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Xenus XSL™ User Guide



Copley Controls Corp.

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This page for notes.

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TABLE OF CONTENTS

About This Manual **8**
Overview and Scope 8
Related Documentation 8
Comments 8
Copyrights 8
Document Validity 8
Product Warnings 9
Revision History 10
1: Introduction **11**
1.1: Amplifier 12
1.2: CME 2 13
1.3: CMO/CML 13
2: Operational Theory **15**
2.1: Amplifier Internal Power 16
2.1.1: Logic/Signal Power 16
2.1.2: High Voltage 16
2.1.3: Power and Grounding Diagram 17
2.2: Synchronizing PWM Switching Frequency 18
2.3: Commutation Modes 18
2.4: Feedback 18
2.4.1: Encoder and Resolver Support 18
2.4.2: Secondary Encoder Interface 18
2.5: Operating Modes 19
2.5.1: Modes and Control Loops 19
2.5.2: Current Mode and Current Loop 20
2.5.3: Velocity Mode and Velocity Loop 22
2.5.4: Position Mode and Position Loop 24
2.5.5: Input Command Types 25
2.5.6: Analog Command Input 25
2.5.7: PWM Input 27
2.5.8: Digital Input 28
2.5.9: CVM Program 29
2.6: CANopen Operation 30
2.6.1: CAN Network and CANopen Profiles for Motion 30
2.6.2: Supported CANopen Modes 30
2.6.3: Architecture 31
2.6.4: CAN Addressing 31
2.7: Limit Switches 32
2.7.1: Use Digital Inputs to Connect Limit Switches 32
2.7.2: Diagram: Sample Placement of Limit Switches 32
2.7.3: How the Amplifier Responds to Limit Switch Activation 32
2.7.4: Using Custom Output to Signal Limit Switch Activation 32
2.8: Brake Operation 33
2.8.1: Digital Output Controls Brake 33
2.8.2: Brake/Stop Sequences 33
2.9: Status Indicators 34
2.9.1: Amplifier and CAN Interface Status Indicators 34
2.9.2: Amplifier Status Indicator Operation 34
2.9.3: CAN Interface Status Indicator Operation 35
2.10: Protection 36
2.10.1: Faults 36
2.11: Position and Velocity Errors 38
2.11.1: Error-Handling Methods 38
2.11.2: Following Error Faults 38
2.11.3: Following Error Warnings 38
2.11.4: Position and Velocity Tracking Windows 38
2.11.5: Following Error Fault Details 39
2.11.6: Tracking Window Details 40
2.12: Communication 41
2.12.1: Communication Interfaces 41
2.12.2: CME 2 and CAN Operation 41
2.13: Inputs 42
2.13.1: Digital Inputs 42
2.13.2: Input Filters 42
2.13.3: Debounce Time 42
2.13.4: Configure for Pull Up/Pull Down Resistors by Groups 42
2.13.5: Programmable Input Functions 42
2.14: Outputs 44
2.14.1: Digital Outputs 44
2.14.2: Standard Programmable Output Functions 44

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2.14.3: Custom Output Functions ... 45
2.15: Regen Resistor Theory ... 47
2.15.1: Regeneration ... 47
2.15.2: Regen Resistor ... 47
2.15.3: Regen Circuit Components ... 47
2.15.4: Regen Circuit Protections ... 47
2.15.5: Configurable Custom Resistor ... 47
3: Specifications ... 49
3.1: Agency Approvals ... 50
3.2: Power Input ... 50
3.3: Power Output ... 50
3.4: Control Loops ... 51
3.5: Regen Circuit Output ... 51
3.6: Digital Command Input ... 51
3.7: Analog Command Input ... 52
3.8: Digital Inputs ... 52
3.9: Digital Outputs ... 52
3.10: Brake Output ... 53
3.11: Encoder Power Supply Output ... 53
3.12: Primary and Secondary Encoder Inputs ... 53
3.13: Analog Encoder Inputs ... 53
3.14: Hall Switch Inputs ... 54
3.15: Resolver Interface ... 54
3.16: Encoder Outputs ... 54
3.17: Serial Interface ... 54
3.18: CAN Interface ... 55
3.19: Status Indicators ... 55
3.20: Fault Levels ... 55
3.21: Power Dissipation ... 56
3.22: Thermal Impedance ... 56
3.23: Mechanical and Environmental ... 56
3.24: Dimensions ... 57
4: Wiring ... 59
4.1: General Wiring Instructions ... 60
4.1.1: Electrical Codes and Warnings ... 60
4.1.2: Grounding Considerations ... 60
4.1.3: Connector Locations ... 61
4.2: AC Mains (J1) ... 62
4.3: Motor (J2) ... 63
4.4: Regen Resistor (J3) (Optional) ... 64
4.5: Logic Supply / Brake (J4) ... 65
4.6: RS-232 Serial Communications (J5) ... 66
4.7: CAN Bus (J6) ... 67
Control (J7) ... 68
4.8: Motor Feedback (J8) ... 72
5: Quick Setup with CME 2 ... 77
5.1: Warnings ... 78
5.2: CME 2 Installation and Serial Port Setup ... 79
5.2.1: Requirements ... 79
5.2.2: Downloading Software from Web (Optional) ... 79
5.2.3: Installing CME 2 Software ... 79
5.2.4: Serial Port Setup ... 80
5.3: Prerequisites ... 82
5.3.1: Hardware and Equipment ... 82
5.3.2: Starting CME 2 and Choosing an Amplifier ... 83
5.4: Basic Setup ... 84
5.4.1: Basic Setup Screen ... 84
5.5: Motor Setup ... 86
5.5.1: Motor Data File ... 86
5.5.2: Rotary Motor ... 87
5.5.3: Linear Motor ... 88
5.6: Feedback Setup ... 89
5.6.1: Overview ... 89
5.6.2: Rotary Motor Feedback Setup Options ... 90
5.6.3: Linear Motor Feedback Setup Options ... 90
5.7: Brake/Stop (Optional) ... 91
5.7.1: Overview ... 91
5.7.2: Procedure ... 91
5.7.3: Calculate ... 92
5.8: Amplifier Configuration ... 93
5.8.1: Digital Inputs ... 93
5.8.2: Standard Digital Outputs ... 95

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5.8.3: Custom Digital Outputs 96
5.8.4: Save Input/Output Changes 96
5.8.5: Fault Latching 97
5.8.6: Regen Resistor 98
5.9: Command Input 98
5.9.1: Analog Input 99
5.9.2: PWM Input 101
5.9.3: Digital Position Input 102
5.9.4: CAN Interface 104
5.10: Auto Phase 105
5.10.1: Auto Phase Warnings and Notes 105
5.10.2: Auto Phase Procedure 106
5.10.3: Guidelines for Choosing Auto Phase Current and Increment Rate Values 109
5.10.4: Trouble Shoot Motor Direction Setup 109
5.10.5: Trouble Shoot Motor Wiring Setup 109
5.10.6: Trouble Shoot Halls Wiring Setup 109
5.10.7: Other Problems 109
5.11: Current Loop 110
5.11.1: Current Loop Settings 110
5.11.2: Manually Tune Current Loop 111
5.12: Velocity Loop 113
5.12.1: Velocity Loop Settings 113
5.12.2: Manually Tune the Velocity Loop 114
5.13: Position Loop 115
5.13.1: Position Loop Settings 115
5.13.2: Manually Tune the Position Loop 116
5.13.3: Test S-Curve Profile 118
5.14: Completion Steps 119
5.14.1: Objective 119
5.14.2: Steps 119
6: Using CME 2 121
6.1: CME 2 Overview 122
6.1.1: Main Screen Overview 122
6.1.2: Tool Bar Overview 122
6.1.3: Main Menu Overview 123
6.1.4: Functional Diagram 124
6.1.5: CAN Information and Status Bar 125
6.1.6: Choosing an Amplifier from a List of Amplifiers 125
6.1.7: Renaming an Amplifier 125
6.2: Manage Amplifier and Motor Data 126
6.2.1: Memory 126
6.2.2: Disk Storage 126
6.2.3: Data Management Tools 127
6.2.4: Quick Copy Setup Procedure 128
6.3: Downloading Firmware 129
6.3.1: Acquiring Firmware from Web Site (Optional) 129
6.3.2: Downloading Firmware to Amplifier 130
6.4: Control Panel 131
6.4.1: Control Panel Overview 131
6.4.2: Status Indicators and Messages 131
6.4.3: Monitor Functions 132
6.4.4: Control Functions 133
6.4.5: Jog Mode 133
6.5: Scope Tool 134
6.5.1: Scope Tool Overview 134
6.5.2: Function Generator and Profile Tabs 135
6.5.3: Scope Settings 136
6.5.4: Scope Tool Controls 139
6.5.5: Control Loop Parameters in the Scope Tool 139
6.5.6: Scope Files 141
6.6: Error Log and Communications Log 142
6.6.1: Error Log 142
6.6.2: Communications Log 143
6.7: CME 2 Virtual Amplifier 144
6.7.1: Virtual Amplifier Overview 144
6.7.2: Virtual Amplifier Creation 144
6.8: Manual Phasing 145
6.8.1: Manual Phase Objectives 145
6.8.2: Manual Phase Instructions, Standard (Non-Resolver) Xenus 145
6.8.3: Manual Phase Instructions, Resolver (-R) Xenus 147
6.8.4: Troubleshooting Manual Phase With Halls and Encoder 148
6.8.5: Verify Motor Pole Count 148

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6.9: Auto Tune Current Loop 149
6.9.1: Auto Tune Objective 149
6.9.2: Auto Tune Instructions 149
6.10: Home Function 152
6.10.1: Overview 152
6.10.2: Homing Functions Settings 152
A: Regen Resistor Sizing and Configuration 153
A.1: Sizing a Regen Resistor 154
A.1.1: Gather Required Information 154
A.1.2: Observe the Properties of Each Deceleration During a Complete Cycle of Operation 154
A.1.3: Calculate Energy Returned for Each Deceleration 155
A.1.4: Determine the Amount of Energy Dissipated by the Motor 155
A.1.5: Determine the Amount of Energy Returned to the Amplifier 155
A.1.6: Determine if Energy Returned Exceeds Amplifier Capacity 156
A.1.7: Calculate Energy to be Dissipated for Each Deceleration 156
A.1.8: Calculate Pulse Power of Each Deceleration that Exceeds Amplifier Capacity 156
A.1.9: Calculate Resistance Needed to Dissipate the Pulse Power 156
A.1.10: Calculate Continuous Power to be Dissipated 157
A.1.11: Select Fuses 157
A.2: Configuring a Custom Regen Resistor 158
A.2.1: Regen Configuration Objective and Warning 158
A.2.2: Regen Configuration Instructions 158
B: I^2T Time Limit Algorithm 161
B.1: I^2T Algorithm 162
B.1.1: I^2T Overview 162
B.1.2: I^2T Formulas and Algorithm Operation 162
B.1.3: I^2T Current Limit Algorithm – Application Example 163
C: Velocity Loop Filters 167
C.1: Advanced Velocity Loop Filter 167
C.1.1: Filter Overview 167
C.1.2: Filter Instructions and Details 167
D: Thermal Considerations 169
D.1: Operating Temperature and Cooling Configurations 170
D.1.2: Heatsink and Fan Configurations 171
D.2: Heatsink Mounting Instructions 172
E: Xenus Filter 173
E.1: Overview 174
E.1.1: Differential and Common Mode Filtering 174
E.1.2: Description and Functional Diagram 174
E.1.3: PWM Output Plot 174
E.2: XSL-FA-01 Edge Filter Specifications 175
E.3: Thermal Considerations 175
E.4: XSL-FA-01 Edge Filter Dimensions 176
E.5: XSL-FA-01 Edge Filter Wiring 177
E.5.2: Electrical Codes and Warnings 177
E.5.2: Connector Locations 178
E.5.3: Cable Notes 179
E.5.4: Input (J1) From Amplifier 179
E.5.5: Output (J2) To Motor 179
E.5.6: Diagram: Edge Filter Wiring with Brushless Motor 180
E.5.7: Diagram: Edge Filter Wiring with Brush Motor 180
E.6: XSL-FA-01 Edge Filter Ordering 181
F: Connecting for Serial Control 183
F.1: Single-Axis and Multi-Drop 184
F.1.2: Single-Axis Connections 184
F.1.3: Multi-Drop Network Connections 184
G: ServoTube Motor Setup 185
G.1: ServoTube Setup and Configuration 186
G.1.1: ServoTube Basic Setup Screen Options 186
G.1.2: ServoTube Motor/Feedback Setup 187
G.1.3: Calculating ServoTube Initial Values 188
G.1.4: Setting Up the Motor Over Temperature Input 188
G.1.5: Other ServoTube I/O and Fault Latching Setup Steps 188
G.2: ServoTube Auto Phase and Manual Phase 189
G.2.1: ServoTube Auto Phase 189
G.2.2: ServoTube Manual Phase 192
G.3: Special ServoTube Setup Completion 192
H: Ordering Guide and Accessories 193
H.1: Amplifier Model Numbers 194
H.2: Accessory Model Numbers 194
H.3: Order Example 195
H.4: Control and Feedback Cable Color Codes 196

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H.4.1: Wire Description Nomenclature 196
H.4.2: Control Cable (XSL-CC-10) 196
H.4.3: Feedback (XSL-FC-10) 197
H.5: Regen Resistor Specifications 198
H.5.1: XTL-RA-03, XTL-RA-04 Specifications 198
H.5.2: XTL-RA-03, XTL-RA-04 Dimensions 198
H.5.3: XSL-RA-01, 02 (Discontinued) Specifications 199
H.5.4: XSL-RA-01, 02 (Discontinued) Dimensions 199

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ABOUT THIS MANUAL

Overview and Scope

This manual describes the operation and installation of the Xenus amplifier manufactured by Copley Controls Corporation.

Related Documentation

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

- *CANopen Programmer's Manual*
- *CML Reference Manual*
- *Copley Motion Objects Programmer's Guide*

Also of related interest:

- *Copley Indexer Program User's Guide* (describes use of Indexer Program to create motion control sequences)
- *Copley Controls ASCII RS-232 User Guide* (describes how to send ASCII format commands over an amplifier's serial bus to set up and control one or more amplifiers)

Information on Copley Controls Software can be found at:
http://www.copleycontrols.com/Motion/Products/Software/index.html

Comments

Copley Controls Corporation welcomes your comments on this manual. See http://www.copleycontrols.com for contact information.

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Product Warnings

Observe all relevant state, regional, and local safety regulations when installing and using this product. For safety and to assure compliance with documented system data, only Copley Controls Corporation should perform repairs to amplifiers.



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 on J1, J2, and J3 are connected to mains power.

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



DANGER

Risk of unexpected motion with non-latched faults.

After the cause of a non-latched fault is corrected, the amplifier 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 CAN operations.

When operating the amplifier as a CAN node, the use of CME 2 or ASCII serial commands may affect CAN operations in progress. Using such commands to initiate motion may cause CAN operations to suspend.

CAN 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 amplifier re-enables without operator intervention. In this case, motion may re-start unexpectedly.

For more information, see Clearing Non-Latched Faults (p. 36).

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



DANGER

Use equipment as described.

Operate amplifiers within the specifications provided in this manual.

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

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Revision History

Revision	Date	DECO #	Comments
1.0	June 2003		Initial publication.
1.1	July 2003		New CAN termination plug requires documentation changes in CAN Interface (p. 55) and CAN Bus (J6) (p. 67).
2.0	April 2005		Support for resolvers and dual feedback configurations, and emulated digital encoder output source. See Feedback (p. 18). Copley Virtual Machine (CVM) and Indexer Program for writing motion control sequences to run on the Xenus. See CVM Program (p. 29). Xenus filter. See Xenus Filter (p.173). High res input. See General Programmable Input Functions (p. 43). Velocity loop input filter. See Velocity Loop Filters (p. 167). Position loop Gain Multiplier. See Position Mode and Position Loop (p. 24). Over Current fault. See Fault Descriptions (p. 37.) RS-232 multi-drop serial control. See Connecting for Serial Control (p. 183). New CAN addressing interface. See CAN Interface (p. 104). New CME 2 homing function for setting up and testing homing moves. See Home Function (p. 152).
3	April 2006	12526	Changed drawing in Heatsink Mounting Instructions (p. 172) to clarify that two sheets of clear plastic carrier should be removed from phase change material and discarded.
4	April 2006	14711	Internal version control adjustment.
5	January 2008	16585	Add XSL to title to avoid confusion with Xenus XTL document.
6	June 2008	17112	Changes to Control and Feedback Cable Color Codes (p. 196) and Regen Resistor Specifications (p. 198).
7	June 2008	17137	Updated Web page references.

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CHAPTER 1: INTRODUCTION

This chapter provides an overview of Copley Controls' Xenus amplifier.

Contents include:

Title	Page
1.1: Amplifier	12
1.2: CME 2	13
1.3: CMO/CML	13

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1.1: Amplifier

Xenus provides 100% digital control of brushless or brush motors in an off-line powered package. It can also control a Copley Controls ServoTube motor (see ServoTube Setup, p. 84). Xenus can operate from single or three-phase mains with a continuous power output of up to 4 kW.

Xenus is offered in two versions to support three types of feedback devices. The standard version supports digital quadrature or analog sin/cos encoders. The -R version supports brushless resolvers. Both versions can emulate a digital quadrature encoder output from the analog encoder or resolver respectively

Xenus can operate in several basic ways:

- As a traditional motor amplifier accepting current, velocity or position commands from an external controller. In current and velocity modes it 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 amplifier to take instruction from a master application over a CAN network to perform torque, velocity, and position profiling, interpolated motion, and homing operations. Multiple drives can be tightly synchronized for high performance coordinated motion.
- As a stand-alone controller running Copley Virtual Machine (CVM) control programs such as the Indexer Program. It can also be controlled directly over an RS232 serial link with simple ASCII format commands.

Mains input voltage to the amplifier can range from 100 to 240 Vac, single or three-phase, and 47 to 63 Hz. This allows Xenus the ability to work in the widest possible range of industrial settings. Several models are available, with peak current ratings of 18 to 40 amps:

Model		Continuous Current	Peak Current	Vac
Encoder	Resolver			
XSL-230-18	XSL-230-18-R	6 A	18 A	100 to 240
XSL-230-36	XSL-230-36-R	12 A	36 A	
XSL-230-40	XSL-230-40-R	20 A	40 A	

A separate +24 Vdc logic supply powers 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 amplifier for safety reasons, but allows the logic side of the amplifier to stay powered. This allows the amplifier to retain position information and maintain communication through the digital I/O or over the serial or CAN ports when disconnected from the mains.

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1.2: CME 2

Amplifier commissioning is fast and simple using Copley Controls CME 2 software. CME 2 communicates with Xenus via an RS-232 link, and all of the operations needed to configure the amplifier are accessible through CME 2.

The multi-drop feature allows CME 2 to a single RS-232 serial connection to one amplifier as a gateway to other amplifiers 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 or resolver wire swapping to establish the direction of positive motion is also eliminated.

Motor data can be saved as *.ccm* files. Amplifier data is saved as *.ccx* files that contain all amplifier settings plus motor data. This makes it possible to quickly set up amplifiers by copying configurations from one amplifier to another.

1.3: CMO/CML

Copley Motion Libraries (CML) and Copley Motion Objects (CMO) make CANopen system 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 an amplifier over the CANopen network. CMO provides a similar suite of COM objects that can be used by Visual Basic, .NET, LabVIEW, or any other program supporting the Microsoft COM object interface.

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CHAPTER 2: OPERATIONAL THEORY

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

Title	Page
2.1: Amplifier Internal Power	16
2.2: Synchronizing PWM Switching Frequency	18
2.3: Commutation Modes	18
2.4: Feedback	18
2.5: Operating Modes	19
2.6: CANopen Operation	30
2.7: Limit Switches	32
2.8: Brake Operation	33
2.9: Status Indicators	34
2.10: Protection	36
2.11: Position and Velocity Errors	38
2.12: Communication	41
2.13: Inputs	42
2.14: Outputs	44
2.15: Regen Resistor Theory	47

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2.1: Amplifier Internal Power

Power distribution within Xenus is divided into three sections: +24 Vdc, logic/signal, and high voltage. Each is isolated from the other.

2.1.1: 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. All the digital and analog inputs, digital outputs (with the exception of OUT4), Hall and encoder inputs are referenced to the same signal common. OUT4 is controlled through an opto-isolator, and is referenced to the +24 Vdc return. The CAN interface is also optically isolated.

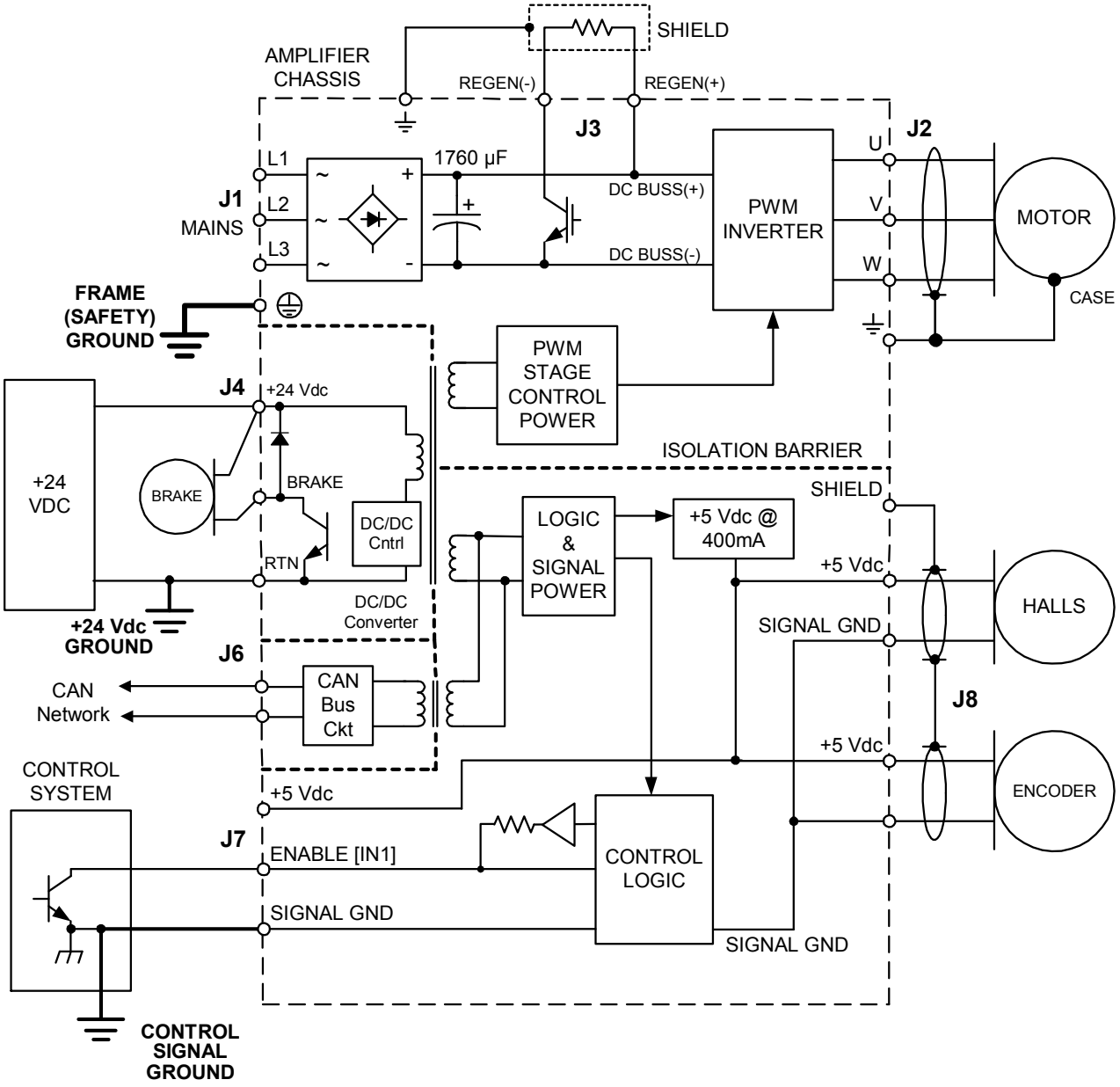
Deriving internal operating voltages from a separate source enables the amplifier to stay on-line when the mains have been disconnected for emergency-stop or operator-intervention conditions. This allows CAN bus and serial communications to remain active so that the amplifier can be monitored by the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

2.1.2: 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 external 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.

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2.1.3: Power and Grounding Diagram



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2.2: Synchronizing PWM Switching Frequency

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

2.3: Commutation Modes

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

In most applications, sinusoidal commutation is preferred over trapezoidal, because it reduces torque ripple and offers the smoothest motion at any velocity or torque. In the sinusoidal commutation mode, an encoder or a resolver are required for all modes of operation.

In AC brushless trapezoidal commutation mode, the amplifier provides traditional six-step commutation.

When driving a DC brush motor, the amplifier operates as a traditional H-Bridge amplifier.

2.4: Feedback

2.4.1: Encoder and Resolver Support

The Xenus amplifier is offered in two versions to support encoder or resolver feedback. The encoder version supports digital quadrature or analog sin/cos encoders. This version normally requires the use of Hall switches for the commutation of brushless motors. The resolver version supports standard, single speed, transmit-type resolvers.

2.4.2: Secondary Encoder Interface

Both versions support a secondary encoder interface. This interface can be configured to:

- Provide a buffered digital encoder output based on the digital encoder input.
- Provide an emulated digital encoder output based on the analog encoder or resolver input.
- 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 or resolver provides velocity loop feedback.

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2.5: Operating Modes

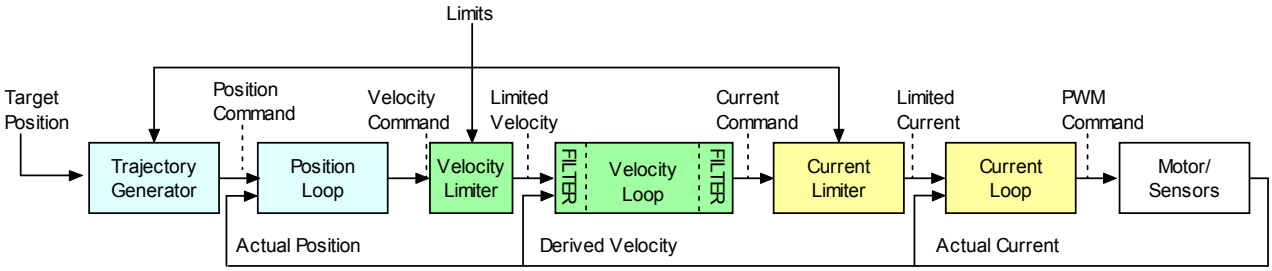
2.5.1: Modes and Control Loops

Nesting of Control Loops and Modes

Copley Controls amplifiers 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 amplifier 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:

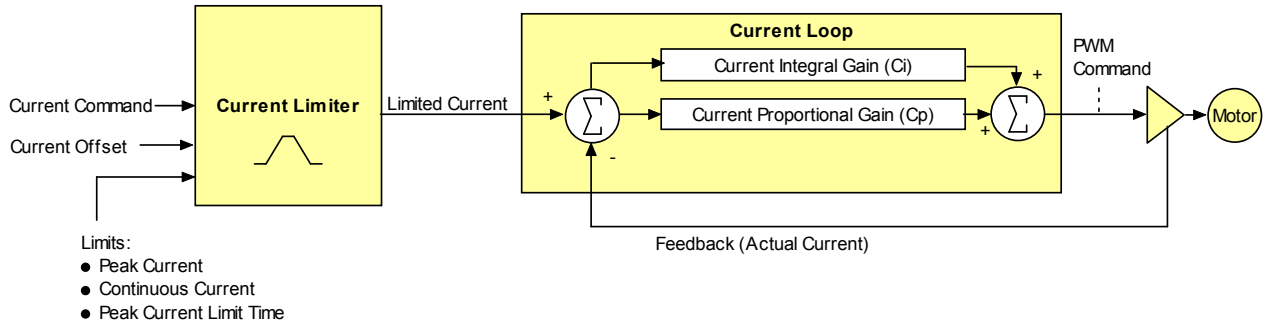
Loop Attribute	Description
Command input	Every loop is given a value to which it will attempt to control. For example, the velocity loop receives a velocity command that is the desired motor speed.
Limits	Limits are set on each loop to protect the motor and/or mechanical system.
Feedback	The nature of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

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2.5.2: 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 commanded current, 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 amplifier’s power stage.



Current Loop Inputs

- The amplifier’s analog or PWM inputs.
- A CANopen network via the amplifier’s CAN interface.
- A Copley Virtual Motion (CVM) control program.
- The amplifier’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 amplifier for a short duration of time. This value cannot exceed the peak current rating of the amplifier.
Continuous Current Limit	Maximum current that can be constantly generated by the amplifier.
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. 161). Note: Although the current limits set by the user may exceed the amplifier's internal limits, the amplifier 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. Used to limit jog moves initiated from the Control Panel Jog function in current mode, and in advanced Indexer Program functions.

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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 amplifier.

Auto Tune

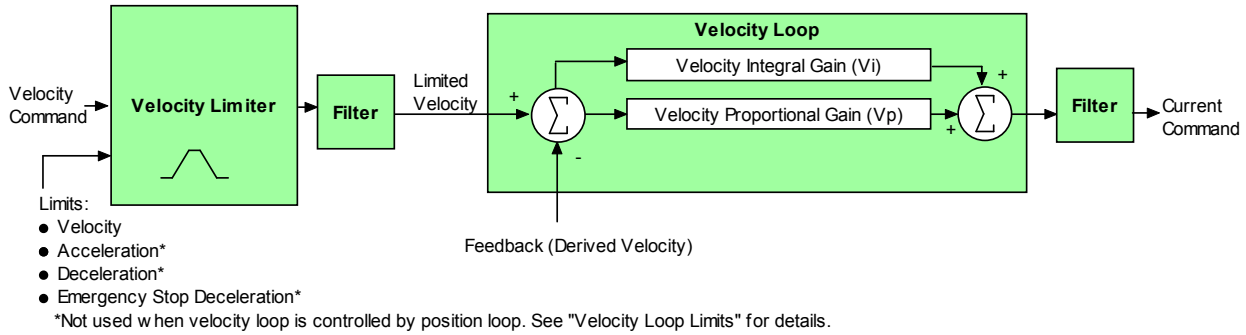
CME 2 provides an Auto Tune feature, which automatically determines optimal Cp and Ci values for the motor. For more information, see Auto Tune Current Loop (p. 149).

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2.5.3: 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 amplifier's analog or PWM inputs.
- A CANopen network via the amplifier's CAN interface.
- A Copley Virtual Motion (CVM) control program.
- The amplifier's internal function generator.

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

Velocity Loop Limits

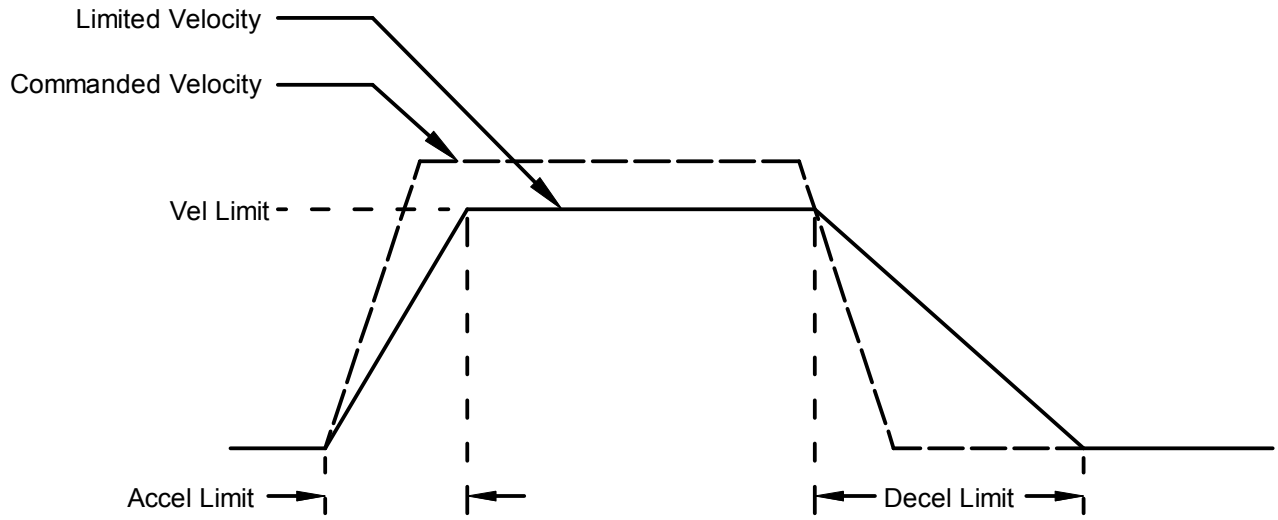
The velocity command is limited based on the following set of parameters designed to protect the motor and/or the mechanical system.

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. In position mode, the trajectory generator handles acceleration limiting.
Deceleration Limit	Limits the maximum deceleration rate of the commanded velocity input to the velocity loop. This limit is used in velocity mode only. In position mode, the trajectory generator handles deceleration limiting.
Fast Stop Ramp	Specifies the deceleration rate used by the velocity loop when the amplifier is hardware disabled. (Fast stop ramp is not used when amplifier is software disabled.) If the brake output is active, 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 amplifier drops into velocity mode and the Fast Stop Ramp is used. For more information, see Following Error Fault Details (p. 39).

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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 Loop Gains Scalar

The *Enable Gains Scalar* feature increases the resolution of the units used to express Vp and Vi, providing more precise tuning. This feature is used when tuning results in non-scaled Vp or Vi values of 64 or less. Such low values are likely to be called for when tuning a linear motor with an encoder resolution finer than a micrometer.

Velocity Loop Command and Output Filters

The velocity loop contains two programmable digital filters. The input filter should be used to reduce the effects of a noisy velocity command signal. The output filter 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, see Velocity Loop Filters (p.167).

Velocity Loop Outputs

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

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2.5.4: Position Mode and Position Loop

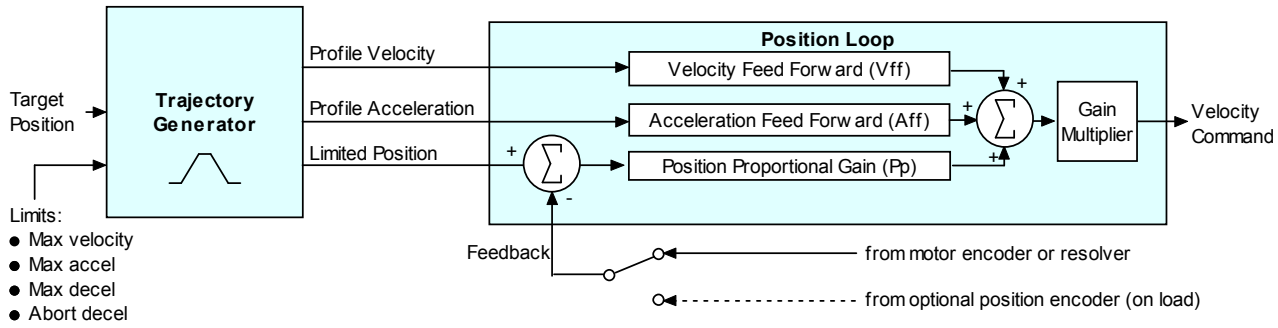
Position Loop Diagram

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

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

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.

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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 supports two position feedback configurations

- Single sensor. Position loop feedback comes from the encoder or resolver 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 or resolver.) For more information, see Feedback (p. 18).

Position Loop Output

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

2.5.5: Input Command Types

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

2.5.6: Analog Command Input

Overview

The amplifier can be driven by an analog voltage signal through the analog command input. The amplifier 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 amplifier's peak current output; +5 Vdc equals half of that.

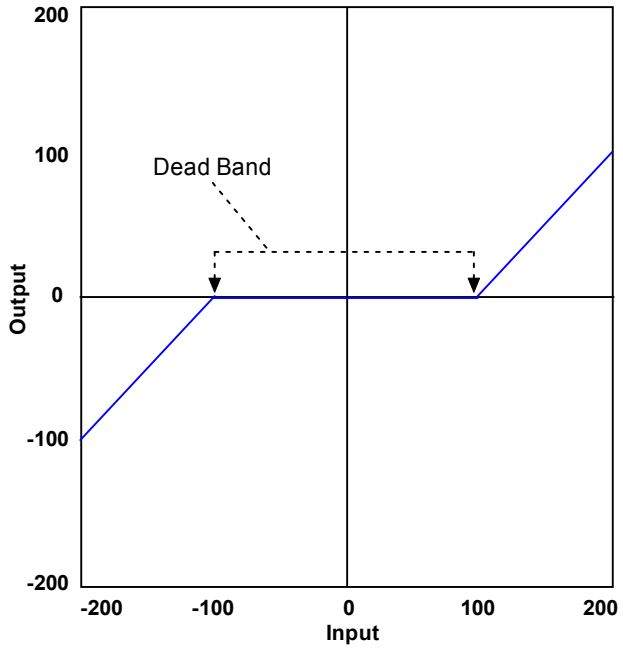
Scaling could also be useful if, for example, the signal source generates a signal range between 0 and +10 Vdc, but the command range only requires +7.5 Vdc of input. In this case, scaling allows the amplifier to equate +7.5 Vdc with the amplifier's peak current (in current mode) or maximum velocity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

Dead Band

To protect against unintended response to low-level line noise or interference, the amplifier can be programmed with a "dead band" to condition the response to the input signal voltage. The

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amplifier 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 amplifier 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 amplifier 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 amplifier 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 oscilloscope. The voltage displayed in both cases is after both offset and deadband have been applied.

Analog Command in Position Mode

The Xenus Analog Position command operates as a relative motion command. When the amplifier 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 amplifier should be homed every time it is enabled. The Homing sequence may be initiated by CAN, ASCII serial, or CVM Indexer program commands.

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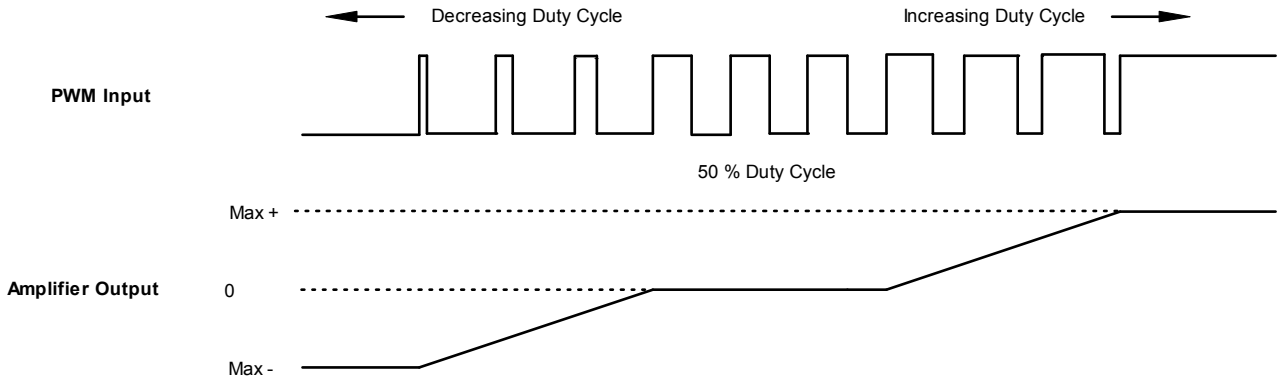
2.5.7: PWM Input

Two Formats

The amplifier 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)

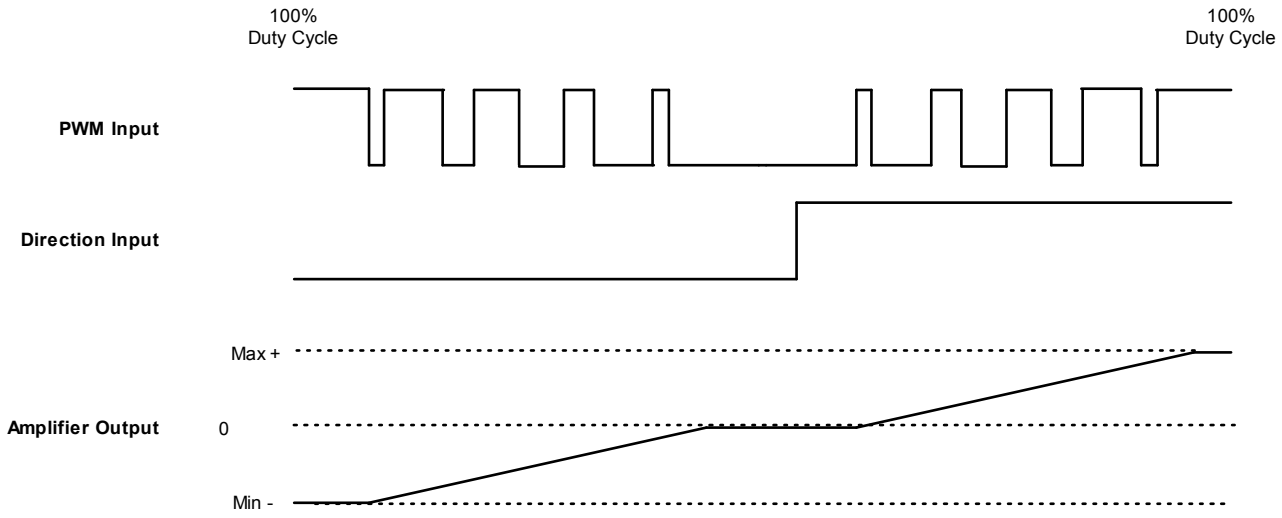
The input takes a PWM waveform of fixed frequency and variable duty cycle. As shown below, a 50% duty cycle produces zero output from the amplifier. Increasing the duty cycle toward 100% commands a positive output, and decreasing the duty cycle toward zero commands a negative output.



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 amplifier 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.

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2.5.8: Digital Input

Three Formats

In position mode, the amplifier 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 amplifier can be configured to invert the command.

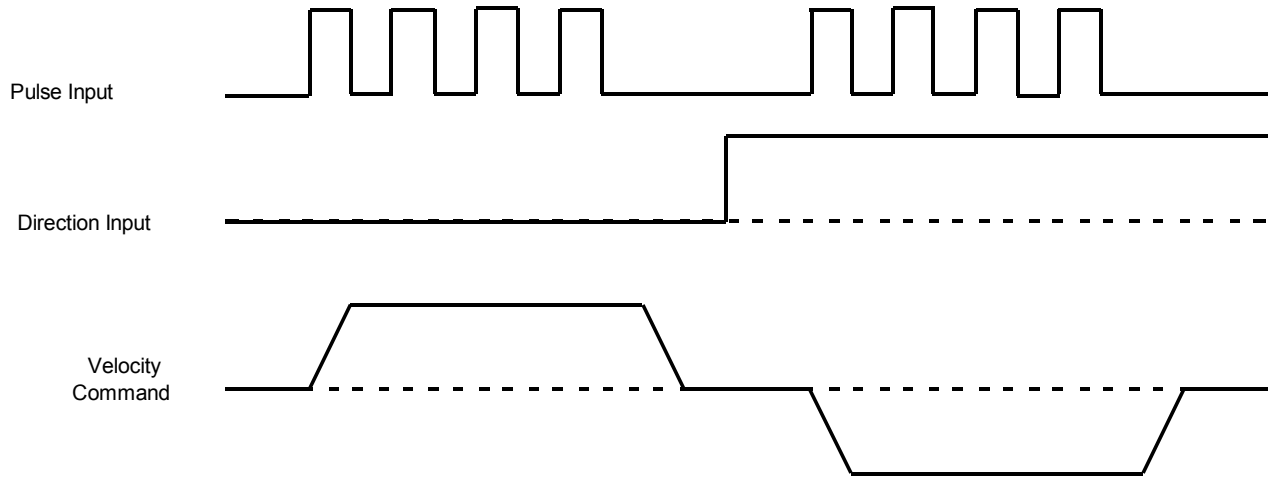
Pulse Smoothing

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

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

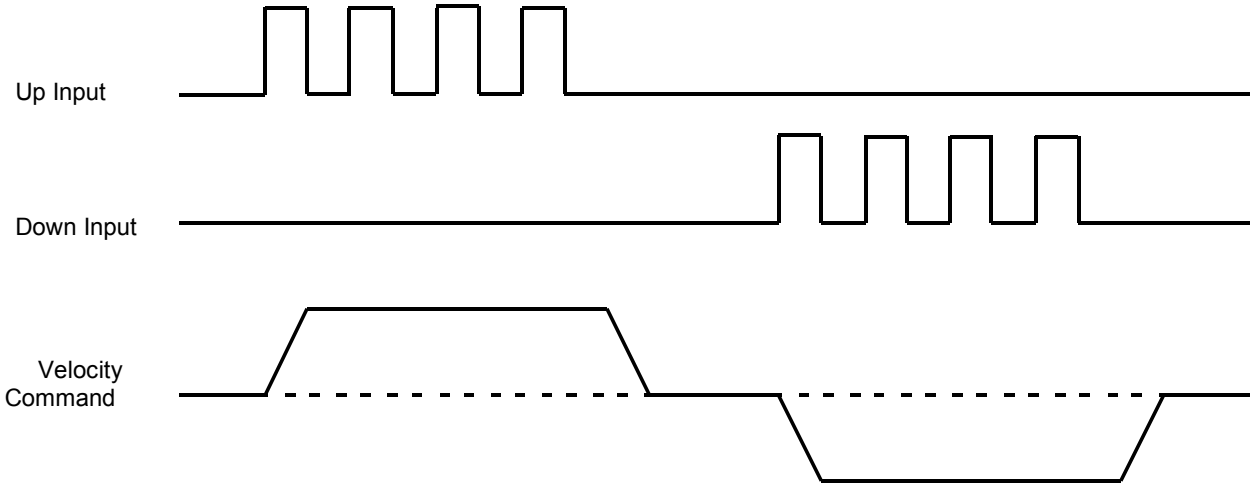


The amplifier can be set to increment position on the rising or falling edge of the signal. Stepping resolution can be programmed for electronic gearing.

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Count Up/Count Down Format

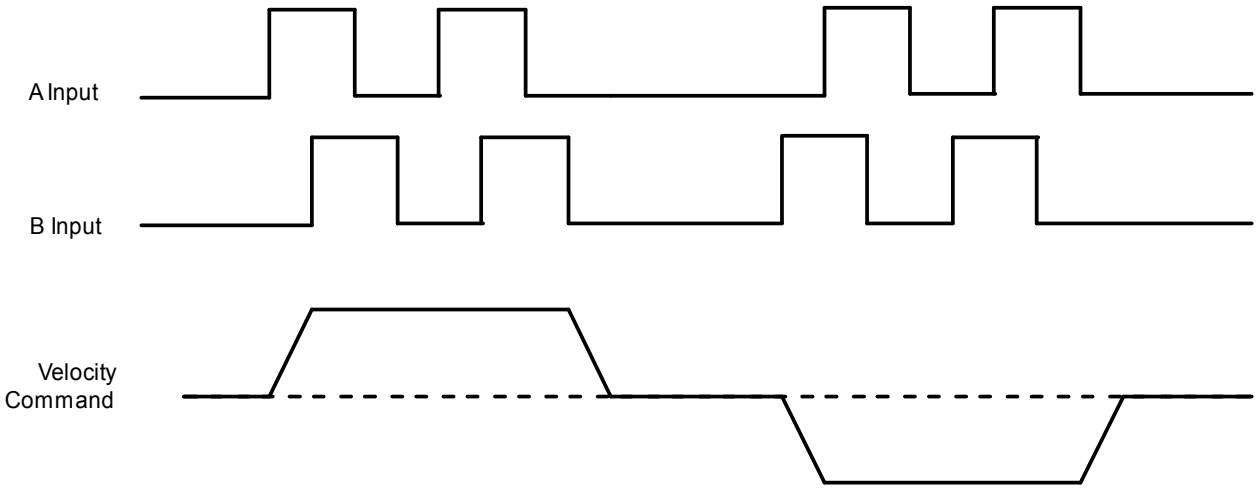
In the count up/count down format, one input takes each pulse as a positive step command, and another takes each pulse as a negative step command, as shown below.



The amplifier 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.

2.5.9: CVM Program

The Copley Virtual Machine (CVM) is a software program that runs motion control programs on supported Copley Controls amplifiers. When a CVM program is running, the amplifier receives input commands from the CVM program.

For more information, see the *Copley Indexer Program User's Guide*.

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2.6: CANopen Operation

2.6.1: CAN Network and CANopen Profiles for Motion

In position mode, the amplifier can take instruction 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 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.

2.6.2: Supported CANopen Modes

In profile torque mode, the amplifier is programmed with a torque command. When the amplifier is enabled, or the torque command is changed, the motor torque ramps to the new value at a programmable rate. When the amplifier is halted, the torque ramps down at the same rate.

In profile velocity mode, the amplifier is programmed with a velocity, a direction, and acceleration and deceleration rates. When the amplifier is enabled, the motor accelerates to the set velocity and continues at that speed. When the amplifier is halted, the velocity decelerates to zero.

In profile position mode, the amplifier is programmed with a velocity, a relative distance or absolute position, and acceleration and deceleration rates. On command, a complete motion profile is executed, traveling the programmed distance or ending at the programmed position. The amplifier supports both trapezoidal and s-curve profiles.

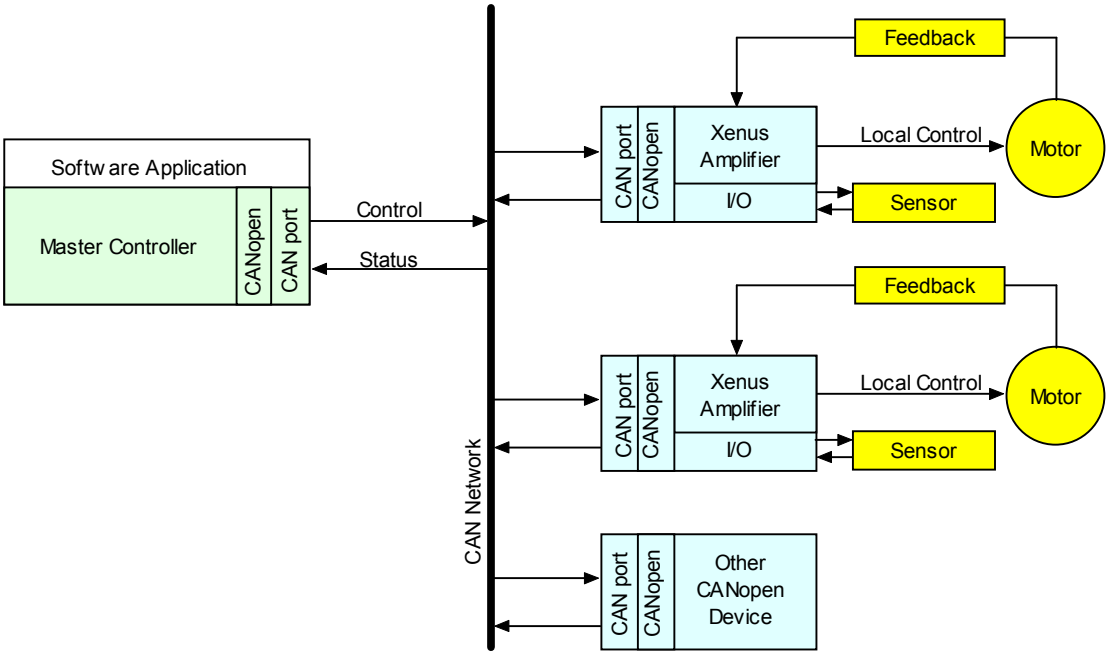
In PVT mode, the controller sends a sequence of points to the amplifier, each of which is a segment of a larger, more complex move, rather than a single index or profile. The amplifier then uses cubic polynomial interpolation to “connect the dots” so that the motor reaches each point at the specified velocity at the programmed time.

Homing mode is 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.

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2.6.3: Architecture

As shown below, in a CANopen motion control system, control loops are closed on the individual amplifiers, 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.



2.6.4: 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 amplifier is serving as a CME 2 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 amplifier'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 CAN Interface (p. 104).

For more information on CAN communications, see Communication (p. 41).

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

- *CANopen Programmer's Manual*
- *CML Reference Manual*
- *Copley Motion Objects Programmer's Guide*

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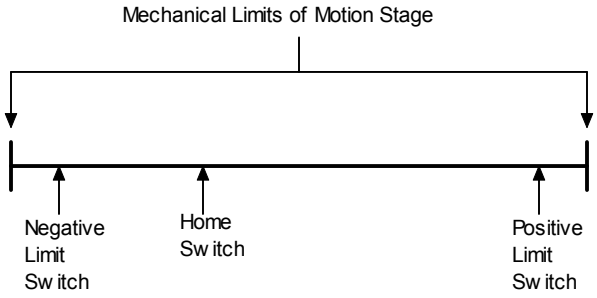
2.7: Limit Switches

2.7.1: Use Digital Inputs to Connect Limit Switches

Limit switches help protect the motion system from unintended travel to the mechanical limits. Any of the digital inputs 2-12 can be can be programmed as positive or negative limit switch inputs. With the amplifier operating as a CAN node, an input can also be programmed as a home limit switch for CANopen homing operations.

2.7.2: Diagram: Sample Placement of Limit Switches

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



2.7.3: How the Amplifier Responds to Limit Switch Activation

The amplifier 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	Amplifier Response to Active Positive (or Negative) Limit Switch
Current	Amplifier prohibits travel in positive (or negative) direction. Travel in the opposite direction is still allowed.
Velocity	Amplifier 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	Amplifier stops responding to position commands until the amplifier is disabled and re-enabled, or the fault is cleared over the CANopen interface. Amplifier status indicator flashes green at fast rate. Warning is displayed on CME 2 Control Panel and CME 2 Control Panel limit indicator turns red. If, after re-enabling the amp, the limit switch is still active, the amplifier will only allow movement in the opposite direction.

2.7.4: Using Custom Output to Signal Limit Switch Activation

In addition to the response described above, any of the amplifier's digital outputs can be configured to go active when a positive or negative limit switch is activated. For more information, see Custom Output Functions (p. 45).

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2.8: Brake Operation

2.8.1: Digital Output Controls Brake

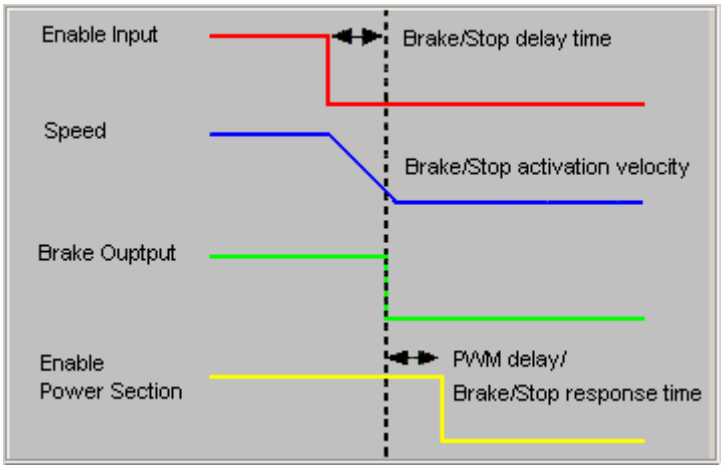
Many control systems employ a brake to hold the axis when the amplifier is disabled. Digital output 4 (OUT4) is designed specifically for a brake output. (Other outputs can be used for brake control, but OUT4 is recommended.) Unlike the other outputs, OUT4 is optically isolated from the control signals and has an internal fly back diode connected to the +24 Vdc input. By eliminating the need to connect into the amplifier 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 Brake Output (p. 53) and Logic Supply / Brake (J4) (p. 65).

2.8.2: Brake/Stop Sequences

Disabling the amplifier 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 amplifier 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 amplifier's output stages are disabled. This delay ensures the brake has time to lock in before disabling the power section.



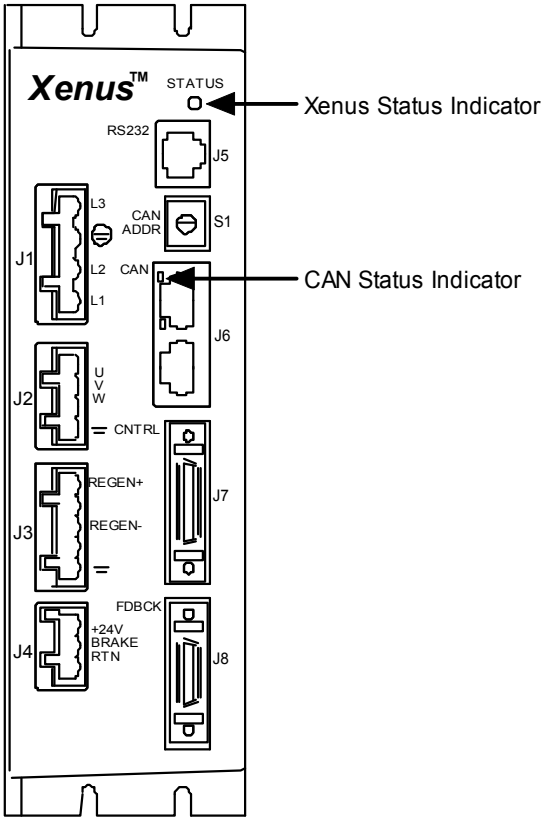
This sequence is not available in the current mode of operation. Instead, in current mode, the amplifier output turns off and the brake output activates immediately when the disable command is received.

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2.9: Status Indicators

2.9.1: Amplifier and CAN Interface Status Indicators

The amplifier's status indicator is a bicolor LED labeled STATUS on the amplifier front panel. The CAN interface status indicator is a bicolor LED labeled CAN. Locations are shown below.



2.9.2: Amplifier Status Indicator Operation

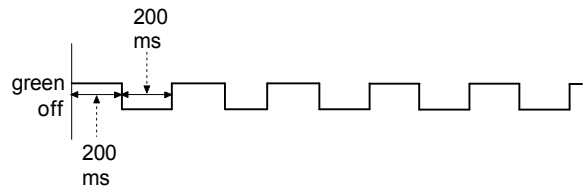
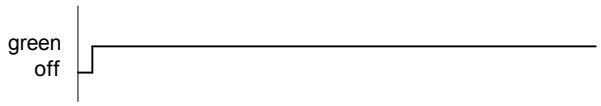
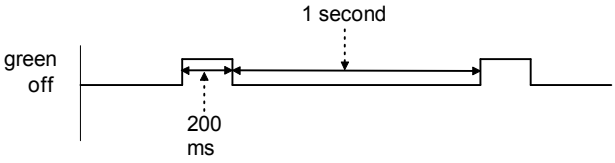
Amplifier status indicator color/blink codes are described below.

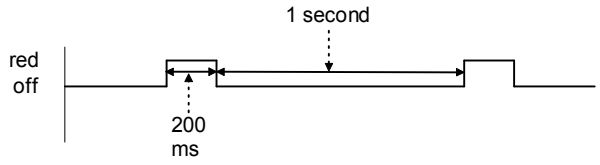
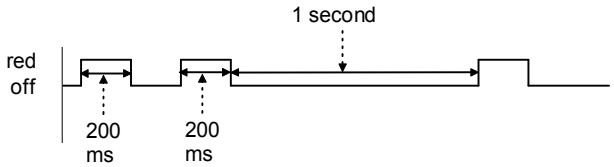
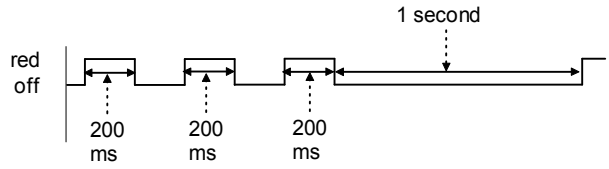
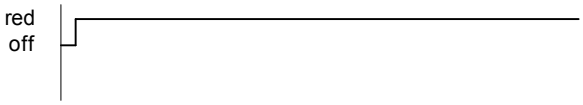
Color/Blink Code	Meaning
Not illuminated	No +24 Vdc power to amplifier.
Steady green	Amplifier is enabled and operational.
Slow-blinking green	Amplifier is disabled. No faults or warnings are active.
Fast-blinking green	A limit switch is active. The amplifier is enabled.
Steady red	A non-latched fault has occurred.
Blinking red	A latched fault has occurred.
20 Fast red blinks on power up or reset	Amplifier has reverted to boot mode.

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2.9.3: CAN Interface Status Indicator Operation

The amplifier status indicator color/blink codes comply with CAN Indicator Specification 303-3 as described below. Note that green and red codes are often interlaced, each indicating a different set of conditions. The green codes indicate the CANopen state machine mode of operation (pre-operational, operational, or stopped). The red codes indicate the status of the physical bus (warning or error conditions).

CANopen State Machine Mode of Operation		
Indicator	**State**	**Diagram**
Blinking green	Pre-operational.	
Steady green	Operational	
Single flash green	Stopped	

Physical Bus Status		
Single flash red	Warning Limit Reached	
Double flash red	Error Control Event	
Triple flash red	Sync Error	
Steady red	Bus Off	

In addition, the CAN status indicator is turned off when the CAN node ID selector (CAN ADDR) is set to 0. A setting of 0, which is invalid, shuts down most operations on the CAN interface, and the light is shut off to indicate this status.

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2.10: Protection

2.10.1: Faults

Overview

Xenus detects and responds to a set of conditions regarded as faults, such as amplifier over temperature and excessive following error. When any fault occurs, with the exception of a following error, the amplifier's PWM output stage is disabled, the fault type is recorded in the amplifier'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. 39).

The amplifier's PWM output stage can be re-enabled after the fault condition is corrected and the amplifier 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. 39).

Clearing Non-Latched Faults

The amplifier clears a non-latched fault, without operator intervention, as soon as 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 amplifier 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 amplifier
- 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 amplifier temperature reaches the fault temperature level and the amplifier reports the fault and disables the PWM output. Then, the amplifier temperature is brought back into operating range. If the *Amplifier Over Temperature* fault is not latched, the fault is automatically cleared and the amplifier's PWM outputs are enabled. If the fault is latched, the fault remains active and the amplifier's PWM outputs remain disabled until the faults are specifically cleared (as described above).

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Fault Descriptions

The set of possible faults is described below. For details on limits and ranges, see Fault Levels (p. 55).

Fault Description	Fault Occurs When…	Fault is Corrected When…
*Amplifier Over Temperature	Amplifier's internal power module 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 resolver feedback or with Halls correction turned off.	Encoder-based phase angle agrees with Hall switch states. See Troubleshooting Manual Phase With Halls and Encoder (p.148).
*Feedback error	Over current condition detected on output of the internal +5 Vdc supply used to power the feedback. Resolver or analog encoder not connected or levels out of tolerance.	Encoder power returns to specified voltage range. Feedback signals stay within specified levels.
*Motor Over Temperature	Motor over-temperature switch changes state to indicate an over-temperature condition.	Temperature switch changes back to normal operating state.
Under Voltage	+DC bus voltage falls below specified voltage limit.	+ DC bus voltage returns to specified voltage range.
Over Voltage	+ DC 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. 38).
*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.	Amplifier is reset and re-enabled.
*Latched by default.		

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2.11: Position and Velocity Errors

2.11.1: 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 amplifier'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 amplifier's velocity loop uses a velocity tracking window method to handle velocity errors. (There is no velocity error fault.)

2.11.2: Following Error Faults

When the position error reaches the programmed *fault* threshold, the amplifier immediately faults. (The following error fault can be disabled.)
For detailed information, see Following Error Fault Details (p. 39).

2.11.3: Following Error Warnings

When the position error reaches the programmed *warning* threshold, the amplifier 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.

2.11.4: 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. 40).

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2.11.5: 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 amplifier 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.

Amplifier Response to Non-Latched Following Error Fault

When a non-latched following error fault occurs, the amplifier drops into velocity mode and applies the *Fast Stop Ramp* deceleration rate to bring the motor to a halt. The amplifier PWM output stage remains enabled, and the amplifier 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 amplifier's mode of operation. Issuing a new trajectory command over the CAN or serial bus will clear the fault and return the amplifier to normal operating condition. If the amplifier is receiving position commands from the digital inputs, then the amplifier must be disabled and then re-enabled using a hardware input or though CME 2 software commands. After re-enabling, the amplifier will operate normally.

Amplifier Response to a Latched Following Error Fault

When a latched following error fault occurs, the amplifier 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 amplifier
- 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

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2.11.6: Tracking Window Details

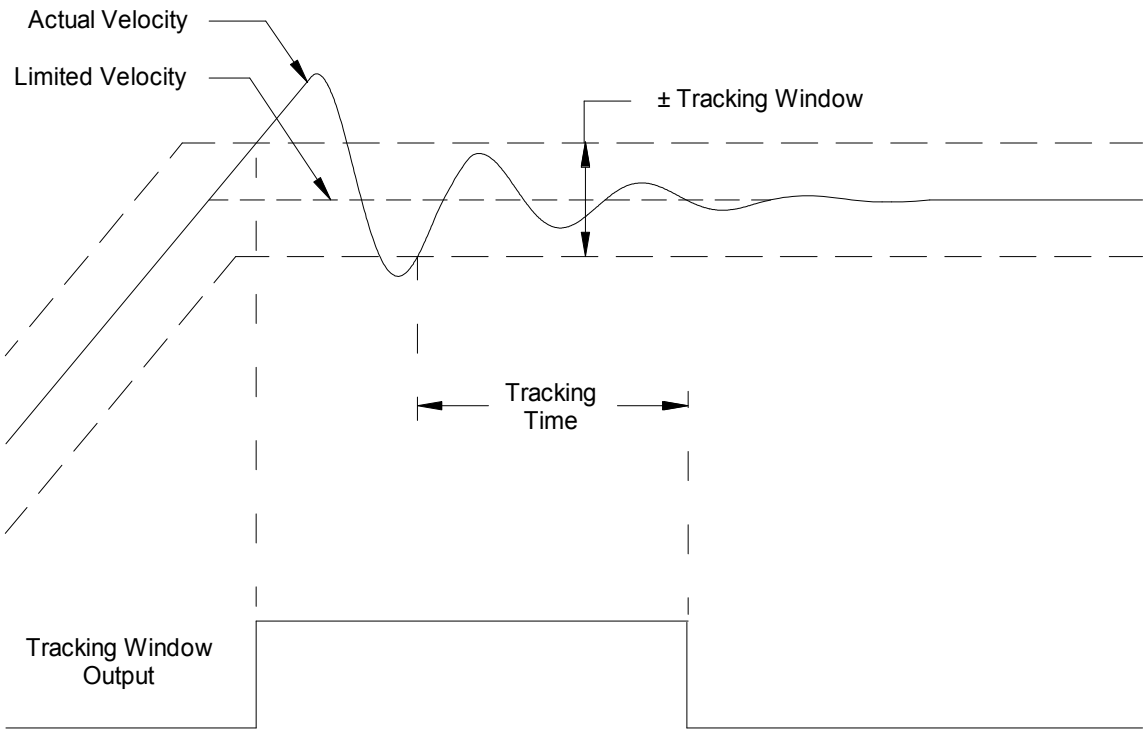
Proper Tracking Over Time

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.



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2.12: Communication

2.12.1: Communication Interfaces

As described below, the amplifier features two communication interfaces, each used for different purposes.

Interface	Description
RS-232 port	The amplifier features a three-wire RS-232 port. CME 2 software communicates with the amplifier using a binary protocol over this link for commissioning, adjustments, and diagnostics. In addition, ASCII commands can be issued over the serial port. For RS-232 port specifications, see Serial Interface (p. 54). For RS-232 port wiring instructions, see RS-232 Serial Communications (J5) (p. 66). In an RS-232 multi-drop configuration, a single amplifier with a serial connection to a controller can act as a gateway, allowing the controller to access other (node) amplifiers (interconnected by CAN bus connections) via the serial connection. CME 2 can be used to make adjustments even when the amplifier is being controlled over the CAN interface or by the digital inputs.
CAN interface	When operating as a CAN node, the amplifier takes command inputs over a CANopen network. CAN communications are described in the next section.

2.12.2: CME 2 and CAN Operation

When the amplifier is operated as a CAN node, CME 2 can be used for programming before and after installation in a CAN network.

CME 2 can also monitor operations while the amplifier is operating as a CAN node.

If CME 2 is used to initiate any movement (using the Control Panel Jog feature or a scope function), the amplifier's CANopen operations are suspended. When adjustments are complete, CME 2 relinquishes control of the amplifier and returns it to the CAN node state.



DANGER

Using CME 2 can affect or suspend CAN operations.

When operating the amplifier as a CAN node, use of CME 2 to change amplifier parameters can affect CAN operations in progress.

Using CME 2 to initiate motion can cause CAN 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.

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2.13: Inputs

2.13.1: Digital Inputs

The amplifier has twelve digital inputs (IN1-IN12). Eleven of them appear on the control connector. IN5 appears on the feedback connector, and is intended for the motor over temperature switch (although it can be programmed for any function).

2.13.2: 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 having the HS filters, and inputs with the GP filters are used for general-purpose logic functions, limit switches, and the motor temperature sensor.

2.13.3: 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 amplifier recognizes the state.

2.13.4: Configure for Pull Up/Pull Down Resistors by Groups

Pre-defined groups of inputs can be programmed to have either an internal pull up or pull down resistor. See J7 Pin Description (p. 69) for groupings.

2.13.5: Programmable Input Functions

Enable Input Functions

IN1 can only be programmed to one of the enable functions described below.

Function	Description
AMP Enable- LO Enables with clear faults	When the input is low, amplifier enables PWM output stage. Amplifier clears faults on the low-to-high transition of the input. When input is high, the amplifier disables the PWM output stage.
AMP Enable- HI Enables with clear faults	When the input is high, amplifier enables PWM output stage. Amplifier clears faults on the high-to-low transition of the input. When input is low, the amplifier disables the PWM output stage.
AMP Enable- LO Enables with reset	When the input is low, amplifier enables PWM output stage. Amplifier resets on the low-to-high transition of the input. When input is high, the amplifier disables the PWM output stage.
AMP Enable- HI Enables with reset	When the input is high, amplifier enables PWM output stage. Amplifier resets on the high-to-low transition of the input. When input is low, the amplifier disables the PWM output stage.
AMP Enable- LO Enables	When the input is low, amplifier enables PWM output stage. When input is high, the amplifier disables the PWM output stage.
AMP Enable- HI Enables	When the input is high, amplifier enables PWM output stage. When input is low, the amplifier disables the PWM output stage.

Multiple Enable Inputs

In addition to IN1, other inputs can be programmed to be additional enables. If there is more than one input programmed as an enable then all the inputs must be in the enabled state before the amplifier PWM output stage will be enabled.

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General Programmable Input Functions

Other inputs, depending on the selected mode of operation, may also have pre-defined functions, as described in Mode-Dependant Dedicated Inputs (p. 70). The remaining inputs can be programmed to functions listed below.

Function	Description
NEG Limit-HI Inhibits	When input is high, amplifier inhibits motion in negative direction.
NEG Limit-LO Inhibits	When input is low, amplifier inhibits motion in negative direction.
POS Limit-HI Inhibits	When input is high, amplifier inhibits motion in positive direction.
POS Limit-LO Inhibits	When input is low, amplifier inhibits motion in positive direction.
Reset on LO-HI Transition	Amplifier resets on the low-to-high transition of the input.
Reset on HI-LO Transition	Amplifier resets on the high-to-low transition of the input.
Motor Temp HI Disables	When the input is high, amplifier generates a *Motor Over Temperature* fault (which disables the PWM output stage).
Motor Temp LO Disables	When the input is low, amplifier generates a *Motor Over Temperature* fault (which disables the PWM output stage).
Home Switch Active HI	When the input is high, the home switch is activated.
Home Switch Active LO	When the input is low, the home switch is activated.
Motion Abort Active HI I	When the input is high, motion stops but the amplifier remains enabled. Any position or velocity commands received while the input is active are ignored. In position mode, upon activation of the input, the motor will decelerate at the trajectory abort deceleration rate to zero velocity and then hold current position. In velocity mode, upon activation of the input, the motor will decelerate to zero velocity at the velocity fast stop ramp rate and then hold zero velocity. In current mode, the input has no effect.
Motion Abort Active LO	When the input is low, motion stops but the amplifier remains enabled. Any position or velocity commands received while the input is active are ignored. In position mode,, upon activation of the input, the motor will decelerate at the trajectory abort deceleration rate to zero velocity and then hold current position. In velocity mode, upon activation of the input, the motor will decelerate to zero velocity at the velocity fast stop ramp rate and then hold zero velocity. In current mode, the input has no effect.
Hi Res Analog Divide Active HI	A high input causes the firmware to divide the level of the analog input signal by 8.
Hi Res Analog Divide Active LO	A low input causes the firmware to divide the level of the analog input signal by 8.
PWM Sync Input	Receives the PWM sync output of a master amplifier. For more information, see Synchronizing PWM Switching Frequency (p. 18). (Only on high-speed inputs.)

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2.14: Outputs

2.14.1: Digital Outputs

The amplifier has four programmable digital outputs. Three of the outputs (OUT1 - 3) are general-purpose outputs. The fourth (OUT4) is specifically designed as a brake output but can be programmed to perform any of the functions.

The general-purpose outputs are open-drain MOSFETs, each with a pull-up resistor, in series with a diode, connected to the amplifier's internal +5 Vdc supply. This design allows the outputs to be directly connected to optically isolated PLC inputs that reference a voltage higher than +5 Vdc, typically +24 Vdc. The diode prevents current flow between the +24 Vdc supply and the internal +5 Vdc supply though the pull-up resistor. This current, if allowed to flow, could turn on the PLC input, giving a false indication of the amplifier's true output state.

The general-purpose outputs require an external fly-back diode to be installed across any inductive loads, such as relays, that are connected to them.

The brake output (OUT4) is described in Brake Operation (p. 33).

2.14.2: Standard Programmable Output Functions

Each digital output can be programmed to perform one of the following standard functions.

Function	Description
Fault – Active High (Low)	The output is high (low) when a fault is active.
Brake – Active High (Low)	The output high (low) when brake is active.
PWM Sync Output	(Only available on OUT1.) Sends the PWM sync input of a slave amplifier. See Synchronizing PWM Switching Frequency (p. 18).
Custom – Active High (Low)	The output is high (low) when at least one of the events selected on the *Custom Output Configuration* form occurs. For more information, see Custom Output Functions (p. 45).
Program Control – Active High (Low)	The state of the output is controlled by the CAN controller or the CVM control program.

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2.14.3: Custom Output Functions

Any of the amplifier's digital outputs can be set up in a custom configuration to respond to a combination of events including faults, warnings, and status indications. The output goes active when one or more of the selected events take place.

Non-Latched and Latched Custom Outputs

Like an amplifier fault, a custom-configured output can be non-latched or latched.

If a non-latched, custom-configured digital output goes active, it goes inactive as soon as the last of the selected events is cleared.

If a latched output goes active, it remains active until at least one of the following actions has been taken:

- power-cycle the +24 Vdc to the amplifier
- 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 faults over the CANopen network



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 amplifier re-enables without operator intervention. In this case, motion may re-start unexpectedly.

For more information, see Clearing Non-Latched Faults (p. 36).

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

Custom Output Faults

A custom output can be configured to go active in response to any of the amplifier faults described in Fault Descriptions (p. 37).

Example: Custom Output Fault Handling vs. Overall Fault Handling

A fault on an output is separate from a fault on the amplifier. For instance, suppose:

- OUT3 has a *Custom* configuration. Only the *Under Voltage* fault condition is selected, and the output is latched.
- *Under Voltage* is not latched on the *Configure Faults* screen.

An under voltage condition occurs, and the amplifier goes into fault condition, output stages are disabled, and faults are reported. At the same time, OUT3 goes active.

The under voltage condition is corrected, and:

- The amplifier fault is cleared. Output stages are enabled.
- OUT3 remains active.

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Custom Output Warning Functions

A custom output can be configured to go active when the amplifier issues any of the following warnings.

Event	Description
Current Output Limited	The current output is being limited by the I^2T algorithm or a latched current fault has occurred. See Limits (p. 20.)
Voltage Output Limited	Current loop is commanding the full bus voltage in an attempt to control current. Commonly occurs when the motor is running as fast as the available bus voltage will allow.
Positive Limit Switch Active	Axis has contacted positive limit switch.
Negative Limit Switch Active	Axis has contacted negative limit switch.
Positive Software Limit	Actual position has exceeded the positive software limit setting. See Home Function (p. 152).
Negative Software Limit	Actual position has exceeded the negative software limit setting. See Home Function (p. 152).
Following Warning	Following error has reached programmed warning limit. See Following Error Fault Details (p. 39).
Velocity Limit Reached	The velocity command (from analog input, PWM input, or position loop) has exceeded the velocity limit that was set as described in Velocity Loop Limits (p. 22).
Acceleration Limit reached	In velocity mode, motor has reached an acceleration or deceleration limit that was set as described in Velocity Loop Limits (p. 22).
Velocity Outside of Tracking Window	Difference between target and actual velocity has exceeded the window. See Tracking Window Details (p. 40).
Position Outside of Tracking Window	The following error has exceeded the programmed value. See Tracking Window Details (p. 40).

Custom Output Status Functions

A custom output can be configured to go active to indicate the following conditions.

Event	Description
Amplifier Disabled by Hardware	Amplifier enable input(s) is not active.
Amplifier Disabled by Software	Amplifier is disabled by a software command.
Attempting to Stop Motor	The amplifier, while in velocity or position mode, has been disabled. In velocity mode, amplifier is using the Fast Stop Ramp described in Velocity Loop Limits (p. 22). In position mode, the amplifier is using the Abort Deceleration rate described in Trajectory Limits (p. 24). The output remains active until the amplifier is re-enabled.
Motor Brake Activated	Motor brake activated. See Brake Operation (p. 33) for more information.
PWM Outputs Disabled	The amplifier's PWM outputs are disabled.
Home Switch is Active	Axis has contacted the home limit switch.
Not Settled	The motor is moving, or it has not yet settled after a move. The amplifier is settled when it comes within the position tracking window and stays there for the tracking time at the end of a move. Once settled, it remains settled until a new move is started.

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2.15: Regen Resistor Theory

2.15.1: 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 I^2R 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 amplifier. The result of this energy being added is an increase in the voltage on the capacitor bank.

2.15.2: Regen Resistor

If too much energy is added to the capacitor bank, the voltage will rise to a point where the amplifier's over voltage protection will shut down the amplifier. To prevent this, a regen circuit shunts some of the energy into an external resistor, known as a regen resistor, when the voltage rises too high.

2.15.3: Regen Circuit Components

The amplifier provides an internal transistor that is used in combination with an external resistor. Copley Controls supplies compatible resistors. When using a resistor acquired from another source, be sure it meets the specifications described in
Regen Resistor Sizing and Configuration (p. 153).

2.15.4: Regen Circuit Protections

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

2.15.5: Configurable Custom Resistor

The following values can be entered for a custom resistor using CME 2:

Option	Description
Resistance Value	Value in ohms of the resistor
Continuous Power	Continuous power rating of the resistor
Peak Power	Peak power rating of the resistor
Time at Peak Power	Time at peak power of resistor

For more information, see Regen Resistor (p. 98) and
Regen Resistor Sizing and Configuration (p. 153)

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CHAPTER 3: SPECIFICATIONS

This chapter describes the amplifier specifications. Contents include:

Title	Page
3.1: Agency Approvals	50
3.2: Power Input	50
3.3: Power Output	50
3.4: Control Loops	51
3.5: Regen Circuit Output	51
3.6: Digital Command Input	51
3.7: Analog Command Input	52
3.8: Digital Inputs	52
3.9: Digital Outputs	52
3.10: Brake Output	53
3.11: Encoder Power Supply Output	53
3.12: Primary and Secondary Encoder Inputs	53
3.13: Analog Encoder Inputs	53
3.14: Hall Switch Inputs	54
3.15: Resolver Interface	54
3.16: Encoder Outputs	54
3.17: Serial Interface	54
3.18: CAN Interface	55
3.19: Status Indicators	55
3.20: Fault Levels	55
3.21: Power Dissipation	56
3.22: Thermal Impedance	56
3.23: Mechanical and Environmental	56
3.24: Dimensions	57

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3.1: Agency Approvals

- CE Compliance:

  89/336/EEC Electromagnetic
  EN 55011 Compatibility
  EN 550082-1
  98/37/EC Safety of Machinery
  EN 60204-1

- UL 508C

3.2: Power Input

Model	XSL-230-18 XSL-230-18-R	XSL-230-36 XSL-230-36-R	XSL-230-40 XSL-230-40-R
Mains Voltage	100 - 240 Vac 1 Ø or 3 Ø		
Mains Frequency	47 to 63 Hz		
Mains Current	15 Arms maximum	20 Arms maximum	
Current Inrush	15 A peak at 120 Vac 35 A peak at 240 Vac		
Logic Supply Voltage	+20 to +32 Vdc		
Logic Supply Current	500 mA maximum		

3.3: Power Output

Model	XSL-230-18 XSL-230-18-R	XSL-230-36 XSL-230-36-R	XSL-230-40 XSL-230-40-R
Peak Current	18 Adc [12.7 Arms]	36 Adc [25.5 Arms]	40 Adc [28.3 Arms]
Peak Current Time	1 Second		
Continuous Current*	6 Adc [4.24 Arms]	12 Adc [8.5 Arms]	20 Adc [14.1 Arms]
Efficiency	>97% @ 230 Vac and rated continuous current		
Output Type	3-phase IGBT inverter 15 kHz center-weighted PWM space-vector modulation		
PWM Ripple Frequency	30 kHz		
Minimum Load Inductance	400 uH line-to-line** NOTE: See Xenus Filter (p. 173).		
* Heat sinking and/or forced air cooling required for continuous output power rating ** Consult factory for operation with inductance lower than 400 uH			

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3.4: Control Loops

Type Current Velocity Position	 100% digital.
Sampling rate (time) Current Velocity Position	 15 kHz (67 µs) 3 kHz (333 µs) 3 kHz (333 µs)
Current Loop Small Signal Bandwidth	> 2 kHz (Tuning and load impedance dependent)
Velocity Loop Filter Type Frequency Range	 Programmable Low Pass, 1 Pole Low Pass, Butterworth, 2 Poles Bi-Quadratic, 2 Poles & 2 Zeros Programmable 20 - 1500 Hz
Bus Voltage Compensation	Changes in bus or mains voltage do not affect tuning.

3.5: Regen Circuit Output

Model	XSL-230-18 XSL-230-18-R	XSL-230-36 XSL-230-36-R	XSL-230-40 XSL-230-40-R
Continuous Power	2 kW	4 kW	
Peak Power	5 kW	10 kW	
Minimum Resistance	30 Ω	15 Ω	
Minimum Resistor Wattage	25 W	50 W	
Turn On Voltage	+390 Vdc		
Turn Off Voltage	+380 Vdc		
DC Bus Capacitance	1760 µF nominal		
Regen Energy Absorption Capacity Input Voltage 120 Vac 208 Vac 240 Vac	 108 joules 57 joules 32 joules		

3.6: Digital Command Input

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

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3.7: Analog Command Input

Channels	1
Type	Differential, non-isolated
Measurement Range	±10 Vdc
Maximum Voltage	
Differential	±10 Vdc
Input to Ground	±10 Vdc
Input Impedance	66 kΩ
Resolution	12 Bit
Bandwidth	7 kHz
Scan Time	67 µSec
Function	Current, velocity, or position command

3.8: Digital Inputs

Channels	12 7 general-purpose 5 high-speed
Type	74HC14 Schmitt trigger w/ RC filter 10 kΩ resistor programmable as pull up or pull down to internal +5 Vdc.
Input Voltage Range	
General-Purpose	0 V - +28 Vdc
High-speed	0 V - +12 Vdc
Logic Low Input Voltage	< +1.35 Vdc
Logic High Input Voltage	> +3.65 Vdc
Scan Time	333 µSec
RC Filter Time Constant	
General-Purpose	330 µSec
High-speed	100 nSec
Debounce	
Type	Digital
Time	Programmable 0 - 10,000 mSec
Function	IN1 enable IN2 - IN12 programmable

3.9: Digital Outputs

Channels	3
Type	Current-sinking MOSFET, non-isolated 1 kΩ pullup to internal +5 Vdc through diode
Maximum Voltage	+40 Vdc
Maximum Sink Current	1 A
Low Level Output Resistance	<0.2 Ω
Function	Programmable

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3.10: Brake Output

Channels	1
Type	Current-sinking MOSFET, optically isolated from control/logic ground. Referenced to +24 Vdc logic supply. Internal fly back diode to +24 Vdc.
Maximum Sink Current	1 A
Low Level Output Resistance	<0.2 Ω
Function	Primary function is brake control. May be programmed to other functions.

3.11: Encoder Power Supply Output

Voltage Output	+5 Vdc ±2%
Maximum Current Output	400 mA
Short Circuit Protection	Fold-back current limiting
Function	Provides power for motor encoder and/or Hall switches.

3.12: Primary and Secondary Encoder Inputs

Channels	3
Type	Differential RS-422 line receiver w/ RC filter Non-isolated
Signals	A, /A, B, /B, X*, /X*
Input Voltage Range	±7 Vdc
Differential Input Threshold	±0.2 Vdc
Differential Input Impedance	121 Ω
Maximum Frequency	5 MHz Line (20 Mcount/sec)
Function	Incremental or analog encoder or resolver required for sinusoidal commutation and position or velocity modes of operation.
* X is equivalent to Marker, Index, or Z channels, depending on the encoder manufacturer. This channel is only required in certain homing modes while under CAN control.	

3.13: Analog Encoder Inputs

Channels	2
Type	Differential, non-isolated
Signals	Sine, cosine
Nominal Voltage	1 Vdc-pk
Maximum Voltage	
Differential	±0.6 Vdc
Input to Ground	0 to +3.5 Vdc
Differential Input Impedance	121 Ω
Bandwidth	230 kHz
Interpolation	1 to 256, programmable
Function	Incremental or analog encoder or resolver required for sinusoidal commutation and position or velocity modes of operation.

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3.14: Hall Switch Inputs

Channels	3
Type	74HC14 Schmitt trigger w/ RC Filter 10 kΩ pull up resistor to internal +5 Vdc
Input Voltage Range	0 Vdc - +28 Vdc
Low Level Input Voltage	< +1.35 Vdc
High Level Input Voltage	> +3.65 Vdc
Scan Time	67 μSec
RC Filter Time Constant	33 μSec
Function	Commutation of brushless motors in trapezoidal mode. Commutation initialization and phase error detection in sinusoidal mode.

3.15: Resolver Interface

Type	Transmit, 1:1 to 2:1 transformation ratio
Resolution	14 bits (equivalent to a 4096 line quadrature encoder)
Reference Frequency	7.5 kHz
Reference Voltage	3 Vrms, auto-adjustable by amplifier to maximize feedback
Reference Max Current	100 mA
Max RPM	10,000
Function	Incremental or analog encoder or resolver required for sinusoidal commutation and position or velocity modes of operation.
Type	Transmit, 1:1 to 2:1 transformation ratio

3.16: Encoder Outputs

Channels	3
Type	Differential, RS-422 line driver (26C31)
Signals	A, /A, B, /B, X, /X
Function Programmable	 Buffered primary incremental encoder Emulated from analog encoder Emulated from resolver
Maximum Frequency Buffered Emulated	 5 MHz Line (20 Mcount/sec) 4.5 MHz Line (18 Mcounts/sec)

3.17: Serial Interface

Channels	1
Type	RS-232
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

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3.18: CAN Interface

Channels	1
Connectors	2 eight-position modular (RJ-45 style) wired as per CAN Cia DR-303-1, V1.1 One connector for signal input. Second connector for daisy chaining to next node.
Signals	CAN H, CAN L, CAN Gnd (CAN +5 Vdc Pass though only)
Format	CAN V2.0b physical layer for high-speed connections compliant
Protocol	Motion Control Device Under DSP-402 of the CANopen DS-301 V4.01 (EN 50325-4) Application Layer
Supported Modes	Profile Current, Velocity, and Position, PVT, and Homing
Node Address Selection	16-position rotary switch on front panel OR programmable digital inputs OR stored in flash memory OR combination of above.
Bus Termination	External 121 Ω resistor across CAN-H and CAN-L when termination plug is installed in second connector.
Function	Real-time motion control

3.19: Status Indicators

Amplifier Status	Bi-Color LED on front panel, labeled *Status.*
CAN Status	Bi-Color LED on front panel, labeled *CAN.* Conforms to *CAN Indicator Specification CiA DR-303-3.*

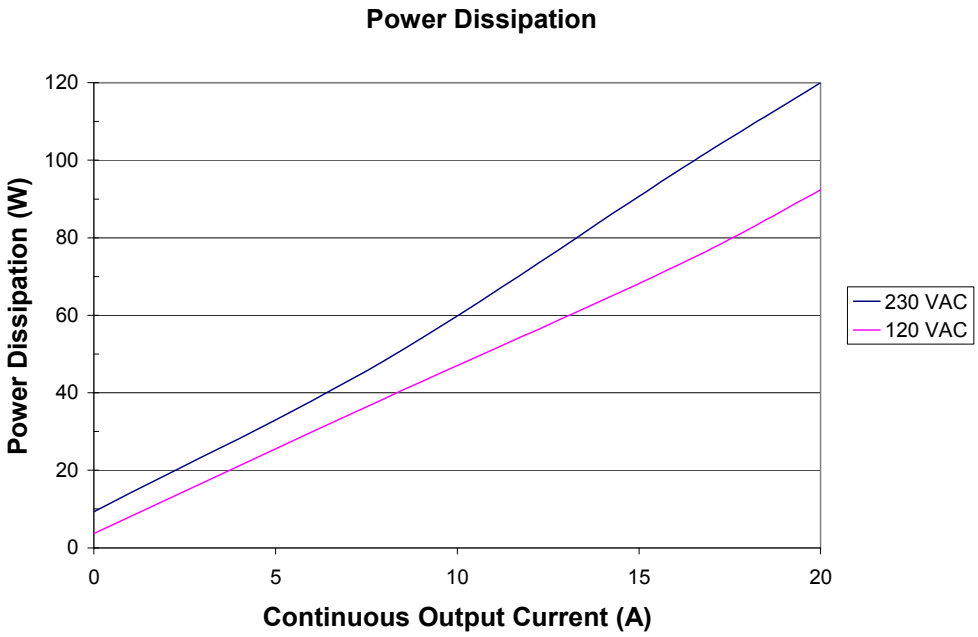
3.20: Fault Levels

Amp Over Temperature	> 80 °C
DC Bus Under Voltage	< +60 Vdc
DC Bus Over Voltage	> +400 Vdc
Encoder Power	< +4.25 Vdc

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3.21: Power Dissipation

	Model:	XSL-230-18 XSL-230-18-R	XSL-230-36 XSL-230-36-R	XSL-230-40 XSL-230-40-R
Output Power	**Mains Voltage**			
Maximum Continuous	120 Vac	30 W	55 W	92 W
	240 Vac	40 W	75 W	120 W



3.22: Thermal Impedance

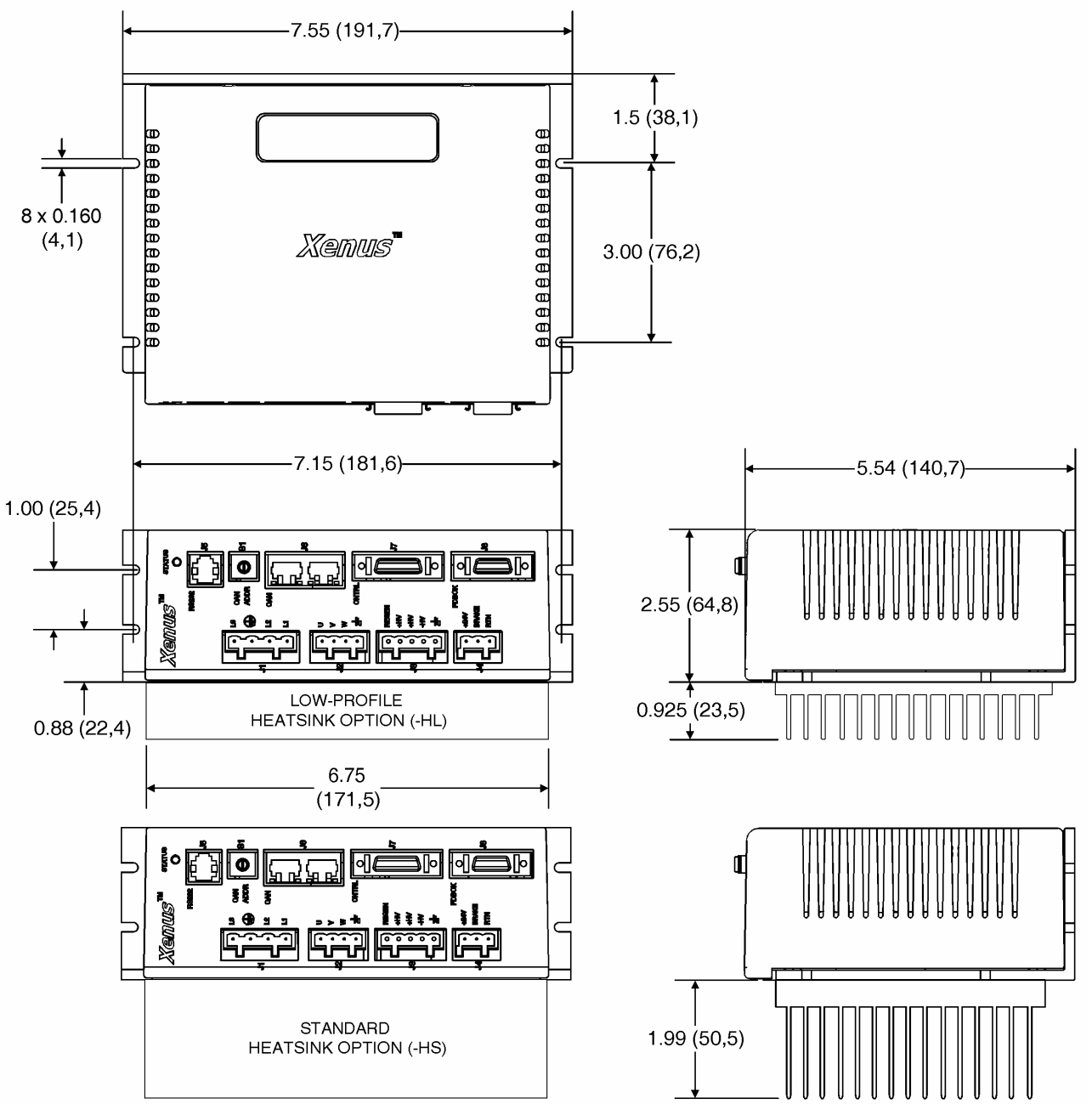
See Thermal Considerations (p. 169).

3.23: Mechanical and Environmental

Size	7.55 in (191,8 mm) X 5.57 in (141,5 mm) X 2.57 in (65,3 mm)
Weight	
Without Heat Sink	3.0 lb (1.36 kg)
With Heat Sink XSL-HL	4.3 lb (1.95 kg)
With Heat Sink XSL-HS	4.8 lb (2.20 kg)
Ambient Temperature	
Storage	-40 to +85°C
Operating	0 to +55°C
Humidity	0% to 95%, non-condensing
Contaminants	Pollution degree 2
Environment	IEC68-2: 1990
Cover Material	Meets U.L. Spec 94 V-0 Flammability Rating
Cooling	Heat sink and/or forced air cooling required for continuous power output

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3.24: Dimensions



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CHAPTER 4: WIRING

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

Title	Page
4.1: General Wiring Instructions	60
4.2: AC Mains (J1)	62
4.3: Motor (J2)	63
4.4: Regen Resistor (J3) (Optional)	64
4.5: Logic Supply / Brake (J4)	65
4.6: RS-232 Serial Communications (J5)	66
4.7: CAN Bus (J6)	67
Control (J7)	68
4.8: Motor Feedback (J8)	72

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4.1: General Wiring Instructions

4.1.1: 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 on J1, J2, and J3 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 J1, J2, and J3, 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.



WARNING

Do not plug or unplug connectors with power applied.

The connecting or disconnecting of cables while the amplifier has 24Vdc and/or mains power applied is not recommended.

Failure to heed this warning may cause equipment damage.

4.1.2: Grounding Considerations

Primary Grounding Functions

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

J1-3 Primary Ground

The primary ground at J1-3 is the 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 amplifier chassis. Wiring to this ground should be done using a conductor of the same gauge wire as that used for the mains. This wire is a “bonding”’ conductor that should be connected to an earthed ground point and must not pass through any circuit interrupting devices.

The pin on the amplifier at J1-3 is longer than the other pins on J1, giving it a first-make, last-break action so that the amplifier chassis is never ungrounded when the mains power is connected.

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J2 and J3 Grounds

The ground terminals at J2-1 and J3-5 also connect to the amplifier chassis.

Motor cases can be safety-grounded either at the motor, by earthing the frame, or by a grounding conductor in the motor cable that connects to J2-1. This conductor should be of the same gauge as the other motor phase conductors.

The case of the regen resistor can also be safety-grounded by earthing the case or by a grounding conductor connected to J3-5. Again, this conductor should be of the same gauge as the other regen resistor conductors.

Cable shields, because of their smaller wire size, must not be used as part of a safety-ground system.

Signal Grounding

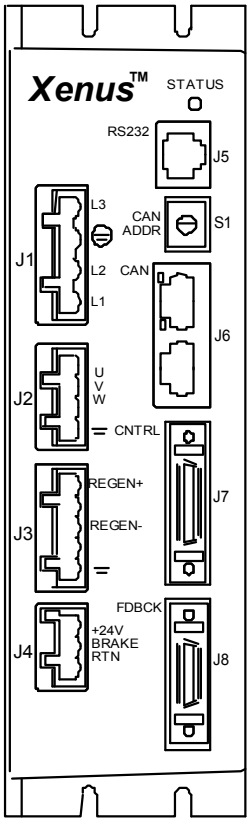
The amplifier signal ground must be connected to the control system signal ground. The amplifier signal ground is not connected to earth ground internal to the amplifier. Therefore, the control system signal ground can be connected to earth ground without introducing a ground loop.

Shielding

Shields on cables reduce emissions from the amplifier 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 both J7 and J8 are connected to the amplifier's chassis.

4.1.3: Connector Locations

Connector locations are shown below.



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4.2: AC Mains (J1)

Mating Connector

Description	Euro-style, 4 position, 7.5 mm pluggable female terminal block.
Manufacturer PN	Wago Standard 721-204/026-045; Right Angle 732-180/026-000
Wire size	22 - 12 AWG
Recommended Wire	12 AWG, 600 V
Wire Insertion/Extraction Tool	Wago 231-131
Standard connector and tool are included in connector kit XSL-CK or XSL-CA	

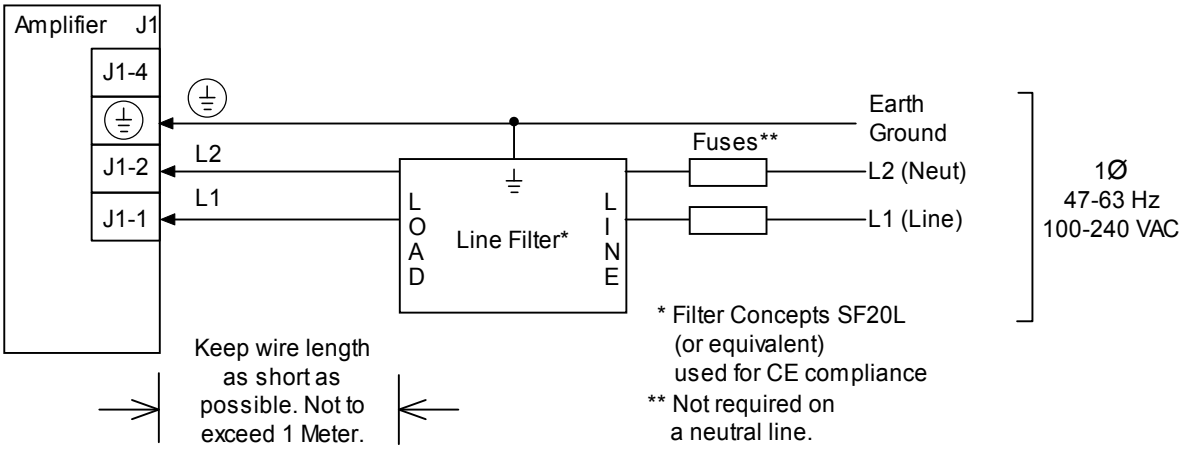
Pin Description

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

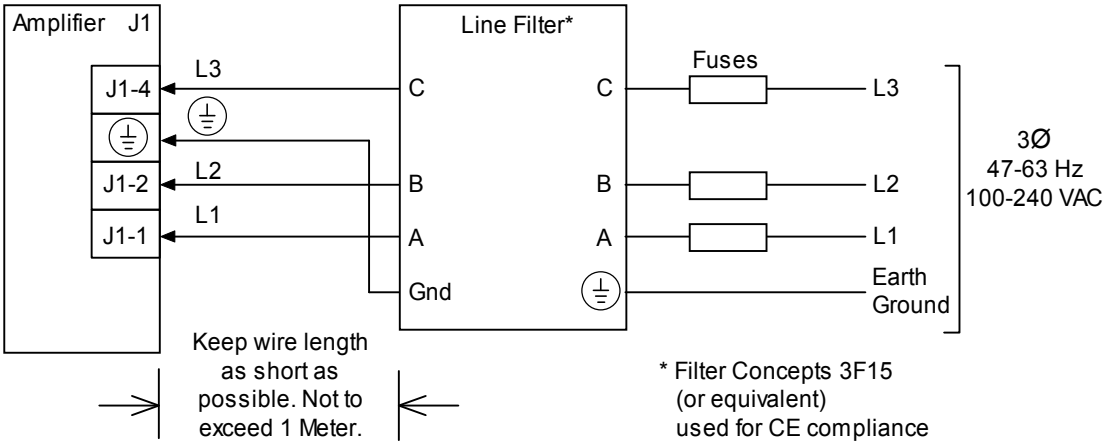
AC Mains Fuse Recommendation

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

AC Mains Wiring Diagram (Single-Phase)



AC Mains Wiring Diagram (Three-Phase)



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4.3: Motor (J2)

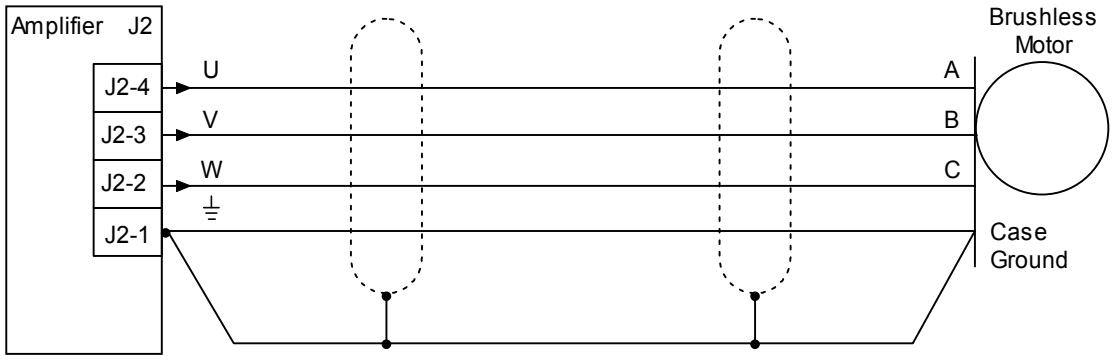
Mating Connector

Description	Euro-style, 4 position, 5.0 mm pluggable female terminal block
Manufacturer PN	Wago Standard 721-104/026-047; Right Angle 722 204/026-000
Wire Size	22 - 12 AWG
Recommended Wire	12 AWG, 600 V (Shielded cable used for CE compliance)
Wire Insertion/Extraction Tool	Wago 231-131
Standard connector and tool are included in connector kit XSL-CK or XSL-CA	

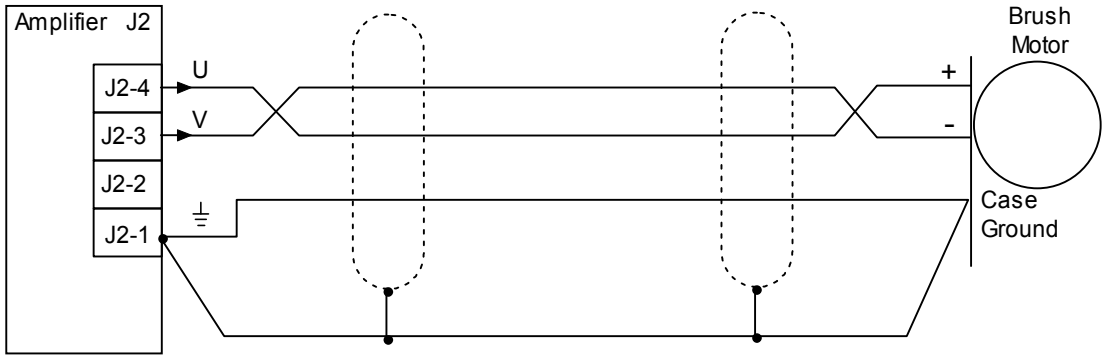
Pin Description

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

Brushless Motor Wiring Diagram



Brush Motor Wiring Diagram



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4.4: Regen Resistor (J3) (Optional)

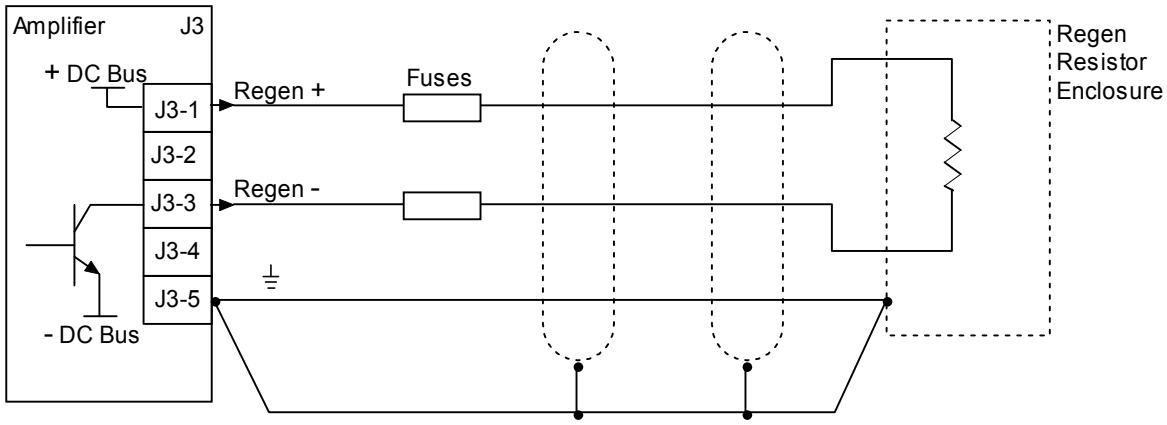
Mating Connector

Description	Euro-style, 5 position, 5.0 mm pluggable male terminal block.
Manufacturer PN	Wago 721-605/000-043
Wire Size	22 - 14 AWG
Recommended Wire	14 AWG, 600 V (Shielded cable used for CE compliance)
Wire Insertion/Extraction Tool	Wago 231-131
Standard connector and tool are included in connector kit XSL-CK or XSL-CA	

Pin Description

Pin	Signal	Function
1	Regen +	+ DC Bus to one side of regen resistor
2	N/C	No connection
3	Regen -	Collector of regen transistor to one side of regen resistor
4	N/C	No connection
5	Ground	Enclosure ground and cable shield

Regen Resistor Wiring Diagram



Regen Resistor Fusing

Recommended Fuses:

Regen Resistor	Fuse type
XSL-RA-01	Cooper Bussman KLM-8 or equivalent
XSL-RA-02	Cooper Bussman KLM-12 or equivalent
User Supplied	See Regen Resistor Sizing and Configuration (p. 153).

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4.5: Logic Supply / Brake (J4)

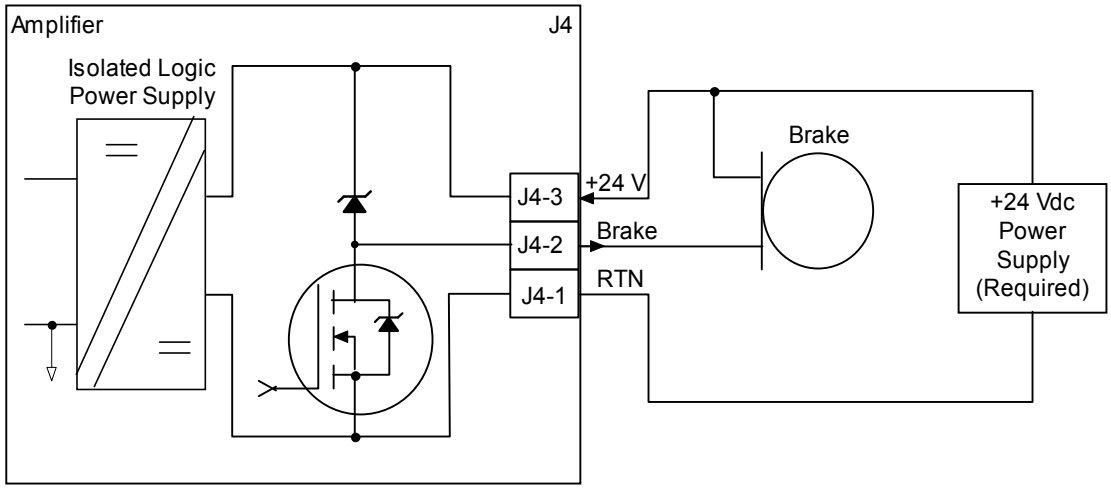
Mating Connector

Description	Euro-style, 3 position, 5.0 mm pluggable female terminal block.
Manufacturer PN	Wago Standard 721-103/026-047; Right Angle 722-203/026-000
Wire Size	22 - 14 AWG
Recommended Wire	18 AWG
Wire Insertion/Extraction Tool	Wago 231-131
Standard connector and tool are included in connector kit XSL-CK or XSL-CA	

Pin Description

Pin	Signal	Function
1	RTN	+24 Vdc return
2	Brake	Return or low side of motor brake
3	+24 Vdc	+24 Vdc Logic power supply

Logic Supply / Brake Wiring Diagram



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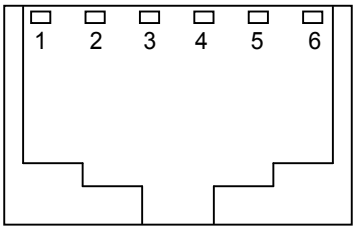
4.6: RS-232 Serial Communications (J5)

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.

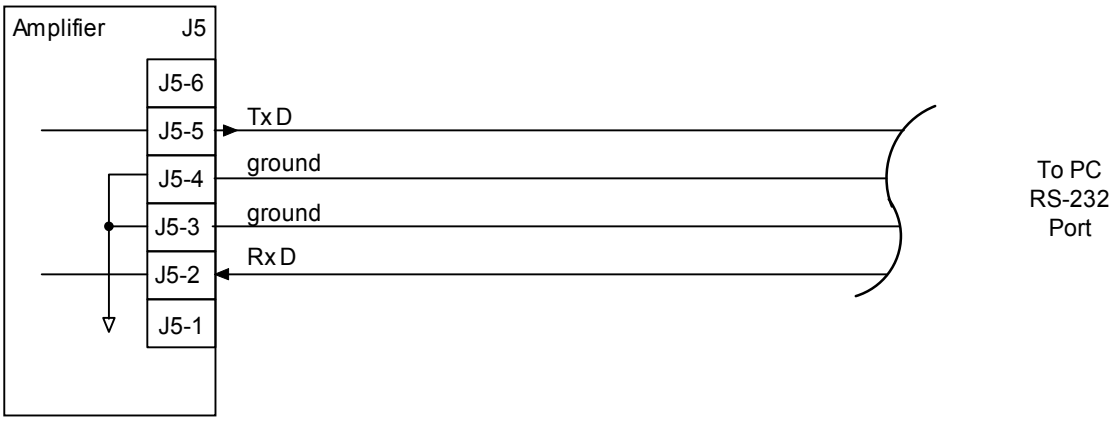
A diagram of the female connector is shown below.



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



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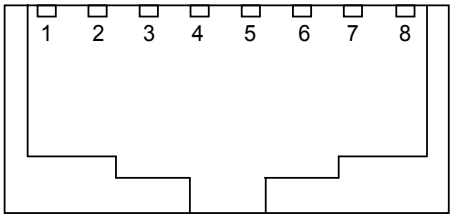
4.7: CAN Bus (J6)

Mating Connector

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

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

A diagram of the female connector is shown below.

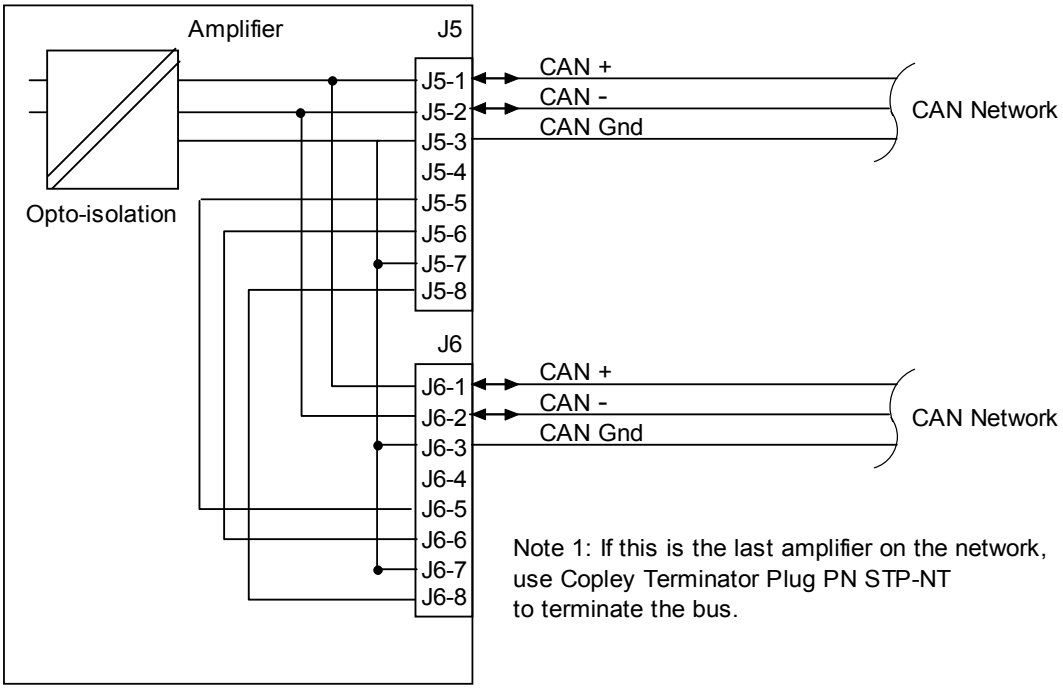


Pin Description*

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 though to second connector, no internal connection
6	CAN_SHLD	Pass though 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



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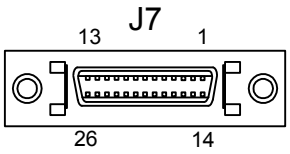
Control (J7)

Mating Connectors

Description	Manufacturer PN	Wire Size
26 Position, .050" Mini D Ribbon (MDR), Solder Style Connector	3M 10126-3000 VE standard Molex 54306-2619 rugged	24 - 30 AWG
26 position, .050" Mini D Connector, Molded Insulation Displacement (IDC) style	Plug assembly: Molex 52316-2611 Boot cover: Molex 52370-2610	28 AWG
Back shell	3M: 10326-52F0-008 standard Molex 54331-0261 rugged	
Standard solder style connector included in Connector Kit PN XSL-CK. 10-foot cable assembly included in Connector Kit PN XSL-CA uses molded IDC style connector.		

NOTE: For color codes, see Control and Feedback Cable Color Codes (p. 196).

Pin connections are shown here:



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J7 Pin Description

Pin	Signal	Function		
1	Frame Ground	Cable shield connection		
2	Signal Ground	Signal ground reference for inputs and outputs		
			Speed	***Pull-Up/Pull-Down***
3	IN1	Enable	Standard	Group 1
4	IN2	Programmable	Standard	Group 1
5	IN3		Standard	Group 1
6	IN4		Standard	Group 2
7	IN6		High	Group 3
8	IN7		High	Group 3
9	IN8		High	Group 3
10	IN9	Mode Dependant	High	Group 4
11	IN10	See Mode-Dependant Dedicated Inputs (p. 70)	High	Group 4
12	IN11	Programmable	Standard	Group 4
13	OUT1	General-purpose, programmable outputs		
14	OUT2			
15	OUT3			
16	Encoder A	Programmable secondary encoder input/output.		
17	Encoder /A			
18	Encoder B			
19	Encoder /B			
20	Encoder X			
21	Encoder /X			
22	+5 Vdc	Encoder +5 Vdc power supply output. Total load current on J7-22 and J8-3 not to exceed 400 mA.		
23	Signal Ground	Signal ground reference for inputs and outputs		
24	Ref + Input	Analog command positive input		
25	Ref - Input	Analog command negative input		
26	IN12	Programmable	Standard	Group 4

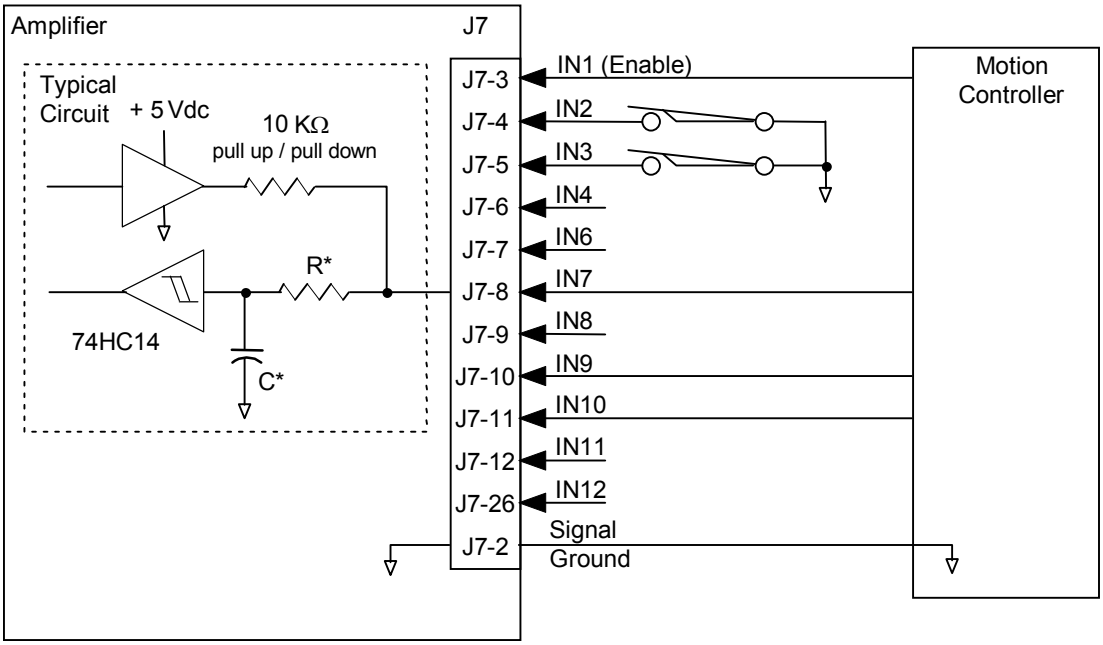
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Mode-Dependant Dedicated Inputs

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

Mode	Input	Function
All	IN1	Enable
Current & Velocity PWM 50%	IN9	PWM Input
Current & Velocity PWM 100%	IN9 IN10	PWM Input Direction Input
Position Pulse & Direction	IN9 IN10	Pulse Input Direction Input
Position Up/Down	IN9 IN10	Count Up Count Down
Position Quadrature	IN9 IN10	Channel A Channel B

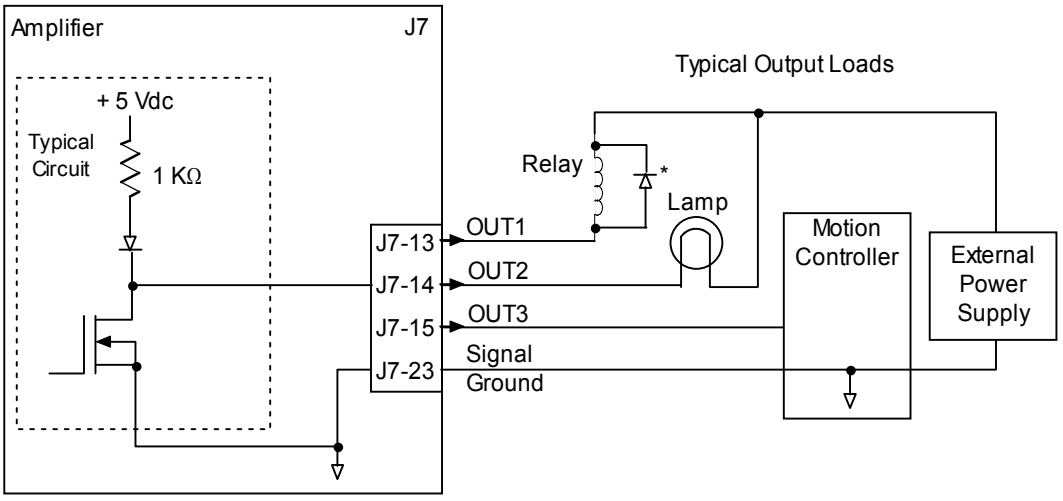
Digital Inputs Wiring Diagram



* Standard input R = KΩ C = 0.033μ*f*
High-speed input R = 1KΩ C = 100 p*f*

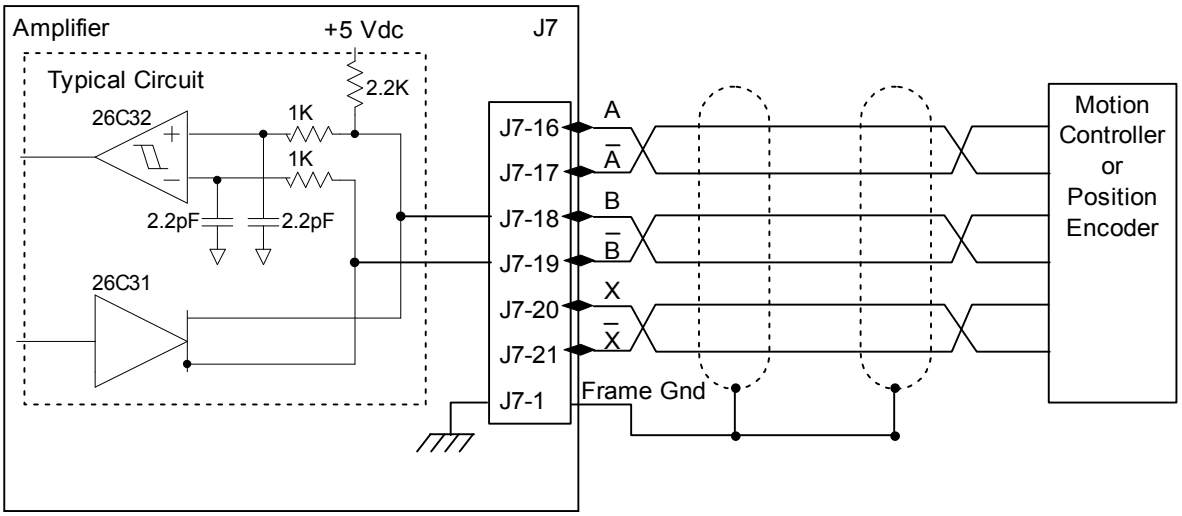
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Digital Outputs Wiring Diagram

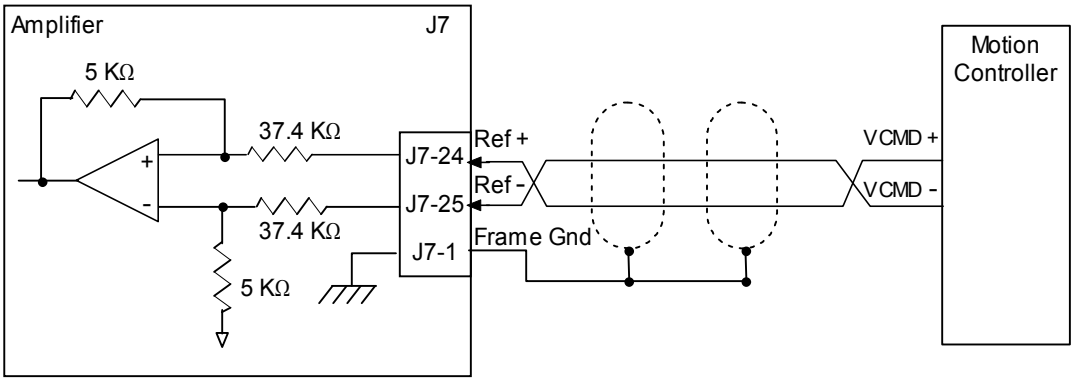


* Flyback diode required for inductive loads

Secondary Encoder Interface Diagram



Analog Input Wiring Diagram



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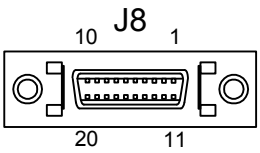
4.8: Motor Feedback (J8)

Mating Connector

Description	Manufacturer PN	Wire Size
20 Position, .050" Mini D Ribbon (MDR) Connector	3M 10120-3000 VE standard Molex 54306-2019 rugged	24 - 30 AWG
20 position, .050" mini D Connector, molded Insulation Displacement (IDC) style	Plug assembly: Molex 52316-2011 Boot cover: Molex 52370-2010	28 AWG
Back shell	3M: 10320-52F0-008 standard Molex 54331-0201 rugged	
Standard solder style connector included in Connector Kit PN XSL-CK 10 foot cable assembly included in Connector Kit PN XSL-CA uses molded IDC style connector		

NOTE: For color codes, see Control and Feedback Cable Color Codes (p. 196).

Pin connections are shown here:



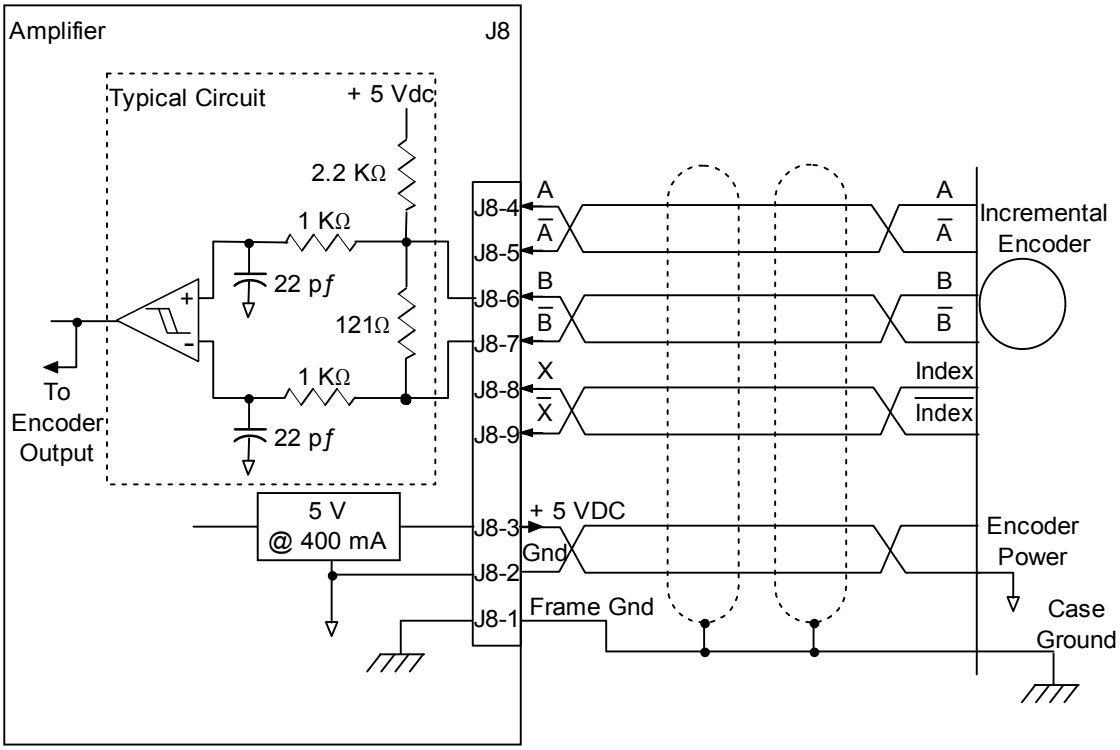
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J8 Pin Description

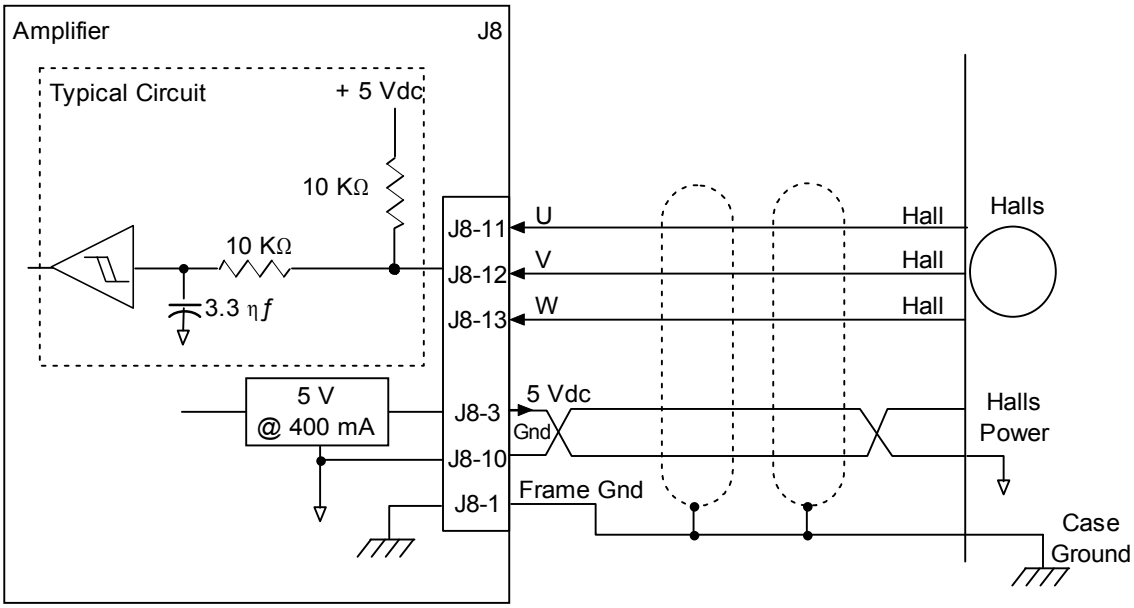
Pin	Signal	Function		
1	Frame Ground	Cable shield connection		
2	Signal Ground	Signal and +5 Vdc ground		
3	+5 Vdc	Encoder and/or Halls +5 Vdc power supply output. Total load current on J7-22 and J8-3 not to exceed 400 mA.		
4	Encoder A Input	Primary incremental encoder inputs		
5	Encoder /A Input			
6	Encoder B Input			
7	Encoder /B Input			
8	Encoder X Input			
9	Encoder /X Input			
10	Signal Ground	Signal and +5 Vdc ground		
11	Digital Hall U	Standard Xenus: Motor Hall switch inputs Resolver Xenus: Resolver outputs		
12	Digital Hall V OR Resolver R1 Output			
13	Digital Hall W OR Resolver R2 Output			
14	Digital Input IN5	Motor over temperature switch May be programmed to other functions	Standard speed	Pull-up/pull-down group 2
15	Signal Ground	Signal and +5 Vdc ground		
16	Encoder Sin(+) In OR Resolver S3 Input	Standard Xenus: Analog encoder inputs Resolver Xenus: Resolver inputs		
17	Encoder Sin(-) In OR Resolver S1 Input			
18	Encoder Cos(+) In OR Resolver S2 Input			
19	Encoder Cos(-) In OR Resolver S4 Input			
20	Signal Ground	Signal and +5 Vdc ground		

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Incremental Encoder Wiring Diagram

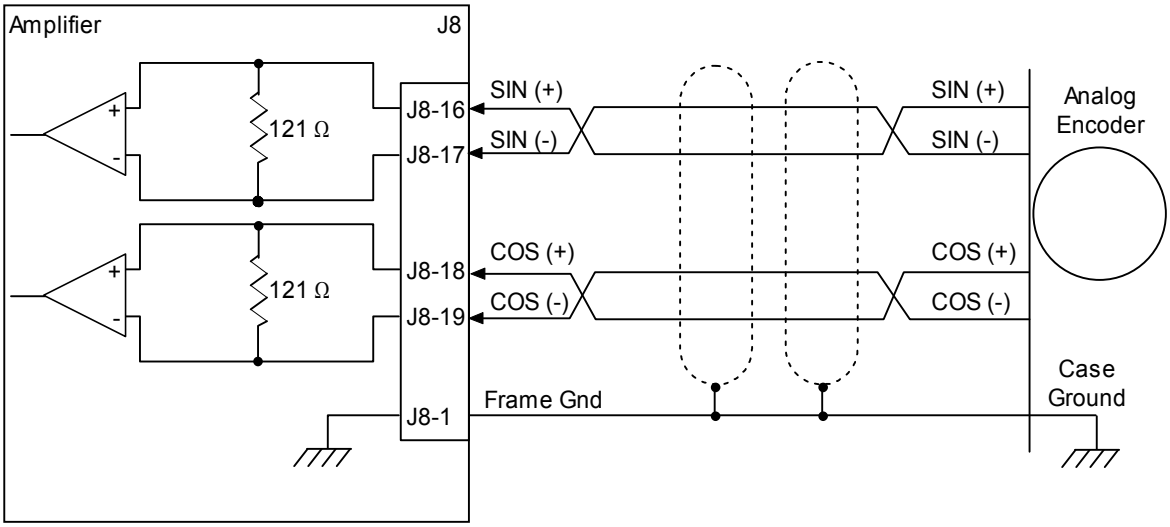


Hall Switch Wiring Diagram

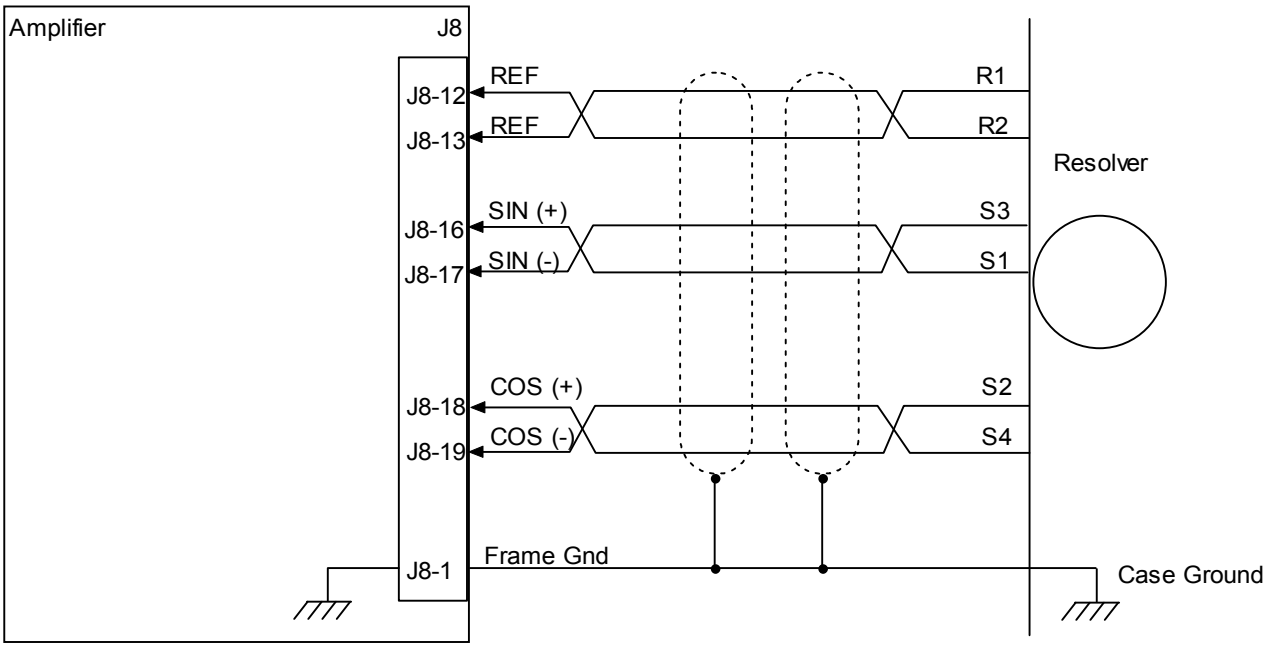


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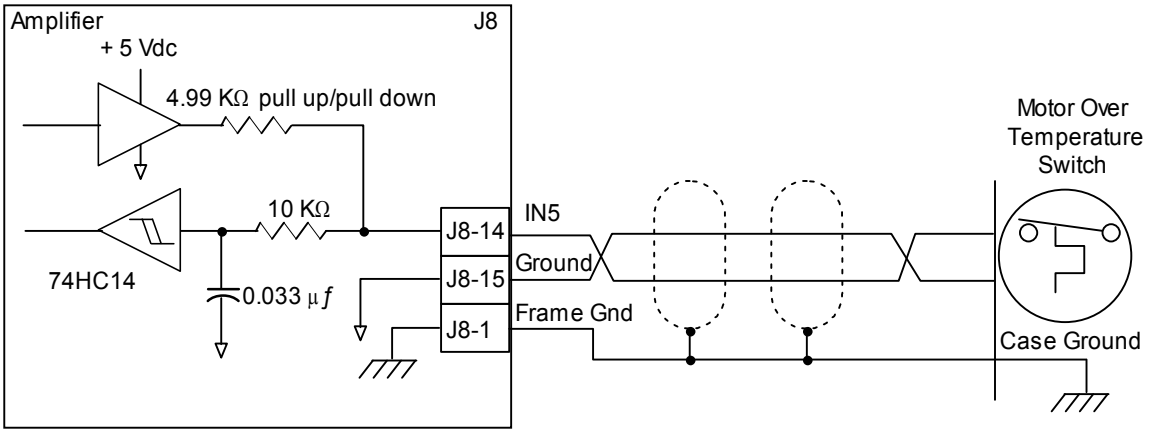
Analog Encoder Wiring Diagram



Resolver Wiring Diagram



Motor Over Temperature Wiring Diagram



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CHAPTER 5: QUICK SETUP WITH CME 2

This chapter describes the general procedure for configuring and tuning an amplifier with a motor.

(To copy setup data from an existing Copley Controls axis file (*.ccx*), skip to Quick Copy Setup Procedure (p. 128).

Step **Page**

5.1: Warnings 78
5.2: CME 2 Installation and Serial Port Setup 79
5.2.1: Requirements 79
5.2.2: Downloading Software from Web (Optional) 79
5.2.3: Installing CME 2 Software 79
5.2.4: Serial Port Setup 80
5.3: Prerequisites 82
5.3.1: Hardware and Equipment 82
5.3.2: Starting CME 2 and Choosing an Amplifier 83
5.4: Basic Setup 84
5.4.1: Basic Setup Screen 84
5.5: Motor Setup 86
5.5.1: Motor Data File 86
5.5.2: Rotary Motor 87
5.5.3: Linear Motor 88
5.6: Feedback Setup 89
5.6.1: Overview 89
5.6.2: Rotary Motor Feedback Setup Options 90
5.6.3: Linear Motor Feedback Setup Options 90
5.7: Brake/Stop (Optional) 91
5.7.1: Overview 91
5.7.2: Procedure 91
5.7.3: Calculate 92
5.8: Amplifier Configuration 93
5.8.1: Digital Inputs 93
5.8.2: Standard Digital Outputs 95
5.8.3: Custom Digital Outputs 96
5.8.4: Save Input/Output Changes 96
5.8.5: Fault Latching 97
5.8.6: Regen Resistor 98
5.9: Command Input 98
5.9.1: Analog Input 99
5.9.2: PWM Input 101
5.9.3: Digital Position Input 102
5.9.4: CAN Interface 104
5.10: Auto Phase 105
5.10.1: Auto Phase Warnings and Notes 105
5.10.2: Auto Phase Procedure 106
5.10.3: Guidelines for Choosing Auto Phase Current and Increment Rate Values 109
5.10.4: Trouble Shoot Motor Direction Setup 109
5.10.5: Trouble Shoot Motor Wiring Setup 109
5.10.6: Trouble Shoot Halls Wiring Setup 109
5.10.7: Other Problems 109
5.11: Current Loop 110
5.11.1: Current Loop Settings 110
5.11.2: Manually Tune Current Loop 111
5.12: Velocity Loop 113
5.12.1: Velocity Loop Settings 113
5.12.2: Manually Tune the Velocity Loop 114
5.13: Position Loop 115
5.13.1: Position Loop Settings 115
5.13.2: Manually Tune the Position Loop 116
5.13.3: Test S-Curve Profile 118
5.14: Completion Steps 119
5.14.1: Objective 119
5.14.2: Steps 119

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5.1: Warnings



DANGER: Hazardous voltages.

Exercise caution when installing and adjusting.

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

DANGER



Make connections with power OFF.

Do not make connections to motor or drive with power applied.

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

DANGER



Spinning motor with power off may damage amplifier.

Do not spin motors with power off. Voltages generated by a motor can damage an amplifier.

Failure to heed this warning can cause equipment damage.

WARNING

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5.2: CME 2 Installation and Serial Port Setup

5.2.1: Requirements

Computer and Operating System

Minimal hardware requirements:

- **CPU**: Minimum: 166 MHZ*. Recommended minimum: 266 MHZ.
- **RAM**: Minimum: 64 MB*. Recommended minimum: 128 MB.
- At least one standard RS-232 serial port or a USB port with a USB to RS-232 adapter.
- At least one serial communication cable. Available from Copley Controls. Copley Controls cable part number: SER-CK.

Operating Systems Supported: Windows 95, 98, ME, NT, 2000, XP.

*Using the minimum requirements will allow CME 2 to run, but performance will be significantly reduced.

Software

Copley Controls CME 2 software, Version 4.0 or higher.

5.2.2: Downloading Software from Web (Optional)

5.2.2.1 Choose or create a folder where you will download the software installation file.

5.2.2.2 In an internet browser, navigate to http://www.copleycontrols.com/Motion/Downloads/index.html .

5.2.2.3 Under *Software Releases*, click on *CME 2.*

5.2.2.4 When prompted, save the *CME2.zip* file to the folder chosen or created in Step 5.2.2.1.

The folder should now contain a file named *CME2.zip*.

5.2.2.5 Extract the contents of the zip file to the same location.

The folder should now contain the files *CME2.zip* and *Setup.exe*.

5.2.2.6 If desired, delete *CME2.zip* to save disk space.

5.2.3: Installing CME 2 Software

5.2.3.1 If installing from a CD, insert the CD (Copley Controls part number *CME2*).

Normally, inserting the CD causes the installation script to launch, and a CME 2 Installation screen appears. If so, skip to Step 5.2.3.3.

5.2.3.2 If the software installation file was downloaded from the Copley Controls website, navigate to the folder chosen or created in Step 5.2.2.1, and then double-click on *Setup.exe*
OR
if you inserted the CD and the CME 2 *Installation* screen did not appear, navigate to the root directory of the installation CD and then double-click on *Setup.exe*.

5.2.3.3 Respond to the prompts on the CME 2 *Installation* screens to complete the installation. We recommend accepting all default installation values.

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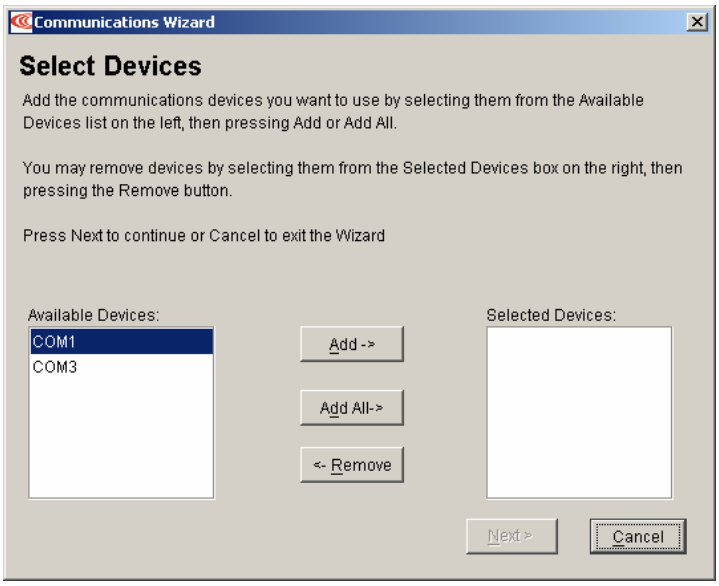
5.2.4: Serial Port Setup

One or more serial ports on a PC can be used to connect amplifiers. Use the following instructions to add (enable) ports for amplifiers, to choose baud rates for those ports, and to remove (disable) ports for amplifiers.

5.2.4.1 Start CME 2 by double-clicking the CME 2 shortcut icon on the Windows desktop:



If a serial port has not been selected, the *Select Devices* screen appears.



5.2.4.2 If the CME 2 *Main* screen appears instead of *Select Devices*, choose **Tools→Communications Wizard**.

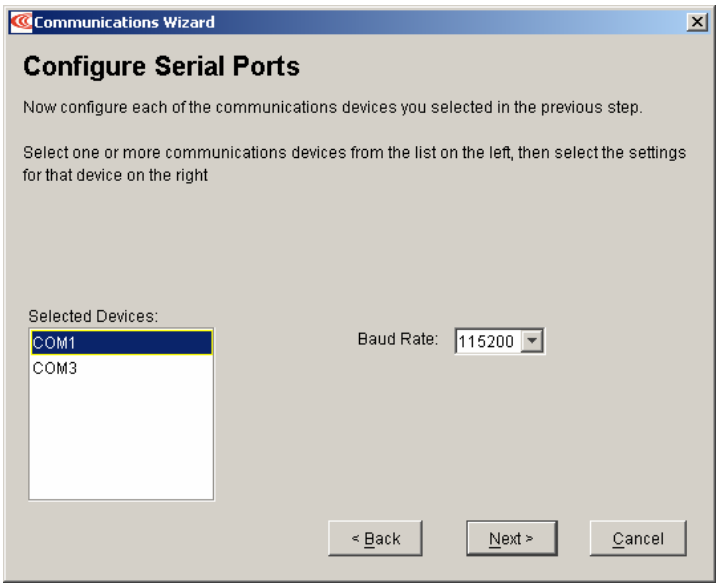


5.2.4.3 From the *Available Devices* list on the *Select Devices* screen, choose the serial ports that will be used to connect to amplifiers.

1. To allow connection of an amplifier through a port, highlight the port name and click **Add** (or click **Add All** to enable all available ports).
2. To remove a port from the *Selected Devices* list, highlight the port name and click **Remove**.

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5.2.4.4 Click **Next** to save the choices and open the *Configure Serial Ports* screen (or click **Cancel** to close the screen without saving changes).



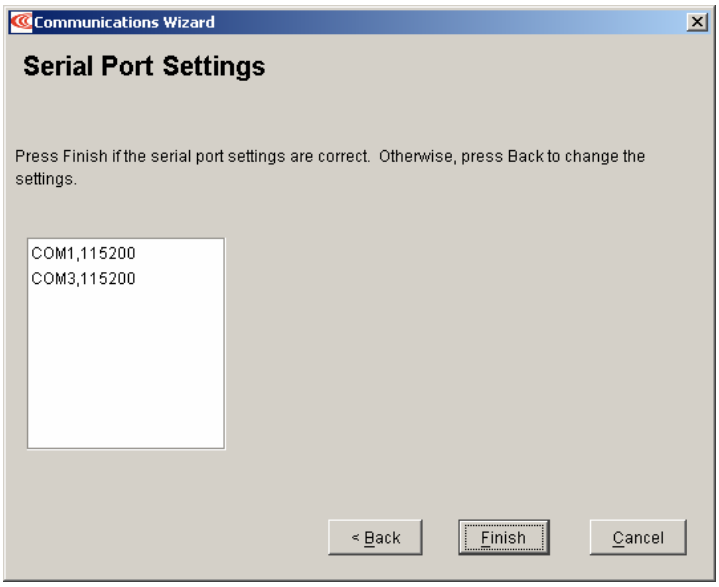
5.2.4.5 Configure the selected ports.

1 Highlight a port in the *Selected Devices* list.

2 Choose a *Baud Rate* for that port.

3 Repeat for each selected port.

5.2.4.6 Click **Next** to save the choices and open the *Serial Ports Settings Review* screen (or click **Cancel** to close the screen without saving changes).



5.2.4.7 Review the settings. To make a change, click **Back**. To accept the settings, click **Finish**. To close without saving changes, click **Cancel**.

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5.3: Prerequisites

5.3.1: Hardware and Equipment

5.3.1.1 Verify that +24 Vdc power is OFF and AC power is OFF.

5.3.1.2 Verify wiring and connections.

Ensure the following connections are wired according to the guidelines in Wiring (p. 59).

1. J8 "FDBCK" motor signals
2. J2 "U V W Earth" motor power
3. J7 "CNTRL" control signals
4. J4 "+24 Vdc, BRAKE" required +24 Vdc (power OFF)
5. J5 "RS-232" PC serial link
6. J1 "L1 L2 L3 Earth" line power (power OFF)

5.3.1.3 Secure the motor:

1. Make sure motor is securely fastened.
2. Make sure that no load is connected to the motor.

5.3.1.4 Apply +24 Vdc to the amplifier's J4 connection.

(Do NOT apply AC voltage to the amplifier at this point.)



DANGER

Risk of unexpected or uncontrolled motion with CME 2 in CAN mode.

CME 2 can be used while the amplifier is under CAN control. However, some extreme changes made with CME 2 could cause unexpected or uncontrolled motion.

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

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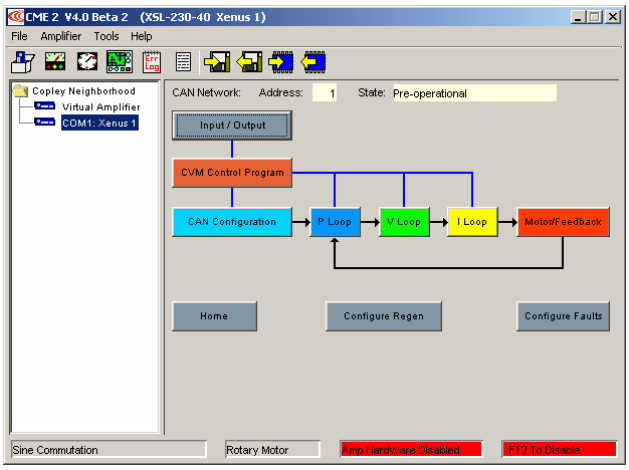
5.3.2: Starting CME 2 and Choosing an Amplifier

NOTE: To immediately software disable the amplifier at any time while running CME 2, press function key **F12**. Also, digital input 1 (IN1) should be configured as a hardware disable, and may be used to disable the amplifier.

5.3.2.1 Verify CME 2 installation and serial port configuration.

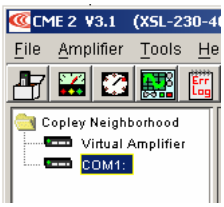
5.3.2.2 Start CME 2 by double-clicking the CME 2 shortcut icon on the Windows desktop:





If you have selected an amplifier that has not been set up, the *Basic Setup* screen appears.

5.3.2.3 If necessary, click the appropriate or amplifier in the *Copley Neighborhood* tree.



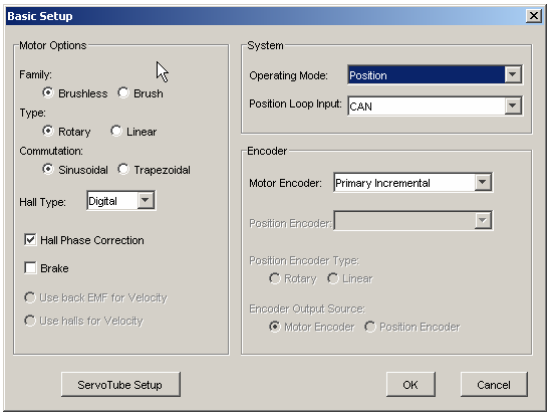
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5.4: Basic Setup

5.4.1: Basic Setup Screen

5.4.1.1 To configure an amplifier for use with a Copley Controls ServoTube motor, skip now to ServoTube Motor Setup (p. 185).

5.4.1.2 Click the **Basic Setup** button ( ) to display the *Basic Setup* screen**.**



5.4.1.3 Enter basic *Motor* options (described below).

Setting	Description
Motor Family	Select motor family. • Brushless • Brush
Motor Type	Select motor type. • Rotary • Linear
Commutation	Select commutation method • Sinusoidal • Trapezoidal See Commutation Modes (p. 18).
Halls Type	Select Hall type. • None • Digital • Analog (used with Copley Controls ServoTube motors)
Hall Phase Correction	If checked, will enable error checking between Hall switches and encoder based phase angle. See Fault Descriptions (p. 37.)
Brake	If checked, will enable brake delay times. See Brake Operation (p. 33) and Brake/Stop (Optional) (p. 91).
Use back EMF for Velocity	If selected, will use the motors measured back EMF to determine motor velocity.
Use Halls for Velocity	If selected, will use transitions of the Hall switches to determine motor velocity.
ServoTube Setup	Configures amplifier for ServoTube operation. See ServoTube Motor Setup (p. 185).

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5.4.1.4 Enter basic *System* options (described below).

Setting	Description
Operating Mode	Choose the mode of operation See Operating Modes (p. 19) • Current • Velocity • Position
Loop Input	Choose the command input source. See Input Command Types (p. 25) • Analog command • PWM command (current and velocity mode only) • Function generator • CVM Control Program • Digital Input (position mode only) • CAN (position mode only). See CANopen Operation (p. 30)

5.4.1.5 Enter Feedback Options, described below.

Setting	Description
Motor Encoder	Select type and source of motor feedback. • None: *No motor feedback* • Primary Incremental: *Incremental encoder on J8* • Secondary Incremental: *Incremental encoder on J7* • Analog: *Analog encoder on J8* • Low Frequency Analog: *Copley ServoTube motor on J8* • Resolver (Resolver version only): *Resolver on J7*
Position Encoder	Select type and source of Position (load) feedback. • Primary Incremental: *Incremental encoder on J8* • Secondary Incremental: *Incremental encoder on J7* • Analog: *Analog encoder on J8*
Position Encoder Type	Select the type of Position (load) encoder • Rotary • Linear (not available in CME 4.0)
Encoder Output Source	Select source of the encoder output signal. Not available if secondary encoder input is used. • Motor Encoder • Position (load) Encoder

For more information see Feedback (p. 18) and Feedback Setup (p. 89).

5.4.1.6 Click **OK** to accept the values and write them to flash memory
OR
to return to the *Main* screen without saving changes, click **Cancel**.

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5.5: Motor Setup

There are three methods for performing motor setup. Choose the appropriate method and perform the steps described.

Method	Step
Load motor data from file (.ccm)	Motor Data File (p. 86)
Enter rotary motor data	Rotary Motor (p. *87*)
Enter linear motor data	Linear Motor (p. 88

5.5.1: Motor Data File

5.5.1.1 To download motor data files from the website:

1. In an internet browser, navigate to http://www.copleycontrols.com/Motion/Downloads/motorData.html
2. Click on the appropriate motor name.
3. When prompted, save the file to the *MotorData* folder in the CME 2 installation folder.
4. (The default installation folder is C:\Program Files\Copley Motion\CME 2\MotorData.)
5. Extract the contents of the zip file to the same location.
6. The folder should now contain the new motor data file (with a *.ccm* filename extension).
7. If desired, delete the *.zip* file to save disk space.

5.5.1.2 To load motor data from a motor data file

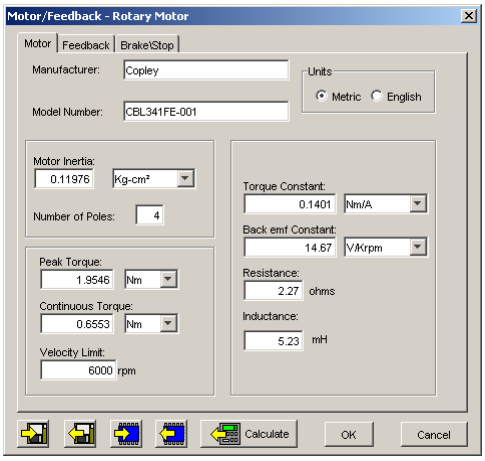
1. Click **Motor/Feedback** (

) to open the *Motor/Feedback* screen.
2. On the *Motor/Feedback* screen, click **Restore Motor Data from Disk** (). When prompted, navigate to the folder containing the file, then click on the file name, and then click **Open**.
3. Proceed to Calculate (p. 92).
   OR
   to return to the *Main* screen without restoring motor data, click **Cancel.**

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5.5.2: Rotary Motor

5.5.2.1 Click **Motor/Feedback** (Motor/Feedback) to open the *Motor/Feedback-Rotary Motor* screen.



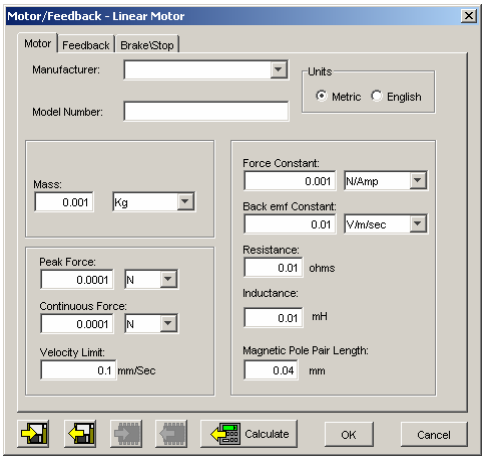
5.5.2.2 Enter the rotary options described below.

Option	Description
Manufacturer	Motor manufacturer's name. Saved for reference in the motor data file.
Model Number	Motor model number. Saved for reference in the motor data file.
Units	Selects whether the parameters entered in this screen are in Metric or English units.
Motor Inertia	The rotor inertia of the motor. Used for calculating initial velocity loop tuning values. Range: 0.00001 to 1,000 kg-cm^2. Default: 0.00001 kg-cm^2.
Number of Poles	(Brushless only.) The number of magnetic poles in the motor. Required for correct commutation of the motor. If the number of poles is not known, refer to Verify Motor Pole Count (p. 148). Range: 2 to 200. Default: 4.
Peak Torque	The peak torque that the motor can produce. Peak Torque divided by torque constant = motor's peak current limit. Range: 0.001 to 1,000 Nm. Default: 0.0001 Nm.
Continuous Torque	The continuous torque that the motor can produce. Used with the torque constant to calculate continuous current. Range: 0.001 to 1,000 Nm. Default: 0.0001 Nm.
Velocity Limit	Maximum speed of the motor. Used to calculate the velocity and acceleration limits for the velocity loop. Range dependent on encoder resolution.
Torque Constant	Relates the motor's input current to torque produced. Sometimes abbreviated as Kt. Range: 0.001 to 1,000 Nm/Amp. Default: 0.001 Nm/Amp.
Back emf Constant	Relates the motor's input voltage to speed. Sometimes abbreviated as Ke. Used for calculating the maximum velocity for a given amplifier bus voltage. Range: 0.01 to 1,000 V/Krpm. Default: 0.01 V/Krpm.
Resistance	Motor resistance line-to-line. Used for calculating the initial current loop tuning values. Range: 0.01 to 327 Ω. Default: 0.01 Ω.
Inductance	Motor inductance line-to-line. Used for calculating the initial current loop tuning values. Range: see Power Output (p. 50).

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5.5.3: Linear Motor

5.5.3.1 Click **Motor/Feedback** to open the *Motor/Feedback - Linear Motor* screen.



5.5.3.2 Enter the linear motor options shown below.

Option	Description
Manufacturer	Motor maker's name. Saved in motor data file. Choose from list or enter manually.
Model Number	Motor model number. Saved in the motor data file. Choose from list or enter manually.
Units	Selects whether the parameters entered in this screen are in Metric or English units.
Mass	The mass of the motor. Used for calculating initial velocity loop tuning values. Range: .0001 Kg to 100,000 Kg. Default: .0001 Kg.
Peak Force	The peak force that the motor can produce. Peak Force divided by Force Constant = motor's peak current limit. Range: 0.00001 to 1,000 N. Default: 0.00001 N.
Continuous Force	The continuous force that the motor can produce. Used with the force constant to calculate continuous current. Range: 0.00001 to 1,000 N. Default: 0.00001 N.
Velocity Limit	Maximum speed of the motor. Used to calculate the velocity and acceleration limits for the velocity loop. Range dependent on encoder resolution.
Force Constant	Relates the motor's input current to force produced. Sometimes abbreviated as Kf. Range: 0.00001 to 1,000 N/Amp. Default: 0.00001 N/Amp.
Back emf Constant	Relates the motor's input voltage to speed. Sometimes abbreviated as Ke. Used for calculating maximum velocity for a given amplifier voltage. Range: 0.01 to 1,000 V/M/Sec. Default: 0.01 V/M/Sec.
Resistance	Motor resistance line to line. Used for calculating the initial current loop tuning values. Range: 0.01 to 327 Ω. Default: 0.01 Ω.
Inductance	Motor inductance line to line. Used for calculating the initial current loop tuning values. Range: see Power Output (p. 50).

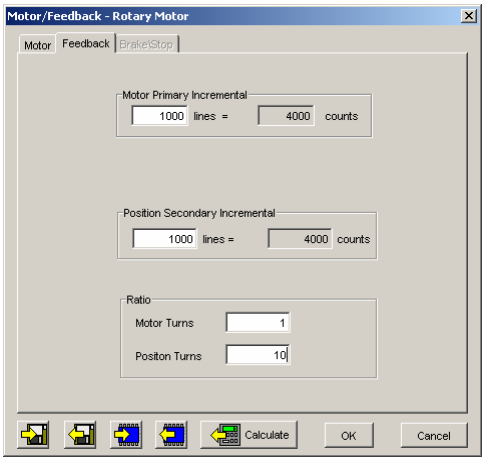
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5.6: Feedback Setup

5.6.1: Overview

A Xenus amplifier can receive position feedback from sensors on the motor, the load, or both, through the Primary feedback channel (J7), the Secondary Feedback channel (J8) or both. (It can also operate in certain modes without encoders or resolvers.)

A dual-feedback setup is shown below. The amplifier receives feedback from an incremental motor encoder through the Primary feedback channel (J8). Position (load) encoder feedback comes through the Secondary channel (J7). The ratio of motor turns to position encoder turns is 1 to 10.

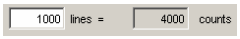
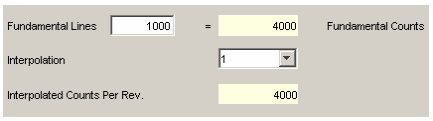


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5.6.2: Rotary Motor Feedback Setup Options

5.6.2.1 Click the **Feedback** tab.

5.6.2.2 As appropriate for each encoder or resolver, enter the options described here.

Feedback Type	Options/Actions
Incremental 	In the **lines** field, enter the number of encoder lines (see encoder or motor data sheet). As indicated by the **counts** field, the number of encoder counts per revolution is equal to 4 x the number of lines.
Analog 	In **Fundamental Lines**, enter the number of fundamental encoder lines (see encoder or motor data sheet). As indicated by the Fundamental Counts field, the number of fundamental encoder counts per revolution is equal to 4 x the number of Fundamental Lines. Optionally modify the encoder resolution by changing the **Interpolation** value. The interpolated resolution (Interpolated Counts Per Rev) is the product of Fundamental Counts value and the Interpolation value.
Resolver 	Optionally modify the feedback resolution by changing the value in **Counts Per Rev**. Default: 16384.

5.6.2.3 If two feedback devices are installed, verify that the values of Motor Turns to Position Turns correctly represent the ratio of motor encoder turns to position encoder turns.

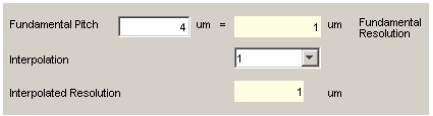
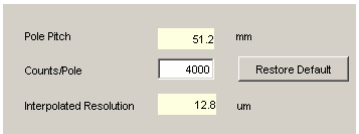


5.6.2.4 If using a brake, then proceed to Brake/Stop (Optional) (p. 91).
Else, proceed to Calculate (p. 92).

5.6.3: Linear Motor Feedback Setup Options

5.6.3.1 Click the **Feedback** tab.

5.6.3.2 As appropriate for each encoder installed, enter the options described below.

Feedback Type	Options/Actions
Incremental 	Choose units (mm, nm, um) and then enter the **Encoder Resolution** (see encoder or motor data sheet).
Analog 	Enter the **Fundamental Pitch** (distance between encoder lines; see encoder or motor data sheet). As indicated by the Fundamental Resolution field, every unit of fundamental pitch produces four encoder counts. The interpolated resolution is the dividend of Fundamental Counts value/Interpolation value. Optionally modify the resolution by changing the **Interpolation** value.
Low Frequency Analog 	(Normally used with ServoTube) Pole Pitch is the distance between poles in a poll pair, as entered in the Magnetic Pole Pair Length field on the Motor tab. The interpolated resolution is the dividend of Pole Pitch/Counts per pole value, expressed in um. Optionally modify the resolution by changing the **Counts/Pole** value. Click **Restore Default** to restore default Counts/Pole.

5.6.3.3 If using a brake, then proceed to Brake/Stop (Optional) (p. 91).
Else, proceed to Calculate (p. 92).

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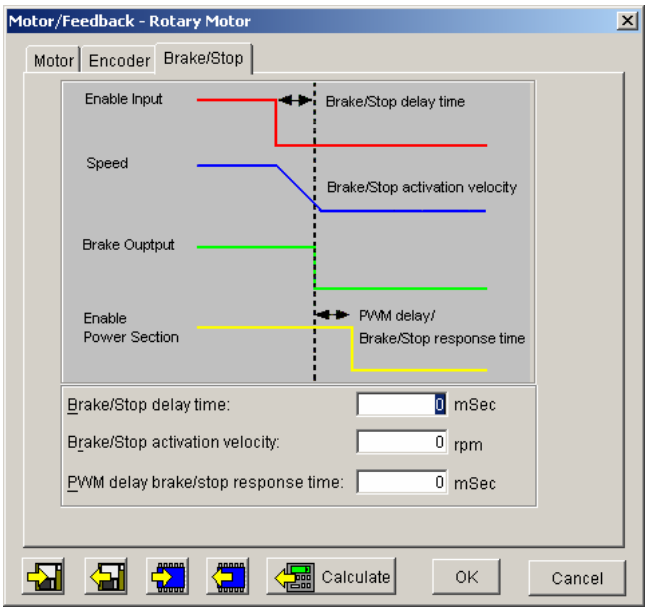
5.7: Brake/Stop (Optional)

5.7.1: Overview

Many control systems employ a brake to hold the axis when the amplifier is disabled. For more information see Brake Operation (p. 33).

5.7.2: Procedure

5.7.2.1 Click the *Brake/Stop* tab.



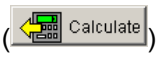
5.7.2.2 Enter the following options.

Option	Description
Brake/Stop Delay Time	Range of accepted values: 0 to 10,000 mSec
Brake Activation Velocity	Range of accepted values: 0 to 100,000 rpm (mm/s for linear motor)
PWM Delay Brake/Stop Response Time	Range of accepted values: 0 to 10,000 mSec

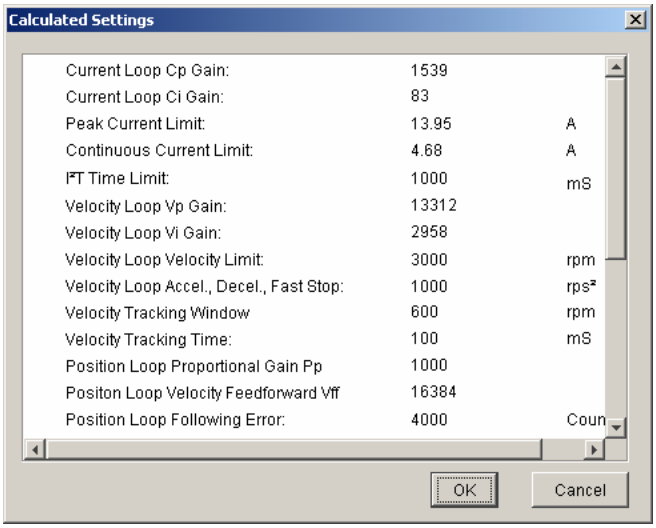
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5.7.3: Calculate

The *Calculate* function uses the motor and encoder values entered to calculate initial loop gains and limits. These can be modified later to fine-tune the amplifier.

5.7.3.1 Click **Calculate** (

) to calculate and display the settings.



5.7.3.2 Verify the peak current limit, continuous current limit, and velocity loop velocity limit.

If one or more of these values seems inappropriate, click **Cancel** and check the following values entered in Motor Setup (p. 86): Peak Torque (or Force), Continuous Torque (or Force), Velocity Limit, and Torque (or Force) Constant. Correct them if needed.

If the Motor/Feedback values were correct but the peak current limit, continuous current limit, or velocity loop velocity limit values are not optimal for the application, change these limits during the tuning process.

5.7.3.3 Load the values into volatile memory by clicking **OK**
OR
to close the screen without saving changes, click **Cancel**.

NOTE: If the motor wiring configuration in the motor file does not match the configuration currently stored in the amplifier, CME prompts for verification on which configuration to use. Select the file configuration by clicking **Yes**. The configuration will be tested later, in Auto Phase (p. 105).

5.7.3.4 Click **Save to Flash** ().

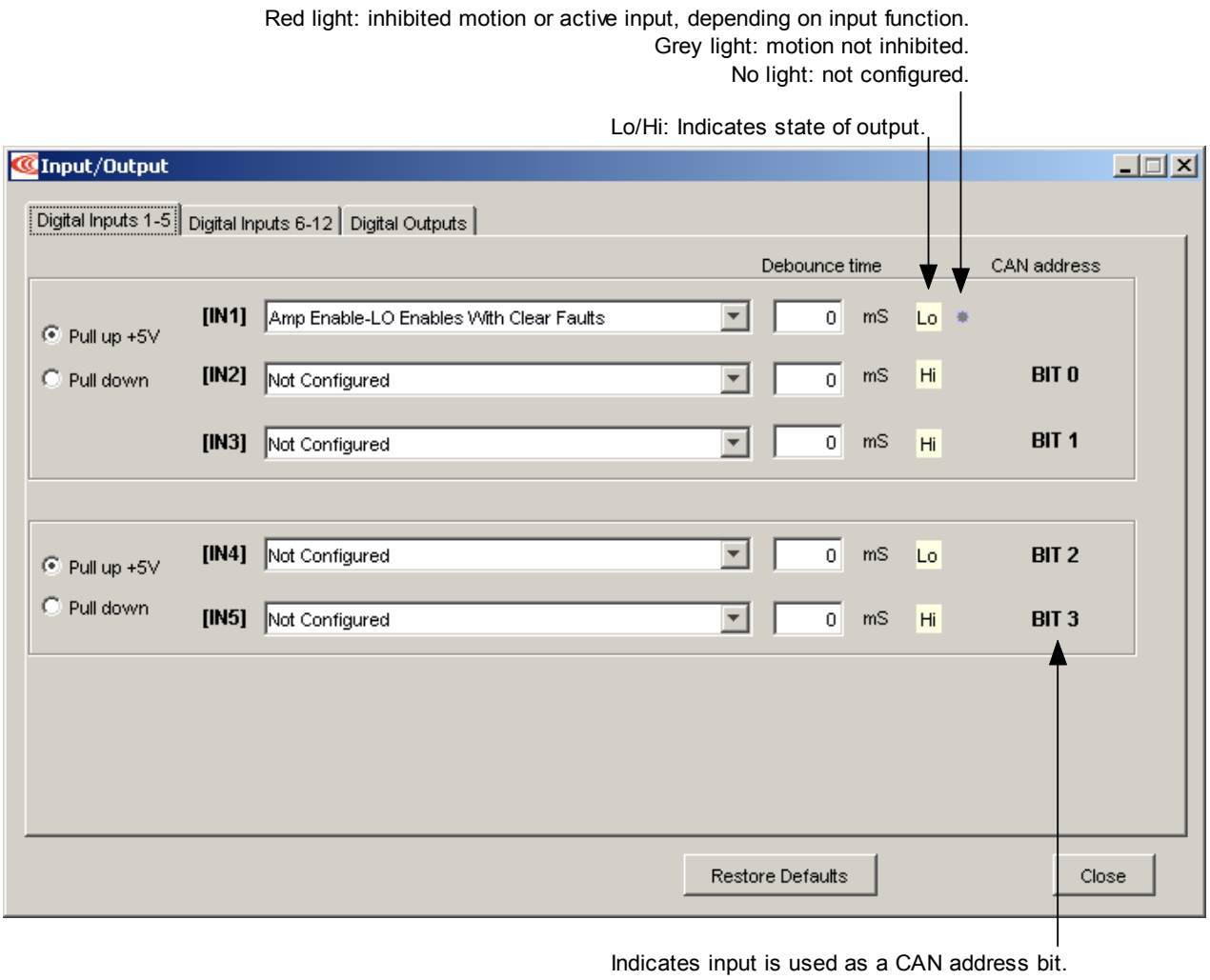
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5.8: Amplifier Configuration

5.8.1: Digital Inputs

5.8.1.1 Click **Input/Output** (

) on the *Main* screen to open the *Input/Output* screen.



5.8.1.2 Enter the following options:

Option	Description
Pull up +5 V	Internally pulls the group of inputs up to internal +5 V.
Pull down	Internally pulls the group of inputs down to signal ground.
Debounce Time	Sets the input debounce time. Range of accepted values: 0 to 10,000 mSec. For more information, see Debounce Time (p. 42).
IN1-IN12	Select the function for the input. See Digital Input Functions (p. 94) for input function descriptions.

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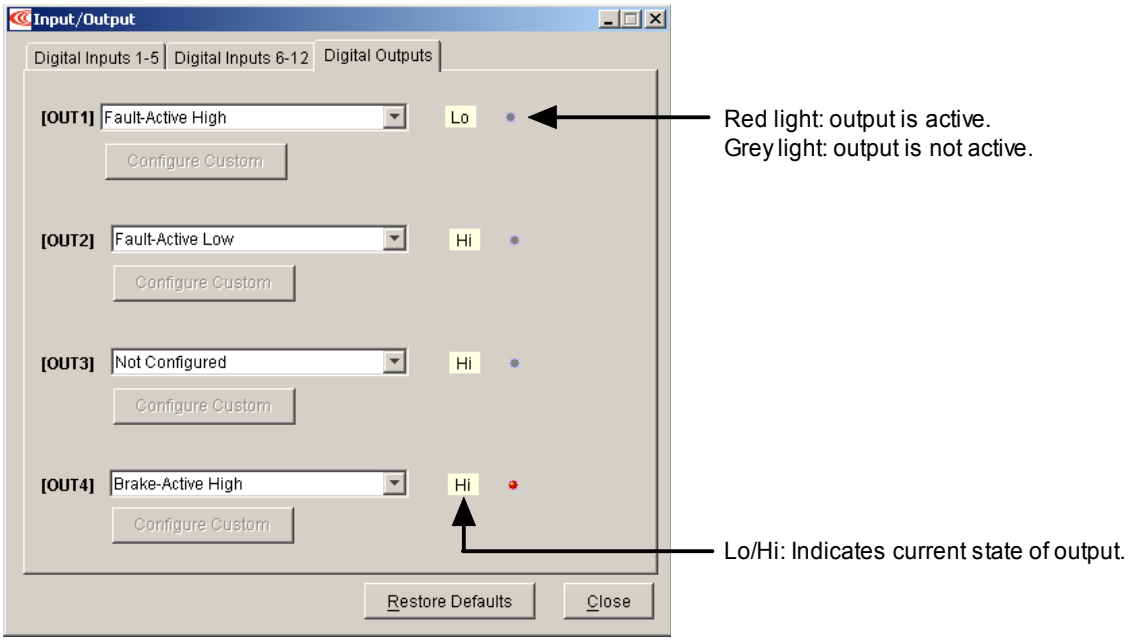
5.8.1.3 Digital Input Functions

Input Function	Description
AMP Enable- LO Enables with clear faults	A low input will enable the amplifier. A low to high transition will clear latched faults and outputs.
AMP Enable- HI Enables with clear faults	A high input will enable the amplifier. A high to low transition will clear latched faults and outputs.
AMP Enable- LO Enables with reset	A low input will enable the amplifier. A low to high transition will reset the amplifier.
AMP Enable- HI Enables with reset	A high input will enable the amplifier. A high to low transition will reset the amplifier.
AMP Enable- LO Enables	A low input will enable the amplifier.
AMP Enable- HI Enables	A high input will enable the amplifier.
Not Configured	No function assigned to the input.
NEG Limit-HI Inhibits	A high input will inhibit motion in negative direction.
NEG Limit-LO Inhibits	A low input will inhibit motion in negative direction.
POS Limit-HI Inhibits	A high input will inhibit motion in positive direction.
POS Limit-LO Inhibits	A low input will inhibit motion in positive direction.
Reset on LO-HI Transition	A low to high transition of the input will reset the amplifier.
Reset on HI-LO Transition	A high to low transition of the input will reset the amplifier.
Motor Temp HI Disables	A high input will generate a Motor Over Temperature fault.
Motor Temp LO Disables	A low input will generate a Motor Over Temperature fault.
Home Switch Active HI	A high input indicates the home switch is activated.
Home Switch Active LO	A low input indicates the home switch is activated.
Motion Abort Active HII	A high input will stop motion, leaving amplifier enabled.
Motion Abort Active LO	A low input will stop motion, leaving amplifier enabled.
Hi Res Analog Divide Active HI	A high input causes the firmware to divide the level of the analog input signal by 8.
Hi Res Analog Divide Active LO	A low input causes the firmware to divide the level of the analog input signal by 8.
PWM Sync Input	PWM synchronization input, see PWM Sync Input (p. 43) and PWM Sync Output (p. 44)..

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5.8.2: Standard Digital Outputs

5.8.2.1 Click the *Digital Outputs* tab of the *Input/Output* screen.



5.8.2.2 Choose any of the following functions for any output. OUT4 is recommended for brake function.

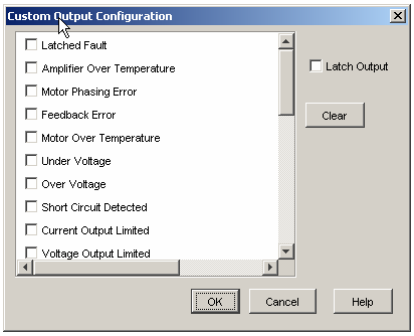
Output Function	Description	For More Information
Not Configured	No function assigned. Output remains high.	
Fault Active High	Output goes high when at least one fault is detected.	Faults (p. 36).
Fault-Active Low	Output goes low when at least one fault is detected.	
Brake-Active High	Output goes high to activate the brake.	Brake Operation (p. 33).
Brake-Active Low	Output goes low to activate the brake.	
PWM Sync Output (OUT1 only)	The PWM synchronization output.	PWM Sync Input (p. 43) and PWM Sync Output (p. 44).
Custom-Active High	The output goes high when one or more of the triggering events are detected. To set the triggering events, see Custom Digital Outputs (p. 96).	
Custom-Active Low	The output goes low when one or more of the triggering events are detected. To set the triggering events, see Custom Digital Outputs (p. 96).	
Program Control High	Output state controlled by CVM or CAN program	
Program Control Low	Output state controlled by CVM or CAN program	

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5.8.3: Custom Digital Outputs

5.8.3.1 Click **Configure Custom** (

) to open *Custom Output Configuration*.



5.8.3.2 If needed, to deselect all events on the list, click **Clear**.

5.8.3.3 Choose any number of events from the list. (Selected events are OR'ed together, so any event activates the output.)

5.8.3.4 To optionally latch the selected events, select **Latch Output** (

). For more information on latching, see Non-Latched and Latched Custom Outputs (p. 45).

5.8.3.5 Click **OK** to save changes to volatile memory and close the *Custom Output Configuration* screen
OR
click **Cancel** to close the screen without saving changes.

5.8.4: Save Input/Output Changes

5.8.4.1 On the *Input/Output* screen, click **Close**.

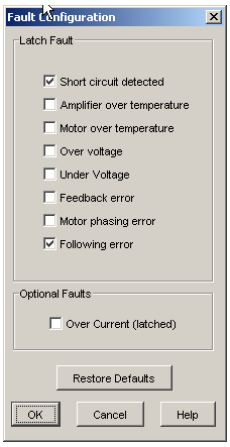
5.8.4.2 On the *Main* screen, click **Save to Flash** ().

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5.8.5: Fault Latching

5.8.5.1 Click **Configure Faults** (

) to open the *Fault Configuration* screen.



5.8.5.2 To make a fault condition latching, click to put a check mark next to the fault description.



DANGER

Risk of unexpected motion with non-latched faults.

After the cause of a non-latched fault is corrected, the amplifier 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.

For more information on faults, see Faults (p. 36).

5.8.5.3 To restore factory defaults if needed, click **Restore Defaults.**

5.8.5.4 Click **OK** to save fault configuration settings to volatile memory and close the *Fault Configuration* screen
OR
click **Cancel** to restore to previous values and close the screen.

5.8.5.5 On the *Main* screen, click **Save to Flash** ().

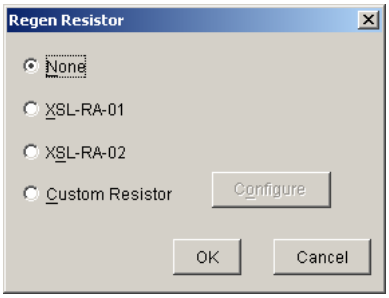
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5.8.6: Regen Resistor

For more information on the external regen resistor, see Regen Resistor Theory (p. 47), and Regen Resistor Sizing and Configuration (p. 153).

5.8.6.1 Click **Configure Regen** (

) to open the *Regen Resistor* screen.



5.8.6.2 Select a resistor option.

Option	Description
None	No external regen resistor is used.
XSL-RA-01	Standard regen resistors supplied by Copley Controls.
XSL-RA-02	
Custom Resistor	User-supplied resistor. See Regen Resistor Sizing and Configuration (p. 153).

5.8.6.3 Click **OK** to save regen settings to flash memory and close the *Regen Resistor* screen
OR
click **Cancel** to restore to previous values and close the screen.

5.9: Command Input

Choose the appropriate step for the input format.

Input Format	Step
Analog	Analog Input (p. 99)
PWM	PWM Input (p. 101)
Digital Position	Digital Position Input (p. 102)
CAN	CAN Interface (p. 104)
ASCII	*Contact Customer Support.*

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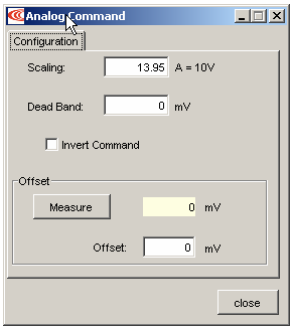
5.9.1: Analog Input

For more information, see Analog Command Input (p. 25).

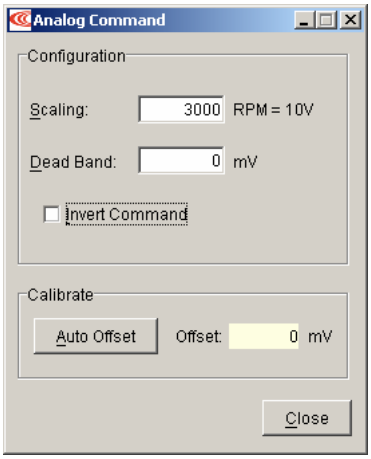
5.9.1.1 Click **Analog Command** (

) to open the mode-specific *Analog Command* screen.

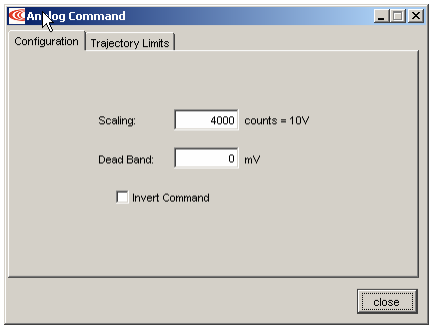
Current mode:



Velocity mode:



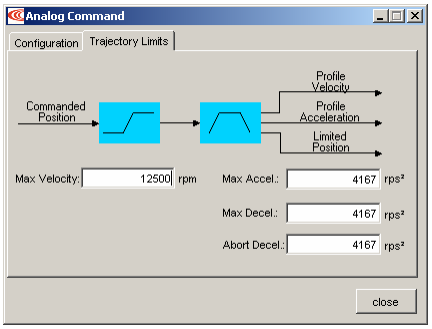
Position mode:



5.9.1.2 Set the input *Configuration* options described below.

Option	Description
Scaling	Current mode: output current produced by +10 Vdc of input. Range: 0 to 10,000,000 A. Default: *Peak Current* value. Velocity mode: output velocity produced by +10 Vdc of input. Range: 0 to 100,000 rpm (mm/sec). Default: *Maximum Velocity* value. Position mode: position change (counts or mm) produced by +10 Vdc of input. Range: 0 to 1,000,000,000 counts. Default: 1 Revolution of a rotary motor or 1 pole pair distance for a linear motor. For more information, see *Scaling* (p. 25).
Dead Band	Sets dead band. Range: -10,000 to 10,000 mV. Default: 0. For more information, see Dead Band (p. 25).
Invert Command	Inverts polarity of amplifier output with respect to input signal.
Calibrate	Used to offset input voltage error in an open loop system. Not recommended for use when the amplifier is part of a closed loop system. Range: -10,000 to 10,000 mV. Default: 0. For more information, see Offset (p. 26).

5.9.1.3 In position mode, open the *Trajectory Limits* tab:



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5.9.1.4 In position mode, set the *Trajectory Limits* described below:

Option	Description
Max Velocity	Maximum trajectory velocity. Max value may depend upon the back EMF and the Max feedback count. Min:0. Default: 0.25 x motor velocity limit.
Max Accel	Maximum trajectory acceleration. Max value may depend upon the load inertia and peak current. Min:0. Default: 0.5 x velocity loop *Accel. Limit* value.
Max Decel	Maximum trajectory deceleration. Max value may depend upon the load inertia and peak current. Min:0. Default: 0.5 x velocity loop *Accel. Limit* value.
Abort Decel	Deceleration rate used by the trajectory generator when motion is aborted. Min:0. Default: 0.5 x velocity loop *Accel. Limit* value.

5.9.1.5 Click **Close.**

5.9.1.6 On the *Main* screen, click **Save to Flash** ().

5.9.1.7 Proceed to Auto Phase (p. 105).

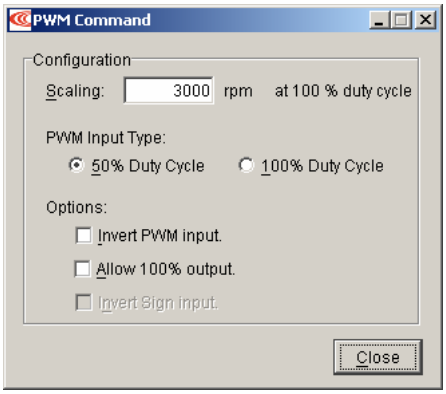
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5.9.2: PWM Input

For more information, see PWM Input (p. 27).

5.9.2.1 Click **PWM Command** (

) to open the *PWM Command* screen.



5.9.2.2 Set the input options described below.

Option	Description
Scaling	Current mode: output current at 100% duty cycle. Range: 0 to 10,000,000 A. Default: *Peak Current* value. Velocity mode: output velocity at 100% duty cycle. Range: 0 to 100,000 rpm (mm/sec). Default: *Maximum Velocity* value.
PWM Input Type	One wire 50% or two wire 100% with direction.
Options	Invert PWM input: Inverts the PWM logic. Allow 100% output: Overrides the 100% command safety measure. See Failsafe Protection from 0 or 100% Duty Cycle Commands (p. 27). Invert Sign Input: In 100% duty cycle mode, inverts the polarity of the directional input.

5.9.2.3 Click **Close**.

5.9.2.4 On the *Main* screen, click **Save to Flash** ().

5.9.2.5 Proceed to Auto Phase (p. 105).

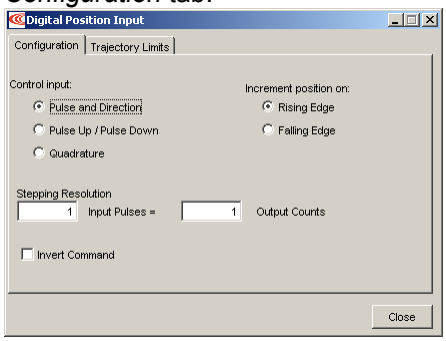
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5.9.3: Digital Position Input

For more information, see Digital Input (p. 28).

5.9.3.1 Click **Digital Position Inputs** (

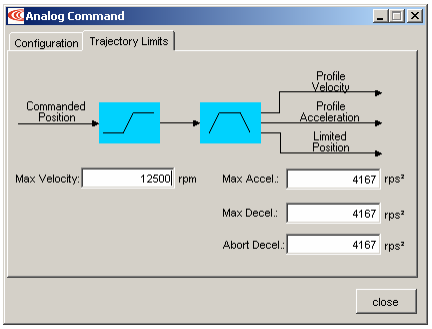
) to open the *Digital Position Input* screen, *Configuration* tab.



5.9.3.2 Set the options described below:

Option	Description
Control Input	Pulse and Direction: One input takes a series of pulses as motion step commands, and another input takes a high or low signal as a direction command. Pulse Up / Pulse Down: One input takes each pulse as a positive step command, and another takes each pulse as a negative step command. Quadrature: A/B quadrature commands from a master encoder (via two inputs) provide velocity and direction commands.
Increment position on	Rising Edge: Increment position on the rising edge of the input pulse. Falling Edge: Increment position on the falling edge of the input pulse.
Stepping Resolution	Input Pulses: Number of Input Pulses required to produce output counts. Range: 1 to 32,767. Default: 1. Output Counts: Number of Output Counts per given number of input pulses. Range: 1 to 32,767. Default: 1.
Invert Command	When checked, inverts commanded direction.

5.9.3.3 Click the *Trajectory Limits* tab.



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5.9.3.4 Enter the options described below:

Option	Description	For More Information
Max Velocity	Maximum trajectory velocity. Max value may depend upon the back EMF and the Max feedback count. Min:0. Default: 0.25 x motor velocity limit.	Position Mode and Position Loop (p. 24)
Max Accel	Maximum trajectory acceleration. Max value may depend upon the load inertia and peak current. Min:0. Default: 0.5 x velocity loop *Accel. Limit* value.	
Max Decel	Maximum trajectory deceleration. Max value may depend upon the load inertia and peak current. Min:0. Default: 0.5 x velocity loop *Accel. Limit* value.	
Abort Decel	Deceleration rate used by the trajectory generator when motion is aborted. Min:0. Default: 0.5 x velocity loop *Accel. Limit* value.	See Brake Operation (p. 33)

5.9.3.5 Click **Close**.

5.9.3.6 Click Save to Flash ().

5.9.3.7 Proceed to Auto Phase (p. 105).

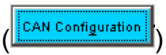
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5.9.4: CAN Interface

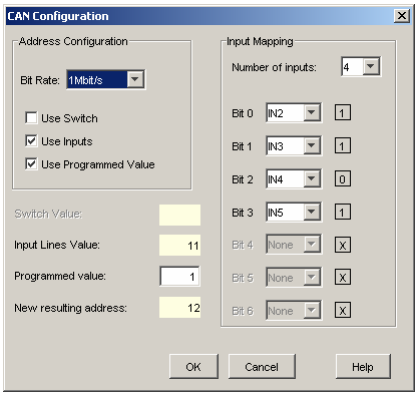
For more information, see CAN Addressing (p. 31).

5.9.4.1 Verify that the following connections are wired according to the instructions in CAN Bus (J6) (p. 67):

1. J6 "CAN" CANopen cable
2. J6 "CAN" Termination plug

5.9.4.2 Click **CAN Configuration** (

) to open the *CAN Configuration* screen. (If CAN is not the Position Loop Input, choose **Amplifier>CAN Configuration** instead.)



5.9.4.3 Choose a **Bit Rate**.

5.9.4.4 Check the appropriate buttons to choose any combination of address sources (Switch, Inputs, and Programmed Value). The address is the sum of the values from these sources.

5.9.4.5 For each source selected, perform the additional steps described below.

Source	Steps	Comments
Use Switch	Verify the S1 switch setting.	Assigns values for Bit 0 – Bit 3 of CAN address.
Use Inputs	Enter the **Number of inputs**. Choose the input that will represent each CAN address bit.	
Use Programmed Value	Enter the **Programmed value**.	

5.9.4.6 Click **OK** to close the screen and save the changes to flash,
OR click **Cancel** to close the screen without saving the changes.

NOTE: CAN address and bit rate are changed only after +24 Vdc power-up or reset.

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5.10: Auto Phase

5.10.1: Auto Phase Warnings and Notes

Warnings



Danger

Motor Motion

Applying AC power to the amplifier may result in motor motion. Be sure that motor motion will not cause injury.

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



Danger

High Voltage

Applying AC power to the amplifier applies high voltage to the amplifier-motor connections and cabling. Protect personnel against electrical shock.

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

Notes

- Do not connect a load to the motor before performing Auto Phase procedure.
- Always connect the motor using the same configuration.
- Wire properly and consistently.
- Connections are actually changed within the DSP, not at the motor terminals, and the results are saved to flash memory. The actual wire configuration should NEVER change.
- Brushless motors require two electrical cycles for auto phasing.

Phasing accomplishes several objectives:

- Checks the encoder or resolver and establishes proper commutation.
- Checks the motor power wires for proper connection and establishes proper phasing.
- Checks the Hall switches and establishes proper commutation.

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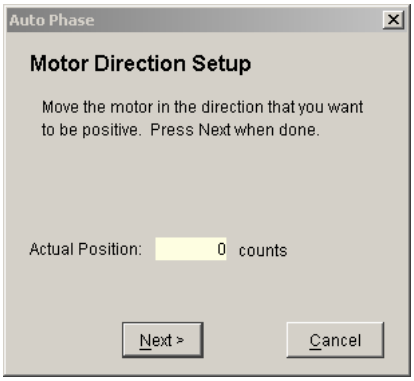
5.10.2: Auto Phase Procedure

NOTE: The following steps use a brushless rotary motor. The screens and sequences vary for other motor types.

5.10.2.1 Verify that the Enable Input is not activated.

5.10.2.2 Apply AC power.

5.10.2.3 Click **Auto Phase** ( ) to open the *Auto Phase Motor Direction Setup* screen.

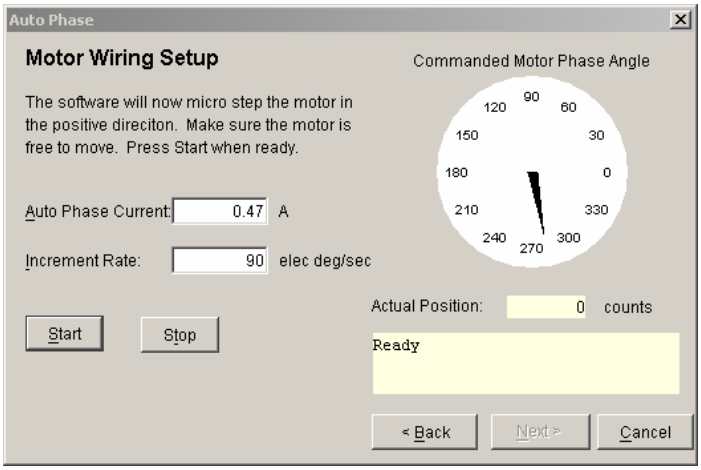


5.10.2.4 Move the motor in the direction you wish to be considered positive.

The *Actual Position* value on the screen should change. If it does not change, see Trouble Shoot Motor Direction Setup (p. 109).

5.10.2.5 Activate the Enable Input.

5.10.2.6 Click **Next** to display the *Auto Phase Motor Wiring Setup* screen.



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5.10.2.7 Click **Start** to begin the motor wiring setup.

The software displays messages: *Configuring Initial Settings, Microstepping, Test Complete, Motor Wiring has been configured*.

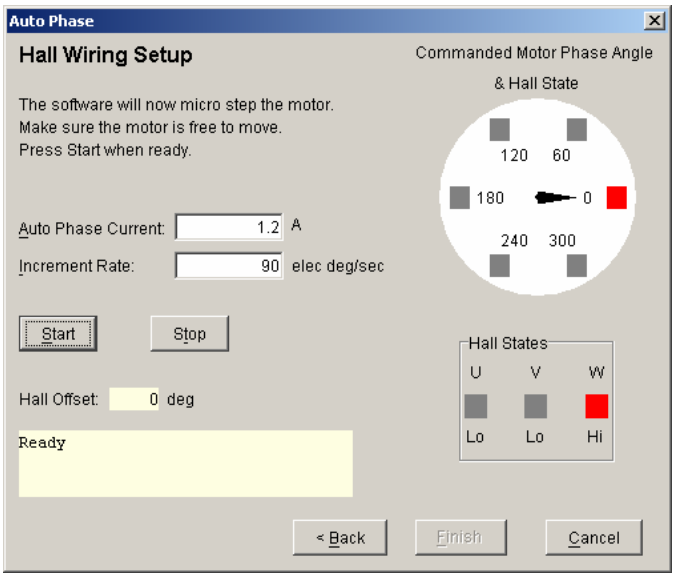
During microstepping, a current vector is applied to the motor windings and microstepped through an electrical cycle at a set rate. The field produced should push on the permanent magnet's magnetic field, causing the motor to move.

If the step fails see Trouble Shoot Motor Wiring Setup (p. 109).

NOTE: If incorrect values were entered for inductance and resistance, the calculated Cp and Ci values may produce current loop oscillation, evidenced by an audible high frequency squeal during auto phasing.

5.10.2.8 For a –R version of Xenus with a resolver, skip to 5.10.2.11.

5.10.2.9 For a standard version Xenus, click **Next** to display the *Halls Wiring Setup* screen.



5.10.2.10 Click **Start** to begin the Halls wiring setup.

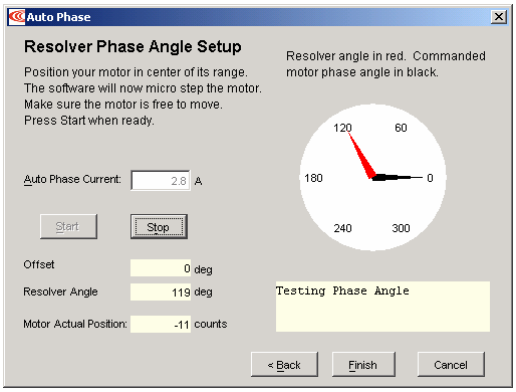
The message area displays the messages: *Microstepping. Test Complete. Motor has been properly phased*.

During microstepping, a current vector is applied to the motor windings and microstepped through an electrical cycle at a set rate. The field produced should push on the permanent magnet's magnetic field causing the motor to move. As the motor moves the Hall lines are decoded for proper commutation.

If the step fails, see Trouble Shoot Halls Wiring Setup (p. 109).

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5.10.2.11 For a resolver (-R) version of Xenus, click **Next** to open the Resolver Phase Angle Setup screen.



5.10.2.12 Click **Start** to start the resolver phase angle setup.

The message area displays status messages.

5.10.2.13 Click **Finish** to close the screen and save values to flash memory
OR
to close the screen without saving changes, click **Cancel**.

5.10.2.14 If the Auto Phase algorithm does not produce desired results, try adjusting the Auto Phase Current and Increment Rate values, using the guidelines in Guidelines for Choosing Auto Phase Current and Increment Rate Values (p. 109).

5.10.2.15 If desired results are not obtained, proceed to Manual Phasing (p. 145).

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5.10.3: Guidelines for Choosing Auto Phase Current and Increment Rate Values

Here are some considerations in choosing Auto Phase Current and Increment Rate values:

- If friction is high, then more current may be required to move the load.
- High static friction may require more current to overcome stiction.
- Transition from static friction to dynamic friction, and back, may produce jerky motion.
- A faster rate will operate in the dynamic friction range.
- A slower rate will operate in the static friction range.
- If the friction is low, as in the case of air bearings, low frequency oscillations may occur; thus, less current and slower rates may be required. If oscillations persist, then friction may need to be temporarily added.

5.10.4: Trouble Shoot Motor Direction Setup

If motor direction setup step failed:

5.10.4.1 Check Encoder or resolver power and signals.

5.10.4.2 Verify that the encoder is differential. (Contact factory if encoder is single-ended.)

5.10.4.3 Check shielding for proper grounding.

5.10.5: Trouble Shoot Motor Wiring Setup

If motor wiring setup step failed:

5.10.5.1 Verify that amplifier is disabled.

5.10.5.2 Check for mechanical jamming.

5.10.5.3 Check for smooth motion with no mechanical jerking.

5.10.5.4 Check for good connections to the motor power wires.

5.10.5.5 Disconnect motor power wires.

5.10.5.6 Measure for proper motor resistance.

5.10.6: Trouble Shoot Halls Wiring Setup

If Halls wiring setup step failed:

5.10.6.1 Check Halls power and signals.

5.10.6.2 Check for smooth motion with no mechanical jerking.

5.10.6.3 Check shielding for proper grounding.

5.10.7: Other Problems

If the auto phase procedure fails despite these corrective measures, see Manual Phasing (p. 145).

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5.11: Current Loop

Initial current loop proportional gain (**Cp**) and current loop integral gain (**Ci**) values were calculated in a previous step. For an introductory overview of the control loops, see Operating Modes (p. 19).

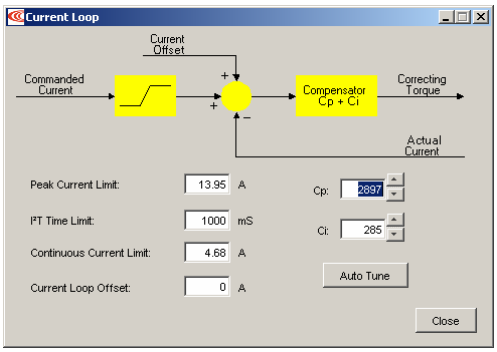
NOTE: For Copley Controls digital amplifiers, the current loop gain is independent of the power supply voltage.

5.11.1: Current Loop Settings

For more information, see Current Mode and Current Loop (p. 20).

5.11.1.1 Click **Current Loop** (

) to open the *Current Loop* screen.



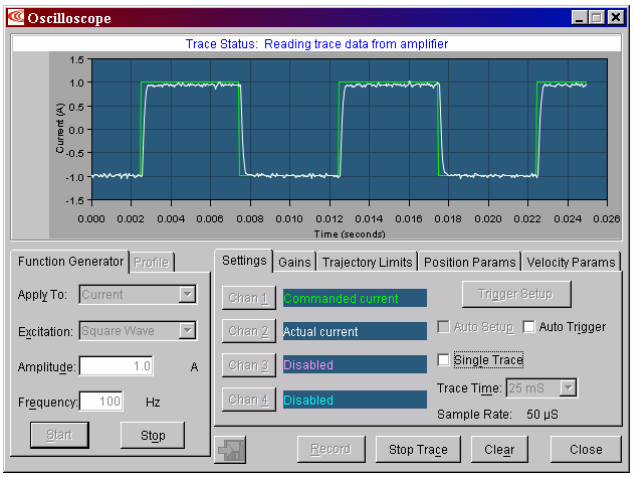
5.11.1.2 Set the following options as needed.

Options	Description
Peak Current Limit	Used to limit the peak phase current to the motor. Max value depends upon the amplifier model; Min value > continuous limit.
I^2T Time Limit	Sets I^2T Time Limit in mS. For more information, see I^2T Time Limit Algorithm (p. 161).
Continuous Current Limit	Used to limit the Phase Current. Max Value is < *Peak Current* and depends upon the amplifier model. Min value: 0
Current Loop Offset	Sets current loop offset. Leave it set to zero until after tuning. For more information, see Offset (p. 20).
Cp	Current loop proportional gain. Range 0 – 32,767.
Ci	Current loop integral gain. Range 0 – 32,767.
Auto Tune	See Auto Tune Current Loop (p. 149).

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5.11.2: Manually Tune Current Loop

To tune the current loop, apply square-wave excitation to the current loop and adjust current loop proportional gain (**Cp**) and current loop integral gain (**Ci**) to obtain a desired waveform.



NOTE: During tuning, observe any warnings that appear to the left of the trace.

NOTE: Some users prefer the Auto Tune feature. See Auto Tune Current Loop (p. 149).

5.11.2.1 Click the **Scope** button ( ) to display the *Oscilloscope* window.

5.11.2.2 On the *Function Generator* tab, choose **Current** from the *Apply To:* list box.

5.11.2.3 On the *Settings* tab, make sure **Auto Setup** is checked.

Auto Setup automatically sets the following options:

Function Generator Tab	
Excitation	Square Wave
Amplitude	10% of continuous current setting.
Frequency	100 Hz
Settings Tab	
Channel 1	Commanded current (green)
Channel 2	Actual current (white)

5.11.2.4 Verify that the Amplitude value is not excessive for the motor.

5.11.2.5 Click **Start**. On the *Gains* tab, adjust current loop proportional gain (**Cp**).

1. Set current loop integral gain (**Ci**) to zero.
2. Raise or lower Cp until desired step response is obtained. Typically, this means little or no overshoot with a 100 Hz, low-current square wave. If the Cp value is too large, ringing may occur. If the Cp value is too low, bandwidth decreases.

TIP: To change a value, highlight the value: 

. Then enter value directly, use mouse and arrow controls, OR use Page Up/Page Down keys to move in increments of 10. To undo a change, type **Ctrl-Z**.

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5.11.2.6 Adjust current loop integral gain (**Ci**) until desired settling time is obtained.

5.11.2.7 Press **Stop** to stop the function generator.

5.11.2.8 On the *Main* screen, click **Save to Flash** ().

5.11.2.9 If the amplifier is to be operated in current mode, skip the velocity and position loop setup procedures and go to Completion Steps (p. 119).

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5.12: Velocity Loop

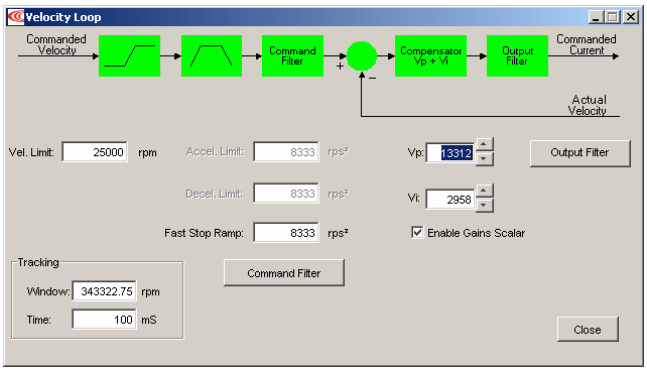
Initial velocity loop proportional gain (**Vp**) and velocity loop integral gain (**Vi**) values were calculated in a previous step.

5.12.1: Velocity Loop Settings

For more information, see Velocity Mode and Velocity Loop (p. 22).

5.12.1.1 Click **V Loop** (

) to open the *Velocity Loop* screen.



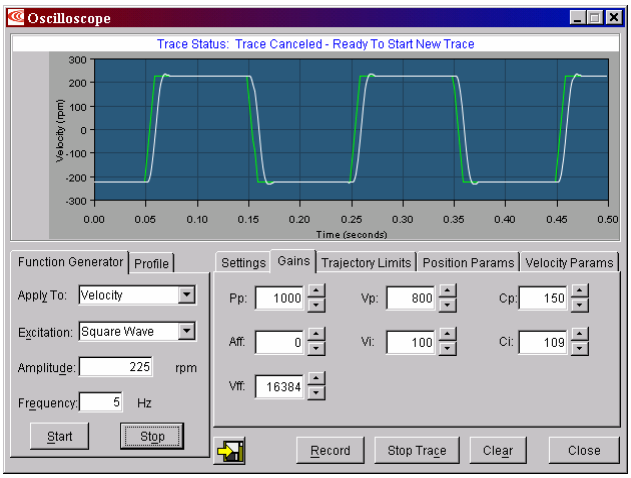
5.12.1.2 Enter the following options as needed.

Option	Description
Velocity Limit	Top speed limit. Max value may depend upon the back EMF & the Encoder value. Min value: 0.
Acceleration Limit	Maximum acceleration rate. Max value may depend upon load, inertia, & peak current. Min value: 1. (Does not apply in position mode.)
Deceleration Limit	Maximum deceleration rate. Max value may depend upon load, inertia, & peak current. Min value: 1. (Does not apply in position mode.)
Tracking Window	See Tracking Window Details (p. 40).
Tracking Time	
Vp	Velocity loop proportional gain. Range: 0 to 32,767.
Vi	Velocity loop integral gain. Range: 0 to 32,767.
Fast Stop Ramp	Deceleration rate used by the velocity loop when the amplifier is hardware disabled. Range: 0 to 100,000,000. Default: velocity loop *Decel. Limit* value. For more information, see Velocity Loop Limits (p. 22).
Enable Gains Scalar	Increases the resolution of the units used to express Vp and Vi, providing more precise tuning. For more information, see Velocity Loop Gains Scalar (p. 23).
Filter	See Velocity Loop Filters (p. 167).

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5.12.2: Manually Tune the Velocity Loop

To tune the velocity loop, apply square-wave excitation to the velocity loop and adjust velocity loop proportional gain (**Vp**) and velocity loop integral gain (**Vi**) to obtain a desired waveform.



NOTE: During tuning, observe any warnings that appear to the left of the trace.

5.12.2.1 Click the **Scope** button ( ) to open the *Oscilloscope* window.

5.12.2.2 On the *Function Generator* tab, choose **Velocity** from the *Apply To:* list box.

5.12.2.3 On the *Settings* tab, make sure **Auto Setup** is checked.

Auto Setup automatically sets the following options:

Function Tab	
Excitation	Square Wave
Amplitude	10% of maximum velocity value.
Frequency	5 Hz
Settings Tab	
Channel 1	Limited velocity (green)
Channel 2	Actual velocity (white)

5.12.2.4 Verify that the Amplitude value is not excessive for the motor.

5.12.2.5 Click **Start**. On the *Gains* tab, adjust velocity loop proportional gain (**Vp**).

1 Set velocity loop integral gain (**Vi**) to zero.

2 Raise or lower velocity loop proportional gain (**Vp**) until desired step response is obtained. Typically, this means little or no overshoot on a 5 Hz small, slow-speed square wave.

5.12.2.6 Adjust velocity loop integral gain (**Vi**) until desired settling time is obtained.

5.12.2.7 Press **Stop** to stop the function generator.

5.12.2.8 On the *Main* screen, click **Save to Flash** ( ).

5.12.2.9 If the amplifier is to be operated in velocity mode, skip the position loop setup procedures and go to Completion Steps (p. 119).

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5.13: Position Loop

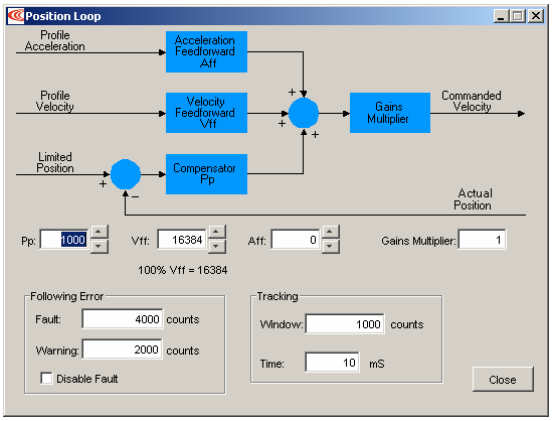
Initial position loop proportional gain (Pp), velocity feed forward (Vff), and acceleration feed forward (Aff) values were calculated in a previous step.

5.13.1: Position Loop Settings

For more information, see Position Mode and Position Loop (p. 24).

5.13.1.1 Click **P Loop** (

) to open the *Position Loop* screen.



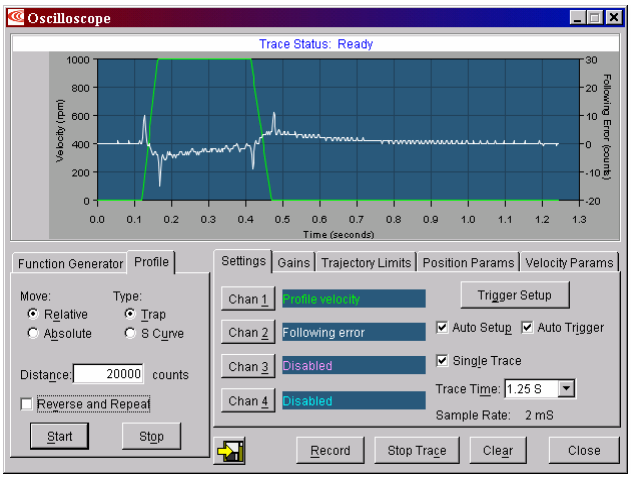
Options are described in the following table.

Option	Description	For More Information…
Gains		
Aff	Acceleration feed forward. Range: 0 to 32,767.	Trajectory Limits (p. 24)
Vff	Velocity feed forward. Range: 0 to 32,767. 100% Vff: 16,384.	
Pp	Position loop proportional gain. Range: 0 to 32,767.	
Gains Multiplier	The output of the position loop is multiplied by this value before being passed to the velocity loop. In dual encoder systems, the multiplier's initial value is calculated based on the ratio of motor encoder turns to position encoder turns.	See Rotary Motor Feedback Setup Options (p. 90) for information on motor/position encoder ratio.
Following Error		
Fault	The level (in encoder counts) at which the following error produces a fault, which stops the servo loop. We recommend raising the fault level before tuning the loop.	Following Error Fault Details (p. 39).
Warning	The level (in encoder counts) at which the following error produces a warning (without stopping the servo loop).	
Disable Fault	Prevents following error from triggering a fault.	
Tracking		
Tracking Window	Width of the tracking window in counts.	Tracking Window Details (p. 40).
Tracking Time	Position must remain in the tracking window for this amount of time to be considered tracking.	

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5.13.2: Manually Tune the Position Loop

To tune the position loop, minimize following error and oscillation by running profiles and adjusting position proportional gain (**Pp**), velocity feed forward (**Vff**), acceleration feed forward (**Aff**) and other settings.



NOTE: During position loop tuning, observe any warnings that appear to the left of the trace.

5.13.2.1 Perform an auto setup test:

1. Click the **Scope** button ( ) to open the *Oscilloscope* window.
2. Select the *Profile* tab.
3. On the *Settings* tab, make sure that **Auto Setup** is checked. Auto Setup automatically sets the following options:

Profile Tab	
Move	Relative
Type	Trap
Distance	2000 counts
Reverse and repeat	Not checked
Settings Tab	
Channel 1	Profile velocity (green)
Channel 2	Following error (white)

4. If the auto setup default profile distance is not appropriate, enter an appropriate short distance.
5. Click **Start**.
   The Profile Generator executes a short move.

NOTES:

1. The profile may not reach constant velocity during a short move.
2. If a following error occurs, open the CME 2 *Control Panel* ( ) and click **Clear Faults**.

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5.13.2.2 Set up a trapezoidal profile by setting the trajectory limits and distance. See table:

Trajectory Limits Tab	
Maximum Velocity	Set values typical of those expected to be used in the application.
Maximum Acceleration	
Maximum Deceleration	
Profile Tab	
Distance	Set the move distance to produce a complete trajectory profile. Be sure that this distance does not exceed mechanical limits of the system.
Move	Relative
Type	Trap

5.13.2.3 Adjust position proportional gain (**Pp**) to minimize following error. Note that too much position loop proportional gain (**Pp**) might cause oscillation.

1. On the *Gains* tab, set velocity feed forward (**Vff)** and acceleration feed forward (**Aff)** to zero.
2. On the *Profile* tab, click **Start**. On the *Gains* tab, adjust position loop proportional gain (**Pp**) until best result is obtained.
3. Click **Start** after each adjustment to test the new value on a new profile move.

NOTE: If a following error occurs, open the CME 2 *Control Panel* () and click **Clear Faults**.

5.13.2.4 Adjust velocity feed forward (Vff):

Velocity feed forward (**Vff)** reduces following error in the constant velocity portion of the profile. Often, a velocity feed forward (**Vff)** value of 16384 (100%) provides best results.

1. Click in the *Vff* field and adjust the value.
2. Click **Start** after each adjustment to test the new value on a new profile move.

5.13.2.5 Adjust acceleration feed forward (Aff):

Acceleration feed forward (**Aff**) reduces following error during profile acceleration and deceleration.

1. Click in the *Aff* field and adjust the value.
2. Click **Start** after each adjustment to test the new value on a new profile move.

NOTES:

1. If, after tuning the position loop, the motor makes a low frequency audible noise while enabled but not moving, the velocity loop gains (Vp and Vi) may be lowered to reduce the noise. If the gain values are set too low, the response to instantaneous rates of change might be reduced (i.e., slow correction to disturbances or transients).
2. If the amplifier is set up to run in position mode under analog input command, and the analog command signal produces too much noise at the motor after tuning, the Velocity Loop Command Filter may be used to reduce the noise further. See Velocity Loop Filters (p. 167).

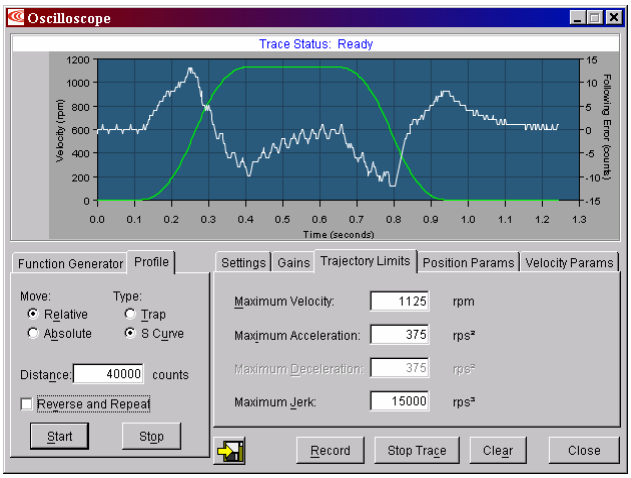
5.13.2.6 Tune to multiple sets of profiles representing typical moves that might be executed in the application. Starting with Set up a trapezoidal profile, repeat the process as needed.

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5.13.3: Test S-Curve Profile

NOTE: Skip this step unless the amplifier will perform CANopen S-Curve profile moves.

Jerk is the rate of change of acceleration. S-Curve moves reduce jerk to provide a smooth profile. To tune the level of jerk, run an S-Curve profile and adjust velocity, acceleration, deceleration, and jerk levels until the desired profile is obtained.



5.13.3.1 On the *Profile* tab, click the **S-Curve** button.

5.13.3.2 Adjust the following options. Set values that represent a typical move under normal operation.

Trajectory Limits Tab	
Maximum Velocity	Maximum speed of the profile.
Maximum Acceleration/Deceleration	Maximum acceleration/deceleration of the profile. The deceleration is set to be the same as acceleration.
Maximum Jerk	The value of jerk set during the calculate procedure produces an S-Curve whose maximum slope is equal to the trajectory profile slope. This value will produce a maximum acceleration that is not more than the initial default value of acceleration. Small values will produce less jerking but will take longer to complete move. Large values will produce more jerking and a more trapezoidal profile but will complete the move faster.
Profile Tab	
Distance	Increase the move distance to produce a complete trajectory profile. Use an acceptable value the does not exceed mechanical limits of the system.
Move	Relative
Type	S-Curve

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5.14: Completion Steps

5.14.1: Objective

Save the work and perform additional testing with load and under normal control source.

5.14.2: Steps

5.14.2.1 On the *Main* screen, click **Save to Flash** ().

5.14.2.2 Remove AC power from connector J1.

5.14.2.3 Attach load.

5.14.2.4 Reconnect AC power to connector J1.

5.14.2.5 Re-tune velocity and position loops if applicable.

5.14.2.6 On the *Main* screen, click **Save to Flash** ().

5.14.2.7 On the *Main* screen, click **Save to Disk** () (for backup or duplication).

5.14.2.8 Click **Control Panel** () and then click **Reset**
OR
Power-cycle the amplifier.

5.14.2.9 The amplifier tuning procedure is complete.

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CHAPTER 6: USING CME 2

This chapter provides an overview of CME 2 software features. Contents include:

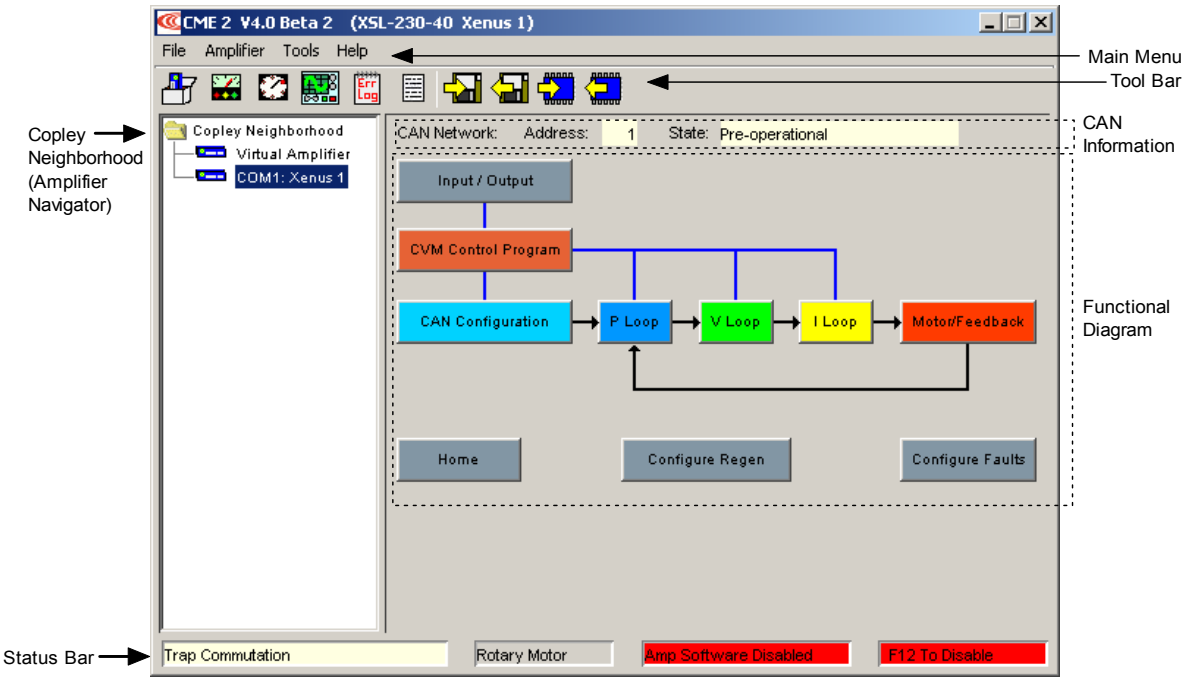
Title	Page
6.1: CME 2 Overview	122
6.1.1: Main Screen Overview	122
6.1.2: Tool Bar Overview	122
6.1.3: Main Menu Overview	123
6.1.4: Functional Diagram	124
6.1.5: CAN Information and Status Bar	125
6.1.6: Choosing an Amplifier from a List of Amplifiers	125
6.1.7: Renaming an Amplifier	125
6.2: Manage Amplifier and Motor Data	126
6.2.1: Memory	126
6.2.2: Disk Storage	126
6.2.3: Data Management Tools	127
6.2.4: Quick Copy Setup Procedure	128
6.3: Downloading Firmware	129
6.3.1: Acquiring Firmware from Web Site (Optional)	129
6.3.2: Downloading Firmware to Amplifier	130
6.4: Control Panel	131
6.4.1: Control Panel Overview	131
6.4.2: Status Indicators and Messages	131
6.4.3: Monitor Functions	132
6.4.4: Control Functions	133
6.4.5: Jog Mode	133
6.5: Scope Tool	134
6.5.1: Scope Tool Overview	134
6.5.2: Function Generator and Profile Tabs	135
6.5.3: Scope Settings	136
6.5.4: Scope Tool Controls	139
6.5.5: Control Loop Parameters in the Scope Tool	139
6.5.6: Scope Files	141
6.6: Error Log and Communications Log	142
6.6.1: Error Log	142
6.6.2: Communications Log	143
6.7: CME 2 Virtual Amplifier	144
6.7.1: Virtual Amplifier Overview	144
6.7.2: Virtual Amplifier Creation	144
6.8: Manual Phasing	145
6.8.1: Manual Phase Objectives	145
6.8.2: Manual Phase Instructions, Standard (Non-Resolver) Xenus	145
6.8.3: Manual Phase Instructions, Resolver (-R) Xenus	147
6.8.4: Troubleshooting Manual Phase With Halls and Encoder	148
6.8.5: Verify Motor Pole Count	148
6.9: Auto Tune Current Loop	149
6.9.1: Auto Tune Objective	149
6.9.2: Auto Tune Instructions	149
6.10: Home Function	152
6.10.1: Overview	152
6.10.2: Homing Functions Settings	152

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6.1: CME 2 Overview

6.1.1: Main Screen Overview

The CME 2 features called out in the diagram below are described in the following sections.



6.1.2: Tool Bar Overview

Click on any of the tools in the toolbar to access the tools described below.

Icon	Name	Description	For More Information
	Basic Setup	Opens *Basic Setup* screen.	Basic Setup (p. 84).
	Control Panel	Opens *Control Panel*.	Control Panel (p. 131).
	Auto Phase	Opens *Auto Phase* tool.	Auto Phase (p. 105).
	Scope	Opens *Scope*.	Scope Tool (p. 134).
	Error Log	Opens *Error Log*.	Error Log (p. 142).
	Amplifier Properties	Displays basic amplifier properties.	
	Save amplifier data to disk	Saves contents of amplifier's volatile RAM to a disk file.	Manage Amplifier and Motor Data (p. 126).
	Restore amplifier data from disk	Restores contents of an amplifier file from disk to amplifier's volatile RAM.	
	Save amplifier data to flash	Saves contents of amplifier's volatile RAM to permanent flash memory.	
	Restore amplifier data from flash	Restores contents amplifier's permanent flash memory to amplifier's volatile RAM.	

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6.1.3: Main Menu Overview

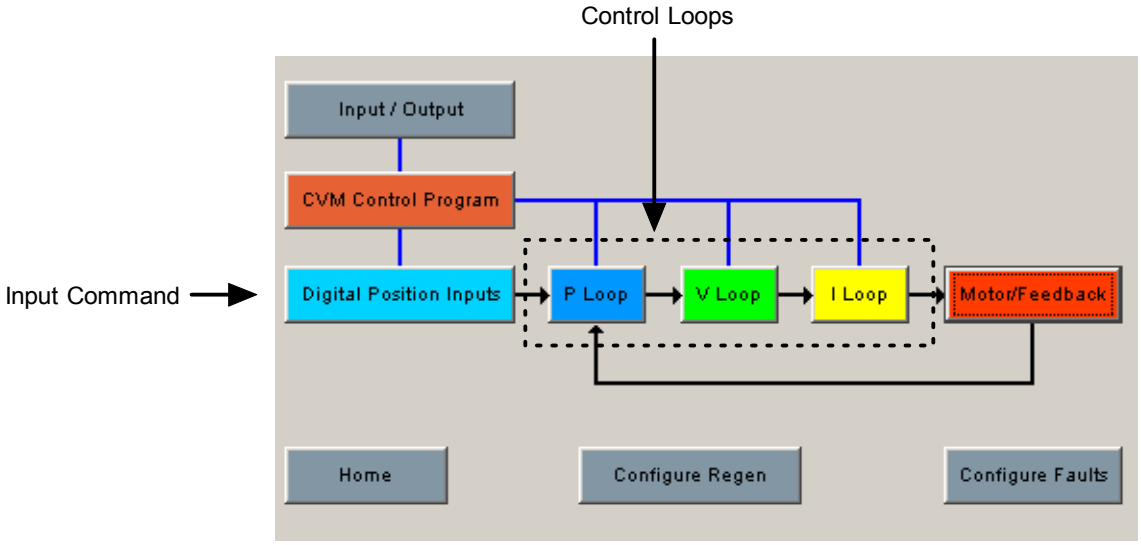
The CME 2 Main Menu choices are described below.

Menu	Selection	Description	For More Information
File	**Exit**	Closes CME 2. Prompts for data-saving decision.	
Amplifier	**Basic Setup**	Opens *Basic Setup* screen.	Basic Setup (p. 84).
	Control Panel	Opens *Control Panel.*	Control Panel (p. 131).
	Auto Phase	Opens *Auto Phase* tool.	Auto Phase (p. 105).
	Scope	Opens *Scope.*	Scope Tool (p. 134).
	Error Log	Opens *Error Log*.	Error Log (p. 142).
	Amplifier Properties	Displays basic amplifier properties.	
	CAN Configuration	Opens CAN Configuration screen.	
	Rename	Prompts for new amplifier name.	Renaming an Amplifier (p. 125).
Tools	**Communications Wizard**	Starts sequence of prompts to set up serial port.	Serial Port Setup (p. 80).
	Communications Log	Opens *Communications Log.*	Communications Log (p. 143).
	Download Firmware	Starts sequence of prompts to download new firmware image from disk to amplifier.	Downloading Firmware (p. 129).
	Manual Phase	Opens *Manual Phase* tool.	Manual Phasing (p. 145).
	View Scope Files	Opens *Trace Viewer* window.	Scope Files (p. 141).
	I/O Line States	Opens I/O Line States window.	
Help	**Using CME 2 with Xenus**	Overview of CME 2 and guide to quick setup of amplifier.	
	Downloads Web Page	Opens default web browser with relevant pages from Copley Controls' website.	
	Software Web Page		
	View Release Notes	Opens latest CME 2 release notes in a text viewer.	
	About	Displays CME 2 version information.	

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6.1.4: Functional Diagram

The functional diagram, shown below, provides button-click access to most of the screens used to configure an amplifier. It also indicates the flow of control from input, across all active control loops, to motor/feedback. Only those control loop buttons that are appropriate to the operational mode appear on the diagram.



Name	Description	For More Information
Input/Output	Opens Input/Output screen.	Theory: Inputs (p. 42) and Outputs (p. 44). Programming instructions: Amplifier Configuration (p. 93).
CVM Control Program	Opens Copley Virtual Machine screen.	*Copley Indexer Program User Guide.*
Input Command	Configure the input command. Button label varies depending on the selected control loop input. Button not present when amplifier programmed to use CVM Control Program for Control Loop Input. Otherwise, the button will be labeled with one of the following: CAN Configuration, Digital Position Inputs, Function Generator, PWM Command, or Analog Command.	Theory: Input Command Types (p. 25. Programming instructions: Basic Setup Screen (p. 84.
Control Loops	Each opens a control loop configuration screen.	Theory: Operating Modes (p. 19). Programming instructions: Current Loop (p. 110), Velocity Loop (p. 113), and Position Loop (p. 115).
Motor/Feedback	Opens the Motor/Feedback screen.	Theory: Feedback (p. 18). Programming instructions: Motor Setup (p. 86).
Home	Configure and test homing.	Home Function (p. 152).
Configure Regen	Opens Regen Resistor screen.	Theory: Regen Resistor Theory (p. 18) Programming instructions: Regen Resistor (p. 98).
Configure Faults	Opens Fault Configuration screen.	Theory: Faults (p. 36). Programming instructions: Fault Latching (p. 97).

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6.1.5: CAN Information and Status Bar

The *Main* screen displays the basic CAN information shown below.



The *Address* field shows the amplifier's present CAN address. This value is updated on +24 Vdc power-up or reset only (for more information, see CAN Addressing [p.31].) When the Position Loop Input is set to CAN, the *State* field shows the state of the amplifier's CANopen state machine (for more information, see Copley Control's *CANopen Programmer's Manual*).

The status bar describes the present commutation mode, motor type, and amplifier control status as shown below. It also includes a reminder that pressing the F12 function key while CME 2 is running disables the amplifier.

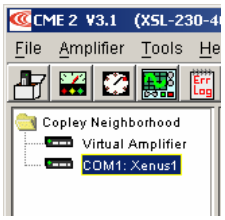
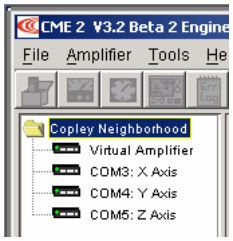
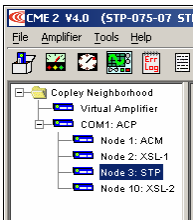


6.1.6: Choosing an Amplifier from a List of Amplifiers

If, as shown on left, below, there is only one serial port set up for communications with an amplifier, CME 2 automatically attempts to connect to the amplifier on that port on CME 2 startup.

If, as shown at center, below, multiple PC serial ports have been set up for communications with multiple amplifiers, CME polls all the amplifiers and displays their names in the *Copley Neighborhood*. To choose an amplifier, click on the amplifier name.

If, as shown on right, below, one amplifier serves as a CME 2 multi-drop gateway for one or more node amplifiers, the node amplifiers are indented under the gateway.

One amplifier:	Multiple amplifiers:	Multi-drop:
		

6.1.7: Renaming an Amplifier

Each amplifier represented in the *Copley Neighborhood* amplifier tree has a name. The default name for an amplifier is *unnamed*. Use this procedure to rename an amplifier.

6.1.7.1 Choose Main Menu **Amplifier→Rename** to open the *Rename Amplifier* screen.



6.1.7.2 Enter the new name.

6.1.7.3 Click **OK** to close the screen and save the new name
or click **Cancel** to close the screen without saving the name.

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6.2: Manage Amplifier and Motor Data

6.2.1: Memory

To maintain amplifier and motor settings, the amplifier uses volatile RAM memory and non-volatile flash memory. Data can also be saved to disk for backup and distribution.

Volatile and Flash Memory

Volatile memory holds status data and certain user-entered information data during operation, whereas flash memory permanently stores the data for loading into volatile memory at +24 Vdc power-up or reset, as described below.

Volatile	Flash
Contents erased when amplifier is reset or powered off.	Permanent. Contents retained when the amplifier is reset or powered off.
Initial contents read from flash on +24 Vdc power-up. Contents then updated in real time to reflect certain operational conditions and changes entered with CME 2 software. At any time, the user can use CME 2 to restore certain data from flash into volatile memory.	Modified only by using a **Save to Flash** tool or by closing certain screens (*Motor/Feedback, Basic Setup, Homing*, or *CAN Configuration*), whose contents are automatically saved to flash upon closing of the screen.

How the Amplifier Uses Volatile and Flash Memory

As described below, some data resides in flash only, some in volatile memory only, and some in both.

Data Resides In	Data
Flash only	This category includes all data represented on the *Motor/Feedback* screen, *Basic Setup* screen, and *CAN Configuration* screen. This data is automatically saved to flash as soon as its entry is confirmed (when the user clicks the appropriate **Save to Flash** button, or closes the screen).
Flash and Volatile	Includes all user-entered data represented on other screens, such as gains, limits, and I/O, faults, and regen settings. Initial values for this data are factory-set in flash. They are loaded from flash to volatile memory with each +24 Vdc power-up or amplifier reset. This data is saved to flash only when a user clicks the appropriate **Save to Flash** button. It is flushed from volatile memory with each +24 Vdc power-down or amplifier reset.
Volatile only	Includes operating status data such as actual position, actual current, and amplifier temperature. Such data is never stored in flash. It is flushed from volatile memory with each +24 Vdc power-down or amplifier reset.

6.2.2: Disk Storage

Amplifier Data Files and Motor Data Files

At any time, the user can save certain data from volatile and flash memory to a file on disk. From the *Main* screen, the user can save all user-entered data represented on all screens (the data described as Flash only and Flash and Volatile on p. 126). This data is saved in a Copley Controls amplifier data file with a *.ccx* filename extension.

From the *Motor/Feedback* screen, the user can save all data represented on the Motor/Feedback screen. This data is saved in a Copley Controls motor data file with a *.ccm* filename extension.

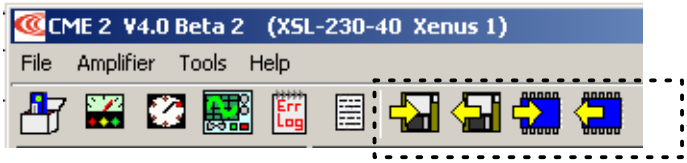
A *.ccx* file can be restored to return the amplifier to a previous state or to copy settings from one amplifier to another, as described in Quick Copy Setup Procedure (p. 128). This procedure can be performed via a direct RS-232 serial connection or on node amplifiers via the serial connection gateway amplifier.

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6.2.3: Data Management Tools

Amplifier Data Management Tools

Operations performed using the amplifier data management tools at the top of the *Main* screen (shown below) affect amplifier settings, including motor/feedback data. (CVM Control Program data is not saved by these operations.)



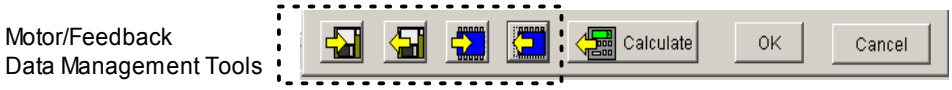
The amplifier data management tools are described below.

Icon	Name	Description
	Save amplifier data to disk	Saves save all user-entered data represented on all screens from volatile and flash memory to a disk file with a *.ccx* filename extension.
	Restore amplifier data from disk	Restores amplifier and motor data from a *.ccx* file to the amplifier's volatile and flash memory. Note that only certain data is saved to flash by this operation (the data described as Flash only on p. 126). To assure that all data (including the data described as Flash and Volatile) is stored in flash, use the *Save amplifier data to flash* tool.
	Save amplifier data to flash	Saves contents of the amplifier's volatile memory to the amplifier's flash memory.
	Restore amplifier data from flash	Restores contents the amplifier's flash memory to amplifier's volatile RAM.

To use a data management tool, click the icon and respond to prompts.

Motor Data Management Tools

Operations performed using the data management tools at the bottom of the *Motor/Feedback* screen (shown below) affect only user-entered data that is represented on the *Motor/Feedback* screen.



The motor data management tools are described below.

Icon	Name	Description
	Save motor data to disk	Saves only motor/feedback data from flash memory to a disk file with a *.ccm* filename extension. Amplifier data that is not represented on the *Motor/Feedback* screen is not saved in this file, and this operation does not affect any *.ccx* files.
	Restore motor data from disk	Restores only motor data from a disk file with a *.ccm* filename extension to the amplifier's flash memory. Amplifier data that is not represented on the *Motor/Feedback* screen is not affected.
	Save motor data to flash	Saves the contents of the Motor/Feedback screen from a buffer in the PC's RAM to the amplifier's flash memory. Amplifier data that is not represented on the *Motor/Feedback* screen is not saved. Can be used to assure that all changes are saved to flash without closing the *Motor/Feedback* screen.
	Restore motor data from flash	Restores only motor data from the amplifier's flash memory to the amplifier's volatile memory. Amplifier data that is not represented on the *Motor/Feedback* screen is not affected. Can be used before closing the Motor/Data screen to restore settings to the previously saved values.

To use a data management tool, click the icon and respond to prompts.

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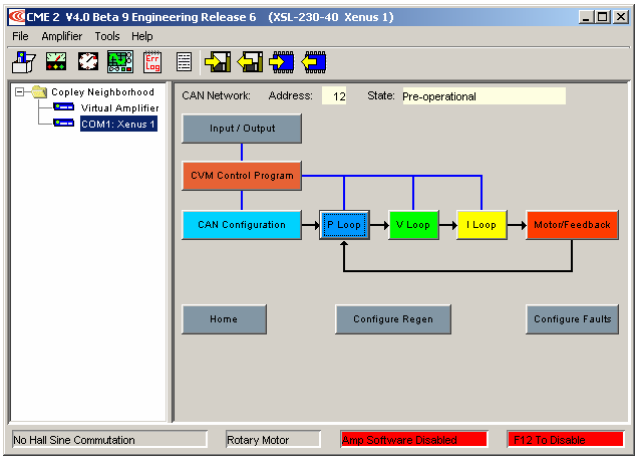
6.2.4: Quick Copy Setup Procedure

Use this procedure to configure an amplifier/motor pair by copying a *.ccx* file that was prepared for the amplifier/motor combination.

6.2.4.1 Make sure the amplifier is connected to the PC using the J5 RS-232 connector.
For wiring instructions, see RS-232 Serial Communications (J5) (p. 66).

6.2.4.2 Start CME 2 by double-clicking the CME 2 shortcut icon on the Windows desktop:





6.2.4.3 On the *Main* screen, click **Restore amplifier data from disk** ().

6.2.4.4 When prompted, navigate to the folder containing the appropriate *.ccx* file.
Highlight the file name and then click **Open** to load the file data into volatile memory.

6.2.4.5 On the *Main* screen, click **Save to Flash** () to commit the new settings to flash memory.

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6.3: Downloading Firmware

6.3.1: Acquiring Firmware from Web Site (Optional)

6.3.1.1 In an internet browser, navigate to
http://www.copleycontrols.com/Motion/Downloads/firmware.html

6.3.1.2 Click on the appropriate firmware name.

6.3.1.3 When prompted, save the file to the *Firmware Image* folder in the CME 2 installation folder.

(The default installation folder is
C:\Program Files\Copley Motion\CME 2\FirmwareImage.)

The folder should now contain a file named *Xenus_Firmware.zip*.

6.3.1.4 Extract the contents of the zip file to the same location.

The folder should now contain the files *Xenus_Firmware.zip* and the latest *.cff* file.

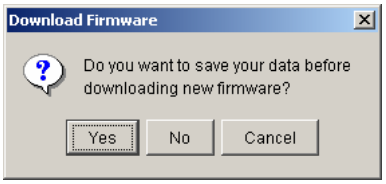
6.3.1.5 If desired, delete *Xenus_Firmware.zip* to save disk space.

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6.3.2: Downloading Firmware to Amplifier

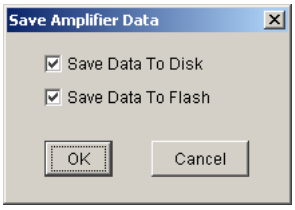
NOTE: Firmware can only be downloaded to an amplifier via a direct serial port connection between the amplifier and the PC. CME 2 does not support downloading firmware to a node amplifier via a multi-drop gateway amplifier.

6.3.2.1 On the *Main* screen choose **Tools→Download Firmware** to open the *Download Firmware* window.



6.3.2.2 To download new firmware without saving amplifier and motor data, click **No** and then proceed to Step 6.3.2.4.

6.3.2.3 To save amplifier and motor data for backup purposes before downloading firmware, click **Yes**.

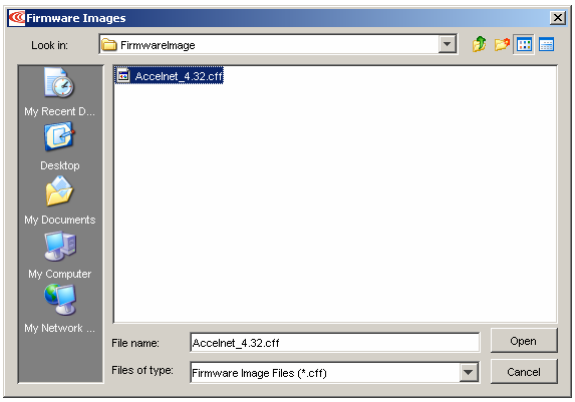


1 Use check marks to select whether to save to disk, flash, both, or neither.

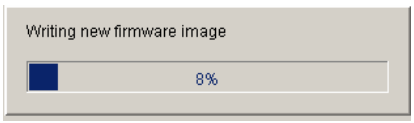
2 Click **OK** to save data and continue to select a firmware image, or click **Cancel** to continue without saving data.

3 If *Save Data to Disk* was checked, use the *Save Amplifier Data to Disk* screen to browse to the folder where you want to save the *.ccx* file. Then enter a name in the *Name* field. Then click **Save**.
When the Firmware Images window appears, proceed to Step 6.3.2.4.

6.3.2.4 Use the *Firmware Images* window to locate and select a firmware image file.



6.3.2.5 Click **Open** to begin the download.
(Or click Cancel to close the screen without downloading new firmware.)
A message window displays a series of progress messages:



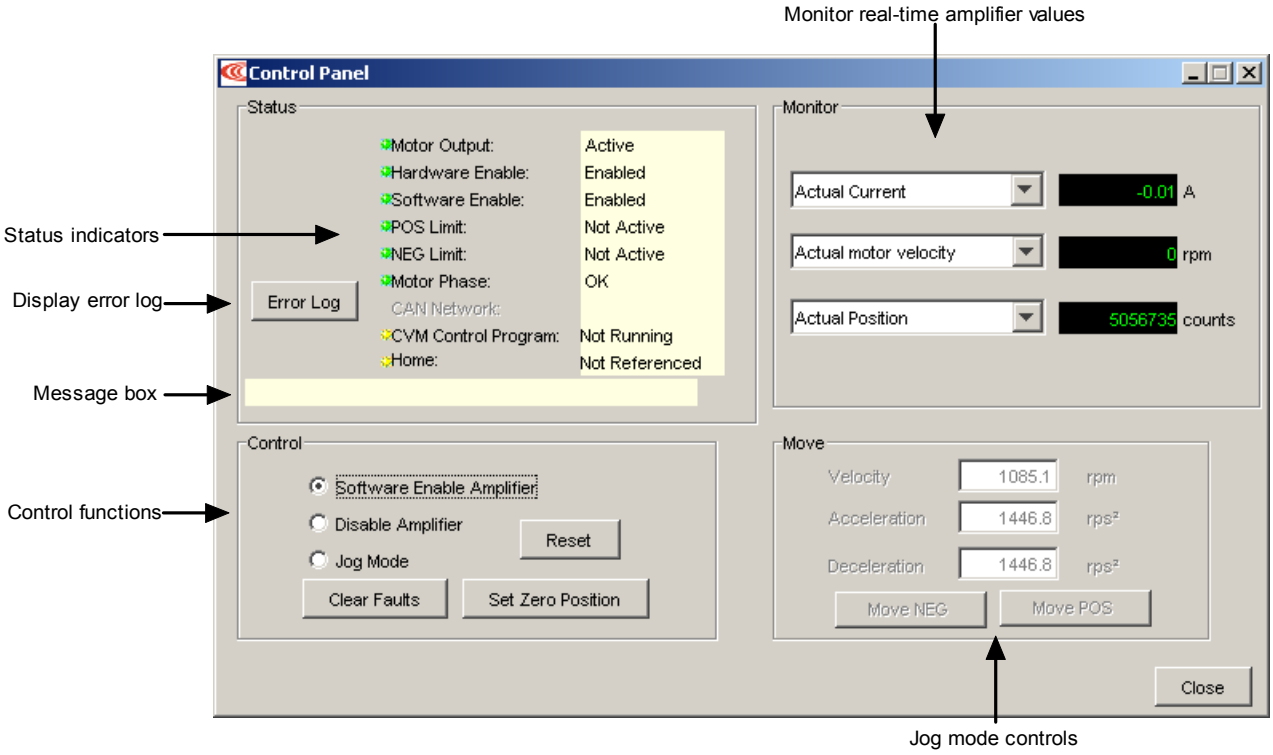
When the message window closes, the firmware download is complete.

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6.4: Control Panel

6.4.1: Control Panel Overview

To access the control panel, click the **Control Panel** icon ( ) on the *Main* screen. Each of the features labeled below is described in the following sections.



6.4.2: Status Indicators and Messages

The *Status* area includes status indicator lights (described below) and a message box. All green lights indicate the amplifier is enabled and ready to accept motion commands.

Indicator	States/Description
Motor Output	State of the PWM output stage. Red indicates the output stage is inactive (disabled)
Hardware Enable	State of the hardware enable input(s). Red indicates one or more enable inputs are inactive.
Software Enable	State of the software enable. Red indicates the amplifier is disabled by software.
POS Limit	State of the positive limit switch input. Red indicates an activated positive limit switch.
NEG Limit	State of the negative limit switch input. Red indicates an activated negative limit switch.
Motor Phase	Indicates a motor phasing error. Red indicates a motor phasing error exists.
CAN Network	The status of the CAN Bus. Yellow indicates a CAN warning limit reached. Red indicates a bus error detected.
CVM Control Program	Status of the CVM Control Program Indexer Program. When running, the Indexer program is ready to accept a Go command.
Home	Indicates whether the axis has successfully been referenced (homed).

The message box below the indicators displays the most recent active fault or warning message.

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6.4.3: Monitor Functions

The Monitor area of the control panel provides real-time monitoring of up to three separate values.



To set up a monitor display box, click in the list box and select a variable from the list.

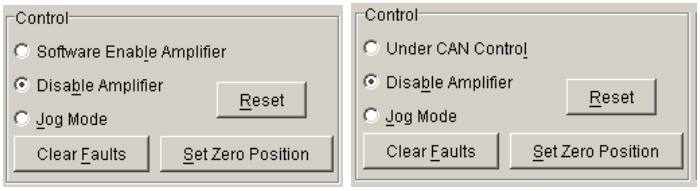
Disabled disables the display. Other options represent the following amplifier values:

- Actual Current
- Actual Velocity
- Actual Position
- Velocity Error
- Following Error
- Commanded Current
- Commanded Velocity
- Commanded Position
- Profile Velocity
- Profile Acceleration
- Limited Position
- Analog Command
- Bus Voltage
- Temperature
- Motor Phase Angle

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6.4.4: Control Functions

The *Control* area of the screen provides functions related to overall amplifier control. The screen options are different when the *Position Loop Input* is **CAN** (as shown on the right).



6.4.4.1 Control the operational state of the amplifier using the radio buttons described below.

Button Text	Description
Software Enable Amplifier	Amplifier is software enabled when button is selected.
Under CAN Control	Amplifier state is under CAN control when button is selected.
Disable Amplifier	Amplifier is software disabled when button is selected.
Jog Mode	See Jog Mode (p. 133).

6.4.4.2 To reset the amplifier, click **Reset**. To clear all amplifier faults, click **Clear Faults**. To set the amplifier's actual position counter to zero, click **Set Zero Position**.



WARNING

Risk of unexpected or uncontrolled motion.

Using the CME 2 *Set Zero Position* function while the amplifier is operating under CANopen control could cause unexpected or uncontrolled motion.

Failure to heed this warning can cause equipment damage.

6.4.5: Jog Mode

Jog mode provides a simple means for generating forward or reverse commands.

6.4.5.1 To put the amplifier in jog mode, select the **Jog Mode** radio button. Then, set up a jog move by setting the following mode-specific options:

Mode	Option	Description
Current	Torque	Current applied to the motor. Limited by current loop *Continuous Current*. Warning: Unloaded motors may, depending on torque setting, ramp up in speed very quickly.
	Current Ramp	Sets the rate at which the current will increase and decrease.
Velocity	Jog Speed	Velocity of the jog move. Limited by velocity loop *Vel. Limit*.
Position	Velocity	Velocity of the jog move. Limited by velocity loop *Vel. Limit*.
	Acceleration	Acceleration rate of the jog move. Limited by Trajectory Limits *Max Accel*.
	Deceleration	Deceleration rate of the jog move. Limited by Trajectory Limits *Max Decel*.

6.4.5.2 Command the move.

Current mode:	Hold **Torque Pos** to apply positive torque to the motor; hold down **Torque Neg** to apply negative torque to the motor. Release the button to stop movement.
Velocity mode:	Hold J**og Pos** to command a forward velocity; hold down **Jog Neg** to command a negative velocity. Release the button to command zero velocity.
Position mode:	Hold **Move Pos** to generate a forward move profile; hold **Move Neg** to generate a negative move profile. Release the button to stop movement. NOTE: Position mode jog is accomplished by continuously updating the commanded position. If a following error develops with Following Error Fault is disabled, motion will not stop on button release. Instead, it stops when actual position = commanded position.

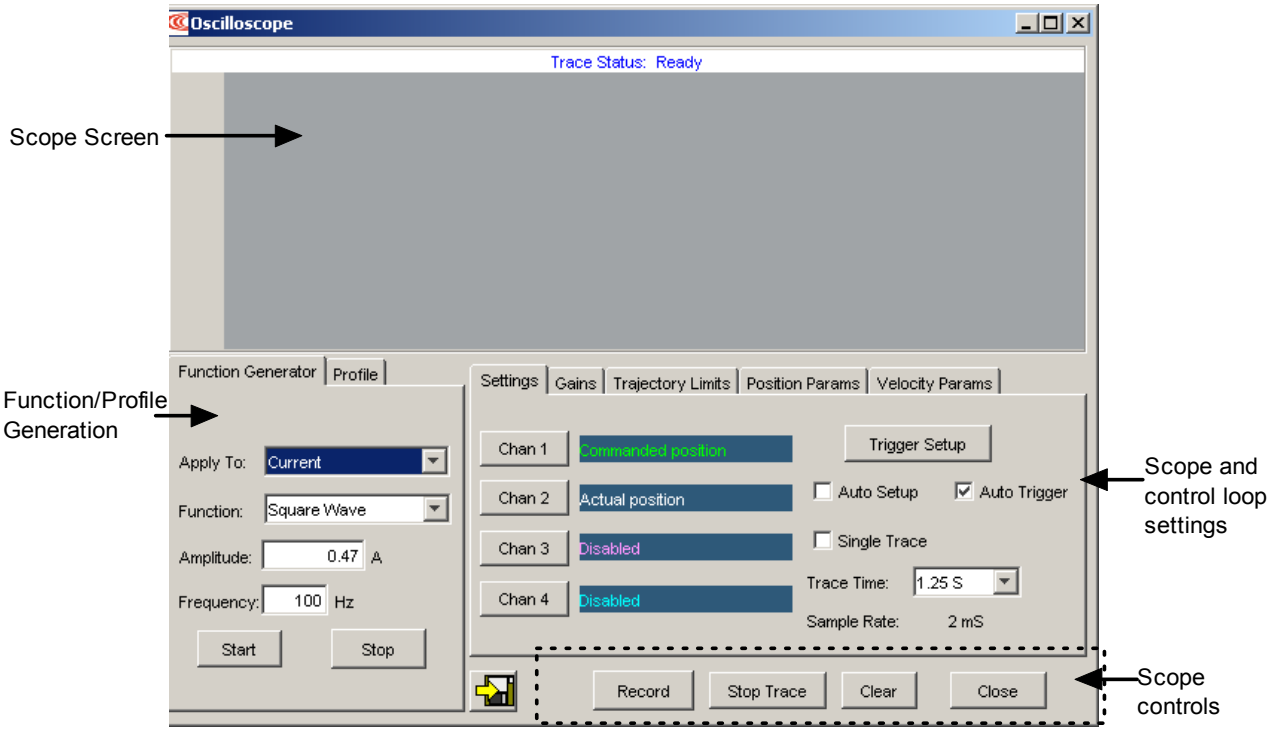
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6.5: Scope Tool

6.5.1: Scope Tool Overview

The CME 2 Scope Tool can be used to tune the amplifier, monitor amplifier performance while in normal operation, and to perform diagnostics. The Scope's *Function Generator* and *Profile Generator* can be used to drive the motor without using an external control source. The *Auto Set Up* feature automatically sets all the scope parameters for the most commonly used tuning scenarios.

Click the **Scope** tool ( ) to access the tool and open the *Oscilloscope* window.



Here are general procedures for performing basic activities with the scope.

☐ To Run a Function Generator Move:

1. Click on the *Function Generator* tab.
2. As required, adjust *Function Generator* settings, scope tool settings, gains, limits, and parameters (as described in the following sections of this chapter).
3. Click **Start** to begin move and trace. Click **Stop** to stop the move.

☐ To Run a Profile Move:

1. Click on the *Profile* tab.
2. As required, adjust *Profile* settings, scope tool settings, gains, limits, and parameters (as described in the following sections of this chapter).
3. Click **Start**. Click **Stop** to stop the move.

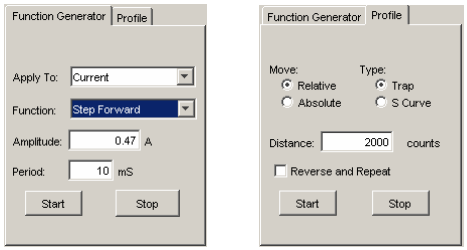
☐ To Monitor Externally Controlled Motion:

1. As required, adjust scope tool settings.
2. Click **Record** to begin trace. Click **Stop Trace** to stop the trace recording.
3. Begin move with external controller.

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6.5.2: Function Generator and Profile Tabs

The *Function* and *Profile* generators can provide inputs to the different control loops for tuning and diagnostics purposes without using an external control source.



The **Start** button starts the function or profile generator. The **Stop** button stops the generator and aborts any profiles in progress.

Function Generator Tab

Option	Description
Apply To	Control loop to which the *Excitation* will be applied: Current (available in all modes), Velocity (available in velocity or position mode), or Position (available in position mode only).
Excitation	Excitation (motion function) that will be applied to the control loop selected in the *Apply To* list box. The choices vary with the control loop selected: **Selected Control Loop** — **Excitations Available** Current — Sine Wave, Square Wave, Step Forward, Step Forward and Reverse, and Impulse Velocity — Sine Wave, Square Wave, Step Forward, Step Forward and Reverse Position — Sine Wave, Square Wave
Amplitude	Amplitude of the command. Units vary depending on the value chosen in the *Apply To* field.
Frequency	(Sine Wave and Square Wave only.) Frequency of input command cycle.
Period	(Step Forward, Step Forward and Reverse, and Impulse only.) Duration of each input pulse.

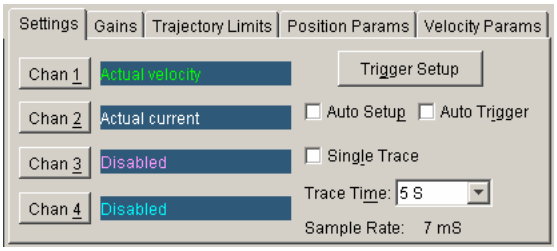
Profile Tab

Option	Description
Move	Relative: Moves axis a specified distance from the starting position. Absolute: Moves axis to a specific position.
Type	Trap or S-Curve.
Distance	Distance for *Relative* move.
Position	Target position for *Absolute* move.
Reverse and Repeat	(*Relative* move only.) When checked, will continuously generate forward and reverse moves of the distance specified until Stop is pressed.

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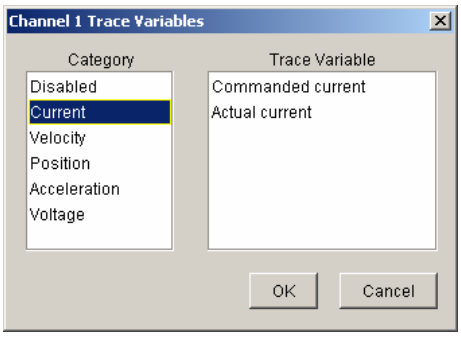
6.5.3: Scope Settings

The settings accessible from the screen and tabs shown below affect the operation of the scope.



Channel Trace Variable Options (Chan 1-4)

To choose which trace variable to display in a scope channel, click the channel button (such as ). Then choose a category, and then a trace variable.



The categories and variables are listed below.

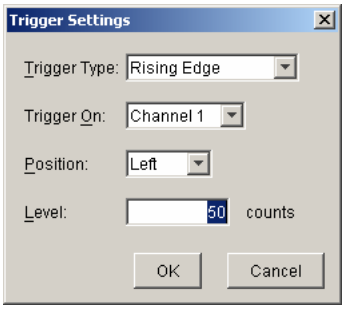
Category	Trace Variable	Category	Trace Variable
Disabled	<Channel disabled, no associated variable>	Position	Commanded Position Limited Position Actual Position Following Error
Current	Commanded Current Actual Current	Acceleration	Profile Acceleration
Velocity	Profile Velocity Commanded Velocity Limited Velocity Actual Velocity Velocity Error	Voltage	Analog Command Bus Voltage Analog sin Input Analog cos Input

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Trigger Setup

Access the screen by clicking Trigger Setup (

).



The settings described below determine what triggers the start of a trace.

Setting	Description
Trigger Type	Selects trigger type. • Immediate Trigger: Trace begins as soon as **Record** is pressed. • Rising Edge: Trace triggers when (after Record is pressed) the trigger signal rises though the trigger level setting. • Falling Edge: Trace triggers when (after Record is pressed) the trigger signal falls though the trigger level setting. • Above Level: Trace triggers when the trigger signal is greater than or equal to the trigger level setting. • Below Level: Trace triggers when the trigger signal is less than or equal to the trigger level setting. • Function Generator: Trace begins in synchronization with the *Function Generator*. • Move Start (position mode only): Trace begins in synchronization with the trajectory generator
Trigger On	Selects which channel will be used as the trigger signal. Channel 1, 2, 3, or 4.
Position	Selects placement of the trigger event on the screen. (Value is not configurable for Immediate, Function Generator, or Move Start trigger types.). • *Left* for optimal viewing of events following the trigger;. • *Middle* for optimal viewing of events preceding and following the trigger. • *Right* for optimal viewing of events preceding the trigger.
Level	Sets the trigger level. The *Level* is expressed in units appropriate to the channel selected.

Auto Trigger

The Auto Trigger option automatically sets the trigger type to Function Generator or Move Start, depending on which generator is being used. Note that Auto Trigger is automatically set (check in box) when Auto Setup is set.

Trace Time and Sample Rate

Trace Time sets the length of the recorded trace. Sample Rate is the rate at which the signals are sampled. The rate depends on the trace time, the number of channels selected, and which variables are being traced.

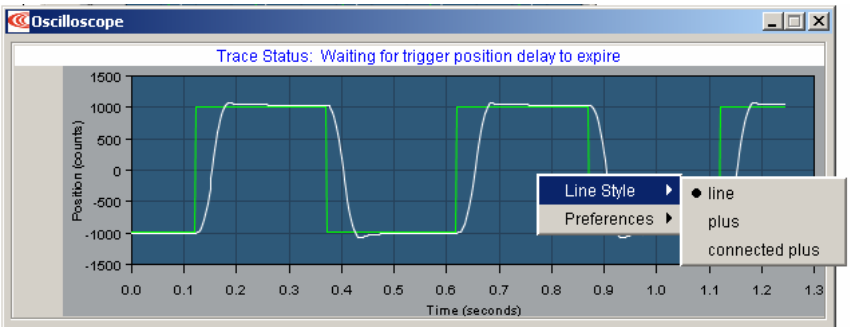
Single Trace

Single Trace puts the scope in a single trace mode of operation. In this mode, the trigger is not re-armed after a trace until the user presses the **Record** button. Single Trace is automatically set by the generators in certain cases.

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Scope Display Options

The user can set the line style and other scope screen preferences. Right-click on the scope screen to display the menus, as shown below.



The Scope display options are described below.

Menu	Option	Description
Line Style	line	A line connects the plotted data points.
	plus	The Scope plots data points as plus signs, with no connecting line.
	connected plus	Data points are plotted as plus signs and are connected with a line.
Preferences	anti-aliasing	When anti-aliasing is checked, the Scope smoothes out any screen-related jaggedness in the displayed trace. Use of this feature may slow down the refreshing of traces on slow computers.
	grid	When checked a grid is displayed on the scope screen.

Auto Scale and Zoom

The Scope automatically scales the display axes to optimally display all channels.

To zoom in one area of a trace, hold the left mouse button and drag a box around the area of interest. Release the button and the display zooms in on the selected area. To restore the normal display, left-click anywhere on the trace image. Normal display is also restored automatically when the next trigger event occurs.

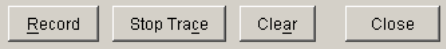
Auto Setup

With *Auto Set Up* selected, if the function generator tab is active, CME 2 automatically sets the scope settings and the function generator's amplitude and frequency/period to best suit the function generator's *Apply To* and *Excitation* mode settings. If the *Profile* tab is active, CME 2 automatically sets the scope settings and sets a standard move into the profile generator. Changing any of the preset settings de-selects the *Auto Set Up* feature.

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6.5.4: Scope Tool Controls

The basic controls for the Scope Tool are shown below.

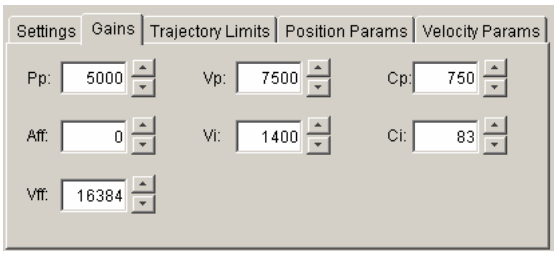


Descriptions follow.

Button	Description
Record	Begins recording a trace.
Stop Trace	Stops recording a trace.
Clear	Clears the trace from the screen and trace data from buffer.
Close	Closes the scope tool.

6.5.5: Control Loop Parameters in the Scope Tool

The Scope tool provides convenient access to all of the control loop parameters that might be used in tuning and diagnosing an amplifier. The user can adjust these parameters and see the results immediately on the scope. Control loop parameters are accessed through a set of tabs, shown below.



Note that the parameters represented on these tabs can also be accessed through the screens used to configure the control loops and the digital position input. Changing a value in the Scope tool automatically updates the value on the other screens where it appears, and vice versa.

Control loop parameter tab descriptions follow.

Gains Tab

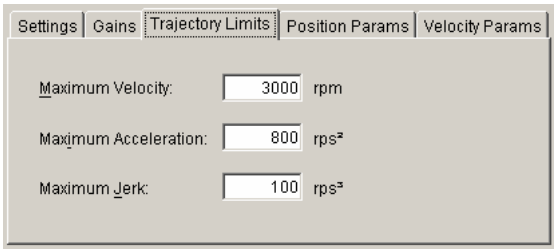
The *Gains* tab provides access to all of the gains appropriate to the operating mode, as described below.

Modes	Gains	Description	For More Information
Position mode only	Pp	Position loop proportional gain.	Trajectory Limits (p. 24).
	Aff	Acceleration feed forward.	
	Vff	Velocity feed forward.	
Position or velocity mode only	Vp	Velocity loop proportional gain.	Velocity Loop Gains (p. 23).
	Vi	Velocity loop integral gain.	
All modes	Cp	Current loop proportional gain.	Current Loop Gains (p. 21).
	Ci	Current loop integral gain.	

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Trajectory Limits Tab

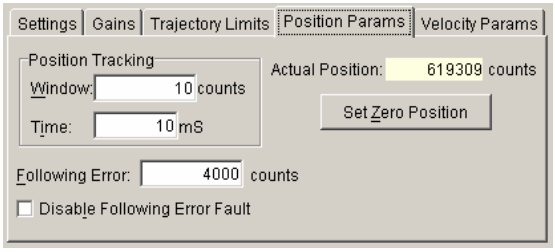
In position mode, the *Trajectory Limits* tab can be used to set trajectory limits.



For more information on the velocity and acceleration limits, see Trajectory Limits (p. 24). For more information on the *Maximum Jerk* setting, see Test S-Curve Profile (p. 118) and Maximum Jerk (p. 118).

Position Loop Parameters

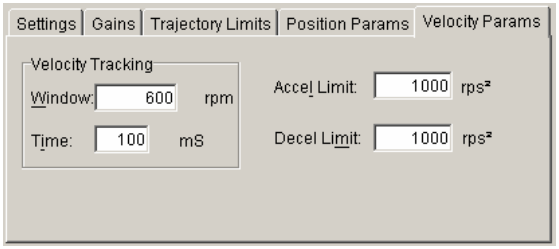
In position mode, the *Position Params* tab can be used to set position loop parameters.



Set Zero Position sets the amplifier's actual position count to zero. For more information on the other settings, see Position and Velocity Errors (p. 38).

Velocity Loop Parameters

In position and velocity modes, the *Velocity Params* tab can be used to set velocity loop parameters.



For information on the Velocity Tracking options, see Position and Velocity Errors (p. 38). For information on the limits, see Velocity Loop Limits (p. 22).

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6.5.6: Scope Files

The Scope Tool can save trace data in Copley Controls scope files (*.sco* files) that can be opened later with the CME 2 *Trace Viewer*.

Simultaneously, a version of the same trace is stored in a comma-separated text file (*.csv*) that can be opened with a spreadsheet application such as Microsoft Excel (or other programs) for mathematical analysis. The format of the *.csv* file is:

Column 1: time
Column 2: Trace Channel 1
Column 3: Trace Channel 2 (if used)
Column n: Trace Channel n (if used)

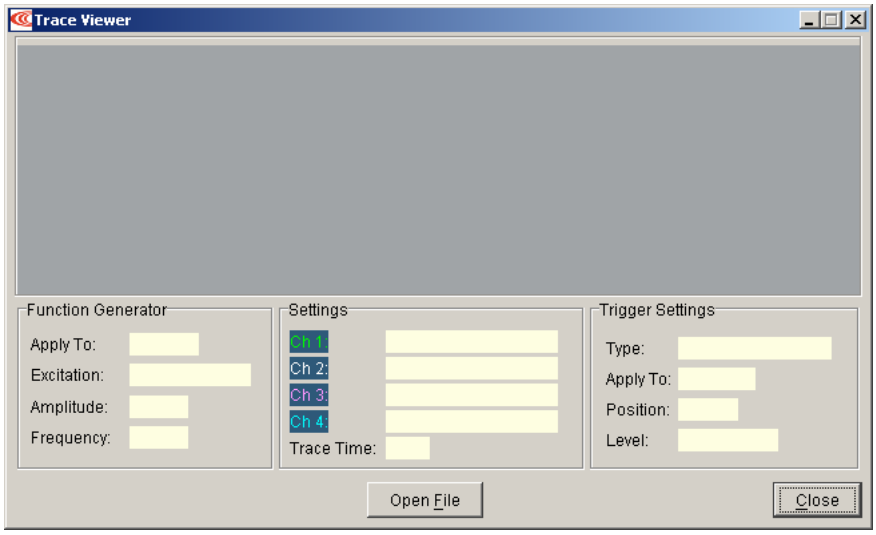
NOTE: By default, scope files are saved in the *ScopeData* folder in the CME 2 installation folder. For instance, c:\Program Files\Copley Motion\CME 2\ScopeData.

☐ To save trace data:

1. Generate the trace you wish to save.
2. In the Oscilloscope window, click the **Save to Disk** icon (). When prompted, enter a *File Name*. If needed, navigate from the default *ScopeData* folder to another folder where you wish to store the file.
3. Click **Save** to save the *.sco* and *.csv* files in the same folder and close the screen or click **Cancel** to close the screen without saving any files.

☐ To view a Trace File with the CME 2 trace viewer

1. On the *Main* screen, choose **Tools→Trace Viewer** to open the *Trace Viewer* window.



2. Click **Open File**. When prompted, select the name of the file you wish to open. Then, click **Open** to display the file in the *Trace Viewer* window.

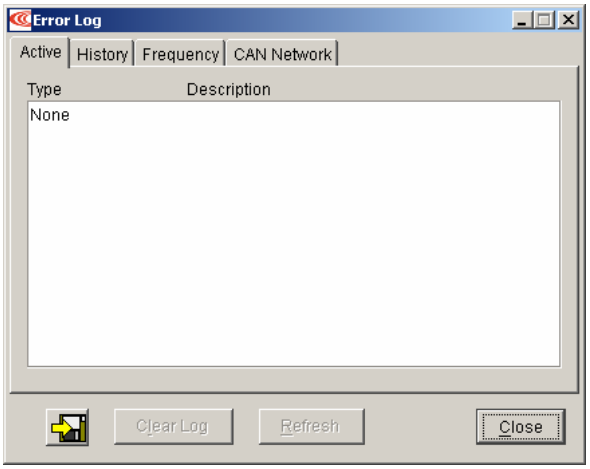
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6.6: Error Log and Communications Log

6.6.1: Error Log

The amplifier tracks faults and warnings in an internal error/event log stored in the amplifier's flash memory.

☐ To view the log click the Error Log tool on the Main screen ()
OR click **Error Log** () on the *Control Panel*.



The log has several sections, accessible by clicking on the tabs described below:

Tab	Contents
Active	Type and description of each active fault and warning. The contents of this tab are automatically refreshed as new events occur.
History	Type, description, and time of occurrence of each fault and most warnings since the log was last cleared. The contents of this tab are not refreshed automatically as new events occur. The contents are refreshed only when the tab is displayed or when **Refresh** is clicked.
Frequency	Type, description, and frequency of each fault and warning that has occurred since the log was last cleared. The contents are refreshed only when the tab is displayed or when **Refresh** is clicked.
CAN Network	(Under CAN control only.) Status of CAN bus. Lists warnings and errors.

☐ To update the contents of the *History* or *Frequency* tabs, click **Refresh**.

☐ To clear the log if needed, press **Clear Log**. (Contents cannot be recovered.)

☐ To save the log to a disk file, click the **Save to Disk** icon () on the log screen.
Then navigate to the appropriate folder, enter a *File Name* for the log, and click **Save**.

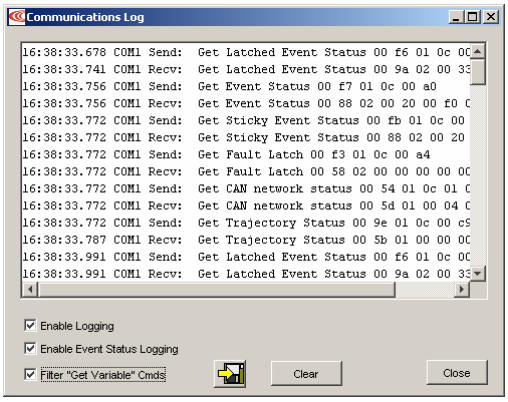
☐ To close the log screen, click **Close**.

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6.6.2: Communications Log

The communications log tracks all communications between CME 2 and the amplifier. The log is maintained in the PC's RAM. Use the following instructions to manage the tracking and storage of these serial port messages.

☐ On the *Main* screen, choose **Tools→Communications Log** to open the *Communications Log* screen.



☐ Select the logging options described below.

Option	Description
Enable Logging	When checked, logging is enabled and all communications, with the exception of status messages, are recorded in the log
Enable Event Status Logging	When checked, status messages are included in the log.
Filter "Get Variable" Cmds	When checked, "Get Variable" commands are not added to the log.

☐ To clear the log contents from the PC's RAM, press **Clear**.

NOTE: The log is limited to 2000 lines. When it reaches that limit, CME 2 automatically clears the oldest 1000 lines.

☐ To save the log contents from the PC's RAM to a disk file, click the **Save to Disk** icon (). When prompted, enter a *File name*.
Then, click **Save** to save the log file and close the window
or click **Cancel** to close the window without saving the log file.

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6.7: CME 2 Virtual Amplifier

6.7.1: Virtual Amplifier Overview

A virtual amplifier can be used for training purposes and for creating motor data files off line.

A new virtual amplifier can be created based on a virtual amplifier template file (*.ccv*). Each CME 2 installation includes a set of *.ccv* files representing all of the Copley Controls amplifier models.

Alternately, a virtual amplifier can be created based on a saved amplifier file (*.ccx*).

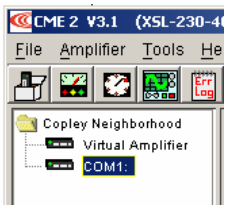
6.7.2: Virtual Amplifier Creation

6.7.2.1 Start CME 2 by double-clicking the CME 2 shortcut icon on the Windows desktop:

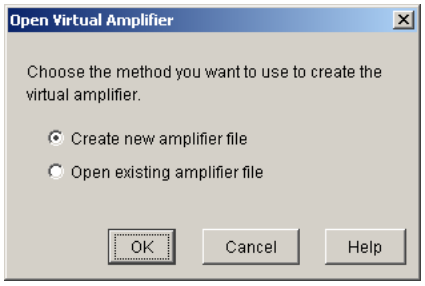


6.7.2.2 Choose **Virtual Amplifier** from the *Copley Neighborhood* tree to (a) display the *Open Virtual Amplifier* screen (b).

(a)



(b)



6.7.2.3 To open a virtual amplifier from an existing amplifier file, skip to Step 6.7.2.4 now. To create a new virtual amplifier file based on a virtual amplifier template file:

1. Select Create new amplifier.
2. When prompted, highlight the virtual amplifier template filename (*.ccv*) that represents the type of virtual amplifier you wish to create.
3. Click Open to open the file and the *Basic Setup* screen.

Motor and amplifier values may now be viewed, entered, and adjusted on the appropriate CME 2 software screens.

6.7.2.4 Alternately, open an existing amplifier file:

1. Select Open existing amplifier file.
2. When prompted, highlight the name of the file you wish to open.
3. Click **Open**.

Motor and amplifier values may now be viewed, entered, and adjusted on the appropriate CME 2 software screens.

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6.8: Manual Phasing

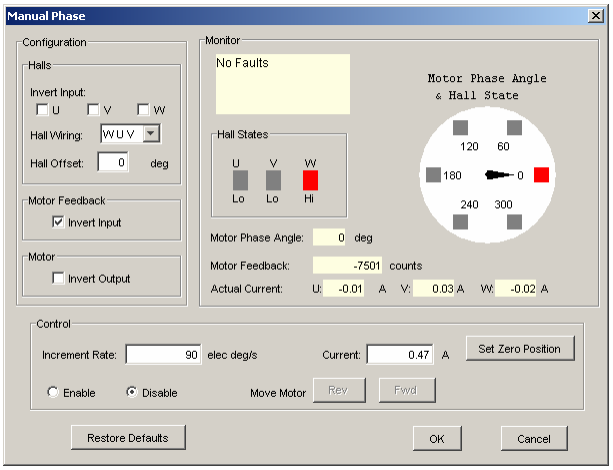
6.8.1: Manual Phase Objectives

The CME 2 Manual Phase tool lets the user phase a brushless motor, monitor signals, check configuration wiring, and control a microstepping current vector. The manual phase procedure is followed by a manual phase troubleshooting procedure.

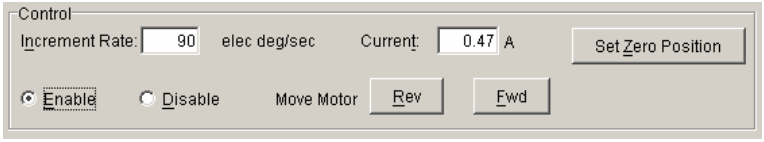
6.8.2: Manual Phase Instructions, Standard (Non-Resolver) Xenus

6.8.2.1 Make sure that no load is connected to the motor.

6.8.2.2 On the *Main* screen, choose **Tools→Manual Phase** to open the *Manual Phase* window.



6.8.2.3 Enable the amplifier by selecting **Enable** as shown here.



6.8.2.4 To control the current vector rotation, command the motor forward or reverse using the buttons shown here.



NOTE: Some motors have bearings stiction, so helping the motor with mechanical force is acceptable. Motors with no friction may need friction added to steady motion.

6.8.2.5 If the motor cannot keep up with the rate of vector rotation, then reduce the *Increment Rate* or increase the *Current*.

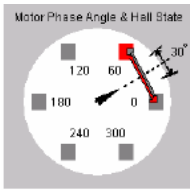
6.8.2.6 Verify that pressing forward button moves motor forward. If it does not, toggle the Motor Invert Output box setting.

6.8.2.7 Verify actual position count agrees with direction of rotation: increasing counts in forward direction and decreasing counts in reverse direction. If it does not, toggle the Encoder Invert Input box setting.

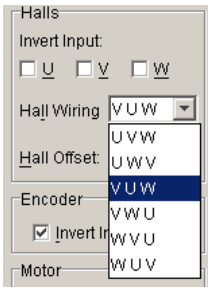
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6.8.2.8 Monitor the vector rotation through one electrical cycle for proper Hall transitions.

1 Verify that the red indicator rotates in the same direction as the motor phase angle, and that the transition occurs when the needle is between indicators (±30 degrees, as shown below).



2 If the needle and Hall states do not track properly, use the *Hall Wiring* list box (shown below) to swap the amplifier's Hall wire configuration.



3 If the red indicator transition leads or lags behind the centered needle by more than 30 degrees, then try adjusting the *Hall Offset* in +/- 30 degree increments:

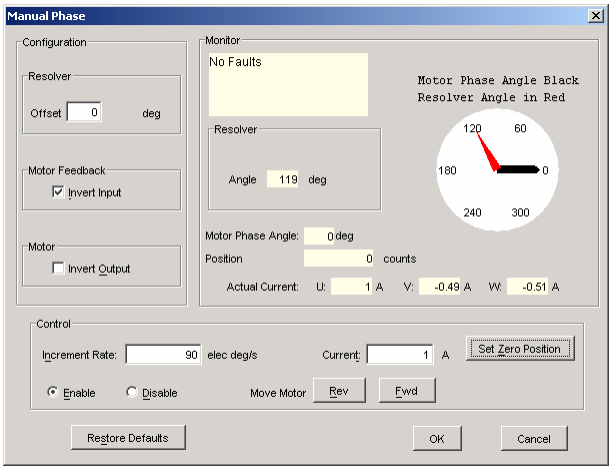


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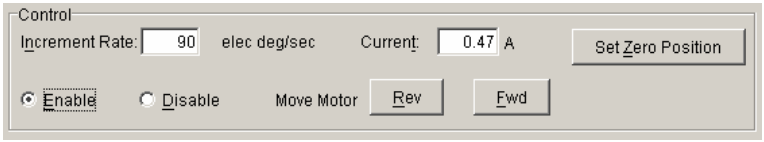
6.8.3: Manual Phase Instructions, Resolver (-R) Xenus

6.8.3.1 Make sure that no load is connected to the motor.

6.8.3.2 Choose **Tools→Manual Phase** to open the *Manual Phase* window.



6.8.3.3 Enable the amplifier by selecting **Enable** as shown here.



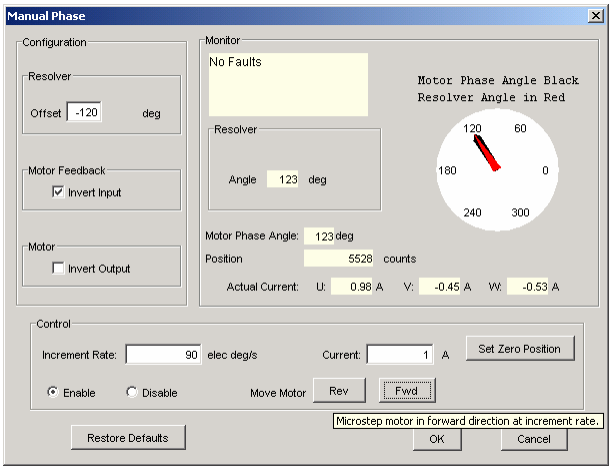
6.8.3.4 To control the current vector rotation, command the motor **Fwd** or **Rev.**
NOTE: Some motors have bearings stiction, so helping the motor with mechanical force is acceptable. Motors with no friction may need friction added to steady motion.

6.8.3.5 If the motor cannot keep up with the rate of vector rotation, then reduce the *Increment Rate* or increase the *Current*.

6.8.3.6 Verify that **Fwd** moves motor forward. If not, toggle Motor Invert Output setting.

6.8.3.7 Verify actual position count agrees with direction of rotation: increasing counts in forward direction and decreasing counts in reverse direction. If it does not, toggle the Motor Feedback Invert Input box setting.

6.8.3.8 Adjust Resolver Offset configuration as required, testing **Fwd** and **Rev**, to produce alignment of Motor Phase Angle with Resolver Angle as shown here.



Note: Motors motor manufacturers typically align the resolve in 30 degree increments, typically by applying current through a pair of motor power wires.

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6.8.4: Troubleshooting Manual Phase With Halls and Encoder

To perform trapezoidal commutation after power-up or reset, the amplifier must receive good Hall signals. After the first Hall transition is detected, then sinusoidal commutation can be performed. In sinusoidal commutation, the amplifier uses the encoder for commutation while monitoring the Halls to verify proper phase. If the error between the encoder count and Hall transition is too large, then the Hall phase correction will not be performed and a phase fault will be triggered

Here are the most common causes of phase fault problems. Test for them in the order presented.

6.8.4.1 Problem: Wrong data.

1. Verify a rotary motor's pole count. See *Verify Motor Pole Count* (p. 148)
2. Verify the encoder line count OR a linear motor's magnetic pair length and the encoder resolution.

6.8.4.2 Problem: Bad wiring of encoders.

If the Halls produce good trapezoidal commutation but a phase fault is persistent in sinusoidal commutation mode, the encoder is highly suspect.

1. Verify the differential encoder signals.
2. Verify proper twisted shielded cable with good grounding.
3. Disable the amplifier and move the motor manually to test for phase fault.
4. If phase fault only occurs under command of current, make sure the motor power cable is not bundled with the encoder cable.

6.8.4.3 Problem: Hall signals bad.

1. Make sure Halls change states as the motor moves through one electrical cycle.
2. Some Hall signals are noisy and require filtering. Check with motor manufacturer.
3. Some Halls are not properly calibrated to the motor manufacturer’s specification.

6.8.4.4 Problem: Hall transition wrong. The location of the Hall transition is not within +/-30 degrees.

1. Adjust Hall offset in smaller increments.
2. Verify Hall alignment.
3. Make sure motion is smooth.

6.8.5: Verify Motor Pole Count

Use this procedure if needed to troubleshoot wrong data.

6.8.5.1 Apply a current vector at zero Increment Rate to lock motor in position.

6.8.5.2 Turn the motor shaft and count the number of distinct locking positions.

6.8.5.3 Calculate the number of poles:

Poles = Number of Positions * 2

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6.9: Auto Tune Current Loop

6.9.1: Auto Tune Objective

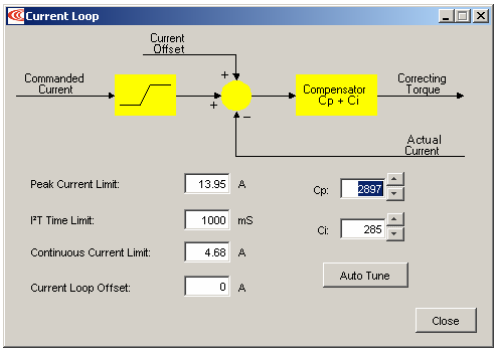
The current loop auto tune algorithm applies a square-wave command to the current loop and adjusts current loop proportional gain (Cp) and current loop integral gain (Ci) until a desirable waveform is obtained.

6.9.2: Auto Tune Instructions

6.9.2.1 Verify that the following steps in Quick Setup with CME 2 (p. 77) have been performed: Prerequisites, Basic Setup, Motor Setup, Amplifier Configuration, Command Input, Auto Phase.

6.9.2.2 Click **Current Loop** (

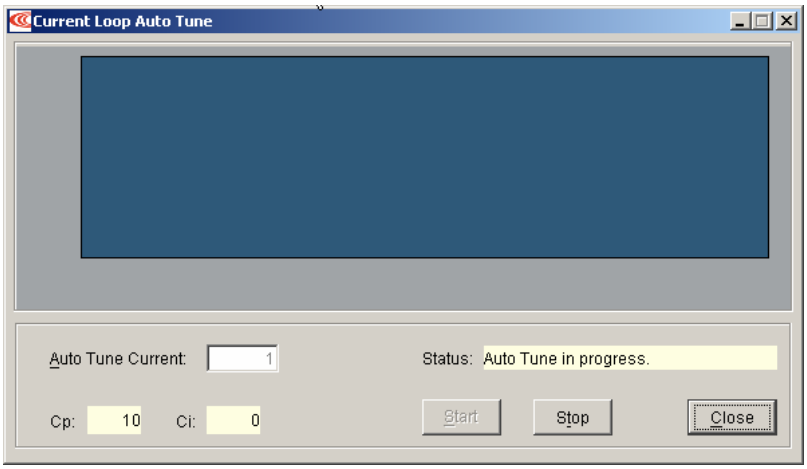
) to open the *Current Loop* screen.



6.9.2.3 Verify that amplifier is hardware enabled.

6.9.2.4 Click **Auto Tune** (

) to open the *Current Loop Auto Tune* screen and start the Auto Tune procedure.



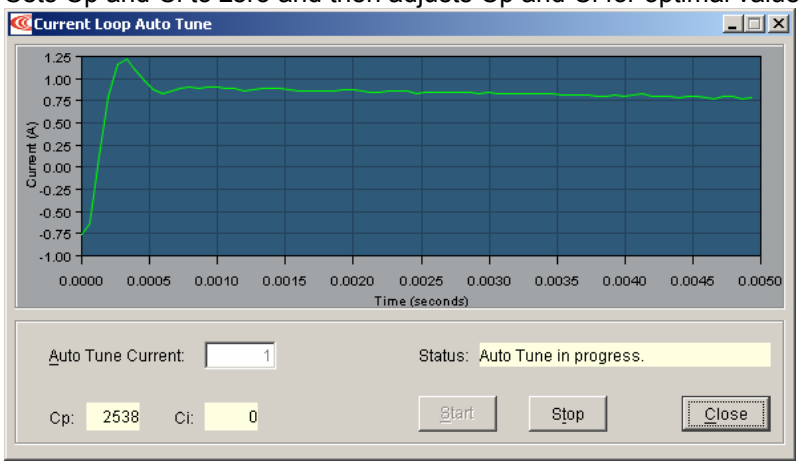
6.9.2.5 To Change the Auto Tune Current, Press **Stop**, enter the new current in the *Auto Tune Current* field, and then press **Start**.

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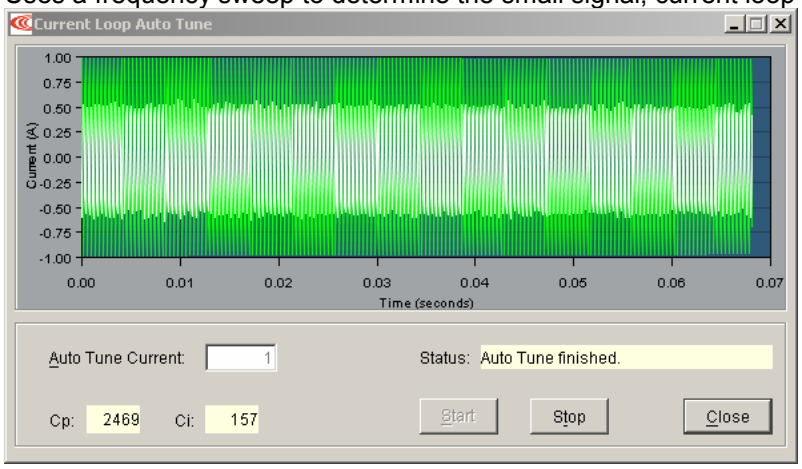
6.9.2.6 Observe the auto tune process and results.

Auto Tune uses a proprietary algorithm to mimic a standard tuning approach that would be used by a trained technician, as described below:

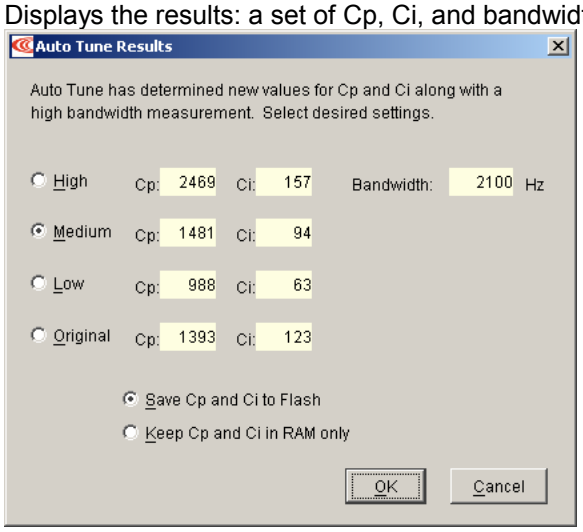
1 Sets Cp and Ci to zero and then adjusts Cp and Ci for optimal values.



2 Uses a frequency sweep to determine the small signal, current loop bandwidth.



3 Displays the results: a set of Cp, Ci, and bandwidth value alternatives.



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6.9.2.7 Choose an action based on Auto Tune results.

1. Optionally choose which set of values to save: *High, Medium, Low,* or *Original.* The *Medium* values, selected by default, are appropriate for most applications.
2. Optionally choose how to save: **Save Cp and Ci to Flash** or **Keep Cp and Ci in RAM only**.
3. Click **OK** to save the values as chosen, and close the *Auto Tune Results* window or click **Cancel** to close the window without saving any changes.

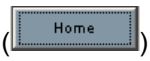
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6.10: Home Function

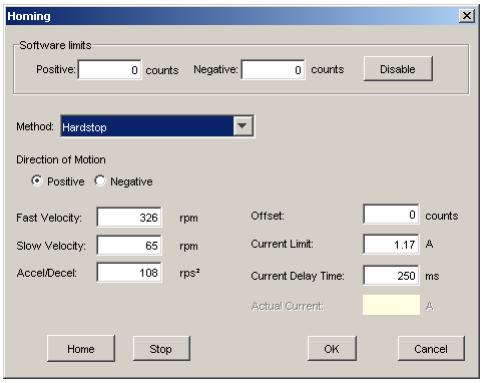
6.10.1: Overview

The CME 2 Home function can be used to set and test homing parameters.

6.10.2: Homing Functions Settings

6.10.2.1 On the CME 2 Main screen, click **Home** (

) to display the *Homing* screen.



6.10.2.2 Select homing options described below.

Option	Description
Software limits: Positive	Position of user-defined travel limits that take effect after homing operation.
Software limits: Negative	
Software limits: Disable	Disables the use of software limits by setting both limits to zero.
Method	Homing method. See *Homing Method Descriptions* in *Copley Indexer Program User's Guide*.
Direction of Motion	Initial direction of motion for the homing method (Positive or Negative)
Fast Velocity	The velocity used to find a limit or home switch. Also used when moving to an offset position.
Slow Velocity	The velocity used to find a switch edge, index pulse, or hard stop.
Accel/Decel	The acceleration and deceleration rate used during homing.
Offset	The axis will execute a move, specified by this distance, after the reference is found. The actual position will be reset to 0 at this new position and it will now be considered home.
Current Limit	A hard stop home is reached when the amplifier outputs the homing Current Limit continuously for the amount of time specified in the Delay Time.
Current Delay Time	
Actual Current	Shows actual current being applied to windings.

6.10.2.3 Click **Home** to begin the homing sequence.

6.10.2.4 To stop the homing sequence before it is completed, click **Stop**.

6.10.2.5 Click **OK** to save the homing move settings to the amplifier's flash memory and close the screen.

6.10.2.6 Click **Cancel** to close the screen without saving the settings..

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APPENDIX A: REGEN RESISTOR SIZING AND CONFIGURATION

This chapter describes the formulas used to determine if a regen resistor is required and what the optimal resistor characteristics would be for a given application. For an overview of regeneration and regen resistors, see Regen Resistor Theory (p. 47).

The contents of this chapter include:

Title	Page
A.1: Sizing a Regen Resistor	154
A.2: Configuring a Custom Regen Resistor	158

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A.1: Sizing a Regen Resistor

A.1.1: Gather Required Information

Calculating the power and resistance of the regen resistor requires information about the amplifier and the rotary or linear motor application.

A.1.1.1 For all applications, gather the following information:

1. Details of the complete motion profile, including times and velocities
2. Amplifier model number
3. Applied line voltage to the amplifier
4. Torque constant of the motor
5. Resistance (line-to-line) of the motor windings.

A.1.1.2 For rotary motor applications, gather this additional information:

1. Load inertia seen by the motor
2. Inertia of the motor.

A.1.1.3 For linear motor applications, gather this additional information:

1. Mass of the moving load
2. Mass of the motor forcer block if the motor rod is stationary
   OR
   Mass of the motor rod if the motor forcer block is stationary.

A.1.2: Observe the Properties of Each Deceleration During a Complete Cycle of Operation

A.1.2.1 For each deceleration during the motion cycle, determine:

1. Speed at the start of the deceleration
2. Speed at the end of the deceleration
3. Time over which the deceleration takes place.

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A.1.3: Calculate Energy Returned for Each Deceleration

Use the following formulas to calculate the energy returned during each deceleration:

Rotary motor:

$E_{dec} = ½ J_t (\omega_1^2 - \omega_2^2)$

Where:

E_{dec} = Energy returned by the deceleration, in joules.
Jt = Load inertia on the motor shaft plus the motor inertia in kg m^2.
ω1 = Shaft speed at the start of deceleration in radians per second.
ω2 = Shaft speed at the end of deceleration in radians per second.
ω = 2π RPS.

Linear motor:

$E_{dec} = ½ M_t (V_1^2 - V_2^2)$

Where:

E_{dec} = Energy returned by the deceleration, in joules.
M_t = Total mass of the load and the moving part of the motor in kg.
V_1 = Velocity at the start of deceleration in meters per second.
V_2 = Velocity at the end of deceleration in meters per second.

A.1.4: Determine the Amount of Energy Dissipated by the Motor

Calculate the amount of energy dissipated by the motor due to current flow though the motor winding resistance using the following formulas.

$P_{motor} = 3/4\ R_{winding} (F / Kt)^2$

Where:

P_{motor} = Power dissipated in the motor in watts.
$R_{winding}$ = Line to line resistance of the motor.
F = Force needed to decelerate the motor:
Nm for rotary applications
N for linear applications
Kt = Torque constant for the motor:
Nm/Amp for rotary applications
N/Amp for linear applications

$E_{motor} = P_{motor}\ T_{decel}$

Where:

E_{motor} = Energy dissipated in the motor in joules
T_{decel} = Time of deceleration in seconds

A.1.5: Determine the Amount of Energy Returned to the Amplifier

Calculate the amount of energy that will be returned to the amplifier for each deceleration using the following formula.

$E_{returned} = E_{dec} - E_{motor}$

Where:

$E_{returned}$ = Energy returned to the amplifier, in joules
E_{dec} = Energy returned by the deceleration, in joules
E_{motor} = Energy dissipated by the motor, in joules

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A.1.6: Determine if Energy Returned Exceeds Amplifier Capacity

Compare the amount of energy returned to the amplifier in each deceleration with the amplifier's energy absorption capacity. For related amplifier specifications, see Regen Circuit Output (p. 51).

For mains voltages not listed in the specification table, use the following formula to determine the energy that can be absorbed by the amplifier.

$$W_{capacity} = ½ C (V_{regen}^2 - (1.414 V_{mains})^2)$$

Where:

$W_{capacity}$ = The energy that can be absorbed by the bus capacitors, in joules.
C = Bus capacitance in farads.
V_{regen} = Voltage at which the regen circuit turns on, in volts.
V_{mains} = Mains voltage applied to the amplifier, in volts AC.

A.1.7: Calculate Energy to be Dissipated for Each Deceleration

For each deceleration where the energy exceeds the amplifier's capacity, use the following formula to calculate the energy that must be dissipated by the regen resistor:

$$E_{regen} = E_{returned} - E_{amp}$$

Where:

E_{regen} = Energy that must be dissipated in the regen resistor, in joules.
$E_{returned}$ = Energy delivered back to the amplifier from the motor, in joules.
E_{amp} = Energy that the amplifier will absorb, in joules.

A.1.8: Calculate Pulse Power of Each Deceleration that Exceeds Amplifier Capacity

For each deceleration where energy must be dissipated by the regen resistor, use the following formula to calculate the pulse power that will be dissipated by the regen resistor:

$$P_{pulse} = E_{regen} / T_{decel}$$

Where:

P_{pulse} = Pulse power in watts.
E_{regen} = Energy that must be dissipated in the regen resistor, in joules.
T_{decel} = Time of the deceleration in seconds.

A.1.9: Calculate Resistance Needed to Dissipate the Pulse Power

Using the maximum pulse power from the previous calculation, calculate the resistance value of the regen resistor required to dissipate the maximum pulse power: For related amplifier specifications, see Regen Circuit Output (p. 51).

$$R = V_{regen}^2 / P_{pulse\ max}$$

Where:

R = Resistance in ohms.
$P_{pulse\ max}$ = The maximum pulse power.
V_{regen} = The voltage at which the regen circuit turns on.

Choose a standard value of resistance less than the calculated value. This value must be greater than the minimum regen resistor value specified in Regen Circuit Output (p. 51).

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A.1.10: Calculate Continuous Power to be Dissipated

Use the following formula to calculate the continuous power that must be dissipated by the regen resistor. Use each deceleration where energy is dissipated by the regen resistor.

$$P_{cont} = (E_{regen\ 1} + E_{regen\ 2} + E_{regen\ ...}) / T_{cycle}$$

Where:

P_{cont} = The continuous power that will be dissipated by the resistor in watts.
$E_{regen\ n}$ = Energy being dissipated during decelerations, in joules.
T_{cycle} = Total cycle time in seconds.

Choose a resistor with a power rating equal to or greater than the calculated continuous power. Verify that the calculated power value is less than the continuous regen power rating specified in Regen Circuit Output (p. 51).

A.1.11: Select Fuses

For custom regen resistors, Cooper Bussman KLM fuses, or equivalent, should be selected. The peak and continuous currents, as well as the peak current time, must be taken into consideration for proper fuse selection. The duration of the peak current is the deceleration time (T_{decel}) associated with the maximum pulse power regen event.

Use the following formulas to determine the minimum peak and continuous current ratings of the fuse. For related amplifier specifications, see Regen Circuit Output (p. 51).

The peak current is determined by the chosen regen resistor value.

$$I_{peak} = V_{regen} / R_{regen}$$

Where:

I_{peak} = The current though the regen resistor during regeneration in amps.
V_{regen} = The voltage at which the regen circuit turns on.
R_{regen} = The resistance value of the chosen regen resistor in ohms.

The continuous current is determined by the continuous regen power.

$$I_{cont} = P_{cont} / V_{regen}$$

Where:

I_{cont} = The minimum continuous current rating the fuse requires in amps.
P_{cont} = The continuous power calculated in the previous step, in watts.
V_{regen} = The voltage at which the regen circuit turns on.

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A.2: Configuring a Custom Regen Resistor

A.2.1: Regen Configuration Objective and Warning

Configure the amplifier to operate properly with the custom resistor.

WARNING

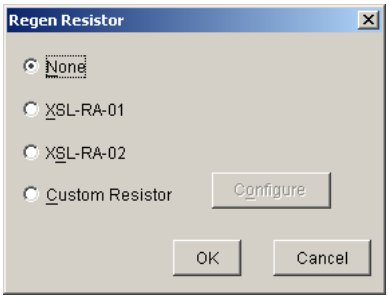
Incorrect values may damage amplifier or external regen resistor.

For the regen I^2T algorithms to work correctly, the values entered in the following steps must be correct. Damage to the external regen resistor may result from incorrect values entered. Damage to the amplifier may result if an incorrect resistance value is entered.

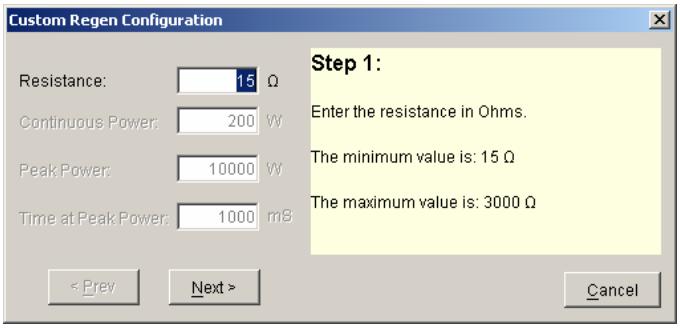
Failure to heed this warning can cause equipment damage.

A.2.2: Regen Configuration Instructions

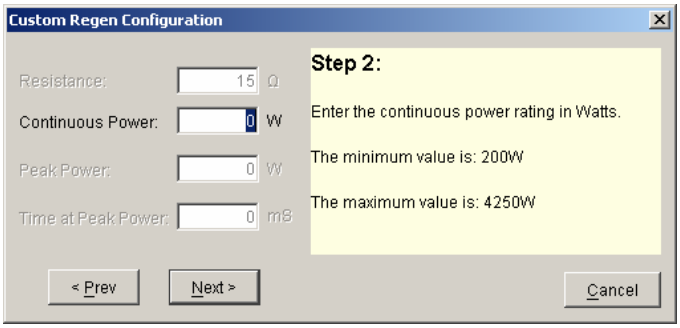
A.2.2.1 On the *Main* screen, click **Configure Regen** (Configure Regen) to open the *Regen Resistor* screen.



A.2.2.2 Select *Custom Resistor* and then click **Configure** to open the *Custom Regen Configuration* screen.

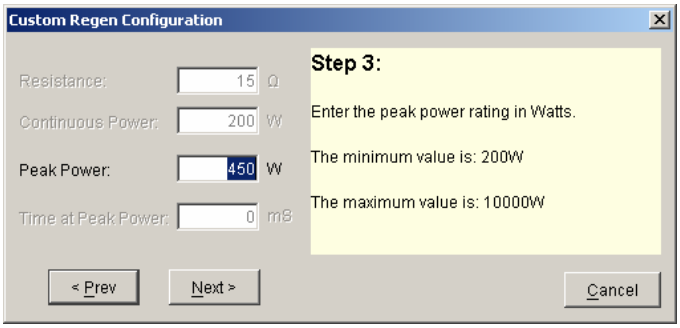


A.2.2.3 Enter a **Resistance** within the range described on the screen. Click **Next** for Step 2.

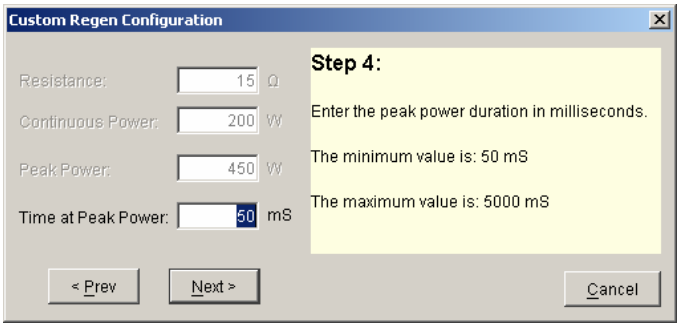


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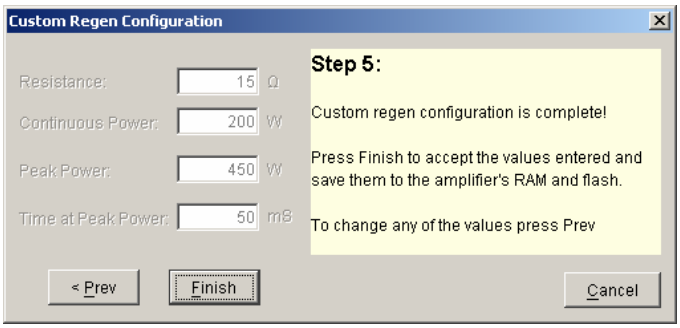
A.2.2.4 Enter a **Continuous Power** within the range described. Click **Next** for Step 3.



A.2.2.5 Enter a **Peak Power** within the range described. Click **Next** for Step 4.



A.2.2.6 Click **Next** for Step 5.



A.2.2.7 Review the configuration.

A.2.2.8 Click **Finish** to save the configuration to volatile and flash memory and close the screen
OR
click **Prev** to modify any values
OR
click **Cancel** to close the screen without saving any changes.

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APPENDIX B: 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.

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B.1: I²T Algorithm

B.1.1: I²T Overview

The I²T current limit algorithm continuously monitors the energy being delivered to the motor using the I²T Accumulator Variable. The value stored in the I²T Accumulator Variable is compared with the I²T setpoint that is calculated from the user-entered Peak Current Limit, I²T Time Limit, and Continuous Current Limit. Whenever the energy delivered to the motor exceeds the I²T setpoint, the algorithm protects the motor by limiting the output current or generates a fault.

B.1.2: I²T Formulas and Algorithm Operation

Calculating the I²T Setpoint Value

The I²T setpoint value has units of Amperes²-seconds (A^2S) and is calculated from programmed motor data. The setpoint is calculated from the Peak Current Limit, the I²T Time Limit, and the Continuous Current Limit as follows:

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

I²T Algorithm Operation

During amplifier operation, the I²T algorithm periodically updates the I²T Accumulator Variable at a rate related to the output current Sampling Frequency. The value of the I²T 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 I²T 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 I²T Accumulator Variable is calculated as follows:

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

After each sample, the updated value of the I²T Accumulator Variable is compared with the I²T setpoint. If the I²T Accumulator Variable value is greater than the I²T Setpoint value, then the amplifier 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.

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B.1.3: I^2T Current Limit Algorithm – Application Example

I^2T Example: Parameters

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

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

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

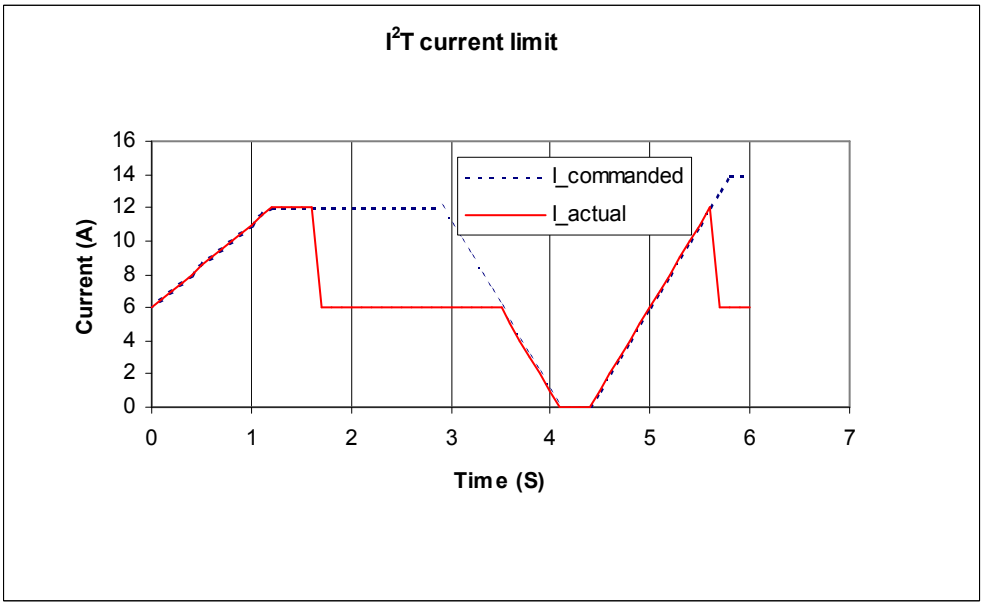
$$I^2T \text{ setpoint} = (12\ A^2 – 6\ A^2) * 1\ S = 108\ A^2S$$

See the example plot diagrams on the next page.

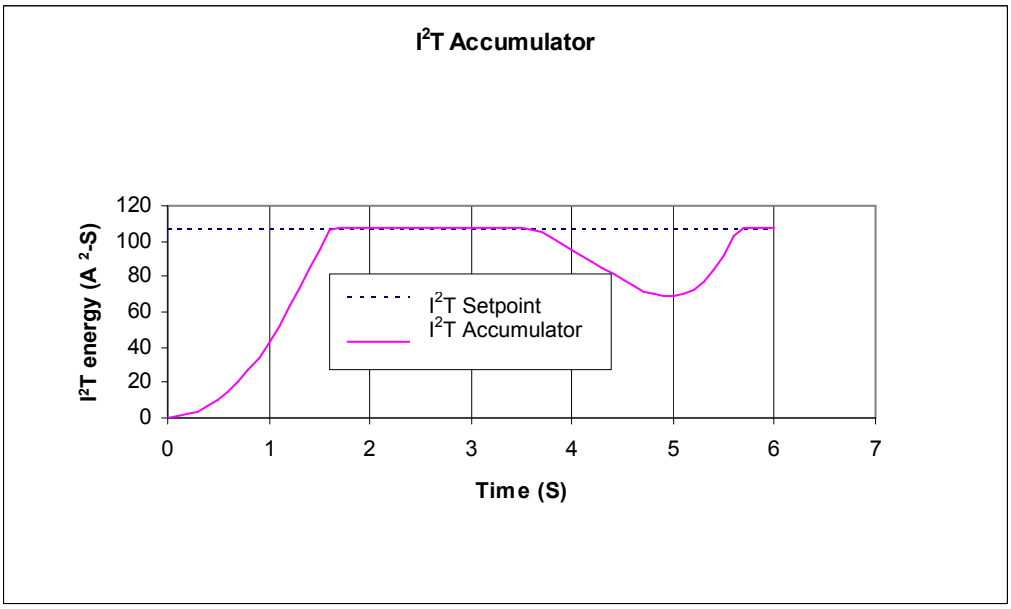
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I²T Example: Plot Diagrams

The plots that follow show the response of an amplifier (configured w/ I²T setpoint = 108 A²S) 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 I²T 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 I²T Accumulator Variable increases in a non-linear fashion because of its dependence on the square of the current.

At about 1.6 seconds, the I²T Accumulator Variable reaches a values equal to the I²T setpoint. At this time, the amplifier limits the output current to the continuous current limit even though the commanded current remains at 12 A. The I²T Accumulator Variable value remains constant during

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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.

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APPENDIX C: VELOCITY LOOP FILTERS

C.1: Advanced Velocity Loop Filter

C.1.1: Filter Overview

CME 2 supports 2 classes of filters: the Low-Pass and the Custom Bi-Quad. The Low-Pass filter class includes the Single-Pole and the Two-Pole Butterworth filter types.

The default filter settings (2-Pole Butterworth with 200 Hz Cut Off Frequency) suit the needs of most applications.

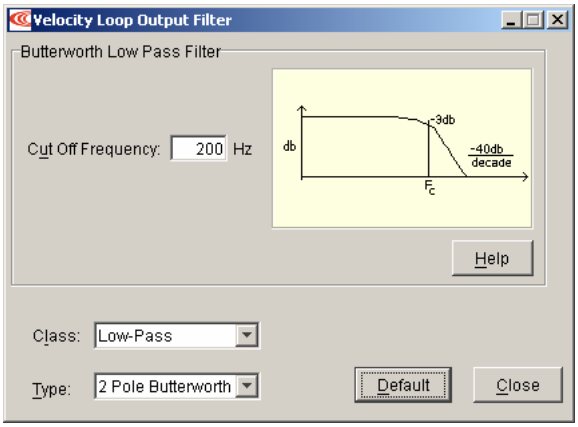
C.1.2: Filter Instructions and Details

C.1.2.1 Click **V Loop** (

) to open the Velocity *Loop* screen.

C.1.2.2 Click **Filter** (

) to open the *Velocity Loop Output Filter* screen.



C.1.2.3 Adjust the filter settings described below.

Filter Class/Type	Description
Low-Pass/ Single Pole	The single-pole low pass filter is the simplest filter. The value entered in the *Cut-off Frequency* field provides the -3 db point. The filter will attenuate at -20 db/decade past the cut-off frequency, reducing excitation of high frequency resonance.
Low-Pass/ 2 Pole Butterworth	The Butterworth filter is a maximally flat low pass filter. This second order two-pole filter has a damping ratio of 0.707 and produces no peaking in the Bode plot. The value entered in the *Cut off Frequency* field provides the -3 db point. The filter attenuates at -40 db/decade past the cut off frequency. The phase-lag at lower frequencies is greater than the phase lag of other second order filters that exhibit more peaking.
Custom Bi-Quad	The Bi-Quadratic filter has two quadratic terms: one in the numerator, and one in the denominator. The numerator affects the filter's two zeros and the denominator affects the filter's two poles. Many filter classes and types can be expressed in the Bi-Quad form by entering the coefficients. The coefficients can be calculated using any commercially available math software package and entered as floating point numbers. However, due to the fixed-point representation, the numbers may be rounded.

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APPENDIX D: THERMAL CONSIDERATIONS

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

D.1: Operating Temperature and Cooling Configurations 170
D.1.2: Heatsink and Fan Configurations 171
D.2: Heatsink Mounting Instructions 172

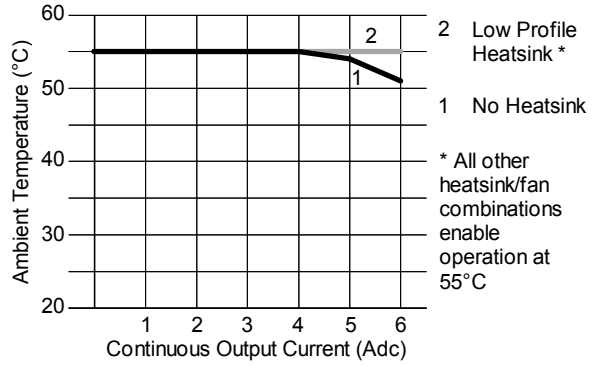
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D.1: Operating Temperature and Cooling Configurations

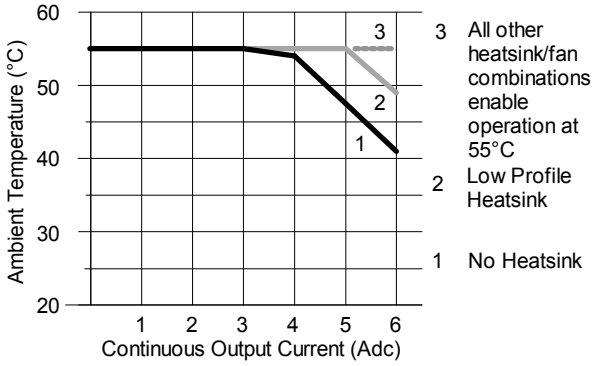
The following charts show the maximum allowable ambient temperature of Xenus amplifiers for a variety of operating conditions and cooling configurations. The cooling options are for Xenus amplifiers with no heatsink, with the low profile heatsink and with the standard heatsink all with and without forced-air cooling. The operating conditions considered cover a range of continuous output currents at both 120 Vac and 240 Vac mains voltages.

Model XSL-230-18, XSL-230-18-R, Mains 120 Vac

Mains 120 Vac

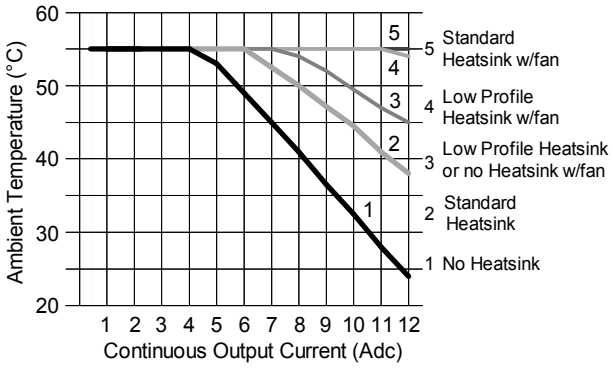


Mains 240 Vac

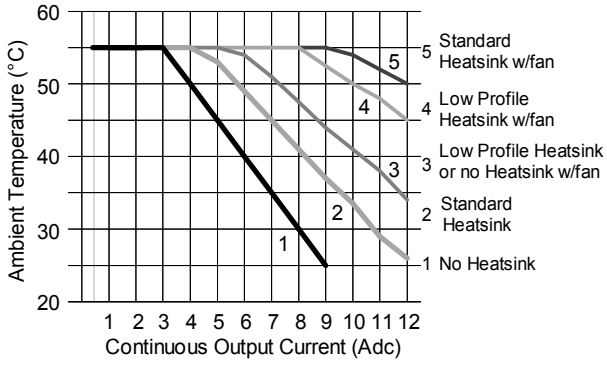


Model XSL-230-36, XSL-230-36-R

Mains 120 Vac

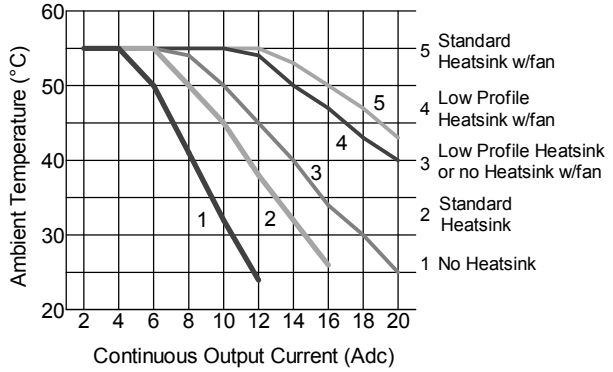


Mains 240 Vac

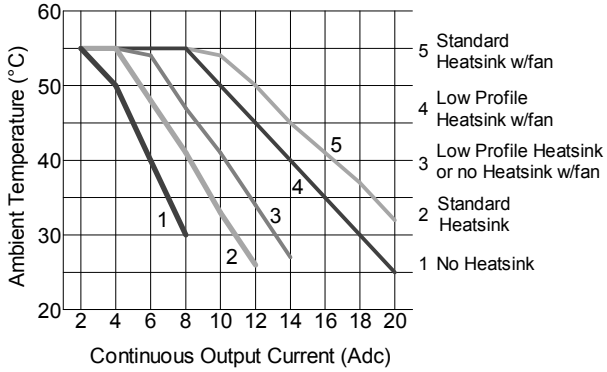


Model XSL-230-40, XSL-230-40-R

Mains 120 Vac



Mains 240 Vac



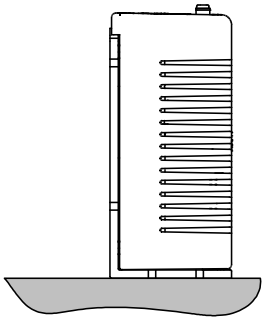
The various cooling configurations are shown on the following page.

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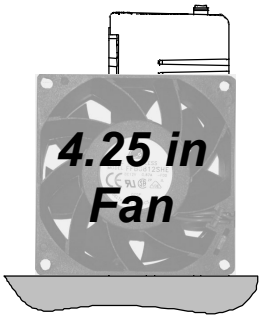
D.1.2: Heatsink and Fan Configurations

No Heatsink

No Fan

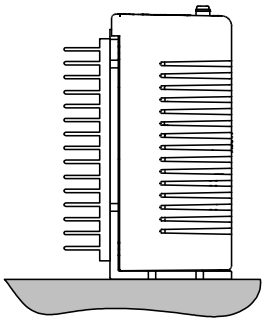


With Fan*

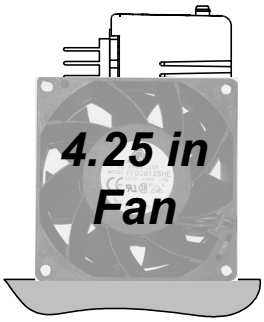


Low-Profile Heatsink

No Fan

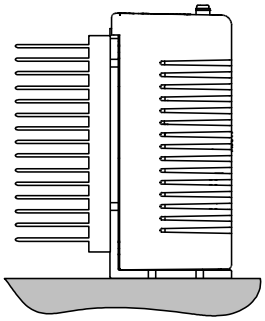


With Fan*

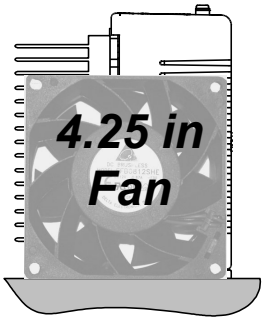


Standard Heatsink

No Fan



With Fan*



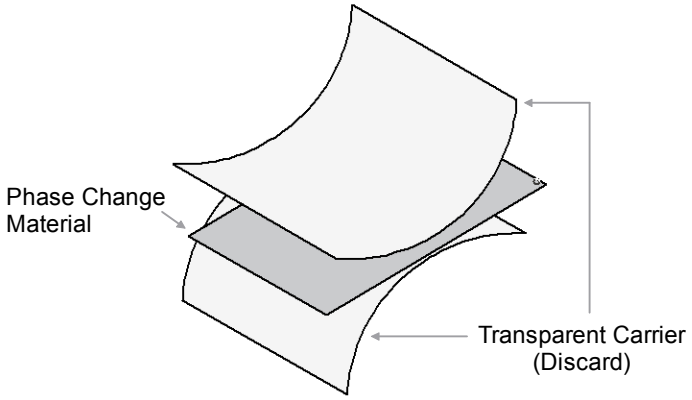
* Select a 4.25-inch square fan that supplies forced air at a minimum rate of 300 linear feet per minute

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D.2: Heatsink Mounting Instructions

Phase change material (PSM) is used in place of thermal grease. This material comes in sheet form and changes from solid to liquid form as the amplifier warms up. This forms an excellent thermal path from amplifier heatplate to heatsink for optimum heat transfer.

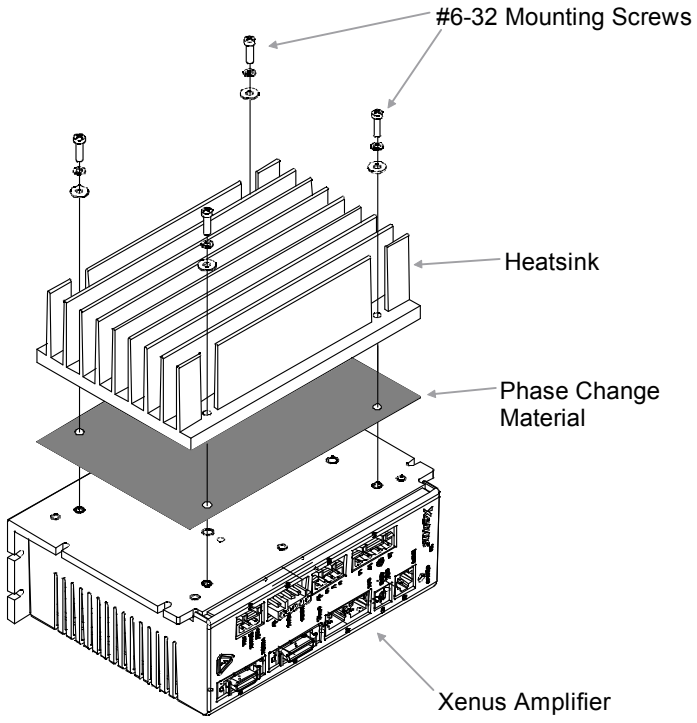
D.2.1 Remove the transparent plastic carrier sheets from both sides of the phase change material.



D.2.2 Place the phase change material on the amplifier, taking care to center the phase change material holes over the heatsink mounting holes.

D.2.3 Mount the heatsink onto the amplifier taking care to see that the holes in the heatsink, phase change material, and amplifier all line up.

D.2.4 Torque the #6-32 mounting screws to 8~10 lb-in (0.9~1.13 Nm).



NOTE: The drawing shows the standard heatsink kit (XSL-HS), but the mounting instructions given are valid for the low profile heatsink kit (XSL-HL) as well.

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APPENDIX E: XENUS FILTER

This chapter provides an overview of the Model XSL-FA-01 edge filter.

The contents of this chapter include:

Title	Page
E.1: Overview	174
E.2: XSL-FA-01 Edge Filter Specifications	175
E.3: Thermal Considerations	175
E.4: XSL-FA-01 Edge Filter Dimensions	176
E.5: XSL-FA-01 Edge Filter Wiring	177
E.6: XSL-FA-01 Edge Filter Ordering	181

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E.1: Overview

The XSL-FA-01 edge filter can be used to minimize noise on the output of any Xenus amplifier.

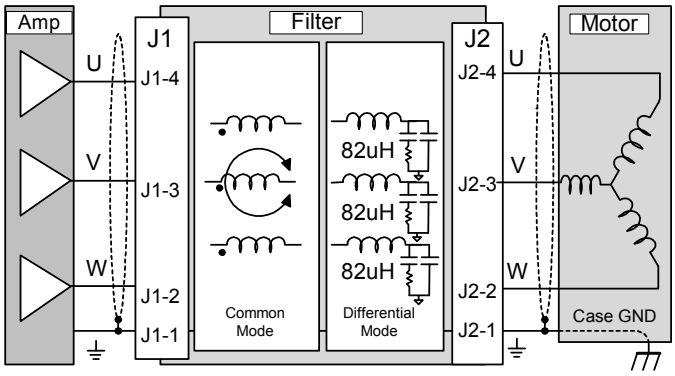
E.1.1: Differential and Common Mode Filtering

Most noise is capacitively coupled from the motor power cable to neighboring cables. To minimize this noise, the XSL-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.

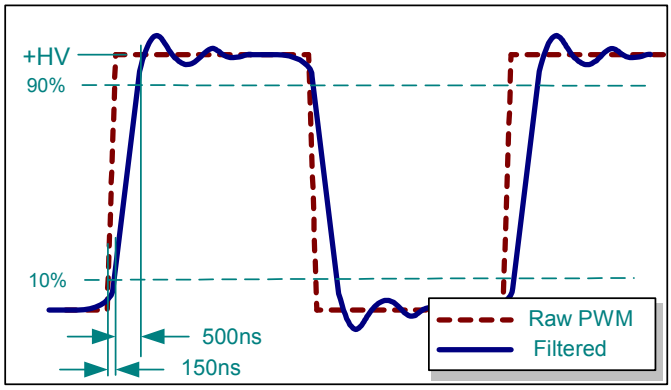
E.1.2: Description and Functional Diagram

The differential filter increases the rise time by at least a factor of 3, substantially reducing noise in the system. Copley Controls amplifiers 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.



E.1.3: PWM Output Plot



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E.2: XSL-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

E.3: Thermal Considerations

Cooling Requirements

When used with XSL-230-18 or XSL 230-36 amplifiers, the XSL-FA-01 operates below maximum temperature values, and thus requires no cooling fan.

When used with XSL-40 amplifiers running continuous currents greater than 12 Adc, the XSL-FA-01 should be cooled with an external fan. The fan should have a flow rate of at least 110 CFM. The filter has been tested using the Comair Rotron MD24B2 24 Vdc powered fan.

Fan Mounting Guidelines

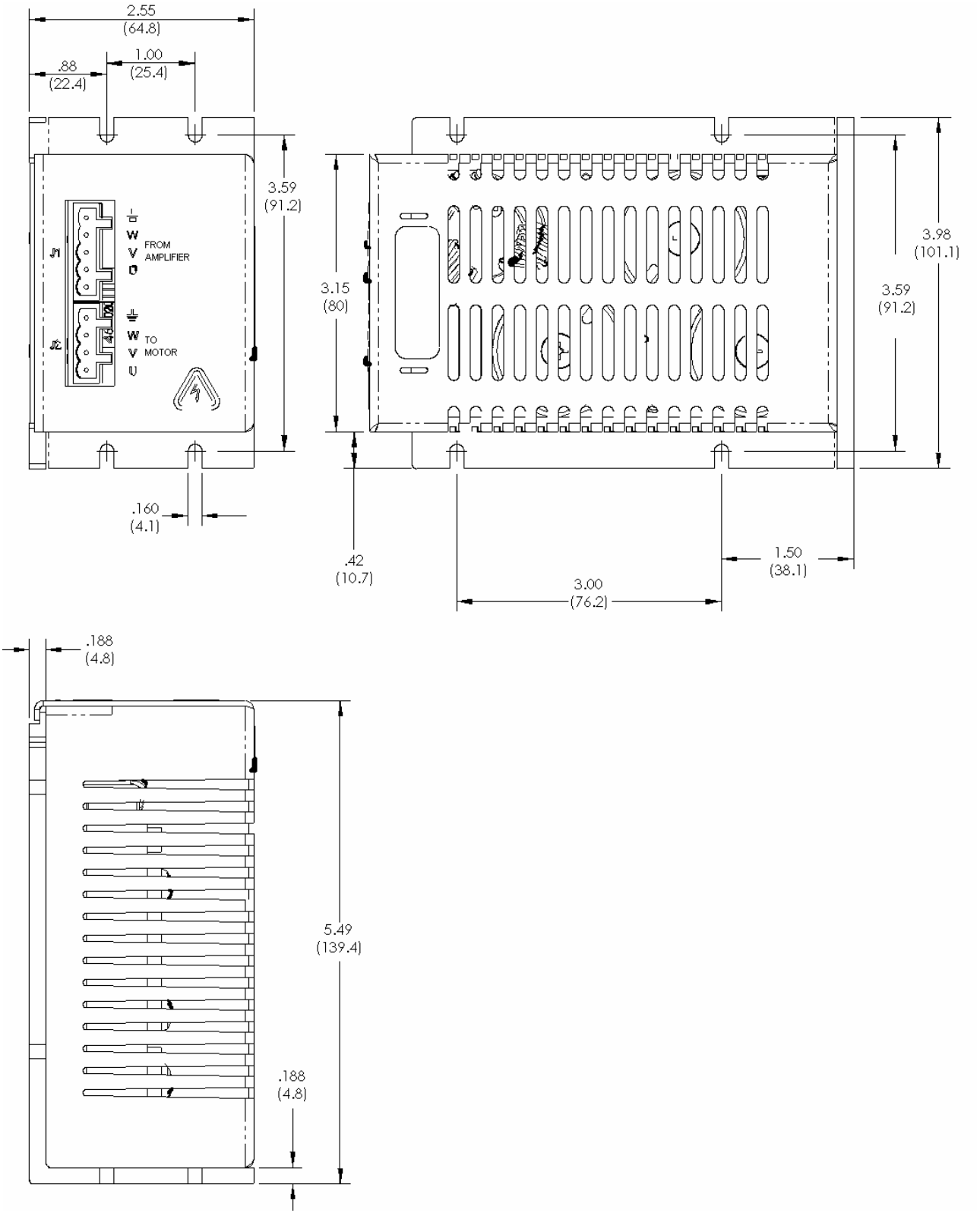
Most of the filter's heat is transferred to ambient air, rather than through the heat plate. Thus, it is very important to mount the filter and fan in such a way that the fan can blow up through the filter's cover slots. Mount the filter on edge and mount the fan below it so that it blows up through the cover slots.

There is no heatsink option for the XSL-FA-01 edge filter.

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E.4: XSL-FA-01 Edge Filter Dimensions

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



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E.5: XSL-FA-01 Edge Filter Wiring

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

E.5.2: 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 J1, J2, and J3 and on Filter 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.

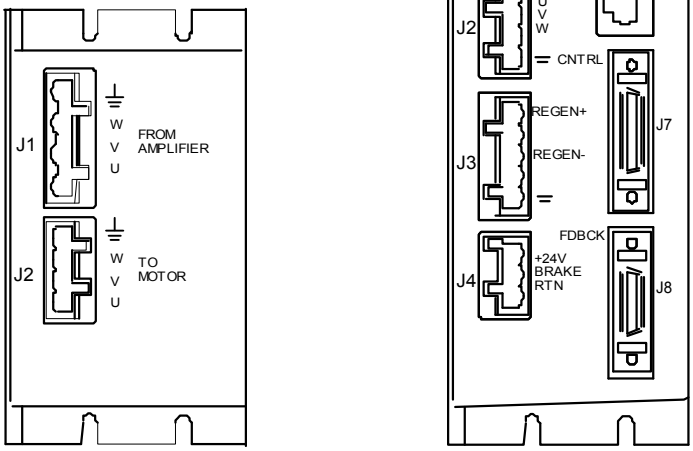
With the exception of the ground pins on Xenus J1, J2, and J3 and on Filter J1 and J2, all of the other circuits on these connectors are mains-connected and must never be grounded.

Failure to heed this warning can cause equipment damage.

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E.5.2: Connector Locations

Edge Filter J1 connects to Xenus J2. Edge Filter J2 connects to the motor.



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E.5.3: Cable Notes

1 Keep the Edge Filter J1 to Xenus J2 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.

E.5.4: Input (J1) From Amplifier

Mating Connector

Description	Euro-style, 5 position, 5.0 mm pluggable female terminal block.
Manufacturer PN	Wago 721-105/026-047
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 XSL-FK.	

Pin Description

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

E.5.5: Output (J2) To Motor

Mating Connector

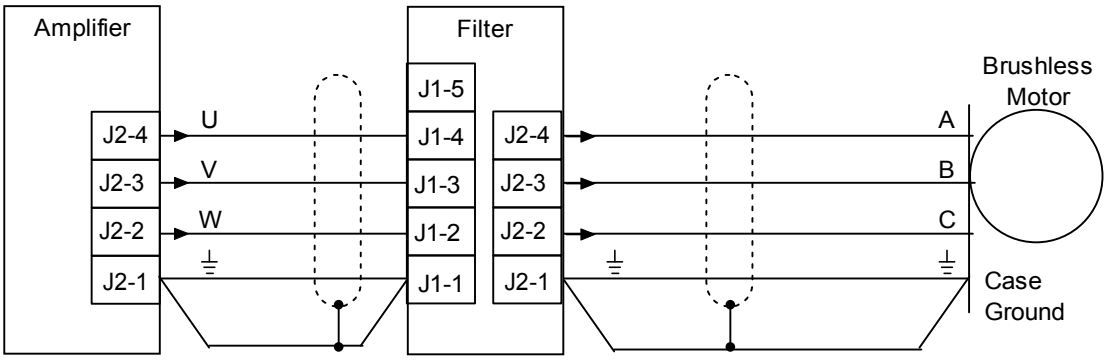
Description	Euro-style, 4 position, 5.0 mm pluggable female terminal block.
Manufacturer PN	Wago 721-104/026-047
Wire Size	22 - 12 AWG
Recommended Wire	12 AWG, 600 V (Shielded cable used for CE compliance)
Wire Insertion/Extraction Tool	Wago 231-131
Connector and tool are included in connector kit XSL-FK.	

Pin Description

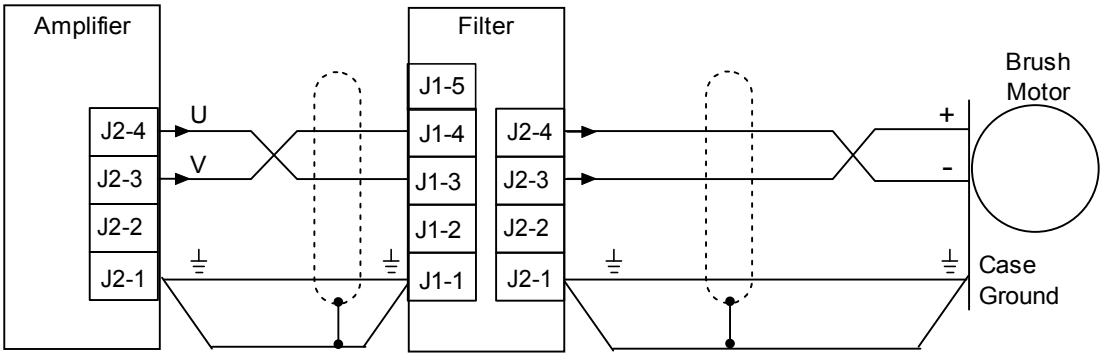
Pin	Signal	Function
1	Ground	Chassis ground and cable shield
2	Phase W	Phase W output to motor
3	Phase V	Phase V output to motor (use for DC motor connection)
4	Phase U	Phase U output to motor (use for DC motor connection)

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E.5.6: Diagram: Edge Filter Wiring with Brushless Motor



E.5.7: Diagram: Edge Filter Wiring with Brush Motor



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E.6: XSL-FA-01 Edge Filter Ordering

Filter

Model	Description
XSL-FA-01	Xenus Edge Filter

Connector Kit

Model	Qty	Ref	Description	Mfr. Model No.
XSL-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

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APPENDIX F: CONNECTING FOR SERIAL CONTROL

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

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F.1: Single-Axis and Multi-Drop

An amplifier's RS-232 serial bus can be used by CME 2 for amplifier 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 amplifier. The control application can issue commands in ASCII format.

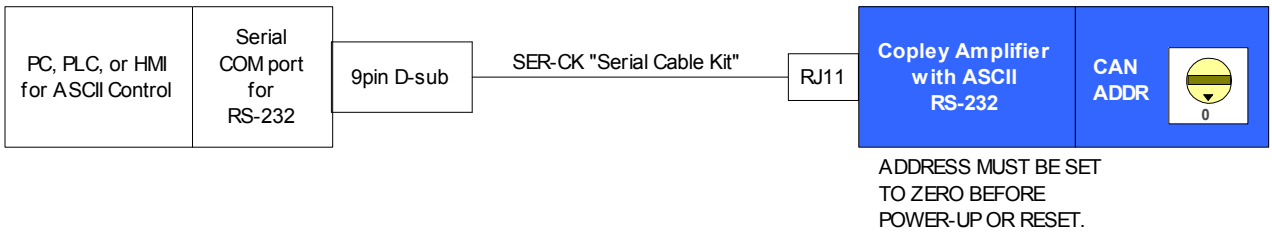
For experimentation and simple setup and control, a telnet device such as the standard Microsoft Windows HyperTerminal can also be used to send commands in ASCII format. For more information, see *Copley Controls ASCII RS-232 User Guide*.

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

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

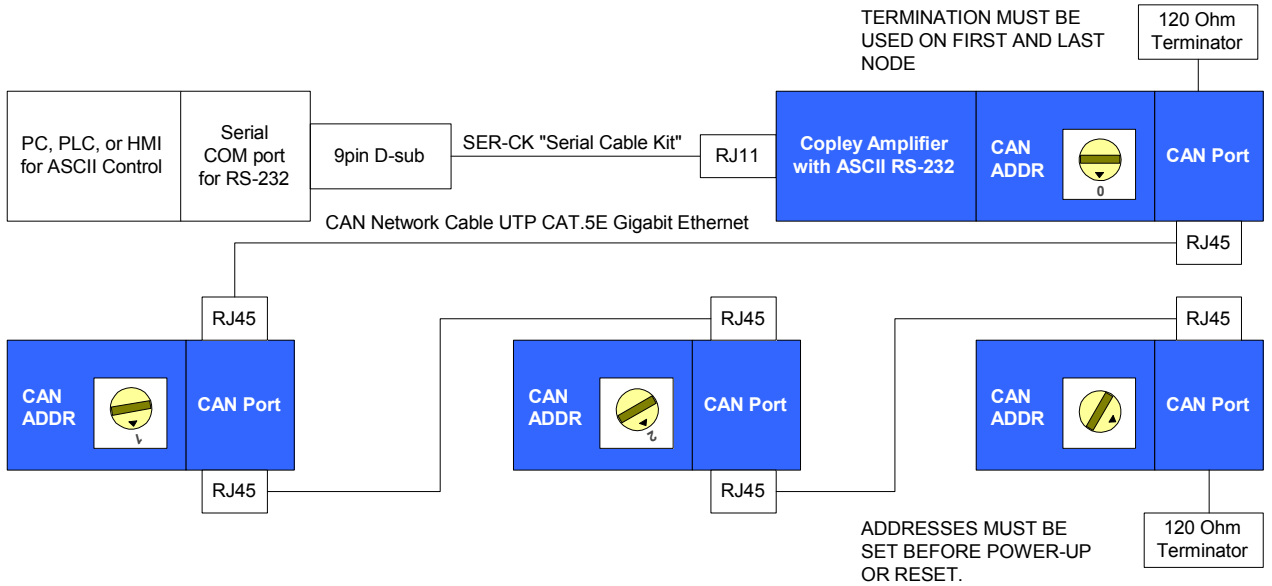
F.1.2: Single-Axis Connections

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



F.1.3: Multi-Drop Network Connections

For RS-232 serial bus control of multiple axes, set the CAN node address of the serially connected amplifier (gateway) to zero (0). Assign each additional amplifier in the chain a unique CAN node address value between 1 and 127. For more information on CAN node address assignment, see CAN Addressing (p. 31) and CAN Interface (p. 104). Use 120 Ohms termination on the first and last amplifier.



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APPENDIX G: SERVOTUBE MOTOR SETUP

This chapter describes the special subset of steps involved in setting up an amplifier to drive a Copley Controls ServoTube motor. Before performing the steps in this chapter, the reader should have performed a set of steps detailed in the beginning of Quick Setup with CME 2 (p. 77), jumping to this chapter as instructed. (See the jump point at Basic Setup, p. 84.) At the end of this chapter, the reader will be instructed to return to the proper location in Quick Setup with CME 2. (The return point is Current Loop, p. 110.)

Contents of this chapter include:

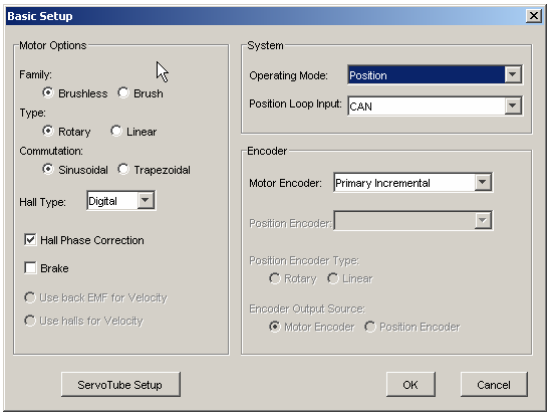
G.1: ServoTube Setup and Configuration 186
G.1.1: ServoTube Basic Setup Screen Options 186
G.1.2: ServoTube Motor/Feedback Setup 187
G.1.3: Calculating ServoTube Initial Values 188
G.1.4: Setting Up the Motor Over Temperature Input 188
G.1.5: Other ServoTube I/O and Fault Latching Setup Steps 188
G.2: ServoTube Auto Phase and Manual Phase 189
G.2.1: ServoTube Auto Phase 189
G.2.2: ServoTube Manual Phase 192
G.3: Special ServoTube Setup Completion 192

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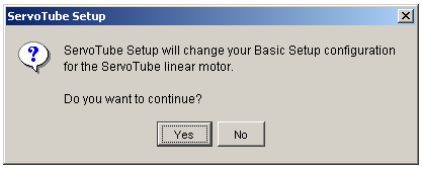
G.1: ServoTube Setup and Configuration

G.1.1: ServoTube Basic Setup Screen Options

G.1.1.1 Click the **Basic Setup** button ( ) to display the *Basic Setup* screen**.**



G.1.1.2 Click **ServoTube Setup**.



G.1.1.3 Click **Yes**.

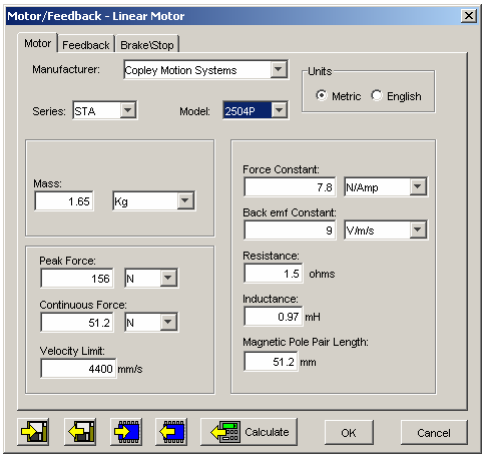
The software automatically sets motor and feedback options appropriate for the ServoTube motor.

G.1.1.4 On the Basic Setup screen, click **OK.**

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G.1.2: ServoTube Motor/Feedback Setup

G.1.2.1 On the CME 2 Main screen, click **Motor/Feedback** (Motor/Feedback) to open the *Motor/Feedback-Rotary Motor* screen.

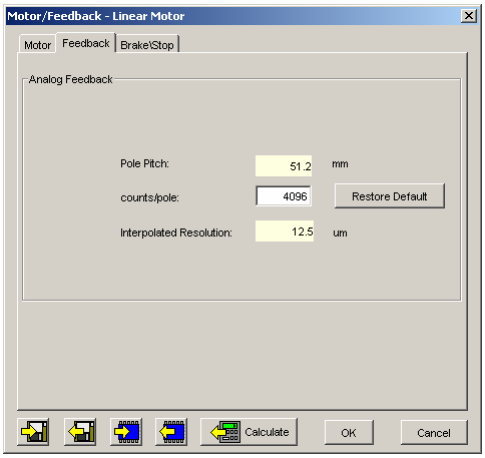


G.1.2.2 In the *Manufacturer* field, choose **Copley Motion Systems** from the pull-down list.

G.1.2.3 In the *Series* field choose **STA** or **STB** to match the ServoTube motor.

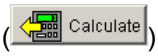
G.1.2.4 In the *Model* field, choose the model number to match the ServoTube motor.

G.1.2.5 Click the **Feedback** tab and verify the *Analog Feedback* settings (defaults shown below).

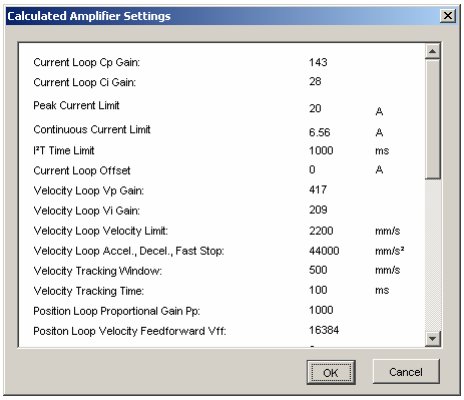


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G.1.3: Calculating ServoTube Initial Values

G.1.3.1 Click **Calculate** (

) to calculate and display initial loop gains and limits.



G.1.3.2 Load the values into volatile memory by clicking **OK**
OR
to close the screen without saving changes, click **Cancel**.

G.1.3.3 Click **Save to Flash** (
).

G.1.4: Setting Up the Motor Over Temperature Input

It is important to program the amplifier to shut down the PWM outputs when a motor over temperature signal is sent over digital input IN5 by the motor temperature sensor.

G.1.4.1 On the CME 2 Main screen, click **Input/Output** to display the *Input/Output* screen**.**

G.1.4.2 Verify that the inputs group containing IN5 is pulled up to internal +5 V and the IN5 function is set to **Motor Temp-HI Disables**.

If the motor temperature sensor is wired to IN5, and the motor temperature is within specified operating range, a grey indicator will show that the input is inactive, and the amplifier is not disabled by a motor over temperature fault.

G.1.5: Other ServoTube I/O and Fault Latching Setup Steps

Before proceeding with this chapter, perform any other required configuration of the amplifier's digital inputs, digital outputs and fault latching.

Inputs and outputs	Digital Inputs (p. 93) Standard Digital Outputs (p. 95) Custom Digital Outputs (p. 96) Save Input/Output Changes (p. 96)
Fault latching	Fault Latching (p. 97)

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G.2: ServoTube Auto Phase and Manual Phase

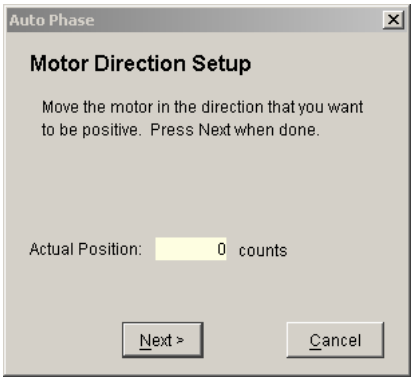
G.2.1: ServoTube Auto Phase

NOTE: The following steps use a ServoTube motor. For short stoke ServoTube motors with less than 2 electrical cycles, proceed to G.2.2: ServoTube Manual Phase (p. 192).

G.2.1.1 Verify that the Enable Input is not activated.

G.2.1.2 Apply power.

G.2.1.3 Click **Auto Phase** ( ) to open the *Auto Phase Motor Direction Setup* screen.

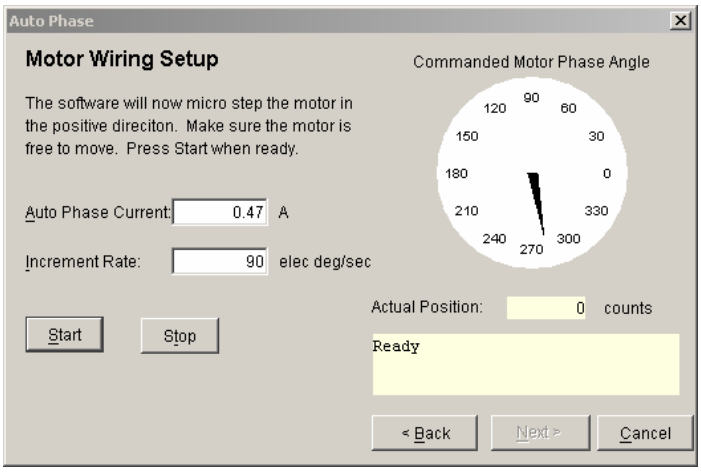


G.2.1.4 Move the motor in the direction you wish to be considered positive.

The *Actual Position* value on the screen should change. If it does not change, see Trouble Shoot Motor Direction Setup (p. 109).

G.2.1.5 Activate the Enable Input.

G.2.1.6 Click **Next** to display the *Auto Phase Motor Wiring Setup* screen.



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G.2.1.7 Click **Start** to begin the motor wiring setup.

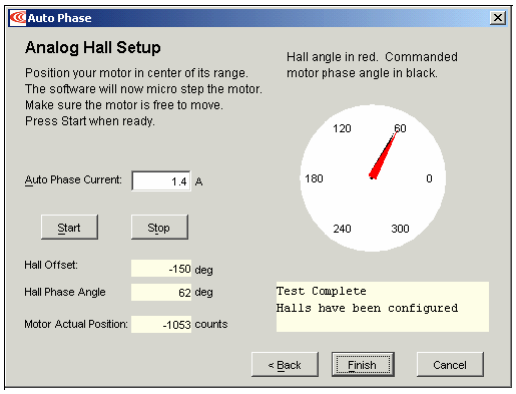
The software displays messages: *Configuring Initial Settings, Microstepping, Test Complete, Motor Wiring has been configured*.

During microstepping, a current vector is applied to the motor windings and microstepped through an electrical cycle at a set rate. The field produced should push on the permanent magnet's magnetic field, causing the motor to move.

If the step fails see Trouble Shoot Motor Wiring Setup (p. 109).

NOTE: If incorrect values were entered for inductance and resistance, the calculated Cp and Ci values may produce current loop oscillation, evidenced by an audible high frequency squeal during auto phasing.

G.2.1.8 Click **Next** to display the Analog *Hall Wiring Setup* screen.



G.2.1.9 Click **Start** to begin the Analog Hall wiring setup.

The message area displays the messages: *Microstepping. Test Complete. Motor has been properly phased*.

During microstepping, a current vector is applied to the motor windings and microstepped through an electrical cycle at a set rate. The field produced should push on the permanent magnet's magnetic field causing the motor to move. As the motor moves the Analog Hall lines are decoded for proper commutation.

If the step fails, see Trouble Shoot Halls Wiring Setup (p. 109).

G.2.1.10 Click **Finish** to close the screen and save values to flash memory
OR
to close the screen without saving changes, click **Cancel**.

G.2.1.11 If the Auto Phase algorithm does not produce desired results, try adjusting the Auto Phase Current and Increment Rate values, using the guidelines in Guidelines for Choosing Auto Phase Current and Increment Rate Values (p. 109).

G.2.1.12 If desired results are not obtained, proceed to Manual Phasing (p. 145).

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Choosing ServoTube Auto Phase Current and Increment Rate Values

Here are some considerations in choosing Auto Phase Current and Increment Rate values:

- If friction is high, then more current may be required to move the load.
- High static friction may require more current to overcome stiction.
- Transition from static friction to dynamic friction, and back, may produce jerky motion.
- A faster rate will operate in the dynamic friction range.
- A slower rate will operate in the static friction range.

Trouble Shoot Motor Direction Setup

If motor direction setup step failed:

- Check feedback power and sin cos signals.
- Check shielding for proper grounding.

Trouble Shoot Motor Wiring Setup

If motor wiring setup step failed:

- Verify that amplifier is disabled.
- Check for mechanical jamming.
- Check for smooth motion with no mechanical jerking.
- Check for good connections to the motor power wires.
- Disconnect motor power wires.
- Measure for proper motor resistance.

Trouble Shoot Analog Hall Wiring Setup

If Analog Hall wiring setup step failed:

- Check feedback power and sin cos signals.
- Check for smooth motion with no mechanical jerking.
- Check shielding for proper grounding.

Other Problems

If the auto phase procedure fails despite these corrective measures, see G.2.2: ServoTube Manual Phase (p. 192).

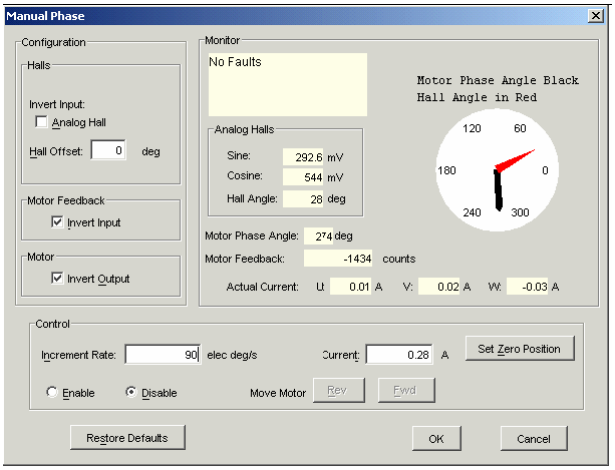
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G.2.2: ServoTube Manual Phase

The CME 2 Manual Phase tool lets the user phase a brushless motor, monitor signals, check configuration wiring, and control a microstepping current vector. The manual phase procedure is followed by a manual phase troubleshooting procedure.

G.2.2.1 Make sure that no load is connected to the motor.

G.2.2.2 On the *Main* screen, choose **Tools→Manual Phase** to open the *Manual Phase* window.



G.2.2.3 Enable the amplifier by selecting.

G.2.2.4 To control the current vector rotation, use **Rev** or **Fwd** to command reverse or forward motion.

NOTE: Some motors have bearings stiction, so helping the motor with mechanical force is acceptable. Motors with no friction may need friction added to steady motion.

G.2.2.5 If the motor cannot keep up with the rate of vector rotation, then reduce the *Increment Rate* or increase the *Current*.

G.2.2.6 Verify that pressing forward button moves motor forward. If it does not, toggle the Motor Invert Output box setting.

G.2.2.7 Verify actual position count agrees with direction of rotation: increasing counts in forward direction and decreasing counts in reverse direction. If it does not, toggle the Encoder Invert Output box setting.

G.2.2.8 Monitor the vector rotation through one electrical cycle for proper Analog Hall rotation.

1. Verify that the red needle rotates in phase and in the same direction as the black motor phase angle ±5 few degrees.
2. If the black needle and the red Analog Hall needles do not track in the same direction properly, check the invert input analog *Hall option* swap the amplifier's analog Hall wire configuration.
3. If the red indicator transition leads or lags behind the centered needle by more than 5 degrees, then try adjusting the *Hall Offset* in +/- 30 degree increments:

G.3: Special ServoTube Setup Completion

Proceed now to Current Loop (p. 110) to complete the general amplifier setup procedure.

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APPENDIX H: ORDERING GUIDE AND ACCESSORIES

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

H.1: Amplifier Model Numbers 194
H.2: Accessory Model Numbers 194
H.3: Order Example 195
H.4: Control and Feedback Cable Color Codes 196
H.4.1: Wire Description Nomenclature 196
H.4.2: Control Cable (XSL-CC-10) 196
H.4.3: Feedback (XSL-FC-10) 197
H.5: Regen Resistor Specifications 198
H.5.1: XTL-RA-03, XTL-RA-04 Specifications 198
H.5.2: XTL-RA-03, XTL-RA-04 Dimensions 198
H.5.3: XSL-RA-01, 02 (Discontinued) Specifications 199
H.5.4: XSL-RA-01, 02 (Discontinued) Dimensions 199

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H.1: Amplifier Model Numbers

Model Number	Description
XSL-230-18	Xenus Servoamplifier 6/18 A
XSL-230-18-HL	Xenus Servoamplifier 6/18 A with factory-fitted, low-profile heatsink
XSL-230-18-HS	Xenus Servoamplifier 6/18 A with factory-fitted, standard heatsink
XSL-230-36	Xenus Servoamplifier 12/36 A
XSL-230-36-HL	Xenus Servoamplifier 12/36 A with factory-fitted, low-profile heatsink
XSL-230-36-HS	Xenus Servoamplifier 12/36 A with factory-fitted, standard heatsink
XSL-230-40	Xenus Servoamplifier 20/40 A
XSL-230-40-HL	Xenus Servoamplifier 20/40 A with factory-fitted, low-profile heatsink
XSL-230-40-HS	Xenus Servoamplifier 20/40 A with factory-fitted, standard heatsink
XSL-230-18-R	Xenus Servoamplifier 6/18 A with resolver feedback
XSL-230-18-R-HL	Xenus Servoamplifier 6/18 A with resolver feedback and factory-fitted, low-profile heatsink
XSL-230-18-R-HS	Xenus Servoamplifier 6/18 A with resolver feedback and factory-fitted, standard heatsink
XSL-230-R-36	Xenus Servoamplifier 12/36 A with resolver feedback
XSL-230-36-R-HL	Xenus Servoamplifier 12/36 A with resolver feedback and factory-fitted, low-profile heatsink
XSL-230-36-R-HS	Xenus Servoamplifier 12/36 A with resolver feedback and factory-fitted, standard heatsink
XSL-230-40-R	Xenus Servoamplifier 20/40 A with resolver feedback
XSL-230-40-R-HL	Xenus Servoamplifier 20/40 A with resolver feedback and factory-fitted, low-profile heatsink
XSL-230-40-R-HS	Xenus Servoamplifier 20/40 A with resolver feedback and factory-fitted, standard heatsink
NOTE: Heatsink kits may be ordered separately.	

H.2: Accessory Model Numbers

Software

Model	Description
CME2	CME 2 Drive Configuration Software (CD-ROM)
CML	Copley Motion Libraries (CD-ROM)
CMO	Copley Motion Objects (CD-ROM)

Connector Kit with Solder-Cup Feedback and Control Connectors

Model	Qty	Ref	Description	Mfr. Model No.
XSL-CK	1	J1	Plug, 4 position, 7.5 mm, female	Wago: 721-204 / 026-045
	1	J2	Plug, 4 position, 5.0 mm, female	Wago: 721-104 /026-047
	1	J3	Plug, 5 position, 5.0 mm, male	Wago: 721-605 /000-043
	1	J4	Plug, 3 position, 5.0 mm, female	Wago: 721-103 / 026-047
	4	J1-4	Tool, wire insertion and extraction	Wago: 231-131
	1	J7	Connector, 26 position, solder-cup	3M: 10: 10126-3000VE
	1		Back shell, for 26-pin connector	3M: 10: 10326-52F0-008
	1	J8	Connector, 20 position, solder-cup	3M: 10: 10120-3000VE
	1		Back shell, for 20 position connector	3M: 10: 10320-52F0-008

Connector Kit with Molded Cables for Feedback and Control

Model	Qty	Ref	Description	Mfr. Model No.
XSL-CA	1	J1	Plug, 4 position, 7.5 mm, female	Wago: 721-204 / 026-045
	1	J2	Plug, 4 position, 5.0 mm, female	Wago: 721-104 /026-047
	1	J3	Plug, 5 position, 5.0 mm, male	Wago: 721-605 /000-043
	1	J4	Plug, 3 position, 5.0 mm, female	Wago: 721-103 / 026-047
	4	J1-4	Tool, wire insertion and extraction	Wago: 231-131
	1	J7	Cable assembly, control, 10 ft (3 m)*	Copley Controls: XSL-CC-10
	1	J8	Cable assembly, feedback, 10 ft (3 m)*	Copley Controls: XSL-FC-10
* For cable color codes see Control and Feedback Cable Color Codes (p. 196).				

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CANopen Connector Kit

Model	Qty	Ref	Description	Mfr. Model No.
XSL-NK	1	--	Sub-D 9-position female to RJ-45 adapter	
	1	J6	CANopen Network Cable, 10 ft (3 m)	Kristamicro: 60-662BY
	1		CANopen Network Terminator	

Individual Cable Assemblies (and Related Accessories)

Model	Ref	Description	Mfr. Model No.
SER-CK	J5	RS-232 Serial Cable Kit (for connecting PC to amplifier)	
XSL-CC-10	J7	Control Cable with molded connector and flying leads, 10 ft (3 m)*	
XSL-FC-10	J8	Feedback Cable with molded connector and flying leads, 10 ft (3 m)*	
XSL-CV		Sub-D 9-position female to RJ-45 adapter (PC to CANopen cable adapter)	
XSL-NC-10	J6	CANopen Network Cable, 10 ft (3 m)	Kristamicro: 60-662BY
XSL-NC-01		CANopen Network Cable, 1 ft (0.3 m)	Kristamicro: 60-660BY
XSL-NT		CANopen Network Terminator	
* For cable color codes see Control and Feedback Cable Color Codes (p. 196).			

Heatsink Kit, Low Profile

Model	Qty	Description
XSL-HL	1	Heatsink, low-profile
	1	Heatsink thermal material
	1	Heatsink hardware mounting kit

Heatsink Kit, Standard

Model	Qty	Description
XSL-HS	1	Heatsink, standard
	1	Heatsink thermal material
	1	Heatsink hardware mounting kit

Regen Resistor Assemblies

Model	Description
XSL-RA-01	Regen Resistor Assembly (for use with XSL-230-18)
XSL-RA-02	Regen Resistor Assembly (for use with XSL-230-36 and XSL-230-40)

Edge Filter

Model	Description
XSL-FA-01	Xenus Edge Filter

XSL-FA-01 Edge Filter Connector Kit

Model	Qty	Ref	Description	Mfr. Model No.
XSL-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

H.3: Order Example

Order 1 XSL-230-18 amplifier with standard heatsink fitted at the factory, Connector Kit, CME 2 CD, and serial cable kit:

Qty	Item	Description
1	XSL-230-18-HS	Xenus Servoamplifier with standard heatsink installed
1	XSL-CK	Connector Kit with solder cup connectors
1	CME 2	CME 2 CD
1	SER-CK	Serial Cable Kit for connecting the PC to the amplifier

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H.4: Control and Feedback Cable Color Codes

H.4.1: Wire Description Nomenclature

Most wires are solid-color with a stripe of an alternate color, shown below as solid/stripe. For instance, “Black/Orange” is a black wire with an orange stripe.

H.4.2: Control Cable (XSL-CC-10)

The molded connector mates with amplifier J7 and has flying-lead terminators with colors shown in the table below.

Note the color changes affecting pins 1 and 2 between XSL-FC-10 Revision B and Revision C.

Signal	Pin	Color (Body/ Stripe)	Pair		Color (Body/ Stripe)	Pin	Signal
Shield	1	Rev A&B: White/Tan Rev C: Brown	1a	8a	White/Violet	14	[OUT2]
Signal Ground	2	Rev A&B: Tan/White Rev C: Orange	1b	8b	Violet/White	15	[OUT3]
Enable [IN1]	3	White/Brown	2a	9a	White/Gray	16	Encoder A In/Out
GP Input [IN2]	4	Brown/White	2b	9b	Gray/White	17	Encoder /A In/Out
GP Input [IN3]	5	White/Pink	3a	10a	Tan/Brown	18	Encoder B In/Out
GP Input [IN4]	6	Pink/White	3b	10b	Brown/Tan	19	Encoder /B In/Out
HS Input [IN6]	7	White/Orange	4a	11a	Tan/Pink	20	Encoder X In/Out
HS Input [IN7]	8	Orange/White	4b	11b	Pink/Tan	21	Encoder /X In/Out
HS Input [IN8]	9	White/Yellow	5a	12a	Tan/Orange	22	+5 Vdc @ 400 mA
HS Input [IN9]	10	Yellow/White	5b	12b	Orange/Tan	23	Signal Ground
HS Input [IN10]	11	White/Green	6a	13a	Tan/Yellow	24	Analog Ref In(+)
GP Input [IN11]	12	Green/White	6b	13b	Yellow/Tan	25	Analog Ref In(-)
[OUT1]	13	White/Blue	7	7b	Blue/White	26	[IN12] GP Input

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H.4.3: Feedback (XSL-FC-10)

The molded connector mates with amplifier J8 and has flying-lead terminators with colors shown in the tables below.

Note the color changes affecting pins 1 and 11 between XSL-FC-10 Revision B and Revision C.

Standard Version (Encoder Feedback)

Signal	Pin	Color (Body/ Stripe)	Pair		Color (Body/ Stripe)	Pin	Signal
Frame Ground	1	Rev A & B: White/Tan Rev C: Brown	1a	1b	Rev A & B: Tan/White Rev C: Orange	11	Digital Hall U
Signal Ground	2	White/Brown	2a	7a	White/Blue	12	Digital Hall V
+5 Vdc @ 400 mA	3	Brown/White	2b	7b	Blue/White	13	Digital Hall W
Encoder A Input	4	White/Pink	3a	8a	White/Violet	14	[IN5] Temp Sensor
Encoder /A Input	5	Pink/White	3b	8b	Violet/White	15	Signal Ground
Encoder B Input	6	White/Orange	4a	9a	White/Gray	16	Encoder Sin(+) Input
Encoder /B Input	7	Orange/White	4b	9b	Gray/White	17	Encoder Sin(-) Input
Encoder X Input	8	White/Yellow	5a	10a	Tan/Brown	18	Encoder Cos(+) Input
Encoder /X Input	9	Yellow/White	5b	10b	Brown/Tan	19	Encoder Cos(-) Input
Signal Ground	10	White/Green	6a	6b	Green/White	20	Signal Ground

Resolver Version

Signal	Pin	Color (Body/ Stripe)	Pair		Color (Body/ Stripe)	Pin	Signal
Frame Ground	1	Rev A & B: White/Tan Rev C: Brown	1a	1b	Rev A & B: Tan/White Rev C: Orange	11	No Connect
Signal Ground	2	White/Brown	2a	7a	White/Blue	12	Resolver R1 Output
+5 Vdc @ 400 mA	3	Brown/White	2b	7b	Blue/White	13	Resolver R2 Output
No connect	4	White/Pink	3a	8a	White/Violet	14	[IN5] Temp Sensor
	5	Pink/White	3b	8b	Violet/White	15	Signal Ground
	6	White/Orange	4a	9a	White/Gray	16	Resolver S3 Input
	7	Orange/White	4b	9b	Gray/White	17	Resolver S1 Input
	8	White/Yellow	5a	10a	Tan/Brown	18	Resolver S2 Input
	9	Yellow/White	5b	10b	Brown/Tan	19	Resolver S4 Input
Signal Ground	10	White/Green	6a	6b	Green/White	20	Signal Ground

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H.5: Regen Resistor Specifications

H.5.1: XTL-RA-03, XTL-RA-04 Specifications

Specifications for Copley's standard regen resistors are described below.

Model	Resistance	Default Continuous Power	Max Continuous Power	Peak Power	Peak Power Time	For Use With
XTL-RA-03	30 ohms	65 W	400 W	5 kW	1000 ms	XSL-230-18 XSL-230-18-R
XTL-RA-04	15 ohms	65 W	400 W	10 kW	1000 ms	XSL-230-36 XSL-230-36-R XSL-230-40 XSL-230-40-R



WARNING

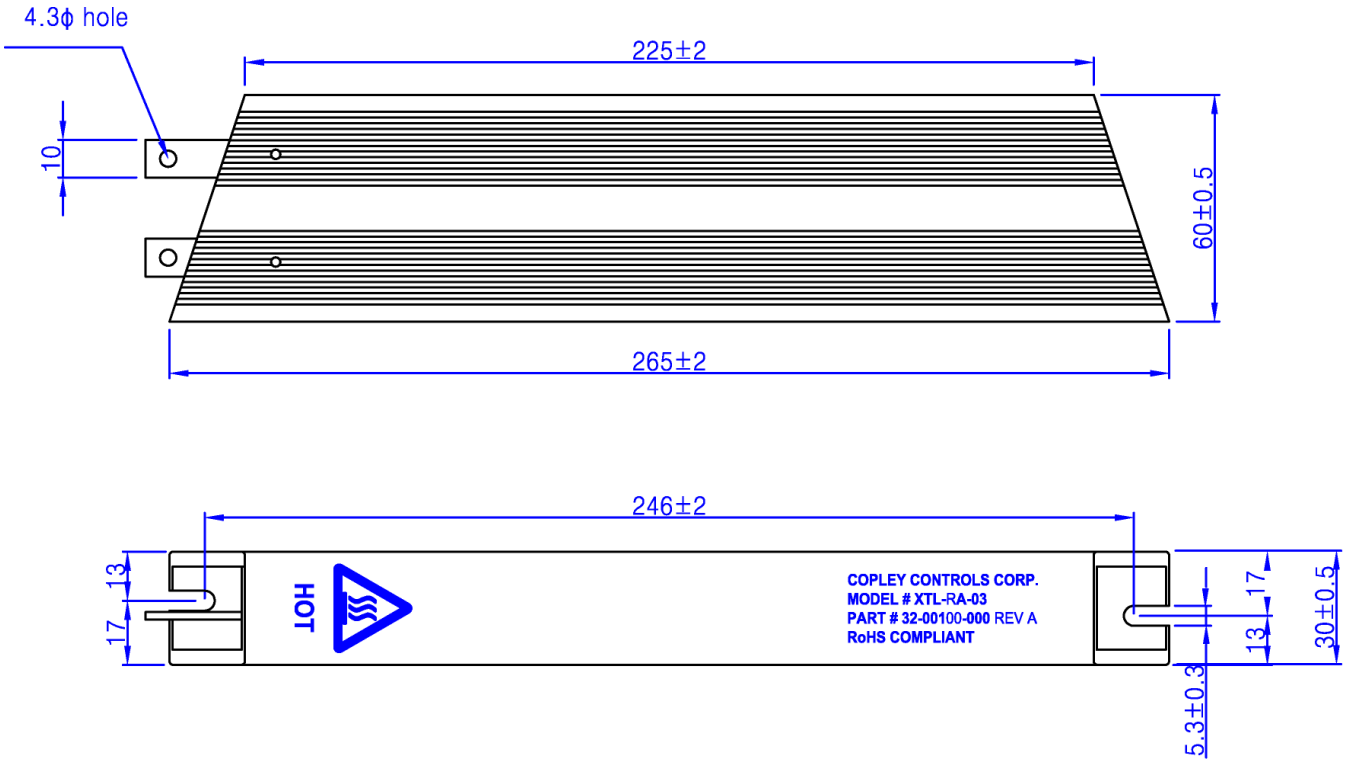
High Temperature Risk.

Setting Default Continuous Power for a standard Copley regen resistor to a value greater than the default of 65 W may cause the resistor casing to heat to temperatures that could cause injury. If higher settings are required, contact Copley Controls customer support.

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

H.5.2: XTL-RA-03, XTL-RA-04 Dimensions

The diagram below shows XTL-RA-03 and XTL-RA-04 mounting dimensions (in mm).



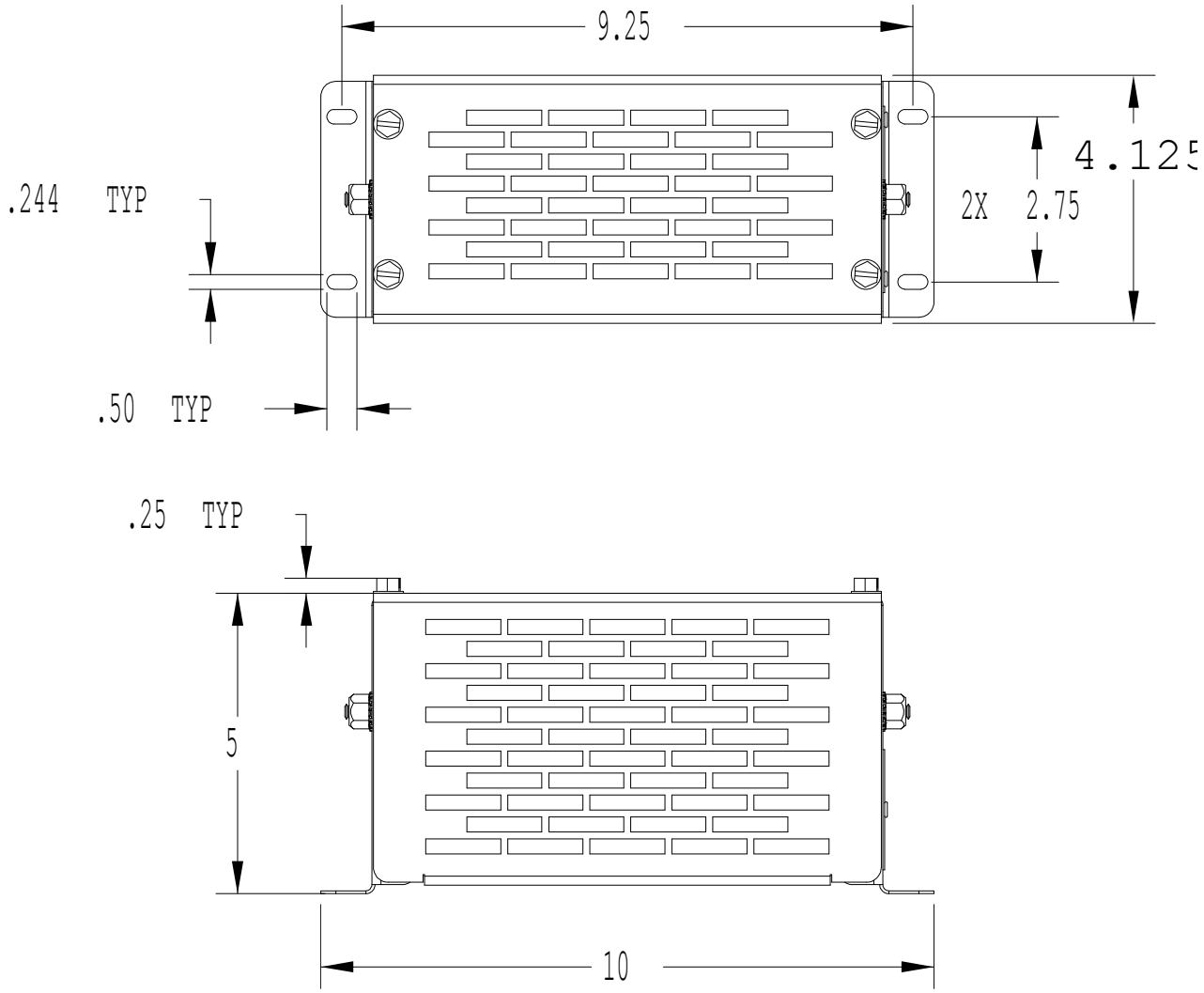
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H.5.3: XSL-RA-01, 02 (Discontinued) Specifications

Copley Controls no longer distributes XSL-RA regen resistors. Resistors with model numbers XSL-RA-01 and XSL-RA-02 have been replaced by models XTL-RA-03 and XTL-RA-04.

Model	Resistance	Continuous Power	Peak Power	For Use With
XSL-RA-01	30 ohms	167 W	5 kW	XSL-230-18 XSL-230-18-R
XSL-RA-02	15 ohms	200 W	10 kW	XSL-230-36 XSL-230-36-R XSL-230-40 XSL-230-40-R

H.5.4: XSL-RA-01, 02 (Discontinued) Dimensions



Dimensions in inches

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Xenus XSL™ User Guide

P/N 95-00286-000

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