ION Digital Drive
User Manual

PERFORMANCE
MOTION DEVICES

Performance Motion Devices, Inc.
1 Technology Park Drive
Westford, MA 01886

Revision 1.9 April, 2020

NOTICE

Warranty

Performance Motion Devices, Inc. warrants that its products shall substantially comply with the specifications applicable at the time of sale, provided that this warranty does not extend to any use of any Performance Motion Devices, Inc. product in an Unauthorized Application (as defined below). Except as specifically provided in this paragraph, each Performance Motion Devices, Inc. product is provided "as is" and without warranty of any type, including without limitation implied warranties of merchantability and fitness for any particular purpose.

Performance Motion Devices, Inc. reserves the right to modify its products, and to discontinue any product or service, without notice and advises customers to obtain the latest version of relevant information (including without limitation product specifications) before placing orders to verify the performance capabilities of the products being purchased. All products are sold subject to the terms and conditions of sale supplied at the time of order acknowledgment, including those pertaining to warranty, patent infringement and limitation of liability.

Unauthorized Applications

Performance Motion Devices, Inc. products are not designed, approved or warranted for use in any application where failure of the Performance Motion Devices, Inc. product could result in death, personal injury or significant property or environmental damage (each, an "Unauthorized Application"). By way of example and not limitation, a life support system, an aircraft control system and a motor vehicle control system would all be considered "Unauthorized Applications" and use of a Performance Motion Devices, Inc. product in such a system would not be warranted or approved by Performance Motion Devices, Inc..

By using any Performance Motion Devices, Inc. product in connection with an Unauthorized Application, the customer agrees to defend, indemnify and hold harmless Performance Motion Devices, Inc., its officers, directors, employees and agents, from and against any and all claims, losses, liabilities, damages, costs and expenses, including without limitation reasonable attorneys' fees, (collectively, "Damages") arising out of or relating to such use, including without limitation any Damages arising out of the failure of the Performance Motion Devices, Inc. product to conform to specifications.

In order to minimize risks associated with the customer's applications, adequate design and operating safeguards must be provided by the customer to minimize inherent procedural hazards.

Disclaimer

Performance Motion Devices, Inc. assumes no liability for applications assistance or customer product design. Performance Motion Devices, Inc. does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right of Performance Motion Devices, Inc. covering or relating to any combination, machine, or process in which such products or services might be or are used. Performance Motion Devices, Inc.'s publication of information regarding any third party's products or services does not constitute Performance Motion Devices, Inc.'s approval, warranty or endorsement thereof.

Patents

Performance Motion Devices, Inc. may have patents or pending patent applications, trademarks, copyrights, or other intellectual property rights that relate to the presented subject matter. The furnishing of documents and other materials and information does not provide any license, express or implied, by estoppel or otherwise, to any such patents, trademarks, copyrights, or other intellectual property rights.

Patents and/or pending patent applications of Performance Motion Devices, Inc. are listed at https://www.pmdcorp.com/company/patents.

Related Documents

Magellan Motion Control IC User Guide

Complete description of the Magellan Motion Control IC features and functions with detailed theory of its operation.

Magellan Motion Control IC Programming Reference

Descriptions of all Magellan Motion Control IC commands, with coding syntax and examples, listed alphabetically for quick reference.

Table of Contents

List of Figures

This page intentionally left blank.

1. Introduction

1

In This Chapter

- ION Digital Drive Overview
- Features and Functions

1.1 Overview of ION Digital Drives

The ION Digital Drives are a family of single-axis motion controllers with integrated power electronics and network communications. Various models are available to drive DC brush, brushless DC, and step motors. In addition, two overall power levels are available: The ION 500, providing up to 500 watts of power output, and the ION 3000, providing up to 3,000 watts of power output.

ION digital drives are based on PMD's Magellan Motion Control IC technology and perform profile generation, encoder position feedback, position servo compensation, step motor stall detection, brushless DC motor commutation, microstep generation, digital current/torque control, and more. Network communication options include Ethernet, CANbus, RS485, and RS232.

All members of the ION family have integrated, high-power drive stages which fully protect from overcurrent, undervoltage, overvoltage, overtemperature, and short-circuit faults. In addition to extensive motion I/O capability, ION also features Auxiliary Encoder inputs and dedicated Enable input and Fault output safety interlocks.

In addition to various configurations of motor type and power level, the ION family is split into two functional versions. The standard IONs provide network connectivity, profile generation, and torque control. The CME IONs provide the additional capability of an internal C-Motion Engine, allowing user code to reside inside the ION. In addition, this version provides an indexer connector for enhanced I/O functionality.

This manual describes the features and functions of the standard ION Digital Drives. For information on the CME versions of the ION, refer to the *ION/CME Digital Drive User Manual*. For more information on the Magellan Motion Control IC and its software command set, refer to the *Magellan Motion Control IC User Guide* and the *Magellan Motion Control IC Programming Reference*.

1.2 Features and Functions

At the heart of ION is the Magellan Motion Control IC. This enhanced member of the Magellan family provides an extensive list of motion control functions, including:

- Host communications over Ethernet, RS232, RS485, or CANbus
- Trajectory generation, including trapezoidal and S-curve point-to-point profiling, velocity contouring, and electronic gearing modes
- Advanced PID position loop with integration limit, derivative sample time, velocity and acceleration feedforward, output bias, dual biquad filters, and support for dual encoder feedback
- Two encoder input channels capable of up to 10 Mcounts per second
- Sinusoidal and six-step (Hall) brushless DC commutation modes

- Microstepping outputs with up to 256 microsteps per step
- Digital current loop with choice of standard A/B or Field Oriented Control (FOC) for both brushless DC and step motors
- Single phase current loop for DC brush motors
- Pulse and direction input (ION 3000 only)

The ION module adds power electronics and signal conditioning circuitry to create a complete digital drive with these key features:

- High-efficiency MOSFET power stages with versions for single-phase brush DC motors, two-phase step motors, and three-phase brushless DC motors
- I^2t current foldback limiting
- Selectable 20 kHz and 40 kHz PWM frequencies to support a broad range of motor inductance
- Overcurrent, short circuit, overvoltage, undervoltage, and overtemperature protection
- Single supply operation. An onboard DC/DC converter supplies all internal circuitry and also provides 5V for encoders and other external I/O.
- Enable input and Fault output safety interlock
- Differential or single-ended encoder input buffers for all encoder channels
- Signal conditioning buffers and analog filters on all I/O signals

ION comes packaged in a rugged enclosure with flexible mounting options and reliable signal and power connectors. ION is fully RoHS compliant and CE marked.

ION 3000 is certified by Underwriters Laboratories (UL).

2. Installation

2

In This Chapter

- ION 500 Part Numbers and Configurations
- ION 3000 Part Numbers
- ION Developer Kits
- Recommended Hardware
- ION Hardware Configuration and Mounting
- Connector Pinouts and Wiring
- Software Installation
- Communications Configuration
- Applying Power
- Status LEDs
- First-Time System Verification

2.1 ION 500 Part Numbers and Configurations

The following table shows the available part numbers and associated configurations for the ION 500.

Model Number	Motor Type	Communications Port	Comments
DD131S0056/15	Brushless DC	Serial	
DD131C0056/15	Brushless DC	CANbus	
DD131D0056/15	Brushless DC	Ethernet/Serial	
DD331D0056/15	Brushless DC	Ethernet/Serial	CME Version
DD111S0056/15	DC Brush	Serial	
DD111C0056/15	DC Brush	CANbus	
DD111D0056/15	DC Brush	Ethernet/Serial	
DD311D0056/15	DC Brush	Ethernet/Serial	CME Version
DD141S0056/15	Step Motor	Serial	
DD141C0056/15	Step Motor	CANbus	
DD141D0056/15	Step Motor	Ethernet/Serial	
DD341D0056/15	Step Motor	Ethernet/Serial	CME Version

2.2 ION 3000 Part Numbers

The following table shows the part numbers and associated configurations for the ION 3000.

Model Number	Motor Type	Communications Port	Comments
DD131S0195/30	Brushless DC	Serial	
DD131C0195/30	Brushless DC	CANbus	
DD111S0195/30	DC Brush	Serial	
DD111C0195/30	DC Brush	CANbus	
DD141S0195/30	Step Motor	Serial	
DD141C0195/30	Step Motor	CANbus	

2.3 ION Developer Kits

To facilitate initial system development and integration, PMD offers a developer kit for IONs.

The following software and accessory products are included in the ION Developer Kit:

- Pro-Motion Windows-based exercisor software
- C-Motion SDK
- PDFs of all ION documentation
- Communications cable (Ethernet, CANbus, or Serial, depending on DK ordered)
- Stub cable set – a complete set of cables with matching ION connectors on one end and flying leads on the other

For more information on these accessory products, refer to Chapter 4, *Options and Accessories*.

2.3.1 Developer Kit Part Numbers

There are six different ION Developer Kit P/Ns. The difference between these six DKs stem from differences in host connection cabling or other connectors for the various types of ION Digital Drive units offered.

Note that the contents of the ION DKs do not include the ION Digital Drive unit itself. The DKs include cables and other items that are useful to prototype with ION Digital Drives. But the ION Digital Drive itself is ordered separately.

The following table shows which DKs should be used with each ION 500 Digital Drive part number.

ION P/N	Corresponding Developer Kit P/N	ION type	Host Comm
DD131S0056/15	DK1X1S0056/15	ION 500	Serial
DD111S0056/15	DK1X1S0056/15	ION 500	Serial
DD141S0056/15	DK1X1S0056/15	ION 500	Serial
DD131C0056/15	DK1X1C0056/15	ION 500	CANbus
DD111C0056/15	DK1X1C0056/15	ION 500	CANbus
DD141C0056/15	DK1X1C0056/15	ION 500	CANbus
DD131D0056/15	DK1X1D0056/15	ION 500	Ethernet/Serial
DD111D0056/15	DK1X1D0056/15	ION 500	Ethernet/Serial
DD141D0056/15	DK1X1D0056/15	ION 500	Ethernet/Serial
DD331C0056/15	DK3X1D0056/15	ION/CME 500	Ethernet/Serial
DD311C0056/15	DK3X1D0056/15	ION/CME 500	Ethernet/Serial
DD341C0056/15	DK3X1D0056/15	ION/CME 500	Ethernet/Serial

2.3.2 ION 3000

The following table shows which DKs should be used with each ION 3000 Digital Drive part number:

ION P/N	Corresponding Developer Kit P/N	ION type	Host Comm
DD131S0195/30	DK1X1S0195/30	ION 3000	Serial
DD111S0195/30	DK1X1S0195/30	ION 3000	Serial
DD141S0195/30	DK1X1S0195/30	ION 3000	Serial
DD131C0195/30	DK1X1C0195/30	ION 3000	CANbus
DD111C0195/30	DK1X1C0195/30	ION 3000	CANbus
DD141C0195/30	DK1X1C0195/30	ION 3000	CANbus

2.4 Recommended Hardware

To install an ION Digital Drive, the following hardware is required:

- Intel (or compatible) processor, 1 Gbyte of available disk space, 256 MB of available RAM, and a CD ROM drive. The supported PC operating systems are Windows XP, Vista, Windows 7, and Windows 8.
- A serial port for RS232 serial communication
- An Ethernet port for Ethernet communications
- For RS485 or CANbus communications, a PCI card, PCMCIA card, or USB adapter supporting the desired standard connected to the PC
- Properly sized DC bus power supply
- Step, DC brush, or brushless DC motor, with encoder corresponding to the ION type you are using.
- Cables. Either the stub cable set that comes with ION Developer Kits or custom cables designed for the system.

2.5 ION Hardware Configuration and Mounting

There are no user-settable switches, jumpers, or potentiometers within the ION module. All hardware features are configurable from the host computer via the communications port.

2.5.1 ION 500 Mounting Options

Cooling Method	Recommended Orientation	Recommended Mounting Surface	Mounting Method
Coldplate	Any	Either	Horizontal - 4 screws Vertical - 2 screws
Convection	Vertical	Back (small side)	2 screws
Forced Air	Any	Either	2 or 4 screws, or DIN rail adapter

Refer to Section 6.6, “ION 500 Mechanical” for information on mounting dimensions and mounting hole sizes for the ION 500.

2.5.2 ION 3000 Mounting Options

Cooling Method	Recommended Orientation	Recommended Mounting Surface	Mounting Method
Coldplate	Any	Either	Horizontal - 4 screws Vertical - 2 screws
Convection	Vertical	Back (small side)	2 screws
Forced Air	Any	Either	2 or 4 screws

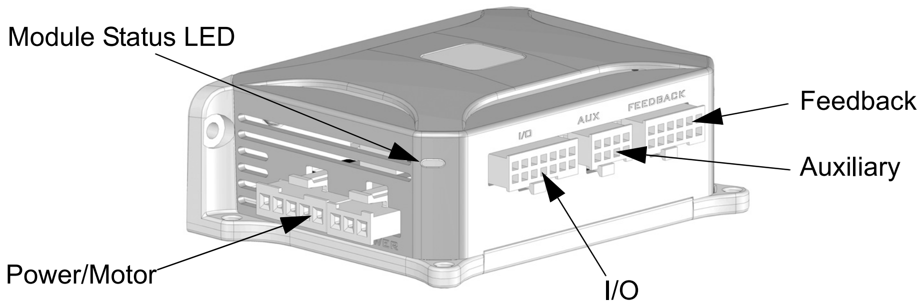
Refer to Section 7.6, “ION 3000 Mechanical” for information on mounting dimensions and mounting hole sizes for the ION 3000.

To minimize electrical noise problems, the metal base of the ION enclosure should be grounded. This is usually accomplished automatically when the module is mounted to a metal part of a grounded system. When mounted to a non-conductive or non-grounded surface, one of the free mounting holes can be used to attach a ground strap.

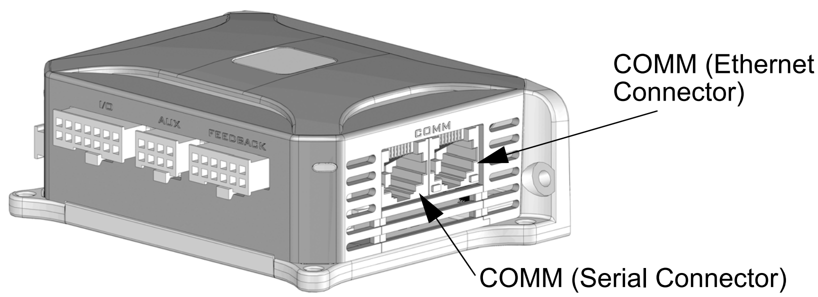
2.6 Connector Pinouts and Wiring

2.6.1 Connector Locator

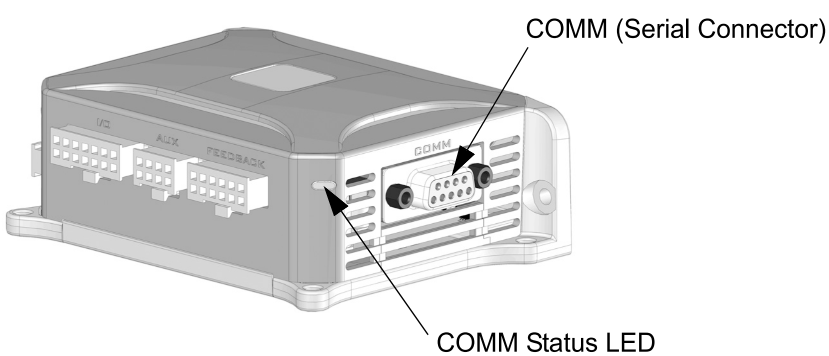
Figure 2-1: Connector Locator



ION 500 with Ethernet Communications

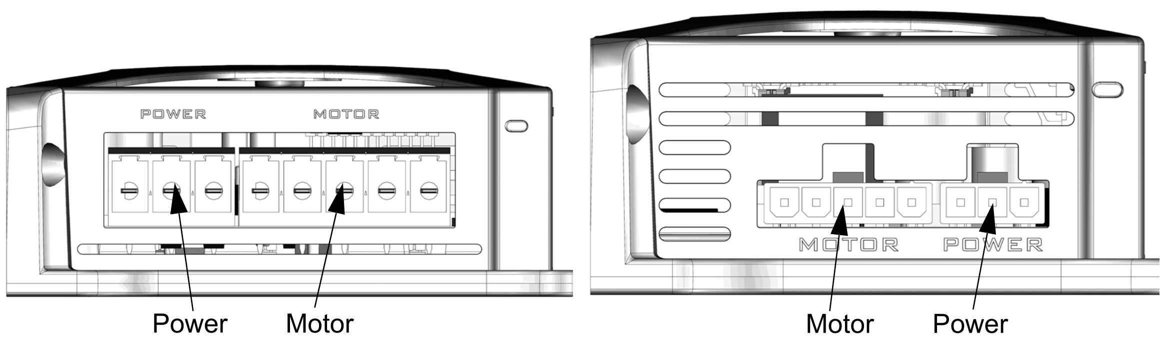


ION 500 with Serial Communications



Connector location diagrams shown in Figure 2-1 are for the ION 500. The ION 3000 form factor is somewhat different, but with similar overall connection locations. Figure 2-2 below shows the left connector view for both the ION 3000 and the ION 500.

Figure 2-2: Left Connector Views



2.6.2 Motor/Module Type Quick Reference

The following table summarizes the recommended connections for the various motor types and the corresponding ION modules:

Module Type	Connector	Required Signals	Optional Signals
All	Power	+HV, Pwr_Gnd	AuxV
DC brush	Motor	Motor+, Motor-, Case/Shield	
	Feedback	Main encoder (Quad A+, Quad A-, Quad B+, Quad B-, Index+, Index-), IO_Gnd, Shield	IO_5V
Brushless DC	Motor	Motor A, Motor B, Motor C, Case/Shield	
	Feedback	Main encoder (Quad A+, Quad A-, Quad B+, Quad B-, Index+, Index-), IO_Gnd, Shield	Commutation (Hall A, Hall B, Hall C), IO_5V
Microstepping	Motor	Motor A+, Motor A-, Motor B+, Motor B-, Case/Shield	
	Feedback		Main encoder (Quad A+, Quad A-, Quad B+, Quad B-, Index+, Index-), IO_Gnd, IO_5V, Shield
All	Auxiliary		Auxiliary encoder (Quad A+, Quad A-, Quad B+, Quad B-), IO_Gnd, IO_5V, Shield, Pulse and Direction input (ION 3000 only; Pulse+, Pulse-, Direction+, Direction-)
All	I/O	/Enable, IO_Gnd	+Limit, -Limit, Home, High Speed Capture, AxisIn, AxisOut, FaultOut, IO_5V, Shield
Serial	Comm	RS232: Tx, Rx, IO_Gnd, Select	
		RS485: Select, Tx+, Tx-, Rx+, Rx-, IO_Gnd	

CAN	Comm	CAN_H, CAN_L, CAN_Gnd	CAN_Shield, CAN_V
Ethernet	Comm	Tx+, Tx-, Rx+, Rx-	

2.6.3 Power Connector

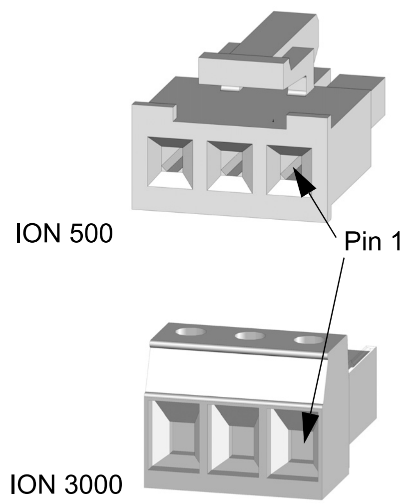


Figure 2-3: Left Connector Views

Pin	Signal
1	+HV
2	AuxV
3	Pwr_Gnd

This connector supplies the main DC power to the ION module. To minimize the voltage drop between the DC power supply and the ION power connector, ION 3000s should be wired with 14 AWG wire. ION 500s should be wired with 16 AWG wire. ION has a built-in DC/DC converter that derives all required internal voltages from the main DC bus. A separate logic supply is not required. This DC/DC converter also provides IO_5V for powering encoders, limit switches, and other system I/O.

As an additional safety feature, ION provides a separate Auxiliary Voltage (*AuxV*) input that can be used to power just this DC/DC converter without powering the main DC bus and the output stage. When the AuxV is not connected, power for the DC/DC converter comes from the main *+HV* input. See Figure 2-4.

A (transformer) isolated power supply should be used for powering ION. The return of this power supply should be grounded. The size of the power supply has to meet the load requirement. If a regulated power supply is used, care should be taken to make sure the power supply can sustain the regenerated power. If a diode is used, the input capacitor should be able to hold the regenerated power without triggering ION into overvoltage protection.

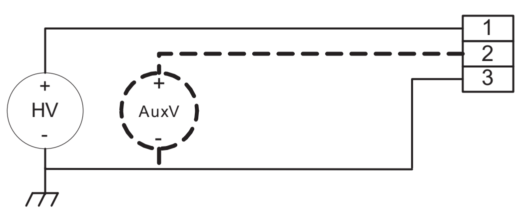
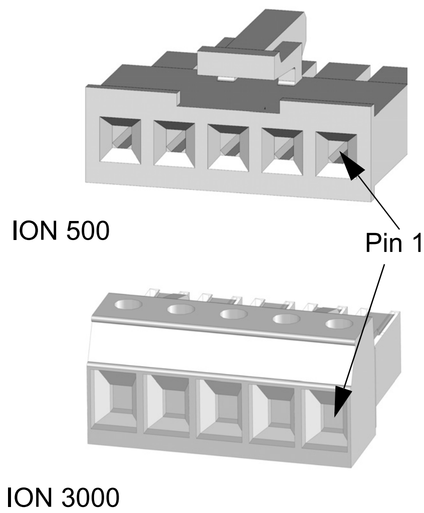


Figure 2-4: Typical Power Wiring

> Pin 3 of the power connector (Pwr_Gnd) should be connected to earth ground as shown in Figure 2-4.

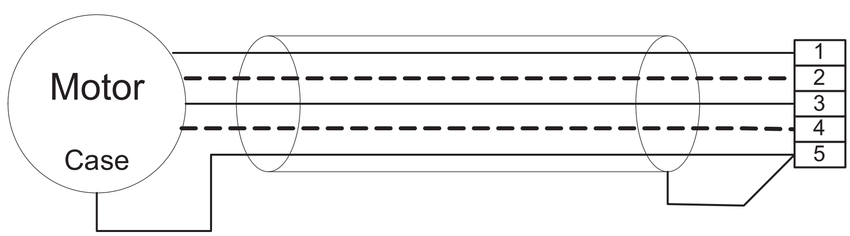
2.6.4 Motor Connector



Pin	DC Brush	Brushless DC	Step
1	Motor+	Motor A (U)	Motor A+
2	Motor- (ION 3000)	Motor B (V)	Motor A-
3	Motor- (ION 500)	Motor C (W)	Motor B+
4	No connect	No connect	Motor B-
5	Case/Shield	Case/Shield	Case/Shield

This connector is used to connect the ION module to the motor. Depending on the type of motor being driven, up to five connections are required. It should be wired with 16 AWG wire (ION 500) or 14 AWG wire (ION 3000) to minimize voltage drops between the ION drive and the motor. The use of shielded cable is recommended to minimize noise (Figure 2-5).

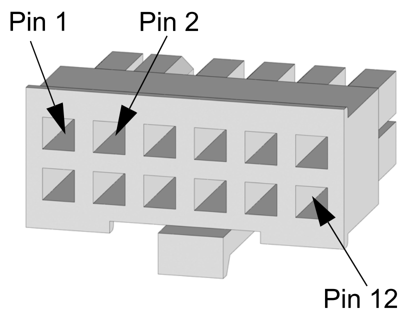
Figure 2-5: Typical Motor Wiring



For best performance, the dedicated case connection should run within the cable shield. If the motor does not come with a case wire or other dedicated case connection, a lug under a motor mounting screw can be used. Pin 5, Case/Shield, is connected to Pwr_Gnd (Pin 3 on the Power Connector).

The shield drain wire should be connected at the ION module connector end only.

2.6.5 Feedback Connector

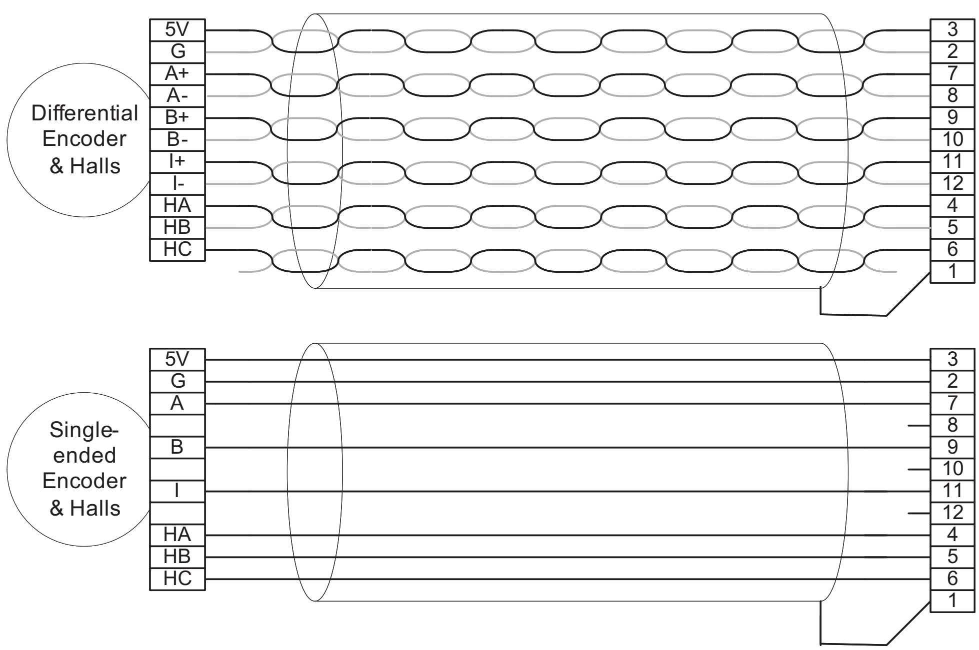


Pin	DC Brush	Brushless DC	Step
1	Shield	Shield	Shield
2	IO_Gnd	IO_Gnd	IO_Gnd
3	IO_5V	IO_5V	IO_5V
4	Not used	Hall A	Not used
5	Not used	Hall B	Not used
6	Not used	Hall C	Not used
7	Quad A+	Quad A+	Quad A+
8	Quad A-	Quad A-	Quad A-
9	Quad B+	Quad B+	Quad B+
10	Quad B-	Quad B-	Quad B-
11	Index+	Index+	Index+
12	Index-	Index-	Index-

This connector is used to wire the signals from the main feedback encoder to the ION module. For brushless DC motors, it also connects the Hall Effect signals typically used to commutate the motor. The Halls are not used with DC brush or step motors.

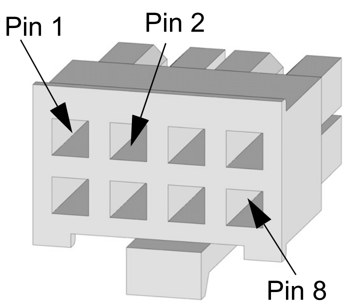
ION directly supports quadrature encoders with either single-ended or differential outputs. *IO_5V* and *IO_Gnd* are provided to power the encoder and Hall Effect transducers. This connector supports wire gauges from 20 to 30 AWG, depending on the crimp terminal used. Wiring with 22 AWG shielded cable is recommended. For differential encoders, twisted-pair cable should be used. Figure 2-6 shows recommended feedback wiring.

Figure 2-6: Recommended Feedback Wiring



The shield drain wire should be connected at the ION module connector end only.

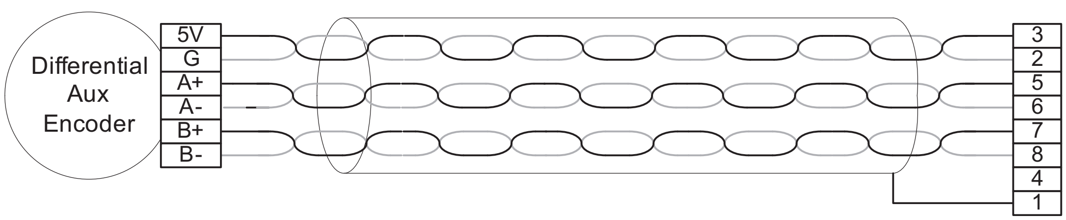
2.6.6 Auxiliary Connector



Pin	Signal
1	Shield
2	IO_Gnd
3	IO_5V
4	No connect
5	Quad A+ or Pulse+ (pulse input available on ION 3000 and Ethernet/Serial ION 500)
6	Quad A- or Pulse- (pulse input available on ION 3000 and Ethernet/Serial ION 500)
7	Quad B+ or Direction+ (direction input available on ION 3000 and Ethernet/Serial ION 500)
8	Quad B- or Direction- (direction input available on ION 3000 and Ethernet/Serial ION 500)

ION provides a second quadrature encoder port for use as a master in master-slave and electronic gearing applications or, for the ION 3000 and Ethernet/Serial ION 500, a pulse and direction input for use in electronic gear applications. As on the main encoder port, ION supports both single-ended and differential signal input. This connector supports wire gauges from 20 to 30 AWG, depending on the crimp terminal used. Wiring with 22 AWG twisted-pair shielded cable is recommended (Figure 2-7).

Figure 2-7: Recommended Auxiliary Encoder Wiring



The shield drain wire should be connected at the ION module connector end only.

2.6.6.1 Single Encoder Connections Summary

ION can be connected to feedback encoders in both a single and a dual encoder configuration. Dual encoder input may be useful for general purpose auxiliary encoder position feedback, master/slave electronic gear operation, or dual loop servo filter operation. See the *Magellan Motion Control IC User Guide* for more information on these control modes.

Figure 2-8 and the table that follows it summarize the connections for a single encoder

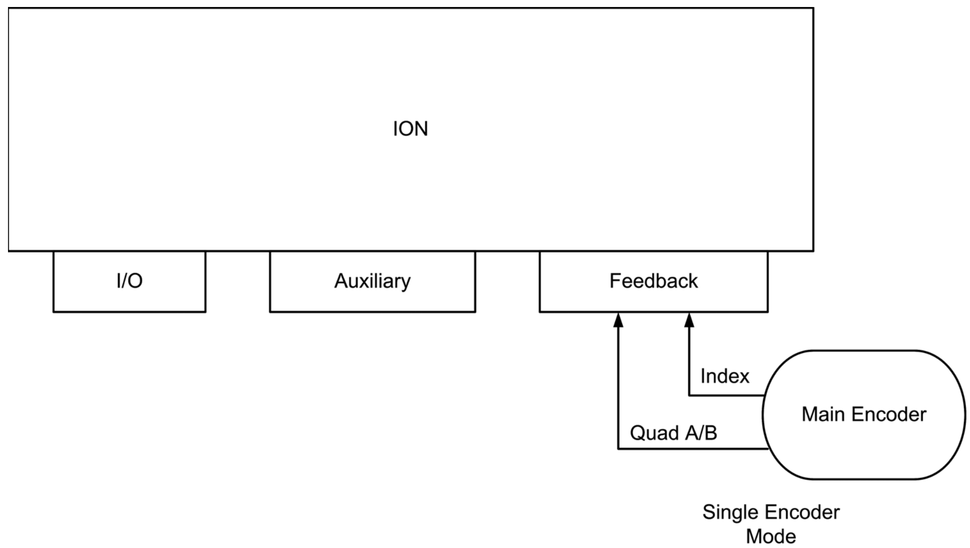


Figure 2-8: Single Encoder Mode Connections

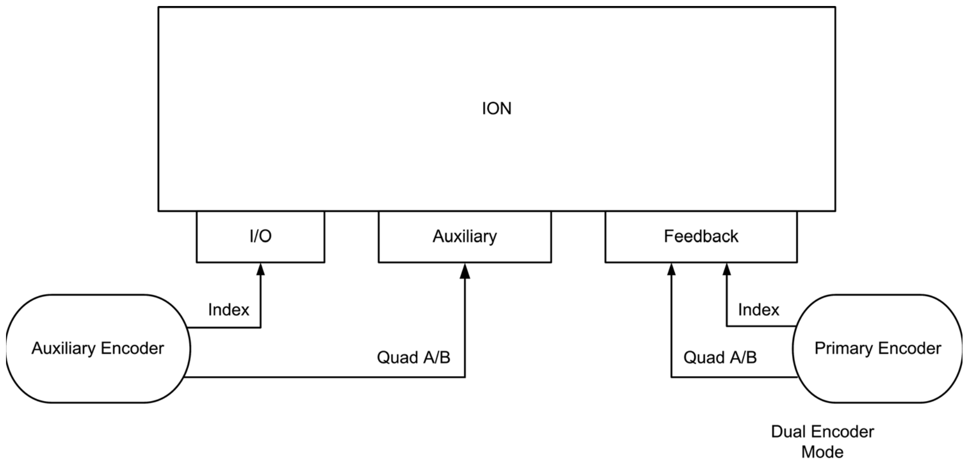
Connection from Encoder	ION Connector	Pin	ION Pin
Quadrature A+	Feedback	7	Quad A+
Quadrature A-	Feedback	8	Quad A-
Quadrature B+	Feedback	9	Quad B+
Quadrature B-	Feedback	10	Quad B-
Index+	Feedback	11	Index+
Index-	Feedback	12	Index-
Hall A*	Feedback	4	Hall A
Hall B*	Feedback	5	Hall B
Hall C*	Feedback	6	Hall C

*Brushless DC motors only

2.6.6.2 Dual Encoder Connections Summary

In a two-encoder connection, one encoder measures the load position and is the primary encoder. The second (auxiliary) encoder is located on the motor shaft, measures the motor position, and is used for stabilization. Figure 2-9 and the table that follows show how to connect two encoders to the ION.

Figure 2-9: Dual Encoder Mode Connections



Connection from Encoder	ION Connector	Pin #	ION Pin
From primary encoder			
Quadrature A+	Feedback	7	Quad A+
Quadrature A-	Feedback	8	Quad A-
Quadrature B+	Feedback	9	Quad B+
Quadrature B-	Feedback	10	Quad B-
Index+	Feedback	11	Index+
Index-	Feedback	12	Index-
From auxiliary encoder			
Quadrature A+	Auxiliary	5	Quad A+
Quadrature A-	Auxiliary	6	Quad A-
Quadrature B+	Auxiliary	7	Quad B+
Quadrature B-	Auxiliary	8	Quad B-
Index+*	I/O	11	High Speed Capture
Hall A**	Feedback	4	Hall A
Hall B**	Feedback	5	Hall B
Hall C**	Feedback	6	Hall C

* For brushless DC motors, an Index signal from the auxiliary encoder is recommended when Hall sensors are not available. For all other configurations, use of the ION's High Speed Capture signal input is optional.

** Brushless DC motors only

2.6.6.3 Pulse & Direction Input Connection Summary (ION 3000 and Ethernet/Serial ION 500)

With ION 3000 and Ethernet/Serial ION 500, it is possible to command the position of the drive using pulse & direction input signals. This mode can be used with all motor types, DC Brush, Brushless DC, and step motor, and allows the ION to interface to any general purpose motion controller that outputs pulse & direction position information. See Figure 2-10.

Operation of the ION in pulse & direction input mode is software selectable. To enter this mode the encoder source for axis #2 should be set to pulse & direction, and the profile mode should be set to electronic gear. See the *Magellan Motion Control IC User Guide* for more information. Alternatively these control settings can be applied via PMD's Pro-Motion exercisor software.

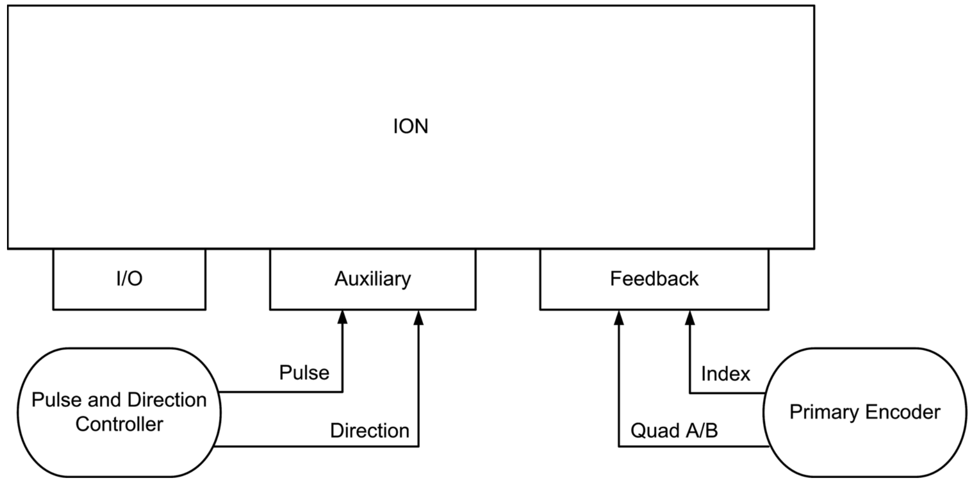


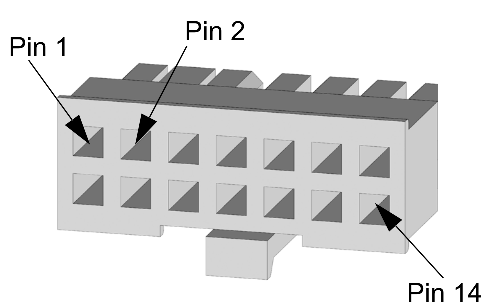
Figure 2-10: Pulse & Direction Mode Connections

To connect to the ION in this configuration, use the following connections:

Connection from Encoder	ION Connector	Pin #	ION Pin
Pulse & Direction input			
Pulse+	Auxiliary	5	Pulse+
Pulse-	Auxiliary	6	Pulse-
Direction+	Auxiliary	7	Direction+
Direction-	Auxiliary	8	Direction-
Encoder input (optional if controlling step motor)			
Quadrature A+	Feedback	7	Quad A+
Quadrature A-	Feedback	8	Quad A-
Quadrature B+	Feedback	9	Quad B+
Quadrature B-	Feedback	10	Quad B-
Index+	Feedback	11	Index+
Index-	Feedback	12	Index-
Hall A*	Feedback	4	Hall A
Hall B*	Feedback	5	Hall B
Hall C*	Feedback	6	Hall C

* Brushless DC motors only

2.6.7 I/O Connector

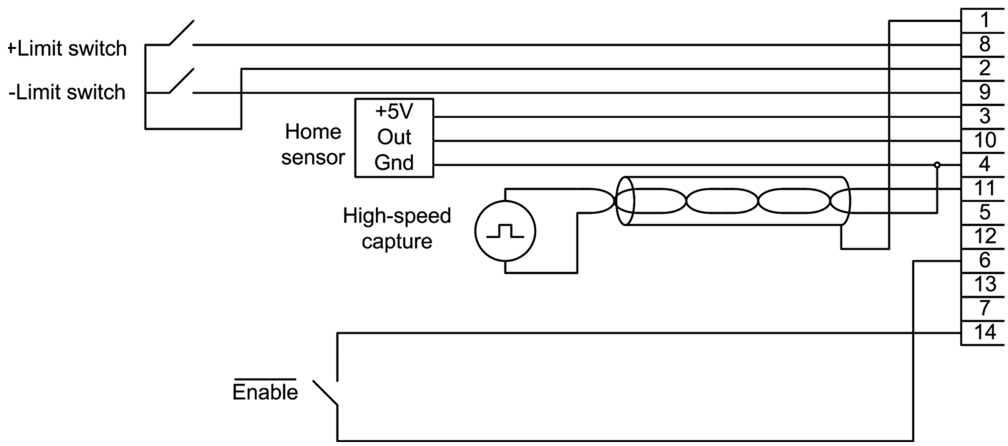


Pin	Signal	Pin	Signal
1	Shield	8	+Limit
2	IO_Gnd	9	-Limit
3	IO_5V	10	Home
4	IO_Gnd	11	High Speed Capture
5	IO_5V	12	AxisIn
6	IO_Gnd	13	AxisOut
7	FaultOut	14	/Enable

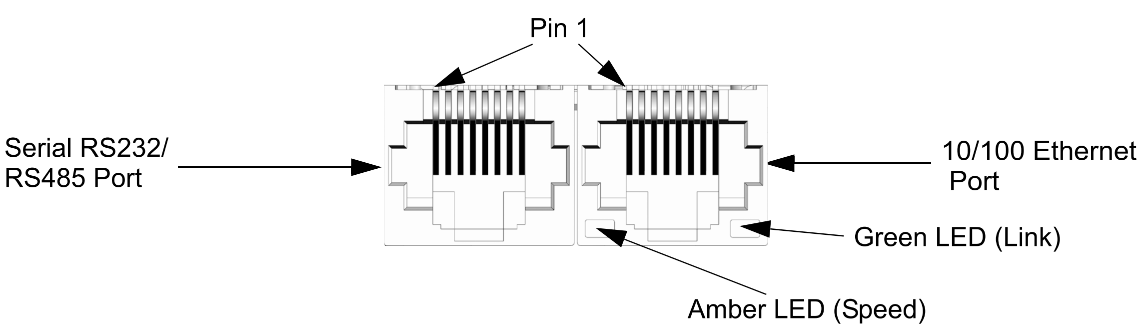
This connector is used to wire motion-specific I/O signals such as overtravel limits, home reference, and high speed capture input as well as the general-purpose *AxisIn* and *AxisOut* signals. It also has pins for the master */Enable* input and *FaultOut* signals. Numerous *IO_5V* and *IO_Gnd* connections are provided to simplify wiring.

This connector supports wire gauges from 20 to 30 AWG, depending on the crimp terminal used. Wiring with 22 AWG shielded cable is recommended. Figure 2-11 shows typical I/O wiring.

Figure 2-11: Typical I/O Wiring



2.6.8 Ethernet Connector



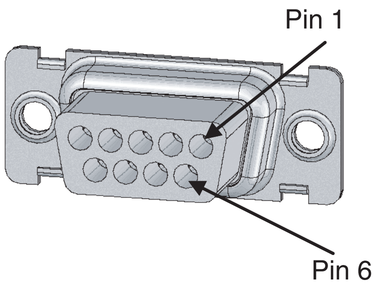
Pin	Signal
1	Txt+
2	Txt-
3	Rx+
4	Unused
5	Unused
6	Rx-
7	Unused
8	Unused

ION has a standard, 8-pin, 8P8C-type (RJ45) connector for Ethernet connection. Standard UTP (unshielded twisted pair) CAT5 Ethernet cabling can be used in most applications. For added noise immunity, use shielded cable.

2.6.9 Serial RS232/485 Connector

2.6.9.1 Serial ION RS232/485

On a serial ION, communication interface is a DB9M connector.



Pin	RS232	RS485
1	Select = float	Select = low
2	Tx	
3	Rx	
4	No connect	No connect
5	IO_Gnd	IO_Gnd
6		Rx+
7		Rx-
8		Tx+
9		Tx-

This DB9M connector has a combination pinout that supports both RS232 and RS485 serial communications. Pin 1 is used to select between the two serial types. For RS232, pin 1 must be left floating. For RS485, pin 1 must be strapped to *IO_Gnd*.

For RS485, ION supports both 4-wire and 2-wire configurations. To use 2-wire network cabling, connect ***Rx+*** to ***Tx+*** and ***Rx-*** to ***Tx-*** at the ION serial connector.

ion does not have built-in termination for RS485. If a network application requires termination at the ION serial connector, the resistors must be added in the network wiring.

Figure 2-12 shows RS232 and 485 wiring.

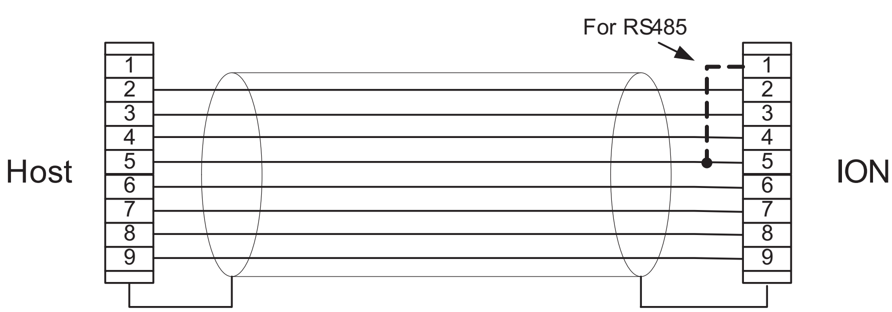
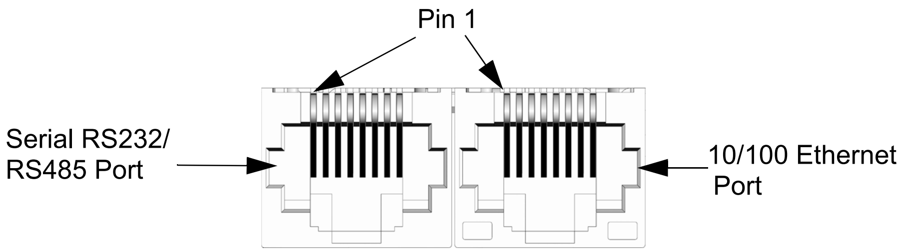


Figure 2-12: RS232/485 Wiring

2.6.9.2 Ethernet/Serial ION RS232/485

An RJ45 type connector provides serial connectivity on the Ethernet/Serial IONs (P/Ns DDIXID0056/15). Similar to the DB9 version, the RJ45 version of the serial connector can support RS232, RS485 full duplex, and RS485 half duplex. Pinouts for these serial protocols are given in the table below.



Pin	RS232	RS485 (full duplex)	RS485 (half duplex)
1	Unused	Unused	Unused
2	Unused	Unused	Unused
3	SrlRcv	$RS485Rcv^+$	$RS485Xmt/Rcv^+$
4	Unused	$RS485Xmt^+$	Unused
5	SrlXmt	$RS485Xmt^-$	$RS485Xmt/Rcv^-$
6	Unused	$RS485Rcv^-$	Unused
7	IO_Gnd	IO_Gnd	IO.Gnd
8	Select = Float/High	Select = low	Select = low

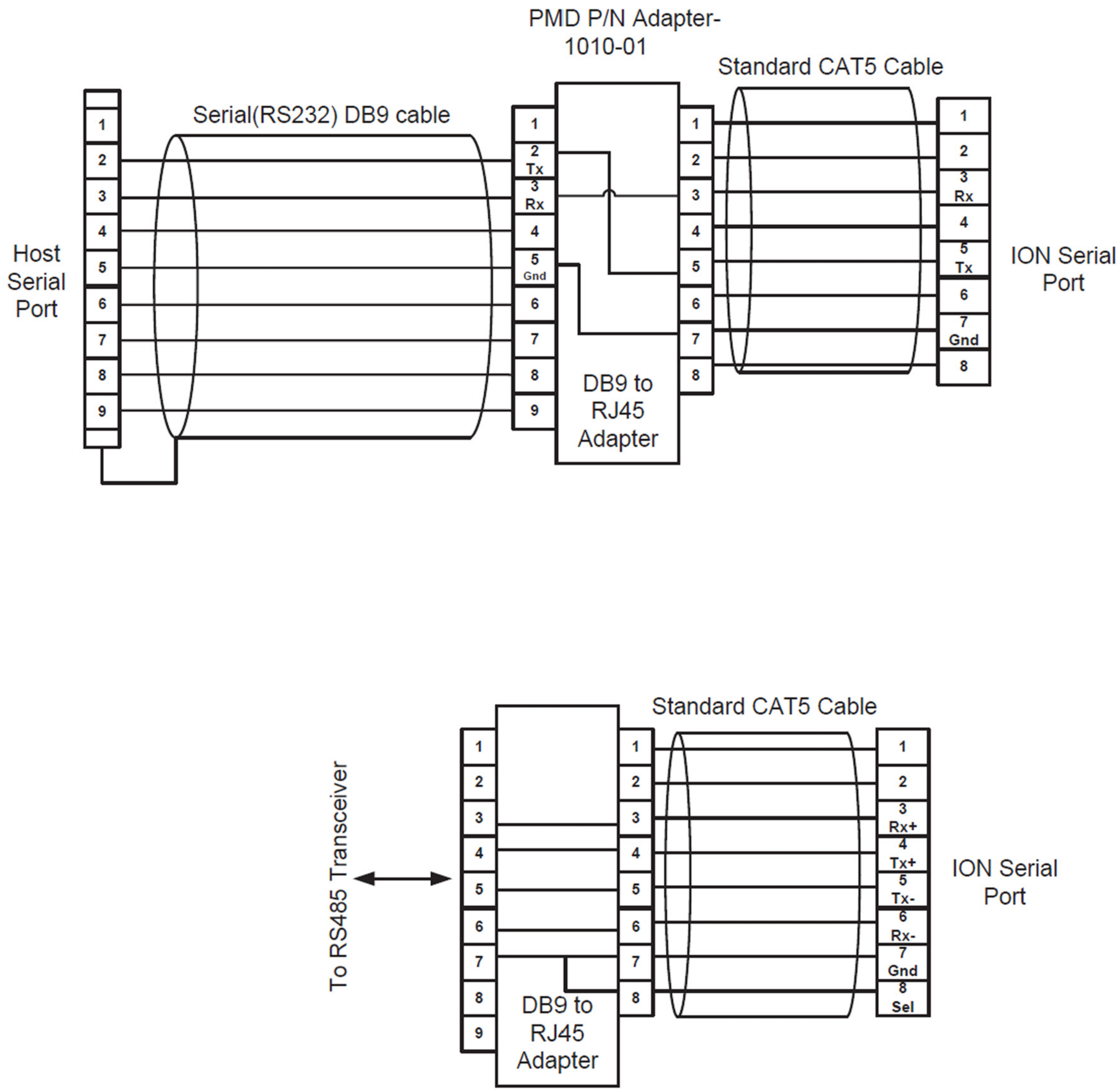
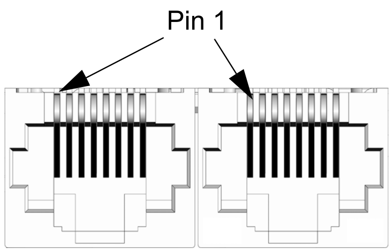


Figure 2-13: RS232/485 Wiring for RJ45

For RS232, pin 1 must be left floating. For RS485, pin 1 must be connected to *IO_Gnd*. To select half duplex RS485 vs full duplex Pro-Motion can be used, or the PRP **SetDefault** command can be used. Note that a change of either of these comm settings will not properly take effect until after a power on or reset of the ION unit.

2.6.10 CANbus Ports



Pin	Signal
1	CAN_H
2	CAN_L
3	CAN_Gnd
4	Reserved
5	Reserved
6	CAN_Shield
7	CAN_Gnd
8	CAN_V

The CANbus version of ION has a dual RJ45 connector to allow daisy-chaining of IONs in a CANbus network. All pins in each port are connected to the corresponding pin the in the other port. *CAN_Shield*, *CAN_V* and the two *Reserved* pins are not used by ION but are passed through from one port to the other. When the ION module is the last node of a CANbus network, the network can be terminated by plugging a RJ45 terminator into the unused port.

Standard UTP (unshielded twisted pair) CAT5 Ethernet cabling can be used in most CANbus applications. For added noise immunity, shielded cable can be used with the shield routed through the *CAN_Shield* pins.

2.7 Software Installation

The software distribution for the ION Digital Drive developer kit is downloaded from the PMD website at the URL: https://www.pmdcorp.com/resources/software.

All software applications are designed to work with Microsoft Windows.

To install the software:

1 Go to the Software Downloads section of PMD's website located at https://www.pmdcorp.com/resources/software and select download for "Developer Kit Software."

2 After selecting download you will be prompted to register your DK and provide information about you and your motion application.

3 After selecting submit the next screen will provide a link to the software download. Select this link and downloading will begin.

4 Once the download is complete extract the zip file and execute the desired install programs from the list below. Every first-time installation should install Pro-Motion, and at least one of the two SDK options. However you may install both SDKs if desired. When installing the SDKs you will be given the option to download the documentation and/or the complete SDK content.

- Pro-Motion – an application for communicating to, and exercising PMD ICs, modules, or cards.
- PMD SDK – a software development kit for creating motion applications using the C/C++ programming languages. Also contains PDF versions* of all PMD product documentation.
- CME SDK – a software development kit for creating motion applications using the .NET (C#, VB) programming languages. Also containsPDF versions* of all PMD product documentation.

*Adobe Acrobat Reader is required for viewing these files. If the Adobe Acrobat Reader is not installed on your computer, it may be freely downloaded from http://www.adobe.com.

Here is more information on each of these software packages:

2.7.1 Pro-Motion

Pro-Motion is a sophisticated, easy-to-use exerciser program which allows all ION parameters to be set and/or viewed, and allows all features to be exercised. Pro-Motion features include:

- Motion oscilloscope graphically displays processor parameters in real-time
- AxisWizard to automate axis setup and configuration
- Position loop and current loop auto-tuning
- Project window for accessing motion resources and connections
- Ability to save and load settings
- Distance, time, and electrical units conversion
- Frequency sweep and bode plot analysis tools
- Motor-specific parameter setup
- Axis shuttle performs continuous back and forth motion between two positions

2.7.2 C-Motion

C-Motion provides a convenient set of callable routines comprising the C language code required for controlling IONs. C-Motion includes the following features:

- Magellan axis virtualization
- Ability to communicate to multiple PMD motion cards or modules
- Ability to communicate via PC/104 bus, serial, CANbus, Ethernet, SPI (Serial Peripheral Interface), or 8/16 bit parallel bus
- Provided as source code, allowing easy compilation & porting onto various run-time environments including a PC, microprocessor, embedded card, or C-Motion Engine
- Can be easily linked to any C/C++ application

C-Motion is described in the *Magellan Motion Control IC Programming Reference.*

2.7.3 .NET Language Support

A complete set of methods and properties is provided for developing applications in Visual Basic and C# using a dynamically loaded library (DLL) containing PMD library software. The DLL may also be used from any language capable of calling C language DLL procedures, such as Labview, but no special software support is provided.

Includes the following features:

- Magellan axis virtualization
- Ability to communicate to multiple PMD motion cards or modules
- Ability to communicate via PCI bus, serial, CANbus, or Ethernet

- Provided as a single DLL and Visual Basic .NET source code for easy porting onto various PC environments

VB Motion is documented in the *PMD Resource Access Protocol Progamming Reference*.

2.8 Communications Configuration

Depending on the communications port you plan to use with your ION, there may be some configuration steps required to communicate correctly between the host computer and the ION module.

2.8.1 Serial ION

The Serial ION (DD1x1S0-xxx/yy) supports both RS232 and RS485 communications.

To communicate by RS232, connect ION to the PC using the straight-through serial cable provided with the Developer Kit. If the PC does not have a serial port, use a USB-to-serial converter and note the COM port number that the converter installed as, using the Device Manager in Windows. Select this COM port in Pro-Motion's Connect dialog.

The following RS232/485 values are pre-programmed into non-volatile memory at the factory. You can change the operational values using Pro-Motion after communications at this default rate has been established. Note that the new parameters will take effect at the next ION powerup.

RS232/485 default values: 57.6 kbaud, no parity, 1 stop bit and multi-drop (networking) mode disabled.

To communicate by RS485 full duplex, a USB-to-485 converter is used, otherwise connection is automatically recognized by Pro-Motion and is the same as for RS232.

See the *Magellan Motion Control IC Programming Reference* for more information on node ID, Transmission Rate, and other serial communications parameters.

First time communication with an ION cannot be accomplished using RS485 half-duplex. To configure an ION for RS485 half-duplex (multi-drop), use either RS232 or RS485 (point-to-point).

Changing the state of the Select pin on the fly is not recommended. Doing so will change the hardware configuration without changing the active set of communication parameters and will most likely result in loss of communications.

2.8.2 CANbus ION

The CANbus ION (DD1x1C0-xxx/yy) supports 2.0B standard CANbus communications.

To communicate by CANbus, no additional steps are required; however it is important to use the proper CANbus connector indicated in Section 2.4, “Recommended Hardware”. Simply connect ION to the PC using a USB to CANbus cable, and the Pro-Motion software will automatically recognize ION.

The following CANbus values are pre-programmed into non-volatile memory at the factory. You can change the operational values using Pro-Motion after communications at this default rate has been established. Note that the new parameters will take effect at the next ION powerup.

CANbus default values: Node ID = 0 and Transmission Rate = 20k baud.

See the *Magellan Motion Control IC Programming Reference* for more information on node ID, Transmission Rate, and other serial communications parameters.

2.8.3 Ethernet/Serial ION

The Ethernet ION (DD1x1D0-xxx/yy) supports 10/100BASE-T/TX standard Ethernet communications, as well as RS232 and RS485 communications.

To communicate by Ethernet, a setup procedure must be executed which first uses the serial port to communicate with the ION and configure the Ethernet port for subsequent communications.

To accomplish this, use the DK-provided DB9 to RJ45 adapter cable and connect the ION to your PC as shown in Figure 2-14. If your computer does not have a dedicated serial port, use a standard USB-to-serial converter.

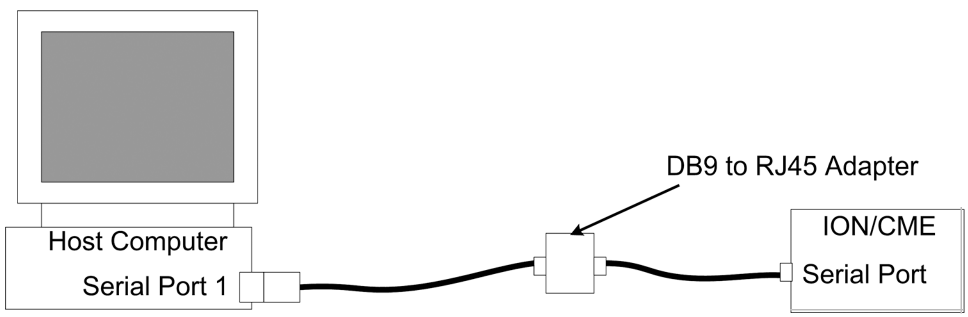


Figure 2-14: Ethernet/Serial ION Serial Port Connection

During this setup the Ethernet connection will not be made until serial communications are established. See Section 2.11.2, "Changing the Ethernet Parameters of the ION" for detailed instructions on when to physically make the Ethernet connection. When Ethernet is ready to connect, use PMD's Cable-RJ45-02-R, or any standard Ethernet cable, and plug one end of the connector into J24, and the other end into a free Ethernet port on your network.

It is also possible to communicate directly via Ethernet without first connecting using the serial port. To do this use the default parameters shown in Section 3.2.1, "Ethernet" and take care that no other Ethernet devices are on the network that use the same IP address. Note however that in the first-time system verification instructions, beginning in Section 2.11, "First-Time System Verification" inital connection via serial port is assumed.

2.9 Applying Power

> Dangerous voltages, temperatures, and currents exist in all motor drive systems. Do not apply power to the ION module until the motor and system wiring is complete and the ION module and motor are securely mounted. It is best to leave the motor disconnected from its load until after power is applied for the first time and correct operation is verified. The customer must not attempt to service or rewire an ION drive without first shutting down the drive and disconnecting it from its power source. Failure to follow this warning may result in fire, bodily harm, or damage to the product.

Upon power up, ION is in a reset condition. In this condition, no motor output will be applied and the motor will remain stationary. If the motor does move or jump, remove power from the module and re-check the wiring. If anomalous behavior is still observed, call PMD for application assistance. Complete PMD contact information is listed on the final page of this manual.

2.10 Status LEDs

ION has two bi-color LEDs to indicate the basic operational status of the module and the communications link. The location of these LEDs is shown in Figure 2-1.

2.10.1 Module Status LED

Upon powerup or reset, the module Status LED should either be solid green or blinking green, depending on the state of the */Enable* input. If enabled, the LED will be solid green.

> The Enable input is active low.

A Status LED of any other color indicates a fault or unusual condition that must be rectified before going further. See Section 3.6, "Operational and Fault Modes" for complete information on ION Operational and Fault modes and the resulting color and blink rate of the Status LED.

2.10.2 Communications Status LED

The Comm Status LED indicates successful packets by blinking green and invalid packets or commands returning an error status by blinking red. A serious fault in the communications port is indicated with solid red. If the LED is solid red, check the cabling and then try cycling power and reconfiguring the communications configuration.

Note that this LED will not blink until communications occur. Therefore, the LED may not blink until further steps in the setup procedure occur.

2.11 First-Time System Verification

The first time system verification procedure summarized below has two overall goals. The first is to connect the ION with the PC so that they are communicating properly, and the second is to initialize the axis and bring it under stable control capable of making trajectory moves. While there are many additional capabilities that Pro-Motion and ION can provide, these steps will create a foundation for further, successful exploration and development.

Here is a summary of the steps used during first time system verification. Each of these steps is described below in a separate manual section.

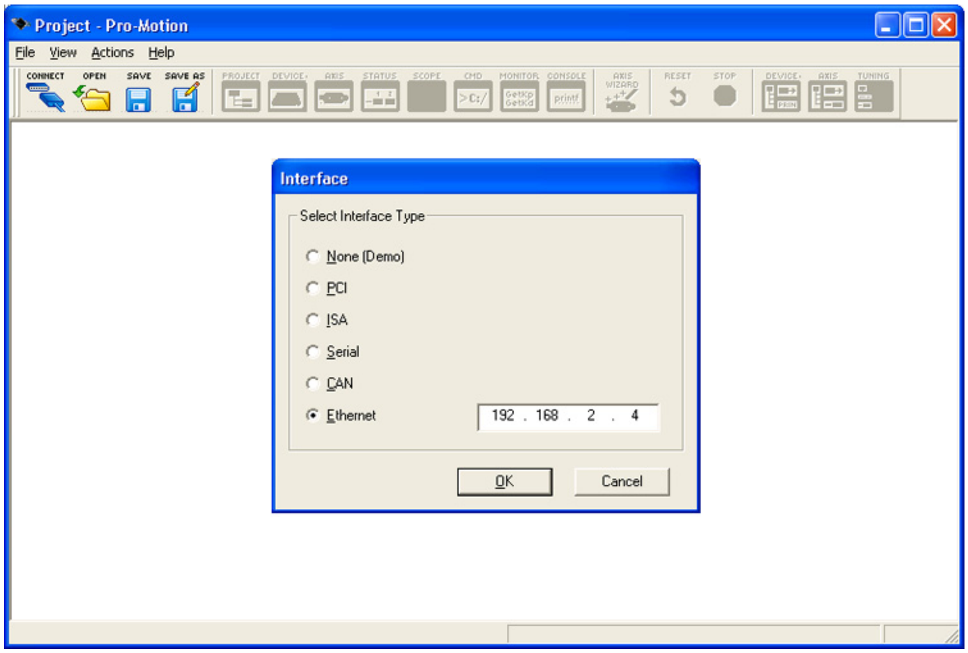
1. Initiate Pro-Motion and establish communication between the PC and the ION. For Serial and CANbus IONs, this is as simple as connecting the ION and running Pro-Motion. For the Ethernet/Serial ION, this involves a few additional steps as detailed below.
2. Run Pro-Motion's Axis wizard for each axis of your system to initialize parameters such as encoder direction and safe servo parameters (if you are using a servo motor).
3. Execute a simple trajectory profile on each axis demonstrating that it is operating correctly and under stable control.

During this first-time system setup you may find it useful to refer to other PMD manuals including the *Magellan Motion Control IC User Guide* to familiarize yourself with operation of the Magellan Motion Control IC, which lies at the heart of all ION Digital Drives.

2.11.1 Establishing Communications

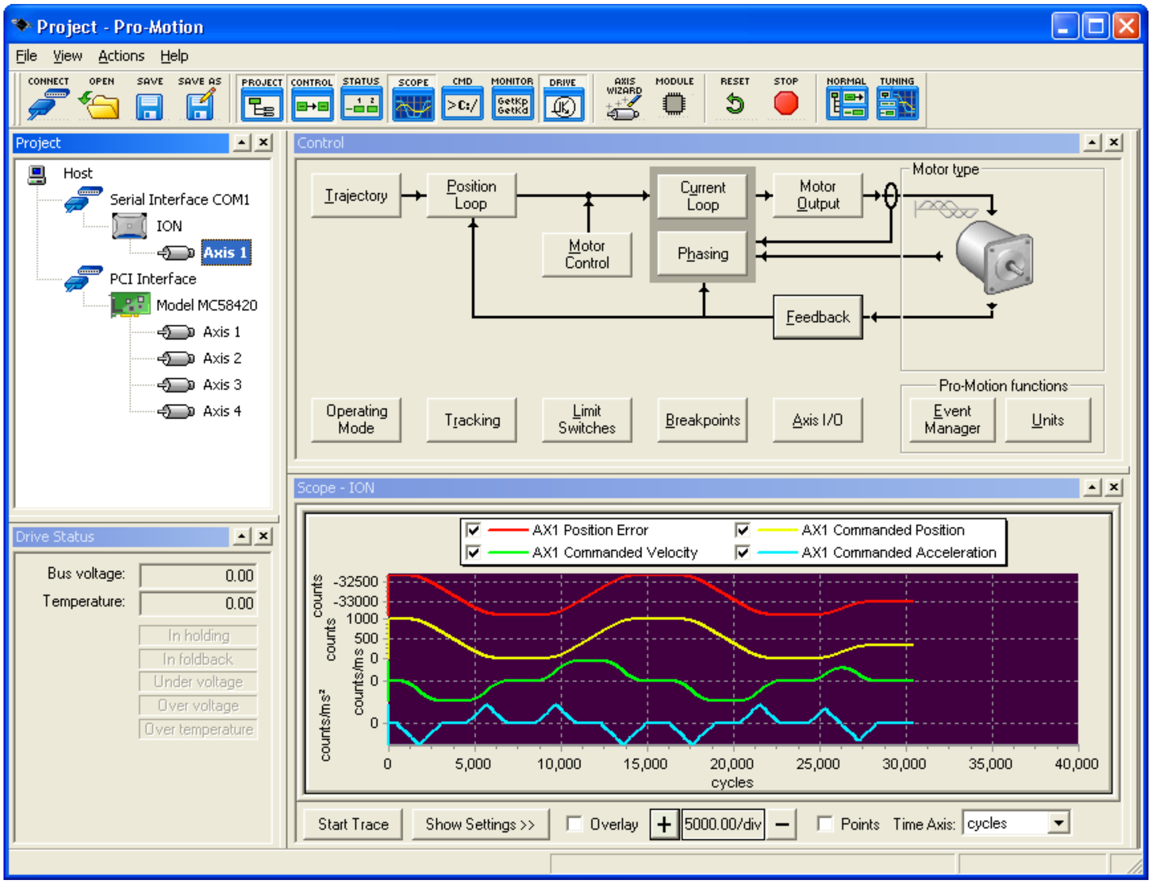
To establish communications:

1. Make sure the ION is powered and connected to the PC.
2. On the Start menu, click the Pro-Motion application. When Pro-Motion is launched you will be prompted with an Interface selection window. A typical screen view when first launching Pro-Motion appears below.



3. Click the Connect icon on the toolbar. Alternatively, on the File menu, select Connect.
4. The purpose of the Interface dialog box is to indicate to Pro-Motion how your ION is connected to the PC. It provides various selectable communication options such as serial, CANbus, Ethernet. Unless you are using CANbus, click Serial, and then click OK. If you are using CANbus, click CANbus, then click OK.
5. The Serial Port dialog box or CANbus port dialog box will display the active default communication values. Click OK without changing any of these settings.

If communication is correctly established, a set of object graphics loads into the Project window to the left, as shown in the following figure.



For example, for an ION, you see the ION name next to an icon of an ION, and below that you see two axes icons. Highlighting (single clicking) either the ION icon or the axis icon with the mouse is used to select specific cards or axes, and is useful later on in the first time system verification.

If communications are not correctly established, after approximately 10 seconds a dialog box appears indicating that a Communications Timeout Error has occurred. If this is the case, recheck your connections and repeat from step 1 above. If after repeated attempts a connection can still not be established, call PMD for assistance.

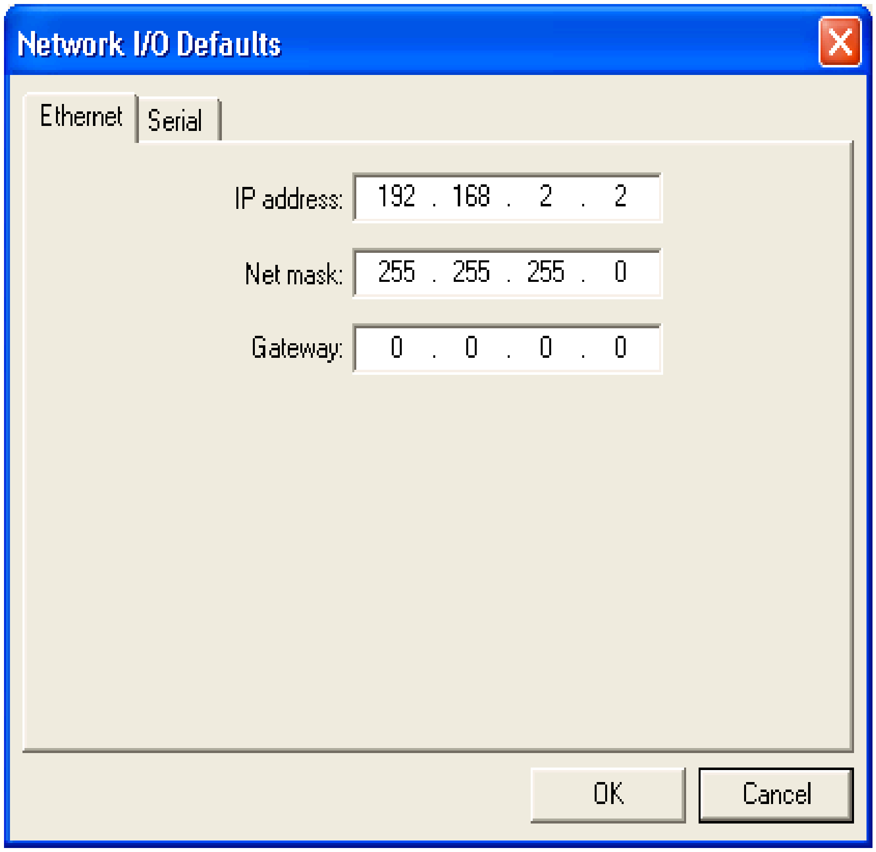
If you are using the Serial ION or the CANbus ION, congratulations! Communication has been established and you are ready to proceed to the next step, described in Section 2.11.5, “Initializing Motion Axes.”

2.11.2 Changing the Ethernet Parameters of the ION

If you are using an Ethernet ION, the next step is to change the Ethernet parameters as follows:

1. With serial communications functioning properly, click the Device toolbar button. The Device window appears.
2. Click Network I/O. The Network I/O Defaults dialog box appears.

3 Click the Ethernet tab. The Ethernet tab appears with data entry fields for the IP Address, the Net Mask, and the Gateway. This is shown below with the default value visible.



4 Enter the IP Address in the corresponding data field as well as the net mask and gateway, if this is required for your network.

For a typical installation, you will not change the Net mask and Gateway default values, but you must specify a valid, unique, IP Address for the ION to be located on your Ethernet network. If you are not sure what IP addresses are free and available for your Ethernet network, contact your system administrator.

5 Click OK to store as the power on default.

6 Click the Reset toolbar button. After the ION is reset, it uses the default parameters that you specified.

7 Connect the Ethernet cable. See Section 2.8, "Communications Configuration" for details.

The ION is now ready for Ethernet communications.

2.11.3 Establishing Ethernet Communications

The ION's IP Address has now been set, but Pro-Motion does not know what IP address it should use for Ethernet communications to the ION.

To establish Ethernet communications:

1. Click the Connect toolbar button.
2. Select Ethernet, and then click OK.
3. Enter the same IP Address as was specified for Ethernet ION.
4. When complete, click OK.

If Ethernet communication is successful, an additional set of graphical icons representing your ION and axis will be loaded into the Project window to the left below the first set created while establishing communications by serial link.

If communication is not successful, a Communications Timeout Error dialog box appears after about 30 seconds. If this happens, recheck your connections, and retry to establish Ethernet communications. See step 1 in Section 2.11.2, "Changing the Ethernet Parameters of the ION" for details.

When Ethernet communications are functioning properly, the final step is to disable serial communications.

2.11.4 Disconnecting Serial Communications

To disconnect serial communications:

1. Select the serial link version of the ION in the Project window to the left.
2. Click the Disconnect toolbar button. A dialog box appears asking if you are sure you want to disconnect.
3. Click OK.

You will notice that the serial ION icon and axes graphical icons in the Project box disappear, leaving only the Ethernet link icons for the ION and axis.

Congratulations! Ethernet communication is now up and running. You are ready to execute all Pro-Motion functions via Ethernet.

> Multiple Pro-Motion users can connect to the same Ethernet ION. Up to four simultaneous connections can be made. There are various situations where this may be useful. For example, one PC can function as a 'monitoring station' for a particular ION while another PC provides commands to that same unit. Be aware, however, that two or more users sending motion commands to the same motion controller can cause unexpected motion, and should be avoided.

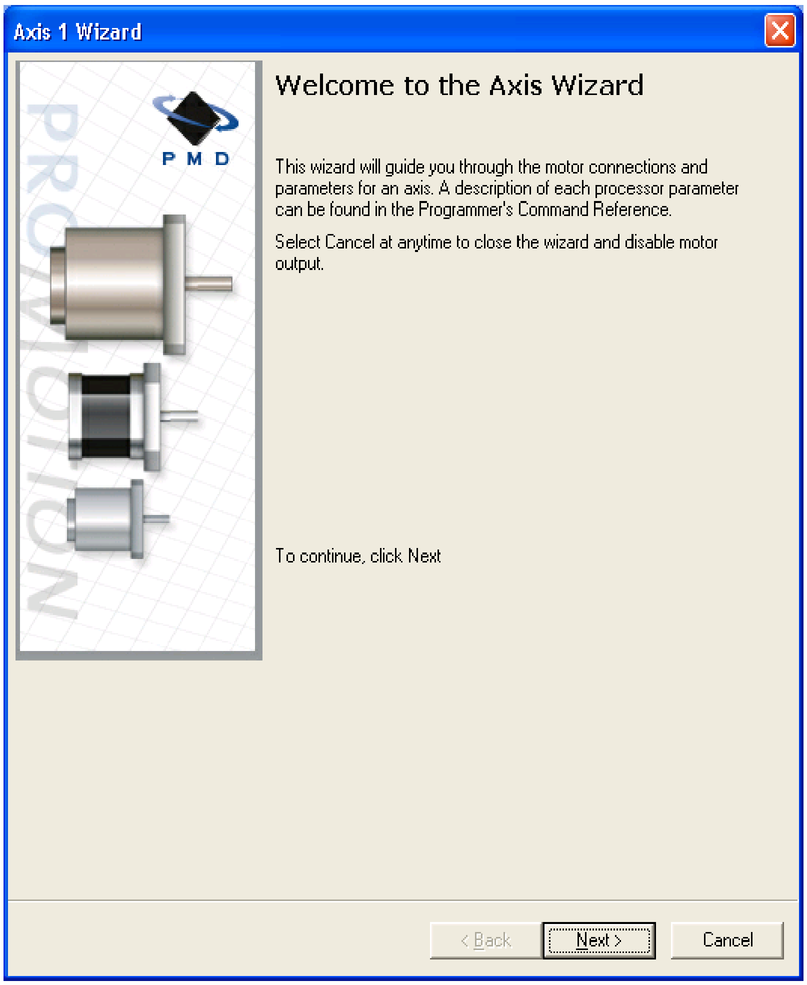
> When connecting your ION for use on an Ethernet network, be sure that the IP address provided for the ION does not conflict with the addresses of other users on the network. See Section 2.11.2, "Changing the Ethernet Parameters of the ION" for a description of changing the IP address.

2.11.5 Initializing Motion Axes

The next step to verify the correct operation of the system is to initialize the axis, thereby verifying correct encoder feedback connections (if an encoder is used), and other motion functions. All of this can be conveniently accomplished using Pro-Motion's Axis Wizard function. This versatile and easy to use tool initializes all supported motor types including step, DC Brush, and Brushless DC.

To operate the axis wizard:

1. Click to select the #axis icon in the Project window to the left of the screen.
2. With this icon highlighted, click the Axis Wizard toolbar button. The Axis Wizard initialization window appears.
3. Click Next and follow the Axis Wizard instructions for each page of the axis initialization process.



A typical axis wizard sequence takes 3-5 minutes. If you have specific questions about the Axis Wizard, refer to *Pro-Motion User Guide* for detailed information on the axis wizard.

Upon a normal completion of the Axis Wizard, the axis will be ready to make a controlled move. For step motors this means the pulse & direction connections are working properly, and for servo motors this means the encoder and amplifiers connections have been validated, and stable (but not necessarily optimal, see caution below for more information) servo tuning parameters have been loaded into the ION's Magellan Motion Control IC. Depending on the signals connected, this may also mean that limit switches, and other hardware connections are functioning properly.

The most common reasons for the Axis Wizard to not complete normally are an inability to auto-tune the servo motor, or problems determining the correct commutation sequence for Brushless DC motors when commutated by the Magellan Motion Control IC. Should this happen, it is possible to perform a manual tuning or commutation setup if desired. Refer to the *Pro-Motion User Guide* for more information, or call PMD for technical assistance.

> The Axis Wizard auto tuning routine is designed to provide stable, but not optimal, parameters for motion. Pro-Motion provides a wealth of functions including Bode plot generation and a high speed hardware trace oscilloscope that can assist you in determining optimal servo parameters. Values provided by the axis wizard during auto tuning may or may not be safe for your system, and it is up to the user to determine if and when they should be used.

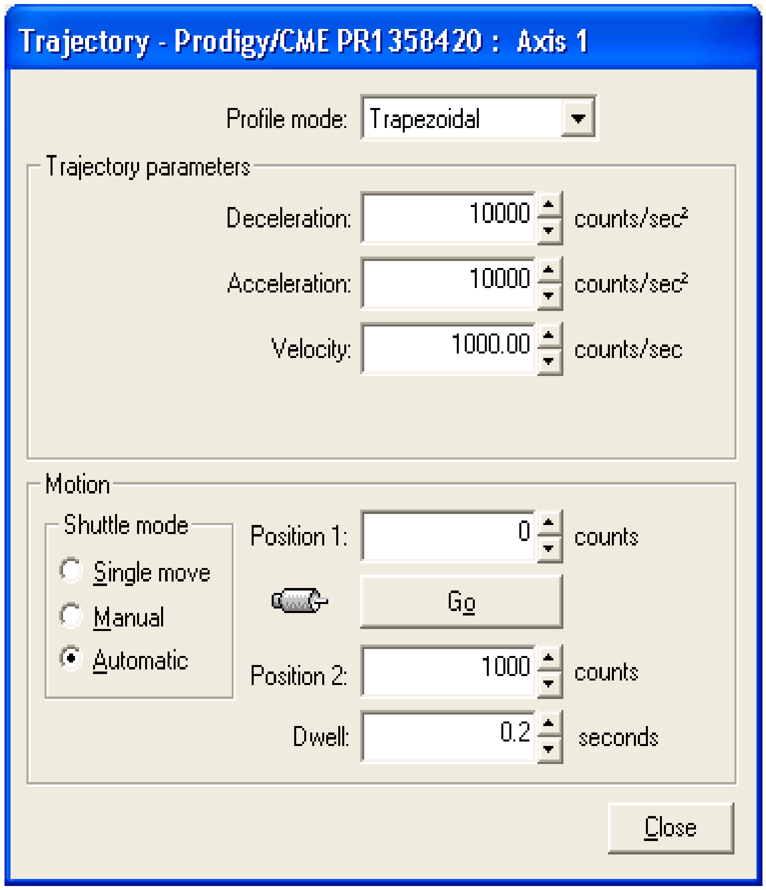
2.11.6 Performing a Simple Trajectory Move

The last step in first time system verification is to perform a simple move for each axis.

To perform a simple move:

1. In the Project Window, select the motion axis that you would like to move by clicking the corresponding icon.
2. Click the Axis view button on the far right of the toolbar. Alternatively, click Axis View on the Axis menu. Your screen organization changes to give easy access to windows that are used while exercising the motion axes.
3. Click the Trajectory button in the Axis Control window. The Trajectory dialog box appears.
4. In the Profile mode list, select Trapezoidal.
5. Enter motion profiles for deceleration, acceleration, velocity, and destination position (Position 1) that are safe for your system and will demonstrate proper motion.

6 Click Go and confirm that the motion occurred in a stable and controlled fashion.



Pro-Motion provides various selectable units for distance and time, but defaults to units of encoder counts (or pulses for step motors) for distance and seconds for time. This means the default units for velocity are counts/sec, and the default units for acceleration and deceleration are counts/sec^2. So for a motor that has 2,000 counts per rotation, to perform a symmetric trapezoidal move of 25 rotations with a top speed of 5 rotations per second and with an acceleration time of two seconds, the parameters in the Trajectory dialog box would be set as follows:

Deceleration: 5,000 counts/sec^2

Acceleration: 5,000 counts/sec^2

Velocity: 10,000 counts/sec

Position 1: 0 counts

Position 2: 50,000 counts

Congratulations! First-time system verification for this axis is now complete. You should now initialize all of the axes in your system. Go to Section 2.11.5, "Initializing Motion Axes" and repeat the steps for each of the remaining axes.

3. Operation

3

In This Chapter

3.1 ION Block Diagram

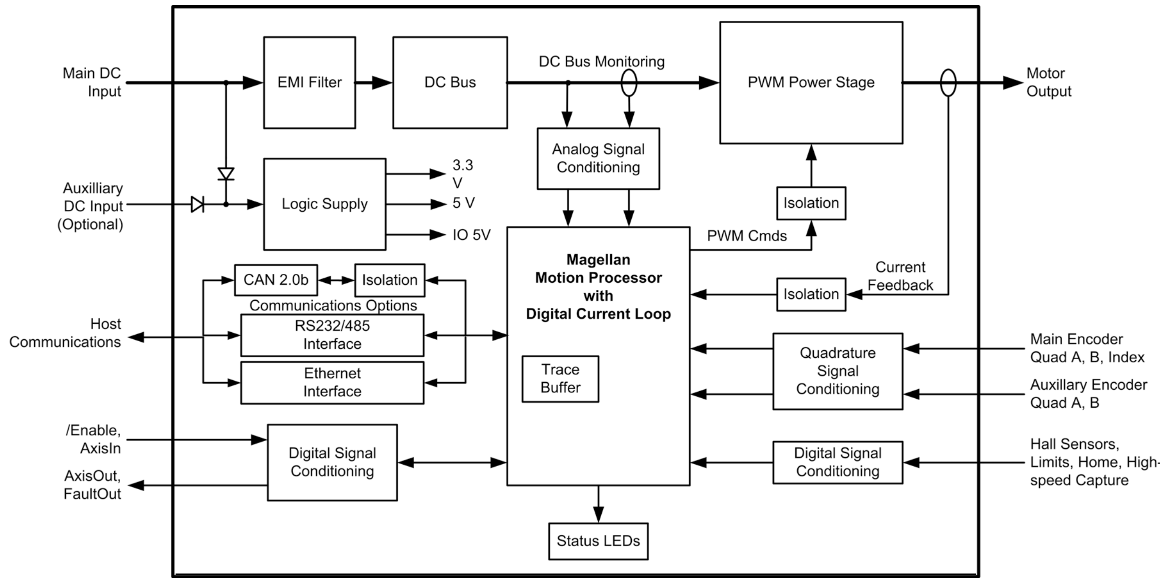
ION combines the function of a motion controller and amplifier. It directly interfaces to a host computer using a serial or CANbus interlace, and connects to all power and feedback signals required to drive a positioning DC Brush, Brushless DC, or step motor.

In addition to the Magellan Motion Control IC, ION incorporates several major subsystems including a communications system, a high performance MOSFET-based power stage, a DC Bus conditioning system, and a trace buffer.

Figure 3-1 shows a block diagram of the ION.

The following sections describe these major sections of the ION Digital Drive. For a complete description of the Magellan Motion Control IC, see the *Magellan Motion Control IC User Guide* and the *Magellan Programming Reference.*

Figure 3-1: ION Block Diagram



3.2 Communication Ports

3.2.1 Ethernet

The Ethernet/Serial IONs support TCP (Transmission Control Protocol). The physical node on the Ethernet network controller is assigned a 32-bit IP (Internet Protocol) address, along with a 32-bit net mask and a 32-bit gateway value. The Netmask is used to indicate which IP addresses are local. To correctly receive communications from the host controller, a 16-bit identifier known as a port must also be specified. To determine what the unused IP addresses are for your Ethernet network, and what values for net mask to use, contact your network administrator.

By convention, the 32-bit values for IP Address, Net mask, and Gateway are shown in Dotted Quad Notation. In this notation each of the four numbers are separated by dots, and denote a decimal value for each byte of the four byte word

After a reset or at power-up, the ION retrieves default information for the ION Stand-Alone Ethernet port. To change these default values, the PRP **Set** command is sent to the **Device** resource.

The table below shows the range and default settings for the Ethernet controller of the ION:

Parameter	Range	Default
IP address	0.0.0.0 – 255.255.255.255	192.168.2.2
Net mask	0.0.0.0 – 255.255.255.255	255.255.255.0
PRP Listen TCP Port	0 - 65,535	40100

For detailed information on PRP action formats and function, refer to the *PMD Remote Access Protocol Programming Reference.*

The Ethernet/Serial ION features a standard 10/100Mpbs Ethernet interface. A standard RJ45 connector with link lights is provided for the connection. Figure 3-2 shows the simplified Internal Ethernet circuit diagram.

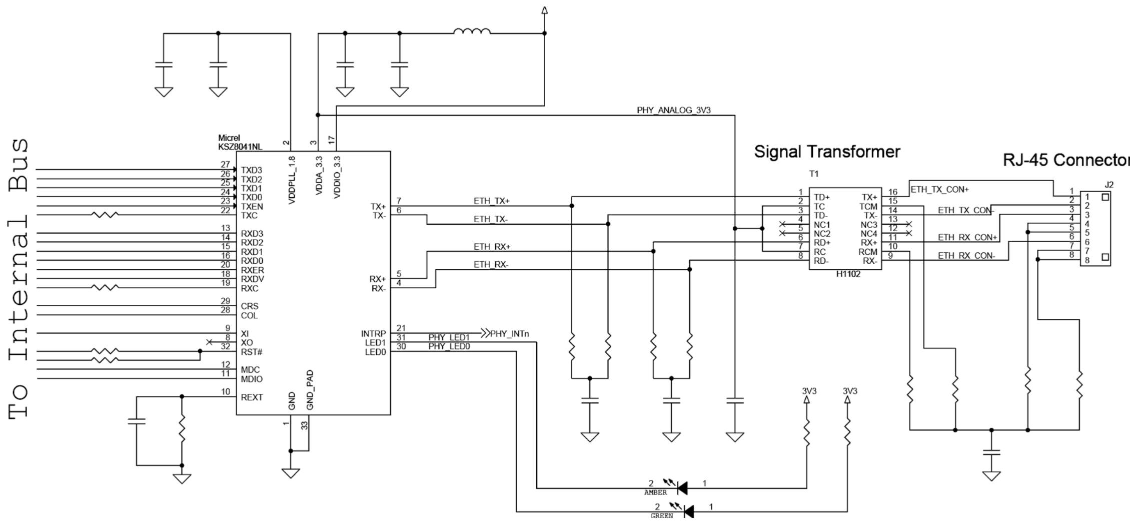


Figure 3-2: Simplified Ethernet Circuit Diagram

3.2.2 Serial RS232/485 on Ethernet/Serial ION

For serial communication with the Ethernet/Serial version of the ION, an RJ45 style connector socket is used.

Pin 8 is used to select between RS232 and RS485 operation. For RS232, pin 8 can be tied high to 3.3V or left floating. For RS485 operation, pin 8 should be connected to *IO_GND*.

The SRL_RS485_Select Line shown in Figure 3-3 is connected to the Magellan Motion Control IC for selecting the mode of serial communication. ION supports both point-to-point and multi-drop networking in RS485 and point-to-point only in RS232.

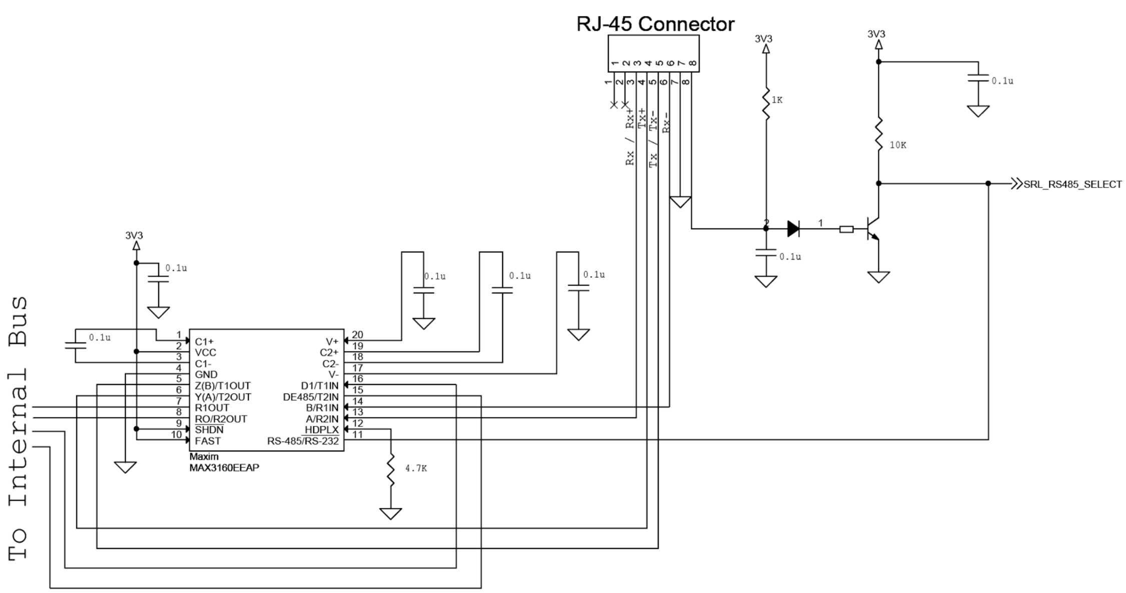
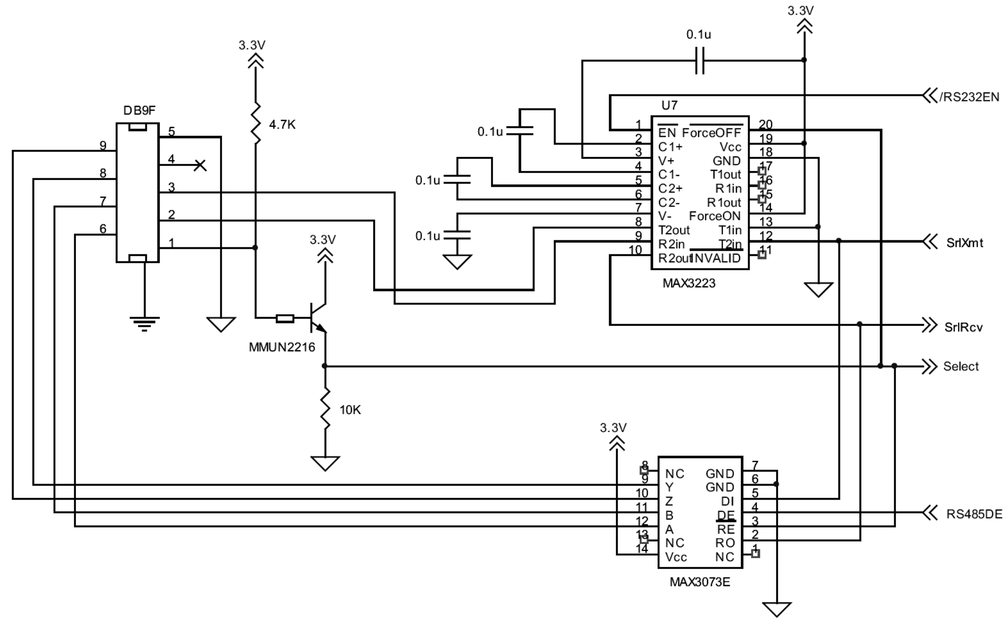


Figure 3-3: Simplified Serial Port on Ethernet Unit Circuit Diagram

3.2.3 RS232/485 on Serial ION

The serial version of ION supports both the RS232 and RS485 protocols. A simplified transceiver circuit diagram is shown in Figure 3-4. Pin 1 is used to select between RS232 and RS485 operation. For RS232, pin 1 can be tied high to 3.3V or simply left floating. For RS485 operation, pin 1 must be strapped to *IO_Gnd*.

Figure 3-4: Simplified Serial Transceiver Diagram



The Select line shown in Figure 3-4 is routed to the Magellan Motion Control IC to inform the processor of the selected serial mode. ION supports point-to-point and multi-drop networking in RS485 and point-to-point only in RS232.

The Select line is read only once when the ION comes out of powerup reset. The communications cable must be connected before power is supplied to the ION module.

3.2.4 CAN

The CAN version of ION features a dual RJ45 connector and can use standard UTP Ethernet cabling for implementing a daisy-chain CANbus network. The two jacks are functionally identical. A simplified circuit diagram is shown in Figure 3-5. Note that only the signals used internally are shown. *CAN_V, CAN_Shield* and the two *Reserved* pins simply pass through to the other RJ45 jack.

To minimize ground loops and noise, the CANbus port is isolated from the rest of the ION module and is powered from an isolated winding of the onboard DC/DC converter. The small capacitor between the isolated and non-isolated grounds is required for EMC. The transceiver and signal isolator used support the high speed CANbus communications rates of up to 1 M baud.

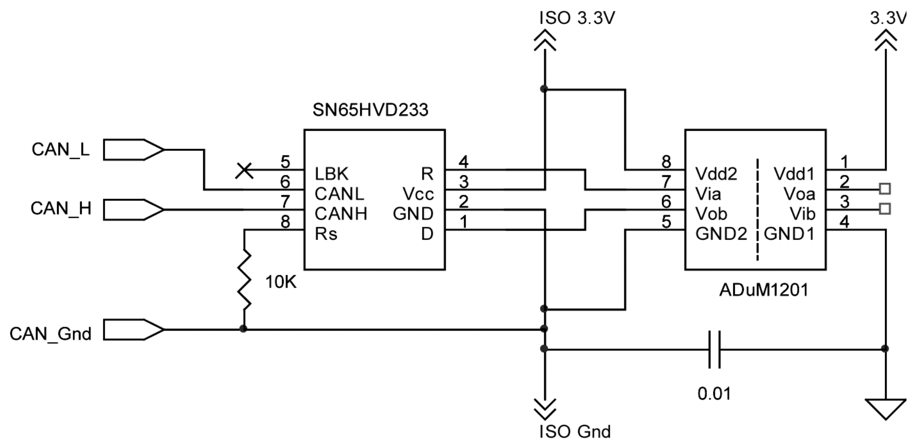


Figure 3-5: Simplified CAN Circuit Diagram

3.3 PWM Power Stage

The ION module contains a high-efficiency MOSFET power stage with PWM control and phase current feedback. A slightly different configuration is used for each motor type:

- DC brush motors are driven with an H-Bridge consisting of 4 MOSFETs
- Brushless DC motors are driven with a 3-phase bridge consisting of 6 MOSFETs
- Step motors are driven with two H-Bridges, one for each phase, for a total of 8 MOSFETs.

The use of 3-phase and H-Bridge topologies provides full 4-quadrant operation from a single non-isolated DC supply.

ION uses an advanced PWM switching scheme that minimizes the ripple current on the motor windings while maximizing the current loop performance. The PWM frequency is selectable between 20 kHz and 40 kHz to cover a broad range of motor inductance. The fundamental frequency of the ripple current is at twice the PWM frequency and well out of the audible range in all cases.

Two channels of phase current feedback are used for brushless DC and step motor current loops. In the brushless DC version, the third phase is simply calculated as the negated sum of the other two phase currents. For DC brush motors, only one phase current feedback is used.

By monitoring the DC bus voltage, the DC bus current, and the output phase currents, the ION Digital Drive's output stage is fully protected from overcurrent, overvoltage, and undervoltage faults and line-to-line, line-to-power supply, and line-to-earth/case ground short circuits. The Magellan Motion Control IC also implements I^2t current foldback and automatic holding current reduction for step motors.

3.3.1 I^2t Current Foldback Protection

ION uses the current feedback to implement I^2t current limiting. This feature protects the drive by controlling its ability to operate above continuous current ratings. This protection feature is active in all operating modes.

When the current loop is enabled and the I^2t energy limit is exceeded, ION will automatically fold back the phase currents to a user programmable continuous current limit value. Alternatively, ION can be configured to fault and disable the output stage when the I^2t energy limit is exceeded.

When the current loop is disabled (ION is operating in voltage control mode only) and the I^2t energy limit is exceeded, ION will always fault and disable the output stage.

3.3.2 Overtemperature Protection

ION uses digital temperature sensors to monitor the operating temperature of the output stage power MOSFETs. The motion control IC communicates with the sensors over the built-in SPI bus. If an overtemperature condition is detected, ION shuts down the output stage, indicates the fault with the Module Status LED and optionally activates FaultOut.

The overtemperature threshold is user-settable to any value below the maximum-rated operating temperature of the output stage. See Section 6.4, “ION 500 Protection Circuits” for the programmable overtemperature range and the *Magellan Motion Control IC Programming Reference* for more information on setting the temperature threshold.

Refer to the *Magellan Motion Control IC User Guide* and the *Magellan Motion Control IC Programming Reference* for more information on Operating Modes and on setting up these current foldback parameters.

3.3.3 Power Stage Scaling Parameters

To correctly control various ION features via the Magellan Motion Control IC it is necessary to know certain drive-specific scale factors. The following tables summarize these values.

3.3.3.1 ION 500 Power Stage Scaling Parameters

Parameter	Commands	Scaling	Example
Current	GetCurrentLoopValue GetFOCValue	1.296 mA/count	A value of 12,345 from the command **GetCurrentLoopValue** for the ActualCurrent parameter corresponds to a current of 12,345 counts * 1.296 mA/count = 15.999A.
Step motor & Brushless DC*: Continuous RMS Current Limit	SetCurrentFoldback GetCurrentFoldback	.4587 mA_{RMS}/count	To set a continuous current limit of 5.00A_{RMS} using the **SetCurrentFoldback** command a value of 5,000 mA_{RMS}/.4587 mA_{RMS}/count = 10,900 should be used.
DC Brush*: Continuous DC Current Limit	SetCurrentFoldback GetCurrentFoldback	.5619 mA_{DC}/count	To set a continuous current limit of 5.00A_{DC} using the **SetCurrentFoldback** command a value of 5,000 mA_{DC}/.5619 mA_{DC}/count = 8,898 should be used.
Step motor & Brushless DC* I^2t Energy	SetCurrentFoldback GetCurrentFoldback	.0923A_{RMS}^2Sec/count	To set a foldback total energy value of 100.0 A_{RMS}^2Sec using the **SetCurrentFoldback** command, a value of 100.0A_{RMS}^2Sec/.0923 A_{RMS}^2Sec/count = 1,083 should be used.
DC Brush* I^2t Energy	SetCurrentFoldback GetCurrentFoldback	.1385A_{DC}^2Sec/count	To set a foldback total energy value of 100.0 A_{DC}^2Sec using the **SetCurrentFoldback** command, a value of 100.0A_{DC}^2Sec/.1385 $Arms^2$Sec/count = 722 should be used.

*Brushless DC motors used in Hall-based commutation should use the A_{DC} scale factors. All other Brushless DC motor modes should use the A_{RMS} scale factors.

For detailed information on the commands used to set or query these parameters, along with the specific subparameters to use, refer to the *Magellan Motion Control IC Programming Reference.*

3.3.3.2 ION 3000 Power Stage Scaling Parameters

Parameter	Commands	Scaling	Example
Current	GetCurrentLoopValue GetFOCValue	2.588 mA/count	A value of 12,345 from the command **GetCurrentLoopValue** for the Actual Current parameter corresponds to a current of 12,345 counts * 2.588 mA/count = 31.949A.
Step motor & Brushless DC*: Continuous RMS Current Limit	SetCurrentFoldback GetCurrentFoldback	.9152 mA_{RMS}/count	To set a continuous current limit of 10.00A_{RMS} using the **SetCurrentFoldback** command a value of 10,000 mA_{RMS}/.9152 mA_{RMS}/count = 10,927 should be used.
DC Brush*: Continuous DC Current Limit	SetCurrentFoldback GetCurrentFoldback	1.121 mA_{DC}/count	To set a continuous current limit of 10.00ADC using the **SetCurrentFoldback** command a value of 10,000 mA_{DC}/1.121 mA_{DC}/count = 8,921 should be used.
Step motor & Brushless DC* I^2t Energy	SetCurrentFoldback GetCurrentFoldback	.3682 A_{RMS}^2Sec/count	To set a foldback total energy value of 1,000.0 A_{RMS}^2Sec using the **SetCurrentFoldback** command, a value of 1,000.0 A_{RMS}^2Sec/.3682 A_{RMS}^2Sec/count = 2,716 should be used.
DC Brush* I^2t Energy	SetCurrentFoldback GetCurrentFoldback	.5524 A_{DC}^2Sec/count	To set a foldback total energy value of 1,000.0 A_{DC}^2Sec using the **SetCurrentFoldback** command, a value of 1000.0 A_{DC}^2Sec/.5524 $Arms^2$Sec/count = 1,810 should be used.

*Brushless DC motors used in Hall-based commutation should use the A_{DC} scale factors. All other Brushless DC motor modes should use the A_{RMS} scale factors.

For detailed information on the commands used to set or query these parameters, along with the specific subparameters to use, refer to the *Magellan Motion Control IC Programming Reference.*

3.3.4 Power Stage Defaults and Limits

To correctly control various ION power stage features via the Magellan Motion Control IC, it is necessary to know certain drive-specific defaults and limits. The following tables summarize these values.

3.3.4.1 ION 500 Power Stage Defaults and Limits

Parameter	Default value	Limit
Brushless DC model: Fold-back Continuous RMS Current	$8.073A_{RMS}$	Must be <= $8.073A_{RMS}$
Brushless DC model: Fold-back Total Energy	$443.1A_{RMS}^2$sec	Must be <= $443.1A_{RMS}^2$sec
DC Brush model: Foldback Continuous DC Current	$9.889A_{DC}$	Must be <= $9.889A_{DC}$
DC Brush model: Foldback Total Energy	$664.7A_{DC}^2$sec	Must be <= $664.7A_{DC}^2$sec
Step motor model: Fold-back Continuous RMS Current	$5.052A_{RMS}$	Must be <= $5.052A_{RMS}$
Step motor model: Fold-back maximum energy	$443.1A_{RMS}^2$sec	Must be <= $443.1A_{RMS}^2$sec

For the ION 500, default values and limits for the Foldback Continuous Current Limit and Foldback Energy Limit are designed to be safe for operation in the drive's highest output mounting option, namely, horizontal to cold plate. See Section 2.5, "ION Hardware Configuration and Mounting" for information on ION mounting options.

If the ION 500 drive is being operated at a lower voltage, it may be possible to specify values for Foldback Continuous Current Limit and Foldback Energy Limit that are higher than the default, but lower than or equal to the limit, since the continuous output current rating of the ION 500 drive is higher for lower input voltages. See Section 6.1, "ION 500 Drive Ratings" for drive output specifications.

For other mounting configurations, or for use with motors that have lower current and energy limits, it may be useful to set these parameters to values lower than the default values.

> It is the responsibility of the user to set the Foldback Continuous Current and Foldback Energy Limit parameters to values that are safe for the specific ION 500 mounting configuration and motor setup being used.

3.3.4.2 ION 3000 Power Stage Defaults and Limits

Parameter	Default value	Limit
Brushless DC model: Foldback Continuous RMS Current	$10.60A_{RMS}$	Must be <= $15.00A_{RMS}$
Brushless DC model: Foldback Total Energy	$68A_{RMS}^2sec$	Must be <= $101A_{RMS}^2sec$
DC Brush model: Foldback Continuous DC Current	$15.00A_{DC}$	Must be <= $20.00A_{DC}$
DC Brush model: Foldback Total Energy	$150A_{DC}^2sec$	Must be <= $203A_{DC}^2sec$
Step motor model: Foldback Continuous RMS Current	$5.7A_{RMS}$	Must be <= $10.6A_{RMS}$
Step motor model: Foldback maximum energy	$101A_{RMS}^2sec$	Must be <= $125A_{RMS}^2sec$

For the ION 3000, default values for the Foldback Continuous Current Limit and Foldback Energy Limit are designed to be safe for operation of the drive in its highest output mounting option and at its highest nominal operating voltage. See Section 2.5, "ION Hardware Configuration and Mounting" for information on ION mounting options.

If the ION 3000 drive is being operated at a lower voltage, it may be possible to specify values for Foldback Continuous Current Limit and Foldback Energy Limit that are higher than the default, but lower than or equal to the limit, since the continuous output current rating of the ION 3000 drive is higher for lower input voltages. See Section 3.6.1, "Hard Fault State" for drive output specifications.

For other mounting configurations, or for use with motors that have lower current and energy limits, it may be useful to set these parameters to values lower than the default values.

> It is the responsibility of the user to set the Foldback Continuous Current and Foldback Energy Limit parameters to values that are safe for the specific ION 3000 input voltage, ION mounting configuration, and motor setup being used.

3.4 DC Bus

3.4.1 DC Bus Current Monitoring

ION monitors both the positive and negative DC bus current to detect overcurrent conditions including: line-to-line, line-to-power supply, and line-to-case-ground short circuits. Both hard short circuits and excessive current conditions are detected. ION can even detect some "ground fault" conditions caused by a partial winding short circuit between winding and case within a motor.

When an overcurrent condition occurs, the output stage is shut down and the ION module goes into the hard fault state. See Section 3.6.1, "Hard Fault State" for a description of this state.

3.4.2 DC Bus Overvoltage and Undervoltage

ION monitors the main DC bus voltage for overvoltage and undervoltage conditions. These thresholds are user-settable within the voltage operating range of the drive.

When the DC bus voltage drops below the undervoltage threshold, ION shuts down the output stage, indicates the fault with the Module Status LED, and optionally activates FaultOut.

There are two ways for the DC bus to exceed the overvoltage threshold:

1 The supplied DC power is too high. There is little the ION module can do about this. ION simply turns off the output stage, indicates the fault with the Module Status LED and optionally activates FaultOut.

2 The motor is decelerating at a rate too high for the DC power supply to absorb the regenerated energy and the DC bus "pumps up." ION will protect itself by turning off the output stage. It also indicates the fault with the Module Status LED and optionally activates FaultOut.

In either case, the DC bus voltage must then fall below the threshold before the module exits this fault state and can be re-enabled.

3.4.3 IO_5V Monitor

ION features a separate 5V supply for powering external encoders, Hall sensors, and other I/O devices. This supply is monitored to detect overloading or out-of-tolerance operation and if either condition occurs, ION goes into the hard fault state. See Section 3.6.1, "Hard Fault State" for a description of this state.

3.4.4 Motion Control IC 3.3V Supply Monitor and Reset Circuit

The 3.3V supply for the motion control IC automatically forces the processor into the reset state if the supply voltage falls out of regulation.

3.4.5 DC Bus Scaling Parameters

To correctly control ION DC Bus features via the Magellan Motion Control IC it is necessary to know the DC Bus scale factor. The following tables summarize this value.

3.4.5.1 ION 500 DC Bus Scaling Parameters

Parameter	Commands	Scaling	Example
Bus Voltage	GetBusVoltage SetBusVoltageLimits GetBusVoltageLimits	1.361 mV/count	A value of 12,345 from the command **GetBusVoltage** corresponds to a voltage of 12,345 counts * 1.361 mV/counts = 16.801V

3.4.5.2 ION 3000 DC Bus Defaults and Limits

Parameter	Commands	Scaling	Example
Bus Voltage	GetBusVoltage SetBusVoltageLimits GetBusVoltageLimits	5.349 mV/count	A value of 12,345 from the command **GetBusVoltage** corresponds to a voltage of 12,345 counts * 5.349 mV/counts = 66.033V

3.4.6 Undervoltage and Overvoltage Limits

3.4.6.1 ION 500 DC Bus Defaults and Limits

Parameter	Default value	Limit
Undervoltage Limit	9.935V	Must be >= 9.935V and <= 56.00V
Overvoltage Limit	60.02V	Must be <= 60.02V and >= 20.00V

3.4.6.2 ION 3000 DC Bus Defaults and Limits

Parameter	Default value	Limit
Undervoltage Limit	20.00V	Must be >= 20.00V and <= 195.00V
Overvoltage Limit	195.00V	Must be <= 195.00V and >= 20.00V

3.5 Trace Buffer

Trace capture is a powerful feature of the Magellan Motion Control IC that allows various parameters and registers to be continuously captured and stored to an internal memory buffer. The captured data may later be downloaded by the host using software commands.

Data traces are useful for optimizing DC brush and brushless DC performance, verifying trajectory behavior, capturing sensor data, or to assist with any type of monitoring where a precise time-based record of the system's behavior is required.

The ION module features 1.5 kB RAM for trace. This will hold up to 384 trace samples. Refer to the *Magellan Motion Control IC User Guide* and the *Magellan Motion Control IC Programming Reference* for complete information on trace configuration and operation.

3.6 Operational and Fault Modes

The ION is commanded by the host controller to perform various motion control functions. During the course of these operations it is possible for the ION to enter various fault states based on operational conditions within the power stage, the motor, the electrical bus, or based on the state of the Enable input signal.

Hard electrical faults are serious module or system malfunctions that must be rectified before proceeding.

The following tables summarize the operational and fault modes of the ION Digital Drive. More information about these modes can be found in the *Magellan Motion Control IC User Guide*.

Condition	Details	Output Stage	FaultOut	Module Status LED
Enabled	/Enable = low. Normal operation in programmed operating mode	On	Low (inactive)	Green/solid
Disabled	/Enable = high	Off	Programmable	Green/blinking (slow)
Overvoltage	DC bus voltage exceeded programmable threshold	Off	Programmable	Red/blinking (fast)
Undervoltage	DC bus voltage below programmable threshold			
I^2t Current Foldback	Output stage disabled by I^2t foldback protection	Off	Programmable	Red/blinking (slow)
Overtemperature	Power stage temperature exceeded programmable threshold			

Hard Electrical Fault	Details	Output Stage	FaultOut	Module Status LED
Overcurrent	Short circuit or overload	Off	High (active)	Red/solid
Ground Fault	Excessive current to ground			
IO_5V Fault	Overloaded/out-of-tolerance			
Internal Logic Fault	Internal hardware failure			

3.6.1 Hard Fault State

As an additional safety feature, all hard electrical faults put the ION module into the hard fault state. In this state the module is completely dormant with even communications disabled. A power cycle is required before normal operation can resume.

> ION module should be disabled and disconnected from its power source before any attempt is made to fix a hard fault condition..

The following sequence should be used to recover from the hard fault state:

1. Unless the failure is clearly caused by external circumstances, the ION module should be disconnected from the Ethernet, serial or CANbus network, as well as disconnected from all external hardware such as the motor, motor encoder or power supply, etc.
2. With all external hardware disconnected, restore the module power. If the unit is still in the hard fault state as indicated by the red Module Status LED, the drive is likely to have sustained an unrecoverable failure, and should be considered unusable thereafter. A replacement ION module should be used in the application.
3. If the Module Status LED indicates that a fault is no longer present, the cause can be determined by reconnecting the communications cable, cycling power again, and reading the Drive Fault Status from the ION module. See the *Magellan Motion Control IC User Guide* for more information on reading the Drive Fault Status.
4. Once the nature of the fault is known, it must be corrected. It is always the responsibility of the user to maintain safe operating conditions of the ION module as well as all associated electronics or hardware.

5 With the source of the problem corrected, the ION module can be reinstalled and reconnected. It should now function normally.

3.7 Magellan Motion Control IC Functions

The Magellan Motion Control IC forms the core of the ION. Here is an overview of the functions either provided, or managed by the Magellan Motion Control IC:

- Profile generation
- Motor output signal generation
- Quadrature encoder processing and index capture
- DC brush and brushless DC servo loop closure
- Breakpoint processing
- *AxisIn* and *AxisOut* signal processing
- Trace
- Motion error detection, tracking windows, and at-settled indicator
- Limit switches

The Magellan Motion Control IC interfaces with motion hardware components such as feedback encoders, motor out signal generation hardware, and others, both directly through its own pin connections, and through various signal conditioning circuitry.

The Magellan instruction set is very flexible and powerful. The following example, which would be used to set up and execute a simple trapezoidal profile, illustrates just a small part of the overall command set:

```
SetProfileMode Axis1, trapezoidal     // set profile mode to trapezoidal for axis 1
SetPosition Axis1, 12345              // load a destination position for axis 1
SetVelocity Axis1, 223344             // load a velocity for axis 1
SetAcceleration Axis1, 1000           // load an acceleration for axis 1
SetDeceleration Axis1, 2000           // load a deceleration for axis 1
SetUpdateMask Axis1, Profile          // specify that an update of profile parameters only
                                      // is to occur
Update Axis1                          // Double buffered registers are copied into
                                      // the active registers, thereby initiating the move
```

Magellan instructions are encoded in packets, which are sent to and from the Magellan Motion Control IC. The Magellan processes these packets, performs requested functions, and returns requested data. Within the ION, the Magellan uses its high-speed parallel-word communications mode to connect to the module's communications bus, which allows the Magellan to be controlled via an external host controller connected to the ION.

3.8 Communications

ION Digital Drives are designed to be controlled by an external host controller, which sends commands via one of the available communications ports (Ethernet, serial, or CANbus). IONs support a rich variety of commands, allowing communication to one or more networked IONs from a single host controller, and allowing all features of the ION and internal Magellan/ION to be exercised.

The protocol for the Serial IONs and CANbus IONs is determined directly by the Magellan/ION Motion Control IC. The protocol for the Ethernet IONs, both for the Ethernet port and the serial port provided with these units is the PRP (PMD Resource Access Protocol). The following table summarizes this, along with the PMD manuals that detail these protocols.

ION	ION Part Number	Protocol	Manuals with Protocol Description
Ethernet/serial	DD1x1D0-xxx/yy	PRP (PMD Resource Access Protocol)	PMD Resource Access Protocol (PRP) Programming Reference
Serial (RS232 and RS485)	DD1x1S0-xxx/yy	Magellan-defined	Magellan Motion Control IC User Guide Magellan/ION Motion Control IC Programming Reference
CANbus	DD1x1C0-xxx/yy	Magellan-defined	Magellan Motion Control IC User Guide Magellan/ION Motion Control IC Programming Reference

3.8.1 Software Development Notes

Most ION users will not concern themselves with the low level details of communication command protocols because they will use the library of C-language routines provided by PMD.

This library of C-language functions insulates the user from protocol and platform details by providing virtualized C-language interfaces to all supported commands. So, for example, code that is written to control a Magellan located on a CANbus-connected ION will work just as well when used with a PCI bus-connected Prodigy card, or microprocessor-connected Magellan IC on a user-designed motion control card.

3.9 Communicating with Serial or CANbus IONs

For Serial IONs and CANbus IONs, the protocol used to communicate with the ION is defined in the *Magellan Motion Control IC User Guide,* along with the *Magellan Motion Control IC Programming Reference*. Please consult these manuals for more information on how to control and communicate with the ION Digital Drive.

3.10 Communicating with Ethernet/ Serial IONs

Whether communicating by Ethernet or serial, access to the Ethernet/serial ION is provided by a protocol called PMD Resource access Protocol (PRP). This easy-to-use yet powerful protocol utilizes actions, resources, and addresses to access the Ethernet ION's functions. The ION functions are organized into resources, and resources process actions sent to them. Actions can send information, request information, or command specific events to occur.

A basic communication consists of a 16-bit PRP header, and an optional message body. The message body contains data associated with the specified PRP action, but some actions do not require a message body. After a PRP communication is sent to the ION, a return communication is sent which consists of a PRP header and an optional return message body. The return message body may contain information associated with the requested PRP action, or it may contain error information if there was a problem processing the requested action.

Although the PRP protocol supports several different resource types, only one resource type is used by the Ethernet/serial ION. This Device resource is the **MotionProcessor** resource, meaning the onboard Magellan/ION Motion Control IC.

For a more complete description of PRP, refer to the *PMD Resource Access Protocol Programming Reference.*

3.10.1 Accessing the Magellan Motion Control IC

To send and receive command packets to the Magellan Motion Control IC the PRP action *Command* is used. The Magellan command packet is loaded into the PRP message body, and the return PRP message body contains the return packet provided by the Magellan. A return without error indicates that the command was processed successfully. If an error occurred while the Magellan was processing the command, the message body is loaded with the specific error that occurred. For more information on Magellan command packet formats and return packet formats, see the *Magellan Motion Control IC Programming Reference.*

3.10.2 Ethernet/Serial ION Command Summary

The following table summarizes all PRP commands provided by the Ethernet/Serial ION.

Action	Resource	Sub-action	C Procedure
NOP	Any		N/A
Reset	Device		PMDDeviceReset
Command	MotionProcessor		Any Magellan or C-Motion Command
Set	Device	Default	PMDDeviceSetDefault
Get	Device	Default Version	PMDDeviceGetDefault PMDDeviceGetVersion

For additional information on how PRP packets are formatted, and how they are carried over Ethernet or serial, as well as other details of PRP processing refer to the *PMD Resource Access Protocol Programming Reference.*

This page intentionally left blank.

4. Options and Accessories

4

In This Chapter

- Stub Cable Set
- Developer Kit Cable and Plug Specifications

4.1 Stub Cable Set

The following tables summarize the cables and other accessories that come with each ION Developer Kit. See the next section for detailed information on each cable type.

ION 500, Serial

Cable (PMD Part #)	Description
Cable-RS232-03-R	9-pin RS232 Communications Cable
Cable-1002-02-R	Feedback Stub Cable
Cable-1003-02-R	Aux Stub Cable
Cable-1004-02-R	I/O Stub Cable
Cable-1005-02-R	ION 500 DC Bus Stub Cable
Cable-1006-02-R	ION 500 Motor Stub Cable
Adapter-1010-01	RJ45 to DB9 Adapter for RS232
Cable-RJ45-01	Standard RJ45 Cable

ION 500, CANbus

Cable (PMD Part #)	Description
Cable-RJ45-02-R	RJ45 CANbus Communications Cable
TRM-RJ45-02-R	RJ45 CANbus terminator
Cable-1002-02-R	Feedback Stub Cable
Cable-1003-02-R	Aux Stub Cable
Cable-1004-02-R	I/O Stub Cable
Cable-1005-02-R	ION 500 DC Bus Stub Cable
Cable-1006-02-R	ION 500 DC Motor Stub Cable

ION 500, Ethernet/Serial

Cable (PMD Part #)	Description
Cable-RJ45-02-R	RJ45 Standard Communications Cable for Ethernet and Serial Communication
Adapter-1010-01	DB9 (female) to RJ45 Socket Adapter for RS232 Serial communication
Cable-1002-02-R	Feedback Stub Cable
Cable-1003-02-R	Aux Stub Cable

Cable (PMD Part #)	Description
Cable-1004-02-R	I/O Stub Cable
Cable-1005-02-R	ION 500 DC Bus Stub Cable
Cable-1006-02-R	ION 500 DC Motor Stub Cable

ION 3000, Serial

Cable (PMD Part #)	Description
Cable-RS232-03-R	9-pin RS232 Communications Cable
Cable-1002-02-R	Feedback Stub Cable
Cable-1003-02-R	Aux Stub Cable
Cable-1004-02-R	I/O Stub Cable
Plug-1007-01-R	ION 3000 DC Bus Plug
Plug-1008-01-R	ION 3000 DC Motor Plug

ION 3000, CANbus

Cable (PMD Part #)	Description
Cable-RJ45-02-R	RJ45 CANbus Communications Cable
TRM-RJ45-02-R	RJ45 CANbus terminator
Cable-1002-02-R	Feedback Stub Cable
Cable-1003-02-R	Aux Stub Cable
Cable-1004-02-R	I/O Stub Cable
Plug-1007-01-R	ION 3000 DC bus Plug
Plug-1008-01-R	ION 3000 DC Motor Plug

4.2 Developer Kit Cable and Plug Specifications

	Pin	Signal	Pairing	Color
PMD Part #: Cable-RS23203-R				
Description: RS232 Comm cable	1	Select	None	Black*
Length: 2m	2	Tx	P2	White
Cable: 4P, 24AWG, foil shield, Alpha 5474C, or equiv.	3	Rx	P1	Red
	4	No connect		
Notes: Shield connected to shells at both ends.	5	Gnd	P1	Black
*Grounded jumper wire included inside DB9M backshell to use for Select.	6	Rx+	P3	Green
	7	Rx-	P3	Black
	8	Tx+	P4	Blue
	9	Tx-	P4	Black

	Pin	Signal	Pairing	Color
PMD Part #: Cable-RJ45-02-R				
Description: CAN Comm cable	1	CAN_H	P1	Orange/ White
Length: 2m	2	CAN_L	P1	Orange
Cable: 4P, 24AWG, UTP, Cat5	3	CAN_Gnd	P2	Green/ White
	4	Reserved	P3	Blue
	5	Reserved	P3	Blue/ White
	6	CAN_Shield	P2	Green
	7	CAN_Gnd	P4	Brown/ White
	8	CAN_V	P4	Brown

	Pin	Signal	Color
PMD Part #: Cable-RJ45-02-R			
Description: Ethernet Communications cable. Male RJ45 to male RJ45 cable wired in a straight- through configuration	1	Ethernet Tx+	-
Length: 2m	2	Ethernet Tx-	-
Cable:4P, 24AWG,UTP, Cat 5E	3	Ethernet Rx+	-
	4	No Connect	-
	5	No Connect	-
	6	Ethernet Rx-	-
	7	No Connect	-
	8	No Connect	-

	Pin	Signal	Pairing	Color
PMD Part #: Cable-1002-02-R				
Description: Feedback stub cable	1	Drain		
Length: 2m	2	IO_Gnd	P1	Black
Cable: 6P, 22AWG, foil shield, Alpha 2216C or equiv.	3	IO_5V	P1	Red
	4	Hall A	P5	Brown
	5	Hall B	P5	Black
	6	Hall C	P6	Yellow

7	A+	P2	White
8	A-	P2	Black
9	B+	P3	Green
10	B-	P3	Black
11	Z+	P4	Blue
12	Z-	P4	Black

PMD Part #: Cable-1003-02-R
Description: Auxiliary stub cable
Length: 2m
Cable: 3P, 22AWG, foil shield, Alpha 2213C or equiv.

Pin	Signal	Pairing	Color
1	Drain		
2	IO_Gnd	P1	Black
3	IO_5V	P1	Red
4	No connect		
5	A+	P2	White
6	A-	P2	Black
7	B+	P3	Green
8	B-	P3	Black

PMD Part #: Cable-1004-02-R
Description: I/O stub cable
Length: 2m
Cable: 13C, 22AWG, foil shield, Alpha 1299C/15 or equiv.

Pin	Signal	Color
1	Drain	
2	IO_Gnd	Black
3	IO_5V	Red
4	IO_Gnd	Blue
5	IO_5V	Red/Yellow
6	IO_Gnd	Brown
7	FaultOut	Pink
8	+Limit	White
9	-Limit	Green
10	Home	Orange
11	High Speed Capture	Yellow
12	AxisIn	Violet
13	AxisOut	Gray
14	/Enable	Tan

PMD Part #: Cable-1005-02-R
Description: ION 500 DC bus stub cable
Length: 2m
Cable: 3C,16AWG, foil shield, Alpha 5363C or equiv.

Pin	Signal	Color
1	HV	Red
2	AuxV	White
3	PGnd	Black

Note: Drain and PGnd spliced together at Pin 3.

PMD Part #: Cable-1006-02-R	Pin	Signal	Color
Description: ION 500 Motor stub cable	1	A+ (U, M+)	White
Length: 2m	2	A- (V)	Green
Cable: 6C,16AWG, foil shield, Alpha 5366C or equiv.	3	B+ (W, M-)	Orange
	4	B-	Blue
Note: Drain and PGnd spliced together at Pin 5.	5	PGnd	Black

PMD Part #: Plug-1007-01-R	Pin	Signal	Color
Description: ION 3000 DC bus plug	1	HV	--
	2	AuxV	--
Cable: Phoenix, p/n 1804917	3	PGnd	--
			--

PMD Part #: Plug-1008-01-R	Pin	Signal	Color
Description: ION 3000 Motor Plug	1	A+ (U, M+)	--
	2	A- (V, M-)	--
Cable: Phoenix, p/n 1804933	3	B+ (W)	--
	4	B-	--
	5	PGnd	--

PMD Part #: Adapter-1010-01 Description: Custom adapter for conversion from DB9 type	**RJ45 Pin**	**DB9 Pin**	**Signal**	**Color**
to RJ45 type serial interface.	1	No Connect	-	
Used to establish RS232 communication link from host computer with ION 500 Unit with serial + Ethernet communication option or	2	No Connect	-	
ION/B 500 Unit.	3	3	Rx	Black
DB9 end of adapter has generic 9-pin female receptacle which mates	4	No Connect	-	
with PMD Cable Part # cable-RS23203-R.	5	2	Tx	Green
Other adapter end is a generic RJ45 female socket mating with PMD	6	No Connect	-	
Cable Part #: Cable-RJ45-02-R or any generic Ethernet CAT5 cable.	7	5	Ground	Brown
Manufacturer and Part #: L-COM RA098F or equivalent	8	No Connect	-	

This page intentionally left blank.

5. Electrical Signal Interfacing

5

In This Chapter

- Motor Feedback
- Auxiliary Position Input
- Limit and Home Inputs
- Position Capture Sources
- AxisIn and AxisOut Signals
- /Enable and FaultOut Signals

5.1 Motor Feedback

The Feedback connector contains the main encoder signals as well as Hall commutation signals. These signals are buffered and filtered in the Quadrature Signal Conditioning and Digital Signal Conditioning blocks, respectively. ION supports incremental quadrature encoders with count rates up to 10 Mcounts per second, and for the ION 3000 module Pulse & Direction input on the auxiliary position input at up to 10 Mpulses per second.

5.1.1 Main Encoder Inputs

The differential input circuitry for the main encoder *A*, *B* and *Index* signals is shown in Figure 5-1. This circuit accepts both differential and single-ended signals in the range of 0-5V. For single-ended operation, the unused input should be left floating.

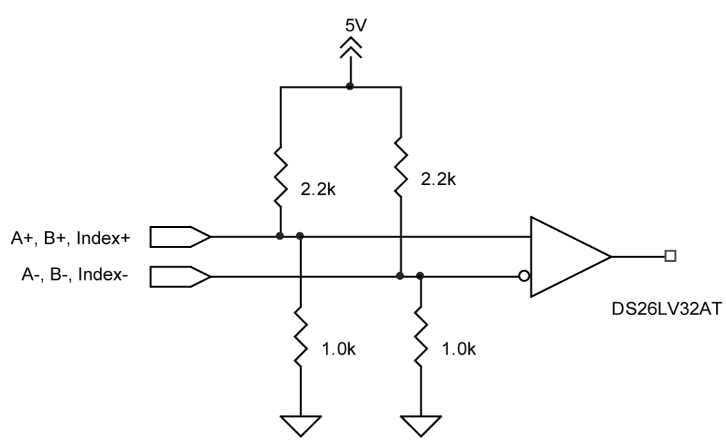
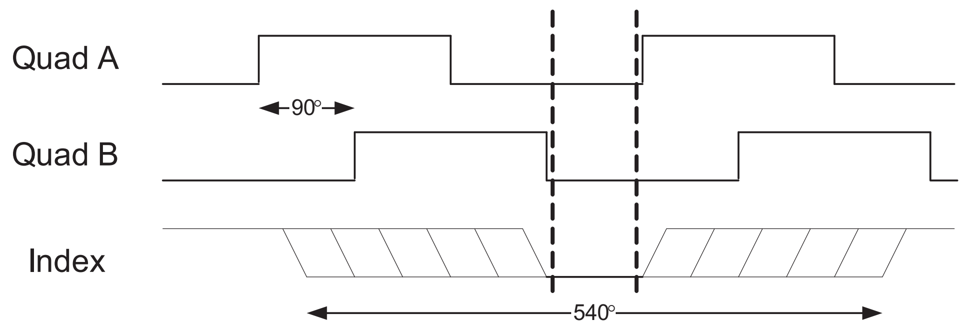


Figure 5-1: Main Encoder Input Circuits

For full functionality, ION requires a three channel (with Index) incremental encoder for the main feedback. The required index alignment is shown in Figure 5-2. ION qualifies the *Index* with the *A* and *B* quadrature inputs and recognizes an Index event when all signals (*A*, *B* and *Index*) are low.

Figure 5-2: Encoder Phasing Diagram



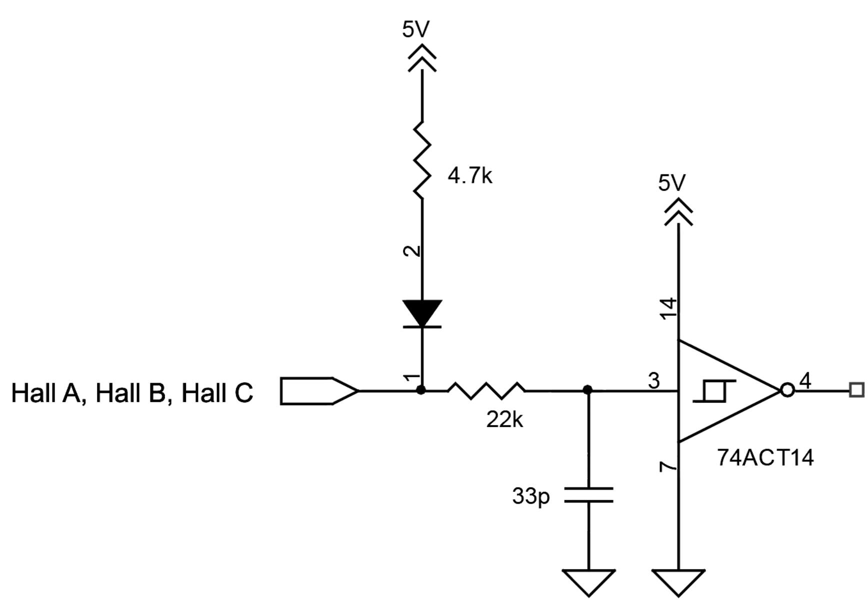
Correct Index phasing and polarity is required for the ION to operate properly. The A & B channels can be swapped and the quadrature signals inverted as required at the differential inputs to achieve the above phasing alignment...

While the motion control IC has the ability to invert the polarity of the A, B and Index signals with a software command, this command cannot be used to alter the index alignment because the inversion takes effect after index qualification.

5.1.2 Hall Inputs

The input buffer for the *Hall A*, *B* and *C* signals is shown in Figure 5-3. This circuit accepts signals in the range of 0-24V and has TTL compatible, Schmitt trigger thresholds. It has a pull-up to 5V to allow direct interfacing to open collector sources without the need for an external pull-up resistor and an R-C low pass filter to reject noise.

Figure 5-3: Ethernet/Serial ION Hall Input Circuits



.The *Hall* signals are only used with brushless DC motors. They are used to directly commutate the motor in 6-step commutation mode or to provide an absolute phase reference for sinusoidal commutation.

On the Ethernet/Serial ION, the circuit is as shown in Figure 5-4.

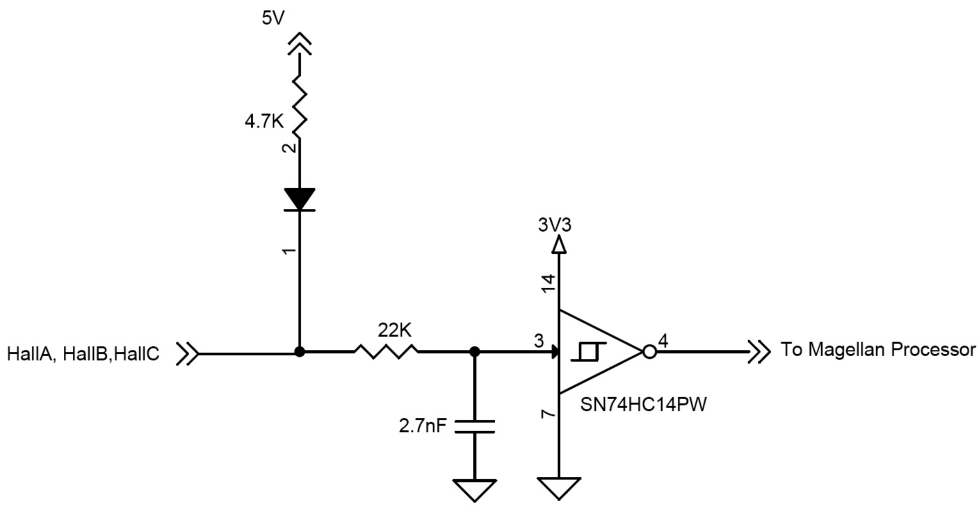


Figure 5-4: Ethernet/Serial ION Limit and Home Circuit

5.2 Auxiliary Position Input

The differential input circuitry for the auxiliary position input signals is shown in Figure 5-5. This circuit accepts both differential and single-ended signals in the range of 0-5V. For single-ended operation, the unused input should be left floating.

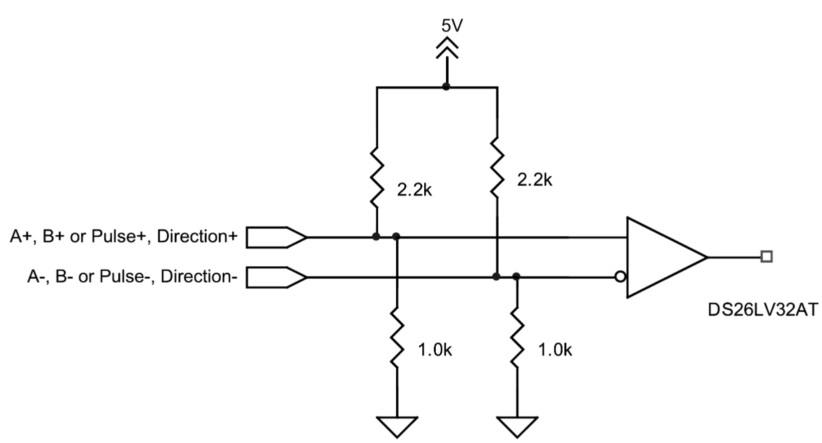


Figure 5-5: Auxiliary Encoder Input Circuits

Auxiliary encoder input is optional and can be used for general-purpose position feedback, as the master in electronic gearing applications, or as part of a dual-loop filter compensation scheme. See the *Magellan Motion Control IC User Manual* for information on these operational modes.

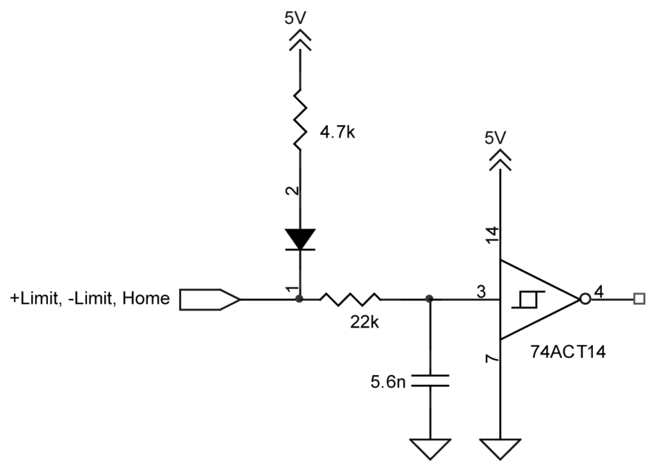
Pulse & direction input (available on ION 3000 only) is optional and can be used for either general purpose position feedback or as the master in electronic gearing applications. To select pulse & direction as the input format for the auxiliary position input, use the Magellan command Set Encoder Source with axis #2 selected. See the *Magellan Motion Control IC User Manual* for more information.

There is no index pulse input on the auxiliary position input.

5.3 Limit and Home Inputs

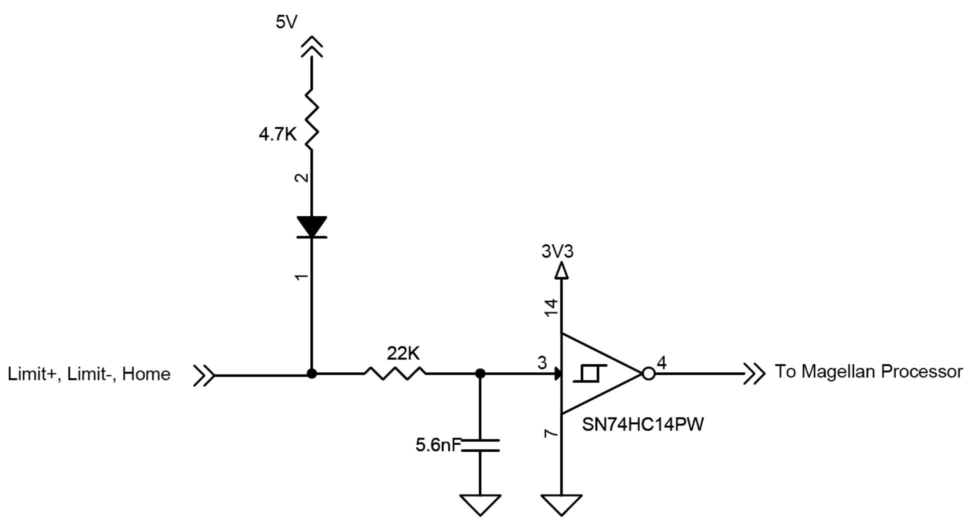
The input buffer for the end-of-travel limit and home signals is shown in Figure 5-6. This circuit accepts signals in the range of 0–24V and has TTL compatible, Schmitt trigger thresholds. It has a pull-up to 5V to allow direct interfacing to open collector sources without the need for an external pull-up resistor and a 1.3 kHz R-C low pass filter to reject noise.

Figure 5-6: Limit and Home Input Circuits



On the Ethernet/Serial ION, the circuit is as shown in Figure 5-7.

Figure 5-7: Ethernet/Serial ION High Speed Capture Circuit



5.4 Position Capture Sources

The Magellan Motion Control IC has the ability to capture the instantaneous position of the main feedback encoder when a trigger is received from a hardware input. The ION module supports three trigger sources: *Encoder Index*, *Home* and *High Speed Capture* input. The choice of trigger source is selectable through software. The input circuits for *Index* and *Home* are described in sections 5.1.1 and 5.3, respectively.

5.4.1 High Speed Capture Input

This dedicated input is specifically designed for high speed signals. It is similar to the Home input with the exception that the R-C low-pass filter bandwidth has been increased to 1.2 MHz. This value is a compromise between noise rejection and trigger latency. The High Speed Capture Circuit is shown in Figure 5-8.

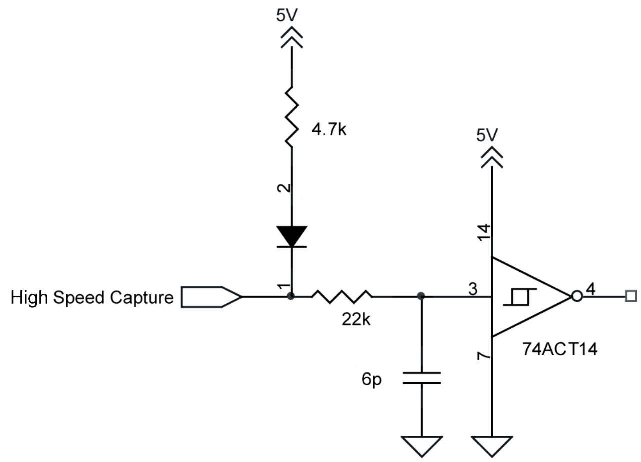


Figure 5-8: High Speed Capture

On the Ethernet/Serial ION, the circuit is as shown in Figure 5-9.

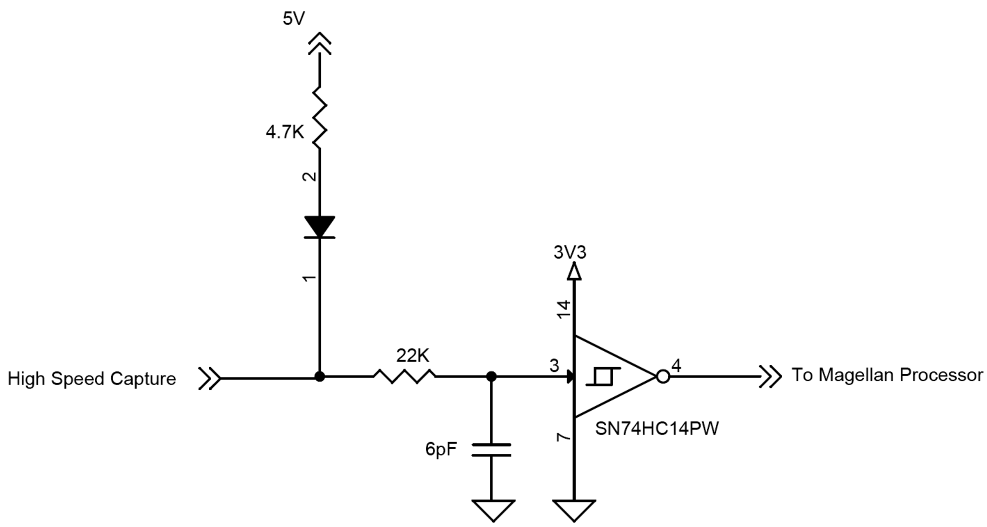
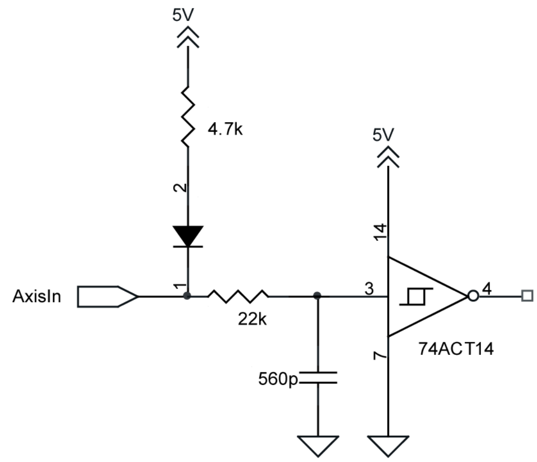


Figure 5-9: Ethernet/Serial ION AxisIn Circuit

5.5 AxisIn and AxisOut Signals

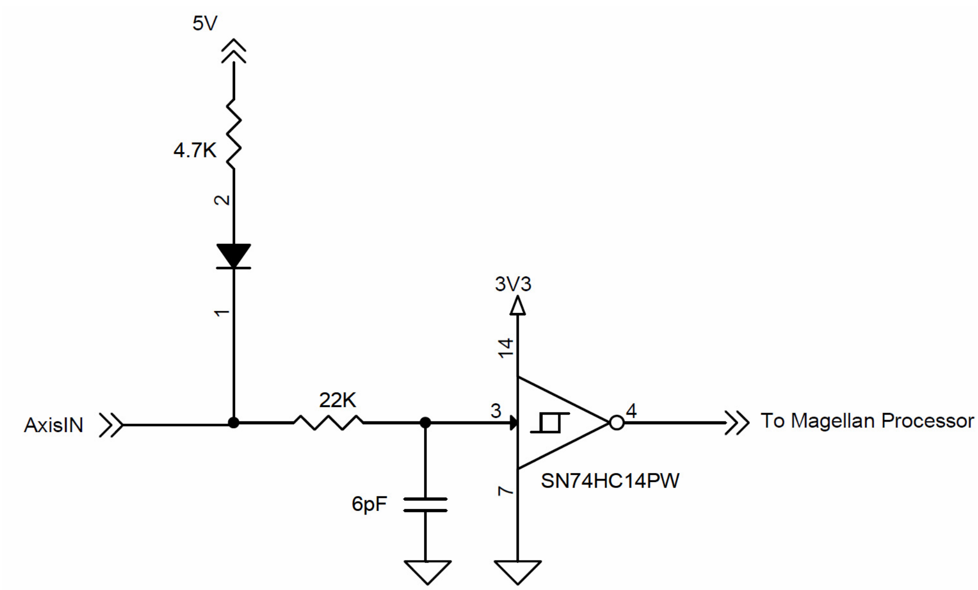
The input buffer for the *AxisIn* signal is shown in Figure 5-10. This circuit accepts signals in the range of 0-24V and has TTL compatible, Schmitt trigger thresholds. It has a pull-up to 5V to allow direct interfacing to open collector sources without the need for an external pull-up resistor and a 13 kHz R-C low pass filter to reject noise.

Figure 5-10: AxisIn Circuit



On the Ethernet/Serial ION, the circuit is as shown in Figure 5-11.

Figure 5-11: Ethernet/Serial ION AxisOut Circuit



The output driver for the *AxisOut* signal is shown in Figure 5-12. This circuit can continuously sink over 100 mA and source 4mA from a pull-up resistor to 5V. The diode in series with the pull-up resistor allows loads powered from up to 24VDC to be switched. The FET driver is internally protected from shorts up to 30V.

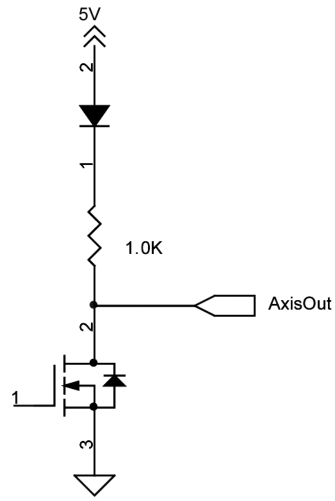


Figure 5-12: AxisOut Circuit

AxisIn and ***AxisOut*** are versatile I/O signals. They are not dedicated to any particular motion control function but can be programmed to implement a wide array of system integration functions. See the *Magellan Motion Control IC User Guide* for more information on configuring and programming these signals.

On the Ethernet/Serial ION, the circuit is as shown in Figure 5-13.

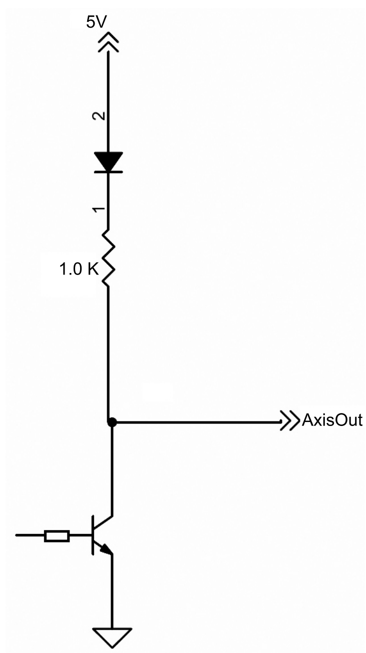


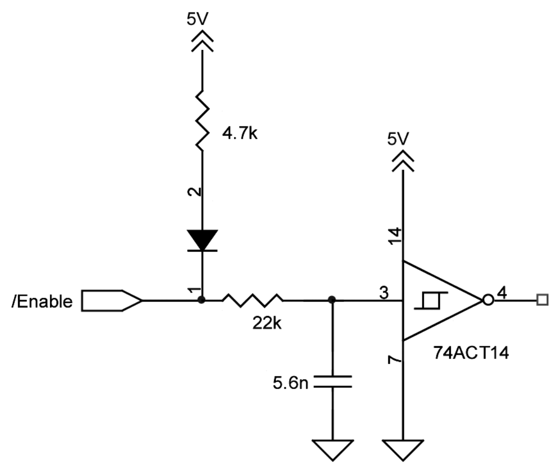
Figure 5-13: Ethernet Serial ION AxisOut Circuit

5.6 /Enable and FaultOut Signals

These dedicated signals are typically used to implement a safety interlock between the ION module and other control portions of the system. ***/Enable*** is an active-low input that must be tied or driven low for the ION output stage to be active. Similarly, ***FaultOut*** indicates any serious problem by going high. When ION is operating properly, ***FaultOut*** is low. The polarity of these signals is fixed and cannot be changed via software.

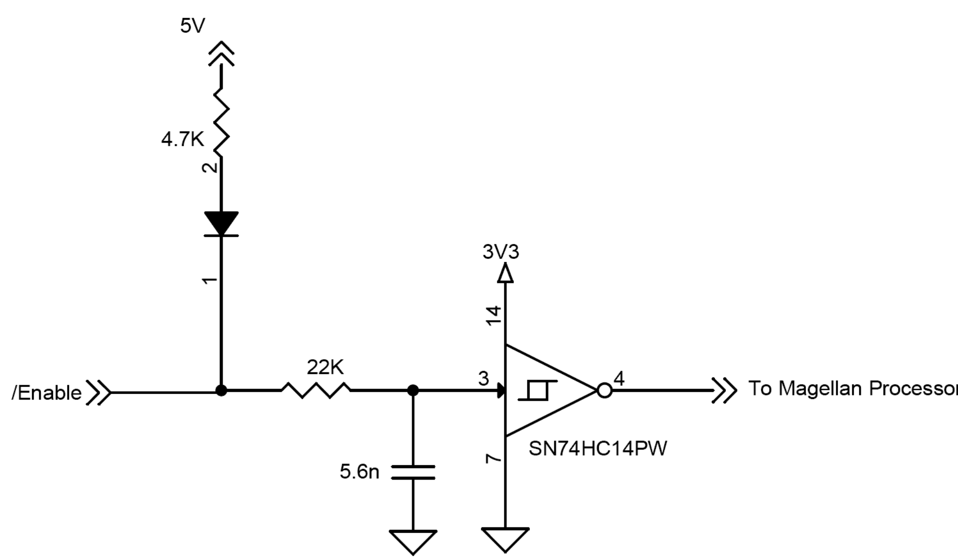
The input buffer for the ***/Enable*** input is shown in Figure 5-14. This circuit accepts signals in the range of 0-24V and has TTL compatible, Schmitt trigger thresholds. It has a pull-up to 5V to allow direct interfacing to open collector enable sources without the need for an external pull-up resistor and a 1.3 kHz R-C low pass filter to reject noise.

Figure 5-14: Enable Input Circuit



On the Ethernet/Serial ION, the circuit is as shown in Figure 5-15.

Figure 5-15: Ethernet/Serial ION/Enable Input Circuit



The output driver for ***FaultOut*** is shown in Figure 5-16. This circuit can continuously sink over 100 mA and source 4mA from a pull-up resistor to 5V. The diode in series with the pull-up resistor allows loads powered from up to 24VDC to be switched. The FET driver is internally protected from shorts up to 30V.

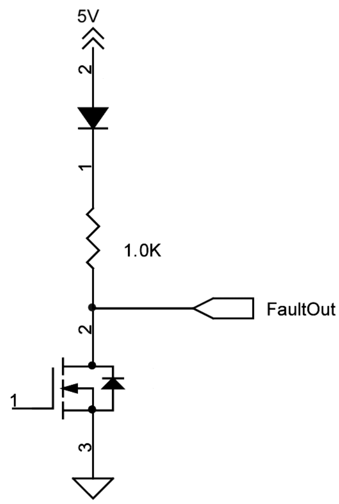


Figure 5-16: FaultOut Circuit

On the Ethernet/Serial ION, the circuit is as shown in Figure 5-17.

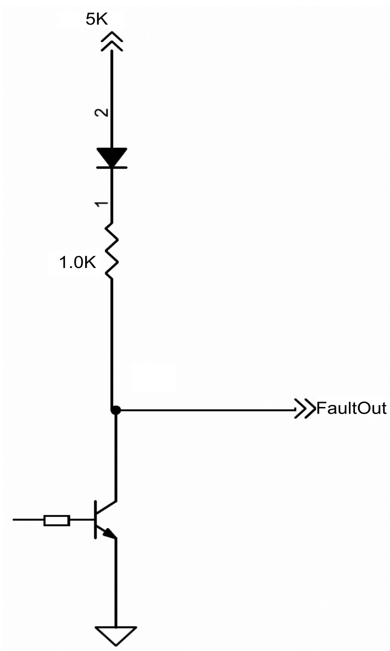


Figure 5-17: Ethernet/Serial ION FaultOut Circuit

When the ION is powered off, *FaultOut* is effectively high impedance and unable to sink current This state should be interpreted as “Fault” by the receiving circuit.

This page intentionally left blank.

6. ION 500 Specifications

In This Chapter

6.1 ION 500 Drive Ratings

	Motor Model		
Specification	**DC Brush**	**Brushless DC**	**Step**
Nominal supply voltage	48VDC	48VDC	48VDC
Supply voltage range transformer isolated power supply	12-56VDC	12-56VDC	12-56VDC
Output current (per phase) - Continuous, DIN rail mount, w/heat sink, free air @ 25 C - Continuous, coldplate mount, Tbp*<50 C - Peak (2 sec)	 6 ADC 9.8 ADC 21.2 ADC	 6 Arms (8.5 ADC) 8 Arms (11.3 ADC) 15 Arms (21.2 ADC)	 5 Arms (7.1 ADC) 5 Arms (7.1 ADC) 15 Arms (21.2 ADC)
Maximum continuous output power - Coldplate mount, Tbp*<50 C	 450 W	 500 W	 350 W

*Tbp = Temperature of base plate

6.2 ION 500 Controller Performance

Supported motor type	DC brush, Brushless DC, Step motor	
Communications options	Ethernet, RS232/485, CANbus	
Profile modes	S-curve point-to-point	Position, velocity, acceleration, deceleration, jerk parameters
	Trapezoidal point-to-point	Position, velocity, acceleration, deceleration
	Velocity-contouring	Velocity, acceleration, deceleration
	Electronic gearing	Using auxiliary encoder
Position loop filter parameters	Scalable PID with Velocity and Acceleration feedforward, integration limit, offset bias, dual biquad filter, and settable derivative sampling time. Also supports dual encoder feedback.	

Position error tracking	Motion error window	Allows axis to be stopped upon exceeding programmable window.
	Tracking window	Allows flag to be set if axis exceeds a programmable position window.
Configurable loop modes	DC brush and brushless DC motor versions	Position, torque/current and voltage
	Step motor version	Open loop with stall detection, current, and voltage
Digital current loop	Filter parameters	Scalable PI with integration limit and torque/current limit
	Configuration	Standard phase A/B control or FOC with state-vector PWM (user selectable)
	Current feedback scaling	100% full scale equals 21.2A
Current foldback	DC brush and brushless DC motor versions	Programmable I^2t peak limiting
Brushless DC commutation modes	Sinusoidal and 6-step (Hall) commutation	
Microstepping resolution	Up to 256 microsteps per step	
Maximum encoder rate	10 Mcounts per second	
PWM frequency	20 or 40 kHz (user selectable)	
Loop rates	Commutation & current loop	51.2 μsec
	Position loop & trajectory generator	102.4 μsec to 1.67 sec, selectable in multiples of 51.2 μsec from n = 2 to 2^{15}-1

6.3 ION 500 Electrical

AuxV input voltage range	12-56VDC	
AuxV maximum current:	0.5A	
IO_5V supply output	5V ±2%, 300 mA (total max.), short circuit protected.	
Differential/single-ended encoder inputs	Signals	Main encoder (A+, A-, B+, B-, Index+, Index-)
		Auxiliary encoder (A+, A-, B+, B-)
	Voltage range	0-5VDC
	Logic threshold	RS422 compatible
	Maximum frequency	2.5 MHz
	Phasing	A leads B by 90°±20°. Index low must align with the A low and B low states and be low for less than 540° total.
Digital inputs	Signals	Hall A, Hall B, Hall C, Home, +Limit, -Limit, AxisIn, High-speed Capture, /Enable
	Voltage range	0-24VDC
	Logic threshold	TTL compatible
Digital outputs	Signal	AxisOut, FaultOut
	Voltage range	0-24VDC
	Output current:	4 mA source, 100 mA sink, short circuit protected to 30V

RS232/485 communications	Baud Rates	1200, 2400, 9600, 19.2k, 57.6k, 115k, 230k, 460k Default baud rate is 57.6k. 460k support for RS485 only
	Isolation	None
	Termination	None
CANbus communications	Compatibility	CANbus 2.0b
	Baud Rates	10k, 20k, 50k, 125k, 250k, 500k, 800k, 1M Default baud rate is 20k.
	Isolation	Optocoupled
	Termination	External 121 Ohm RJ45 terminator
Ethernet communications	Compatibility	100BASE-TX
	Termination	External 121 Ohm RJ45 terminator

6.4 ION 500 Protection Circuits

Overtemperature	User programmable between 0°-70°C
Overvoltage	User programmable between 20V-60V
Undervoltage	User programmable between 10V-56V
Overcurrent	Fixed at <= 200% of drive peak rating
Short circuit protection	Line-to-line, line-to-power supply, and line-to-case ground

6.5 ION 500 Connectors and Pinouts

6.5.1 High Power Connectors

Connector: Power
Mating connector mfg/type: Molex MiniFit Jr. plug
Mating connector P/N: 39-01-4031
Wire range, AWG: 16
Recommended crimp terminal: 44476-3112

Pin	Signal
1	+HV
2	AuxV
3	Pwr_Gnd

Connector: Motor
Mating connector mfg/type: Molex MiniFit Jr. plug
Mating connector P/N: 39-01-4051
Wire range, AWG: 16
Recommended crimp terminal: 44476-3112

Pin	Signal
1	Motor+, Motor A, Motor A+
2	Motor B, Motor A-
3	Motor-, Motor C, Motor B+
4	Motor B-
5	Case/Shield

6.5.2 Signal Connectors

Connector: Feedback
Mating connector mfg/type: Molex MicroFit 3.0 plug
Mating connector P/N: 43025-1200
Wire range, AWG: 20-24
Recommended crimp terminal: 43030-0009
Alternate wire range, AWG: 26-30
Alternate crimp terminal: 43030-0012

Pin	Signal
1	Shield
2	IO_Gnd
3	IO_5V
4	Hall A
5	Hall B
6	Hall C
7	Quad A+
8	Quad A-
9	Quad B+
10	Quad B-
11	Index+
12	Index-

Connector: Auxiliary
Mating connector mfg/type: Molex MicroFit 3.0 plug
Mating connector P/N: 43025-0800
Wire range, AWG: 20-24
Recommended crimp terminal: 43030-0009
Alternate wire range, AWG: 26-30
Alternate crimp terminal: 43030-0012

Pin	Signal
1	Shield
2	IO_Gnd
3	IO_5V
4	No connect
5	Quad A+
6	Quad A-
7	Quad B+
8	Quad B-

Connector: I/O
Mating connector mfg/type: Molex MicroFit 3.0 plug
Mating connector P/N: 43025-1400
Wire range, AWG: 20-24
Recommended crimp terminal: 43030-0009
Alternate wire range, AWG: 26-30
Alternate crimp terminal: 43030-0012

Pin	Signal
1	Shield
2	IO_Gnd
3	IO_5V
4	IO_Gnd
5	IO_5V
6	IO_Gnd
7	FaultOut
8	+Limit
9	-Limit
10	Home
11	High Speed Capture
12	AxisIn
13	AxisOut
14	/Enable

6.5.3 Communications Connectors

Connector: RS232/485

Mating connector mfg/type: Generic DB9M (Male)

Used For: ION 500 Unit with Serial Communication Option

Pin	Signal
1	Select
2	Tx (RS232)
3	Rx (RS232)
4	No connect
5	IO_Gnd
6	Rx+ (RS485)
7	Rx- (RS485)
8	Tx+ (RS485)
9	Tx- (RS485)

Connector: CANbus

Mating connector mfg/type: Generic RJ45 8P8C

Used For: ION 500 Unit with CAN Communication Option

*The dual RJ45 jacks are fully connected in parallel. CANbus_V, CANbus_Shield, and the Reserved pins are not connected internally and simply pass the signals through to the other jack.

Pin	Signal
1	CANbus_H
2	CANbus_L
3	CANbus_Gnd
4	Reserved*
5	Reserved*
6	CANbus_Shield*
7	CANbus_Gnd
8	CANbus_V*

Connector: Serial RS232/485

Mating connector mfg/type: Generic RJ45 8P8C

Used For: ION 500 Unit with Serial + Ethernet Communication Option.

Pin	RS232	RS485
1	Unused	Unused
2	Unused	Unused
3	Rx	Rx+
4	Unused	Tx+
5	Tx	Tx-
6	Unused	Rx-
7	Gnd	Gnd
8	Select = Float/High	Select = low

Connector: Ethernet

Mating connector mfg/type: Generic RJ45 8P8C

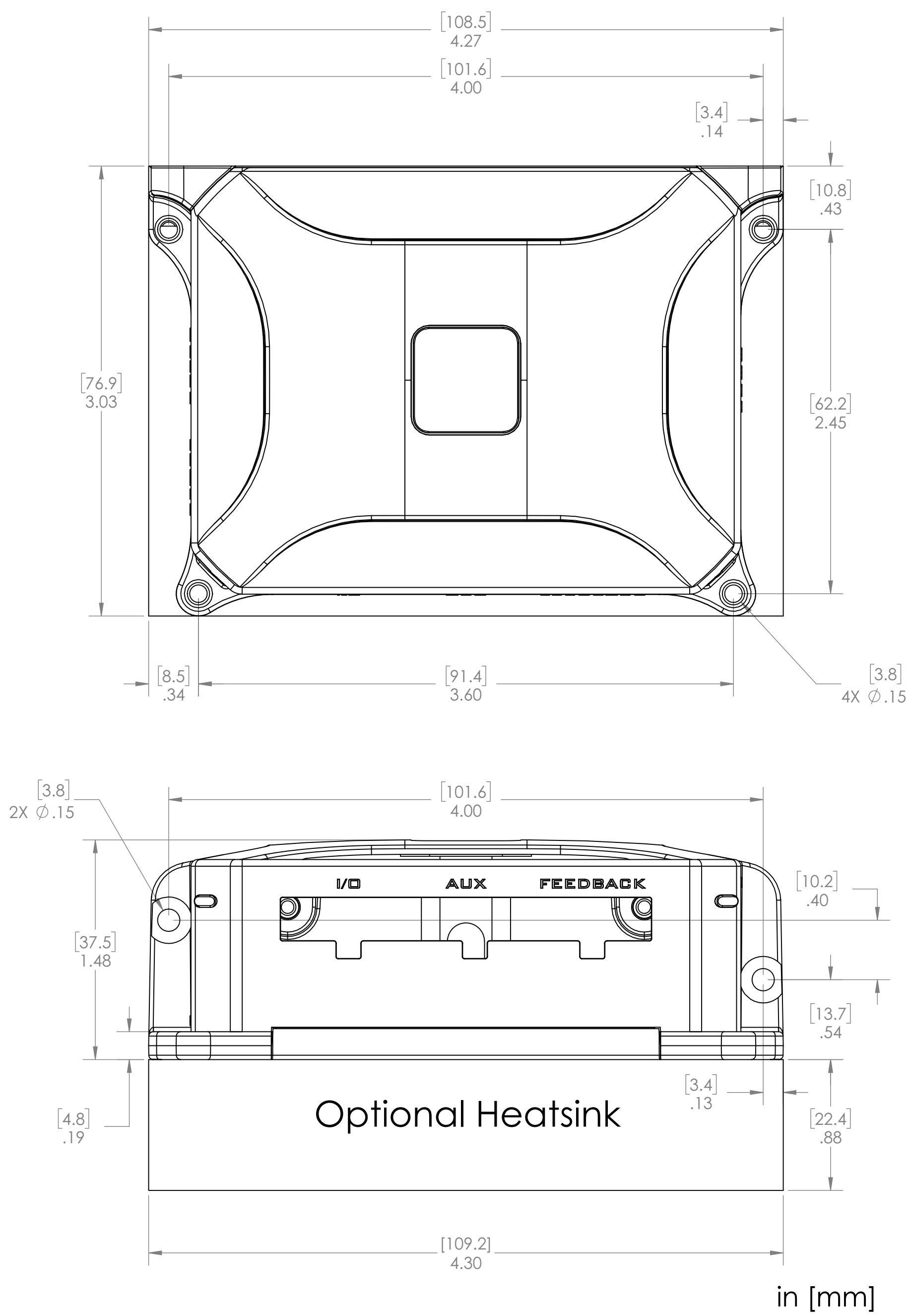
Used For: ION 500 Unit with Serial + Ethernet Communication Option

Pin	Signal
1	Transmit+
2	Transmit-
3	Receive+
4	Unused
5	Unused
6	Receive-
7	Unused
8	Unused

6.6 ION 500 Mechanical

Specification	Value
Dimensions	See Figure 6-1
Weight - without heat sink - with heat sink	 0.6 lb [0.28 kg] 1.1 lb [0.5 kg]
Enclosure materials	Aluminum base and molded plastic cover
Mounting options	Coldplate, panell
Recommended mounting screws	#6, M3, or M3.5
Protection class	IP20

Figure 6-1: ION 500 Dimensions



6.7 ION 500 Environmental

Specification	Value
Operating ambient temperature	0°-60 °C
Maximum base plate temperature	70°C
Storage temperature	-20° to 85°C
Humidity	0 to 95%, non-condensing
Altitude	Up to 2000 meters without derating
Contamination	Pollution Degree 2

6.8 ION 500 Safety and Compliance

Specification	Standards
CE	LVD: EN60204-1 EMC-D: EN61000-6-1, EN61000-6-3, EN55011
Electrical safety	Designed to UL508c, UL840, and EN60204-1
Hazardous materials	RoHS compliant
Flammability	UL 94-V2 or V0
Enclosure	IP20

6.9 ION 500 Thermal Operating Curves

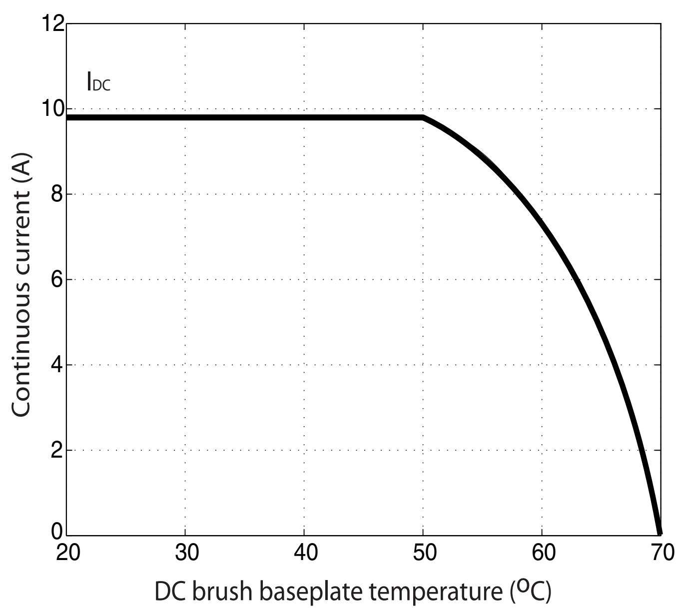
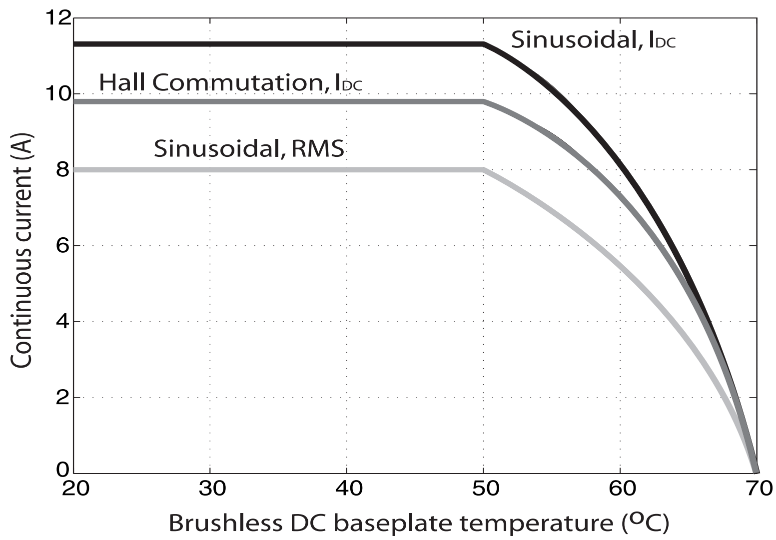


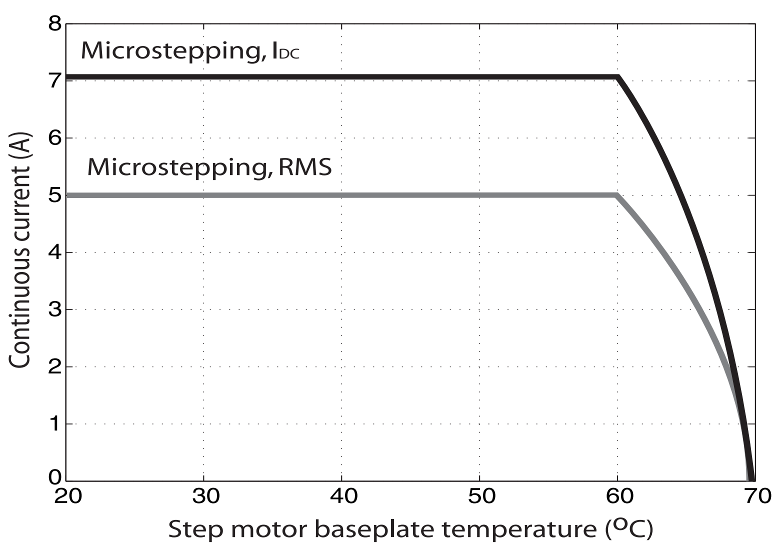
Figure 6-2: ION 500 Derating Curve for DC Brush Module

Figure 6-3: ION 500 Derating Curves for Brushless DC Module



Note: $I_{DC} = 1.414*I_{RMS}$

Figure 6-4: ION 500 Derating Curves for Step Motor Module



Note: $I_{DC} = 1.414*I_{RMS}$

7. ION 3000 Specifications

In This Chapter

7.1 ION 3000 Drive Ratings

	Motor Model		
Specification	**DC Brush**	**Brushless DC**	**Step**
Supply voltage range transformer isolated power supply	20-195 VDC	20-195VDC	20-195VDC
Output current (per phase) at 48V nominal voltage			
- Continuous, coldplate mount, Tbp*<40 C	20 ADC	15 Arms	10.6 Arms
- Peak (per phase)	30 A	30 A	30 A
Maximum continuous output power at 48V nominal voltage	960 W	882 W	650 W
Output current (per phase) at 180V nominal voltage			
- Continuous, coldplate mount, Tbp*<40 C	15 ADC	10.6 Arms	5.7 Arms
- Peak (per phase)	30 A	30 A	30 A
Max continuous output power at 180V nominal voltage	2700 W	2336 W	1310 W

*Tbp = Temperature of base plate

7.2 ION 3000 Controller Performance

Supported motor types	DC brush, brushless DC, step motor	
Communications options	RS232/485 and CANbus. Both RS485 and CAN versions are networkable	
Profile modes	S-curve point-to-point	Position, velocity, acceleration, deceleration, jerk
	Trapezoidal point-to-point	Position, velocity, acceleration, deceleration.
	Velocity-contouring	Velocity, acceleration, deceleration.
	Electronic gearing	Using auxiliary encoder or pulse and direction.

Position loop filter parameters	Scalable PID with Velocity and Acceleration feedforward, integration limit, offset bias, dual biquad filter, and settable derivative sampling time. Also supports dual encoder feedback	
Position error tracking	Motion error window	Allows axis to be stopped upon exceeding programmable window.
	Tracking window	Allows flag to be set if axis exceeds a programmable position window.
Configurable loop modes	DC brush and brushless DC motor versions	Position, torque/current and voltage.
	Step motor version	Open loop with stall detection, current, and voltage
Digital current loop	Filter parameters	Scalable PI with integration limit and torque/current limit
	Configuration	Standard phase A/B control or FOC with state-vector PWM (user selectable)
	Current feedback scaling	100% full scale equals 42.4A
Current foldback	DC brush and brushless DC motor versions	Programmable I^2t peak limiting
	Step motor version	Programmable automatic holding current reduction
Brushless DC commutation modes	Sinusoidal and 6-step (Hall) commutation	
Microstepping resolution	Up to 256 microsteps per step	
Maximum encoder rate	10 Mcounts per second.	
PWM frequency	20 kHz or 40 kHz (user selectable)	
Loop rates	Commutation & current loop	51.2 µsec
	Position loop & trajectory generator	102.4 µsec to 1.67 sec, selectable in multiples of 51.2 µsec from $n = 2$ to $2^{15}-1$

7.3 ION 3000 Electrical

AuxV input voltage range	20-95VDC	
AuxV maximum current:	0.5A	
IO_5V supply output	5V ±2%, 300 mA (total max.), short circuit protected	
Differential/single-ended encoder inputs	Signals	Main encoder (A+, A-, B+, B-, Index+, Index-)
		Auxiliary encoder (A+, A-, B+, B-) or Pulse+, Pulse-, Direction+, Direction-
	Voltage range	0-5VDC
	Logic threshold	RS422 compatible
	Maximum frequency	2.5 MHz
	Phasing	A leads B by 90°±20°. Index low must align with the A low and B low states and be low for less than 540° total.
Digital inputs	Signals	Hall A, Hall B, Hall C, Home, +Limit, -Limit, AxisIn, High-speed Capture, /Enable
	Voltage range	0-24VDC
	Logic threshold	TTL compatible
Digital outputs	Signal	AxisOut, FaultOut
	Voltage range	0-24VDC
	Output current:	4 mA source, 100 mA sink, short circuit protected to 30V
RS232/485 communications	Baud Rates	1200, 2400, 9600, 19.2k, 57.6k, 115k, 230k, 460k
		Default baud rate is 57.6k.
		460k support for RS485 only
	Isolation	None
	Termination	None
CAN communications	Compatibility	CAN 2.0b
	Baud Rates	10k, 20k, 50k, 125k, 250k, 500k, 800k, 1M
		Default baud rate is 20k.
	Isolation	Optocoupled
	Termination	External 121 Ohm RJ45 terminator

7.4 ION 3000 Protection Circuits

Overtemperature	User programmable between 0°-80°C
Overvoltage	User programmable between 20V-95V
Undervoltage	User programmable between 20V-195V
Overcurrent	Fixed at >50A
Short circuit protection	Line-to-line, line-to-power supply, and line-to-case ground

7.5 ION 3000 Connectors and Pinouts

7.5.1 High Power Connectors

Connector: Power
Mating connector mfg/type: Phoenix
Mating connector P/N: 1804917
Wire range, AWG: 14

Pin	Signal
1	+HV
2	AuxV
3	Pwr_Gnd

Connector: Motor
Mating connector mfg/type: Phoenix
Mating connector P/N: 1804933
Wire range, AWG: 14

Pin	Signal
1	Motor+, Motor A, Motor A+
2	Motor-, Motor B, Motor A-
3	Motor C, Motor B+
4	Motor B-
5	Case/Shield

7.5.2 Signal Connectors

Connector: Feedback
Mating connector mfg/type: Molex MicroFit 3.0 plug
Mating connector P/N: 43025-1200
Wire range, AWG: 20-24
Recommended crimp terminal: 43030-0009
Alternate wire range, AWG: 26-30
Alternate crimp terminal: 43030-0012

Pin	Signal
1	Shield
2	IO_Gnd
3	IO_5V
4	Hall A
5	Hall B
6	Hall C
7	Quad A+
8	Quad A-
9	Quad B+
10	Quad B-
11	Index+
12	Index-

Connector: Auxiliary	Pin	Signal
Mating connector mfg/type: Molex MicroFit 3.0 plug	1	Shield
Mating connector P/N: 43025-0800	2	IO_Gnd
Wire range, AWG: 20-24	3	IO_5V
Recommended crimp terminal: 43030-0009	4	No connect
Alternate wire range, AWG: 26-30	5	Quad A+ or Pulse+
Alternate crimp terminal: 43030-0012	6	Quad A- or Pulse-
	7	Quad B+ or Direction+
	8	Quad B- or Direction-

Connector: I/O	Pin	Signal
Mating connector mfg/type: Molex MicroFit 3.0 plug	1	Shield
Mating connector P/N: 43025-1400	2	IO_Gnd
Wire range, AWG: 20-24	3	IO_5V
Recommended crimp terminal: 43030-0009	4	IO_Gnd
Alternate wire range, AWG: 26-30	5	IO_5V
Alternate crimp terminal: 43030-0012	6	IO_Gnd
	7	FaultOut
	8	+Limit
	9	-Limit
	10	Home
	11	High Speed Capture
	12	AxisIn
	13	AxisOut
	14	/Enable

7.5.3 Communication Connectors

Connector: RS232/485	Pin	Signal
Mating connector mfg/type: Generic DB9M	1	Select
	2	Tx (RS232)
	3	Rx (RS232)
	4	No connect
	5	IO_Gnd
	6	Rx+ (RS485)
	7	Rx- (RS485)
	8	Tx+ (RS485)
	9	Tx- (RS485)

Connector: CAN	Pin	Signal
Mating connector mfg/type: Generic RJ45 8P8C	1	CAN_H
*The dual RJ45 jacks are fully connected in parallel. CAN_V, CAN_Shield and the Reserved pins are not connected internally and simply pass the signals through to the other jack.	2	CAN_L
	3	CAN_Gnd
	4	Reserved*
	5	Reserved*
	6	CAN_Shield*
	7	CAN_Gnd
	8	CAN_V*

7.6 ION 3000 Mechanical

Specification	Value
Dimensions	See Figure 7-1
Weight	1lb 1 oz [0.50 kg]
Enclosure materials	Aluminum base and molded plastic cover
Mounting options	Coldplate and panel
Recommended mounting screws	#6, M3, or M3.5
Protection class	IP20

7.7 ION 3000 Environmental

Specification	Value
Operating ambient temperature	0°-40°C
Maximum base plate temperature	70°C
Storage temperature	-20° to 85°C
Humidity	0 to 95%, non-condensing
Altitude	Up to 2000 meters without derating
Contamination	Pollution Degree 2

7.8 ION 3000 Safetly and Compliance

Specification	Standards
CE	LVD: EN60204-1 EMC-D: EN61000-6-1, EN61000-6-3, EN55011
Safety	UL recognized
Hazardous materials	RoHS compliant
Flammability	UL 94-V0
Enclosure	IP20

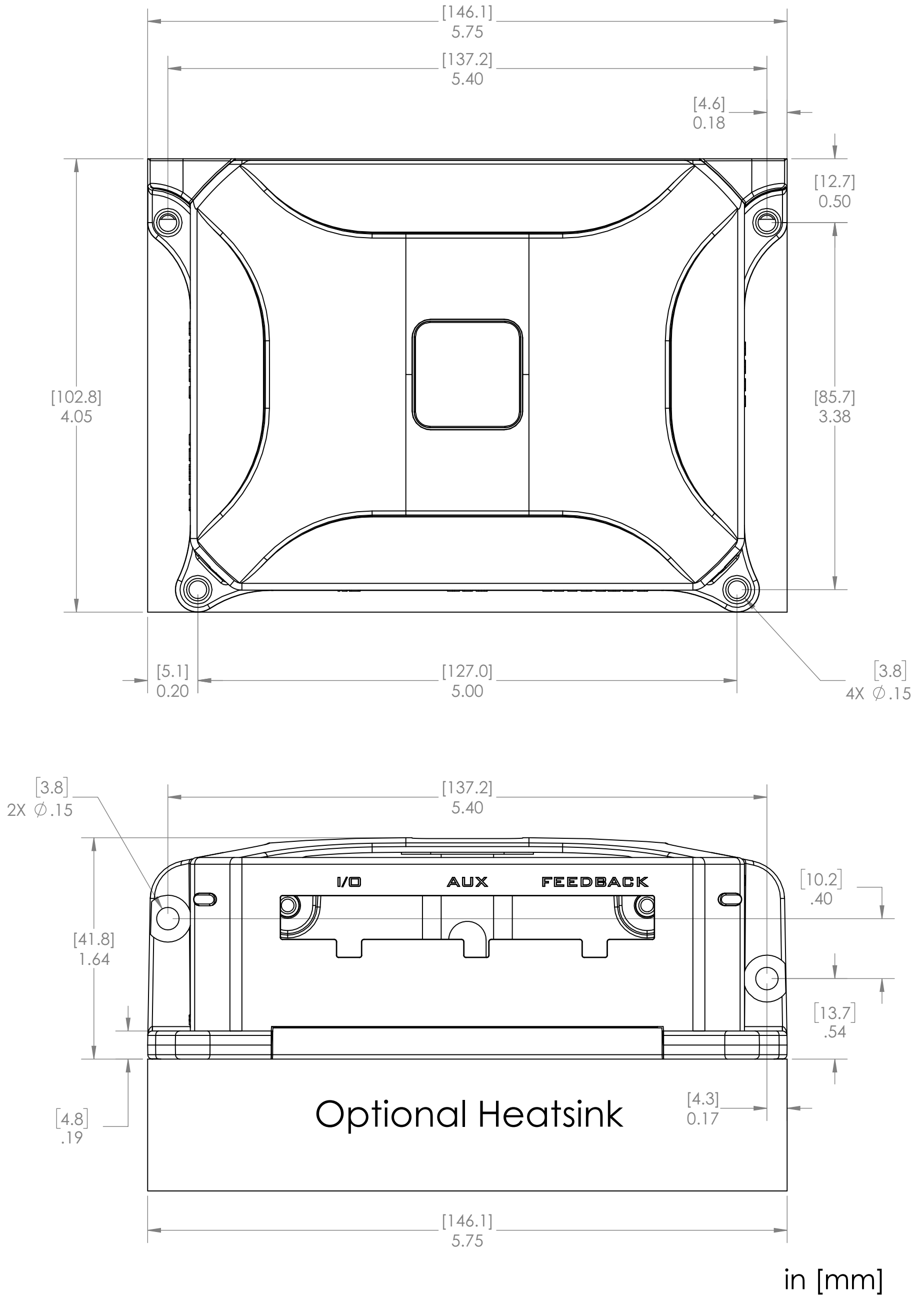


Figure 7-1: ION 3000 Dimensions

7.9 ION 3000 Thermal Operating Curves

Figure 7-2: BLDC Output Current vs Bus Voltage at 40°C Ambient

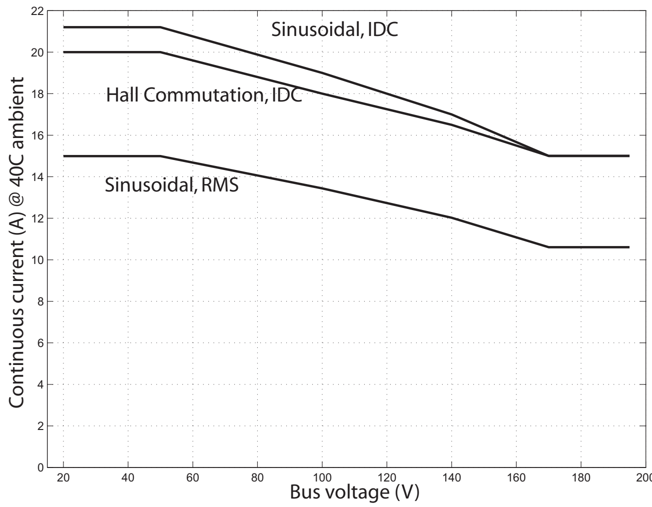
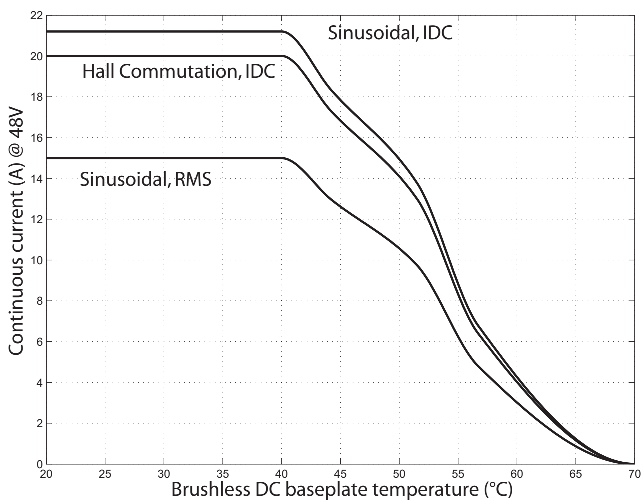


Figure 7-3: BLDC Output Current vs Temperature with 48V Input



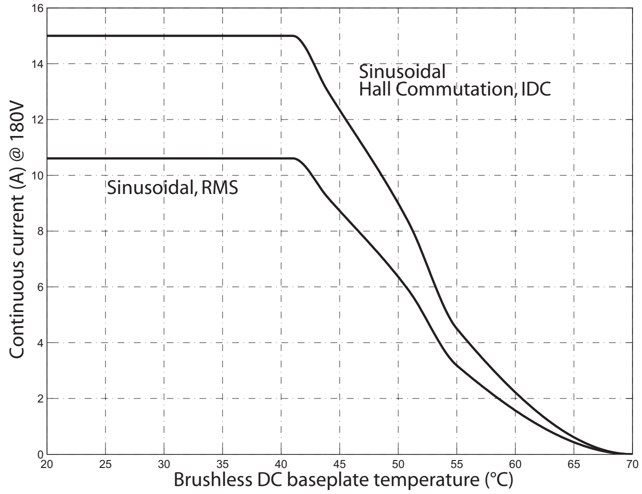


Figure 7-4: BLDC Output Current vs Temperature with 180V Input

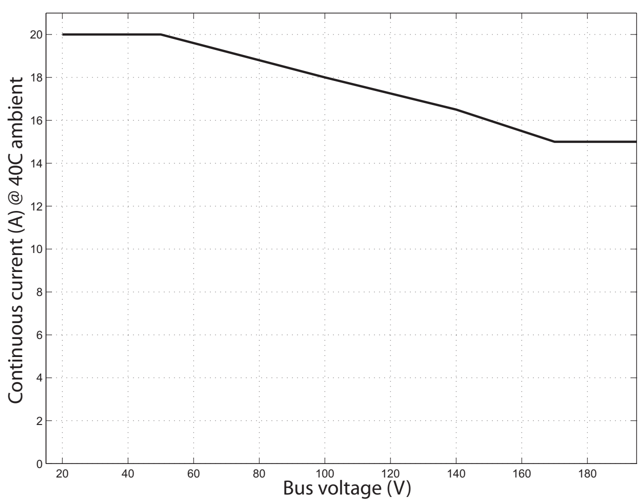


Figure 7-5: DC Brush Output Current vs Bus Voltage at 40°C Ambient

Figure 7-6: DC Brush Output Current vs Temperature with 48V Input

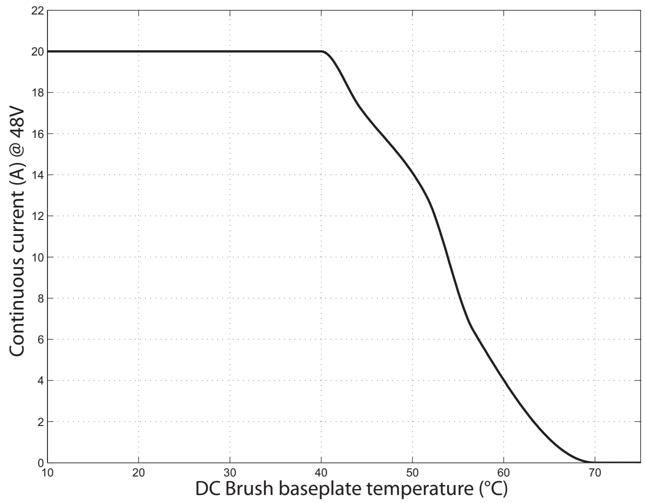
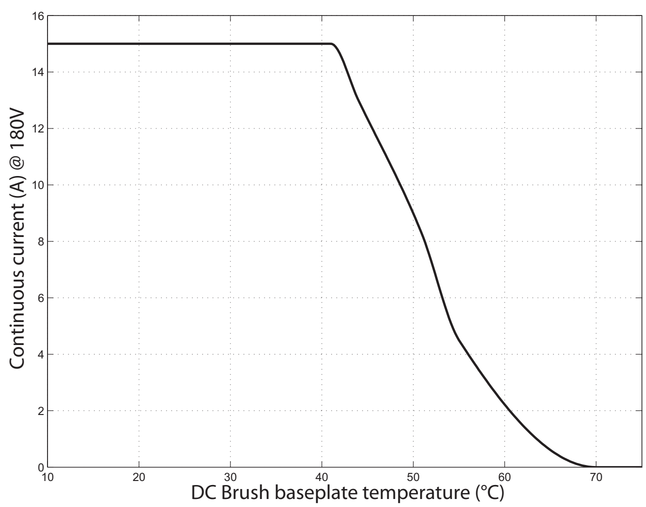


Figure 7-7: DC Brush Output Current vs Temperature with 180V Input



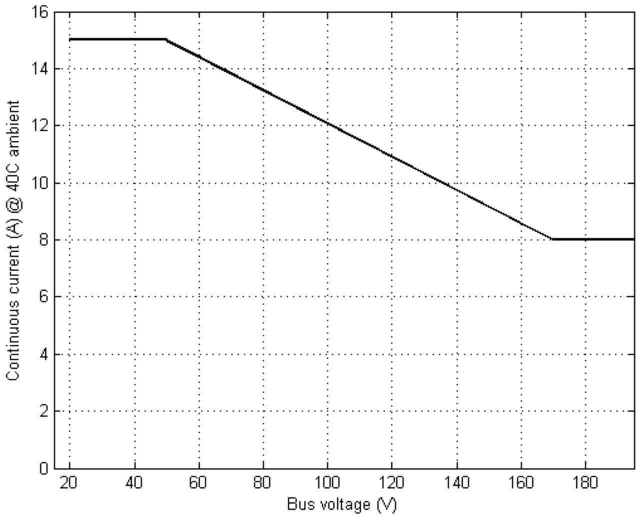


Figure 7-8: Microstepping Output Current vs Bus Voltage at 40°C Ambient

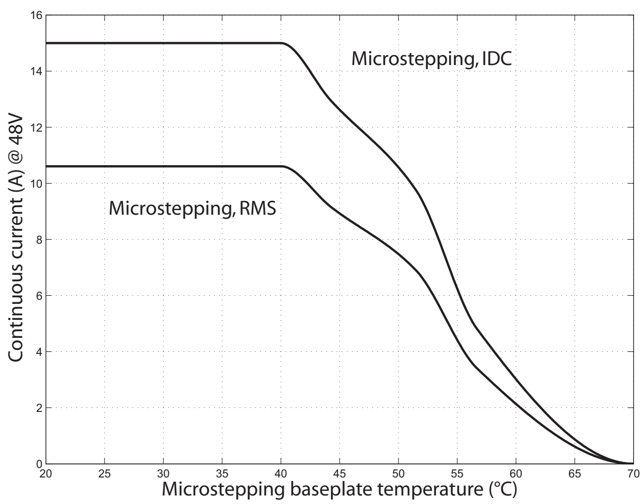
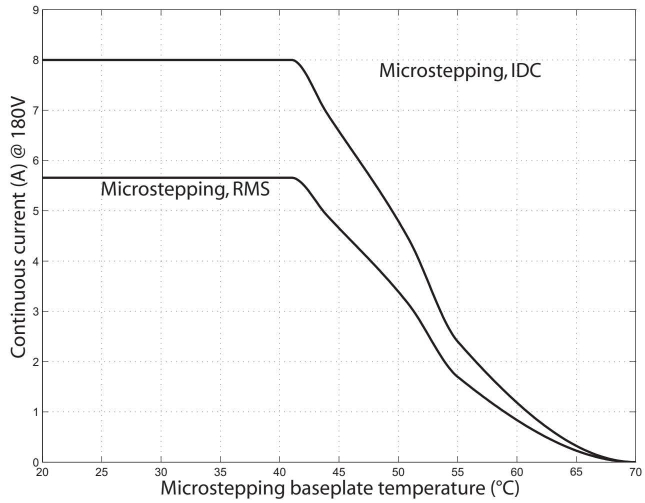


Figure 7-9: Microstepping Output Current vs Temperature with 48V Input

Figure 7-10: Microstepping Output Current vs Temperature with 180V Input



Index

S

T

U

W

For additional information or for technical assistance, please contact PMD at (781) 674-9860.

You may also e-mail your request to support@pmdcorp.com

Visit our website at http://www.pmdcorp.com

PMD

Performance Motion Devices
1 Technology Park Drive
Westford, MA 01886