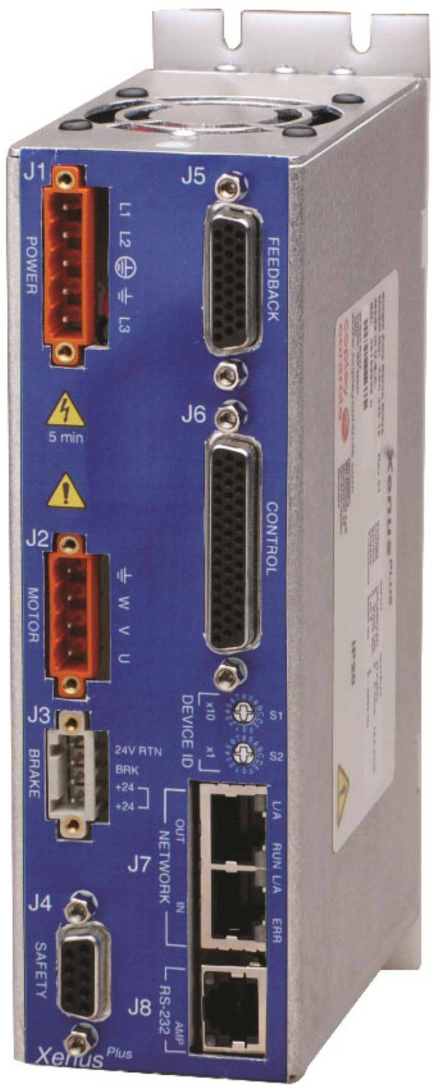
Xenus Plus[TM] Compact

User Guide



P/N 16-01552
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September 12, 2016

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1 ABOUT THIS MANUAL

1.1 Title, Number, Revision

Title	**Xenus Plus Compact User Guide**
Document Number	16-01552
Current Revision	00

1.1 Revision History

Revision	Date	ECO	Comments
00	September 12, 2016	ECO-063895	Initial Release

1.2 EC Declaration of Conformity

The products covered by this manual comply with the EC Directives 2014/30/EU (EMC Directive), 2014/35/EU (Low Voltage Directive), 2006/42/EC (Machinery Directive) and 2011/65/EU (RoHS Directive). The complete EC Declaration of Conformity is available on the internet at www.copleycontrols.com.

Name and Address of the Manufacturer:
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Herlev
Denmark

1.3 Overview and Scope

This manual describes the operation and installation of the *Xenus Plus Compact* servo drives manufactured by Copley Controls. All *Xenus Plus Compact* products have serial numbers that incorporate the week and year of production into the first 4 digits (WWYY) of the serial number.

1.4 EC Declaration of Conformity

The complete EC Declaration of Conformity for all products are available on the internet at www.copleycontrols.com.

copley controls
Analogic Motion Controls

EC DECLARATION OF CONFORMITY

Objects of this declaration:

Product Description	Model Numbers
Xenus Plus Compact EtherCAT Servo Drive	XEC-230-09, XEC-230-12, XEC-230-15 XEC-230-09-R, XEC-230-12-R, XEC-230-15-R 801-1891, 801-1892, 801-1893
Xenus Plus Compact CANopen Servo Drive	XPC-230-09, XPC-230-12, XPC-230-15 XPC-230-09-R, XPC-230-12-R, XPC-230-15-R

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 61800-3:2004 /A1:2011 — Adjustable Speed Electric Power Drive Systems – Part 3: EMC Requirements and Specific Test Methods. Category 3 PDS.

PRODUCT SAFETY

IEC 61800-5-1:2007 — Adjustable Speed Electric Power Drive Systems – Part 5-1: Safety Requirements – Electrical, Thermal and Energy

FUNCTIONAL SAFETY

IEC 61800-5-2:2007 — 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 61800-5-1-2012 — 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
TÜV SÜD America 10040 Mesa Rim Road, San Diego, CA 92121, www.tuv-sud-america.com

Year in which the CE Marking was affixed: ***2016***

Signed for and on behalf of the above named manufacturer

Place and date of issue: *Canton, MA USA* *08/23/2016*

Name, function: *Michael Doyle, Director, Global Regulatory & Clinical Affairs*

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

16-01554 rev00

1.5 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.

1.6 Related Documentation

These documents have additional information on the *Xenus Plus Compact* and are required for proper installation and commissioning of the drives.

Available upon request from Copley Controls:

User Guide

Xenus Plus Compact STO Manual (Document No. 16-01553)

Datasheet

Xenus Plus XEC Datasheet (Document No. 16-01435)

Xenus Plus XPC Datasheet (Document No. 16-01436)

Available on the Copley Controls web site:

http://www.copleycontrols.com/Motion/Downloads/index.html

Downloads > Documents > Xenus Plus > Manual:

Absolute & Serial Encoder Guide

CME2 User Guide

Indexer 2 User Guide

ASCII Programmers Guide

CMO Programmers Guide

1.7 Comments

Copley Controls welcomes your comments on this manual.
For contact information, see http://www.copleycontrols.com/Motion/Contact/index.html.

1.8 Copyrights

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CME 2 is a registered trademark of Copley Controls.

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EtherCAT is a registered trademark and patented technology, licensed by Beckhoff Automation GmbH, Germany.

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

Observe all relevant state, regional and local safety regulations when installing and using this product. There are no user serviceable parts in the *Xenus Plus Compact* 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 *Xenus Plus Compact* servo drives must be experienced in all aspects of electrical equipment installations. There are no user serviceable parts in the *Xenus Plus Compact* servo drives. Removal of the cover, fan assembly or tampering with internal components may expose hazardous voltages and will void the warranty. **Failure to heed this warning can cause equipment damage, injury, or death.**
DANGER	**Risk of electric shock. Wait 5 minutes after disconnecting mains power before handling.** High-voltage circuits connected to mains power. After disconnecting mains power, wait 5 minutes before handling drive to allow for discharge of internal DC bus capacitance. XEC, XPC, 801-1891, 801-1892, 801-1893 | J1, J2 **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 2 or serial commands may affect or suspend CANopen operations.** When operating the drive as a CANopen node, the use of CME 2 or ASCII serial commands may affect CANopen operations in progress. Using such commands to initiate motion may cause CANopen operations to suspend. CANopen 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. For more information, see Clearing Latched Faults (p.42). **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.**

This page for notes.

2 INTRODUCTION

This chapter provides an overview of the Copley Controls *Xenus Plus Compact* drives.

Contents include:

2.1 *Xenus Plus Compact* Family Overview

The *Xenus Plus Compact* servo drives provide 100% digital control of brushless or brush motors in an off-line powered package. They operate from single or three-phase mains with a continuous power output of up to 2 kW.

The XEC supports EtherCAT communications, and the XPC supports CANopen.

All models provide a Safe Torque Off (STO) function. Two inputs 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 STO inputs are energized, the control core will be able to control the on/off state of the PWM outputs.

The *Xenus Plus Compact* 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. They can emulate a digital quadrature A/B encoder output from the analog sin/cos signals.

The *Xenus Plus Compact* models can operate in several basic ways:

- As traditional motor drives accepting 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.
- As a node 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.
- As a node on an EtherCAT network.
- As a stand-alone controller running CVM control programs such as the Indexer 2 Program. It can also be controlled directly over an RS232 serial link with simple ASCII format commands.

Mains input voltage to the drive can range from 100 to 240 Vac, single or three-phase, and 47 to 63 Hz. This allows the *Xenus Plus Compact* drives to work in the widest possible range of industrial settings. Several models are available, with peak output current ratings of 9 to 15 Amps.

A separate +24 Vdc logic supply is required to power the internal logic and control circuits. These are isolated from the high-voltage power supply and inverter stage that connect to the mains. This simplifies system design by allowing the mains to be completely disconnected from the drive for safety reasons while allowing the logic side of the drive to stay powered. This allows the drive to retain position information and maintain communication through the digital I/O or over the serial, CAN, or EtherCAT ports when disconnected from the mains.

The *Xenus Plus Compact* models are RoHS compliant.

2.2 Model Numbering

Model		Data		
Standard	**Resolver**	**Continuous Current Adc (Arms)**	**Peak Current Adc (Arms)**	**Vac**
XEC-230-09 *XPC-230-09*	*XEC-230-09-R* *XPC-230-09-R* *801-1891*	3 (2.12)	9 (6.4)	100~240 1Ø, 3Ø 47~63 Hz
XEC-230-12 *XPC-230-12*	*XEC-230-12-R* *XPC-230-12-R* *801-1892*	6 (4.24)	12 (8.5)	
XEC-230-15 *XPC-230-15*	*XEC-230-15-R* *XPC-230-15-R* *801-1893*	7.5 (5.3)	15 (7.5)	

Note that as a convenience to customers Copley offers a certain level of customization to tailor *Xenus Plus Compact* drives for a given application. This level of customization is most often limited to factory configuration of user programmable parameters, but can include signal level hardware differences to accommodate less common motor feedback devices. Drives with this customization carry the "*XENUS PLUS*" marking, but are assigned customer specific model numbers that begin with "800- or 801-" followed by four or five alphanumeric characters. These *Xenus Plus Compact* number models are included within the scope of this manual unless otherwise noted.

2.3 CME 2

Drive commissioning is fast and simple using Copley Controls CME 2 software. CME 2 communicates with *Xenus Plus Compact* via an RS-232, CANopen, or EtherCAT link, and all of the operations needed to configure the drive are accessible through CME 2.

The multi-drop feature allows CME 2 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 2 does the rest. Encoder wire swapping to establish the direction of positive motion is also eliminated.

Motor data can be saved as .CCM files. Drive data is saved as .CCX files that contain all drive settings plus motor data. This makes it possible to quickly set up drives by copying configurations from one drive to another.

2.4 CML/CMO

Copley Motion Libraries (CML) and Copley Motion Objects (CMO) make 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. CML provides a suite of C++ libraries, allowing a C++ application program to communicate with and control a drive over the CANopen network. CMO is a .NET assembly targeting the Microsoft .NET Framework. CMO can be used with programming languages such as Visual Basic and Visual C#.

2.5 Copley Virtual Machine (CVM)

CVM is a virtual machine that runs Indexer 2 or CPL programs.

2.6 Indexer 2

Copley's Indexer 2 is an indexer configured with up to 32 sequences using the tools built into CME2.

2.7 CPL

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

3 OPERATIONAL THEORY

This chapter describes the basics of *Xenus Plus Compact* operation. Contents include:

3.1 Drive Power Architecture

Power distribution within *Xenus Plus Compact* is divided into four sections: +24 Vdc & brake, logic/signal, EtherCAT, and high voltage. Each is isolated from the other.

3.1.1 Logic/Signal Power

An internal DC/DC converter operates from the +24 Vdc Logic Supply input and creates the required logic/signal operating voltages, the isolated voltages required for the high-voltage control circuits, and a +5 Vdc supply for powering the motor encoder and Hall circuits.

Within the *Xenus Plus Compact*, digital inputs IN1~6 and IN11, analog inputs AIN, digital outputs OUT1~3, Hall inputs and encoder inputs are all referenced to signal ground. Inputs IN7~10 are four opto-isolated inputs with a common terminal. Outputs OUT4 is a high-speed CMOS buffer. The brake output OUT5 is opto-isolated and referenced to the +24Vdc return. The CAN interface is optically isolated and the EtherCAT port is magnetically isolated.

Deriving internal operating voltages from a separate source enables the drive to stay on-line when the mains have been disconnected for emergency-stop or operator-intervention conditions. This allows EtherCAT, CAN bus, and serial communications to remain active so that the drive can be monitored by the control system while the mains power is removed.

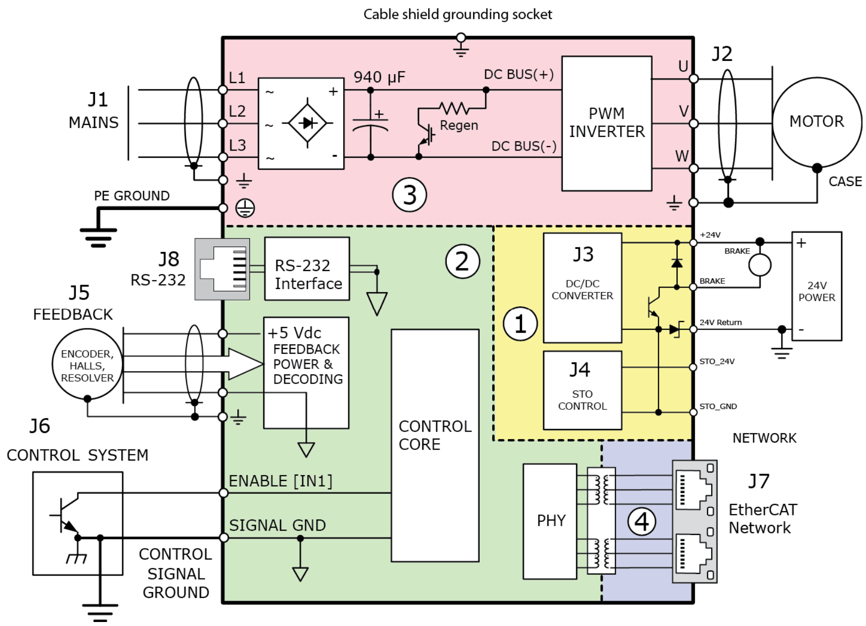
3.1.2 High Voltage

Mains power drives the high-voltage section. It is rectified and capacitor-filtered to produce the DC bus: the DC “link” power that drives the PWM inverter, where it is converted into the voltages that drive a three-phase brushless or DC brush motor. An internal solid-state switch, together with an internal power resistor, provides dissipation during regeneration when the mechanical energy of the motor is converted back into electrical energy. This prevents charging the internal capacitors to an overvoltage condition.

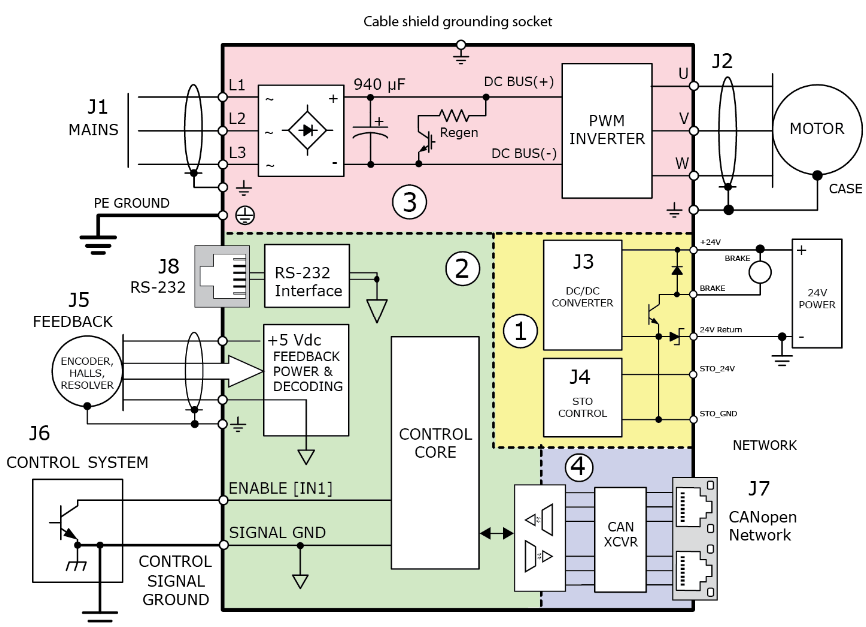
3.1.3 POWER AND ISOLATION DIAGRAM

The graphic below shows the different power sections within the *Xenus Plus Compact* drives and the isolation barriers between them.

XEC & 801-1891~1893 POWER & ISOLATION



XPC POWER & ISOLATION



The isolation barriers associated with the general purpose inputs and outputs or the STO inputs are not shown.

3.2 Operating Modes

3.2.1 Commutation Modes

The drive supports three commutation modes to drive brush and brushless motors: brushless sinusoidal, brushless trapezoidal, and DC brush.

Brushless motors driven with sinusoidal phase currents are commonly called AC brushless, while those which commutate using only Hall feedback are called DC brushless motors. In DC brushless motors, only two phases are driven at a time and the current between them is controlled to be DC. AC brushless motors drive all three phases, each with sinusoidal currents and 120 degrees of phase shift between them. In most applications, sinusoidal commutation is preferred over trapezoidal, because it reduces torque ripple and offers the smoothest motion at any velocity or torque. In the sinusoidal commutation mode, an encoder is required for all modes of operation. When driving a DC brush motor, the drive operates as a traditional H-Bridge drive using only the U & V PWM outputs.

3.2.2 Position Feedback Types

ENCODER SUPPORT

The standard versions of the *Xenus Plus Compact* drives support digital quadrature encoders, analog sin/cos encoders, and a variety of serial and absolute encoder formats.

Resolver versions, designated by "–R" in the model number, support standard, single speed, transmit-type resolvers.

The "801-" number models support a proprietary resolver feedback type.

Digital quadrature and sin/cos analog encoders are "incremental" types that typically use Hall feedback for commutating brushless motors. Absolute encoders do not require Halls for commutation because they provide the absolute feedback of the position of the motor rotor.

MULTI-MODE PORT

All models support a multi-mode port. This interface can be configured to:

- Provide a buffered digital encoder output based on the digital quadrature encoder input.
- Provide emulated digital encoder A/B outputs based on analog encoder, absolute encoder, or resolver feedback. An emulated X (index) output only works for encoders that have an index channel such as digital quad A/B/X or analog encoders.
- Provide a second digital encoder input 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 provides velocity loop feedback.

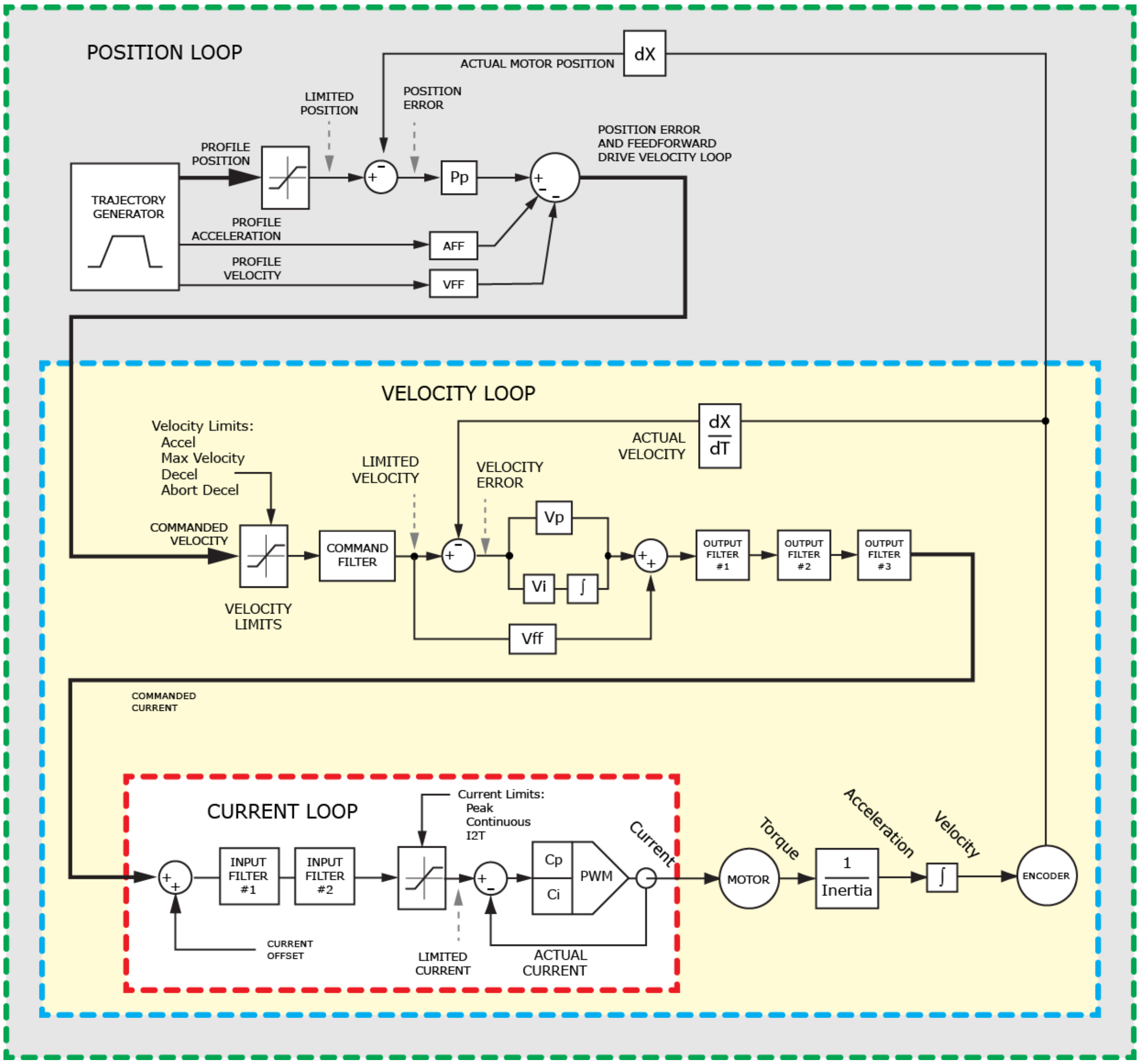
3.2.4 CONTROL MODES AND LOOPS

NESTING OF CONTROL LOOPS AND MODES

Copley Controls drives use up to three nested control loops - current, velocity, and position - to control a motor in three associated operating modes.

CONTROL LOOPS ILLUSTRATION

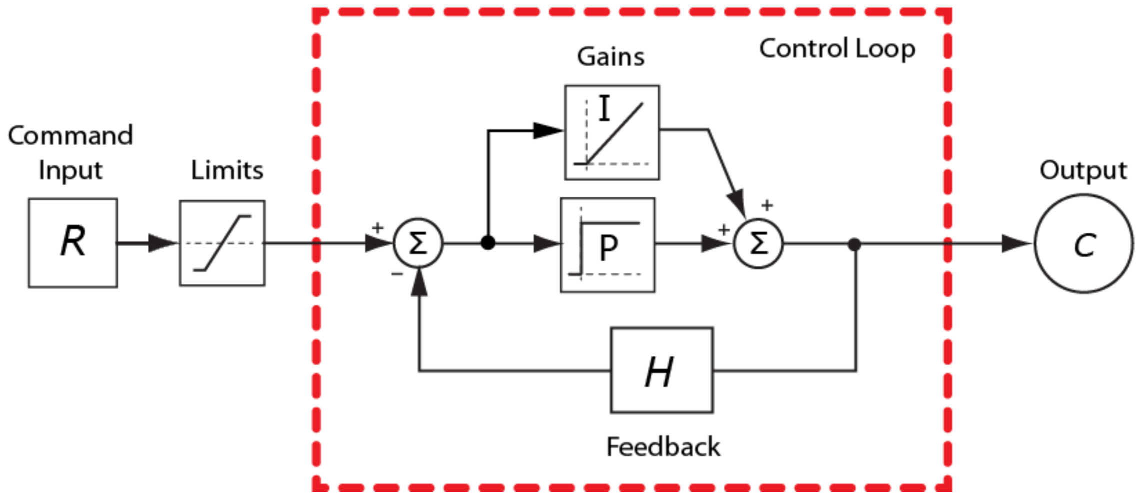
In position mode, the drive uses all three loops. As shown below, the position loop drives the nested velocity loop, which drives the nested current loop. In velocity mode, the velocity loop drives the current loop. In current mode, the current loop is driven directly by external or internal current commands.



BASIC ATTRIBUTES OF ALL CONTROL LOOPS

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

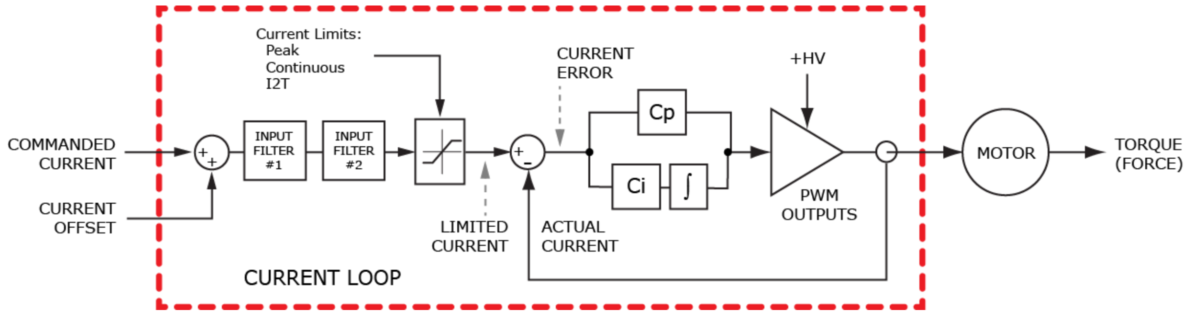
Loop Attribute	Description
Command input	Every loop is given a value to which it will attempt to control. For example, the velocity loop receives a velocity command that is the desired motor speed.
Limits	Limits are set on each loop to protect the motor and/or mechanical system.
Feedback	The nature of 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.



3.2.5 Current Mode and Current Loop

CURRENT LOOP DIAGRAM

As shown below, the "front end" of the current loop is 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 takes the limited current command, subtracts the actual current (represented by the feedback signal), and produces an error signal. This error signal is then processed using the integral and proportional gains to produce a command. This command is then applied to the drive's power stage.



CURRENT LOOP INPUTS

- The drive's analog or PWM inputs.
- A network command, EtherCAT, CAN, or RS-232 Serial.
- A CVM control program.
- 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
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 (p. 91). 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.

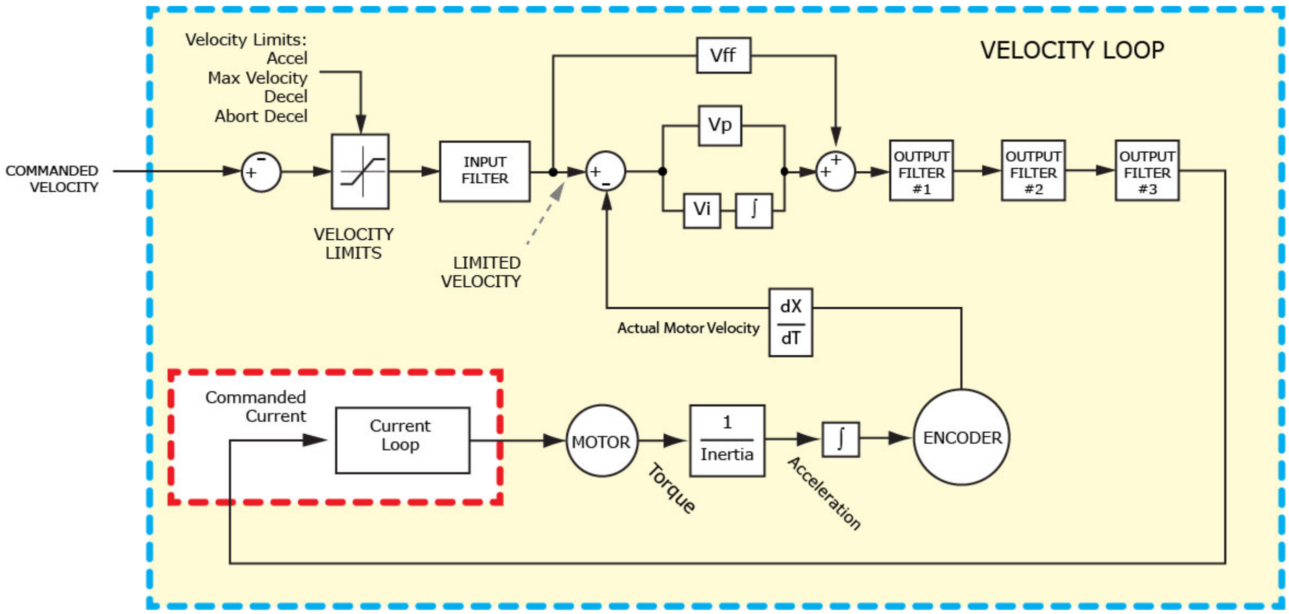
AUTO TUNE

CME 2 provides a current loop Auto Tune feature, which automatically determines the Cp and Ci values which result in a reasonable bandwidth for the motor.
For more information, see the *CME 2 User Guide*.

3.2.6 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 input filter. The filter then passes a velocity command to the summing junction. The summing junction subtracts the actual velocity, represented by the feedback signal, and produces an 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 error signal is then processed using the integral and proportional gains to produce a current command. Programmable digital filters are provided on both the input and output command signals.



INPUTS

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

- The drive's analog or PWM inputs.
- A network command, EtherCAT, CAN, or RS-232 Serial.
- A CVM control program.
- The drive's internal function generator.

In position mode, the velocity command is generated by the position loop.

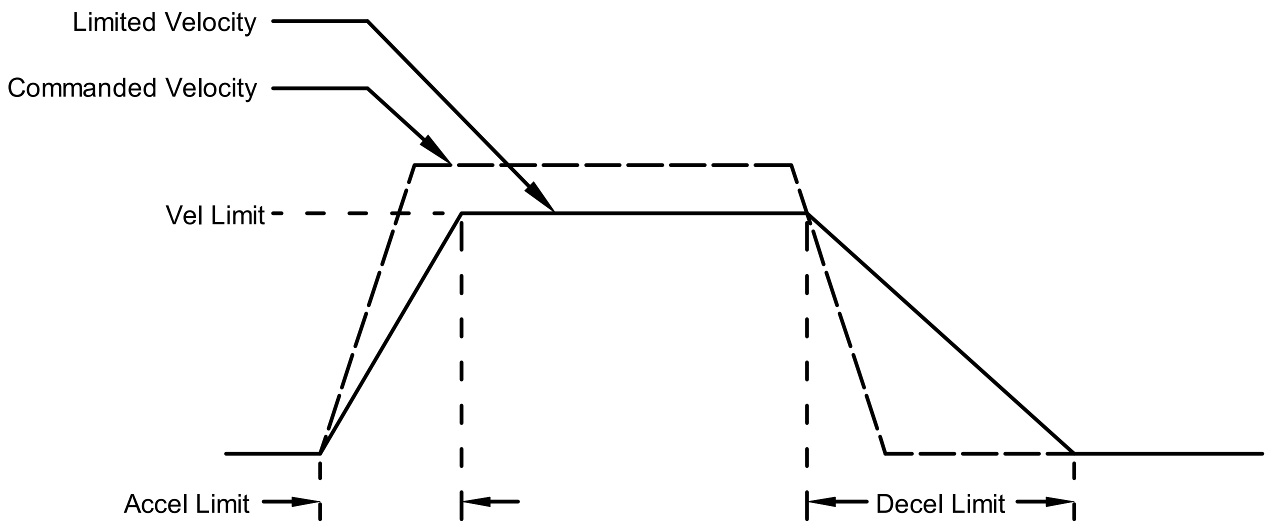
VELOCITY LOOP LIMITS

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 (p. 44).

DIAGRAM: EFFECTS OF LIMITS ON VELOCITY COMMAND

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



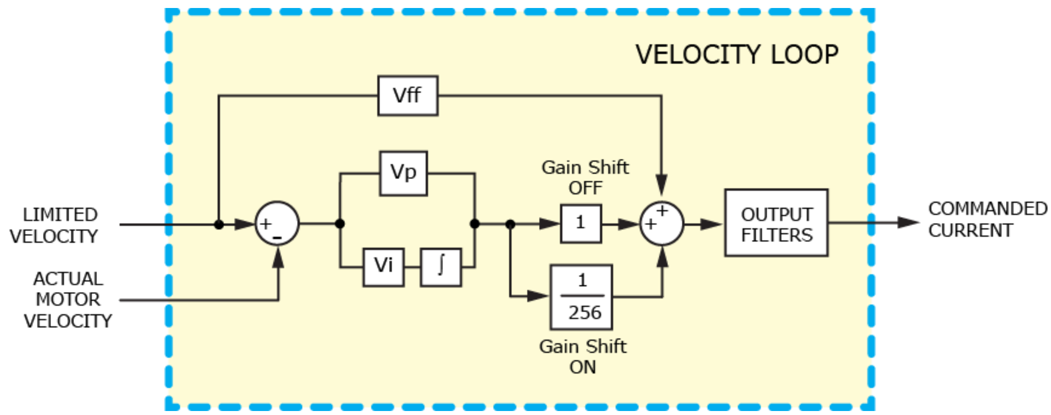
VELOCITY LOOP GAINS

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 two types of programmable digital filters. The input filter should be used to reduce the effects of a noisy velocity command signal. The output filters can be used to reduce the excitation of any resonance in the motion system.

Two filter classes 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 2 User Guide*.

VELOCITY LOOP OUTPUTS

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

3.2.7 Position Mode and Position Loop

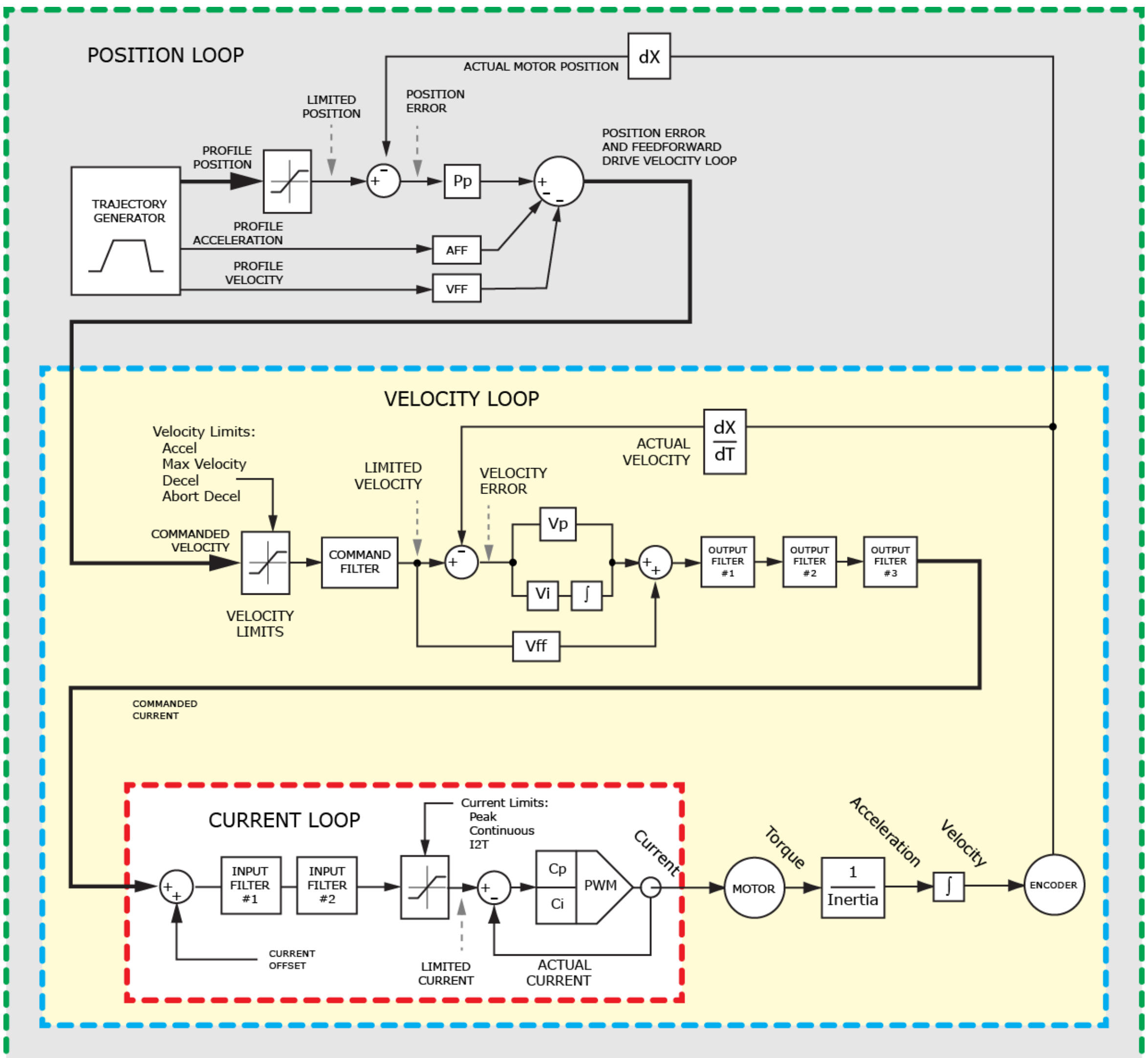
POSITION LOOP DIAGRAM

The drive receives position commands from the digital or analog command inputs, over the EtherCAT, CAN interface, RS-232-serial, 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 EtherCAT, CAN bus, RS-232 serial, 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 speed 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

Xenus Plus Compact supports two position feedback configurations

- Single sensor. Position loop feedback comes from the encoder on the motor.
- Dual sensor. Position loop feedback comes from the encoder attached to the load.

(Note that in either case, velocity loop feedback comes from the motor encoder.)
For more information, see Position Feedback (p. 18).

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 2 User Guide*.

3.3 Input Command Types

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

3.3.1 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

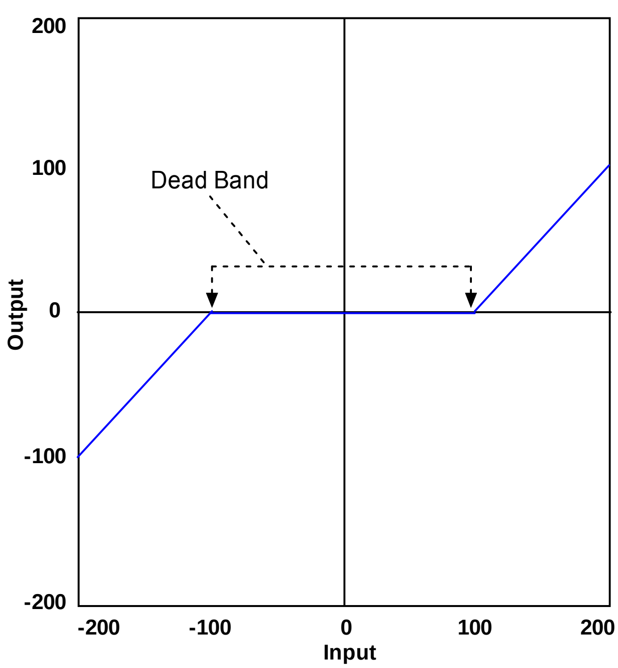
The magnitude of the command generated by an input signal is proportional to the input signal voltage. Scaling controls the input-to-command ratio, allowing the use of an optimal command range for any given input voltage signal range.

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 2 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 2 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 *Xenus Plus Compact* 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 EtherCAT, CAN, ASCII serial, or CVM Indexer program commands.

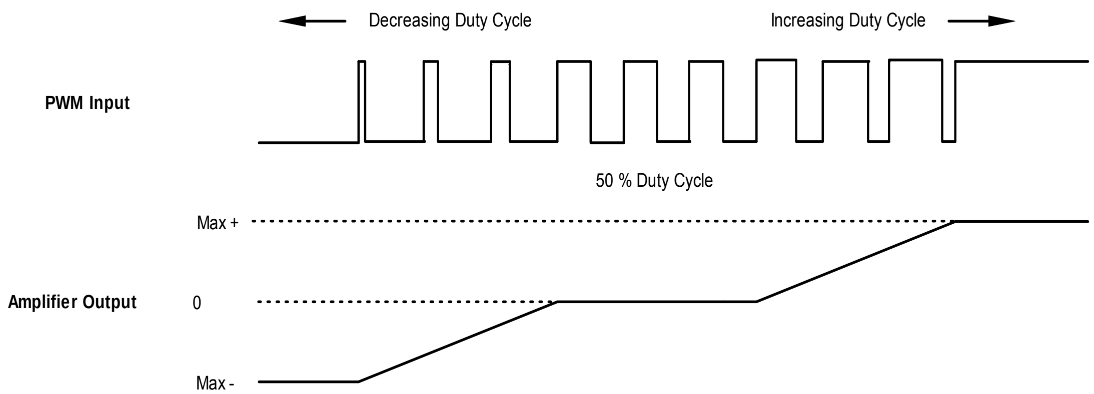
3.3.2 PWM INPUT

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)

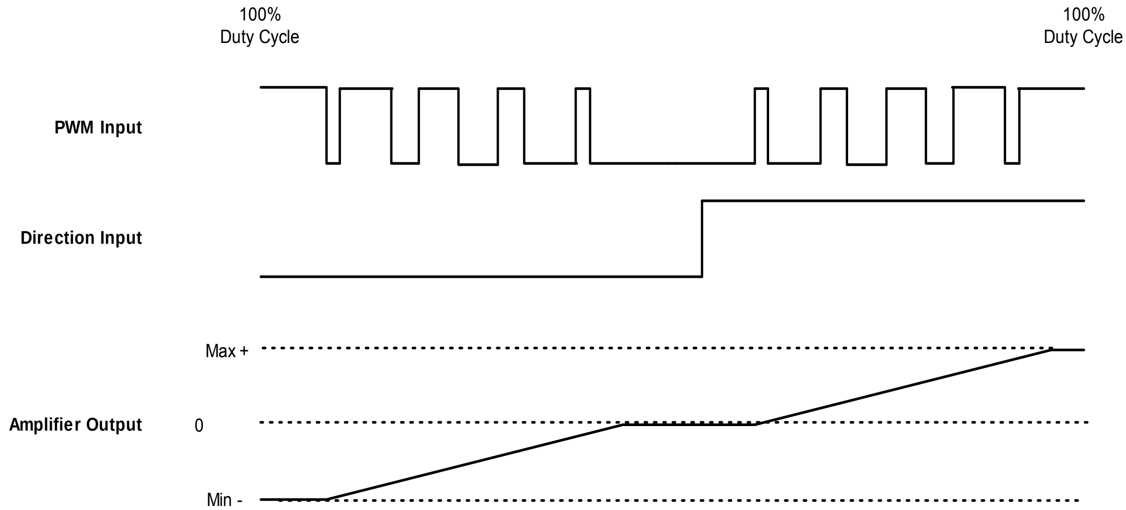
The input takes a PWM waveform of fixed frequency and variable duty cycle. As shown below, a 50% duty cycle produces zero output from the drive. Increasing the duty cycle toward 100% commands a positive output, and decreasing the duty cycle toward zero commands a negative output.



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.



FAILSAFE 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 provides a measure of safety in case of a controller failure or a cable break.

3.3.3 DIGITAL INPUT

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.

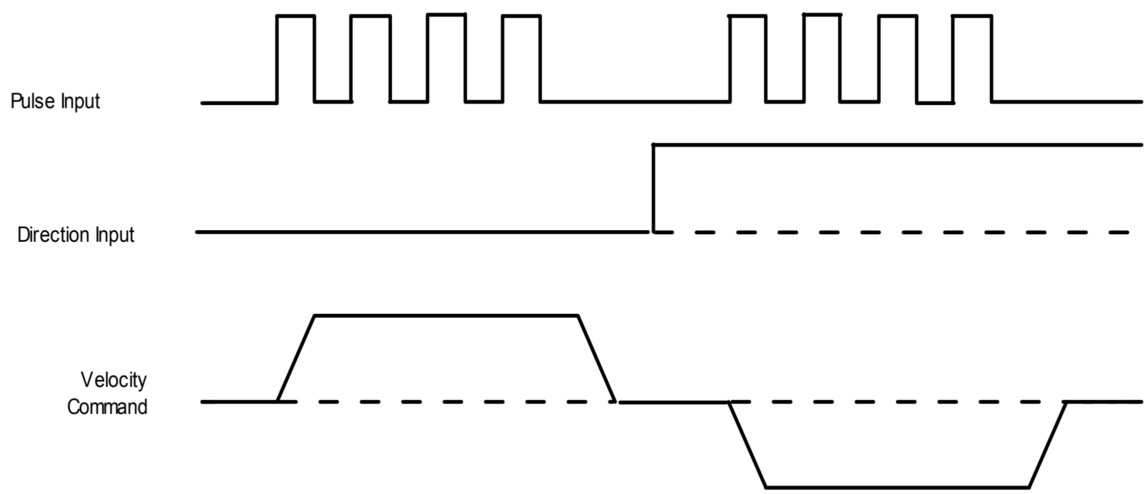
PULSE SMOOTHING

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 EtherCAT, CAN bus, serial bus, or CVM Control Program, setting Max Accel to zero prevents motion.)

PULSE AND DIRECTION FORMAT

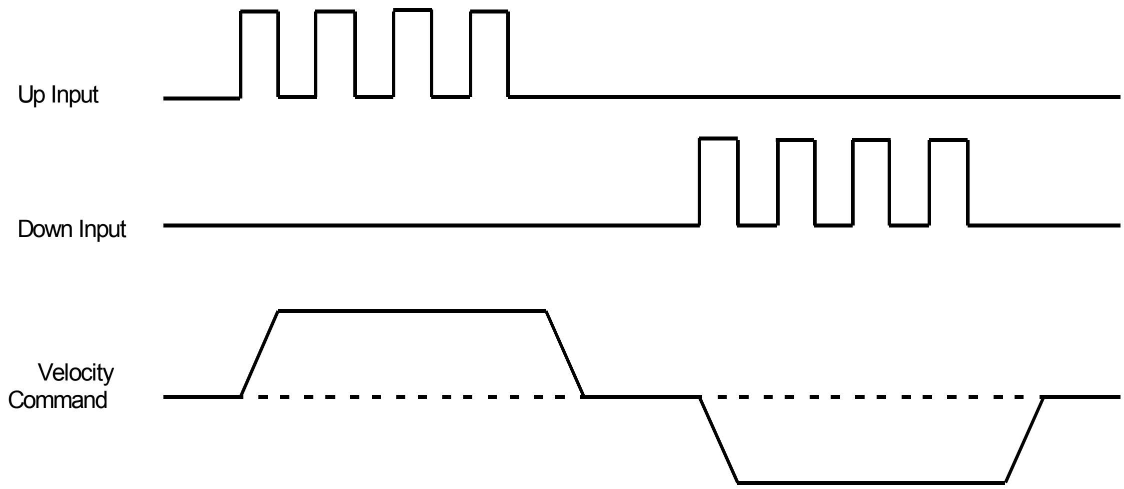
In pulse and direction format, one input takes a series of pulses as motion step commands, and another input takes a high or low signal as a direction command, as shown below.



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 FORMAT

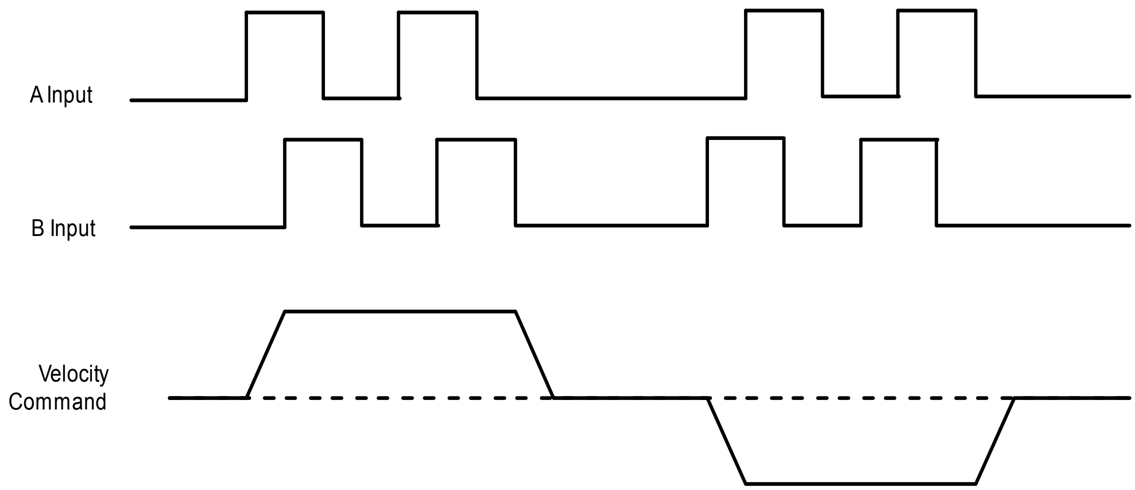
In the count up/count down format, one input takes each pulse as a positive step command, and another takes each pulse as a negative step command, as shown below.



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

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.

3.4 Communication

As described below, the drive features multiple communication interfaces, each used for different purposes.

Interface	Description
RS-232 port	The drive features a three-wire RS-232 port operating as a DTE device. Control commands can be sent over the RS-232 port using Copley Controls ASCII interface commands. In addition, CME 2 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. 60). For RS-232 port wiring instructions, see RS-232 Serial Communications (p. 77). Note that CME 2 should not be used to make adjustments when the drive is being controlled over the EtherCAT, or CAN interface
CAN interface (XPC)	When operating as a CAN node, the drive takes command inputs over a CANopen network. CAN communications are described in the next section.
EtherCAT (XEC, and 801-1891~1893)	XEC accepts CANopen application protocol over EtherCAT (CoE) commands over EtherCAT.

DANGER	**Using CME 2 can affect or suspend EtherCAT or CAN operations.**
	When operating the drive as an EtherCAT or CANopen node, use of CME 2 to change drive parameters can affect CANopen operations in progress. Using CME 2 to initiate motion can cause EtherCAT or CANopen operations to suspend. The operations may restart unexpectedly when the CME 2 move is stopped. **Failure to heed this warning can cause equipment damage, injury, or death.**

3.4.1 CAN Communication Details (XPC)

CAN NETWORK AND CANOPEN PROFILES FOR MOTION

In position mode, the XPC can take instructions over a two-wire Controller Area Network (CAN). CAN specifies the data link and physical connection layers of a fast, reliable network.

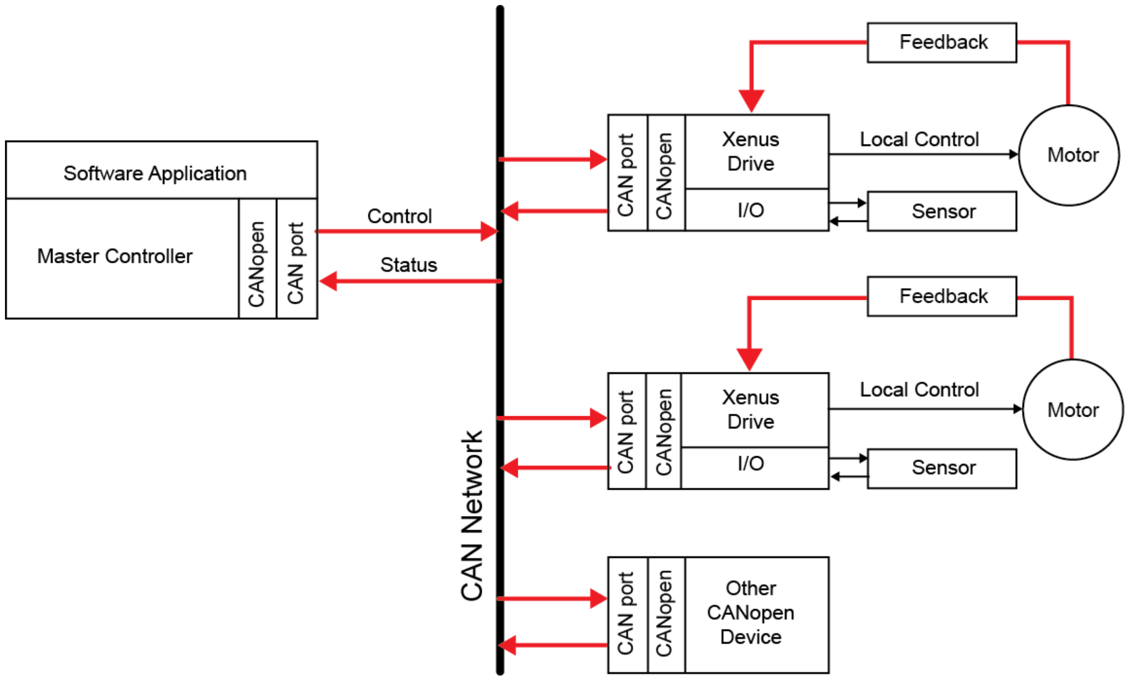
CANopen is a set of profiles (specifications) built on a subset of the CAN application layer protocol. These profiles specify how various types of devices, including motion control devices, can use the CAN network in a highly efficient manner. *Xenus Plus Compact* supports the relevant CANopen profiles, allowing it to operate in the following modes of operation: profile torque, profile velocity, profile position, 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 velocity, direction, acceleration, and deceleration values. 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 on 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 and should only be used when the drive is serving as a serial port multi-drop gateway.)

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

For more information on CAN addressing, see the *CME 2 User Guide*.

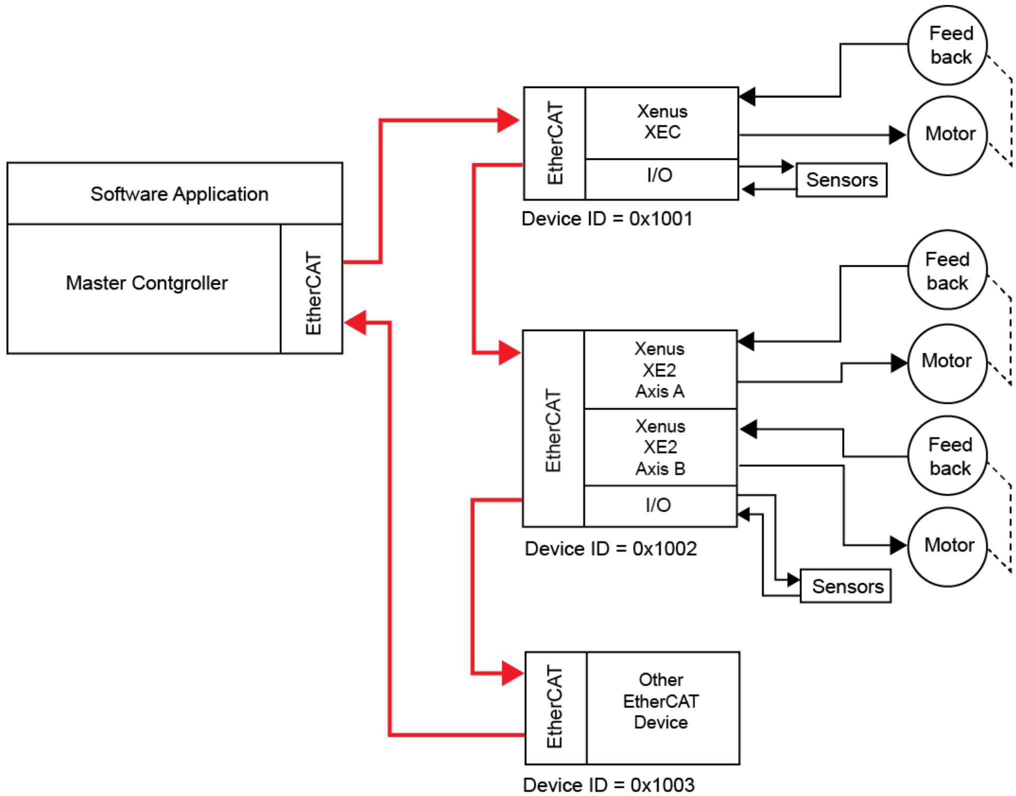
For more information on CANopen operations, see the following Copley Controls documents:

- *CANopen Programmer's Manual*
- *CML Reference Manual*
- *CMO Programmer's Guide*

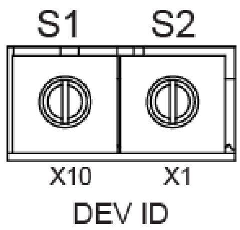
3.4.2 EtherCAT Communication Details (XEC, 801-1891~1893)

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

EtherCAT supports two types of addressing nodes on the network: auto-increment and fixed. Nodes on an EtherCAT network are automatically addressed by their physical position on the network. The first drive found on the network is 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.



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).
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.

3.4.3 PWM Switching Frequency Synchronizing

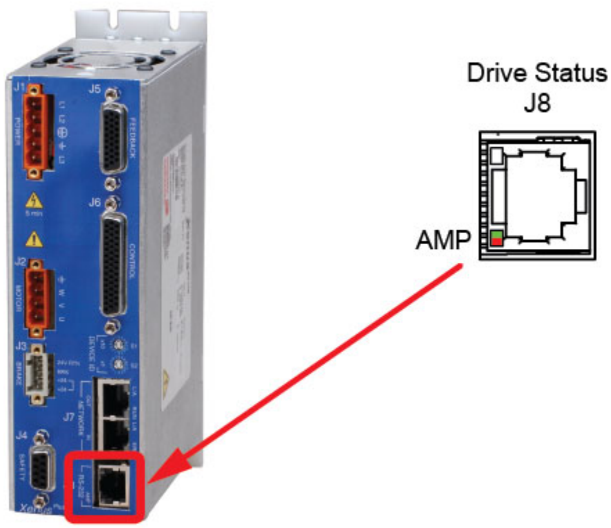
In some situations, such as sampling small analog signals, it is desirable to synchronize the PWM switching frequency among multiple drives. In these cases, one drive serves as a master for one or more slave drives.

The distributed clock feature of EtherCAT or the Time function in CANopen can be used to establish PWM switching frequency synchronization among the network connected drives.

Note that when the STO function is active, there is no PWM switching or current at the drive motor outputs. See Safe Torque Off (p. 41).

3.5 Status Indicators

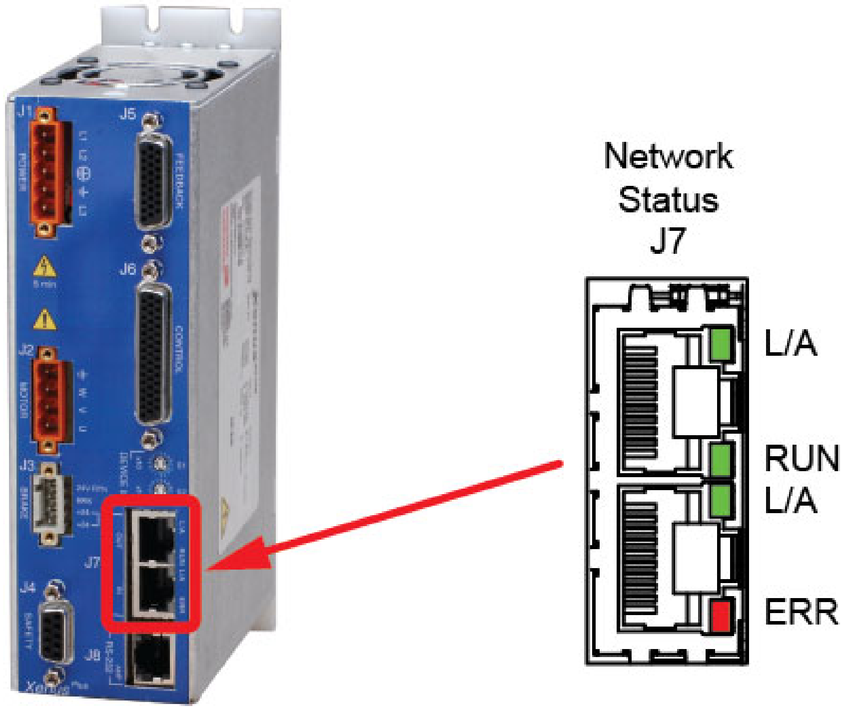
J8: Drive Status Indicator



Drive status indicator color/blink codes are described below.

Color/Blink Code	Meaning
Not illuminated	No +24 Vdc power to drive.
Steady green	Drive is enabled and operational.
Slow-blinking green	Drive is disabled. No faults or warnings are active.
Fast-blinking green	A limit switch is active. The drive is enabled.
Green flash twice followed by a pause	STO is active, One or both STO inputs are de-energized. The drive is hardware & software enabled but the PWM outputs cannot produce torque in the motor when STO is active.
Steady red	A non-latched fault has occurred.
Blinking red	A latched fault has occurred.

3.5.2 J7: EtherCAT Network Status Indicators



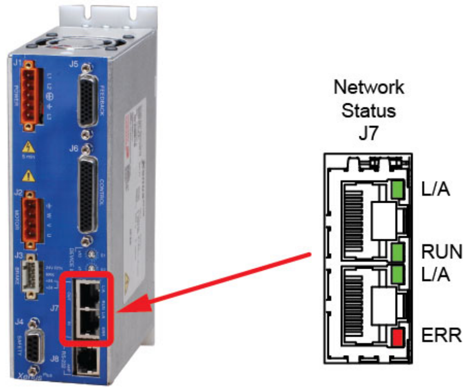
The color/blink codes of the EtherCAT indicators comply with ETG 1300 Indicator and Labeling Specification, and ETG 5003-1 Semiconductor Device Profile, Part 1 Common Device Profile.

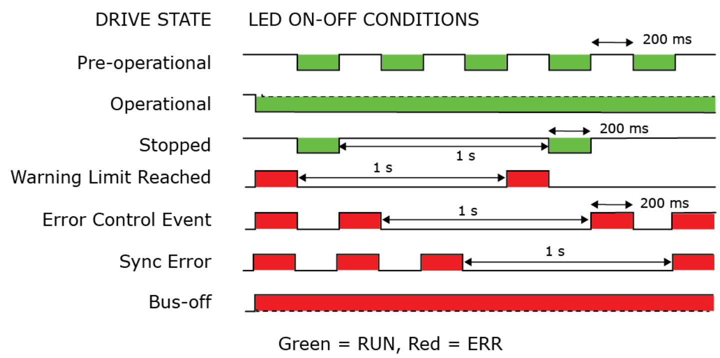
RUN	Green:	Shows the state of the ESM (EtherCAT State Machine)
Off	=	Init
Blinking	=	Pre-operational
Single-flash	=	Safe-operational
On	=	Operational

ERR	Red:	Shows errors such as watchdog timeouts and unsolicited state changes in the XEC due to local errors.
Off	=	EtherCAT communications are working correctly
Blinking	=	Invalid configuration, general configuration error
Single Flash	=	Local error, slave has changed EtherCAT state autonomously
Double Flash	=	PDO or EtherCAT watchdog timeout, or an application watchdog timeout has occurred

L/A	Green:	Activity	Condition
Off	=	(N/A)	Port Closed
Flickering	=	Yes	Port Open with activity
ON	=	No	Port Open

3.5.3 J7 CAN NETWORK STATUS INDICATORS





The color/blink codes of the NET indicators on J6 comply with CAN Indicator Specification CiA 303-3.The green RUN LED shows the CAN FSA state. The red ERR LED displays the type of errors. Note that green and red codes alternate, each indicating their own conditions.

The green L/A LEDs indicate the status and activity of the physical layer.
In addition, these are turned off when the CAN node ID selector (CAN ADDR) is set to 0.
A setting of 0, which is invalid for CAN slaves, shuts down most operations on the CAN interface, and the LEDs are shut off to indicate this status.

RUN	Green:	Shows the state of the FSA (Finite State Automaton)
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 drive due to local errors.
Off	=	CANopen communications are working correctly
Blinking	=	Invalid configuration, general configuration error
Single Flash	=	Local error, slave has changed CANopen state autonomously
Double Flash	=	PDO or CANopen watchdog timeout,or an application watchdog timeout has occurred

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

LED	Link	Activity	Condition
Off	No	(N/A)	Port Closed
Flickering	Yes	Yes	Port Open with activity
ON	Yes	No	Port Open

3.6 Protection

3.6.1 Safe Torque Off

All models provide a Safe Torque Off (STO) function. Two inputs are provided which, when de-energized, prevent 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 inputs 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.

The STO feature was developed in accordance with several functional safety standards and has both SIL and Category/Performance Level ratings. The design and development of the STO feature in these models is being submitted to UL for approval. Pending such approval the *Xenus Plus Compact* models will bear the UL Functional Safety mark. For more information on STO, see the *Xenus Plus Compact STO Manual*

3.6.2 Faults

OVERVIEW

The 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 2), and the status 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 (p.44)

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 (p.44)

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 Enables with Clear Faults or Enables with Reset
- Access the CME 2 Control Panel and press Clear Faults or Reset
- Clear the fault over the CANopen network or serial bus

EXAMPLE: NON-LATCHED VS. LATCHED FAULTS

For example, the drive temperature reaches the fault temperature level and the drive reports the fault and disables the PWM output. Then, the drive temperature is brought back into operating range. If the Drive Over Temperature fault is not latched, the fault is automatically cleared and the drive's PWM outputs are 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 (p.63)

Fault Description	Fault Occurs When…	Fault is Corrected When…
*Drive Over Temperature	Drive's internal temperature exceeds specified temperature.	Power module temperature falls below specified temperature.
Motor Phasing Error	Encoder-based phase angle does not agree with Hall switch states. This fault can occur only with brushless motors set up using sinusoidal commutation. It does not occur with Halls correction turned off.	Encoder-based phase angle agrees with Hall switch states.
*Feedback error	Over current condition detected on the output of the internal +5 Vdc supply used to power the feedback. Analog encoder not connected or signal levels out of tolerance.	Encoder power returns to specified voltage range. Feedback signals stay within specified levels.
*Motor Over Temperature	Motor over-temperature switch changes state to indicate an over-temperature condition.	Temperature switch changes back to normal operating state.
Under Voltage	Bus voltage falls below specified voltage limit.	+ DC bus voltage returns to specified voltage range.
Over Voltage	Bus voltage exceeds specified voltage limit.	+ DC bus voltage returns to specified voltage range.
*Following Error	User set following error threshold exceeded.	See Position and Velocity Errors (p. 43).
*Short Circuit Detected	Output to output, output to ground, internal PWM bridge fault.	Short circuit has been removed.
** Over Current (Latched)	Output current I^2T limit has been exceeded.	Drive is reset and re-enabled.
*Latched by default.		
** Non-latched by default. Selectable to be latching.		

3.7 Position and Velocity Errors

3.7.1 Error-Handling Methods

In position mode, any difference between the limited position output of the trajectory generator and the actual motor position is a position 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.)

3.7.2 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 (p.44).

3.7.3 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 the CAN network. It can also be used to activate a digital output.

3.7.4 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 (p. 45).

3.7.5 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.

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 +24 Vdc to the drive
- Cycle (disable and then enable) an enable input that is configured as Enables with Clear Faults or Enables with Reset
-  Access the CME 2 Control Panel and press Clear Faults or Reset
- Clear the fault over the EtherCAT or CANopen network, or serial bus

3.7.6 Tracking Window Details

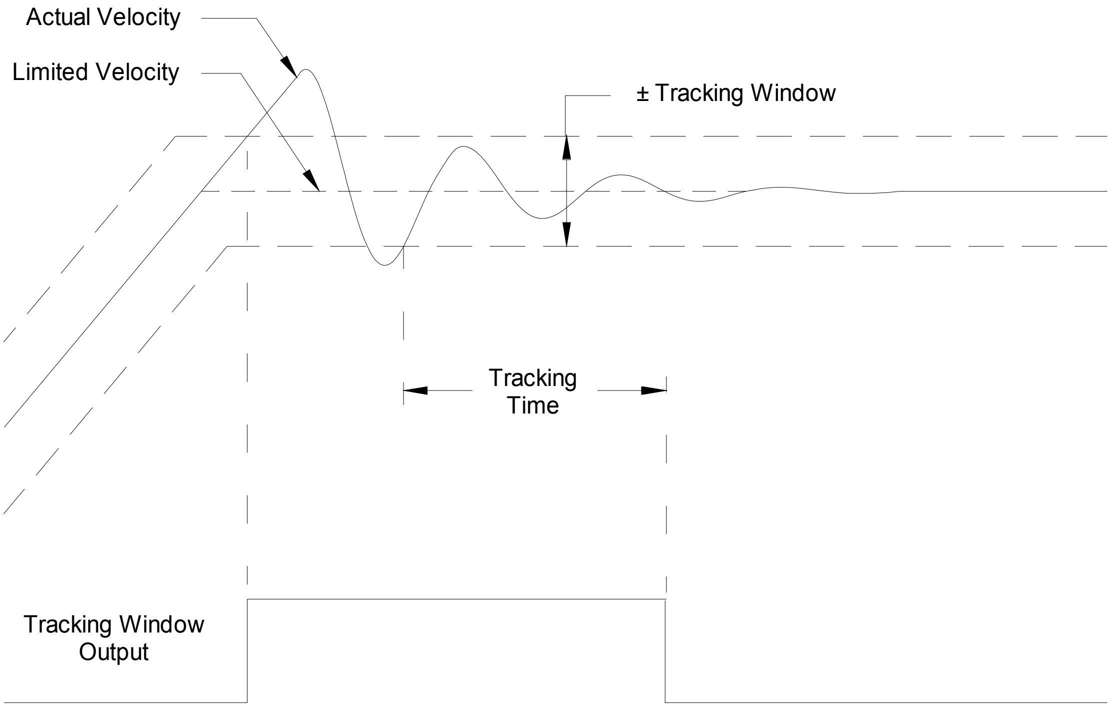
PROPER TRACKING OVER TIME

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.



3.8 Inputs

The *Xenus Plus Compact* drives have 11 digital inputs and 1 analog input.

3.8.1 DIGITAL INPUTS

IN1 & IN2 are Schmitt trigger single ended inputs with programmable pull-up/down to +5 Vdc/ground and 1.5 µs RC filters (24 Vdc compatible). IN3~IN4 and IN5~IN6 are programmable as four single ended or two differential inputs. IN7~IN10 are single ended opto-isolated inputs with a common terminal for each group that can connect to ground or +24 Vdc to work with current-sourcing or current-sinking outputs from a control system.
IN1~IN10 are found on the Control connector J6.
IN11 is for a motor overtemp switch and has a fixed pull-up to +5 Vdc and 330 µs RC filter to a Schmitt trigger. This is found on the feedback connector J5.

For a list of input functions, see the *CME 2 User Guide*.

INPUT FILTERS

Two types of input RC filters are used: GP (general-purpose) and HS (high-speed). Input reference functions such as Pulse and Direction, Pulse Up/Pulse Down, and Quadrature A/B are wired to inputs that have the HS filters, and inputs with the GP filters are used for general-purpose logic functions, limit switches, and the motor temperature sensor. Inputs IN3~IN6 are HS.
IN1~IN2, IN7~IN10, and IN11 are GP types.

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 PULL UP/PULL DOWN RESISTORS

Inputs IN1~IN6 are individually programmable to switch the 15k resistor to either +5V or Signal Ground. The default setting is pull-up to +5V.

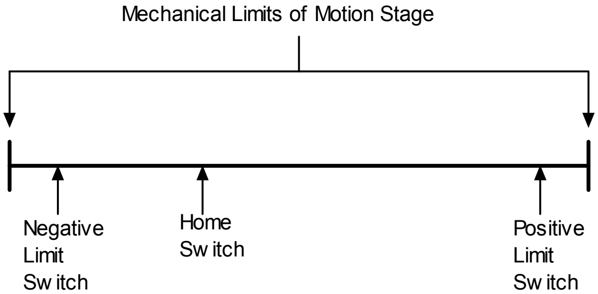
3.8.2 Limit Switches

USE DIGITAL INPUTS TO CONNECT LIMIT SWITCHES

Limit switches help protect the motion system from unintended travel to the mechanical limits.
In the *Xenus Plus Compact* models, any of the digital inputs 1-11, can be can be programmed as positive limit, negative limit, or Home switches.

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 2 Control Panel and CME 2 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 2 Control Panel and CME 2 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 2 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 2 User Guide*.

3.8.2 Analog Input

One programmable differential analog input, AIN1 is connected on J6. As a reference input this can take position/velocity/torque commands from a controller. If not used as command input, this can be used as general-purpose analog input. The input voltage range is ±10V.

3.9 Outputs

The *Xenus Plus Compact* drives have 5 programmable digital outputs. OUT1~3 are general-purpose isolated 2-terminal outputs. OUT4 is a non-isolated, high-speed buffer. OUT5 is specifically designed as a brake output but can be programmed for other functions. For a list of digital output functions, see Control I/O (p. 83)

OUT1~OUT4 are on J6. OUT5 (Brake) is on J3.

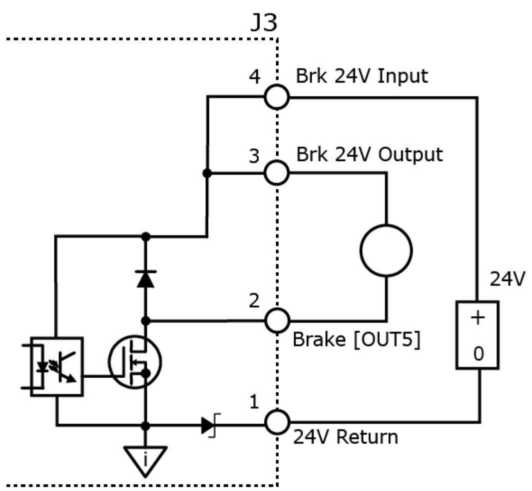
OUT1~3 are isolated, two-terminal MOSFETs with a 30 Vdc maximum output. If the source (-) terminal is grounded, they become current sinking outputs. If the drain (+) terminal is connected to +24V, then they are current sourcing outputs driving grounded loads. Zener clamping diodes across outputs allow driving of resistive-inductive (R-L) loads without external flyback diodes. The output current rating is 300 mA.

OUT4 is a 5V high speed buffered CMOS output.

3.9.1 Brake Operation

DIGITAL OUTPUT CONTROLS BRAKE

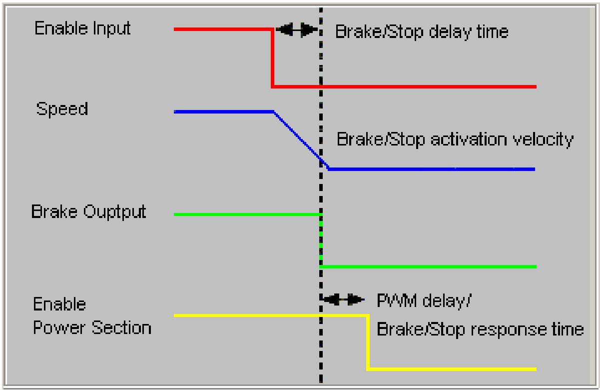
Many control systems employ a brake to hold the axis when the drive is disabled. *Xenus Plus Compact* drives have a digital output designed specifically for brake control. Unlike the other outputs, the brake output is optically isolated from the control signals and has an internal fly back diode connected to the +24 Vdc input. By eliminating the need to connect into the drive control connector, having the brake output on the +24 Vdc power connector simplifies wiring when the brake wires are in the power cable of the motor.



For more information, see (p. 77).

BRAKE/STOP SEQUENCES

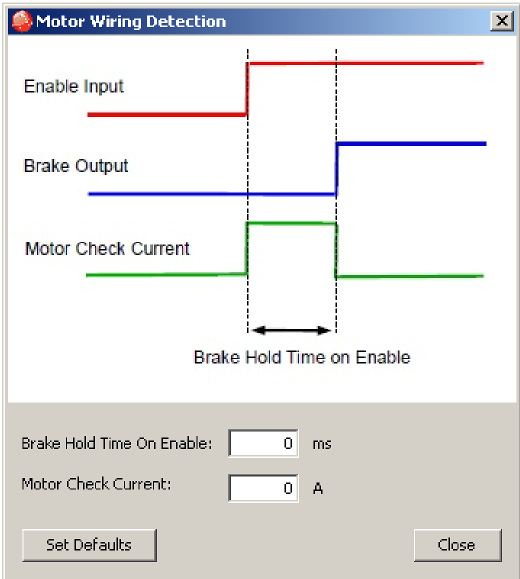
- Disabling the drive by a hardware or software command starts the following sequence of events.
- The motor begins to decelerate (at Abort Deceleration rate in position mode or Fast Stop Ramp rate in velocity mode). At the same time, the Brake/Stop Delay Time count begins. This allows the drive to slow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



This sequence is not available in the current mode of operation. Instead, in current mode, the drive output turns off and the brake output activates immediately when the disable command is received.

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.



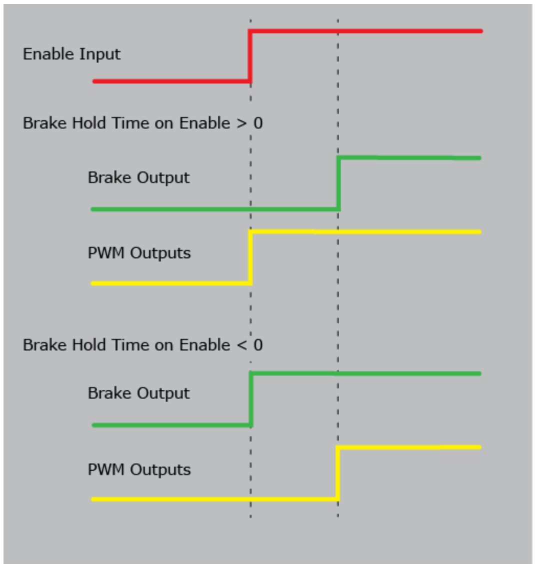
MOTOR BRAKE ENABLE DELAY TIME

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 CME2, but shows the timings in the same colors as the Brake setting screen.



3.10 Regen Resistor Theory

3.10.1 Regeneration

When a load is accelerated, electrical energy is converted into mechanical energy. During deceleration the conversion is reversed. This is called regeneration. Some of this regenerated energy is lost to friction in the mechanical system. More of this energy is converted to heat due to I2R losses in the motor windings, cabling, and drive electronics. The remainder of the energy is added to the electrical energy already stored in the internal capacitor bank of the drive. The result of this energy being added is an increase in the voltage on the capacitor bank.

3.10.2 Regen Circuit Protections

The drive protects the regen circuit against short circuit, and uses I^2T peak current/time algorithms to protect both the internal resistor and transistor.

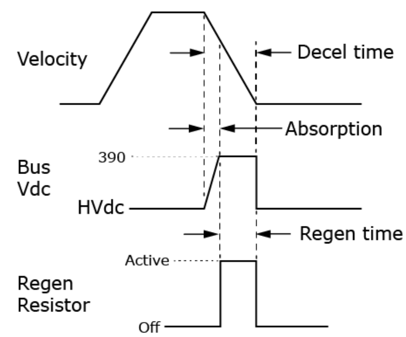
3.10.3 OPERATION

The *Xenus Plus Compact* drives have an internal regen resistor which can dissipate regenerative energy that exceeds the absorption capacity of the internal bus capacitance. The regen resistor will be switched on when the energy shown in the table has been absorbed and the bus voltage driven up to 390 Vdc at which point the regen resistor will be switched OFF/ON to dissipate the kinetic energy of the load.

Absorption	
Vac	*E*
100	62
120	58
200	34
240	17

Absorption is the energy that can be transferred to the internal capacitors during deceleration. This table shows the energy absorption in W·s (Joules) for a drive operating at some typical mains voltages. The capacitor bank is 940 uF. If the deceleration energy is less than the absorption capacity of the drive, then the regeneration resistor will not be used because the bus voltage will not rise enough to hit the over-voltage level that would disable the PWM outputs.

E	Energy	Joules, Watt·seconds
J	Rotary Moment of Inertia	$kg \cdot m^2$
P	Power	Watts



Step 1: Find the energy of motion for a rotating load, for this example let it be 75 Joules:

$E = J * RPM^2 / 182 = 75 J$

Step 2: Subtract the absorption at your mains voltage to get the energy that must be dissipated in the regen resistor during the Regen Time. Use 240 Vac:

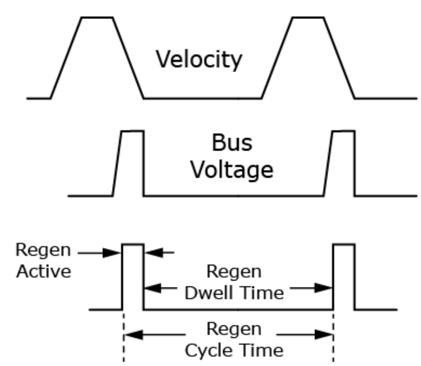
75J - 17J = 58 J

Step 3: Divide the regen energy by the continuous power rating of 20 Watts to get the regen cycle time that can dissipate the energy in the resistor:

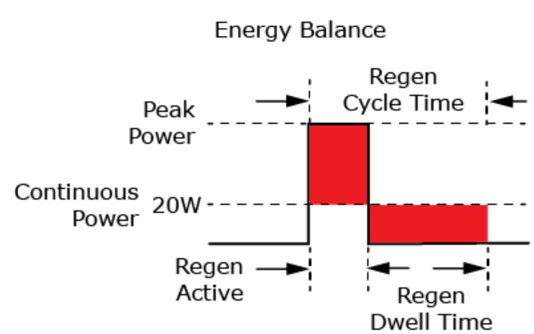
Cycle Time = 58 Joules / 20 Watts = 2.9 sec

Step 4: Find the dwell time by subtracting the deceleration time from the cycle time:

Cycle Time = 2.9 sec
Regen Time = 1.25 sec
Dwell Time = 1.65 sec



Internal Regen Resistor Ratings	
Max Energy	248 W·s (J)
Resistance	60 Ω
Power, continuous	20 W
Power, peak	2500 W
Time	100 ms



4 SPECIFICATIONS

This chapter describes the drive specifications. Contents include:

4.1 Agency Approvals

- CE Compliant
- UL Compliant
- RoHS Compliant

Specification	Requirement
UL	UL 61800-5-1-2012 Adjustable Sspeed Electric Power Drive Systems - Part 5-1: Safety Requirements – Electrical, Thermal, and Energy (File No. E168959)
Functional Safety	IEC 61800-5-2:2007 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 of Design IEC 61508-1:2010 Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 1: General requirements IEC 61508-2: 2010 Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 2: Requirements for electrical/electronic/programmable electronic safety related systems
Product Safety	IEC 61800-5-1:2007 Adjustable Speed Electric Power Drive Systems - Part 5-1: Safety Requirements – Electrical, Thermal, and Energy
EMC	IEC 61800-3:2004/A1: 2011, Adjustable Speed Electric Power Drive Systems Part 3: EMC Requirements and Specific Test Methods. Category 3 PDS
Markings	• UL recognized component (Canada and US) • CE • UL Functional Safety <pending>
Hazardous Substances	Lead free and RoHS compliant

*CE Declaration of Conformity available at
http://www.copleycontrols.com/Motion/Downloads/xenusData.html

4.2 Power Input

Model	XEC-230-09(-R) XPC-230-09(-R) 801-1891	XEC-230-12(-R) XPC-230-12(-R) 801-1892	XEC-230-15(-R) XPC-230-15(-R) 801-1893
Mains Voltage	100 - 240 Vac, 1 Ø or 3 Ø, 47 - 60 Hz		
Max Mains Current, 1Ø*	4.7 Arms	9.4 Arms	11.8 Arms
Max Mains Current, 3Ø*	2.6 Arms	5.2 Arms	6.5 Arms
Current Inrush	15 A peak at 120 Vac, 35 A peak at 240 Vac		
Mains Supply Short Circuit Current Rating (SCCR)	25 kArms maximum		
Logic Supply Voltage	+20 to +32 Vdc		
Logic Supply Current	320 mA typ, with no +5V output current 750 mA max, with both +5V outputs @ 500 mA		

*The actual mains current is dependent on the mains voltage, number of phases, and motor load and operating conditions. The Maximum Mains 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.

4.3 Power Output

Model	XEC-230-09(-R) XPC-230-09(-R) 801-1891	XEC-230-12(-R) XPC-230-12(-R) 801-1892	XEC-230-15(-R) XPC-230-15(-R) 801-1893
Peak Current, Adc(RMS)	9 (6.4)	12 (8.5)	15 (10.6)
Peak Current Time	1 second		
Continuous Current, Adc(RMS)	3 (2.12)	6 (4.24)	7.5 (5.3)
Efficiency	>97% @ 230 Vac and rated continuous current		
Output Type	3-phase IGBT inverter 16 kHz center-weighted PWM space-vector modulation		
PWM Ripple Frequency	32 kHz		
Minimum Load Inductance	400 uH line-to-line Consult factory for operation with inductance lower than 400 uH		
Capacitor Discharge	Wait 5 minutes after disconnecting mains power before handling		

4.4 Control Loops

Type: Current Velocity Position	100% digital.
Sampling rate (time): Current Velocity Position	 16 kHz (62.5 µs) 4 kHz (250 µs) 4 kHz (250 µs)
Current Loop Small Signal Bandwidth	> 2 kHz (Tuning and load impedance dependent)
Loop Filters	Programmable Velocity loop output filter default: 200 Hz low pass.
Bus Voltage Compensation	Changes in bus or mains voltage do not affect tuning.

4.5 Internal Regeneration

Internal Regen Resistor Ratings	
Max Energy	248 W·s (J)
Resistance	60 Ω
Power, continuous	20 W
Power, peak	2500 W
Time	100 mS

4.6 Digital Command Inputs

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

4.7 Analog Inputs

Channels	1
Type	Differential, non-isolated
Measurement Range	±10 Vdc
Maximum Voltage Differential Input 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

4.8 Digital Inputs

Input	IN1~IN2	IN3~IN6	IN7~IN10	IN11
Type	Schmitt trigger w/ RC filter, 24Vdc max	Non-isolated line receiver w/ RC filter, programmable as 4 single-ended (SE) or 2 differential (DIFF)	Opto-isolated, bi-polar, with common terminal	Schmitt trigger w/ RC filter, 24Vdc max
Input Voltage Range	0~24 Vdc	0-12Vdc	±15 - 30 Vdc	0~24 Vdc
Logic Low Input Voltage	VT- ≤ 1.13 Vdc	<= +2.3 Vdc SE ≤ 200 mVdc DIFF	N/A	VT- ≤ 1.13 Vdc
Logic High Input Voltage	Vt+ ≥ 3.15 Vdc	>= +2.7 Vdc SE ≥ 200 mVdc DIFF	N/A	Vt+ ≥ 3.15 Vdc
Hysteresis		VH = 45 mV typ SE and DIFFF	N/A	
Scan Time	250 µs			
Debounce Type Time	Digital Programmable 0 - 10,000 ms			
Functions	IN1 Programmable Default as Enable IN2 programmable	Note: Inputs 3~4 and 5~6 can be programmed to function as differential pairs as digital command inputs.	General purpose Programmable	Motemp Default as Motor overtemp sensor input Programmable

4.9 Digital Outputs

Output	OUT1~OUT 3	OUT4	OUT5
Type	Two-terminal MOSFET with flyback Xener diode for driving inductive loads	High-speed 5Vdc CMOS buffer	Opto-isolated motor brake control, current-sinking with flyback diode to +24V
Maximum Voltage	+30 Vdc	5Vdc	+30 Vdc
Maximum Sink Current	300 mAdc	+/- 8 mA	1 Adc
Low Level Output Resistance	Internal 1 Ω resistor in series with MOSFET drain terminal.	Not applicable	0.14 Ω
Function	Programmable		Brake & Programmable

4.10 Encoder Power Outputs

Number	2
Voltage Output	+5 Vdc ±2%
Maximum Current Output	500 mA each output, total 1000 mA.
Protection	Thermal and overload protected
Function	Provides power for motor encoder and/or Hall switches.

4.11 Primary Digital Incremental Encoder Inputs

Channels	3
Type	MAX3097 differential line receiver. Non-isolated
Signals	A, /A, B, /B, X, /X
Input Voltage Range	±7 Vdc
Differential Input Threshold	±0.2 Vdc
Termination Resistance	121 Ω
Maximum Frequency	5 MHz Line (20 Mcount/sec)
Function	Motor position feedback for sinusoidal commutation and velocity feedback when load position feedback is connected through Multi-Port..

4.12 Primary Analog Incremental Encoder Inputs

Channels	2
Type	Differential, non-isolated
Signals	Sin(+), Sin(-), Cos(+), Cos(-)
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 counts per sin/cos cycle, programmable
Function	Motor position feedback for sinusoidal commutation and velocity feedback when load position feedback is connected through Multi-Port.

4.13 Hall Sensor Inputs

Channels	3
Type	Single-ended, non-isolated, 10 kΩ pull-up to +5 Vdc
Signals	Hall U, Hall V, Hall W, 120 degree phasing
Input Voltage Range	0 Vdc - +24 Vdc
Low Level Input Voltage	VT- = 1.3~2.2 Vdc
High Level Input Voltage	Vt+ = 2.5~3.5 Vdc
Hysteresis	VH = 0.7~1.5 Vdc
RC Filter Time Constant	1 µs when driven by active sources.
Function	Commutation of brushless motors in trapezoidal mode. Velocity feedback Commutation initialization and phasing error detection in sinusoidal mode.

4.14 Resolver Interface (XEC-R)

Channels	3
Type	Brushless 2-phase resolver, 1:1 to 2:1 transformation ratio
Signals	Ref(+), Ref(-), Sin(+) S3, Sin(-) S1, Cos(+) S2, Cos(-) S4
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	Single-speed resolvers provide absolute feedback of motor position.

4.15 Resolver Interface (801-1891, 801-1892, 801-1893)

Contact Copley Controls for details.

4.16 Multi-Mode Port

Channels	4
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	A/B channels: none, X channel 130 Ω, S channel 221 Ω 1 kΩ pull-up to +5V on X, 1 kΩ pull-down to ground on /X
Programmable Functions	Output Mode Buffered primary incremental encoder Emulated incremental A/B encoder from analog encoders, resolvers or absolute encoders Input Mode Secondary position input from digital incremental or absolute encoders. Current / Velocity mode, PWM input Position Mode, Digital command input
Maximum Frequency	
Output Mode	
Buffered Encoder	5 MHz Line (20 Mcount/sec)
Emulated Encoder	4.5 MHz Line (18 Mcount/sec)
Input Mode	
PWM Input	100 kHz
Digital Command	5 MHz (50% Duty Cycle)
Secondary Encoder	5 MHz Line (20 Mcount/sec)

4.17 RS-232 Serial Interface

Channels	1
Type	RS-232, DTE
Signals	Rxd, Txd, Gnd
Baud Rate	9,600 to 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

4.18 Network Interfaces

ETHERCAT

Model	XEC
Channels	1
Connectors	2 eight-position (RJ-45 style).
Signals	100BASE-TX
Format	EtherCAT
Protocol	CANopen application protocol over EtherCAT (CoE) based on CiA® 402 CANopen device profile for drives and motion control.
Supported Modes	Cyclic Synchronous Position/Velocity/Torque (CSP/CSV/CST) and Cyclic Synchronous Torque with Commutation Angle (CSTCA) Profile Position/Velocity/Torque.
Node Address Selection	Slaves are automatically assigned addresses based on their position in the bus. Two 16-position hexadecimal rotary switches can be used to define a cabling-independent Station Alias.
Bus Termination	No termination required.
Function	Real-time motion control

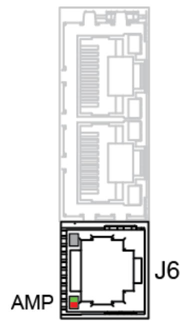
CAN

Model	XPC
Channels	1
Connectors	2 eight-position (RJ-45 style).
Signals	CAN_HI, CAN_LO, CAN_GND
Format	CiA® 402 CANopen device profile for drives and motion control
Supported Modes	Profile Position/Velocity/Torque, Interpolated Position, Homing
Node Address Selection	Two 16-position hexadecimal rotary switches can be used to set the node address.

4.19 EtherCAT Drive State Indicator

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

1) Red/Blinking = Latching fault. Operation will not resume until drive is Reset.
2) Red/Solid = Transient fault condition. Drive will resume operation when the condition causing the fault is removed.
3) Green/Double-Blinking = STO circuit active, drive outputs are Safe-Torque-Off
4) Green/Slow-Blinking = Drive OK but NOT-enabled. Will run when enabled.
5) Green/Fast-Blinking = Positive or Negative limit switch active. Drive will only move in direction not inhibited by limit switch.
7) Green/Solid = Drive OK and enabled. Will run in response to reference inputs or EtherCAT commands.



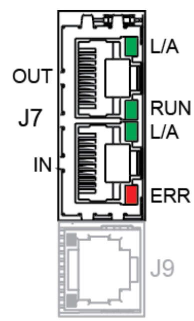
Latching Faults

Default
- 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 Lost
- Motor Wiring Disconnected
- STO Active
- Over Current (latched)

4.19.1 EtherCAT Network State Indicator

EtherCAT LEDs (ON RJ-45 connectors)



L/A	Green	Indicates the state of the EtherCAT network:	
LED	Link	Activity	Condition
ON	Yes	No	Port Open
Flickering	Yes	Yes	Port Open with activity
Off	No	(N/A)	Port Closed

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 XEC 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

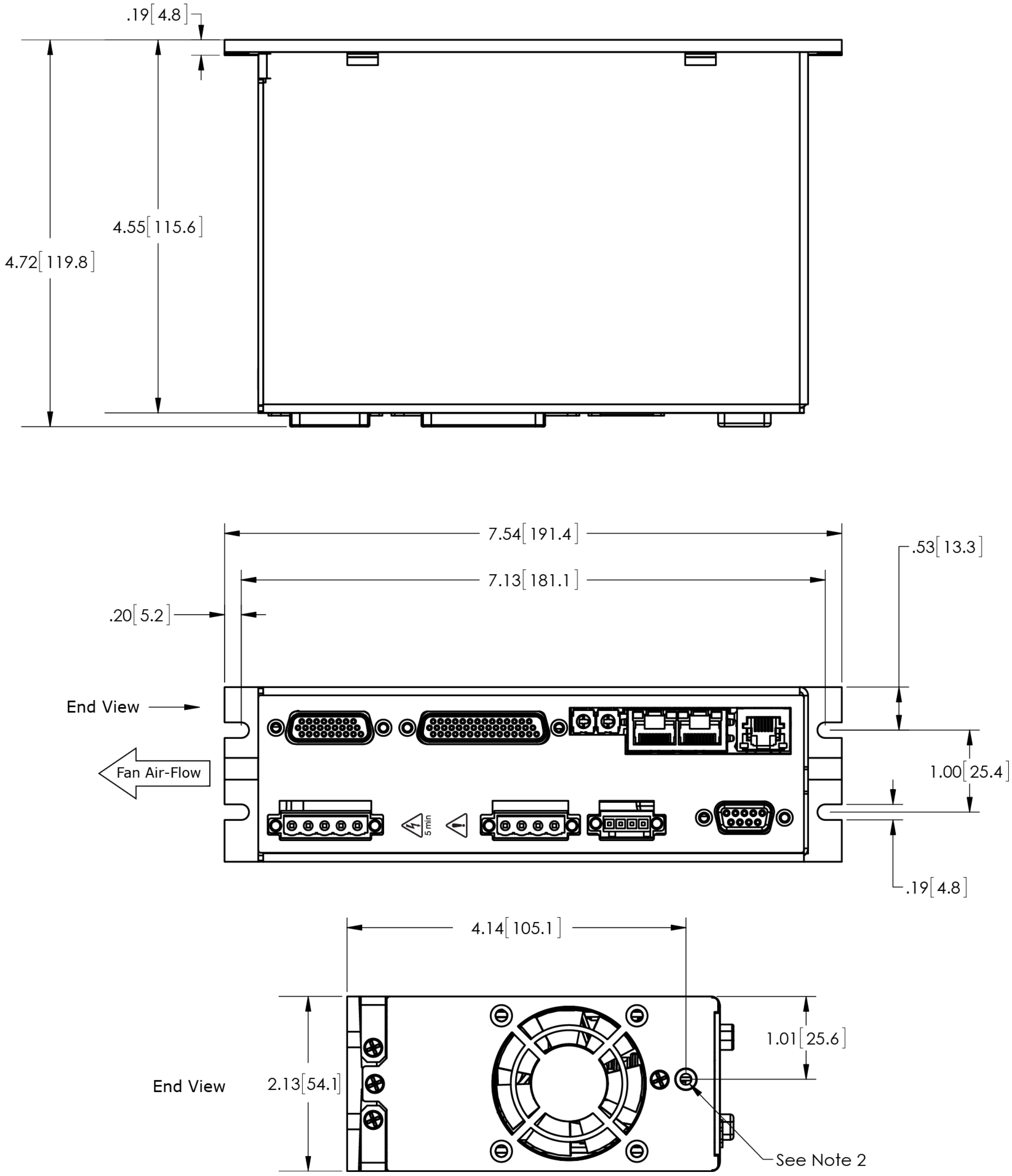
4.20 Fault Conditions

Over Temperature	IGBT > 80 °C ±3ºC
DC Bus Under Voltage	< +60 Vdc
DC Bus Over Voltage	> +400 Vdc
Encoder Power	< +4.25 Vdc
AC Loss Detection	Loss of mains voltage between L1 & L2 pins of J1
Short Circuits	Motor: Output to output, output to ground Internal: PWM bridge faults
Motor Over-temperature	IN11 programmable for Motemp function. Configurable as latching or non-latching fault
Feedback Loss	Programmable to detect loss of A OR B channels, or of A OR B OR X channels.
Command Signal Loss	EtherCAT: network cable unplugged, or master stops cyclical updates Programmable as latching or non-latching fault

4.21 4.21 Mechanical and Environmental

Size	7.54 in (191.4 mm) X 4.55 in (115.6 mm) X 2.13 in (54.1 mm)
Weight	2.2 lb (1.0 kg)
Ambient Temperature Storage Operating	 -40 to +85°C 0 to +45 °C
Altitude	≤ 2000 m per IEC 60068-2-13:1983 or ≤ 4000 m if an isolation transformer is used to establish an OVC II environment.
Humidity	0% to 95%, non-condensing
Contaminants	Pollution degree 2
Vibration	2 *g* peak, 10~500 Hz (sine), IEC60068-2-6
Shock	10 *g*, 10 ms, half-sine pulse, IEC60068-2-27
Cooling	Internal fan allows operation at rated continuous current to 45 ºC ambient

4.22 Dimensions



Notes:
1) Recommended screws for mounting slots: #8-32 or M4 external tooth SEMS
2) Cable shield grounding socket: #8-32 external tooth SEMS

5 WIRING

This chapter describes the wiring of drive and motor connections. Contents include:

5.1 General Wiring Instructions

5.1.1 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. **Failure to heed this warning can cause equipment damage, injury, or death.**
DANGER	**Risk of electric shock.** High-voltage circuits connected to mains power. *Xenus Plus Compact* — J1, J2 **Failure to heed this warning can cause equipment damage, injury, or death.**
DANGER	**Refer to the *Xenus Plus Compact STO Manual*** The information provided in the *Xenus Plus Compact STO User Manual* must be considered for any application using the *Xenus Plus Compact* 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 24Vdc and/or mains power applied is not recommended. **Failure to heed this warning may cause equipment damage.**
WARNING	**Do not ground mains-connected circuits.** Do not ground *Xenus Plus Compact* Mains connected circuits: J1, J2. **Failure to heed this warning can cause equipment damage.**
WARNING	**Risk of Radio Frequency Interference** The *Xenus Plus Compact* drives are not intended for use on a low-voltage public network which supplies domestic premises. Radio frequency interference should be expected if used on such a network
WARNING	**EMI Line Filter is necessary to meet EMC requirements** Use of an EMI Line Filter with *Xenus Plus Compact* drives is mandatory for meeting EMC requirements
WARNING	**A surge protection device (SPD) is required to establish an over-voltage category II environment** The AC mains supplying the *Xenus Plus Compact* drives must be limited to over-voltages of Category II. The relevant standards assume AC mains with over-voltages per OVC III. An SPD is required to limit over-voltages to OVC II levels. Alternatively, an isolation transformer connected between AC mains and the drive may be used to establish an OVC II environment.

5.1.2 Grounding Considerations

PRIMARY GROUNDING FUNCTIONS

A grounding system has three primary functions: electrical safety, voltage-reference, and shielding.

J1-3 PROTECTIVE EARTH GROUND

The protective earth (PE) ground at J1-3 is the electrical safety ground and is intended to carry the fault currents from the mains in the case of an internal failure or short-circuit of electronic components. This ground is connected to the drive chassis. Wiring to this ground should be done using the same gauge wire as that used for the mains. This wire is a “protective bonding” conductor that should be connected to an earthed ground point and must not pass through any circuit interrupting devices.

J2-1 MOTOR CONNECTOR GROUND

On *Xenus Plus Compact* drives, the ground terminal at J2-1 connects to the drive chassis. This ground terminal is provided as a cable shield and protective earth connection point for the motor cable. Connection of the cable shield to this point is made to provide electrical noise reduction. Connection of the motor cable protective earth conductor to this point is made to prevent the motor housing from becoming hazardous live in the event of an insulation failure. Protective earth connection for the motor housing is 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 housing 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 housing.

SIGNAL GROUNDING

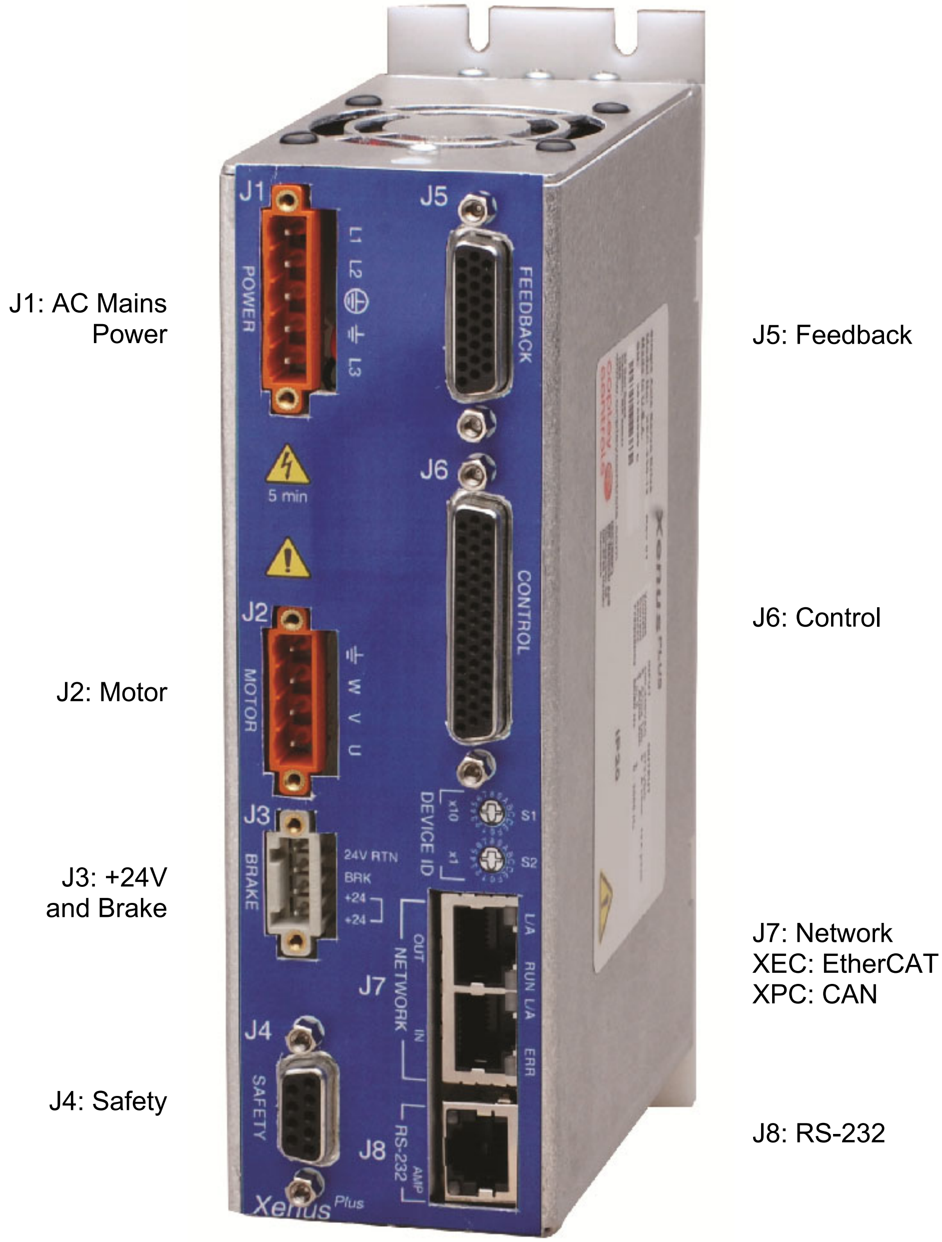
The drive signal ground must be connected to the control system signal ground. The drive signal ground is not connected to earth ground internal to the drive. Therefore, the control system signal ground can be connected to earth ground without introducing a ground loop.

CABLE SHIELDING

Shields on 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. Cable shields should be tied at both ends to earth or chassis ground. The housing and pin 1 of J4, J5, and J6 are connected to the drive’s chassis.

Feedback cables with inner/outer shielding should connect the outer shield to the motor and drive frame grounds. The inner shield should connect to Signal Ground on the drive and be unconnected at the encoder.

CONNECTOR LOCATIONS



FERRULES

AC POWER, AND MOTOR OUTPUTS: J1~J2

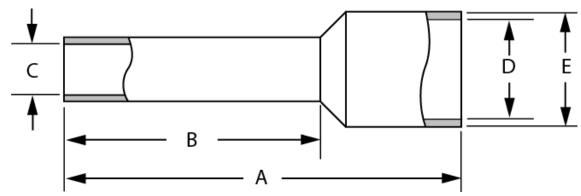
Wago MCS-MIDI Classic: 231-305/107-000 (J1), 231-304/107-000 (J2),
female connector; with screw flange; pin spacing 5.08 mm / 0.2 in

Conductor capacity
Bare stranded: AWG 28~14 [0.08~2.5 mm2]
Insulated ferrule: AWG 24~16 [0.25~1.5 mm2]
Stripping length: 8~9 mm
Operating Tool: Wago MCS-MIDI Classic: 231-159

J1 J2 Tool

AWG	mm^2	Color	Mfgr	PNUM	A	B	C	D	E	SL
14	2.5	Blue	Wago	216-206	15.0 (0.59)	8.0 (0.31)	2.05 (.08)	4.2 (0.17)	4.8 (0.19)	10 (0.39)
16	1.5	Black	Wago	216-204	14.0 (0.59	8.0 (0.31)	1.7 (.07)	3.5 (0.14)	4.0 (0.16)	10 (0.39)
18	1.0	Red	Wago	216-223	12.0 (.47)	6.0 (.24)	1.4 (.055)	3.0 (.12)	3.5 (.14)	8 (.31)
	0.75	Gray	Wago	216-222	12.0 (.47)	6.0 (.24)	1.2 (.047)	2.8 (.11)	3.3 (.13)	8 (.31)
22	0.5	White	Wago	216-221	12.0 (.47)	6.0 (.24)	1.0 (.039)	2.6 (.10)	3.1 (.12)	7.5 (.30)

NOTES
PNUM = Part Number
SL = Stripping length
Dimensions: mm (in)



24V & BRAKE: J3

Wago MCS-MINI: 734-104/107-000, female connector; with screw flange,
pin spacing 3.5 mm / 0.138 in

Conductor capacity
Bare stranded: AWG 28~16 [0.08~1.5 mm2]
Insulated ferrule: AWG 24~16 [0.25~1.5 mm2]
Stripping length: 0.24~0.28 in[6~7 mm]
Operating tool: Wago MCS-MINI: 734-231

J3 Tool

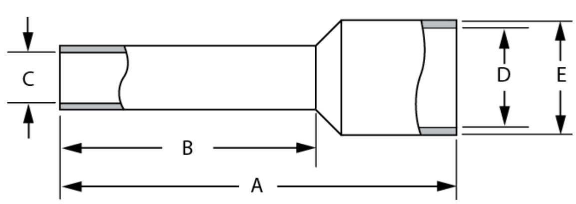
FERRULE PART NUMBERS: SINGLE-WIRE INSULATED

AWG	mm^2	Color	Mfgr	PNUM	A	B	C	D	E	SL
18	1.0	Red	Wago	216-223	12.0 (.47)	6.0 (.24)	1.4 (.06)	3.0 (.12)	3.5 (.14)	8 (.31)
20	0.75	Gray	Wago	216-222	12.0 (.47)	6.0 (.24)	1.2 (.05)	2.8 (.11)	3.3 (.13)	8 (.31)
22	0.5	White	Wago	216-221	12.0 (.47)	6.0 (.24)	1.0 (.04)	2.6 (.10)	3.1 (.12)	7.5 (.30)

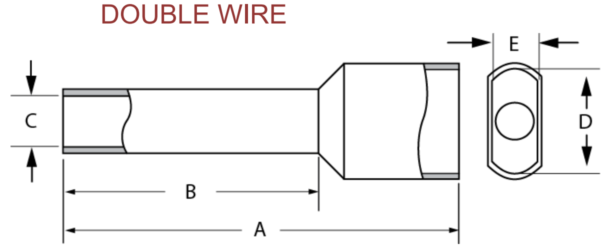
FERRULE PART NUMBERS: DOUBLE-WIRE INSULATED

AWG	mm^2	Color	Mfgr	PNUM	A	B	C	D	E	SL
2 x 18	2 x 1.0	Red	Altech	2776.0	15.4 (.61)	8.2 [.32]	2.4 (.09)	3.2 (.13)	5.8 (.23)	11.0 (.43)
2 x 18	2 x 1.0	Gray	Altech	2775.0	14.6 (.57)	8.2 (.32)	2.0 (.08)	3.0 (.12)	5.5 (.22)	11.0 (.43)
2 x 20	2 x 0.75	White	Altech	2794.0	14.6 (.57)	8.2 (.32)	1.7 (.07)	3.0 (.12)	5.0 (.20)	11.0 (.43)
2 x 20	2 x 0.75	Gray	TE	966144-2	15.0 (.59)	8.0 (.31)	1.70 (.07)	2.8 (.11)	5.0 (.20)	10 (.39)
2 x 22	2 x 0.50	White	TE	966144-1	15.0 (.59)	8.0 (.31)	1.40 (.06)	2.5 (.10)	4.7 (.19)	10 (.39)

SINGLE WIRE



DOUBLE WIRE



5.2 AC Mains (J1)

5.2.1 Mating Connector

Description	Euro-style 5.08 mm pluggable female terminal block with preceding ground receptacle.
Manufacturer PN	Wago: 231-305/107-000 (Note 1)
Wire size	28-14 AWG
Recommended Wire	15 A model: 14 AWG, 600 V 6 A, 12 A models: 16 AWG, 600 V Shielded cable required for CE compliance
Wire Insertion/Extraction Tool	Wago: 231-159
Connector and tool are included in Connector Kits.	

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

PIN DESCRIPTION

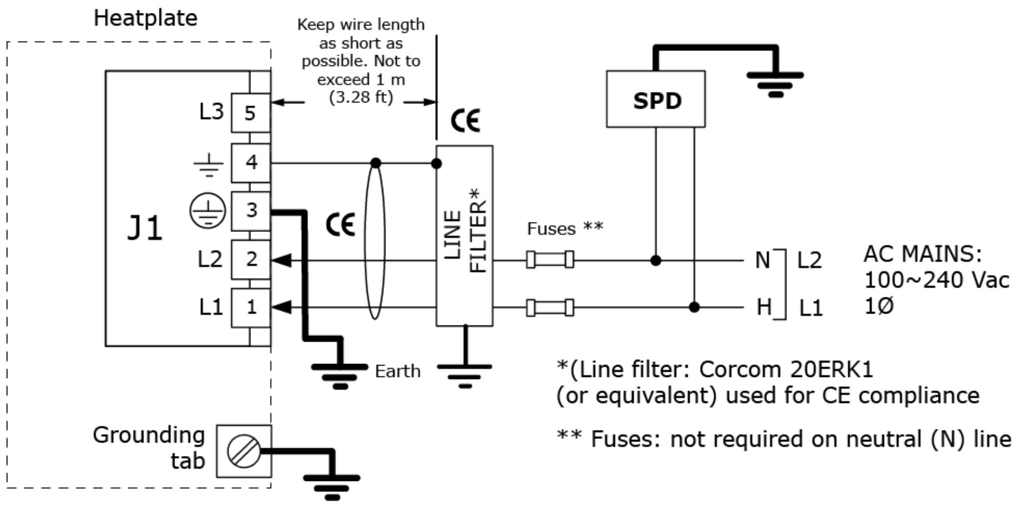
Pin	Signal	Function
1	L1	AC power input (hot or L1)
2	L2	AC power input (neutral or L2)
3	PE ground	Chassis safety ground (Protective Earth)
4	Frame ground	Frame ground
5	L3	AC power input (L3)

5.2.2 AC Mains Fuse Recommendation

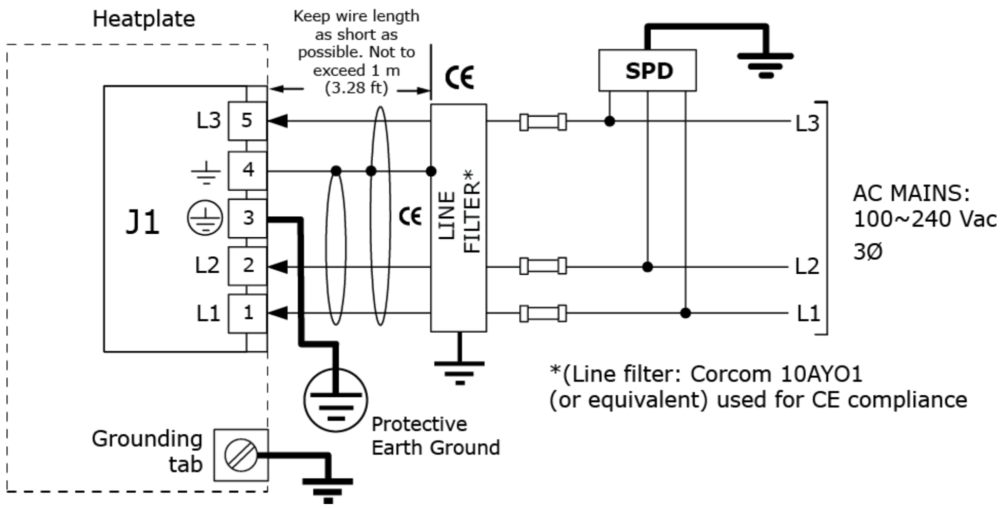
Recommended fuse type: Class CC, 600 Vac rated, Ferraz-Shawmut ATDR, Littelfuse CCMR, Bussman LP-CC, or equivalent.

WARNING	**EMI Line Filter is necessary to meet EMC requirements** Use of an EMI Line Filter with *Xenus Plus Compact* drives is mandatory for meeting EMC requirements
WARNING	**A surge protection device (SPD) is required to establish an over-voltage category II environment** The AC mains supplying the drive must be limited to over-voltages of Category II. The relevant standards assume AC mains with over-voltages per OVC III. An SPD is required to limit over-voltages to OVC II levels. Alternatively, an isolation transformer connected between AC mains and the drive may be used to establish an OVC II environment.

AC MAINS WIRING DIAGRAM (SINGLE-PHASE)



AC MAINS WIRING DIAGRAM (THREE-PHASE)



In the end product installation, a UL RC (Recognized Component) SPD (Surge Protective Device) type 1CA, 2CA, 3CA or a UL Listed (VZCA) SPD type 1, 2, or 3 rated 2500 V, with a minimum SCCR of 5 kA, 240 Vac, and surge voltage monitoring needs to be provided. The purpose of the SPD is to establish an over-voltage CAT II environment. Example parts are Cooper Bussman BSPM3240DLG (3 phase) or BSPM2240S3G (two-pole). Alternatively, an isolation transformer connected between AC mains and the drive may be used to establish an OVC II environment.

In order to minimize electrical noise it is important to keep the connection between the drive heatplate and earth/equipment frame as short as possible. A threaded hole for a #8-32 external tooth SEMS screw is provided adjactent to the fan is provided for making this connection. Note that this connection is for electrical noise control and is not the protective earth (PE) connection. The PE connection is located at J1 pin 3.

The *Xenus Plus Compact* models use a diode rectifier and DC bus capacitance to convert the incoming AC mains voltage to DC for powering the output stage inverter. Depending on actual drive load conditions, the total harmonic distortion (THD) of the current drawn from the AC mains can exceed 10%. Management of current THD must be considered in the overall system and harmonic filtering may be required. Users should refer to Clause B.4 of IEC 61800-3:2004+A1:2011 for further details.

In the presence of commutation notch disturbances on the incoming AC mains, the DC bus voltage in the *Xenus Plus Compact* models can exceed the overvoltage shutdown level (400V). In the event that commutation notches result in DC bus voltages above the overvoltage shutdown threshold in the end use system, measures to reduce commutation notch disturbances may be required.

5.3 Motor (J2)

5.3.1 Mating Connector

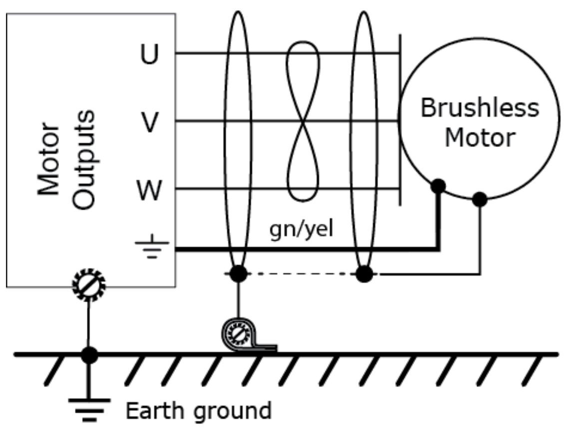
Description	Euro-style, 4 position, 5.08 mm pluggable female terminal block
Manufacturer PN	Wago: 231-304/107-000 (Note 1)
Wire Size	28-14 AWG
Recommended Wire	15 A model: 14 AWG, 600 V 6 A, and 12 A models: 16 AWG, 600 V Shielded cable required for CE compliance
Wire Insertion/Extraction Tool	Wago: 231-159
Standard connector and tool are included in Connector Kits XEC-CK, XPC-CK.	

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

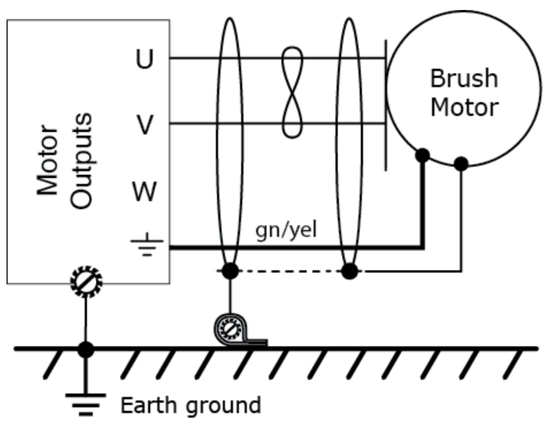
PIN DESCRIPTION

PIN	SIGNAL	FUNCTION
1	Ground	Motor frame ground and cable shield
2	W	Phase W output of drive
3	V	Phase V output of drive (use for DC motor connection)
4	U	Phase U output of drive (use for DC motor connection)

5.3.2 Brushless Motor Wiring Diagram



5.3.3 Brush Motor Wiring Diagram



5.3.4 801-1891, 801-1892, 801-1893 MOTOR WIRING DIAGRAM

Contact Copley Controls for details

5.4 Logic Supply / Brake (J3)

5.4.1 Mating Connector

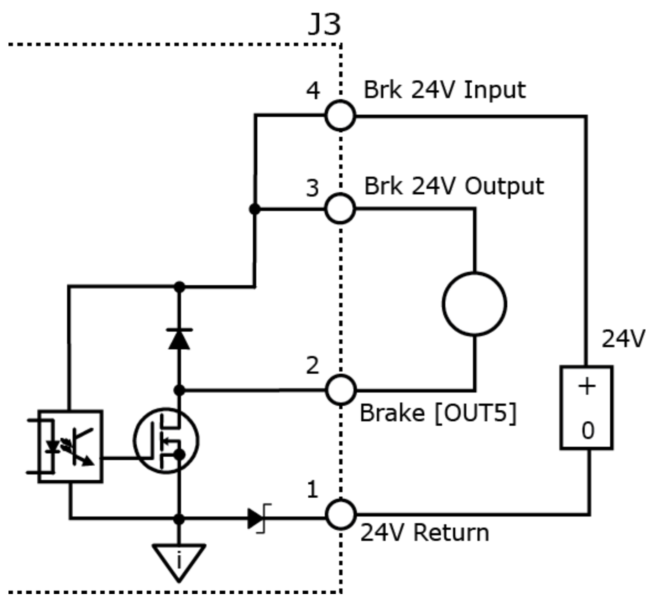
Description	Euro-style, 4 position, 3.5 mm pluggable female terminal block.
Manufacturer PN	Wago: 734-104/107-000 (Note 1)
Wire Size	28~16 AWG
Recommended Wire	16 AWG
Wire Insertion/Extraction Tool	Wago: 734-231
Standard connector and tool are included in Connector Kits XEC-CK and XPC-CK.	

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

PIN DESCRIPTION

Pin	Signal	Function
1	RTN	+24 Vdc return
2	Brake [OUT5]	Return or low side of motor brake
3	+24 Vdc	+24 V Output to brake
4	+24	+24 Vdc From power supply

LOGIC SUPPLY / BRAKE WIRING DIAGRAM



5.5 Safety (J4)

5.5.1 MATING CONNECTOR

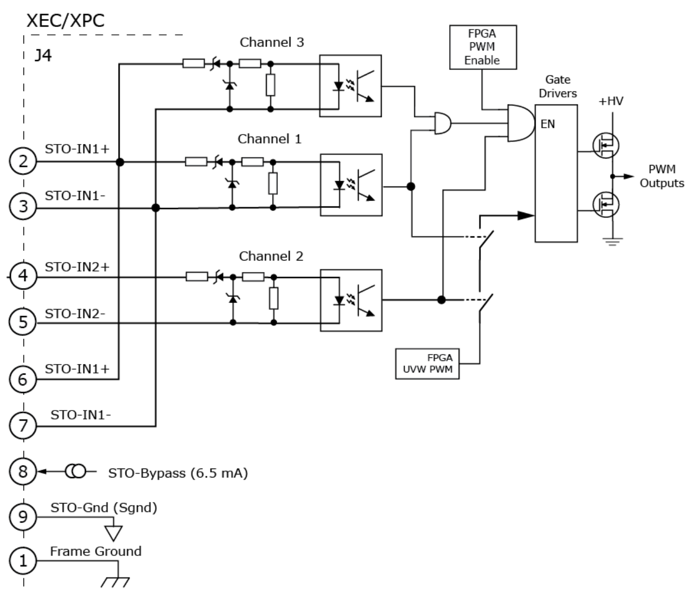
Description	Manufacturer PN	Qty
Connector, D-Sub, 9-position, male	TE/AMP: 205204-4	1
AMPLIMITE HD-20 Crimp-Snap contacts, 24~20 AWG, AU flash	TE/AMP: 66506-9	9
Backshell, D-Sub, RoHS, metallized, for above	3M: 3357-9209	1
Jumper, with pins crimped to both ends	Copley: 10-75177-01	4

PIN DESCRIPTION

Pin	Signal	Function
1	Frame Ground	Cable shield connection.
2	STO-1(+)	STO Channels 1 & 3
3	STO-1(-)	
4	STO-2(+)	STO Channel 2
5	STO-2(-)	
6	STO-1(+)	STO Channels 1 & 3
7	STO-1(-)	
8	STO-24V	Internal current source for STO bypassing
9	STO-GND	Signal Ground

SAFE TORQUE OFF WIRING DIAGRAM

NOTE: The diagram below shows the STO function architecture.



DANGER

Refer to the *Xenus Plus Compact STO Manual*

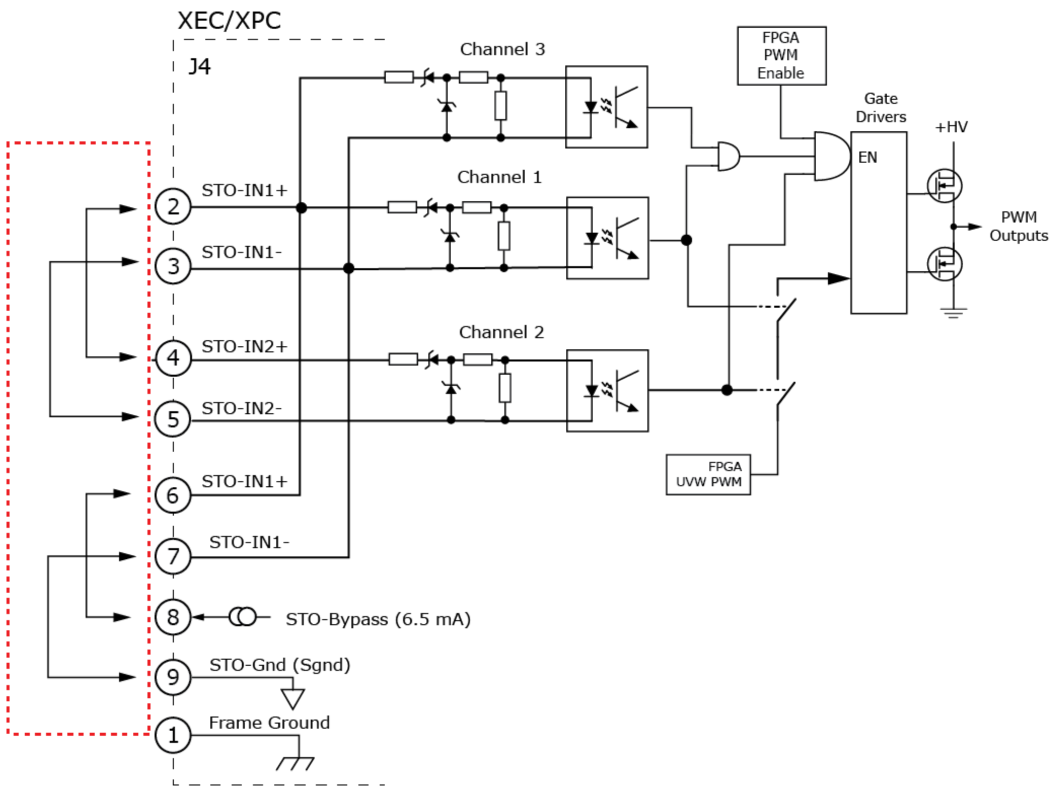
The information provided in the *Xenus Plus Compact STO Manual* must be considered for any application using the XEC & XPC drives STO feature.

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

SAFE TORQUE OFF BYPASS (MUTING) (J4)

The diagram below includes the STO bypass connections that will energize the two inputs (three opto-couplers). When this is done the STO feature is de-activated and control of the output PWM stage is delegated to the digital control core.

If the STO feature is not used, these connections must be made in order for the Xenus Plus Compact to be enabled.



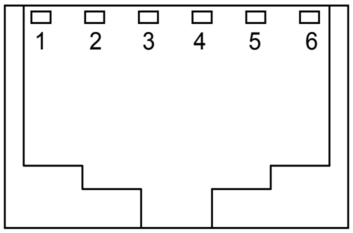
5.6 RS-232 Serial Communications (J8)

5.6.1 Mating Connector

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

Copley Controls provides a prefabricated cable and modular-to-9-pin sub-D adapter in RS-232 Serial Cable Kit, PN SER-CK.

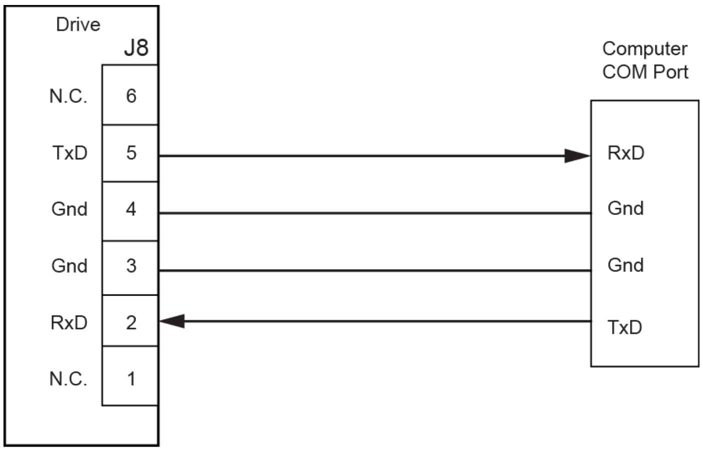
A diagram of the female connector is shown below.



PIN DESCRIPTION

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

RS-232 SERIAL COMMUNICATIONS WIRING DIAGRAM

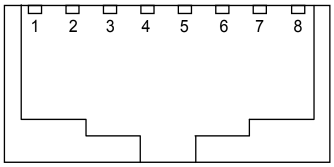


5.7 Network Ports (J7)

5.7.1 EtherCAT

MATING CONNECTOR

Dual RJ-45 sockets accept standard Ethernet cables. The IN port connects to a master, or to the OUT port of a device that is 'upstream' between the *XEC or 801-1891~1893* and the master.
The OUT port connects to 'downstream' nodes. If the drive is the last node on a network, only the IN port is used.
Terminators are not used for EtherCAT communications



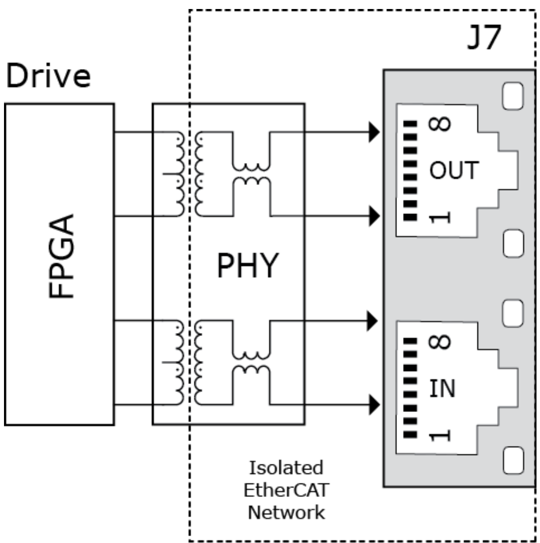
PIN DESCRIPTION*

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

The XEC drive uses connector J7.



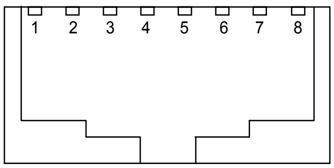
5.7.2 CAN

MATING CONNECTOR

8-position, modular connector (RJ-45 style). Copley Controls provides the following assemblies:

- Prefabricated 10 foot cable, PN XPC-NC-10
- Prefabricated 1 foot cable, PN XPC-NC-01
- Terminator Plug, PN XPC-NT

A diagram of the female connector is shown below.



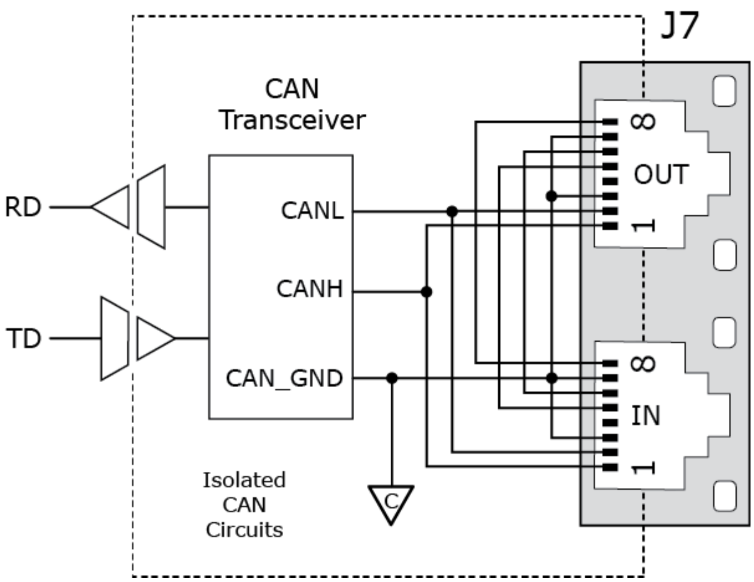
PIN DESCRIPTION*

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 WIRING DIAGRAM

The XPC drive uses connector J7.

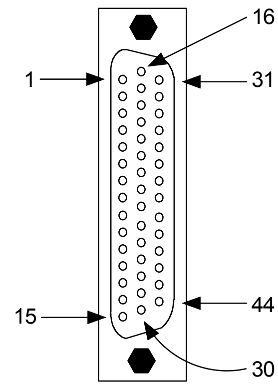


5.8 Control I/O (J6)

5.8.1 MATING CONNECTOR

Description	Manufacturer PN	Wire Size
44 Position, 0.1 x 0.09 High Density D-Sub Male, Solder Style Connector	Norcomp 180-044-103L001	24 - 30 AWG
Back shell	3M: 3357-9225	
Solder style connector included in Connector Kit XEC-CK and XPC-CK		

Pin connections for the connector on the drive are shown here:



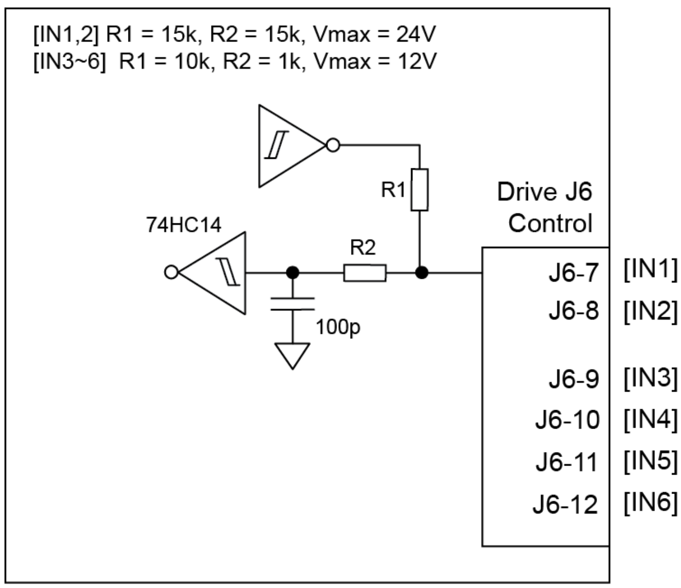
Pin	Signal	Pin	Signal	Pin	Signal
1	Frame Ground	16	Signal Ground	31	Signal Ground
2	Ref(-)	17	+5V Out2	32	+5V Out2
3	Ref(+)	18	Multi Enc /S	33	Multi Enc S
4	N.C.	19	Multi Enc /X	34	Multi Enc X
5	N.C.	20	Multi Enc /B	35	Multi Enc B
6	Signal Ground	21	Multi Enc /A	36	Multi Enc A
7	[IN1] GP	22	Signal Ground	37	Signal Ground
8	[IN2] GP	23	[OUT4] HS	38	N.C.
9	[IN3] HS	24	N.C.	39	N.C.
10	[IN4] HS	25	[OUT3-] ISO	40	[OUT3+] ISO
11	[IN5] HS	26	[OUT2-] ISO	41	[OUT2+] ISO
12	[IN6] HS	27	[OUT1-] ISO	42	[OUT1+] ISO
13	[IN7] ISO	28	[INCOM] ISO	43	N.C.
14	[IN8] ISO	29	N.C	44	Signal Ground
15	[IN9] ISO	30	[IN10] ISO		

MODE DEPENDENT DEDICATED INPUTS

These inputs are dedicated to specific functions, depending on operating mode.

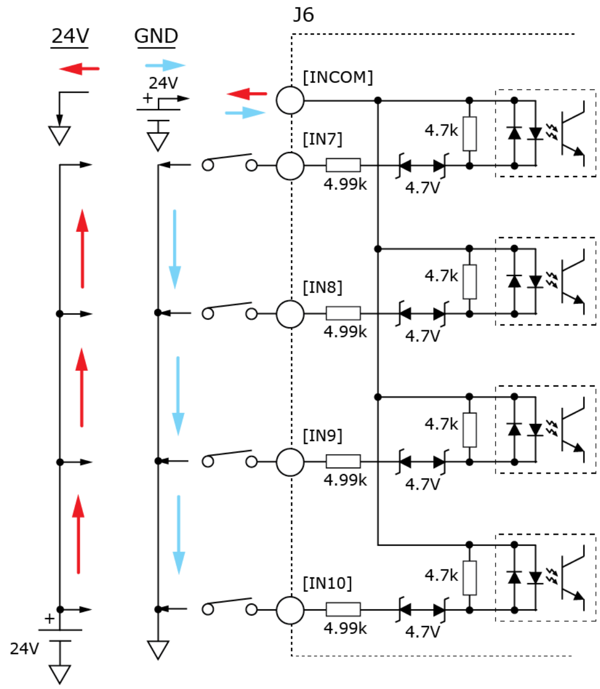
Mode	Selected Command Source			Function
	Digital Input Single Ended	Digital Input Differential	Multi-Mode Port	
Current & Velocity PWM 50%	IN 5	IN3(+) & IN4(-)	A & /A	PWM Input
Current & Velocity PWM 100%	IN 5 IN 6	IN3(+) & IN4(-) IN5(+) & IN6(-)	A & /A B & /B	PWM Input Direction Input
Position Pulse & Direction	IN 5 IN 6	IN3(+) & IN4(-) IN5(+) & IN6(-)	A & /A B & /B	Pulse Input Direction Input
Position Up/Down	IN 5 IN 6	IN3(+) & IN4(-) IN5(+) & IN6(-)	A & /A B & /B	Count Up Count Down
Position Quadrature	IN 5 IN 6	IN3(+) & IN4(-) IN5(+) & IN6(-)	A & /A B & /B	Channel A Channel B

DIGITAL INPUTS (IN1~IN2, IN3~IN6) WIRING DIAGRAM



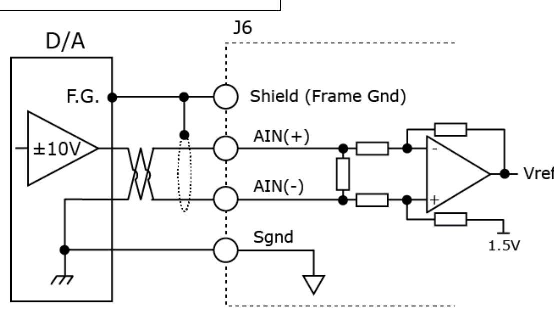
ISOLATED INPUTS (IN7~IN10) WIRING DIAGRAM

Pin	Signal	Function
13	IN7	Isolated IN7
14	IN8	Isolated IN8
15	IN9	Isolated IN9
30	IN10	Isolated IN10
28	INCOM	Isolated Input ±Common



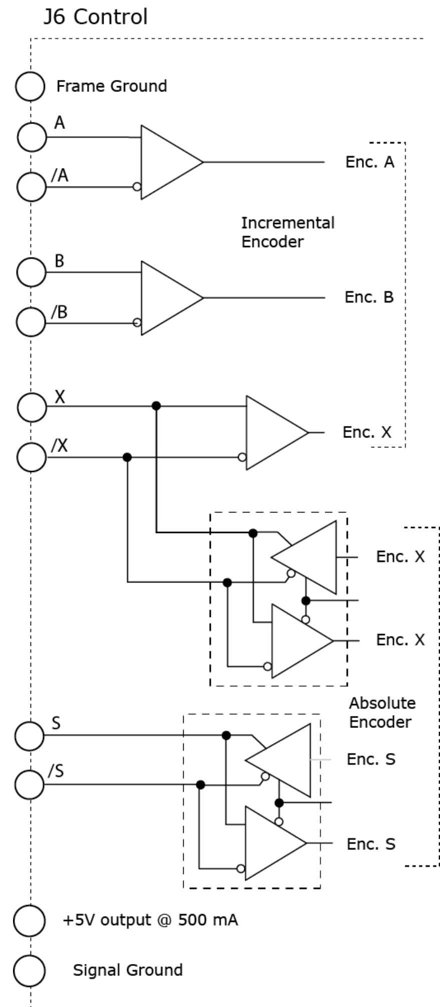
ANALOG INPUT WIRING DIAGRAM

Pin	Signal	Function
3	AIN(+)	Analog Reference (+) Input
2	AIN(-)	Analog Reference (-) Input
6	Sgnd	Signal Ground



MULTI-MODE PORT INTERFACE DIAGRAM

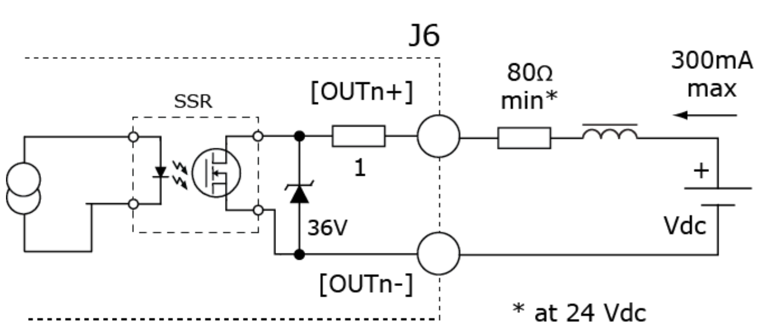
J6 Pin	Signal	Function
36	Multi Enc A	Pulse, CW, Encoder A
21	Multi Enc /A	/Pulse, /CW, Encoder /A
35	Multi Enc B	Direction, CCW, Encoder B
20	Multi Enc /B	/Direction, /CCW, Encoder /B
34	Multi Enc X	Quad Enc X, Absolute Clock
19	Multi Enc /X	Quad Enc /X, /Absolute Clock
33	Multi Enc S	Enc S, Absolute (Clock) Data
18	Multi Enc /S	Enc /S, / Absolute (Clock) Data
6, 16, 22, 31, 37, 44	Signal Ground	Signal Ground
1	Frame Ground	Shield connection



OPTICALLY ISOLATED PROGRAMMABLE OUTPUTS WIRING DIAGRAM

Pin	Signal	Function
42	OUT1+	OUT1 positive terminal
27	OUT1-	OUT1 negative terminal
41	OUT2+	OUT2 positive terminal
26	OUT2-	OUT2 negative terminal
40	OUT3+	OUT3 positive terminal
25	OUT3-	OUT3 negative terminal

J6 Wiring



5.9 Motor Feedback (J5)

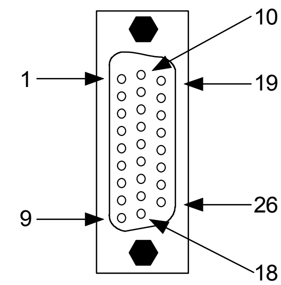
5.9.1 Mating Cable Connector

Description	Manufacturer PN	Wire Size
26 Position, 0.1 x 0.09, High-Density D-Sub Male, Solder Style Connector	Norcomp: 180-026-103L001	24 - 30 AWG
Back shell	3M: 3357-9209	
Solder style connector included in Connector Kits		

Pin connections for the bulkhead connector on the drive are shown here:

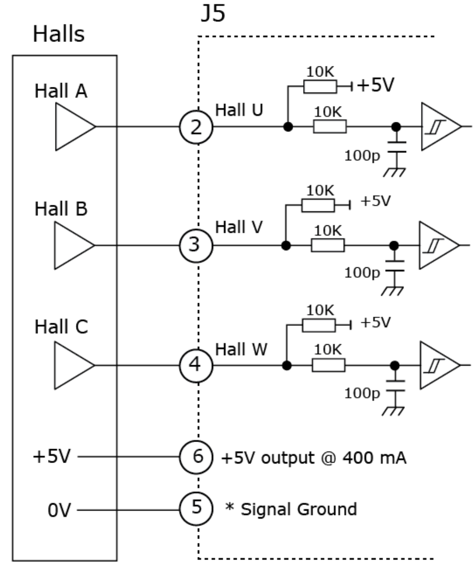
PIN DESCRIPTION QUAD A/B INCREMENTAL ENCODER

Pin	Signal	Function
1	Frame Ground	Cable shield connection.
2	Hall U	Digital Hall feedback inputs
3	Hall V	
4	Hall W	
5	Signal Ground	Signal and +5 Vdc ground.
6	+5 Vdc	Encoder and/or Halls +5 Vdc power supply output.
7	Motemp	Motor over temperature switch. May be programmed to other functions..
8	Encoder /X	Primary digital incremental encoder inputs.
9	Encoder X	
10	Encoder /B	
11	Encoder B	
12	Encoder /A	
13	Encoder A	
14	Encoder /S	
15	Encoder S	
16	Signal Ground	Signal and +5 Vdc ground.
17	+5 Vdc	Encoder and/or Halls +5 Vdc power supply output.
18	Sin1(-)	Analog Sin/Cos encoder inputs
19	Sin1(+)	
20	Cos1(-)	
21	Cos1(+)	
22	N.C.	No Connection
23	N.C.	
24	N.C.	
25	Signal Ground	Signal and +5 Vdc ground.
26	Signal Ground	



5.9.2 Hall Switch Wiring Diagram

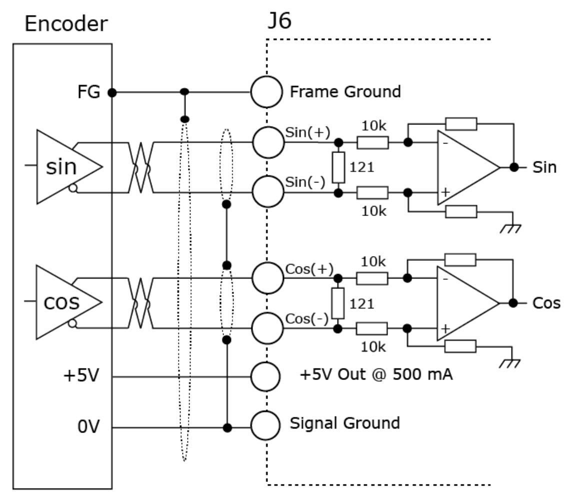
Pin	Signal	Function
2	Hall U	Primary feedback Hall U
3	Hall V	Primary feedback Hall V
4	Hall W	Primary feedback Hall W
6	+5 Vout1	Primary encoder +5V
5	Sgnd	Signal Ground



* Alternate Sgnd connections on J5 are pins 16, 25, 26

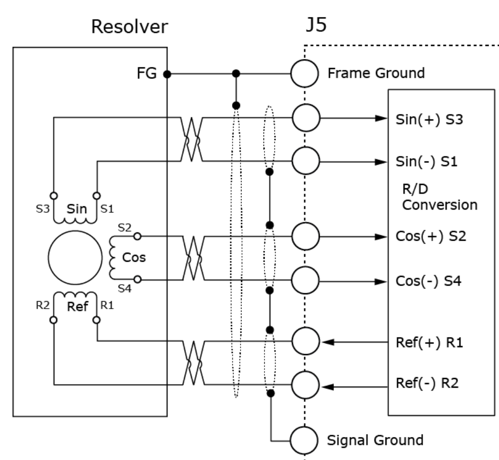
5.9.3 Analog Sin/Cos Encoder Wiring Diagram

Pin	Signal	Function
19	Sin(+) S3	Encoder Sin(+) Input
18	Sin(-) S1	Encoder Sin(-) Input
21	Cos(+) S2	Encoder Cos(+) Input
20	Cos(-) S4	Encoder Cos(-) Input
6	+5 Vout1	Primary encoder +5V
5	Sgnd	Signal Ground



5.9.4 Resolver Wiring Diagram: XEC/XPC

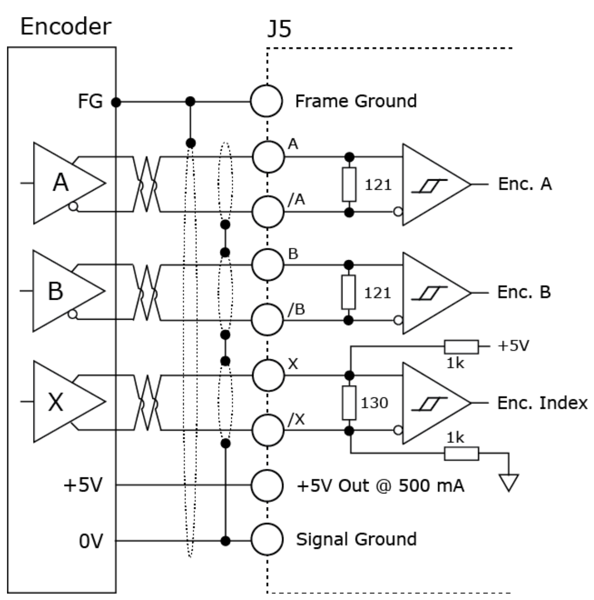
Pin	Signal	Function
19	Sin(+) S3	Resolver Sin(+) Input
18	Sin(-) S1	Resolver Sin(-) Input
21	Cos(+) S2	Resolver Cos(+) Input
20	Cos(-) S4	Resolver Cos(-) Input
34	Ref(+)	Resolver Excitation(+)
19	Ref(-)	Resolver Excitation(-)
5	Sgnd	Signal Ground



5.9.5 Digital Incremental Encoder Wiring: XEC/XPC

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.

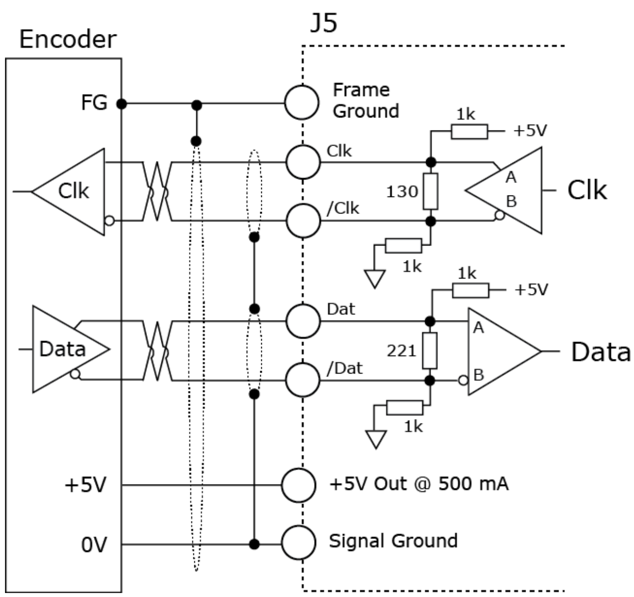
Pin	Signal	Function
13	Enc A	Channel A
12	Enc /A	
11	Enc B	Channel B
10	Enc /B	
9	Enc X	Channel X
8	Enc /X	
6,17	+5 Vdc1	+5 Output 1
5,16,25,26	Sgnd	Signal Ground
1	F.G.	Frame Ground



5.9.6 SSI ABSOLUTE ENCODER: XEC/XPC

The SSI (Synchronous Serial Interface) is an interface used to connect an absolute position encoder to a motion controller or control system. The XEC 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

Pin	Signal	Function
9	Clk	Clock output to encoder
8	/Clk	
15	Data	Data input from encoder
14	/Data	
6,17	+5 Vout1	+5 Vdc Output 1
5,16,25,26	Sgnd	Signal Ground
1	F.G.	Frame Ground

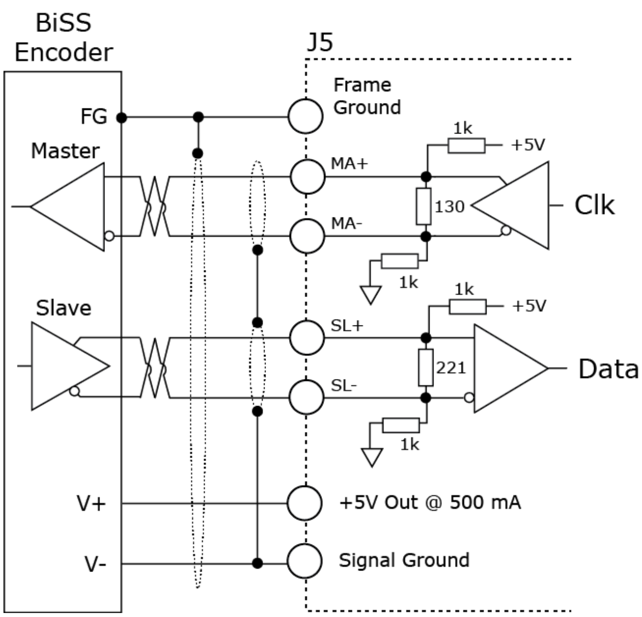


5.9.7 BISS ABSOLUTE ENCODER: XEC/XPC

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

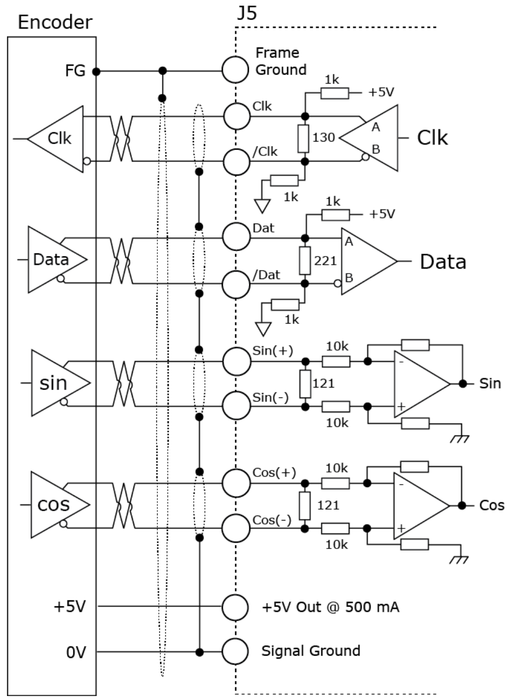
Pin	Signal	Function
9	MA+	Clock output to encoder
8	MA-	
15	SL+	Data input from encoder
14	SL-	
6,17	+5 Vout1	+5 Vdc Output 1
5,16,25,26	Sgnd	Signal Ground
1	F.G.	Frame Ground



5.9.8 ENDAT ABSOLUTE ENCODER: XEC/XPC

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.

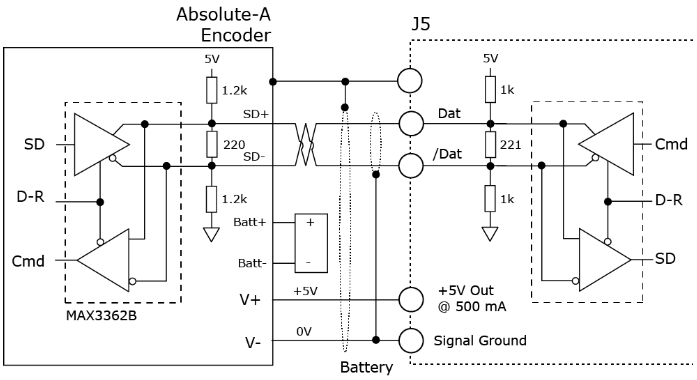
Pin	Signal	Function
9	Clk	Clock output to encoder
8	/Clk	
15	Data	Data input from encoder
14	/Data	
19	Sin(+)	Sin input from encoder
18	Sin(-)	
21	Cos(+)	Cod input from encoder
20	Cos(-)	
6,17	+5 Vout1	+5 Vdc Output 1
5,16,25,26	Sgnd	Signal Ground
1	F.G.	Frame Ground



5.9.9 ABSOLUTE-A ABSOLUTE ENCODER: XEC/XPC

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

Pin	Signal	Function
15	Data	Data input from encoder
14	/Data	
6,17	+5 Vout1	+5 Vdc Output 1
5,16,25,26	Sgnd	Signal Ground
1	F.G.	Frame Ground

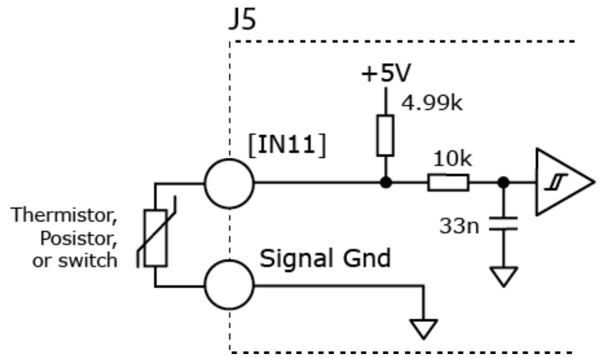


5.9.10 RESOLVER: 801-1891, 801-1892, 801-1893

Contact Copley Controls for details.

5.9.11 MOTOR OVER TEMPERATURE

Pin	Signal	Function
7	IN11	Motemp input
5	Sgnd	Signal Ground



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. Contents Include:

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.

I^2T FORMULAS AND ALGORITHM OPERATION

CALCULATING THE I^2T SETPOINT VALUE

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

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

I^2T ALGORITHM OPERATION

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

ACCUMULATOR INCREMENT FORMULA

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

I^2T Accumulator Variable n+1 =
I^2T Accumulator Variable n
+(Actual Output Current n+1^2 – Continuous Current Limit^2) * Update period

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

I^2T Current Limit Algorithm – Application Example

I^2T EXAMPLE: PARAMETERS

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

- Peak Current Limit – 12 A
- I^2T Time Limit – 1 S
- Continuous Current Limit – 6 A

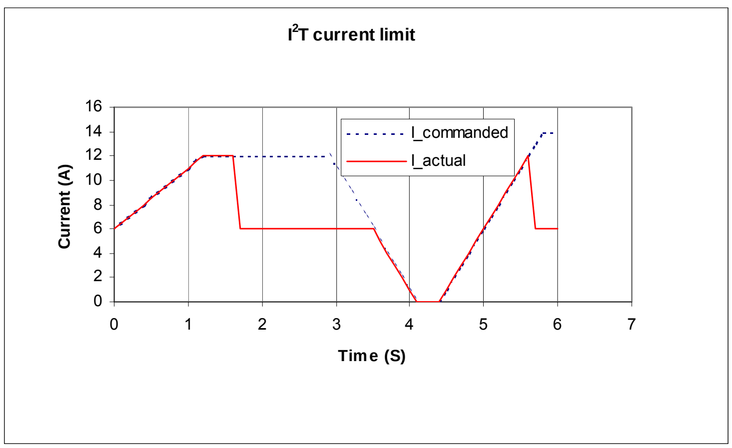
From this information, the I^2T setpoint is:

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

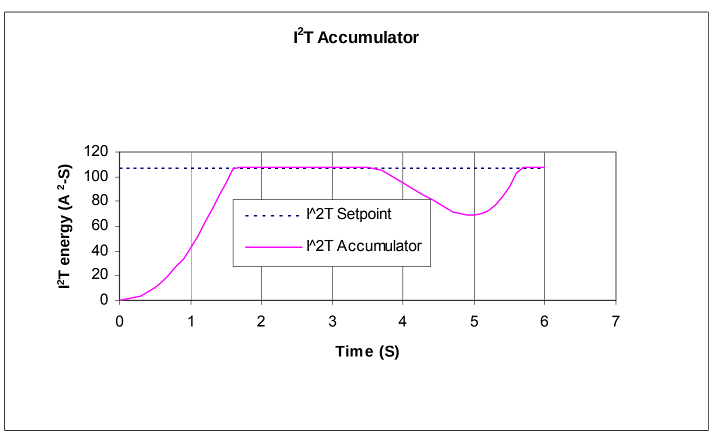
See the example plot diagrams on the next page.

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.

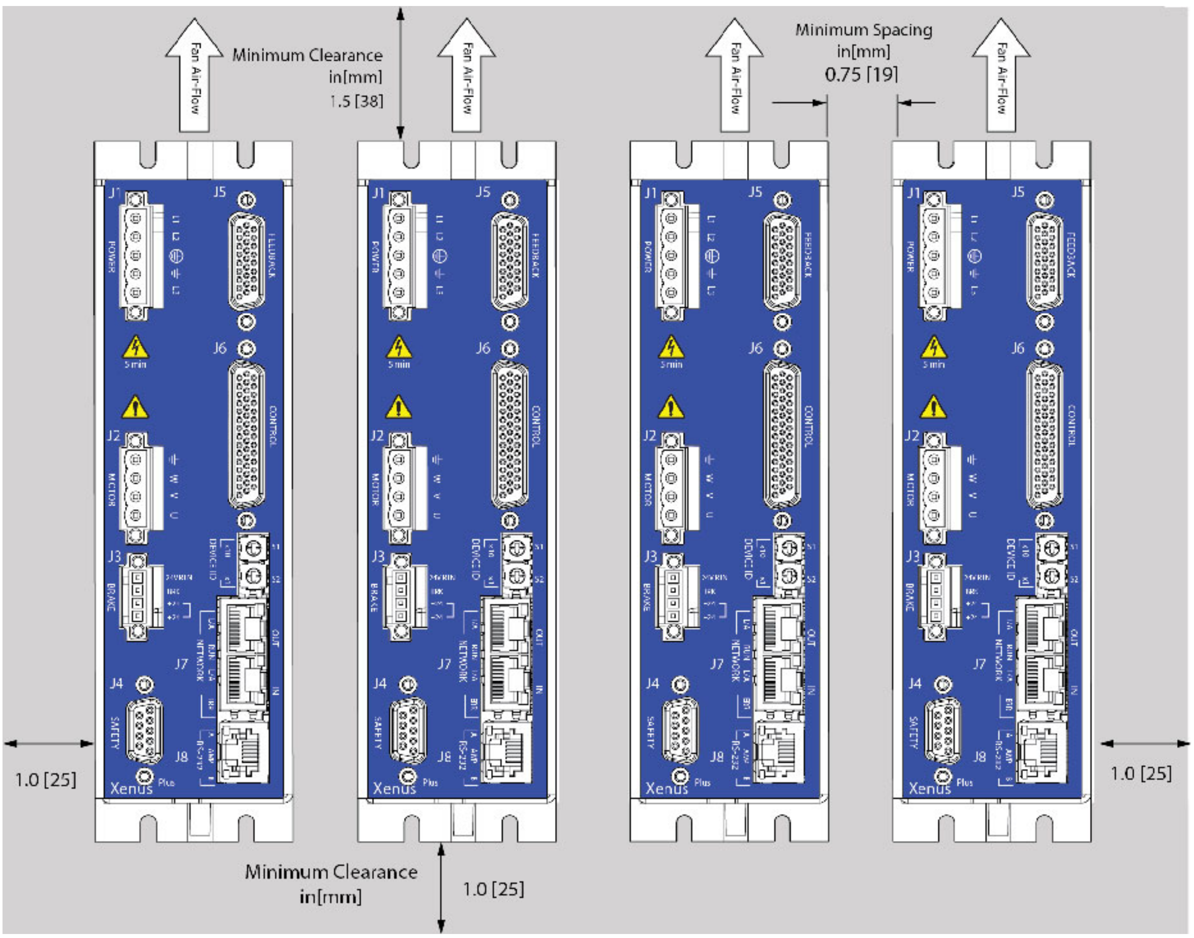
The I^2T Accumulator Variable value continues to fall until at approximately 5.0 seconds when the commanded current goes above the continuous current limit again. The actual output current follows the current command until the I^2T Accumulator Variable value reaches the I^2T setpoint and current limiting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

B: Thermal Considerations

This chapter describes operating temperature characteristics, heatsink options, and heatsink mounting instructions. Contents include:

Mounting

The internal fan and cooling fins are internal and can operate the drive in ambient temperatures up to 45 ºC. When mounting in enclosures, follow the recommendations in the graphic below to allow sufficient spacing for air to circulate.



C: XTL-FA-01 EDGE FILTER FOR XENUS

This chapter provides an overview of the Model XTL-FA-01 edge filter. Contents include:

Overview

The XTL-FA-01 edge filter can be used to minimize noise on the output of any *Xenus Plus Compact* drive.

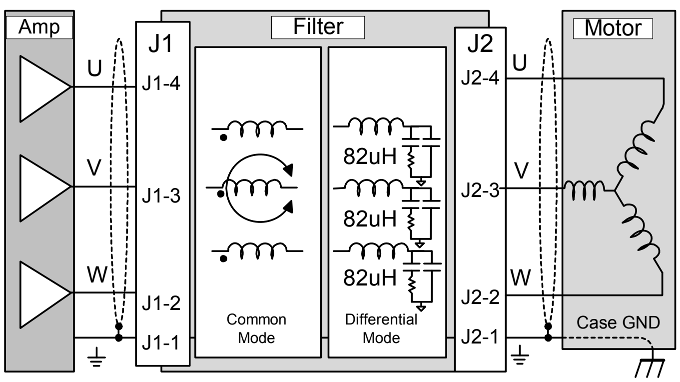
DIFFERENTIAL AND COMMON MODE FILTERING

Most noise is capacitively coupled from the motor power cable to neighboring cables. To minimize this noise, the XTL-FA-01 edge filter uses both differential edge filtering and common mode filtering. Differential edge filtering reduces the high frequency component of the PWM signal, thus producing a signal with less energy that can be coupled during transmission. Common mode filtering reduces the unnecessary common mode noise generated by PWM signals.

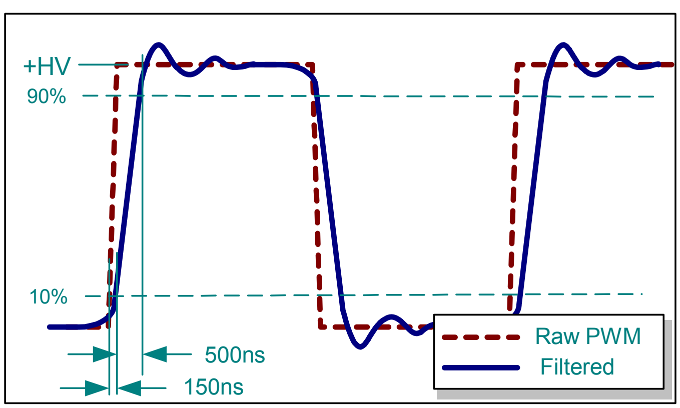
DESCRIPTION AND FUNCTIONAL DIAGRAM

The differential filter increases the rise time by at least a factor of 3, substantially reducing noise in the system. Copley Controls drives typically have a 150 ns rise-time (high frequency component in the MHz range). Thus, the edge filter can increase rise time to 500 ns, reducing the high frequency noise emissions by the square law. The differential filter is designed with 82 μH inductors and a proprietary passive circuit. The inductance will provide a total of 164μH in series with the load, helping to reduce ripple current. This brings low inductance motors into the required range.

The common mode filter is designed with a 220 μH common mode toroid that works with the cable capacitance to earth ground to remove common mode switching noise.



PWM OUTPUT PLOT



XTL-FA-01 Edge Filter Specifications

Input	Voltage, maximum	373 Vdc
	Current, maximum	20 Adc
Output	Voltage, maximum	373 Vdc
	Current, maximum	20 Adc
Peak Current/Peak Current Time		40 Adc for 1 second
Rise/Fall Time		500 ns (typical)
Differential Mode Inductance		82 µH per phase, 162 uH phase-phase (nominal)
Common Mode Inductance		220 µH (nominal)
Nominal Resistance		27 milliohms per leg, 54 milliohms phase-phase (nominal)
Agency Approvals		UL508C, EN60204, RoHS
Weight		1 lb. 11 oz.

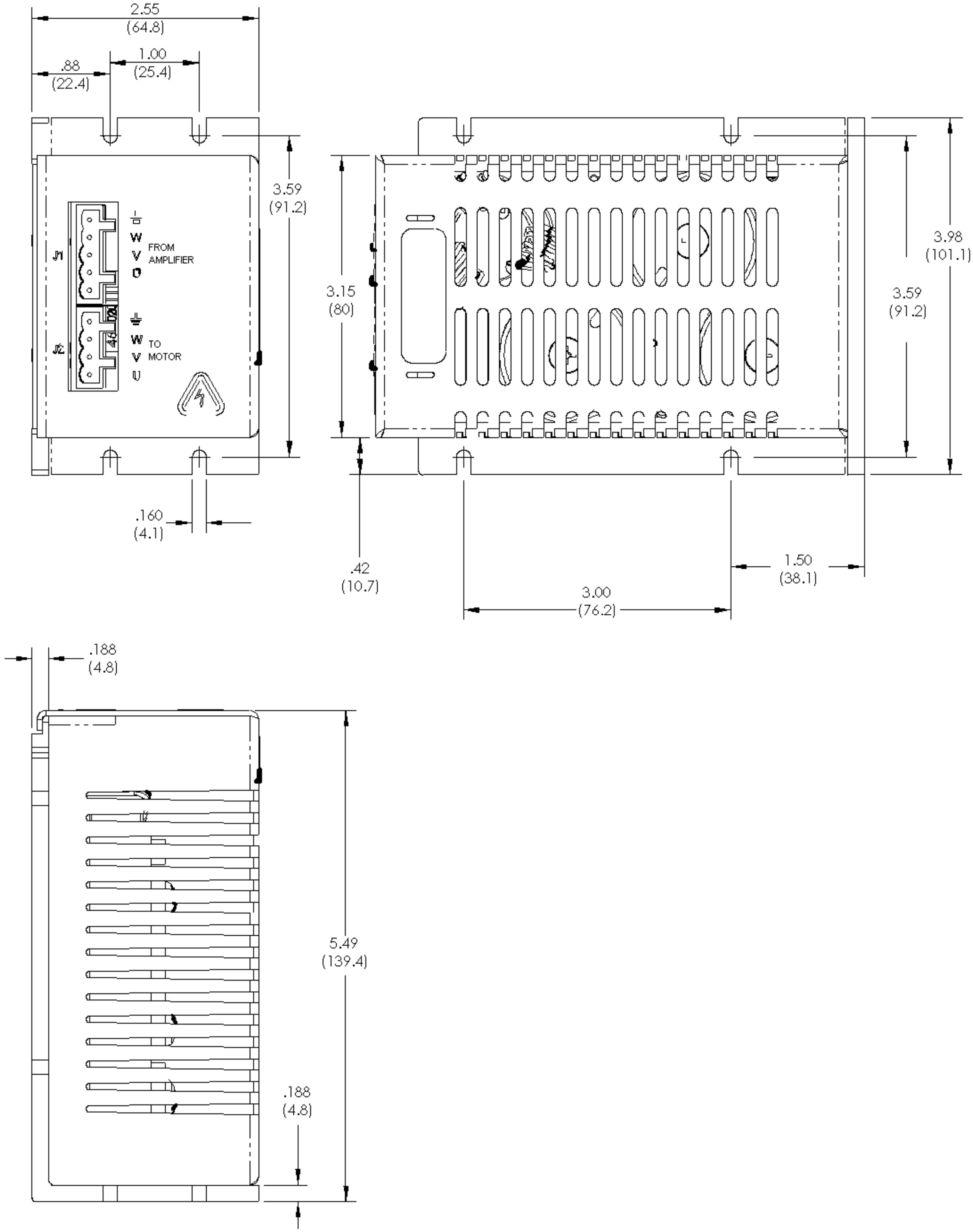
Thermal Considerations

Cooling Requirements

When used with *Xenus Plus Compact* drives, the XTL-FA-01 operates below maximum temperature values, and thus requires no cooling fan.

XTL-FA-01 Edge Filter Dimensions

The following diagram shows the mounting dimensions of the XTL-FA-01 Edge Filter.



XTL-FA-01 Edge Filter Wiring

This section describes the wiring of the XTL-FA-01 Edge Filter.

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. **Failure to heed this warning can cause equipment damage, injury, or death.**
DANGER	**Risk of electric shock.** High-voltage circuits on *Xenus Plus Compact* J1 and J2 are connected to mains power. **Failure to heed this warning can cause equipment damage, injury, or death.**
WARNING	**Do not ground mains-connected circuits.** With the exception of the ground pins on *Xenus Plus Compact* J1 and J2, and on Filter J1 and J2, all of the other circuits on these connectors are mains-connected and must never be grounded. **Failure to heed this warning can cause equipment damage.**

Connector Locations

Edge Filter J1 connects to the drive's Motor connector J2
Edge Filter J2 connects to the motor.

Cable Notes

1 Keep the Edge Filter to *Xenus Plus Compact* cable as short as possible.
A typical length is 7 inches.

2 To reduce noise, twisted shielded cable must be used and the signal cables should not be bundled in the same conduit.

Edge Filter Input (J1) From Drive

MATING CONNECTOR

Description	Euro-style, 5 position, 5.0 mm pluggable female terminal block
Manufacturer PN	Wago 721-105/026-047 (Note 1)
Connector Wire Size	22-12 AWG
Recommended Wire	12 AWG, 600 V (Shielded cable used for CE compliance)
Wire Insertion/Extraction Tool	Wago 231-131
Connector and tool are included in Connector Kit XTL-FK.	

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

PIN DESCRIPTION

Pin	Signal	Function
1	Frame Ground	Chassis ground and cable shield
2	Phase W	Phase W input from drive
3	Phase V	Phase V input from drive (use for DC motor connection)
4	Phase U	Phase U input from drive (use for DC motor connection)
5	---	No connection

Edge Filter Output (J2) To Motor

MATING CONNECTOR

Description	Euro-style, 4 position, 5.0 mm pluggable female terminal block.
Manufacturer PN	Wago: 721-104/026-047 (Note 1)
Connector Wire Size	22-12 AWG
Recommended Wire	12 AWG, 600 V (Shielded cable used for CE compliance)
Wire Insertion/Extraction Tool	Wago: 231-131
Connector and tool are included in Connector Kit XTL-FK.	

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

PIN DESCRIPTION

Pin	Signal	Function
1	Ground	Chassis ground and cable shield
2	Phase W	Phase W output to motor
3	Phase V	Phase V output to motor (use for DC motor connection)
4	Phase U	Phase U output to motor (use for DC motor connection)

DIAGRAM: EDGE FILTER WIRING WITH BRUSHLESS MOTOR

This is an example for a *Xenus Plus Compact* drive. Connector J2 on the drive is used for the output to the filter.

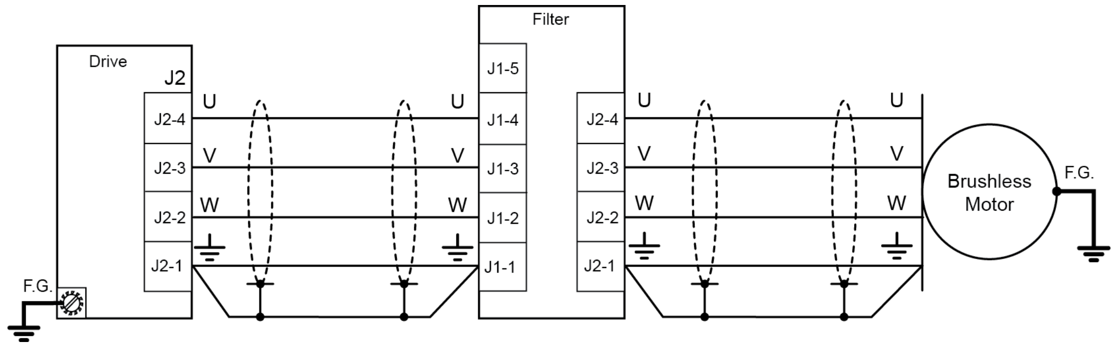
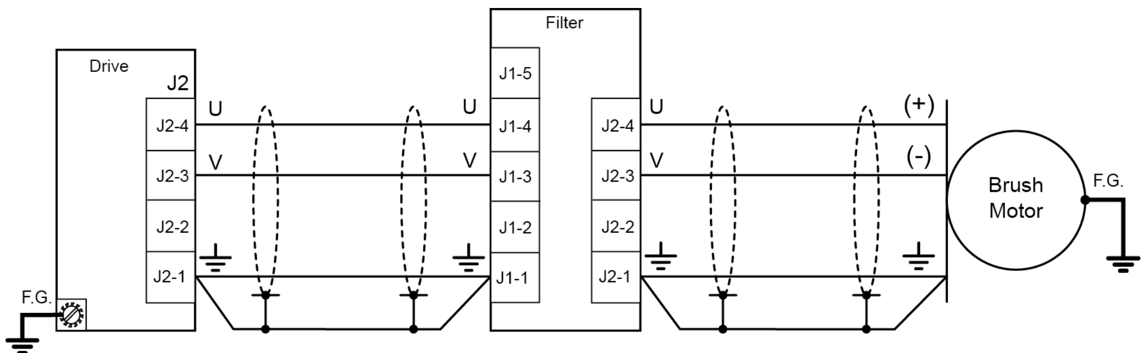


DIAGRAM: EDGE FILTER WIRING WITH BRUSH MOTOR

This is an example for a *Xenus Plus Compact* drive. Connector J2 on the drive is used for the output to the filter.



XTL-FA-01 EDGE FILTER ORDERING

FILTER

Model	Description
XTL-FA-01	Edge Filter for Xenus

CONNECTOR KIT

Model	Qty	Ref	Description	Mfr. Model No.
XTL-FK	1	J1	Plug, 5 position, 5.0 mm, female	Wago: 721-105/026-047
	1	J2	Plug, 4 position, 5.0 mm, female	Wago: 721-104/026-047
	2	--	Insertion / Extraction Tool	Wago: 231-131

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

D: CONNECTING XPC FOR SERIAL CONTROL

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

D.1: Single-Axis and Multi-Drop

An XPC drive's RS-232 serial bus can be used by CME 2 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.

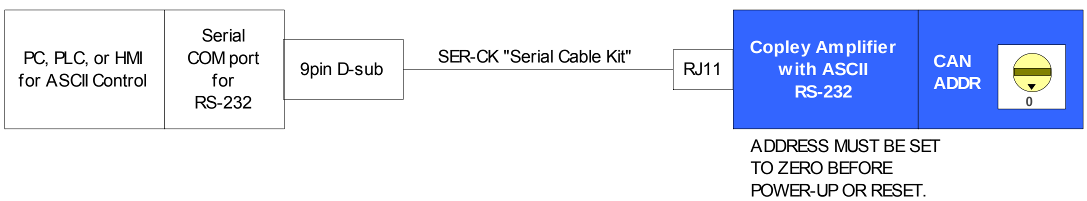
For experimentation and simple setup and control, a telnet device such as the standard Microsoft Windows HyperTerminal can also be used to send commands in ASCII format. For more information, see Copley Controls ASCII RS-232 User Guide.

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.

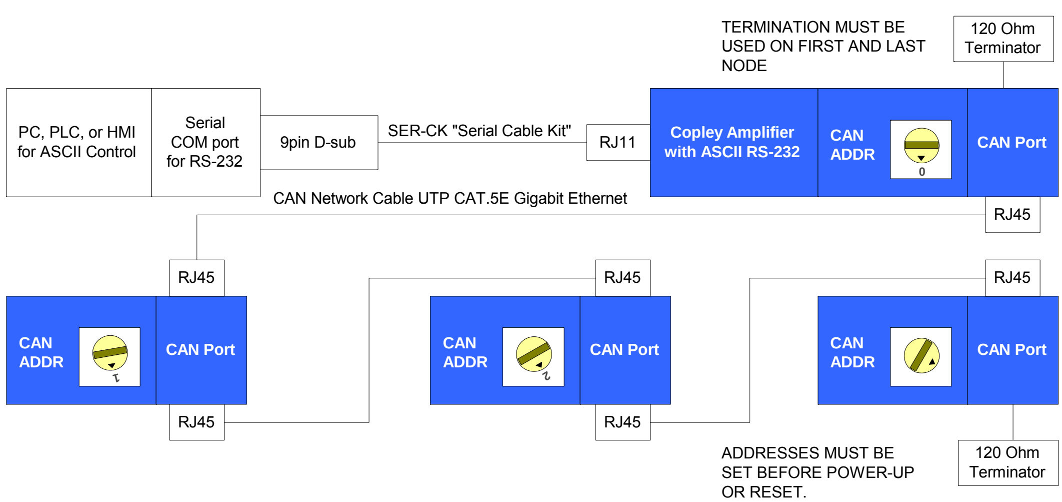
SINGLE-AXIS CONNECTIONS

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 XPC drive can be used as a multi-drop gateway for access to other XPC drives linked in a series of CAN bus connections. Set the CAN node address of the serially connected drive (gateway) to zero (0). Assign each additional drive in the chain a unique CAN node address value between 1 and 127. Use 120 Ohms termination on the first and last drive.



E: ORDERING GUIDE AND ACCESSORIES

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

E.1: Drive Model Numbers

XEC

Model	Description
XEC-230-09 (-R)	XEC Compact EtherCAT Servo drive 3/9 Adc
XEC-230-12 (-R)	XEC Compact EtherCAT Servo drive 6/12 Adc
XEC-230-15 (-R)	XEC Compact EtherCAT Servo drive 7.5/15 Adc

XPC

Model	Description
XPC-230-09 (-R)	XPC Compact EtherCAT Servo drive 3/9 Adc
XPC-230-12 (-R)	XPC Compact EtherCAT Servo drive 6/12 Adc
XPC-230-15 (-R)	XPC Compact EtherCAT Servo drive 7.5/15 Adc

801

Model	Description
801-1891	Compact EtherCAT Servo drive 3/9 Adc with custom resolver interface
801-1892	Compact EtherCAT Servo drive 6/12 Adc with custom resolver interface
801-1893	Compact EtherCAT Servo drive 7.5/15 Adc with custom resolver interface

E.2: Accessory Model Numbers

SOFTWARE

Model	Description
CME2	CME 2 Drive Configuration Software (Download)
CML	Copley Motion Libraries (Download, license required)
CMO	Copley Motion Objects (Download)
CPL	Copley Programming Language (Download, license required)

Links to these software releases can be found at: http://www.copleycontrols.com/Motion/Downloads/index.html

CONNECTOR KIT

Model	Qty	Ref	Name	Description	Mfr. Model No.
XEC-CK **XPC-CK** Connector Kit Note 3	1	J1	AC Pwr	Plug, 5 position, 5.08 mm, female	Wago: 231-305/107-000 (Note 1)
	1			Strain relief, snap-on, 5.08 mm, 5 position, orange	Wago: 232-635
	1	J2	Motor	Plug, 4 position, 5.08 mm, female	Wago: 231-304/107-000 (Note 1)
	1			Strain relief, snap-on, 5.08 mm, 4 position, orange	Wago: 232-634
		J1,J2	Tool	Tool, wire insertion & extraction, 231 series	Wago: 231-159
	1	J3	Brake	Plug, 4 position, 3.5 mm, female	Wago: 734-104/107-000 (Note 1)
	1			Strain relief, snap-on, 3.5 mm, 5 position, grey	Wago: 734-604
	1	J5	Tool	Tool, wire insertion & extraction, 734 series	Wago: 734-231
	1	J4 Note 2	Safety	Connector, DB-9M, 9-position, standard, male	TE/AMP: 205204-4
	9			AMPLIMITE HD-20 Crimp-Snap contacts, 24-20AWG, AU flash	TE/AMP: 66506-9
	1			Metal Backshell, DB-9, RoHS	3M: 3357-9209
	4			Jumper, with pins crimped on both ends	Copley: 10-75177-01
	1	J5	Feed-back	Connector, high-density DB-26M, 26 position, male, solder cup	Norcomp: 180-026-103L001
	1			Metal Backshell, DB-15, RoHS	3M: 3357-9215
	1	J6	Control	Connector, high-density DB-44M, 44 position, male, solder cup	Norcomp: 180-044-103L001
	1			Metal Backshell, DB-25, RoHS	3M: 3357-9225

Note 1: For RoHS compliance, append "/RN01-0000" to the Wago part numbers listed above.
Note 2: Insertion/extraction tool for J4 contacts is AMP/Tyco 91067-2 (not included in XEC-CK or XPC-CK)
Note 3: The 801-189x models can use the XEC-CK connector kit.

CANOPEN CONNECTOR KIT (XPC)

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

INDIVIDUAL CABLE ASSEMBLIES (AND RELATED ACCESSORIES)

Model	Ref	Description
SER-CK	J8	RS-232 Serial Cable Kit (for connecting PC to drive)
XPC-CV	J7	Sub-D 9-position female to RJ-45 adapter for XPC (PC to CANopen cable adapter)
XPC-NC-10		CAN bus Network Cable for XPC, 10 ft (3 m)
XPC-NC-01		CAN bus Network Cable for XPC, 1 ft (0.3 m)
XPC-NT		CAN bus Network Terminator for XPC
XEC-NC-10		EtherCAT Network Cable for XEC, 10 ft (3 m)
XEC-NC-01		EtherCAT Network Cable for XEC, 1 ft (0.3 m)

E.3: Edge Filter

Model	Description
XTL-FA-01	Edge Filter for Xenus

XTL-FA-01 EDGE FILTER CONNECTOR KIT

Model	Qty	Ref	Description	Mfr. Model No.
XTL-FK	1	J1	Plug, 5 position, 5.0 mm, female	Wago: 721-104/026-047
	1	J2	Plug, 4 position, 5.0 mm, female	Wago: 721-105/026-047
	2	--	Insertion / Extraction Tool	Wago 231-131

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

E.4: Order Example

Order 1: XEC-230-12 drive with connector kit, and serial cable kit:

Qty	Item	Description
1	XEC-230-12	XEC Compact EtherCAT Servo drive
1	XEC-CK	Connector Kit with solder cup connectors
1	SER-CK	Serial Cable Kit for connecting the PC to the drive

Xenus Plus Compact User Guide

P/N 16-01552

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