

**MFORCE™**  
**POWER DRIVE**  
*Plus*  
**MICROSTEPPING**



**OPERATING  
INSTRUCTIONS**



## Important information

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

## Qualification of personnel

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

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

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

## Intended Use

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

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

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

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

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

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

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

*This page intentionally left blank*

# Table Of Contents

<b>Getting Started: Microstepping MForce PowerDrive .....</b>	<b>1-1</b>
Before You Begin.....	1-1
Tools and Equipment Required.....	1-1
Connecting the Power Supply .....	1-1
Connect Opto Reference and Logic Inputs.....	1-2
Connecting the Motor .....	1-2

## Part 1: Hardware Reference

<b>Section 1.1: Introduction to the Microstepping MForce PowerDrive .....</b>	<b>1-5</b>
Configuring .....	1-5
Features and Benefits.....	1-6
<b>Section 1.2: Microstepping MForce PowerDrive Detailed Specifications .....</b>	<b>1-7</b>
General Specifications .....	1-7
Setup Parameters .....	1-8
Mechanical Specifications.....	1-8
Pin Assignment and Description .....	1-9
P1 12-Pin Locking Wire Crimp Connector - Power, I/O and SPI Communications.....	1-9
P3 Connector - DC Power, 2-Pin Locking Wire Crimp .....	1-10
P4 Connector - Motor .....	1-10

## Part 2: Connecting and Interfacing

<b>Section 2.1: Mounting and Connection Guidelines .....</b>	<b>3</b>
Mounting Recommendations.....	3
Securing Power Leads and Logic Leads.....	4
Layout and Interface Guidelines.....	4
Rules of Wiring .....	5
Rules of Shielding .....	5
Recommended Wiring.....	5
Recommended Mating Connectors and Pins .....	5
<b>Section 2.2: Interfacing DC Power.....</b>	<b>7</b>
Choosing a Power Supply for Your MForce PowerDrive .....	7
DC Power Supply Recommendations.....	8
Recommended IMS Power Supplies.....	8
Basic DC Power Connection.....	9
Recommended Power and Cable Configurations .....	9
Example A: DC Power Cabling Under 50 Feet.....	9
Example B: AC Power to Full Wave Bridge Cabling Over 50 Feet.....	10
Example C – Cabling 50 Feet or Greater, AC Power to Power Supply .....	10
<b>Section 2.3: Motor Selection and Interface .....</b>	<b>11</b>
Selecting a Motor .....	11
Types and Construction of Stepping Motors.....	11
Sizing a Motor for Your System.....	11
Recommended IMS Motors .....	12
IMS Inside Out Stepper Motors.....	13
Connecting the Motor .....	14
8 Lead Motors .....	14
6 Lead Motors.....	15
4 Lead Motors.....	16
Recommended Motor Cabling .....	16
Example A: Motor Cabling Less Than 50 Feet .....	16
Example B: Motor Cabling Greater Than 50 Feet.....	17
Recommended Motor Cable AWG Sizes.....	17
<b>Section 2.4: Logic Interface and Connection .....</b>	<b>19</b>
Optically Isolated Logic Inputs.....	19
Isolated Logic Input Pins and Connections .....	19
Isolated Logic Input Characteristics.....	19

Enable Input .....	19
Clock Inputs .....	20
Optocoupler Reference.....	22
Input Connection Examples.....	23
Open Collector Interface Example .....	
Switch Interface Example .....	24
Minimum Required Connections.....	25
<b>Section 2.5: Connecting SPI Communications .....</b>	<b>26</b>
Connecting the SPI Interface .....	26
SPI Signal Overview.....	26
SPI Pins and Connections .....	27
Logic Level Shifting and Conditioning Circuit.....	27
SPI Master with Multiple Microstepping MForce PowerDrive .....	28
<b>Section 2.6: Using the IMS SPI Motor Interface.....</b>	<b>29</b>
Installation .....	29
Configuration Parameters and Ranges .....	29
Color Coded Parameter Values.....	29
IMS SPI Motor Interface Menu Options.....	30
Screen 1: The Motion Settings Configuration Screen .....	31
MSEL (Microstep Resolution Selection) .....	32
HCDDT (Hold Current Delay Time) .....	33
MRC (Motor Run Current) .....	33
MHC (Motor Hold Current).....	33
DIR (Motor Direction).....	33
User ID.....	33
IMS SPI Motor Interface Button Functions .....	33
Screen 2: I/O Settings Configuration Screen .....	34
Input Clock Type.....	34
Input Clock Filter.....	34
Enable Active High/Low .....	34
Warning Temperature .....	34
IMS Part Number/Serial Number Screen .....	35
Fault Indication.....	35
Upgrading the Firmware in the Microstepping MForce PowerDrive.....	36
The IMS SPI Upgrader Screen.....	36
Upgrade Instructions.....	36
Initialization Screen.....	37
Port Menu.....	37
Motor Settings Screen (PWM Current Control) .....	38
PWM Mask .....	38
Maximum PWM Duty Cycle (%) Parameter .....	39
PWM Frequency Range Parameter.....	39
PWM Control Bits .....	40
Example PWM Settings By Motor Specifications .....	40
<b>Section 2.7: Using User-Defined SPI.....</b>	<b>41</b>
SPI Timing Notes.....	41
Check Sum Calculation for SPI.....	41
SPI Commands and Parameters.....	42
SPI Communications Sequence .....	43

## Appendices

<b>Appendix A: Optional Prototype Development Cables.....</b>	<b>A-3</b>
MD-CC300-000: USB to SPI Parameter Setup Cable .....	A-3
Adapter Cables .....	A-3
Installation Procedure for the MD-CC300-000 .....	A-4
Installing the Cable/VCP Drivers.....	A-4
Determining the Virtual COM Port (VCP) .....	A-6
PD12-1434-FL3 — Power, I/O and SPI.....	A-7
Prototype Development Cable PD02-2300-FL3 .....	A-8
Prototype Development Cable PD04-MF34-FL3 .....	A-8

## List of Figures

Figure GS.1: Minimum Logic and Power Connections .....	1-1
--	-----

### Part 1: Hardware Reference

Figure 1.1.1: Microstepping MForce PowerDrive .....	1-5
Figure 1.2.1: MForce PowerDrive Mechanical Specifications.....	1-8
Figure 1.2.2: P1 — 12-Pin Locking Wire Crimp Pin Configuration .....	1-9
Figure 1.2.3: P3 — 2-Pin Locking Wire Crimp Pin Configuration .....	1-10
Figure 1.2.4: P4 — 4-Pin Locking Wire Crimp Pin Configuration .....	1-10

### Part 2: Connecting and Interfacing

Figure 2.1.1: Base Mounting the MForce PowerDrive .....	3
Figure 2.1.2: End Mounting the MForce PowerDrive .....	4
Figure 2.2.1: IMS ISP300 Switch Mode Power Supply.....	7
Figure 2.2.2: MForce PowerDrive DC Power Connection .....	9
Figure 2.2.3: DC Cabling - Under 50 Feet.....	9
Figure 2.2.4: AC To Full Wave Bridge Rectifier, Cabling over 50 Feet .....	10
Figure 2.2.5: AC Cabling - 50 Feet or Greater - AC To Power Supply .....	10
Figure 2.3.1 A & B: Per Phase Winding Inductance .....	12
Figure 2.3.2: 8 Lead Motor Series Connections .....	14
Figure 2.3.3: 8 Lead Motor Parallel Connections.....	14
Figure 2.3.4: 6 Lead Half Coil (Higher Speed) Motor Connections .....	15
Figure 2.3.5: 6 Lead Half Coil (Higher Speed) Motor Connections .....	15
Figure 2.3.6: 4 Lead Motor Connections.....	16
Figure 2.3.7: Motor Cabling Less than 50 Feet.....	16
Figure 2.3.8: Motor Cabling Greater than 50 Feet.....	17
Figure 2.4.1: Isolated Logic Pins and Connections .....	19
Figure 2.4.2: Input Clock Functions .....	20
Figure 2.4.3: Clock Input Timing Characteristics.....	21
Figure 2.4.4: Optocoupler Input Circuit Diagram.....	22
Figure 2.4.5: Open Collector Interface Example.....	23
Figure 2.4.6: Switch Interface Example .....	24
Figure 2.4.7: Minimum Required Connections .....	25
Figure 2.5.1: MD-CC300-000 Parameter Setup Cable.....	26
Figure 2.5.2: SPI Pins and Connections, 12-Pin Wire Crimp.....	27
Figure 2.5.3: Logic Level Shifting and Conditioning Circuit .....	27
Figure 2.5.4: SPI Master with a Single Microstepping MForce PowerDrive .....	28
Figure 2.5.5: SPI Master with Multiple Microstepping MForce PowerDrives .....	28
Figure 2.6.1: SPI Motor Interface Color Coding .....	30
Figure 2.6.2: SPI Motor Interface File Menu.....	30
Figure 2.6.3: SPI Motor Interface View Menu.....	30
Figure 2.6.4: SPI Motor Interface Recall Menu .....	31
Figure 2.6.5: SPI Motor Interface Upgrade Menu .....	31
Figure 2.6.6: SPI Motor Interface Help Menu and About Screen .....	31
Figure 2.6.7: SPI Motor Interface Motion Settings Screen.....	32
Figure 2.6.8: SPI Motor Interface I/O Settings Screen.....	34
Figure 2.6.9: SPI Motor Interface Part and Serial Number Screen .....	35
Figure 2.6.10: SPI Motor Interface Upgrade Utility .....	36
Figure 2.6.11: SPI Motor Interface Initialization .....	37
Figure 2.6.12: SPI Motor Interface Port Menu .....	37
Figure 2.7.1: SPI Timing.....	38
Figure 2.7.2: Read/Write Byte Order for Parameter Settings (Default Parameters Shown) .....	40
Figure 2.6.13: Motor Settings Screen.....	38
Figure 2.6.14: PWM Mask Bits.....	38
Figure 2.6.15: PWM Frequency Range .....	39
Figure 2.6.16: PWM Control Bits.....	40
Figure 2.7.1: SPI Timing.....	41
Figure 2.7.2: Read/Write Byte Order for Parameter Settings (Default Parameters Shown) .....	43

## Appendices

Figure A.1: MD-CC300-000 .....	A-3
Figure A.2: MD-CC300-000 Mechanical Specifications.....	A-3
Figure A.3: Typical Setup, Adapter and Prototype Development Cable .....	A-4
Figure A.4: Hardware Update Wizard .....	A-4
Figure A.5: Hardware Update Wizard Screen 2 .....	A-5
Figure A.6: Hardware Update Wizard Screen 3 .....	A-5
Figure A.7: Windows Logo Compatibility Testing.....	A-5
Figure A.8: Hardware Update Wizard Finish Installation.....	A-6
Figure A.9: Hardware Properties.....	A-6
Figure A.10: Windows Device Manager .....	A-6
Figure A.11 PD12-1434-FL3 .....	A-7
Figure A.12: PD02-3400-FL3 .....	A-8
Figure A.13: PD04-MF34-FL3 .....	A-8

## List of Tables

### Part 1: Hardware Reference

Table 1.2.1: Electrical Specifications.....	1-7
Table 1.2.2: Thermal Specifications.....	1-7
Table 1.2.3: I/O Specifications .....	1-7
Table 1.2.4: Communications Specifications .....	1-7
Table 1.2.5: Motion Specifications .....	1-7
Table 1.2.6: Setup Parameters.....	1-8
Table 1.2.7: P1 Connector – Power, I/O and SPI Communications .....	1-9
Table 1.2.8: P3 Connector .....	1-10
Table 1.2.9: P4 Connector.....	1-10

### Part 1: Interfacing and Configuring

Table 2.2.1: Recommended Wire Gauges .....	10
Table 2.3.1: Recommended Wire Gauges.....	17
Table 2.4.1: Input Clocks Timing Table .....	21
Table 2.4.2: Optocoupler Reference Connection.....	22
Table 2.6.1: Setup Parameters and Ranges.....	29
Table 2.6.2: Microstep Resolution Settings.....	32
Table 2.6.3: Hold and Run Current Percentage Equivalents .....	33
Table 2.6.4: Input Clock Filter Settings.....	34
Table 2.6.5: Microstepping MForce PowerDrive Fault Codes .....	35
Table 2.6.6: PWM Mask Settings.....	38
Table 2.6.7: Typical PWM Mask Settings.....	39
Table 2.6.8: Maximum and Initial PWM Frequency .....	39
Table 2.6.9: Example PWM Settings .....	40
Table 2.7.1: SPI Commands and Parameters .....	42

## Appendices

Table A.1: PD12-1434-FL3 Wire Color Codes .....	A-7
Table A.2: PD04-MF34-FL3.....	A-8



# GETTING STARTED

## Microstepping MForce PowerDrive

### Before You Begin

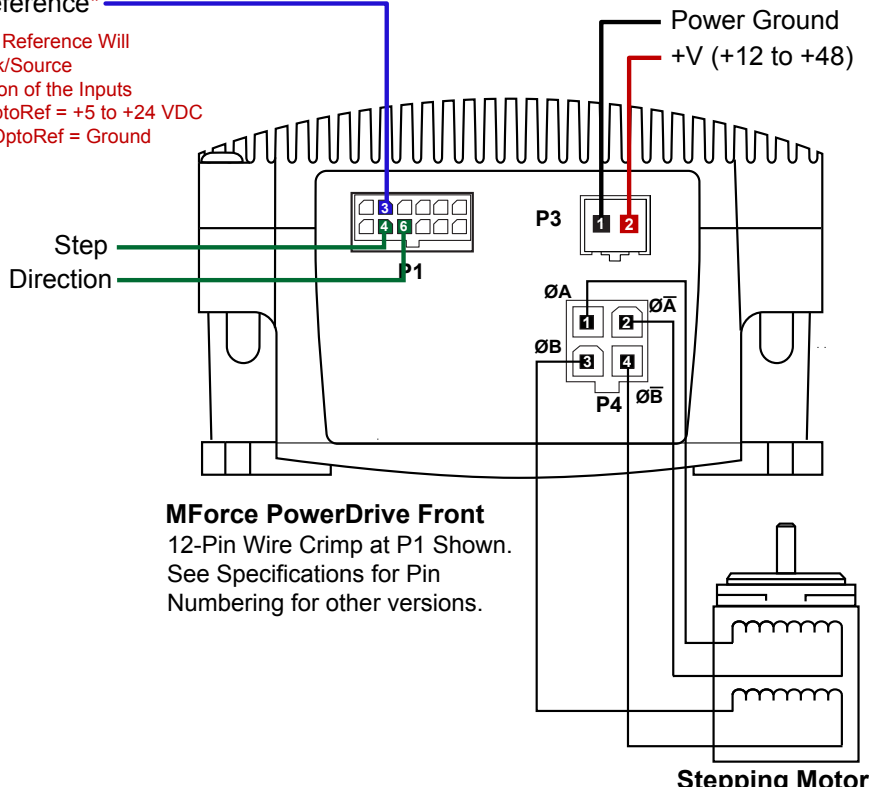
The Getting Started Section is designed to help quickly connect and begin using your Microstepping MForce PowerDrive. The following examples will help you get a motor turning for the first time and introduce you to the basic settings of the drive.

### Tools and Equipment Required

- Microstepping MForce PowerDrive Unit (MFM)
- A NEMA 23 or 34 Size Stepping Motor
- Control Device for Step/Direction
- +5 to +24 VDC Optocoupler Supply (if using sinking output type)
- An Unregulated +12 to +48VDC Power Supply
- Basic Tools: Wire Cutters / Strippers / Screwdriver
- Wire for Power Supply (18 AWG) and Motor (16 AWG)
- 22 AWG Wire for Logic Connections

#### Opto Reference\*

\* The Opto Reference Will set the Sink/Source Configuration of the Inputs  
Sinking: OptoRef = +5 to +24 VDC  
Sourcing: OptoRef = Ground



**MForce PowerDrive Front**  
12-Pin Wire Crimp at P1 Shown.  
See Specifications for Pin Numbering for other versions.

**Stepping Motor**

Figure G.S.1: Minimum Logic and Power Connections

### Connecting the Power Supply

Using the recommended wire, connect the DC output of the power supply to the +V input of the connector appropriate for your Microstepping MForce PowerDrive model.

Connect the power supply ground to the Power Ground pin appropriate for your Microstepping MForce PowerDrive.



**WARNING!** The MForce 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 MForce product.



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



**Note:** 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 MForce PowerDrive.

## **Connect Opto Reference and Logic Inputs**

Using 22 AWG wire, connect the Opto Reference to the desired reference point. The reference will determine whether or not the logic input is sinking or sourcing. If Sinking Inputs are desired, connect the Opto reference to a +5 to +24 VDC Supply. If Sourcing Outputs are desired, the Opto Reference needs to be connected to the Controller Ground.

Connect the Step and Direction inputs to the appropriate outputs of your PLC or controller.

## **Connecting the Motor**

Using the recommended wire, connect the Motor Phases to P3 as shown in Figure GS.1. Ensure that the phases are connected correctly.



# **PART 1: HARDWARE REFERENCE**

**Section 1.1: Introduction to the Microstepping MForce PowerDrive**

**Section 1.2: Microstepping MForce PowerDrive Detailed Specifications**



# SECTION 1.1

## Introduction to the Microstepping MForce PowerDrive

The Microstepping MForce PowerDrive is a high performance, low cost microstepping driver that delivers unsurpassed smoothness and performance achieved through IMS's advanced 2nd generation current control. By applying innovative techniques to control current flow through the motor, resonance is significantly dampened over the entire speed range and audible noise is reduced.

Microstepping MForce PowerDrives accept a broad input voltage range from +12 to +75 VDC, delivering enhanced performance and speed. Oversized input capacitors are used to minimize power line surges, reducing problems that can occur with long runs and multiple drive systems.

An extended operating range of  $-40^{\circ}$  to  $+85^{\circ}\text{C}$  provides long life, trouble free service in demanding environments.

The high, per phase output current of up to 5 Amps RMS, 7 Amps Peak, allows the extremely compact MForce PowerDrive to control a broad array of motors from size 23 to size 42.

The microstepping drive accepts up to 20 resolution settings from full to 256 microsteps per full step, including: degrees, metric and arc minutes. These settings may be changed on-the-fly or downloaded and stored in nonvolatile memory with the use of a simple GUI which is provided. This eliminates the need for external switches or resistors. Parameters are changed via an SPI port.

The versatile Microstepping MForce PowerDrive comes with dual mounting configurations to fit various system needs. All interface connections are accomplished using pluggable locking wire crimp connectors. Optional cables are available for ease of connecting and configuring the MForce, and are recommended with first order.

The Microstepping MForce PowerDrive is a compact, powerful and inexpensive solution that will reduce system cost, design and assembly time for a large range of applications.



Figure 1.1.1: Microstepping MForce PowerDrive

### Configuring

The IMS SPI Motor Interface software is an easy to install and use GUI for configuring the Microstepping MForce PowerDrive from a computer's USB port. GUI access is via the IMS SPI Motor Interface included on the CD shipped with the product, or from [www.imshome.com](http://www.imshome.com). Optional cables are available for ease of connecting and configuring the MForce.

The IMS SPI Motor Interface features:

- Easy installation.
- Automatic detection of MForce version and communication configuration.
- Will not set out-of-range values.
- Tool-tips display valid range setting for each option.
- Simple screen interfaces.

## Features and Benefits

- High Performance Microstepping Driver
- Advanced 2nd Generation Current Control for Exceptional Performance and Smoothness
- Single Supply: +12 to +75 VDC
- Low Cost
- Extremely Compact
- High Output Current:  
Up to 5 Amps RMS, 7 Amps Peak (Per Phase)
- 20 Microstep Resolutions up to 51,200 Steps Per Rev Including:  
Degrees, Metric, Arc Minutes
- Optically Isolated Logic Inputs will Accept +5 to +24 VDC Signals, Sourcing or Sinking
- Automatic Current Reduction
- Configurable:
  - Motor Run/Hold Current
  - Motor Direction vs. Direction Input
  - Microstep Resolution
  - Clock Type: Step and Direction, Quadrature, Step Up and Step Down
  - Programmable Digital Filtering for Clock and Direction Inputs
  - Current and Microstep Resolution May Be Switched On-The-Fly
- Dual Mounting Configurations
- Power, Motor and Signal Interface via locking wire crimp style connectors.
- Graphical User Interface (GUI) for Quick and Easy Parameter Setup

# SECTION 1.2

## Microstepping MForce PowerDrive Detailed Specifications

### General Specifications

Electrical Specifications	
Input Voltage (+V) Range*	+12 to +75 VDC
Max Power Supply Current (Per MForce PowerDrive)*	4 Amps
Output Current RMS	5 Amps
Output Current Peak (Per Phase)	7 Amps

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

Table 1.2.1: Electrical Specifications

Thermal Specifications	
Heat Sink Temperature	-40°C to +85°C

Table 1.2.2: Thermal Specifications

I/O Specifications	
Isolated Inputs — Step Clock, Direction and Enable	
Resolution	10 Bit
Voltage Range (Sourcing or Sinking)	+5 to +24 VDC
Current (+5 VDC Max)	8.7 mA
Current (+24 VDC Max)	14.6 mA

Table 1.2.3: I/O Specifications

Communications Specifications	
Protocol	SPI

Table 1.2.4: Communications Specifications

Motion Specifications	
Microstep Resolution	
Number of Resolutions	20

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

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

Digital Filter Range	50 nS to 12.9 μS (10 MHz to 38.8kHz)
Clock Types	Step/Direction, Quadrature, Clock Up/ Clock Down
Step Frequency (Max)	5.0 MHz
Step Frequency Minimum Pulse Width	100 nS

Table 1.2.5: Motion Specifications

## Setup Parameters

The following table illustrates the setup parameters. These are easily configured using the IMS SPI Motor Interface configuration utility. An optional Parameter Setup Cable is available and recommended with the first order.

Microstepping MForce PowerDrive Setup Parameters				
Name	Function	Range	Units	Default
MHC	Motor Hold Current	0 to 100	percent	5
MRC	Motor Run Current	1 to 100	percent	25
MSEL	Microstep Resolution	1, 2, 4, 5, 8, 10, 16, 25, 32, 50, 64, 100, 108, 125, 127, 128, 180, 200, 250, 256	μsteps per full step	256
DIR	Motor Direction Override	0/1	—	CW
HCDT	Hold Current Delay Time	0 or 2-65535	mSec	500
CLK TYPE	Clock Type	Step/Dir. Quadrature, Up/Down (CW/CCW)	—	Step/Dir
CLK IOF	Clock and Direction Filter	50 nS to 12.9 μS (10 MHz to 38.8kHz)	nS (MHz)	200nS(2.5 MHz)
USER ID	User ID	Customizable	1-3 characters	IMS
WARN TEMP	Warning Temperature	0 to +125	°C	80
EN ACT	Enable Active High/Low	High or Low	—	High
PWM MSK	PWM Mask	0 to 255	—	102
PWM PER	PWM Duty Cycle	0 to 95	Percent	90%
PWM FREQ	PWM Frequency Range	0 to 255	—	170 (20kHz to 60 kHz)
PWM CTL	PWM Control	See Section 2.4	See Section 2.4	0-10010

Table 1.2.6: Setup Parameters

## Mechanical Specifications - Dimensions in Inches (mm)

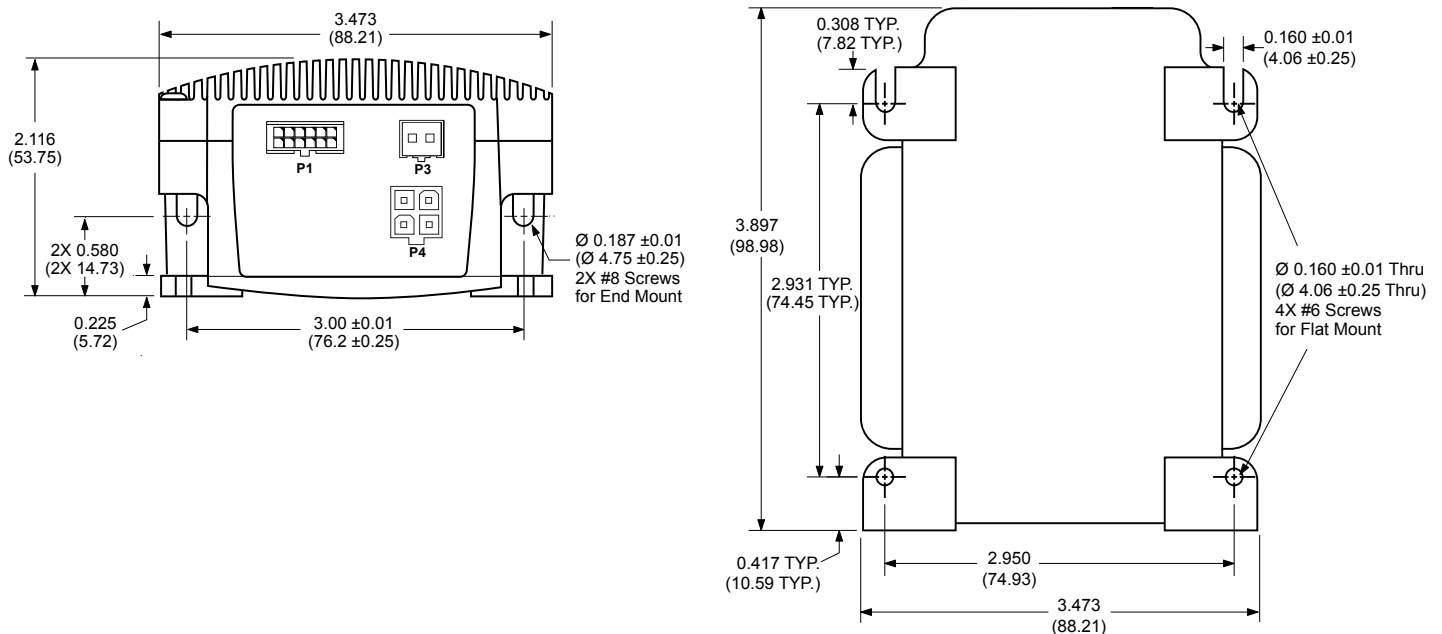


Figure 1.2.1: MForce PowerDrive Mechanical Specifications

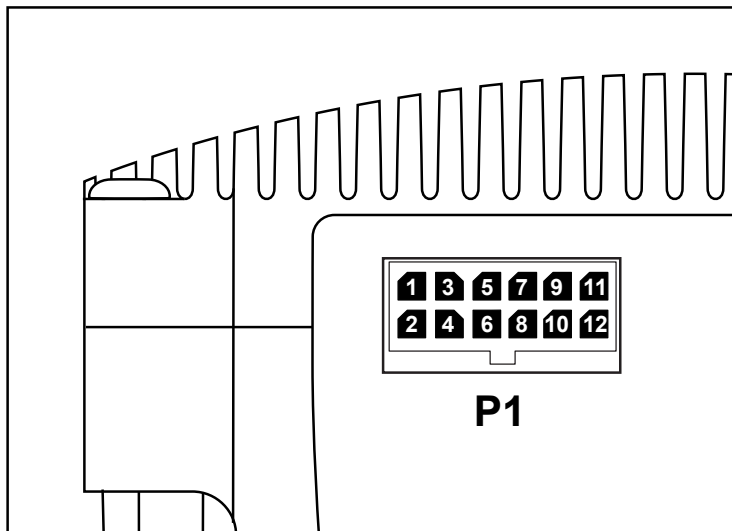


## Pin Assignment and Description

### P1 12-Pin Locking Wire Crimp Connector Option - Power, I/O and SPI Communications

Pin Assignment - P1 Power, I/O and SPI Connections		
Pin #	Function	Description
Pin 1	N/C	No Connect
Pin 2	N/C	No Connect
Pin 3	Opto Reference	The Signal applied to the Optocoupler Reference will determine the sinking/ or sourcing configuration of the inputs. To set the inputs for sinking operation, a +5 to +24 VDC supply is connected. If sourcing, the Reference is connected to Ground.
Pin 4	Step Clock/Channel A/ Clock Up	Step Clock input. The step clock input will receive the clock pulses which will step the motor 1 step for each pulse. It may also receive quadrature and clock up type inputs if so configured.
Pin 5	Enable	Enable/Disable Input will enable or disable the driver output to the motor. In the disconnected state the driver outputs are enabled in either sinking or sourcing configuration.
Pin 6	Direction/Channel B/ Clock Down	Direction input. The axis direction will be with respect to the state of the Direction Override Parameter. It may also receive quadrature and clock up type inputs if so configured.
Pin 7	+5 VDC Output	Supply voltage for the MD-CC300-000 Cable ONLY!
Pin 8	SPI Clock	The Clock is driven by the SPI Master. The clock cycles once for each data bit.
Pin 9	GND	Communications Ground.
Pin 10	MISO	Master-In/Slave-Out. Carries output data from the MFM back to the SPI Master.
Pin 11	CS	SPI Chip Select. This signal is used to turn communications on multiple MFM units on or off.
Pin 12	MOSI	Master-Out/Slave-In. Carries output data from the SPI Master to the MFM.

Table 1.2.7: P1 Connector – Power, I/O and SPI Communications



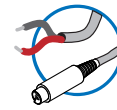
#### Recommended Connector Shell and Pins

Shell: AMP P/N 1-794617-2

Pins: 12 x AMP P/N 794610-1

Wire: 22 AWG Shielded Twisted Pair

Figure 1.2.2: P1 — 12-Pin Locking Wire Crimp Pin Configuration



**NEED A CABLE?**  
The following cables and converters are available to interface with P1:

**12-Pin Locking Wire Crimp**  
PD12-1434-FL3



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

**USB to SPI:**  
MD-C300-000

**10-Pin IDC to 12-Pin Locking Wire Crimp Adapter**

All SPI Communications will connect to the P1 Connector.

An adapter is available to interface the MD-CC300-000 to the 12-Pin Locking Wire Crimp connector.

MD-ADP-1723C

This adapter may be used in conjunction with the following Prototype Development cables to interface power and logic:

PD12-1434-FL3 (10')  
ADP-3512-FL (12")

See Appendix A for details.



**NEED A CABLE?**  
The following cables and converters are available to interface with P3:

**2-Pin Locking Wire Crimp**  
PD02-3400-FL3



**WARNING!** Do not plug or unplug DC Power with power applied.

### P3 Connector - DC Power, 2-Pin Locking Wire Crimp

Pin Assignment - P3 Power		
2-Pin Locking Wire Crimp	Function	Description
Pin 1	+V	+12 to +75 VDC, 4 Amps Maximum per MDrive34Plus.
Pin 2	GND	Power Supply Return.

Table 1.2.8: P3 Connector

#### Recommended Connector Shell and Pins

Shell: Molex P/N 510-67-0200  
Pins: 2 x Molex P/N 502-17-9101  
Wire: 18 AWG Shielded Twisted Pair

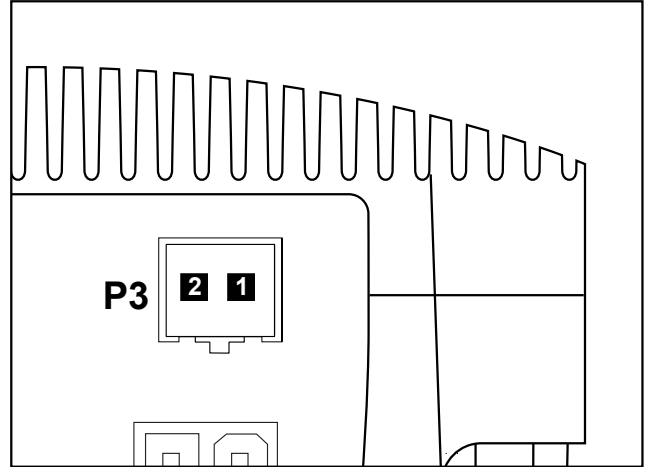


Figure 1.2.3: P3 — 2-Pin Locking Wire Crimp Pin Configuration



**NEED A CABLE?**  
The following cables and converters are available to interface with P4:

**4-Pin Locking Wire Crimp**  
PD04-MF34-FL3

### P4 Connector - Motor

Pin Assignment - P4 Motor		
5-Pin Locking Wire Crimp	Function	Description
Pin 1	Phase A	Phase A Motor Output
Pin 2	Phase A	Phase A Motor Return
Pin 3	Phase B	Phase B Motor Output
Pin 4	Phase B	Phase B Motor Return
Recommended Cable		
PD04-MF34-FL3		

Table 1.2.9: P4 Connector

#### Recommended Connector Shell and Pins

Shell: Molex P/N 39-01-2045  
Pins: 4 x Molex P/N 44476-3112  
Wire: 16 AWG Shielded Twisted Pair

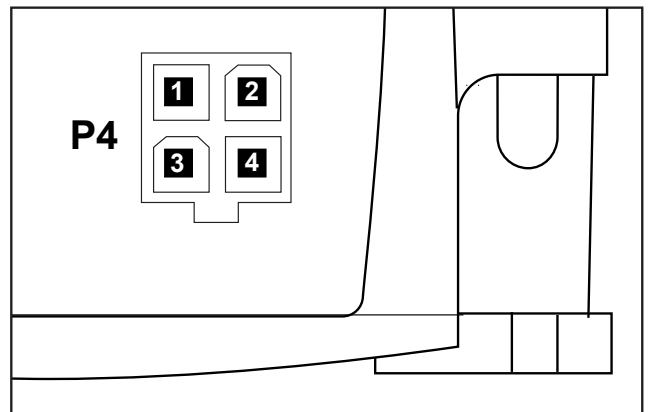


Figure 1.2.4: P4 — 4-Pin Locking Wire Crimp Pin Configuration

## Options and Accessories

### Parameter Setup Cable and Adapters

The optional 12.0' (3.6m) parameter setup cable part number MD-CC300-000 facilitates communications wiring and is recommended with first order. It connects from the 10-Pin IDC Connector located at P2 to a PC's USB port. If the 12-pin pluggable locking wire crimp connector is used at P1, adapter MD-ADP-1723C is required to use the MD-CC300-000.

USB to SPI.....MD-CC300-000

### Prototype Development Cable

To speed prototype development, these cables connect to user interface via flying leads with MForce mating connector on opposite end.

Mating connector to 12-pin pluggable locking wire crimp plugs into MForce or adapter MD-ADP-1723C. Choose from 2 lengths:

12.0" (30.5cm).....ADP-3512-FL

10.0' (3.0m)..... PD12-1434-FL3

#### *Mating connector to MForce 4-pin motor interface:*

10.0' (3.0m)..... PD04-MF17-FL3





# **PART 2: INTERFACING AND CONFIGURING**

**Section 2.1: Mounting and Connection Recommendations**

**Section 2.2: Logic Interface and Connection**

**Section 2.3: Connecting SPI Communications**

**Section 2.4: Using the IMS SPI Motor Interface**

**Section 2.5: Using User-Defined SPI**

*Page Intentionally Left Blank*

# SECTION 2.1

## Mounting and Connection Guidelines

### Mounting Recommendations

The Microstepping MForce PowerDrive may be mounted two ways: end mounted or flat mounted. End mounting will use #8 hardware, flat mounting will use standard #6 hardware. Do not exceed the recommended mounting torque specification. The diagrams in Figures 2.1.1 and 2.1.2 illustrate the mounting methods.

**Recommended Tightening Torque:  
7 - 8 lb-in (78.4 - 89.6 N-cm)**



**NOTE:** Mounting Hardware is not supplied.

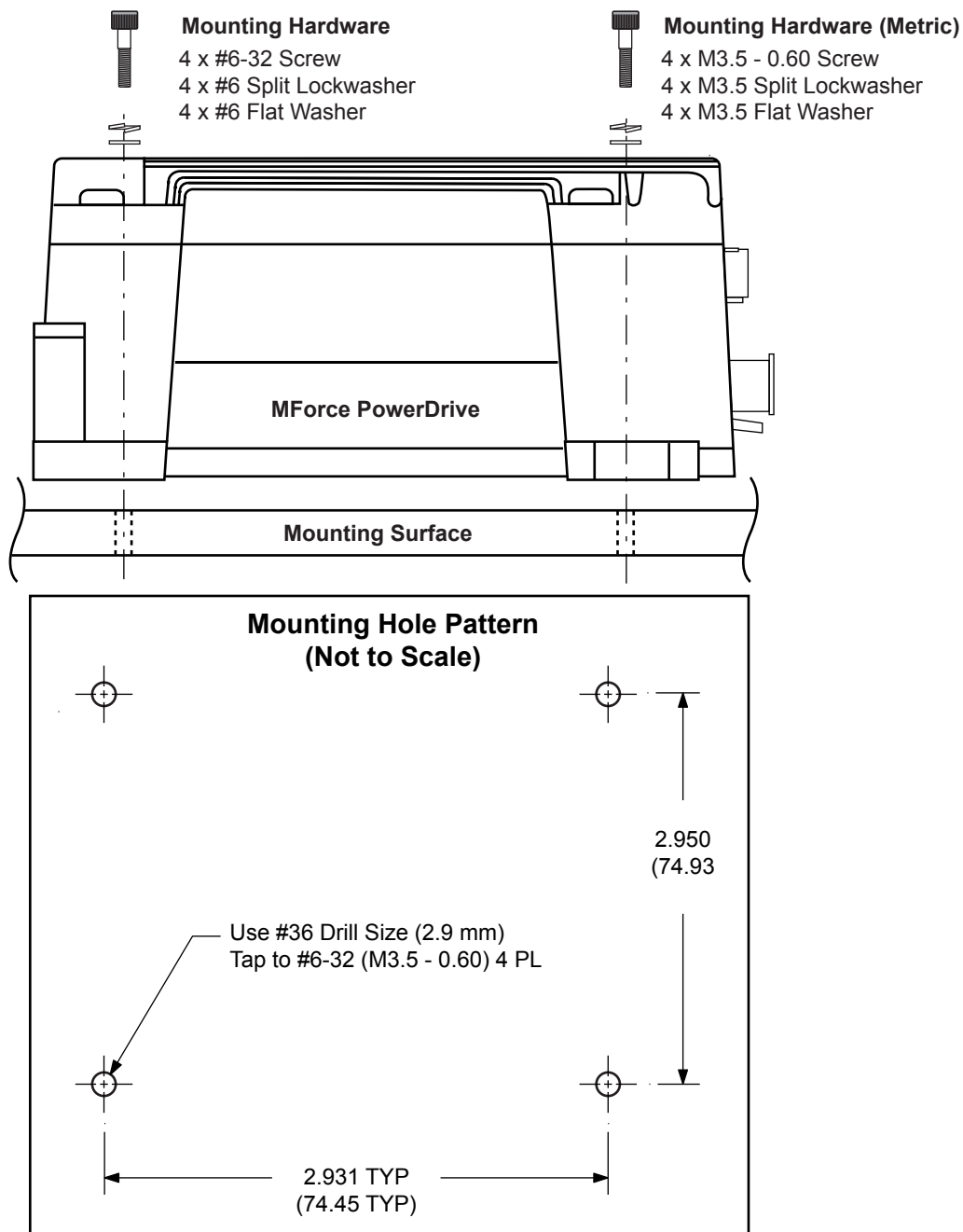


Figure 2.1.1: Base Mounting the MForce PowerDrive

**N** NOTE: Ensure that proper clearance is allowed for wiring and cabling. Especially when end mounting the device.

**N** NOTE: Mounting Hardware is not supplied.

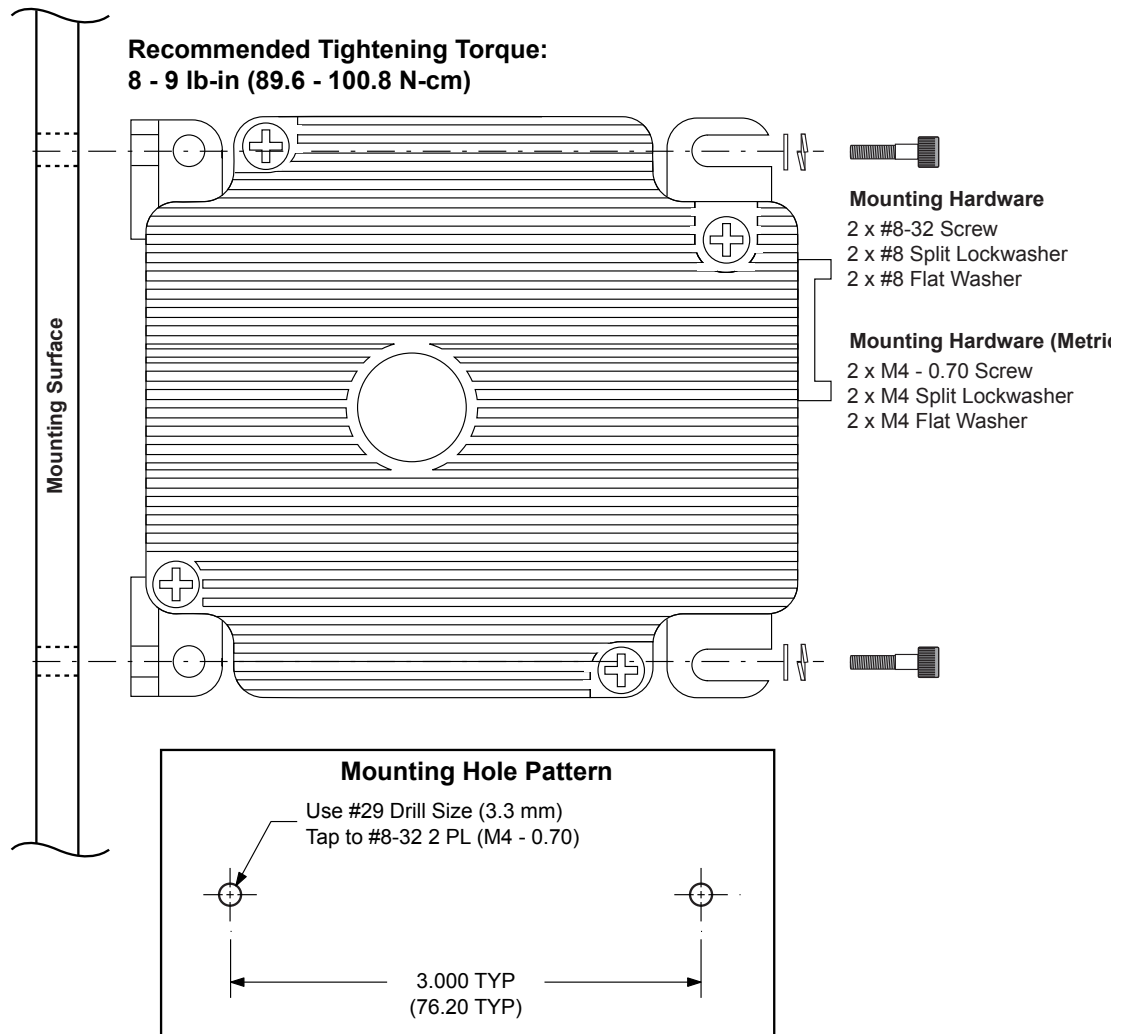


Figure 2.1.2: End Mounting the MForce PowerDrive

## Securing Power Leads and Logic Leads

Some applications may require that the MForce and/or the connected motor to move with the axis motion. If this is a requirement of your application, the motor leads must be properly anchored. This will prevent flexing and tugging which can cause damage at critical connection points on the MForce connectors.

## Layout and Interface Guidelines

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

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

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



### Rules of Wiring

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

### Rules of Shielding

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

### Recommended Wiring

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

Logic Wiring.....	22 AWG
Wire Strip Length .....	0.25" (6.0 mm)
Power and Ground .....	18 AWG Shielded Twisted Pair*
Motor.....	16 AWG Shielded Twisted Pair

\*See Table 2.2.1 if using a power cable longer than 10 feet. The Gauge used is dependant upon supply current and length.

### Recommended Mating Connectors and Pins

#### Logic and SPI Communications (P1)

12-pin Locking Wire Crimp Connector Shell .....	AMP 1-794617-2
Crimp Pins.....	AMP 794610-1

#### Power (P3)

2-pin Locking Wire Crimp Connector Shell .....	Molex 51067-0200
Crimp Pins.....	Molex 50217-9101 Brass

#### Motor (P4)

4-pin Locking Wire Crimp Connector Shell .....	Molex 3901-2045
Crimp Pins.....	Molex 44476-3112

*Page Intentionally Left Blank*

### Choosing a Power Supply for Your MForce PowerDrive

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

Motors have windings that are electrically just inductors, and with inductors comes resistance and inductance. Winding resistance and inductance result in a L/R time constant that resists the change in current. It requires five time constants to reach nominal current. To effectively manipulate the di/dt or the rate of charge, the voltage applied is increased. When traveling at high speeds there is less time between steps to reach current. The point where the rate of commutation does not allow the driver to reach full current is referred to as Voltage Mode. Ideally you want to be in Current Mode, which is when the drive is achieving the desired current between steps. Simply stated, a higher voltage will decrease the time it takes to charge the coil, and therefore will allow for higher torque at higher speeds.

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

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

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

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

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

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

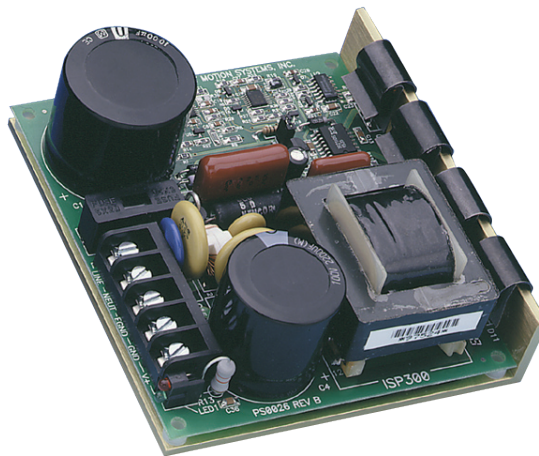


Figure 2.2.1: IMS ISP300 Switch Mode Power Supply

## DC Power Supply Recommendations

The power requirements for the Microstepping MForce PowerDrive are:

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

### Recommended IMS Power Supplies

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

#### IP804 Unregulated Linear Supply

##### Input Range

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

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

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

#### IP806 Unregulated Linear Supply

##### Input Range

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

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

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

#### ISP300-7 Unregulated Switching Supply

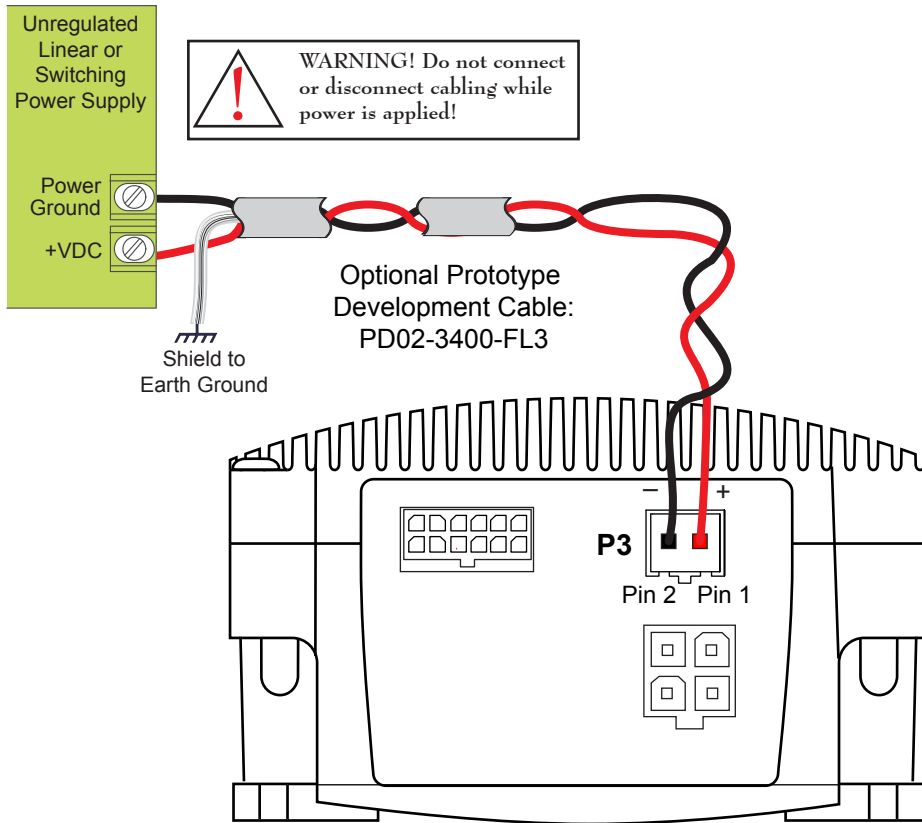
##### Input Range

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

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

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

## Basic DC Power Connection



**WARNING!** Do not connect or disconnect cabling while power is applied!



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

Figure 2.2.2: MForce PowerDrive DC Power Connection

## Recommended Power and Cable Configurations

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

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 Table 2.2.1 for recommended wire gauges.

### Example A: DC Power Cabling Under 50 Feet

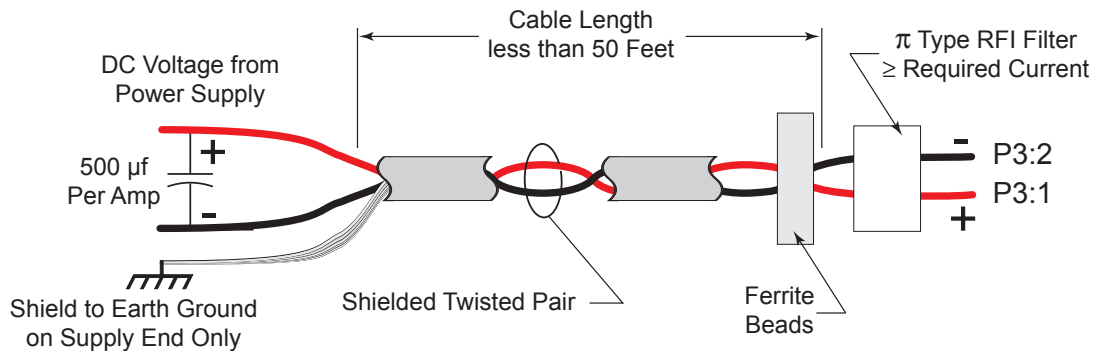


Figure 2.2.3: DC Cabling - Under 50 Feet



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

**Example B: AC Power to Full Wave Bridge Cabling Over 50 Feet**

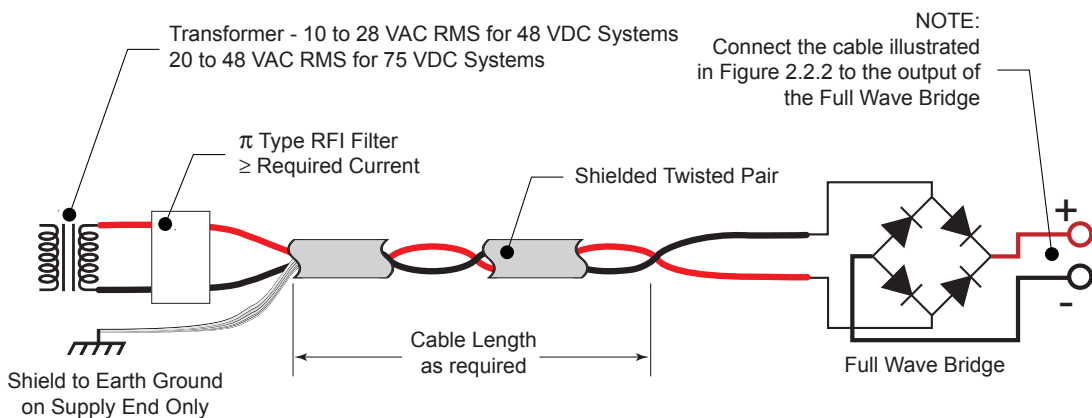


Figure 2.2.4: AC To Full Wave Bridge Rectifier, Cabling over 50 Feet

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

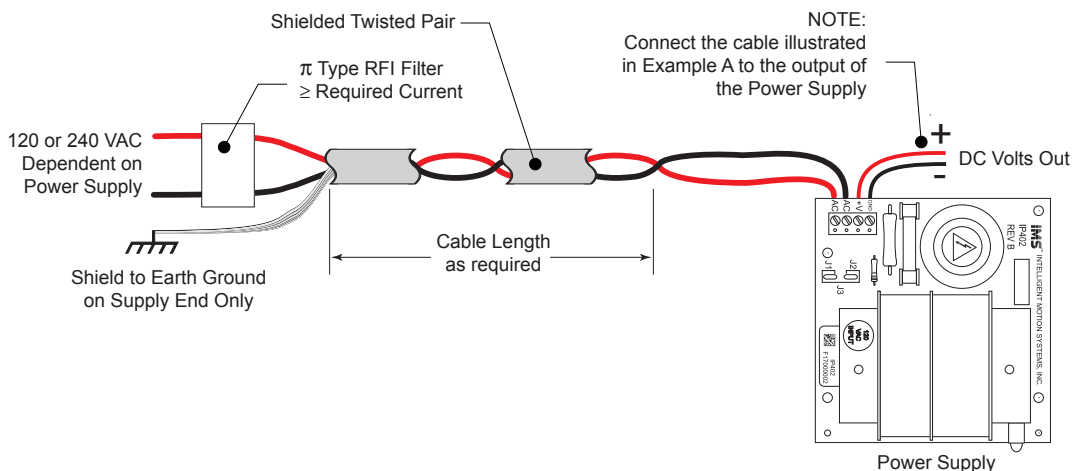


Figure 2.2.5: AC Cabling - 50 Feet or Greater - AC To Power Supply

MForce PowerDrive Recommended Power Supply Cable AWG											
1 Amperes (Peak)						3 Amperes (Peak)					
Length (Feet)	10	25	50*	75*	100*	Length (Feet)	10	25	50*	75*	100*
Minimum AWG	20	20	18	18	16	Minimum AWG	18	16	14	12	12
2 Amperes (Peak)						4 Amperes (Peak)					
Length (Feet)	10	25	50*	75*	100*	Length (Feet)	10	25	50*	75*	100*
Minimum AWG	20	18	16	14	14	Minimum AWG	18	16	14	12	12

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

Table 2.2.1: Recommended Wire Gauges

### Selecting a Motor

When selecting a stepper motor for your application, there are several factors that need to be taken into consideration:

- How will the motor be coupled to the load?
- How much torque is required to move the load?
- How fast does the load need to move or accelerate?
- What degree of accuracy is required when positioning the load?

While determining the answers to these and other questions is beyond the scope of this document, they are details that you must know in order to select a motor that is appropriate for your application. These details will affect everything from the power supply voltage to the type and wiring configuration of your stepper motor. The current and microstepping settings of your Microstepping MForce PowerDrive will also be affected.

### Types and Construction of Stepping Motors

The stepping motor, while classed as a DC motor, is actually an AC motor that is operated by trains of pulses. Although it is called a “stepping motor”, it is in reality a polyphase synchronous motor. This means it has multiple phases wound in the stator and the rotor is dragged along in synchronism with the rotating magnetic field. The MForce PowerDrive is designed to work with the following types of stepping motors:

- 1) Permanent Magnet (PM)
- 2) Hybrid Stepping Motors

Hybrid stepping motors combine the features of the PM stepping motors with the features of another type of stepping motor called a variable reluctance motor (VR). VR motors are low torque and load capacity motors which are typically used in instrumentation. The MForce PowerDrive cannot be used with VR motors as they have no permanent magnet.

On hybrid motors, the phases are wound on toothed segments of the stator assembly. The rotor consists of a permanent magnet with a toothed outer surface which allows precision motion accurate to within  $\pm 3$  percent. Hybrid stepping motors are available with step angles varying from  $0.45^\circ$  to  $15^\circ$  with  $1.8^\circ$  being the most commonly used. Torque capacity in hybrid steppers ranges from 5 - 8000 ounce-inches. Because of their smaller step angles, hybrid motors have a higher degree of suitability in applications where precise load positioning and smooth motion is required.

### Sizing a Motor for Your System

The MForce PowerDrive is a bipolar driver which works equally well with both bipolar and unipolar motors (i.e. 8 and 4 lead motors, and 6 lead center tapped motors).

To maintain a given set motor current, the MForce PowerDrive chops the voltage using a variable chopping frequency and a varying duty cycle. Duty cycles that exceed 50% can cause unstable chopping. This characteristic is directly related to the motor's winding inductance. In order to avoid this situation, it is necessary to choose a motor with a low winding inductance. The lower the winding inductance, the higher the step rate possible.

### Winding Inductance

Since the MForce PowerDrive is a constant current source, it is not necessary to use a motor that is rated at the same voltage as the supply voltage. What is important is that the MForce PowerDrive is set to the motor's rated current.

The higher the voltage used the faster the current can flow through the motor windings. This in turn means a higher step rate, or motor speed. Care should be taken not to exceed the maximum voltage of the driver. Therefore, in choosing a motor for a system design, the best performance for a specified torque is a motor with the lowest possible winding inductance used in conjunction with highest possible driver voltage.

The winding inductance will determine the motor type and wiring configuration best suited for your system. While the equation used to size a motor for your system is quite simple, several factors fall into play at this point.

The winding inductance of a motor is rated in milliHenrys (mH) per Phase. The amount of inductance will depend on the wiring configuration of the motor.



**NOTE:** In calculating the maximum phase inductance, the minimum supply output voltage should be used when using an unregulated supply.

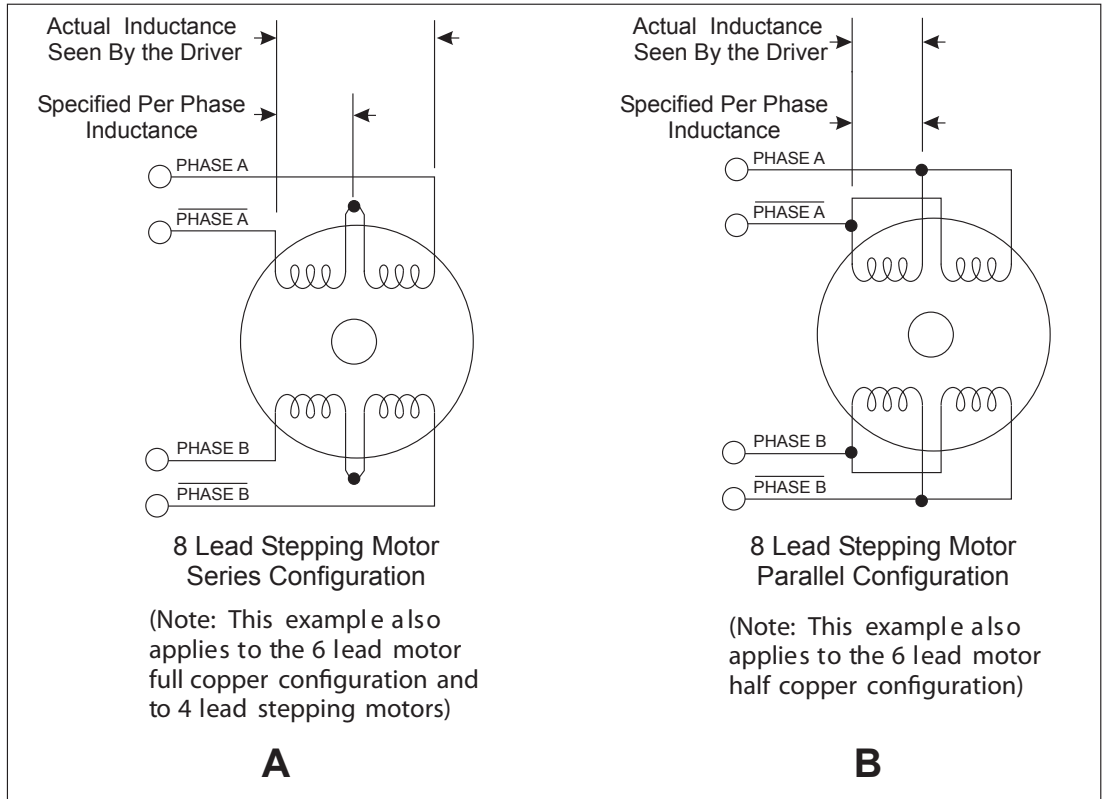


Figure 2.3.1 A & B: Per Phase Winding Inductance

The per phase winding inductance specified may be different than the per phase inductance seen by your MForce PowerDrive driver depending on the wiring configuration used. Your calculations must allow for the actual inductance that the driver will see based upon the wiring configuration.

Figure 2.3.1A shows a stepper motor in a series configuration. In this configuration, the per phase inductance will be 4 times that specified. For example: a stepping motor has a specified per phase inductance of 1.47mH. In this configuration the driver will see 5.88 mH per phase.

$$\text{Maximum Motor Inductance (mH per Phase)} = .2 \times \text{Minimum Supply Voltage}$$

Figure 2.3.1B shows an 8 lead motor wired in parallel. Using this configuration the per phase inductance seen by the driver will be as specified.

Using the following equation we will show an example of sizing a motor for a MForce PowerDrive used with an unregulated power supply with a minimum voltage (+V) of 18 VDC:

$$.2 \times 18 = 3.6 \text{ mH}$$

The recommended per phase winding inductance we can use is 3.6 mH.

### Recommended IMS Motors

IMS also carries a series of 23 and 34 frame enhanced stepping motors that are recommended for use with the MForce PowerDrive. These motors use a unique relationship between the rotor and stator to generate more torque per frame size while ensuring more precise positioning and increased accuracy.

The special design allows the motors to provide higher torque than standard stepping motors while maintaining a steadier torque and reducing torque drop-off.

Each frame size is available in 3 stack sizes, single or double shaft, with or without encoders. They handle currents up to 2.4 Amps in series or 6 Amps parallel, and holding torque ranges from 90 oz.-in. (M-2218-2.4) to 1303 oz.-in (M-3447-6.3) (64 N-cm to 920 N-cm).

These CE rated motors are ideal for applications where higher torque is required.

For more detailed information on these motors, please see the IMS Full Line catalog or the IMS web site at <http://www.imshome.com>.



### 23 Frame Enhanced (2.4A - Not Available with Double Shaft)

Single Shaft	Double Shaft
M-2218-2.4S .....	N/A
M-2222-2.4S .....	N/A
M-2231-2.4S .....	N/A

### 23 Frame Enhanced (3.0A)

Single Shaft	Double Shaft
M-2218-3.0S .....	M-2218-3.0D
M-2222-3.0S .....	M-2222-3.0D
M-2231-3.0S .....	M-2231-3.0D

### 23 Frame Enhanced (6.0A)

Single Shaft	Double Shaft
M-2218-6.0S .....	M-2218-6.0D
M-2222-6.0S .....	M-2222-6.0D
M-2231-6.0S .....	M-2231-6.0D

### 34 Frame Enhanced (6.3A)

Single Shaft	Double Shaft
M-3424-6.3S .....	M-3424-6.3-D
M-3431-6.3S .....	M-3431-6.3D
M-3447-6.3S .....	M-3447-6.3D

IMS also offers 23 and 34 Frame hybrid linear actuators for use with the MForce PowerDrive. Please see the IMS Full Line catalog or the IMS web site at <http://www.imshome.com>.

### IMS Inside Out Stepper Motors

The new inside out stepper (IOS) motor was designed by IMS to bring versatility to stepper motors using a unique multi-functional, hollow core design.

This versatile new motor can be converted to a ball screw linear actuator by mounting a miniature ball screw to the front shaft face. Ball screw linear actuators offer long life, high efficiency, and can be field retrofitted. There is no need to throw the motor away due to wear of the nut or screw.

The IOS motors offer the following features:

- The shaft face diameter offers a wide choice of threaded hole patterns for coupling.
- The IOS motor can be direct coupled in applications within the torque range of the motor, eliminating couplings and increasing system efficiency.
- The IOS motor can replace gearboxes in applications where gearboxes are used for inertia damping between the motor and the load. The induced backlash from the gearbox is eliminated providing improved bidirectional position accuracy.
- Electrical or pneumatic lines can be directed through the center of the motor enabling the motors to be stacked end-to-end or applied in robotic end effector applications. The through hole is stationary, preventing cables from being chaffed by a moving hollow shaft.
- Light beams can be directed through the motor for refraction by a mirror or filter wheel mounted on the shaft mounting face.
- The IOS motor is adaptable to valves enabling the valve stem to protrude above the motor frame. The stem can be retrofitted with a dial indicator showing valve position.
- The motor is compatible with IMS bipolar drivers, keeping the system cost low.
- The IOS motor can operate up to 3000 rpm's.

The IOS motor is available in the following frames:

Frame Size	IMS PN
23 Frame.....	M3-2220-IOS
34 Frame.....	M3-3424-IOS

## Connecting the Motor

The motor leads are connected to the following connector pins:

Phase	Connector: Pin
Phase A .....	P4: 1
Phase A .....	P4: 2
Phase B .....	P4: 3
Phase B .....	P4: 4

## 8 Lead Motors

8 lead motors offer a high degree of flexibility to the system designer in that they may be connected in series or parallel, thus satisfying a wide range of applications.

### Series Connection

A series motor configuration would typically be used in applications where a higher torque at lower speeds is required. Because this configuration has the most inductance, the performance will start to degrade at higher speeds. Use the per phase (or unipolar) current rating as the peak output current, or multiply the bipolar current rating by 1.4 to determine the peak output current.

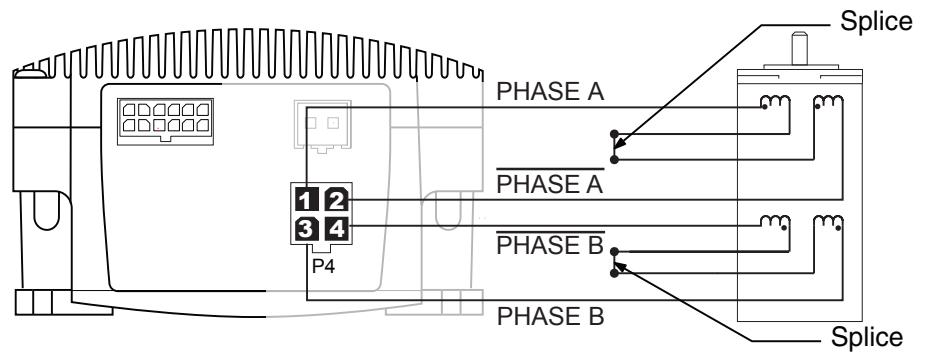


Figure 2.3.2: 8 Lead Motor Series Connections

### Parallel Connection

An 8 lead motor in a parallel configuration offers a more stable, but lower torque at lower speeds. But because of the lower inductance, there will be higher torque at higher speeds. Multiply the per phase (or unipolar) current rating by 1.96, or the bipolar current rating by 1.4, to determine the peak output current.

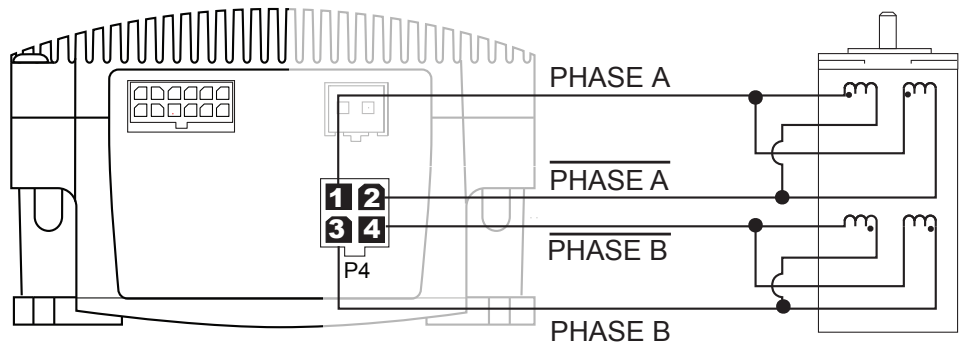


Figure 2.3.3: 8 Lead Motor Parallel Connections

## 6 Lead Motors

Like 8 lead stepping motors, 6 lead motors have two configurations available for high speed or high torque operation. The higher speed configuration, or *half coil*, is so described because it uses one half of the motor's inductor windings. The higher torque configuration, or *full coil*, uses the full windings of the phases.

### Half Coil Configuration

As previously stated, the half coil configuration uses 50% of the motor phase windings. This gives lower inductance, hence, lower torque output. Like the parallel connection of 8 lead motor, the torque output will be more stable at higher speeds. This configuration is also referred to as *half copper*. In setting the driver output current multiply the specified per phase (or unipolar) current rating by 1.4 to determine the peak output current.

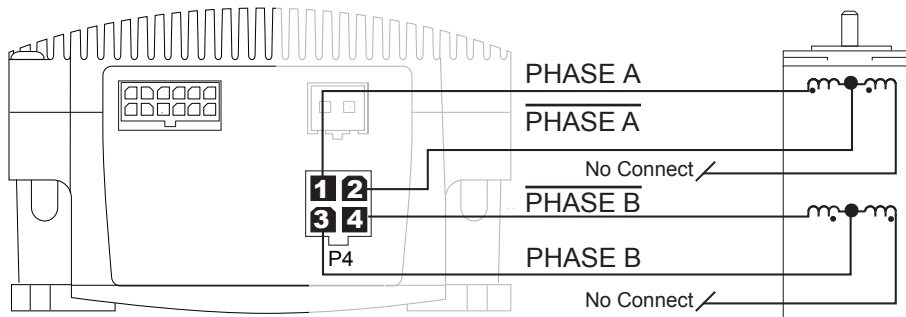


Figure 2.3.4: 6 Lead Half Coil (Higher Speed) Motor Connections

### Full Coil Configuration

The full coil configuration on a six lead motor should be used in applications where higher torque at lower speeds is desired. This configuration is also referred to as *full copper*. Use the per phase (or unipolar) current rating as the peak output current.

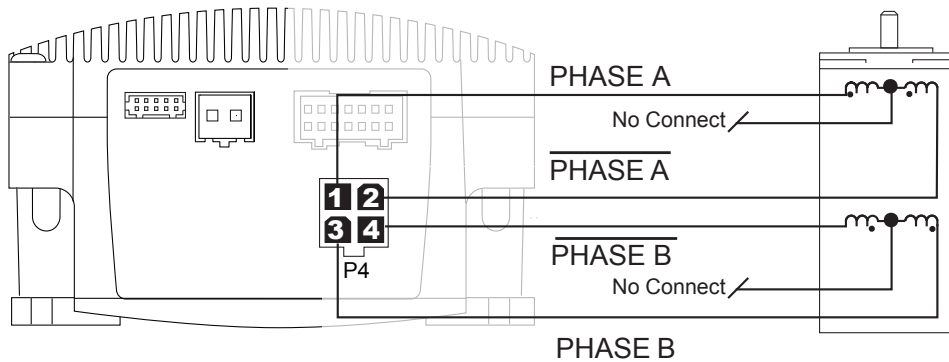


Figure 2.3.5: 6 Lead Full Coil (Higher Torque) Motor Connections

### 4 Lead Motors

4 lead motors are the least flexible but easiest to wire. Speed and torque will depend on winding inductance. In setting the driver output current, multiply the specified phase current by 1.4 to determine the peak output current.

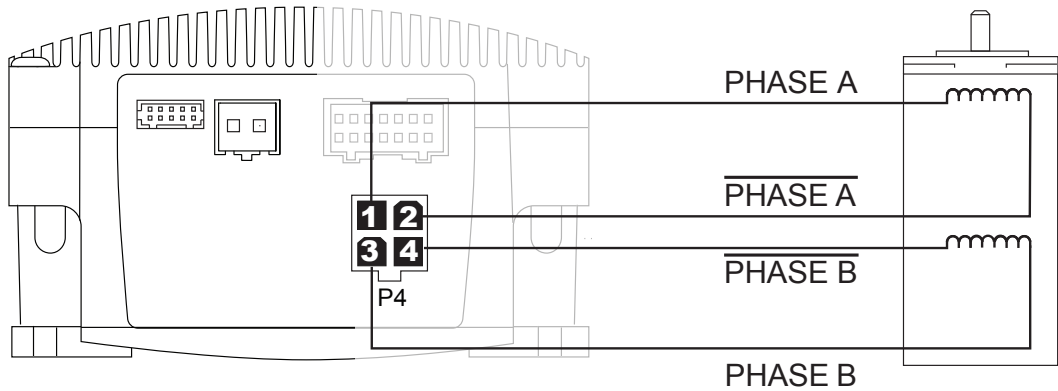


Figure 2.3.6: 4 Lead Motor Connections

### Recommended Motor Cabling

As with the power supply wiring, motor wiring should be run separately from logic wiring to minimize noise coupled onto the logic signals. Motor cabling exceeding 1' in length should be shielded twisted pairs to reduce the transmission of EMI (Electromagnetic Interference) which can lead to rough motor operation and poor system performance.

Cable length, wire gauge and power conditioning devices play a major role in the performance of your MForce PowerDrive and Stepper Motor.

NOTE: The length of the DC power supply cable between the MForce PowerDrive and the Motor should not exceed 50 feet.

Example A demonstrates the recommended cable configuration for the MForce PowerDrive to Motor cabling under 50 Feet long. If cabling of 50 feet or longer is required, the additional length can be gained with the cable configuration in Example B.

Correct AWG wire size is determined by the current requirement plus cable length. Please see Table 2.3.1 on the following page.

#### Example A: Motor Cabling Less Than 50 Feet

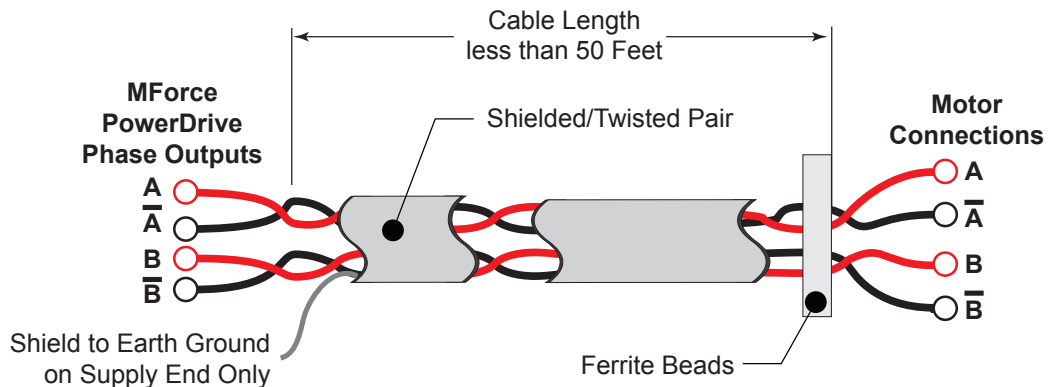
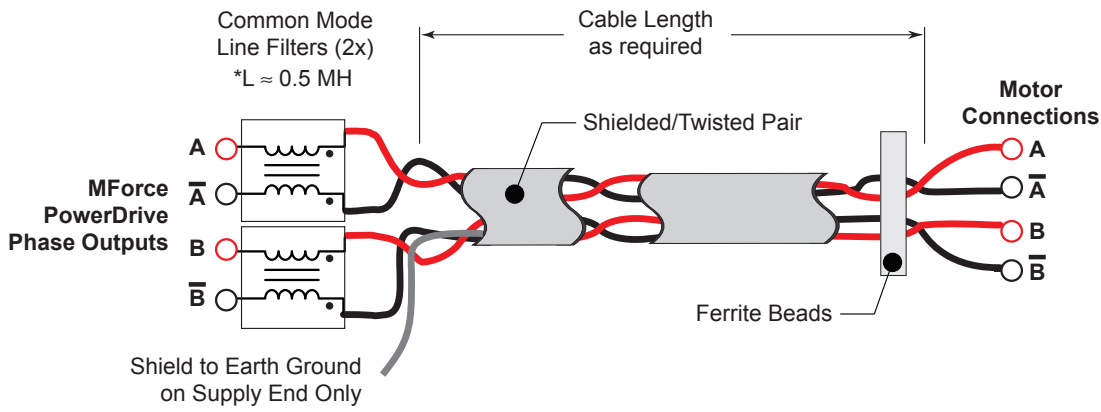


Figure 2.3.7: Motor Cabling Less than 50 Feet

### Example B: Motor Cabling Greater Than 50 Feet



\* 0.5 MH is a typical starting point for the Common Mode Line Filters. By increasing or decreasing the value of L you can set the drain current to a minimum to meet your application's requirements.

Figure 2.3.8: Motor Cabling Greater than 50 Feet

### Recommended Motor Cable AWG Sizes

MForce PowerDrive Recommended Motor Cable AWG											
1 Amperes (Peak)						5 Amperes (Peak)					
Length (Feet)	10	25	50*	75*	100*	Length (Feet)	10	25	50*	75*	100*
Minimum AWG	20	20	18	18	16	Minimum AWG	16	16	14	12	12
2 Amperes (Peak)						6 Amperes (Peak)					
Length (Feet)	10	25	50*	75*	100*	Length (Feet)	10	25	50*	75*	100*
Minimum AWG	20	18	16	14	14	Minimum AWG	14	14	14	12	12
3 Amperes (Peak)						7 Amperes (Peak)					
Length (Feet)	10	25	50*	75*	100*	Length (Feet)	10	25	50*	75*	100*
Minimum AWG	18	16	14	12	12	Minimum AWG	12	12	12	12	12
4 Amperes (Peak)											
Length (Feet)	10	25	50*	75*	100*						
Minimum AWG	18	16	14	12	12						

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

Table 2.3.1: Recommended Wire Gauges



### Optically Isolated Logic Inputs

The Microstepping MForce PowerDrive has three 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 or +5 to +24 VDC sourcing outputs on a controller or PLC. These inputs are:

- 1) Step Clock (SCLK)/Quadrature (CH A)/Clock UP
- 2) Direction (DIR)/Quadrature (CH B)/ Clock DOWN
- 3) Enable (EN)

Of these inputs only step clock and direction are required to operate the Microstepping MForce PowerDrive.

### Isolated Logic Input Pins and Connections

The following diagram illustrates the pins and connections for the Microstepping MForce PowerDrive family of products. Careful attention should be paid to verify the connections on the model Microstepping MForce PowerDrive you are using.

### Isolated Logic Input Characteristics

#### Enable Input

This input can be used to enable or disable the driver output circuitry. Leaving the enable switch open (Logic HIGH, Disconnected) for sinking or sourcing configuration, the driver outputs will be enabled and the step clock pulses will cause the motor to advance. When this input switch is closed (Logic LOW) in both sinking

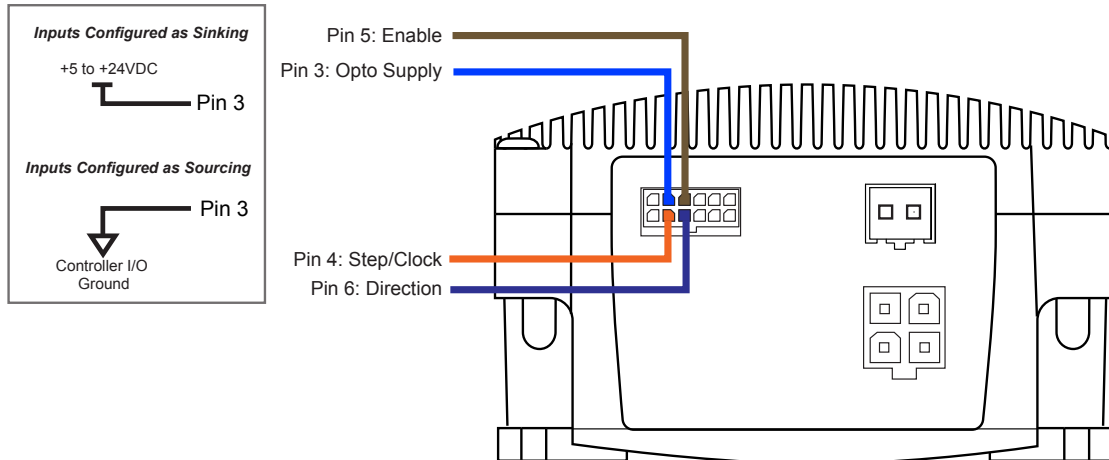


Figure 2.4.1: Isolated Logic Pins and Connections

and sourcing configurations, 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 Microstepping MForce PowerDrive.

### Clock Inputs

The Microstepping MForce PowerDrive features the ability to configure the clock inputs based upon how the user will desire to control the drive. By default the unit is configured for the Step/Direction function.

#### Step Clock

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

The direction input controls the CW/CCW direction of the motor. The input may be configured as sinking or sourcing based upon the state of the Optocoupler Reference. The CW/CCW rotation, based upon the state of the input may be set using the IMS Motor Interface software included with the Microstepping MForce PowerDrive.

#### Quadrature

The Quadrature clock function would typically be used for following applications where the Microstepping MForce PowerDrive would be slaved to an MForce PowerDrive Microstepping (or other controller) in an electronic gearing application.

#### Up/Down

The Up/Down clock would typically be used in a dual-clock direction control application.

#### 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 following figure and table list the timing specifications.

#### Input Filtering

The clock inputs may also be filtered using the Clock IOF pull down of the IMS SPI Motor Interface. The filter range is from 50 nS (10 MHz) to 12.9 μSec. (38.8 kHz).

The configuration parameters for the input filtering is covered in detail in Section 2.4: Configuring the Microstepping MForce PowerDrive.

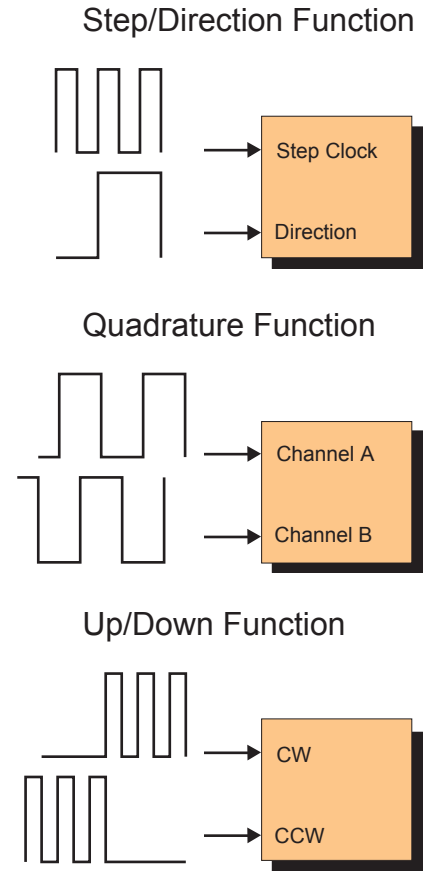


Figure 2.4.2: Input Clock Functions



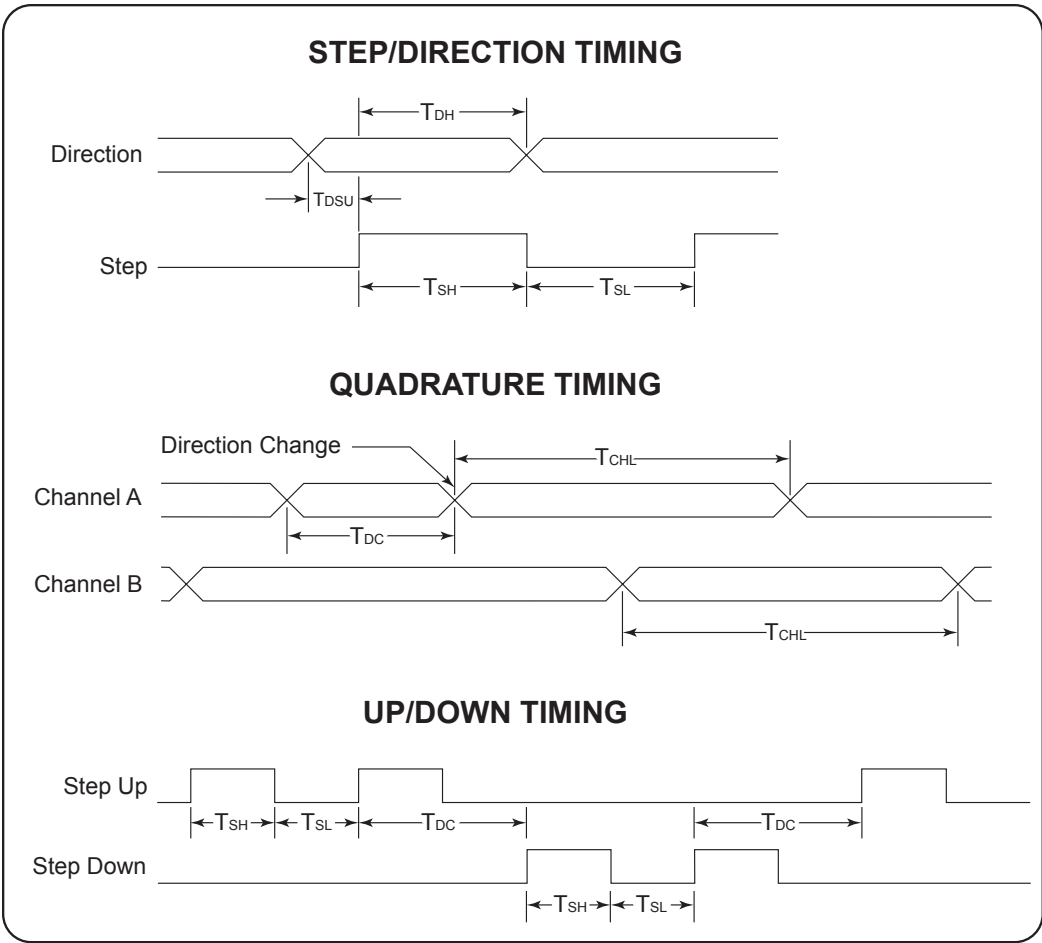


Figure 2.4.3: Clock Input Timing Characteristics

Clock Input Timing					
Symbol	Parameter	Type and Value			
		Step/Direction	Step Up/Down	Quadrature	Units
$T_{DSU}$	T Direction Set Up	50	—	—	nS min
$T_{DH}$	T Direction Hold	100	—	—	nS min
$T_{SH}$	T Step High	100	100	—	nS min
$T_{SL}$	T Step Low	100	100	—	nS min
$T_{DL}$	T Direction Change	—	200	200	nS min
$T_{CHL}$	T Channel High/Low	—	—	400	nS min
$F_{SMAX}$	F Step Maximum	5	5	—	MHz Max
$F_{CHMAX}$	F Channel Maximum	—	—	1.25	MHz Max
$F_{ER}$	F Edge Rate	—	—	5	MHz Max

Table 2.4.1: Input Clocks Timing Table



**NOTE:** When connecting the Optocoupler Supply, it is recommended that you do not use MForce Power Ground as Ground as this will defeat the optical isolation.

## Optocoupler Reference

The Microstepping MForce PowerDrive Logic Inputs are optically isolated to prevent electrical noise being coupled into the inputs and causing erratic operation.

There are two ways that the Optocoupler Reference will be connected depending whether the Inputs are to be configured as sinking or sourcing.

Optocoupler Reference	
Input Type	Optocoupler Reference Connection
Sinking	+5 to +24 VDC
Sourcing	Controller Ground

Table 2.4.2: Optocoupler Reference Connection

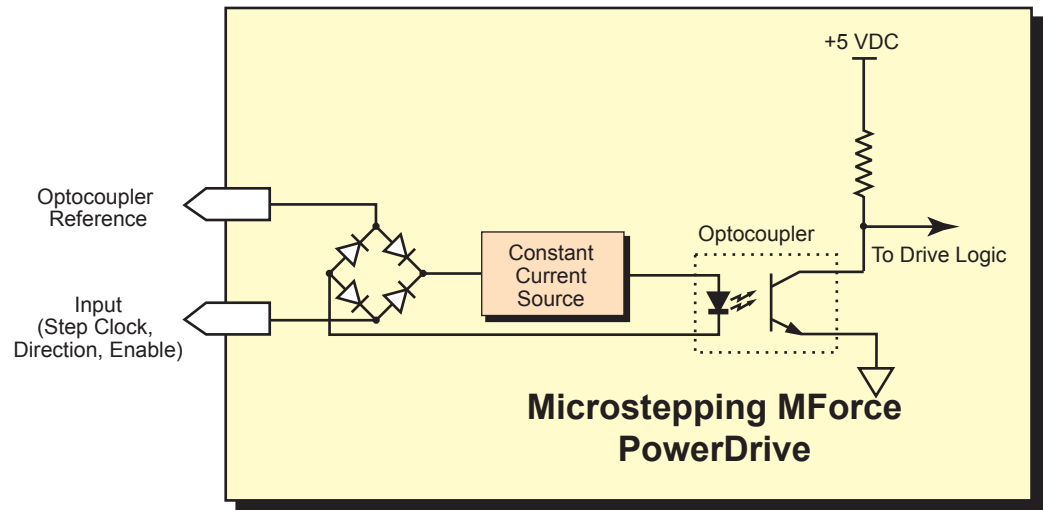
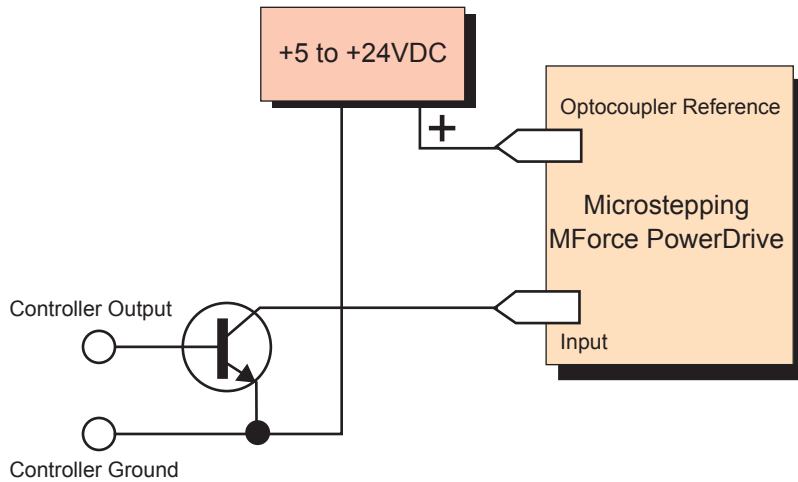


Figure 2.4.4: Optocoupler Input Circuit Diagram

## Input Connection Examples

The following diagrams illustrate possible connection/application of the Microstepping MForce PowerDrive Logic Inputs.

### NPN Open Collector Interface (Sinking)



### PNP Open Collector Interface (Sourcing)

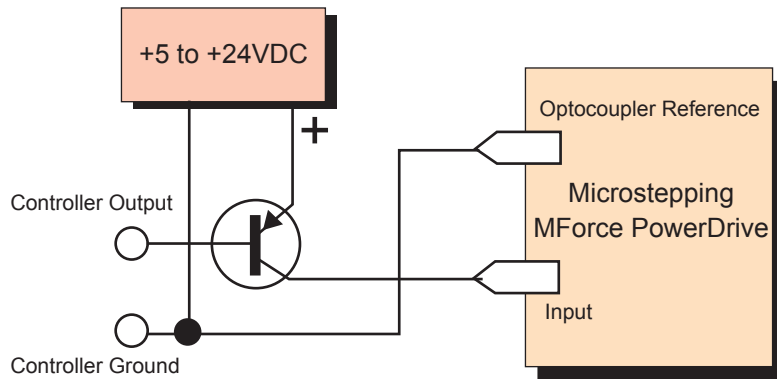
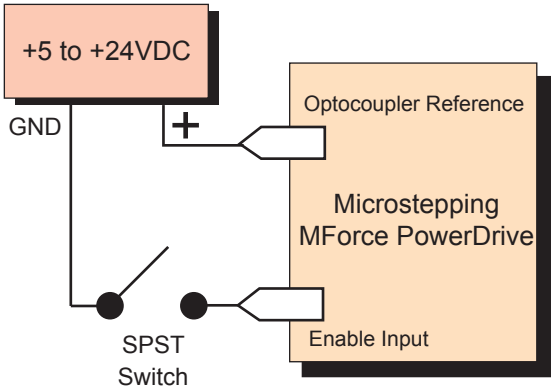


Figure 2.4.5: Open Collector Interface Example

Switch Interface Example

Switch Interface (Sinking)



Switch Interface (Sourcing)

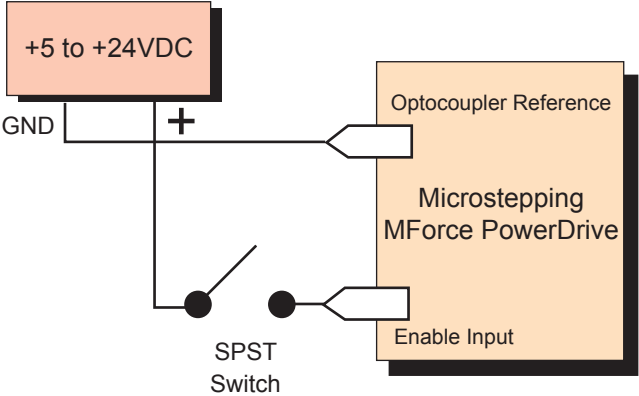


Figure 2.4.6: Switch Interface Example

## Minimum Required Connections

The connections shown are the minimum required to operate the Microstepping MForce PowerDrive. These are illustrated in both Sinking and Sourcing Configurations. Please reference the Pin Configuration diagram and Specification Tables for the Microstepping MForce PowerDrive connector option you are using.

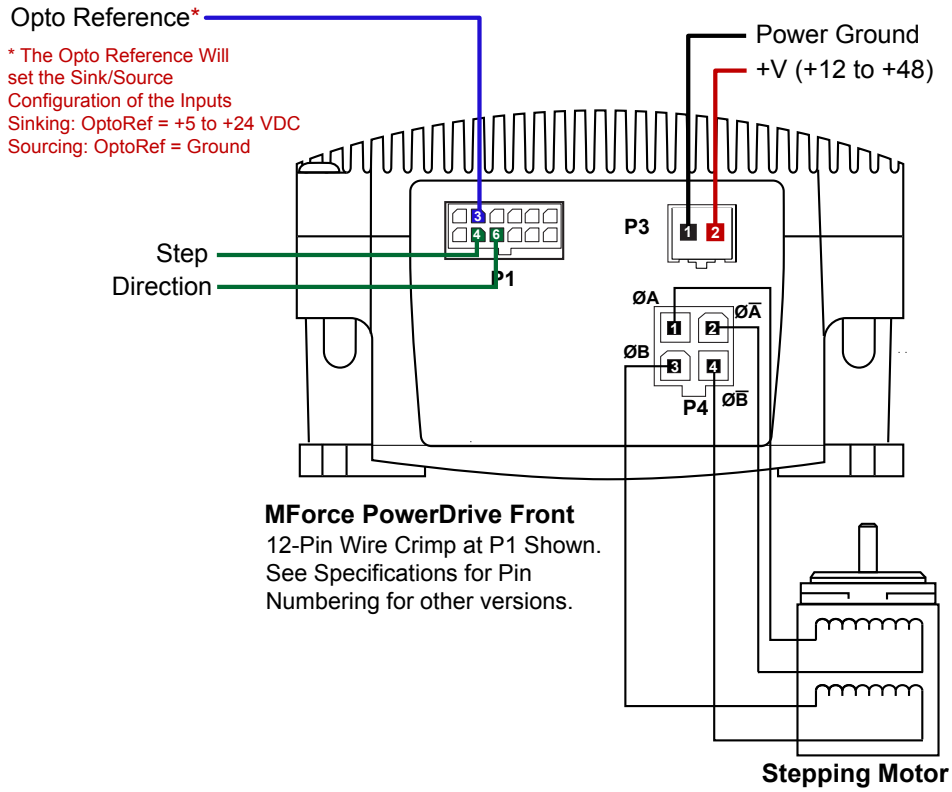


Figure 2.4.7: Minimum Required Connections

### Connecting the SPI Interface

The SPI (Serial Peripheral Interface) is the communications and configuration interface.

For prototyping we recommend the purchase of the parameter setup cable MD-CC300-000. If using the Microstepping MForce PowerDrive with the 10-Pin IDC on P2, this cable will plug directly into the P2 Connector.

If using the model with a 12-Pin Locking Wire Crimp connector, adapters are available to interface the parameter setup cable to P1.

For more information on prototype development cables, please see Appendix: Prototype Development Cables.



Figure 2.5.1: MD-CC300-000 Parameter Setup Cable

### SPI Signal Overview

#### +5 VDC (Output)

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

#### 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.

#### Logic Ground

This is the ground for all Communications.

#### MISO (Master In/Slave Out)

Carries output data from the Microstepping MForce PowerDrive units back to the SPI Master. Only one MForce PowerDrive can transmit data during any particular transfer.

#### CS (SPI Chip Select)

This signal is used to turn multiple Microstepping MForce PowerDrive units on or off.

#### MOSI (Master Out/Slave In)

Carries output data from the SPI Master to the Microstepping MForce PowerDrive.

## SPI Pins and Connections

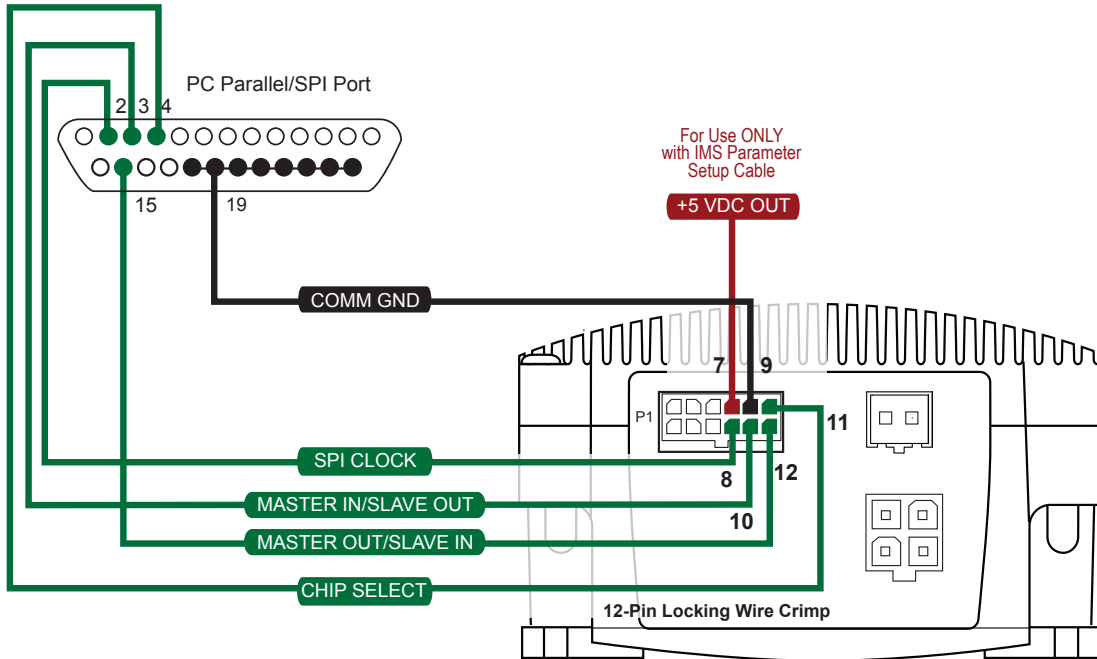


Figure 2.5.2: SPI Pins and Connections, 12-Pin Wire Crimp

## Logic Level Shifting and Conditioning Circuit

The following circuit diagram is of a Logic Level shifting and conditioning circuit. This circuit should be used if you are making your own parameter cable and are using a laptop computer with 3.3 V output parallel ports.

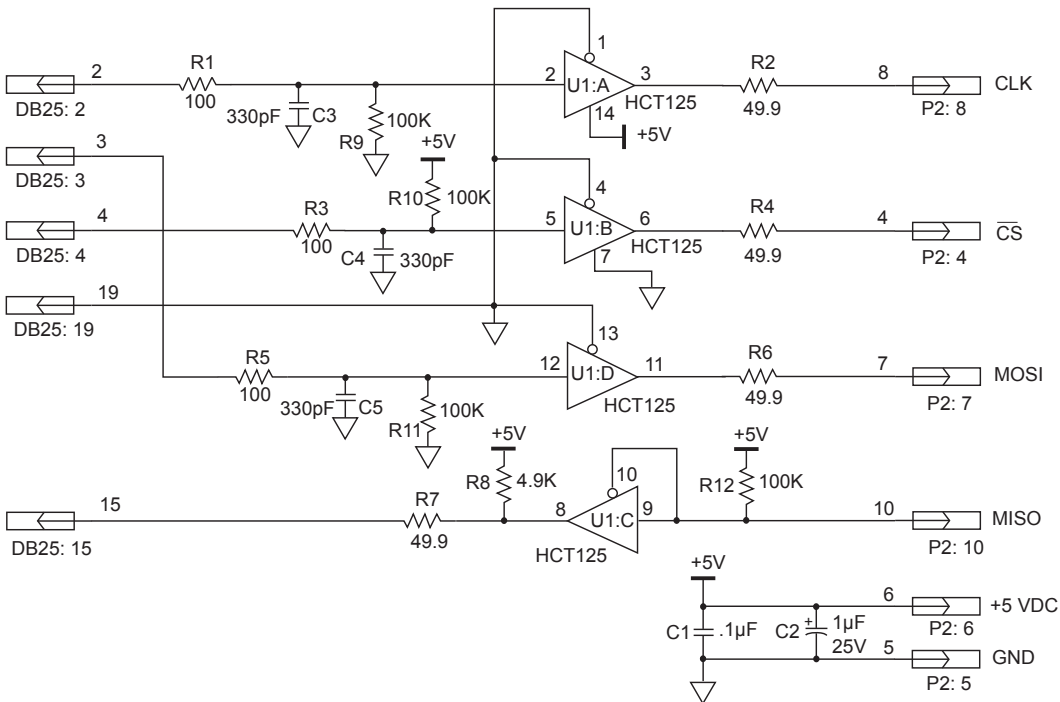


Figure 2.5.3: Logic Level Shifting and Conditioning Circuit

**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.

## SPI Master with Multiple Microstepping MForce PowerDrive

It is possible to link multiple Microstepping MForce PowerDrive units in an array from a single SPI Master by wiring the system and programming the user interface to write to multiple chip selects.

Each MForce on the bus will have a dedicated chip select. Only one system MForce can be communicated with/Parameters changed at a time.

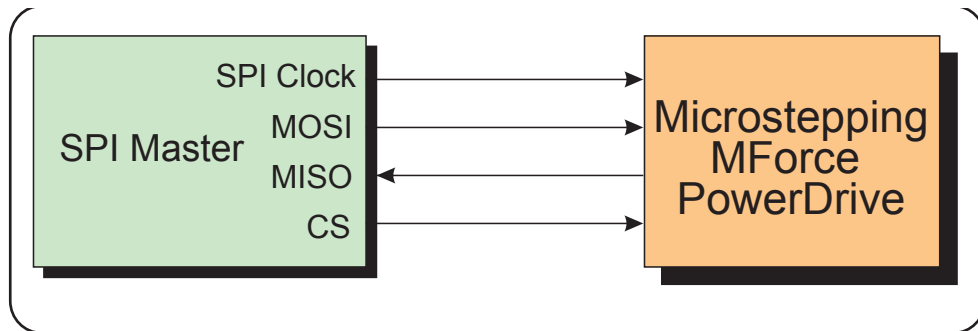


Figure 2.5.4: SPI Master with a Single Microstepping MForce PowerDrive

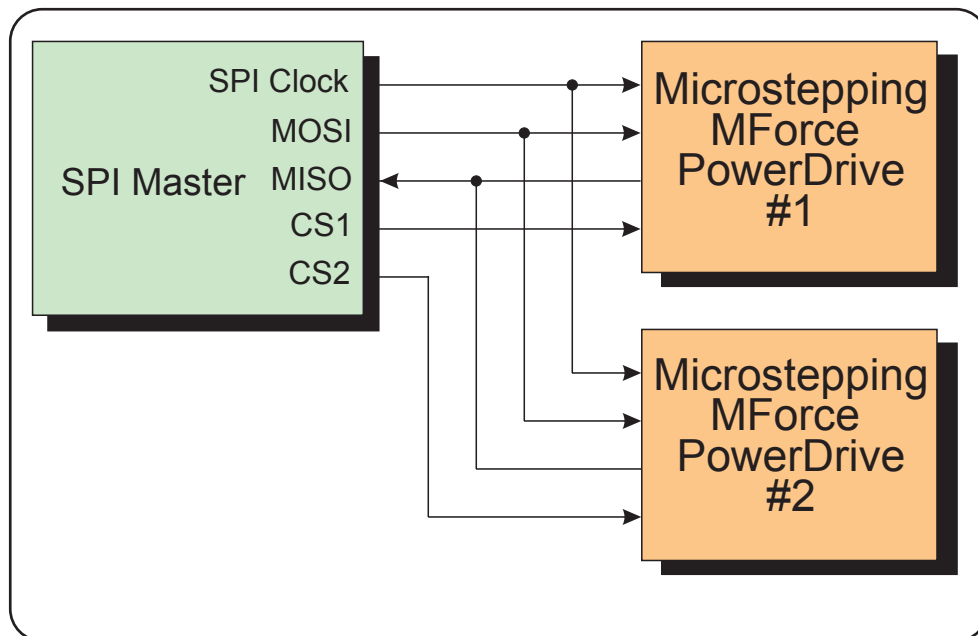


Figure 2.5.5: SPI Master with Multiple Microstepping MForce PowerDrives



## Using the IMS SPI Motor Interface

### Installation

The IMS SPI Motor Interface is a utility that easily allows you to set up the parameters of your Microstepping MForce PowerDrive. It is available both on the CD that came with your product and on the IMS web site at [http://www.imshome.com/software\\_interfaces.html](http://www.imshome.com/software_interfaces.html).

1. Insert the CD into the CD Drive of your PC.  
If not available, go to [http://www.imshome.com/software\\_interfaces.html](http://www.imshome.com/software_interfaces.html).
2. The CD will auto-start.
3. Click the Software Button in the top-right navigation Area.
4. Click the IMS SPI Interface link appropriate to your operating system.
5. Click SETUP in the Setup dialog box and follow the on-screen instructions.
6. Once IMS SPI Motor Interface is installed, the Microstepping MForce PowerDrive settings can be checked and/or set.

### Configuration Parameters and Ranges

Microstepping MForce PowerDrive Setup Parameters				
Name	Function	Range	Units	Default
MHC	Motor Hold Current	0 to 100	percent	5
MRC	Motor Run Current	1 to 100	percent	25
MSEL	Microstep Resolution	1, 2, 4, 5, 8, 10, 16, 25, 32, 50, 64, 100, 108, 125, 127, 128, 180, 200, 250, 256	µsteps per full step	256
DIR	Motor Direction Override	0/1	—	CW
HCDT	Hold Current Delay Time	0 or 2-65535	mSec	500
CLK TYPE	Clock Type	Step/Dir. Quadrature, Up/Down	—	Step/Dir
CLK IOF	Clock and Direction Filter	50 nS to 12.9 µS (10 MHz to 38.8kHz)	nS (MHz)	50nS (10 MHz)
USER ID	User ID	Customizable	1-3 characters	IMS
EN ACT	Enable Active High/Low	High/Low	—	High
WARN TEMP	Warning Temperature	0 to + 125	°C	80

Table 2.6.1: Setup Parameters and Ranges

### Color Coded Parameter Values

The SPI Motor Interface displays the parameter values using a predefined system of color codes to identify the status of the parameter.

1. Black: the parameter settings currently stored in the device NVM will display as black.
2. Blue: Blue text indicates a changed parameter setting that has not yet been written to the device.
3. Red: Red text indicates an out-of-range value which cannot be written to the device. When an out-of-range parameter is entered into a field, the "set" button will disable, preventing the value to be written to NVM. To view the valid parameter range, hover the mouse pointer over the field. The valid range will display in a tool tip.

The color coding is illustrated in Figure 2.5.1.

Blue: New Value which has not yet been set to NVM.

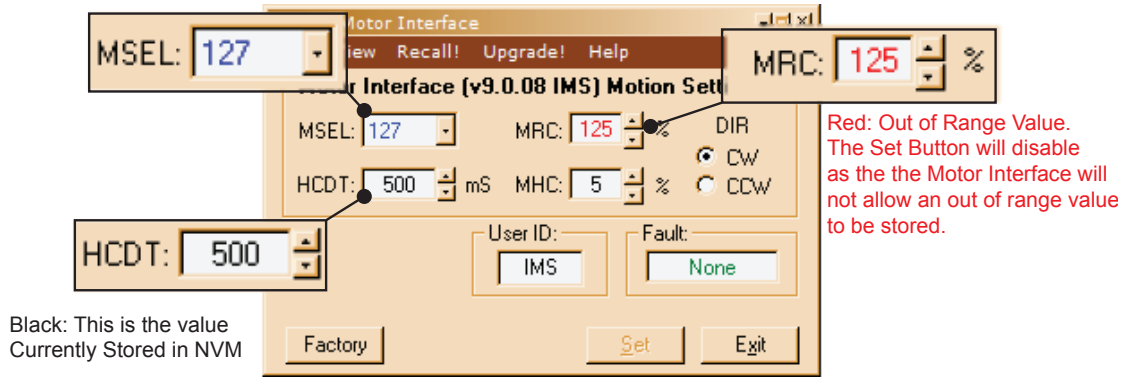


Figure 2.6.1: SPI Motor Interface Color Coding

## IMS SPI Motor Interface Menu Options

### File

- > Open: Opens a saved \*.mot (Motor Settings) file.
- > Save: Saves the current motor settings as a \*.mot file for later re-use
- > Save As
- > Exit - Disconnects from the device and opens the Initialization Dialog.

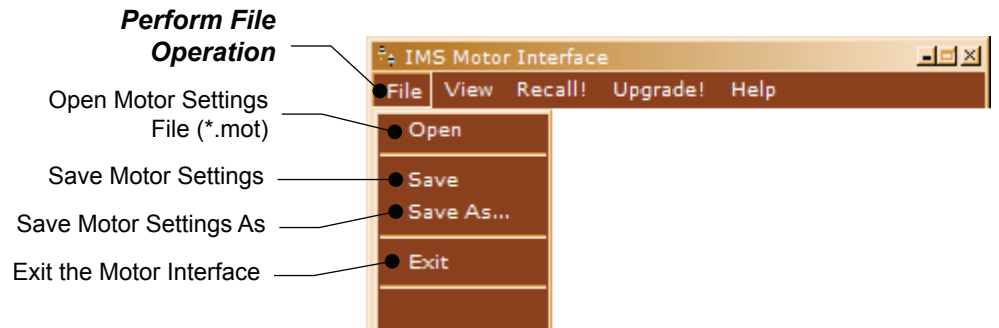


Figure 2.6.2: SPI Motor Interface File Menu

### View

- > Motion Settings: Displays the Motion Settings screen
- > IO Settings: Displays the IO Settings Screen
- > Part and Serial Number: Displays the part and serial number

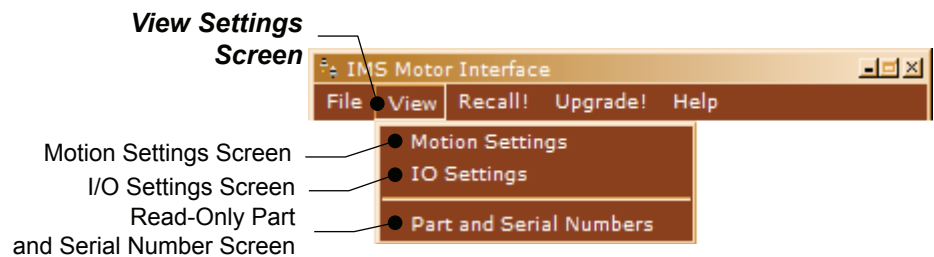


Figure 2.6.3: SPI Motor Interface View Menu

### Recall!

Retrieves the settings from the Microstepping MForce PowerDrive.

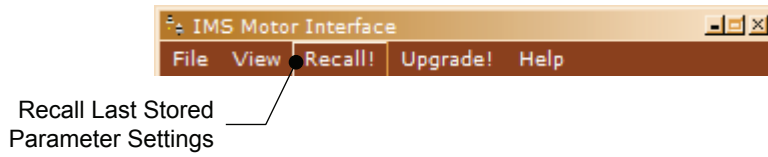


Figure 2.6.4: SPI Motor Interface Recall Menu

### Upgrade!

Upgrades the Microstepping MForce PowerDrive firmware by placing the device in Upgrade Mode and launching the firmware upgrader utility.

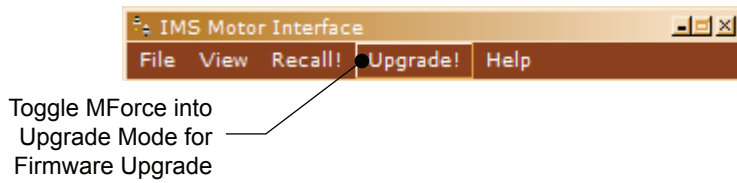


Figure 2.6.5: SPI Motor Interface Upgrade Menu

### Help

- > IMS Internet Tutorials: Link to an IMS Web Site page containing Interactive flash tutorials.
- > About: Opens the About IMS and IMS SPI Motor Interface Screen.

Links to the Software Tutorial page of the IMS Website

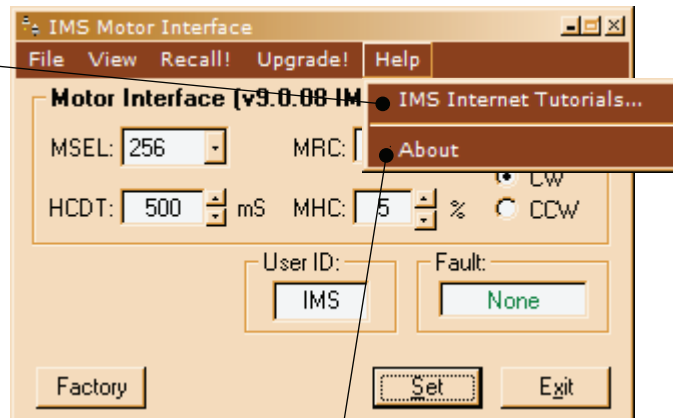


Figure 2.6.6: SPI Motor Interface Help Menu and About Screen

1. MSEL: Microstep Resolution Select.

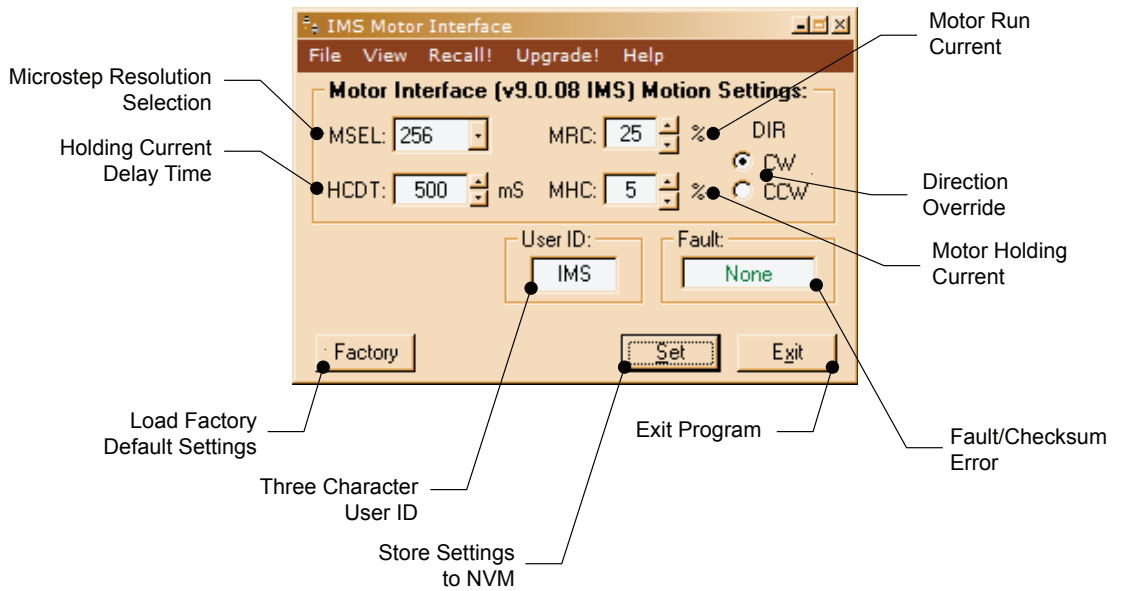


Figure 2.6.7: SPI Motor Interface Motion Settings Screen

2. HCDT: Holding Current Delay Time.
3. MRC: Motor Run Current
4. Motor Holding Current
5. User ID: 3-character ID
6. Direction Override: Allows the user to set the CW/CCW direction of the motor in relation to the Direction Input from the SPI Motor Interface.

**MSEL (Microstep Resolution Selection)**

The Microstepping MForce PowerDrive features 20 microstep resolutions. This setting specifies the number of microsteps per step the motor will move.

The MForce PowerDrive uses a 200 step (1.8°) stepping motor which at the highest (default) resolution of 256 will yield 51,200 steps per revolution of the motor shaft.

See Table 2.3.2 for available Microstep Resolutions.

Microstep Resolution Settings			
Binary $\mu$ Step Resolution Settings		Decimal $\mu$ Step Resolution Settings	
MS=< $\mu$ Steps/Step>	Steps/Revolution	MS=< $\mu$ Steps/Step>	Steps/Revolution
1	200	5	1000
2	400	10	2000
4	800	25	5000
8	1600	50	10000
16	3200	100	20000
32	6400	125	25000
64	12800	200	40000
128	25600	250	50000
256	51200		
Additional Resolution Settings			
180	36000 (0.01°/ $\mu$ Step)		
108	21600 (1 Arc Minute/ $\mu$ Step)		
127	25400 (0.001 mm/ $\mu$ Step)		

Table 2.6.2: Microstep Resolution Settings

### **HCDT (Hold Current Delay Time)**

The HCDT Motor Hold Current Delay sets time in milliseconds for the Run Current to switch to Hold Current when motion is complete. When motion is complete, the Microstepping MForce PowerDrive will reduce the current in the windings of the motor to the percentage specified by MHC when the specified time elapses.

### **MRC (Motor Run Current)**

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

### **MHC (Motor Hold Current)**

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 HCDT setting mS following the last clock pulse.

Run and Hold Current Settings	
HC=(%) RC=(%)	MForce PowerDrive (Amps RMS)
10	0.5
20	1.0
30	1.5
40	2.0
50	2.5
60	3.0
70	3.5
80	4.0
90	4.5
100	5.0

Table 2.6.3: Hold and Run Current Percentage Equivalents

### **DIR (Motor Direction)**

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

### **User ID**

The User ID is a three character (viewable ASCII) identifier which can be assigned by the user. Default is IMS.

### **IMS SPI Motor Interface Button Functions**

The following appear on all of the IMS SPI Motor Interface screens, but will only be documented here.

#### **Factory**

Clicking the Factory button will load the Microstepping MForce PowerDrive unit's factory default settings into the IMS SPI Motor Interface.

#### **Connected/Disconnected Indicator**

Displays the connected/disconnected state of the software, and if connected, the port connected on.

#### **Set**

Set writes the new settings to the MForce PowerDrive. Un-set settings will display as blue text in the setting fields. Once set they will be in black text. Setting the Parameters will also clear most Fault Conditions.

#### **Exit**

Disconnects and opens the Initialization dialog.

## Screen 2: I/O Settings Configuration Screen

The I/O Settings screen may be accessed by clicking View > IO Settings on the menu bar. This screen is used to configure the Input Clock Type, the filtering and the Active High/Low State of the Enable Input.

### Input Clock Type

The Input Clock Type translates the specified pulse source that the motor will use as a reference for establishing stepping resolution based on the frequency.

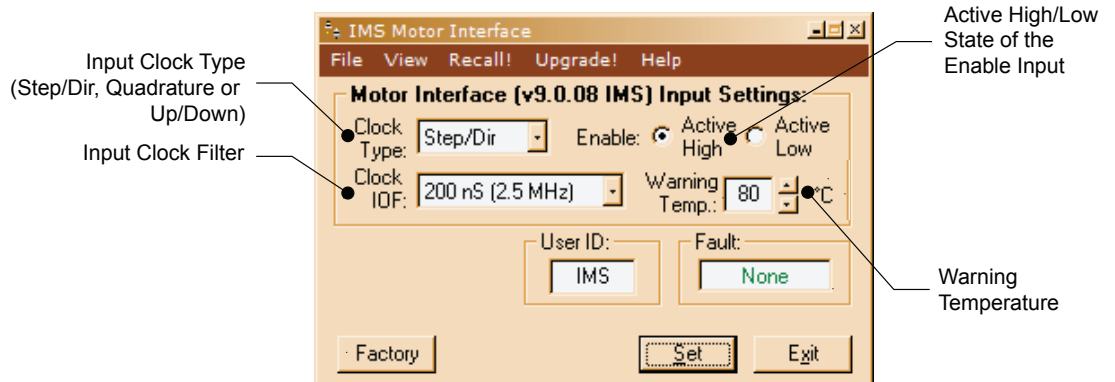


Figure 2.6.8: SPI Motor Interface I/O Settings Screen

The three clock types supported are:

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

The Clock types are covered in detail in Section 2.2: Logic Interface and Connection.

### Input Clock Filter

The clock inputs may also be filtered using the Clock IOF pull down of the IMS SPI Motor Interface. The filter range is from 50 nS (10 MHz) to 12.9  $\mu$ Sec. (38.8 kHz). Table 2.4.3 shows the filter settings.

Input Clock Filter Settings	
Min. Pulse	Cutoff Frequency
50 nS	10 MHz
150 nS	3.3 MHz
200 nS	2.5 MHz
300 nS	1.67 MHz
500 nS	1.0 MHz
900 nS	555 kHz
1.7 $\mu$ S	294.1 kHz
3.3 $\mu$ S	151 kHz
6.5 $\mu$ S	76.9 kHz
12.9 $\mu$ S	38.8 kHz

Table 2.6.4: Input Clock Filter Settings

### Enable Active High/Low

The parameter sets the Enable Input to be Active when High (Default, Disconnected) or Active when Low.

### Warning Temperature

The parameter sets the temperature at which a TW, or temperature warning fault code will be generated. In the warning condition the MForce PowerDrive will continue to operate as normal. The thermal shutdown is +85°C.

## IMS Part Number/Serial Number Screen

The IMS Part Number and Serial Number screen is accessed by clicking "View > Part and Serial Numbers".

This screen is read-only and will display the part and serial number, as well as the fault code if existing. IMS may require this information if calling the factory for support.

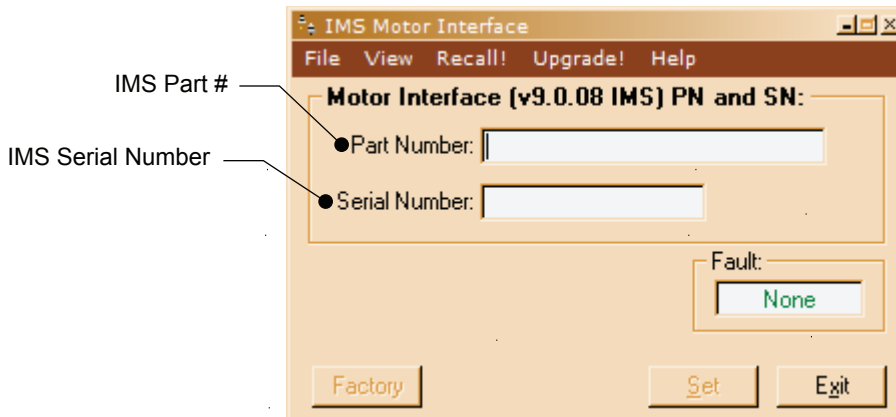


Figure 2.6.9: SPI Motor Interface Part and Serial Number Screen

## Fault Indication

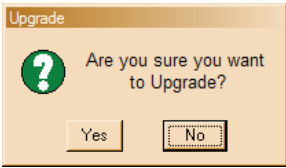
All of the IMS SPI Motor Interface Screens have the Fault field visible. This read-only field will display a 2 character error code to indicate the type of fault. The table below shows the error codes.

MForce34Plus Microstepping Fault Codes				
Binary Case*	Error Code	Description	Action	To Clear
—	None	No Fault	—	—
4	CS	SPI Checksum Error	Error Displayed	Write to MDM (Set Button)
8	SC/CS	SPI Checksum Error/ Sector Changing	Error Displayed	Write to MDM (Set Button)
16	DFLT	Defaults Checksum Error	Error Displayed	Write to MDM (Set Button)
32	DATA	Settings Checksum Error	Error Displayed	Write to MDM (Set Button)
64	TW	Temperature Warning	Error Displayed	Write to MDM (Set Button)

\*All Fault Codes are OR'ed together

Table 2.6.5: Microstepping MForce PowerDrive Fault Codes

**N** NOTE: Once entered into Upgrade Mode, you MUST complete the upgrade. If the upgrade process is incomplete the IMS SPI Motor Interface will continue to open to the Upgrade dialog until the process is completed!



## Upgrading the Firmware in the Microstepping MForce PowerDrive

### The IMS SPI Upgrader Screen

New firmware releases are posted to the IMS web site at <http://www.imshome.com>.

The IMS SPI Motor Interface is required to upgrade your Microstepping MForce PowerDrive product. To launch the Upgrader, click "Upgrade!" on the IMS SPI Motor Interface menu.

The Upgrader screen has 4 read-only text fields that will display the necessary info about your Microstepping MForce PowerDrive.

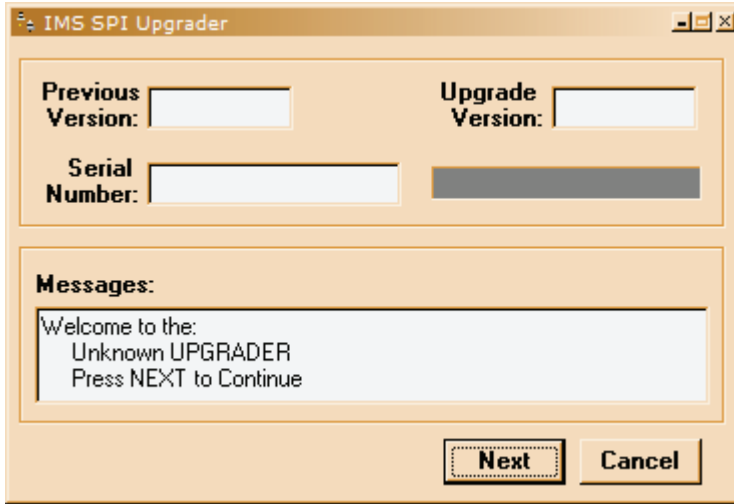


Figure 2.6.10: SPI Motor Interface Upgrade Utility

1. Previous Version: this is the version of the firmware currently on your Microstepping MForce PowerDrive.
2. Serial Number: the serial number of your unit.
3. Upgrade Version: will display the version number of the firmware being installed.
4. Messages: the messages text area will display step by step instructions through the upgrade process.

### Upgrade Instructions

Below are listed the upgrade instructions as they will appear in the message box of the IMS SPI Upgrader. Note that some steps are not shown as they are accomplished internally, or are not relevant to the model IMS product you are updating. The only steps shown are those requiring user action.

Welcome Message: Welcome to the Motor Interface UPGRADER! Click NEXT to continue.

Step 2: Select Upgrade File

When this loads, an explorer dialog will open asking you to browse for the firmware upgrade file. This file will have the extension \*.ims.

Step 3: Connect SPI Cable

Step 4: Power up or Cycle Power to the MForce

Step 6: Press Upgrade Button

Progress bar will show upgrade progress in blue, Message box will read "Resetting Motor Interface"

Step 8: Press DONE, then select Port/Reconnect.



## Initialization Screen

This screen will be active under five conditions:

1. When the program initially starts up and seeks for a compatible device.
2. The User selects File > Exit when connected to the device.
3. The User clicks the Exit button while connected to the device.
4. The Upgrade Process completes.
5. The SPI Motor Interface is unable to connect to a compatible device.

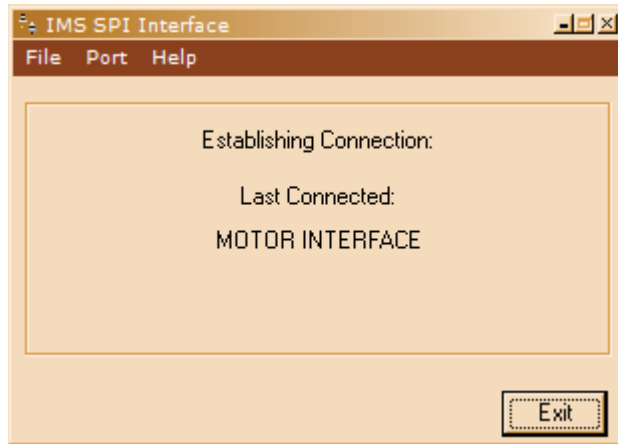


Figure 2.6.11: SPI Motor Interface Initialization

## Port Menu

The Port Menu allows the user to select the COM Port that the device is connected to, either a parallel (LPT) Port, or a Hardware Serial or Virtual Serial Port via USB.

The Reconnect option allows the user to reconnect to a unit using the previously used settings.

On open or reconnect, the SPI Motor Interface will also try to auto seek for a connected device.

## Communications Port Operations

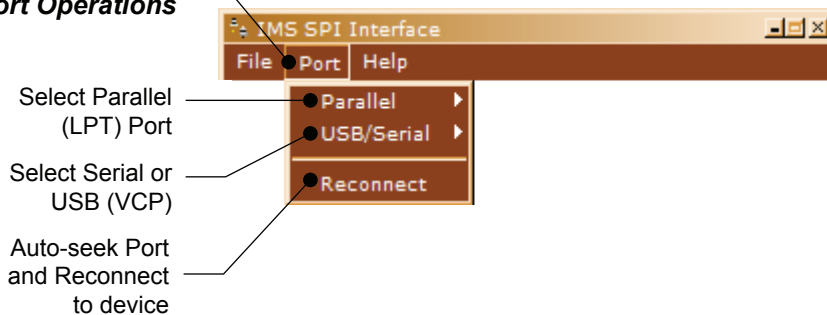


Figure 2.6.12: SPI Motor Interface Port Menu

## Motor Settings Screen (PWM Current Control)

The Motor settings screen allows the user to fine tune the settings of the PWM to optimize the current output for a variety of stepping motors.

There are four parameters that may be set:

1. PWM Mask
2. PWM Period (Duty Cycle)
3. PWM Frequency Range
4. PWM Control

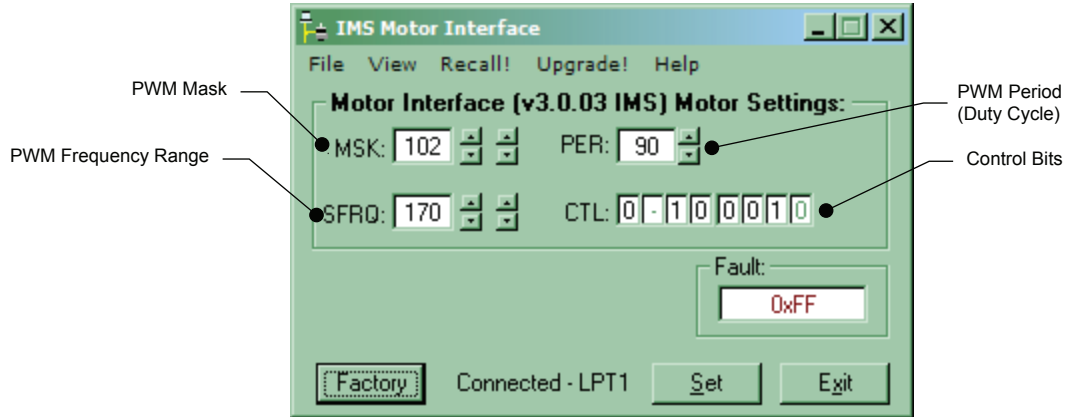


Figure 2.6.13: Motor Settings Screen

### PWM Mask

The PWM mask parameter prevents the premature end of the forward period caused by switching transients when the motor phase current is at low levels. Adjusting this value can impact the zero-crossing performance of the motor. If experiencing the “tick” which is inherit in stepper motor systems, this may be minimized or eliminated by adjusting this value. The range of this value is 0 to 255d and will be entered as a decimal value.

The Mask will act as a filter on the PWM signal to allow time for any ringing in the output circuitry to settle.

This range represents a 8-bit Hex value that specifies the Bridge Reverse Measure Time (REVTM) and the Minimum Bridge Forward On Time (FORTM) ranging from 600 ns to 3.4  $\mu$ S each (see table and diagram below). Typically these values would be balanced. The table below shows the decimal value for each time.

Note that these are typical values and the currents may be unbalanced to fine tune the motor performance.

The default value for this parameter is 204 (0xCC), which represents a Reverse Measure Time and Minimum Forward On Time of 2.5  $\mu$ S.

Reverse Measure Time/Minimum Forward On Time							
Hex	Time	Hex	Time	Hex	Time	Hex	Time
0x0	600 ns	0x4	1.0 $\mu$ S	0x8	1.6 $\mu$ S	0xC	2.5 $\mu$ S
0x1	700 ns	0x5	1.1 $\mu$ S	0x9	1.8 $\mu$ S	0xD	2.8 $\mu$ S
0x2	800 ns	0x6	1.2 $\mu$ S	0xA	2.0 $\mu$ S	0xE	3.1 $\mu$ S
0x3	900 ns	0x7	1.4 $\mu$ S	0xB	2.2 $\mu$ S	0xF	3.4 $\mu$ S

Table 2.6.6: PWM Mask Settings

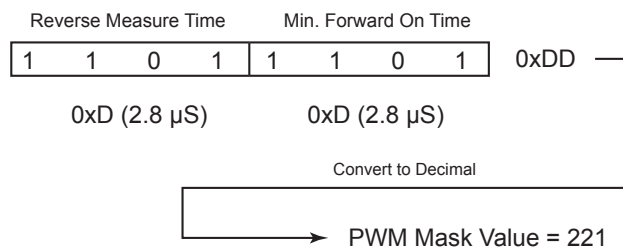


Figure 2.6.14: PWM Mask Bits

Typical PWM Mask Settings (Currents Balanced)							
Mask (hex)	Mask (dec)	REVTM	FORTM	Mask (hex)	Mask (dec)	REVTM	FORTM
0x00	0	600 ns	600 ns	0x88	135	1.6 $\mu$ s	1.6 $\mu$ s
0x11	17	700 ns	700 ns	0x99	153	1.8 $\mu$ s	1.8 $\mu$ s
0x22	34	800 ns	800 ns	0xAA	170	2.0 $\mu$ s	2.0 $\mu$ s
0x33	51	900 ns	900 ns	0xBB	187	2.2 $\mu$ s	2.2 $\mu$ s
0x44	68	1.0 $\mu$ s	1.0 $\mu$ s	0xCC	204	2.5 $\mu$ s	2.5 $\mu$ s
0x55	85	1.1 $\mu$ s	1.1 $\mu$ s	0xDD	221	2.8 $\mu$ s	2.8 $\mu$ s
0x66	102	1.2 $\mu$ s	1.2 $\mu$ s	0xEE	238	3.1 $\mu$ s	3.1 $\mu$ s
0x77	119	1.4 $\mu$ s	1.4 $\mu$ s	0xFF	255	3.4 $\mu$ s	3.4 $\mu$ s

Table 2.6.7: Typical PWM Mask Settings

### Maximum PWM Duty Cycle (%) Parameter

This parameter sets the maximum duty cycle as a percentage of the bridge PWM oscillator period. The range for this parameter is 0 to 95%. The default value for this parameter is 95%.

### PWM Frequency Range Parameter

The PWM Frequency Parameter sets the initial and maximum frequencies for the PWM. As with the MASK parameter, the PWM Frequency is a two part 8-bit hex number which is entered as a decimal value ranging from 0 to 255.

The default for this 170 (0xAA) with an initial PWM Frequency of 20 kHz and a Maximum of 60 kHz.

Maximum PWM Frequency (kHz)							
Hex	Freq.	Hex	Freq	Hex	Freq	Hex	Freq
0x0	40	0x4	48	0x8	56	0xC	64
0x1	42	0x5	50	0x9	58	0xD	66
0x2	44	0x6	52	0xA	60	0xE	68
0x3	46	0x7	54	0xB	62	0xF	70

Initial PWM Frequency (kHz)							
Hex	Freq.	Hex	Freq	Hex	Freq	Hex	Freq
0x0	10	0x4	14	0x8	18	0xC	22
0x1	11	0x5	15	0x9	19	0xD	23
0x2	12	0x6	16	0xA	20	0xE	24
0x3	13	0x7	17	0xB	21	0xF	25

Table 2.6.8: Maximum and Initial PWM Frequency

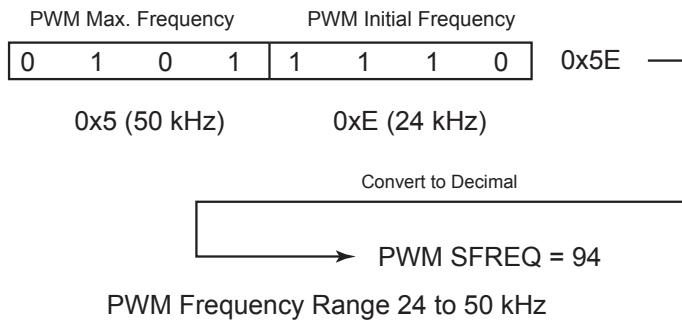


Figure 2.6.15: PWM Frequency Range

## PWM Control Bits

Bit	7	6	5	4	3	2	1	0	
0x0203	QUIET	—	SYNC_EN	RECIR	TODLY[2:0]			ENABLE	PWMCT
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	
Initial Value	0	0	1	0	0	0	1	0	

Figure 2.6.16: PWM Control Bits

### ■ Bit 7 – QUIET

This bit changes PWM operation. When quiet is set, the bridge logic does not enter the reverse measure period, therefore there are fewer transitions. The bridge is disabled during zero cross. This mode is used at rest or when moving very slowly. When quiet is cleared, normal bridge operation is selected.

### ■ Bit 6 – Not used

### ■ Bit 5 – SYNC\_EN

This bit controls the synchronization of the bridge PWM with the zero cross. When the sync\_en bit is set, the bridge PWM will be synchronized with the positive front slope of the sin phase at each zero cross.

### ■ Bit 4 – RECIR

This bit controls where the motor current will recirculate within the bridge during the recirculate period. When recir is set, the motor current will recirculate in the high portion of the bridge. When recir is cleared, the motor current will recirculate in the low portion of the bridge.

### ■ Bits 3..1 – TODLY - Turn on Delay

This value sets the bridge control turn on delay to prevent shoot through if a discrete FET bridge is in use. The range is 0 to 350 nS with 50 nS resolution. Each LSB is 50 nS. The default setting for a bridge driver is 50 nS (0x1).

### ■ Bit 0 – ENABLE

Bridge Enable, this bit is set at the factory and is inaccessible to the user.

## Example PWM Settings By Motor Specifications

The following settings are based upon IMS settings per motor specifications and should serve as a baseline to work from with regard to the manufacturer specifications of the motor being utilized. Note that these are example settings ONLY!

Example PW Settings								
Frame Size	Stack Size	Phase Current (A <sub>RMS</sub> )	Phase Resistance (Ω)	Phase Inductance (mH)	MASK <mask>	Duty Cycle <period>	Frequency <sfreq>	Checksum <chksum>
14	Single	0.75	4.30	4	102	90	170	106
17	Single	1.5	1.30	2.1	136	90	170	140
	Double	1.5	2.10	5.0	136	90	170	140
	Triple	1.5	2.00	3.85	136	90	170	140
23	Single	2.4	0.95	2.4	136	90	170	140
	Double	2.4	1.20	4.0	136	90	170	140
	Triple	2.4	1.50	5.4	136	90	170	140
MForce Default	—	—	—	—	204	95	170	—

Table 2.6.9: Example PWM Settings

# SECTION 2.7

## Using User-Defined SPI

The MForce can be configured and operated through the end-user's SPI interface without using the IMS SPI Motor Interface software and optional parameter setup cable.

An example of when this might be used is in cases where the machine design requires parameter settings to be changed on-the-fly by a software program or multiple system Microstepping MForce PowerDrive units parameter states being written/read.

### SPI Timing Notes

1. MSb (Most Significant bit) first and MSB (Most Significant Byte) first.
2. 8 bit bytes.
3. 25 kHz SPI Clock (SCLK).
4. Data In (MOSI) on rising clock.
5. Data Out (MISO) on falling clock.

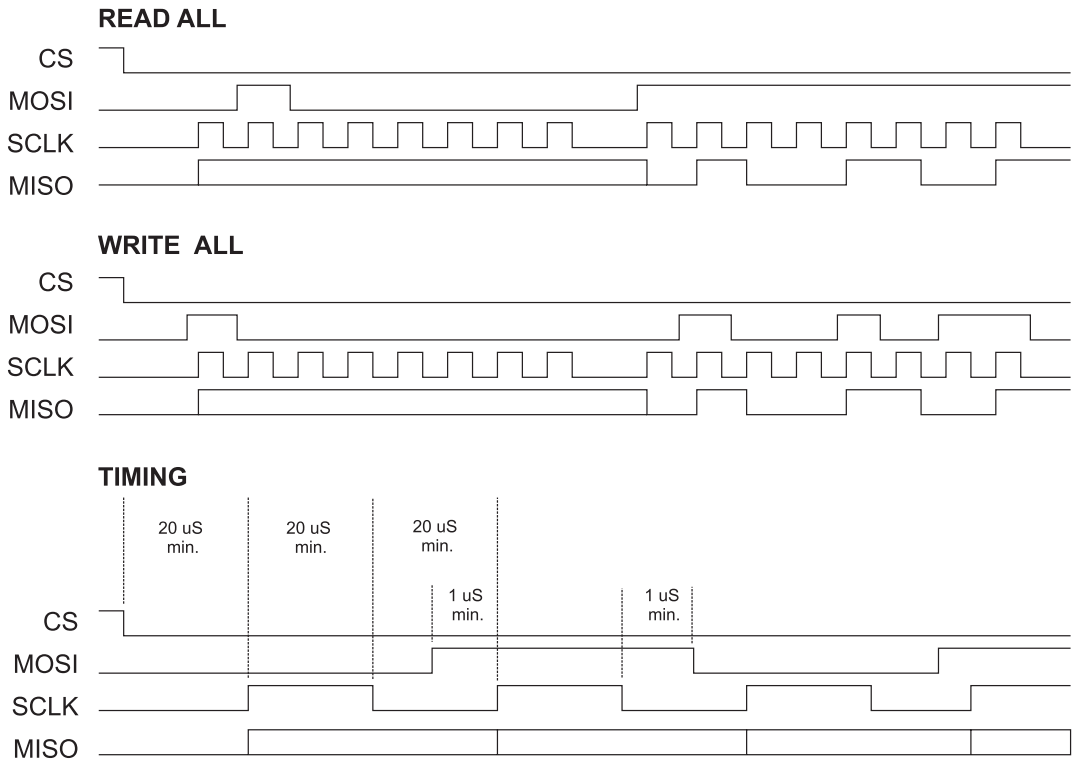


Figure 2.7.1: SPI Timing

### Check Sum Calculation for SPI

The values in the example below are 8-bit binary hexadecimal conversions for the following SPI parameters: MRC=25%, MHC=5%, MSEL=256, HCDT=500 mSec, WARNTEMP=80.

The Check Sum is calculated as follows:

(Hex) 80+19+05+00+00+01+F4+50

Sum = E3                      1110 0011

1's complement = 1C        0001 1100 (Invert)

2's complement = 1D        0001 1101 (Add 1)

Send the check sum value of 1D

Note: 80 is always the first command on a write.

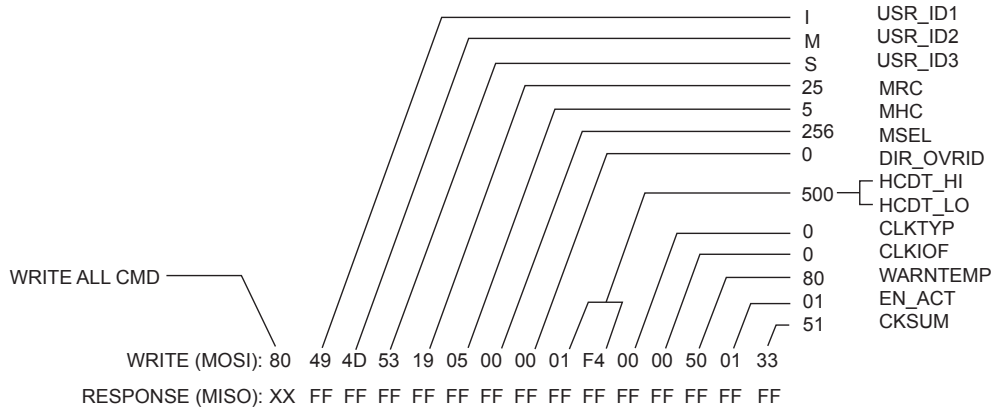
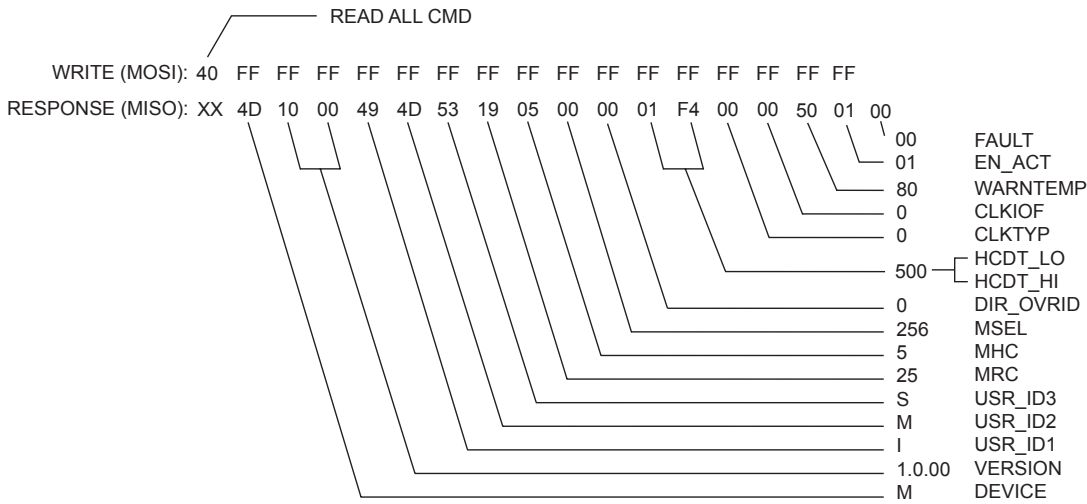
Note: Once a write is performed, a read needs to be performed to see if there is a fault. The fault is the last byte of the read.

## SPI Commands and Parameters

Use the following table and figure found on the following page together as the Byte order read and written from the MDrivePlus Microstepping, as well as the checksum at the end of a WRITE is critical.

SPI Commands and Parameters				
	Command/ Parameter	HEX (Default)	Range	Notes
	READ ALL	0x40	—	Reads the hex value of all parameters
MSB	Device (M)	0x4D	—	M Character precedes every READ
	Version_MSB	0x10	<1-8>.<0-9>	Firmware Version.Sub-version, eg 1.0
	Version_LSB	0x00	<0-99>	Firmware Version Appends to Version_MSB, eg.00
	USR_ID1	0x49	—	Uppercase Letter <I>
	USR_ID2	0x4D	—	Uppercase Letter <M>
	USR_ID3	0x53	—	Uppercase Letter <S>
	MRC	0x19	1-67%	Motor Run Current
	MHC	0x05	0-67%	Motor Hold Current
	MSEL	0x00	0*, 1-259 *0=256	Microstep Resolution (See Table in Section 2.4 for settings)
	DIR_OVRID	0x00	0=no override 1=override dir	Direction Override
	HCDT_HI	0x01	0 or 2-65535	Hold Current Delay Time High Byte
	HCDT_LO	0xF4		Hold Current Delay Time Low Byte
	CLKTYP	0x00	0=s/d, 1=quad, 2=u/d	Input Clock Type
	CLKIOF	0x00	<0-9>	Clock Input Filtering
	WARNTMP	0x50		OVER_TEMP - 5° C
	EN_ACT	0x01	0=Low 1=High,	Enable Active High/Low
LSB	FAULT	0x00	—	See Fault Table, Section 2.4
	WRITE ALL	0x80	—	Writes the hex value to the following parameters.
MSB	USR_ID1	0x49	—	Uppercase Letter <I>
	USR_ID2	0x4D	—	Uppercase Letter <M>
	USR_ID3	0x53	—	Uppercase Letter <S>
	MRC	0x19	1-100%	Motor Run Current
	MHC	0x05	0-100%	Motor Hold Current
	MSEL	0x00	0*, 1-259 *0=256	Microstep Resolution (See Table in Section 2.4 for settings)
	DIR_OVRID	0x00	0=no override 1=override dir	Direction Override
	HCDT_HI	0x01	0 or 2-65535	Hold Current Delay Time High Byte
	HCDT_LO	0xF4		Hold Current Delay Time Low Byte
	CLKTYP	0x00	0=s/d, 1=quad, 2=u/d	Input Clock Type
	CLKIOF	0x00	<0-9>	Clock Input Filtering
	WARNTMP	0x50		OVER_TEMP - 5° C
	EN_ACT	0x01	0=Low 1=High	Enable Active High/Low
LSB	CKSUM			34

Table 2.7.1: SPI Commands and Parameters



**CHECKSUM CALCULATION**  
 $80+49+4D+53+19+05+00+00+01+F4+00+00+50+01=CD$   
 BINARY = 1100 1101  
 1'S COMPLEMENT = 0011 0010  
 2'S COMPLEMENT = 0011 0011  
 DEC = 51  
 HEX = 33

Figure 2.7.2: Read/Write Byte Order for Parameter Settings (Default Parameters Shown)

### SPI Communications Sequence

See Timing Diagram and Byte Order figures.

#### READ

1. Send READ ALL Command 0x40 down MOSI to Microstepping MForce PowerDrive followed by FF (15 Bytes).
2. Receive Parameter settings from MISO MSB First (M-Device) and ending with LSB (Fault).

#### Write

1. Send WRITE ALL Command (0x80) down MOSI followed by Parameter Bytes beginning with MSB (MRC) and ending with the LSB (Checksum of all parameter Bytes).
2. Response from MISO will be FF (10) Bytes.

*Page Intentionally Left Blank*





# APPENDICES

## Appendix A: Optional Prototype Development Cables

*Page Intentionally Left Blank*

# APPENDIX C

## Optional Prototype Development Cables

### MD-CC300-000: USB to SPI Parameter Setup Cable

The MD-CC300-000 USB to SPI Parameter Setup Cable provides a communication between the 10-pin connector on some Microstepping MForce PowerDrives and the USB port on a PC.

IMS SPI Interface Software communicates to the Parameter Setup Cable through the PC's USB port.

The Parameter Setup Cable interprets SPI commands and sends these commands to the MForce PowerDrive through the SPI interface.

Supplied Components: MD-CC300-000 Parameter Setup Cable, USB Cable, USB Drivers, IMS SPI Interface Software.



Figure A.1: MD-CC300-000



**WARNING! DO NOT connect or disconnect the MD-CC300-000 Communications Converter Cable from MForce while power is applied!**

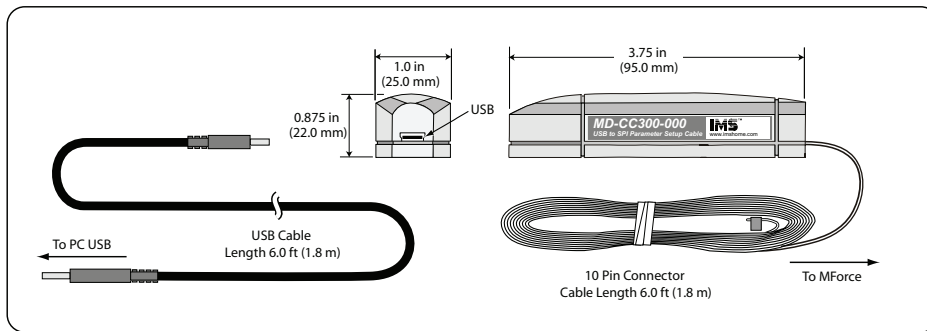


Figure A.2: MD-CC300-000 Mechanical Specifications

### Adapter Cables

#### Parameter Setup Cable and Adapters

The optional 12.0' (3.6m) parameter setup cable part number MD-CC300-000 facilitates communications wiring and is recommended with first order. It connects from the P2 connector to a PC's USB port. Models with the 12-pin pluggable locking wire crimp require adapter MD-ADP-1723C.

#### Prototype Development Cable

For testing and development using the 12-pin pluggable locking wire crimp, the 12.0" (30.5cm) prototype development cable plugs into the MD-ADP-1723C adapter and has flying leads for connection to the user interface. Part number ADP-3512-FL.

See Figure A.3 on the following page for dimensional and connection information.

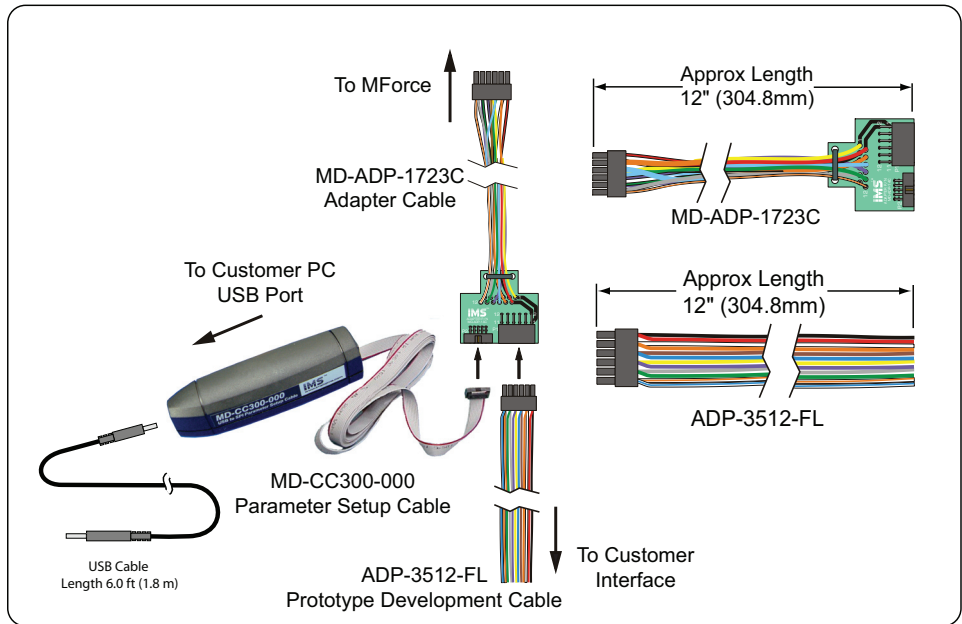


Figure A.3: Typical Setup, Adapter and Prototype Development Cable

## Installation Procedure for the MD-CC300-000

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

The installation of the MD-CC300-000 requires the installation of two sets of drivers:

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

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

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

### Installing the Cable/VCP Drivers

- 1) Plug the USB Converter Cable into the USB port of the MD-CC300-000.
- 2) Plug the other end of the USB cable into an open USB port on your PC.
- 3) Your PC will recognize the new hardware and open the Hardware Update dialog.
- 4) Select “No, not this time” on the radio buttons in answer to the query “Can Windows Connect to Windows Update to search for software?” Click “Next” (Figure A.4).
- 5) Select “Install from a list or specific location (Advanced)” on the radio buttons in answer to the query “What do you want the wizard to do?” Click “Next” (Figure A.5).



Figure A.4: Hardware Update Wizard

- 6) Select “Search for the best driver in these locations”.
  - (a) Check “Include this location in the search”.

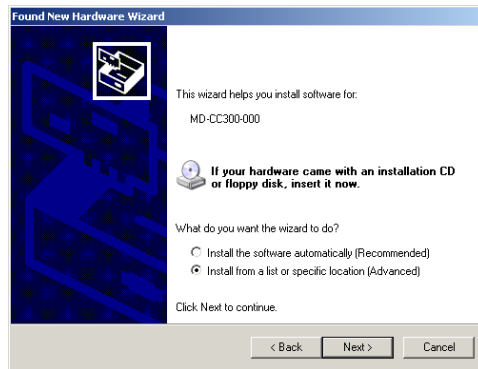


Figure A.5: Hardware Update Wizard Screen 2

- (b) Browse to the CD [Drive Letter]:\ Cable\_Drivers\MD-CC303-000\_DRIVERS.
  - (c) Click Next (Figure A.6).

- 7) The drivers will begin to copy.

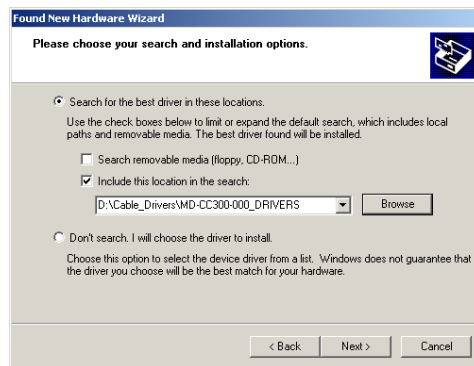


Figure A.6: Hardware Update Wizard Screen 3

- 8) On the Dialog for Windows Logo Compatibility Testing, click “Continue Anyway” (Figure A.7).



Figure A.7: Windows Logo Compatibility Testing

- 9) The Driver Installation will proceed. When the Completing the Found New Hardware Wizard dialog appears, Click “Finish” (Figure A.8).
- 10) Upon finish, the Welcome to the Hardware Update Wizard will reappear to guide you through the second part of the install process. Repeat steps 1 through 9 above to complete the cable installation.
- 11) Your IMS MD-CC300-000 is now ready to use.

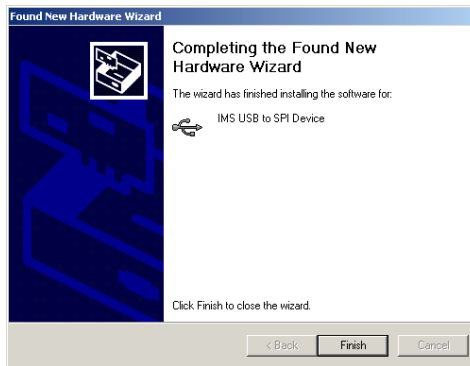


Figure A.8: Hardware Update Wizard Finish Installation

### Determining the Virtual COM Port (VCP)

The MD-CC300-000 uses a Virtual COM Port to communicate through the USB port to the MForce. A VCP is a software driven serial port which emulates a hardware port in Windows.

The drivers for the MD-CC300-000 will automatically assign a VCP to the device during installation. The VCP port number will be needed when IMS Terminal is set up in order that IMS Terminal will know where to find and communicate with your IMS Product.

To locate the Virtual COM Port.

- 1) Right-Click the “My Computer” Icon and select “Properties”.
- 2) Browse to the Hardware Tab (Figure A.9), Click the Button labeled “Device Manager”.
- 3) Look in the heading “Ports (COM & LPT)” IMS USB to SPI Converter Cable (COMx) will be listed (Figure A.10). The COM # will be the Virtual COM Port connected. You will enter this number into your IMS SPI Motor Interface Configuration.

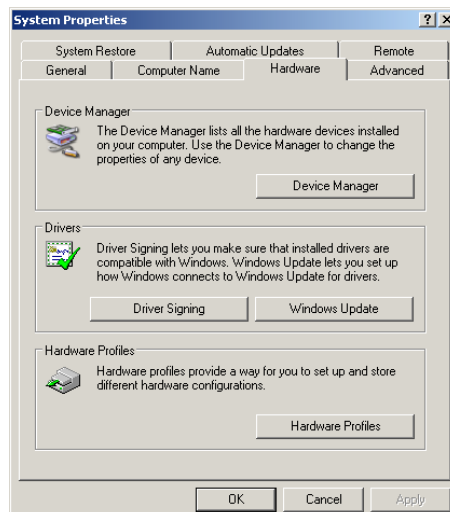


Figure A.9: Hardware Properties

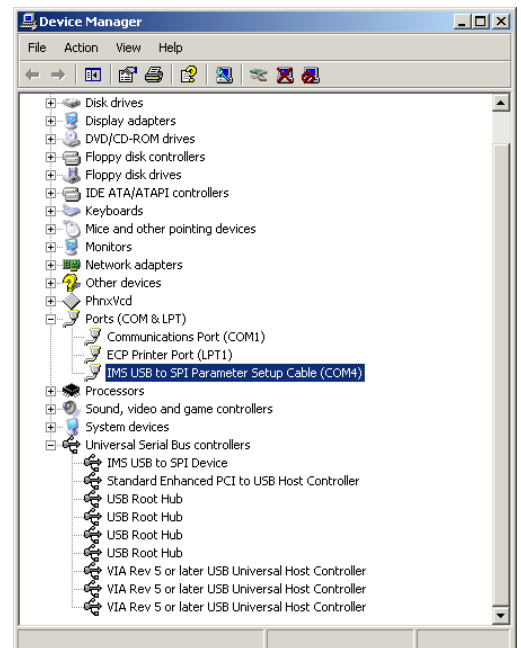


Figure A.10: Windows Device Manager

## PD12-1434-FL3 — Power, I/O and SPI

The PD12-1434-FL3 is a 10' (3.0 m) Prototype Development Cable used to connect to the 12-Pin Locking Wire Crimp Connector. The Connector end plugs into the P1 Connector of the MForce PowerDrive. The Flying Lead end connects to a Control Interface such as a PLC, an SPI Interface such as a PC Parallel port and the users motor power supply.

Wire Color Code			
Pair Number (Cable/Pair)	Color Combination	Interface Signal	MForce Wire Crimp Connection Pin Number
1/1	White/Blue	Opto Reference	3
	Blue/White	Step Clock	4
1/2	White/Orange	Enable	5
	Orange/White	Direction	6
1/3	White/Green	SPI Clock	8
	Green/White	COMM GND	9
1/4	White/Brown	+5VDC	7
	Brown/White	Master In - Slave Out	12
1/5	White/Gray	Master Out - Slave In	10
	Gray/White	SPI Chip Select	11
2/1	Black	Not Used	1
	Red	Not Used	2

Table A.1: PD12-1434-FL3 Wire Color Codes

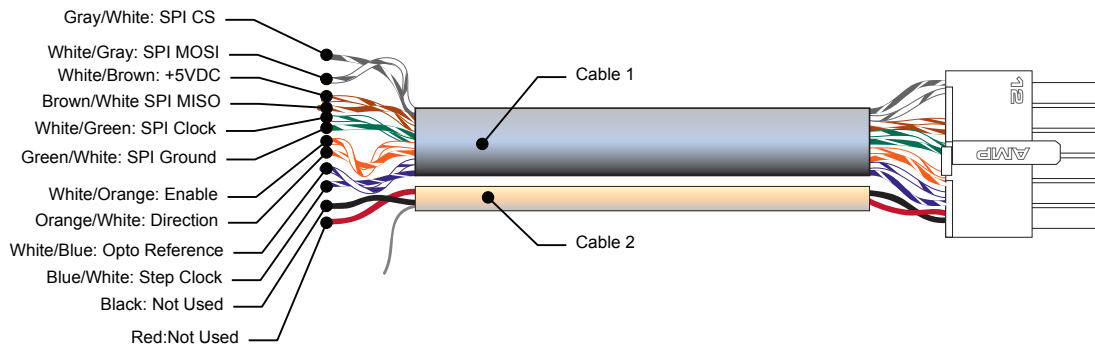


Figure A.11 PD12-1434-FL3

## Prototype Development Cable PD02-2300-FL3

IMS recommends the Prototype Development Cable PD02-3400-FL3 for interfacing power to the MForce PowerDrive.

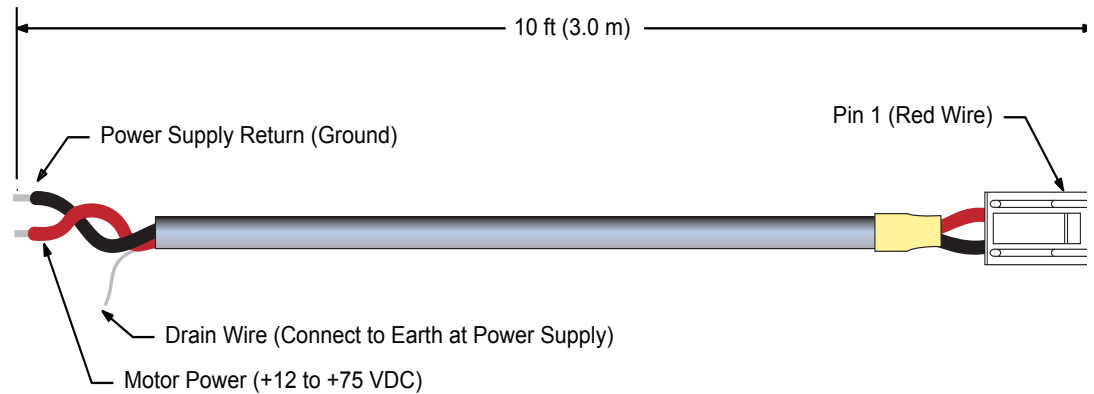


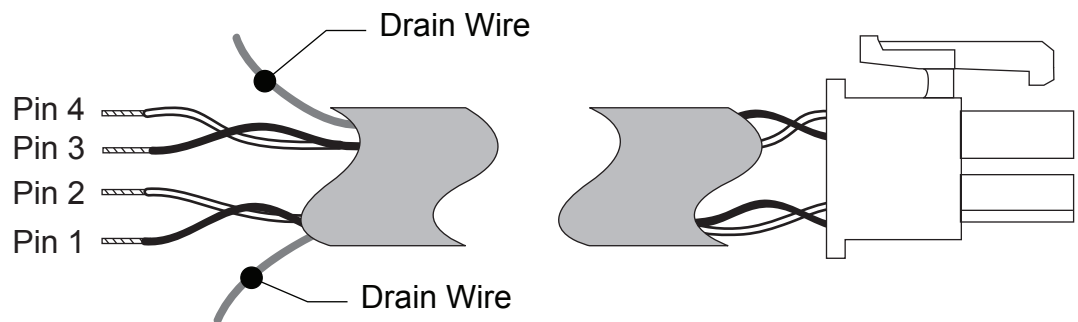
Figure A.12: PD02-3400-FL3

## Prototype Development Cable PD04-MF34-FL3

The PD04-MF34FL3 is a 10' (3.0 M) Prototype Development Cable used to connect the MForce PowerDrive to a stepping motor:

Pair Number (Cable/Pair)	Color Combination	Interface Signal	MForce Wire Crimp Connection Pin Number
1/1	Black	Phase A	1
	White	Phase A	2
1/2	Black	Phase B	3
	White	Phase B	4

Table A.2: PD04-MF34-FL3



### General Specifications

Length: 10 Feet (3.0 Meters)  
 Conductor: 16 AWG  
 Twisted Pairs  
 Shield: 100% Flexfoil  
 Jacket: PVC

Figure A.13: PD04-MF34-FL3



# 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 charges for Products returned to IMS for warranty service and IMS shall pay for return of Products to Customer by ground transportation. However, Customer shall pay all shipping charges, duties and taxes for Products returned to IMS from outside the United States.



## INTELLIGENT MOTION SYSTEMS, INC.

*Excellence in Motion™*

[www.imshome.com](http://www.imshome.com)

370 N. Main St., P.O. Box 457  
Marlborough, CT 06447 U.S.A.  
Phone: 860/295-6102  
Fax: 860/295-6107  
E-mail: [info@imshome.com](mailto:info@imshome.com)

**TECHNICAL SUPPORT (U.S.A.)**  
Phone: 860/295-6102  
Fax: 860/295-6107  
E-mail: [etech@imshome.com](mailto:etech@imshome.com)

**IMS ASIA PACIFIC OFFICE**  
30 Raffles Pl., 23-00 Caltex House  
Singapore 048622  
Phone: +65/6233/6846  
Fax: +65/6233/5044  
E-mail: [wlee@imshome.com](mailto:wlee@imshome.com)

**IMS EUROPEAN SALES MGT.**  
4 Quai Des Etroits  
69005 Lyon, France  
Phone: +33/4 7256 5113  
Fax: +33/4 7838 1537  
E-mail: [bmartinez@imshome.com](mailto:bmartinez@imshome.com)

**IMS UK Ltd.**  
25 Barnes Wallis Road  
Segensworth East  
Fareham, Hampshire PO15 5TT  
Phone: +44/0 1489-889825  
Fax: +44/0 1489-889857  
E-mail: [mcheckley@imshome.com](mailto:mcheckley@imshome.com)

**U.S.A. SALES OFFICES**

**Eastern Region**  
Phone: 973/661-1270  
Fax: 973/661-1275  
E-mail: [jroake@imshome.com](mailto:jroake@imshome.com)

**Central Region**  
Phone: 260/402-6016  
Fax: 419/858-0375  
E-mail: [dwaksmen@imshome.com](mailto:dwaksmen@imshome.com)

**Western Region**  
Phone: 602/578-7201  
E-mail: [dweisenberger@imshome.com](mailto:dweisenberger@imshome.com)

DISTRIBUTED BY: