

IMS™



Patent Pending

INTELLIGENT MOTION SYSTEMS, INC.

Excellence in Motion™

M DRIVE 17 & 23™

MOTOR+DRIVER

OPERATING INSTRUCTIONS



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*MDrive Operating Instructions
Revision 042905*

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IMPORTANT! READ THIS FIRST!

Notes and Warnings



WARNING! The MDrive has components which are sensitive to Electrostatic Discharge (ESD). All handling should be done at an ESD protected workstation.



WARNING! Hazardous voltage levels may be present if using an open frame power supply to power your MDrive product.



WARNING! Ensure that the power supply output voltage does not exceed the maximum input voltage of the MDrive product that you are using!



WARNING! The maximum Input Voltage of the MDrive17 and MDrive23 includes Motor Back EMF, Power Supply Ripple and High Line.

A characteristic of all motors is back EMF. Back EMF is a source of current that can push the output of a power supply beyond the maximum operating voltage of the driver. As a result, damage to the stepper driver could occur over a period of time. Care should be taken so that the back EMF does not exceed the maximum input voltage rating of the MDrive17 and MDrive23.

The Product Manual

Using This Manual

This manual is divided into three parts:

Part 1 is **General Information**, which covers details common to the entire MDrive product line such as operational theory, connection and interface instructions, and troubleshooting.

Part 2 is **MDrive17 Hardware Reference**. This part contains sections with information specific to each individual MDrive17 version. Here you will find details such as mechanical, electrical and thermal specifications and other product specific details.

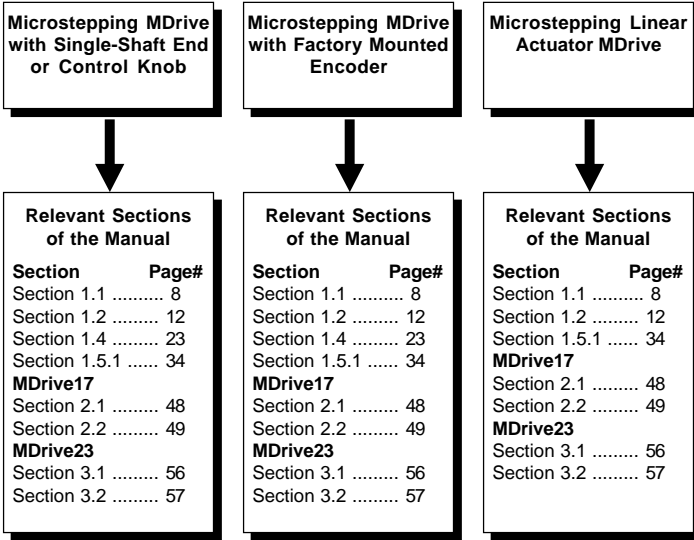
Part 3 is **MDrive23 Hardware Reference**. This part contains sections with information specific to each individual MDrive23 version. Here you will find details such as mechanical, electrical and thermal specifications and other product specific details.

Do not attempt to connect or use your MDrive without first consulting the section specific to the type of MDrive you purchased!

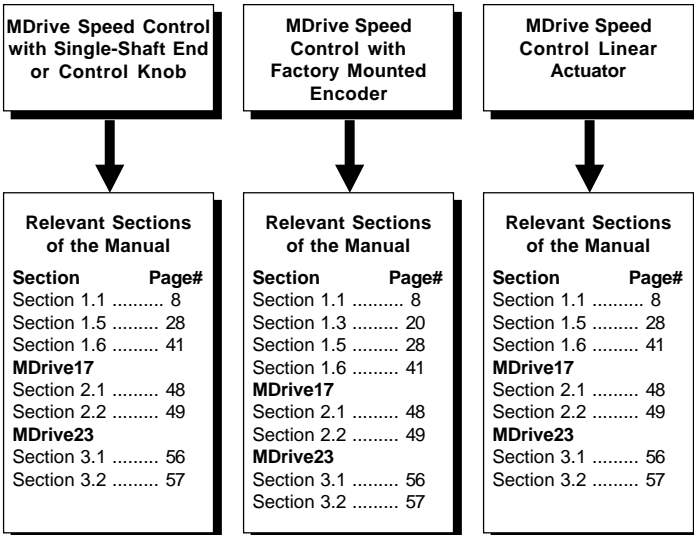
As this document covers all of the variations of the MDrive, please use the chart on the following page to help guide you through the sections of this manual relevant to the version of the MDrive you purchased.

USING THE MDRIVE PRODUCT MANUAL

Microstepping MDrive Variants



MDrive Speed Control Variants



PART I

MDRIVE INTEGRATED MOTOR AND ELECTRONICS

GENERAL INFORMATION



SECTION 1.1

The MDrive Integral Motor+Driver

Section Overview

The purpose of this section is to introduce the user to the MDrive integrated high torque motor and microstepping driver. Covered are:

- Introduction to the Microstepping MDrive
 - Microstepping MDrive Features and Benefits
 - Introduction to the Speed MDrive Control
 - MDrive Speed Control Features and Benefits
-

Introduction to the Microstepping MDrive

The MDrive high-torque Integrated Motor and Driver is ideal for designers who want the simplicity of a motor with on-board electronics, but without the expense of an indexer on each axis. The low cost MDrive puts the system designer in the driver's seat to decide the best method of control. The Drive's integrated electronics eliminates the need to run the motor cabling through the machine, reducing the potential for problems due to electrical noise.

The MDrive uses a NEMA 17 or NEMA 23 1.8° motor combined with a microstepping drive, and accepts up to 14 resolution settings from 1/2 to 256 microsteps per step. Setup parameters include Microstep Resolution, Run and Hold currents, Motor Direction vs. Direction Input and can be changed on-the-fly or downloaded and stored in non-volatile memory with the use of a simple user interface program which is provided, eliminating the need for external switches or resistors. Parameters are changed via an SPI (Serial Peripheral Interface) port located on connector P2. This port connects to the printer port on your PC. Operating voltage for the MDrive17 ranges from +12 to +48 VDC. The MDrive23 is available in two voltage ranges, either +12 to +48 or +24 to +75 VDC.

The versatile, compact MDrive is available in multiple configurations to fit various system needs including a single shaft stand-alone device, a rotary motor with optical encoder, a planetary gearbox, an Acme screw linear actuator, or with an optional rear knob for hand operation of the motor. The rotary MDrive is available in three different stack lengths: 13, 15 & 19 for the MDrive17; and 18, 22 & 31 for the MDrive23. Interface connections are accomplished using either a 7 position terminal block, 12" (30.5cm) flying leads, or optional 12-position keyed and locking pin and receptacle (C Connector).

The MDrive is a small, powerful and inexpensive solution that will reduce system cost, design and assembly time for a large range of stepping motor applications.

IMS Motor Interface Software

The IMS Motor Interface Software is accessed through the IMS SPI Interface which is an easy to install and use software program. The SPI Interface is included on the CD that ships with the MDrive or is available for download at www.imshome.com. Use of this utility and the optional 6 foot MD-CC100-000 Parameter Setup Cable is the suggested method of configuring the MDrive17 and MDrive23. Purchase of this cable is recommended with the first order as it includes built-in logic level shifting circuitry to make the MDrive17/23 SPI port compatible with all PC LPT (printer) port voltage levels. The Cable Part # is **MD-CC100-000**.

Features include:

- Easy installation.
- Ease of use via single screen interface.
- Automatic communication configuration.
- Will not allow out-of-range values to be set.
- Tool-tips display valid range settings for each option.

Features and Benefits of the Microstepping MDrive

- Integrated Microstepping Drive/NEMA 17 or 23 Motor
- +12 to +48 VDC (MD17)/+12 to +48 or +24 to +75 VDC (MD23) Input Voltage
- Low Cost
- Extremely Compact
- Optically Isolated Logic Inputs
- Automatic Current Reduction
- Configurable:
 - Motor Run/Hold Current
 - Microstep Resolution to 256 Microsteps/Step
- Available Configurations:
 - Single Shaft*
 - Planetary Gearbox*
 - Linear Actuator
 - Factory-Mounted Optical Encoder*
 - Double Shaft End with Knob For Manual Positioning*
- Available in Three Stack Sizes*
- Current and Resolution May Be Switched On-The-Fly
- Single Supply
- Interface Uses a Pluggable Terminal Strip, 12" (30.5 cm) Flying Leads, or 12-Position Keyed and Locking Pin and Receptacle (C Connector)
- Graphical User Interface (GUI) for Quick and Easy Parameter Setup

*Rotary Motor Only

Introduction to the MDrive Speed Control

The MDrive Speed Control offers the system designer low cost, intelligent velocity control integrated with a NEMA 17 or NEMA 23 enhanced torque stepping motor and a +12 to +48 (MD17 and MD23-4) or +24 to +75 (MD23-7) volt microstepping drive.

The MDrive Speed Control features a digital oscillator for accurate velocity control with an output frequency of up to 100 kilohertz. Output frequency will vary with the voltage level on the speed control input. The speed control input can be adjusted by using one of the following methods:

- 10k Potentiometer.
- 0 to +5V applied directly to the input.
- 15 - 25kHz (0 to 100% duty cycle) PWM applied to the input.
- 4 - 20mA or 0 - 20mA applied to input.

There are two basic modes of operation: bidirectional and unidirectional. In bidirectional mode, both speed and direction are controlled by the analog speed control input. In unidirectional mode, only velocity is controlled by the speed control input; direction is controlled by a separate digital input.

The MDrive Speed Control has 12 setup parameters which are configured by using the included IMS Speed Control Interface. These enable the user to configure all of the operational parameters of the MDrive which are stored in non-volatile memory.

The versatile, compact MDrive Speed Control is available in multiple configurations to fit various system needs. These options include: a single shaft stand-alone device, a rotary motor with optical encoder, a planetary gearbox, control knob, or an Acme screw linear actuator. The rotary MDrive Speed Control is also available in three different stack lengths: 13, 15 and 19 for the MD17 and 18, 22 & 31 for the MD23. Interface connections are accomplished using either a 7 position terminal block or optional 12" (30.5cm) flying leads.

Speed Control Interface

The IMS Speed Control Interface Software is accessed through the IMS SPI Interface which is easy to install and use graphical user interface (GUI) for configuring the MDrive from the parallel/SPI port on your computer. It is required for configuring your MDrive Speed Control and is included on a CD with the product, or it may be downloaded at www.imshome.com.

The IMS Speed Control Interface Software features include:

- Easy installation.
- Automatic communication configuration.
- Will not set out-of-range values.
- Tool-tips display valid range setting for each option.
- Ease of use via single screen interface.

Features and Benefits of the MDrive Speed Control

- Integrated Speed Control, Driver and NEMA17 or 23 Motor
- +12 to +48 (MDO17 and MDO23-4) or +24 to +75 VDC (MDO23-7) Input Voltage
- Digital Oscillator for Accurate Speed Control
- Low Cost
- Extremely Compact
- Available Configurations:
 - Single Shaft*
 - Planetary Gearbox*
 - Linear Actuator
 - Factory-Mounted Optical Encoder*
 - Double Shaft End with Knob For Manual Positioning*
- Available in Three Stack Sizes*
- Electronically Configurable (Eliminates Potentiometers):
 - Motor Run/Hold Current
 - Acceleration/Deceleration
 - Initial and Max Velocity
 - Microstep Resolution to 256 Microsteps/Step
- 2 Modes of Operation: Bidirectional or Unidirectional
- 0 to +5 VDC, 4 - 20mA, 0 - 20mA or 15 - 25kHz PWM Speed Control Input with programmable center point
- Single Supply
- Interface Uses Pluggable Terminal Strip or Optional 12" (30.5 cm) Flying Leads
- Graphical User Interface (GUI) for Quick and Easy Parameter Setup

*Rotary Motor Only

SECTION 1.2

Interfacing The Microstepping MDrive

Section Overview

This section will acquaint the user with connecting and using the microstepping MDrive products. If your MDrive is equipped with a factory mounted encoder, also refer to Section 1.3: Interfacing an Encoder. Covered in this section are:

- Layout and Interface Guidelines
- Interfacing Power and Logic Inputs (Connector P1)
- Interfacing the SPI Interface (Connector P2)

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 AC ground. 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 driver 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.

Recommended Wiring

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

Recommended Wire Size

Logic Wiring	22 AWG
Power and Ground	See Appendix A "Recommended Cable Configurations"

General Practices

The following wire strip length is recommended:

Wire Strip Length	0.250" (6.0 mm)
-------------------------	-----------------

NOTE: Wire and insulation type are subject to the user's application and environment.



WARNING! DO NOT connect or disconnect power leads when power is applied! Disconnect the AC power side to power down the DC power supply. For battery operated systems, connect a "transient suppressor" across the power switch to prevent arcs and high voltage spikes.



WARNING! See Part II for power supply requirements for the MDrive17, Part III for the MDrive23.

Interfacing Power and Logic Inputs (Connector P1)

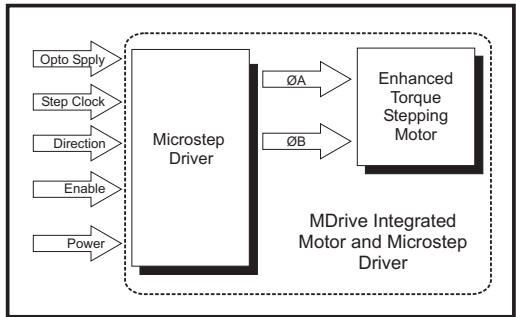


Figure 1.2.1: Microstepping MDrive Block Diagram

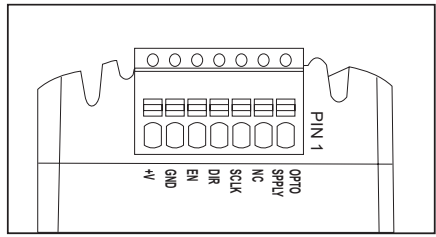


Figure 1.2.2: Connector P1 Pin Configuration for the Microstepping MDrive

MDrive Connector P1 Configuration			
Pin #	Flying Lead	Wire Size	Function and Description
1	White	AWG 22	+5 VDC Optocoupler Supply: This input is used to supply power to the isolated logic inputs. A higher voltage may be used but care must be taken to limit the current through the Optocoupler.
2	---	AWG 22	Not Connected
3	Orange	AWG 22	Step Clock: A positive going edge on this input advances the motor one increment. The size of the increment is dependant on the Microstep Resolution Setting.
4	Blue	AWG 22	CW/CCW Direction Input: This input changes the direction of the motor logic. A HIGH state (open) = Clockwise.
5	Brown	AWG 22	Enable Input: The input enables or disables the output section of the driver. A logic HIGH (open) enables the outputs. However, this input does not inhibit the Step Clock. The outputs will update by the number of clock pulses (if any) applied while the driver was disabled.
6	Black	AWG 20*	Power Ground
7	Red	AWG 20*	+V: +12 to +48 VDC (MD17, MD23-4) / +24 to +75 VDC (MD23-7)

* For supplies 10 feet or less.

Table 1.2.1: P1 Pin Descriptions for the Microstepping MDrive

Interfacing the MDrive Logic Inputs

Logic Input Electrical Specifications

MDrive Logic Input Electrical					
Specification	Test Conditon	Min	Typ	Max	Unit
Input Foward Current	Step Clock and Direction		7.0	15	mA
Input Forward Voltage	Step Clock and Direction		1.4	1.7	V
Input Forward Current	Enable		5.0	9.4	mA
Input Forward Voltage	Enable		1.1	1.4	V
Input Reverse Breakdown Voltage	Isolated Inputs	5			V

Table 1.2.2: Microstepping MDrive Logic Input Electrical Characteristics

Optically Isolated Logic Inputs

The MDrive has 3 optically isolated logic inputs which are located on connector P1. These inputs are isolated to minimize or eliminate electrical noise coupled onto the drive control signals. Each input is internally pulled-up to the level of the optocoupler supply and may be connected to sinking outputs on a controller such as the IMS LYNX or a PLC. These inputs are:

- 1) Step Clock (P1:3)
- 2) Direction (P1:4)
- 3) Enable (P1:5)

Of these inputs only step clock and direction are required to operate the MDrive.

The schematic below illustrates the inputs.

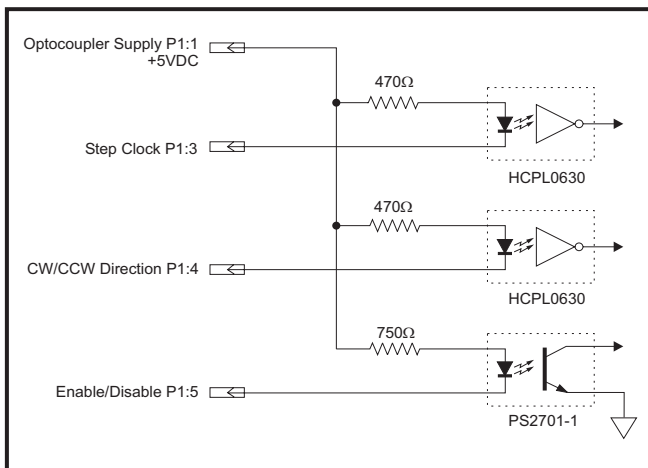


Figure 1.2.3: Optocoupler Inputs

Powering the Optocouplers

In order to maintain isolation, the optocouplers must be powered by an external power supply connected to P1:1, with the opto supply ground connected to the ground of the input control circuitry. The logic inputs are internally limited to allow for a +5VDC power supply.

A power supply in excess of +5 volts may be used, however a current limiting resistor **MUST** be placed in series with the input to limit the input forward current to the recommended 7 milliamps. At no time can the input forward current exceed 15 milliamps or damage may occur to the driver portion of the MDrive.

Isolated Logic Input Characteristics

Step Clock (P1:3)

The step clock input is where the motion clock from your control circuitry will be connected. The motor will advance one microstep in the plus or minus direction (based upon the state of the direction input) on the rising edge of each clock pulse. The size of this increment or decrement will depend on the microstep resolution setting.

Direction (P1:4)

The direction input controls the CW/CCW direction of the motor. A logic HIGH (default, unconnected) will cause the motor to rotate in the CW direction (seen while looking at the face of the motor). A logic LOW on the input will cause the motor to rotate in the CCW direction. This input is synchronized to the positive going edge of the Step Clock input.

Enable (P1:5)

This input can be used to enable or disable the driver output circuitry. When in a logic HIGH (default, unconnected) state the driver outputs will be enabled and step clock pulses will cause the motor to advance. When this input is pulled LOW, by means of a switch or sinking output, the driver output circuitry will be disabled. Please note that the internal sine/cosine position generator will continue to increment or decrement as long as step clock pulses are being received by the MDrive.

This input is asynchronous to any other input and may be changed at any time.



WARNING! The isolated logic inputs on the MDrive are internally limited to allow for an optocoupler supply voltage of +5 VDC. If using a higher voltage supply, a current limiting resistor must be placed in series with the input or damage will occur to the MDrive's input circuitry, rendering the drive inoperable.

Input Timing

The direction input and the microstep resolution inputs are internally synchronized to the positive going edge of the step clock input. When a step clock pulse goes HIGH, the state of the direction input and microstep resolution settings are latched. Any changes made to the direction and/or microstep resolution will occur on the rising edge of the step clock pulse following this change.

Run and Hold Current changes are updated immediately.

The table below lists the timing specifications.

MDrive Logic Input Timing		
Specification	Input	Time
Minimum Pulse Width	Step Clock	400 nS
Max. Frequency	Step Clock	2.0 MHz

Table 1.2.3: Logic Input Timing

Interface Options

Open Collector Interface

The figure below shows an open collector interface connected to the direction input (P1:3). This interface method may be used with any of the logic inputs. Remember that a current limiting resistor must be used in series with the input if an opto supply voltage greater than +5 volts is used. Refer to next table for resistor values.

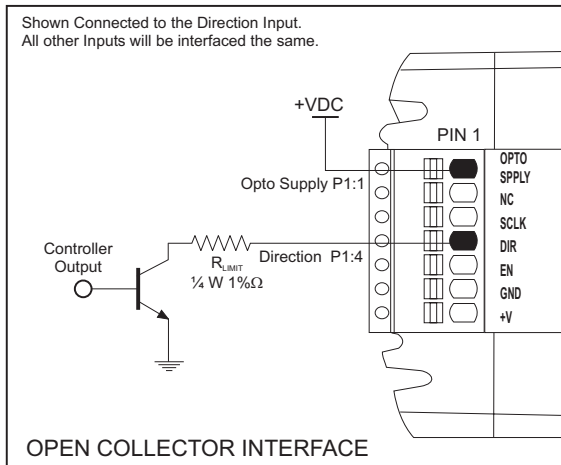


Figure 1.2.4: Open Collector Interface

TTL Interface

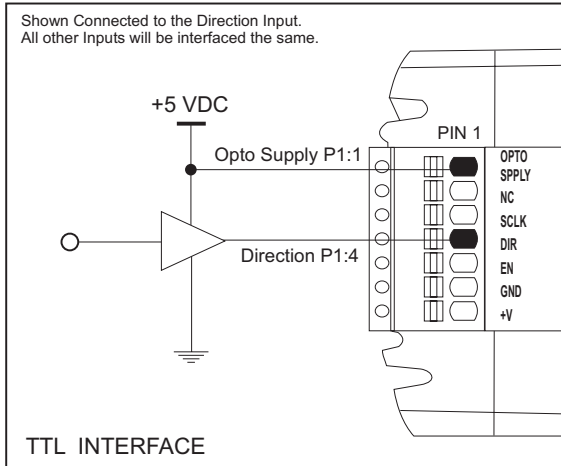


Figure 1.2.5: TTL Interface

Switch Interface

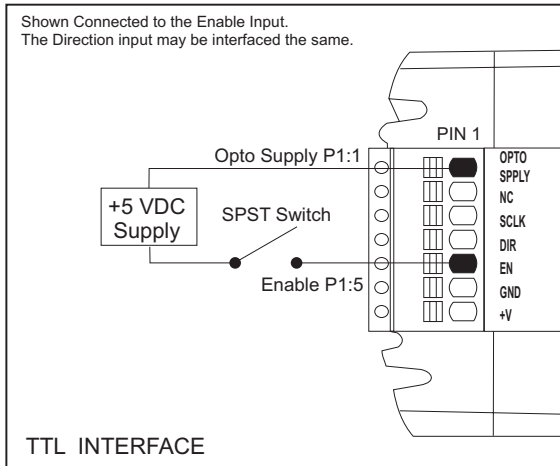


Figure 1.2.6: Switch Interface

Isolated Input Current Limiting Resistors		
Opto Supply (+VDC)	Resistor Value (Ohms 5%)	Resistor Value (Ohms 1%)
5	-	-
10	680	681
12	1000	1000
15	1300	1300
24	2700	2670

Table 1.2.4: Recommended Input Current Limiting Resistor Values

Interfacing the MDrive SPI Interface (Connector P2)

The MDrive’s SPI communications connector is a 10 pin IDC header. The recommended means of connecting to the header is with the 6 foot (1.8m) Parameter Setup Cable MD-CC100-000.

The setup cable eliminates the need for the user to wire communications to the MDrive. In addition to offering ease of connection, this cable features a built-in logic level shifter for PC’s that run on 3.3V output ports. This cable plugs in easily to connect a standard DB-25 PC Parallel/SPI port to the MDrive’s 10 pin pin-header (P2).

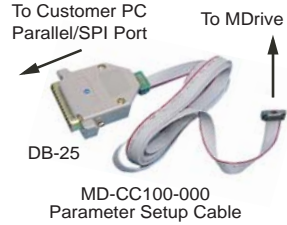


Figure 1.2.7: Parameter Setup Cable for MDrive 17/23

MDrive Connector P2 (SPI Interface)			
Pin #	Pin Name	Wire Size	Description
1	N/C		No Connect
2	N/C		No Connect
3	N/C		No Connect
4	\overline{CS}	AWG 22	Chip Select
5	GND	AWG 22	Communications Ground
6	+5 VDC	AWG 22	+5 VDC Output (See Warning Below)
7	MOSI	AWG 22	Master Out/Slave In
8	CLK	AWG 22	Clock
9	N/C		No Connect
10	MISO	AWG 22	Master In/Slave Out

Table 1.2.5: P2 Pin Assignment and Description



WARNING! The +5VDC output on connector P2 is used for the setup cable **ONLY!** This output is not designed to power external devices!



WARNING! The Parallel/SPI Port on your PC must be set to one of the following:
 ■ output only ■ bi-directional ■ EPP (Extended Parallel Port)

Try the SPI connection using the default parallel port setting first. If necessary, the Parallel/SPI port may be configured in the bios of your PC.

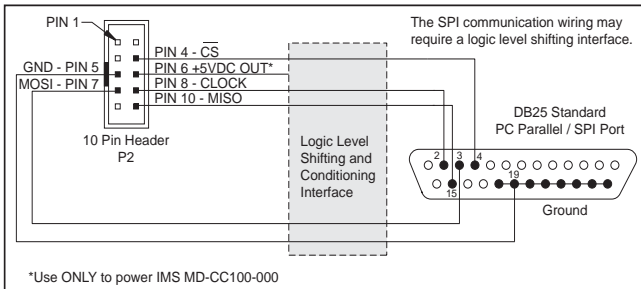


Figure 1.2.8: SPI Interface Wiring and Connections

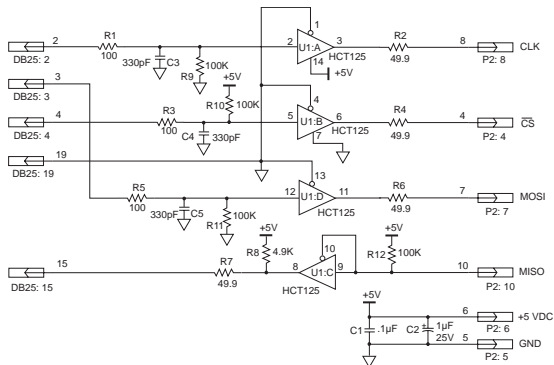


Figure 1.2.9: SPI Logic Level Shifting and Conditioning Schematic

N **NOTE:** If making your own parameter setup cable, be advised the 3.3V output parallel ports on some laptop PC's may not be sufficient to communicate with the device without use of a logic level shifting and conditioning Interface.

Minimum Required Connections

The connections shown below are the minimum required to operate the Microstepping MDrive.

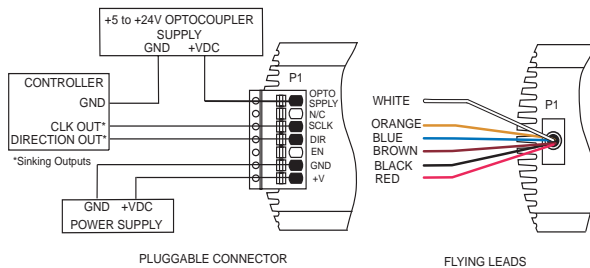


Figure 1.2.10: Minimum Required Connections

Securing MDrive Power, Logic and Encoder Leads

Some applications may require that the MDrive move with the axis motion. If this is a requirement of your application, the motor leads (pluggable or flying) and the Optional Encoder leads (if equipped) must be properly anchored. This will prevent flexing and tugging which can cause damage at critical connection points in the MDrive electronics and the Encoder. **DO NOT** bundle the Logic Leads or Optional Encoder Leads with the MDrive17/23 Power Leads.

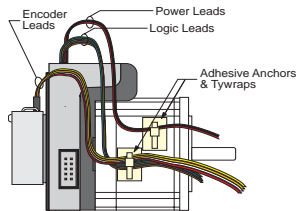


Figure 1.2.11: Typical MDrive with Power Leads, Data Leads and Optional Encoder Leads Secured

SECTION 1.3

Interfacing An Encoder

Section Overview

This section will cover interfacing the Factory Mounted Encoder version of the Microstepping MDrive17/23. Included are the pin configurations for both the single-end and differential models and the recommended cables and connectors.

Factory-Mounted Encoder

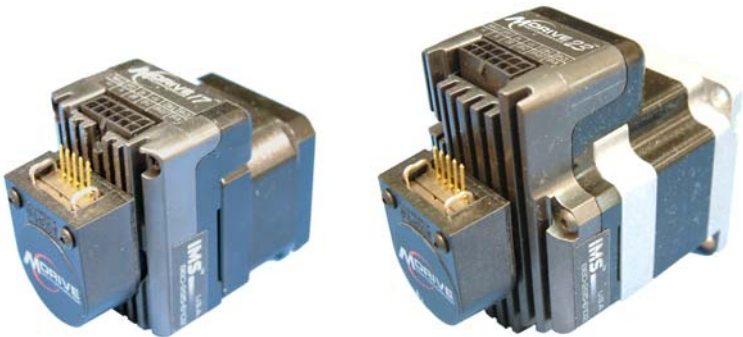
The MDrive17 and MDrive23 are available with a factory-mounted optical encoder. Available line counts are:

- 100
- 200
- 250
- 400
- 500
- 1000
- 2000 (MDrive23 Only)

Encoders are available in both single-end and differential configurations. All encoders, except the 1000 line encoder, have an index mark.

Use of the encoder feedback feature of this product requires a controller such as an IMS LYNX or PLC.

The encoder has a 100kHz maximum output frequency.



General Specifications

	Min	Typ	Max	Units
Supply Voltage (VDC)	-0.5		7	Volts
Supply Current	30	57	85	mA
Output Voltage	-0.5		Vcc	Volts
Output Current (Per Channel)	-1.0		5	mA
Maximum Frequency				100kHz
Inertia	0.565 g-cm ²	(8.0 x 10 ⁻⁶ oz-in-sec ²)		
Temperature				
Operating			-40 to +100° C	
Storage			-40 to +100° C	
Humidity			90% (noncondensing)	

N NOTE: The 2000 Line Encoder is only available on the MDrive23.

Pin Configuration

Single-End Encoder

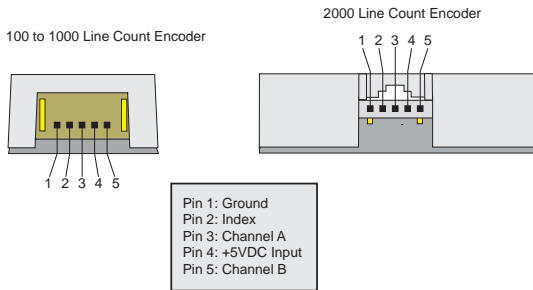


Figure 1.3.1: Single-End Encoder Pin Configuration

Differential Encoder

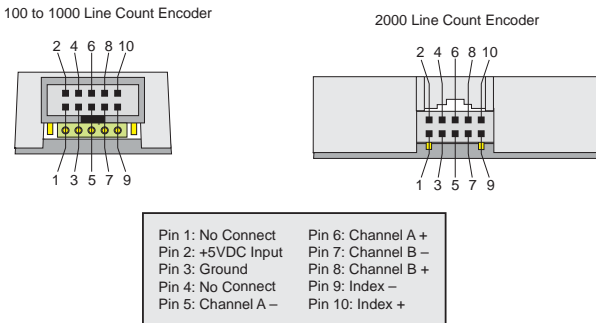


Figure 1.3.2: Differential Encoder Pin Configuration

Encoder Signals

Single-End Encoder

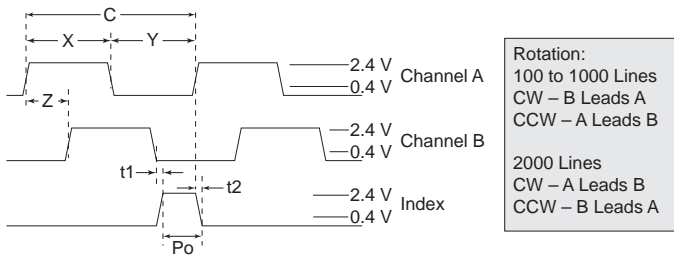


Figure 1.3.3: Single-End Encoder Signal Timing

Differential Encoder

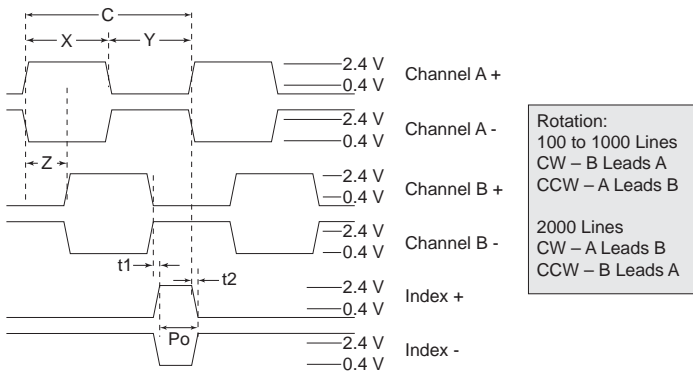


Figure 1.3.4: Differential Encoder Signal Timing

Note: Rotation is as viewed from the cover side.

- (C)** One Cycle: 360 electrical degrees ($^{\circ}e$)
- (X/Y)** Symmetry: A measure of the relationship between X and Y, nominally $180^{\circ}e$.
- (Z)** Quadrature: The phase lag or lead between channels A and B, nominally $90^{\circ}e$.
- (Po)** Index Pulse Width: Nominally $90^{\circ}e$.

Characteristics

Parameter	Symbol	Min	Typ	Max	Units
Cycle Error		3	5.5		$^{\circ}e$
Symmetry		130	180	230	$^{\circ}e$
Quadrature		40	90	140	$^{\circ}e$
Index Pulse Width	Po	60	90	120	$^{\circ}e$
Index Rise After CH B or CH A fall	t1	-300	100	250	ns
Index Fall After CH A or CH B rise	t2	70	150	1000	ns

Over recommended operating range. Values are for worst error over a full rotation.

Encoder Profiles

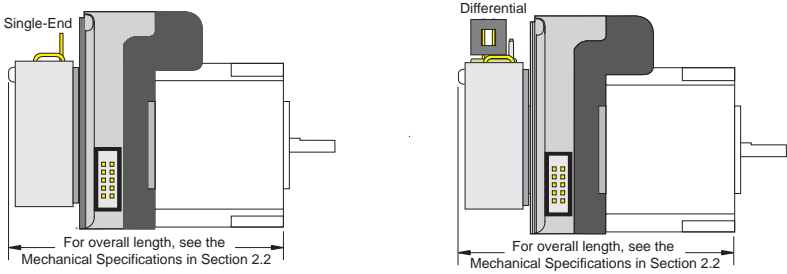


Figure 1.3.5: MDrive17 with Encoder; Side Profile

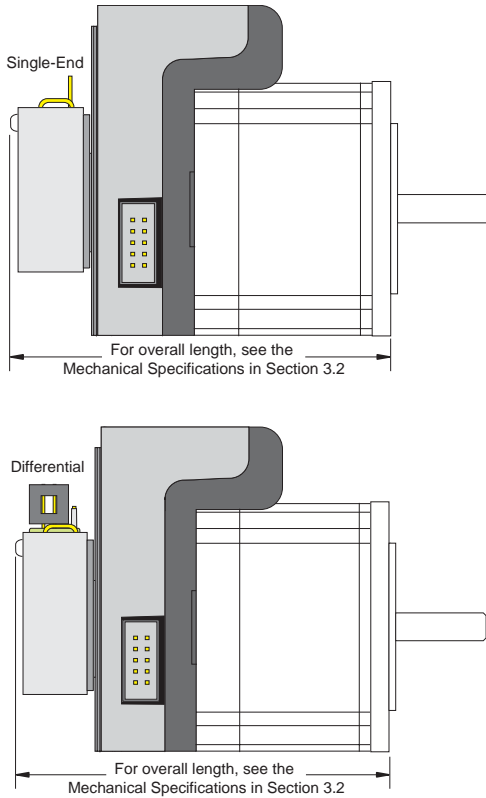


Figure 1.3.6: MDrive23 with 100-1000 Line Encoder; Side Profile

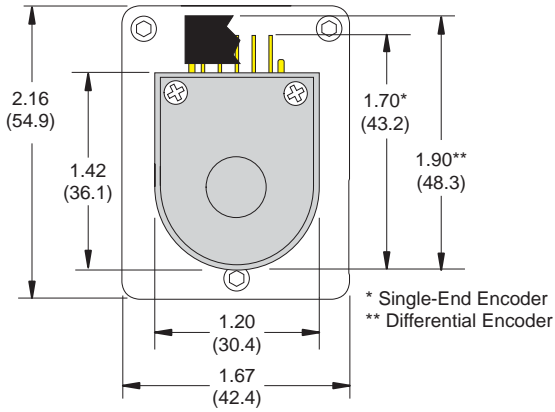


Figure 1.3.7: MDrive17 with Encoder, Rear View

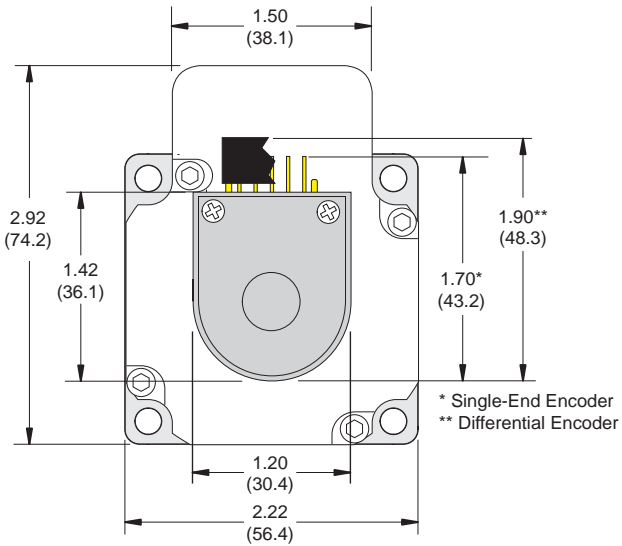


Figure 1.3.8 MDrive23 with Encoder, Rear View

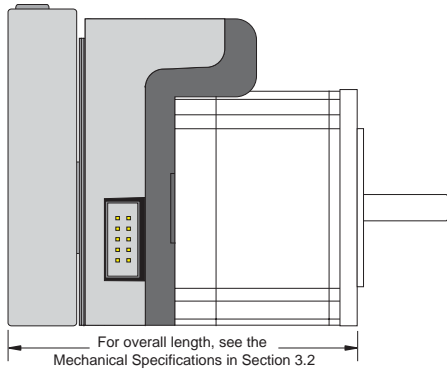


Figure 1.3.9: MDrive23 with 2000 Line Encoder, Side Profile

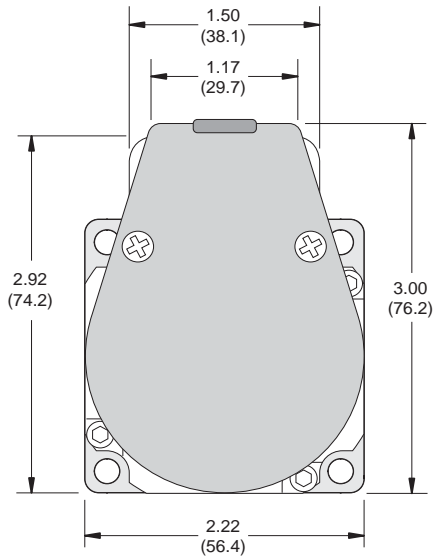


Figure 1.3.10: MDrive23 with 2000 Line Encoder, Rear Profile



NOTE: The 2000 Line Encoder is only available on the MDrive23.

Encoder Cables

IMS offers assembled cables for both the Single-End and Differential Encoders. The IMS Part Numbers are listed below.

100 to 1000 Line Encoders:

Single-End Encoder Cable (12" leads)	ES-CABLE-2
Differential Encoder Cable (36" leads)	ED-CABLE-2

2000 Line Encoders:

Single-End Encoder Cable (12" leads)	ES-CABLE-6
Differential Encoder Cable (36" leads)	ED-CABLE-6

Recommended Encoder Mating Connectors

IMS recommends the following mating connectors (or equivalent) if you make your own cables.

Single-End Encoder

100 to 1000 Line:

AMP 5 Pin Connector Shell	1-87175-2
Pins* (5 required) AMP Part Number	87165-1
*For AWG 22 to 28 wires.	

AMP MTA 0.1 IDC Loaded Connector

AWG 22 (Red)	640440-5
AWG 24 (Natural)	640441-5
AWG 26 (Blue)	640442-5
AWG 28 (Green)	640443-5

2000 Line:

MOLEX Finger Latch Polarized with 5 Pins

AWG 22	14-56-7052
AWG 24	14-60-0052
AWG 26	14-60-0054
AWG 28	14.60-0056

Differential Encoder

100 to 1000 Line:

AMP Connector with 10 Preloaded IDC Pins*	102694-3
Shell with Polarizing Key	102537-3
Back Cover	102536-3

AMP 10 Pin IDC Ribbon Cable Connector	499997-1
3M 28 AWG x 0.5 x 10 Conductor Ribbon Cable	3365/10

2000 Line:

MOLEX Finger Latch Connector Shell	15-04-5104
Two (2) IDC 5 Pin* Inserts MOLEX Part Number	14-60-0058
*For AWG 22 to 28 wires.	

SECTION 1.4

Configuring The Microstepping MDrive

Section Overview

This section applies to all MDrive17 and MDrive23 Microstepping versions-MDMF (flying leads), MDMP (pluggable leads) and MDMC (C connector). This section will acquaint the user with the following:

- The IMS Motor Interface
- Installing the IMS SPI Interface
- The IMS Motor Interface Configuration Utility
- Configuration Parameters

The IMS Motor Interface Software

The IMS Motor Interface Software is accessed through the IMS SPI Interface which is an easy to install and use software program. Use of this utility and the optional 6 foot MD-CC100-000 Parameter Setup Cable is the suggested method of configuring the MDrive17 and MDrive23. The SPI Interface is included on the CD that ships with the MDrive or is available for download at www.imshome.com. This utility features the following:

- Easy installation.
- Ease of use via single screen interface.
- Automatic communication configuration.
- Will not allow out-of-range values to be set.
- Tool-tips display valid range settings for each option.

Installing the IMS SPI Interface Software

NOTE: IMS recommends that you install the latest version of the SPI Interface which is backward compatible and ensures compatibility with the latest MDrives.

System Requirements

- A Pentium Class or Higher IBM Compatible PC.
- Windows 9x (95/98) or Windows NT (Windows NT4.0 SP6, Windows 2000 SP1, Windows XP).
- 10 MB hard drive space.
- A free parallel communications port.

Installation

Insert the IMS Product CD into your CD-ROM Drive. The CD should autostart to the IMS Main Index Page. If the CD does not autostart, click “Start > Run” and type “x:\IMS.exe” in the “Open” box and click OK.

NOTE: “x” is your CD ROM drive letter.

- 1) After the CD starts, the IMS Main Index Page will be displayed.



Figure 1.4.1: The IMS CD Main Index Page

- 2) Place your mouse pointer over the MDrive Icon. The icon will be highlighted and the text message "MDrive Integrated Motor & Electronics" will be displayed. This verifies you have selected the correct software.
- 3) Click the MDrive Motor Icon. This opens the MDrive Software Selection Page.



Figure 1.4.2: The IMS CD Software Selection Page

- 4) Place the mouse pointer over the menu and select SPI Interface (Win9x) or SPI Interface (WinNT). The displayed text will again verify your selection. Click your selection and the "Setup" dialog box will be displayed.

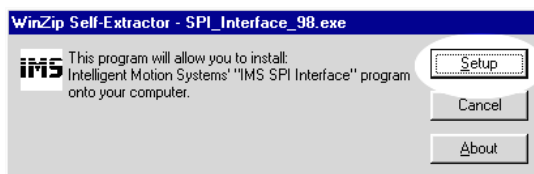


Figure 1.4.3: The SPI Setup Dialog Box

- 5) Click SETUP in the Setup dialog box and follow the on-screen instructions.

Once the SPI Interface is installed and started the Communications Settings will be set automatically.

Startup

Select “Start>Programs>IMS SPI Interface>IMS SPI Interface”. The configuration utility will automatically scan your LPT ports for the connected MDrive and configure the communications. The connection status and port are displayed at the bottom of the configuration screen. The Version Number of the Firmware in your MDrive will also be displayed at the top of the configuration utility as shown below.

The IMS Motor Interface GUI Configuration Utility

The IMS Motor Interface GUI (Graphical User Interface) simplifies use with a single screen interface for configuring the MDrive17 and MDrive23. All of the parameters and commands are controlled from this single screen.

There are three versions of MDrive.

MDMF - MDrive Microstepping with Flying Leads

MDMP - MDrive Microstepping with a Pluggable Connector

MDMC - MDrive Microstepping with “C” Connector

GUI for Flying Leads or Pluggable Connector

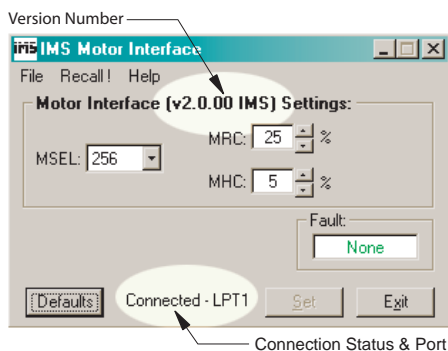


Figure 1.4.4: Typical MDMF, MDMP GUI

Your GUI may appear slightly different than the example shown above due to different versions of MDrive Firmware. The Firmware is not upgradable but the IMS Motor Interface will configure itself to your current Firmware version. The Version Number will be displayed as indicated above.

The Factory Default settings are shown in the figure above and the following figure. These settings may be changed to suit the user’s application.

GUI for “C” Connector

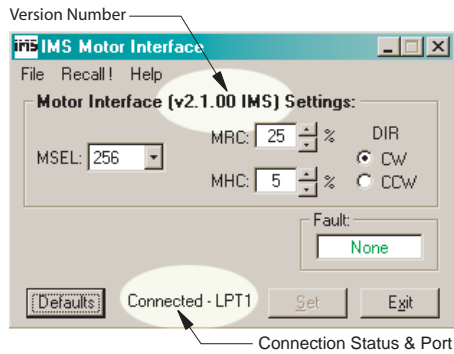


Figure 1.4.5: Typical MDMC GUI

NOTE: The following functions are applicable to all GUI versions.

Changing Parameters

When a Parameter is changed, the font color will change to blue and the “Set” button will be activated. The change will not take place until Set is clicked.

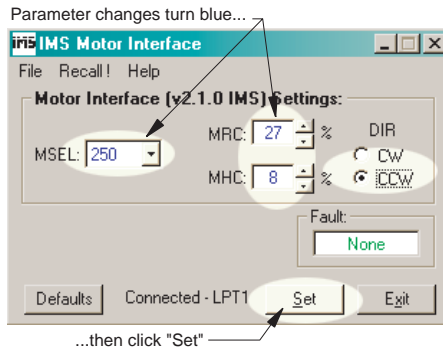


Figure 1.4.6: Changing the Parameter Settings

Illegal Parameters/Tool Tips

If an illegal parameter is entered it will be displayed in red. By placing the mouse pointer over the parameter the “Tool Tips” dialog will be displayed. The range for that parameter will be shown in the dialog box.

NOTE: The Tool Tips are always functional.

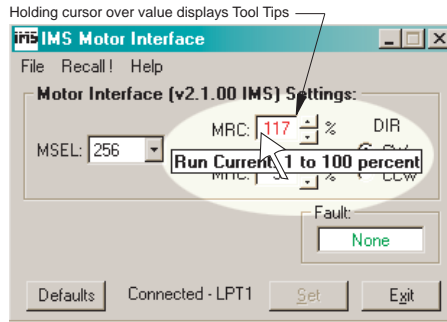


Figure 1.4.7: Illegal Parameters/Tool Tips

Returning to Factory Defaults

To return to the Factory Defaults, click the “Default” button and the “Set” button. The Factory Defaults will be restored.

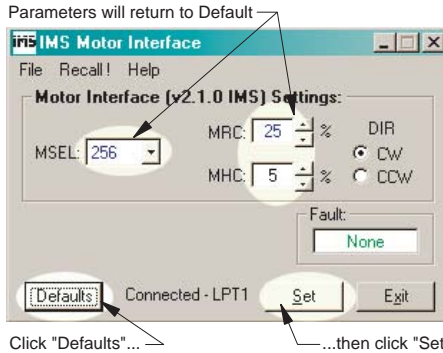


Figure 1.4.8: Returning to Factory Defaults

If a fault occurs it will be displayed in the Fault window. If more than one fault occurs each one will be displayed with the + (plus sign) between them. The Table below lists the faults and the characters displayed for each.

Fault Table		
Binary Code*	Display	Fault Condition
0	None	No Fault
4	CS	SPI Write to Settings Check Sum
8	CS	SPI Write to Defaults Check Sum
16	DFLT	Defaults Check Sum
32	DATA	EEPROM Check Sum Fault

*NOTE: All fault codes are "OR"ed together.

Table 1.4.1: Fault Indication

Description of the Faults

NONE

No Faults exist in the MDrive

CS - SPI Write Check Sum

Check Sum indicates an error or problem with the last transmission of data to the MDrive. A RECALL will clear the fault and the screen will display the stored parameters.

DFLT & DATA

These faults indicate a Driver failure. Contact the factory.

Configuration Parameters

There are 4 configuration parameters for the MDrive. Please note that the motor Direction Override (DIR) is only available on MDrive Microstepping "C" Connector versions. Parameter settings are automatically saved to memory when the "SET" button is clicked on the IMS Motor Interface screen. These parameters may all be changed on-the-fly.

The Table below summarizes the parameters and their function, range, units and default setting.

MDrive Setup Parameters				
NAME	FUNCTION	RANGE	UNITS	DEFAULT
MHC	Hold Current	0 to 100	percent	5
MRC	Run Current	1 to 100	percent	25
MSEL	Microstep Resolution	2, 4, 5, 8, 10, 16, 25, 32, 50, 64, 125, 128, 250, 256	μsteps per step	256
DIR*	Motor Direction Override	0/1	—	CW

*NOTE: The Motor Direction Override is only available on MDrive Microstepping "C" Connector versions.

Table 1.4.2: Setup Parameters

Motor Holding Current (MHC)

The MHC parameter sets the motor holding current as a percentage of the full output current of the driver. If the hold current is set to 0, the output circuitry of the driver section will disable when the hold current setting becomes active.

The hold current setting becomes active 200ms following the last clock pulse.

Motor Run Current (MRC)

The Motor Run Current (MRC) parameter sets the motor run current to a percentage of the full output current of the MDrive driver section.

Microstep Resolution Select (MSEL)

The MSEL parameter specifies the microstep resolution of the MDrive. See the following Table for valid MSEL parameter settings.

Motor Direction Override (DIR)

The DIR motor Direction Override parameter changes the motor direction relative to the direction input signal, adapting the direction of the MDrive to operate as your system expects.

Microselect Values

Microstep Resolution Settings (MSEL)			
Binary Microstep Resolution Settings		Decimal Microstep Resolution Settings	
MSEL=	Steps/Rev	MSEL=	Steps/Rev
2	400	5	1,000
4	800	10	2,000
8	1,600	25	5,000
16	3,200	50	10,000
32	6,400	125	25,000
64	12,800	250	50,000
128	25,600		
256	51,200		

Table 1.4.3: Microstep Resolution Settings

Configuring the MDrive With User Defined SPI

The MDrive may be configured and operated through the end user's SPI interface without using the previously discussed IMS Motor Interface GUI and the optional Parameter Setup Cable (see the beginning of this section).

If the optional cable is not being used you will need to make one using the diagram (SPI Interface Wiring and Connections) shown in Section 1.2 of this document for all MDrive Microstepping with Flying Leads and MDrive Microstepping with Pluggable Connector. The SPI connections diagram for MDrive Microstepping with "C" Connector can be found in Section 1.6.

Timing Notes

- 1) MSb (most significant bit) and MSB (most significant byte) first
- 2) 8 bit bytes
- 3) 25kHz SCK
- 4) Data In (MOSI) on rising clock
- 5) Data Out (MISO) on falling clock

SPI Commands

SPI Commands and Parameters				
	CMD/PRM	HEX	RANGE	NOTES
SPI Commands	READ ALL	0x40	—	Reads the hex value of all parameters
	WRITE ALL	0x80	—	Writes the hex value to the following parameters
Data READ	"M"	0x4D	—	M Character precedes every READ
	Version_MSB	0x10	<1-8><0-9>	Firmware Version Subversion, eg 1.0
	Version_LSB	0x00	<0-99>	Firmware Version Appends to Version mSB, eg .00
	USR_ID1	0x49	—	Upper Case Letter < I >
	USR_ID2	0x4D	—	Upper Case Letter < M >
	USR_ID2	0x53	—	Upper Case Letter < S >
	MRC	0x19	1-100%	Motor Run Current
	MHC	0x05	0-100%	Motor Hold Current
	MSEL	0x00	0*, 2-250	Microstep Resolution
	DIR**	0x00	0/1	1 Complements Hardware Direction
	DFLT_MRC	0x19	1-100%	Default Motor Run Current
	DFLT_MHC	0x05	0-100%	Default Motor Hold Current
	DFLT_MSEL	0x00	0*, 2-250	Default Microstep Resolution
	DFLT_DIR**	0x00	0/1	Default Direction Override
FAULT	0x00	—	(See Fault Table)	
DATA WRITE	MRC	0x19	1-100%	Motor Run Current
	MHC	0x05	0-100%	Motor Hold Current
	MSEL	0x00	0*, 2-250	Microstep Resolution
	DIR**	0x00	0/1	1 Complements Hardware Direction
	CKSUM	0x62	—	2s Complement of all WRITES including Command
<p>NOTE: The READ and WRITE commands in shaded areas apply only to Firmware Versions <2.0.00, All of the Commands apply to Firmware Versions ≥ 2.0.00, <3.00.00. *Zero (0) = 256 Microsteps Resolution ** The Direction Override (DIR) is only available on MDrive Microstepping with "C" Connector.</p>				

Table 1.4.4: SPI Command Summary



WARNING! The Parallel/SPI Port on your PC must be set to one of the following:
 ■ output only ■ bi-directional ■ EPP (Extended Parallel Port)

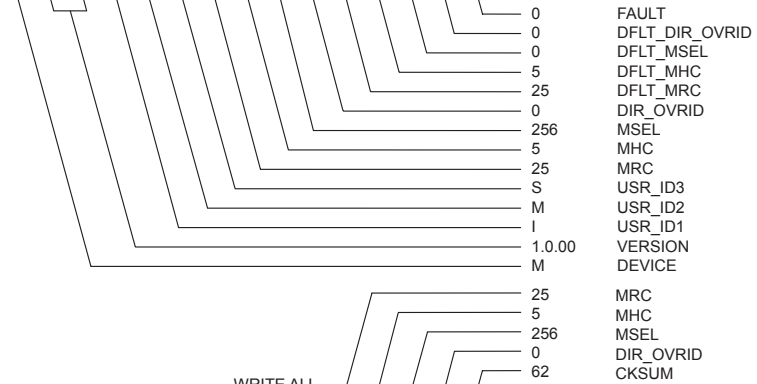
Try the SPI connection using the default parallel port setting first. If necessary, the Parallel/SPI port may be configured in the bios of your PC.

SPI Read/Write Example

READ ALL

MOSI: 40 FF FF FF FF FF FF FF FF FF FF FF FF FF FF

MISO: XX 4D 10 00 49 4D 53 19 05 00 00 19 05 00 00 00



WRITE ALL

MOSI: 80 19 05 00 00 62

MISO: XX FF FF FF FF FF

Figure 1.4.9: SPI Read/Write

Check Sum Calculation for SPI

The values in the example above are 8-bit binary hexadecimal conversions for the following SPI parameters: MRC=25%, MHC=5%, MSEL=256.

The Check Sum is calculated as follows:

80+19+05+00+00
 Sum = 9E 1001 1110
 1's complement = 51 0110 0001
 2's complement = 62 0110 0010
 Send the check sum value of 62

Note: 80 is always the first command on a write.
 Note: Once a write is performed, a read needs to be performed to see if there is a fault. The fault is the last byte of the read.

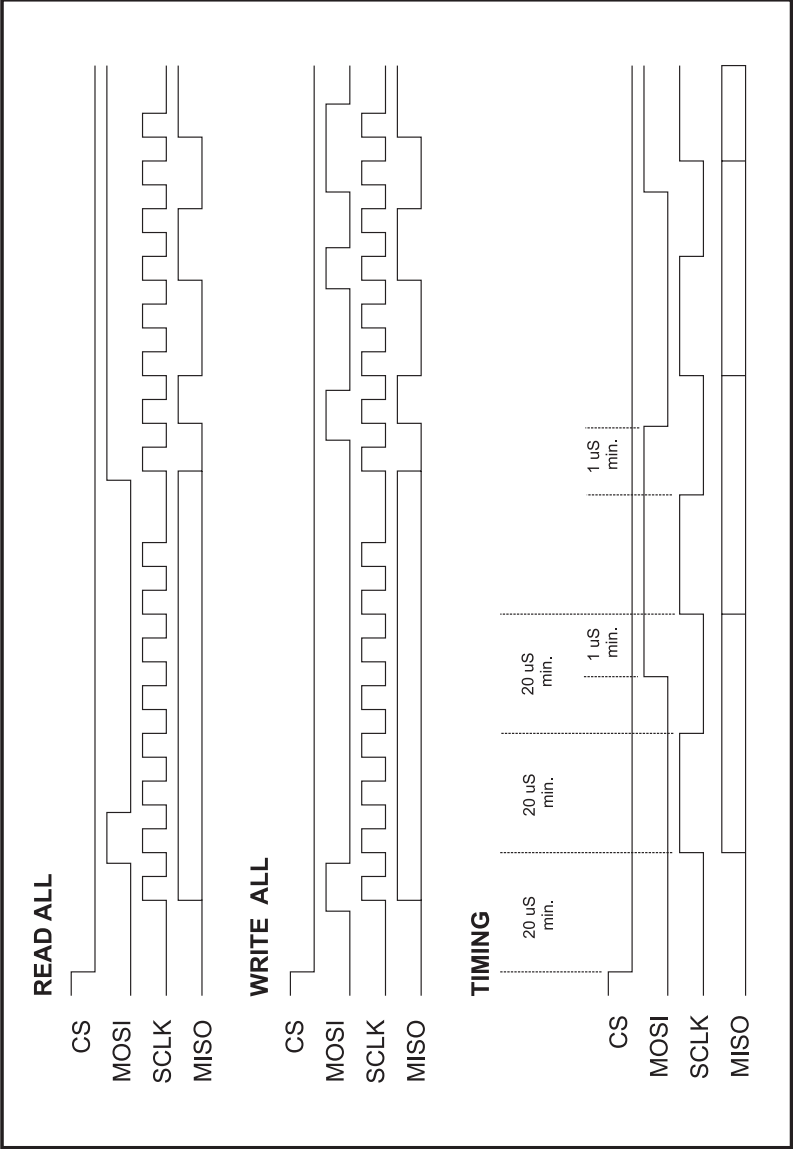


Figure 1.4.10: SPI Waveforms & Timing Diagram

SECTION 1.5

Interfacing The MDrive Speed Control

Section Overview

This section covers the hardware interface of the MDrive versions with integrated speed control electronics. Refer to Section 1.6 for Parameter setup and configuration. Covered in the section are:

- Layout and Interface Guidelines
- Interfacing Power and Speed Control Inputs (Connector P1)
- Interfacing the SPI Interface (Connector P2)

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

Recommended Wiring

The following wiring/cablings is recommended for use with the MDrive:

Recommended Wire Size

Logic Wiring	22 AWG
Power and Ground	See Appendix A “Recommended Cable Configurations”

General Practices

The following wire strip length is recommended:

Wire Strip Length	0.250” (6.0 mm)
-------------------------	-----------------

NOTE: Wire and insulation type are subject to the user's application and environment.



WARNING! DO NOT connect or disconnect power leads when power is applied! Disconnect the AC power side to power down the DC power supply. For battery operated systems, connect a “transient suppressor” across the power switch to prevent arcs and high voltage spikes.



WARNING! See Part II for power supply requirements for the MDrive17, Part III for the MDrive23.

Interfacing Power and Speed Control Inputs (Connector P1)

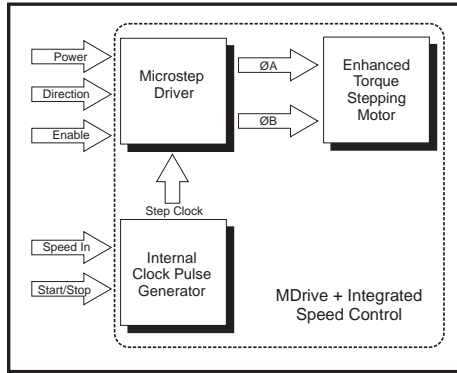


Figure 1.5.1: MDrive Speed Control Block Diagram

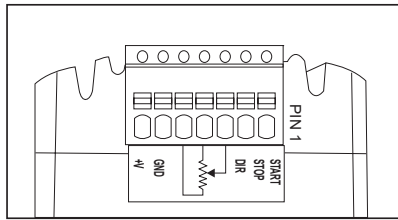


Figure 1.5.2: P1 Pin Configuration for the MDrive Speed Control

MDrive Speed Control Connector P1 Configuration			
Pin #	Flying Lead	Wire Size	Function and Description
1	Violet	AWG 22	Stop/Start Input: This input will start the internal pulse generator when pulled LOW by means of a switch or sinking input. It is internally pulled up to +5 VDC.
2	Blue	AWG 22	CW/CCW Direction Input: This input is used to change the direction of the motor. In unidirectional mode a logic HIGH (open) equals CW.
3	Green	AWG 22	Speed Control Input: Volts = 0 to +5 VDC or PWM 4 - 20 mA = 4 - 20 mA Input 0 - 20 mA = 0 - 20 mA Input
4	Yellow	AWG 22	+5 VDC Output: This output is not to be used to power external devices.
5	Gray	AWG 22	Logic Ground
6	Black	AWG 20*	Power Ground
7	Red	AWG 20*	+V: +12 to 48 VDC (MD17 & MD23-4) + 24 to 75 VDC (MD23-7)

* For supplies 10 feet or less.

Table 1.5.1: P1 Pin Description for the MDrive Speed Control

Interfacing the MDrive Speed Control Inputs

The MDrive has 2 logic inputs which are located on connector P1. These inputs control the ON/OFF state of the internal clock pulse generator and the direction of motor rotation. Each input is internally pulled-up to +5 Volts and may be connected to sinking outputs on a controller such as the IMS LYNX or a PLC. These inputs are:

- 1] Start/Stop (P1:1)
- 2] Direction (P1:2)

There are also three connections for a Joystick or a Potentiometer. These are:

- 1] Speed Control Input (P1:3)
- 2] +5V Output (P1:3)
- 3] Logic Ground (P1:3)

The Speed Control input may also be interfaced to a PLC 15 - 25 kHz PWM output or a 4 - 20mA or 0 - 20mA output analog device. If a 4 - 20mA or 0 - 20mA device is used, the corresponding input mode **MUST** be selected on the Analog Speed Control Interface software.

The two figures below illustrate Interface options for the Speed Control Version of the MDrive.

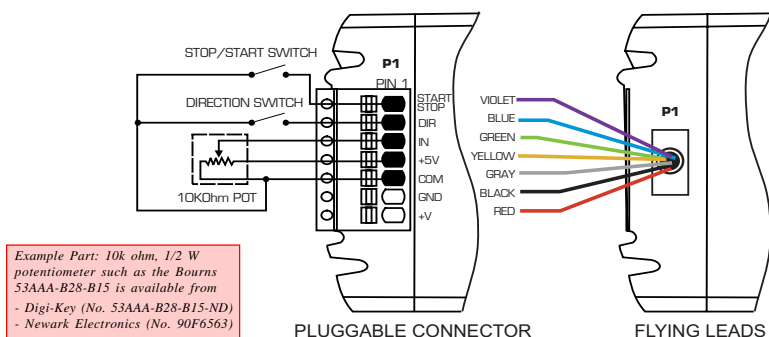


Figure 1.5.3: Interfacing the MDrive Speed Control Using Switches and a Potentiometer

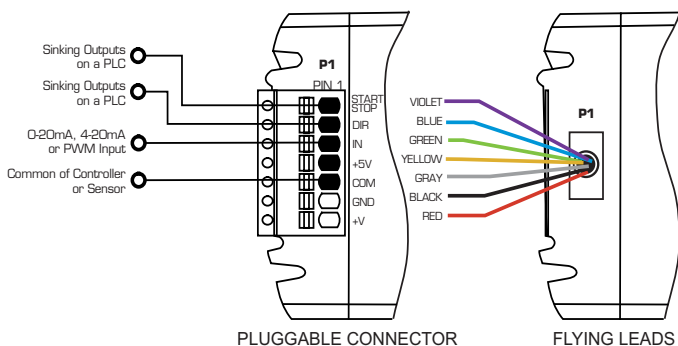


Figure 1.5.4: Interfacing the MDrive Speed Control Using a 4 - 20mA / 0 - 20mA Analog or PWM Output

Velocity Control Input Characteristics

Start/Stop (Pin 1)

The /Start input is internally pulled-up to +5VDC through a 4.99k Ω resistor. When in a logic HIGH, or disconnected, state the internal step clock generator will be off. Connecting this input to logic ground (pin 5) or a sinking output in a LOW state will enable the internal step clock oscillator.

This input may be controlled by means of a switch between the input (pin 1) and logic ground (pin 5) or a sinking output. Leakage current due to external interface circuitry must not exceed 200 micro amps.

Direction (Pin 2)

The CW/CCW direction input is internally pulled-up to +5VDC through a 4.99k Ω resistor.

This input may be connected by means of a switch between the input (Pin 2) and logic ground (Pin 5) or a sinking output. Leakage current due to external interface circuitry must not exceed 200 micro amps.

Speed Control Input (Pin 3)

The Speed Control input is the input by which the internal step clock frequency, hence the velocity of the axis, is controlled.

This 0 - 5 volt analog input will typically be interfaced using a 10k Ω potentiometer as illustrated in *Figure 1.5.3*, a joystick wiper, a 4 - 20mA / 0 - 20mA analog output or a 15 to 25 kHz (100% Duty Cycle) output of a PLC. If a 4 - 20mA or 0 - 20mA device is used, the corresponding input mode **MUST** be selected on the Analog Speed Control Interface software.

If a constant velocity is desired, the speed control input can be connected directly to the +5VDC output and the desired velocity set using the VM parameter. When the START input is brought to a logic LOW state, the motor will begin to move at the velocity specified by the VI variable. It will then accelerate at the rate specified by ACCL until it reaches the speed set by VM.

+5VDC Output (Pin 4)

The +5VDC output is to be connected to the signal end of the 10k Ω potentiometer used to control velocity **only**. It is not the design intent of this output to supply power to external loads.



WARNING: The +5 VDC Output (P1:4) is intended to control velocity **ONLY!** It is not to be used to power external devices!



NOTE: If using the 4 - 20mA or 0 - 20mA input mode, the corresponding mode **MUST** be selected on the Speed Control Interface software. By default the MDrive Speed Control is configured for 0 - 5VDC or PWM input mode.

Interfacing the MDrive SPI Interface (Connector P2)

The MDrive’s SPI communications connector is a 10 pin IDC header. The recommended means of connecting to the header is with the 6 foot (1.8m) Parameter Setup Cable MD-CC100-000.

The setup cable eliminates the need for the user to wire communications to the MDrive. In addition to offering ease of connection, this cable features a built-in logic level shifter for PC’s that run on 3.3V output ports. This cable plugs in easily to connect a standard DB-25 PC Parallel/SPI port to the MDrive’s 10 pin pin-header (P2).

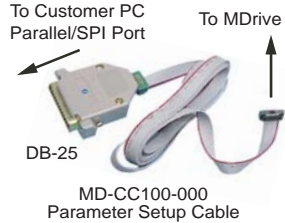


Figure 1.5.5: Parameter Setup Cable for MDrive 17/23

MDrive Connector P2 (SPI Interface)			
Pin #	Pin Name	Wire Size	Description
1	N/C		No Connect
2	N/C		No Connect
3	N/C		No Connect
4	CS	AWG 22	Chip Select
5	GND	AWG 22	Communications Ground
6	+5 VDC	AWG 22	+5 VDC Output (See Warning Below)
7	MOSI	AWG 22	Master Out/Slave In
8	CLK	AWG 22	Clock
9	N/C		No Connect
10	MISO	AWG 22	Master In/Slave Out

Table 1.5.2: P2 Pin Assignment and Description

WARNING! The +5VDC output on connector P2 is used for the setup cable **ONLY!** This output is not designed to power external devices!

WARNING! The Parallel/SPI Port on your PC must be set to one of the following:
 ■ output only ■ bi-directional ■ EPP (Extended Parallel Port)

Try the SPI connection using the default parallel port setting first. If necessary, the Parallel/SPI port may be configured in the bios of your PC.

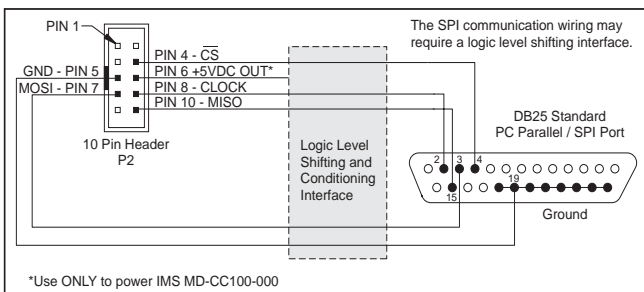


Figure 1.5.6: SPI Interface Wiring and Connections

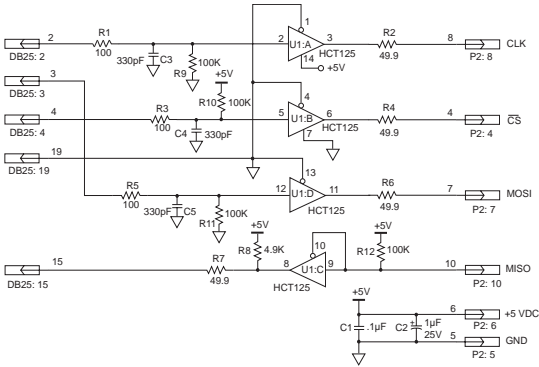


Figure 1.5.7: SPI Logic Level Shifting and Conditioning Schematic

N **NOTE:** If making your own parameter setup cable, be advised the 3.3V output parallel ports on some laptop PC's may not be sufficient to communicate with the device without use of logic level shifting and conditioning Interface.

Minimum Required Connections

The connections shown here are the minimum required to operate the MDrive Speed Control.

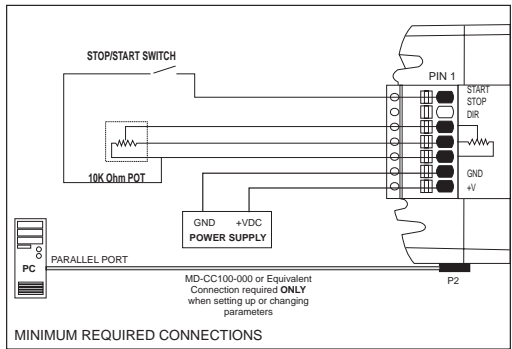


Figure 1.5.8: Minimum Required Connections

Securing MDrive Power, Logic and Encoder Leads

Some applications may require that the MDrive move with the axis motion. If this is a requirement of your application, the motor leads (pluggable or flying) and the Optional Encoder leads (if equipped) must be properly anchored. This will prevent flexing and tugging which can cause damage at critical connection points in the MDrive electronics and the Encoder. DO NOT bundle the Logic Leads or Optional Encoder Leads with the MDrive 17/23 Power Leads.

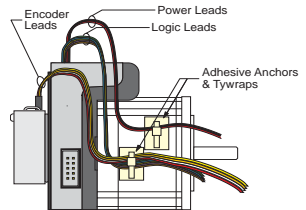


Figure 1.5.9: Typical MDrive with Power Leads, Data Leads and Optional Encoder Leads Secured

SECTION 1.6

Interfacing The MDrive17 And MDrive23 With “C Connector”

Section Overview

This section will acquaint the user with connecting and using MDrive17 and MDrive23 C Connector Versions which have a 12 Position, Keyed and Locking Pin and Receptacle. If your MDrive17/23 is equipped with a factory mounted encoder, also refer to Section 1.3: Interfacing an Encoder. Covered in this section are:

- Interface Guidelines
- Interfacing the I/O
- Interfacing the SPI Interface

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

Interfacing the I/O

MDrive17 and MDrive23 C Connector Versions utilize a 12 Position, Keyed and Locking Pin and Receptacle for interfacing the I/O. For quick connection and setup, the following cables are available from IMS.

Parameter Setup Cable

A low cost accessory which eliminates the need for the user to wire communications. Included in this cable is built-in logic level shifting circuitry to accommodate the 3.3v ports on some PCs.

Order Cable Part No. **MD-CC100-000** plus Adapter Cable Part No. **MD-ADP-1723C** to connect the MDrive C Connector to a standard DB-25 PC Parallel/SPI port.

Prototype Development Cable

To expedite interfacing to MDrive17 and MDrive23 with C Connector. Order Cable Part No. **ADP-3512-FL**.



WARNING! DO NOT connect or disconnect power leads when power is applied! Disconnect the AC power side to power down the DC power supply. For battery operated systems, connect a “transient suppressor” across the power switch to prevent arcs and high voltage spikes.

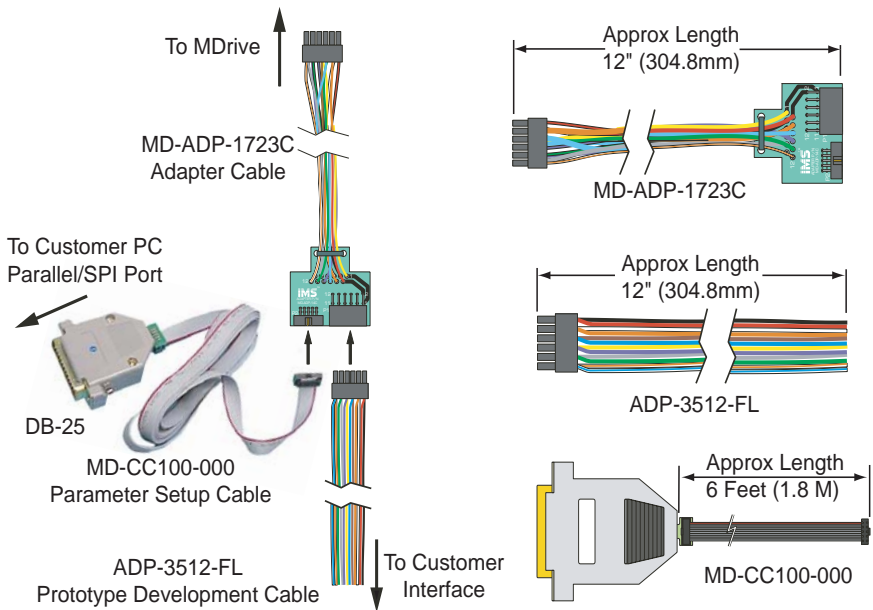


Figure 1.6.1: Typical Setup, Adapter, and Prototype Development Cable Connections for MDrive17/23 with C Connector

Parameter Setting

The MD-CC100-000 Setup Cable is 6 feet in length and connects to the MD-ADP-1723C Adapter Cable and to the Customer PC Parallel/SPI Port. This allows the customer to setup the desired parameters of the MDrive. The Adapter Cable plugs into the C Connector of the MDrive17/23.

Prototype Testing

The ADP-3512-FL Prototype Development Cable connects to the MD-ADP-1723C Adapter Cable and has “flying leads” for the customer to make connections to his interface for testing and development of the MDrive17/23. The Prototype Development Cable can also be connected directly to the MDrive17/23 as the permanent customer interface.

Mating C Connector Information

In production situations, customers specify socket type and type of wire termination and purchase directly from the Connector Distributor. The following information is provided as an aid in this process.

Manufacturer:	AMP	Molex
Type:	Micro Mate-N-Lock	Micro-Fit 3.0
Receptacle Housing:	1-794617-2	43025-1200
Receptacle Contacts:	See AMP Table	See Molex Table

AMP CONTACT AND TOOL PART NUMBERS						
WIRE SIZE	CONTACT PLATING	STRIP PART NO.	LOOSE PIECE PART NO.	SEMI-AUTOMATIC APPLICATOR	INSERTION HAND TOOL	EXTRACTION HAND TOOL
20-24 AWG	Tin	794606-1	794610-1	680893-*	91501-1	843996-3
	15µ" Gold	794606-2	794610-2			
	30µ" Gold	794606-3	794610-3			
26-30 AWG	Tin	794607-1	794611-1	680894-*	91502-1	843996-3
	15µ" Gold	794607-2	794611-2			
	30µ" Gold	794607-3	794611-3			

* 1 = 2 CLS, 2 = K Terminator, 3 = G Terminator For more information contact www.amp.com

MOLEX CONTACT AND TOOL PART NUMBERS						
WIRE SIZE	CONTACT PLATING	STRIP PART NO.	LOOSE PIECE PART NO.	SEMI-AUTOMATIC APPLICATOR	INSERTION HAND TOOL	EXTRACTION HAND TOOL
20-24 AWG	Tin	4043-0001	4043-0007	63820-8100	63811-2800	11-03-0043
	15µ" Gold	4043-0002	4043-0008			
	30µ" Gold	4043-0003	4043-0009			
26-30 AWG	Tin	4043-0004	4043-0010	63820-8100	63811-2800	11-03-0043
	15µ" Gold	4043-0005	4043-0011			
	30µ" Gold	4043-0006	4043-0012			

For more information contact www.molex.com

Table 1.6.1: C Connector Contact and Tool Part Numbers

Description of the I/O

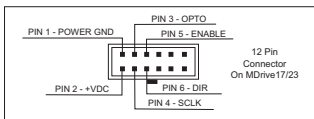


Figure 1.6.2: I/O Interface Connections with C Connector

C CONNECTOR PINS 1-6 ASSIGNMENT				
PIN #	WIRE COLOR*	WIRE SIZE	FUNCTION	PRODUCT LABEL
1	Black	AWG 20†	POWER GROUND (RETURN)	PWR-G
2	Red	AWG 20†	+12 TO +48 VDC	+V
3	White	AWG 22	OPTOCOUPLER REFERENCE	OPTO
4	Orange	AWG 22	STEP CLOCK INPUT	IN
5	Brown	AWG 22	ENABLE INPUT	EN
6	Blue	AWG 22	CW/CCW DIRECTION INPUT	DIR
PINS 7 to 12			SEE SPI SECTION	

* The wire colors refer to the ADP-3512-FL Prototype Development Cable. † For supplies 10 feet or less.

Table 1.6.2: C Connector I/O Pin Assignment and Description

C Connector I/O Description (Pins 1-6)

Pin 1 - Power Ground

This is the Power Ground from the power supply to the C Connector (Pin 1) on the MDrive17 and MDrive23.

Pin 2 - +12 to +48 VDC

This is the Input Voltage from the power supply to the C Connector (Pin 2) on the MDrive17 and MDrive23.

Pin 3 - External Optocoupler Reference

The External Optocoupler Reference supplies +5 to +24 VDC for sinking or logic ground for sourcing to the C Connector (Pin 3). (See the following figure.)

Pin 4 - Step Clock (Input)

The Step Clock Input is where the motion clock from your control circuitry will be connected. The motor will advance one microstep in the plus or minus direction (based on the state of the direction input) on the transition of the input from closed to open. The size of this increment or decrement will depend on the microstep resolution setting. (See the following figure.)

Pin 5 - Enable (Input)

The Enable Input can be used to enable or disable the driver output circuitry. When open, for either sinking or sourcing, the driver outputs will be enabled and the step clock pulses will cause the MDrive17/23 to advance. When the input is closed, the driver output circuitry will be disabled. Please note that the internal sine/cosine position generator will continue to increment or decrement as long as step clock pulses are being received by the MDrive. This input is asynchronous to any other input and may be changed at any time. (See the following figure.)

Pin 6 - Direction (Input)

The Direction Input controls the Clockwise/Counterclockwise direction of the motor. It may be configured as sinking or sourcing depending on the state of the Optocoupler Reference. The direction, based on the state of the input, may be set using the IMS Motor Interface software accessed through the IMS SPI Interface on the CD included with the MDrive17/23. The direction input may be connected by means of a switch between Pin 6 and logic ground when the Optocoupler reference is +5 to +24 VDC (sinking) or between Pin 6 and the +5 to +24 VDC when the Optocoupler reference is logic ground (sourcing). (See the following figure.)

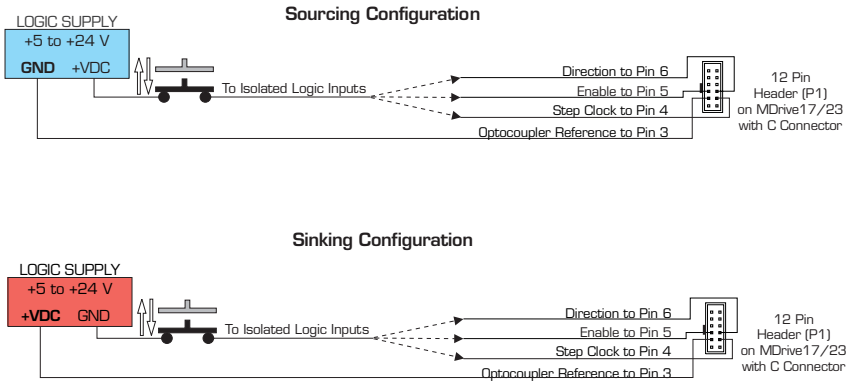


Figure 1.6.3: Sourcing or Sinking the MDrive17/23 with C Connector

In the illustration above, when the circuit(s) are closed the Optocoupler will be Active. When the circuit(s) are open, the Optocoupler will be inactive.

NOTE: The mechanical switch shown is for illustration purposes. The actual switching of the circuits can be done mechanically or electronically.

Minimum Required Connections

The connections shown in below are the minimum required to operate the MDrive17 or MDrive23 with C Connector.

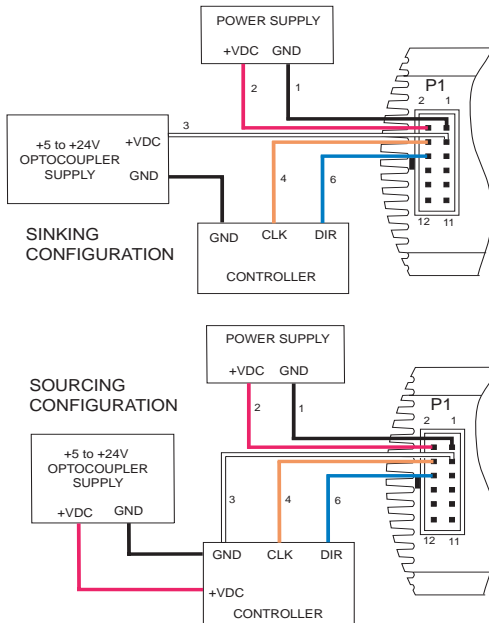


Figure 1.6.4: Minimum Required Connections with C Connector

Connecting the SPI Interface

The SPI (Serial Peripheral Interface) for the MDrive17/23 with C Connector utilizes a 12 Position, Keyed and Locking Pin and Receptacle. The recommended method of connecting to this receptacle is the Parameter Setup Cable. Included in this cable is built-in logic level shifting circuitry to accommodate the 3.3v ports on some PCs. This cable is 6 feet in length and connects a standard DB-25 PC parallel/SPI port to the 12 pin side of the Adapter. Order Cable Part Number **MD-CC100-000** plus Adapter Cable Part Number **MD-ADP-1723C**. Once the MDrive is configured, the SPI Interface can be connected through the Prototype Development Cable, Part Number **ADP-3512-FL**.



NOTE: Should you choose to make your own parameter setup cable, be advised the 3.3V output parallel ports on some laptop PCs may not be sufficient to communicate with the device.

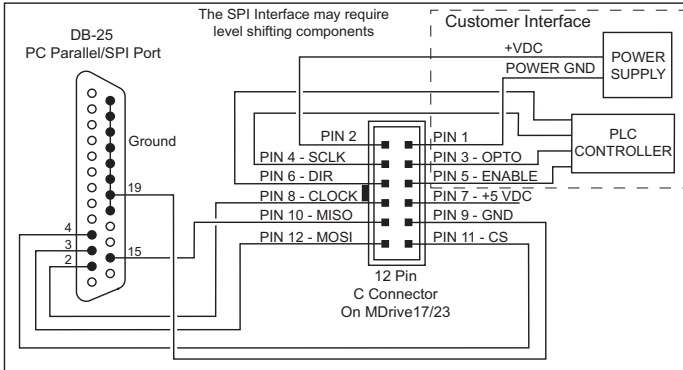


Figure 1.6.5: SPI Interface Connections with C Connector

C CONNECTOR PINS 7-12 ASSIGNMENT				
PIN #	WIRE COLOR*	WIRE SIZE	FUNCTION	PRODUCT LABEL
7	Yellow	AWG 22	+5 VDC OUTPUT	+5 V
8	Violet	AWG 22	SPI CLOCK	SPI-C
9	Grey	AWG 22	COMMUNICATION GROUND	COM-G
10	Green	AWG 22	SPI MASTER IN/SLAVE OUT	SPI-OUT
11	White / Orange	AWG 22	SPI CHIP SELECT	SPI-CS
12	White / Blue	AWG 22	SPI MASTER OUT/SLAVE IN	SPI-IN
PINS 1 to 6			SEE I/O INTERFACE	

* The wire colors refer to the ADP-3512-FL Prototype Development Cable.

Table 1.6.3: C Connector SPI Pin Assignment and Description



WARNING! The Parallel/SPI Port on your PC must be set to one of the following:
■ output only ■ bi-directional ■ EPP (Extended Parallel Port)

Try the SPI connection at the default parallel port setting first. If necessary, the Parallel/SPI port may be configured in the bios of your PC.

C Connector SPI Description (Pins 7-12)

Pin 7 - +5 VDC (Output)

This output is a voltage supply for the setup cable only. It is not designed to power any external devices

Pin 8 - SPI Clock

The Clock is driven by the Master and regulates the flow of the data bits. The Master may transmit data at a variety of baud rates. The Clock cycles once for each bit that is transferred.

Pin 9 - Logic Ground

This is the Ground for all Communication.

Pin 10 - MISO (Master In / Slave Out)

Carries output data from the MDrive17 and MDrive 23 back to the SPI Master. Only one MDrive can transmit data during any particular transfer.

Pin 11 - CS (SPI Chip Select)

This signal is used to turn multiple MDrive17 or MDrive23 on or off.

Pin 12 - MOSI (Master Out / Slave In)

Carries output data from the SPI Master to the MDrive17 or MDrive23.

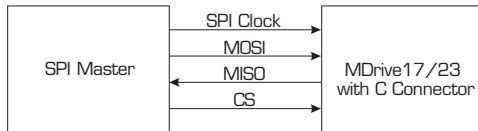


Figure 1.6.6: SPI Master with Single MDrive17/23

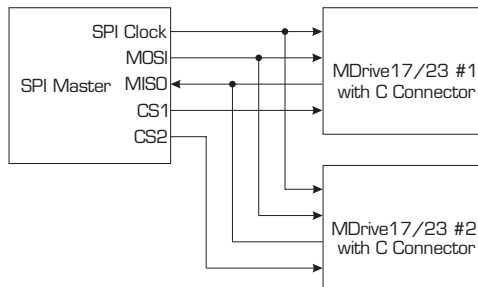


Figure 1.6.7: SPI Master with Multiple MDrive17/23

SECTION 1.7

Configuring The MDrive Speed Control

Section Overview

This section applies to all MDrive Speed Control Versions. The software utility is the only method for configuring your MDrive Speed Control. This section will acquaint the user with the following:

- Easy installation.
 - Ease of use via single screen interface.
 - Automatic communication configuration.
 - Will not allow out-of-range values to be set.
 - Tool-tips display valid range settings for each option.
-

The IMS Analog Speed Control Utility

The IMS Analog Speed Control is accessed through the IMS SPI Interface which is an easy to install and use software program. Use of this utility and the optional 6 foot MD-CC100-000 Parameter Setup Cable is the suggested method of configuring the MDrive17 and MDrive23 Speed Control. The SPI Interface is included on the CD that ships with the MDrive or is available for download at www.imshome.com.

Installing the IMS SPI Interface

NOTE: IMS recommends that you install the latest version of the SPI Interface which is backward compatible and ensures compatibility with the latest MDrives.

System Requirements

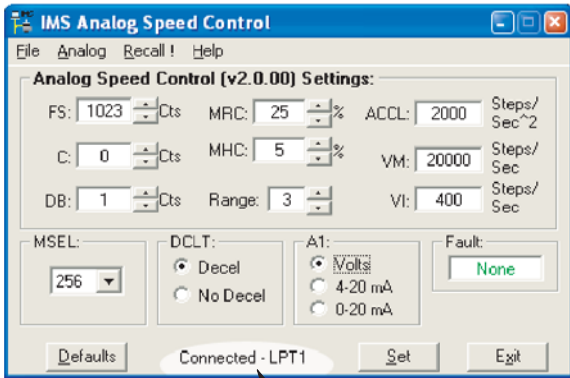
- A Pentium Class or Higher IBM Compatible PC.
- Windows 9x (95/98) or Windows NT (Windows NT4.0 SP6, Windows 2000 SP1, Windows XP).
- 10 MB hard drive space.
- A free parallel communications port.

Installation

Please refer to Section 1.4 “Installing the IMS SPI Interface” and follow steps 1 through 5.

Start-up

Select “Start>Programs>Analog Speed Control>Analog Speed Control”. The configuration utility will automatically scan your LPT ports for the connected MDrive and configure communications. The connection status and port are displayed at the bottom of the configuration screen as shown below.



Connection status and port

Figure 1.7.1: Speed Control Configuration Utility Screen

Configuration Parameters Explained

There are 12 configuration parameters for the MDrive. Parameter settings are automatically saved to memory when the “SET” button is clicked on the configuration utility screen.

The table below summarizes the parameters and their function, range, units and default setting.

Speed Control Parameters				
Parameter	Function	Range	Units	Default
ACCL	Acceleration / Deceleration	2000-65000	Steps/sec ²	2000
C	Joystick Center Position	0 to 1022 (0.005 to 4.995)	Counts (Volts)	0 (0.000)
DB	Potentiometer / Joystick Deadband	0 to 255 (0.000 to 1.245)	Counts (Volts)	1 (0.005)
DCLT	Deceleration Type	Decelerate Do Not Decelerate	–	Decel
FS	Full Scale of the Potentiometer / Joystick	1 to 1023 (0.005 to 4.995)	Counts (Volts)	1023 (4.995)
MHC	Motor Holding Current	0 - 100	Percent	5
MRC	Motor Run Current	1 - 100	Percent	25
A1	Input Mode	Volts / 4-20mA / 0-20mA or PWM	–	Volts
RANGE	VI / VM Range Setting	1 - 8	–	3
MSEL	Resolution Select Parameter	See Table	per-step-division	256
VI	Initial Velocity	1-100000	Steps/sec.	800
VM	Maximum Velocity	1-100000	Steps/sec.	20000

Table 1.7.1: MDrive Speed Control Parameter Summary

Acceleration (ACCL)

The ACCL parameter sets the acceleration and deceleration in steps per second².

Joystick Center Position (C)

The parameter sets the center position of the joystick. It can be set by two methods. Using method one the user will manually enter a value between 0 (default) and 1022 into the parameter box. This count will represent the voltage that the MDrive will interpret as the zero-reference position. Any voltage seen on the speed control input will accelerate from 0 to the maximum set velocity. The second method is to select Analog>Initialize from the menu bar of the configuration utility. Move the joystick or rotate the pot to the end of travel on both directions, move or rotate the input device to the desired center and click the “Accept” button. See the setup procedure located in “Setting the Configuration Parameters”, the next subsection of this document.

Potentiometer Deadband (DB)

The DB parameter sets the deadband of the potentiometer. The range for this parameter is a relative term as the actual deadband value is based upon the settings of the VI and VM parameters. The deadband is the amount of deflection seen on the potentiometer until the velocity is changed.

With DB=1 it is possible that the motor will oscillate between two velocities. This can be eliminated by setting the deadband to a higher value.

Note that when the voltage seen at the speed control input is $\leq 0.005V$, the step clock output of the oscillator will be zero (0). When the potentiometer or joystick deflects to the level specified by the DB parameter the axis will start to accelerate, beginning at the velocity specified by the VI, or initial velocity parameter.



USAGE NOTE: If the motor oscillates between two velocities, increase the potentiometer deadband to a higher value. This will add coarseness to the pot and eliminate the oscillation.

Deceleration Type (DCLT)

This parameter sets the motor deceleration to an ON/OFF state. If Decel is selected on the speed control utility, the motor will decelerate to stop at the rate specified by the ACCL parameter. If No Decel is selected, the motor will hard stop.

Full Scale (FS)

The full scale parameter sets the deflection of the potentiometer or joystick. While the min/max range of the speed control input is 0 to 1023 counts (0.005 to 4.995 volts) (0 counts = no motion, 1023 counts = max velocity, or VM) the user has the option of setting the full scale to a different value. For instance, setting FS=500 counts (2.411 volts) will cause the MDrive’s oscillator to output the appropriate step clock frequency set for VM when the voltage on the speed control input is 2.411V.

Motor Holding Current (MHC)

The MHC parameter sets the motor holding current as a percentage of the full output current of the driver. If the hold current is set to 0, the output circuitry of the driver will disable when the hold current setting becomes active.

The hold current setting becomes active 200ms following the last step clock pulse.

Motor Run Current (MRC)

The Motor Run Current (MRC) parameter sets the motor run current to a percentage of the full output current of the driver.

RANGE PARAMETER SETTINGS								
RANGE	1	2	3	4	5	6	7	8
VI	200	100	50	20	10	5	2	1
VM	100000	50000	25000	10000	5000	2500	1000	500

Table 1.7.2: RANGE Parameter Settings

Input Mode (A1)

The Input mode setting selects the input method to be used, either Voltage, 4 - 20mA or 0 - 20mA. **NOTE:** In the Voltage mode you may also use a 15 kHz to 25 kHz PWM Input.

Velocity Range (RANGE)

The RANGE parameter specifies the maximum ranges available for the initial velocity (VI) and maximum velocity (VM). When the range is set to a value, the VI and VM parameters will automatically default to the value specified by the range setting. The value of VI and VM can then be set within the range specified by RANGE. The previous table illustrates the range settings.

Microstep Resolution Select (MSEL)

The MSEL parameter specifies the microstep resolution of the MDrive. See the table below for valid MSEL parameter settings.

Microstep Resolution Settings (MSEL)			
Binary Microstep Resolution Settings		Decimal Microstep Resolution Settings	
MSEL=	Steps/Rev	MSEL=	Steps/Rev
2	400	5	1,000
4	800	10	2,000
8	1,600	25	5,000
16	3,200	50	10,000
32	6,400	125	25,000
64	12,800	250	50,000
128	25,600		
256	51,200		

Table 1.7.3: MSEL Parameter Settings

Initial Velocity (VI)

The VI parameter establishes the initial velocity of the controlled axis in steps per second. The setting of this parameter represents the slowest speed the motor will turn. This is the velocity of the axis when the voltage on the speed control input = 0V. The valid settings for VI is dependent on the RANGE setting.

Maximum Velocity (VM)

The VM parameter establishes the maximum velocity of the controlled axis in steps per second. The setting of this parameter represents the highest speed that the motor will turn. This is the velocity of the axis when the voltage on the speed control input = 5V. The valid setting for VM is dependent on the RANGE setting.

Setting the Configuration Parameters

In order to follow the procedures set forth in this subsection, the following is necessary:

- The Parameter Setup Cable (MD-CC100-000) or equivalent must be connected between your PC Parallel (Printer) Port and the 10 pin IDC connector (P2) on the MDrive.
- The Analog Speed Control configuration utility must be installed and operating on your PC. Correct connection of the device and operation of the software will be indicated by a "Connected - LPTx" message at the bottom of the configurator screen.
- The Stop/Start input must be in a HIGH (Disconnected, Stopped) state.

Configuring the MDrive for Unidirectional Operation

When operating as a unidirectional device, the internal clock pulse generator will output step clock pulses to the MDrive's driver section. The initial and maximum frequency of these pulses, and the rate which they accelerate between these values, is established by the following four parameters:

- 1] Initial Velocity (VI)
- 2] Maximum Velocity (VM)
- 3] Acceleration (ACCL)
- 4] Velocity Range (RANGE)

Set the Run Current (MRC) and the Holding Current (MHC) to the desired value.

When using the MDrive in velocity mode the settings for FS, C and DB will likely be left in their default state. These three parameters may be displayed as either counts or volts. The displayed value is changed by clicking the "Cts" to the right of the parameter's text box. It may be changed from volts back to counts by clicking "volts".

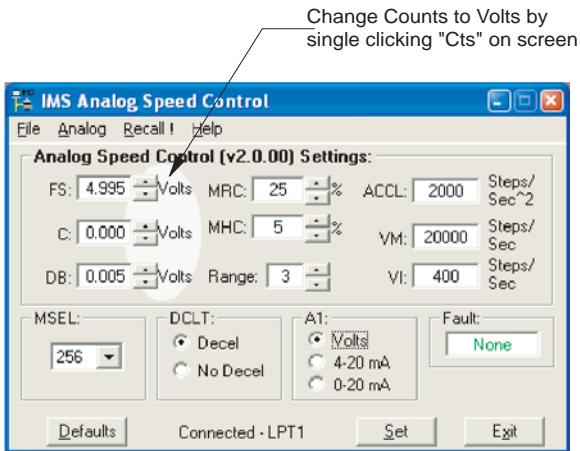


Figure 1.7.2: Changing Counts Readout to Volts

Illegal Parameters

When certain parameters such as the Range is changed, other parameters adopt different min/max values. If a parameter is illegal it will be displayed in red. To determine a legal parameter value place your mouse pointer over the parameter in question. A "Tool Tips" dialog will appear and show the legal range of that parameter. **NOTE:** The Tool Tips are always functional.

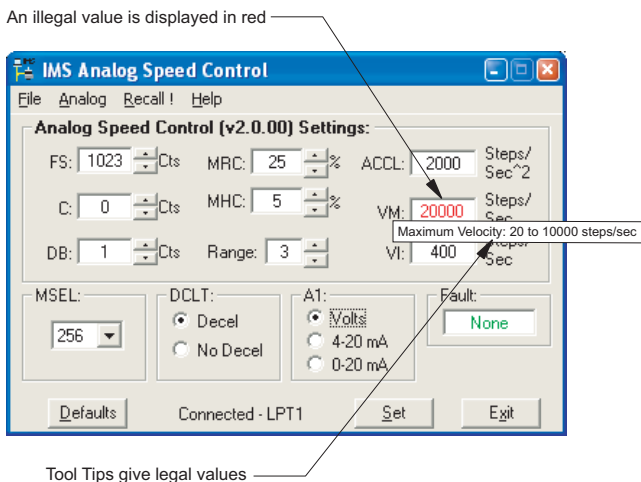


Figure 1.7.3: Illegal Parameters/Tool Tips

Returning to the Default Parameters

To return to the Default Parameters, click the “Defaults” button and then click the “Set” button.

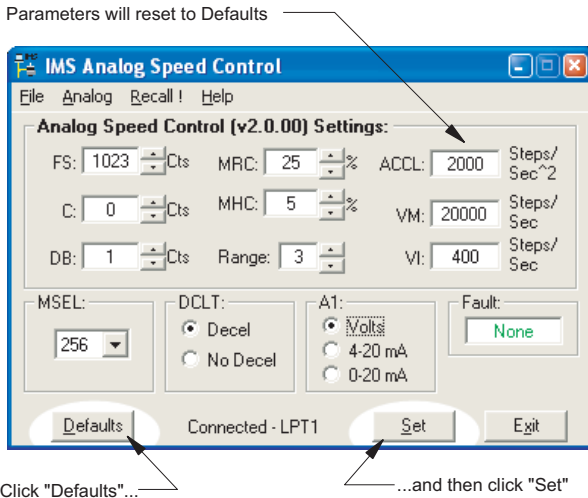


Figure 1.7.4: Returning to Default Parameters

If the motor oscillates between frequencies, increase the potentiometer deadband (DB). If desired, these may be changed. For example: Setting the FS parameter to 511 would configure the MDrive such that it will be at maximum velocity when the potentiometer is at 1/2 of its full deflection.

Test the settings by pulling the Stop/Start input to ground by means of a switch or sinking output. Turn the potentiometer between its stops, the motor should accelerate and decelerate between the VI and VM settings. Note that there will be no motion at the zero reference point of the potentiometer. The motion will not start until the speed control input sees the voltage equivalent of $0 + DB$.

Fine-tune the ACCL, VI, VM and RANGE settings to the requirements of your application. Clicking the “Set” button saves the parameter settings to non-volatile memory.

Configuring the MDrive Speed Control for Bidirectional Operation

When setting the MDrive Speed Control for bidirectional operation, it is necessary that the joystick or pot be calibrated. First, a center position must be established, as well as the full scale range of the input device in two directions. The following steps outline the calibration procedures.

- 1] With the input device in the center position, click “Analog>Initialize” on the menu bar.
- 2] Move the input device to its full scale position, first in the max direction, then in the min direction. Re-center the input device.
- 3] Click the “Accept” button.
- 4] Set the other parameters to the desired value.
- 5] Click the “Set” button to save the parameter settings to non-volatile memory.

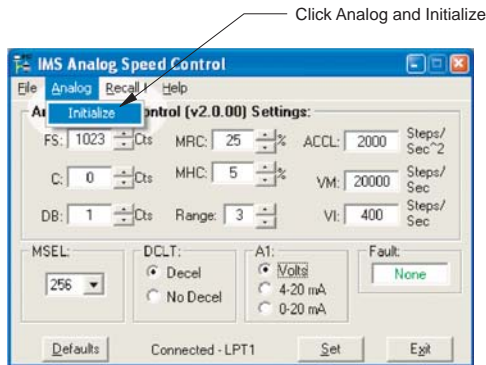


Figure 1.7.5: Initialization Mode

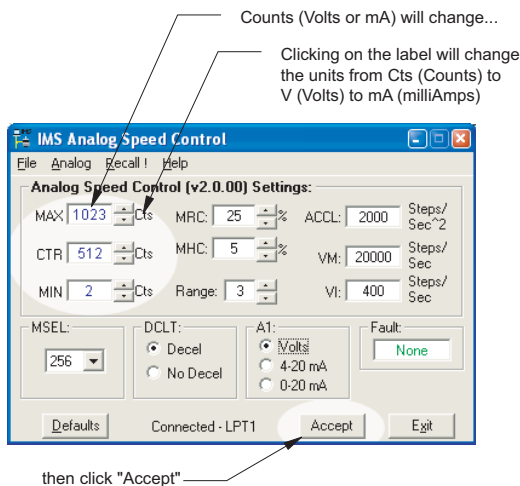


Figure 1.7.6: Accepting the Analog Initialization Values

If a fault occurs it will be displayed in the Fault window. If more than one fault occurs each one will be displayed with the + (plus sign) between them. The Table below lists the faults and the characters displayed for each.

Fault Table		
Binary Code*	Display	Fault Condition
0	None	No Fault
4	CS	SPI Write to Settings Check Sum
8	CS	SPI Write to Defaults Check Sum
16	DFLT	Defaults Check Sum
32	DATA	EEPROM Check Sum Fault

*NOTE: All fault codes are "OR"ed together.

Table 1.7.4 Fault Indication

Description of the Faults

NONE

No Faults exist in the MDrive

CS - SPI Write Check Sum

Check Sum indicates an error or problem with the last transmission of data to the MDrive. A RECALL will clear the fault and the screen will display the stored parameters.

DFLT & DATA

These faults indicate a Driver failure. Contact the factory.

Configuring the MDrive Speed Control With User Defined SPI

The MDrive Speed Control may be setup and operated without the included IMS Motor Interface GUI.

If the optional cable is not being used you will need to make one using the diagram (SPI Interface Wiring and Connections) shown in Section 1.5 of this document.

Timing Notes

- 1) MSb (most significant bit) and MSB (most significant byte) first
- 2) 8 bit bytes
- 3) 25kHz SCK
- 4) Data In (MOSI) on rising clock
- 5) Data Out (MISO) on falling clock



WARNING! The Parallel/SPI Port on your PC must be set to one of the following:
 ■ output only ■ bi-directional ■ EPP (Extended Parallel Port)

Try the SPI connection at the default parallel port setting first. If necessary, the Parallel/SPI port may be configured in the bios of your PC.

SPI Commands

SPI COMMANDS AND PARAMETERS				
	CMD/PRM	HEX/DEFAULT	RANGE	NOTES
SPI Commands	READ ALL	0X40		Reads the hex value of all parameters
	WRITE ALL	0X80		Writes the hex value to the following parameters
Data READ	"u"	0x75		"u" character precedes every read
	Version MSB	0x80		Defines the SPI Version and revision number i.e.; Version 1.2 Rev. 02
	Version LSB	0x12		
	ACCL, MSB	0x07	2000-65000	Acceleration in Steps/Sec ² The default is 2000
	ACCL, LSB	0xD0		
	DB	0x01	0-255	Potentiometer/Joystick Deadband
	RANGE	0x03	1-8	VI/VM Range Setting
	VI, MSB	0x00	1-100000	Establishes the maximum velocity (highest speed) of the controlled axis in steps per second
	VI, MB	0x01		
	VI, LSB	0x90		
	VM, MSB	0x00	1-100000	Establishes the maximum velocity (highest speed) of the controlled axis in steps per second The default is 20000
	VM, MB	0x4E		
	VM, LSB	0x20		
	FULLSCALE, MSB	0x03	1-1023	Sets the deflection of the potentiometer or joystick
	FULLSCALE, LSB	0xFF		
	CENTER, MSB	0x00	1-1022	Sets the center position of the joystick The default is 0.0000
	CENTER, LSB	0x00		
	MRC	0x19	1-100%	Motor Run Current - Default = 25
	MHC	0x05	0-100%	Motor Hold Current - Default = 5
	DCLT	0x00	0-1	Deceleration (On/Off) Default = 0
	MSEL	0x00	0, 2-250	Microstep Resolution Default = 256
	TYPE	0x01	1-Microstep	Fixed
	INP_MODE ... A1A2_PWM MA_4_20 MA_0_20 DIR1	0x00 0x01 0x04 0x08 0x40	A1&A2, A1Volt, CW 0 = A1-A2, 1 = PWM 0 = A1Volts, 1 = A1Current 0 = 0-20mA, 1 = 4-20mA 0 = CW, 1 = CCW	Defined by the following parameters ... A1 and A2 or PWM Volts or Current 0 to 20 mA or 4 to 20 mA Direction Override
FAULT	0x00		(See Fault Table)	
Data WRITE	ACCL, MSB	0x07	2000-65000	Acceleration in Steps/Sec ² The default is 2000
	ACCL, LSB	0xD0		
	DB	0x01	0-255	Potentiometer/Joystick Deadband
	RANGE	0x03	1-8	VI/VM Range Setting
	VI, MSB	0x00	1-100000	Establishes the initial velocity (slowest speed) of the controlled axis in steps per second The default is 800
	VI, MB	0x01		
	VI, LSB	0x90		
	VM, MSB	0x00	1-100000	Establishes the maximum velocity (highest speed) of the controlled axis in steps per second The default is 20000
	VM, MB	0x4E		
	VM, LSB	0x20		
	FULLSCALE, MSB	0x03	1-1023	Sets the deflection of the potentiometer or joystick
	FULLSCALE, LSB	0xFF		
	CENTER, MSB	0x00	1-1022	Sets the center position of the joystick The default is 0.0000
	CENTER, LSB	0x00		
	MRC	0x19	1-100 %	Motor Run Current - Default = 25
	MHC	0x05	0-100 %	Motor Hold Current - Default = 5
	DCLT	0x00	0-1	Deceleration (On/Off) Default = 0
	MSEL	0x00	0, 2-250	Microstep Resolution Default = 256
	INP_MODE ... A1A2_PWM MA_4_20 MA_0_20 DIR1	0x00 0x01 0x04 0x08 0x40	A1&A2, A1Volt, CW 0 = A1-A2, 1 = PWM 0 = A1Volts, 1 = A1Current 0 = 0-20mA, 1 = 4-20mA 0 = CW, 1 = CCW	Defined by the following parameters ... A1 and A2 or PWM Volts or Current 0 to 20 mA or 4 to 20 mA Direction Override
	CKSUM	0x5D		2s Complement of all WRITES including Command

Table 1.7.5: MDrive17&23 Speed Control SPI Command Summary

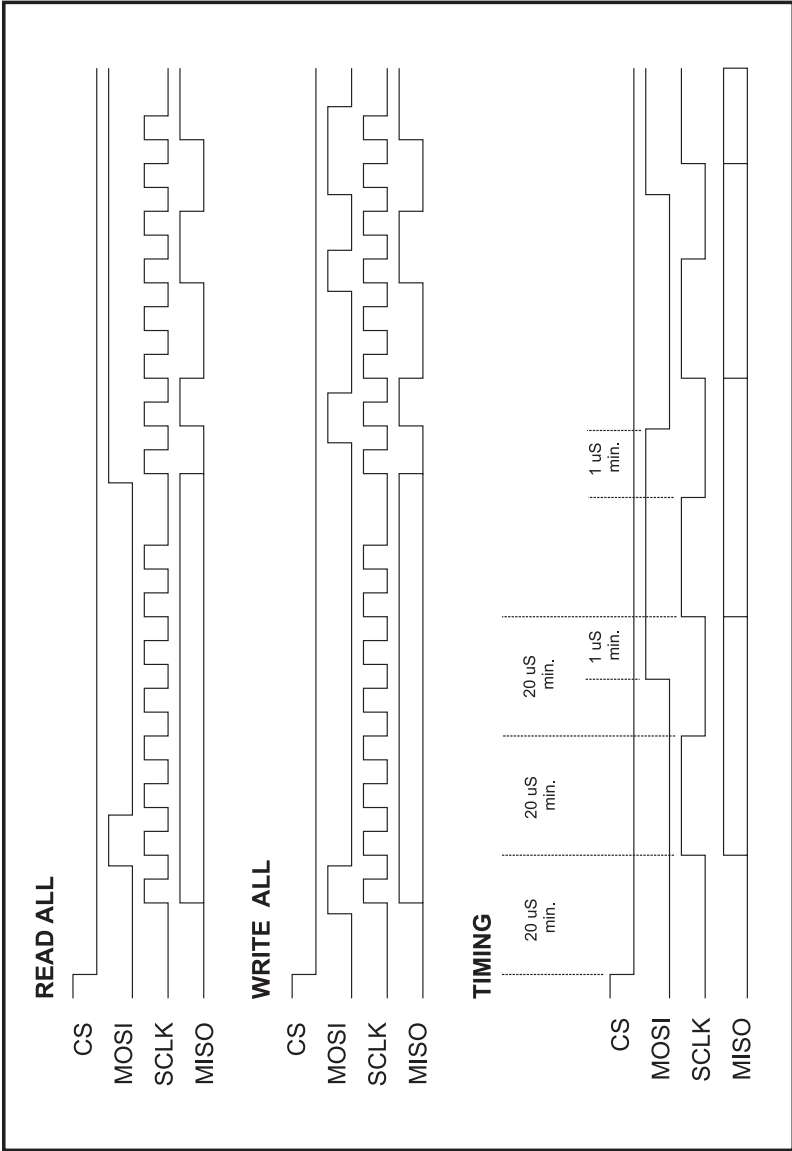


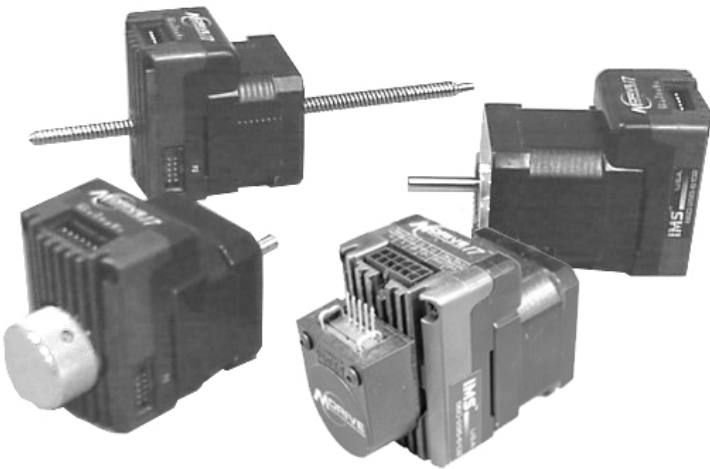
Figure 1.7.7: SPI Waveforms & Timing Diagram

PART II

MDRIVE 17 INTEGRATED MOTOR AND ELECTRONICS

ROTARY

LINEAR ACTUATOR



SECTION 2.1


MDrive17 Power Supply & Thermal Requirements

Power Supply Specifications

MDrive Power Supply Specifications	
Recommended Supply Type	Unregulated DC
Ripple Voltage	±10 %
Output Voltage	+12 to +45 VDC
Output Current	3A Peak

Power supply current requirements = 2A (**MAX**) per MDrive17.
Actual power supply current will depend upon voltage and load.

Table 2.1.1: MDrive17 Recommended Power Supply Specifications



WARNING! The maximum +48 VDC Input Voltage of the MDrive17 includes Motor Back EMF, Power Supply Ripple and High Line.

A characteristic of all motors is back EMF. Back EMF is a source of current that can push the output of a power supply beyond the maximum operating voltage of the driver. As a result, damage to the stepper driver could occur over a period of time. Care should be taken so that the back EMF does not exceed the maximum input voltage rating of the MDrive17.

Recommended IMS Power Supplies

Listed below is the power supplies recommended for use with the MDrive17.

Unregulated Linear Supply

Input Range

120 VAC Version 102-132 VAC

240 VAC Version 204-264 VAC

Output

No Load Output Voltage* 39 VDC @ 0 Amps

Continuous Output Rating* 30 VDC @ 1 Amps

Peak Output Rating* 25 VDC @ 2 Amps

* All measurements were taken at 25°C, 120 VAC, 60 Hz.

Thermal Specifications

Because the MDrive consists of two core components, a drive and a motor, close attention must be paid to the thermal environment where the device is used. The following maximum temperatures apply to the MDrive17.

Heat Sink Temperature (Max) 85°C

Motor Temperature (Max) 100°C

SECTION 2.2

Rotary MDrive17 Specifications

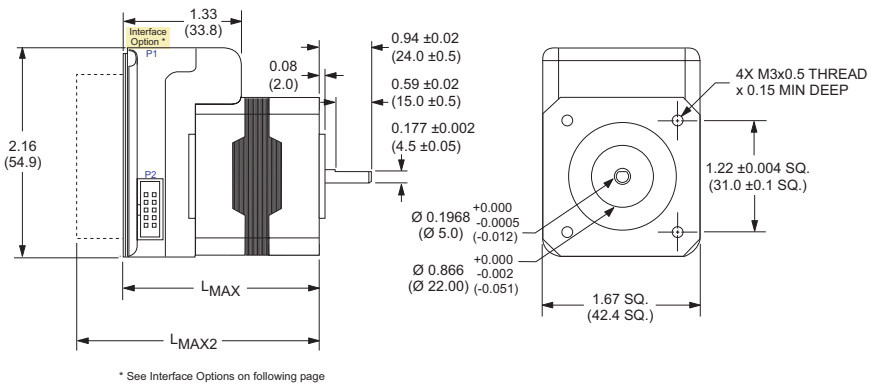
Section Overview

This section contains mechanical, motor and electrical specifications specific to each version of the Rotary MDrive17. Shown are:

- Mechanical Specifications
- Motor Specifications
- Electrical Specifications

Mechanical Specifications

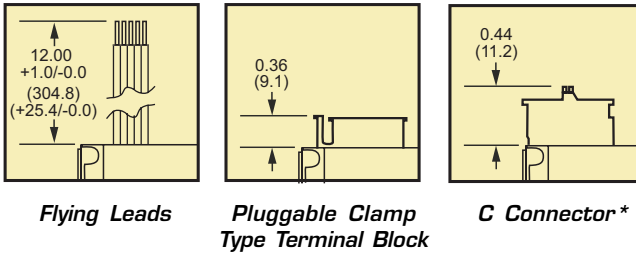
Dimensions in inches (mm)



L_{MAX}		L_{MAX2}	
Single Shaft Version		Control Knob or Encoder Version	
Stack	In (mm)	Stack	In (mm)
1713	2.20 (55.9)	1713	2.92 (74.2)
1715	2.43 (61.7)	1715	3.15 (80.0)
1719	2.75 (69.8)	1719	3.47 (88.1)

Figure 2.2.1: Rotary MDrive17 Mechanical Specifications

Interface Options - MDrive17



* Not available for MDO17 Speed Control

Figure 2.2.2: Interface Options

Motor Specifications

N **NOTE!** The following specifications apply to all rotary variants of the MDrive17, the standard rotary as well as the encoder and control knob versions.

MDrive1713 Motor Specifications and Speed/Torque Curves

MD1713	
Holding Torque oz-in (N-cm)	32 (22.6)
Detent Torque oz-in (N-cm)	1.66 (1.17)
Rotor Inertia oz-in-sec ² (kg-cm ²)	0.00053 (0.038)
Weight (Motor & Driver) oz (g)	9.8 (277.8)

Table 2.2.1: MD1713 Motor Specifications

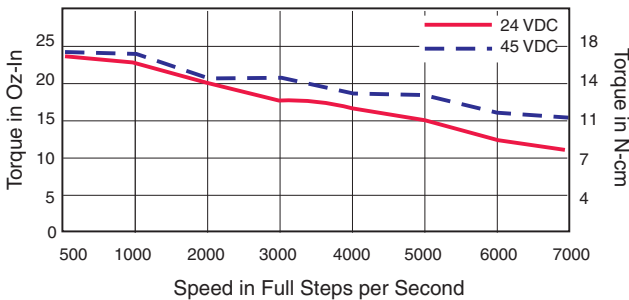


Figure 2.2.3: Rotary MDrive 1713 Torque/Speed Data (100% Current)

MDrive1715 Motor Specifications and Speed/Torque Curves

MD1715	
Holding Torque oz-in (N-cm)	60 (42.4)
Detent Torque oz-in (N-cm)	2.08 (1.47)
Rotor Inertia oz-in-sec ² (kg-cm ²)	0.00080 (0.057)
Weight (Motor & Driver) oz (g)	10.5 (297.7)

Table 2.2.2: Rotary MDrive 1715 Motor Specifications

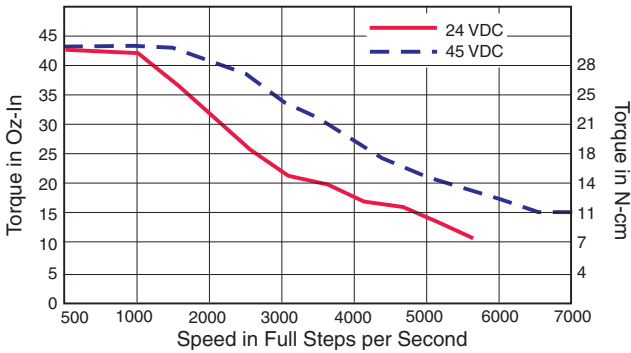


Figure 2.2.4: Rotary MDrive 1715 Torque/Speed Data (100% Current)

MDrive1719 Motor Specifications and Speed/Torque Curves

MD1719	
Holding Torque oz-in (N-cm)	74.9 (52.9)
Detent Torque oz-in (N-cm)	3.47 (2.45)
Rotor Inertia oz-in-sec ² (kg-cm ²)	0.00116 (0.082)
Weight (Motor & Driver) oz (g)	15.1 (428.1)

Table 2.2.3: Rotary MDrive 1719 Motor Specifications

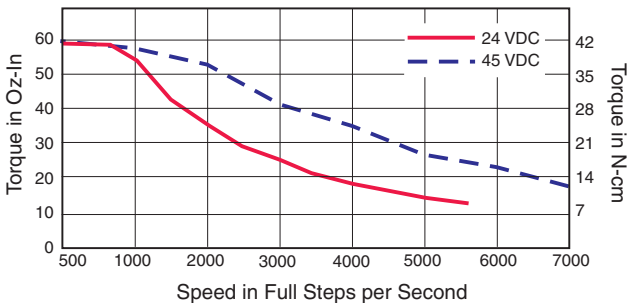


Figure 2.2.5: Rotary MDrive 1719 Torque/Speed Data (100% Current)

Electrical Specifications

MDrive17 Microstepping

Input Voltage (+V) Range	+12 to +48 VDC
Isolated Inputs	Step Clock, Direction & Enable
Isolated Input Voltage Range* (Sinking or Sourcing)	+5 to +24VDC
Isolated Current*	
+5 Volt (Max)	8.7 mA
+24 Volt (Max)	14.6 mA
Step Frequency (Max)	2 MHz
Step Frequency Minimum Pulse Width	400 nS
Steps per Revolution	400, 800, 1000, 1600, 2000, 3200, 5000, 6400, 10000, 12800, 25000, 25600, 50000, 51200

* Only available for MDrive17 with C connector.

MDrive17 Speed Control

Input Voltage (+V) Range	+24 to +75 VDC
Speed Control Input	0 to +5 VDC / PWM, 0 to 20mA or 4 to 20mA
A/D Resolution	10 bit
Speed Control Potentiometer Resistance	10 k Ohm
Start/Stop, Direction (Low Level Input)	0 to 1.5 VDC
Start/Stop, Direction (High Level Input)	+3.0 to +5.0 VDC
Input Pull-up Resistance (to +5 VDC) Stop/Start, Direction	4.99 k Ω
Isolated Inputs	Voltage/Current/PWM, Start/Stop, Direction
PWM Input Frequency	15 to 25 kHz

Recommended Wire Sizes

Recommended Wire Size

Logic Wiring	22 AWG
Power and Ground	See Appendix A "Recommended Cable Configurations"



WARNING! The maximum +48 VDC Input Voltage of the MDrive17 includes Motor Back EMF, Power Supply Ripple and High Line.

A characteristic of all motors is back EMF. Back EMF is a source of current that can push the output of a power supply beyond the maximum operating voltage of the driver. As a result, damage to the stepper driver could occur over a period of time. Care should be taken so that the back EMF does not exceed the maximum input voltage rating of the MDrive17.

SECTION 2.3

Linear MDrive17 Specifications

Section Overview

This section contains mechanical, motor and electrical specifications specific to the Linear MDrive17. Shown are:

- Mechanical Specifications
- Motor Specifications
- Electrical Specifications

Mechanical Specifications

Dimensions in inches (mm)

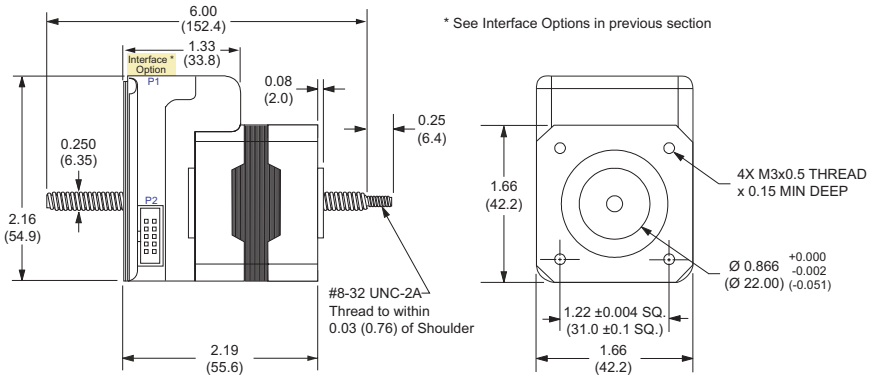


Figure 2.3.1: Linear Actuator MDrive17 Mechanical Specifications

Motor Specifications (Linear)

Linear Actuator	
Maximum Thrust lbs (kg)	50 (22.7)
Weight (Motor+Driver without screw) oz (g)	10.4 (294.8)

Table 2.3.1: Linear Actuator MDrive17 Motor Specifications



WARNING: The maximum axial load limit for the MDrive17 Motor is 50 lbs (22.7 kg). Do not exceed this rating!



WARNING: The Acme screw **MUST NOT** deflect more than ± 1 degree perpendicular to the motor face. Additional support for radial loads may be required!

Force/Speed Curve: 24 VDC

Refer to the table below for screw pitch information.

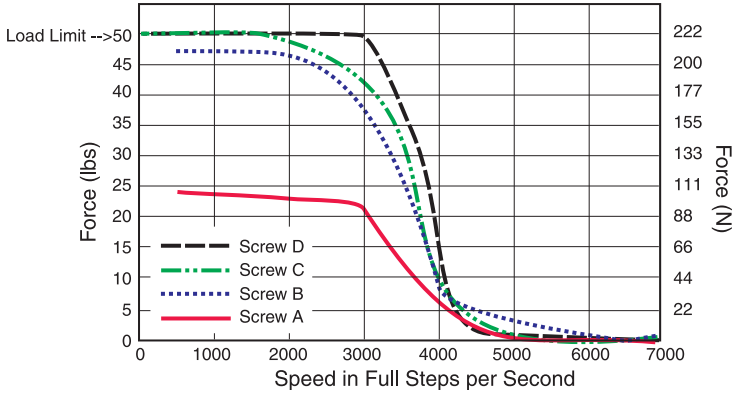


Figure 2.3.2: Force/Speed Curve - 24VDC (100% Current)

Force/Speed Curve: 45 VDC

Refer to the table below for screw pitch information.

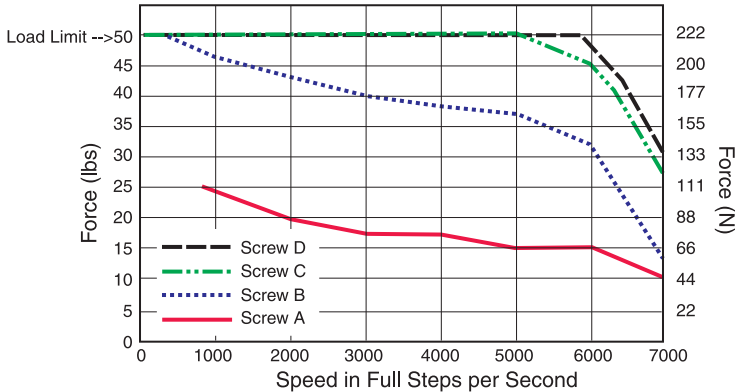


Figure 2.3.3: Force/Speed Curve - 45VDC (100% Current)

Acme Screws for MDrive17	
Screw	Travel/Full Step inches (mm)
A	0.00125 (0.03175)
B	0.000625 (0.015875)
C	0.0003125 (0.0079375)
D	0.00015625 (0.00396875)

Table 2.3.2: Acme Screws for the MDrive17 Linear Actuator

MDrive17 Mounting Screws

Care must be observed when installing the mounting screws on ALL MDrive17 versions including Linear Actuators. 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 MDrive17.



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).

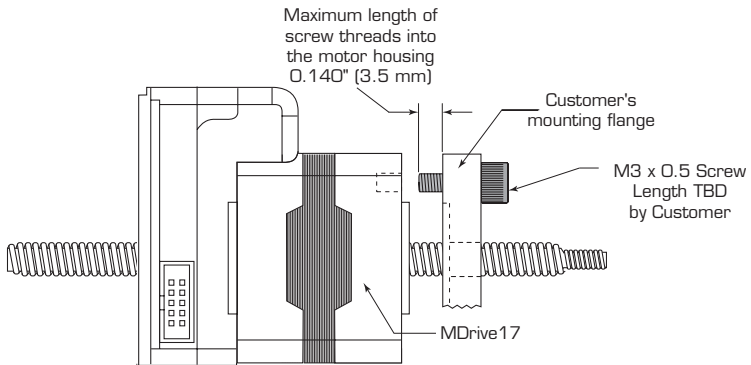


Figure 2.3.4: MDrive17 Mounting Screw Depth



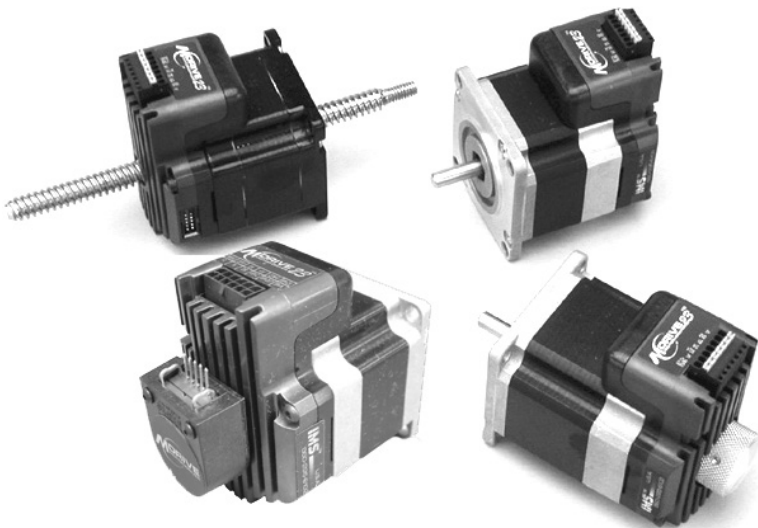
MAXIMUM TORQUE! The maximum torque for the M3x0.5 screw is 7.8 lb-in (9 kg-cm) with a thread engagement of 6.5 threads (3.3 mm deep). A lesser thread engagement diminishes the maximum torque.

PART III

MDRIVE 23 INTEGRATED MOTOR AND ELECTRONICS

ROTARY

LINEAR ACTUATOR



SECTION 3.1

MDrive23 Power & Thermal Requirements

Motor Power Supply Requirements		
Specifications	48V MD23 (-4)	75V MD23 (-7)
Recommended Supply Type	Unregulated DC	
Ripple Voltage	±10 %	
Output Voltage	+12 to +45 VDC	+24 to +75 VDC
Output Current	3A Peak	4A Peak

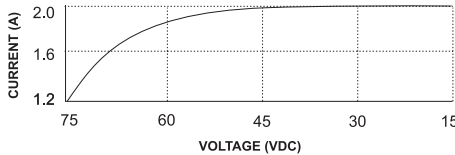


Table 3.1.1: MDrive23 Recommended Power Supply Specifications

The graph above illustrates the power supply current (MAX) per MDrive23. Actual power supply current will depend upon voltage and load.

Recommended IMS Power Supplies

Listed below are the power supplies recommended for use with both voltage ranges of the MDrive23.

IP404 (MD23-4) / IP804 (MD23-7)

Input Range

120 VAC Versions 102-132 VAC

240 VAC Versions 204-264 VAC

IP404 Output

No Load Output Voltage* 43 VDC @ 0 Amps

Continuous Output Rating* 32 VDC @ 2 Amps

Peak Output Rating* 26 VDC @ 4 Amps

IP804 Output

No Load Output Voltage* 76 VDC @ 0 Amps

Continuous Output Rating* 65 VDC @ 2 Amps

Peak Output Rating* 58 VDC @ 4 Amps

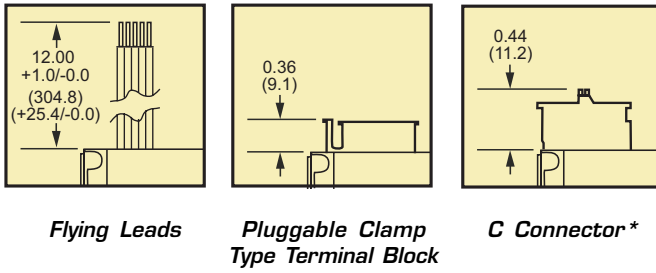
* All measurements were taken at 25°C, 120 VAC, 60 Hz.

Thermal Specifications

Because the MDrive consists of two core components, a drive and a motor, close attention must be paid to the thermal environment where the device is used. The following maximum temperatures apply to the MDrive23:

Heat Sink Temperature (Max) 85°C

Motor Temperature (Max) 100°C



* Not available for MDO23 Speed Control or 75 VDC MDM23 Microstepping

Figure 3.2.2: Interface Options

Motor Specifications

N **NOTE!** The following specifications apply to all rotary variants of the MDrive23, the standard rotary as well as the encoder and control knob versions.

MDrive 2218 Motor Specifications and Speed/Torque Curves

MD2218	
Holding Torque oz-in (N-cm)	90 (64)
Detent Torque oz-in (N-cm)	3.9 (2.7)
Rotor Inertia oz-in-sec ² (kg-cm ²)	0.0025 (0.18)
Weight (Motor & Driver) oz (g)	20.1 (569.8)

Table 3.2.1: Rotary MDrive2218 Motor Specifications

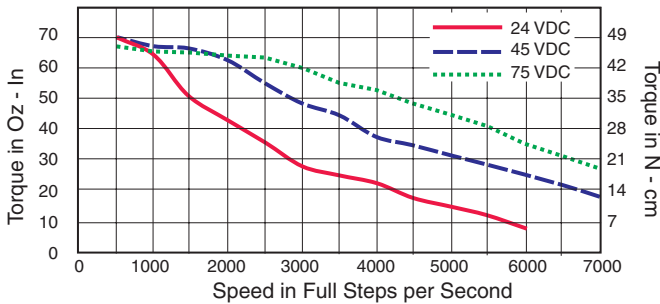


Figure 3.2.3: Rotary MDrive 2218 Speed/Torque Data (100% Current)

MDrive 2222 Motor Specifications and Speed/Torque Curves

MD2222	
Holding Torque oz-in (N-cm)	144 (102)
Detent Torque oz-in (N-cm)	5.6 (3.92)
Rotor Inertia oz-in-sec ² (kg-cm ²)	0.0037 (0.26)
Weight (Motor & Driver) oz (g)	24.4 (691.7)

Table 3.2.2: Rotary MDrive2222 Motor Specifications

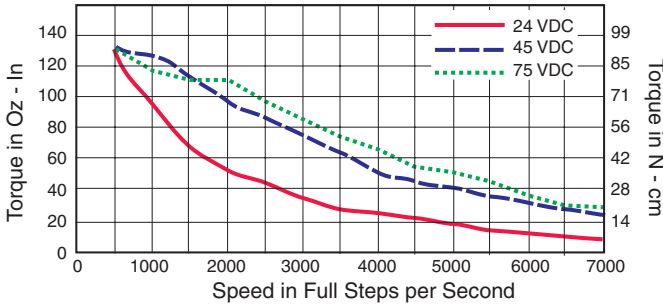


Figure 3.2.4: Rotary MDrive 2222 Speed/Torque Data (100% Current)

MDrive 2231 Motor Specifications and Speed/Torque Curves

MD2231	
Holding Torque oz-in (N-cm)	239 (169)
Detent Torque oz-in (N-cm)	9.7 (6.86)
Rotor Inertia oz-in-sec ² (kg-cm ²)	0.0065 (0.46)
Weight (Motor & Driver) oz (g)	38.5 (1091.5)

Table 3.2.3: Rotary MDrive2231 Motor Specifications

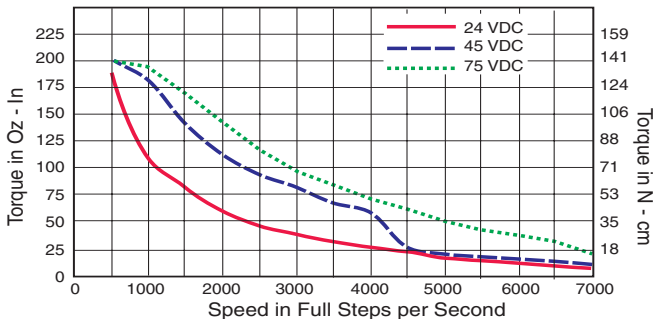


Figure 3.2.5: Rotary MDrive 2231 Speed/Torque Data (100% Current)

Electrical Specifications

MDrive23 Microstepping

Input Voltage (+V) Range	+12 to +48* / +24 to +75 VDC
Isolated Inputs	Step Clock, Direction & Enable
Isolated Input Voltage Range** (Sinking or Sourcing)	+5 to +24VDC
Isolated Current**	
+5 Volt (Max)	8.7 mA
+24 Volt (Max)	14.6 mA
Step Frequency (Max)	2 MHz
Step Frequency Minimum Pulse Width	400 nS
Steps per Revolution	400, 800, 1000, 1600, 2000, 3200, 5000, 6400, 10000, 12800, 25000, 25600, 50000, 51200

* 12-48 VDC is the only input voltage available for MDrive23 with C Connector.

** Only available for MDrive23 with C connector.

MDrive23 Speed Control

Input Voltage (+V) Range	+12 to +48 / +24 to +75 VDC
Speed Control Input	0 to +5 VDC / PWM, 0 to 20mA or 4 to 20mA
A/D Resolution	10 bit
Speed Control Potentiometer Resistance	10 k Ohm
Start/Stop, Direction (Low Level Input)	0 to 1.5 VDC
Start/Stop, Direction (High Level Input)	+3.0 to +5.0 VDC
Input Pull-up Resistance (to +5 VDC) Stop/Start, Direction	4.99 k Ω
Isolated Inputs	Voltage/Current/PWM, Start/Stop, Direction
PWM Input Frequency	15 to 25 kHz

Recommended Wire Sizes

Recommended Wire Size

Logic Wiring	22 AWG
Power and Ground	See Appendix A “Recommended Cable Configurations”



WARNING! The maximum +48 or +75 VDC Input Voltage of the MDrive23 includes Motor Back EMF, Power Supply Ripple and High Line.

A characteristic of all motors is back EMF. Back EMF is a source of current that can push the output of a power supply beyond the maximum operating voltage of the driver. As a result, damage to the stepper driver could occur over a period of time. Care should be taken so that the back EMF does not exceed the maximum input voltage rating of the MDrive23.

SECTION 3.3

Linear MDrive23 Specifications

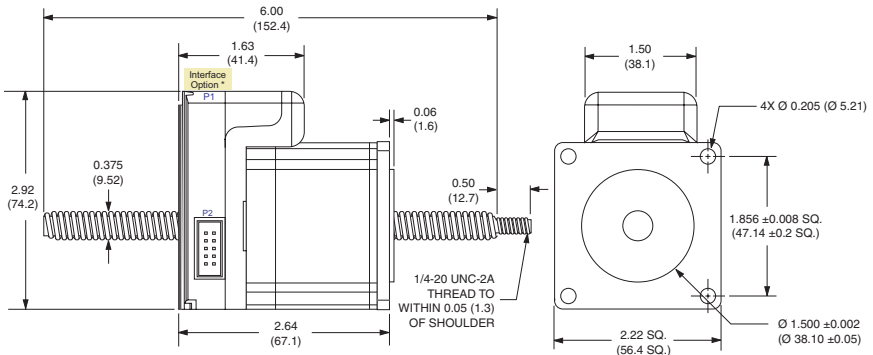
Section Overview

This section contains mechanical, motor and electrical specifications specific to the Linear MDrive23. Shown are:

- Mechanical Specifications
- Motor Specifications
- Electrical Specifications

Mechanical Specifications

Dimensions in inches (mm)



* See Interface Options on previous page

Figure 3.3.1: Linear Actuator MDrive23 Mechanical Specifications

Motor Specifications (Linear)

MDrive23 Linear Actuator	
Maxium Thrust lbs (kg)	200 (90.7)
Weight (Motor+Driver without screw) oz (g)	20.4 (578.3)

Table 3.3.1: Linear Actuator MDrive23 Motor Specifications

Force/Speed Curve: 24 VDC

Refer to the table on the following page for screw pitch information.

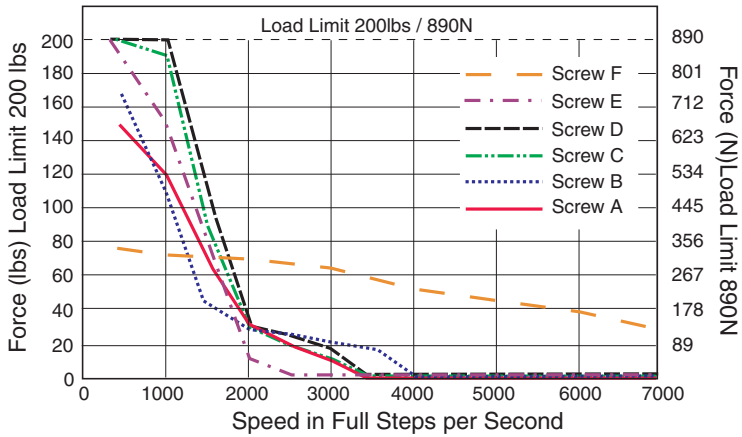


Figure 3.3.2: Force/Speed Curve - 24VDC (100% Current)

Force/Speed Curve: 45 VDC

Refer to the table on the following page for screw pitch information.

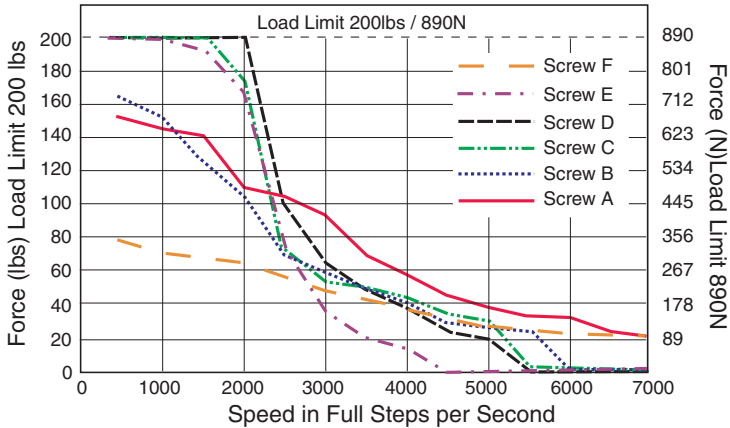


Figure 3.3.3: Force/Speed Curve - 45VDC (100% Current)

Force/Speed Curve: 75 VDC

Refer to the table below for screw pitch information.

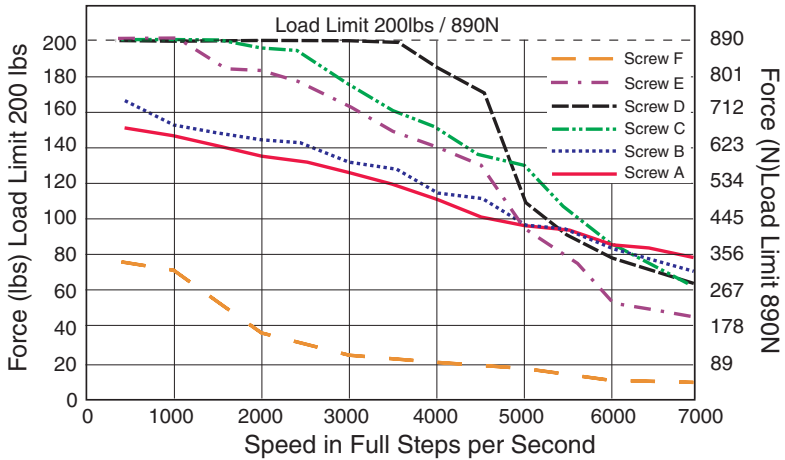


Figure 3.3.4: Force/Speed Curve - 75VDC (100% Current)

Acme Screws for MDrive23	
Screw	Travel/Full Step - Inches (mm)
F	0.002 (0.0508)
A	0.001 (0.0254)
B	0.000833 (0.0211582)
C	0.0005 (0.0127)
D	0.0004167 (0.01058418)
E	0.0003125 (0.0079375)

Table 3.3.2: Acme Screws for the MDrive23 Linear Actuator



WARNING: The maximum axial load limit for the MDrive23 motor is 200 lbs (90.7 kg). Do not exceed this rating!



WARNING: The Acme screw **MUST NOT** deflect more than ± 1 degree perpendicular to the motor face. Additional support for radial loads may be required!

APPENDIX A

Recommended Cable Configurations

Cable length, wire gauge and power conditioning devices play a major role in the performance of your MDrive17 and MDrive23.

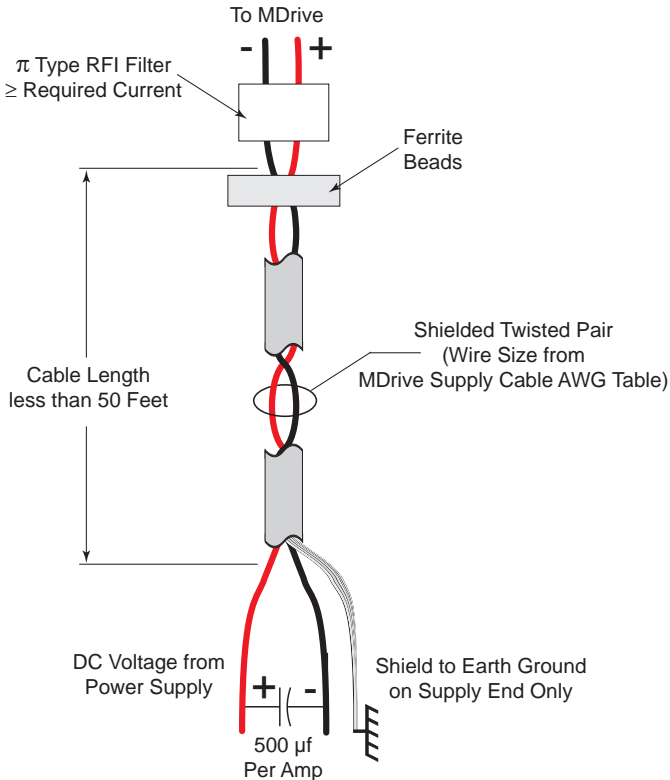
NOTE: These recommendations will provide optimal protection against EMI and RFI. The actual cable type, wire gauge, shield type and filtering devices used are dependent on the customer's application and system.

NOTE: The length of the DC power supply cable to an MDrive17 or MDrive23 should not exceed 50 feet.

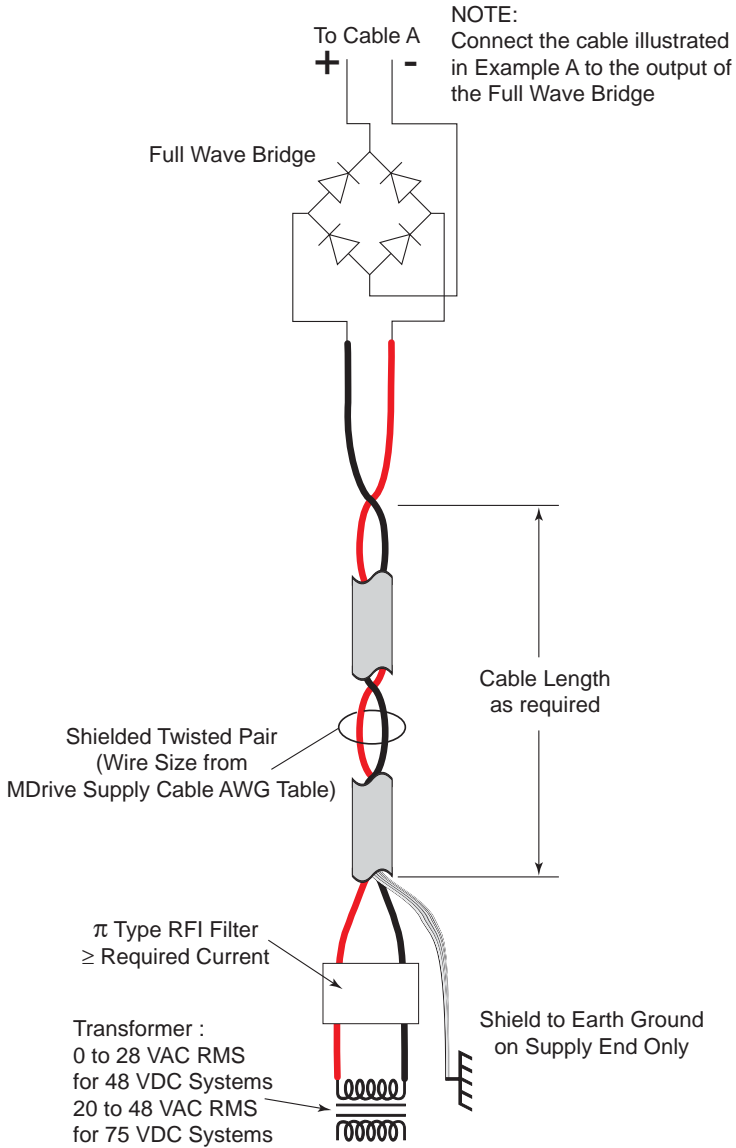
Example A demonstrates the recommended cable configuration for DC power supply cabling under 50 feet long. If cabling of 50 feet or longer is required, the additional length may be gained by adding an AC power supply cable (see Examples B & C).

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

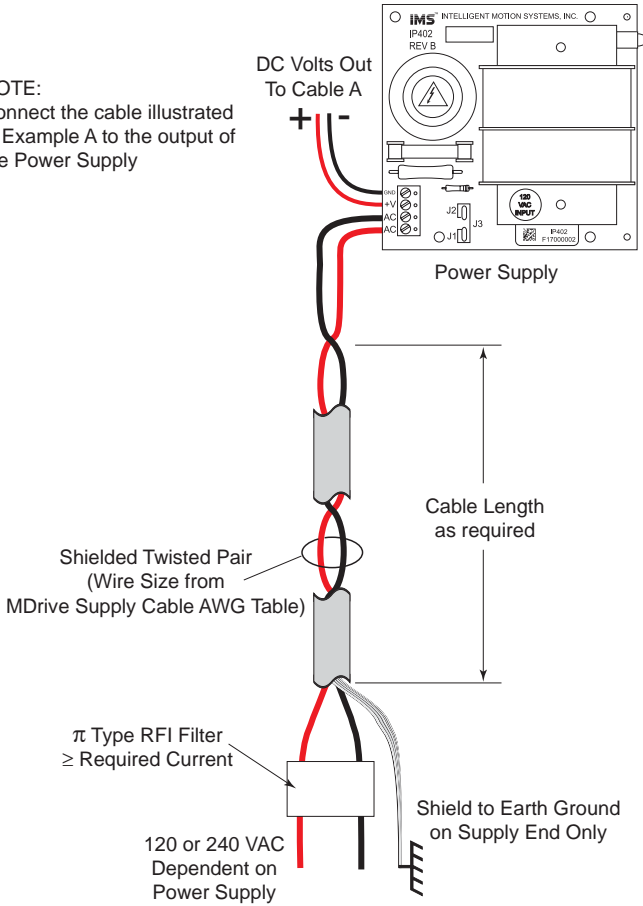


Example B – Cabling 50 Feet or Greater, AC Power to Full Wave Bridge



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

NOTE:
Connect the cable illustrated
in Example A to the output of
the Power Supply





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.

MDrive 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 innustrated in Examples B and C when the cable length is \geq 50 feet. Also, use the same current rating when the alternate AC power is used.					

MDrive17 and MDrive23 Wire Size



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

ADDENDUM

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 $+140^{\circ}$ C. However, the temperature range recommended for the Heat Sink of the MDrive is 0 to $+85^{\circ}$ 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 by diameter and corresponding MDrive.

Gearbox Diameter	MDrive
32 mm	MDrive14
42 mm	MDrive17
52 mm	MDrive23
81 mm	MDrive34

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.

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.

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 recalculate the shock load output torque.

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

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's speed by the required Planetary Gearbox output speed.

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

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 Speed/Torque Tables.

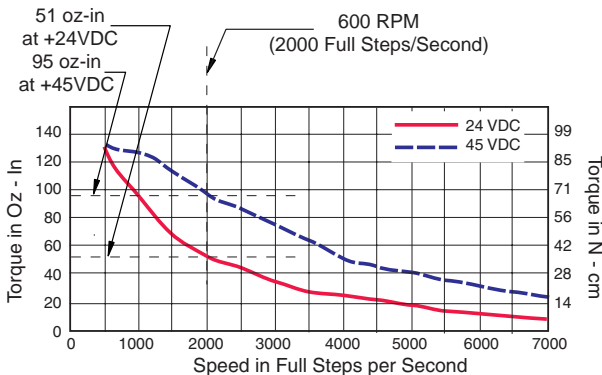
Nominal output torque (T_N) is the actual torque generated at the Planetary Gearbox output shaft which includes reduction ratio (i), gear efficiency (η) and the safety factor (s_f) for the MDrive. Once the reduction ratio (i) is determined, the nominal output torque (T_N) can be calculated as follows:

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

Motor torque \times reduction ratio \times gear efficiency \div safety factor = 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.)



The Speed/Torque Table above is for an MDrive 2222. 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)

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

or

$35 \times 6.75 = 236.25 \times 0.8 = 189 \div 0.7 = 270$ 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 MDrive23 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.

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:

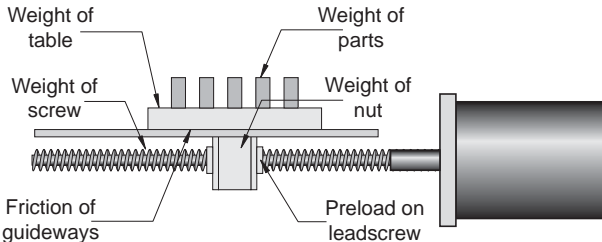
- lead screw
- rack and pinion
- conveyor belt
- rotary table
- belt drive
- chain drive

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:

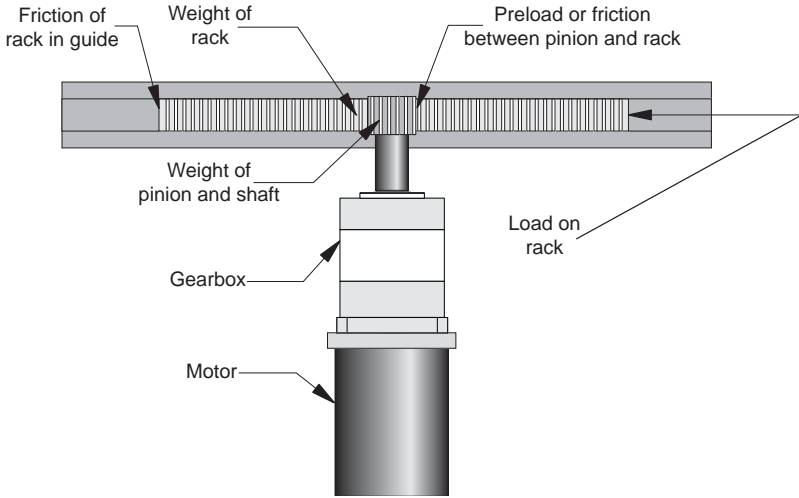
- the weight and preload of the screw
- the weight of the lead screw nut
- the weight of a table or slide
- the friction caused by the table guideways
- the weight of any parts



Rack and Pinion

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

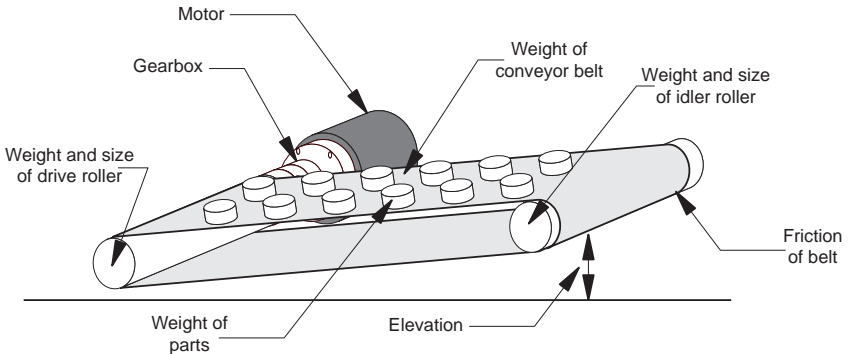
- the weight or mass of the pinion
- the weight or mass of the rack
- the friction and/or preload between the pinion and the rack
- any friction in the guidance of the rack
- the weight or mass of the object the rack is moving



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



Rotary Table

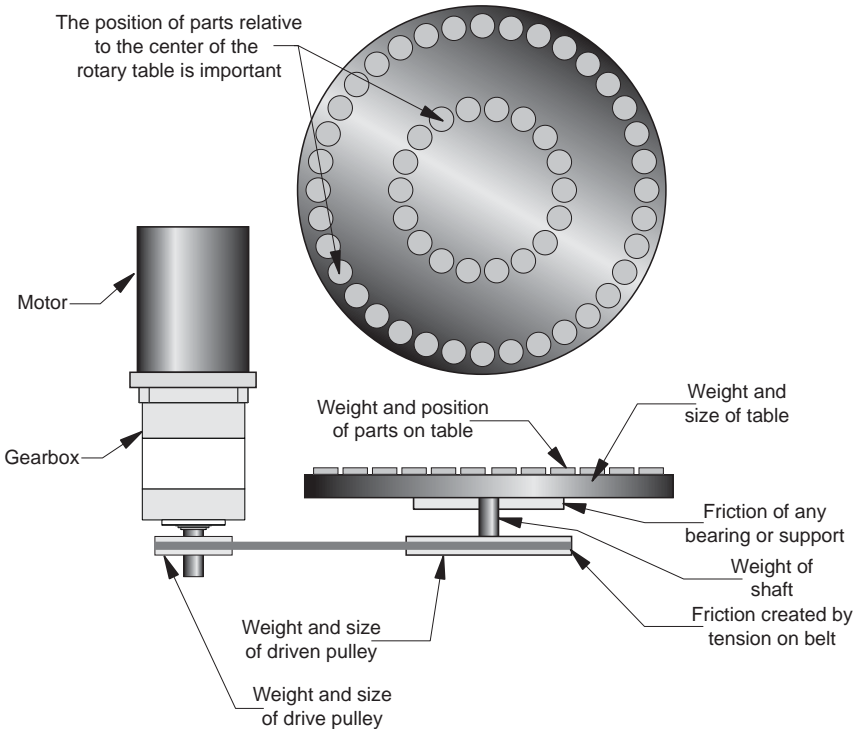
In a system with a rotary table, the following must be considered:

- 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:

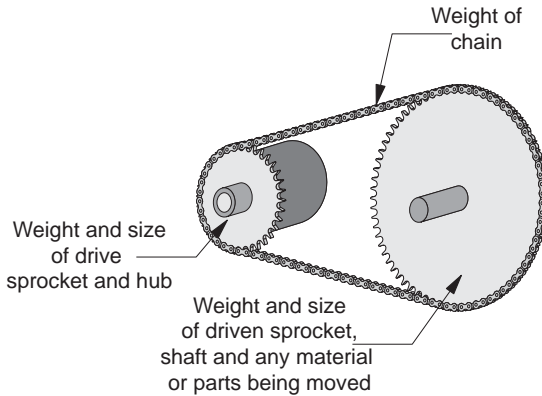
- the weight or mass and size of the driving pulley
- the tension and/or friction of the belt
- the weight or mass and size of the driven pulley
- any load the system may be moving or carrying



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



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:

$$J_L = \text{System Inertia in oz-in-sec}^2$$

$$J_{ref} = \text{Reflected Inertia in oz-in-sec}^2$$

$$Z = \text{Gearbox Ratio}$$

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.

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

Where:

$$Z_{opt} = \text{Optimal Gearbox Ratio}$$

$$J_L = \text{System Inertia in oz-in-sec}^2$$

$$J_{ref} = \text{Desired Reflected Inertia in oz-in-sec}^2 \text{ (Motor Inertia)}$$

Planetary Gearbox Inertia

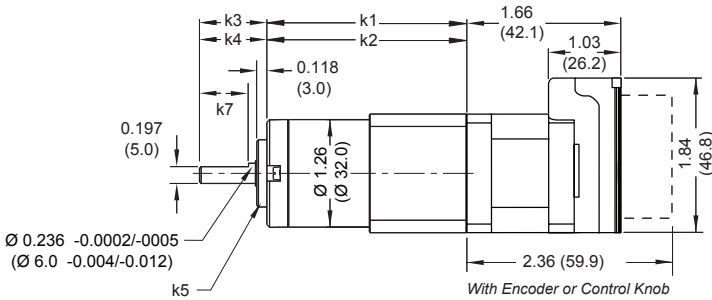
In addition to System Inertia, the Planetary Gearbox inertia must also be included when matching system inertia to motor inertia. The Planetary Gearbox inertia varies with the ratio and the number of stages. The table below lists the inertia values for the MDrive14, 17, 23 and 34 Planetary Gearbox. The values are in oz-in-sec² (ounce-inches-second squared). To calculate the inertia in kg-cm² (kilograms-centimeter squared) multiply oz-in-sec² by 70.6154.

Planetary Gearbox Inertia Moments (oz-in-sec ²)					
Stages	Rounded Ratio	MDrive 14 Gearbox	MDrive 17 Gearbox	MDrive 23 Gearbox	MDrive 34 Gearbox
1-Stage	4:1	0.00002181	0.00006627	0.00025986	0.00233660
	5:1	0.00001614	0.00004362	0.00017461	0.00154357
	7:1	0.00001260	0.00003328	0.00016030	0.00128867
2-Stage	14:1	0.00002110	0.00006245	0.00024230	0.00219499
	16:1	0.00001770	0.00005084	0.00020406	0.00179847
	18:1	0.00001784	0.00005070	0.00020335	0.00182679
	19:1	0.00001586	0.00004149	0.00016512	0.00141612
	22:1	0.00001586	0.00004135	0.00016469	0.00148693
	25:1	0.00001359	0.00003200	0.00013453	0.00177015
	27:1	0.00001600	0.00004121	0.00016441	0.00148693
	29:1	0.00001359	0.00003186	0.00013425	0.00124619
	35:1	0.00001374	0.00003186	0.00013411	0.00126035
	46:1	0.00001388	0.00003186	0.00013411	0.00126035
3-Stage	51:1	0.00002110	0.00006245	0.00024230	0.00218082
	59:1	0.00001770	0.00005084	0.00020406	0.00178431
	68:1	0.00001784	0.00005070	0.00020335	0.00179847
	71:1	0.00001586	0.00004149	0.00016512	0.00147276
	79:1	0.00001784	0.00005070	0.00020335	0.00179847
	93:1	0.00001359	0.00003200	0.00016441	0.00124619
	95:1	0.00001586	0.00004135	0.00020335	0.00147276
	100:1	0.00001600	0.00004121	0.00016441	0.00148693
	107:1	0.00001359	0.00003186	0.00013425	0.00124619
	115:1	0.00001600	0.00004121	0.00016441	0.00148693
	124:1	0.00001359	0.00003186	0.00013425	0.00124619
	130:1	0.00001374	0.00003186	0.00013411	0.00124619
	139:1	0.00001600	0.00004121	0.00016441	0.00144444
	150:1	0.00001374	0.00003186	0.00013411	0.00124619
	169:1	0.00001359	0.00003186	0.00013411	0.00126035
	181:1	0.00001374	0.00003186	0.00013411	0.00124619
	195:1	0.00001359	0.00003186	0.00013411	0.00126035
	236:1	0.00001359	0.00003186	0.00013411	0.00126035
308:1	0.00001359	0.00003186	0.00013411	0.00126035	

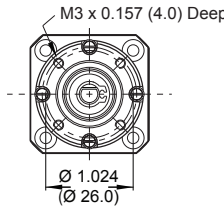
Mechanical Specifications

MDrive14 with Planetary Gearbox

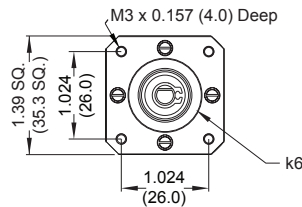
Dimensions in Inches (mm)



**Front View
Planetary Gearbox**



**Front View
Optional NEMA 14
Output Flange for Planetary Gearbox**

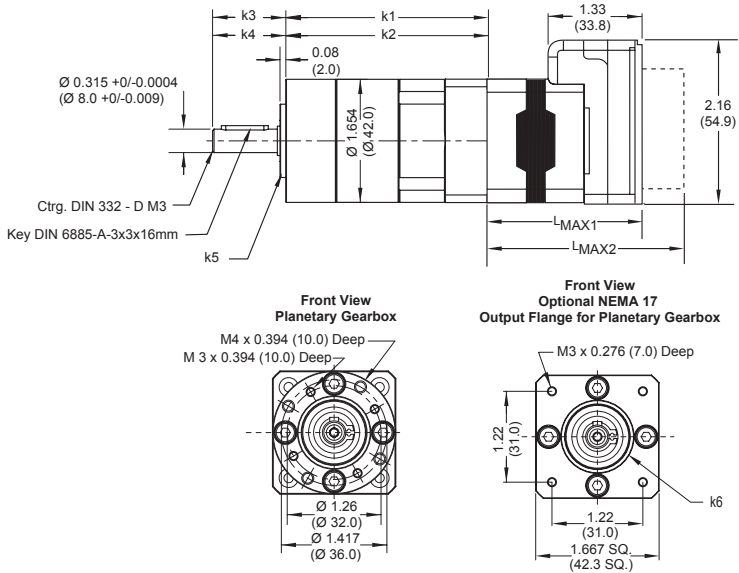


Parameters	Planetary Gearbox	1-Stage	2-Stage	3-Stage
	k1	Standard Gearbox	1.969 (50.0) ±0.02 (0.5)	2.343 (59.5) ±0.02 (0.5)
k2	w/NEMA Flange	2.008 (51.0) ±0.02 (0.5)	2.382 (60.5) ±0.02 (0.5)	2.756 (70.0) ±0.02 (0.5)
k3	Standard Shaft	0.787 (20.0)		
k4	Shaft w/NEMA Flange	0.748 (19.0)		
k5	Standard Locator Diameter	0.787 (20.0) +0/-0.0013 (+0/-0.033)		
k6	Locator Diameter w/NEMA Flange	0.866 (22.0) +0/-0.0013 (+0/-0.033)		
k7	Length of Flat on Shaft	0.394 (10.0)		
Parameters	Max Output Torque	106 oz-in (0.75 Nm)	318 oz-in (2.25 Nm)	637 oz-in (4.5 Nm)
	Efficiency	80%	75%	70%
	Max Backlash	1.5°	2.0°	2.5°
Loads	Max Radial Load	9.0 lb-force (40 N)	15.7 lb-force (70 N)	22.0 lb-force (100 N)
	Max Axial Load	2.2 lb-force (10 N)	4.5 lb-force (20 N)	6.7 lb-force (30 N)
Weight	Gearbox Only	5.7 oz (162 gm)	7.5 oz (213 gm)	9.3 oz (264 gm)
	Gearbox w/NEMA Flange	5.9 oz (168 gm)	7.8 oz (221 gm)	9.6 oz (273 gm)

Planetary Gearbox Specifications for MDrive14

MDrive17 with Planetary Gearbox

Dimensions in Inches (mm)

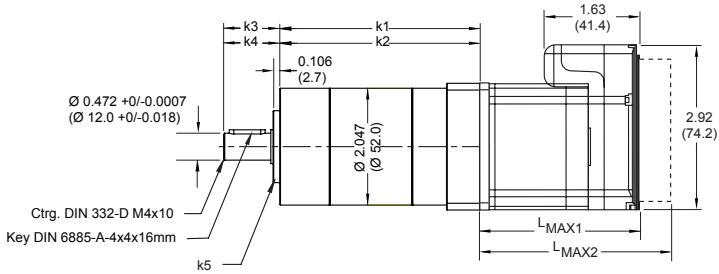


		Planetary Gearbox	1-Stage	2-Stage	3-Stage
Dimensions Inches (mm)	k1	Standard Gearbox	2.736 (69.5) ±0.02 (0.5)	3.248 (82.5) ±0.02 (0.5)	3.760 (95.5) ±0.02 (0.5)
	k2	w/NEMA Flange	2.858 (72.6) ±0.02 (0.5)	3.370 (85.5) ±0.02 (0.5)	3.882 (98.6) ±0.02 (0.5)
	k3	Standard Shaft	0.984 (25.0)		
	k4	Shaft w/NEMA Flange	0.846 (21.5)		
	k5	Standard Locator Diameter	0.984 (25.0) +0/-0.002 (+0/-0.052)		
	k6	Locator Diameter w/NEMA Flange	0.866 (22.0) +0/-0.002 (+0/-0.052)		
Parameters	Max Output Torque	425 oz-in (3.0 Nm)	1062 oz-in (7.5 Nm)	2124 oz-in (15.0 Nm)	
	Efficiency	80%	75%	70%	
	Max Backlash	0.80°	0.85°	0.90°	
Loads	Max Radial Load	36 lb-force (160 N)	52 lb-force (230 N)	67.5 lb-force (300 N)	
	Max Axial Load	11 lb-force (50 N)	18 lb-force (80 N)	25 lb-force (110 N)	
Weight	Gearbox Only	14.3 oz (406 gm)	17.9 oz (508 gm)	21.5 oz (609 gm)	
	Gearbox w/NEMA Flange	14.8 oz (420 gm)	18.5 oz (525 gm)	22.2 oz (630 gm)	
Length Inches (mm)	MDrive17	Size 1713	Size 1715	Size 1719	
	L_{MAX1} Single Shaft Version	2.20 (55.9)	2.43 (61.7)	2.75 (69.8)	
	L_{MAX2} Encoder or Control Knob Version	2.92 (74.2)	3.15 (80.0)	3.47 (88.1)	

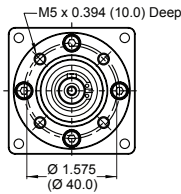
Planetary Gearbox Specifications for MDrive17

MDrive23 with Planetary Gearbox

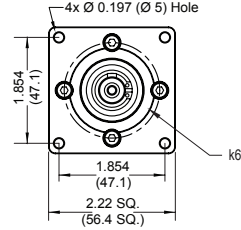
Dimensions in Inches (mm)



Front View
Planetary Gearbox



Front View
Optional NEMA 23
Output Flange for Planetary Gearbox



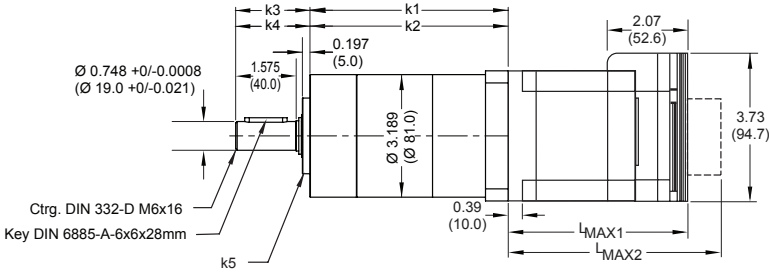
Dimensions Inches (mm)	Planetary Gearbox	1-Stage	2-Stage	3-Stage
	k1	Standard Gearbox	2.976 (75.6) ± 0.02 (0.5)	3.531 (89.7) ± 0.02 (0.5)
k2	w/NEMA Flange	3.036 (77.1) ± 0.02 (0.5)	3.590 (91.2) ± 0.02 (0.5)	4.146 (105.3) ± 0.02 (0.5)
k3	Standard Shaft	0.984 (25.0)		
k4	Shaft w/NEMA Flange	0.925 (23.5)		
k5	Standard Locator Diameter	1.260 (32.0) $+0/-0.0015$ ($+0/-0.039$)		
k6	Locator Diameter w/NEMA Flange	1.50 (38.1) $+0/-0.0015$ ($+0/-0.039$)		
Parameters	Max Output Torque	566 oz-in (4.0 Nm)	1699 oz-in (12.0 Nm)	3540 oz-in (25.0 Nm)
	Efficiency	80%	75%	70%
	Max Backlash	0.70°	0.75°	0.80°
Loads	Max Radial Load	45 lb-force (200 N)	72 lb-force (320 N)	101 lb-force (450 N)
	Max Axial Load	13 lb-force (60 N)	22 lb-force (100 N)	34 lb-force (150 N)
Weight	Gearbox Only	25.0 oz (711 gm)	32.2 oz (914 gm)	39.4 oz (1117 gm)
	Gearbox w/NEMA Flange	25.9 oz (735 gm)	33.3 oz (945 gm)	40.7 oz (1155 gm)

Length Inches (mm)	MDrive23	Size 2218	Size 2222	Size 2231
	L_{MAX1} Single Shaft Version		2.63 (66.8)	3.00 (76.2)
L_{MAX2} Encoder or Control Knob Version		3.35 (85.1)	3.70 (94.0)	4.57 (116.1)

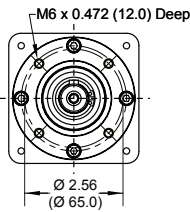
Planetary Gearbox Specifications for MDrive23

MDrive34 with Planetary Gearbox

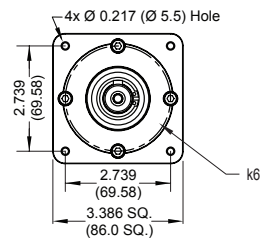
Dimensions in Inches (mm)



Front View
Planetary Gearbox



Front View
Optional NEMA 34
Output Flange for Planetary Gearbox



Dimensions Inches (mm)	Planetary Gearbox		1-Stage	2-Stage	3-Stage
	k1	Standard Gearbox	4.315 (109.6) ±0.02 (0.5)	5.169 (131.3) ±0.02 (0.5)	6.024 (153.0) ±0.02 (0.5)
k2	w/NEMA Flange	4.433 (112.6) ±0.02 (0.5)	5.287 (134.3) ±0.02 (0.5)	6.142 (156.0) ±0.02 (0.5)	
k3	Standard Shaft	1.929 (49.0)			
k4	Shaft w/NEMA Flange	1.811 (46.0)			
k5	Standard Locator Diameter	1.969 (50.0) +0.0006/-0.0004 (+0.015/-0.010)			
k6	Locator Diameter w/NEMA Flange	2.874 (73.0) +0/-0.0012 (+0/-0.030)			
Parameters	Max Output Torque	2832 oz-in (20.0 Nm)	8496 oz-in (60.0 Nm)	16992 oz-in (120.0 Nm)	
	Efficiency	80%	75%	70%	
	Max Backlash	1.0°	1.5°	2.0°	
Loads	Max Radial Load	90 lb-force (400 N)	135 lb-force (600 N)	225 lb-force (1000 N)	
	Max Axial Load	18 lb-force (80 N)	27 lb-force (120 N)	45 lb-force (200 N)	
Weight	Gearbox Only	64.4 oz (1827 gm)	89.5 oz (2538 gm)	114.6 oz (3248 gm)	
	Gearbox w/NEMA Flange	66.7 oz (1890 gm)	92.6 oz (2625 gm)	118.5 oz (3360 gm)	
Length Inches (mm)	MDrive34	Size 3424	Size 3431	Size 3447	
	L_MAX1 Single Shaft or Encoder Version	3.81 (96.8)	4.60 (116.80)	6.17 (156.7)	
	L_MAX2 Control Knob Version	4.97 (126.2)	5.76 (146.3)	7.34 (186.4)	

Planetary Gearbox Specifications for MDrive34

Available Ratios

Available Ratios for Planetary Gearbox			
Stages	Rounded Ratio	Fractional Ratio	Decimal Ratio*
1-Stage	4:1	63 / 17	3.7058823529411764
	5:1	57 / 11	5.1818181818181818
	7:1	27 / 4	6.7500000000000000
2-Stage	14:1	3969 / 289	13.7335640138408304
	16:1	270 / 17	15.8823529411764705
	18:1	900 / 49	18.3673469387755102
	19:1	3591 / 187	19.2032085561497326
	22:1	1710 / 77	22.2077922077922077
	25:1	1701 / 68	25.0147058823529411
	27:1	3249 / 121	26.8512396694215000
	29:1	405 / 14	28.9285714285714876
	35:1	1539 / 44	34.9772727272727272
	46:1	729 / 16	45.5625000000000000
3-Stage	51:1	250047 / 4913	50.8949725218807246
	59:1	17010 / 289	58.8581314878892733
	68:1	8100 / 119	68.0672268907563025
	71:1	226223 / 3179	71.1616860648002516
	79:1	27000 / 343	78.7172011661807581
	93:1	107163 / 1156	92.7015570934256055
	95:1	51300 / 539	95.1762523191094619
	100:1	204687 / 2057	99.5075352455031599
	107:1	3645 / 34	107.2058823529411764
	115:1	97470 / 847	115.0767414403778040
	124:1	6075 / 49	123.9795918367346938
	130:1	96957 / 748	129.6216577540106951
	139:1	185193 / 1331	139.1382419233658903
	150:1	23085 / 154	149.9025974025974025
	169:1	45927 / 272	168.8492647058823529
	181:1	87723 / 484	181.2458677685950413
	195:1	10935 / 56	195.2678571428571428
	236:1	41553 / 176	236.0965909090909090
308:1	19683 / 64	307.5468750000000000	

* The Decimal Ratio shown here has been limited to 16 places.

Installing a Driving Device on a Planetary Gearbox



WARNING!

The MDrive and its Heat Sink must not be subjected to any axial or other pressing force as damage may result to the unit and void the Warranty.

When installing a gear, pulley, coupling or other driving device to the output shaft of the Planetary Gearbox, IMS recommends that it be “slip-fit” onto the shaft and properly secured, i.e. with set screws.

DO NOT press fit the device onto the shaft.

NEVER tap or hammer a driving device onto the output shaft of the Planetary Gearbox.

Disconnecting the Planetary Gearbox from the MDrive may void the Warranty.

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."

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 changes 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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Excellence in Motion™

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