positioning
 - Linear Slide
- Three Rotary Motor Lengths Available
- Auxiliary Logic Power Supply Input
- 20 Microstep Resolutions up to 51,200 Steps Per Rev Including: Degrees, Metric, Arc Minutes
- Open or Optional Closed Loop Control
- Programmable Motor Run and Hold Currents
- Four +5 to +24 VDC I/O Lines Accept Sourcing or Sinking Outputs
- One 10 Bit Analog Input Selectable: 0 to +10VDC, 0 to +5VDC, 0-20 mA, 4-20 mA
- 0 to 5MHz Step Clock Rate Selectable in 0.59Hz Increments
- RS-422/485 Communications
- 62 Software Addresses for Multi-Drop Communications
- Simple 1 to 2 Character Instructions
- Interface Options:
 - Pluggable Terminal Strip
 - 12.0" (30.5cm) Flying Leads

The MDrive17Plus Motion Control Key Differences and Enhanced Features

There are three different variants of the MDrive17Plus Motion Control, these are:

1. MDrive17Plus Motion Control

The MDrive17Plus Motion Control is the standard version of the MDrive17Plus and is drop-in compatible with the legacy MDrive17 Motion Control product. The key feature additions from the original MDrive17 Motion Control are:

- Improved current control.
- 20 Microstep resolutions to 51,200 steps per rev including degrees, metric and arc minutes.
- 4 +5 to +24 VDC I/O lines which accept sinking or sourcing inputs.
- One 0 to +10 VDC Analog input.
- Optional pluggable strip for interface.

See Section 1.2 of this document for detailed specifications on the MDrive17Plus Motion Control.

2. MDrive17Plus² Motion Control

The MDrive17Plus² Motion Control adds expanded functionality to the MDrive17Plus in the form of:

- Enhanced and expanded I/O set (8 lines) which can be configured as sinking or sourcing inputs or outputs.
- Remote Encoder option (Reduces I/O set to 4 lines).
- High speed position capture input or trip output.
- Pluggable wire crimp interface.
- Electronic gearing.

See Section 1.3 of this document for detailed specifications on the MDrive17Plus² Motion Control.

3. MDrive17Plus²-65 Motion Control

The MDrive17Plus²-65 Motion Control adds protection against the ingress of fluids and dust to the MDrive17Plus² by changing the motor-drive enclosure to meet IP65 specifications. With this change the connector configuration changes to industry standard M12/M23 circular connectors.

See Section 1.4 of this document for detailed specifications on the MDrive17Plus²-65 Motion Control.

SECTION 1.2

MDrive17Plus Detailed Specifications

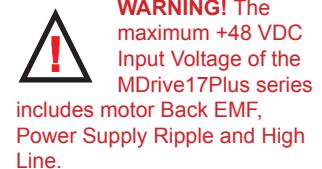
General Specifications

Electrical Specifications	
Input Voltage (+V) Range*	+12 to +48 VDC
Max Power Supply Current (Per MDrive17Plus)*	2 A
Aux-Logic Input Voltage**	+12 to +24 VDC
Max Aux-Logic Supply Current (Per MDrive17Plus)	161 mA

* Actual Power Supply Current will depend on Voltage and Load.

** Maintains power to control and feedback circuits [only] when input voltage is removed

Table 1.2.1: MDrive17Plus Electrical Specifications



WARNING! Because the MDrivePlus consists of two core components, a drive and a motor, close attention must be paid to the thermal environment where the device is used. See Thermal Specifications.

Environmental Specifications		
Operating Temperature (non-condensing humidity)	Heat Sink	-40°C to +85°C
	Motor	-40°C to +100°C

Table 1.2.2: MDrive17Plus Thermal Specifications

I/O Specifications	
General Purpose I/O - Number and Type	
Plus (I/O Points 1-4)	4 I/O points configurable as sinking or sourcing inputs or sinking outputs
General Purpose I/O - Electrical	
Inputs	TTL up to +24 VDC
Sinking Outputs (All)	Up to +24 VDC
Output Sink Current (Plus)	up to 600 mA (One Channel)
Logic Threshold (Logic 0)	< 0.8 VDC
Logic Threshold (Logic 1)	> 2.2 VDC
Protection (Sinking)	Over Temp, Short Circuit
Protection (Sourcing)	Transient Over Voltage, Inductive Clamp
Analog Input	
Resolution	10 Bit
Range (Voltage Mode)	0 to +5 VDC, 0 to +10 VDC
Range (Current Mode)	4 to 20 mA, 0 to 20mA
Clock I/O	
Types	Step/Direction, Up/Down, Quadrature
Logic Threshold	+5 VDC TTL Input, TTL Output (with 2 kΩ Load to Ground)
Trip Output/Capture Input	
Logic Threshold	+5 VDC TTL Input, TTL Output (with 2 kΩ Load to Ground)

Table 1.2.3: MDrive17Plus I/O Specifications

Communications Specifications	
Protocol	RS-422/RS-485
BAUD Rate	4.8k, 9.6k, 19.2k, 38.4k, 115.2 kbps

Table 1.2.4: MDrive17Plus Communications Specifications

**WARNING!**

When using the MDrivePlus Motion Control with optional internal magnetic encoder, no axial force may be applied to the motor shaft without use of a load bearing isolation coupling.

Motion Specifications**Microstep Resolution - Open Loop**

Number of Resolutions

20

Available Microsteps Per Revolution									
200	400	800	1000	1600	2000	3200	5000	6400	10000
12800	20000	25000	25600	40000	50000	51200	36000 ¹	21600 ²	25400 ³

1=0.01 deg/μstep 2=1 arc minute/μstep 3=0.001 mm/μstep

Microstep Resolution - Closed Loop Configuration (Optional)

Steps Per Revolution (Fixed)

51200

Position Resolution

2048

Optional Differential Encoder (Internally Mounted)

Type

Internal, Magnetic

Resolution (Lines)

512

Resolution (Edges)

2048

Counters

Counter 1 (C1) Type

Position

Counter 2 (C2) Type

Encoder

Resolution

32 Bits

Maximum Edge Rate

5 MHz

Velocity

Range

±5,000,000 Steps/Sec.

Resolution

0.5961 Steps/Sec.

Acceleration/Deceleration

Range

1.5 x 10⁹ Steps/Sec.²

Resolution

90.9 Steps/Sec.²

* Microstep Resolution must be set to 2x the Encoder Counts/Rev minimum.

Table 1.2.5: MDrive17Plus Motion Specifications

Software Specifications

Program Storage Type/Size	Flash/6384 Bytes
User Registers	(4) 32 Bit
User Program Labels and Variables	192
Math, Logic and Conditional Functions	+, -, X, ÷, <, >, =, ≤, ≥, AND, OR, XOR, NOT
Branch Functions	Branch and Call (Conditional)
Party Mode Addresses	62
Encoder Functions	Stall Detect, Position Maintenance, Find Index
Predefined I/O Functions	
Input Functions	Home, Limit+, Limit -, Go, Stop, Pause, Jog+, Jog-, Analog Input
Output Functions	Moving, Fault, Stall, Velocity Changing
Trip Functions	Trip on Input, Trip on Position, Trip on Time, Trip Capture

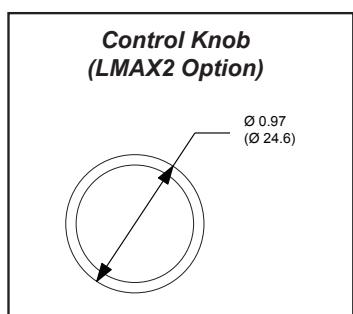
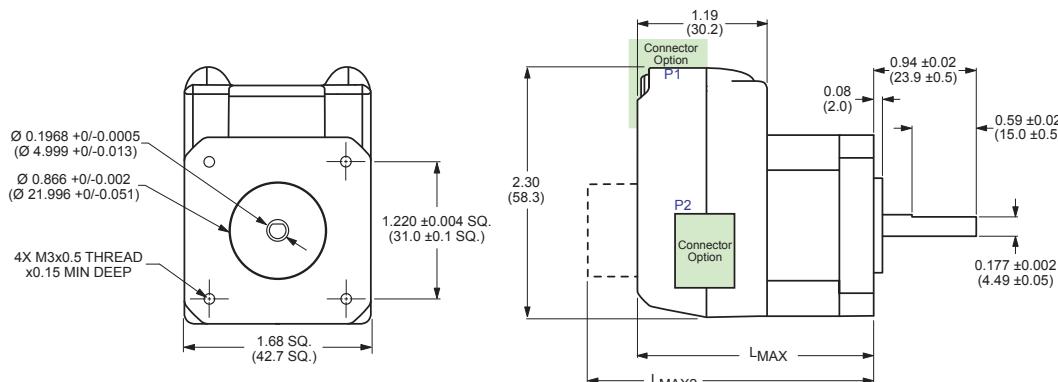
Table 1.2.6: MDrive17Plus Software Specifications

Motor Specifications	
Single Length	
Holding Torque	32 oz-in/22.6 N-cm
Detent Torque	1.66 oz-in/1.17 N-cm
Rotor Inertia	0.00053 oz-in-sec ² /0.038 kg-cm ²
Weight (Motor + Driver)	9.8 oz/277.8 g
Double Length	
Holding Torque	60 oz-in/42.46 N-cm
Detent Torque	2.08 oz-in/1.47 N-cm
Rotor Inertia	0.00080 oz-in-sec ² /0.057 kg-cm ²
Weight (Motor + Driver)	10.5 oz/297.7 g
Triple Length	
Holding Torque	74.9 oz-in/52.9 N-cm
Detent Torque	3.47 oz-in/2.45 N-cm
Rotor Inertia	0.00116 oz-in-sec ² /0.082 kg-cm ²
Weight (Motor + Driver)	15.1 oz/428.1 g

Table 1.2.7: MDrive17Plus Motor Specifications

Mechanical Specifications

Dimensions in Inches (mm)



Dimensions in inches (mm)		
Motor Length	LMAX1 (Single Shaft)	LMAX2 (Control Knob)
Single	2.20 (55.9)	2.79 (70.9)
Double	2.43 (61.7)	3.02 (76.7)
Triple	2.77 (70.4)	3.37 (85.6)

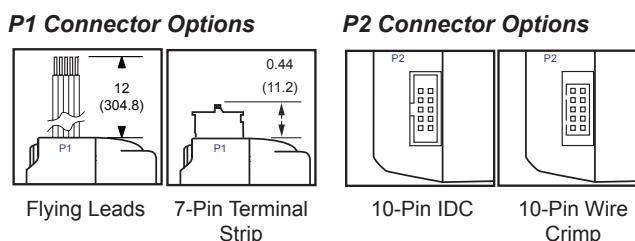


Figure 1.2.1: MDrive17Plus Mechanical Specifications

Pin Assignment And Description

P1 Connector - Power and I/O

Pin Assignment - P1 Power and I/O Connections

Flying Lead Wire Color	7-Pin Pluggable Terminal Strip	Function	Description
White/Yellow	Pin 1	I/O 1	0 to +24 VDC Programmable I/O Point 1
White/Orange	Pin 2	I/O 2	0 to +24 VDC Programmable I/O Point 2
White/Violet	Pin 3	I/O 3	0 to +24 VDC Programmable I/O Point 3
White/Blue	Pin 4	I/O 4	0 to +24 VDC Programmable I/O Point 4
Green	Pin 5	AIN	0 to 10 V / 4 to 20 mA / 0 to 20 mA Analog Input.
Black	Pin 6	GND	Power and Auxiliary Ground
Red	Pin 7	+V	+12 to +48 VDC Motor Power Supply input.

Table 1.2.8: P1 — Pin Assignment, Power and I/O

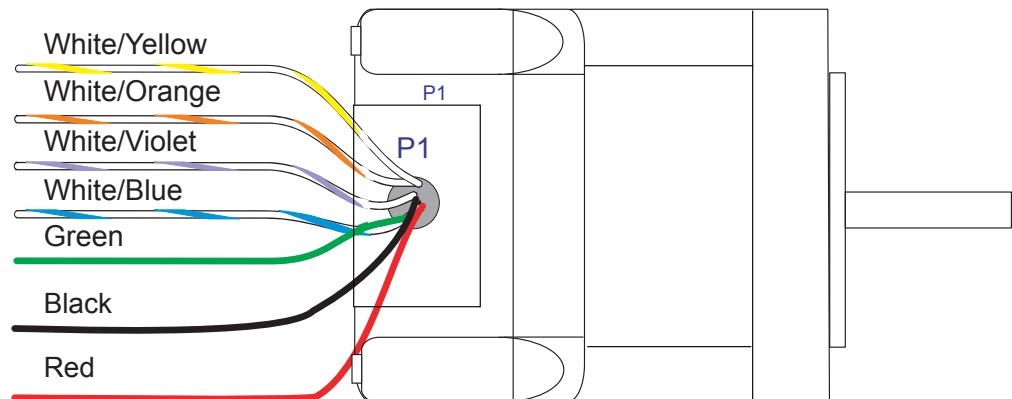


Figure 1.2.2: MDrive17Plus – Flying Leads - I/O and Power

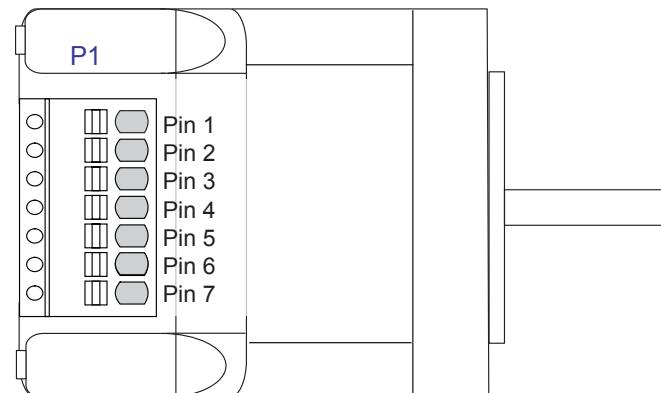


Figure 1.2.3: MDrive17Plus P1 Connector – 7-Pin Terminal Strip - I/O and Power

P2 Connector - RS-422/485 Communications

Pin Assignment - P2 RS-422/485 Communications

10-Pin IDC	10-Pin Wire Crimp	Function	Description
Pin 1	Pin 9	TX +	Transmit +: Connects to Receive + of the Communications Host.
Pin 2	Pin 10	TX -	Transmit -: Connects to Receive - of the Communications Host.
Pin 3	Pin 7	RX +	Receive +: Connects to Transmit + of the Communications Host.
Pin 4	Pin 8	RX -	Receive -: Connects to Transmit - of the Communications Host.
Pin 5	Pin 5	Aux-Logic	+12 to +24 VDC Auxiliary Logic Supply Input. This provides power to control and logic circuits if main power is removed.
Pin 6	Pin 6	RX +	Receive +: This point will typically be used to connect to RX+ of a second MDrivePlus for Multidrop Communications.
Pin 7	Pin 3	RX -	Receive -: This point will typically be used to connect to RX - of a second MDrivePlus for Multidrop Communications.
Pin 8	Pin 4	TX -	Transmit -: This point will typically be used to connect to TX - of a second MDrivePlus for Multidrop Communications.
Pin 9	Pin 1	TX +	Transmit +: This point will typically be used to connect to TX + of a second MDrivePlus for Multidrop Communications.
Pin 10	Pin 2	COMM GND	Communications Ground. This Ground is ONLY to be used to ground communications. Auxiliary Logic Supply must be grounded at the motor supply ground.
Recommended Converter/Cable	Recommended Converter/Cable	* For multi-drop communications systems IMS offers the PD10-1434-FL3 Prototype Development Cable. See Cables and Cordsets in the Appendices for more details.	
MD-CC400-000	MD-CC402-000		

Table 1.2.9: P2 — Pin Assignment, RS-422/485 Communications



WARNING! Because the MDrive17Plus Motion Control DOES NOT have a Pin

Configuration label on the body of the device please ensure that all wiring connections are cross-checked against these tables and figures.



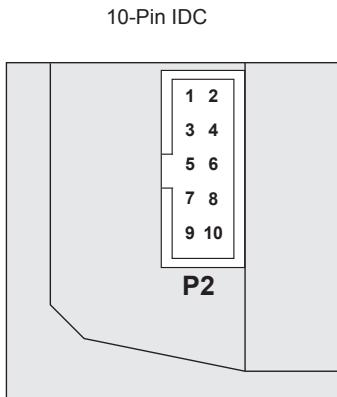
NEED A CABLE?
The following cables and converters are available to interface communications with P2:

USB to RS-422/485:

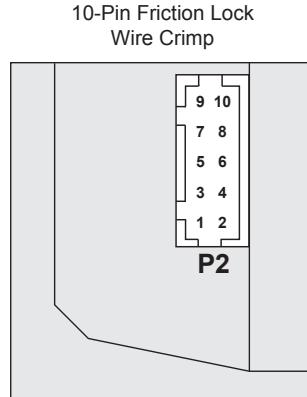
MD-CC400-001 10-Pin IDC)
MD-CC402-001 (10 Pin Wire-Crimp)

Multi-Drop for 10-Pin Wire Crimp Party-Mode

PD10-1434-FL3



Recommended Cable:
P/N MD-CC400-000



Recommended Cables:
P/N MD-CC402-000

Figure 1.2.4: P2 Connector - RS-422/485 Communications

Connectivity

QuickStart Kit

For rapid design verification, all-inclusive QuickStart Kits have communication converter, prototype development cable(s), instructions and CD for MDrivePlus initial functional setup and system testing.

Communication Converter Cables

These convenient 12.0' (3.6m) accessory cables connect a PC's USB Port to the MDrivePlus P2 Connector. An in-line RS-422 converter enables communications and programming to a single MDrivePlus Motion Control. Cable purchase recommended with first orders. Versions include:

USB to 10-Pin IDC	Part No. MD-CC401-001
USB to 10-Pin Wire Crimp	Part No. MD-CC402-001
Cable Assembly for Party-Mode	Part No. PD10-1434-FL3

Mating Connector Kits

Use to build your own cables. Kit contains 5 mating shells with pins. Cable not supplied. Manufacturer's crimp tool recommended.

Matches to connector:

10-Pin Wire Crimp CK-02

Kit contains 5 mating connectors that press fit onto ribbon cable. Cable not supplied.

10-Pin IDC..... CK-01

Options and Accessories

Control Knob

The MDrive17Plus Motion Control is available with a factory-mounted rear control knob for manual shaft positioning.

Planetary Gearbox

Efficient, low maintenance Planetary Gearboxes are offered assembled with the MDrive17Plus. (For specifications and details see Appendix C: MDrive17Plus Planetary Gearbox Specification.)

Internal Encoder

All MDrive17Plus Motion Control versions are available with an optional internal 512-line (2048 count) magnetic encoder with index mark.

Linear Slide

Integrated linear slides are available factory installed for precision linear movement. Screw pitches are 0.1", 0.2", 0.5" or 1.0" of travel per rev. Slides are 10.0" (25.4cm) to 36.0" (91.44cm) long. Contact factory for custom lengths.

SECTION 1.3

MDrive17Plus² Detailed Specifications

General Specifications

Electrical Specifications	
Input Voltage (+V) Range*	+12 to +48 VDC
Max Power Supply Current (Per MDrive17Plus)*	2 A
Aux-Logic Input Voltage**	+12 to +24 VDC
Max Aux-Logic Supply Current (Per MDrive17Plus)	161 mA

* Actual Power Supply Current will depend on Voltage and Load.

** Maintains power to control and feedback circuits [only] when input voltage is removed

Table 1.3.1: MDrive17Plus² Electrical Specifications

 **WARNING!**
The maximum
+48 VDC Input
Voltage of the
MDrive17Plus series includes
motor Back EMF, Power
Supply Ripple and High Line.

WARNING! Because the MDrivePlus consists of two core components, a drive and a motor, close attention must be paid to the thermal environment where the device is used. See Thermal Specifications.

Environmental Specifications		
Operating Temperature (non-condensing humidity)	Heat Sink	-40°C to +85°C
	Motor	-40°C to +100°C

Table 1.3.2: MDrive17Plus² Thermal Specifications

I/O Specifications	
General Purpose I/O - Number and Type	
Plus ² (I/O Points 1-4, 9-12)	8 I/O Points configurable as sinking or sourcing inputs or outputs
General Purpose I/O - Electrical	
Inputs	TTL up to +24 VDC
Sinking Outputs (All)	Up to +24 VDC
Sourcing Outputs (Plus ²)	+12 to +24 VDC
Output Sink Current (Plus)	up to 600 mA (One Channel)
Output Sink Current (Plus ²)	up to 600 mA (One Channel in each I/O Bank)
Logic Threshold (Logic 0)	< 0.8 VDC
Logic Threshold (Logic 1)	> 2.2 VDC
Protection (Sinking)	Over Temp, Short Circuit
Protection (Sourcing)	Transient Over Voltage, Inductive Clamp
Analog Input	
Resolution	10 Bit
Range (Voltage Mode)	0 to +5 VDC, 0 to +10 VDC
Range (Current Mode)	4 to 20 mA, 0 to 20mA
Clock I/O	
Types	Step/Direction, Up/Down, Quadrature
Logic Threshold	+5 VDC TTL Input, TTL Output (with 2 kΩ Load to Ground)
Trip Output/Capture Input	
Logic Threshold	+5 VDC TTL Input, TTL Output (with 2 kΩ Load to Ground)

Table 1.3.3: MDrive17Plus² I/O Specifications

Communications Specifications	
Protocol	RS-422/RS-485
BAUD Rate	4.8k, 9.6k, 19.2k, 38.4k, 115.2 kbps

Table 1.3.4: MDrive17Plus² Communications Specifications

Motion Specifications									
Microstep Resolution - Open Loop									
Number of Resolutions									20
Available Microsteps Per Revolution									
200	400	800	1000	1600	2000	3200	5000	6400	10000
12800	20000	25000	25600	40000	50000	51200	36000 ¹	21600 ²	25400 ³
1=0.01 deg/µstep 2=1 arc minute/µstep 3=0.001 mm/µstep									
Microstep Resolution - Closed Loop Configuration (Optional)									
Steps Per Revolution (Fixed)									51200
Position Resolution									2048
Optional Differential Encoder (Internally Mounted)									
Type									Internal, Magnetic
Resolution (Lines)									512
Resolution (Edges)									2048
Counters									
Counter 1 (C1) Type									Position
Counter 2 (C2) Type									Encoder
Resolution									32 Bits
Maximum Edge Rate									5 MHz
Velocity									
Range									±5,000,000 Steps/Sec.
Resolution									0.5961 Steps/Sec.
Acceleration/Deceleration									
Range									1.5 x 10 ⁹ Steps/Sec. ²
Resolution									90.9 Steps/Sec. ²
Electronic Gearing (Plus ² Only) ‡									
Range (Ratio)									0.001 to 2.000
Resolution									32 Bits
Voltage									+5 VDC Logic Level
Input Filter Range									50 nS to 12.9 µS
Secondary Output Clock Range									1 to 1
High Speed I/O (Plus ² Only)									
Position Capture Input - Resolution									32 Bits
Position Capture Input - Filtering									50 nS to 12.9 µS
Trip Output - Speed									150 nS
Trip Output - Resolution									32 Bits
Trip Output Voltage									+5 VDC Logic Level
Optional Remote Encoder (Plus ² Only)‡									
Type									User Defined Differential
Steps Per Revolution									See Microstep Resolution - Open Loop
Resolution									User Defined*

* Microstep Resolution must be set to 2x the Encoder Counts/Rev minimum.

‡With Optional Remote Encoder the Encoder Inputs replace I/O Points 9-12 and the Step/Direction Clock I/O Points. Electronic Gearing (following) is not available on remote encoder models.

Table 1.3.5: MDrive17Plus² Motion Specifications

Software Specifications	
Program Storage Type/Size	Flash/6384 Bytes
User Registers	(4) 32 Bit
User Program Labels and Variables	192
Math, Logic and Conditional Functions	+, -, X, ÷, <, >, =, ≤, ≥, AND, OR, XOR, NOT
Branch Functions	Branch and Call (Conditional)
Part Mode Addresses	62
Encoder Functions	Stall Detect, Position Maintenance, Find Index
Predefined I/O Functions	
Input Functions	Home, Limit+, Limit -, Go, Stop, Pause, Jog+, Jog-, Analog Input
Output Functions	Moving, Fault, Stall, Velocity Changing
Trip Functions	Trip on Input, Trip on Position, Trip on Time, Trip Capture

Table 1.3.6: MDrive17Plus² Software Specifications

Motor Specifications	
Single Length	
Holding Torque	32 oz-in/22.6 N-cm
Detent Torque	1.66 oz-in/1.17 N-cm
Rotor Inertia	0.00053 oz-in-sec ² /0.038 kg-cm ²
Weight (Motor + Driver)	9.8 oz/277.8 g
Double Length	
Holding Torque	60 oz-in/42.46 N-cm
Detent Torque	2.08 oz-in/1.47 N-cm
Rotor Inertia	0.00080 oz-in-sec ² /0.057 kg-cm ²
Weight (Motor + Driver)	10.5 oz/297.7 g
Triple Length	
Holding Torque	74.9 oz-in/52.9 N-cm
Detent Torque	3.47 oz-in/2.45 N-cm
Rotor Inertia	0.00116 oz-in-sec ² /0.082 kg-cm ²
Weight (Motor + Driver)	15.1 oz/428.1 g

Table 1.3.7: MDrive17Plus² Motor Specifications

Mechanical Specifications

Dimensions in Inches (mm)

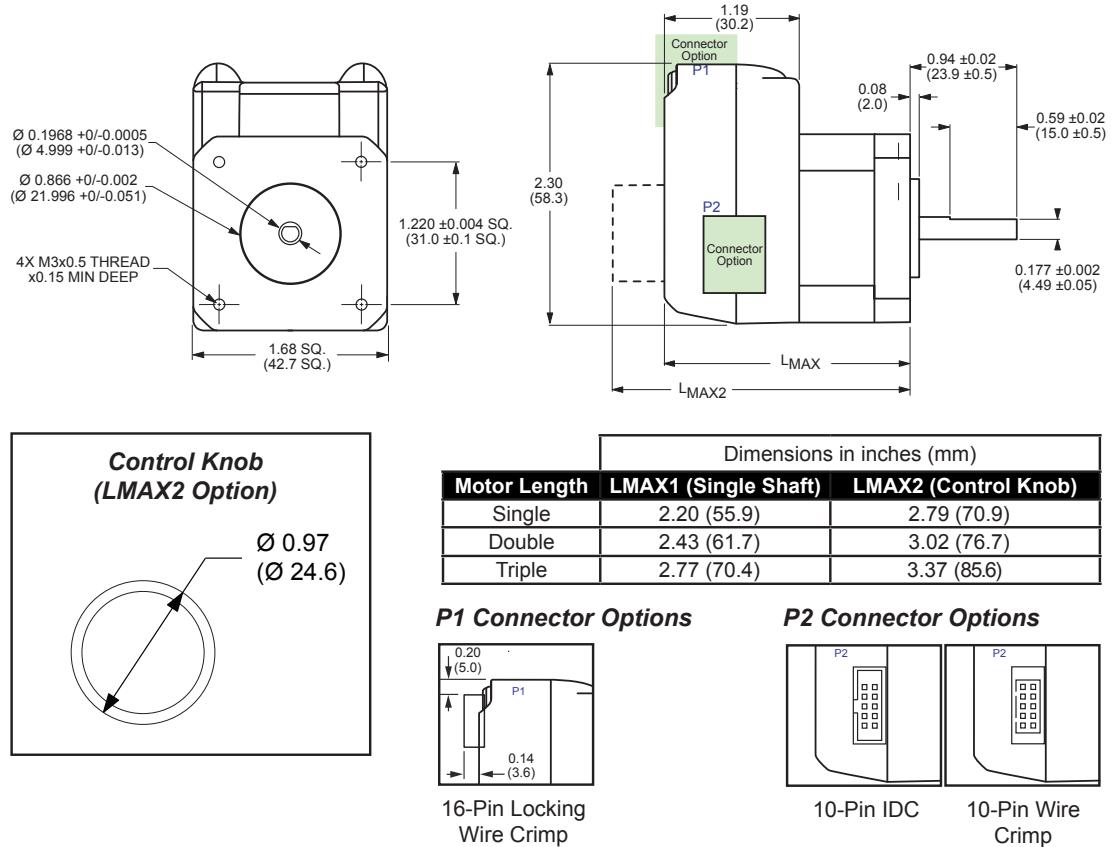


Figure 1.3.1: MDrive17Plus² Mechanical Specifications

Pin Assignment And Description

P1 Connector - Power and I/O, Expanded I/O Configuration

P1 - Expanded I/O Configuration		
16-Pin Wire Crimp	Function	Description
Pin 1	I/O PWR	I/O Power, used with sourcing inputs or outputs. See Section 2.3 for more details.
Pin 2	I/O GND	Non-isolated I/O Ground. Common with Power Ground.
Pin 3	I/O 1	0 to +24 VDC Programmable I/O Point 1
Pin 4	I/O 2	0 to +24 VDC Programmable I/O Point 2
Pin 5	I/O 3	0 to +24 VDC Programmable I/O Point 3
Pin 6	I/O 4	0 to +24 VDC Programmable I/O Point 4
Pin 7	I/O 9	0 to +24 VDC Programmable I/O Point 9
Pin 8	I/O 10	0 to +24 VDC Programmable I/O Point 10
Pin 9	I/O 11	0 to +24 VDC Programmable I/O Point 11
Pin 10	I/O 12	0 to +24 VDC Programmable I/O Point 12
Pin 11	Capture/Trip I/O	High Speed Capture Input or Trip Output. +5 VDC Logic Level.
Pin 12	AIN	0 to 10 V / 4 to 20 mA / 0 to 20 mA Analog Input.
Pin 13	SCLK	Step Clock I/O. Can also be configured as Quadrature or Clock Up/Down. +5 VDC Logic Level.
Pin 14	DIR	Direction I/O. Can also be configured as Quadrature or Clock Up/Down. +5 VDC Logic Level.
Pin 15	+V	+12 to +48 VDC Motor Power Supply Input.
Pin 16	GND	Power and Auxiliary Ground

Recommended Cable

PD16-1417-FL3 - See Appendix G for Details

Table 1.3.8: P1 — Pin Assignment, Expanded I/O Configuration

P1 Connector - Power and I/O, Remote Encoder Configuration

P1 - Expanded I/O Configuration		
16-Pin Wire Crimp	Function	Description
Pin 1	I/O PWR	I/O Power, used with sourcing inputs or outputs. See Section 2.3 for more details.
Pin 2	I/O GND	Non-isolated I/O Ground. Common with Power Ground.
Pin 3	I/O 1	0 to +24 VDC Programmable I/O Point 1
Pin 4	I/O 2	0 to +24 VDC Programmable I/O Point 2
Pin 5	I/O 3	0 to +24 VDC Programmable I/O Point 3
Pin 6	I/O 4	0 to +24 VDC Programmable I/O Point 4
Pin 7	Channel A +	Encoder Channel Channel A + Input. +5 VDC Logic Level.
Pin 8	Channel A -	Encoder Channel Channel A - Input. +5 VDC Logic Level.
Pin 9	Channel B +	Encoder Channel Channel B + Input. +5 VDC Logic Level.
Pin 10	Channel B -	Encoder Channel Channel B - Input. +5 VDC Logic Level.
Pin 11	Capture/Trip I/O	High Speed Capture Input or Trip Output. +5 VDC Logic Level.
Pin 12	AIN	0 to 10 V / 4 to 20 mA / 0 to 20 mA Analog Input.
Pin 13	Index +	Encoder Index + Input. +5 VDC Logic Level.
Pin 14	Index -	Encoder Index - Input. +5 VDC Logic Level.
Pin 15	+V	+12 to +48 VDC Motor Power Supply Input.
Pin 16	GND	Power and Auxiliary Ground

Recommended Cable

PD16-1417-FL3 - See Appendix G for Details

Table 1.3.9: P1 — Pin Assignment, Remote Encoder Configuration



WARNING! Because the MDrive17Plus² Motion Control DOES NOT have a Pin Configuration label on the body of the device please ensure that all wiring connections are cross-checked against these tables.



WARNING! Ensure proper orientation of P1, Pin 1 when creating your own cabling!



NEED A CABLE?
The following Prototype Development cable is available to interface Power and I/O:

Flying Leads to 16-Pin Connector
PD16-1417-FL3

See Appendix F for description and wire color chart.

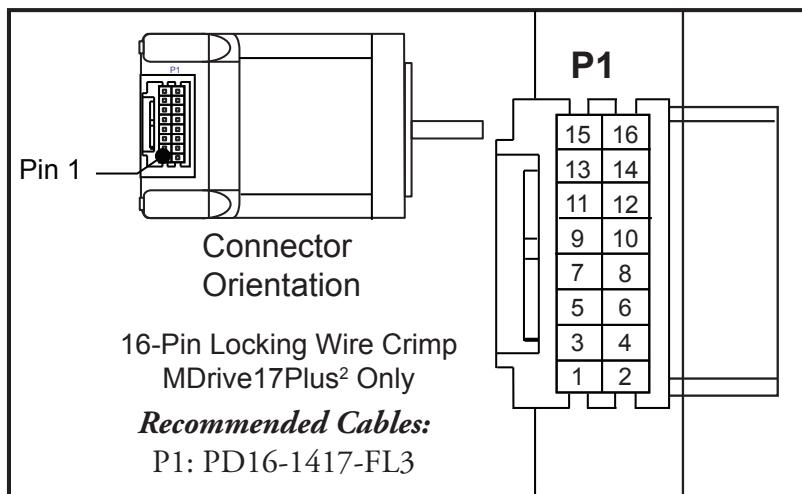
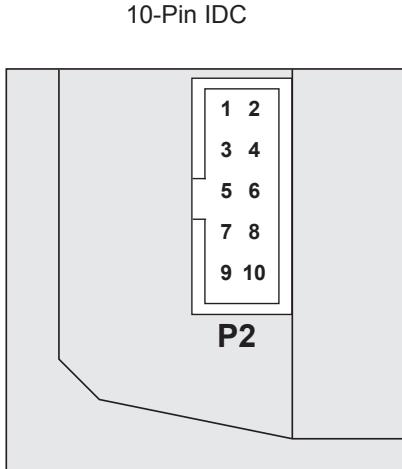


Figure 1.3.2: P1 Connector, Power and I/O

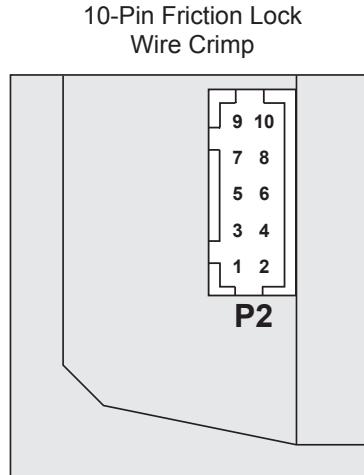
P2 Connector - RS-422/485 Communications

Pin Assignment - P2 RS-422/485 Communications			
10-Pin IDC	10-Pin Wire Crimp	Function	Description
Pin 1	Pin 9	TX +	Transmit +: Connects to Receive + of the Communications Host.
Pin 2	Pin 10	TX -	Transmit -: Connects to Receive - of the Communications Host.
Pin 3	Pin 7	RX +	Receive +: Connects to Transmit + of the Communications Host.
Pin 4	Pin 8	RX -	Receive -: Connects to Transmit - of the Communications Host.
Pin 5	Pin 5	Aux-Logic	+12 to +24 VDC Auxiliary Logic Supply Input. This provides power to control and logic circuits if main power is removed.
Pin 6	Pin 6	RX +	Receive +: This point will typically be used to connect to RX+ of a second MDrivePlus for Multidrop Communications.
Pin 7	Pin 3	RX -	Receive -: This point will typically be used to connect to RX - of a second MDrivePlus for Multidrop Communications.
Pin 8	Pin 4	TX -	Transmit -: This point will typically be used to connect to TX - of a second MDrivePlus for Multidrop Communications.
Pin 9	Pin 1	TX +	Transmit +: This point will typically be used to connect to TX + of a second MDrivePlus for Multidrop Communications.
Pin 10	Pin 2	COMM GND	Communications Ground. This Ground is ONLY to be used to ground communications. Auxiliary Logic Supply must be grounded at the motor supply ground.
Recommended Converter/Cable	Recommended Converter/Cable	* For multi-drop communications systems IMS offers the PD10-1434-FL3 Prototype Development Cable. See Cables and Cordsets in the Appendices for more details.	
MD-CC400-000	MD-CC402-000		

Table 1.3.10: P2 — Pin Assignment, RS-422/485 Communications



Recommended Cable:
P/N MD-CC400-000



Recommended Cables:
P/N MD-CC402-000



NEED A CABLE?
The following cables
and converters are
available to interface
communications with
P2:

USB to RS-422/485:
MD-CC400-001 (10-Pin IDC)
MD-CC402-001 (10-Pin Wire
Crimp)

**Multi-Drop for 10-Pin Wire Crimp
Party-Mode**
PD10-1434-FL3

See Appendix F for details.

Figure 1.3.3: P2 Connector - RS-422/485 Communications

Connectivity

QuickStart Kit

For rapid design verification, all-inclusive QuickStart Kits have communication converter, prototype development cable(s), instructions and CD for MDrivePlus initial functional setup and system testing.

Communication Converter Cables

These convenient 12.0' (3.6m) accessory cables connect a PC's USB Port to the MDrive17Plus² P2 Connector. An in-line RS-422 converter enables parameter setting to a single MDrive17Plus² Motion Control. Cable purchase recommended with first orders. Versions include:

USB to 10-Pin IDC	Part No. MD-CC400-001
USB to 10-Pin Wire Crimp	Part No. MD-CC402-001
Cable Assembly for Party-Mode	Part No. PD10-1434-FL3

Prototype Development Cable

To speed prototyping of Plus² versions, IMS recommends the following 10' (3m) interface cable with first orders:

16-pin Wire Crimp Cable	Part No. PD16-1417-FL3
-------------------------------	------------------------

Mating Connector Kits

Use to build your own cables. Kit contains 5 mating shells with pins. Cable not supplied.

Manufacturer's crimp tool recommended.

Matte to connector:

10-Pin Wire Crimp	CK-02
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Kit contains 5 mating connectors that press fit onto ribbon cable. Cable not supplied.

10-Pin IDC	CK-01
------------------	-------

16-Pin Wire Crimp	CK-10
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Options and Accessories

Control Knob

The MDrive17Plus² Motion Control is available with a factory-mounted rear control knob for manual shaft positioning.

Planetary Gearbox

Efficient, low maintenance Planetary Gearboxes are offered assembled with the MDrive17Plus² (For specifications and details see Appendix C: MDrive17Plus Planetary Gearbox Specification.)

Encoder

The MDrive17Plus² Motion Control is available with an internal 512-line (2048 count) magnetic encoder with index mark.

Remote Encoder

The MDrive17Plus² Motion Control is available with differential encoder inputs for use with a remotely mounted encoder (not supplied).

Linear Slide

Integrated linear slides are available factory installed for precision linear movement. Screw pitches are 0.1", 0.2", 0.5" or 1.0" of travel per rev. Slides are 10.0" (25.4cm) to 36.0" (91.44cm) long. Contact factory for custom lengths.

SECTION 1.4

MDrive17Plus²-65 Detailed Specifications

General Specifications

Electrical Specifications	
Input Voltage (+V) Range*	+12 to +48 VDC
Max Power Supply Current (Per MDrive17Plus)*	2 A
Aux-Logic Input Voltage**	+12 to +24 VDC
Max Aux-Logic Supply Current (Per MDrive17Plus)	161 mA

* Actual Power Supply Current will depend on Voltage and Load.

** Maintains power to control and feedback circuits [only] when input voltage is removed

Table 1.4.1: MDrive17Plus²-65 Electrical Specifications

 **WARNING!** The maximum +48 VDC Input Voltage of the MDrive17Plus series includes motor Back EMF, Power Supply Ripple and High Line.

 **WARNING!** Because the MDrivePlus consists of two core components, a drive and a motor, close attention must be paid to the thermal environment where the device is used. See Thermal Specifications.

Environmental Specifications		
Operating Temperature (non-condensing humidity)	Heat Sink	-40°C to +85°C
	Motor	-40°C to +100°C
Sealing (Sealed against Dust, Water Jets)		IP65

Table 1.4.2: MDrive17Plus²-65 Environmental and Thermal Specifications

I/O Specifications	
General Purpose I/O - Number and Type	
Plus ² (I/O Points 1-4, 9-12)	8 I/O Points configurable as sinking or sourcing inputs or outputs
General Purpose I/O - Electrical	
Inputs	TTL up to +24 VDC
Sinking Outputs (All)	Up to +24 VDC
Sourcing Outputs (Plus ²)	+12 to +24 VDC
Output Sink Current (Plus)	up to 600 mA (One Channel)
Output Sink Current (Plus ²)	up to 600 mA (One Channel in each I/O Bank)
Logic Threshold (Logic 0)	< 0.8 VDC
Logic Threshold (Logic 1)	> 2.2 VDC
Protection (Sinking)	Over Temp, Short Circuit
Protection (Sourcing)	Transient Over Voltage, Inductive Clamp
Analog Input	
Resolution	10 Bit
Range (Voltage Mode)	0 to +5 VDC, 0 to +10 VDC
Range (Current Mode)	4 to 20 mA, 0 to 20mA
Clock I/O	
Types	Step/Direction, Up/Down, Quadrature
Logic Threshold	TTL Input, TTL Output (with 2 kΩ Load to Ground)
Trip Output/Capture Input	
Logic Threshold	TTL Input, TTL Output (with 2 kΩ Load to Ground)

Table 1.4.3: MDrive17Plus²-65 I/O Specifications

Communications Specifications	
Protocol	RS-422/RS-485
BAUD Rate	4.8k, 9.6k, 19.2k, 38.4k, 115.2 kbps

Table 1.4.4: MDrive17Plus²-65 Communications Specifications

Motion Specifications									
Microstep Resolution - Open Loop									
Number of Resolutions	20								
Available Microsteps Per Revolution									
200	400	800	1000	1600	2000	3200	5000	6400	10000
12800	20000	25000	25600	40000	50000	51200	36000 ¹	21600 ²	25400 ³
$1 = 0.01 \text{ deg}/\mu\text{step}$									
$2 = 1 \text{ arc minute}/\mu\text{step}$									
$3 = 0.001 \text{ mm}/\mu\text{step}$									
Microstep Resolution - Closed Loop Configuration (Optional)									
Steps Per Revolution (Fixed)	51200								
Position Resolution	2048								
Optional Differential Encoder (Internally Mounted)									
Type	Internal, Magnetic								
Resolution (Lines)	512								
Resolution (Edges)	2048								
Counters									
Counter 1 (C1) Type	Position								
Counter 2 (C2) Type	Encoder								
Resolution	32 Bits								
Maximum Edge Rate	5 MHz								
Velocity									
Range	$\pm 5,000,000 \text{ Steps/Sec.}$								
Resolution	0.5961 Steps/Sec.								
Acceleration/Deceleration									
Range	$1.5 \times 10^9 \text{ Steps/Sec.}^2$								
Resolution	90.9 Steps/Sec. ²								
Electronic Gearing (Plus² Only)‡									
Range (Ratio)	0.001 to 2.000								
Resolution	32 Bits								
Voltage	+5 VDC Logic Level								
Input Filter Range	50 nS to 12.9 μ S								
Secondary Output Clock Range	1 to 1								
High Speed I/O (Plus² Only)									
Position Capture Input - Resolution	32 Bits								
Position Capture Input - Filtering	50 nS to 12.9 μ S								
Trip Output - Speed	150 nS								
Trip Output - Resolution	32 Bits								
Trip Output Voltage	+5 VDC Logic Level								
Optional Remote Encoder (Plus² Only)‡									
Type	User Defined Differential								
Steps Per Revolution	See Microstep Resolution - Open Loop								
Resolution	User Defined*								

* Microstep Resolution must be set to 2x the Encoder Counts/Rev minimum.

‡With Optional Remote Encoder the Encoder Inputs replace I/O Points 9-12 and the Step/Direction Clock I/O Points. Electronic Gearing (following) is not available on Remote Encoder models.

Table 1.4.5: MDrive17Plus²-65 Motion Specifications

Software Specifications	
Program Storage Type/Size	Flash/6384 Bytes
User Registers	(4) 32 Bit
User Program Labels and Variables	192
Math, Logic and Conditional Functions	+, -, x, ÷, <, >, =, ≤, ≥, AND, OR, XOR, NOT
Branch Functions	Branch and Call (Conditional)
Part Mode Addresses	62
Encoder Functions	Stall Detect, Position Maintenance, Find Index
Predefined I/O Functions	
Input Functions	Home, Limit+, Limit -, Go, Stop, Pause, Jog+, Jog-, Analog Input
Output Functions	Moving, Fault, Stall, Velocity Changing
Trip Functions	Trip on Input, Trip on Position, Trip on Time, Trip Capture

Table 1.4.6: MDrive17Plus²-65 Software Specifications

Motor Specifications	
Single Length	
Holding Torque	32 oz-in/22.6 N-cm
Detent Torque	1.66 oz-in/1.17 N-cm
Rotor Inertia	0.00053 oz-in-sec ² /0.038 kg-cm ²
Weight (Motor + Driver)	9.8 oz/277.8 g
Double Length	
Holding Torque	60 oz-in/42.46 N-cm
Detent Torque	2.08 oz-in/1.47 N-cm
Rotor Inertia	0.00080 oz-in-sec ² /0.057 kg-cm ²
Weight (Motor + Driver)	10.5 oz/297.7 g
Triple Length	
Holding Torque	74.9 oz-in/52.9 N-cm
Detent Torque	3.47 oz-in/2.45 N-cm
Rotor Inertia	0.00116 oz-in-sec ² /0.082 kg-cm ²
Weight (Motor + Driver)	15.1 oz/428.1 g

Table 1.4.7: MDrive17Plus²-65 Motor Specifications

Mechanical Specifications

Dimensions in Inches (mm)

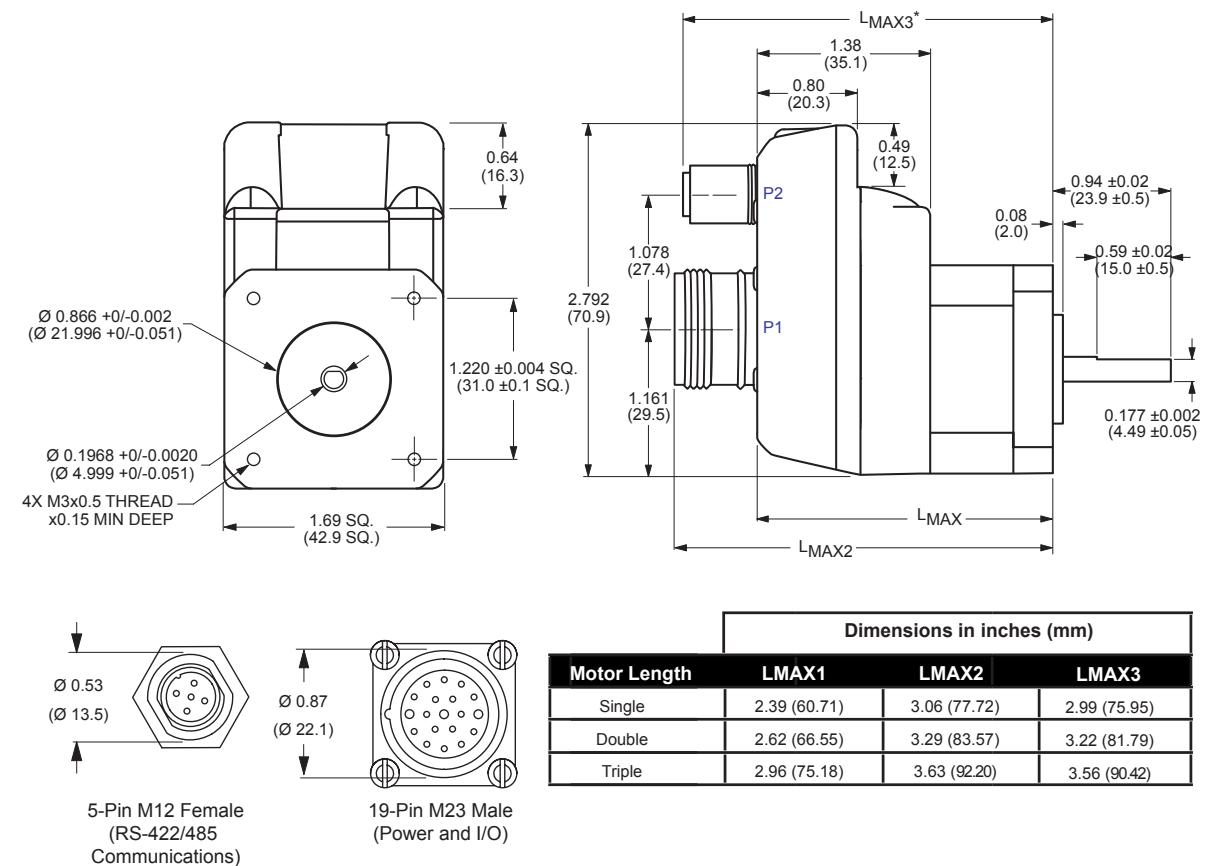


Figure 1.4.1: MDrive17Plus2-65 Motion Control

Pin Assignment and Description

P1 Connector - I/O and Power Connections, Expanded I/O Configuration

P1 - Expanded I/O Configuration		
19-Pin M23	Function	Description
Pin 1	I/O 9	0 to +24 VDC Programmable I/O Point 9.
Pin 2	I/O 11	0 to +24 VDC Programmable I/O Point 11.
Pin 3	SCLK	Step Clock I/O. Can also be configured as Quadrature or Clock Up/Down. +5 VDC Logic Level.
Pin 4	I/O 1	0 to +24 VDC Programmable I/O Point 1.
Pin 5	DIR	Direction I/O. Can also be configured as Quadrature or Clock Up/Down. +5 VDC Logic Level.
Pin 6	+V	+12 to +48 VDC Motor Power Supply Input.
Pin 7	Aux-Logic	+12 to +24 VDC Auxiliary Logic Supply Input. This provides power to control and logic circuits if main power is removed.
Pin 8	Aux-Ground	Auxiliary Ground.
Pin 9	I/O 3	0 to +24 VDC Programmable I/O Point 3.
Pin 10	I/O GND	Non-isolated I/O Ground. Common with Power Ground.
Pin 11	I/O PWR	I/O Power, used with sourcing inputs or outputs. See Section 2.3 for more details.
Pin 12	Earth Ground	Earth Ground, Connects to connector shell.
Pin 13	I/O 12	0 to +24 VDC Programmable I/O Point 12.
Pin 14	Capture/Trip I/O	High Speed Capture Input or Trip Output. +5 VDC Logic Level.
Pin 15	AIN	0 to 10 V / 4 to 20 mA / 0 to 20 mA Analog Input.
Pin 16	I/O 2	0 to +24 VDC Programmable I/O Point 2.
Pin 17	I/O 4	0 to +24 VDC Programmable I/O Point 4.
Pin 18	I/O 10	0 to +24 VDC Programmable I/O Point 10.
Pin 19	GND	Power Ground.
Recommended Cordset		
MD-CS100-000 or MD-CS101-000		

Table 1.4.8: P1 — Pin Assignment, Expanded I/O Configuration



NEED A CABLE?
The following cordset is available to interface to the 19-Pin M23 Connector:

Straight Termination
MD-CS100-000

Right Angle Termination
MD-CS-101-000

See Appendix F for details.

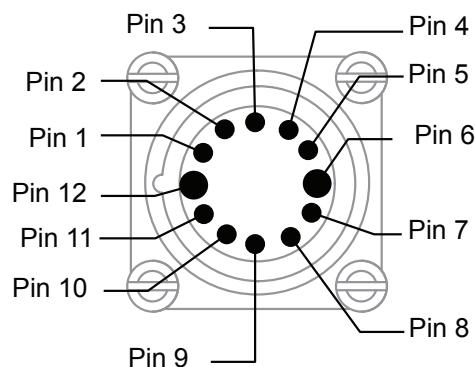
P1 Connector - I/O and Power Connections, Remote Encoder Configuration

P1 - Expanded I/O Configuration		
19-Pin M23	Function	Description
Pin 1	Channel A +	Encoder Channel Channel A + Input. +5 VDC Logic Level.
Pin 2	Channel B +	Encoder Channel Channel B + Input. +5 VDC Logic Level.
Pin 3	Index +	Encoder Index + Input. +5 VDC Logic Level.
Pin 4	I/O 1	0 to +24 VDC Programmable I/O Point 1.
Pin 5	Index –	Encoder Index – Input. +5 VDC Logic Level.
Pin 6	+V	+12 to +48 VDC Motor Power Supply Input.
Pin 7	Aux-Logic	+12 to +24 VDC Auxiliary Logic Supply Input. This provides power to control and logic circuits if main power is removed.
Pin 8	Aux-Ground	Auxiliary Ground.
Pin 9	I/O 3	0 to +24 VDC Programmable I/O Point 3.
Pin 10	I/O GND	Non-isolated I/O Ground. Common with Power Ground.
Pin 11	I/O PWR	I/O Power, used with sourcing inputs or outputs. See Section 2.3 for more details.
Pin 12	Earth Ground	Earth Ground, Connects to connector shell.
Pin 13	Channel B –	Encoder Channel Channel B – Input. +5 VDC Logic Level.
Pin 14	Capture/Trip I/O	High Speed Capture Input or Trip Output. +5 VDC Logic Level.
Pin 15	AIN	0 to 10 V / 4 to 20 mA / 0 to 20 mA Analog Input.
Pin 16	I/O 2	0 to +24 VDC Programmable I/O Point 2.
Pin 17	I/O 4	0 to +24 VDC Programmable I/O Point 4.
Pin 18	Channel A –	Encoder Channel Channel A – Input. +5 VDC Logic Level.
Pin 19	GND	Power Ground.

Recommended Cordset
MD-CS100-000 or MD-CS101-000

Table 1.4.9: P1 — Pin Assignment, Remote Encoder Configuration

Outside: Pins 1 -12



Inside: Pins 13 - 19

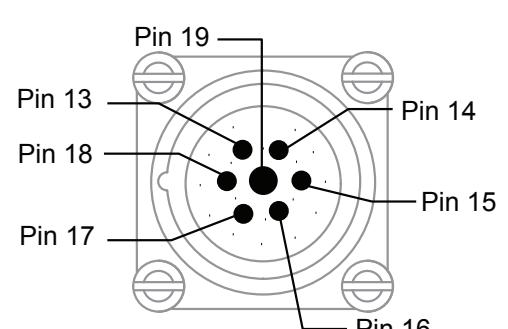


Figure 1.4.2: MDrive17Plus²-65 P1 Connector, Power and I/O

P2 Connector - RS-422/485 Communications

Pin Assignment - P2 RS-422/485 Communications		
10-Pin IDC	Function	Description
Pin 1	TX –	Transmit –: This point will typically be used to connect to TX – of a second MDrivePlus for Multidrop Communications.
Pin 2	TX +	Transmit +: Connects to Receive + of the Communications Host.
Pin 3	RX +	Receive +: Connects to Transmit + of the Communications Host.
Pin 4	RX –	Receive –: Connects to Transmit – of the Communications Host.
Pin 5	COMM GND	Communications Ground. This Ground is ONLY to be used to ground communications. Auxiliary Logic Supply must be grounded at the motor supply ground.
Recommended Converter/Cable		
MD-CC401-000		

N Note: To reduce wiring time, please order Part# MD-CC401-000, the USB to M12 accessory cable with inline RS-422 Converter.

Table 1.4.10: MDrive17Plus² -65 P2 Connector, RS-422/RS-485 Communications

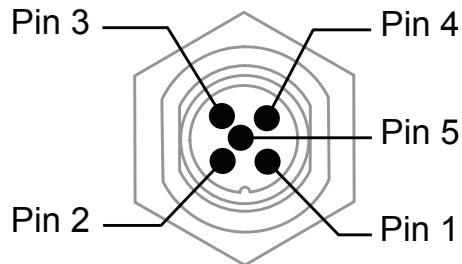


Figure 1.4.3: MDrive17Plus² -65 P2 Connector, RS-422/RS-485 Communications



NEED A CABLE?
The following communications converter/cable is available:

USB to RS-422/485 Converter
MD-CC401-001

See Appendix F for details.

Connectivity

QuickStart Kit

For rapid design verification, all-inclusive QuickStart Kits have communication converter, prototype development cable(s), instructions

Communication Converter Cable

This convenient 12.0' (3.6m) accessory cable connects a PC's USB Port to the MDrive17Plus²-65 P2 5-Pin M12 Connector. An in-line RS-422 converter enables parameter setting to a single MDrive17Plus²-65 Motion Control. Cable purchase recommended with first orders.

USB to M12 Circular (sealed version)..... Part No. MD-CC401-001

Cordsets

19-Pin M23 single-ended cordsets are offered to speed prototyping of MDrive17Plus²-65 Motion Control units. Measuring 13.0' (4.0m) long, they are available in either straight or right angle termination and attach to the MDrivePlus P1 Connector. PVC jacketed cables come with a foil shield and unconnected drain wire.

Straight Termination..... Part No. MD-CS100-000
Right Angle Termination Part No. MD-CS101-000

Options and Accessories

Planetary Gearbox

Efficient, low maintenance Planetary Gearboxes are offered assembled with the MDrive17Plus²-65 (For specifications and details see Appendix D: MDrive17Plus Planetary Gearbox Specification.)

Encoder

The MDrive17Plus²-65 Motion Control is available with an internal 512-line (2048 count) magnetic encoder with index mark.

SECTION 1.5

MDrive23Plus Motion Control Product Introduction



Note: The MDrivePlus Motion Control is available in a CAN communications configuration. For more information and Hardware Specifications see Appendix H of this document.



Introduction to the MDrive23Plus Motion Control System

The MDrive23Plus Motion Control offers system designers a low cost, intelligent motion controller integrated with a NEMA 23 high torque brushless motor and a +12 to +75* volt microstepping driver.

The unsurpassed smoothness and performance delivered by the MDrive23Plus Motion Control are achieved through IMS's advanced 2nd generation current control. By applying innovative techniques to control current flow through the motor, resonance is significantly damped over the entire speed range and audible noise is reduced.

The MDrive23Plus accepts a broad input voltage range from +12 to +75* VDC, delivering enhanced performance and speed. Oversized input capacitors are used to minimize power line surges, reducing problems that can occur with long runs and multiple drive systems. An extended operating temperature range of -40° to +85°C provides long life, trouble free service in demanding environments.

Standard features available in the MDrive23Plus Motion Control include four +5 to +24 volt general purpose I/O lines, one 10 bit analog input, 0 to 5MHz step clock rate, 20 microstep resolutions up to 51,200 steps per revolution, and full featured easy-to-program instruction set.

Expanded features in the MDrive23Plus² version include up to eight +5 to +24 volt general purpose I/O lines and the capability of electronic gearing by following a rotary or linear axis at an electronically controlled ratio, or an output clock can be generated fixed to the internal step clock.

For use in environments where exposure to chemical, dust and liquids may occur, a sealed assembly MDrive-23Plus²-65 version is designed to meet IP65 specifications.

All MDrive23Plus Motion Control are available with optional closed loop control. This increases functionality by adding stall detection, position maintenance and find index mark.

The closed loop configuration is added via a 512 line (2048 edge) magnetic encoder with index mark, internal to the unit so there is no increase in length. Or, for an expanded choice of line counts and resolutions with MDrive23Plus² versions only, closed loop control is available with an interface to a remotely mounted user-supplied external encoder.

The MDrive communicates over RS-422/485 which allows for point-to-point or multiple unit configurations utilizing one communication port. Addressing and hardware support up to 62 uniquely addressed units communicating over a single line. Baud rate is selectable from 4.8 to 115.2kbps.

Available motor configurations include a single shaft rotary motor and a linear actuator with long life Acme screw. Rotary versions are available in three motor lengths. Interface connections are accomplished using 12.0" (30.5cm) flying leads or a 7 position terminal strip. Plus² versions come with pluggable locking wire crimp connectors. Plus²-65 sealed versions come with M12/M23 circular connectors.

The MDrive23Plus is a compact, powerful and inexpensive solution that will reduce system cost, design and assembly time for a large range of brushless motor applications

* 12-75 VDC single, double & triple length motors;

12-60 VDC quad length motor.



Figure 1.5.1: MDrive23Plus



Figure 1.5.2: MDrive23Plus²-65

Standard Feature Summary

- Highly Integrated Microstepping Driver, Motion Controller and NEMA 23 High Torque Brushless Motor
- Advanced 2nd Generation Current Control for Exceptional Performance and Smoothness
- Single Supply: +12 to +75* VDC
- Low Cost
- Extremely Compact
- Available Options:
 - Long Life Linear Actuator

- Internal Magnetic Encoder for Closed Loop Control
- Integrated Planetary Gearbox
- Control Knob for Manual Positioning
- Linear Slide
- Three Rotary Motor Lengths Available
- Auxiliary Logic Power Supply Input
- 20 Microstep Resolutions up to 51,200 Steps Per Rev Including: Degrees, Metric, Arc Minutes
- Open or Optional Closed Loop Control
- Programmable Motor Run and Hold Currents
- Four +5 to +24 VDC I/O Lines Accept Sourcing or Sinking Outputs
- One 10 Bit Analog Input Selectable: 0 to +10VDC, 0 to +5VDC, 0-20 mA, 4-20 mA
- 0 to 5MHz Step Clock Rate Selectable in 0.59Hz Increments
- RS-422/485 Communications
- 62 Software Addresses for Multi-Drop Communications
- Simple 1 to 2 Character Instructions
- Interface Options:
 - Pluggable Terminal Strip
 - 12.0" (30.5cm) Flying Leads

* 12-75 VDC single, double & triple length motors;

12-60 VDC quad length motor.

The MDrive23Plus Motion Control Key Differences and Enhanced Features

There are three different variants of the MDrive23Plus Motion Control, these are:

1. MDrive23Plus Motion Control

The MDrive23Plus Motion Control is the standard version of the MDrive23Plus and is drop-in compatible with the legacy MDrive23 Motion Control product. The key feature additions from the original MDrive23 Motion Control are:

- Improved current control.
- 20 Microstep resolutions to 51,200 steps per rev including degrees, metric and arc minutes.
- 4 +5 to +24 VDC I/O lines which accept sinking or sourcing inputs.
- One 0 to +10 VDC Analog input.
- Optional pluggable strip for interface.

See Section 1.6 of this document for detailed specifications on the MDrive23Plus Motion Control.

2. MDrive23Plus2 Motion Control

The MDrive23Plus² Motion Control adds expanded functionality to the MDrive23Plus in the form of:

- Enhanced and expanded I/O set (8 lines) which can be configured as sinking or sourcing inputs or outputs.
- Remote Encoder option (Reduces I/O set to 4 lines).
- High speed position capture input or trip output.
- 14-pin locking wire crimp interface for I/O (P1).
- 2-pin locking wire crimp for power.
- Electronic gearing.

See Section 1.7 of this document for detailed specifications on the MDrive23Plus² Motion Control.

3. MDrive23Plus2-65 Motion Control

The MDrive23Plus²-65 Motion Control adds protection against the ingress of fluids and dust to the MDrive23Plus² by changing the motor-drive enclosure to meet IP65 specifications. With this change the connector configuration changes to industry standard M12/M23 circular connectors.

See Section 1.8 of this document for detailed specifications on the MDrive23Plus²-65 Motion Control.

SECTION 1.6

MDrive23Plus Detailed Specifications

Electrical Specifications

Input Voltage (+V) Range* (Single, Double and Triple Length)	+12 to +75 VDC
Input Voltage (+V) Range* (Quad Length)	+12 to +60 VDC
Max Power Supply Current (Per MDrive23Plus)*	2 A
Aux-Logic Input Voltage**	+12 to +24 VDC
Max Aux-Logic Supply Current (Per MDrive23Plus)	194 mA

* Actual Power Supply Current will depend on Voltage and Load.

** Maintains power to control and feedback circuits [only] when input voltage is removed

Table 1.6.1: MDrive23Plus Electrical Specifications

WARNING!

The maximum +75 VDC Input Voltage of the

MDrive23Plus series includes motor Back EMF, Power Supply Ripple and High Line.

WARNING! Because the MDrivePlus consists of two core components, a drive and a motor, close attention must be paid to the thermal environment where the device is used. See Thermal Specifications.

Environmental Specifications

Operating Temperature (non-condensing humidity)	Heat Sink	-40°C to +85°C
	Motor	-40°C to +100°C

Table 1.6.2: MDrive23Plus Thermal Specifications

I/O Specifications

General Purpose I/O - Number and Type

I/O Points 1-4	4 I/O points configurable as sinking or sourcing inputs or sinking outputs
----------------	--

General Purpose I/O - Electrical

Inputs	TTL up to +24 VDC
Sinking Outputs	Up to +24 VDC
Output Sink Current	up to 600 mA (One Channel)
Logic Threshold (Logic 0)	< 0.8 VDC
Logic Threshold (Logic 1)	> 2.2 VDC
Protection (Sinking)	Over Temp, Short Circuit
Protection (Sourcing)	Transient Over Voltage, Inductive Clamp

Analog Input

Resolution	10 Bit
Range (Voltage Mode)	0 to +5 VDC, 0 to +10 VDC
Range (Current Mode)	4 to 20 mA, 0 to 20mA

Clock I/O

Types	Step/Direction, Up/Down, Quadrature
Logic Threshold	TTL Input, TTL Output (with 2 kΩ Load to Ground)

Trip Output/Capture Input

Logic Threshold	TTL Input, TTL Output (with 2 kΩ Load to Ground)
-----------------	--

Table 1.6.3: MDrive23Plus I/O Specifications

WARNING!

The maximum +60 VDC Input Voltage of the

MDrive23Plus Quad Size motor includes motor Back EMF, Power Supply Ripple and High Line.

Communications Specifications

Protocol	RS-422/RS-485
BAUD Rate	4.8k, 9.6k, 19.2k, 38.4k, 115.2 kbps

Table 1.6.4: MDrive23Plus Communications Specifications

**WARNING!**

When using the MDrivePlus Motion Control with optional internal magnetic encoder, no axial force may be applied to the motor shaft without use of a load bearing isolation coupling.

optional internal magnetic encoder, no axial force may be applied to the motor shaft without use of a load bearing isolation coupling.

Motion Specifications									
Microstep Resolution - Open Loop									
Number of Resolutions									20
Available Microsteps Per Revolution									
200	400	800	1000	1600	2000	3200	5000	6400	10000
12800	20000	25000	25600	40000	50000	51200	36000 ¹	21600 ²	25400 ³
1=0.01 deg/ μ step 2=1 arc minute/ μ step 3=0.001 mm/ μ step									
Microstep Resolution - Closed Loop Configuration (Optional)									
Steps Per Revolution (Fixed)									51200
Position Resolution									2048
Optional Differential Encoder (Internally Mounted)									
Type									Internal, Magnetic
Resolution (Lines)									512
Resolution (Edges)									2048
Counters									
Counter 1 (C1) Type									Position
Counter 2 (C2) Type									Encoder
Resolution									32 Bits
Maximum Edge Rate									5 MHz
Velocity									
Range									$\pm 5,000,000$ Steps/Sec.
Resolution									0.5961 Steps/Sec.
Acceleration/Deceleration									
Range									1.5×10^9 Steps/Sec. ²
Resolution									90.9 Steps/Sec. ²

Table 1.6.5: MDrive23Plus Motion Specifications

Software Specifications	
Program Storage Type/Size	Flash/6384 Bytes
User Registers	(4) 32 Bit
User Program Labels and Variables	192
Math, Logic and Conditional Functions	+, -, X, ÷, <, >, =, ≤, ≥, AND, OR, XOR, NOT
Branch Functions	Branch and Call (Conditional)
Part Y Mode Addresses	62
Encoder Functions	Stall Detect, Position Maintenance, Find Index
Predefined I/O Functions	
Input Functions	Home, Limit+, Limit -, Go, Stop, Pause, Jog+, Jog-, Analog Input
Output Functions	Moving, Fault, Stall, Velocity Changing
Trip Functions	Trip on Input, Trip on Position, Trip on Time, Trip Capture

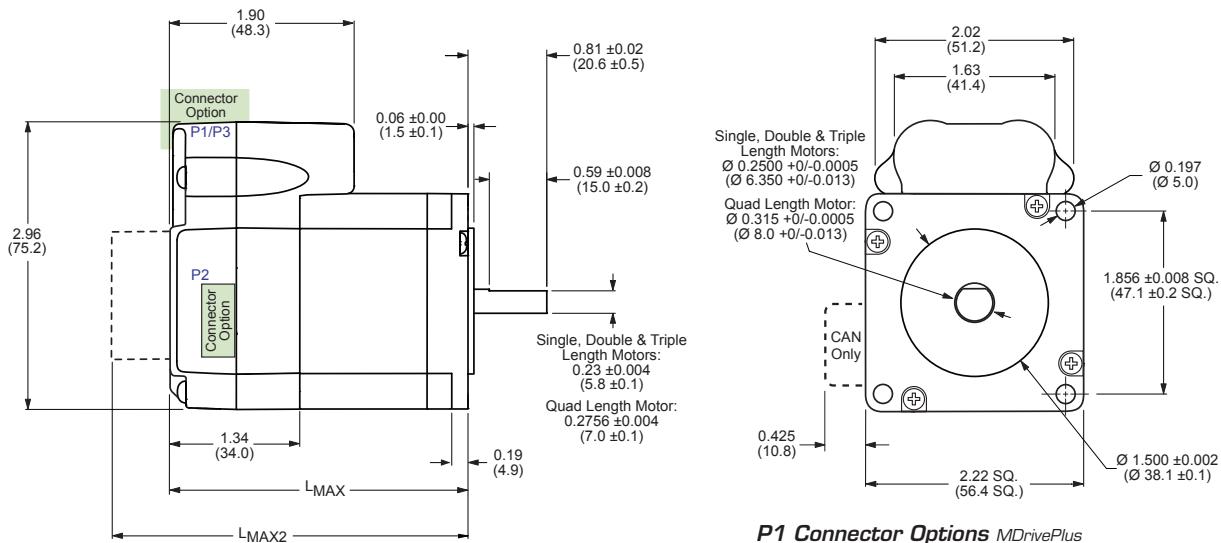
Table 1.6.6: MDrive23Plus Software Specifications

Motor Specifications	
Single Length	
Holding Torque	90 oz-in/64 N-cm
Detent Torque	3.9 oz-in/2.7 N-cm
Rotor Inertia	0.0025 oz-in-sec ² /0.26 kg-cm ²
Weight (Motor + Driver)	21.6 oz/784.4 g
Double Length	
Holding Torque	144 oz-in/102 N-cm
Detent Torque	5.6 oz-in/3.92 N-cm
Rotor Inertia	0.0037 oz-in-sec ² /0.26 kg-cm ²
Weight (Motor + Driver)	26.4 oz/784.4 g
Triple Length	
Holding Torque	239 oz-in/169 N-cm
Detent Torque	9.7 oz-in/6.86 N-cm
Rotor Inertia	0.065 oz-in-sec ² /0.46 kg-cm ²
Weight (Motor + Driver)	39.2 oz/1111.3 g
Quad Length	
Holding Torque	283 oz-in/200 N-cm
Detent Torque	14.2 oz-in/10.0 N-cm
Rotor Inertia	0.018 oz-in-sec ² /0.76 kg-cm ²
Weight (Motor + Driver)	61.6 oz/1746.3 g

Table 1.6.7: MDrive23Plus Motor Specifications

Mechanical Specifications

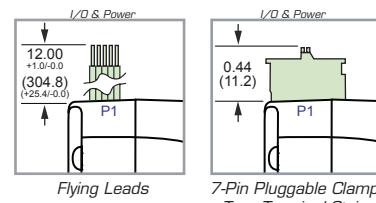
Dimensions in Inches (mm)



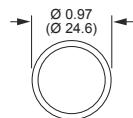
MDrive Lengths Inches (mm)

Motor Length	L _{MAX}	L _{MAX2}
SINGLE SHAFT, INTERNAL ENCODER or LINEAR ACTUATOR VERSION	CONTROL KNOB VERSION	
Single	2.65 (67.31)	3.36 (85.34)
Double	3.02 (76.71)	3.73 (94.74)
Triple	3.88 (98.55)	4.59 (116.59)
Quad	5.28 (134.15)	5.99 (152.19)

P1 Connector Options MDrivePlus



L_{MAX2} Options



Control Knob

Figure 1.6.1: MDrive23Plus Mechanical Specifications

Pin Assignment And Description

P1 Connector - Power and I/O

Pin Assignment - P1 Power and I/O Connections

Flying Lead Wire Color	7-Pin Pluggable Terminal Strip	Function	Description
White/Yellow	Pin 1	I/O 1	0 to +24 VDC Programmable I/O Point 1
White/Orange	Pin 2	I/O 2	0 to +24 VDC Programmable I/O Point 2
White/Violet	Pin 3	I/O 3	0 to +24 VDC Programmable I/O Point 3
White/Blue	Pin 4	I/O 4	0 to +24 VDC Programmable I/O Point 4
Green	Pin 5	AIN	0 to 10 V / 4 to 20 mA / 0 to 20 mA Analog Input.
Black	Pin 6	GND	Power and Auxiliary Ground
Red	Pin 7	+V	+12 to +75 VDC Motor Power Supply input.

Table 1.6.8: P1 — I/O and Power Connections

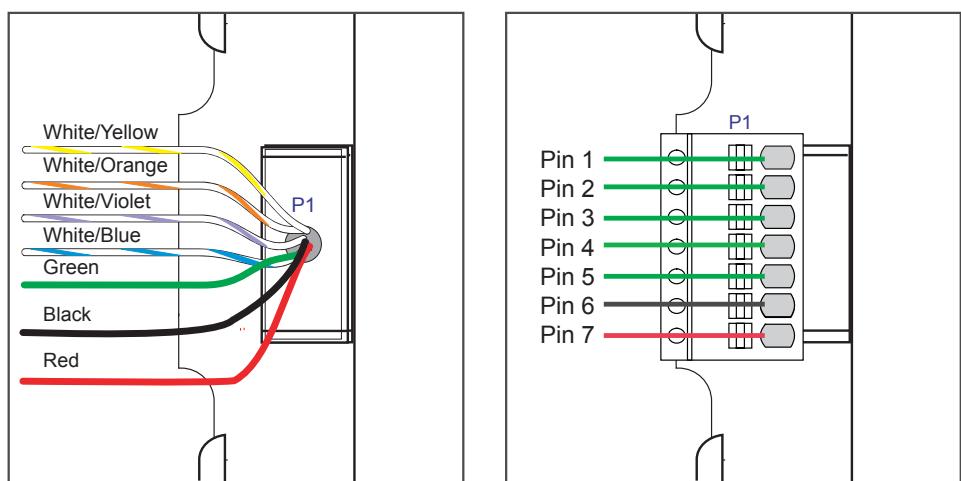


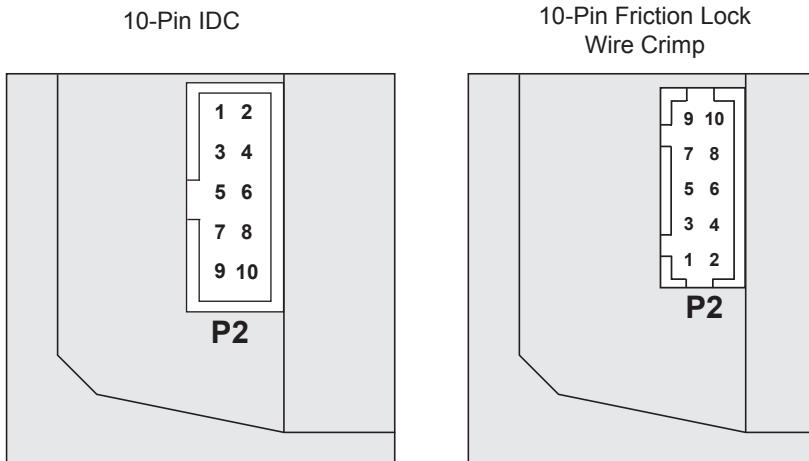
Figure 1.6.2: P1 Connector — Power and I/O Connections

P2 Connector - RS-422/485 Communications



Pin Assignment - P2 RS-422/485 Communications			
10-Pin IDC	10-Pin Wire Crimp	Function	Description
Pin 1	Pin 9	TX +	Transmit +: Connects to Receive + of the Communications Host.
Pin 2	Pin 10	TX -	Transmit -: Connects to Receive - of the Communications Host.
Pin 3	Pin 7	RX +	Receive +: Connects to Transmit + of the Communications Host.
Pin 4	Pin 8	RX -	Receive -: Connects to Transmit - of the Communications Host.
Pin 5	Pin 5	Aux-Logic	+12 to +24 VDC Auxiliary Logic Supply Input. This provides power to control and logic circuits if main power is removed.
Pin 6	Pin 6	RX +	Receive +: This point will typically be used to connect to RX+ of a second MDrivePlus for Multidrop Communications.
Pin 7	Pin 3	RX -	Receive -: This point will typically be used to connect to RX - of a second MDrivePlus for Multidrop Communications.
Pin 8	Pin 4	TX -	Transmit -: This point will typically be used to connect to TX - of a second MDrivePlus for Multidrop Communications.
Pin 9	Pin 1	TX +	Transmit +: This point will typically be used to connect to TX + of a second MDrivePlus for Multidrop Communications.
Pin 10	Pin 2	COMM GND	Communications Ground. This Ground is ONLY to be used to ground communications. Auxiliary Logic Supply must be grounded at the motor supply ground.
Recommended Converter/Cable	Recommended Converter/Cable	* For multi-drop communications systems IMS offers the PD10-1434-FL3 Prototype Development Cable. See Cables and Cordsets in the Appendices for more details.	
MD-CC400-000	MD-CC402-000		

Table 1.6.9: P2 — RS-422/485 Communications



Recommended Cable:
P/N MD-CC400-000

Recommended Cables:
P/N MD-CC402-000

Figure 1.6.3: P2 Connector - RS-422/485 Communications

Connectivity

QuickStart Kit

For rapid design verification, all-inclusive QuickStart Kits have communication converter, prototype development cable(s), instructions

Communication Converter Cables

These convenient 12.0' (3.6m) accessory cables connect a PC's USB Port to the MDrivePlus P2 Connector. An in-line RS-422 converter enables communications and programming to a single MDrivePlus Motion Control. Cable purchase recommended with first orders. Versions include:

USB to 10-Pin IDC.....	Part No. MD-CC401-001
USB to 10-Pin Wire Crimp	Part No. MD-CC402-001
Cable Assembly for Party-Mode	Part No. PD10-1434-FL3

Mating Connector Kits

Use to build your own cables. Kit contains 5 mating shells with pins. Cable not supplied.
Manufacturer's crimp tool recommended.

Matte to connector:

10-Pin Wire Crimp.....CK-02

Kit contains 5 mating connectors that press fit onto ribbon cable. Cable not supplied.

10-Pin IDC.....CK-01

Options and Accessories

Control Knob

The MDrive23Plus Motion Control is available with a factory-mounted rear control knob for manual shaft positioning.

Planetary Gearbox

Efficient, low maintenance Planetary Gearboxes are offered assembled with the MDrive23Plus. (For specifications and details see Appendix C: MDrivePlus Planetary Gearbox Specification.)

Encoder

The MDrive23Plus Motion Control is available with an internal 512-line (2048 count) magnetic encoder with index mark.

Linear Slide

Integrated linear slides are available factory installed for precision linear movement. Screw pitches are 0.1", 0.2", 0.5" or 1.0" of travel per rev. Slides are 10.0" (25.4cm) to 36.0" (91.44cm) long. Contact factory for custom lengths.

SECTION 1.7

MDrive23Plus² Detailed Specifications

General Specifications



WARNING!
The maximum
+75 VDC Input
Voltage of the
MDrive23Plus series includes
motor Back EMF, Power
Supply Ripple and High Line.

Electrical Specifications	
Input Voltage (+V) Range*	+12 to +75 VDC
Max Power Supply Current (Per MDrive23Plus)*	2 A
Aux-Logic Input Voltage**	+12 to +24 VDC
Max Aux-Logic Supply Current (Per MDrive23Plus)	194 mA

* Actual Power Supply Current will depend on Voltage and Load.

** Maintains power to control and feedback circuits [only] when input voltage is removed

Table 1.7.1: MDrive23Plus² Electrical Specifications

WARNING! Because the MDrivePlus consists of two core components, a drive and a motor, close attention must be paid to the thermal environment where the device is used. See Thermal Specifications.

Environmental Specifications		
Operating Temperature (non-condensing humidity)	Heat Sink	-40°C to +85°C
	Motor	-40°C to +100°C

Table 1.7.2: MDrive23Plus² Thermal Specifications

I/O Specifications	
General Purpose I/O - Number and Type	
I/O Points 1-4, 9-12	8 I/O Points configurable as sinking or sourcing inputs or outputs
General Purpose I/O - Electrical	
Inputs	TTL up to +24 VDC
Sinking Outputs	Up to +24 VDC
Sourcing Outputs	+12 to +24 VDC
Output Sink Current	up to 600 mA (One Channel in each I/O Bank)
Logic Threshold (Logic 0)	< 0.8 VDC
Logic Threshold (Logic 1)	> 2.2 VDC
Protection (Sinking)	Over Temp, Short Circuit
Protection (Sourcing)	Transient Over Voltage, Inductive Clamp
Analog Input	
Resolution	10 Bit
Range (Voltage Mode)	0 to +5 VDC, 0 to +10 VDC
Range (Current Mode)	4 to 20 mA, 0 to 20mA
Clock I/O	
Types	Step/Direction, Up/Down, Quadrature
Logic Threshold	+5 VDC TTL Input, TTL Output (with 2 kΩ Load to Ground)
Trip Output/Capture Input	
Logic Threshold	+5 VDC TTL Input, TTL Output (with 2 kΩ Load to Ground)

Table 1.7.3: MDrive23Plus² I/O Specifications

Communications Specifications	
Protocol	RS-422/RS-485
BAUD Rate	4.8k, 9.6k, 19.2k, 38.4k, 115.2 kbps

Table 1.7.4: MDrive23Plus² Communications Specifications

**WARNING!**

When using the
MDrivePlus Motion
Control with

optional internal magnetic
encoder, no axial force may
be applied to the motor shaft
without use of a load bearing
isolation coupling.

Motion Specifications									
Microstep Resolution - Open Loop									
Number of Resolutions	20								
Available Microsteps Per Revolution									
200	400	800	1000	1600	2000	3200	5000	6400	10000
12800	20000	25000	25600	40000	50000	51200	36000 ¹	21600 ²	25400 ³
$1 = 0.01 \text{ deg}/\mu\text{step}$									
$2 = 1 \text{ arc minute}/\mu\text{step}$									
$3 = 0.001 \text{ mm}/\mu\text{step}$									
Microstep Resolution - Closed Loop Configuration (Optional)									
Steps Per Revolution (Fixed)	51200								
Position Resolution	2048								
Optional Differential Encoder (Internally Mounted)									
Type	Internal, Magnetic								
Resolution (Lines)	512								
Resolution (Edges)	2048								
Counters									
Counter 1 (C1) Type	Position								
Counter 2 (C2) Type	Encoder								
Resolution	32 Bits								
Maximum Edge Rate	5 MHz								
Velocity									
Range	$\pm 5,000,000 \text{ Steps}/\text{Sec.}$								
Resolution	0.5961 Steps/Sec.								
Acceleration/Deceleration									
Range	$1.5 \times 10^9 \text{ Steps}/\text{Sec.}^2$								
Resolution	90.9 Steps/Sec. ²								
Electronic Gearing ‡									
Range (Ratio)	0.001 to 2.000								
Resolution	32 Bits								
Voltage	+5 VDC Logic Level								
Input Filter Range	50 nS to 12.9 μ S								
Secondary Output Clock Range	1 to 1								
High Speed I/O									
Position Capture Input - Resolution	32 Bits								
Position Capture Input - Filtering	50 nS to 12.9 μ S								
Trip Output - Speed	150 nS								
Trip Output - Resolution	32 Bits								
Trip Output Voltage	+5 VDC Logic Level								
Optional Remote Encoder ‡									
Type	User Defined Differential								
Steps Per Revolution	See Microstep Resolution - Open Loop								
Resolution	User Defined*								

* Microstep Resolution must be set to 2x the Encoder Counts/Rev minimum.

‡With Optional Remote Encoder the Encoder Inputs replace I/O Points 9-12 and the Step/Direction Clock I/O Points. Electronic Gearing (following) not available on remote encoder models.

Table 1.7.5: MDrive23Plus² Motion Specifications

Software Specifications	
Program Storage Type/Size	Flash/6384 Bytes
User Registers	(4) 32 Bit
User Program Labels and Variables	192
Math, Logic and Conditional Functions	+, -, X, ÷, <, >, =, ≤, ≥, AND, OR, XOR, NOT
Branch Functions	Branch and Call (Conditional)
Party Mode Addresses	62
Encoder Functions	Stall Detect, Position Maintenance, Find Index
Predefined I/O Functions	
Input Functions	Home, Limit+, Limit -, Go, Stop, Pause, Jog+, Jog-, Analog Input
Output Functions	Moving, Fault, Stall, Velocity Changing
Trip Functions	Trip on Input, Trip on Position, Trip on Time, Trip Capture

Table 1.7.6: MDrive23Plus² Software Specifications

Motor Specifications	
Single Length	
Holding Torque	90 oz-in/64 N-cm
Detent Torque	3.9 oz-in/2.7 N-cm
Rotor Inertia	0.0025 oz-in-sec ² /0.26 kg-cm ²
Weight (Motor + Driver)	21.6 oz/784.4 g
Double Length	
Holding Torque	144 oz-in/102 N-cm
Detent Torque	5.6 oz-in/3.92 N-cm
Rotor Inertia	0.0037 oz-in-sec ² /0.26 kg-cm ²
Weight (Motor + Driver)	26.4 oz/784.4 g
Triple Length	
Holding Torque	239 oz-in/169 N-cm
Detent Torque	9.7 oz-in/6.86 N-cm
Rotor Inertia	0.065 oz-in-sec ² /0.46 kg-cm ²
Weight (Motor + Driver)	39.2 oz/1111.3 g
Quad Length	
Holding Torque	283 oz-in/200 N-cm
Detent Torque	14.2 oz-in/10.0 N-cm
Rotor Inertia	0.018 oz-in-sec ² /0.76 kg-cm ²
Weight (Motor + Driver)	61.6 oz/1746.3 g

Table 1.7.7: MDrive23Plus² Motor Specifications

Mechanical Specifications

Dimensions in Inches (mm)

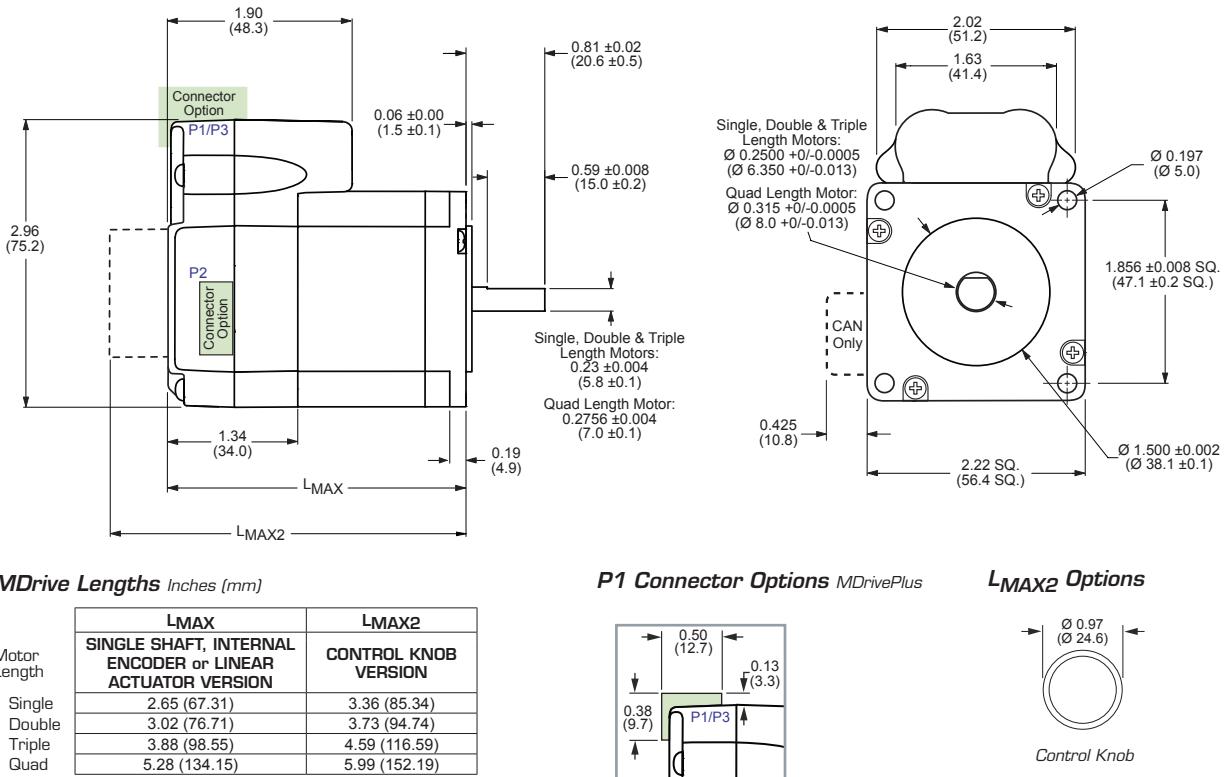


Figure 1.7.1: MDrive23Plus² Mechanical Specifications

Pin Assignment And Description

P1 Connector - Expanded I/O Configuration

P1 - Expanded I/O Configuration		
16-Pin Wire Crimp	Function	Description
Pin 1	I/O PWR	I/O Power, used with sourcing inputs or outputs. See Section 2.3 for more details.
Pin 2	I/O GND	Non-isolated I/O Ground. Common with Power Ground.
Pin 3	I/O 1	0 to +24 VDC Programmable I/O Point 1
Pin 4	I/O 2	0 to +24 VDC Programmable I/O Point 2
Pin 5	I/O 3	0 to +24 VDC Programmable I/O Point 3
Pin 6	I/O 4	0 to +24 VDC Programmable I/O Point 4
Pin 7	I/O 9	0 to +24 VDC Programmable I/O Point 9
Pin 8	I/O 10	0 to +24 VDC Programmable I/O Point 10
Pin 9	I/O 11	0 to +24 VDC Programmable I/O Point 11
Pin 10	I/O 12	0 to +24 VDC Programmable I/O Point 12
Pin 11	Capture/Trip I/O	High Speed Capture Input or Trip Output. +5 VDC Logic Level.
Pin 12	AIN	0 to 10 V / 4 to 20 mA / 0 to 20 mA Analog Input.
Pin 13	SCLK	Step Clock I/O. Can also be configured as Quadrature or Clock Up/Down. +5 VDC Logic Level.
Pin 14	DIR	Direction I/O. Can also be configured as Quadrature or Clock Up/Down. +5 VDC Logic Level.

Recommended Cable

PD14-2334-FL3 - See Appendix G for more details.

Table 1.7.8: P1 — Pin Assignment, Expanded I/O Configuration



Configuration label on the body of the device please ensure that all wiring connections are cross-checked against these tables.



WARNING! Ensure proper orientation of P1, Pin 1 when creating your own cabling!



NEED A CABLE?

The following Prototype Development cable is available to interface Power and I/O:

Power Interface
PD02-2300-FL3

Logic Interface
PD14-2334-FL3

See Appendix F for description and wire color chart.

P1 Connector - Remote Encoder Configuration

P1 - Expanded I/O Configuration		
16-Pin Wire Crimp	Function	Description
Pin 1	I/O PWR	I/O Power, used with sourcing inputs or outputs. See Section 2.3 for more details.
Pin 2	I/O GND	Non-isolated I/O Ground. Common with Power Ground.
Pin 3	I/O 1	0 to +24 VDC Programmable I/O Point 1
Pin 4	I/O 2	0 to +24 VDC Programmable I/O Point 2
Pin 5	I/O 3	0 to +24 VDC Programmable I/O Point 3
Pin 6	I/O 4	0 to +24 VDC Programmable I/O Point 4
Pin 7	Channel A +	Encoder Channel Channel A + Input. +5 VDC Logic Level.
Pin 8	Channel A -	Encoder Channel Channel A - Input. +5 VDC Logic Level.
Pin 9	Channel B +	Encoder Channel Channel B + Input. +5 VDC Logic Level.
Pin 10	Channel B -	Encoder Channel Channel B - Input. +5 VDC Logic Level.
Pin 11	Capture/Trip I/O	High Speed Capture Input or Trip Output. +5 VDC Logic Level.
Pin 12	AIN	0 to 10 V / 4 to 20 mA / 0 to 20 mA Analog Input.
Pin 13	Index +	Encoder Index + Input. +5 VDC Logic Level.
Pin 14	Index -	Encoder Index - Input. +5 VDC Logic Level.

Recommended Cable

PD14-2334-FL3 - See Appendix G for more details.

Table 1.7.9: P1 — Pin Assignment, Remote Encoder Configuration

P3 Connector - Power

P3 -Power		
2-Pin Wire Crimp	Function	Description
Pin 1	+V	+12 to +75 VDC Motor Power Supply Input
Pin 2	GND	Power Ground.
Recommended Cable		
PD02-2300-FL3 See Appendix G for more details.		

Table 1.7.10: P3 — Pin Assignment, Power

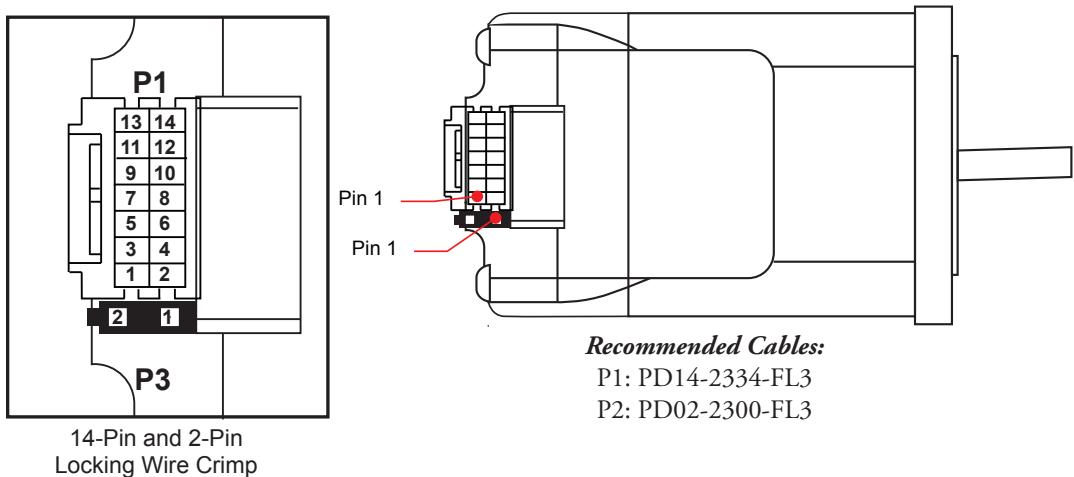


Figure 1.7.2: P1 and P3: Connector Orientation and Pin Assignment

P2 Connector - RS-422/485 Communications



USB to RS-422/485:
MD-CC400-001 (10-Pin IDC)
MD-CC402-001 (10-Pin Wire Crimp)

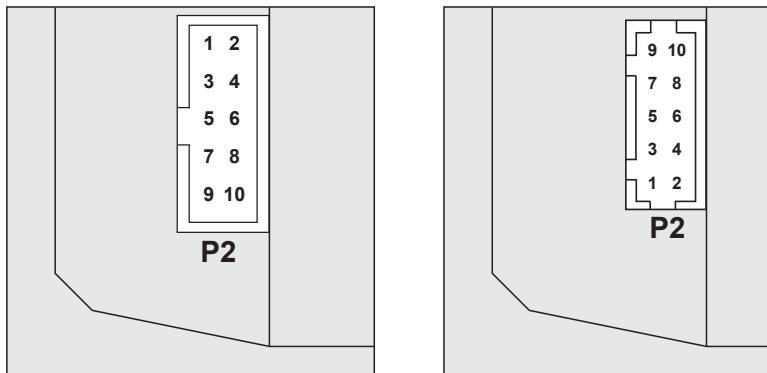
Multi-Drop for 10-Pin Wire Crimp Party-Mode
PD10-1434-FL3

See Appendix F for details.

Pin Assignment - P2 RS-422/485 Communications			
10-Pin IDC	10-Pin Wire Crimp	Function	Description
Pin 1	Pin 9	TX +	Transmit +: Connects to Receive + of the Communications Host.
Pin 2	Pin 10	TX -	Transmit -: Connects to Receive - of the Communications Host.
Pin 3	Pin 7	RX +	Receive +: Connects to Transmit + of the Communications Host.
Pin 4	Pin 8	RX -	Receive -: Connects to Transmit - of the Communications Host.
Pin 5	Pin 5	Aux-Logic	+12 to +24 VDC Auxiliary Logic Supply Input. This provides power to control and logic circuits if main power is removed.
Pin 6	Pin 6	RX +	Receive +: This point will typically be used to connect to RX+ (Pin 3/7*) of a second MDrivePlus for Multidrop Communications.
Pin 7	Pin 3	RX -	Receive -: This point will typically be used to connect to RX - (Pin 4/8*) of a second MDrivePlus for Multidrop Communications.
Pin 8	Pin 4	TX -	Transmit -: This point will typically be used to connect to TX - (Pin 1/9*) of a second MDrivePlus for Multidrop Communications.
Pin 9	Pin 1	TX +	Transmit +: This point will typically be used to connect to TX + (Pin 2/10*) of a second MDrivePlus for Multidrop Communications.
Pin 10	Pin 2	COMM GND	Communications Ground. This Ground is ONLY to be used to ground communications. Auxiliary Logic Supply must be grounded at the motor supply ground.
Recommended Converter/Cable	Recommended Converter/Cable	* For multi-drop communications systems IMS offers the PD10-1434-FL3 Prototype Development Cable. See Cables and Cordsets in the Appendices for more details.	
MD-CC400-000	MD-CC402-000		

Table 1.7.11: P2 — Pin Assignment and Description, RS-422/485 Communications

Wire Crimp



Recommended Cable:
P/N MD-CC400-000

Recommended Cables:
P/N MD-CC402-000

Figure 1.7.3: P2 Connector - RS-422/485 Communications

Options and Accessories

QuickStart Kit

For rapid design verification, all-inclusive QuickStart Kits have communication converter, prototype development cable(s), instructions

Control Knob

The MDrive23Plus Motion Control is available with a factory-mounted rear control knob for manual shaft positioning.

Planetary Gearbox

Efficient, low maintenance Planetary Gearboxes are offered assembled with the MDrive23Plus. (For specifications and details see Appendix C: MDrivePlus Planetary Gearbox Specification.)

Encoder

The MDrive23Plus Motion Control is available with an internal 512-line (2048 count) magnetic encoder with index mark.

Linear Slide

Integrated linear slides are available factory installed for precision linear movement. Screw pitches are 0.1", 0.2", 0.5" or 1.0" of travel per rev. Slides are 10.0" (25.4cm) to 36.0" (91.44cm) long. Contact factory for custom lengths.

Communication Converter Cables

These convenient 12.0' (3.6m) accessory cables connect a PC's USB Port to the MDrive17Plus² P2 Connector. An in-line RS-422 converter enables parameter setting to a single MDrive17Plus² Motion Control. Cable purchase recommended with first orders. Versions include:

USB to 10-Pin IDC	Part No. MD-CC400-001
USB to 10-Pin Wire Crimp	Part No. MD-CC402-001
Cable Assembly for Party-Mode	Part No. PD10-1434-FL3

Prototype Development Cable

To speed prototyping of Plus² versions, IMS recommends the following 10' (3m) interface cable with first orders:

2-pin Wire Crimp Cable	Part No. PD02-2300-FL3
14-pin Wire Crimp Cable	Part No. PD16-1417-FL3

Mating Connector Kits

Use to build your own cables. Kit contains 5 mating shells with pins. Cable not supplied. Manufacturer's crimp tool recommended.

Matches to connector:

10-Pin Wire Crimp	CK-02
Kit contains 5 mating connectors that press fit onto ribbon cable. Cable not supplied.	
10-Pin IDC.....	CK-01
14-Pin Wire Crimp	CK-09
2-Pin Wire Crimp	CK-04

SECTION 1.8

MDrive23Plus²-65 Detailed Specifications

Electrical Specifications

Input Voltage (+V) Range*	+12 to +75 VDC
Max Power Supply Current (Per MDrive23Plus)*	2 A
Aux-Logic Input Voltage**	+12 to +24 VDC
Max Aux-Logic Supply Current (Per MDrive23Plus)	194 mA

* Actual Power Supply Current will depend on Voltage and Load.

** Maintains power to control and feedback circuits [only] when input voltage is removed

Table 1.8.1: MDrive23Plus²-65 Electrical Specifications

 **WARNING!**
The maximum
+75 VDC Input
Voltage of the
MDrive23Plus series includes
motor Back EMF, Power
Supply Ripple and High Line.

Environmental Specifications

Operating Temperature	Heat Sink	-40°C to +85°C
	Motor	-40°C to +100°C
Humidity, non condensing	0 to 95%	
Sealing (against dust and water jets)	IP65	

Table 1.8.2: MDrive23Plus²-65 Thermal and Environmental Specifications

 **WARNING!**
Because the
MDrivePlus
consists of two
core components, a drive
and a motor, close attention
must be paid to the thermal
environment where the
device is used. See Thermal
Specifications.

I/O Specifications

General Purpose I/O - Number and Type	
Plus ² (I/O Points 1-4, 9-12)	8 I/O Points configurable as sinking or sourcing inputs or outputs
General Purpose I/O - Electrical	
Inputs	TTL up to +24 VDC
Sinking Outputs (All)	Up to +24 VDC
Sourcing Outputs (Plus ²)	+12 to +24 VDC
Output Sink Current (Plus ²)	up to 600 mA (One Channel in each I/O Bank)
Logic Threshold (Logic 0)	< 0.8 VDC
Logic Threshold (Logic 1)	> 2.2 VDC
Protection (Sinking)	Over Temp, Short Circuit
Protection (Sourcing)	Transient Over Voltage, Inductive Clamp
Analog Input	
Resolution	10 Bit
Range (Voltage Mode)	0 to +5 VDC, 0 to +10 VDC
Range (Current Mode)	4 to 20 mA, 0 to 20mA
Clock I/O	
Types	Step/Direction, Up/Down, Quadrature
Logic Threshold	+5 VDC TTL Input, TTL Output (with 2 kΩ Load to Ground)
Trip Output/Capture Input	
Logic Threshold	+5 VDC TTL Input, TTL Output (with 2 kΩ Load to Ground)

Table 1.8.3: MDrive23Plus²-65 I/O Specifications

Communications Specifications

Protocol	RS-422/RS-485
BAUD Rate	4.8k, 9.6k, 19.2k, 38.4k, 115.2 kbps

Table 1.8.4: MDrive23Plus²-65 Communications Specifications

Motion Specifications									
Microstep Resolution - Open Loop									
Number of Resolutions									20
Available Microsteps Per Revolution									
200	400	800	1000	1600	2000	3200	5000	6400	10000
12800	20000	25000	25600	40000	50000	51200	36000 ¹	21600 ²	25400 ³
1=0.01 deg/ μ step 2=1 arc minute/ μ step 3=0.001 mm/ μ step									
Microstep Resolution - Closed Loop Configuration (Optional)									
Steps Per Revolution (Fixed)									51200
Position Resolution									2048
Optional Differential Encoder (Internally Mounted)									
Type	Internal, Magnetic								
Resolution (Lines)	512								
Resolution (Edges)	2048								
Counters									
Counter 1 (C1) Type	Position								
Counter 2 (C2) Type	Encoder								
Resolution	32 Bits								
Maximum Edge Rate	5 MHz								
Velocity									
Range	$\pm 5,000,000$ Steps/Sec.								
Resolution	0.5961 Steps/Sec.								
Acceleration/Deceleration									
Range	1.5×10^9 Steps/Sec. ²								
Resolution	90.9 Steps/Sec. ²								
Electronic Gearing (Plus ² Only) \ddagger									
Range (Ratio)	0.001 to 2.000								
Resolution	32 Bits								
Voltage	+5 VDC Logic Level								
Input Filter Range	50 nS to 12.9 μ S								
Secondary Output Clock Range	1 to 1								
High Speed I/O (Plus ² Only)									
Position Capture Input - Resolution	32 Bits								
Position Capture Input - Filtering	50 nS to 12.9 μ S								
Trip Output - Speed	150 nS								
Trip Output - Resolution	32 Bits								
Trip Output Voltage	+5 VDC Logic Level								
Optional Remote Encoder (Plus ² Only) \ddagger									
Type	User Defined Differential								
Steps Per Revolution	See Microstep Resolution - Open Loop								
Resolution	User Defined*								

* Microstep Resolution must be set to 2x the Encoder Counts/Rev minimum.

\ddagger With Optional Remote Encoder the Encoder Inputs replace I/O Points 9-12 and the Step/Direction Clock I/O Points. Electronic Gearing (following) not available on remote encoder models.

Table 1.8.5: MDrive23Plus²-65 Motion Specifications

Software Specifications	
Program Storage Type/Size	Flash/6384 Bytes
User Registers	(4) 32 Bit
User Program Labels and Variables	192
Math, Logic and Conditional Functions	+, -, x, ÷, <, >, =, ≤, ≥, AND, OR, XOR, NOT
Branch Functions	Branch and Call (Conditional)
Party Mode Addresses	62
Encoder Functions	Stall Detect, Position Maintenance, Find Index
Predefined I/O Functions	
Input Functions	Home, Limit+, Limit -, Go, Stop, Pause, Jog+, Jog-, Analog Input
Output Functions	Moving, Fault, Stall, Velocity Changing
Trip Functions	Trip on Input, Trip on Position, Trip on Time, Trip Capture

Table 1.8.6: MDrive23Plus²-65 Software Specifications

Motor Specifications	
Single Length	
Holding Torque	90 oz-in/64 N-cm
Detent Torque	3.9 oz-in/2.7 N-cm
Rotor Inertia	0.0025 oz-in-sec ² /0.26 kg-cm ²
Weight (Motor + Driver)	21.6 oz/784.4 g
Double Length	
Holding Torque	144 oz-in/102 N-cm
Detent Torque	5.6 oz-in/3.92 N-cm
Rotor Inertia	0.0037 oz-in-sec ² /0.26 kg-cm ²
Weight (Motor + Driver)	26.4 oz/784.4 g
Triple Length	
Holding Torque	239 oz-in/169 N-cm
Detent Torque	9.7 oz-in/6.86 N-cm
Rotor Inertia	0.065 oz-in-sec ² /0.46 kg-cm ²
Weight (Motor + Driver)	39.2 oz/1111.3 g

Table 1.8.7: MDrive23Plus²-65 Motor Specifications

Mechanical Specifications

Dimensions in Inches (mm)

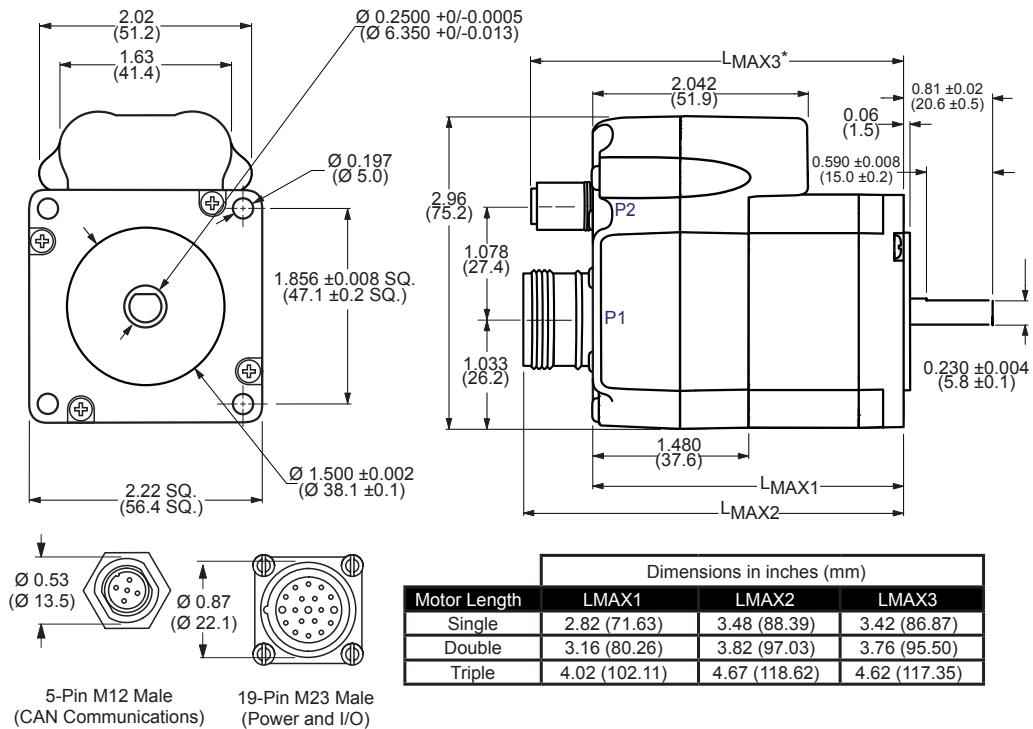


Figure 1.8.1: MDrive23Plus²-65 Motion Control

Pin Assignment and Description

P1 Connector - I/O and Power Connections, Expanded I/O Configuration

P1 - Expanded I/O Configuration		
19-Pin M23	Function	Description
Pin 1	I/O 9	0 to +24 VDC Programmable I/O Point 9.
Pin 2	I/O 11	0 to +24 VDC Programmable I/O Point 11.
Pin 3	SCLK	Step Clock I/O. Can also be configured as Quadrature or Clock Up/Down. +5 VDC Logic Level.
Pin 4	I/O 1	0 to +24 VDC Programmable I/O Point 1.
Pin 5	DIR	Direction I/O. Can also be configured as Quadrature or Clock Up/Down. +5 VDC Logic Level.
Pin 6	+V	+12 to +75 VDC Motor Power Supply Input.
Pin 7	Aux-Logic	+12 to +24 VDC Auxiliary Logic Supply Input. This provides power to control and logic circuits if main power is removed.
Pin 8	Aux-Ground	Auxiliary Ground.
Pin 9	I/O 3	0 to +24 VDC Programmable I/O Point 3.
Pin 10	I/O GND	Non-isolated I/O Ground. Common with Power Ground.
Pin 11	I/O PWR	I/O Power, used with sourcing inputs or outputs. See Section 2.3 for more details.
Pin 12	Earth Ground	Earth Ground, Connects to connector shell.
Pin 13	I/O 12	0 to +24 VDC Programmable I/O Point 12.
Pin 14	Capture/Trip I/O	High Speed Capture Input or Trip Output. +5 VDC Logic Level.
Pin 15	AIN	0 to 10 V / 4 to 20 mA / 0 to 20 mA Analog Input.
Pin 16	I/O 2	0 to +24 VDC Programmable I/O Point 2.
Pin 17	I/O 4	0 to +24 VDC Programmable I/O Point 4.
Pin 18	I/O 10	0 to +24 VDC Programmable I/O Point 10.
Pin 19	GND	Power Ground.
Recommended Cordset		
MD-CS100-000 or MD-CS101-000		

Table 1.8.8: P1 — Pin Assignment, Expanded I/O Configuration

P1 Connector - I/O and Power Connections, Remote Encoder Configuration

P1 - Expanded I/O Configuration

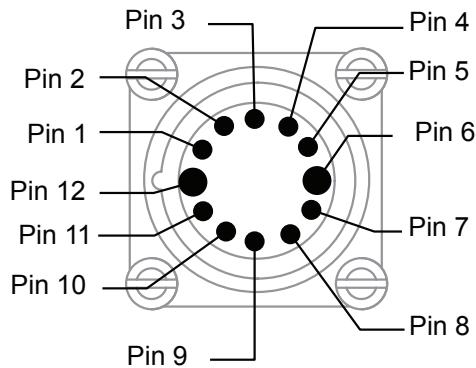
19-Pin M23	Function	Description
Pin 1	Channel A +	Encoder Channel Channel A + Input. +5 VDC Logic Level.
Pin 2	Channel B +	Encoder Channel Channel B + Input. +5 VDC Logic Level.
Pin 3	Index +	Encoder Index + Input. +5 VDC Logic Level.
Pin 4	I/O 1	0 to +24 VDC Programmable I/O Point 1.
Pin 5	Index -	Encoder Index - Input. +5 VDC Logic Level.
Pin 6	+V	+12 to +75 VDC Motor Power Supply Input.
Pin 7	Aux-Logic	+12 to +24 VDC Auxiliary Logic Supply Input. This provides power to control and logic circuits if main power is removed.
Pin 8	Aux-Ground	Auxiliary Ground.
Pin 9	I/O 3	0 to +24 VDC Programmable I/O Point 3.
Pin 10	I/O GND	Non-isolated I/O Ground. Common with Power Ground.
Pin 11	I/O PWR	I/O Power, used with sourcing inputs or outputs. See Section 2.3 for more details.
Pin 12	Earth Ground	Earth Ground, Connects to connector shell.
Pin 13	Channel B -	Encoder Channel Channel B - Input. +5 VDC Logic Level.
Pin 14	Capture/Trip I/O	High Speed Capture Input or Trip Output. +5 VDC Logic Level.
Pin 15	AIN	0 to 10 V / 4 to 20 mA / 0 to 20 mA Analog Input.
Pin 16	I/O 2	0 to +24 VDC Programmable I/O Point 2.
Pin 17	I/O 4	0 to +24 VDC Programmable I/O Point 4.
Pin 18	Channel A -	Encoder Channel Channel A - Input. +5 VDC Logic Level.
Pin 19	GND	Power Ground.

Recommended Cordset

MD-CS100-000 or MD-CS101-000

Table 1.8.9: P1 — Pin Assignment, Remote Encoder Configuration

Outside: Pins 1 -12



Inside: Pins 13 - 19

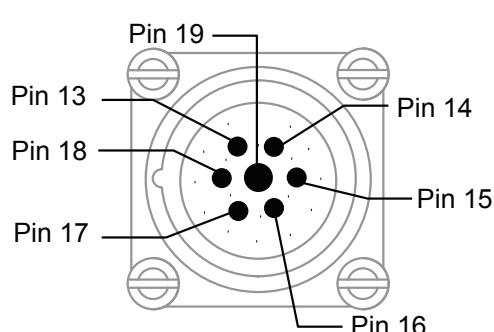


Figure 1.8.2: MDrive23Plus²-65 P1 Connector, Power and I/O



NEED A CABLE?
The following communications converter/cable is available:

USB to RS-422/485 Converter
MD-CC401-000

See Appendix F for details.

P2 Connector - RS-422/485 Communications

Pin Assignment - P2 RS-422/485 Communications		
10-Pin IDC	Function	Description
Pin 1	TX –	Transmit –: This point will typically be used to connect to TX – (Pin 1/9*) of a second MDrivePlus for Multidrop Communications.
Pin 2	TX +	Transmit +: Connects to Receive + of the Communications Host.
Pin 3	RX +	Receive +: Connects to Transmit + of the Communications Host.
Pin 4	RX –	Receive -: Connects to Transmit – of the Communications Host.
Pin 5	COMM GND	Communications Ground. This Ground is ONLY to be used to ground communications. Auxiliary Logic Supply must be grounded at the motor supply ground.
Recommended Converter/Cable		
MD-CC401-000		

Table 1.8.10: P2 — Pin Assignment, 5-Pin M12 RS-422/485 Communications

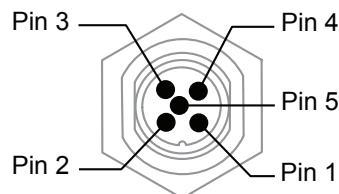


Figure 1.8.3: MDrive23Plus²-65 P2 Connector, RS-422/RS-485 Communications

Connectivity

Communication Converter Cable

This convenient 12.0' (3.6m) accessory cable connects a PC's USB Port to the MDrive23Plus²-65 P2 5-Pin M12 Connector. An in-line RS-422 converter enables parameter setting to a single MDrive23Plus²-65 Motion Control. Cable purchase recommended with first orders.

USB to M12 Circular (sealed version)..... Part No. MD-CC401-001



Note: To reduce wiring time, please order Part# MD-CC401-000, the USB to M12 accessory cable with inline RS-422 Converter.

Cordsets

19-Pin M23 single-ended cordsets are offered to speed prototyping of MDrive23Plus²-65 Motion Control units attaching to the P1 Connector. Measuring 13.0' (4.0m) long, they are available in either straight or right angle termination. PVC jacketed cables come with a foil shield and unconnected drain wire.

Straight Termination..... Part No. MD-CS100-000

Right Angle Termination Part No. MD-CS101-000



NEED A CABLE?
The following cordset is available to interface to the 19-pin M23 Connector:

Straight Termination
MD-CS100-000

Right Angle Termination
MD-CS-101-000

See Appendix F for details.

Options and Accessories

QuickStart Kit

For rapid design verification, all-inclusive QuickStart Kits have communication converter, prototype development cable(s), instructions

Planetary Gearbox

Efficient, low maintenance Planetary Gearboxes are offered assembled with the MDrive23Plus²-65 (For specifications and details see Appendix D: MDrive23Plus Planetary Gearbox Specification.)

Encoder

The MDrive23Plus²-65 Motion Control is available with an internal 512-line (2048 count) magnetic encoder with index mark.

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PART 2: CONNECTING AND INTERFACING

Section 2.1: Mounting and Connection Recommendations

Section 2.2: Interfacing DC Power and Auxiliary Logic

Section 2.3: Interfacing Communications

Section 2.4: Interfacing and Using the MDrivePlus Motion Control I/O

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SECTION 2.1

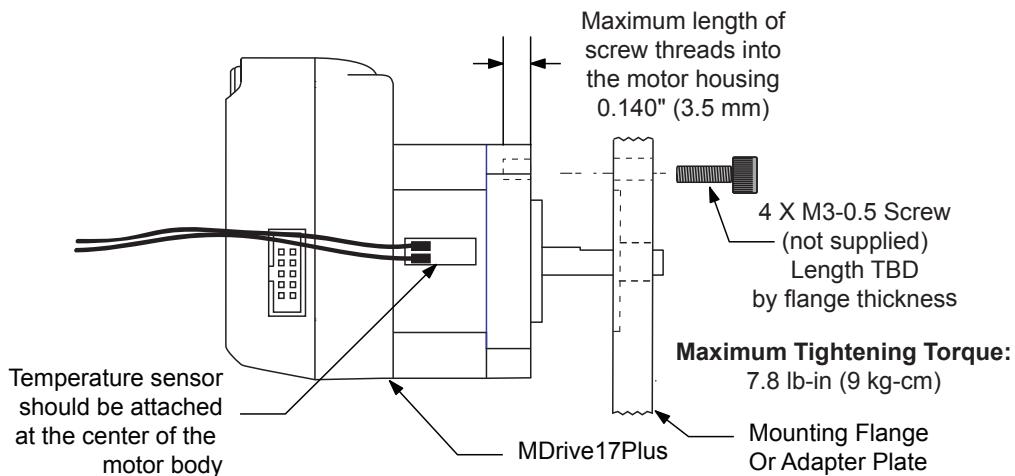
Mounting and Connection Recommendations

Mounting Recommendations

MDrive17Plus Motion Control

Care must be observed when installing the mounting screws on ALL MDrive17Plus versions. The mounting holes on the flange are not drilled through and have a maximum depth of 0.150" (3.81 mm).

The warning note and Figure below illustrate the maximum safe thread length and maximum torque for mounting all versions of the MDrive17Plus.



WARNING! The mounting holes in the MDrive17 mounting flange are not through holes. The maximum length of the screw threads into the motor flange is 0.140" (3.5 mm).



MAXIMUM TORQUE! The maximum torque for the M3x0.5 screw is 7.8 lb-in (9 kg-cm) with a thread engagement of 5 threads (3.3 mm deep). A lesser thread engagement diminishes the maximum torque.



WARNING! DO NOT connect or disconnect power leads when power is applied! Disconnect the AC power side to power down the DC power supply.

Drill Pattern for Mounting Flange or Adapter Plate

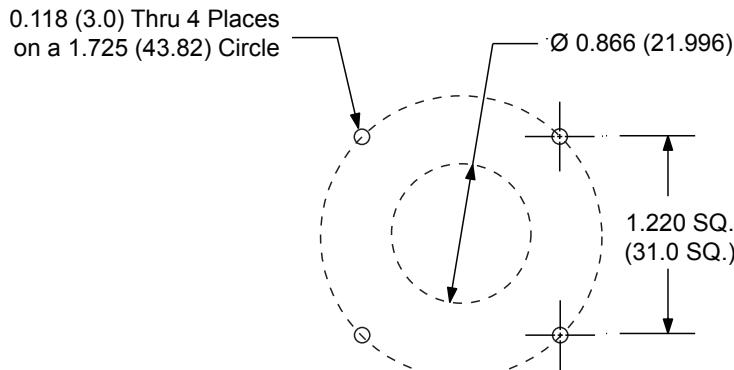
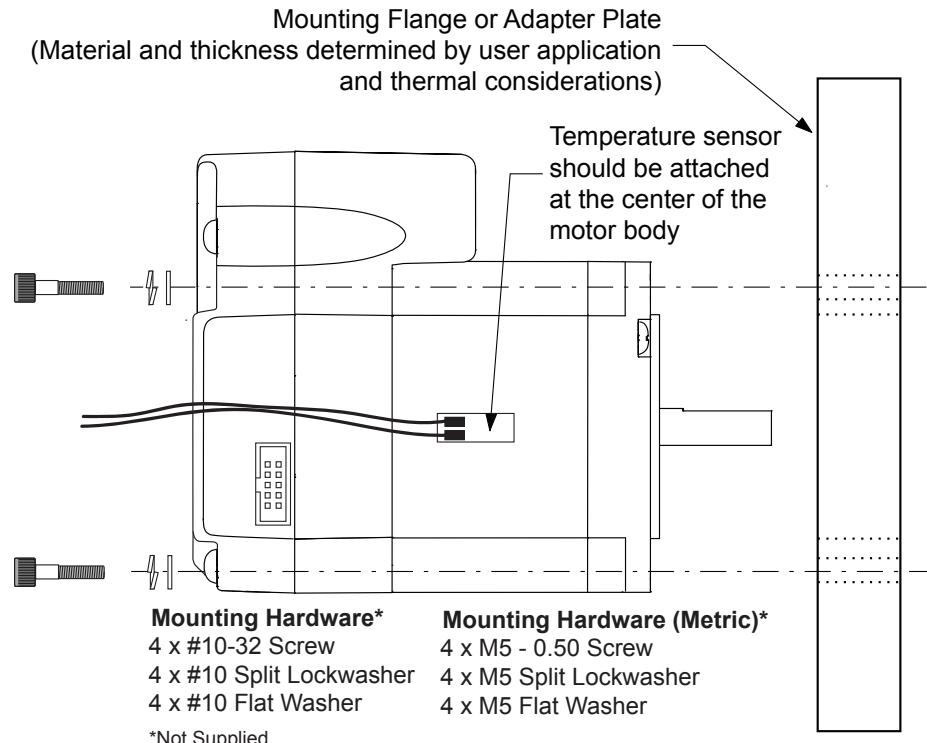


Figure 2.1.1: MDrive17Plus Mounting Screw Depth

MDrive23Plus Microstepping

Flange mounting holes are drilled and tapped to take standard #10-32 (M5) screws. The length of the screw used will be determined by the mounting flange or adapter plate thickness. When choosing a material for the mounting adapter plate or flange, keep the maximum motor temperature of 100°C in mind.



Drill Pattern

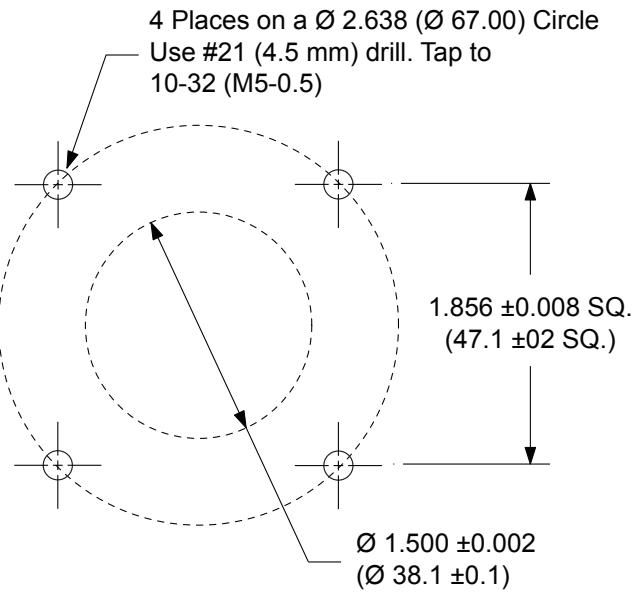


Figure 2.1.2: MDrive23Plus Mounting Recommendations

Layout and Interface Guidelines

Logic level cables must not run parallel to power cables. Power cables will introduce noise into the logic level cables and make your system unreliable.

Logic level cables must be shielded to reduce the chance of EMI induced noise. The shield needs to be grounded at the signal source to earth. The other end of the shield must not be tied to anything, but allowed to float. This allows the shield to act as a drain.

Power supply leads to the MDrivePlus need to be twisted. If more than one driver is to be connected to the same power supply, run separate power and ground leads from the supply to each driver.

Rules of Wiring

- Power Supply and Motor wiring should be shielded twisted pairs, and run separately from signal-carrying wires.
- A minimum of one twist per inch is recommended.
- Motor wiring should be shielded twisted pairs using 20 gauge, or for distances of more than 5 feet, 18 gauge or better.
- Power ground return should be as short as possible to established ground.
- Power supply wiring should be shielded twisted pairs of 18 gauge for less than 4 amps DC and 16 gauge for more than 4 amps DC.

Rules of Shielding

- The shield must be tied to zero-signal reference potential. It is necessary that the signal be earthed or grounded, for the shield to become earthed or grounded. Earthing or grounding the shield is not effective if the signal is not earthed or grounded.
- Do not assume that Earth ground is a true Earth ground. Depending on the distance from the main power cabinet, it may be necessary to sink a ground rod at the critical location.
- The shield must be connected so that shield currents drain to signal-earth connections.
- The number of separate shields required in a system is equal to the number of independent signals being processed plus one for each power entrance.
- The shield should be tied to a single point to prevent ground loops.
- A second shield can be used over the primary shield; however, the second shield is tied to ground at both ends.

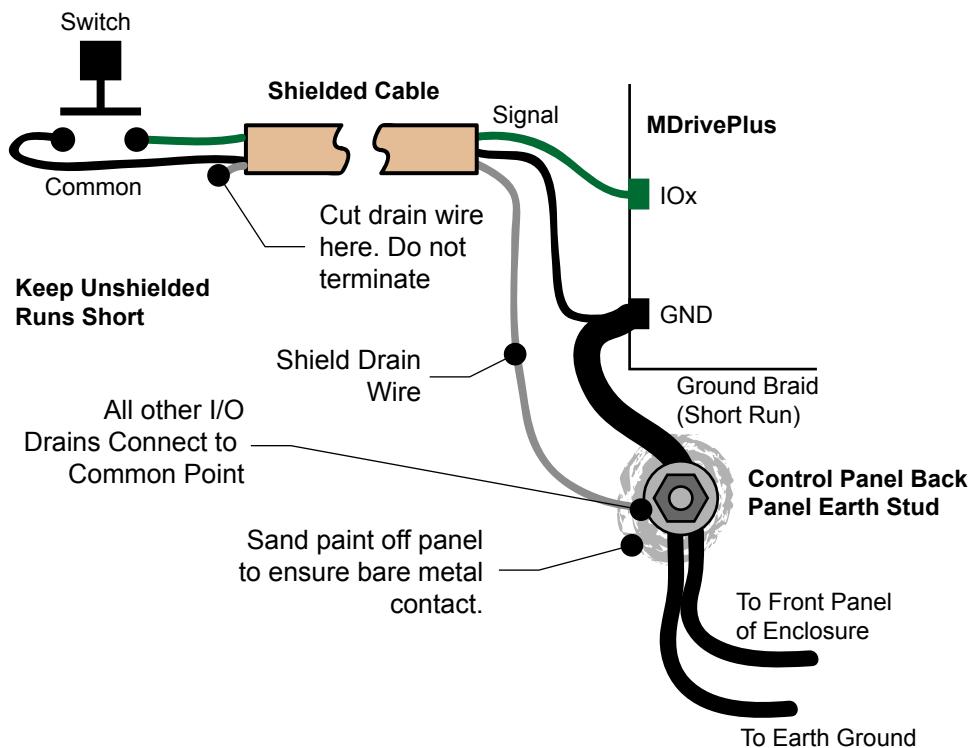


Figure 2.1.3: Grounding and Shielding for Logic Connections



NEED A CABLE?
The following
Prototype
Development Cables
are available to
interface Power and I/O

MDI17Plus²
PD16-1417-FL3

MDI23Plus² Power
PD02-2300-FL3

MDI23Plus² I/O
PD14-2334-FL3

See Appendix G for details.

To Interface Communications:

USB to RS-422/485
MD-CC400-000 (10-Pin IDC)
MD-CC401-000 (5-Pin M12)
MD-CC402-000 (10-Pin Wire
Crimp)

10-Pin Wire Crimp (Multi-Drop)
PD10-1434-FL3

Cordsets for Sealed (-65) Models:

Straight Termination (M23)
MD-CS100-000

Right-Angle Termination (M23)
MD-CS101-000

See Appendices F and G for
details.

Recommended Wiring

The following wiring/cabling is recommended for use with the MDrivePlus:

Logic Wiring.....	22 AWG
Wire Strip Length	0.25" (6.0 mm)
Power and Ground	See Appendix B: Recommended Power and Cable Configurations

Recommended Mating Connectors and Pins

Communications

10-pin Friction Lock (P2)	Hirose DF11-10DS-2C
Crimp Contact for 10-pin Friction Lock (22 AWG).....	DF11-22SC
Crimp Contact for 10-pin Friction Lock (24 - 28 AWG)	DF11-2428SC
Crimp Contact for 10-pin Friction Lock (30 AWG).....	DF11-30SC

Logic and Power

The following mating connectors are recommended for the MDrivePlus2 Units ONLY! Please contact a JST distributor for ordering and pricing information.

MDrive17Plus²

16-pin Locking Wire Crimp Connector Shell	JST PN PADP-16V-1-S
Crimp Pins.....	JST PN SPH-001T-P0.5L

MDrive23Plus²

14-pin Locking Wire Crimp Connector Shell	JST PN PADP-14V-1-S
Crimp Pins.....	JST PN SPH-001T-P0.5L

Securing Power Leads and Logic Leads

Some applications may require that the MDrive move with the axis motion. If this is a requirement of your application, the motor leads (flying, pluggable or threaded) must be properly anchored. This will prevent flexing and tugging which can cause damage at critical connection points within the MDrive.

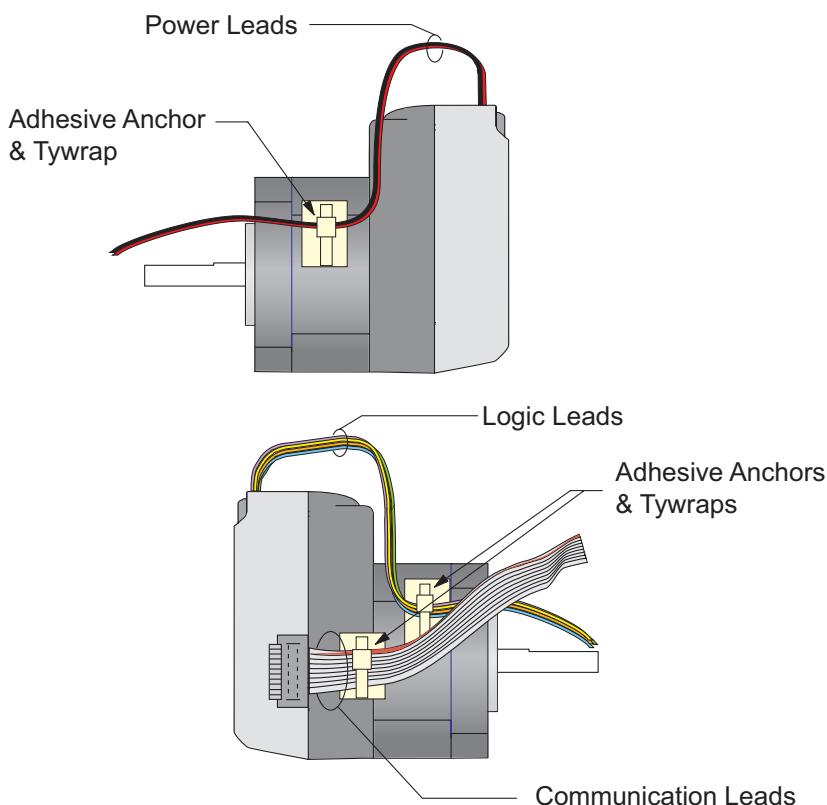


Figure 2.1.4: Typical MDrive Shown with Leads Secured

SECTION 2.2

Interfacing DC Power and Auxiliary Logic

Choosing a Power Supply for Your MDrive

When choosing a power supply for your MDrivePlus there are performance and sizing issues that must be addressed. An undersized power supply can lead to poor performance and even possible damage to the device, which can be both time consuming and expensive. However, the design of the MDrivePlus is quite efficient and may not require as large a supply as you might suspect.

Motors have windings that are electrically just inductors, and with inductors comes resistance and inductance. Winding resistance and inductance result in a L/R time constant that resists the change in current. It requires five time constants to reach nominal current. To effectively manipulate the di/dt or the rate of charge, the voltage applied is increased.

When traveling at high speeds there is less time between steps to reach current. The point where the rate of commutation does not allow the driver to reach full current is referred to as Voltage Mode. Ideally you want to be in Current Mode, which is when the drive is achieving the desired current between steps. Simply stated, a higher voltage will decrease the time it takes to charge the coil, and therefore will allow for higher torque at higher speeds.

Another characteristic of all motors is Back EMF, and though nothing can be done about back EMF, we can give a path of low impedance by supplying enough output capacitance. Back EMF is a source of current that can push the output of a power supply beyond the maximum operating voltage of the driver and as a result could damage the MDrivePlus over time.

The MDrivePlus is very current efficient as far as the power supply is concerned. Once the motor has charged one or both windings of the motor, all the power supply has to do is replace losses in the system. The charged winding acts as an energy storage in that the current will re-circulate within the bridge, and in and out of each phase reservoir. While one phase is in the decaying stage of the variable chopping oscillator, the other phase is in the charging stage, this results in a less than expected current draw on the supply.

The MDrivePlus is designed with the intention that a user's power supply output will ramp up to greater or equal to the minimum operating voltage. The initial current surge is quite substantial and could damage the driver if the supply is undersized. If a power supply is undersized, upon a current surge the supply could fall below the operating range of the driver. This could cause the power supply to start oscillating in and out of the voltage range of the driver and result in damaging either the supply, driver or both. There are two types of supplies commonly used, regulated and unregulated, both of which can be switching or linear. All have their advantages and disadvantages.

An unregulated linear supply is less expensive and more resilient to current surges, however, voltage decreases with increasing current draw. This can cause serious problems if the voltage drops below the working range of the drive. Also of concern is the fluctuations in line voltage. This can cause the unregulated linear supply to be above or below the anticipated voltage.

A regulated supply maintains a stable output voltage, which is good for high speed performance. They are also not bothered by line fluctuations, however, they are more expensive. Depending on the current regulation, a regulated supply may crowbar or current clamp and lead to an oscillation that as previously stated can lead to damage. Back EMF can cause problems for regulated supplies as well. The current regeneration may be too large for the regulated supply to absorb and may lead to an over voltage condition.

Switching supplies are typically regulated and require little real-estate, which makes them attractive. However, their output response time is slow, making them ineffective for inductive loads. IMS has designed a series of low cost miniature non-regulated switchers that can handle the extreme varying load conditions which makes them ideal for the MDrivePlus.

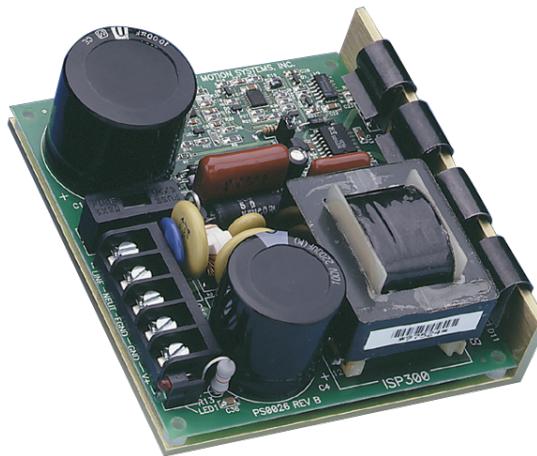


Figure 2.2.1: IMS ISP300 Switch Mode Power Supply

DC Power Supply Recommendations

The power requirements for the MDrivePlus are:

MDrive17Plus

Output Voltage	+12 to +48 VDC (Includes Back EMF)
Current (max. per unit).....	2A
<i>(Actual power supply current requirement will depend upon voltage and load)</i>	

MDrive23Plus

Output Voltage (Single, Double and Triple Size)	+12 to +75 VDC (Includes Back EMF)
Output Voltage (Quad Size)	+12 to +60 VDC (Includes Back EMF)
Current (max. per unit).....	4A
<i>(Actual power supply current requirement will depend upon voltage and load)</i>	

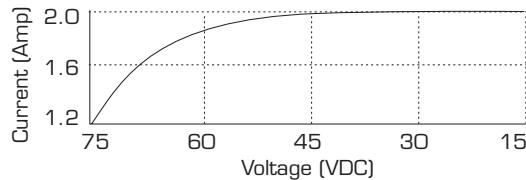


Figure 2.2.2: MDrive23Plus Motion Control Current Requirements

Recommended IMS Power Supplies

IMS unregulated linear and unregulated switching power supplies are the best fit for IMS drive products.

IP402 Unregulated Linear Supply (MDrive17Plus)

Input Range

120 VAC Versions	102-132 VAC
240 VAC Versions	204-264 VAC

Output (All Measurements were taken at 25°C, 120 VAC, 60 Hz)

No Load Output Voltage.....	39 VDC @ 0 Amps
Continuous Output Rating.....	30 VDC @ 1.0 Amps
Peak Output Rating	25 VDC @ 2.0 Amps

IP404 Unregulated Linear Supply (MDrive17Plus)

Input Range

120 VAC Versions	102-132 VAC
240 VAC Versions	204-264 VAC

Output (All Measurements were taken at 25°C, 120 VAC, 60 Hz)

No Load Output Voltage.....	43 VDC @ 0 Amps
Continuous Output Rating.....	32 VDC @ 1.5 Amps
Peak Output Rating	26 VDC @ 3 Amps

ISP200-4 Unregulated Switching Supply (MDrive17Plus, MDrive23Plus)

Input Range

120 VAC Versions	102-132 VAC
240 VAC Versions	204-264 VAC

Output (All Measurements were taken at 25°C, 120 VAC, 60 Hz)

No Load Output Voltage.....	41 VDC @ 0 Amps
Continuous Output Rating.....	38 VDC @ 1.5 Amps
Peak Output Rating	35 VDC @ 3 Amps

IP804 Unregulated Linear Supply (MDrive23Plus)

Input Range

120 VAC Versions	102-132 VAC
240 VAC Versions	204-264 VAC

Output (All Measurements were taken at 25°C, 120 VAC, 60 Hz)

No Load Output Voltage.....	76 VDC @ 0 Amps
Half Load Output.....	65 VDC @ 2 Amps
Full Load output.....	58 VDC @ 4 Amps

IP806 Unregulated Linear Supply (MDrive23Plus)

Input Range

120 VAC Versions	102-132 VAC
240 VAC Versions	204-264 VAC

Output (All Measurements were taken at 25°C, 120 VAC, 60 Hz)

No Load Output Voltage.....	76 VDC @ 0 Amps
Half Load Output.....	68 VDC @ 3 Amps
Full Load Output.....	64 VDC @ 6 Amps

ISP300-7 Unregulated Switching Supply (MDrive23Plus)

Input Range

120 VAC Versions	102-132 VAC
240 VAC Versions	204-264 VAC

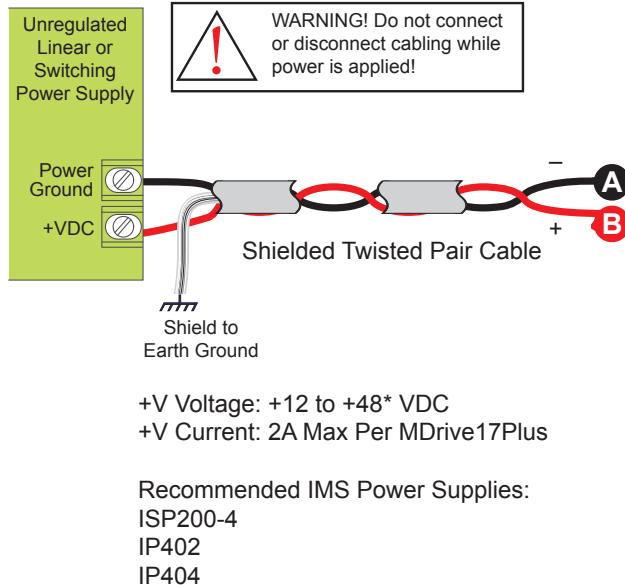
Output (All Measurements were taken at 25°C, 120 VAC, 60 Hz)

No Load Output Voltage.....	68 VDC @ 0 Amps
Continuous Output Rating.....	63 VDC @ 2 Amps
Peak Output Rating.....	59 VDC @ 4 Amps

Connecting DC Power

Connect the DC Power Supply to your MDrivePlus in accordance with the following illustrations.

MDrive17Plus



*Includes Back EMF!

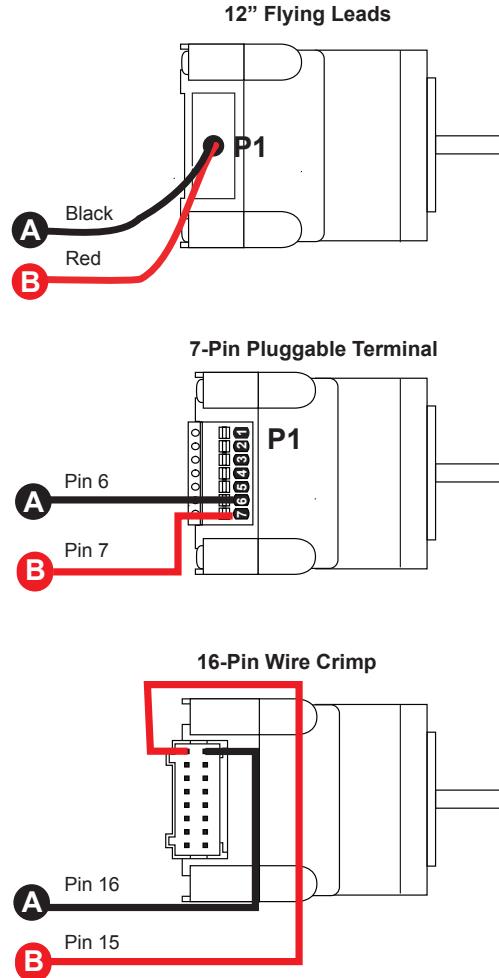


Figure 2.2.3: DC Power Connections — MDrive17Plus



NOTE: The length of the DC power supply cable to an MDrive should not exceed 50 feet.



NOTE: These recommendations will provide optimal protection against EMI and RFI. The actual cable type, wire gauge, shield type and filtering devices used are dependent on the customer's application and system.



NOTE: Always use Shielded/Twisted Pairs for the MDrive DC Supply Cable and the AC Supply Cable.

MDrive23Plus

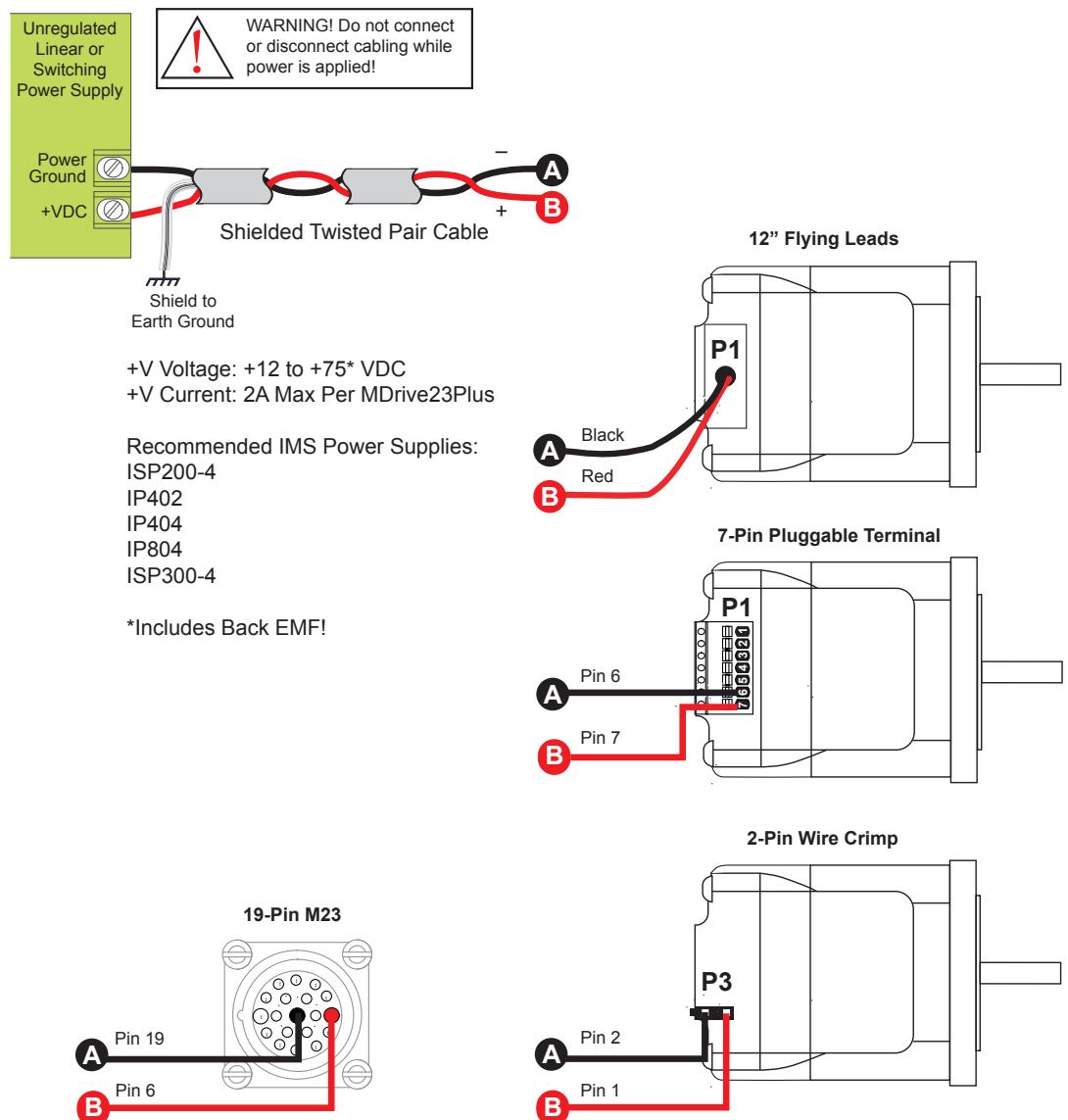


Figure 2.2.4 DC Power Connections — MDrive23Plus

Recommended Power and Cable Configurations

Cable length, wire gauge and power conditioning devices play a major role in the performance of your MDrive.

Example A demonstrates the recommended cable configuration for DC power supply cabling under 50 feet long. If cabling of 50 feet or longer is required, the additional length may be gained by adding an AC power supply cable (see Examples B & C).

Correct AWG wire size is determined by the current requirement plus cable length. Please see the MDrive Supply Cable AWG Table at the end of this Appendix.

Example A – Cabling Under 50 Feet, DC Power

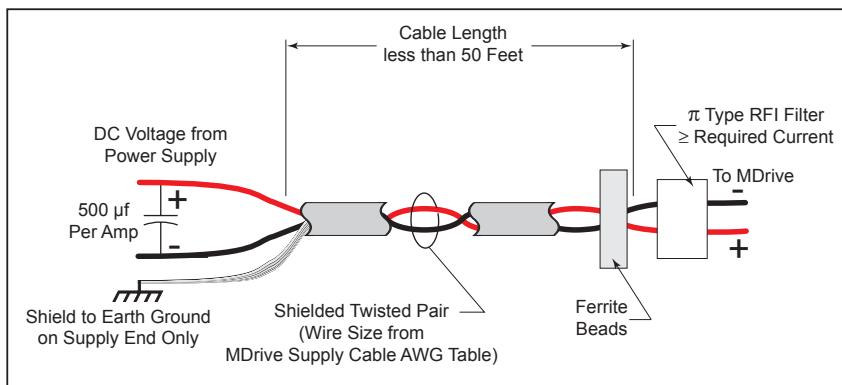


Figure 2.2.5: DC Cabling - Under 50 Feet

Example B – Cabling 50 Feet or Greater, AC Power to Full Wave Bridge

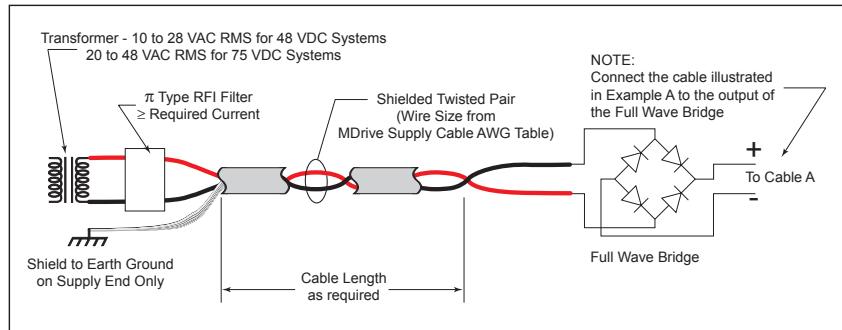


Figure 2.2.6: DC Cabling - 50 Feet or Greater - AC To Full Wave Bridge Rectifier

Example C – Cabling 50 Feet or Greater, AC Power to Power Supply

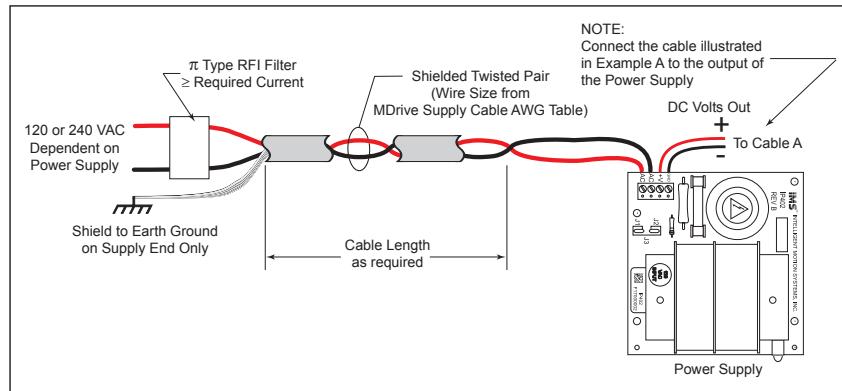


Figure 2.2.7: AC Cabling - 50 Feet or Greater - AC To Power Supply

Recommended Power Supply Cabling

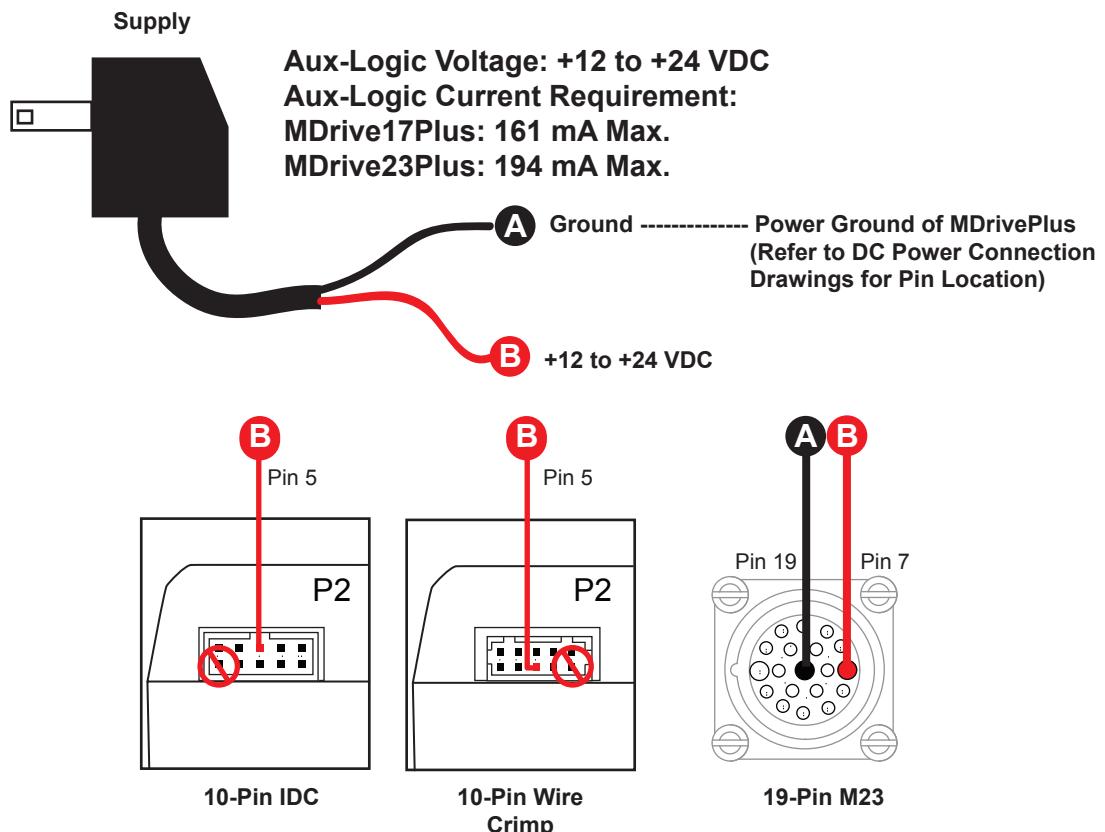
MDrivePlus Supply Cable AWG Table					
1 Ampere (Peak)					
Length (Feet)	10	25	50*	75*	100*
Minimun AWG	20	20	18	18	16
2 Amperes (Peak)					
Length (Feet)	10	25	50*	75*	100*
Minimun AWG	20	18	16	14	14

*Use the alternative methods illustrated in examples B and C when cable length is \geq 50 feet. Also, use the same current rating when the alternate AC power is used.

Table 2.2.1: Recommended Supply Cables

Aux-Logic Supply Connection

The Auxiliary Logic input will maintain power to the Logic circuitry in the absence of motor power. The user will still be able to communicate with the device, however motion commands will be ignored and the internal counter will update by the number of pulses commanded. If stall detection is enabled a stall will register.



DO NOT Ground the Logic Supply at Communications Ground or damage will occur to the drive. Ground Aux Logic at Power Ground. This warning does not apply to MDrivePlus units with the 19-pin M23 connector at P1.

Figure 2.2.8: Aux-Logic Connection

SECTION 2.3

Interfacing MDrivePlus Communications

Available Communications Cables/Converters

To simplify the wiring and connection process IMS offers USB to RS-422 communications cables for each of the MDrivePlus Motion Control models. These convenient 12.0' (3.6m) accessory cables connect a PC's USB Port to the MDrivePlus P2 Connector. An in-line RS-422 converter enables parameter setting to a single MDrivePlus Motion Control. Cable purchase recommended with first orders. Versions include:

USB to 10-Pin IDC	Part No. MD-CC400-000
USB to 10-Pin Wire Crimp	Part No. MD-CC402-000
USB to M12 Circular (sealed version).....	Part No. MD-CC401-000
10-Pin Wire Crimp for Multi-drop	Part No. PD10-1434-FL3

For more information on these cables please reference Appendix F: Optional Cables and Cordsets.

Interfacing Single Mode Communications

The MDrivePlus Motion Control communicate to the host using the RS-422/485 protocol. Communications may be configured as either half duplex (RS-485) or full duplex (RS-422) using the EM (Echo Mode) Instruction. RS-422/485 may be used in two ways: either to communicate to a single MDrivePlus Motion Control, or to address up to 62 individually named MDrivePlus nodes in a multidrop system.

Single Mode Communications Full Duplex (RS-422)

To interface the MDrivePlus Motion Control using RS-422 protocol you will need one of the following:

- A PC equipped with RS-422 Interface.
- A PC RS-232 to RS-422/485 Converter.
- The USB to RS-422 accessory cable appropriate to your MDrivePlus Motion Control model.

Use the following diagrams to connect RS-422 communications to the MDrivePlus Motion Control.



Note: See the Specifications Section of this document specific to the MDrivePlus model you purchased for detailed connector and pin information.



WARNING! Do not connect or disconnect the Communications Converter Cables while power is applied!



WARNING! If using AUX-Logic, the Power return MUST be connected to the Motor Power Ground. DO NOT connect the return to Communications Ground!



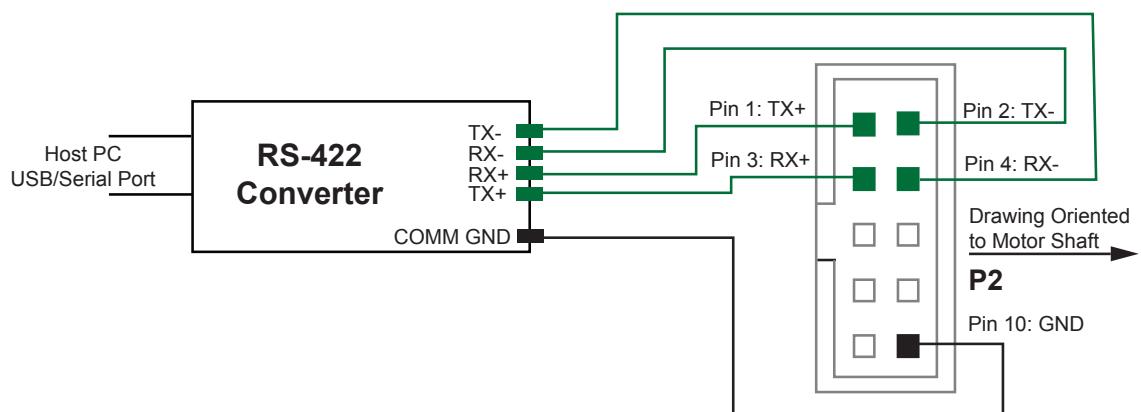
NEED A CABLE?

The following cables and converters are available to interface communications with P2:

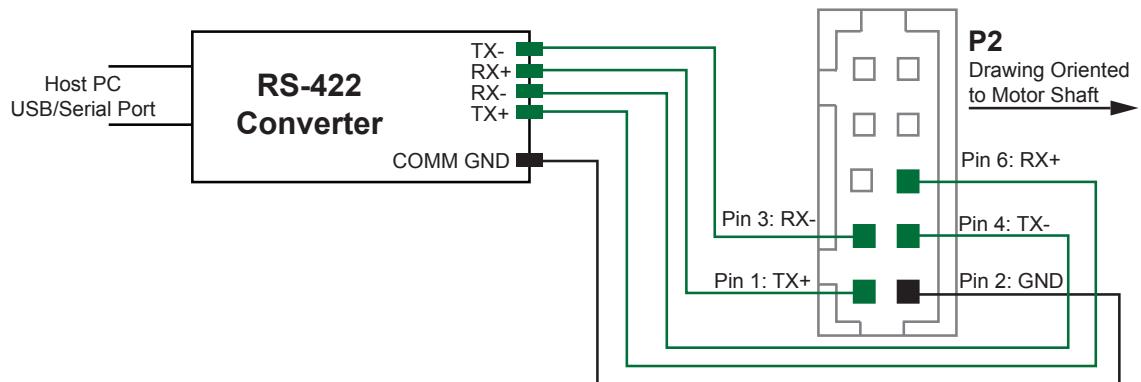
USB to RS-422/485:
MD-CC400-000 (10-Pin IDC)
MD-CC401-000 (5-Pin M12)
MD-CC402-000 (10-Pin Wire Crimp)

Multi-Drop for 10-Pin Wire Crimp Party-Mode
PD10-1434-FL3

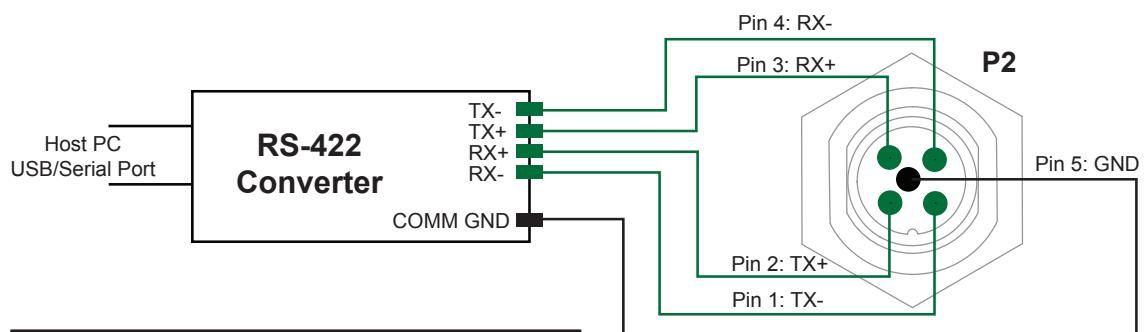
10-Pin IDC Connector



10-Pin Wire Crimp Connector



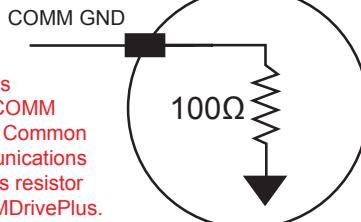
5-Pin M12-F Circular



COMMUNICATIONS GROUND

COMM GND

A 100Ω Resistor is placed between COMM GND and MDrive Common to prevent communications ground loops. This resistor is internal to the MDrivePlus.



COMM GND is ONLY to be used for grounding communications. Grounding Aux-Logic or any other device to COMM GND may damage the MDrivePlus!

Figure 2.3.1: Full Duplex Communications (RS-422)

Single Mode Communications Half Duplex (RS-485)

The MDrivePlus Motion Control can be operated in a 2 wire RS-485 communication bus. Before connecting the 2 wire RS-485, download your program and setup instructions using the standard 4 wire RS-422 Communications Cable. If a program is not being used, download and save any setup parameters. To ensure the MDrivePlus responds only to commands specifically meant for it, set the unit in Party Mode (Please see Party Mode below). The Echo Mode command (EM) must be set to the value of 1 (EM=1). This will set the MDrivePlus communication into “half duplex” mode. Connect the driver in the 2 wire RS-485 configuration. The following diagram illustrates how to connect the MDrivePlus 4 wire RS-485 to operate as a 2 wire system.

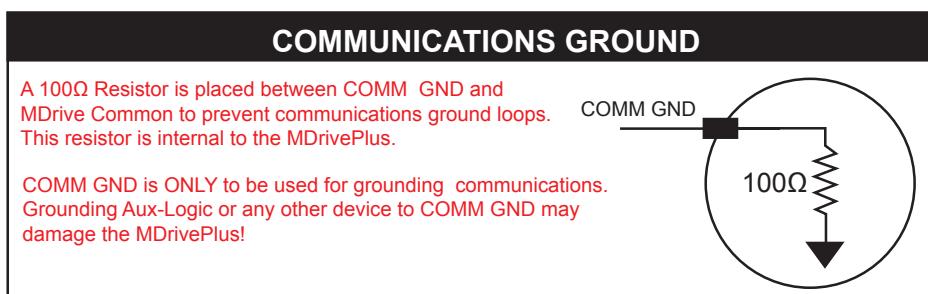
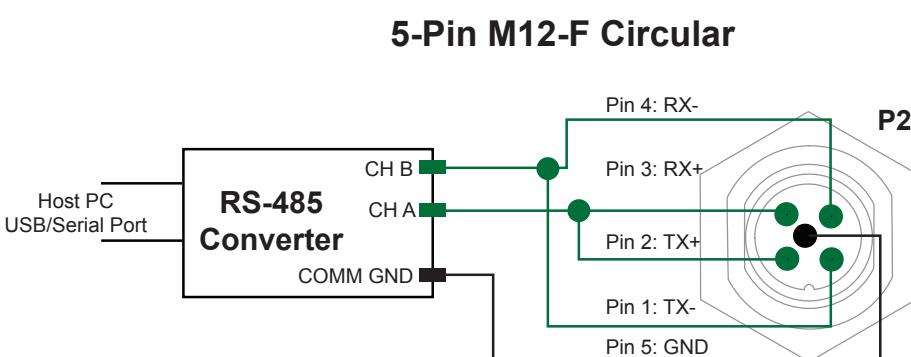
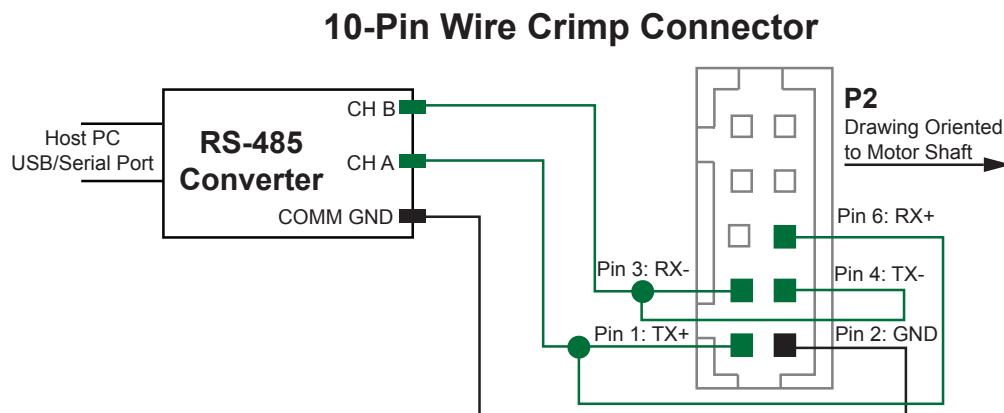
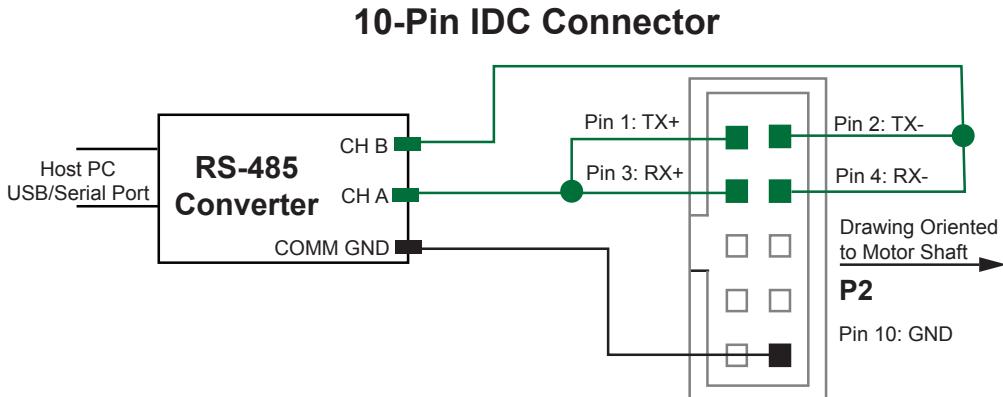


Figure 2.3.2: Half Duplex 2 Wire Communications (RS-485)



NEED A CABLE?

The following communications converter and prototype

development cable is available to interface multidrop communications. These are used in combination with each other.

USB to RS-422/485:
MD-CC402-000 (10-Pin Wire Crimp)

Multi-Drop for 10-Pin Wire Crimp Party-Mode

PD10-1434-FL3

This combination is only available if using the 10-Pin Wire Crimp style connector at P2.

Interfacing Party Mode Communications

In systems with multiple controllers it is necessary to communicate with the control modules using party mode (PY=1). The MDrivePlus Motion Control nodes in the system are configured in software for this mode of operation by setting the Party Flag (PY) to True (1). It is necessary for all of the nodes in a system to have this configuration selected. When operating in party mode, each MDrive Motion Control in the system will need a unique address, or name, to identify it in the system. This is accomplished by using the software command DN, or Device Name. For example, to set the name of an MDrive to "A" you would use the following command: DN=65 or DN="A" (65 is the ASCII decimal equivalent of uppercase A). The factory default name is "!". The asterisk character "*" is used to issue global commands to every device in the system. NOTE: When using the asterisk "*" in Party Mode, typed entries and commands will not be echoed. See Appendix B for ASCII table.

In setting up your system for party operation, the most practical approach is to observe the following steps:

Party Mode Setup Procedure

1. Connect the first MDrivePlus Motion Control to the Host PC configured for Single Mode Operation.
2. Establish communications and download program if required.
3. Using the command DN, name the MDrivePlus Motion Control. This can be any upper or lower case ASCII character or number 0-9. (DN="A"*{enter}*) (Note: The quotation marks before and after the device name are required.)
4. Set the party flag PY=1*{enter}*.
5. Press CTRL+J to activate the Party Mode.
6. Type the letters AS and press CTRL+J (Save device name and Party Mode).
7. Remove power.
8. Repeat steps 1 through 7 for each additional MDrive in the system.
9. After all MDrives are assigned a Device Name the Multiple MDrive Interface can be configured as shown in the following figure.

Data Cable Termination Resistors

Data Cable lengths greater than 15 feet (4.5 meters) are susceptible to signal reflection and/or noise. IMS recommends 120 Ω termination resistors in series with 0.1 μ f capacitors at both ends of the Receive Lines of the Communications Cables. An example of resistor placement is shown in Figure 2.2.3. For systems with Data Cables 15 feet (4.5 meters) or less, the termination resistors are generally not required.

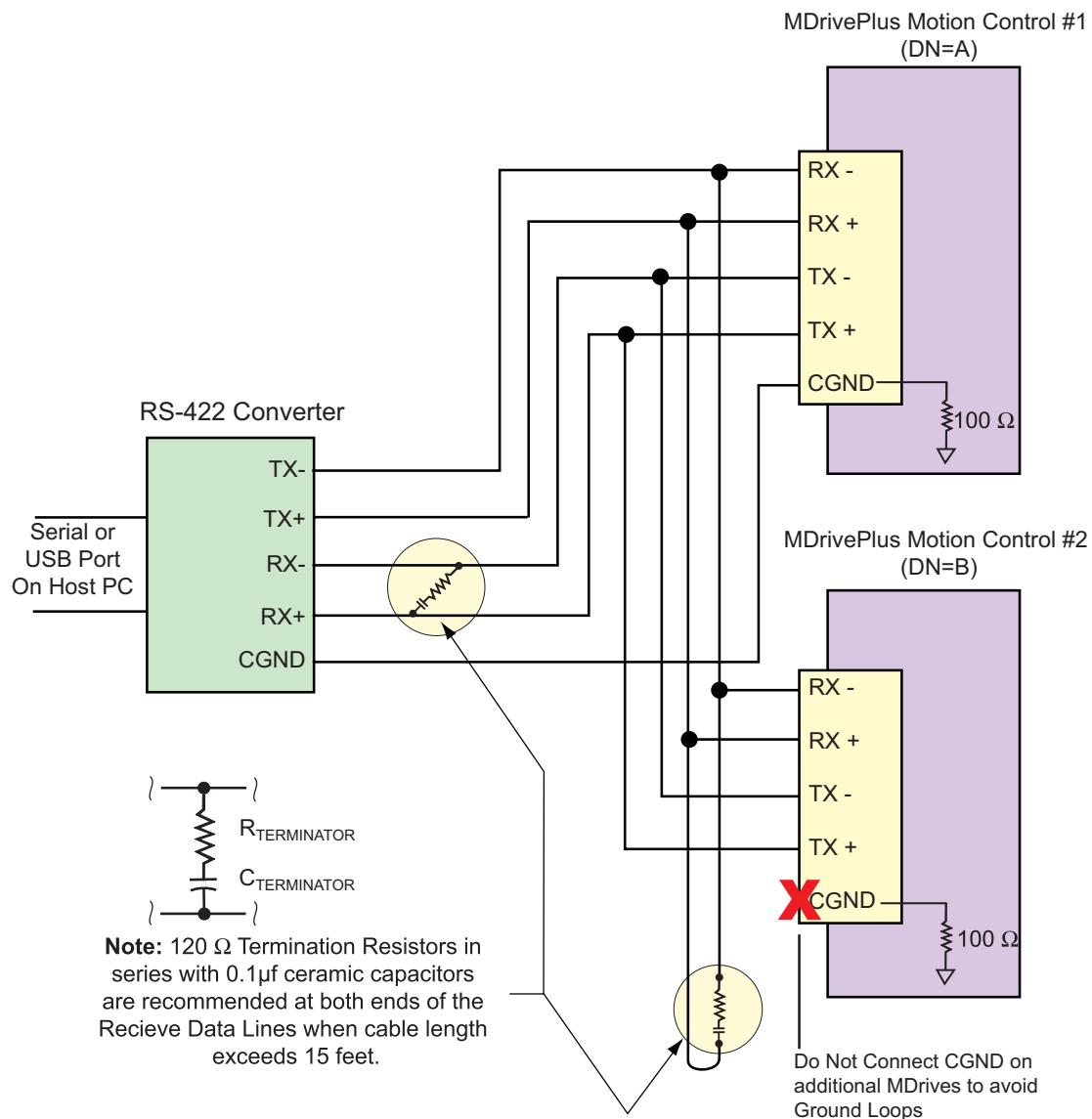


Figure 2.3.3: RS-485 Interface, Multiple MDrivePlus Motion Control System

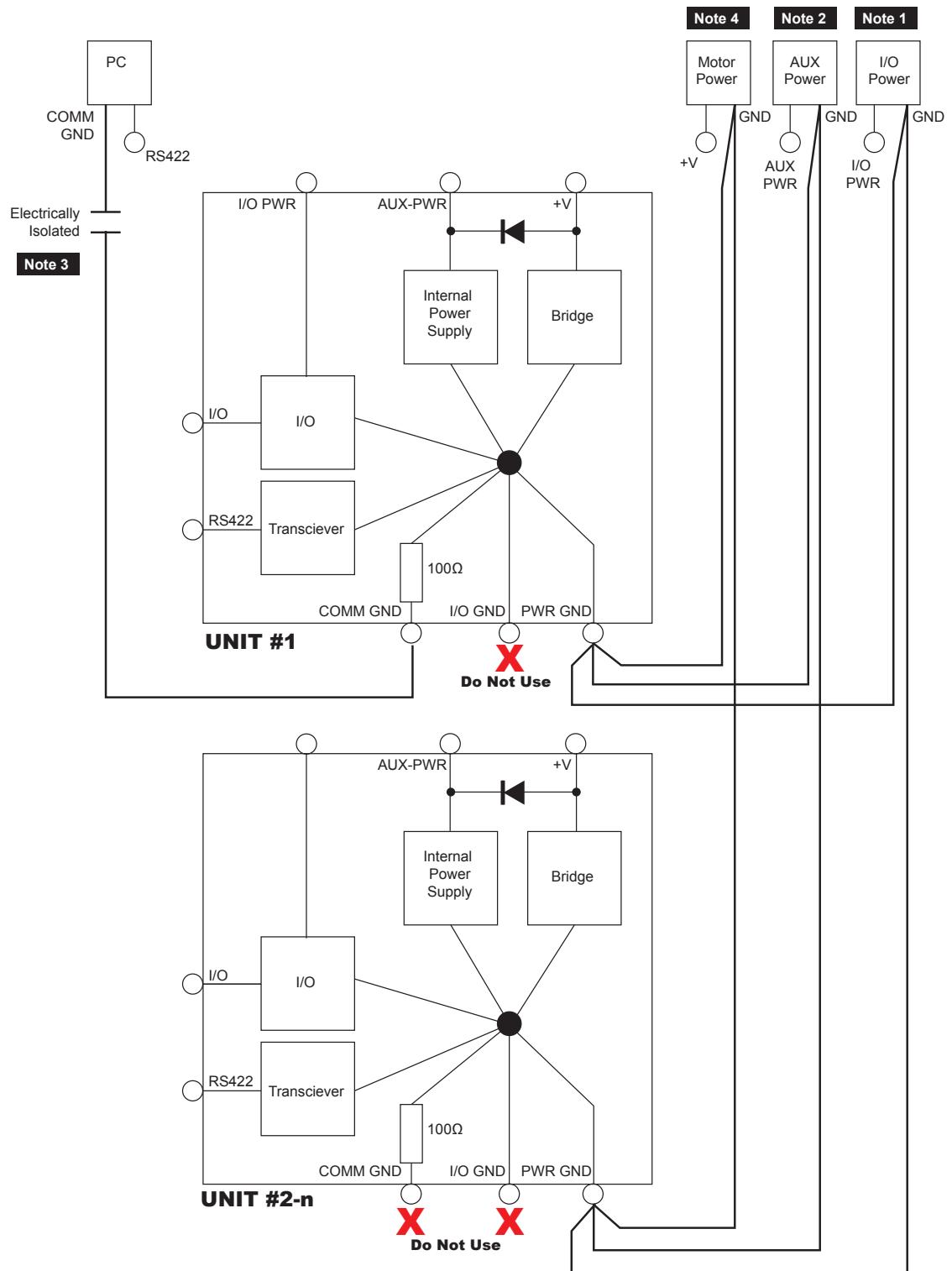


Figure 2.3.4: Party Mode Connection to avoid Communications Ground Loops

MDrivePlus Motion Control Communication Format

The following communication formats, used by MDrivePlus Motion Control (MDI) units, began with firmware version 1.043.

```

{}           The contents between the {} symbols are transmitted.
{0D}         Hex equivalent for a CR (Carriage Return).
{0A}         Hex equivalent for a LF (Line Feed).
{DN}         Represents the Device Name being sent.
{CS}         Check Sum; {ACK} 06 Hex; {NAK} 15 Hex
EM = Echo Mode; PY = Party Mode; CK= Check sum
  
```

The word {command} represents the immediate command sent to the MDI.

Command Execution Time (CET) is the time the MDI takes to execute a command. This varies from command to command and usually is in the 1-5 millisecond range.

MDrivePlus Motion Control (MDI) Response to Echo Mode

Dependent on how the Echo Mode (EM) is set in conjunction with Party Mode (PY) and Check Sum (CK), the MDI will respond differently. The following tables illustrate the various responses based on how the EM, PY and CK parameters are set.

Parameter Setting	Transmission to MDI	MDI Initial Response	MDI Final Response	Notes
EM=0 & PY=0 CK=0	(command) (D)	(command) Echoed back one character at a time as the character is entered.	CET (0D) (0A)>	The last character sent is the prompt >
EM=1 & PY=0 CK=0	(command) (0D)	-	CET (0D) (0A)	The last character sent is LF
EM=2 & PY=0 CK=0	(command) (0D)	-	-	No response except to PR and L commands
EM=3 & PY=0 CK=0	(command) (0D)	-	CET command (0D) (0A)	Queued response. The last character sent is the LF

Table 2.3.1: MDI Response to Echo Mode - Party and Check Sum are Zero (0)

Parameter Setting	Transmission to MDI	MDI Initial Response	MDI Final Response	Notes
EM=0 & PY=1 CK=0	(DN) (command) (0A)	(command) Echoed back one character at a time as the character is entered.	CET (0D) (0A)>	The last character sent is the prompt >
EM=1 & PY=1 CK=0	(DN) (command) (0A)	-	CET (0D) (0A)	The last character sent is LF
EM=2 & PY=1 CK=0	(DN) (command) (0A)	-	-	No response except to PR and L commands
EM=3 & PY=1 CK=0	(DN) (command) (0A)	-	CET command (0D) (0A)	Queued response. The last character sent is the LF

Table 2.3.2: MDI Response to Echo Mode - Party is One (1) and Check Sum is Zero (0)

Parameter Setting	Transmission to MDI	MDI Initial Response	MDI Final Response	Notes
EM=0 & PY=0 CK=1	(DN) (command) (0A)	(command) Echoed back one character at a time as the character is entered.	CET (0D) (0A)>	The last character sent is the prompt >
EM=1 & PY=0 CK=1	(DN) (command) (0A)	-	CET (0D) (0A)	The last character sent is LF
EM=2 & PY=0 CK=1	(DN) (command) (0A)	-	-	No response except to PR and L commands
EM=3 & PY=0 CK=1	(DN) (command) (0A)	-	CET command (0D) (0A)	Queued response. The last character sent is the LF

Table 2.3.3: MDI Response to Echo Mode - Party is Zero (0) and Check Sum is One (1)

Parameter Setting	Transmission to MDI	MDI Initial Response	MDI Final Response	Notes
EM=0 & PY=1 CK=1	(DN) (command) (CS) (0A)	(command) Echoed back one character at a time as the character is entered.	CET (ACK) or (NAK)>	The last character sent is the prompt >
EM=1 & PY=1 CK=1	(DN) (command) (CS) (0A)	-	CET (ACK) or (NAK)>	The last character sent is ACK or NAK
EM=2 & PY=1 CK=1	(DN) (command) (CS) (0A)	-	-	No response except to PR and L commands
EM=3 & PY=1 CK=1	(DN) (command) (CS) (0A)	-	CET command (CS) (ACK) (NAK)	Queued response. The last character sent is ACK or NAK

Table 2.3.4: MDI Response to Echo Mode - Party and Check Sum are One (1)

Using Check Sum

For communication using Check Sum, the following 2 commands demonstrate sending and receiving.

1. Check Sum set to ZERO before first character is sent.
2. All characters (ASCII values) are added to Check Sum, including the Device Name DN (if PY=1), to the end of the command, but not including terminator.
3. Check Sum is 2's complement, then “OR” ed with Hex 80 (prevents Check Sum from being seen as Command Terminator).

- Terminator Sent.

MR (space) 1

77 82 32 49
4D 52 20 31
77+82+32+49 = 240
1111 0000 = 240
0000 1111
0001 0000
1000 0000
1001 0000 144

Note: Any combination of upper/lower case may be used. In this example, if a lower case <mr> were to be used, the decimal values will change to 109 and 114. Subsequently the Result Check Sum value will change. (Possible entries: MR, mr, Mr, mR.) (M = 77, R = 82, m = 109, r = 114) (See ASCII table appendix in MDI Software Manual)
 Decimal value of M, R, <space> and 1
 Hex
 Add decimal values together
 Change 240 decimal to binary
 1's complement (invert binary)
 Add 1 [2's complement]
 OR result with 128 (Hex 80)
 Result Check Sum value

Once the result is reached, add the check Sum value (144 in this example) to your string by typing: MR 1(Alt Key + 0144) (Use the symbol of 0144 in your string by holding down the alt key and typing 0144). You must type the numbers from the Numlock key pad to the right of the keyboard. The numbers at the top of the keyboard will not work.

- Check Sum set to ZERO.
- All characters are added to Check Sum.
- When receiving a Command Terminator, the lower 7 bits of the Check Sum should be equal to ZERO.
 - If not ZERO, the command is ignored and NAK echoed.
 - If ZERO, ACK is sent instead of CR/LF pair.
- Responses to PR commands will be Check Summed as above, but the receiving device should NOT respond with ACK or NAK.

MDrivePlus Motion Control Party Mode Sample Codes

- Download this segment of code into the first MDrivePlus Motion Control. After downloading the program to the unit, follow the Party Mode Setup Procedure described earlier. Be sure to set your first unit with the unique Device Name of A (DN="A"). The device name is case sensitive.

```

RC=25          'Run current
HC=5          'Hold current
MS=256         'Microstep selection
A=250000       'Acceleration
D=250000       'Deceleration
PG 1          'Enter program mode
S1=0,0         'Setup I/O 1 as an input low true
LB SU          'Start program upon power up
LB AA          'Label program AA
MR 104400      'Move relative 104400 counts
H              'Hold program execution to complete the move
LB DD          'Label program DD
BR DD,I1=0      'Branch to DD if I1=0
PR "Bex 1"      'Print device name B to execute program
                'at address 1
                'Hold program execution 2000 milliseconds
PR "Cex 1"      'Print device name C to execute program at
                'address 1
                'Hold program execution 2000 milliseconds
H 2000          'Branch to label AA
PR "Cex 1"
H 2000          'Exit program, return to immediate mode
BR AA
E
PG

```



NOTE: When instructed to type Ctrl+J, that is the key + the key. It will not display in the Terminal Window so be certain you press the correct keys. CtrlJ activates the Party Mode.



NOTE: Once you have activated Party Mode with the first Ctrl+J you do not have to type it before each successive command. However, every command must be followed with a Ctrl+J.



NOTE: The asterisk (*) is a global command which addresses all units. Since three units can not answer together, the asterisk (*) as well as other global commands will not be displayed in the Terminal Window.

- Download this segment of code into your second MDrivePlus Motion Control. After downloading the program to the unit, follow the Party Mode Setup Procedure. Be sure to set your second unit with the unique address of B (device name is case sensitive).

```

RC=25          'Run current
HC=5           'Hold current
MS=256          'Microstep selection
A=250000        'Acceleration
D=250000        'Deceleration
PG 1            'Enter program mode
LB BB           'Label program BB
MR 208000       'Move relative 208000 counts
H                'Hold program execution to complete the move
E
PG              'Exit program, return to immediate mode

```

- Download this segment of code into your third MDrivePlus Motion Control. After downloading the program to the unit, follow the Party Mode Setup Procedure . Be sure to set your third unit with the unique address of C (device name is case sensitive).

```

RC=25          'Run current
HC=5           'Hold current
MS=256          'Microstep selection
A=250000        'Acceleration
D=250000        'Deceleration
PG 1            'Enter program mode
LB CC           'Label program CC
MR 300000       'Move relative 300000 counts
H                'Hold program execution to complete the move
E
PG              'Exit program, return to immediate mode

```

MDrivePlus Motion Control Immediate Party Mode Sample Codes

Once Party Mode has been defined and set up as previously described under the heading “Multiple MDrivePlus Motion Control System (Party Mode)”, you may enter commands in the Immediate Mode in the IMS Terminal Window. Some examples follow.

Move MDrive A, B or C 10000 Steps

Assuming there are three MDrives set up in Party Mode as shown in the Sample Codes above.

- To move MDrive Unit “A”, Press Ctrl+J and then type: AMR^10000 and press Ctrl+J. MDrive Unit “A” will move 10000 steps.
- To print the position type: APR P and press Ctrl+J. The position of MDrive Unit “A” will be printed.
- To move MDrive Unit “B” type: BMR 10000 and press Ctrl+J. MDrive Unit “B” will move 10000 steps.
- To move all three MDrives at the same time type: *MR 10000 and press Ctrl+J. All MDrives will move 10000 steps.
- To change a Variable in the “C” unit type: C<variable name><number> and press Ctrl+J. The variable will be changed. To verify the change type: CPR <variable name> and press Ctrl+J. The new value will be displayed.

All Commands and Variables may be programmed in this manner.

- To take an MDrive out of Party Mode type: <device name>PY=0 and press Ctrl+J. That unit will be taken out of Party Mode. To take all units out of Party Mode type: *PY=0 and press Ctrl+J. All units will be taken out of Party Mode.

SECTION 2.4

Interfacing and Using the MDrivePlus Motion Control I/O

The MDrivePlus Motion Control Digital I/O

The MDrivePlus Motion Control product line is available with two digital I/O configurations, Standard and Enhanced.

The digital I/O may be defined as either active HIGH or active LOW. When the I/O is configured as active HIGH, the level is +5 to +24 VDC and the state will be read/set as a "1". If the level is 0 VDC, then the state will be read/set as "0". Inversely, if configured as active LOW, then the state of the I/O will be read/set as a "1" when the level is LOW, and "0" when the level is HIGH. The active HIGH/LOW state is configured by the third parameter of the I/O Setup (S1-4, S9-12) variable. The goal of this I/O configuration scheme is to maximize compatibility between the MDrivePlus Motion Control and standard sensors and switches.

Standard All MDrivePlus Models

Available Points IO1, IO2, IO3, IO4 (Sinking or
Sourcing Inputs, Sinking
Outputs ONLY)

Enhanced Plus², Plus²-65

Available Points IO1, IO2, IO3, IO4 (Sinking
Sourcing, Outputs/Inputs)
Additional Points IO9, IO10, IO11, IO12 (Sinking
Sourcing, Outputs/Inputs)
Dedicated I/O Step/Clock Input, Step/Direction
I/O, Capture Input/Trip Output

Standard I/O Set - All MDrivePlus Motion Control Models

The MDrivePlus Motion Control comes standard with a set of four I/O — (4) sinking or sourcing 0 to +24 VDC inputs or (4) sinking 0 to +24 VDC outputs, which may be programmed individually as either general purpose or dedicated inputs or outputs, or collectively as a group.

Enhanced I/O Set - MDrivePlus²/Plus²-65

The MDrivePlus² Motion Control is equipped with a set of eight I/O — (8) sinking or sourcing 0 to +24 VDC inputs or (8) sinking or sourcing +12 to +24 VDC outputs, which may be programmed individually as either general purpose or dedicated inputs or outputs, or collectively as a group. The eight I/O consist of two separate banks of four points: Bank 1: IO1 - IO4, Bank 2: IO9 - IO12.

Uses of the Digital I/O

The I/O may be utilized to receive input from external devices such as sensors, switches or PLC outputs. When configured as outputs, devices such as relays, solenoids, LEDs and PLC inputs may be controlled from the MDrivePlus Motion Control.

Each I/O point may be individually programmed to any one of 9 dedicated input functions, 4 dedicated output functions, or as general purpose inputs or outputs. The I/O may be addressed individually, or as a group. The active state of the line or group may also be set. All of these possible functions are accomplished with the I/O Setup Variable (S1-4, S9-12)

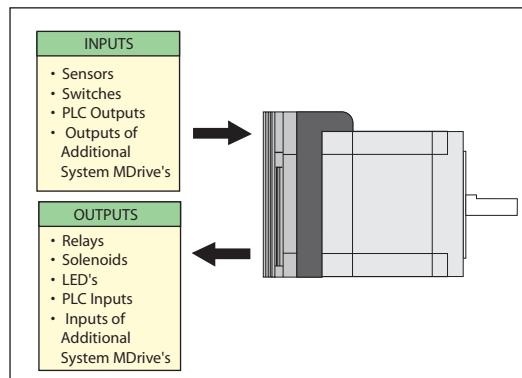


Figure 2.4.1: Uses for the Digital I/O

When the level is HIGH. The active HIGH/LOW state is configured by the second parameter of the I/O Setup (S1-4, S9-12) variable. The goal of this I/O configuration scheme is to maximize compatibility between the MDrivePlus Motion Control and standard sensors and switches.



NOTE: On the Standard MDrivePlus, when configured as outputs, the I/O set is sinking ONLY! The Plus² Models add the functionality of I/O Power, which enables the user to use all the outputs, both Standard and Enhanced, as Sinking or Sourcing.



NOTE: If the unit purchased has the remote encoder option, the additional points become dedicated to encoder functions!

MDrivePlus Motion Control Digital Input Functions

The MDrivePlus Motion Control inputs may be interfaced to a variety of sinking or sourcing devices. An input may be programmed to be a general purpose user input, or to one of nine dedicated input functions. These may then be programmed to have an active state of either HIGH or LOW.

The inputs are configured using the “S” Variable (See MDrive Motion Control Software Reference Manual for precise details on this command). The command is entered into the IMS terminal or program file as S<IO point>=<IO Type>,<Active State><Sink/Source>.

Example:

```
S9=3,1,0      'set IO point 9 to be a Limit- input, Active HIGH, Sinking
S3=0,0,1      'set IO Point 3 to be a General Purpose input, Active LOW,
                'Sourcing
```

Input Functions (I/O Points 1-4, 9-12)

The following table lists the programmable input functions of the MDrive Motion Control.

MDrivePlus Motion Control Input Functions				
Function	Description	Parameter (S1-S4, S9-S12)	Active	Sink/ Source
General Purpose	General Purpose Input function used to control program branches, subroutine calls or BCD functions when input bank is used as a group	0	0/1	0/1
Home	Homing input. Will function as specified by the Home (HM) command.	1	0/1	0/1
Limit +	Positive Limit Input. Will function as specified by the Limit (LM) Command.	2	0/1	0/1
Limit -	Negative Limit Input. Will function as specified by the Limit (LM) Command.	3	0/1	0/1
G0	G0 Input. Will run program located at address 1 on activation.	4	0/1	0/1
Soft Stop	Soft Stop input. Stops motion with deceleration and stops program execution.	5	0/1	0/1
Pause	Pause/Resume program with motion.	6	0/1	0/1
Jog +	Will Jog motor in the positive direction at Max. Velocity (VM). The Jog Enable (JE) Flag must be set for this to function.	7	0/1	0/1
Jog -	Will Jog motor in the negative direction at Max. Velocity (VM). The Jog Enable (JE) Flag must be set for this to function.	8	0/1	0/1
Reset	When set as RESET input, then the action is equivalent to a ^C entered into a terminal.	11	0/1	0/1

Table 2.4.1: Programmable Input Functions

Input Functions (Points 7 & 8 — Clock Inputs and Point 13 — Capture)

MDrivePlus Motion Control Input Functions		Parameter (S7, S8)	Active
Function	Description		
Step/Direction	Sets I/O 7 and 8 to receive step and direction inputs from an external source. The motion will occur based on the input frequency seen at I/O 7 in the Direction relative to the logic state of I/O 8. The step rate will be based upon the ratio set by Clock Ratio (CR)	33	0/1
Quadrature	Sets I/O 7 and 8 to receive Channel A and Channel B Quadrature inputs from an external source such as an encoder. The motion will follow the Quadrature Input.	34	0/1
Up/Down	Sets I/O 7 and 8 to receive Clock Up/Clock Down inputs from an external source. The motion will occur based upon the input clock frequency in the direction relative to the input being clocked. The step rate will be based upon the ratio set by Clock Ratio (CR)	35	0/1
Function	Description	Parameter (S13)	Active
High Speed Capture	The Capture input is a momentary high speed input that operates with the Trip Capture (TC) variable to run a subroutine upon the trip. It features variable input filtering ranging from 50 nS to 12.9 µS	60	0/1

Table 2.4.2: Dedicated Input Functions



NOTE: On the Standard MDrivePlus, when configured as outputs, the I/O set is sinking ONLY! The Plus² Models add the functionality of I/O Power, which enables the user to use all the outputs, both Standard and Enhanced, as Sinking or Sourcing.

Active States Defined

The Active State determines at what voltage level the input will be active.

Active HIGH The input will be active when +5 to +24 VDC is applied to the input.

Active LOW The input will be active when it is grounded (0 VDC).

IO 1 is to be configured as a Jog- input which will activate when a switch is toggled to ground (Sinking Input):

```
S1=8,0,0      'set IO point 1 to Jog-, Active LOW, Sinking
```

IO 4 is to be configured as a Home input which will activate when instructed by a PLC (+24VDC Sourcing Input):

```
S4=1,1,1      'set IO point 1 to Home, Active HIGH, Sourcing
```

MDrivePlus Motion Control Digital Output Functions

The MDrivePlus Motion Control Outputs may be configured as general purpose or set to one of two dedicated functions, Fault or Moving. These outputs will sink up to 600 mA (one channel of two banks) and may be connected to an external VDC source. See Output Functions Table and I/O Ratings Table.

The outputs are set using the "S" command (See MDrive Motion Control Software Reference Manual for precise details on this command). The command is entered into the IMS terminal or program file as S<IO point>=<IO Type>,<Active State><Sink/Source>.

Example:

```
S9=17,1,0      'set IO point 9 to be a Moving Output, Active HIGH, Sinking
S3=18,0,0      'set IO Point 3 to be a Fault Output, Active LOW, Sinking
```

Output Functions

The MDrivePlus Motion Control Output functions may be programmed to be a general purpose user output or to one of four output functions.

MDrivePlus Motion Control Input Functions				
Function	Description	Parameter (S1-S4, S9-S12)	Active	Sink/ Source
General Purpose User	A general purpose output can be set in a program or in immediate mode to trigger external events. When used as a group they can be a BCD output.	16	0/1	0/1
Moving	Will be in the Active State when the motor is moving.	17	0/1	0/1
Fault	Will be in the Active State when an error occurs. See Software Manual for error code listing.	18	0/1	0/1
Stall	Will be in the Active State when a stall is detected. Encoder Required, Stall Detect Mode (SM) must be enabled.	19	0/1	0/1
Velocity Changing	Will be in the Active State when the velocity is changing. Example: during acceleration and deceleration.	20	0/1	0/1

Table 2.4.3: Programmable Output Functions

Output Functions (Points 7 & 8 — Clock Outputs and Point 13 — Trip)

MDrivePlus Motion Control Input Functions			
Function	Description	Parameter (S7, S8)	Active
Step/Direction	Step clock pulses will be output from Point 7, Direction from Point 8. The step clock output rate will be based upon the Pulse Width set by Clock Width (CW). The logic state of the Direction output will be with respect to the direction of the motor.	49	0/1
Quadrature	Will output Quadrature signals.	50	0/1
Up/Down	Will output Clock Up/Clock Down signals. The step clock output rate will be based upon the Pulse Width set by Clock Width (CW). The Active output will be based on the motor direction.	51	0/1
Function	Description	Parameter (S13)	Active
High Speed Trip	The trip output will activate on Position Trips (TP) only. The output will pulse out at the trip point. The pulse width will be determined by Clock Width (CW)	61	0/1

Table 2.4.4: Dedicated Output Functions

MDrivePlus Motion Control I/O Ratings

MDrivePlus I/O Ratings			
MDrivePlus Output Voltage (IOPWR) Rating	0 to +24 VDC		
MDrivePlus2 Output Voltage (IOPWR) Rating	+12 to +24 VDC (Sourcing) 0 to +24 VDC (Sinking)		
Load Rating* (equal current per I/O Point)	I/O State	I Continuous	I Peak (D=0.84)
* Heatsink Temp = 85°C	1 on, 3 off	550 mA	600 mA
	2 on, 2 off	390 mA	425 mA
	3 on, 1 off	320 mA	350 mA
	4 on, 0 off	275 mA	300 mA
To compute FET dissipation for unequal loads, calculate the FET power for each I/O not to exceed 425 mW.			
Continuous Current	$\text{FET Power} = I_{\text{cont}}^2 \times 1.4$		
Peak Current	$\text{FET Power} = I_{\text{peak}}^2 \times D \times 1.4$		
Duty Cycle	(D = T on / T period) = ≤ 1.0 seconds at 85°C heat sink temperature.		
Protection Ratings			
Independent Over-temperature			
Current Limit	0.6A to 1.2 A		
Clamp	+45V, -20V		

Table 2.4.5: MDrivePlus Motion Control I/O and Protection Ratings

MDrivePlus Motion Control I/O Connections

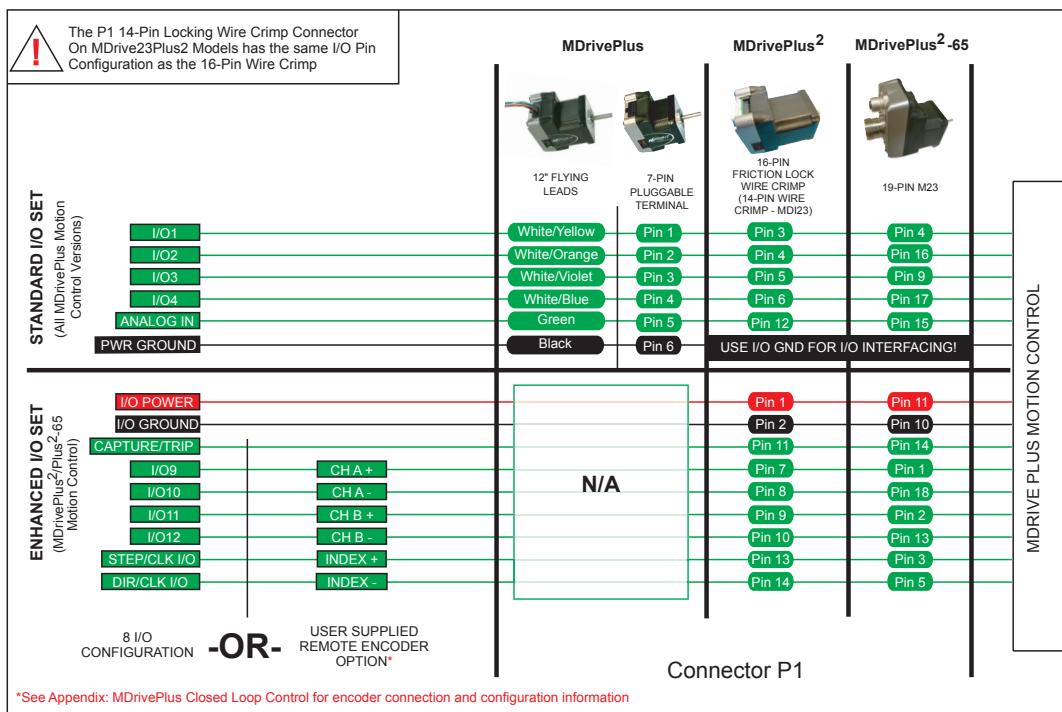


Figure 2.4.2: I/O Connection Map



NOTE: On the Standard MDrivePlus, power ground is used to ground the I/O interface.



NOTE: Advanced I/O interface circuit diagrams and application examples are available in Appendix D: I/O Applications Guide.

I/O Usage Examples — MDrivePlus Standard I/O Set

The circuit examples below illustrate possible interface examples for using the MDrivePlus Motion Control Digital I/O. Additional diagrams and code snippets are available in Appendix D: I/O Application Guide.

The code samples included with these examples will also serve to introduce the user to MDrivePlus Motion Control programming. Please reference the MDrive software manual for more information on the Instructions, Variables and Flags that make up the MDI command set as well as material on setting up and using the IMS Terminal.

Input Interface Example - Switch Input Example (Sinking Input)

The following circuit example shows a switch connected between an I/O point and power ground.

Code Sample

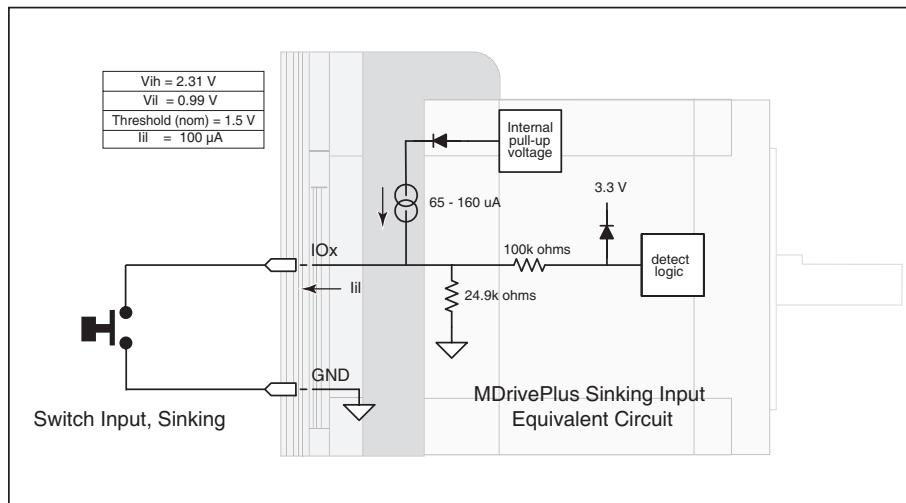


Figure 2.4.3: Sinking Input Example using a Push Button Switch

For the code sample, this switch will be set up as a G0 sinking input, active when low. When pressed, the switch will launch the program beginning at address 1 in MDrive memory:

```
***Setup Variables***  
Sx=4,0,0      'set IO point x to be a G0 input, active when LOW, sinking  
  
*****Program***  
PG1  
MR 20000      'Move +20000 steps relative to current position  
H  
MR -20000     'Hold program execution until motion completes  
H  
E  
PG            'End program, exit program mode
```

Input Interface Example - Switch Input Example (Sourcing Input)

The following circuit example shows a switch connected between an I/O point and a voltage supply which will source the input to perform a function.

Code Sample

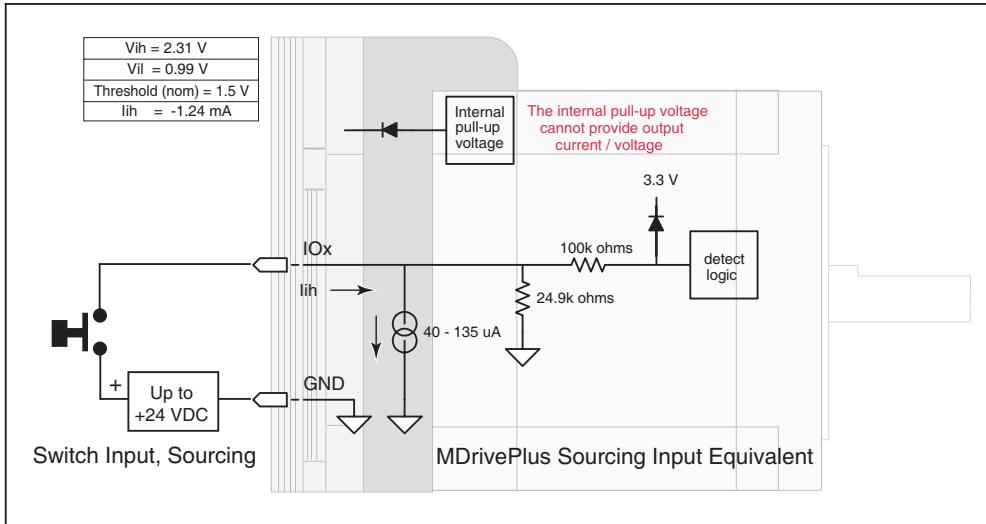


Figure 2.4.4: Sourcing Input Example using a Push Button Switch

For the code sample, the switch will be set up as a Soft Stop sourcing input, active when HIGH. When pressed, the switches will stop the motor.

```
S1=5,1,1      'set IO point 1 to be a Soft Stop input, active when HIGH,  
              'sourcing  
SL 200000    'enter this to slew the motor at 200000 ussteps/sec
```

When the switch is depressed the motor will decelerate to a stop.



NOTE: On the Standard MDrivePlus, when configured as outputs, the I/O set is sinking.

ONLY! The Plus² Models add the functionality of I/O Power, which enables the user to use all the outputs, both Standard and Enhanced, as Sinking or Sourcing.

Output Interface Example (Sinking Output)

The following circuit example shows a load connected to an I/O point that will be configured as a sinking output.

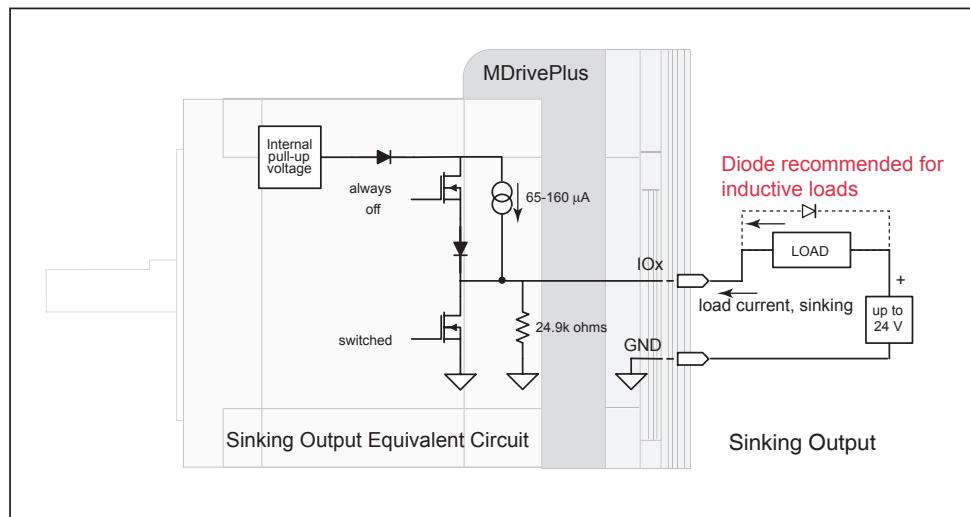


Figure 2.4.5: Sinking Output Example

For the code sample, the load will be an LED. The I/O point will be configured such that the LED will be unlit while the velocity is changing. Use the switch set-up from the previous input, modified to be sinking, example to soft stop the motor.

```
S1=5,0,0      'set IO point 1 to be a Soft Stop input, active when LOW,  
              'sinking.  
S1=20,0,0     'set IO point 2 to be a Velocity Changing output, active when  
              'LOW  
SL 2000000    'enter this to slew the motor at 200000 µsteps/sec
```

While the motor is accelerating the LED will be dark, but will light up when the motor reaches a constant velocity. When the Soft Stop switch is depressed the motor will begin to decelerate, the LED will go dark again while velocity is changing.

General Purpose I/O Usage Examples — Enhanced I/O Set

The MDrivePlus² models add the functionality of either an additional 4 I/O points or an optional interface for a user-defined remote encoder. Additionally, the I/O points, when configured as outputs have the added functionality of being configured as sinking or sourcing outputs.

The circuit examples below illustrate possible interface examples for using the MDrivePlus² Motion Control Digital I/O. Additional diagrams and code samples are available in Appendix D: I/O Applications Guide.

The code samples included with these examples will also serve to introduce the user to MDrivePlus Motion Control programming . Please reference the MDrive software manual for more information on the Instructions, Variables and Flags that make up the MDI command set as well as material on setting up and using the IMS Terminal.



NOTE: Advanced I/O interface circuit diagrams and application examples are available in Appendix D: I/O Applications Guide.

Input Interface Example - Switch Input Example (Sinking Input)

The following circuit example shows a switch connected between an I/O point and I/O Ground.

Code Sample

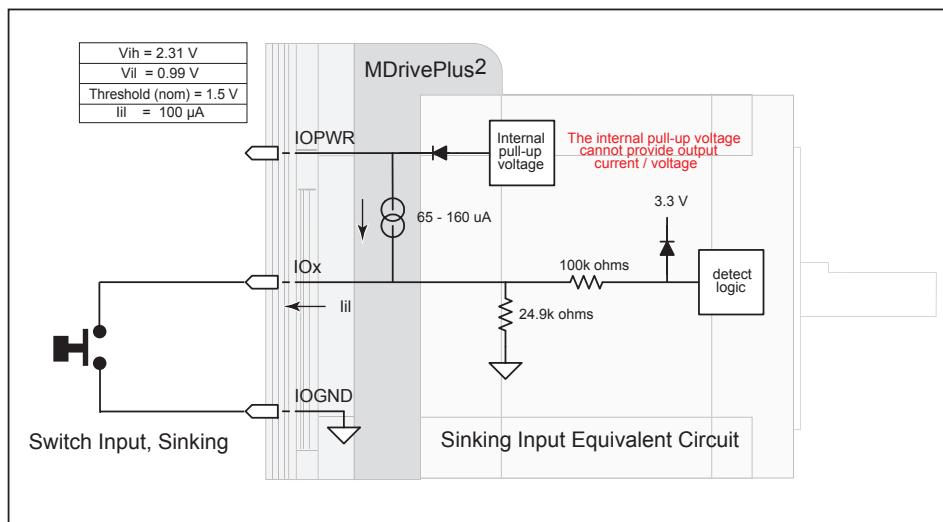


Figure 2.4.6: Switch Interface to Input, Sinking

For the code sample, this switch will be set up as a G0 sinking input, active when low. When pressed, the switch will launch the program beginning at address1 in MDrive memory:

```
***Setup Variables***  
Sx=4,0,0      'set IO point x to be a G0 input, active when LOW, sinking  
  
****Program***  
PG1  
MR 20000      'Move +20000 steps relative to current position  
H              'Hold program execution until motion completes  
MR -20000     'Move -20000 steps  
H              'Hold program execution until motion completes  
E  
PG            'End program, exit program mode
```

Input Interface Example - Switch Input Example (Sourcing Input)

The following circuit example shows a switch connected between an I/O point and a voltage supply which will source the input to perform a function.

Code Sample

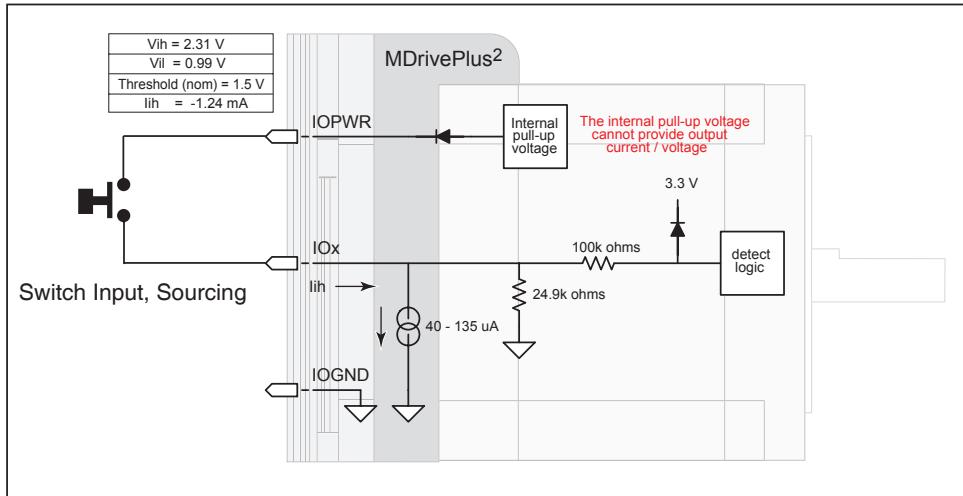


Figure 2.4.7 Sourcing Input Example using a Push Button Switch

For the code sample, the switch will be set up as a Soft Stop sourcing input, active when HIGH. When pressed, the switches will stop the motor.

```
S1=5,1,1      'set IO point 1 to be a Soft Stop input, active when HIGH,  
              'sourcing  
SL 200000    'enter this to slew the motor at 200000 µsteps/sec
```

When the switch is depressed the motor will decelerate to a stop.

Output Interface Example (Sinking Output)

The following circuit example shows a load connected to an I/O point that will be configured as a sinking output.

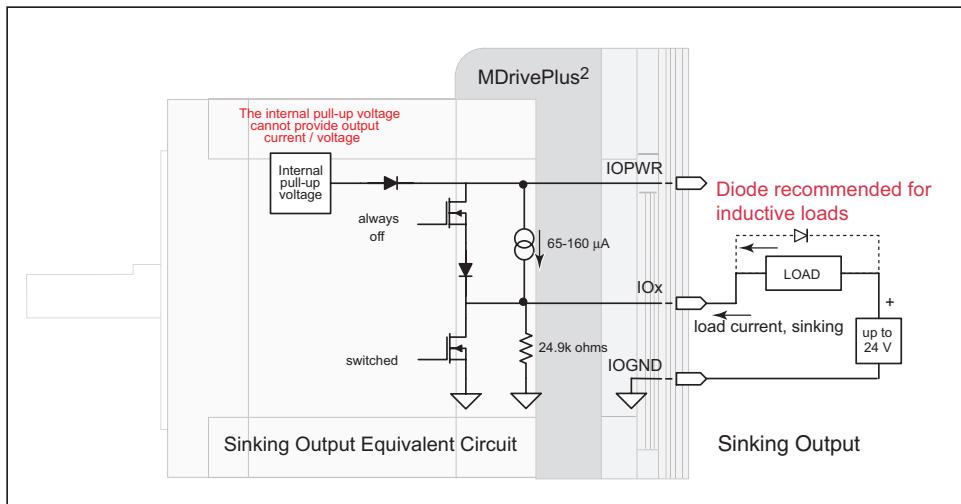


Figure 2.4.8: Sinking Output Example

Code Sample

For the code sample, the load will be an LED. The I/O point will be configured such that the LED will be unlit while the velocity is changing. Use the switch set-up from the previous input, modified to be sinking, example to soft stop the motor.

```
S1=5,0,0      'set IO point 1 to be a Soft Stop input, active when LOW,  
              'sinking.  
S1=20,0,0     'set IO point 2 to be a Velocity Changing output, active  
              'when LOW  
SL 2000000    'enter this to slew the motor at 200000 µsteps/sec
```

While the motor is accelerating the LED will be dark, but will light up when the motor reaches a constant velocity. When the Soft Stop switch is depressed the motor will begin to decelerate, the LED will go dark again while velocity is changing.

Output Interface Example (Sourcing Output)

The following circuit example shows a load connected to an I/O point that will be configured as a sourcing output.

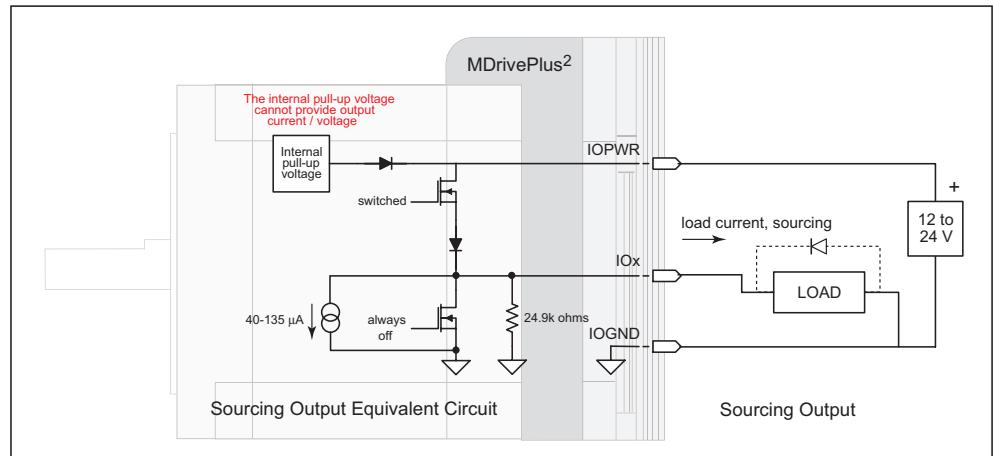


Figure 2.4.9: Sourcing Output Example

Code Sample

For the code sample, the load will be a relay. The output will be configured to be a General Purpose user output that will be set active when a range of motion completes.

```
*****Setup Variables*****
S1=16,1,1      'set IO point 1 to be a user output, active when HIGH,
                 'sourcing.

*****Program*****
PG 100          'Enter program at address 100
MR 2000000     'Move some distance in the positive direction
H               'Hold execution until motion completes
MR -1000000    'Move some distance in the negative direction
H               'Hold execution until motion completes
O1=1           'Set output 1 HIGH
```

Enter EX 100 to execute the program, the motion will occur and the output will set high.

Dedicated Digital I/O - Enhanced I/O Set

Step/Direction/Clock I/O

These dedicated I/O lines are used to receive clock inputs from an external device or provide clock outputs to an external device such as a counter or a second MDrivePlus in a system. The Clock I/O can be configured as one of three clock types using the S7 and S8 variable:

1. Step/Direction
2. Quadrature
3. Up/Down

Step/Direction

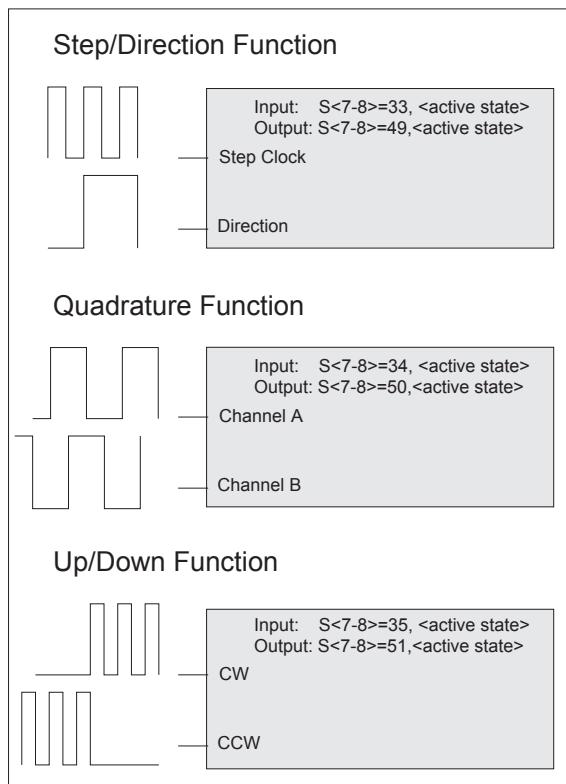
The Step/Direction function would typically be used to receive step and direction instructions from a second system MDrivePlus or secondary controller. When configured as outputs the MDrivePlus Motion Control can provide step and direction control to another system drive for electronic gearing applications.

Quadrature

The Quadrature clock function would typically be used for following applications where the MDrivePlus would either be a master or slave in an application that would require two MDrives to move the same distance and speed.

Up/Down

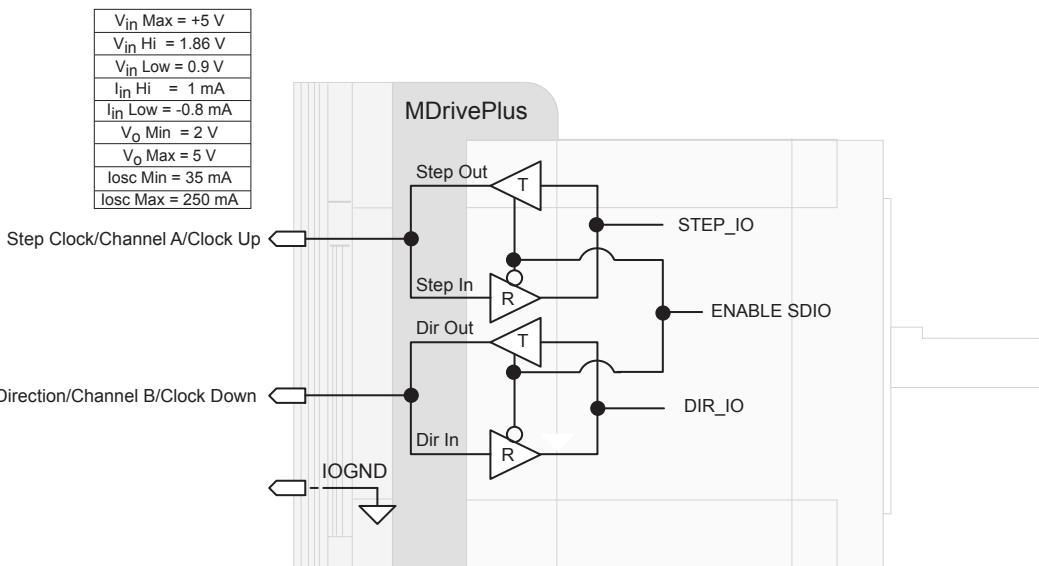
The Up/Down clock would typically be used in a dual-clock direction control application, or to increment/decrement an external counter.



NOTE: Advanced I/O interface circuit diagrams and application examples are available in Appendix I/O Applications Guide.



NOTE: When using the MDrivePlus2 with the external encoder option, the step an direction I/O are not available! These I/O points become Index + and Index -. See Appendix: MDrivePlus Motion Control Closed Loop Control for encoder connection and configuration information.



WARNING! The Capture/Trip operates at TTL levels. Do not apply more than +5VDC.

Figure 2.4.11: Step Direction I/O Equivalent Circuit

Capture/Trip

The Capture Input/Trip Output point is a high speed I/O point which can be used for time critical events in motion applications.

Capture Input

When configured as a capture input I/O point 13 has programmable filtering with a range of 50nS to 12.9 μ S and has a resolution of 32 bits.

To configure the Capture input

```
S13=60,<0/1> 'configure IO13 as a capture input, <active HIGH/LOW>
FC <0-9>      'set input filtering to <range>
```

Trip Output

When configured as a trip output I/O 13 trip speed is 150 nS with 32 bit resolution.

To configure the Trip output

```
S13=61,<0/1> 'configure IO13 as a trip output, <active HIGH/LOW>
```

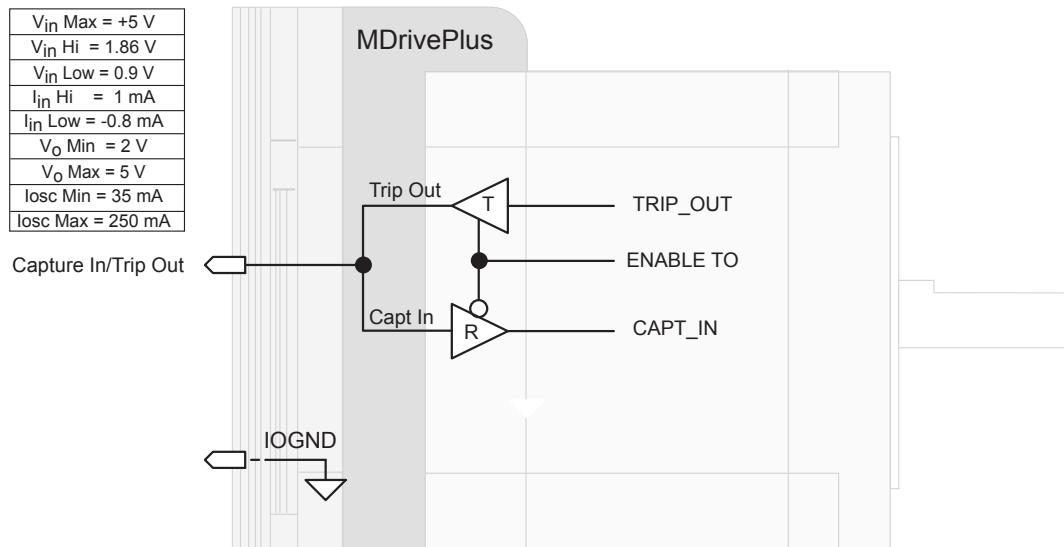


Figure 2.4.12: Capture/Trip I/O Equivalent Circuit

Interfacing the Analog Input

The analog input of the MDrivePlus Motion Control is configured from the factory as a 0 to 5V, 10 bit resolution input (S5=9). This offers the user the ability to receive input from temperature, pressure, or other forms of sensors, and then control events based upon the input.

The value of this input will be read using the I5 instruction, which has a range of 0 to 1023, where 0 = 0 volts and 1024 = 5.0 volts. The MDrivePlus Motion Control may also be configured for a 4 to 20 mA or 0 to 20 mA Analog Input (S5 = 10). If used as a 4 to 20mA input the range is 0 to 800 units.

Sample Usage

```
*****Main Program*****
S5=9,0      'set analog input to read variable voltage (0 to +5VDC)
PG 100      'start prog. address 100
LB A1        'label program A1
CL A2, I5<500 'Call Sub A2, If I5 is less than 500
CL A3, I5>524 'Call Sub A3, If I5 is greater than 524
BR A1        'loop to A1

*****Subroutines*****
LB A2        'label subroutine A2
MA 2000 'Move Absolute 2000 steps
H           'Hold program execution until motion ceases
RT          'return from subroutine

LB A3        'label subroutine A3
MA -2000   'Move Absolute -2000 steps
H           'Hold program execution until motion ceases
RT          'return from subroutine
E           'End
PG          'Exit program
```

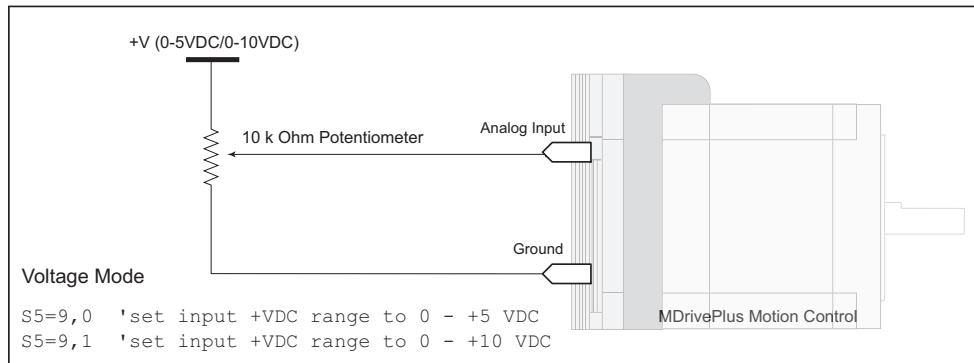


Figure 2.4.13: Analog Input - Voltage Mode

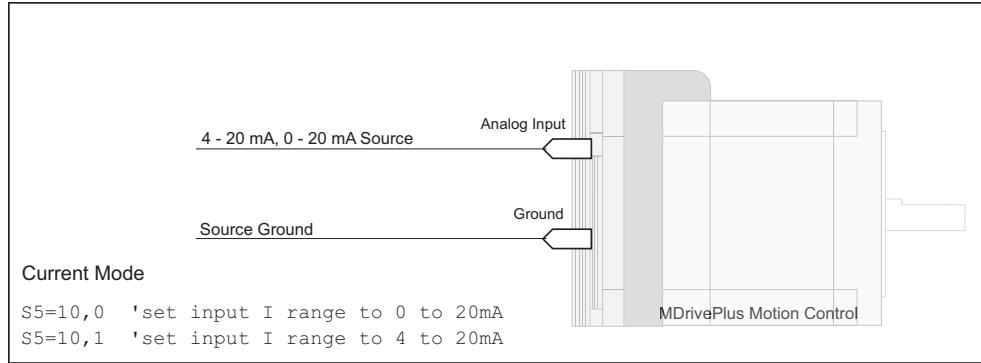


Figure 2.4.14 Analog Input - Current Mode

INTELLIGENT MOTION SYSTEMS, INC.

Excellence in Motion™



APPENDICES

Appendix A: MDrivePlus Motion Control Motor Performance

Appendix B: Recommended Power and Cable Configurations

Appendix C: Planetary Gearbox Specification and Application Guide

Appendix D: I/O Application Guide

Appendix E: MDrivePlus Motion Control Closed Loop Control

Appendix F: Connectivity

Appendix G: Linear Slides

Appendix H: CANopen Communications

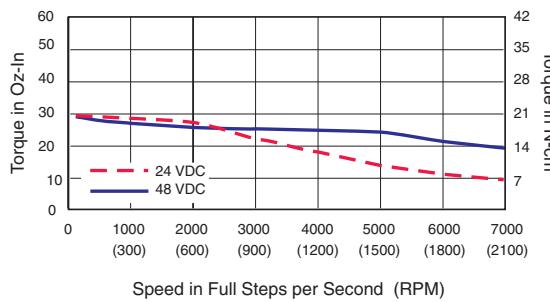
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APPENDIX A

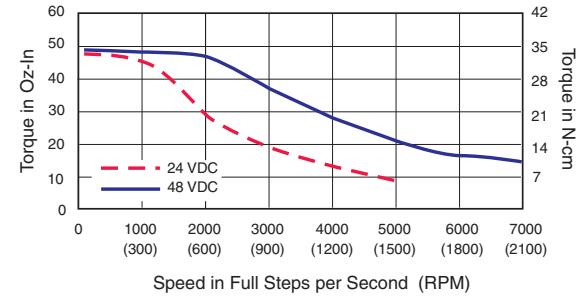
MDrivePlus Motion Control Motor Performance

MDrive17Plus Speed-Torque

Single Length Rotary Motor



Double Length Rotary Motor



Triple Length Rotary Motor

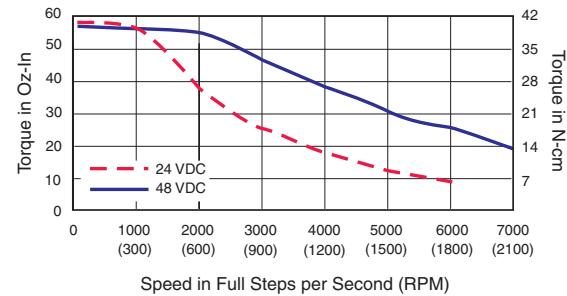
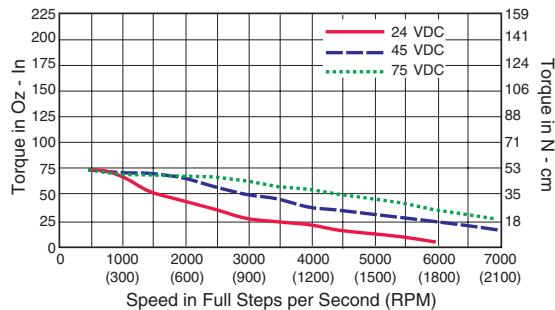


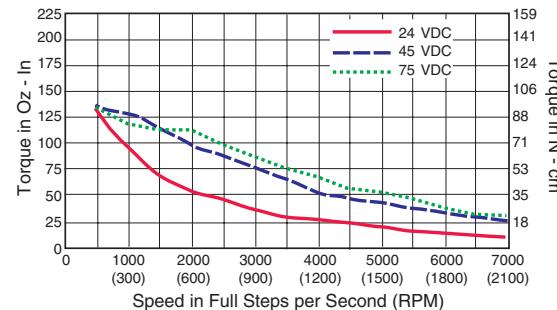
Figure A.1: MDrive17Plus Motion Control Speed-Torque Curves

MDrive23Plus Speed-Torque

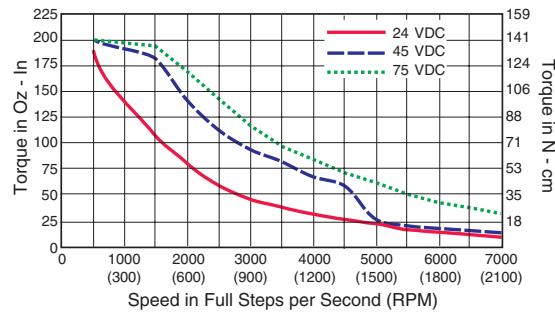
Single Length Rotary Motor



Double Length Rotary Motor



Triple Length Rotary Motor



Quad Length Rotary Motor

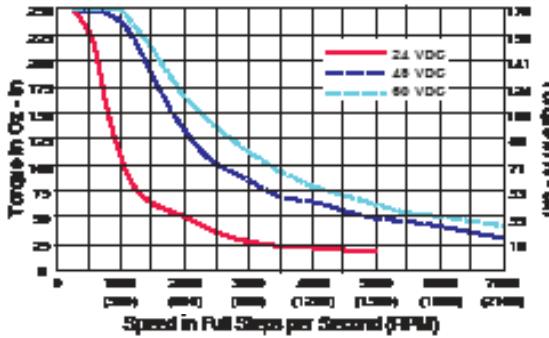


Figure A.2: MDrive23Plus Motion Control Speed-Torque Curves

APPENDIX B

Recommended Power and Cable Configurations



NOTE: The length of the DC power supply cable to an MDrive should not exceed 50 feet.



NOTE: These recommendations will provide optimal protection against EMI and RFI. The actual cable type, wire gauge, shield type and filtering devices used are dependent on the customer's application and system.



NOTE: Always use Shielded/Twisted Pairs for the MDrive DC Supply Cable and the AC Supply Cable.

Cable length, wire gauge and power conditioning devices play a major role in the performance of your MDrive.

Example A demonstrates the recommended cable configuration for DC power supply cabling under 50 feet long. If cabling of 50 feet or longer is required, the additional length may be gained by adding an AC power supply cable (see Examples B & C).

Correct AWG wire size is determined by the current requirement plus cable length. Please see the MDrive Supply Cable AWG Table at the end of this Appendix.

Example A – Cabling Under 50 Feet, DC Power

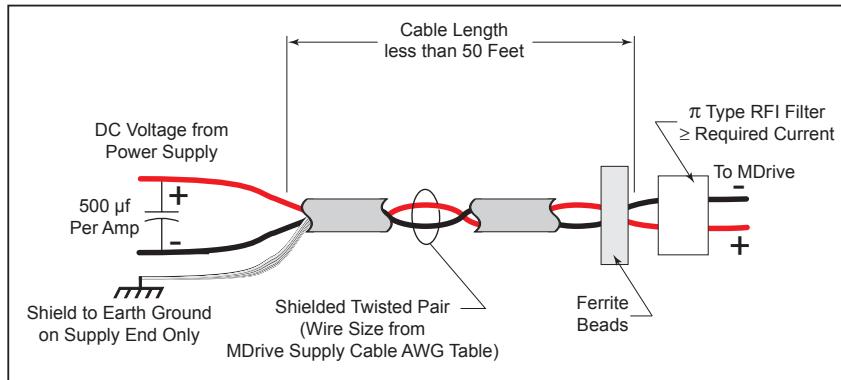


Figure B.1: DC Cabling - Under 50 Feet

Example B – Cabling 50 Feet or Greater, AC Power to Full Wave Bridge

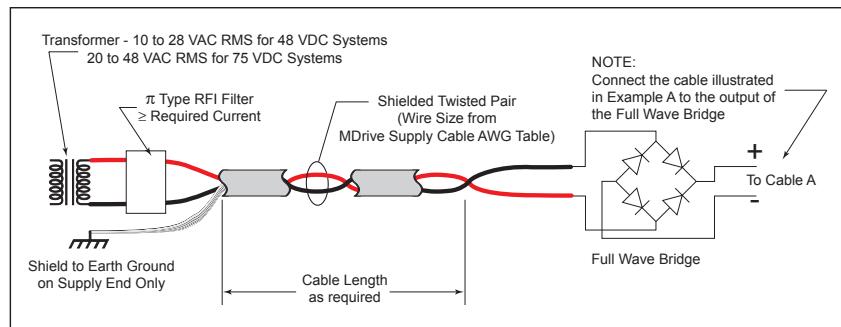


Figure B.2: DC Cabling - 50 Feet or Greater - AC To Full Wave Bridge Rectifier

Example C – Cabling 50 Feet or Greater, AC Power to Power Supply

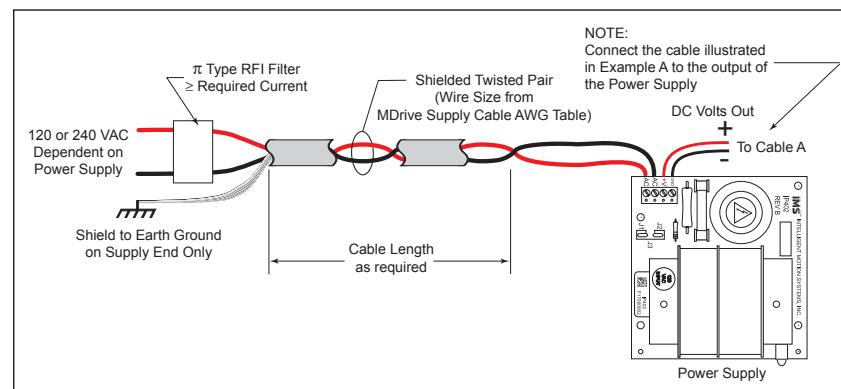


Figure B.3: AC Cabling - 50 Feet or Greater - AC To Power Supply

Recommended IMS Power Supplies

IMS unregulated linear and unregulated switching power supplies are the best fit for IMS drive products.

IP404 Unregulated Linear Supply

Input Range

120 VAC Versions	102-132 VAC
240 VAC Versions	204-264 VAC

Output (All Measurements were taken at 25°C, 120 VAC, 60 Hz)

No Load Output Voltage.....	43 VDC @ 0 Amps
Continuous Output Rating.....	32 VDC @ 1.5 Amps
Peak Output Rating	26 VDC @ 3 Amps

ISP200-4 Unregulated Switching Supply

Input Range

120 VAC Versions	102-132 VAC
240 VAC Versions	204-264 VAC

Output (All Measurements were taken at 25°C, 120 VAC, 60 Hz)

No Load Output Voltage.....	41 VDC @ 0 Amps
Continuous Output Rating.....	38 VDC @ 1.5 Amps
Peak Output Rating	35 VDC @ 3 Amps

Recommended Power Supply Cabling

MDrivePlus Supply Cable AWG Table					
1 Ampere (Peak)					
Length (Feet)	10	25	50*	75*	100*
Minimum AWG	20	20	18	18	16
2 Amperes (Peak)					
Length (Feet)	10	25	50*	75*	100*
Minimum AWG	20	18	16	14	14
3 Amperes (Peak)					
Length (Feet)	10	25	50*	75*	100*
Minimum AWG	18	16	14	12	12
4 Amperes (Peak)					
Length (Feet)	10	25	50*	75*	100*
Minimum AWG	18	16	14	12	12

*Use the alternative methods illustrated in examples B and C when cable length is \geq 50 feet. Also, use the same current rating when the alternate AC power is used.

Table B.1: Recommended Supply Cables

APPENDIX C

MDrive with Planetary Gearbox

Section Overview

This section contains guidelines and specifications for MDrives equipped with an optional Planetary Gearbox, and may include product sizes not relevant to this manual.

Shown are:

- Product Overview
- Selecting a Planetary Gearbox
- Mechanical Specifications

Product Overview

All gearboxes are factory installed.

Mode of Function

Optional Planetary Gearbox operate as their name implies: the motor-driven sun wheel is in the center, transmitting its movement to three circumferential planet gears which form one stage. They are arranged on the bearing pins of a planet carrier. The last planet carrier in each sequence is rigidly linked to the output shaft and so ensures the power transmission to the output shaft. The planet gears run in an internally toothed outer ring gear.

Service Life

Depending on ambient and environmental conditions and the operational specification of the driving system, the useful service life of a Planetary Gearbox is up to 10,000 hours. The wide variety of potential applications prohibits generalizing values for the useful service life.

Lubrication

All Planetary Gearbox are grease-packed and therefore maintenance-free throughout their life. The best possible lubricant is used for our MDrive/Planetary Gearbox combinations.

Mounting Position

The grease lubrication and the different sealing modes allow the Planetary Gearbox to be installed in any position.

Operating Temperature

The temperature range for the Planetary Gearbox is between -30 and +140° C. However, the temperature range recommended for the Heat Sink of the MDrive is 0 to +85° C.

Overload Torque

The permitted overload torque (shock load) is defined as a short-term increase in output torque, e.g. during the start-up of a motor. In these all-metal Planetary Gearbox, the overload torque can be as much as 1.5 times the permitted output torque.

Available Planetary Gearbox

The following lists available Planetary Gearbox, diameter and corresponding MDrive.

Gearbox Diameter	MDrive
42 mm	MDrive17
52 mm	MDrive23

Selecting a Planetary Gearbox

There are many variables and parameters that must be considered when choosing an appropriate reduction ratio for an MDrive with Planetary Gearbox. This Addendum includes information to assist in determining a suitable combination for your application.

Calculating the Shock Load Output Torque (T_{AB})

Note: The following examples are based on picking “temporary variables” which may be adjusted.

The shock load output torque (T_{AB}) is not the actual torque generated by the MDrive and Planetary Gearbox combination, but is a calculated value that includes an operating factor (C_B) to compensate for any shock loads applied to the Planetary Gearbox due to starting and stopping with no acceleration ramps, payloads and directional changes. The main reason the shock load output torque (T_{AB}) is calculated is to ensure that it does not exceed the maximum specified torque for a Planetary Gearbox.

Note: There are many variables that affect the calculation of the shock load output torque. Motor speed, motor voltage, motor torque and reduction ratio play an important role in determining shock load output torque. Some variables must be approximated to perform the calculations for the first time. If the result does not meet your requirements, change the variables and re-calculate the shock load output torque.

Use the equation compendium below to calculate the shock load output torque.



Note: The MDrive23
and the numbers and
values used in these
examples have been chosen
randomly for demonstration
purposes. Be certain you
obtain the correct data for the
MDrive you have purchased.

Factors

i	= Reduction Ratio - The ratio of the Planetary Gearbox.
n_M	= Motor Speed - In Revolutions Per Minute (Full Steps/Second).
n_{AB}	= Output Speed - The speed at the output shaft of the Planetary Gearbox.
T_N	= Nominal Output Torque - The output torque at the output shaft of the Planetary Gearbox.
T_M	= Motor Torque - The base MDrive torque. Refer to MDrive Speed/Torque Tables.
η	= Gear Efficiency - A value factored into the calculation to allow for any friction in the gears.
T_{AB}	= Shock Load Output Torque - A torque value calculated to allow for short term loads greater than the nominal output torque.
C_B	= Operating Factor - A value that is used to factor the shock load output torque.
s_f	= Safety Factor - A 0.5 to 0.7 factor used to create a margin for the MDrive torque requirement.

Reduction Ratio

Reduction ratio (i) is used to reduce a relatively high motor speed (n_M) to a lower output speed (n_{AB}).

With: $i = n_M \div n_{AB}$ or: motor speed \div output speed = reduction ratio

Example:

The required speed at the output shaft of the Planetary Gearbox is 90 RPM.

You would divide motor speed (n_M) by output speed (n_{AB}) to calculate the proper gearbox ratio.

The MDrive speed you would like to run is approximately 2000 full steps/second or 600 RPM.

NOTE: In reference to the MDrive speed values, they are given in full steps/second on the Speed/Torque Tables. Most speed specifications for the Planetary Gearbox will be given in RPM (revolutions per minute). To convert full steps/second to RPM, divide by 200 and multiply by 60.

Where: 200 is the full steps per revolution of a 1.8° stepping motor.

$2000 \text{ full steps/second} \div 200 = 10 \text{ RPS (revolutions per second)} \times 60 \text{ Seconds} = 600 \text{ RPM}$

For the Reduction Ratio (i), divide the MDrive speed by the required Planetary Gearbox output speed.

$600 \text{ RPM} \div 90 = 6.67:1$ Reduction Ratio

Referring to the Available Ratio Table at the end of this section, the reduction ratio (i) of the Planetary Gearbox will be 7:1. The numbers in the left column are the rounded ratios while the numbers in the right column are the actual ratios. The closest actual ratio is 6.75:1 which is the rounded ratio of 7:1. The slight difference can be made up in MDrive speed.

Nominal Output Torque

Calculate the nominal output torque using the torque values from the MDrive's Speed/Torque Tables.

Nominal output torque (T_N) is the actual torque generated at the Planetary Gearbox output shaft which includes reduction ratio (i), gear efficiency (η) and the safety factor (s_f) for the MDrive. Once the reduction ratio (i) is determined, the nominal output torque (T_N) can be calculated as follows:

$$T_N = T_M \times i \times \eta \div s_f \text{ or:}$$

$$\text{Motor torque} \times \text{reduction ratio} \times \text{gear efficiency} \div \text{safety factor} = \text{nominal output torque.}$$

For gear efficiency (η) refer to the Mechanical Specifications for the 7:1 Planetary Gearbox designed for your MDrive.

For motor torque (T_M) see the appropriate MDrive Speed/Torque Table. Dependent on which MDrive you have, the torque range will vary. The torque will fall between the high voltage line and the low voltage line at the indicated speed for the MDrive. (See the example Speed/Torque Table below.)

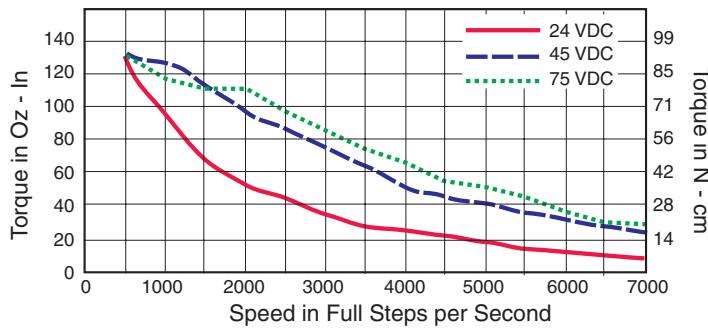


Figure C.1: MDrive23 Torque-Speed Curve

The Speed/Torque Table above is for an MDrive23 Double Size. This MDrive will produce a torque range of 51 to 95 oz-in in the full voltage range at the speed of 2000 Full Steps/Second (600 RPM).

Please note that this is not the usable torque range. The torque output to the Planetary Gearbox must include a safety factor (s_f) to allow for any voltage and current deviations supplied to the MDrive.

The motor torque must include a safety factor (s_f) ranging from 0.5 to 0.7. This must be factored into the nominal output torque calculation. A 0.5 safety factor is aggressive while a 0.7 safety factor is more conservative.

Example:

The available motor torque (T_M) is 51 to 95 oz-in.

NOTE: You may specify a torque less than but not greater than the motor torque range.

For this example the motor torque (T_M) will be 35 oz-in.

A 6.75:1 reduction ratio (i) has been determined.

Gear efficiency (η) = 80% from the appropriate table for the Planetary Gearbox which is used with an MDrive23.

Nominal output torque would be:

Motor torque ($T_M = 35$) \times reduction ratio ($i = 6.75$) \times gear efficiency ($\eta = 0.8$) \div safety factor ($s_f = 0.5$ or 0.7)

$$35 \times 6.75 = 236.25 \times 0.8 = 189 \div 0.5 = 378 \text{ oz-in nominal output torque } (T_N)$$

or

$$35 \times 6.75 = 236.25 \times 0.8 = 189 \div 0.7 = 270 \text{ oz-in nominal output torque } (T_N)$$

With the safety factor (s_f) and gear efficiency (η) included in the calculation, the nominal output torque (T_N) may be greater than the user requirement.

Shock Load Output Torque

The nominal output torque (T_N) is the actual working torque the Planetary Gearbox will generate. The shock load output torque (T_{AB}) is the additional torque that can be generated by starting and stopping with no acceleration ramps, payloads, inertia and directional changes. Although the nominal output torque (T_N) of the Planetary Gearbox is accurately calculated, shock loads can greatly increase the dynamic torque on the Planetary Gearbox.

Each Planetary Gearbox has a maximum specified output torque. In this example a 7:1 single stage MD23 Planetary Gearbox is being used. The maximum specified output torque is 566 oz-in. By calculating the shock load output torque (T_{AB}) you can verify that value is not exceeding the maximum specified output torque.

When calculating the shock load output torque (T_{AB}), the calculated nominal output torque (T_N) and the operating factor (C_B) are taken into account. C_B is merely a factor which addresses the different working conditions of a Planetary Gearbox and is the result of your subjective appraisal. It is therefore only meant as a guide value. The following factors are included in the approximate estimation of the operating factor (C_B):

- Direction of rotation (constant or alternating)
- Load (shocks)
- Daily operating time

Note: The higher the operating factor (C_B), the closer the shock load output torque (T_{AB}) will be to the maximum specified output torque for the Planetary Gearbox. Refer to the table below to calculate the approximate operating factor (C_B).

With the most extreme conditions which would be a C_B of 1.9, the shock load output torque (T_{AB}) is over the maximum specified torque of the Planetary Gearbox with a 0.5 safety factor but under with a 0.7 safety factor.

The nominal output torque (T_N) \times the operating factor (C_B) = shock load or maximum output torque (T_{AB}).

With a 0.5 safety factor, the shock load output torque is greater than the maximum output torque specification of the MDrive23 Planetary Gearbox.

($378 \times 1.9 = 718.2$ oz-in.)

With a 0.7 safety factor the shock load output torque is within maximum output torque specification of the MDrive23 Planetary Gearbox.

($270 \times 1.9 = 513$ oz-in.)

The 0.5 safety factor could only be used with a lower operating factor (C_B) such as 1.5 or less, or a lower motor torque.

Note: All published torque specifications are based on $C_B = 1.0$. Therefore, the shock load output torque (T_{AB}) = nominal output torque (T_N).

WARNING! Excessive torque may damage your Planetary Gearbox. If the MDrive/Planetary Gearbox should hit an obstruction, especially at lower speeds (300 RPM or 1000 Full Steps/Second), the torque generated will exceed the maximum torque for the Planetary Gearbox. Precautions must be taken to ensure there are no obstructions in the system.

Determining the Operating Factor (C_B)				
Direction of Rotation	Load (Shocks)	Daily Operating Time		
		3 Hours	8 Hours	24 Hours
Constant	Low*	$C_B=1.0$	$C_B=1.1$	$C_B=1.3$
	Medium**	$C_B=1.2$	$C_B=1.3$	$C_B=1.5$
Alternating	Low†	$C_B=1.3$	$C_B=1.4$	$C_B=1.6$
	Medium††	$C_B=1.6$	$C_B=1.7$	$C_B=1.9$

* Low Shock = Motor turns in one direction and has ramp up at start.

** Medium Shock = Motor turns in one direction and has no ramp up at start.

† Low Shock = Motor turns in both directions and has ramp up at start.

†† Medium Shock = Motor turns in both directions and has no ramp up at start.

Table C.1: Planetary Gearbox Operating Factor

System Inertia

System inertia must be included in the selection of an MDrive and Planetary Gearbox. Inertia is the resistance an object has relative to changes in velocity. Inertia must be calculated and matched to the motor inertia. The Planetary Gearbox ratio plays an important role in matching system inertia to motor inertia. There are many variable factors that affect the inertia. Some of these factors are:

- The type of system being driven.
- Weight and frictional forces of that system.
- The load the system is moving or carrying.

The ratio of the system inertia to motor inertia should be between 1:1 and 10:1. With 1:1 being ideal, a 1:1 to 5:1 ratio is good while a ratio greater than 5:1 and up to 10:1 is the maximum.

Type of System

There are many systems and drives, from simple to complex, which react differently and possess varied amounts of inertia. All of the moving components of a given system will have some inertia factor which must be included in the total inertia calculation. Some of these systems include:

- Lead screw
- Rack and pinion
- Conveyor belt
- Rotary table
- Belt drive
- Chain drive

Not only must the inertia of the system be calculated, but also any load that it may be moving or carrying. The examples below illustrate some of the factors that must be considered when calculating the inertia of a system.

Lead Screw

In a system with a lead screw, the following must be considered:

- The weight and preload of the screw
- The weight of the lead screw nut
- The weight of a table or slide
- The friction caused by the Table Guideways
- The weight of any parts

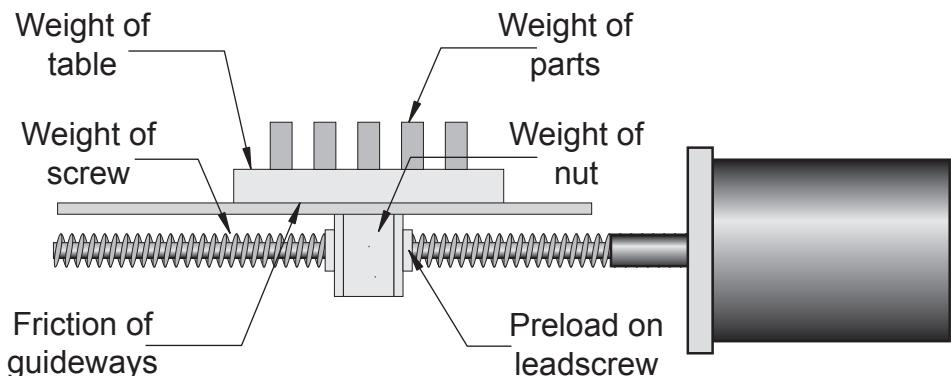


Figure C.2: Lead Screw System Inertia Considerations

Rack and Pinion

In a system with a rack and pinion, the following must be considered:

- The weight or mass of the pinion
- The weight or mass of the rack
- The friction and/or preload between the pinion and the rack
- Any friction in the guidance of the rack
- The weight or mass of the object the rack is moving

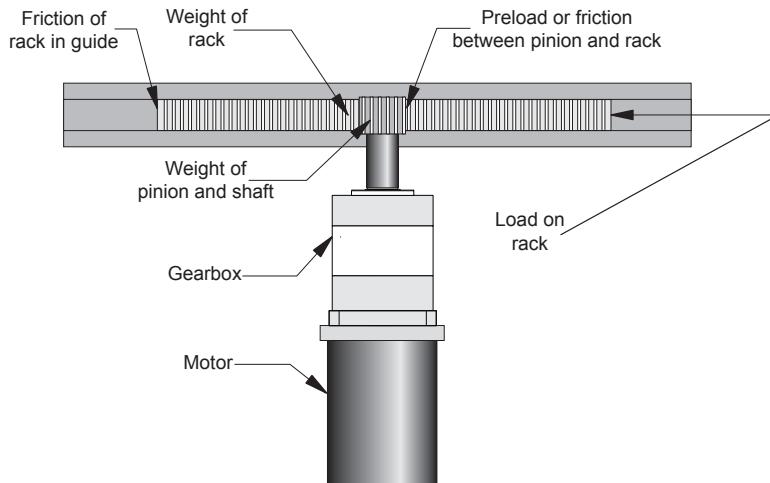


Figure C.3: Rack and Pinion System Inertia Considerations

Conveyor Belt

In a system with a conveyor belt, the following must be considered:

- The weight and size of the cylindrical driving pulley or roller
- The weight of the belt
- The weight or mass and size of the idler roller or pulley on the opposite end
- The angle or elevation of the belt
- Any load the belt may be carrying

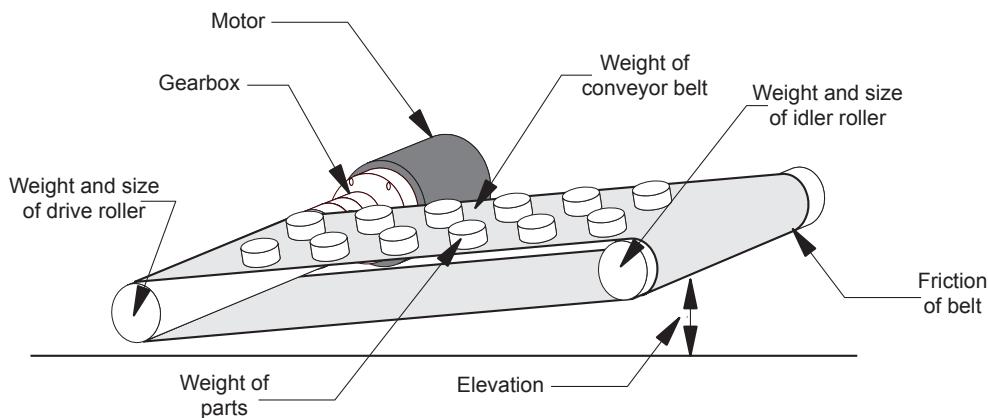


Figure C.4: Conveyor System Inertia Considerations

Rotary Table

In a system with a rotary table, the following must be considered:

- The weight or mass and size of the table
- Any parts or load the table is carrying
- The position of the load on the table, the distance from the center of the table will affect the inertia
- How the table is being driven and supported also affects the inertia

Belt Drive

In a system with a belt drive, the following must be considered:

- The weight or mass and size of the driving pulley
- The tension and/or friction of the belt
- The weight or mass and size of the driven pulley
- Any load the system may be moving or carrying

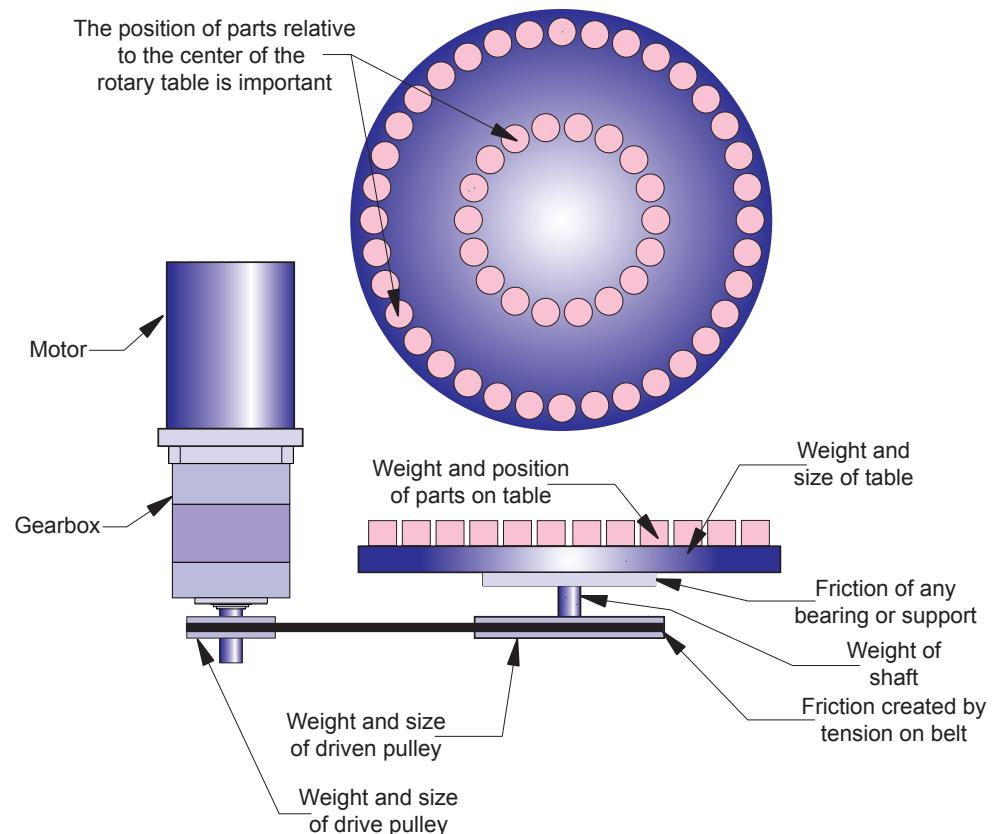


Figure C.5: Rotary Table System Inertia Considerations

Chain Drive

In a system with a chain drive, the following must be considered:

- the weight and size of drive sprocket and any attaching hub
- the weight and size of the driven sprocket and shaft
- the weight of the chain
- the weight of any material or parts being moved

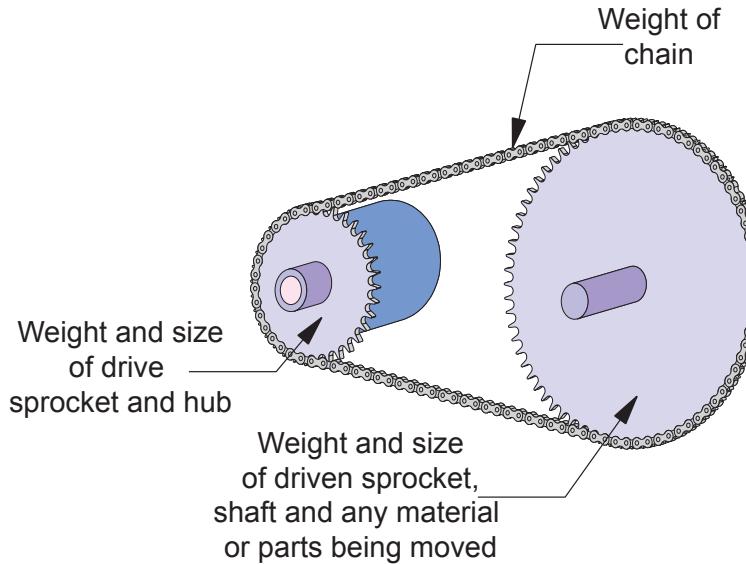


Figure C.6: Chain Drive System Inertia Considerations

Once the system inertia (J_L) has been calculated in oz-in-sec², it can be matched to the motor inertia. To match the system inertia to the motor inertia, divide the system inertia by the square of the gearbox ratio. The result is called Reflected Inertia or (J_{ref}).

$$J_{ref} = J_L \div Z^2$$

Where:

J_L = System Inertia in oz-in-sec²

J_{ref} = Reflected Inertia in oz-in-sec²

Z = Gearbox Ratio

The ideal situation would be to have a 1:1 system inertia to motor inertia ratio. This will yield the best positioning and accuracy. The reflected inertia (J_{ref}) must not exceed 10 times the motor inertia.

Your system may require a reflected inertia ratio as close to 1:1 as possible. To achieve the 1:1 ratio, you must calculate an Optimal Gearbox Ratio (Z_{opt}) which would be the square root of J_L divided by the desired J_{ref} . In this case since you want the system inertia to match the motor inertia with a 1:1 ratio, J_{ref} would be equal to the motor inertia.

$$Z_{opt} = J_L \div J_{ref}$$

Where:

Z_{opt} = Optimal Gearbox Ratio

J_L = System Inertia in oz-in-sec²

J_{ref} = Desired Reflected Inertia in oz-in-sec² (Motor Inertia)

MDrive17Plus with Planetary Gearbox

The MDrive17Plus is available with a Planetary Gearbox option developed to increase torque at lower speeds, enable better inertia matching and produce finer positional resolutions. These efficient, low maintenance Planetary Gearbox come fully assembled with the MDrive and are offered in a large number of reduction ratios in 1-, 2- and 3-stage configurations.

An optional NEMA Flange allows mounting the Planetary Gearbox to the load using a standard NEMA bolt circle. Planetary Gearbox may be combined with other MDrive17Plus options.

MDrive17Plus Planetary Gearbox Parameters

	Permitted Output Torque (oz-in/Nm)	Gearbox Efficiency	Maximum Backlash	Output Side with Ball Bearing			
				Maximum Load (lb-force/N)		Weight (oz/g)	
				Radial	Axial	Gearbox	with Flange
1-STAGE	425/3.0	0.80	0.80°	36/60	11/50	14.3/406	14.8/420
2-STAGE	1062/7.5	0.75	0.85°	52/230	18/80	17.9/508	18.5/525
3-STAGE	2124/15.0	0.70	0.90°	67.5/300	25/110	21.5/609	22.2/630

Table C.2: MDrive17Plus Planetary Gearbox Parameters

MDrive17Plus Gearbox Ratios and Inertia Moments

Planetary Gearbox	Ratio (Rounded)	Inertia Moments (oz-in-sec ²)*
1-Stage	3.71:1	0.00006627
1-Stage	5.18:1	0.00004362
1-Stage	6.75:1	0.0003328
2-Stage	13.73:1	0.00006245
2-Stage	15.88:1	0.00005084
2-Stage	18.37:1	0.00005070
2-Stage	19.20:1	0.00004149
2-Stage	22.21:1	0.00004135
2-Stage	25.01:1	0.00003200
2-Stage	26.85:1	0.00004121
2-Stage	28.93:1	0.00003186
2-Stage	34.98:1	0.00003186
2-Stage	45.56:1	0.00003186

*To calculate the inertia in kg-cm² (kilograms-centimeter squared) multiply oz-in-sec² by 70.6154.

Planetary Gearbox	Ratio (Rounded)	Inertia Moments (oz-in-sec ²)*
3-Stage	50.89:1	0.00006245
3-Stage	58.86:1	0.00005084
3-Stage	68.07:1	0.00005070
3-Stage	71.16:1	0.00004149
3-Stage	78.72:1	0.00005070
3-Stage	92.70:1	0.00003200
3-Stage	95.18:1	0.00004135
3-Stage	99.51:1	0.00004121
3-Stage	107.21:1	0.00003186
3-Stage	115.08:1	0.00004121
3-Stage	123.98:1	0.00003186
3-Stage	129.62:1	0.00003186
3-Stage	139.14:1	0.00004121
3-Stage	149.90:1	0.00003186
3-Stage	168.85:1	0.00003186
3-Stage	181.25:1	0.00003186
3-Stage	195.27:1	0.00003186
3-Stage	236.10:1	0.00003186
3-Stage	307.55:1	0.00003186

Table C.3: MDrive17Plus Planetary Gearbox Ratios and Inertia Moments

MDrive17Plus Planetary Gearbox

Dimensions in Inches (mm)

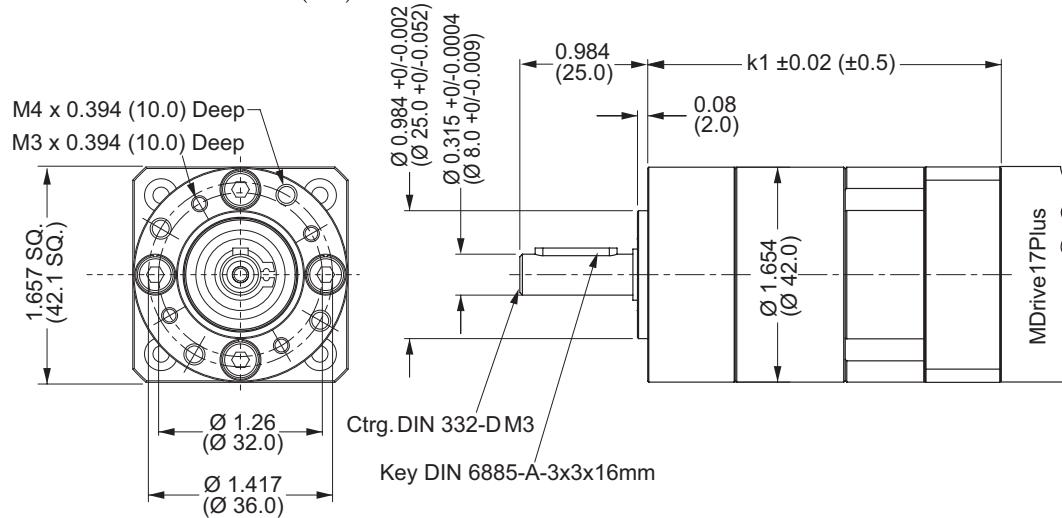


Figure C.7: Planetary Gearbox Specifications for MDrive17Plus

MDrive 17 & 23 Plus Motion Control Hardware Manual Revision R111108

MDrive17Plus Planetary Gearbox With Optional NEMA Output Flange

Dimensions in Inches (mm)

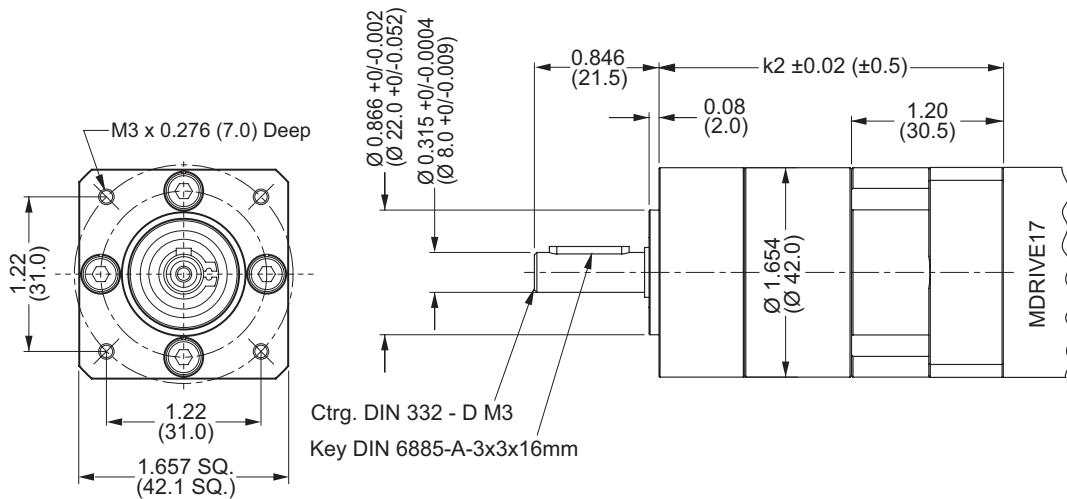


Figure C.8: Planetary Gearbox Specifications for MDrive17Plus with NEMA Output Flange

MDrive23Plus with Planetary Gearbox

The MDrive23Plus is available with a Planetary Gearbox option developed to increase torque at lower speeds, enable better inertia matching and produce finer positional resolutions. These efficient, low maintenance Planetary Gearbox come fully assembled with the MDrive and are offered in a large number of reduction ratios in 1-, 2- and 3-stage configurations.

An optional NEMA Flange allows mounting the Planetary Gearbox to the load using a standard NEMA bolt circle. Planetary Gearbox may be combined with other MDrive23Plus options.

MDrive23Plus Planetary Gearbox Parameters

	Permitted Output Torque (oz-in/Nm)	Gearbox Efficiency	Maximum Backlash	Output Side with Ball Bearing			
				Maximum Load (lb-force/N)		Weight (oz/g)	
				Radial	Axial	Gearbox	with Flange
1-STAGE	566/4.0	0.80	0.70°	45/200	13/60	25.0/711	25.9/735
2-STAGE	1699/12.0	0.75	0.75°	72/320	22/100	32.2/914	33.3/945
3-STAGE	3540/25.0	0.70	0.80°	101/450	34/150	39.4/1117	40.7/1155

Table C.4: MDrive23Plus Planetary Gearbox Parameters

MDrive23Plus Gearbox Ratios and Inertia Moments

Planetary Gearbox	Ratio (Rounded)	Inertia Moments (oz-in-sec ²) [*]
1-Stage	3.71:1	0.00025986
1-Stage	5.18:1	0.00017461
1-Stage	6.75:1	0.00016030
2-Stage	13.73:1	0.00024230
2-Stage	15.88:1	0.00020406
2-Stage	18.37:1	0.00020335
2-Stage	19.20:1	0.00016512
2-Stage	22.21:1	0.00016469
2-Stage	25.01:1	0.00013453
2-Stage	26.85:1	0.00016441
2-Stage	28.93:1	0.00013425
2-Stage	34.98:1	0.00013411
2-Stage	45.56:1	0.00013411

*To calculate the inertia in kg-cm² (kilograms-centimeter squared) multiply oz-in-sec² by 70.6154.

Planetary Gearbox	Ratio (Rounded)	Inertia Moments (oz-in-sec ²) [*]
3-Stage	50.89:1	0.00024230
3-Stage	58.86:1	0.00020406
3-Stage	68.07:1	0.00020335
3-Stage	71.16:1	0.00016512
3-Stage	78.72:1	0.00020335
3-Stage	92.70:1	0.00016441
3-Stage	95.18:1	0.00020335
3-Stage	99.51:1	0.00016441
3-Stage	107.21:1	0.00013425
3-Stage	115.08:1	0.00016441
3-Stage	123.98:1	0.00013425
3-Stage	129.62:1	0.00013411
3-Stage	139.14:1	0.00016441
3-Stage	149.90:1	0.00013411
3-Stage	168.85:1	0.00013411
3-Stage	181.25:1	0.00013411
3-Stage	195.27:1	0.00013411
3-Stage	236.10:1	0.00013411
3-Stage	307.55:1	0.00013411

Table C.5: MDrive23Plus Planetary Gearbox Ratios and Inertia Moments

MDrive23Plus Planetary Gearbox

Dimensions in Inches (mm)

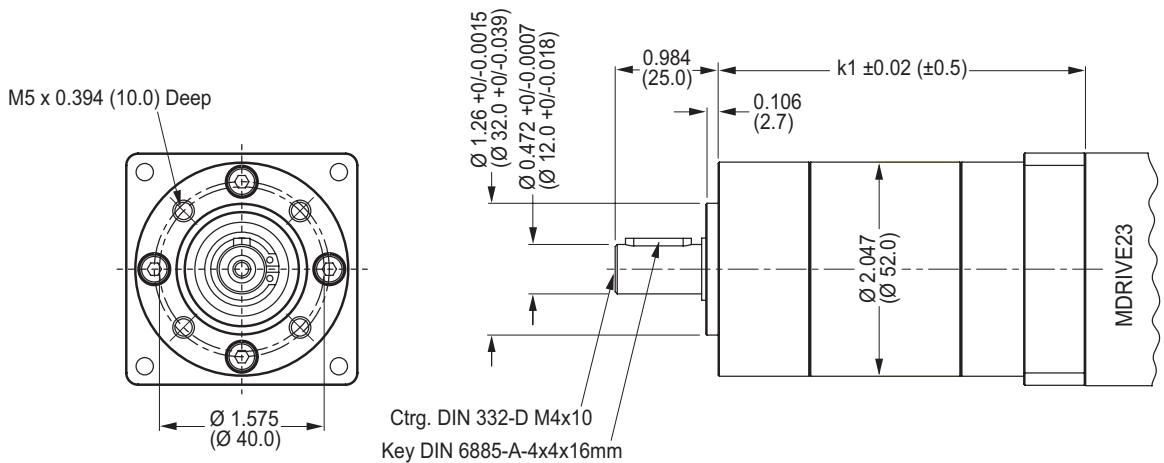


Figure C.9: Planetary Gearbox Specifications for MDrive23Plus

MDrive23Plus Planetary Gearbox With Optional NEMA Output Flange

Dimensions in Inches (mm)

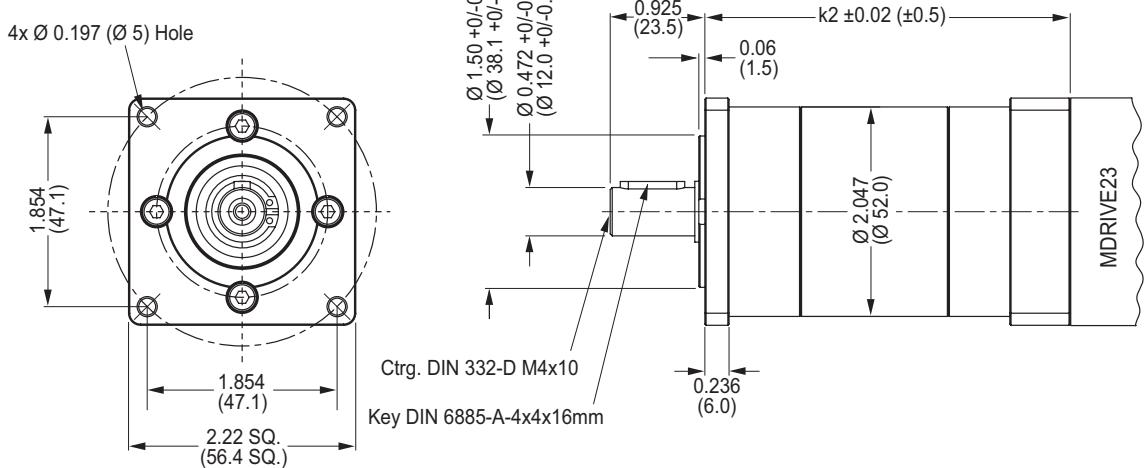


Figure C.10: Planetary Gearbox Specifications for MDrive23Plus with NEMA Flange

APPENDIX D

I/O Application Guide

Standard I/O Set Interfacing and Application

NPN Sinking Input

Application Example

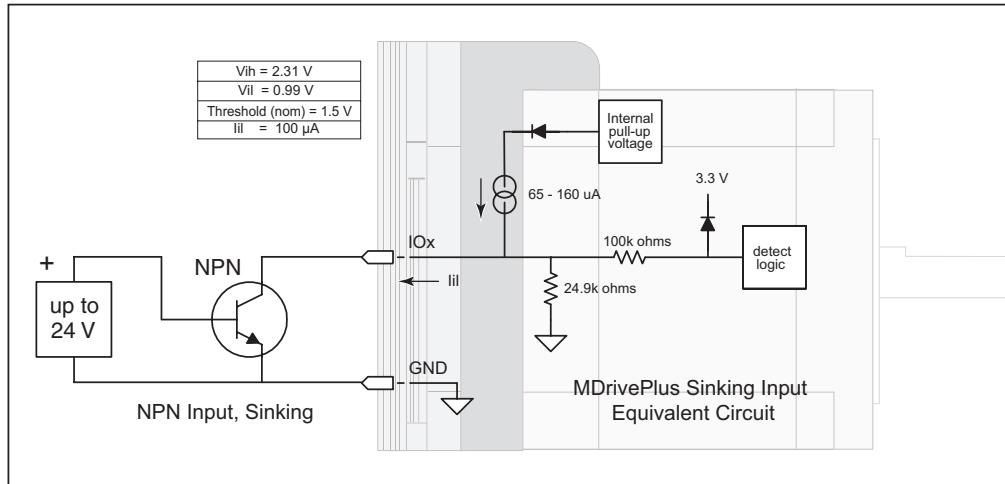


Figure D.1: NPN Interface to an MDI Sinking Input

Proximity sensor will operate as a +Limit. When active LOW will index the motor to a specified position.

```
'[VARIABLES]
S1=2,0,0          'set IO1 to Limit+, Active LOW, sinking
'[PROGRAMS]
PG   100          'enter program mode at address 100
LB  AA           'label program AA
    MR 200000000  'move relative x distance
    H              'hold program execution until move completes
    CL AB , I1 =  0 'call subroutine AB if I1 = 0 (limit reached)
    BR AA , I1 =  1 'branch to AA if I1=1
LB  AB           'Label Sub AB
    PR "Error 83, Positive Limit Reached"
    ER=0
    MA - 10000      'Absolute move to Pos. -10000
    H              'hold program execution until move completes
E
PG
'[END]
```

PNP Sourcing Input

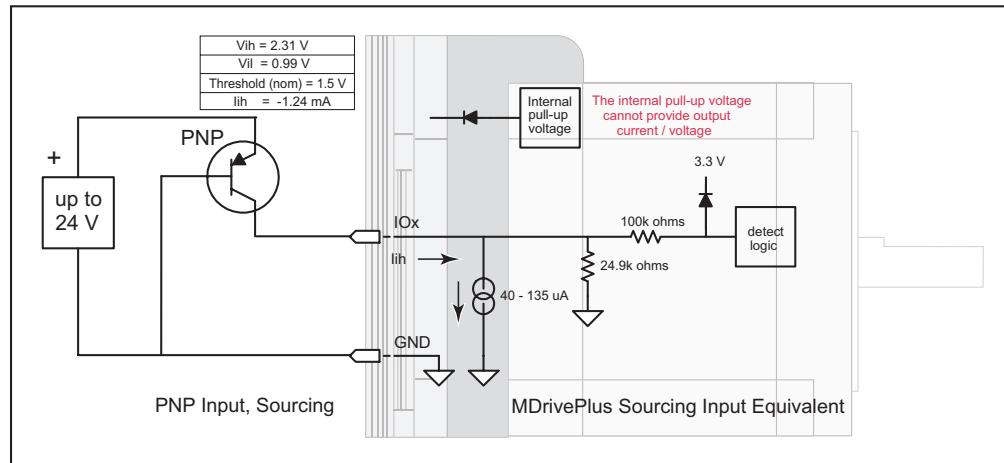


Figure D.2: PNP Interface to a Sourcing Input

Application Example

Will use this input as a general purpose input which will run a motion subroutine when HIGH.

```

' [VARIABLES]
S1=0,1,1           'set IO1 Gen Purpose User, active HIGH, src
S2=0,1,1           'set IO1 Gen Purpose User, active HIGH, src
'[PROGRAMS]
*****Main Program*****
PG 100
LB AA
    CL SA,I1=1      'call sub SA if IO1=1
    CL SB,I2=1      'call sub SB if IO2=1
    BR AA
*****Subroutines*****
LB SA              'Subroutine will perform some motion
    MR 200000
    H
    MR -200000
    H
    BR SA,I1=1      'conditional branch to beginning of sub
    BR AA,I1=0      'Branch to main program if IO1=0
    RT
LB SB              'Subroutine will perform some motion
    MR 10000
    H
    MR -10000
    H
    BR SB,I2=1      'conditional branch to beginning of sub
    BR AA,I2=0      'Branch to main program if IO1=0
    RT
E
PG
'[END]
```

Sinking Output

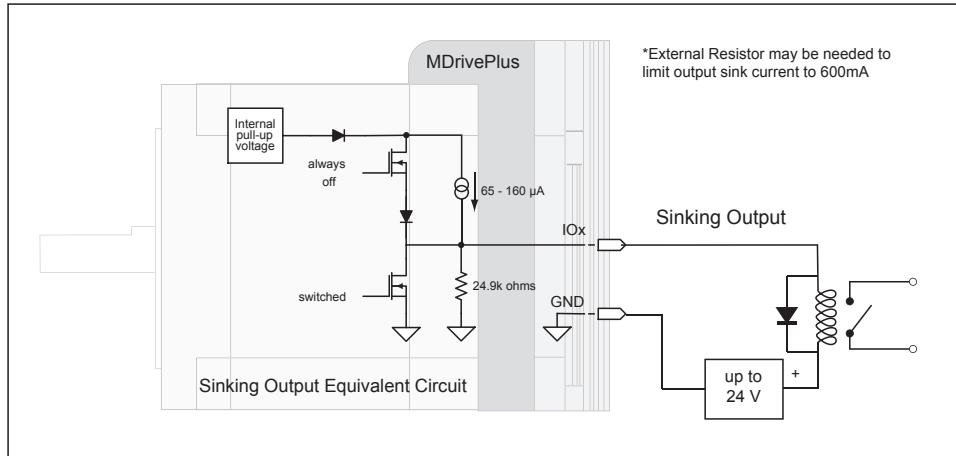


Figure D.3: Sinking Output to Relay



NOTE: On the Standard MDrivePlus, when configured as outputs, the I/O set is sinking ONLY! The Plus² Models add the functionality of I/O Power, which enables the user to use all the outputs, both Standard and Enhanced, as Sinking or Sourcing.

Application Example

Active LOW Output will be open a relay, useful for Fault.

```
'[VARIABLES]
S1=19,0,0          'Configure IO 1 as a Fault output.
```

Mixed Input/Output Example

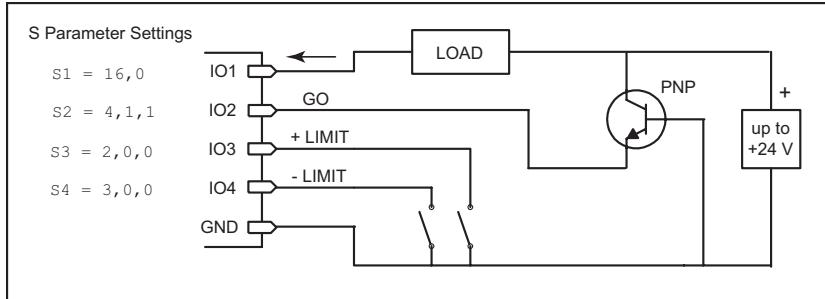
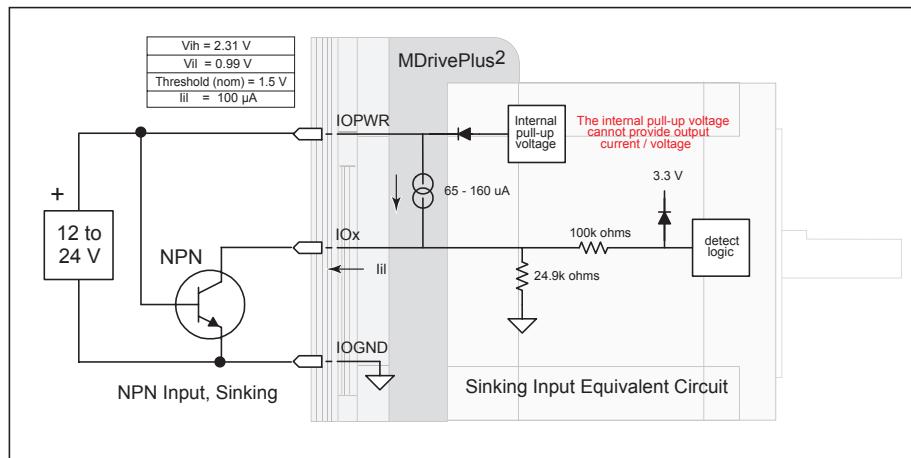


Figure D.4: Mixed Output Example- Standard I/O Set

Enhanced I/O Set Interfacing and Application

NPN Sinking Input



Application Example

Sensor using the HOME function.

```
'[VARIABLES]
S2=1,1,0           'Configure IO2 as a Home Input, active HIGH, sinking.

Enter to IMS Terminal in Immediate mode or in a Program

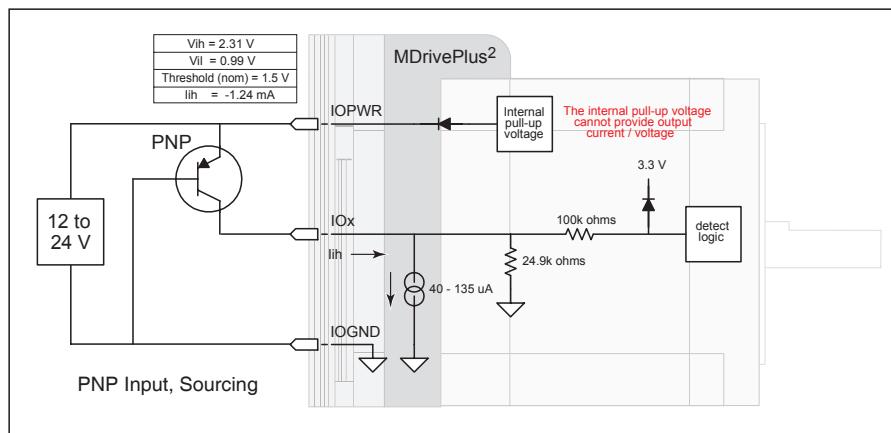
HM 1               'Slew at VM - until IO2 = 1, Creep off + at VI
```

PNP Sourcing Input

Application Example

Sensor using the Jog+ function.

```
JE=1               'Enable Jog function
```



```
S11=7,1,1
```

```
'Configure IO11 as a Jog+ Input, active HIGH, sourcing
```

Sourcing Output

Application Example

This application example will illustrate two MDrivePlus² units in a system. In the program example MDrivePlus² #1 will be configured as a Fault Output, which when HIGH will trip an input on MDrivePlus2 #2 which will be configured as a Pause Input.

MDrive #1

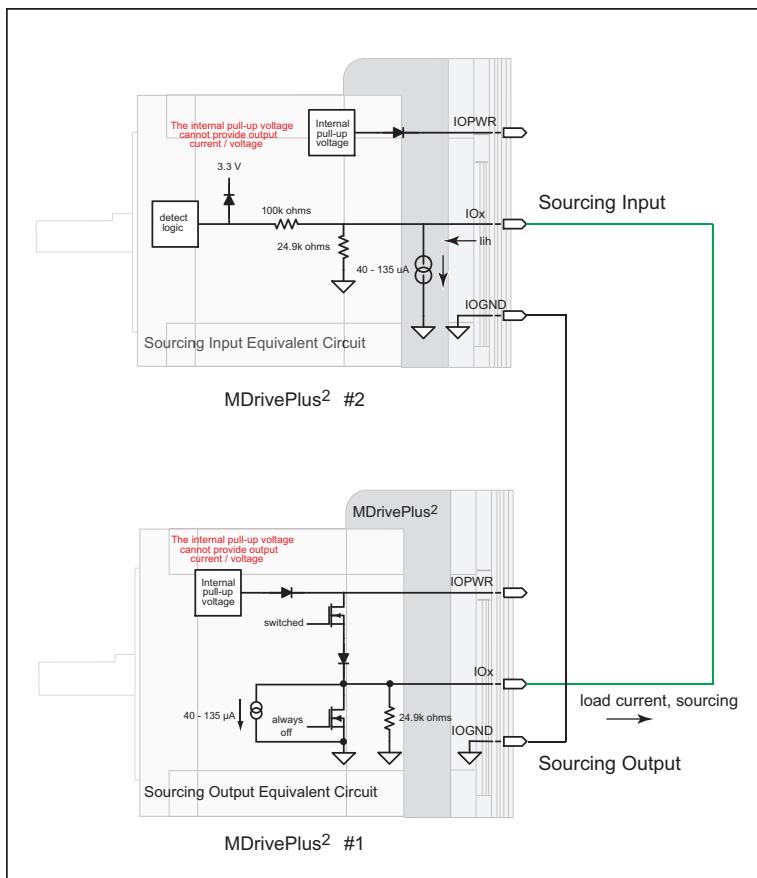


Figure D.7: Sourcing Output to Sourcing Input

```
S9=18,1,1      'Configure IO9 as a Fault output, active HIGH, sourcing
```

```
MDrive #2
S9=6,1,1      'Configure IO9 as a Pause Input, active HIGH, sourcing.
```

Mixed Input/Output Example

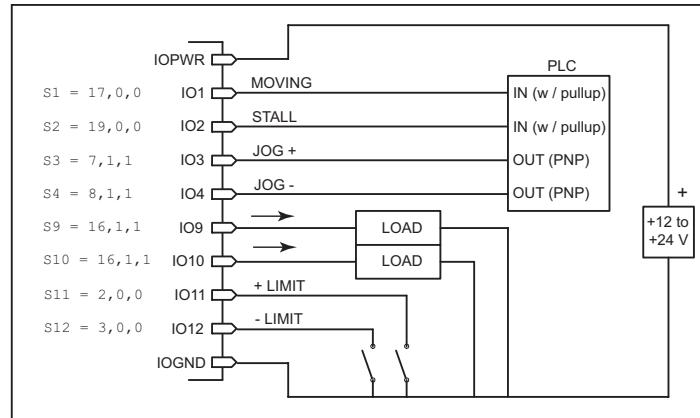


Figure D.8: Mixed Input/Output Example - Enhanced I/O

Interfacing Inputs as a Group Example

The MDrivePlus inputs may read as a group using the IL, IH and IN keywords. This will display as a decimal between 0 to 15 representing the 4 bit binary number (IL, IH) or as a decimal between 0 and 255 representing the 8 bit binary number on the MDrivePlus² models. The IN keyword will function on the Standard MDrivePlus but will only read inputs 1 - 4. Inputs will be configured as user inputs (S<point>=0).

Standard MDrivePlus Motion Control

PR IN	'Reads Inputs 4 (MSB) through 1 (LSB)
PR IN	'Reads Inputs 4 (MSB) through 1 (LSB)

Enhanced MDrivePlus2

PR IL	'Reads Inputs 4 (MSB) through 1 (LSB)
PR IH:	'Reads Inputs 12 (MSB) through 9 (LSB)
PR IN:	'Reads Inputs 12 (MSB) - 9 and 4 - 1 (LSB)

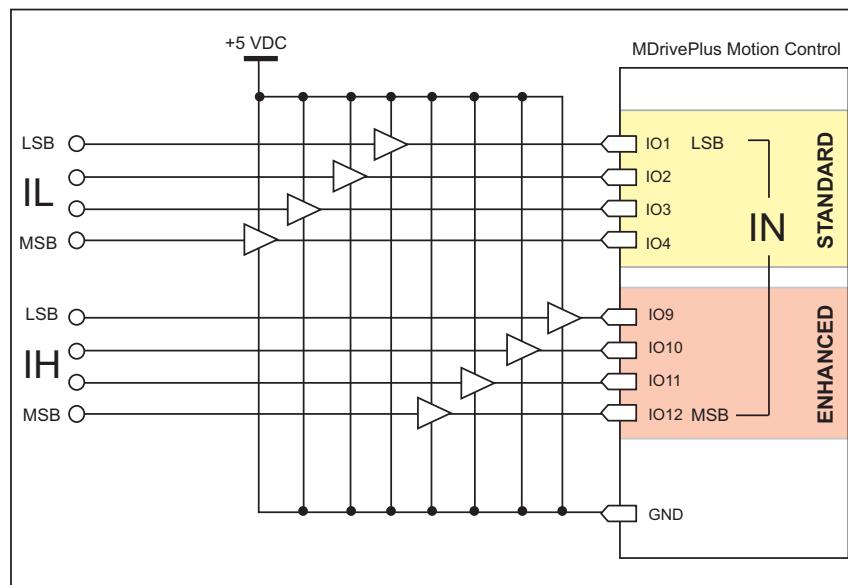


Figure D.9: TTL Interface to an Input Group

Interfacing Outputs as a Group Example

The MDrivePlus inputs may be written to as a group using the OL, OH and OT keywords. This will set the outputs as a binary number representing the decimal between 0 to 15 representing the 4 bit binary number (OL, OH) or as an 8 bit binary number representing the decimal 0 to 255 on the MDrivePlus² models. The OT keyword will function on the Standard MDrivePlus but will only set inputs 1 - 4. Outputs will be configured as user outputs ($S<point>=16$).

Standard MDrivePlus Motion Control

```
OL=3           'set the binary state of the standard I/O to 0011
OT=13          'set the binary state of the standard I/O to 1101
```

Enhanced MDrivePlus2

```
OL=5           'set the binary state of the standard I/O to 0101
OH=9           'set the binary state of the expanded I/O to 1001
OT=223         'set the binary state of the combined I/O to 1101 1111
```

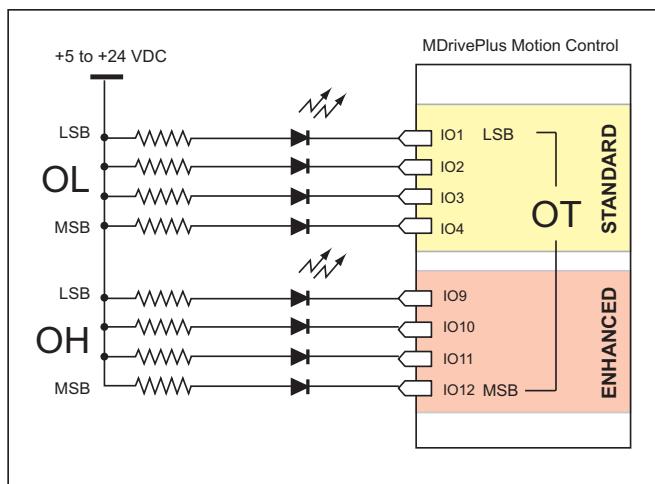


Figure D.10: Outputs Interfaced to LED's as a Group

Output Bit Weight Examples								
I/O Set	Enhanced (Plus ²)				Standard			
	IO12 (MSB)	IO11	IO10	IO9	IO4	IO3	IO2	IO1 (LSB)
OL=13 OT=13	NOT AVAILABLE				1	1	0	1
	1	0	0	1	NOT ADDRESSED BY OH			
OH=9	1	0	0	1	NOT ADDRESSED BY OH			
	1	1	0	1	1	1	1	1
OT=223	1	1	0	1	1	1	1	1
	1	1	0	1	1	1	1	1

Table D.1: Output Bit Weight Examples - Outputs set as a group

APPENDIX E

MDrivePlus Motion Control Closed Loop Control

MDrive Motion Control Closed Loop Options

The MDrive Motion control has two closed loop options: Internal magnetic encoder on all MDrivePlus models or interface to a remote user supplied encoder on MDrivePlus² models.

Internal Encoder

All models of the MDrivePlus motion control are available with an internal magnetic encoder, which adds the functionality of Stall Detection, Position Maintenance and Home to Index.

The encoder itself has a resolution of 512 lines or 2048 edges per revolution.

Remote Encoder

The MDrivePlus² models are available with the option of using a remote encoder through the enhanced I/O. The advantage of using a remote encoder is that the encoder can be stationed directly on the load for increased accuracy.

Set Up and Configuration

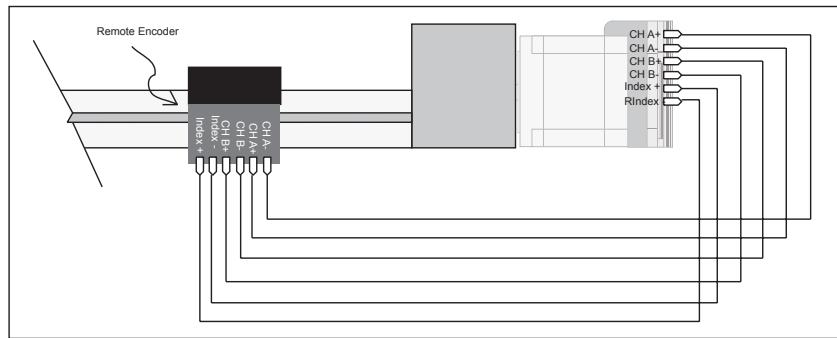


Figure E.1: Connecting a Remote Encoder

APPENDIX F

Connectivity

MD-CC40x-001 Communications Cable

WARNING! DO NOT connect or disconnect the Communications Converter Cable from MDrive while power is applied!

The MD-CC40x-001 is an in-line USB to RS-422/4895 converter with attachable cable to interface with the MDrivePlus P2 Communications connector. The included components will allow you to connect the USB port of a PC directly to the MDrive Motion Control. The converter will automatically detect if RS422 or RS485 is being used and configure itself accordingly.

There are three variations of this cable, which can be used with the different P2 connector variations of the MDrivePlus:

1. MD-CC400-001 USB to 10-Pin IDC connector.
2. MD-CC401-001 USB to 5-Pin M12 Circular connector.
3. MD-CC402-001 USB to 10-Pin Friction Lock Wire Crimp Connector. Note that this cable also has an optional prototype development cable available to interface to multiple MDrives for party mode communications. Part Number PD10-1430-FL3.

The MD-CC40x-001 communications converter cable is designed to be used with all MDrive, MDrivePlus and MDrivePlus² Motion Control devices that utilize an RS-422/485 interface.

Supplied Components: MD-CC40x-001 Communications Converter, Drive Interface Cable, USB Cable, USB Drivers, IMS Terminal Interface Software.

Electrical Specifications

MD-CC400-001 Specifications	
BAUD Rate	Up to 115 kbps
Power Requirement	Power from USB

Table F.1: MD-CC400-001 Electrical Specifications

MD-CC400-001 Mechanical Specifications and Connector Details

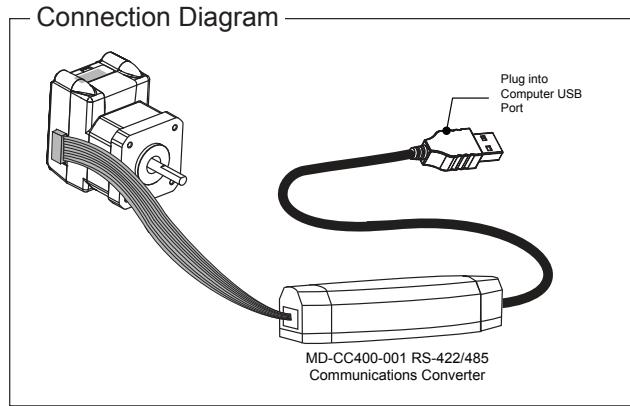
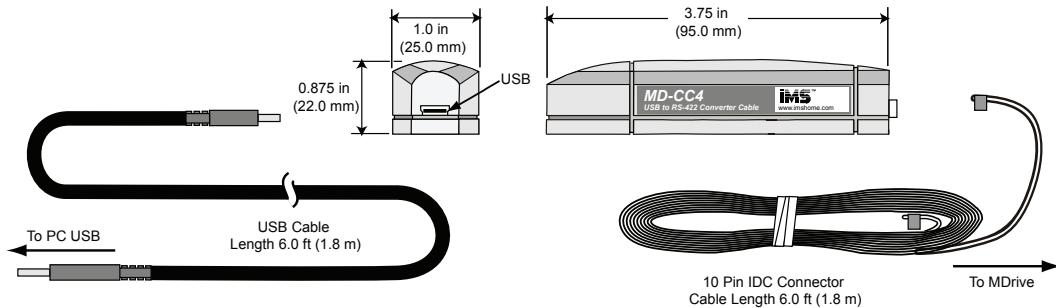


Figure F.1: MD-CC400-001 Mechanical Specifications and Connection

Connector Detail and Mating Connector Kit

Should you choose to create your own interface cable IMS now has mating connector kits available which assist you in creating interface cables in small quantities. These kits come with the connector shells and crimp pins (if applicable) to create five interface cables.

Connector Details

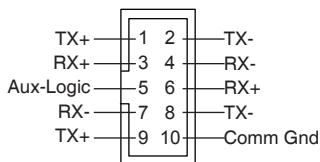


Figure F.2: 10-Pin IDC

Mating Connector Kit p/n: CK-01

Description: 5 mating connector shells for making interface cables to MDrive's 10-pin IDC connector. 2-piece connector shell crimps onto a 10 conductor AMP ribbon cable. Ribbon Cable is not included.

IDC Parts: Shell: SAMTEC TCSD-05-01-N
Ribbon Cable: AMP 1-57051-9

Using the MD-CC400-001 in MultiDrop Configuration

Required: MD-CC400-001 USB to RS-422 Communications Converter

Mating Connector Kit CK-01 or equivalent

1. Crimp the required number of IDC connectors on the ribbon cable. If additional length is required, cable extenders are available from SAMTEC or an interface ribbon cable may be made to the length required. (IMS recommends not exceeding 15' cable length with ribbon cable).
2. Remove the ground conductor (Pin 10) between all connectors except the connector for the first MDrive in the daisy chain. This is to prevent communication errors and potential damage due to ground loops. See Figure F.3

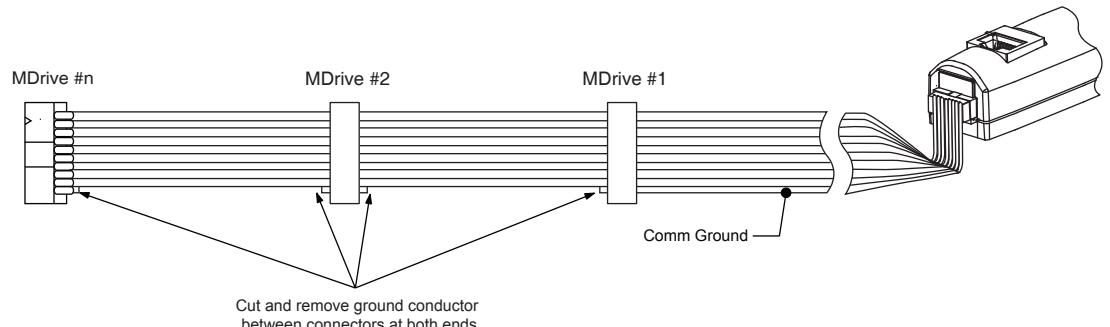


Figure F.3: Configuring the MD-CC400-001 for Multi-drop (Party Mode) Communications

MD-CC401-000 Mechanical Specifications and Connection

No Mating Connector kit is available for this connector style. Compatible mating connectors may be purchased from the following suppliers:

- Phoenix
- Turck
- RDE Connectors

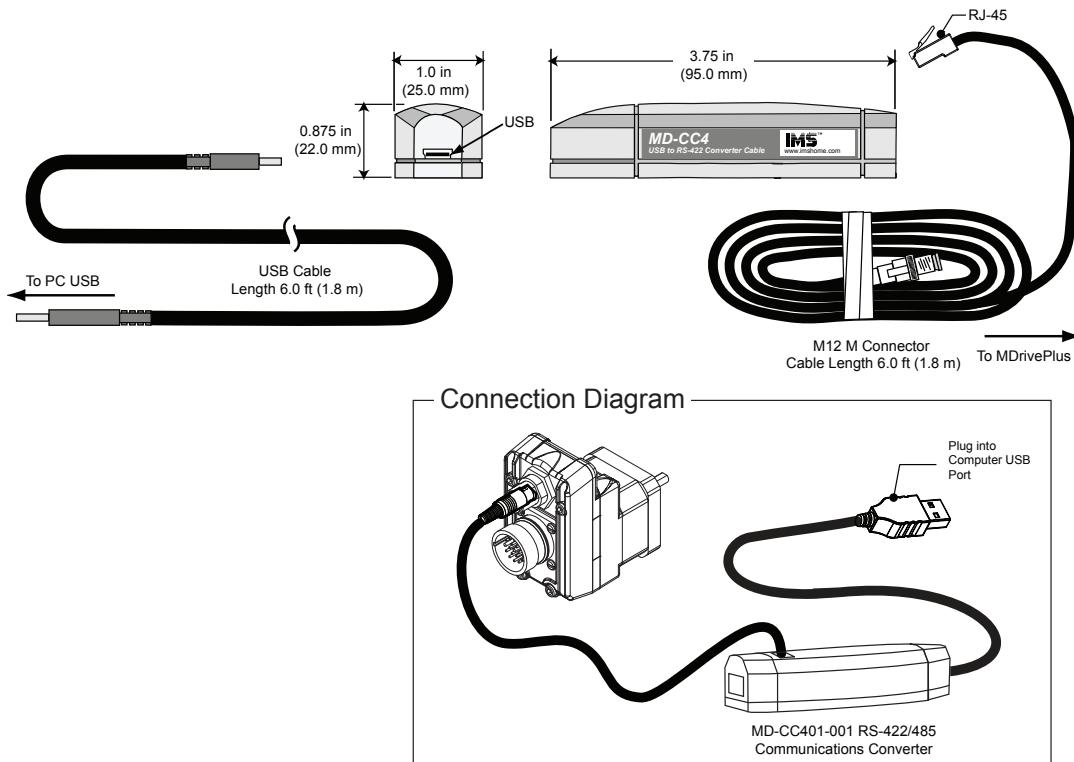


Figure F.4: MD-CC401-000 Mechanical Specifications and Connection

MD-CC402-001 Mechanical Specifications and Connection

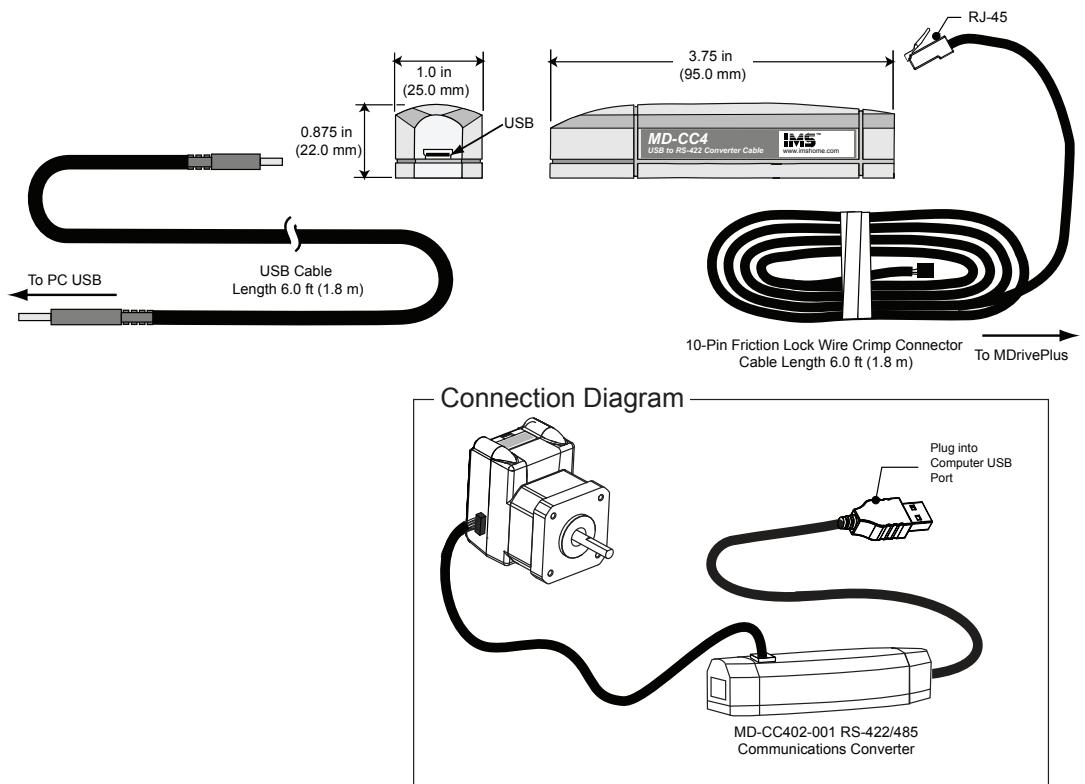
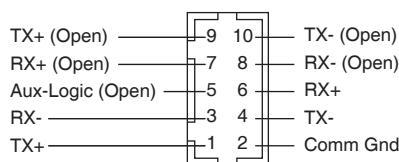


Figure F5: MD-CC402-000 Mechanical Specifications and Connection

Connector Detail and Mating Connector Kit

Should you choose to create your own interface cable IMS now has mating connector kits available which assist you in creating interface cables in small quantities. These kits come with the connector shells and crimp pins to create five interface cables.

Connector Details



Pins 5-10 are left open to facilitate use of the PD10-1434-FL3 for multi-drop communications and connection of Aux-Logic.

Figure F6: 10-Pin Wire Crimp

Mating Connector Kit p/n: CK-02

Description: 5 mating connector shells and crimp pins. Recommend Hirose Crimp tool (Not included).

Hirose Parts:	Shell:	DF11-10DS-2C
	Pins:	DF11-2428SC
	Crimp Tool:	DF11-TA2428HC

PD-10-1434-FL3 and MD-CC402-001 in MultiDrop Configuration

Required: MD-CC402-001 USB to RS-422 Communications Converter

Prototype Development Cable PD10-1434-FL3

1. Connect crimp pins into the appropriate connector locations on the 10-pin wire crimp that are left open on the MD-CC402-001 for this purpose.
2. Remove the ground conductor (Pin 10) between all connectors except the connector for the first MDrive in the daisy chain. This is to prevent communication errors and potential damage due to ground loops. See Figure F.6

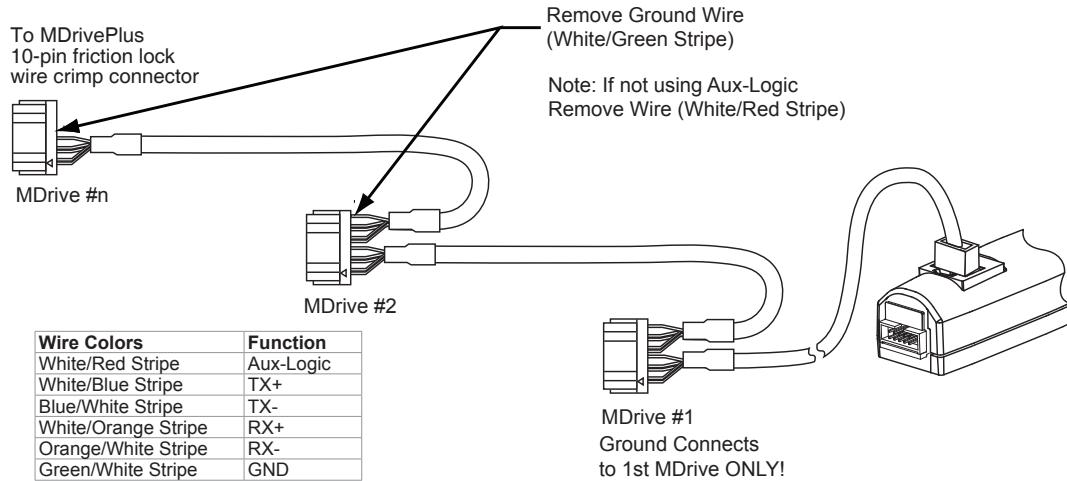


Figure F7: Configuring the MD-CC402-001 for Multi-drop (Party Mode) Communications

Driver Installation Procedure for the MX-CC40x-001

These Installation procedures are written for Microsoft Windows XP Service Pack 2. Users with earlier versions of Windows please see the alternate installation instructions at the IMS web site (<http://www.imshome.com>).

The installation of the MD-CC40x-000 requires the installation of two sets of drivers:

- Drivers for the IMS USB to RS-422 Converter Hardware.
- Drivers for the Virtual Communications Port (VCP) used to communicate to your IMS Product.

Therefore the Hardware Update wizard will run twice during the installation process.

The full installation procedure will be a two-part process: Installing the Cable/VCP drivers and Determining the Virtual COM Port used.

Installing the Cable/VCP Drivers

- 1) Plug the USB Converter Cable into the USB port of the MD-CC40x-001.
- 2) Plug the other end of the USB cable into an open USB port on your PC.
- 3) Your PC will recognize the new hardware and open the Hardware Update dialog.
- 4) Select “No, not this time” on the radio buttons in answer to the query “Can Windows Connect to Windows Update to search for software?” Click “Next” (Figure F.8).
- 5) Select “Install from a list or specific location (Advanced)” on the radio buttons in answer to the query “What do you want the wizard to do?” Click “Next” (Figure F.9).



Figure F.8: Hardware Update Wizard

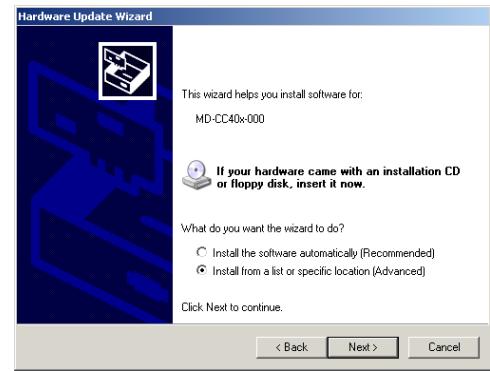


Figure F.9 Hardware Update Wizard Screen 2

- 6) Select “Search for the best driver in these locations.”
 - (a) Check “Include this location in the search.”
 - (b) Browse to the MDrive CD [Drive Letter]:\ Cable_Drivers\MD CC40x000_DRIVERS.
 - (c) Click Next (Figure F.10).



Figure F.10: Hardware Update Wizard Screen 3

- 7) The drivers will begin to copy.
- 8) On the Dialog for Windows Logo Compatibility Testing, click “Continue Anyway” (Figure F.7).
- 9) The Driver Installation will proceed. When the Completing the Found New Hardware Wizard dialog appears, Click “Finish” (Figure F.8).
- 10) Upon finish, the Welcome to the Hardware Update Wizard will reappear to guide you through the second part of the install process. Repeat steps 1 through 9 above to complete the cable installation.
- 11) Your IMS MD-CC40x-001 is now ready to use.



Figure F.11: Windows Logo Compatibility Testing



Figure F.12: Hardware Update Wizard Finish Installation

Determining the Virtual COM Port (VCP)

The MD-CC40x-000 uses a Virtual COM Port to communicate through the USB port to the MDrive. A VCP is a software driven serial port which emulates a hardware port in Windows.

The drivers for the MD-CC40x-000 will automatically assign a VCP to the device during installation. The VCP port number will be needed when IMS Terminal is set up in order that IMS Terminal will know where to find and communicate with your IMS Product.

To locate the Virtual COM Port.

- 1) Right-Click the “My Computer” Icon and select “Properties”.
- 2) Browse to the Hardware Tab (Figure F.12), Click the Button labeled “Device Manager”.
- 3) Look in the heading “Ports (COM & LPT)” IMS USB to RS422 Converter Cable (COMx) will be listed (Figure F.12). The COM # will be the Virtual COM Port connected. You will enter this number into your IMS Terminal Configuration.

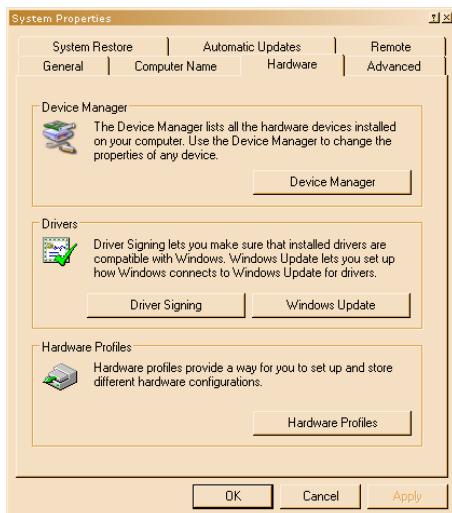


Figure F.13: Hardware Properties

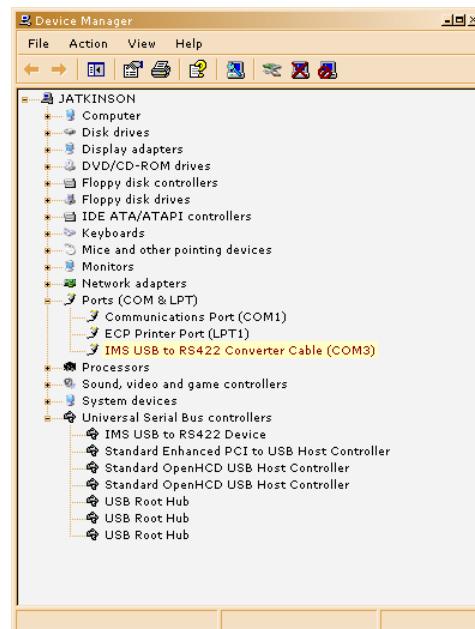


Figure F.14: Windows Device Manager

Prototype Development Cable PD10-1434-FL3 For Multi-Drop Communications

The PD10-1434-FL3 is a 10' (3.0 M) Prototype Development Cable used to connect multi-drop communications to the MDrivePlus Motion Control. The Flying Lead End connects to the user's RS-422 Interface. The Connector End connects to the 10-Pin Wire Crimp Connector located at P2 on the MDrive.

Setup Instructions — Cable #1

1. Cut crimp pins from Communications Wires and strip insulation back approximately 1/4".
2. Connect receive (RX) and transmit (TX) lines as shown in the diagram and table above to your RS-422/485 Host interface.
3. Connect Communications Ground line to the Comm Ground of your RS-422/485 Host.
4. Connect Aux-Power (if used) to the +VDC Output of a +12 to +24 VDC Supply.
5. Connect the return (GND) of the Aux-Supply to Power Ground of the MDrivePlus.
6. Plug the wire crimp connector of Cable #1 into P2 of the MDrivePlus #1.

Setup Instructions — Cable #2 and Subsequent MDrives

1. Insert the crimped transmit and receive lines into the 10-Pin wire crimp connector of Cable #1 as shown in the diagram and table above.
2. Connect communications ground (May be daisy-chained).
3. Connect Aux-Supply at the +VDC output of the +12 to +24 VDC Supply (May NOT be daisy-chained).
4. Plug the wire crimp connector of Cable #2 into P2 of MDrivePlus #2
5. Repeat Steps 1-4 for each additional MDrivePlus in the system.

Wire Color Code			
Pair Number (Cable/Pair)	Color Combination	Communications Host Connection	MDrive Wire Crimp Connection
1/1	White/Blue	RX+	TX+
	Blue/White	RX+	TX-
1/2	White/Orange	TX+	RX+
	Orange/White	TX-	RX-
1/3	White/Green	NC	NC
	Green/White	COMM GND	COMM GND
2/1	White/Blue	TX+	TX+
	Blue/White	TX-	TX-
2/2	White/Orange	RX+	RX+
	Orange/White	RX-	RX-
2/3	White/Green	NC	NC
	Green/White	COMM GND	COMM GND
3		AUX Power	AUX Power

Table F2: PD10-1434-FL3 Wire Color Codes

MDrive17Plus² Recommended Prototype Development Cable

P1: PD16-1417-FL3 — Power and I/O

The PD16-1417-FL3 is a 10' (3.0 M) Prototype Development Cable used to connect to the 16-Pin Locking Wire Crimp Connector. The Connector end plugs into the P1 Connector of the MDrivePlus. The Flying Lead end connects to a Control Interface such as a PLC and the users motor power supply.

Wire Color Code		Signal Name (Expanded I/O)	Signal Name (Remote Encoder)	P1 Pin Number
1	Black	Power Ground	Power Ground	16
	Red	+V (+12 to +48 VDC)	+V (+12 to +48 VDC)	15
2	Black	Direction	Index -	14
	White	Step Clock	Index +	13
3	Black	Analog In	Analog In	12
	Green	Capture In/Trip Out	Capture In/Trip Out	11
4	Black	I/O 12	Channel B -	10
	Blue	I/O 11	Channel B +	9
5	Black	I/O 10	Channel A -	8
	Yellow	I/O 9	Channel A +	7
6	Black	I/O 4	I/O 4	6
	Brown	I/O 3	I/O 3	5
7	Black	I/O 2	I/O 2	4
	Orange	I/O 1	I/O 1	3
8	White	I/O GND	I/O GND	2
	Red	I/O Power	I/O Power	1

Table F.3: PD16-1417-FL3 Wire Color Codes

To MDrivePlus 16-pin wire crimp
JST connector

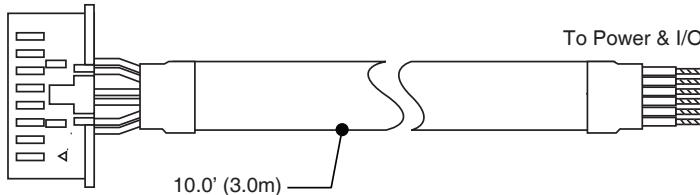


Figure F.15: PD16-1417-FL3 Prototype Development Cable

Connector Detail and Mating Connector Kit

Should you choose to create your own interface cable IMS now has mating connector kits available which assist you in creating interface cables in small quantities. These kits come with the connector shells and crimp pins to create five interface cables.

Connector Details

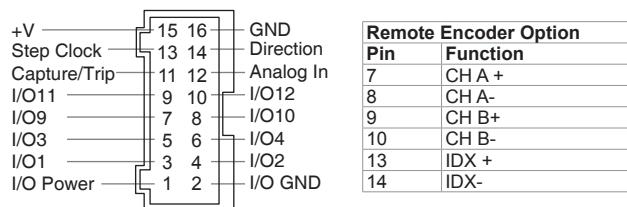


Figure F.16: 16-Pin Wire Crimp

Mating Connector Kit p/n: CK-10

Description: 5 mating connector shells and crimp pins. Recommend JST Crimp tool (Not included).

JST Parts: Shell: PADP-16V-1-S
Pins: SPH-001T-P0.5L
Crimp Tool: YHT2622

! **WARNING! DO NOT connect or disconnect the Prototype Development Cables Cable from MDrive while power is applied!**

! **WARNING! Ensure that the Black-Color pair is correctly matched prior to power application.**

WARNING! DO NOT connect or disconnect the Prototype Development Cables Cable from MDrive while power is applied!

WARNING! Ensure that the Black-Color pair is correctly matched prior to power application.

MDrive23Plus² Recommended Prototype Development Cables

P1: PD14-2334-FL3 — I/O

IMS recommends the Prototype Development Cable PD14-2334-FL3 for interfacing I/O and Logic to the MDrive23Plus² Motion Control. IMS recommends the Prototype Development Cable PD14-2334-FL3 with the first order of an MDrive23Plus² Motion Control to mate with the 14-pin locking wire crimp connector P1.

Care should be observed to ensure that the black leads are connected in the correct location in relation to their paired color.

Pair Number	Color Combination	Signal Name (Expanded I/O)	Signal Name (Remote Encoder)	P1 Pin Number
1	Black	Direction	Index –	14
	White	Step Clock	Index +	13
2	Black	Analog In	Analog In	12
	Green	Capture In/Trip Out	Capture In/Trip Out	11
3	Black	I/O 12	Channel B –	10
	Blue	I/O 11	Channel B +	9
4	Black	I/O 10	Channel A –	8
	Yellow	I/O 9	Channel A +	7
5	Black	I/O 4	I/O 4	6
	Brown	I/O 3	I/O 3	5
6	Black	I/O 2	I/O 2	4
	Orange	I/O 1	I/O 1	3
7	White	I/O GND	I/O GND	2
	Red	I/O Power	I/O Power	1

Table F4: PD14-2334-FL3 Wire Color Codes

To MDrivePlus 14-pin wire crimp JST connector

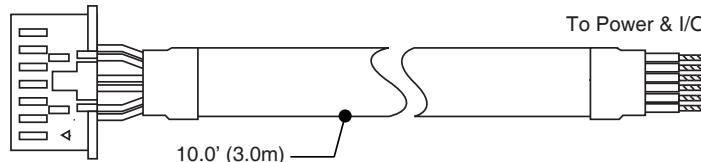


Figure F17: PD14-2334-FL3 Prototype Development Cable

Connector Detail and Mating Connector Kit

Should you choose to create your own interface cable IMS now has mating connector kits available which assist you in creating interface cables in small quantities. These kits come with the connector shells and crimp pins to create five interface cables.

Connector Details

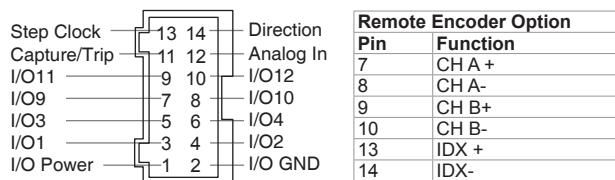


Figure F18: 16-Pin Wire Crimp

Mating Connector Kit p/n: CK-10

Description: 5 mating connector shells and crimp pins. Recommend JST Crimp tool (Not included).

JST Parts: Shell: PADP-14V-1-S
Pins: SPH-001T-P0.5L
Crimp Tool: YHT2622

P3: PD02-2300-FL3 — I/O

IMS recommends the Prototype Development Cable PD02-2300-FL3 for interfacing power to the MDrive-23Plus² Motion Control.

Wire Color Code	Signal Name (Expanded I/O)	P3 Pin Number
Black	Power Ground	2
Red	+V (+12 to +48 VDC)	1

Table F.5: PD14-2334-FL3 Wire Color Codes

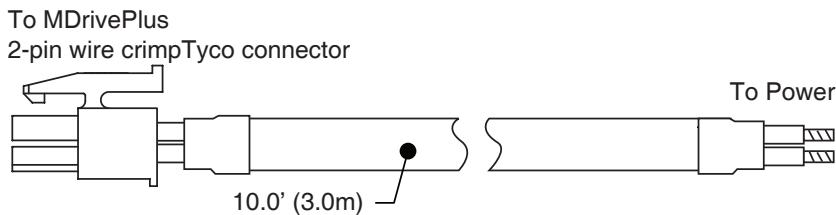


Figure F.19: PD02-2300-FL3

Connector Detail and Mating Connector Kit

Should you choose to create your own interface cable IMS now has mating connector kits available which assist you in creating interface cables in small quantities. These kits come with the connector shells and crimp pins to create five interface cables.

Connector Details

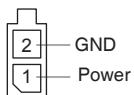


Figure F.20: 2-Pin Wire Crimp

Mating Connector Kit p/n: CK-04

Description: 5 mating connector shells and crimp pins. Recommend JST Crimp tool (Not included).

Tyco Parts: Shell: 794617-2
Pins: 794610-1
Crimp Tool: 91501-1

MDrive17Plus²-65 and MDrive23Plus²-65 Cordsets

19-pin M23 single-ended cordsets are offered to speed prototyping of sealed MDrivePlus² units. Measuring 13.0' (4.0m) long, either straight or right-angle termination is available. PVC jacketed cables come with a foil shield and an unconnected drain wire.

- Straight Termination MD-CS100-000
- Right Angle Termination MD-CS101-000

Pin Assignment and Wire Colors

P1 - Expanded I/O Configuration			
Cordset Wire Color	Function (Expanded I/O)	Function (Remote Encoder)	MDrive P1
Violet	I/O 9	Channel A +	Pin 1
Red	I/O 11	Channel B +	Pin 2
Grey	Step Clock	Index +	Pin 3
Red/Blue	I/O 1	I/O 1	Pin 4
Green	Direction	Index -	Pin 5
Blue	+V	+V	Pin 6
Gray/Pink	Aux-Logic	Aux-Logic	Pin 7
White/Green	Comm Ground	Comm Ground	Pin 8
White/Yellow	I/O 3	I/O 3	Pin 9
White/Gray	I/O GND	I/O GND	Pin 10
Black	I/O PWR	I/O PWR	Pin 11
Green/Yellow	Shell Connect	Shell Connect	Pin 12
Yellow/Brown	I/O 12	Channel B -	Pin 13
Brown/Green	Capture/Trip	Capture/Trip	Pin 14
White	AIN	AIN	Pin 15
Yellow	I/O 2	I/O 2	Pin 16
Pink	I/O 4	I/O 4	Pin 17
Gray/Brown	I/O 10	Channel A -	Pin 18
Brown	GND	GND	Pin 19

Table F.6: MD-CS10x-000 Wire Color Chart

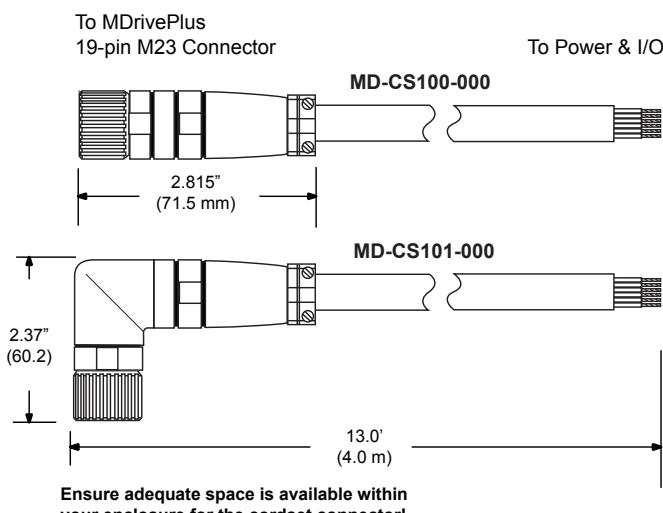


Figure E.21: MD-CS10x-000 Prototype Development Cordset

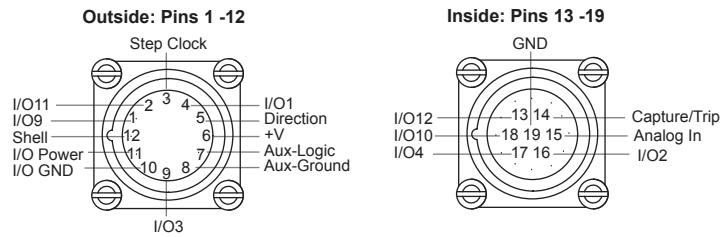
Connector Details

Should you choose to create your own interface cable field solderable 19-pin M23 connectors are available from a variety of suppliers referenced below.

- Lumberg
- Phoenix
- Turck
- RDE Connectors

Connector Details

Expanded I/O



Remote Encoder

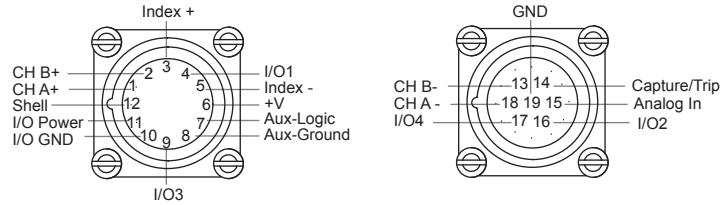


Figure F.22: 19-Pin M23 Circular Connector

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APPENDIX G

Linear Slides

Features

- Screw driven slide offering exceptional linear speed, accurate positioning and long life at a compelling value
- High bidirectional repeatability of up to 50 micro-inches (1.25 microns)
- Positional lead accuracy of 0.0006"/in. – accuracies to 0.0001"/in. available
- Linear speeds not limited by critical screw speed
- Standard leads:
 - 0.10" travel per revolution
 - 0.20" travel per revolution
 - 0.50" travel per revolution
 - 1.00" travel per revolution
- Achieve speeds that exceed 60.0"/second while offering excellent repeatability, accuracy and axial stiffness
- Optional sensor flag kit available for home, limits and general purpose inputs
- Assembly includes a precision aluminum guide and carriage which is driven by a precision rolled stainless steel lead screw
- Sliding contact areas coated with TFE (Teflon) permanent lubrication to offer a low 0.09 coefficient of friction
- Exceptional torsional stiffness and stability
- Standard lengths from 10.0" to 36.0" (MDrive17Plus) and 12.0" to 36.0" (MDrive23Plus), longer sizes available upon request*
- Comes standard with wear-compensating, anti-backlash driven carriage
- Additional passive carriages or slides available to support cantilevered loads
- Easily mountable with provided mounting flange and holes
- Extrusions provided for sensor mounts

MDrive17Plus Linear Slide

MDrive17Plus Linear Slide Speed-Force Limitations[†]

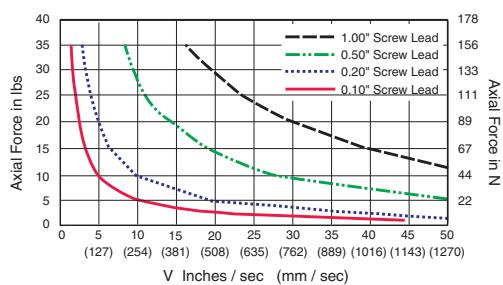


Figure G.1: MDrive17Plus Linear Slide Speed Force Limitations

[†]Speed/Force correlating equations:

1 Axial Force = $F_{\text{friction}} + F_{\text{acceleration}} + F_{\text{gravity}}$

$F_{\text{friction}} = (\text{Weight})(0.09)$

$F_{\text{acceleration}} = (\text{Weight})(\text{Acceleration}) / \text{Accel. of gravity}$

$F_{\text{gravity}} = 0$ for horizontal application and 1 Weight for vertical application

2 Torque = $\frac{(\text{Axial Force})(\text{Screw Lead})}{(0.393)(\text{Screw Efficiency})}$

Force in lbs; Torque in oz-in, Lead in inches/rev

3 Full Steps = $\frac{(200 \text{ Full Steps}/\text{Rev})(\text{Velocity})}{\text{Second Lead}}$

Lead in inches/rev; Velocity in inches/second

MDrive17Plus Speed-Torque Curves

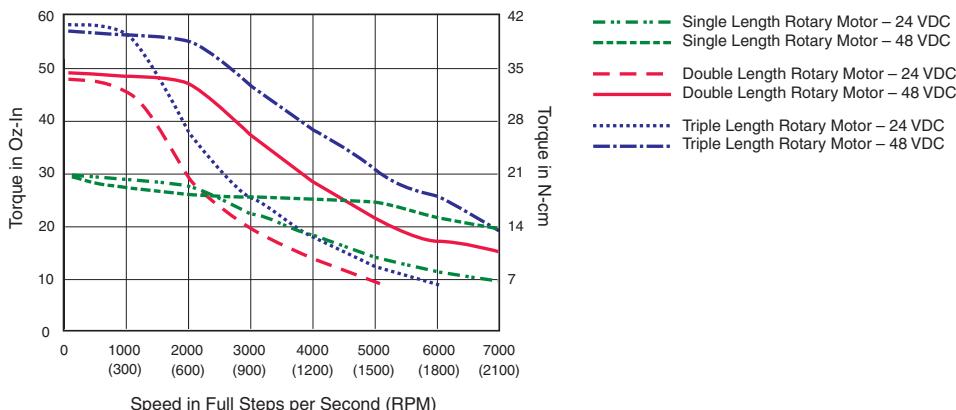


Figure G.2: MDrive17Plus Speed Torque Curves

MDrive17Plus Linear Slide Specifications

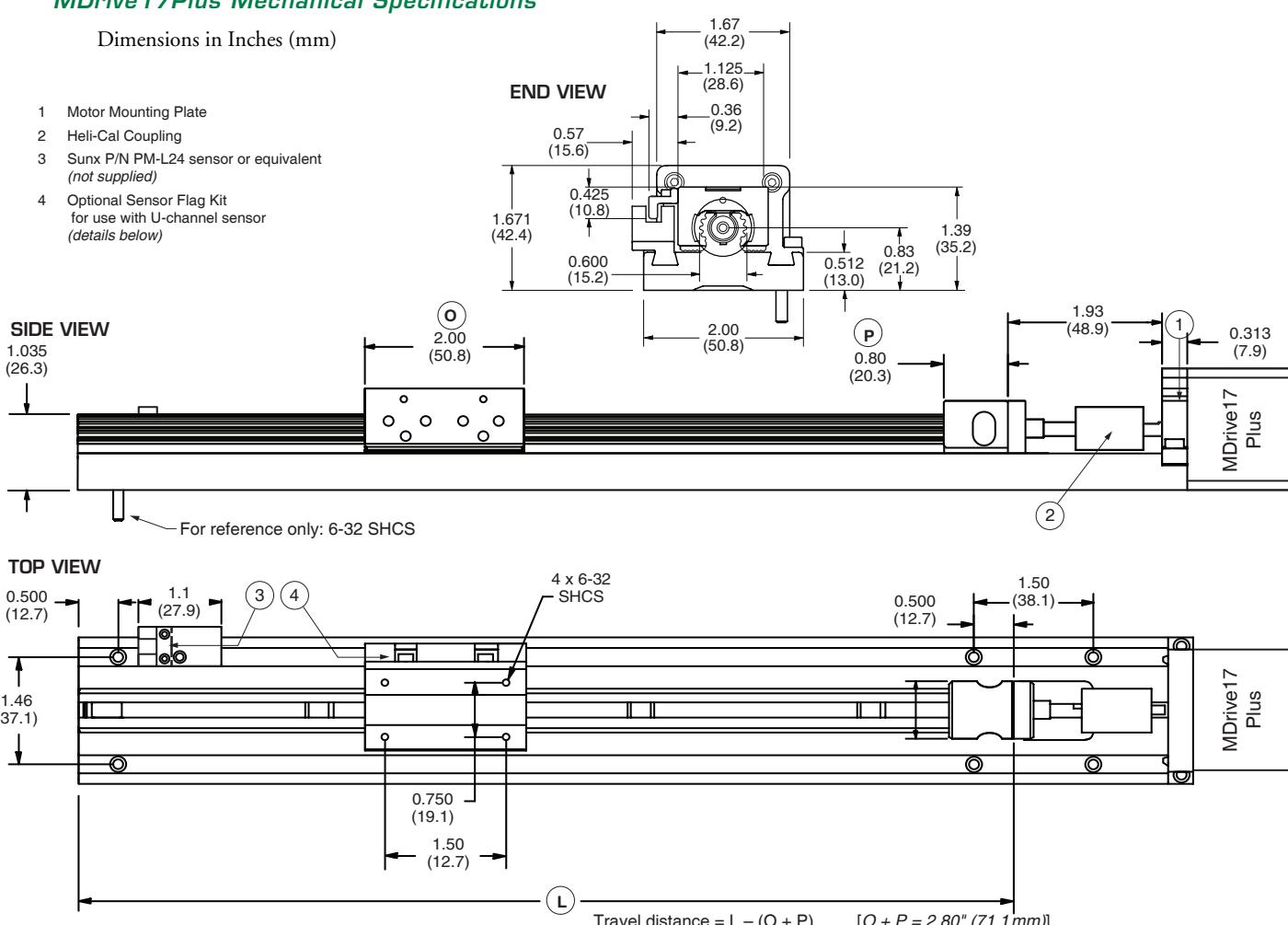
Screw Lead	Screw Efficiency	Nom. Screw Diam.	Inch Lead	Max Drag Torque	Life @ 1/4 Design Load	Torque to Move Load	Axial Design Load	Screw Inertia
	%	inches (mm)	inches (mm)	oz inch (Nm)	inches (cm)	oz inch/lb (Nm/kg)	lbs (kg)	oz.in.sec ² /inch (Kgm ² /m)
0.10"	53	0.375" (9.5)	0.100 (2.54)	4.0 (0.03)	100,000,000 (254,000,000)	1.0 (0.016)	35 (16)	0.3×10^{-5} (6.5×10^{-6})
0.20"	69	0.375" (9.5)	0.200 (5.08)	5.0 (0.04)	100,000,000 (254,000,000)	1.5 (0.023)	35 (16)	0.3×10^{-5} (6.5×10^{-6})
0.50"	81	0.375" (9.5)	0.500 (12.70)	6.0 (0.04)	100,000,000 (254,000,000)	2.5 (0.039)	35 (16)	0.3×10^{-5} (6.5×10^{-6})
1.00"	84	0.375" (9.5)	1.000 (25.40)	7.0 (0.05)	100,000,000 (254,000,000)	4.5 (0.070)	35 (16)	0.3×10^{-5} (6.5×10^{-6})

Table G.1: MDrive17Plus Linear Slide Specifications

MDrive17Plus Mechanical Specifications

Dimensions in Inches (mm)

- 1 Motor Mounting Plate
- 2 Heli-Cal Coupling
- 3 Sunx P/N PM-L24 sensor or equivalent (not supplied)
- 4 Optional Sensor Flag Kit for use with U-channel sensor (details below)



Sensor Flag Kit Option

P/N RSM06-K Includes:

- A #2-56 X 1/4" Long BHCS
- B Sensor Holder (Qty. 3)
- C #4-40 X 1/4" Long SHCS
- D Flag for Optical Sensor

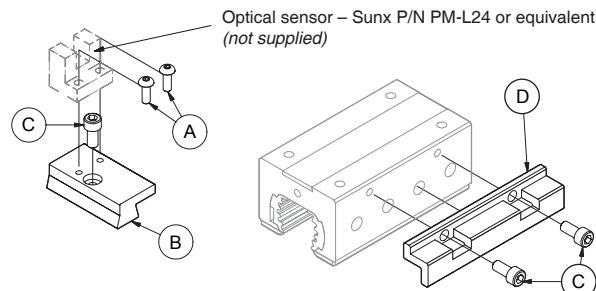


Figure G.3: MDrive17Plus Linear Slide Mechanical Specifications

MDrive23Plus Linear Slide

MDrive23Plus Linear Slide Speed-Force Limitations [†]

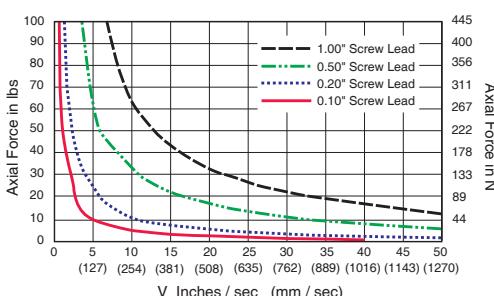


Figure G.4: MDrive23Plus Linear Slide Speed Force Limitations

[†]Speed/Force correlating equations:

$$1 \quad \text{Axial Force} = F_{\text{friction}} + F_{\text{acceleration}} + F_{\text{gravity}}$$

$$F_{\text{friction}} = (\text{Weight})(0.09)$$

$$F_{\text{acceleration}} = (\text{Weight})(\text{Acceleration}) / \text{Accel. of gravity}$$

$$F_{\text{gravity}} = 0 \text{ for horizontal application and 1 Weight for vertical application}$$

$$2 \quad \text{Torque} = \frac{(\text{Axial Force})(\text{Screw Lead})}{(0.393)(\text{Screw Efficiency})}$$

Force in lbs; Torque in oz-in, Lead in inches/rev

$$3 \quad \text{Full Steps} = \frac{(200 \text{ Full Steps}/\text{Rev})(\text{Velocity})}{\text{Second Lead}}$$

Lead in inches/rev; Velocity in inches/second

MDrive23Plus Speed-Torque Curves

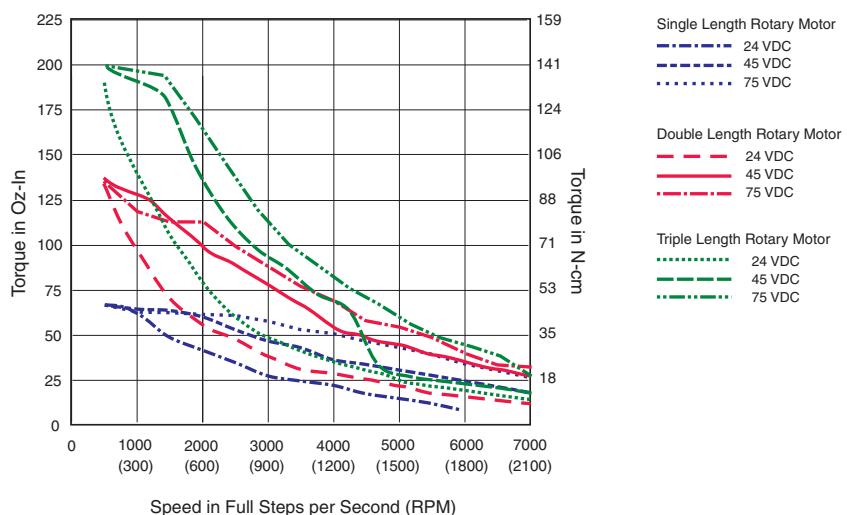


Figure G.5: MDrive23Plus Speed Torque Curves

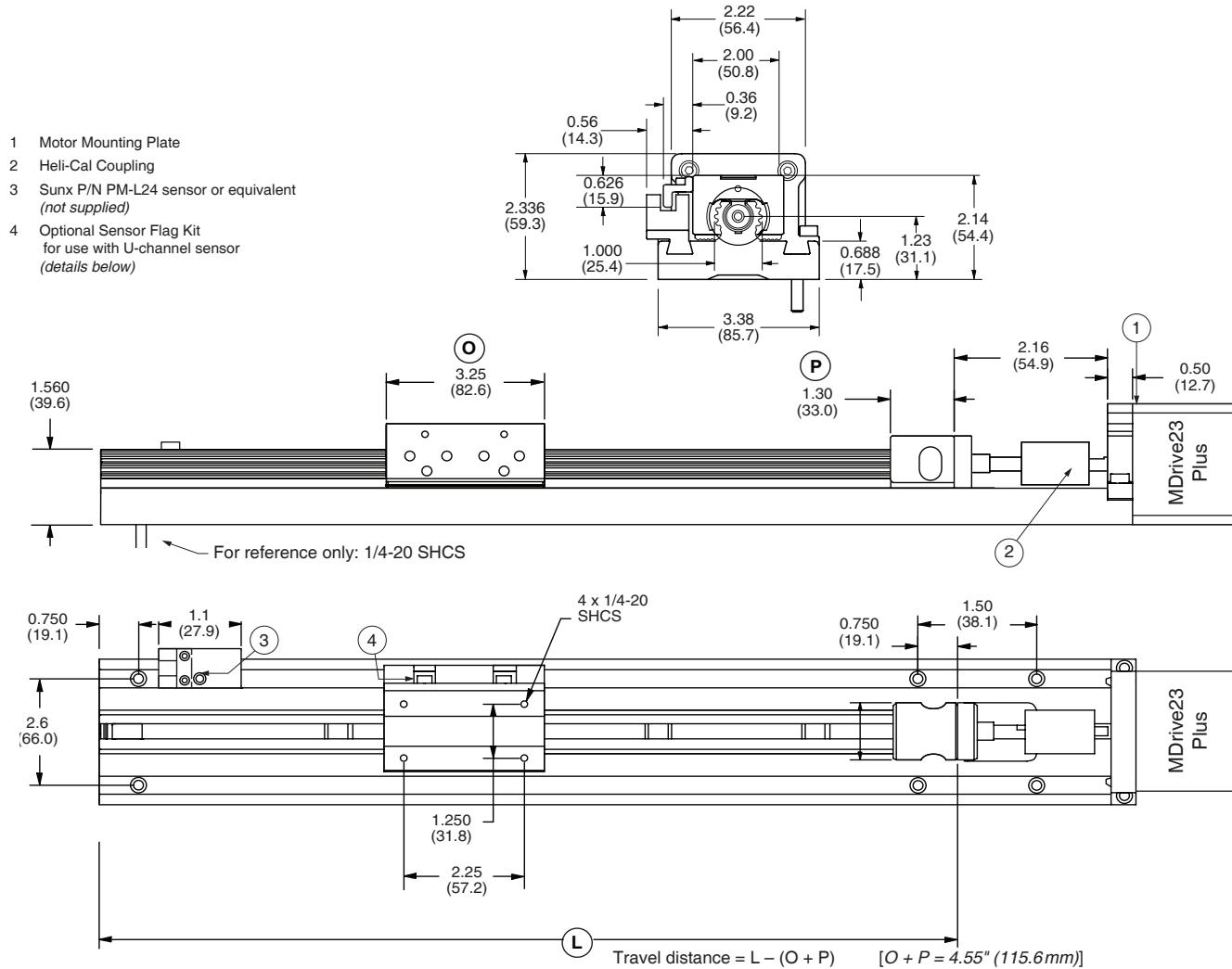
MDrive23Plus Linear Slide Specifications

Screw Efficiency	Nom. Screw Diam.	Inch Lead	Max Drag Torque	Life @ 1/4 Design Load	Torque to Move Load	Axial Design Load	Screw Inertia
Screw Lead	%	inches (mm)	inches (mm)	oz inch (Nm)	inches (cm)	oz inch/lb (Nm/kg)	lbs (kg)
0.10"	40	0.625" (15.9)	0.100 (2.54)	5.0 (0.03)	100,000,000 (254,000,000)	1.3 (0.020)	100 (46)
0.20"	53	0.625" (15.9)	0.200 (5.08)	6.0 (0.04)	100,000,000 (254,000,000)	2.0 (0.031)	100 (46)
0.50"	76	0.625" (15.9)	0.500 (12.70)	7.0 (0.05)	100,000,000 (254,000,000)	3.0 (0.047)	100 (46)
1.00"	81	0.625" (15.9)	1.000 (25.40)	8.5 (0.06)	100,000,000 (254,000,000)	6.5 (0.101)	100 (46)

Table G.2: MDrive23Plus Linear Slide Specifications

MDrive23Plus Mechanical Specifications

Dimensions in Inches (mm)



Sensor Flag Kit Option

P/N RSM10-K Includes:

- A #2-56 X 1/4" Long BHCS
- B Sensor Holder (Qty. 3)
- C #4-40 X 1/2" Long SHCS
- D Flag for Optical Sensor
- E #6-32 X 1/2" Long SHCS

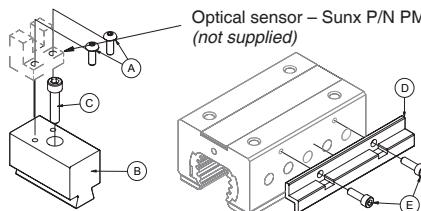


Figure G.6: MDrive23Plus Linear Slide Mechanical Specifications

APPENDIX H

CANopen Communications

Features

- CANopen DS-301 and DS-402
- Galvanically Isolated Communications
- 3 Dynamically Mappable Process Data Objects (PDO)
- Layer Setting Services to Establish Node ID and BAUD
- Node Guarding
- Heartbeat Producer
- Emergency Objects
- Upgradable Software

N NOTE: All other Specifications such as power and I/O are identical to the MDrivePlus Motion Control with RS-422/485 Communications Interface.

The CANopen Model MDrivePlus may not have all of the features/ functionality of its equivalent MDrivePlus Motion Control, such as the ability to store programs or I/O functions.

Communications Specifications

Communications Specifications	
Protocol	CAN 2.0b
Communications Profile	CiA DS-301
Device Profile	CiA DSP-402
BAUD Rate	10, 20, 50, 125, 250, 500, 800 KBits/s, 1MBit/s (default)

Table H.1: CANopen Communications Specifications

N NOTE: See the IMS DSP-402 Application Manual for supported objects and modes of operation.

Mechanical Specifications

The DB-9 Connector at location P2 adds 0.425" (10.79 mm) to the profile of the MDrive17Plus or MDrive23Plus as views from the motor face. Please allow additional space inside your enclosure for the connector body.

The 5-Pin M12 connector does not change the L_{MAX} value.

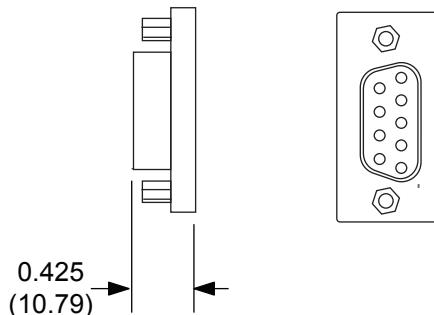


Figure H.1: DB-9 Mechanical Specifications

Pin Assignments

DB-9 Style Connector

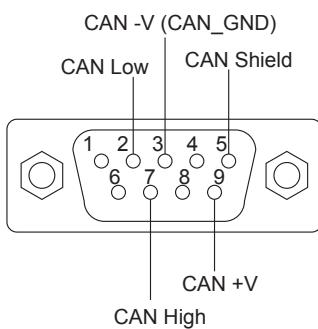


Figure H.2: DB-9 Pin Configuration

P2 Connector - CAN Communications		
DB9	Function	Description
Pin 1	N/C	No Connect
Pin 2	CAN LOW	CAN_L bus line (dominant low)
Pin 3	CAN -V	CAN Communications Ground
Pin 4	AUX-Logic	Auxiliary Logic Supply
Pin 5	CAN Shield	Optional CAN Shield
Pin 6	CAN -V	Optional Ground
Pin 7	CAN HIGH	CAN_H bus line (dominant high)
Pin 8	N/C	No Connect
Pin 9	CAN +V	+7 to +30 VDC supply

Table H.2: DB-9 Pin Assignments and Description

5-Pin M12 Connector

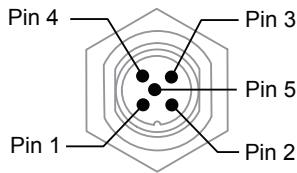


Figure H.3: 5-Pin M12 Pin Configuration

P2 Connector - CAN Communications		
M12	Function	Description
Pin 1	CAN Shield	Optional CAN Shield
Pin 2	CAN +V	+7 to +30 VDC supply
Pin 3	CAN -V	CAN Communications Ground
Pin 4	CAN HIGH	CAN_H bus line (dominant high)
Pin 5	CAN LOW	CAN_L bus line (dominant low)

Table H.3: 5-Pin M12 Pin Assignments and Description

Interfacing The CAN Bus

The MDrivePlus CANopen communicates using the CAN 2.0B Active Protocol and the CiA DS-301 Application Layer and Communications Profile. The full DS-301 V4.02 Specification may be downloaded free at <http://www.can-cia.org>. The default BAUD rate is 1 Mbit/Sec. The default Node ID is 41_h.

CAN Bus Connections

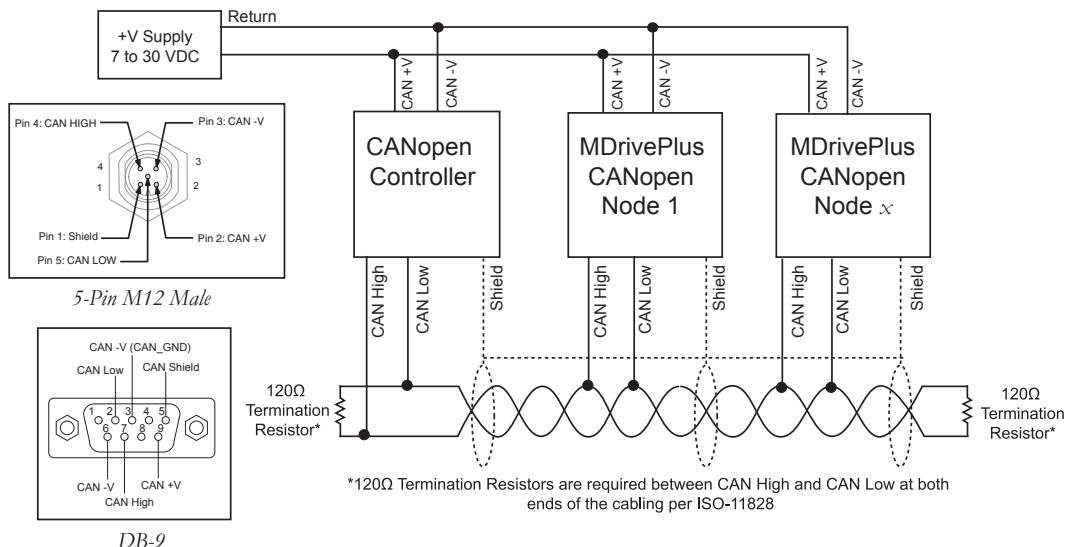


Figure H.: CANOpen Network using MDrivePlus.

Recommended CANopen Dongle

In order to use the IMS GUI and upgrade utility for the MDrivePlus CANopen you must purchase the MD-CC500-000 Communications Cable. When purchased from IMS, the User Interface software for upgrading and prototyping is included. This is required to upgrade the firmware in the MDrivePlus as CANopen updates become available.

This device is also available from Phytec at: <http://www.phytec.com/can/hardware/pccaninterface/peakusb.htm>, but does not include the IMS CANopen GUI and Upgrader software.

Interface Cable Construction

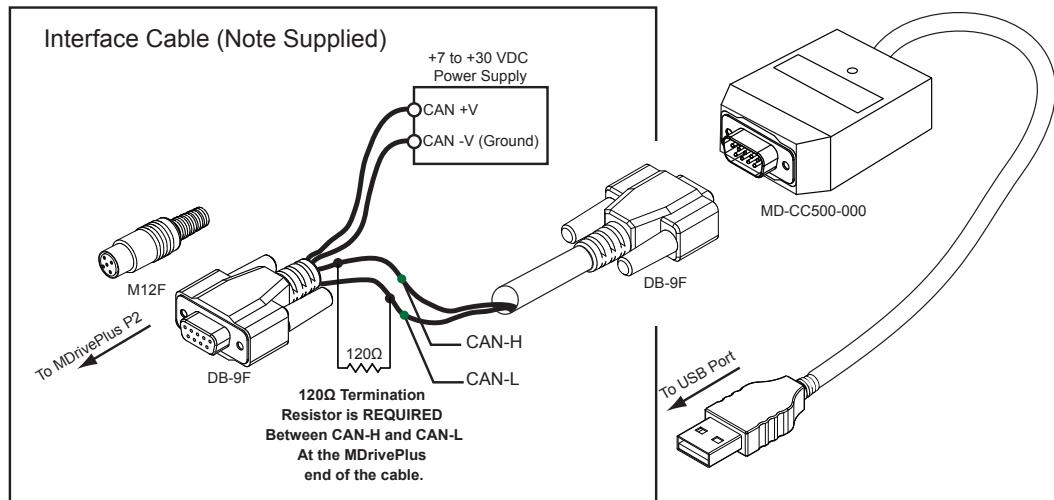
To connect the MD-CC500-000 dongle to the MDrivePlus CANopen product an interface cable will need to be constructed. The figure below shows the parts required.

Installation Instructions

1. Install the MD-CC500-000 adapter per the Phytec PCAN-USB Operating Instructions included on the PEAK CD included with the product.
2. Install the IMS CANOpen_Tester Interface available online at <http://www.imshome.com/canopen.html>
3. Using the interface cable (not supplied), connect the MDrivePlus product to the MD-CC500-000.
4. Apply Power to the MDrivePlus CANopen product.

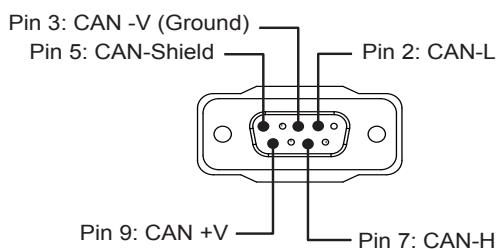


NOTE: The MD-CC500-000 USB to CAN Adapter is required to upgrade the firmware in the MDrivePlus with CANOpen. Any CAN adapter/Controller can be used to communicate to the device using CANOpen Objects and Indexes.



DB-9F

Connector Front View



M12F

Connector Front View

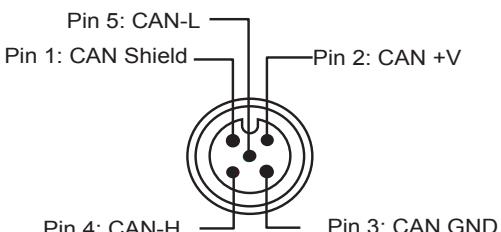


Figure H.5: Communications Cable, Phytec PCAN-USB to MDrivePlus

CANopen Tester Quick Start

Installation

1. Open the CANopen CD using Windows Explorer.
2. Browse to the CANopen_Tester Folder.
3. Double-Click the Setup.exe file.
4. Follow the prompts to install the program.

To ensure you have the latest version of the IMS CANopen Tester, please visit the IMS web site at <http://www.imshome.com/canopen.html>.

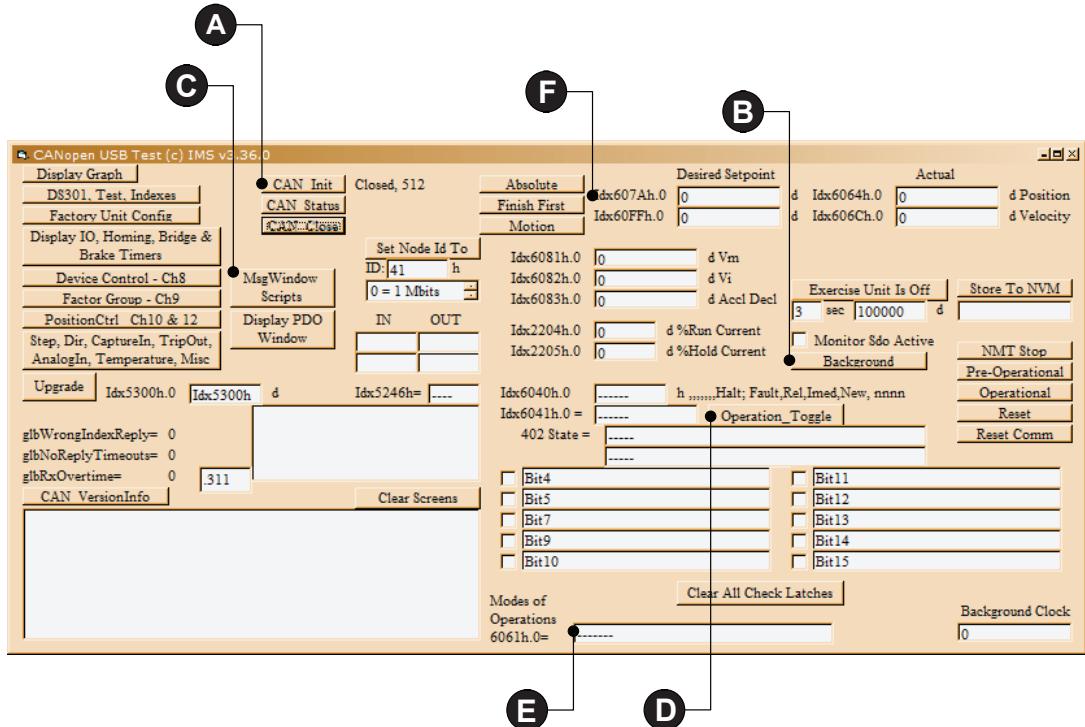


Figure H.6: CANopen Tester Interface Showing Getting Started Sequence

Getting Started

The below instructions are for IMS CANopen products being used with IMS's MD-CC500-000, USB to CANopen communication, and the IMS CANopen Tester software. Use the illustration above to follow along with the usage steps. This getting started will step the user from initializing the CAN bus to moving the motor in Profile Position mode.

Before applying power and launching software.

- 1) Install PEAK Drivers from CD
- 2) Run SetUp.exe from IMS CD
- 3) Connect power according to CANopen Hardware Reference Manual, Section 2.2 - Connecting Power.
- 4) Connect communication according to this appendix.

You can now power the MDrive or MForce product and launch the CANopen Tester software.

With the MDrive or MForce powered and the CANopen Tester software launched, select through the following sequence.

- A. Click CAN Init
- B. Click Background – Background Clock should start running and data fields should be populated with current Index values.
- C. Click Msg Window Scripts – This will open another window to allow the user to

see data being sent to MDrive or MForce in the following steps.

- D. Click Operation_Toggle three times (this steps through Index 0x6040 Control Word ending with Operation Enabled). This enables the output bridge of the driver.
- E. Enter the number “1” in the Modes of Operations field, this places the MDrive into Profile Position mode.
- F. Enter 512000 into the IDX67AH field, strike the return (Enter) key on your key board, the motor should move 10 revolutions.

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WARRANTY

TWENTY-FOUR (24) MONTH LIMITED WARRANTY

Intelligent Motion Systems, Inc. ("IMS"), warrants only to the purchaser of the Product from IMS (the "Customer") that the product purchased from IMS (the "Product") will be free from defects in materials and workmanship under the normal use and service for which the Product was designed for a period of 24 months from the date of purchase of the Product by the Customer. Customer's exclusive remedy under this Limited Warranty shall be the repair or replacement, at Company's sole option, of the Product, or any part of the Product, determined by IMS to be defective. In order to exercise its warranty rights, Customer must notify Company in accordance with the instructions described under the heading "Obtaining Warranty Service."

NOTE: MDrivePlus Motion Control electronics are not removable from the motor in the field.
The entire unit must be returned to the factory for repair.

This Limited Warranty does not extend to any Product damaged by reason of alteration, accident, abuse, neglect or misuse or improper or inadequate handling; improper or inadequate wiring utilized or installed in connection with the Product; installation, operation or use of the Product not made in strict accordance with the specifications and written instructions provided by IMS; use of the Product for any purpose other than those for which it was designed; ordinary wear and tear; disasters or Acts of God; unauthorized attachments, alterations or modifications to the Product; the misuse or failure of any item or equipment connected to the Product not supplied by IMS; improper maintenance or repair of the Product; or any other reason or event not caused by IMS.

IMS HEREBY DISCLAIMS ALL OTHER WARRANTIES, WHETHER WRITTEN OR ORAL, EXPRESS OR IMPLIED BY LAW OR OTHERWISE, INCLUDING WITHOUT LIMITATION, ANY WARRANTIES OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. CUSTOMER'S SOLE REMEDY FOR ANY DEFECTIVE PRODUCT WILL BE AS STATED ABOVE, AND IN NO EVENT WILL THE IMS BE LIABLE FOR INCIDENTAL, CONSEQUENTIAL, SPECIAL OR INDIRECT DAMAGES IN CONNECTION WITH THE PRODUCT.

This Limited Warranty shall be void if the Customer fails to comply with all of the terms set forth in this Limited Warranty. This Limited Warranty is the sole warranty offered by IMS with respect to the Product. IMS does not assume any other liability in connection with the sale of the Product. No representative of IMS is authorized to extend this Limited Warranty or to change it in any manner whatsoever. No warranty applies to any party other than the original Customer.

IMS and its directors, officers, employees, subsidiaries and affiliates shall not be liable for any damages arising from any loss of equipment, loss or distortion of data, loss of time, loss or destruction of software or other property, loss of production or profits, overhead costs, claims of third parties, labor or materials, penalties or liquidated damages or punitive damages, whatsoever, whether based upon breach of warranty, breach of contract, negligence, strict liability or any other legal theory, or other losses or expenses incurred by the Customer or any third party.

OBTAINING WARRANTY SERVICE

Warranty service may be obtained by a distributor, if the Product was purchased from IMS by a distributor, or by the Customer directly from IMS, if the Product was purchased directly from IMS. Prior to returning the Product for service, a Returned Material Authorization (RMA) number must be obtained. Complete the form at <http://www.imshome.com/rma.html> after which an RMA Authorization Form with RMA number will then be faxed to you. Any questions, contact IMS Customer Service (860) 295-6102.

Include a copy of the RMA Authorization Form, contact name and address, and any additional notes regarding the Product failure with shipment. Return Product in its original packaging, or packaged so it is protected against electrostatic discharge or physical damage in transit. The RMA number MUST appear on the box or packing slip. Send Product to: Intelligent Motion Systems, Inc., 370 N. Main Street, Marlborough, CT 06447.

Customer shall prepay shipping charges for Products returned to IMS for warranty service and IMS shall pay for return of Products to Customer by ground transportation. However, Customer shall pay all shipping charges, duties and taxes for Products returned to IMS from outside the United States.

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