

CME User Guide

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1 About This Manual

1.1 Related Documentation

- Indexer 2 Program User Guide
- ASCII Interface Programmer's Guide
- Camming User Guide
- CANopen Programmers Manual
- Parameter Dictionary
- Serial Encoder Guide

Copley Controls software and related information are located on the website: www.copleycontrols.com.

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1.4 Product Warnings

Observe all relevant state, regional and local safety regulations when installing and using Copley Controls drives. For safety and to ensure compliance with documented system data, only Copley Controls should perform the repairs to the drives.

Risk of Personal Injury and Equipment Damage	
 **DANGER**	**Hazardous voltages.**
	Exercise caution when installing and adjusting Copley drives.
	Risk of electric shock.
	On some Copley Controls drives, high-voltage circuits are connected to mains power. Refer to the hardware documentation.
	Risk of unexpected motion with non-latched faults.

Risk of Personal Injury and Equipment Damage	
	After the cause of a non-latched fault is corrected, the drive re-enables the PWM output stage without operator intervention. In this case, motion may re-start unexpectedly. Configure faults as latched unless a specific situation calls for non-latched behavior. When using non-latched faults, be sure to safeguard against unexpected motion.
	Latching an output does not eliminate the risk of unexpected motion with non-latched faults.
	Associating a fault with a latched, custom-configured output does not latch the fault itself. After the cause of a non-latched fault is corrected, the drive re-enables without operator intervention. In this case, motion may re-start unexpectedly. For more information, see Non-Latched Faults.
	When operating the drive as a CAN or EtherCAT node, the use of CME or ASCII serial commands may affect operations in progress. Using such commands to initiate motion may cause network operations to suspend. Operation may restart unexpectedly when the commanded motion is stopped.
	Use equipment as described.
	Operate drives within the specifications provided in the relevant hardware manual or data sheet. **FAILURE TO HEED THESE WARNINGS CAN CAUSE EQUIPMENT DAMAGE, INJURY, OR DEATH.**

1.5 Revision History

Revision	Date	Applies to	Comments
00	January 2014	CME 2 Software version 7.0	Changes include updated screenshots, information updates, and filter data.
01	March 2019	CME Software version 8.0	Incorporated new screenshots, added Frequency Analysis section
02	April 2019	CME Software version 8.0	Fixed minor issues.
03	September 2024	CME Software version 8.1	Incorporated new screenshots and updated the Frequency Analysis section. To comply with the new CME software version 8.1, updated relevant information, features for Inputs/Outputs, Network Config & setup.
04	November 2024	CME Software version 8.1	Fixed minor issues.
05	July 2026	CME Software version 9.0	Incorporated new screenshots and updated Network Configuration section. To comply with the new CME software version 9.0, updated screenshots & text changes.

2 INTRODUCTION

2.1 Host Computer Requirements

2.1.1 Computer and Operating System

Operating Systems Supported: 64-bit Windows 10 or greater.

2.1.2 Default File Locations

The default location for CME data files (ccx, ccm, etc.) is standardized.

C:\Users\Public\Public Documents\Copley Motion\CME2

CME Installer creates a convenient link named, "Copley Motion" on the desktop.

2.1.3 Serial Communications

- Standard RS-232 serial port or an SER-USB-RJ11 adapter.
- Serial communication cable. See the data sheet for the part numbers.

2.1.4 CAN Communications (with Copley CANopen Drives)

CAN card. The following CAN card manufacturers are supported:

- Copley Controls CAN PCI card:
  (CAN-PCI-02, CAN-PCIe-01, CAN-PCIe-02, CAN-USB-01, CAN-PC104-02)
- Kvaser
- CANopen network cable (see the data sheet for the part number and wiring instructions).

2.1.5 DeviceNet Communications (with Copley CANopen Drives)

Copley DeviceNet cabling, and connections are identical to the Copley CAN cabling and connection.

2.1.6 EtherCAT Communications (with Copley EtherCAT Drives)

- Ethernet adapter dedicated to the EtherCAT network.
- EtherCAT network cable. See the data sheet for the wiring instructions.

2.1.7 Ethernet Communications (with Copley EtherCAT Drives)

- Ethernet adapter dedicated to the Ethernet network.
- Ethernet network cable

2.2 Overview

2.2.1 Setup and Tuning

Java based CME configuration software is powerful and intuitive. It offers the following features.

- Comprehensive diagnostics, auto-tuning, and advanced oscilloscope tools simplify the system commissioning.
- Auto-phasing eliminates time consuming rewire-and-try for the encoder/Halls/motor connections.
- CME automatically compensates for crossed wires, eliminating the most common cause of startup issues.

2.2.2 Indexing

Point-and-click to define up to 32 indexes or index sequences. Simply select the index/sequence and the command GO. Index sequences can include the following:

- motion
- dwell times
- parameter changes
- I/O control

Any parameter can be assigned to a register for efficient control by a PLC.

Custom functions can be provided for complex applications. Install the Java "bean" and enter the relevant settings. Copley also provides a flexible OEM programming environment. Copley Virtual Machine assembler/debugger enables the development of a fast, compact control program.

2.2.3 Cam Tables

Camming is an effective way to produce repetitive motion synchronized to an external device. A pre-defined cam-table of sub device positions is typically cycled through by a master device encoder connected to the drive. The drive performs linear interpolation between points to minimize cam-table size.

NOTE: In this manual, the feature descriptions may not apply to all Copley Controls drives under all configurations. Significant differences between the drive models are noted. See the relevant hardware manual or data sheet for more information.

2.3 Servo Operating Modes and Control Loops

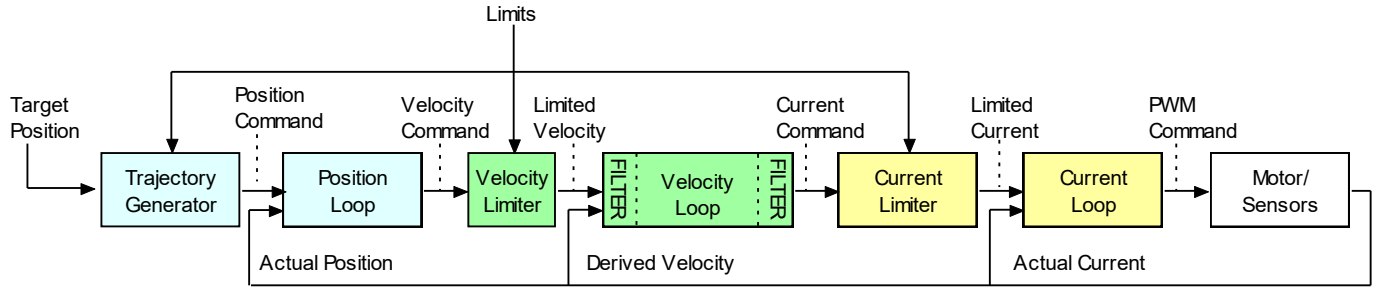
Copley Controls drives use up to the following three nested control loops to control a motor in three associated operating modes.

- current
- velocity
- position

(Stepper drives operated in Stepper mode function as traditional open position loop stepper drives).

2.3.1 Control Loops Model

In the Position Mode, the drive can use all three loops. The following diagram shows a typical system, where the position loop drives the nested velocity loop, which subsequently drives the nested current loop.



Control Loops Model Diagram

In the Velocity Mode, the velocity loop drives the current loop. In the Current Mode, the current loop is driven directly by the external or internal current commands.

2.3.2 Basic Attributes of All Servo Control Loops

The following table lists the loop attributes and descriptions for all servo control loops.

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 purpose 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 gains are constant values that are used in the mathematical equation of the servo loop. The values of these gains can be adjusted during the drive setup to improve the loop performance. Adjusting these values is often referred to as tuning the loop.
Output	The loop generates a control signal. This signal can be used as the command signal to another control loop or it can be used as the input to a power drive.

For more information on using the CME software to set up and tune Control Loops, see Control Loops.

3 Installation, Startup, and Interface Tour

3.1 Download and Install CME Software

1. Downland and install the CME software. Refer to the following steps and the website. www.copleycontrols.com.
2. Navigate to Support and select **General Resources**.
3. Click on **Software**.
4. Navigate to **CME2 Software Ver 9.0**.
5. Click on download.
6. Add the email address to register. The link to download the software will be sent to the email address.
7. Click on the link and download the software.
8. Extract the contents of CME.zip.
9. Run Setup.exe and follow the instructions on the Installer screens.

NOTE: It is recommended that all default installation settings are accepted.

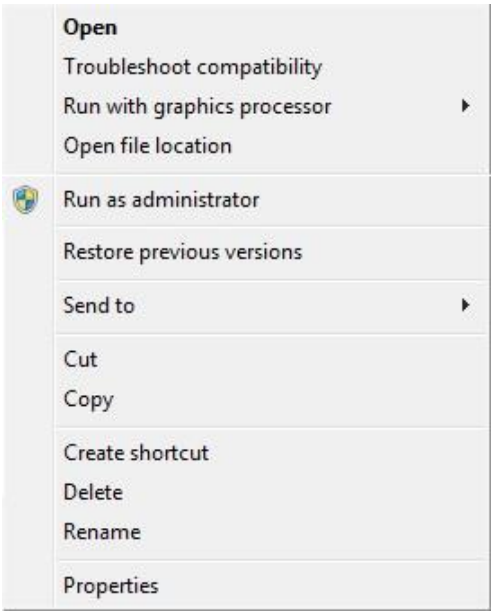
3.2 Installing and Running CME

3.2.1 Installer

When the Installer starts, Windows will display a dialog screen prompting for permission to make changes to your computer. Click the button to allow the Installer to continue, and CME will be installed.

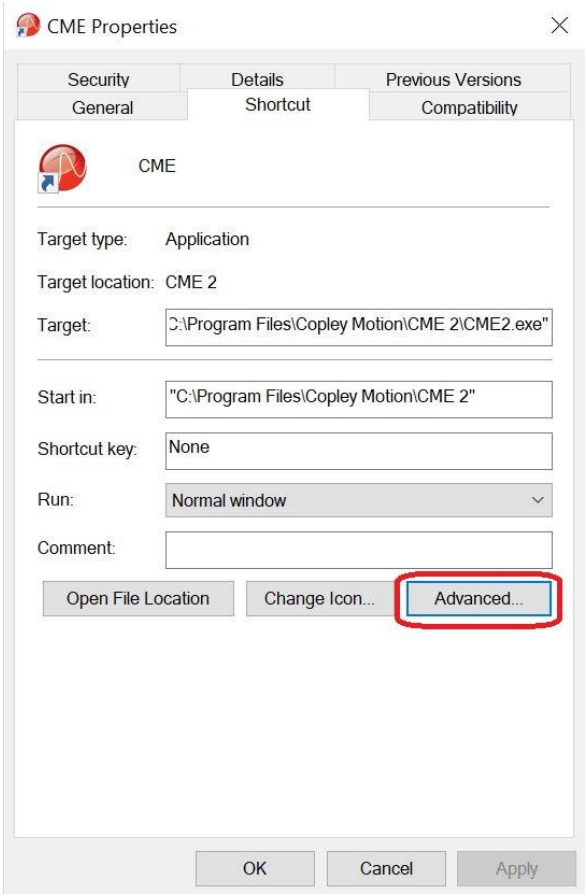
3.2.2 Set Up CME to Run as Administrator

1. On some versions of Windows, setup the CME software to run as administrator to access the communications drivers (for example, Serial, CANopen, EtherCAT).
2. On the desktop, right-click the **CME** icon.
3. From the Pop-up Menu, choose **Properties**.



Menu Screen

4. On the CME Properties screen, click the **Advanced** button.



CME Properties Screen

NOTE: Although the name of the application was changed from CME 2 to CME, the files will be downloaded to a "CME 2" folder and the executable file is CME2.exe.

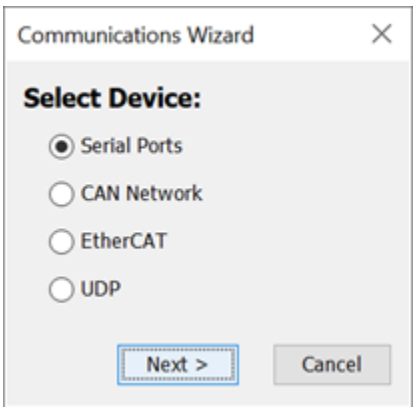
5. From the Advance Properties screen, select **Run as Administrator**.
6. Click **OK** to close the Advanced Properties dialog, then click **OK** to close the Properties dialog.



Advanced Properties Screen

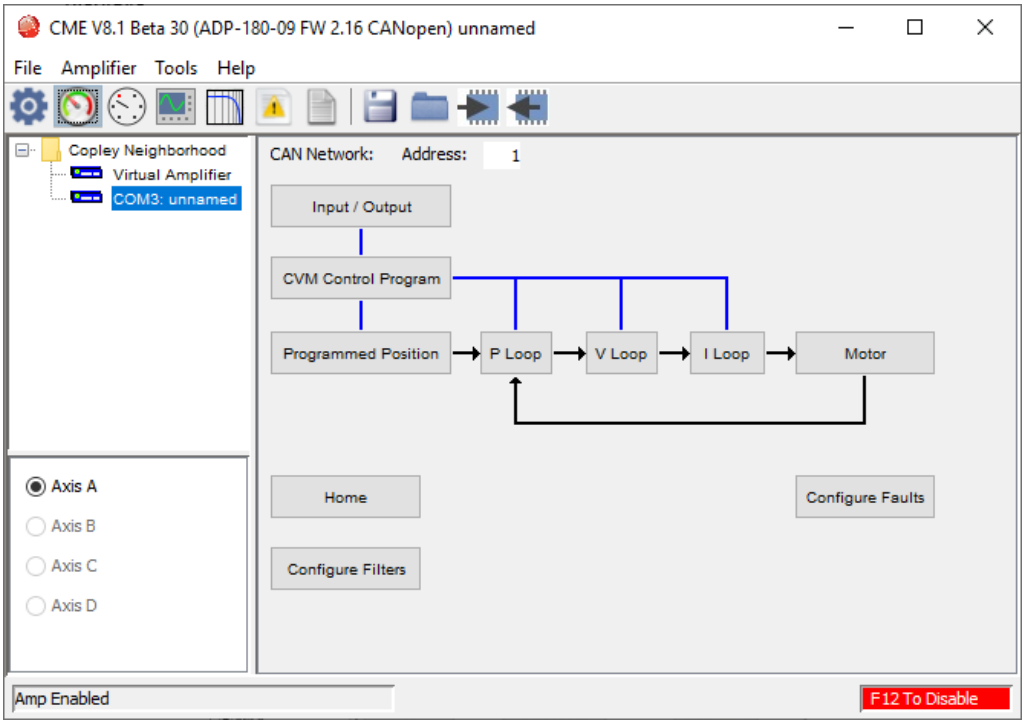
3.3 Procedure to Start CME

1. To start the CME program, on the Windows desktop, double-click the CME shortcut icon.
   If the communications were previously configured, the CME Main Screen opens.
   If the communications were not configured, the following Communications Wizard screen displays.



Communications Wizard (Select Device) Menu

In this case, proceed to the Communications Wizard.
The following screen shows an example of a CME Main screen after a drive is selected.



Example of CME Main Screen

3.4 Communications Wizard

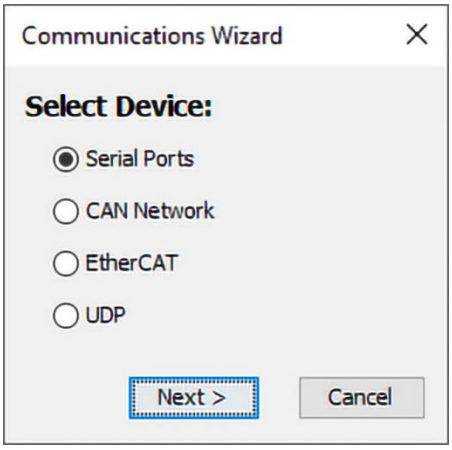
3.4.1 Configure Serial Ports

1. Start the **Communications Wizard**.

   If the communications were not set up, the Communications Wizard will automatically display when CME starts up.

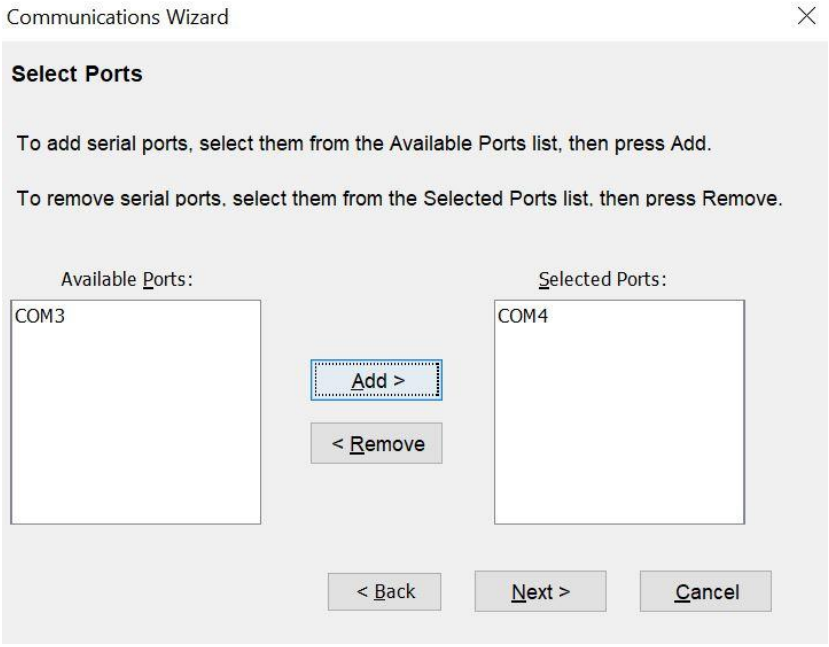
   If the communications were set up, choose **Tools→Communications Wizard**.

2. On the Communications Wizard screen, choose **Serial Ports** and click the **Next** button.



Communications Wizard Select (Serial Ports) Screen

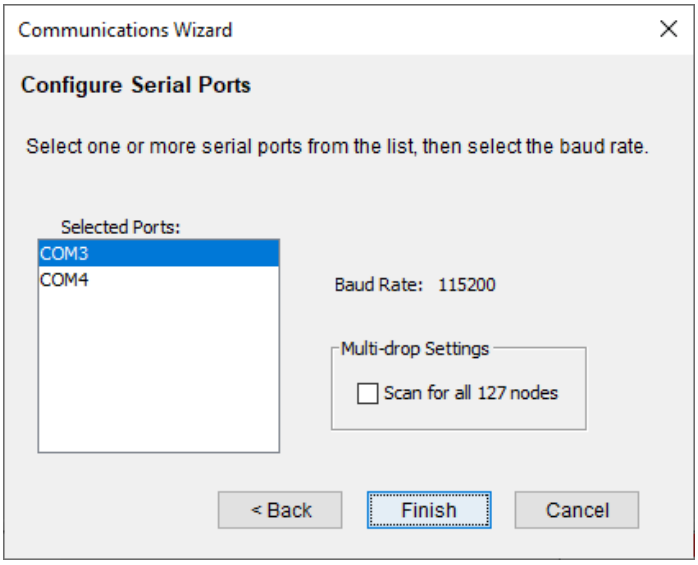
3. On the Select Ports screen, select one or more serial ports from the **Available Ports** list.
4. Click the **Add** button.



Communications Wizard (Select Ports) Screen

5. When all the desired ports are added, click **Next**.

6. To configure the serial ports, do the following steps.
   a. On the Communications Wizard screen, from the **Selected Ports** list, select a port.

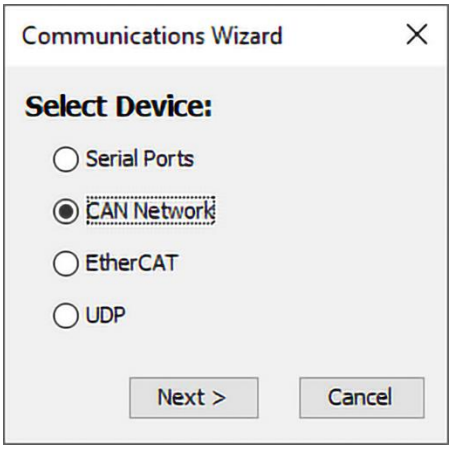


Communications Wizard (Configure Serial Ports) Screen

7. To save the settings, click the **Finish** button.

3.4.2 Configure CANopen Network

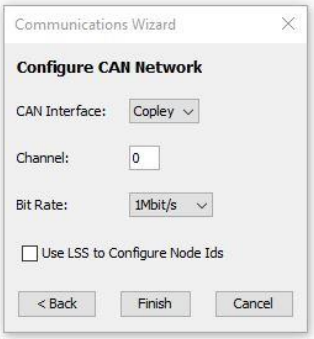
1. Start the **Communications Wizard**.
   If communications were not set up, when the CME starts up, the Communications Wizard automatically displays.
   If communications have already been set up, choose **Tools→Communications Wizard**.
2. Choose **CAN Network** and click **Next**.



Communications Wizard (CAN Network) Screen

To configure the CANopen Network, do the following steps.

a. Select the **CAN Card** from the list.
b. In the **Channel**: field, enter the channel number (0 is used for single channel CAN cards).
c. Select the **Bit Rate** (1Mbit/s Drive default).



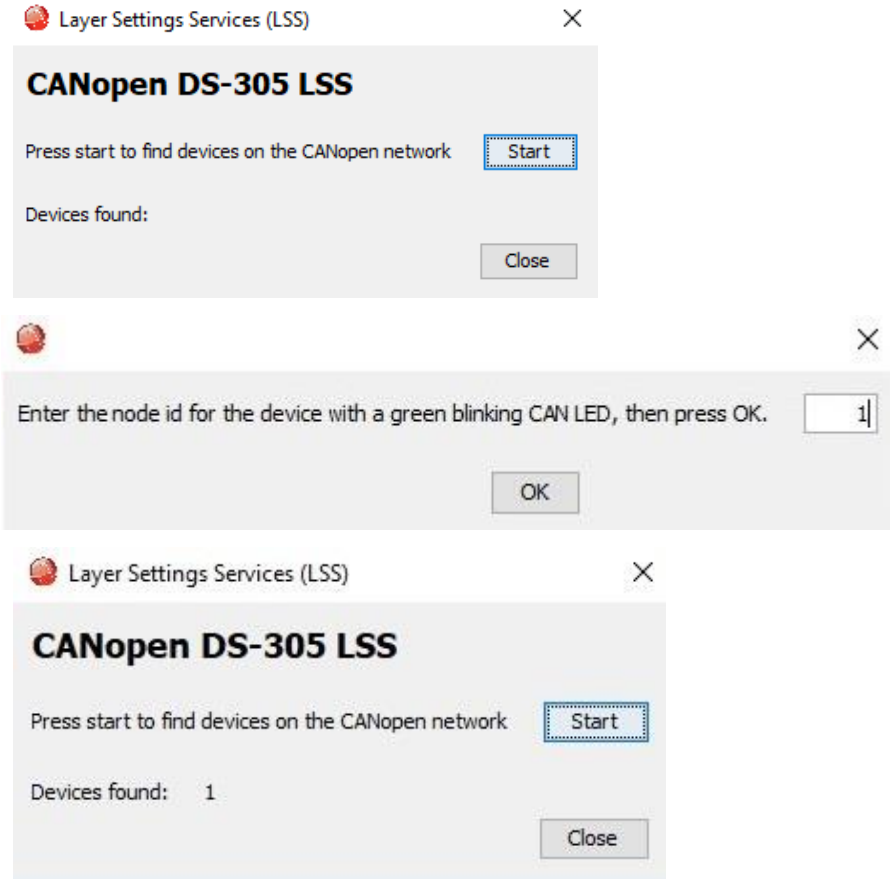
Configure CAN Network Screen

3. To save the settings, click the **Finish** button.

   NOTES:

   a) The CAN Card list only shows the CAN cards that are supported by CME and shows that they are properly installed on the PC.

   b) Use LSS to set the device IDs of any Copley node(s) connected to the CAN card. Each node will be set to ignore the switches and use a programmed value. Typically, it is used to simultaneously configure multiple drives on a single network.



Layer Setting Services (LSS) Windows

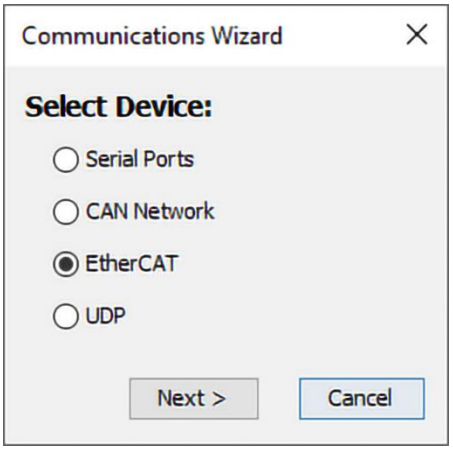
3.4.3 Configure EtherCAT Network

1. Start the Communications Wizard.

   NOTE: Disconnect from any active VPN before attempting to connect to the drive over the EtherCAT network.

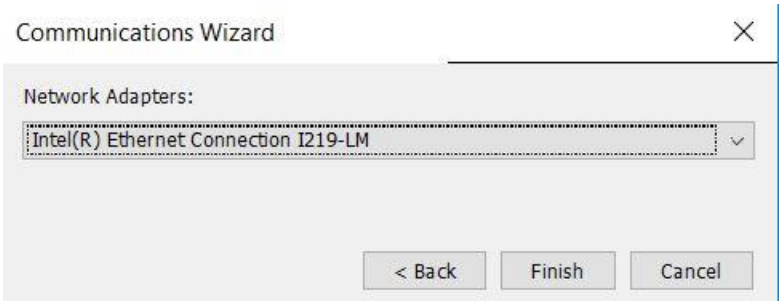
   - If communications were not previously configured, the **Communications Wizard** automatically displays when CME starts up.
   - If communications were configured, choose **Tools→Communications Wizard**.

2. Choose **EtherCAT** and click the **Next** button.



EtherCAT Selection Screen

3. Select the appropriate **Network Adapter**.



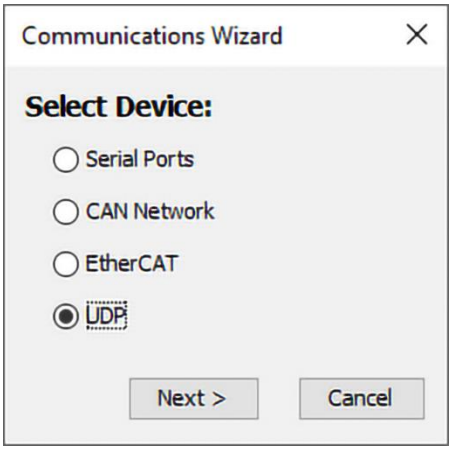
Network Adapters: Selection

4. To save the settings, click the **Finish** button.

   NOTE: If there are issues connecting over the EtherCAT, refer to the Applications Note AN152 (Debugging CME Ethernet Connectivity). This document is available on the Copley Controls website: www.copleycontrols.com.

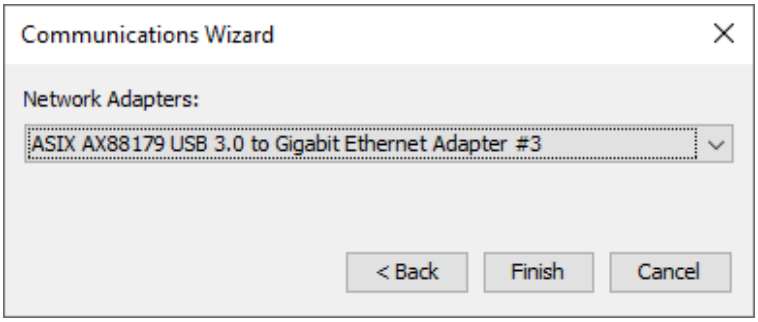
3.4.4 Configure Ethernet Network

1. Start the Communications Wizard.
   NOTE: Disconnect from any active VPN before attempting to connect to the drive over the Ethernet network.
   - If communications were not set up, the **Communications Wizard** automatically displays when CME starts up.
   - If communications were set up, choose **Tools→Communications Wizard**.
2. Choose **UDP** and click the **Next** button.



Select Device: (UDP) Screen

3. On the Communications Wizard screen, in the **Network Adapters:** field, select the appropriate Network Adapter.



Network Adapters: Selection

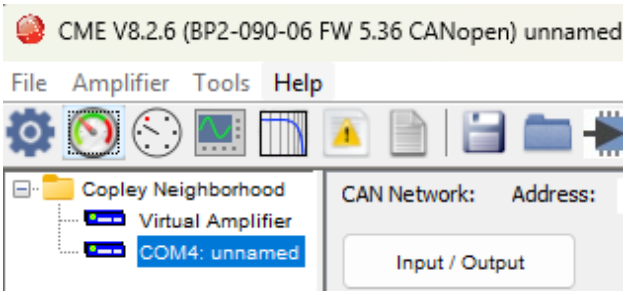
4. To save the settings, click the **Finish** button.

   NOTE: If there are issues connecting over the Ethernet, refer to the Applications Note, AN152 (Debugging CME Ethernet Connectivity). This document is available on the Copley Controls website, www.copleycontrols.com.

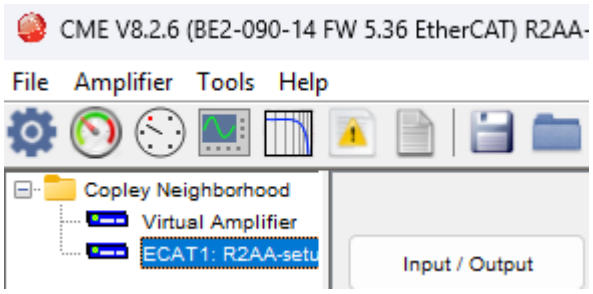
3.5 Connect to a Drive

To choose a drive from the **Copley Neighborhood** folder, click on the drive's name. If there is only one drive, CME will automatically connect on startup.

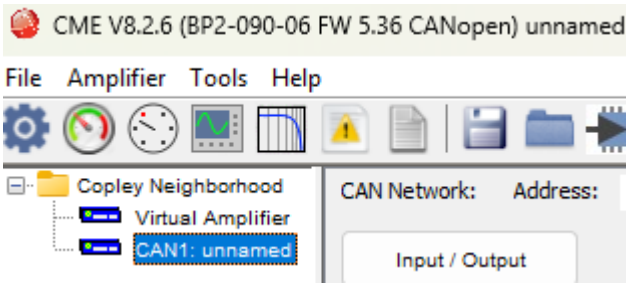
Serial Port



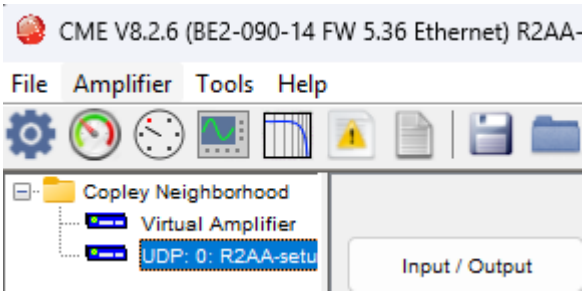
EtherCAT Network



CAN Network

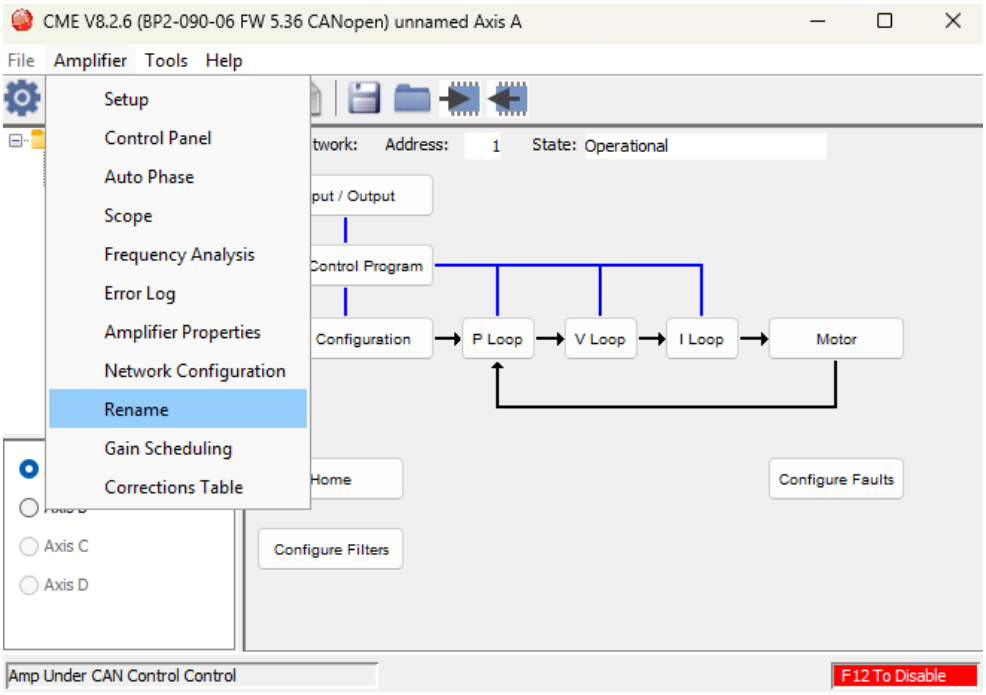


Ethernet Network

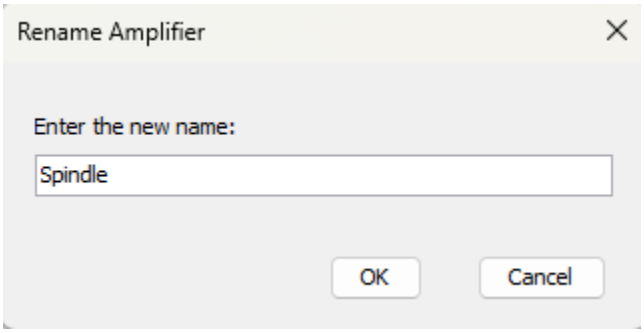


3.6 Rename a Drive

1. From the Main Menu, select **Amplifier→Rename** to open the Rename Amplifier screen.

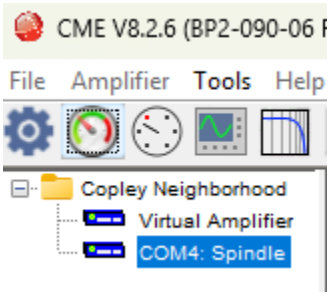


Amplifier Menu



Rename Amplifier Screen

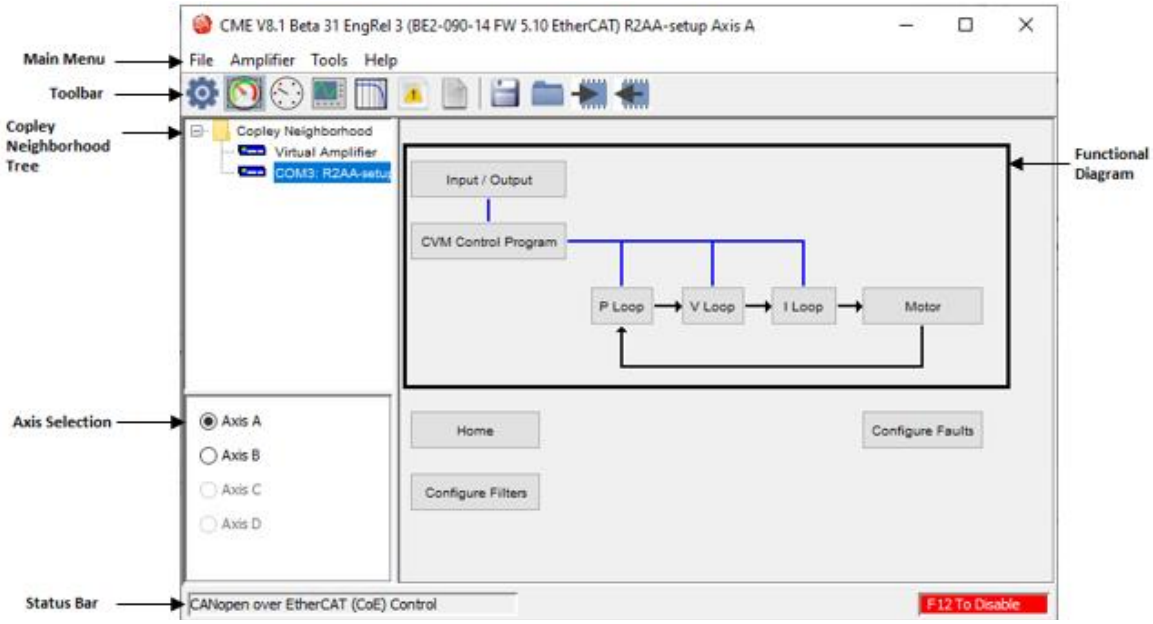
2. On the Rename Amplifier screen, enter the new name and click **OK** to close the screen. The Drive name is now in FLASH and can be seen in the Copley Neighborhood tree.



Amplifier Drive Name

3.7 CME Interface Tour

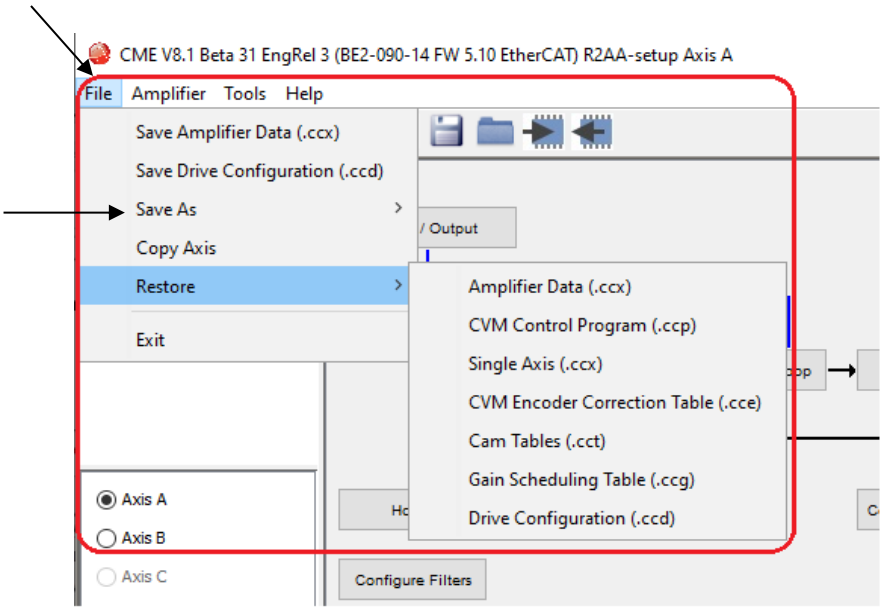
The following diagram shows the CME features. The screen details vary depending on the drive.



CME Screen Diagram

3.7.1 Main Menu

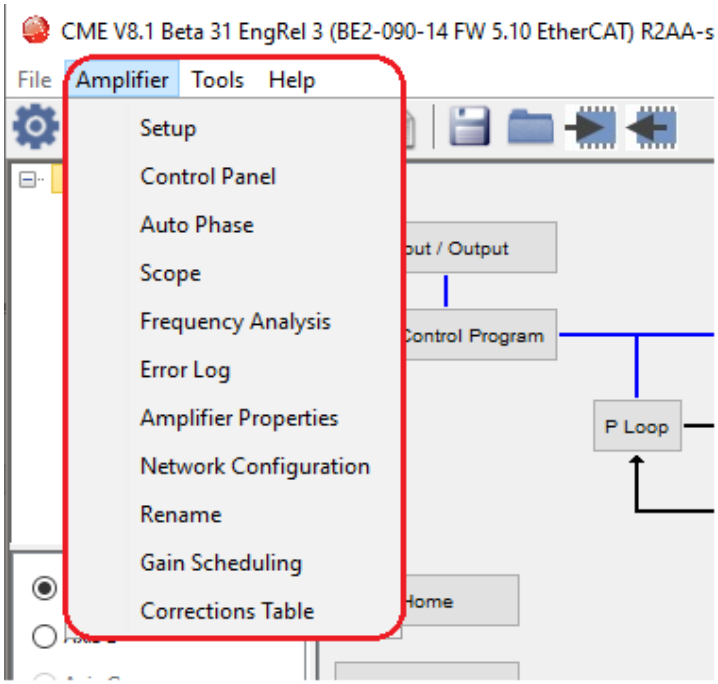
File Menu



File Menu Screen

Option	Type	Description	For More Information
Save Drive Configuration	**.ccd**	Saves the entire contents of the drive's flash memory to a drive configuration file. This includes all drive parameters and CVM flash space (CVM programs, gain scheduling, etc.).	Data, Firmware, Logs
Save Amplifier Data	**.ccx**	Saves the parameters of the drive's RAM and Flash only parameters to a file on disk.	
Save As→Single Axis	**.ccx**	For multi-axis drives only: saves the parameters of the drive RAM to a file on disk for a single axis.	
Copy Axis		For multi-axis drives only: copies the settings from one axis to another.	
Restore→Drive Configuration	**.ccd**	Restores the entire contents of a drive configuration file to a drive's flash. This includes all drive parameters, CVM programs and tables (gain scheduling, correction, etc.).	
Save MACRO File	**.pmc**	(MACRO drives only) Saves the drive setup and tuning parameters in a format that can be read by Delta Tau controllers.	
Restore→Amplifier Data	**.ccx**	Restores the parameters of the amplifier data file from disk to drive RAM.	
Restore→Single Axis	**.ccx**	For multi axis drives only: restores the contents of an amplifier data file to only one axis.	
Restore→CVM Control Program	**.ccp**	Restores a CVM program from a file to the CVM Flash.	
Restore→CVM Encoder Correction Table	**.cce**	Restores a correction table from a file to the CVM flash.	
Restore→Cam Tables	**.cct**	Restores a Cam Table file (.cct) to the drive's CVM flash. For more information, refer to the Copley Camming User Guide located on the Copley Controls website, www.copleycontrols.com.	
Restore→Gain Scheduling Table	**.ccg**	Restores Gain Scheduling Table from a file (.ccg) to the drive's CVM flash.	Gain Scheduling
Exit		Closes CME.	

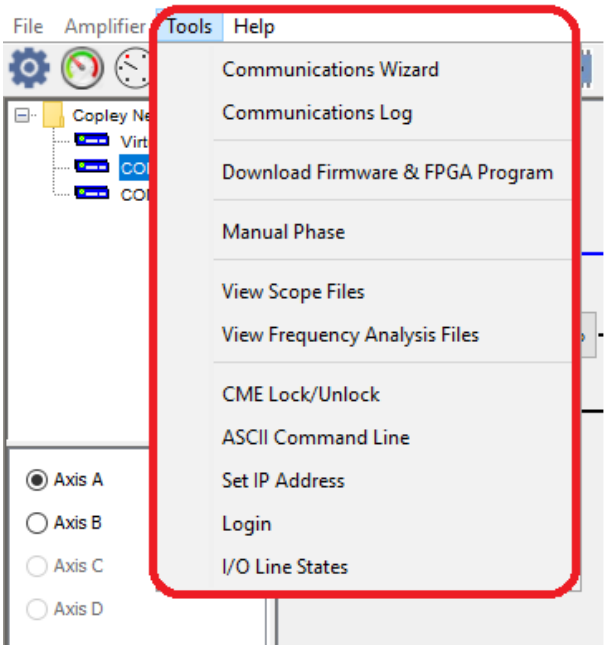
Amplifier Menu



Amplifier Menu Options

Option	For more information, see the Sections below:
Setup	Setup and Tuning
Control Panel	Control Panel
Auto Phase	Motor Phasing
Scope	Scope
Frequency Analysis	Frequency Analysis
Error Log	Error Log
Amplifier Properties	Amplifier Properties
Network Configuration	Network Configuration
Rename	Rename a Drive
Gain Scheduling	Gain Scheduling
Corrections Table	Corrections Table

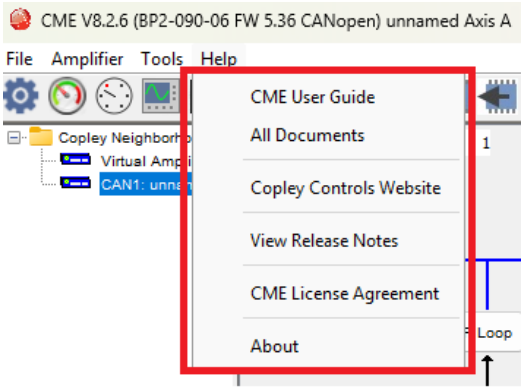
Tools Menu



Tools Menu Options

Selection	For More Information, see the Sections below.
Communications Wizard	Communications Wizard
Communications Log	Communications Log
Download Firmware & FPGA Program	Firmware Download
Manual Phase	Manual Phase
View Scope Files	Scope Trace Files
View Frequency Analysis Files	View Frequency Analysis Files
CME Lock/Unlock	Lock/Unlock CME
ASCII Command Line	Copley ASCII Interface
Set IP Address	Set IP Address
Login	Login
I/O Line States	I/O Line States

Help Menu



Help Menu Options

Selection	Description
CME User Guide	Opens this manual.
All Documents	Opens the Doc folder in the CME installation folder (typically c://Program Files/Copley Motion/CME2/Doc). This folder contains all the related documents that are installed with CME.
Copley Controls Website	Opens the default web browser with pages from Copley Controls' website.
View Release Notes	Opens the latest CME release notes in a text viewer.
CME License Agreement	Opens the CME End User License Agreement.
About	Displays the CME version information.

3.7.2 Tool Bar

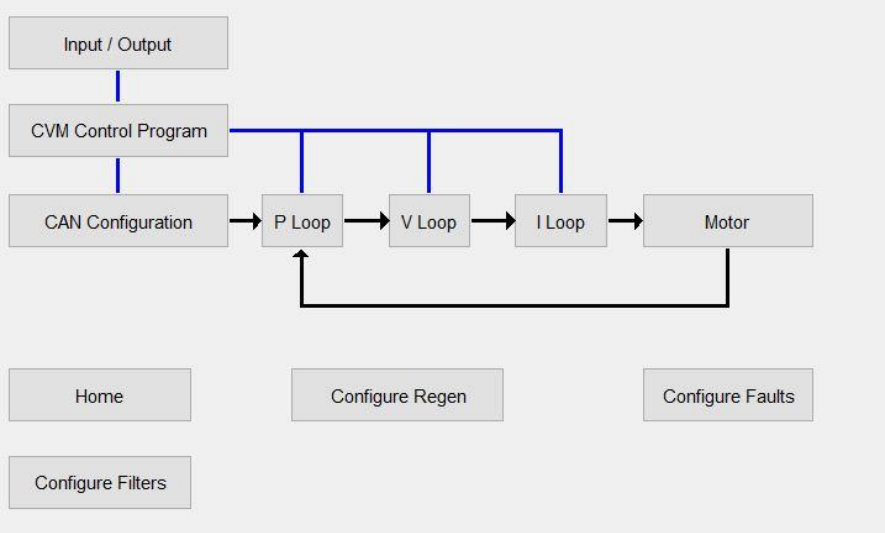
The following table lists the Tool Bar icons, names, and links to Sections.

Icon	Name	For More Information, see the following sections.
	Setup	Setup
	Control Panel	Control Panel
	Auto Phase	Motor Phasing
	Scope	Scope
	Frequency Analysis	Frequency Analysis
	Error Log	Error Log
	Amplifier Properties	Amplifier Properties
	Save to disk	Data Management Tools
	Restore from disk	
	Save to flash	

Icon	Name	For More Information, see the following sections.
	Restore from flash	

3.7.3 Functional Diagram

The functional diagram, shown below, provides access to most of the screens used to configure a drive. It also indicates the flow of control from input, across all active control loops, to motor. Only those control loop buttons that are appropriate to the drive and operational mode appear on the diagram.



Functional Diagram

Button	For More Information, see the following sections.
Input/Output	Input/Output
CVM Control Program	Copley Indexer Program User's Guide.
CAN Configuration	CAN Configuration
Input Command	Command Inputs
P Loop	P Loop
V Loop	V Loop
I Loop	I Loop
Motor	Motor
Home	Homing
Configure Regen	Regen Resistor Configuration
Configure Faults	Fault
Configure Filters	Filters
Encoder Correction	Encoder Correction
Stepper Drive with Encoder only	Stepper Drive
Detent	Detent Compensation Gain
Position Limits	Position Limits (Stepper Drive)

3.7.4 CAN Information and Status Bar

3.7.4.1 CAN Information

The Main screen displays the basic CAN information.

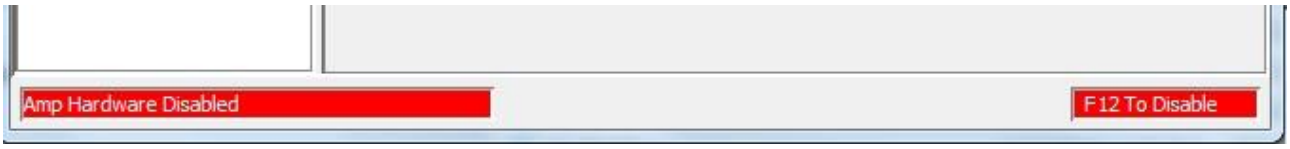
The example below shows the CAN information.



The Address field shows the drive's present CAN address. For more information, see Network Configuration. When the Position Loop Input is set to CAN, the State field shows the state of the drive's CANopen state machine. For more information, see Copley Control's CANopen Programmer's Manual).

3.7.4.2 Status Bar

The status bar describes the drive control status as shown below. It also includes a reminder that indicates if the F12 function key is pressed while CME is running, it disables the drive.



4 DRIVE SETUP

4.1 Setup Procedure

4.1.1 Warnings and Notes

NOTE: To software disable the drive at any time while running CME, press the **F12** function key. Also, the drive's enable input can be used to disable the drive.

 **DANGER**	**DANGER: Hazardous voltages.**
	Exercise caution when installing and adjusting.
	Do not make connections to the motor or the drive with power applied.
	Risk of unexpected or uncontrolled motion with CME in CAN mode.
	CME can be used while the drive is under CAN or EtherCAT control. However, some extreme changes made with CME could cause unexpected or uncontrolled motion. **Failure to heed these warnings can cause equipment damage, injury, or death.**
 **WARNING**	**Spinning motor with power off may damage drive.**
	Do not spin motors with power OFF. Voltages generated by a motor can damage a drive. **Failure to heed this warning can cause equipment damage.**

4.1.2 CME Setup Steps

Setup

1. To prepare for the CME setup, do the following.
   a. Understand the procedure's Warnings and Notes.
   b. Verify that the drive power is **OFF**.
   c. Verify the wiring and the connections.
   d. Make sure the motor is securely fastened with no load connected.
   e. Apply power to the drive.
      - For AC drives, apply 24V only. OR
      - For DC drives, apply AUX HV only.
2. Start CME and enter the Setup parameters.
3. To start CME, from the Desktop, double-click the CME icon.
4. If necessary, connect to a drive from the list in the Copley Neighborhood Tree.
5. If the **Setup** screen does not appear, click the **Setup** button.
6. In most cases, click **Change Settings** button to change the Setup Settings.
   Then either return to Step 2 to enter the Setup parameters or do the following:
   a) Click the **Change Settings** button to change the system settings.
   b) If the settings were previously saved to a file, they can be loaded using either the **Load ccx File** button or the **Load ccd File** button, displayed to the right of the **Change Settings** button.
7. Enter Motor parameters and calculate. See the Section: Motor Data.
8. Configure the Digital I/O. See the Section: Digital I/O.
9. Configure the command input. See the Section: Command Inputs.

a. Based on the command source settings in the **Setup** screen, one of the following buttons will appear in the main screen.



Click the appropriate button to configure the drive's command input.

NOTE: If the drive is to run CVM programs or run in Camming mode, see the relevant documents.

10. After setting the command input parameters, Click **Close**.

Configure:

11. Configure Homing. See the Section: Homing.
12. Configure an optional regen resistor. See the Section: Regen Resistor Configuration.
13. Configure faults. See the Section: Faults.
14. Phase and jog the motor. See the Section: Auto Phase.

Tune:

15. Tune the control loops. See the following Sections:
    a. Tune Control Loop I (Current).
    b. Tune Control Loop V (Velocity).
    c. Tune Control Loop P (Position).
16. If out tuning a stepper drive in Stepper mode, do the following:
    a. Set Position Limits in Stepper Mode. See the Section: Position Limits (Stepper Drive).
    b. If the Encoder Correction is used, see the Section: Encoder Correction.
    c. Tune Detent Compensation Gain.

Test:

17. Test with the load attached.
    a. On the CME Main screen, click **Save to Flash**.
    b. Remove the drive power.
    c. Attach the load.
    d. Reconnect the drive power.
    e. If necessary, re-tune the velocity and position loops.
    f. On the CME Main screen, click **Save to Flash**.
    g. On the CME Main screen, click **Save to Disk** (for backup or duplication).
    h. The drive tuning procedure is complete.

NOTE: To copy the results of this setup to other drives, see the Sections: Drive Configuration or Copy Drive Data.

5 SETUP

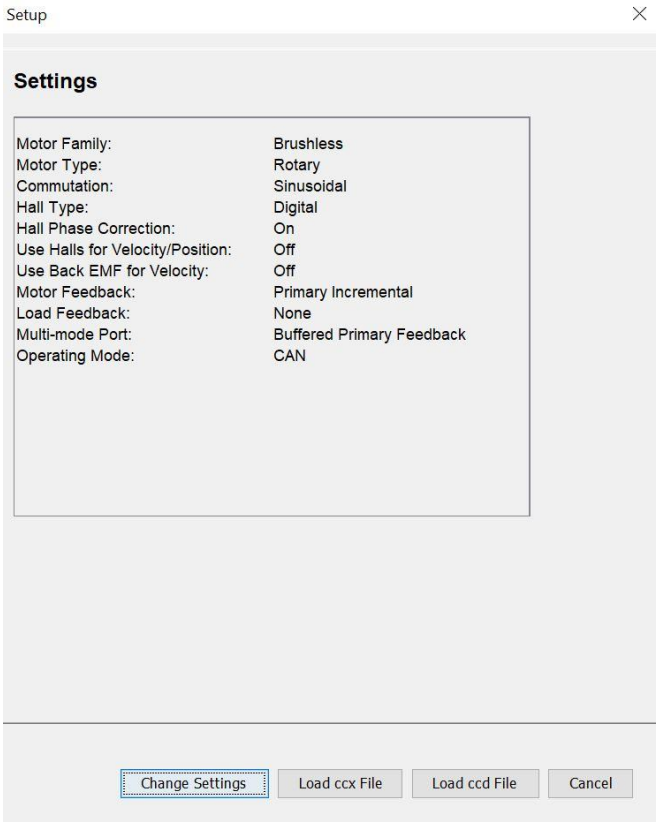
5.1 Overview

The Setup Wizard is used to set up the parameters that define the fundamental characteristics of the system. This wizard is used to setup the motor, feedback and operating mode. The setup can be done in the following ways:

- manually change the settings.
- load the settings from a ccx file.
- load the settings from a ccd file.

Each of these methods are explained in this section.

1. On the Main screen, click the **Setup** button on the toolbar.



Setup (Settings Option) Screen

2. Review the settings.
3. Choose any of the following options:
   - Click **Change Settings** to manually change the setup.
     OR
   - If you have a .ccx file, see the Section: Copy Drive Data.
     OR
   - If you have a .ccd file, see the Section: Copy Drive Data.
4. To accept the displayed settings, click **Cancel**.

5.2 Feedback Notes

5.2.1 Encoder and Resolver Support

Some Copley Controls drives are offered in multiple versions to support different types of Encoder or Resolver Feedback. Some encoder versions support the following encoders:

- Digital Quadrature Encoders
- Analog Sin/Cos Encoders
- Both encoder types

Encoder versions normally require Halls for the commutation of brushless motors. The Resolver versions support standard, single and multiple speed, transmit-type resolvers.

Due to the introduction of the Copley Serial Resolver (CSR), various non-resolver versions of Copley Controls drives can now support resolver feedback. This feature is allowed on ARM and FPGA-based Copley Controls drives that support BiSS/SSI encoders and may require either ARM Firmware 1.80 or FPGA Firmware 4.50.

For example, IES supports BiSS, SSI, CSR, and Incremental.

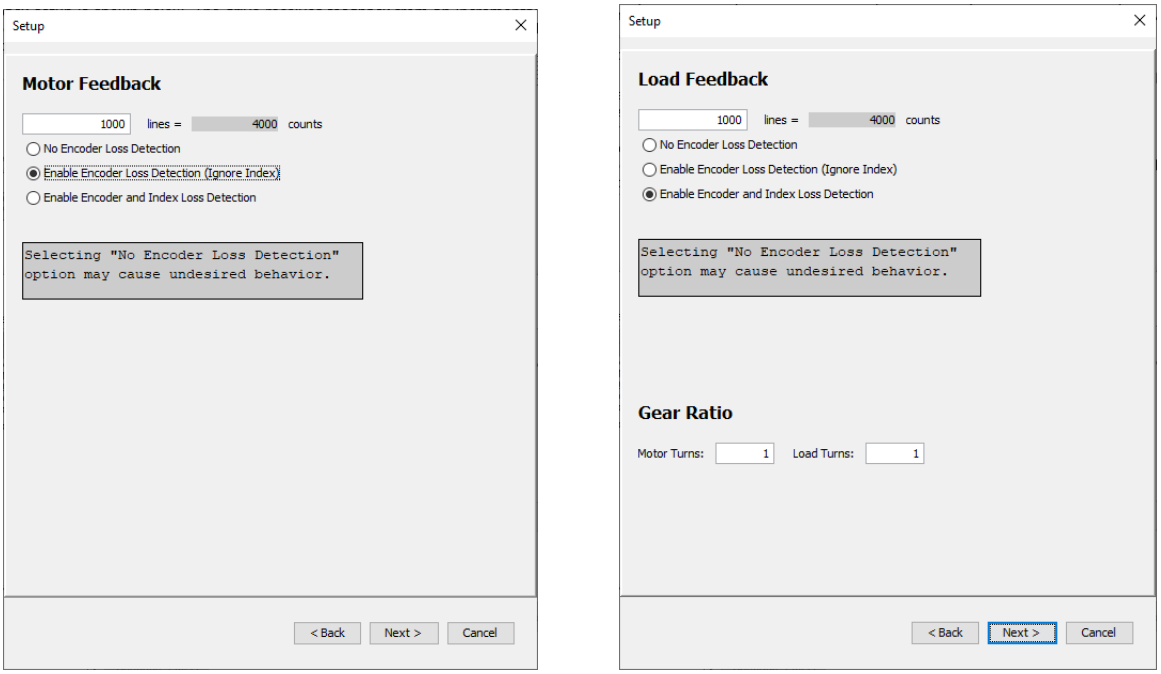
5.2.2 Dual Feedback

Some Copley Controls drives can receive position feedback from sensors on the motor, the load, or both, through the Primary Feedback channel, a Secondary Feedback channel (multi-mode port) or both. (Some drives can also operate in certain modes without encoders or resolvers).

A drive configured with a multi-mode port can do the following:

- 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.

A dual-feedback setup is shown below. The drive receives feedback from an incremental motor encoder through the primary feedback channel. Position (load) encoder feedback comes through the multi-mode port. The ratio of motor turns to position encoder turns is 1 to 1.

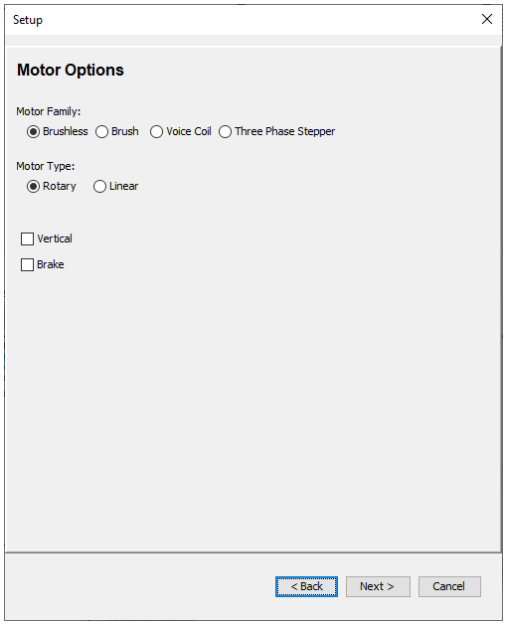


Motor and Load Feedback Screens

5.3 Change Settings

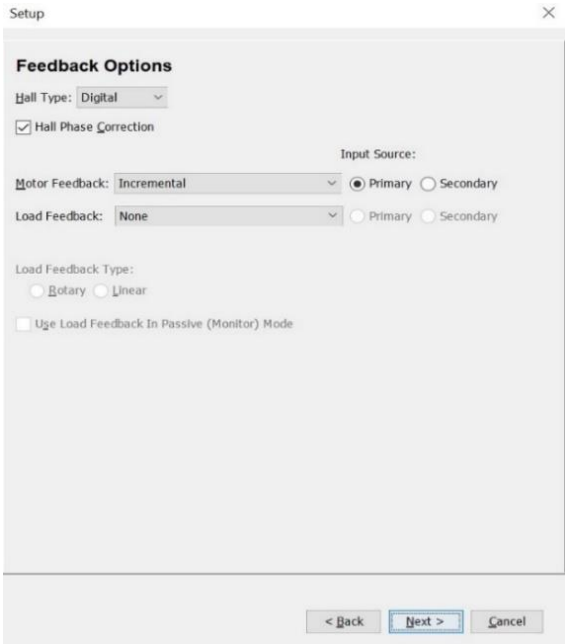
1. On the Setup screen, click **Change Settings** button to manually change all the Setup settings.
   Use the **<Back** and **Next>** buttons to navigate between screens. Screen details vary depending on the drive model and the mode selection.
2. Set the Motor Options.

   NOTE: Three Phase Stepper mode is only available on FPGA 5.0 or greater and ARM 2.12 or greater firmware.



Motor Options Screen

3. Click **Next>** to go to the Feedback Options step.

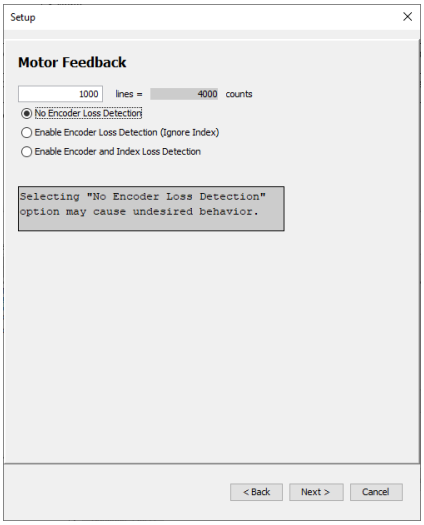


Feedback Options Screen

Setting	Description
Hall Type	Select Hall type: None, Digital, or Analog Hall effect sensors are a common method of determining rotor position in brushless DC (BLDC) motors.
Hall Phase Correction	This Setting will enable the error checking between Hall sensors and encoder Phase angle.
Motor Feedback	Select the type and source of the motor feedback. NOTE: The feedback options supported by the drives may vary. See the drive data sheet for more information. • None: No motor encoder. • Incremental: Incremental encoder on primary feedback connector. • Tertiary Incremental: Incremental encoder using digital inputs as encoder inputs. • Resolver: Resolver (–R) version of a Copley Controls drive on primary feedback connector. • Copley Serial Resolver: When the Copley Serial Resolver is installed, it allows standard versions of Copley Controls drives to use resolver feedback. • BiSS (B & C) • SSI • Analog Sin/Cos: Analog encoder on primary feedback connector. • Low Frequency Analog • Analog Tachometer Input[RA2] [RA3] • Analog Potentiometer • EnDat • Absolute A • Hiperface Sin/Cos • Panasonic Absolute A Format • Panasonic Incremental A Format • Sanyo Denki Absolute A • Sanyo Denki Wire Saving Incremental • Hiwin Wire Saving Incremental • Tamagawa Absolute A • Tamagawa TS5643 • Trio (Reagles) Absolute A
*Load Feedback (See Note 1)	Select the type and source of the Load Feedback. NOTE: See the above list for Load Feedback types.
*Load Feedback Type (See Note 1)	Select the type of Load Feedback: • Rotary • Linear (See the above NOTE).
*Use Load Feedback in Passive (Monitor) Mode (See Note 1)	When this is checked, the position of the load encoder will be reported by the passive load position variable, but it will not be used to control the position of the axis. (See the above NOTE).
NOTE 1: Feedback options may differ between drives. For more information on Load Feedback options, refer to the above Load Feedback types.	

Setting	Description
Stepper Drives Only	
Motor Encoder	Select the encoder type: • None • Incremental • Absolute types
Run in Servo Mode	(Requires encoder) Drive operates as a true, closed loop, servo drive controlling a stepper motor.
Enable Feedback Correction	(Requires encoder) Drive runs as a stepper drive; encoder feedback is used to correct positional errors. See the Section: Encoder Correction.

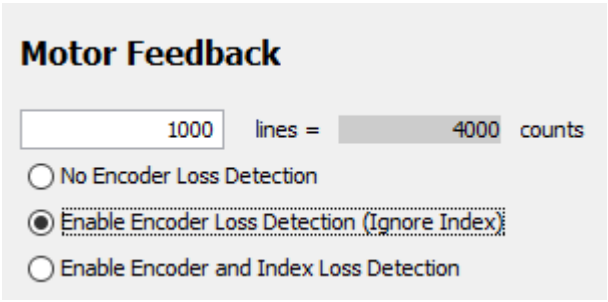
4. Click **Next>** to go to the Motor Options step.

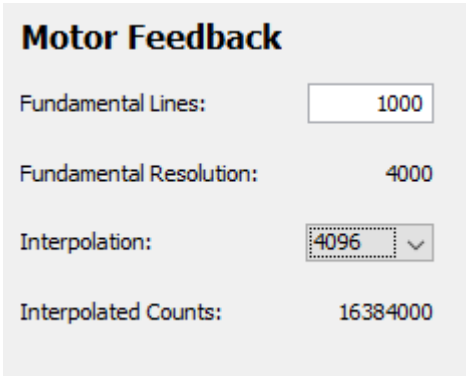
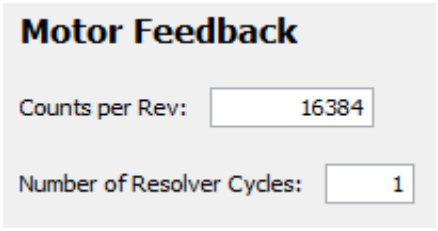
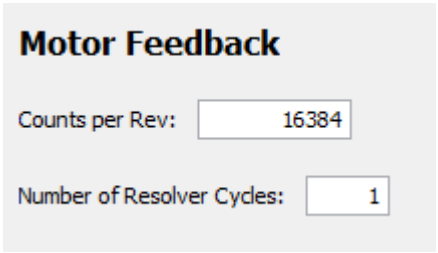
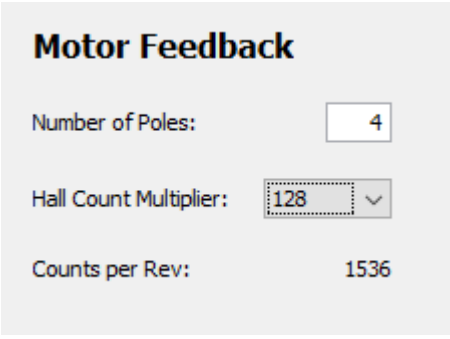


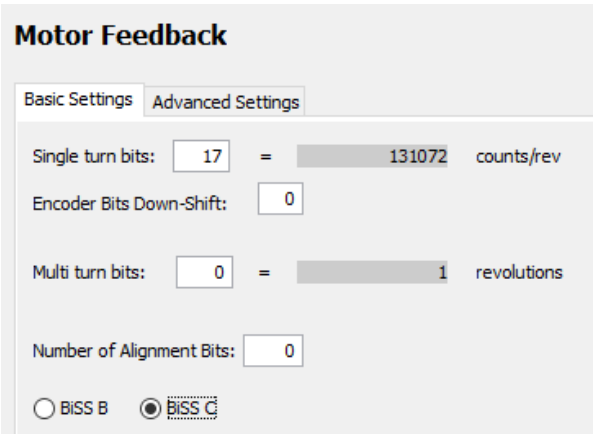
Motor Feedback Screen

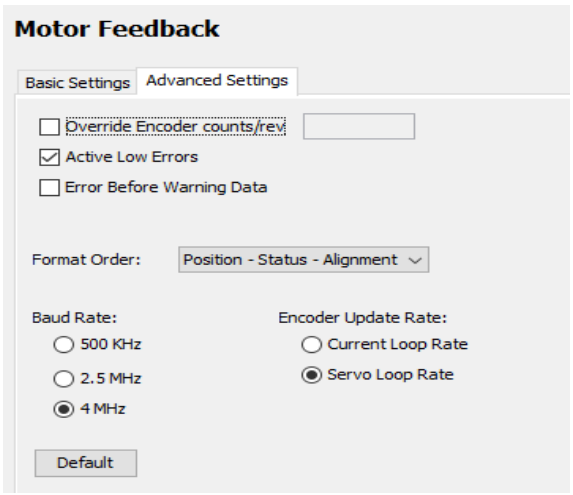
5.3.1 Feedback Parameters, Rotary

For detailed information on the serial encoders, refer to the Serial Encoder Guide.

Feedback Type	Parameters/Actions
Incremental	In the Motor Encoder **lines** or Position Encoder **lines** field, enter the number of encoder lines (see the Encoder or Motor Datasheet). As indicated by the **counts** field, the number of encoder counts per revolution is equal to 4 x the number of lines. Enable Encoder Loss Detection and/or Index Loss detection if desired. 

Feedback Type	Parameters/Actions
Analog	In the **Fundamental Lines** field, enter the number of fundamental encoder lines (see the Encoder or Motor Datasheet). 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. 
Copley Serial Resolver	Optionally, modify the feedback resolution by changing the value in **Counts Per Rev**. Default: 16384. 
Halls	With the drive set to **Use Halls for Velocity/Position**, optionally increase the counts per rev ratio by incrementing the **Halls Count Multiplier**. 

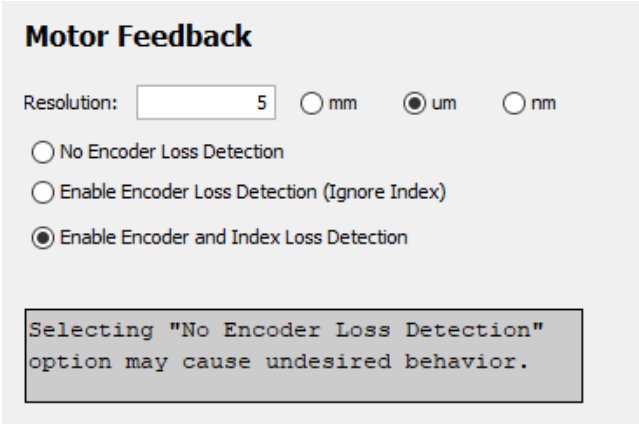
<table>
<tr><th>Feedback Type</th><th>Parameters/Actions</th></tr>
<tr><td>BiSS Basic Settings</td><td>Basic Settings screen


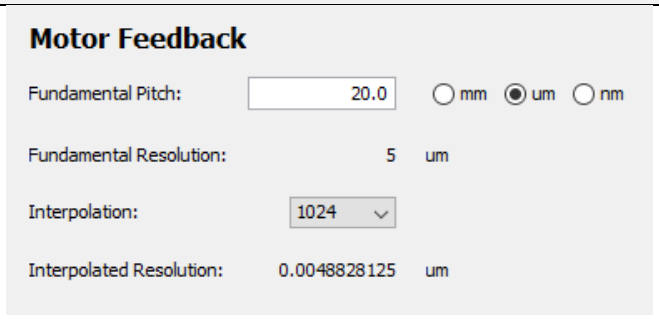
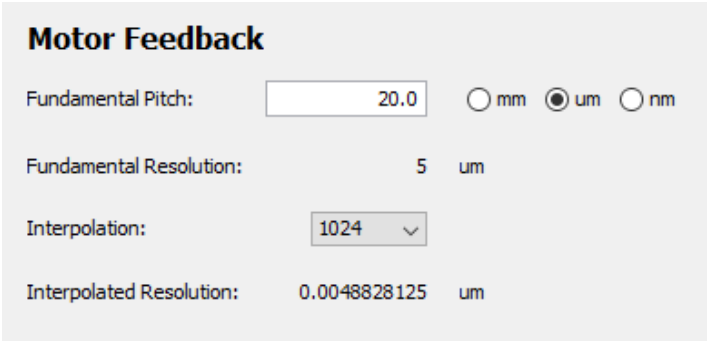
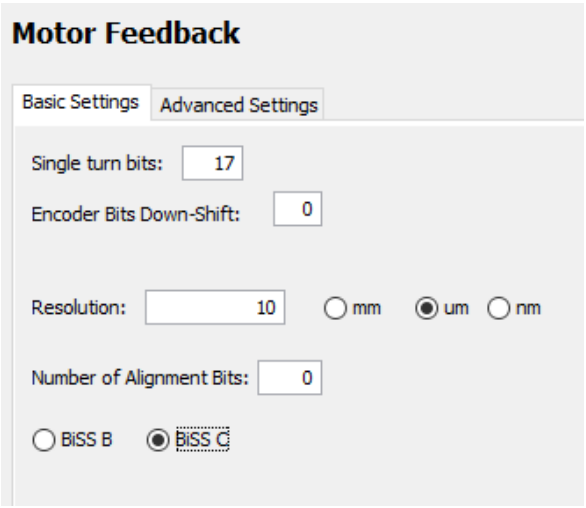
<table>
<tr><th>Setting</th><th>Descriptions</th></tr>
<tr><td>Single Turn Bits:</td><td>Sets the number of bits for a single turn of the feedback. This defines the resolution in counts/rev.</td></tr>
<tr><td>Encoder Bits Down-Shift</td><td>It reduces the number of bits for a single turn. Reduces the counts/rev. The resolution will be decreased accordingly. This is required if using excessive bits and limited by INT32 velocity.</td></tr>
<tr><td>Multi Turn Bits:</td><td>Set the number of multi turn bits used to count multiple turns.</td></tr>
<tr><td>Number of Alignment Bits:</td><td>Set the number of alignment bits if position data has more bits than defined by resolution. Normally, these bits don’t change and they are only used to align to bits that change.</td></tr>
<tr><td>BiSS B</td><td>Legacy Biss Specification
Select the BiSS specification used by the motor.</td></tr>
<tr><td>BiSS C</td><td>Latest Biss Specification</td></tr>
</table></td></tr>
<tr><td>BiSS Advanced Settings</td><td>Advanced Settings screen

</td></tr>
</table>

Feedback Type	Parameters/Actions	
	Setting	**Description**
	Override Encoder counts/rev	Use this setting to overwrite the resolution of the motor. This setting is used when the actual resolution is not in normal powers of 2. Example: 2^n bits counts/rev.
	Active Low Errors	Set the default error bit active state to low instead of high. Invert if misinterpretation of BiSS set them high when active.
	Error Before Warning Data	Default Error bits before warning.
	Format Order:	The default order of bits in encoder data message is Position, Status, then Alignment. To reorder the default order, use this setting. Do not use at the current loop rate if not in the current mode.
	Baud Rate:	Rate of clock to get data. Use this setting to adjust the rate of the clock getting data. It is recommended to only use the 500 KHz option for ARM-based drives with a long cable.
	Encoder Update Rate:	Select the applicable update rate for the drive's mode of operation. For Position and Velocity modes, the typical update rate is the servo loop update rate. NOTE: The encoder should only be running on the current loop update rate when running in the current mode.

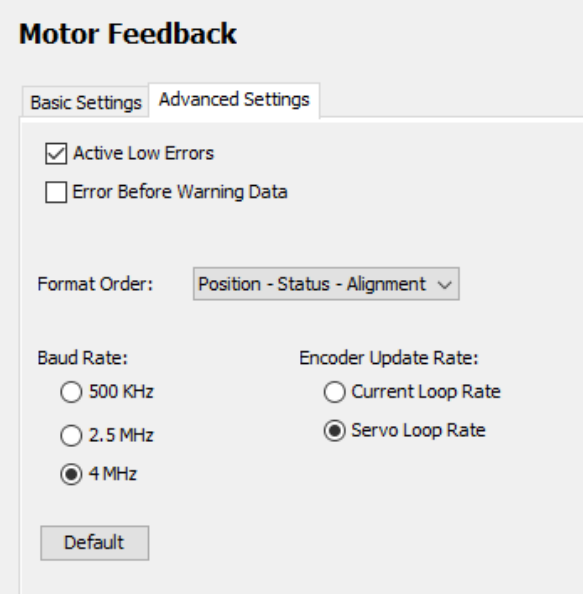
5.3.2 Feedback Parameters, Linear

For detailed information on serial encoders, refer to the Serial Encoder Guide.

Feedback Type	Parameters/Actions
Incremental	Choose units and then enter the **Encoder Resolution** (see the Encoder or Motor Datasheet). Enable Encoder Loss Detection and/or Index Loss detection if desired. 
Analog	In the **Fundamental Pitch**: field, enter the Fundamental Pitch (distance between encoder lines; see the Encoder or Motor Datasheet). As indicated by the **Fundamental Resolution** field, the Fundamental Pitch divided by four gives Fundamental Resolution. The Interpolated Resolution is the dividend of Fundamental Resolution value/Interpolation value. Optionally, modify the Interpolated Resolution by changing the **Interpolation** value.

<table>
<tr><th>Feedback Type</th><th>Parameters/Actions</th></tr>
<tr><td></td><td>
</td></tr>
<tr><td>Low Frequency Analog</td><td>This Feedback Type is normally used with ServoTube, the Pole Pitch is measured by the distance between poles in a pole 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 micrometers. Optionally, modify the resolution by changing the Counts/Pole value. Click Restore Default to restore the default Counts/Pole.

</td></tr>
<tr><td>BiSS-
Basic Settings</td><td>Basic Settings screen


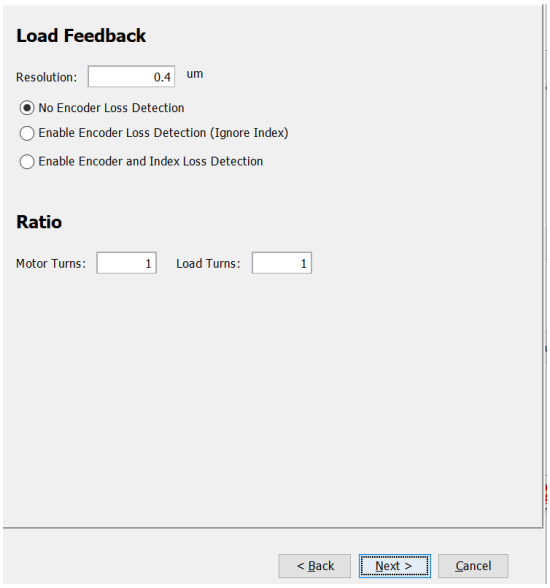
<table>
<tr><th>Setting</th><th>Descriptions</th></tr>
<tr><td>Single Turn Bits:</td><td>Set the number of bits for a single turn of the feedback. This defines the resolution in counts/rev.</td></tr>
<tr><td>Encoder Bits Down-Shift</td><td>It reduces the number of bits for a single turn. Reduces the counts/rev. The resolution will be decreased accordingly. This is required if using excessive bits and limited by INT32 velocity.</td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Feedback Type</th><th>Parameters/Actions</th></tr>
<tr><td></td><td>
<table>
<tr><td>Resolution</td><td>Set the resolution in the field and select the linear units to use (mm, um, nm).
The units of the final encoder resolution are defined in encoder units per count. For example, if the encoder units is 10 um, then the resolution is in 10 um/count.</td></tr>
<tr><td>Number of Alignment Bits:</td><td>Set the number of alignment bits if position data has more bits than defined by resolution. Normally, these bits don’t change and they are only used to align to bits that change.</td></tr>
<tr><td>BiSS B</td><td>Legacy Biss Specification
Select the BiSS specification used by the motor.</td></tr>
<tr><td>BiSS C</td><td>Latest Biss Specification</td></tr>
</table>
</td></tr>
<tr><td>BiSS-Advanced Settings</td><td>Advanced Settings screen
For detailed information on the serial encoders, refer to the Serial Encoder Guide.


<table>
<tr><th>Setting</th><th>Description</th></tr>
<tr><td>Active Low Errors</td><td>Set the default error bit active state to low instead of high.</td></tr>
<tr><td>Error Before Warning Data</td><td>By default, the drive reads the error bits after the warning data. To change the default, use this setting.</td></tr>
<tr><td>Format Order:</td><td>The default order of bits in encoder data message is Position, Status, then Alignment. To reorder the default order, use this setting.</td></tr>
<tr><td>Baud Rate:</td><td>Rate of clock to get data.
Use this setting to adjust the rate of the clock getting data. It is recommended to only use the 500 KHz option for ARM-based drives with a long cable.</td></tr>
<tr><td>Encoder Update Rate:</td><td>Select the applicable update rate for the drive’s mode of operation.
For Position and Velocity modes, the typical update rate is the Servo Loop update rate.
NOTE: The encoder should only be running on the current loop update rate when it is running in the current mode.</td></tr>
</table>
</td></tr>
</table>

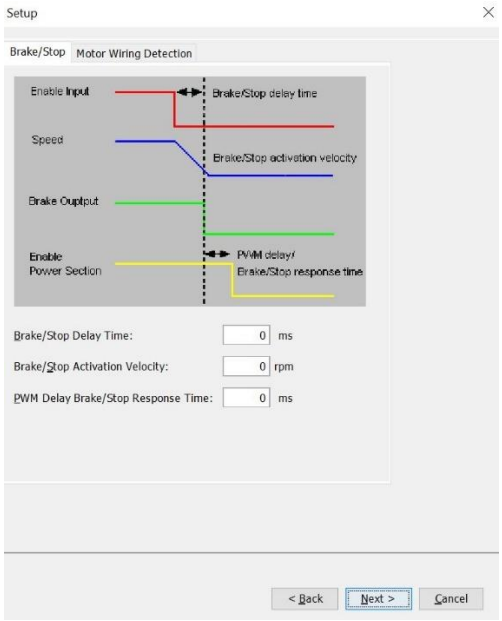
5. Click **Next** to go to the **Load Feedback** step.

   NOTE: In Dual Encoder Systems, the ratio is used to represent the ratio of the motor encoder turns to the position encoder turns.



Load Feedback Screen

6. Click **Next** to go to the **Brake/Stop** step.



Brake/Stop Screen

5.3.3 Disabling the Drive

Many control systems employ a brake to hold the axis when the drive is disabled. On the Brake-Equipped Systems, disabling the drive by hardware or software command starts the following sequence of events.

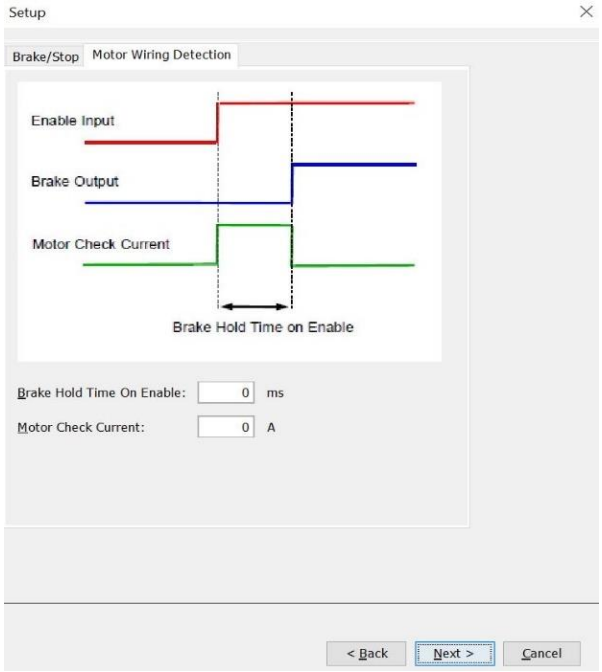
1. The motor begins to decelerate (at Abort Deceleration rate in Position mode or Fast Stop Ramp rate in Velocity mode). At the same time, the Brake/Stop Delay Time count begins. This event allows the drive to slow the motor before applying the brake.
2. When the response time has passed, the drive's output stages are disabled. This delay ensures the brake has time to lock in before disabling the power section.

Systems that do not employ brakes may still come to a controlled stop. On such systems, disabling the drive by a hardware or software command initiates the motor deceleration (at Abort Deceleration rate in Position mode or Fast Stop Ramp rate in Velocity mode). After the Brake/Stop Delay Time and any PWM Delay Response Time, the drive will be disabled. This allows the drive to bring the motor to a controlled stop before disabling the drive.

NOTE: This feature is not available when the drive is configured for Current mode. In this mode, the drive output turns off and the brake output activates immediately when the disabled command is received.

Parameter	Description
Brake/Stop Delay Time	Time taken to stop the system. Range of accepted values: 0 to 10,000 mS
Brake/Stop Activation Velocity	Typical values are low to protect the brake mechanism (a few rpm). "0" disables velocity-based brake activation.
PWM Delay Brake/Stop Response Time	Time delay taken for the brake to engage after brake output is activated. Range of accepted values: 0 to 10,000 mS

7. Click on the **Motor Wiring Detection** tab.



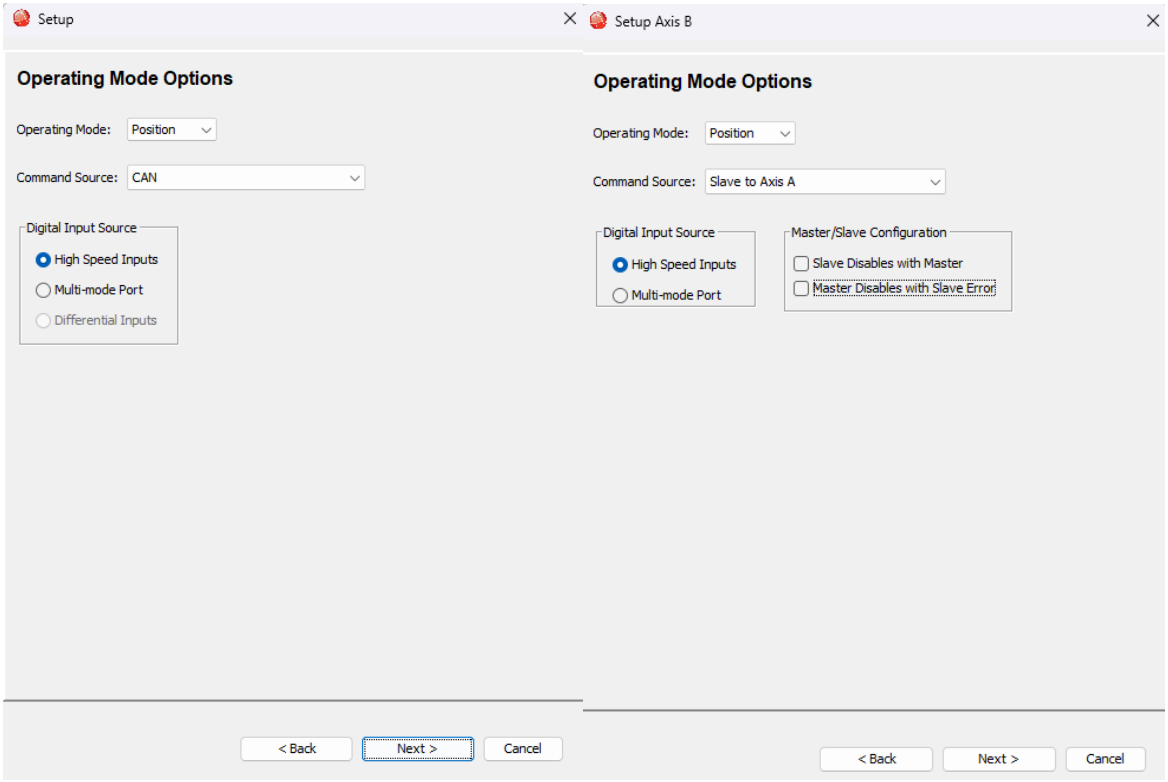
Setup (Motor Wiring Detection) Screen

On some drives, the drive can check for a disconnected motor. Upon enable, the drive will apply a current to the motor windings, while keeping the brake engaged for the brake hold time.

- If the current vector cannot be applied, then a motor disconnected fault will occur, and the brake will not be released.
- If the motor is connected, the brake will be released after the brake hold time expires.

Parameter	Description
Brake Hold Time on Enable	The time during which the drive is enabled, but the brake is engaged, and the current is applied to the motor windings.
Motor Check Current	The amount of current to apply to the motor windings.

8. Click **Next** to access the **Operating Mode Options**.

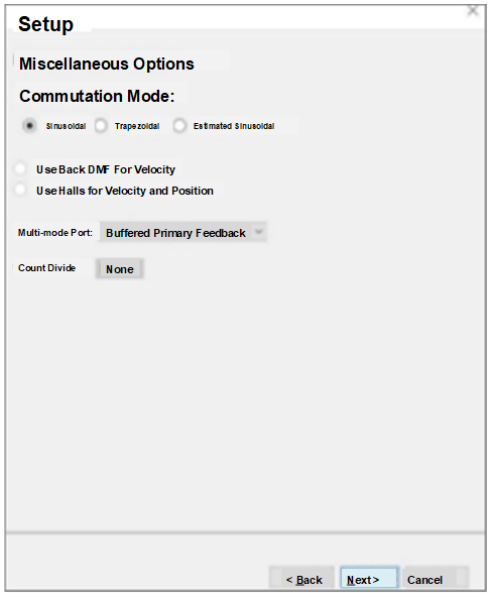


Operating Mode Options Screen

Setting	Description
Operating Mode	Choose the mode of operation: Current, Velocity, or Position. See the Section: Control Loops.
Command Source	Choose the command input source (see Command Inputs): • Analog Command (Current & Velocity Modes): Analog voltage provides command input. • PWM command (Current and Velocity modes): Digital pulse-width modulated signal provides command input. Command input is provided via the chosen Input Source (described by the inputs listed below). • Function Generator (Current, Velocity & Position modes): Internal function generator provides command input. • Software Programmed (Current, Velocity & Position modes): The drive is controlled by software commands from either the Copley Virtual Machine (CVM) or an external source. See Copley Indexer Program User's Guide or the Copley ASCII Interface Programmer's Guide. • Analog Command Position (Position mode) • Analog Command, Profile Velocity (Position mode) • Digital Input (Position mode): Command input is provided via the chosen Input Source (by the inputs listed below). • CAN or CANopen Over EtherCAT (CoE) (Position mode): Command input is provided over the CANopen or EtherCAT network. See the CANopen Programmer's Guide. • Camming (Position mode): Runs in Camming Mode. See the Copley Camming User Guide. • Slave (Current, Velocity & Position Modes). When set as a "slave", it follows the command source of the master. (Only available in Multi-axis drives).

Setting	Description
Digital Input Source	Choose the input source for PWM or Digital input commands: • Single-ended Inputs: Command input is provided via two of the drive's programmable digital inputs. • Multi-Mode Port: Command input is provided via differential inputs on the drive's multi-mode port. • Differential Inputs: Command is provided via differential inputs. • High Speed Inputs. Command is provided via two of the drive's high-speed inputs.
Master/Slave Configuration	Available when Slave command source is selected. Optional settings for the master and slave configuration. • Slave Disables With Master: If selected, the slave axis will be disabled when the master is disabled. • Master Disables with Slave Error: If selected, an error on the slave axis will disable the master.

9. Set the Miscellaneous Options.



Miscellaneous Options Screen

Setting	Description
Commutation	Commutation is the process of converting the current vector to be 90 degrees to the magnetic vector. Commutation method: includes the following: Trapezoidal, Sinusoidal or Estimated Sinusoidal • Trapezoidal Commutation: By driving the current through the windings of the stator, the magnetic fields are induced on the permanent magnet rotor to apply a force. By energizing the windings in a six-step pattern, the motor will begin to spin. As a result, the current waveforms give a trapezoidal pattern, giving trapezoidal commutation its name. • Sinusoidal Commutation: To make the motor spin smoothly, sinusoidal commutation eliminates hard current switching produced by trapezoidal commutation. This process is done by having a sinusoidal current waveform which spans 180 electrical degrees. This operation optimizes the performance of sinusoidally wound brushless DC (BLDC) motors. • Estimated Sinusoidal Commutation: To smooth the edges of the current waveform produced by trapezoidal commutation, the phase angle will be linearly interpolated to look more sinusoidal.

Setting	Description
Use back EMF for Velocity	If selected, this setting will use the motor's measured back EMF to determine the motor velocity. Recommended only for medium- to high-speed. The accuracy depends on the accuracy of the programmed Back EMF value, and it may be affected by factors such as cable resistance.
Use Halls for Velocity and Position	If selected, this setting will use transitions of the Hall switches to determine the motor velocity and position. Recommended only for medium- to high-speed applications (may run roughly at low speeds).
Multi-Mode Port	Selects the mode for the drive's Multi-Mode Port: ▪ Buffered Primary Feedback- The Multi-Mode Port functions as a buffered digital encoder output based on the digital encoder input. ▪ Differential Input. The Multi-Mode Port functions as a differential command input. ▪ Emulated Motor Feedback- The Multi-Mode Port functions as an emulated digital encoder output based on the motor analog encoder or motor resolver and absolute encoders. Reduce Maximum Output Frequency- Optionally scale the maximum output frequency by 2, 4, or 8.

10. When the changes are complete, click **Finish**. The changes will be saved to **Flash**.

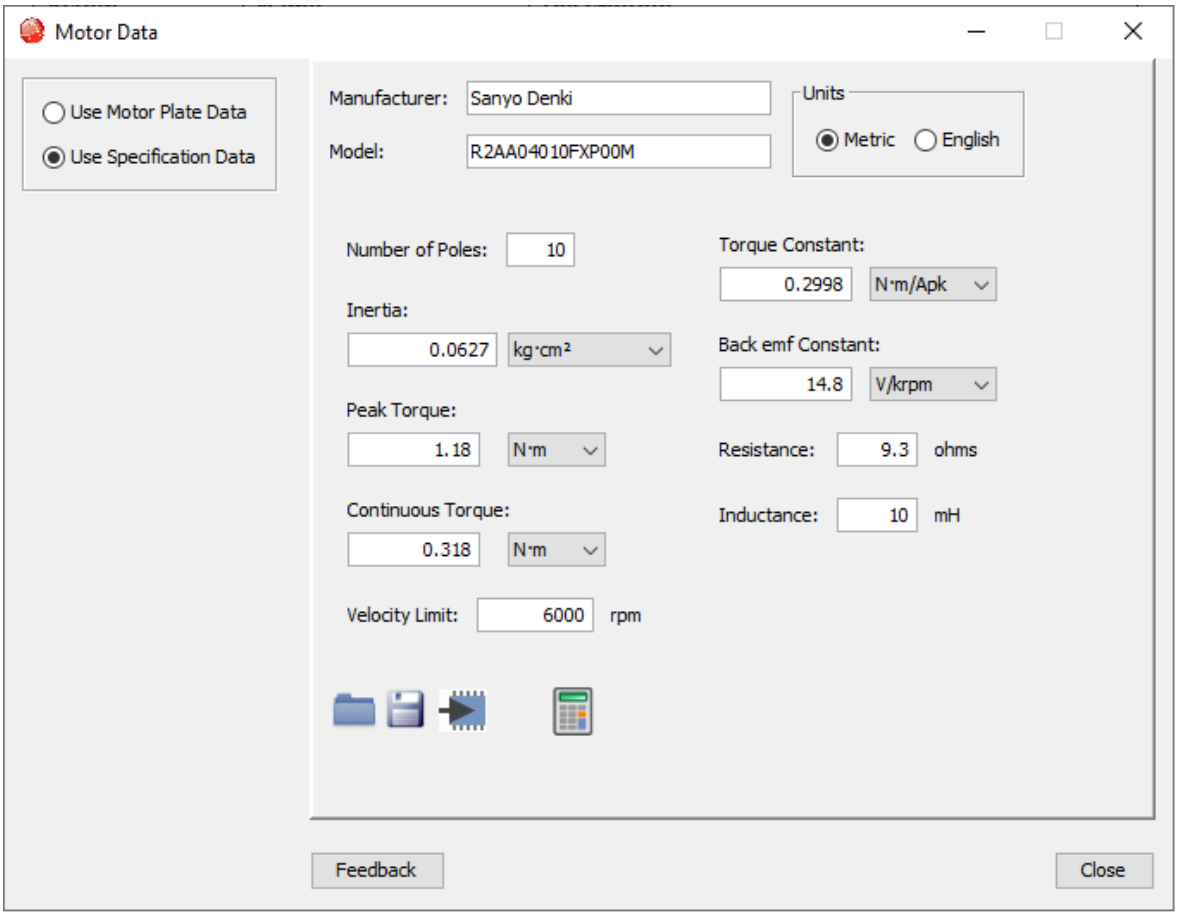
6 MOTOR DATA

6.1 Motor Data Screen Overview

The Motor Data screen is used as the interface for the user to provide the important motor characteristics to CME. It is a crucial step that must be done correctly. If the user does not enter the accurate motor data in this screen, unstable motion or irreparable damage to the motor may result.

6.1.1 Use Specification Data

If accurate, use the motor specification data (i.e. if available, refer to the Motor Manufacturer's Datasheet). Use this screen to enter the required information.



Motor Data (Use Specification Data) Screen

Action	Name	Description
	Save motor data	Saves the motor/feedback/brake settings from the PC to a file with a .ccm name extension.
	Restore motor data	Restores the contents of a .ccm file to the PC.
	Save motor data to flash	Saves the motor/feedback/brake settings from the PC to the drive permanent flash memory.
	Calculate	Calculates the initial tuning and limit values.

6.1.2 Rotary Motor Parameters

Setting	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 4,294 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, verify the motor's pole count using the Data Accuracy Test. 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 CurrentLlimit. Range: 0.0001 to 5,000 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: 0.0001 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 the encoder resolution.
Torque Constant	Relates the motor's input current to torque produced. Sometimes abbreviated as Kt. Range: 0.001 to 1,000 Nm/Apk. Default: 0.001 Nm/Apk.
Back emf Constant	Relates the motor's input voltage to speed. Sometimes abbreviated as Ke. Used for calculating the maximum velocity for a given drive bus voltage. Range: 0.01 to 21,000,000 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 the hardware documentation.
Stepper Drives Only	
Rated Torque	Motor's rated operating torque. Range:0.0001 to 1,000 Nm. Default 0.0001 Nm.
Rated Current	Motor's rated continuous current. Range: 0.01 to 1,000 A. Default 0.01 A."
Basic Step Angle	Fundamental stepper motor step, in degrees. Min: 0.225. Max: 22.5. Default 1.8.
Microsteps/Rev	Number of microsteps per revolution of the motor. Min: 4. Max: 100,000,000. Default 4000.
Full Steps/Rev	This read-only value can be used after entering the Basic Step Angle to cross-check against the Motor Datasheet.

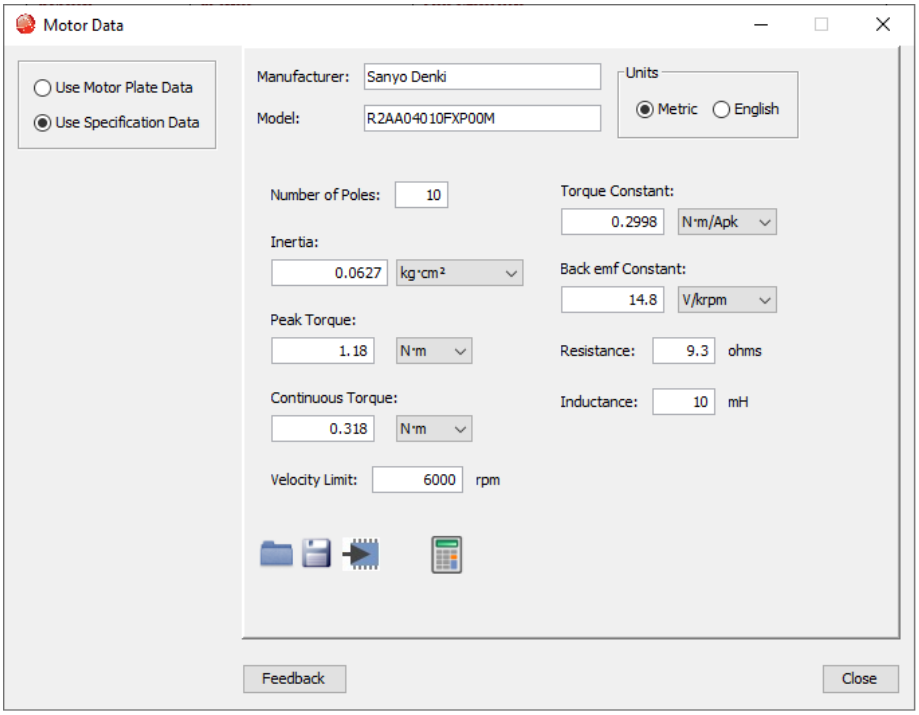
6.1.3 Linear Motor Parameters

Setting	Description
Manufacturer	Motor maker's name. Saved in the motor data file. Choose from the list or enter it manually.
Model Number	Motor model number. Saved in the motor data file. Choose from the list or enter it 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 5,000 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 the encoder resolution.
Force Constant	Relates the motor's input current to force produced. Sometimes abbreviated as Kf. Range: 0.00001 to 2,000 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 drive 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 the hardware documentation.
Magnetic Pole Pair Length	The length of a pair of magnets which equals the distance moved in one electrical cycle of the motor.
Stepper Drives Only	
Rated Force	Motor's rated operating force. Min .001 N. Max 5000 N.
Rated Current	Motor's rated continuous current. Min: 0.01 A. Max 1000 A.
Full Step	Fundamental stepper motor step distance. Min: 0.0001mm. Max: 5000 mm.
Microsteps/ Full Step	Number of microsteps per full step. Min: 1. Max: 100,000,000.

6.1.4 Steps for Using Specification Data

1. To access the Motor Data screen, click the **Motor** button.

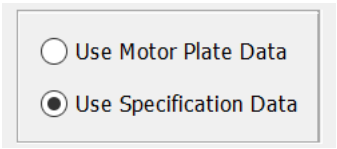
NOTE: The **Feedback** button is used to view or change the motor and/or load feedback settings.



Motor Data (Use Specification Data) Screen

NOTE: The above screenshot reflects the Motor Data Screen layout when using a brushless rotary servo motor. Options chosen for Motor Family and Motor Type in the Setup procedure will affect the type of data that can be entered on this screen (Rotary vs Linear, Brushless vs Stepper, etc.).

2. Choose **Use Specification Data** (See the Section: Use Specification Data).



3. Load data from the file.

   OR

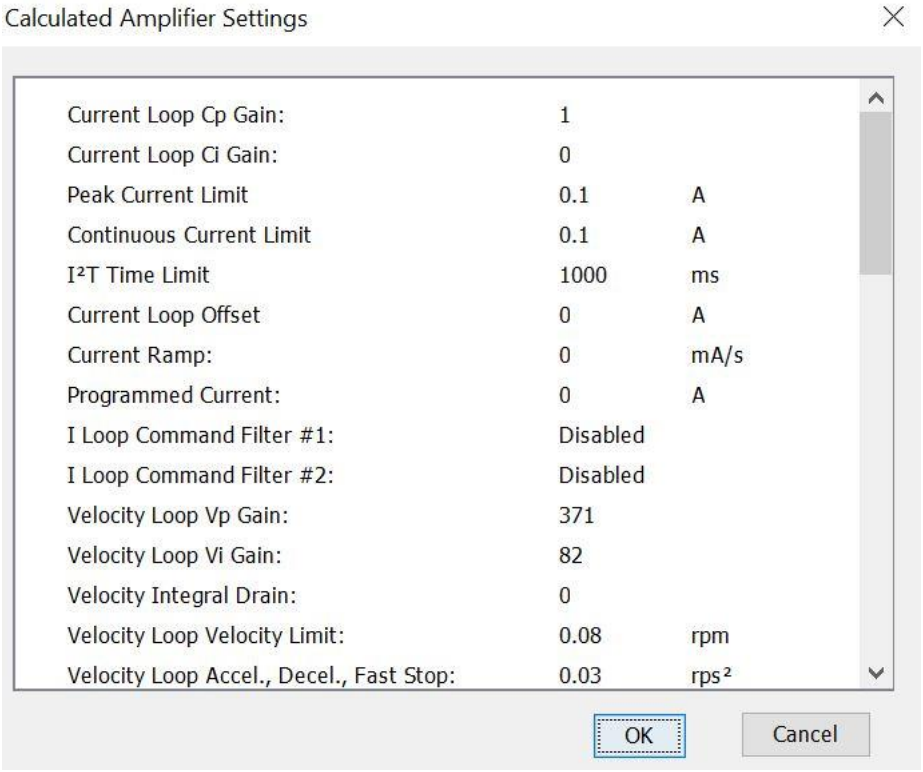
4. Enter the settings manually.
5. Click to calculate the initial gains and limits. (See the Section: Calculate).
6. On the Main screen, click -**Save to Flash**- to avoid losing the calculated data.

6.1.5 Calculate

The Calculate function uses the motor data to calculate initial gains and limits. These values can be modified to fine-tune the drive. To use the function, refer to the following steps.

Warning	**Calculate Function** In this Section, the values represent estimates and would need further tuning and load calculations.

1. Click the **Calculate** button to calculate and display settings.



Calculated Amplifier Settings Screen

2. Verify the peak current limit, continuous current limit, and velocity loop velocity limit.
3. If one or more of these values seems inappropriate, click **Cancel** and check the following:
   - Peak Torque (or Force)
   - Continuous Torque (or Force)
   - Velocity Limit
   - Torque (or Force) Constant

   Correct them if needed.

   See the Sections: Rotary Motor Parameters or Linear Motor Parameters.

   If the Motor values are 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.
4. Save the values into the drive RAM by clicking **OK**.

   NOTE: When loading motor data from a file, if the motor wiring configuration in the motor file does not match the configuration currently stored in the drive, CME prompts for verification on which configuration to use. Select the file configuration by clicking **Yes**. The configuration will be tested as part of Motor Phasing.
5. On the Main screen, click **OK** button to avoid losing the calculated data by saving to **Flash**.

6.2 Motor Plate Data

If accurate, and the motor specification data is not available (i.e., the information is not included on the Motor Manufacturer's Datasheet), use this screen to enter the Motor Plate data. If a Motor Plate exists, it is physically attached to the side of the motor, and it displays the Motor Plate data.

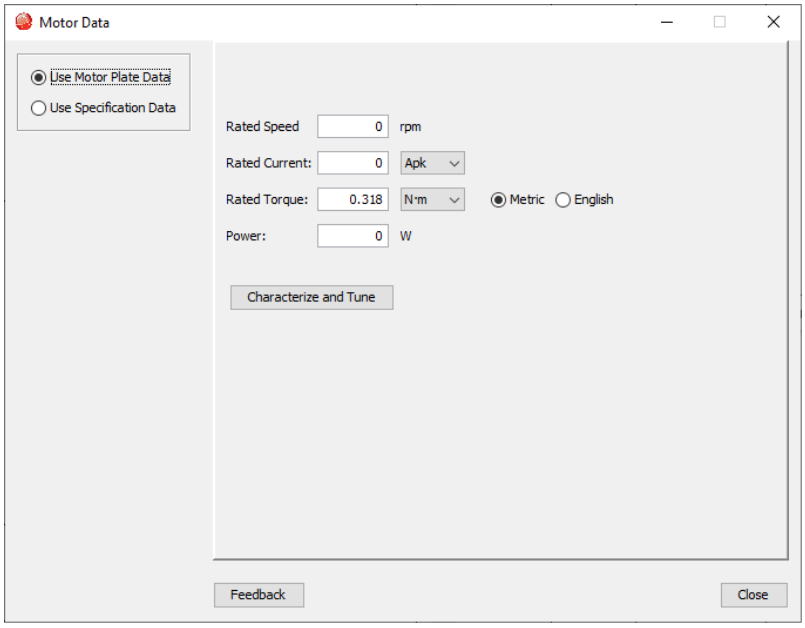
6.2.1 Motor Plate Data Parameters

The following table lists the Motor Plate Data parameters.

Parameter	Description
Rated Speed	Speed of the motor at which it produces its rated (maximum) power, when the specified (rated) voltage is given at its rated Load.
Rated Current	Maximum safe continuous current of the motor.
Rated Torque	Maximum safe continuous torque of the motor.
Power	Continuous safe motor power.

6.2.2 Steps for Using Motor Data

1. On the Motor Data screen, choose the **Use Motor Plate Data** option.



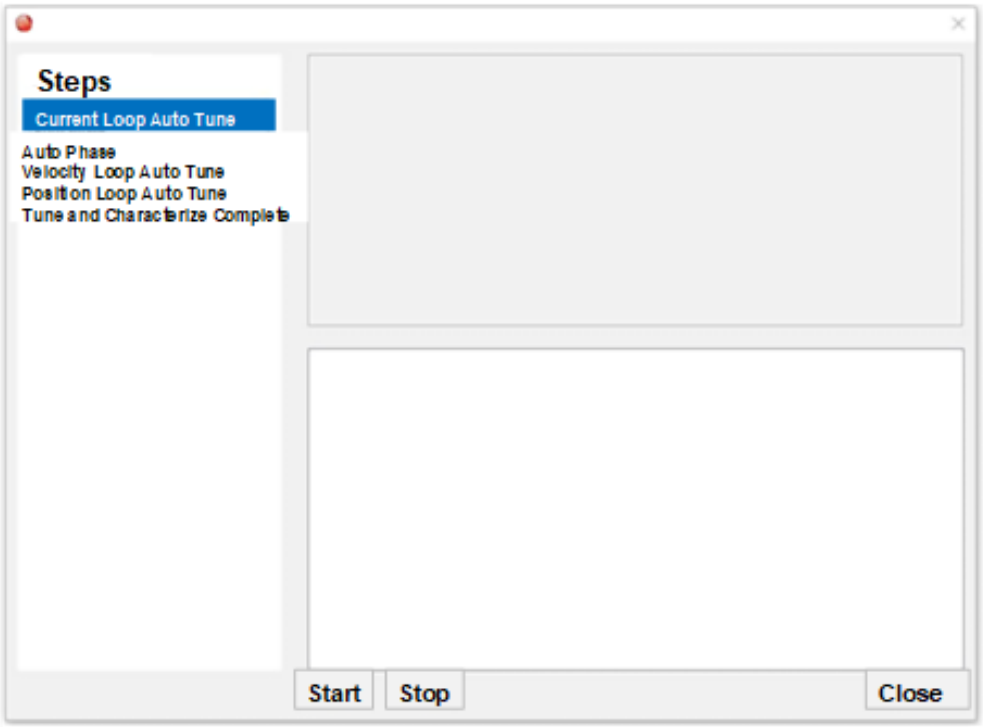
Motor Data (Use Motor Plate Data) Screen

2. In the **Rated Speed** field, enter Rated Speed.
3. In the **Rated Current** field, enter Rated Current.
4. In the **Rated Torque** field, enter Rated Torque from the motor label.

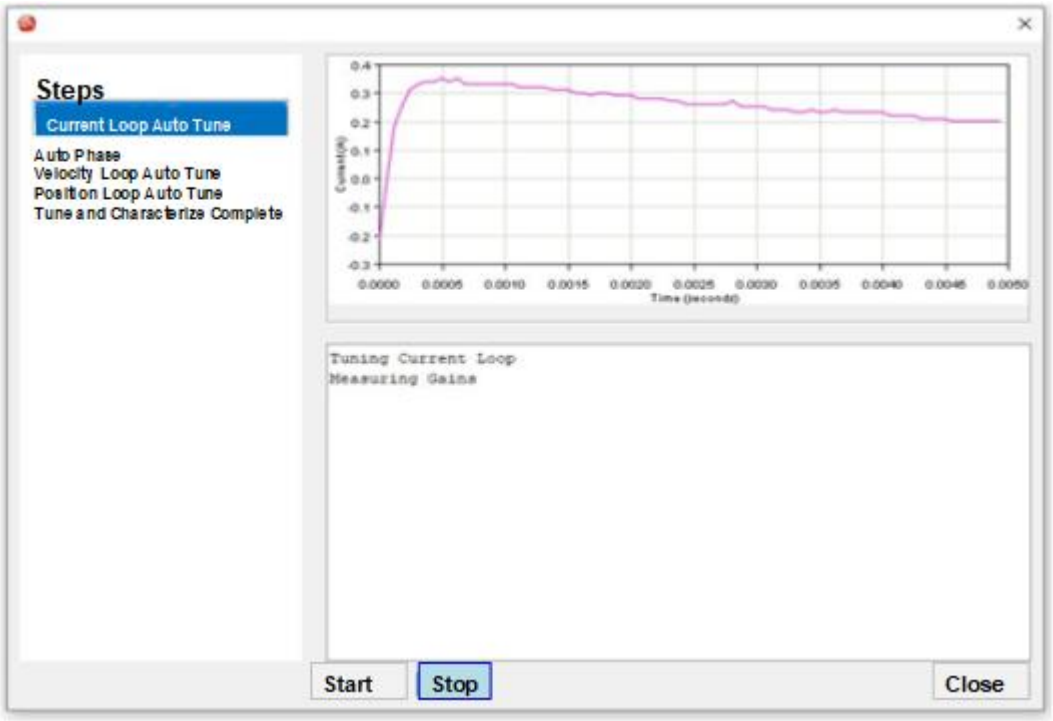
   NOTE: The Rated Torque will be defaulted to a minimum value. It should not be 0. It will be calculated if the Motor Power is entered.
5. Click **Characterize and Tune** and follow the instructions in the Section: Characterize and Tune.
6. Click the **Feedback** button to view or change the motor and/or load feedback settings.

6.2.3 Characterize and Tune

1. To start the Current Loop Auto Tune, click **Start**.

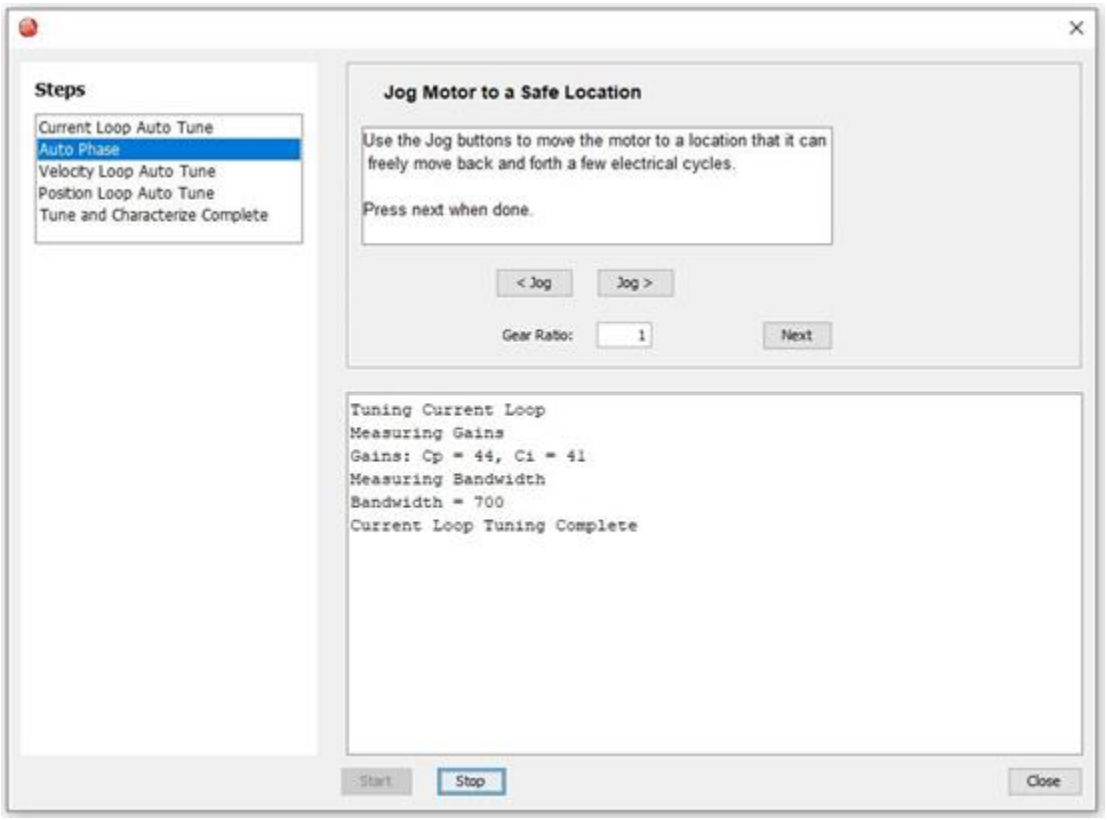


Current Loop Auto Tune Screen



Current Loop Auto Tune Example

2. When the Current Loop Auto Tune step is complete, it proceeds to the Auto Phase step.

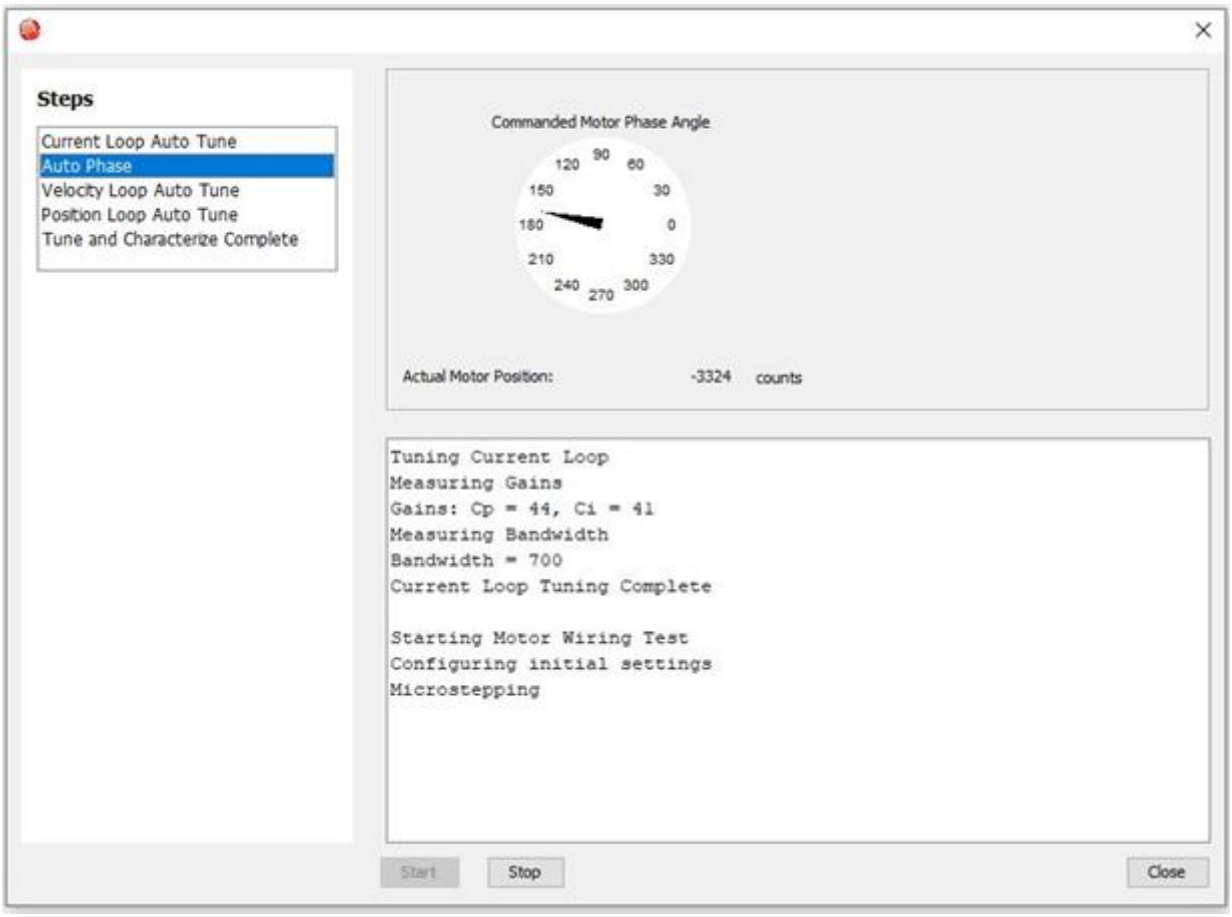


Auto Phase Screen

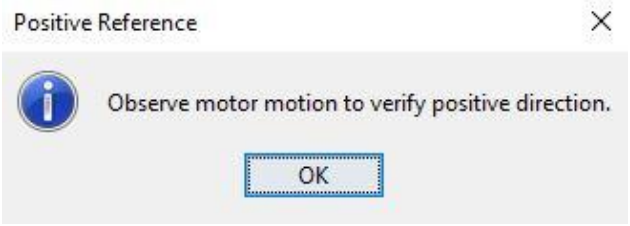
3. Press either (backspace) <Jog or Jog> (forward space) button depending on which direction you want the motor rotating.
4. Click **Next** and answer the question(s) from the prompts.



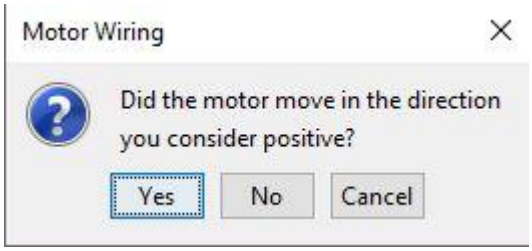
Motor Position Prompt



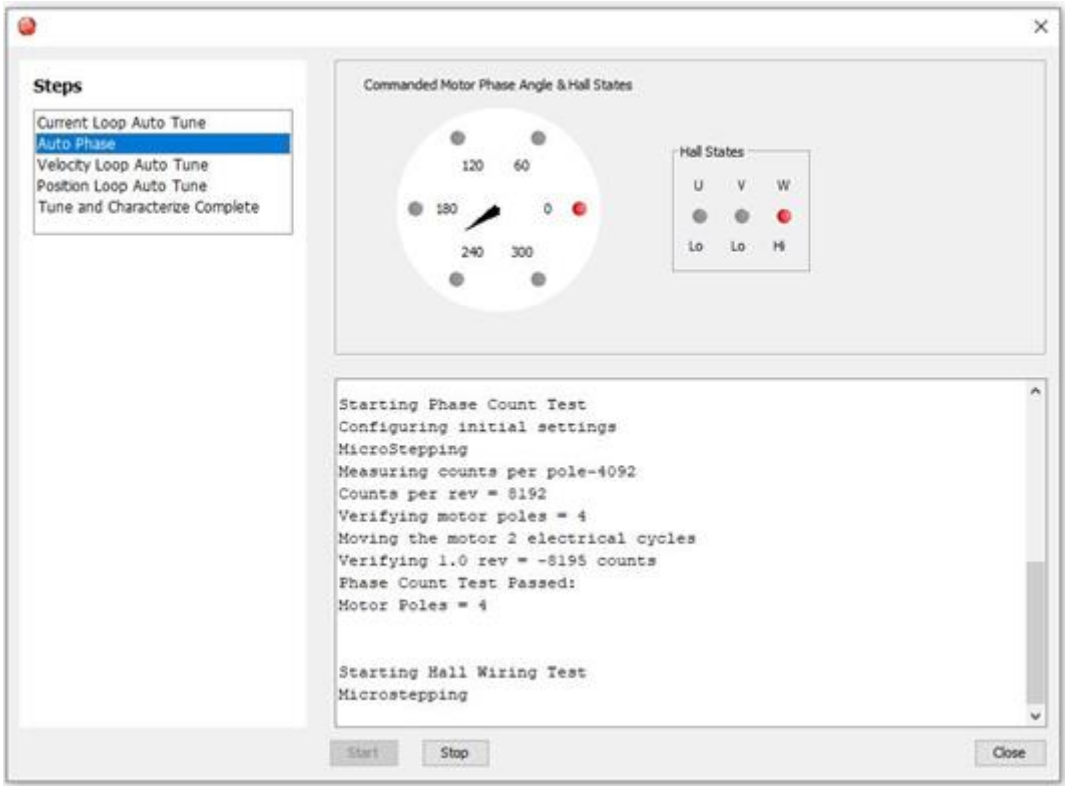
Auto Phase (Actual Motor Position) Example



Positive Reference Prompt

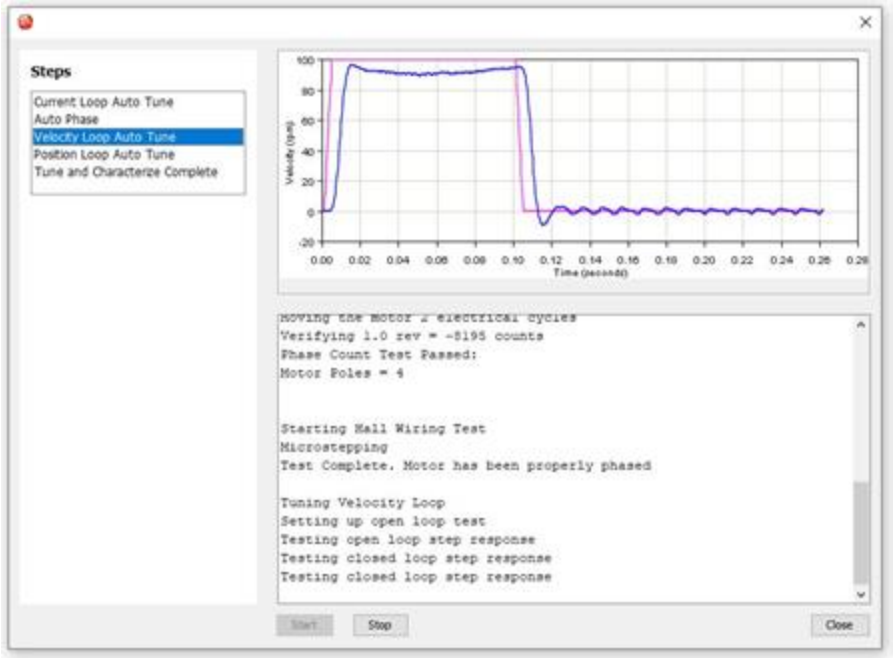


Motor Wiring Prompt

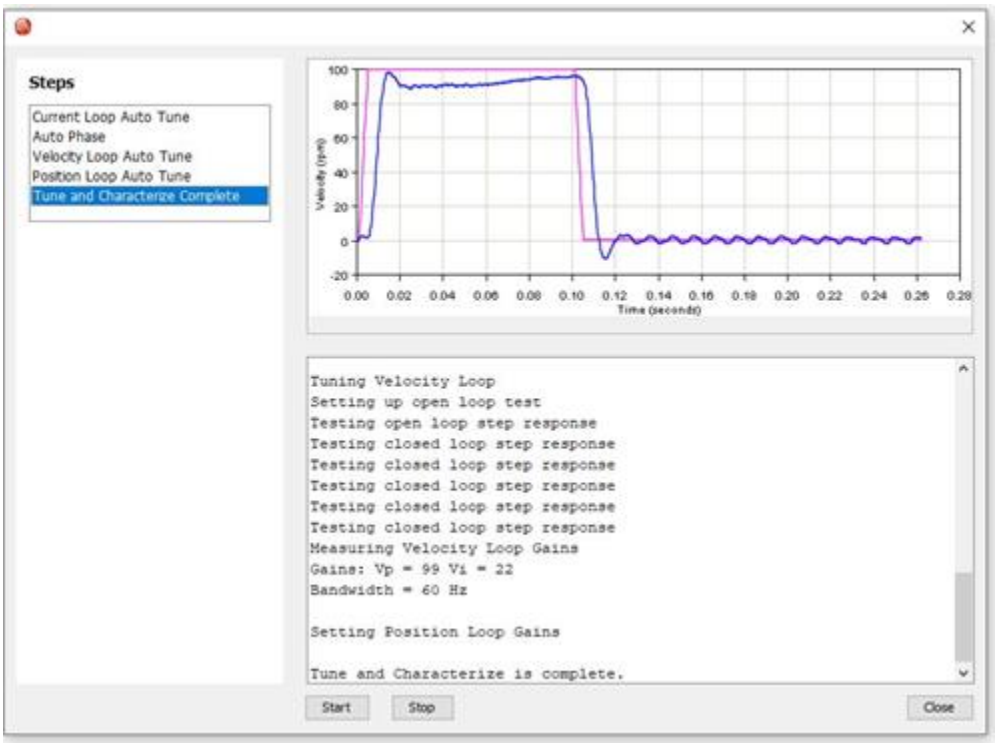


Auto Phase (Motor Phase Angle & Hall States) Example

5. When the Auto Phase step is complete, it proceeds to the Velocity Loop Auto Tune step.

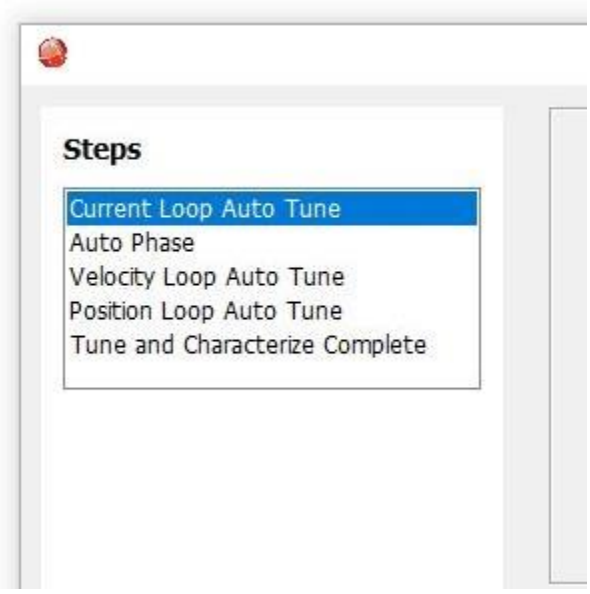


Velocity Loop Auto Tune Example



Tune and Characterize Complete Example

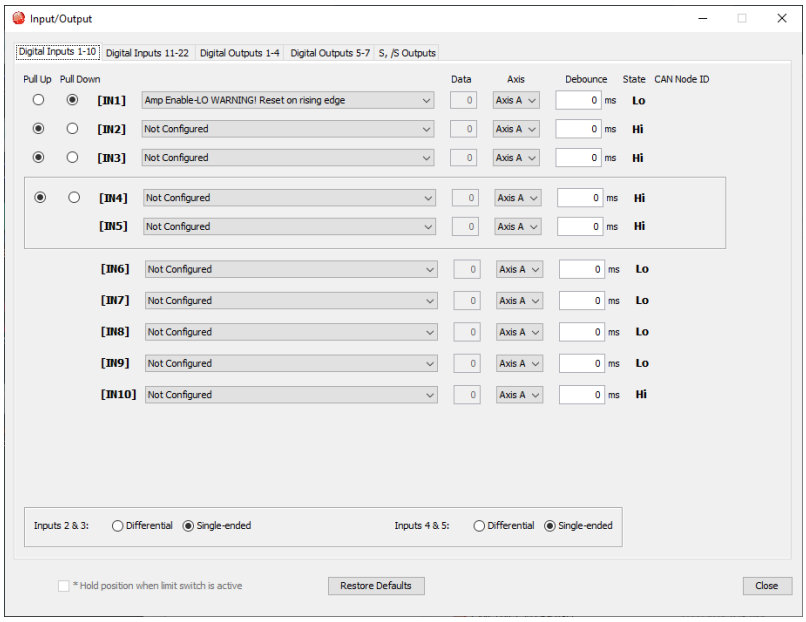
NOTE: If you completed all the other previous steps, you can start your tuning from any of the steps.



Steps Menu

7 INPUT/OUTPUT

From the Main screen, click the **Input/Output** button. A typical screen is shown below.
NOTE: The options vary with the model and the configuration.



Input/Output Screen

Parameter	Description
Pull up +5 V	Pulls the group of inputs up to internal +5 V.
Pull down	Pulls the group of inputs down to internal signal ground.
Data	If the input pin configuration deals with CVM Indexer Registers, enter the desired CVM Indexer Register in the Data Textbox.
Axis	If applicable, the configuration can be applied to one or all axes using the Axis selection combo-box.
Debounce Time	Specifies how long an input must remain stable at a new state before the drive recognizes the state. Increase to prevent multiple triggering caused by switch bounce upon switch closures. Range: 0 to 10,000 mS. Debounce does not affect inputs that have been configured as PWM, Pulse and Direction, Quadrature Control Inputs or Tertiary Encoder.C
State	The binary state of the input can be read from the State column.
CAN Node ID	If the input pin is used to configure the CAN Node ID, this column will display the bit of the CAN Node ID that this input pin represents. (i.e., Bit 0, Bit 1, etc.).
IN1 to INn	Select the function for the input.
Differential/Single-Ended Options	If the drive contains inputs that can be used as a command source (i.e., PWM circuitry), select the Differential or Single-Ended buttons to configure them.
*Hold Position when Limit Switch is Active (See Caution)	**Available in Position Mode only**: Use this parameter when one or more inputs are configured as a limit switch (NEG Limit-HI Inhibits, NEG Limit-LO Inhibits, POS Limit-HI Inhibits, or POS Limit-LO Inhibits). The *Hold position option prevents any motion while a limit switch is active. This option uses the Abort Deceleration rate to stop the motor as described in Trajectory Limits.
Restore Defaults	Restores all inputs and outputs to factory defaults.

CAUTION!	**Risk of Equipment Malfunction:**
	CAUTION: If the drive is switched back to the Current or Velocity mode with the (Hold Position) option selected, the limit switches will no longer function.

7.1 Digital Input Functions

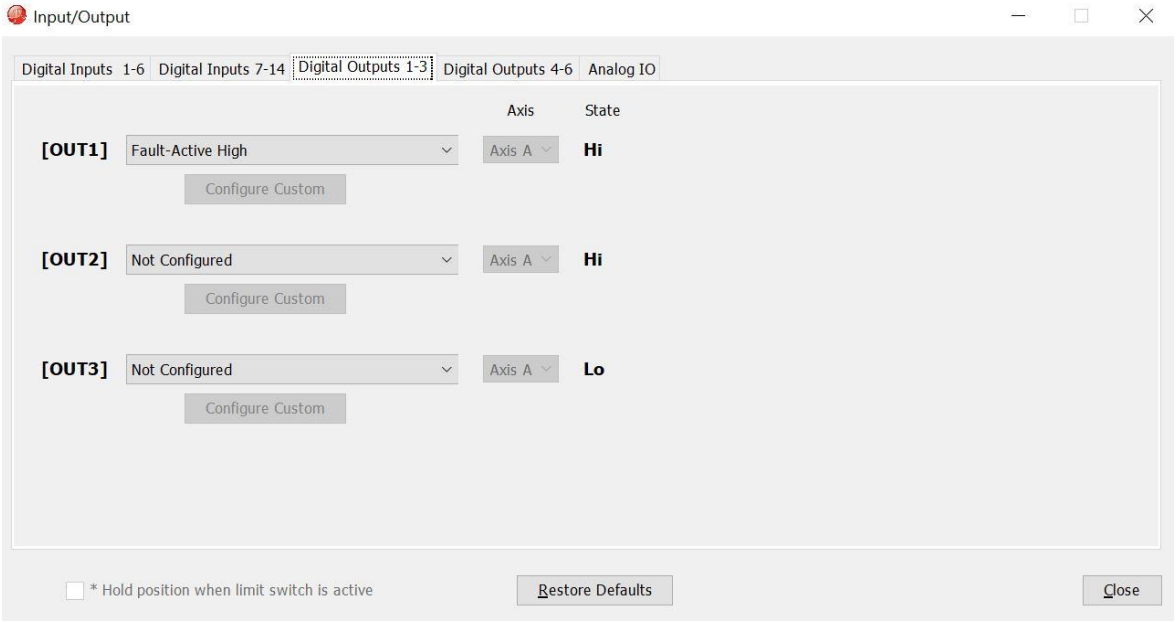
Depending on the mode of operation, some inputs may have a predefined function such as enable or motor temperature sensor. Typically, IN1 is defined as an enable input.

Input Function	Description
AMP Enable- LO Clear Faults on rising or falling edge.	A low input will enable the drive. Any transition will clear latched faults and outputs.
AMP Enable- HI Clear Faults on rising or falling edge.	A high input will enable the drive. Any transition will clear latched faults and outputs.
AMP Enable-LO WARNING! Reset on rising edge.	A low input will enable the drive. A low to High transition will reset the drive.
AMP Enable-HI WARNING! Reset on falling edge.	A high input will enable the drive. A high to low transition will reset the drive.
AMP Enable-LO Enables	A low input will enable the drive.
AMP Enable-HI Enables	A high input will enable the drive.
Not Configured	No function assigned to the input.
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.
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.
Reset on LO-HI Transition	A low to high transition of the input will reset the drive.
Reset on HI-LO Transition	A high to low transition of the input will reset the drive.
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.
Halt Motor-Active HI	A high input causes the drive to stop motion, using the Abort Deceleration rate described in Trajectory Limits. The drive remains enabled.
Halt Motor-Active LO	A low input causes the drive to stop motion, using the Abort Deceleration rate described in Trajectory Limits. The drive remains enabled.
High Res Analog Divide Active HI	A high input causes the firmware to divide the level of the analog input signal by 8.
High Res Analog Divide Active LO	A low input causes the firmware to divide the level of the analog input signal by 8.
Simulated Absolute Encoder Burst on LO-HI Transition	Disable simulated encoder output when low. Burst current position on encoder output on rising edge.
Simulated Absolute Encoder Burst on HI-LO Transition	Disable simulated encoder output when high. Burst current position on encoder output on falling edge.
Clear Faults and Event Latch on LO-HI Transition	Clear faults & event latch on rising edge.

Input Function	Description
Clear Faults and Event Latch on HI- LO Transition	Clear faults & event latch on falling edge.
Abort Move on LO-HI if >N Counts From Dest in Reg	Abort move on rising edge, if further, then N counts from destination position. Number of counts (N) is stored in an Index Register identified by bits 8-11.
Abort Move on HI-LO if >N Counts From Dest in Reg	Abort move on falling edge, if further, then N counts from destination position. Number of counts (N) is stored in an Index Register identified by bits 8-11.
Encoder Fault- Active HI	Encoder fault input, active high.
Encoder Fault- Active LO	Encoder fault input, active low.
Trajectory Update on LO-HI Transition	On the low to high transition of this input, the Trajectory Generator will generate a previously configured trajectory.
Trajectory Update on HI-LO transition	On the high to low transition of this input, the Trajectory Generator will generate a previously configured trajectory.
Count Rising Edges, Save To Reg	Count rising edges of input to Indexer Register. (Register number identified by bits 8-11).
Count Falling Edges, Save To Reg	Count falling edges of input to Indexer Register. (Register number identified by bits 8-11).
Amp Disable-HI with AC Removed	For a controlled stop, the AC power is cut, and the drive is disabled with a high input.
Amp Disable-LO with AC Removed	For a controlled stop, the AC power is cut, and the drive is disabled with a low input.
High Speed Position Capture on LO-HI Transition	High Speed Position Capture on LO-HI Transition
High Speed Position Capture on HI-LO Transition	High Speed Position Capture on HI-LO Transition
Abort Move on Rising Edge	Abort move on LO-HI Transition
Abort Move on Falling Edge	Abort move on HI-LO Transition
PWM Sync Input	PWM synchronization input. Synchronizing PWM Switching Frequency. (For high-speed inputs only).

7.2 Digital Outputs

The following diagram shows a typical Digital Outputs screen.

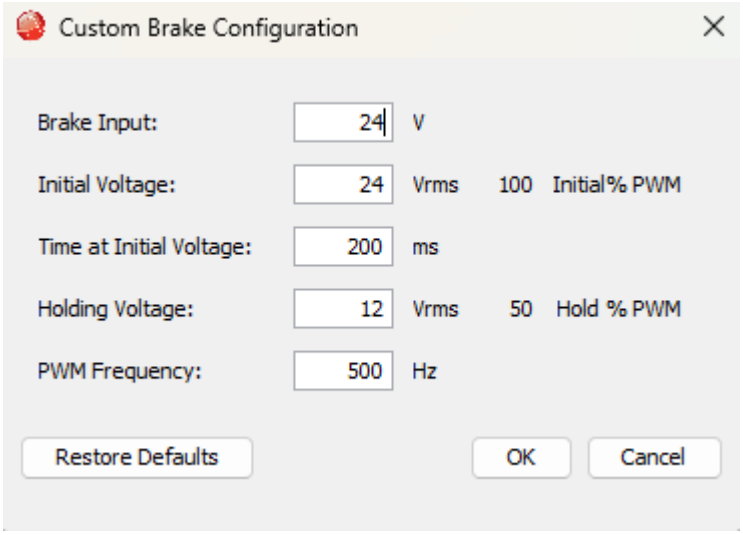


Digital Outputs Screen

NOTE: Options vary with the models and the configurations.

7.2.1 Digital Output Functions

Output Function	Description
Not Configured	No function. Output remains HI/OFF.
Fault Active High	Output goes HI/OFF when one or more faults are detected.
Fault-Active Low	Output goes LO/ON when one or more faults are detected.
Brake-Active High	(Brake hold) Output goes HI/OFF to activate the brake.
Brake-Active Low	(Brake release) Output goes LO/ON to activate the brake.
PWM Sync Output	The PWM synchronization output.
Custom Event	See Custom Triggered Event Output.
Custom Trajectory Status	See Custom Trajectory Status.
Custom Position Triggered Output	See Custom Position Triggered Output.

<table>
<tr><th>Output Function</th><th>Description</th></tr>
<tr><td>Custom Brake Output</td><td>Manually control PWM settings for the brake output. One per axis. Most drives have one brake output per axis that has special PWM circuitry for powering a brake. This output can be configured as a Custom Brake Output, which allows the user to customize the brake settings.


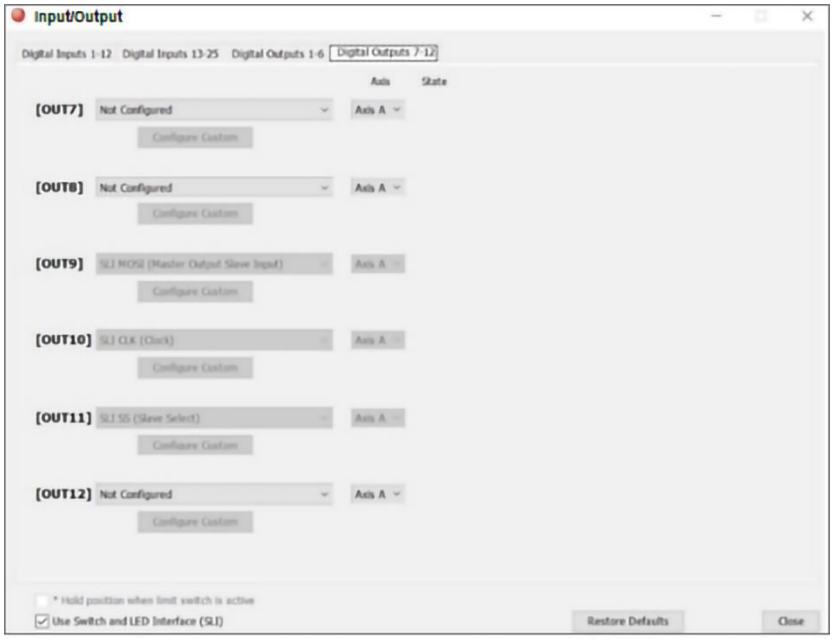
<table>
<tr><th>Fields</th><th>Description</th></tr>
<tr><td>Brake Input:</td><td>Bus voltage for Brake.</td></tr>
<tr><td>Initial Voltage:</td><td>Maximum Voltage to be applied to the brake when it first engages.</td></tr>
<tr><td>Time at Initial Voltage:</td><td>Time to allow the brake to engage at the maximum voltage.</td></tr>
<tr><td>Holding Voltage:</td><td>Voltage applied to the brake after the engage time to reduce the heating of the brake.</td></tr>
<tr><td>PWM Frequency</td><td>Coil inductance to limit current if the bus voltage is greater than the brake’s maximum voltage.</td></tr>
</table></td></tr>
<tr><td>Program Control Active High</td><td>Output state controlled by CVM or external program.</td></tr>
<tr><td>Program Control Active Low</td><td>Output state controlled by CVM or external program.</td></tr>
<tr><td>External Regen Active High</td><td rowspan="2">Use the output to trigger an external Regen Resistor. The output can be configured either as Active High or Active Low.
See External Regen Settings.</td></tr>
<tr><td>External Regen Active Low</td></tr>
<tr><td>STO Status-Active High</td><td>Output goes HIGH/OFF when STO is inactive.</td></tr>
<tr><td>STO Status-Active Low</td><td>Output goes LOW/ON when STO is inactive.</td></tr>
<tr><td>Hardware Position Triggered Output</td><td>Enable Output compare module to trigger output on position.
For Plus drives with 1.40 firmware or later.</td></tr>
</table>

7.2.2 ID Switch and Network LED SLI

ID Switches and Network LED SLI can be configured to identify inputs and outputs. This feature is only available for module drives, not panels.

The **Use Switch and LED Interface (SLI)** checkbox is used to automatically configure inputs and outputs to be used for SLI communication. If the SLI interface is not used, please uncheck this checkbox to make these inputs and outputs available for other configuration modes.

NOTE: To configure additional I/O (3 outputs, 1 input), uncheck the **Use Switch and LED Interface (SLI)** field to disable the Network ID switch and LED.

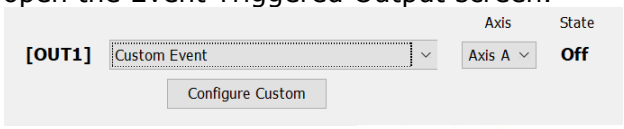


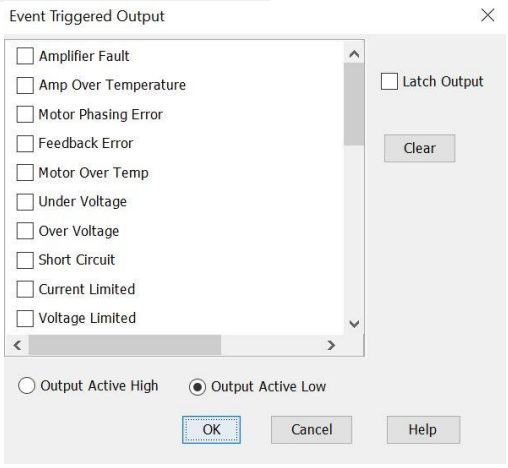
Input/Output Screen

7.2.3 Custom Event Triggered Output

Digital outputs can be configured for one or more bits in the Event Status (faults, warnings, and status).

1. Choose **Custom Event** for the output configuration, then click **Configure Custom** button to open the Event Triggered Output screen.





Event Triggered Output Screen

2. On the Event Triggered Output screen, select one or more events from the list. Selections are OR'ed together, so that any event will cause the output to go active.
   To clear all selections, click the **Clear** button.
3. Choose either Output Active High/OFF or Output Active LOW/ON.
4. To latch the output, check the **Latch Output** field.

 **DANGER**	**Latching an output does not eliminate the risk of unexpected motion with non-latched faults.**
	Associating a fault with a latched, custom-configured output does not latch the fault itself. After the cause of a non-latched fault is corrected, the drive re-enables without operator intervention. In this case, motion may restart unexpectedly.
	Failure to heed this warning can cause equipment damage, injury, or death.

5. Click **OK** to save changes to the drive RAM and close the screen.

Event	Description
Drive Fault	A latched fault is active. Bit 22 of the Event Status Register is only set in the event of a latched fault. An active fault that is not configured as a latched fault will not set this bit.
Amp Over Temperature	For descriptions of these fault events, see Fault Descriptions.
Motor Phasing Error	
Feedback Error	
Motor Over Temp	
Under Voltage	
Over Voltage	
Short Circuit	
Current Limited	The current output is being limited by the I^2T Algorithm.
Voltage Limited	Current loop is commanding the full bus voltage to control the current. This event commonly occurs when the motor is running as fast as the available bus voltage will allow.
Positive Limit Switch	Axis has contacted positive limit switch.
Negative Limit Switch	Axis has contacted negative limit switch.
Amp Disabled by Hardware	Drive enable input(s) is not active.
Amp Disabled by Software	Drive is disabled by a software command.
Attempting to Stop Motor	The drive, while in Velocity or Position mode, has been disabled. In Velocity mode, the drive is using the Fast Stop Ramp described in Velocity Loop Limits. In the Position mode, the drive is using the Abort Deceleration rate described in Trajectory Limits. The output remains active until the drive is re-enabled.
Motor Brake Active	Motor brake activated.
PWM Outputs Disabled	The drive's PWM outputs are disabled.
Positive Software Limit	Actual position has exceeded the positive software limit setting. See Homing.
Negative Software Limit	Actual position has exceeded the negative software limit setting. See Homing
Following Error	Following Error has reached programmed fault limit. See Following Error Faults
Following Warning	Following Error has reached programmed warning limit. See Following Error Faults
Position has Wrapped	The position counters have exceeded the maximum range of -2^{31} – $2^{31}-1$ and have wrapped. Normal drive operation is not affected.

Event	Description
Velocity Limited	The velocity command (from analog input, PWM input, or position loop) has exceeded the velocity limit. See Velocity Loop Limits.
Acceleration Limited	In Position mode, the motor has reached an acceleration or deceleration limit that was set as described in Position mode.
Pos Outside of Tracking Window	The Following Error has exceeded the programmed value. See Position and Velocity Tracking Windows.
Home Switch Active	Axis has contacted the home limit switch.
In Motion	The motor is moving, or it has not yet settled after a move. The drive is settled when it comes within the position tracking window and stays there for the tracking time at the end of a move. Once this bit is set, it remains set until a new move is started.
Vel Outside of Tracking Window	Difference between target and actual velocity has exceeded the window. See Position and Velocity Tracking Windows.
Phase not Initialized	Drive is using Phase Initialization function and phase is not initialized.
Command Input Fault	PWM or other command signal (e.g., EtherCAT MainDevice) not present. If the Allow 100% Output option is enabled by a setting Bit 3 of Digital Input Command Configuration, this fault will not detect a missing PWM command.

7.2.4 Latched vs. Non-Latched Custom Event

An output that is configured for a custom event can be latched or non-latched.

If a non-latched output goes active, it becomes 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 is taken:

- Reset or power-cycle the drive.
- Cycle (disable and then enable) an input that is configured as Enable with Clear Faults or Enable with Reset.
- Open the Control Panel and press Clear Faults.

The latched/non-latched behavior of an output configured as a custom event is independent of the drive's latched/non-latched fault. Consider the following example:

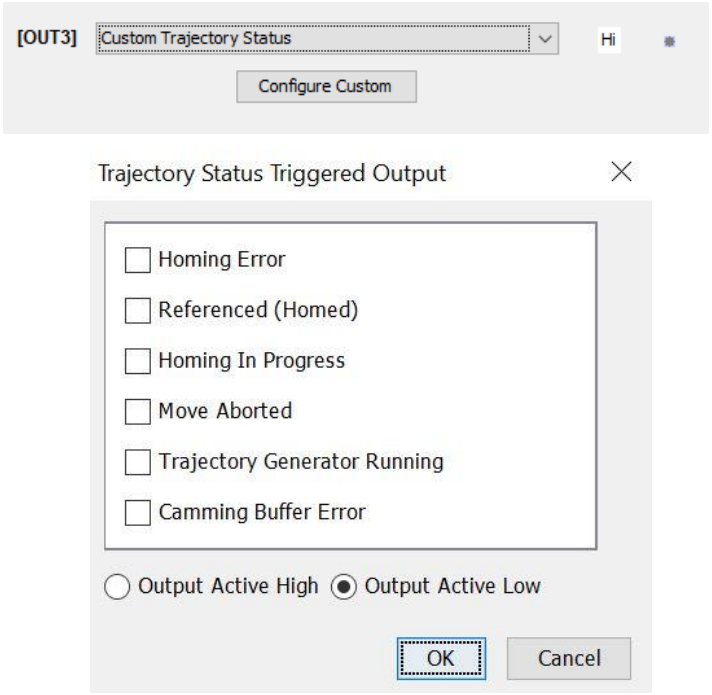
Example: OUT3 is configured as a custom event: under voltage and latched, but the Under Voltage fault on the Configure Faults screen is set to non-latched. The table below shows the difference in behavior between the output and the drive's fault.

Condition	Drive	OUT3
Under voltage condition occurs.	Disables PWM outputs and reports under voltage faults.	Goes to active state.
Under voltage condition is corrected.	Under voltage fault is not reported and PWM outputs are enabled.	Stays active.

7.2.5 Custom Trajectory Status

Digital outputs can be configured for one or more events in the Trajectory Status.

1. Choose **Custom Trajectory Status** for an output and then click **Configure Custom** to open the Trajectory Status Triggered Output screen.



Trajectory Status Triggered Output Screen

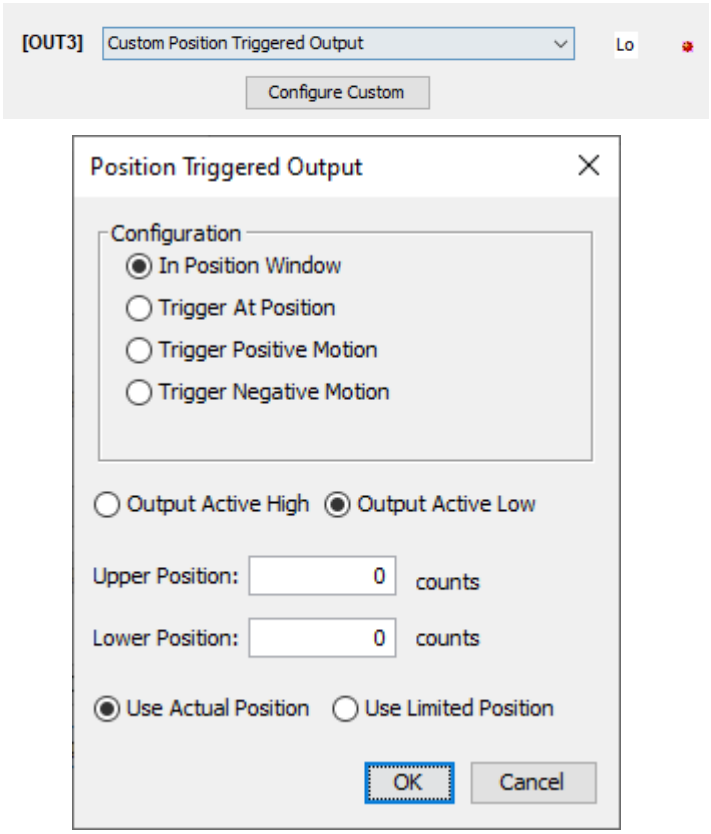
2. Select one or more events from the list. Selections are OR'ed together, so that any event will cause the output to go active.

Status	Description
Homing Error	Activate output if an error occurred in the last homing attempt.
Referenced (Homed)	Activate output if the most recent homing attempt was successful.
Homing in Progress	Activate output when a homing move is in progress.
Move Aborted	Activate output if move is aborted.
Trajectory Generator Running	Activate output while trajectory generator is generating a move.
Camming Buffer Error	A camming buffer error has occurred.

3. To activate the output to go high when active, choose **Output Active High**.
4. To activate the output to go low when active, choose **Output Active Low**.
5. Click **OK** to save the changes to the drive RAM and close the screen.

7.2.6 Custom Position Triggered Output

1. Choose **Custom Position Triggered Output** for an output and then click **Configure Custom** button to open the In Position Triggered Output screen.



Position Triggered Output Screen

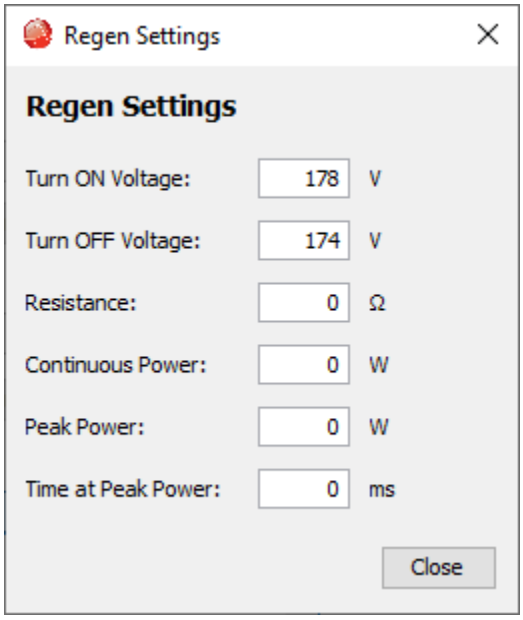
2. Select one of the configurations described in the following table and enter the appropriate values for the parameters.

Configuration	Description and Parameters
In Position Window	Activates the output while the axis is in the window between the programmed **Upper** and **Lower** positions.
Trigger at Position	Activates the output for the programmed **Time** when the axis travels through the programmed **Position**.
Trigger Positive Motion	Activates the output for the programmed **Time** when the axis travels in the positive direction through the programmed **Position**.
Trigger Negative Motion	Activates the output for the programmed **Time** when the axis travels in the negative direction through the programmed **Position**.

3. To activate the output to increase to high when active, choose **Output Active High**.
   To activate the output to decrease to low when active or choose **Output Active Low**.
4. In Stepper mode with no encoder, choose **Use Limited Position**.
   Otherwise, choose **Use Actual Position**.
5. Click **OK** to save changes to the drive RAM and close the Custom Output Configuration screen.

7.3 External Regen Settings

The brake output, if available, can be configured to trigger an external regen resistor on either an active Hi or active Lo signal. If too much back EMF is generated during the brake operation, it can flood the bus of the drive, damaging parts. Regen resistors are used to safely drain the back EMF voltage during the brake operation.

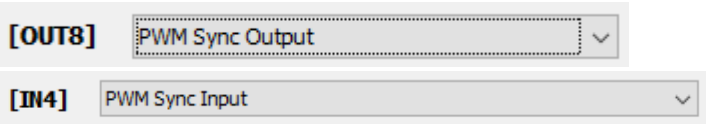


Regen Settings Screen

Settings	Description
Turn ON Voltage:	Voltage at which the regen circuit will activate.
Turn OFF Voltage:	Voltage at which the regen circuit will deactivate.
Resistance:	Regen resistor resistance.
Continuous Power:	Continuous power rating of the regen resistor.
Peak Power:	Peak power rating of the regen resistor.
Time a Peak Power:	Maximum time at which the peak power is applied to the regen resistor.

7.4 Synchronizing PWM Switching Frequency

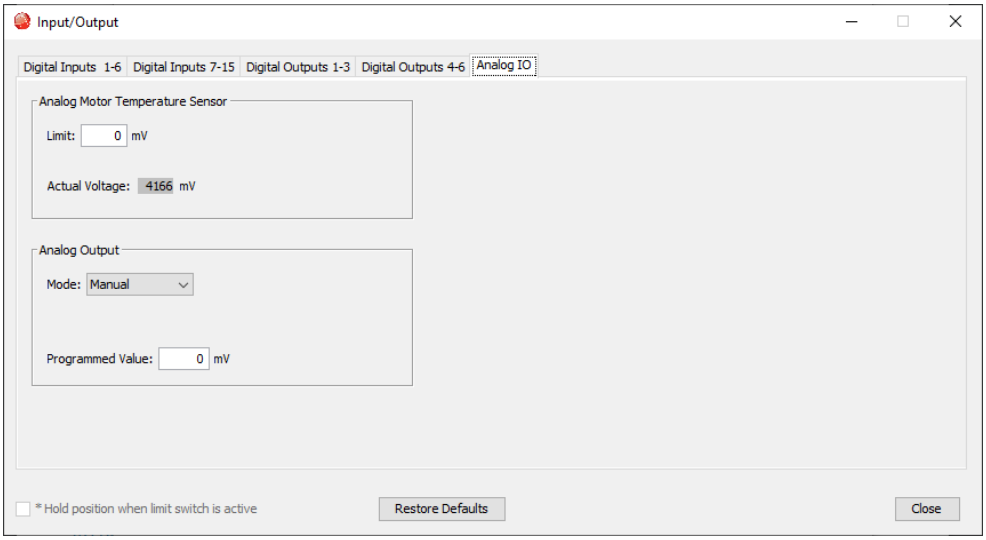
In some situations, such as when sampling small analog signals, it is desirable to synchronize the PWM switching frequency among multiple drives. In these cases, one drive serves as a master for one or more slave drives. The PWM sync output of the master ends a signal that is received as a PWM sync input by each slave. To configure this, an output of the master must be configured as PWM Sync Output and one input on each of the slave must be configured as the PWM Sync Input.



7.5 Analog I/O

The following shows a typical Analog I/O screen.

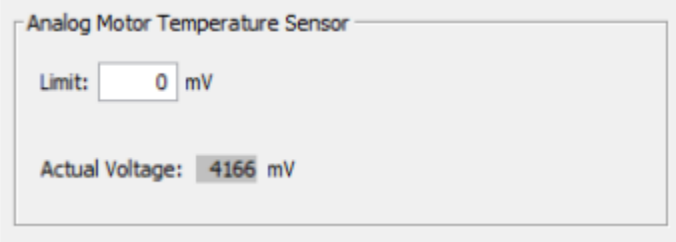
NOTE: Only products with an analog output will have this option.



Input/Output Screen

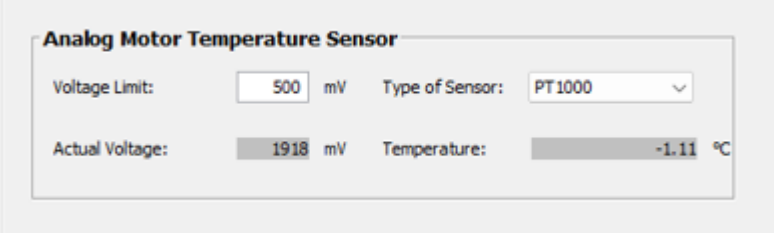
7.5.1 Analog Motor Temperature Sensor

Enter a voltage limit in mV. This limit should reflect the maximum level of voltage to safely operate the motor without overheating. A Fault will occur when the voltage is above the limit for positive values. For a Fault set below the limit, enter the limits value as a negative value. Actual voltage is the sensor reading in mV.



Analog Motor Temperature Sensor Screen

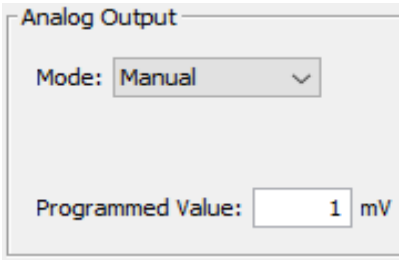
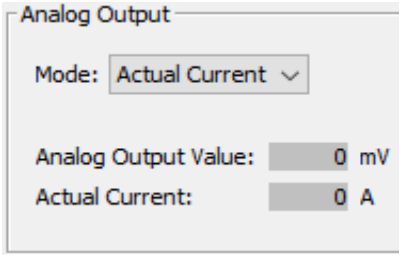
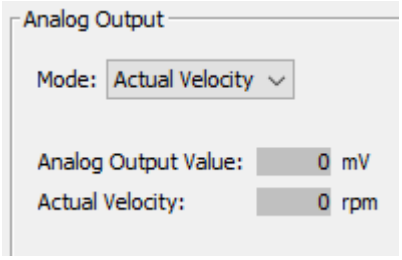
For certain drives, CME also provides a feature to display the temperature equivalent of the voltage reading in degrees Celsius. Note that this is used for display purposes only and the temperature reading is not stored in the drive.



Analog Motor Temperature, Converted to °C

7.5.2 Analog Output

The Analog Output has three modes of operation.

• Manual In the Mode: section, if you select Manual, in the **Programmed Value:** field, set the output to the programmed value, +/- 5V, in mV.	
• Actual Current In the Mode: section, if you select Actual Current, in the **Analog Output Value:** field, set the output value and it is proportional to the Actual Motor Current.	
• Actual Velocity In the Mode: section, if you selected Actual Velocity, in the **Analog Output Value:** field, set the output value and it is proportional to the Actual Motor Velocity.	

7.5.3 Multiple Analog Reference Inputs

Some drives are equipped with two analog reference inputs. For drives that have them, the voltage reading of each reference input can be read from the Analog I/O screen.

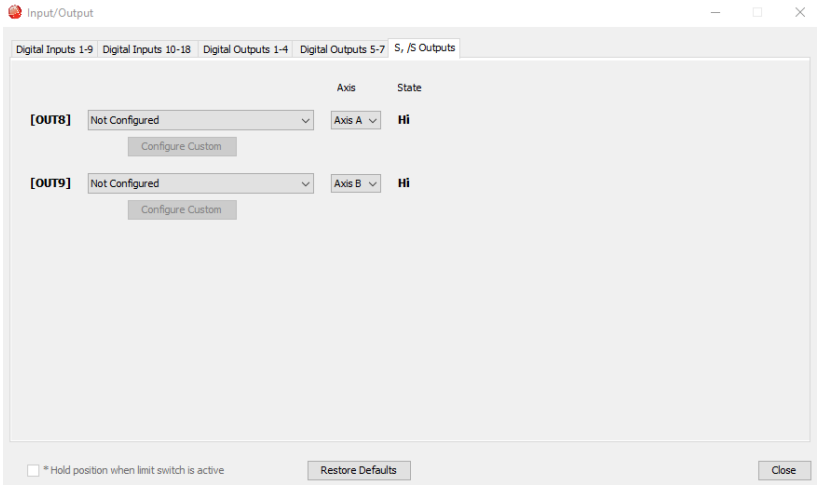


Input/Output Screen, Multiple Analog Reference Inputs

7.6 S, /S Channel Inputs

FPGA-based "Plus" drives with at least one multi-mode port are allowed to use additional outputs by utilizing the encoder's S channel. A drive can have up to 2 secondary S channels depending on the number of axes. Drives with 3+ axes do not support this feature.

To use this feature, the drive must be using Firmware feature 2.76 or greater and it is not using the multi-mode port for something else. These outputs are global and can be used for any output function on any axis.



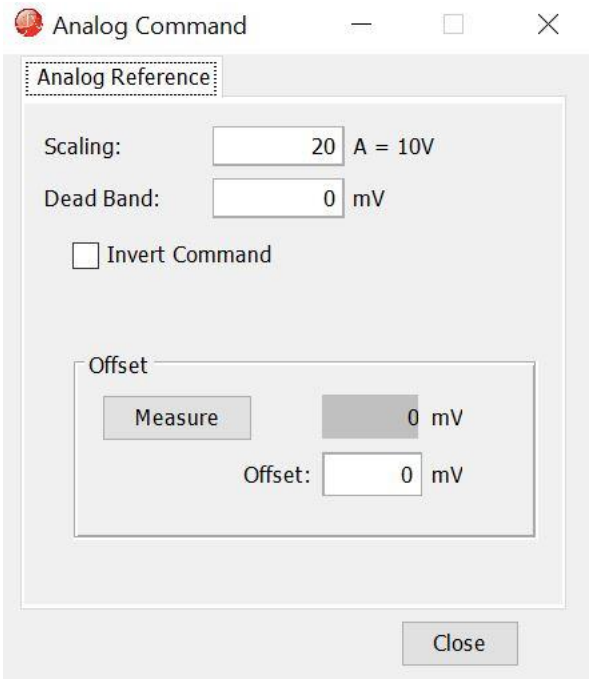
Input/Output Screen

8 COMMAND INPUTS

8.1 Analog Command

The drive can be driven by an analog voltage signal through the Analog Command input. The drive converts the signal to a Current, Velocity, or Position Command as appropriate for Current, Velocity, or Position mode operation, respectively. The Analog input signal is conditioned by the Scaling, Dead Band, and Offset settings.

1. From the Main screen, click the **Analog Command** button.



Analog Command Screen

Analog Reference Parameter	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) 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 the Section: Scaling.
Dead Band	Sets dead band. Range: -10,000 to 10,000 mV. Default: 0. For more information, see the Section: Dead Band.
Invert Command	Inverts polarity of drive output with respect to input signal.
Offset	(Current and Velocity modes only.) Used to offset the input voltage error in an open loop system. Not recommended for use when the drive is part of a closed loop system. Range: -10,000 to 10,000 mV. Default: 0. For more information, see the Section: Offset.

8.1.1 Scaling

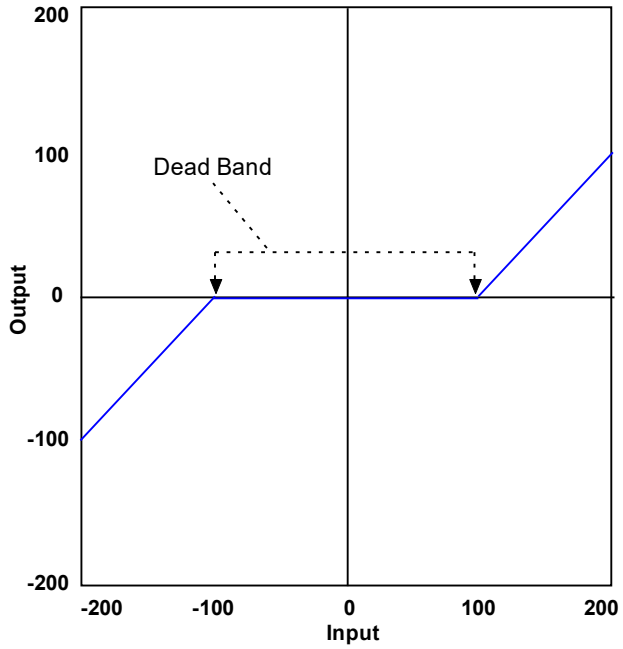
The magnitude of the command generated by an input signal is proportional to the input signal voltage. Scaling controls the input-to-command ratio, allowing the use of an optimal command range for any given input voltage signal range.

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

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

8.1.2 Dead Band

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



Dead Band Example

8.1.3 Offset

To remove the effects of voltage offsets between the controller and the drive-in open loop systems, CME provides an Offset parameter and a Measure function.

- The Measure function takes 10 readings of the analog input voltage over a period of approximately 200 ms, averages the readings, and then displays the results.
- The Offset parameter allows the user to enter a corrective offset to be applied to the input voltage. The Offset can also set up the drive for bi-directional operation from a uni-polar input voltage.

An example of this would be a 0 to +10 Vdc velocity command that had to control 1000 rpm CCW to 1000 rpm CW. Scale would be set to 2000 rpm for a +10 Vdc input and Offset set to -5V. After this, a 0 Vdc input command would be interpreted as -5 Vdc, which would produce 1000 rpm CCW rotation. A +10 Vdc command would be interpreted as +5 Vdc and produce 1000 rpm CW rotation.

8.1.4 Monitoring the Analog Command Voltage

The Analog Input Voltage can be monitored in the Control Panel and in the Scope. The voltage displayed in both cases occurs after both offset and dead band are applied.

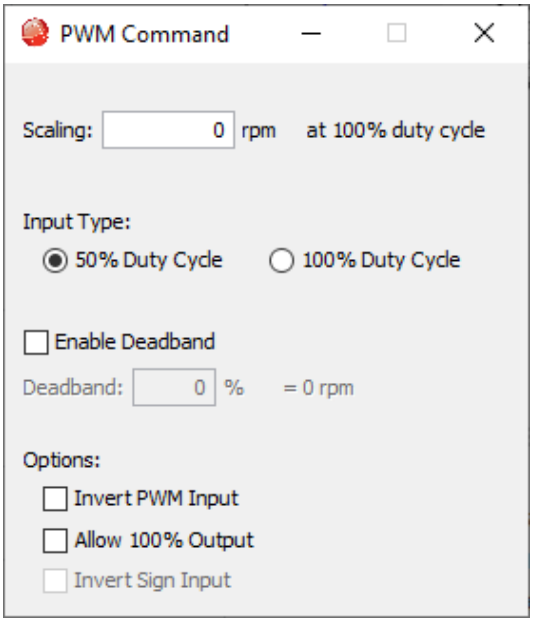
8.1.5 Analog Command in Position Mode

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

To use the Analog Position command as an Absolute Position command, the drive should be homed every time it is enabled. The Homing sequence may be initiated by CAN, ASCII serial, or CVM Indexer program commands.

8.2 PWM Input

1. From the Main screen, click the **PWM Command** button.



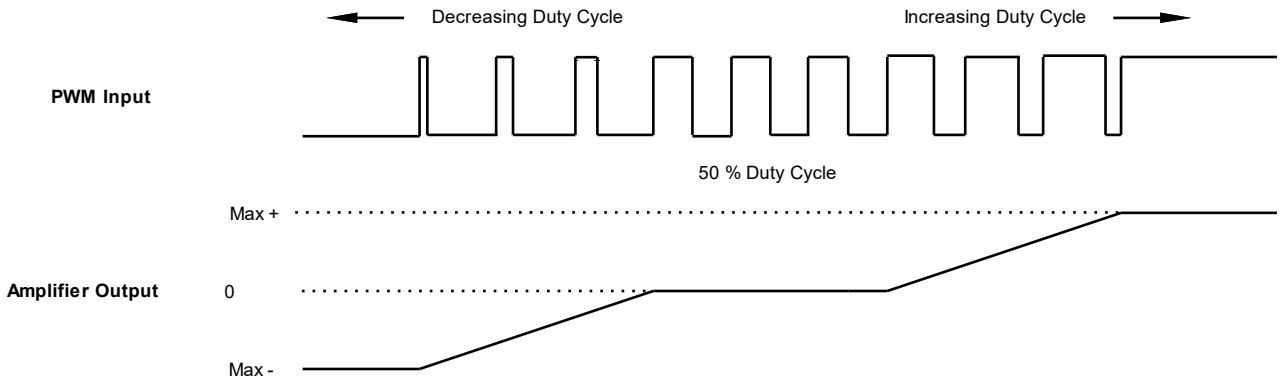
PWM Command Screen

Parameter	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 **Invert Sign Input:** In 100% Duty Cycle mode, inverts the polarity of the directional input.
Deadband	**Velocity mode:** If enabled, set the dead band from 0 to 100% of the PWM duty cycle.

8.2.1 50% Duty Cycle (One-Wire)

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

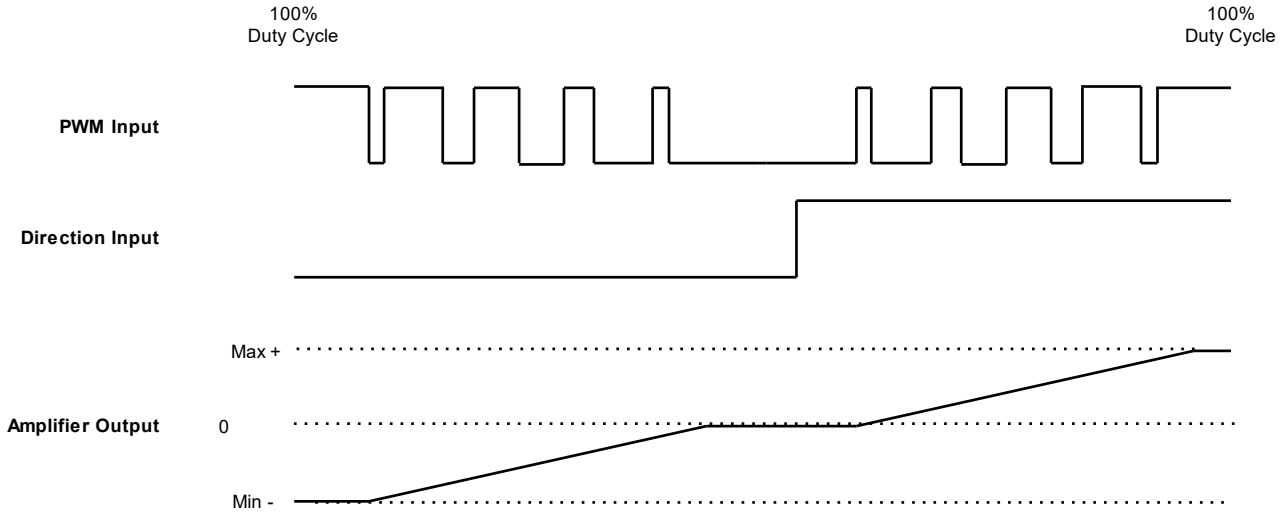
NOTE: The command can be inverted so that the increased duty cycle commands negative output and vice versa.



50% Duty Cycle (One-Wire) Diagram

8.2.2 100% Duty Cycle (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.



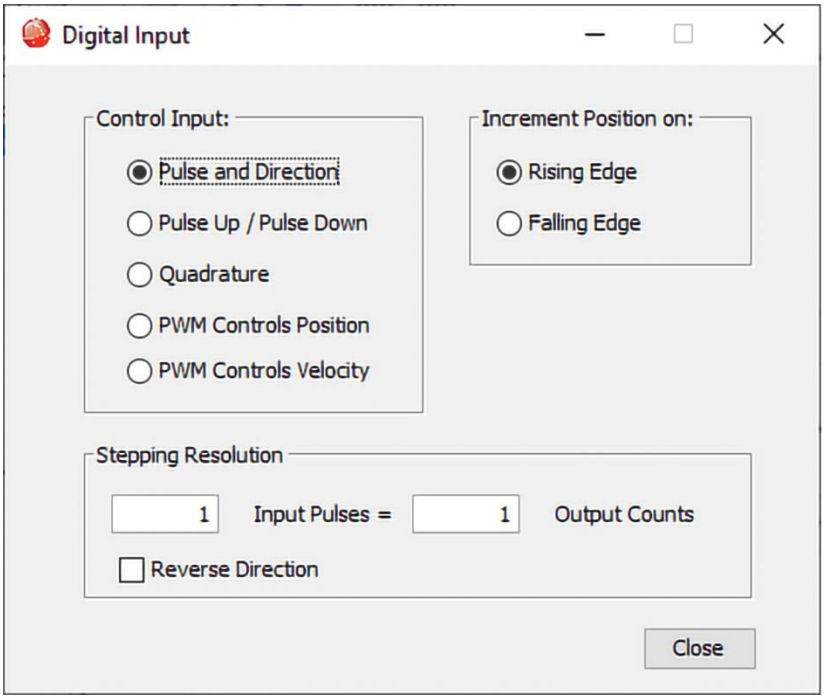
100% Duty Cycle (Two-Wire) Diagram

8.2.3 Failsafe Protection from 0 or 100% Duty Cycle Commands

In both formats, the drive can be programmed to interpret 0 or 100% duty cycle as a zero command, providing a measure of safety in case of a controller failure or a cable break.

8.3 Digital Position Input

1. From the Main screen, click the **Digital Input** button.



Digital Input Screen

Parameter	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 input 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. **PWM Controls Position:** The input takes a frequency with variable pulse width as a Position command. **PWM Controls Velocity**: The input takes a frequency with variable pulse width as a Velocity command.
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.
Reverse Direction	When selected, it inverts commanded direction.
Full Scale	In **PWM Controls Position** mode, gives the range of commanded position in encoder counts. In **PWM Controls Velocity** mode, gives the range of commanded velocity in units of 0.1 encoder counts/second.
Offset	In **PWM Controls Position** mode, this value is added to the calculated absolute position.

Parameter	Description
Minimum Pulse Width	In **PWM Controls Position** mode, PWM input pulse width is captured by the drive and used to calculate an absolute position. Any pulse width less than or equal to this value (units: us) will result in an absolute position of 0 (+OFFSET). In **PWM Controls Velocity** mode, PWM input pulse width is captured by the drive and used to calculate velocity. Any pulse width less than or equal to this value (units: us) will result in a negative velocity.
Maximum Pulse Width	In **PWM Controls Position** mode, PWM input pulse width is captured by the drive and used to calculate an absolute position. This is the maximum pulse width (in microseconds) that can be used to calculate position. In **PWM Controls Velocity** mode, PWM input pulse width is captured by the drive and used to calculate velocity. This is the maximum pulse width (in microseconds) that can be used to calculate velocity.
Invert PWM Input Signal	Available in **PWM Controls Position** or **PWM Controls Velocity** mode. If selected, invert the PWM input.

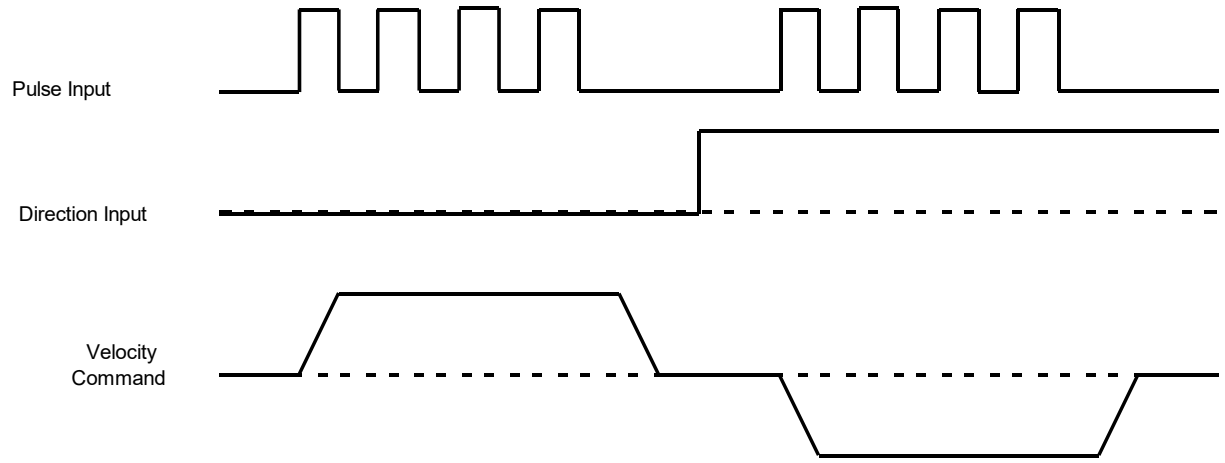
8.3.1 Trajectory Limiting

In Digital Position mode, the drive's Trajectory Generator can be used to create trapezoidal profiles, with programmed acceleration, deceleration, and velocity, from a simple pulse train or burst of pulses. To prevent acceleration limiting by the Trajectory Generator while in Digital or Analog Position modes, set the maximum acceleration to zero. The only limits in effect will now be the velocity loop, velocity limit, and the current limits. (Note that leaving the maximum acceleration set to zero will prevent the other Position modes from operating correctly).

8.3.2 Pulse and Direction

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 in the following diagram.

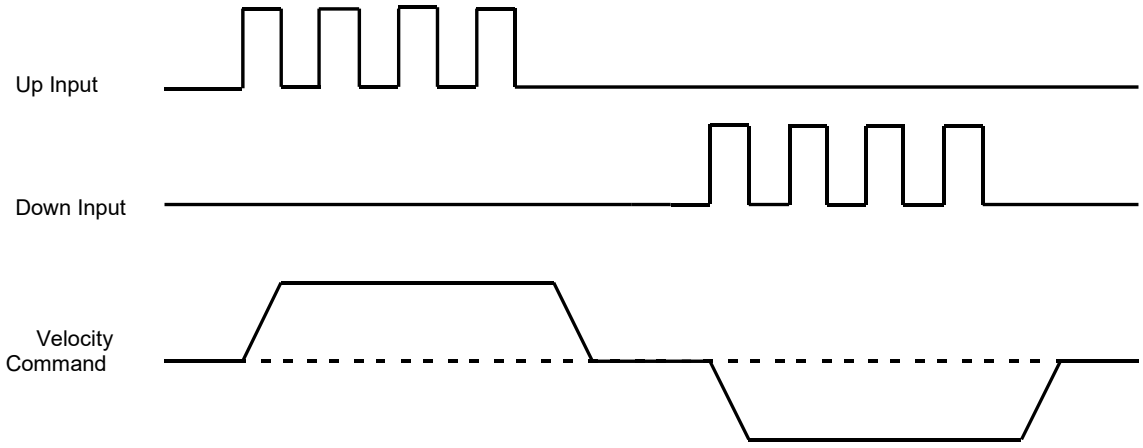
The drive can be set to increment position on the rising or falling edge of the signal. Stepping resolution can be programmed for electronic gearing.



Pulse and Direction Diagram

8.3.3 Count Up/Count Down

In the Count Up/Count Down format, one input takes each pulse as a positive step command, and another input takes each pulse as a negative step command, as shown in the following diagram.



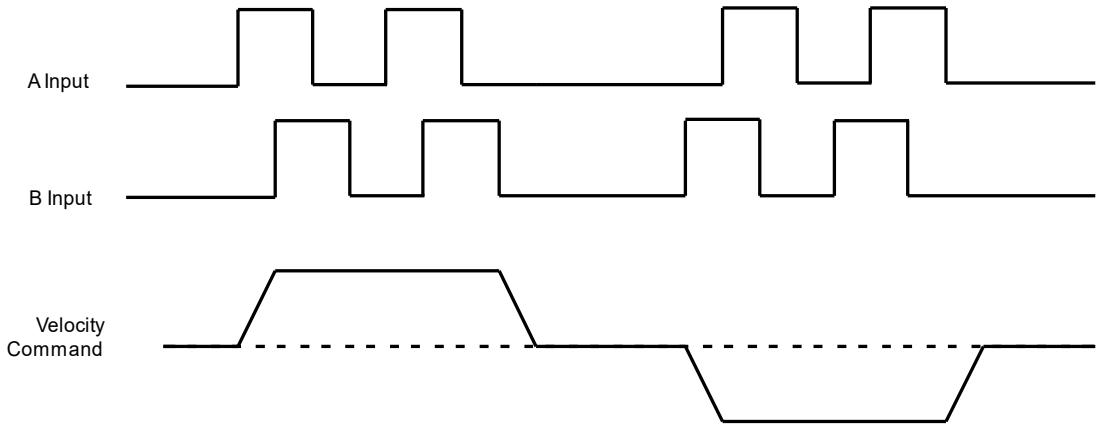
Count Up/Count Down Diagram

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

8.3.4 Quadrature

In Quadrature format, A/B Quadrature commands originating from a Master Encoder provide Velocity and Direction commands, as shown in the following diagram.

NOTE: The ratio can be programmed for electronic gearing.



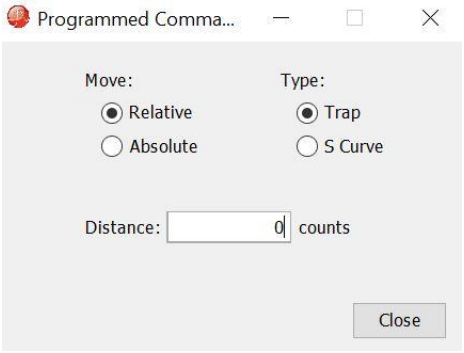
Quadrature Diagram

8.4 Software Programmed Input Settings

The input settings can be saved to flash to allow default conditions to be set. Then, use these settings when the drive is powered up or reset.

8.4.1 Programmed Position

1. From the Main screen, click the **Programmed Position** button.

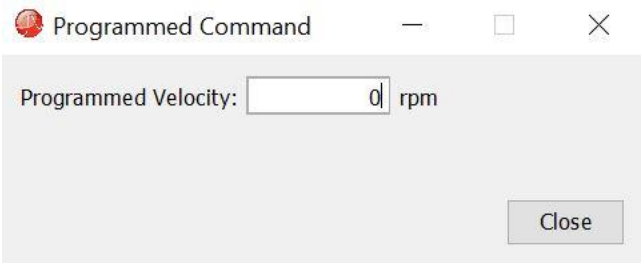


Programmed Command Screen

Setting	Description
Move: Relative	A Relative Move is one that interprets the commanded position as an offset to be added to the actual position. The distance to be traveled is the commanded position.
Move: Absolute	An Absolute Move is one that interprets the commanded position as an absolute position. The distance to be traveled is the difference between the commanded position and the actual position.
Type: Trap (Trapezoidal Profile)	A Trapezoidal Motion Profile allows a specified time (or distance) to be spent at a constant velocity.
Type: S-Curve Profile	An S-Curve Motion Profile smooths the edges of the Trapezoidal Profile, reducing abrupt acceleration changes, thereby improving point-to-point transfer speeds.
Distance	Identify the Move distance (relative) or location (absolute).

8.4.2 Programmed Velocity

1. From the Main screen, click the **Programmed Velocity** button.



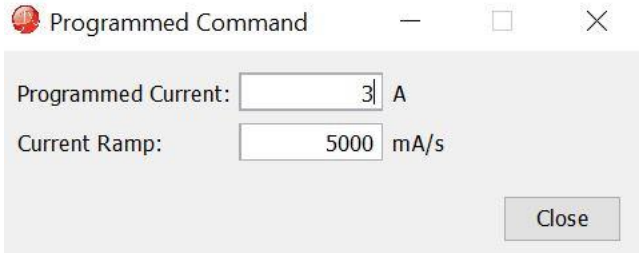
Programmed Command (Velocity) Screen

DANGER	**Risk of potential unexpected movement.** If the Programmed Velocity is set to values other than 0, the motor will move after power-up or reset if the drive is hardware enabled. **Failure to heed this warning can cause equipment damage, injury, or death.**

Setting	Description
Programmed Velocity	Move velocity. Units: rpm (rotary) or mm/s (linear).

8.4.3 Programmed Current

1. From the Main screen, click the **Programmed Current** button.



Programmed Command (Current) Screen

DANGER	**Risk of potential unexpected movement.** If the Programmed Current is set to values other than 0, the motor will move after power-up or reset if the drive is hardware enabled. **Failure to heed this warning can cause equipment damage, injury, or death.**

Setting	Description
Programmed Current	Current applied during the constant velocity portion of the move. Units: A.
Current Ramp	Acceleration/deceleration current. Units: mA/s.

9 NETWORK CONFIGURATION

9.1 CANopen Network

9.1.1 Configuration

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

CAN drives support either CAN or DeviceNet network types. The following groups of CAN capable drives may be configured for the CAN and/or the DeviceNet network.

- ARM & DSP
- PCF (APV, NPP)

  The above groups are available and allow the user to change the Network Type without a new firmware version.
- Other CAN Capable Plus products

  The firmware controls which Network Type is available. To change the Network Type, the user is required to download another firmware option.

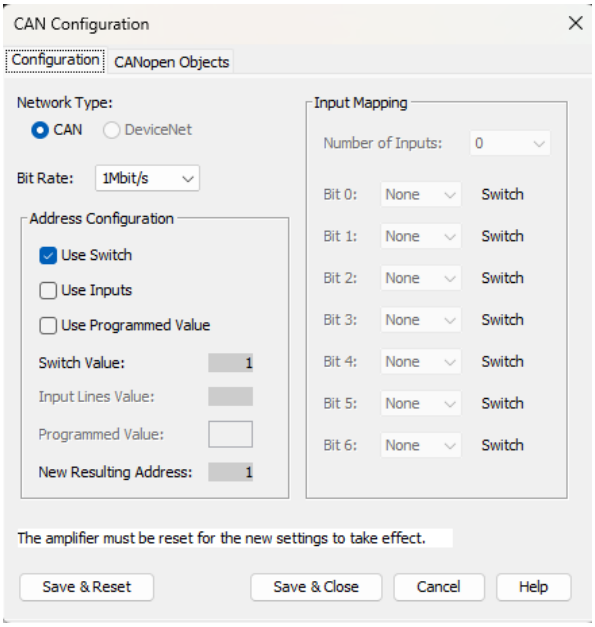
To determine if new firmware is needed to change the Network Type, refer to the applicable datasheet.

The network speed connected to the drive can be configured using the Bit Rate combo box. The CANopen related network settings programmed by the MainDevice are displayed (i.e., Heartbeat, Node Guard Time, Life Time Factor). To clear the settings, press the **Clear** button.

To configure the drive, refer to the following steps.

1. Verify that the CAN network is cabled and terminated as described in the drive datasheet.
2. To open the CAN Configuration screen, click **CAN Configuration** button.

   (If CAN is not the Position Loop Input, choose **Amplifier→Network Configuration** instead).



CAN Configuration Screen

3. Choose a Bit Rate and choose any combination of address sources (Switch, Inputs, and Programmed Value). The address is the sum of the values from these sources.

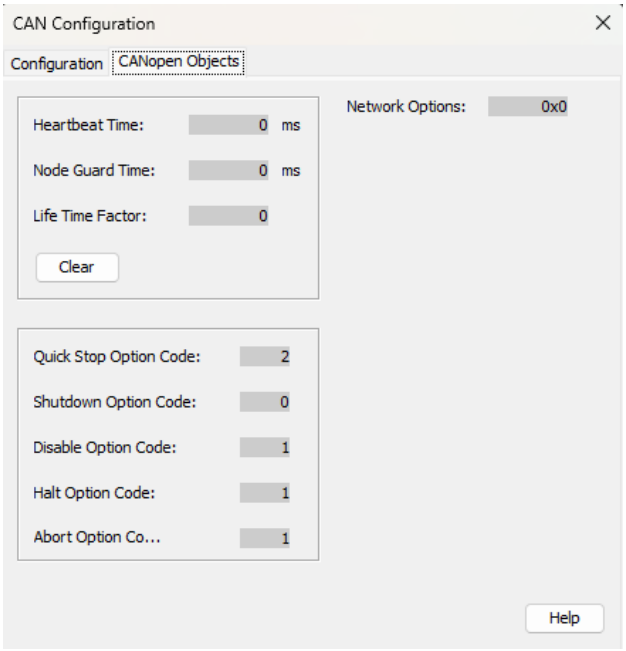
4. For each source selected, perform the additional steps described below.

Source	Additional Steps
Use Switch	Verify the S1 switch setting. (Assigns values for Bit 0 – Bit 3 of CAN address). Also, verify the S2 switch setting.
Use Inputs	Enter **Number of Inputs**, then choose inputs to represent each CAN address bit.
Use Programmed Value	Enter the **Programmed Value**.

5. To ensure the address and bit rate changes take effect, click **Save & Reset**.
6. To save the changes to the drive flash without resetting, click **Save & Close**.
   NOTE: The Address and bit rate changes take effect only after the power-up or the reset.

9.1.2 CANopen Objects

The Network Configuration screen allows the user to monitor the value of certain drive parameters having to do with network management. These parameters are mostly applicable to CANopen network management, so they are referred to as CANopen objects. However some parameters, such as the Network Options parameter, can apply to other types of networks. Please refer to the *Parameter Dictionary* and the *CANopen and EtherCAT Programmer's Manual* for a more detailed description of the objects listed on this screen. The documents are available on the Copley Controls website: www.copleycontrols.com.



CANopen Object	Description
Heartbeat Time	CANopen heartbeat message timeout value. Set to 0 to disable heartbeat messages. Can be cleared using **Clear**. Units: ms.
Node Guard Time	CANopen node guarding timeout value. Set to 0 to disable heartbeat messages. Can be cleared using **Clear**. Units: ms.
Life Time Factor	CANopen node guarding life time factor. Used as a multiplier to Node Guard Time to determine the timeout period. Can be cleared using **Clear**.
Quick Stop Option Code	CANopen quick stop option code. Determines the behavior of the drive when a Quick Stop command is issued.

CANopen Object	Description
Shutdown Option Code	CANopen shutdown option code. Determines the behavior of the drive when its NMT state is changed from "Operation Enabled" to "Ready to Switch On".
Disable Option Code	CANopen disable option code. Determines the behavior of the drive when its NMT state is changed from "Operation Enabled" to "Switched On".
Halt Option Code	CANopen halt option code. Determines the behavior of the drive when a halt command is issued.
Abort Option Code	Abort option code for CANopen/EtherCAT drives. Determines the behavior of the drive when a motion abort occurs.
Network Options	Active (RAM) value of the network options parameter 0x121 in HEX.

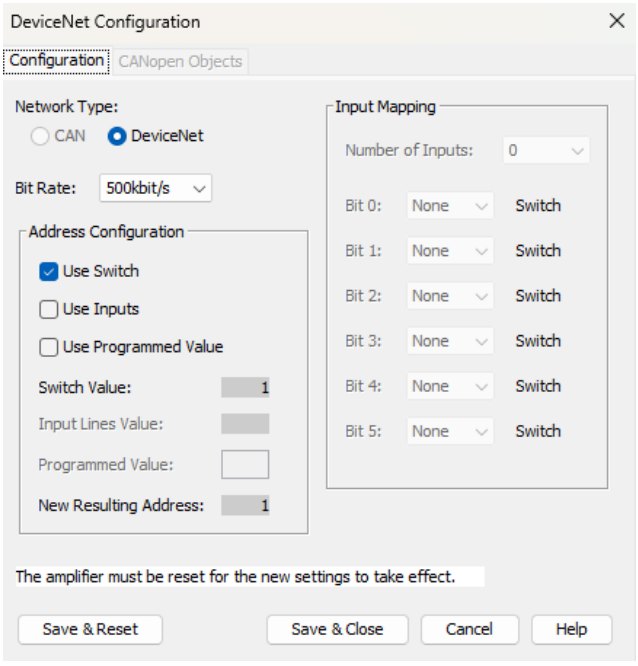
9.2 DeviceNet Network

Copley Controls CANopen drives can be operated over a DeviceNet network by PLCs and other controllers. This function is available to all FPGA and PCF (i.e. APV, NPP) products as well as some ARM (i.e. NPS) products. Only Plus products require a separate DeviceNet firmware to enable this feature. The following groups of CAN capable drives may be configured for the CAN and/or the DeviceNet network.

- ARM & DSP
- PCF (APV, NPP)

  The above groups are available and allow the user to change the Network Type without a new firmware version.
- Other CAN Capable Plus products

  The firmware controls which Network Type is available. To change the Network Type, the user is required to download another firmware option.



DeviceNet Configuration Screen

9.3 MACRO Network

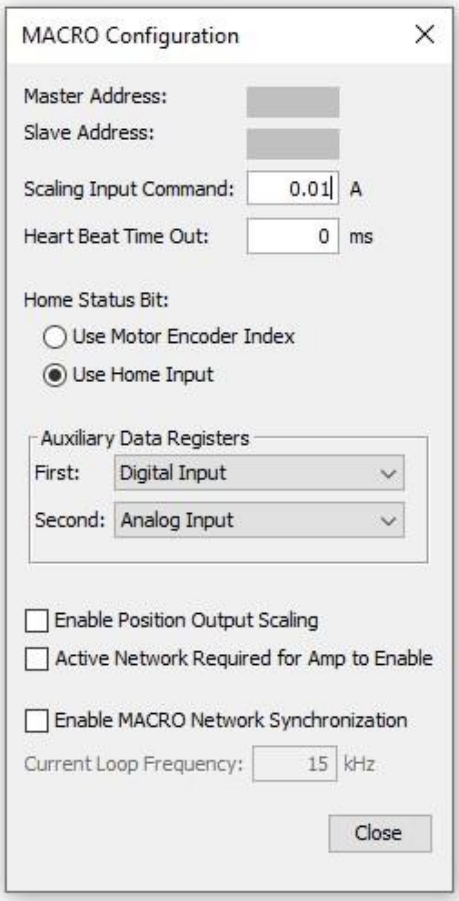
A Delta Tau PMAC controller can hold up to four MACRO IC's, each of which is a master on a MACRO ring. Each master IC can address 16 stations (nodes, slaves), enabling the addressing of up to 64 devices on a ring. Of these devices, 32 can be motion devices such as Copley Macro drives. A node address is an 8-bit value with bits 7-4 addressing the master IC and bits 3-0 addressing the slave.

XML switches S1 and S2 are set to select the master IC to which the Xenus will be linked. The four possible values for this setting are 0,1,2, and 3.

As a MACRO station or node, the XML has eight available addresses as a motion control device. These addresses are: 0,1,4,5,8,9,12, & 13.

1. Verify the S1 and S2 switch settings.
2. From the CME Main screen, select **Amplifier→Network Configuration** to open the MACRO Configuration screen as shown in the following example.

The MACRO Configuration screen is used to view and edit important MACRO network configuration settings. It allows the user to view both the Master and Slave addresses, configure the auxiliary data registers and home status bit. Other important network related settings can be changed from this screen (for example, the Heartbeat Timeout and the Scaling Input Command, among others).



MACRO Configuration Screen

Parameter	Description
Scaling Input Command	**Current Mode**: Output current produced by +10 Vdc of input. Range: 0 to 10,000,000 A. Default: Peak Current value. **Velocity Mode:** Velocity produced by +10 Vdc of input. Range: 0 to 100,000 rpm (mm/sec). Default: Maximum Velocity value.
Heart Beat Time Out	The frequency at which the drive will produce heartbeat messages. This parameter may be set to zero to disable heartbeat production.
Home Status Bit	**Use Motor Encoder Index:** Return the primary encoder index state in the home status bit of the MACRO status word. **Use Home Input:** The state of any general-purpose input configured as a home input will be returned in the home status bit of the MACRO status word.
Auxiliary Data Registers	Defines what type of additional data is transmitted in the Auxiliary data registers of every MACRO response message. **First Register**: Digital Input Value, Secondary Analog Input Value. **Second Register**: Analog Input, Motor Encoder, Position Encoder.
Enable Position Output Scaling	When selected, the position data sent over the MACRO network is shifted up 5-bits to be compatible with Delta-Tau controllers.
Enable MACRO Network Synchronization	Allows the drive's PWM frequency to be adjusted to allow synchronous operation with the MACRO ring. Note that changing the PWM Frequency will affect the current loop tuning. Therefore, current loop tuning will need to be checked.
Current Loop Frequency	
Active Network Required for Amp to Enable	If selected, the drive will not enable if the network is not active.

9.4 EtherCAT Network

An EtherCAT network enables high-speed control of multiple axes while maintaining tight synchronization of clocks in the nodes. Data protocol is CANopen over EtherCAT (CoE) based on DS-402 for motion control devices.

Nodes on EtherCAT are automatically addressed by their bus location.

- The first drive on the network is assigned node address -1.
- The second drive on the network is node address -2, and continues sequentially.

As an alternate to the default addressing, switches S1 and S2 may be used to program a node alias. If the switch-based node alias is used, it is the responsibility of the user to ensure that each drive has a unique node alias.

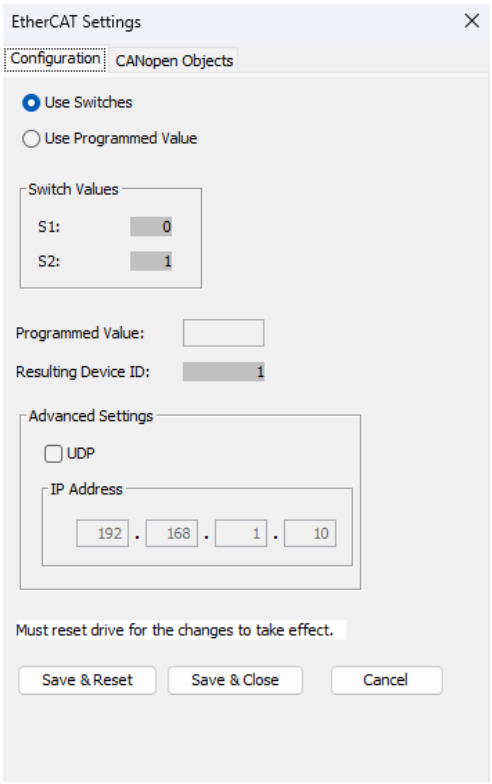
For EtherCAT capable PCF products, the user can change the Network Type without a new firmware version between EtherCAT and Ethernet. The following options are also available.

- EtherCAT capable ARM products (IES, NES, XES, etc.) are only EtherCAT available.
- Some MACRO amplifiers (BML, XM2) may be configured for the EtherCAT or Ethernet network if the specific firmware option is downloaded.
- Other EtherCAT Capable Plus products

  The user is required to download another firmware option.

EtherCAT Address (Node Alias)

1. From the CME Main screen, select **Amplifier→Network Configuration** to open the EtherCAT Settings screen as shown in the following example.
2. Choose either address sources (Switch or Programmed Value). The address is the sum of the values from these sources.



EtherCAT Settings Screen

Source	Additional Steps
Use Switch	Verify the S1 and S2 switch settings. (Assigns values for Bit 0 – Bit 3 of node address.)
Use Programmed Value	Enter the Programmed Value.

9.5 Ethernet Network

Copley Controls EtherCAT drives can communicate over standard Ethernet protocols when the drive is set to standard Ethernet mode. Standard Ethernet mode disables EtherCAT support and enables a number of different Ethernet protocols. Copley Controls EtherCAT drives can communicate using the following Ethernet protocols.

- UDP Command
- DHCP Support
- Ethernet/IP
- TCP/IP
- Modbus over TCP

Additionally, PCF drives and some ARM drives can support both EtherCAT and Ethernet. Only "Plus" drives require special firmware.

For EtherCAT capable PCF products, the user can change the Network Type without a new firmware version between EtherCAT and Ethernet. The following options are also available.

- EtherCAT capable ARM products (IES, NES, XES, etc.) are only EthercCAT available.
- Some MACRO amplifiers (BML, XM2) may be configured for the EtherCAT or Ethernet network if the specific firmware option is downloaded.
- Other EtherCAT Capable Plus products

  The user is required to download another firmware option.

When establishing Ethernet communications, two parameters need to be set on the drive.

1. Parameter 0x121 (Network Configuration) should be set to the value 0x0200.
   This parameter configures the drive to listen for Ethernet packets. Drives using Ethernet firmware have this value set by default.
2. Parameter 0x11F (IP Address) should be set to a valid IPV4 address for the Ethernet network to which the drive is attached.

IP addresses are normally written out as a series of four decimal values separated by periods such as: 192.168.1.1

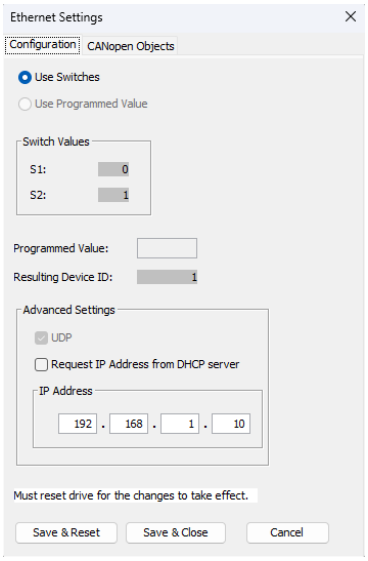
When passed to parameter 0x11F, the four decimal values should be packed into a single 32-bit value in little endian format.

The IP address can be set in the following way through the CME GUI.

3. In the CME Main screen, go to **Amplifier->Network Configuration** to open the following screen. Enter the desired IP address into the corresponding text field, then click "**Save and Reset**" or "**Save and Close**". This will save the IP address in the drive.

9.5.1 Ethernet Settings Screen

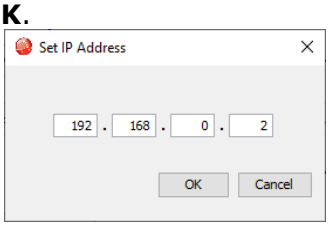
The Ethernet Settings screen is used to configure important settings related to the Ethernet network. The user can read the switch values and resulting device ID. They can also set the IP address manually or request the IP address be set via Dynamic Host Configuration Protocol (DHCP) from an external network server connected to the drive.



Ethernet Settings Screen

Options	Description
Use Switches	Not applicable to Ethernet applications. Used for node addressing in CAN/ECAT networks.
Use Programmed Value	Not applicable to Ethernet applications. Used for node addressing in CAN/ECAT networks.
Switch Values S1: & S2:	Resulting values from hardware network switches. Not applicable to Ethernet applications.
Programmed Value:	Not applicable to Ethernet applications. Used for node addressing in CAN/ECAT networks.
Resulting Device ID:	Resulting value from software programmed network address. Not applicable to Ethernet applications.
Advanced Settings-UDP	Checking this option sets the Network Options Parameter to operate in Ethernet mode instead of standard EtherCAT operation. Checked by default when using Ethernet flavor firmware.
Advanced Settings- Request IP Address from DHCP Server	Dynamic Host Configuration Protocol (DHCP) can be used to request the IP address to be set in the drive from an external network server connected to the drive.
IP Address	Use these text fields to write a valid IP address to the drive so that it can be recognized on an Ethernet network.
Save & Reset	Saves the entered values from the above fields to the drive's Flash memory as a Reset (this is done to set the values in RAM as well).
Save & Close	Saves the entered values from the fields above to the drive's Flash memory and closes the Network Configuration screen.
CANopen Objects	Shows the active value of the network options parameter 0x121 in HEX.

1. In the CME Main screen, select **Tools->Set IP Address** to open the following screen. Enter the desired IP address and click **OK**.



Set IP Address Screen

10 FAULTS

10.1 Overview

10.1.1 Latched vs Non-Latched Faults

When a fault is configured to be latched, the fault can only be cleared after the fault is corrected and at least one of the following actions is done:

- Power-cycle the drive.
- Cycle (disable and then enable) an input that is configured as Enable with Clear Faults or Enable with Reset.
- Open the Control Panel and press **Clear Faults** or **Reset**.
- Clear the fault over the CANopen network or serial bus.

After the fault condition is removed, a non-latched fault is cleared. This action can occur without the operator intervention.

DANGER	**Risk of unexpected motion with non-latched faults.** After the cause of a non-latched fault is corrected, the drive re-enables the PWM output stage without operator intervention. In this case, motion may unexpectedly re-start. Configure the 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.**

10.1.2 Fault Example

The drive's temperature reaches the fault level. The drive reports the fault and disables the PWM output. Then, the drive temperature falls below the fault level.

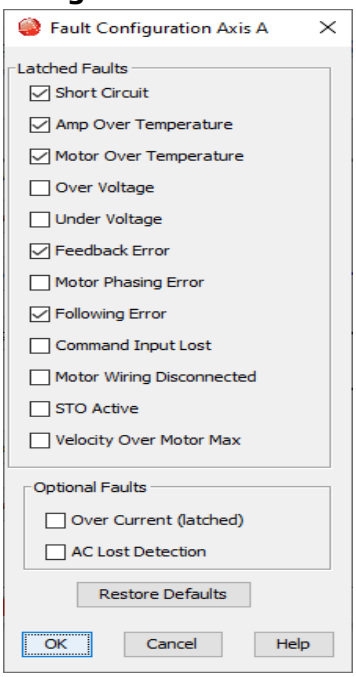
Non-Latched Fault Operation:

The fault is cleared and the drive's PWM outputs are enabled without operator intervention.

Latched Fault Operation:

The fault remains active and the drive's PWM outputs remain disabled until the faults are cleared as described above.

1. From the Main screen, click the **Configure Faults** button.



Fault Configuration Axis A Options Screen

2. Select the faults to latch. See the Section: Fault Descriptions.
3. To close the screen and save the changes to drive RAM, click **OK**.
4. On the Main screen, click **Save to Flash** to avoid losing the changes.

NOTE: On the Fault Configuration Axis A screen, refer to the following descriptions for the Restore Defaults and Help buttons.

- The **Restore Defaults** button will restore the fault configuration to the factory default settings.
- The **Help** button displays a helpful message detailing the use of the Fault Configuration screen and what happens in the event of a latched fault.

10.2 Fault Descriptions

NOTE: The list of faults may vary with the drive model.

Fault Description	Fault Condition Error	Fault Condition Correction
*Amp Over Temperature	Drive's internal temperature exceeds specified temperature.	Drive's internal 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 the Section: Troubleshoot Manual Phase w/ Encoder and Halls
*Feedback Error	Over current condition detected on the output of the internal +5 Vdc supply used to power the feedback. Resolver or analog encoder is not connected, or the levels are out of tolerance. Differential signals from the incremental encoder are not connected.	Encoder power returns to specified voltage range. Feedback signals stay within specified levels. Differential signals connected.
*Motor Over Temp	Motor over-temperature switch changes state to indicate an over-temperature condition.	Temperature switch changes back to normal operating state.
Under Voltage	Bus voltage falls below specified voltage limit.	Bus voltage returns to specified voltage range.
Over Voltage	Bus voltage exceeds specified voltage limit.	Bus voltage returns to specified voltage range.
*Following Error	User set Following Error threshold exceeded.	See the Section: Following Error Fault Details
*Short Circuit Detected	Output to output, output to ground, internal PWM bridge fault.	Short circuit has been removed.
Command Input Lost	PWM or other command signal is not present.	Command signal restored.
Over Current (Latched)	Output current I^2T limit has been exceeded.	Drive is reset and re-enabled.
Motor Wiring Disconnected	The drive detects that it cannot push current through the motor windings.	The motor is reconnected.
STO Active	STO Activated for safe torque OFF.	STO is deactivated and the fault bit is cleared.
Velocity Over Motor Max (Plus drives only)	Filtered velocity exceeds the motor's maximum velocity setting.	Velocity is within the admissible range and the fault bit is cleared.
*Latched by default.		

11 MOTOR PHASING

11.1 Auto Phase

In this Section, the examples show the drive operating modes and the motor feedback configurations. Some screens and choices may vary from those described in this Section.

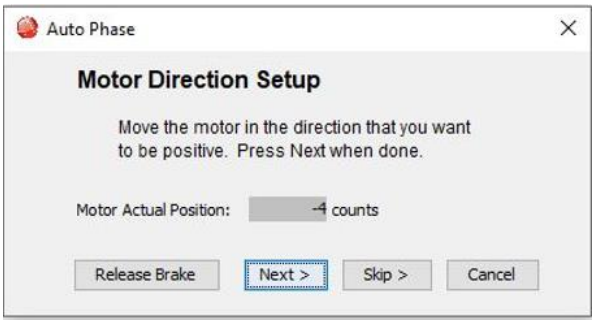
11.1.1 Auto Phase Example: Servo Drive

During Microstepping, a current vector is applied to the motor windings and microstepped through an electrical cycle at a set rate, causing the motor to move.

- If you chose to Skip the Motor Direction Setup step, Auto Phase will prompt for confirmation of the correct motor direction.

NOTE: The following steps describe the Auto Phase with a Brushless Rotary Motor, Digital Halls, and an Incremental Quadrature Encoder. The screens may vary for other configurations.

1. Verify the Enable Input is active and the HV or AC power is applied.
2. On the Main screen, click **Auto Phase** button on the toolbar.



Auto Phase Screen

3. Move the motor in the direction to be considered positive.

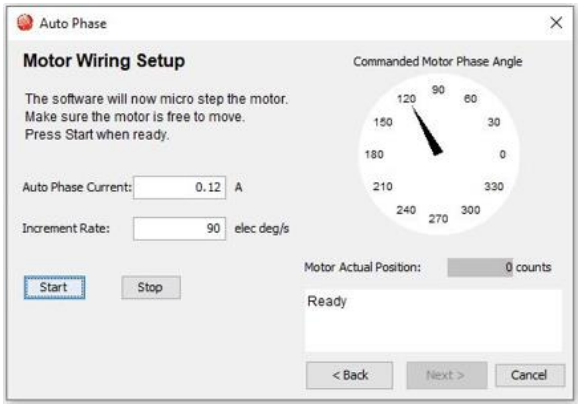
   OR

   If you cannot move the motor, click **Skip** (you can confirm the motor direction later).

NOTE: If an output is configured as a brake, you can temporarily release the brake by holding down the **Release Brake** button. The brake will be reactivated when you release the button.

WARNING	**Brake Warning** If you are working with the vertical axis releasing the brake may cause the system to drop!

4. To access the Motor Wiring Setup step, click **Next**.



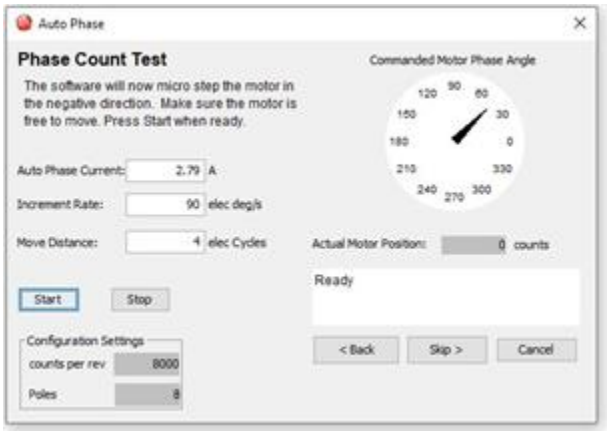
Motor Wiring Setup Screen

5. To start the Motor Wiring Setup process, click **Start** button.
6. The message area displays the following messages:
   - Configuring Initial Settings
   - Microstepping
   - Test Complete
   - Motor Wiring is configured.

If the step fails, see the Section: Troubleshooting the Auto Phase Problems.

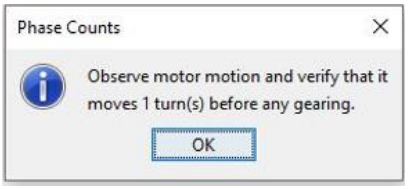
NOTE: If incorrect values were entered for inductance and resistance, the calculated Cp and Ci values may produce current loop oscillation, evidenced by an audible high frequency squeal during auto phasing.

7. To go to the Phase Count Test step, click **Next**.

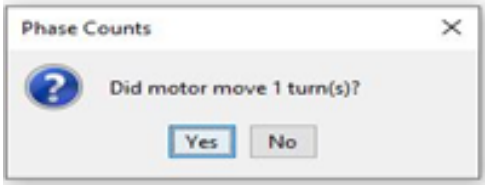


Auto Phase (Phase Count Test) Screen

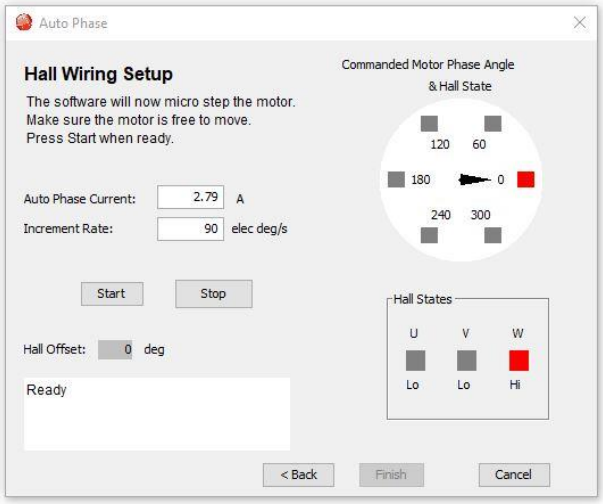
8. Click **Start** button to begin the Phase Count Test. Observe the status messages. See the following prompt.



9. When you are ready to observe motion, click **OK**.
   When the motion is complete, the prompt will be displayed.
   - If the motor did not turn one-full turn, click **No** and see the Section: Troubleshooting the Auto Phase Problems.
   - If the motor turned one-full turn, click **Yes**.



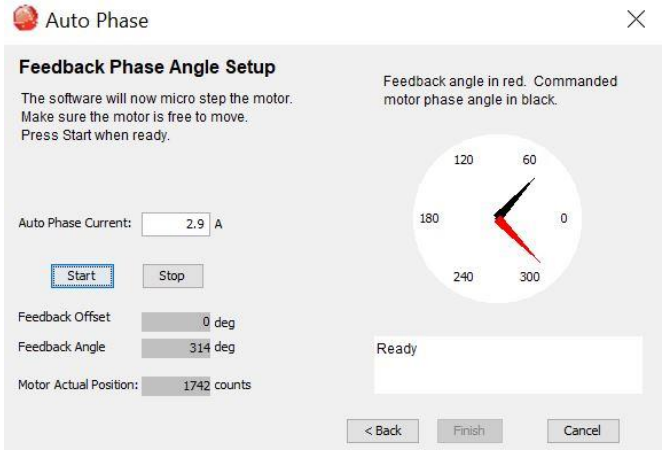
For a Resolver (–R) version of a Copley Controls drive, skip to Step 12.
For a non-resolver drive, click the **Next** button to open the Hall Wiring Setup screen.



Auto Phase (Hall Wiring Setup) Screen

10. Click **Start** to begin the Halls Wiring Setup. The message area displays the messages: **Microstepping. Test Complete. Motor is properly phased**.

    If the step fails, see the Section: Troubleshooting the Auto Phase Problems.
11. For a Resolver (-R) version of a Copley Controls drive, click **Next** to open the Resolver Phase Angle Setup screen.



Auto Phase (Feedback Phase Angle Setup) Screen

12. To start the Resolver Phase Angle Setup, click **Start**. The message area displays status messages.
13. To close the screen and save the values to flash memory, click **Finish**.
    Or, to close the screen without saving changes, click **Cancel**.
14. If the Auto Phase algorithm does not produce the desired results, adjust the Auto Phase Current and Increment Rate values, using the guidelines in the Section: Guidelines for Auto Phase Current and Increment Rate.
15. If the desired results are not obtained or you need to confirm the results, proceed to the Manual Phase.

11.1.2 Auto Phase Example: Stepper Drive, No Encoder

1. Verify the Enable Input is active and the HV power is applied.
2. On the Main screen, click the **Auto Phase** button on the toolbar.



Auto Phase (Motor Direction Setup) Screen

3. To move the motor in the direction considered positive and observe the direction of the movement, press the **Move POS** button.
   If the motor does not move, see the Section: Troubleshooting the Auto Phase Problems.
4. If the motor moved opposite to the direction that you want to program as positive, click **Invert Motor Output field**.
5. To save the direction setting, click **OK**.

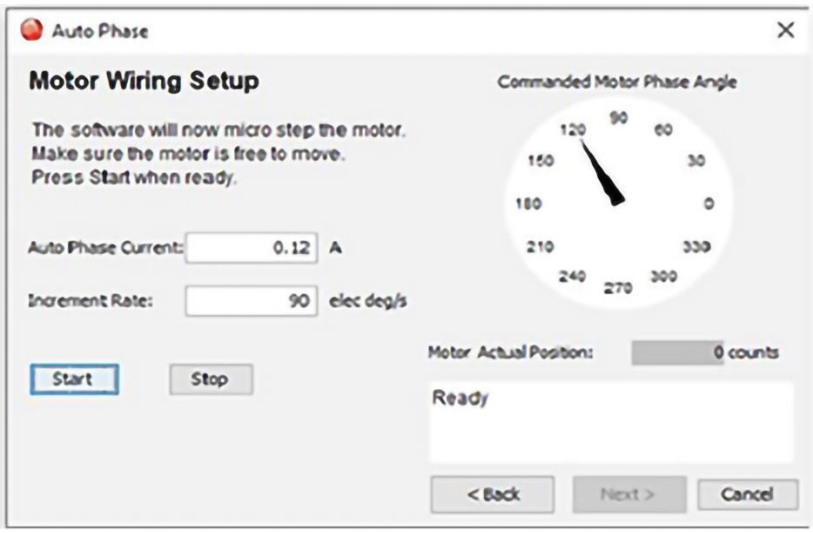
11.1.3 Auto Phase Example: Stepper Drive with Encoder, in Stepper Mode

1. Verify the Enable Input is active and the HV power is applied.
2. On the Main screen, click **Auto Phase** button on the toolbar.



Motor Direction Setup Window

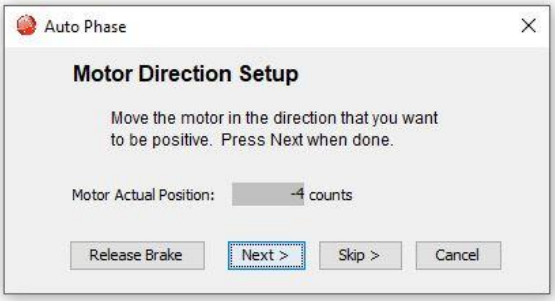
3. Move the motor in the direction you want to assign as positive.
4. Activate the Enable Input.
5. Click **Next** to open the Auto Phase Motor Wiring Setup screen.
6. To begin the Motor Wiring Setup with default values, click **Start**.
7. After the successful Motor Wiring Setup, the message "Test Complete" appears.
8. To close the screen and save the values to the flash memory, click **Finish**.



Auto Phase (Motor Wiring Setup) Example

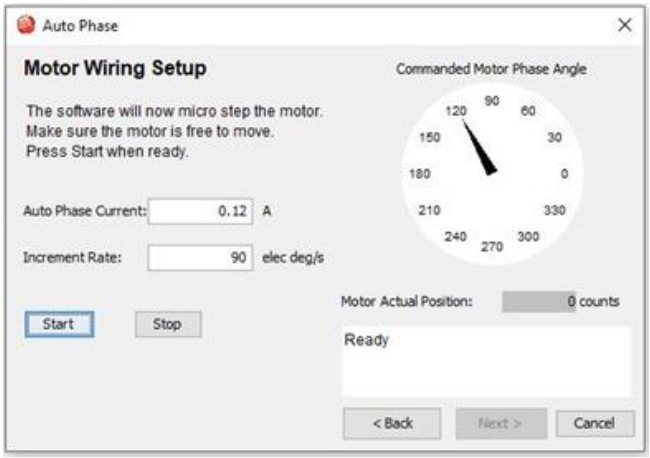
11.1.4 Auto Phase Example: Stepper Drive with Encoder, in Servo Mode

1. Verify the Enable Input is active and the HV power is applied.
2. On the Main screen, click **Auto Phase** button on the toolbar.



Motor Direction Setup Window

3. Move the motor in the direction to which you want to assign as positive.
4. Activate the Enable Input.
5. To open the Auto Phase Motor Wiring Setup screen, click **Next**.

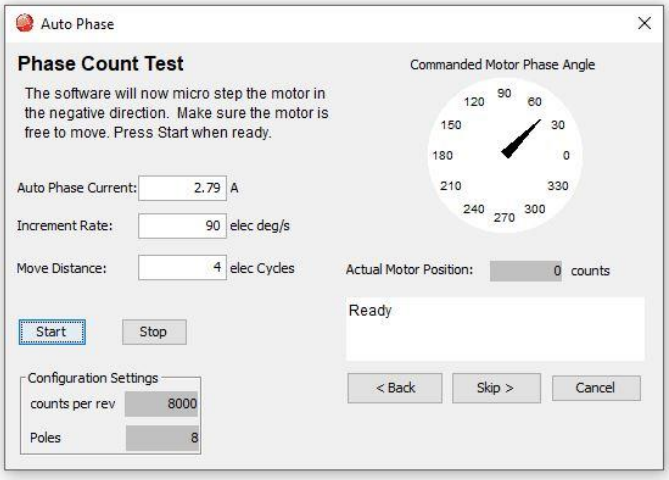


Auto Phase (Motor Wiring Setup) Example

6. To begin the Motor Wiring Setup process, click **Start**.
   The message area displays any of the following messages:
   - Configuring Initial Settings
   - Microstepping
   - Test Complete
   - Motor Wiring is configured.

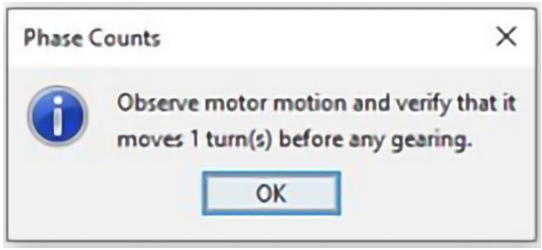
   If the step fails, see the Section: Troubleshooting the Auto Phase Problems.

   NOTE: If the 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 that resounds during the Auto Phasing process.
7. To open the Auto Phase Count Test screen, click **Next**.



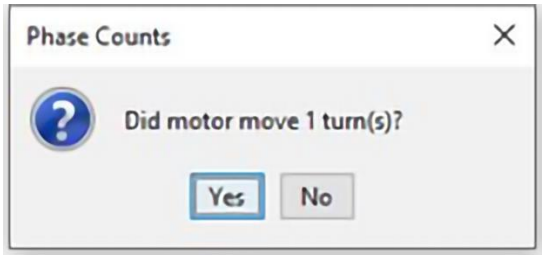
Auto Phase Count Test Screen

8. To begin the Phase Count Test step, click **Start**. Observe the status messages and the following prompt displays.



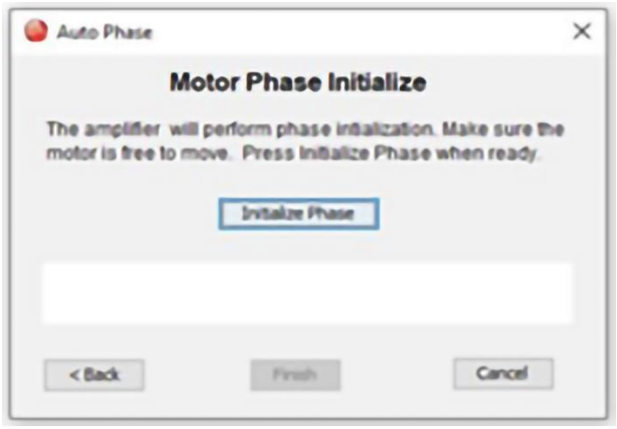
Phase Counts (Verify) Prompt

9. When you are ready to observe the motion, click **OK**. The following prompt displays.



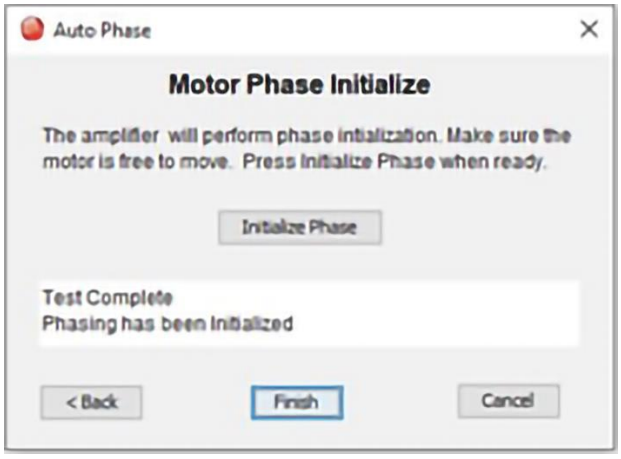
Phase Counts (Motor Turn) Prompt

10. Click **Next** to open the Auto Phase Motor Phase Initialize screen.



Auto Phase (Initialize Phase) Prompt

11. Click **Initialize Phase** to start the phase initialization. If successful, a message displays: **"Test Complete. Phasing has been initialized."**
12. Click **Finish** to close the screen and save the values to flash memory.



Auto Phase (Motor Phase Initialize) Screen

11.2 Guidelines for Auto Phase Current and Increment Rate

The following is a list of the recommended guidelines for the Auto Phase Current and Increment Rate.

- If the friction is high, then more current may be required to move the load.
- High static friction (stiction) may require more current to begin motion.
  NOTE: Stiction is a high static friction.
- Transition from static friction to dynamic friction, and back, may produce a jerky motion.
- A faster increment 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.

11.3 Troubleshooting the Auto Phase Problems

11.3.1 Motor Direction Setup	
Issue	**Troubleshooting Steps**
If the Motor Direction Setup step failed:	• Check the Encoder or the resolver power and signals. • Verify that the encoder is differential. (Contact the factory if the encoder is single-ended). • Check the shielding for proper grounding.
11.3.2 Motor Wiring Setup	
If the Motor Wiring Setup step failed:	• Verify that the drive is disabled. • Check for any mechanical jamming. • Check for smooth motion with no mechanical jerking. • Check for good connections to the motor power wires. • Disconnect the motor power wires and measure for the proper motor resistance.
11.3.3 Phase Count Test	
If the Phase Count Test failed:	Verify that in the Motor/Feedback screen the following parameters have been set correctly: • Number of Poles for rotary motors. • Verify the motor's pole count. • Magnetic Pole Pair Length for linear motors. • Encoder Lines or Fundamental Lines for rotary encoders.
11.3.4 Halls Wiring Setup	
If the Halls wiring setup step failed:	• Check Halls power and signals. • Check for smooth motion with no mechanical jerking. • Check shielding for proper grounding.
If the Auto Phase procedure fails despite these corrective measures, see the Section: Manual Phase.	

11.4 Manual Phase

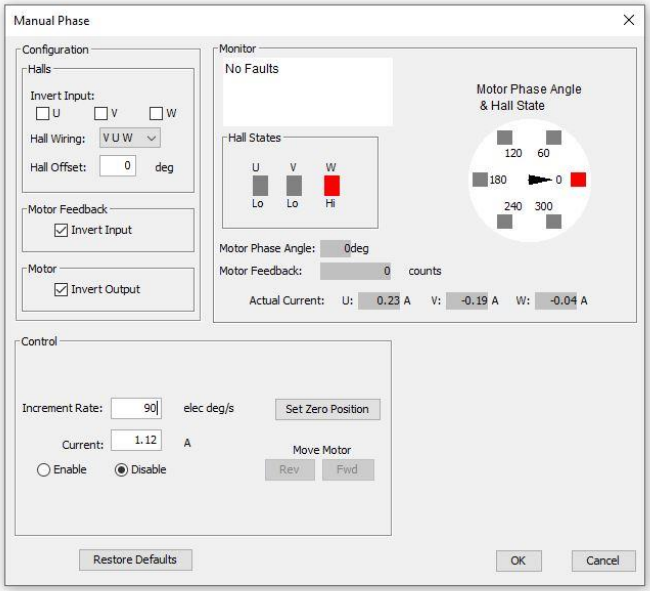
11.4.1 Manual Phase Options

The Manual Phase screen is used to view the difference between commanded and actual motor phase angle as well as the corresponding hall states while moving the motor. The user can do the following:

- configure the amplitude and increment rate of the commanded electrical phase angle.
- set the zero position of the feedback device.
- enable/disable the motor or move forward/reverse.

The user can also invert any or all of the motor hall inputs or change the hall offset or hall wiring.

1. Remove the load from the motor.
2. On the Main screen, choose **Tools→Manual Phase** to open the window.

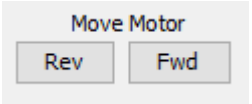


Manual Phase Screen

3. Verify the **Current** setting before enabling the drive.



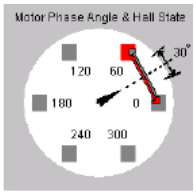
4. To control the current vector rotation, command the motor forward or reverse.



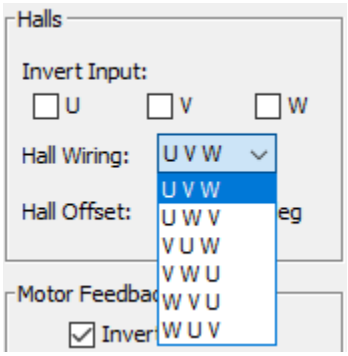
NOTE: Some motors have bearings stiction, so helping the motor with mechanical force is acceptable. Motors with no friction may need friction added to steady motion.

5. If the motor cannot keep up with the rate of vector rotation, then reduce the Increment Rate or increase the Current.
6. Verify that pressing the **Forward** button moves the motor forward.
   If the motor moves in the wrong direction, toggle the Motor Invert Output setting.
7. Verify actual position count agrees with the 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.
8. If the motor has no Halls, skip to Phase Initialization for Motor without Halls.
9. Monitor the vector rotation through one electrical cycle for proper Hall transitions.

10. Verify the following events occur:
    - the red indicator rotates in the same direction as the motor phase angle.
    - the transition occurs when the needle is between indicators (±30 degrees, as shown below).



If the needle and Hall states do not track properly, use the Hall Wiring list box and/or Invert Input options (shown in the Halls screen) to swap the drive's Hall wire configuration.



Halls Screen

If the red indicator transition leads or lags behind the centered needle by more than 30 degrees, then adjust the Hall Offset in +/- 30-degree increments.



11. Phasing of a motor with encoder and Halls is complete. Click **OK**.

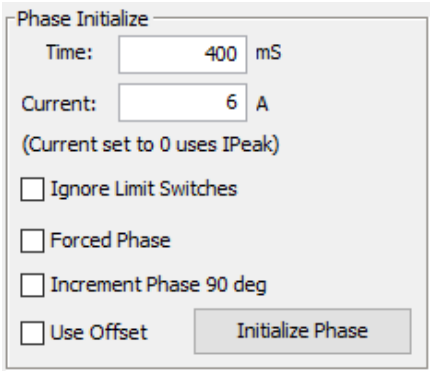
11.4.1.1 Phase Initialization for Motor without Halls (Algorithmic Phase Initialization Mode)

The Phase Initialization is designed to phase a motor with no Halls.

DANGER	**Halls are strongly recommended for a safe, redundant system.**
	Copley strongly recommends the use of Halls or a commutating encoder for commutation to provide a safe, redundant system. If the application requires it. Otherwise, the customer accepts responsibility for verifying the system performance and reliability.
	Failure to heed these warnings can cause equipment damage, injury, or death.

The Phase Initialization function uses as little motion as possible (less than 1/3 of one electrical cycle) to determine phasing. Phase Initialization drives the motor in an open loop current mode, using micro stepping of a current vector.

1. Ensure the motor is free to move (for instance, make sure the brake is OFF).
2. Ensure that no external force, such as gravity, will cause the motor to move. If it is not practical to eliminate such forces, it may be necessary to use the Forced Phase feature described later in table settings on the next page.
3. To phase a motor with an encoder and no Halls, click **Initialize Phase**.
   Observe the status messages under Monitor.
4. If the message "Phase Initialized" appears, the phasing of a motor with the encoder and no Halls is complete. Click **OK** to close the Manual Phase window.



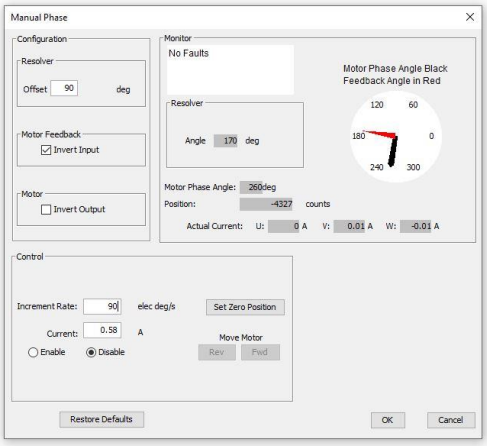
Phase Initialize Screen

If the phasing function fails (for instance, message "Phase Initialized" is not displayed, or if a phasing fault is indicated) adjust the phase initialization settings described below and try Step 4 (**Initialize Phase**) again.

Setting	Description
Time	Used first as a delay, allowing the drive to ramp up the current to drive a small move. Then, it is used as a settling time. If the value is too low, the settling may not occur in time, resulting in jerky motion. Default: 400 ms.
Current	Use to overcome stiction when rotating the current vector. If the current is too large, the motion may not settle; a low value may not provide enough current to drive a move.
Ignore Limit Switches	If selected, Limit Switches are not activated.
Forced Phase	When selected, Forced Phase causes the Phase Initialization function to apply Phase Init Current to alternate pairs of motor wires using the Phase Init Time. Forced Phasing has been used to overcome various phasing problems, including situations where gravity introduces unwanted motion. Forced Phasing tends to produce more jerk and apparent motion.
Increment Phase 90 deg	If set, the drive will increase the starting phase angle by 90 degrees after every failed initialization attempt.
Use Offset	If set, the drive uses the Hall Offset value as the initialization starting angle.

11.4.2 Manual Phase Example: Motor with Resolver

1. Make sure that no load is connected to the motor.
2. On the Main screen, choose **Tools→Manual Phase** to open the window.

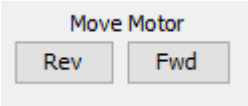


Manual Phase Screen

3. Verify the **Current** setting before enabling the drive.



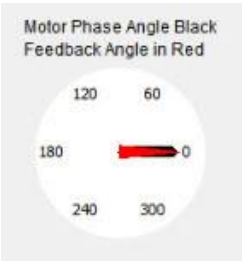
4. To control the current vector rotation, in the Move Motor section, click **Rev** button to reverse the motor or click **Fwd** button to move the motor forward.



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

5. If the motor cannot keep up with the rate of the vector rotation, then reduce the Increment Rate or increase the Current.
6. Verify that pressing the **Fwd** button moves the motor forward. If it does not move, toggle the Motor Invert Output box setting.
7. Verify the actual position count agrees with the 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.
8. Adjust the Resolver Offset configuration as required, testing **Fwd** and **Rev**, to produce the alignment of the Motor Phase Angle with the Resolver Angle as shown in the diagram.

NOTE: Motor manufacturers typically align the resolver in 30-degree increments, by applying the current through a pair of motor power wires.



11.5 Troubleshoot Manual Phase w/ Encoder and Halls

To perform Trapezoidal Commutation after power-up or reset, the drive must receive good Hall signals. After the first Hall transition is detected, then Sinusoidal Commutation can be performed.

In Sinusoidal Commutation, the drive uses the encoder for commutation while monitoring the Halls to verify the proper phase. If the error between the encoder count and the Hall transition is too large, then the Hall phase correction will not be performed and a phase fault will be triggered. Test for the phase fault problems in the order shown in the following table.

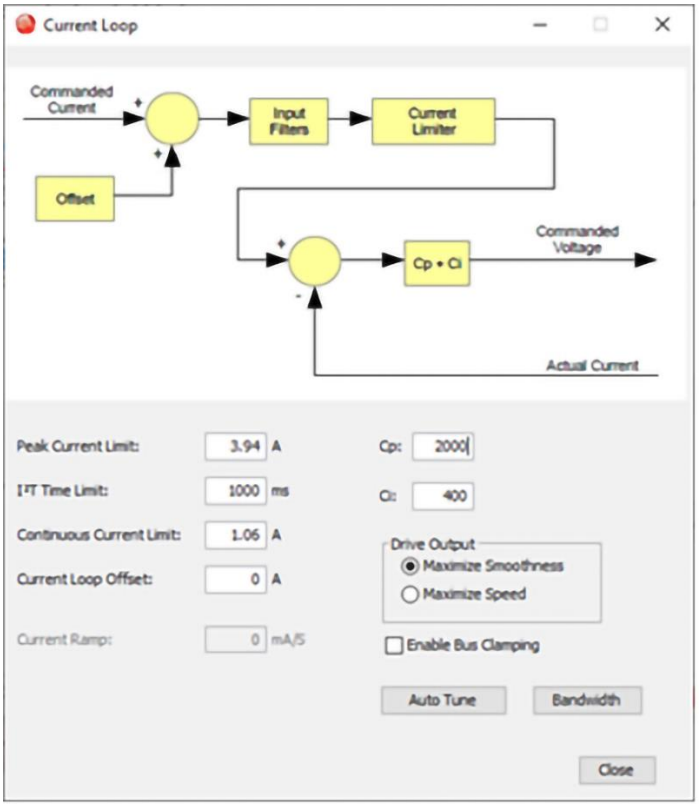
Tests for Phase Fault Issues:	Troubleshooting Steps:
11.5.1 Data Accuracy Test	
1.-Verify the motor's pole count. 2.-Verify the encoder line count OR a linear motor's magnetic pair length and the encoder resolution.	• Apply a current vector at zero Increment Rate to lock the motor in position. • Turn the motor shaft and count the number of distinct locking positions. • Calculate the number of poles. • Poles = number of locking positions *2.
11.5.2 Encoder Wiring Test	
If the Halls produce good trapezoidal commutation but a phase fault is persistent in sinusoidal commutation mode, the encoder is highly suspect:	• Verify the differential encoder signals. • Verify there is proper twisted-shielded cable with good grounding. • Disable the drive and move the motor manually to test for the phase fault. • If the phase fault only occurs under command of current, make sure the motor power cable is not bundled with the encoder cable.
11.5.3 Hall Signals Test	
If the Halls signals are suspected to be faulty:	• Make sure Halls change states as the motor moves through one electrical cycle. • Some Hall signals are noisy and require filtering. Check with motor manufacturer. • Some Halls are not properly calibrated to the motor manufacturer's specification.
11.5.4 Hall Transition Test	
If the location of the Hall transition is not within +/-30 degrees:	• Adjust the Hall offset in smaller increments. • Verify the Hall alignment. • Make sure the motion is smooth.

12 CONTROL LOOPS

12.1 Current Loop Setup and Tuning

Initial Current Loop Proportional Gain (**Cp**) and Current Loop Integral Gain (**Ci**) values can be calculated with Calculate.

To open the Current Loop screen, click **I Loop** button.



Current Loop Screen

Parameter	Description
Peak Current Limit	Used to limit the peak phase current to the motor. Max. value depends upon the drive model; Min. value > continuous limit.
I^2T Time Limit	Sets I^2T Time Limit in ms. See I^2T Time Limit Algorithm.
Continuous Current Limit	Used to limit the Phase Current. Max. Value is < Peak Current and depends upon the drive model. Min. value: 0
Current Loop Offset	Sets the Current Loop Offset. Leave it set to zero until after tuning. For more information, see the Section: Current Loop Offset.
Cp	Current Loop Proportional Gain. Range 0 – 32,767.
Ci	Current Loop Integral Gain. Range 0 – 32,767.
Current Ramp (mA/s)	Used only when it is in the Current mode. Default value is 0 which disables the ramp rate limit.
Drive Output	**Maximize Smoothness:** Drive uses circular vector limiting to produce smooth operation even into the voltage limits. **Maximize Speed:** Allows for slightly more of the bus voltage to be used when in the voltage limit. This may produce a small disturbance at top speed.

Parameter	Description
Enable Bus Clamping	Checking the option disables space vector modulation and may reduce 120 Hz AC line ripple when holding position near zero current. If unchecked, it may allow for higher speeds.
Auto Tune	See the Section Current Loop Auto Tune.
Bandwidth	Measure bandwidth using the Cp and Ci values now in the drive.

12.1.1 Current Loop Manual Tune

Scope

The Scope is a powerful tool that can be used to tune the gains in each of the control loops of the drive. During the tuning process, the Scope traces are recorded while the Trajectory Function Generator commands functional waves to any of the active control loops. The effect of changing the gain values and/or Trajectory Generator limits can be seen in the scope and saved to a file(s).

The user can also test moves and make accurate measurements using the measurement tools provided by the scope. The scope can also be used while an external command source is controlling the drive. In this way, it is a powerful debugging tool, allowing up to six trace variables to be recorded at the same time.

NOTE: During tuning, observe any warnings or faults that appear in the status bar of the scope. Some users prefer the Auto Tune feature. See the Section: Current Loop Auto Tune.

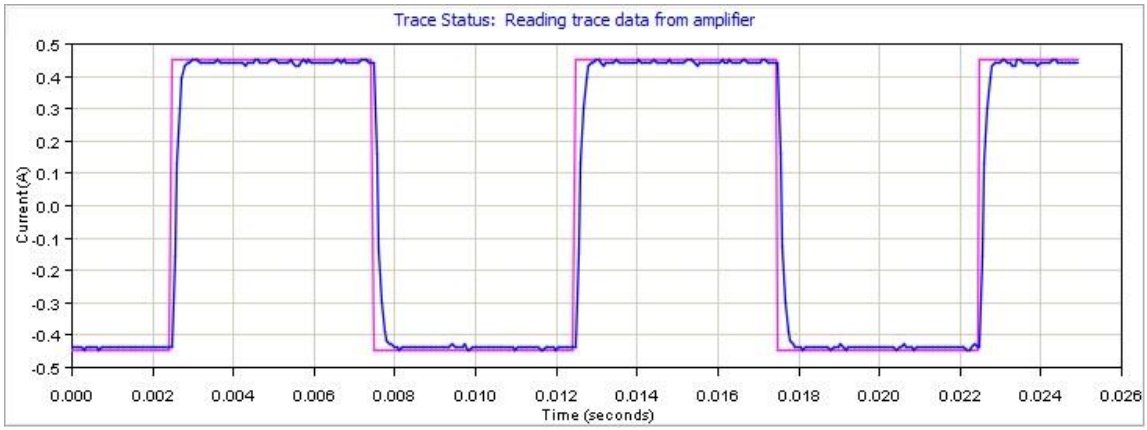
1. On the Main screen, click the **Scope** button on the toolbar.
2. From the Function Generator Apply To: drop list, choose **Current**.
3. On the Settings tab, make sure the Auto Setup is selected.
   Auto Setup automatically sets the following parameters in the table below.

Functional Generator Tab	
Parameter	**Description**
Function	Square Wave
Amplitude	10% of continuous current value
Frequency	100 Hz
Settings Tab	
Channel 1	Commanded Current
Channel 2	Actual Current

4. Verify that the Amplitude value is not excessive for the motor.
5. Click **Start**.
6. On the **Gains** tab, adjust the Current Loop Proportional Gain (Cp) and the Current Loop Integral Gain (CI) to obtain a desired wave form.
   - Set the Current Loop Integral Gain (Ci) to zero.
   - Raise or lower Cp to obtain the desired step response.
     (Typically, 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, the bandwidth decreases.

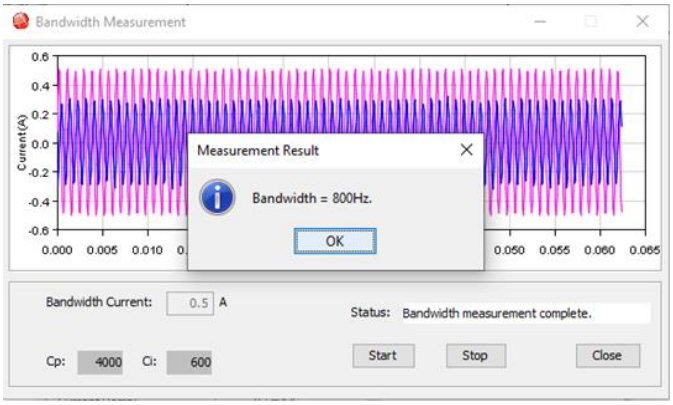
7. Adjust the Current Loop Integral Gain (Ci) until the desired setting time is obtained.

   NOTE: The following diagram shows an example of a good current loop tuning, in which the wave forms for the commanded and the actual current are similar, without any ringing or overshoot.



Example of Current Loop Tuning

8. Press **Stop** to stop the Function Generator.
9. On the Main screen, click **Save to Flash** to avoid losing the changes.
10. On the Main screen, select I Loop and click on Bandwidth to measure the bandwidth. Verify that the bandwidth measured is sufficient for the application. Typical bandwidth value is 1.2kHz ± 200 Hz.

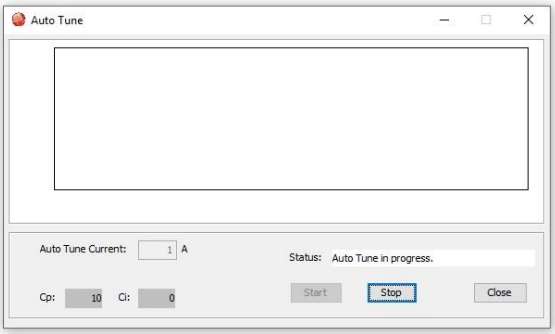


Bandwidth Measurement Screen

12.1.2 Current Loop Auto Tune

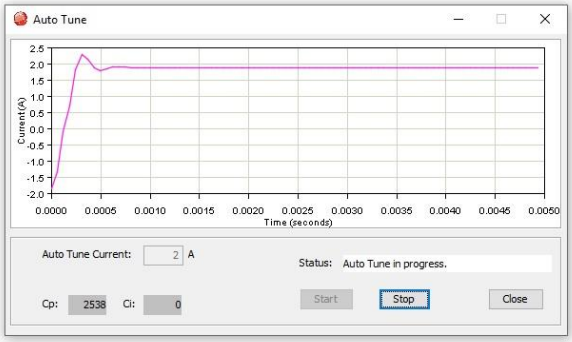
The Current Loop Auto Tune algorithm applies a square-wave command to the current loop and adjusts the Current Loop Proportional Gain (Cp) and Current Loop Integral Gain (Ci) until a desirable waveform is obtained.

Initial Current Loop Proportional Gain (**Cp**) and Current Loop Integral Gain (**Ci**) values can be calculated with Calculate.



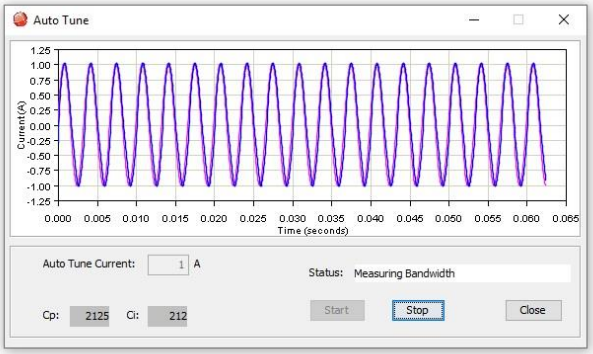
Auto Tune Screen

1. Click **I Loop** to open the Current Loop screen.
2. Verify the drive is hardware enabled.
3. Click Auto Tune button to open the screen and start the Current Loop Auto Tune.
4. To Change the Auto Tune Current, click **Stop**. Enter the new current in the **Auto Tune Current** field, and then click **Start.**
5. Observe the Auto Tune process and the results. A typical example is shown below.
6. Set Cp and Ci to zero and adjust Cp and Ci for optimal values.



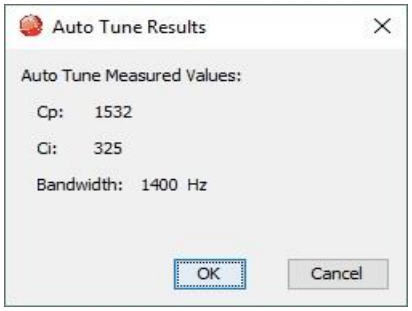
Example of Auto Process

7. Use a frequency sweep to determine the small signal, current loop bandwidth.



Auto Tune Diagram

8. A set of Cp and Ci alternatives, and the bandwidth measured using the high Cp and Ci values are displayed.

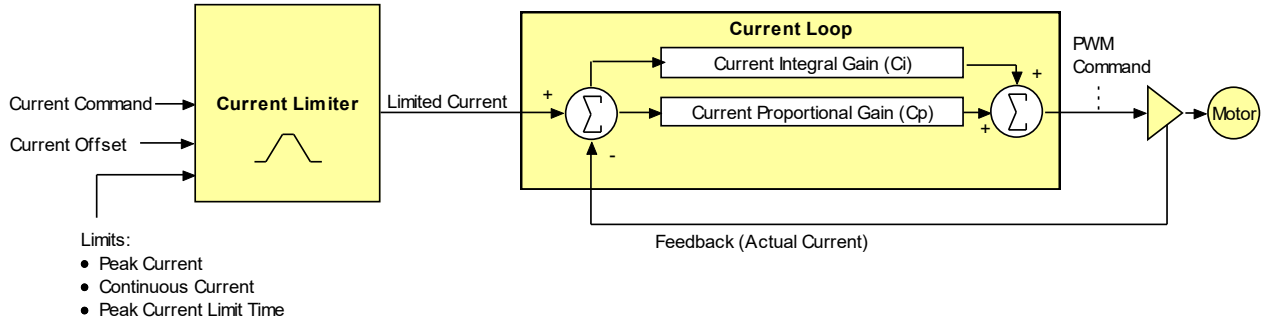


Auto Tune Results Screen

9. Click **OK** to keep the new Cp and Ci values in RAM that auto tune measured.
10. To restore the original Cp and Ci values, click **Cancel**.

12.1.3 Notes on the Current Mode and Current Loop

The following diagram shows, the "front end" of the current loop in 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 drive's power stage.



Current Loop Diagram

12.1.4 Current Loop Inputs

The following is a list of the types of Current Loop Inputs.

- Programmed Current
- The drive's analog or PWM inputs
- A CANopen network via the drive's CAN interface
- A Copley Virtual Motion (CVM) control program
- The drive's internal function generator

In Velocity or Position modes, the Current Command is generated by the velocity loop.

12.1.5 Current 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.

12.1.6 Limits

The current command is limited based on the following parameters.

Limiter	Description
Peak Current Limit	Maximum current that can be generated by the drive for a short duration of time. This value cannot exceed the peak current rating of the drive.
Continuous Current Limit	Maximum current that can be constantly generated by the drive.
I^2T Time Limit	Maximum amount of time that the peak current can be applied to the motor before it must be reduced to the continuous limit or generate a fault. For more details, see I^2T Time Limit Algorithm. NOTE: Although the current limits set by the user may exceed the drive's internal limits, the drive operates using both sets of limits in parallel, and therefore will not exceed its own internal limits regardless of the values programmed.
Ramp	Rate of change in current command. Used to limit jog moves initiated from the Control Panel Jog function in the Current mode, and in the advanced Indexer Program functions.

12.1.7 Current Loop 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.

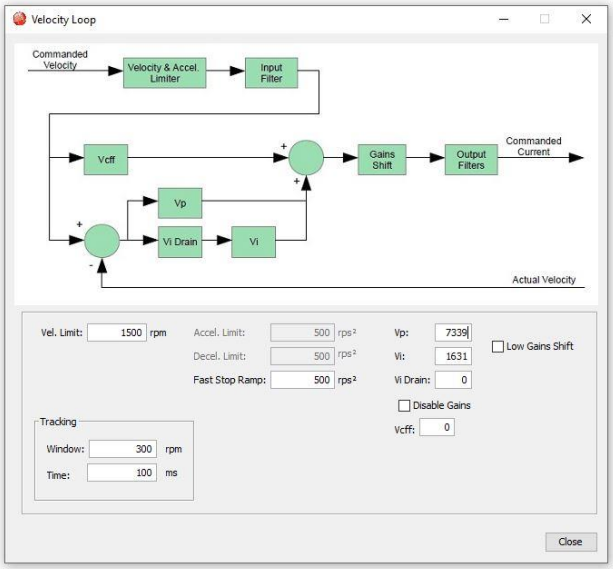
12.1.8 Current Loop Output

The output of the current loop is a command that sets the duty cycle of the PWM output stage of the drive.

12.2 Velocity Loop Setup and Tuning

Initial Velocity Loop Proportional Gain (**Vp**) and Velocity Loop Integral Gain (**Vi**) values can be calculated with Calculate.

1. From the Main screen, click the **V Loop** button (contents vary with the model and the configuration).



Velocity Loop Screen

Parameter	Description
Velocity Limit	Top speed limit. Maximum value may depend upon the back EMF & the Encoder value. Min value: 0. Sets the maximum velocity command input to the velocity loop.
Acceleration Limit	Maximum acceleration rate. Maximum value may depend upon load, inertia, & peak current. Min value: 1. (Does not apply in Position mode). Limits the maximum acceleration rate of the commanded velocity input to the velocity loop. This limit is used in the Velocity mode only. In the Position mode, the trajectory generator handles acceleration limiting.
Deceleration Limit	Maximum deceleration rate. Maximum value may depend upon load, inertia, & peak current. Min value: 1. (Does not apply in Position mode). Limits the maximum deceleration rate of the commanded velocity input to the velocity loop. This limit is used in the Velocity mode only. In the Position mode, the trajectory generator handles deceleration limiting.
Tracking Window	See the Section: Position and Velocity Tracking Windows.
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 drive is hardware disabled. Range: 0 to 100,000,000. Default: velocity loop Decel. Limit value. Specifies the deceleration rate used by the velocity loop when the drive is hardware disabled. (Fast stop ramp is not used when the drive is software disabled.) If the brake output is active, the fast stop ramp is used to decelerate the motor before applying the brake.

Parameter	Description
	Note that Fast Stop Ramp is used only in Velocity mode. In Position mode, the trajectory generator handles controlled stopping of the motor. There is one exception: if a non-latched Following Error occurs in Position mode, then the drive drops into Velocity mode and the Fast Stop Ramp is used.
Low Gains Shift	Increases the resolution of the units used to express Vp and Vi, providing more precise tuning. For more information, see the Section: Velocity Gains Shift.
Hi Gains Shift	Decreases the resolution of the units used to express Vp and Vi, providing more precise tuning. For more information, see the Section: Velocity Gains Shift.
Vi Drain (integral bleed)	Vi drain modifies the effect of velocity loop integral gain. The higher the Vi Drain value, the faster the integral sum is lowered. Range: 0 to 32,000. Default: 0.
Vcff	Velocity loop command feed forward. The input command to the velocity loop (after limiting) is scaled by this value and added to the output of the velocity loop.
Disable Gains	If selected, disable Velocity Loop gains. Velocity Loop gains will no longer affect commanded current for velocity moves. Velocity command feed forward and Velocity Loop output filters are still active.

12.3 Manually Tune the Velocity Loop

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

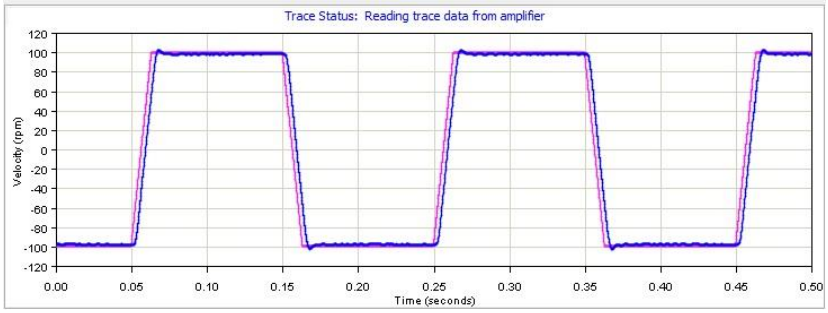
1. On the Main screen, click the **Scope** button on the toolbar.
2. From the **Function Generator Apply To**: in the dropdown list, choose **Velocity**.
3. On the Settings tab, make sure **Auto Setup** is selected.
   Auto Setup automatically sets the following parameters listed in the table below.

Function Generator Tab	
Function	Square Wave
Amplitude	10% of maximum velocity value
Frequency	5 Hz
Settings Tab	
Channel 1	Limited velocity
Channel 2	Actual Motor Velocity

4. Verify that the **Amplitude Value** is not excessive for the motor.
5. Click **Start**.
6. On the Gains tab, adjust the Velocity Loop Proportional Gain (Vp):
   - Set the Velocity Loop Integral Gain (Vi) to zero.
     WARNING! On vertical axes, this may cause the axis to fall to 0 position. Move the motor to the 0 position before following this step.
   - Raise or lower the Proportional Gain (Vp) to obtain the desired step response. (Typically, it is little or no overshoot on a 5 Hz small, slow-speed square wave).

7. Adjust the Velocity Loop Integral Gain (Vi) until the desired setting time is obtained.

   NOTE: The following diagram shows an example of a good velocity loop tuning, in which the wave forms for the commanded and the actual velocity are similar.



Example of Velocity Loop Tuning

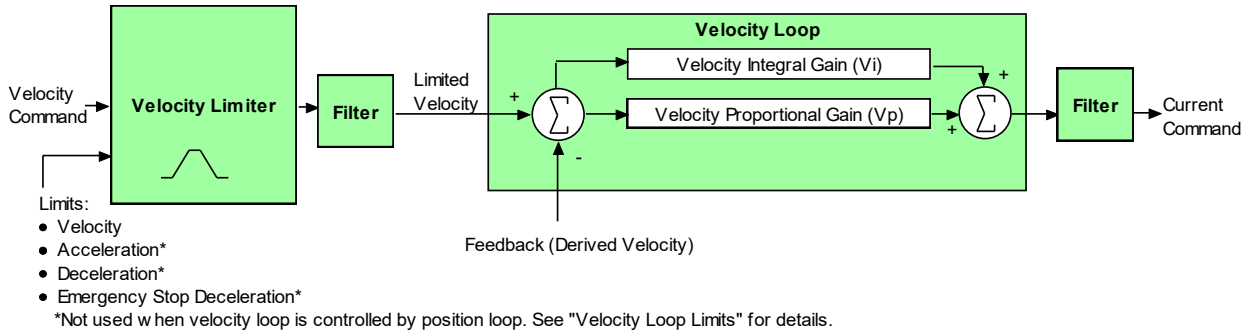
8. Click **Stop** to stop the Function Generator.
9. On the Main screen, click **Save to Flash** to avoid losing the changes.

12.4 Notes on the Velocity Mode and Velocity Loop

12.4.1 Velocity Loop Diagram

In the following diagram, 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 acquired 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.



Velocity Loop Process Diagram

12.4.2 Inputs

In Velocity mode, the velocity command originates from one of the following:

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

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

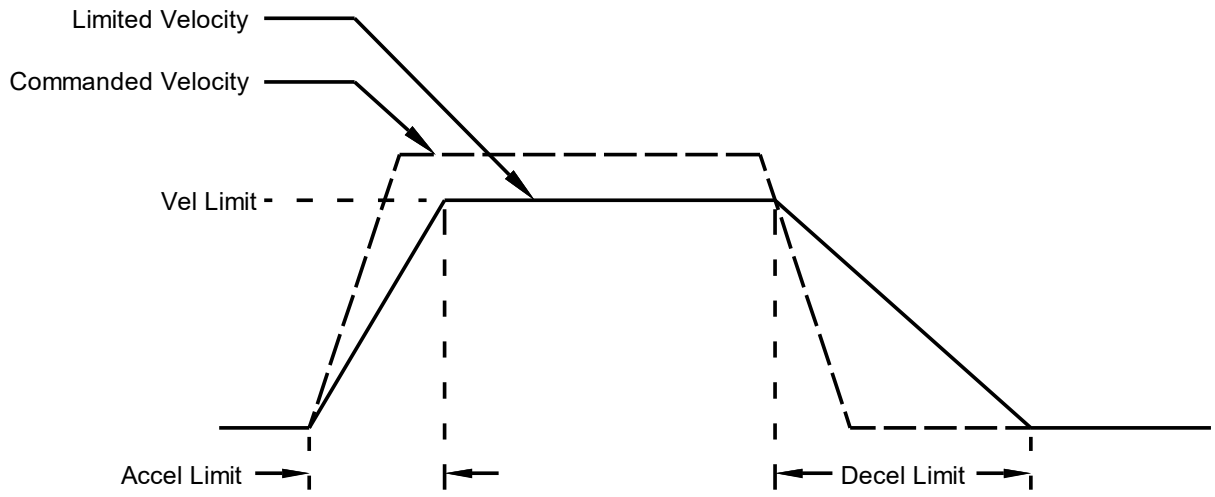
12.4.3 Velocity Loop Limits

The Velocity command is limited based on the set of parameters designed to protect the motor and/or the mechanical system as described in the following table.

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 drive is hardware disabled. (Fast stop ramp is not used when drive 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 drive drops into Velocity mode and the Fast Stop Ramp is used.

12.4.4 Diagram: Effects of Limits on Velocity Command

The following diagram illustrates the effects of the Velocity Loop Limits.



Velocity Loop Limits Diagram

12.4.5 Velocity Loop Gains

The Velocity Loop uses the following gains described in the table below.

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.

12.4.6 Velocity Gains Shift

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

12.4.7 Velocity Loop Filters

See the Section: Standard Filter Types.

12.4.8 Velocity Loop Outputs

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

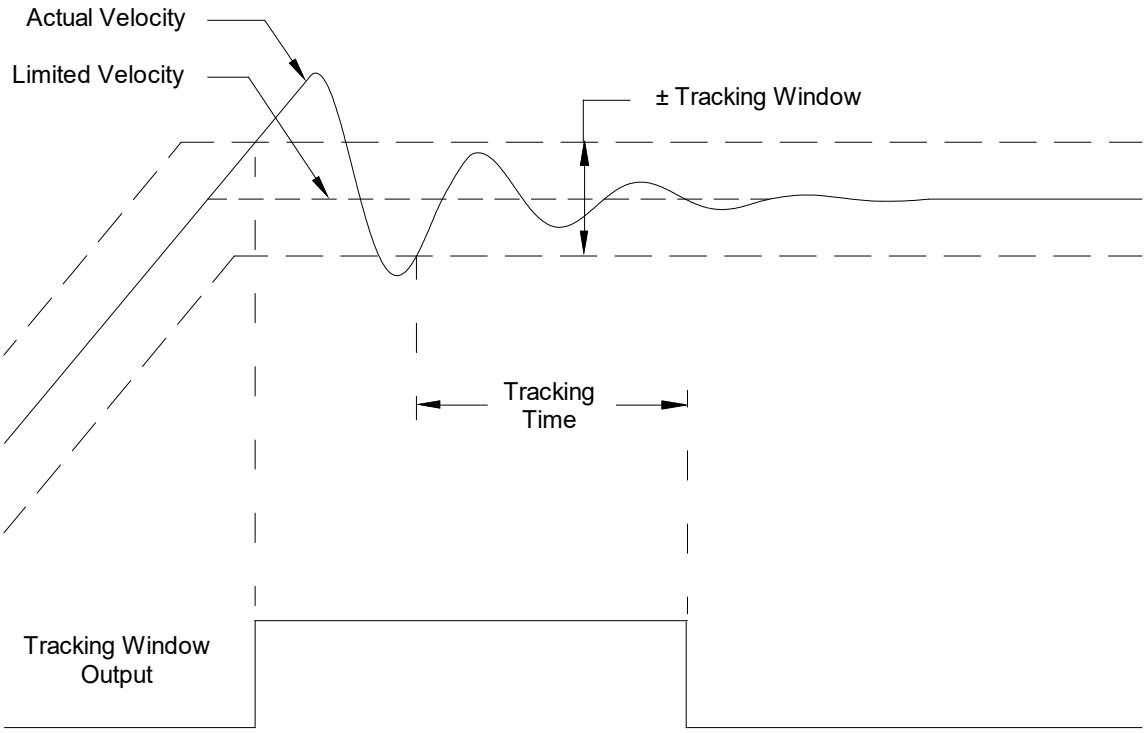
12.4.8.1 Proper Tracking Over Time

As described in previous sections, the Position error is based on the difference between the limited position output of the trajectory generator and the actual position. Velocity error is based on 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.

12.4.9 Velocity Tracking Illustration

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

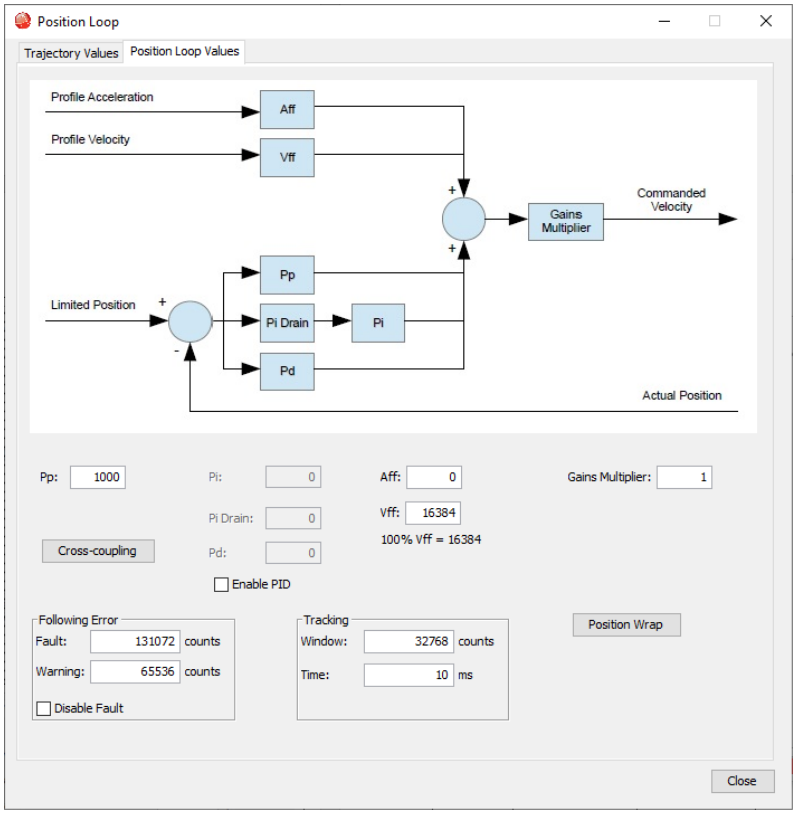


Velocity Tracking Diagram

12.5 Position Loop Setup and Tuning

Initial Position Loop Proportional Gain (Pp), Velocity Feed Forward (Vff), and Acceleration Feed Forward (Aff) values can be calculated with Calculate.

1. On the Main screen, click the **P Loop** button.

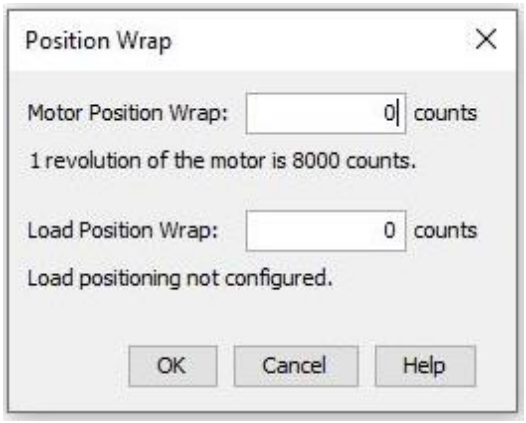


Position Loop Screen

Parameter	Description
Aff	Acceleration Feed Forward. Range: 0 to 32,767. See the Section:Trajectory Limits.
Vff	Velocity Feed Forward. Range: 0 to 32,767. 100% Vff: 16,384. See the Section: Trajectory Limits.
Pp	Position Loop Proportional Gain. Range: 0 to 32,767. See the Section: Trajectory Limits.
Gains Multiplier	Position loop output is multiplied by this value before going to the velocity loop. In Dual Encoder Systems, the multiplier's initial value is calculated based on the ratio of motor encoder turns to the position encoder turns.
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. See the Section: Following Error Faults.
Following Error Warning	The level (in counts) at which the Following Error produces a warning (without stopping the loop). See the Section: Following Error Warnings.
Disable Fault	Stops Following Error from faulting. See the Section: Following Error Faults.
Tracking Window	Width of tracking window in counts. See the Section: Position and Velocity Tracking Windows.
Tracking Time	Position must remain in the tracking window for this amount of time to be considered tracking. See the Section: Position and Velocity Tracking Windows.
Pi Position Loop Integral Gain	This gain value is multiplied by the integral of the position loop error. The position loop error is the difference between the drive's commanded position and actual position.

Parameter	Description
Pd Position Loop Derivative Gain	This gain value is multiplied by the derivative of the position loop error.
Pi Drain Position Loop Integral Drain	Modifies the effect of position loop integral gain. The higher the Pi Drain value, the faster the integral sum is lowered.
Enable PID Enables the PID parameters	Enable Pi, Pd, and Pi Drain.

1. Click the **Position Wrap** button.

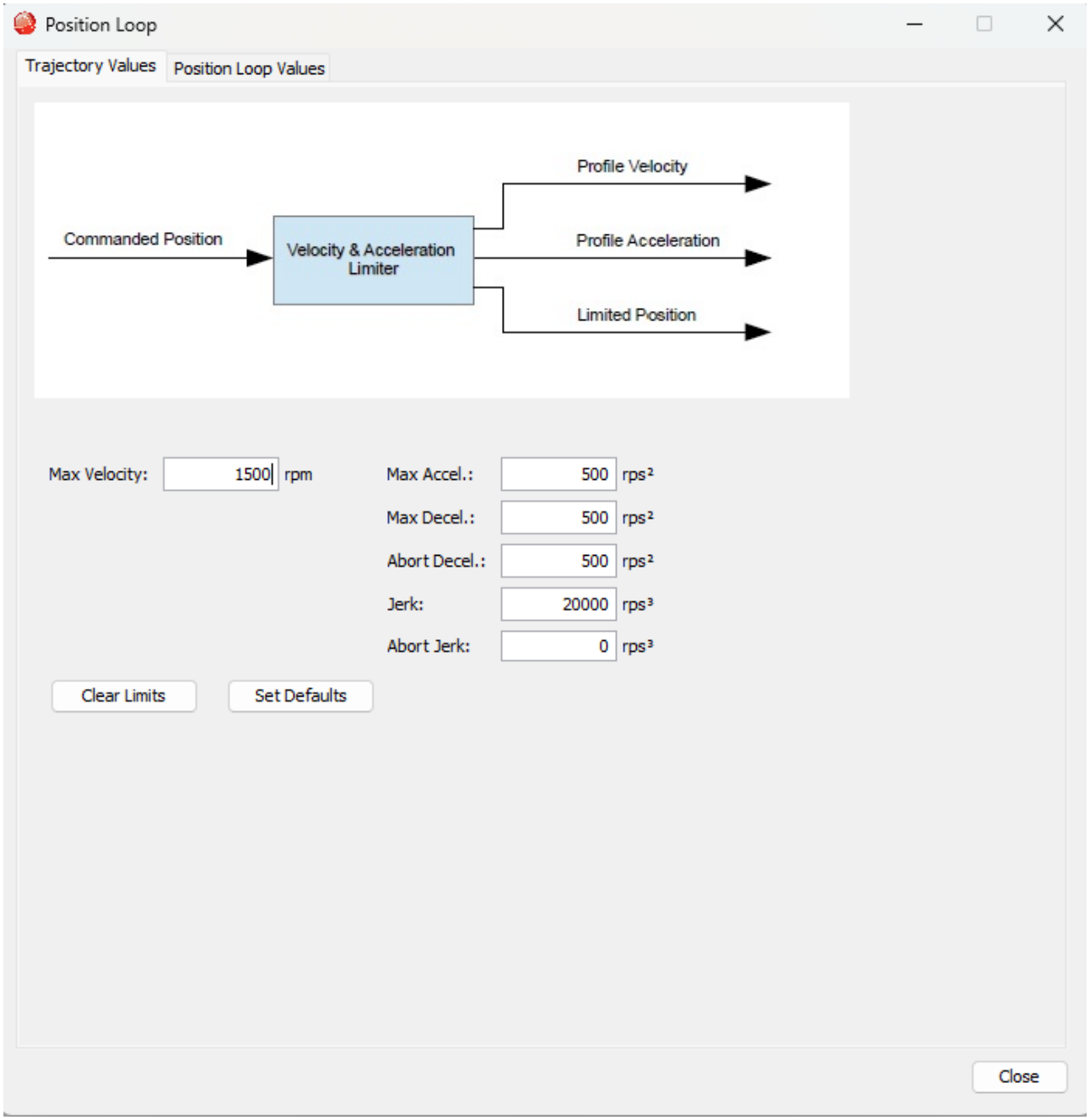


Position Wrap Screen

Change/verify the position wrap parameters as needed. Set both values to zero to disable position wrapping. Note that the changes do not take effect until **OK** is pressed. For more information about this feature, see the Section: Position Wrap.

Parameter	Description
Motor Position Wrap	Position at which the actual motor position count returns to zero. In a single feedback system, it also applies to the actual load position.
Load Position Wrap	Position at which the actual load position count returns to zero in dual feedback systems. If the position encoder is set to passive mode, this value applies to the passive encoder position.

2. Click on the **Trajectory Values** tab.



Trajectory Values Screen

Parameter	Description
Max Velocity	Maximum Trajectory Velocity. Maximum value may depend upon the back EMF and the Maximum feedback count. Min:0. Default: 0.25 x motor velocity limit.
Max Accel	Maximum Trajectory Acceleration. Maximum 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. Maximum value may depend upon the load inertia and peak current. Min:0 (disables limit). 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.

Parameter	Description
Jerk	Rate of change of acceleration. 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.
Note that setting limits to zero disables the Trajectory Generator so that the command input is not limited by the generator. Velocity is only limited by the Velocity Limit set in the Velocity Loop.	

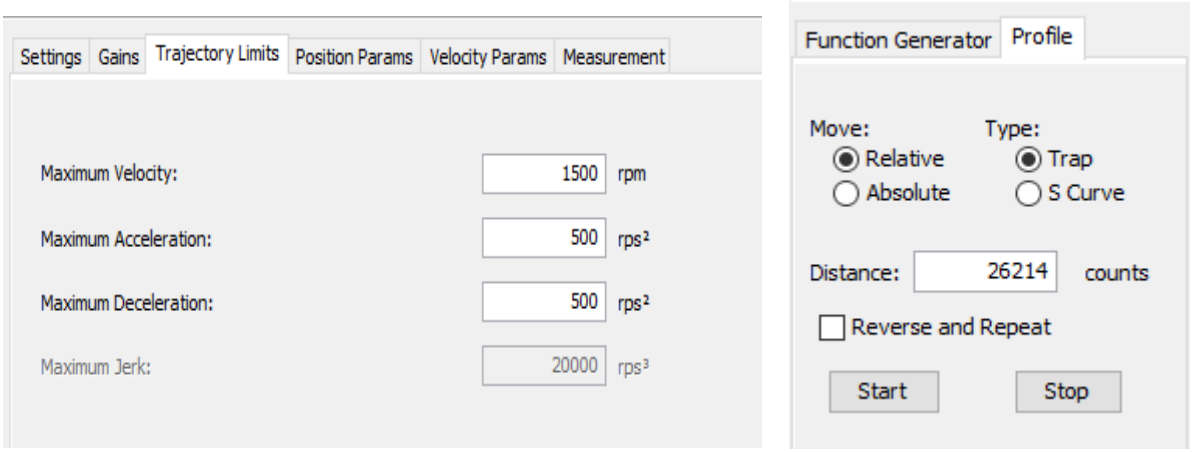
12.5.1 Manually Tune the Position Loop

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

1. Click the **Scope** Tool.
2. Select the **Profile** tab.
3. On the Settings tab, make sure **Auto Setup** is selected. Auto Setup automatically sets the parameters.
4. If the Auto Setup default profile distance is not appropriate, enter an appropriate short distance in the **Distance:** field.
5. Click **Start**. The Profile Generator executes a short move.
   NOTES:
   - The profile may not reach the constant velocity during a short move.
   - If the Following Error occurs, open the Control Panel and click **Clear Faults** button.
6. Set up a Trapezoidal Profile by setting the trajectory limits and distance.
   See the Profile and Settings Table.

Profile Tab	
Tab	**Setting**
Move	Relative
Type	Trap
Distance	2000 counts
Reverse and Repeat	Not selected
Settings Tab	
Channel 1	Profile Velocity
Channel 2	Following Error

Profile and Settings Table



Trajectory Limits and Profile Tabs

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

7. Adjust the Position Proportional Gain (Pp) to minimize the Following Error.
   a. On the Gains tab, set Velocity Feed Forward (Vff) and Acceleration Feed Forward (Aff) to zero.
   b. On the Profile tab, click **Start**.
   c. On the Gains tab, adjust the Position Loop Proportional Gain (Pp) until the best result is obtained.
8. Click **Start** after each adjustment to test a new profile move.

   NOTE:
   • Too much Position Loop Proportional Gain (Pp) might cause oscillation.
   • If a Following Error occurs, open the Control Panel and click **Clear Faults**.
9. Adjust the Velocity Feed Forward (Vff).

   Velocity Feed Forward (Vff) reduces the Following Error in the constant velocity portion of the profile. Often, a Velocity Feed Forward (Vff) value of 16384 (100%) provides the best results.
10. Click in the **Vff** field and adjust the value.
11. Click **Start** after each adjustment to test on a new profile move.
12. Adjust the Acceleration Feed Forward (Aff):

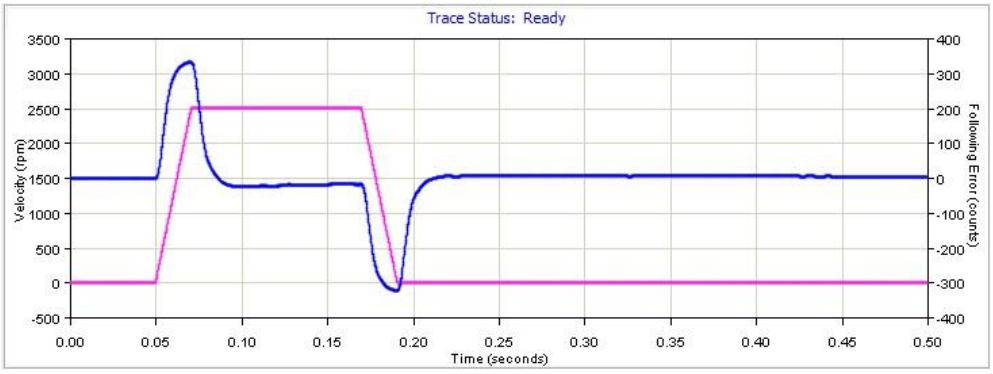
    Acceleration Feed Forward (Aff) reduces the Following Error during the profile acceleration and deceleration.
13. Click in the **Aff** field and adjust the value.
14. Click **Start** after each adjustment to test on a new profile move.

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 drive is set up to run in Position mode under the Analog Input command, and the analog command signal produces too much noise at the motor after tuning, the Analog Command Filter or the Velocity Loop Command Filter may be used to reduce the noise further.

Tune to multiple sets of profiles representing the typical moves that might be executed in the application. Starting with Step 6, repeat the process as needed.

NOTE: The image below shows an example of a good Position Loop Tuning.

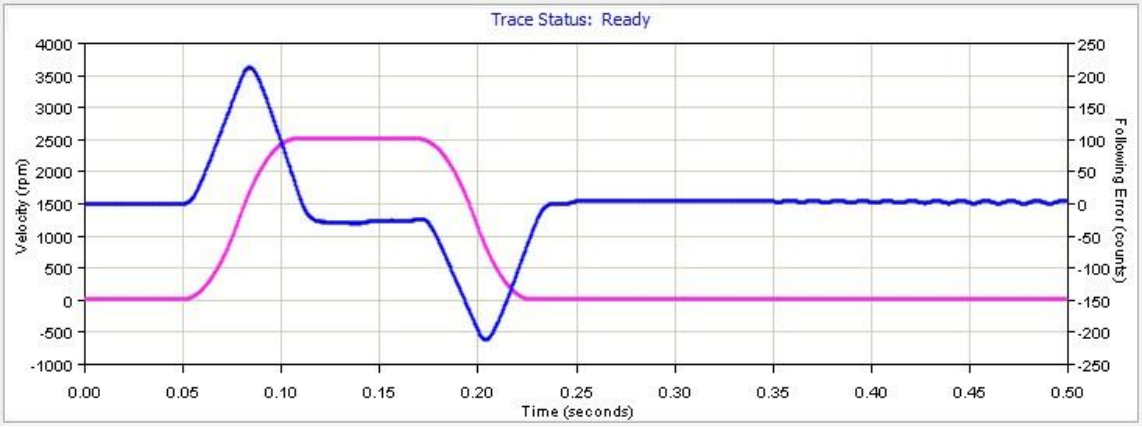


Example of Position Loop Tuning

12.5.2 Test S-Curve Profile

If the drive will perform S-Curve Profile moves, use this procedure to tune the level of jerk. NOTE: The term, jerk, is defined as the rate of change of the acceleration. The S-Curve moves reduce the jerk to provide a smooth profile.

Run an S-Curve Profile and adjust the velocity, acceleration, deceleration, and jerk levels until the desired profile is obtained. For example, see the following diagram.



Example of S-Curve Profile

1. On the **Profile** tab, click the **S-Curve** button.
2. Set up an S Curve profile by adjusting the following parameters to 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 that does not exceed mechanical limits of the system.
Move	Relative
Type	S-Curve

3. Click **Start**.

Try multiple sets of profiles representing typical moves that might be executed in the application. Starting with Step 2, repeat the process as needed.

12.6 Notes on the Position Mode and Position Loop

12.6.1 Position Loop Diagram

The drive receives position commands from the digital or analog command inputs, over the CAN interface, serial bus or from the CVM Control Program.

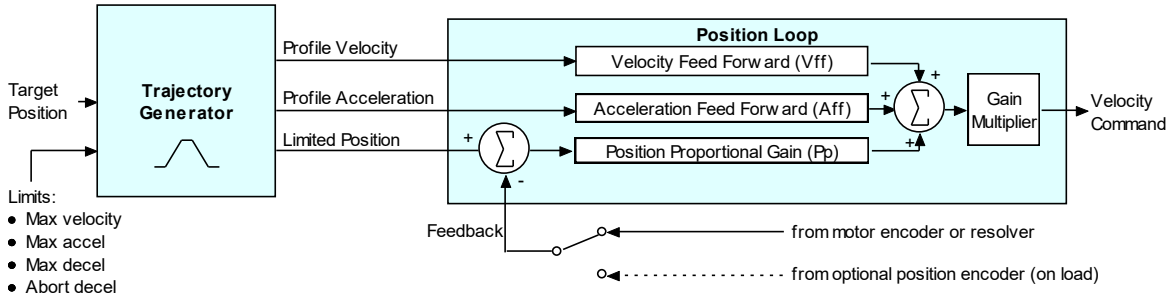
When using the digital or analog inputs, the drive's internal Trajectory Generator calculates a trapezoidal motion profile based on the Trajectory Limit parameters.

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 the position commands are received.

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

To bypass the Trajectory Generator while in the Digital or Analog Position modes, set the maximum acceleration to zero. The only limits in effect will now be the velocity loop, velocity limit and the current limits. (Note that leaving the maximum acceleration set to zero will prevent other Position modes from operating correctly).

The following diagram summarizes the Position Loop.



Position Loop Process Diagram

12.6.2 Trajectory Limits

In Position mode, the Trajectory Generator applies these limits to generate the 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.

12.6.3 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.

12.6.4 Position Loop Gains

The Position Loop uses the following gains 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.
Pi Position Loop Integral Gain (KI)	This gain value is multiplied by the integral of the position loop error.
Pi Drain Position Loop PI Drain (Integral Bleed)	Modifies the effect of Position Loop Integral Gain. The higher the Pi Drain value, the faster the integral sum is lowered.
Pd Position Loop Derivative Gain (KD)	This gain value is multiplied by the derivative of the position loop 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.

12.6.5 Position Loop Feedback

Some Copley Controls drives feature dual-sensor Position Loop Feedback, configured as follows:

- 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, the velocity loop feedback originates from the motor encoder or resolver.

12.6.6 Position Loop Output

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

12.6.7 Position Wrap

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

Relative moves with the wrap value set will move the relative distance required. For example, if the wrap value is set to 1000 and a relative move of 2500 is commanded, the axis will turn 2 ½ revolutions.

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

12.6.8 Following Error Faults

When the position error reaches the programmed fault threshold, the drive immediately faults. (The Following Error Fault can be disabled at the Configure Faults tab on the Main screen).

12.6.9 Following Error Warnings

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

12.6.10 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 manage velocity errors.

12.6.11 Following Error Fault Details

12.6.11.1 Position Error Reaches Fault Level

As described in other Sections, the Position Error is based on the difference between the limited position output of the Trajectory Generator and the actual position. When the Position Error reaches the programmed Following Error Fault level, the drive faults (unless the Following Error Fault is disabled). As with a warning, a status bit is set. In addition, the fault is recorded in the Error Log. See the Section: Error Log.

Additional responses and considerations depend on whether the fault is non-latched or latched, as described in the next Sections.

12.6.11.2 Drive Response to Non-Latched Following Error Fault

When a non-latched Following Error Fault occurs, the drive drops into Velocity mode and applies the Fast Stop Ramp deceleration rate to bring the motor to a halt. The drive PWM Output Stage remains enabled, and the drive holds the velocity at zero, using the velocity loop.

12.6.11.3 Resuming Operations After a Non-Latched Following Error Fault

The clearing of a Non-Latched Following Error depends on the drive's mode of operation. Issuing a new trajectory command over the CAN bus or the ASCII interface will clear the fault and return the drive to normal operating condition.

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

12.6.11.4 Drive Response to a Latched Following Error Fault

When a Latched Following Error Fault occurs, the drive disables the output PWM stage before attempting to apply a deceleration rate.

12.6.11.5 Resuming Operations After a Latched Following Error Fault

A Latched Following Error Fault can be cleared using the steps used to clear other latched faults.

- Power-cycle the drive.
- Cycle (disable and then enable) an enable input that is configured as Enable with Clear Faults or Enable with Reset.
- Access the CME Control Panel and press **Clear Faults** or **Reset.**
- Clear the fault over the CANopen network or the serial bus.

12.7 Motor Plate Data Characterization

The Motor Plate Characterization feature is also available for use with rotary motors and linear motors.

If the motor specification cannot be obtained from the motor manufacturer due to part obsolescence or insufficient information, then refer to the Motor Ratings label.

 **DANGER**	Make sure the motor is mounted firmly and verify the accuracy and completeness of the motor data.
	Failure to heed this warning can cause equipment damage, injury, or death.

13 STEPPER TUNING

13.1 Stepper Motor Support

Copley stepper drives can run in Stepper mode or Servo mode.

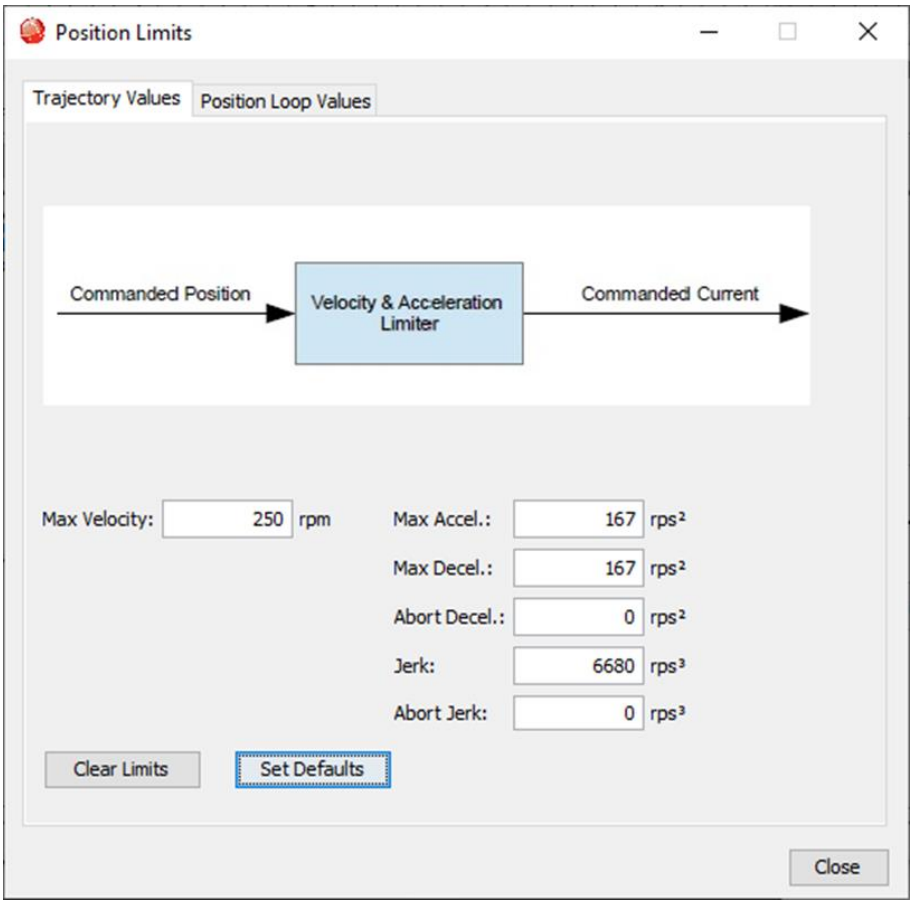
This section describes the controls that can be used to fine-tune a stepper drive in Stepper mode: Encoder Correction and Detent Compensation Gain. It also describes the screen used in Stepper mode to set the Position Limits.

When a stepper drive is used in Servo mode, it operates as a true, closed loop, servo drive controlling a stepper motor. After putting the stepper drive into Servo mode, set it up and tune it just as you would a servo drive.

13.2 Position Limits (Stepper Drive)

To set the position limits for a stepper drive connected to an encoder with the Encoder Correction enabled (for example, not operating in Servo mode), perform the following steps.

1. On the Main screen, click the **Pos Limits** button.



Trajectory Values Example

Parameter	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	Maximum trajectory deceleration. Max value may depend upon the load inertia and peak current. Min:0 (disables limit). Default: 0.5 x velocity loop Accel. Limit value.

Parameter	Description
Abort Decel	Deceleration rate used by the Trajectory Generator when motion is aborted. Min:0. Default: 0.5 x velocity loop Accel. Limit value.
Jerk	Rate of change of acceleration. 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.
Abort Jerk	The value of Jerk used when a move is aborted.
Note that setting limits to zero disables the Trajectory Generator so that the command input is not limited by the generator. Velocity is only limited by the Velocity Limit set in the Velocity Loop.	

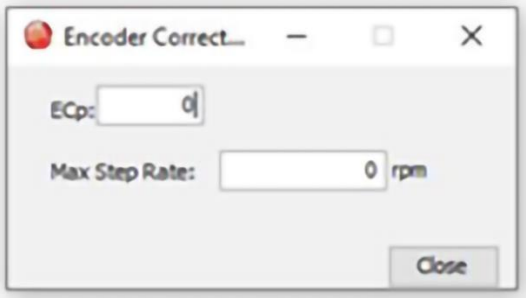
13.3 Encoder Correction

For a stepper motor with an encoder, use the Encoder Correction to compensate for lost micro steps. Normally, in an open loop Micro Stepping mode with an encoder, the total number of micro steps per revolution is set to the number of encoder counts per revolution. However, a Following Error can accumulate when micro steps are lost.

In the Encoder Correction mode, when a commanded position is not equal to the actual position, indicated by the encoder counts, the Following error is multiplied by the Encoder Corrections Proportional Gain (ECp), and the micro steps are added to the open loop micro stepping loop.

If the error is large or the gain is high, the micro steps are added at a higher rate, up to the Maximum step rate limit. If the ECp gain is too high, the loop will become unstable, and the corrections will not reduce the position error. The position error will not be reduced if the Max step rate is outside of the motors stepping ability. If the steps are lost during a move, the Encoder Corrections are made during the move but will tend to accumulate during the trajectory profile and become resolved by the end of the move.

1. To open the Encoder Correction screen, click the **Enc Correction** button.
2. On the Encoder Correction screen, set the Encoder Correction parameters.



Encoder Correct Screen

Parameter	Description
ECp	Proportional gain used to compensate for lost microsteps. Default: 0.
Max Step Rate	Maximum velocity allowed while using ECp to correct position errors. Excessive velocity can result in more lost microsteps. Default: 0.

13.3.1 Test Encoder Correction

While in the Holding position, introduce a position error by manually rotating the motor shaft.

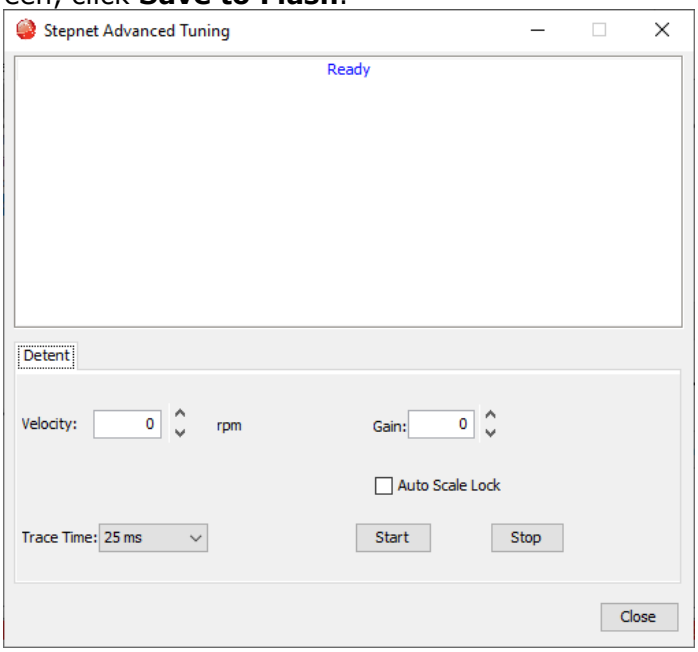
NOTE: Reduce the holding current slightly if you are unable to rotate the shaft.

The ECp will act on the error and the motor will settle into a position slower than a servo motor, but in a reasonable amount of time.

13.4 Detent Compensation Gain

Stepper motors are subject to torque detent that can cause undesired velocity fluctuation between full steps of motion. The Detent Gain feature can compensate for this detent.

1. Click **Detent** to open the Stepper Drive Advanced Tuning screen.
2. Click **Start** to begin the tuning.
3. Adjust the **Velocity** from 0 until the mechanical system begins to resonate. (Using a 1.8-degree step motor with 200 full steps, this will typically occur at a velocity of 40-70 rpm).
4. Adjust the **Gain** until the resonance increases, and then back it down until the resonance is minimized.
5. Click **Stop** to stop the tuning.
6. Click **Close** to close the window.
7. On the CME Main screen, click **Save to Flash**.



Stepnet Advance Tuning Screen

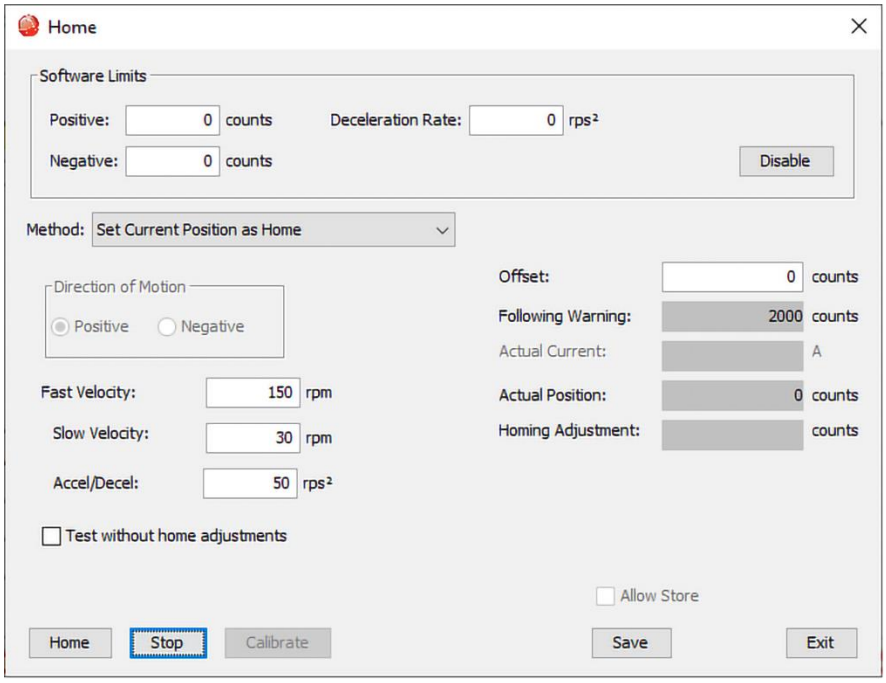
Setting	Description
Velocity	Tuning velocity. Default: 0.
Trace Time	Length of trace interval to be shown on screen. Default: 25 ms.
Gain (Detent Gain)	The Stepper Detent Gain value. Default: 0.
Auto Scale Lock	When selected, prevents trace display from rescaling during tuning.

14 HOMING

14.1 Overview

The Homing screen allows homing to be configured and tested. Changes made to this screen are saved to the drive RAM. On drives configured for Absolute Encoders, calibration can be performed.

1. To open the Home screen, on the Main screen, click the **Home** button.



Home Screen

Parameter	Description
Software Limits: Positive	Position of user-defined travel limits that take effect after homing operation.
Software Limits: Negative	
Software Limits: Deceleration Rate	Deceleration rate used to stop a motor when approaching a software limit.
Software Limits: Disable	Disables the use of software limits by setting both limits to zero.
Method	Homing method. See Homing Method Descriptions.
Direction of Motion-Positive or Negative	Initial direction of motion for the homing method (Pos or Neg).
Fast Velocity:	The velocity used to find a limit or Home Switch. Also used when moving to an offset position, or a resolver or Servo Tube index position.
Slow Velocity:	The velocity used to find a switch edge, incremental or analog encoder index pulse, or hard stop.
Accel/Decel:	The acceleration and deceleration rate used during homing.
Offset:	Execute a move of this distance after the reference is found. Set actual position to 0 and call the new position home.
Current Threshold	Hard stop home is reached when the drive outputs the homing Current Limit continuously for the time specified in the Delay Time.
Current Delay Time	

Parameter	Description
Following Warning	Shows the programmed following warning level.
Actual Current	Shows actual current being applied to windings during homing.
Actual Position	Shows the actual position of the axis.
Homing Adjustment	Shows the Home offset measured after homing is performed.
Test without home adjustments	Selecting this option and pressing the Home Button tests the adjusted home position without making any changes to the saved home position. The resulting homing offset is reported in the Homing Adjustment text field.
Use Virtual Index	This feature allows the firmware to simulate an index pulse when using an absolute encoder. It is only available for absolute encoders. When this option is selected, the absolute encoder single turn zero position will be treated as an index for any homing method that requires an index. Requires FPGA "Plus" firmware version 5.02 or later.
Allow Store	This option is only available when 'Test without home adjustments' is checked. When this box is checked, the homing method can be saved to Flash with the option to not make any adjustment to the saved home position.
Home	Starts the homing sequence using the settings shown on the screen.
Stop	Stops the homing sequence.
Calibrate	Starts the Calibration routine for absolute encoders. See Absolute Encoder Calibration.
Save	Saves the homing parameters to drive flash.
Exit	Discards unsaved homing parameters, then closes the screen. The rules for discarding unsaved values are as follows: • If the Save button was never clicked, all the homing parameters will be reverted to the values at the time that the screen was opened. • If the Save button was clicked, then the homing parameters will be reverted to the values at the time of the last Save event. Upon closing, any home sequence in progress will be aborted.

14.2 Absolute Encoder Calibration

When absolute encoders are used, the absolute encoder value that corresponds to the zero position in the machine's reference frame is saved to the flash memory in the drive. This value is then added to the absolute encoder reading so that all position measurements are in absolute units in the machine's coordinate system. Movement of the motor to 'find' the machine's reference point is not necessary. This process is called calibration because it is done once when the machine and drive are commissioned together and does not need to be repeated until the encoder is changed or the adjustment of the machine-zero location is changed.

NOTE: This feature is only available on the Plus family of drives with a minimum firmware version of 2.00.

Calibration of an absolute encoder is a two-part process:

1. Mechanical Homing
2. Calibration

14.2.1 Mechanical Homing

Mechanical homing is the process of moving the motor to the position that is machine-zero. This is the location from which all dimensions are absolute in the machine's position reference frame.

1. Enter the values of the appropriate homing parameters.
2. Click the **Home** button to run the home sequence.
3. Repeat if necessary, until the motor is positioned at machine zero.
4. Click the **Save** button.

14.2.2 Calibration

Calibrating the encoder involves saving the absolute position at machine-zero to the drive's flash. This value will be saved as a negative number and added to the absolute encoder positions thereafter by the firmware to convert them to machine absolute values. This value is stored in the Home Offset parameter. CME provides a single button-click operation to perform this calibration.

1. Click the **Calibrate** button to initiate the Calibration routine.

   CME will perform the following routine steps in sequence.
2. Set the calibration bit of the Homing Configuration Register.
3. Initiate the Homing sequence.

The drive will then perform the following routine steps in sequence.

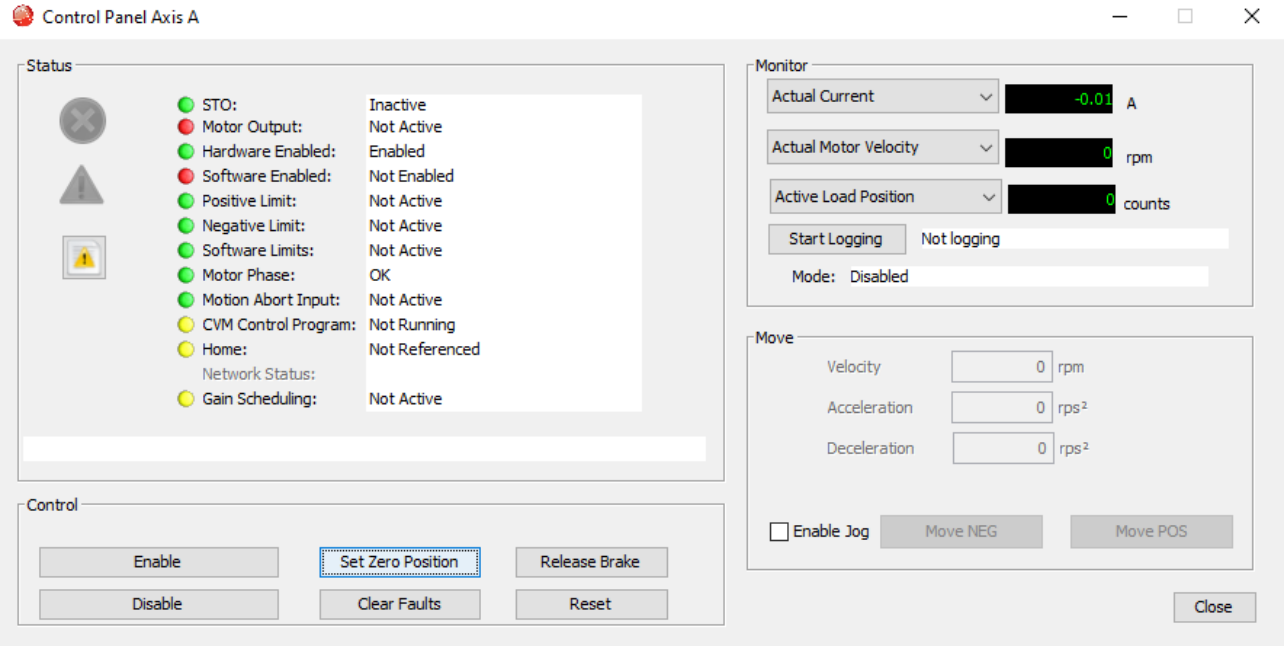
4. Run the Home sequence.
5. Save the Home Offset in flash.
6. Change the Home method to Absolute Encoder Immediate Home.
   a. On the Home screen, the **Homing Adjustment** field will show the offset value saved in flash.
   b. Once the calibration is complete, the **Calibrate** button will be disabled until another Home sequence is run by clicking the **Home** button.
   c. To remove the calibration, change the Home Method from Absolute Encoder Immediate Home to some other method, and run the Home sequence.

For additional information on Homing, see Appendix B (Homing Methods).

15 CONTROL PANEL

15.1 Control Panel Overview

1. On the Main screen, click the **Control Panel** button on the toolbar.



Control Panel Screen

15.2 Status Indicators and Messages

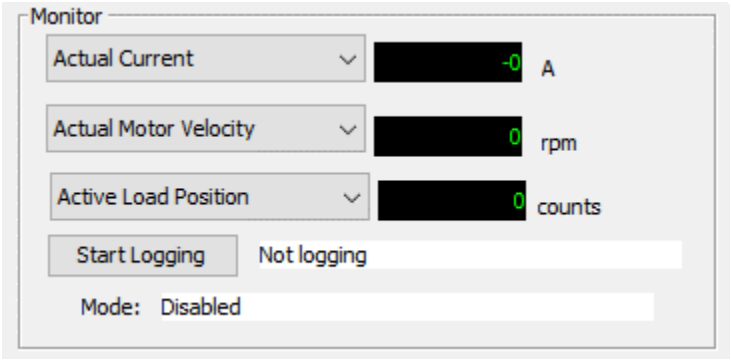
The Status area includes status indicator lights (described below) and a message box. Any red lights indicate that the motion will be inhibited.

Indicator	States/Description
STO	State of the safety circuit. Enabled or HI/LO disabled. On drives with safety circuit. This indicator displays the MTO for Motor Torque OFF which functions the same as STO.
Motor Output	State of the PWM output stage. Red indicates if the output stage is inactive (disabled).
Hardware Enabled	State of the hardware enables input(s). Red indicates if one or more enable inputs are inactive.
Software Enabled	State of the software enable. Red indicates if the drive is disabled by software.
Positive Limit	State of the positive limit switch input. Red indicates an activated positive limit switch.
Negative Limit	State of the negative limit switch input. Red indicates an activated negative limit switch.
Software Limits	State of the software limits. Red indicates an activated software limit.
Motor Phase	Indicates a motor phasing error. Red indicates a motor phasing error exists.
Motion Abort Input	State of the programmed Motion Abort Input. Red indicates the input is active.
CVM Control Program	Status of the CVM Control Program.

Indicator	States/Description
Home	Indicates whether the axis has successfully been referenced (homed).
Network Status	Status of the network communication. Yellow indicates warning limit reached. Red indicates bus error detected.
Gain Scheduling	Indicates whether Gain Scheduling is active.
	Indicates that a fault is active. Check the status message box for a description of the most recent fault: Fault: Under Voltage. Check the Error Log for a full history of faults and warnings.
	Indicates that a warning is active. Check the status message box for a description of the most recent: Warning: Pos Outside of Tracking Window. Check the Error Log for a full history of faults and warnings.
Error Log 	Contains a full history of faults and warnings, including all active faults and warnings.
Status Message Box	Gives a description of the most recent fault or warning. Check the Error Log for a full history of faults and warnings.

15.3 Control Panel Monitor

The Control Panel Monitor displays real-time values of selected variables.



Control Monitor Screen

Monitor Variables		
Actual Current	Following Error	Passive Load Position
Actual Motor Velocity	Commanded Current	Limited Position
Actual Motor Position	Commanded Velocity	Analog Command
Actual Load Velocity	Commanded Position	Bus Voltage
Actual Load Position	Profile Velocity	Amplifier Temperature
RMS Current Over Period	Velocity Error	Profile Acceleration
Motor Phase Angle	Disabled	

Monitor Variable Log:

To start logging the values of the Control Panel monitor variables in a .csv file, click the **Start Logging** button.

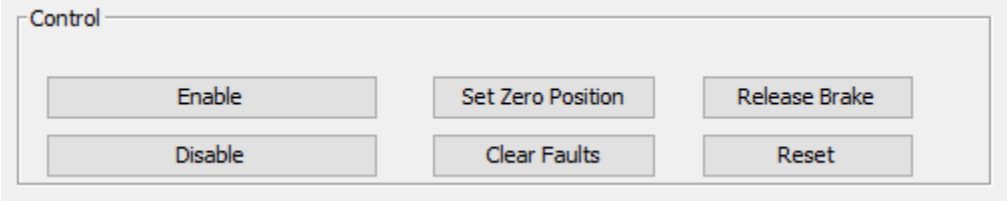
Once the process has started, the **Start Logging** button is replaced by the **Stop Logging** button. Any time during the logging process, the user can stop logging by pressing the **Stop Logging** button.

Mode:

Displays the drive's operating mode in RAM. In the Camming mode, it also displays the active cam table number.

15.4 Control Functions

The Control area of the screen provides functions related to the overall drive control. The screen options vary with the model and the configuration.



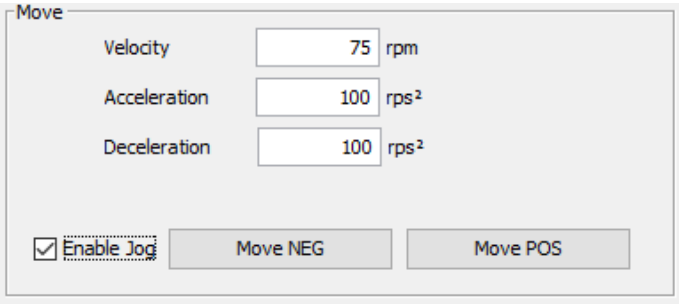
Control	Description
Enable	Click to software enable the drive.
Disable	Click to software disable the drive. This will also stop any CVM programs that are running.
Set Zero Position	Click to set the drive's actual position counter to zero.
Clear Faults	Click to clear all drive faults.
Release Brake	Click to release the motor's brake, if present. This button is available when there is 1 Output pin per axis set to use a brake function and the drive is disabled.
Reset	Click to reset the drive.

WARNING	**Risk of unexpected or uncontrolled motion.** Using the CME, if the Set Zero Position function is used while the drive is operating under the external control, it could cause unexpected or uncontrolled motion. **Failure to heed this warning can cause equipment damage.**

15.5 Jog Mode

The Jog mode provides a simple means for moving/jogging the motor.

NOTE: After performing the Jog operation, click the **Enable** button.



Move Screen

1. To put the drive in Jog mode, select **Enable Jog**.
2. To set up a Jog move, in the table below, set the following mode-specific parameters.

Mode	Parameter	Description
Current	Current	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.
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 limit of the jog move.
	Deceleration	Deceleration limit of the jog move.

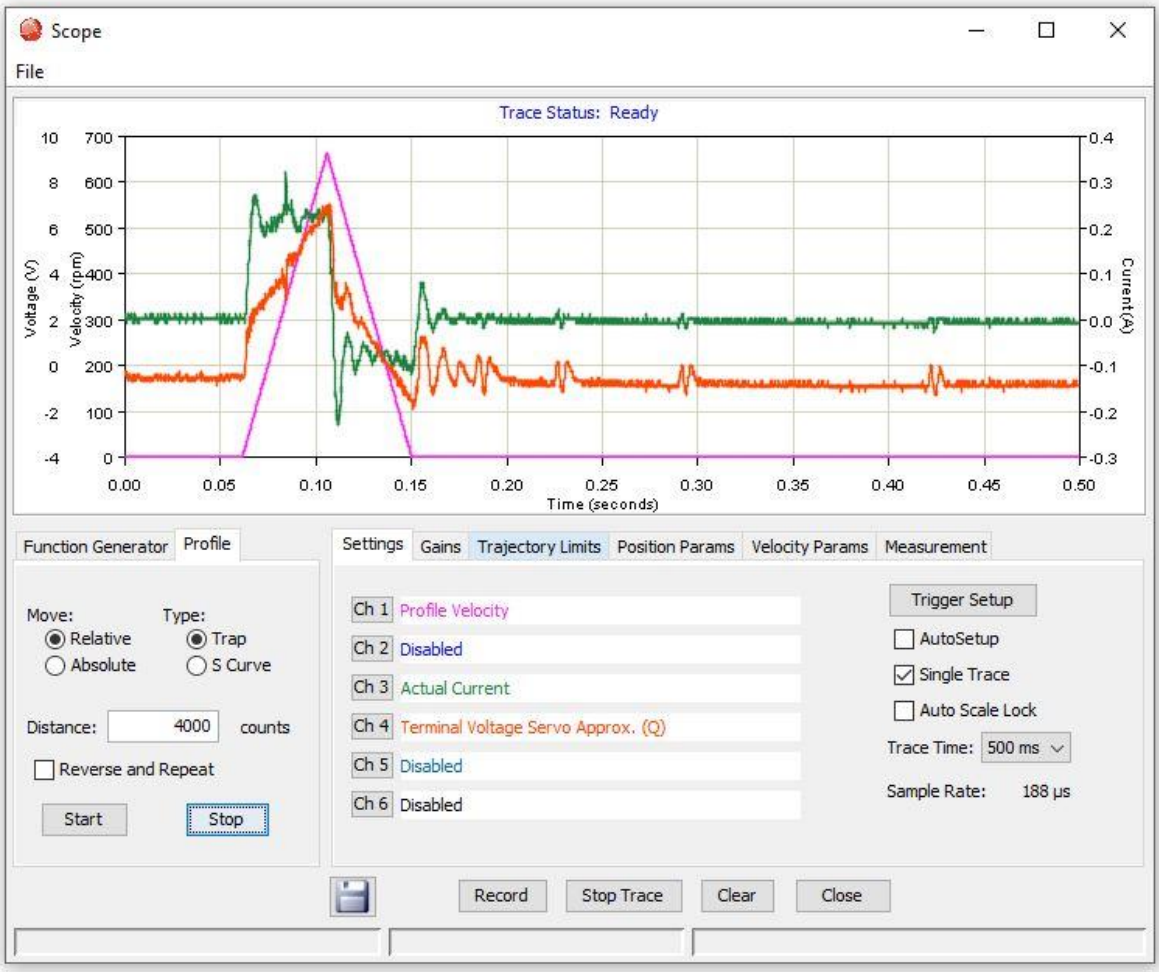
3. To Command the move, refer to the following steps in the table below.

Mode	Steps
Current	1. Hold **Pos** to apply positive current to the motor or hold down **Neg** to apply negative current to the motor. 2. Release the button to command zero current.
Velocity	3.Hold J**og Pos** to command a forward velocity or hold down **Jog Neg** to command a negative velocity. 4.Release the button to command zero velocity.
Position	5.Hold **Move Pos** to generate a forward move profile or hold **Move Neg** to generate a negative move profile. 6.Release the button to stop movement. NOTE: The Position mode jog is accomplished by continuously updating the commanded position. If a Following Error develops with Following Error Fault disabled, the motion will not stop when the button is released. Instead, it stops when the actual position = commanded position.

16 SCOPE

16.1 Overview

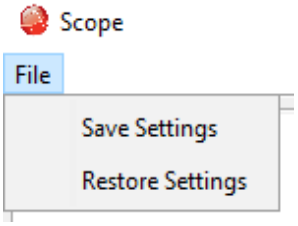
The Scope can be used to tune the drive, monitor performance, and perform diagnostics. Function Generator and Profile Generator can drive the motor without external control. The Auto Set Up feature sets typical initial values for the Scope parameters.



Scope Screen

16.2 Menu, Display and Controls

16.2.1 File Menu

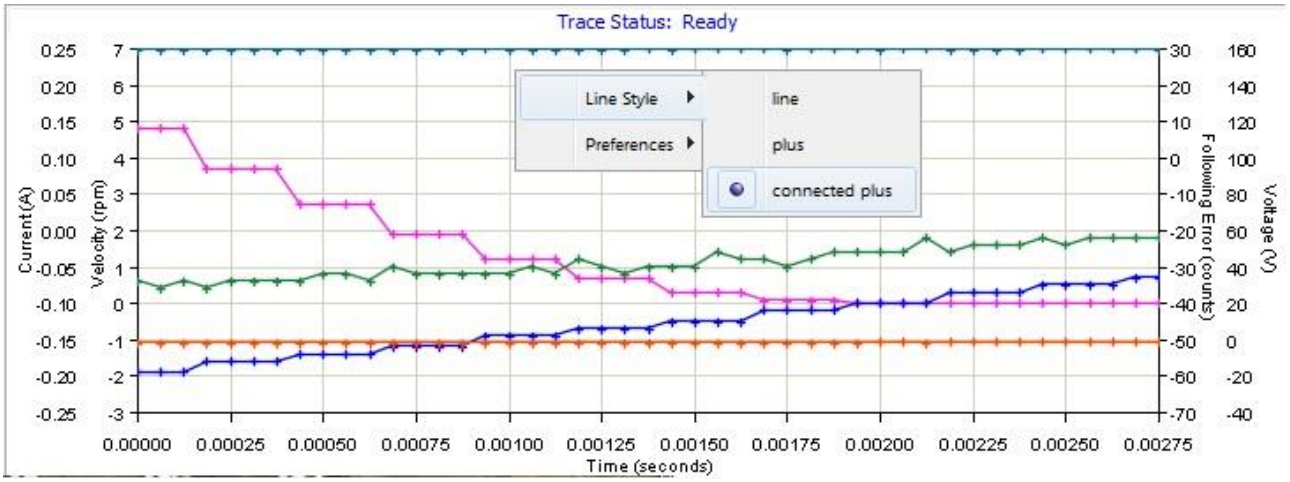


The File menu contains the options to save/restore scope settings. This feature is useful for saving custom settings used for the tests that are run frequently.

File Menu	
Save Settings	Saves the current scope settings to a file.
Restore Settings	Restores the settings from a file.

16.2.2 Display

To access the Trace Display menu, right-click in the Trace display area.

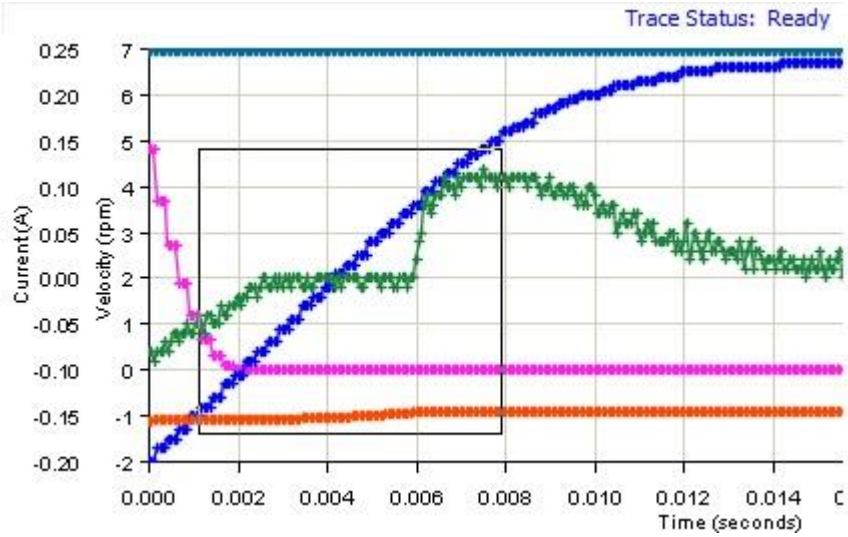


Trace Display Screen

Menu	Parameter	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 a line connects each data point.
Preferences	Anti-Aliasing	When anti-aliasing is selected, the Scope removes the screen-related jaggedness in the displayed trace. Using this feature may slow down the refreshing of traces on slow computers.
	Grid	When selected, a grid is displayed on the scope screen.

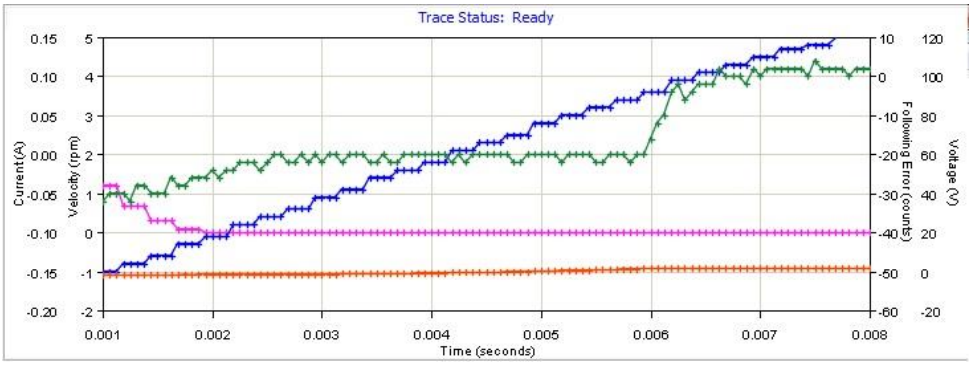
16.2.3 Trace Display (Zoom Option)

1. To use the Zoom feature, select the area, hold the left mouse button down while dragging a box around the area of interest.



Trace Display Screen

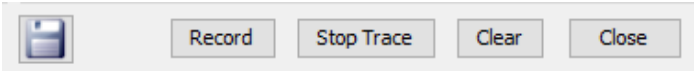
2. Release the button to enable the display to zoom-in on the selected area.



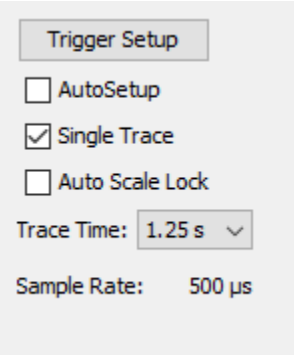
Trace Display Screen

3. To restore the normal zoom level immediately, left-click anywhere on the trace. (Normal zoom level is also restored when the next trigger event occur).

16.2.4 Controls



Settings	Description
	Save a trace. See Scope Trace Files.
Record	Begins recording a trace.
Stop Trace	Stops recording a trace.
Clear	Clears the trace from the screen and the trace data from the buffer.

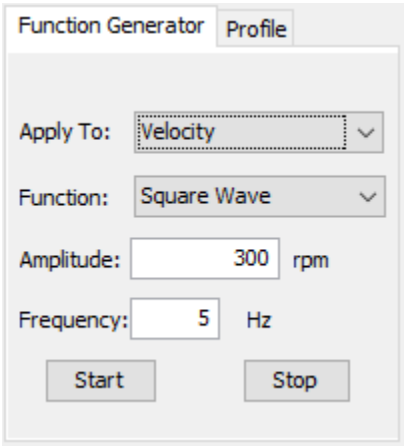


Trigger Setup Screen

Function	Description
Auto Setup	If checked, this checkbox sets the default scope settings based on the applied loop of the function generator. If unchecked, the present settings may differ from the default, and they are overwritten.
Single Trace	If checked, this checkbox configures the scope to stop recording once one trace is captured. If unchecked, the scope will automatically record another trace.
Auto Scale Lock	If checked, this checkbox will lock the scaling of the channel traces in the scope. If unchecked, the Auto Scale feature will be unlocked.
Trace Time	The time of the trace in milliseconds.
Sample Rate	The calculated time that the drive will be sampling the trace variables.

16.3 Function Generator

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



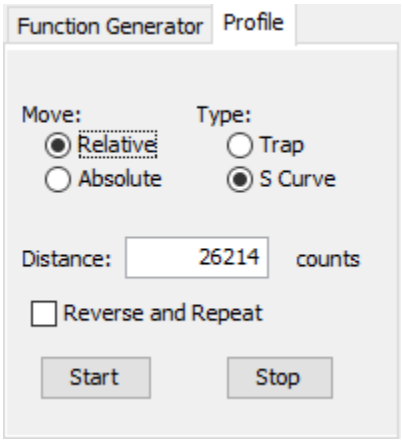
Function Generator Screen

The **Start** button starts the Function or Profile Generator.

The **Stop** button stops the Generator and aborts any profiles in progress.

<table>
<tr><th>Parameter</th><th>Description</th></tr>
<tr><td>Apply To</td><td>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).</td></tr>
<tr><td>Function</td><td>Function that will be applied to the control loop selected in the Apply To list box. The choices vary with the control loop selected:
<table>
<tr><th>Selected Control Loop</th><th>Functions Available</th></tr>
<tr><td>Current</td><td>Sine Wave, Square Wave, Step Forward, Step Forward and Reverse, and Impulse</td></tr>
<tr><td>Velocity</td><td>Sine Wave, Square Wave, Step Forward, Step Forward and Reverse</td></tr>
<tr><td>Position</td><td>Sine Wave, Square Wave</td></tr>
</table>
</td></tr>
<tr><td>Amplitude</td><td>Amplitude of the command. Units vary depending on the value chosen in the Apply To field.</td></tr>
<tr><td>Frequency</td><td>(Sine Wave and Square Wave only.) Frequency of input command cycle.</td></tr>
<tr><td>Period</td><td>(Step Forward, Step Forward and Reverse, and Impulse only.) Duration of each input pulse.</td></tr>
</table>

16.4 Profile Generator

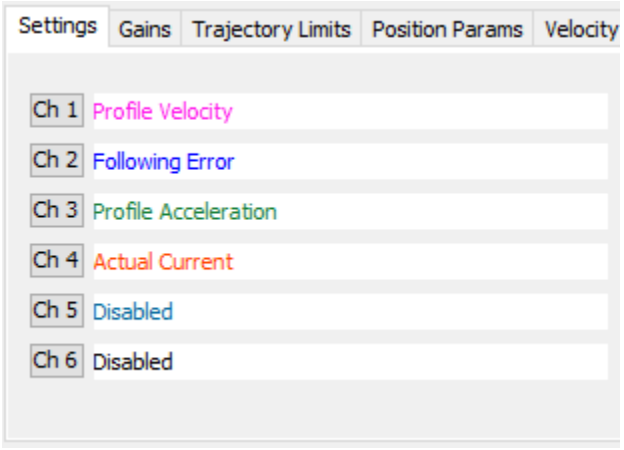


Profile Generator Screen

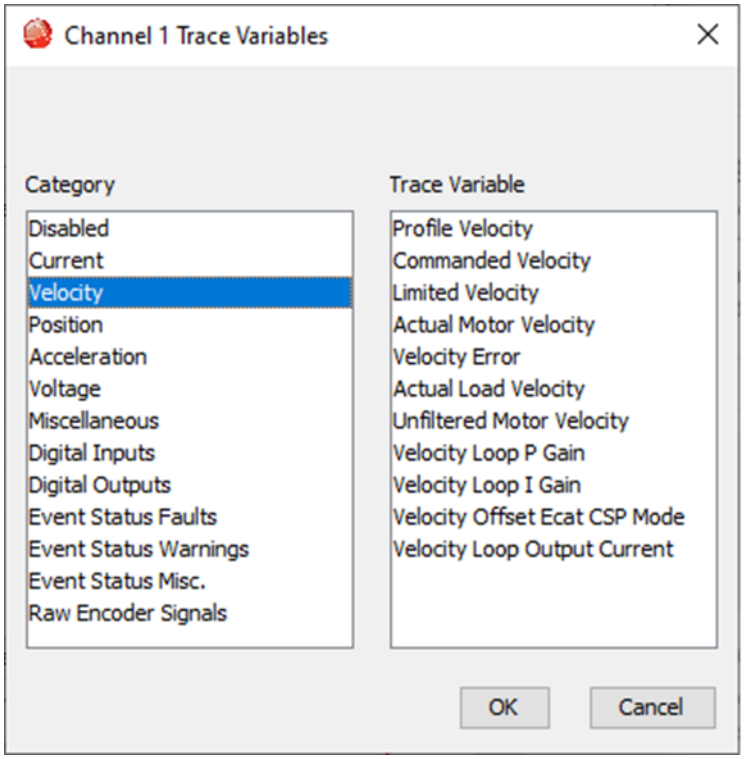
Parameter	Description
Move	Relative: Moves axis a specified distance from the starting position. Absolute: Moves axis to a specific position.
Type	Trap or S-Curve.
Distance	Distance for Relative move.
Position	Target position for Absolute move.
Reverse and Repeat	(Relative move only.) When selected,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

16.5 Trace Channel Variables

1. To open the Trace Variable selection screen, click the **Channel** button.



Trace Variable Selection Screen



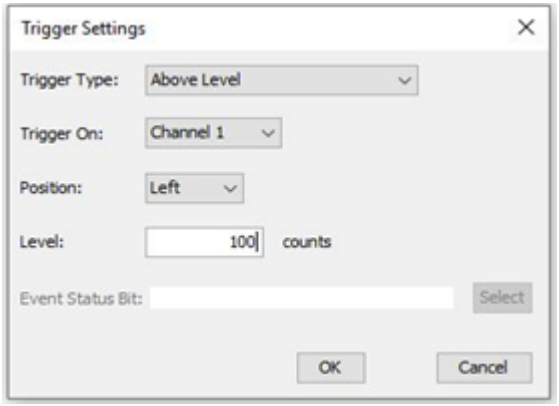
Channel 1 Trace Variables Screen

Category	Trace Variable
Disabled	<Channel disabled, no associated variable>
Current	Commanded Current, Actual Current, Limited Current, I^2T Drive Accumulator, I^2T Motor Accumulator, Current Error (D rotor axis), Current Error (Q rotor axis)
Velocity	Profile Velocity, Commanded Velocity, Limited Velocity, Actual Motor Velocity, Velocity Error, Actual Load Velocity, Unfiltered Motor Velocity, Velocity Loop P Gain, Velocity Loop I Gain, Velocity Output Current.
Position	Commanded Position, Limited Position, Actual Load Position, Actual Motor Position, Following Error, Passive Load Position

Category	Trace Variable
Acceleration	Profile Acceleration
Voltage	Analog Command, Bus Voltage, Analog sin Input, Analog cos Input, Terminal Voltage Stepper, Terminal Voltage Servo
Miscellaneous	Motor Phase Angle, Drive Temperature, Hall States
Digital Inputs	Digital input line states
Digital Outputs	Digital output line states
Event Status Faults	Short Circuit, Amp Over Temperature, Over Voltage, Under Voltage, Motor Over Temperature, Feedback Error, Motor Phasing Error, Following Error, Command Input Fault, Drive Fault (a latched fault is active).
Event Status Warnings	Current Limited, Voltage Limited, Positive Limit Switch, Negative Limit Switch, Following Warning, Velocity Limited, Acceleration Limited, Positive Software Limit, Negative Software Limit, Pos Outside of Tracking Window, Vel Outside of Tracking Window.
Event Status Misc.	Amp Disabled by Hardware, Amp Disabled by Software, Attempting to Stop Motor, Motor Brake Active, PWM Outputs Disabled, Position Has Wrapped, Home Switch Active, In Motion, Phase Not Initialized.
Raw Encoder Signals	Primary Encoder A, Primary Encoder B, Primary Encoder X, Primary Encoder S, Secondary Encoder A, Secondary Encoder B, Secondary Encoder X, Secondary Encoder S

16.6 Trigger Setup

1. To open the Trigger Settings screen, click the **Trigger Setup** button.



Trigger Settings Screen

Setting	Description	
Trigger Type	**Type**	**Condition**
	Immediate Trigger	Trigger as soon as a trace is started (when the **Record** button is pressed).
	Rising Edge	Trigger when the selected channel's input changes from below to above the trigger level.
	Falling Edge	Trigger when the selected channel's input changes from above to below the trigger level.
	Above Level	Trigger as soon as the selected channel's input is greater than or equal to the trigger level.
	Below Level	Trigger as soon as the selected channel's input is less than or equal to the trigger level.
	Function Generator	Trigger on the start of the next function generator cycle.
	Input Level High	Trigger when specified input is high.
	Input Level Lo	Trigger when specified input is low.
	Output Active/Inactive	Trigger when specified output is active/inactive.
	Event Status Rising Edge/Falling Edge	Trigger on the rising or falling edge of an event status bit.
	Raw Encoder Signal Level High	Triggers when the raw encoder signal is High.
	Raw Encoder Signal Level Low	Triggers when the raw encoder signal is Low.
Trigger On	Selects which channel will be used as the trigger source.	
Position	Selects placement of the trigger event on the screen. (Value is not configurable for Immediate or Function Generator 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, in units appropriate to the channel selected.	
Event Status Bit	With an event status trigger type selected, choose the status bit that will trigger the trace. This setting is used for descriptions of the event status word.	

16.7 Measurement Tab

The Measurement tab allows you to measure and analyze the data from up to three parameters during an interval defined by adjustable cursors. The Cursor Data area displays a parameter's values at the left and right cursor locations and shows the difference between the two values (Delta). The Analysis area displays the minimum, maximum, average, and root mean square of the parameters during the cursor period.



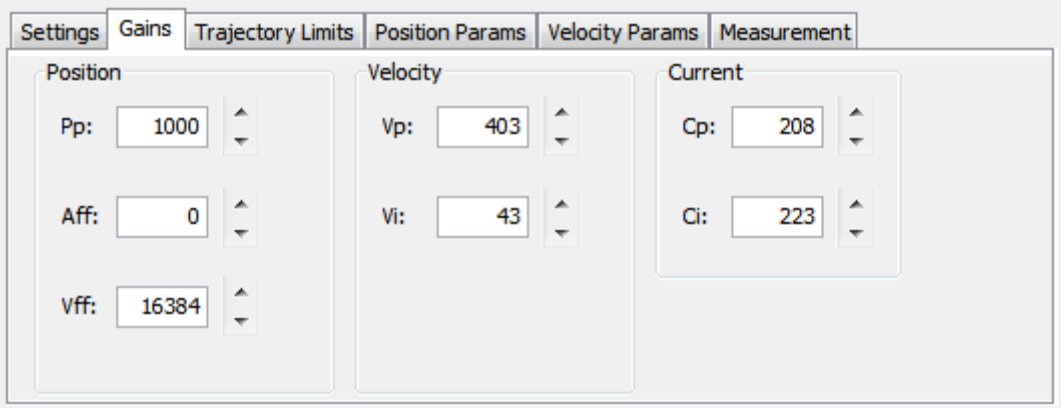
Example of Measurement Tab

When **Show Cursors** is not set, the **Cursor Data** fields are inactive and the **Analysis** fields show calculations based on the data calculated from the entire trace cycle.

1. To display cursors and activate the **Cursor Data** fields, set **Show Cursors**.
2. To move a cursor, click on the cursor and hold the left button while dragging the cursor to the desired location. Release the left button to place the cursor in the new location.
3. To select a parameter to measure and analyze within the cursors, choose a channel in one of the three channel listed on the Measurement tab.

16.8 Control Loop Parameters

The Oscilloscope provides convenient access to all the Control Loop parameters that might be used in tuning and diagnosing a drive. 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.



Gains Tab Screen

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.

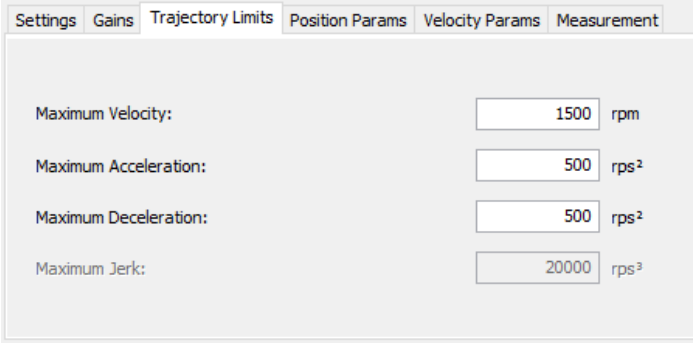
The Control Loop parameter tab descriptions are listed in the table in Section Gains Tab.

16.8.1 Gains Tab

Modes	Gains	Description	For More Information
Position Mode only	Pp	Position Loop Proportional Gain.	Position Loop Gains
	Aff	Acceleration Feed Forward.	
	Vff	Velocity Feed Forward.	
Position or Velocity Mode only	Vp	Velocity Loop Proportional Gain.	Velocity Loop Gains
	Vi	Velocity Loop Integral Gain.	
All Modes	Cp	Current Loop Proportional Gain.	Current Loop Gains
	Ci	Current Loop Integral Gain.	
	ECp	Encoder Correction Gain (Stepper only)	Encoder Correction

16.8.2 Trajectory Limits Tab

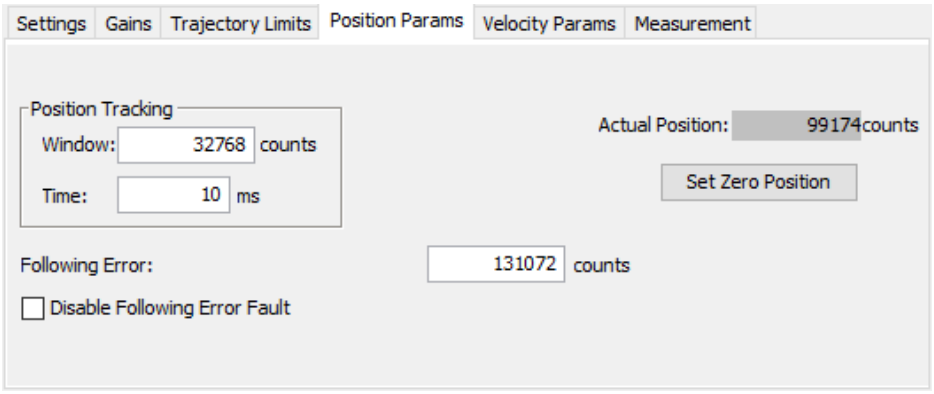
The Trajectory Limits tab is available in the Position mode.
For more information, see the Section: Position Loop Setup and Tuning.



Trajectory Limits Tab Screen

16.8.3 Position Loop Parameters

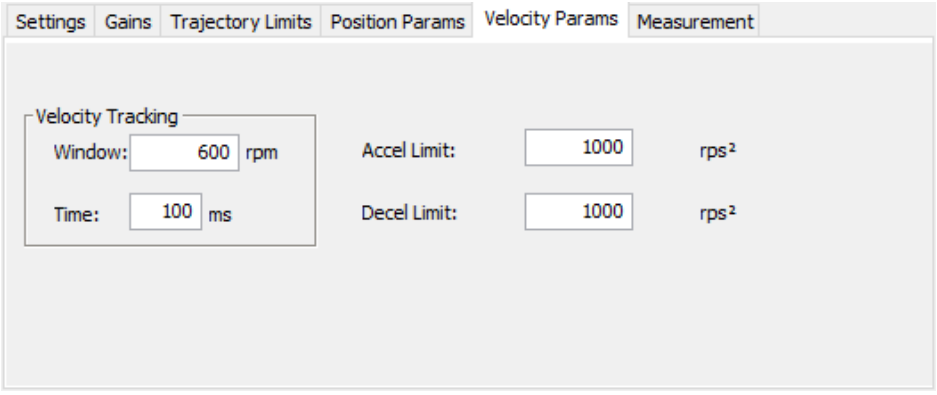
The Position Loop parameter is available in the Position mode.
Use the **Set Zero Position** button to set the drive's actual position count to zero.
For more information, see the Section: Position Loop Setup and Tuning.



Position Params Tab Screen

16.8.4 Velocity Loop Parameters

The Velocity Loop parameter is available in the Position and Velocity modes.



Velocity Params Tab Screen

For more information, see the Section: Velocity Loop Setup and Tuning.

The Oscilloscope can save trace data to a disk that can be opened later with the Trace Viewer. When the save trace data to disk operation is performed, CME saves the data in three different files:

- File .**sco** : This file is a CME 2 format which contains scope settings and trace data.
- File .**csv**: This file is a standard comma-separated value file format that can be imported into the spreadsheet software like Microsoft Excel.
- File .**txt**: This file is a tab-separated value file similar to the .csv file. This file is intended to be imported by software that can only read tab-separated values.

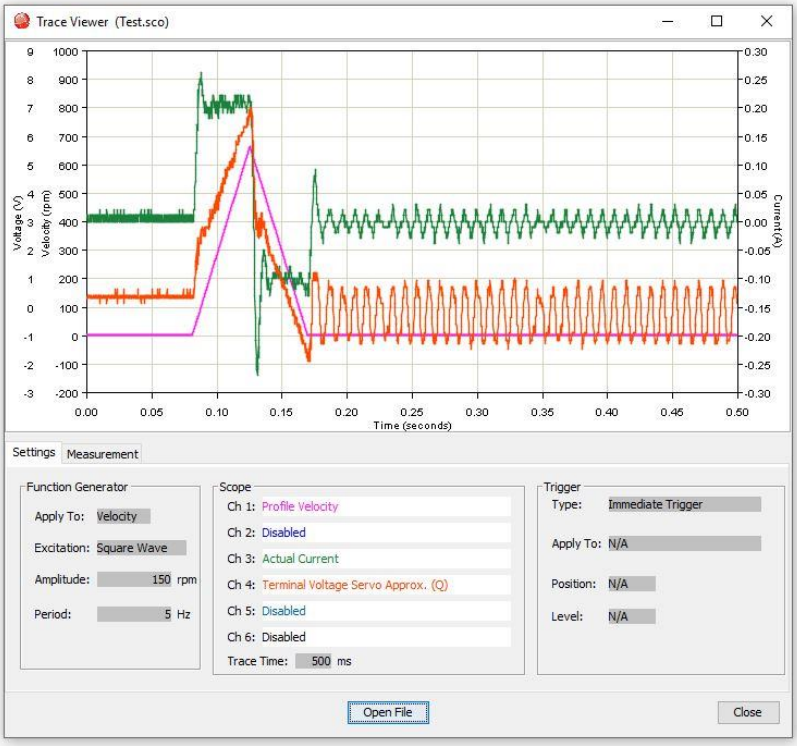
The format of the .csv and the .txt files are identical except for the separator:

- Column 1: Time
- Column 2: Trace Channel 1 data
- Column 3: Trace Channel 2 data (if used)
- Column n: Trace Channel n data (if used)
  The trace data is measured in drive units, not user units (see the Parameter Dictionary for units).

16.9 Trace Viewer

The Trace Viewer screen displays the contents of the scope files. All of the trace display features (zooming, line style, etc.) as well as the measurement functions are available in this screen.

1. On the Main screen, choose **Tools→View Scope Files** to open the 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.

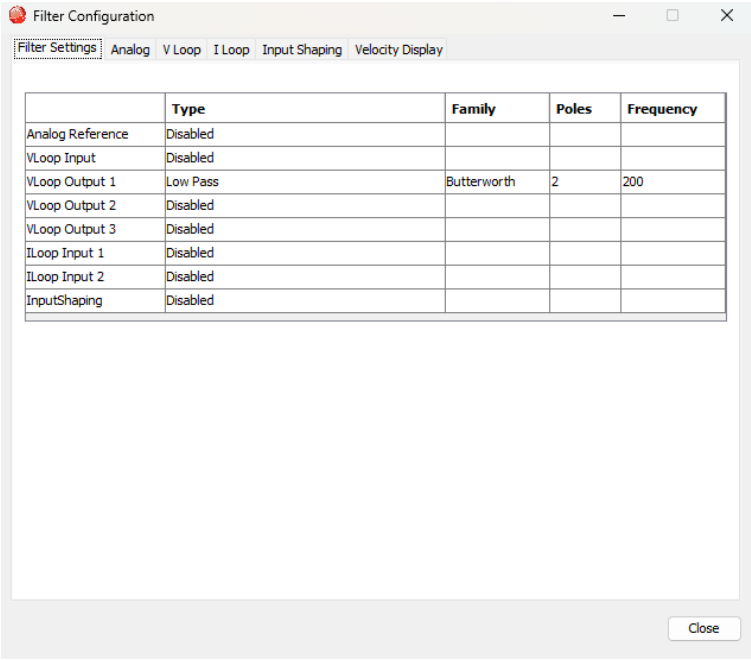


Trace Viewer Window

17 FILTERS

17.1 Filter Settings

Use the Filter Settings tab to open a window that shows what filters were selected.



	Type	Family	Poles	Frequency
Analog Reference	Disabled			
VLoop Input	Disabled			
VLoop Output 1	Low Pass	Butterworth	2	200
VLoop Output 2	Disabled			
VLoop Output 3	Disabled			
ILoop Input 1	Disabled			
ILoop Input 2	Disabled			
InputShaping	Disabled			

Filter Settings Tab Screen

17.2 Filter Configuration Windows

In addition to the location of a Cut-Off Frequency on the filter curve, there are several filter configuration parameters available to select depending on whether you choose: Standard Filter Types or Standard Filter Families.

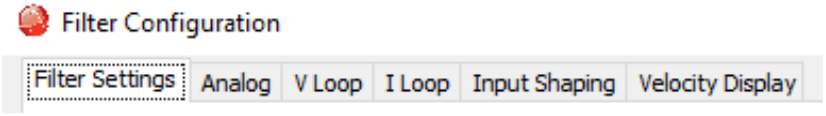
The Filter configuration choices may include the following options:

- Number of Poles (For example, the location of a Cut-Off Frequency on the filter curve).
- Cut-Off Frequency
- Frequency 2 (If two poles are chosen).
- Pass Band Ripple
- Stop Band Ripple
- Decimation value (For example, how often the filter is updated in terms of servo loops).

17.3 Setting Parameters

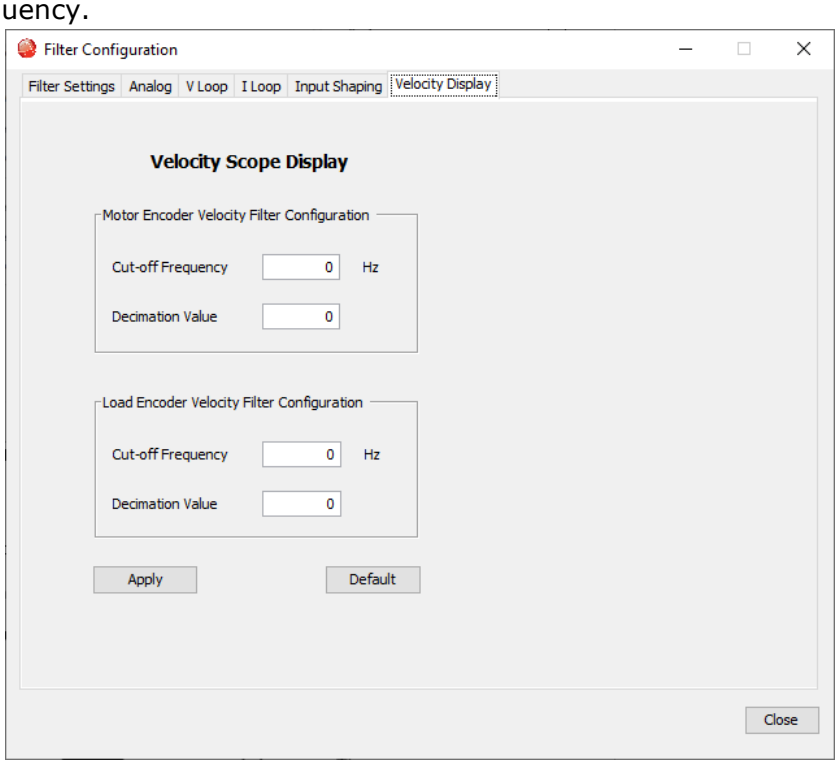
To change or view the filter configurations, follow these steps:

1. To open the Filter Configuration screen, from the Main screen choose the **Configure Filters** button.
2. To view the present filter settings, choose the Filter Settings tab. Choose other tabs to configure the following settings:
   - Analog
   - V Loop
   - I Loop
   - Input Shaping
   - Motor Velocity Filter
   - Load Velocity Filter



17.3.1 Velocity Filter Configuration Tab

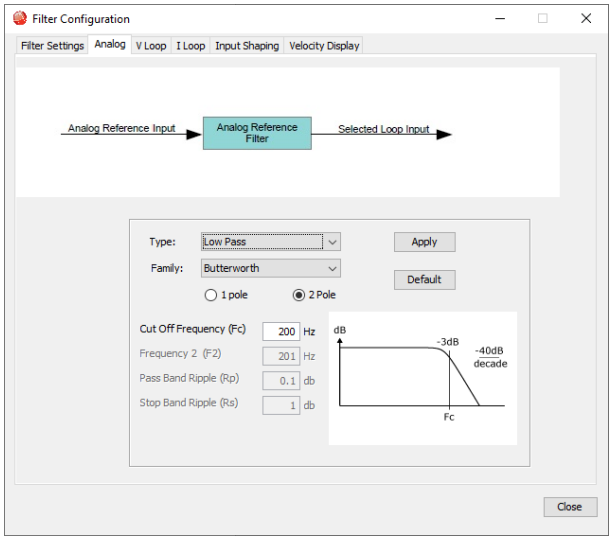
CME provides users the option to adjust the cutoff frequency and decimation value for velocity filters on both the motor and load feedback. Note that this screen has no effect on the servo loops. The raw velocity is first averaged for N cycles where N is the programmed decimation value + 1. Then, every N cycles this average velocity is filtered using a low pass filter with the specified cut-off frequency.



Velocity Filter Configuration Tab Screen

17.3.2 Analog

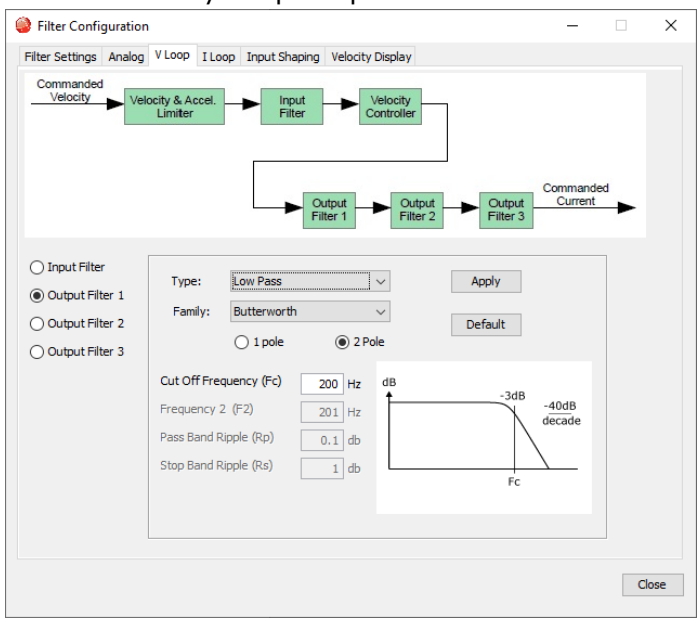
Use the Analog tab to open a window that shows the analog filter choices and a representative curve. Modify the settings as needed and press **Apply**.



Analog Tab Screen

17.3.3 Velocity Loop

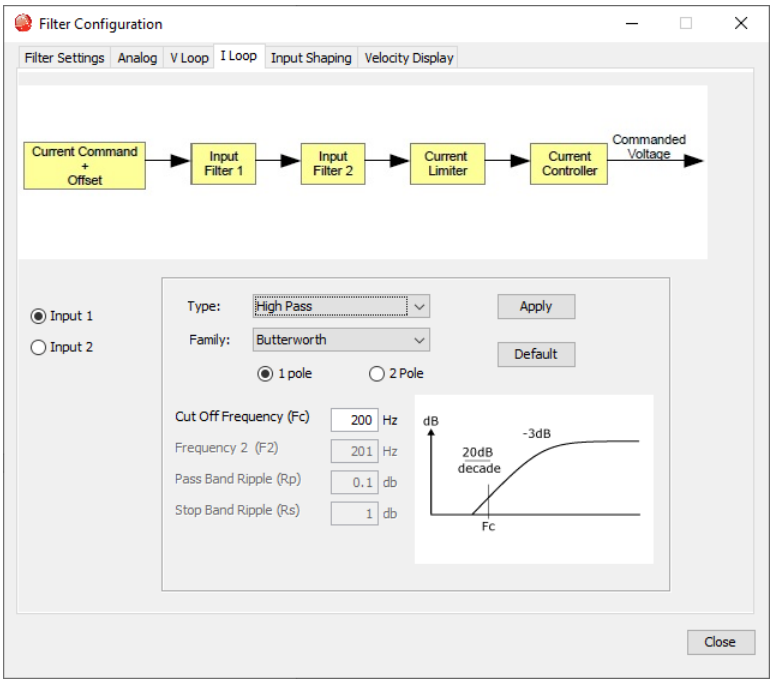
The V Loop tab opens a window that shows the Velocity Loop Filter options and a representative curve. Modify the settings as needed and press **Apply**. If you select **Default,** it will supply a 200 Hz Low Pass filter to the first Velocity Loop Output Filter.



V Loop Tab Screen

17.3.4 Current Loop

The I Loop tab opens a window that shows the Current Loop Filter choices and a representative curve. Modify the settings as needed and press **Apply**.



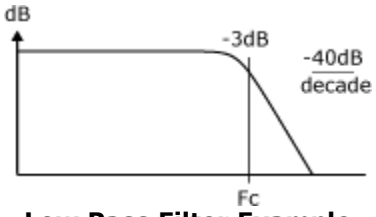
I Loop Tab Screen

17.4 Standard Filter Types

The following Sections describe the Standard Filter types.

17.4.1 Low Pass Filter

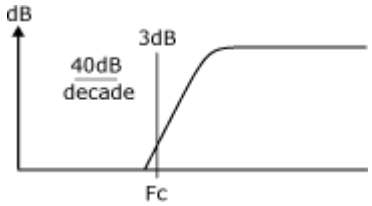
The Low Pass Filter Example diagram shows the frequencies that are below the selectable cut-off and that are allowed to pass.



Low Pass Filter Example

17.4.2 High Pass Filter

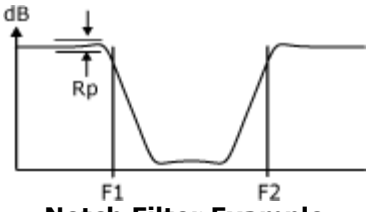
The High Pass Filter Example diagram shows the frequencies that are above the selectable cut-off and that are allowed to pass.



High Pass Filter Example

17.4.3 Notch Filter

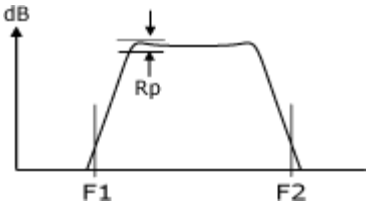
Notch filters allow a bandstop in a range between two selectable frequencies. It may be Butterworth (no ripple), Chebyshev (selectable passband ripple), or elliptical (ripple on both passband and bandstop).



Notch Filter Example

17.4.4 Band Pass Filter

Band pass filters allow a range of frequencies, between two selectable cut-offs, to pass. It may be Butterworth, Chebyshev, or Elliptical.



Band Pass Filter Example

17.4.5 Custom Biquad Filter

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.

$$H(z) = \frac{b_0 + b_1 z^{-1} + b_2 z^{-2}}{1 - a_1 z^{-1} - a_2 z^{-2}}$$

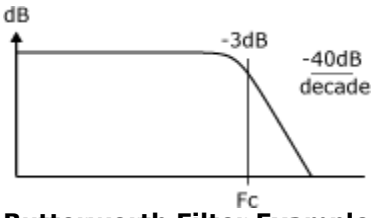
Custom Biquad Filter Example

17.5 Standard Filter Families

The following Sections describe the Standard Filter Families.

17.5.1 Butterworth Filter

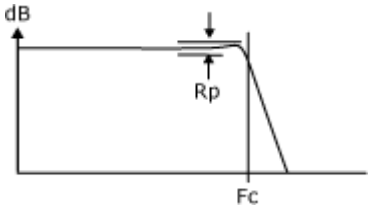
A Butterworth filter has two poles for faster roll-off at the cut-off frequency.



Butterworth Filter Example

17.5.2 Chebyshev Filter

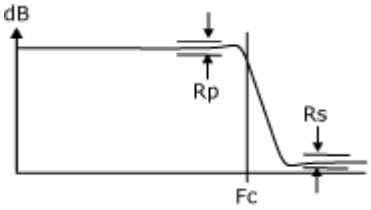
A Chebyshev filter has a faster roll-off than a Butterworth filter, but, as a result of the fast roll-off, ripple is introduced into the passband frequency.



Chebychev Filter Example

17.5.3 Elliptic Filter

The Elliptic Filter is similar to a Chebyshev filter but ripple is introduced into both the passband and the stopband. It has a faster roll-off than a Chebyshev filter.



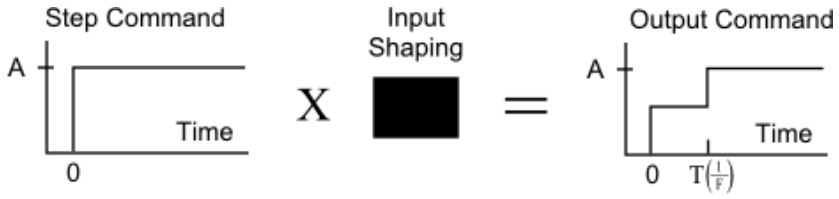
Elliptic Filter Example

17.6 Input Shaping

Input Shaping is a method by which the unwanted command induced vibrations (mechanical frequency) are kept to a minimum by damping them with superimposed impulses. This produces a command that will drive the system with limited residual vibration.

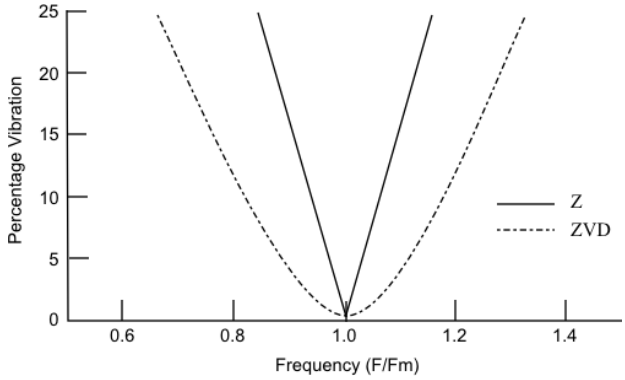
1. To set the Input Shaping parameters, first measure the mechanical frequency.

The following diagram shows the Input Shaping process.



Input Shaping Diagram

The diagram below shows a Sensitivity Curve. When F = Fm, there is zero vibration.

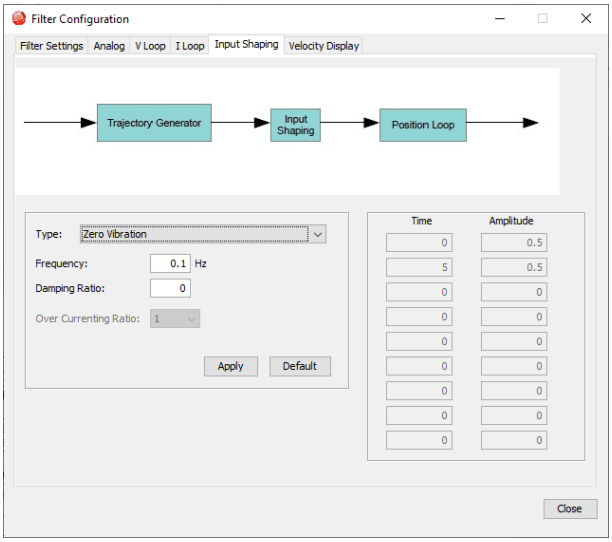


Sensitivity Curve Diagram

The Input Shaping tab opens a window that shows the Input Shaping choices and a representative Time and Amplitude table.

2. Modify the settings as needed and press **Apply**.

The Type, Frequency, Damping Ratio of the mechanical resonance and Number of Impulses may be adjusted. Overcurrent is adjustable when a Negative Zero Vibration or a Negative Zero Vibration and Derivative filter is chosen. If the Custom is chosen as the Type, the Time and Amplitude may be set manually.



Input Shaping Tab Screen

17.6.1 Input Shaping Types

Type	Description
Zero Vibration	Single step inputs are replaced with two step inputs of smaller magnitude. One of which is delayed by one-half the period of vibration. Sensitive to some modeling errors.
Zero Vibration and Derivative	A zero derivative (of the vibration) constraint is added to Zero Vibration impulse shaping, thereby reducing modeling errors.
Negative Zero Vibration	Faster than positive input shaping (Zero Vibration, and Zero Vibration and Derivative), but may magnify high frequency vibrations.
Negative Zero Vibration and Derivative	A zero derivative (of the vibration) constraint is added to Negative Zero Vibration impulse shaping.
Custom	Time and Amplitude can be set manually.

17.6.2 Measuring Mechanical Vibration

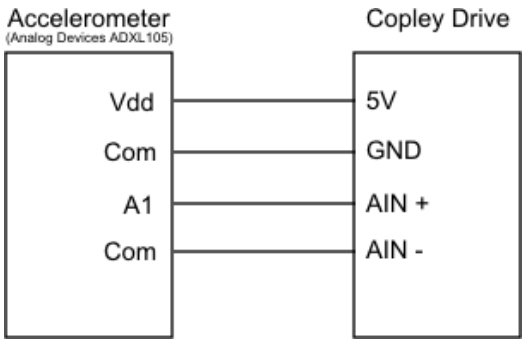
There are several ways to measure the mechanical vibration. The following list the two options to measure the mechanical vibration.

- Use the Accelerometer with the CME software.
- Use the CME software to monitor Following Error.

17.6.3 Using an Accelerometer with CME

To start, use a Copley drive that is operational and controlled by the CME software.

1. Connect the accelerometer analog output to the Copley drive's Analog **+** and **-** on the signal input as shown in the diagram below.



Accelerometer and Copley Drive Diagram

2. On the Main screen, click the **Scope** button on the toolbar.
3. Select the Measurement tab, choose a Channel, select Voltage, then the Analog Command.
4. Perform a move.
5. After the move is complete, measure Tm (1/Fm), which is the period of mechanical oscillation.

17.6.4 Using CME to Monitor Following Error

To monitor the Following Error using the CME 's scope option, do the following.

Begin with a Copley drive that is operational and controlled by the CME software.

1. On the Main screen, click the **Scope** button on the toolbar.
2. Select the Measurement tab, choose a Channel, select **Position**, then **Following Error**.
3. Perform a move.
4. After the move is complete, measure Tm (1/Fm), which is the period of mechanical oscillation.

18 FREQUENCY ANALYSIS

18.1 Overview

The Frequency Analysis screen expands on the functionality of CME by providing a tool to measure the frequency response of a system while running a sine sweep. This feature further enhances the ability to tune and troubleshoot systems, particularly when there is a mechanical resonance present. The Frequency Analysis tool will measure and plot the current/velocity loop frequency response on a semi-log graph. A list of available Frequency Analysis modes is described in the Available Modes section.

18.2 Open Loop Safety Considerations

There are two approaches to safety implemented in the Open Loop modes. These approaches, Position Limits and Velocity Limits, are described in further detail below. The Open Loop modes require no feedback to the outermost loop (i.e., no position feedback for Position Open Loop mode). Once a limit has been reached, the outer loop has no way to perform a controlled stop of the motion. Instead, the drive stops pushing current in the direction of the limit (i.e. positive limit -> No added current in the positive direction) and does not actively stop the motion. The inertia present in the motor once a limit has been hit causes the motor to decelerate at an uncontrolled rate which for Position Limits can cause continued motion through the limits.

18.2.1 Position Based Limits

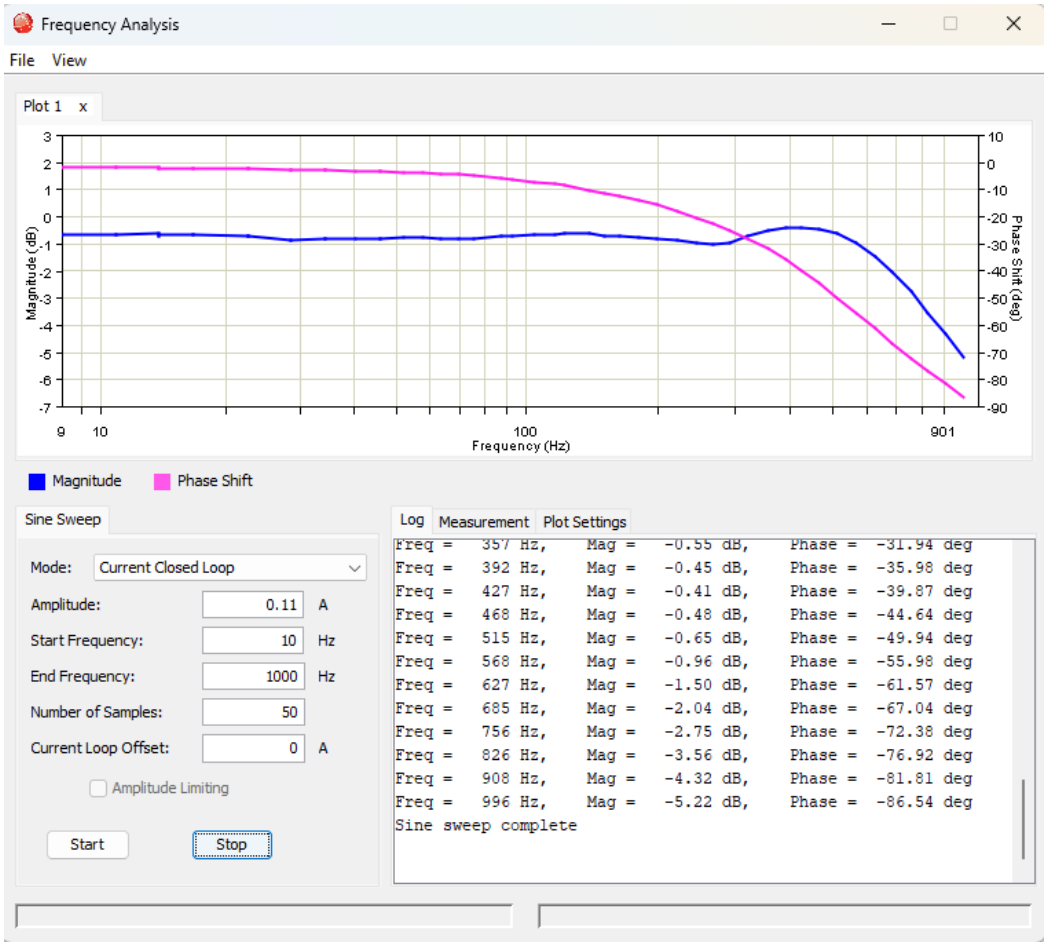
The first approach is using the positive and negative software limits to limit the position. This type of limiting is optional since not all applications have position based limiting needs. When using this type of limit, there is a requirement that the homing must be referenced prior to starting the analysis. For the Position Open Loop mode, the starting position should be just above the negative position limit because during Open Loop the commanded position is the position error which means the actual position sine wave will be offset by 90 degrees. This approach uses the Velocity Loop Velocity Limit value to limit the velocity. This value should be set to a reasonable number for the desired frequency range as it will directly affect the inertia in the motor.

18.2.2 Velocity Based Limits

The second approach is using a velocity fault that trips once the motor maximum velocity value has been exceeded. Once this fault occurs, the current loop will stop actively pushing current in the positive direction which allows the motor to coast to a stop. The stopping time will be dependent on the inertia of the motor.

18.3 User Interface

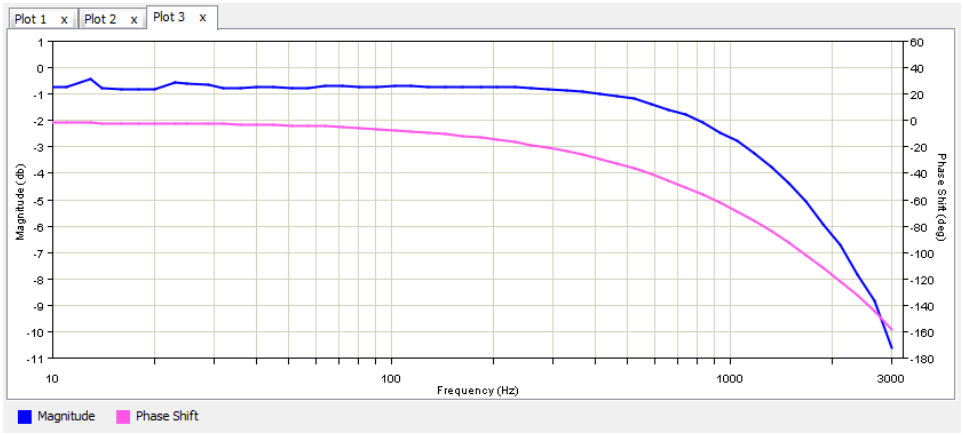
1. On the Main screen, click the **Frequency Analysis** button on the toolbar.



Example Frequency Analysis Screen

18.3.1 Graph

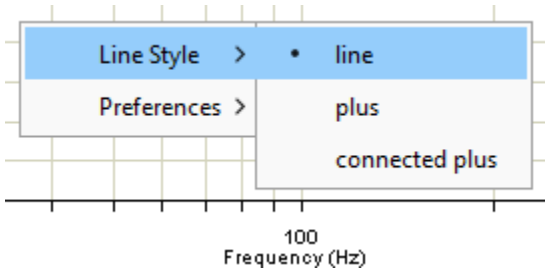
The frequency response data is plotted on a semi-log graph when the sign sweep completes. Each time a sine sweep is run, the data is plotted on a graph in a new tab. The tabs are named with the plot number (Plot 1, Plot 2, etc.). For multi-axis drives, the axis letter is appended to the tab name (e.g. Plot 1A, Plot 2B, etc.). The magnitude scale is displayed on the left Y axis and the phase shift scale is displayed on the right Y axis.



Graph Diagram

18.3.1.1 Graph Options Menu

To display the Plot Options menu, right-click anywhere on the graph.



Graph Options Menu

Menu	Menu Items	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 relate to a line.
Preferences	anti-aliasing	When anti-aliasing is selected, the Scope removes screen-related jaggedness in the displayed trace. Use of this feature may slow down the refreshing of traces on slow computers.
	grid	When selected a grid is displayed on the scope screen.

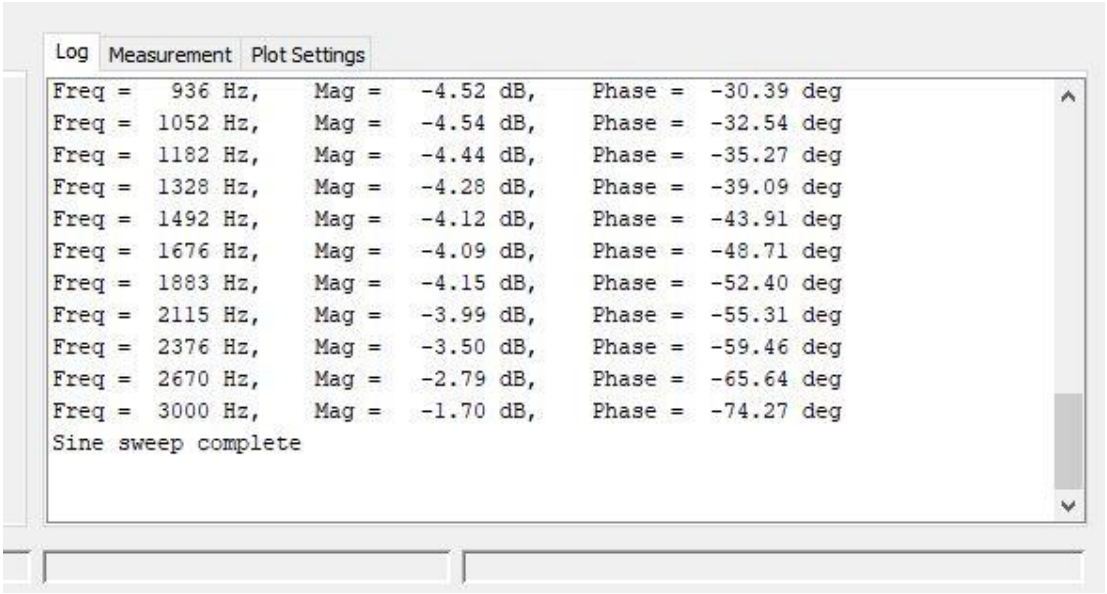
18.3.2 Sine Sweep Controls

Position	Description
Default:	Current: 10% of the current loop continuous current. Velocity: 5% of the velocity loop velocity limit.
Start Frequency Default:	Current: 10 Hz Velocity: 5 Hz
End Frequency Default:	Current: 3000 Hz Velocity: 250 Hz
Mode	
Description:	The loop to which the excitation will be applied, and the response will be measured. See Available Modes for details.
Units:	None
Default:	Current Closed Loop
Amplitude	
Description:	The amplitude of the sine wave.
Units:	A (current), rpm (velocity, rotary motor), mm/s (velocity, linear motor).
Default:	Current: 10% of the current loop continuous current. Velocity: 5% of the velocity loop velocity limit.
Start Frequency	
Description:	The first frequency of the sine sweep.
Range:	0.1 to 9999 Hz
Units:	Hz
Default:	Current: 10 Hz, Velocity: 5 Hz
End Frequency	
Description:	The last frequency of the sine sweep.
Range:	0.2 to 10000 Hz
Units:	Hz
Default:	Current: 3000 Hz Velocity: 250 Hz

Number of Samples	Description
Description:	The number of sine wave frequencies to run during the sine sweep. The frequencies are calculated so that there are an equal number of frequencies per decade.
Range:	2 to 100
Units:	None
Default:	50
Start	
Description:	Starts the sine sweep.
Units:	N/A
Default:	N/A
Stop	
Description:	Cancels the sine sweep in progress.
Units:	N/A
Default:	N/A

18.3.3 Log Text Window

The Log Text window shows the progress of the sine sweep. For each frequency, the measured frequency response (magnitude and phase shift) is displayed. These are the values that are plotted in the graph.



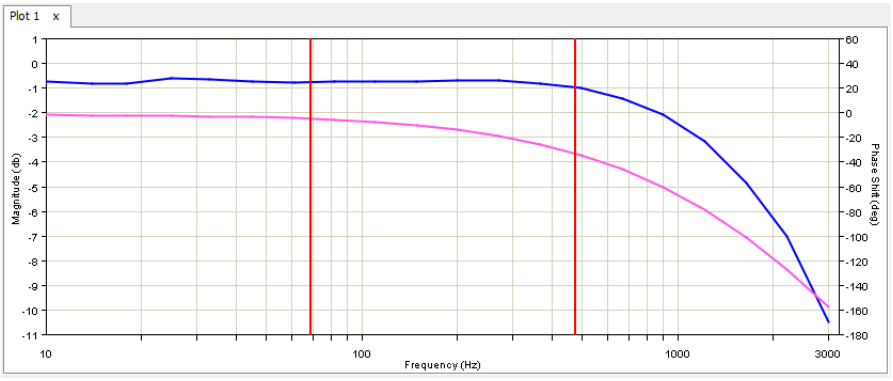
Log Text Screen

18.3.4 Log Text Screen Measurement

The Measurement tab contains tools to analyze the data displayed on the graph.

Cursors

Select **Show Cursors** button to display the cursors on the graph.



Cursors Shown on the Screen

To move the cursors, left-click a cursor and drag it to the left or right.

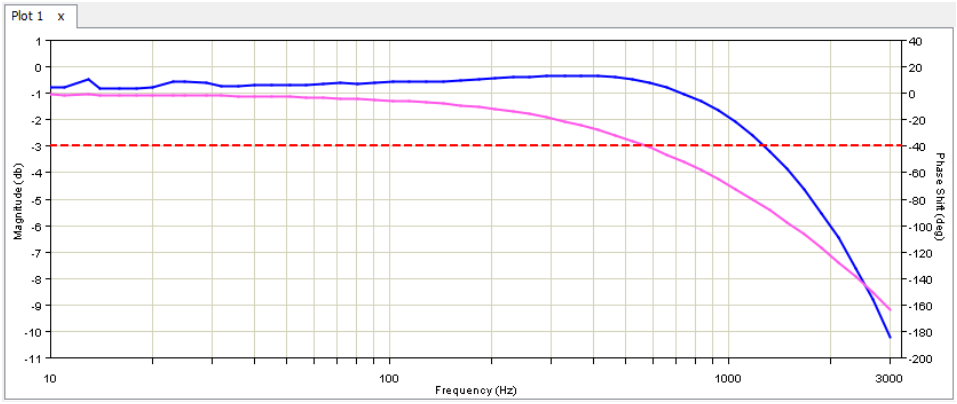
As the cursor is moved along the plot, the values for Frequency, Magnitude, and Phase Shift are updated in the Measurement tab.



Measurement Screen

18.3.4.1 Show -3db Line

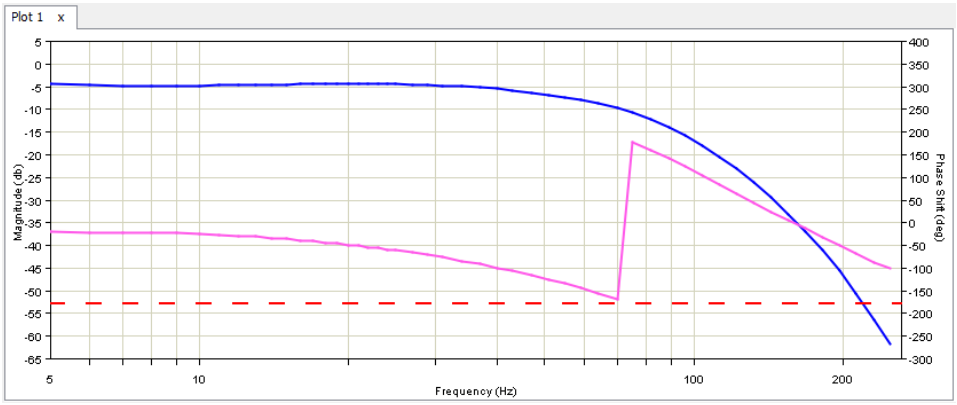
Select **Show – 3db Line** icon to display a horizontal dashed line where the magnitude is -3db. The -3db point on the magnitude plot is used to determine the bandwidth of the system.



Example of -3db Line Diagram

18.3.4.2 Show -180 Degree Line

Select **Show 180 Line** icon to display a horizontal dashed line where the phase shift is -180 degrees. This line is useful for determining the phase and gain margins of your system.



Example of 180 Degree Line Diagram

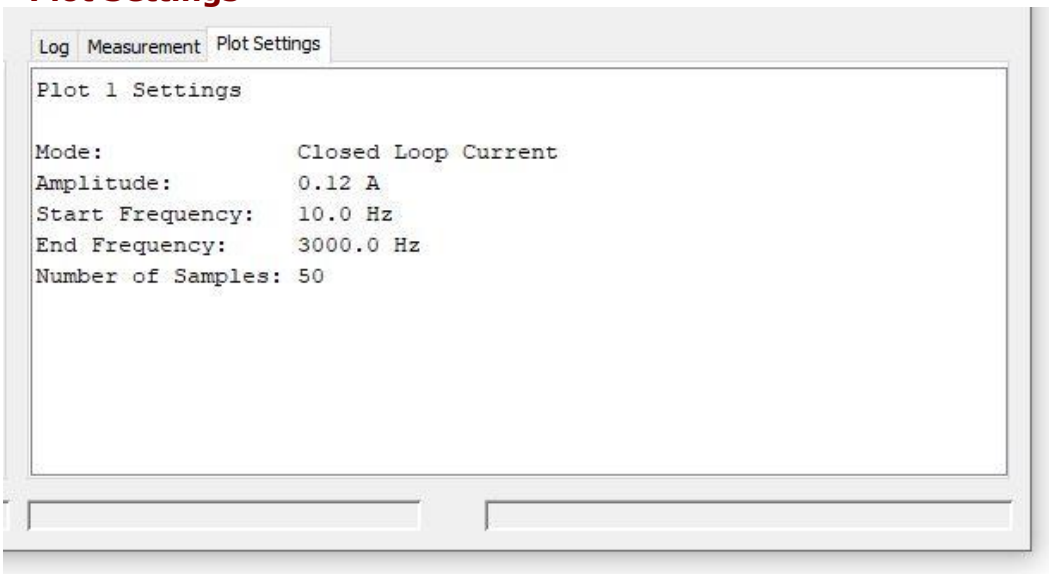
18.3.4.3 Manually Measuring Gain Margin

Assuming the phase starts at 180 degrees and goes to 0 degree (a phase shift of 180 degrees), measure the gain margin from 0 db at this phase inversion and determine how many decibels of gain margin exist. A critically damped loop may have approximately 15 db of gain margin.

18.3.4.4 Manually Measuring Phase Margin

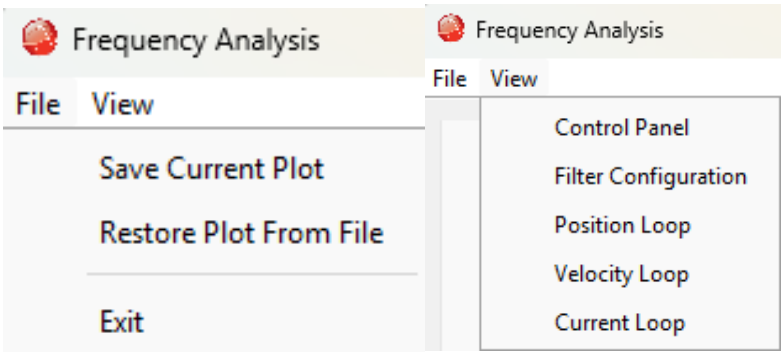
Assuming the phase starts at 180 degrees and goes to 0 degree, (a phase shift of 180 degrees), measure the phase shift at the 0 db gain from the initial phase to the new phase to determine the phase margin. A critically damped loop may have approximately 75 db of phase margin.

18.3.5 Plot Settings



Plot Settings Screen

18.3.6 File Menu



File Menu Items	Description
Save Current Plot	Saves the data from the sine sweep of the plot currently displayed in a .csv format that can be imported to other software such as spreadsheets or mathematical analysis programs.
Restore Plot From File	Open a plot using the data from a previously saved .csv file.

18.3.7 View Menu

18.3.7.1 View Menu Button Options

The View Menu options are listed in the table below.

Menu Option	Description
Control Panel	Opens the Control Panel screen.
Filter Configuration	Opens the Filter Configuration screen.
Position Loop	Opens the Position Loop screen.
Velocity Loop	Opens the Velocity Loop screen.
Current Loop	Opens the Current Loop screen.

18.3.8 Filter Screen

To open the Filter Configuration screen, click **Configure Filters** button.

18.3.9 Status Bar

In the Status Bar, use the left and middle text fields to show the various faults and warnings while the Frequency Analysis screen is open.

18.3.9.1 Faults/Warnings Status

The left text field of the status bar shows the faults and warnings.

- Faults will be displayed with a red background.
- Warnings will be displayed with a yellow background.

Only two warnings are monitored during the Frequency Analysis: Current Limited Warning and Voltage Limited Warning. All faults are monitored during the Frequency Analysis.



18.3.9.2 Motion Inhibited Status

The middle text field of the status bar shows the conditions that will prevent motion. The conditions that are not faults, but will prevent motion are as follows:

- Positive and negative software limits
- Positive and negative limit switches
- Drive is disabled by hardware (enable input not active).
- Phase not initialized (only applies when feedback is set up for phase initialization).



18.4 Available Modes

The modes described below are available starting in CME V8.1 Beta 26 and are supported by Plus products and/or ARM products. The Closed Loop/Servo modes (current and velocity) are supported as follows:

- For Plus products, beginning in firmware versions 2.28
- For ARM products, firmware versions 1.02

The Open Loop modes and Position Loop Servo modes are supported on Plus products by firmware version 4.92 and above.

Some of the available modes have keys in parentheses. The keys are LF, HF, and Servo. The LF and HF (Low Frequency and High Frequency, respectively) modes refer to the changes in the implementation that improve the reliability and robustness of the collected data for the corresponding frequency ranges. The specific ranges that constitute "High" or "Low" will vary depending on multiple factors including, but not limited to encoder resolutions and load properties. An example of the general procedure for determining which mode should be used in each case is detailed at the end of this document. Servo refers to the addition of feedback in the outermost loop of the Open Loop modes.

18.4.1 Usages

Open Loop modes (no feedback) are used to characterize and analyze an unknown system. In Open Loop, the motor is always stable and there is no way for the system to become unstable. Once the system is tuned and is stable, the Servo modes give more accurate system data for analysis and system characterization.

Modes 1 – 8 below have feedback, while modes 9 - 12 have none.

1. Current Closed Loop
2. Velocity Closed Loop
3. Velocity Open Loop (HF – Servo)
4. Velocity Open Loop (LF – Servo)
5. Velocity Plant (HF – Servo)
6. Velocity Plant (LF – Servo)
7. Position Plant (HF – Servo)
8. Position Plant (LF – Servo)
9. Velocity Open Loop
10. Velocity Plant
11. Position Open Loop
12. Position Plant

18.4.2 Block Diagrams

All three general types of frequency analysis modes (Closed Loop, Open Loop, Plant) can be described using the following block diagrams.

- Closed loop refers to the Controller and Plant with feedback.
- Open loop refers to the Controller and Plant without feedback.
- Plant refers to the system without feedback and without the controller.

The Controller always refers to the outermost control loop controlling motion (i.e. the position Controller in Position mode). The Plant always includes the motor/load and includes the closed inner loops (e.g., when controlling velocity, the plant is comprised of the motor/load and the closed loop current).

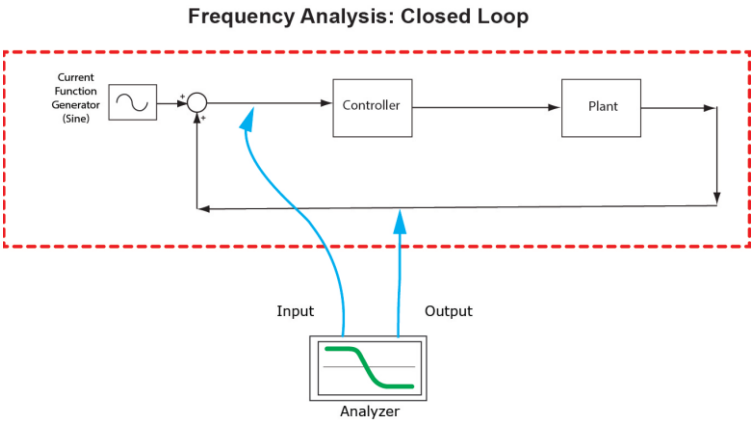


Figure 1: Closed Loop Block Diagram

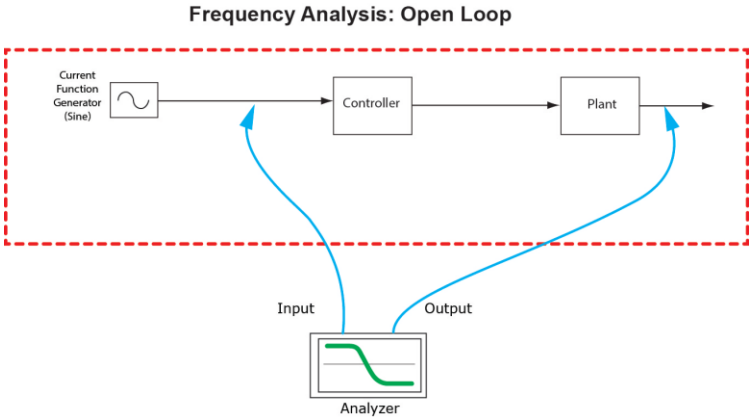


Figure 2: Open Loop Block Diagram

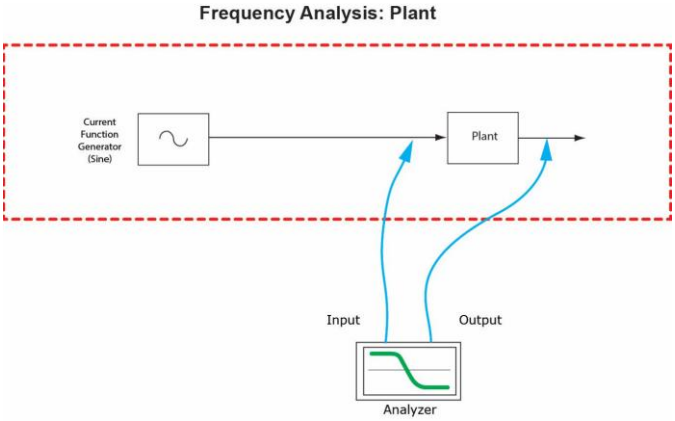


Figure 3: Plant Block Diagram

18.4.3 Choosing between HF and LF Modes

When determining if a High Frequency (HF) or Low Frequency (LF) mode should be chosen, use the following procedure:

1. Pick the desired frequency range.
2. Ensure all calculations for determining amplitudes and relevant limits (i.e. acceleration limits, etc.) are complete and values have been sent to the drive.
3. For the entire frequency range, run a Frequency Analysis using both the HF and LF modes.
4. Save the data for both modes and compare the full range (overlaying the plots with graphic software is recommended).

Depending on the frequency ranges chosen, there will be an overlap at some frequencies before the two traces deviate at the higher frequencies.

The HF mode should be used for frequencies from the convergence and higher, while the LF mode should be used for frequencies from the convergence and lower. It is possible that for the frequency range chosen, both Frequency Analysis modes should be used.

18.4.3.1 Amplitude Limiting

Some modes have an Amplitude Limiting feature that can be enabled during Frequency Analysis. This feature modulates the desired amplitude to a lower level than chosen depending on some of the limits involved (e.g. velocity and/or acceleration).

If Amplitude Limiting is not used and the chosen amplitude is sufficiently low compared to the associated limits, the limits will alter the injected waveform, and it might not be a smooth sine wave. Depending on the severity of limiting, this could affect the quality of the frequency analysis trace at some frequencies.

When in use, the Amplitude Limiting feature calculates an amplitude that can be achieved at a frequency without being limited and changes the injected sine amplitude to this new value.

NOTE: If the limiting values are low enough, Amplitude Limiting could result in an amplitude that is too small to achieve a quality frequency response. It is up to the user to properly set all limits.

19 DATA, FIRMWARE, AND LOGS

19.1 Drive RAM and Flash Memory

19.1.1 Drive RAM

Drive RAM is labeled as Volatile. In this process, the Contents are erased when the drive is RESET or powered-OFF. The Initial contents read from flash on/power-up. Then, the Contents is updated in real-time to reflect certain operational conditions and changes entered with the CME software. At any time, the user can use CME to restore the data from flash into drive RAM.

19.1.2 Flash

Flash is labeled as Non-volatile. In this process, the Contents are retained when the drive is RESET or powered-OFF. To modify the Contents, do either of the following:

- Use a **Save to Flash** tool.
- Close certain screens (i.e., Motor, Setup, Homing, or CAN Configuration), where the contents are automatically saved to flash upon closing the screen.

Parameters reside in RAM only, Flash only, or both RAM and Flash.

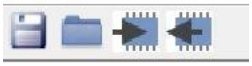
The table below illustrates the typical parameter locations. Refer to the Parameter Dictionary for information about specific parameters.

Data Resides In	Data
Flash only	This category includes all Motor/Feedback screen data and Setup screen (motor/feedback data only). This data is saved to flash when the user confirms the values and closes the screens without cancelling.
Drive RAM only	Includes operating status data such as actual position, actual current, and drive temperature. Such data is never stored in flash. It is destroyed from drive RAM with each power-down or drive reset.
Flash and drive RAM	Includes all other data not represented in the two categories above. When changing these parameters in CME, the value is saved to drive RAM only. To save these values to flash, the Save To Flash operation must be performed or data will be lost on power down or reset.

19.2 Data Management Tools

19.2.1 Drive

Use the Drive Data Management tools to perform the operations that affect the drive settings, including motor/feedback data. (CVM Control Program data is not saved by these operations). On the Main screen, the Drive, Data Management tools are listed in the following table.



Data Management Tools

Action	Name	Description
	Save amplifier data to disk	Saves both drive and motor/feedback data to a disk with a .ccx filename extension.
	Restore amplifier data from disk	Restores drive and motor/feedback data from a .ccx file to the drive's RAM, or flash for the flash only variables. See Parameter Dictionary for parameter descriptions. A To Flash operation should be performed to ensure that all data is saved to flash
	Save to flash	Saves contents of drive RAM to drive flash memory.
	Restore from flash	Restores contents of drive flash memory to drive RAM.

19.2.2 Motor Screen

Use the Motor Screen, Data Management tools to perform operations that apply to only the Motor parameters. The Motor Data Management tools are listed in the following table.



Motor Data Management tools

Action	Name	Description
	Save motor data to disk	Saves only motor data to disk with a .ccm filename extension. Drive data that is not represented on the Motor screen is not saved in this file.
	Restore motor data from disk	Restores only motor data from a disk file with a .ccm filename extension drive flash (the motor parameters are flash only).
	Save motor data to flash	Saves the contents of the Motor screen from to drive flash memory. Drive data that is not represented on the Motor screen is not saved. Can be used to ensure that all changes are saved to flash without closing the Motor screen.
	Restore motor data from flash	Restores only motor data from drive flash memory to the PC. Drive data that is not represented on the Motor screen is not affected. Can be used before closing the Motor data screen to restore settings to the previously saved values.

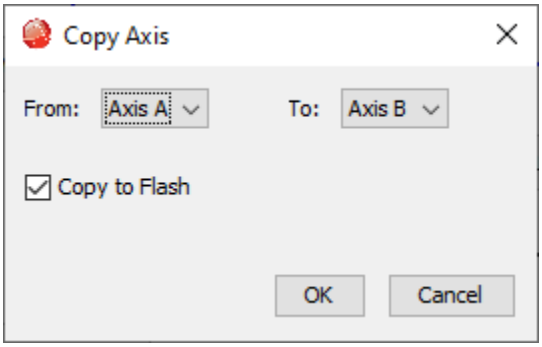
19.3 Multi-Axis Data Tools

In this section, the descriptions only apply to multi-axis drives (XE2, BE2, etc.).

19.3.1 Copy Axis

CME allows one axis to be copied to another. This feature allows a quick set up of multiple axes, since only one axis needs to be set up. The Copy Axis operation copies all RAM/Flash and Flash Only parameters to the other axis.

From the menu on the Main screen, select **File→Copy Axis**. This will display the Copy Axis screen:



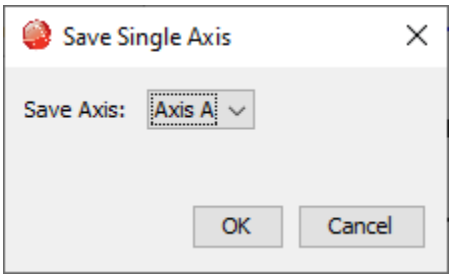
Copy Axis Screen

Select the source and destination axes, then click **OK**. Note that Copy to Flash is selected by default. If this option is not selected, then the RAM/Flash parameters will only be copied to the destination axis' RAM, while still copying the Flash Only data to the destination axis' Flash.

19.3.1.1 Save/Restore Single Axis

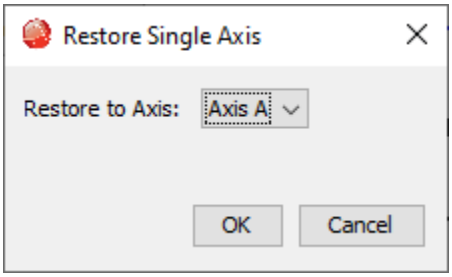
CME allows a single axis of data to be saved/restored on a multi-axis drive. This feature is useful when one axis of tuning/setup data is common across many multi-axis drives, but only on one axis. The file will be saved as a .ccx file. Restoring a .ccx file to a single axis, the file must be written as a single axis, otherwise an error will be displayed.

From the menu on the Main screen, select **File→Save As→Single Axis**. This will display the Save Single Axis screen. Select the axis to be saved, click **OK**, and then continue with naming and saving the file.



Save Single Axis Screen

From the menu on the Main screen, select **File→Restore→Single Axis**. This option will display the Restore Single Axis screen. Select the axis to restore the file data to, click OK, then browse to the single axis file.



Restore Single Axis Screen

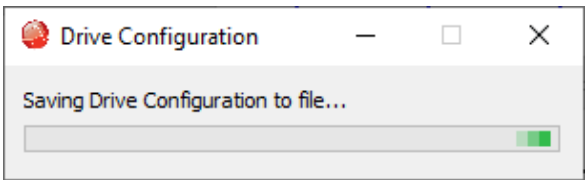
19.4 Drive Configuration

The Plus and ARM drives can save/load .ccd files. The drives have the capability of saving/restoring the entire drive configuration to a file. The drive configuration consists of all parameters (RAM/Flash and Flash Only) and the entire contents of the CVM flash, which includes any CVM programs, cam tables, gain scheduling tables and correction tables. The file is saved using a .ccd file extension.

This feature is useful to clone drives in one step rather than separately loading each file (.ccx, .ccp, .cct, .ccg). Additionally, the file is in XML format which can be read by some EtherCAT main devices as an ESI file for File over EtherCAT (FOE).

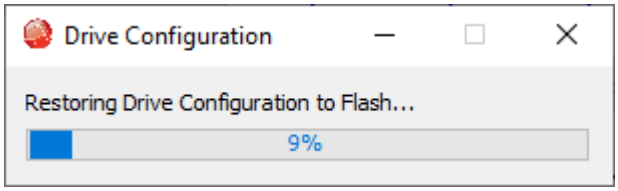
19.4.1 Save Drive Configuration

From the menu on the Main screen, select **File→Save Drive Configuration**, then choose a filename. A progress bar will be displayed while the data is being saved to the file.



19.4.2 Restore Drive Configuration

From the menu on the Main screen, select **File→Restore Drive Configuration**, then choose a filename. A progress bar will be displayed while the data is being saved to the file.

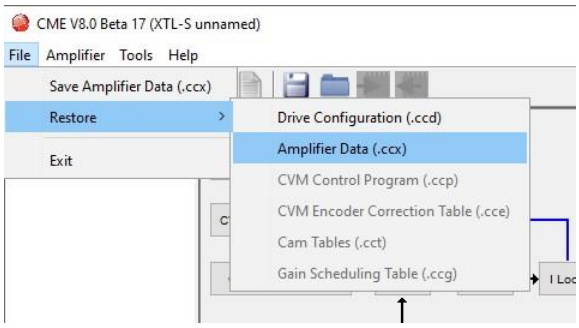


All the data read from the file is saved to the drive's Flash. After all the data is written, the drive will be reset, so that the Flash data is copied to RAM.

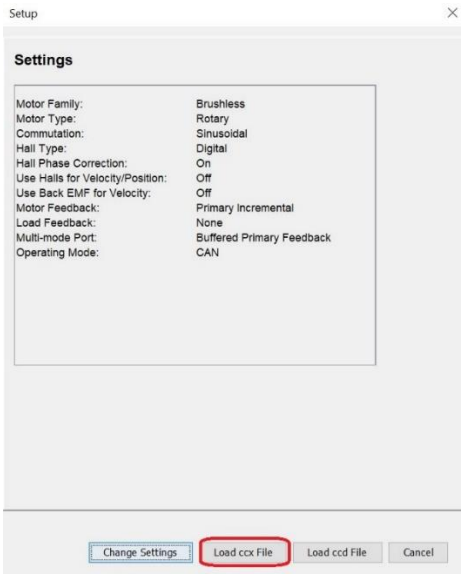
19.5 Copy Drive Data

On drives that do not support Drive Configuration Files, multiple steps are required to clone one drive to the next.

1. Load the .ccx file.
2. From the Main screen, click **Restore → Amplifier Data (.ccx)**. OR
3. From the **Setup** screen, click **Load ccx File**.



Amplifier Data (.ccx) Menu



Settings Screen

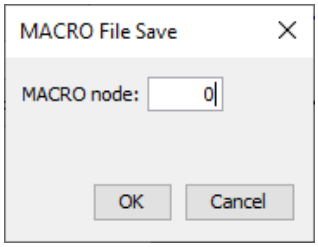
4. When prompted, browse to the folder containing the .ccx file and open it.
5. On the Main screen, click **Save to Flash** to save the new settings to flash memory.

6. Load a CVM program .ccp file:
   a. From the menu on the Main screen, choose **File→Restore→CVM Control Program**.
   b. When prompted, navigate to the folder containing the appropriate .ccp file and open it.
   This procedure also results in setting the Enable Control Program on the Startup option, which configures the program to auto start when the drive is powered up or reset.
7. Load Cam Table .cct files:
   From the menu on the Main screen, choose **File→Restore→Cam Tables**.
   When prompted, navigate to the folder containing the appropriate .cct file and open it.
8. Load Gains Scheduling Table .ccg files
   From the menu on the Main screen, choose **File→Restore→Gains Scheduling Tables**.
   When prompted, navigate to the folder containing the appropriate .ccg file and open it.
   TIP: When copying the drive data to multiple drives in a production environment, consider locking CME to prevent accidental changes to settings. See Lock/Unlock CME.
9. Encoder Correction Files .cce files:

19.6 Save MACRO File for Delta Tau Controllers

This feature is available only on Copley MACRO drives such as the XML Xenus MACRO.

1. On the CME Main screen, choose **File→Save MACRO File** to open the MACRO File Save window.



MACRO File Save Screen

2. Enter the ID of the MACRO node assigned with the settings you want to save and click **OK**.
3. When prompted, enter a File Name. If needed, navigate from the default AmpData folder to another folder where you want to store the file.
4. Click **Save** to save the .pmc file in the same folder and close the screen.

19.7 Lock/Unlock CME

The Lock feature of CME is used to lock out most screens to prevent data from being changed.

CME Locked Conditions:

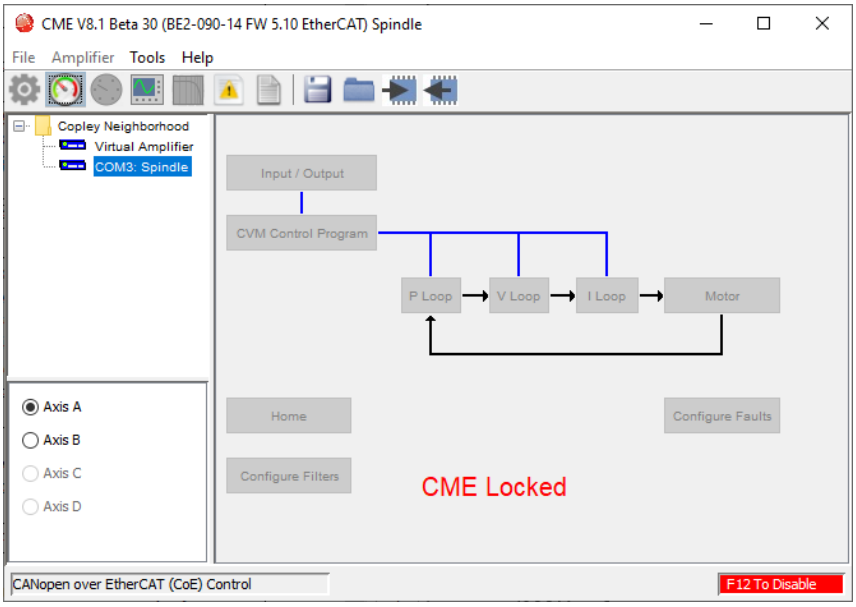
- User cannot change any drive or motor settings.
- User can download the drive and motor files and Cam Tables, jog the motor, run scope functions and profiles, and monitor drive performance with the scope and control panel.

1. On the Main screen choose **Tools→CME Lock/Unlock.**
2. Set a new password in the **Password** and **Verify Password** fields.



CME Lock Screen

3. Click **OK** to lock out the drive setting controls.



Example of CME Locked Screen

4. To unlock the CME, choose **Tools→CME Lock/Unlock**.
5. On the CME Unlock screen, in the **Password** field enter the password. Click **OK**.



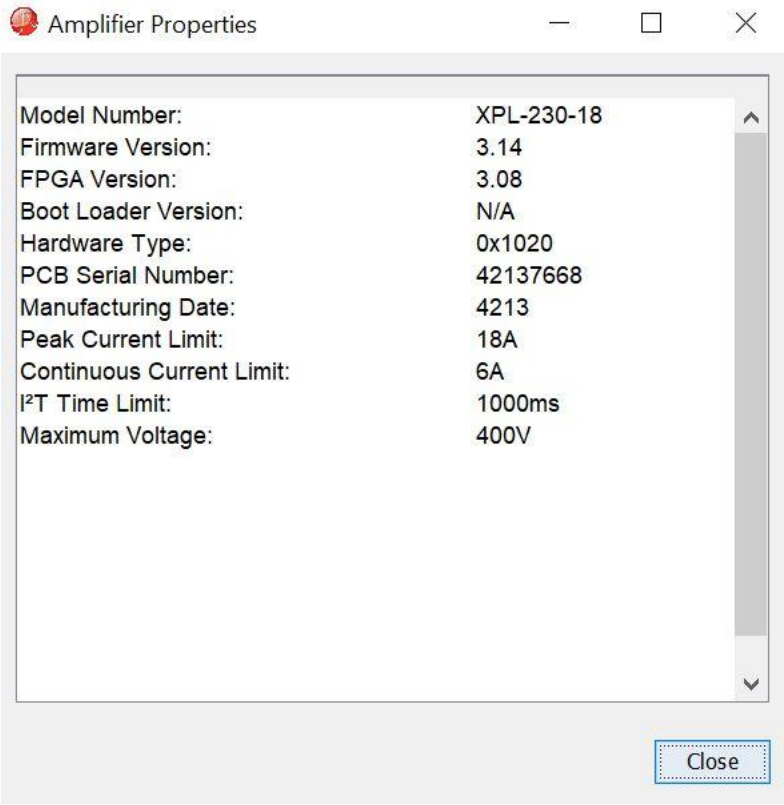
CME Unlock Screen

19.8 Firmware Download

The drive's flash memory holds the drive's firmware. As needed, perform the following steps to obtain new firmware and download it to drive flash memory.

NOTE:

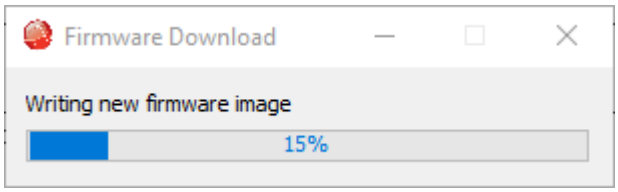
- To check the firmware version currently loaded, click the **Amplifier Properties** button or choose **Help→About**.



Amplifier Properties Screen

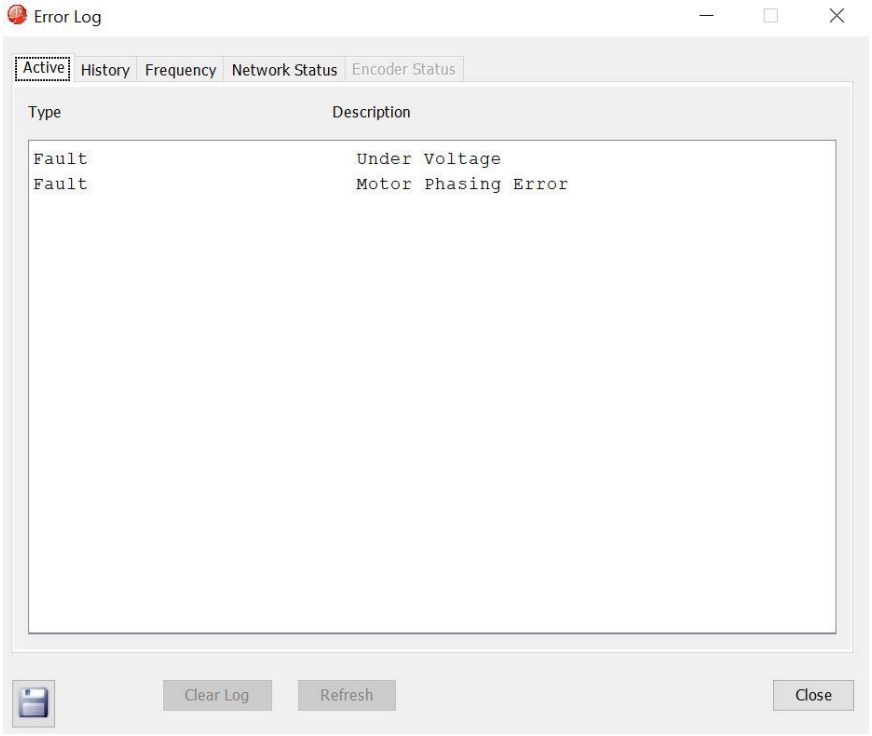
WARNING	**Firmware Download Warning**
	Do not power down or disconnect the drive during firmware download.

1. On the Main screen choose **Tools→Download Firmware** to open the Download Firmware window.
2. Browse to where the firmware file is located and click **Open** to start the download.
   The progress will be displayed while downloading.
   When the progress dialog closes, the firmware download is complete.

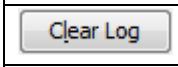


19.9 Error Log

1. On the Main screen, click the **Error Log** button on the toolbar.



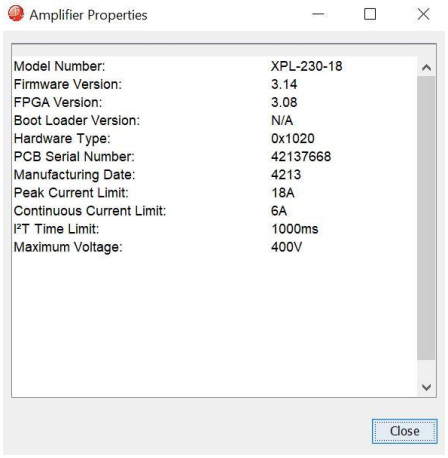
Error Log Screen

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.
Network Status	(Under CAN control only.) Status of CANopen network. Lists warnings and errors.
Encoder Status	Reads the encoder and it is only available for specific encoders.
	Saves the contents of the History and Frequency tabs to a text file.
	Clears all History and Frequency entries in the drive.
	Updates the contents of the History or Frequency tabs.

19.10 Amplifier Properties

This screen provides the general information including the drive's hardware type, firmware etc.

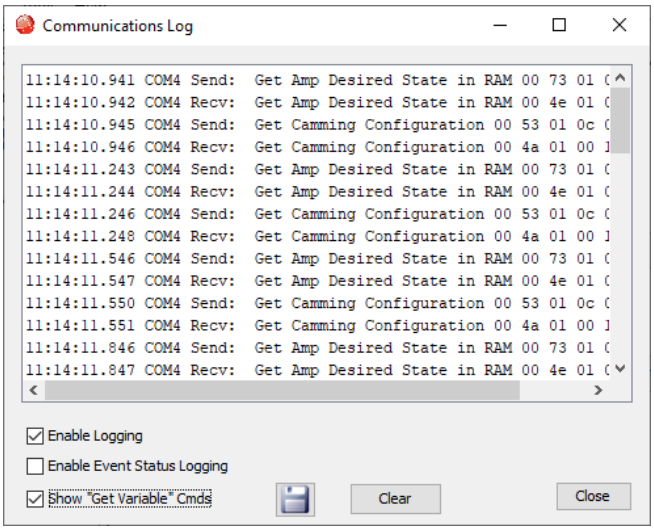
1. On the Main screen, click the **Amplifier Properties** button on the toolbar.



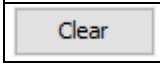
Amplifier Properties Screen

19.11 Communications Log

1. The Communications Log displays all communications between CME and the drive. The data is only stored in the PC's RAM by CME; it is not part of the drive's data.
2. On the Main screen, choose **Tools→Communications Log**.



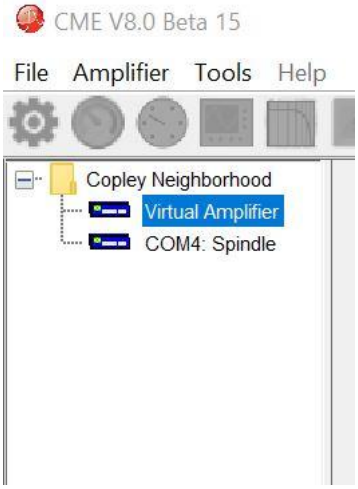
Communications Log Screen

Option	Description
Enable Logging	When selected, logging is enabled and all communications, except status messages are recorded in the log.
Enable Event Status Logging	When selected, status messages are included in the log. Note that **Show "Get Variable" Cmnds** must also be checked to log Event Status commands.
Show "Get Variable" Cmds	When selected, "Get Variable" commands are added to the log.
	Saves the contents of the Communications Log to a text file.
	Clears the log contents from the PC's RAM.

20 VIRTUAL AMPLIFIER

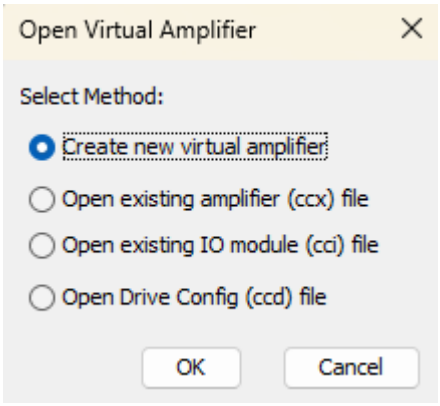
20.1 Overview

Virtual amplifiers can be used for creating drive and motor data files off-line. A new virtual drive can be created based on a virtual drive template file (.ccv) or from an existing .ccx file. CME includes a set of .ccv files for each model that is supported.



Virtual Amplifier Folder

1. From the Copley Neighborhood, select the **Virtual Amplifier** node. This screen will display the Open Virtual Amplifier screen.



Open Virtual Amplifier Screen

Procedure to Create a New Amplifier File

1. From the Open Virtual Amplifer screen, select Create new virtual amplifier and click **OK**.
2. When prompted, select the .ccv file that represents the appropriate drive model.
3. Click **Open**. The Setup screen will be displayed.
4. Motor and drive values may now be viewed, entered, and adjusted.

Procedure to Open an Existing Amplifier File

1. From the Open Virtual Amplifier screen, select **Open** existing amplifier file and click **OK**.
2. When prompted, select the appropriate .ccx file.
3. Click **Open**.
4. Motor and drive values may now be viewed, entered, and adjusted.

21 ENCODER CORRECTION TABLES

The quality of positioning control that a servo drive may achieve is limited by the resolution and accuracy of the position data provided by the encoder. For some high accuracy applications, it may be desirable to measure the encoder errors and provide a table of compensation values that the drive can use to correct for these errors in real time. Starting with firmware version 2.24, Copley feature set E drives (aka Plus drives) support the use of such tables to compensate for encoder errors.

The Encoder table is a binary formatted file that is uploaded to the drive's internal file system. This file consists of a short header section followed by a list of 16-bit offsets that will be added to the position information read from the encoder. The resulting values (position from encoder plus offset) will be used in place of the position data read from the encoder. This feature allows for known errors in the encoder position data to be compensated for by the drive.

For more information on the Encoder Correction tables, refer to the Applications Note AN126 available on the Copley Controls website, https://copleycontrols.com.

22 GAIN SCHEDULING

22.1 Overview

The Gains Scheduling feature allows you to schedule gain adjustments based on changes to a key parameter. For instance, Pp, Vp, Vi, and Current Offset (A) could be adjusted based on changes to commanded velocity.

Gain adjustments are specified in a Gain Scheduling Table. Each table row contains a key parameter value and the corresponding gain settings. The drive uses linear interpolation to make smooth gain adjustments between the programmed settings.

Gain scheduling involves the basic steps outlined below.

Storage Limits

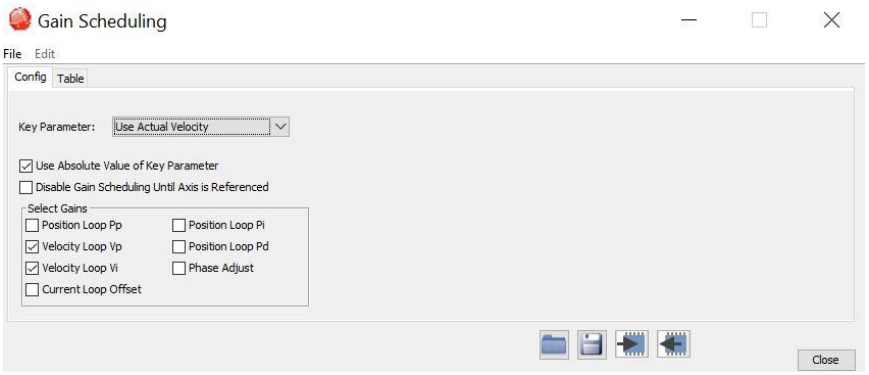
The maximum number of lines that can be stored in the Gain Scheduling Table is 1000. A typical Gain Schedule Table will contain far fewer lines. The number of Gain Scheduling Table lines is also limited by the amount of CVM memory space available in the drive. A Gain Scheduling Table shares that space with CVM programs and Camming Tables. Therefore, the maximum number of Gain Schedule Table lines will decrease if CVM programs or Camming Tables are stored in the drive.

The Table tab of the Gain Scheduling screen displays the percentage of drive memory used.



22.2 Configure Gain Scheduling

1. From the menu on Main screen, choose **Amplifier→Gain Scheduling**.



Gain Scheduling Screen

2. Select any of the following Key Parameters listed in the table below.

Key Parameter	Description
Disable Gain Scheduling.	Disable gain scheduling.
Use Written Parameter.	An external controller can write to this parameter using any of several protocols and corresponding parameter IDs. • Copley ASCII Interface • Copley Indexer 2 Program (ID 0x128) • CANopen and EtherCAT (Index 0x2371) • MACRO I-variable (0x528) For additional information, refer to the following documents. • Copley ASCII Interface Programmer's Guide • Copley Indexer 2 Program User Guide • Copley CANopen Programmer's Guide

Key Parameter	Description
Use Commanded Velocity.	Schedule gain adjustments based on changes to commanded velocity.
Use Actual Velocity.	Schedule gain adjustments based on changes to actual velocity.
Use Commanded Position.	Schedule gain adjustments based on changes to commanded position.
Use Actual Position.	Schedule gain adjustments based on changes to actual position.

Optionally, set the controls.

Control	Description
Use Absolute Value of Key Parameter	If a velocity or position value is chosen for the Key Parameter and this option is set, the Key Parameter is interpreted as an absolute value.
Disable Gain Scheduling Until Axis is Referenced	When this option is set, the scheduled gain adjustments do not take place until the axis is referenced (homed).

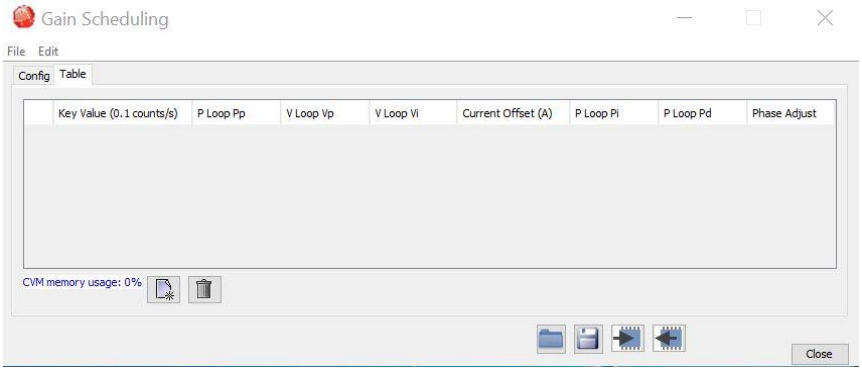
3. Select the gains that you want to adjust by schedule. The following choices are available to select.

   - Pp
   - Vp
   - Vi
   - Current Offset (A)

4. For each gain you select, a column will be enabled in the Gain Scheduling Table.

22.3 Set Up Gain Scheduling Tables

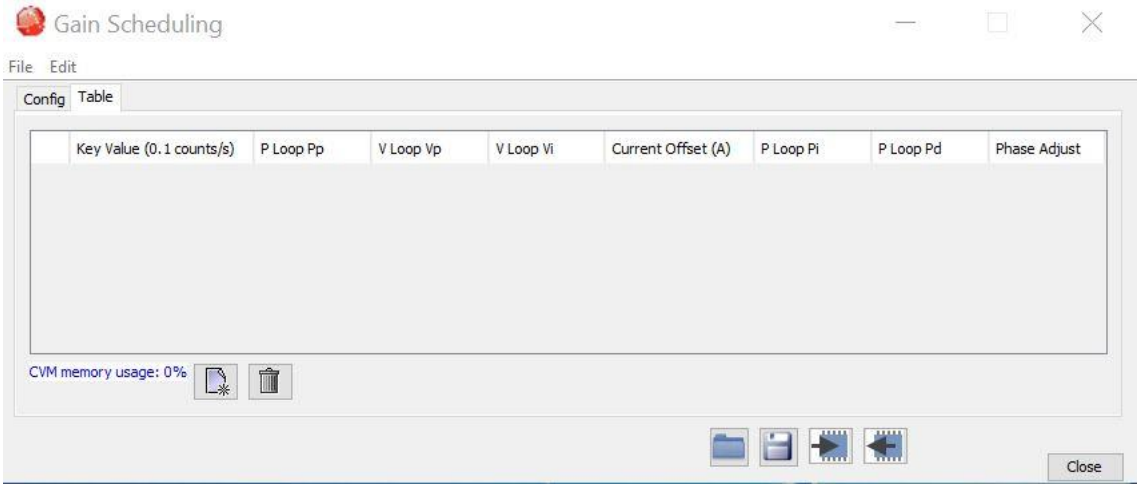
1. On the Gain Scheduling screen, open the Table tab.



Gain Scheduling Table Screen

Action	Description
	Creates a new table
	Deletes the table from drive flash and PC RAM
	Saves configuration and table to disk
	Restores configuration and table to PC only
	Saves configuration and table to drive flash
	Restores configuration and table from drive flash to PC. This operation overwrites all data on the Gains Scheduling screen.

1. On the Gain Scheduling screen, open the Table tab.



Gain Scheduling Screen

2. Click the **Create New Table** button and enter the number of lines for the table.

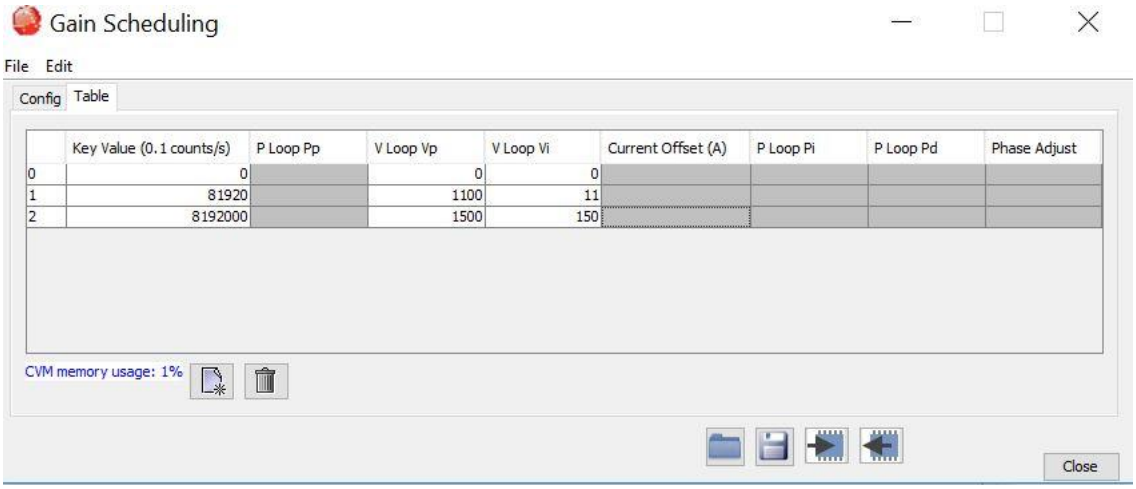


3. Enter the Key Parameter and gain adjustment values.

NOTE:

- All values must be whole numbers (no fractional values).
- All Key Values must be increasing.

4. After all values have been entered, click the **Save Table** button. This action saves both the configuration and the table data.



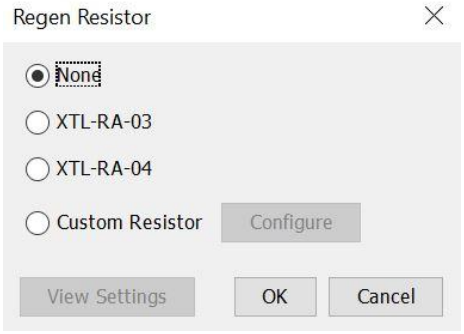
Gain Scheduling Table

23 Regen Resistor Configuration

WARNING	**Incorrect values may damage the drive 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 drive may result if an incorrect resistance value is entered. **Failure to heed this warning can cause equipment damage.**

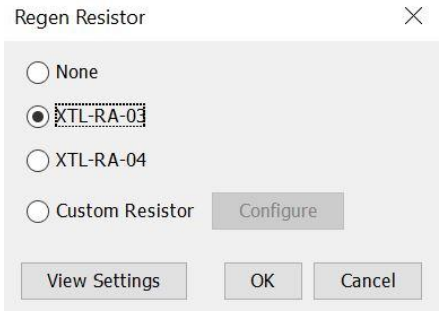
23.1 Configure a Standard Copley Controls Regen Resistor

1. To open the Regen Resistor screen, click **Configure Regen** button.



Regen Resistor Screen

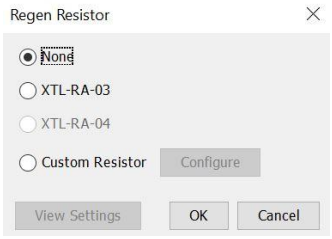
2. Select the model number XTL-RA-03 or XTL-RA-04 based on your drive and click **OK** to save the configuration and close the screen.



XTL-RA-03 Model

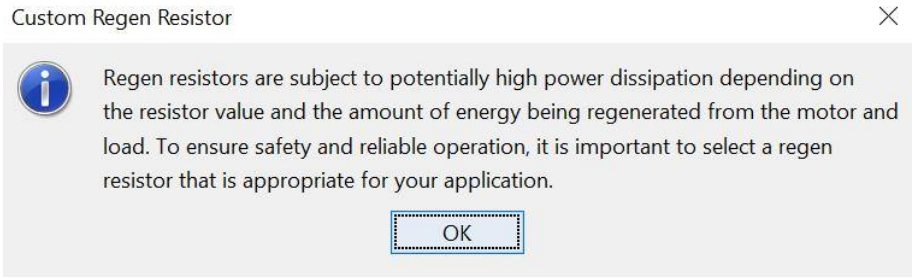
23.2 Configure a Custom Regen Resistor

1. To open the Regen Resistor screen, click **Configure Regen** button.



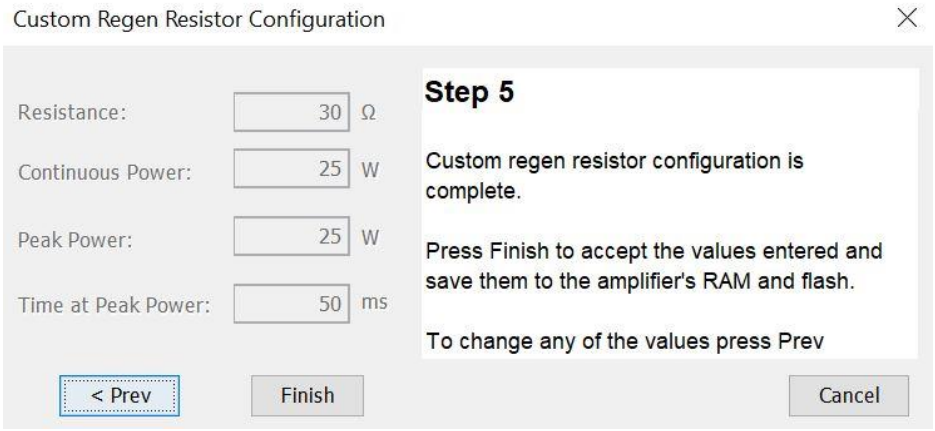
Regen Resistor Screen

2. Select Custom Resistor and click **Configure** to enter the custom resistor data. Read the information displayed and click **OK**.



Custom Regen Resistor Prompt

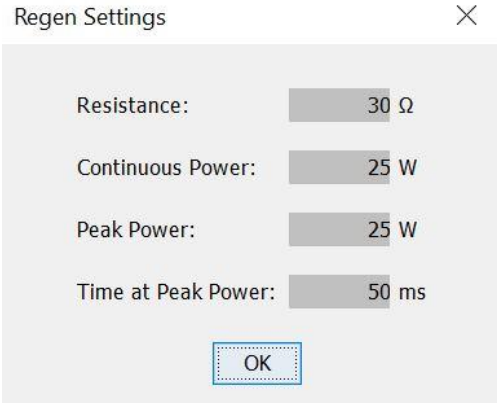
3. Follow the instructions on step 1 through 5 of the Custom Regen Wizard, then click **Finish**.



Custom Regen Resistor Configuration Screen

23.2.1 View Regen Settings

1. To open the Regen Resistor screen, click **Configure Regen** button .
2. To open the Regen Settings screen, click **View Settings** button.



Regen Settings Screen

APPENDIX A

I^2T TIME LIMIT ALGORITHM

Overview

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

Formulas and Algorithm Operation

Calculating the I^2T Setpoint Value

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

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

Algorithm Operation

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

Accumulator Increment Formula

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

I^2T Accumulator Variable $_{\mathbf{n+1}}$ =

I^2T Accumulator Variable $_{\mathbf{n}}$

+(Actual Output Current $_{\mathbf{n+1}}^{\mathbf{2}}$ – Continuous Current Limit^2) * Update period

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

Application Example

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 as follows:

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

Plot Diagrams

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

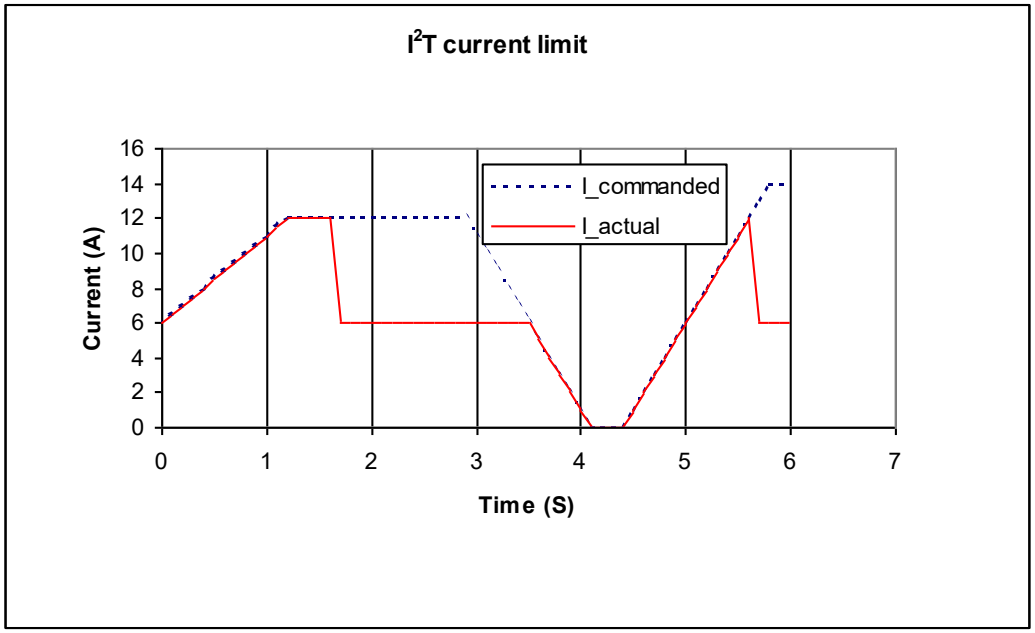


Diagram A

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

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

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

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

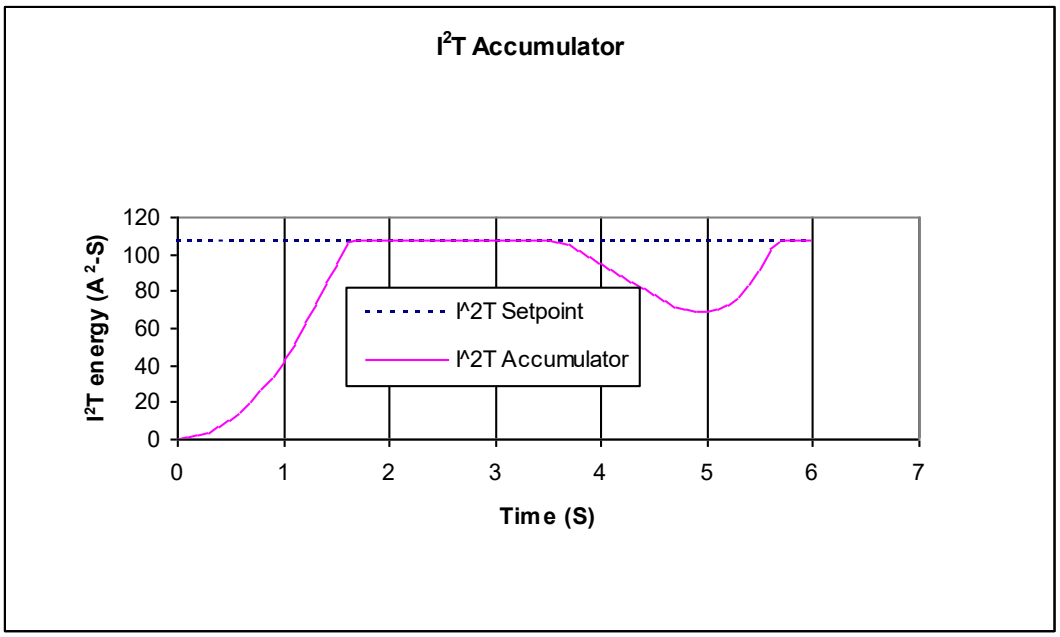


Diagram B

I^2T Scope Trace Variables

Two Scope Tool trace variables are available for monitoring whether the I^2T accumulator is accumulating or discharging.

- The I^2T Amplifier Accumulator variable evaluates the accumulator against the factory set current limits of the drive.
- The I^2T Motor Accumulator variable evaluates the accumulator against the user-programmed current loop values.

The value shown in Diagram B is normalized so that 100% equals the I^2T setpoint.

When either trace variable line reaches 100%, current limiting will be invoked.

APPENDIX B

HOMING METHODS

Overview

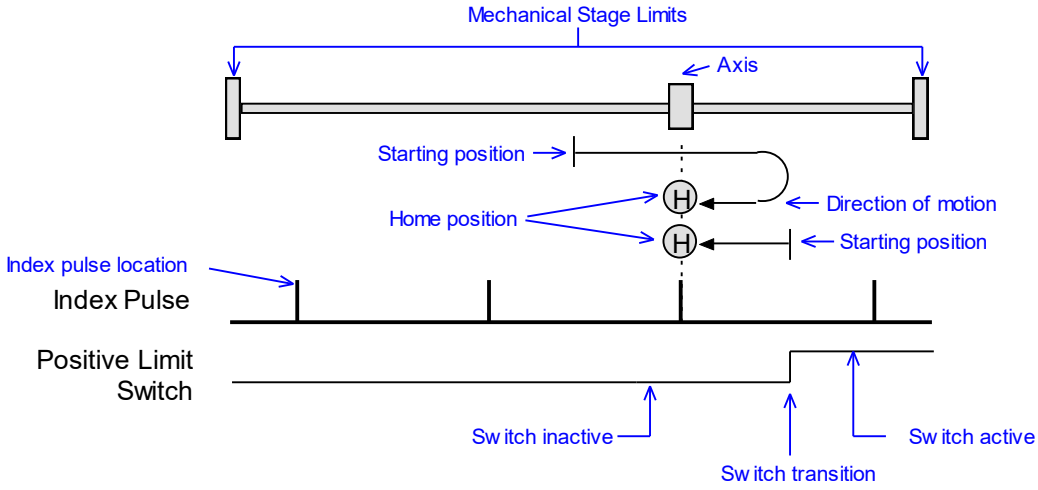
There are several Homing methods. Each method establishes the following:

- Home reference (limit or Home Switch transition or encoder index pulse).
- Direction of motion and, where appropriate, the relationship of the index pulse to limit or Home Switches.

Homing Diagram Legend

As highlighted in the example below, each homing method diagram shows the starting position on a mechanical stage.

- The arrow line indicates the direction of motion.
- A circled H indicates the home position.
- Solid line stems on the index pulse line indicate index pulse locations.
- Longer dashed lines overlay these stems as a visual aid.
- Finally, the relevant limit switch is represented showing the active and inactive zones and transition.



Homing Diagram Example

Note that in the Homing method descriptions, negative motion is leftward (counter-clockwise) and positive motion is rightward (clockwise).

Homing Method Descriptions

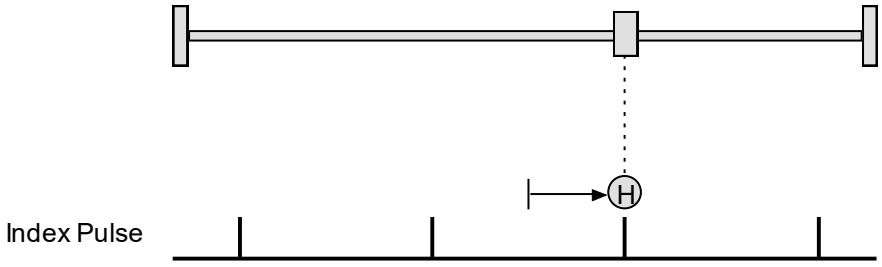
Set Current Position as Home

The current position is the Home position.

Next Index

Direction of Motion: Positive

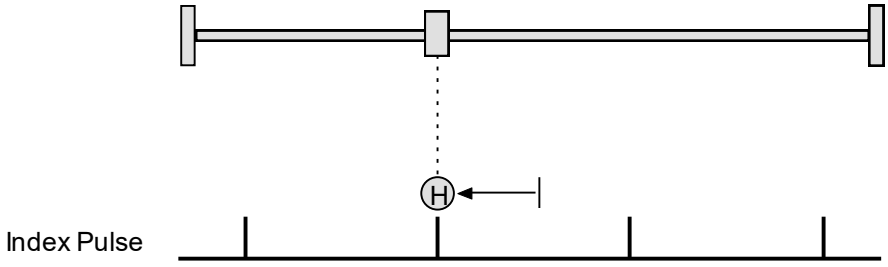
Home is the first index pulse found in the positive direction. Direction of motion is positive. If a positive limit switch is activated before the index pulse, an error is generated.



Index Pulse (Positive Direction) Example

Direction of Motion: Negative

Home is the first index pulse found in the negative direction. Direction of motion is negative. If a negative limit switch is activated before the index pulse, an error is generated.

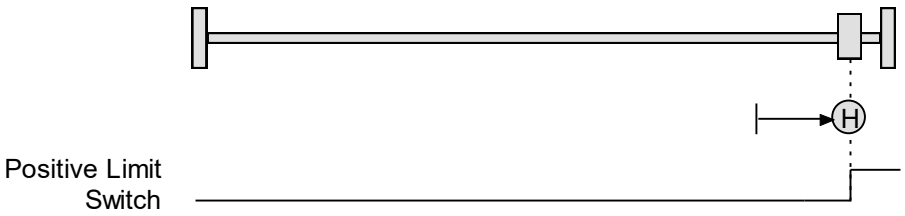


Index Pulse (Negative Direction) Example

Limit Switch

Direction of Motion: Positive

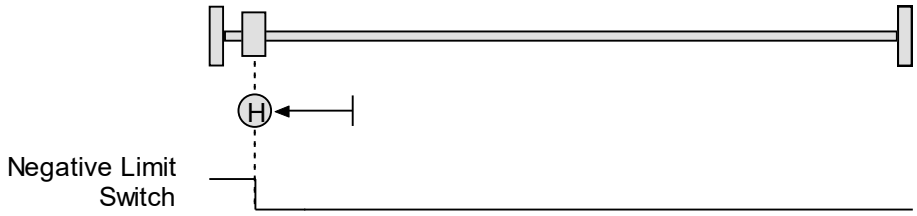
Home is the transition of the positive limit switch. Initial direction of motion is positive if the positive limit switch is inactive.



Limit Switch (Positive Direction) Example

Direction of Motion: Negative

Home is the transition of the negative limit switch. Initial direction of motion is negative if the negative limit switch is inactive.

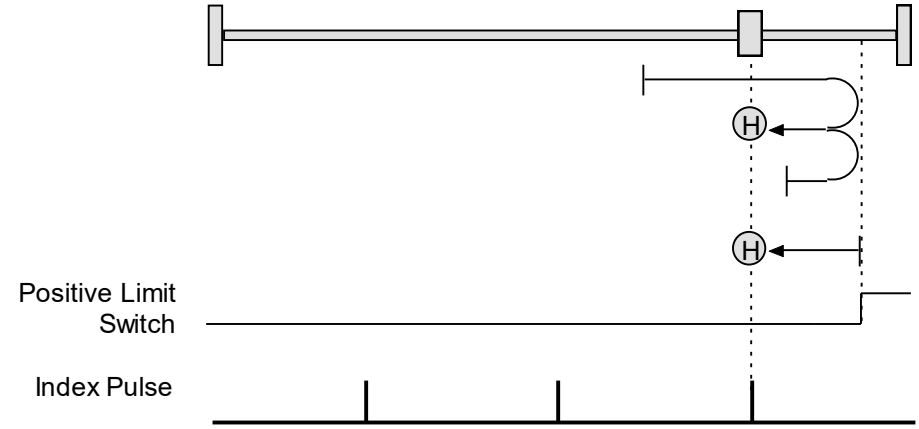


Limit Switch (Negative Direction) Example

Limit Switch Out to Index

Direction of Motion: Positive

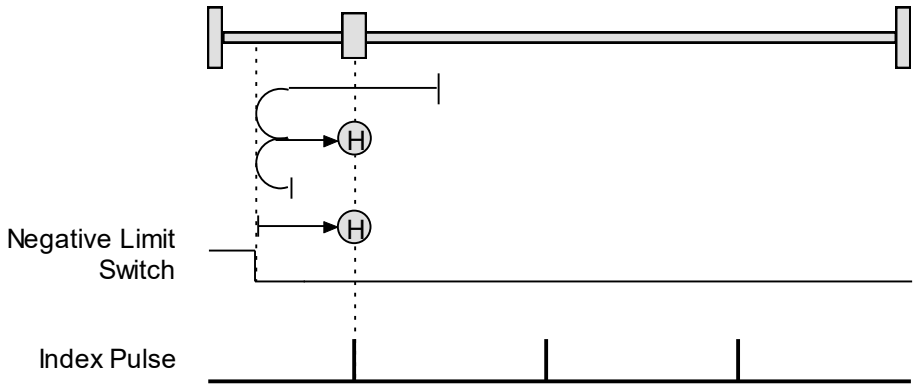
Home is the first index pulse to the negative side of the positive limit switch transition. Initial direction of motion is positive if the positive limit switch is inactive (shown here as low).



Limit Switch Out to Index (Positive Direction) Example

Direction of Motion: Negative

Home is the first index pulse to the positive side of the negative limit switch transition. Initial direction of motion is negative if the negative limit switch is inactive (in the following diagram, it is shown as low).



Limit Switch Out to Index (Negative Direction) Example

Hardstop

Direction of Motion: Positive

Home is the positive hard stop. Direction of motion is positive. In Servo modes, the hard stop is reached when the drive outputs the homing Current Limit continuously for the specified amount of time in the Delay Time.

If a positive limit switch is activated before the hard stop, an error is generated.



Hardstop (Positive Direction) Example

Direction of Motion: Negative

Home is the negative hard stop. Direction of motion is negative. The hard stop is reached when the drive outputs the homing Current Limit continuously for the specified amount of time in the Delay Time. If a negative limit switch is activated before the hard stop, an error is generated.



Hardstop (Negative Direction) Example

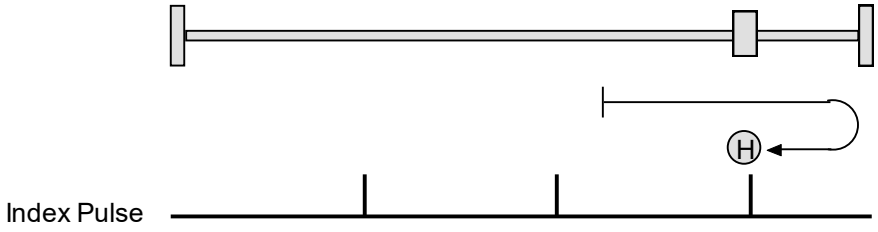
Hardstop Methods in Stepper Mode

In Stepnet drives operating in stepper mode with an encoder, the hard stop is reached when the Following Error is exceeded. When using hardstop methods in Stepper mode, do not disable Following Error.

Hardstop Out to Index

Direction of Motion: Positive

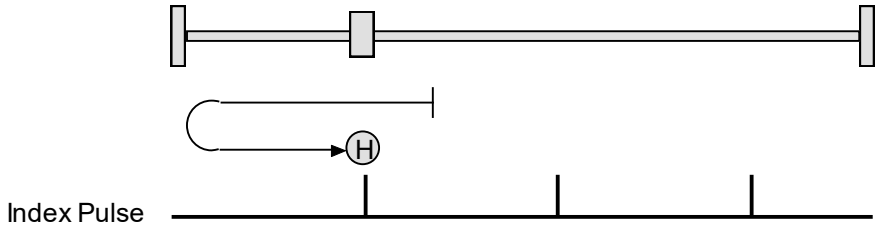
Home is the first index pulse on the negative side of the positive hard stop. Initial direction of motion is positive. The hard stop is reached when the drive outputs the homing Current Limit continuously for the amount of time specified in the Delay Time. If a positive limit switch is activated before the hard stop, an error is generated.



Hardstop Out to Index (Positive Direction) Example

Direction of Motion: Negative

Home is the first index pulse on the positive side of the negative hard stop. Initial direction of motion is negative. The hard stop is reached when the drive outputs the Homing Current Limit continuously for the specified amount of time in the Delay Time. If a negative limit switch is activated before the hard stop, an error is generated.



Hardstop (Negative Direction) Example

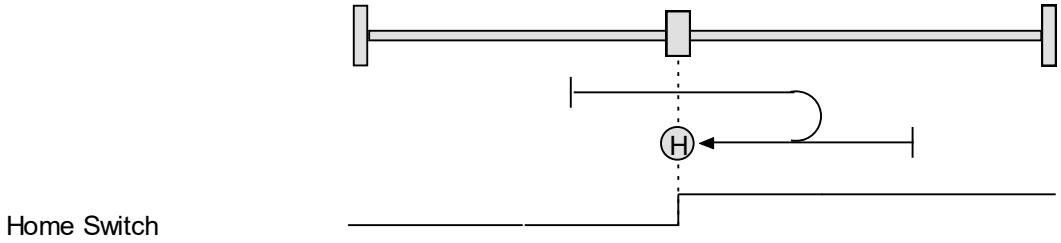
Hardstop Out to Index Methods in Stepper Mode

In Stepnet drives operating in Stepper mode with an encoder, the hard stop is reached when the Following Error is exceeded. When using hard stop methods in the Stepper mode, do not disable Following Error.

Home Switch

Direction of Motion: Positive

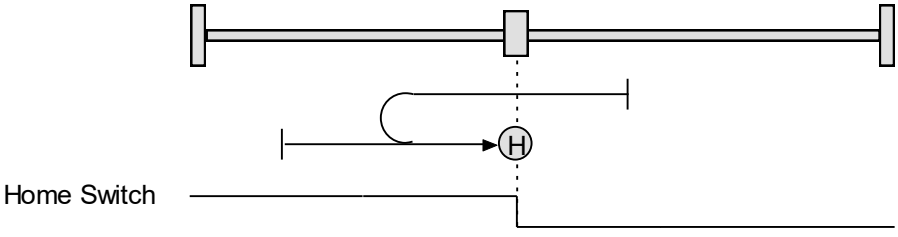
Home is the Home Switch transition. Initial direction of motion is positive if the Home Switch is inactive. If a limit switch is activated before the Home Switch transition, an error is generated.



Home Switch (Positive Direction) Example

Direction of Motion: Negative

Home is the Home Switch transition. Initial direction of motion is negative if the Home Switch is inactive. If a limit switch is activated before the Home Switch transition, an error is generated.

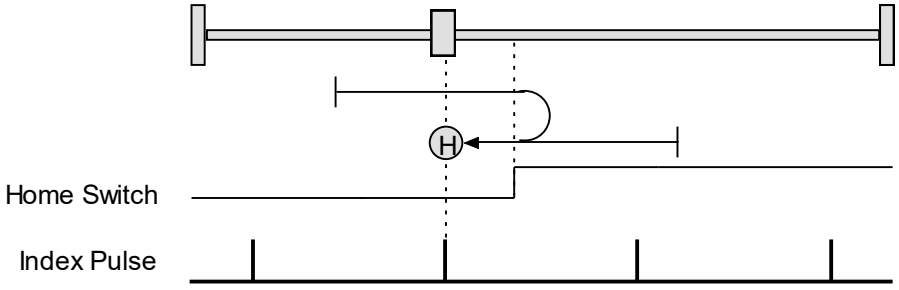


Home Switch (Negative Direction) Example

Home Switch Out to Index

Direction of Motion: Positive

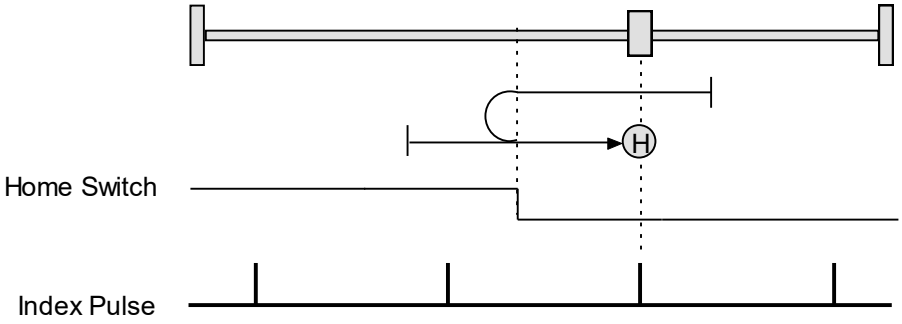
Home is the first index pulse to the negative side of the Home Switch transition. Initial direction of motion is positive if the Home Switch is inactive. If a limit switch is activated before the Home Switch transition, an error is generated.



Home Switch Out to Index (Positive Direction) Example

Direction of Motion: Negative

Home is the first index pulse to the positive side of the Home Switch transition.
Initial direction of motion is negative if the Home Switch is inactive. If a limit switch is activated before the Home Switch transition, an error is generated.

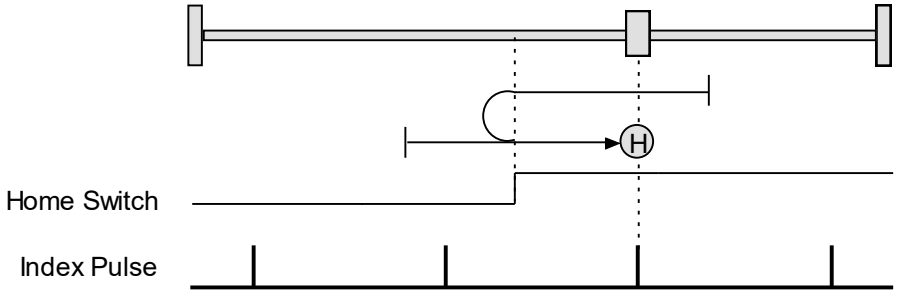


Home Switch Out to Index (Negative Direction) Example

Home Switch In to Index

Direction of Motion: Positive

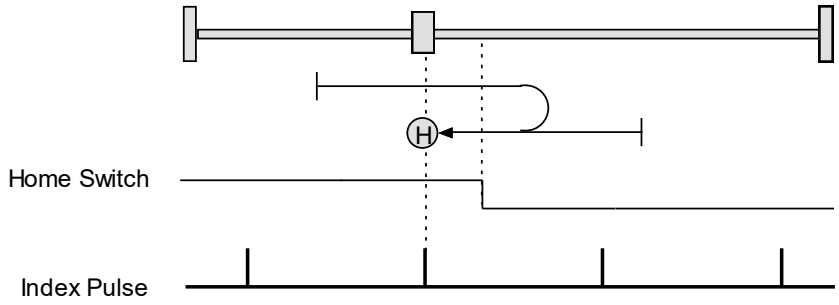
Home is the first index pulse to the positive side of the Home Switch transition. Initial direction of motion is positive if the Home Switch is inactive. If a limit switch is activated before the Home Switch transition, an error is generated.



Home Switch In to Index (Positive Direction) Example

Direction of Motion: Negative

Home is the first index pulse to the negative side of the Home Switch transition. Initial direction of motion is negative if the Home Switch is inactive. If a limit switch is activated before the Home Switch transition, an error is generated.

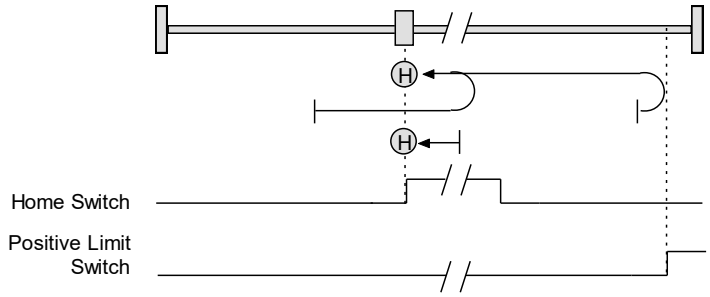


Home Switch In to Index (Negative Direction) Example

Lower Home

Direction of Motion: Positive

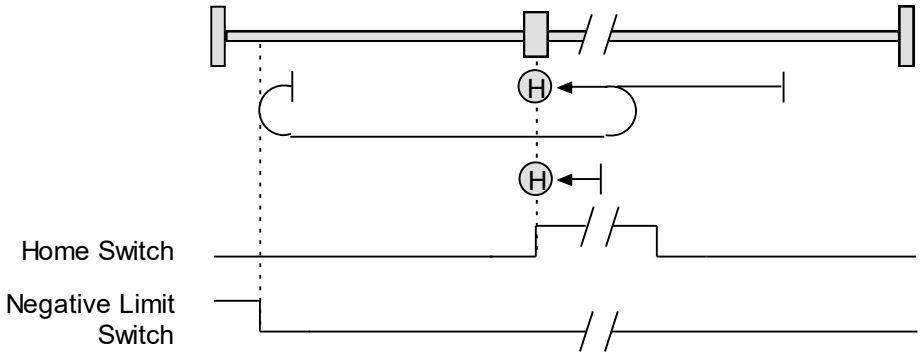
Home is the negative edge of a momentary Home Switch. Initial direction of motion is positive if the Home Switch is inactive. Motion will reverse if a positive limit switch is activated before the Home Switch; then, if a negative limit switch is activated before the Home Switch, an error is generated.



Lower Home (Positive Direction) Example

Direction of Motion: Negative

Home is the negative edge of a momentary Home Switch. Initial direction of motion is negative. If the initial motion leads away from the Home Switch, the axis reverses on encountering the negative limit switch; then, if a positive limit switch is activated before the Home Switch, an error is generated.

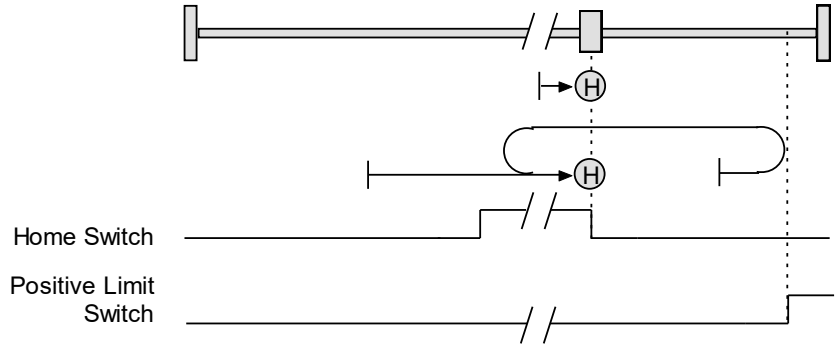


Lower Home (Negative Direction) Example

Upper Home

Direction of Motion: Positive

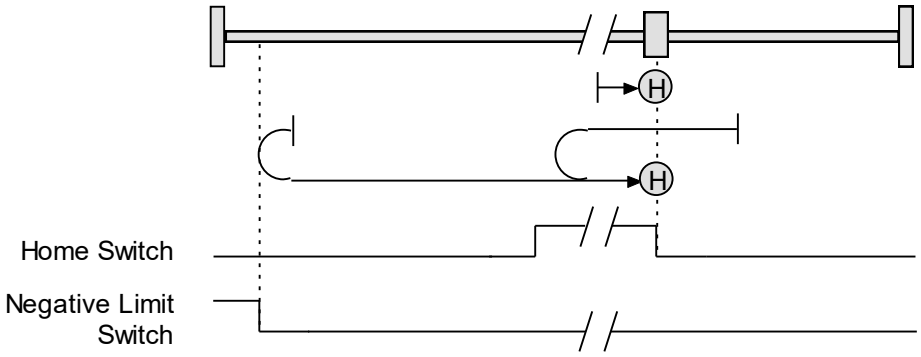
Home is the positive edge of a momentary Home Switch. Initial direction of motion is positive. If the initial motion leads away from the Home Switch, the axis reverses on encountering the positive limit switch; then, if a negative limit switch is activated before the Home Switch, an error is generated.



Upper Home (Positive Direction) Example

Direction of Motion: Negative

Home is the positive edge of momentary Home Switch. Initial direction of motion is negative if the Home Switch is inactive. If the initial motion leads away from the Home Switch, the axis reverses on encountering the negative limit switch; then, if a positive limit switch is activated before the Home Switch, an error is generated.

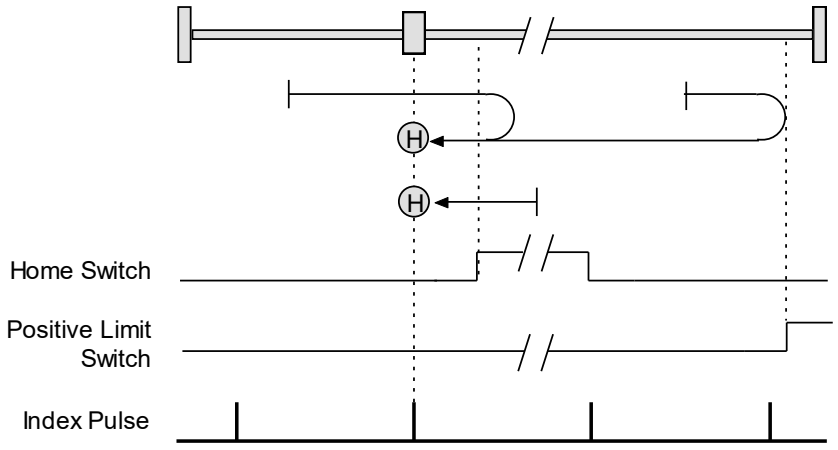


Upper Home (Negative Direction) Example

Lower Home Outside Index

Direction of Motion: Positive

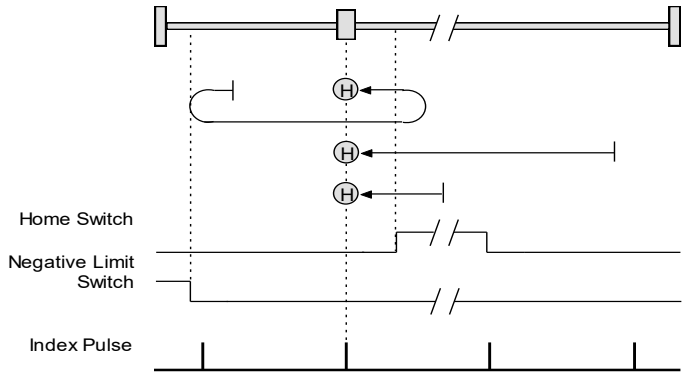
Home is the first index pulse on the negative side of the negative edge of a momentary Home Switch. Initial direction of motion is positive if the Home Switch is inactive. If the initial motion leads away from the Home Switch, the axis reverses on encountering the positive limit switch; then, if a negative limit switch is activated before the Home Switch, an error is generated.



Lower Home Outside Index (Positive Direction) Example

Direction of Motion: Negative

Home is the first index pulse on the negative side of the negative edge of a momentary Home Switch. Initial direction of motion is negative. If the initial motion leads away from the Home Switch, the axis reverses on encountering the negative limit switch; then, if a negative limit switch is activated before the Home Switch, an error is generated.

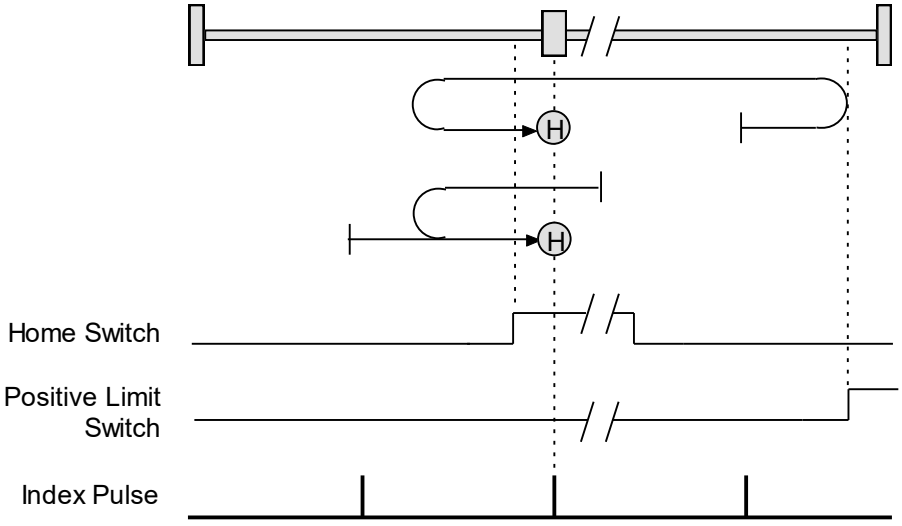


Lower Home Outside Index (Negative Direction) Example

Lower Home Inside Index

Direction of Motion: Positive

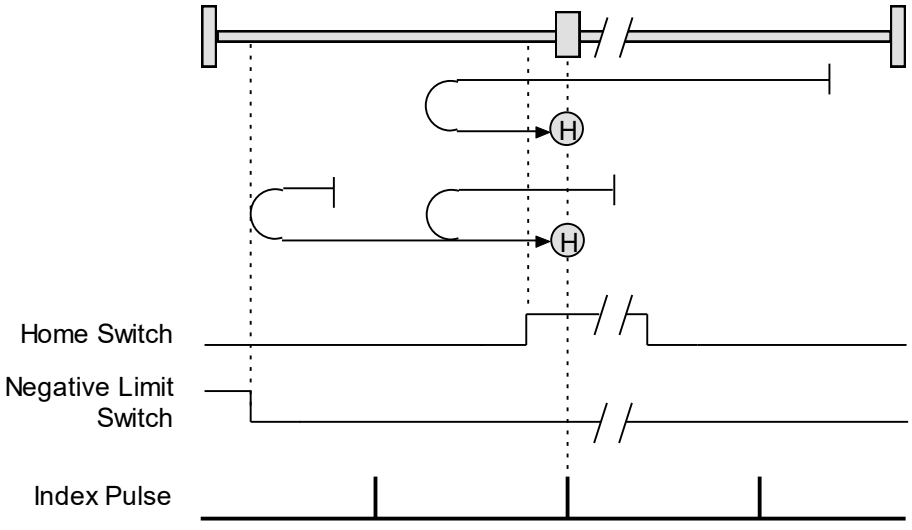
Home is the first index pulse on the positive side of the negative edge of a momentary Home Switch. Initial direction of motion is positive if the Home Switch is inactive. If the initial motion leads away from the Home Switch, the axis reverses on encountering the positive limit switch; then, if a negative limit switch is activated before the Home Switch, an error is generated.



Lower Home Inside Index (Positive Direction) Example

Direction of Motion: Negative

Home is the first index pulse on the positive side of the negative edge of a momentary Home Switch. Initial direction of motion is negative. If the initial motion leads away from the Home Switch, the axis reverses on encountering the negative limit switch; then, if a negative limit switch is activated before the Home Switch, an error is generated.

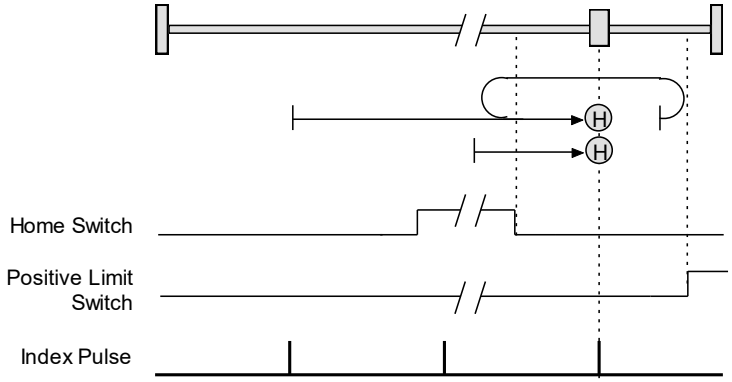


Lower Home Inside Index (Negative Direction) Example

Upper Home Outside Index

Direction of Motion: Positive

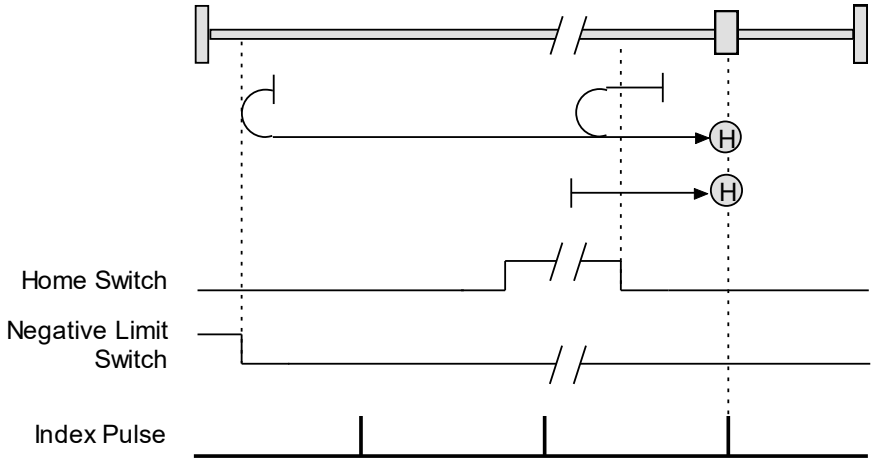
Home is the first index pulse on the positive side of the positive edge of a momentary Home Switch. Initial direction of motion is positive. If the initial motion leads away from the Home Switch, the axis reverses on encountering the positive limit switch; then, if a negative limit switch is activated before the Home Switch, an error is generated.



Upper Home Outside Index (Positive Direction) Example

Direction of Motion: Negative

Home is the first index pulse on the positive side of the positive edge of a momentary Home Switch. Initial direction of motion is negative if the Home Switch is inactive. If the initial position is to the right of the home position, the axis reverses on encountering the Home Switch.

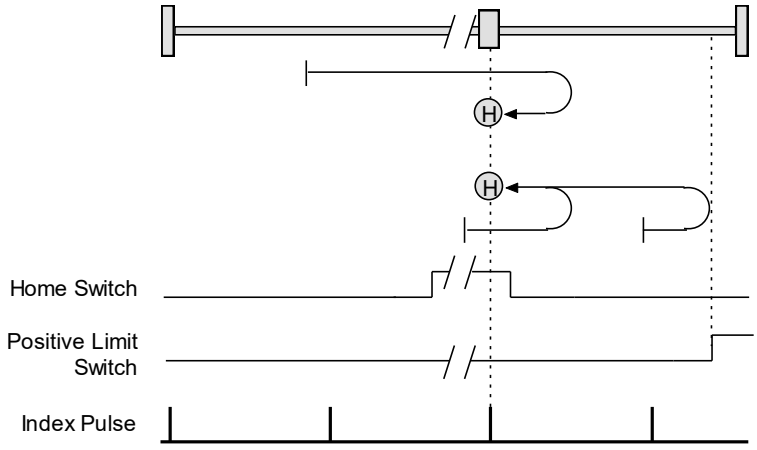


Upper Home Outside Index (Negative Direction) Example

Upper Home Inside Index

Direction of Motion: Positive

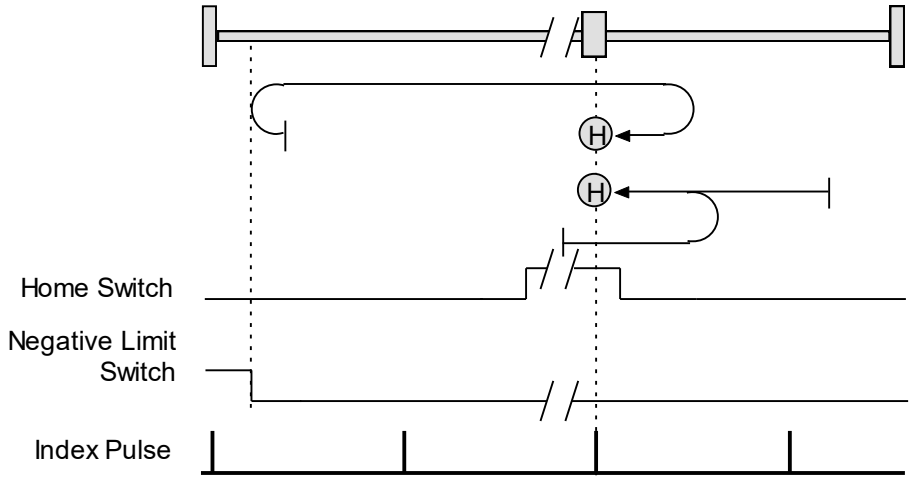
Home is the first index pulse on the negative side of the positive edge of momentary Home Switch. Initial direction of motion is positive. If initial motion leads away from the Home Switch, the axis reverses on encountering the positive limit switch; then, if a negative limit switch is activated before the Home Switch, an error is generated.



Upper Home Inside Index (Positive Direction) Example

Direction of Motion: Negative

Home is the first index pulse on the negative side of the positive edge of a momentary Home Switch. Initial direction of motion is negative if the Home Switch is inactive. If initial motion leads away from the Home Switch, the axis reverses on encountering the negative limit; then, if a negative limit switch is activated before the Home Switch, an error is generated.



Upper Home Inside Index (Negative Direction) Example

Immediate Home

Drive is referenced immediately on power-up. Once the encoder is initialized, the home offset value is added to the encoder position. The resulting value is set as the current referenced position. This method is primarily useful with absolute encoders.

APPENDIX C

ASCII COMMANDS/SERIAL CONTROL

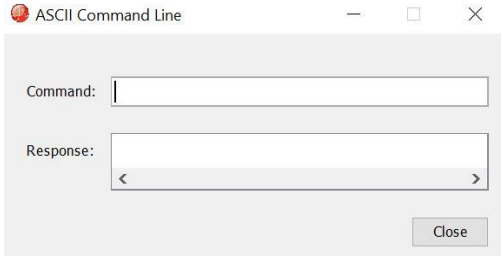
Copley ASCII Interface

A drive's RS-232 serial bus can be used by an external control application (HMI, PLC, PC, etc.) for setup and direct serial control of the drive. The control application can issue drive commands from the set of ASCII format commands that make up the Copley Controls ASCII Interface. For more information, see the Copley ASCII Interface Programmer's Guide and the Parameter Dictionary.

CME ASCII Command Line Interface Tool

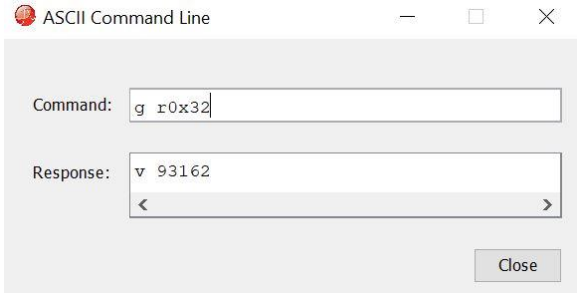
As described below, the CME ASCII Command Line Interface tool provides a simple way to enter the Copley ASCII commands.

1. From the Main screen, choose **Tools→ASCII Command Line** to open the tool.



ASCII Command Line Screen

2. Enter an ASCII Command in the **Command** field.
3. Press the **Enter** key to send the command to the drive. Observe the values in the **Response** field. If a value is returned, it is preceded by the letter "v." In the following example, the get command was used to retrieve the drive RAM value of variable 0x32 (actual position).

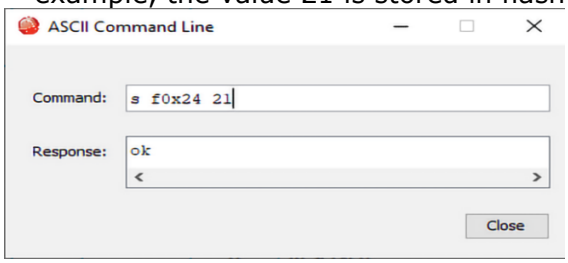


ASCII Command Line Screen

An error code would be preceded by the letter "e."
TIP: To view an error definition, hold the mouse pointer over the error number.

ASCII Set

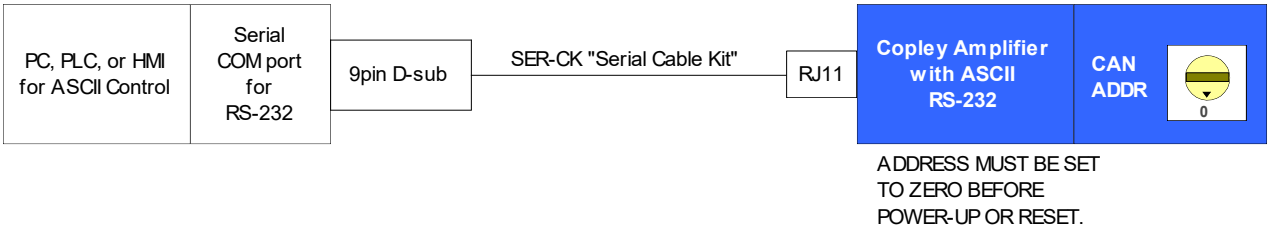
4. If the user attempts to store a value into a drive parameter, use the set command. After a successful set command, in the **Response** field, "**OK**" appears. In the following example, the value 21 is stored in flash for the drive's parameter 0x24 (Desired State).



ASCII Command Line Screen

Single-Axis Serial Connection

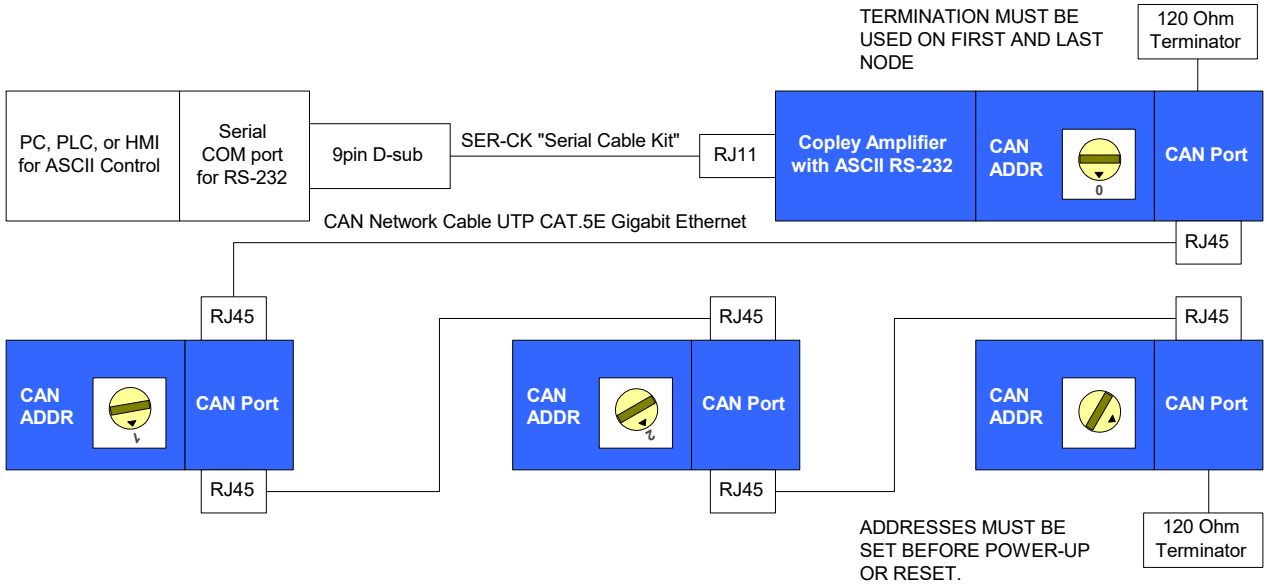
For RS-232 serial bus control of a single axis, set the CAN node address of that axis to zero (0). Note that if the CAN node address is switched to zero after power-up, the drive must be reset or power cycled to make the new address setting take effect.



Single-Axis Serial Connection Diagram

Multi-Drop Serial Connection

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



Multi-Drop Serial Connection Diagram

APPENDIX D

COPLEY USB TO RJ11

Recommended Device

Copley Controls recommends using **Copley SER-USB-RJ11**.

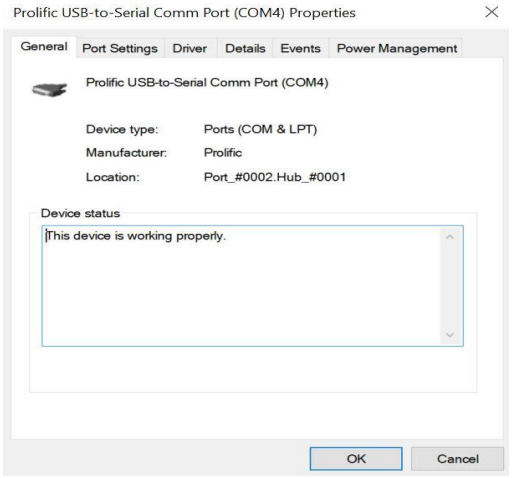
Factory Settings

The factory settings for this device functions properly. To confirm that the drivers are installed, and the default settings are correct, use the Windows Device Manager.

1. Open the Device Manager dialog from the Windows Control Panel and expand the **Ports (COM &LPT)** node:

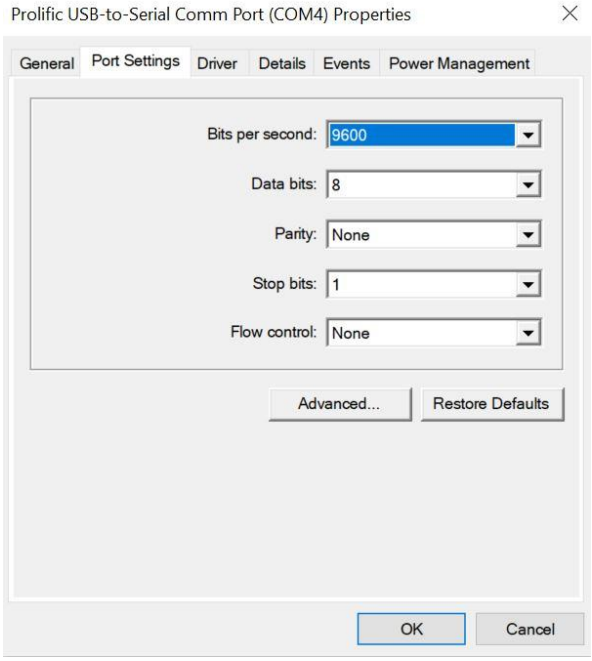


2. Select the COM port that is used by the USB to Serial Adapter. Confirm the drivers are installed and the device is working properly.

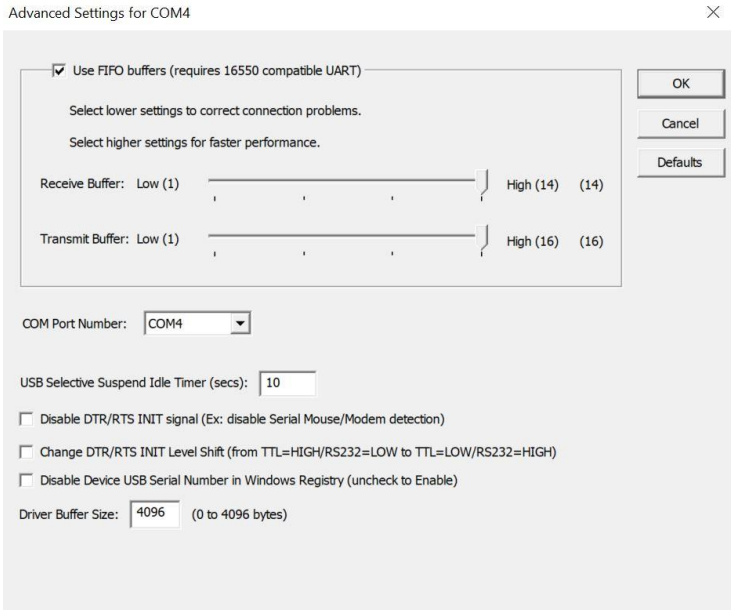


Prolific USB-to-Serial Comm Port (COM4) Properties Screen

3. Select the **Port Settings** tab, then click the **Advanced** button. Do not change the Baud rate or any port settings. CME through Windows can perform this process.



Prolific USB-to-Serial Comm Port (COM4) Properties Screen



Advanced Settings for COM4 Screen

APPENDIX E

Faults, Warnings & Status

Bit	Event	Name	Description	Fault Corrective Actions
0	Fault	Short Circuit	Output to motor or regen measured is greater than twice peak.	Check cable and motor or regen for short output to ground or output to output.
1	Fault	Drive Over Temp	Amp over temp drive protection.	Increase air flow, add heatsink kit, or reduce duty cycle.
2	Fault	Over Voltage	DC bus is above drive rating. Output shutdown	Check DC bus for pump up when stopping, add capacitance, or reduce deceleration rate.
3	Fault	Under Voltage	DC bus is below minimum.	Check DC bus for drooping or collapsing, improve power source, or reduce acceleration.
4	Fault	Motor Temp Sensor	Motor temperature sensor open or closed.	Check motor temperature confirm sensor circuit. If no motor temperature sensor is installed, make sure this is not configured.
5	Fault	Feedback Error	Problem with feedback circuits.	Check Encoder Status for more details, check voltage levels, Confirm Encoder power regulated.
6	Fault	Phasing Error	Problem with commutation or phasing.	Check Halls states vs Encoder count. Test encoder for no drift. Do not hot swap. Check manual phasing.
7	Warning	Current Limited	Current folds back to protect the drive or motor.	Reduce duty cycle, remove friction, and check motor Arms vs drive Ic Apk ratings. (1Arms = 1.414Apk).
8	Warning	Voltage Limited	PWM output hits 95% duty cycle.	Momentary voltage limit is okay. However, if output speed is limited and warning is constant then, increase DC bus or slow down.
9	Fault	Pos Limit Switch	Positive limit switch is active move aborts.	If hold position at limit is selected, then motor will servo in position. Otherwise, no current in direction of limit.
10	Fault	Neg Limit Switch	Negative limit switch is active move aborts.	If hold position at limit is selected, then motor will servo in position. Otherwise, no current in direction of limit.
11	Status	HW Enable Inactive	Hardware Enable	Check IN1 for correct levels. Typically, IN1 input (SW input 0) is active low enable and stop settings are configured for controlled stop.
12	Status	SW Enable Inactive	Software Enable	Check that master can move drive to op-state. If Copley mode is "Disabled", change to another mode.
13	Warning	Stopping	Trajectory aborted attempting to stop.	Normal event when hardware disabled or master commands. Trajectory will abort when fault occurs so check faults for root cause.
14	Status	Brake Activated	Brake FET is turned On.	Check that the brake is holding.
15	Fault	PWM Disabled	Drive PWM output H-bridge stage is OFF.	Check for HW and SW enable or no faults.

Bit	Event	Name	Description	Fault Corrective Actions
16	Status	Pos Soft Limit	Positive Software limit	Soft limits apply after homing. Move will stop using soft limit deceleration rate and hold on soft limit. Check soft limit deceleration rate.
17	Status	Neg Soft Limit	Negative Software limit	Soft limits apply after homing. Move will stop using soft limit deceleration rate and hold on soft limit. Check soft limit deceleration rate.
18	Fault	Tracking Error	Following Error limit exceeded	Some limit is preventing move. Check mechanical system and current limits. Reduce duty cycle.
19	Warning	Tracking Warning	Following Error above warning limit,	Danger of Following Error. Some limit is affecting move. Check mechanical system and current limits. Reduce duty cycle.
20	Status	Resetting	Drive is presently being reset,	Wait for reset to complete.
21	Status	Position Wrap	Position has wrapped.	If wrap is set to some value count, it will start at 0 again at that value. Otherwise, if wrap is not set, the Position variable wraps at full scale range. This type of counting is called position wrapping or modulo count.
22	Fault	Drive Fault	Power-up diagnostic	Rest or power cycle the drive. Make sure power cabling and grounding is correct.
23	Warning	Velocity Limit	Velocity limited to configured value	Increase the velocity limit to 10% greater than rated or required speed.
24	Warning	Acceleration Limit	Acceleration limits command	Velocity mode only. If command exceeds limit, the summing junction will only get limit.
25	Warning	Tracking Window.	Following error is in tracking window.	If Position Loop Error is outside of the Position Tracking Error Limit, then position is not tracking, or move has not settled.
26	Status	Home Switch Active	Home Switch input is active.	An input configured as Home Switch will capture the position when activated. Normally, used for purposes of homing.
27	Status	In Motion	Moving or not settled	Set if the trajectory generator is running a profile, or the Position Tracking Error Limit is outside the tracking window. Clear when settled into position.
28	Status	Velocity Window	Velocity not tracking.	Set if the absolute velocity error exceeds the velocity window value.
29	Warning	Phase Not Initialized	Algorithmic (No Halls) commutation is run after enable.	After enable algorithmic phasing, it will wiggle the motor to find phase. Confirm phase initialized and good before commanding move.
30	Fault	Command Input	Master command signal not present.	Master (CANopen or ECAT) not connected or not sending message in time configured by master. Turn off guard time if CANopen master is not connected. If PWM command source, check for command or allow 100% command.
31	Fault	Not Defined.		

CME User Guide

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