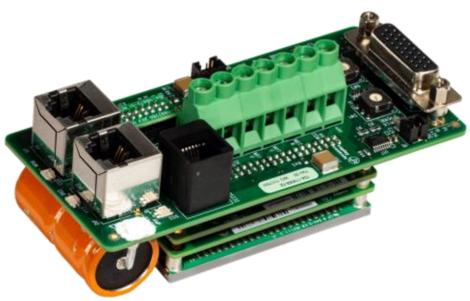
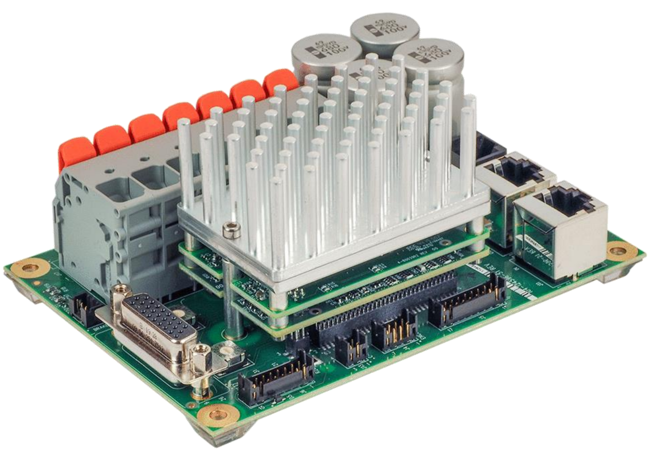
Accelnet Plus Micro Modules User Guide

Module



EZ Board



Development Board

Table of Contents

1 About This Manual

1.1 Title, Number, Revision

Title	Accelnet Plus Micro Modules User Guide
Document Number	16-01687
Current Revision	04

1.2 Revision History

Revision	Date	Comments
00	March 10, 2020	Initial Release
01	March 27, 2020	Beta Release
02	April 22, 2020	Official Release
03	October 21, 2020	Data tables now have "Signals" columns that contain the labels shown in the Reference Design schematics. Other columns show the labels that have been used in the datasheets and manuals.
04	July 27, 2023	Add R43/EZ board and R44/EZ board models and information.

1.3 Overview and Scope

This manual describes the operation and installation of the AEV, APV Accelnet Plus Micro Module drives, and the R44/R43/EZ Boards, ruggedized module drives manufactured by Copley Controls. All Accelnet Plus Micro Module products have serial numbers that incorporate the week and the year of production into the first 4 digits (WWYY) of the serial number.
Note: In this Document, all references to the Models, AEV/APV and EZ boards include the ruggedized models: R44/R43, and R44/R43-EZ boards, unless otherwise explicitly differentiated.

1.4 Original Instructions

This manual is considered to be "original instructions" as defined in EC Directive 2006/42/EC and the contents have been verified by Copley Controls.

1.5 Related Documentation

The following documents can be found on the Copley Controls website:
https://www.copleycontrols.com

- CANopen Programmer's Manual
- CMO (Copley Motion Objects) Programmer's Guide
- Indexer 2 User Guide (describes use of Indexer Program to create motion control sequences)
- ASCII Programmer's Guide (describes how to send ASCII format commands over a drive's serial bus to set up and control one or more drives)
- Parameter Dictionary
- Encoder Guide

1.6 EC Declaration of Conformity

copley controls
Analogic Motion Controls

EC DECLARATION OF CONFORMITY

Objects of this declaration:

Product Description	Model Numbers
Accelnet Micro Plus Module EtherCAT Drive SN: 9XX23XXXX	**AEV-090-14, AEV-090-30, AEV-090-50, AEV-090-50-C, AEV-EZ-090, AEV-180-10, AEV-180-20, AEV-EZ-180, AEZ-090-50, AEZ-090-50-C, R44-090-14, R44-090-30, R44-090-50, R44-090-50-C, R44-EZ-090, R44-180-10, R44-180-20, R44-EZ-180**
Accelnet Micro Plus Module CANopen Drive SN: 9XX23XXXX	**APV-090-14, APV-090-30, APV-090-50, APV-090-50-C, APV-EZ-090, APV-180-10, APV-180-20, APV-EZ-180, APZ-090-50, APZ-090-50-C, R43-090-14, R43-090-30, R43-090-50, R43-090-50-C, R43-EZ-090, R43-180-10, R43-180-20, R43-EZ-180**

We, Analogic Corporation d/b/a Copley Controls 20 Dan Rd. Canton, MA USA under the sole responsibility of the manufacturer, hereby declare that the objects of this declaration manufactured by us and described above are in conformity with EC Directives 2006/42/EC (Machinery Directive), 2014/30/EU (Electromagnetic Compatibility Directive) and 2011/65/EC (RoHS Directive). EU Authorised Representative: Authorised Representative Service, 77 Camden Street Lower, Conformity Dublin, D02 XE80, Ireland is authorised to compile the technical files for these models. Conformity is declared under the following relevant Union harmonisation legislation:

RoHS

EN 63000:2018 Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances

ELECTROMAGNETIC CAPATIBILITY (EMC)

EN 61800-3: 2018 (IEC 61800-3: 2017) Adjustable Speed Electric Power Drive Systems – Part 3: EMC Requirements and specific Test Methods. Category 3 PDS.

PRODUCT SAFETY

EN 61800-5-1:2007/A1:2017 (IEC 61800-5-1:2016) Adjustable Speed Electric Power Drive Systems – Part 5-1: Safety Requirements Electrical, Thermal and Energy

FUNCTIONAL SAFETY

EN 61800-5-2:2017 (IEC 61800-5-2:2016) Adjustable Speed Electric Power Drive Systems – Part 5-2: Safety Requirements – Functional

EN ISO 13849-1:2015 Safety of Machinery – Safety-Related Parts of Control Systems – Part 1: General Principles for Design

These products also comply with the following Underwriters Laboratories standard

UL 61800-5-1-2016 Adjustable Speed Electric Power Drive Systems – Part 5-1: Safety Requirements – Electrical, Thermal and Energy (File No. E168959, Notified Body No. 2821)

Testing Performed By:

Underwriters Laboratories 1285 Walt Whitman Road Melville, NY www.ul.com
The Compliance Management Group, 257 Simarano Drive, Marlboro, MA www.cmgcorp.net

Year in which the CE Marking was affixed: 2023

Signed for and on behalf of the above-named manufacturer

Place and date of issue: *Canton, MA USA 06/08/2023*

Name, function: *Gary Escher, Director of Quality*

Signature:

Analogic dba Copley Controls
EU Authorised Representative: Authorised Representative Service, 77 Camden Street Lower, Dublin, D02 XE80, Ireland

16-126156 rev01

1.7 Abbreviations and Acronyms

Acronym	Description
Safety-Related	
a,b,c,d,e	Denotation of performance level (PL)
Cat	Category
CCF	Common Cause Failure
DC	Diagnostic Coverage
EMC	Electro Magnetic Compatibility
HFT	Hardware Fault Tolerance
MTTF	Mean Time to Failure
MTTFd	Mean Time to Dangerous Failure
PDS(SR)	Power Drive Systems (Safety Related)
PE	Protective Earth
PELV	Protected Extra Low Voltage (power supply)
PFD	Probability of Dangerous Failure upon Demand
PFH	Probability of Dangerous Failure per Hour
PL	Performance Level
PWM	Pulse Width Modulation
S, S1, S2	Severity of Injury
SELV	Safety Extra Low Voltage (power supply)
SFF	Safety Failure Fraction
SIL	Safety Integrity Level
SIL CL	Safety Integrity Level Claim Limit, SIL Capability
STO	Safe Torque Off
Vdc	Volts DC (Direct Current)
Copley Controls Related	
AEV	Accelnet Plus Micro Module EtherCAT
AEZ	Accelnet Plus Micro Module EtherCAT + EZ board
R44	Accelnet Plus Micro Module EtherCAT Ruggedized R44
R44 EZ-Board	Accelnet Plus Micro Module EtherCAT + EZ board
APV	Accelnet Plus Micro Module CANopen
APZ	Accelnet Plus Micro Module CANopen + EZ board
R43	Accelnet Plus Micro Module CANopen Ruggedized R43
R43 EZ-Board	Accelent Plus Micro Module CANopen + EZ Board

1.8 Comments

Copley Controls welcomes your comments on this manual. For contact information, see www.copleycontrols.com.

1.9 Copyrights

1.10 Document Disclaimer

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1.11 Product Warnings

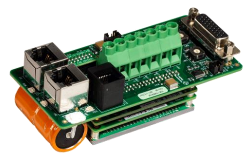
DANGER	**DANGER: HAZARDOUS VOLTAGES.** Exercise caution when installing and adjusting. Persons responsible for installing and commissioning Accelnet Plus Micro Module servo drives must be experienced in all aspects of electrical equipment installations. **FAILURE TO HEED THIS WARNING CAN CAUSE EQUIPMENT DAMAGE, INJURY, OR DEATH.**
DANGER	**RISK OF ELECTRIC SHOCK.** DC Supplies used to power Accelnet Plus Micro Module drives must be transformer-isolated and provide reinforced insulation from AC mains power. **FAILURE TO HEED THIS WARNING CAN CAUSE EQUIPMENT DAMAGE, INJURY, OR DEATH.**
DANGER	**RISK OF UNEXPECTED MOTION WITH NON-LATCHED FAULTS.** After the cause of a non-latched fault is corrected, the drive re-enables the PWM output stage without operator intervention. In this case, motion may re-start unexpectedly. Configure faults as latched unless a specific situation calls for non-latched behavior. When using non-latched faults, be sure to safeguard against unexpected motion. **FAILURE TO HEED THIS WARNING CAN CAUSE EQUIPMENT DAMAGE, INJURY, OR DEATH.**
DANGER	**USING CME OR SERIAL COMMANDS MAY AFFECT OR SUSPEND CAN OR ETHERCAT OPERATIONS.** When operating the drive as a CAN or EtherCAT node over a network, the use of CME or ASCII serial commands may affect network operations in progress. Using such commands to initiate motion may cause network operations to suspend. Network operations may restart unexpectedly when the commanded motion is stopped. **FAILURE TO HEED THIS WARNING CAN CAUSE EQUIPMENT DAMAGE, INJURY, OR DEATH.**
DANGER	**LATCHING AN OUTPUT DOES NOT ELIMINATE THE RISK OF UNEXPECTED MOTION WITH NON-LATCHED FAULTS.** Associating a fault with a latched, custom-configured output does not latch the fault itself. After the cause of a non-latched fault is corrected, the drive re-enables without operator intervention. In this case, motion may re-start unexpectedly. **FAILURE TO HEED THIS WARNING CAN CAUSE EQUIPMENT DAMAGE, INJURY, OR DEATH.**
DANGER	**USE EQUIPMENT AS DESCRIBED.** Operate drives within the specifications provided in this manual. **FAILURE TO HEED THIS WARNING CAN CAUSE EQUIPMENT DAMAGE, INJURY, OR DEATH.**
DANGER	**REFER TO SECTIONS 5, 6, & 7 OF THIS DOCUMENT** The information provided in these sections of this document must be considered for any application using the STO feature. **FAILURE TO HEED THIS WARNING CAN CAUSE EQUIPMENT DAMAGE, INJURY, OR DEATH.**
WARNING	**DO NOT PLUG OR UNPLUG CONNECTORS WITH POWER APPLIED.** The connecting or disconnecting of cables while the drive has VLOGIC and/or +HV power applied is not recommended. **FAILURE TO HEED THIS WARNING MAY CAUSE EQUIPMENT DAMAGE.**
DANGER	**REFER TO THE INFORMATION IN SECTION 6 OF THIS USER MANUAL REGARDING STO AND FUNCTIONAL SAFETY.** The information provided within must be considered for any application using the STO feature **FAILURE TO HEED THIS WARNING MAY CAUSE EQUIPMENT DAMAGE, INJURY OR DEATH**
WARNING	Models AEV-EZ-090, AEV-EZ-180, APV-EZ-090 and the APV-EZ-180 EZ boards are not compatible with and must not be used with the AEV-090-50, AEV-090-50-C, APV-090-50, or APV-090-50-C Accelnet Micro Modules. Refer to models AEZ-090-50, AEZ-090-50-C, APZ-090-50, and APZ-090-50-C instead. **Failure to heed this warning may cause equipment damage or injury.**

Observe all relevant state, regional and local safety regulations when installing and using this product. Be sure that all wiring complies with the National Electrical Code (NEC) or its national equivalent, and all prevailing local codes. There are no user serviceable parts in the *Accelnet Plus Micro Module* servo drives.

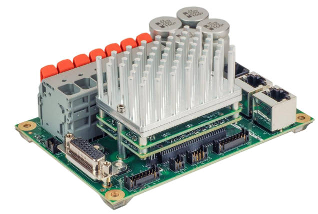
2 Introduction

2.1 Accelnet Plus Micro Modules Overview

AEV/APV



AEZ/APZ-50



AEZ/APZ-50-C

The Accelnet Plus Micro Module drives provide 100% digital control of brushless or brush servo motors in DC powered module packages. All these models provide a Safe Torque Off (STO) function. Two opto-couplers are provided which, when de-energized, prevent the upper and lower devices in the PWM outputs from being operated by the digital control core. This provides a positive OFF capability that cannot be overridden by the control firmware, or associated hardware components. When the opto-couplers are energized (current is flowing through the input diodes), the control core will be able to control the on/off state of the PWM outputs. For more information on STO for these models,
see Section 6.

All models support a wide range of feedback devices. These include digital quadrature encoders, analog Sin/Cos encoders, EnDat, BiSS, SSI Absolute A encoders and digital Halls.

Accelnet Plus Micro Modules models can operate in several basic ways:

- AEV & AEZ models operate as slave devices on an EtherCAT network. Servo drives can perform the CoE (CANopen protocol over EtherCAT) operating modes with the additional cyclic-synchronous position, velocity, and torque modes.
- R44 and EZ Board models are a ruggedized version of the commercial AEV Servo Drive. They have a protective, conformal coating with sockets good to 15A continuous, 30A peak.
- APV & APZ models can be nodes on a CANopen network. CANopen compliance allows the drive to take instruction from a master application to perform torque, velocity, and position profiling, interpolated position, and homing operations. Multiple drives can be tightly synchronized for high performance coordinated motion.
- R43 and EZ board models are a ruggedized version of the commercial APV Servo Drive. They have a protective, conformal coating with sockets good to 15A continuous, 30A peak.
- All models can receive current, velocity or position commands from an external controller. In current and velocity modes they can accept ±10 Vdc analog, digital 50% PWM or PWM/polarity inputs. In position mode, inputs can be incremental position commands from step-motor controllers in Pulse and Direction or Count Up/Count Down format, as well as A/B quadrature commands from a master-encoder. Pulse-to-position ratio is programmable for electronic gearing.
- Controlled directly over an RS-232 serial link with simple ASCII format commands.
- All models can work as stand-alone controllers running CVM control programs with Indexer 2.

2.2 Accelnet Plus Micro Module Models

The following table includes the Accelnet Plus Micro Module models and values.

<table>
<tr><th>Network</th><th>Models</th><th>Ic</th><th>Ip</th><th>+HV</th><th>VLOGIC</th></tr>
<tr><td rowspan="8">EtherCAT</td><td>AEV-090-14</td><td>7</td><td>14</td><td rowspan="6">9~90</td><td rowspan="32">9~60</td></tr>
<tr><td>AEV-090-30</td><td>15</td><td>30</td></tr>
<tr><td>AEV-090-50</td><td rowspan="2">25</td><td rowspan="2">50</td></tr>
<tr><td>AEZ-090-50 *</td></tr>
<tr><td>AEV-090-50-C</td><td rowspan="2">50</td><td rowspan="2">50</td></tr>
<tr><td>AEZ-090-50-C **</td></tr>
<tr><td>AEV-180-10</td><td>5</td><td>10</td><td rowspan="2">20~180</td></tr>
<tr><td>AEV-180-20</td><td>10</td><td>20</td></tr>
<tr><td rowspan="8">R44
Ruggedized</td><td>R44-090-14</td><td>7</td><td>14</td><td rowspan="5">9~90</td></tr>
<tr><td>R44-090-30</td><td>15</td><td>30</td></tr>
<tr><td>R44-090-50</td><td>25</td><td>50</td></tr>
<tr><td>R44-090-50-C</td><td>50</td><td>50</td></tr>
<tr><td>R44-EZ-090</td><td></td><td></td></tr>
<tr><td>R44-180-10</td><td>5</td><td>10</td><td rowspan="2">20~180</td></tr>
<tr><td>R44-180-20</td><td>10</td><td>20</td></tr>
<tr><td>R44-EZ-180</td><td></td><td></td><td>20~90</td></tr>
<tr><td rowspan="8">CANopen</td><td>APV-090-14</td><td>7</td><td>14</td><td rowspan="6">9~90</td></tr>
<tr><td>APV-090-30</td><td>15</td><td>30</td></tr>
<tr><td>APV-090-50</td><td rowspan="2">25</td><td rowspan="2">50</td></tr>
<tr><td>APZ-090-50 *</td></tr>
<tr><td>APV-090-50-C</td><td rowspan="2">50</td><td rowspan="2">50</td></tr>
<tr><td>APZ-090-50-C **</td></tr>
<tr><td>APV-180-10</td><td>5</td><td>10</td><td rowspan="2">20~180</td></tr>
<tr><td>APV-180-20</td><td>10</td><td>20</td></tr>
<tr><td rowspan="8">R43
Ruggedized</td><td>R43-090-14</td><td>7</td><td>14</td><td rowspan="5">9~90</td></tr>
<tr><td>R43-090-30</td><td>15</td><td>30</td></tr>
<tr><td>R43-090-50</td><td>25</td><td>50</td></tr>
<tr><td>R43-090-50-C</td><td>50</td><td>50</td></tr>
<tr><td>R43-EZ-090</td><td></td><td></td></tr>
<tr><td>R43-180-10</td><td>5</td><td>10</td><td rowspan="2">20~180</td></tr>
<tr><td>R43-180-20</td><td>10</td><td>20</td></tr>
<tr><td>R43-EZ-180</td><td></td><td></td><td>20~90</td></tr>
</table>

Legend:

<table>
<tr><th>Terms</th><th>Descriptions</th></tr>
<tr><td>Ic =</td><td>Continuous Output Current, Adc (peak of sine)</td></tr>
<tr><td>Ip =</td><td>Peak Output Current, Adc (peak of sine)</td></tr>
<tr><td>+HV =</td><td>Power supply voltage for PWM outputs to motors (DC, line-isolated)</td></tr>
<tr><td>VLOGIC =</td><td>Power supply for the drives control circuits and external encoder +5 Vdc</td></tr>
<tr><td rowspan="2">*</td><td>AEZ-090-50 is an AEV-090-50 soldered into an AEV EZ Board</td></tr>
<tr><td>APZ-090-50 is an APV-090-50 soldered into an APV EZ Board</td></tr>
<tr><td rowspan="2">**</td><td>AEZ-090-50-C is an AEV-090-50-C soldered into an AEV EZ Development Board</td></tr>
<tr><td>APZ-090-50-C is an APV-090-50-C soldered into an APV EZ Development Board</td></tr>
</table>

3 Specifications

3.1 Agency Approvals

Specification	Requirement
Approvals	UL and cUL recognized component to UL 61800-5-1 UL Functional Safety to IEC 61800-5-2,(E168959-20200424A)
Functional Safety	IEC 61508-1, IEC 61508-2, IEC 61508-3, (SIL 3), EN (ISO) 13849-1, (Cat 3 PL e) ISO 13849-2, IEC 61800-5-2 (SIL 3)
Electrical Safety	Directive 2014/35/EU – Low Voltage, UL 61800-5-1
Machinery	Directive 2006/42/EC
EMC	Directive 2014/30/EU IEC 61800-3, Category C3, IEC 61800-5-2
Markings	Label is visible on PC board.
Hazardous Substances	Lead free and RoHS compliant,

3.2 Input Power

+HV is required for the operation of the drives. VLOGIC is optional for supply voltages <= 60 Vdc and powers the communications, feedback, and I/O functions, but not the PWM outputs. VLOGIC is recommended for drives operating on a control network, because it enables the network master to maintain communication with the drives when the +HV has been removed, most commonly for safety or EMO (Emergency Off) conditions.

Specification	AEV-090-14 APV-090-14	AEV-090-30 APV-090-30	AEV-090-50 APV-090-50	AEV-090-50-C APV-090-50-C	AEZ-090-50 APZ-090-50	AEZ-090-50-C APZ-090-50-C	AEV-180-10 APV-180-10	AEV-180-20 APV-180-20	Unit
+HV Voltage	+9 to +90 Vdc						+20 to +180 Vdc		
+HV Current Peak *	14	30	50	50	50	50	10	20	ADC ARMS
+HV Time Peak	1								Sec
+HV Current Cont.	7	15	25	50	25	50	5	10	ADC ARMS
VLOGIC Vdc	+9 to ~+60 Vdc								Vdc
VLOGIC Power **	4 W with no encoders, 6.6 W with two encoders, +5V @ 500 mA Vlogic @ 9 Vdc 3.4 W, @ 24 Vdc 3.5 W, @ 60 Vdc 4.2 W with 2 encoders @ +5 V, 500 mA total								

* The actual +HV current is dependent on the input voltage, motor load, and operating conditions.
The Maximum +HV currents shown above occur when the drive is operating from the maximum input voltage and is producing the rated continuous output current at the maximum output voltage. Unit is Adc.
** VLOGIC supply current depends on the number of encoders connected to the drive.
The maximum current draw given assumes that the encoder +5V output is loaded to 500mA Unit is Vdc.

3.3 Output Power

Specification	AEV-090-14 APV-090-14	AEV-090-30 APV-090-30	AEV-090-50 APV-090-50	AEV-090-50-C APV-090-50-C	AEZ-090-50 APZ-090-50	AEZ-090-50-C APZ-090-50-C	AEV-180-10 APV-180-10	AEV-180-20 APV-180-20	Unit
Peak Current	14	30	*50 **32@70C	*50 **32@70C	50	50	10	20	ADC
Peak Current	9.9	21.2	35.4 **(22.6)@70C	35.4 **(22.6)@70C	35.4	35.4	7.07	14.1	ARMS
Peak Current Time (s)	1	1	1	1	n/a	1	1		Sec
Continuous Current	7	15	*25 **16@70C	*50 **32@70C	25	50	5	10	ADC
Continuous Current	4.95	10.6	17.7 **(11.3)@70C	35.4 **(22.6)@70C	17.7	35.4	3.54	7.07	ARMS
Peak Output Power	1.26	2.7	4.5	4.5	4.5	4.5	1.8	3.6	Kw
Cont. Output Power	0.63	1.35	2.25	4.5	2.25	4.5	0.9	1.8	Kw
Notes: *AEV-090-50/AEV-090-50-C and APV-090-50/APV-090-50-C must be soldered to a mounting board for these ratings. **R44-090-50/R44-090-50-C and R43-090-50/R43-090-50-C peak and continuous curents are @70C ambient.									
Efficiency		>97% @ rated max Vdc and rated continuous current							
Output Type		3-phase MOSFET inverter, 16 kHz center-weighted PWM space-vector modulation							
PWM Ripple Frequency		32 kHz							
Minimum Load Inductance		400 µH line-to-line ***							
* Adc is peak of sine, Arms is RMS of sine. ** Heat sinking and/or forced air cooling may be required for continuous output power rating. *** Consult factory for operation with inductance lower than 400 µH.									

3.4 Control Loops

Type Current Velocity Position	100% digital.
Sampling rate (time) Current Velocity Position	 16 kHz (62.5 µs) 4 kHz (250 µs) 4 kHz (250 µs)
Current Loop Small Signal Bandwidth	> 2.5 kHz (Typical, tuning and load impedance dependent)
Digital Filters	Programmable: Analog Reference Input Velocity Loop Input Velocity Loop Output1 Velocity Loop Output2 Velocity Loop Output3 Current Loop Input1 Current Loop Input2 Input Shaping Velocity loop output filter1 default: is 200 Hz low pass.
Bus Voltage Compensation	Changes in +HV voltage do not affect tuning.

3.5 Digital Command Inputs

Digital Position Command	Pulse and direction, Count up / Count down	Maximum rate: 2 MHz (with active driver)
	Pulse, count minimum width	220 ns
	Quadrature A/B encoder maximum rate	2 M line/sec (8 M count/sec after quadrature)
Digital Current & Velocity Command	PWM and Polarity	PWM = 0~100%, Polarity = 1/0 PWM Frequency: 1~100 kHz
	PWM 50%	PWM: 50% ±50%, 1~100 kHz
	PWM Minimum pulse width	220 ns
Indexing	Up to 32 sequences can be launched from digital inputs or ASCII commands.	
Camming	Up to 10 CAM tables can be stored in flash memory	
Serial ASCII	RS-232 *, 9600~230,400 Baud, 3-wire	
*Note: In the table, the asterisk indicates the format is RS-232, TxD, RxD, Gnd, but voltage levels are TTL. An external circuit is required if RS-232 voltages are needed. This circuit is provided in the EZ Boards and EZ Development Boards.		

3.6 Analog Inputs

Update rate (scan time) is 16 kHz (62.5 μs)

Specification	Data
Channels	1
Name	AIN1
Type	Differential, non-isolated
Measurement Range	±10 Vdc
Maximum Differential Input Voltage Maximum Input Voltage to Ground	±10 Vdc ±10 Vdc
Input Impedance	5.09 kΩ
Resolution	16 Bit
Anti-aliasing filter -3 dB frequency	14 kHz
Function	Programmable: current, velocity, or position command General purpose analog input.

3.7 Digital Inputs

- Update rate (scan time) is 4 kHz (250 μs)
- Functions programmable
- Debounce time: 0~10,000 ms

* The default functions of these inputs are programmable to other functions.
The SLI is the Switch and LED Interface, where outputs and an input work together to read the network address switches and control the LEDs that indicate the drive status and the operating state. When it is not used for the SLI function, the outputs and input can be programmed for other functions.

Specification	IN1~IN6	IN7
Type	Schmitt trigger w/ RC filter, 3.3 V logic	Schmitt trigger w/ RC filter, 5.0 V logic
RC Filter	1k / 100pF (100 ns when driven by active source)	
Pull-up to +5V	10k	
Input Voltage Range	0~6 Vdc	
Logic Low Input Voltage	0.68~1.6 Vdc	0.55~1.30 Vdc
Logic High Input Voltage	1.42~2.38 Vdc	1.30~2.0 Vdc
Input Hysteresis	0.44~1.26 Vdc	0.40~0.79 Vdc
Default Function	IN1 – Enable * IN2 – Not Configured	MISO input for SLI mode *

3.8 Safe Torque Off (STO)

Refer to **Section 6** for specifications related to this function.

3.9 Digital Outputs

Specification	Data	
Channels	6 (OUT1~6)	
Outputs	OUT1~OUT3*	OUT4~6
Type	HCT CMOS inverters, 5 V, 74HCT2G14	LVC CMOS inverters, 3.3 V, 74LVC3G14
Sourcing	-8 mA @ VOH = 2.4 Vdc	-24 mA @ VOH = 2.3 Vdc
Sinking	6 mA @ VOL = 0.5 Vdc	24 mA @ VOL = 0.55 Vdc
Function	Brake / Programmable	SLI Port / Programmable
*Note: OUT3 is wired to and controls a dedicated Brake output on the AEZ and APZ models. See Section 5 for specification details for this dedicated Brake circuit and its function.		

3.10 Encoders

Encoder +5V Power Output

Specification	Data
Number	1
Voltage Output	+5 Vdc ±2%
Maximum Current Output	500 mA
Short Circuit Protection	Thermal and short-circuit protected
Function	Provides power for motor encoders and/or Hall switches. Shared by all encoders & Halls

Primary Encoder Inputs

Digital Incremental Encoders

Specification	Data
Channels	3: A, B, X
Type	A, X: MAX3362 Differential RS-422 line driver/receiver. Non-isolated B: MAX3281 Differential RS-422 line receiver
Signals	A, /A, B, /B, X, /X for incremental, Clk, /Clk, Data, /Data for absolute
Input Voltage Range	-7 to +12 V common-mode
Input Voltage Hysteresis	25 mV
Differential Input Threshold	±200 mVdc
Termination Resistance	AEV, APV: None. AEZ, APZ: 121 Ω, with 1 kΩ pull-up to +5V from X, 1 kΩ pull-down to Sgnd from /X
Maximum Frequency	5 MHz Line (20 Mcount/sec)
Encoder Loss Detection	AEV, APV: None. AEZ, APZ: Loss detection circuity is wired to IN6. See Section 5 for details.

DIGITAL HALL SENSORS

Specification	Data
Channels	3 (U, V and W)
Type	74LVC3G17 Schmitt trigger 3.3 V 15 kΩ pull up resistor to internal +5 Vdc
Input Voltage Range	0 Vdc ~ +24 Vdc
Low Level Input Voltage	< + 1.3~2.2 Vdc
High Level Input Voltage	> 2.5~3.5 Vdc
Hysteresis Voltage	0.7~1.5 Vdc
Timing	Edge detection.
RC Filter Time Constant	1.5 μSec when driven by active sources.
Function	Commutation of brushless motors in trapezoidal mode. Commutation initialization and phase error detection in sinusoidal mode.

ANALOG (SIN/COS) INCREMENTAL ENCODERS

Specification	Data
Channels	2
Type	Differential, non-isolated with zero-crossing detection
Signals	Sin(+), Sin(-), Cos(+), Cos(-)
Nominal Voltage	1 Vpk-pk ±20%
Maximum Voltage Differential Input to Ground	±0.6 Vdc 0 to +3.5 Vdc
Termination Resistance	121 Ω
Bandwidth	300 kHz
Interpolation	1 to 1024, programmable
Resolution	16 bit

3.11 Multi-Port Input / Output

The Multi-Port consists of three MAX3362 digital differential bi-directional transceivers. This feature provides the following modes of operation:

- Position Command Input
- Current / Velocity Command Input
- Secondary Encoder Input
- Buffered or emulated encoder Output

Specification	Data
Channels	3 Differential: A, B, X
Type	A, X: MAX3362 Differential RS-422 line driver/receiver. Non-isolated B: MAX3281 Differential RS-422 line receiver
Signals	A, /A, B, /B, X, /X for incremental, Clk, /Clk, Data, /Data for absolute
Input Voltage Range	-7 to +12 V common-mode
Input Voltage Hysteresis	25 mV
Differential Input Threshold	±200 mVdc
Termination Resistance	AEV, APV: None. AEZ, APZ: 121 Ω, with 1 kΩ pull-up to +5V from X, 1 kΩ pull-down to Sgnd from /X
Maximum Frequency	5 MHz Line (20 Mcount/sec)
Encoder Loss Detection	None

Direction	Mode	Data
Input	Commanded Position	Pulse / Direction, Count-up / Count-down
	Commanded Velocity	PWM / Direction, PWM Magnitude 50%
	Secondary Encoder Input	Incremental digital A/B/X, Absolute bi-directional or Clock / Data
Output	Buffered Encoder	Digital incremental A/B/X channels
	Emulated Encoder	Emulated A/B channels from Sin/Cos or digital absolute encoder

3.12 Serial Interface

The serial port operates the same in all Accelnet Plus Micro Module models.
After a power-on or drive reset, the Baud rate defaults to 9600.
Thereafter, it can be set to a higher rate by setting ASCII parameter 0x90 to the desired rate. Common settings used are: 9600, 19200, 57600, and 115,300 (230,400 maximum) Baud.
After sending 0x90, the drive will reply immediately at the higher Baud rate so the sender should wait some time (10 ms or more) before resuming communications with the drive at the newly programmed higher rate.
AEV & APV RxD & TxD signal levels are 3.3 V LVTTL. For actual RS-232 voltage levels external components are necessary. The AEZ and APZ models have these components on the EZ boards and can connect directly to RS-232 sources.

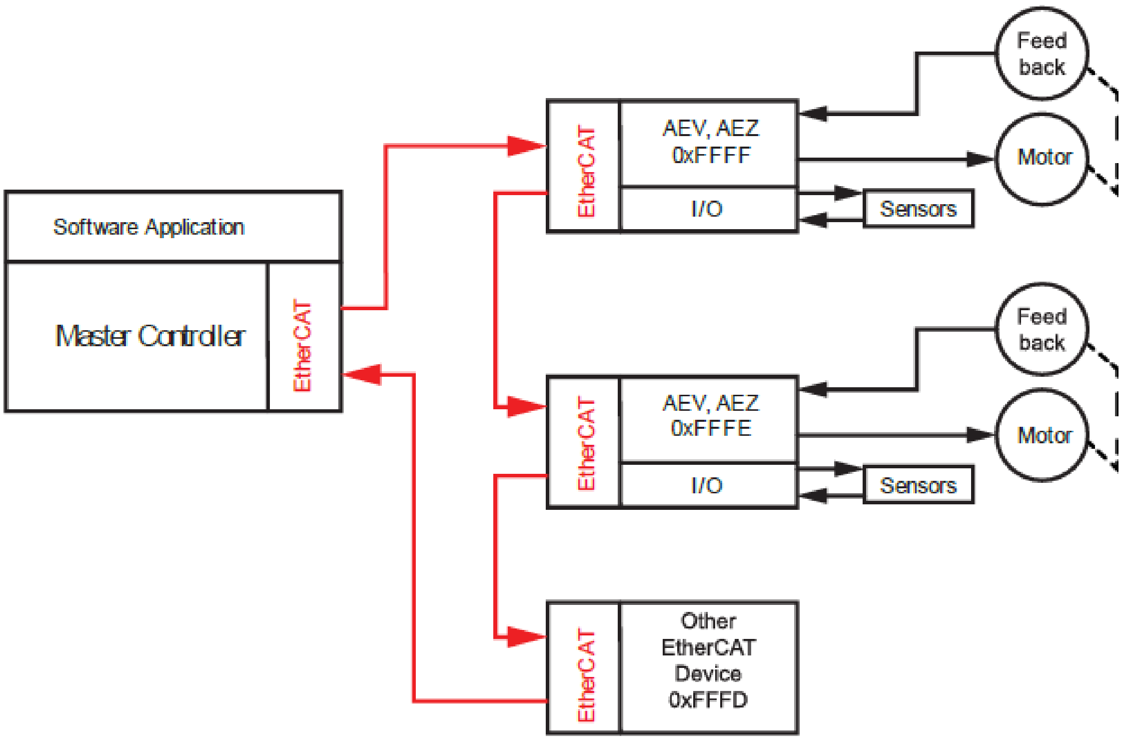
Parameter	**Data**
Channels	1, full-duplex
Type	AEV, APV: LVTTL: 74LVC2G14, 3.3 V. AEZ, APZ: RS-232 transceiver
Signals	Rxd, Txd, Gnd
Baud Rate	9600, 19200, 57600, 115,200, 230,400 (defaults to 9600 on power up or reset)
Data Format	N, 8, 1
Flow Control	None
Protocol	Binary or ASCII format

3.13 Network Interfaces

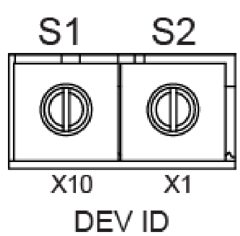
Specification	AEV, AEZ	APV, APZ
Signals	Ethernet 100BASE-TX: RX1+, RX1-, TX1+, TX1- RX2+, RX2-, TX2+, TX2-	CAN_H, CAN_L, CAN_Gnd (CAN +5 Vdc Pass though only)
Isolation	Magnetics External required for AEV Integral in EZ board and EZ Development Board RJ-45 sockets	2-channel isolated transceiver on APV feeds through directly to sockets on APZ and EZ board
Data Format	EtherCAT	CAN V2.0b physical layer for high-speed connections compliant
Protocol	CANopen Application protocol over EtherCAT (CoE) based on CiA 402	CiA 402: CANopen device profile for drives and motion control
Supported Modes	Cyclic Synchronous Position, Velocity, Torque (CSP, CSV, CST), Cyclic Synchronous Torque with Commutation Angle (CSTCA), Profile Current, Velocity, and Position, PVT, and Homing	Profile Current, Velocity, and Position, PVT, and Homing.
Node Address Selection	AEV: Slaves are automatically assigned addresses based on their position on the bus. Station Alias address can be saved to flash memory. AEZ: Two 16-position hexadecimal rotary switches define a cabling-independent Station Alias.	APV: Node address can be defined by inputs, or saved to flash memory APZ: Two 16-position hexadecimal rotary switches on EZ board. OR programmable digital inputs OR stored in flash memory OR combination of above.
Cable	AEZ: Cat 5 or Cat-5e minimum 100 m maximum length between nodes	APZ: Cat 5 or Cat-5e minimum with 121 Ω terminator across CAN_H and CAN_L on last node in the chain.
Bus Termination	No termination required.	A 121 Ω resistor across CAN_H and CAN_L at the CAN master, and at the last device on the CAN network.

3.14 EtherCAT Interface: AEV Models

The Accelnet Plus Micro Modules accept *CAN application protocol over EtherCAT* (CoE) commands. EtherCAT supports two types of addressing nodes on the network: auto-increment and fixed. Nodes on an EtherCAT network are automatically addressed by their physical position on the network. The first drive found on the network is auto-increment address -1 (0xFFFF). The second drive on the network is -2 (0xFFFE) and continues on. Fixed addresses are assigned by the master when it scans the network to identify all of the nodes and are independent of the physical position on the network. Fixed addresses begin with 1001 (0x3E9) and increment thereafter as nodes are found.



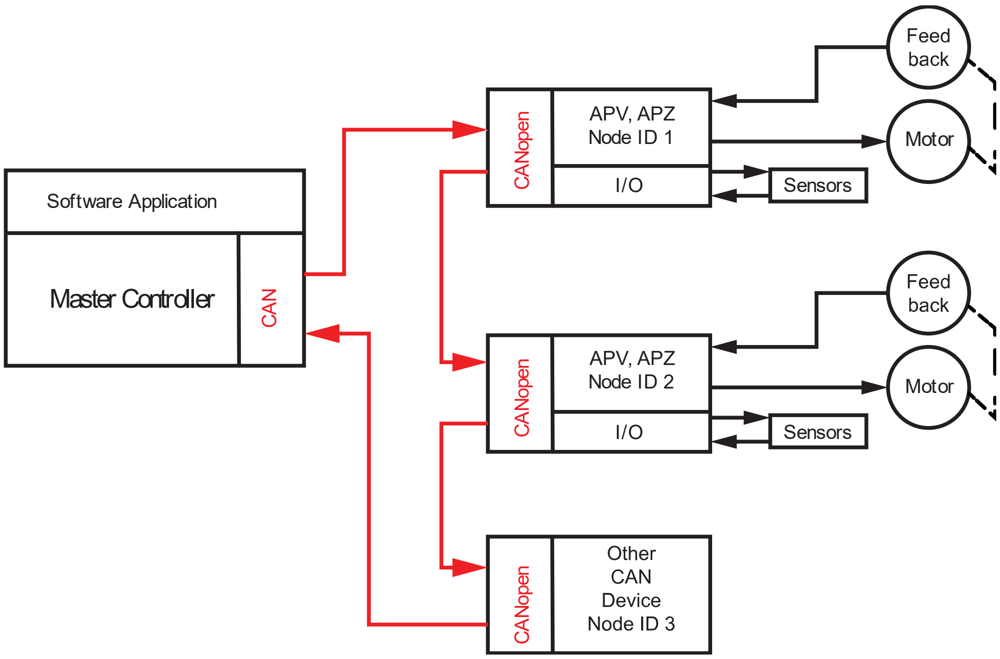
As an alternate to the default addressing, switches S1 and S2 may be used to program a drive's Device ID, or Station Alias with a value between 0x01 and 0xFF (1-255 decimal). In dual axis drives, the second drive follows the first Device ID value. Using a station alias guarantees that a given drive can be accessed independently of the cabling configuration.



The fixed address and the station alias are always available. If the switch-based station alias is used, it is the responsibility of the user to ensure that each drive has a unique station alias.

3.15 CAN Architecture: APV Models

As shown below, in a CANopen motion control system, control loops are closed on the individual drives, and not across the network. A master application coordinates multiple devices, using the network to transmit commands and receive status information. Each device can transmit to the master or any other device on the network. CANopen provides the protocol for mapping device and master internal commands to messages that can be shared across the network.



CAN Addressing

A CANopen network can support up to 127 nodes. Each node must have a unique and valid seven-bit address (Node ID) in the range of 1-127. (Address 0 is reserved and should only be used when the drive is serving as a CME serial port multi-drop gateway).
There are several basic methods for setting the CAN address, as described below. These methods can be used in any combination, producing a CAN address equal to the sum of the settings.

Addressing Method	Description
Use switch	If the address number <= 15, CAN address can be set using the CAN ADDR switch only.
Use inputs	Use the drive's programmable digital inputs (user selects how many (1-7) and which inputs are used).
Use programmed value	Program address into flash only.

For more information on CAN addressing, see the CME User Guide.
For more information on CANopen operations, see the following Copley Controls documents:
- CANopen Programmer's Manual
- CML Reference Manual
- CMO (Copley Motion Objects) Programmer's Guide

3.16 Status Indicators

There are no status indicators on the AEV or APV modules. However, there are status indicators on the AEZ and APZ board assemblies. Details are provided in **Section 5**.

3.17 Fault Levels

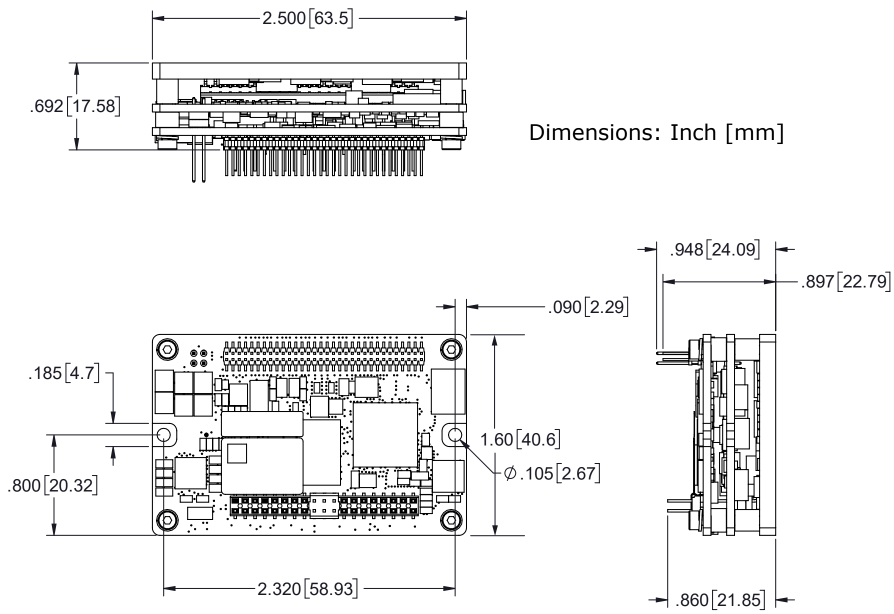
Fault Condition	**Threshold**
Drive Overtemperature	PC board > 90 °C +3/-0 °C, programmable as latching or temporary fault.
DC Bus Undervoltage	+HV < +8.5 ±0.5 Vdc, PWM outputs turn off until +HV > +8.5 Vdc ±0.5 Vdc (90 V models) +HV < +19.5 ±0.5 Vdc, PWM outputs turn off until +HV > +19.5 Vdc ±0.5 Vdc (180 V models)
DC Bus Overvoltage	+HV > +95 ±1 Vdc, PWM outputs turn off until +HV is < +95 ±1 Vdc (90 V models) +HV > +185 ±1 Vdc PWM outputs turn off until +HV is < +185 ±1 Vdc (180 V models)
Encoder Power	+5 Vdc, 500 mA maximum, protected for overload or shorts. Shared by dual encoders
Encoder Loss Detection	AEZ, APZ Only

3.18 Dimensions

Modules

AEV-090-14,-090-30,-180-10-180-20
APV-090-14, -090-30-180-10, -180-20

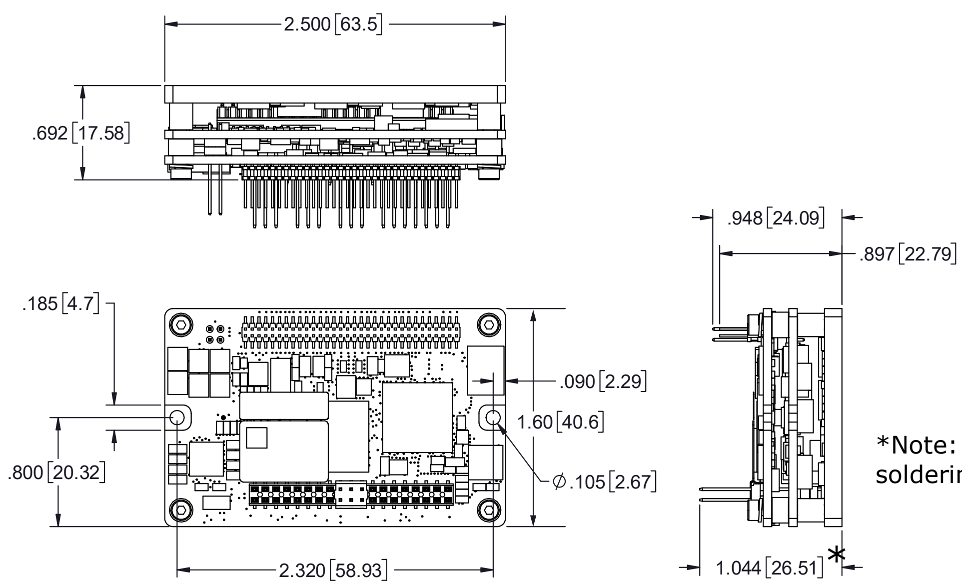
Dimensions



Modules

AEV-090-50, AEV-090-50-C &
APV-090-50, APV-090-50-C

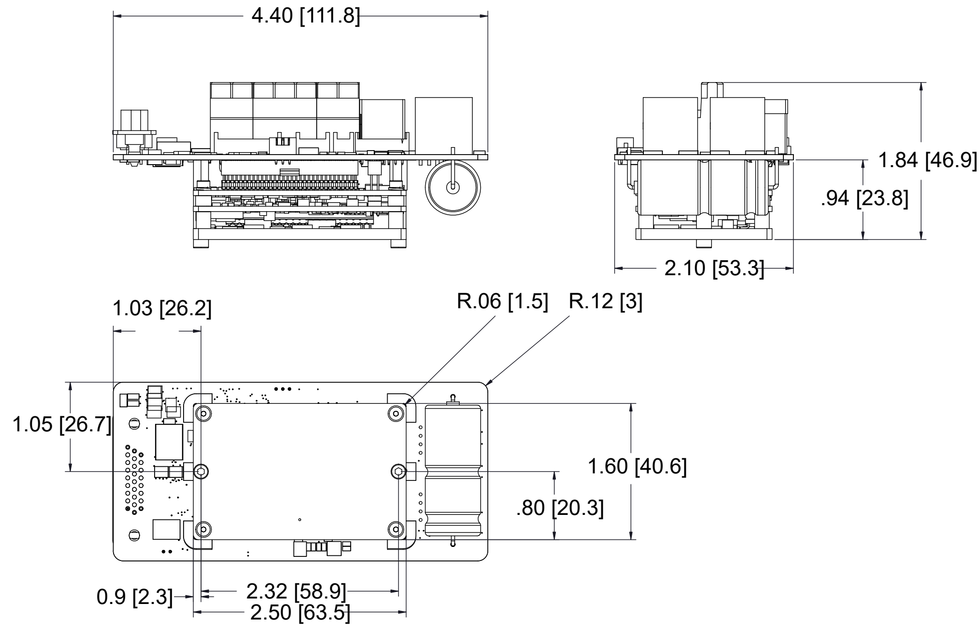
Dimensions



*Note: These pins are longer for soldering into the user PC board.

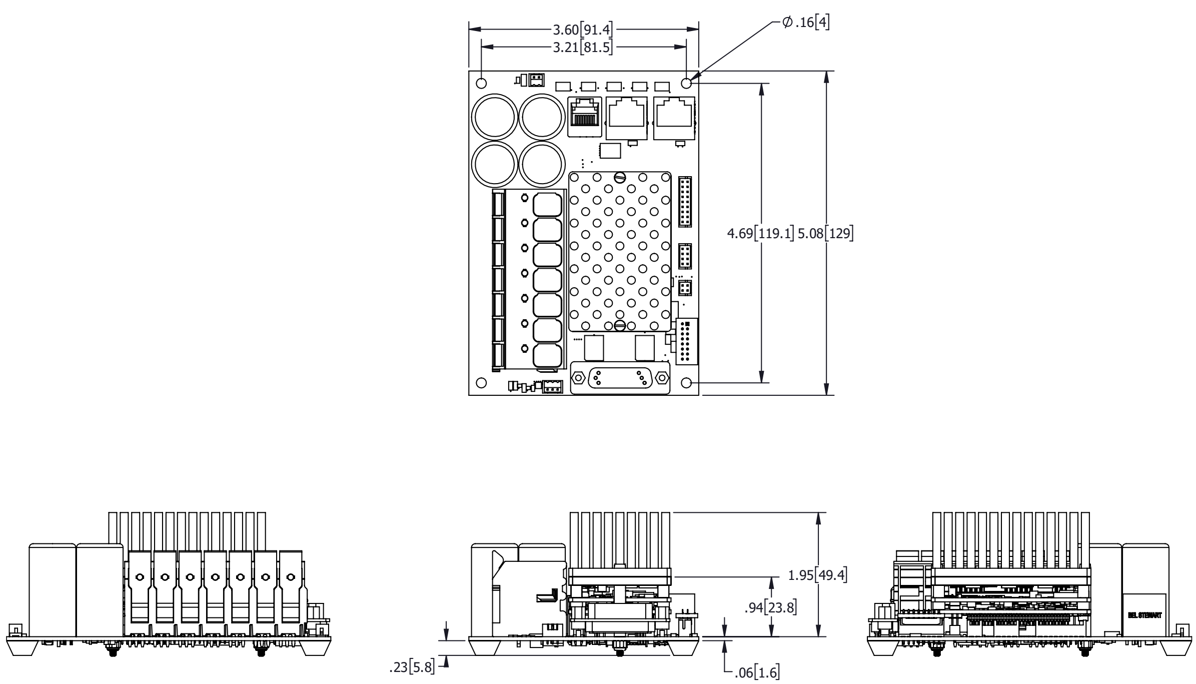
EZ Boards

AEZ-090-50 EZ Board Dimensions



EZ Development Boards

AEZ-090-50-C EZ Development Board Dimensions



3.19 Mechanical and Environmental

AEV/APV

Specification	Data
Size	2.5 x 1.6 x 0.692 in (63.5 x 40.6 x 17.58 mm)
Weight	≤ 0.16 lb (0.073 kg), add 0.106 lb 1.73 oz (0.048 kg) for pins heatsink

AEZ/APZ

Specification	Data
Size	4.4 x 2.1 x 1.85 in (112 x 53.3 x 479 mm)
Weight	≤ 0.40 lb (0.18 kg), add 1.73 oz (0.049 kg) for pins heatsink

AEZ-50-C, APZ-50-C

Specification	Data
Size	3.6 x 5.08 x 1.95 (91.4 x 129.0 x 49.4 mm)
Weight	0.72 lb (0.33 kg)

All Models

Specification	Data
ALL STANDARD MODELS (AEV/APV)	
Ambient Temperature	Operating: 0° to +45° C, Non-operating: -50° to +85° C
Relative Humidity	Operating:0% to 95%, non-condensing
Altitude	Operating: up to 2,000m*
Shock	Operating: 10 g peak, 10 millisecond, half-sine pulse
Vibration	Operating: 10 Hz to 500 Hz, up to 2 grms
Environment	IEC- 60068-2
Contaminants	Pollution Degree 2
Cooling	Heat sink and/or forced air cooling are required for continuous power output.
RUGGEDIZED MODELS (R44/R43)	
Ambient Temperature	Operating: -40° to +70° C, Non-operating: -50° to +85° C
Relative Humidity	Operating: 95%, non-condensing at 70°C Non-operating: 95% non-condensing at 70°C
Altitude	Operating:-400 m to 5,000m*, Non-operating: 400 m to 12,200 m
Thermal Shock	Operating: -40° to 70°C in 1 minute
Vibration	Operating: 5 Hz to 500 Hz, up to 3.85 *g*rms
Specification	**Data**
Shock	Crash Safety: 75 *g* peak acceleration Operating: 40 *g* peak acceleration
MIL-STD Specifications	MIL-STD- (461, 704, 810, 1275, 1399)
IEC Specifications	IEC- (60068, 60079)
Contaminants	Pollution Degree 2
Cooling	Heat sink and/or forced air cooling are required for continuous power output.
*Altitude Note: For additional or higher environmental standards, please consult the Factory.	

3.20 THERMALS

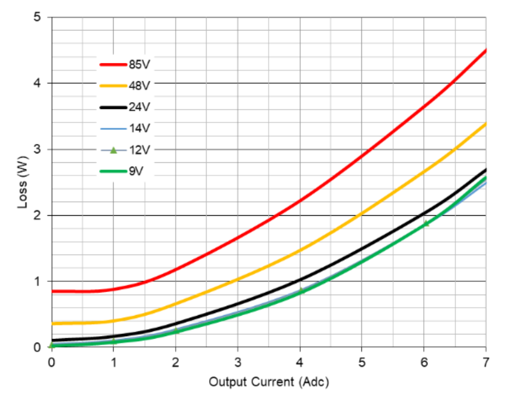
***Note**: For information on the thermals related to the ruggedized models (R44/R43), contact Copley Applications Engineering.

OUTPUT POWER DISSIPATION VS. OUTPUT CURRENT AND +HV

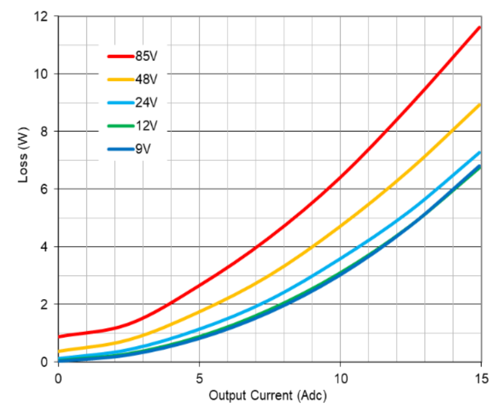
AEV/APV/AEZ, APZ

Draw a vertical line using the effective output current during a typical motion cycle. Find the intersection with a curve closest to the +HV from the power supply. Draw a horizontal line from there to the left which will show the losses in Watts. On the following page find the VLOGIC power dissipation. Add these together to produce the total Watts of losses.

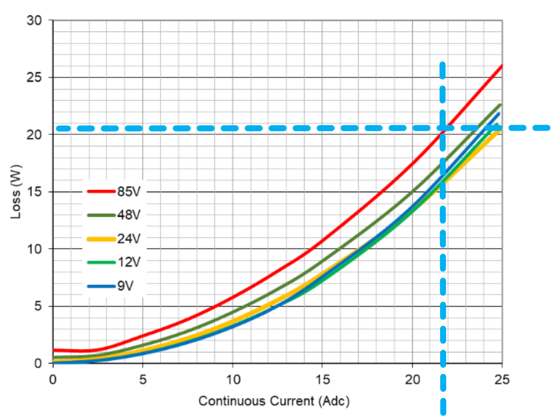
AEV-090-14
APV-090-14



AEV-090-30
APV-090-30

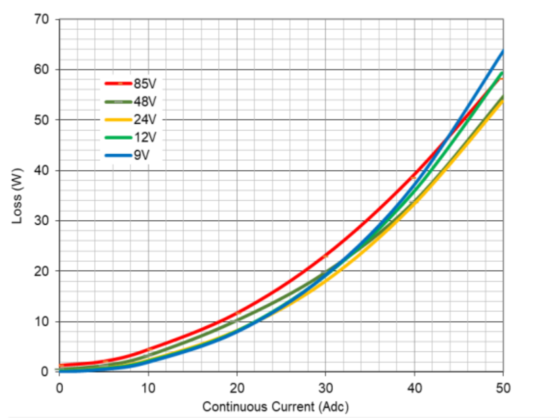


AEV-090-50, AEZ-090-50
APV-090-50, APZ-090-50



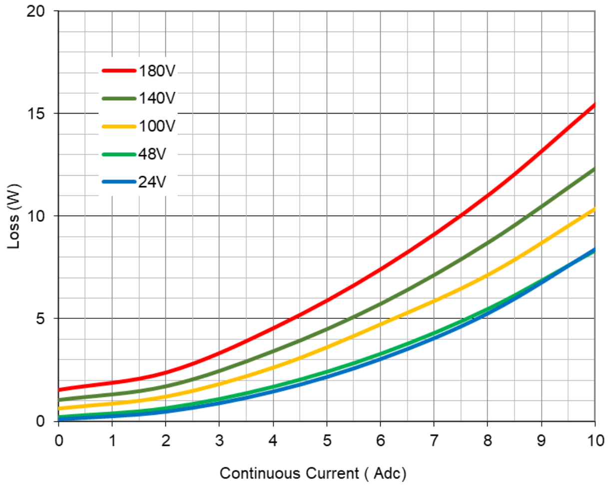
Note: In the above example, the application output current is 22 Adc, at +HV = 85 Vdc the PWM loss is 20.5 Watts.

AEV-090-50-C, AEZ-090-50-C
APV-090-50-C, APZ-090-50-C



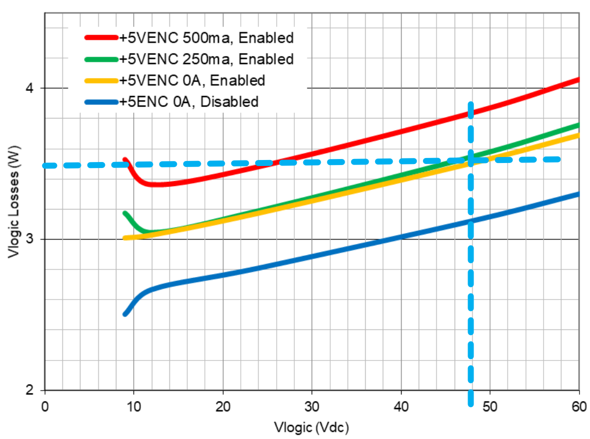
Output Power Dissipation vs. Output Current and +HV

AEV-180-10, AEV-180-20



VLOGIC Dissipation vs. +5V Output Current and +HV

AEV-090-14



Example:
VLOGIC = 48 Vdc.
Dual encoders are used, each using 125 mA for a total of 250 mA.
The total VLOGIC dissipation is ~3.5 W.

Note: In the equation, adding the dissipations of VLOGIC and +HV = 20.5 + 3.5 = 24 Watts.

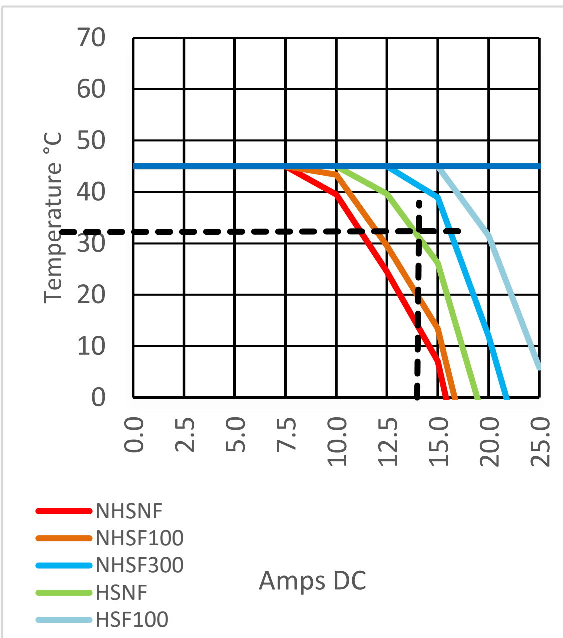
Maximum Operating Temperature vs. Output Current

This chart shows the maximum operating temperature for the drive based on the mounting and cooling options. Fan cooling applies when it is mounted so that the airflow is directed on to the drive to produce the CFM (Cubic Feet per Minute) values shown below.

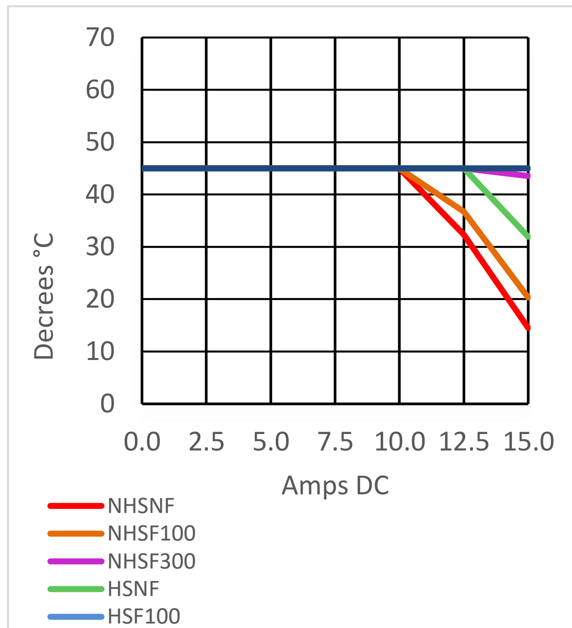
45 °C is the maximum environmental temperature in which to operate the drive.

- NHSNF = No Heatsink, No Fan
- NHSF100 = No Heatsink, Fan at 100 CFM
- NHSF300 = No Heatsink, Fan at 300 CFM
- HSNF = With heatsink, No Fan
- HSF100 = With heatsink, Fan at 100 CFM
- HSF300 = With heatsink, Fan at 300 CFM

AEV-090-50, APV-090-50



AEV-180-10, APV-180-10



Example

In the above charts, the dashed lines show that at an output current of 20 Adc, the maximum operating temperature with a heatsink, and the fan at 100 CFM, the value would be 32 °C (89 °F).

3.21 Operating Temperature and Cooling Configurations

The temperature rise due to Watts of dissipation depends on the *thermal resistance* of the drive which depends on the mounting and cooling means. Thermal energy (heat) will move from a hot location to a colder one much in the way that water does. Given the drive heat and environment heat as constants, the rate at which heat moves depends on thermal resistance in units of degrees-C per Watt and expressed as Rth. As Rth goes down, speeding the flow of heat out of the drive, the temperature rise in the drive will be reduced.

Factors affecting Rth are the area of the surface of the drive and the movement of air over the surfaces. Conduction through solid materials is another path for heat flow. Forced air over the drive or heatsink surfaces will increase the flow of heat as will mounting of the drive's heat plate to a metal surface.

Thermal Resistance vs. Mounting & Cooling

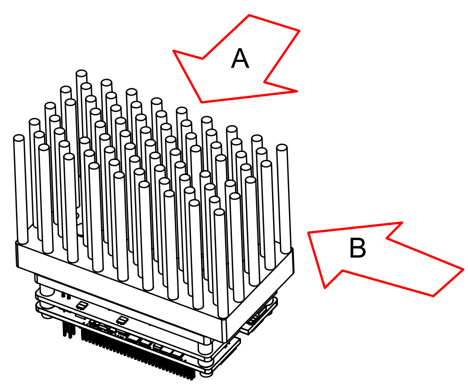
The following tables show the thermal resistance Rth in degrees-C per Watt (C/W) for typical mounting and cooling configurations. LFM is Linear Feet per Minute which is the velocity of air flow produced by a fan directed in line with the heatsink fins.

No Heatsink

LFM	0	100	200	300
Rth	8.5	6.5	5.5	4.0

Pins Heatsink A-Airflow

LFM	0	100	200	300
Rth	4.2	2.9	1.8	1.4



Pins Heatsink B-Airflow

LFM	0	100	200	300
Rth	-	4.2	2.6	1.9

Tall Pins Heatsink A-Airflow

LFM	0	100	200	300
Rth	2.0	1.3	0.9	0.7

Tall Pins Heatsink B-Airflow

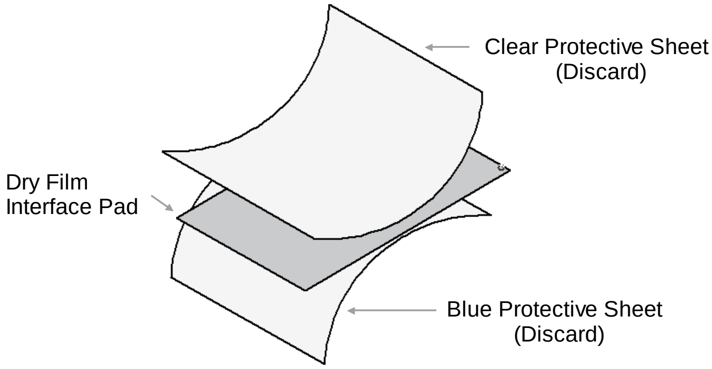
LFM	0	100	200	300
Rth	-	2.2	1.4	1.1

Note:Tall pins heatsink are not shown.

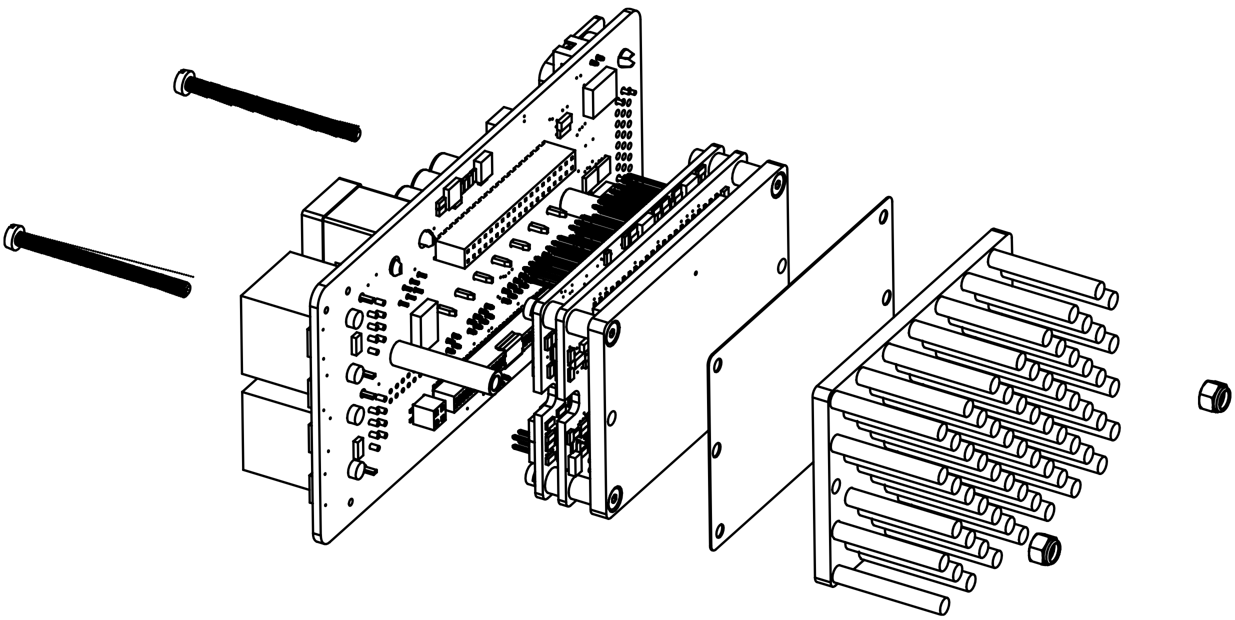
3.22 EZ Board Pins Heatsink Mounting

A thermal pad is used in place of heatsink grease. The pad is die-cut to shape and has holes for the heat sink mounting screws. There are two protective sheets, blue on one side and clear on the other. Both must be removed when the interface pad is installed.

1. Remove the blue protective sheet from one side of the pad.



2. Place the interface pad on the drive, make sure to center the pad holes over the heat plate mounting holes.
3. Remove the clear protective sheet from the pad.
4. Mount the heatsink onto the drive and make sure that the the holes in the heatsink, interface pad, and drive are aligned and line up.
5. Torque the M2.5 mounting screws to 4 in-lb., 64 in-oz, 0.45 Nm.



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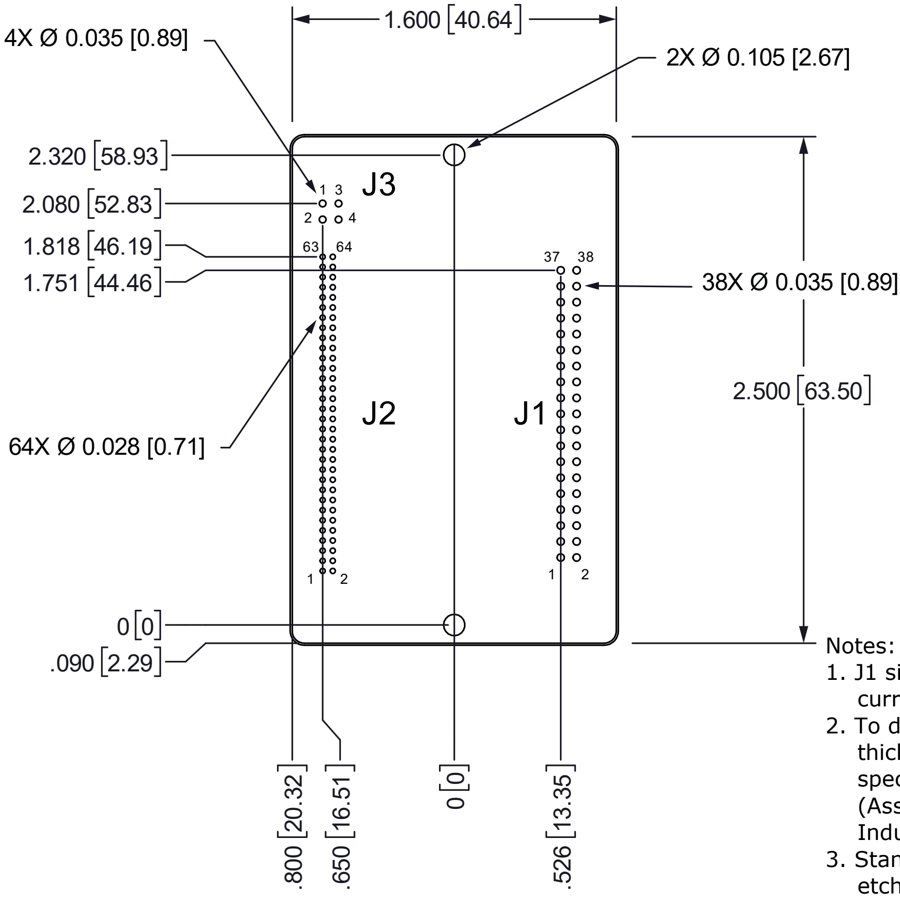
Note: The above instructions apply to all models.
This illustration is an example that shows the components and their placements.

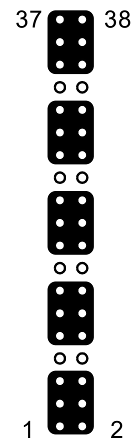
4 CONNECTIONS AND WIRING - MODULES

Top view looking down on mounting PC board



Dimensions are in inches [mm]

J1 Signal Grouping for current-sharing



Notes:
1. J1 signals must be connected for current-sharing.
2. To determine copper width and thickness for J1 signals, refer to specification IPC-2221. (Association Connecting Electronic Industries, http://www.ipc.org)
3. Standoffs should be connected to etches on the PC board that connects to frame ground for maximum noise suppression and immunity. They also provide the PE (Protective Earth) connection between the heat plate and ground.

For Sockets on the User PC Board:

Qty	Description	Mfgr	Part Number	Ref Des	Remarks
1	Socket Strip	Samtec	SQT-119-01-G-D	J1	2.00 mm (0.0787 in) pitch
1	Socket Strip	Samtec	FLE-132-01-G-DV	J2	0.050" (1.27 mm) pitch
1	Socket Strip	Samtec	TLE-102-01-G-DV-TR	J3	2.00 mm (0.0787 in) pitch
2	Standoff	hex, 13 mm long, M2,5 mm thread			

For Soldering to the User PC Board:

1	For J1, refer to the Paste and Hole Printing document from Speedline Technology, Franklin, MA. http://suddendocs.samtec.com/processing/through-hole-printing.pdf				
1	Socket Strip	Samtec	CLP-132-02-L-D-BE-A-K-TR	J2	0.050" (1.27 mm) pitch
1	Socket Strip	Samtec	CLT-102-2-G-D-BE	J3	2.00 mm (0.0787 in) pitch
2	Standoff	hex, 19 mm long, M 2.5 mm thread			

4.1 AEV PC Board Connectors and Pinout

J3 SAFETY

Signal	J3 Pin		Signal
STO_1	1	3	STO_2
STO1_RTN	2	4	STO2_RTN

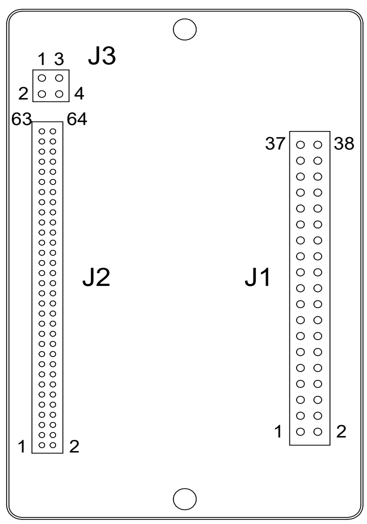
Note: J3: Safety
Dual row, 2 mm centers
4 position female header
SAMTEC TLE-102-01-G-DV-TR

J2 SIGNAL

Signal	J2 Pin		Signal
Reserved	6	64	Reserved
Reserved	6	62	Reserved
SGND	5	60	SGND
+5VENC	5	58	+5VENC
ENCX2	5	56	/ENCX2
ENCB2	5	54	/ENCB2
ENCA2	5	52	/ENCA2
SGND	4	50	SGND
ENCX1	4	48	/ENCX1
ENCB1	4	46	/ENCB1
ENCA1	4	44	/ENCA1
HALLW	4	42	SGND
HALLU	3	40	HALLV
COS1-	3	38	COS1+
SIN1-	3	36	SIN1+
SGND	3	34	SGND
SGND	3	32	SGND
ECATTX1-	2	30	ASYNC_TxD
ECATTX1+	2	28	ASYNC_RxD
ECATTX2-	2	26	ECATRX1-
ECATTX2+	2	24	ECATRX1+
+3.3V_TXRX2	2	22	ECATRX2-
+3.3V_TXRX1	1	20	ECATRX2+
(SLI-CLK)	1	18	SGND
(BRAKE) DOUT3	1	16	DOUT6 (SLI-
DOUT1	1	14	DOUT4 (SLI-
(SLI-MISO) IN7	1	12	DOUT2
IN5	9	10	IN6
IN3	7	8	IN4
(Enable) IN1	5	6	IN2
SGND	3	4	SGND
REFIN(-)	1	2	REFIN(+)

Note: J2: Signal
Dual row, 0.050 inch centers
64 position female header
SAMTEC: FLE-132-01-G-DV-K-TR

TOP VIEW
The following graphic shows the topside board, viewed from above looking down on the connectors or PC board footprint, to which the module is mounted.



J1 POWER & MOTOR

Signal	J1 Pin		Signal
	37	38	
MOTU	35	36	MOTU
	33	34	
	31	32	
	29	30	
MOTV	29	28	MOTV
	25	26	
	23	24	
	21	22	
MOTW	19	20	MOTW
	17	18	
	15	16	
	13	14	
HVCOM	11	12	HVCOM
	9	10	
	7	8	VLOGI
	5	6	
+HV	3	4	+HV
	1	2	

4.2 APV PC Board Connectors and Pinout

J3 SAFETY

Signal	J3 Pin		Signal
STO_1	1	3	STO_2
STO1_RTN	2	4	STO2_RTN

Note: J3: Safety
Dual row, 2 mm centers
4 position female header
SAMTEC TLE-102-01-G-DV-TR

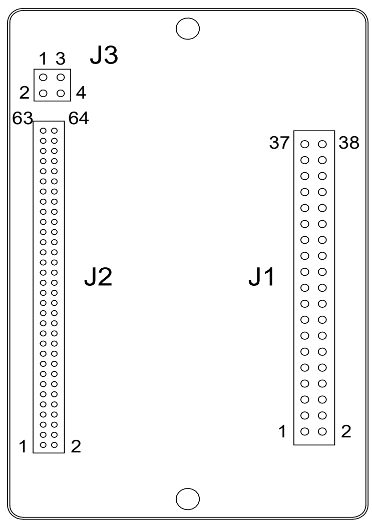
J2 SIGNAL

Signal	J2 Pin		Signal
Reserved	63	64	Reserved
Reserved	61	62	Reserved
SGND	59	60	SGND
+5VENC	57	58	+5VENC
ENCX2	55	56	/ENCX2
ENCB2	53	54	/ENCB2
ENCA2	51	52	/ENCA2
SGND	49	50	SGND
ENCX1	47	48	/ENCX1
ENCB1	45	46	/ENCB1
ENCA1	43	44	/ENCA1
HALLW	41	42	SGND
HALLU	39	40	HALLV
COS1-	37	38	COS1+
SIN1-	35	36	SIN1+
SGND	33	34	SGND
SGND	31	32	SGND
CANH	29	30	ASYNC_TXD
CANL	27	28	ASYNC_RXD
CANGND	25	26	CANGND
SGND	23	24	SGND
SGND	21	22	SGND
SGND	19	20	SGND
(SLI-CLK)	17	18	SGND
(BRAKE)	15	16	DOUT6 (SLI-
DOUT1	13	14	DOUT4 (SLI-
(SLI-MISO) IN7	11	12	DOUT2
IN5	9	10	IN6
IN3	7	8	IN4
(Enable) IN1	5	6	IN2
SGND	3	4	SGND
REFIN(-)	1	2	REFIN(+)

Note: J2: Signal
Dual row, 0.050 inch centers
64 position female header
SAMTEC FLE-132-01-G-DV-K-TR

TOP VIEW

The following graphic shows the topside board, viewed from above looking down on the connectors or PC board footprint, to which the module is mounted.



J1 POWER & MOTOR

Signal	J1 Pin		Signal
MOTU	37	38	MOTU
	35	36	
	33	34	
	31	32	
MOTV	29	30	MOTV
	29	28	
	25	26	
	23	24	
MOTW	21	22	MOTW
	19	20	
	17	18	
	15	16	
HVCOM	13	14	HVCOM
	11	12	
	9	10	
	7	8	VLOGIC
+HV	5	6	+HV
	3	4	
	1	2	

Note: J1: HV & Motor
Dual row, 2 mm centers
38 position female header
SAMTEC SQT-119-01-G-D

4.3 Mounting Configurations

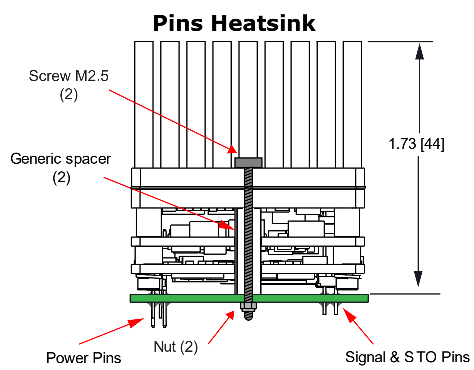
Soldered into the User PC Board

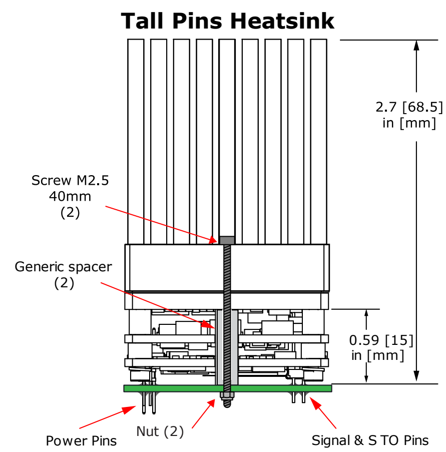
AEV-090-50, AEV-090-50-C,
APV-090-50, APV-090-50-C

The Kits are not available for this configuration. The following list the required parts supplied by the user.

Part	Description
Standoffs	15 mm, diameter 4.5 mm, hollow, aluminum, RAF M0514-24, qty 2
Thermal pad:	Copley 6-83985-01, qty 1
Pins Heatsink:	Copley 21-126260-01, qty 1
Screws:	M2.5, Length dependent on assembly, qty 2
Nuts:	M2.5, Dependent on assembly, qty 2

The Accelnet Plus Micro Module drives do not emit noise above 70 dB(A) when they are mounted and operating.

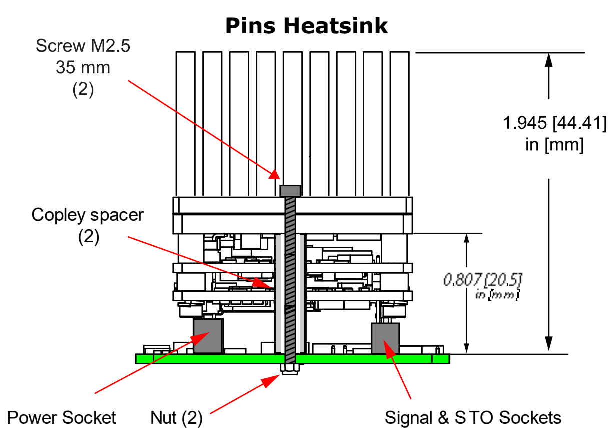


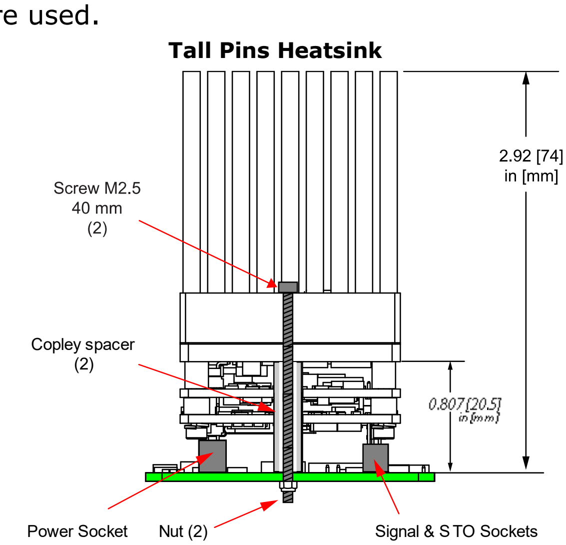


Socketed into the User PC Board

AEV-090-14, AEV-090-30, AEV-180-10, AEV-180-20,
APV-090-14, APV-090-30, APV-180-10, APV-180-20

All connections shown are socketed. With the pins heatsink, the 35 mm screws are used. With the long pins heatsink, the 40 mm screws are used.



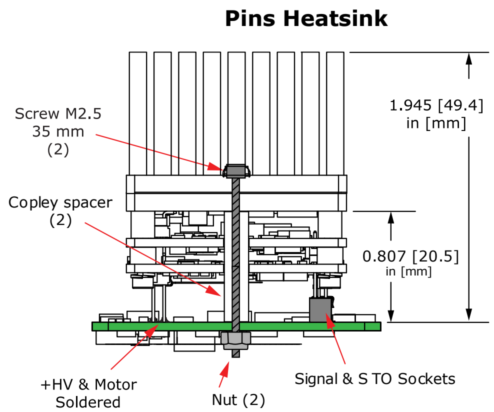


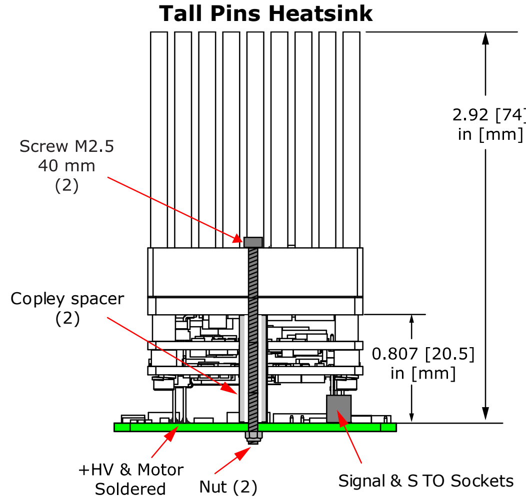
Half-Socketed into the User PC Board

Signal J2 and STO J3 are socketed. Power & motor J1 are soldered. With the pins heatsink, use 35 mm screws . With the long pins heatsink, use 40 mm screws.

CONNECTORS FOR HALF-SOCKETING

Part	Mfgr	Part Number	Qty
Signal Socket J2	Samtec	FLE-132-01-DV-K-TR	1
STO Socket J3	Samtec	TLE-102-01-G-DV-TR	1

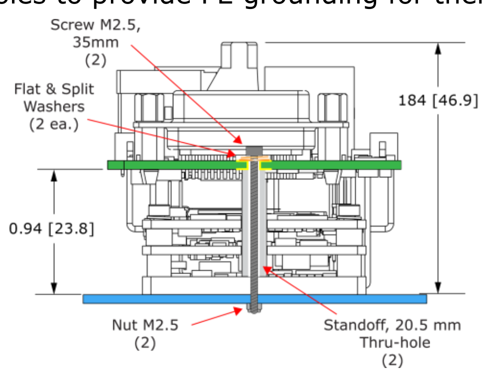




Panel Mounting with EZ Board

AEV/APV-090-14, AEV/APV-090-30, AEV/APV-180-10, AEV/APV-180-20

These models are shown below socketed into an EZ Board. Screws pass through the EZ Board and standoffs to nuts that hold the drive to the panel. Tapping a hole in the panel to accept the M2.5-0.45 screw allows the drive to be mounted and removed from one side of the panel. User-designed mounting boards should have the same conductive etch rings around the screw holes to provide PE grounding for their circuits.



IMPORTANT

Standoffs must be metal, preferably brass. The EZ Board has conductive etch rings on each side of the screw holes which connect via etch through the holes. The screws then provide a path from the PE circuits on the drive through the standoffs and drive heat plate to the mounting panel which should be earthed. The etch on the bottom of the holes connects to the standoffs and drive heat plate, providing a PE ground for the heat plate. The thermal material between the mounting board and heat plate of the drive is non-conductive so effective grounding of the heat plate is provided through the standoffs.

PANEL MOUNTING PARTS

Part	Part Number	Qty	AEZ/APZ-090-50
Screw	M2.5-0.45 x 35 mm slotted cheese head	2	These models have the motor, +HV, and grounding pins soldered to the EZ board. The signal and STO pins are socketed. The dimensions and mounting to a panel are the same as the AEV and APV models.
Nut	M2.5-0.45 DIN nylon lock nut	2	
Thermal material	Copley	1	
Spacer	Copley non-threaded spacer 20.5 mm	2	
Flat Washer	Metric, M2.5, flat	2	
Split Lock Washer	Metric, M2.5, lock	2	
Note: In the above example, it shows the EZ Board, but it does not apply to the panel mounting of the following drives: AEV-090-50, AEV-090-50-C, APV-090-50, and APV-090-50-C. These models are incompatible with the EZ board.			

HEATSINK & HARDWARE KITS

PINS HEATSINK KIT: AEV-HK, APV-HK

Part	Part Number	Qty
Screw	M2.5-0.45 x 35 mm slotted drive cheese head	2
Nut	M2.5x0.45 DIN zinc plated nylon insert lock nut	2
Thermal material	Copley	1
Spacer	Copley non-threaded spacer 20.5 mm	2
Heatsink	Pins Heatsink, 1 inch tall	1

TALL PINS HEATSINK KIT: AEV-THK, APV-THK

Part	Part Number	Qty
Screw	M2.5-0.45 x 40 mm slotted drive cheese head	2
Nut	M2.5x0.45 DIN zinc plated nylon insert lock nut	2
Thermal material	Copley	1
Spacer	Copley non-threaded spacer 20.5 mm	2
Heatsink	Tall Pins Heatsink, 1.97 inch tall	1

MOUNTING BOARD CONNECTORS FOR SOCKETING

Part	Manufacturer	Part Number	Qty
Power Socket J1	Samtec	SQT-119-01-G-D	1
Signal Socket J2	Samtec	FLE-132-01-G-DV-K-TR	1
STO Socket J3	Samtec	TLE-102-01-G-DV-TR	1

4.4 Integration Guidelines for AEV & APV Modules

User Mounting Board (UMB) Design

UMB Design Rules

The UMB board design should incorporate three zones, each with a different design rule.

- STO
- Signals
- Power & Motor

Standard IPC 2152 is used to determine trace thickness and widths needed to carry the required currents. Standard IEC 60664-1 provides the spacing of conductors that will provide the necessary insulation required to ensure that the circuits in each zone function well without interfering with circuits in other zones.

PCB Spacings

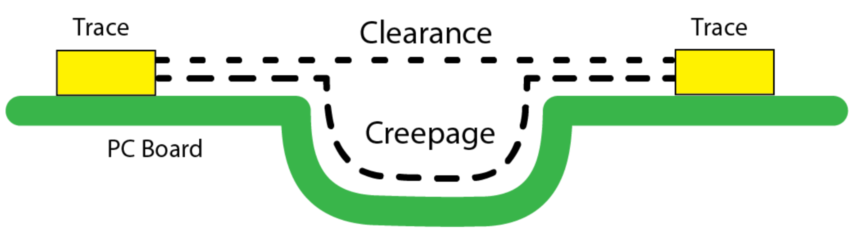
The AEV and APV drives do not have the shielding and grounding provided by the enclosed panel-mounting drives. As a result, the user must provide for grounding and spacing of the conductors in their PCB design.

Spacings of conductors on the UMB are of two types: Clearance and Creepage.

- **Clearance** is the straight-line distance between two traces.
  Primarily affected by air pressure (altitude) and voltage between the traces.
- **Creepage** is the distance between traces over the surface of the UMB.
  Primarily affected by air pressure (altitude) and humidity
- **Spacings** between safety and non-safety circuits must be designed to exclude the possibility of short circuit faults between safety and non-safety circuits.

Mandatory Design Rules for STO

When the STO feature of the drive is used, these rules are required. These are illustrated in the graphic below. Sufficient clearance and creepage distances must be exist for the STO connections to exclude certain short circuit faults from consideration in the FMEDA. Additional details provided in Section 6.11.



Spacings are based on the Pollution Degree which is defined in IEC 60664-1.
The AEV & APV are designed for Pollution Degree 2:

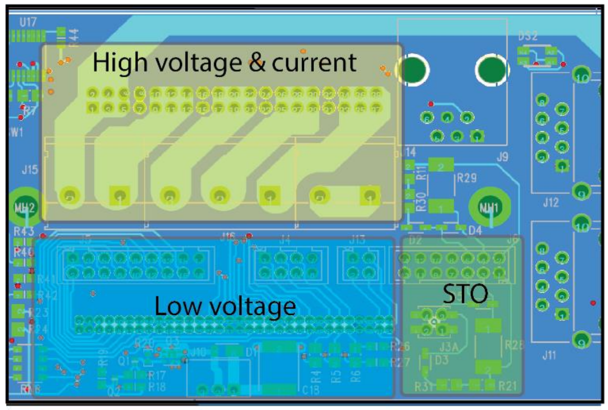
- Pollution Degree 2: Normally only nonconductive pollution occurs. Occasionally, however, a temporary conductivity caused by condensation is to be expected, when the drive is out of operation.

Circuits Zoning

- High-Voltage & Current: Input from the DC power supply.
- Low-Voltage: Signals
- STO:Safety inputs

In the High Voltage & Current/Low Voltage Diagram, it shows the traces from the EZ board as an example of the zones on the UMB that have different rules for spacings, etc.

- The Seven high-current traces are used for the +HV, HVCOM, motor U/V/W outputs, Frame Ground, and Protective Earth (PE).
- Traces used on the EZ Board are paired on the top and the bottom layers, connected by vias. This gives a 3 oz., 0.50-inch width combination



High Voltage & Current/Low Voltage Diagram

Creepage & Clearance for Outer Layers of PC Boards

- No conformal coating
- Creepage and clearance based on standard IEC 60664-1
- Dominant requirement: Fault Exclusion against short circuits.

Description	Creepage & Clearance
Between Low Voltage circuits and STO circuits	0.200 mm
Between High Voltage circuits and STO circuits	0.630 mm
Between Low Voltage circuits and High Voltage circuits	0.630 mm
Between Low Voltage circuits and chassis	0.200 mm
Between High Voltage circuits and chassis	0.630 mm

Creepage & Clearance for Inner Layers of PC Boards

- Creepage and clearance based on standard IEC 60664-1
- Dominant requirement: Fault Exclusion and Short Circuits

Description	Creepage & Clearance
Between Low Voltage circuits and STO circuits	0.200 mm
Between High Voltage circuits and STO circuits	0.500 mm
Between Low Voltage circuits and High Voltage circuits	0.500 mm
Between Low Voltage circuits and chassis	0.200 mm
Between High Voltage circuits and chassis	0.500 mm

Recommended Design Rules

The Manufacturer recommends the user refer to the design rules in the PC board design, although there are no standard compliance requirements.

4.5 Grounding Considerations

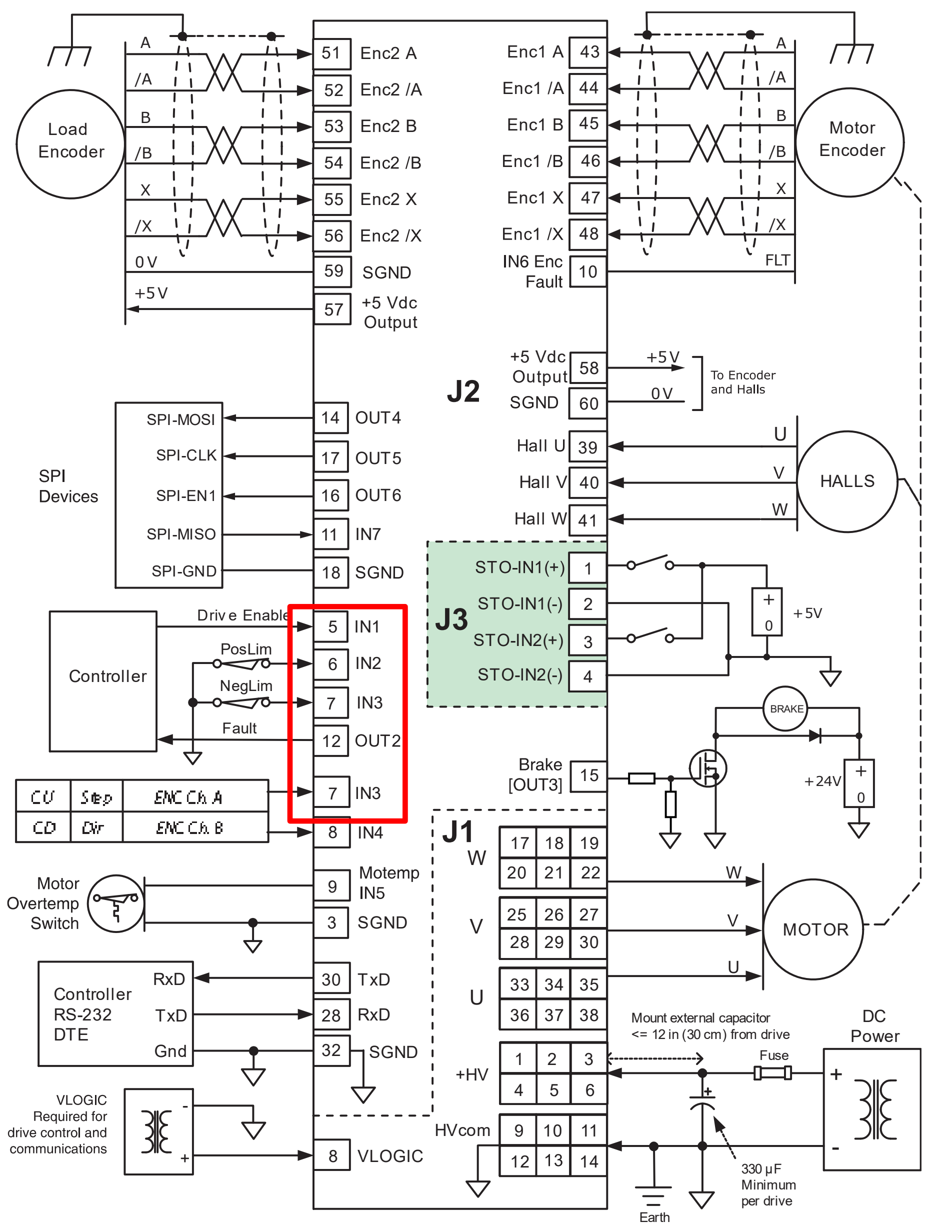
Signal Ground and HVCOM are all connected in the drive. The HV and PWM outputs carry high currents, and the signal circuits and I/O are low-current circuits. In the graphic below, the circuits highlighted in green are isolated from Signal Gnd to avoid ground-loops with the external equipment.

User equipment connecting to the drive's non-isolated circuits should have a circuit ground that is at the same potential as the drive Signal Ground.

Connections & Grounding – AEV/APV Example

The networking CAN and EtherCAT connections are not shown in this diagram.

Note: The [IN3] is shown twice but use the [IN3] for no more than one function.



Connections Diagram

DC Power Grounding

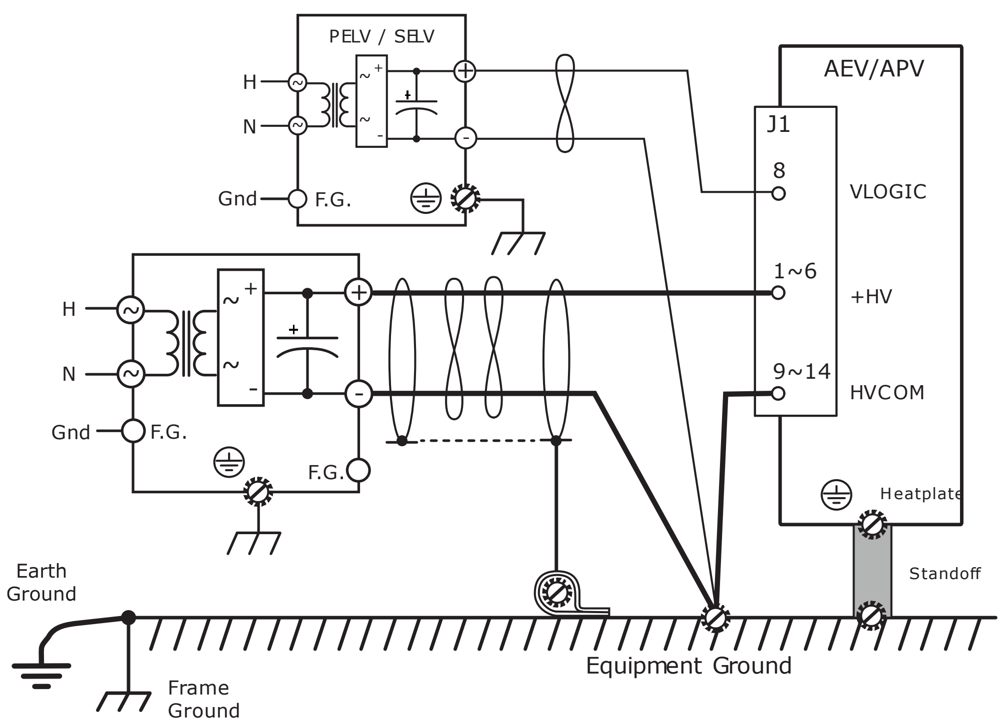
The graphic below shows the basic elements of a DC power supply system for a Plus Micro Module drive. The Plus Micro Module drives are Protective Class I equipment to comply with protection against electric shock. Accordingly, the drives have both basic insulation between circuits and accessible conductive parts. This feature provides a process of connecting a protective earthing conductor to prevent accessible conductive parts from becoming hazardous live in the event of a failure of the basic insulation. A protective earthing conductor must be connected to the drive at the grounding point on the drive marked with the PE (Protective Earth) symbol. Note that the Plus Micro Module drives require the DC power supply be galvanically isolated from AC mains as shown in the figure below.

The PE marking is shown to illustrate the point for connecting the protective earth conductor to the drive. Aside from the electrical safety aspects of grounding, the user must comply with the following wiring and grounding practices:

- reduce susceptibility to external EMI (Electro-Magnetic Interference) sources
- suppress EMI emissions
- minimize differences in signal grounds due to cable length and equipment connections

The (-) terminal of the power supply is connected by a short, direct path to the equipment ground terminal (sometimes called the "star" or equipment ground). This practice is common when drives are installed in the same cabinet with short connections to the drives.

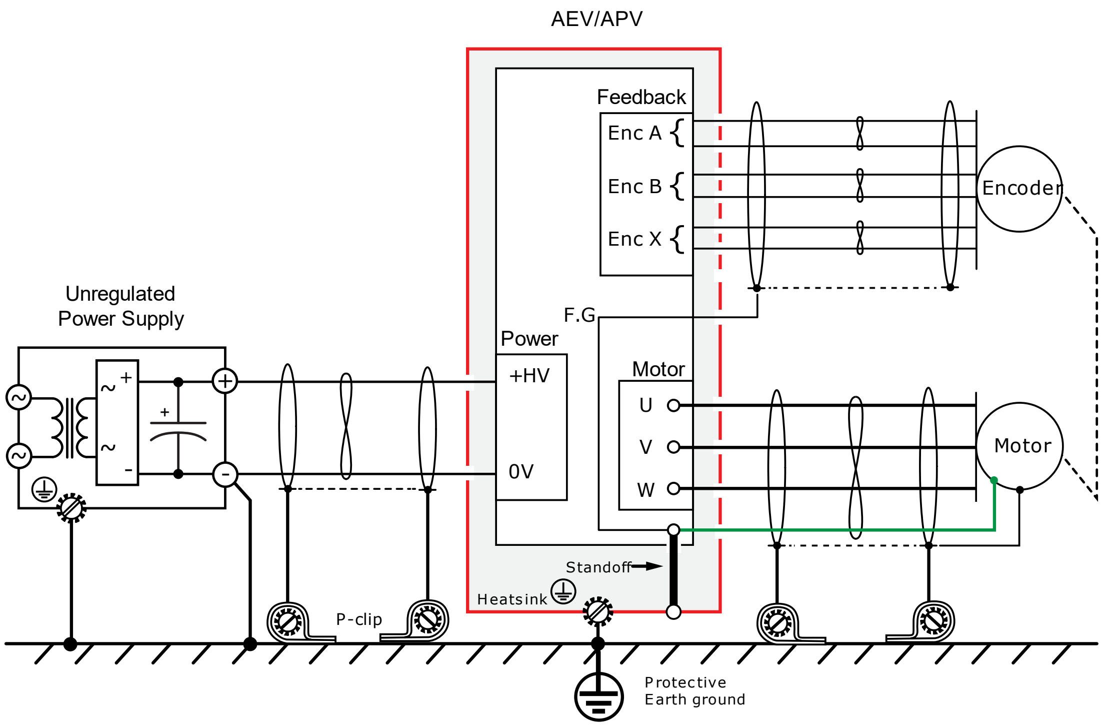
The DC power wiring is shown as a shielded, twisted pair of a gauge suitable for the input current rating of the drive. The shield should connect to the (-) terminal of the power supply on one end and connect to a screw that holds the heat plate to the mounting plate for best results. This connection will provide the lowest impedance path between the power supply and the drive for noise originating in the drive. Doing so will minimize noise currents flowing in the mounting plate or the cabinet.



DC Power Supply Wiring Diagram

Motor Connection Grounding

On AEV and APV modules, the connection to Frame Ground is made by a standoff that connects the drive heat plate on one end to a copper trace on the mounting PC board with a path to earth on the other end. The motor cable shield should connect to this trace. Connection of cable shield to this point is made to provide electrical noise reduction and to prevent the motor housing from becoming hazardous live in the event of an insulation failure. Protective earth connections for the motor housing are subject to local electrical codes and must be reviewed for compliance with those codes. It is the responsibility of the end user to ensure compliance with local electrical codes and any other applicable standards. It is strongly recommended that motor also be connected to protective earth connection points located as close to the motor as possible. In many applications, the machine frame is used as a primary or supplemental protective earth connection point for the motor housings.



Motor Cable Shielding

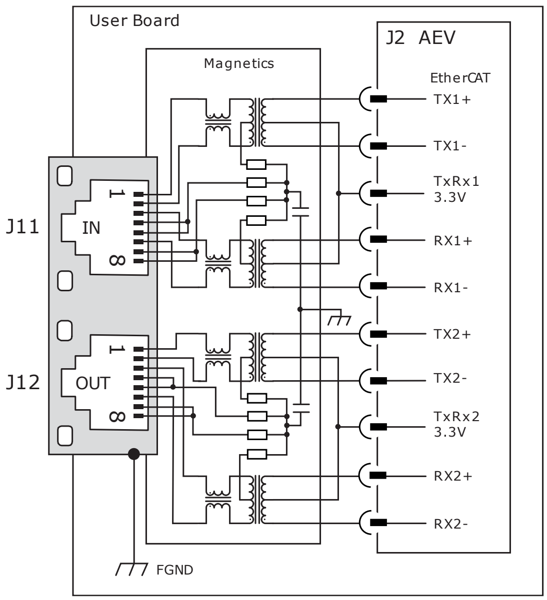
Shields on motor cables reduce emissions from the drive and help protect internal circuits from interference due to external sources of electrical noise. The shields shown in the wiring diagrams are also required for CE compliance. Motor cable shields should be tied to Frame Ground at the drive end, and to the motor frame on the motor end. Motors are typically grounded to equipment frames, too.

Feedback Cable Shielding

Shields on feedback cables reduce emissions from the drive and help protect internal circuits from interference due to external sources of electrical noise.

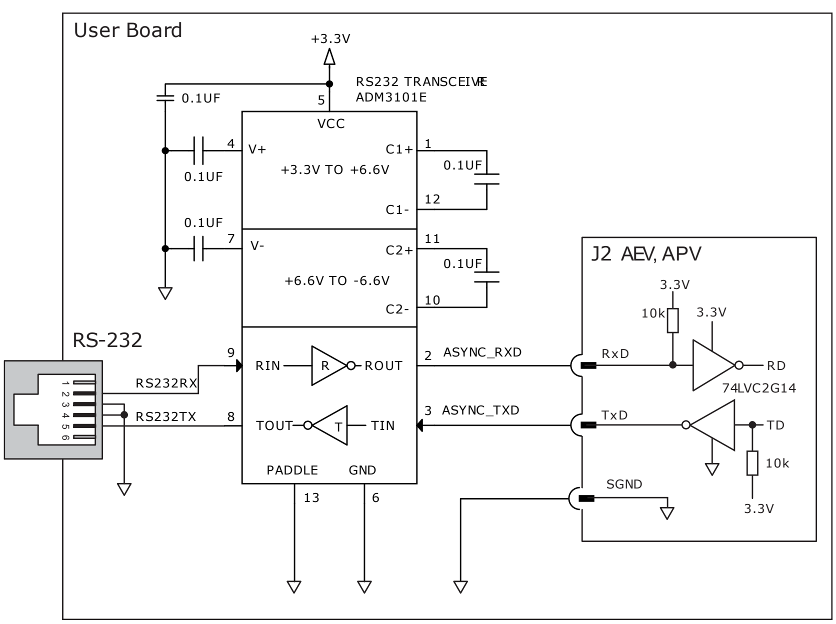
4.6 EtherCAT Communications

EtherCAT is the open, real-time Ethernet network developed by Beckhoff based on the widely used 100BASE-TX cabling system. EtherCAT enables high-speed control of multiple axes while maintaining tight synchronization of clocks in the nodes. Data protocol is CANopen application protocol over EtherCAT (CoE) based on CiA 402 for motion control devices. More information on EtherCAT can be found on this website: http://ethercat.org



Signal	J2 Pins
ECATTX1+	27
ECATTX1-	29
+3.3V_TXRX1	19
ECATRX1+	24
ECATRX1-	26
ECATTX2+	23
ECATTX2-	25
+3.3V_TXRX2	21
ECATRX2+	20
ECATRX2-	22

4.7 RS-232 Communications



The serial port is a full-duplex, three-wire (RxD, TxD, Sgnd) type that operates from 9,600 to 230,400 Baud. It can be used by CME for drive configuration and setup or used by external equipment sending the ASCII commands. The circuit shown here is used on the EZ board and is recommended for user's PC boards. It converts the single-ended TTL signals levels in the AEV into the ANSI RS-232 levels which are the standard for serial communications and computer COMM ports.

RS-232	Signal	J2 Pins
RxD	ASYNC_RXD	28
TxD	ASYNC_TXD	30
SGND	SGND	32

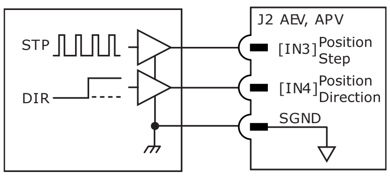
4.8 Digital Command Inputs: Position

Stand-Alone Mode Digital Position -CONTROL Inputs

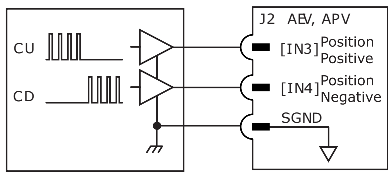
AEV-APV work with motion controllers that output pulses to command position. The following formats are supported:

- Step/Direction
- Count-Up/Count-Down (CU/CD)
- A/B Quadrature Encoder

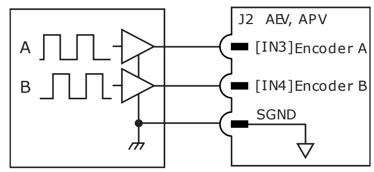
In Step/Direction mode, a pulse-train controls motor position, and the direction is controlled by a DC level at the Direction input. CU/CD (Count-Up/Count-Down) signals command the motor to move CW or CCW depending on which input the pulse-train is directed to. The motor can also be operated in an electronic gearing mode by connecting the inputs to a quadrature encoder on another motor. In all cases the ratio between input pulses and motor revolutions is programmable.



STEP/DIRECTION INPUTS



COUNT-UP/COUNT-DOWN INPUTS



QUAD A/B ENCODER INPUTS

Command Options	Signal	J2 Pins
Step, Position Positive, Encoder A	IN3	7
Direction, Position Negative, Encoder B	IN4	8

J2 Sgnd Pins (APV)
3,4,18,31,32,33,34,42,49 ,50,59,60 (19~24)

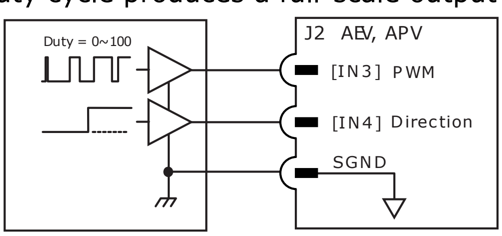
4.9 Digital Command Inputs: Velocity, Torque

Stand-Alone Mode Digital VELOCITY/TORQUE CONTROL Inputs

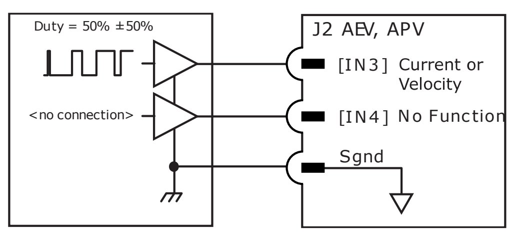
AEV-APV work with motion controllers that output pulses to command velocity and torque (current). These formats are supported:

- PWM/Direction
- 50 % PWM

In PWM/Direction mode, a pulse-train with variable duty-cycle controls motor Vel/Trq, and the polarity or direction is controlled by HI/LO levels at the Direction input.
With 50% PWM operation there is a single signal. A 50% duty cycle produces zero output. Increasing the duty cycle to 100% produces a full-scale output in one direction and 0% duty cycle produces a full-scale output in the opposite direction.



PWM/DIRECTION INPUTS



50% PWM

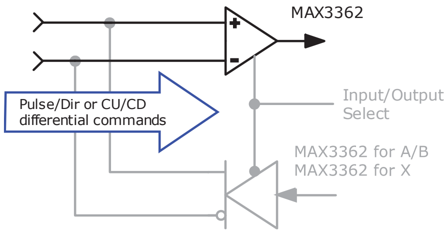
Command Options	Signal	J2 Pins
PWM Vel/Trq, 50% PWM +/- Vel/Trq	IN3	7
Hi/Lo Direction, No connection	IN4	8

4.10 Multi-Mode Port as an Input

COMMAND INPUT

POSITION COMMANDS: DIFFERENTIAL

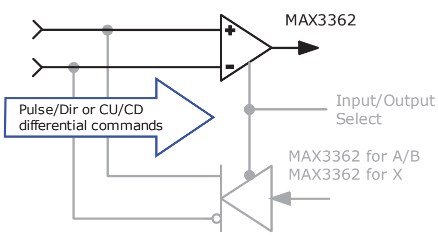
- Pulse & Direction
- CW & CCW (Clockwise & Counter-Clockwise)
- Encoder Quad A & B
- Camming Encoder A & B input

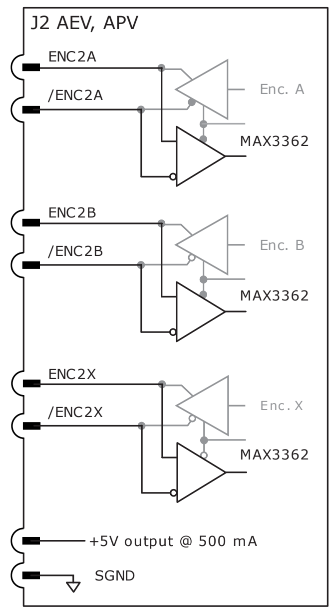


Command Signals	Signal	J2 Pins
Pulse, CW, Quad Encoder A, Vel-Curr-Magnitude, Vel-Curr-50%	ENCA2	51
/Pulse, /CW, Quad Encoder /A, /Vel-Curr-Magnitude, /Vel-Curr-50%	/ENCA2	52
Direction, CCW, Quad Encoder B, Vel-Curr-Direction	ENCB2	53
/Direction, /CCW, Quad Encoder /B, /Vel-Curr-Direction	/ENCB2	54

CURRENT or VELOCITY COMMANDS: DIFFERENTIAL

- Current/Velocity Magnitude & Direction
- Current/Velocity 50%

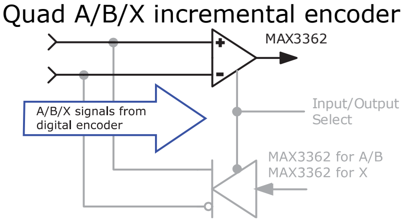




FEEDBACK INPUT: ENCODER 2

SECONDARY FEEDBACK: INCREMENTAL

- Quad A/B/X incremental encoder

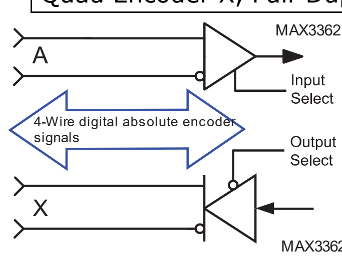


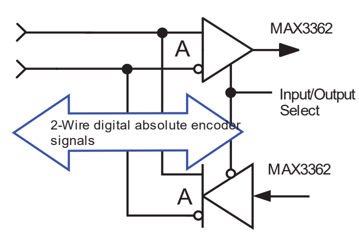
SECONDARY FEEDBACK: ABSOLUTE

- Half-Duplex: Absolute A encoders (2-wire) The A channel first transmits a Clock signal and then switches to a receiver to receive data from the encoder.
- Full-Duplex: SSI, BiSS, EnDat encoders (4-wire). The X channel sends the Clock signal to the encoder, which initiates data transmission to the A-channel.

J2 Sgnd Pins (APV)
3,4,18,31,32,33,34,42,49,50,59,60 (19~24)

Feedback Signals	Signal	J2 Pins
Quad Encoder A, Half-Duplex CLK-DATA, Full-Duplex DATA	ENCA2	51
Quad Encoder /A, Half-Duplex CLK-DATA, Full-Duplex DATA	/ENCA2	52
Quad Encoder B	ENCB2	53
Quad Encoder /B	/ENCB2	54
Quad Encoder X, Full-Duplex CLOCK	ENCX2	55
Quad Encoder X, Full-Duplex /CLOCK	/ENCX2	56





4.11 Multi-Mode Port as an Output

OUTPUT TYPES

BUFFERED FEEDBACK OUTPUTS: DIFFERENTIAL

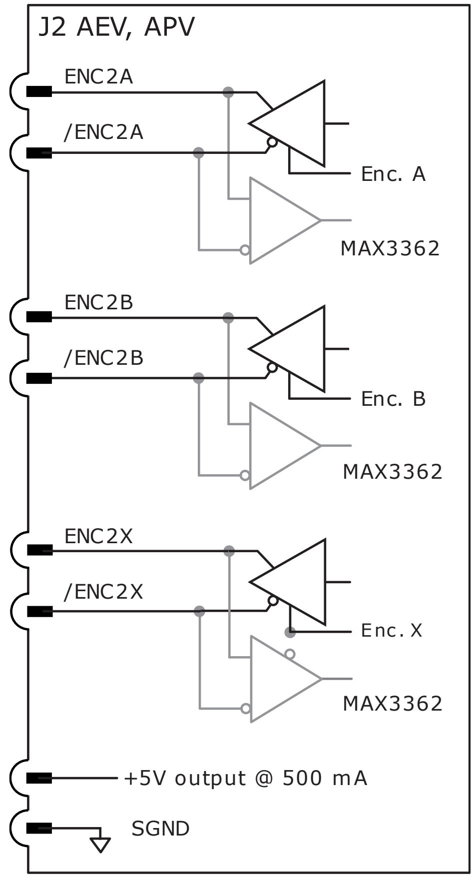
An incremental encoder connected as primary feedback from the motor is internally connected to the multi-port configured as an output. This can then be wired to a motion controller that needs position data without the need for split-wiring cables from the encoder alone.

- Encoder Quad A, B, X channels
- Direct internal connection between quad A/B/X encoder feedback and differential line drivers for A/B/X outputs

EMULATED FEEDBACK OUTPUTS: DIFFERENTIAL

Firmware produces emulated quad A/B signals from feedback data from the following devices:

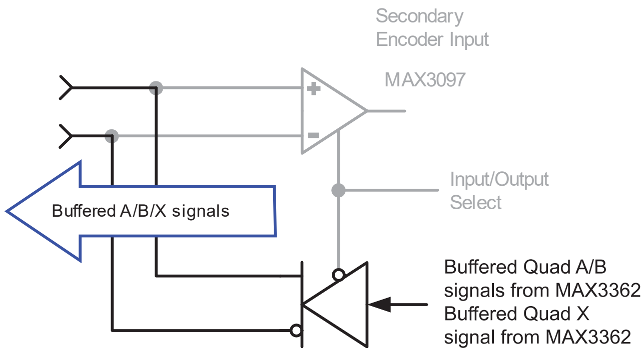
- Absolute encoders
- Analog Sin/Cos incremental encoders
  The X channel is not used in this mode.



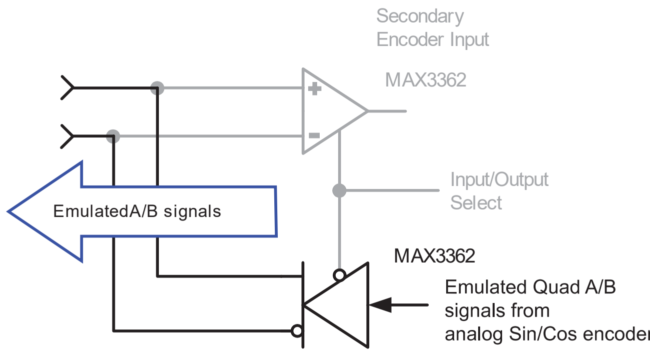
Signal	Signal	J2 Pins
Enc2 A	ENCA2	51
Enc2 /A	/ENCA2	52
Enc2 B	ENCB2	53
Enc2 /B	/ENCB2	54
Enc2 X	ENCX2	55
Enc2 /X	/ENCX2	56

J2 Sgnd Pins APV
3,4,18,31,32,33,34,42,49,40,49,60 (19~24)

BUFFERED QUAD A/B/X OUTPUTS



EMULATED QUAD A/B OUTPUTS



4.12 CME Defaults

The following tables show the CME default settings. They are user-programmable, and the settings can be saved to non-volatile flash memory as CCX or CCD files.

Input / Output > Digital Inputs

Name	Configuration
IN1	Amp Enable-LO Enables with Clear Faults
IN2	Not Configured
IN3	Not Configured
IN4	Not Configured
IN5	Motor Temp-Hi Disables
IN6	Encoder Fault-Active HI
IN7*	SLI MISO (Master Input Slave Output)

Input / Output > Digital Outputs

Name	Notes
OUT1	Fault-Active LO
OUT2	Not Configured
OUT3	Brake-Active Low
OUT4*	SLI MOSI (Master Output Slave Input)
OUT5*	SLI CLK (Clock)
OUT6*	SLI SS (Slave Select)

* If these outputs are not used for an SLI port, these outputs can be programmed for other functions.

Configure Filters > Filter Settings

Name	Notes
Analog Reference	Disabled
V Loop Input	Disabled
V Loop Output 1	Low Pass, Butterworth, 2 poles, 200 Hz
V Loop Output 2	Disabled
V Loop Output 3	Disabled
I Loop Input 1	Disabled
I Loop Input 2	Disabled
Input Shaping	Disabled, 0.1 Poles

Configure Faults > Latched Faults

Active	Notes
√	Short Circuit
√	Amp Over Temperature
√	Motor Over Temp
	Over Voltage
	Under Voltage
√	Feedback Error
	Motor Phasing Error
√	Following Error
	Command Input Lost
	Motor Wiring Disconnected
	STO Active

Home

Software Limits	Positive, Negative, Deceleration
Method	Set Current Position as Home
Fast Velocity	RPM
Slow Velocity	RPM
Accel / Decel	RPS
Offset	Counts
Homing Adjustment	Counts

Configure Faults > Optional Faults

Active	Notes
	Over Current (Latched)

√ These are the default settings for Latched Faults. Using CME, these can be checked or unchecked.

4.13 HIGH SPEED INPUTS: IN1, IN2, IN3, IN4, IN5, 1N6

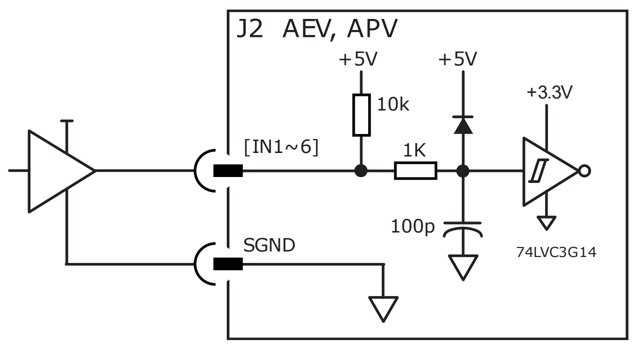
The six digital inputs to the AEV are programmable to a selection of functions.
All have 100 ns RC filters when driven by active sources (CMOS, TTL, etc.) and all have 10 kΩ pull-up resistors to +5 Vdc. In addition to the selection of functions, the active level for each input is individually programmable. Input level functions have programmable HI or LO to activate the function.
Input transition functions are programmable to activate on LO -> HI, or HI -> LO transitions.

INPUT LEVEL FUNCTIONS	INPUT TRANSITION FUNCTIONS
• Drive Enable, Enable with Clear Faults, Enable with Reset	• Clear Faults and Event Latch
• PWM Sync	• Drive Reset
• Positive Limit Switch	• PWM Sync Input
• Negative Limit Switch	• Trajectory Update
• Home Switch	• Count Input Edges, Save to Register
• Encoder Fault	• High-Speed Position Capture *
• Motor Temperature Sensor Input	• Simulated Absolute Encoder Burst
• Motion Abort	• Abort Move if > N Counts From Destination in Register
• High-Resolution Analog Divide	
*Note: The asterisk indicates the Encoder Index Pulse Capture is 2.5 us minimum pulse width, 0.1 us between active edge of input and capture of position, 5 us minimum pulse.	

SPECIFICATIONS

Input	Data	Notes
Input Voltages	HI	$V_T+ \geq$ 1.42~2.38 Vdc
	LO	$V_T^- \leq$ 0.68~1.6 Vdc
	Hys	V_H = 0.44~1.26
	Max	+6 Vdc
	Min	0 Vdc
Pull-up	R1	10 kΩ
Low Pass Filter	R2	1 kΩ
	C1	100 pF
	RC[1]	0.1 µs

J2 Sgnd Pins (APV)
3,4,18,31,32,33,34,42,49,50,59,60 (19~24)



CONNECTIONS

Signal	J2 Pins
IN1	5
IN2	6
IN3	7
IN4	8
IN5	9
IN6	10

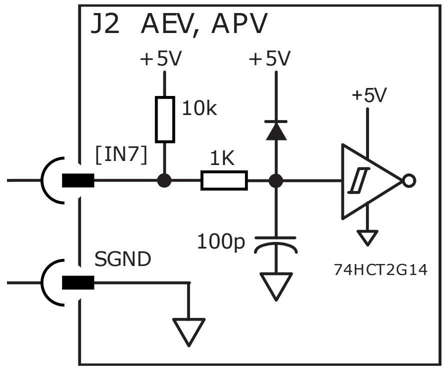
HIGH SPEED INPUT: IN7

- Digital, non-isolated
- Programmable functions
- MISO Input when SLI port is in use

SPECIFICATIONS

Input	Data	Notes
Input Voltages	HI	$V_T+ \geq$ 1.3~2.0 dc
	LO	$V_T^- \leq$ 0.55~1.3 Vdc
	Hys	V_H = 0.40~0.79 Vdc
	Max	+6 Vdc
	Min	0 Vdc
Pull-up	R1	10 kΩ
Low Pass Filter	R2	1 kΩ
	C1	100 pF
	RC	0.1 µs *

*Note: The asterisk indicates the RC time constant applies when input is driven by an active High/Low device.



CONNECTIONS

Signal	J2 Pins
IN7	11

J2 Sgnd Pins (APV)
3,4,18,31,32,33,34,42,49,50,59,60 (19~24)

4.14 ANALOG INPUT: AIN1

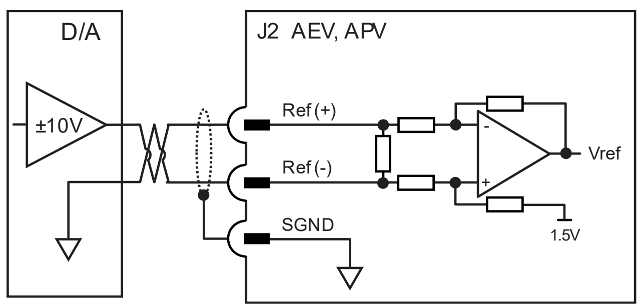
As a reference input, it takes Position/Velocity/Torque commands from a controller.
If it is not used as a command input, it can be used as a general-purpose analog input.

SPECIFICATIONS

Specifications	Data	Notes
Input Voltage	Vref	±10 Vdc
Input Resistance	Rin	5.09 kΩ

CONNECTIONS

AIN1	Signal	J2 Pins
Ref(+)	REFIN(+)	2
Ref(-)	REFIN(-)	1

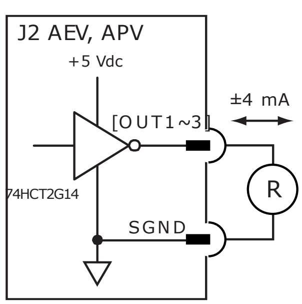


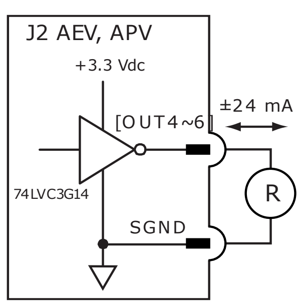
4.15 DIGITAL OUTPUTS: OUT1~OUT6

Digital outputs [OUT1~3] are HCT CMOS inverters. They operate from +5V and can source/sink 4 mAdc. [OUT4~6] are LVC CMOS inverters. They operate from 3.3V and can source/sink 24 mA. The output functions shown below are programmable to turn the output ON (HI) or OFF (LO) when active.

OUTPUT FUNCTIONS

- Fault
- Brake
- Custom event
- PWM Sync
- Custom Trajectory status
- Custom position-triggered output
- Program control





CONNECTIONS

Outputs	Signal	J2 Pins
OUT1	DOUT1	13
OUT2	DOUT2	12
OUT3	DOUT3	15
OUT4	DOUT4	14
OUT5	DOUT5	17
OUT6	DOUT6	1

4.16 SLI (Switch & LED Interface) PORT

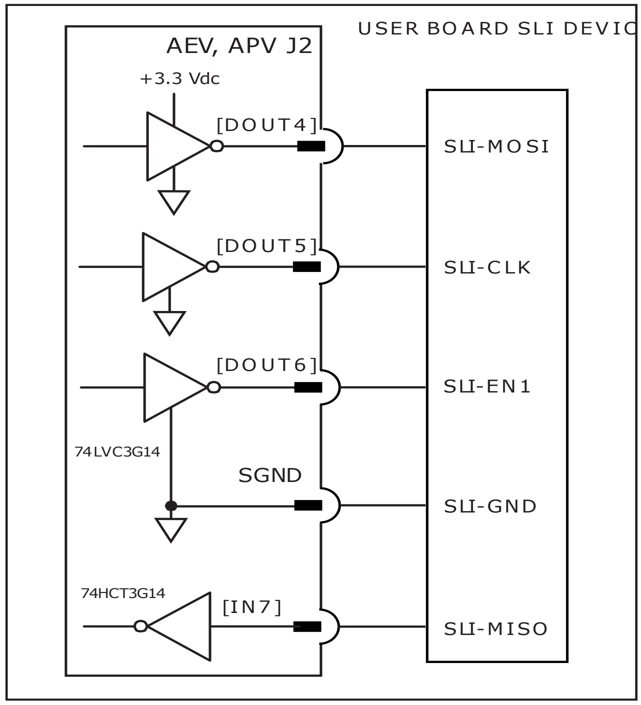
The three outputs and one input operate as an SLI (Switch and LED Interface) port for controlling LEDs and reading the settings of the network address switches. The graphic below shows them in SLI mode. If they are not used for SLI, they are programmable for other functions to turn the output ON (HI) or OFF (LO) when active. In the diagram, [IN7] is shown for completeness as part of the SLI function.

OUTPUT FUNCTIONS

- Fault
- Brake
- Custom event
- PWM Sync
- Custom Trajectory status
- Custom position-triggered output
- Program control

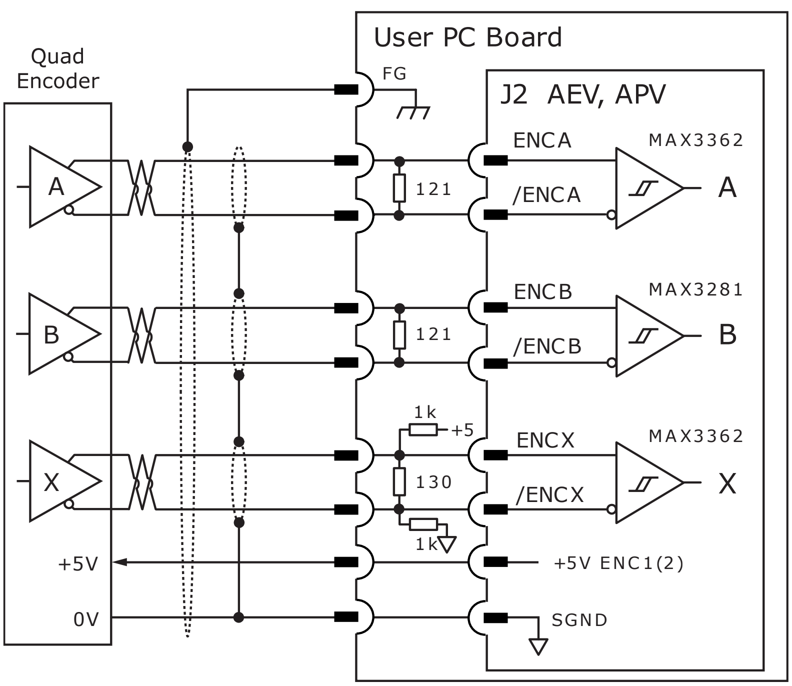
CONNECTIONS

SLI Port	Signal	J2 Pins
SLI-MOSI	DOUT4	14
SLI-CLK	DOUT5	17
SLI-EN1	DOUT6	16
SLI-GND	SGND	18
SLI-MISO	IN7	11



4.17 Encoder 1 (Primary Feedback)

QUAD A/B/X ENCODER



QUAD A/B/X SIGNALS

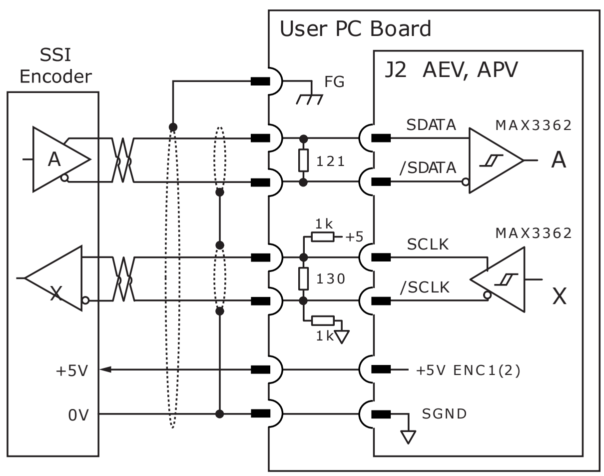
Quad Enc	Signal	J2 Pins
Enc A	ENCA1	43
Enc /A	/ENCA1	44
Enc B	ENCB1	45
Enc /B	/ENCB1	46
Enc X	ENCX1	47
Enc /X	/ENCX1	48
+5V	+5VENC	57,58

J2 Sgnd Pins (APV)
3,4,18,31,32,33,34,42,49,50,59,60 (19~24)

SSI ABSOLUTE ENCODER

The SSI (Synchronous Serial Interface) is an interface used to connect an absolute position encoder to a motion controller or control system. The drive provides a train of clock signals in differential format to the encoder which initiates the transmission of the position data on the subsequent clock pulses. The number of encoder data bits and counts per motor revolution are programmable.

The hardware bus consists of two signals: SCLK and SDATA. The SCLK signal is only active during transfers. Data is clocked in on the falling edge of the clock signal.



SSI Encoder

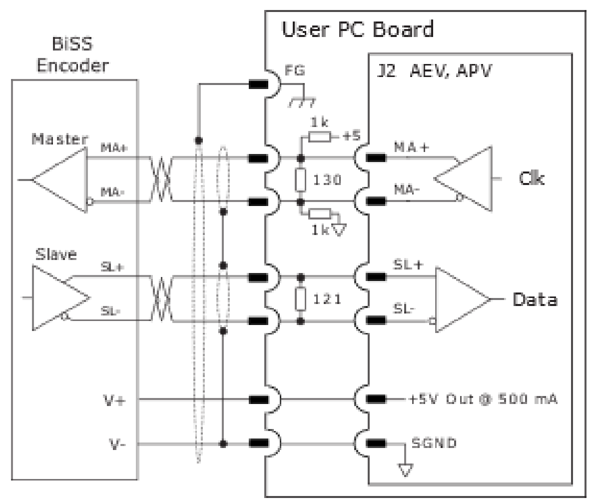
SSI, BiSS SIGNALS

SSI	BiSS	Signal	J2 Pins
SCLK	MA+	ENCX1	47
/SCLK	MA-	/ENCX1	48
SDATA	SL+	ENCA1	43
/SDATA	SL-	/ENCA1	44
+5V		+5VENC	57,58

BiSS ABSOLUTE ENCODER

BiSS is an Open Source digital interface for sensors and actuators. BiSS refers to principles of well-known industrial standards for Serial Synchronous Interfaces like SSI, AS-Interface® and Interbus® with additional options.

- Serial Synchronous Data Communication
- Cyclic at high speed
- 2 unidirectional lines Clock and Data
  - -Line delay compensation for high-speed data transfer
  - -Request for data generation at slaves
  - -Safety capable: CRC, Errors, Warnings
  - -Bus capability incl. actuators
- Bidirectional
  - -BiSS B-protocol: Mode choice at each cycle start
  - -BiSS C-protocol: Continuous mode



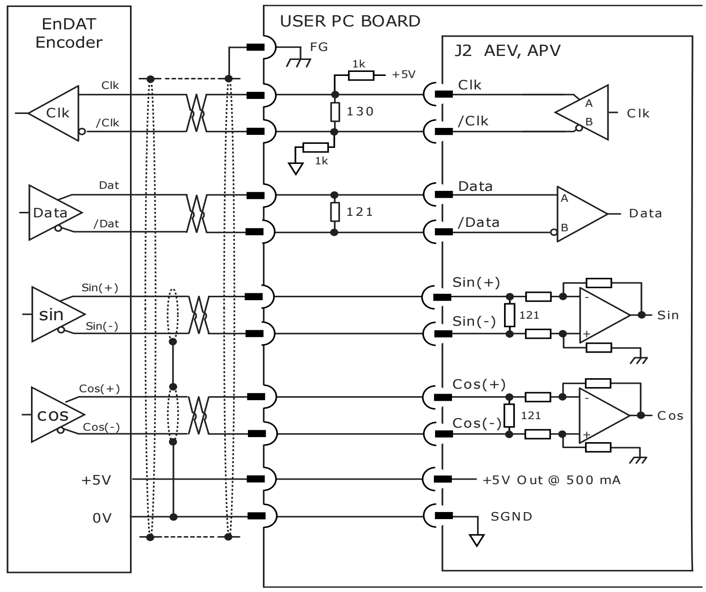
BiSS Encoder

Note: Single (outer) shields should be connected at the drive end. Inner shields are optional for digital encoders and should only be connected to Signal Ground on the drive.

J2 Sgnd Pins (APV)
3,4,18,31,32,33,34,42,49,50,59,60 (19~24)

ENDAT ABSOLUTE ENCODER

The EnDat interface is a Heidenhain interface that is similar to SSI in the use of clock and data signals, but which also supports analog Sin/Cos channels from the same encoder. The number of position data bits is programmable as is the use of Sin/Cos channels. Use of Sin/Cos incremental signals is optional in the EnDat specification.



ENDAT SIGNALS

EnDAT	Signal	J2 Pins
Clk	ENCX1	47
/Clk	/ENCX1	48
Data	ENCA1	43
/Data	/ENCA1	44
Sin(+) *	SIN1+	36
Sin(-) *	SIN1-	35
Cos(+) *	COS1+	38
Cos(-) *	COS1-	37
+5V	+5VENC	57,58

* Note: The asterisk indicates that the Sin/Cos are optional with EnDat 2.2, or any 1 Mbit or faster Endat Sin/Cos required if EnDat 2.1 < 1 Mbit.

J2 Sgnd Pins (APV)
3,4,18,31,32,33,34,42,49,50,59,60 (19~24)

ABSOLUTE-A ENCODER

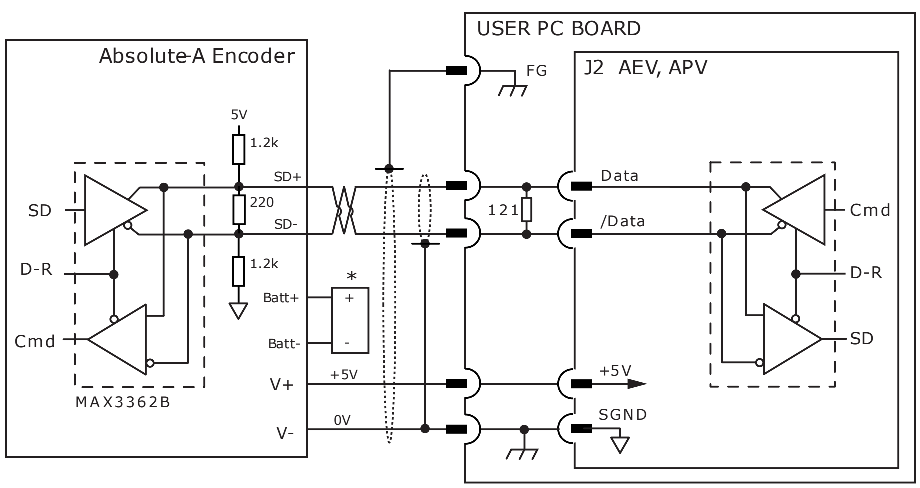
The Absolute A interface is a serial, half-duplex type that is electrically the same as RS-485. Note the battery which must be connected. Without it, the encoder will produce a fault condition.

ABS-A SIGNALS

Abs-A	Signal	J2 Pins
SD+	ENCA1	43
SD-	/ENCA1	44
+5V	+5VENC	57,58

- Absolute A
- Tamagawa Absolute A
- Panasonic Absolute A Format
- Sanyo Denki Absolute A

*Battery optional

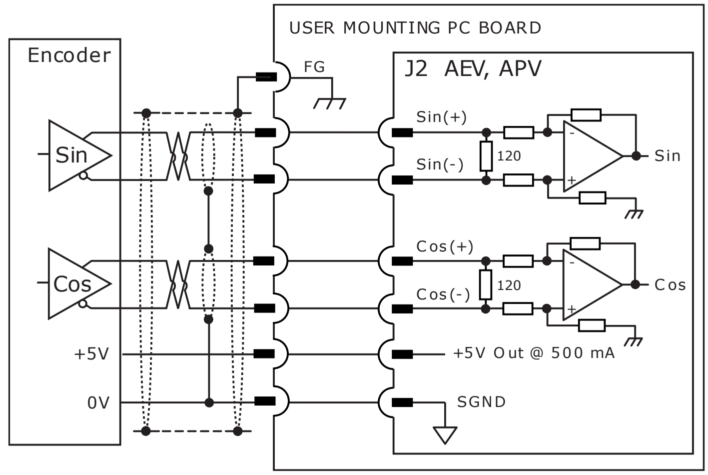


Note: Single (outer) shields should be connected at the drive end. The inner shield is optional for digital encoders and should only be connected to Signal Ground on the drive.

4.18 Analog Encoder

SIN/COS ENCODERS

Sin/Cos sensors in linear brushless motors are produced from the magnetic field in the rod and provide commutation feedback as well as higher resolution position feedback by interpolating of the signals. Incremental rotary encoders are also available with Sin/Cos outputs. Programmable interpolation enables the number of counts per revolution or linear movement to be programmable.



Sin/Cos	Signal	J2 Pins
SIN(+)	SIN1+	36
SIN(-)	SIN1-	35
COS(+)	COS1+	38
COS(-)	COS1-	37
+5V	+5VENC	57,58

J2 Sgnd Pins (APV)
3,4,18,31,32,33,34,42,49,50,59,60 (19~24)

4.19 Other Motor Connections

MOTOR TEMPERATURE SENSOR

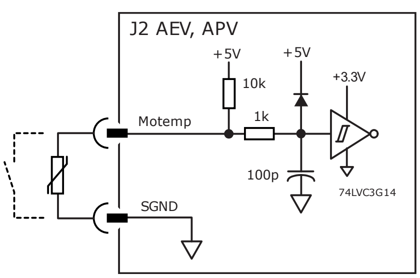
Any digital input is programmable for use with a motor overtemperature switch. Either a HI or LO input level is programmable to signal an over-temp condition.

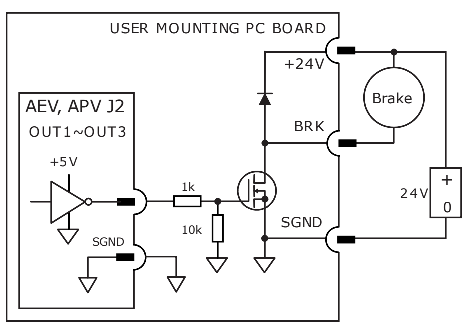
MOTOR BRAKE

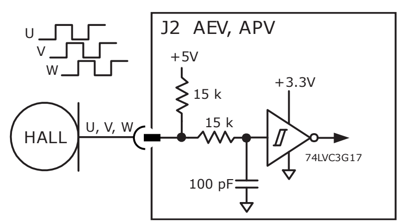
OUT1~OUT3 have +5V outputs that can control a MOSFET. When programmed for brake control with an active HI level, the output will turn on the MOSFET, releasing the brake and allowing the motor to move.

HALLS

Hall sensors in a brushless motor are produced from the magnetic field in the motor and provide commutation feedback without an encoder. When used with incremental encoders, they enable the motor to operate without a phase-finding cycle.







Motemp	Signal	J2 Pins
Motemp IN5	IN5	9

Brake	Signal	J2 Pins
OUT1	DOUT1	13
OUT2	DOUT2	12
OUT3	DOUT3	15

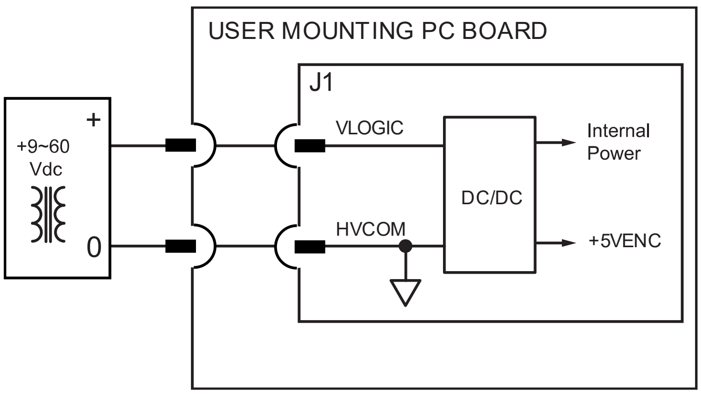
Halls	Signal	J2 Pins
Hall U	HALLU	39
Hall V	HALLV	40
Hall W	HALLW	41

4.20 VLOGIC

DESCRIPTION

Powers the internal logic and control circuits in the drive.
When using the STO feature, it must be produced by power supplies with transformer isolation from the mains and PELV or SELV ratings and a maximum output voltage of 60 Vdc. If the motor can operate from voltages of 60 Vdc or less, the +HV and VLOGIC can be driven from a single power supply.

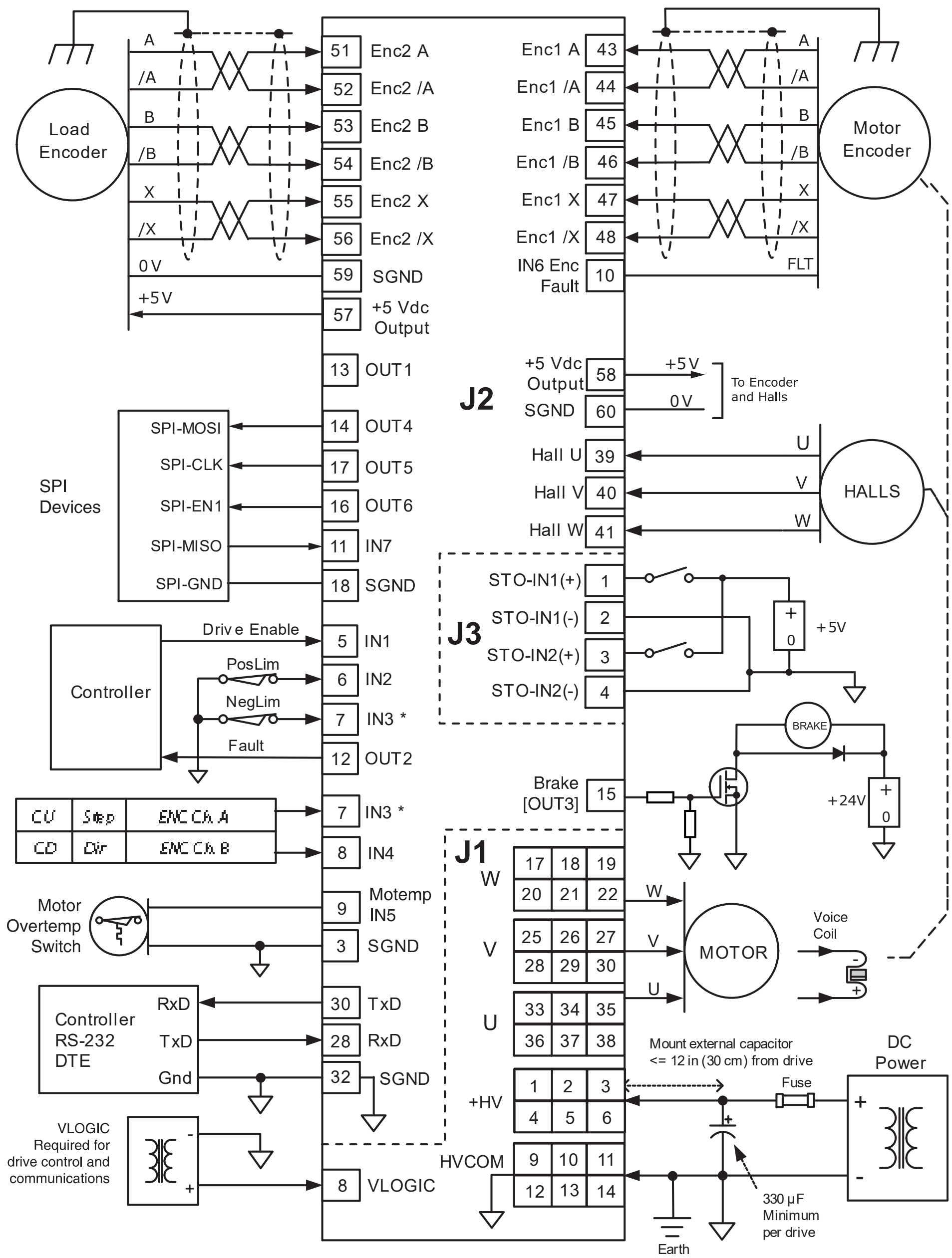
CAUTION	If +HV and VLOGIC are driven from the same power supply, the maximum voltage must not exceed 60 Vdc, the maximum voltage for VLOGIC. This maximum value can damage the VLOGIC circuits if exceeded. If motor/load deceleration can 'pump-up' the +HV, then VLOGIC should be supplied from a regulated power supply.



Signal	J1 Pins
VLOGIC	8
HVCOM	9,10,11 12,13,14

4.21 Typical Connections

The following graphic shows the functional connections between the AEV connectors and the various devices. The User mounting board connections are not shown.



Connections Diagram

Notes:

1. [IN1] is shown as Drive Enable and [IN2] and [IN3] are shown with some typical functions. [IN3] and [IN4] are shown as digital command inputs. Although [IN3] is shown twice, it should be used for no more than one function. If SLI function is used, it will not be available for other functions. All inputs are programmable.
2. [OUT2] is shown as a Fault signal to the controller and [OUT3] is shown as control for a motor brake. All outputs are programmable.
3. Encoder connections are shown for incremental types, but absolute encoders are supported on both primary and load encoder inputs.

5 CONNECTIONS AND WIRING – EZ BOARDS

The AEZ-090-50 and APZ-090-50 models consist of modules soldered into EZ boards to make a single assembly able to output the maximum rated 50 A currents. AEV and APV drives can plug into the same EZ boards except for the 50 A models which must be soldered to achieve their rated output currents.

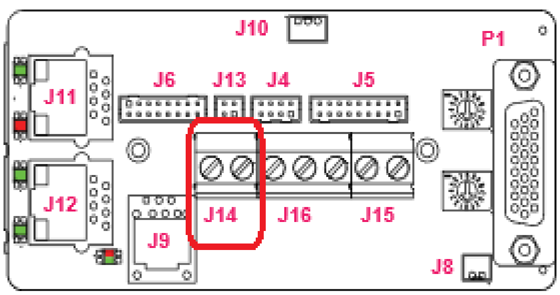
WARNING	**Model Restrictions:** • AEV-EZ-090, AEV-EZ-180 EZ boards are not compatible with AEV-090-50, AEV-090-50-C. • APV-EZ-090 and APV-EZ-180 EZ boards are not compatible with and must not be used with the APV-090-50, or APV-090-50-C Accelnet Micro Module models. • Refer to models: AEZ-090-50, AEZ-090-50-C, APZ-090-50, and APZ-090-50-C instead.
	Failure to heed this warning may cause equipment damage or injury.

POWER CONNECTOR LOCATIONS EZ BOARD MODELS

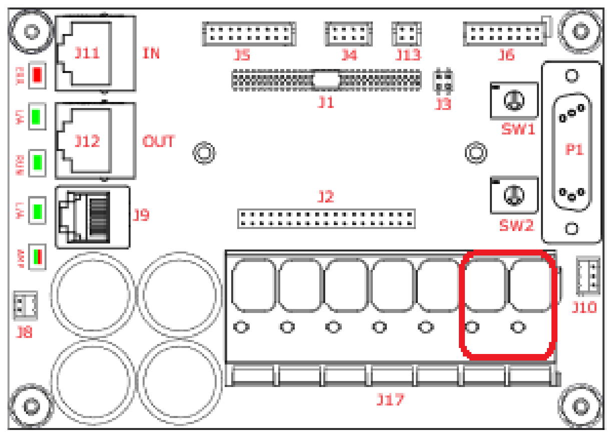
PROTECTIVE EARTH

Top View

APV models have the same connector numbers as the AEV models shown here.



EZ BOARD



EZ DEVELOPMENT BOARD

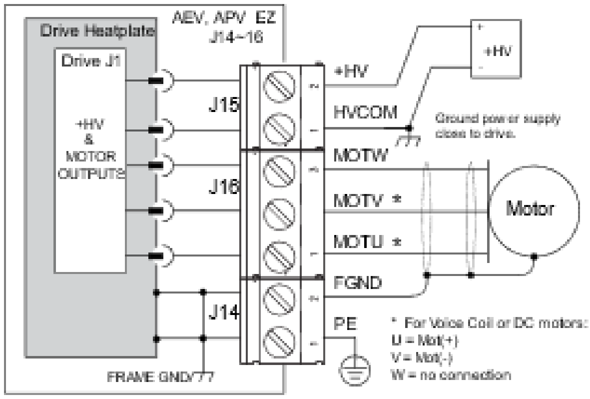
PROTECTIVE EARTH RECEPTACLE

Data	EZ Board J14	EZ Development Board J17
Description	Screw connection, 6.35 mm, 2-position, terminal block	Push-in CAGE CLAMP, 10 mm, 7-position, terminal block
Manufacturer PN	Phoenix Contact: 1714955	Wago: 2616-3107/020-000

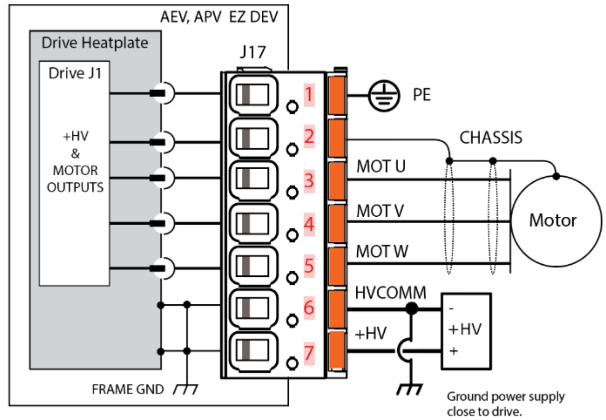
PROTECTIVE EARTH WIRING

Data	EZ Board J14	EZ Development Board J17
Wire size	22~10 AWG	18~4 AWG
Recommended Wire	22~10 AWG, 600 V Shielded cable required for CE compliance	18~4 AWG, 600 V Shielded cable required for CE compliance
Wire Insertion/Extraction Tool	Slotted screwdriver	Tool not required.

EZ BOARD



EZ DEVELOPMENT BOARD



Protective Earth & Ground Connections

EZ Board J14			EZ Development Board J17		
Pin	**Signal**	**Function**	**Pin**	**Signal**	**Function**
2	FGND	Frame Ground	1	PE	Protective Earth
1	PE	Protective Earth	2	FGND	Frame Ground (CHGND on PC board)

Motor Connections

EZ Board J16			EZ Development Board J17		
Pin	**Signal**	**Function**	**Pin**	**Signal**	**Function**
3	MOTW	Motor W	3	MOTU	Motor U
2	MOTV	Motor V	4	MOTV	Motor V
1	MOTU	Motor U	5	MOTW	Motor W

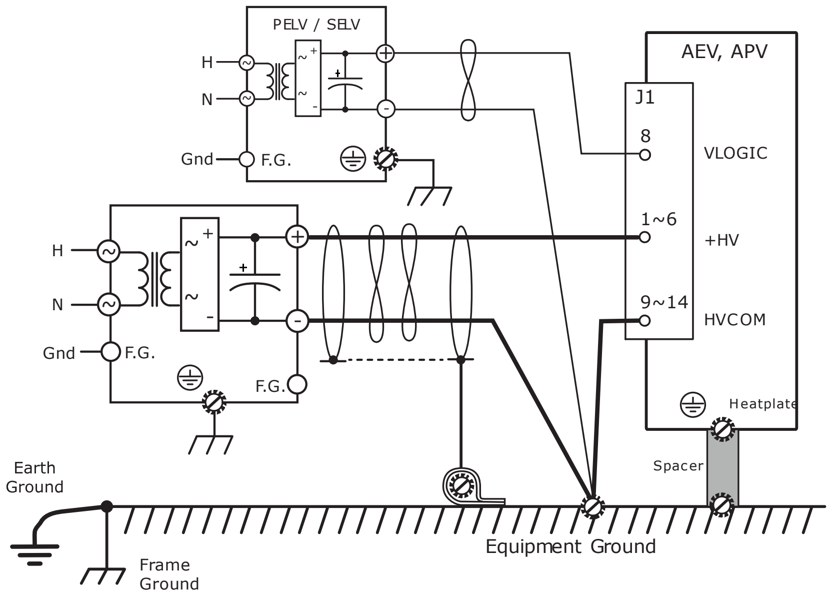
+HV Connections

EZ Board J15			EZ Development Board J17		
Pin	**Signal**	**Function**	**Pin**	**Signal**	**Function**
2	+HV	DC Power	6	HVCOMM	DC Ground
1	HVCOMM	DC Ground	7	+HV	DC Power

PROTECTIVE EARTH & POWER WIRING

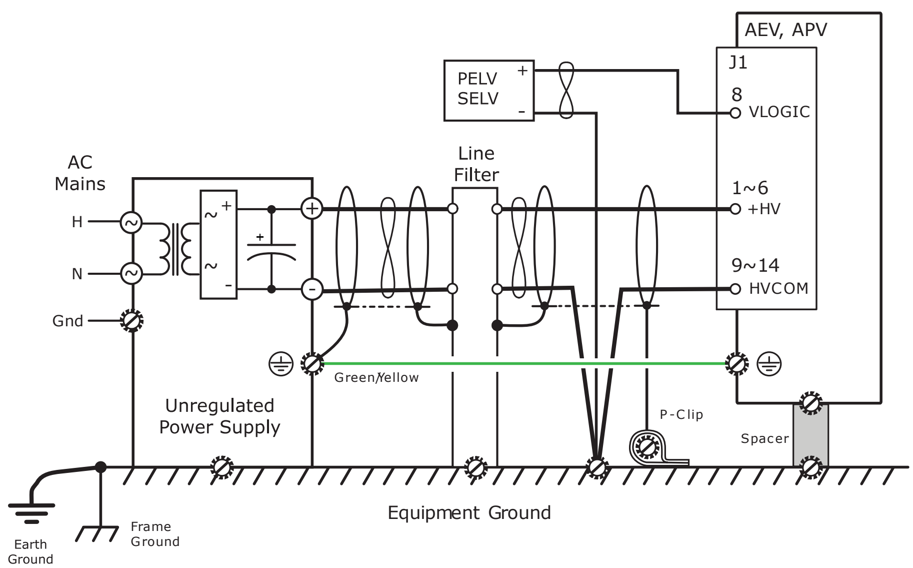
In soldered or socketed mounting of the drive, the PE (Protective Earth) connection is made by a conductive spacer that connects the drive heat plate to the mounting surface which has been grounded or connected to earth. When the drive is mounted with the heat plate against a panel that has a grounding connection, the mounting screws connect the drive to the panel. Power supplies should have the negative terminals grounded to the panel near to the drives.

NO AC Line Filter



WITH AC Line Filter

An EMI filter in the DC power cabling is not needed for operation. However, if it is important to minimize the RF emissions, this diagram shows the recommended practice for cable shielding and grounding.



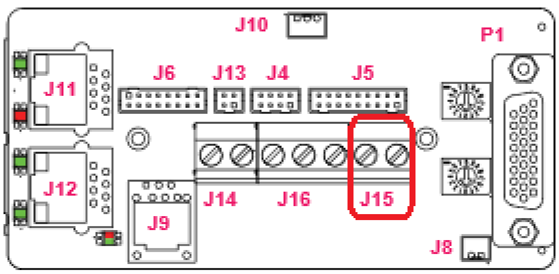
AC Line Filter

Manufacturer	Part Number
Schaffner	FN2200-50-34

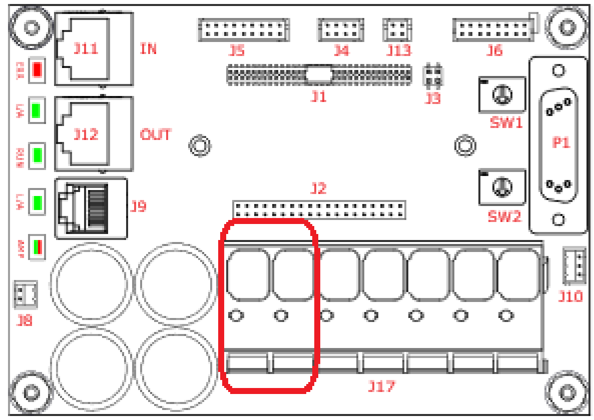
+HV Power

Top View

APZ models have the same connector numbers as the AEZ models shown here.



EZ Board



EZ Development Board

Power Receptacles

Data	EZ Board J15	EZ Development Board J17
Description	Screw connection, 6.35 mm, 2-position, terminal block	Push-in CAGE CLAMP, 10 mm, 7-position, terminal block
Manufacturer PN	Phoenix Contact: 1714955	Wago: 2616-3107/020-000

Power Cables

Data	EZ Board J15	EZ Development Board J17
Wire size	24~10 AWG	18~4 AWG
Recommended Wire	24~10 AWG, 600 V Shielded cable required for CE compliance	18~4 AWG, 600 V Shielded cable required for CE compliance
Wire Insertion/Extraction Tool	Slotted screwdriver	Hand-operated spring latch

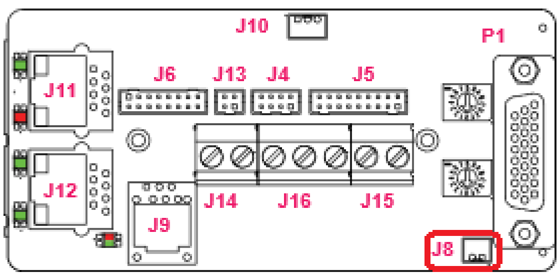
Power Pin Descriptions

EZ Board J15			EZ Development Board J17		
Pin	**Signal**	**Function**	**Pin**	**Signal**	**Function**
1	HVCOM	HV COM	6	HVCOMM	HVCOM
2	+HV	+HV	7	+HV	+HV

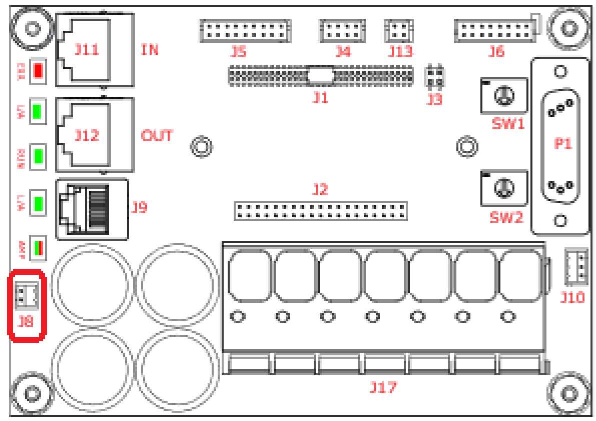
VLOGIC POWER

Top View

APZ models have the same connector numbers as the AEZ models shown here.



EZ BOARD



EZ DEVELOPMENT BOARD

VLOGIC Receptacle

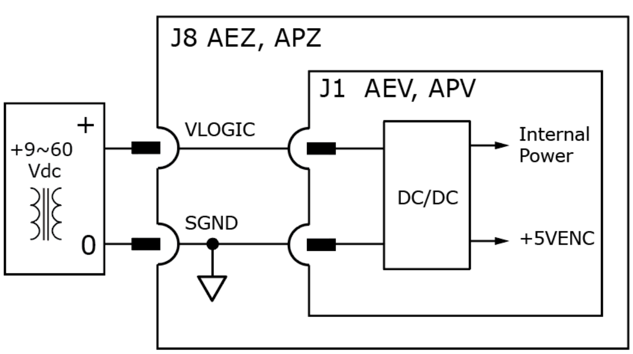
Description	Male receptacle, 2.0 mm, 2-position
Manufacturer PN	Hirose Electric: DF3-2P-2DSA(01)

VLOGIC Cable Mate

Description	Locking, 2.0 mm, 2-position, pluggable female receptacle.
Manufacturer PN	Hirose Electric: DF3-2S-2C
Wire Size	28~22 AWG
Recommended Wire	28~22 AWG, 600 V Shielded cable required for CE compliance
Connectors and contacts are included in Connector Kits AEV-EZ-CK, APV-EZ-CK	

VLOGIC Pin Descriptions

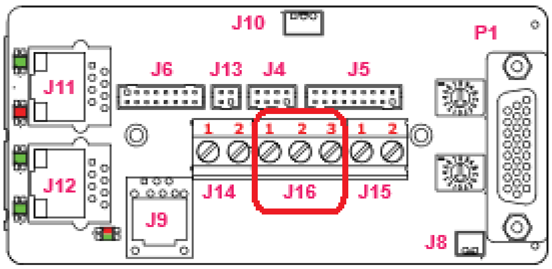
EZ Board J8			**EZ Development Board J8**		
Pin	**Signal**	**Function**	**Pin**	**Signal**	**Function**
1	+24V_VLOGIC	VLOGIC	1	+24V_VLOGIC	VLOGIC
2	SGND	SGND	2	SGND	SGND



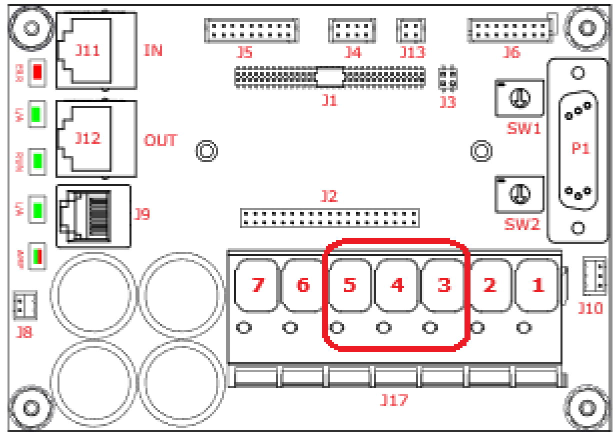
Note: When using the STO feature, VLOGIC must be produced by the power supplies with a transformer isolation from the mains, PELV or SELV ratings, and a maximum output voltage of 60 Vdc.

AEZ - Motor Connectors

Top View
APZ models have the same connector numbers as the AEZ models shown here.



EZ BOARD



EZ DEVELOPMENT BOARD

Motor Receptacle

Specifications	EZ Board	EZ Development Board
Description	Screw connection, 6.35 mm, 3-position, terminal block	Push-in CAGE CLAMP, 10 mm, 7-position, terminal block
Manufacturer PN	Phoenix Contact: 1714968	Wago: 2616-3107/020-000

Motor Cable

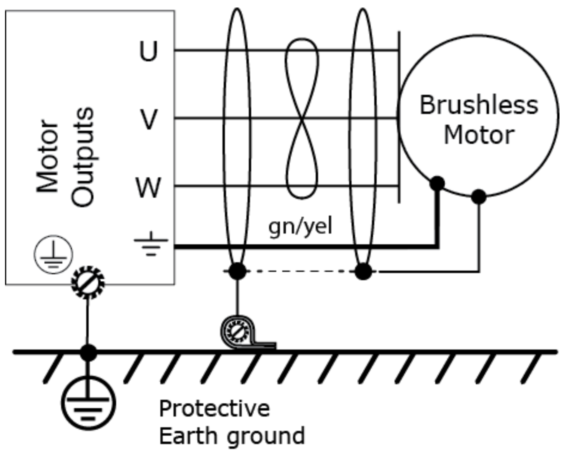
Specifications	EZ Board	EZ Development Board
Wire size	22~10 AWG	18~4 AWG
Recommended Wire	22~10 AWG, 600 V Shielded cable required for CE compliance	18~4 AWG, 600 V Shielded cable required for CE compliance
Wire Insertion/Extraction Tool	Slotted screwdriver.	Finger actuated spring clamps.

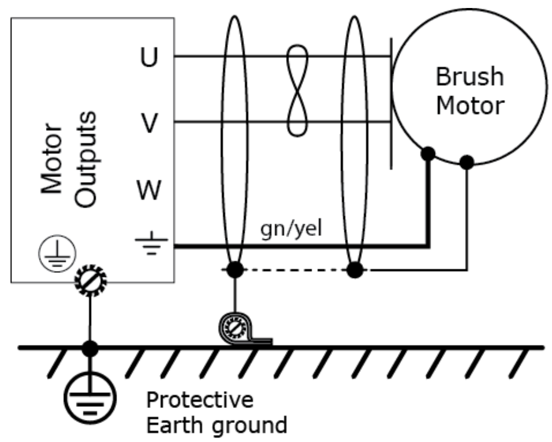
Pin Descriptions

EZ Board J16			EZ Development Board J17		
Pin	**Signal**	**Function**	**Pin**	**Signal**	**Function**
1	U	Phase U output (brush motor DC(+) connection)	3	U	Phase U output (brush motor DC(+) connection)
2	V	Phase V output (brush motor DC(-) connection)	4	V	Phase V output (brush motor DC(-) connection)
3	W	Phase W output	5	W	Phase W output

MOTOR CONNECTIONS

Typically, motor wires have connections for phases and for grounding the motor's frame. The grounding wire is commonly colored green with a yellow stripe. This should connect to the ground terminal of the motor connector. There should be a connection between the PE (Protective Earth) terminal to an earthed grounding point. PE and Ground are connected in the drive. This wiring ensures that the motor frame will always be at ground potential. Using shielded cable which connects to the motor frame and earth ground close to the drive provides a return path for currents induced in the shield and motor by the PWM outputs. P-clamps provide the best way to ground the shield for high-frequency noise suppression.



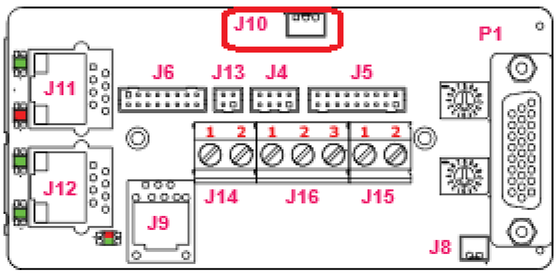


MOTOR BRAKE CONNECTOR

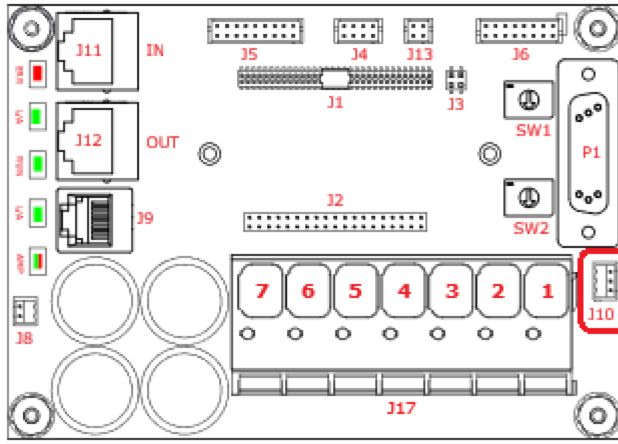
AEZ Brake Connector Locations

Top View

APZ models have the same connector numbers as the AEZ models shown here.



EZ BOARD



EZ DEVELOPMENT BOARD

Brake Receptacle

Description	Male receptacle, 2.0 mm, 3-position
Manufacturer PN	Hirose Electric: DF3-3P-2DSA(01)

Brake Cable Plug

Description	Locking, 2.0 mm, 3-position, pluggable female receptacle.
Manufacturer PN	Hirose Electric: DF3-3S-2C
Wire Size	28~22 AWG
Recommended Wire	28~22 AWG, 600 V Shielded cable required for CE compliance
Connectors and contacts are included in the AEV-EZ-CK and APV-EZ-CK Connector Kits.	

Connector Tools

Note: The following part is shown as a reference. It is not included in the connector kits, and it is not sold by Copley Controls.

Description	Manufacturer & PN
Contact Extraction tool for contacts	Hirose Electric: DF-C-PO (A)

Pin Descriptions

EZ Board J10			EZ Development Board J10		
Pin	**Signal**	**Function**	**Pin**	**Signal**	**Function**
1	+24V_IN	+24V Input	1	+24V_IN	+24V Input
2	BRAKE	Brake Output	2	BRAKE	Brake Output
3	HVCOM	HVCOM	3	HVCOM	HVCOM

Motor Brake Pin Descriptions

The brake output is an open-drain MOSFET with an internal flyback diode for driving inductive loads. It can sink up to 1A from a motor brake connected to the +24 Vdc supply. The operation of the brake is programmable with *CME*. It can also be programmed as general-purpose digital output (shown in the table below).

Pin	Signal	Function
1	+24V_IN	+24V Input
2	BRAKE	Brake Output
3	HVCOM	HVCOM

Specifications

Output	Data	Notes
Voltage Range	Max	+30 Vdc
Output Current	Ids	1.0 Adc

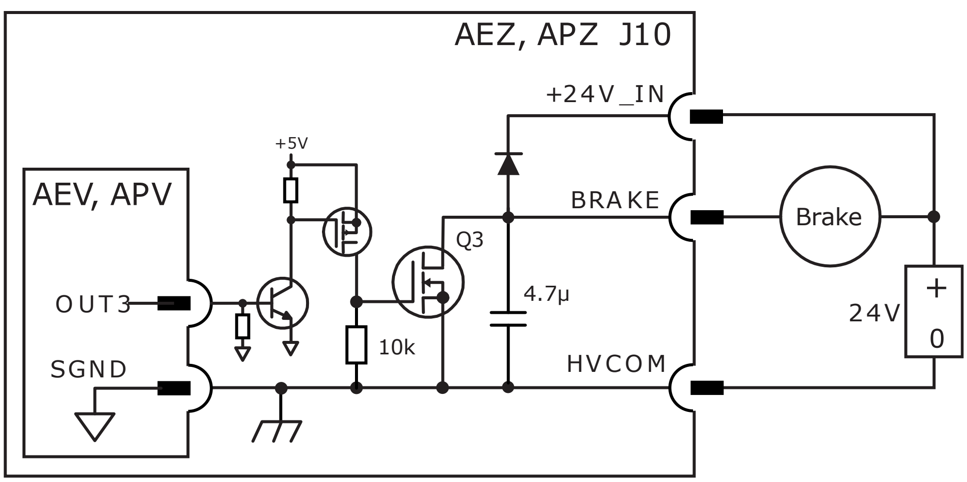
Hi/Lo Definitions: Outputs

Input	State	Condition
BRAKE [OUT3]	LO	Output MOSFET Q3 is OFF. Brake is un-powered and locks motor. Motor cannot move. Brake state is Active
	HI	Output MOSFET Q3 is ON. Brake is powered, releasing motor. Motor is free to move. Brake state is NOT-Active.

CME Default Setting for Brake Output [OUT3] is "Brake-Active Low".

Active = Brake is holding motor shaft (i.e., the *Brake is Active*).
- Motor cannot move.
- No current flows in coil of brake.
- CME I/O Line States shows [OUT3] as LO.
- BRK Output voltage is HI (24V), MOSFET Q3 is OFF.
- Servo drive output current is zero.
- Servo drive is disabled, PWM outputs are off.

Inactive = Brake is not holding motor shaft (i.e., the *Brake is Inactive*).
- Motor can move.
- Current flows in coil of brake.
- CME I/O Line States shows [OUT3] as HI.
- BRK output voltage is LO (~0V), MOSFET Q3 is ON.
- Servo drive is enabled, PWM outputs are ON.
- Servo drive output current is flowing.

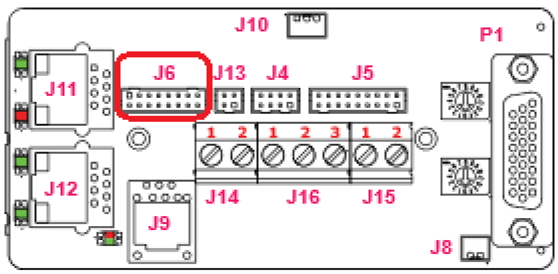


The EZ brake circuit is referenced to HVCOM and SGND in the AEZ, APZ.

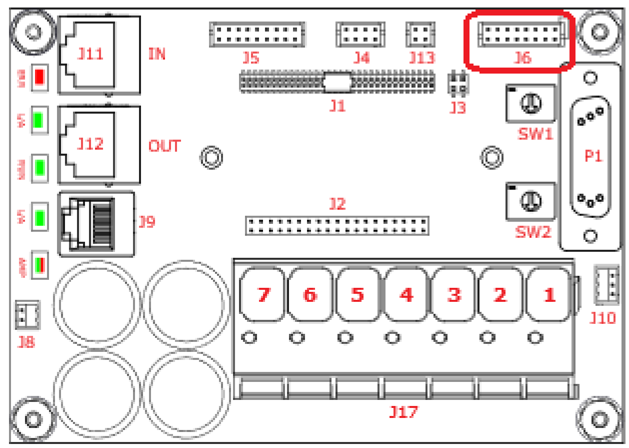
5.1 Safe Torque Off

WARNING	The information provided in Section 6 of this document must be considered for any application using the STO feature.
	Failure to heed this warning can cause equipment damage, injury, or death.

STO Connector Locations



EZ Board



EZ Development Board

STO Receptacle

Description	Male receptacle, 2.0 mm, 2 row, 16-position
Manufacturer PN	Hirose Electric: DF11-16DP-2DSA(01)

STO Connector

Description	Locking, 2.0 mm, 2 row, 16-position, pluggable female receptacle.
Manufacturer PN	Hirose Electric: DF11-16DS-2C
Wire Size	28~22 AWG
Recommended Wire	28~22 AWG, 600 V Shielded cable required for CE compliance
Connectors and contacts are included in Connector Kits AEV-EZ-CK, APV-EZ-CK.	

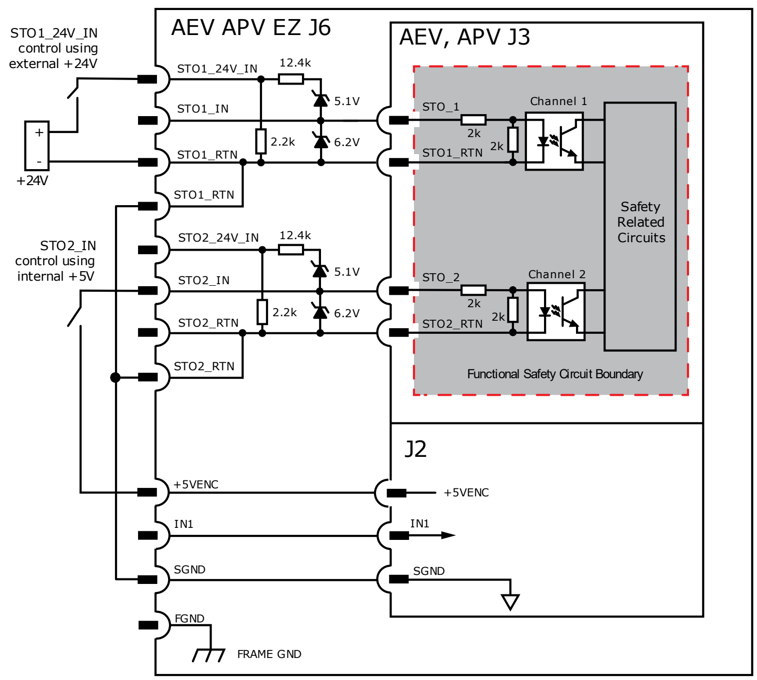
Connector Tools

Note: Although the following part is not included in the Connnector Kits, and it is not sold by Copley Controls, it may be used and it is included for the user's reference.

Description	Manufacturer & PN
Contact Extraction tool for contacts	Hirose Electric: DF-C-PO (B)

STO Pin Description

Pin	Signal	Function	Pin	Signal	Function
1	STO1_RTN	Low Side of IN1	9	STO2_RTN	Low Side of IN1
2	STO1_24V_IN	+24V Compatible High Side of IN1	10	STO2_IN	+5V Compatible High Side of IN1
3	STO1_RTN	Low Side of IN1	11	N.C.	No Connection
4	STO1_IN	+5V Compatible High Side of IN1	12	N.C.	No Connection
5	N.C.	No Connection	13	SGND	Signal Ground
6	N.C.	No Connection	14	FGND	Chassis
7	STO2_RTN	Low Side of IN1	15	IN1	Input 1
8	STO2_24V_IN	+24V Compatible High Side of IN1	16	+5VENC	+5V Encoder Power



EZ Board STO Diagram

The above graphic shows how the EZ Board STO inputs can be driven from 5V or 24V sources.
The AEV and APV EZ Development boards have the same connections as the EZ board shown in the above example.

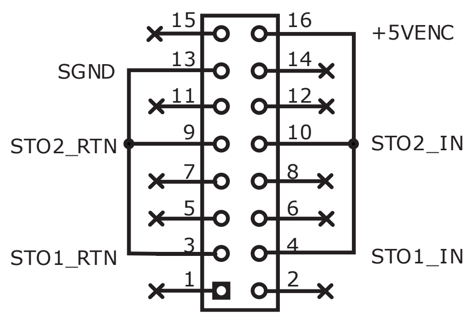
Note: When the STO feature is used, the voltages used to disable the STO function must be produced by the power supplies with transformer isolation from the mains and PELV or SELV

STO Disabling

If an application does not require the STO feature, then it can be disabled by energizing the STO inputs with a power source as shown in the EZ Board STO Diagram. When the STO feature is not used, these connections must be made for the Accelnet Plus Micro Module to be enabled by software or hardware means.

STO Disabling Accessory

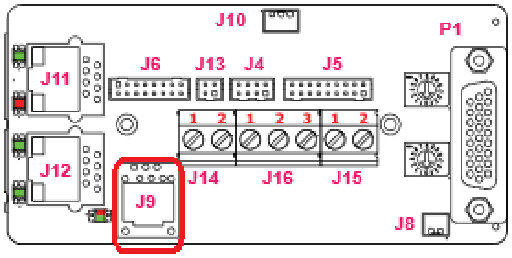
This is a small PCB that plugs into J6. It makes connections between the STO inputs and the internal +5V that energize the inputs, disabling the STO feature.
It is included in the AEV-EZ-CK and APV-EZ-CK Connector Kits.



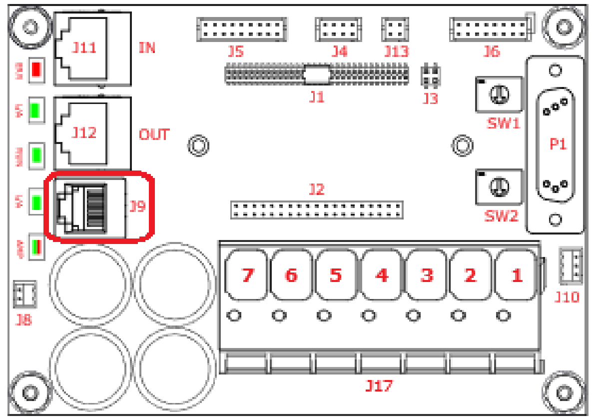
AEV-EZ-STO
APV-EZ-STO

5.2 RS-232 Serial Communications

Connector Locations



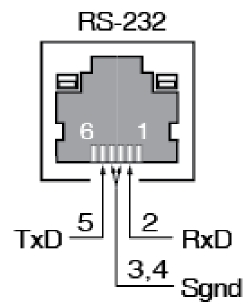
EZ Board



EZ Development Board

RS-232 J9 Connector

6-position, 4-contact, modular connector (RJ-11 style).



RS-232 J9 Pins

The RS-232 port connections function as DTE (Data Terminal Equipment).

Pin	Signal	RS-232 J9	Function
1	N/C	N/C	No connection
2	RS232RX	RxD	Receive data input from computer
3	SGND	SGND	Signal Ground
4	SGND	SGND	Signal Ground
5	RS232TX	TxD	Transmit data output to computer
6	N/C	N/C	No connection

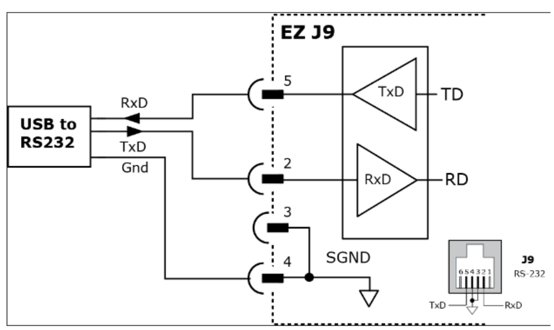
RS-232 Serial Cable Kit

This table shows the Serial Cable Kit part number used for the different drive families.

Part Number	Description
SER-USB-RJ11	Serial Interface Cable: USB to RJ11

RS-232 CONNECTION

The RS-232 port is used to configure the drive for stand-alone applications, or for configuration before it is installed into an CANopen network. CME software communicates with the drive over this link and is then used for complete drive setup. The CANopen Device ID that is set by the rotary switches can be monitored, and a Device ID programmed as well. The RS-232 connector, J9, is a modular RJ-11 type that uses a 6-position plug, four wires of which are used for RS-232. A Serial Interface Cable: USB to RJ11 (SER-USB-RJ11) is available that includes the USB and the RJ-11 connectors to interface this cable with a 6-pin RS-232 port.



EZ Board J9 Connection

SER-USB-RJ11

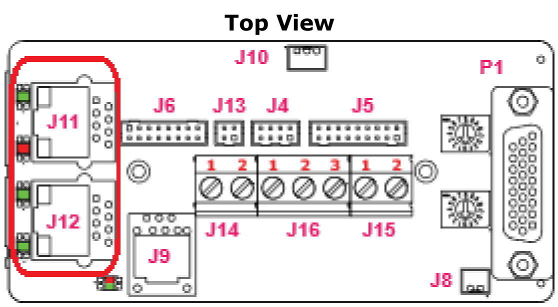
This device provides connectivity between a USB connector and the RJ-11 connector J9 on the DEV board.

Note: The Serial Interface Cable USB to RJ11 (SER-USB-RJ11) can be used to plug-into either a customer-designed board with an RJ11 or a Copley Development board. When you order either type of board, the Manufacturer recommends you order the Serial Interface Cable USB to RJ11 (SER-USB-RJ11).

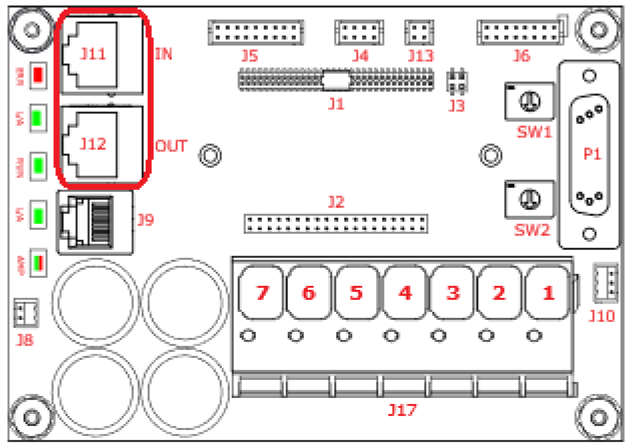
SER-USB-RJ11

5.3 Network Ports

EtherCAT:



EZ Board



EZ Development Board

Mating Connector

Dual RJ-45 sockets accept standard Ethernet cables and are categorized as 100BASE-TX (100 Mb/sec) ports. Cat 5 or Cat 5e (or higher) cables should be used. The IN port connects to a master, or to the OUT port of a device that is 'upstream' between the Accelnet Plus Micro Modules and the master. The OUT port connects to 'downstream' nodes. If a Accelnet Plus Micro Module drive is the last node on a network, only the IN port is used. No terminator is required on the OUT port.

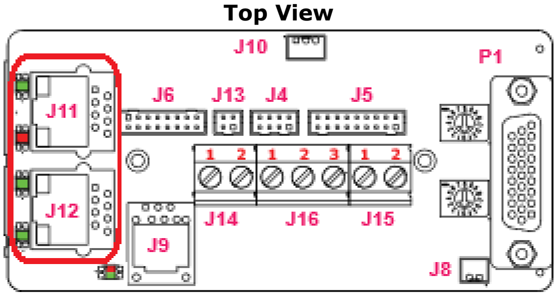
Pin Description*

Pin	Signal J11	Function
1	ECATTX1+	Transmit Data1(+)
2	+3.3V_TXRX1	Terminator 1
3	ECATTX1-	Transmit Data1(-)
4	ECATRX1+	Receive Data1(+)
5	+3.3V_TXRX1	Terminator 1
6	ECATRX1-	Receive Data1(-)
7	n.c.	No connection
8	FGND	Frame Ground

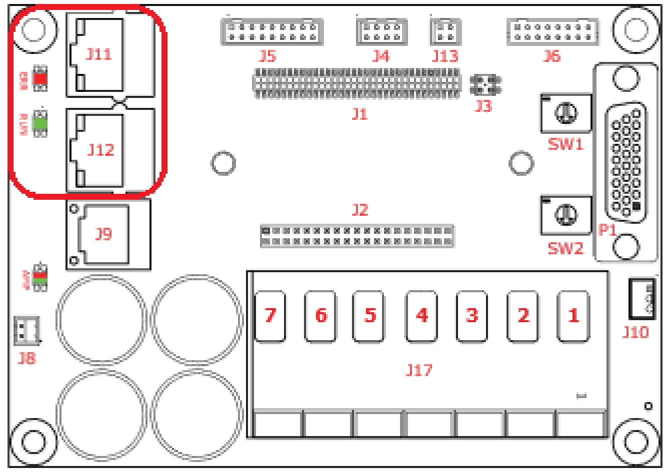
Pin	Signal J12	Function
1	ECATTX2+	Transmit Data2(+)
2	+3.3V_TXRX2	Terminator 2
3	ECATTX2-	Transmit Data2(-)
4	ECATRX2+	Receive Data2(+)
5	+3.3V_TXRX2	Terminator 2
6	ECATRX2-	Receive Data2(-)
7	n.c.	No connection
8	FGND	Frame Ground

CAN Bus: APZ

Top View



EZ Board

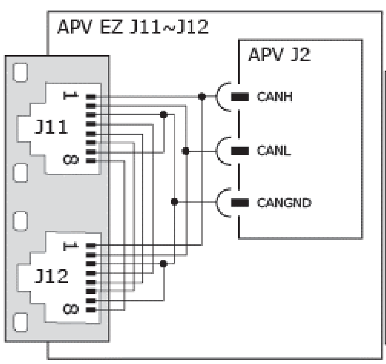


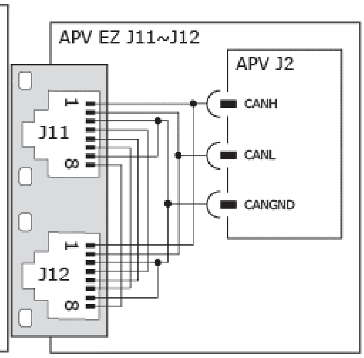
EZ Development Board

Pin Description

Pin	Signal J11	Function
1	CANH	TxRx-HI
2	CANL	TxRx-LO
3	CANGND	TxRx-GND
4	Pass-thru	None
5	Pass-thru	
6	Pass-thru	
7	CANGND	TxRx-GND
8	Pass-thru	None

Pin	Signal J12	Function
1	CANH	TxRx-HI
2	CANL	TxRx-LO
3	CANGND	TxRx-GND
4	Pass-thru	None
5	Pass-thru	
6	Pass-thru	
7	CANGND	TxRx-GND
8	TX2 Term	None





Note: There are no IN and OUT labels on a CAN network. CANH and CANL are shared by all drives on a network and an arbitration method determines which node can send or receive with the bus master. Pass-thru signals have no connections to the drives.

Mating Connector

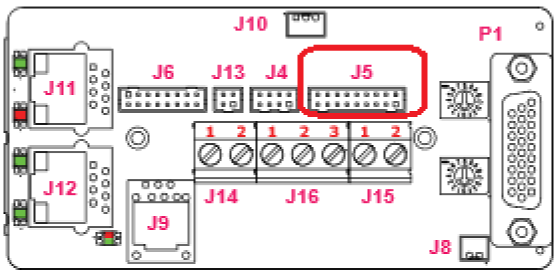
Dual RJ-45 sockets accept standard Ethernet cables for CAN bus communications. Ports are wired pin-to-pin making the IN and OUT ports electrically identical. The last drive on a single-string network should have a 121 Ω CAN terminator in the unused port.

5.4 Control I/O

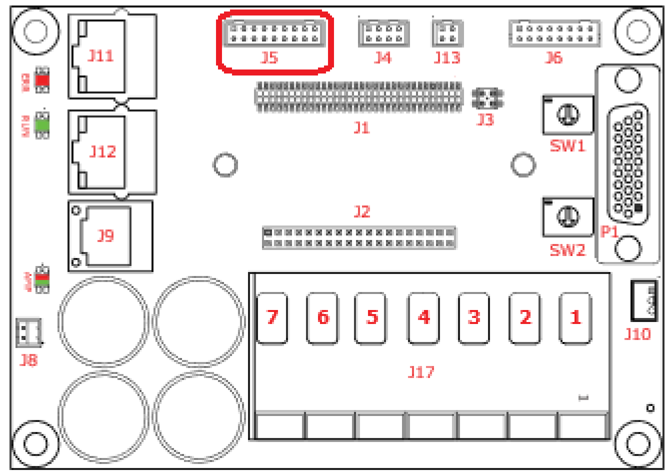
AEZ, APZ I/O Connector J5 Location

Top View

The views show the AEV, but the I/O connectors are the same for the APV.



EZ Board



EZ Development Board

I/O Receptacle

Description	Male receptacle, 2.0 mm, 2 row, 18-position
Manufacturer PN	Hirose Electric: DF11-18DP-2DSA(01)

I/O Plug

Description	Locking, 2.0 mm, 2 row, 18-position, pluggable female receptacle.
Manufacturer PN	Hirose Electric: DF11-18DS-2C
Wire Size	28~22 AWG
Recommended Wire	28~22 AWG, 600 V Shielded cable required for CE compliance
Connectors and contacts are included in Connector Kits AEV-EZ-CK, APV-EZ-CK.	

J5 Pin Descriptions

Pin	EZ BOARDS
1	Aref(+)
2	Aref(-)
3	IN2
4	IN1 Enable
5	IN4
6	IN3

Pin	EZ BOARDS
7	IN6 Enc Fault
8	IN5 Motemp
9	OUT2
10	IN7 SLI-MISO
11	OUT4 SLI-MOSI
12	OUT1

Pin	EZ BOARDS
13	OUT6 SLI-EN1
14	OUT3 Brake
15	SGND
16	OUT5 SLI-CLK
17	SGND
18	SGND

J5 Pin Signals

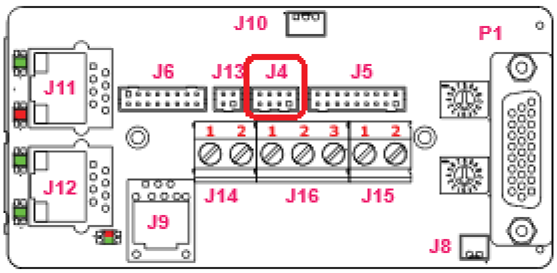
Pin	Signal
1	REFIN1+
2	REFIN1-
3	IN2
4	IN1
5	IN4
6	IN3

Pin	Signal
7	IN6
8	IN5
9	DOUT2
10	IN7
11	DOUT4
12	DOUT1

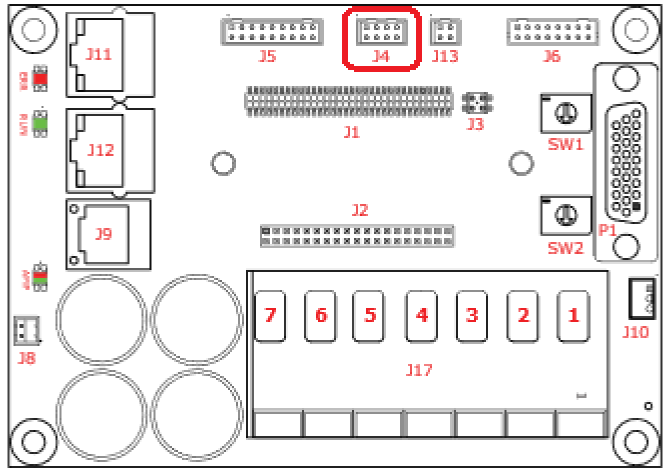
Pin	Signal
13	DOUT6
14	DOUT3
15	SGND
16	DOUT5
17	SGND
18	SGND

AEZ, APZ Secondary Encoder Connector J4 Location

Top View
The views shown are of AEV but the I/O connectors are the same for the APV.



EZ Board



EZ Development Board

Secondary Encoder Receptacle

Description	Male receptacle, 2.0 mm, 2 row, 8-position
Manufacturer PN	Hirose Electric: DF11-8DP-2DSA(01)

Secondary Encoder Plug

Description	Locking, 2.0 mm, 2 row, 8-position, pluggable female receptacle.
Manufacturer PN	Hirose Electric: DF11-8DS-2C
Wire Size	28~22 AWG
Recommended Wire	28~22 AWG, 600 V Shielded cable required for CE compliance
Connectors and contacts are included in Connector Kits AEV-EZ-CK, APV-EZ-CK.	

J4 Pin Descriptions

Pin	EZ Boards
1	Enc2 /A
2	Enc2 A
3	Enc2 /B
4	Enc3 B

Pin	EZ Boards
5	Enc2 /X
6	Enc2 X
7	+5V ENC
8	SGND

J4 Pin Signals

Pin	Signal
1	/ENCA2
2	ENCA2
3	/ENCB2
4	ENCB2

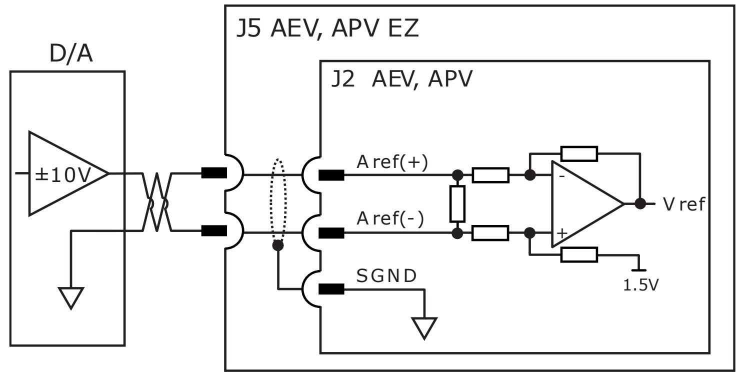
Pin	Signal
5	/ENCX2
6	ENCX2
7	+5VENC
8	SGND

Analog Inputs

The analog input has a ±10 Vdc range at 16-bit resolution
As reference input, it can take Position/Velocity/Torque commands from the controller.
If it is not used as a command input, it can be used as a general-purpose analog input.

Analog Input J5 Wiring Diagram

EZ Boards	Signal	J5 Pins
Aref(+)	REFIN1+	1
Aref(-)	REFIN1-	2
SGND	SGND	15, 17, 18

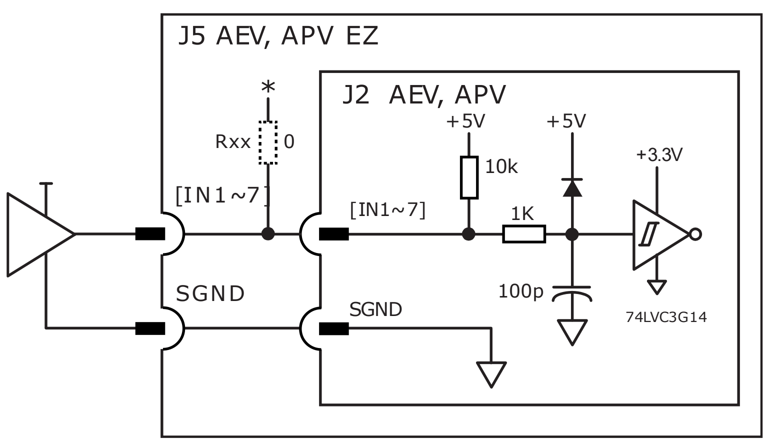


Digital Inputs: Non-Isolated

EZ Boards	Signal	J5 Pins
IN1 In1 Enable	IN1	4
IN2	IN2	3
IN3	IN3	6
IN4	IN4	5
IN5 Motemp	IN5	8
IN6 Encoder Fault	IN6	7
IN7 SLI-MISO	IN7	10
Signal Ground	SGND	15, 17, 18

Note:
Logic inputs max. input voltage is +6 Vdc.
Rxx shows the location of a 0 Ω resistors that are in place as R40 and R44.

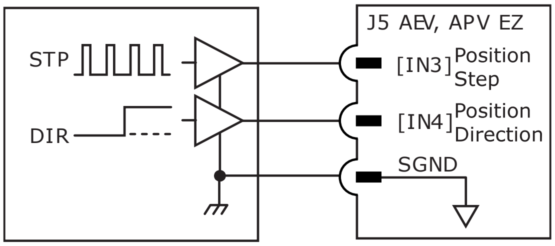
- R40 connects the SLI-MISO signal to IN7 which is used by the SLI port that controls the LEDs and reads the address switches.
- R44 connects the Encoder Fault signal to IN6. If neither of these functions are needed, then R40 and R44 can be removed making IN6 & IN7 available as logic inputs.



Digital Inputs for Position Command: AEZ, APZ

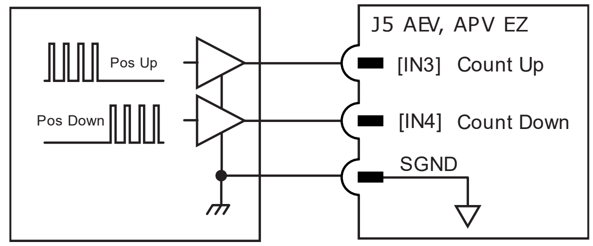
Step / Direction

Single-Ended



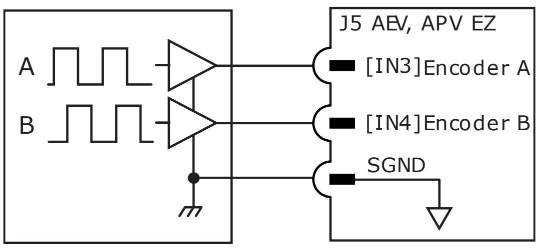
Count-Up/Count-Down (CU/CD)

Single-Ended



Quad A/B Encoder

Single-Ended

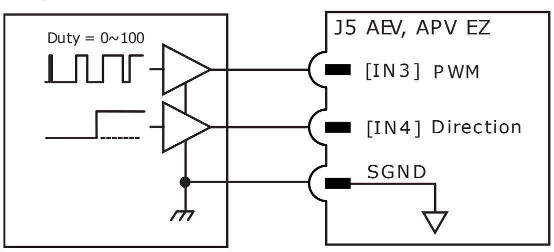


EZ Boards			Signal	J5 Pins
STP	Pos Up	A	IN3	6
DIR	Pos Down	B	IN4	5

Digital Inputs for Velocity / Torque Command: AEZ, APZ

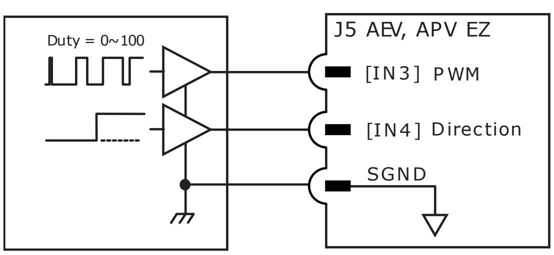
Single-Ended

PWM / Direction



Single-Ended

PWM 50%

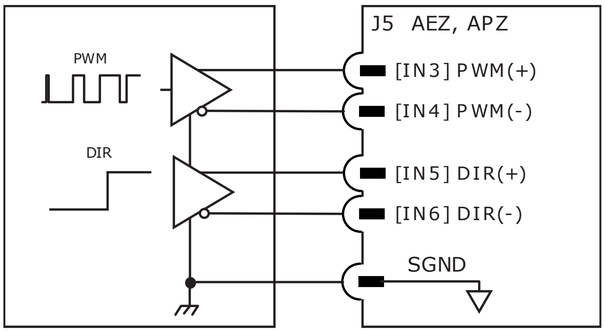


EZ Boards		Signal	J5 Pins
PWM	PWM 50%	IN3	6
DIR	N.C.	IN4	5

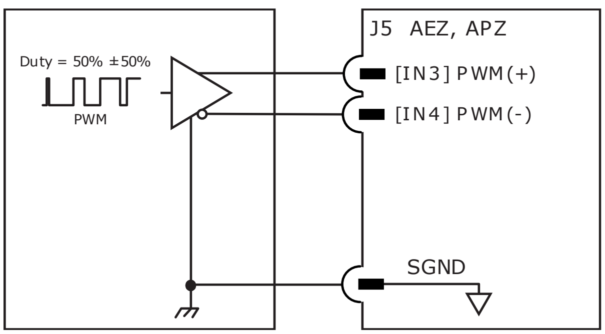
DIGITAL INPUTS AS DIFFERENTIAL COMMAND: AEZ & APZ

The following diagrams show the inputs used with the differential command input signal formats.

PWM / DIRECTION



PWM 50%



EZ Boards		Signal	J5 Pins
PWM	PWM 50%	IN3	6
		IN4	5
DIR	N.C.	IN5	8
		IN6	7

SECONDARY ENCODER AS MULTI-MODE PORT

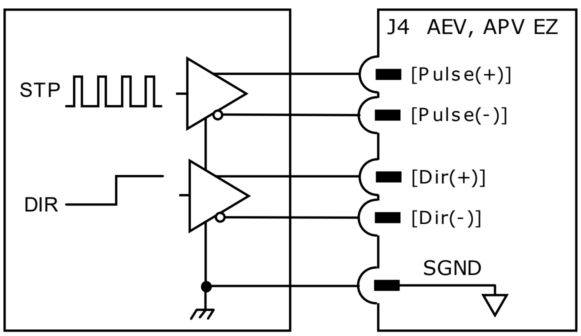
OVERVIEW

This port consists of three differential input/output channels that take their functions from the Basic Setup of the drive. With Quad A/B Motor Encoder Feedback, the port works as an output, buffering the signals from the encoder. With Sin/Cos Encoders, the feedback is converted to "emulated" quad A/B signals with programmable resolution. These signals can then be fed back to an external motion controller that closes the position or velocity loops. As an input, the port can take quad A/B signals to produce a dual-loop position control system or use the signals as master-encoder commands in camming mode. In addition, the port can take stepper command signals (CU/CD or Pulse/Direction) in the differential format. Absolute encoders are used frequently for feedback of the load position with the motor using incremental feedback for commutation and velocity feedback.

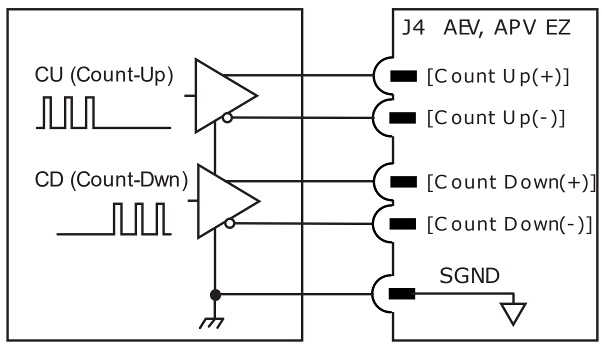
DIFFERENTIAL COMMAND INPUTS

- Pulse & Direction
- CW & CCW (Clockwise & Counter-Clockwise)
- Encoder Quad A & B
- Camming Encoder A & B input

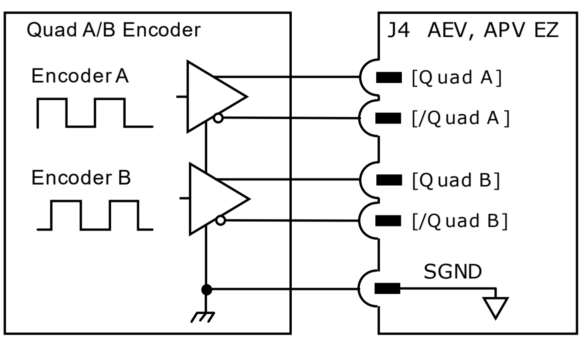
PULSE-DIRECTION



COUNT-UP/COUNT-DOWN (CU/CD)



QUAD A/B ENCODER

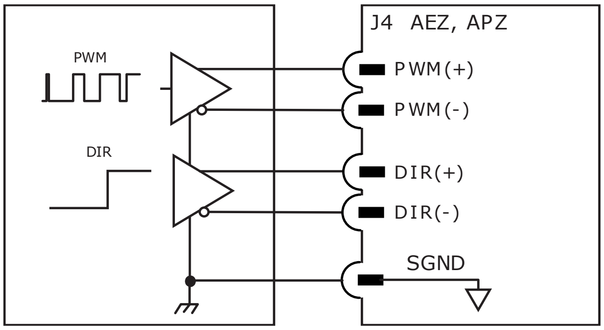


Input Type			EZ Board	Signals	J4 Pins
Pulse(+)	Count-Up(+)	Quad A	Enc2 A	ENCA2	2
Pulse(-)	Count-Up(-)	/Quad A	Enc2 /A	/ENCA2	1
Dir(+)	Count-Down(+)	Quad B	Enc2 B	ENCB2	4
Dir(-)	Count-Down(-)	/Quad B	Enc2 /B	/ENCB2	3
Sgnd					8

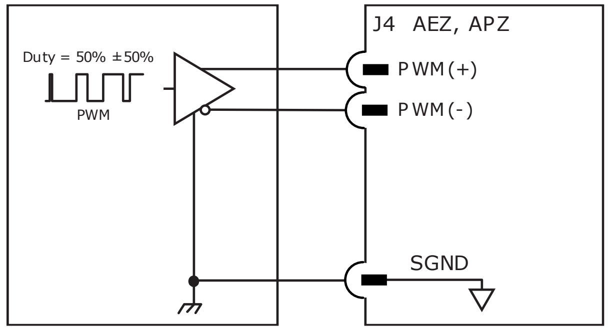
Multi-Mode Port Differential Current (Torque) or Velocity Command Input Connections

- PWM & Direction
- PWM 50%

PWM-Direction



PWM 50%



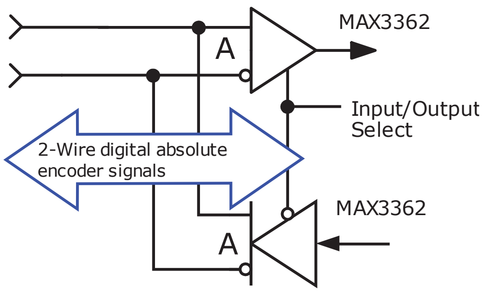
AEZ, APZ

Input Type	J4 EZ	Signals	J4 Pins
PWM(+)	Enc2 A	ENCA2	2
PWM(-)	Enc2 /A	/ENCA2	1
Dir(+)	Enc2 B	ENCB2	4
Dir(-)	Enc2 /B	/ENCB2	3
Signal Ground			8

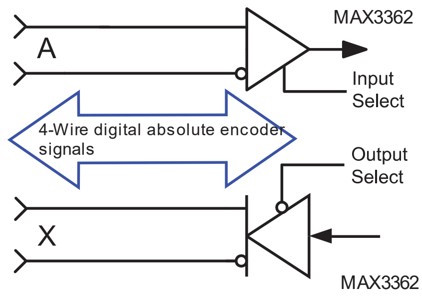
MULTI-MODE PORT SECONDARY ABSOLUTE ENCODER INPUTS

- 2-Wire: Absolute A
- 4-Wire: BiSS, SSI, EnDat

2-WIRE

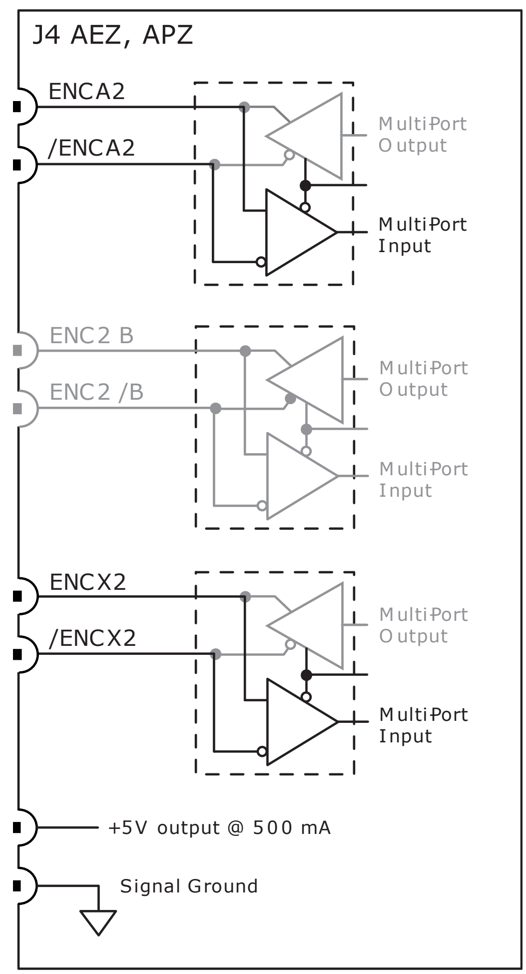


4-WIRE



AEZ, APZ

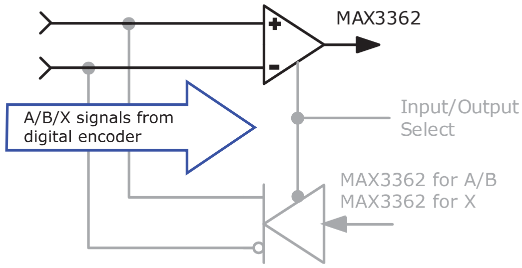
Abs A	SSI, BiSS, EnDat	J4 Ez	Signals	J4 Pins
Data	Data	Enc2 A	ENCA2	2
/Data	/Data	Enc2 /A	/ENCA2	1
	Clk	Enc2 X	ENCX2	6
	/Clk	Enc2 /X	/ENCX2	5
Signal Ground				8



Multi-Mode Port Secondary Incremental Encoder Inputs

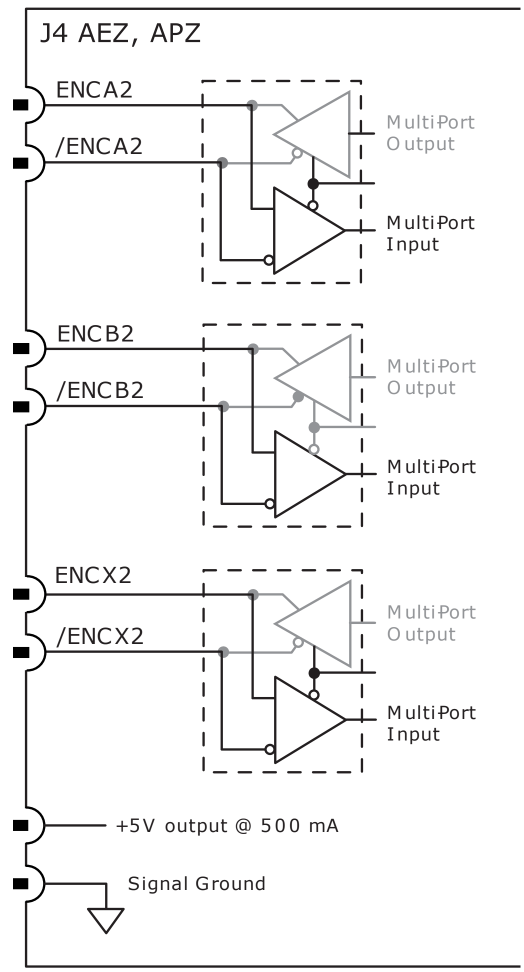
- Quad A/B/X Digital Encoders

Quad A/B/X Encoder



AEZ, APZ

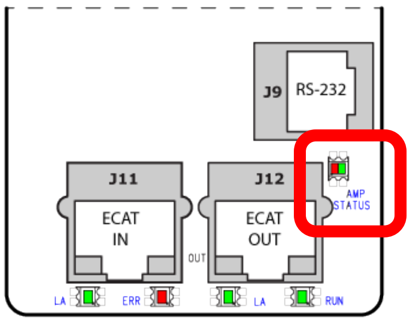
Input Type	J4 EZ	Signals	J4 Pins
Quad A	Enc A	ENCA2	2
Quad /A	Enc /A	/ENCA2	1
Quad B	Enc B	ENCB2	4
Quad /B	Enc /B	/ENCB1	3
Quad X	Enc X	ENCX2	6
Quad /X	Enc /X	/ENCX2	5
Signal Ground			8



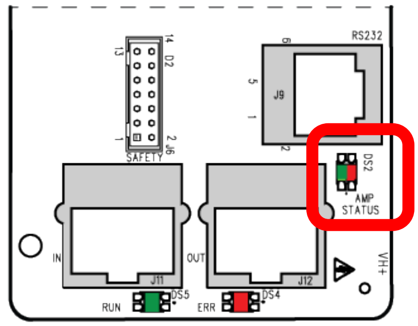
5.5 EZ Board Indicators

Drive Status Indicator

AEZ EtherCAT



APZ CANopen



STATUS LED

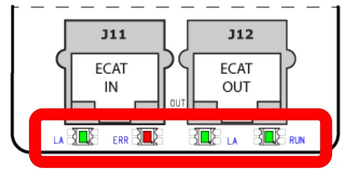
The bi-color AMP LED gives the state of the drive.
Colors do not alternate and can be solid ON or blinking.
When multiple conditions occur, only the top-most condition will be displayed.
When that condition is cleared, the next condition in the table below will be shown.

LED	Description
RED/BLINKING	= Latching fault. Operation will not resume until drive is Reset.
RED/SOLID	= Transient fault condition. Drive will resume operation when the condition causing the fault is removed.
GREEN/DOUBLE-BLINKING	= STO circuit active, drive outputs are Safe-Torque-Off.
GREEN/SLOW-BLINKING	= Drive OK but NOT-enabled. Will run when enabled.
GREEN/FAST-BLINKING	= Positive or Negative limit switch active. Drive will only move in direction not inhibited by limit switch.
GREEN/SOLID	= Drive OK and enabled. Will run in response to reference inputs or commands from CAN or EtherCAT master.
OFF	= No HV or VLOGIC power to drive.

Latching Faults (* Default)	Optional Faults
Short circuit (Internal or external)	Over-current (Latched, I^2T)
Drive over-temperature	Over-voltage
Motor over-temperature	Under-voltage
Feedback Error	Motor Phasing Error
Following Error	Command Input Lost
	Motor Wiring Disconnected
	STO Active

Network Status Indicators

EtherCAT Network Status Indicators: AEZ

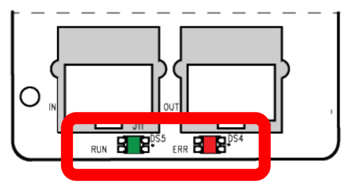


RUN Green: Shows the state of the ESM (EtherCAT State Machine).	
OFF	= INIT
BLINKING	= Pre-operational
SINGLE-FLASH	= Safe-operational
ON	= Operational
ERR Red: Shows errors such as watchdog timeouts and unsolicited state changes in the AEZ due to local errors.	
OFF	= EtherCAT communications are working correctly.
BLINKING	= Invalid configuration, general configuration error.
SINGLE FLASH	= Local error, slave has changed EtherCAT state autonomously.
DOUBLE FLASH	= PDO or EtherCAT watchdog timeout, or an application watchdog timeout has occurred.

L/A Green: Indicates the state of the physical EtherCAT network and activity on the network:

LED	**Link**	**Activity**	**Condition**
ON	Yes	No	Port Open
FLICKERING	Yes	Yes	Port Open with activity
OFF	No	(N/A)	Port Closed

CANopen Network Status Indicators: APZ

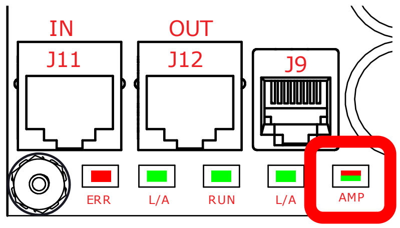


RUN Green: Shows the state of the CANopen network state machine.	
OFF	= INIT
BLINKING	= Pre-operational
SINGLE-FLASH	= Stopped
ON	= Operational
ERR Red: Shows status of CAN physical layer and errors such as watchdog timeouts and unsolicited state changes in the drive due to local errors.	
OFF	= No errors, communications are working correctly.
BLINKING	= Invalid configuration, general configuration error.
SINGLE FLASH	**=** Warning limit reached; an error counter of the CAN controller has reached or exceeded the warning level.
DOUBLE FLASH	= Error control event. A guard event or heartbeat event has occurred.
ON	Bus off. The CAN controller is bus off.

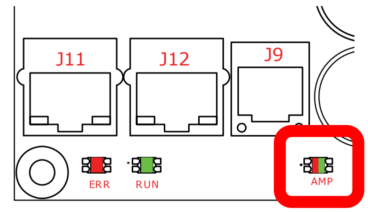
5.6 EZ Development Board Indicators

Drive Status Indicator

AEZ EtherCAT



APZ CANopen



STATUS LED

The bi-color AMP LED gives the state of the drive. Colors do not alternate and can be solid ON or blinking. When multiple conditions occur, only the top-most condition will be displayed. When that condition is cleared, the next condition in the table below will be shown.

LED	Description
RED/BLINKING	= Latching fault. Operation will not resume until drive is Reset.
RED/SOLID	= Transient fault condition. Drive will resume operation when the condition causing the fault is removed.
GREEN/DOUBLE-BLINKING	= STO circuit active, drive outputs are Safe-Torque-Off.
GREEN/SLOW-BLINKING	= Drive OK but NOT-enabled. Will run when enabled.
GREEN/FAST-BLINKING	= Positive or Negative limit switch active. Drive will only move in the direction not inhibited by limit switch.
GREEN/SOLID	= Drive OK and enabled. Will run in response to reference inputs or commands from CAN or EtherCAT master.
OFF	= No HV or VLOGIC power to drive.

Latching Faults (* Default)	Optional Faults
Short circuit (Internal or external)	Over-current (Latched, I^2T)
Drive over-temperature	Over-voltage
Motor over-temperature	Under-voltage
Feedback Error	Motor Phasing Error
Following Error	Command Input Lost
	Motor Wiring Disconnected
	STO Active

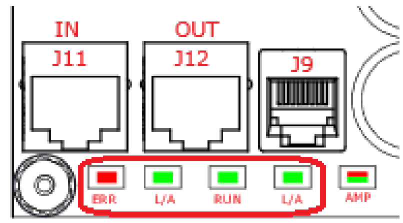
NETWORK STATUS INDICATORS

ETHERCAT NETWORK STATUS INDICATORS: AEZ

RUN Green: Shows the state of the ESM (EtherCAT State Machine).	
OFF	= INIT
BLINKING	= Pre-operational
SINGLE-FLASH	= Safe-operational
ON	= Operational
ERR Red: Shows errors such as watchdog timeouts and unsolicited state changes in the AEZ) due to local errors.	
OFF	= EtherCAT communications are working correctly.
BLINKING	= Invalid configuration, general configuration error.
SINGLE FLASH	= Local error, slave has changed EtherCAT state autonomously.
DOUBLE FLASH	= PDO or EtherCAT watchdog timeout, or an application watchdog timeout has occurred.

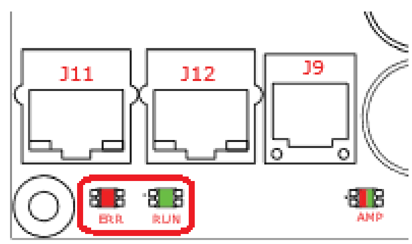
L/A Green: Indicates the state of the physical EtherCAT network and activity on the network:

LED	Link	Activity	Condition
ON	Yes	No	Port Open
FLICKERING	Yes	Yes	Port Open with Activity
OFF	No	(N/A)	Port Close

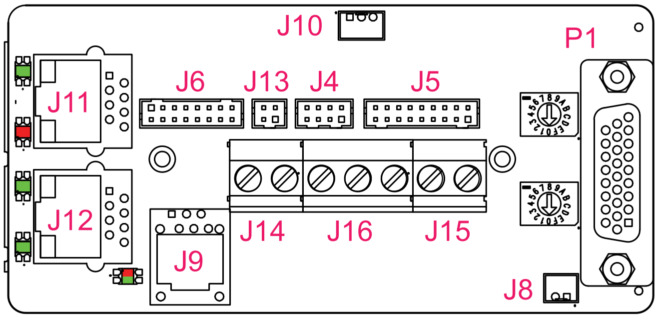


CANopen Network Status Indicators: APZ

RUN Green: Shows the state of the CANopen network state machine.	
OFF	= INIT
BLINKING	= Pre-operational
SINGLE-FLASH	= Stopped
ON	= Operational
ERR Red: Shows status of CAN physical layer and errors such as watchdog timeouts and unsolicited state changes in the drive due to local errors.	
OFF	= No errors, communications are working correctly.
BLINKING	= Invalid configuration, general configuration error.
SINGLE FLASH	= Warning limit reached; an error counter of the CAN controller has reached or exceeded the warning level.
DOUBLE FLASH	= Error control event. A guard event or heartbeat event has occurred
ON	= Bus off. The CAN controller is bus off.

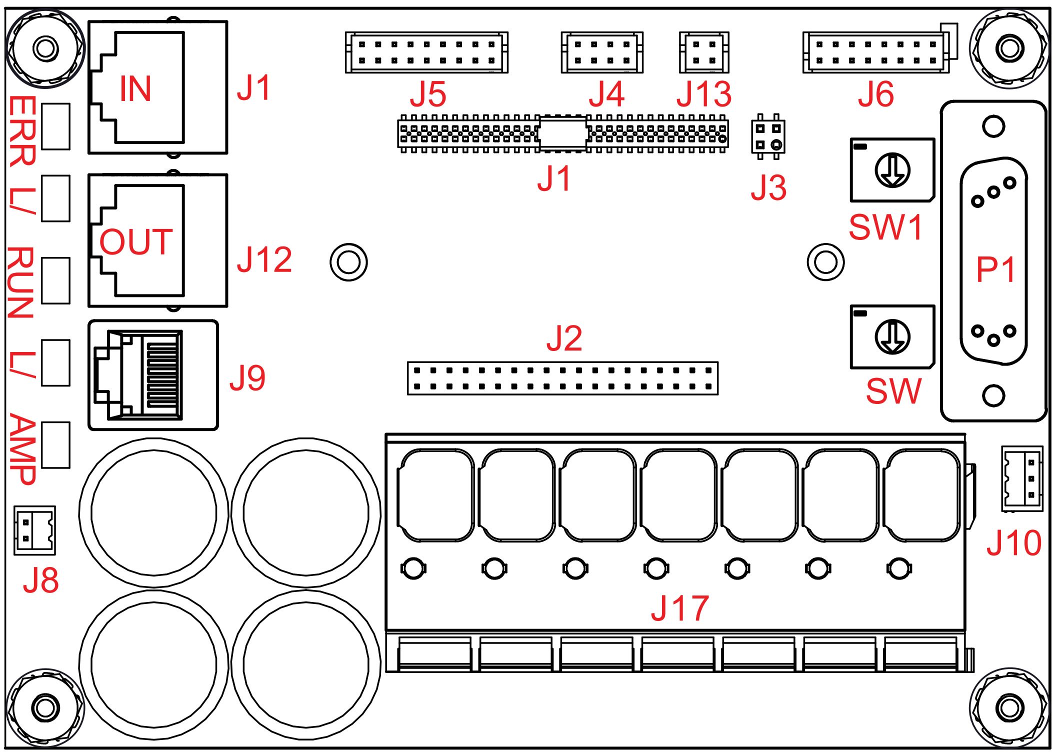


AEV-EZ Board Connector Locations



Note: APV models have the same connector numbers as the AEV models shown here.

AEV-EZ Development Board Connector Locations

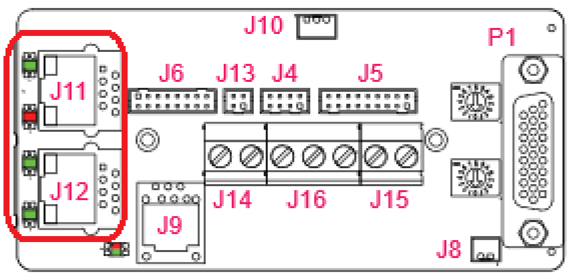


Note: When the STO feature is used, VLOGIC must be produced by power supplies with a transformer isolation from the mains, PELV or SELV ratings, and a maximum output voltage of 60 Vdc.

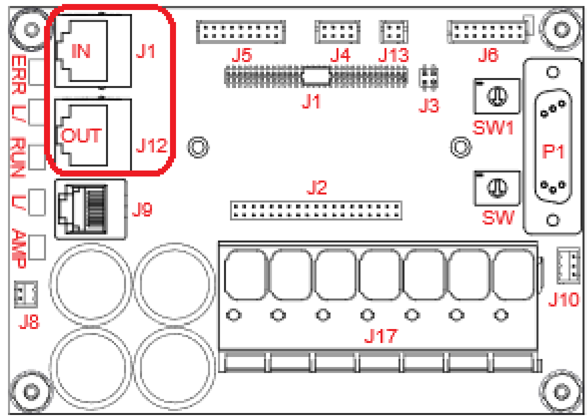
5.7 Motor Feedback

AEZ, APZ Feedback Connector Location

Top View



EZ BOARD



EZ DEVELOPMENT BOARD

Secondary Encoder Receptacle

Description	Manufacturer PN
HDsub, female, 26-position receptacle	Harting: 09562517512

Mating Connector

Description	Manufacturer PN
Connector: HDsub DA-26M, male, 26-position plug, solder cup	Norcomp: 180-026-103L001
Backshell: HDsub, 26 pin, RoHS, metallized	Norcomp: 979-015-020R121

Pin Descriptions (Encoder Feedback) P1

Pin	Name
1	Frame Ground
2	Hall U
3	Hall V
4	Hall W
5	Signal Gnd
6	+5Vout
7	Motemp
8	Enc /X
9	Enc X

Pin	Name
10	Enc /B
11	Enc B
12	Enc /A
13	Enc A
14	Enc /S
15	Enc S
16	Signal Gnd
17	+5Vout
18	Sin(-)

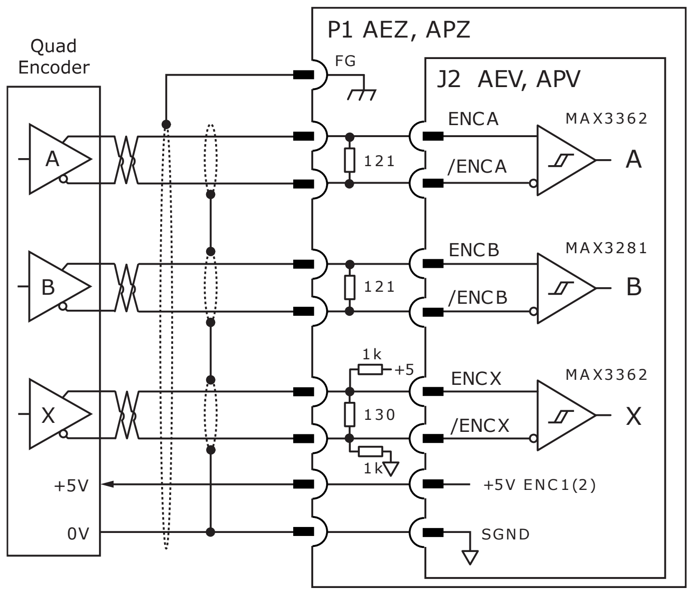
Pin	Name
19	Sin(+)
20	Cos(-)
21	Cos(+)
22	N/C
23	N/C
24	N/C
25	Signal Gnd
26	Signal Gnd

Quad A/B Incremental Encoder

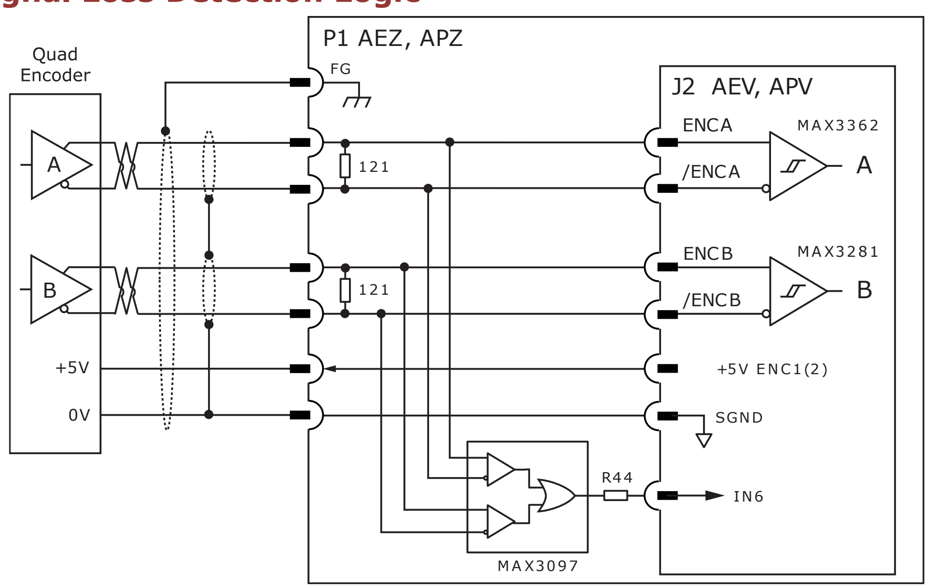
Encoders with differential line-driver outputs are required (single-ended encoders are not supported) and provide incremental position feedback via the A/B signals and the optional index signal (X) gives a once per revolution position mark. The MAX3097 receiver has differential inputs with fault protections for the following conditions:

Condition	Example
Line-line shorts	A shorted to /A
Open-circuits:	A disconnected, /A connected. Terminator resistor pulls A & /A together for a cable short-circuit fault.
Low-voltage	Va - Vb ≤ 200 mV, or ≥ -200 mV Encoder power loss, cabling, etc.

Quad Encoder with Index

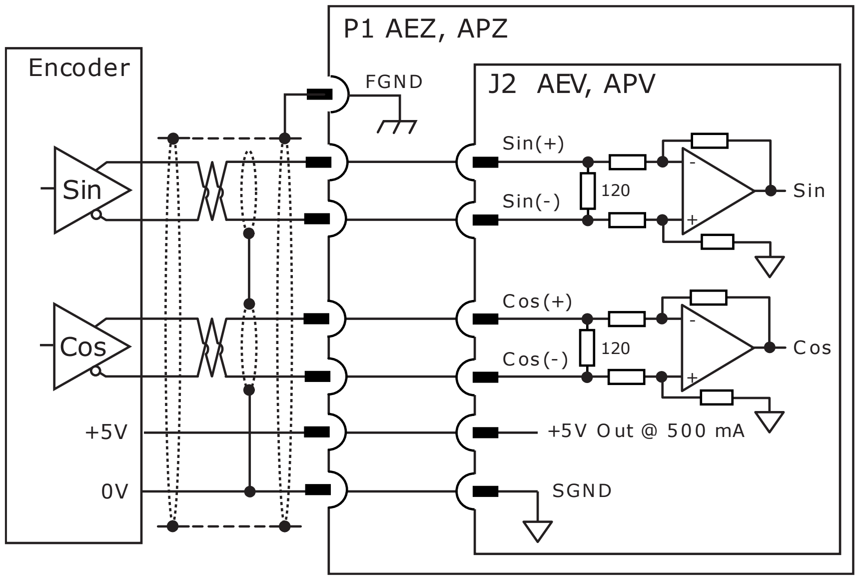


Signal Loss Detection Logic



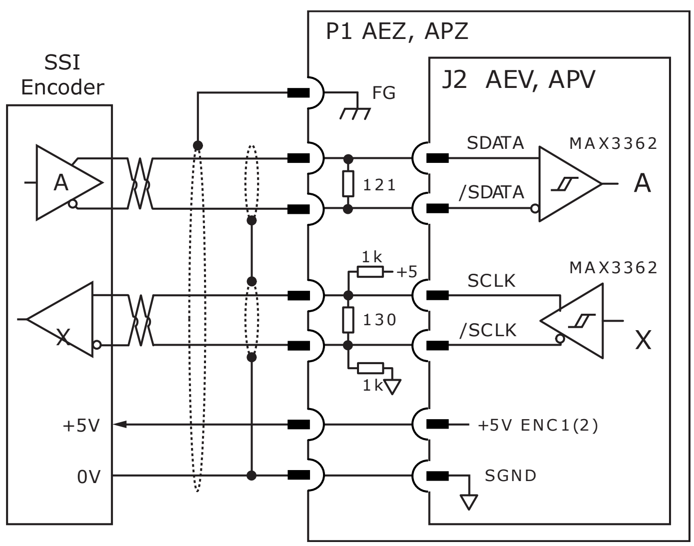
Analog Sin/Cos Incremental Encoder

The Sin/Cos inputs are differential with 121 Ω terminating resistors and accept 1 Vp-p signals in the format used by incremental encoders with analog outputs. The index input is digital.



SSI Absolute Encoder

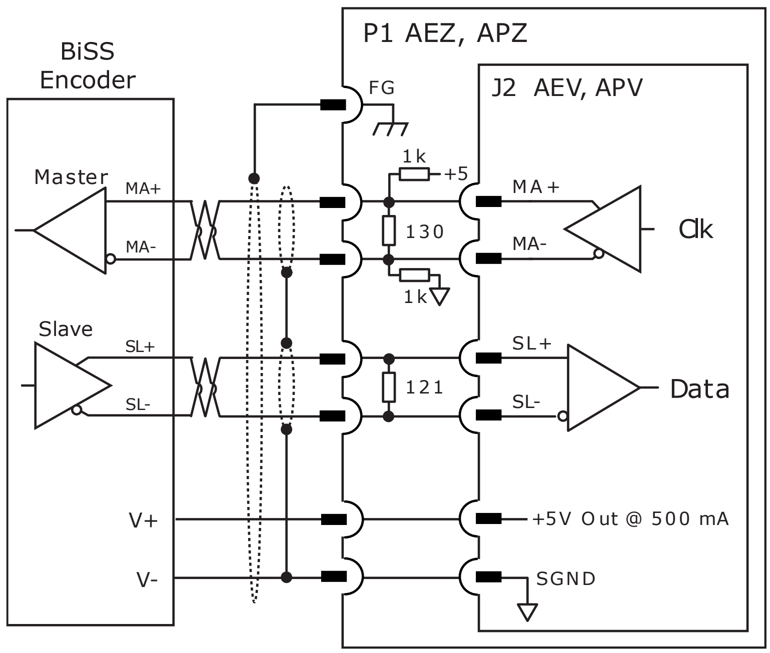
The SSI (Synchronous Serial Interface) is an interface used to connect an absolute position encoder to a motion controller or a control system. The drive provides a train of clock signals in differential format to the encoder which initiates the transmission of the position data on the subsequent clock pulses. The polling of the encoder data occurs at the current loop frequency (16 kHz). The number of encoder data bits and counts per motor revolution are programmable. The hardware bus consists of two signals: SCLK and SDATA. Data is sent in 8-bit bytes, LSB first. The SCLK signal is only active during transfers. Data is clocked out on the falling edge and clock in on the rising edge of the Master.



BiSS Absolute Encoder

BiSS is an Open Source digital interface for sensors and actuators. BiSS refers to principles that comply with industrial standards for Serial Synchronous Interfaces like SSI, AS-Interface® and Interbus® with additional options.

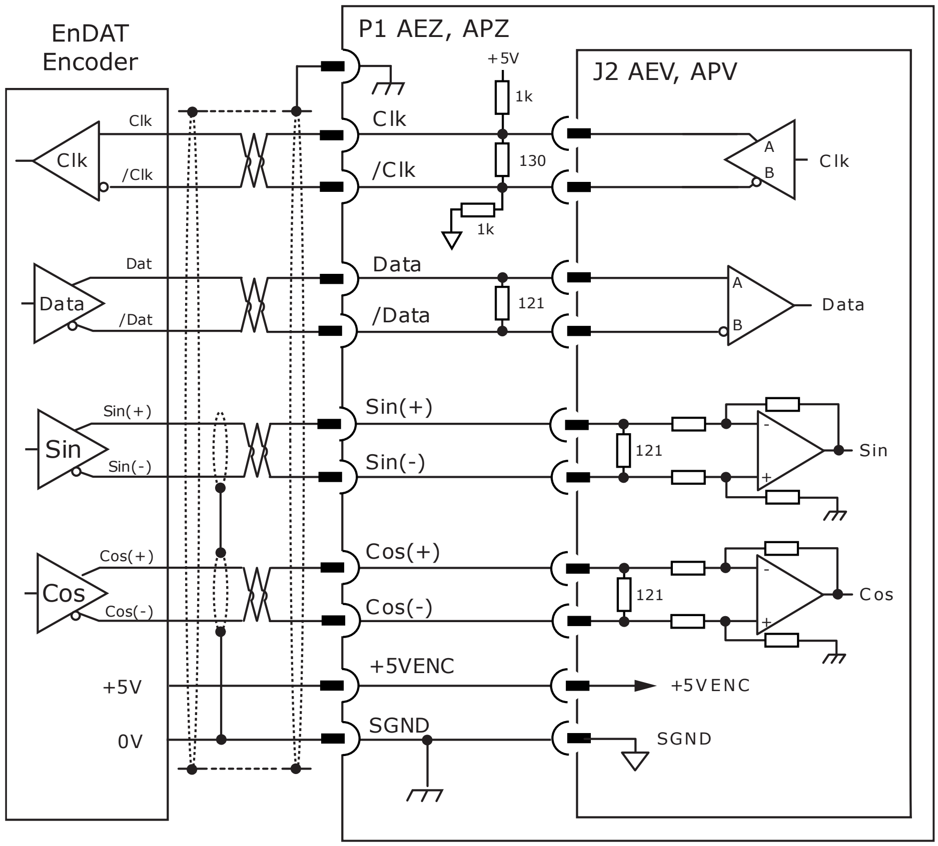
- Serial Synchronous Data Communication
- Cyclic at high speed
- 2 unidirectional lines Clock and Data
  -Line delay compensation for high-speed data transfer
  -Request for data generation at slaves
  -Safety capable: CRC, Errors, Warnings
  -Bus capability incl. actuators
- Bidirectional
  -BiSS B-protocol: Mode choice at each cycle start
  -BiSS C-protocol: Continuous mode



SSI	BiSS	EnDat	Abs-A	Signal	P1 Pins
SDATA	SL+	Data	Data	ENCA1	13
/SDATA	SL-	Data	/Data	/ENCA1	12
SCLK	MA+	CLK		ENCX1	9
/SCLK	MA-	CLK		/ENCX1	8
		Sin(+)		SIN1+	19
		Sin(-)		SIN1-	18
		Cos(+)		COS1+	21
		Cos(-)		COS1-	20
+5V				+5VENC	6, 17

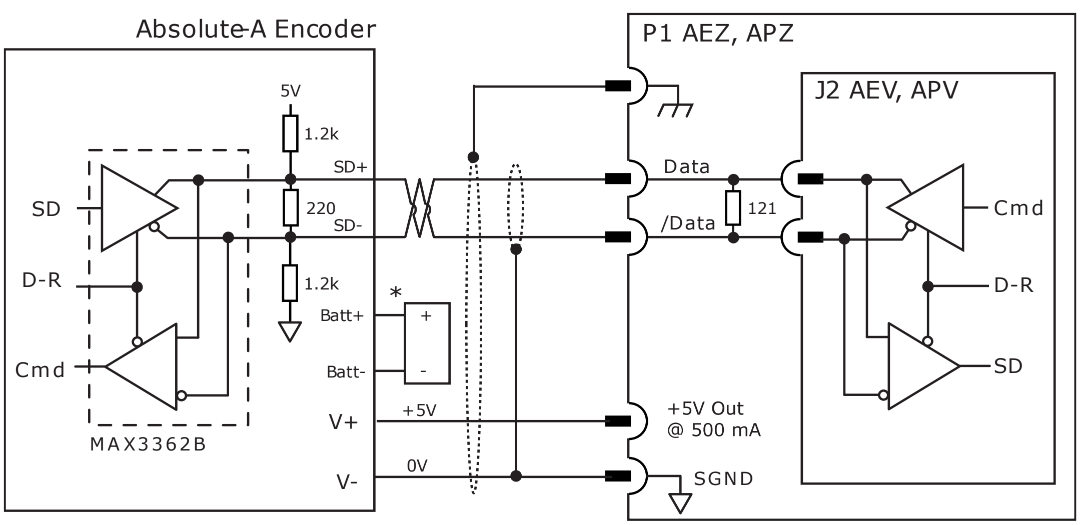
EnDat Absolute Encoder

The EnDat interface is a Heidenhain interface that is similar to SSI in the use of clock and data signals, but which also supports analog Sin/Cos channels from the same encoder. The number of position data bits is programmable as is the use of Sin/Cos channels. Use of Sin/Cos incremental signals is optional in the EnDat specification.



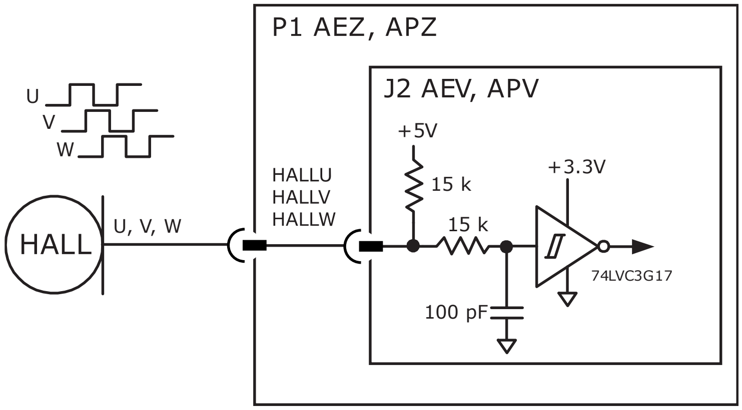
Absolute A Encoder

The Absolute A interface is a serial, half-duplex type that is electrically the same as RS-485.



HALLS

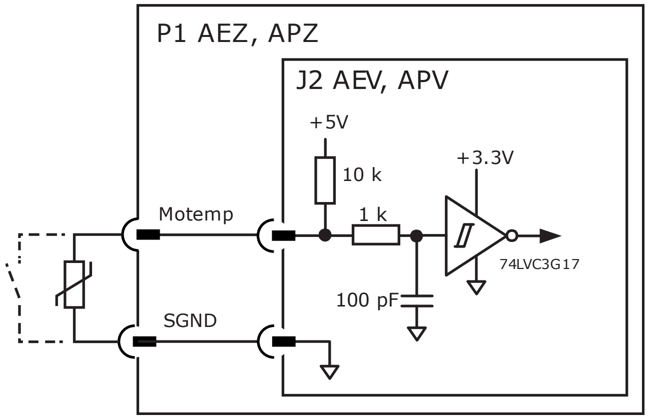
Hall signals are single-ended signals that provide absolute feedback within one electrical cycle of the motor. There are three of them (U, V, & W) and they may be sourced by magnetic sensors in the motor, or by encoders that have Hall tracks as part of the encoder disc. They typically operate at much lower frequencies than the motor encoder signals, and are used for commutation-initialization after startup, and for checking the motor phasing after the drive has switched to sinusoidal commutation.



Halls	Signal	P1
Hall U	HALLU	39
Hall V	HALLV	40
Hall W	HALLW	41

MOTEMP (MOTOR OVER TEMPERATURE) INPUT

IN5 defaults to the Motemp function but any input may be programmed for that function. The digital input HI threshold voltage is 1.3~2.0 Vdc. A sensor resistance of 3514~6667 Ω will produce those voltages. The BS 4999 sensor example below will produce a HI state for the Motemp input when the sensor temperature is > 105 C.



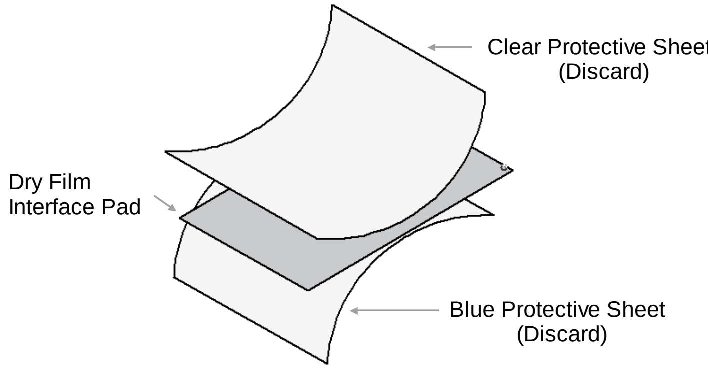
Motemp	Signal	P1 Pins
[IN5] Motemp	IN5	7
SGND	SGND	5,16,25,

BS 4999 Thermistor/Posistor Property	Ohms
Resistance in the temperature range 20°C to +70°C	60~750
Resistance at 85°C	≤1650
Resistance at 95°C	≥3990

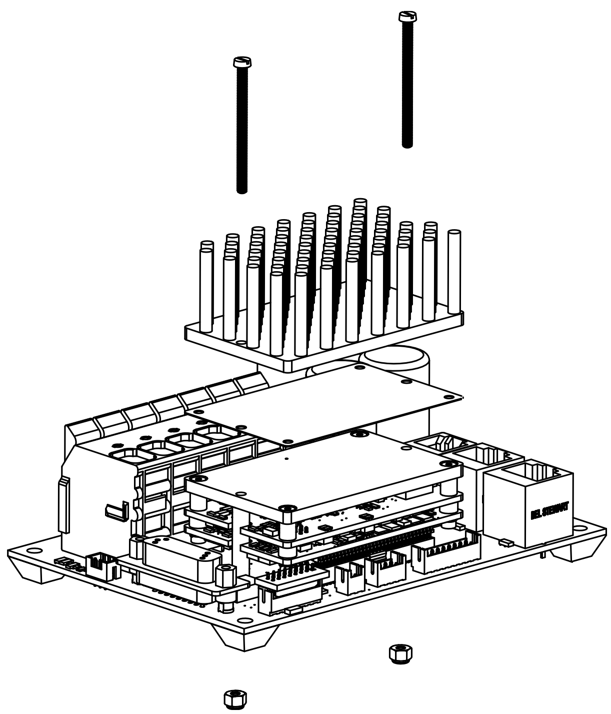
5.8 EZ Development Board Pins Heatsink Mounting

A thermal pad is used in place of heatsink grease. The pad is die-cut to shape and has holes for the heatsink mounting screws. There are two protective sheets, blue on one side and clear on the other side. Both sheets must be removed when the interface pad is installed.

1. Remove the blue protective sheet from one side of the pad.



2. Place the interface pad on the drive. Be sure to center the pad holes over the heat plate mounting holes.
3. Remove the clear protective sheet from the pad.
4. Mount the heatsink onto the drive. Align the holes in the heatsink, interface pad, and drive, so they line up.
5. Torque the M2.5 mm mounting screws to 4 in-lb, 64 in-oz, 0.45 Nm.



6 Safe Torque Off (STO) – Use, Connections and Wiring

Overview

This chapter is intended to inform the reader about the Functional Safety features of the AEV & APV drives and to provide information on the steps required to install it into systems so that a target level of Functional Safety performance can be achieved. The scope of this document is limited to those aspects of Functional Safety that relate to the installation, operation, and maintenance of the AEV and APV drives.

Disclaimer

This manual contains information on the Safe Torque Off (STO) feature of the AEV and APV drives and how it may be incorporated into an industrial motion control system. While every effort has been made to ensure the completeness and accuracy of this manual it must be emphasized that the responsibility for functional safety in the overall system into which the drive is installed rests ultimately with the manufacturer of the system into which the AEV and APV drives are installed.

The equipment manufacturer must consider all the aspects of the system in which the AEV & APV drives are components.

Copley Controls does not accept any liability for direct or indirect injury or damage caused by the use of information in this document. The equipment manufacturer is always responsible for the safety of its product and its suitability under applicable laws. Copley Controls hereby disclaims all liabilities that may result from this document.

Risk Assessment & Responsibility of the Installer

The STO feature of the AEV and APV drives is capable of the safety integrity level (SIL) and category/performance level (PL) stated in this manual and operates in accordance with the characteristics and limitations described herein. But it must be noted that the drive STO function is intended to be used only as one element of an overall safety chain and is not a complete safety function unto itself. Therefore, the suitability for use of the AEV & APV drives in a given application must be determined in part by one or more risk assessments of the overall safety of the end machine conducted in accordance with the applicable standards. Such risk assessments normally consist of a thorough review of overall machine operation to identify potential hazards. For each identified hazard, typical risk assessments take into account the severity of any potential injury resulting from the hazard, the frequency of exposure of persons to the hazard, and the probability that the persons can avoid the hazard if it were to occur. The machine designer is solely responsible for conducting any necessary risk assessments. Moreover, the machine designer is responsible for the ultimate determination as to the suitability of the AEV and APV drives and the STO function for use in realizing a given overall safety function. The installer should be experienced in motion control and functional safety.

Operate drives within the specifications provided in this document

The information in this manual is specific to the functional safety features of the AEV and APV drives. The user must use this manual to comply with the proper safety installation and the overall commissioning of the drives.

Risk of electric shock

The AEV and APV drives are made for operation from transformer-isolated, DC power supplies. Therefore, hazardous voltages are connected to and exist within these drives under normal operating conditions. Persons responsible for installing and commissioning these drives must be experienced in all aspects of electrical equipment installations.

DISCLAIMER

There are no user serviceable parts in the AEV & APV drives.
Disassembly of the PC boards or tampering with components will void the warranty.

DEFINITIONS

There are certain terms used throughout this document that serve an important role in describing the operation and behavior of the AEV & APV STO feature. These terms are discussed and defined as follows:

Term	Definition
Activate	This term is used to refer to an action taken that results in the safe state being entered. In the case of the STO feature, the STO function is activated (made active) by making the voltage at one or both STO inputs less than or equal to the maximum rated de-energize threshold voltage.
De-Activate	This term is used to refer to an action taken that results in the safe state being exited. In the case of the STO feature, the STO function is de-activated (made inactive) by making the voltage at both STO inputs greater than or equal to the minimum rated energize threshold voltage.
Energize	This term refers to the application of voltage greater than or equal to the minimum rated energize threshold voltage to an individual STO input. Note that simultaneously energizing both STO inputs results in the STO function being de-activated
De-Energize	This term refers to the application of voltage less than or equal to the maximum rated de-energize threshold voltage to an individual STO input. Note that de-energizing an STO input results in the STO function being activated AEV-APV User Board External STO Muting.

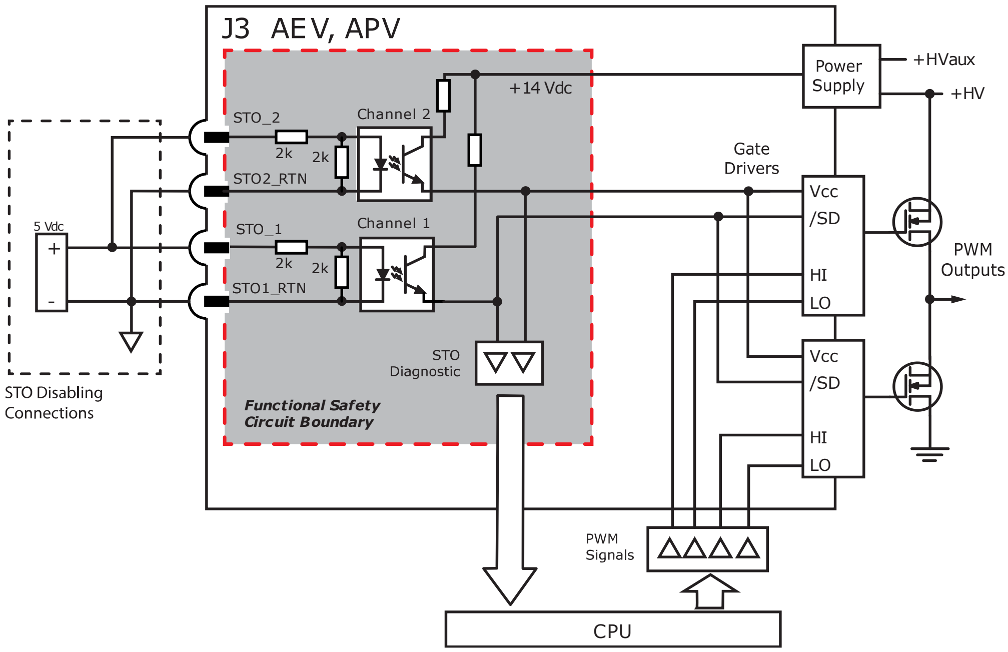
6.1 STO Reference Standards

Standard	Description
ISO 13849-1	Safety of machinery Safety-related parts of control systems Part 1: General Principles for Design
ISO 13849-2	Safety of machinery Safety-related parts of control systems — Part 2: Validation
IEC 61508-1	Functional safety of electrical/electronic/programmable electronic safety-related systems Part 1: General requirements
IEC 61508-2	Functional safety of electrical/electronic/programmable electronic safety-related systems Part 2: Requirements for electrical/electronic/programmable electronic safety related systems
IEC 61508-3	Functional safety of electrical/electronic/programmable electronic safety-related systems Part 3: Software Requirements
IEC 61800-5-1	Adjustable speed electrical power drive systems Part 5-1: Safety requirements – Electrical, thermal and energy
IEC 61800-5-2	Adjustable speed electrical power drive systems Part 5-2: Safety requirements – Functional
IEC 60664-1	Product Safety Considerations for Insulation Coordination of Low-Voltage Equipment Table F.2 Clearances to Withstand Transient Overvoltages
IEC 62061	Functional safety of safety-related electrical, electronic, and programmable electronic control systems

6.2 STO Architecture and Function

The STO function in AEV & APV is suitable for use in safety loops up to SIL 3 and/or Cat. 3 PL e performance. Because Cat. 3 PL e performance requires that the safety function continues to operate even in the event of two failures, the STO circuit has a built-in diagnostic capability. This architecture is shown in the system block diagram below. The dotted red outline represents the components in the drive that implement the safety function.

AEV-APV STO Safety Control-NoPins



In the Safe State, the drive will not produce torque or force in the motor. The STO function achieves and maintains a safe state by disabling the ability of the attached motor to produce torque/force. This halts any drive induced acceleration already in process and prevents initiation of motion. The expectation is that an inability of the motor to produce torque/force translates into a reduction of risk of hazardous motion for the larger system.

The STO circuit concept involves disabling the ability of the motor drive output stages to produce current. The output stage consists of one subset of high side output MOSFETs that switch motor terminals to the positive rail of the DC bus (+HV), and a second subset of low side output devices that switch motor terminals to negative rail of the DC bus (HVCOM). The STO circuit architecture is derived from the fact that current flow in the motor, and therefore torque/force production, requires both subsets to function. STO Channel 2 disables the drive by removing power from the MOSFET gate drivers. STO Channel 1 uses the Enable input of the drivers to disable all of them. Either of the two channels by itself is therefore sufficient to prevent the initiation of motion or halt drive induced acceleration when the STO function is activated.

Each STO channel receives an input in the form of a voltage applied to STO-IN1 STO_1, STO1_RTN and STO-IN2 STO_2, STO2_RTN. Both STO inputs must be simultaneously energized for torque/force to be produced. To achieve the rated SIL and PL capability, both STO inputs must be held simultaneously de-energized by the larger system when the STO function is activated. In a typical machine application, each STO input is driven by a voltage from a SELV or PELV power supply and switched through a safety relay. By definition, the output of a SELV or PELV rated power supply is a maximum of +60 Vdc in a fault condition. Therefore, a constraint on the larger system is that the power supply used to energize the STO inputs must be an SELV or PELV type.

6.3 STO Channel Operation

STO Function Active = No force/torque production is possible in the motor.
STO Function Inactive = Force/torque production in motor is under control of the drive.

STO IN1	STO IN2	STO Function State
0	0	STO function is active, both inputs de-energized
1	0	STO function is active, one input de-energized
0	1	
1	1	STO function is inactive, both inputs energized

The above table shows the operation of the STO channels.

0 = Voltage applied to the STO input is less than or equal to the rated maximum de-energize level.

1 = Voltage applied to the STO input is greater than or equal to the rated minimum energize level.

A motion control system design for Cat. 3 PL e, and/or SIL 3 rating must use 2 channels for the STO function.

6.4 STO Function Specifications

Specification	Requirement
Operation	When STO is active, motor current that can cause rotation (or motion in the case of a linear motor) is not applied. The PWM output is disabled and cannot source or sink current. This STO function is defined in IEC-61800-5-2, clause 4.2.2.2
Standards Conformance	IEC-61508-1, IEC-61508-2, IEC-61508-3, IEC-61800-5-2, ISO 13489-1
Safety Integrity Level	SIL 3
Category & Performance Level	Category 3, Performance Level PL e
Certifications	UL Functional Safety Mark
Signals (Functional Safety Related)	STO_1, STO1_RTN, STO_2, STO2_RTN Frame ground (shield)
Signals (for Disabling)	STO-Bypass, STO-Gnd
STO DC Power AEV & APV	+5 Vdc, typical, +6 Vdc maximum
STO 24V DC Power AEZ/APZ AEZ/APZ-50, AEZ/APZ-50-C	+24 Vdc, typical, +30 Vdc maximum
STO DC Power Source	SELV or PELV power supply required
STO Input Energize Voltage	Vin-HI ≥ +3.3 Vdc between STO_x and STOx_RTN (AEV, APV) Vin-HI ≥ +20.0 Vdc between STO_x and STOx_RTN(using +24V interface)
STO Input De-energize Voltage	Vin-LO ≤ +2.0 Vdc or open between STO_x and STOx_RTN(AEV,APV) Vin-LO ≤ +13.0 Vdc or open between STO_x and STOx_RTN -(using + 24V interface)
Input current (typical)	STO_1: 1.8 mA, STO_22: 1.8 mA Current flow is into STO_1 and STO2 and out of STO1_RTN and STO2_RTN respectively. STO inputs must be connected in parallel when driven from a single power supply. (AEV,APV) STO1_1: 11 mA, STO_2: 11 mA Current flow is into STO_1 and STO_2 and out of STO1_RTN and STO2_RTN respectively. STO inputs must be connected in parallel when driven from a single power supply. (AEZ, APZ)
Response Time	From Vin ≤ 2.0 Vdc or open to PWM outputs disabled (off): ≤ 1.5 ms
Type	Opto-isolators, +5 VDC compatible
Maximum cable length	30 m (98.4 ft)

6.5 Safety Related Parameters

IEC 61508-1					ISO 13849-1			
SIL	3	HFT	1		PL	e	Category	3
PFH	8.49×10^{-10}	SFF	87%		CCF	80	$MTTF_D$	100 yrs
PFD	7.44×10^{-5}	PTI	N/A		DC	90.87%		

6.6 R44/R43 Safety Related Parameters

IEC 61508-1					ISO 13849-1			
SIL	3	HFT	1		PL	e	Category	3
PFH	1.71×10^{-9}	SFF	87%		CCF	80	$MTTF_D$	100 yrs
PFD	1.49×10^{-4}	PTI	N/A		DC	90.74%		

6.7 Regulatory Specifications

Specification	Requirement
Approvals	UL and cUL recognized component to UL 61800-5-1 UL Functional Safety to IEC 61800-5-2, (E168959-20200424A) EMC to IEC 61800-3
Functional Safety	IEC 61508-1, IEC 61508-2, IEC 61508-3, EN (ISO) 13849-1, (CAT 3, PL e) ISO 13849-2, IEC 61800-5-2. (SIL 3)
Electrical Safety	Directive 2014/35/EU – Low Voltage, UL 61800-5-1:2016
Machinery	Directive 2006/42/EC
EMC	Directive 2014/30/EU IEC 61800-5-2, IEC 61800-3:2017, Category C3
Markings	Label is visible on PC board
Hazardous Substances	Lead free and RoHS compliant

6.8 Limitations and Necessary Risk Reductions

Electrical Isolation

The STO function does not provide electrical isolation between the drive and the motor. Hazardous voltages may be present on the motor output terminals even with the STO function activated.

DC Brush Motors

Failure of a MOSFET in the outputs of the drive that renders the MOSFET a virtual short-circuit might result in continuous torque/force production in a DC motor. Unlike brushless motors that limit rotation to one half of an electrical cycle, a DC motor can rotate uncontrollably under a failed MOSFET scenario.
As result, the STO function cannot be used with DC brush motors.

180 Degree Electrical Movement

In the event of MOSFET failures in the PWM outputs, unexpected motor movement of up to 180 electrical degrees can occur. It is the responsibility of the designer of the larger system to assess and address any hazards that this unexpected movement could create.

Loads and Other Torque/Force Producing Sources

The STO function produces an uncontrolled stop of category 0 as described in IEC 60204-1.
Any motor that is moving when the STO function is activated will coast to a stop unless there are other forces operating on the same load. The STO function only removes torque/force produced by current flow from the drive to the associated motor. Torque/force created by gravity-influenced loads or other torque/force producing components mechanically connected to the motor shaft cannot and will not be affected by the drive STO function. It is the responsibility of the designer of the larger system to assess and address any hazards arising from torque/force producing sources.

+HV DC Power Supply

The power supply used to provide the +HV drive power to a 90V model Accelnet Plus Micro Module must have protections to limit the output voltage to 100 Vdc or less even in a single fault condition. The power supply used to provide the +HV drive power to a 180V model Accelnet Plus Micro Module must have protections to limit the output voltage to 200 Vdc or less even in a single fault condition. Furthermore, the power supply output must have galvanic isolation from AC mains that meets the requirements for reinforced or double insulation.

VLOGIC DC Power Supply STO

The VLOGIC power supply must have protections to limit the output voltage to 60 Vdc or less even in a single fault condition. Furthermore, the power supply output must have galvanic isolation from AC mains that meets the requirements for reinforced or double insulation. If the drive +HV can be 60 Vdc or less, then the VLOGIC and +HV can be driven from a single SELV or PELV type source.

Control Modes and STO

The drive can control the position, velocity, and torque of motors while operating from a number of control sources. But it can only do this when the STO function is inactive. And, although the digital control core and firmware of the drive can observe the state of the STO function, it cannot interact with, or exercise any control over the STO function.

DANGER	**The STO function operates completely independently of the control core of the drive. It does not depend on the control core for its operation and the control core of the drive has no control over the STO function.**

STO Input Signal Level

The STO inputs STO_1, STO_2 are +3.3V logic level inputs with +5V nominal and +6V maximum ratings.

In typical machinery, STO inputs are driven from a safety relay or similar device with 24Vdc level signals. The AEV/APV models are not designed as stand-alone devices and are designed for installation as components on the end user motherboard. It is the responsibility of the designer of the larger system to take this into consideration that the motherboard design must contain level translation and overvoltage protections to interface between 24V (nominal) signals and the STO inputs on the AEV/APV drives. A constraint on the larger system is that the power supply used to drive the STO inputs must be a SELV or PELV type.

STO DC Power Supply

The recommended DC power for STO inputs on the AEV and APV Modules should be +5 Vdc nominal, +6 Vdc maximum, and must be supplied by power supplies with a SELV or PELV rating.

The EZ board has STO inputs that are +24 Vdc compatible, +30 Vdc maximum, in addition to the +5 Vdc inputs.

Wiring to the STO Inputs

Electrical connections to the STO inputs must meet the requirements for fault exclusions for short circuits between conductors and short circuits between conductors and other conductive parts or earth or the protective bonding conductor. Fault exclusion requirements are given in ISO 13849-2 and IEC 61800-5-2.

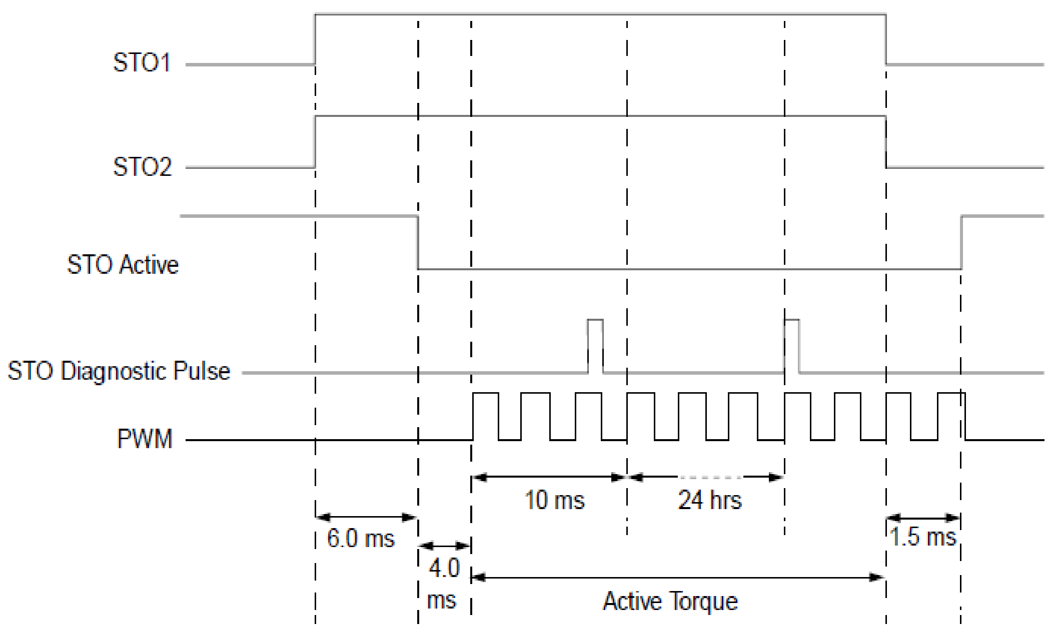
Connections to the STO inputs must provide spacing that is greater than the minimum creepage and clearance of 1.24 mm. that is required for fault exclusion when considering the FMEDA (Failure Modes, Effects, and Diagnostic Analysis) of the system.

Periodic STO Testing Interval

To meet SIL 3 and/or Cat. 3 PL e performance of the Safety Function, periodic diagnostic testing is required to be performed every 3 months, per IEC 61800-5-2. The AEV and APV drives have internal diagnostics testing software to verify the function of the STO circuits every 24 hours. If a fault is detected, the AEV/APV drive shall be put into a Safe State until the fault is cleared. The internal diagnostics testing software of the AEV/APV products fulfills this requirement without intervention of the operator.

Internal Diagnostics Pulses

The AEV and APV drives have internal diagnostics to verify the function of the STO circuits. The diagnostics test sends short (60 microseconds) pulses that propagate through the STO circuits and monitors a response to verify hardware integrity of each channel without interfering with drive operation. When both STO1 and STO2 inputs are energized the diagnostics test runs within 20 milliseconds. If the diagnostics test passes, the diagnostics test shall run every 24 hours as STO1 and STO2 remain energized. If the STO diagnostic test detects a failure, then the drive shall be put into a safe state and the test shall be run every 5 seconds until the test passes on STO1 and STO2 input channels. The following figure is intended as a visualization of the internal diagnostics testing.



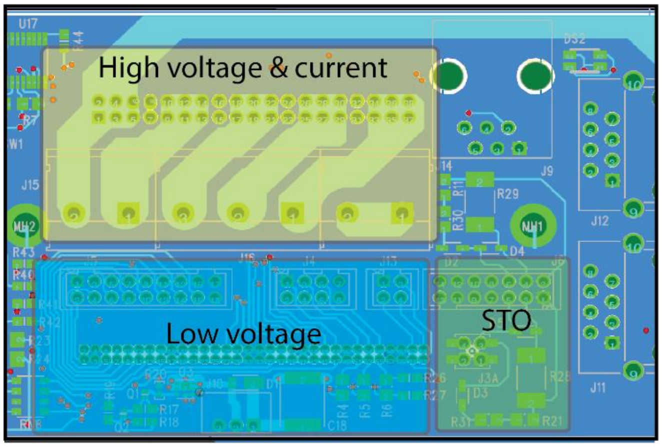
6.9 PC Board Design for STO

General Considerations

The general PCB design guidelines presented in section 4.4 must be considered in addition to the following STO guidelines for any User Mounted Board (UMB).

STO Circuits Zone

- High-voltage & current: Input from the DC power supply and output to motor windings.
- Low-voltage: Signals, Input/Output, communications, motor feedback
- Safety: STO inputs



High Voltage & Current/Low Voltage Diagram

The High Voltage & Current/Low Voltage diagram shows the traces from the EZ board as an example of the zones on the UMB that have different rules for spacings, etc.

- Seven high-current traces are used for the +HV, HVCOM, and the Motor U, V, and W outputs.
- Traces used on EZ board are paired on top and bottom layers, connected by vias. This gives a 3 oz, 0.50-inch width combination.

STO Circuits Creepage & Clearance for Outer Layers of PC Boards

- No conformal coating
- Creepage and clearance based on standard IEC 60664-1
- Dominant requirement: Fault Exclusion against short circuits.

Description	Creepage & Clearance
Between adjacent STO circuits	0.200 mm
Between STO circuits and control circuits	0.630 mm
Between STO circuits and chassis	0.200 mm

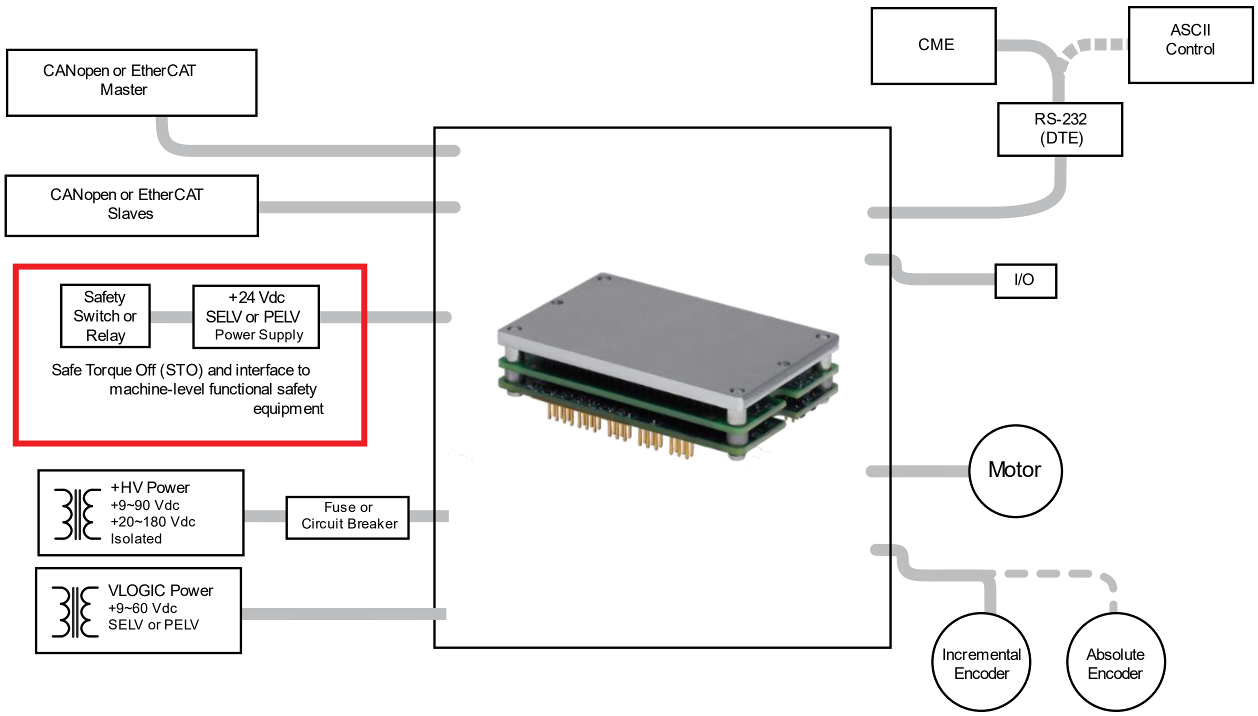
STO Circuits Creepage & Clearance for Inner Layers of PC Boards

- No conformal coating
- Creepage and clearance based on standard IEC 60664-1
- Dominant requirement: Fault Exclusion against short circuits.

Description	Creepage & Clearance
Between adjacent STO circuits	0.200 mm
Between STO circuits and control circuits	0.500 mm
Between STO circuits and chassis	0.200 mm

6.10 Installation Overview

This graphic shows the elements of a complete *AEV & APV* drive installation.
The STO feature and interface to the machine-level functional safety equipment are highlighted in red to emphasize the aspects of the installation that are addressed in this manual.



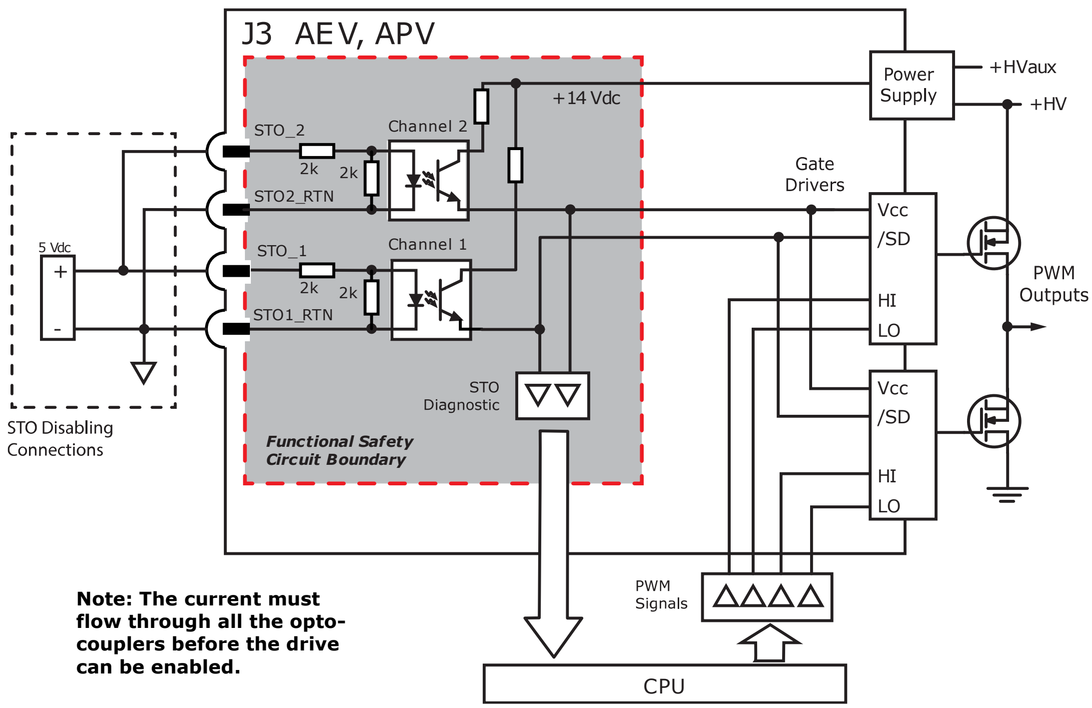
STO Disable

For the PWM outputs of the AEV to be activated, the current must be flowing through the opto-couplers that are connected to the STO_IN1 and STO_IN2 terminals and the drive must be in an ENABLED state. When either of the opto-couplers are OFF, the drive is in a Safe Torque Off (STO) state and the PWM outputs cannot be activated by the control core to drive a motor.

This diagram shows connections that will energize all the opto-couplers from a +5V source. When this is done the STO feature is disabled and control of the output PWM stage is under control of the digital control core.

If the STO feature is not used, these connections must be made for the drive to be enabled.

STO Disable Connections



J3 STO

Signal	Pin		Signal
STO_1	1	3	STO_2
STO1_RTN	2	4	STO2_RTN

STO Operation

STO Input Voltage	STO State
STO-IN1 *AND* STO-IN2 ≥ 3.3 Vdc	STO Inactive. Drive can be enabled to produce torque
STO-IN1 *OR* STO-IN2 ≤ 2.0 Vdc	STO Active. Drive cannot be enabled to produce torque
STO-IN1 *OR* STO-IN2 Open	
Note: Voltages in the above table are referenced between an STO_X and an STOX_RTN. For Example, V(STO_1) = STO_1 – V(STO1_RTN)	

STO Status

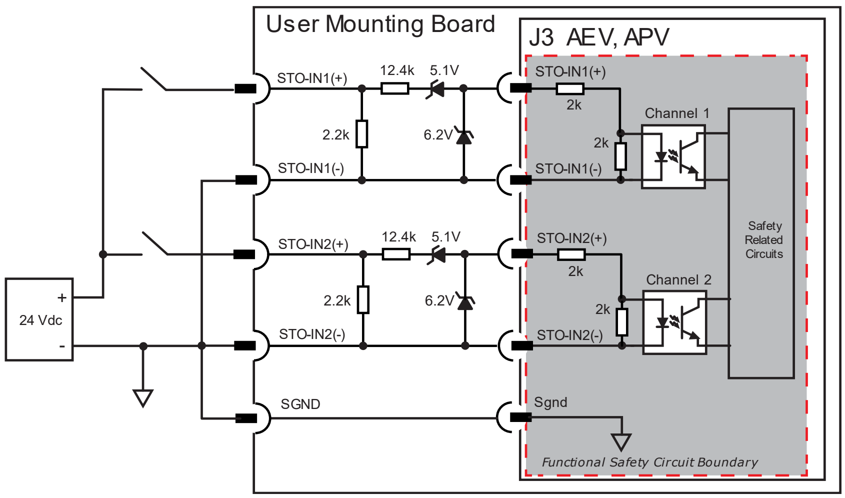
A digital output can be programmed to be active when the drive is disabled by the STO function. The active level of the output is programmable to be HI or LO.

6.11 STO: Installation for AEV & APV Modules

Energizing STO Inputs

This diagram shows the two STO channels that are the essential channels to prevent current flow in the motor when the STO function is activated. These inputs can be driven by either current sourcing or sinking devices.

STO Inputs from 24V Control Signals



Part	PartNum	Qty	Mfgr
Diode, zener, 6.2V, 200mW	DDZ6V2BS-7	2	Diodes Inc
Diode, zener, 5.1V, 500mW	DDZ5V1BSF-7	2	Diodes Inc
Resistor, 6.19 k, 0.4 W, 1%	ESR10EZPF6191	4	Rohm Semiconductor
Resistor, 2.2 k, 2 W, 1%	RHC2512FT2K20	2	Stackpole Electronics

Note: The 12.4k resistors in the graphic represent the 6.19k resistors in the table.

STO Power Requirements

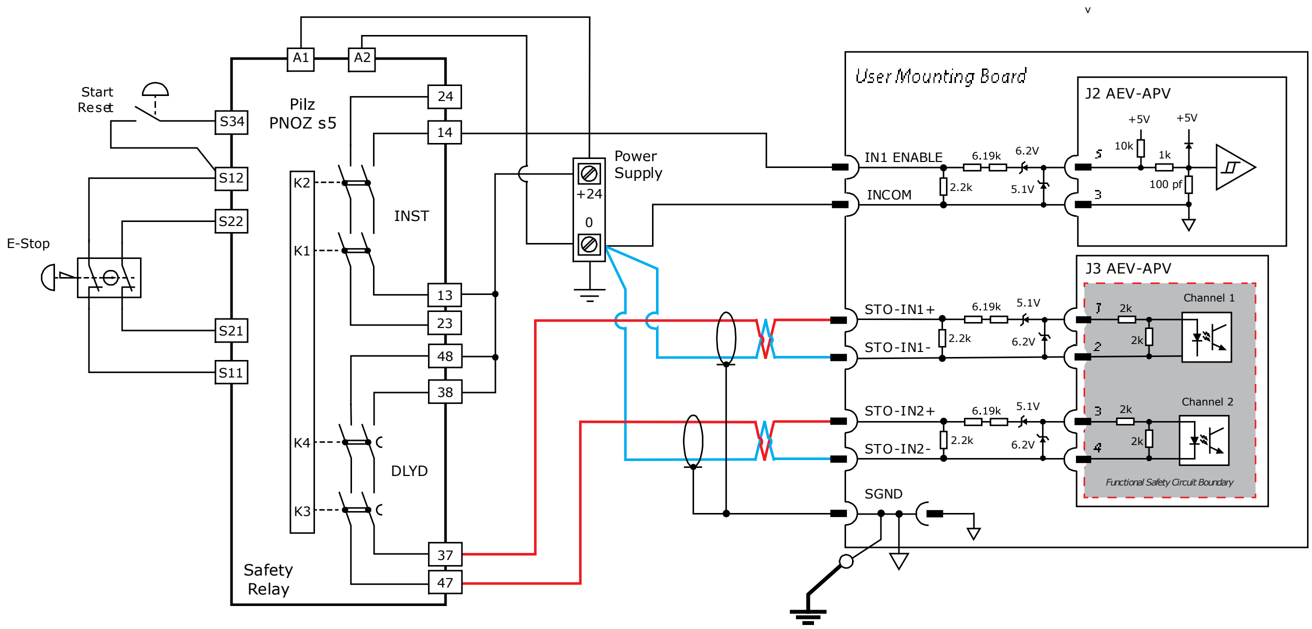
The +24 Vdc power supply for the STO inputs must be SELV or PELV rated. (refer to Section 6.4).

STO Wiring Requirements

Electrical connections to the STO inputs must meet the requirements for fault exclusions for short circuits between conductors and short circuits between conductors and other conductive parts or earth or the protective bonding conductor. These requirements are given in ISO 13849-2 and IEC 61800-5-2.

When driven from a single +24 Vdc power supply, the STO inputs must be connected in parallel as shown above. Driving the STO inputs in series would require a higher voltage than the nominal +24 Vdc, and if one of the STO inputs or its wiring were to fail as a short-circuit, it would apply the full DC power to a single input.

Example Wiring Diagram (SIL 3 and Cat. 3 PL e STO Implementation)



Emergency Stop: Stopping Category 1

In the above graphic, it shows a wiring example for implementing a SIL 3, Cat. 3 PL e emergency stop function using an AEV & APV drive. The example shows a safety relay with two sets of output contacts – one set (K1, K2) reacts immediately to changes on the safety relay inputs and the other set (K3, K4) reacts after a user-programmable delay. A double pole, single throw E-stop switch is used to drive two independent inputs to the safety relay.

A momentary switch is wired to the safety relay reset input and it is used to reset the relay at start-up and after an E-stop event. The enable input on the drive is wired to one of the immediate response contacts.

The drive is programmed such that when this input is de-energized, the drive decelerates the motor speed in a controlled fashion. After the user-programmed delay time, contacts K3 and K4 open and de-energize the STO inputs to the drive. The drive STO function responds accordingly, and the safe state is entered within the specified drive STO response time. This type of implementation brings the motor speed to near zero before the STO function is activated. It is important to note that the safe state is not entered immediately upon actuation of the E-stop button. The safe state is entered only after the STO inputs have become de-energized and the specified STO response time has elapsed.

This table shows the components needed on the User Board as shown in the above Example Wiring Diagram.

Part	PartNum	Qty	Mfgr
Diode, zener, 6.2V, 200mW	DDZ6V2BS-7	3	Diodes Inc
Diode, zener, 5.1V, 500mW	DDZ5V1BSF-7	3	Diodes Inc
Resistor, 6.19 k, 0.4 W, 1%	ESR10EZPF6191	6	Rohm Semiconductor
Resistor, 2.2 k, 2 W, 1%	RHC2512FT2K20	3	Stackpole Electronics

Note Important:

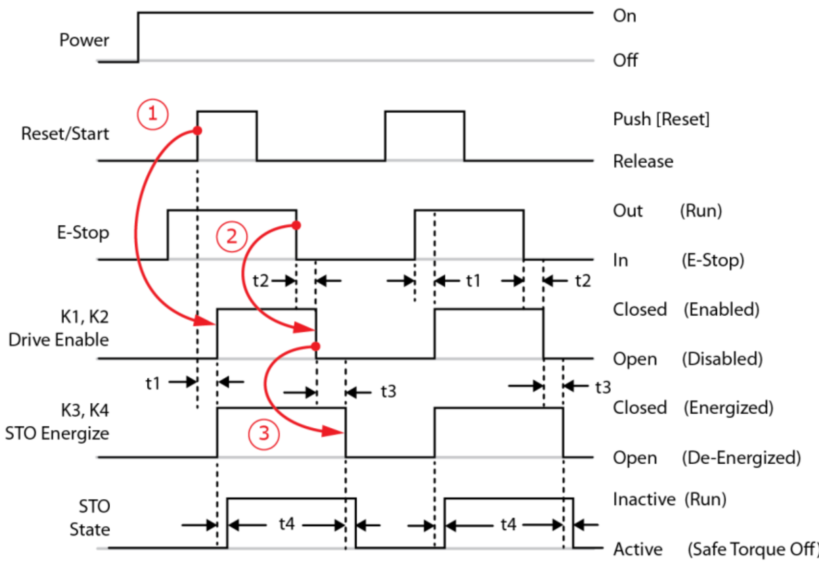
The locations of the Zener diodes for the IN1 channel are different than the locations of the diodes for the STO-IN1 and STO-IN2 channels.

AEV & APV Configuration

[IN1] is shown as the input for the Enable function. The [INCOM] signal for [IN1] connects to ground.

When +24 Vdc is applied to [IN1], it will enable the AEV & APV if no other inputs are configured as Enables and no Enable inputs are inactive. If more than one input is configured as Enable, then all inputs must be active to enable the drive. The PNOZ relay uses both contacts of the delayed relay for two-channel control of the STO function, which is necessary for SIL 3, Cat. 3 PL e.

Example STO Timing



Terms	Description
Power	+24 VDC supplied to the safety relay.
Reset/Start	Momentary push-button that causes the K1~K2 relay contacts to close, supplying power to the STO inputs of the drive, and de-activating the STO function. This allows the drive to produce torque/force in the motor when it is enabled.
E-Stop	The latching push-button switch inputs to the safety relay. The HI level of this indicates that the button has been released, opening the NC (Normally Closed) contacts.
K1, K2	The instantaneous contacts in the relay. A HI level indicates that the contacts are closed, supplying power to an Enable input of the drive to place it in an enabled state.
K3, K4	Relay contacts that will open after a pre-set time delay. This allows time for the drive to remain in an enabled state, while it performs a controlled deceleration that brings the motor to a standstill before the STO function is activated, preventing any torque/force production in the motor.
t1	Switch-on delay. If the E-Stop button is out, this is the delay after the Reset/Start button is pressed in and the K1~K4 relay contacts close, deactivating the STO function and enabling the drive (1).
t2	Delay-on de-energization. When the E-Stop button is pressed in (E-Stop), this is the delay to the opening of the K1~K2 contacts which disables the drive initiating a controlled deceleration of the motor (2).
t3	Waiting period. This is the time-delay that allows for the controlled deceleration of the motor. When the E-Stop button is pressed in, this is the time delay to the K3~K4 contact opening which will activate the STO (3).
t4	STO response time. This is the time between the de-energizing of the drive STO inputs (K3~K4 contacts open) and the entry into the safe-state.

Start-Up Checklist

Proper operation of a safety function must be validated at various points in the product lifetime of the end-use machine.
Validation tests, in accordance with the checklist given in Table 15, must be conducted by an authorized person experienced in the functional safety of machines. Validation tests must be conducted.

Check √	Requirement
☐	At initial installation and start-up of the safety function.
☐	After any changes related to the safety function (wiring, components, settings, etc.).
☐	After any maintenance work related to the safety function.
☐	At the required periodic test intervals.

Preliminary checks

Before powering the drive, and commencing with the functional safety tests, check:

Check √	Requirement
☐	Specifically ensure that proper grounding, shielding, overcurrent, and overvoltage protection measures are in place in regard to electrical safety and electromagnetic compatibility.
☐	That the wiring between the machine level safety circuits and the drive STO inputs meets the requirements set forth in this manual and those in IEC 61800-5-2 and ISO 13849-1 for wiring-associated fault exclusions.
☐	That the motor and associated load is free to move.
☐	That any other safety measures or warnings needed to ensure safe execution of periodic tests are in place.

Start-Up Checklist

Chk √	Requirement	Comments	Initials
☐	Ensure that the drive can be run and stopped freely during the commissioning.		
☐	Stop the drive (if running), and safely remove +HV power from the drive.		
☐	Check the STO-IN1 and STO-IN2 circuits and connections against a wiring diagram.		
☐	Apply +HV mains power to the drive. Energize both the STO-IN1 and STO-IN2 circuits.		
☐	Test the operation of the STO-IN1 function when the motor is stopped. Give a stop command for the drive (if running) and wait for the motor to come to a standstill. While keeping STO-IN2 energized, de-energize the STO-IN1 circuit and give a start command for the drive. Ensure that the motor remains at a standstill. Then, energize the STO-IN1 circuit.		
☐	Test the operation of the STO-IN2 function when the motor is stopped. Give a stop command for the drive (if running) and wait for the motor to come to a standstill. While keeping STO-IN1 energized, de-energize the STO-IN2 circuit and give a start command for the drive. Ensure that the motor remains at a standstill. Then, energize the STO-IN2 circuit.		
☐	Restart the drive and check that the motor runs normally		
☐	Test the operation of the STO-IN1 function when the motor is running: Start the drive and ensure that the motor is running. While keeping STO-IN2 energized, de-energize the STO-IN1 circuit. Ensure that the motor stops. Reset any latching fault that may have occurred (these depend on the drive's control mode settings). Try to start the drive. Ensure that the motor stays at a standstill. Energize the STO-IN1 circuit		
☐	Test the operation of the STO-IN2 function when the motor is running: Start the drive and ensure that the motor is running. While keeping STO-IN1 energized, de-energize the STO-IN2 circuit. Ensure that the motor stops. Reset any latching fault that may have occurred (these depend on the drive's control mode settings). Try to start the drive. Ensure that the motor stays at a standstill. Then, energize the STO-IN2 circuit		
☐	Restart the drive and ensure that the drive and motor operate normally.		

STO Status Indications

Although they are not and must not be considered part of the safety function, indications of the STO status are available from the AEV & APV drive for convenience purposes. Specifically, two user-accessible data objects bits, and the CME Control Panel provide some information on STO status. The data objects and CME are not part of the drive safety function.

STO Circuit Status Data Objects

The AEV & APV have a variety of data objects that can be read by the end user via EtherCAT, or serial communications. The status of the STO circuit is available in DS-402 parameter 0x219D (ASCII parameter 0x139). Bits-0 & 1 show the status of the STO-IN1 and STO-IN2 inputs. Bit-8 has no function in the AEV & APV. In 0x2183 (ASCII 0xA4), bit-14 is latched when the STO function is active, and it will remain set until the user clears it.

Bit	Safety Circuit Status 0x219D
0	Set (1) when STO-IN1 is active and preventing the drive from producing torque
1	Set (1) when STO-IN2 is active and preventing the drive from producing torque
Bit	**Latching Fault Status Register 0x2183**
14	Set (1) when STO function is active and preventing the drive from producing torque

Troubleshooting

The status of the STO function in the AEV & APV servo drives can be viewed via data objects accessible over CANopen or EtherCAT connections, or by using the configuration software CME. Other Copley software products such as CMO (Copley Motion Objects), CML (Copley Motion Libraries), CPL (Copley Programming Language) and ASCII communications can read the status of the STO function.

Note: The data parameters are not part of the drive safety function. They are used for information only and cannot be relied upon for any safety related functions of the user.

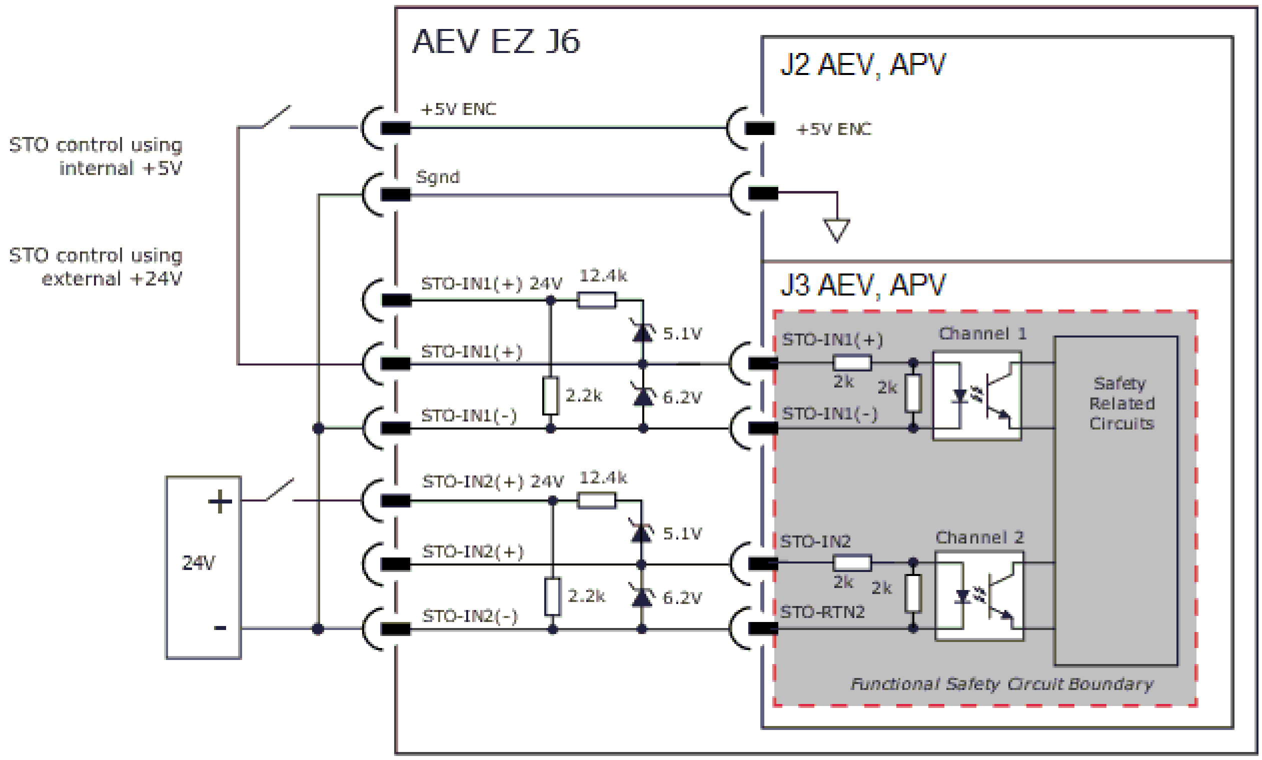
Condition	Troubleshooting Causes
How to tell if the STO function is active.	• The voltage to one or both STO channels in the drive is < 2.0 Vdc or open. • Bit-0 OR bit-1 of ASCII parameter 0x139 (DS-402 0x219D) is set (1). • Bit-6 of the DS-402 Status Word 0x6041 will be set (1) indicating a switch-on-disabled state. This bit is controlled by any input that is programmed for the Enable function, and by the STO function. When bit is set (1), then it is necessary to check 0x219D (ASCII 0x139) to verify if bit-0 or bit-1 is set (1). If this condition is true, then the STO function is active.
How to tell if the STO function is inactive.	• The voltage applied to both STO inputs of the drive is ≥ 3.3 Vdc (wired in parallel). • Bit-0 AND bit-1 of ASCII parameter 0x139 (DS-402 0x219D) are zero. • Bit-2 of the CANopen Status Word 0x6041 (Axis A) or 0x6841 (Axis B) is set (1) indicating a hardware-enabled state. • The drive cannot be hardware-enabled until all inputs programmed as Enable inputs are true AND the bits-0 AND bit-1 in the STO function status parameter (0x219D) are zero.
Why can’t the STO function be deactivated?	• The voltage between STO_1 and STO1_RTN is < 2.0 Vdc OR the voltage between STO_2 and STO2_RTN is < 2.0 Vdc, both voltages must be ≥ 3.3 Vdc to deactivate the STO function.
Why can’t the STO function be activated?	• The voltage between STO_1 and STO1_RTN is > 3.3 Vdc AND the voltage between STO_2 and STO2_RTN is > 3.3 Vdc. One or both voltages must be < 2.0 Vdc to activate the STO function.
The drive is hardware-enabled but the motors don’t move.	• The STO function may be active. Check the object 0x219D to verify if either bit-0 OR bit-1 is set (1). If either of bits-0 or bit-1 are set, or if both are set, then the STO function will be activated.

6.12 STO: Installation for AEZ & APZ Modules

The following modules are soldered into the EZ boards to make a single assembly.

• AEZ-090-50 and APZ-090-50

For AEV and APV modules that plug into the EZ boards, the connections are the same. The design of the EZ board adds components to provide STO inputs that are 24 Vdc compatible in addition to 5 Vdc STO inputs that are also brought out. The graphic below shows wiring for both +5 and +24 Vdc connections.



WARNING	**Warranty Requirements for Repair and Replacement Parts**
	There are no user-replaceable parts in the AEV & APV. The warranty will be void if the user attempts any repairs. For safety and to assure compliance with the documented system data, only Copley Controls shall perform repairs to the AEV & APV.

Periodic STO Testing Interval

To meet SIL 3 and/or Cat. 3 PL e performance of the Safety Function, periodic diagnostic testing is required to be performed every 3 months, per IEC 61800-5-2. The AEV and APV drives have internal diagnostics testing software to verify the function of the STO circuits every 24 hours. If a fault is detected, the AEV & APV drive shall be put into a Safe State until the fault is cleared. The internal diagnostics testing software of the AEV & APV products fulfills this requirement without intervention of the operator.

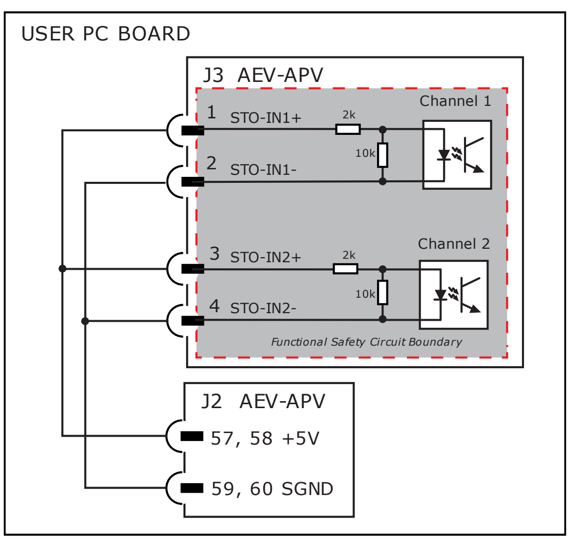
Disabling & Suspension of Safety Functions: STO Disabling

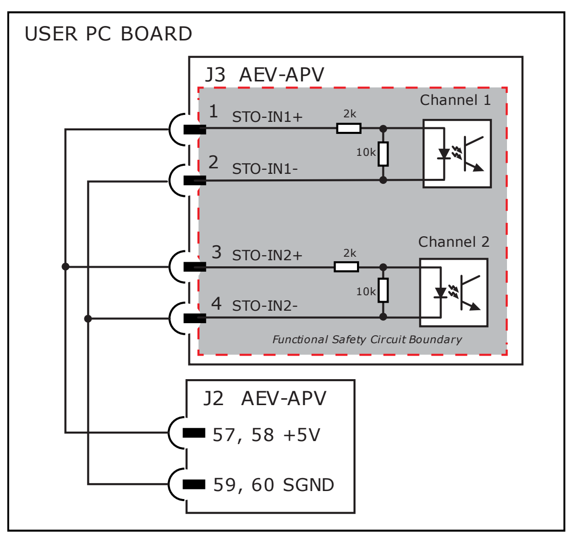
Disabling (bypassing) means de-activating the STO function. A convenient method for disabling the STO function is shown here for those installations that do not use the STO function.

An internal power source in the drive is brought out to the Safety connector. Connecting the STO inputs between this bypass power source and ground supplies power to the STO opto-couplers, energizing them, and enabling the PWM outputs to be controlled by the drive. The figure below shows the connections to either mute the STO function permanently, or to bring it out to a connector so that the user can wire it into their system.

STO Disabling Connections: AEV & APV

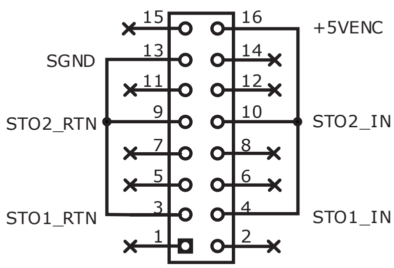
These figures show the disabling connections for two configurations. The figure on the left brings the disabling connections out to the user on their mounting board to give them access to the STO feature. The figure on the right shows the disabling connections made permanently on the user board for applications that do not use the STO function.

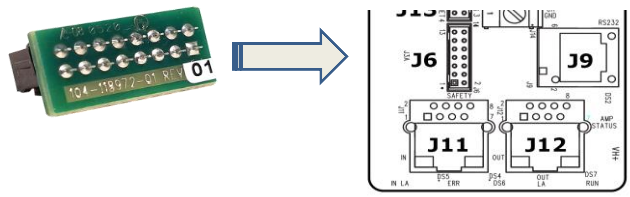




STO Disabling AEZ & APZ with AEV-EZ-STO

The AEV-EZ-STO accessory, when inserted into J6 of the AEZ or APZ models will disable the STO function, allowing normal operation of the drive when the STO function is not required. As shown below, the STO inputs are energized in parallel using the encoder +5V from the drive.





AEV-EZ-STO

Decommissioning

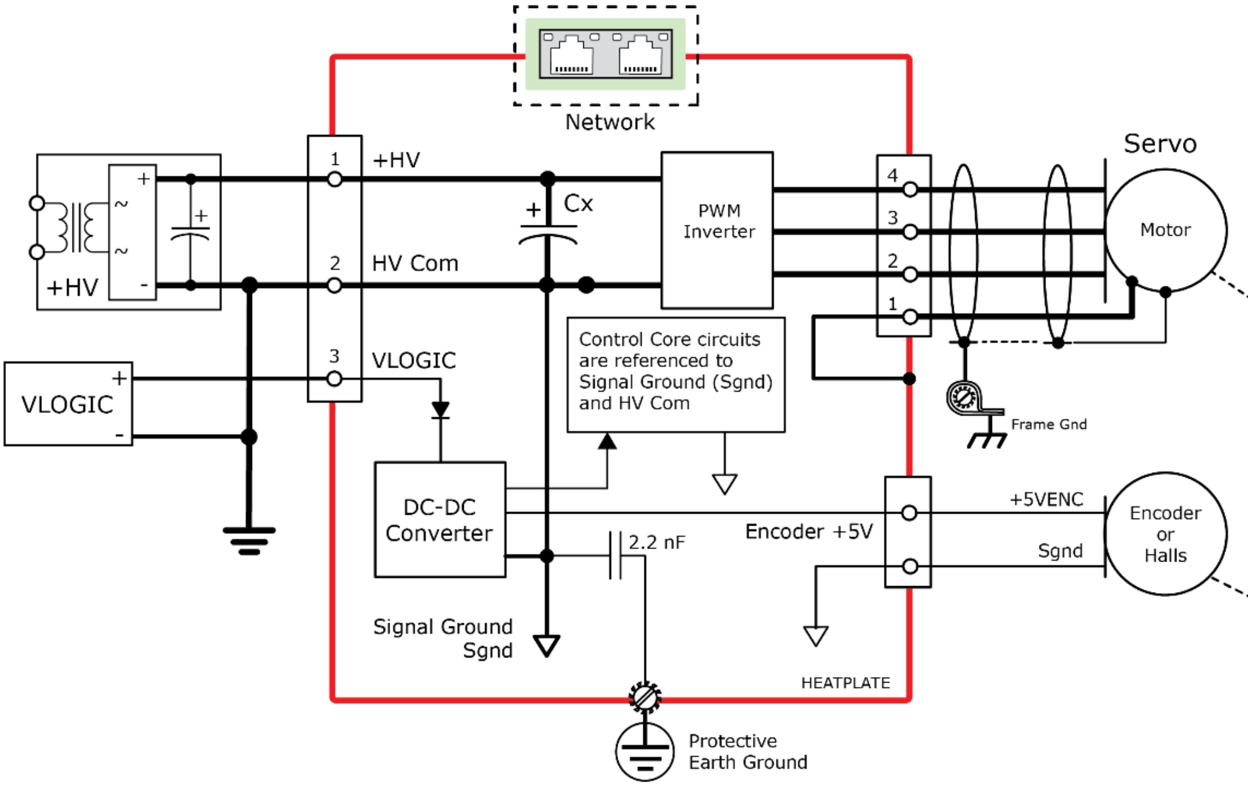
Before decommissioning any safety system from active service, do the following:

- Evaluate the impact of decommissioning on adjacent operating units and facilities or other field services.
- Conduct a proper review and obtain required authorization.
- Ensure that the safety functions remain appropriate during decommissioning activities.
- Implement appropriate change management procedures for all decommissioning activities.

7 Operational Theory

7.1 Drive Input Power

Power distribution within Accelnet Plus Micro Modules has a common ground which is isolated from the heat plate. The CANopen and EtherCAT network signals are isolated from all the drive circuits.



VLOGIC Power

An internal DC/DC converter operates from the VLOGIC input and creates the logic/signal operating voltages. This enables the drive to stay on-line when the +HV power has been disconnected for emergency-stop or operator-intervention conditions. Network and serial communications remain active so that the drive can be monitored by the control system when the +HV is removed. The control core, feedback devices, and network connections are all maintained by the VLOGIC power so that the system controller has visibility of the drive status, motor position, I/O states, etc. When the +HV is 60 Vdc or less it, and the VLOGIC can be driven from a single power supply. When using the STO feature, the VLOGIC must be produced by a power supply with transformer isolation from the mains, PELV or SELV rating, and a maximum output voltage of 60 Vdc.

+HV Power

The +HV input drives the high-voltage PWM outputs. When this is not connected to the VLOGIC input, the full range of rated voltages can be used.

7.2 Commutation Modes

The drives support three commutation modes to drive brush and brushless motors:

- AC brushless sinusoidal: U-V-W PWM outputs are sinusoidal with 120 degrees of separation
- DC brushless trapezoidal: U-V-W PWM outputs DC values at 60-degree increments
- DC brush: U-V outputs are DC values from the maximum positive and negative ratings

In most applications, sinusoidal commutation is preferred over trapezoidal, because it reduces torque ripple and offers the smoothest motion at any velocity or torque. In the sinusoidal commutation mode, an encoder is required for brushless sinusoidal commutation. Halls are sufficient for trapezoidal commutation. When driving a DC brush motor, the drive operates as a traditional H-Bridge drive. All the commutation modes are used to produce current in the motor resulting in acceleration of a load.

7.3 Feedback

All the Accelnet Plus Micro Module drives support digital quadrature encoders, analog Sin/Cos encoders, and a variety of absolute encoder formats. They typically use Hall sensors for the commutation of brushless motors when incremental encoders are used. Without Halls, algorithmic phase initialization (aka 'wake 'n shake') occurs when the drive is first enabled. Absolute encoders can be auto-phased using CME and the results saved in the drives flash memory, eliminating the need for Halls. Brush motors are self-commutating and do not require feedback for torque production.

7.4 Synchronization

Using EtherCAT, the distributed clock feature can be used to establish PWM switching frequency synchronization among the network connected drives. Typically, one drive acts as the Sync 0 reference clock. The master then adjusts the Sync 0 frequency and phase in the slaves to so that they are all in-sync.

Over CANopen, one drive produces a Sync message that carries a high-resolution time-stamp. The other drives on the network receive the Sync message and adjust their internal clocks so that all the drives on the network have their PWM frequencies synchronized.

7.5 Input Command Types

The drive can be controlled by a variety of external sources: analog voltage or digital inputs, CAN network (CANopen), EtherCAT, CoE (CANopen application protocol over EtherCAT), or from an RS-232 serial connection using ASCII commands. The drive can also function as a stand-alone motion controller running an internal CVM or CPL program or using its internal function generator.

Analog Command Input

Overview

The drive can be driven by an analog voltage signal through the analog command input which has a range of ±10 Vdc. The drive converts the signal to a current, velocity, or position command as appropriate for current, velocity, or position mode operation, respectively. The analog input signal is conditioned by the scaling, dead band, and offset settings.

Scaling

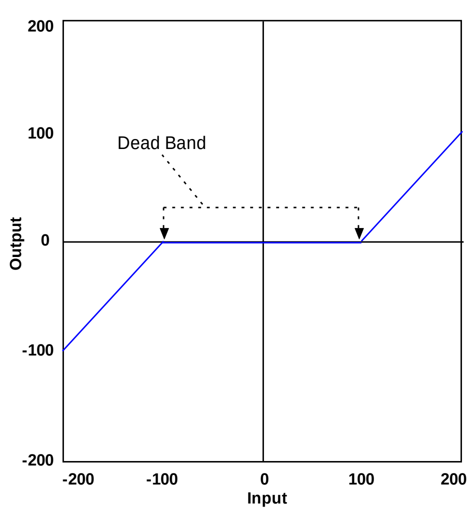
The magnitude of the command generated by an input signal is proportional to the input signal voltage. Scaling controls the input-to-command ratio, allowing the use of an optimal command range for any given input voltage signal range.

For example, in current mode, with default scaling, +10 Vdc of input generates a command equal to the drive's peak current output; +5 Vdc equals half of that.

Scaling could also be useful if, for example, the signal source generates a signal range between 0 and +10 Vdc, but the command range only requires +7.5 Vdc of input. In this case, scaling allows the drive to equate +7.5 Vdc with the drive's peak current (in current mode) or maximum velocity (in velocity mode), increasing the resolution of control.

Dead Band

To protect against unintended response to low-level line noise or interference, the drive can be programmed with a "dead band" to condition the response to the input signal voltage. The drive treats anything within the dead band ranges as zero and subtracts the dead band value from all other values. For instance, with a dead band of 100 mV, the drive ignores signals between –100 mV and +100 mV, and treats 101 mV as 1 mV, 200 mV as 100 mV, and continues on.



Offset

To remove the effects of voltage offsets between the controller and the drive in open loop systems, CME provides an Offset parameter and a Measure function. The Measure function takes 10 readings of the analog input voltage over a period of approximately 200 ms, averages the readings, and then displays the results. The Offset parameter allows the user to enter a corrective offset to be applied to the input voltage.

The offset can also set up the drive for bi-directional operation from a unipolar input voltage. An example of this would be a 0 to +10 Vdc velocity command that had to control 1000 rpm CCW to 1000 rpm CW. Scale would be set to 2000 rpm for a +10 Vdc input and Offset set to -5V. After this, a 0 Vdc input command would be interpreted as -5 Vdc, which would produce 1000 rpm CCW rotation. A +10 Vdc command would be interpreted as +5 Vdc and produce 1000 rpm CW rotation.

Monitoring the Analog Command Voltage

The analog input voltage can be monitored in the CME control panel and oscilloscope. The voltage displayed in both cases is after both offset and deadband have been applied.

Analog Command in Position Mode

The Accelnet Analog Position command operates as a relative motion command. When the drive is enabled the voltage on the analog input is read. Then any change in the command voltage will move the axis a relative distance, equal to the change in voltage, from its position when enabled.

To use the analog position command as an absolute position command, the drive must be homed every time it is enabled. The Homing sequence may be initiated by CAN, ASCII serial, CVM or CPL Indexer program commands.

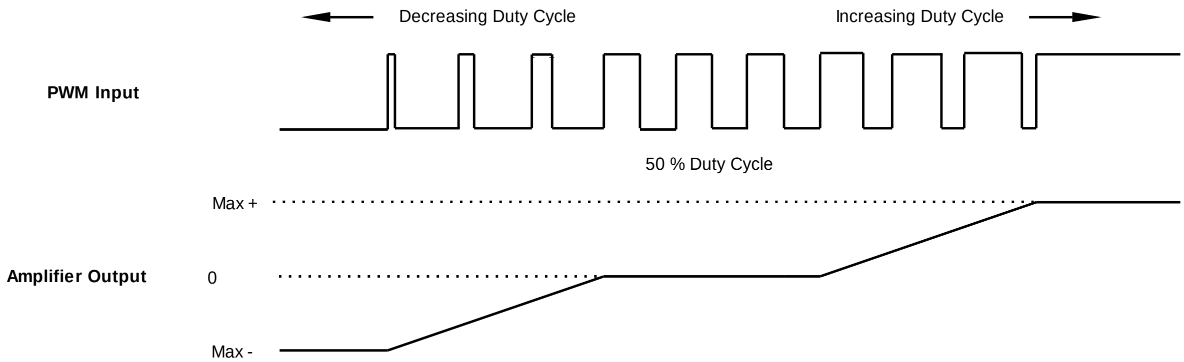
PWM Input Commands

Two Formats

The drive can accept a pulse width modulated signal (PWM) signal to provide a current command in current mode and a velocity command in velocity mode. The PWM input can be programmed for two formats: 50% duty cycle (one-wire) and 100% duty cycle (two-wire).

50% Duty Cycle Format (One-Wire)

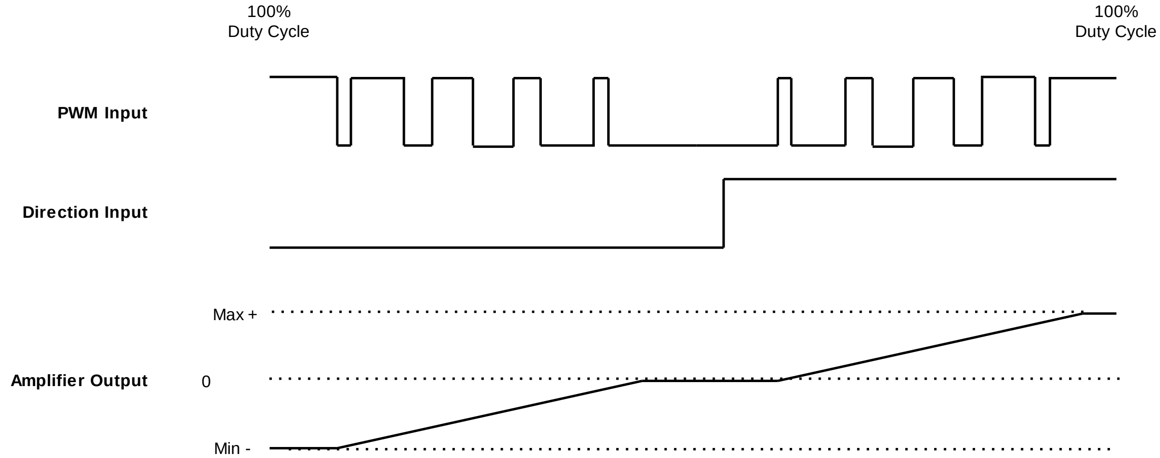
The input takes a PWM waveform of fixed frequency and variable duty cycle. As shown below, a 50% duty cycle produces zero output from the drive. Increasing the duty cycle toward 100% commands a positive output and decreasing the duty cycle toward zero commands a negative output.



The command can be inverted so that increased duty cycle commands negative output and vice versa.

100% Duty Cycle Format (Two-Wire)

One input takes a PWM waveform of fixed frequency and variable duty cycle, and the other input takes a DC level that controls the polarity of the output. A 0% duty cycle creates a zero command, and a 100% duty cycle creates a maximum command level. The command can be inverted so that increasing the duty cycle decreases the output and vice versa.



Protection from 0 or 100% Duty Cycle Commands

In both formats, the drive can be programmed to interpret 0 or 100% duty cycle as a zero command. This prevents the 0% or 100% commands that would result from a controller failure or a cable break which could result in the input pulled up to +5V or pulled-down to Signal Ground (0V).

Digital Input Commands

Three Formats

In the position mode, the drive can accept position commands via two digital inputs, using one of these signal formats: pulse and direction, count up/count down, and quadrature.

In all three formats, the drive can be configured to invert the command.

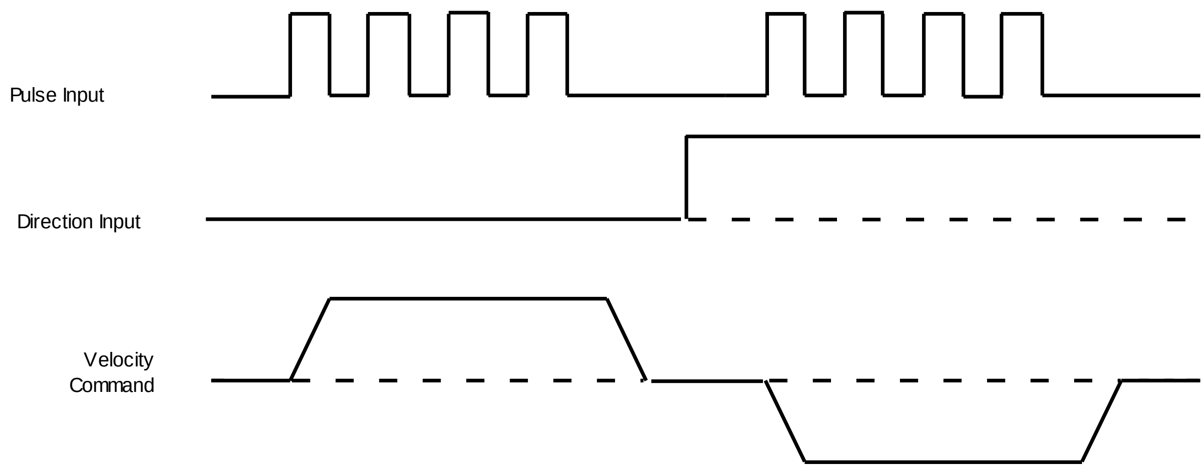
Pulse Smoothing

In the position mode, the drive's trajectory generator ensures smooth motion even when the command source cannot control the acceleration and the deceleration rates.

When using digital or analog command inputs, the trajectory generator can be disabled by setting the Max Accel limit to zero. (Note that when using the CAN bus, serial bus, EtherCAT, or CVM Control Program, setting Max Accel to zero prevents motion.)

Pulse and Direction Format

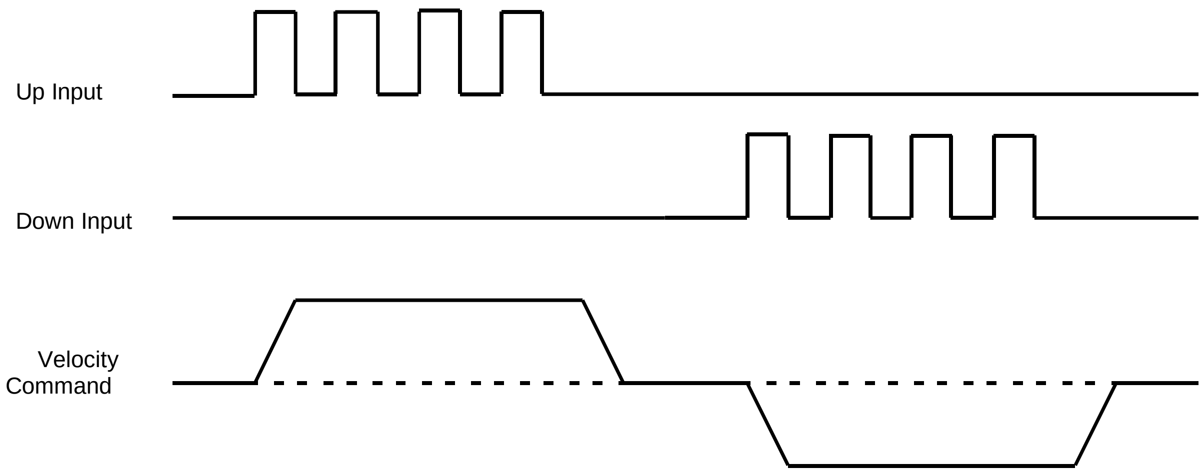
In the pulse and direction format, one input takes a series of pulses as the motion step commands, and another input takes a high or low signal as the direction command, as shown below.



The drive can be set to increment position on the rising or falling edge of the signal. Stepping resolution can be programmed for electronic gearing.

Count Up/Count Down Commands

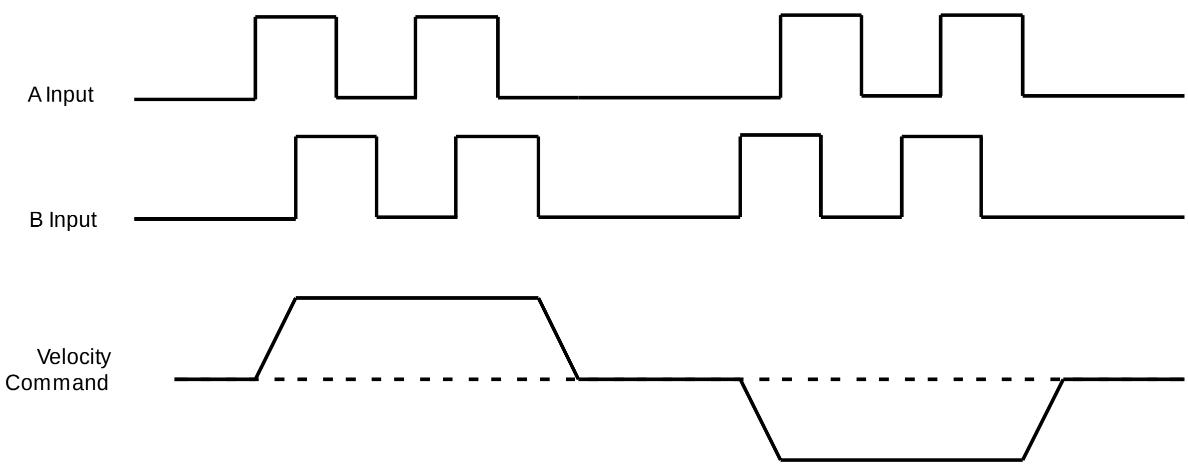
In the count up/down format, one input takes each pulse as a positive step command, and another takes each pulse as a negative step command, as shown below.



The drive can be set to increment position on the rising or falling edge of the signal. Stepping resolution can be programmed for electronic gearing.

Quadrature Format Commands

In the quadrature format, A/B quadrature commands from a master encoder (via two inputs) provide velocity and direction commands, as shown below.



The ratio can be programmed for electronic gearing.

7.6 Communications

The drives support multiple communication interfaces, each used for different purposes.

Interface	Description
EtherCAT (AEV, AEZ)	Drives support CANopen application protocol over EtherCAT (CoE) via a 100BASE-TX physical layer.
CAN interface (APV, APZ)	When operating as a CAN node, the drive takes command inputs over a CANopen network. CAN communications are described in the next section.
RS-232 Serial	The RS-232 port is a three-wire, DTE, full-duplex port. Control commands can be sent over the RS-232 port using Copley Controls ASCII interface commands. In addition, CME software communicates with the drive (using a binary protocol) over this link for drive commissioning, adjustments, and diagnostics. Note that CME can be used to make adjustments even when the drive is being controlled over the CAN interface or by the digital inputs.

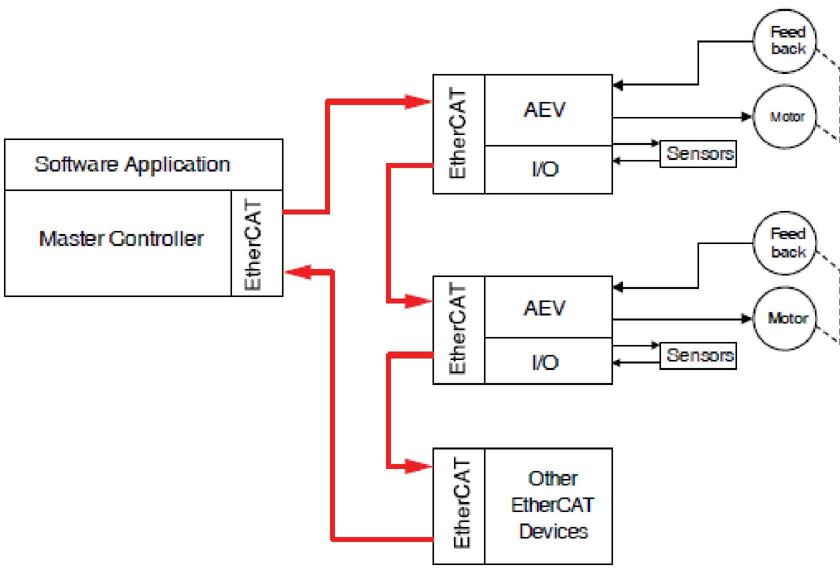
DANGER	**CME Restrictions: Using CME can affect or suspend CAN operations.** When operating the drive as a CANopen node, using the CME to change the drive parameters can affect the CANopen operations in progress. Using CME to initiate motion can cause CANopen operations to suspend. The operations may restart unexpectedly when the CME move is stopped. **Failure to heed this warning can cause equipment damage, injury, or death.**

EtherCAT Communication Details (AEV, AEZ)

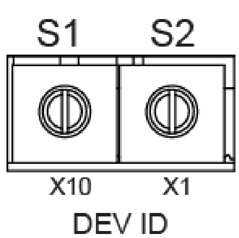
These models accept CANopen application protocol over EtherCAT (CoE) commands.

EtherCAT Addressing

EtherCAT supports two types of addressing nodes on the network: auto-increment and fixed. Nodes on an EtherCAT network are automatically addressed by their physical position on the network. The first drive found on the network is address -1 (0xFFFF). The second drive is -2 (0xFFFE) and continues on. Fixed addresses are assigned by the master when it scans the network to identify all the nodes and are independent of the physical position on the network. Fixed addresses begin with 1001 (0x3E9) and increment thereafter as nodes are found. Each dual axis drive is addressed as a single physical node on the EtherCAT network having two axes of motion.



As an alternate to the default addressing, switches S1 and S2 may be used to program a drive's Device ID, or Station Alias with a value between 0x01 and 0xFF (1-255 decimal). In dual axis drives, the second drive follows the first's Device ID value. Use of a station alias guarantees that a given drive can be accessed absolutely independent of the cabling configuration.



The fixed address and station alias are always available. If the switch-based station alias is used, it is the responsibility of the user to ensure that each drive has a unique station alias.

CAN Communication Details (APV, APZ)

CAN Network and CANopen Profiles for Motion

These drives communicate over a two-wire Controller Area Network (CAN).
The CAN specification defines the data link layer of a fast, reliable network and it is an international standard ISO 11898-1. The physical layer is a two-wire, serial-data connection.

CANopen is the CAN-based higher-layer protocol used for embedded control systems. CiA 402 is the CANopen profile for drives and motion controllers, internationally standardized in IEC 61800-7-201 and IEC 61800-7-301. It is supported by Copley CANopen servo and stepper drives, allowing them to operate in the following modes of operation:

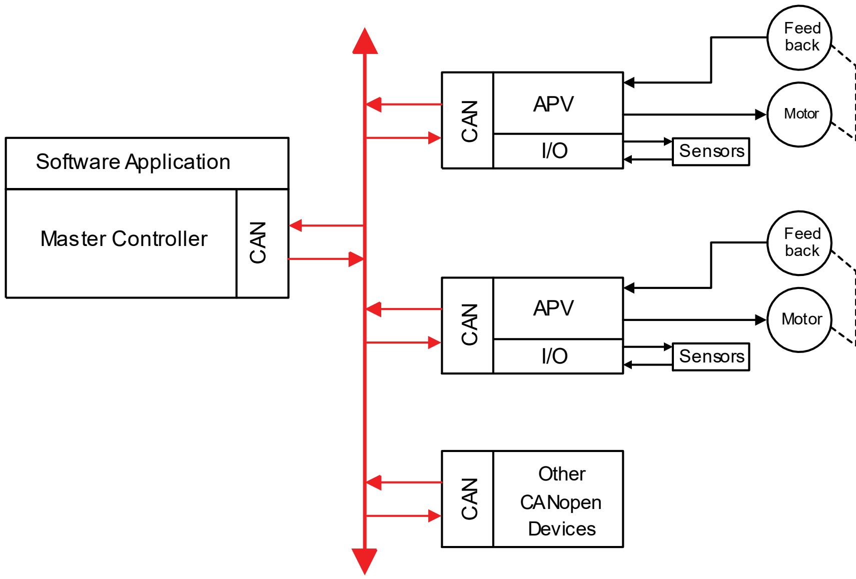
- Profile Position
- Profile Velocity
- Profile Torque
- Interpolated Position
- Homing

Supported CANopen Modes

- **Profile Position: Mode 1**
  The drive is programmed with a velocity, a relative or absolute target position, acceleration, and deceleration rates. On command, a complete motion profile is executed, traveling the programmed distance, or ending at the programmed position. The drive supports both trapezoidal and s-curve profiles.
- **Profile Velocity: Mode 3**
  The drive is programmed with a velocity, a direction, and acceleration and deceleration rates. When the drive is enabled, the motor accelerates to the set velocity and continues at that speed. When the drive is halted, the velocity decelerates to zero.
- **Profile Torque: Mode 4**
  The drive is programmed with a torque command. When the drive is enabled, or the torque command is changed, the motor torque ramps to the new value at a programmable rate. When the drive is halted, the torque ramps down at the same rate.
- **Homing: Mode 6**
  Used to move the axis from an unknown position to a known reference or zero point with respect to the mechanical system. The homing mode is configurable to work with a variety of combinations of encoder index, home switch, and limit switches.
- **Interpolated Position (PVT, or Position, Velocity, Time): Mode 7**
  The controller sends the drive a sequence of points, each of which is a segment of a larger, more complex move, rather than a single index or profile. The drive then uses cubic polynomial interpolation to “connect the dots” so that the motor reaches each point at the specified velocity at the programmed time.

CANopen Architecture

The following diagram shows a CANopen Motion Control System, the control loops are closed in the individual drives, not across the network. A master application coordinates the multiple devices, using the network to transmit commands and receive status information. Each device can transmit to the master or any other device on the network. CANopen provides the protocol for the mapping device and the master internal commands to the messages that can be shared across the network.



CAN Addressing

A CANopen network can support up to 127 nodes. Each node must have a unique and valid seven-bit address (Node ID) in the range of 1-127. Address 0 is reserved for the CAN master and should only be used when the drive is serving as a CME serial port multi-drop gateway.

The graphic above is an example of addressing for two Copley drives as the first two devices on a network that also contains other CAN devices.

There are several methods for setting the CAN address, as described below. These methods can be used in any combination, producing a CAN address equal to the sum of the settings.

Addressing Method	Description
Address switches	If the address number <= 127, CAN address can be set using the CAN ADDR switches only.
Digital inputs	Use the drive's programmable digital inputs (user selects how many (1-7) and which inputs are used).
Programmed value in flash memory	Program the address into flash only.

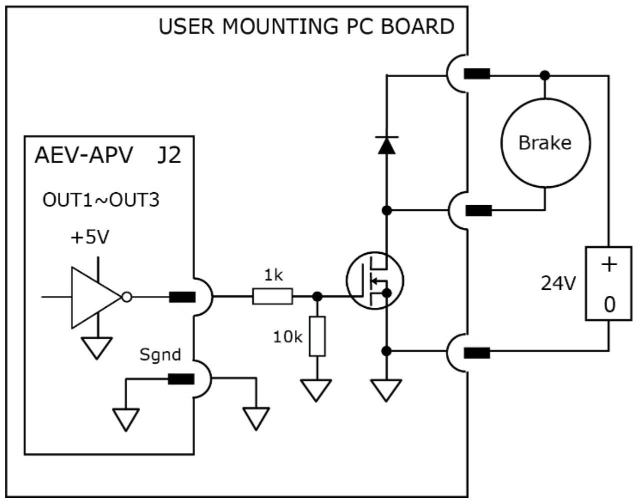
For more information on CAN addressing, see the CME User Guide.
For more information on CANopen operations, see the following Copley Controls documents:

- CANopen Programmer's Manual
- CML Reference Manual
- CMO (Copley Motion Objects) Programmer's Guide

7.7 Brake Operation

Brake Outputs

Many control systems employ a brake to hold an axis when the drive is disabled. Accelnet Plus Micro Module drives have digital outputs that can drive MOSFETs for brake control.

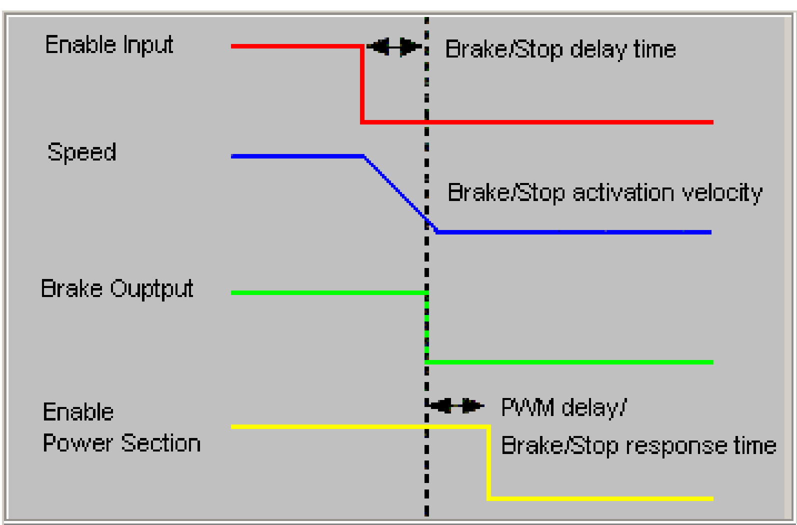


Brake/Stop Sequences

Disabling the drive by a hardware or software command starts the following sequence of events The motor begins to decelerate (at Abort Deceleration rate in position mode or Fast Stop Ramp rate in velocity mode). At the same time, the Brake/Stop Delay Time count begins. This allows the drive to slow the motor before applying the brake.

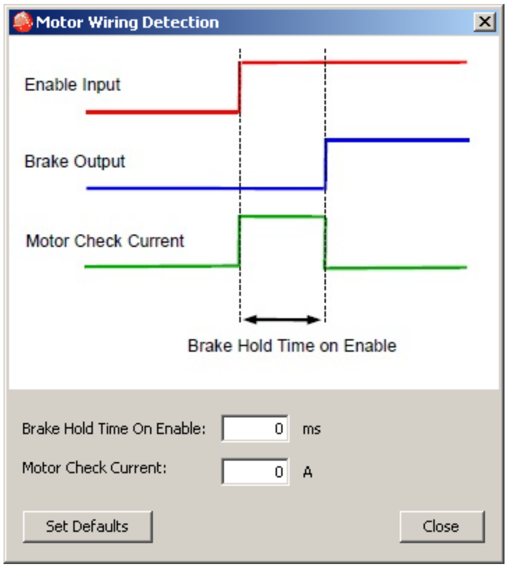
When the motor slows to Brake/Stop Activation Velocity OR the Brake/Stop Delay Time expires, the brake output activates and PWM Delay Brake/Stop Response Time count begins.

When the response time has passed, the drive's output stages are disabled. This delay ensures the brake has time to lock in before disabling the power section.



Motor Wiring Detection

When a brake is in use, the drive can check for a disconnected motor. Upon enable, the drive will apply the current to the motor output while keeping the brake engaged for the Brake Hold Time on Enable. If no current can be detected in the windings, the brake will not be released, and a Wiring Detection Fault will occur. If the motor is connected and the current can be detected, the brake will be released after the programmable time expires.

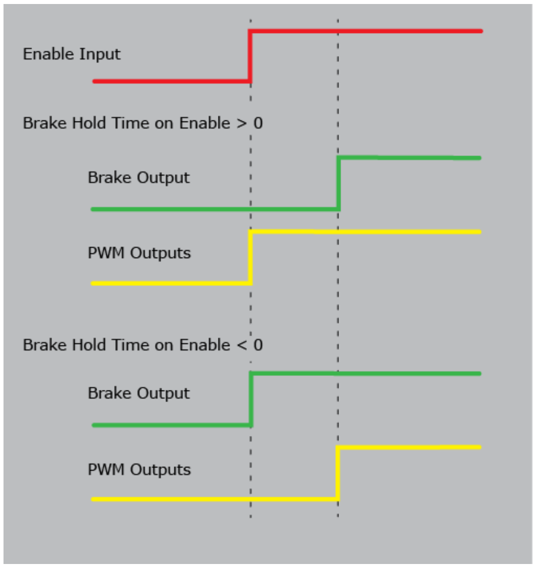


Motor Brake Enable Delay Time

The programmable value in the Motor Wiring Detection also sets the time between the activation of the brake and the PWM outputs of the drive.

- When the value is positive, the PWM outputs will turn on when the drive is enabled, and the brake will be released after the programmable delay expires.
- When the value is negative, the brake is released immediately when the drive is enabled and the PWM outputs are enabled after the programmable delay expires.

The graphic below is not part of CME but shows the timings in the same colors as the Brake Setting screen.



7.8 Protection

Faults Overview

Accelnet Plus Micro Modules detect and respond to a set of conditions regarded as faults, such as Drive Over-Temperature and excessive Following Error. When any fault occurs, except for a Following Error, the drive's PWM output stage is disabled, the fault type is recorded in the drive's internal Error Log (which can be viewed with CME). On the EZ boards, the drive status (AMP) LED changes to indicate a fault condition exists. A digital output can also be programmed to activate on a fault condition. The Following Error Fault behaves with slight differences, as described in Following Error Fault Details.

The drive's PWM output stage can be re-enabled after the fault condition is corrected and the drive faults are cleared. The process for clearing faults varies depending on whether the fault is configured as non-latched or latched. The fault-clearing descriptions below apply to all faults except for the following error fault, which is described in Following Error Fault Details.

Clearing Non-Latched Faults

The drive clears a non-latched fault, without operator intervention, when the fault condition is corrected.

DANGER	**Risk of unexpected motion with non-latched faults.**
	After the cause of a non-latched fault is corrected, the drive re-enables the PWM output stage without the operator intervention. In this case, motion may re-start unexpectedly. Configure faults as latched unless a specific situation calls for non-latched behavior. When using non-latched faults, be sure to safeguard against unexpected motion. **Failure to heed this warning can cause equipment damage, injury, or death.**

Clearing Latched Faults

A latched fault is cleared only after the fault has been corrected and at least one of the following actions has been taken:

- Power-cycle the VLOGIC to the drive.
- Cycle (disable and then enable) an enable input that is configured as *Enable with Clear Faults* or *Enable with Reset.*
- Open the CME Control Panel and press *Clear Faults* or *Reset* buttons.
- Clear the fault over the CAN ot EtherCAT network, or serial bus.

Example: Non-Latched vs. Latched Faults

When the drive temperature reaches the over-temperature level, the drive disables the PWM outputs. The drive temperature then cools into the normal operating range. If the Drive Over Temperature fault is not latched, the fault is automatically cleared and the drive's PWM outputs are re-enabled. If the fault is latched, the fault remains active and the drive's PWM outputs remain disabled until the faults are specifically cleared (as described above).

Fault Descriptions

In the following table, the set of faults is described. For details on limits and ranges, see Fault Levels.

Fault Description	Fault Occurs When the following takes place.	Fault is Corrected When the following is done.
* Short Circuit Detected	Output to output, output to ground, internal PWM bridge fault.	Short circuit has been removed.
* Amp Over Temperature	Drive's internal temperature exceeds specified temperature.	Drive temperature falls below specified temperature.
* Motor Over Temperature	Motor over-temperature switch changes state to indicate an over-temperature condition.	Temperature switch changes back to normal operating state.
Over Voltage	Bus voltage exceeds specified voltage limit.	+ DC bus voltage returns to specified voltage range.
Under Voltage	Bus voltage falls below specified voltage limit.	+ DC bus voltage returns to specified voltage range.
* Feedback error	Over current condition detected on the output of the internal +5 Vdc supply used to power the encoders not connected or levels out of tolerance.	Encoder power returns to specified voltage range. Feedback signals stay within specified levels.
Motor Phasing Error	Encoder-based phase angle does not agree with Hall switch states. This fault can occur only with brushless motors set up using sinusoidal commutation. It does not occur with Halls correction turned off.	Encoder-based phase angle agrees with Hall switch states.
* Following Error	User set following error threshold exceeded.	See Position and Velocity Errors (3.13).
Command Input Fault	Loss of PWM input, or network command data	PWM signals restored, network communications resume
Motor Wiring Disconnected	Used with motor brakes, a programmable time during which current-flow in the motor will be tested before the brake is released. If current is not detected, it is a fault.	Motor current is detected during programmable delay before brake is released to stop the motor.
Over Current (Latched)	Optional: The I2T current-limit for the drive has been reached	Reduce drive current
*Note: The asterisk indicates that it is Configured as latching by default. Programmable to be non-latching.		

7.9 Position and Velocity Errors

Error-Handling Methods

In the position mode, the difference between the limited position output of the trajectory generator and the actual motor position is the position or following error. The drive's position loop uses complementary methods for handling position errors: following error fault, following error warning, and a position-tracking window.

Likewise, in velocity or position mode, any difference between the limited velocity command and actual velocity is a velocity error. The drive's velocity loop uses a velocity tracking window method to handle velocity errors. (There is no velocity error fault).

Following Error Faults

When the position error reaches the programmed fault threshold, the drive immediately faults. (The following error fault can be disabled). For detailed information, see Following Error Fault Details.

Following Error Warnings

When the position error reaches the programmed warning threshold, the drive immediately sets the following error warning bit in the status word. This bit can be read over a CAN or EtherCAT. It can also be used to activate a digital output.

Position and Velocity Tracking Windows

When the position error exceeds the programmed tracking window value, a status word bit is set. The bit is not reset until the position error remains within the tracking window for the programmed tracking time. A similar method is used to handle velocity errors.

For detailed information, see Tracking Window Details.

Following Error Fault Details

Position Error Reaches Fault Level

As described earlier, the position error is the difference between the limited position output of the trajectory generator and the actual position. When the position error reaches the programmed Following Error Fault level, the drive faults (unless the following error fault is disabled.) As with a warning, a status bit is set. In addition, the fault is recorded in the error log. Additional responses and considerations depend on whether the fault is non-latched or latched, as described below.

Drive Response to Non-Latched Following Error Fault

When a non-latched following error fault occurs, the drive drops into velocity mode and applies the Fast Stop Ramp deceleration rate to bring the motor to a halt. The drive PWM output stage remains enabled, and the drive holds the velocity at zero, using the velocity loop.

Resuming Operations After a Non-Latched Following Error Fault

The clearing of a non-latched following error depends on the drive's mode of operation. Issuing a new trajectory command over the CAN bus or the ASCII interface, will clear the fault and return the drive to normal operating condition.

If the drive is receiving position commands from the digital or differential inputs, then the drive must be disabled and then re-enabled using the drive's enable input or though software commands. After re-enabling, the drive will operate normally.

Drive Response to a Latched Following Error Fault

When a latched following error fault occurs, the drive disables the output PWM stage without first attempting to apply a deceleration rate. If a motor brake is in use, the brake output will turn off immediately, engaging the motor brake.

Resuming Operations After a Latched Following Error Fault

A latched following error fault can be cleared using the steps used to clear other latched faults:

- Power-cycle the drive. If VLOGIC HV is used, then both VLOGIC HV and +HV must be turned OFF/ON. If either one is >= 14 Vdc, the drive will not reset.
- Cycle (disable and then enable) an enable input that is configured as *Enable with Clear Faults* or *Enable with Reset.*
- Open the CME Control Panel and press *Clear Faults* or *Reset* buttons.
- Clear the fault over the CANopen or EtherCAT network, or serial bus.

Tracking Window Details

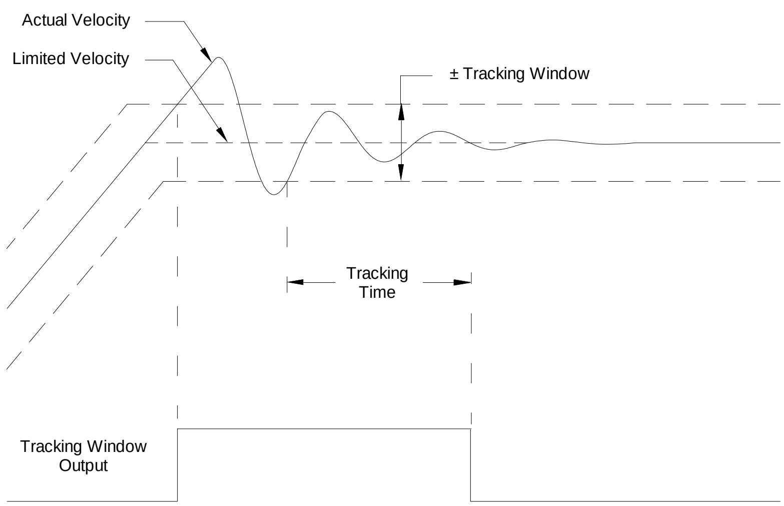
Proper Tracking Over Time

As described earlier, the position error is the difference between the limited position output of the trajectory generator and the actual position. Velocity error is the difference between commanded and actual velocity.

When the position or velocity error exceeds the programmed tracking window value, a status word bit is set. The bit is not reset until the error remains within the tracking window for the programmed tracking time.

Velocity Tracking Illustration

The following diagram illustrates the use of the tracking window and the time settings in velocity mode.



7.10 Digital Inputs

Digital Inputs

All the drives feature 7 programmable digital inputs. IN1~6 are high-speed 3.3 V Schmitt triggers. IN7 is a 5.0 V Schmitt trigger. All are +6 Vdc tolerant and all have 100 ns RC filters.

Debounce Time

To prevent undesired multiple triggering caused by switch bounce upon switch closures, each input can be programmed with a debounce time. The programmed time specifies how long an input must remain stable at a new state before the drive recognizes the state. The debounce time is ignored if the input is used as a digital command input.

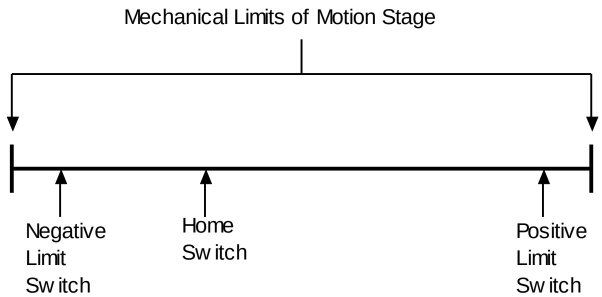
Limit Switches

Use Digital Inputs to Connect Limit Switches

Limit switches help protect the motion system from unintended travel to the mechanical limits. With the drive operating as a CAN or EtherCAT node, an input can also be programmed as a home limit switch for homing operations over the network.

Diagram: Sample Placement of Limit Switches

The following diagram shows these limit switches in use on a sample motion stage.



How the Drive Responds to Limit Switch Activation

The drive stops any motion in the direction of an active limit switch, as described below. The response is identical in current and velocity modes, and slightly different in position mode.

Mode	Drive Response to Active Positive (or Negative) Limit Switch
Current Velocity	Drive prohibits travel in positive (or negative) direction. Travel in the opposite direction is still allowed. Drive status indicator flashes green at fast rate. Warning is displayed on CME Control Panel and CME Control Panel limit indicator turns red.
Position	Drive stops responding to position commands until the drive is disabled and re-enabled, or the fault is cleared over the CANopen interface. Drive status indicator flashes green at fast rate. Warning is displayed on CME Control Panel and CME Control Panel limit indicator turns red. Default behavior: If, after re-enabling the amp, the limit switch is still active, the drive will only allow movement in the opposite direction. "Hold position" behavior: If the *Hold position when limit switch is active option is set, the drive prevents any motion while a limit switch is active. CAUTION: If the drive is switched back to current or velocity mode with this option selected, the limit switches will no longer function. For more information on *Hold position when limit switch is active, see the CME User Guide.

Using Custom Output to Signal Limit Switch Activation

In addition to the response described above, any of the drive's digital outputs can be configured to go active when a positive or negative limit switch is activated.
For more information, see the *CME User Guide*.

7.11 Analog Inputs

The programmable differential analog input AIN1 has a ±10 Vdc range. As a reference input, AIN1 can take position/velocity/torque commands from a controller. The ratio of drive output current or velocity vs. reference input voltage is programmable.

7.12 Outputs

These drives have 6 programmable digital outputs. OUT1~3 are 5 V Schmitt triggers and OUT4~5 are 3.3 V Schmitt triggers.

On the EZ Board and the EZ Development Board, OUT3 is an isolated MOSFET referenced to the 24V Return of the brake connector. The MOSFET drain is connected to the Brake pin of the Brake connector. A flyback diode is connected between the drain of the MOSFET and +24V Input pin of the Brake connector. This provides an internal flyback diode for motor brakes. The brake output (OUT3) is described in Brake Operation.

APPENDIX

I^2T TIME LIMIT ALGORITHM

The current loop I^2T limit specifies the maximum amount of time that the peak current can be applied to the motor before it must be reduced to the continuous limit or generate a fault. This chapter describes the algorithm used to implement the I^2T limit.

I^2T OVERVIEW

The I^2T current limit algorithm continuously monitors the energy being delivered to the motor using the I^2T Accumulator Variable. The value stored in the I^2T Accumulator Variable is compared with the I^2T setpoint that is calculated from the user-entered Peak Current Limit, I^2T Time Limit, and Continuous Current Limit. Whenever the energy delivered to the motor exceeds the I^2T setpoint, the algorithm protects the motor by limiting the output current or generates a fault.

CALCULATING THE I^2T SETPOINT VALUE

The I^2T setpoint value has units of Amperes^2-seconds (A^2S) and is calculated from programmed motor data. The setpoint is calculated from the Peak Current Limit, the I^2T Time Limit, and the Continuous Current Limit as follows:

I^2T setpoint = (Peak Current Limit^2 – Continuous Current Limit^2) * I^2T Time Limit

I^2T ALGORITHM OPERATION

During drive operation, the I^2T algorithm periodically updates the I^2T Accumulator Variable at a rate related to the output current Sampling Frequency. The value of the I^2T Accumulator Variable is incrementally increased for output currents greater than the Continuous Current Limit and is incrementally decreased for output currents less than the Continuous Current Limit. The I^2T Accumulator Variable is not allowed to have a value less than zero and is initialized to zero upon reset or +24 Vdc logic supply power-cycle.

ACCUMULATOR INCREMENT FORMULA

At each update, a new value for the I^2T Accumulator Variable is calculated as follows:

I^2T Accumulator Variable n+1 = I^2T Accumulator Variable n +

((Actual Output Current n+1)^2 – Continuous Current Limit^2) * Update period

After each sample, the updated value of the I^2T Accumulator Variable is compared with the I^2T setpoint. If the I^2T Accumulator Variable value is greater than the I^2T Setpoint value, then the drive limits the output current to the Continuous Current Limit. When current limiting is active, the output current will be equal to the Continuous Current Limit if the commanded current is greater than the Continuous Current Limit. If instead the commanded current is less than or equal to the Continuous Current Limit, the output current will be equal to the commanded current.

I^2T Current Limit Algorithm – Application Example

I^2T Example: Parameters

Operation of the I^2T current limit algorithm is best understood through an example. For this example, a motor with the following characteristics is used:

- Peak Current Limit – 12 A
- I2T Time Limit – 1 S
- Continuous Current Limit – 6 A

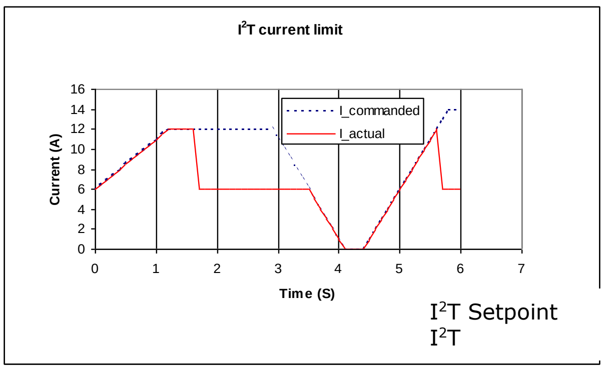
From this information, the I^2T setpoint is:

I^2T setpoint = (12 A^2–6 A^2) * 1 S = 108 A^2S

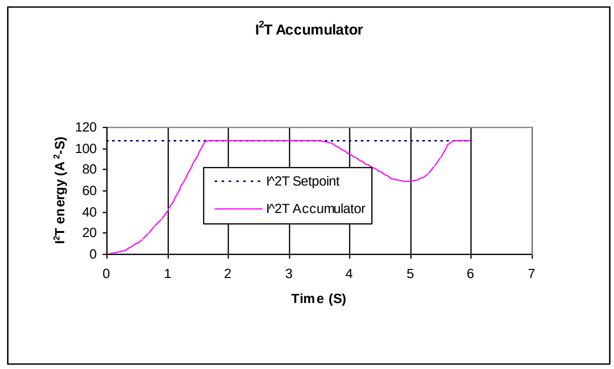
See the plot diagrams in the Section I^2T Example: Plot Diagrams.

I^2T Example: Plot Diagrams

The plots that follow show the response of a drive (configured w/ I^2T setpoint = 108 A^2S) to a given current command. For this example, DC output currents are shown to simplify the waveforms. The algorithm calculates the RMS value of the output current, and thus operates the same way regardless of the output current frequency and wave shape.



(A)



(B)

At time 0, plot diagram A shows that the actual output current follows the commanded current. Note that the current is higher than the continuous current limit setting of 6 A. Under this condition, the I^2T Accumulator Variable begins increasing from its initial value of zero. Initially, the output current linearly increases from 6 A up to 12 A over the course of 1.2 seconds. During this same period, the I^2T Accumulator Variable increases in a non-linear fashion because of its dependence on the square of the current.

At about 1.6 seconds, the I^2T Accumulator Variable reaches a value equal to the I^2T setpoint. At this time, the drive limits the output current to the continuous current limit even though the commanded current remains at 12 A. The I^2T Accumulator Variable value remains constant during the next 2 seconds since the difference between the actual output current and the continuous current limit is zero.

At approximately 3.5 seconds, the commanded current falls below the continuous current limit and once again the output current follows the commanded current. Because the actual current is less than the continuous current, the I^2T Accumulator Variable value begins to fall incrementally.

The I^2T Accumulator Variable value continues to fall until at approximately 5.0 seconds when the commanded current goes above the continuous current limit again. The actual output current follows the current command until the I^2T Accumulator Variable value reaches the I^2T setpoint and current limiting is invoked.

A: Connecting AEZ/APZ for Serial Control

This chapter describes how to connect one or more drives for control via the RS-232 bus on one of the drives.

Single-Axis and Multi-Drop

The drive's RS-232 serial bus can be used by CME for drive commissioning. The serial bus can also be used by an external control application (HMI, PLC, PC, etc.) for setup and direct serial control of the drive. The control application can issue commands in ASCII format.

For experimentation and simple setup and control, a TELnet device such as the standard Microsoft Windows HyperTerminal can also be used to send commands in ASCII format.

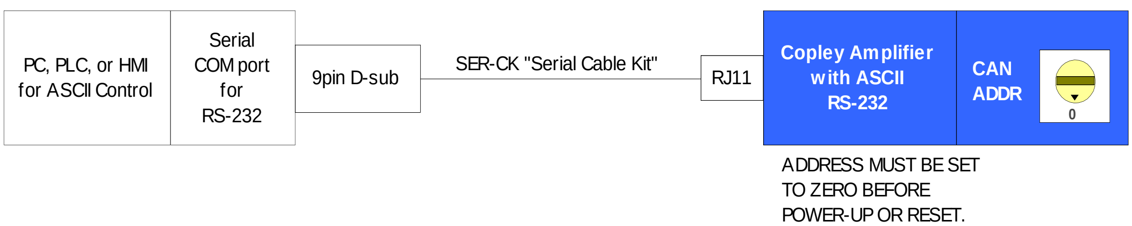
For more information, see *Copley ASCII Interface Programmer's Guide*.

The serially connected drive can also be used as a multi-drop gateway for access to other drives linked in a series of CAN bus connections.

Instructions for hooking up a single-axis connection and a multi-drop network appear below.

Single-Axis Connections

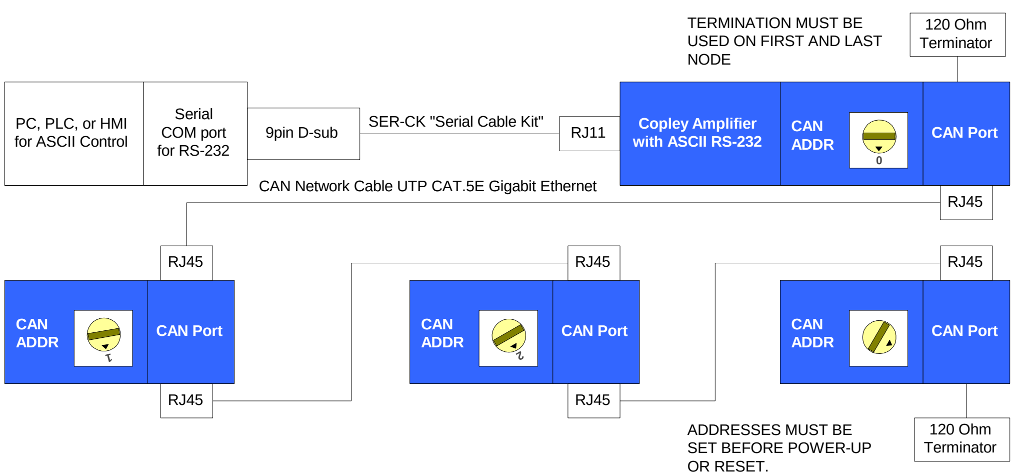
For RS-232 serial bus control of a single axis, set the CAN node address of that axis drive to zero (0). Note that if the CAN node address is switched to zero after power-up, the drive must be reset, or power cycled to make the new address setting take effect.



Multi-Drop Network Connections

A serially connected APZ drive can be used as a multi-drop gateway for access to other APZ drives linked in a series of CAN bus connections. Set the CAN node address of the serially connected drive (gateway) to zero (0). Assign each additional drive in the chain a unique CAN node address value between 1 and 127.

Use 120 Ohms termination on the first and last drive.



B: Ordering Guide and Accessories

This chapter lists part numbers for drives and accessories. Contents include:

Micro Modules: EtherCAT

Part Number	Description
AEV-090-14	Accelnet Plus Micro Module EtherCAT servo drive, 7/14 A, 90 Vdc,
AEV-090-30	Accelnet Plus Micro Module EtherCAT servo drive, 15/30 A, 90 Vdc
AEV-090-50 *	Accelnet Plus Micro Module EtherCAT servo drive, 25/50 A, 90 Vdc
AEV-090-50-C *	Accelnet Plus Micro Module EtherCAT servo drive, 50/50 A, 90 Vdc
AEV-180-10	Accelnet Plus Micro Module EtherCAT servo drive, 5/10 A, 180 Vdc
AEV-180-20	Accelnet Plus Micro Module EtherCAT servo drive, 10/20 A, 180 Vdc

* **Not compatible with AEV-EZ-090 board. Use AEZ-090-50 or AEZ-090-50-C if connectorized version is needed.**

Micro Modules Soldered: EtherCAT

Part Number	Description
AEZ-090-50	Accelnet Plus Micro Module EtherCAT servo drive, 25/50 A, 90 Vdc, soldered to EZ board
AEZ-090-50-C	Accelnet Plus Micro Module EtherCAT servo drive, 50/50 A, 90 Vdc, soldered to EZ Development board

Accessories for Micro Modules: EtherCAT

Part Number	Description
AEV-EZ-090	EZ Board (Pluggable for 90V AEV modules) **Not compatible with AEV-090-50 or AEV-090-50-C**
AEV-EZ-180	EZ Board (Pluggable for 180V AEV modules)
AEV-EZ-CK	Connector Kit for EZ Board and EZ Development Board (see details below)
AEV-HK	Heatsink Kit (Pins heatsink, thermal pad, and hardware)
AEV-THK	Heatsink Kit (Tall Pins heatsink, thermal pad, and hardware)
SER-USB-RJ11	Serial Interface Cable: USB to RJ11

MICRO MODULES: CANOPEN

Part Number	Description
APV-090-14	Accelnet Plus Micro Module CANopen servo drive, 7/14 A, 90 Vdc
APV-090-30	Accelnet Plus Micro Module CANopen servo drive, 15/30 A, 90 Vdc
APV-090-50 *	Accelnet Plus Micro Module CANopen servo drive, 25/50 A, 90 Vdc
APV-090-50-C *	Accelnet Plus Micro Module CANopen servo drive, 50/50 A, 90 Vdc
APV-180-10	Accelnet Plus Micro Module CANopen servo drive, 5/10 A, 180 Vdc
APV-180-20	Accelnet Plus Micro Module CANopen servo drive, 10/20 A, 180 Vdc

*** Note: Not compatible with APV-EZ-090 board. Use APZ-090-50 or APZ-090-50-C if connectorized version is needed.**

MICRO MODULES SOLDERED: CANOPEN

Part Number	Description
APZ-090-50	Accelnet Plus Micro Module CANopen servo drive, 25/50 A, 90 Vdc, soldered to EZ board
APZ-090-50-C	Accelnet Plus Micro Module CANopen servo drive, 50/50 A, 90 Vdc, soldered to EZ Development board

ACCESSORIES FOR MICRO MODULES: CANOPEN

Part Number	Description
APV-EZ-090	EZ Board (Pluggable for 90V APV modules) **Not compatible with APV-090-50 or APV-090-50-C**
APV-EZ-180	EZ Board (Pluggable for 180V APV modules)
APV-EZ-CK	EZ Board Connector Kit (see below)
APV-HK	Heatsink Kit (Pins heatsink, thermal pad, and hardware)
APV-THK	Tall Heatsink Kit (Tall Pins heatsink, thermal pad, and hardware)
SER-USB-RJ11	Serial Interface Cable: USB to RJ11

AEV & APZ EZ Boards Connector Kit

<table>
<tr><th>Model</th><th>Qty</th><th>Ref</th><th>Name</th><th>Description</th><th>Manufacturer Part Number</th></tr>
<tr><td rowspan="15">AEV-EZ-CK
APV-EZ-CK</td><td>1</td><td>J4</td><td>Encoder 2</td><td>Connector, socket, double-row, 2.00 mm, 8 pos</td><td>Hirose:DF11-8DS-2C</td></tr>
<tr><td>1</td><td>J5</td><td>I/O</td><td>Connector, socket, double row, 2.00 mm, 18 pos</td><td>Hirose:DF11-18DS-2C</td></tr>
<tr><td>1</td><td>J6</td><td>STO</td><td>Connector, socket, double row, 2.00 mm,16 pos</td><td>Hirose:DF11-16DS-2C</td></tr>
<tr><td>1</td><td>J8</td><td>VLOGIC</td><td>Connector, socket, single row, 2.00 mm, 2 pos</td><td>Hirose:DF3-2S-2C</td></tr>
<tr><td>1</td><td>J10</td><td>Brake</td><td>Connector, socket, single row, 2.00 mm, 3 pos</td><td>Hirose:DF3-3S-2C</td></tr>
<tr><td>40</td><td>J4,J5,J6</td><td colspan="2">Crimp socket, 24~28 AWG, gold</td><td>Hirose:DF11-2428-SCFA</td></tr>
<tr><td>5</td><td>J8, J10</td><td colspan="2">Crimp socket, 24~28 AWG, gold</td><td>Hirose:DF3-2428-SCC</td></tr>
<tr><td>15</td><td rowspan="3">J4,J5,J6</td><td colspan="2">White Flying Lead with contacts at both ends, 26 AWG, gold, 12”</td><td>Hirose:H3BBG-10112-W6</td></tr>
<tr><td>2</td><td colspan="2">Red Flying Lead with socket at both ends, 26 AWG, gold, 12”</td><td>Hirose:H3BBG-10112-R6</td></tr>
<tr><td>3</td><td colspan="2">Black Flying Lead with socket at both ends, 26 AWG, gold, 12”</td><td>Hirose:H3BBG-10112-B6</td></tr>
<tr><td>1</td><td rowspan="3">J8,J10</td><td colspan="2">Blue Flying Lead with socket at both ends, 26 AWG, gold, 12”</td><td>Hirose:H2BBG-10112-L6</td></tr>
<tr><td>1</td><td colspan="2">Red Flying Lead with socket at both ends, 26 AWG, gold, 12”</td><td>Hirose:H2BBG-10112-R6</td></tr>
<tr><td>1</td><td colspan="2">Black Flying Lead with socket at both ends, 26 AWG, gold, 12”</td><td>Hirose:H2BBG-10112-B6</td></tr>
<tr><td>1</td><td rowspan="2">P1</td><td rowspan="2">Encoder 1</td><td>Connector, high-density DB-26M, 26 pos, male, solder cup</td><td>Norcomp:
180-026-103L001</td></tr>
<tr><td>1</td><td>Metal Backshell, DB-15, RoHS</td><td>3M: 3357-9215</td></tr>
<tr><td></td><td></td><td>J6</td><td>APV-EZ-STO</td><td colspan="2">EZ Boards plug-in to J6 for disabling STO function</td></tr>
</table>

AEV Accessories

Part Number	Description
AEV-EZ-090	EZ Board Pluggable for 90V AEV modles (*Note: Not compatible with APV-090-50 or APV-090-50-C*)
AEV-EZ-180	EZ Board Pluggable for 180V AEV modles
AEV-EZ-CK	EZ Board Connector Kit (see table previous page)
AEV-HK	Heatsink Kit (Pins heatsink, thermal pad, and hardware)
AEV-THK	Tall Heatsink Kit (Tall Pins heatsink, thermal pad, and hardware)
SER-USB-RJ11	SER-USB-RJ11 Copley USB to Serial Adapter 5.9 ft (1.8 m)

APV Accessories

Part Number	Description
APV-EZ-090	EZ Board Pluggable for 90V APV modles (*Note: Not compatible with APV-090-50 or APV-090-50-C*)
APV-EZ-180	EZ Board Pluggable for 180V APV modles
APV-EZ-CK	EZ Board Connector Kit (see table previous page)
APV-HK	Heatsink kit (Pins heatsink, thermal pad, and hardware)
APV-THK	Heatsink kit (Tall Pins heatsink, thermal pad, and hardware)
SER-USB-RJ11	SER-USB-RJ11 Copley USB to Serial Adapter 5.9 ft (1.8 m)

Serial Cable Kits

Model	Ref	Description
SER-SK	J2	Serial Cable Kit: Dsub-9 receptacle molded cable with RJ-11 plug for 6-pin modular RJ11 socket on EZ boards and EZ Development Boards
SER-USB-RJ11	J3	Serial interface cable: USB to RJ11 plug for 6-pin modular RJ11 socket on EZ Boards and EZ Development Boards

Heatsink Kit For Pins Heatsink

Model	Qty	Description
AEV-HK APV-HK	2	Screw, M2.5-0.45 x 35 mm Slotted Drive Cheese Head
	2	Nut, M2.5-0.45 DIN Zinc Plated Nylon Insert Lock Nut
	1	Thermal material
	2	Copley non-threaded spacers, 20.5 mm
	1	Pins Heatsink, 1 inch tall

Heatsink Kit For Tall Pins Heatsink

Model	Qty	Description
AEV-THK APV-THK	2	Screw, M2.5 x 40 mm Philips head screw
	2	Nut, M2.5-0.45 DIN Zinc Plated Nylon Insert Lock Nut
	1	Thermal material
	2	Copley non-threaded spacers, 20.5 mm
	1	Tall Pins Heatsink, 2 inch tall

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Copley Controls
Analogic Motion Controls
20 Dan Road
Canton, MA 02021 USA