

MForce

Step / direction input



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MForce Step/direction input

Part 1: General Usage

1. Introduction
2. Safety
3. Interfacing DC power
4. Interfacing a motor
5. Communications and parameter setup
6. Interfacing logic
7. Minimum connection requirements

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1 Introduction

The Step/direction input MForce step and direction driver is ideal for designers who want the simplicity of a motor with on-board electronics. The integrated electronics of the MForce eliminate the need to run motor cabling through the machine, reducing the potential for problems due to electrical noise

The MForce 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 non-volatile memory with the use of SPI Motor Interface, a simple software tool which is provided. This eliminates the need for external switches or resistors. Parameters are changed via an SPI port.

The Step/direction input MForce is a compact, powerful and cost effective solution that will reduce system cost, design and assembly time for a large range of brushless step motor applications.

1.1 MForce versions

MForce

The MForce is available in the following power ranges:

- MicroDrive: +12 to +24 VDC, 3.0 A RMS (4.2 A Peak) output
- PowerDrive: +12 to +75 VDC, 5.0 A RMS (7.0 A Peak) output

1.2 Documentation reference

The following user's manuals are available for the MForce:

- Product hardware manual, describes the technical data, installation and configuration of the product.
- Quick Reference, describes the basic wiring, connection and use of this product. The quick reference is shipped in printed form with the product.

This documentation is also available for download from the web site at www.novantaims.com

1.3 Product software

1.3.1 Communications converter drivers

If using the recommended communications converter, drivers are required, these drivers are available for download from the web site at <https://novantaims.com/dloads/>.

1.3.2 SPI motor interface

The Step / direction input MForce is configured using the SPI motor interface, a GUI that grants access to all the features of the Step / direction input MForce and automatically detects the model MForce being configured.

Installation and usage instructions are to be found in Section 5 of this document.

This software may be downloaded from <https://novantaims.com/dloads/>

2 Safety

2.1 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.

2.2 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 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).

2.3 Hazard Categories

Safety notes and general information are indicated by hazard messages in the manual. In addition there are symbols and instructions affixed to the product that warn of possible hazards and help to operate the product safely.

Depending on the seriousness of the hazard, the messages are divided into three hazard categories.

DANGER

DANGER indicates an imminently hazardous situation, which, if not avoided, **will result** in death, serious injury, or equipment damage.

WARNING

WARNING indicates a potentially hazardous situation, which, if not avoided, **can result** in death, serious injury, or equipment damage.

CAUTION

CAUTION indicates a potentially hazardous situation, which, if not avoided, **can result** in injury or equipment damage.

2.4 General safety instructions

DANGER

EXPOSED SIGNALS

Hazardous voltage levels may be present if using an open frame power supply to power the product.

Failure to follow these instructions will result in death or serious injury.

 **WARNING****LOSS OF CONTROL**

- Observe the accident prevention regulations. (For USA see also NEMA ICS1.1 and NEMA ICS7.1)
- The system manufacturer must take the potential error possibilities of the signals and the critical functions into account to ensure a safe status during and after errors. Some examples are: emergency stop, final position limitation, power failure and restart.
- The assessment of error possibilities must also include unexpected delays and the failure of signals or functions.
- Suitable redundant control paths must be in place for dangerous functions.
- Check that measures taken are effective.

Failure to follow these instructions can result in death or serious injury.

 **CAUTION****HOT PLUGGING!**

Do not connect or disconnect power, logic, or communications while the device is in a powered state.

Remove DC power by powering down at the AC side of the DC power supply.

Failure to follow these instructions can result in equipment damage.

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3 Power supply selection and connection

⚠ DANGER

EXPOSED SIGNALS

Hazardous voltage levels may be present if using an open frame power supply to power the product.

Failure to follow these instructions will result in death or serious injury.

⚠ CAUTION

MAXIMUM VOLTAGE INPUT

Do not exceed the maximum rated voltage of the device! Motor Back EMF, power supply ripple and high line must be taken into account when selecting a power supply voltage level.

Failure to follow these instructions may result in damage to system components!

⚠ CAUTION

GENERAL POWER SUPPLY PRACTICE

Do not connect or disconnect the power supply while power is applied.

Disconnect the AC side to power down the DC supply.

For battery operated systems connect a “transient suppressor” across the switch to prevent arcs and high-voltage spikes.

Failure to follow these instructions may result in damage to system components!

⚠ CAUTION

HOT PLUGGING!

Do not connect or disconnect power, logic, or communications while the device is in a powered state.

Remove DC power by powering down at the AC side of the DC power supply.

Failure to follow these instructions may result in damage to system components!



Detailed specifications, voltage limits, current requirements and connectivity information are located in the product detail section corresponding to the MForce linear actuator model you purchased.

3.1 Selecting a power supply (+V)

Proper selection of a power supply to be used in a motion system is as important as selecting the drive itself. When choosing a power supply for a stepping motor driver, there are several performance issues that must be addressed. An undersized power supply can lead to poor performance and possibly even damage to your drive.

3.1.1 Power supply — motor relationship

Motor windings can basically be viewed as inductors. Winding resistance (R) and inductance (L) result in an L/R time constant that resists the change in current. To effectively manipulate 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. 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. This is especially prevalent with overhauling loads.

3.1.2 Power supply — driver relationship

The MForce linear actuator 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 recirculate within the bridge and in and out of each phase reservoir. This results in a less than expected current draw on the power supply.

Stepping motor drivers are designed with the intent that a user's power supply output will ramp up to greater than or equal to the minimum operating voltage of the drive. The initial current surge is substantial and could damage the driver if the supply is undersized. The output of an undersized power supply could fall below the operating range of the driver upon a current surge. This could cause the power supply to start oscillating in and out of the voltage range of the driver and result in damage to either the supply, the driver, or both.

There are two types of supplies commonly used, regulated and unregulated, both of which can be switching or linear. Each have advantages and disadvantages.

3.1.3 Regulated vs unregulated

An unregulated linear supply is less expensive and more resilient to current surges, however, the voltage decreases with increasing current draw. This may cause problems if the voltage drops below the working range of the drive.


Fluctuations in line voltage are also a point of concern. These fluctuations may cause the unregulated linear supply to be above or below the anticipated or acceptable voltage.

A regulated supply maintains a stable output voltage, which is good for high speed performance. These supplies are also not affected 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 cause damage to the driver and/or supply. Back EMF can cause problems for regulated supplies as well. The current regeneration may be too large for the regulated supply to absorb. This could lead to an over voltage condition which could damage the output circuitry of the MForce.

Switching power supplies and regulated linear supplies with over current protection are not recommended because of their inability to handle the surge currents inherent in stepping motor systems.

See the product detail section of this document for specific power supply voltage and current requirements.

3.3 Power supply cabling best practices and recommendations

 CAUTION
<p>EMI and RFI</p> <p>These recommendations will provide optimal protection against EMI and RFI. The actual cable type, wire gauge, shield type and filtering devices used are dependent on the customer's application and system.</p> <p>The length of the DC power supply cable to an MForce should not exceed 50 feet.</p> <p>Always use Shielded/Twisted Pairs for the MForce DC Supply Cable and the AC Supply Cable.</p> <p>Failure to follow these instructions may result in damage to system components!</p>

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

Figure 3.1 illustrates 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 Figures 3.2 and 6.3).

Correct AWG wire size is determined by the current requirement plus

cable length. Please see Table 3.1.

3.3.1 DC Cabling Under 50' (15.24 m)

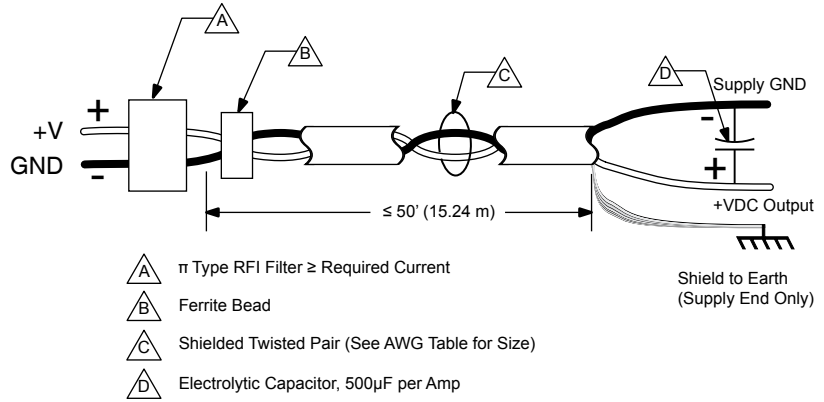


Figure 3.1 DC power supply cabling under 50' (15.24 m)

3.3.2 50' (15.24 m) or greater, AC power to full wave bridge

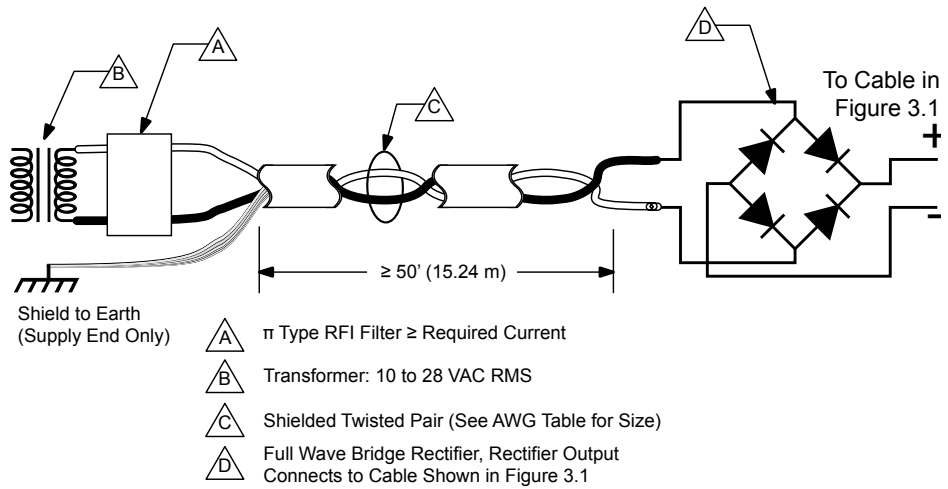


Figure 3.2 50' (15.24 m) or greater, AC power to full wave bridge

3.3.3 50' (15.24 m) or greater, AC power DC supply

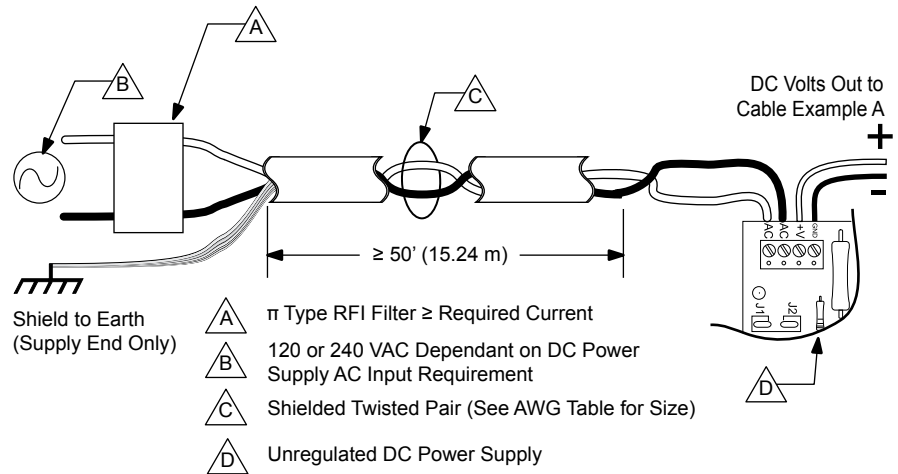


Figure 3.3 50' (15.24 m) or greater, AC power to DC supply

3.3.4 Recommended power supply cable wire gauges

For cable lengths exceeding 50' (15.2 meters), use the cable configurations shown in Sections 3.3.2 or 3.3.3.

Cable Length: Feet (meters)	10 (3.0)	25 (7.6)	50 (15.2)	75 (22.9)	100 (30.5)
Amps Peak	Minimum AWG				
1 Amp Peak	20	20	18	18	18
2 Amps Peak	20	18	16	14	14
3 Amps Peak	18	16	14	12	12
4 Amps Peak	18	16	14	12	12

Table 3.1 Power supply cable AWG recommendations



Detailed specifications, voltage limits and connectivity information are located in the product detail section corresponding to the MForce linear actuator model you purchased.

3.4 Switching DC power (DPM75 accessory)

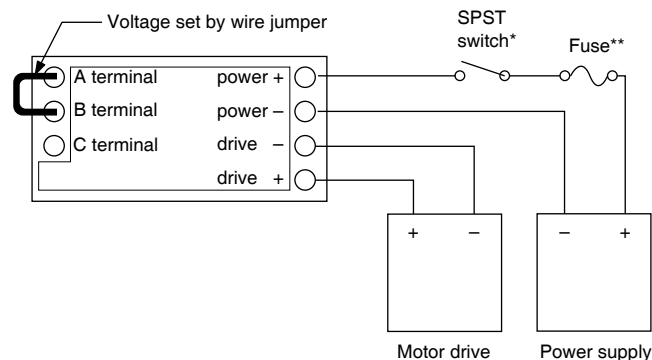
⚠ CAUTION
<p>HOT PLUGGING!</p> <p>Do not connect or disconnect power, logic, or communications while the device is in a powered state without additional protection.</p> <p>Remove DC power by powering down at the AC side of the DC power supply.</p> <p>Failure to follow these instructions may result in damage to system components!</p>

The function of the DPM75 Drive Protection Module is to limit the surge current and voltage to a safe level when DC input power is switched on and off to a motor drive. This provides the added protection necessary for reliable motor drive operation when switching the DC power, instead of the recommended AC power to the DC power supply. The device is designed to protect the motor drive when operating under all load conditions. This device does not protect the motor drive from wiring the power incorrectly.

The unit is capable of being used with 48, 60, and 75 volt rated motor drives. An external jumper selection is available so the user can match the circuit to their particular application. The DPM75 is capable of a steady state operating current of 4 amps.

The DPM75 can be used for any frame size motor drive, when properly configured. It can also be used for more than one unit provided the current and voltage do not exceed the DPM75's ratings. The maximum DPM75 ratings are 75 volts and 4 amps.

Power requirements and wiring details are available in the product detail section pertaining to the product purchased.



* Do not switch negative side of supply

**Fuse = 6.3 Amp slow blow (recommended: Bussman S505-6.3A or Littelfuse 215006.3). The fuse is optional.

Figure 3.4 DPM75 basic wiring and connection

4 Interfacing a stepper motor

DANGER

EXPOSED SIGNALS

Hazardous voltage levels may be present if using an open frame power supply to power the product.

Failure to follow these instructions will result in death or serious injury.

CAUTION

MOTOR TEMPERATURE

Although stepping motors will run hot when configured correctly, damage may occur to a motor if a higher than specified current is used. In most cases, the specified motor currents are maximum values and should not be exceeded!

Failure to follow these instructions may result in damage to system components!

4.1 Selecting a motor

The MForce 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 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.

4.1.1 Winding inductance

Since the MForce 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 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.

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

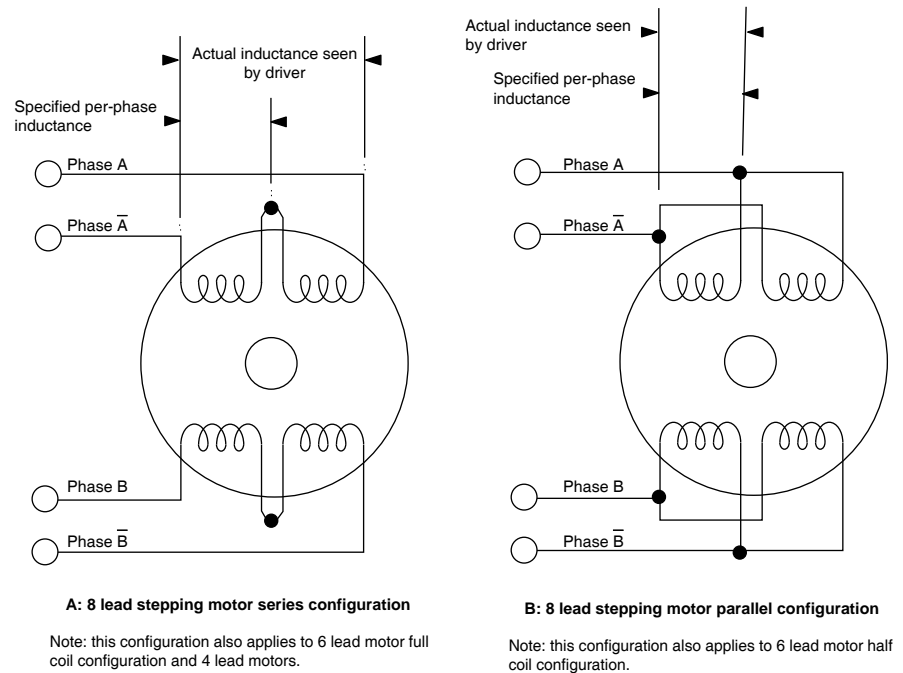


Figure 4.1 Motor winding inductance

Figure 4.1A 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.

Figure 4.1B shows an 8 lead motor wired in parallel. Using this configuration the per phase inductance seen by the driver will be as specified below.

Using the following equation we will show an example of sizing a motor used with an unregulated power supply with a minimum voltage (+V) of 24 VDC:

$$.2 \times \text{min power supply voltage (VDC)} = \text{min. inductance (mH/phase)}$$

$$.2 \times 24 = 4.8 \text{ mH}$$

The recommended per phase winding inductance we can use is 4.8 mH.

4.2 Recommended motor cable configurations

⚠ CAUTION
<p>EMI AND RFI</p> <p>These recommendations will provide optimal protection against EMI and RFI. The actual cable type, wire gauge, shield type and filtering devices used are dependent on the customer's application and system.</p> <p>Always use Shielded/Twisted Pairs for the Motor Cable</p> <p>Failure to follow these instructions may result in damage to system components!</p>

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

NOTE: The length of the cable between the MForce and the motor should not exceed 50' (15.0 m).

4.2.1 demonstrates the recommended cable configuration for the MForce to motor cabling under 50' (15.0 m). If cabling of 50' (15.0 m) or longer is required, the additional length can be gained with the cable configuration in 4.2.2.

Correct AWG wire size is determined by the current requirement plus cable length. Please see the motor cable AWG table at the end of this subsection.

4.2.1 Motor cabling under 50' (15.0 m)

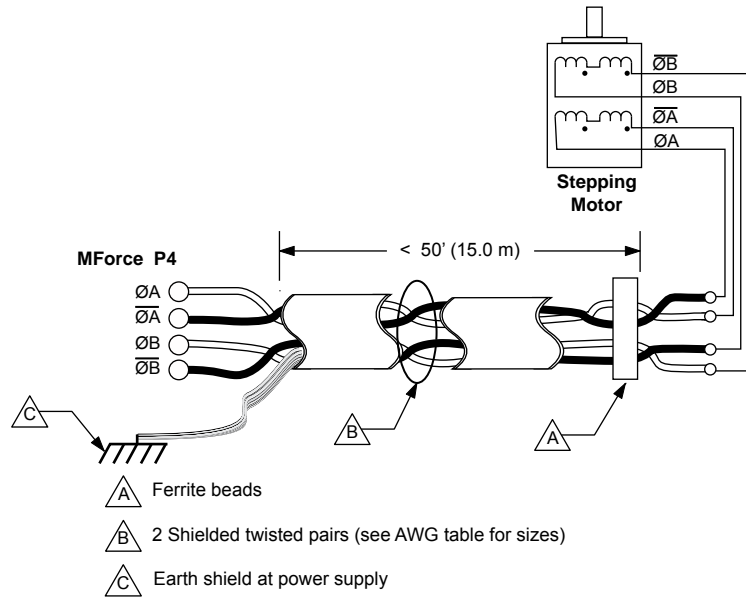


Figure 4.2 Motor cabling under 50' (15.0 m)

4.2.2 Motor cabling over 50' (15.0 m)

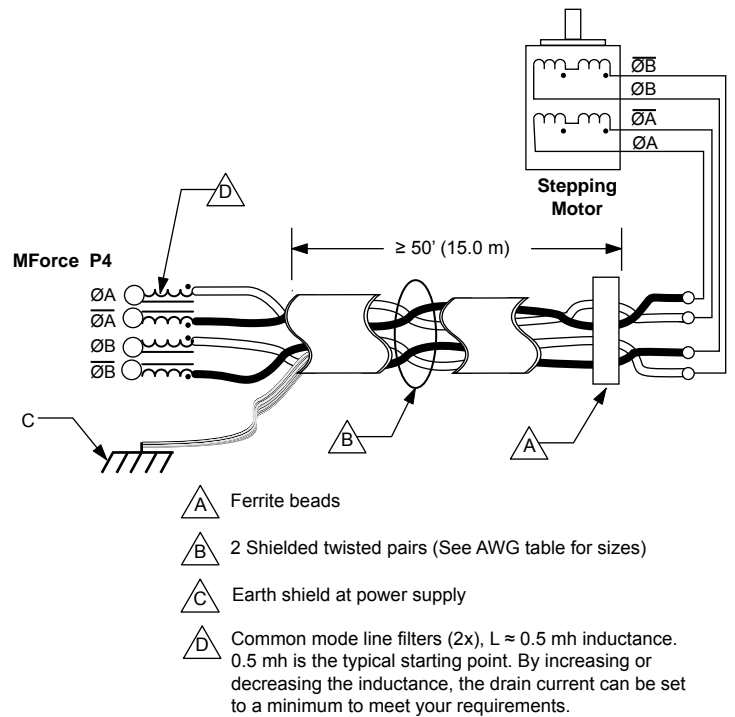


Figure 4.3 Motor cabling over 50' (15.0 m)

4.2.3 Recommended motor cable wire gauges

For cable lengths exceeding 50' (15.0 m), use the cable configurations shown in 4.2.2

Cable Length: Feet (meters)	10 (3.0)	25 (7.6)	50 (15.2)	75 (22.9)	100 (30.5)
Amps Peak	Minimum AWG				
1 Amp Peak	20	20	18	18	18
2 Amps Peak	20	18	16	14	14
3 Amps Peak	18	16	14	12	12
4 Amps Peak	18	16	14	12	12

Table 4.1 Motor cable AWG recommendations

4.3 Wiring configurations for various motor types

⚠ CAUTION

CORRECT WIRING

Ensure that the motor phase leads are connected to the corresponding connector pins to avoid Phase A to Phase B crossover.

Failure to follow these instructions may result in damage to system components!

4.3.1 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.

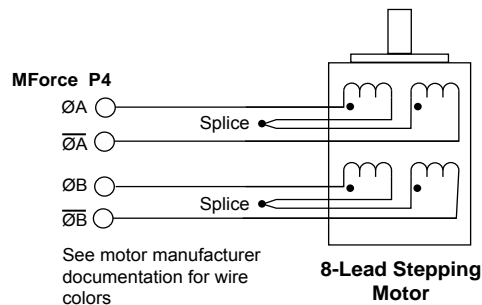


Figure 4.4 8-lead motor series connection

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.

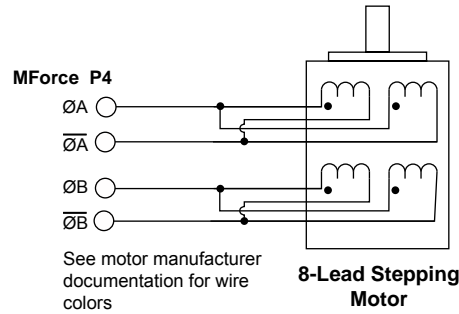


Figure 4.5 8-lead parallel connection

4.3.2 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.

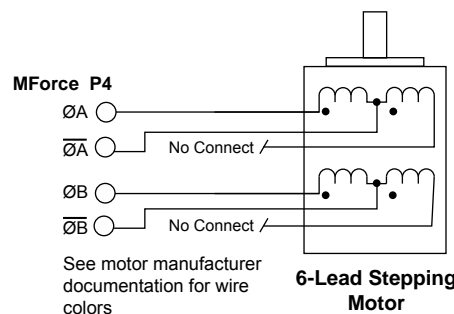


Figure 4.6 6-lead half coil configuration

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.

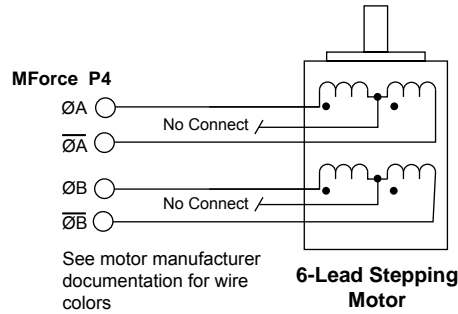


Figure 4.7 6-lead motor full coil configuration

7.3.3 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.

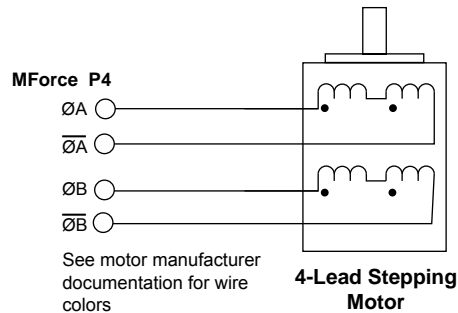



Figure 4.8 4-lead motor connection

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5 Communications and parameter setup

 CAUTION
HOT PLUGGING! Do not connect or disconnect power, logic, or communications while the device is in a powered state. Remove DC power by powering down at the AC side of the DC power supply. Failure to follow these instructions may result in damage to system components!



CONNECTOR OPTIONS

The Step/direction input MForce product family has an extensive set of connector options. The purpose of this section is to give a general overview of the SPI communications interface methods and practices.

Please see the section specific to the MForce product you purchased in the second part of this document for connectors, pin configurations and connectivity options.

5.1 SPI communications interface

The Step/direction input MForce High Performance Step/direction input Driver use the Serial Peripheral Interface (SPI) to configure the setup parameters.

Optionally available are parameter setup and logic interface cable with inline USB to SPI converter for each connector variation. Installation and connection of this covered in the product specific section in Part 2 of this document.

5.1.1 SPI definition

The Serial Peripheral Interface or SPI bus is a synchronous serial data link standard that operates in full duplex mode. Devices communicate in master/slave mode where the master device initiates the data frame. Multiple slave devices are allowed with individual slave select (chip select) lines.

5.1.3 SPI connection methods

⚠ CAUTION
<p>HOT PLUGGING!</p> <p>Do not connect or disconnect communications while the device is in a powered state.</p> <p>Failure to follow these instructions may result in damage to system components!</p>

⚠ CAUTION
<p>CHANGING PARAMETERS</p> <p>Do not attempt to change parameter settings while the device is in operation. Parameters must be set while the device is in a disabled state. The motor cannot be in motion.</p> <p>Failure to follow these instructions may result in damage to system components!</p>

Typically, the parameters are set on a work bench prior to the installation of the MForce into a machine. The ideal accessory for this setup method is the Novanta IMS USB to SPI communications converter cable (see product specific section in Part 2 of this document). If a continuous connection to the SPI port is required, see the following figures. Figure 5.1 illustrates a single MForce on the SPI bus. Figures 5.2 and 5.3 illustrate multi-drop configurations:

- Independent: MForces communicating independently with different setup parameters.
- Cooperative: MForces communicating simultaneously with identical setup parameters.

SPI connection: Single master - single MForce slave

The single master - single MForce slave is the most common connection method for the MForce. It is also the only connection method which will allow use of the Novanta IMS SPI Motor Interface utility, which is used to setup and change the motion and current control parameters of the MForce14Plus.

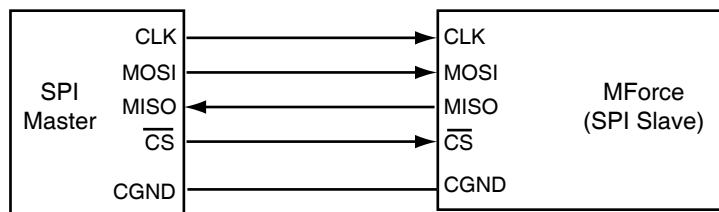


Figure 5.1 Single SPI master - single MForce slave

SPI connection: Single master - Independent MForce slaves

This connection method allows for multiple MForces in a system to be continually connected to the SPI bus. This method is useful in systems using multiple size devices with different setup parameters.

Using this method the user will have to create a user interface to communicate with the MForces.

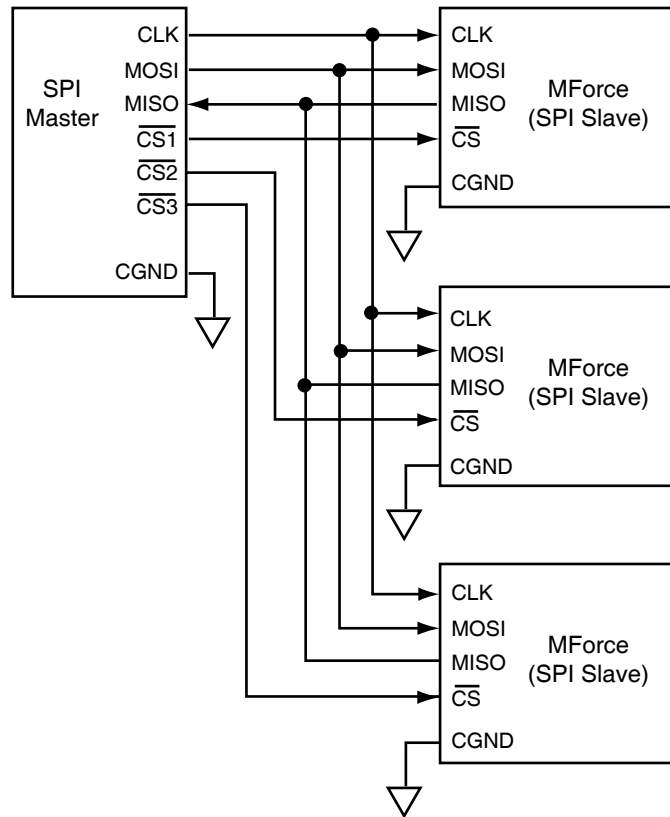


Figure 5.2 Single SPI master - Independent MForce slaves

SPI connection: Single master - cooperative MForce slaves

This connection method allows for multiple MForces in a system to be continually connected to the SPI bus. This method is useful in systems using multiple devices where the setup parameters need to be identical in each device.

Using this method the user will have to create a user interface to communicate with the MForces.

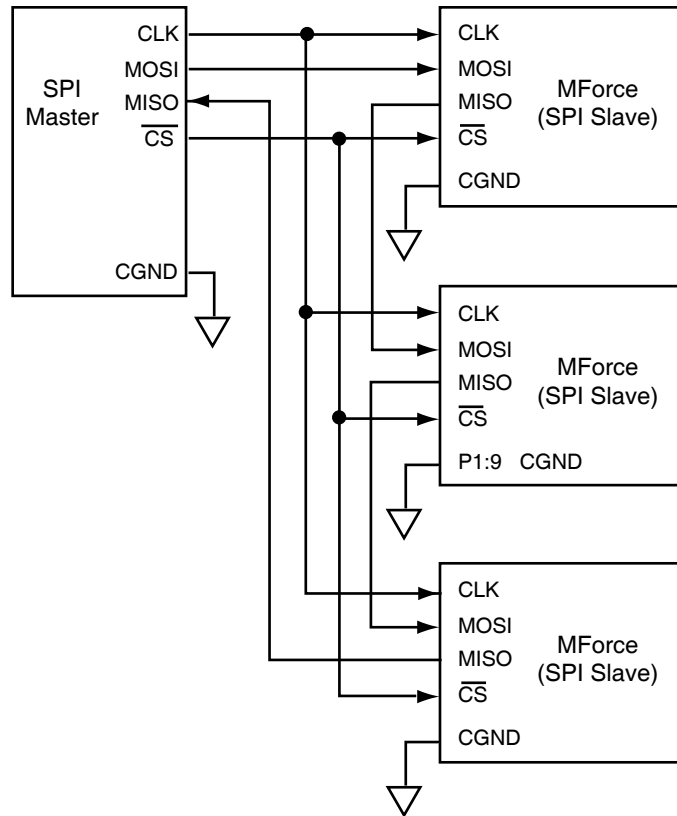


Figure 5.3 Single SPI master - Cooperative MForce slaves

Logic level shifting circuit A logic level shifting and conditioning circuit may be required if communicating to the MForce using a notebook computer with 3.3 VDC parallel port. The schematic in Figure 5.4 shows this circuit.

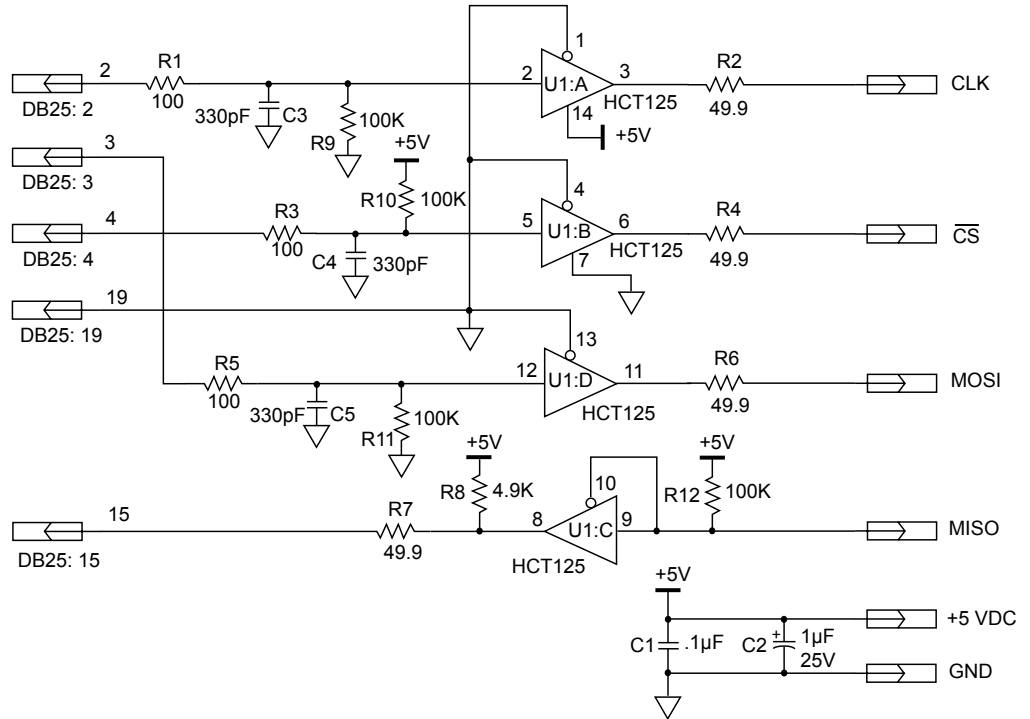


Figure 5.4 Logic level shifting and conditioning circuit

5.1.4 SPI Timing

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

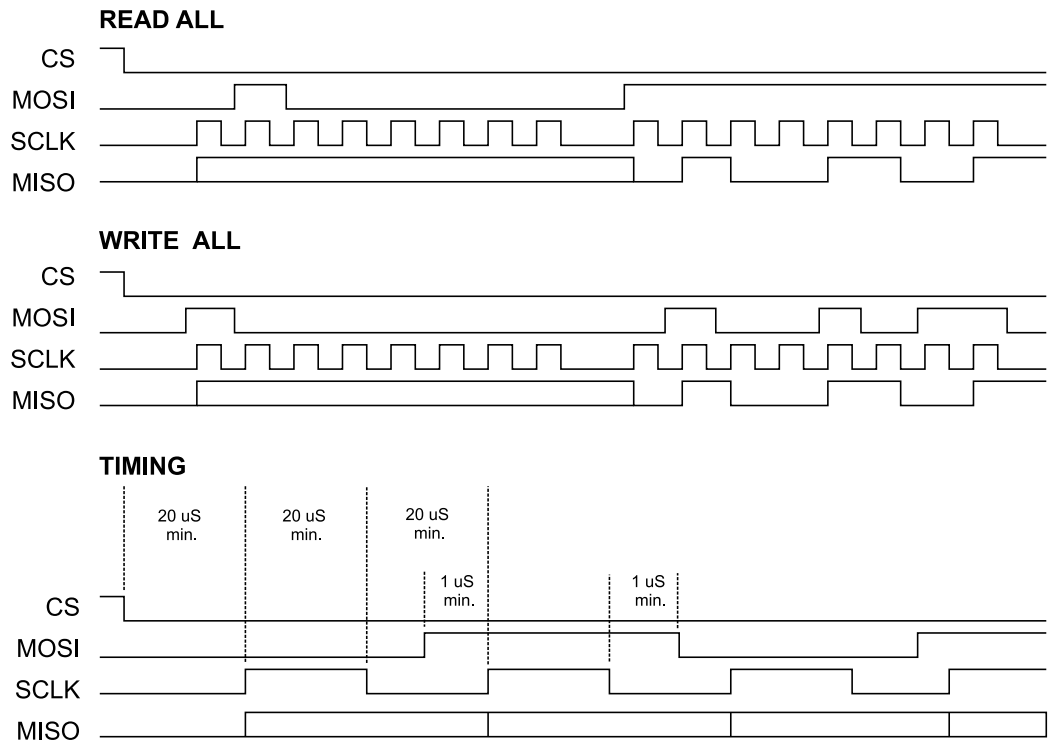
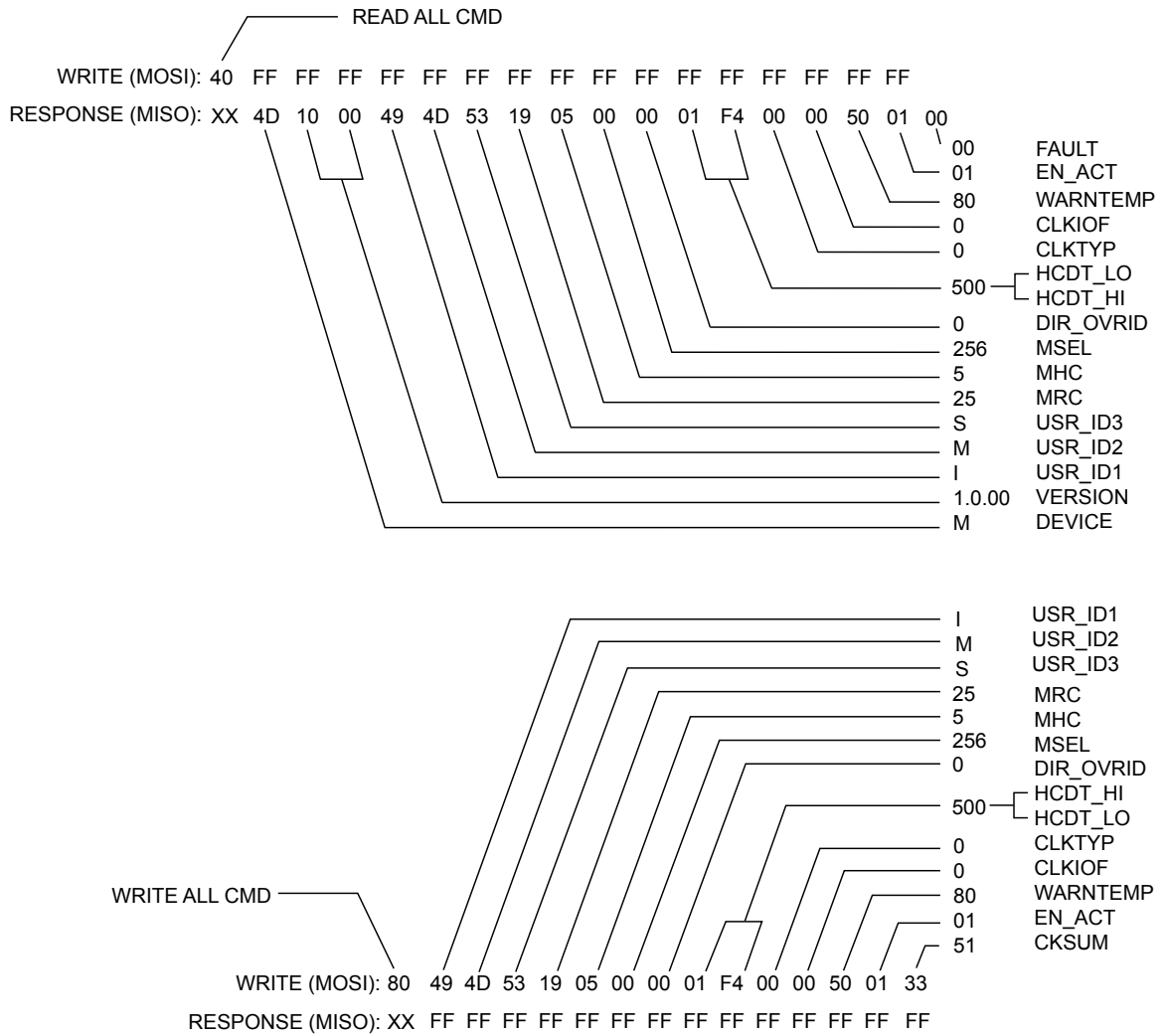


Figure 5.5 SPI Timing

5.1.5 SPI Commands and parameters

CMD/PRM	HEX Default	Dec. Default	Range	Notes
Read All	0x40			Reads the Hex value of all parameters
Write All	0x80			Writes the Hex value to the parameters
DATA READ				
"M"	0x4D			"M" character precedes every data read
Version MSB	0x10		<1-8>.<0-9>	Firmware version MSB
Version LSB	0x01		<0-99>	Firmware version LSB
USR_ID1	0x49	I	Viewable ASCII	Uppercase letter <I>
USR_ID2	0x4D	M	Viewable ASCII	Uppercase letter <M>
USR_ID3	0x53	S	Viewable ASCII	Uppercase letter <S>
MHC	0x05	5%	0 to 100%	Motor Hold Current
MRC	0x19	25%	1 to 100%	Motor Run Current
MSEL	0x00	0	See Table 5.4	Microstep resolution select
DIR_OVRID	0x01	1	0/1	Direction override CCW (0) or CW (1)
HCDT_HI	0x01	500 ms	0 to 65535	Hold Current Delay Time high byte
HCDT_LO	0xF4			Hold Current Delay Time low byte
CLKTYPE	0x00	0 (step/dir)	0-2	0=step/dir, 1=clk up/clk dn, 2=quad
CLKIOF	0x00	0	<0-9>	Input clock filtering
WARNTMP	0x50	80°C		Warning temperature= overtemp -5°C
ENACT	0x01	1=Active	<0/1>	Enable Active 0=low, 1=high
FAULT	0	0x00	—	See fault error code table
DATA WRITE				
Version MSB	0x10		<1-8>.<0-9>	Firmware version MSB
Version LSB	0x01		<0-99>	Firmware version LSB
USR_ID1	0x49	I	Viewable ASCII	Uppercase letter <I>
USR_ID2	0x4D	M	Viewable ASCII	Uppercase letter <M>
USR_ID3	0x53	S	Viewable ASCII	Uppercase letter <S>
MHC	0x05	5%	0 to 100%	Motor Hold Current
MRC	0x19	25%	1 to 100%	Motor Run Current
MSEL	0x00	0	See Table 5.4	Microstep resolution select
DIR_OVRID	0x01	1	0/1	Direction override CCW (0) or CW (1)
HCDT_HI	0x01	500 ms	0 to 65535	Hold Current Delay Time high byte
HCDT_LO	0xF4			Hold Current Delay Time low byte
CLKTYPE	0x00	0 (step/dir)	0-2	0=step/dir, 1=clk up/clk dn, 2=quad
CLKIOF	0x00	0	<0-9>	Input clock filtering
WARNTMP	0x50	80°C		Warning temperature= overtemp -5°C
ENACT	0x01	1=Active	<0/1>	Enable Active 0=low, 1=high
CKSUM		33		Checksum

Table 5.1 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 5.6 SPI Commands and parameters

5.1.6 SPI Communications sequence

See Timing Diagram and Byte Order figures.

- Read*
- 1) Send READ ALL Command 0x40 down MOSI to Step/direction input MForce followed by FF (15 Bytes).
 - 2) Receive Parameter settings from MISO MSB First (M-Device) and ending with LSB (Fault).
- Write*
- 3) 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).
 - 4) Response from MISO will be FF (10) Bytes.

5.2 SPI Motor Interface

SPI Motor Interface is the setup and configuration utility developed to provide the customer with a Graphical User Interface (GUI) to easily configure Novanta IMS products that communicate over the SPI bus.

5.2.1 System Requirements

- PC or notebook running Windows XP™ service pack 2 or greater.

5.2.2 Installation

- 1) Download the installation package from <https://novantaims.com/dloads/>
- 2) Browse to the download location on your PC hard-drive and extract the filesfromthezip file
- 3) Double-click setup.exe.
- 4) Follow the installation prompts to complete the installation.

5.2.3 Connect to the SPI port

To connect to the SPI port on the MForce14Plus:

- 1) Apply power to the MForce
- 2) Open the SPI Motor Interface program
- 3) Select the PC COM port that the MForce is connected to (see Figure 5.7) See Appendix A: Connectivity for details on determining the COM port.
- 4) If communications is established, the setup dialog will display (Figure 5.8)

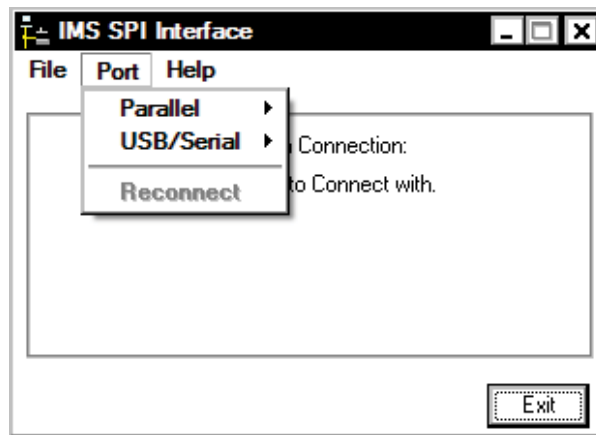


Figure 5.7 SPI Motor Interface startup dialog

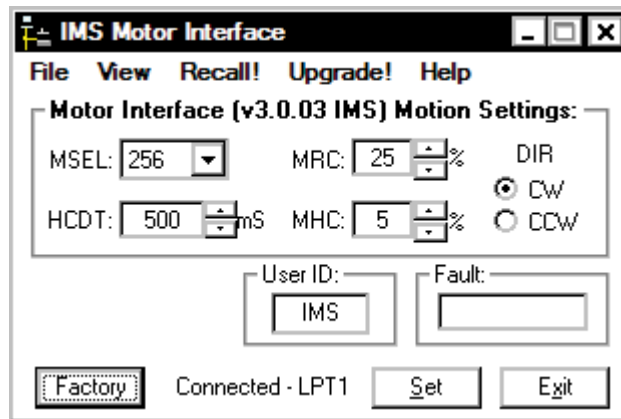


Figure 5.8 SPI Motor Interface parameter setup dialog

5.2.4 Setup Parameters

Parameter	Default	Range	Notes
MHC	5%	0 to 100%	Motor Hold Current
MRC	25%	1 to 100%	Motor Run Current
MSEL	256	See Table 5.4	Microstep resolution
ENACT	High	High/Low	Enable active state
HCDT	500 ms	0 to 65000	Hold Current Delay Time in milliseconds
DIR	CW	CCW/CW	Direction override CCW or CW
CLK TYPE	Step/Dir	See Specifications	Input clock type
CLK IOF	200ns (250 MHz)	50 ns to 12.9 μ s (10 MHz to 38.8 kHz)	Input clock filter
USER ID	IMS	Viewable ASCII	User identification code

Table 5.2 MForce setup parameters

5.2.5 Color coded parameter values

The SPI Motor Interface displays the parameter values using a pre-defined 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.

5.2.7 Motor settings configuration screen

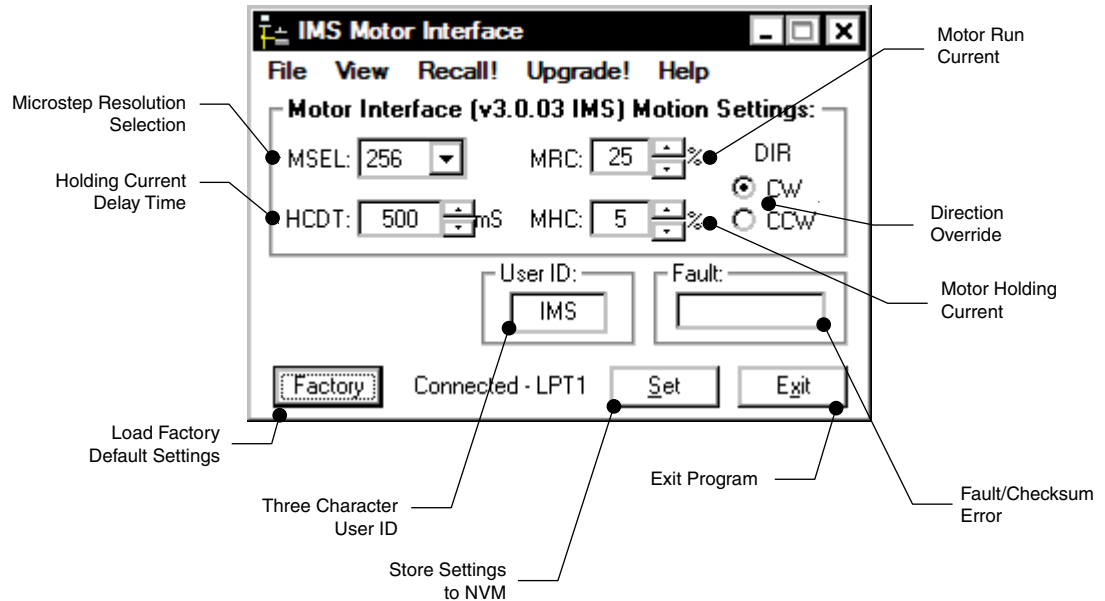


Figure 5.9: SPI Motor Interface motion settings screen

The Novanta IMS SPI Motor Interface Software opens by default to the Motion Settings Screen shown on the left.

- 1) There are six basic parameters that may be set here:
- 2) MSEL: Microstep Resolution Select.
- 3) HCDT: Holding Current Delay Time.
- 4) MRC: Motor Run Current
- 5) Motor Holding Current
- 6) User ID: 3-character ID
- 7) 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 Step/direction input MForce features 20 microstep resolutions. This setting specifies the number of microsteps per step the motor will move.

The MForce 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 5.3 for available Microstep Resolution.

Binary		Decimal	
microsteps/step	steps/revolution	microsteps/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	52100		
Additional resolution settings			
180	36000 (0.01°/μstep)		
108	21600 (1 arc-min/μstep)		
127	25400 (0.001 mm/μstep)		

Table 5.3 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 Step/direction input MForce 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 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 the amount of time specified by the HCDT setting following the last clock pulse.
- DIR (Motor Direction)* The DIR Motor Direction parameter changes the motor direction relative to the direction input signal, adapting the direction of the MForce 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 Novanta IMS.

Novanta IMS SPI Motor Interface Button Functions

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

Factory

Clicking the Factory button will load the Step/direction input MForce unit's factory default settings into the Novanta 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. Un-set settings will display as blue text in the setting fields. Once set they will be in black text. Set-ting the Parameters will also clear most Fault Conditions.

Exit

Disconnects and opens the Initialization dialog.

5.2.8 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.

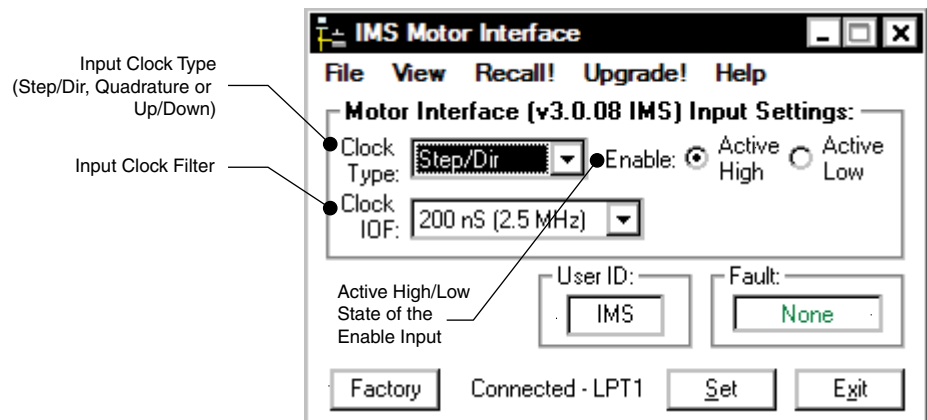


Figure 5.10: SPI Motor Interface I/O settings screen

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.

The three clock types supported are:

- 1) Step/Direction
- 2) Quadrature
- 3) Up/Down
- 4) CW/CCW - Note that CW/CCW is functionally the same as Up/Down.

Input Clock Filter The clock inputs may also be filtered using the Clock IOF pull down of the Novanta IMS SPI Motor Interface. The filter range is from 50 nS (10 MHz) to 12.9 μ Sec. (38.8 kHz). Table 5.5 shows the filter settings.

Minimum pulse width	Cut-off 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 μ s	295.1 kHz
3.3 μ s	151 kHz
5.5 μ s	79.6 kHz
12.9 μ s	38.8 kHz

Table 5.4 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.

5.2.9 Novanta IMS part number/serial number screen

The Novanta 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. Novanta IMS may require this information if calling the factory for support.

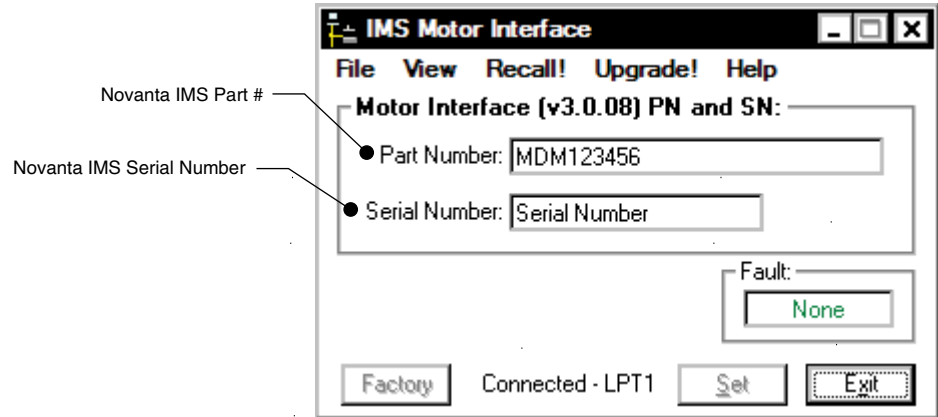


Figure 5.11: SPI Motor Interface part number serial number screen

5.2.10 Fault codes

All of the Novanta 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.

Binary case	Error code	Description	Action	To clear
—	None	No fault	—	—
4	CS	SPI checksum error	Error displayed	Write to device
8	SC/CS	SPI checksum error/sector changing	Error displayed	Write to device
16	DFLT	Defaults checksum error	Error displayed	Write to device
32	DATA	Settings checksum error	Error displayed	Write to device

Table 5.5 Fault error codes

5.2.11 Upgrading the firmware in the Step/direction input MForce

The Novanta IMS SPI Upgrader New firmware releases are posted to the Novanta IMS web site at www.novantaims.com

The Novanta IMS SPI Motor Interface is required to upgrade your Step/direction input MForce product. To launch the Upgrader, click "Upgrade!" on the Novanta IMS SPI Motor Interface menu.

The Upgrader screen has 4 read-only text fields that will display the necessary info about your Step/direction input MForce.

Previous Version: this is the version of the firmware currently on your Step/direction input MForce.

Serial Number: the serial number of your unit.

Upgrade Version: will display the version number of the firmware being installed.

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 Novanta IMS SPI Upgrader. Note that some steps are not shown as they are accomplished internally, or are not relevant to the model Novanta 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.

5.2.12 Configuring the Motor PWM Current Control Settings

⚠ CAUTION

ADVANCED SETTINGS!

The Motor PWM current control settings are advanced setting which under normal circumstances need not be changed from the default settings.

Failure to follow these instructions may result in erratic, rough motor operation

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

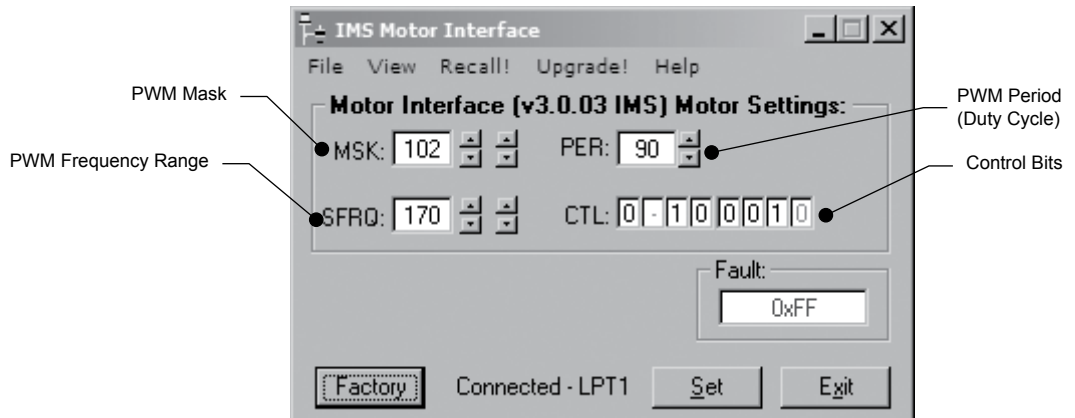


Figure 5.12: SPI Motor Interface PWM settings

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 μS 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 μ S.

Reverse Measure Time/Minimum Forward On Time

Hex	Time	Hex	Time	Hex	Time	Hex	Time
0x0	600 ns	0x4	1.0 μ s	0x8	1.6 μ s	0xC	2.5 μ s
0x1	700 ns	0x5	1.1 μ s	0x9	1.8 μ s	0xD	2.8 μ s
0x2	800 ns	0x6	1.2 μ s	0xA	2.0 μ s	0xE	3.1 μ s
0x3	900 ns	0x7	1.4 μ s	0xB	2.2 μ s	0xF	3.4 μ s

Table 5.6: PWM Mask Settings

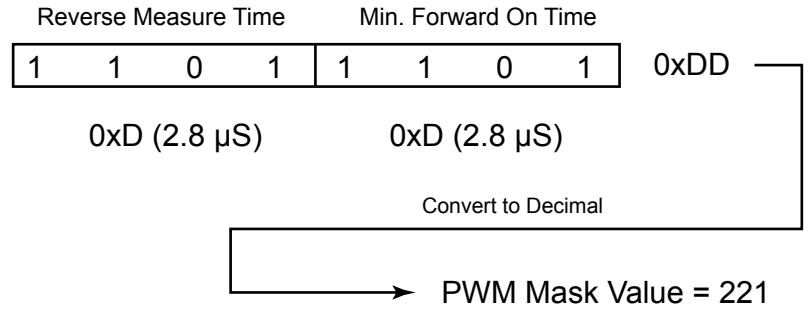


Figure 5.13: PWM mask settings

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 μ s	1.6 μ s
0x11	17	700 ns	700 ns	0x99	153	1.8 μ s	1.8 μ s
0x22	34	800 ns	800 ns	0xAA	170	2.0 μ s	2.0 μ s
0x33	51	900 ns	900 ns	0xBB	187	2.2 μ s	2.2 μ s
0x44	68	1.0 μ s	1.0 μ s	0xCC	204	2.5 μ s	2.5 μ s
0x55	85	1.1 μ s	1.1 μ s	0xDD	221	2.8 μ s	2.8 μ s
0x66	102	1.2 μ s	1.2 μ s	0xEE	238	3.1 μ s	3.1 μ s
0x77	119	1.4 μ s	1.4 μ s	0xFF	255	3.4 μ s	3.4 μ s

Table 5.7: Typical PWM Mask Settings

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 5.8: Maximum and Initial PWM Frequency

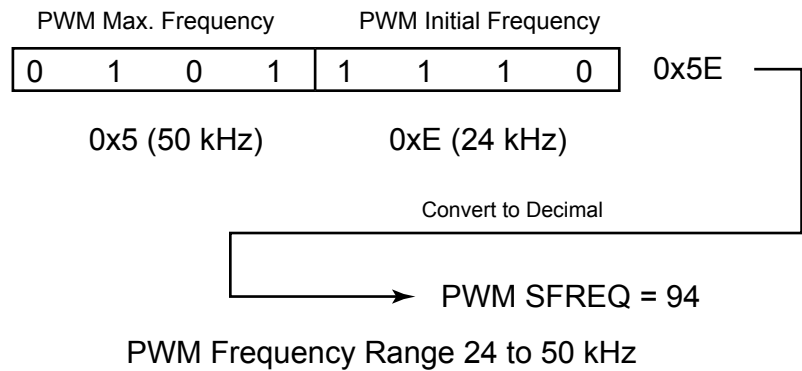


Figure 5.14: PWM frequency settings

PWM Control Bits

Bit	7	6	5	4	3	2	1	0	
0x0203	QUIET	–	SYNC_EN	RECIR	TODLY[2:0]			ENABLE	PWMCTL
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 5.15: 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 recirc 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 Novanta 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 _{RMS})	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	—

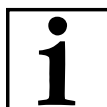
Table 5.9: Example PWM Settings

5 Interfacing logic inputs

 CAUTION
ELECTRICAL OVERSTRESS
The universal logic inputs are tolerant to +24 VDC. The differential input version inputs are TTL level and only tolerant to +5 VDC:
Do not exceed +5 VDC on the differential inputs.
Failure to follow these instructions can result in equipment damage.

 CAUTION
HOT PLUGGING!
Do not connect or disconnect power, logic, or communications while the device is in a powered state.
Remove DC power by powering down at the AC side of the DC power supply.
Failure to follow these instructions may result in damage to system components!

 CAUTION
EMI and RFI
These recommendations will provide optimal protection against EMI and RFI. The actual cable type, wire gauge, shield type and filtering devices used are dependent on the customer's application and system.
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.
Failure to follow these instructions may result in damage to system components!



CONNECTOR OPTIONS

The Step/direction input MForce product family has an extensive set of connector options. The purpose of this section is to give a general overview of the I/O interface methods and practices.

Please see the section specific to the MForce product you purchased in the second part of this document for connectors, pin configurations and connectivity options.

6.1 Logic inputs (universal input version)

The MForce has three optically isolated 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)
- 2) Direction (DIR)
- 3) Enable (EN)

Of these inputs only step clock and direction are required to operate the Step/direction input MForce.

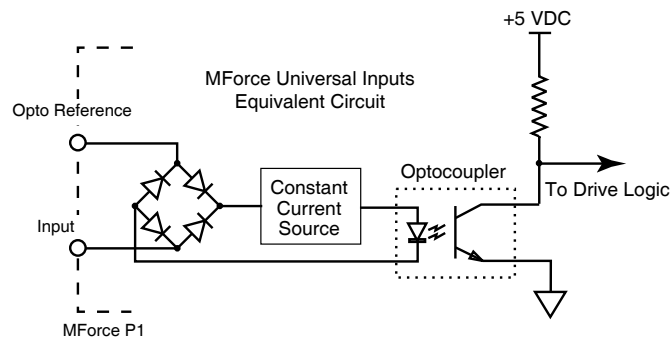


Figure 6.1 Universal optically isolated input equivalent circuit

6.1.1 Logic inputs

Function	Description
OPTO	Optocoupler reference input
SCLK	Step Clock input
EN	The Enable Input can be used to enable or disable the driver output circuitry.
DIR	The direction Input controls the clockwise/ counterclockwise direction of the motor. It may be configured as sinking or sourcing depending on the state of the Optocoupler Reference.

Table 6.1 Universal logic inputs

6.1.2 Optically isolated input description

P1:4 — 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 setting

P1:6 — 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 Novanta IMS Motor Interface software included with the MForce14Plus Step/direction input.

Clock Input Timing

STEP/DIR interface mode

The motor angle step with the rising edge of the pulse signal, the direction of rotation is controlled by the DIR signal.

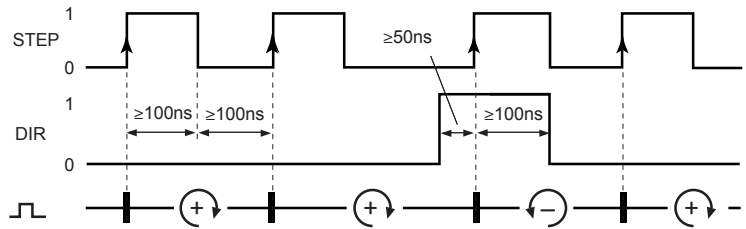


Figure 6.1 Step /direction signal timing

CW/CCW interface mode

The motor angle step with the rising edge of the pulse signal, the direction of rotation is controlled by the input receiving pulses.

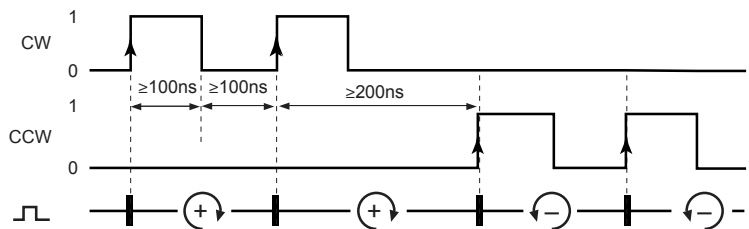


Figure 6.2 CW/CCW signal timing

A/B (quadrature) interface mode

In A/B interface mode, quadrature signals are supplied as reference values.

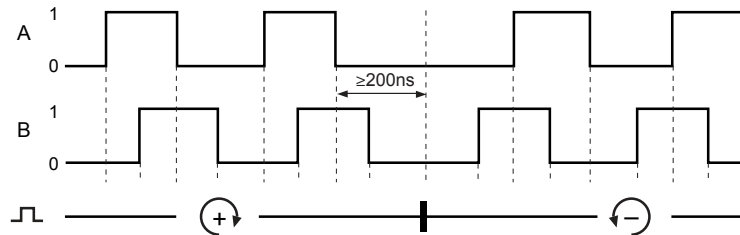


Figure 6.3 A/B quadrature signal timing

P1:5 — Enable Input

This input can be used to enable or disable the driver output circuitry. Leaving the enable switch open, (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 (active signal) in both sinking 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 device.

6.1.3 Optocoupler reference input

The optocoupler reference sets the reference state, sinking or sourcing, for the universal isolated logic inputs.

If a +5 to +24 VDC power source is connected to the reference, the inputs will be sinking-type inputs.

If the reference is connected to ground, the inputs will be sourced by a +5 to +24 VDC signal. Section 6.3 details both connection methods.

6.1.4 Interfacing the isolated logic inputs

NPN Sinking inputs

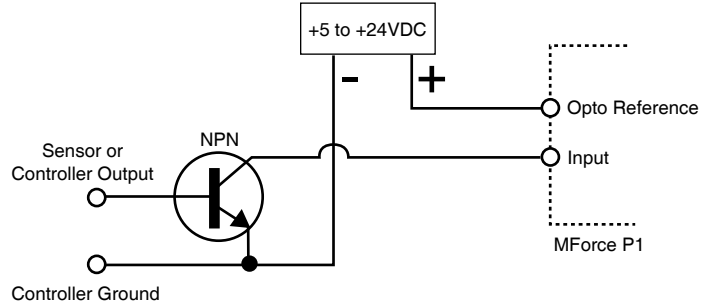


Figure 6.4 Open collector sinking input

PNP sourcing inputs

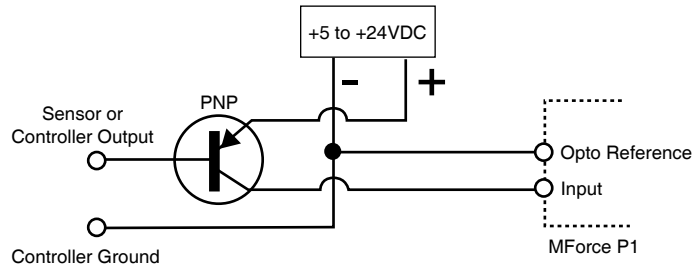


Figure 6.5 Open collector sourcing input

Sinking inputs

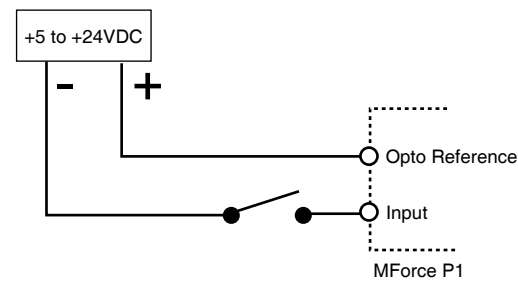


Figure 6.6 Switch interface sinking input

Sourcing inputs

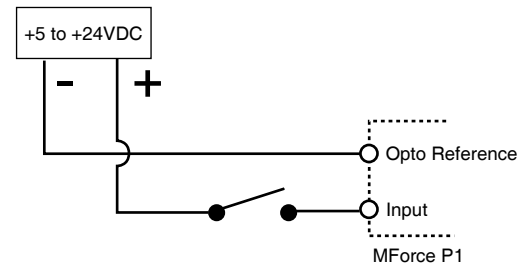


Figure 6.7 Switch interface sourcing input

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7 Minimum connection requirements

⚠ DANGER

EXPOSED SIGNALS

Hazardous voltage levels may be present if using an open frame power supply to power the optocouplers and motor power.

Failure to follow these instructions will result in death or serious injury.

⚠ CAUTION

HOT PLUGGING!

Do not connect or disconnect DC power, logic or communications while the device is in a powered state.

Failure to follow these instructions can result in equipment damage.

⚠ CAUTION

EMI and RFI

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

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.

Failure to follow these instructions may result in damage to system components!



CONNECTOR OPTIONS

The Step/direction input MForce products family has an extensive set of connector options. The purpose of this section is to give a general overview of the I/O interface methods and practices.

Please see the section specific to the MForce product you purchased in the second part of this document for connectors, pin configurations and connectivity options.

7.1 Minimum connection requirements

The diagrams below illustrates the minimum connections required to operate the Step/direction input MForce High Performance Step/direction input Driver.

These connections are:

- +V Motor power
- Power ground
- Optocoupler reference
- Step clock
- CW/CCW direction

Connecting SPI communications is not required as the device will operate using the factory default settings in full step mode at 25% run current.

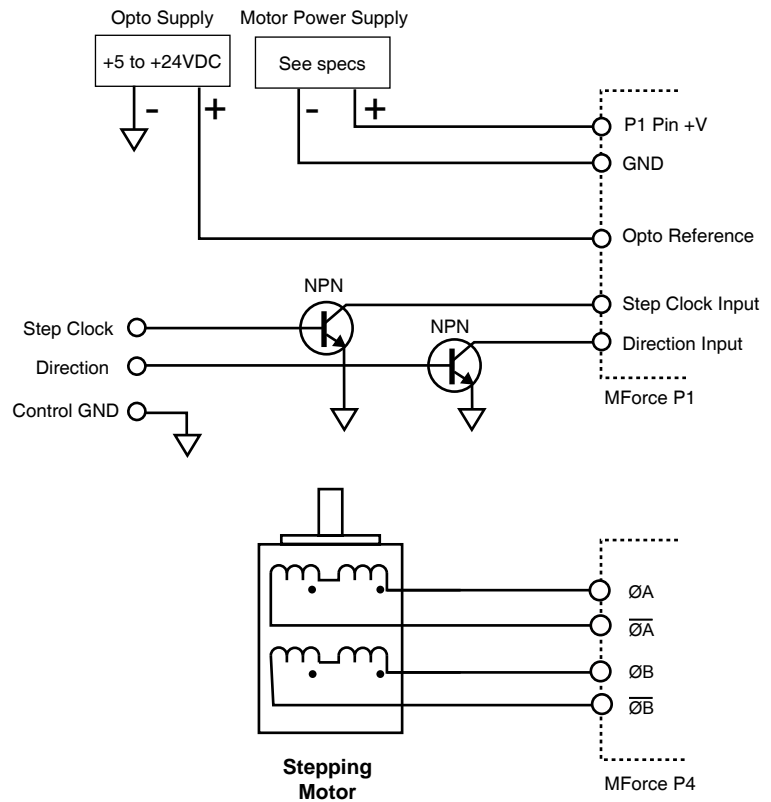


Figure 7.1 Minimum connections, open-collector sinking configuration

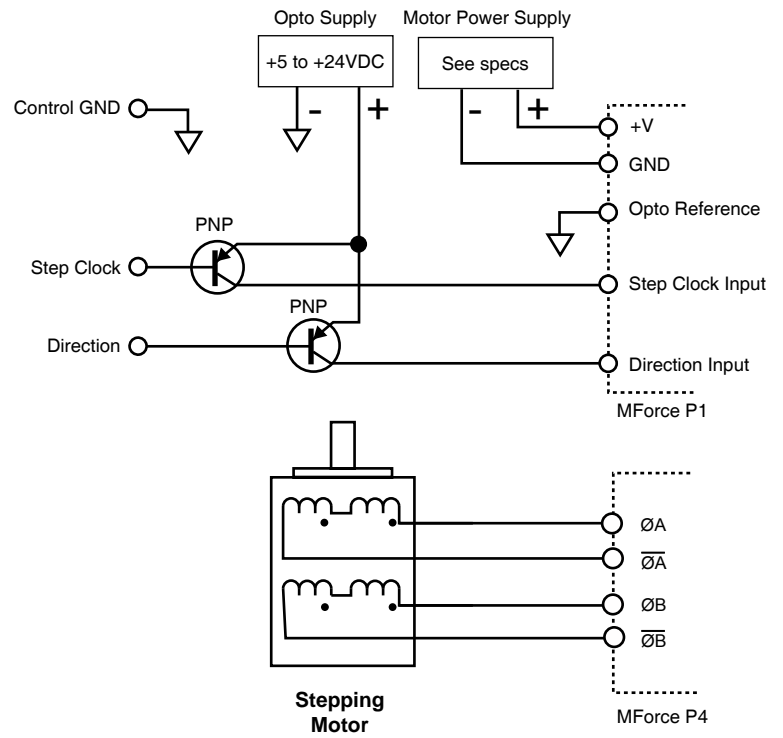


Figure 7.2 Minimum connections, open-collector sourcing configuration

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Step/direction input

MForce

Part 2: Detailed

Specifications and

Connectivity Information

1. MForce MicroDrive
2. MForce PowerDrive

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MForce MicroDrive

Step/direction input



1. Introduction
2. Specifications
3. Mounting Recommendations
4. Interface and Connectivity

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1 Introduction

The ultra compact Step/direction input MForce MicroDrive is a high performance, low cost microstepping driver that delivers

unsurpassed smoothness and performance achieved through 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.

1.1 MForce MicroDrive unit overview

Step/direction input MForce MicroDrives accept a broad input voltage range from +12 to +48 VDC, delivering enhanced performance and speed. Oversized input capacitors are used to minimize power line surges, reducing problems that can occur with long runs and multiple drive systems. An extended operating range of -40° to $+85^{\circ}\text{C}$ provides long life, trouble free service in demanding environments.

The high, per phase output current of up to 3 Amps RMS, 4.2 Amps Peak, allows the extremely compact MForce MicroDrive to control a broad array of motors from size 11 to size 34.

The microstepping drive accepts up to 20 resolution settings from full to 256 micro-steps 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.

Power and signal interface connections are accomplished with either a pluggable locking wire crimp, terminal strip or 12.0" (30.5cm) flying leads. Motor phases are connected via a pluggable 4-pin locking wire crimp connector.

MForce connectivity has never been easier with options ranging from all-inclusive QuickStart Kits to individual interfacing cables and mating connector kits to build your own cables. See

The Step/direction input MForce MicroDrive is a compact, powerful and inexpensive solution that will reduce system cost, design and assembly time for a large range of applications.

1.3 Product identification

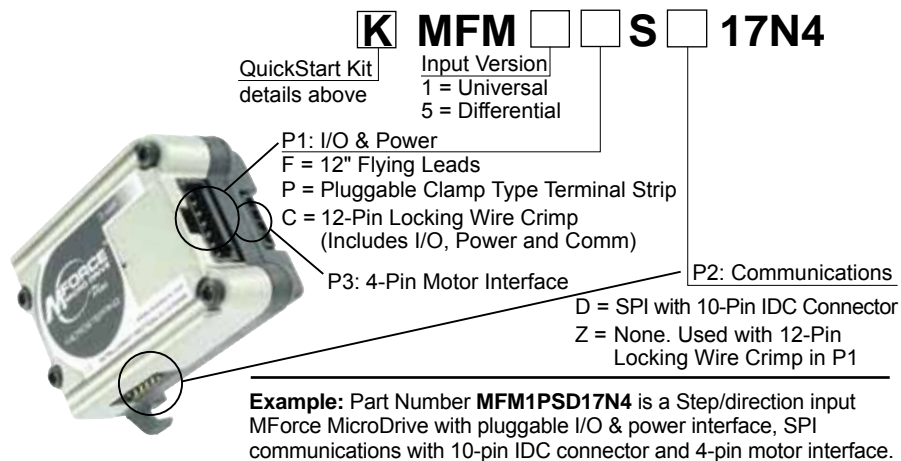


Figure 1.1 Standard product options

1.4 Documentation reference

The following user's manuals are available for the MForce Micro-Drive:

- Product manual, describes the technical data, installation, configuration and programming of the product.
- Quick Reference, describes the basic wiring, connection and use of this product. The quick reference is shipped in printed form with the product.

This documentation is also available for download from the web site at www.novantaims.com

1.5 Product software

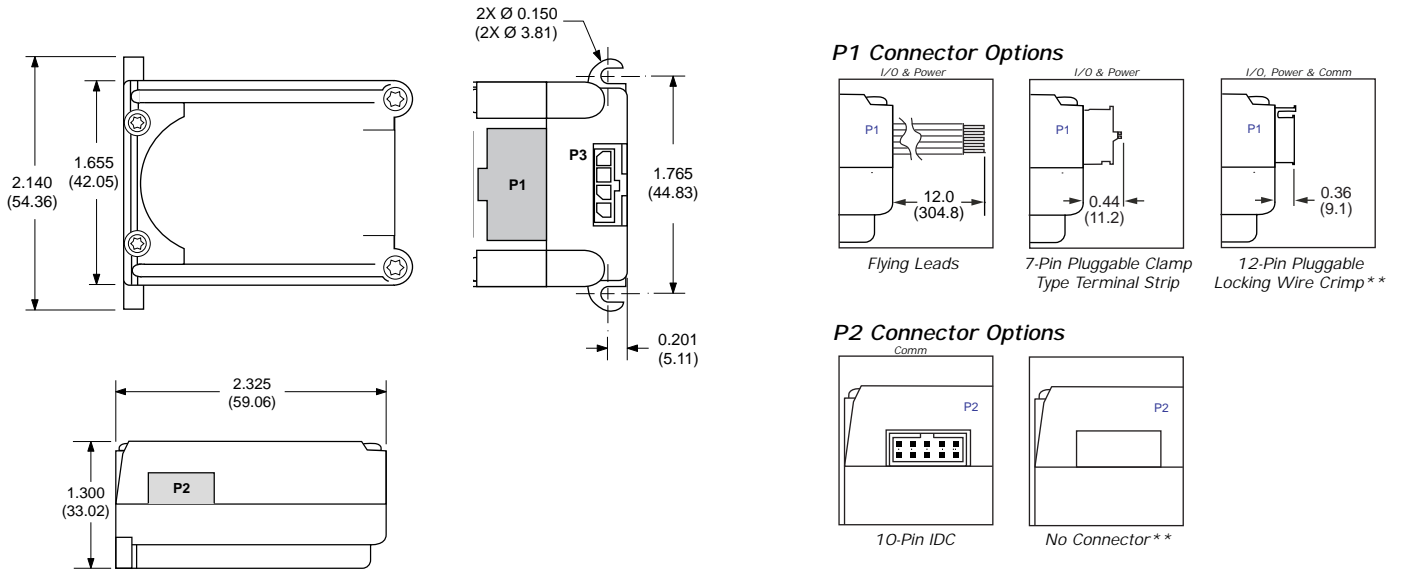
The Step / direction input MForce MicroDrive High Performance Step / direction input Driver is configured using the SPI motor interface graphical user interface. This free software may be downloaded from <https://novantaims.com/dloads/>.

Installation and usages instructions are to be found in Part 1 of this document, Section 5.

2 Specifications

2.1 Mechanical specifications

2.1.1 MForce MicroDrive mechanical specifications



**The 12-Pin Pluggable Locking Wire Crimp connector at P1 eliminates the P2 connector.

Figure 2.1 MForce MicroDrive Mechanical Specifications

2.2 General specifications

2.2.1 Electrical specifications

	Condition	Min	Typ	Max	Unit
Input voltage range	—	+12	—	+48	VDC
Output Current	RMS			3.0	A
	Peal			4.2	A
Max power supply current	—	—	—	2.0*	A

*per MForce MicroDrive, Actual current depends on voltage and load.

Table 2.1 Electrical specifications

2.2.2 Logic specifications

	Condition	Min	Typ	Max	Unit
Universal Inputs					
Isolated input voltage range (sourcing or sinking)	Isolated inputs	+5	—	+24	VDC
Current	+5 VDC max	—	—	8.7	mA
Current	+24 VDC max	—	—	14.6	mA
Differential Inputs					
Voltage range	—	0	—	+5	VDC
High level input voltage	—	+3.75	—	+5.75	VDC
Low level input voltage	—	—	—	≤+1.2	VDC

Table 2.2 I/O specifications

2.2.3 Communications specifications

Protocol	SPI
----------	-----

Table 2.3 Communications specifications

2.2.4 Thermal specifications

		Min	Typ	Max	Unit
Heat sink temperature	non-condensing humidity	-40	—	+85	°C

Table 2.4 Thermal specifications

2.2.5 Motion specifications

Number of microstep resolutions	20								
Available microsteps per revolution									
200	400	800	1000	1600	2000	3200	5000	6400	10000
12800	20000	25000	25600	40000	50000	51200	36000 ¹	21600 ²	25400 ³
1=0.01 deg/μstep 2=1 arc minute/μstep *3=0.001 mm/μstep									
* 1" per revolution lead screw									
Digital filter range	50 ns to 12.9 μs (10 MHz to 38.8 kHz)								
Clock types	step/direction, up/down, quadrature								
Step frequency (max)	5 MHz								
Step frequency minimum pulse width	100 ns								

Table 2.5 Motion specifications

2.2.6 Speed-force performance curves - NEMA 17 Motors

This performance information is based on our stepping motors, actual performance will vary with the characteristics of the motor being used. Consult the documentation provided by the manufacturer of the motor being used for actual performance information.

Single length motor

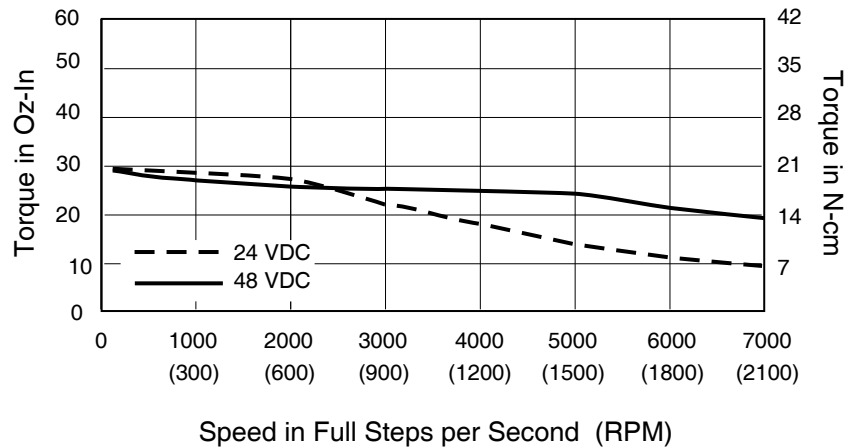


Figure 2.2 Single length NEMA 17 motor

Double length motor

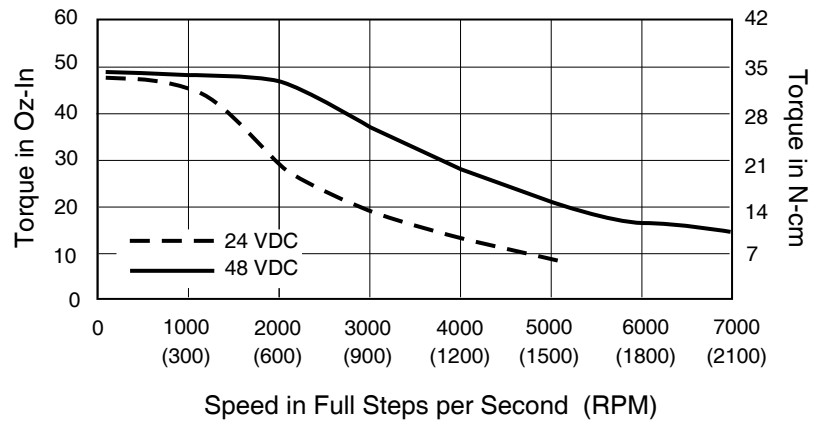


Figure 2.3 Double length NEMA 17 motor

Triple length motor

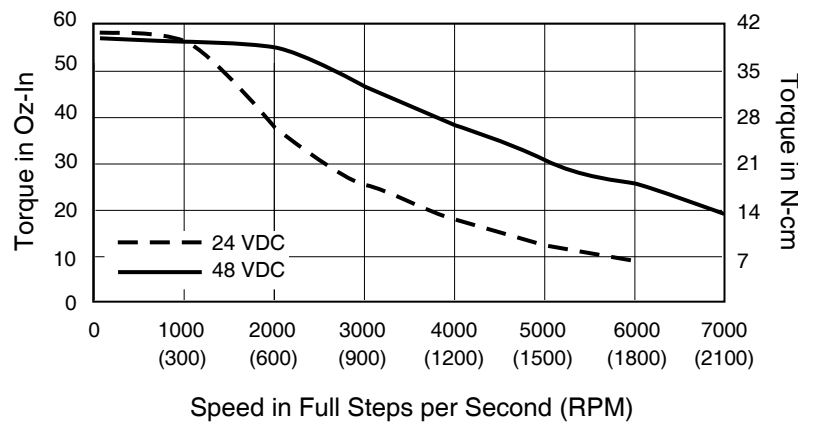


Figure 2.4 Triple length NEMA 17 motor

2.2.7 Speed-force performance curves - NEMA 23 Motors

This performance information is based on our stepping motors, actual performance will vary with the characteristics of the motor being used. Consult the documentation provided by the manufacturer of the motor being used for actual performance information.

Single length motor

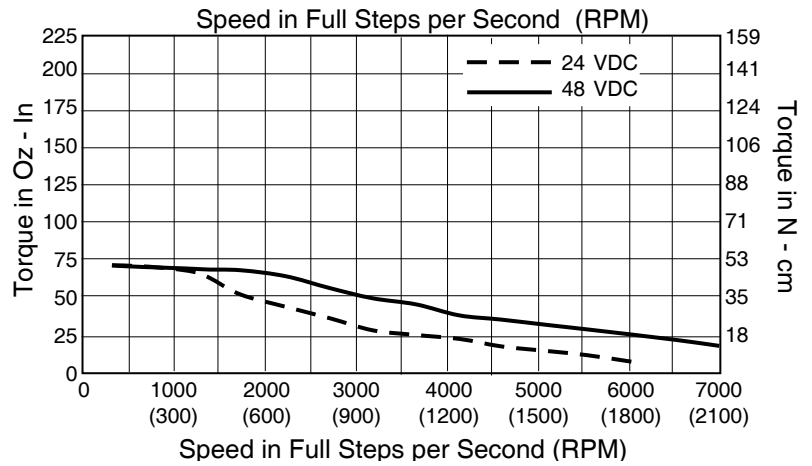


Figure 2.5 Single length NEMA 23 motor

Double length motor

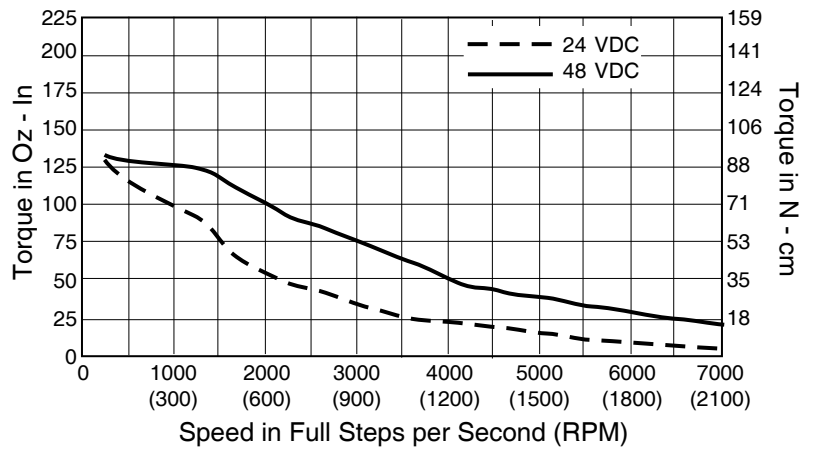


Figure 2.6 Double length NEMA 23 motor

Triple length motor

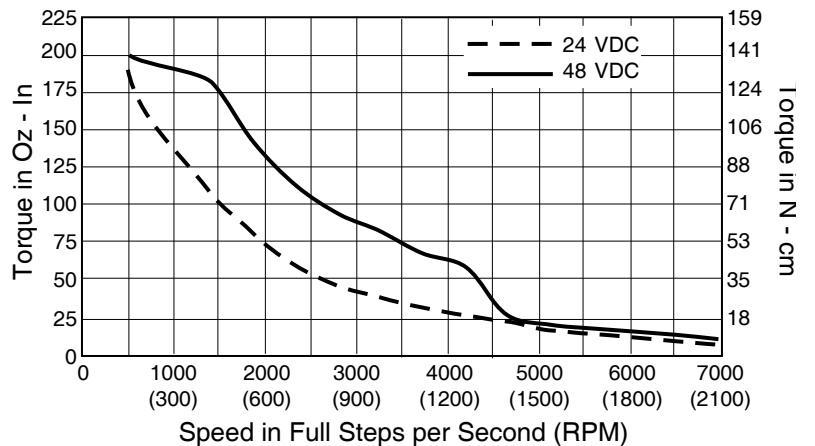


Figure 2.7 Triple length NEMA 23 motor

2.3 Connectivity specifications/pin assignments - Communications

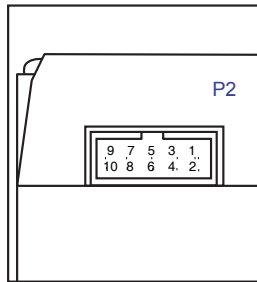
2.3.1 SPI communications - connector P2

⚠ CAUTION
<p>+5VDC OUTPUT</p> <p>The +5 VDC output on connector P2 is for the express purpose of powering the Novanta IMS isolated communications converter cables. Do not use to power external devices.</p> <p>Failure to follow these instructions may result in damage to system components!</p>



If using the model MForce with the 12-pin locking wire crimp connector at connector position P1, the P2 connector is eliminated and SPI communications are bundled with power and logic.

10-pin IDC style connector



Connectivity Options
 USB to SPI Converter:
 MD-CC300-001

Mating connector kit:
 CK-01 (ribbon cable not included)

Mfg P/N:
 Shell
 SAMTEC TSD-05-01-N

Ribbon cable
 Tyco: 1-57051-9

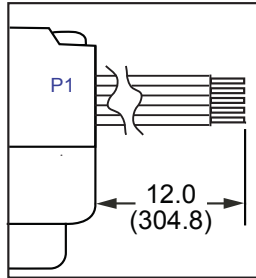
Pin #	Function	Description
1	N/C	Not connected
2	N/C	Not connected
3	N/C	Not connected
4	CS	SPI chip select, selected when low.
5	GND	Communications ground
6	+5V	+ 5 VDC output. Used to power the Novanta IMS communications converter ONLY! Not for general purpose use.
7	MOSI	SPI master out - slave in
8	CLK	SPI clock
9	N/C	Not connected
10	MISO	SPI master in - slave out

Table 2.6 P2 communications, 10-pin locking wire crimp

2.4 Connectivity specifications/pin assignments - power and logic

2.4.1 Power and logic

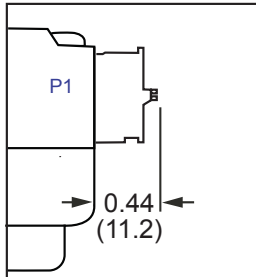
12" (304.8 mm) flying leads



Wire Color	Function	Description
White	Opto	Optocoupler reference
Orange	Step clock	Step clock input
Blue	Direction	CW/CCW direction input
Brown	Enable	Output bridge enable input
Black	GND	Power ground
Red	+V	Motor Power (+12 to +48 VDC)

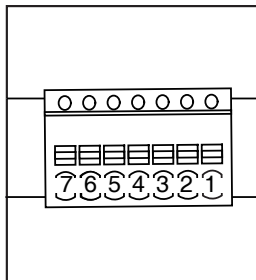
Table 2.7 Power and logic interface - 12" (308.8.mm) flying leads

7-pin pluggable terminal



Pin #	Function	Description
1	Opto	Optocoupler reference
2	N/C	Not connected
3	Step clock	Step clock input
4	Direction	CW/CCW direction input
5	Enable	Output bridge enable input
6	GND	Power ground
7	+V	Motor Power (+12 to +48 VDC)

Table 2.8 Power and logic interface - 7-pin pluggable terminal



2.4.3 Power, logic and communications — 12-pin wire crimp

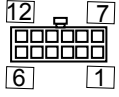
⚠ CAUTION

CONNECTOR PRODUCT ALERT!

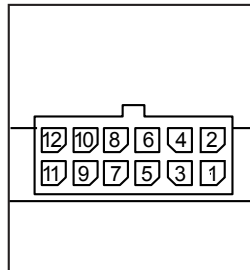
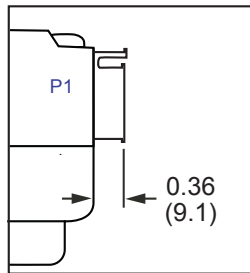
The manufacturer of the Tyco 12-pin connector has begun marking the connector shell, PN 1-794617-2, with pin numbers as shown in the diagram on the right.

Disregard these pin number markings. Use the pin numbering scheme as shown below.

Failure to follow these instructions can result in equipment damage.



Disregard these markings



Pin #	Function	Description
1	GND	Motor power supply return (ground)
2	+V	+12 to +48 VDC motor power supply input
3	OPTO	Optocoupler power supply input
4	SCLK	Step Clock input
5	EN	The Enable Input can be used to enable or disable the driver output circuitry.
6	DIR	The direction Input controls the clockwise/ counterclockwise direction of the motor. It may be configured as sinking or sourcing depending on the state of the Optocoupler Reference.
7	+5 VDC	+5 VDC output. This output is only to be used to power the optional communications converter cable MD-CC305-001. Do not use to power external devices.
8	CLK	SPI Clock
9	CGND	Communications ground
10	MOSI	SPI Master In - Slave Out
11	CS	SPI Chip Select input
12	MISO	SPI Master In - Slave Out

Table 2.9 P1 Power, logic and communications

Connectivity Options
 USB to SPI Converter:
MD-CC303-001

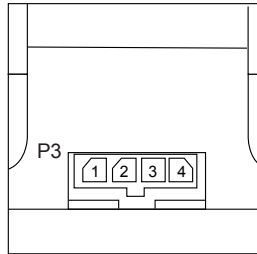
Prototype development cable:
PD12-1434-FL3

Mating connector kit:
CK-03

Mfg P/N:
 Shell
Tyco: 1-794617-2

Pins
Tyco: 794610-1

2.5 Connectivity specifications/pin assignments - Motor



Pin #	Function	Description
1	$\overline{\text{ØA}}$	Phase A return
2	ØA	Phase A output
3	$\overline{\text{ØB}}$	Phase B return
4	ØB	Phase B output

Table 2.10 P3 motor, 4-pin locking wire crimp

Connectivity Options
 Prototype development cable
PD04-MF17-FL3

Mating connector kit:
CK-06

Mfg P/N:
 Shell
Tyco 1445022-4
 Pins
Tyco 1-794610-1

2.6 Options

Drive Protection Module The function of the DPM75 Drive Protection Module is to limit the surge current and voltage to a safe level when DC input power is switched on. e counts available: 100, 200, 250, 256, 400, 500, 512, 800, 1000

2.7 Connectivity

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

Communication Converters Electrically isolated, in-line converters pre-wired with mating connectors to conveniently set/program communication parameters for a single MForce product via a PC's USB port. Length 12.0' (3.6m).

Mates to connector:

P2 10-pin IDC MD-CC300-001

P1 12 pin locking wire crimp MD-CC303-001

Prototype Development Cables Speed test/development with pre-wired mating connectors that have flying leads other end. Length 10.0' (3.0m).

Mates to connector:

P1 12-pin locking wire crimp PD12-1434-FL3

P3 4-pin wire crimp (encoder) PD04-MF17-FL3

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

Mates to connector:

P2 10-pin IDC CK-01

P1 12-pin wire crimp CK-03

P3 4-pin wire crimp CK-06

3 Mounting and connection recommendations

⚠ DANGER**EXPOSED SIGNALS**

Hazardous voltage levels may be present if using an open frame power supply to power the product.

Failure to follow these instructions will result in death or serious injury.

⚠ CAUTION**SWITCHING DC POWER/HOT PLUGGING**

Do not connect or disconnect power, logic, or communications while the device is in a powered state.

Remove DC power by powering down at the AC side of the DC power supply.

Failure to follow these instructions can result in equipment damage.

⚠ CAUTION**LEAD RESTRAINT**

Some MForce MicroDrive mounting configurations require that the MForce MicroDrive move along the screw. Ensure that all cabling is properly restrained to provide strain relief on connection points..

Failure to follow these instructions can result in equipment damage.

⚠ CAUTION**THERMAL MANAGEMENT**

Do not remove the thermal pad attached to the mounting surface of the MForce MicroDrive. It is essential to maintaining a safe driver temperature at full current..

Failure to follow these instructions can result in equipment damage.

3.1 Mounting

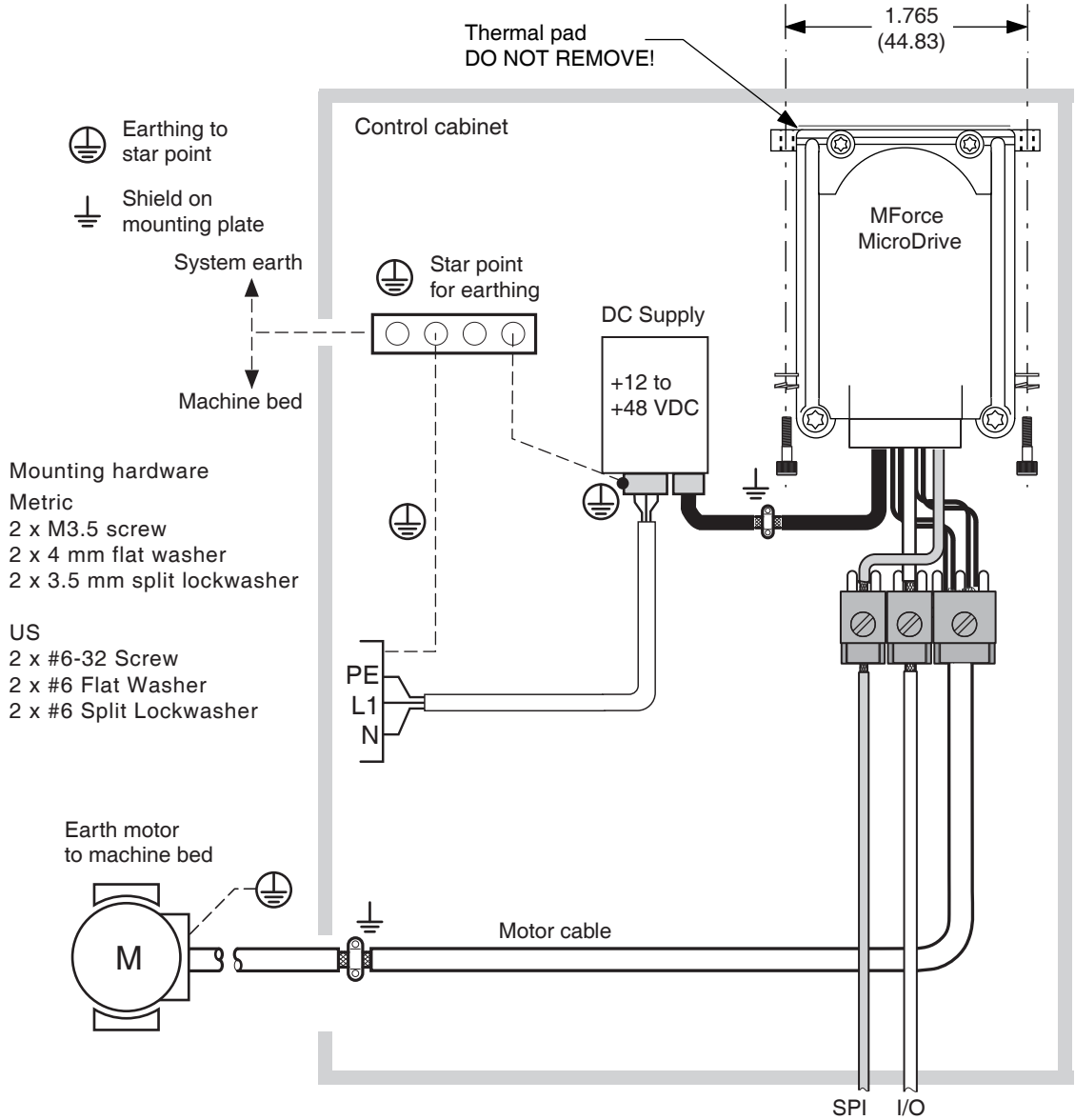


Figure 3.1 MForce Step/direction input mounting and cabinet layout

3.2 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 MicroDrive 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.

3.2.1 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.

3.2.2 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.

3.3 Recommended wiring

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

- Logic Wiring..... 22 AWG
- Wire Strip Length..... 0.25" (6.0 mm)
- Power and Ground 20 AWG
- Motor Wiring 20 AWG

3.3.1 Recommended mating connectors and pins

- Communications*
 - 10-pin IDC (P2)..... SAMTEC TCSD-05-01-N
 - Recommended ribbon cable..... Tyco 1-57051-9
- Logic and Power*
 - The following mating connectors are recommended for the MForce
 - 12-pin Locking Wire Crimp Connector Shell..... Tyco 1-794617-2
 - Crimp Pins..... Tyco 794610-1
- Motor*
 - The following mating connectors are recommended for the MForce
 - 4-pin Locking Wire Crimp Connector Shell..... Tyco 1445022-4
 - Crimp Pins..... Tyco 1-794610-1

4 Connection and interface

⚠ DANGER

EXPOSED SIGNALS

Hazardous voltage levels may be present if using an open frame power supply to power the product.

Failure to follow these instructions will result in death or serious injury.

⚠ CAUTION

SWITCHING DC POWER/HOT PLUGGING

Do not connect or disconnect power, logic, or communications while the device is in a powered state.

Remove DC power by powering down at the AC side of the DC power supply.

Failure to follow these instructions can result in equipment damage.

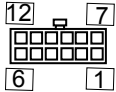
⚠ CAUTION

CONNECTOR PRODUCT ALERT!

The manufacturer of the Tyco 12-pin connector has begun marking the connector shell, PN 1-794617-2, with pin numbers as shown in the diagram on the right.

Disregard these pin number markings. Use the pin numbering scheme as shown in this document.

Failure to follow these instructions can result in equipment damage.



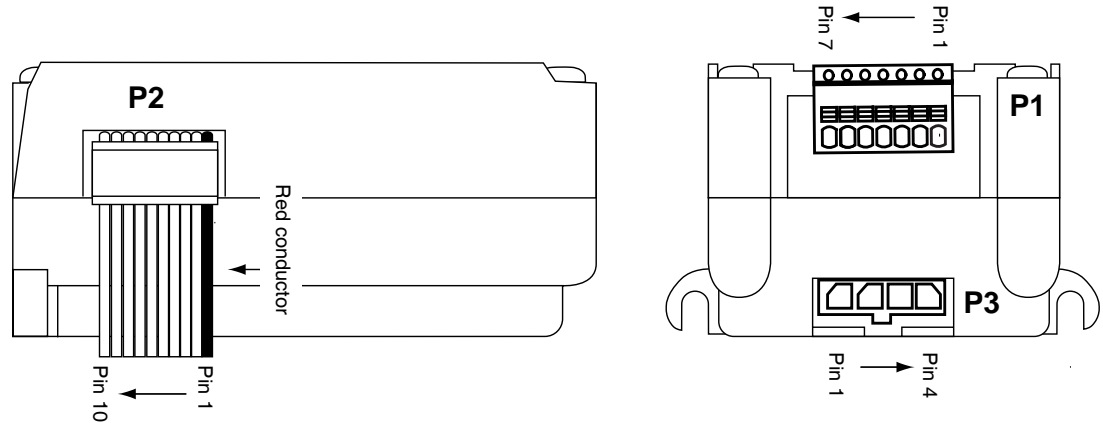
Disregard these markings

4.1 Connector orientation

The illustration below shows the connector positions and orientation with regard to the location of pin 1.

All connector drawings in this section will show this orientation.

Pluggable terminal or flying leads



12-pin wire crimp

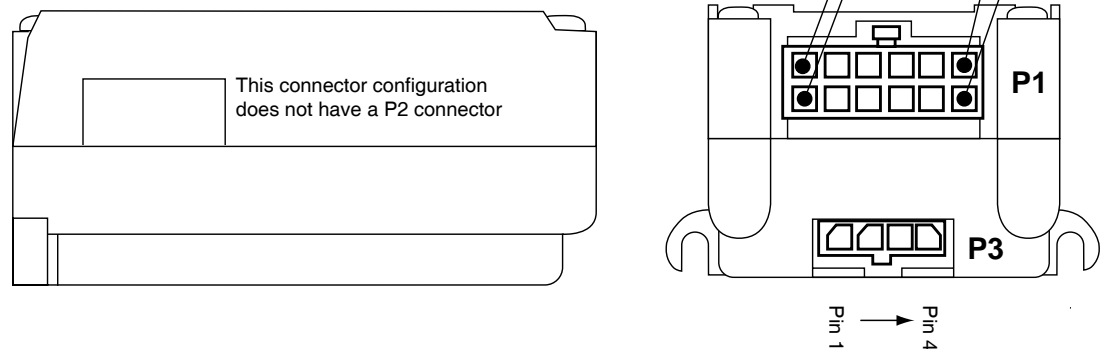


Figure 4.1 Connector orientation

4.2 Interfacing communications

SPI communications may be interfaced using one of two possible connector options:

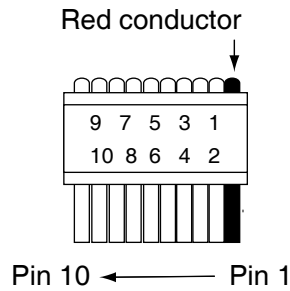
1. 10-pin IDC connector at P2
2. 12-pin locking wire crimp connector at P1



If using the 12-pin locking wire crimp connector at P1, there will be no P2 connector. The P1 option will bundle power, logic and communications on a single connector.

For general SPI communications methods and practices please see Part 1, Section 5 of this document.

4.2.1 P2 - 10-pin IDC style connector



Pin #	Function	Description
1	N/C	Not connected
2	N/C	Not connected
3	N/C	Not connected
4	CS	SPI chip select, selected when low.
5	GND	Communications ground
6	+5V	+ 5 VDC output. Used to power the Novanta IMS communications converter ONLY! Not for general purpose use.
7	MOSI	SPI master out - slave in
8	CLK	SPI clock
9	N/C	Not connected
10	MISO	SPI master in - slave out

Table 4.1 Communications connections, P2 - 10-pin IDC

Connectivity accessories

Mating connector kit CK-01
(contains 5 connector shells, ribbon cable not included)

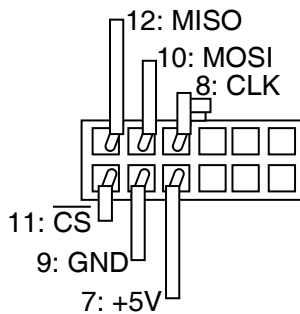
Communications converter cable (10'/3.0 m).....MD-CC300-001

Manufacturer (SAMTEC) part numbers

Connector shell..... TCSD-05-01-N

Ribbon cable..... Tyco 1-57051-9

4.2.2 P1 - 12-pin wire crimp connector



Pin #	Signal	IMS cable wire colors	
		MD-CC303-001	PD14-1434-FL3
7	+ 5 VDC output	—	White/brown
8	SPI clock	—	White/green
9	Comm ground	—	Green/white
10	SPI MOSI	—	White/gray
11	SPI chip select	—	Gray/white
12	SPI MISO	—	Brown/white

Table 4.2 Communications connections, 12-pin locking wire crimp

Connectivity accessories

Mating connector kit CK-03
(contains 5 connector shells and the appropriate quantity of pins to make 5 cables)

Prototype development cable (10'/3.0 m)..... PD12-1434-FL3

Manufacturer (Tyco) part numbers

Connector shell..... 1-794617-2

Pins..... 794610-1

4.3 Interfacing DC power

See part 1 of this document, section 3, for recommended power cable configurations.

⚠ CAUTION

OVER VOLTAGE

The DC voltage range for the MForce MicroDrive is +12 to +48 VDC for single, double and triple length motors, +12 to +60 VDC for quad length motors. Ensure that motor back EMF is factored into your power supply size calculations.

Allow 2.0 A maximum power supply output current per MForce MicroDrive in the system. Actual power supply current will depend on voltage and load.

Failure to follow these instructions can result in equipment damage.

4.3.1 Recommended power supply characteristics

Voltage range	+12 to +48 VDC
Type	Unregulated linear
Ripple	± 5%
Output current	2.0 A (per MDrive 17

Table 4.3 Recommended power supply characteristics

4.3.2 Recommended wire gauge

Cable Length: Feet (meters)	10 (3.0)	25 (7.6)	50 (15.2)	75 (22.9)	100 (30.5)
Amps Peak	Minimum AWG				
1 Amp Peak	20	20	18	18	18
2 Amps Peak	20	18	16	14	14

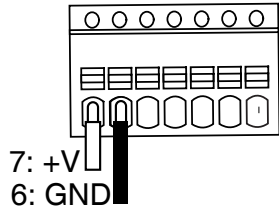
Table 4.4 Recommended power supply wire gauge

4.3.3 P1 — 12' (30.5 cm) flying leads interface

Wire Color	
Red	+12 to +48 VDC supply
Black	Power ground

Table 4.5 Power and ground connections, flying leads

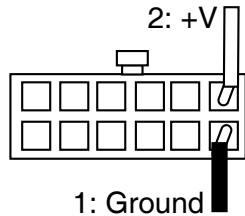
4.3.4 P1 — 7-pin pluggable terminal interface



Pin #	Signal
6	Power ground
7	+12 to +48 VDC supply

Table 4.6 Power and ground connections, 7-pin terminal

4.3.5 P1 — 12-pin locking wire crimp interface



Pin #	Signal	IMS cable wire colors	
		MD-CC303-001	PD14-1434-FL3
2	+12 to +48 VDC supply	Red	Red
1	Power ground	Black	Black

Table 4.7 Power and ground connections, 12-pin locking wire crimp

Connectivity accessories

Mating connector kit CK-03
(contains 5 connector shells and the appropriate quantity of pins to make 5 cables)

Prototype development cable (10'/3.0 m)..... PD12-1434-FL3

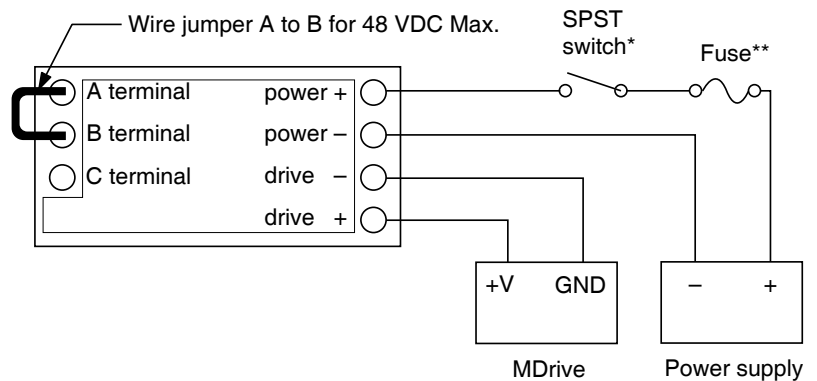
Manufacturer (Tyco) part numbers

Connector shell..... 1-794617-2

Pins..... 794610-1

4.3.6 Power Interface using Drive Protection Module DPM75

The DPM75 Drive Protection Module will limit surge currents for up to three (3) MForce MicroDrive units at up to 48 VDC to allow switching DC Power.



* Do not switch negative side of supply

**Fuse = 6.3 Amp slow blow (recommended: Bussman S505-6.3A or Littelfuse 215006.3). The fuse is optional.

Figure 4.2 DPM75 Drive Protection Module

4.4 Interfacing Logic (Universal Inputs)

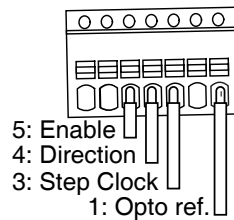
See part 1 of this document, section 6, for logic interface configurations and methods.

4.4.1 P1 — 12' (30.5 cm) flying leads interface

Wire Color	Signal
White	Opto reference
Orange	CW/CCW direction input
Blue	Step clock input
Brown	Enable input

Table 4.8 Universal input connections, flying leads

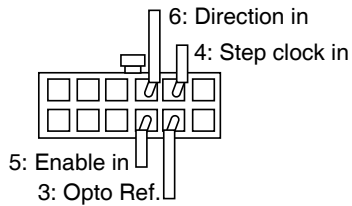
4.4.2 P1 — 7-pin pluggable terminal interface



Pin #	Signal
1	Opto reference
3	Step clock input
4	CW/CCW direction input
5	Enable input

Table 4.9 Universal input connections, 7-pin terminal

4.4.3 P1 — 12-pin locking wire crimp



Pin #	Signal	IMS cable wire colors	
		MD-CC303-001	PD14-1434-FL3
3	Opto reference	White	White/blue
4	Step clock input	Green	Blue/white
5	Enable input	Orange	White/orange
6	Direction input	Blue	Orange/white

Table 4.10 Universal input connections, 12-pin locking wire crimp

Connectivity accessories

Mating connector kit CK-03
(contains 5 connector shells and the appropriate quantity of pins to make 5 cables)


Prototype development cable (10'/3.0 m)..... PD12-1434-FL3

Manufacturer (Tyco) part numbers

Connector shell..... 1-794617-2

Pins..... 794610-1

4.5 Interfacing Logic (Differential Inputs)

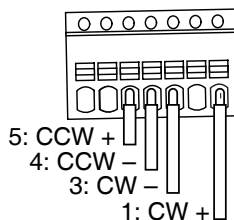
 CAUTION
<p>ELECTRICAL OVERSTRESS</p> <p>The universal logic inputs are tolerant to +24 VDC. The differential input version inputs are TTL level and only tolerant to +5 VDC:</p> <p>Do not exceed +5 VDC on the differential inputs.</p> <p>Failure to follow these instructions can result in equipment damage.</p>

4.5.1 P1 — 12' (30.5 cm) flying leads interface

Wire Color	Signal
White	CW +
Orange	CW —
Blue	CCW —
Brown	CCW +

Table 4.11 Differential input connections, flying leads

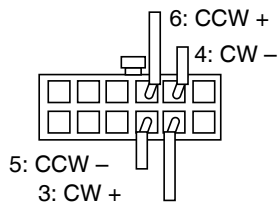
4.5.2 P1 — 7-pin pluggable terminal interface



Pin #	Signal
1	CW +
3	CW —
4	CCW —
5	CCW +

Table 4.12 Differential input connections, 7-pin terminal

4.5.3 P1 — 12-pin locking wire crimp



Pin #	Signal	Wire colors	
		MD-CC303-001	PD12-1434-FL3
3	CW +	White	White/blue
4	CW —	Green	Blue/white
5	CCW —	Orange	White/orange
6	CCW +	Blue	Orange/white

Table 4.13 Differential input connections, 12-pin locking wire crimp

Connectivity accessories

Mating connector kit CK-03
(contains 5 connector shells and the appropriate quantity of pins to make 5 cables)

Prototype development cable (10'/3.0 m)..... PD12-1434-FL3

Manufacturer (Tyco) part numbers

Connector shell..... 1-794617-2

Pins..... 794610-1

4.6 USB to SPI communications converters

4.6.1 USB to 10-pin wire crimp — MD-CC300-001

Electrically isolated in-line USB to SPI converter pre-wired with mating connector to conveniently program and set configuration parameters.

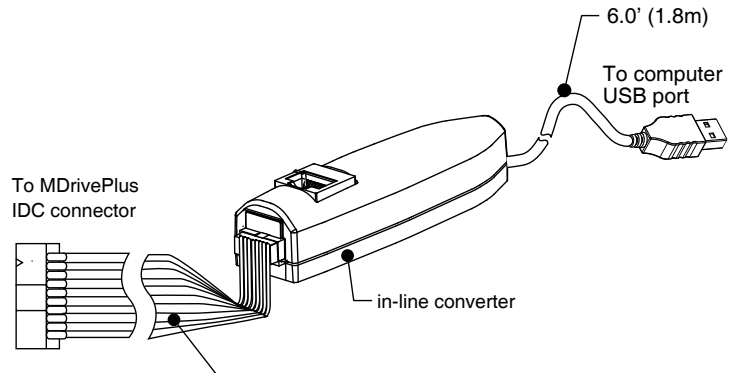


Figure 4.3 MD-CC300-001 communications converter cable

4.6.2 USB to 12-pin wire crimp — MD-CC303-001

Electrically isolated in-line USB to SPI converter pre-wired with mating connector to conveniently program and set configuration parameters. Power and logic signals are bundled into this connector via a second cable with signal accessibility via flying leads.

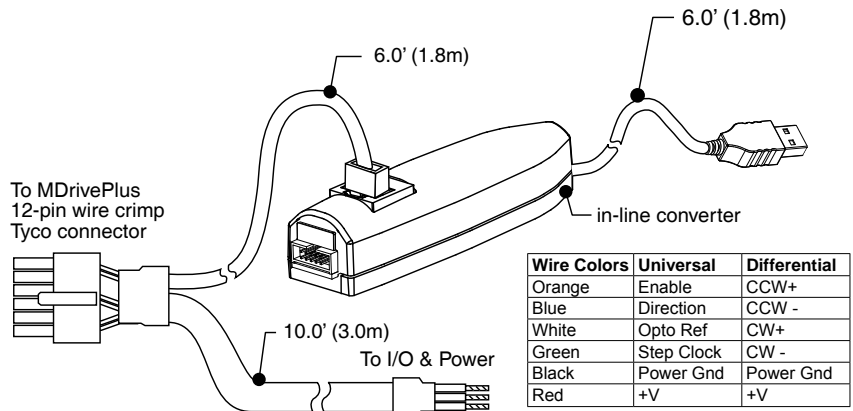


Figure 4.4 MD-CC303-001 communications converter cable

4.7 Prototype development cables

4.7.1 P1 — 12-pin locking wire crimp PD12-1434-FL3

The PD12-1434-FL3 prototype development cable is used to rapidly interface the MForce to the users power, communications and logic interface. This 10' (3.0 m) cable consists of a 12-pin locking wire crimp connector to plug directly into the MForce P1 connector with flying leads on the opposite end to interface to power, communications and logic.

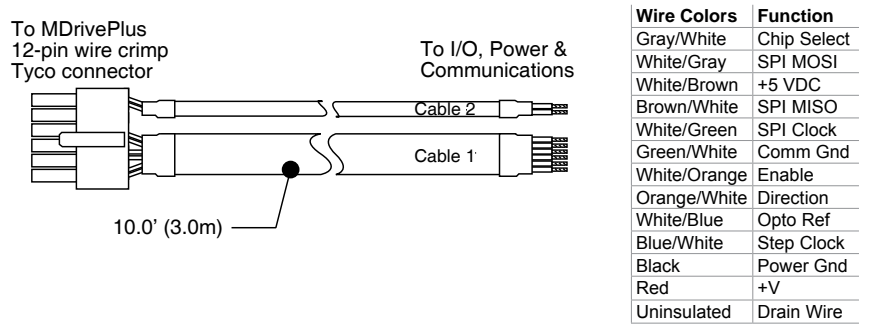


Figure 4.5 Prototype development cable PD12-1434-FL3

4.8 Mating connector kits

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

Mates to connector:

P2 10-pin IDC CK-01

P1 12-pin wire crimp CK-03

MForce PowerDrive

Step/direction input



1. Introduction
2. Specifications
3. Mounting Recommendations
4. Interface and Connectivity

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1 Introduction

The compact Step/direction input MForce PowerDrive is a high performance, low cost microstepping driver that delivers

unsurpassed smoothness and performance achieved through 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.

1.1 MForce PowerDrive unit overview

Step/direction input 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 -240° 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 micro-steps 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.

Power and signal interface connections are accomplished with either a pluggable locking wire crimp, terminal strip or 12.0" (30.5cm) flying leads. Motor phases are connected via a pluggable 4-pin locking wire crimp connector.

MForce connectivity has never been easier with options ranging from all-inclusive QuickStart Kits to individual interfacing cables and mating connector kits to build your own cables. See

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

1.2 Product identification

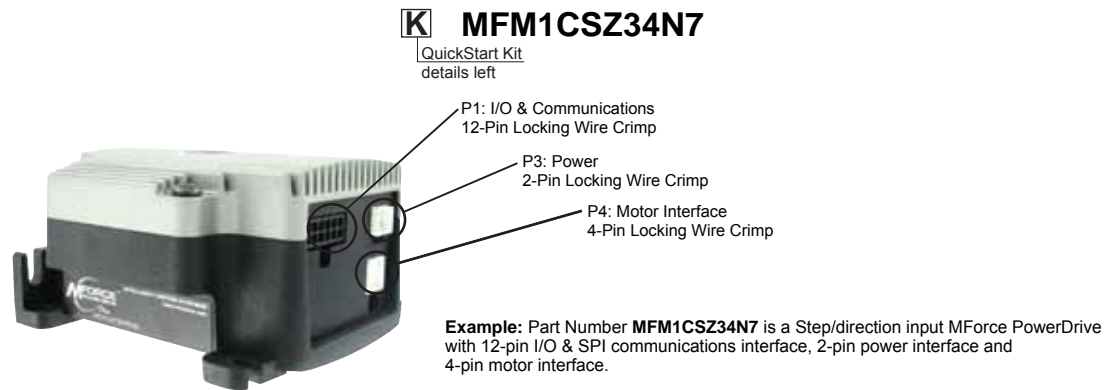


Figure 1.1 Standard product options

1.3 Documentation reference

The following user's manuals are available for the MForce PowerDrive:

- Product manual, describes the technical data, installation, configuration and programming of the product.
- Quick Reference, describes the basic wiring, connection and use of this product. The quick reference is shipped in printed form with the product.

This documentation is also available for download from the web site at www.novantaims.com

1.4 Product software

The Step / direction input MForce PowerDrive High Performance Step/direction input Driver is configured using the SPI motor interface graphical user interface. This free software may be downloaded from <https://novantaims.com/downloads/>.

Installation and usages instructions are to be found in Part 1 of this document, Section 5.

2 Specifications

2.1 Mechanical specifications

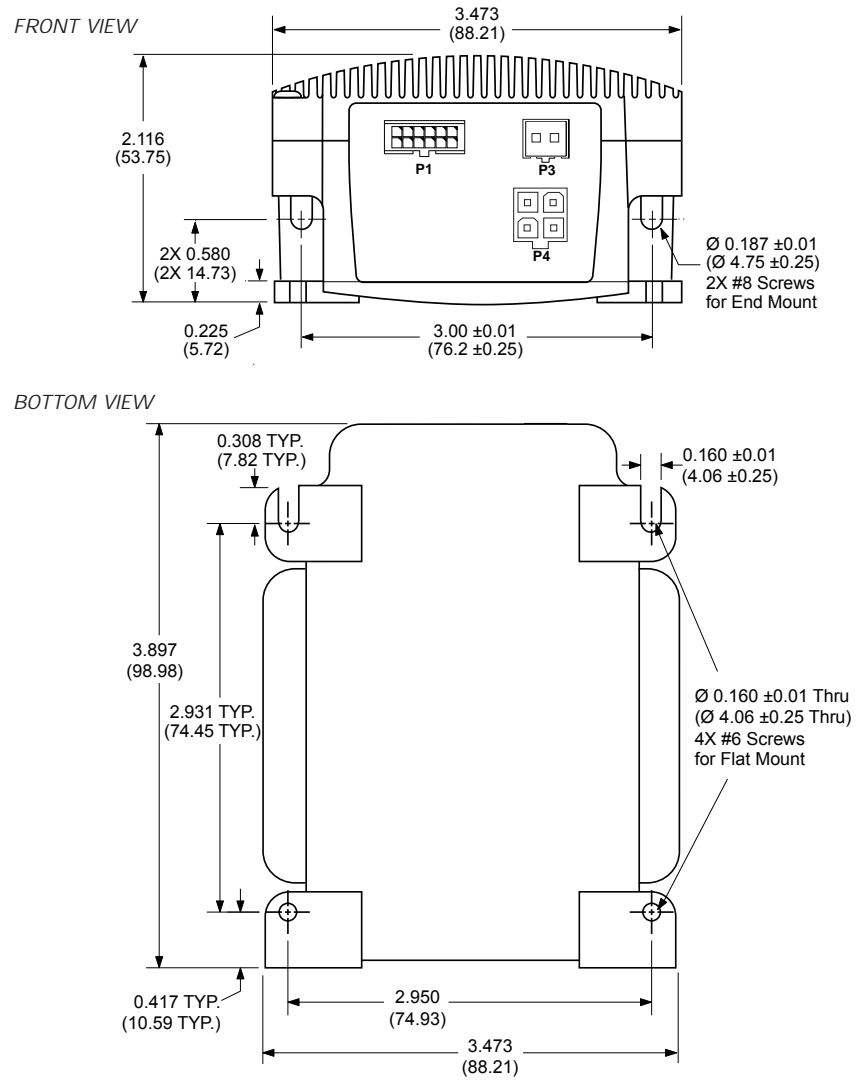


Figure 2.1 Mechanical specifications - dimensions in inches (mm)

2.2 General specifications

2.2.1 Electrical specifications

	Condition	Min	Typ	Max	Unit
Input voltage range	—	+12	—	+75	VDC
Max power supply current	—	—	—	4.0*	A
Output Current	RMS	—	—	5.0	A
	Peak	—	—	7.0	A

*per MForce PowerDrive, Actual current depends on voltage and load.

Table 2.1 Electrical specifications

2.2.2 Logic specifications

	Condition	Min	Typ	Max	Unit
Universal Inputs					
Isolated input voltage range (sourcing or sinking)	Isolated inputs	+5	—	+24	VDC
Current	+5 VDC max	—	—	8.7	mA
Current	+24 VDC max	—	—	14.6	mA
Differential Inputs					
Voltage range	—	0	—	+5	VDC
High level input voltage	—	+3.75	—	+5.75	VDC
Low level input voltage	—	—	—	≤+1.2	VDC

Table 2.2 I/O specifications

2.2.3 Communications specifications

Protocol	SPI
----------	-----

Table 2.3 Communications specifications

2.2.4 Thermal specifications

		Min	Typ	Max	Unit
Heat sink temperature	non-condensing humidity	-40	—	+75	°C
Motor temperature	non-condensing humidity	-40	—	+90	°C

Table 2.4 Thermal specifications

2.2.5 Motion specifications

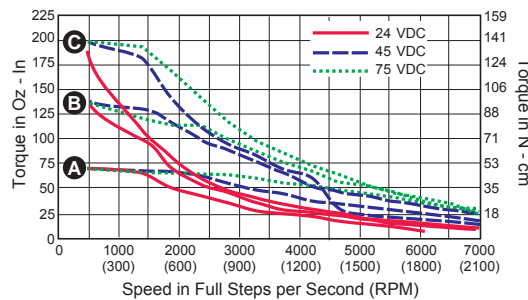
Number of microstep resolutions	20								
Available microsteps per revolution									
200	400	800	1000	1600	2000	3200	5000	6400	10000
12800	20000	25000	25600	40000	50000	51200	36000 ¹	21600 ²	25400 ³
1=0.01 deg/μstep		2=1 arc minute/μstep		*3=0.001 mm/μstep					
* 1" per revolution lead screw									
Digital filter range	50 ns to 12.9 μs (10 MHz to 38.8 kHz)								
Clock types	step/direction, up/down, quadrature								
Step frequency (max)	5 MHz								
Step frequency minimum pulse width	100 ns								

Table 2.5 Motion specifications

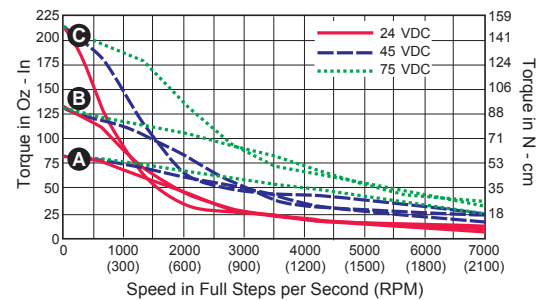
2.2.6 Performance curves

Motor performance curves were generated using stock motors sold by Novanta IMS. For performance information specific to the motor you are using see the manufacturer documentation.

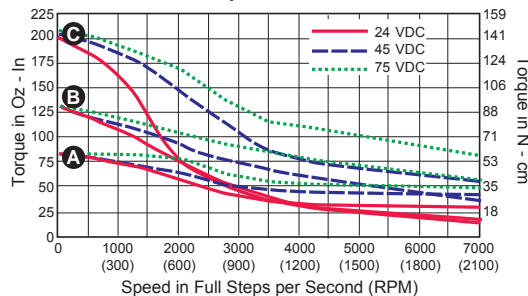
NEMA 23 — 2.4 Amps RMS



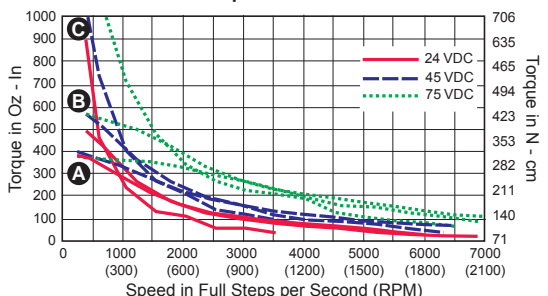
NEMA 23 — 3.0 Amps RMS



NEMA 23 — 6.0 Amps RMS



NEMA 34 — 6.3 Amps RMS



A Single Stack **B** Double Stack **C** Triple Stack

Figure 2.2 Speed-torque curves

2.3 Connectivity specifications/pin assignments

2.3.1 P1 — Communications and logic

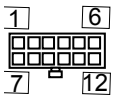
⚠ CAUTION

CONNECTOR PRODUCT ALERT!

The manufacturer of the Tyco 12-pin connector has begun marking the connector shell, PN 1-794617-2, with pin numbers as shown in the diagram on the right.

Disregard these pin number markings. Use the pin numbering scheme as shown below.

Failure to follow these instructions can result in equipment damage.



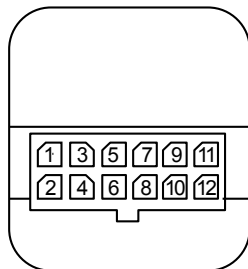
Disregard these markings

⚠ CAUTION

+5VDC OUTPUT

The +5 VDC output on connector P1 is for the express purpose of powering the MD-CC303-001 isolated communications converter cables. Do not use to power external devices.

Failure to follow these instructions may result in damage to system components!



Connectivity Options
 USB to SPI Converter:
 MD-CC303-001

Prototype development cable:
 PD12-1434-FL3

Mating connector kit:
 CK-03

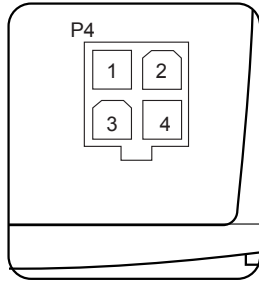
Mfg P/N:
 Shell
 Tyco: 1-794617-2

Pins
 Tyco: 794610-1

Pin #	Function	Description
1	NC	Not connected
2	NC	Not connected
3	OPTO	Optocoupler power supply input
4	SCLK	Step Clock input
5	EN	The Enable Input can be used to enable or disable the driver output circuitry.
6	DIR	The direction Input controls the clockwise/ counterclockwise direction of the motor. It may be configured as sinking or sourcing depending on the state of the Optocoupler Reference.
7	+5 VDC	+5 VDC output. This output is only to be used to power the optional communications converter cable MD-CC303-001. Do not use to power external devices.
8	CLK	SPI Clock
9	CGND	Communications ground
10	MOSI	SPI Master In - Slave Out
11	CS	SPI Chip Select input
12	MISO	SPI Master In - Slave Out

Table 2.6 P1 — Communications and logic, 12-pin locking wire crimp

2.3.2 Motor



Pin #	Function	Description
1	∅A	Phase A output
2	∅A	Phase A return
3	∅B	Phase B output
4	∅B	Phase B return

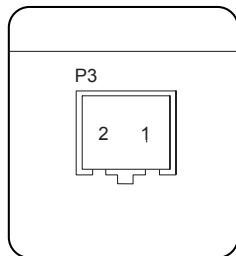
Table 2.7 P4 motor, 4-pin locking wire crimp

Connectivity Options
 Prototype development cable
PD02-3400-FL3

Mating connector kit:
CK-07

Mfg P/N:
 Shell
Molex 39-01-2045
 Pins
Molex 44476-3112

2.3.3 Power



Pin #	Function	Description
1	+V	+24 to +48 VDC
2	Ground	Power supply return

Table 2.8 P3 power, 2-pin locking wire crimp

Connectivity Options
 Prototype development cable
PD02-3400-FL3

Mating connector kit:
CK-05

Mfg P/N:
 Shell
Molex 510-67-0200
 Pins
Molex 502-17-91011

2.4 Options

Drive Protection Module The function of the DPM75 Drive Protection Module is to limit the surge current and voltage to a safe level when DC input power is switched on and off to the MForce.

2.5 Connectivity

QuickStart Kit For rapid design verification, all-inclusive QuickStart Kits include connectivity, instructions and CD for MDrivePlus initial functional setup and system testing.

Parameter Setup Cable The optional 12.0' (3.6m) parameter setup cable assembly with inline USB to SPI converter facilitates communications, power and logic wiring and is recommended with first order.

12-pin wire crimpMD-CC303-001

Prototype Development Cable Speed test/development with pre-wired mating connectors that have flying leads other end. Length 10.0' (3.0m).

Mates to connector:

12-Pin Wire CrimpPD12-1434-FL3
(Not required if using the MD-CC303-001)

4-pin wire crimp PD04-MF34-FL3

2-pin wire crimp PD02-3400-FL3

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

Mates to connector:

12-Pin Wire CrimpCK-03

4-pin wire crimpCK-07

2-pin wire crimpCK-05

3 Mounting and connection recommendations

⚠ DANGER**EXPOSED SIGNALS**

Hazardous voltage levels may be present if using an open frame power supply to power the product.

Failure to follow these instructions will result in death or serious injury.

⚠ CAUTION**SWITCHING DC POWER/HOT PLUGGING**

Do not connect or disconnect power, logic, or communications while the device is in a powered state.

Remove DC power by powering down at the AC side of the DC power supply.

Failure to follow these instructions can result in equipment damage.

⚠ CAUTION**LEAD RESTRAINT**

Some MForce mounting configurations require that the drive move along a screw. Ensure that all cabling is properly restrained to provide strain relief on connection points..

Failure to follow these instructions can result in equipment damage.

⚠ CAUTION**THERMAL MANAGEMENT**

Do not remove the thermal pad attached to the mounting surface of the MForce PowerDrive. It is essential to maintaining a safe driver temperature at full current..

Failure to follow these instructions can result in equipment damage.

3.1 Mounting

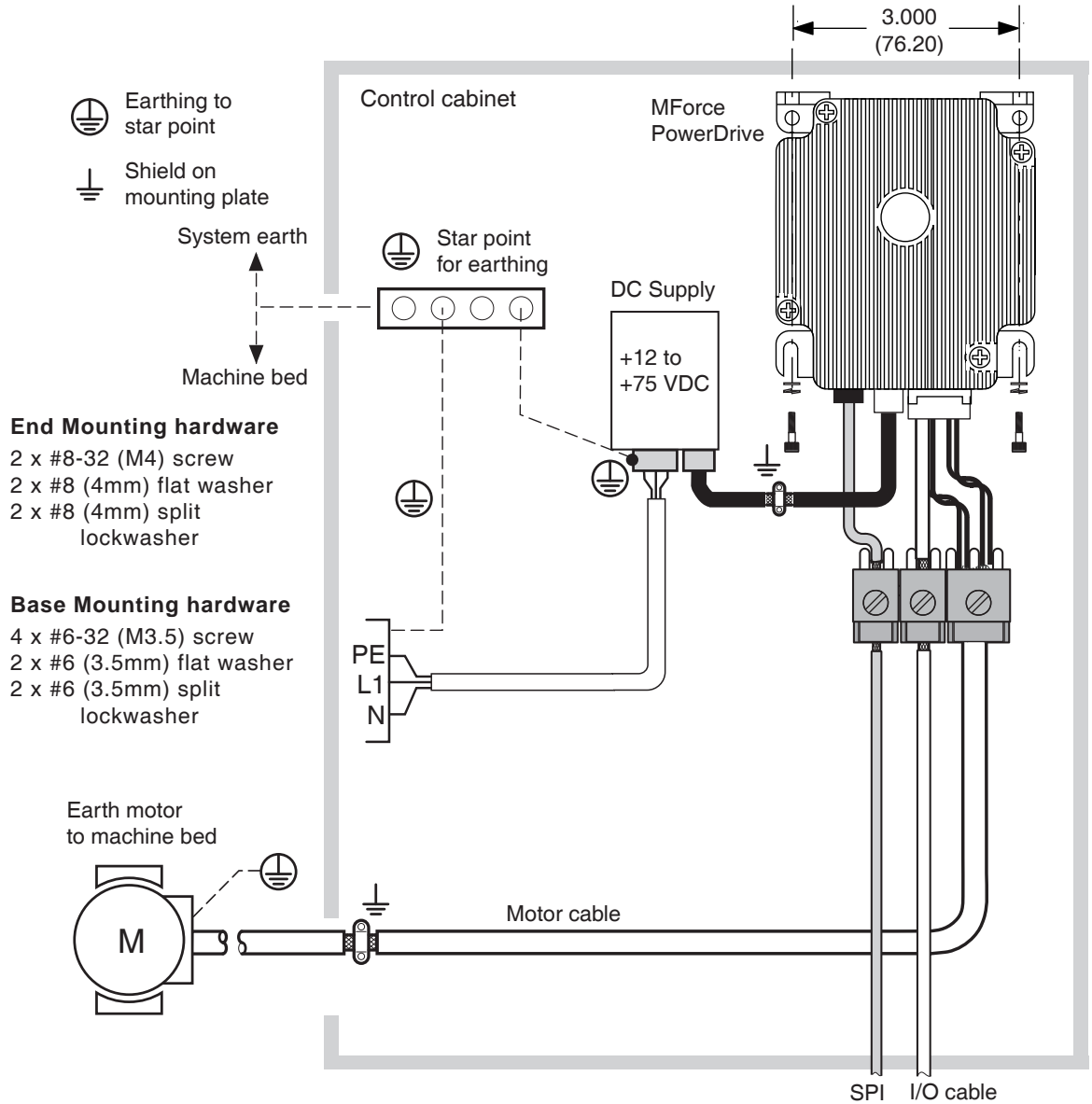


Figure 3.1 MForce PowerDrive Step/direction input mounting

3.2 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 Step/direction input 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.

3.2.1 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 2 m, 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.

3.2.2 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.

3.3 Recommended wiring

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

Logic wiring..... 22 AWG

Wire strip length..... 6.0 mm

Power and ground See Table 3.2 in Part 1, Section 3 of this document

3.3.1 Recommended mating connectors and pins

I/O and Communications 12-pin locking wire crimp connector shell..... Tyco 1-794617-2
 Crimp pins Tyco 794610-1

Power 2-pin locking wire crimp connector shell..... Molex 51067-0200
 Crimp pins Molex 51027-9101

Motor 4-pin locking wire crimp connector shell..... Molex 39-01-2045
 Crimp pins Molex 44476-3112

4 Connection and interface

⚠ DANGER

EXPOSED SIGNALS

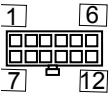
Hazardous voltage levels may be present if using an open frame power supply to power the product.

Failure to follow these instructions will result in death or serious injury.

⚠ CAUTION

CONNECTOR PRODUCT ALERT!

The manufacturer of the Tyco 12-pin connector has begun marking the connector shell, PN 1-794617-2, with pin numbers as shown in the diagram on the right.



Disregard these markings

Disregard these pin number markings. Use the pin numbering scheme as shown below.

Failure to follow these instructions can result in equipment damage.

⚠ CAUTION

SWITCHING DC POWER/HOT PLUGGING

Do not connect or disconnect power, logic, or communications while the device is in a powered state.

Remove DC power by powering down at the AC side of the DC power supply.

Failure to follow these instructions can result in equipment damage.

4.1 Connector orientation and overview

The Communications, logic, power and motor signals are interfaced to the following connectors:

- Communications and LogicP1
- PowerP2
- MotorP4

The illustration below shows the connector positions and orientation with regard to the location of pin 1.

All connector illustrations in this section will match this orientation.

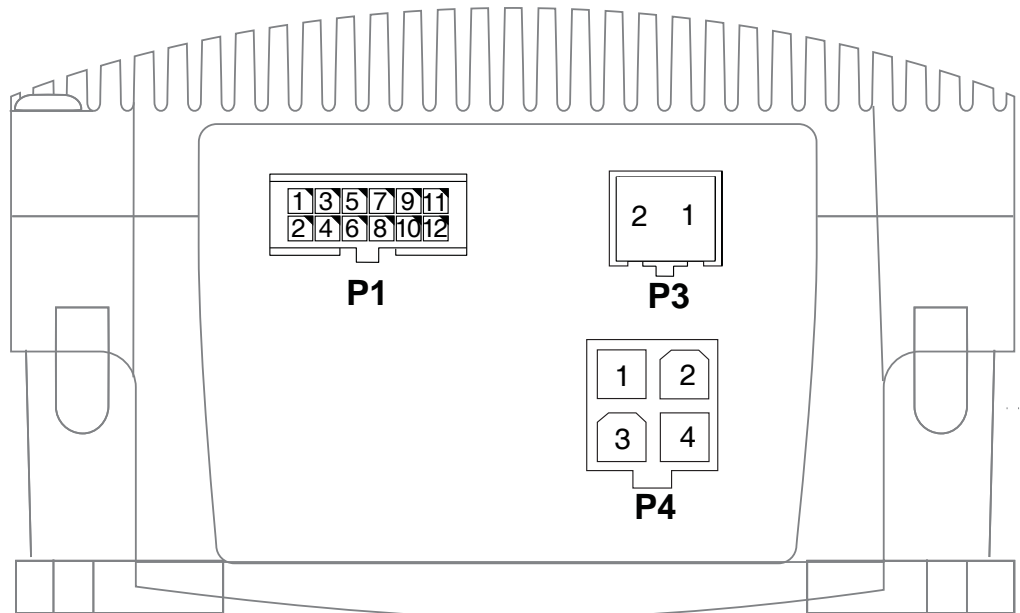


Figure 4.1 Connector orientation

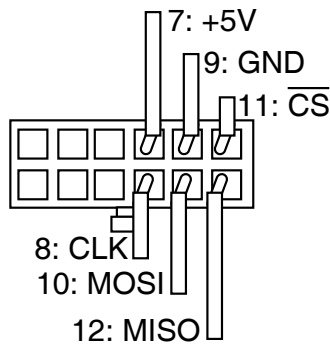
4.2 Interfacing communications



SPI communications may be interfaced using a 12-pin locking wire crimp connector at P1

For general SPI communications methods and practices please see Part 1, Section 5 of this document.

4.2.1 P1 — 12--pin wire crimp connector



Pin #	Function	Description
7	+5V	+ 5 VDC output. Used to power the MD-CC303-001 communications converter ONLY! Not for general purpose use.
8	CLK	SPI clock
9	GND	Communications ground
10	MOSI	SPI master out - slave in
11	CS	SPI chip select, selected when low.
12	MISO	SPI master in - slave out

Table 4.1 Communications connections, P1 - 12-pin wire crimp

4.3 Interfacing DC power

See part 1 of this document, section 3, for recommended power cable configurations.

⚠ CAUTION

OVER VOLTAGE

The DC voltage range for the MForce PowerDrive Step/direction input is +24 to +75 VDC. Ensure that motor back EMF is factored into your power supply size calculations.

Allow 4.0 A maximum power supply output current per MForce PowerDrive Step/direction input in the system. Actual power supply current will depend on voltage and load.

Failure to follow these instructions can result in equipment damage.

4.3.1 Recommended power supply characteristics

Voltage range	+12 to +75 VDC
Type	Unregulated linear
Ripple	± 5%
Output current	4.0 A (per MForce PowerDrive)

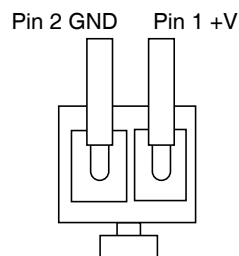
Table 4.2 Recommended power supply characteristics

4.3.2 Recommended wire gauge

Cable Length: Meters	3,0	8.0	15.0	23.0	30.0
Amps Peak	Minimum AWG				
1 Amp Peak	20	20	18	18	18
2 Amps Peak	20	18	16	14	14
3 Amps Peak	18	16	14	12	12
4 Amps Peak	18	16	14	12	12

Table 4.3 Recommended power supply wire gauge

4.3.3 P3 — 2-pin locking wire crimp interface

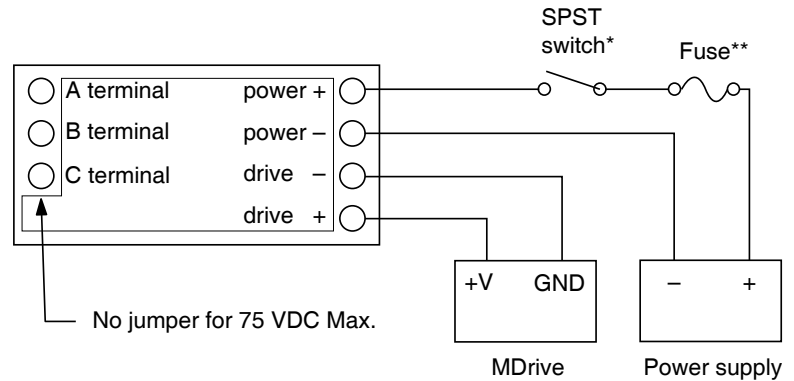


Pin #	Signal	Wire colors
		PD12-1434-FL3
1	+24 to + 48 VDC	Red
2	Power supply return (ground)	Black

Table 4.4 Power and ground connections, 2-pin locking wire crimp

4.3.4 Power Interface using Drive Protection Module DPM75

The DPM75 Drive Protection Module will limit surge currents for one (1) MForce PowerDrive at 75 VDC to allow switching DC Power.



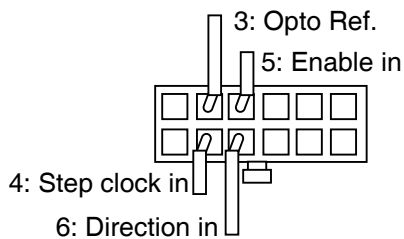
- * Do not switch negative side of supply
- **Fuse = 6.3 Amp slow blow (recommended: Bussman S505-6.3A or Littelfuse 215006.3). The fuse is optional.

Figure 4.2 DPM75 Drive Protection Module

4.4 Interfacing Logic

See part 1 of this document, section 4, for logic interface configurations and methods.

4.4.1 P1 — 12-pin locking wire crimp



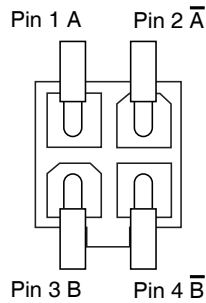
Pin #	Signal	Cable wire colors	
3	Opto reference	MD-CC303-001	PD12-1434-FL3
4	Step clock input	White	See section 4.2.2 for wire colors.
5	Enable input	Green	
6	Direction input	Orange	
		Blue	

Table 4.5 Signal input connections, 12-pin locking wire crimp

4.5 Interfacing the motor

See part 1 of this document, section 5, for motor selection and interface configurations.

4.5.1 P1 — 4-pin locking wire crimp interface



Pin Numbers	Signal	Prototype development cable wire colors (twisted pairs are labeled)
1	Phase A output	Black (pair 2)
2	Phase A return	White (pair 2)
3	Phase B output	Black (pair 1)
4	Phase B return	White (pair 1)

Table 4.6 Motor connections, 4-pin locking wire crimp

4.6 Connectivity accessory details

4.6.1 MD-CC303-001 communications converter cable

The MD-CC303-001 is an interface cable which combines Power, Logic and communications with an inline USB to SPI converter.

It is recommended with the first purchase.

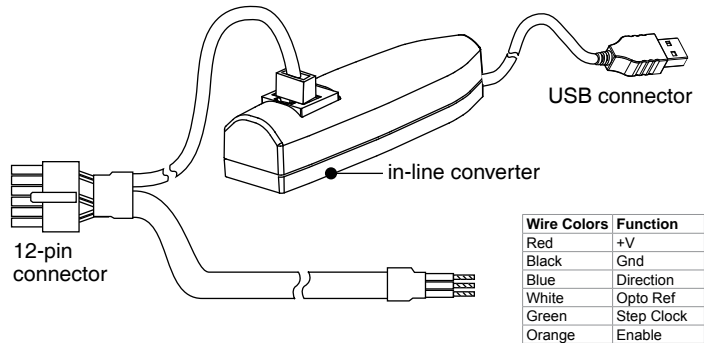
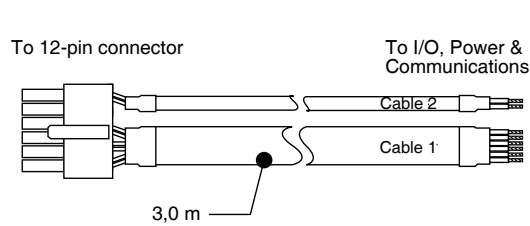


Figure 4.3 MD-CC303-001 USB to SPI converter cable

4.6.2 PD12-1434-FL3 prototype development cable

Description: Pre-wired mating connector interfaces to an MForce’s 12-pin wire crimp connector, with flying leads other end, for quick test/development.

Function: I/O & Communications Interface.



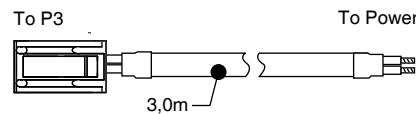
Wire Colors	Function
Gray/White	Chip Select
White/Gray	SPI MOSI
White/Brown	+5 VDC
Brown/White	SPI MISO
White/Green	SPI Clock
Green/White	Comm Gnd
White/Orange	Enable
Orange/White	Direction
White/Blue	Opto Ref
Blue/White	Step Clock
Black	Not connected
Red	Not connected
Uninsulated	Drain Wire

Figure 4.4 Prototype development cable PD12-1434-FL3

4.6.3 Prototype development cable PD02-3400-FL3

Description: Pre-wired mating connector interfaces to an MForce 2-pin wire crimp connector, with flying leads other end, for quick test/development.

Function: Power Interface.



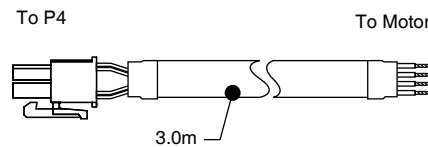
Wire Colors	Function
Black	Power Ground
Red	+V

Figure 4.5 Prototype development cable PD02-3400-FL3

4.6.4 Prototype development cable PD04-MF34-FL3

Description: Pre-wired mating connector interfaces to an MForce 4-pin wire crimp connector, with flying leads other end, for quick test/development.

Function: Motor Interface.



Wire Colors	Function
Black (Pair 1)	Phase B
White (Pair 1)	Phase B\
Black (Pair 2)	Phase A
White (Pair 2)	Phase A\

Note that pairs are marked with the pair number.

Figure 4.6 Prototype development cable PD04-MF34-FL3

4.6.5 Mating connector kits

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

Mates to connector:

- P1 12-pin wire crimp.....CK-03
- P3 2-pin wire crimp.....CK-05
- P4 4-pin wire crimp.....CK-07



California Proposition 65 Warning—Lead and Lead Compounds

Advertencia de la Proposición 65 de California—Plomo y compuestos de plomo

Avertissement concernant la Proposition 65 de Californie—Plomb et composés de plomb

⚠️ WARNING: This product can expose you to chemicals including lead and lead compounds, which are known to the State of California to cause cancer and birth defects or other reproductive harm. For more information go to: www.P65Warnings.ca.gov.

⚠️ ADVERTENCIA: Este producto puede exponerle a químicos incluyendo plomo y compuestos de plomo, que es (son) conocido(s) por el Estado de California como causante(s) de cáncer y defectos de nacimiento u otros daños reproductivos. Para mayor información, visite : www.P65Warnings.ca.gov.

⚠️ AVERTISSEMENT: Ce produit peut vous exposer à des agents chimiques, y compris plomb et composés de plomb, identifiés par l'État de Californie comme pouvant causer le cancer et des malformations congénitales ou autres troubles de l'appareil reproducteur. Pour de plus amples informations, prière de consulter: www.P65Warnings.ca.gov.

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Novanta IMS

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Marlborough, CT 06447
860-295-6102
www.novantaims.com

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TWENTY-FOUR (24) MONTH LIMITED WARRANTY

Novanta IMS warrants only to the purchaser of the Product from Novanta IMS (the "Customer") that the product purchased from Novanta 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 Novanta IMS to be defective. In order to exercise its warranty rights, Customer must notify Company in accordance with the instructions described under the heading "Obtaining Warranty Service".

NOTE: MDrive Motion Control electronics are not removable from the motor in the field. The entire unit must be returned to the factory for repair.

This Limited Warranty does not extend to any Product damaged by reason of alteration, accident, abuse, neglect or misuse or improper or inadequate handling; improper or inadequate wiring utilized or installed in connection with the Product; installation, operation or use of the Product not made in strict accordance with the specifications and written instructions provided by Novanta 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 Novanta IMS; improper maintenance or repair of the Product; or any other reason or event not caused by Novanta IMS.

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OBTAINING WARRANTY SERVICE

If the Product was purchased from a Novanta IMS Distributor, please contact that Distributor to obtain a Returned Material Authorization (RMA). If the Product was purchased directly from Novanta IMS, please contact Customer Service at custservicegroup@novanta.com or 860-295-6102 (Eastern Time Zone).

Customer shall prepay shipping charges for Products returned to Novanta IMS for warranty service and Novanta 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 Novanta IMS from outside the United States.

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