



Ndrive HPe 150/200 Hardware Manual

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Table of Contents

Ndrive HPe 150/200 Hardware Manual	1
Table of Contents	3
List of Figures	5
List of Tables	7
EU Declaration of Conformity	9
Agency Approvals	10
Safety Procedures and Warnings	11
Quick Installation Guide	13
Chapter 1: Introduction	15
1.1. Drive and Software Compatibility	19
1.2. Electrical Specifications	20
1.2.1. System Power Requirements	21
1.3. Mechanical Design	22
1.4. Environmental Specifications	23
Chapter 2: Installation and Configuration	25
2.1. Communication Channel Settings	25
2.2. Power Connections	27
2.2.1. Control Supply Connections	27
2.2.2. Motor Supply Connections	28
2.2.3. Minimizing Conducted, Radiated, and System Noise	29
2.3. Motor Output Connections	30
2.3.1. Brushless Motor Connections	31
2.3.1.1. Powered Motor Phasing	32
2.3.1.2. Unpowered Motor and Feedback Phasing	33
2.3.2. DC Brush Motor Connections	34
2.3.2.1. DC Brush Motor Phasing	35
2.3.3. Stepper Motor Connections	36
2.3.3.1. Stepper Motor Phasing	37
2.4. Motor Feedback Connections (J207)	38
2.4.1. Encoder Interface (J207)	39
2.4.1.1. RS-422 Line Driver Encoder (Standard)	40
2.4.1.2. Absolute Encoder Interface (J207)	41
2.4.1.3. Analog Encoder Interface	42
2.4.1.4. Encoder Phasing	44
2.4.2. Hall-Effect Interface (J207)	46
2.4.3. Thermistor Interface (J207)	47
2.4.4. Encoder Fault Interface (J207)	48
2.4.5. End Of Travel Limit Input Interface (J207)	49
2.4.5.1. End Of Travel Limit Phasing	51
2.4.6. Brake Output (J207)	52
2.5. Emergency Stop Sense Input (TB201)	53
2.5.1. Typical ESTOP Interface	54
2.6. Auxiliary I/O Connector (J205)	55
2.6.1. Auxiliary Encoder Channel (J205)	56
2.6.2. Position Synchronized Output (PSO)/Laser Firing (J205)	58
2.6.3. Digital Outputs 8-11 (J205)	60
2.6.4. Digital Inputs 8-11 (J205)	62
2.6.5. High-Speed Digital Inputs 12-13 (J205)	64
2.6.6. Analog Output 0 (J205)	65
2.6.7. Differential Analog Input 0 (J205)	66
2.7. Brake Power Supply (TB202)	67

- 2.8. FireWire Interface 69
- 2.9. RS-232 Interface (J206) 70
- 2.10. -EXTSHUNT Option (TB101) 71
- 2.11. PC Configuration and Operation Information 73
- Chapter 3: -I/O Expansion Board 75**
 - 3.1. Relay Connector (TB301) 76
 - 3.2. PSO Output Interface (TB302) 78
 - 3.2.1. -DUALPSO and -TRIPLEPSO Laser Firing Options 79
 - 3.2.1.1. Multi-Axis Firing 79
 - 3.3. Analog Outputs (TB303) 81
 - 3.4. Analog Inputs (TB304) 82
 - 3.5. User Power (TB305, TB306) 83
 - 3.6. Opto In Connector (Digital Inputs) (TB305, TB306) 84
 - 3.7. Opto Out Connector (Digital Outputs) (TB307, TB308) 87
 - 3.8. SSINET (J302/J303) 91
- Chapter 4: -RDP Expansion Board 93**
- Chapter 5: Standard Interconnection Cables 97**
 - 5.1. Joystick Interface 98
 - 5.2. Handwheel Interface 100
- Chapter 6: Maintenance 101**
 - 6.1. Power Board 102
 - 6.2. Control Board 103
 - 6.3. Preventative Maintenance 105
- Appendix A: Warranty and Field Service 107**
- Appendix B: Revision History 109**
- Index 111**

List of Figures

Figure 1-1:	Ndrive HPe 150/200 Networked Digital Drive	15
Figure 1-2:	Functional Diagram	18
Figure 1-3:	Dimensions	22
Figure 2-1:	Device Number (S1) Location	25
Figure 2-2:	Control Supply Connections	27
Figure 2-3:	Motor Bus Input Connections	28
Figure 2-4:	Brushless Motor Configuration	31
Figure 2-5:	Encoder and Hall Signal Diagnostics	32
Figure 2-6:	Motor Phasing Oscilloscope Example	33
Figure 2-7:	Brushless Motor Phasing Goal	33
Figure 2-8:	DC Brush Motor Configuration	34
Figure 2-9:	Clockwise Motor Rotation	35
Figure 2-10:	Stepper Motor Configuration	36
Figure 2-11:	Clockwise Motor Rotation	37
Figure 2-12:	Line Driver Encoder Interface (J207)	40
Figure 2-13:	Serial Data Stream Interface	41
Figure 2-14:	Analog Encoder Phasing Reference Diagram	42
Figure 2-15:	Analog Encoder Interface (J207)	43
Figure 2-16:	Encoder Phasing Reference Diagram (Standard)	44
Figure 2-17:	Position Feedback in the Diagnostic Display	45
Figure 2-18:	Hall-Effect Inputs (J207)	46
Figure 2-19:	Thermistor Interface Input (J207)	47
Figure 2-20:	Encoder Fault Interface Input (J207)	48
Figure 2-21:	End of Travel Limit Input Connections	49
Figure 2-22:	End of Travel Limit Interface Input (J207)	50
Figure 2-23:	Limit Input Diagnostic Display	51
Figure 2-24:	ESTOP Sense Input (TB201)	53
Figure 2-25:	Typical Emergency Stop Circuit	54
Figure 2-26:	Auxiliary Encoder Channel (J205)	57
Figure 2-27:	PSO Interface	59
Figure 2-28:	Digital Outputs Connected in Current Sourcing Mode (J205)	61
Figure 2-29:	Digital Outputs Connected in Current Sinking Mode (J205)	61
Figure 2-30:	Digital Inputs Connected in Current Sourcing Mode (J205)	63
Figure 2-31:	Digital Inputs Connected in Current Sinking Mode (J205)	63
Figure 2-32:	High-Speed User Inputs (J205)	64
Figure 2-33:	Analog Output 0 (J205)	65
Figure 2-34:	Analog Input 0 (J205)	66
Figure 2-35:	Brake Connected to J207	68
Figure 2-36:	Brake Connected to TB202	68
Figure 3-1:	Ndrive HPe 150/200 with -IO Option Board	75
Figure 3-2:	Brake Connected to J207	77
Figure 3-3:	Brake Connected to TB301	77
Figure 3-4:	PSO Output Sources Current	78
Figure 3-5:	PSO Output Sinks Current	78
Figure 3-6:	Two/Three Axis Laser Firing Interconnection	80
Figure 3-7:	Analog Output Connector (TB303)	81
Figure 3-8:	Analog Input Typical Connection (TB304)	82
Figure 3-9:	Digital Opto-Isolated Inputs	85
Figure 3-10:	Digital Inputs Connected to a Current Sourcing Device	86
Figure 3-11:	Digital Inputs Connected to a Current Sinking Device	86
Figure 3-12:	Digital Opto-Isolated Outputs (-IO Board)	89

Figure 3-13: Digital Outputs Connected in Current Sourcing Mode90

Figure 3-14: Digital Outputs Connected in Current Sinking Mode 90

Figure 3-15: J302/J30392

Figure 4-1: -RDP Option Board 93

Figure 4-2: Resolver/Inductosyn Recommended Wiring 95

Figure 4-3: Resolver Inputs 95

Figure 4-4: Encoder Emulation Outputs96

Figure 5-1: Single Axis Joystick Interface (to Aux I/O) 98

Figure 5-2: Two Axis Joystick Interface (to the Aux I/O of two drives) 98

Figure 5-3: Two Axis Joystick Interface (to the Aux I/O and I/O Board)99

Figure 5-4: Two Axis Joystick Interface (to the I/O Board) 99

Figure 5-5: Handwheel Interconnection (to Aux I/O)100

Figure 5-6: Handwheel Interconnection (to Aux I/O via a BBA32 Module)100

Figure 6-1: Power Board Assembly102

Figure 6-2: Control Board Assembly103

List of Tables

Table 1-1:	Feature Summary	16
Table 1-2:	Ordering Options	16
Table 1-3:	Ordering Options (continued)	17
Table 1-4:	Accessories	17
Table 1-5:	Drive and Software Compatibility	19
Table 1-6:	Electrical Specifications	20
Table 1-7:	Physical Specifications	22
Table 2-1:	Device Number Switch Settings (S1)	26
Table 2-2:	Control Supply AC Input Wiring	27
Table 2-3:	Ferrite Noise Suppression Part Numbers	29
Table 2-4:	Motor Power Output Connections	30
Table 2-5:	Wire Colors for Aerotech Supplied Cables (Brushless)	31
Table 2-6:	Wire Colors for Aerotech Supplied Cables (DC Brush)	34
Table 2-7:	Wire Colors for Aerotech Supplied Cables (Stepper)	36
Table 2-8:	Motor Feedback Connector Pinout (J207)	38
Table 2-9:	Mating Connector Part Numbers for the Motor Feedback Connector (J207)	38
Table 2-10:	Encoder Interface Pins on the Motor Feedback Connector (J207)	39
Table 2-11:	Encoder Specifications	40
Table 2-12:	Analog Encoder Specifications	42
Table 2-13:	Hall-Effect Feedback Interface Pins on the Motor Feedback Connector (J207)	46
Table 2-14:	Thermistor Interface Pin on the Motor Feedback Connector (J207)	47
Table 2-15:	Encoder Fault Interface Pin on the Motor Feedback Connector (J207)	48
Table 2-16:	End of Travel Limit Input Interface Pins on the Motor Feedback Connector (J207)	49
Table 2-17:	Brake Output Pins on the Motor Feedback Connector (J207)	52
Table 2-18:	Electrical Noise Suppression Devices	53
Table 2-19:	Mating Connector Part Numbers for the ESTOP Connector (TB201)	53
Table 2-20:	Typical ESTOP Relay Ratings	54
Table 2-21:	Auxiliary I/O Connector Pinout (J205)	55
Table 2-22:	Mating Connector Part Numbers for the Auxiliary I/O Connector (J205)	55
Table 2-23:	Auxiliary Encoder Specifications	56
Table 2-24:	Auxiliary Encoder Channel Pins on the Auxiliary I/O Connector (J205)	56
Table 2-25:	PSO Specifications	58
Table 2-26:	PSO Output Pins on the Auxiliary I/O Connector (J205)	58
Table 2-27:	Digital Output Specifications	60
Table 2-28:	Digital Output Pins on the Auxiliary I/O Connector (J205)	60
Table 2-29:	Digital Input Specifications	62
Table 2-30:	Digital Input Pins on the Auxiliary I/O Connector (J205)	62
Table 2-31:	High-Speed Input Specifications	64
Table 2-32:	High-Speed Digital Input Pins on the Auxiliary I/O Connector (J205)	64
Table 2-33:	Input Voltage Jumper Configuration	64
Table 2-34:	Analog Output 0 Specifications (J205)	65
Table 2-35:	Analog Output Pins on the Auxiliary I/O Connector (J205)	65
Table 2-36:	Differential Analog Input 0 Specifications	66
Table 2-37:	Analog Input Pins on the Auxiliary I/O Connector (J205)	66
Table 2-38:	Relay Specifications	67
Table 2-39:	Brake Output Connector Pinout (TB202)	67
Table 2-40:	Mating Connector Part Numbers for the Brake Power Supply Connector (TB202)	67
Table 2-41:	FireWire Card Part Numbers	69
Table 2-42:	FireWire Repeaters (for cables exceeding 4.5 m (15 ft) specification)	69
Table 2-43:	FireWire Cables (copper and glass fiber)	69
Table 2-44:	-EXTSHUNT Component Information	71

Table 2-45: Maximum Additional Storage Energy	72
Table 3-1: -IO Expansion Board Jumper Configuration	75
Table 3-2: -IO Option Board Fuse Information	75
Table 3-3: Voltage and Current Specifications (TB301)	76
Table 3-4: Relay Connector Pinout (TB301)	76
Table 3-5: Mating Connector Part Numbers for the Relay Connector (TB301)	76
Table 3-6: -IO Expansion Board Brake Jumper Configuration	76
Table 3-7: PSO Output Connector Pinout (TB302)	78
Table 3-8: Mating Connector Pin Numbers for the PSO Output Connector (TB302)	78
Table 3-9: PSO Output Polarity Settings for JP2	78
Table 3-10: PSO Opto Output Specifications	78
Table 3-11: SSINet Cable Part Numbers	79
Table 3-12: Analog Output Specifications (TB303)	81
Table 3-13: Analog Output Connector Pinout (TB303)	81
Table 3-14: Mating Connector Part Numbers for the Analog Output Connector (TB303)	81
Table 3-15: Differential Analog Input 1 Specifications (TB304)	82
Table 3-16: Analog Inputs Connector Pinout (TB304)	82
Table 3-17: Analog Input Mating Connector Part Numbers for the Analog Input Connector (TB304) ..	82
Table 3-18: User Common Pin on the Opto In Connector (TB305)	83
Table 3-19: +5 Volt Power Pin on the Opto In Connector (TB306)	83
Table 3-20: Digital Input Device Specifications	84
Table 3-21: Opto In Connector Pinout (TB305)	84
Table 3-22: Opto In Connector Pinout (TB306)	84
Table 3-23: Mating Connector Part Numbers for the Opto In Connector (TB305/TB306)	84
Table 3-24: Digital Output Specifications (TB307, TB308)	87
Table 3-25: Opto Out Connector Pinout (TB307)	88
Table 3-26: Opto Out Connector Pinout (TB308)	88
Table 3-27: Mating Connector for the Opto Out Connector (TB307/TB308)	88
Table 3-28: J302, J303 2-Channel SSINet Connector Pin Assignment	91
Table 4-1: -RDP Expansion Board Jumper Configuration	93
Table 4-2: -RDP Connector Pin Assignment (J401/J402)	94
Table 4-3: Resolver Mating Connector	94
Table 4-4: Resolver Test Points	96
Table 5-1: Standard Interconnection Cables	97
Table 5-2: Cable Part Numbers	99
Table 6-1: LED Description	101
Table 6-2: Fuse Information	102
Table 6-3: Control Board Jumper Configuration	103
Table 6-4: Control Board Fuse Information	104
Table 6-5: LED Description	104
Table 6-6: Preventative Maintenance	105

EU Declaration of Conformity

Manufacturer Aerotech, Inc.
Address 101 Zeta Drive
 Pittsburgh, PA 15238-2811
 USA
Product Ndrive HPe 150/200
Model/Types All

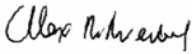
This is to certify that the aforementioned product is in accordance with the applicable requirements of the following Directive(s):

- | | |
|------------|---|
| 2014/30/EU | Electromagnetic Compatibility Directive |
| 2014/35/EU | Low Voltage Directive |
| 2011/65/EU | RoHS 2 Directive |

and has been designed to be in conformity with the applicable requirements of the following Standard(s) when installed and used in accordance with the manufacturer’s supplied installation instructions.

- | | |
|-----------------|---|
| EN 61800-3:2004 | EMC Requirements for Power Drives |
| EN 61326-1:2013 | EMC Requirements for Measurement, Control, & Laboratory Use |
| EN 61010-1:2010 | Safety Requirements for Electrical Equipment |

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Date 6/20/2019



Agency Approvals

Aerotech, Inc. Model Ndrive HPe 150/200 Series Digital Drives have been tested and found to be in accordance to the following listed Agency Approvals:

Approval / Certification:	CUS NRTL
Approving Agency:	TUV SUD America Inc.
Certificate #:	U8 17 01 68995 023
Standards:	CAN/CSA-C22.2 No. 61010-1:2012; UL 61010-1:2012

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Safety Procedures and Warnings

This manual tells you how to carefully and correctly use and operate the Ndrive HPe 150/200. Read all parts of this manual before you install or operate the Ndrive HPe 150/200 or before you do maintenance to your system. To prevent injury to you and damage to the equipment, obey the precautions in this manual. The precautions that follow apply when you see a Danger or Warning symbol in this manual. If you do not obey these precautions, injury to you or damage to the equipment can occur. If you do not understand the information in this manual, contact Aerotech Global Technical Support.

This product has been designed for light industrial manufacturing or laboratory environments. The protection provided by the equipment could be impaired if the product is used in a manner not specified by the manufacturer.

NOTE: Aerotech continually improves its product offerings; listed options may be superseded at any time. All drawings and illustrations are for reference only and were complete and accurate as of this manual's release. Refer to www.aerotech.com for the most up-to-date information.



DANGER: This product contains potentially lethal voltages. To reduce the possibility of electrical shock, bodily injury, or death the following precautions must be followed.

1. Disconnect electrical power before servicing equipment.
2. Disconnect electrical power before performing any wiring.
3. Access to the Ndrive HPe 150/200 and component parts must be restricted while connected to a power source.
4. To minimize the possibility of electrical shock and bodily injury, extreme care must be exercised when any electrical circuits are in use. Suitable precautions and protection must be provided to warn and prevent persons from making contact with live circuits.
5. Install the Ndrive HPe 150/200 inside a rack or enclosure.
6. The shunt resistor temperature can exceed 70°C during normal operation and contains lethal voltage on its terminals and surface. It must be properly enclosed and shielded to avoid risk of fire and operator shock.
7. Do not connect or disconnect any electrical components or connecting cables while connected to a power source.
8. All components must be properly grounded in accordance with local electrical safety requirements.
9. Operator safeguarding requirements must be addressed during final integration of the product.



DANGER: The Ndrive HPe 150/200 case temperature may exceed 70°C in some applications.

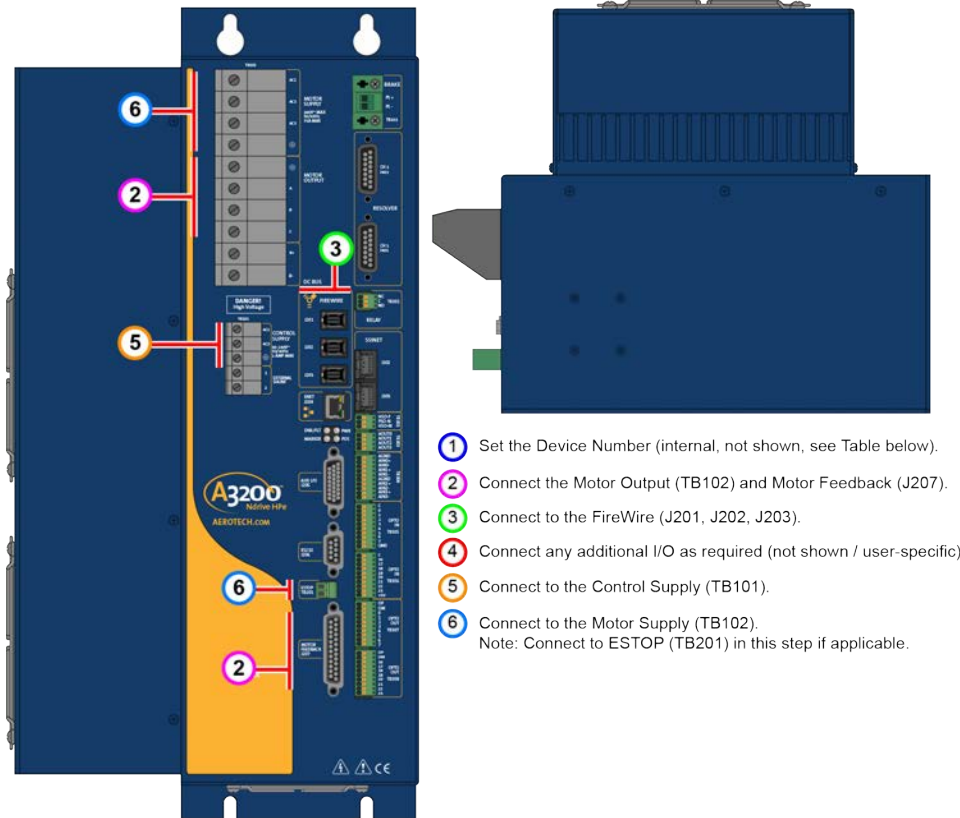


WARNING: To minimize the possibility of electrical shock, bodily injury or death the following precautions must be followed.

1. If the product is used in a manner not specified by the manufacturer, the protection provided by the product can be impaired and result in damage, shock, injury, or death.
2. Moving parts can cause crushing or shearing injuries. Access to all stage and motor parts must be restricted while connected to a power source.
3. Cables can pose a tripping hazard. Securely mount and position all system cables to avoid potential hazards.
4. Do not expose this product to environments or conditions outside of the listed specifications. Exceeding environmental or operating specifications can cause damage to the equipment.
5. Operators must be trained before operating this equipment.
6. All service and maintenance must be performed by qualified personnel.

Quick Installation Guide

This chapter describes the order in which connections and settings should typically be made to the Ndrive HPe 150/200. If a custom interconnection drawing was created for your system (look for a line item on your Sales Order under the heading “Integration”), that drawing can be found on your installation device.



- ① Set the Device Number (internal, not shown, see Table below).
- ② Connect the Motor Output (TB102) and Motor Feedback (J207).
- ③ Connect to the FireWire (J201, J202, J203).
- ④ Connect any additional I/O as required (not shown / user-specific).
- ⑤ Connect to the Control Supply (TB101).
- ⑥ Connect to the Motor Supply (TB102).
Note: Connect to ESTOP (TB201) in this step if applicable.

Figure 1: Quick Start Connections

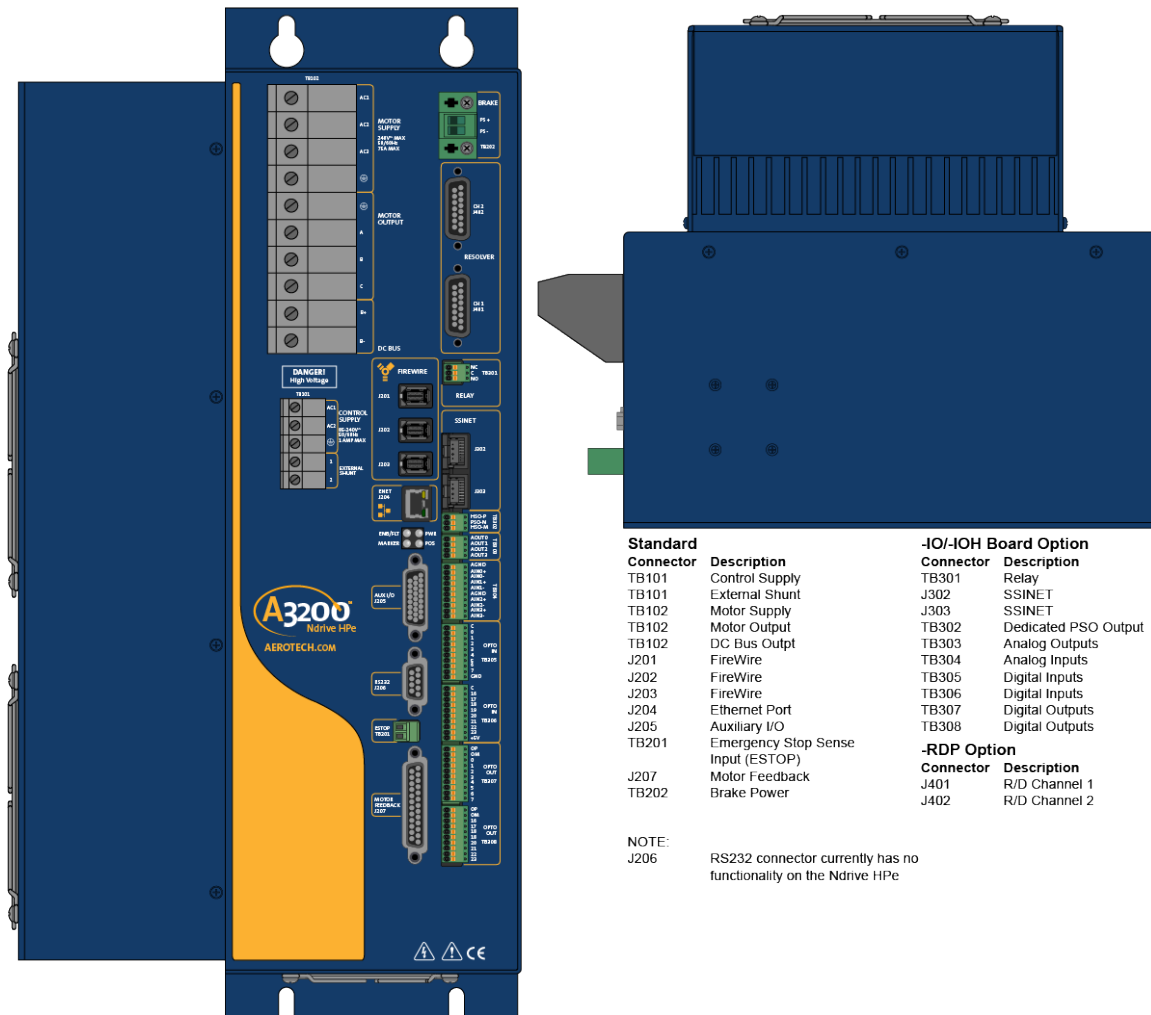
Topic	Section
Device Number	Section 2.1. Communication Channel Settings
Motor Output	Section 2.3. Motor Output Connections
Motor Feedback	Section 2.4. Motor Feedback Connections (J207)
FireWire	Section 2.8. FireWire Interface
Control Supply	Section 2.2.1. Control Supply Connections
Motor Supply	Section 2.2.2. Motor Supply Connections
Additional I/O	User / Application dependent

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Chapter 1: Introduction

Aerotech's Ndrive HPe 150/200 (High Power PWM) network digital drive is a high performance amplifier. The drive provides deterministic behavior, auto-identification, and easy software setup. The Ndrive HPe 150/200's high performance double precision floating point DSP controls the digital PID and current loops. All system configuration is done using software-settable parameters, including control loop gains and system safety functions.

The Ndrive HPe 150/200 is offered with an optional encoder interpolation feature (-MXH), an auxiliary square wave encoder input for dual loop control, dedicated analog and digital I/O (expandable with the -IO option), a resolver input (-RDP option), and separate power connections for motor and control supply voltages.



Standard Connector	Description	-IO/-IOH Board Option Connector	Description
TB101	Control Supply	TB301	Relay
TB101	External Shunt	J302	SSINET
TB102	Motor Supply	J303	SSINET
TB102	Motor Output	TB302	Dedicated PSO Output
TB102	DC Bus Output	TB303	Analog Outputs
J201	FireWire	TB304	Analog Inputs
J202	FireWire	TB305	Digital Inputs
J203	FireWire	TB306	Digital Inputs
J204	Ethernet Port	TB307	Digital Outputs
J205	Auxiliary I/O	TB308	Digital Outputs
TB201	Emergency Stop Sense Input (ESTOP)	-RDP Option	
J207	Motor Feedback	Connector	Description
TB202	Brake Power	J401	R/D Channel 1
		J402	R/D Channel 2

NOTE:
J206 RS232 connector currently has no functionality on the Ndrive HPe

Figure 1-1: Ndrive HPe 150/200 Networked Digital Drive

Table 1-1: Feature Summary

Standard Features	
• 85 - 240 VAC control supply inputs	Section 2.2.1.
• 240 VAC (max) motor supply inputs	Section 2.2.2.
• Primary quadrature encoder input channels	Section 2.4.1.
• Absolute Encoder support	Section 2.4.1.2.
• Dedicated Home and Limit inputs	Section 2.4.5.
• Dedicated 5-24 V Emergency Stop sense input	Section 2.5.
• Auxiliary quadrature encoder input channels	Section 2.6.1.
• Single-axis PSO capability	Section 2.6.2.
• Four digital outputs (opto-isolated)	Section 2.6.3.
• Four digital inputs (opto-isolated)	Section 2.6.4.
• Two high-speed digital inputs (opto-isolated)	Section 2.6.5.
• One 16-bit analog output (± 10 VDC)	Section 2.6.6.
• One 16-bit analog differential input (± 10 VDC)	Section 2.6.7.
• One 24 VDC, 1 A brake relay	Section 2.7.

Table 1-2: Ordering Options

Options	
Power Stage Options (Section 1.2.)	
150-S	150 A peak; 75 A continuous; 440 W continuous internal shunt resistor; requires FAN-115 or FAN-230 option
200-S	200 A peak, 75 A continuous, 440 W continuous internal shunt resistor; shared DC bus wiring interface; fan cooling
I/O (Chapter 3) and Feedback (Section 2.4.1.3.) Options	
-IO	Expansion board with 16 digital inputs (opto-isolated); 16 digital outputs (opto-isolated); three 16-bit differential analog inputs (± 10 V); three 16-bit analog outputs (± 10 V); 2 SSI Net; absolute encoder interface; one mechanical brake relay
-MXH	Programmable encoder multiplier up to x16384 (x65,536 after quadrature); supports single/dual axis PSO and real-time encoder quadrature output
PSO Options (Section 3.2.)	
-DUALPSO	Two axis Position Synchronized Output (PSO)
-TRIPLEPSO	Three axis Position Synchronized Output (PSO); requires I/O option
-PSONC	Normally closed PSO output (default normally open); requires I/O option
Ethernet Option (refer to the Help file)	
-ENET	10/100 BASE-T Ethernet port for use with Ethernet I/O modules

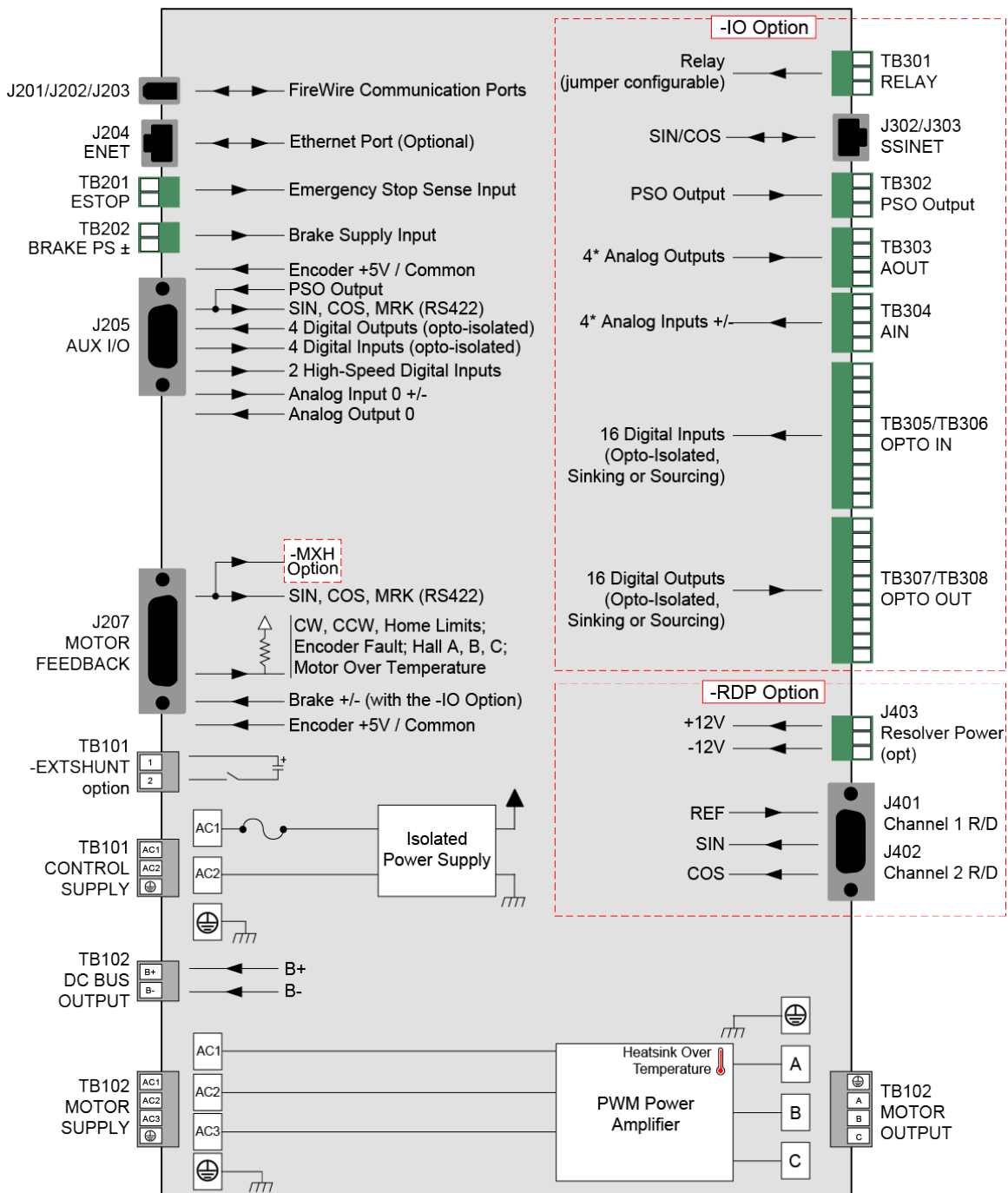
Table 1-3: Ordering Options (continued)

Options	
Drive Options	
-ESH	Two-pin connector for external shunt resistor network (Section 2.10.). NOTE: Excludes -S option (440 W continuous internal shunt resistor).
-FAN-115	115 VAC external cooling fan
-FAN-230	230 VAC external cooling fan
Resolver Options (Chapter 4)	
-RDP1-10K	One-channel resolver to digital converter input; 10 kHz carrier frequency
-RDP1-7.5K	One-channel resolver to digital converter input; 7.5 kHz carrier frequency
-RDP1-5K	One-channel resolver to digital converter input; 5 kHz carrier frequency
-RDP2-10K	Two-channel resolver to digital converter input; 10 kHz carrier frequency
-RDP2-7.5K	Two-channel resolver to digital converter input; 7.5 kHz carrier frequency
-RDP2-5K	Two-channel resolver to digital converter input; 5 kHz carrier frequency.

Table 1-4: Accessories

Accessories	
MCK-NDRIVE	Mating connector kit for J206 (J205 mate is always provided)
J1	Industrial Joystick (NEMA12 (IP54) rated); refer to Section 5.1.
PS24-1	24 VDC, 1 A power supply for optional brake/relay output
BRAKE24-2	24 VDC, 2 A power supply for optional brake
Transformers	
	Refer to Section 0.0.1. for listings, wiring, and specifications
Cables	
Interconnection	A complete list of Aerotech cables can be found on the website at http://www.aerotechmotioncontrol.com/manuals/index.aspx
Joystick/Handwheel	Refer to Section 5.1. or Section 5.2.
FireWire	Refer to Section 2.8.

The following block diagram shows a connection summary. For detailed connection information, refer to Chapter 2 and Chapter 3.



* There are a total of four analog inputs and four analog outputs available if the -IO Option has been purchased. The analog I/O normally available on J205 is accessed through TB303 and TB304.

Figure 1-2: Functional Diagram

1.1. Drive and Software Compatibility

The following table lists the available drives and which version of the software first supported the drive. Drives that list a specific version number in the **Last Software Version** column will not be supported after the listed version.

Table 1-5: Drive and Software Compatibility

Drive Type	Firmware Revision	First Software Version	Last Software Version
Ndrive HPe	-	2.22	Current

1.2. Electrical Specifications

Table 1-6: Electrical Specifications

Description		HPe 150	HPe 200
Motor Supply	Input Voltage	240 VAC max	
	Input Frequency	50-60 Hz	
	Maximum Continuous Input Current	43.30 A _{rms}	57.74 A _{rms}
	Input Current	Refer to Section 1.2.1. System Power Requirements	
Control Supply	Input Voltage	85-240 VAC	
	Input Frequency	50-60 Hz	
	Input Current	.25 A max	
Output Voltage ⁽¹⁾		340 VDC max	
Peak Output Current (1 second)		150 A	200 A
Continuous Output Current		75 A	75 A
Power Amplifier Bandwidth		2500 Hz maximum (software selectable)	
Power Amplifier Efficiency		85% - 95% ⁽²⁾	
PWM Switching Frequency		20 kHz	
Minimum Load Inductance		0.8 mH @ 160 VDC (1 mH @ 320 VDC)	
User Power Supply Output		5 VDC (@ 500 mA)	
Modes of Operation		Brushless; Brush; Stepper	
Protective Features		Output short circuit; Peak over current, DC bus over voltages; RMS over current; Over temperature; Control power supply under voltage; Power stage bias supply under voltage	
Isolation		Optical and transformer isolation between control and power stages.	
(1) AC input voltage and load dependent.			
(2) Dependent on total output power: efficiency increases with increasing output power.			

1.2.1. System Power Requirements

The following equations can be used to determine total system power requirements. The actual power required from the mains supply will be the combination of actual motor power (work), motor resistance losses, and efficiency losses in the power electronics or power transformer. An EfficiencyFactor of approximately 90% should be used in the following equations.

Brushless Motor

Output Power

Rotary Motors $P_{out} [W] = \text{Torque [N}\cdot\text{m]} * \text{Angular velocity[rad/sec]}$

Linear Motors $P_{out} [W] = \text{Force [N]} * \text{Linear velocity[m/sec]}$

Rotary or Linear Motors $P_{out} [W] = \text{Bemf [V]} * I(\text{rms}) * 3$

$$P_{loss} = 3 * I(\text{rms})^2 * R(\text{line-line})/2$$

$$P_{in} = \text{SUM} (P_{out} + P_{loss}) / \text{EfficiencyFactor}$$

DC Brush Motor

$$P_{out} [W] = \text{Torque [N}\cdot\text{m]} * \text{Angular velocity[rad/sec]}$$

$$P_{loss} = I(\text{rms})^2 * R$$

$$P_{in} = \text{SUM} (P_{out} + P_{loss}) / \text{EfficiencyFactor}$$

1.3. Mechanical Design

Install the unit into a construction compliant for unlimited circuits enclosure. Each unit should be separated from other drives and surrounded by 25 mm (1") of free air space. A space of 100 mm (4") should be allowed along the front of the unit for cable connections.

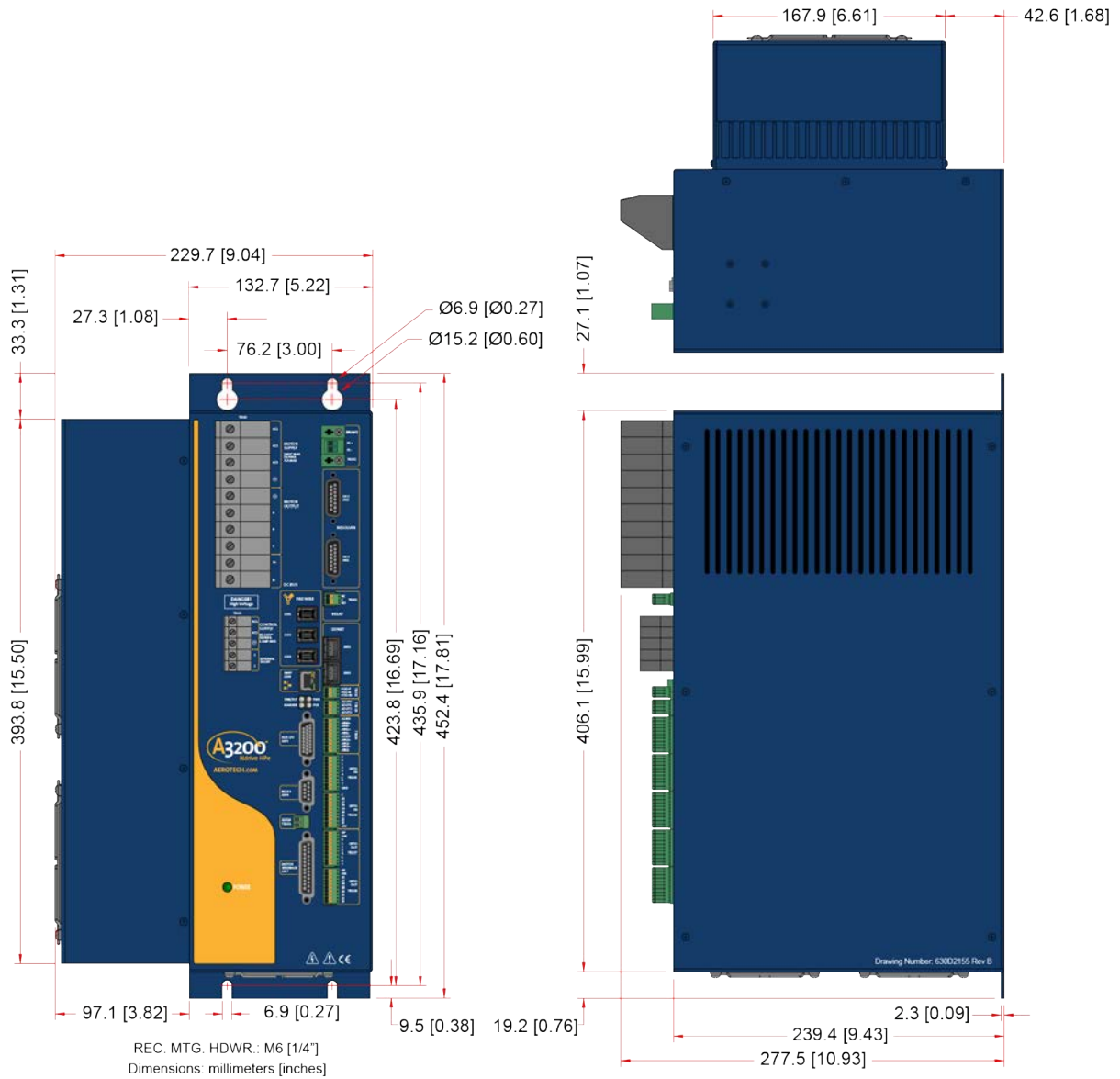


Figure 1-3: Dimensions

Table 1-7: Physical Specifications

	Weight
Standard	11.06 kg (24.4 lb)
w/ -IO option	11.46 kg (25.28 lb)
w/ -RDP option	11.46 kg (25.28 lb)

1.4. Environmental Specifications

The environmental specifications for the Ndrive HPe 150/200 are listed below.

Ambient Temperature	Operating: 0° to 50°C (32° to 122° F)
	Storage: -30° to 85°C (-22° to 185° F)
Humidity	Maximum relative humidity is 80% for temperatures up to 31°C. Decreasing linearly to 50% relative humidity at 40°C. Non condensing.
Altitude	Up to 2000 meters.
Pollution	Pollution degree 2 (normally only non-conductive pollution).
Use	Indoor use only.

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Chapter 2: Installation and Configuration

2.1. Communication Channel Settings

Use the Device Number switches to assign a communication channel number to the Ndrive HPe 150/200. If you are using multiple drives, each drive must be assigned a unique communication channel. Multiple drives are typically configured using sequential communication channels.

To access the S1 Device Number switch, the outer case must be removed.



DANGER: Always disconnect the Mains power connection before opening the Ndrive HPe 150/200 chassis.



DANGER: Residual voltages greater than 60V may be present inside Ndrive HPe 150/200 chassis for longer than 15 minutes after power has been disconnected.

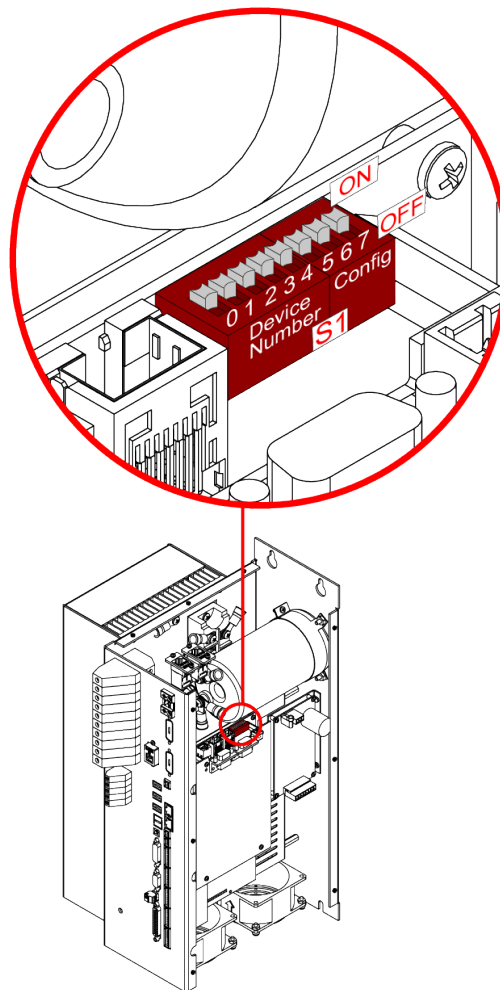


Figure 2-1: Device Number (S1) Location

NOTE: The drive assigned to the first communication channel number (all switches set to ON) will be configured by the Axis 1 parameters defined in the software. The drive assigned to the second communication channel will be configured by the Axis 2 parameters, etc.

Table 2-1: Device Number Switch Settings (S1)

⊙	Switch Settings (OFF is indicated by " - ")							
	7	6	5	4	3	2	1	0
1	ON	ON	ON	ON	ON	ON	ON	ON
2	ON	ON	ON	ON	ON	ON	ON	-
3	ON	ON	ON	ON	ON	ON	-	ON
4	ON	ON	ON	ON	ON	ON	-	-
5	ON	ON	ON	ON	ON	-	ON	ON
6	ON	ON	ON	ON	ON	-	ON	-
7	ON	ON	ON	ON	ON	-	-	ON
8	ON	ON	ON	ON	ON	-	-	-
9	ON	ON	ON	ON	-	ON	ON	ON
10	ON	ON	ON	ON	-	ON	ON	-
11	ON	ON	ON	ON	-	ON	-	ON
12	ON	ON	ON	ON	-	ON	-	-
13	ON	ON	ON	ON	-	-	ON	ON
14	ON	ON	ON	ON	-	-	ON	-
15	ON	ON	ON	ON	-	-	-	ON
16	ON	ON	ON	ON	-	-	-	-
17	ON	ON	ON	-	ON	ON	ON	ON
18	ON	ON	ON	-	ON	ON	ON	-
19	ON	ON	ON	-	ON	ON	-	ON
20	ON	ON	ON	-	ON	ON	-	-
21	ON	ON	ON	-	ON	-	ON	ON
22	ON	ON	ON	-	ON	-	ON	-
23	ON	ON	ON	-	ON	-	-	ON
24	ON	ON	ON	-	ON	-	-	-
25	ON	ON	ON	-	-	ON	ON	ON
26	ON	ON	ON	-	-	ON	ON	-
27	ON	ON	ON	-	-	ON	-	ON
28	ON	ON	ON	-	-	ON	-	-
29	ON	ON	ON	-	-	-	ON	ON
30	ON	ON	ON	-	-	-	ON	-
31	ON	ON	ON	-	-	-	-	ON
32	ON	ON	ON	-	-	-	-	-

2.2. Power Connections

The Ndrive HPe 150/200 has two AC input connectors; one for control power and a second for motor power. For a complete list of electrical specifications, refer to [Section 1.2](#).

NOTE: The machine integrator, OEM or end user is responsible for meeting the final protective grounding requirements of the system.

2.2.1. Control Supply Connections

NOTE: This product requires two power supply connections. The Motor Supply and Control Supply must both be connected for proper operation.

The control power supply input allows the Ndrive HPe 150/200 to maintain communications if the motor power is removed, such as in an Emergency Stop condition. The control power supply requires a minimum of 85 VAC input to operate properly. The AC1 input is internally fused. The AC2 input is not internally fused but can be connected to a voltage source other than Neutral if an external 2 A time-delay fuse is used.

Although the control power supply contains an internal filter, an additional external filter located as close as possible to the Ndrive HPe 150/200 may be required for CE compliance (Aerotech recommends Schaffner FN2080).

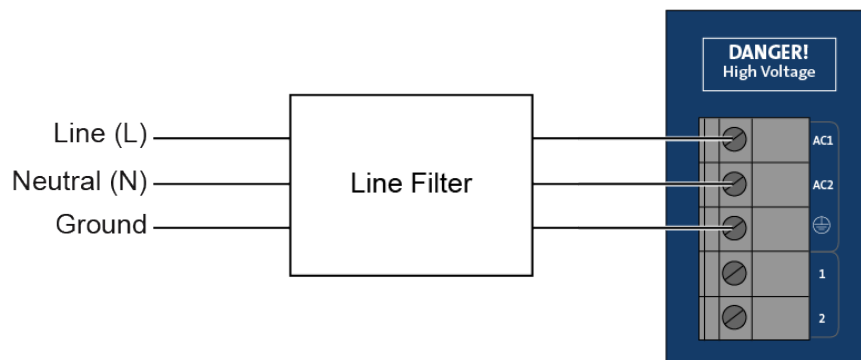


Figure 2-2: Control Supply Connections

Table 2-2: Control Supply AC Input Wiring

Pin	Description	Recommended Wire Size ⁽¹⁾
AC1	Line (L): 85-240 VAC Control Power Input	0.8 mm ² (#18 AWG)
AC2	Neutral (0V) or 85-240 VAC Control Power Input with external fuse	0.8 mm ² (#18 AWG)
⊕	Protective Ground (Required for Safety)	0.8 mm ² (#18 AWG)

(1) Refer to local electrical safety requirements to correctly size external system wires.

2.2.2. Motor Supply Connections

NOTE: This product requires two power supply connections. The Motor Supply and Control Supply must both be connected for proper operation.

Motor power is applied to the Ndrive HPe 150/200 Motor Supply connector (refer to [Figure 2-3](#) for locations).

Refer to local electrical safety requirements to correctly size external system wires and match wires to fuses or circuit breakers.

- The recommended wire size is 8.34 mm² (#8 AWG).
- External fuses or a circuit breaker (60 A maximum, time delay type) are required for the AC1, AC2, and AC3 inputs.

Power for the cooling fan is supplied through the motor supply connection. The fan connects between the AC1 and AC2 inputs and uses approximately 20W of power.



WARNING: Do not operate the Ndrive HPe 150/200 without the safety ground connection in place.



WARNING: Do not operate the Ndrive HPe 150/200 without proper branch protection.

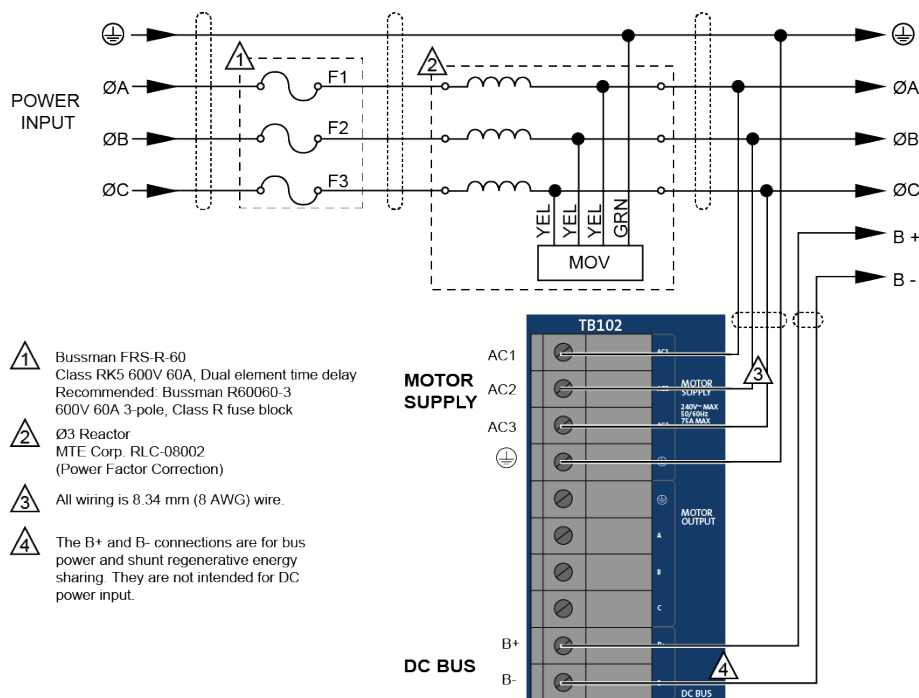


Figure 2-3: Motor Bus Input Connections

2.2.3. Minimizing Conducted, Radiated, and System Noise

The Ndrive HPe 150/200 generates conducted (AC line) and radiated noise. Conducted emissions are minimized by using line filters and should be located as close to the drive as possible for maximum effectiveness. User connections to the product must be made using shielded cables with metal D-style connectors and back shells. The shield of the cables must be connected to the metal back shell in order for the product to conform to radiated emission standards. The Ndrive HPe 150/200 is a component designed to be integrated with other electronics. EMC testing must be conducted on the final product configuration.

Ferrite beads can be used on the motor leads to reduce the effects of PWM noise.

Table 2-3: Ferrite Noise Suppression Part Numbers

Wire Size	Aerotech P/N	Third Party P/N
13.3 mm ² (#6 AWG)	N/A	#2643626502 Elna Fair-Rite Products
8.3 mm ² (#8 AWG)	ECZ00285	#2643626502 Elna Fair-Rite Products
2.0 mm ² (#14 AWG)	EIZ01027	#2643002402 Elna Fair-Rite Products
1.3 mm ² (#16 AWG)	EIZ01025	#2643250402 Elna Fair-Rite Products
0.8 mm ² (#18 AWG)	EIZ01001	#2673000801 Elna Fair-Rite Products
0.5 mm ² (#20 AWG)	EIZ01001	#2673000801 Elna Fair-Rite Products


2.3. Motor Output Connections

The Ndrive HPe 150/200 is capable of controlling three motor types:

- Brushless (see [Section 2.3.1.](#))
- DC Brush (see [Section 2.3.2.](#))
- Stepper (see [Section 2.3.3.](#))

For a complete list of electrical specifications, refer to [Section 1.2.](#)

Table 2-4: Motor Power Output Connections

Pin	Description	Recommended Wire Size
ØA	Phase A Motor Lead	13.3 mm ² (#6 AWG)
ØB	Phase B Motor Lead	13.3 mm ² (#6 AWG)
ØC	Phase C Motor Lead	13.3 mm ² (#6 AWG)
	Earth Ground to Motor (required for safety)	13.3 mm ² (#6 AWG)

2.3.1. Brushless Motor Connections

The configuration shown in Figure 2-4 is an example of a typical brushless motor connection.

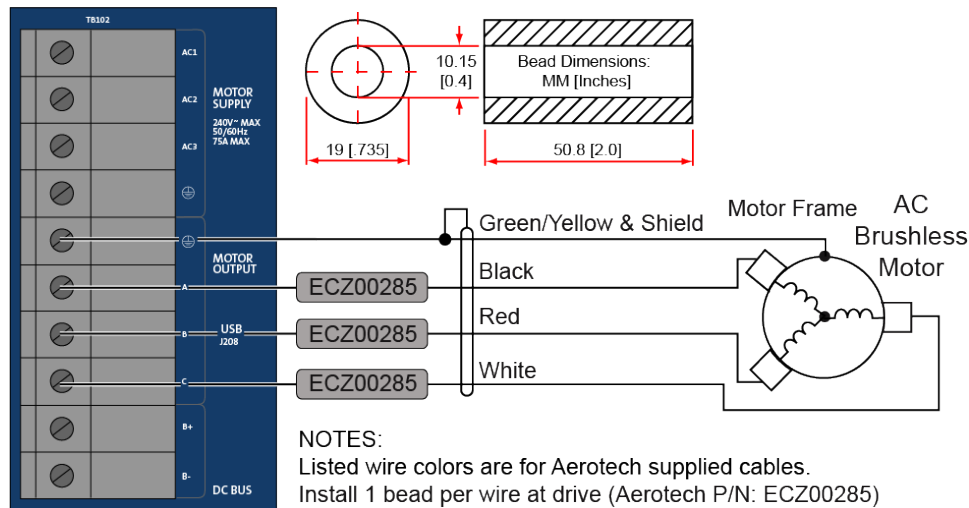


Figure 2-4: Brushless Motor Configuration

Table 2-5: Wire Colors for Aerotech Supplied Cables (Brushless)

Pin	Wire Color Set 1 ⁽¹⁾	Wire Color Set 2	Wire Color Set 3	Wire Color Set 4
⊕	Green/Yellow & Shield ⁽²⁾	Green/Yellow & Shield	Green/Yellow & Shield	Green/Yellow & Shield
A	Black	Blue & Yellow	Black #1	Black & Brown
B	Red	Red & Orange	Black #2	Red & Orange
C	White	White & Brown	Black #3	Violet & Blue

(1) Wire Color Set #1 is the typical Aerotech wire set used by Aerotech.
 (2) "&" (Red & Orange) indicates two wires; "/" (Green/White) indicates a single wire

NOTE: Brushless motors are commutated electronically by the controller. The use of Hall effect devices for commutation is recommended.

The controller requires that the Back-EMF of each motor phase be aligned with the corresponding Hall-effect signal. To ensure proper alignment, motor, Hall, and encoder connections should be verified using one of the following methods: *powered*, through the use of a test program; or *unpowered* using an oscilloscope. Both methods will identify the A, B, and C Hall/motor lead sets and indicate the correct connections to the controller. Refer to Section 2.3.1.1. for powered motor phasing or Section 2.3.1.2. for unpowered motor and feedback phasing.

NOTE: If using standard Aerotech motors and cables, motor and encoder connection adjustments are not required.

2.3.1.1. Powered Motor Phasing

Refer to the Motor Phasing Calculator in the Configuration Manager for motor, Hall, and encoder phasing.

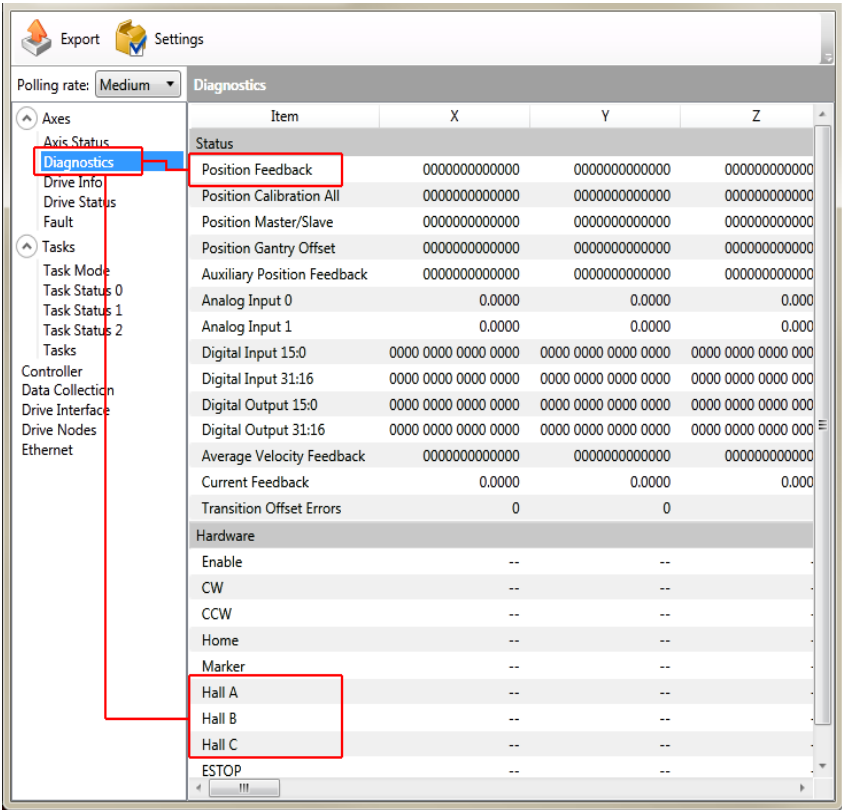


Figure 2-5: Encoder and Hall Signal Diagnostics

2.3.1.2. Unpowered Motor and Feedback Phasing

Disconnect the motor from the controller and connect the motor in the test configuration shown in [Figure 2-6](#). This method will require a two-channel oscilloscope, a 5V power supply, and six resistors (10,000 ohm, 1/4 watt). All measurements should be made with the probe common of each channel of the oscilloscope connected to a neutral reference test point (TP4, shown in [Figure 2-6](#)). Wave forms are shown while moving the motor in the positive direction.

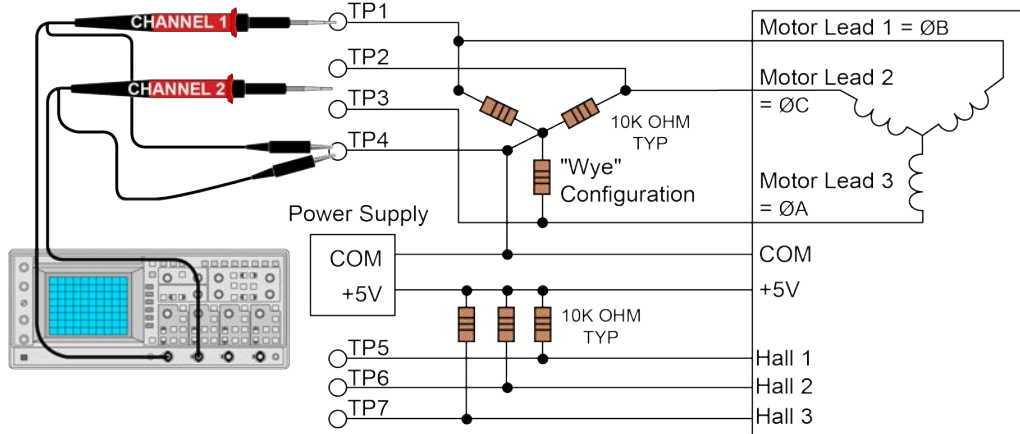


Figure 2-6: Motor Phasing Oscilloscope Example

With the designations of the motor and Hall leads of a third party motor determined, the motor can now be connected to an Aerotech system. Connect motor lead A to motor connector A, motor lead B to motor connector B, and motor lead C to motor connector C. Hall leads should also be connected to their respective feedback connector pins (Hall A lead to the Hall A feedback pin, Hall B to Hall B, and Hall C to Hall C). The motor is correctly phased when the Hall states align with the Back EMF as shown in ([Figure 2-7](#)). Use the CommutationOffset parameter to correct for Hall signal misalignment.

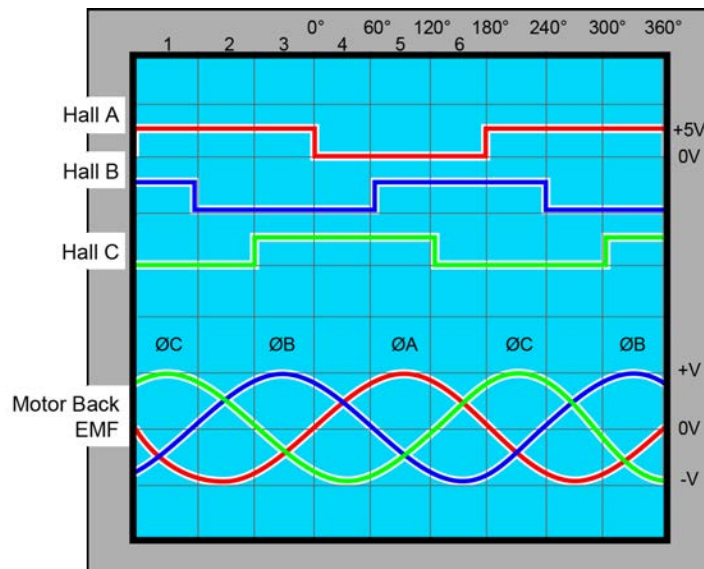


Figure 2-7: Brushless Motor Phasing Goal

2.3.2. DC Brush Motor Connections

The configuration shown in Figure 2-8 is an example of a typical DC brush motor connection. Refer to Section 2.3.2.1. for information on motor phasing.

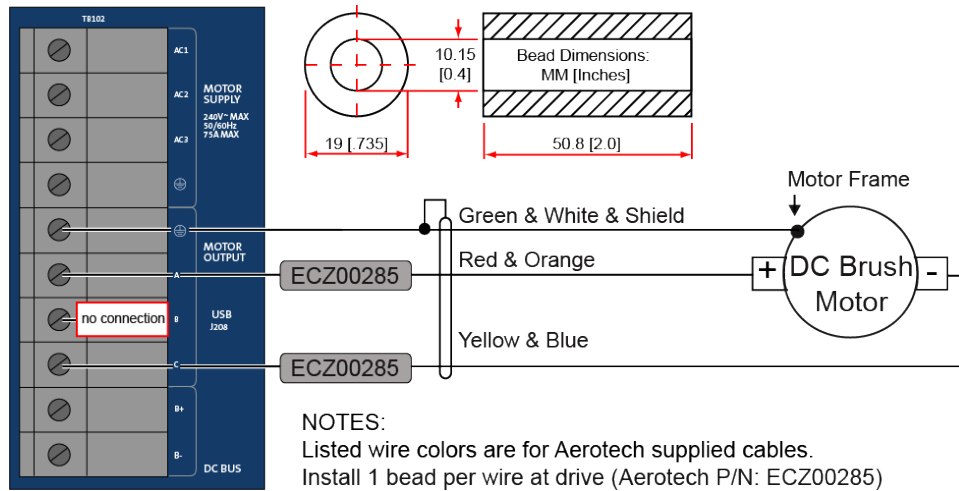


Figure 2-8: DC Brush Motor Configuration

Table 2-6: Wire Colors for Aerotech Supplied Cables (DC Brush)

Pin	Wire Color Set 1 ⁽¹⁾	Wire Color Set 2	Wire Color Set 3
⊕	Green & White & Shield ⁽²⁾	Green/Yellow & Shield	Green/Yellow & Shield
A	Red & Orange	Red	Red & Orange
C	Yellow & Blue	Black	Yellow & Blue

(1) Wire Color Set #1 is the typical Aerotech wire set used by Aerotech.
(2) "&" (Red & Orange) indicates two wires; "/" (Green/White) indicates a single wire

2.3.2.1. DC Brush Motor Phasing

A properly phased motor means that the positive motor lead should be connected to the $\emptyset A$ motor terminal and the negative motor lead should be connected to the $\emptyset C$ motor terminal. To determine if the motor is properly phased, connect a voltmeter to the motor leads of an un-powered motor:

1. Connect the positive lead of the voltmeter to the one of the motor terminals.
2. Connect the negative lead of the voltmeter to the other motor terminal.
3. Rotate the motor clockwise by hand.

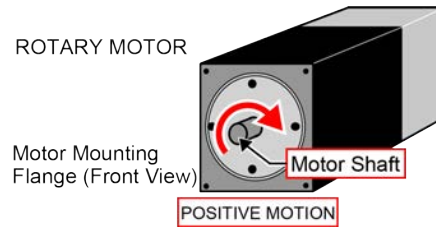


Figure 2-9: Clockwise Motor Rotation

4. If the voltmeter indicates a negative value, swap the motor leads and rotate the motor (CW, by hand) again. When the voltmeter indicates a positive value, the motor leads have been identified.
5. Connect the motor lead from the voltmeter to the $\emptyset A$ motor terminal on the Ndrive HPe 150/200. Connect the motor lead from the negative lead of the voltmeter to the $\emptyset C$ motor terminal on the Ndrive HPe 150/200.

NOTE: If using standard Aerotech motors and cables, motor and encoder connection adjustments are not required.

2.3.3. Stepper Motor Connections

The configuration shown in Figure 2-10 is an example of a typical stepper motor connection. Refer to Section 2.3.3.1. for information on motor phasing.

In this case, the effective motor voltage is half of the applied bus voltage. For example, an 80V motor bus supply is needed to get 40V across the motor.

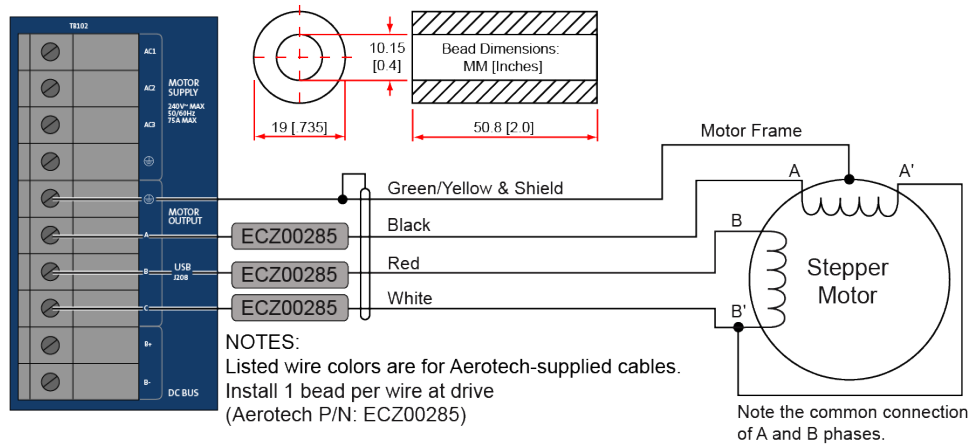


Figure 2-10: Stepper Motor Configuration

Table 2-7: Wire Colors for Aerotech Supplied Cables (Stepper)

Pin	Wire Color Set 1 ⁽¹⁾	Wire Color Set 2
⊕	Green/Yellow & Shield ⁽²⁾	Green/Yellow & Shield
A	Black	Brown
B	Red	Yellow
C	White	White & Red

(1) Wire Color Set #1 is the typical Aerotech wire set used by Aerotech.
(2) "&" (Red & Orange) indicates two wires; "/" (Green/White) indicates a single wire

2.3.3.1. Stepper Motor Phasing

A stepper motor can be run with or without an encoder. If an encoder is not being used, phasing is not necessary. With an encoder, test for proper motor phasing by running a positive motion command.

If there is a positive scaling factor (determined by the CountsPerUnit parameters) and the motor moves in a clockwise direction, as viewed looking at the motor from the front mounting flange, the motor is phased correctly. If the motor moves in a counterclockwise direction, swap the motor leads and re-run the command.

Proper motor phasing is important because the end of travel (EOT) limit inputs are relative to motor rotation.

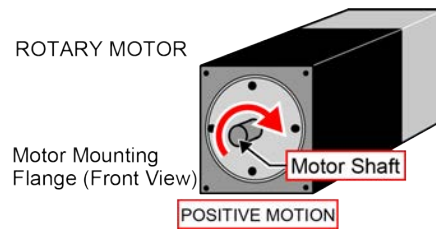


Figure 2-11: Clockwise Motor Rotation

NOTE: If using standard Aerotech motors and cables, motor and encoder connection adjustments are not required.

NOTE: After the motor has been phased, use the ReverseMotionDirection parameter to change the direction of “positive” motion.

2.4. Motor Feedback Connections (J207)

The motor feedback connector (a 25-pin, D-style connector) has inputs for an encoder, limit switches, Hall-effect devices, motor over-temperature device, 5 Volt encoder and limit power, and optional brake connection. The connector pin assignment is shown below with detailed connection information in the following sections.

Table 2-8: Motor Feedback Connector Pinout (J207)

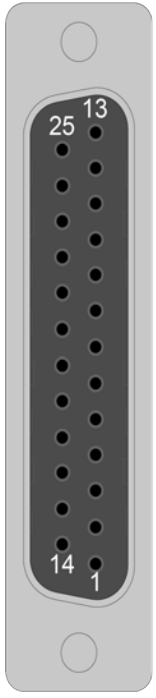
Pin#	Description	In/Out/Bi	Connector
1	Chassis Frame Ground	N/A	
2	Motor Over Temperature Thermistor	Input	
3	+5V Power for Encoder (500 mA max)	Output	
4	Reserved	N/A	
5	Hall-Effect Sensor B (brushless motors only)	Input	
6	Encoder Marker Reference Pulse -	Input	
7	Encoder Marker Reference Pulse +	Input	
8	Absolute Encoder Interface Data -	Bidirectional	
9	Reserved	N/A	
10	Hall-Effect Sensor A (brushless motors only)	Input	
11	Hall-Effect Sensor C (brushless motors only)	Input	
12	Clockwise End of Travel Limit	Input	
13	Brake Output -	Output	
14	Encoder Cosine +	Input	
15	Encoder Cosine -	Input	
16	+5V Power for Limit Switches (500 mA max)	Output	
17	Encoder Sine +	Input	
18	Encoder Sine -	Input	
19	Absolute Encoder Interface Data +	Bidirectional	
20	Signal Common for Limit Switches	N/A	
21	Signal Common for Encoder	N/A	
22	Home Switch Input	Input	
23	Encoder Fault Input	Input	
24	Counterclockwise End of Travel Limit	Input	
25	Brake Output +	Output	

Table 2-9: Mating Connector Part Numbers for the Motor Feedback Connector (J207)

Mating Connector	Aerotech P/N	Third Party P/N
25-Pin D-Connector	ECK00101	FCI DB25P064TXLF
Backshell	ECK00656	Amphenol 17E-1726-2

2.4.1. Encoder Interface (J207)

The Ndrive HPe 150/200 is equipped with standard and auxiliary encoder feedback channels. The standard encoder interface is accessible through the Motor Feedback (J207) connector. The standard encoder interface will accept an RS-422 differential line driver signal. If the Ndrive HPe 150/200 has been purchased with the -MXH option, the standard encoder interface can be configured for an analog encoder input via parameter settings.

Refer to [Section 2.4.1.4](#) for encoder feedback phasing. Refer to [Section 2.6](#) for the auxiliary encoder channel.

NOTE: Encoder wiring should be physically isolated from motor, AC power, and all other power wiring.

Table 2-10: Encoder Interface Pins on the Motor Feedback Connector (J207)

Pin#	Description	In/Out/Bi
1	Chassis Frame Ground	N/A
3	+5V Power for Encoder (500 mA max)	Output
6	Encoder Marker Reference Pulse -	Input
7	Encoder Marker Reference Pulse +	Input
14	Encoder Cosine +	Input
15	Encoder Cosine -	Input
17	Encoder Sine +	Input
18	Encoder Sine -	Input
21	Signal Common for Encoder	N/A

2.4.1.1. RS-422 Line Driver Encoder (Standard)

The standard encoder interface accepts an RS-422 differential quadrature line driver signal. Invalid or missing signals will cause a feedback fault when the axis is enabled.

An analog encoder is used with the -MXH option (refer to [Section 2.4.1.3.](#) for more information).

Table 2-11: Encoder Specifications

Specification	Value
Encoder Frequency	10 MHz maximum (25 nsec minimum edge separation)
x4 Quadrature Decoding	40 million counts/sec

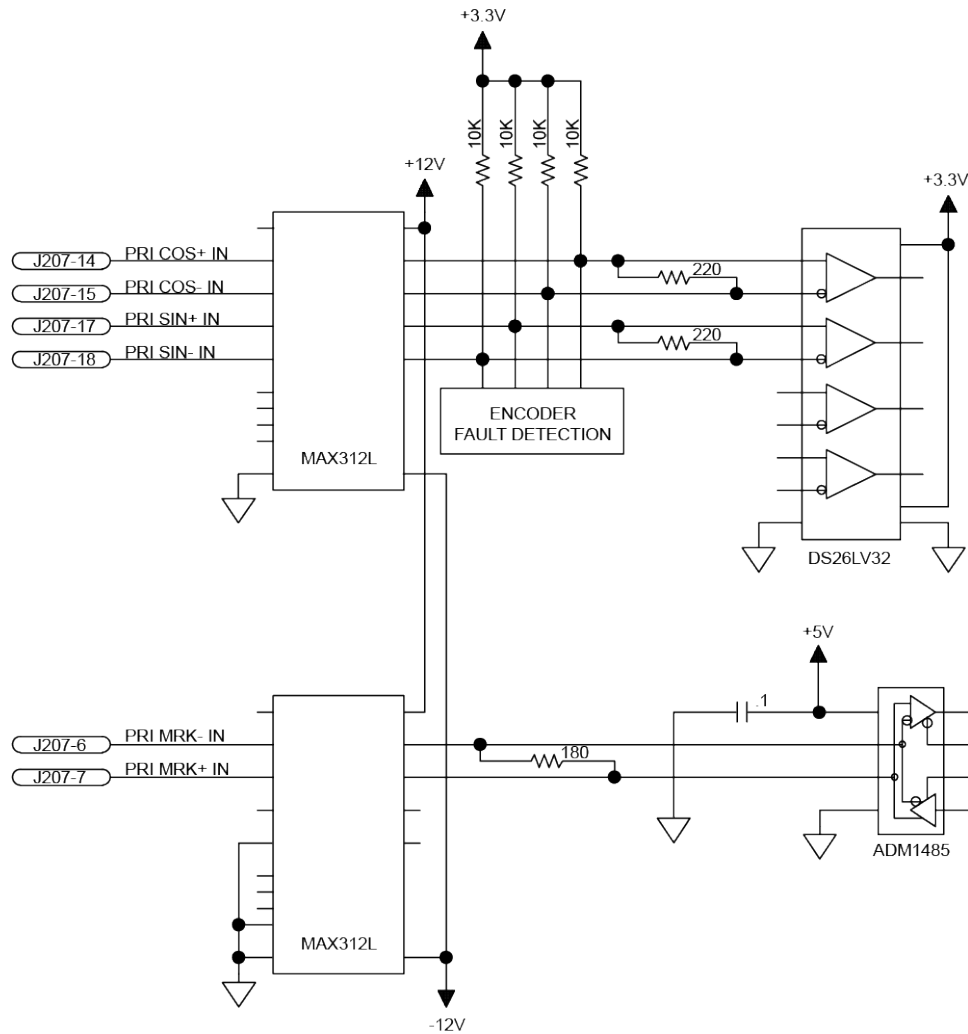


Figure 2-12: Line Driver Encoder Interface (J207)

2.4.1.2. Absolute Encoder Interface (J207)

The Ndrive HPe 150/200 retrieves absolute position data along with encoder fault information via a serial data stream from the absolute encoder. See [Figure 2-13](#) for the serial data stream interface. Refer to the Help file for information on how to set up your EnDat or Resolute absolute encoder parameters.

The encoder interface pinout is indicated in [Section 2.4.1](#).

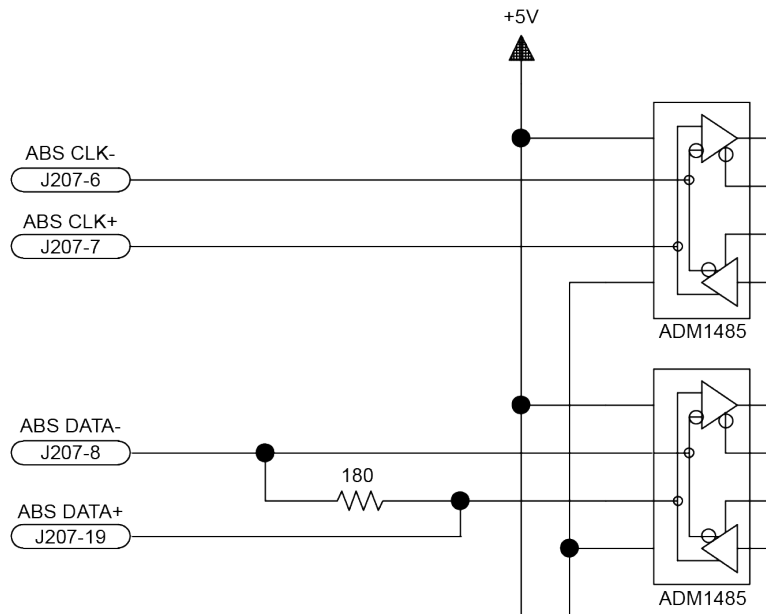


Figure 2-13: Serial Data Stream Interface

2.4.1.3. Analog Encoder Interface

If the -MXH option has been purchased, the standard encoder channel will accept a differential analog encoder input signal. The interpolation factor is determined by the EncoderMultiplicationFactor parameter and is software selectable (refer to the A3200 Help file).

Table 2-12: Analog Encoder Specifications

Specification	MXH
Input Frequency (max)	500 kHz
Input Amplitude	0.6 to 2.25 Vpk-Vpk
Interpolation Factor (software selectable)	65,536
MXH Interpolation Latency	~ 3.25 μ sec (analog input to quadrature output)

Refer to [Figure 2-14](#) for the typical input circuitry.

The encoder interface pin assignment is indicated in [Section 2.4.1](#).

The gain, offset, and phase balance of the analog Sine and Cosine encoder input signals can all be adjusted via controller parameters. Encoder signals should be adjusted using the Feedback Tuning tab of the Digital Scope, which will automatically adjust the encoder parameters for optimum performance. See the A3200 Help file for more information.

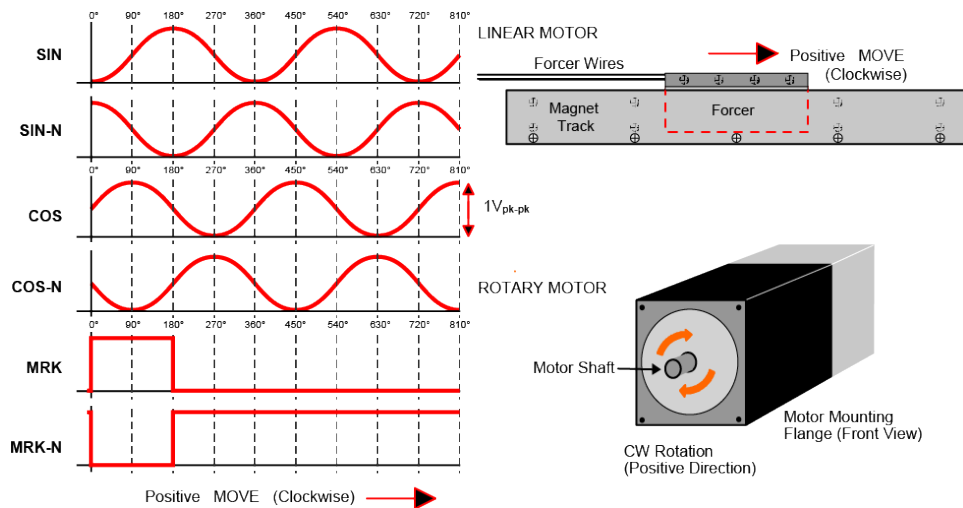


Figure 2-14: Analog Encoder Phasing Reference Diagram

NOTE: The input amplitude is measured peak to peak for any encoder signal (sin, sin-n, cos, cos-n) relative to signal common. These signals have a typical offset voltage of 2V to 2.5V.

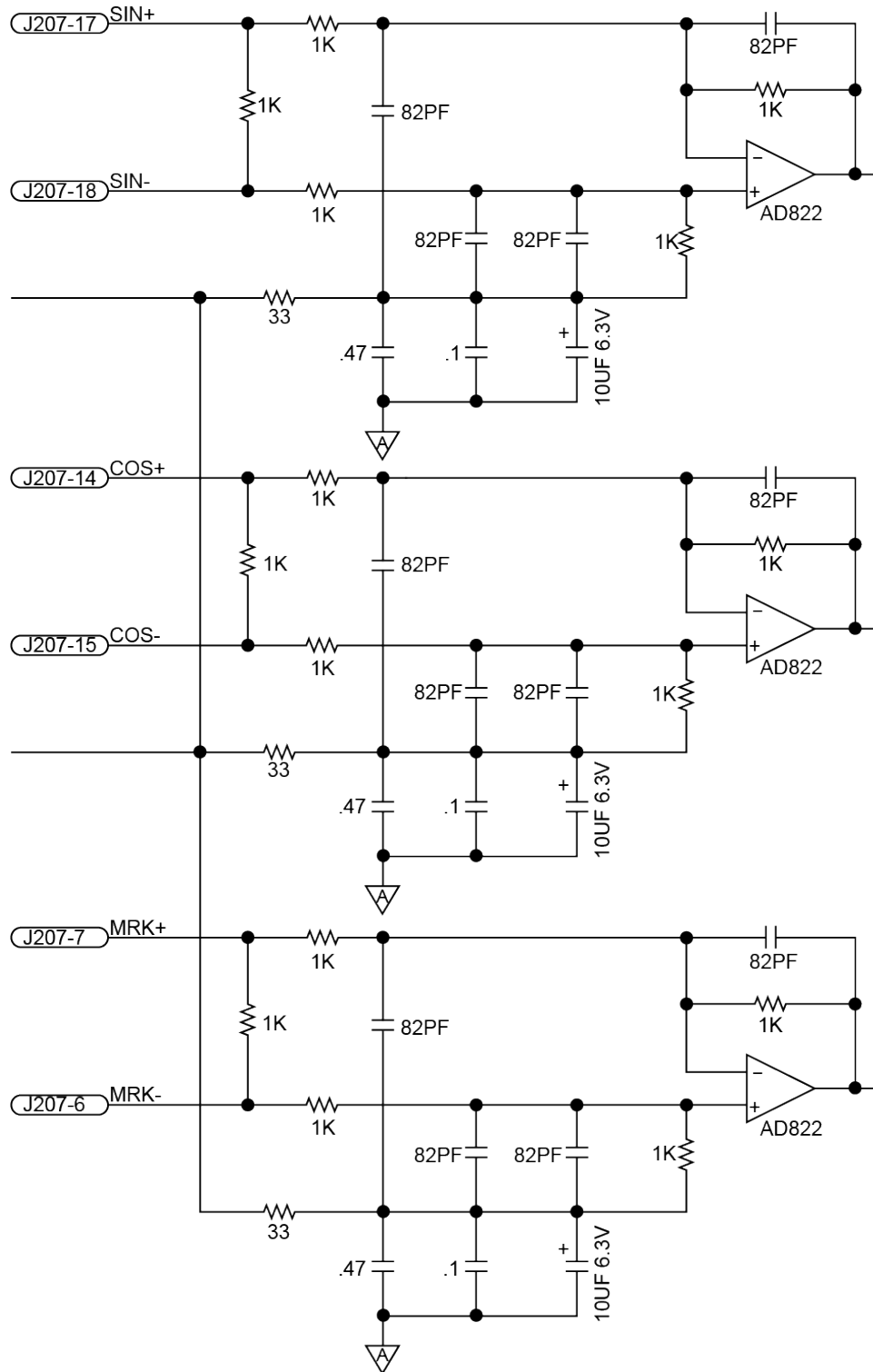


Figure 2-15: Analog Encoder Interface (J207)

2.4.1.4. Encoder Phasing

Incorrect encoder polarity will cause the system to fault when enabled or when a move command is issued. Figure 2-16 illustrates the proper encoder phasing for clockwise motor rotation (or positive forcer movement for linear motors). To verify, move the motor by hand in the CW (positive) direction while observing the position of the encoder in the diagnostics display (see Figure 2-17). The Motor Phasing Calculator in the Configuration Manager can be used to determine proper encoder polarity.

For dual loop systems, the velocity feedback encoder is displayed in the diagnostic display (Figure 2-17).

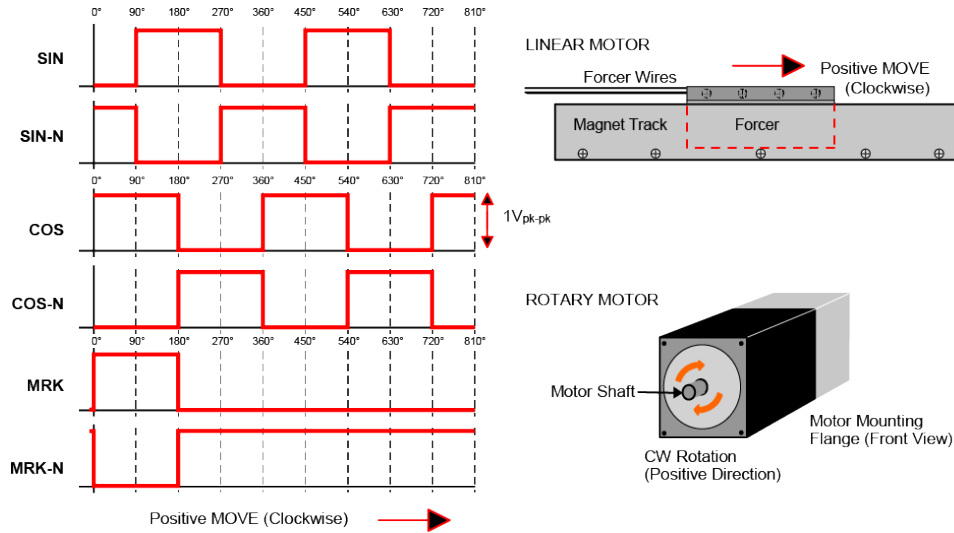


Figure 2-16: Encoder Phasing Reference Diagram (Standard)

NOTE: Encoder manufacturers may refer to the encoder signals as A, B, and Z. The proper phase relationship between signals is shown in Figure 2-16.

Export Settings

Polling rate: Medium

Diagnostics

Item	X	Y	Z
Status			
Position Feedback	000000000000	000000000000	000000000000
Position Calibration All	000000000000	000000000000	000000000000
Position Master/Slave	000000000000	000000000000	000000000000
Position Gantry Offset	000000000000	000000000000	000000000000
Auxiliary Position Feedback	000000000000	000000000000	000000000000
Analog Input 0	0.0000	0.0000	0.0000
Analog Input 1	0.0000	0.0000	0.0000
Digital Input 15:0	0000 0000 0000 0000	0000 0000 0000 0000	0000 0000 0000 0000
Digital Input 31:16	0000 0000 0000 0000	0000 0000 0000 0000	0000 0000 0000 0000
Digital Output 15:0	0000 0000 0000 0000	0000 0000 0000 0000	0000 0000 0000 0000
Digital Output 31:16	0000 0000 0000 0000	0000 0000 0000 0000	0000 0000 0000 0000
Average Velocity Feedback	000000000000	000000000000	000000000000
Current Feedback	0.0000	0.0000	0.0000
Transition Offset Errors	0	0	
Hardware			
Enable	--	--	
CW	--	--	
CCW	--	--	
Home	--	--	
Marker	--	--	

Figure 2-17: Position Feedback in the Diagnostic Display

2.4.2. Hall-Effect Interface (J207)

The Hall-effect switch inputs are recommended for AC brushless motor commutation but not absolutely required. The Hall-effect inputs accept 5-24 VDC level signals. Hall states (0,0,0) or (1,1,1) are invalid and will generate a "Hall Fault" axis fault.

Refer to [Section 2.3.1.1](#) for Hall-effect device phasing.

Table 2-13: Hall-Effect Feedback Interface Pins on the Motor Feedback Connector (J207)

Pin#	Description	In/Out/Bi
1	Chassis Frame Ground	N/A
3	+5V Power for Encoder (500 mA max)	Output
5	Hall-Effect Sensor B (brushless motors only)	Input
10	Hall-Effect Sensor A (brushless motors only)	Input
11	Hall-Effect Sensor C (brushless motors only)	Input
21	Signal Common for Encoder	N/A

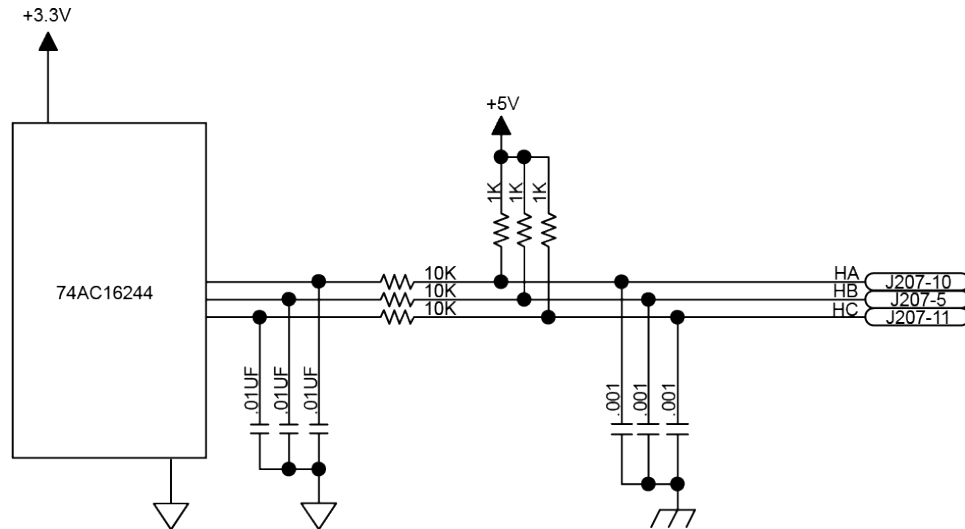


Figure 2-18: Hall-Effect Inputs (J207)

2.4.3. Thermistor Interface (J207)

The thermistor input is used to detect a motor over temperature condition by using a positive temperature coefficient sensor. As the temperature of the sensor increases, so does the resistance. Under normal operating conditions, the resistance of the thermistor is low (i.e., 100 ohms) which will result in a low input signal. As the increasing temperature causes the thermistor’s resistance to increase, the signal will be seen as a logic high triggering an over temperature fault. The nominal trip value of the sensor is 1k Ohm.

Table 2-14: Thermistor Interface Pin on the Motor Feedback Connector (J207)

Pin#	Description	In/Out/Bi
2	Motor Over Temperature Thermistor	Input

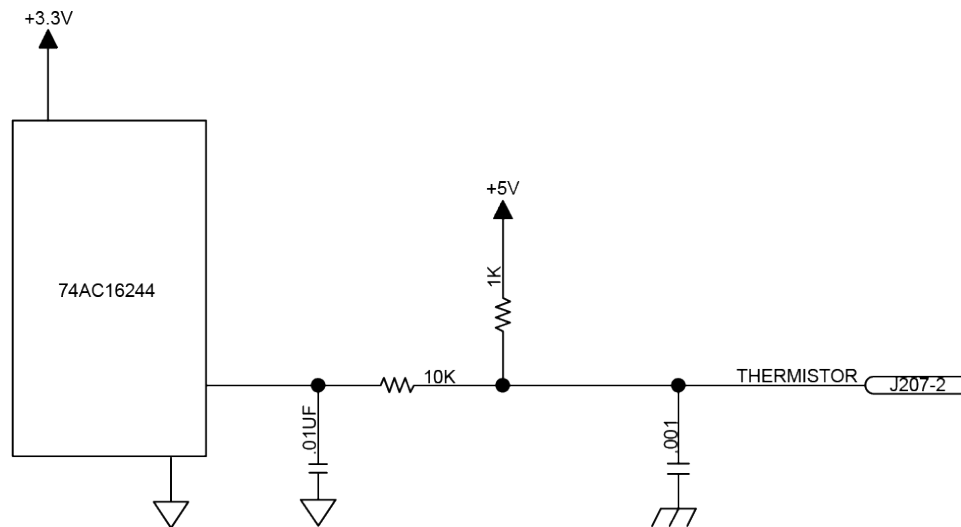


Figure 2-19: Thermistor Interface Input (J207)

2.4.4. Encoder Fault Interface (J207)

The encoder fault input is for use with encoders that have a fault output. This is provided by some manufactures and indicates a loss of encoder function. The active state of this input is parameter configurable and the controller should be configured to disable the axis when the fault level is active.

Table 2-15: Encoder Fault Interface Pin on the Motor Feedback Connector (J207)

Pin#	Description	In/Out/Bi
23	Encoder Fault Input	Input

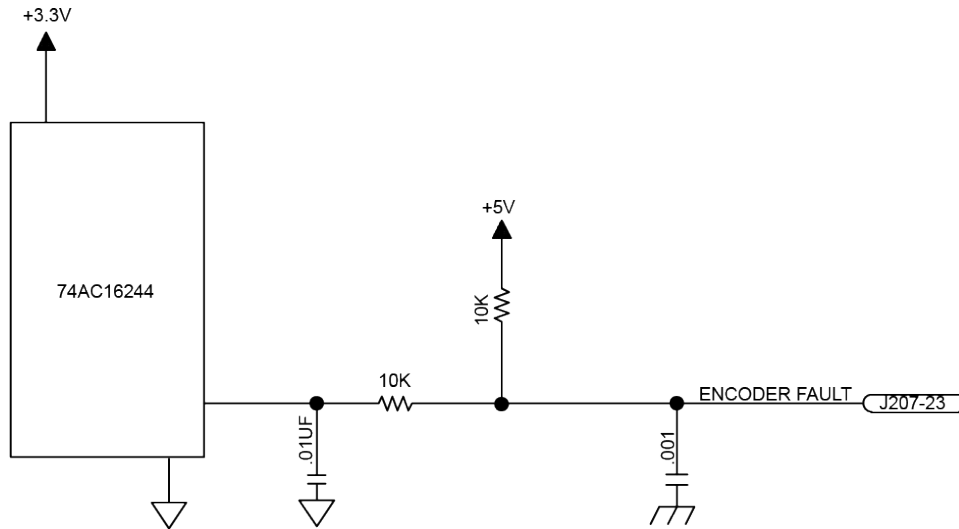


Figure 2-20: Encoder Fault Interface Input (J207)

2.4.5. End Of Travel Limit Input Interface (J207)

End of Travel (EOT) limits are used to define the end of physical travel. The EOT limit inputs accept 5-24 VDC level signals. The active state of the EOT limits is software selectable by the EndOfTravelLimitSetup axis parameter (refer to the A3200 Help file). Limit directions are relative to the encoder polarity in the diagnostics display (refer to [Figure 2-23](#)).

Positive motion is stopped by the clockwise (CW) end of travel limit input. Negative motion is stopped by the counterclockwise (CCW) end of travel limit input. The Home Limit switch can be parameter configured for use during the home cycle, however, the CW or CCW EOT limit is typically used instead.

Opto-isolated user inputs 8-11 can also be used as the end-of-travel limit inputs, see [Section 2.6.4](#).

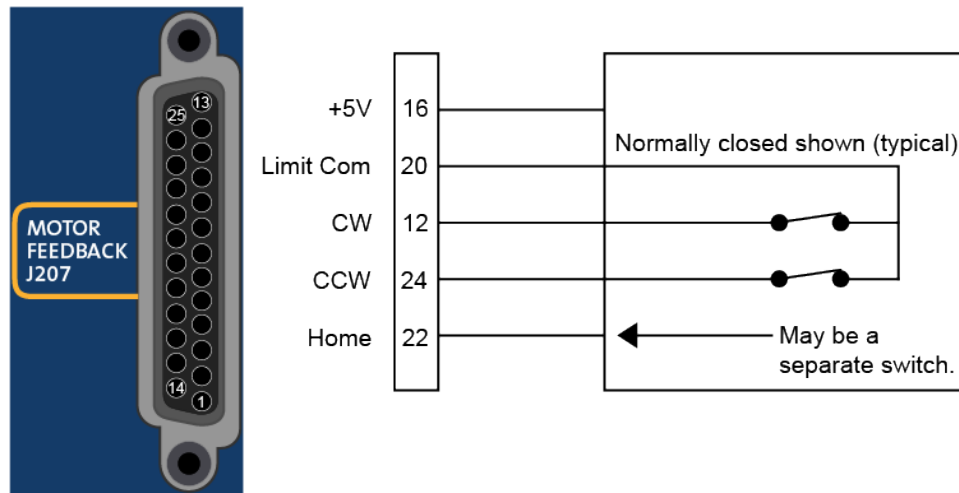


Figure 2-21: End of Travel Limit Input Connections

Table 2-16: End of Travel Limit Input Interface Pins on the Motor Feedback Connector (J207)

Pin#	Description	In/Out/BI
12	Clockwise End of Travel Limit	Input
16	+5V Power for Limit Switches (500 mA max)	Output
20	Signal Common for Limit Switches	N/A
22	Home Switch Input	Input
24	Counterclockwise End of Travel Limit	Input

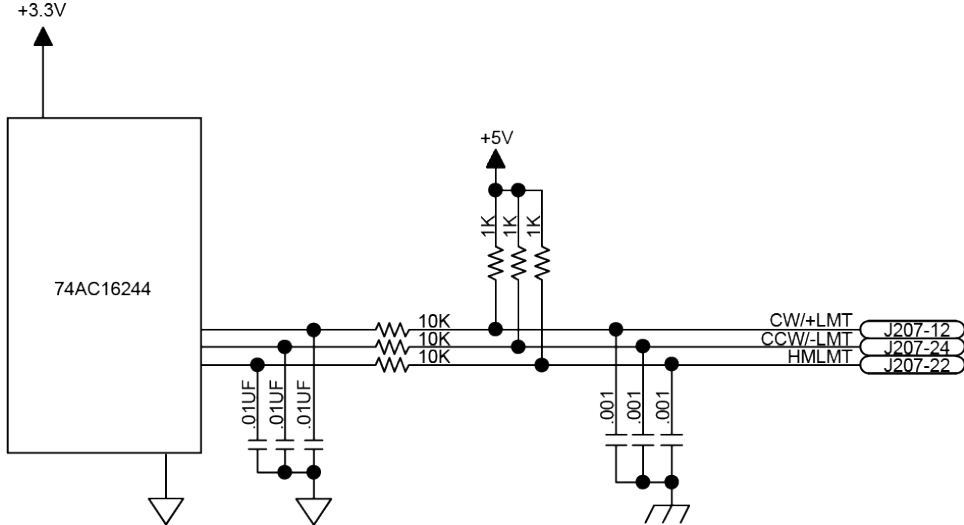


Figure 2-22: End of Travel Limit Interface Input (J207)

2.4.5.1. End Of Travel Limit Phasing

If the EOT limits are reversed, you will be able to move further into a limit but be unable to move out. To correct this, swap the connections to the CW and CCW inputs at the motor feedback connector. The logic level of the EOT limit inputs may be viewed in the Status Utility (shown in [Figure 2-23](#)).

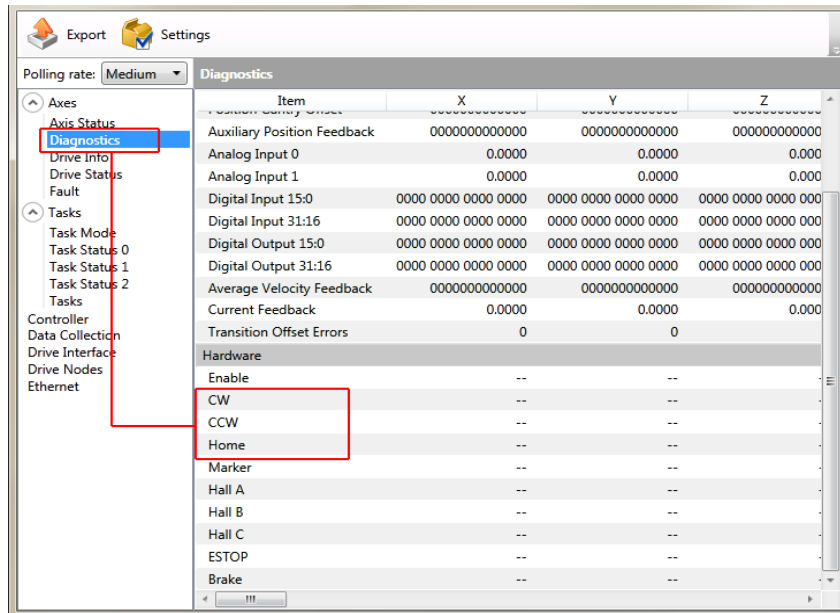


Figure 2-23: Limit Input Diagnostic Display

2.4.6. Brake Output (J207)

The Brake Output pins provide a direct connection to either the solid state relay on the Ndrive HPe 150/200 or the mechanical relay on the optional -IO board. The brake output pins in J207 permit the brake to be wired with other signals in the feedback cable. The brake is configured for automatic or manual control using controller parameters (refer to the A3200 Help file for more information).

Use either the solid state relay on the Ndrive HPe 150/200 or the mechanical relay on the -IO board when connecting a power supply to the brake outputs on J207. Do not use both relays at the same time.

Refer to [Section 2.7](#) for more information on using the brake output with the solid-state relay.

Refer to [Section 3.1](#) for more information on using the brake output with the mechanical relay.

Table 2-17: Brake Output Pins on the Motor Feedback Connector (J207)

Pin#	Description	In/Out/BI
13	Brake Output -	Output
25	Brake Output +	Output

2.5. Emergency Stop Sense Input (TB201)

The ESTOP sense input is used to monitor the state of an external safety circuit only. This state is indicated by the software and may be used to facilitate system restart. This ESTOP sense input is not intended to be a complete safety system.

Refer to [Section 2.5.1.](#) for interconnection details.



WARNING: The user is responsible for assessing operator risk levels and designing the external safety circuits appropriately.



WARNING: Opening the motor leads at the Motor Output while the axis is enabled will damage the drive. To protect the drive, the ESTOP circuit should open the AC motor power input (Motor Supply). Refer to [Figure 2-25](#) for interconnection details.

The ESTOP input is scaled for an input voltage of 5-24 volts.

If the ESTOP bit is enabled in the FaultMask axis parameter, the ESTOP input must be driven to prevent the ESTOP fault condition.

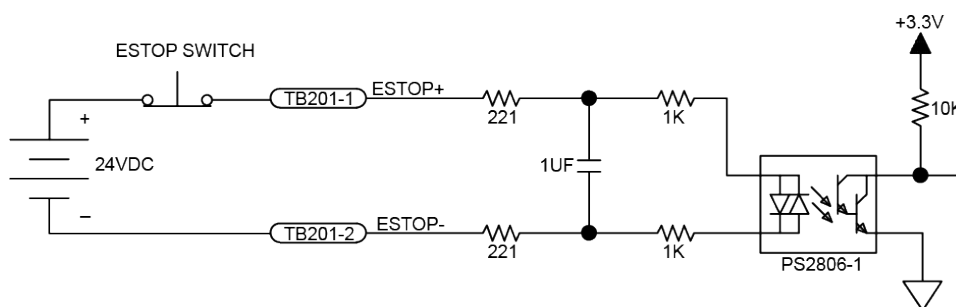


Figure 2-24: ESTOP Sense Input (TB201)

NOTE: Connecting the ESTOP input to a relay or other noise producing device requires the use of noise suppression devices such as those in [Table 2-18](#). These devices are applied across the switched coil to suppress transient voltages.

Table 2-18: Electrical Noise Suppression Devices

Device	Aerotech P/N	Third Party P/N
RC (.1uf / 200 ohm) Network	EIC00240	Electrocube RG1782-8
Varistor	EID00160	Littelfuse V250LA40A

Table 2-19: Mating Connector Part Numbers for the ESTOP Connector (TB201)

Description	Aerotech P/N	Phoenix P/N	Tightening Torque (Nm)	Wire Size: AWG [mm ²]
2-Pin Terminal Block	ECK01250	1803578	0.22 - 0.25	0.14 - 1.5 [26-16]

2.5.1. Typical ESTOP Interface

The user can connect an external emergency stop relay circuit to the Ndrive HPe 150/200's motor power supply input. This will remove power to the motor while maintaining control power, as shown in the [Figure 2-25](#).

The external relay must be sized based on the number of the Ndrive HPe 150/200s connected and the peak current rating of each drive.

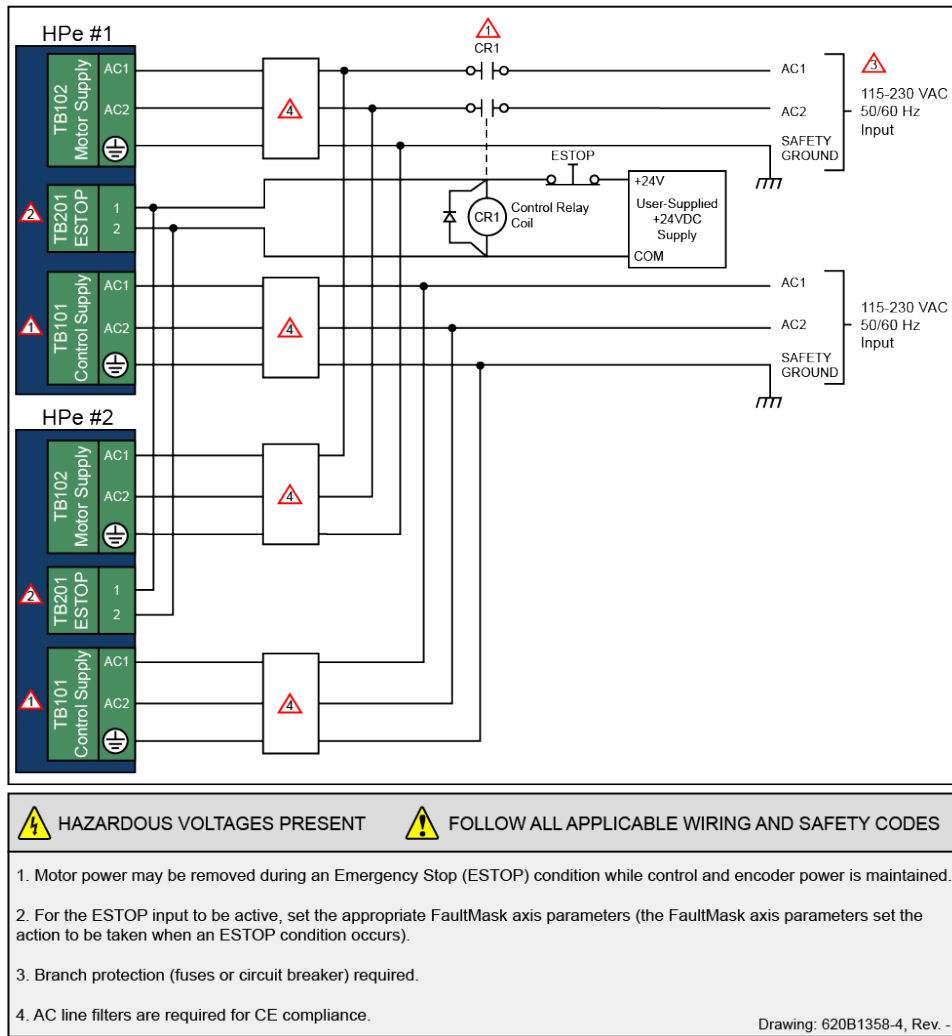


Figure 2-25: Typical Emergency Stop Circuit

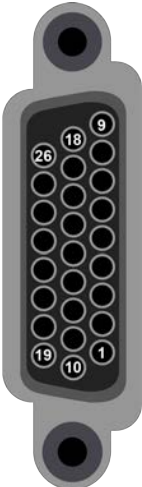
Table 2-20: Typical ESTOP Relay Ratings

	AC1	AC3	Aerotech P/N	Third Party P/N
HPe 150	250	115	N/A	Sprecher & Schuh CA6-115C-xx-xxx
HPe 200	250	115	N/A	Sprecher & Schuh CA6-115C-xx-xxx

2.6. Auxiliary I/O Connector (J205)

The Auxiliary I/O connector (J205) provides 1 analog and 6 digital inputs, 1 analog and 4 digital outputs, and a secondary RS-422 line driver encoder input.

Table 2-21: Auxiliary I/O Connector Pinout (J205)

Pin#	Description	In/Out/Bi	Connector
1	Auxiliary Sine+	Bidirectional	
2	Auxiliary Sine-	Bidirectional	
3	High-Speed Input 12 + user interrupt	Input	
4	High-Speed Input 12 - user interrupt	Input	
5	High-Speed Input 13 + user interrupt	Input	
6	High-Speed Input 13 - user interrupt	Input	
7	Digital Output 8	Output	
8	Digital Output 9	Output	
9	Digital Output 10	Output	
10	Auxiliary Cosine+	Bidirectional	
11	Auxiliary Cosine-	Bidirectional	
12	+5 Volt (500 mA max)	Output	
13	Analog Input 0 + (Differential)	Input	
14	Analog Input 0- (Differential)	Input	
15	Output Common	-	
16	Digital Output 11	Output	
17	Digital Input 8 / CCW EOT Input ⁽¹⁾	Input	
18	Digital Input 9 / CW EOT Input ⁽¹⁾	Input	
19	Auxiliary Marker- / PSO output ⁽²⁾	Bidirectional	
20	Auxiliary Marker+ / PSO output ⁽²⁾	Bidirectional	
21	Common (+5 Volt User Supply, 500 mA max)	-	
22	Analog Output 0	Output	
23	Analog Common	-	
24	Input Common	-	
25	Digital Input 10 / Home Input ⁽¹⁾	Input	
26	Digital Input 11	Input	

(1) Software configured option
 (2) For PSO, see [Section 2.6.2](#).

Table 2-22: Mating Connector Part Numbers for the Auxiliary I/O Connector (J205)

Mating Connector	Aerotech P/N	Third Party P/N
Connector	ECK01259	Kycon K86-AA-26P
Backshell	ECK01022	Amphenol 17E-1725-2

NOTE: These items are provided as a set under the Aerotech P/N: MCK-26HDD-CE.

2.6.1. Auxiliary Encoder Channel (J205)

The auxiliary encoder interface accepts an RS-422 differential quadrature line driver signal. Invalid or missing signals will cause a feedback fault when the axis is enabled.

This encoder channel can be used as an input for master/slave operation (handwheel) or for dual feedback systems. The auxiliary encoder interface does not support analog encoders and cannot be used as an input for the -MXH option.

The auxiliary encoder channel can also be used to echo the standard encoder signals or as the PSO output. Configuring the PSO hardware will automatically configure this encoder channel as an output (refer to [Section 2.6.2.](#)) and will remove the 180 ohm terminator resistors.

Table 2-23: Auxiliary Encoder Specifications

Specification	Value
Encoder Frequency	10 MHz maximum (25 nsec minimum edge separation)
x4 Quadrature Decoding	40 million counts/sec

NOTE: Use the EncoderDivider parameter to configure the bi-directional encoder interface on the auxiliary I/O connector. The EncoderDivider parameter converts the auxiliary encoder interface to an output and defines a divisor for the encoder echo. Refer to the A3200 Help file for more information.

Table 2-24: Auxiliary Encoder Channel Pins on the Auxiliary I/O Connector (J205)

Pin#	Description	In/Out/Bi
1	Auxiliary Sine+	Bidirectional
2	Auxiliary Sine-	Bidirectional
10	Auxiliary Cosine+	Bidirectional
11	Auxiliary Cosine-	Bidirectional
12	+5 Volt (500 mA max)	Output
19	Auxiliary Marker- / PSO output ⁽²⁾	Bidirectional
20	Auxiliary Marker+ / PSO output ⁽²⁾	Bidirectional
21	Common (+5 Volt User Supply, 500 mA max)	-

(2) For PSO, see [Section 2.6.2.](#)

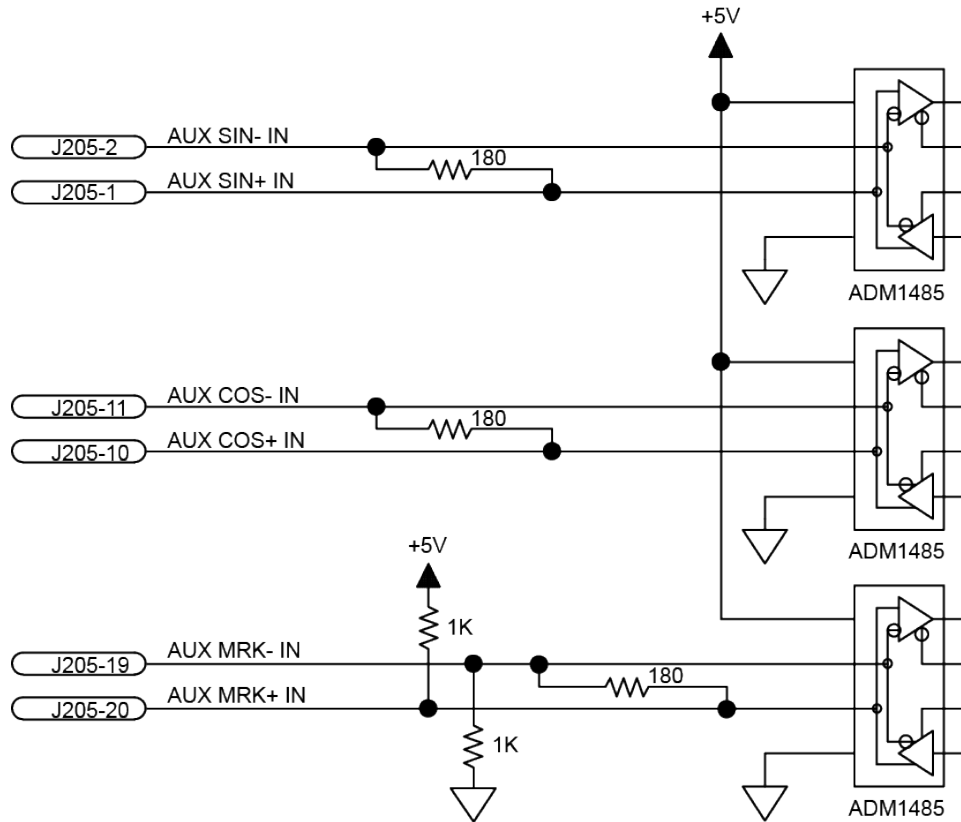


Figure 2-26: Auxiliary Encoder Channel (J205)

2.6.2. Position Synchronized Output (PSO)/Laser Firing (J205)

The PSO can be programmed to generate an output synchronized to the feedback position and is typically used to fire a laser or sequence an external device. Trigger signals may be derived from a feedback channel or a software trigger. The position synchronized output pulse is generated using high-speed hardware, allowing minimal latency between the trigger condition and the output.

The PSO output is available on the dual-function AUX Marker/PSO signal lines. The auxiliary marker must be configured as an output using the PSOOUTPUT CONTROL command. Refer to the Help File for more information.

An opto-isolated output is available on the TB302 connector of the -IO option (see [Section 3.2.](#) for more information).

An RS-422 line receiver or opto-isolator is recommended, especially when using long cable lengths in noisy environments or when high frequency pulse transmission is required. It is best to locate the line receiver or opto-isolator close to the receiving electronics.

Table 2-25: PSO Specifications

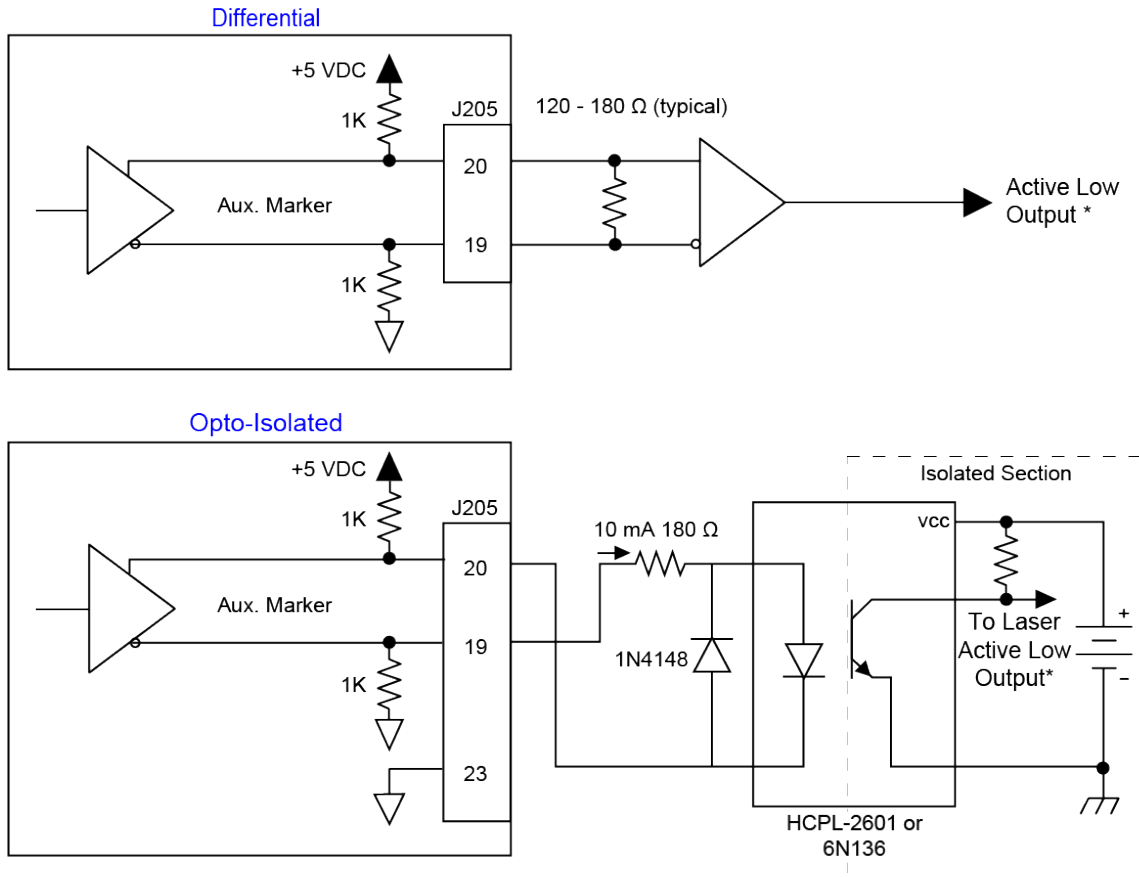
Specification		Value
Maximum Input Tracking Rate ⁽¹⁾	Single-Axis Tracking	16.6 MHz
	Dual-Axis Tracking	8.33 MHz
	Triple-Axis Tracking	8.33 MHz
Maximum Quadrature Encoder Output Frequency	Standard Feedback	40 MHz
	-MXH Feedback	25 MHz
Maximum PSO Output (Fire) Frequency ⁽²⁾		12.5 MHz
Firing Latency ⁽³⁾	Single-Axis Tracking	160 nsec
	Dual-Axis Tracking	220 nsec
	Triple-Axis Tracking	220 nsec
<ol style="list-style-type: none"> 1. Signals in excess of this rate will cause a loss of PSO accuracy. 2. The optocoupler that you use on the output might have an effect on this rate. 3. MXH encoder multiplier options have an additional latency of ~3.25 microseconds between the measurement position and the update of the PSO hardware. 		

NOTE: When using the MRK± signals with single-ended systems, **do not** connect MRK+ or MRK- to GROUND (GND).

Software controlled PSO pre-scalars may be used to limit the data rate of each encoder being tracked without affecting the servo loop data rate.

Table 2-26: PSO Output Pins on the Auxiliary I/O Connector (J205)

Pin#	Description	In/Out/Bi
19	Auxiliary Marker- / PSO output	Bidirectional
20	Auxiliary Marker+ / PSO output	Bidirectional
23	Analog Common	-



* Active low output shown. Opposite polarity available by reversing connections to Pins 19 and 20.

Figure 2-27: PSO Interface

2.6.3. Digital Outputs 8-11 (J205)

The digital outputs are optically-isolated and can be connected in sourcing or sinking configurations. The digital outputs are designed to connect to other ground referenced circuits and are not intended to provide high-voltage isolation.

The outputs are software-configurable and must be connected in either all sinking or all sourcing mode. [Figure 2-28](#) and [Figure 2-29](#) illustrate how to connect to an output in current sourcing and current sinking modes.

The opto-isolator's common connections can be directly connected to the drive's power supply; however, doing so will effectively defeat the isolation and will reduce noise immunity.

Table 2-27: Digital Output Specifications

Opto Device Specifications	Value
Maximum Voltage	24 V maximum
Maximum Sink/Source Current	60 mA/channel @ 50°C
Output Saturation Voltage	2.75 V at maximum current
Output Resistance	33 Ω
Rise / Fall Time	250 usec (typical)
Reset State	Output Off (High Impedance State)

Table 2-28: Digital Output Pins on the Auxiliary I/O Connector (J205)

Pin#	Description	In/Out/Bi
7	Digital Output 8	Output
8	Digital Output 9	Output
9	Digital Output 10	Output
15	Output Common	-
16	Digital Output 11	Output

NOTE: Outputs must be connected as all sourcing or all sinking.

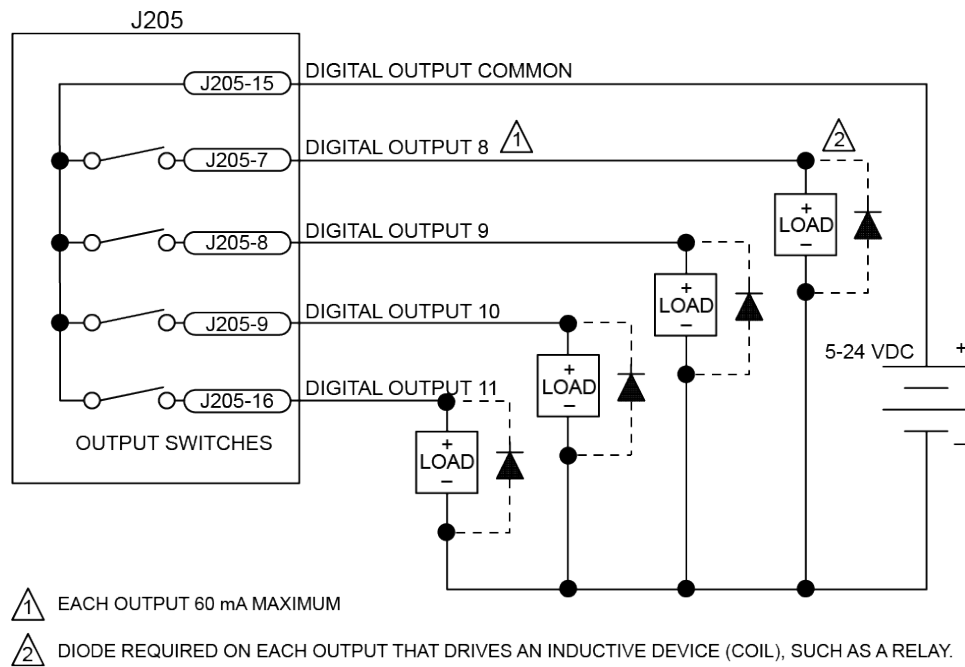


Figure 2-28: Digital Outputs Connected in Current Sourcing Mode (J205)

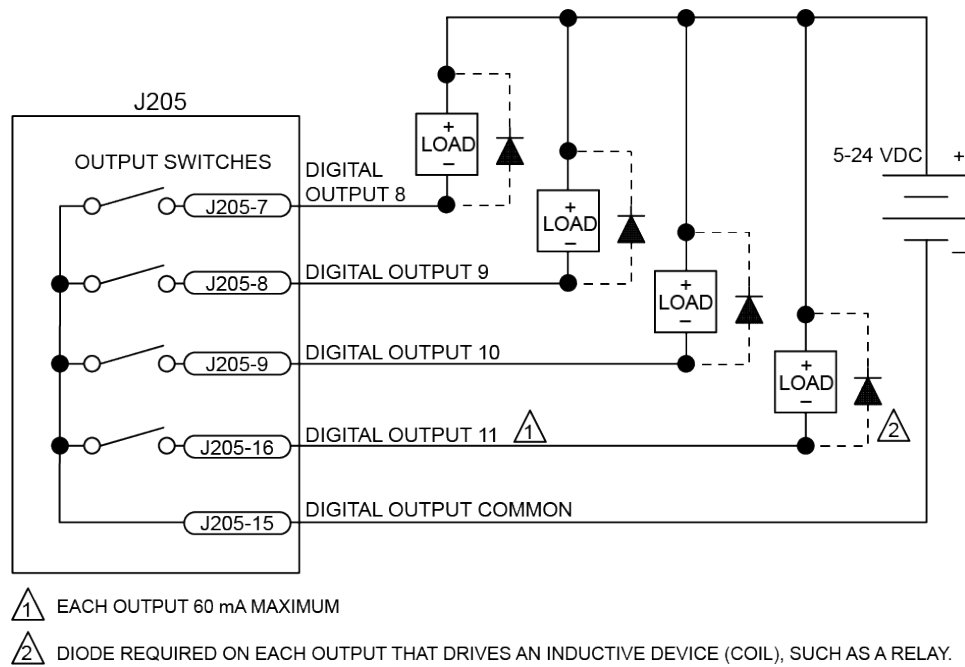


Figure 2-29: Digital Outputs Connected in Current Sinking Mode (J205)

2.6.4. Digital Inputs 8-11 (J205)

The digital inputs are opto-isolated and may be connected to current sourcing or current sinking devices, as shown in [Figure 2-30](#) and [Figure 2-31](#). These inputs are designed to connect to other ground-referenced circuits and are not intended for high-voltage isolation.

The opto-isolator's common connections can be directly connected to the drive's power supply; however, doing so will effectively defeat the isolation and will reduce noise immunity.

Table 2-29: Digital Input Specifications

Input Voltage	Approximate Input Current	Turn On Time	Turn Off Time
+5 V	1 mA	200 usec	2000 usec
+24 V	6 mA	4 usec	1500 usec

Table 2-30: Digital Input Pins on the Auxiliary I/O Connector (J205)

Pin#	Description	In/Out/Bi
17	Digital Input 8 / CCW EOT Input ⁽¹⁾	Input
18	Digital Input 9 / CW EOT Input ⁽¹⁾	Input
24	Input Common	-
25	Digital Input 10 / Home Input ⁽¹⁾	Input
26	Digital Input 11	Input

(1) Software configured option

NOTE: Each bank of 8 Inputs must be connected in the all sourcing or all sinking configuration.

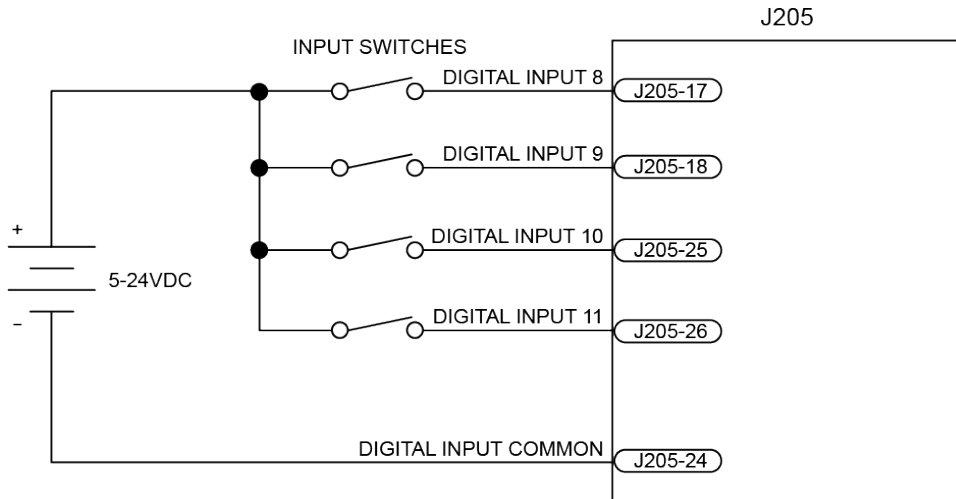


Figure 2-30: Digital Inputs Connected in Current Sourcing Mode (J205)

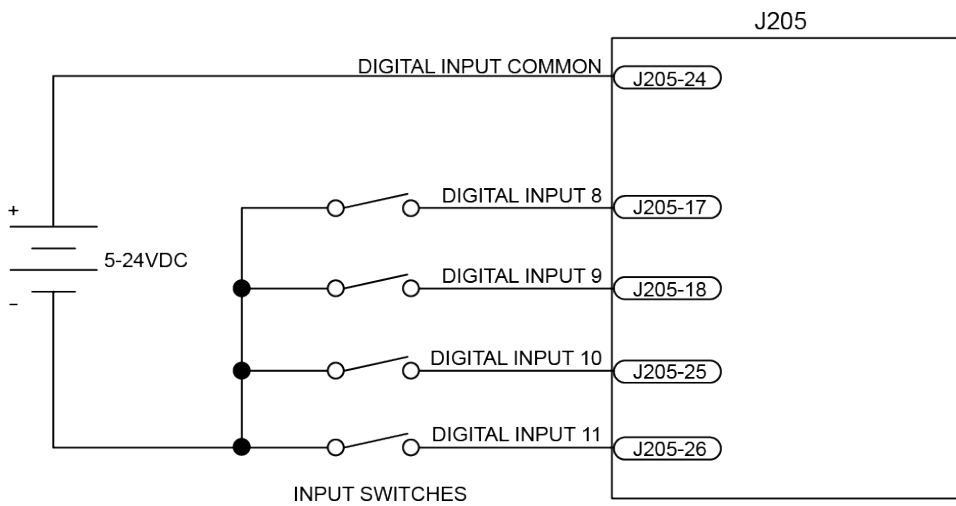


Figure 2-31: Digital Inputs Connected in Current Sinking Mode (J205)

2.6.5. High-Speed Digital Inputs 12-13 (J205)

The high-speed inputs 12-13 are typically used as a sample signal for data collection.

Table 2-31: High-Speed Input Specifications

Specification	Value
Input Voltage	5V or 24 V input voltages based on a jumper setting (Table 2-33)
Input Current	10 mA
Input Device	HCPL-0630
Delay	50 nsec

Table 2-32: High-Speed Digital Input Pins on the Auxiliary I/O Connector (J205)

Pin#	Description	In/Out/Bi
3	High-Speed Input 12 + user interrupt	Input
4	High-Speed Input 12 - user interrupt	Input
5	High-Speed Input 13 + user interrupt	Input
6	High-Speed Input 13 - user interrupt	Input

Table 2-33: Input Voltage Jumper Configuration

Jumper	Setting	Description
JP3	1-2 ⁽¹⁾	24 V operation (High Speed Input 13)
	2-3	5 V operation (High Speed Input 13)
JP4	1-2 ⁽¹⁾	24 V operation (High Speed Input 12)
	2-3	5 V operation (High Speed Input 12)

(1) Default

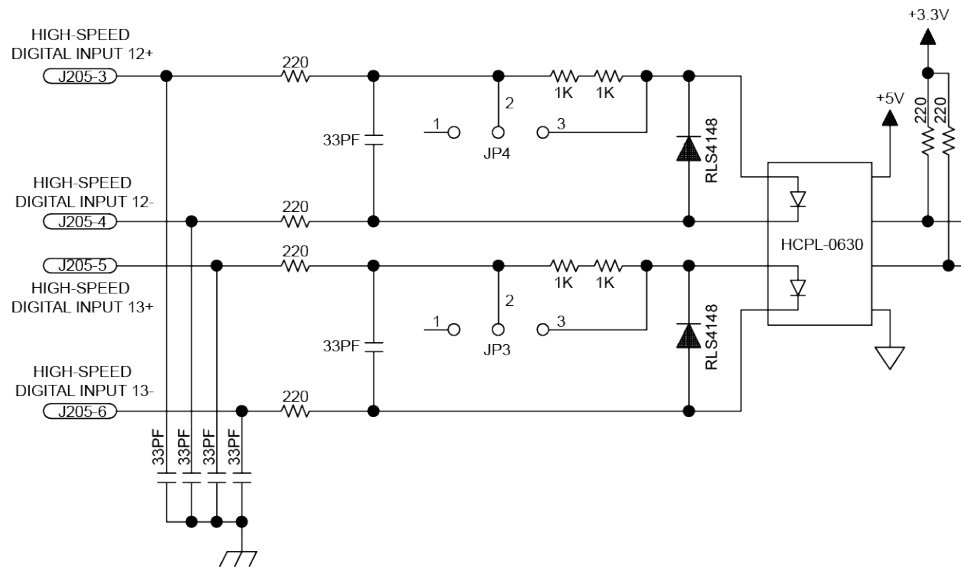


Figure 2-32: High-Speed User Inputs (J205)

2.6.6. Analog Output 0 (J205)

The analog output is set to zero when power is first applied to the system or during a system reset.

Table 2-34: Analog Output 0 Specifications (J205)

Specification	Value
Output Voltage	-10 V to +10 V
Output Current	5 mA
Resolution (bits)	16 bits
Resolution (volts)	305 μ V

Table 2-35: Analog Output Pins on the Auxiliary I/O Connector (J205)

Pin#	Description	In/Out/Bi
22	Analog Output 0	Output
23	Analog Common	-

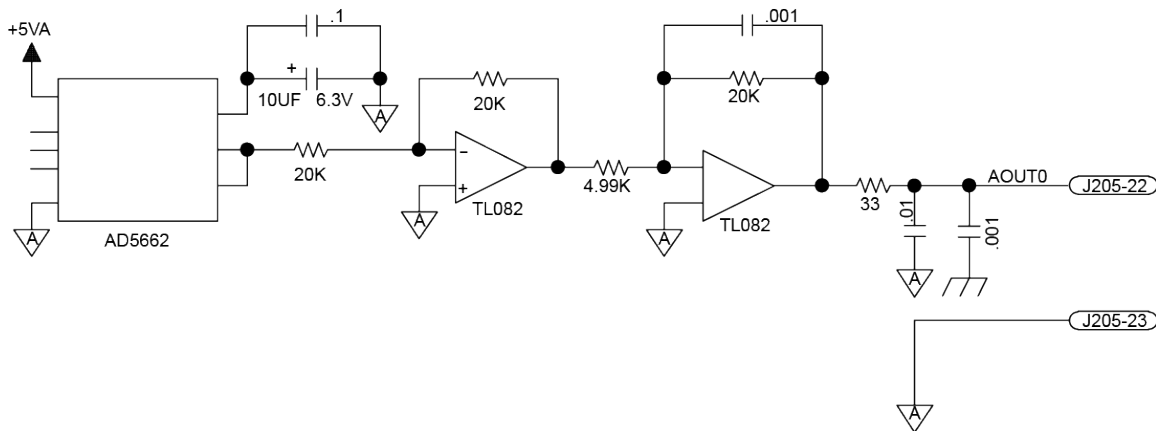


Figure 2-33: Analog Output 0 (J205)

2.6.7. Differential Analog Input 0 (J205)

To interface to a single-ended (non-differential) voltage source, connect the signal common of the source to the negative input and the analog source signal to the positive input. A floating signal source should be referenced to the analog common as shown in [Figure 2-34](#).

Table 2-36: Differential Analog Input 0 Specifications

Specification	Value
(AI+) - (AI-)	+10 V to -10 V ⁽¹⁾
Resolution (bits)	16 bits
Resolution (volts)	305 μ V

1. Signals outside of this range may damage the input

Table 2-37: Analog Input Pins on the Auxiliary I/O Connector (J205)

Pin#	Description	In/Out/Bi
13	Analog Input 0 + (Differential)	Input
14	Analog Input 0- (Differential)	Input
23	Analog Common	-

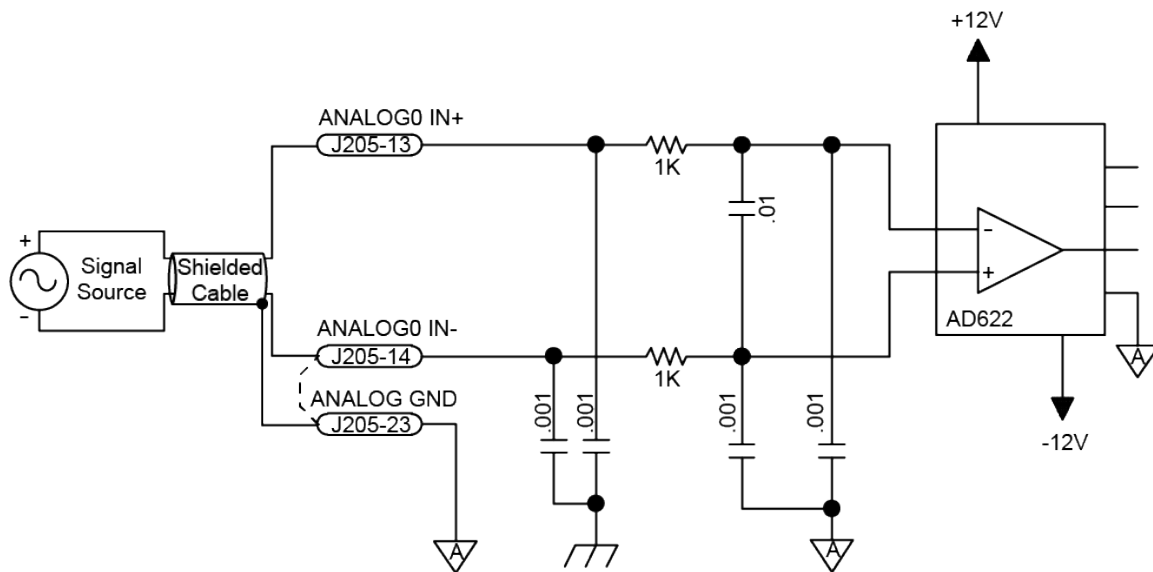


Figure 2-34: Analog Input 0 (J205)

2.7. Brake Power Supply (TB202)

TB202 is the power supply connection to the onboard solid state brake control relay. The relay can be used to automatically control a fail-safe brake on a vertical axis. It can also be used as a general purpose output.

The brake is typically wired directly to the Motor Feedback connector and the brake power supply is connected to TB202 (shown in [Figure 2-35](#)). The brake may also be connected in series with the Brake Power Supply and interlocked using Motor Feedback brake pins ([Figure 2-36](#)). A varistor must be connected across the brake to minimize high voltage transients.

The brake output can be software configured; refer to the A3200 Help file for more information (see topics for the EnableBrakeControl parameter and the BRAKE command).

When TB202 is used to power the solid state brake control relay, the mechanical brake control relay present on the I/O board should not be used.

NOTE: The brake power supply must be externally fused.

The user must verify that the brake power requirements are within the specifications of the brake control relay.

Table 2-38: Relay Specifications

Solid State Relay Rating	
Maximum Voltage	24 VDC
Maximum Current	2.5 Amps
Turn-On/Turn-Off Time	< 3.2 ms Turn-On (typical) / 0.1 ms Turn-Off (typical)



WARNING: Do not exceed the maximum specifications.

Table 2-39: Brake Output Connector Pinout (TB202)

Pin#	Description	In/Out/BI
1	Brake Power Supply (+)	Input
2	Brake Power Supply (-)	Input

Table 2-40: Mating Connector Part Numbers for the Brake Power Supply Connector (TB202)

Description	Aerotech P/N	Phoenix P/N	Tightening Torque (Nm)	Wire Size: AWG [mm ²]
2-Pin Terminal Block	ECK01250	1803578	0.22 - 0.25	0.14 - 1.5 [26-16]

Figure 2-35 is an example of a +24 VDC brake connected to the Motor Feedback connector. In this example the external +24 VDC power source is connected to TB202.

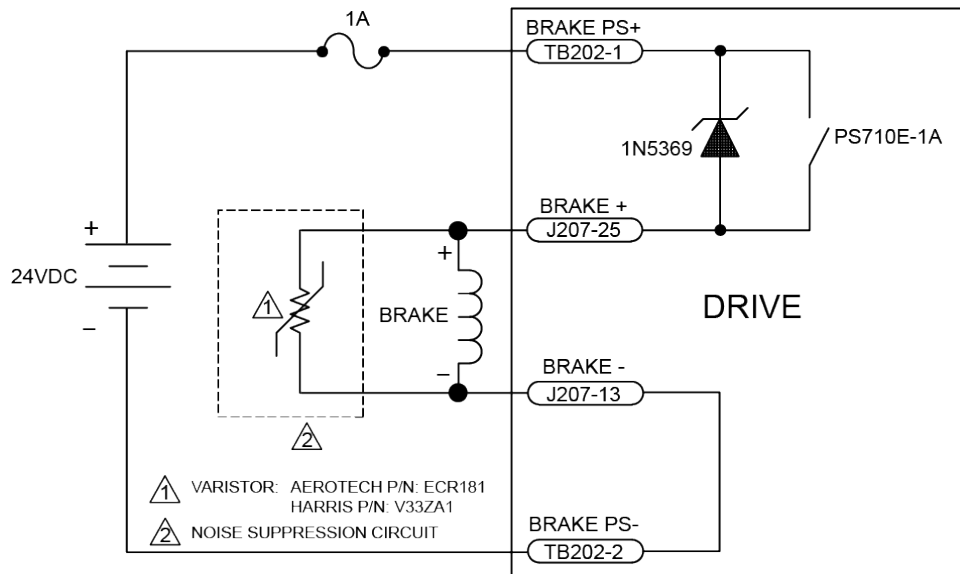


Figure 2-35: Brake Connected to J207

NOTE: The user is responsible for providing fuse protection for the brake circuit.

Figure 2-36 is an example of a 24 VDC brake connected to TB202. The user must connect J207 pin 13 to J207 pin 25. In this case, J207 would function as an interlock to prevent the brake from releasing if the Motor Feedback connector is not connected.

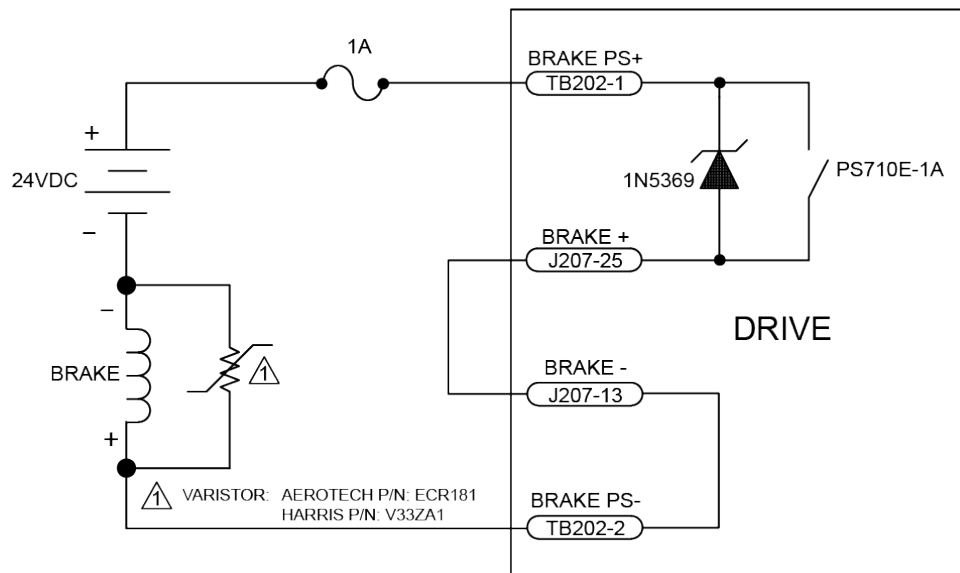


Figure 2-36: Brake Connected to TB202

2.8. FireWire Interface

The FireWire bus is the high-speed communications connection to the Ndrive HPe 150/200 operating at 400 megabits per second. All command and configuration information is sent via the FireWire port.

Table 2-41: FireWire Card Part Numbers

Part Number	Description
NFIRE-PCI	OHCI compliant FireWire PCI interface card, 3 port
NFIRE-PCIE	OHCI compliant FireWire PCIe x1 interface card, 2 port
NFIRE-PCI-TI-LP	Low Profile, OHCI compliant, PCI
NFIRE-PCIE-GOF	FireWire PCIe X1 Glass Optical Fiber Board

Table 2-42: FireWire Repeaters (for cables exceeding 4.5 m (15 ft) specification)

Part Number	Description
NFIRE-RPTR-1394A-1394A	Extender for copper cable lengths greater than 4.5 m (15 feet).
NFIRE-RPTR-1394A-GOF	Glass Optical Fiber FireWire Repeater, Qty. 1 (Fiber Cable not included)

Table 2-43: FireWire Cables (copper and glass fiber)

Part Number	Description
NCONNECT-60	6 m (20 ft) long, 6 pin to 6 pin
NCONNECT-45	4.5 m (15 ft) long, 6 pin to 6 pin
NCONNECT-30	3 m (10 ft) long, 6 pin to 6 pin
NCONNECT-15	1.5 m (5 ft) long, 6 pin to 6 pin
NCONNECT-9	0.9 m (3 ft) long, 6 pin to 6 pin
NCONNECT-10000-GOF	10 m (32.8 ft), glass fiber optical cable
NCONNECT-15000-GOF	15 m (49.2 ft), glass fiber optical cable
NCONNECT-20000-GOF	20 m (65.6 ft), glass fiber optical cable
NCONNECT-30000-GOF	30 m (101.7 ft), glass fiber optical cable

2.9. RS-232 Interface (J206)

The RS-232 Interface (J206) currently has no functionality on the NdriveHPe150/200.

2.10. -EXTSHUNT Option (TB101)

The -EXTSHUNT option provides a connection for a user-provided shunt resistor to dissipate excess energy and keep the internal drive voltage within safe levels. The drive switches this resistor "ON" when the internal bus voltage reaches approximately 380 VDC. This option is generally required for systems that have a large amount of stored mechanical energy (i.e. large rotating drums).

Proper sizing, mounting, and protection of the shunt resistor is critical due to the potentially large amounts of power dissipated.



DANGER: The shunt resistor temperature can exceed 70°C during normal operation and contains lethal voltage on its terminals and surface. It must be properly enclosed and shielded to avoid risk of fire and operator shock.

Table 2-44: -EXTSHUNT Component Information

Component	Description	Aerotech P/N
Recommended Shunt Resistor	50 Ω (min), 300 W Vishay/Dale: RBEF030050R00KFBVT	ECR01039
Fuse (F1 on the Power Board)	8 A S.B. (3 AG) Littelfuse: 32008	EIF00122
Recommended Wire Size	16 AWG (1.3 mm ²) High Temperature	--
NOTE: Multiple resistors can be connected in parallel if required by the application. If multiple resistors are used, the internal fuse may also need to be increased.		

The first step in sizing the external shunt resistor is to calculate the kinetic energy of the system (**Equation 1**). Neglecting the system's losses, this is the energy that can potentially be regenerated to the DC bus.

Equation 1:

$$E_M = \left[\frac{1}{2} \right] [J_M + J_L] \omega_M^2 \quad \text{or} \quad E_M = \left[\frac{1}{2} \right] [M_M + M_L] v_M^2$$

(for rotary motors) (for linear motors)

- J_M rotor inertia (kg·m²)
- J_L load inertia (kg·m²)
- ω_m motor speed before deceleration (rad/s)

- M_M forcer mass (kg)
- M_L load mass (kg)
- v_m velocity (m/s)

A shunt resistor is required if the regenerated energy is greater than the additional energy that the internal bus capacitor can store (**Equation 2**).

Equation 2:

$$E_{Ca} = \frac{1}{2}C (V_M^2 - V_{NOM}^2)$$

- C bus capacitor (F) [4,700 uF]
 V_M turn on voltage for shunt circuit (V) [380 V]
 V_{NOM} nominal bus voltage (V) [160 V or 320 V, Typical]

For a standard Ndrive HPe 150/200, the maximum additional energy the internal bus capacitor can store without requiring a shunt resistor is indicated in [Table 2-45](#).

Table 2-45: Maximum Additional Storage Energy

Bus Voltage	Maximum Additional Energy
160 V	279.2 J
320 V	98.7 J

If a shunt resistor is required, the next step is to calculate the value of resistance necessary to dissipate the energy. Use **Equations 3, 4, and 5** to calculate the parameters of the shunt resistor.

Equation 3:

$$P_{PEAK} = \frac{E_M - E_{Ca}}{t_D}$$

- P_{PEAK} peak power that the regeneration circuit must accommodate (W)
 t_D deceleration time (s)

Equation 4:

$$P_{AV} = \frac{E_M - E_{Ca}}{t_{CYCLE}}$$

- P_{AV} average power dissipated on shunt resistor (W)
 t_{CYCLE} time between deceleration events (s)

Equation 5:

$$R = \frac{(2V_M - V_{HYS})^2}{4P_{PEAK}}$$

- V_{HYS} hysteresis voltage of regeneration circuit (V) [10 V, Typical]

Additional useful equations:

- 1 lb·ft = 1.356 N·m
 1 rad/s = 9.55 rpm

2.11. PC Configuration and Operation Information

For additional information about PC configuration, hardware requirements, programming, utilities, and system operation refer to the A3200 Help file.

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Chapter 3: -I/O Expansion Board

The -IO option board is 16 digital opto-inputs, 16 digital opto-outputs, 2 SSINET connections, 3 analog inputs, 3 analog outputs, and a brake/relay output.



DANGER: Always disconnect the Mains power connection before opening the Ndrive HPe 150/200 chassis.

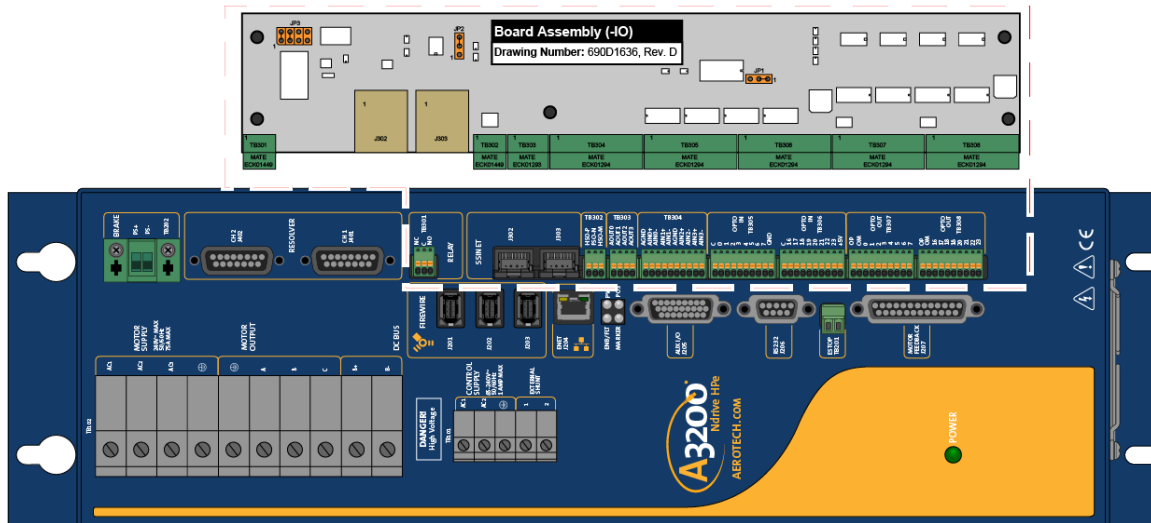


Figure 3-1: Ndrive HPe 150/200 with -IO Option Board

Table 3-1: -IO Expansion Board Jumper Configuration

Jumper	Setting	Description
JP2	1-2	PSO Output Active High, Low Z during reset
	2-3 ⁽¹⁾	PSO Output Active Low, High Z during reset
JP3	1-2, 3-4	Switch Brake +
	5-6, 7-8 ⁽¹⁾	Switch Brake -
	1-3	Relay Only
⁽¹⁾ default		

Table 3-2: -IO Option Board Fuse Information

Fuse	Description	Size	Aerotech P/N	Manufacturer's P/N
F1	+5 VDC User Power	3 A, resettable	EIF01001	Raychem RGE300

3.1. Relay Connector (TB301)

The relay can be used to automatically control a fail-safe brake on a vertical axis. It can also be used as a general purpose relay. The normally-open relay contacts are accessible through TB301 and the Motor Feedback connector. The normally-closed relay contact is only accessible through TB301 (see [Figure 3-3](#)). The Motor Feedback connector allows the brake wires to be included in the motor feedback cable and eliminate the need for a separate brake cable.

The brake output can be software configured; refer to the A3200 Help file for more information (see topics for the EnableBrakeControl parameter and the BRAKE command).

When TB301 is used to power the mechanical brake control relay, the solid state brake control relay (TB202) should not be used.

The user must verify that the application will be within the specifications of the Brake/Relay contacts.

Table 3-3: Voltage and Current Specifications (TB301)

Relay K1 Contact Ratings	
Maximum Switched Voltage	150 VDC, 125 VAC
Maximum Switched Current	1A
Maximum Carrying Current	1A
Maximum Switched Power	30 W (DC), 60 VA (AC)

NOTE: Do not exceed Maximum Current or Maximum Power specifications.

Table 3-4: Relay Connector Pinout (TB301)

Pin#	Description	In/Out/BI
1	Brake Relay Output Normally Closed Contact	Output
2	Brake Relay Output Common Contact	Output
3	Brake Relay Output Normally Open Contact ⁽¹⁾	Output

(1) For JP3 jumper configuration, refer to [Table 1-1](#).

Table 3-5: Mating Connector Part Numbers for the Relay Connector (TB301)

Description	Aerotech P/N	Phoenix P/N	Wire Size: AWG [mm ²]
3-Pin Terminal Block	ECK01449	1881338	0.5 - 0.080 [20-28]

The configuration of JP3 ([Table 3-6](#)) allows either the Brake + or the Brake - output to be switched by the relay and connected at the Motor Feedback connector or for the brake to be connected at TB301. Refer to [Section .](#) for more information.

Table 3-6: -IO Expansion Board Brake Jumper Configuration

Jumper	Setting	Description
JP2	1-2	PSO Output Active High, Low Z during reset
	2-3 ⁽¹⁾	PSO Output Active Low, High Z during reset
JP3	1-2, 3-4	Switch Brake +
	5-6, 7-8 ⁽¹⁾	Switch Brake -
	1-3	Relay Only

(1) default

NOTE: The user is responsible for providing fuse protection for the brake circuit.

Figure 3-2 is an example of a +24 VDC Brake connected to the Motor Feedback connector. In this example the external +24 power source is connected to TB301. Note that JP3 is set 1-2 and 3-4 with all others removed.

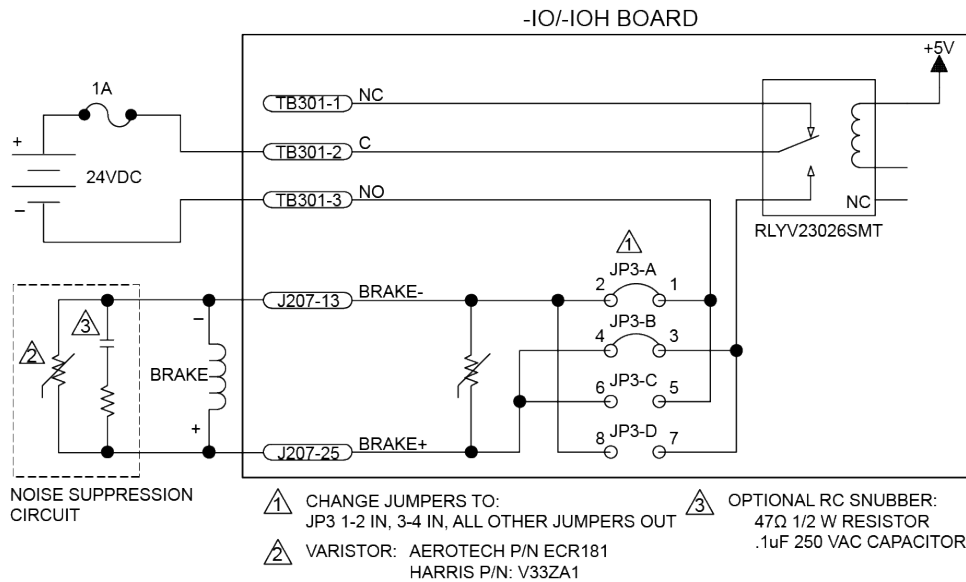


Figure 3-2: Brake Connected to J207

Figure 3-3 is an example of a +24 VDC Brake connected to TB301. In this example, JP3 must be set 1-3 and all other jumpers removed. Otherwise, the user must connect J207 pin 13 to J207 pin 25. In this case, J207 would function as an interlock to prevent the Brake from releasing if the Motor Feedback connector is not connected.

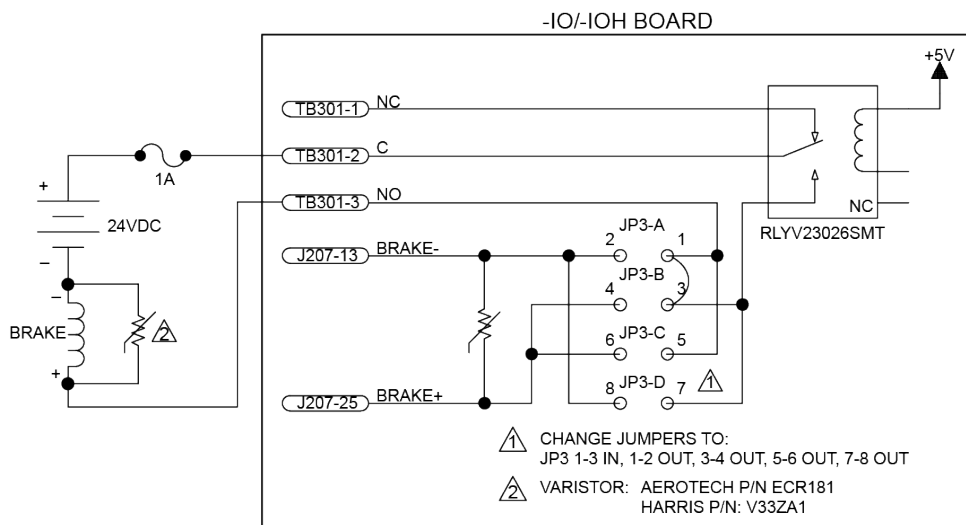


Figure 3-3: Brake Connected to TB301

3.2. PSO Output Interface (TB302)

The output may be used to source (or sink) current (as shown in [Figure 3-4](#) and [Figure 3-5](#)).

By default, JP2 is installed in the 2-3 position for normally open operation. If the PSO-NC option is ordered, JP2 is installed in the 1-2 position giving normally-closed operation. This mode should be used with caution since the Ndrive HPe 150/200 cannot maintain the closed state when its AC mains power is turned off. The PSO-NC (JP2 1-2 setting) should not be used when fail-safe operation is required. JP2 jumper settings are shown in [Table 3-9](#). For the JP2 jumper location, refer to [Figure 3-1](#).

Table 3-7: PSO Output Connector Pinout (TB302)

Pin #	Description	In/Out/Bi
1	Reserved	--
2	PSO Output	Output
3	Opto-Isolator Common	Input

Table 3-8: Mating Connector Pin Numbers for the PSO Output Connector (TB302)

Description	Aerotech P/N	Phoenix P/N	Wire Size: AWG [mm ²]
3-Pin Terminal Block	ECK01449	1881338	0.5 - 0.080 [20-28]

Table 3-9: PSO Output Polarity Settings for JP2

PSO Output Polarity	JP2 Setting
Normally Open	2-3 (Recommended)
Normally Closed	1-2

Table 3-10: PSO Opto Output Specifications

Description	Specification
Maximum Voltage	24 V
Current	250 mA
Latency	120 ns
Maximum Frequency	5 MHz

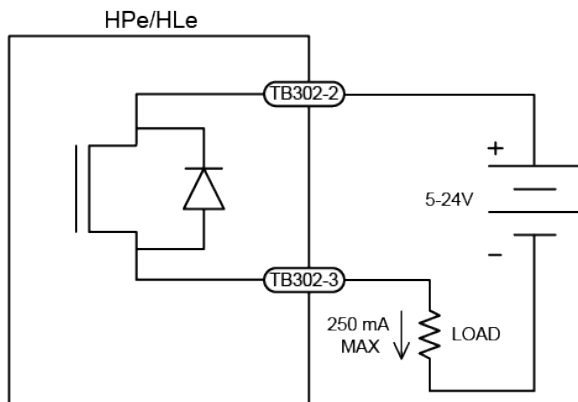


Figure 3-4: PSO Output Sources Current

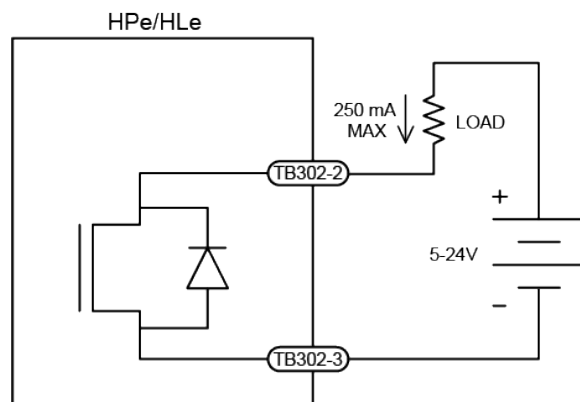


Figure 3-5: PSO Output Sinks Current

3.2.1. -DUALPSO and -TRIPLEPSO Laser Firing Options

The -TRIPLEPSO option is only available on the -IO option board.

The Ndrive HPe 150/200 allows two and three-axis laser firing via its -DUALPSO and -TRIPLEPSO options. To accomplish this, the encoder signals from a second/third drive must be jumpered (or daisy-chained) from that Ndrive HPe 150/200 to the drive with the -DUALPSO or -TRIPLEPSO options. This requires an encoder signal from another axis via the J205 connector or via one of the two SSINet connectors. If the SSINet is used it requires a cable (see [Table 3-11](#) and [Figure 3-6](#)) from J302 to J302 of each HPe (J302 to J302 or J303 to J303 of the other Ndrive HPe 150/200, both connectors have two bi-directional ports). Refer to the A3200 Help File for programming information.

Software controlled PSO pre-scalars may be used to limit the data rate of each encoder being tracked without affecting the servo loop data rate.

See [Section 3.2.1.1](#) for an example of two and three-axis firing. See the A3200 Help file for more information on parameter configurations.

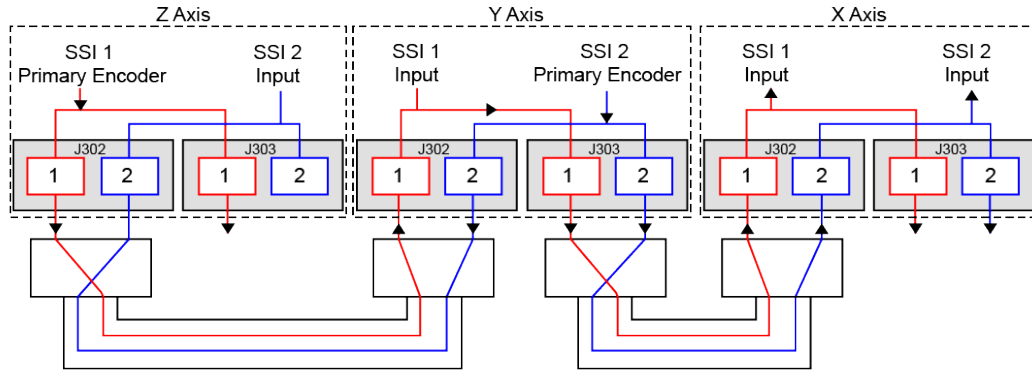
3.2.1.1. Multi-Axis Firing

In this example, the X axis has the -TRIPLEPSO option and the Y and Z axes represent the other two axes that will be tracked. The Y and Z axes output their encoder feedback through SSINet ports 1 and 2, respectively, to the X axis. The Z axis must have its SSINet port 1 configured as an output for its encoder feedback signal, and the Y axis must have its SSINet port 2 configured as an output for its encoder feedback signal. Since the Z axis does not use its SSINet port 2, it should be configured as an Input. Similarly, the Y axis does not use its SSINet port 1 so it should also be configured as an Input. The X axis must have both SSINet ports 1 and 2 configured as Inputs.

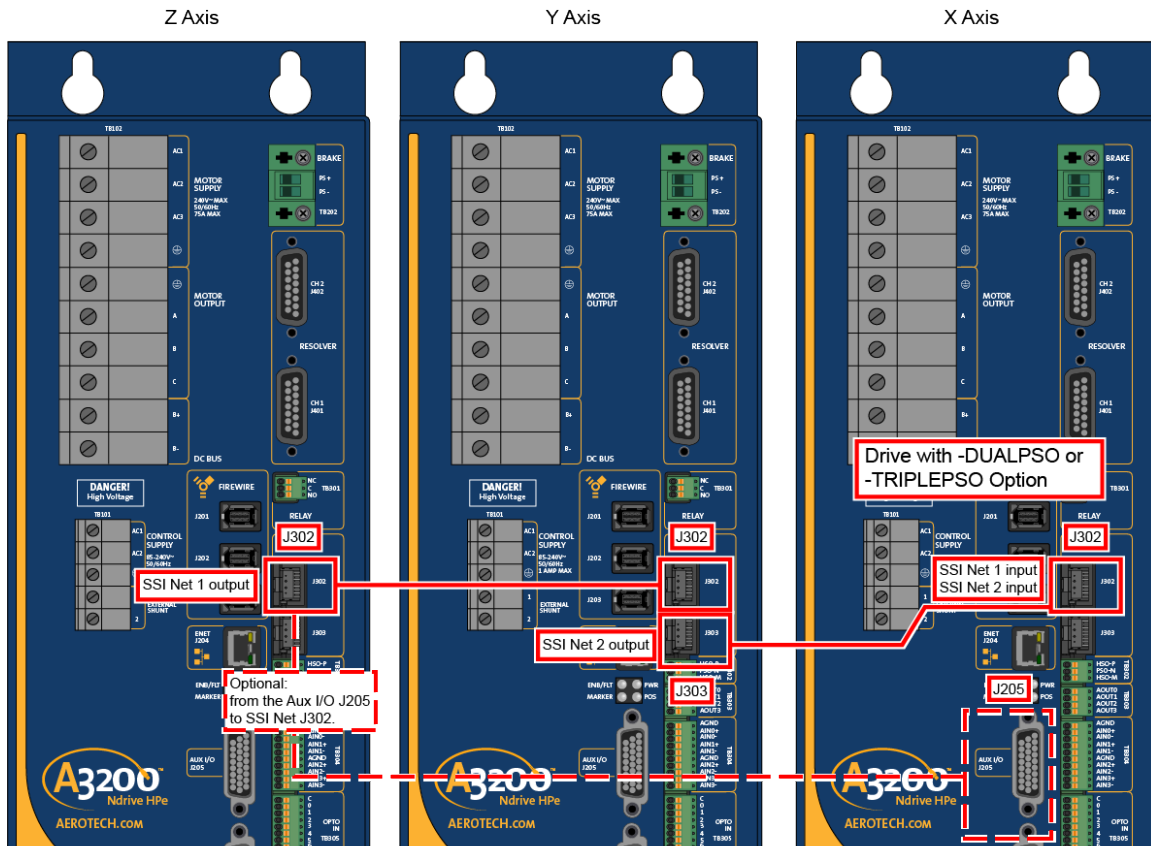
In general, if an axis has an SSINet port configured as an output, then that SSINet port must be configured as an input on all other axes which it is connected to. Otherwise, encoder or marker data may be faulty.

Table 3-11: SSINet Cable Part Numbers

Part #	Description
NConnect-SSINet-4500	4.5 M (15 FT) SSINet Cable
NConnect-SSINet-3000	3.0 M (10 FT) SSINet Cable
NConnect-SSINet-1500	1.5 M (5 FT) SSINet Cable
NConnect-SSINet-900	0.9 M (3 FT) SSINet Cable
C19891-X	J302/J303 to J205 Cable
C19892-X	J302/J303 to J205 Cable



NOTES:
 Z axis is routing its primary encoder data to X axis (as well as Y axis) through SSI port 1.
 Y axis is routing its primary encoder data to X axis (as well as Z axis) through SSI port 2.



NOTES:
 J302 and J303 contain both SSI Net ports 1 and 2.
 Use Nconnect-SSINet-XX cable between J302 and J303.
 Use C19891-X or C19892-X cable between J302/J303 and J205.

Figure 3-6: Two/Three Axis Laser Firing Interconnection

3.3. Analog Outputs (TB303)

The analog output is set to zero when power is first applied to the system or during a system reset.

Table 3-12: Analog Output Specifications (TB303)

Specification	Value
Output Voltage	-10 V to +10 V
Output Current	5 mA
Resolution (bits)	16 bits
Resolution (volts)	305 μ V

NOTE: Analog Output 0 on TB303 is tied to Analog Output 0 on J205 (see [Section 2.6.6.](#)). TB303 lets you connect to all of the analog outputs from one connector (do not connect to AOUT0 at both TB303 and J205).

Table 3-13: Analog Output Connector Pinout (TB303)

Pin#	Description	In/Out/Bi
1	Analog Output 0	Output
2	Analog Output 1	Output
3	Analog Output 2	Output
4	Analog Output 3	Output

Table 3-14: Mating Connector Part Numbers for the Analog Output Connector (TB303)

Type	Aerotech P/N	Phoenix P/N	Wire Size: AWG [mm ²]
4-Pin Terminal Block	ECK01293	1881341	20-28 [0.5- 0.080]

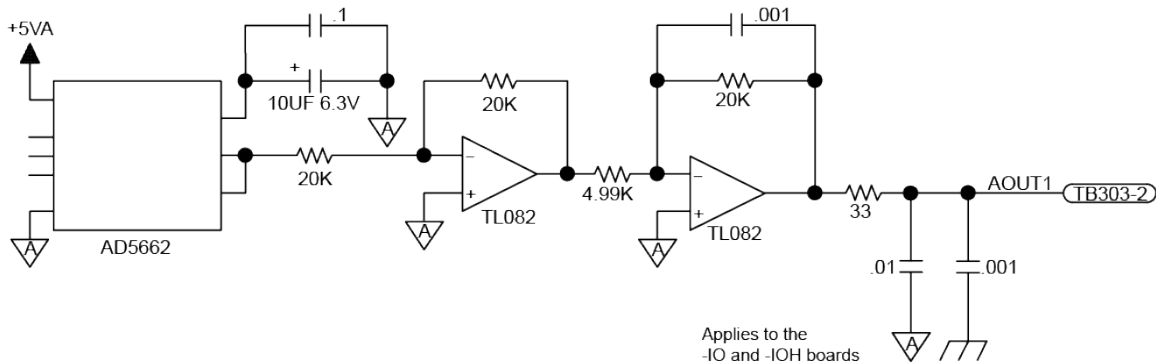


Figure 3-7: Analog Output Connector (TB303)

3.4. Analog Inputs (TB304)

To interface to a single-ended (non-differential) voltage source, connect the signal common of the source to the negative input and the analog source signal to the positive input. A floating signal source should be referenced to the analog common as shown in [Figure 3-8](#).

Table 3-15: Differential Analog Input 1 Specifications (TB304)

Specification	Value
(AI+) - (AI-)	+10 V to -10 V ⁽¹⁾
Resolution (bits)	16 bits
Resolution (volts)	305 μ V

1. Signals outside of this range may damage the input

NOTE: Analog Input 0 on the I/O board is tied to Analog Input 0 on J205 (see [Section 2.6.7.](#)). TB304 lets you connect to all of the analog inputs in one place (do not connect to AIN0 at both TB304 and J205).

Table 3-16: Analog Inputs Connector Pinout (TB304)

Pin#	Description	In/Out/Bi
1	Analog Common	N/A
2	Non-Inverting Analog Input 0	Input
3	Inverting Analog Input 0	Input
4	Non-Inverting Analog Input 1	Input
5	Inverting Analog Input 1	Input
6	Analog Common	N/A
7	Non-Inverting Analog Input 2	Input
8	Inverting Analog Input 2	Input
9	Non-Inverting Analog Input 3	Input
10	Inverting Analog Input 3	Input

Table 3-17: Analog Input Mating Connector Part Numbers for the Analog Input Connector (TB304)

	Aerotech P/N	Phoenix P/N	Wire Size: mm ² [AWG]
10-Pin Terminal Block	ECK01294	1881406	0.5-0.080 [20-28]

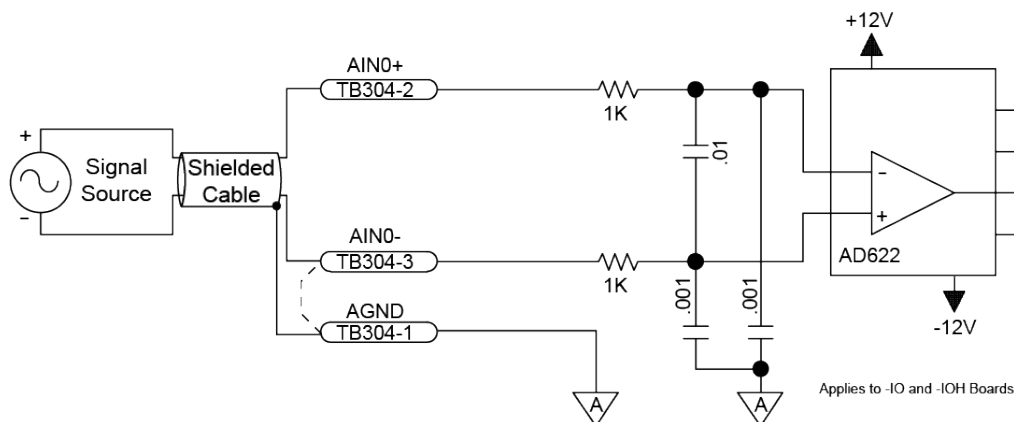


Figure 3-8: Analog Input Typical Connection (TB304)

3.5. User Power (TB305, TB306)

A user accessible power supply (+5V at 0.5 A) is available between the TB306 +5V terminal and TB305 GND terminal.

Table 3-18: User Common Pin on the Opto In Connector (TB305)

Pin#	Description	In/Out/Bi
10	Signal Common	N/A

Table 3-19: +5 Volt Power Pin on the Opto In Connector (TB306)

Pin#	Description	In/Out/Bi
10	Internal +5 Volt Power Supply (0.5 A max)	N/A



WARNING : Opto-isolated inputs and outputs should not be powered by the user output power. Doing so would compromise the isolation provided by the opto-isolator.

3.6. Opto In Connector (Digital Inputs) (TB305, TB306)

The digital inputs are opto-isolated and may be connected to current sourcing or current sinking devices, as shown in [Figure 3-10](#) and [Figure 3-11](#). These inputs are designed to connect to other ground-referenced circuits and are not intended for high-voltage isolation.

Inputs 0-7 and inputs 16-23 have separate common inputs (refer to [Table 3-21](#) for TB305 and [Table 3-22](#) for TB306). Each port can be referenced independently.

The opto-isolator's common connections can be directly connected to the drive's power supply; however, doing so will effectively defeat the isolation and will reduce noise immunity.

Table 3-20: Digital Input Device Specifications

Input Voltage	Approximate Input Current	Turn On Time	Turn Off Time
+5 V	1 mA	200 usec	2000 usec
+24 V	6 mA	4 usec	1500 usec

Table 3-21: Opto In Connector Pinout (TB305)

Pin#	Description	In/Out/Bi
1	Digital Input Common for inputs 0 - 7	Input
2	Digital Input 0 (Optically-Isolated)	Input
3	Digital Input 1 (Optically-Isolated)	Input
4	Digital Input 2 (Optically-Isolated)	Input
5	Digital Input 3 (Optically-Isolated)	Input
6	Digital Input 4 (Optically-Isolated)	Input
7	Digital Input 5 (Optically-Isolated)	Input
8	Digital Input 6 (Optically-Isolated)	Input
9	Digital Input 7 (Optically-Isolated)	Input
10	Signal Common	N/A

Table 3-22: Opto In Connector Pinout (TB306)

Pin#	Description	In/Out/Bi
1	Digital Input Common for inputs 16-23	Input
2	Digital Input 16 (Optically-Isolated)	Input
3	Digital Input 17 (Optically-Isolated)	Input
4	Digital Input 18 (Optically-Isolated)	Input
5	Digital Input 19 (Optically-Isolated)	Input
6	Digital Input 20 (Optically-Isolated)	Input
7	Digital Input 21 (Optically-Isolated)	Input
8	Digital Input 22 (Optically-Isolated)	Input
9	Digital Input 23 (Optically-Isolated)	Input
10	Internal +5 Volt Power Supply (0.5 A max)	N/A

Table 3-23: Mating Connector Part Numbers for the Opto In Connector (TB305/TB306)

	Aerotech P/N	Phoenix P/N	Wire Size: mm ² [AWG]
10-Pin Terminal Block	ECK01294	1881406	0.5-0.080 [20-28]

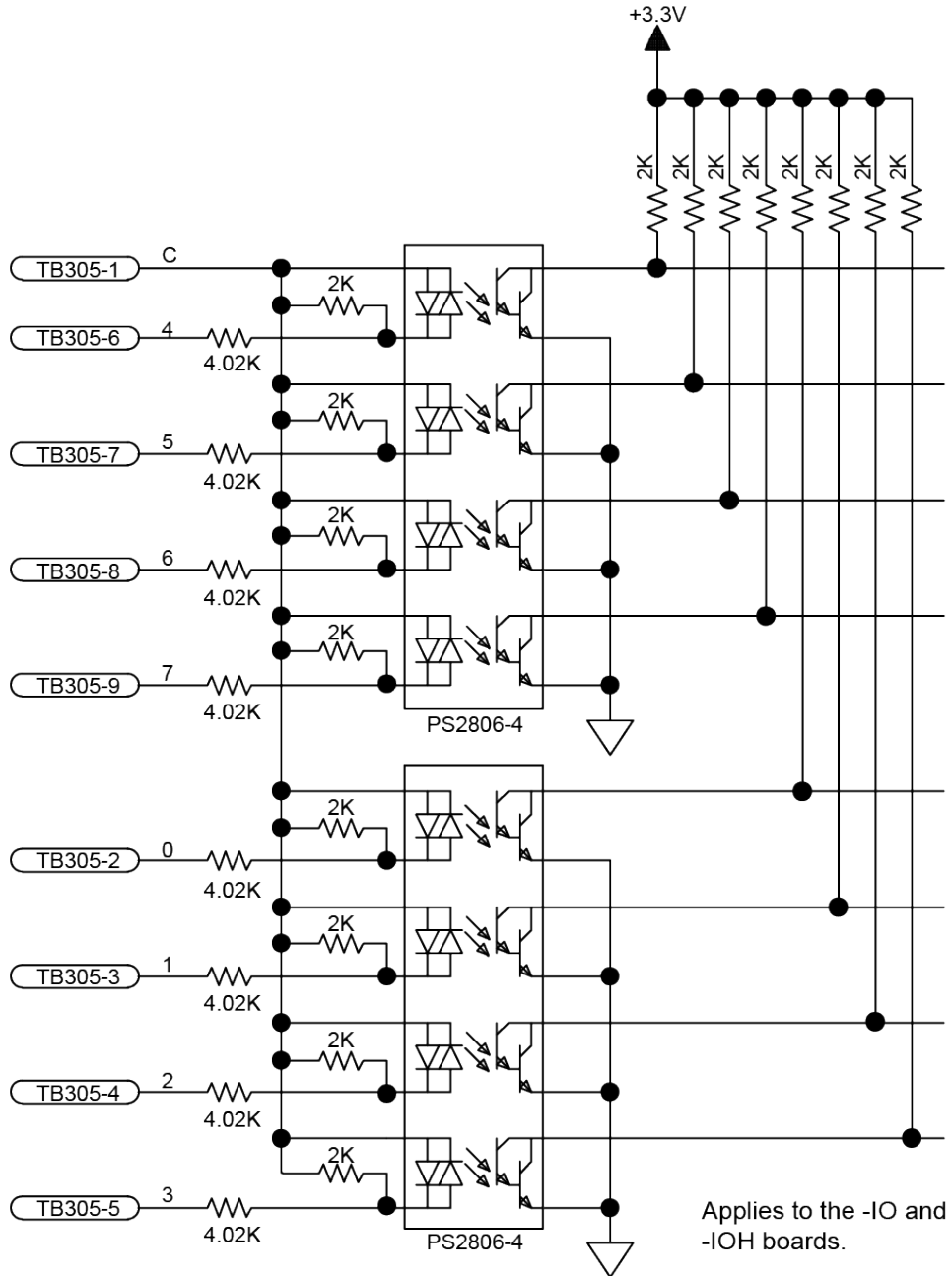
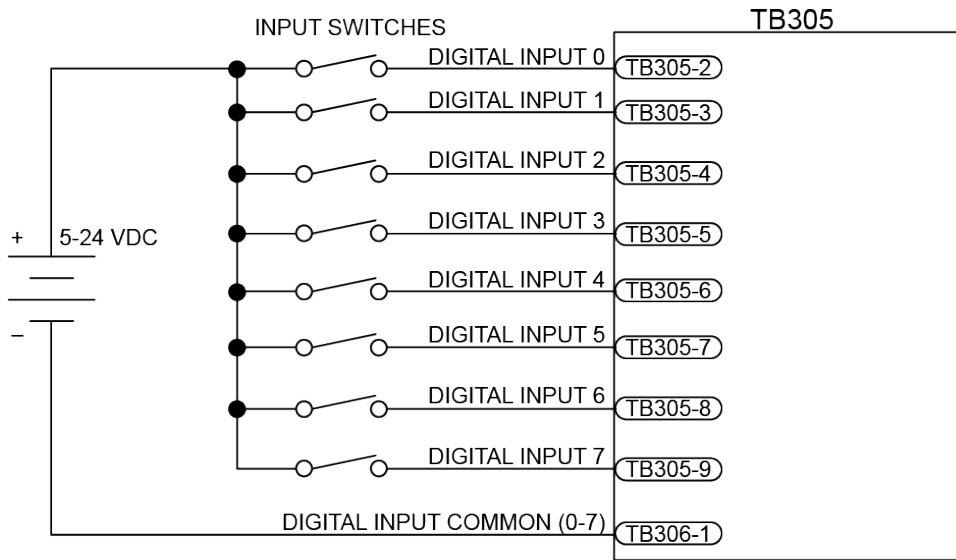


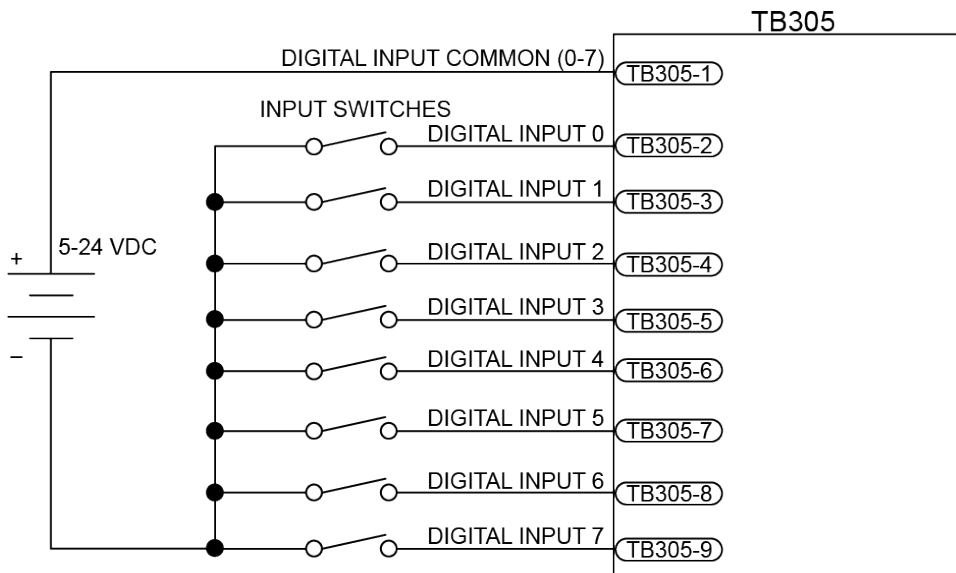
Figure 3-9: Digital Opto-Isolated Inputs

NOTE: Each bank of 8 Inputs must be connected in the all sourcing or all sinking configuration.



Applies to -IO and -IOH boards

Figure 3-10: Digital Inputs Connected to a Current Sourcing Device



Applies to IO and IOH Boards

Figure 3-11: Digital Inputs Connected to a Current Sinking Device

3.7. Opto Out Connector (Digital Outputs) (TB307, TB308)

The digital outputs are optically-isolated and can be connected in sourcing or sinking configurations. The digital outputs are designed to connect to other ground referenced circuits and are not intended to provide high-voltage isolation.

The outputs are software-configurable and must be connected in either all sinking or all sourcing mode. [Figure 3-13](#) and [Figure 3-14](#) illustrate how to connect to an output in current sourcing and current sinking modes.

The opto-isolator's common connections can be directly connected to the drive's power supply; however, doing so will effectively defeat the isolation and will reduce noise immunity.

Table 3-24: Digital Output Specifications (TB307, TB308)

Opto Device Specifications	Value
Maximum Voltage	24 V maximum
Maximum Sink/Source Current	60 mA/channel @ 50°C
Output Saturation Voltage	2.75 V at maximum current
Output Resistance	33 Ω
Rise / Fall Time	250 usec (typical)
Reset State	Output Off (High Impedance State)

Suppression diodes must be installed on outputs driving relays or other inductive devices. This protects the outputs from damage caused by inductive spikes. Suppressor diodes, such as the 1N914, can be installed on all outputs to provide protection. It is important that the diode be installed correctly (normally reversed biased). Refer to [Figure 3-14](#) for an example of a current sinking output with diode suppression and [Figure 3-13](#) for an example of a current sourcing output with diode suppression.

NOTE: Power supply connections must always be made to both the Output Common Plus (OP) and Output Common Minus (OM) pins as shown in [Figure 3-13](#) and [Figure 3-14](#).

NOTE: Outputs must be connected as all sourcing or all sinking.

Table 3-25: Opto Out Connector Pinout (TB307)

Pin#	Description	In/Out/Bi
1	Digital Output Common Plus	Input
2	Digital Output Common Minus	Input
3	Digital Output 0 (Optically-Isolated)	Output
4	Digital Output 1 (Optically-Isolated)	Output
5	Digital Output 2 (Optically-Isolated)	Output
6	Digital Output 3 (Optically-Isolated)	Output
7	Digital Output 4 (Optically-Isolated)	Output
8	Digital Output 5 (Optically-Isolated)	Output
9	Digital Output 6 (Optically-Isolated)	Output
10	Digital Output 7 (Optically-Isolated)	Output

Table 3-26: Opto Out Connector Pinout (TB308)

Pin#	Description	In/Out/Bi
1	Digital Output Common Plus	Input
2	Digital Output Common Minus	Input
3	Digital Output 16 (Optically-Isolated)	Output
4	Digital Output 17 (Optically-Isolated)	Output
5	Digital Output 18 (Optically-Isolated)	Output
6	Digital Output 19 (Optically-Isolated)	Output
7	Digital Output 20 (Optically-Isolated)	Output
8	Digital Output 21 (Optically-Isolated)	Output
9	Digital Output 22 (Optically-Isolated)	Output
10	Digital Output 23 (Optically-Isolated)	Output

Table 3-27: Mating Connector for the Opto Out Connector (TB307/TB308)

	Aerotech P/N	Phoenix P/N	Wire Size: mm ² [AWG]
10-Pin Terminal Block	ECK01294	1881406	0.5-0.080 [20-28]

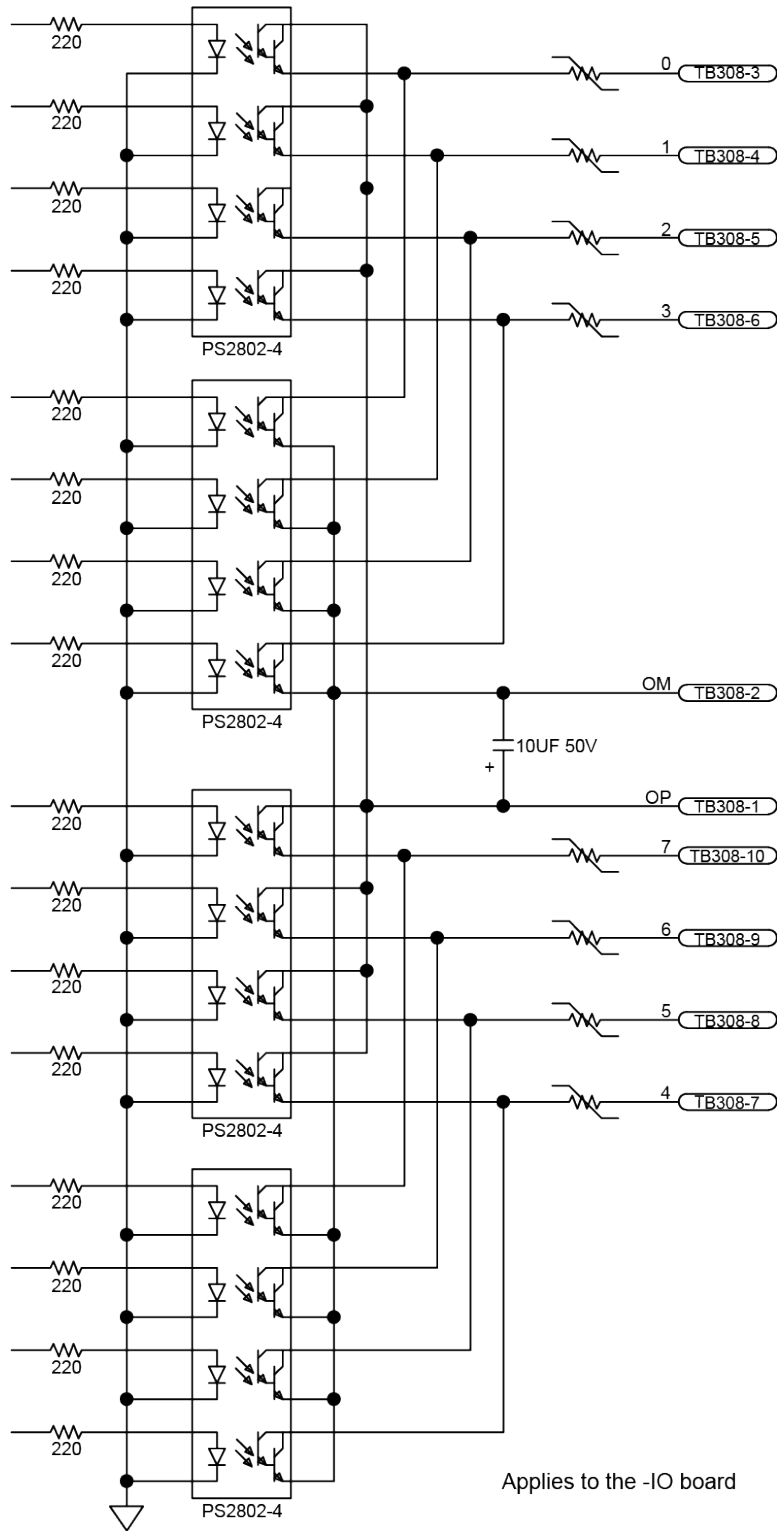


Figure 3-12: Digital Opto-Isolated Outputs (-IO Board)

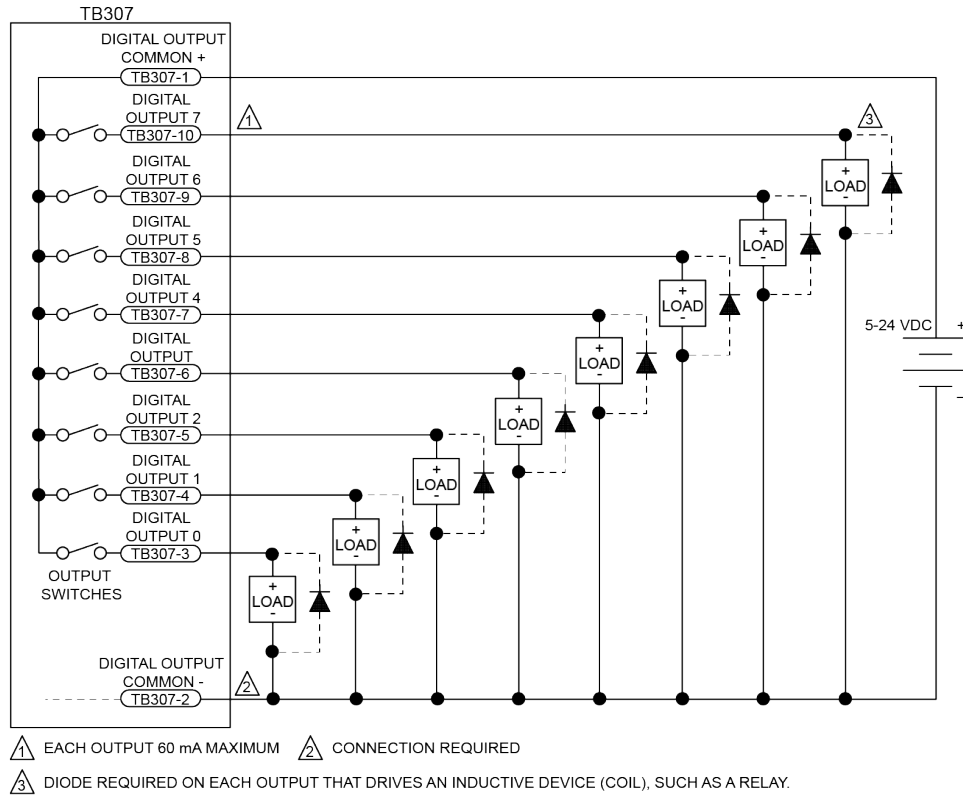


Figure 3-13: Digital Outputs Connected in Current Sourcing Mode

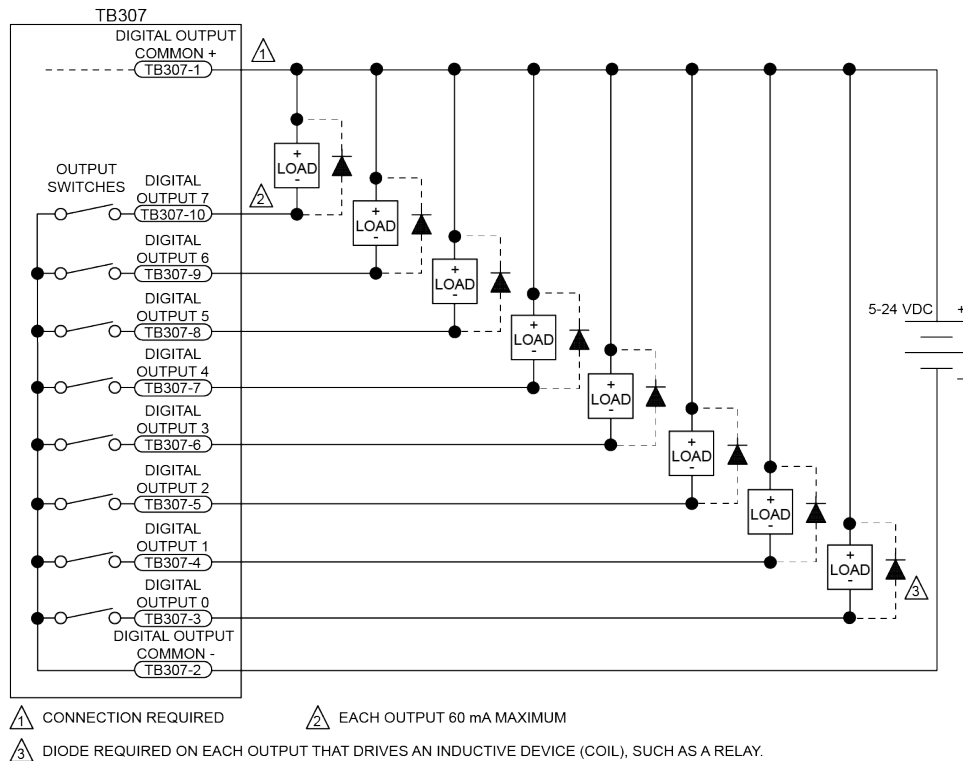


Figure 3-14: Digital Outputs Connected in Current Sinking Mode

3.8. SSINET (J302/J303)

The SSINet is designed for daisy-chaining encoder signals from one Ndrive HPe 150/200 to another for two/three-axis PSO (laser firing). This allows one Ndrive HPe 150/200 containing the -DUALPSO or -TRIPLEPSO options to track the vectorial position change of two/three axes in real-time. These encoder signals may also be used for user-defined purposes. Refer to [Figure 3-15](#) and [Figure 3-6](#). These four channels are bi-directional and configured via the SSINet1Setup and SSINet2Setup parameters; refer to the A3200 Help File for more information. The signals from these ports will be the same as the differential line driver encoder signal input to the Ndrive HPe 150/200, unless the -MXH option is present.

NOTE: The SSINet #1 and #2 interfaces are both physically hardwired to the J302 and J303 connectors. If SSINet #1 is configured as an input, a signal driven into the SSINet #1 connections on J302 will also be present on the SSINet #1 connections of J303, effectively making SSINet #1 on J303 an (un-buffered) output of this same signal. Likewise, this would also be true for the SSINet #2 interface.

Table 3-28: J302, J303 2-Channel SSINet Connector Pin Assignment

Pin#	Description	In/Out/Bi
1	SSINet #1 Sin-N	Bidirectional
2	SSINet #1 Sin	Bidirectional
3	SSINet #2 Cosine-N / Marker-N	Bidirectional
4	SSINet #2 Sin-N	Bidirectional
5	SSINet #2 Sin	Bidirectional
6	SSINet #2 Cosine / Marker	Bidirectional
7	SSINet #1 Cosine-N / Marker-N	Bidirectional
8	SSINet #1 Cosine / Marker	Bidirectional

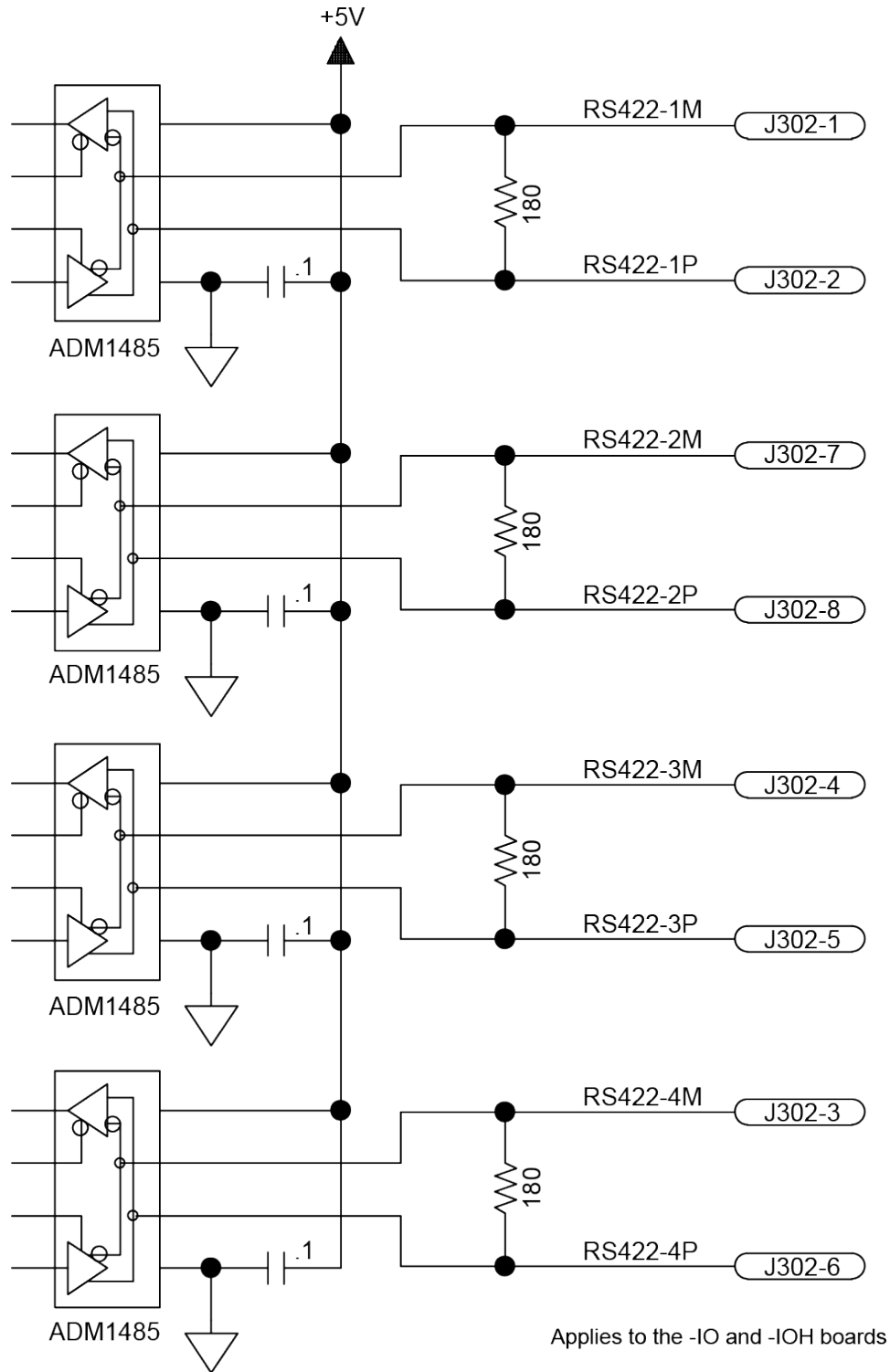


Figure 3-15: J302/J303

Chapter 4: -RDP Expansion Board

The resolver to digital option (-RDP) provides up to two industry standard resolver or inductosyn channels that can be used as a feedback device. The standard reference frequency output is 5 kHz, with factory options for either 7.5 kHz or 10.0 kHz. The amplitude of this signal can be adjusted on both channels through a single setting in the software. The -RDP can also be configured to generate encoder emulation signals.

For correct commutation of the motor, the alignment between the resolver and motor must be known. This alignment can be determined by using the controller's software. Refer to the A3200 Help file for information on configuring parameters for an axis with resolver feedback.

Channel 1 is on J401 and channel 2 is on J402. The -RDP option can supply up to 7 VRMS reference voltage and requires 2 VRMS on the sine and cosine inputs.



DANGER: Always disconnect the Mains power connection before opening the Ndrive HPe 150/200 chassis.

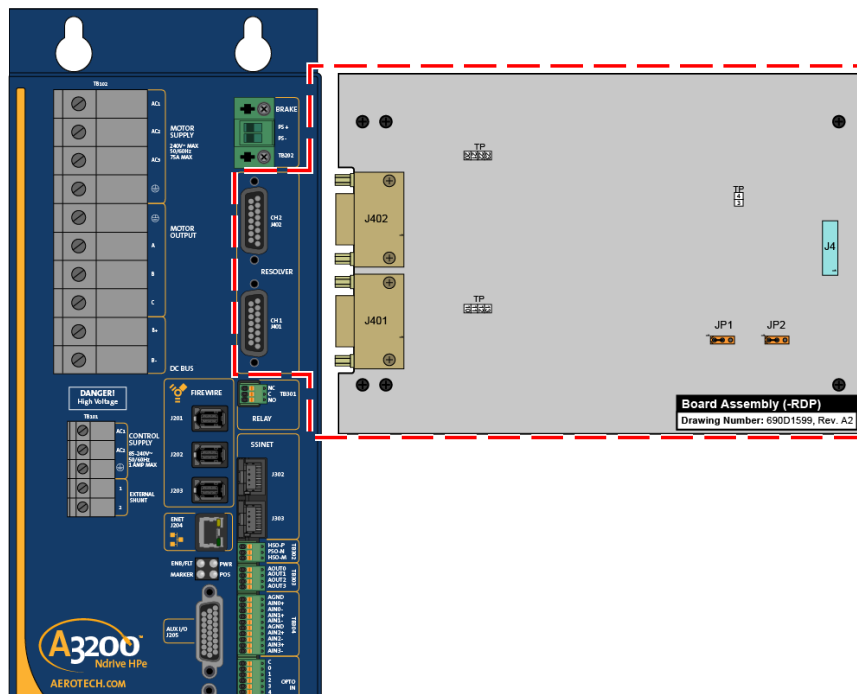


Figure 4-1: -RDP Option Board

Table 4-1: -RDP Expansion Board Jumper Configuration

Jumper	Setting	Description
JP1	1-2	Resolver (default)
	2-3	Inductosyn
JP2	1-2	Resolver (default)
	2-3	Inductosyn

Table 4-2: -RDP Connector Pin Assignment (J401/J402)

Pin#	Label	Description	In/Out/BI
Shell	Shield	Connector shell for cable shield termination	Input
4	SIN+	Resolver Sine +	Input
5	SIN-	Resolver Sine -	Input
3	Shield	Resolver Sine Shield	Shield
14	COS+	Resolver Cosine +	Input
15	COS-	Resolver Cosine -	Input
13	Shield	Resolver Cosine Shield	Shield
10	REF+	Resolver Reference +	Output
9	REF-	Resolver Reference -	Output
8	Shield	Reference Shield	
7	ENC SIN+	Encoder Emulation Sine + (optional)	Output
11	ENC SIN-	Encoder Emulation Sine - (optional)	Output
1	ENC COS+	Encoder Emulation Cosine + (optional)	Output
6	ENC COS-	Encoder Emulation Cosine - (optional)	Output
2	ENC MRK+	Encoder Emulation Marker + (optional)	Output
12	ENC MRK-	Encoder Emulation Marker - (optional)	Output

Table 4-3: Resolver Mating Connector

15-Pin Male D-style	Aerotech P/N	Third Party P/N
Connector	ECK01287	Amphenol 17EHD-015P-AA000
Backshell	ECK01021	Amphenol 17E-1724-2

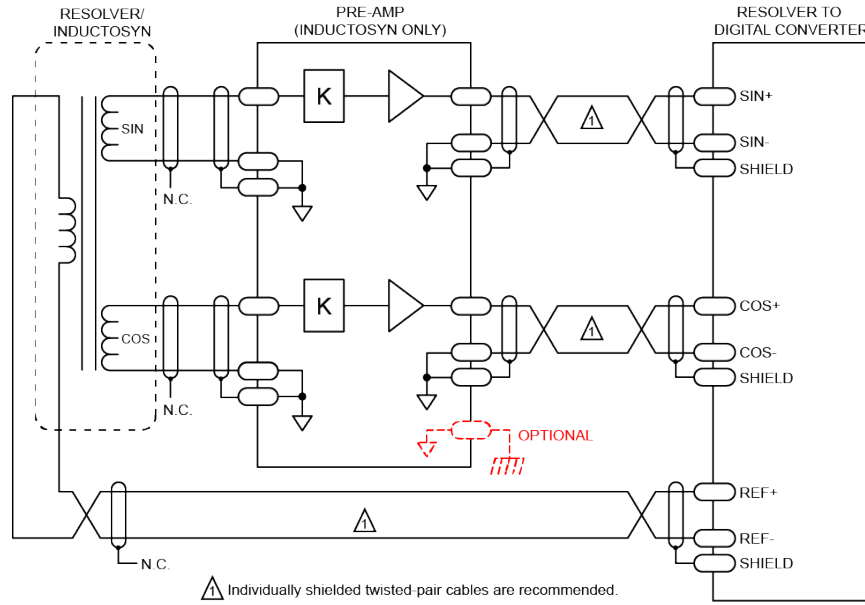


Figure 4-2: Resolver/Inductosyn Recommended Wiring

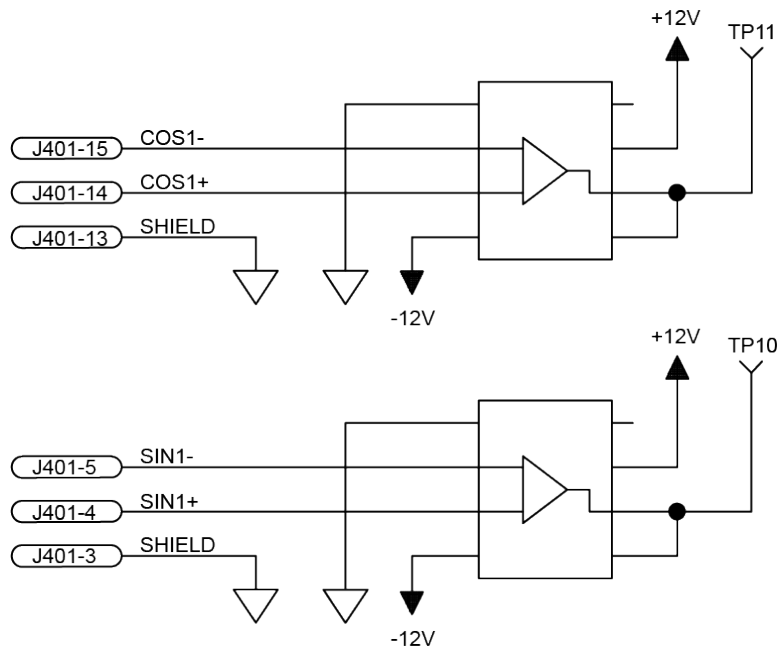


Figure 4-3: Resolver Inputs

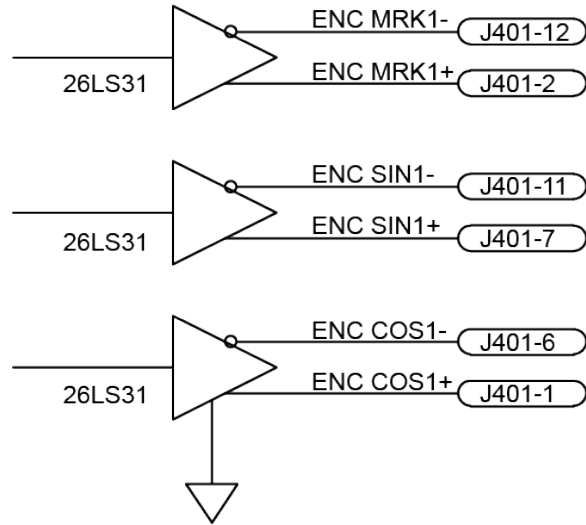


Figure 4-4: Encoder Emulation Outputs

The external power connector (J403) is a factory-select configuration and is not available on all drives.

Table 4-4: Resolver Test Points

Test Point #	Description
TP4	Signal Common
TP10	Sine Input Channel 1
TP11	Cosine Input Channel 1
TOP	Reference Signal Channel 1
TP13	Resolver Channel 1 Error
TP20	Sine Input Channel 2
TP21	Cosine Input Channel 2
TP22	Reference Signal Channel 2
TP23	Resolver Channel 2 Error

Chapter 5: Standard Interconnection Cables

NOTE: A complete list of Aerotech cables can be found on the website at <http://www.aerotechmotioncontrol.com/manuals/index.aspx>.

Table 5-1: Standard Interconnection Cables

Cable Part #	Description
Joystick	See Section 5.1 .
ECZ01231	BBA32 Interconnect Cable
(1) The “-xx” indicates length in decimeters. “-yy” would indicate length in feet.	

5.1. Joystick Interface

Aerotech joysticks J1 (NEMA12 (IP54) rated) and JBV are powered from 5V and have a nominal 2.5V output in the center detent position. Three buttons are used to select axis pairs and speed ranges. An optional interlock signal is used to indicate to the controller that the joystick is present. Joystick control will not activate unless the joystick is in the center location. Third party devices can be used provided they produce a symmetric output voltage within the range of -10V to +10V.

The following drawings illustrate how to connect a single- or two-axis joystick . For cable details refer to [Table 5-2](#). Refer to the A3200 Help file for programming information about how to change joystick parameters.

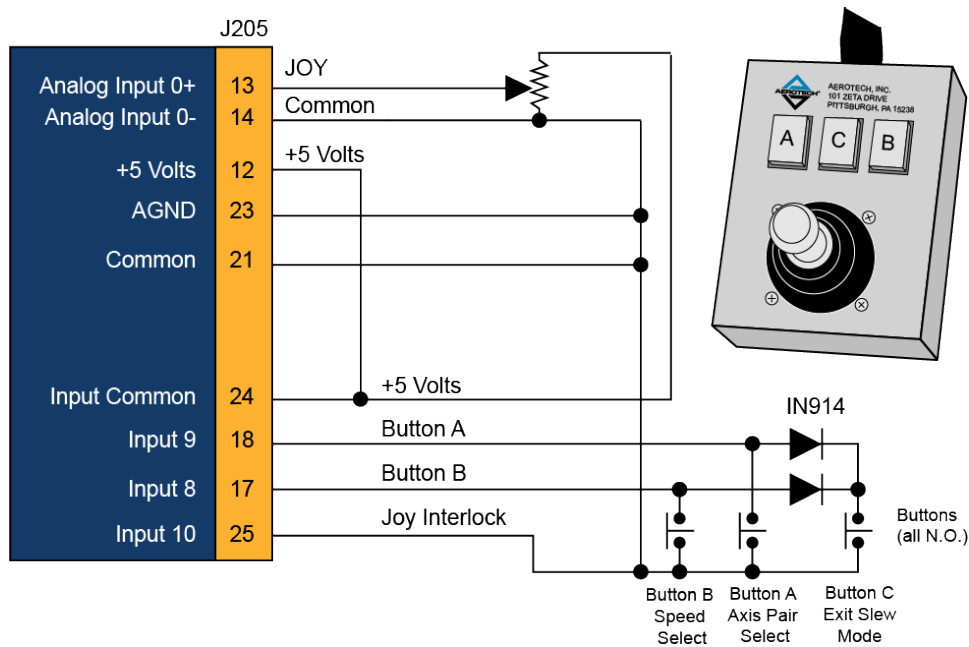


Figure 5-1: Single Axis Joystick Interface (to Aux I/O)

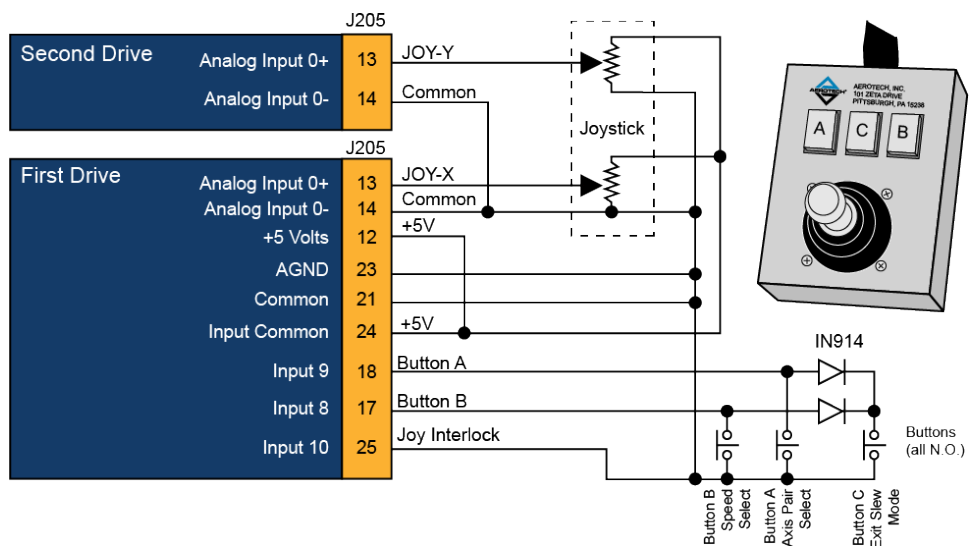


Figure 5-2: Two Axis Joystick Interface (to the Aux I/O of two drives)

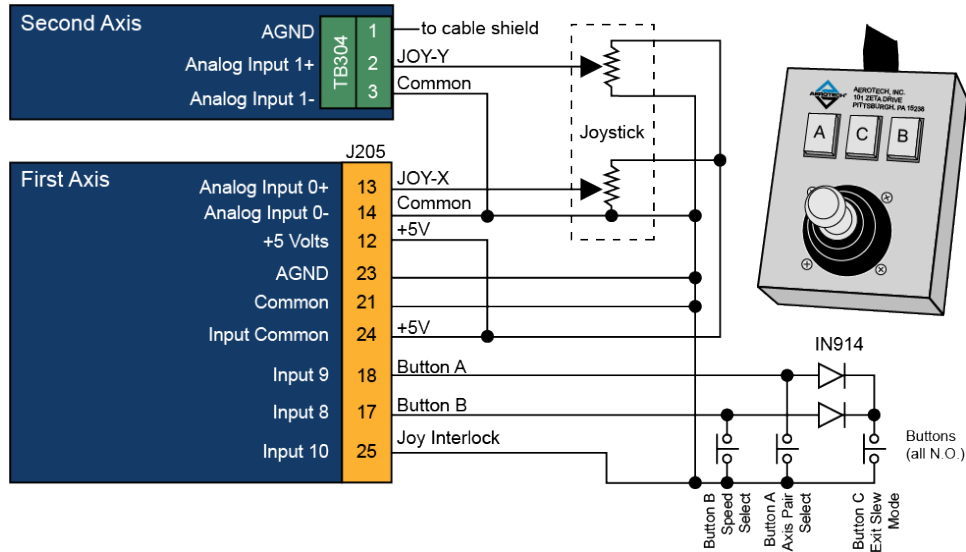


Figure 5-3: Two Axis Joystick Interface (to the Aux I/O and I/O Board)

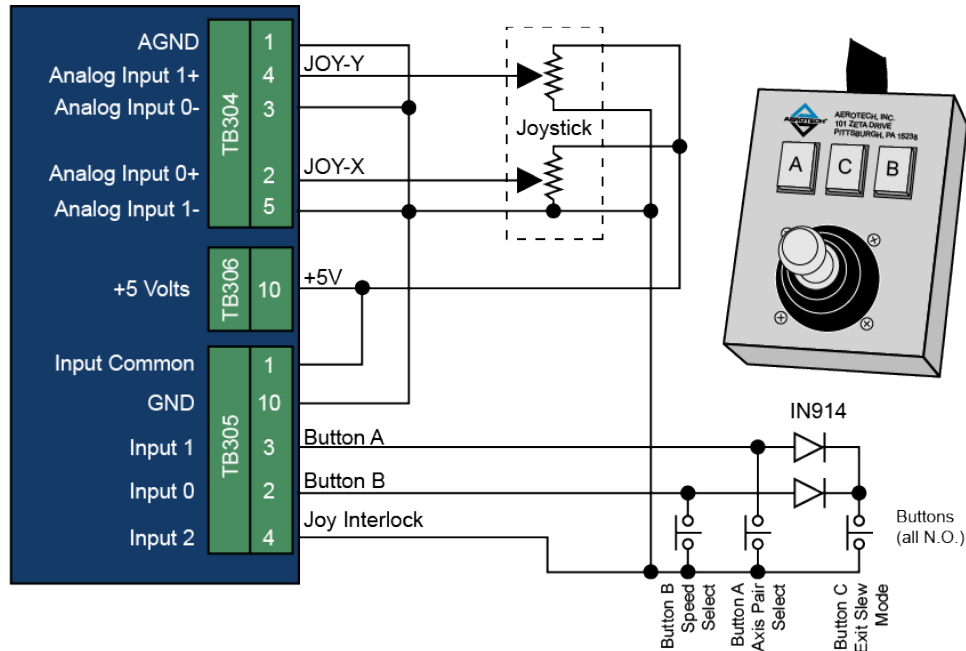


Figure 5-4: Two Axis Joystick Interface (to the I/O Board)

Table 5-2: Cable Part Numbers

Part #	Cable Description	UPC #
C22759-XX	JSXT-FLY 26HD-15DU-MAX300DM NDRIVEHPE DUAL AXIS	630B2275-9
C227510-XX	JSXT-26HD-15DU-MAX300DM NDRIVEHPE SINGLE AXIS	630B2275-10
C227511-XX	JSXT-26HD 26HD-15DU-MAX300DM NDRIVEHPE DUAL AXIS	630B2275-11
C227515-XX	JSXT-FLY-15DU-MAX 300 DM NDRIVEHPE DUAL AXIS	630B2275-15

5.2. Handwheel Interface

A handwheel (such as the Aerotech HW-xxx-xx) can be used to manually control axis position. The handwheel must provide 5V differential quadrature signals to the Ndrive HPe 150/200.

A handwheel can be connected to the Aux I/O as shown in Figure 5-5 or Figure 5-6.

NOTE: See the A3200 Help file for information on enabling the handwheel.

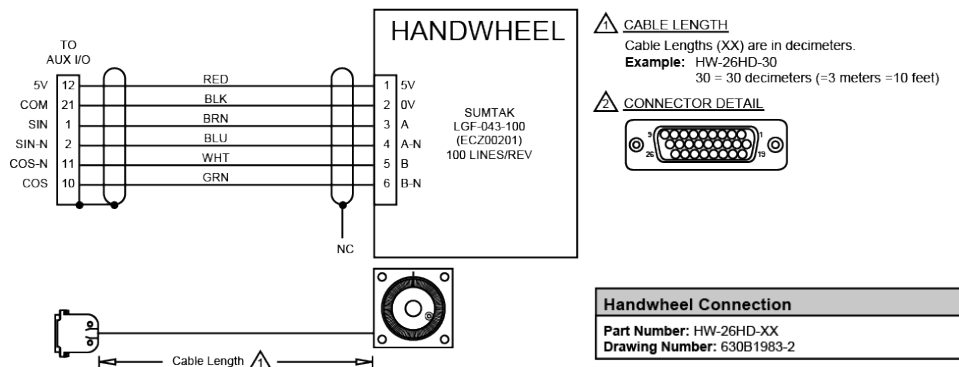


Figure 5-5: Handwheel Interconnection (to Aux I/O)

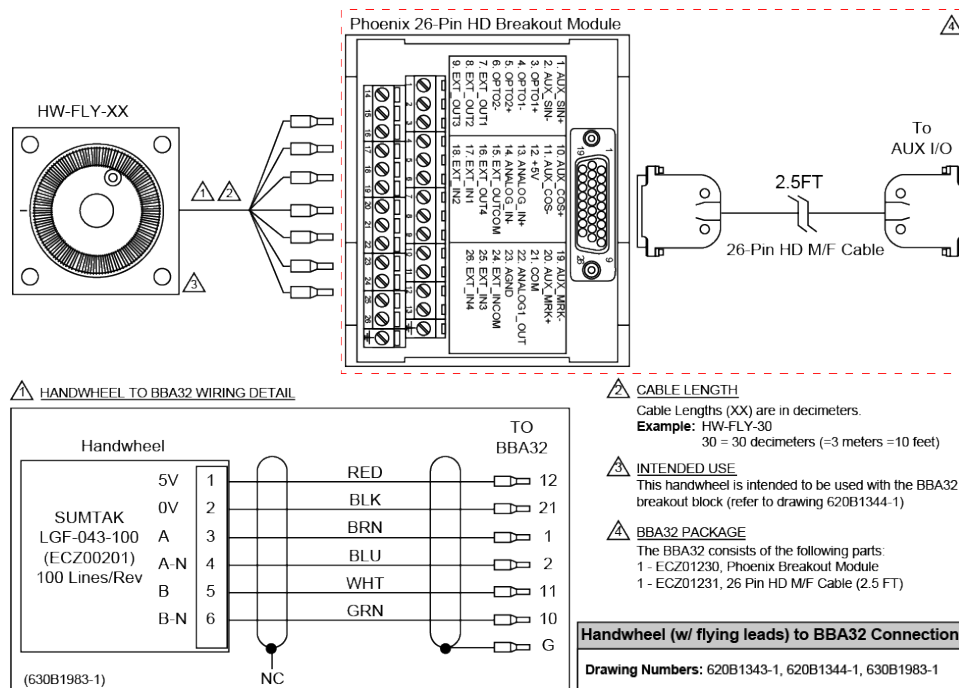


Figure 5-6: Handwheel Interconnection (to Aux I/O via a BBA32 Module)

Chapter 6: Maintenance



DANGER: Always disconnect the Mains power connection before opening the Ndrive HPe 150/200 chassis.



DANGER: Before performing any tests, be aware of lethal voltages inside the controller and at the input and output power connections. A qualified service technician or electrician should perform these tests.

Table 6-1: LED Description

LED	Description
ENB/FLT	Turns green to indicate that the axis is enabled. Turns red to indicate a fault condition. The ENB/FLT LED will flash between RED and GREEN if the drive is enabled and in a fault condition.
MARKER	Turns green to indicate that the marker input is high.
PWR*	Turns green when power is applied.
POS	Turns green to indicate that the axis is in position.
* If the power light flashes continuously and the unit does not operate, there is too much current draw from the 5V power supply or the control supply voltage level is low.	

6.1. Power Board



DANGER: Always disconnect the Mains power connection before opening the Ndrive HPe 150/200 chassis.

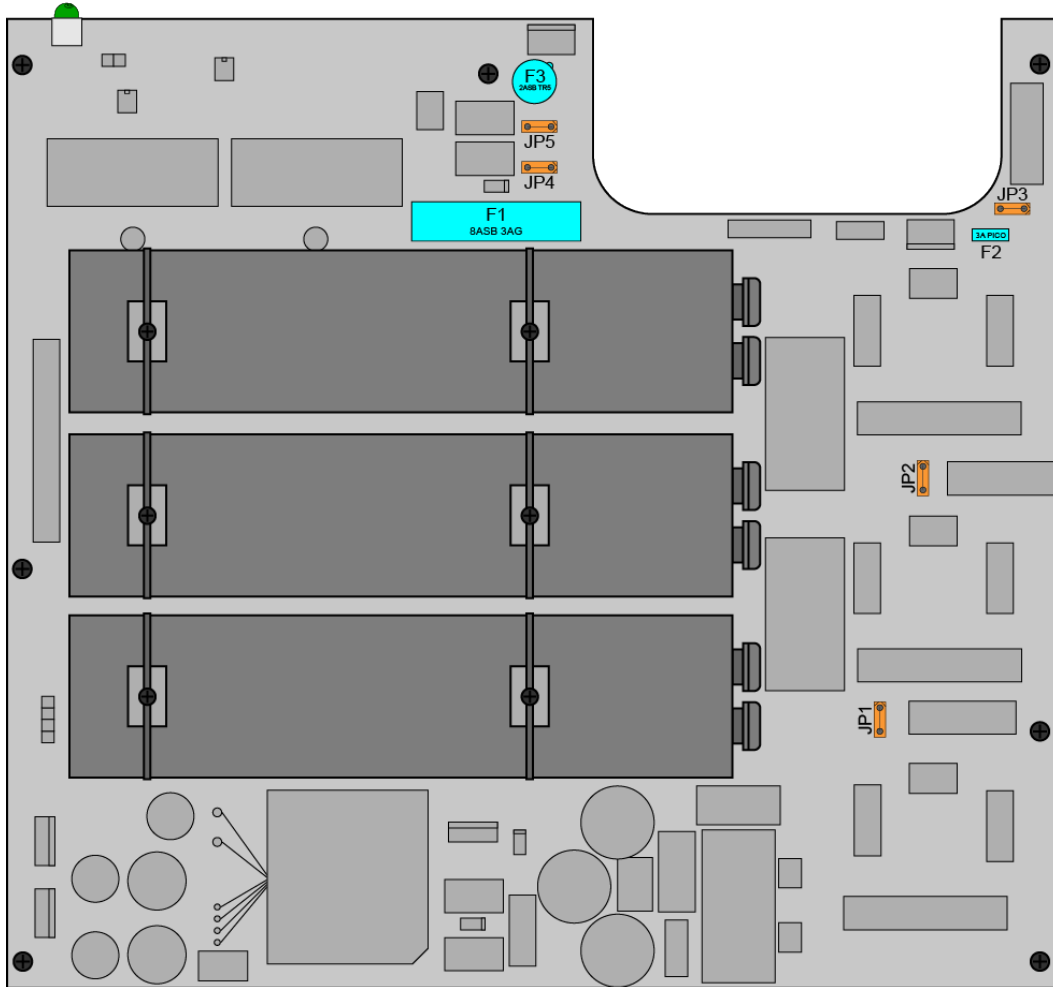


Figure 6-1: Power Board Assembly

Table 6-2: Fuse Information

Fuse	Description	Size	Aerotech P/N	Manufacturer's P/N
F1	External Shunt Fuse (-EXTSHUNT Option)	8 A S.B. (3 AG)	EIF00109	Littelfuse 0313008.HXP
F2	Fan Fuse	3 A Pico	EIF01016	Littelfuse 0263003.MXL
F3	Control Power	2 A S.B.	EIF01029	Littelfuse 37212000411

6.2. Control Board



DANGER: Always disconnect the Mains power connection before opening the Ndrive HPe 150/200 chassis.

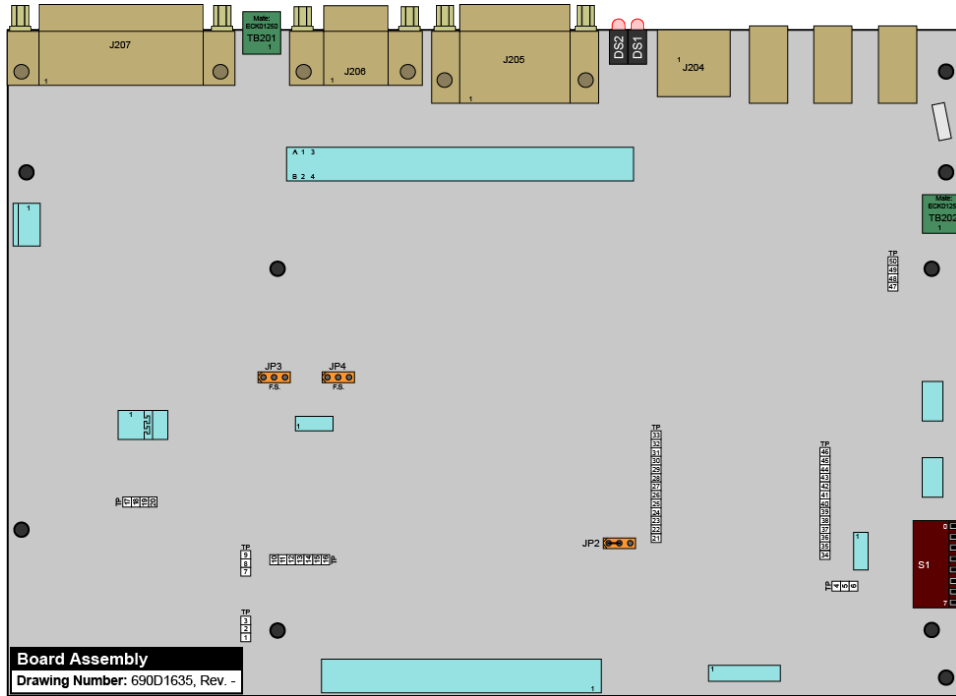


Figure 6-2: Control Board Assembly

Table 6-3: Control Board Jumper Configuration

Jumper	Setting	Description
JP2	1-2 ⁽¹⁾	Watchdog enabled
	2-3	Watchdog disabled
JP3	1-2 ⁽¹⁾	24 V operation (High Speed Input 13)
	2-3	5 V operation (High Speed Input 13)
JP4	1-2 ⁽¹⁾	24 V operation (High Speed Input 12)
	2-3	5 V operation(High Speed Input 12)

(1) Default

Table 6-4: Control Board Fuse Information

Fuse	Description	Size	Aerotech P/N	Manufacturer's P/N
F1	Radial Lead Resettable Fuse	3 A	EIF01001	Littelfuse RGEF300
F2	Surface Mount Fuse	.05 A	EIF01028	Raychem MICROSMMD005F-2
F3	Surface Mount Fuse	.05 A	EIF01028	Raychem MICROSMMD005F-2
F4	Surface Mount Fuse	.05 A	EIF01028	Raychem MICROSMMD005F-2
F5	Surface Mount Fuse	.05 A	EIF01028	Raychem MICROSMMD005F-2
F6	Resettable Fuse	.5 A	EIF01002	Littelfuse MINISMDC050F-2

Table 6-5: LED Description

LED	Description
ENB/FLT	Turns green to indicate that the axis is enabled. Turns red to indicate a fault condition. The ENB/FLT LED will flash between RED and GREEN if the drive is enabled and in a fault condition.
MARKER	Turns green to indicate that the marker input is high.
PWR*	Turns green when power is applied.
POS	Turns green to indicate that the axis is in position.
* If the power light flashes continuously and the unit does not operate, there is too much current draw from the 5V power supply or the control supply voltage level is low.	

6.3. Preventative Maintenance

The Ndrive HPe 150/200 and external wiring should be inspected monthly. Inspections may be required at more frequent intervals, depending on the environment and use of the system.



DANGER: To minimize the possibility of bodily injury or death, disconnect all electrical power prior to performing any maintenance or making adjustments to the equipment.

Table 6-6: Preventative Maintenance

Check	Action to be Taken
Visually Check chassis for loose or damaged parts / hardware. Note: Internal inspection is not required.	Parts should be repaired as required. If internal damage is suspected, these parts should be checked and repairs made if necessary.
Inspect cooling vents.	Remove any accumulated material from vents.
Check for fluids or electrically conductive material exposure.	Any fluids or electrically conductive material must not be permitted to enter the Ndrive HPe 150/200.
Visually inspect all cables and connections.	Tighten or re-secure any loose connections. Replace worn or frayed cables. Replace broken connectors.

Cleaning

The Ndrive HPe 150/200 chassis can be wiped with a clean, dry, soft cloth. The cloth may be slightly moistened if required with water or isopropyl alcohol to aid in cleaning if necessary. In this case, be careful not to allow moisture to enter the Ndrive HPe 150/200 or onto exposed connectors / components. Fluids and sprays are not recommended because of the chance for internal contamination, which may result in electrical shorts and/or corrosion. The electrical power must be disconnected from the Ndrive HPe 150/200 while cleaning. Do not allow cleaning substances or other fluids to enter the Ndrive HPe 150/200 or to get on to any of the connectors. Avoid cleaning labels to prevent removing the label information.

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Appendix A: Warranty and Field Service

Aerotech, Inc. warrants its products to be free from harmful defects caused by faulty materials or poor workmanship for a minimum period of one year from date of shipment from Aerotech. Aerotech's liability is limited to replacing, repairing or issuing credit, at its option, for any products that are returned by the original purchaser during the warranty period. Aerotech makes no warranty that its products are fit for the use or purpose to which they may be put by the buyer, whether or not such use or purpose has been disclosed to Aerotech in specifications or drawings previously or subsequently provided, or whether or not Aerotech's products are specifically designed and/or manufactured for buyer's use or purpose. Aerotech's liability on any claim for loss or damage arising out of the sale, resale, or use of any of its products shall in no event exceed the selling price of the unit.

THE EXPRESS WARRANTY SET FORTH HEREIN IS IN LIEU OF AND EXCLUDES ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, BY OPERATION OF LAW OR OTHERWISE. IN NO EVENT SHALL AEROTECH BE LIABLE FOR CONSEQUENTIAL OR SPECIAL DAMAGES.

Return Products Procedure

Claims for shipment damage (evident or concealed) must be filed with the carrier by the buyer. Aerotech must be notified within thirty (30) days of shipment of incorrect material. No product may be returned, whether in warranty or out of warranty, without first obtaining approval from Aerotech. No credit will be given nor repairs made for products returned without such approval. A "Return Materials Authorization (RMA)" number must accompany any returned product(s). The RMA number may be obtained by calling an Aerotech service center or by submitting the appropriate request available on our website (www.aerotech.com). Products must be returned, prepaid, to an Aerotech service center (no C.O.D. or Collect Freight accepted). The status of any product returned later than thirty (30) days after the issuance of a return authorization number will be subject to review.

Visit <https://www.aerotech.com/global-technical-support.aspx> for the location of your nearest Aerotech Service center.

Returned Product Warranty Determination

After Aerotech's examination, warranty or out-of-warranty status will be determined. If upon Aerotech's examination a warranted defect exists, then the product(s) will be repaired at no charge and shipped, prepaid, back to the buyer. If the buyer desires an expedited method of return, the product(s) will be shipped collect. Warranty repairs do not extend the original warranty period.

Fixed Fee Repairs - Products having fixed-fee pricing will require a valid purchase order or credit card particulars before any service work can begin.

All Other Repairs - After Aerotech's evaluation, the buyer shall be notified of the repair cost. At such time the buyer must issue a valid purchase order to cover the cost of the repair and freight, or authorize the product(s) to be shipped back as is, at the buyer's expense. Failure to obtain a purchase order number or approval within thirty (30) days of notification will result in the product(s) being returned as is, at the buyer's expense.

Repair work is warranted for ninety (90) days from date of shipment. Replacement components are warranted for one year from date of shipment.

Rush Service

At times, the buyer may desire to expedite a repair. Regardless of warranty or out-of-warranty status, the buyer must issue a valid purchase order to cover the added rush service cost. Rush service is subject to Aerotech's approval.

On-site Warranty Repair

If an Aerotech product cannot be made functional by telephone assistance or by sending and having the customer install replacement parts, and cannot be returned to the Aerotech service center for repair, and if Aerotech determines the problem could be warranty-related, then the following policy applies:

Aerotech will provide an on-site Field Service Representative in a reasonable amount of time, provided that the customer issues a valid purchase order to Aerotech covering all transportation and subsistence costs. For warranty field repairs, the customer will not be charged for the cost of labor and material. If service is rendered at times other than normal work periods, then special rates apply.

If during the on-site repair it is determined the problem is not warranty related, then the terms and conditions stated in the following "On-Site Non-Warranty Repair" section apply.

On-site Non-Warranty Repair

If any Aerotech product cannot be made functional by telephone assistance or purchased replacement parts, and cannot be returned to the Aerotech service center for repair, then the following field service policy applies:

Aerotech will provide an on-site Field Service Representative in a reasonable amount of time, provided that the customer issues a valid purchase order to Aerotech covering all transportation and subsistence costs and the prevailing labor cost, including travel time, necessary to complete the repair.

Service Locations

<http://www.aerotech.com/contact-sales.aspx?mapState=showMap>

USA, CANADA, MEXICO	CHINA	GERMANY
Aerotech, Inc. Global Headquarters Phone: +1-412-967-6440 Fax: +1-412-967-6870	Aerotech China Full-Service Subsidiary Phone: +86 (21) 5508 6731	Aerotech Germany Full-Service Subsidiary Phone: +49 (0)911 967 9370 Fax: +49 (0)911 967 93720
TAIWAN	UNITED KINGDOM	
Aerotech Taiwan Full-Service Subsidiary Phone: +886 (0)2 8751 6690	Aerotech United Kingdom Full-Service Subsidiary Phone: +44 (0)1256 855055 Fax: +44 (0)1256 855649	

Have your customer order number ready before calling.

Appendix B: Revision History

Revision	Description
4.08.00	The following sections have been updated: <ul style="list-style-type: none"> Section 2.10. -EXTSHUNT Option (TB101)
4.07.00	The following sections have been updated: <ul style="list-style-type: none"> EU Declaration of Conformity Safety Procedures and Warnings Section 2.3. Motor Output Connections <ul style="list-style-type: none"> Section 2.3.1.1. Powered Motor Phasing Section 2.3.1.2. Unpowered Motor and Feedback Phasing Section 2.4.1.1. RS-422 Line Driver Encoder (Standard) Section 2.4.2. Hall-Effect Interface (J207) Section 2.4.4. Encoder Fault Interface (J207) Section 2.6.1. Auxiliary Encoder Channel (J205) Section 2.6.2. Position Synchronized Output (PSO)/Laser Firing (J205) Section 2.6.3. Digital Outputs 8-11 (J205) Section 2.6.4. Digital Inputs 8-11 (J205) Section 2.6.5. High-Speed Digital Inputs 12-13 (J205) Section 2.6.6. Analog Output 0 (J205) Section 2.6.7. Differential Analog Input 0 (J205) Section 2.10. -EXTSHUNT Option (TB101) Section 3.2. PSO Output Interface (TB302) Section 3.3. Analog Outputs (TB303) Section 3.4. Analog Inputs (TB304) Section 3.6. Opto In Connector (Digital Inputs) (TB305, TB306) Section 3.7. Opto Out Connector (Digital Outputs) (TB307, TB308)
4.06.00	Revision changes have been archived. If you need a copy of this revision, contact Aerotech Global Technical Support.
4.05.00	
4.04.00	
4.03.00	
4.02.00	
4.01.00	
4.00.00	

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Index

-		Analog Output 1 Connector Pin Assignment	81
-DUALPSO and -TRIPLEPSO Laser Firing Options	79	Analog Outputs (I/O Board)	81
-I/O Expansion Board	75	Auxiliary Encoder Channel	56-57
-IO Board Fuse Information	75	Auxiliary Encoder Channel Pin Assignment	56,58
-IO Expansion Board Jumper Configuration	75	Auxiliary I/O Connector	55
-IO Option Board	75	Auxiliary I/O Connector Pin Assignment	55
-IO Options	75	B	
-IO/-IOH Expansion Board Brake Jumper Configuration	76	Brake / Mechanical Relay	76
-MXH Option	40,42	Brake / Mechanical Relay Connector Pin Assignment	76
-RDP Connector Pin Assignment	94	Brake Connected to J207	68,77
-RDP Expansion Board	93	Brake Connected to TB20	68
-RDP Expansion Board Jumper Configuration	93	Brake Connected to TB301	77
-TRIPLEPSO	79	Brake Output	52
		Brake Output Connector Pin Assignment	67
+		Brake Output Pin Assignment	52
+5 Volt Power Connector Pin Assignment	83	Brake Power Supply	67
2		Brushless Motor Connections	31
2-Channel SSINet Connector Pin Assignment	91	Brushless Motor Phasing Goal	33
2014/35/EU	9	C	
A		Check chassis for loose or damaged parts / hardware	105
Altitude	23	Check for fluids or electrically conductive material exposure	105
Ambient Temperature	23	Cleaning	105
Analog Encoder Phasing Reference Diagram	42	Communication Channel Settings	25
Analog Encoder Specifications	42	Continuous Output Current specifications	20
Analog Input	66	Control Board	103
Analog Input (I/O Board)	82	Control Board Assembly	103
Analog Input 1 Connector	82	Control Board Fuse Information	104
Analog Input Connector Pin Assignment	66	Control Board Jumper Configuration	103
Analog Inputs Connector Pin Assignment	82	Control Supply AC Input Wiring	27
Analog Output	65	Control Supply Connections	27
Analog Output 1 Connector	81	Control Supply specifications	20

D			
DC Brush Motor Connections	34	End Of Travel Limit Input Interface (J207)	49
DC Brush Motor Phasing	35	End of Travel Limit Input Interface Pin Assignment	49
Declaration of Conformity	9	End of Travel Limit Interface Input	50
Device Number (Switch S1)	25	End Of Travel Limit Phasing	51
Digital Input Connector Pin Assignment	62,84	EnDat absolute encoder	41
Digital Input Specifications	84	EnDat Encoder Interface	41
Digital Inputs	62,84-85	Environmental Specifications	23
Digital Output Connector Pin Assignment	60,88	external emergency stop relay circuit	54
Digital Output Specifications	60	external power connector	96
Digital Outputs	60,87	F	
Digital Outputs (-IO Board)	89	fan	28
dimensions	22	FireWire Cables	69
Drive and Software Compatibility	19	FireWire Card Part Numbers	69
E		FireWire Interface	69
Efficiency of Power Amplifier specifications	20	FireWire Repeaters	69
Electrical Specifications	20	Fuse Information	102
Emergency Stop Sense Input	53	G	
EN 61326-1	9	Global Technical Support	2
EN 61800-3	9	H	
encoder		Hall-Effect Feedback Interface Pin Assignment	46
absolute	41	Hall-Effect Inputs	46
Encoder and Hall Signal Diagnostics	32	Hall-Effect Interface	46
Encoder Emulation Outputs	96	Handwheel Interconnection	100
Encoder Fault Interface (J207)	48	Handwheel Interface	100
Encoder Fault Interface Input	48	High Speed Digital Input Connector Pin Assignment	64
Encoder Fault Interface Pin Assignment	48	High Speed User Inputs	64
Encoder Interface (J207)	39	Humidity	23
Encoder Interface Pin Assignment	39	I	
Encoder Phasing	44	Input Voltage Jumper Configuration	64
Encoder Phasing Reference Diagram	44	Inputs Connected in Current Sinking Mode	63
End of Travel Limit Input Connections	49	Inputs Connected in Current Sourcing Mode	63

Inputs Connected to a Current Sinking Device	86	Multi-Axis Firing	79
Inputs Connected to a Current Sourcing Device	86	O	
inspect all cables and connections	105	optional joysticks	98
Inspect cooling vents	105	Options	16
Inspection	105	Output Specifications	87
Installation and Configuration	25	Output Voltage specifications	20
Isolation	20	Outputs Connected in Current Sinking Mode	61,90
		Outputs Connected in Current Sourcing Mode	61,90
J		P	
J205	55-56,58,60-66	PC Configuration and Operation Information	73
J206	70	Peak Output Current specifications	20
J207	38-41,43,46-47,47-50,52,68,77	Pollution	23
J302	91	Position Feedback in the Diagnostic Display	45
J303	91	Position Synchronized Output (PSO)/Laser Firing	58
J401	94	Power Amplifier Bandwidth specifications	20
J402	94	Power Board	102
Joystick Interface	98	Power Board Assembly	102
L		Powered Motor Phasing	32
Limit Input Diagnostic Display	51	Preventative Maintenance	105
Line Driver Encoder Interface	40	Protective Features	20
M		PS2806-4 Opto-Device Specifications	62
Mating Connector	67	PSO Interface	59
Maximum Additional Storage Energy	72	PSO Output Interface	78
Mechanical Design	22	PSO Output Interface Connector Pin Assignment	78
Minimizing Conducted, Radiated, and System Noise	29	PSO Output Polarity Settings for JP1	78
Minimum Load Inductance specifications	20	PSO Output Sources	58
Modes of Operation	20	PWM Switching Frequency specifications	20
Motor Feedback Connections	38	Q	
Motor Feedback Connector Pin Assignment	38	Quick Installation Guide	13
Motor Phasing Oscilloscope Example	33	R	
Motor Supply Connections	28	Relay Specifications	67
Motor Supply Input Wiring	29	Resolute absolute encoder	41
Motor Supply specifications	20		

Resolver Inputs	95	Thermistor Interface	47
Resolver Mating Connector	94	Thermistor Interface Input	47
Resolver Test Points	96	Two Axis Joystick Interface	98
resolver to digital option	93	Two/Three Axis Laser Firing Interconnection	80
Resolver/Inductosyn Recommended Wiring	95	Typical Emergency Stop Circuit	54
RS-422 Line Driver Encoder (Standard)	40	Typical ESTOP Interface	54
S		U	
S1 (Communication Channel Setting)	25	unit separation	22
serial data stream	41	unit weight	22
Single Axis Joystick Interface	98	Unpowered Motor and Feedback Phasing	33
solid state brake control relay	67	Use	23
SSINET	91	User Common Connector Pin Assignment	83
SSINet Cable Part Numbers	79	User Power	83
SSINet port	79	User Power Supply specifications	20
Standard Features	16	V	
Stepper Motor Connections	36	Voltage and Current Specifications	76
Stepper Motor Phasing	37	W	
Support	2	Wire Colors for Supplied Cables	31,34,36
Switch S1 (Communication Channel Setting)	25	Wiring	
T		Control Supply	27
TB101	71		
TB201	53		
TB202	67-68,76		
TB301	76-77		
TB302	78		
TB303	81		
TB304	82		
TB305	83-84		
TB306	83-84		
TB307	87		
TB308	87		
Technical Support	2		