Galil EtherCAT Master

Setup Guide

Rev. 1.0d

The DMC-52xx0
2, 4, 8, 16, and 32 axes

The DMC-500x0
1-8 axes EtherCAT / 1-4 axes Local

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Using This Guide

Note	This manual is a supplement to the DMC-500x0 and DMC-52xx0 User Manuals and covers the installation and configuration of 3rd party external EtherCAT drives to interface with a Galil EtherCAT Master.

This setup guide provides information for proper set up and configuration of an EtherCAT station for use with a Galil EtherCAT Master. In addition, the EtherCAT Command Reference contains a description of the additional commands available with this option. It is recommended that the user download the latest version of the Command Reference and User Manual from http:\\www.galil.com.

The DMC-500x0 and DMC-52x00 motion controllers have been designed to work with many motor and drive combinations. For installation and configuration of servo or stepper motors using either Galil's internal amplifiers or 3rd party external non-EtherCAT amplifiers, see the DMC-500x0 and DMC-52xx0 User Manuals.

Review the brief EtherCAT Glossary on page 58 to familiarize yourself with the terms used in this manual.

WARNING	**Machinery in motion can be dangerous!** It is the responsibility of the user to design effective error handling and safety protection as part of the machinery. Galil shall not be liable or responsible for any incidental or consequential damage.

Contents

1 Overview

1.1 Galil EtherCAT Masters

Galil offers two EtherCAT Masters, the DMC-500x0 and the DMC-52xx0. Features, capabilities, and a comparison of each platform is listed in Table 1 below.

Comparison	DMC-52xx0	DMC-500x0
Axis Count	Up to 32 axes of control (available in 2,4,8,16 and 32 axes configurations)	Up 8 axes of control (maximum 4 local)
Ethernet	(1) 10/100 Base-T	(1) 10/100 Base-T
EtherCAT	(1)	(1)
RS232	No	(1) Main, (1) Aux, 115 kbaud
USB	(1)	No
Allowed EtherCAT IO Slaves	(2)	(2)
Uncommitted Digital Inputs	(8) optoisolated	(8) optoisolated
Uncommitted Digital Outputs	(8) optoisolated, high power sourcing	(8) optoisolated, high power sourcing
Uncommitted Analog Inputs	(8) programmable	(8) programmable
Uncommitted Analog Outputs	(8) programmable	No
Compatible Drives	Supported EtherCAT amplifiers	Galil's entire line of internal servo/stepper amplifiers, external servo/stepper amplifiers, and supported EtherCAT amplifiers
Enclosure Dimensions	1.60” x 5.00” x 9.75”	8.05” x 7.25” x 1.41”

Table 1: Summary of features and comparison of Galil EtherCAT Masters

1.2 Supported EtherCAT Drives and IO Modules

The full part numbers for each drive and IO module currently supported and tested are listed below:

1.2.1 EtherCAT Drives

- AMC DZEANTU EtherCAT Servo Drive Series
- Copley Xenus Plus EtherCAT Servo Drive Series
- Delta ASDA-A2E EtherCAT Servo Drive[1]
- LS Mecapion Pegasus EtherCAT Servo Systems
- LS Mecapion L7NHA EtherCAT Servo Drive Series
- Panasonic Minas A5B EtherCAT Servo Drive Series
- Sanyo-Denki RS2A01A0KA4 EtherCAT Servo Drive[1, 2]
- Yaskawa ΣV (Sigma 5) and ΣVII (Sigma 7) EtherCAT Servo Drive Series
- Parker PD-10C EtherCAT Servo Drive
- Estun Automation ProNet Servo Drive Series[1]

1.2.2 EtherCAT IO Modules

- Galil RIO-574x0 EtherCAT IO
- VIPA IM 053-1EC00 IO[3]

[1] Hardware Latch and Latch on Index functions are not supported by these drives

[2] Home sensor not supported by these drives

[3] See chapter 4 for specific IO hardware supported

2 EtherCAT Communication

2.1 Overview

The EtherCAT communication protocol is a deterministic, highly coordinated method of distributed control allowing fast communication between a Master and multiple Slave devices. The EtherCAT communication protocol is built on TCP/Ethernet, incorporating the physical and data link layers of the OSI networking model. This means that standard Ethernet hardware, Network Interface Cards and CAT5 cabling, can be used to relay communication between nodes at 100 Mbps.

Note	Standard Ethernet hubs, switches and routers are not compatible with EtherCAT networks

2.2 Supported EtherCAT Modes and Features

Galil EtherCAT Masters operate in Cyclic Synchronous Position (CSP) Mode and Cyclic Synchronous Torque (CST) Mode[1]. In CSP mode, motion profiling data is sent from the EtherCAT Master to the Slave at regular, deterministic intervals which the Slave then interprets via hardware and translates into motion. The Slave also returns data to the Master such as encoder position and I/O status. This streamlined amount of data allows for very tight control due to high update rates, for Galil EtherCAT Masters, the EtherCAT cycle time is 1 ms.

In addition to low cycle times, EtherCAT networks rely on the Distributed Clock feature to synchronize and coordinate communication. When an EtherCAT network is initialized, the Master measures communication times to and from each drive. Each drive is then assigned a time offset to ensure that commands are executed simultaneously with minimal latency.

The additional hardware and processing required on both the Master and Slave ends does increase the cost for an EtherCAT control system. Standard analog command line signals and 'dumb' drives will likely be lower cost for some time. However, for some applications the added cost is offset by the ease of wiring, upgradeability and versatility that EtherCAT offers for distributed control systems.

The EtherCAT standard also includes support for dedicated I/O modules. Communication with these modules is much simpler than with drives since no motion profiling is needed. Digital and Analog IO are queried and/or set at the rate specified by the EtherCAT Network Cycle Time. As a result, the RIO-574x0 and VIPA IO modules can be interfaced with a Galil EtherCAT Master with no additional set up needed. The RIO-574x0 offers programmable analog IO ranges among other other features. Consult the RIO-574x0 user manual for additional configuration details.

The EtherCAT standard defines a complex and tightly coordinated communication scheme with many hardware and software layers. Configuration and operation of an EtherCAT Master requires a working knowledge of Ethernet communications, programming, and complex logic.

One the primary benefits of using a Galil EtherCAT Master is that all of the configuration of an EtherCAT network is handled in firmware. All EtherCAT level communication is transparent to the user who can simply command motion on an EtherCAT axis as if it were a local axis powered by a Galil internal drive or external analog drive.

[1] Cyclic Synchronous Torque (CST) Mode is only supported on the DMC-500x0 with AMC DZEANTU and Yaskawa Σ5 drives

3 Configuring EtherCAT Drives

This chapter is meant as a 'bare bones' guide that will get supported drives up and running with a Galil EtherCAT Master. For more advanced tuning or drive configuration options, consult the User Manual for your specific drive. Configuring EtherCAT Drives to function with a Galil EtherCAT Master involves using drive manufacturer software to make the drive's digital I/O accessible to the Master. In addition, some drives include error handling for various conditions such as excessive position or speed. In general, these features should be disabled to allow the Master to handle their associated error conditions.

This guide assumes that the EtherCAT drive and motor have been correctly configured as per by the drive manufacturer documentation.

3.1 AMC-DZE Servo Drive Series

The AMC-DZEANTU drives are a family of compact servo amplifiers that can be paired with a variety of motors. This chapter will detail the process of both resetting and configuring an AMC DZEANTU-020B080 drive to operate with a Galil BLM-N23-50-1000-B 3-phase brushless motor, hereafter referred to as a Galil BLM.

3.1.1 Resetting the Drive to Factory Defaults

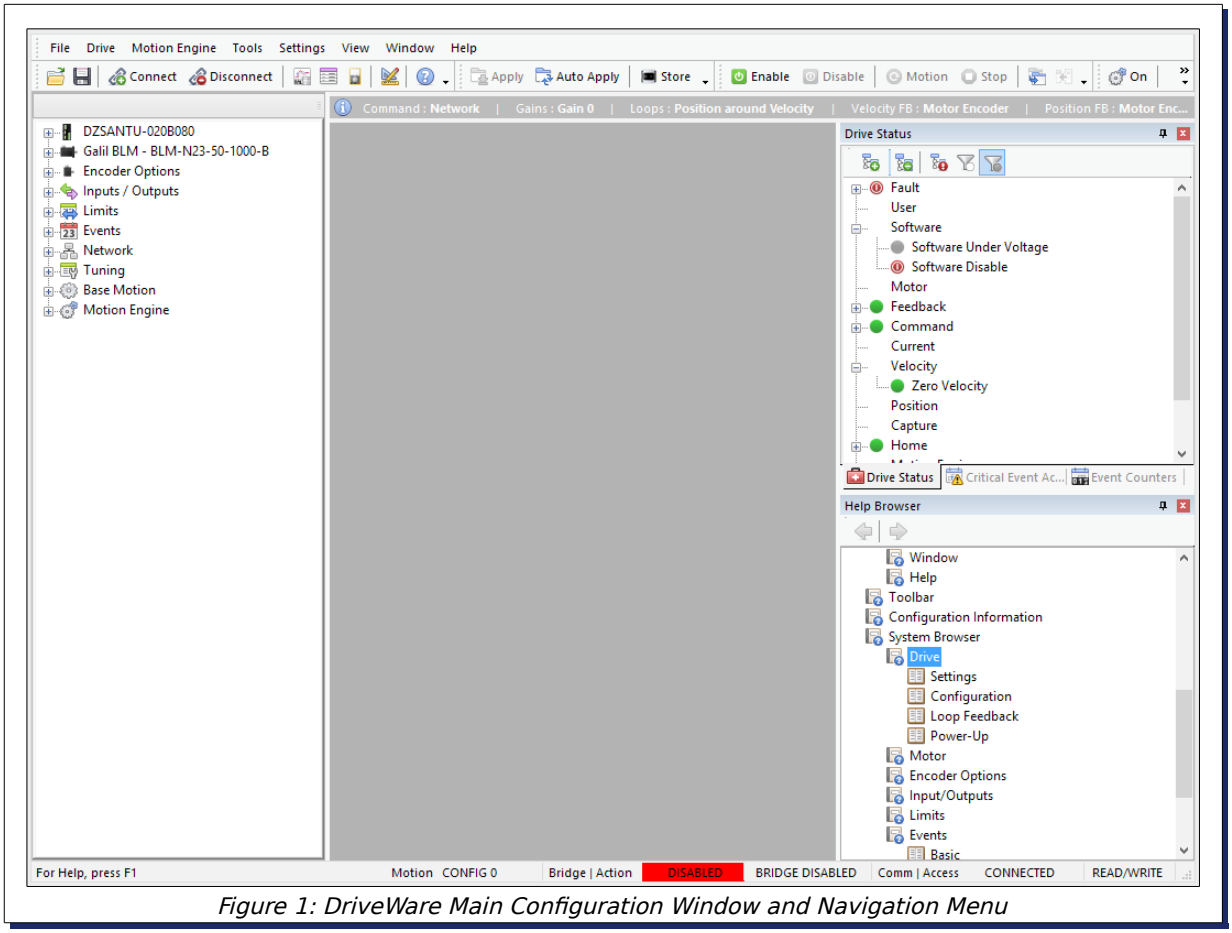


Figure 1: DriveWare Main Configuration Window and Navigation Menu

1 Install DriveWare and Connect to the Drive

Install AMC's DriveWare Software (this guide uses version 7.3.2) on a Windows PC and start the application. When prompted with an Open/Connect window, select 'Connect' and then connect to the drive via the window shown in Figure 2. Be sure that Interface Access Control is set to 'Read/Write' and USB is selected for the Communication Interface.

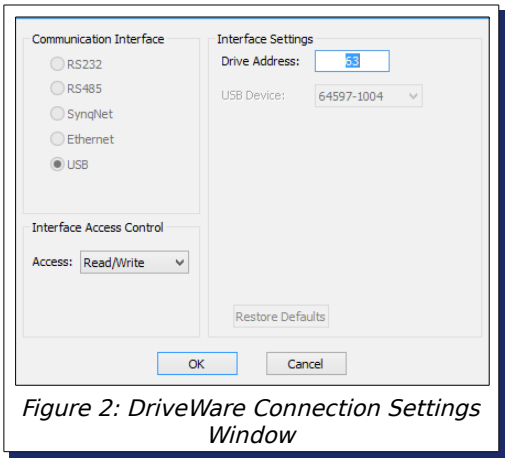


Figure 2: DriveWare Connection Settings Window

2 Select and Download the Default Project File

During installation, DriveWare places the default project files in:

'Documents\DriveWare7.3.2\My Projects\Sample Projects'

Note	Default project files are write protected although it is recommended to copy the files to an separate directory as backups.

Reconnect to the drive and when prompted to 'Upload/Download', select 'Download' and navigate to the above listed path. Select the "DZEANTU-020B080.Adf" file and click 'OK' to load the project into DriveWare. On the top menu bar, click the 'Apply' and 'Store' buttons. The AMC-DZEANTU drive has now been reset to factory defaults.

3.1.2 Configuring an AMC-DZE Drive for use with a Galil EtherCAT Master

This section will outline the steps necessary to configure an AMC-DZE drive to control a Galil BLM and interface with a Galil EtherCAT Master.

1 Rotary Switches

Set the drive's Station ID using the two rotary switches located on the front panel. This number is the address the EtherCAT Master will use to communicate with the drive. Each drive on the network should have a unique address to avoid communication conflicts.

2 Set Basic Drive Configuration

Connect to the drive via mini USB cable. Once connected, the main DriveWare window will load. This window includes a navigation bar on the left that will be used to view and configure parameters. See Figure 1.

The first menu item in the navigation bar shows the amplifier model currently saved and/or connected. Expanding the drive menu will open up four configuration options: 'Settings', 'Configuration 0', 'Loop Feedback' and 'Power-Up'. Select the 'Configuration 0' menu item.

The configuration settings to be used here will depend on the EtherCAT mode to be used; Cyclic Torque (Current) or Cyclic Position (Position Around Velocity). A brief description of each mode is listed in Table 2. Values are listed in Table 3. Note that CST Mode is only supported on the DMC-500x0 with AMC DZEANTU and Yaskawa Σ5 drives.

Cyclic Synchronous Position Mode (CSP)	Cyclic Synchronous Torque Mode (CST)
The DMC-500x0 EtherCAT Master sends cyclic position commands to the EtherCAT slaves, with the position and velocity loops being closed by the AMC amplifier. Cyclic Position mode should be set up in the Configuration window as shown in Figure 4.	The DMC-500x0 EtherCAT Master sends cyclic torque commands to the EtherCAT slaves, with the PID position loop closed by the DMC-500x0. Current mode should be set up in the Configuration windows as shown in Figure 3.

Figure 4: CSP Mode Settings

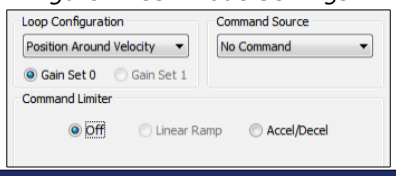


Figure 3: CST Mode Settings

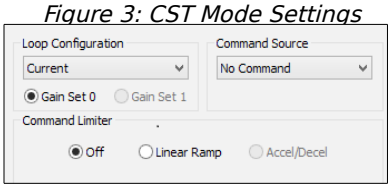


Table 2: CSP and CST mode descriptions

Setting	CSP Mode	CST Mode
Loop Configuration	Position Around Velocity	Current
Command Source	No Command	No Command
Gain Set	0	0
Command Limiter	Off	Off

Table 3: AMC DriveWare 'Configuration 0' values

3 Motor Parameters

The second menu item allows the entry of the motor parameters. These values must be taken from the motor datasheet in order to ensure proper motor operation within electrical and mechanical limits. The relevant Galil BLM values can be found in Table 32 in the Appendices.

The motor polarity can be set via the selection box at the bottom of the motor parameters box. Galil recommends configuring the rotation direction such that a forward (counts increasing) move is in the Clockwise direction.

4 Limits and Home Switches

The AMC-DZE drives are equipped with a bank of general I/O that the EtherCAT Master utilizes for limit and home switch sensors as well as the motor encoder index and hardware latches. In

order for the controller to read these inputs, it is necessary to disable the drive's default functions assigned to them. Expand the 'Inputs/Outputs' menu item and select the 'Digital Inputs' section. Remove any assigned function to inputs 1, 2, 3, and 4 by clicking the red X near the bottom right of the window. Also be sure that inputs 1,2, and 3 are set to 'Active Low'. See Figure 5.

5 Index & Hardware Latches

In order to set inputs 4 and 5 as the motor encoder index latch and hardware latch respectively, expand the 'Capture' menu item and drag/drop the 'High Speed Capture' item onto Inputs 4 and 5. Next, click the 'Capture Edit' button and set 'Captured Signal' to 'Primary Feedback Position'. Input 4 should be set to 'Active High', while input 5 should be set to 'Active

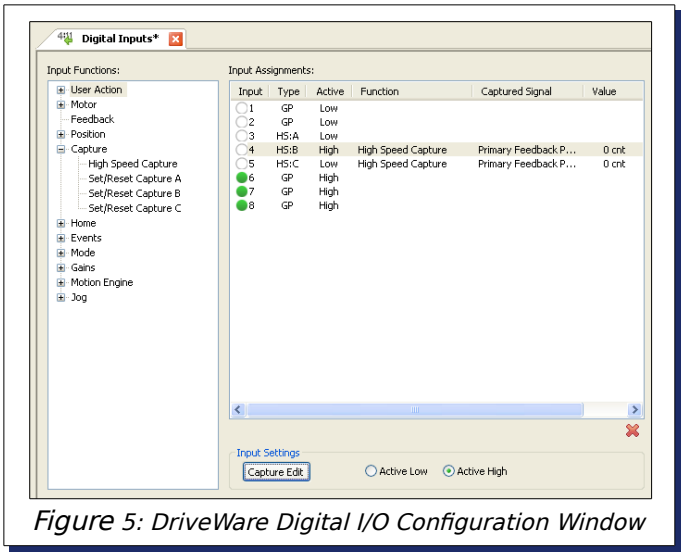


Figure 5: DriveWare Digital I/O Configuration Window

Low' see Figure 5. Pin outs for the various IO can be found in Section 7.1.1.

Input	Type	Active	Function	Captured Signal
1	GP	Low		
2	GP	Low		
4	HS:A	High	High Speed Capture	Primary Feedback Position
5	HS:C	Low	High Speed Capture	Primary Feedback Position

Table 4: AMC DriveWare Digital Input Settings

6 Event Handling

The 'Events' menu item lists functions that the drive will run automatically when certain events occur. In order to take advantage of the DMC-500x0 EtherCAT Master's event handling, un-check the "Latch" box on the right of each item. All but two of these will need to be disabled on the drive.

The 'Comm Channel Error' Action needs to be set to 'Disable Power Bridge' to immediately shut down the drive in the event of a communications interruption between the drive and the DMC-500x0 EtherCAT Master. In addition, the 'Position Following Error' Action should be set to 'No

Action' in order to allow access to the DMC-500x0 EtherCAT Master's automatic subroutines. See Figure 6.

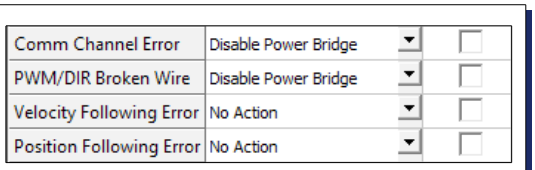


Figure 6: DriveWare Event Handling Settings

7 Set Current Limits

In order to avoid damage to the motor, the AMC-DZE drive's current limits must be set to within motor datasheet specifications. Set the current limits for the Galil BLM as shown in Figure 7 and listed in Table 5.

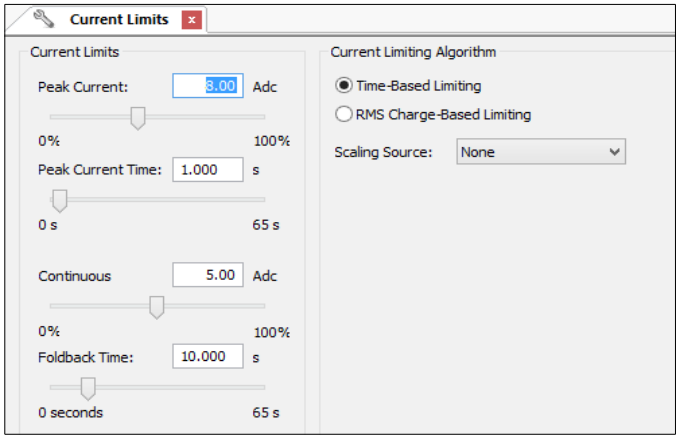


Figure 7: DriveWare Current Limits Configuration Window

Parameter	Value
Peak Current	8.00 Amps
Peak Current Time	1.000 sec
Continuous Current	5.00 Amps
Current Limiting Algorithm	Time-Based Limiting

Table 5: DriveWare Current Limit Values

8 EtherCAT Communication Settings

Configure the AMC-DZE drive's network settings by expanding the 'Network' menu item. Table 6 lists the values necessary to enable communication between the AMC-DZE drive and the DMC-500x0 EtherCAT Master. 'Cyclic Torque' and 'Target Current' are valid settings for both torque mode and position mode.

Settings	RPDOs	TPDOs
Station alias: 1 Initial mode of Operation: Cyclic Torque Cyclic mode period: 1 msec	Word 0 - Control Word (6040:00) Word 1 - Target Current (6071:00) Word 2 - User Bits (2001:03)	Word 0: Status Word (6041:00) Word 1: Digital Inputs (2023:01) Word 2: Actual Position (6064:00) Word 3: Actual Position*

Table 6: EtherCAT Communication Setting Values

*'TPDO Actual Position' is a 2 byte value that spans Word 2 and Word 3.

9 Current Loop Gains

The AMC-DZE drive requires the user to tune the current loop based on the motor specifications. In the 'Tuning' menu item, expand the 'Current Loop Gains' item. These gains will vary with motor type and manufacturer. For the Galil BLM, values for K_P and K_I are listed in Table 7. Consult with AMC's technical support for specific instructions on tuning the AMC-DZE drive's current loop gains.

Parameter	Value
Current Loop K_P	4.857
Current Loop K_I	0.113

Table 7: Current Loop Gain Values for a Galil BLM

10 Position and Velocity Loop Gains

If planning to use the system in position mode, it is necessary to set the drive's position and velocity loop gains. These values are highly dependent on motor type and system mechanics. However for the purposes of setting up a free spinning (no mechanics coupled to motor) Galil BLM, the values listed in Table 8 list values that will provide sufficient servo control to confirm correct operation. Consult with AMC's technical support for specific instructions on tuning the AMC-DZE drive's velocity and position loop gains.

Parameter	Value
Velocity Loop K_P	6.10E-005
Position Loop K_P	0.003

Table 8: Velocity and Position Loop Gain Values for a Galil BLM

11 Motor Commutation

One of the last steps is to commutate the motor using DriveWare's 'AutoComm' function. Expand the 'Motor' menu item and click on the 'AutoComm' item. Click 'Start AutoCommutation' in the AutoComm window, and follow the prompts. This procedure will spin the motor shaft roughly 2.5 revolutions in each direction, setting the motor brushless modulus and hall sequencing. This process must be performed any time the motor is changed.

12 Save and Apply Changes

The final step is to save this configuration to a project file on the PC. Do so by going to File/Save Project in the top menu bar.

Note	Be sure that the project is not saved over a default project file

Lastly, click 'Apply' then 'Store' in the top menu bar to write the changes to the drive's non-volatile memory. Disconnect the software from the AMC-DZE drive, power cycling the drive is not necessary for the changes to take effect.

The drive is now configured to communicate with a Galil EtherCAT Master.

3.2 Yaskawa ΣV and ΣVII Servo Drive Series

The Yaskawa ΣV and ΣVII Servopacks are single drive systems which integrate both drive and motor into one package. As a result, there are only a few parameters that need to be set in order for the drive to interface with a Galil EtherCAT Master.

3.2.1 Resetting the Drive to Factory Defaults

1 Install SigmaWin+ Software and USB Drivers

Install the SigmaWin+ () version 5.56a shown below) drive configuration software on a Windows PC. SigmaWin+ requires that the USB drivers be installed manually. This can be done by opening the PC's Device Manager, selecting the Yaskawa item and selecting 'Update Driver'. Navigate to the file that contains the relevant USB driver and click 'OK'.

2 Connect to the drive

Connect the drive to the PC via mini USB cable. Open the SigmaWin+ application, select the drive type, then search for and connect to the drive.

3 Initialize the Drive

Click on the 'Edit Parameter' icon in the toolbar to bring up the Parameter Editing Window shown in Figure 8.

Click the 'Initialize' Button to write default parameters to the drive.

Power cycle the drive for the changes to take effect.

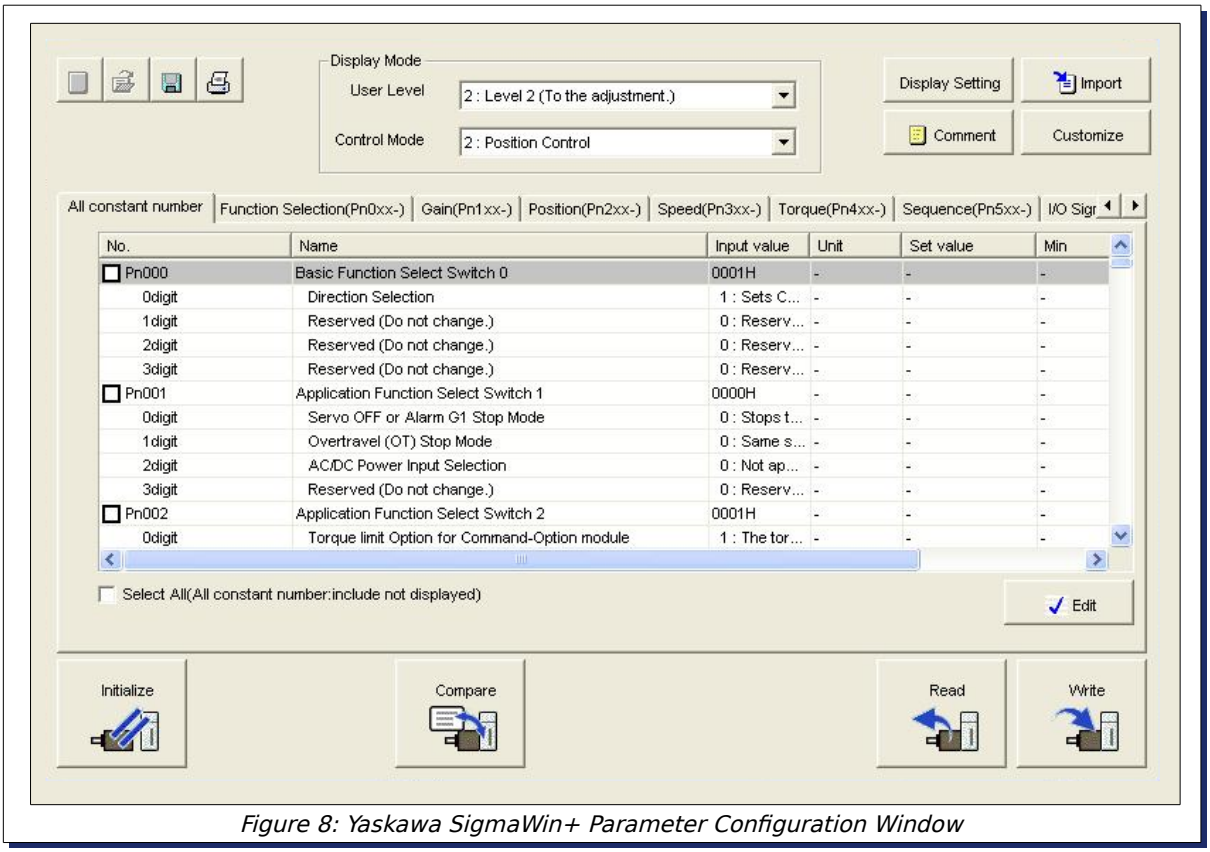


Figure 8: Yaskawa SigmaWin+ Parameter Configuration Window

3.2.2 Configuring a Yaskawa ΣV/ΣVII Drive for use with a Galil EtherCAT Master

This section will outline the steps necessary to configure a Yaskawa ΣV/ ΣVII drive to operate with a Galil EtherCAT Master from factory default settings. All parameter editing listed in the following steps is done from the Parameter Editing Window shown in Figure 8

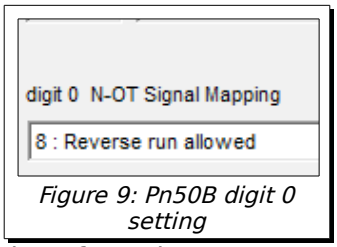


Figure 9: Pn50B digit 0 setting

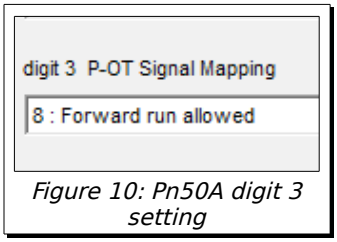


Figure 10: Pn50A digit 3 setting

1 Set Rotary Switches

Set the drive's Station ID using the two rotary switches located on the drive. This number is the address the EtherCAT Master will use to communicate with the drive. Each drive on the network should have a unique address to avoid communication conflicts.

2 Set Drive Polarity

The Yaskawa ΣV and ΣVII motor/encoder polarity can be configured by setting digit 0 of the Pn000 parameter. By default, Pn000 digit 0 is set to 0. In this configuration, the motor will rotate counter clockwise when a forward move (counts increasing) is issued. Setting Pn000 digit 0 to 1 will reverse the motor/encoder polarity, defining a forward move as a clockwise rotation. Valid values are listed in Table 9.

Pn000 digit 0 value	Forward (counts increasing) direction of rotation
0 (Default)	Counter Clockwise
1	Clockwise

Table 9: Pn000 digit 0 parameter values

3 Set Encoder Resolution

The Yaskawa ΣV drive's default resolution is 2^{20} counts per revolution. The ΣVII drive's default encoder resolution is scaled internally to 2^{20} counts per revolution as well. The encoder resolution for both drives can be scaled down if necessary[1] . This is done by setting the PnB02 parameter, see Figure 11. Equation 1 lists the formula for changing the Yaskawa ΣV/ ΣVII drive's encoder resolution.

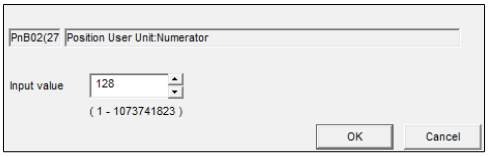


Figure 11: SigmaWin+ PnB02 value selection box

$$\frac{\text{Encoder Counts}}{\text{Rev}} = \frac{2^{20}}{\text{PnB02}}$$

Equation 1: Scaling Encoder Counts per Revolution

[1] If using the ΣV in Cyclic Synchronous Torque Mode (MT11) on the DMC-500x0, it is necessary to scale down the encoder resolution to account for the DAC resolution of the drive.

4 Limit Switches

In order to provide the Galil EtherCAT Master access to the Yaskawa ΣV/ ΣVII drive's limit and home switches, the drive's local input switch functions must be disabled. To do this, two parameters need to be changed on the Yaskawa ΣV/ ΣVII drive. These values are shown in Figure 10 and Figure 9. Pin outs for the various IO can be found in Section 7.1.2.

5 Home Switch and Hardware Latch

To give the Galil EtherCAT Master access to the home switch and hardware latch on the Yaskawa ΣV/ ΣVII drive, digits 2 and 3 of the Pn511 parameter must be set. Digits 0 and 1 are unavailable to the EtherCAT Master. The settings for digits 2 and 3 are shown in Figure 12. Pin outs for the various IO can be found in Section 7.1.2.

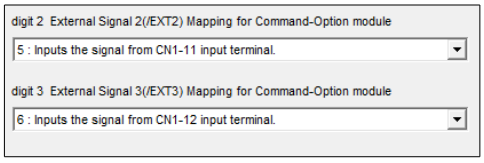


Figure 12: Pn511 digit 2 and 3 value selection menus

6 Set Position Error Alarm Level

In order to take advantage of the Galil EtherCAT Master's position error commands and subroutines, the Yaskawa ΣV/ ΣVII drive must be configured to ignore its internal error limit. Since SigmaWin+ does not allow this function to be disabled, setting the corresponding parameter to its maximum value ensures position error handling is processed by the Galil EtherCAT Master. To do this, set the Pn520 parameter to its maximum value of 1,073,741,823 as shown in Figure 13.

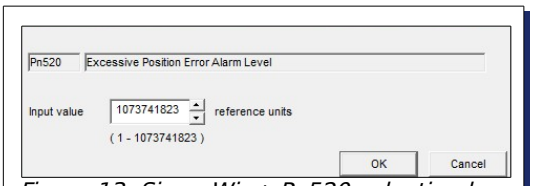


Figure 13: SigmaWin+ Pn520 selection box

7 Apply Parameters to the Drive

Click the 'Write' button to write the parameters to the Yaskawa ΣV/ ΣVII drive's non-volatile memory.

A verification window will appear showing the parameters that have been changed, and will be written to the drive, click 'OK'. Once the write is complete, cycle the power to the drive for the changes to take effect.

The drive is now configured to communicate with a Galil EtherCAT Master.

3.3 LS Mecapion Pegasus and L7NHA Servo Drive Series

The LS Mecapion Pegasus series is an integrated motor and drive package meaning there is minimal wiring required. The L7NHA Series is capable of interfacing with multiple motor types and vendors.

3.3.1 Resetting the Drive to Factory Defaults

1 Install Drive CM and USB Drivers

Install the most recent version of the DriveCM (Drive Configuration Manager) software and install the recommended USB driver

2 Connect to the Drive

Connect the drive to the PC via mini USB Cable and open DriveCM. Make sure that 'USB' and 'PEGASUS' or 'L7NHA' 

are selected and click the connect icon.

3 Load Default Settings

Click the 'Object Dictionary' icon to bring up the Object Dictionary Editor Window shown in Figure 14.

In order to restore the drive to its factory default settings, Index 0x1011 must be set to the value listed in Table 10.

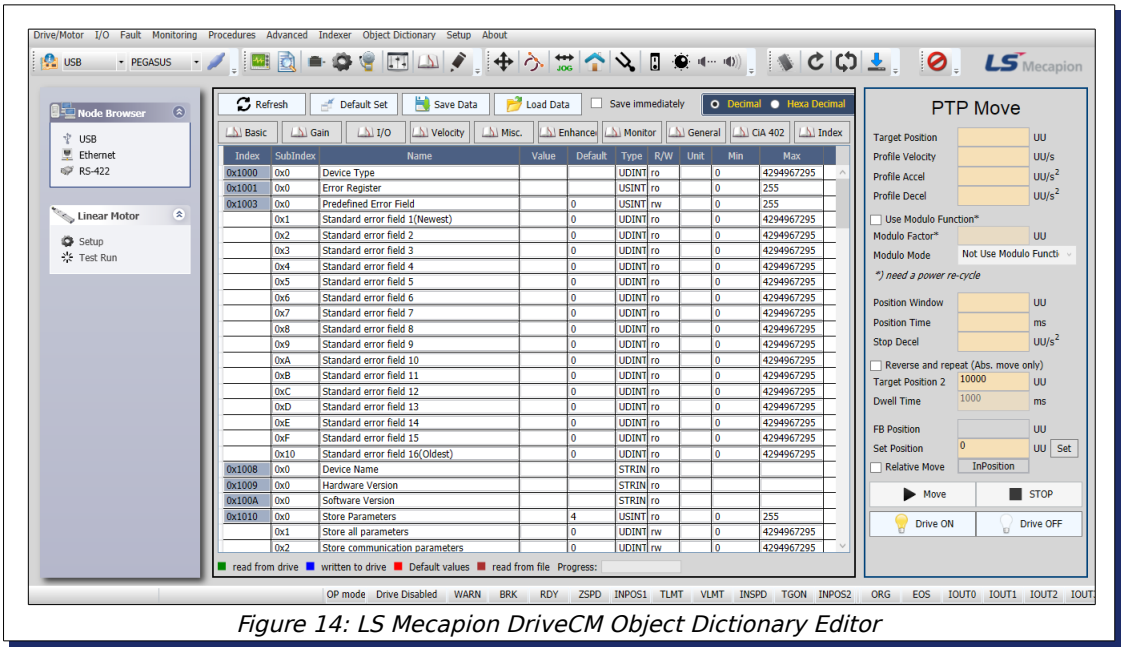


Figure 14: LS Mecapion DriveCM Object Dictionary Editor

Object Dictionary Index	Value
0x1011	0x64616F6C (ASCII "load" in reverse order)

Table 10: Index 0x1011 value to reset drive to default parameters

Once the value has been written, click the 'Save to  Memory' Icon.

3.3.2 Configuring an LS Mecapion Pegasus Drive for Use with a Galil EtherCAT Master

1 Set drive polarity

Click the 'General Config  Setup' icon to bring up the General Configuration Window shown in Figure 15.

Drive polarity can be set by checking/unchecking the 'Reverse' box at the top of the window.

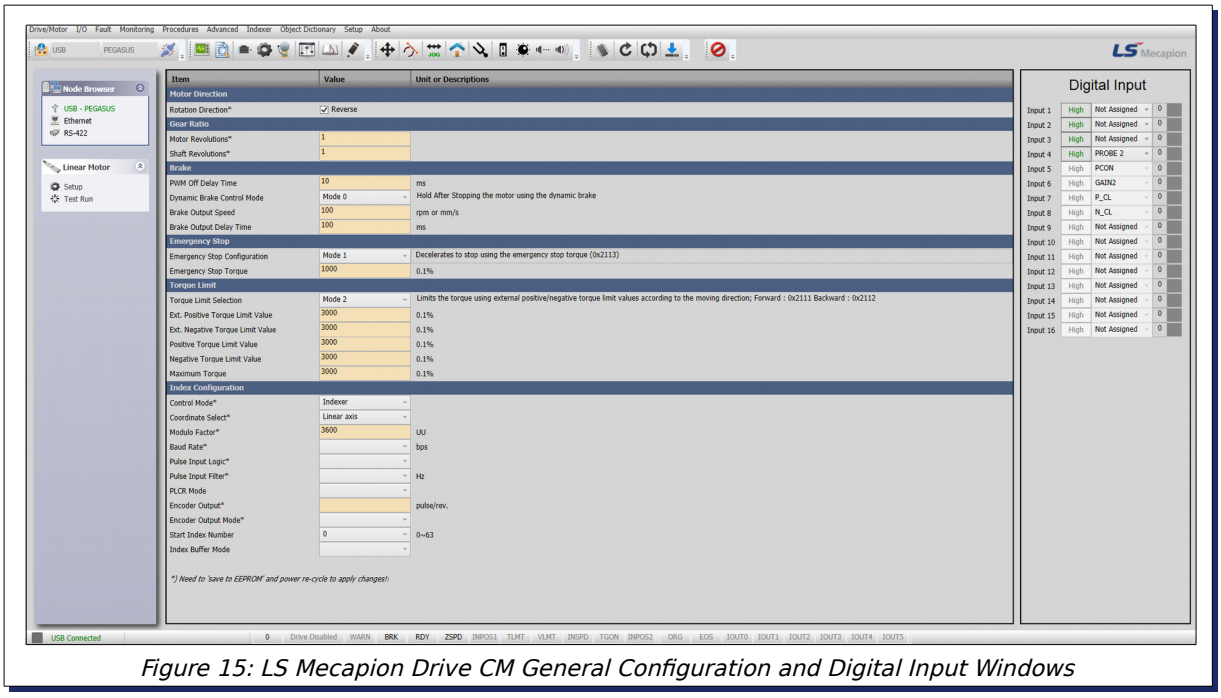


Figure 15: LS Mecapion Drive CM General Configuration and Digital Input Windows

2 Configure Digital Inputs

Click the 'Digital  Input' icon

This will bring up the Digital Input configuration bar. Set Inputs 1 through 4 according to the values listed in Table 11. Pin outs for the various IO can be found in Sections 7.1.3 and 7.1.4

Input #	Polarity	Assignment
1	High	Not Assigned
2	High	Not Assigned
3	High	Not Assigned
4	High	Probe 2

Table 11: DriveCM Digital Input Settings for LS Mecapion Pegasus Drive

Click the 'Save to  Memory' icon

The new settings will take effect once the drive has been power cycled.

The drive is now configured to communicate with a Galil EtherCAT Master.

3.4 Delta ASDA A2-E Servo Drive Series

3.4.1 Resetting the Drive to Factory Defaults

1 Install ASDA-Soft Communication Software and USB Communication Drivers

2 Connect to the drive via USB-B cable

3 Open the Parameter Editor Window

Under the 'P2-XX' Tab in the Parameter Editor Window Tab, double click on the 'Value' field to the right of the 'P2-08' Parameter and set the value to 10. Click the 'Write to Servo' button and power cycle the drive for the changes to take effect.

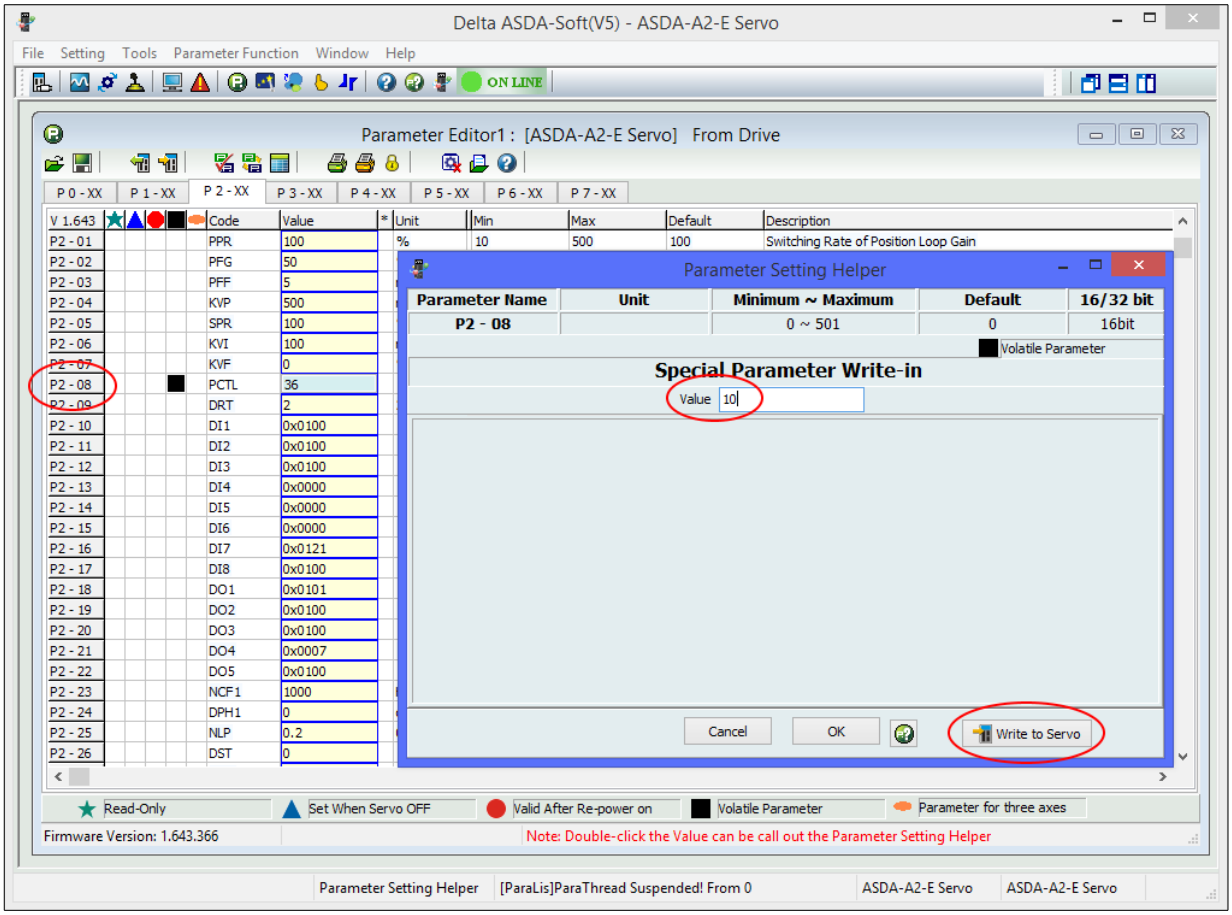


Figure 16: ASDA Soft Parameter Editor Window

3.4.2 Configuring a Delta ASDA A2-E Drive for use with a Galil EtherCAT Master

1 Configure IO

Under the 'P2-XX' tab in the Parameter Editor Window shown in Figure 17, set each of the parameters listed in Table 12 to the values shown.

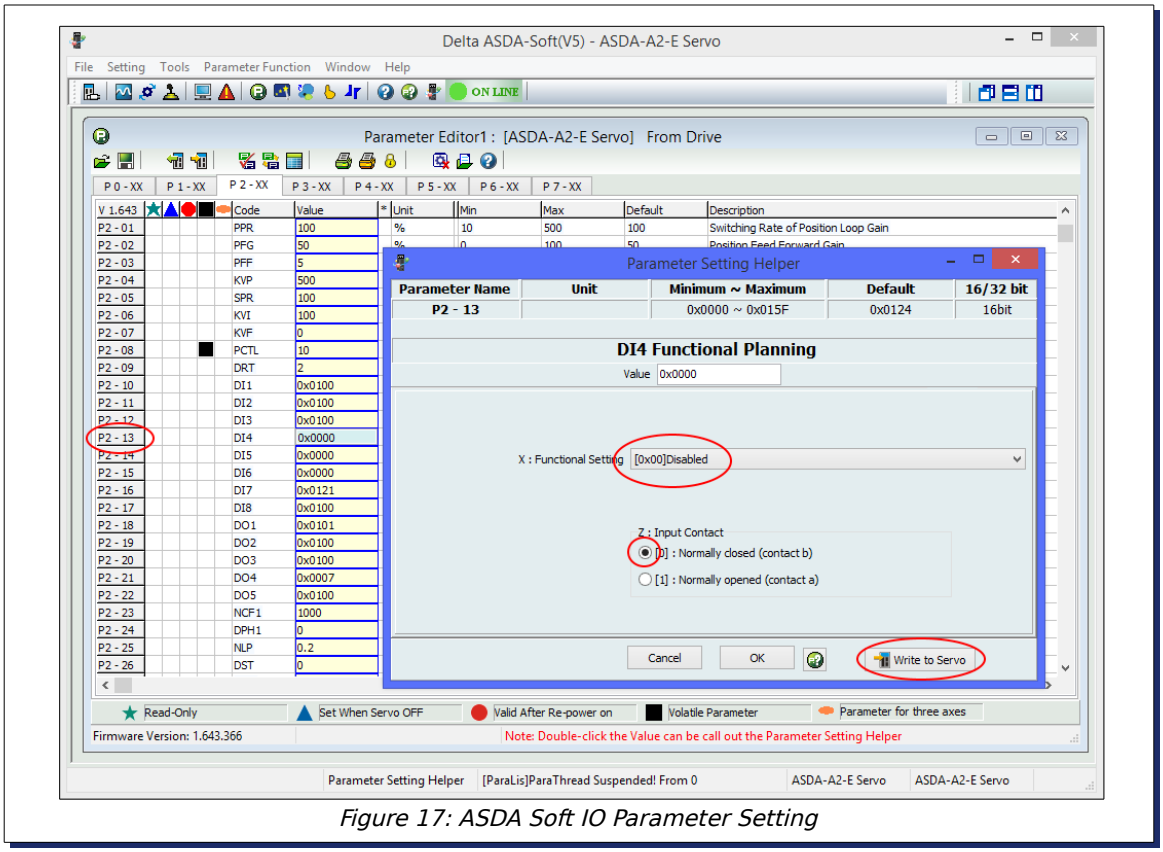


Figure 17: ASDA Soft IO Parameter Setting

Parameter	Name	Functional State	Input Contact
P2 - 13	DI 4	Disabled	Normally Closed
P2 -14	DI 5	Disabled	Normally Closed
P2 -15	DI 6	Disabled	Normally Closed
P2 -16	DI7	Emergency Stop*	Normally Open
P2 - 40	EDI13	Disabled	Normally Closed

Table 12: ASDA Soft IO Parameter Configuration Values

To enable IO over EtherCAT, under the 'P3-XX' Tab, set parameter 'P3-18' to 0x1000.

Pin outs for the various IO can be found in Section 7.1.8.

Power cycle the drive for the changes to take effect.

The drive is now configured to communicate with a Galil EtherCAT Master.

3.5 Panasonic Minas A5B Servo Drive Series

The Minas-A5B Servo Drive provides EtherCAT Communication and high resolution encoder feedback in one drive/motor package.

3.5.1 Resetting the Drive to Factory Defaults

1 Install Panaterm Software and Connect to the Drive

Install the Panaterm Software on a Windows machine and connect to the Minas A5B drive via mini USB cable. The Panaterm Connection Window is shown in Figure 18.

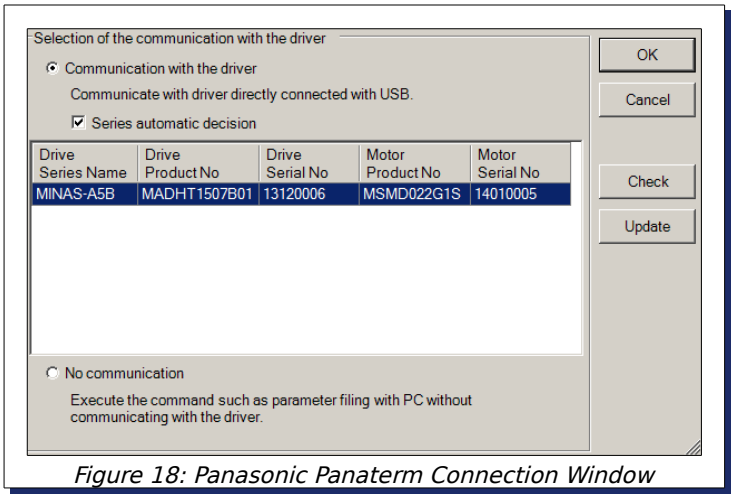


Figure 18: Panasonic Panaterm Connection Window

2 Reset the Drive to Defaults

From the main menu bar, navigate to 'Parameter -> Read the default' to open the parameters window.

In the parameters window menu bar, select the 'Trans' button to transmit the default parameters to the drive.

After transmitting, click the 'EEP' Icon to write the parameters to the drive's EEPROM.

3.5.2 Configuring the Panasonic Minas A5B Drive for Use with a Galil EtherCAT Master

Figure 19 shows the Parameter Editing Window. The drop down menu to the left will be used to navigate to and set the following parameters.

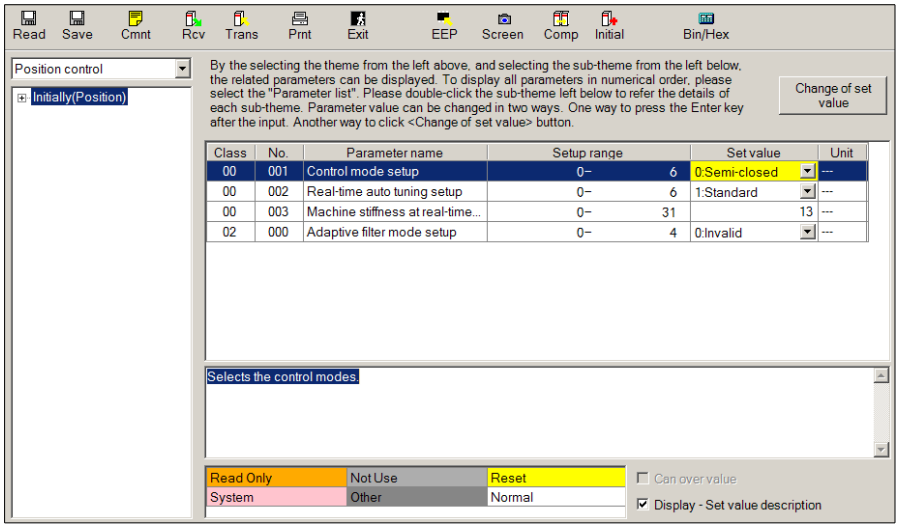


Figure 19: Panaterm Parameters Editing Window

1 Motor Polarity

In the drop down menu, select 'Revolution direction Setting'. The parameter 'For manufacturer's use' can be set to either 0 or 1 depending on application requirements. The behavior for each value is detailed in Table 13

Value	Function
0	A positive move (counts increasing) will rotate the motor Clockwise (CW)
1	A positive move (counts increasing) will rotate the motor Counter Clockwise (CCW)

Table 13: Revolution Direction Settings

2 Disable Drive Position Error Monitoring

Select 'Protection level setting function' in the column below the 'Function by Function' drop down menu. Change the 'Position deviation excess setup' parameter's set value from 10000 to 0, this will disable this parameter.

3 Disable Drive Speed Monitoring

Change the 'Speed deviation excess setup' parameter's set value to 0, this will disable the drive's speed monitoring function.

4 Set Encoder Resolution

In the main tool bar select 'Other' and click on 'Object Editor'. This will open the Object Editor Window shown in Figure 20. In the object tree to the left, select the '6000h' object. Scroll down and select the 'Feed' object. The Default for this setting is 2^{20} (4294967295). The 'setting value' for this parameter will allow you to set the number of encoder counts per revolution for your motor. Set it to a value appropriate for your application.

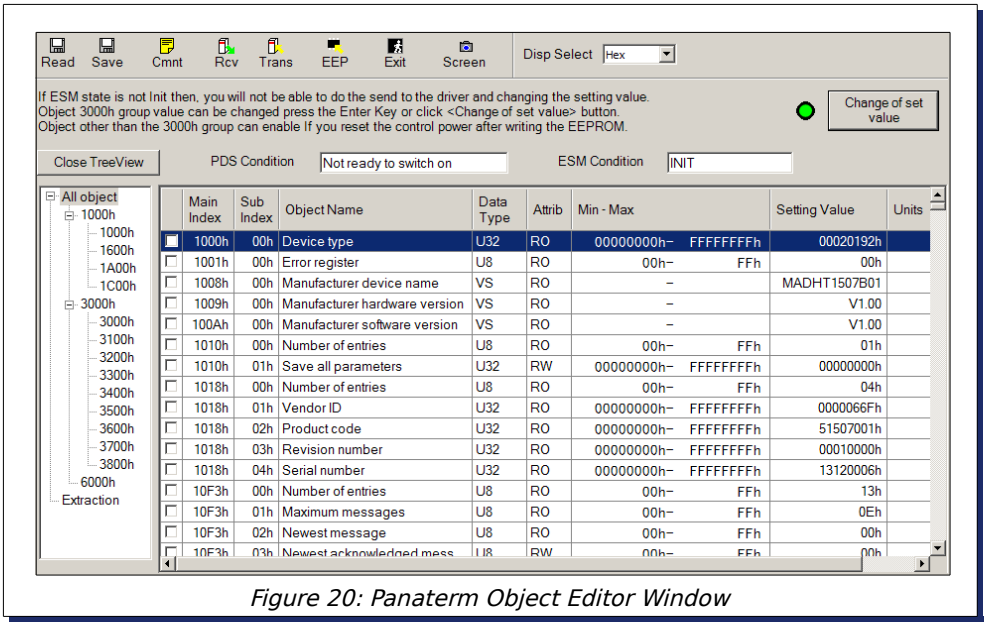


Figure 20: Panaterm Object Editor Window

5 Configuring I/O

Select the 'Display D' drop down menu in the main toolbar, and click 'Pin Assign R'. This will bring up the 'Pin Assign' window. Set the values for the pins listed under 'Input' as shown in Table 14. Pin outs for the various IO can be found in Section 7.1.10.

Pin Number	Position/Full-Closed Control	Velocity Control	Torque Control
07 (SI2)	SI-MON3_ConnectA	Invalid	Invalid
08 (SI3)	SI-MON4_ConnectA	Invalid	Invalid
10 (SI5)	SI-MON5_ConnectA	Invalid	Invalid
11 (SI6)	EXT2_ConnectA	EXT2_ConnectA	EXT2_ConnectA

Table 14: Panaterm Digital IO Settings

6 Saving Configuration to Memory

After setting all required parameters, transmit them to the drive by clicking the 'Trans' icon.

Write the parameters to the drive's non-volatile memory by clicking the 'EEP' icon. 

Power cycle the drive for the changes to take effect.

The drive is now configured to communicate with a Galil EtherCAT Master.

3.6 Copley Xenus Plus Servo Drive Series

This section will detail the process of both resetting and configuring a Copley Xenus Plus XEL-230-36 drive to operate with a Galil BLM-N23-50-1000-B 3-phase brushless motor, hereafter referred to as a Galil BLM.

3.6.1 Resetting the Drive to Factory Defaults

1 Install CME 2 and Connect to the Drive

Install the Copley CME 2 Software on a Windows machine and connect to the drive via the Copley Serial to RJ45 communications cable. If using Windows 7 or 8, Copley advises installing and running CME 2 as Administrator to allow access to COM ports.

In the main menu bar, navigate to Tools -> Communication Wizard to configure the Serial Communications Port. Once communications are correctly configured, the drive should be listed in the 'Copley Neighborhood' menu.

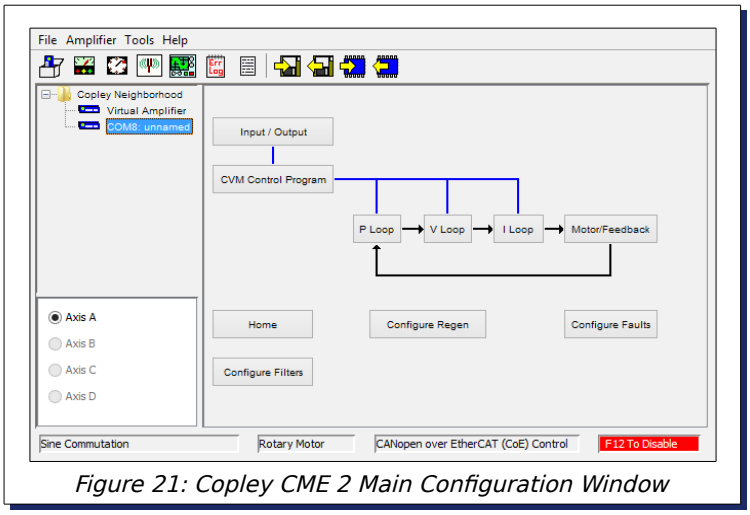


Figure 21: Copley CME 2 Main Configuration Window

2 Save Drive Default Values to File

Select the 'Virtual Amplifier' item in the 'Copley Neighborhood' window. Ignore prompts to save data before switching to the Virtual Amplifier and select 'Create new amplifier file' in the 'Open Virtual Amplifier' Window shown in Figure 22.

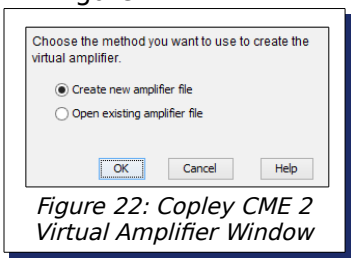


Figure 22: Copley CME 2 Virtual Amplifier Window

Select the 'XE2_XenusPlusEtherCAT.ccv' file and save it as 'XE2 Default Settings.ccx' click the 'Cancel' button in the 'Basic Setup Axis A' prompt that follows.

The drive's default configuration values have now been saved to an amplifier configuration file

that can be downloaded and saved to the amplifier.

3 Save Default Values to the Drive

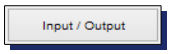
With the Drive selected in the 'Copley Neighborhood' menu, navigate to File -> Restore -> Amplifier Data. Select the 'XE2 Default Settings.ccx' file that was saved in step 2.

Now click the 'Save Working Memory to  Flash' icon.

Power cycle the drive for the changes to take effect.

3.6.2 Configuring the Copley Xenus Plus Drive for use with a Galil EtherCAT Master

1 Configure IO

In the Main Configuration Window, click on the 

Input/Output Button.

This will bring up the IO Configuration Window shown in Figure 23.

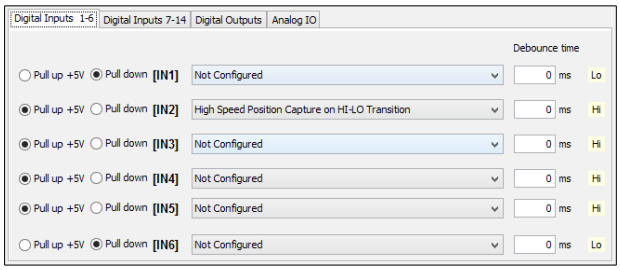


Figure 23: Copley CME 2 IO Configuration Window

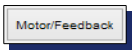
Values for Digital Inputs 1 - 6 are shown in Table 15.

Input	Polarity	Setting
[IN1]	Pull up	Not Configured
[IN2]	Pull up +5V	High Speed Position Capture on HI-LO Transition
[IN3]	Pull up +5V	Not Configured
[IN4]	Pull up +5V	Not Configured
[IN5]	Pull up +5V	Not Configured
[IN6]	Pull Down	Not Configured

Table 15: Copley CME 2 Digital Input Settings

Pin outs for the various IO can be found in Section 7.1.6.

2 Setup Motor Parameters for Galil BLM

In the Main Configuration Window, click on the 

Motor/Feedback Button.

This will bring up the Motor/Feedback Window.

When using the Galil BLM, enter the values pictured shown in Figure 24 . These values can also be found in the Appendix on page 60.

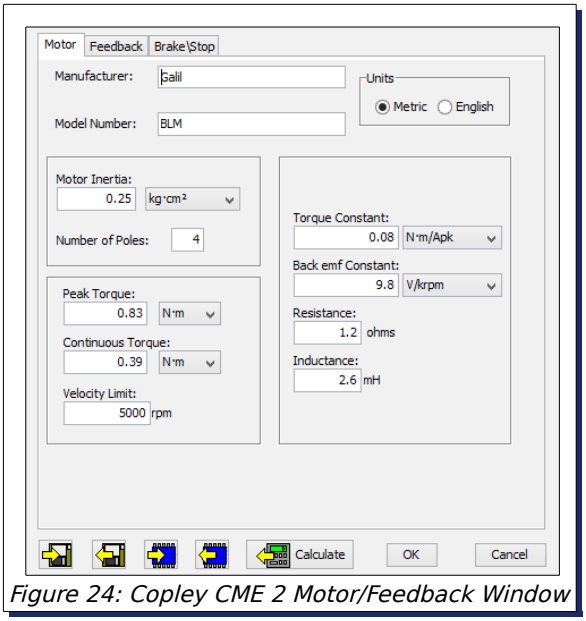
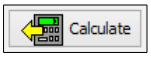


Figure 24: Copley CME 2 Motor/Feedback Window

Once these values have been entered, click the 

'Calculate' Button.

This will populate the amplifier's current loop values appropriate for the specified motor. Click OK to close the window and save the parameters to the drive's flash memory.

3 Calibrate Motor for Commutation

Click the Auto Phase Icon in the main  window toolbar.

Follow the instructions detailed by the pop up windows to set up the amplifier for sinusoidal commutation of the Galil BLM.

Warning	This procedure will apply power to the motor and cause it to rotate one revolution. Be sure that the motor is secured and uncoupled from any mechanics.

Click the 'Save Working Memory to  Flash' Icon.

Power cycle the drive for the changes to take effect.

The drive is now configured to communicate with a Galil EtherCAT Master.

3.7 Sanyo-Denki R Advanced Servo Drive

3.7.1 Resetting the Drive to Factory Defaults

1 Install R ADVANCED MODEL Setup Software and Connect to the Drive

Install the software R ADVANCED MODEL Setup Software on a Windows PC. Using the serial cable specified by Sanyo-Denki, connect the drive to the PC and launch the R ADVANCED MODEL application. When the application launches the 'Communications Setting' dialog box will appear, see Figure 25.

Check the 'Selection' box and choose the correct COM port and Baud Rate (38400 bps) then

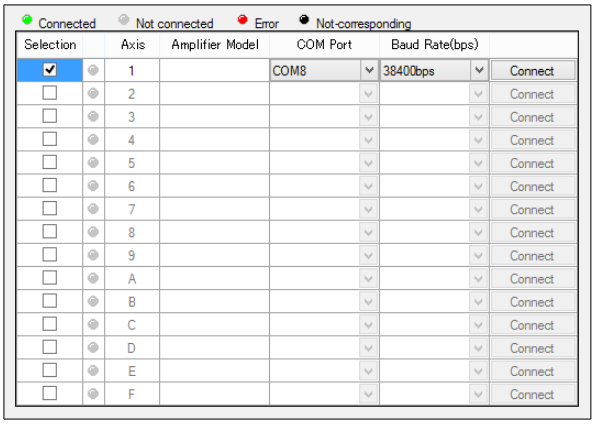


Figure 25: Sanyo-Denke R Advanced Software Connection Window

click 'Connect'.

2 Load Default Settings

Note	The non-volatile memory on the R Advanced Drive contains a section for parameter backup and restoration. However this section is not write protected. Therefore, Sanyo-Denke strongly recommends saving this initial configuration to a back up file on the PC before changing any parameters.

In the main menu bar, navigate to Parameter -> Parameter Transmission (To File)

In order to copy parameters from a file to the drive: In the main menu bar, navigate to Parameter -> Parameter Transmission (To Amplifier)

Use the 'Save to the Backup Memory' and 'Restore from the Backup Memory' menu items to write parameters to the drive's back up memory space or copy parameters from it.

3.7.2 Configuring the Sanyo-Denke R Advanced Drive for Use with a Galil EtherCAT Master

1 Connect to the drive and open the Parameter Editing Window

From the main menu bar, select Parameters -> Parameter Setting to bring up the editing window shown in Figure 26

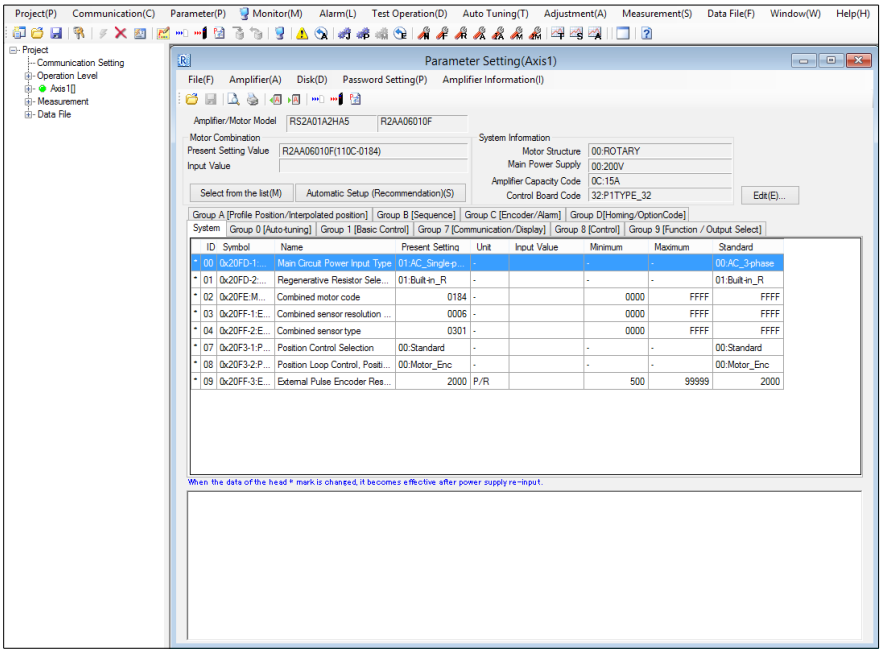


Figure 26: Sanyo-Denke R Advanced Software Parameter Editing Window

2 Set Motor Polarity

Select the Tab labeled 'Group 8 [Control]' and set the first object (Polarity)

3 Configure IO

Select the Tab labeled 'Group 9 [Function / Output Select]' and ensure that the functions listed in Table 16 are set to '00 Always Disabled'. Pin outs for the various IO can be found in Section 7.1.7.

Name	Input Value
Positive Limit Switch Function	00 Always Disabled
Negative Limit Switch Function	00 Always Disabled
Main Power Discharge Function	00 Always Disabled (this is required to support hardware latching)

Table 16: IO Settings for Sanyo-Denke R Advanced Drive

Click the 'Write in Amplifier' Icon to save the changes to the  drive's EEPROM.

Power cycle the drive for the changes to take effect.

The drive is now configured to communicate with a Galil EtherCAT Master.

3.8 Parker PD-10C Servo Drive Series

3.8.1 Resetting Drive to Factory Defaults

1 Install Drive Support Tool and USB Drivers

Install the most recent version of the Drive Support Tool software and install the recommended USB driver.

2 Connect to the Drive

a) Ensure that all motor and encoder wiring is complete as per the Drive's User Manual.

b) Install Parker's Drive Support Tool Software and USB drivers provided on the manufacturer's website.

c) Connect the drive to the PC via USB Cable and provide power to the drive.

d) Start the Drive Support Tool software, and configure communications as shown in Figure 27.

e) Click the  button to transition from 'Offline' to 'Online'.

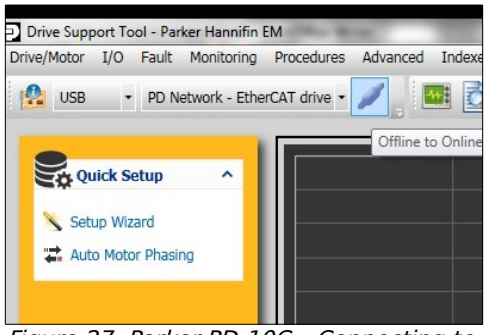


Figure 27: Parker PD-10C – Connecting to drive with Drive Support Tool

f) A 'Drive Information' Dialog box will appear shown in Figure 28. Close this window to continue.

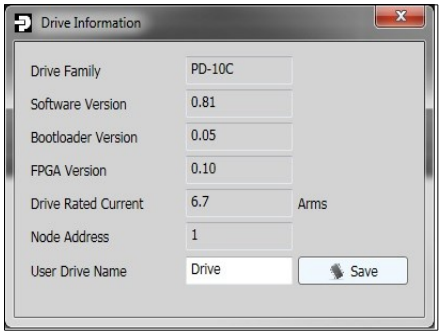


Figure 28: Parker PD-10C Drive Information Dialog Box

3 Load Default Settings

a) Select the ‘Setup’ Toolbar and select ‘Return to Factory Set’ as shown in Figure 29.

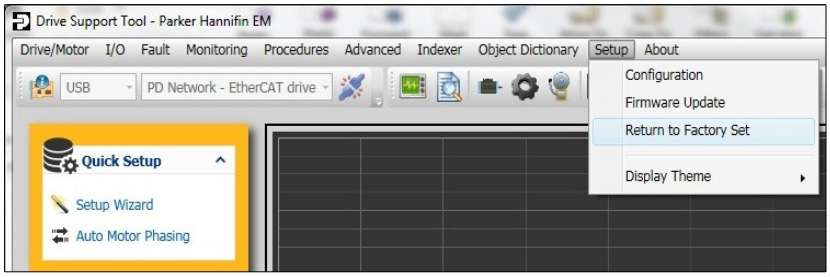


Figure 29: Parker PD-10C Return to Factory Set

b) A dialog box will appear asking to confirm reset of all parameters to factory setting, click ‘OK’. Once the drive has been reset, power cycle the drive and reconnect.

3.8.2 Configuring the Parker PD-10C EtherCAT drive for use with a Galil EtherCAT Master

1 Setup Wizard

a) Click on th Setup Wizard icon in Drive Support Tool. This will launch the Setup Wizard. Select 'On-line' for USB connection.

b) A dialog box will ask to read the parameters from the drive, click ‘Yes’. Once the Drive Information section has updated, click ‘Next’ to continue.

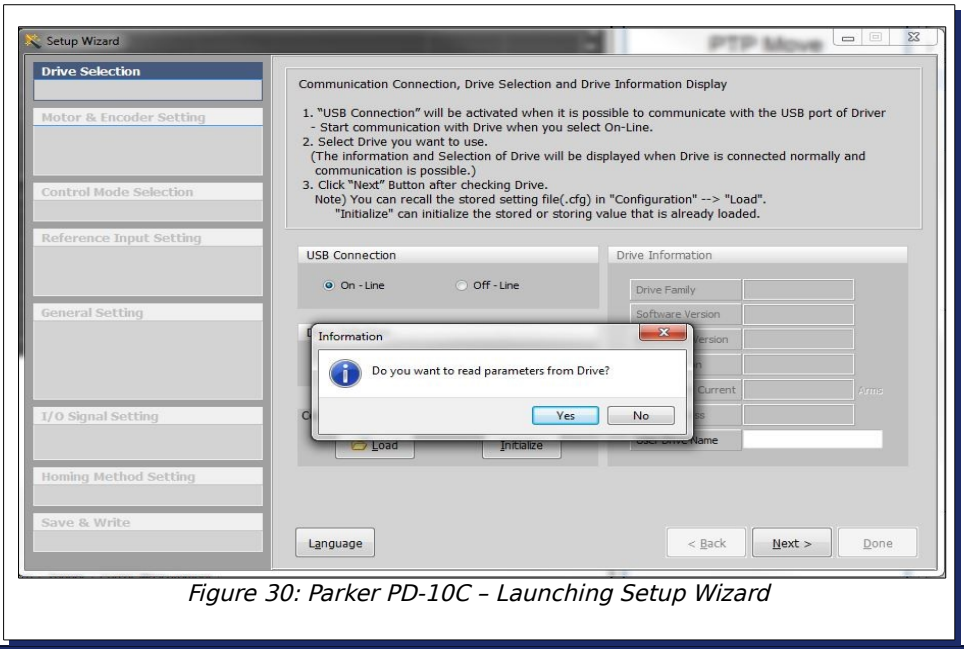
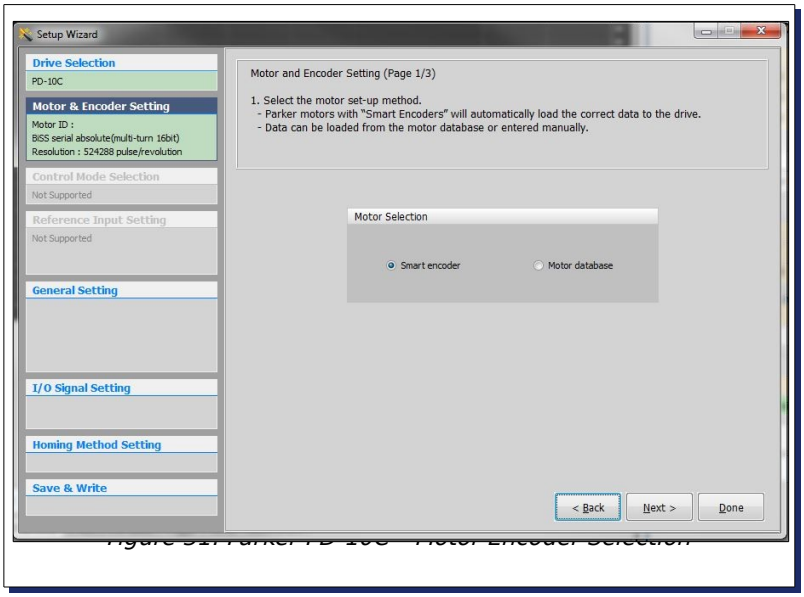
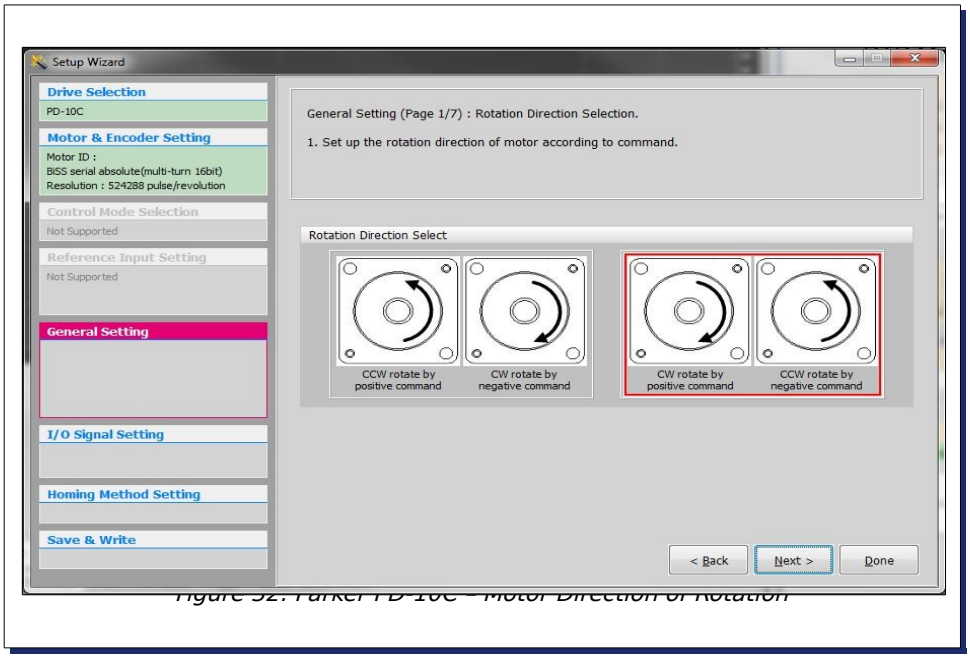


Figure 30: Parker PD-10C – Launching Setup Wizard

c) Motor & Encoder Setting (Page 1/3) – For the Motor Selection Page select ‘Smart Encoder’, and click ‘Next’.



d) For the ‘General Setting (Page 1/7) Rotation Direct Select’ page, select ‘CW rotate by positive command CCW rotate by negative command’ as shown in Figure 7. Click ‘Next’ to continue.



e) For the ‘General Setting (Page 2/7) Setup Electric Gear and Encoder Output’, leave the default setting of 1 for both the ‘Motor Revolutions’ and the ‘Shaft Revolutions’. Click ‘Next’ to continue.

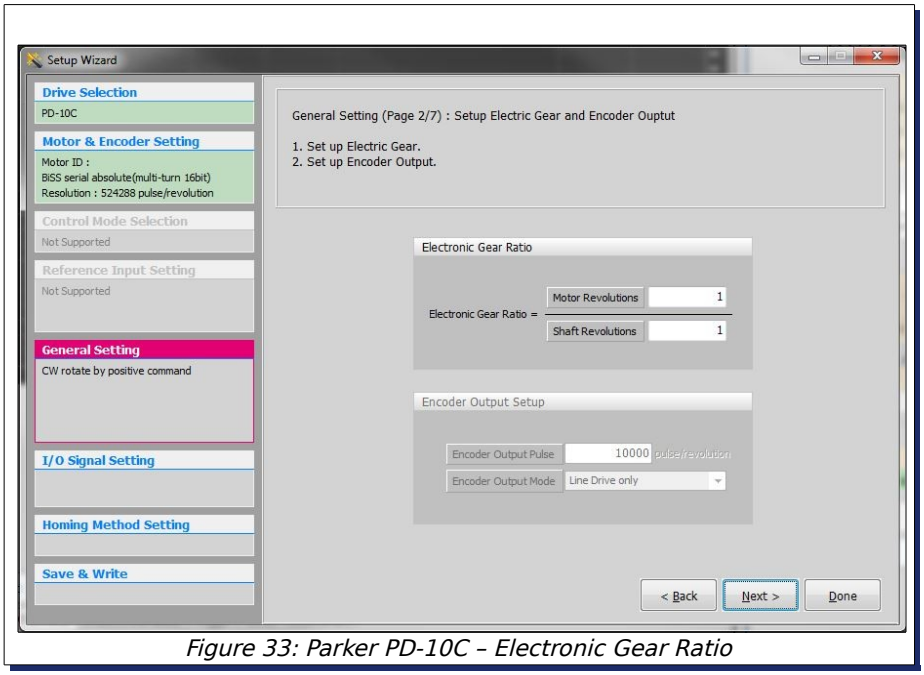


Figure 33: Parker PD-10C – Electronic Gear Ratio

$$\text{Encoder Resolution}\left(\frac{\text{Counts}}{\text{Revolution}}\right)=\frac{2^{19}}{\left(\frac{\text{Motor Revolutions}}{\text{Shaft Revolutions}}\right)}$$

Equation 2: Scaling Encoder Counts per Revolution

The Encoder counts per revolution reported to the EtherCAT Master can be scaled by changing the value of the Electronic Gear Ratio (Motor Revolutions/Shaft Revolutions) as shown in Equation 2 above.

f) For the ‘General Setting (Page 3/7) Set up Emergency Stop Method’, leave the default setting and click ‘Next’.

g) For the ‘General Setting (Page 4/7) Set up Dynamic Brake Control Mode’, leave the default setting and click ‘Next’.

h) For the ‘General Setting (Page 5/7) Set up Brake Output Signal Function’, leave the default settings and click ‘Next’.

i) For the ‘General Setting (Page 6/7) Set up Torque Limit Function’, leave the default value of ‘External Torque Limit’ selected and click ‘Next’.

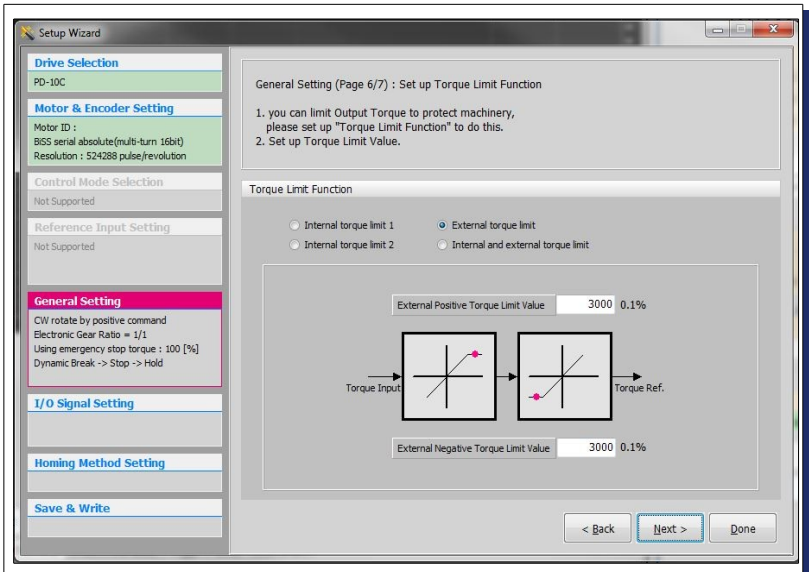


Figure 34: Parker PD-10C – Setting Torque Limit Function

j) For 'General Setting (Page 7/7) Set up signals related with control', leave the default values selected and click 'Next'.

k) For the Input/Output Setting, set all of the Digital Inputs as shown in Figure 10. Click 'Next' when values have been set. Pin outs for the various IO can be found in Section 7.1.9.

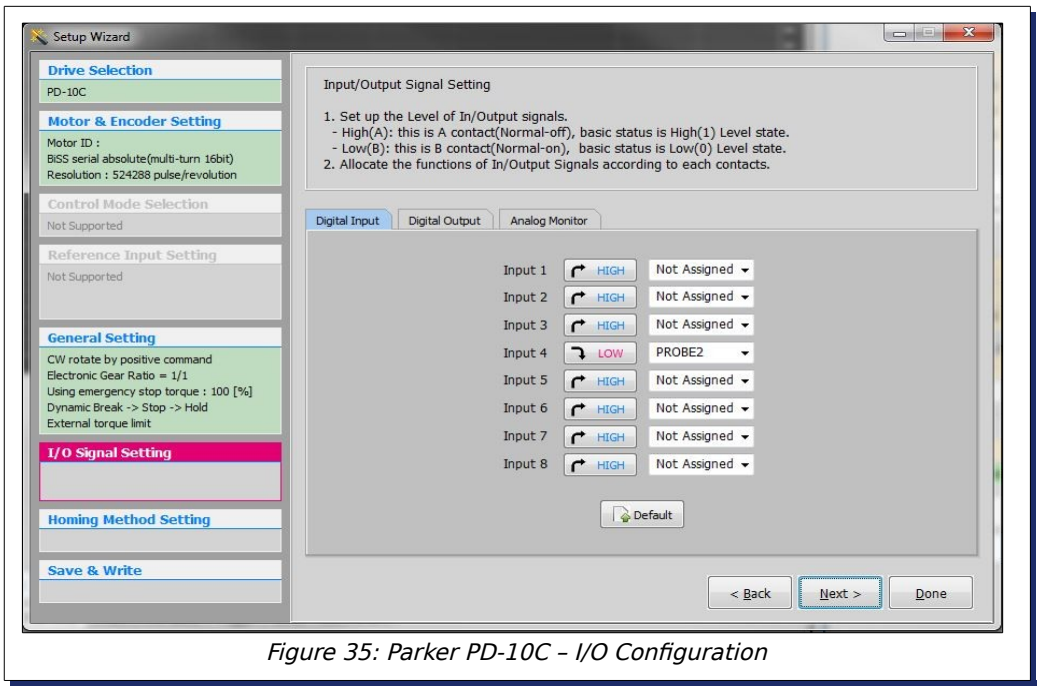


Figure 35: Parker PD-10C – I/O Configuration

l) For the 'Homing Method Setting', leave all of the default values and click 'Next'.

m) On the final page of the Setup Wizard, click on the ‘Write to Drive button’. When the settings have been written to the drive a dialog box will pop, and state “Software Reset or Power Re-cycle to apply changes”. Click ‘Ok’ to continue.

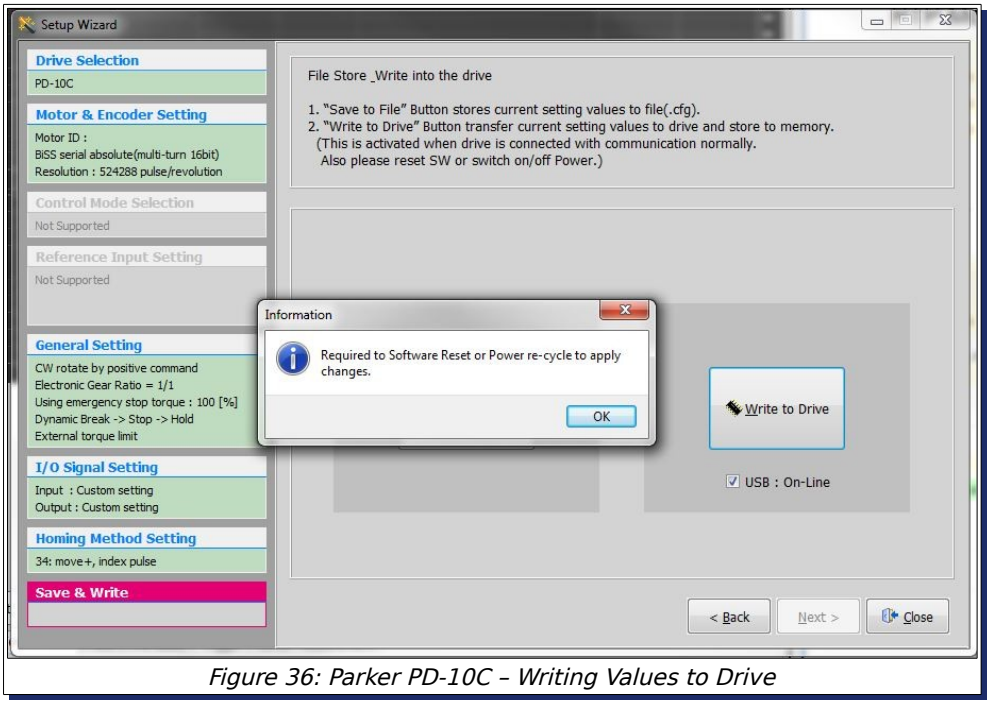


Figure 36: Parker PD-10C – Writing Values to Drive

n) Close the setup wizard, click ‘Yes’ when prompted to exit. Now click the 'Software Reset' button in the Drive Support Tool menu. Click ‘Yes’ when prompted to software reset the drive. During this process connection the drive will be lost. Once the drive’s LCD shows ‘-.66’ power cycle the drive.

The drive is now ready to use with a Galil EtherCAT Master.

If desired the settings can be confirmed by connecting to the drive with Drive Support Tool, and running through Setup Wizard again. The values in the Wizard should reflect the values that were set in this procedure.

Note	If the drive is enabled during a software reset, it will not reset. Confirm the drive LCD shows '-.66' prior to issuing a Software Reset.

3.9 Estun ProNet Servo Drive Series

The Estun ProNet Servo Drive provides two means of initialization, either through the ESView Software or the operator panel located on the front of the drive. This set up guide will detail configuration using ESView Software wherever possible.

This setup guide was written using Estun ESView Software v2.1. Estun provides a USB to RS422 adapter for communication with the Estun ProNet Series Drives.

3.9.1 Resetting the Drive to Factory Defaults

1 Install ESView Software and Connect to the Drive

2 Navigate to the main parameter editing window

Once connected to the drive, open the main parameter editing window, shown in Figure 37. From here, nearly all drive parameters can be set.

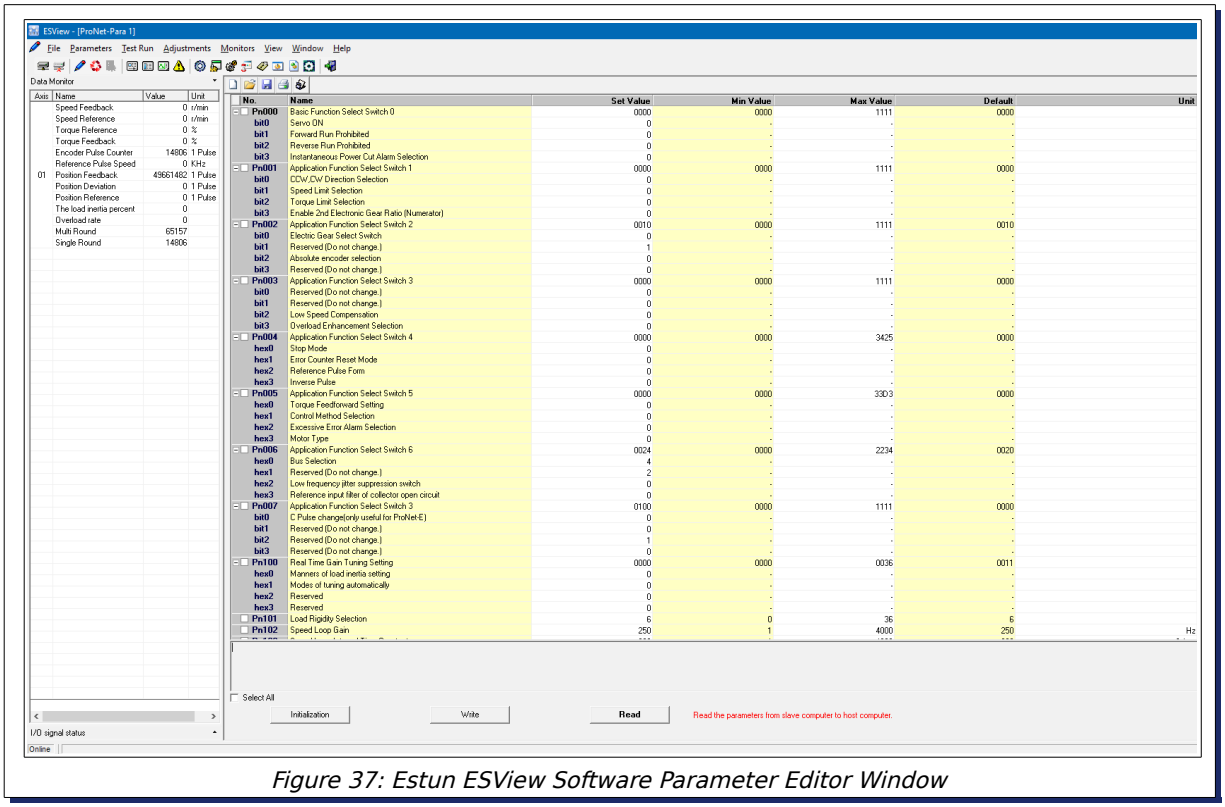


Figure 37: Estun ESView Software Parameter Editor Window

3 Click the 'Initialize' Button to reset all parameters to factory defaults.

Click 'OK' when prompted to overwrite all existing parameters and power cycle the drive for the changes to take effect.

3.9.2 Configuring the Estun ProNet Servo Drive for use with a Galil EtherCAT Master

1 Connect to the Drive using the ESView Software and open the Parameter Editor Window.

2 Set Drive Parameters

Enter the parameter values listed in Table 17.

Parameter	Value	Function
Pn000.01	1	Disables Forward Limit Switch Handling
Pn000.02	1	Disables Reverse Limit Switch Handling
Pn001.00	1	Sets Clockwise rotation as forward
Pn201	1	Encoder Scaling Numerator
Pn202	1	Encoder Scaling Denominator
Pn509.01	C | HmRef	Home Sensor Input
Pn509.02	2 | P-OT	Forward Limit Switch Input
Pn509.03	3 | N-OT	Reverse Limit Switch Input

Table 17: ESView Parameter Editor Window Values

The effective encoder resolution, the value which will be reported to the Galil via the EtherCAT Network, can be set via the Pn201 and Pn202 parameters and Equation 3. Pin outs for the

$$Encoder\ Counts/Revolution = \frac{Pn201}{Pn202} 2^{15}$$

Equation 3: Encoder Scaling Equation for the Estun ProNet Servo Drive

various IO can be found in Section 7.1.10.

3 Configure the Drive for EtherCAT Control

ESView v2.1 does not allow access to the drive parameter setting necessary for EtherCAT Operation. This parameter must be set via the operator panel located on the drive. Instructions on navigating the relevant menu options and setting parameters can be found in the Estun ProNet Drive Series User Manual.

In order to enable operation over EtherCAT, 'Bus Mode' Parameter must be set to the value listed in Table 18.

Parameter	Value	Function
Pn006.0	4	Enable EtherCAT Control

Table 18: Bus Mode Selection Parameter Value

Power cycle the drive for the changes to take effect.

The drive is now configured to communicate with a Galil EtherCAT Master.

4 Configuring EtherCAT IO

EtherCAT communication with IO hardware is simpler than communication with EtherCAT drives since profiling information is not required. As a result, configuring EtherCAT IO hardware is typically minimal.

4.1 Galil RIO-574x0 EtherCAT IO

For for a complete reference, refer to the RIO-574x0 manual.

4.1.1 Resetting a Galil RIO-574x0

The RIO-574x0 can be easily reset to factory conditions by performing a master reset. This procedure is detailed below:

1. Power down the RIO
2. Install a jumper on the MR jumper header
3. Power on the RIO
4. Wait for the red ERR LED to turn off
5. Power down the RIO and remove the MR jumper

4.1.2 Configuring a Galil RIO-574x0

The RIO-574x0 comes from the factory pre-configured to work with a Galil EtherCAT Master 'out of the box.' No further configuration is necessary. However, the RIO's analog input and output ranges can be configured using Galil Communication Software.

4.2 VIPA EtherCAT IO

Currently the VIPA IO Unit will operate with a Galil EtherCAT Master with no configuration necessary. Galil includes support for specific Digital Inputs/Outputs and Analog Inputs only, see Table 19 . The analog inputs are non configurable.

Part #	Description
VIPA 053-1EC00	EtherCAT Communication Module
VIPA 021-1BF00	8 x 24V DC Digital Inputs
VIPA 022-1HB10	2 x 3A Digital Outputs
VIPA 031-1BB70	2 x +/-10V Analog Inputs

Table 19: Supported VIPA IO components

Note	The VIPA IO Module does not include support for Distributed Clock and therefore can not be the first node in an EtherCAT network.

5 Features and Limitations

5.1 General

5.1.1 Position Feedback

Upon boot-up, the EtherCAT Master assumes a position of zero on all axes. When an EtherCAT axis is initialized with the EX and EU commands, the position feedback read in from the EtherCAT drive will replace any value currently held by the local main encoder inputs (TP). In addition, the reference position (RP) will mirror the change in TP to prevent any position error (TE) during initialization. After initialization, any commands used to query the position of the motor will report back the EtherCAT drive position data. After an EU0 is issued to turn off the EtherCAT network, the RP and TP values will both be zero.

The CN command will configure logic polarity for local and EtherCAT axes limit switches and hardware latch, active high or active low. However the command does not change the drive's actual limit switch logic. This must be done per the manufacturer's instructions. In addition, the CN command will configure the initial movement direction when the HM command is issued. See the User Manuals and Command References for details on the use of the CN and HM commands.

5.1.2 Limit Switches

After EtherCAT axes have been activated with the EX and EU commands, the EtherCAT Master will report back with the status of the remote EtherCAT drive's forward and reverse limit switch inputs. The status of these inputs can be queried using _LFm,_LRm, TS, and the data record where m is the EtherCAT axis of interest.

The #LIMSWI automatic subroutine and the OE command will both function based on the status of EtherCAT axes limits and position error.

5.1.3 Homing Routines

Homing can be customized using the HM and FI commands. After EtherCAT axes have been activated with the EX and EU commands, the EtherCAT Master will report back the status of the remote EtherCAT drive's home input. The status of the home inputs can be queried using _HMm, TS and the data record where m is the axis of interest.

5.1.4 Configuration Commands

CE configures the local auxiliary encoder on an EtherCAT axis [1].

5.1.5 Non Supported Commands and Error Routines

The following commands are not available for use with an EtherCAT axis and will generate an error. TC1 will return "186 Not available on EtherCAT"

AG, AU, BA, BB, BC, BO, BQ, BS, BX, BZ, OC, QH

The TA command and the #AMPERR routine will only run due to local DMC internal amplifier errors[1]. To monitor the status of an EtherCAT drive, the user should use the EU and EZ commands and the #ECATERR automatic subroutine.

[1] Applies only to the DMC-500x0

5.2 Drive Limitations

5.2.1 Support for Cyclic Synchronous Torque Mode[1]

Cyclic Synchronous Torque Mode is only supported on the DMC-500x0 with Yaskawa Sigma 5 and AMC-DZEANTU Drives.

5.2.2 Delta ASD-A2

The Delta ASD-A2 does not include support for the hardware latch. Issuing the AL command will throw error 190, 'Feature not supported by drive.'

5.2.3 Estun ProNet

Hardware latch and latch on index are not supported on this drive. Issuing the AL, ALT,FI or HM commands will throw error 190, 'Feature not supported by drive.'

5.2.4 Sanyo-Denki

Hardware latch is not supported on this drive. Issuing the ALm command will throw error 190, 'Not valid with this motor type.'

5.2.5 Yaskawa Sigma 5

As of EtherCAT Communication Module firmware revision 0006, drive DAC resolution requires scaling encoder resolution when in Cyclic Synchronous Torque mode. [1]

[1] Applies only to the DMC-500x0

6 DMC Quick Start Guide

Below are a few examples demonstrating the commands necessary to bring up an EtherCAT network and handle possible EtherCAT errors. For more detail on a particular command please see the DMC-500x0 and DMC-52000 Command References. To disable a previously enabled EtherCAT axis[1], issue an `MTm=0` for axes E-H, and `MTm=1` axes A-D, where `m` is the axis to be disabled.

6.1 Example 1: Single Axis Position Relative Move

This example demonstrates how to map one axis to an EtherCAT slave and perform a relative move.

```
#setup
MO ;    'turn off all motors
MT 10 ; 'set A axis for position mode
EX -1 ; 'set first ECAT drive as A axis
EU 1 ;  'bring up ECAT network
SH A ;  'servo motor

#move
SP 10000 ;  'set speed
AC 100000 ; 'set acceleration
DC 100000 ; 'set deceleration
PR 10000 ;  'position relative move
BG A ;      'begin motion on A axis
AM A ;      'after A axis move
EN ;        'end program
```

6.2 Example 2: Four Axes and single IO EtherCAT Network Setup

This example expands upon Example 1 and demonstrates how to setup a 4 axis controller with all 4 axes mapped to EtherCAT slaves. In addition, a single IO Module will also be added to the Network using the `IO` command. With the `MT` command set to a value of 10 axes A, B, C, and D will run in position mode.

```
#setup
MO ; ' turn all motors off
'set axes A,B,C,and D for position mode
MT 10,10,10,10

'Map ECAT drives to local axes using wire position (negative numbers)
'and station ID (positive numbers). $ designates a hex number
EX -1,$5,$C1,-4

'Map IO Module to first IO position using line position
IO -5

EU 1<6000 ; 'bring up the ECAT network with a 6,000 ms timeout
SH ; 'servo all axes

#move
SP*= 10000 ; 'set speed for all axes
AC*= 100000 ; 'set acceleration for all axes
```

```
DC*= 100000 ; 'set deceleration for all axes
PR*= 10000 ; 'position relative move for all axes
BG ; 'begin motion on all axes
AM ; 'after move
'Query first Analog Input on IO Module
MG @AN[11001]
EN ; 'end program
```

[1] Applies only to the DMC-500x0

6.3 Example 3: EtherCAT Error Handling

This example demonstrates use of the #ECATERR automatic subroutine which will run if there is an error reported by any EtherCAT drive on the network. The EZ command will print the error to the user in a table which will contain all the drive error information. See Appendix 7.2.2 for more detail on the EZ command.

```
'Galil DMC Code Example
' assumes that the AMC drive is on the A axis and in
'position 1 and the Yaskawa drive is on the B axis and in position 2
#setup
ST
AM
MO
EU 0
MT 10,10
EX -1,-2
EU 1

#move
SH AB
JG 1000,2000
BG AB
EN

#ECATERR
EZ 0;' query drive faults
JS #amcerr, (_EU1 & $0001)
JS #yaserr, (_EU1 & $0002)
EU 0;'turn off EtherCAT network
RE;'Exit routine and return to main code execution

'Subroutine to handle an AMC drive Hall Error on the A axis.
#amcerr
IF (_EZA2 = 4);' check for specific AMC hall error
  MG "Hall Error on A Axis AMC Drive"
ENDIF
EN

#yaserr
IF (_EZB0 = $0C90);' check for specific Yaskawa error
  MG "Encoder Error on B Axis Yaskawa Drive"
ENDIF
EN
```

7 Appendices

7.1 I/O Pin Outs

7.1.1 AMC-DZE P7 I/O Connector

Name	Pin #	Galil Function	Description
PDI-1	3	Forward Limit Input	Indicates when the forward travel limit sensor has been activated
PDI-2	5	Reverse Limit Input	Indicates when the forward travel limit sensor has been activated
PDI-3	7	Home Sensor Input	Indicates when the Home Sensor has been activated
PDI-4+	4	Index input +	High speed differential input +
PDI-4-	6	Index input -	High speed differential input -
PDI-5+	8	Latch input +	High speed differential input +
PDI-5-	10	Latch input -	High speed differential input -
+5V OUT	14	+5V	Logic power supply
GND	16	GND	Logic ground

7.1.2 Yaskawa Sigma 5 and Sigma 7 CN1 I/O Connector

Name	Pin #	Galil Function	Description
P-OT	CN1-7	Forward Limit Input	Indicates when the forward travel limit sensor has been activated
N-OT	CN1-8	Reverse Limit Input	Indicates when the forward travel limit sensor has been activated
/Home {/S16}	CN1-12	Home Sensor Input	Indicates when the Home Sensor has been activated
/Probe2 {/SI5}	CN1-11	External Latch input	Hardware latch trigger
+24VIN	CN1-6	N/A	Digital input optoisolation common

7.1.3 LS Mecapion Pegasus CN1 I/O Connector

Name	Pin #	Galil Function	Description
DI1	2	Forward Limit Input	Indicates when the forward travel limit sensor has been activated
DI2	3	Reverse Limit Input	Indicates when the forward travel limit sensor has been activated
DI3	4	Home Sensor Input	Indicates when the Home Sensor has been activated
PROBE2	5	External Latch input	Hardware latch trigger
+24 VDC	1	N/A	Digital input optoisolation common

7.1.4 LS Mecapion L7NHA CN1 I/O Connector

Name	Pin #	Galil Function	Description
DI1	11	Forward Limit Input	Indicates when the forward travel limit sensor has been activated
DI2	12	Reverse Limit Input	Indicates when the forward travel limit sensor has been activated
DI3	7	Home Sensor Input	Indicates when the Home Sensor has been activated
DI4	8	External Latch input	Hardware latch trigger
+24 VDC	6	N/A	Digital input optoisolation common

7.1.5 Panasonic X4 I/O Connector

Name	Pin #	Galil Function	Description
SI-MON2	7	Forward Limit Input	Indicates when the forward travel limit sensor has been activated
SI-MON3	8	Reverse Limit Input	Indicates when the forward travel limit sensor has been activated
SI5	10	Home Sensor Input	Indicates when the Home Sensor has been activated
SI6	11	External Latch input	Hardware latch trigger
I-COM (+24 VDC)	6	N/A	Digital input optoisolation common

7.1.6 Copley Xenus Plus J8 I/O Connector

Name	Pin #	Galil Function	Description
IN3	6	Forward Limit Input	Indicates when the forward travel limit sensor has been activated
IN4	7	Reverse Limit Input	Indicates when the forward travel limit sensor has been activated
IN5	8	Home Sensor Input	Indicates when the Home Sensor has been activated
IN2	5	External latch Input	Hardware latch trigger

7.1.7 Sanyo-Denki R Advanced CN3 I/O Connector

Name	Pin #	Galil Function	Description
CONT1	5,6	Forward Limit	Indicates when forward limit switch has been activated
CONT2	7,8	Reverse Limit	Indicates when reverse limit switch has been activated

7.1.8 Delta ASD-A2 CN1 I/O Connector

Name	Pin #	Galil Function	Description
DI 6	12	Forward Limit Input	Indicates when the forward travel limit sensor has been activated
DI 5	11	Reverse Limit Input	Indicates when the forward travel limit sensor has been activated
DI 4	10	Home Sensor Input	Indicates when the Home Sensor has been activated
COM	14	N/A	Digital Input GND

7.1.9 Parker PD-10C – I/O Connector

Name	Pin #	Galil Function	Description
DI 1	11	Forward Limit Input	Indicates when the forward travel limit sensor has been activated
DI 2	12	Reverse Limit Input	Indicates when the forward travel limit sensor has been activated
DI 3	7	Home Sensor Input	Indicates when the Home Sensor has been activated
DI 4	8	External Latch Input	Hardware Latch Trigger
+24 VDC	6	N/A	Digital Input Optoisolation Common

7.1.10 Estun Pronet CN1 IO Connector

Name	Pin #	Galil Function	Description
P-OT	17	Forward Limit Input	Indicates when the forward travel limit sensor has been activated
N-OT	18	Reverse Limit Input	Indicates when the forward travel limit sensor has been activated
HmRef	16	Home Sensor Input	Indicates when the Home Sensor has been activated
DICOM (+24V)	20	N/A	Digital Input Optoisolation Common

7.2 Error Handling

Galil EtherCAT Masters include support for drive specific status and error codes. Below are tables containing return values to the EZ command for all supported drives. The _EU1 operand contains a bitmask that corresponds to the error status of each drive on the network.

There are two types of recoverable drive errors. Some errors require that the EtherCAT network be reinitialized (EU0 then EU1) and others require a motor off command (MO). An example of this is a hall error on the AMC-DZE drive which can be simulated by unplugging the encoder while the drive is servoed. #ECATERR will run when a drive reports a fault. Encoder faults are recoverable on the AMC-DZE drive and in this case it can be brought back to the servoed state by clearing the error (reconnecting the encoder), issuing EKm, MOm and then SHm where m is the axis of interest. Consult the drive manufacturer's documentation for recoverable faults.

Please note that some drives take longer to initialize. If a '181- EtherCAT Timeout error' occurs after issuing EU 1, increase the timeout value using the '<' operand. For example, issuing EU1<5500 will allow the EtherCAT network 5500 ms to initialize before timing out. See the DMC-500x0 and DMC-52xx0 Command References for details.

7.2.1 _EU1 Operand

The _EU1 operand stores a bit mask containing the current EtherCAT error state, as shown in Table 20. Note that _EU1 is 0 when no EtherCAT error is detected by the controller for any given axis. There are three types of faults that cause a change in _EU1: A drive fault, an EtherCAT slave not responding or a dropped EtherCAT packet. The _EU1 operand will indicate when a drive on a given EtherCAT axis is faulted. For example, if MG _EU1 prints out the decimal value 36 to the terminal or host, the equivalent binary value is 0000 0000 0010 0100, indicating that a fault has occurred on both the C and F axes. An error code is a numerical value that contains information about the type of fault that occurred on a drive. Error codes are drive specific but may include under voltage, over current and over temperature among other conditions. These more specific values can be queried with the EZ command.

_EU1 Bit	Cause
0	Fault on axis A
1	Fault on axis B
2	Fault on axis C
3	Fault on axis D
4	Fault on axis E
5	Fault on axis F
6	Fault on axis G
7	Fault on axis H
8-14	Reserved
15	EtherCAT network error

Table 20: _EU1 operand status bits

7.2.2 EK - Clear EtherCAT Error

When an EtherCAT error occurs, The _EU1 operand is populated with the drive fault status bit

mask for all axes. After resolving the issue that caused the fault(s), EK _EU1 can be issued to clear all drive's error status bits. Note that some drives require that the EtherCAT Network be reinitialized or a that the drive be power cycled in order to clear error conditions. Consult the drive documentation for specifics.

7.2.3 EZ - EtherCAT Errors

Drive specific error codes can be interrogated using the EZ command and _EZmn operand, where m is the axis of interest. When the EZ command is issued, the _EZmn operands are assigned the error code value and can be interrogated from the terminal or host PC.

When EZ 1 is issued, the controller will return a list of the drives that have reported errors along with their corresponding error codes in the format shown in Table 21. Each field of the _EZm operand contains a 2 byte number that reflects the error reported. Not all fields are used by all vendors. Consult the drive's user manual for more information on error codes, their location and their meaning.

Axis [m]	Vendor	EZm0	EZm1	EZm2	EZm3	EZm4	EZm5	EZm6	EZm7	Error
A	Delta	$7305	$0000	$0000	$0000	$0000	$0000	$0000	$0000	Encoder Data Error
C	Mecapion	$0028	$0000	$0000	$0000	$0000	$0000	$0000	$0000	Under Voltage

Table 21: EZ return values for Delta and LS Mecapion Drives

7.2.4 #ECATERR - EtherCAT Error Automatic Subroutine

#ECATERR is an automatic subroutine that interrupts thread zero and executes when there is an EtherCAT error. EtherCAT Errors are defined as either alarms raised on individual drives or network wide. For instance a severed CAT5 cable would raise trigger the #ECATERR routine.

This allows the user to create an automated custom response under fault conditions. The #ECATERR subroutine can be used to alert a user or system to EtherCAT drive faults and take appropriate actions. See section Example 3: EtherCAT Error Handling in Chapter 6 for sample DMC code illustrating uses of the #ECATERR subroutine.

7.2.5 Drive Specific Error Codes

This section lists some of the drive error codes for each drive compatible with Galil EtherCAT Masters. Consult the drive's documentation for a full list of error codes and descriptions.

1 AMC

AMC-DZE drive responses to the EZ command are bit masks that must be interpreted according to the drive documentation. For example if the _EZA2 operand contains the number 4, the equivalent binary value is 0000 0000 0000 0100 indicating that there is an invalid hall state on the A axis. See Table 22 for a short list of AMC drive error codes.

Operand	Bit	Error Description
_EZm1	4	Under Voltage
_EZm1	3	Over Current
_EZm3	14	Shunt Regulator
_EZm2	6	Feedback Sensor Error

Table 22: Example AMC DZE Drive Error Codes

2 Yaskawa

Some example Yaskawa ΣV/ΣVII drive responses to the EZ command are shown in Table 23 . The "A" in the error code is not included in the returned value, only the hexadecimal number following it. These codes are also shown on the Yaskawa ΣV drive's 7 segment LED display.

Value	Error Description
0x410	Under Voltage
0x840	Encoder Data Error
0xCA0	Encoder Parameter Error
0x300	Regeneration Error

Table 23: Example Yaskawa ΣV Drive Error Codes

3 Panasonic

The Panasonic MINAS-A5BA4 reports only the main alarm number as a hexadecimal. The lower 8 bits of the value (FF00h to FFFFh) indicate the main alarm number as listed in Table 24

Value	Error Description
12.0	Over voltage protection
16.0	Over-load protection
21.1	Encoder communication error
27.7	Position information initialization error

Table 24: Example Panasonic MINAS A5B Error Codes

4 Copley

The Copley Xenus Plus Model XEL-230-36 reports errors to a 32-bit object that is a bit-mapped status register with the fields defined in Table 25.

Bit	Error Description
0	Short Circuit Detected
4	Motor Temp. Sensor Active
21	Position has wrapped
29	Motor phase not yet initialized

Table 25: Example Copley Xenus Plus Error Codes

5 Sanyo-Denke

The Sanyo-Denki RS2A01A0KA4 drive displays errors, referred to as 'Alarms' with hexadecimal values. Some values for these alarms are shown below in Table 26

Value	Error Description
0x52	RS Overheat
0x22	Current Detection Error 0
0x62	Main Circuit Under Voltage
0x81	Encoder 1 Disconnected

Table 26: Example Sanyo-Denke R Advanced Error Codes

6 LS Mecapion

Example Pegasus and L7NHA error codes are listed below in Table 27. These codes are also displayed on the drive's 4 digit LED display as 'Alarms'.

Value	Error Description
14	Over Current
23	Regeneration Overload
30	Encoder Cable Error
40	Under Voltage

Table 27: Example LS Mecapion Error Codes

7 Delta

Delta Error Codes are listed in Table 28. These codes are also displayed on the drive's 4 digit LED display.

Value	Error Description
2310	Over Current
7122	Motor Error
7305	Encoder Data Error
3300	U,V,W wiring error

Table 28: Example Delta Electronics Drive Error Codes

8 Parker

Parker PD-10C Error Codes are listed in Table 29. These codes are also displayed on the drive's 4 digit LED display.

Value	Error Description
14	Over Current
24	Motor Error
32	Encoder Data Error
40	Under Voltage

Table 29: Example Parker Drive Error Codes

9 Estun

Estun Pronet Error Codes are listed in Table 30. These codes are also displayed on the drive's 4 digit LED display.

Value	Error Description
04	Torque Limit Exceeded
12	Over Current
14	Under Voltage
16	Regenerative Error

Table 30: Example Estun Pronet Drive Series Error Codes

7.3 EtherCAT Glossary

Term	Definition
Clockwise	Defined as the direction of rotation as seen when facing the "front" of the motor.
Counter Clockwise	Defined as the direction of rotation as seen when facing the "front" of the motor.
Cyclic Position Mode	Set with the MT 10 command. Configures the Galil EtherCAT Master to output motion profiling data. Servo loop PID tuning is left to the external drive.
Cyclic Torque Mode	Set with with the MT 11 command, closes the servo loop on the DMC-500x0 EtherCAT Master.
Drive Fault	A condition that causes a drive to cease functioning as expected on the EtherCAT network.
EtherCAT	Communication protocol allowing communication between an EtherCAT Master and external servo drives over CAT5 Ethernet cables.
EtherCAT "Up"	Configure and initialize an EtherCAT network using the EX and EU commands. Refer to the command reference for details.
EtherCAT "Down"	Disable a configured and initialized EtherCAT network using the EU command.
EtherCAT Axis	An axis that has been selected for use with an EtherCAT drive and is initialized with the EX and EU commands. Refer to the command reference for details.
EtherCAT Drives	Used interchangeably with **EtherCAT slaves**.
EtherCAT Master	A motion controller that is configured to communicate with and control a network of EtherCAT enabled drives. An EtherCAT Network can include only one EtherCAT Master.
EtherCAT Slave	An EtherCAT drive that is on the same EtherCAT network as the Galil EtherCAT Master. This drive may or may not be exchanged for a local axis. Used interchangeably with **EtherCAT drives**.
Galil BLM	Galil 3 phase brushless motor part # BLM-N23-50-1000-B. "Free spinning" refers to a motor that is not attached to any external mechanics.
Initialization	The process of assigning a local axis to an EtherCAT station and initializing the EtherCAT Network with the EX and EU commands. Refer to the command reference for details.
Local Axis	An axis that has not been assigned or initialized for use with EtherCAT axis. This axis will function as described in the DMC-500x0 and DMC-52xx0 User Manuals.
Position	Each EtherCAT station has a physical position within the daisy chain. This position can be queried using the EH command. The EX command uses the Station ID to assign and EtherCAT axis. Refer to the command reference for details.

Station ID	Each EtherCAT station needs a unique address on the EtherCAT network, this address is called the Station ID. Most EtherCAT axes are assigned a Station ID using rotary or other physical switches present on the drive. The EX command uses the Station ID to assign an EtherCAT station to a local axis. Refer to the command reference for details.

Table 31: Definition of Terms used in this Setup Guide

7.4 Galil BLM-N23-1000-B Specifications

Specification	Units	Value
K_T - Torque Constant	N•m/A oz•in/A	0.08 12.1
T_P - Peak Torque	N•m oz•in	0.83 120
T_C - Continuous Torque	N•m oz•in	0.39 55
Continuous Current	A	4.9
Peak Current	A	10.4
J_m - Moment of Inertia	$kg•m^2$ $oz•in•s^2$	2.5 x 10 -5 3.5 x 10 -3
Maximum speed	rpm	5000
Resistance	Ω	1.2
Inductance	mH	2.6
K_V Motor Constant	V/krpm	29
Encoder Resolution	counts/rev	4000

Table 32: Galil BLM Motor Specifications

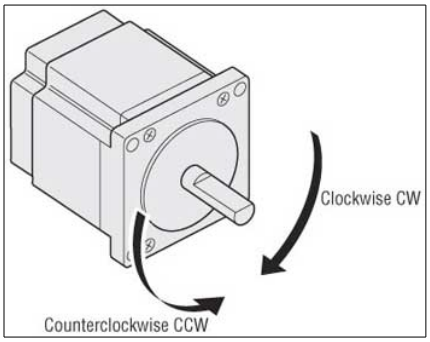


Figure 38: Motor Rotation Reference