Accelnet & Stepnet Plus Panels User Guide

16-01339
Revision 07
September 16, 2021

Contents

1 About This Manual

1.1 Title, Number, Revision

Title	Accelnet & Stepnet Plus Panels User Guide
Document Number	16-01339
Current Revision	07

1.2 Revision History

Revision	Date	ECO	Comments
AA	December 30, 2014	ECO-056909	Originated from 16-01169 Rev 00
00	March 23, 2015	ECO-057405	Updated PE and grounding graphics
01	February 23, 2017	ECO-065615	Add BML models
02	March 21, 2017	ECO-066296	Update to reflect EN 61800-5-2:2007
03	April 18, 2018	ECO-069980	Changed the analog input pin 3 to pin 34
04	June 27, 2019	ECO-073565	Pin out typos for the Power Pins fixed
05	October 22, 2020	ECO-077762	Update to reflect IEC 61800-5-2:2016
06	December 8, 2020	ECO-078133	Update to reflect latest edition of IEC 61800-3 and IEC 61800-5-1
07	September 16, 2021	ECO-080110	Update to relfect changes to front panel brake signals

1.3 Overview and Scope

This manual describes the operation and installation of the *Accelnet* BEL, BE2, BPL, BP2, BML and *Stepnet* TEL, TE2 and TP2 drives manufactured by Copley Controls.
All Accelnet and Stepnet Plus Panel products have serial numbers that incorporate the week and year of production into the first 4 digits (WWYY) of the serial number.

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

For important setup and operation information, see the *CME User Guide (*www.copleycontrols.com)

Users of the CANopen features should also read these Copley Controls documents:

CANopen Programmer’s Manual

CMO (Copley Motion Objects) Programmer’s Guide

CML Reference Manual (License required)

MACRO Network User Guide

Also of related interest:

Indexer 2 Program User’s 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)

Copley Amplifier Parameter Dictionary

Copley Camming User Guide

Copley Controls Serial Encoder Guide

CPL User Guide (License required)

Accelnet & Stepnet Plus Panels STO Manual

Links to these publications, along with other documents, data sheets and software releases, can be found at www.copleycontrols.com.

1.6 EC Declaration of Conformity – Contents

1.6.1 EC Declaration of Conformity for Accelnet Plus BE2 BP2

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EC DECLARATION OF CONFORMITY

Objects of this declaration:

Product Description	Model Numbers
Accelnet Plus 2-Axis Panel EtherCAT Drive	BE2-090-06, BE2-090-06-H, BE2-090-06-R, BE2-090-06-R-H BE2-090-14, BE2-090-14-H, BE2-090-14-R, BE2-090-14-R-H BE2-090-20, BE2-090-20-H, BE2-090-20-R, BE2-090-20-R-H
Accelnet Plus 2-Axis Panel CANopen Drive	BP2-090-06, BP2-090-06-H, BP2-090-06-R, BP2-090-06-R-H BP2-090-14, BP2-090-14-H, BP2-090-14-R, BP2-090-14-R-H BP2-090-20, BP2-090-20-H, BP2-090-20-R, BP2-090-20-R-H

We, Analogic Corporation d/b/a Copley Controls, 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 (EMC Directive), 2014/35/EU (Low Voltage Directive) and 2011/65/EU (RoHS Directive). Conformity is declared under the following standards:

EMC

IEC 61800-3:2017 Adjustable Speed Electric Power Drive Systems – Part 3: EMC Requirements and Specific Test Methods. Category 3 PDS.

PRODUCT SAFETY

IEC 61800-5-1:2016 Adjustable Speed Electric Power Drive Systems – Part 5-1: Safety Requirements – Electrical, Thermal and Energy

FUNCTIONAL SAFETY

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

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)

Testing Performed By:

Underwriters Laboratories 1285 Walt Whitman Road Melville, NY www.ul.com

Compliance Management Group 257 Simarano Drive Marlborough, MA www.cmgcorp.net

Year in which the CE Marking was affixed: 2014

Signed for and on behalf of the above named manufacturer

Place and date of issue: *Canton, MA USA* *12/2/2020*

Name, function: *Ed Gayron, Director of Quality, Reliability & Compliance*

Signature:

EC Authorized Representative and Legal Person Authorized to Compile the Technical File

BK Medical ApS, Mileparken 34, DK-2730, Herlev, Denmark, Tel: 45 44528100, info@bkmed.dk

Analogic Corporation d/b/a Copley Controls 20 Dan Road, Canton, MA 02021 781-828-8090 www.copleycontrols.com

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1.6.2 EC DECLARATION OF CONFORMITY FOR ACCELNET PLUS BEL BPL

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EC DECLARATION OF CONFORMITY

Objects of this declaration:

Product Description	Model Numbers
Accelnet Plus Panel EtherCAT Drive	BEL-090-06, BEL-090-06-H, BEL-090-06-R, BEL-090-06-R-H BEL-090-14, BEL-090-14-H, BEL-090-14-R, BEL-090-14-R-H BEL-090-30, BEL-090-30-H, BEL-090-30-R, BEL-090-30-R-H
Accelnet Plus Panel CANopen Drive	BPL-090-06, BPL-090-06-H, BPL-090-06-R, BPL-090-06-R-H BPL-090-14, BPL-090-14-H, BPL-090-14-R, BPL-090-14-R-H BPL-090-30, BPL-090-30-H, BPL-090-30-R, BPL-090-30-R-H
Accelnet Plus Panel MACRO Drive	BML-090-06, BML-090-06-H, BML-090-14, BML-090-14-H, BML-090-30, BML-090-30-H

We, Analogic Corporation d/b/a Copley Controls, 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 (EMC Directive), 2014/35/EU (Low Voltage Directive) and 2011/65/EU (RoHS Directive). Conformity is declared under the following standards:

EMC

IEC 61800-3:2017 — Adjustable Speed Electric Power Drive Systems – Part 3: EMC Requirements and Specific Test Methods. Category 3 PDS.

PRODUCT SAFETY

IEC 61800-5-1:2016 — Adjustable Speed Electric Power Drive Systems – Part 5-1: Safety Requirements – Electrical, Thermal and Energy

FUNCTIONAL SAFETY

EN 61800-5-2:2016 — Adjustable Speed Electric Power Drive Systems – Part 5-2: Safety Requirements – Functional

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

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Underwriters Laboratories 1285 Walt Whitman Road Melville, NY www.ul.com

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16-01377 rev04

1.6.3 EC Declaration of Conformity for Stepnet Plus TE2 TP2

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EC DECLARATION OF CONFORMITY

Objects of this declaration:

Product Description	Model Numbers
Stepnet Plus 2-Axis Panel EtherCAT Drive	**TE2-090-07, TE2-090-07-H, TE2-090-10, TE2-090-10-H**
Stepnet Plus 2-Axis Panel CANopen Drive	**TP2-090-07, TP2-090-07-H, TP2-090-10, TP2-090-10-H**

We, Analogic Corporation d/b/a Copley Controls, 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 (EMC Directive), 2014/35/EU (Low Voltage Directive) and 2011/65/EU (RoHS Directive). Conformity is declared under the following standards:

EMC

IEC 61800-3:2017 — Adjustable Speed Electric Power Drive Systems – Part 3: EMC Requirements and Specific Test Methods. Category 3 PDS.

PRODUCT SAFETY

IEC 61800-5-1:2016 — Adjustable Speed Electric Power Drive Systems – Part 5-1: Safety Requirements – Electrical, Thermal and Energy

FUNCTIONAL SAFETY

IEC 61800-5-2:2016 — Adjustable Speed Electric Power Drive Systems – Part 5-2: Safety Requirements – Functional

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)

Testing Performed By:

Underwriters Laboratories 1285 Walt Whitman Road Melville, NY www.ul.com
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Year in which the CE Marking was affixed: 2014

Signed for and on behalf of the above named manufacturer

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1.6.4 EC Declaration of Conformity for Stepnet Plus TEL TPL

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EC DECLARATION OF CONFORMITY

Objects of this declaration:

Product Description	Model Numbers
Stepnet Plus Panel EtherCAT Drive	TEL-090-07, TEL-090-07-H, TEL-090-10, TEL-090-10-H

We, Analogic Corporation d/b/a Copley Controls, 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 (EMC Directive), 2014/35/EU (Low Voltage Directive) and 2011/65/EU (RoHS Directive). Conformity is declared under the following standards:

EMC

IEC 61800-3:2017 Adjustable Speed Electric Power Drive Systems – Part 3: EMC Requirements and Specific Test Methods. Category 3 PDS.

PRODUCT SAFETY

IEC 61800-5-1:2016 Adjustable Speed Electric Power Drive Systems – Part 5-1: Safety Requirements – Electrical, Thermal and Energy

FUNCTIONAL SAFETY

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

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)

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Underwriters Laboratories 1285 Walt Whitman Road Melville, NY www.ul.com
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1.7 COMMENTS

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

1.8 COPYRIGHTS

1.9 DOCUMENT VALIDITY

We reserve the right to modify our products. The information in this document is subject to change without notice and does not represent a commitment by Copley Controls.
Copley Controls assumes no responsibility for any errors that may appear in this document.

1.10 PRODUCT WARNINGS

GENERAL

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 or Stepnet Plus Panel* servo drives. Removal of the cover or tampering with internal components will void the warranty.

 **DANGER**	**DANGER: HAZARDOUS VOLTAGES.**
	Exercise caution when installing and adjusting. Persons responsible for installing and commissioning Accelnet Plus servo drives and Stepnet Plus stepper 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 and Stepnet Plus Panel 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 THE ACCELNET & STEPNET PLUS PANELS STO MANUAL** The information provided in the Accelnet & Stepnet Plus Panels STO Manual 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 HVAUX and/or HV DC power applied is not recommended. **FAILURE TO HEED THIS WARNING MAY CAUSE EQUIPMENT DAMAGE.**

2 INTRODUCTION

2.1 *ACCELNET & STEPNET PLUS PANELS* OVERVIEW

This table shows the model families and characteristics:

	Axes	EtherCAT	CANopen	MACRO	Motor
Accelnet	1	BEL	BPL	BML	Servo
	2	BE2	BP2	-	
Stepnet	1	TEL	-	-	Stepper
	2	TE2	TP2	-	

All of these drives provide 100% digital control of brushless, brush, or stepper motors in DC powered panel packages. Accelnet Plus models drive servo motors and Stepnet Plus drives are for stepper motors.

All of these Plus Panel 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 the *Accelnet & Stepnet* Plus Dual Axis models, see the *Accelnet & Stepnet Plus Panel STO Manual*.

Accelnet Plus models support a wide range of feedback devices. The standard versions support digital quadrature encoders, analog sin/cos encoders, and EnDat, BiSS, SSI, and Absolute A encoders. The -R versions support brushless resolvers. The standard and -R versions can emulate a digital quadrature encoder output from the analog encoder or resolver respectively.

Accelnet & Stepnet Plus Panels models can operate in several basic ways:

- *Accelnet Plus Panel* drives accept 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.
- *Stepnet Plus Panel* drives typically accept position commands from an external controller as 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. Stepper motors with encoders can be operated in *servo mode* providing position, velocity, or torque control.
- CANopen 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.
- EtherCAT models operate as slave devices on the network. Servo drives can perform the CANopen operating modes with the additional cyclic-synchronous position, velocity, and torque modes.
- MACRO models can be nodes on a MACRO network.
- All models can work as stand-alone controllers running CVM control programs such as the Indexer 2 Program. Or they can be controlled directly over an RS-232 serial link with simple ASCII format commands.

2.2 ACCELNET PLUS PANEL MODELS

Network	Axes	Models	Ic	Ip	Vdc
EtherCAT	1-Axis	BEL-090-06	3	6	14~90
		BEL-090-14	7	14	
		BEL-090-30	15	30	
	2-Axis	BE2-090-06	3	6	
		BE2-090-14	7	14	
		BE2-090-20	10	20	
CANopen	1-Axis	BPL-090-06	3	6	
		BPL-090-14	7	14	
		BPL-090-30	15	30	
	2-Axis	BP2-090-06	3	6	
		BP2-090-14	7	14	
		BP2-090-20	10	20	
MACRO	1-Axis	BML-090-06	3	6	
		BML-090-14	7	14	
		BML-090-30	15	30	

Ic = Continuous Output Current, Adc (peak of sine)
Ip = Peak Output Current, Adc (peak of sine)
Vdc = HV power supply voltage (DC, line-isolated)

The models listed above are available with the following options added to the part number:

-R: Resolver feedback (Example BEL-090-14-R). Resolver feedback not available on BML models.

-H: Factory-installed heatsink (Example: BEL-090-14-H)

-R-H: Resolver option with factory-installed heatsink (Example: BEL-090-14-R-H)

2.3 STEPNET PLUS PANEL MODELS

Network	Axes	Models	Ic	Ip	Vdc
EtherCAT	1-Axis	TEL-090-07	5	7	14~90
		TEL-090-10	10	10	
	2-Axis	TE2-090-07	5	7	
		TE2-090-10	10	10	
CANopen	2-Axis	TP2-090-07	5	7	
		TP2-090-10	10	10	

Ic = Continuous Current, Adc (peak of sine)
Ip = Peak Current, Adc (peak of sine)
Vdc = HV power supply voltage (DC, line-isolated)

The models listed above are available with the following option added to the part number:

-H: Factory-installed heatsink (Example: TEL-090-10-H)

2.4 CME

Drive commissioning is fast and simple using Copley Controls CME software. CME communicates with *Accelnet & Stepnet* via an RS-232, CANopen, or EtherCAT link, and all of the operations needed to configure the drive are accessible through CME.

The serial multi-drop feature allows CME to use a single RS-232 serial connection to one drive as a gateway to other drives linked together by CAN bus connections.

Auto phasing of brushless motor Hall sensors and phase wires eliminates “wire and try.” Connections are made once and CME does the rest. Encoder or resolver wire swapping to establish the direction of positive motion is also eliminated.

Drive data can be saved & restored in a number of file types with the following file type extensions:

- CCM Motor, encoder, and brake settings
- CCX Drive configuration and settings
- CCP Indexer 2 (CVM, Copley Virtual Machine) programs
- CCT Cam tables
- CCG Gain-scheduling tables
- CCD Drive settings

2.5 CVM (Copley Virtual Machine, Indexer 2)

CVM is an embedded virtual programmable controller used to download Copley’s Indexer 2 programs to Copley drives. It is accessed via CME and can be opened from CME’s main window.

2.6 CMO (Copley Motion Objects)

Copley Motion Objects (CMO) makes CANopen or EtherCAT network commissioning fast and simple. All network housekeeping is taken care of automatically by a few simple commands linked into your application program. CMO provides a suite of .NET objects that can be used by Visual Basic, LabVIEW, or any other program supporting the Microsoft .NET object interface.

2.7 CML (Copley Motion Libraries)

CML provides a suite of C++ source code, allowing a C++ application program to communicate with and control a drive over the CANopen or EtherCAT network.

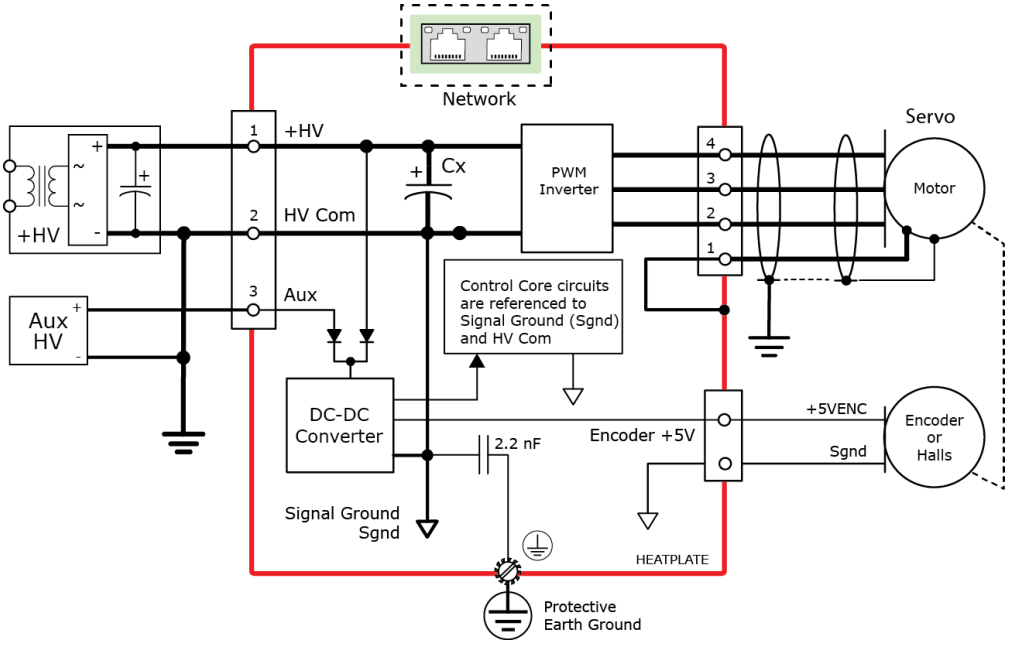
2.8 CPL (Copley Programming Language)

CPL is Copley’s high level programming language for writing custom CVM programs. It expands on CVM’s Indexer 2 capabilities with interrupts and features that are faster and more flexible, including looping and branching capabilities.

3 OPERATIONAL THEORY

3.1 DRIVE INPUT POWER

Power distribution within *Accelnet & Stepnet Plus Panels* has a common ground which is isolated from the heatplate. The CANopen, EtherCAT and MACRO network signals are isolated from all of the drive circuits.



LOGIC/SIGNAL POWER

An internal DC/DC converter operates from the either the +HV or Aux inputs and creates the required logic/signal operating voltages. Deriving internal operating voltages from the Aux input enables the drive to stay on-line when the +HV power has been disconnected for emergency-stop or operator-intervention conditions. This allows network and serial communications to remain active so that the drive can be monitored by the control system while the +HV power is removed.

+HV POWER

The +HV input drives the high-voltage PWM outputs. When this is used without the Aux power, all of the drive control and PWM output power is derived from the +HV power.

AUX POWER

The Aux input only drives the DC/DC converter and is diode-isolated from the PWM outputs. It has the same voltage range as the +HV power and is recommended when the drives are in a network. The control core, feedback devices, and network connections are all maintained by the Aux power so that the system controller has visibility of the drive status, motor position, I/O states, etc. while the +HV is removed for safety, loading/unloading work stations, etc.

PWM SWITCHING FREQUENCY SYNCHRONIZING

In some situations, such as when sampling small analog signals, it is desirable to synchronize the PWM switching frequency among multiple drives. In these cases, one drive serves as a master for one or more slave drives. The PWM sync output of the master sends a signal that is received as a PWM sync input by each slave.

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 message producer. 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 of the drives on the network have their PWM frequencies synchronized.

In a MACRO ring, the master frequency must be a multiple of the drive's current loop frequency.
When this is done the PWM frequencies of all the drives will be synchronized.

3.2 Commutation Modes

The servo drive models (Bxx) support three commutation modes to drive brush and brushless motors:
AC brushless sinusoidal, DC brushless trapezoidal, and DC brush.

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 or resolver 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. No feedback is required for torque (current) control but is needed for velocity or position control.

Stepper drives in microstepping mode have no need for commutation because the motor rotor is always following the current vector created by the master. If operating in servo-mode, Stepnet drives use the encoder feedback to auto-phase when the drive is enabled (wake-and-shake, or wake-and-wiggle).

3.3 Feedback

Encoder and Resolver Support

The standard versions of the *Accelnet & Stepnet Plus Panel* drives support digital quadrature encoders, analog sin/cos encoders, and a variety of absolute encoder formats. These versions normally require the use of Hall switches for the commutation of brushless motors when incremental encoders are used. Absolute encoders provide position and commutation feedback thus Halls are not required.
The resolver versions, designated by "–R" in the model number, support standard, single speed, resolvers. Resolvers provide absolute position feedback of the motor rotor and are sufficient for commutation as well as high-resolution motor rotor position reporting.
DC brush motors are self-commutating and only require feedback that reports the rotor position in either absolute or incremental format.

Multi-Mode Port

The multi-mode port on the control connector can be configured for various functions, depending on type of drive.

- Output buffered digital encoder A/B/X signals from a digital incremental motor encoder.
- Output emulated digital A/B encoder signals derived from analog sin/cos encoder or resolver.
- Output emulated digital A/B encoder signals from an absolute encoder
- Input a secondary digital encoder to be used in the dual encoder position mode. In this mode, an encoder attached to the load provides position loop feedback, and the motor encoder or resolver provides velocity loop feedback.

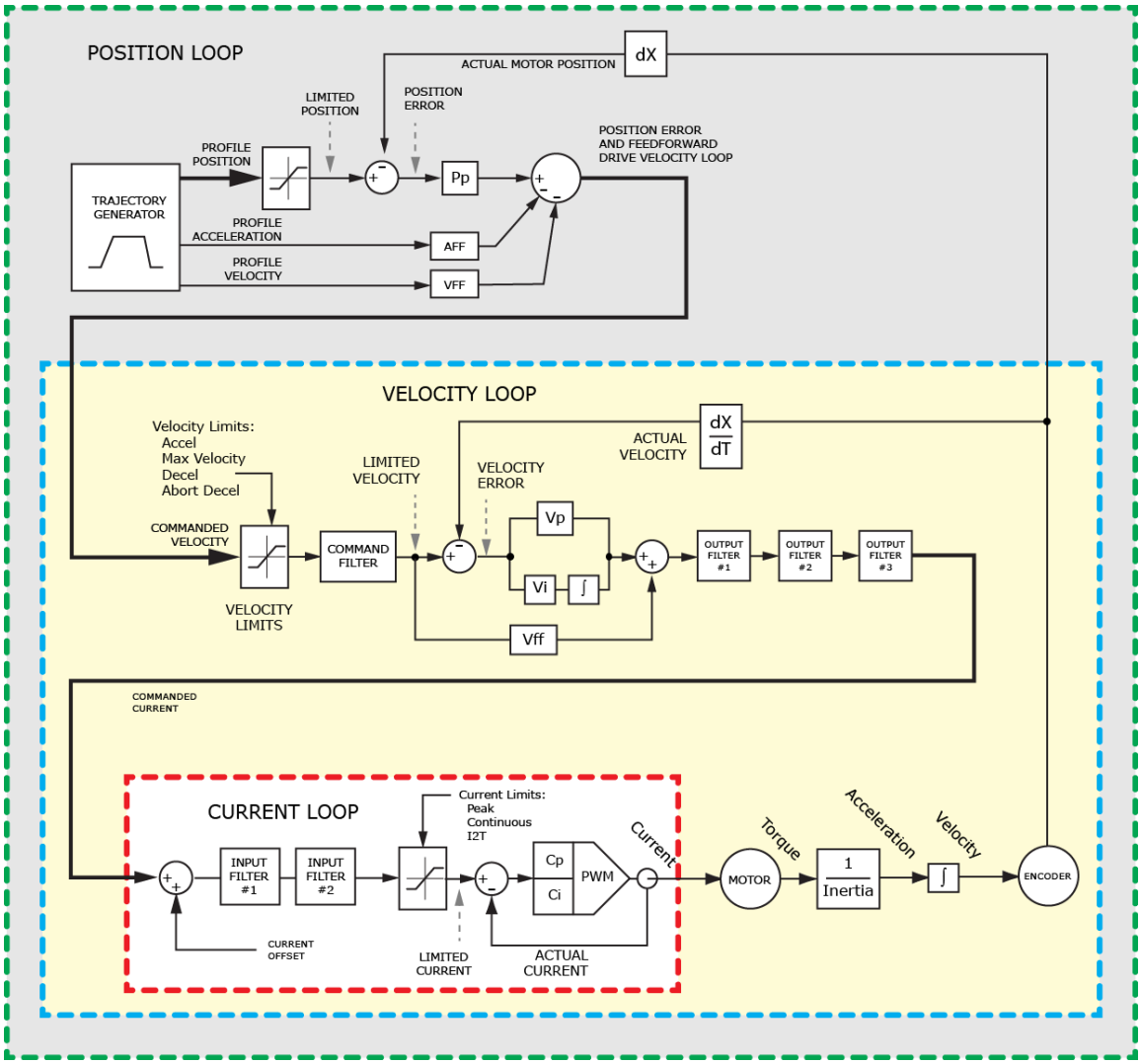
3.4 Operating Modes

Modes and Control Loops

Nesting of Control Loops and Modes

Copley Controls *Accelnet & Stepnet Plus Panel* servo drives use up to three nested control loops, current, velocity, and position, to control a motor in three associated operating modes. *Plus Panel* stepper drives typically operate in microstepping mode which is a form of open-loop position and velocity control. When stepper motors are equipped with encoders, they can operate stepper motors as brushless servo motors that use the same nested control loops as the servo drives.

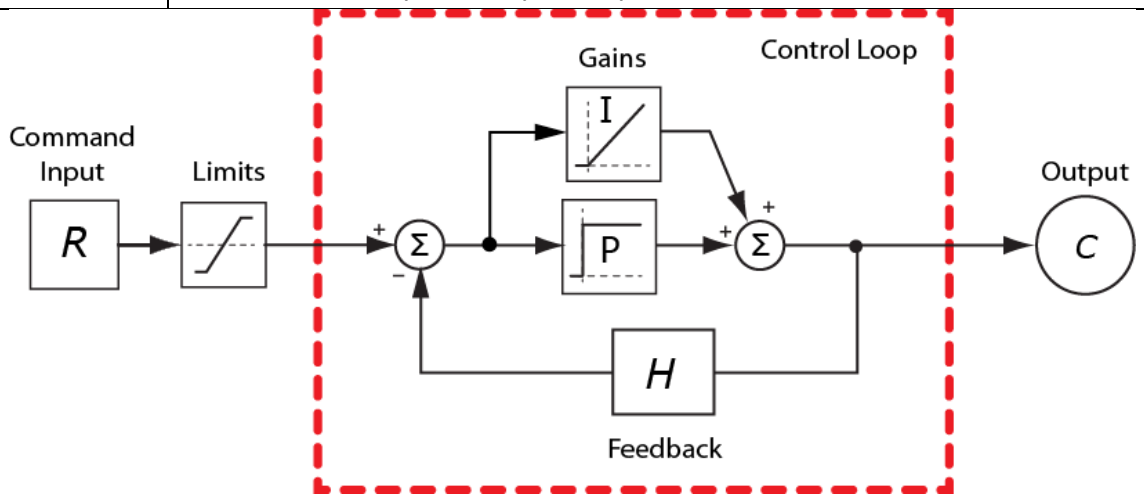
This graphic shows the three control loops in a Plus Panel drive. The innermost loop controls current. This loop becomes an element in the velocity loop. Finally, the position loop takes the command input from a position commanding source which could be analog inputs, digital inputs, or commands over a network such as EtherCAT or CANopen.



Basic Attributes of All Control Loops

Control loops (and servo control loops in general) share several common attributes:

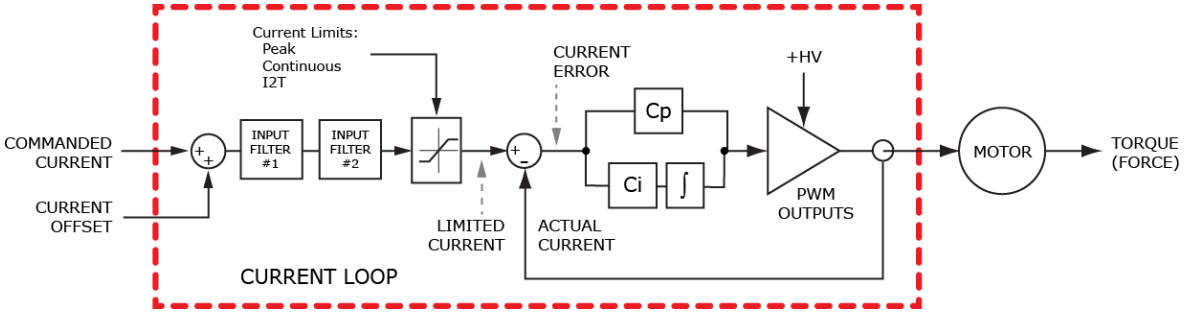
Loop Attribute	Description
Command input	Every loop is given a value to which it will attempt to control. For example, the velocity loop receives a velocity command that is the desired motor speed.
Limits	Limits are set on each loop to protect the motor and/or mechanical system.
Feedback	The nature of servo control loops is that they receive feedback from the device they are controlling. For example, the position loop uses the actual motor position as feedback.
Gains	These are constant values that are used in the mathematical equation of the servo loop. The values of these gains can be adjusted during drive setup to improve the loop performance. Adjusting these values is often referred to as tuning the loop.
Output	The loop generates a control signal. This signal can be used as the command signal to another control loop or the input to a power drive.



Current Mode and Current Loop

Current Loop Diagram

As shown below, the “front end” of the current loop has filters and a limiting stage. The limiting stage accepts a current command, applies limits, and passes a limited current command to the summing junction. The summing junction subtracts the actual current (represented by the feedback signal) from the limited current and produces an error signal. This error signal is then processed using the integral and proportional gains to produce a voltage-control command which is applied to the drive’s PWM power outputs.



Current Loop Inputs

Current commands can come from these sources:

- Analog or digital PWM inputs.
- A CANopen, MACRO or EtherCAT network, or RS-232 command.
- A CVM indexer program.
- CMO, CML, or CPL program commands.
- The drive’s internal function generator.
- In velocity or position modes, the current command is generated by the velocity loop.

Offset

The current loop offset is intended for use in applications where there is a constant force applied to, or required of, the servomotor and the system must control this force. Typical applications would be a vertical axis holding against gravity, or web tensioning. This offset value is summed with the current command before the limiting stage.

Limits

The current command is limited based on the following parameters:

Limiter	Description
Peak Current Limit	Maximum current that can be generated by the drive for a short duration of time. This value cannot exceed the peak current rating of the drive.
Continuous Current Limit	Maximum current that can be constantly generated by the drive cannot exceed the continuous current rating of the drive.
I^2T Time Limit	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. For more details, see I^2T Time Limit Algorithm. Note: Although the current limits set by the user may exceed the drive's internal limits, the drive operates using both sets of limits in parallel, and therefore will not exceed its own internal limits regardless of the values programmed.
Ramp	Rate of change in current command.

Current Loop Gains

The current loop uses these gains:

Gain	Description
Cp - Current loop proportional	The current error (the difference between the actual and the limited commanded current) is multiplied by this value. The primary effect of this gain is to increase bandwidth (or decrease the step-response time) as the gain is increased.
Ci - Current loop integral	The integral of the current error is multiplied by this value. Integral gain reduces the current error to zero over time. It controls the DC accuracy of the loop, or the flatness of the top of a square wave signal. The error integral is the accumulated sum of the current error value over time.

Current Loop Output

The output of the current loop is a command that sets the duty cycle of the PWM output stage of the drive. This provides a variable voltage-source.

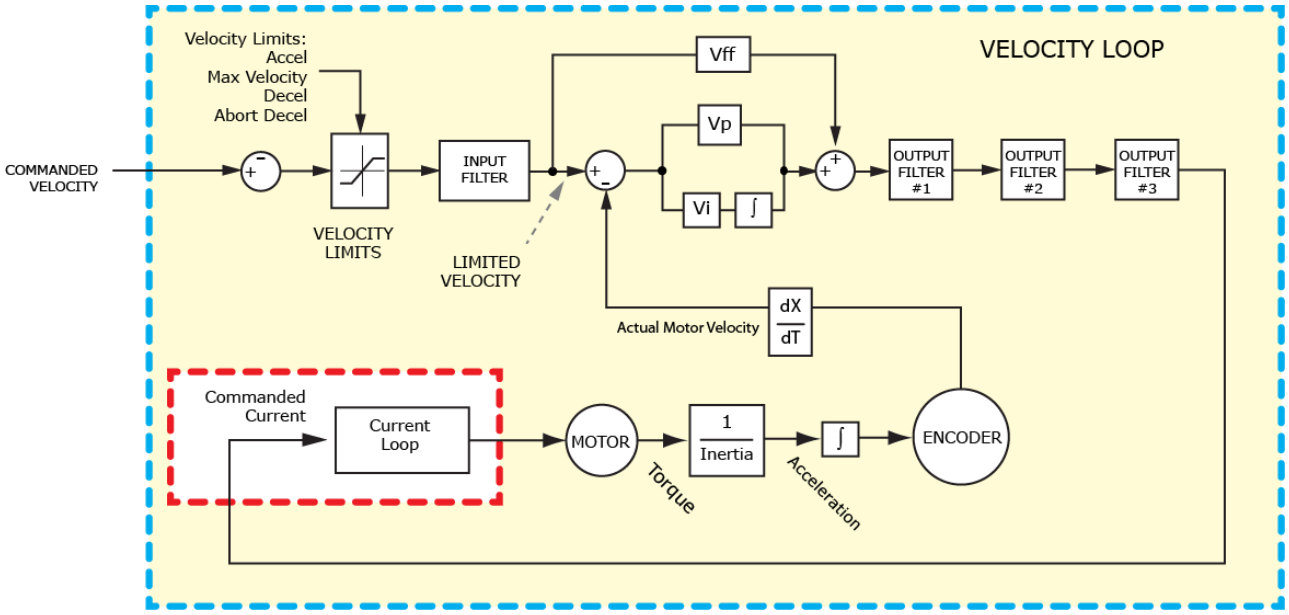
Auto Tune

CME provides a current loop Auto Tune feature, which automatically determines optimal Cp and Ci values for the motor. For more information, see the CME User Guide.

Velocity Mode and Velocity Loop

Velocity Loop Diagram

As shown below, the velocity loop limiting stage accepts a velocity command, applies limits, and passes a limited velocity command to the command filter. The output of the filter is a velocity command to the summing junction. The summing junction subtracts the actual velocity derived from the feedback device (encoder, resolver), and produces a velocity error signal. The velocity loop feedback signal is always from the motor feedback device even when an additional encoder is attached to the load. The velocity error is then processed using the integral and proportional gains which is added to a feedforward signal to produce the commanded current. Programmable digital filters are provided on the input of the velocity loop, following the limiting stage, and on the output of the velocity loop that will become the commanded current which controls the current loop.



Velocity Loop Inputs

In velocity mode, the Commanded Velocity command comes from one of the following sources:

- Analog or digital PWM inputs
- A network command, CAN, or RS-232 Serial.
- A CVM indexer control program.
- CMO, CML, or CPL program commands.
- The drive's internal function generator.
- In position mode, the velocity command is generated by the position loop error.

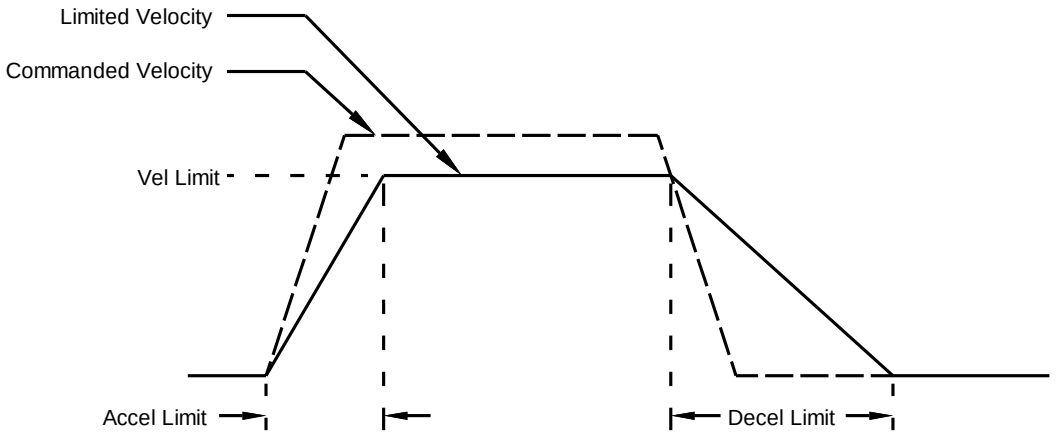
Velocity Loop Limits

The velocity command is limited based on the following set of parameters designed to protect the motor and/or the mechanical system.

Limiter	Description
Velocity Limit	Sets the maximum velocity command input to the velocity loop.
Acceleration Limit	Limits the maximum acceleration rate of the commanded velocity input to the velocity loop. This limit is used in velocity mode only.
Deceleration Limit	Limits the maximum deceleration rate of the commanded velocity input to the velocity loop. This limit is used in velocity mode only.
Fast Stop Ramp	Specifies the deceleration rate used by the velocity loop when the drive is hardware disabled. (Fast stop ramp is not used when drive is software disabled.) If the brake delay option is programmed, the fast stop ramp is used to decelerate the motor before applying the brake. Note that Fast Stop Ramp is used only in velocity mode. In position mode, the trajectory generator handles controlled stopping of the motor. There is one exception: if a non-latched following error occurs in position mode, then the drive drops into velocity mode and the Fast Stop Ramp is used. For more information, see Following Error Fault Details.

Diagram: Effects of Limits on Velocity Command

The following diagram illustrates the effects of the velocity loop limits.



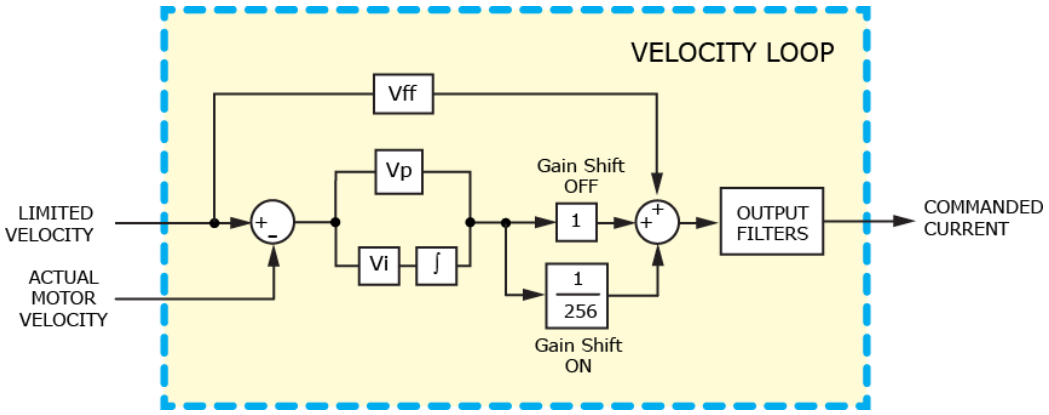
Velocity Loop Gains

The velocity loop uses these gains:

Gain	Description
Vp - Velocity loop proportional	The velocity error (the difference between the actual and the limited commanded velocity) is multiplied by this gain. The primary effect of this gain is to increase bandwidth (or decrease the step-response time) as the gain is increased.
Vi - Velocity loop integral	The integral of the velocity error is multiplied by this value. Integral gain reduces the velocity error to zero over time. It controls the DC accuracy of the loop, or the flatness of the top of a square wave signal. The error integral is the accumulated sum of the velocity error value over time.

Velocity Gains Shift

The Velocity Gains Shift feature adjusts the resolution of the units used to express Vp and Vi, providing more precise tuning. If the non-scaled value of Vp or Vi is 64 or less, the Low Gains Shift option is available to increase the gains adjustment resolution. (Such low values are likely to be called for when tuning a linear motor with an encoder resolution finer than a micrometer.) If the non-scaled value of Vp or Vi is 24001 or higher, the High Gains Shift option is available to decrease the gains adjustment resolution.



Velocity Loop Command and Output Filters

The velocity loop contains four programmable digital filters. The input filter should be used to reduce the effects of a noisy velocity command signal. The three output filters are used to reduce the excitation of any resonance in the motion system.

Two filter types can be programmed: the Low-Pass and the Custom Bi-Quadratic. The Low-Pass filter class includes the Single-Pole and the Two-Pole Butterworth filter types. The Custom Bi-Quadratic filter allows advanced users to define their own filters incorporating two poles and two zeros.

For more information on the velocity loop filters, see the CME User Guide.

Velocity Loop Outputs

The output of the velocity loop is Commanded Current which is the input to the current loop.

Position Mode and Position Loop

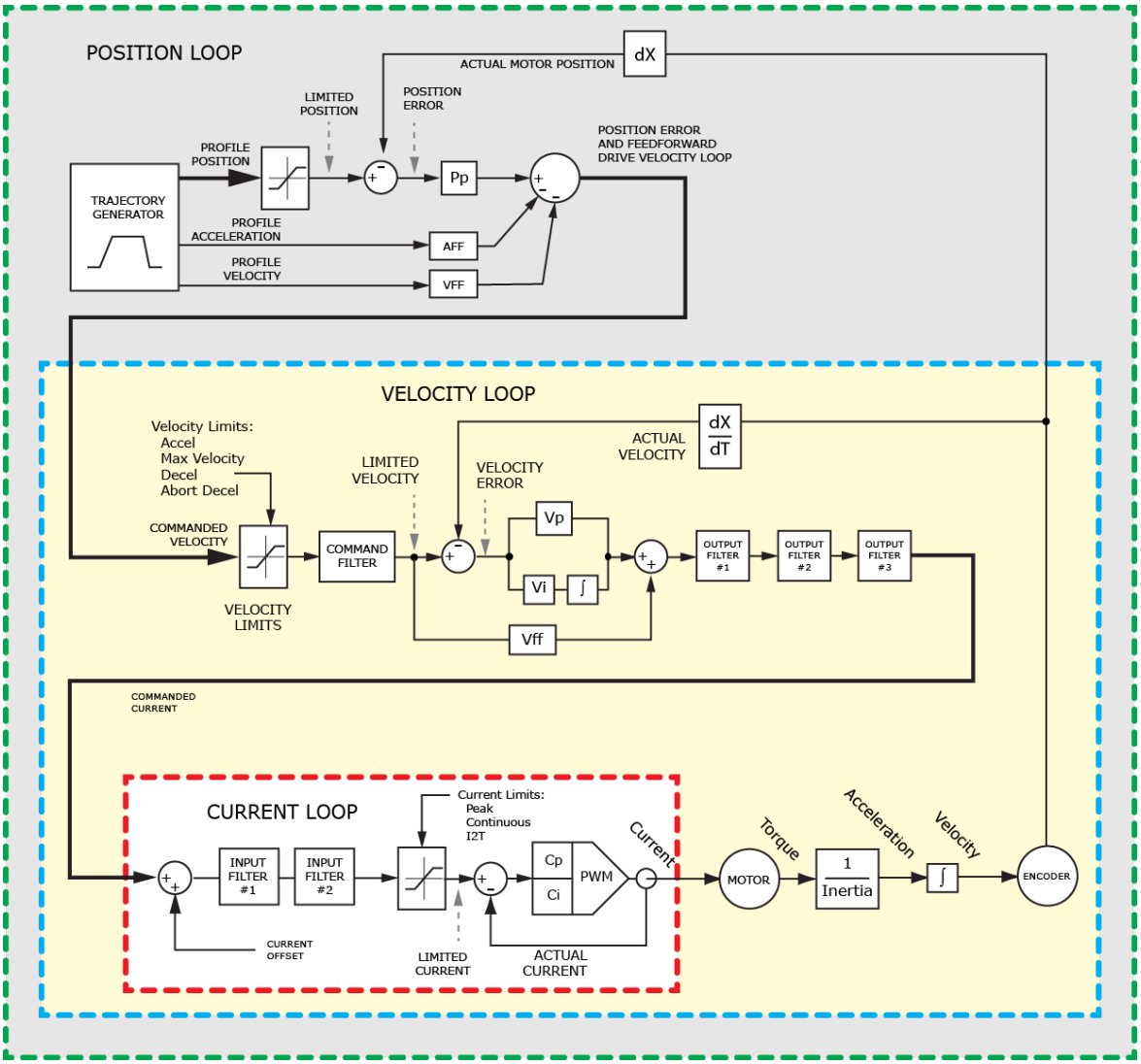
Position Loop Diagram

The drive receives position commands from the digital or analog command inputs, over the CAN interface or serial bus, or from the CVM Control Program. When using digital or analog inputs, the drive's internal trajectory generator calculates a trapezoidal motion profile based on trajectory limit parameters. When using the CAN bus, serial bus, or CVM Control Program, a trapezoidal or S-curve profile can be programmed. The trajectory generator updates the calculated profile in real time as position commands are received.

The output of the generator is an instantaneous position command (limited position). In addition, values for the instantaneous profile velocity and acceleration are generated. These signals, along with the actual position feedback, are processed by the position loop to generate a velocity command.

To bypass the trajectory generator while in digital or analog position modes, set the maximum acceleration to zero. The only limits in effect will now be the velocity loop velocity limit and the current limits. (Note that leaving the maximum acceleration set to zero will prevent other position modes from operating correctly.)

The following diagram summarizes the position loop.



Trajectory Limits

In position mode, the trajectory generator applies the following user-set limits to generate the motion profile.

Limiter	Description
Maximum Velocity	Limits the maximum velocity of the profile.
Maximum Acceleration	Limits the maximum acceleration rate of the profile.
Maximum Deceleration	Limits the maximum deceleration rate of the profile.
Abort Deceleration	Specifies the deceleration rate used by the trajectory generator when motion is aborted.

Position Loop Inputs From the Trajectory Generator

The position loop receives the following inputs from the trajectory generator.

Input	Description
Profile Velocity	The instantaneous velocity value of the profile. Used to calculate the velocity feed forward value.
Profile Acceleration	The instantaneous acceleration/deceleration value of the profile. Used to calculate the acceleration feed forward value.
Limited Position	The instantaneous commanded position of the profile. Used with the actual position feedback to generate a position error.

Position Loop Gains

The following gains are used by the position loop to calculate the velocity command:

Gain	Description
Pp - Position loop proportional	The loop calculates the position error as the difference between the actual and limited position values. This error in turn is multiplied by the proportional gain value. The primary effect of this gain is to reduce the following error.
Vff - Velocity feed forward	The value of the profile velocity is multiplied by this value. The primary effect of this gain is to decrease following error during constant velocity.
Aff - Acceleration feed forward	The value of the profile acceleration is multiplied by this value. The primary effect of this gain is to decrease following error during acceleration and deceleration.
Gain Multiplier	The output of the position loop is multiplied by this value before being passed to the velocity loop.

Position Loop Feedback

Accelnet & Stepnet Plus models support two position feedback configurations:

- Single sensor. Position and velocity feedback comes from the encoder or resolver on the motor.
- Dual sensor. Position feedback comes from the encoder attached to the load.
  Velocity feedback comes from the encoder mounted on the motor

For more information, see Feedback (p. 15).

Position Loop Output

The output of the position loop is a velocity command used as the input to the velocity loop.

Position Wrap

The position wrap feature causes the position reported by the drive to “wrap” back to zero at a user-defined value instead of continually increasing. Once set, the reported position will be between 0 and n-1 where n is the user entered wrap value. This feature is most useful for rotary loads that continually turn in one direction and only the position within a revolution is of interest to the user.

With the wrap value set, relative moves will move the relative distance called for. Example: if the wrap value is set to 1000 and a relative move of 2500 is commanded, the axis will turn 2 ½ revolutions.

Absolute moves will move the shortest distance to arrive at the programmed position. This could be in the positive or negative direction. Moves programmed to a point greater than the wrap value will cause an error.

To configure the position wrap feature, see the *CME User Guide*.

3.5 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), MACRO 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. 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

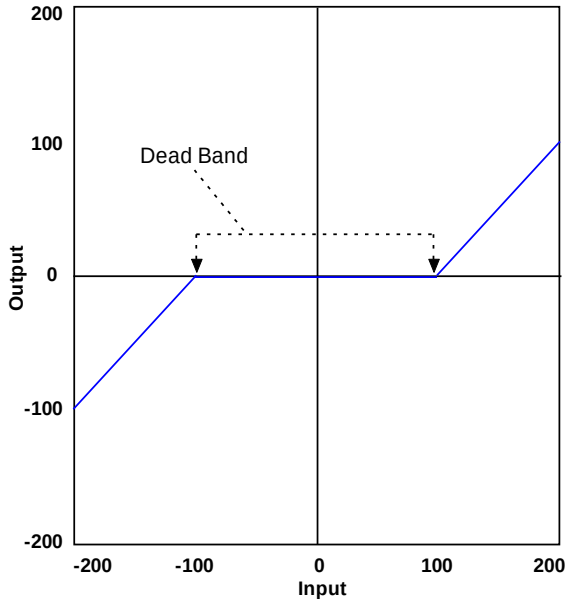
The magnitude of the command generated by an input signal is proportional to the input signal voltage. Scaling controls the input-to-command ratio, allowing the use of an optimal command range for any given input voltage signal range.

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 so 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 uni-polar 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 & Stepnet 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 should be homed every time it is enabled. The Homing sequence may be initiated by CAN, ASCII serial, CVM or CPL Indexer program commands.

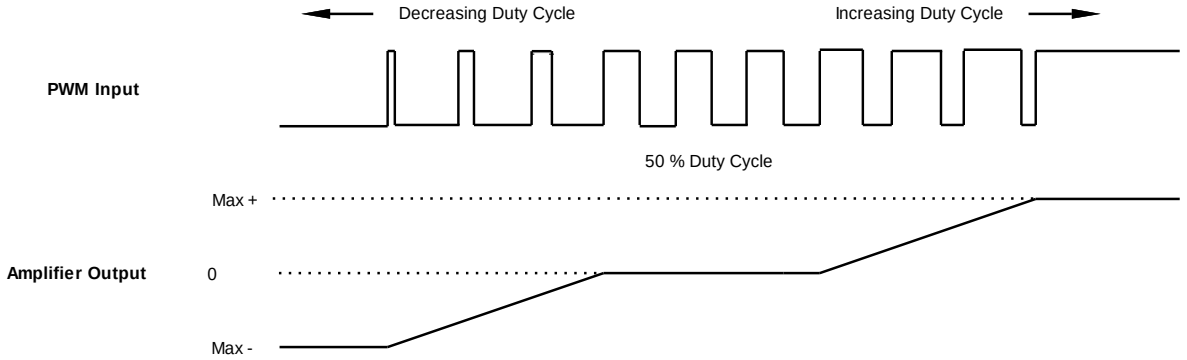
PWM Input Commands

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)

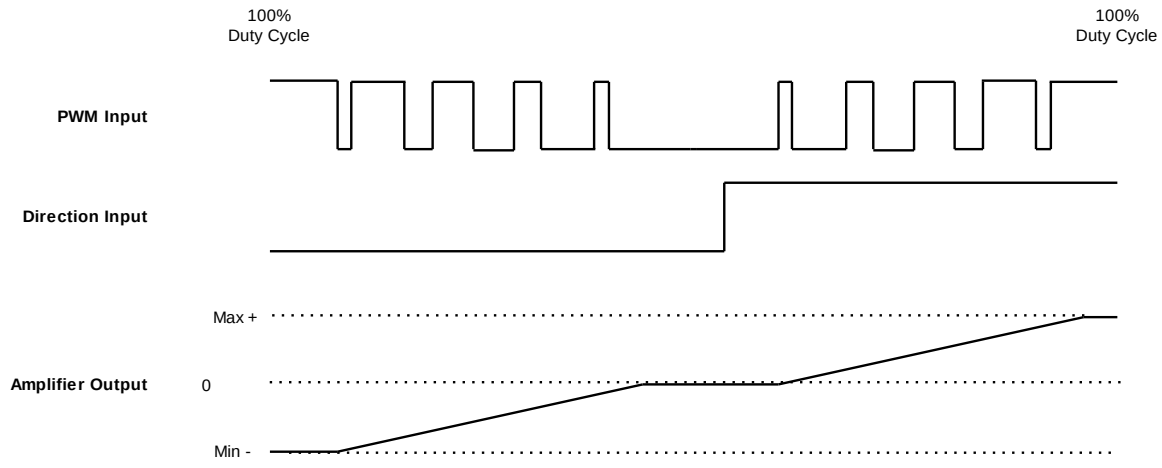
The input takes a PWM waveform of fixed frequency and variable duty cycle. As shown below, a 50% duty cycle produces zero output from the drive. Increasing the duty cycle toward 100% commands a positive output, and decreasing the duty cycle toward zero commands a negative output.



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 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.

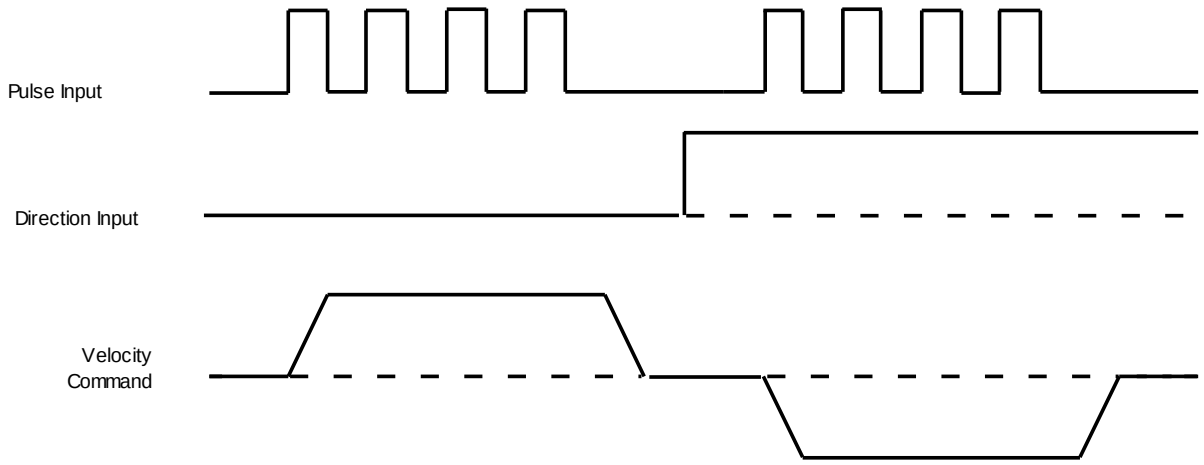
Pulse Smoothing

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

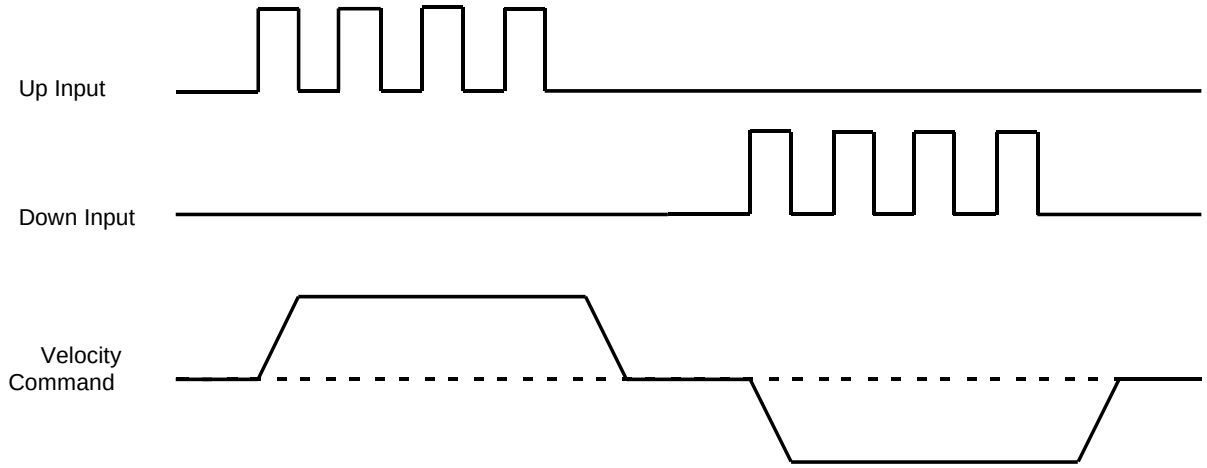
In pulse and direction format, one input takes a series of pulses as motion step commands, and another input takes a high or low signal as a direction command, as shown below.



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

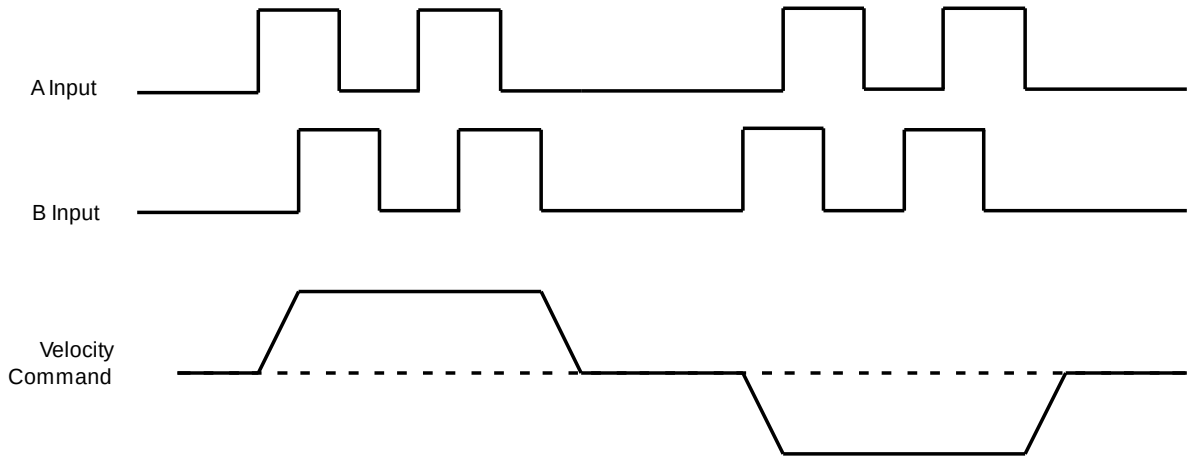
In the count up/down format, one input takes each pulse as a positive step command, and another takes each pulse as a negative step command, as shown below.



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 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.

3.6 COMMUNICATIONS

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

Interface	Description
RS-232 port	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. For RS-232 port specifications, see Serial Interface (p. 54). For RS-232 port wiring instructions, see RS-232 Serial Communications (p. 83). 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.
CAN interface (BPL, BP2, TP2)	When operating as a CAN node, the drive takes command inputs over a CANopen network. CAN communications are described in the next section.
EtherCAT (BEL, BE2, TEL, TE2)	Drives support CANopen application protocol over EtherCAT (CoE) via a 100BASE-TX physical layer.
MACRO (BML)	The BML typically runs in torque mode accepting commands over the MACRO network. (Velocity mode is also supported.)

 DANGER	Using CME can affect or suspend CAN operations.
	When operating the drive as a CANopen node, use of CME to change drive parameters can affect 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.

CAN Communication Details (BPL/BP2/TP2)

CAN Network and CANopen Profiles for Motion

The BPL/BP2/TP2 communicate over a two-wire Controller Area Network (CAN).
The CAN specification defines the data link layer of a fast, reliable network and is an international standard ISO 11898-1. The physical layer is a two-wire, serial-data connection.

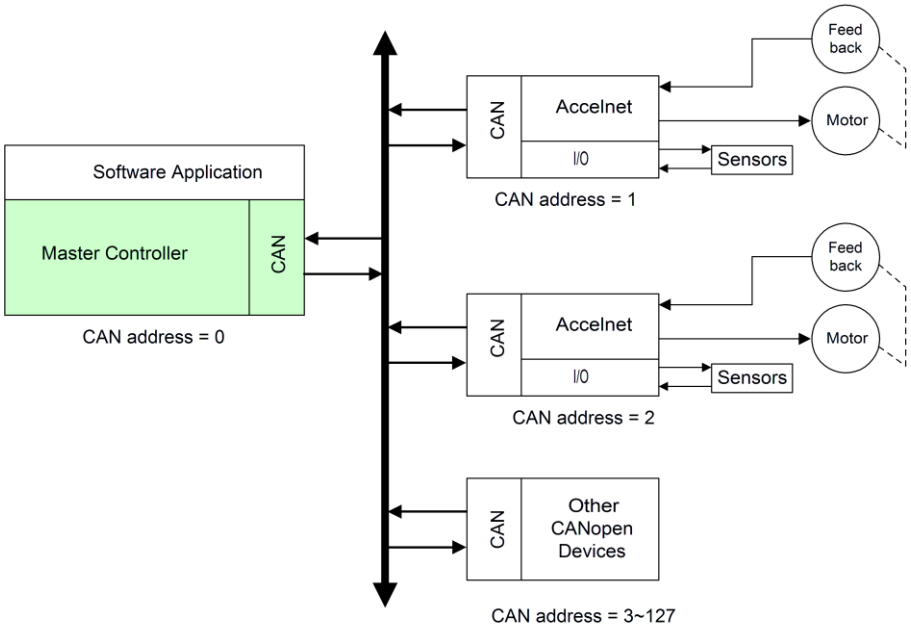
CANopen is the CAN-based higher-layer protocol for embedded control systems. CiA 402 is the CANopen profile for drives and motion controllers, internationally standardized in IEC 61800-7-201 and
IEC 61800-7-301. It is supported by Copley CANopen servo and stepper drives, allowing them to operate in the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

As shown below, in a CANopen motion control system, control loops are closed in the individual drives, 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 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 method 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:

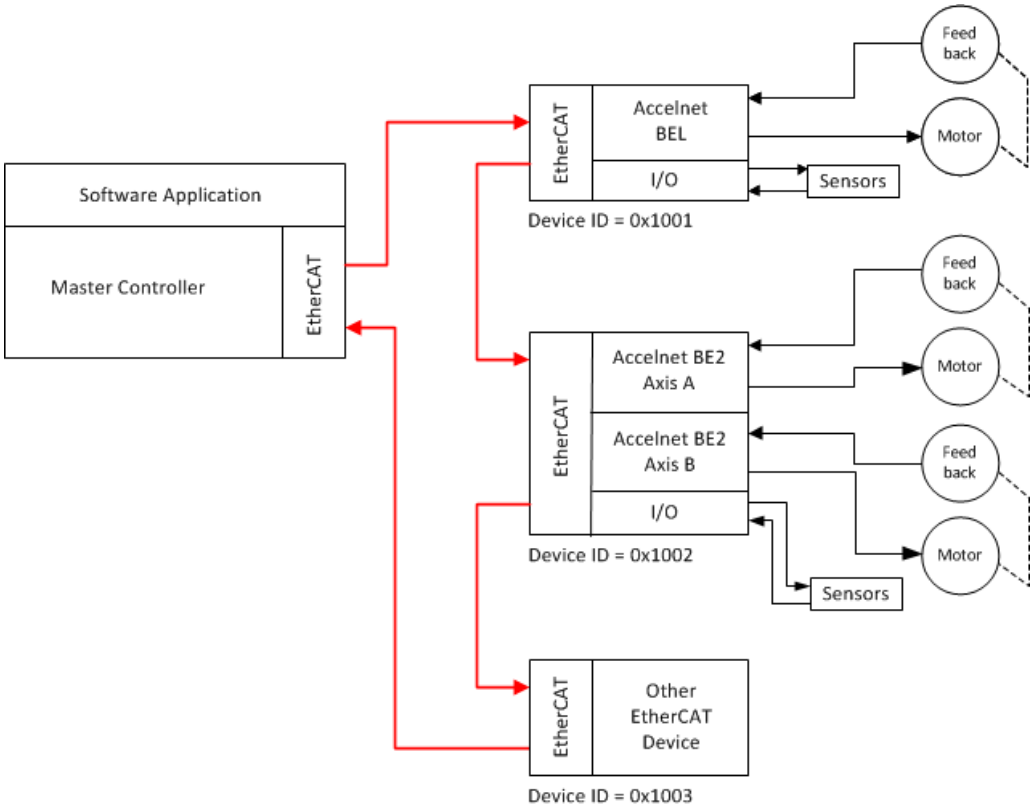
- CANopen Programmer's Manual
- CML Reference Manual
- CMO (Copley Motion Objects) Programmer's Guide

EtherCAT Communication Details (BEL/BE2/TEL/TE2)

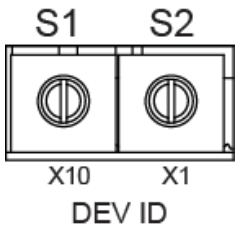
These models accept CANopen application protocol over EtherCAT (CoE) commands.

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 is -2 (0xFFFE), and so 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. 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.

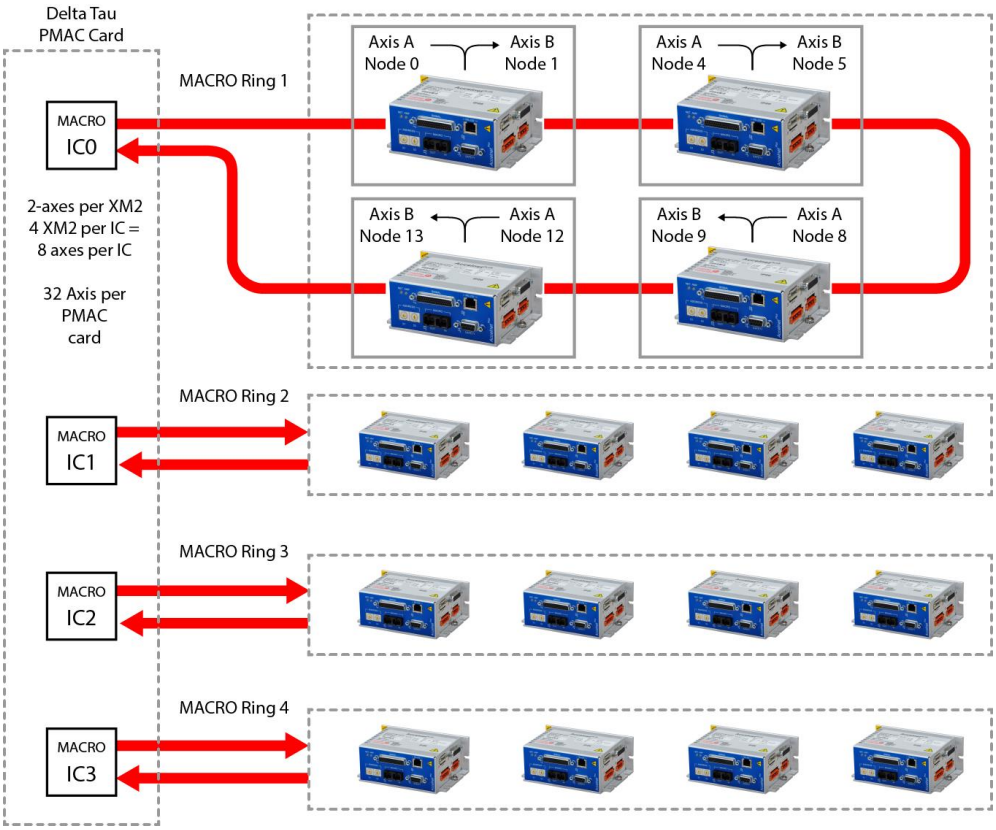
MACRO Communication Details (BML)

The XML/XM2 typically runs in torque mode accepting commands over the MACRO network. (Velocity mode is also supported.)

MACRO Addressing

A MACRO network, or ring for the BML can have up to sixteen master controllers with hex addresses from 0x00 to 0x0F. Each master can control up to eight servo drives. This works out to a maximum of 128 servo drives on a MACRO ring.

A MACRO address is eight bits long. Switch S1 controls bits 7~4 to select the MACRO master and switch S2 controls bits 3~0 and selects the node address. Node addresses available for servo drives are: 0~1, 4~5, 8~9, and 12~13.



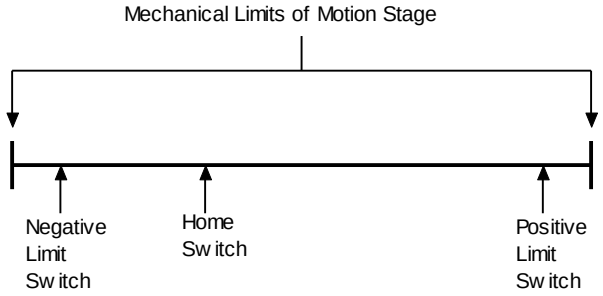
3.7 Limit Switches

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, EtherCAT, or MACRO 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

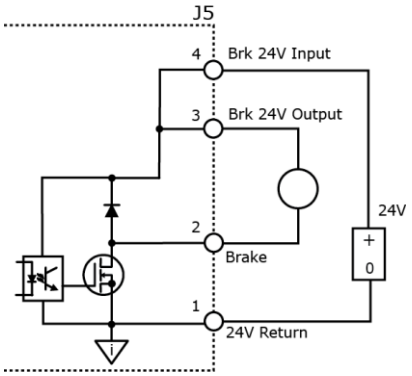
In addition to the response described above, any of the drive’s digital outputs can be configured to go active when a positive or negative limit switch is activated.
For more information, see the *CME User Guide*.

3.8 Brake Operation

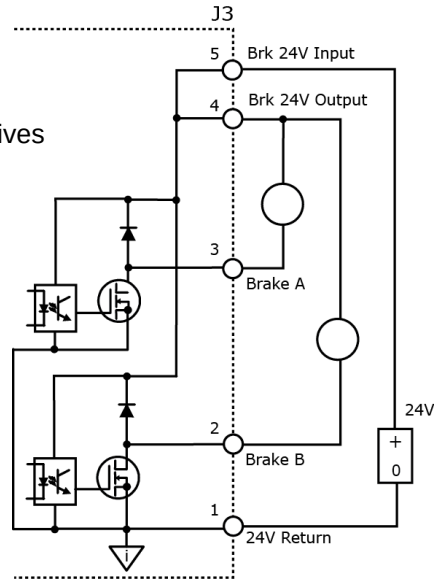
Brake Outputs

Many control systems employ a brake to hold an axis when the drive is disabled. *Accelnet & Stepnet Plus Panel* drives have digital outputs designed specifically for brake control. Unlike the other outputs, these brake outputs have internal fly-back diodes connected to +24 Vdc input. By eliminating the need to connect into the drive control connector, the brake outputs simplify wiring when the brake wires are in the power cable of the motor. Non-brake outputs require external fly-back diodes if they are used for brake control.

1-Axis Drives



2-Axis Drives



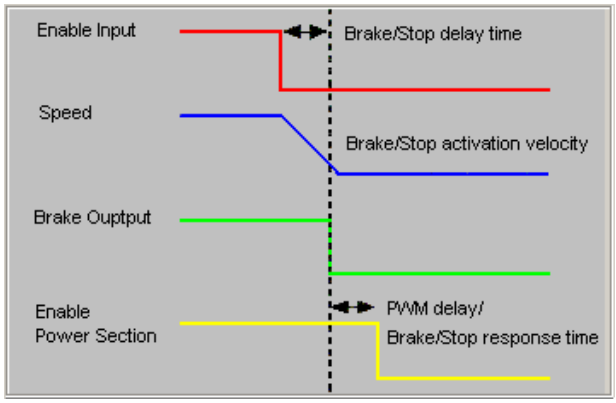
Brake/Stop Sequences

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.

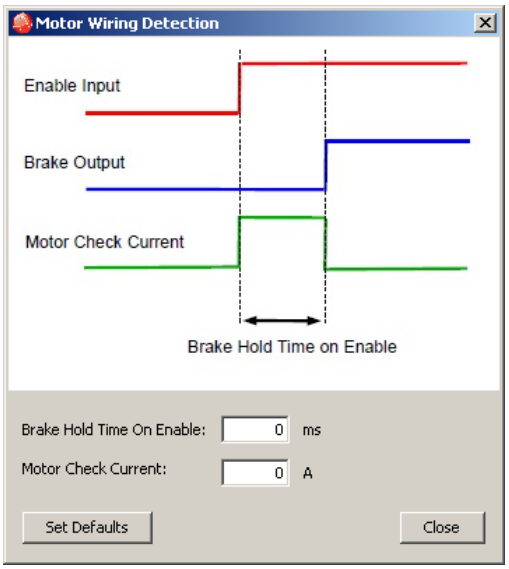
When the motor slows to Brake/Stop Activation Velocity OR the Brake/Stop Delay Time expires, the brake output activates and PWM Delay Brake/Stop Response Time count begins.

When 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 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 current can be detected, the brake will be released after the programmable time expires.

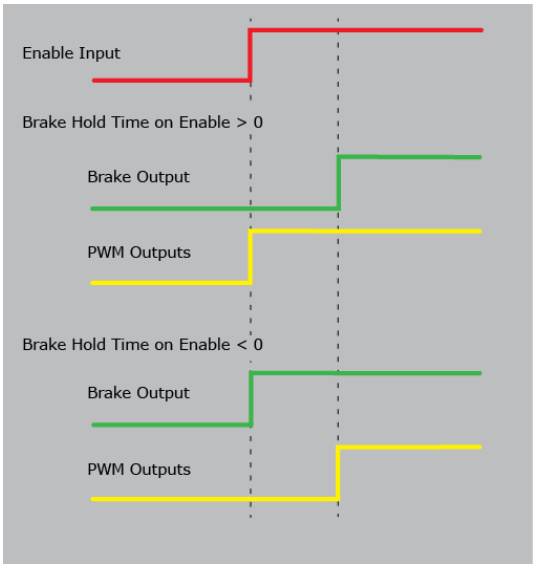


Motor Brake Enable Delay Time

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



3.9 PROTECTION

SAFE TORQUE OFF (STO)

All of the *Accelnet & Stepnet Plus Panels* 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 further information and installation guidelines, refer to the *Accelnet & Stepnet Plus Panels STO Manual*

FAULTS OVERVIEW

Accelnet & Stepnet Plus Panels drives detect and respond to a set of conditions regarded as faults, such as drive over temperature and excessive following error. When any fault occurs, with the exception of 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), and 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 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 +24 Vdc 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, EtherCAT, MACRO 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

The set of possible faults is described below. For details on limits and ranges, see Fault Levels (4.17).

Fault Description	Fault Occurs When…	Fault is Corrected When…
* 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 feedback. Resolver or analog encoder 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 resolver feedback or 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.
Over Current (Latched)	Optional: The I^2T current-limit for the drive has been reached	Reduce drive current

* Configured as *latching* by default. Programmable to be *non-latching*.

3.10 Position and Velocity Errors

Error-Handling Methods

In 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, EtherCAT, or MACRO network. 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, position error is the difference between the limited position output of the trajectory generator and the actual position. When 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 Aux HV is used, then both Aux 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

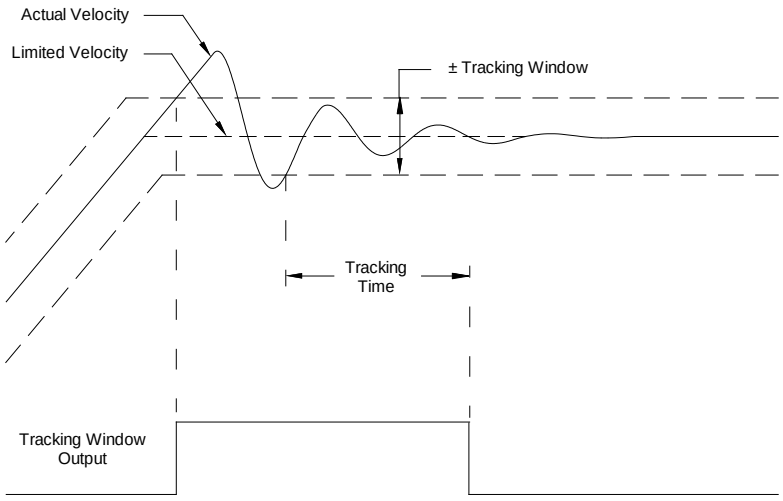
Proper Tracking Over Time

As described earlier, 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 tracking window and time settings in velocity mode.



3.11 Digital Inputs BEL, BPL, BML, TEL

Digital Inputs

The BEL, BPL, BML and TEL drives feature 11 programmable digital inputs. Inputs IN1-IN10 are connected on the Signal connector J1. The Motemp input IN11, connects to the Feedback connector J5..

Input Filters

DC inputs IN1~2 have 1 µs RC filters and are 24 Vdc tolerant. Inputs IN3~6 have a lower 12 Vdc tolerance, but have faster 100 ns RC filters and can be configured as four single-ended inputs, or two differential inputs. IN7~10 are single ended opto-isolated inputs connected on J1. These are ±24 Vdc compatible in a group of four with a common terminal that can be connected to +24 Vdc or ground to work with current-sinking or current-sourcing outputs from controllers. The Motemp input IN11, is for use with a motor over temperature switch or sensor connected to J5 and has a 330 us RC filter.

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.

Configure for Pull Up/Pull Down Resistors

IN1~6 have individually programmable pull-up or pull-down resistors. Pull-up resistors work devices having current-sinking outputs such as NPN transistors, grounded relay contacts, or N-channel MOSFETs. Pull-down resistors work well with PLC that have current-sourcing outputs wired to +24 Vdc (IN1~2), or less than 12 Vdc (IN3~6).

Analog Inputs

The programmable differential analog input AIN1 is connected to J1 with ±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.

3.12 Inputs: BE2, BP2, TE2, TP2

The BE2, BP2, TE2 and TP2 drives have 18 digital and 2 analog inputs. Inputs IN1-IN4 and IN10-13 are connected on the Signal connector J1. Inputs IN5-IN8 and IN14-IN17 are connected on the I/O connector J2. The Motemp inputs IN9 and IN18, connect to the Feedback connectors J7 and J8 respectively.

Digital Inputs

In IN1~2 and IN10~11 are general purpose Schmitt trigger single ended inputs with 1 µs RC filters (24 Vdc compatible). IN3-4 and IN12-13 are programmable as single ended or differential inputs with 100 ns RC filters connected on J1 (12 Vdc compatible). Inputs IN1~4 and IN10~13 have individually programmable pull-up/pull-down resistors.

IN5-8 and IN14-17 are single ended opto-isolated inputs connected on J1. These are ±24 Vdc compatible in two groups of four, each with a common terminal that can be connected to +24 Vdc or ground to work with current-sinking or current-sourcing outputs from controllers.

For a list of input functions, see the CME User Guide.

Input Filters

DC inputs IN1~2 and IN10~11 on J1 have 1 µs RC filters and are 24 Vdc tolerant. Inputs IN3~4 and IN12~13 have a lower 12 Vdc tolerance, but have faster 100 ns RC filters and can be configured as four single-ended inputs, or two differential inputs.
IN5~8 and IN14~17 are single ended opto-isolated inputs on the I/O connector J2. These are ±24 Vdc compatible in a group of eight with a common terminal that can be connected to +24 Vdc or ground to work with current-sinking or current-sourcing outputs from controllers.

The Motemp inputs IN9 & IN18 on Feedback connectors J6 & J7 are for use with a motor over temperature switches or sensors connected to the Motemp inputs and have 330 µs RC filters. These are 12 Vdc compatible and have pull-up resistors to +5 Vdc.

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.

Analog Inputs

Two programmable differential analog inputs, AIN1 and AIN2 are connected on Signal connector J1. As reference inputs they can take position/velocity/torque commands from a controller. If not used as command inputs, they can be used as general-purpose analog inputs.

3.13 Outputs: BEL, BPL, BML, TEL

These drives have 4 programmable digital outputs. OUT1~3 are opto-isolated SSR (Solid State Switch) devices with (+) and (-) connections brought out to J1. These are 24 Vdc compatible and have 36V Zener diodes between collector and emitter for flyback damping of inductive loads.

OUT4 is an optically isolated MOSFET referenced to the 24V Return of the brake connector. The MOSFET drain is connected to the Brake pin if 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 (OUT4) is described in Brake Operation

.

3.14 Outputs: BE2, BP2, TE2 and TP2

These drives have 7 programmable digital outputs. OUT1~5 are MOSFET devices with source and drain from each output connecting to the I/O connector J2. These are 24 Vdc compatible and have 36V Zener diodes between source and drain for flyback damping of inductive loads.

OUT6~7 are optically isolated MOSFETs referenced to the 24V Return of the brake connector. The MOSFET drains are connected to the Brake A and Brake B pins of the Brake connector. Flyback diodes are connected between the drain of each MOSFET and the +24V Input pin of the Brake connector. These provide internal flyback diodes for two motor brakes. The brake outputs (OUT6~7) are described in Brake Operation.

4 SPECIFICATIONS

4.1 DC INPUT POWER

+HV is required for operation of the drives. AuxHV is optional and powers the communications, feedback, and I/O functions but not the PWM outputs. AuxHV 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.

SINGLE-AXIS SERVO MODELS: BEL, BPL, BML

Model	BEL-090-06 BPL-090-06 BML-090-06	BEL-090-14 BPL-090-14 BML-090-14	BEL-090-30 BPL-090-30 BML-090-30	Unit
DC +HV Voltage***	+14 to +90 (transformer-isolated from AC mains)			Vdc
Peak +HV Current	6	14	30	Adc
Peak Current Time	1			Sec
Continuous +HV Current	3	7	15	Adc
AuxHV Supply Voltage***	+14 to +90 (transformer-isolated from AC mains)			Vdc
AuxHV Supply Current	500 mA maximum			Adc**
*The actual +HV current is dependent on the input voltage and 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.				
** AuxHV 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.				
*** Supply Short Circuit Current Rating (SCCR) must be 5k Arms maximum				

DUAL-AXIS SERVO MODELS: BE2, BP2

Model	BE2-090-06 BP2-090-06	BE2-090-14 BP2-090-14	BE2-090-20 BP2-090-20	Unit
DC +HV Voltage***	+14 to +90 (transformer-isolated from AC mains)			Vdc
Peak +HV Current	12	28	40	Adc
Peak Current Time	1			Sec
Continuous +HV Current	6	14	20	Adc
AuxHV Supply Voltage***	+14 to +90 (transformer-isolated from AC mains)			Vdc
AuxHV Supply Current	500 mA maximum			Adc**
*The actual +HV current is dependent on the input voltage and 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.				
** AuxHV supply current depends on the number of encoders connected to the drive. The maximum current draw given assumes that the two encoder +5V outputs are each loaded to 500mA.				
*** Supply Short Circuit Current Rating (SCCR) must be 5k Arms maximum				

DC Input Power (cont'd)

Single-Axis Stepper Model: TEL

Model	TEL-090-07	TEL-090-10	Unit
DC +HV Voltage***	+14 to +90 (transformer-isolated from AC mains)		Vdc
Peak +HV Current	7	10	Adc
Peak Current Time	1		Sec
Continuous +HV Current	5	10	Adc
AuxHV Supply Voltage***	+14 to +90 (transformer-isolated from AC mains)		Vdc
AuxHV Supply Current	500 mA maximum		Adc**
*The actual +HV current is dependent on the input voltage and 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.			
**Logic supply current draw 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.			
*** Supply Short Circuit Current Rating (SCCR) must be 5k Arms maximum			

Dual-Axis Stepper Models: TE2, TP2

Model	TE2-090-07 TP2-090-07	TE2-090-10 TP2-090-10	Unit
DC +HV Voltage***	+14 to +90 (transformer-isolated from AC mains)		Vdc
Peak +HV Current	14	20	Adc
Peak Current Time	1		Sec
Continuous +HV Current	10	20	Adc
AuxHV Supply Voltage***	+14 to +90 (transformer-isolated from AC mains)		Vdc
AuxHV Supply Current	500 mA maximum		Adc**
*The actual +HV current is dependent on the input voltage and 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.			
**Logic supply current draw depends on the number of encoders connected to the drive. The maximum current draw given assumes that the two encoder +5V outputs are each loaded to 500mA.			
*** Supply Short Circuit Current Rating (SCCR) must be 5k Arms maximum			

4.2 Power Output

Single-Axis Servo Models: BEL, BPL, BML

Model	BEL-090-06 BPL-090-06 BML-090-06	BEL-090-14** BPL-090-14** BML-090-14**	BEL-090-30** BPL-090-30** BML-090-30**	Unit
Peak Current	6 (4.24)	14 (9.9)	30 (21.2)	Adc (Arms)*
Peak Current Time	1			Sec
Continuous Current**	3 (2.12)	7 (4.95)	15 (10.6)	Adc (Arms)*
Efficiency	>97% @ 90 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				

Dual-Axis Servo Models: BE2, BP2

Model	BE2-090-06 BP2-090-06	BE2-090-14** BP2-090-14**	BE2-090-20** BP2-090-20**	Unit
Peak Current	6 (4.24)	14 (9.9)	20 (14.4)	Adc (Arms)*
Peak Current Time	1			Sec
Continuous Current**	3 (2.21)	7 (4.95)	10 (7.07)	Adc (Arms)*
Efficiency	>97% @ 90 Vdc and rated continuous current			
Output Type	3-phase MOSFET inverter each axis 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				

Power Output (cont'd)

Single-Axis Stepper Model: TEL

Model	TEL-090-07 TPL-090-07	TEL-090-10 TPL-090-10	Unit
Peak Current	7 (4.95)	10 (7.07)	Adc (Arms*)
Peak Current Time	1		Sec
Continuous Current**	5 (3.54)	10 (7.07)	Adc (Arms*)
Efficiency	>97% @ 90 Vdc and rated continuous current		
Output Type	2 H-bridge MOSFET inverters 16 kHz center-weighted PWM space-vector modulation		
PWM Ripple Frequency	32 kHz		
Minimum Load Inductance	400 µH line-to-line***		
* Arms is peak-of-sine ** Heat sinking and/or forced air cooling is required for continuous output power rating *** Consult factory for operation with inductance lower than 400 µH			

Dual-Axis Stepper Models: TE2, TP2

Model	TE2-090-07 TP2-090-07	TE2-090-10 TP2-090-10	Unit
Peak Current	7 (4.95)	10 (7.07)	Adc (Arms*)
Peak Current Time	1		Sec
Continuous Current	5 (3.54)	10 (7.07)	Adc (Arms*)
Efficiency	>97% @ 90 Vdc and rated continuous current		
Output Type	2 H-bridge MOSFET inverters per axis 16 kHz center-weighted PWM space-vector modulation		
PWM Ripple Frequency	32 kHz		
Minimum Load Inductance	400 µH line-to-line***		
* Arms is peak-of-sine ** Heat sinking and/or forced air cooling is required for continuous output power rating *** Consult factory for operation with inductance lower than 400 µH			

4.3 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 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.

4.4 DIGITAL COMMAND INPUT

Digital Position Command	Pulse and direction, Count up / count down maximum rate	2 MHz (with active driver)
	Quadrature A/B encoder maximum rate	2 M line/sec (8 M count/sec after quadrature)
Digital Current & Velocity Command	PWM frequency range	1 kHz - 100 kHz
	PWM minimum pulse width	220 ns

4.5 Analog Inputs

BEL, BPL, BML, TEL

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 kΩ
Resolution	12 Bit
Anti-aliasing filter	14.5 kHz
Scan Time	62.5 µs
Function	Programmable. current, velocity, or position command

BE2, BP2, TE2, TP2

Channels	2
Names	AIN1-AIN2
Type	Differential, non-isolated
Measurement Range	±10 Vdc
Maximum Differential Input Voltage Maximum Input Voltage to Ground	±10 Vdc ±10 Vdc
Input Impedance	5 kΩ
Resolution	12 bit
Anti-aliasing filter	14.5 kHz
Scan Time	62.5 µSec
Function	Programmable. current, velocity, or position command

4.6 DIGITAL INPUTS

- Update rate (scan time) is 4 kHz (250 µs)
- Programmable (the default functions of some inputs are programmable to other functions)
- Programmable debounce time: 0~10,000 ms

BEL, BPL, BML, TEL

	IN1~IN2 (J1)	IN3~IN6 (J1)	IN7~IN10 (J1)	IN11 (J6)
Type	Schmitt trigger w/ RC filter, 24Vdc max	Non-isolated RS-422 line receiver w/ RC filter, programmable as 4 single-ended or 2 differential Single-ended	Opto-isolated, bi-polar, group of 4 with common	Schmitt trigger w/ RC filter
RC Filter	15k/100pF (1.5uS)	10k/100pF (100nS)	2mS	10k/33nF (330uS)
Input Voltage Range	0 Vdc-24 Vdc	0-12Vdc	±15 - 30 Vdc	0-12Vdc
Pull-up/Pull-down	Programmable, each input independently, 15k, +5V (PU), Signal Gnd (PD)	Programmable, each input independently, 10k, +5V (PU), Signal Gnd (PD)	NA	Fixed Pull-up to +5V, 4.99k
Logic Low Input Voltage	1.3~2.2 Vdc	≤+2.3 Vdc (Single Ended) ≤+200mV (Differential)	≤ 7.6 Vdc	≤+1.3~2.2 Vdc, 1.7 typ
Logic High Input Voltage	2.5~3.5 Vdc	≥ +2.7 Vdc (Single Ended) ≥+200mV (Differential)	≥ 7.7 Vdc	≥ +2.5~3.5 Vdc, 2.9 typ
Input Hysteresis	0.7~1.5 Vdc	45 mVdc	~100 mV	0.7~1.5 Vdc
Default Function	IN1 – Enable IN2 – Not Configured	Not Configured	Not Configured	Motor Temp

BE2, BP2, TE2, TP2

	IN1~IN2, IN10~IN11 (J1)	IN3~IN4, IN12~IN13 (J1)	IN5~IN8, IN14~IN17 (J2)	IN9 (J7), IN18 (J8)
Type	Schmitt trigger w/ RC filter, 24Vdc max	Non-isolated RS-422 line receiver w/ RC filter, programmable as 4 single-ended or 2 differential Single-ended	Opto-isolated, bi-polar, 2 groups of 4 with a common for each group	Schmitt trigger w/ RC filter
RC Filter	15k/100pF (1.5uS)	10k/100pF (100nS)	2mS	10k/33nF (330uS)
Input Voltage Range	0 Vdc-24 Vdc	0-12Vdc	±15 - 30 Vdc	0-12Vdc
Pull-up/Pull-down	Programmable, each input independently, 15k, +5V (PU), Signal Gnd (PD)	Programmable, each input independently, 10k, +5V (PU), Signal Gnd (PD)	NA	Fixed Pull-up to +5V, 4.99k
Logic Low Input Voltage	≤ +1.13 Vdc	≤+2.3 Vdc (Single Ended) ≤+200mV (Differential)	≤ 7.6 Vdc	≤+1.3~2.2 Vdc, 1.7 typ
Logic High Input Voltage	≥ +3.15 Vdc	≥ +2.7 Vdc (Single Ended) ≥+200mV (Differential)	≥ 7.7 Vdc	≥ +2.5~3.5 Vdc, 2.9 typ
Input Hysteresis	0.7~1.5 Vdc	45 mVdc	~100 mV	0.7~1.5 Vdc
Default Function	IN1 – Enable Axis A IN10 – Enable Axis B IN2, IN11 – Not Configured	Not Configured	Not Configured	IN9 - Motor Temp Axis A IN18 – Motor Temp Axis B

4.7 DIGITAL OUTPUTS

BEL, BPL, BML, TEL

Specification	Data	
Channels	4 (OUT1~4)	
	OUT1~OUT3 (J1)	OUT4 (J5)
Type	Opto-isolated SSR, two-terminal, 36 V Zener flyback diode between SSR +/- outputs, 1Ω series resistor between SSR(+) and output pins	Opto-isolated MOSFET with internal flyback diode from Brake [OUT4] to Brk 24V Input
Maximum Voltage	32Vdc	+32 Vdc
Maximum Current	300 mA	1 Adc
Output Data	~600 us turn-on, ~25 us turn-off, 0-90%	On resistance 0.14 Ω
Function	Programmable	Brake/Programmable

BE2, BP2, TE2, TP2

Specification	Data	
Channels	7 (OUT1-OUT7)	
	OUT1~OUT5 (J2)	OUT6~OUT7 (J3)
Type	Opto-isolated SSR, two-terminal, 36 V Zener flyback diode between SSR +/- outputs, 1Ω series resistors between SSR(+) and output pins	Opto-isolated MOSFETs with internal flyback diodes from Brake A [OUT6] & Brake B [OUT7] to Brk 24V Input
Maximum Voltage	32Vdc	+32 Vdc
Maximum Current	300 mA	1 Adc
Output Data	~600 us turn-on, ~25 us turn-off, 0-90%	On resistance 0.14 Ω
Function	Programmable	Brake/Programmable

4.8 Encoder +5V Power Output

BEL, BPL, BML, TEL

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 encoder and/or Hall switches.
Output Pins	J1-17, J1-32, 7, J6-6, J6-17

BE2, BP2, TE2, TP2

Number	2
Voltage Output	+5 Vdc ±2%
Maximum Current Output	500 mA for Axis A, 500 mA for Axis B
Short Circuit Protection	Thermal and short-circuit protected
Function	Provides power for motor encoders and/or Hall switches.
Output Pins	Axis A: J1-17, J2-32, J7-6, J7-17 Axis B: J1-23, J1-38, J8-6, J8-17

4.9 Primary Encoder Inputs

The Primary encoder connections are on the feedback connectors.

Digital Encoders

Supported by drives	BEL, BE2, BPL, BP2, BML, TEL, TE2, TP2
Channels	4 for each axis
Type	Differential RS-422 line receiver w/ RC filter Non-isolated
Signals	A, /A, B, /B, X, /X, S, /S for each axis
Input Voltage Range	±7 Vdc
Differential Input Threshold	±0.2 Vdc
Termination Resistance	121 Ω on A, B inputs, 130 Ω with 1 kΩ pull-up on X, 1 kΩ pull-down on /X , 221 Ω with 1 kΩ pull-up on S, 1 kΩ pull-down on /S
Maximum Frequency	5 MHz Line (20 Mcount/sec)

Analog (Sin/Cos) Incremental Encoders

BEL, BPL, BML, BE2, BP2

Channels	2 per axis
Type	Differential, non-isolated
Signals	Sin(+), Sin(-), Cos(+), Cos(-) for each axis
Nominal Voltage	1 Vpk-pk
Maximum Voltage Differential Input to Ground	 ±0.6 Vdc 0 to +3.5 Vdc
Differential Input Impedance	121 Ω
Bandwidth	230 kHz
Interpolation	1 to 1024, programmable

4.10 Digital Hall Sensor Inputs

BEL, BPL, BML, BE2, BP2

Channels	3 (U, V and W) for each axis
Type	74HC14 Schmitt trigger w/ RC Filter 10 kΩ pull up resistor to internal +5 Vdc
Input Voltage Range	0 Vdc - +24 Vdc
Low Level Input Voltage	< +1.35 Vdc
High Level Input Voltage	> +3.65 Vdc
Timing	Edge detection.
RC Filter Time Constant	1 μSec when driven by active sources.
Function	Commutation of brushless motors in trapezoidal mode. Commutation initialization and phase error detection in sinusoidal mode.

4.11 RESOLVER FEEDBACK

Resolver feedback is available as the "-R" option on BEL, BPL, BE2, and BP2 drives. Resolver feedback is not available on BML drives.

BEL, BPL, BE2, BP2

Channels	3 per axis
Type	Transmit, 1:1 to 2:1 transformation ratio
Signals	Ref(+), Ref(-), Sin(+), Sin(-), Cos(+), Cos(-) for each axis
Resolution	14 bits (equivalent to a 4096 line quadrature encoder)
Reference Frequency	8 kHz
Reference Voltage	2.8 Vrms, auto-adjustable by drive for proper feedback levels.
Reference Max Current	100 mA
Max RPM	20,000
Function	Incremental or analog encoder or resolver required for sinusoidal commutation and position or velocity modes of operation.

4.12 MULTI-MODE PORT

The Multi-Mode Port has three functions:

Input for digital incremental or absolute encoders

Output of buffered primary digital incremental encoder A,B, and X signals

Output of emulated A, B, X digital incremental encoder signals from analog encoders or resolvers

Channels BEL/BPL/BML/TEL BE2/BP2/TE2/TP2	 4 8
Type	Bi-Directional, Differential RS-422. Non-isolated
Signals	A, /A, B, /B, X, /X, S, /S
Input Voltage Range	±7 Vdc
Differential Input Threshold	±0.2 Vdc
Termination Resistance	None on A and B channels, 130 Ω with 1 kΩ pull-up on X, 1 kΩ pull-down on /X , 221 Ω with 1 kΩ pull-up on S, 1 kΩ pull-down on /S
Function Programmable	Output Mode Buffered primary incremental encoder Emulated incremental or serial encoder from analog encoder or resolver Input Mode Secondary digital quadrature input Current / Velocity mode, PWM input Position Mode, Digital command input
Maximum Frequency Output Mode Buffered Encoder Emulated Encoder	 5 MHz Line (20 Mcount/sec) 4.5 MHz Line (18 Mcount/sec)

Input Mode PWM Input Digital Command Secondary Encoder	100Khz 5 MHz (50% Duty Cycle) 5 MHz Line (20 Mcount/sec)

4.13 SERIAL INTERFACE

The serial port operates the same in all Accelnet Plus Panel and Stepnet Plus Panel 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 a higher Baud rate:
9600, 19200, 57600, and 115,200 (maximum) are common settings used.
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.

BEL, BPL, BML, BE2, BP2, TEL, TE2, TP2

Channels	1
Type	RS-232, DTE
Signals	Rxd, Txd, Gnd
Baud Rate	9600, 19200, 57600, 115,200 (defaults to 9600 on power up or reset)
Data Format	N, 8, 1
Flow Control	None
Protocol	Binary or ASCII format
Function	Set up, control and diagnostics status
Drive Connectors	BEL, BPL, BML, TEL, BE2, BP2, TE2, TP2: RJ-11, 6-position, 4-contact

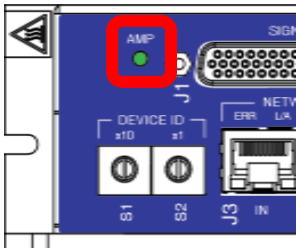
4.14 NETWORK INTERFACES

Model	BEL, BE2, TEL, TE2	BPL, BP2, TP2	BML
Connectors	Dual eight-position receptacle (RJ-45 style).		Duplex type SC optical fiber conector
Signals	Ethernet 100BASE-TX	CAN_H, CAN_L, CAN_Gnd (CAN +5 Vdc Pass though only)	MACRO
Data Format	EtherCAT	CAN V2.0b physical layer for high-speed connections compliant	MACRO
Protocol	CANopen Application protocol over EtherCAT (CoE) based on DSP-402 for motion control devices.	Motion Control Device Under DSP-402 of the CANopen DS-301 V4.01 (EN 50325-4) Application Layer	MACRO
Supported Modes	Cyclic Synchronous Position, Velocity, Torque, Profile Current, Velocity, and Position, PVT, and Homing	Profile Current, Velocity, and Position, PVT, and Homing.	Current, Velocity
Node Address Selection	Slaves are automatically assigned addresses based on their position on the bus. Two 16-position hexadecimal rotary switches can be used to define a cabling-independent Station Alias.	Two 16-position hexadecimal rotary switches on front panel OR programmable digital inputs OR stored in flash memory OR combination of above.	Two 16-position hexadecimal rotary switches on front panel. S1 selects master IC (0, 1, 2 or 3). S2 selects slave address (0, 1, 4, 5, 8, 9, 12 or 13)
Cable	Cat 5 or Cat-5e minimum 100 m maximum length between nodes	Cat 5 or Cat-5e minimum with 121 Ω terminator across CAN_H and CAN_L on last node in the chain.	Fiber optic
Bus Termination	No termination required.	A 121 Ω resistor across CAN_H and CAN_L when termination plug is installed in second connector. Copley part numbers for these terminators are: Model Part Number BPL BPL-NT BP2 BP2-NT TP2 TP2-NT	No termination required

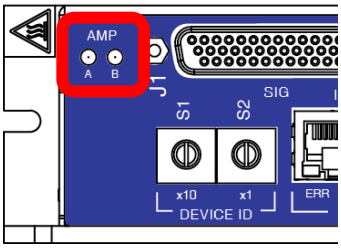
4.15 Status Indicators

Drive Status Indicator

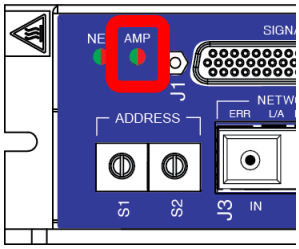
BEL, BPL, TEL



BE2, BP2, TE2, TP2



BML



AMP LED

A bi-color LED gives the state of the BEL 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 has been cleared the next one below will shown.

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 EtherCAT commands.
Off	=	No HV or HVAUX power to drive

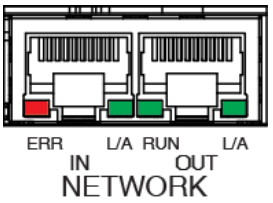
Latching Faults

Defaults
- Short circuit (Internal or external)
- Drive over-temperature
- Motor over-temperature
- Feedback Error
- Following Error

Optional (programmable)
- Over-voltage
- Under-voltage
- Motor Phasing Error
- Command Input Fault
- Motor Wiring Disconnected
- Over-current (Latched, I^2T)

Network Status Indicators

CANopen Network Status Indicators: BPL, BP2, TP2



RUN Green: Shows the state of the CANopen network state machine

Off	=	Init
Blinking	=	Pre-operational
Single-flash	=	Stopped
On	=	Operational

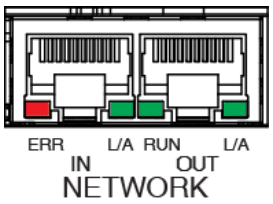
ERR Red: Shows status of CAN physical layer and errors such as watchdog timeouts and unsolicited state changes in the drive due to local errors.

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.

L/A Green: Shows the state of the physical link and activity on the link.

Off	=	No Link
On	=	Port open, no activity
On & Flickering	=	Port open and activity

EtherCAT Network Status Indicators: BEL, BE2, TEL, TE2



RUN Green: Shows the state of the ESM (EtherCAT State Machine)

Off	=	Init
Blinking	=	Pre-operational
Single-flash	=	Safe-operational
On	=	Operational

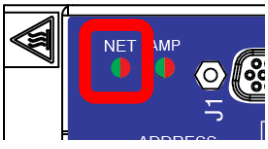
ERR Red: Shows errors such as watchdog timeouts and unsolicited state changes in the BEL due to local errors.

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 A green LED 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

MACRO Network Status Indicator: BML



NET A bi-color LED gives the state of the MACRO interface by changing color, and either blinking or remaining solid. The possible color combinations are:

Off	=	MACRO network has not been detected
Green/Blinking	=	MACRO network detected and has disabled the drive
Green	=	MACRO network detected and is trying to enable the drive. This condition can occur while the AMP LED shows any of its possible color combinations
Red/Solid	=	MACRO network errors have been detected

4.16 Fault Levels

Amp Over Temperature	> 70 °C
DC Bus Under Voltage	< +14 Vdc
DC Bus Over Voltage	> +90 Vdc
Encoder Power	< +4.25 Vdc

4.17 Operating Temperature and Cooling Configurations

Heatsink and Fan Configurations

The graphics below show the mounting and cooling configurations used to obtain the thermal data for the drives. The Rth (thermal resistance) is the temperature rise in degrees C per Watt of dissipation in the drive. The mounting surface is not thermally conducting and does not contribute to the Rth data.

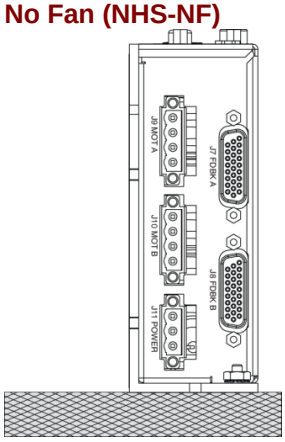
Thermal Resistance vs. Mounting & Cooling

This table shows the thermal resistance Rth in degrees-C per Watt (C/W) for standard mounting and cooling configurations.

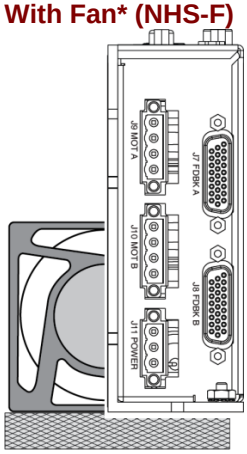
Mounting	Description	BEL, BPL, BML, TEL	BE2, BP2, TE2, TP2
NHSNF	No HeatSink, No Fan	3.4	2.33
NHSF	No HeatSink, Fan	1.32	0.97
HSNF	HeatSink, No Fan	2.02	1.28
HSF	HeatSink, Fan	0.91	0.57

No Heatsink

No Fan (NHS-NF)



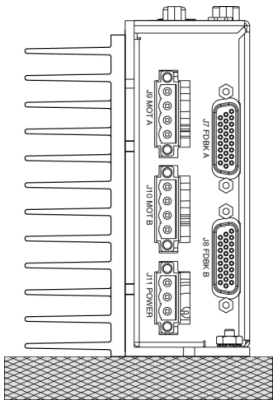
With Fan* (NHS-F)

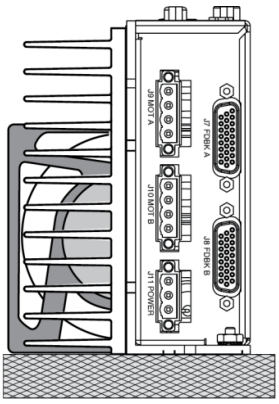


With Heatsink

No Fan (HS-NF)

With Fan* (HS-F)



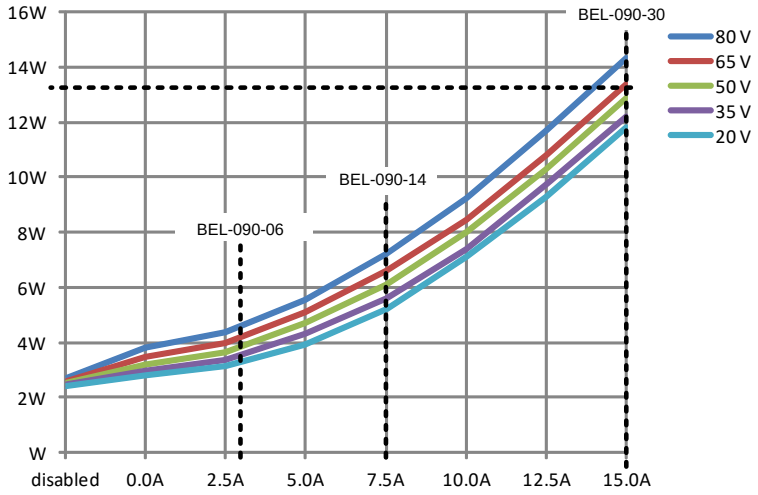


* The fan shown is a 70 mm (2.76 in) square fan that supplies forced air at a minimum rate of 300 linear feet per minute.

BEL, BPL, BML Models

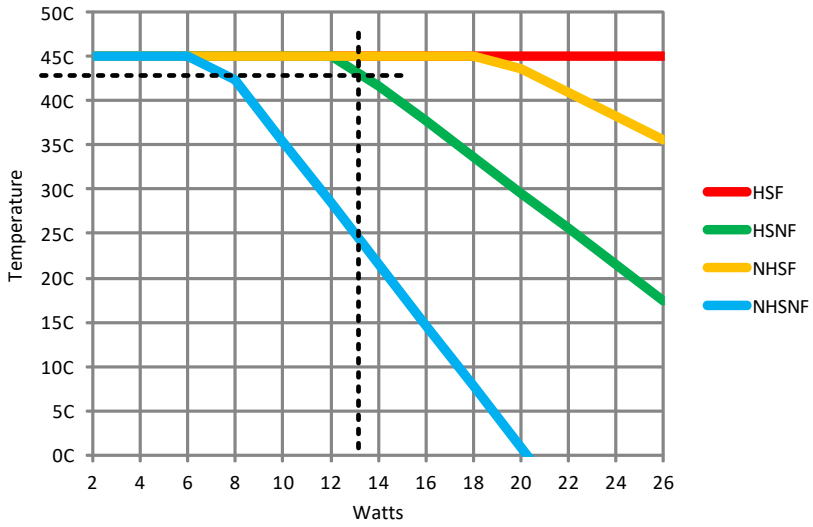
Power Dissipation vs. Output Current

Beginning with the continuous current rating of the drive, use the curve for the +HV voltage to find the power dissipation. The vertical dashed lines show the continuous current ratings of the three BEL/BPL models. Example: A BEL-090-30 is operating at 65 Vdc. Power dissipation is ~13.4 W.



Maximum Operating Temperature vs. Power Dissipation

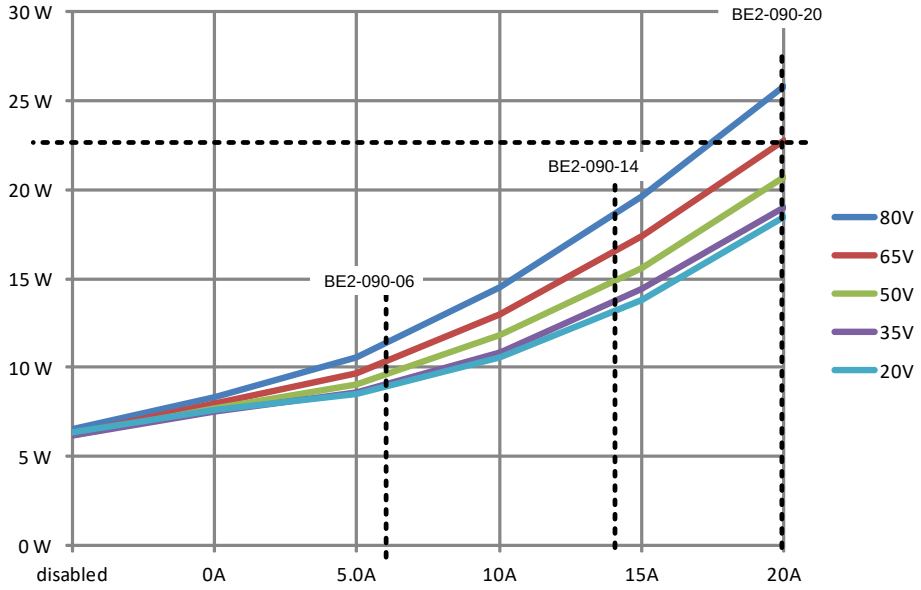
Using the power dissipation from the chart above, draw a vertical line from that number on the X-axis upwards in the chart below. The intersection of this line and the curves now shows the maximum ambient temperature that is allowed for the four mounting/cooling options.
Example: at 13.4W the maximum ambient temperature with a Heatsink and No Fan (HSNF) is 43C.



BE2, BP2 Models

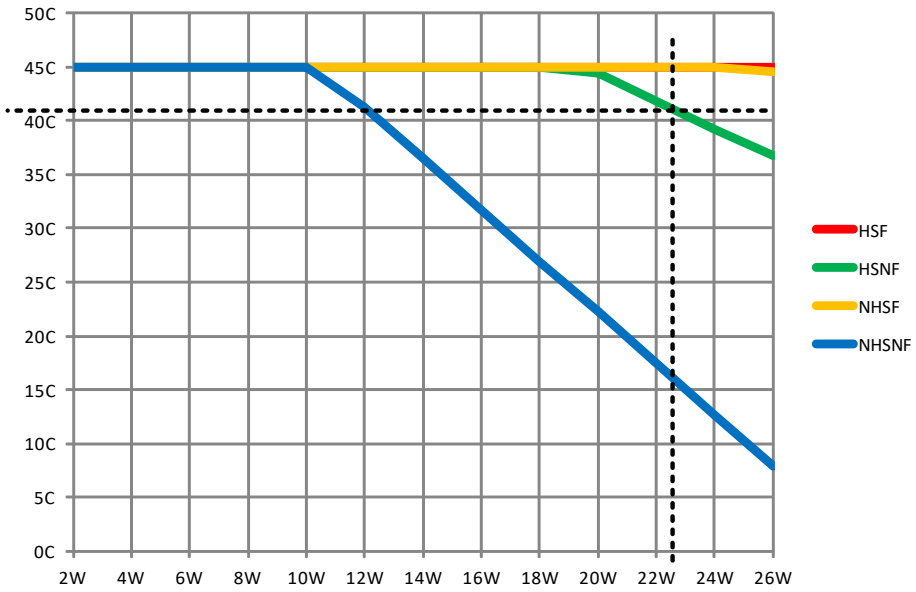
Power Dissipation vs. Output Current

Beginning with the continuous current (both axes combined) rating of the drive, use the curve for the +HV voltage to find the power dissipation. The vertical dashed lines show the continuous current ratings of the three BE2/BP2 models. Example: A BE2-090-20 is operating at 65 Vdc. Power dissipation is ~22.5 W.



Maximum Operating Temperature vs. Power Dissipation

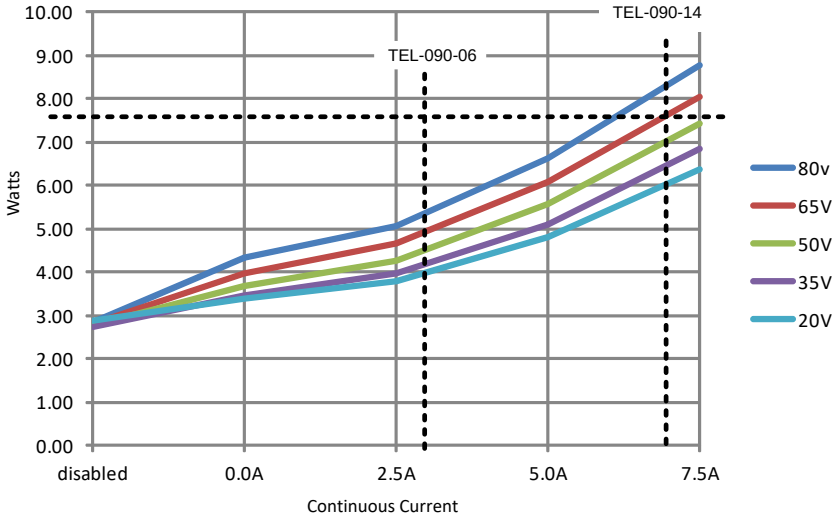
Using the power dissipation from the chart above, draw a vertical line from that number on the X-axis upwards in the chart below. The intersection of this line and the curves now shows the maximum ambient temperature that is allowed for the four mounting/cooling options.
Example: at 22.5W the maximum ambient temperature with a Heatsink and No Fan (HSNF) is 41C.



TEL Models

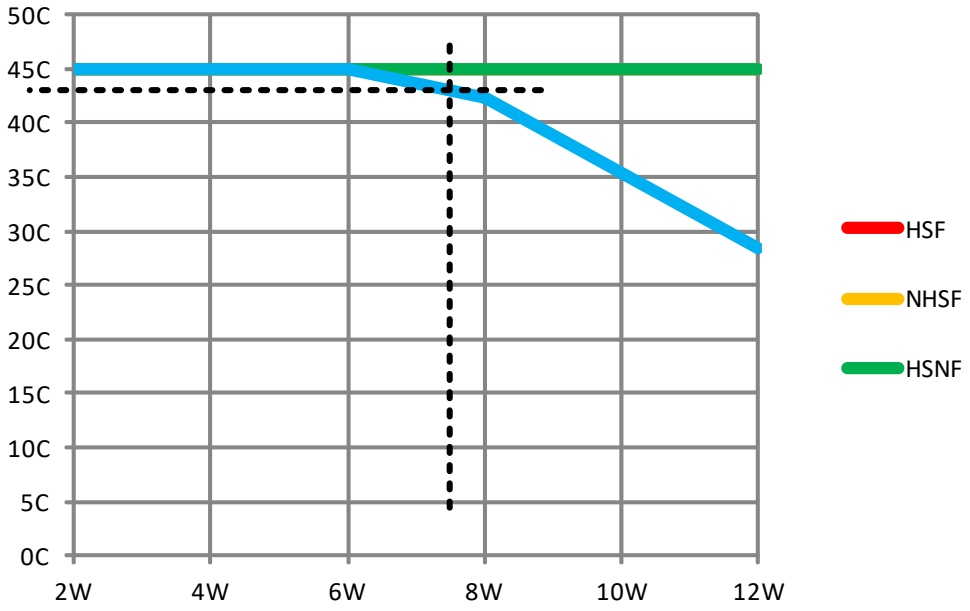
Power Dissipation vs. Output Current

Beginning with the continuous current (both axes combined) rating of the drive, use the curve for the +HV voltage to find the power dissipation. The vertical dashed lines show the continuous current ratings of the TEL-090-06 and TEL-090-14 models.
Example: A TEL-090-14 is operating at 65 Vdc. Power dissipation is ~7.6 W.



Maximum Operating Temperature vs. Power Dissipation

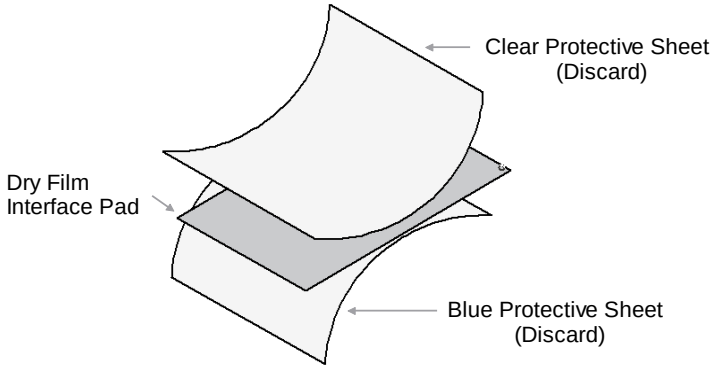
Using the power dissipation from the chart above, draw a vertical line from that number on the X-axis upwards in the chart below. The intersection of this line and the curves now shows the maximum ambient temperature that is allowed for the four mounting/cooling options.
Example: at 7.6W the maximum ambient temperature with a Heatsink and No Fan (HSNF) is 43C.



HEATSINK MOUNTING INSTRUCTIONS

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.

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

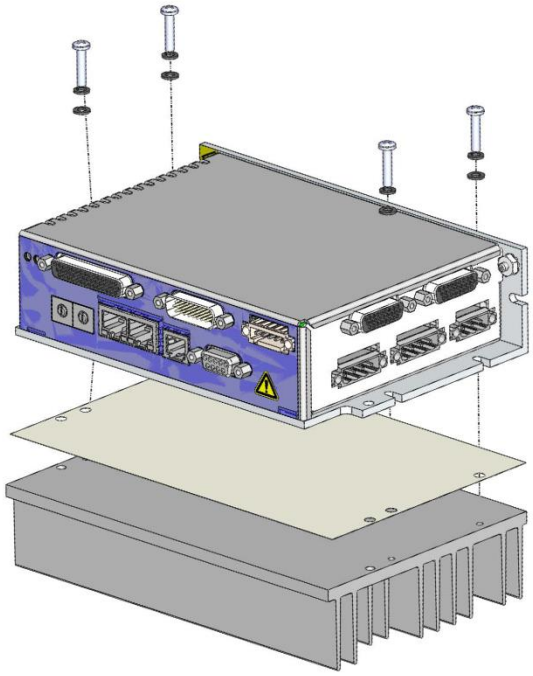


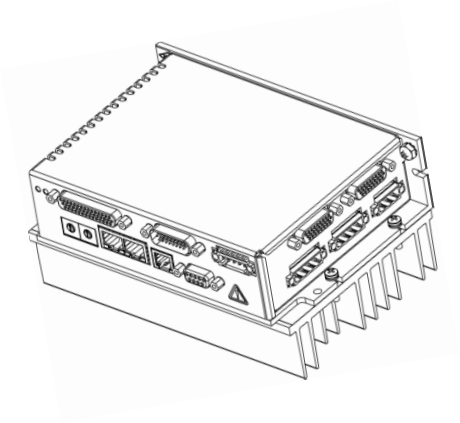
Place the interface pad on the drive, taking care to center the pad holes over the heatsink mounting holes.

Remove the clear protective sheet from the pad.

Mount the heatsink onto the drive taking care to see that the holes in the heatsink, interface pad, and drive all line up.

Torque the #8-32 mounting screws to 16~20 lb-in (1.8~2.3 Nm).





The drive shown above is a BE2, but the heatsink mounting procedure is the same for all models.

4.18 Mechanical and Environmental

BEL/BPL/BML

Size	5.08 x 3.41 x 1.99 in [129 x 86.6 x 50.4 mm] with no heatsink 5.08 x 3.41 x 3.39 in [129 x 86.6 x 86 mm] heatsink
Weight Driver Heat Sink Driver + Heatsink	 0.75 lb [0.34 kg] 0.95 lb [0.43 kg] 1.70 lb [0.77 kg]
Ambient Temperature Storage Operating	 -40 to +85 C [-40 to +185 F] 0 to +45°C [+32 to +113 F]
Humidity	0% to 95%, non-condensing
Vibration	2 *g* peak, 10~500 Hz (sine), IEC60068-2-6
Shock	10 *g*, 10 ms, half-sine pulse, IEC60068-2-27
Contaminants	Pollution degree 2
Ingress Protection	IP20
Environment	IEC68-2: 1990
Cover Material	Meets U.L. Spec 94 V-0 Flammability Rating
Cooling	Heat sink and/or forced air cooling required for continuous power output

BE2/BP2

Size	6.78 x 4.69 x 1.74 in [172 x 119 x 44.1 mm] without heatsink 6.78 x 4.69 x 3.14 in [172 x 119 x 79.8 mm] with heatsink
Weight Driver Heat Sink Driver + Heatsink	 1.5 lb [0.68 kg] 1.25 lb [0.57 kg] 2.75 lb [1.25 kg]
Ambient Temperature Storage Operating	 -40 to +85 C [-40 to +185 F] 0 to +45°C [+32 to +113 F]
Humidity	0% to 95%, non-condensing
Vibration	2 *g* peak, 10~500 Hz (sine), IEC60068-2-6
Shock	10 *g*, 10 ms, half-sine pulse, IEC60068-2-27
Contaminants	Pollution degree 2
Ingress Protection	IP20
Environment	IEC68-2: 1990
Cover Material	Meets U.L. Spec 94 V-0 Flammability Rating
Cooling	Heat sink and/or forced air cooling required for continuous power output

TEL

Size	5.08 x 3.41 x 1.99 in [129 x 86.6 x 50.4 mm] with no heatsink 5.08 x 3.41 x 3.39 in [129 x 86.6 x 86 mm] heatsink
Weight Driver Heat Sink Driver + Heatsink	 0.75 lb [0.34 kg] 0.95 lb [0.43 kg] 1.70 lb [0.77 kg]
Ambient Temperature Storage Operating	 -40 to +85 C [-40 to +185 F] 0 to +45°C [+32 to +113 F]
Humidity	0% to 95%, non-condensing
Vibration	2 *g* peak, 10~500 Hz (sine), IEC60068-2-6
Shock	10 *g*, 10 ms, half-sine pulse, IEC60068-2-27
Contaminants	Pollution degree 2
Ingress Protection	IP20
Environment	IEC68-2: 1990
Cover Material	Meets U.L. Spec 94 V-0 Flammability Rating
Cooling	Heat sink and/or forced air cooling required for continuous power output

TE2/TP2

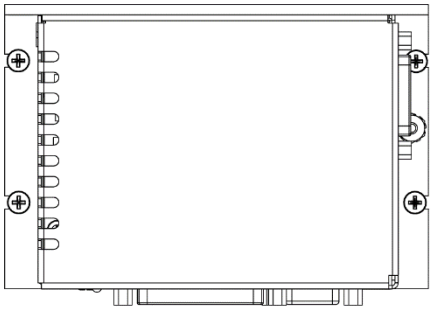
Size	6.78 x 4.69 x 1.74 in [172 x 119 x 44.1 mm] without heatsink 6.78 x 4.69 x 3.14 in [172 x 119 x 79.8 mm] with heatsink
Weight Driver Heat Sink Driver + Heatsink	 1.5 lb [0.68 kg] 1.25 lb [0.57 kg] 2.75 lb [1.25 kg]
Ambient Temperature Storage Operating	 -40 to +85 C [-40 to +185 F] 0 to +45°C [+32 to +113 F]
Humidity	0% to 95%, non-condensing
Vibration	2 *g* peak, 10~500 Hz (sine), IEC60068-2-6
Shock	10 *g*, 10 ms, half-sine pulse, IEC60068-2-27
Contaminants	Pollution degree 2
Ingress Protection	IP20
Environment	IEC68-2: 1990
Cover Material	Meets U.L. Spec 94 V-0 Flammability Rating
Cooling	Heat sink and/or forced air cooling required for continuous power output

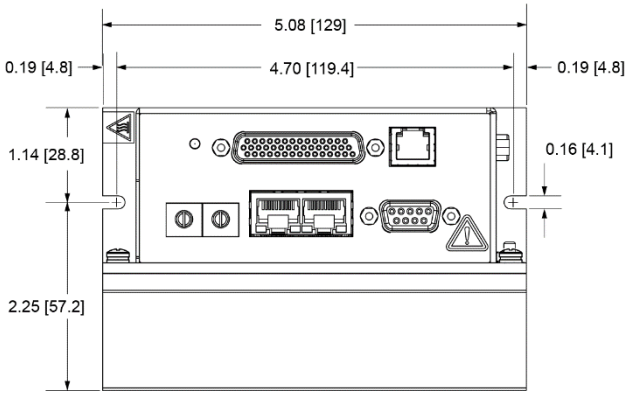
4.19 Agency Standards & Conformance

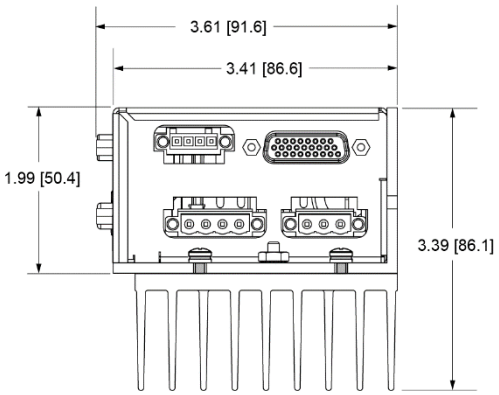
- *Approvals*
  UL and cUL recognized component to UL 61800-5-1 (file no. E168959)
  TÜV SÜD Functional Safety to IEC 61508 and ISO 13849-2
- *Functional Safety*
  IEC 61508-1, IEC 61508-2, EN(ISO) 13849-1, EN(ISO) 13849-2, IEC 61800-5-2:2016
  (see the ***Accelnet & Stepnet Plus Panels STO Manual*** for further details)
- *Electrical Safety*
  Directive 2014/35/EU Low Voltage: IEC 61800-5-1:2007+AMD1:2016 CSV
  UL 61800-5-1
- *EMC*
  Directive 2014/30/EU EMC: IEC 61800-3:2017
- *Hazardous Substances*
  Directive 2011/65/EU (RoHS Directive)

4.20 DIMENSIONS

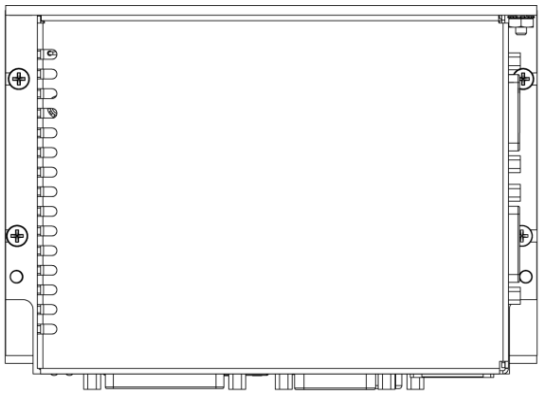
BEL, BPL, BML DIMENSIONS

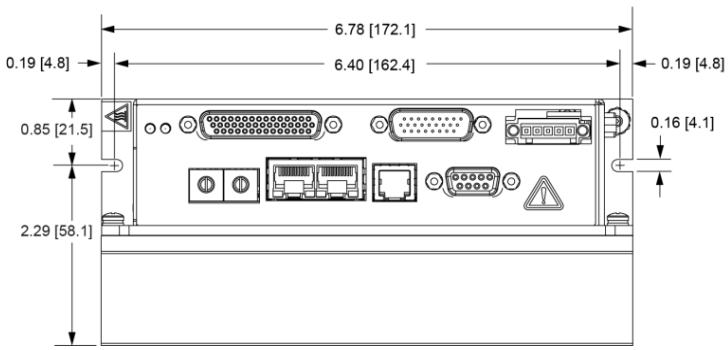


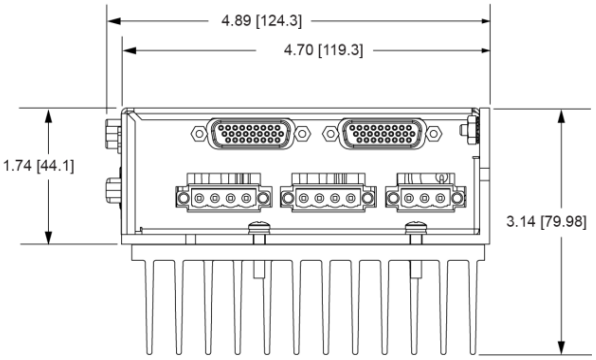




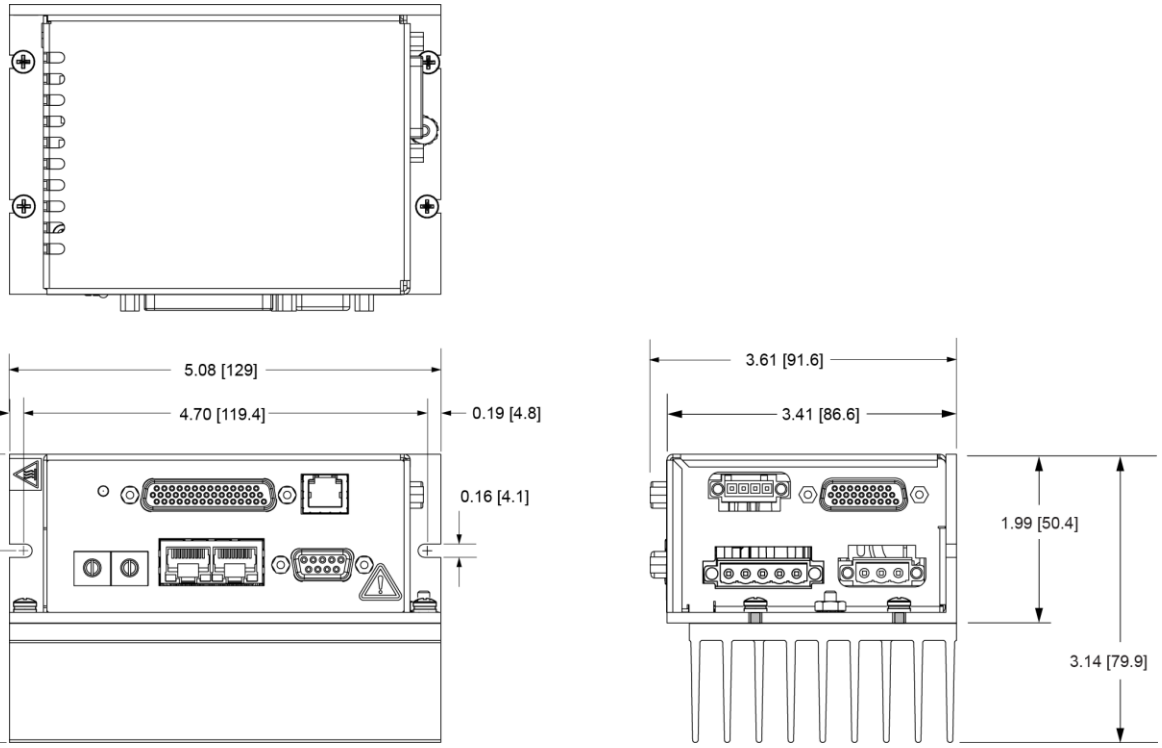
BE2, BP2 DIMENSIONS



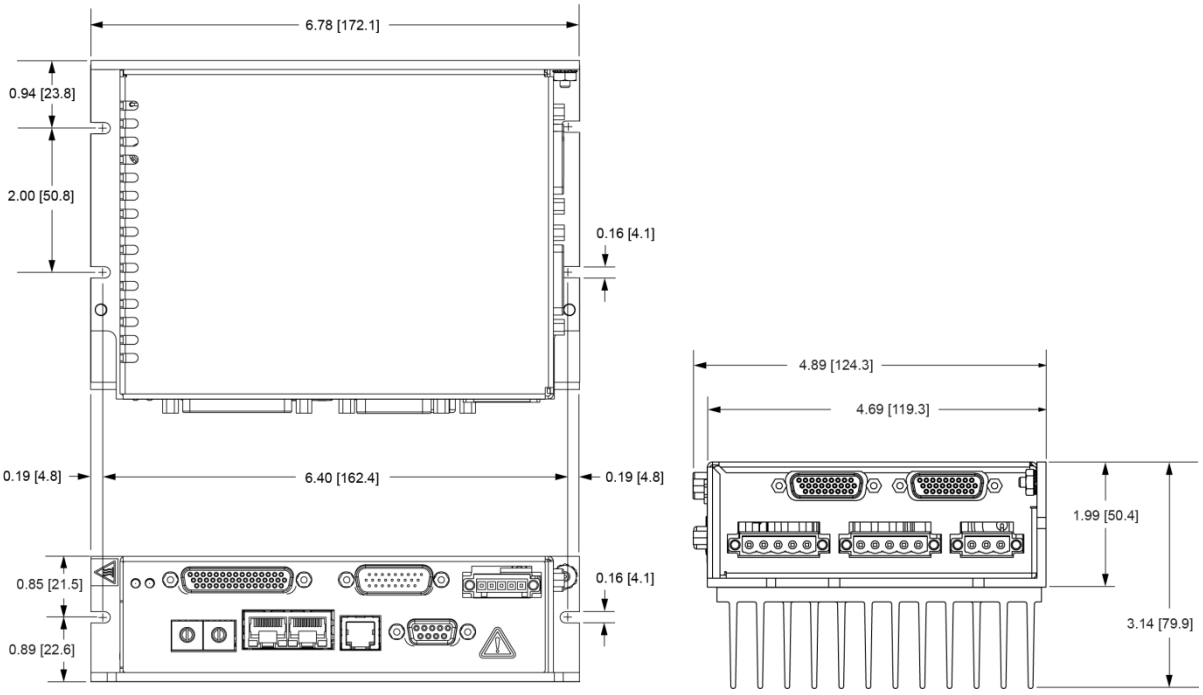




TEL Dimensions



TE2, TP2 Dimensions



5 WIRING & CONNECTIONS

5.1 ELECTRICAL CODES AND WARNINGS

Be sure that all wiring complies with the National Electrical Code (NEC) or its national equivalent, and all prevailing local codes.

DANGER	**DANGER: HAZARDOUS VOLTAGES.**
	Exercise caution when installing and adjusting. Persons responsible for installing and commissioning Accelnet Plus servo drives and Stepnet Plus stepper 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 and Stepnet Plus Panel 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	**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 THE ACCELNET & STEPNET PLUS PANELS STO MANUAL**
	The information provided in the Accelnet & Stepnet Plus Panels STO Manual 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 HVAUX and/or HV DC power applied is not recommended. **FAILURE TO HEED THIS WARNING MAY CAUSE EQUIPMENT DAMAGE.**
WARNING	**A LINE FILTER IS REQUIRED TO MEET CONDUCTED EMISSIONS REQUIREMENTS.**
	An EMI line filter is required to reduce conducted emissions from the +HV input to source DC supply **FAILURE TO HEED THIS WARNING CAN CAUSE RADIO FREQUENCY INTERFERENCE**

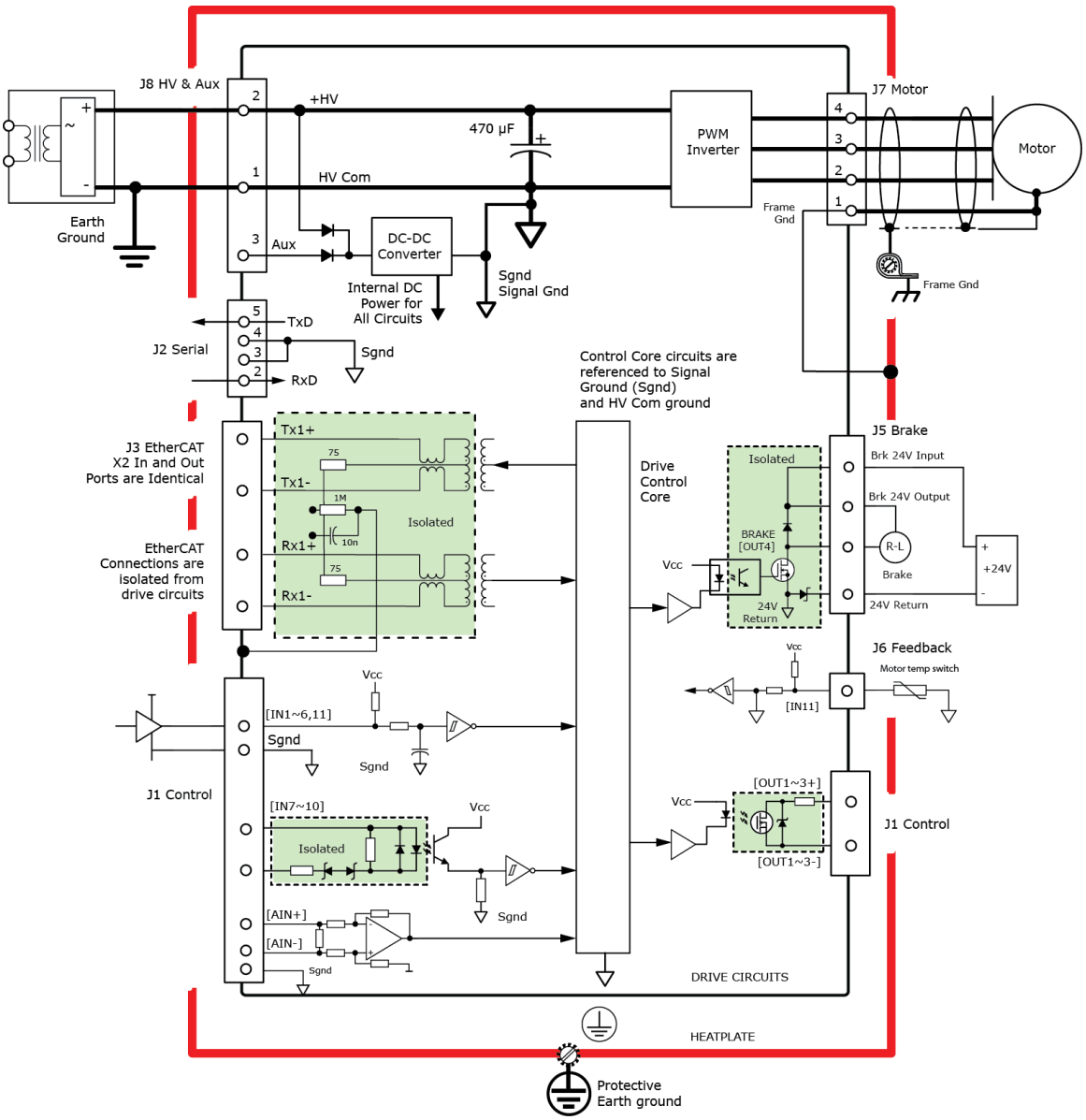
5.2 Grounding Considerations

Internal Connections & Grounding

Signal Ground and HV Com 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. Circuits highlighted in green in the graphic below are isolated from Signal Gnd to avoid ground-loops with external equipment.

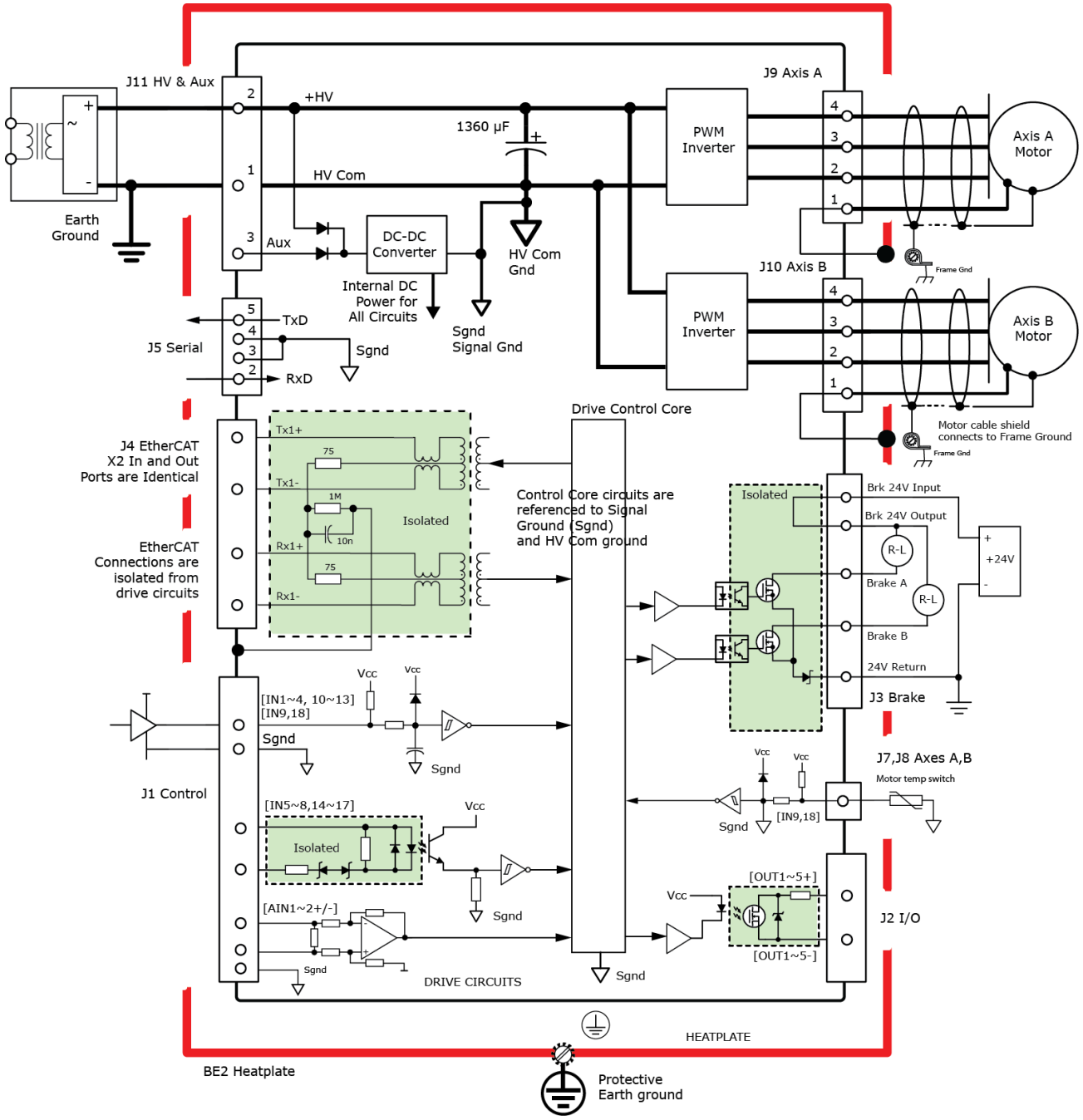
User equipment connecting to the drive's non-isolated circuits should have a circuit ground that is at the same potential as the drive's Signal Ground.

Single Axis Internal Connections & Grounding – BEL Example



The isolation sections in the BPL and TEL are the same as the BEL.

DUAL AXIS INTERNAL CONNECTIONS & GROUNDING – BE2 EXAMPLE



The isolation sections in the BP2, TE2, and TP2, are the same as the BE2.

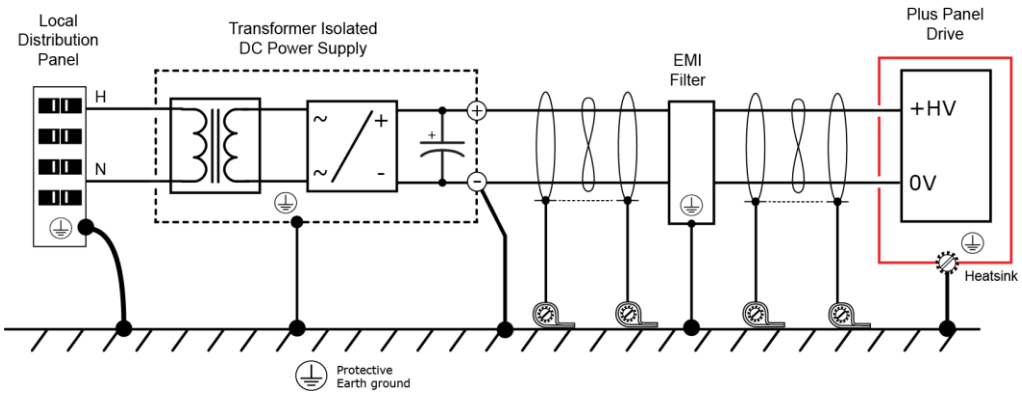
DC Power Grounding

The graphic below shows the basic elements of a DC power supply system for a Plus Panel drive. The Plus Panel drives are Protective Class I equipment in regards to protection against electric shock. Accordingly, the drives have both basic insulation between circuits and accessible conductive parts and a means 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 stud on the drive marked with the PE (Protective Earth) symbol. Note that the Plus Panel drives require that 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, attention must also be paid to the wiring and grounding practices required to reduce susceptibility to external EMI (Electro-Magnetic Interference) sources, to suppress EMI emissions, and to 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 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 to a screw that holds the heatplate to the mounting plate for best results. This connection will provide the lowest impedance path between the power supply and drive for noise originating in the drive. Doing so will minimize noise currents flowing in the mounting plate or the cabinet.



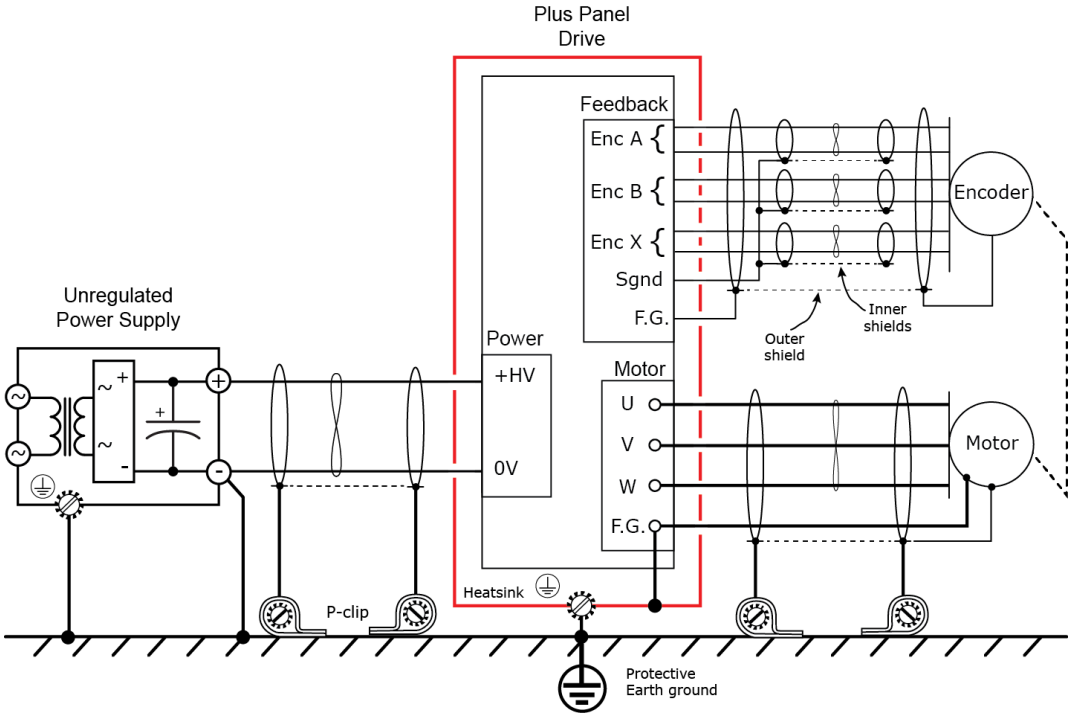
Note that in order to meet conducted emissions requirements, an EMI filter is needed between the +HV input of the drive and the output of the power supply as shown above. Details on EMI filter requirements are given in sections 5.4 and 5.5.

Motor Connection Grounding

On BEL/BPL/BML, the Frame Ground terminal at J7-1 connects to the drive chassis.

On BE2/BP2, the Frame Ground terminal at J9-1 and J10-1 connects to the drive chassis.

These ground terminals are provided as cable shield and protective earth connection points for the motor cables. Connection of cable shields to these points is made to provide electrical noise reduction. Connection of motor cable protective earth conductors to these points is made to prevent the motor housing from becoming hazardous live in the event of an insulation failure. Protective earth connections for the motor housings 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.

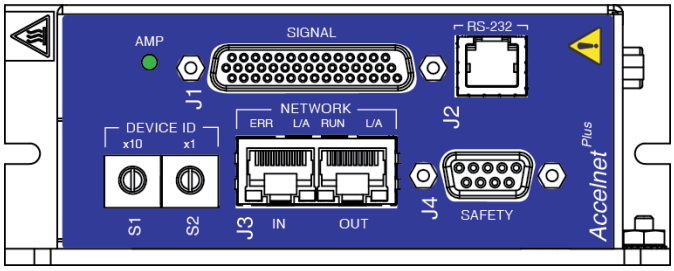
Feedback Cable Shielding

Shields on feedback cables reduce emissions from the drive and help protect internal circuits from interference due to external sources of electrical noise. For maximum effectiveness, feedback cables may use double-shielding as shown in the graphic above. The outer shield connects to the drive Frame Ground on one end and to the motor frame on the other. The inner shields, one for each twisted-pair, connect to the drive Signal Ground but not to the motor frame. This eliminates shield currents between the motor and drive that could couple into the feedback signals.

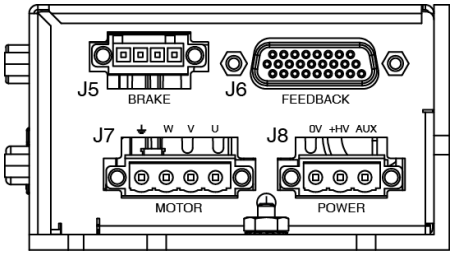
5.3 Connector Locations

BEL, BPL, BML Connector Locations

Front View

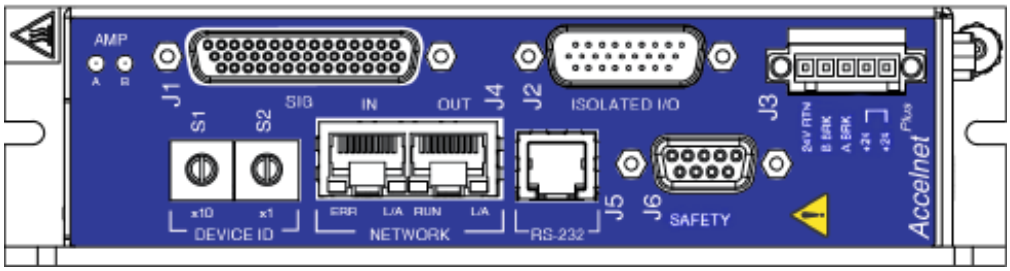


End View

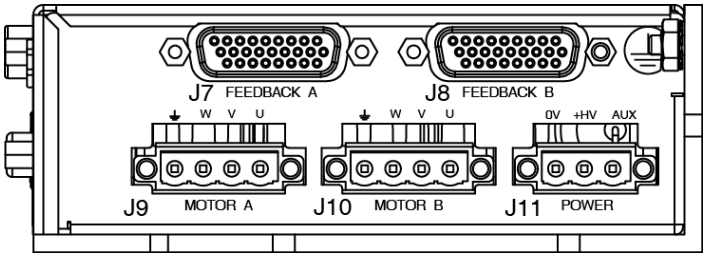


BE2, BP2 Connector Locations

Front View

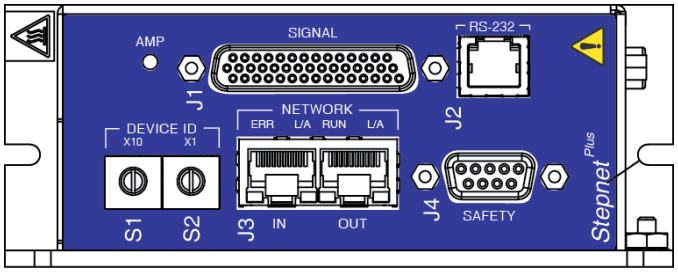


End View

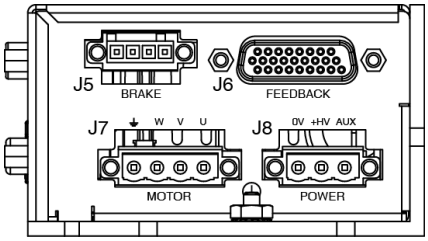


TEL Connector Locations

Front View

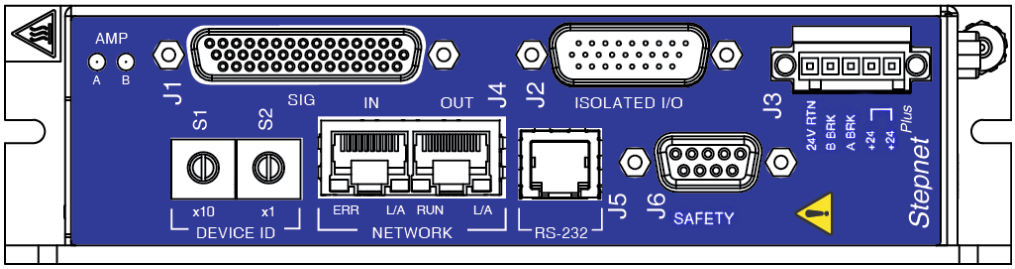


End View

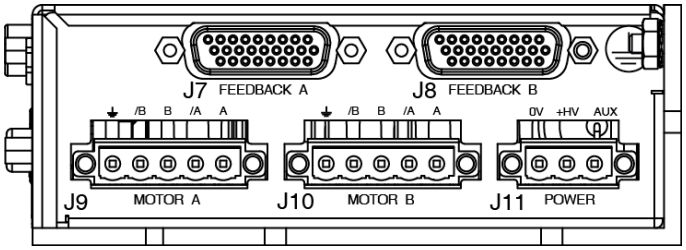


TE2, TP2 Connector Locations

Front View

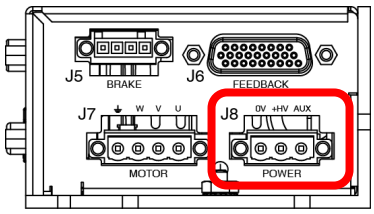


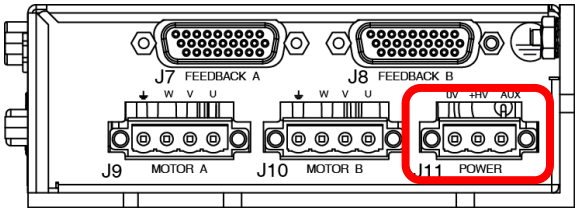
End View



5.4 Power Connector Locations – Accelnet Models

BEL, BPL, BML, BE2, BP2 - DC Power





Power Receptacle

Description	Euro-style 5.08 mm, 3-position, male receptacle
Manufacturer PN	Wago: 231-563/108-000

Power Cable Plug

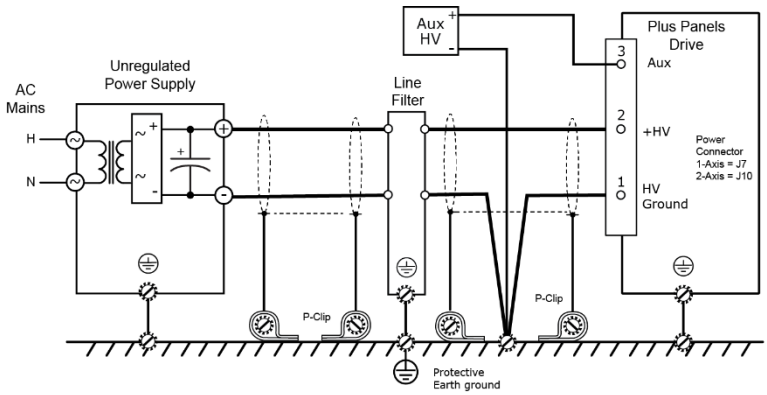
Description	Euro-style 5.08 mm plug
Manufacturer PN	Wago: 231-303/107-000
Wire size	22~14 AWG
Recommended Wire	22~14 AWG, 600 V Shielded cable required for CE compliance
Wire Insertion/Extraction Tool	Wago: 231-159
Connectors and tool are included in Connector Kits BEL-CK, BE2-CK, BPL-CK, BP2-CK, BML-CK	

Power Pin Descriptions

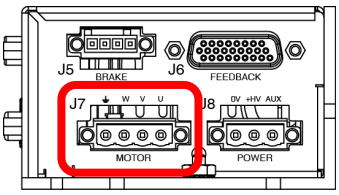
Pin	Signal	Function
1	0V	DC power input (-), also internal: Signal Ground
2	+HV	DC power input (+)
3	AuxHV	Aux DC power input for logic power

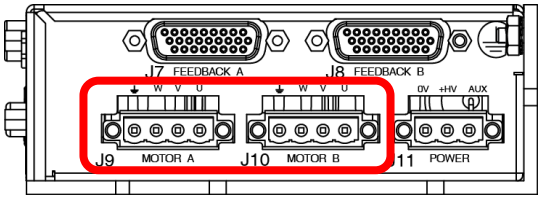
EMI Line Filter

Manufacturer	TE Connectivity (Corcom)
Part Number	20ERK1 used for the BE2, BP2 15ERK1 used for the BEL, BPL, BML



BEL, BPL, BE2, BP2 - Motor Connectors





Motor Receptacle

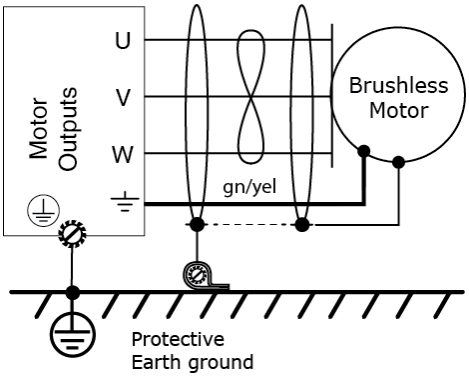
Description	Euro-style 5.08 mm, 4-position, male receptacle
Manufacturer PN	Wago: 231-564/108-000

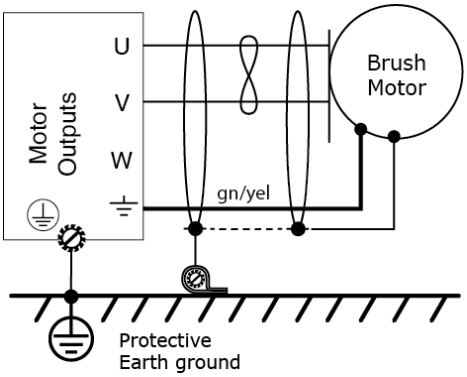
Motor Cable Plug

Description	Euro-style, 4 position, 5.08 mm pluggable female terminal block
Manufacturer PN	Wago: 231-304/107-000
Wire Size	22 - 14 AWG
Recommended Wire	22~14 AWG, 600 V Shielded cable required for CE compliance
Wire Insertion/Extraction Tool	Wago: 231-131
Connectors and tool are included in Connector Kits BEL-CK, BPL-CK, BE2-CK, and BP2-CK.	

Pin Descriptions

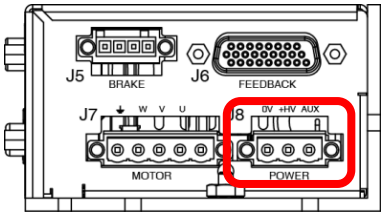
Pin	Signal	Function
1	Ground	Motor frame ground and cable shield
2	W	Phase W output
3	V	Phase V output (brush motor DC(-) connection)
4	U	Phase U output (brush motor DC(+) connection)

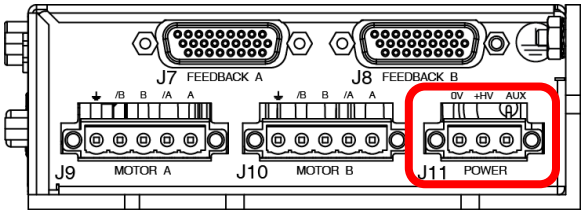




5.5 Power Connector Locations – Stepnet Models

TEL, TE2, TP2 - DC Power





Power Receptacle

Description	Euro-style 5.08 mm, 3-position, male receptacle
Manufacturer PN	Wago: 231-563/108-000

Power Cable Plug

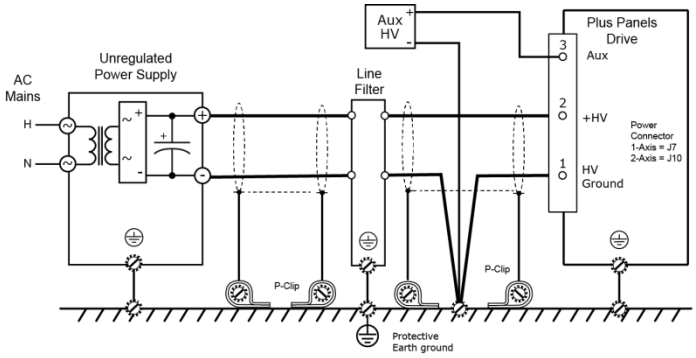
Description	Euro-style 5.08 mm plug
Manufacturer PN	Wago: 231-303/107-000
Wire size	22~14 AWG
Recommended Wire	22~14 AWG, 600 V Shielded cable required for CE compliance
Wire Insertion/Extraction Tool	Wago: 231-159
Connectors and tool are included in Connector Kits TEL-CK, TE2-CK, and TP2-CK.	

Pin Descriptions

Pin	Signal	Function
1	0V	DC power input (-), also internal: Signal Ground
2	+HV	DC power input (+)
3	AuxHV	Aux DC power input for logic power

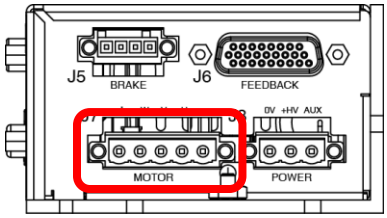
EMI Line Filter

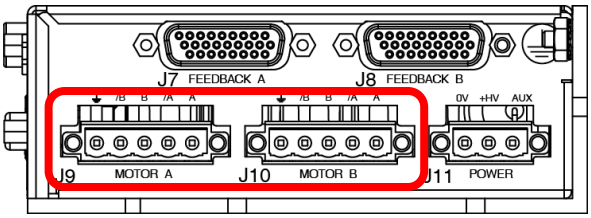
Manufacturer	TE Connectivity (Corcom)
Part Number	20ERK1 used for the TE2, TP2 10ERK1 used for the TEL



5.6 TEL, TE2, TP2 Motor Connectors

Motor Connector Locations





Motor Receptacle

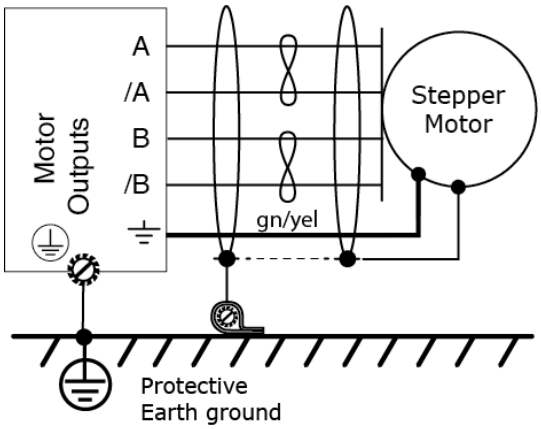
Description	Euro-style 5.08 mm, 5-position, male receptacle
Manufacturer PN	Wago: 231-564/108-000

Cable Plug

Description	Euro-style, 5 position, 5.08 mm pluggable female terminal block
Manufacturer PN	Wago: 231-305/107-000
Wire Size	22 - 14 AWG
Recommended Wire	22~14 AWG, 600 V Shielded cable required for CE compliance
Wire Insertion/Extraction Tool	Wago: 231-131
Standard connector and tool are included in Connector Kits TEL-CK, TE2-CK, and TP2-CK.	

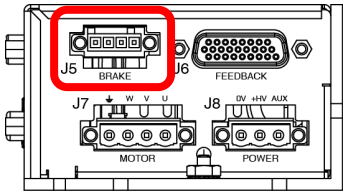
Pin Description

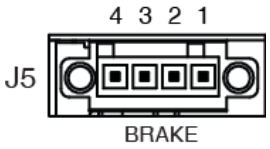
Pin	Signal	Function
1	Ground	Motor frame ground and cable shield
2	/B	Output /B
3	B	Output B
4	/A	Output /A
5	A	Output A



5.7 Motor Brake Connector

BEL, BPL, BML, TEL Brake Connector Locations





BEL, BPL, BML,TEL Receptacle

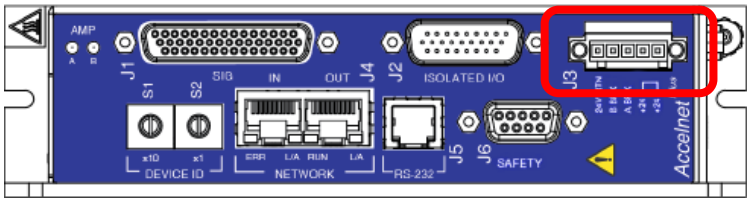
Description	Euro-style male receptacle, 3.5 mm,4-position, screw-lock
Manufacturer PN	Wago MCS-MINI: 734-164/108-000

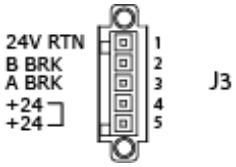
BEL, BPL,BML,TEL Cable Plug

Description	Euro-style female plug, 3.5 mm,4-position, screw-lock
Manufacturer PN	Wago MCS-MINI: 734-104/107-000

BE2, BP2, TE2, TP2 Receptacle

Description	Euro-style male receptacle, 3.5 mm, 5-position, screw-lock
Manufacturer PN	Wago MCS-MINI: 734-165/108-000





BE2, BP2, TE2, TP2 Cable Plug

Description	Euro-style female plug, 3.5 mm, 5-position, screw-lock
Manufacturer PN	Wago MCS-MINI: 734-105/107-000

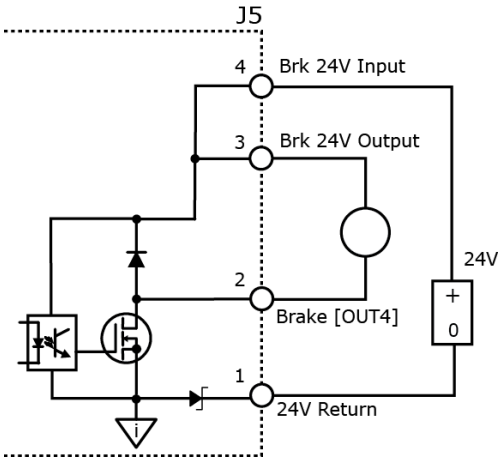
MOTOR BRAKE PIN DESCRIPTIONS

These outputs are open-drain MOSFETs with internal flyback diodes for driving inductive loads.
Each can sink up to 1A from a motor brake connected to the +24 Vdc supply.
The operation of the brake is programmable with *CME* .
They can also be programmed as general-purpose digital outputs (shown in the table below).

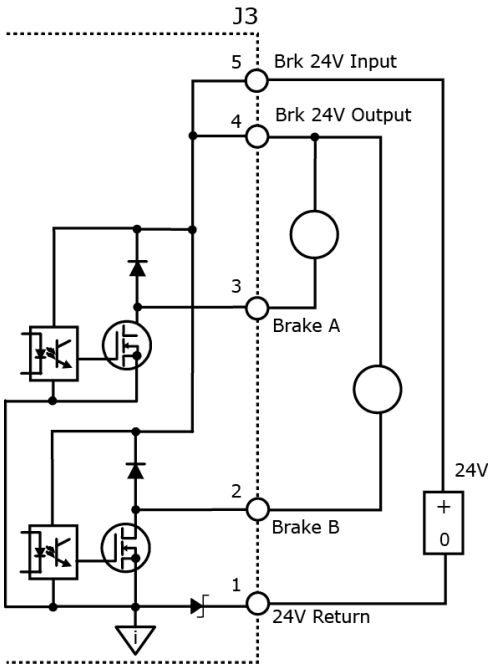
Signal	BEL, BPL, BML,TEL
	J5 Pins
Brake 24V Input	4
Brake 24V Output	3
Brake [OUT4]	2
24V Return	1

Signal	BE2, BP2, TE2, TP2
	J3 Pins
Brake 24V Input	5
Brake 24V Output	4
Brake [OUT6]	3
Brake [OUT7]	2
24V Return	1

BEL, BPL, BML,TEL



BE2, BP2, TE2, TP2



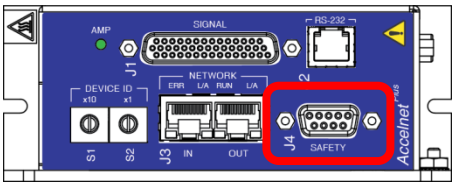
5.8 Safe Torque Off

The information provided in the *Accelnet & Stepnet Plus Panels STO Manual* must be considered for any application using the STO feature.

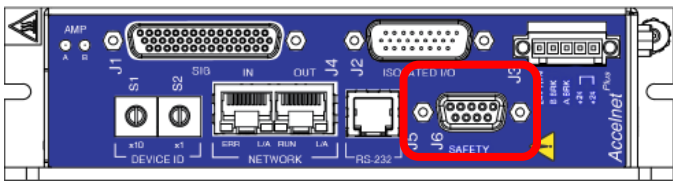
Failure to heed this warning can cause equipment damage, injury, or death

STO Connector Locations

BEL, BPL, BML,TEL,



BE2, BP2, TE2, TP2



Drive Receptacle

Description	Dsub DE-09F, 9-position female receptacle, #4-40 jack screws

Cable Connector

Description	Manufacturer & PN
Connector, Dsub DE-09F, poke-crimp, with locking tab	AMP/Tyco: 205204-4
AMPLIMITE HDP-20, Crimp-Snap contacts, 24~20 AWG, sel AU/NI	AMP/Tyco: 66506-9
Backshell, D-Sub, RoHS, metallized, #4-40 locking screws	Norcomp: 979-009-020R121

Connector Tools

Note: Th1s part is shown here for convenience. It is not included in connector kits, and is not sold by Copley Controls.

Description	Manufacturer & PN
Insertion/extraction tool for HDP-20 contacts	AMP/Tyco 91067-2

Pin Description

Pin	Signal	Function
1	Frame Gnd	Cable shield connection
2	STO-IN1(+)	High Side of IN1
3	STO-IN1(-)	Low Side of IN1
4	STO-IN2(+)	High Side of IN2
5	STO-IN2(-)	Low Side of IN2
6	STO-IN1(+)	High Side of IN1
7	STO-IN1(-)	Low Side of IN1
8	STO-Bypass	Internal current source for STO bypassing
9	STO-Gnd	STO ground, for bypass current

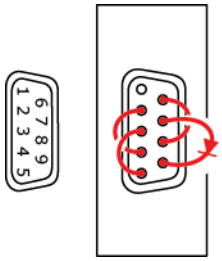
SAFE TORQUE OFF MUTING (BYPASSING)

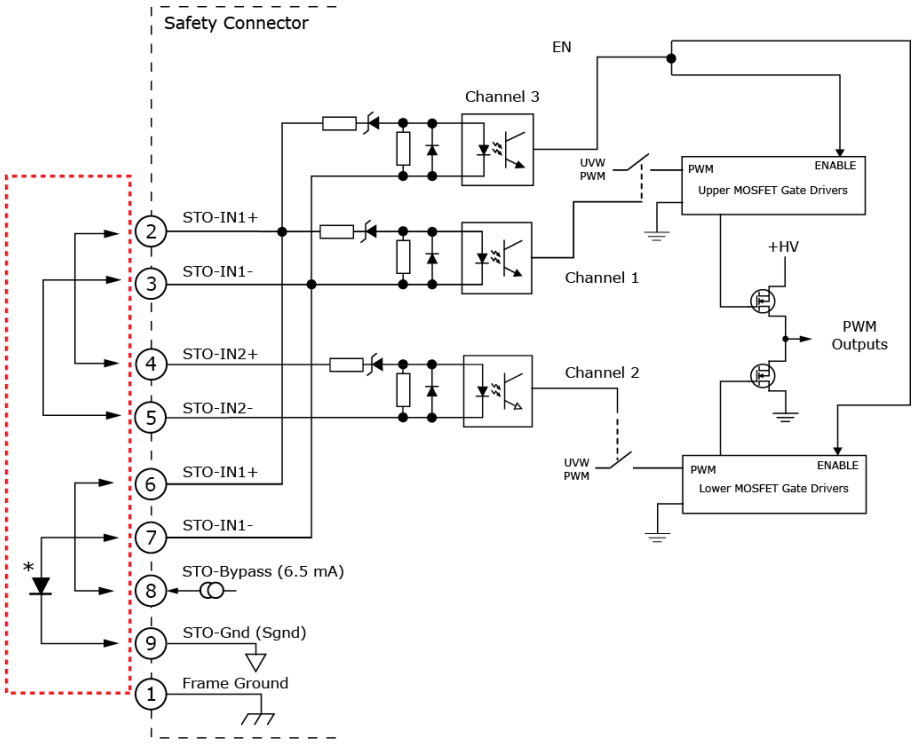
If an application does not require the STO feature, then is can be *muted* or bypassed by energizing the STO inputs with a power source that is in the *Plus Panel* drive. And, when the STO feature is not used, these connections must be made in order for the *Accelnet & Stepnet Plus Panels* to be enabled by software or hardware means.

The diagram below shows the STO bypass connections that will energize both STO-IN1 and STO-IN2 opto-couplers. When this is done the STO feature is de-activated and control of the output PWM stage is under control of the digital control core.

The connections shown can be made with four jumpers. When wired as shown it is not necessary to crimp two wires into a single contact.

Jumper Wiring, no diode:
2-4, 3-5, 6-8, 7-9
Jumper Wiring, with diode:
2-4, 3-5, 6-8, 7-anode, 9-cathode



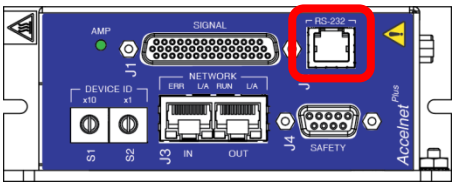


* STO bypass connections on the Plus Panel drives and Xenus Plus XEL/XPL models are different. If both drives are installed in the same cabinet, the diode should be wired as shown to prevent damage that could occur if the STO bypass connectors are installed on the wrong drive. The diode is not required for STO bypass on the Plus Panel drives and can be replaced by a wire between pins 7 and 9.

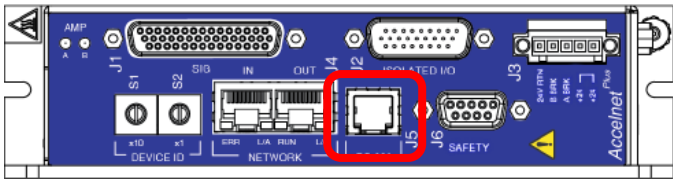
5.9 RS-232 Serial Communications

Connector Locations

BEL, BPL, BML,TEL,

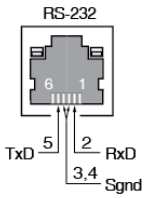


BE2, BP2, TE2, TP2



Drive Connector

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



Pin Description

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

Pin	Signal	Function
1	N/C	No connection
2	RxD	Receive data input from computer
3	Signal ground	Signal Ground
4	Signal ground	Signal Ground
5	TxD	Transmit data output to computer
6	N/C	No connection

RS-232 Serial Cable Kit

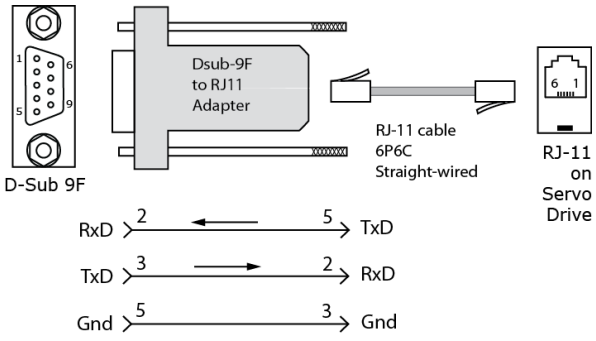
This table shows the Serial Cable Kit part numbers for different drive families:

Type	Part Number
BEL	BEL-SK
BE2	BE2-SK
TEL	TEL-SK

Type	Part Number
BPL	BPL-SK
BP2	BP2-SK
TE2	TE2-SK

Type	Part Number
TP2	TP2-SK
BML	BML-SK

Serial Cable Kit Signals

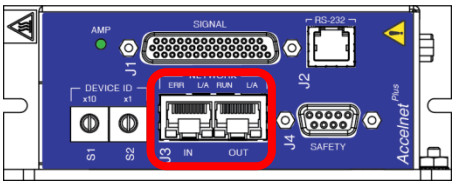


Dsub Signal	Pin	Color	Pin	Drive Signal
Rxd	2	Green	5	TxD
TxD	3	Red	2	RxD
Ground	5	Black	4	Signal Ground

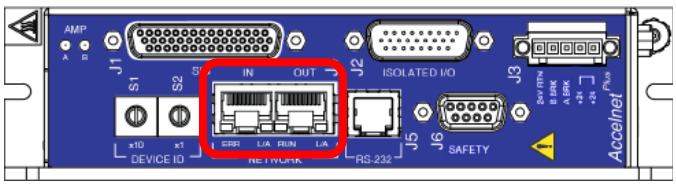
5.10 Network Ports

EtherCAT: BEL, BE2, TEL, TE2

BEL, BPL, TEL,



BE2, BP2, TE2, TP2



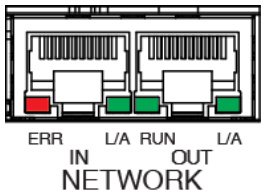
Mating Connector

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 *Plus Panels* and the master. The OUT port connects to 'downstream' nodes. If a *Plus Panel* drive is the last node on a network, only the IN port is used. No terminator is required on the OUT port.

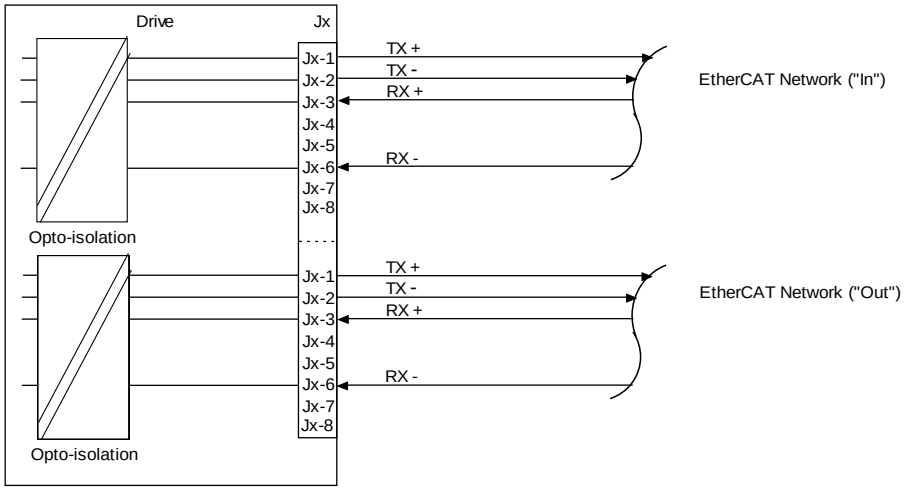
Pin Description*

Pin	Signal	Function
1	TX+	Transmit data +
2	TX-	Transmit data -
3	RX+	Receive data +
4	-	
5	-	
6	RX-	Receive data -
7	-	
8	-	

*Table applies to both EtherCAT connectors

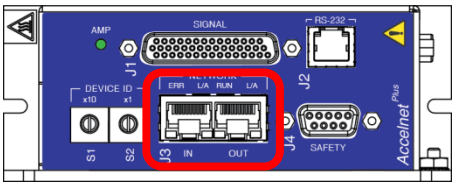


EtherCAT Bus Wiring Diagram

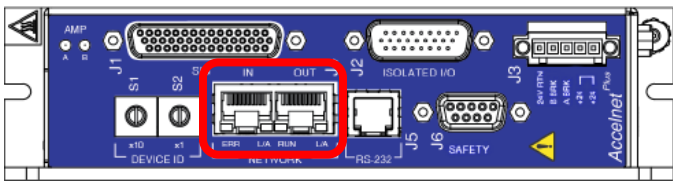


CAN Bus: BPL, BP2, TP2

BEL, BPL, TEL,

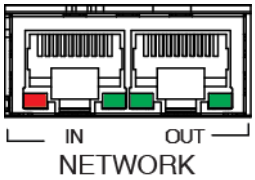


BE2, BP2, TE2, TP2



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.

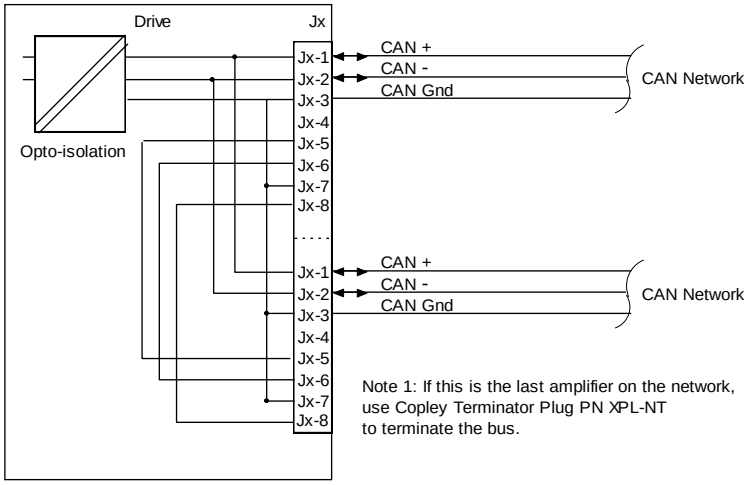


Pin Description*

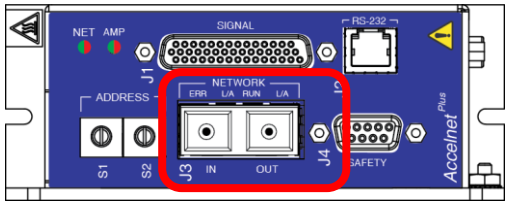
Pin	Signal	Function
1	CAN_H	CAN_H bus line (dominant high)
2	CAN _L	CAN_L bus line (dominant low)
3	CAN_Gnd	Ground / 0 V / V-
4	--	No connection
5	--	Pass through to second connector, no internal connection
6	CAN_SHLD	Pass through to second connector, no internal connection
7	CAN_Gnd	Ground / 0 V / V-
8	CAN V+	Pass through to second connector, no internal connection

*Table applies to both CAN connectors

CAN Bus: BPL, BP2, TP2



MACRO: BML



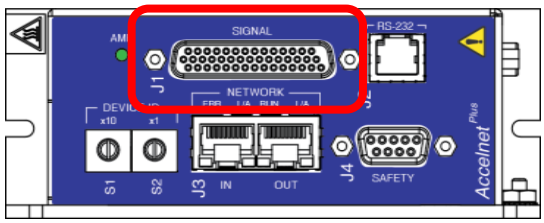
MATING CONNECTOR

Dual SC sockets accept standard optical fiber. The IN port connects to a master, or to the OUT port of a device that is 'upstream', between the Accelnet and the master. The OUT port connects to 'downstream' nodes. If Accelnet is the last node on a network, only the IN port is used. No terminator is required on the OUT port..

5.11 CONTROL I/O

BEL, BPL, BML,TEL SIGNAL CONNECTOR

Description	Manufacturer PN
Connector, High-density Dsub DB-44M, 44 position, male, solder-cup, with #4-40 locking screws	Norcomp: 180-044-103L001
Backshell, Dsub, RoHS, metallize	Norcomp: 979-025-020R121



J1 PIN DESCRIPTIONS

Pin	Signal
1	Frame Ground
2	Ain(-)
3	Ain(+)
4	N/C
5	N/C
6	Signal Gnd
7	[IN1]
8	[IN2]
9	[IN3] Diff1(+)
10	[IN4] Diff1(-)
11	[IN5] Diff2(+)
12	[IN6] Diff2(-)
13	[IN7]
14	[IN8]
15	[IN9]

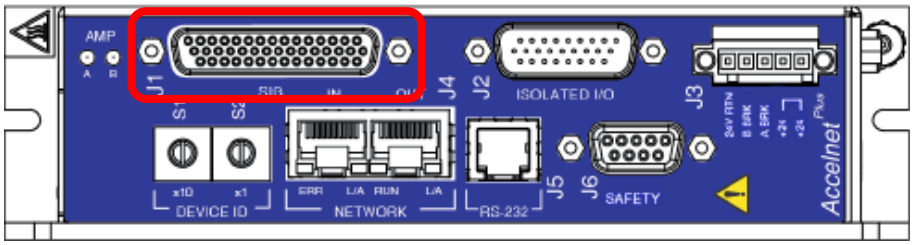
Pin	Signal
16	Signal Gnd
17	+5Vdc Out1
18	MultiEnc /S
19	MultiEnc /X
20	MultiEnc /B
21	MultiEnc /A
22	Signal Gnd
23	N/C
24	N/C
25	[OUT3-]
26	[OUT2-]
27	[OUT1-]
28	[INCOM]
29	N/C
30	[IN10]

Pin	Signal
31	Signal Gnd
32	+5Vdc Out1
33	MultiEnc S
34	MultiEnc X
35	MultiEnc B
36	MultiEnc A
37	Signal Gnd
38	N/C
39	N/C
40	[OUT3+]
41	[OUT2+]
42	[OUT1+]
43	N/C
44	Signal Gnd

BE2, BP2, TE2, TP2 Signal Connector

Cable Connector

Description	Manufacturer PN
Connector, High-density Dsub DB-44M, 44 position, male, solder-cup, with #4-40 locking screws	Norcomp: 180-044-103L001
Backshell, Dsub, RoHS, metallize	Norcomp: 979-025-020R121



Pin Descriptions

Pin	Signal
1	Frame Ground
2	Ain1(-)
3	Ain1(+)
4	Ain2(-)
5	Ain2(+)
6	Signal Gnd
7	[IN1]
8	[IN2]
9	[IN3] Diff1(+)
10	[IN4] Diff1(-)
11	N/C
12	[IN10]
13	[IN11]
14	[IN12] Diff2(+)
15	[IN13] Diff2(-)

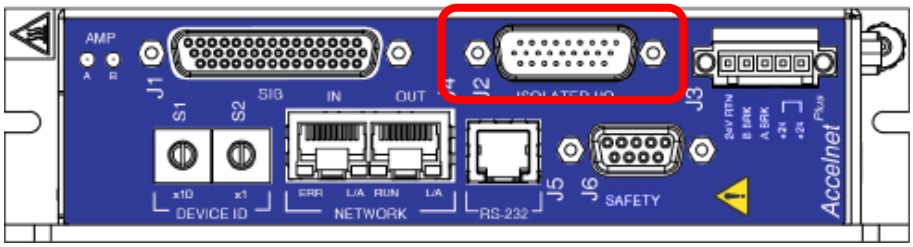
Pin	Signal
16	Signal Gnd
17	A +5Vdc Out1
18	A-MultiEnc /S
19	A-MultiEnc /X
20	A-MultiEnc /B
21	A-MultiEnc /A
22	Signal Gnd
23	B +5Vdc Out2
24	B-MultiEnc /S
25	B-MultiEnc /X
26	B-MultiEnc /B
27	B-MultiEnc /A
28	N/C
29	N/C
30	N/C

Pin	Signal
31	Signal Gnd
32	A +5Vdc Out1
33	A-MultiEnc S
34	A-MultiEnc X
35	A-MultiEnc B
36	A-MultiEnc A
37	Signal Gnd
38	B +5Vdc Out2
39	B-MultiEnc S
40	B-MultiEnc X
41	B-MultiEnc B
42	B-MultiEnc A
43	N/C
44	Signal Gnd

BE2, BP2, TE2, TP2 Isolated I/O Connector

Cable Connector

Description	Manufacturer PN
Connector, High-density Dsub DA-26F, 26 position, female, solder-cup, with #4-40 locking screws	Norcomp: 180-026-203L001
Backshell, Dsub, RoHS, metallize	Norcomp: 979-015-020R121



Pin Descriptions

Pin	Signal
1	Frame Ground
2	[IN5] GPI
3	[IN6] GPI
4	[IN7] GPI
5	[IN8] GPI
6	COM1 [IN5~8]
7	[IN14] GPI
8	[IN15] GPI
9	[IN16] GPI

Pin	Signal
10	[OUT1-] GPI
11	[OUT2-] GPI
12	[OUT3-] GPI
13	[OUT4-] GPI
14	[OUT5-] GPI
15	N/C
16	N/C
17	COM2 [IN14~17]
18	[IN17] GPI

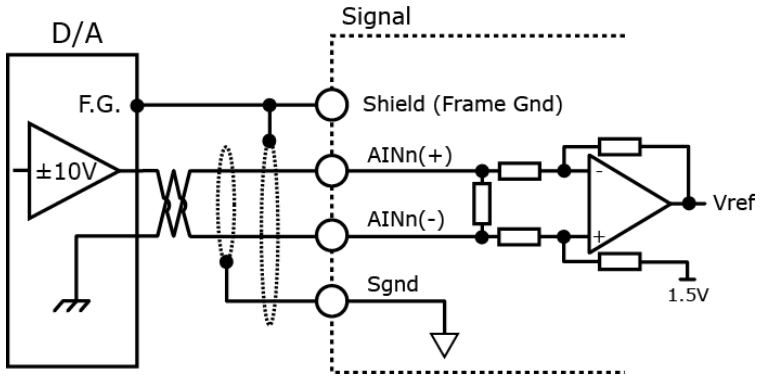
Pin	Signal
19	[OUT1+] GPI
20	[OUT2+] GPI
21	[OUT3+] GPI
22	[OUT4+] GPI
23	[OUT5+] GPI
24	N/C
25	N/C
26	N/C

Analog Inputs

The analog inputs have a ±10 Vdc range at 12-bit resolution
As reference inputs they can take position/velocity/torque commands from a controller.
If not used as command inputs, they can be used as general-purpose analog inputs.

Analog Input Wiring Diagram

Signal	BEL, BPL, BML,TEL	BE2, BP2, TE2, TP2	
	J1 Pins	J1 Axis-A Pins	J1 Axis-B Pins
Analog Ref(+)	3	3	5
Analog Ref(-)	2	2	4
Signal Ground	6,16,22,31,37,44	6,16,22,31,37,44	
Frame Ground	1	1	



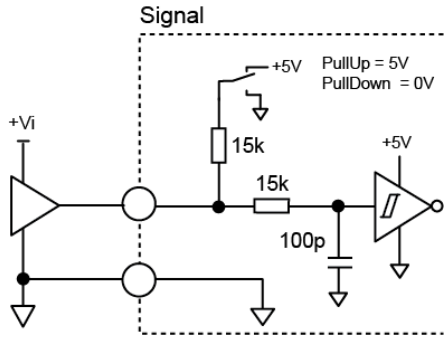
DIGITAL INPUTS: NON-ISOLATED

PROGRAMMABLE PULL-UP/PULL-DOWN

The input resistor of these inputs is programmable to pull-up to +5V or pull-down to 0V. Pull-up is the default and works with current-sinking outputs from a controller. Pull-down works with current-sourcing outputs, typically PLC's that drive grounded loads.

BEL, BPL, BML,TEL	J1 Pins
IN1	7
IN2	8
Signal Ground	6,16,22,31,37,44

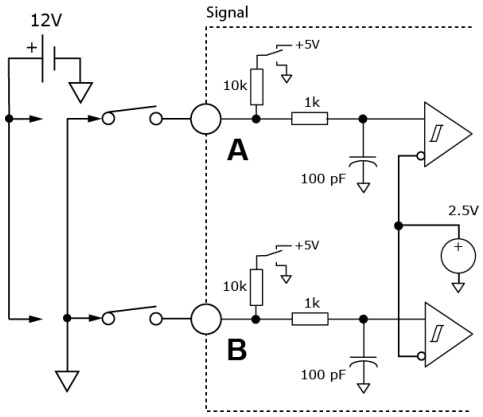
BE2, BP2, TE2, TP2	J1 Pins
IN1	7
IN2	8
IN10	12
IN11	13
Signal Ground	6,16,22,31,37,44



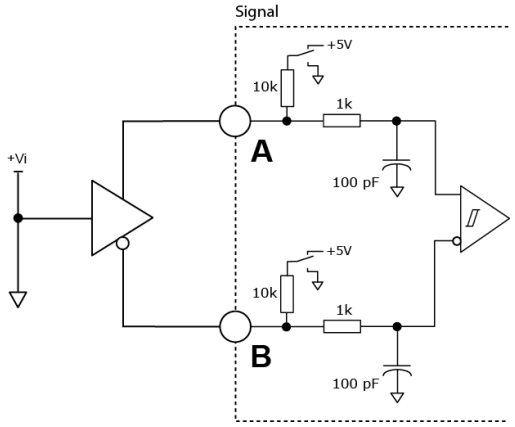
PROGRAMMABLE SINGLE-ENDED OR DIFFERENTIAL

BEL, BPL, BML,TEL	J1 Pins		BE2, BP2, TE2, TP2	J1 Pins
IN3 Diff1+	9	A	IN3 Diff1+	9
IN4 Diff1-	10	B	IN4 Diff1-	10
IN5 Diff2+	11	A	IN12 Diff2+	14
IN6 Diff2-	12	B	IN13 Diff2-	15
Signal Ground	6, 16, 22,31,37, 44		Signal Ground	6, 16, 22,31,37, 44

Single-Ended



Differential



USE AS COMMAND INPUTS: BEL, BPL, BML,TEL

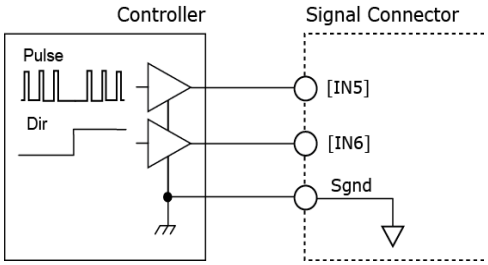
DIGITAL POSITION

This shows the inputs used with different command input signal formats.
S.E. = Single-Ended
Diff = Differential

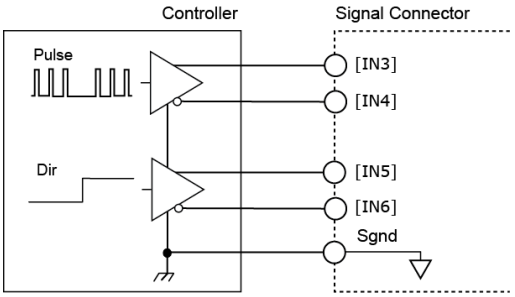
Command Input			S.E.	Diff
Pulse	CU	A	IN5	IN3
/Pulse	/CU	/A		IN4
Dir	CD	B	IN6	IN5
/Dir	/CD	/B		IN6

PULSE /DIRECTION

Single-Ended

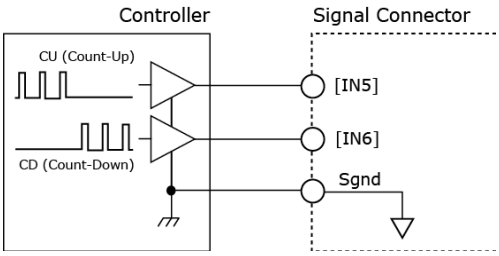


Differential

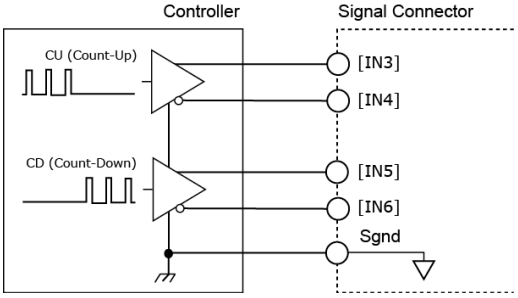


COUNT-UP/COUNT-DOWN (CU/CD)

Single-Ended

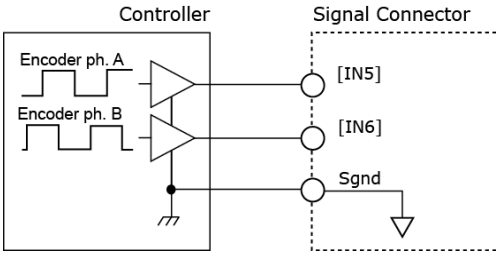


Differential

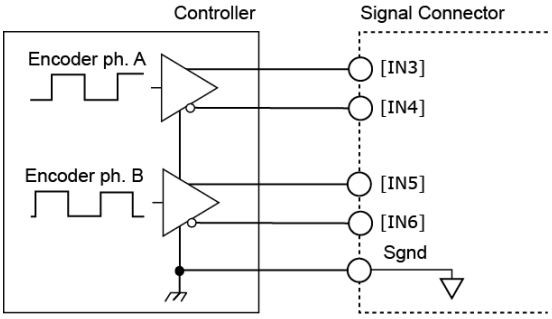


QUAD A/B ENCODER

Single-Ended



Differential



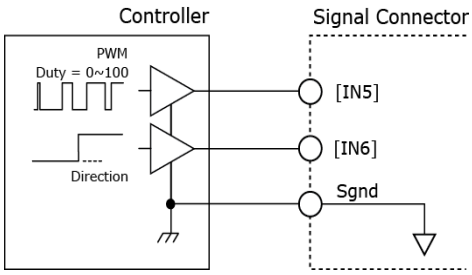
DIGITAL CURRENT (TORQUE) & VELOCITY

This shows the inputs used with different command input signal formats.
S.E. = Single-Ended
Diff = Differential

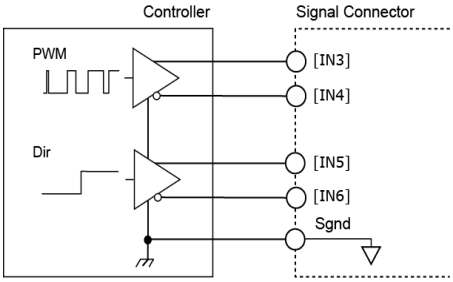
Command Inputs		S.E.	Diff
PWM	PWM 50%	IN5	IN3
/PWM			IN4
Dir		IN6	IN5
/Dir			IN6

PWM / POLARITY

Single-Ended

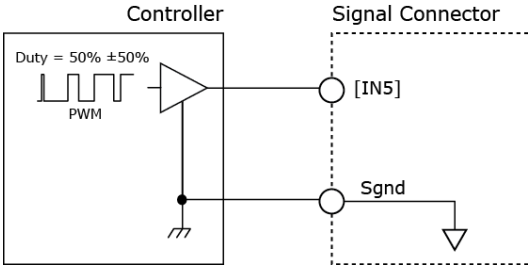


Differential

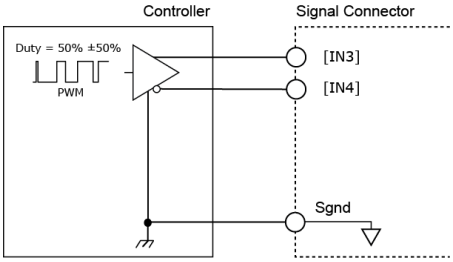


PWM 50%

Single-Ended



Differential



USE AS COMMAND INPUTS: BE2, BP2, TE2, TP2

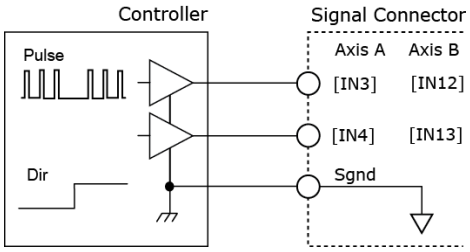
DIGITAL POSITION

This shows the inputs used with different command input signal formats.
S.E. = Single-Ended

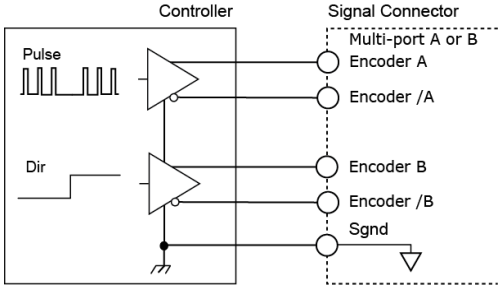
Command Input			S.E.		Multi-Port	
			Axis A	Axis B	Axis A	Axis B
Pulse	CU	A	IN3	IN12	Enc A	
/Pulse	/CU	/A			Enc /A	
Dir	CD	B	IN4	IN13	Enc B	
/Dir	/CD	/B			Enc /B	

PULSE-DIRECTION

Single-Ended

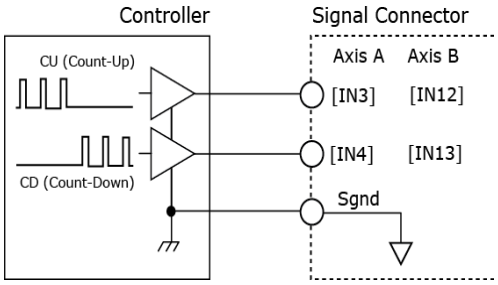


Differential

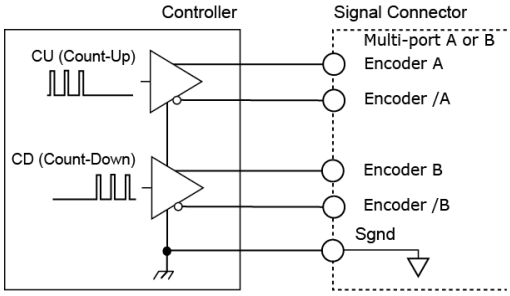


COUNT-UP/COUNT-DOWN (CU/CD)

Single-Ended

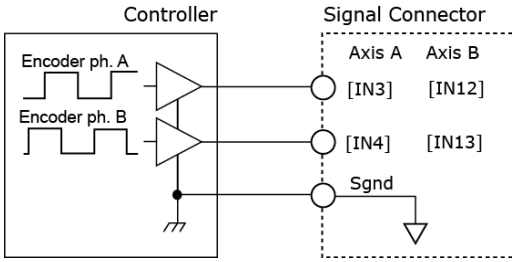


Differential

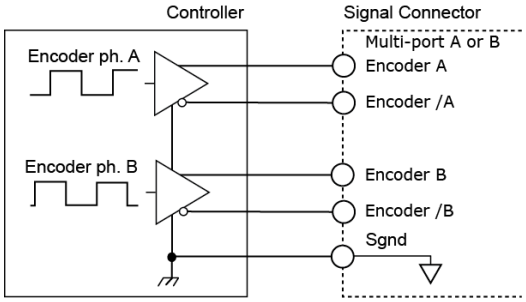


QUAD A/B ENCODER

Single-Ended



Differential



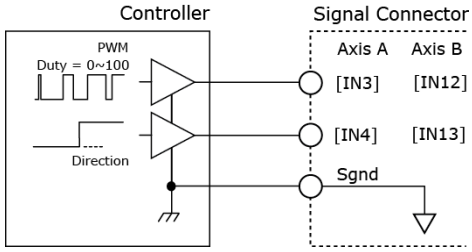
CURRENT (TORQUE) & VELOCITY

This shows the inputs used with different command input signal formats.
S.E. = Single-Ended

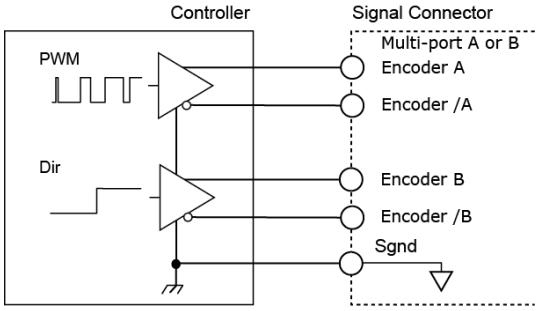
Command Input		S.E.		Multi-Port	
		Axis A	Axis B	Axis A	Axis B
PWM	PWM 50%	IN3	IN12	Enc A	
/PWM	/PWM 50%			Enc /A	
Dir		IN4	IN13	Enc B	
/Dir				Enc /B	

PWM / DIRECTION

Single-Ended

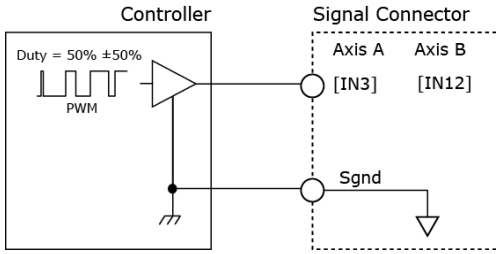


Differential

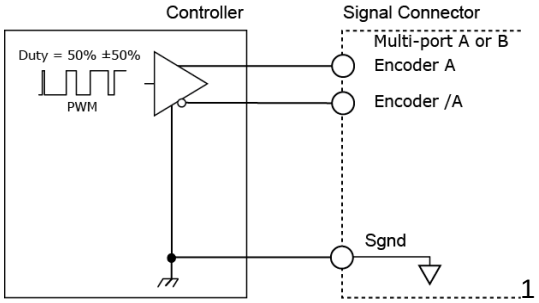


PWM 50%

Single-Ended



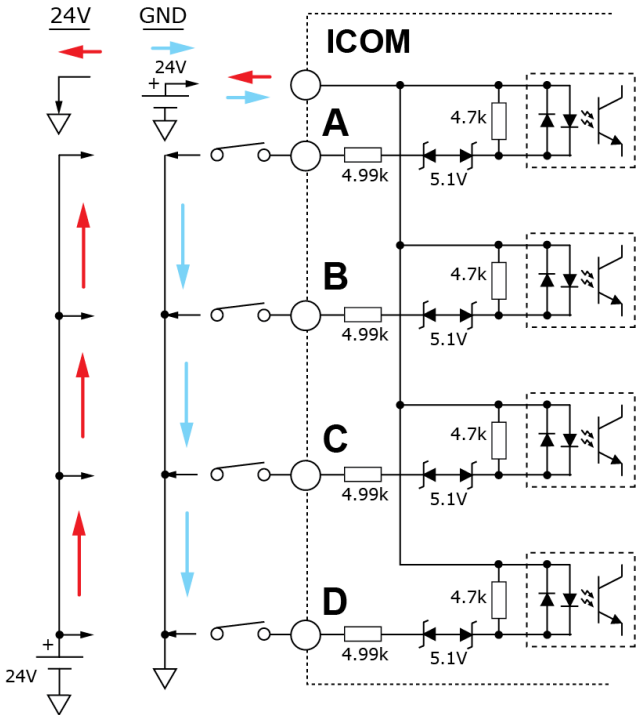
Differential



DIGITAL INPUTS: ISOLATED

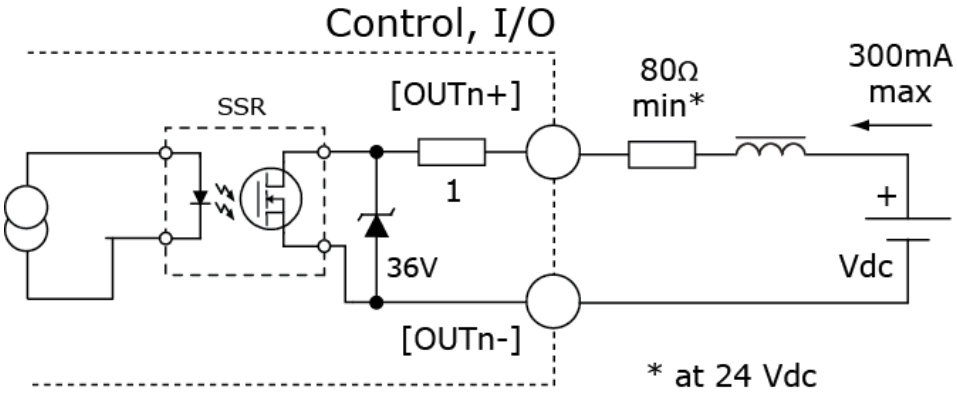
These inputs have all the programmable functions of the GP inputs plus opto-isolation. Groups of four inputs, share a Common terminal. Grounding the common terminal configures the group to work with current-sourcing outputs from controllers like PLC's. Connecting the common terminal to +24V configures them to be activated by current-sinking devices such as NPN transistors or N-channel MOSFETs.
The minimum ON threshold of the inputs is ±15 Vdc.

BEL, BPL, BML,TEL			BE2, BP2, TE2, TP2			
Input	J1 Pins		Input	J2 Pins	Input	J2 Pins
IN7	13	**A**	IN5	2	IN14	7
IN8	14	**B**	IN6	3	IN15	8
IN9	15	**C**	IN7	4	IN16	9
IN10	30	**D**	IN8	5	IN17	18
ICOM	28	**ICOM**	COM1	6	COM2	17



ISOLATED OUTPUTS

These are opto-isolated SSR (Solid-State Relay) outputs, 30 Vdc max. The +/- terminals of each output is accessible, allowing them to act as current sourcing or current sinking devices. There is a Zener clamping diode across each output that acts as a flyback diode when driving resistive-inductive (R-L) loads.



	BEL, BPL, BML,TEL: J1 Pins			BE2, BP2, TE2, TP2: J2 Pins				
Output	OUT1	OUT2	OUT3	OUT1	OUT2	OUT3	OUT4	OUT5
OUTn+	42	41	40	19	20	21	22	23
OUTn-	27	26	25	10	11	12	13	14

5.11.1 Multi-Mode Port

Overview

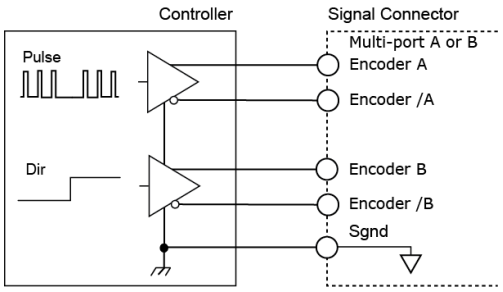
This port consists of three differential input/output channels (per axis) that take their functions from the Basic Setup of the drive. With quad A/B motor encoder feedback, the port works as an output, buffering the signals from the encoder. With resolver or sin/cos encoder versions, the feedback is converted to “emulated” quad A/B/X 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 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

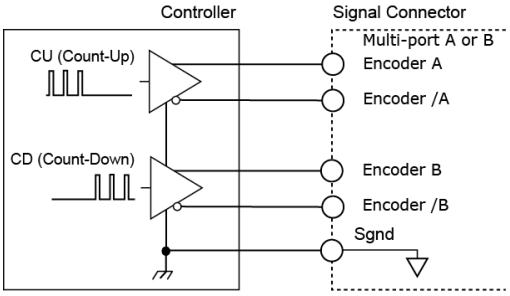
Position Command Inputs

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

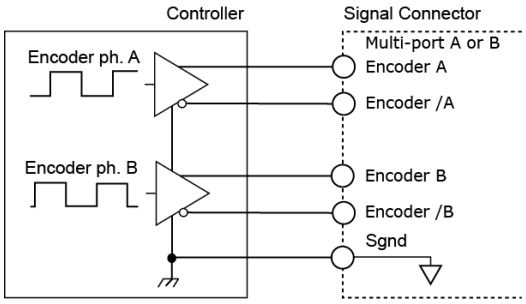
Pulse-Direction



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



Quad A/B Encoder, Camming



Multi-Mode Port Differential Position Command Input Connections

BEL, BPL, BML and TEL

Input Type			J1 Signal	J1 Pins Axis-A
Pulse(+)	Count-Up(+)	Quad A	Enc A	36
Pulse(-)	Count-Up(-)	Quad /A	Enc /A	21
Dir(+)	Count-Down(+)	Quad B	Enc B	35
Dir(-)	Count-Down(-)	Quad /B	Enc /B	20

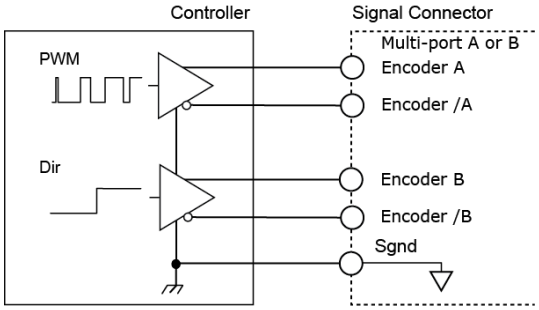
BE2, BP2, TE2, TP2

Input Type			J1 Signal	Axis-A J1 Pins	Axis-B J1 Pins
Pulse(+)	Count-Up(+)	Quad A	Enc A	36	42
Pulse(-)	Count-Up(-)	Quad /A	Enc /A	21	27
Dir(+)	Count-Down(+)	Quad B	Enc B	35	41
Dir(-)	Count-Down(-)	Quad /B	Enc /B	20	26

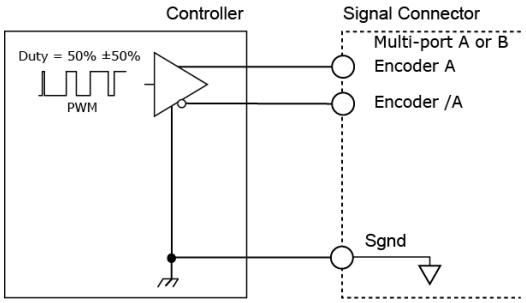
Multi-Mode Port Differential Current (Torque) or Velocity Command Input Connections

- PWM & Direction
- PWM 50%

PWM-Direction



PWM 50%



BEL, BPL, BML and TEL

Input Type	J1 Signal	J1 Pins
PWM(+)	Enc A	36
PWM(-)	Enc /A	21
Dir(+)	Enc B	35
Dir(-)	Enc /B	20
Signal Ground		6,16,22,31,37,44

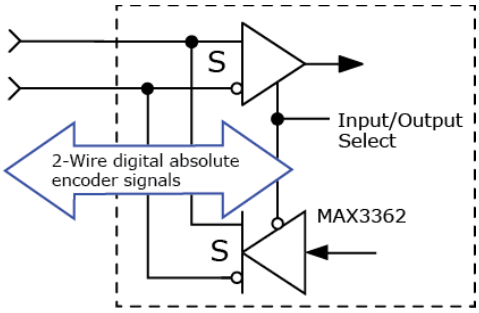
BE2, BP2, TE2, TP2

Input Type	J1 Signal	J1 Pins Axis-A	J1 Pins Axis-B
PWM(+)	Enc A	36	42
PWM(-)	Enc /A	21	27
Dir(+)	Enc B	35	41
Dir(-)	Enc /B	20	26
Signal Ground		6,16,22,31,37,44	

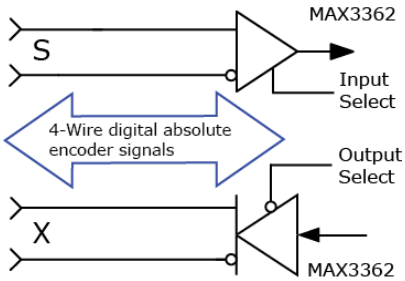
Multi-Mode Port Secondary Absolute Encoder Inputs

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

2-Wire

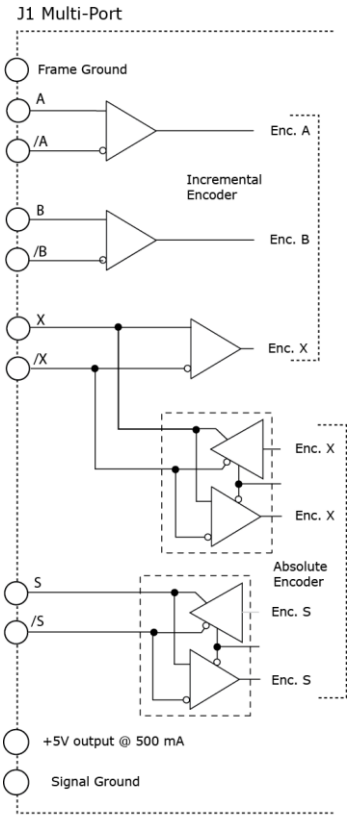


4-Wire



BEL, BPL, BML and TEL Models

Abs A	SSI, BiSS, EnDat	J1 Signal	J1 Pins Axis-A	J1 Pins Axis-B
	Clk	Enc X	34	40
	/Clk	Enc /X	19	25
Data	Data	Enc S	33	39
/Data	/Data	Enc /S	18	24
Signal Ground		6,16,22,31,37,44		



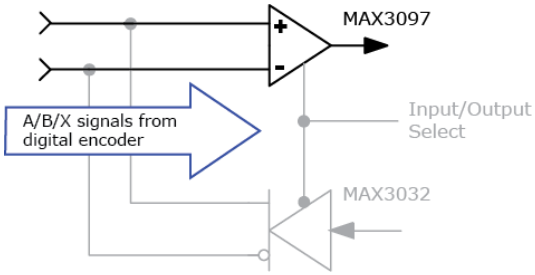
BE2, BP2, TE2, TP2 Models

Abs A	SSI, BiSS, EnDat	J1 Signal	J1 Pins Axis-A	J1 Pins Axis-B
	Clk	Enc X	34	40
	/Clk	Enc /X	19	25
Data	Data	Enc S	33	39
/Data	/Data	Enc /S	18	24
Signal Ground		6,16,22,31,37,44		

Multi-Mode Port Secondary Incremental Encoder Inputs

- Quad A/B/X Digital Encoders

QUAD A/B/X ENCODER



BEL, BPL, BML AND TEL

Input Type	J1 Signal	J1 Pins
Quad A	Enc A	36
Quad /A	Enc /A	21
Quad B	Enc B	35
Quad /B	Enc /B	20
Quad X	Enc X	34
Quad /X	Enc /X	19
Signal Ground		6,16,22,31,37,44

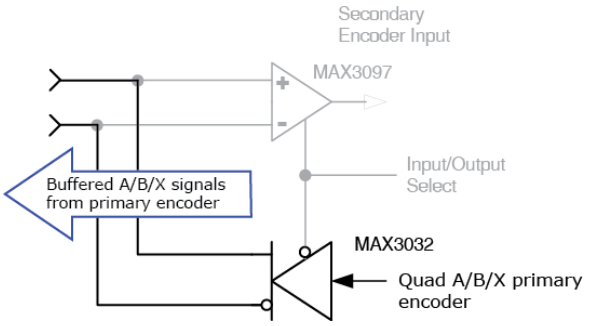
BE2, BP2, TE2, TP2

Input Type	J1 Signal	J1 Pins Axis-A	J1 Pins Axis-B
Quad A	Enc A	36	42
Quad /A	Enc /A	21	27
Quad B	Enc B	35	41
Quad /B	Enc /B	20	26
Quad X	Enc X	34	40
Quad /X	Enc /X	19	25
Signal Ground		6,16,22,31,37,44	

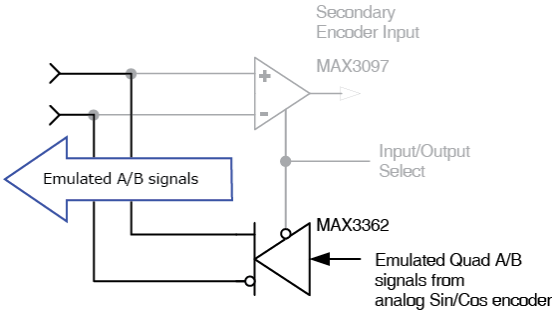
Multi-Mode Port Outputs

- Buffered outputs from primary quad A/B/X encoder inputs
- Emulated quad A/B encoder outputs from resolvers or absolute encoder feedback

Buffered A/B/X

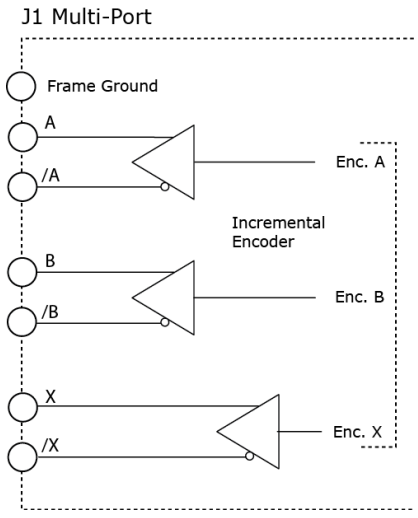


Emulated Quad A/B



BEL, BPL, BML and TEL

Input Type	J1 Signal	J1 Pins
Quad A	Enc A	36
Quad /A	Enc /A	21
Quad B	Enc B	35
Quad /B	Enc /B	20
Quad X	Enc X	34
Quad /X	Enc /X	19
Signal Ground		6,16,22,31,37,44



BE2, BP2, TE2, TP2

Input Type	J1 Signal	J1 Pins Axis-A	J1 Pins Axis-B
Quad A	Enc A	36	42
Quad /A	Enc /A	21	27
Quad B	Enc B	35	41
Quad /B	Enc /B	20	26
Quad X	Enc X	34	40
Quad /X	Enc /X	19	25
Signal Ground		6,16,22,31,37,44	

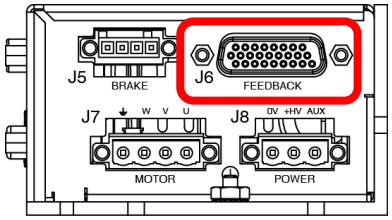
5.12 Motor Feedback

BEL, BPL, BML, BE2, BP2, TEL, TE2, TP2 Feedback Connectors

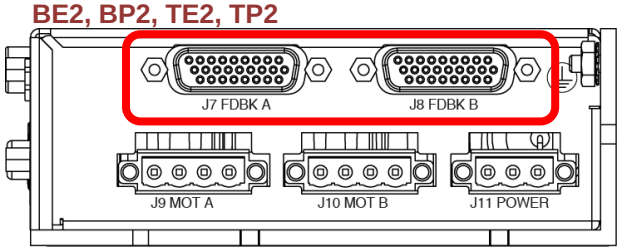
Cable Connectors

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

BEL, BPL, TEL



BE2, BP2, TE2, TP2



Pin Descriptions (Encoder Feedback)

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

Pin Descriptions (Resolver Option Feedback)

Pin	Signal
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	Signal
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(-) S1

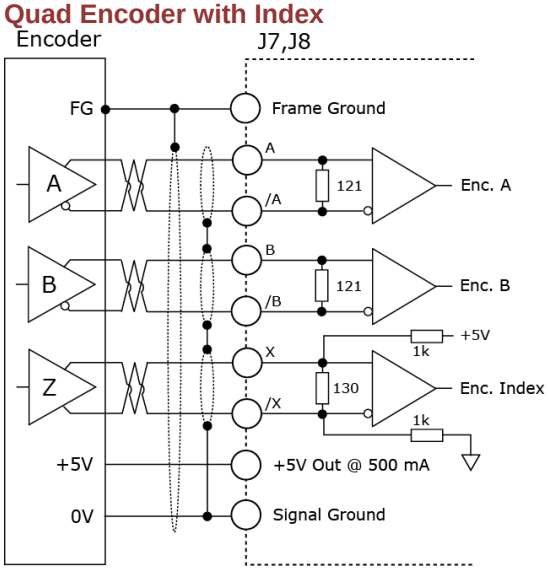
Pin	Signal
19	Sin(+) S3
20	Cos(-) S4
21	Cos(+) S2
22	Ref(-) R2
23	Ref(+) R1
24	N/C
25	Signal Gnd
26	Signal Gnd

QUAD A/B INCREMENTAL ENCODER

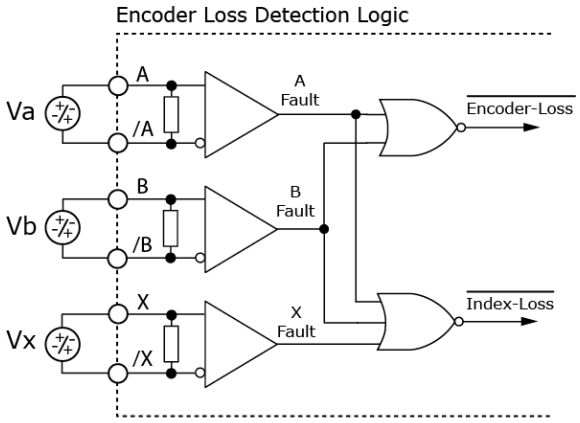
Encoders with differential line-driver outputs are required (single-ended encoders are not supported) and provide incremental position feedback via the A/B signals and the optional index signal (X) gives a once per revolution position mark. The MAX3097 receiver has differential inputs with fault protections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



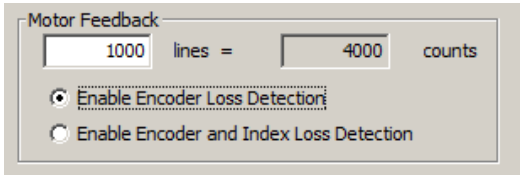
CME Feedback Options

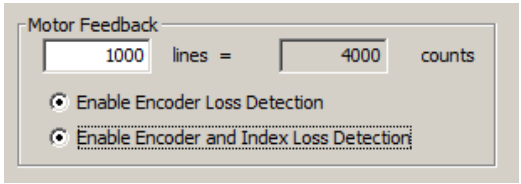
CME options for encoder fault detection are made in the Feedback tab of the Motor/Feedback box on the main page.

(•) Enable Encoder Loss Detection
An Encoder Fault occurs with the loss of the A or B channels of the encoder

(•) Enable Encoder Loss Detection

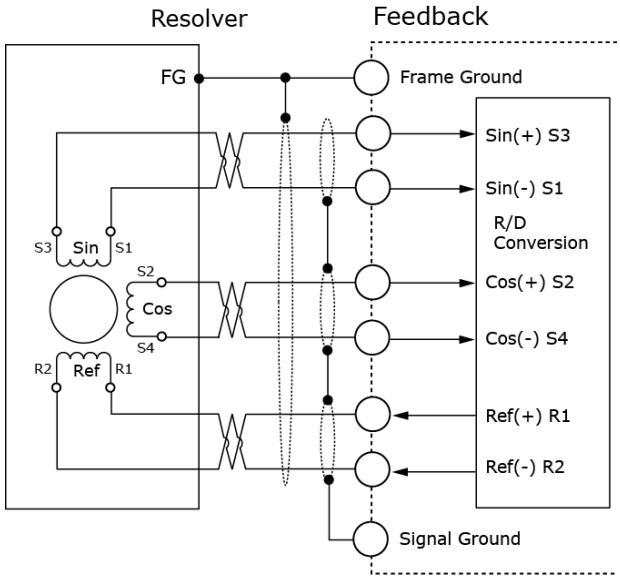
(•)Enable Encoder and Index Loss Detection
An Encoder Fault occurs with the loss of the A, B, or X channels of the encoder





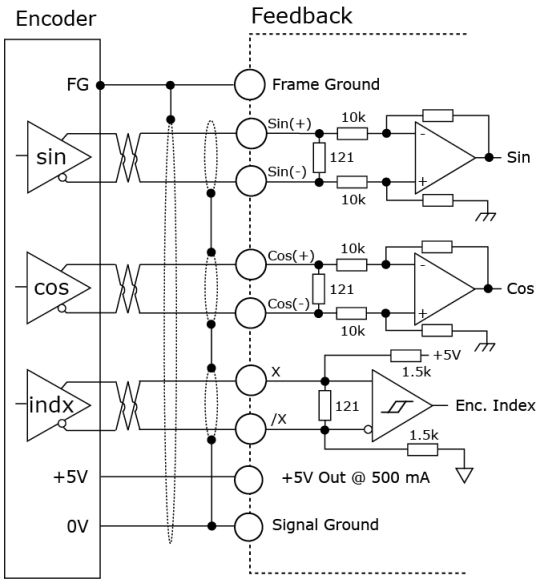
RESOLVER (-R OPTION)

Connections to the resolver should be made with shielded cable that uses three twisted-pairs. Once connected, resolver set up, motor phasing, and other commissioning adjustments are made with CME software. There are no hardware adjustments.



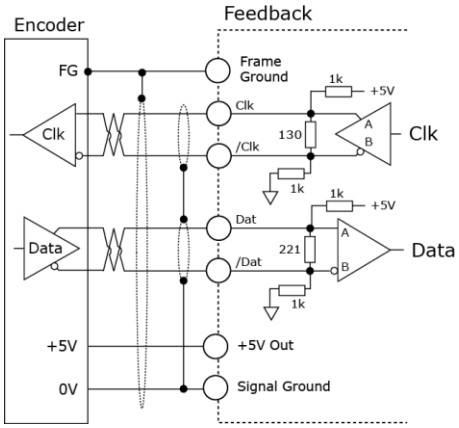
ANALOG SIN/COS ENCODER

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, or with ServoTube motors. The index input is digital.



SSI Absolute Encoder

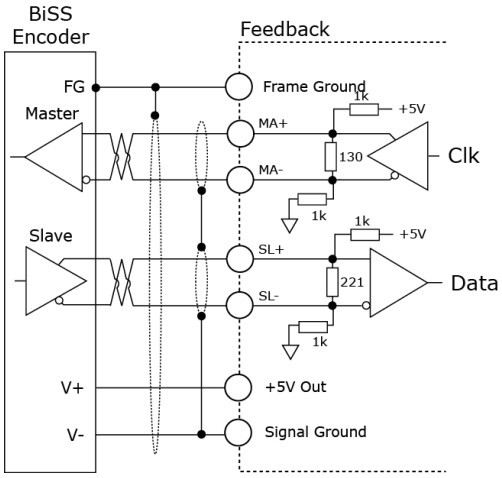
The SSI (Synchronous Serial Interface) is an interface used to connect an absolute position encoder to a motion controller or control system. The drive provides a train of clock signals in differential format to the encoder which initiates the transmission of the position data on the subsequent clock 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

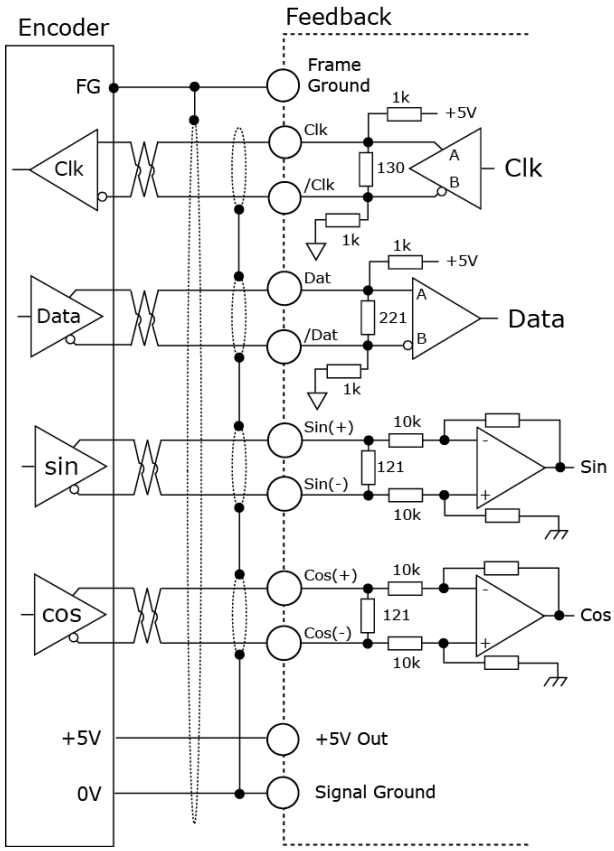
BiSS is an Open Source digital interface for sensors and actuators. BiSS refers to principles of well known industrial standards for Serial Synchronous Interfaces like SSI, AS-Interface® and Interbus® with additional options.

- 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



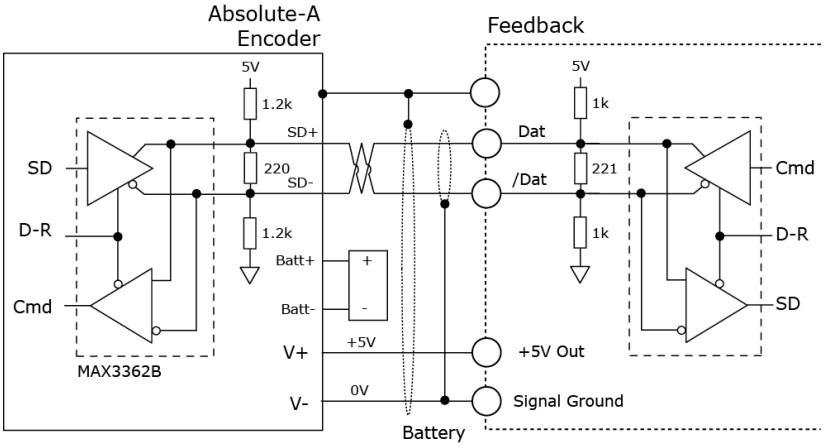
EnDat Absolute Encoder

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.



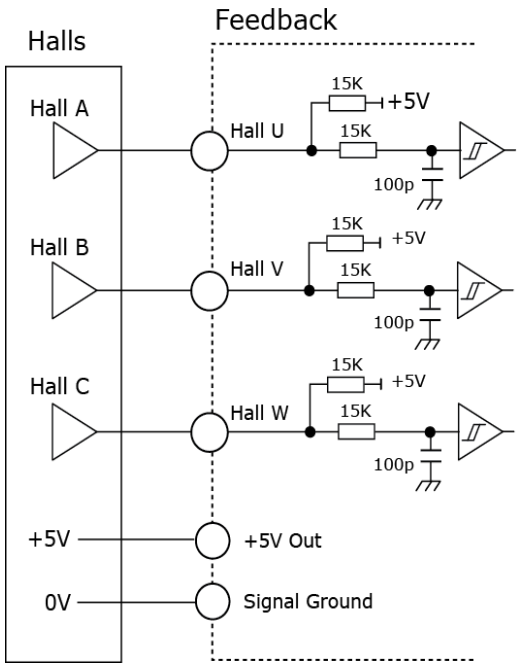
Absolute A Encoder

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



HALLS

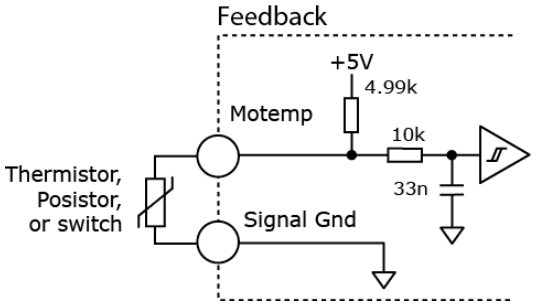
Hall signals are single-ended signals that provide absolute feedback within one electrical cycle of the motor. There are three of them (U, V, & W) and they may be sourced by magnetic sensors in the motor, or by encoders that have Hall tracks as part of the encoder disc. They typically operate at much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



MOTEMP (MOTOR OVER TEMPERATURE) INPUT

The 4.99k pull-up resistor works with PTC (positive temperature coefficient) thermistors that conform to BS 4999:Part 111:1987 (table below), or switches that open/close indicating a motor over-temperature condition. The active level is programmable. These inputs are programmable for other functions if not used as Motemp inputs. And, other inputs are programmable for the Motemp function.

Drive Models	BEL, BPL, BML, TEL	BE2, BP2, TE2, TP2	
Connector	J6	J7 Axis-A	J8 Axis-B
Motemp Pin	7		
Motemp Input	IN11	IN9	IN18
Signal Ground	5, 16, 25, 26		



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
Resistance at 105°C	≥12000

6 APPENDIX

A: 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 (A2S) 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:

$$I^2T \text{ setpoint} = (\text{Peak Current Limit}^2 - \text{Continuous Current Limit}^2) * I^2T \text{ Time Limit}$$

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:

$$I^2T \text{ Accumulator Variable } n+1 = I^2T \text{ Accumulator Variable } n + ((\text{Actual Output Current } n+1)^2 - \text{Continuous Current Limit}^2) * \text{Update period}$$

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
- I^2T Time Limit – 1 S
- Continuous Current Limit – 6 A

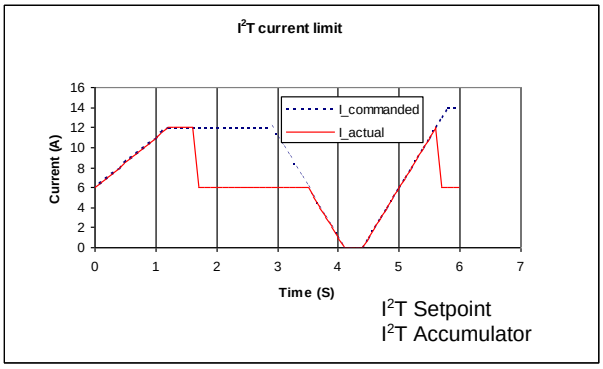
From this information, the I^2T setpoint is:

$$I^2T \text{ setpoint} = (12\ A^2 – 6\ A^2) * 1\ S = 108\ A^2S$$

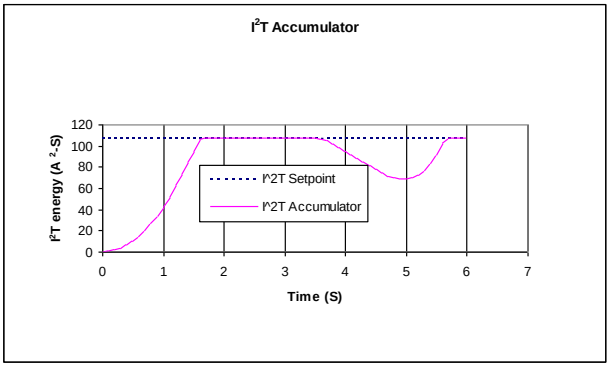
See the example plot diagrams on the next page.

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 in order to simplify the waveforms. The algorithm essentially 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.

B: Connecting BPL/BP2/TP2 for Serial Control

This chapter describes how to connect one or more BPL/BP2/TP2 drives for control via the RS-232 bus on one of the drives.

Single-Axis and Multi-Drop

A BPL/BP2/TP2 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.

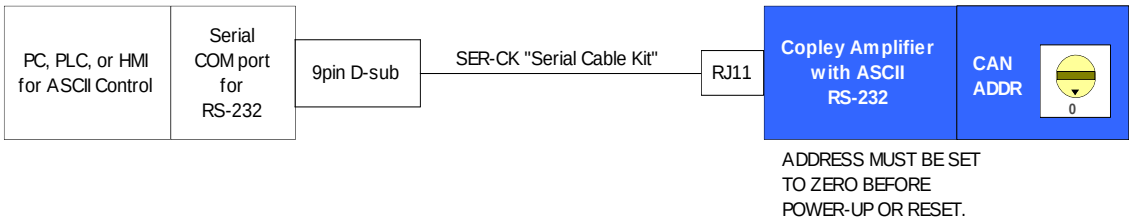
For experimentation and simple setup and control, a TELnet device such as the standard Microsoft Windows HyperTerminal can also be used to send commands in ASCII format. For more information, see *Copley ASCII Interface Programmer's Guide*.

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.

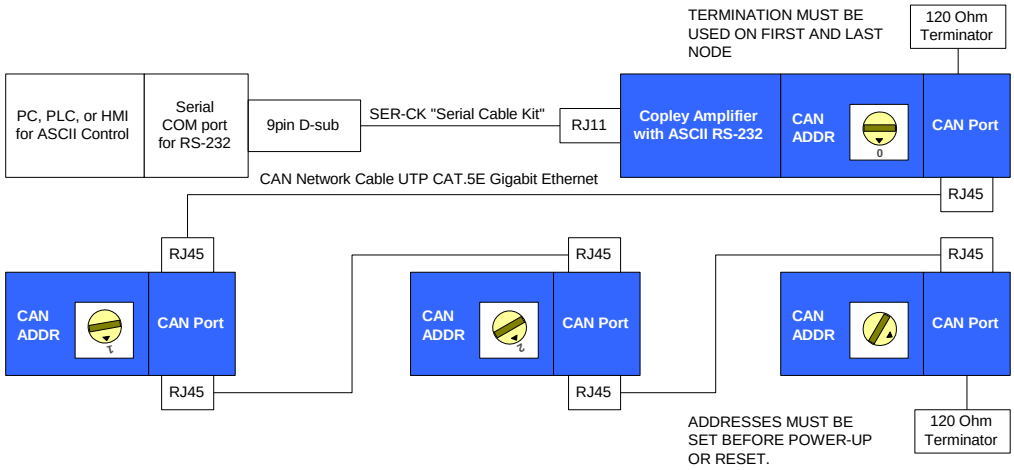
Single-Axis Connections

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 BPL/BP2/TP2 drive can be used as a multi-drop gateway for access to other BPL/BP2/TP2 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. If the BP2 is used as the master, axis B is sequentially addressed automatically. Also, when using BP2 as a master, axis A will not be available for CAN controls. Use 120 Ohms termination on the first and last drive.



C: Ordering Guide and Accessories

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

BEL Model Numbers

Model Number	Description
BEL-090-06	*Accelnet Plus* EtherCAT Servo drive 3/6 A, encoder feedback
BEL-090-06-H	*Accelnet Plus* EtherCAT Servo drive 3/6 A, encoder feedback, with factory-fitted heatsink
BEL-090-06-R	*Accelnet Plus* EtherCAT Servo drive 3/6 A resolver feedback
BEL-090-06-R-H	*Accelnet Plus* EtherCAT Servo drive 3/6 A resolver feedback, with factory-fitted heatsink
BEL-090-14	*Accelnet Plus* EtherCAT Servo drive 7/14 A, encoder feedback
BEL-090-14-H	*Accelnet Plus* EtherCAT Servo drive 7/14 A, encoder feedback, with factory-fitted heatsink
BEL-090-14-R	*Accelnet Plus* EtherCAT Servo drive 7/14 A resolver feedback
BEL-090-14-R-H	*Accelnet Plus* EtherCAT Servo drive 7/14 A resolver feedback with factory-fitted heatsink
BEL-090-30	*Accelnet Plus* EtherCAT Servo drive 15/30 A, encoder feedback
BEL-090-30-H	*Accelnet Plus* EtherCAT Servo drive 15/30A, encoder feedback, with factory-fitted heatsink
BEL-090-30-R	*Accelnet Plus* EtherCAT Servo drive 15/30A resolver feedback
BEL-090-30-R-H	*Accelnet Plus* EtherCAT Servo drive 15/30A resolver feedbac,k with factory-fitted heatsink

NOTE: Heatsink kits for field installations may be ordered separately.

BE2 Model Numbers

Model Number	Description
BE2-090-06	*Accelnet Plus* EtherCAT 2-Axis Servo drive 3/6 A, encoder feedback
BE2-090-06-H	*Accelnet Plus* EtherCAT 2-Axis Servo drive 3/6 A, encoder feedback, with factory-fitted heatsink
BE2-090-06-R	*Accelnet Plus* EtherCAT 2-Axis Servo drive 3/6 A resolver feedback
BE2-090-06-R-H	*Accelnet Plus* EtherCAT 2-Axis Servo drive 3/6 A resolver feedback with factory-fitted heatsink
BE2-090-14	*Accelnet Plus* EtherCAT 2-Axis Servo drive 7/14 A, encoder feedback
BE2-090-14-H	*Accelnet Plus* EtherCAT 2-Axis Servo drive 7/14 A, encoder feedback, with factory-fitted heatsink
BE2-090-14-R	*Accelnet Plus* EtherCAT 2-Axis Servo drive 7/14 A resolver feedback
BE2-090-14-R-H	*Accelnet Plus* EtherCAT 2-Axis Servo drive 7/14 A resolver feedback with factory-fitted heatsink
BE2-090-20	*Accelnet Plus* EtherCAT 2-Axis Servo drive 10/20 A, encoder feedback
BE2-090-20-H	*Accelnet Plus* EtherCAT 2-Axis Servo drive 10/20 A, encoder feedback, with factory-fitted heatsink
BE2-090-20-R	*Accelnet Plus* EtherCAT 2-Axis Servo drive 10/20 A ,resolver feedback
BE2-090-20-R-H	*Accelnet Plus* EtherCAT 2-Axis Servo drive 10/20 A resolver feedback with factory-fitted heatsink

NOTE: Heatsink kits for field installations may be ordered separately.

BPL Model Numbers

Model Number	Description
BPL-090-06	*Accelnet Plus* CANopen Servo drive 3/6 A, encoder feedback
BPL-090-06-H	*Accelnet Plus* CANopen Servo drive 3/6 A, encoder feedback, with factory-fitted heatsink
BPL-090-06-R	*Accelnet Plus* CANopen Servo drive 3/6 A resolver feedback
BPL-090-06-R-H	*Accelnet Plus* CANopen Servo drive 3/6 A resolver feedback, with factory-fitted heatsink
BPL-090-14	*Accelnet Plus* CANopen Servo drive 7/14 A, encoder feedback
BPL-090-14-H	*Accelnet Plus* CANopen Servo drive 7/14 A, encoder feedback, with factory-fitted heatsink
BPL-090-14-R	*Accelnet Plus* CANopen Servo drive 7/14 A resolver feedback
BPL-090-14-R-H	*Accelnet Plus* CANopen Servo drive 7/14 A resolver feedback, with factory-fitted heatsink
BPL-090-30	*Accelnet Plus* CANopen Servo drive 15/30 A, encoder feedback
BPL-090-30-H	*Accelnet Plus* CANopen Servo drive 15/30A, encoder feedback, with factory-fitted heatsink
BPL-090-30-R	*Accelnet Plus* CANopen Servo drive 15/30A resolver feedback
BPL-090-30-R-H	*Accelnet Plus* CANopen Servo drive 15/30A resolver feedback, with factory-fitted heatsink

NOTE: Heatsink kits for field installations may be ordered separately.

BP2 Model Numbers

Model Number	Description
BP2-090-06	*Accelnet Plus* CANopen 2-Axis Servo drive 3/6 A, encoder feedback
BP2-090-06-H	*Accelnet Plus* CANopen 2-Axis Servo drive 3/6 A, encoder feedback, with factory-fitted heatsink
BP2-090-06-R	*Accelnet Plus* CANopen 2-Axis Servo drive 3/6 A resolver feedback
BP2-090-06-R-H	*Accelnet Plus* CANopen 2-Axis Servo drive 3/6 A resolver feedback with factory-fitted heatsink
BP2-090-14	*Accelnet Plus* CANopen 2-Axis Servo drive 7/14 A, encoder feedback
BP2-090-14-H	*Accelnet Plus* CANopen 2-Axis Servo drive 7/14 A, encoder feedback, with factory-fitted heatsink
BP2-090-14-R	*Accelnet Plus* CANopen 2-Axis Servo drive 7/14 A resolver feedback
BP2-090-14-R-H	*Accelnet Plus* CANopen 2-Axis Servo drive 7/14 A resolver feedback, with factory-fitted heatsink
BP2-090-20	*Accelnet Plus* CANopen 2-Axis Servo drive 10/20 A, encoder feedback
BP2-090-20-H	*Accelnet Plus* CANopen 2-Axis Servo drive 10/20 A, encoder feedback, with factory-fitted heatsink
BP2-090-20-R	*Accelnet Plus* CANopen 2-Axis Servo drive 10/20 A ,resolver feedback
BP2-090-20-R-H	*Accelnet Plus* CANopen 2-Axis Servo drive 10/20 A resolver feedback, with factory-fitted heatsink

NOTE: Heatsink kits for field installations may be ordered separately.

BML Model Numbers

Model Number	Description
BML-090-06	*Accelnet Plus* MACRO Servo drive 3/6 A, encoder feedback
BML-090-06-H	*Accelnet Plus* MACRO Servo drive 3/6 A, encoder feedback, with factory-fitted heatsink
BML-090-14	*Accelnet Plus* MACRO Servo drive 7/14 A, encoder feedback
BML-090-14-H	*Accelnet Plus* MACRO Servo drive 7/14 A, encoder feedback, with factory-fitted heatsink
BML-090-30	*Accelnet Plus* MACRO Servo drive 15/30 A, encoder feedback
BML-090-30-H	*Accelnet Plus* MACRO Servo drive 15/30A, encoder feedback, with factory-fitted heatsink

NOTE: Heatsink kits for field installations may be ordered separately.

TEL Model Numbers

Model Number	Description
TEL-090-07	*Stepnet Plus* EtherCAT Stepper drive 5/7 A, encoder feedback
TEL-090-07-H	*Stepnet Plus* EtherCAT Stepper drive 5/7 A, encoder feedback, with factory-fitted heatsink
TEL-090-10	*Stepnet Plus* EtherCAT Stepper drive 10/10 A, encoder feedback
TEL-090-10-H	*Stepnet Plus* EtherCAT Stepper drive 10/10 A, encoder feedback, with factory-fitted heatsink

TE2 Model Numbers

Model Number	Description
TE2-090-07	*Stepnet Plus* EtherCAT 2-Axis Stepper drive 5/7 A, encoder feedback
TE2-090-07-H	*Stepnet Plus* EtherCAT 2-Axis Stepper drive 5/7 A, encoder feedback, with factory-fitted heatsink
TE2-090-10	*Stepnet Plus* EtherCAT 2-Axis Stepper drive 10/10 A, encoder feedback
TE2-090-10-H	*Stepnet Plus* EtherCAT 2-Axis Stepper drive 10/10 A, encoder feedback, with factory-fitted heatsink

TP2 Model Numbers

Model Number	Description
TP2-090-07	*Stepnet Plus* CANopen 2-Axis Stepper drive 5/7 A, encoder feedback
TP2-090-07-H	*Stepnet Plus* CANopen 2-Axis Stepper drive 5/7 A, encoder feedback, with factory-fitted heatsink
TP2-090-10	*Stepnet Plus* CANopen 2-Axis Stepper drive 10/10 A, encoder feedback
TP2-090-10-H	*Stepnet Plus* CANopen 2-Axis Stepper drive 10/10 A, encoder feedback, with factory-fitted heatsink

ACCESSORIES

BEL CONNECTOR KIT

	Qty	Ref	Label	Description	Manufacturers Part Number
BEL-CK Connector Kit	1	J1	Control	Connector, high-density HD-Sub, 44 position, male, solder cup	Norcomp: 180-044-103L001
	1			Backshell, HD-Sub, 44 Pin, RoHS, metallized	Norcomp: 979-025-020R121
	1	J4	Safety	Connector, D-Sub, 9-position, standard	AMP/Tyco: 205204-4
	9			AMPLIMITE HDP-20 Crimp-Snap contacts, 24-20AWG, sel AU/NI	AMP/Tyco: 66506-9
	1			Backshell, D-Sub, , 9-position, standard RoHS, metallized, for J6	Norcomp: 979-009-020R121
	1	J5	Brake	Plug 3.5 mm, screw-lock, 4 position, female	Wago: 734-104/031-000
	1			Tool, wire insertion & extraction	Wago: 734-231
	1	J6	Feedback	Connector, high-density HD-Sub, 26 position, male, solder cup	Norcomp: 180-026-103L001
	1			Backshell, HD-Sub, 26 Pin, RoHS, metallized	Norcomp: 979-015-020R121
	1	J7	Motor	Plug, 4 position, 5.08 mm, screw-lock, female	Wago: 231-304/107-000
	1	J8	HV-Aux	Plug, 3 position, 5.08 mm, screw-lock, female	Wago: 231-303/107-000
	1	J7 J8	Tool	Tool, wire insertion & extraction	Wago: 231-159

BEL CABLE KITS & ASSEMBLIES

Model	Ref	Description
BEL-SK	J2	RS-232 Cable Kit: Dsub-9 molded cable with plug for J2
BEL-NC-10	J3	EtherCAT Network Cable, 10 ft (3 m)
BEL-NC-01		EtherCAT Network Cable, 1 ft (0.3 m)

BPL Connector Kits

	Qty	Ref	Label	Description	Manufacturers Part Number
BPL-CK Connector Kit	1	J1	Control	Connector, high-density HD-Sub, 44 position, male, solder cup	Norcomp: 180-044-103L001
	1			Backshell, HD-Sub, 44 Pin, RoHS, metallized	Norcomp: 979-025-020R121
	1	J4	Safety	Connector, D-Sub, 9-position, standard	AMP/Tyco: 205204-4
	9			AMPLIMITE HDP-20 Crimp-Snap contacts, 24-20AWG, sel AU/NI	AMP/Tyco: 66506-9
	1			Backshell, D-Sub, , 9-position, standard RoHS, metallized, for J6	Norcomp: 979-009-020R121
	1	J5	Brake	Plug 3.5 mm, screw-lock, 4 position, female	Wago: 734-104/031-000
	1			Tool, wire insertion & extraction	Wago: 734-231
	1	J6	Feedback	Connector, high-density HD-Sub, 26 position, male, solder cup	Norcomp: 180-026-103L001
	1			Backshell, HD-Sub, 26 Pin, RoHS, metallized	Norcomp: 979-015-020R121
	1	J7	Motor	Plug, 4 position, 5.08 mm, screw-lock, female	Wago: 231-304/107-000
	1	J8	HV-Aux	Plug, 3 position, 5.08 mm, screw-lock, female	Wago: 231-303/107-000
	1	J7 J8	Tool	Tool, wire insertion & extraction	Wago: 231-159

CANopen Connector Kit

Model	Qty	Ref	Description
BPL-NK	1	J3	BPL-CV: Sub-D 9-position female to RJ-45 adapter
	1		BPL-NC:-10 CAN bus Network Cable, 10 ft (3 m)
	1		BPL-NT: CAN bus RJ-45 Network Terminator

Individual Cable Assemblies (and Related Accessories)

Model	Ref	Description
BPL-SK	J2	RS-232 Cable Kit: Dsub-9 molded cable with plug for J2
BPL-CV	J3	Sub-D 9-position female to RJ-45 adapter (PC to CANopen cable adapter)
BPL-NC-10		CAN bus Network Cable, 10 ft (3 m)
BPL-NC-01		CAN bus Network Cable, 1 ft (0.3 m)
BPL-NT		CAN bus Network Terminator

BML Connector Kit

	Qty	Ref	Label	Description	Manufacturers Part Number
BML-CK Connector Kit	1	J1	Control	Connector, high-density HD-Sub, 44 position, male, solder cup	Norcomp: 180-044-103L001
	1			Backshell, HD-Sub, 44 Pin, RoHS, metallized	Norcomp: 979-025-020R121
	1	J4	Safety	Connector, D-Sub, 9-position, standard	AMP/Tyco: 205204-4
	9			AMPLIMITE HDP-20 Crimp-Snap contacts, 24-20AWG, sel AU/NI	AMP/Tyco: 66506-9
	1			Backshell, D-Sub, , 9-position, standard RoHS, metallized, for J6	Norcomp: 979-009-020R121
	1	J5	Brake	Plug 3.5 mm, screw-lock, 4 position, female	Wago: 734-104/031-000
	1			Tool, wire insertion & extraction	Wago: 734-231
	1	J6	Feedback	Connector, high-density HD-Sub, 26 position, male, solder cup	Norcomp: 180-026-103L001
	1			Backshell, HD-Sub, 26 Pin, RoHS, metallized	Norcomp: 979-015-020R121
	1	J7	Motor	Plug, 4 position, 5.08 mm, screw-lock, female	Wago: 231-304/107-000
	1	J8	HV-Aux	Plug, 3 position, 5.08 mm, screw-lock, female	Wago: 231-303/107-000
	1	J7 J8	Tool	Tool, wire insertion & extraction	Wago: 231-159

BML Cable Kits & Assemblies

Model	Ref	Description
BML-SK	J2	RS-232 Cable Kit: Dsub-9 molded cable with plug for J2

BE2 Connector Kits

	Qty	Ref	Label	Description	Manufacturers Part Number
BE2-CK Connector Kit	1	J1	Control	Connector, high-density HD-Sub, 44 position, male, solder cup	Norcomp: 180-044-103L001
	1			Backshell, HD-Sub, 44 Pin, RoHS, metallized	Norcomp: 979-025-020R121
	1	J2	I/O	Connector, high-density HD-Sub, 26 position, female, solder cup	Norcomp: 180-026-203L001
	1	J3	Brake	Plug 3.5 mm, screw-lock, 5 position, female	Wago: 734-105/031-000
	1			Tool, wire insertion & extraction	Wago: 734-231
	1	J6	Safety	Connector, D-Sub, 9-position, standard	AMP/Tyco: 205204-4
	9			AMPLIMITE HDP-20 Crimp-Snap contacts, 24-20AWG, sel AU/NI	AMP/Tyco: 66506-9
	1			Backshell, D-Sub, 9-position, standard RoHS, metallized, for J6	Norcomp: 979-009-020R121
	2	J7,J8	Feedback	Connector, high-density HD-Sub, 26 position, male, solder cup	Norcomp: 180-026-103L001
	3	J2,J7,J8	I/O, Feedback	Backshell, HD-Sub, 26 Pin, RoHS, metallized	Norcomp: 979-015-020R121
	2	J9,J10	Motor	Plug, 4 position, 5.08 mm, screw-lock, female	Wago: 231-304/107-000
	1	J11	HV-Aux	Plug, 3 position, 5.08 mm, screw-lock, female	Wago: 231-303/107-000
	1	J9, J10, J11	Tool	Tool, wire insertion & extraction	Wago: 231-159

Individual Cable Assemblies (and Related Accessories)

Model	Ref	Description
SER-CK	J4	RS-232 Serial Cable Kit (for connecting PC to drive)
BE2-NC-10	J3	EtherCAT Network Cable, 10 ft (3 m)
BE2-NC-01		EtherCAT Network Cable, 1 ft (0.3 m)

BP2 Connector Kit

	Qty	Ref	Label	Description	Manufacturers Part Number
BP2-CK Connector Kit	1	J1	Control	Connector, high-density HD-Sub, 44 position, male, solder cup	Norcomp: 180-044-103L001
	1			Backshell, HD-Sub, 44 Pin, RoHS, metallized	Norcomp: 979-025-020R121
	1	J2	I/O	Connector, high-density HD-Sub, 26 position, female, solder cup	Norcomp: 180-026-203L001
	1	J3	Brake	Plug 3.5 mm, screw-lock, 5 position, female (Brake)	Wago: 734-105/031-000
	1			Tool, wire insertion & extraction	Wago: 734-231
	1	J6	Safety	Connector, D-Sub, 9-position, standard	AMP/Tyco: 205204-4
	9			AMPLIMITE HDP-20 Crimp-Snap contacts, 24-20AWG, sel AU/NI	AMP/Tyco: 66506-9
	1			Backshell, D-Sub, , 9-position, standard RoHS, metallized,for J6	Norcomp: 979-009-020R121
	2	J7,J8	Feedback	Connector, high-density HD-Sub, 26 position, male, solder cup	Norcomp: 180-026-103L001
	3	J2,J7,J8	I/O, Feedback	Backshell, HD-Sub, 26 Pin, RoHS, metallized	Norcomp: 979-015-020R121
	2	J9,J10	Motor	Plug, 4 position, 5.08 mm, screw-lock, female	Wago: 231-304/107-000
	1	J11	HV-Aux	Plug, 3 position, 5.08 mm, screw-lock, female	Wago: 231-303/107-000
	1	J9 J10 J11	Tool	Tool, wire insertion & extraction	Wago: 231-159

Note 1: For RoHS compliance, append “/RN01-0000” to the Wago part numbers listed above.

BP2 CANopen Connector Kit

Model	Qty	Ref	Description
BP2-NK	1	J7	BPL-CV: Sub-D 9-position female to RJ-45 adapter
	1	J7	BPL-NC:-10 CAN bus Network Cable, 10 ft (3 m)
	1		BPL-NT: CAN bus RJ-45 Network Terminator

BP2 Individual Cable Assemblies (and Related Accessories)

Model	Ref	Description
SER-CK	J4	RS-232 Serial Cable Kit (for connecting PC to drive)
BP2-NC-10	J3	CANopen Network Cable, 10 ft (3 m)
BP2-NC-01		CANopen Network Cable, 1 ft (0.3 m)
BP2-CV		D-Sub 9F to RJ-45 Adapter
BP2-NT		CANopen Network Terminator

TEL Connector Kit

	Qty	Ref	Label	Description	Manufacturers Part Number
TEL-CK Connector Kit	1	J1	Control	Connector, high-density HD-Sub, 44 position, male, solder cup	Norcomp: 180-044-103L001
	1			Backshell, HD-Sub, 44 Pin, RoHS, metallized	Norcomp: 979-025-020R121
	1	J4	Safety	Connector, D-Sub, 9-position, standard	AMP/Tyco: 205204-4
	9			AMPLIMITE HDP-20 Crimp-Snap contacts, 24-20AWG, sel AU/NI	AMP/Tyco: 66506-9
	1			Backshell, D-Sub, , 9-position, standard RoHS, metallized, for J6	Norcomp: 979-009-020R121
	1	J5	Brake	Plug 3.5 mm, screw-lock, 4 position, female	Wago: 734-104/031-000
	1			Tool, wire insertion & extraction	Wago: 734-231
	1	J6	Feedback	Connector, high-density HD-Sub, 26 position, male, solder cup	Norcomp: 180-026-103L001
	1			Backshell, HD-Sub, 26 Pin, RoHS, metallized	Norcomp: 979-015-020R121
	1	J7	Motor	Plug, 5 position, 5.08 mm, screw-lock, female	Wago: 231-305/107-000
	1	J8	HV-Aux	Plug, 3 position, 5.08 mm, screw-lock, female	Wago: 231-303/107-000

	1	J7, J8	Tool	Tool, wire insertion & extraction	Wago: 231-159

Note 1: For RoHS compliance, append "/RN01-0000" to the Wago part numbers listed above.

Individual Cable Assemblies (and Related Accessories)

Model	Ref	Description
TEL-SK	J2	RS-232 Cable Kit: Dsub-9 molded cable with plug for J2
TEL-NC-10	J3	EtherCAT Network Cable, 10 ft (3 m)
TEL-NC-01		EtherCAT Network Cable, 1 ft (0.3 m)

TE2 Connector Kit

	Qty	Ref	Label	Description	Manufacturers Part Number
TE2-CK Connector Kit	1	J1	Control	Connector, high-density HD-Sub, 44 position, male, solder cup	Norcomp: 180-044-103L001
	1			Backshell, HD-Sub, 44 Pin, RoHS, metallized	Norcomp: 979-025-020R121
	1	J2	I/O	Connector, high-density HD-Sub, 26 position, female, solder cup	Norcomp: 180-026-203L001
	1	J3	Brake	Plug 3.5 mm, screw-lock, 5 position, female	Wago: 734-105/031-000
	1			Tool, wire insertion & extraction	Wago: 734-231
	1	J6	Safety	Connector, D-Sub, 9-position, standard	AMP/Tyco: 205204-4
	9			AMPLIMITE HDP-20 Crimp-Snap contacts, 24-20AWG, sel AU/NI	AMP/Tyco: 66506-9
	1			Backshell, D-Sub, , 9-position, standard RoHS, metallized, for J6	Norcomp: 979-009-020R121
	2	J7 J8	Feedback	Connector, high-density HD-Sub, 26 position, male, solder cup	Norcomp: 180-026-103L001
	3	J2 J7 J8	I/O, Feedback	Backshell, HD-Sub, 26 Pin, RoHS, metallized	Norcomp: 979-015-020R121
	2	J9 J10	Motor	Plug, 5 position, 5.08 mm, screw-lock, female	Wago: 231-305/107-000
	1	J11	HV-Aux	Plug, 3 position, 5.08 mm, screw-lock, female	Wago: 231-303/107-000
	1	J9 J10 J11	Tool	Tool, wire insertion & extraction	Wago: 231-159

Note 1: For RoHS compliance, append "/RN01-0000" to the Wago part numbers listed above.

Individual Cable Assemblies (and Related Accessories)

Model	Ref	Description
SER-SK	J2	RS-232 Serial Cable Kit (for connecting PC to drive)
TE2-NC-10	J3	EtherCAT Network Cable, 10 ft (3 m)
TE2-NC-01		EtherCAT Network Cable, 1 ft (0.3 m)

TP2 Connector Kit

	Qty	Ref	Label	Description	Manufacturers Part Number
TP2-CK Connector Kit	1	J1	Control	Connector, high-density HD-Sub, 4 position, male, solder cup	Norcomp: 180-044-103L001
	1			Backshell, HD-Sub, 44 Pin, RoHS, metallized	Norcomp: 979-025-020R121
	1	J2	I/O	Connector, high-density HD-Sub, 26 position, female, solder cup	Norcomp: 180-026-203L001
	1	J3	Brake	Plug 3.5 mm, screw-lock, 5 position, female	Wago: 734-105/031-000
	1			Tool, wire insertion & extraction	Wago: 734-231
	1	J6	Safety	Connector, D-Sub, 9-position, standard	AMP/Tyco: 205204-4
	9			AMPLIMITE HDP-20 Crimp-Snap contacts, 24-20AWG, sel AU/NI	AMP/Tyco: 66506-9
	1			Backshell, D-Sub, , 9-position, standard RoHS, metallized, for J6	Norcomp: 979-009-020R121
	2	J7 J8	Feedback	Connector, high-density HD-Sub, 26 position, male, solder cup	Norcomp: 180-026-103L001
	3	J2 J7 J8	I/O, Feedback	Backshell, HD-Sub, 26 Pin, RoHS, metallized	Norcomp: 979-015-020R121
	2	J9,J10	Motor	Plug, 5 position, 5.08 mm, screw-lock, female	Wago: 231-305/107-000
	1	J11	HV-Aux	Plug, 3 position, 5.08 mm, screw-lock, female	Wago: 231-303/107-000
	1	J9 J10 J11	Tool	Tool, wire insertion & extraction	Wago: 231-159

TP2 CANopen Connector Kit

Model	Qty	Ref	Description
TP2-NK	1	J3	BPL-CV: Sub-D 9-position female to RJ-45 adapter
	1		BPL-NC:-10 CAN bus Network Cable, 10 ft (3 m)
	1		BPL-NT: CAN bus RJ-45 Network Terminator

TP2 Individual Cable Assemblies (and Related Accessories)

Model	Ref	Description
SER-CK	J4	RS-232 Serial Cable Kit (for connecting PC to drive)
TP2-CV	J3	Sub-D 9-position female to RJ-45 adapter (PC to CANopen cable adapter)
TP2-NC-10		CAN bus Network Cable, 10 ft (3 m)
TP2-NC-01		CAN bus Network Cable, 1 ft (0.3 m)
TP2-NT		CAN bus Network Terminator

Heatsink Kits

BEL, BPL, BML

Model	Qty	Description
BEL-HK BPL-HK BML-HK	1	BEL/BPL/BML Heatsink
	1	BEL/BPL/BML Heatsink thermal material
	4	Heatsink mounting hardware

BE2, BP2

Model	Qty	Description
BE2-HK BP2-HK	1	BE2/BP2 Heatsink
	1	BE2/BP2 Heatsink thermal material
	4	Heatsink mounting hardware

TEL

Model	Qty	Description
TEL-HK	1	TEL Heatsink
	1	Heatsink thermal material
	4	Heatsink mounting hardware

TE2, TP2

Model	Qty	Description
TE2-HK TP2-HK	1	TE2/TP2 Heatsink
	1	TE2/TP2 Heatsink thermal material
	4	Heatsink mounting hardware

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