CDHD2 Servo Drive

User Manual

ORIGINAL DOCUMENT
Revision: 2.5
Firmware Version 2.38.x

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Revision History

Doc. Rev.	Date	Remarks
2.6	Feb.2022	Updated compliance declaration: 2011/65/EU RoHS EN 50581 and Directive (EU) 2015/863, 1907/2006 REACH
2.5	Jan. 2022	Firmware 2.38.x. No content changes.
2.4	Oct. 2021	TUV updates: (2.4) updated standards references years; (10.3) added safety parameter.
2.3	July 2019	Firmware 2.15.x. Updates and corrections.
2.2	Feb. 2019	Firmware 2.15.x. Updates and corrections.
2.1	Oct. 2018	Firmware 2.15.x. Updates and corrections.
2.0	June 2018	Firmware 2.15.x. Updates and new content for CDHD2-33A-44A-55A models
1.1	4 Mar. 2018	Firmware 2.15.x.
1.0	Dec. 2017	CDHD2 – General Release. Firmware 2.15.x
0.1	1 June 2017	CDHD2 – Preliminary. Internal use only.

Copyright Notice

Disclaimer

This product documentation was accurate and reliable at the time of its release. Servotronix Motion Control Ltd. reserves the right to change the specifications of the product described in this manual without notice at any time.

Trademarks

ServoStudio 2 and sensAR are trademarks of Servotronix Motion Control Ltd.
CANopen and CiA are registered trademarks of the CAN in Automation User's Group
EtherCAT is a registered trademark of Beckhoff Automation GmbH
EnDat is a registered trademark of Dr. Johannes Heidenhain GmbH
HIPERFACE is a registered trademark of Sick Stegmann GmbH
BiSS-C is a registered trademark of iC-Haus GmbH
Windows is a registered trademark of Microsoft Corporation

Contact Information

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Israel
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Fax: +972 (3) 922 8075
Website: www.servotronix.com

Technical Support

If you need assistance with the installation and configuration of the CDHD2 drive, contact Servotronix Technical Support: tech.support@servotronix.com

Customer Service

Servotronix is committed to delivering quality customer service and support for all our products. Our goal is to provide our customers with the information and resources so that they are available, without delay, if and when they are needed. In order to serve in the most effective way, we recommend that you contact your local sales representative for order status and delivery information, product information and literature, and application and field technical assistance. If you are unable to contact your local sales representative for any reason, please use the most relevant of the contact details below:

For product support, contact: tech.support@servotronix.com

To order products, contact: orders@servotronix.com

For all other inquiries regarding CDHD2 drives or other Servotronix products, contact: customer.service@servotronix.com

Warranty

The Product Warranty statement can be found in the Terms and Conditions document on the Servotronix website: servotronix.com/terms-conditions

Unpacking

The package contains the CDHD2 drive only.

Upon receipt, open the package and remove all packing materials.

Check to ensure there is no visible damage to the CDHD2 drive. If damage is detected, notify the carrier immediately.

Contents

1. Introduction

1.1 CDHD2 Product Overview

CDHD2 is a high-performance servo drive based on innovative technologies and advanced control algorithms. It is the second generation of this servo drive series, and features many enhancements and improved capabilities.

Refer to the *Ordering Information* for the various options for the CDHD2 drive.

CDHD2 drives that use a medium voltage power supply (120–240 VAC) are referred to as **MV** models, and drives that use a low voltage power supply (20–90 VDC) are referred to as **LV** models.

CDHD2-33	CDHD2-020	CDHD2-008	CDHD2-4D5	CDHD2-1D5
CDHD2-44	CDHD2-024	CDHD2-010	CDHD2-006	CDHD2-003
CDHD2-55		CDHD2-013		

Figure 1-1. CDHD2 – 120-240 VAC (MV) Models

Figure 1-2. CDHD2 – 20–90 VDC (LV) Models

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1.2 CDHD2 Models

The various models in the CDHD2 servo drive series are differentiated by means of the communication methods and protocols they use. The following table presents the different models and their distinguishing characteristics.

Table 1-1. CDHD2 Models - Communication and Protocols

CDHD2 Model	Physical Layer	Communication Protocol	Configuration Language
CDHD2 (AP) Standard CDHD2 model.	Serial (RS232)	ASCII commands	VarCom*
	Analog	±10V	
	Pulse Train	Pulse and Direction, CW/CCW, AB Quadrature	
CDHD2 CAN (AF) A CAN drive, which uses CANopen protocol. Referred to as CDHD2 CANopen drive.	Serial (USB|RS232)	ASCII commands	VarCom
	Analog	±10V	
	Pulse Train	Pulse and Direction, CW/CCW, AB Quadrature	
	CAN	Communication: CANopen CiA 301, CiA 402	VarCom CANopen
CDHD2 EtherCAT (EC) An EtherCAT drive, which uses CANopen over EtherCAT (CoE) protocol.	Serial (USB|RS232)	ASCII commands	VarCom
	Analog	±10V	
	Pulse Train	Pulse and Direction, CW/CCW, AB Quadrature	
	EtherCAT	Communication: CANopen over EtherCAT (CoE) CiA 402	VarCom CANopen
CDHD2 EtherCAT (EB) An EtherCAT drive, which uses CANopen over EtherCAT (CoE) protocol	Serial (USB)	ASCII commands	VarCom
	Analog	±10V	
	EtherCAT	Communication: CANopen over EtherCAT (CoE) CiA 402	VarCom CANopen

Note VarCom is a proprietary set of parameters and commands for configuring, operating and tuning CDHD2 drives. The VarCom Reference Manual and EtherCAT and CANopen Reference Manual for CDHD2 can be downloaded from the product page on the Servotronix website: http://www.servotronix.com/products/cdhd-servo-drives/

1.3 Ordering Information

The following diagram shows the ordering options that comprise the various model numbers of the drives in the CDHD2 product line. To enquire about product availability, contact Servotronix.

Table 1-2. CDHD2 Ordering Options

	CDHD2	–	006	2A	AP1	–	RO	000

	CDHD2 Servo Drive – HD Series				
	Rating				
	120 / 240 VAC (MV)		**20–48 / 90 VDC (LV)**		
	Cont. [A rms]	**Peak [A rms]**	**Cont. [A rms]**	**Peak [A rms]**	
1D5	1.5	4.5			
003	3	9	3	9	
4D5	4.5	18			
006	6	18	6	18	
008	8	28			
010	10	28			
012			12	24	
013	13	28			
015			15	30	
018			18	54	(*future release*)
020	20	60			
024	24	72			
033	33	130			
044	44	130			
055	55	130			

	Input Power Supply
1D	Low Voltage Input Power Supply • 20–90 VDC for motor power (for 3A–12A models) • 20–48 VDC for motor power (for 15A model) • 20–48 VDC (optional) for logic power
2A	Medium Voltage Input Power Supply • Single Phase 120 L-N VAC +10% -15% 50/60 Hz • Single Phase 240 L-N VAC +10% -15% 50/60 Hz • Three Phase 120-240 L-L VAC +10% -15% 50/60 Hz

	Communication Interfaces	**Analog Inputs**
APx	Analog Voltage, Pulse Train, RS232.	1* or 2
AFx	CANopen, Analog Voltage, Pulse Train, USB, RS232	1* or 2
ECx	EtherCAT, Analog Voltage, Pulse Train, USB, RS232	1 or 2*
EB2	EtherCAT, USB.	2
	x = 1: One analog input, 16 bit x = 2: Two analog inputs, 14 bit each	* Standard configuration
	AF1 and EC2 options only for LV and MV-33/44/55 models	

	Motor Type
[*blank*]	Rotary and linear servo motors
RO	Rotary servo motors. Available in Asia market only.

	Special Options
[*blank*]	Standard

1.4 CDHD2 Product Label

Different product models may appear identical. Model numbers and specifications appear on the product label on the drive’s back panel.

Table 1-3. CDHD2 Product Label Codes

Item	Description
Model	Catalog number (ordering info)
S/N	Product serial number. Digit 1 = manufacturer code Digits 2, 3 = year code Digit 4 = month code Last 7 digits = serial code
Ref	Manufacturer's part number
Rev	Part number revision. 2 digits.

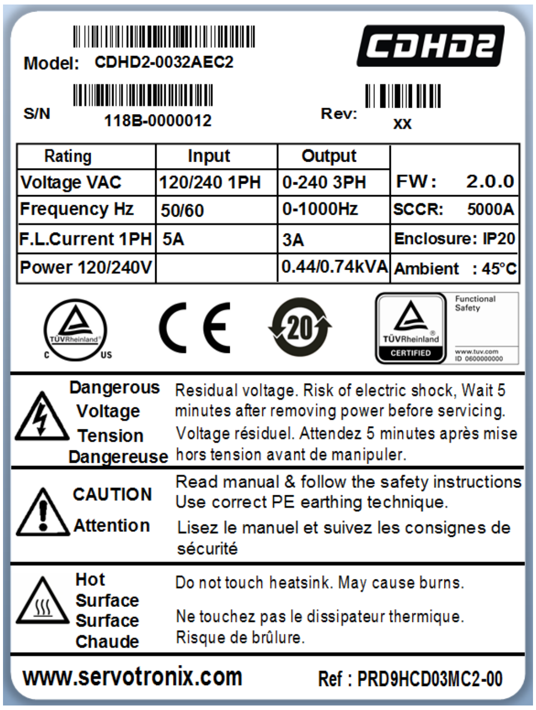

Figure 1-3. CDHD2 Product Label – Example

1.5 Documentation Set for CDHD2

The documentation set for the CDHD2 servo drive consists of the manuals listed below.

The CDHD2 manuals can be downloaded from the product page on the Servotronix website:
http://www.servotronix.com/products/cdhd-servo-drives/

- **CDHD2 User Manual**. Hardware setup, operation and tuning.
  Intended for persons who are qualified to transport, assemble, commission, and maintain the drive.
- **ServoStudio 2 Reference Manual**. Graphical user interface (GUI) provided with the CDHD2 for configuring, operating and tuning the drive.
- **VarCom Reference Manual**. Parameters and commands for configuring, operating and tuning the drive.

- **EtherCAT and CANopen Reference Manual**.
  CDHD2 implementation of CANopen protocol for CDHD2 EtherCAT (EC and EB) and CAN (AF) drives.

Note Documentation is also available in the online Help package that is bundled with ServoStudio 2 software.

2 Safety and Standards

2.1 Safety Symbols

Safety symbols indicate a potential for personal injury or equipment damage if the prescribed precautions and safe operating practices are not followed.

The following safety-alert symbols are used on the drive and in the documentation.

Table 2-1. Safety-Alert Symbols

Symbol	Meaning	Description	ISO 7000/ IEC 60417
	Caution	Indicates caution is necessary when operating the device. Also indicates the current situation needs operator awareness or operator action to avoid undesirable consequences.	0434
	Dangerous voltage	Indicates hazards arising from dangerous voltages.	5036
	Protective earth; protective ground	Identifies any terminal which is intended for connection to an external conductor for protection against electric shock in case of a fault, or the terminal of a protective earth (ground) electrode.	5019
	Caution, hot surface	Indicates the marked item can be hot and should not be touched without taking care.	5041

2.2 Safety Guidelines

The CDHD2 servo drive is intended for use as a component within a machine system.

The machine builder and integrator must ensure the protection of both personnel and the complete machine system.

The machine builder and/or integrator must perform a risk assessment in view of using the CDHD2 drive in the intended application. Based on the results, the appropriate safety measures must be implemented.

The CDHD2 drive must be used in compliance with all applicable safety regulations and directives, and all technical specifications and requirements.

The CDHD2 drive utilizes hazardous voltages. It must be properly grounded.

The machine builder and the machine owner are responsible for the safety of the machine operators.

⚠ The machine owner and the machine operator are responsible for ensuring personnel cannot enter the hazard zone while the machine is energized unless adequate functional safety mechanisms are in place.

Only qualified personnel may perform installation, operation, service and maintenance procedures. These persons must have sufficient technical training and knowledge to foresee and recognize potential hazards that may occur when using the product, modifying settings, and operating the mechanical, electrical and electronic components of the entire machine system.

All persons working on and with the product must be fully familiar with all applicable standards, directives, and accident prevention regulations when performing such work.

2.2.1 Installation Safety

Note Incorrect handling of the CDHD2 may cause personal injury and/or damage to equipment.

⚠ When connecting the CDHD2 to other control equipment, be sure to follow two basic guidelines to prevent damage to the drive:

- The CDHD2 must be grounded via the earth ground of the main AC voltage supply.
- Any motion controller, PLC or PC that is connected to the CDHD2 must be grounded to the same earth ground as the CDHD2.

- Before installing or commissioning the CDHD2, review all relevant product documentation.
- Perform the installation in strict compliance with product specifications and installation instructions.
- All system components must be connected to ground. Electrical safety is provided through a low-resistance earth ground connection. (Protective Class 1 according standard EN/IEC 618005-1.) The motor should be connected to protective earth by an independent earthing conductor rated not less than the motor wire.
- As part of the machine design, the machine builder must generate a hazard analysis for the machine and take appropriate measures to ensure that unforeseen movements cannot cause personal injury and/or damage to equipment.
- The drive meets IP20 (per IEC 60529), and type 1 (per UL 50); therefore, the machine builder must select a suitable enclosure. The enclosure must meet at least IP54 (per IEC 60529), and at least type 2 (per UL 50), and be composed of metal or a material with rating flammability of 5 VA, and not have any openings in the bottom.
- The leakage current to protective earth is greater than 3.5 mA; therefore, compliance with IEC61800-5-1 and UL 508C requires either doubling of the PE connection (by one grounding connection through the mains power cable earthing wire, and another connection through the heat sink connection to the grounded machine base), or the use of a copper connecting cable with a cross-section greater than 10 mm². Use the drive mount screws and the PE connection screws to meet this requirement.
- Wiring of a yellow color with or without one or more green stripes must not be used, except for protective bonding.
- Power cables should be rated at least 600V, 75°C.

- Altitude: If in accordance with specified clearances, per IEC 61800-5-1, the CDHD2 is rated for use at altitudes up to 2000m above sea level.
- A fault exclusion must be carried out for the STO input wiring according to EN 61800-5-2 Table D.1 and D.3 / EN ISO 13849-2, Table D.5.
- Users must perform a manual test of the STO function at least once every three months. The diagnostic test entails removing the STO supply voltage and verifying that the drive is indeed in the STO Fault state, and that motion is inhibited.

2.2.2 Operational Safety

Note Machine builder are responsible for machine safety implementation, testing and certification. The machine manual must define operational and maintenance conditions and safety precautions.

- Perform all machine operations in strict compliance with product specifications and installation instructions.
- The machine builder must provide a power mains disconnect device in accordance with local regulations.
- During operation, keep all covers and cabinet doors shut.
- During operation the machine has electrically charged components and hot surfaces. The CDHD2 heat sink can reach temperatures of 90°C. Control and power cables can carry a high voltage, even when the motor is not rotating.
- Machine axes with a suspended load or unbalanced load must have an additional mechanical safety block (such as a motor-holding brake) to prevent the load from falling out of control. The CDHD2 cannot keep the load suspended when STO is active. Serious injury may result if the load is not properly safeguarded.

2.2.3 Maintenance Safety

Note Incorrect handling of the CDHD2 may cause personal injury and/or damage to equipment.

- Before performing maintenance on the CDHD2 (or the machine it drives), review all relevant product documentation.
- Perform maintenance procedures in strict compliance with the product maintenance requirements and instructions.
- To prevent electric arcing and hazards to personnel and electric contacts, never disconnect or connect the product while the power source is energized.
- After disconnecting the power source from the machine, wait at least 5 minutes before touching or disconnecting parts of the machine that normally carry electrical charges (such as capacitors, contacts, screwed connections).
- Before touching the machine, measure the electrical contact points with a meter. Be certain voltage is below 30 VDC before handling components.

2.3 Material Safety Data

The CDHD2 is marked is in accordance with SJ/T 11364, which applies to electronic and electrical products sold in the People's Republic of China.

The data in the Hazardous Substances table below is in accordance with China RoHS 2.0: Administrative Measures for the Restriction of Hazardous Substances in Electric Appliances and Electronic Products; released January 21, 2016.

CDHD2 contains certain hazardous substances, and can be used safely for 20 years, after which it should enter the recycling system.

Table 2-2. Hazardous Substances

Part Name	Lead (Pb)	Mercury (Hg)	Cadmium (Cd)	Hexavalent Chromium (Cr (VI))	Polybrominated biphenyls (PBB)	Polybrominated diphenyl ethers (PBDE)
Metal parts	X	O	O	O	O	O
Plastic parts	O	O	O	O	O	O
Electronic	X	O	O	O	O	O
Contacts	O	O	O	O	O	O
Cables and cabling accessories	O	O	O	O	O	O

O: Indicates that the concentration of hazardous substance contained in all of the homogeneous materials for this product is below the limit stipulated in GB/T 26572.

X: Indicates that the concentration of hazardous substance contained in at least one of the homogeneous materials used for this product is above the limit stipulated in GB/T 26572.

2.4 Standards Compliance

The CDHD2 has been tested and certified according to the following standards.

Table 2-3. Standards Compliance

Standard	Directive/Description	Certif. Mark
IEC 61800-5-1:2017	**Low Voltage Directive 2014/35/EU** Adjustable speed electrical power drive systems.	CE
IEC 61800-5-2:2017	**Machinery Directive 2006/42/EC** Adjustable speed electrical power drive systems – Safety requirements – Functional.	CE
IEC 61800-3:2018	**Electromagnetic Compatibility (EMC) Directive 2004/108/E** Adjustable speed electrical power drive systems.	CE
IEC 61800-3:2018	**Electromagnetic Compatibility (EMC) Directive 2014/30/EU** Adjustable speed electrical power drive systems. Intended for use in second environment.	CE
EN 50581:2012	**European Regulations 2011/65/EU RoHS (Restriction of Hazardous Substances) and Directive (EU) 2015/863** Technical documentation required for declaring compliance with the applicable substance restrictions.	CE
SJ/T 11364	**Marking for the Restricted Use of Hazardous Substances in Electronic and Electrical Products (China RoHS 2.0)** Hazardous substances in electronic and electrical products; environmental protection use period and recyclability.	20
UL 508C	**Power Conversion Equipment** Open or enclosed equipment that supplies power to control a motor or motors operating at a frequency or voltage different than that of the input supply.	TÜVRheinland c us
CSA C22.2 NO. 14-10	**Industrial Control Equipment** Control and protective devices, and accessory devices, rated at not more than 1500V, for starting, stopping, regulating, controlling, or protecting electric motors, generators, heating apparatus, or other equipment used to control an industrial process that is intended to be installed and used in non-hazardous locations.	TÜVRheinland c us
EU REACH	**Regulation (EC) 1907/2006 Concerning the Registration, Evaluation, Authorization and Restriction of Chemicals.** The production and use of chemical substances, and their potential impacts on both human health and the environment.	REACH COMPLIANT

IEC International Electrotechnical Commission
EN European Standard (Euro Norm)
UL Underwriters Laboratory
CSA Canadian Standards Association
EU European Parliament and Council of the European Union

2.5 Certificates of Compliance

Certificate

TÜVRheinland

Certificate no. CU 72151669 07

License Holder:
Servotronix Motion Control Ltd.
21C Yagia Kapayim St.
4913020 Petach Tikva
Israel

Manufacturing Plant:
A.M.S. Electronics Ltd.
14 Ha'amal St.
Rosh Ha'ayn 4809250
Israel

Test report no.: USA-AS 31380097 011

Client Reference: Nurit Barlev

Tested to: UL 508C:2016
C22.2 NO. 14-13

Certified Product: Servo Drive

License Fee - Units

Change:

Upgrade of standard for all models: see above

Output Ratings: see appendix (CDF page 23)

contd.

Appendix: 1, 1-23

Licensed Test mark:

TÜVRheinland C US

Date of Issue (day/mo/yr) 21/06/2017

TUV Rheinland of North America, Inc., 12 Commerce Road, Newtown, CT 06470, Tel (203) 426-0888 Fax (203) 426-4009

Certificate

TÜVRheinland®

Certificate no. CU 72151669 08

License Holder:
Servotronix Motion Control Ltd.
21C Yagia Kapayim St.
4913020 Petach Tikva
Israel

Manufacturing Plant:
Servotronix Motion Technology
Development (Shenzhen) Ltd.
6F 13 Building
Dongfangjianfuyusheng
Industrial Park, Xixiang Town
518126 Baoan District, Shenzhen
China

Test report no.: USA-AS 31380097 011

Client Reference: Nurit Barlev

Tested to: UL 508C:2016
C22.2 NO. 14-13

Certified Product: Servo Drive

License Fee - Units

contd. Addition:
Model Designation:
1) CDHD2-1D52cdddddddd, 2) CDHD2-0032cdddddddd,
3) CDHD2-0034cdddddddd, 4) CDHD2-4D52cdddddddd,
5) CDHD2-0062cdddddddd, 6) CDHD2-0064cdddddddd,
7) CDHD2-0082cdddddddd, 8) CDHD2-0102cdddddddd,
9) CDHD2-0124cdddddddd, 10) CDHD2-0132cdddddddd,
11) CDHD2-0202cdddddddd, 12) CDHD2-0242cdddddddd,
(c = D, A, U; d = 0-9, A-Z, blank)

Input Ratings: see pages 2-3
Output Ratings: see appendix (CDF page 23)

Licensed Test mark:

TÜVRheinland
C US

Date of Issue (day/mo/yr)
21/06/2017

TUV Rheinland of North America, Inc., 12 Commerce Road, Newtown, CT 06470, Tel (203) 426-0888 Fax (203) 426-4009

SERVOTRONIX
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February 26, 2019
Ref: 710717 Ver.04

EC Declaration of Conformity

We: Servotronix Motion Control Ltd.
21C Yagia Kapayim, P.O.B. 3919,
Petach Tikva 49130, Israel

Hereby under our sole responsibility, declare that the following products –

CDHD2 Servo Drive HD Series:

Models: CDHD2-aaabbccdee-fff

While:

aaa = 1D5, 003, 4D5, 006, 008, 010, 012, 013, 015, 020, 024, 033, 044, 055 denoting Rating Current;

20-48/20-90Vdc:

003: 3A/9A (Cont./Peak);
006: 6A/18A;
012: 12A/24A;
015: 15A/30A;

120/240Vac:

1D5: 1.5A/4.5A (Cont./Peak);
003: 3A/9A;
4D5: 4.5A/18A;
006: 6A/18A;
008: 8A/28A;
010: 10A/28A;
013: 13A/28A;
020: 20A/60A;
024: 24A/72A;
033: 33A/130A;
044: 44A/130A;
055: 55A/130A;

bb = 1D, 2A denoting Input Power Supply;
1D: 20-90VDC (3A, 6A, 12A); 20-48VDC (15A);
2A: 120/240Vac 1/3Ph;

cc = AP, AF, EC, EB denoting Communication Interfaces;
AP: Analog Voltage, P&D, RS232;
AF: Analog Voltage, P&D, CANopen, USB, RS232;
EC: Analog Voltage, EtherCAT, USB, RS232;
EB: Analog Voltage, EtherCAT, USB (EB2 only available);

d = 1, 2 denoting Analog Inputs;
1: One Analog Input, 16 bit;
2: Two Analog Inputs, 14 bit each;

ee = [Blank], RO denoting Motor Type;
[Blank]: Rotary and Linear servo motors;
RO: Rotary servo motors (*Available in Asia market only*);

fff = [Blank], XXX denoting Special Options;
[Blank]: Standard;

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February 26, 2019
Ref: 710717 Ver.04

Subject to their installation, in accordance with the applicable installation's manual and instructions, to meet their applicable guidelines and their intended use, are in conformity with the following EC directives, which are corresponding with the harmonized standards (including all their applicable amendments):

Directive	*Harmonized Standard*
DIRECTIVE 2006/42/EC *Machinery Directive (MD)*	*EN 61800-5-2: 2016*
DIRECTIVE 2014/35/EU *Low Voltage Directive (LVD)*	*IEC/EN 61800-5-1: 2007 (second Edition)*
Directive 2014/30/EU *Electromagnetic Compatibility (EMC)*	*IEC/EN 61800-3:2004+A1:2012*
Directive 2011/65/EU *Restriction of the use of certain hazardous substances (RoHS2)*	*EN 50581:2012*

Servotronix Motion Control Ltd. keeps records of the technical documents, installation's manual or instructions, diagrams and other technical documentation for examination for the EU authorities only.

First year of affixing CE Marking: 2017

Issued at: Servotronix Motion Control Ltd.; Petach Tikva; Israel;

Signatures, February 26, 2019

Servotronix Motion Control Ltd.

By: Mrs. Nurit Barlev
Title: VP Engineering

By: Mr. Eran Katzir
Title: VP Technology

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REACH SVHC Declaration

CDHD
CDHD2

Registration, Evaluation, Authorization and restriction of Chemicals
205 Substances of Very High Concern (SVHC) on ECHA Candidate List

April 30 2021

Dear Valued Customer,

Servotronix Motion Control Ltd. hereby declares the conformity of the CDHD Servo Drive Series, with European Union Regulation (EC) 1907/2006 concerning the Registration, Evaluation, Authorization, and Restriction of Chemicals (REACH), which came into effect on June 1, 2007.

Under Article 33 of REACH, product (article) manufacturers or importers into Europe are obligated to inform recipients of any articles that contain chemicals on the Substances of Very High Concern (SVHC) candidate list above a 0.1% concentration (by weight per article).

Based on reliable information provided by our suppliers, we can confirm that the complete product range of CDHD Servo Drive manufactured by Servotronix Motion Control does not contain any of the substances on the REACH SVHC candidate list (as published by the ECHA) in concentrations greater than 0.1% by weight per article.

CDHD Servo Drive Series are non-chemical articles; therefore, Servotronix is not subject to any obligation to register or to compile safety data sheets.

In the highly unlikely event that we find a CDHD Servo Drive product contains a substance listed in the ECHA candidate list with a weight exceeding 0.1%, we will promptly fulfill our obligation to make such information known to our product users.

For additional information on this subject contact:

Zadok Shani [*zadok.shani@servotronix.com*]
Engineering Manager
Servotronix Motion Control Ltd.

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Declaration of RoHS Conformity

CDHD , CDHD2

[In accordance with EU Directive 2011/65/EU and China-RoHS2]

April 30, 2021

Servotronix Motion Control Ltd. hereby declares the conformity of the CDHD Servo Drive Series, with European Union Regulation *2011/65/EU RoHS EN 50581* of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment.

On 4 June 2015, the EU commission has published a new *Directive (EU) 2015/863* to amend Annex II to EU RoHS 2 (Directive 2011/65/EU) to add the following 4 phthalates onto the list of restricted substances.

- Lead (Pb)
- Mercury (Hg)
- Cadmium (Cd), - 0.01% by mass (100 PPM)
- Hexavalent Chromium (Cr VI)
- Polybrominated biphenyls (PBB) and
- Polybrominated diphenyl ethers (PBDE)

- Bis(2-Ethylhexyl) phthalate (DEHP) _amends by Directive (EU) 2015/863
- Benzyl butyl phthalate (BBP) _ amends by Directive (EU) 2015/863
- Dibutyl phthalate (DBP) _ amends by Directive (EU) 2015/863
- Diisobutyl phthalate (DIBP) _ amends by Directive (EU) 2015/863

Based on reliable information provided by our suppliers, we can confirm that the product manufactured by Servotronix Motion Control does not contain any of the substances which are known to pose health risks and cause damage to the environment. The maximum permitted concentrations are 0.1% by mass (1000PPM), unless otherwise mensioned.

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SERVOTRONIX always in motion

Declaration of RoHS Conformity

We further declare compliance with the Ministry of Industry and Information Technology (MIIT) of the People's Republic of China "Administrative Measures for the Restriction of the Use of Hazardous Substances in Electrical & Electronic Products" (*China RoHS-2*).

The data shown below are related to the following version of the China RoHS 2.0: Administrative Measures for the Restriction of Hazardous Substances in Electric Appliances and Electronic Products" released January 21st 2016.

部件名称 Part name	有害物质 - Hazardous Substances					
	铅 (Pb)	汞 (Hg)	镉 (Cd)	六价铬 (Cr (VI))	多溴联苯 (PBB)	多溴二苯醚 (PBDE)
金属部件 Metal parts	X	O	O	O	O	O
塑料部件 Plastic parts	O	O	O	O	O	O
电子件 Electronic	X	O	O	O	O	O
触点 Contacts	O	O	O	O	O	O
线缆和线缆附件 Cables & cabling accessories	O	O	O	O	O	O

本表格依据 SJ/T11364 的规定编制。

O: 表示该有害物质在该部件所有均质材料中的含量均在 GB/T 26572 规定的限量要求以下。

X: 表示该有害物质至少在该部件的某一均质材料中的含量超出 GB/T 26572 规定的限量要求。

This table is made according to SJ/T 11364.

O: indicates that the concentration of hazardous substance in all of the homogeneous materials for this part is below the limit as stipulated in GB/T 26572.

X: indicates that concentration of hazardous substance in at least one of the homogeneous materials used for this part is above the limit as stipulated in GB/T 26572

Servotronix Motion Control is committed in its goal of responsible manufacturing, and is ready to meet environmental standards, domestic and international.

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3 Specifications

3.1 Dimensions

Several different enclosures house the various models of CDHD2 drives. The exterior dimensions of the enclosures are shown in the figures below.

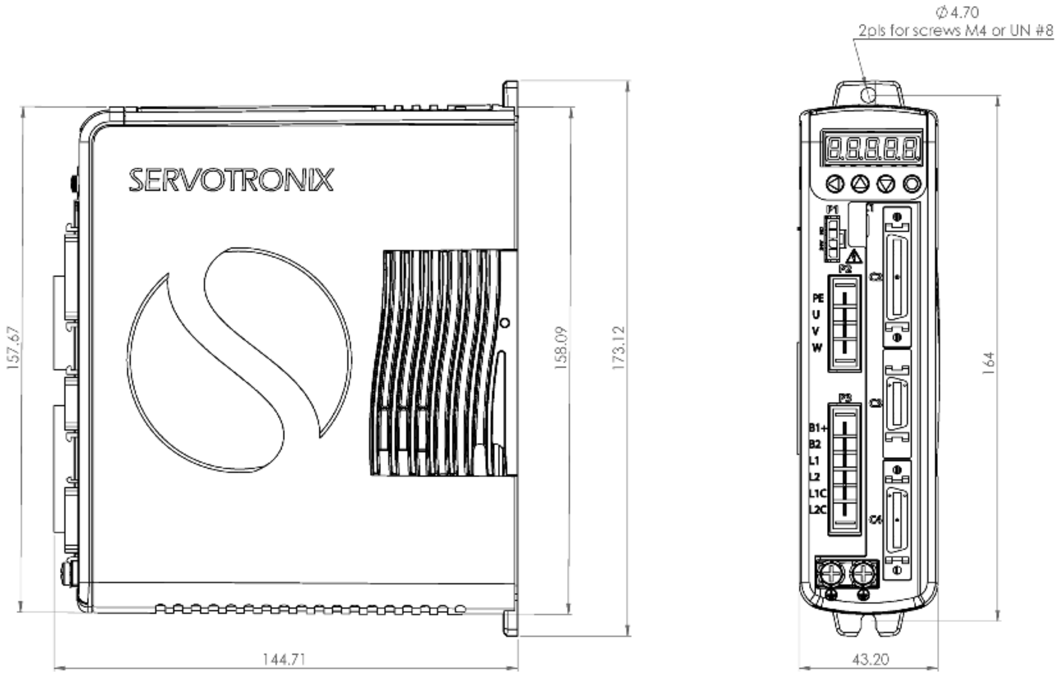


Figure 3-1. CDHD2-1D5/CDHD2-003 (MV) – Dimensions (mm)

Note CDHD2-1D5 does not have a fan. CDHD2-003 has a fan.

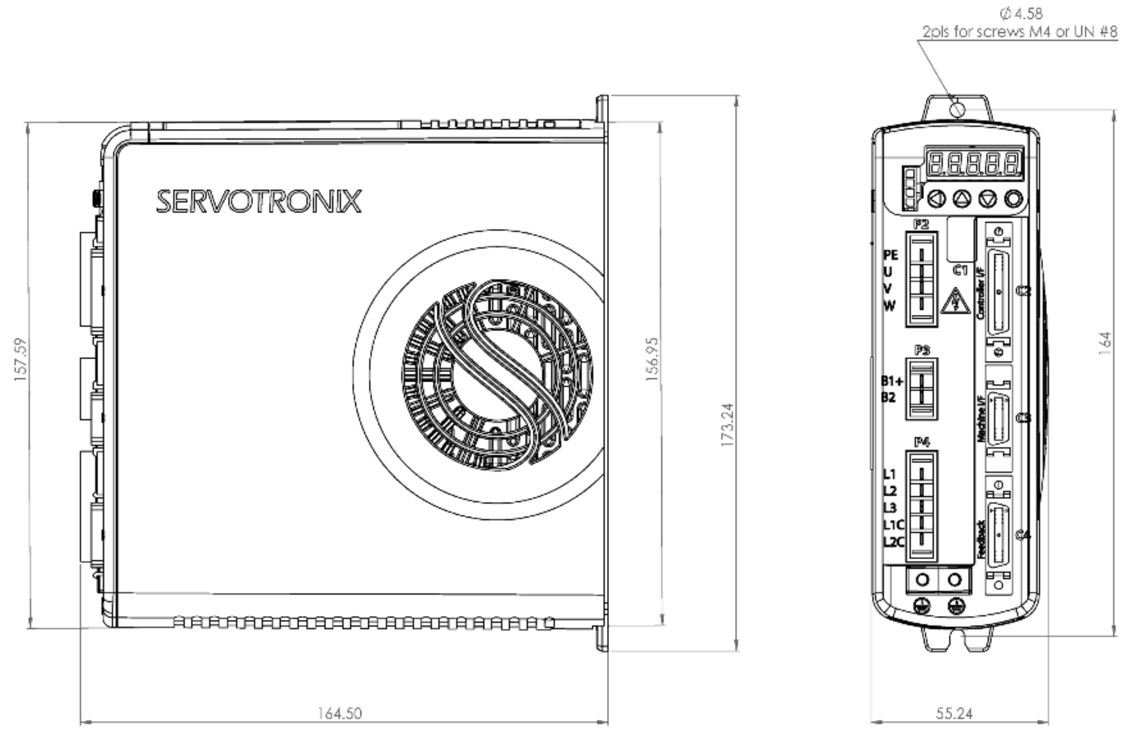


Figure 3-2. CDHD2-4D5/CDHD2-006 (MV) – Dimensions (mm)

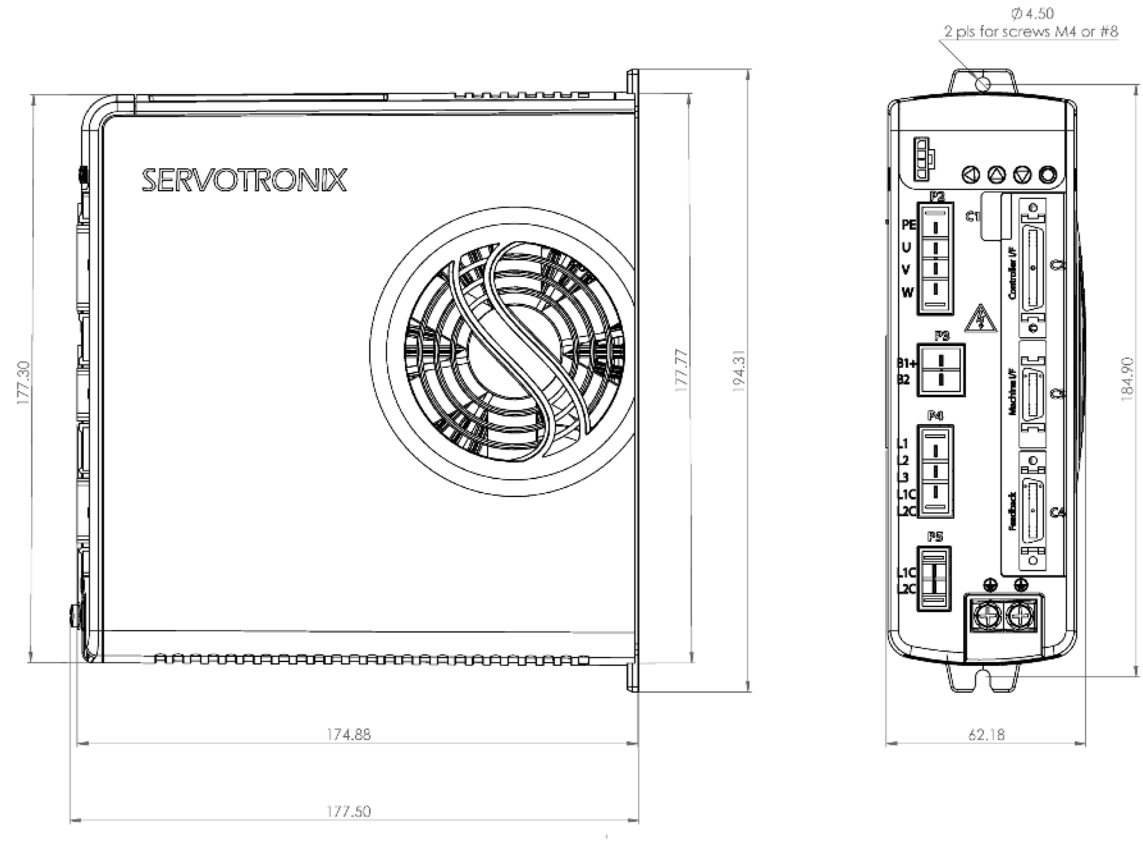


Figure 3-3. CDHD2-008/CDHD2-010/CDHD2-013 (MV) – Dimensions (mm)

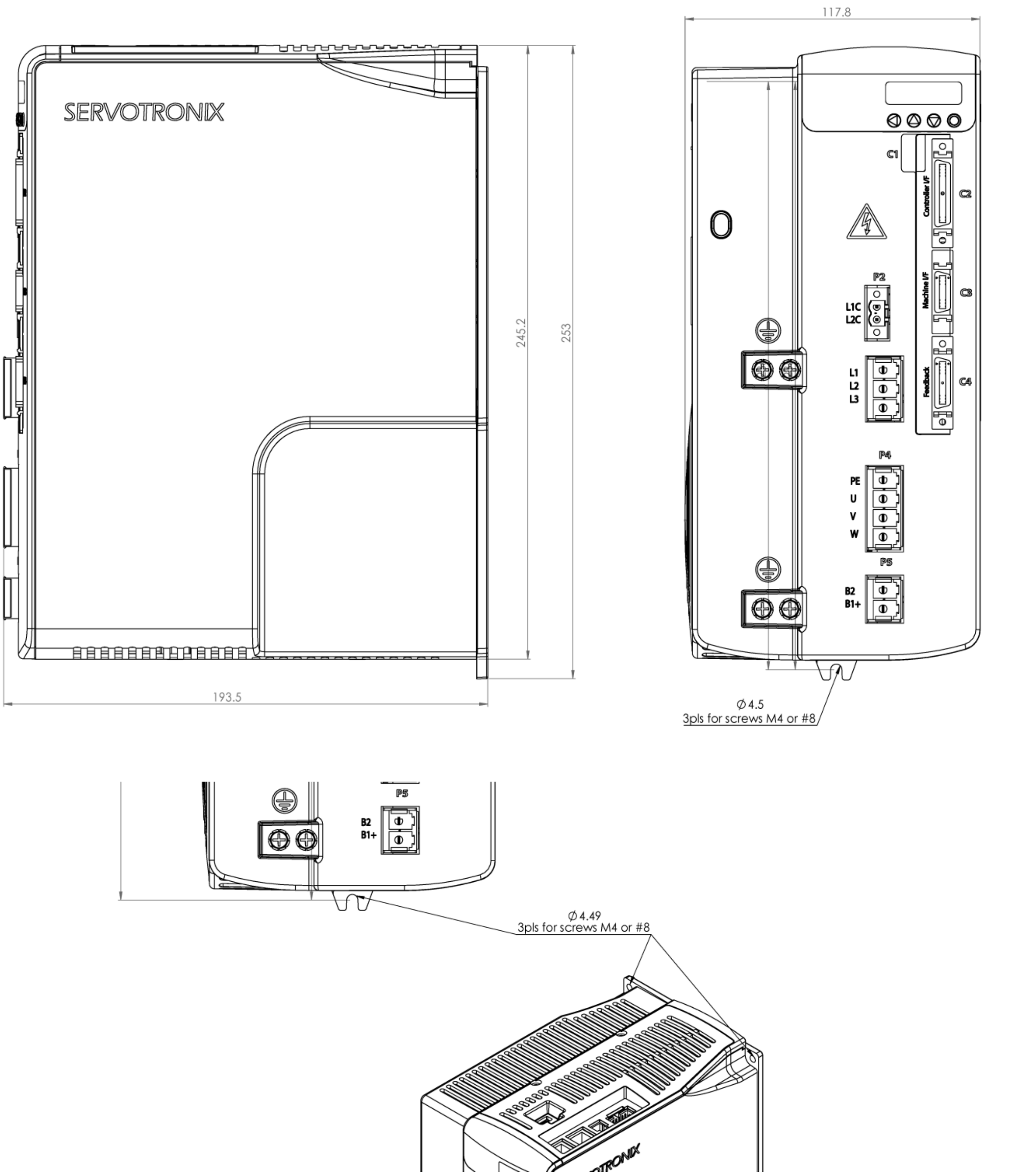


Figure 3-4. CDHD2-020/CDHD2-024 (MV) – Dimensions (mm)

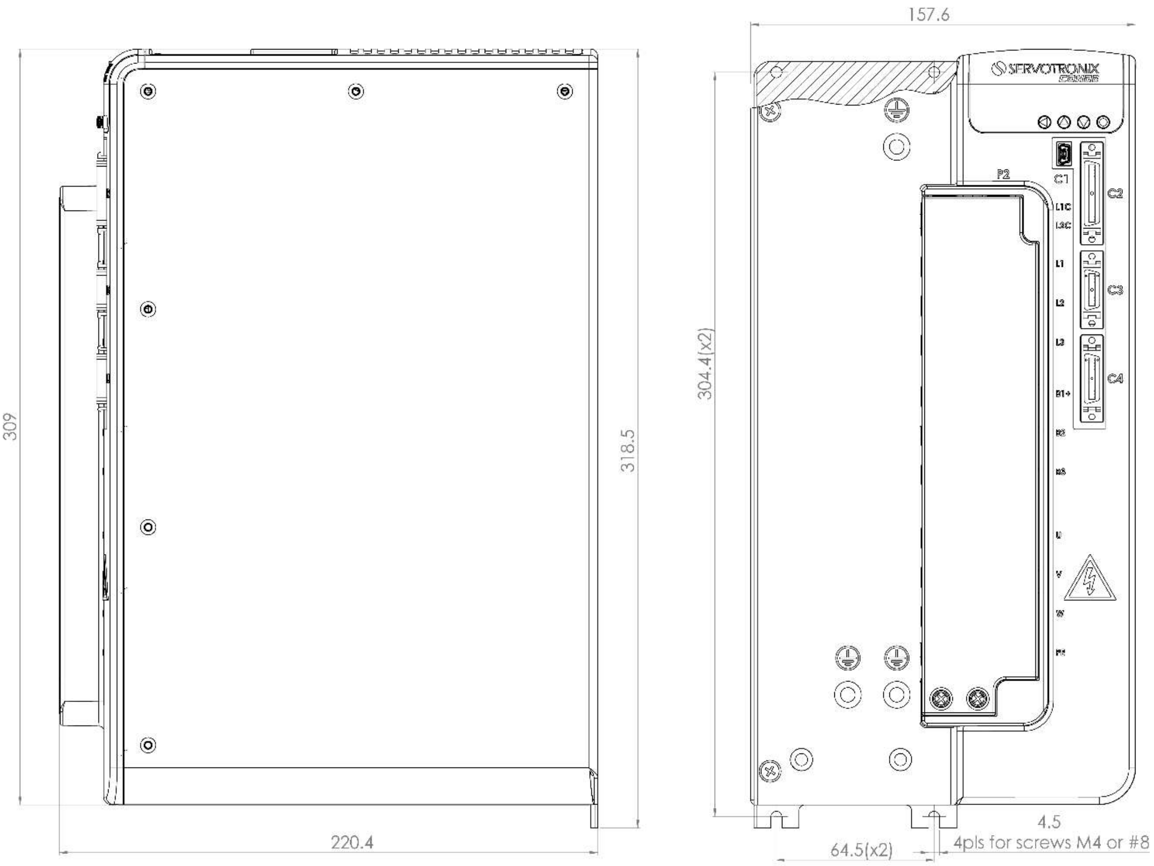


Figure 3-5. CDHD2-033/CDHD2-044/CDHD2-055 (MV) – Dimensions (mm)

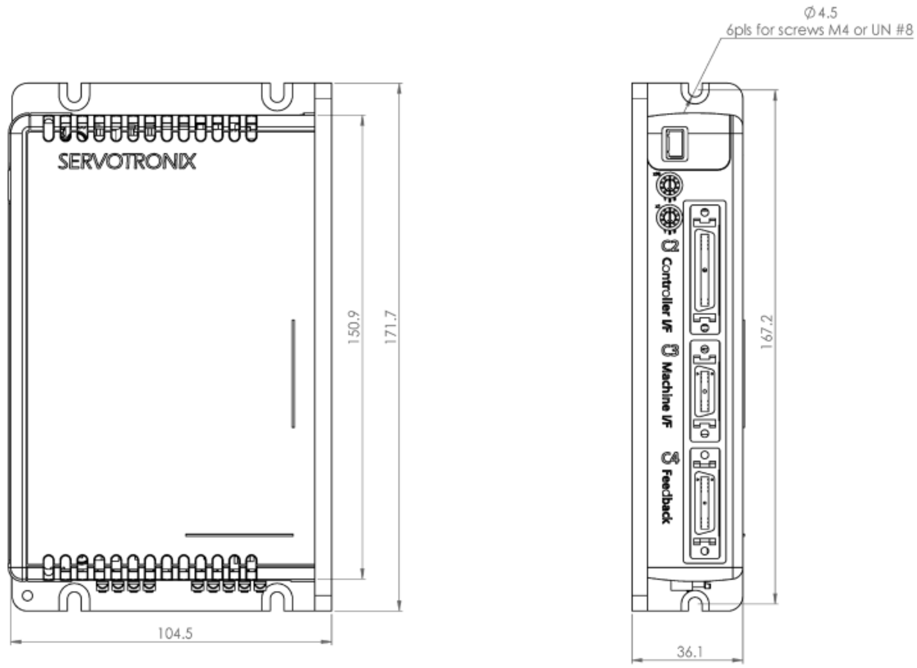


Figure 3-6. CDHD2-003/CDHD2-006/CDHD2-012/CDHD2-015/CDHD2-018 (LV) – Dimensions (mm)

3.2 Mechanical and Electrical Specifications

Table 3-1. Mechanical and Electrical Specifications – CDHD2-1D5/CDHD2-003 (MV)

Single Phase 120/240 VAC	Specification	MV CDHD2-1D5	MV CDHD2-003
Ratings			
Input Power Circuit: L1, L2	Voltage (VAC Line-Neutral) Nominal ±10%	120/240	120/240
	Line Frequency (Hz)	50/60	50/60
	120/240 VAC	1 Phase	1 Phase
	Continuous Current (Single Phase A rms)	2.5	5
	Line Fuses (FRN-R, LPN, or equivalent) (A)	4	6
	Withstand Voltage (Primary to Earth)	1500 VAC (2121 VDC)	1500 VAC (2121 VDC)
Control Circuit Input Power (L1C, L2C)	120 ±10 or 240 ±10 VAC	1 Phase	1 Phase
Logic Input Fuse (Time Delay)	120 or 240 VAC (A)	0.5	0.5
STO (Safe Torque Off)	STO Power Supply (VDC)	24 ±10%	24 ±10%
STO Fuse (Time Delay)	120 or 240 VAC (A)	1.5	1.5
Drive Output	Continuous Output Current (A rms)	1.5	3
	Continuous Output Current (A peak)	2.12	4.24
	Peak Output Current (A rms) for 2 seconds	4.5	9
	Peak Output Current (A peak) for 2 seconds	6.3	12.72
	kVA at 120 VAC	0.28	0.44
	kVA at 240 VAC	0.37	0.74
	PWM Frequency (kHz)	16	16
Soft Start	Max. Surge Soft Start Current (A)	7	7
	Max. Charge Time (ms)	350	350
Control Circuit Loss	W	5	5
Hardware			
Unit Weight	kg	0.7	0.75
Connection Hardware	PE Ground Screw Size/Torque	M4/1.35 Nm	M4/1.35 Nm
Wire Size	Control Circuit (AWG) up to 3 meters	24–28	24–28
	Main Circuit Motor Lines (AWG)	18	18
	Main Circuit AC Inputs (AWG)	18	18
	PE Ground Screw	M4	M4
Mounting	Book mounting		
Clearance Distance	Side-to-Side (mm)	10	10
	Top/Bottom (mm)	50	50

Single Phase 120/240 VAC	Specification	MV CDHD2-1D5	MV CDHD2-003
Voltage Trip			
	Under-Voltage Trip (Nominal) (VDC)	User-defined	User-defined
	Over-Voltage Trip (VDC)	420	420
Power Temperature			
Fan	Normally operates at quarter power; when temperature exceeds high-speed fan trigger temperature, operates at full power	No	Yes
	Trigger Temperature for High Speed Fan (°C)	NA	45
Power Module	Power Module Over-Temperature Fault Regulated (°C)	80 ±5%	80 ±5%
	Power Module Over-Temperature Fault Non-regulated (°C)	100 ±5%	100 ±5%
External Regenerative Resistor (B1+, B2)			
External regenerative resistor requirement (regen resistor not supplied with drive)	Peak Current (A)	6.3	12.7
	Minimum Resistance (Ω)	64	31.5
	Power Rating (W)	System-dependent	System-dependent
Application Information	Internal Bus Capacitance (μF)	360	660
	VLOW (Regen Circuit Turn Off) (VDC)	380	380
	VMAX (Regen Circuit Turn On) (VDC)	400	400

Table 3-2. Mechanical and Electrical Specifications – CDHD2-4D5/CDHD2-006 (MV)

Single or Three Phase 120/240 VAC	Specification	MV CDHD2-4D5	MV CDHD2-006
Ratings			
Input Power Circuit: Single Phase: L1, L3 Three Phase: L1, L2, L3	Voltage Nominal ±10% (VAC)	120/240	120/240
	Line Frequency (Hz)	50/60	50/60
	120 VAC	1 Phase or 3 Phase	1 Phase or 3 Phase
	240 VAC	1 Phase	1 Phase
	Continuous Current (1 Phase A rms)	8.5	10
	Continuous Current (3 Phase A rms)	4	5.8
	Line Fuses (FRN-R, LPN, or equivalent) (A)	10	10
	Withstand Voltage (Primary to Earth)	1500 VAC (2121 VDC)	1500 VAC (2121 VDC)
Control Circuit Input Power (L1C, L2C)	120 ±10 or 240 ±10 VAC	Single Phase	Single Phase
Logic Input Fuse (Time Delay)	120 or 240 VAC (A)	0.5	0.5
STO (Safe Torque Off)	STO Power Supply (VDC)	24 ±10%	24 ±10%
STO Fuse (Time Delay)	120 or 240 VAC (A)	1.5	1.5
Drive Output	Continuous Output Current (A rms)	4.5	6
	Continuous Output Current (A peak)	6.63	8.48
	Peak Output Current (A rms) for 2 seconds	18	18
	Peak Output Current (A peak) for 2 seconds	25.45	25.45
	kVA at 120 VAC	0.5	0.7
	kVA at 240 VAC	1.1	1.5
	PWM Frequency (kHz)	16	16
Soft Start	Max. Surge Soft Start Current (A)	7	7
	Max. Charge Time (ms)	350	350
Control Circuit Loss	W	5	5
Hardware			
Unit Weight	kg	0.97	0.97
Connection Hardware	PE Ground Screw Size/Torque	M4/1.35 Nm	M4/1.35 Nm
Wire Size	Control Circuit (AWG) up to 3 meters	24–28	24–28
	Main Circuit Motor Lines (AWG)	16	16
	Main Circuit AC Inputs (AWG)	16	16
	PE Ground Screw	M4	M4
Mounting	Book mounting		
Clearance Distance	Side-to-Side (mm)	10	10
	Top/Bottom (mm)	50	50

Single or Three Phase 120/240 VAC	Specification	MV CDHD2-4D5	MV CDHD2-006
Voltage Trip			
	Under-Voltage Trip (Nominal) (VDC)	User-defined	User-defined
	Over-Voltage Trip (VDC)	420	420
Power Temperature			
Fan	Normally operates at quarter power; when temperature exceeds high-speed fan trigger temperature, operates at full power	Yes	Yes
	Trigger Temperature for High Speed Fan (°C)	45	45
Power Module	Power Module Over-Temperature Fault Regulated (°C)	80 ±5%	80 ±5%
	Power Module Over-Temperature Fault Non-regulated (°C)	100 ±5%	100 ±5%
External Regenerative Resistor (B1+, B2)			
External regenerative resistor requirement (regen resistor not supplied with drive)	Peak current (A)	25.5	25.5
	Minimum resistance (Ω)	16	16
	Power Rating (W)	System-dependent	System-dependent
Application Information	Internal Bus Capacitance (μF)	1120	1120
	VLOW (Regen Circuit Turn Off) (VDC)	380	380
	VMAX (Regen Circuit Turn On) (VDC)	400	400

Table 3-3. Mechanical and Electrical Specifications – CDHD2-008/CDHD2-010/CDHD2-013 (MV)

Three Phase 120/240 VAC	Specification	MV CDHD2-008	MV CDHD2-010	MV CDHD2-013
Ratings				
Input Power Circuit: L1, L2, L3	Voltage (VAC Line-Line) Nominal ±10%	120/240	120/240	120/240
	Line Frequency (Hz)	50/60	50/60	50/60
	120/240 VAC	3 Phase	3 Phase	3 Phase
	Continuous Current (3 Phase A rms)	5	8	10
	Line Fuses (FRN-R, LPN, or equivalent)	10	10	15
	Withstand Voltage (Primary to Earth)	1500 VAC (2121 VDC)	1500 VAC (2121 VDC)	1500 VAC (2121 VDC)
Control Circuit Input Power (L1C, L2C)	120 ±10 or 240 ±10 VAC	Single Phase	Single Phase	Single Phase
Logic Input Fuse (Time Delay)	120 or 240 VAC (A)	0.5	0.5	0.5
STO (Safe Torque Off)	STO Power Supply (VDC)	24 ±10%	24 ±10%	24 ±10%
STO Fuse (Time Delay)	120 or 240 VAC (A)	1.5	1.5	1.5
Drive Output	Continuous Output Current (A rms)	8	10	13
	Continuous Output Current (A peak)	11.31	14.14	18.38
	Peak Output Current (A rms) for 2 seconds	28	28	28
	Peak Output Current (A peak) for 2 seconds	39.56	39.56	39.56
	kVA at 120 VAC	1.1	1.3	1.7
	kVA at 240 VAC	1.7	2.2	2.8
	PWM Frequency (kHz)	8	8	8
Soft Start	Max. Surge Soft Start Current (A)	15	15	15
	Max. Charge Time (ms)	350	350	350
Control Circuit Loss	W	5	5	5
Hardware				
Unit Weight	kg	1.15	1.15	1.15
Connection Hardware	PE Ground Screw Size/Torque	M4/1.35 Nm	M4/1.35 Nm	M4/1.35 Nm
Wire Size	Control Circuit (AWG) up to 3 meters	24-28	24-28	24-28
	Main Circuit Motor Lines (AWG)	14	14	14
	Main Circuit AC Inputs (AWG)	14	14	14
	PE Ground Screw	M4	M4	M4

Three Phase 120/240 VAC	Specification	MV CDHD2-008	MV CDHD2-010	MV CDHD2-013
Mounting	Book mounting			
Clearance Distance	Side-to-Side (mm)	10	10	10
	Top/Bottom (mm)	50	50	50
Voltage Trip				
	Under-Voltage Trip (nominal) (VDC)	User-defined	User-defined	User-defined
	Over-Voltage Trip (VDC)	420	420	420
Power Temperature				
Fan	Normally operates at quarter power; when temperature exceeds high-speed fan trigger temperature, operates at full power	Yes	Yes	Yes
	Trigger Temperature for High Speed Fan (°C)	45	45	45
Power Module	Power Module Over-Temperature Fault Regulated (°C)	80 ±5%	80 ±5%	80 ±5%
	Power Module Over-Temperature Fault Non-regulated (°C)	100 ±5%	100 ±5%	100 ±5%
External Regenerative Resistor (B1+, B2)				
External regenerative resistor requirement (regen resistor not supplied with drive)	Peak current (A)	40	40	40
	Minimum resistance (Ω)	10	10	10
	Power Rating (W)	System-dependent	System-dependent	System-dependent
Application Information	Internal Bus Capacitance (µF)	2110	2110	2110
	VLOW (Regen Circuit Turn Off) (VDC)	380	380	380
	VMAX (Regen Circuit Turn On) (VDC)	400	400	400

Table 3-4. Mechanical and Electrical Specifications – CDHD2-020/CDHD2-024 (MV)

Three Phase 240 VAC	Specification	MV CDHD2-020	MV CDHD2-024
Ratings			
Input Power Circuit (L1, L2, L3)	Voltage (VAC Line-Line) Nominal ±10%	120/240	120/240
	Line Frequency (Hz)	50/60	50/60
	240 VAC	3 Phase	3 Phase
	Continuous Current (3 Phase A rms)	20@240V	20@240V
	Line Fuses (FRN-R, LPN, or equivalent) (A)	25	30
	Withstand Voltage (Primary to Earth)	1500 VAC (2121 VDC)	1500 VAC (2121 VDC)
Control Circuit Input Power (L1C, L2C)	240 VAC	Single Phase	Single Phase
Logic Input Fuse (Time Delay)	240 VAC (A)	0.5	0.5
STO (Safe Torque Off)	STO Power Supply (VDC)	24 ±10%	24 ±10%
STO Fuse (Time Delay)	24 VDC ±10%	1.5	1.5
Drive Output	Continuous Output Current (A rms)	20	24
	Continuous Output Current (A peak)	28.28	34.93
	Peak Output Current (A rms) for 2 seconds	60	72
	Peak Output Current (A peak) for 2 seconds	84.6	101.5
	kVA at 120 VAC	3	3.5
	kVA at 240 VAC	5	6
	PWM Frequency (kHz)	8	8
Soft Start	Max. Surge Soft Start Current (A)	15	15
	Max. Charge Time (ms)	1000	1000
Control Circuit Loss	W	5	5
Hardware			
Unit Weight	kg	3.2	3.2
Connection Hardware	PE Ground Screw Size/Torque	M4/1.35 Nm	M4/1.35 Nm
Wire Size	Control Circuit (AWG) up to 3 meters	24-28	24-28
	Main Circuit Motor Lines (AWG)	12	12
	Main Circuit AC Inputs (AWG)	12	12
	PE Ground Screw	M4	M4
Mounting	Book mounting		
Clearance Distance	Side-to-Side (mm)	10	10
	Top/Bottom (mm)	50	50

Three Phase 240 VAC	Specification	MV CDHD2-020	MV CDHD2-024
Voltage Trip			
	Under-Voltage Trip (nominal) (VDC)	User-defined	User-defined
	Over-Voltage Trip (VDC)	420	420
Power Temperature			
Fan	Normally operates at quarter power; when temperature exceeds high-speed fan trigger temperature, operates at full power	Yes	Yes
	Trigger Temperature for High Speed Fan (°C)	45	45
	Power Module Over-Temperature Fault Regulated (°C)	80 ±5%	80 ±5%
	Power Module Over-Temperature Fault Non-regulated (°C)	100 ±5%	100 ±5%
External Regenerative Resistor (B1+, B2)			
External regenerative resistor requirement (regen resistor not supplied with drive)	Peak current (A)	44	44
	Minimum resistance (Ω)	8.4	8.4
	Power Rating (W)	System-dependent	System-dependent
Application Information	Internal Bus Capacitance (μF)	3280	3280
	VLOW (Regen Circuit Turn Off) (VDC)	380	380
	VMAX (Regen Circuit Turn On) (VDC)	400	400

Table 3-5. Mechanical and Electrical Specifications – CDHD2-033/CDHD2-044/CDHD2-055 (MV)

Three Phase 230 VAC	Specification	MV CDHD2-033 CDHD2-044 CDHD2-055
Ratings		
Input Power Circuit (L1, L2, L3)	Voltage (VAC Line-Line) Nominal ±10%	230
	Line Frequency (Hz)	50/60
	230 VAC	3 Phase
	Continuous Current (3 Phase A rms)	26@230V
	Line Fuses (FRN-R, LPN, or equivalent) (A)	60
	Withstand Voltage (Primary to Earth)	1500 VAC (2121 VDC)
Control Circuit Input Power (L1C, L2C)	230 VAC	Single Phase
Logic Input Fuse (Time Delay)	230 VAC (A)	0.5
STO (Safe Torque Off)	STO Power Supply (VDC)	24 ±10%
STO Fuse (Time Delay)	24 VDC ±10%	1.5
Drive Output	Continuous Output Current (A rms)	33/44/55
	Continuous Output Current (A peak)	46.5/62/77.5
	Peak Output Current (A rms) for 2 seconds	130
	Peak Output Current (A peak) for 2 seconds	183
	kVA at 240 VAC	6.8/9.1/11.4
	PWM Frequency (kHz)	8
Soft Start	Max. Surge Soft Start Current (A)	44.8
	Max. Charge Time (ms)	1
Control Circuit Loss	W	5
Hardware		
Unit Weight	kg	7.8
Connection Hardware	PE Ground Screw Size/Torque	M6/5 Nm
Wire Size	Control Circuit (AWG) up to 3 meters	22-20
	Main Circuit Motor Lines (AWG)	5
	Main Circuit AC Inputs (AWG)	4
	Motor Lines / AC Input/PE Ground Screw	M6
Mounting	Book mounting	
Clearance Distance	Side-to-Side (mm)	10
	Top/Bottom (mm)	50
Voltage Trip		
	Under-Voltage Trip (nominal) (VDC)	User-defined
	Over-Voltage Trip (VDC)	420

Three Phase 230 VAC	Specification	MV CDHD2-033 CDHD2-044 CDHD2-055
Power Temperature		
Fan	ON/OFF control	
	Power Module Over-Temperature Fault Regulated (°C)	80 ±5%
	Power Module Over-Temperature Fault Non-regulated (°C)	100 ±5%
External Regenerative Resistor (B1+, B2)		
External regenerative resistor requirement (regen resistor not supplied with drive)	Peak current (A)	97
	Minimum resistance (Ω)	4
	Power Rating (W)	System-dependent
Application Information	Internal Bus Capacitance (μF)	5740
	VLOW (Regen Circuit Turn Off) (VDC)	380
	VMAX (Regen Circuit Turn On) (VDC)	400

Table 3-6. Mechanical and Electrical Specifications – CDHD2-003/006/012/015/018 (LV)

20–90 VDC	Specification	LV CDHD2 -003	LV CDHD2 -006	LV CDHD2 -012	LV CDHD2 -015	LV CDHD2 -018 *
Ratings						
Bus Input Power	Voltage Nominal ±10%	20–90	20–90	20–90	20–48	20–48
(VIN+, VIN-)	Line Fuses (FRN-R, LPN, or equivalent)	2	4	6	8	10
	Withstand Voltage (Primary to Earth)	–	–	–	–	–
Control Input Power (VL+, VL-)	Voltage Nominal ±10%	20 – 48	20 – 48	20 – 48	20 – 48	20 – 48
STO (Safe Torque Off)	STO Power Supply (VDC)	24 ±10%	24 ±10%	24 ±10%	24 ±10%	24 ±10%
STO Fuse (Time Delay)	120 or 240 VAC (A)	1.5	1.5	1.5	1.5	1.5
Drive Output	Continuous Output Current (A rms)	3	6	12	15	18
	Continuous Output Current (A peak)	4.24	8.48	16.97	21.15	25.45
	Peak Output Current (A rms) for 2 seconds	9	18	24	30	54
	Peak Output Current (A peak) for 2 seconds	12.72	25.45	33.93	42.3	76.36
	kVA at 20 VDC	0.06	0.12	0.24	0.3	0.3
	kVA at 48 VDC	0.144	0.288	0.576	0.72	0.864
	kVA at 90 VDC	0.27	0.54	1.08	–	–
	PWM Frequency (kHz)	16	16	16	16	16
Soft Start	Max. Surge Soft Start Current (A)	–	–	–	–	–
	Max. Charge Time (ms)	–	–	–	–	–
Control Circuit Loss	W	5	5	5	5	5
Hardware						
Unit Weight	kg	0.7	0.7	0.7	0.7	0.7
Connection Hardware	PE Ground Screw Size/Torque	M4/1.35 Nm	M4/1.35 Nm	M4/1.35 Nm	M4/1.35 Nm	M4/1.35 Nm

20–90 VDC	Specification	LV CDHD2 -003	LV CDHD2 -006	LV CDHD2 -012	LV CDHD2 -015	LV CDHD2 -018 *
Wire Size	Control Circuit (AWG) up to 3 meters	24–28	24–28	24–28	24–28	24–28
	Main Circuit Motor Lines (AWG)	16	14	14	14	14
	Main Circuit AC Inputs (AWG)	16	14	14	14	14
	PE Ground Screw	M4	M4	M4	M4	M4
Clearance Distance	Side-to-Side Book Mounting (mm)	10	10	10	10	10
	Top/Bottom Book Mounting (mm)	50	50	50	50	50
Clearance Distance	Side-to-Side Brick Mounting (mm)	50	50	50	50	50
	Top/Bottom Brick Mounting (mm)	50	50	50	50	50
Voltage Trip						
	Under-Voltage Trip (nominal) (VDC)	19	19	19	19	19
	Over-Voltage Trip (VDC)	92	92	92	50	50
Power Temperature						
	Power Module Over-Temperature Fault Regulated (°C)	80 ±5%	80 ±5%	80 ±5%	80 ±5%	80 ±5%
	Power Module Over-Temperature Fault (°C)	85 ±5%	85 ±5%	85 ±5%	85 ±5%	85 ±5%

Note: LV model CDHD2-018: for future release.

3.3 Control Specifications

Table 3-7. Control Specifications

Feature	Specification	
Motors	Types	DC brushless, DC brushed, Voice coil, Rotary servo, Linear servo
	Automatic Motor Phasing	Automatic configuration of motor phasing, encoder direction, Hall sensor sequence
Operation Modes	Selectable Control Modes	Current (Torque) control, Velocity control, Position control, HD control, Dual loop control, Gantry control
Current (Torque) Control	Performance	Update rate 31.25 µs (32 kHz), Output waveform sinusoidal
	Step Response Time	Actual current reaches command in two cycles, 62.5 µs
	Control Loop	DQ, PI, Feedforward
	Reference Command*	Analog Voltage ±10 VDC, Serial RS232 or USB, CANopen, EtherCAT
	Autotuning	Automatic setting of current control loop parameters
Velocity Control	Performance	Update rate 125 µs (8 kHz)
	Selectable Velocity Control Loops	PI, PDFF, Standard pole placement, Advance pole placement, Standard pole placement high frequency, Pole placement with active dumping
	Filters	First order low pass filter, Double first order low pass filter, Notch, High pass filter, Band pass filter, User defined polynomial filter
	Reference Command	Analog Voltage ±10 VDC, Serial RS232 or USB*, CANopen, EtherCAT
Position Control	Performance	Update rate 250 µs (4 kHz)
	Control Loop	PID and feedforward
	Reference Command*	Pulse and direction with electronic gearing, Serial RS232 or USB, CANopen, EtherCAT
HD Control	Performance	Update rate 125 µs (8 kHz)
	Control Loop	Nonlinear control algorithm provides very low tracking error, zero or minimum settling time and smooth movement; includes an adaptive feedforward feature that is applied at end of movement to achieve zero or minimum settling time.
	Filters	One second order low pass, two notch filters, and other filters to handle flexible and resonant systems
	Reference Command*	Velocity: Analog Voltage ±10 VDC, Serial RS232 or USB, CANopen, EtherCAT Position: Pulse Train, Serial RS232 or USB, CANopen, EtherCAT
	Autotuning	Automatic inertia load measurement, automatic setting and optimization of HD control loop parameters.
Gantry Control	Control Loop	Position control for H-shaped mechanical structures

Feature	Specification	
Brake	Method	Controlled stop, Dynamic braking, Motor electromechanical braking.
Display	User Interface	MV models: 5 digit 7-segment LED display LV models: 1 digit 7-segment LED display
Keypad	User Interface	Operator panel for editing and monitoring parameter values; No keypad on LV models
GUI	User Interface	ServoStudio 2 Windows-based application
	Function	Setting connection, Drive information, Power information, Motor, Feedback, I/O selection/configuration, Motion setting/tuning, Fault history/display, Setup wizard, Expert view
Electronic Gearing	Method	User defined input signal ratio
Rotary Units	Position	Revolutions, counts, degrees
	Velocity	rps, rpm, deg/s
	Acceleration/ Deceleration	rps/s, rpm/s, deg/s2
Linear Units	Position	Counts, pitch, mm, µm
	Velocity	mm/s, µm/s
	Acceleration/ Deceleration	mm/s2, µm2/s

Note * Some features are not available on all models. Refer to *Ordering Information*.

3.4 Protective Functions and Environmental Specifications

Table 3-8. Protective Functions and Environmental Specifications – All CDHD2 Models

Feature	Specification
Protective Functions	Including, but not restricted to: Under- and over-voltage, Over-current, Drive and motor over-temperature, Motor foldback, Drive foldback, Feedback loss, Secondary feedback loss, STO signal not connected, Not configured, Circuit failure.
Compliance	IEC 61800-5-1: Low Voltage Directive 2014/35/EU. Adjustable speed electrical power drive systems.
	IEC 61800-5-2:2016: Machinery Directive 2006/42/EC. Adjustable speed electrical power drive systems – Safety requirements – Functional.
	IEC 61800-3: EMC Directive 2014/30/EU. Adjustable speed electrical power drive systems.
	EN 50581: Support Essential Requirements of EU RoHS Directive 2011/65/EU. Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment.
	UL 508C and UL 61800-5-1: TÜV Rheinland certification. Power Conversion Equipment. Note: Certification pending for LV models.
	REACH: EC Regulation 1907/2006. Regulation on chemicals and their safe use.
Environment	Ambient temperature: Operation 0–45°C, Storage 0–70°C
	Humidity: 10–90%
	Altitude: If in accordance with specified clearances, per IEC 61800-5-1, the CDHD2 is rated for use at altitudes up to 2000m
	Vibration: 1.0g
Operating Conditions	Protection class: IP20, pollution degree: 2 as per IEC 60664-1. The end user must select an enclosure that permits safe operation of the drive and the enclosure must meet at least IP54 according to IEC 60529. Do not use in the following locations: corrosive or flammable gasses, water oil or chemical, dust including iron dust and salts

3.5 STO/Functional Safety Specifications

Note STO certification is currently pending for all CDHD2 models.

Table 3-9. STO Electrical Specifications

Feature	Specification	
STO Supply Voltage	Nominal voltage	24 VDC
	Voltage levels per Type 2 EN 61131-2 exception (operation from 15 VDC and not 11 VDC)	15–30 VDC: STO function not active (motion allowed) 0–5 VDC: STO function active (motion inhibited) 5–15 VDC: STO function not defined and not guaranteed
	Power supply - external	SELV/PELV required
	Power supply - internal	STO jumper required
Cable	Max. length	30 m
	Wire size	22-24 AWG
Current Drain		At 15 VDC < 300 mA At 24 VDC < 200 mA At 30 VDC < 150 mA
Maximum Reaction Time	Time within which the motion is inhibited	40 ms
Maximum Duration of OSSD Test Pulse	OSSD test pulse is ignored by the drive	1 ms
Maximum Frequency of OSSD Test Pulses	Absolute maximum frequency of 1 ms test pulses that will be successfully filtered by the drive	475 Hz

Note A fault exclusion must be carried out for the STO input wiring according to EN 61800-5-2 Table D.1 and D.3 / EN ISO 13849-2, Table D.5.

3.6 Communication Specifications

Table 3-10. Communication Specifications

Feature	Specification
CANopen*	CiA 301 application layer and CiA 402 device profile for drives and motion control
	Baud rate: 0.5M 1M bit/s
	Integrated 120Ω termination resistor, with on/off switch
	Addressing: Operator panel (MV models), Rotary switch (LV models)
EtherCAT*	CiA 301 application layer and CiA 402 device profile for drives and motion control
	Communication cycle time: up to 250 µs
RS232	ASCII-based, ServoStudio 2, HyperTerminal
	Baud rate: 115200 bit/s
	Maximum cable length: 10 m
USB*	ASCII-based, ServoStudio 2, HyperTerminal
	Baud rate: 115200 bit/s
	Maximum cable length: 3 m
Daisy Chain	Up to 8 axes. Axis address setting from 0-99
	Maximum cable length: 1 m

Note * Some features are not available on all models. Refer to *Ordering Information*.

3.7 I/O Specifications

Table 3-11 I/O Specifications

Feature	Specification			
	CDHD2 Model	**AP/AF**	**EC**	**EB**
First Analog Input	Voltage Range	Analog ±10 VDC differential		
	Input Resolution	16 bit (14 bit on version with two analog inputs)		
	Input Impedance	8 kΩ (when using two analog inputs 20 kΩ.)		
	Bandwidth (-3 dB)	8 kHz		
	Accuracy	2%		
Second Analog Input*	Voltage Range	Analog ±10 VDC differential		
	Input Resolution	14 bit		
	Input Impedance	20 kΩ		
	Bandwidth (-3 dB)	8 kHz		
	Accuracy	2%		
Pulse Train	Signal	RS 422 Line receiver		
	Max. Input Frequency	5 MHz		
Equivalent Encoder Output	Signal	AB quadrature and index differential, RS422 line transmitter		
	Max. Output Frequency	5 MHz		
Digital Inputs	Quantity	8	8	4
	Signal	Configurable. Opto-isolated. Sinking or sourcing supply.		
	Voltage	24V (IEC 61131)		
	EMI Protection	yes		
	Max. Input Current	6 mA		
	Propagation Delay Time	1 ms		
	Frequency	1 kHz		
Fast Digital Inputs	Quantity	3	3	1
	Signal	Configurable. Opto-isolated. Sinking or sourcing supply.		
	Voltage	24V (IEC 61131)		
	EMI Protection	yes		
	Max. Input Current	12.5 mA		
	Propagation Delay Time	1 µs		
	Frequency	1 MHz		

Feature	Specification			
	CDHD2 Model	**AP/AF**	**EC**	**EB**
Digital Output	Quantity	6	6	3
	Signal	Configurable. Opto-isolated. Open collector. Sinking or sourcing supply.		
	Voltage	24V (IEC 61131)		
	EMI Protection	yes		
	Max. Output Current	100 mA		
	Over-Current Protection	yes		
	Propagation Delay Time	1 ms		
Fast Digital Outputs	Quantity	2	2	–
	Signal	Configurable. Opto-isolated. Open collector. Sinking supply.		–
	Voltage	5 to 24 V		–
	Max. Output Current	50 mA		–
	Propagation Delay Time	1 µs		–
Analog Output	Signal	Configurable analog output		–
	Voltage	±10 V		–
	Resolution	12 bit		–
	Bandwidth	2 kHz		–
	Max. Load	100 kΩ		–
Fault Output Relay	Signal	Configurable dry contacts		–
	Voltage	24V		–
	Max. Current	1 A		–

Note * Some features are not available on all models. Refer to *Ordering Information*.

3.8 Motor Feedback Specifications

Table 3-12. Motor Feedback Specifications – All CDHD2 Models

Feature	Specification	
Power Supply	Supply Voltage from Drive	5 VDC (8 VDC*)
	Max. Supply Current from Drive to Primary Encoder**	320 mA @5V 140 mA @8V
Cable	Max. Length	50 m for sensAR encoder. For other feedback devices, per device specifications
Incremental Encoder	Differential RS422 or RS485	AB quadrature, with or without index, 8-channel Tamagawa
	AB Quad Max. Input Frequency	5 MHz (before quadrature)
	Min. Index Pulse Width	1 µs
Hall Sensor	Signal	Open collector single-ended (optional differential)
Resolver	Signal	Sine/cosine differential
	Transformation Ratio	0.45 – 0.8
	Excitation Frequency	8 kHz
	Input Voltage from Drive	6 – 22 Vpp
	Max. DC Resistance	120 Ω (stator)
	Max. Drive Current	55 mA rms
	Output Voltage to Drive	10 Vpp
Sine Encoder	Signal	Sine/cosine differential, with or without Halls
	Signal Level	1 Vpp @ 2.5 V
	Max. Input Frequency	300 kHz
	Protocols	EnDat 2.1, HIPERFACE
	Input Impedance	120 Ω
	Interpolation	Up to 16384 (14 bit)
Serial Synchronous (SSI) Encoder	Signal	Differential data and clock for synchronous encoders Data only for asynchronous encoders
	Protocols	sensAR, EnDat 2.2, BiSS-C (up to 26 bit), Nikon, Tamagawa
Motor Temperature	Signal	Thermal resistor PTC or NTC, User-defined fault threshold

Notes

* Some features are not available on all models. Refer to *Ordering Information*.

** Combined maximum current from motor and secondary feedback must not exceed 500 mA.

3.9 Secondary Feedback Specifications

Table 3-13. Secondary Feedback Specifications – All CDHD2 Models

Feature	Specification	
Power Supply	Supply Voltage from Drive	5 VDC
	Max. Supply Current from Drive to Encoder*	320 mA
Incremental Encoder	Differential RS422 or RS485	AB quadrature with or without index
	AB Quad. Max. Input Frequency	5 MHz (before quadrature)
	Min. Index Pulse Width	1 µs
Serial Encoder	Signal	Differential data and clock for synchronous encoders. Data only for asynchronous encoders.
	Protocols	EnDat 2.2, BiSS-C (up to 26 bit)
Functions		Dual loop, Master/Slave or Handwheel, Encoder readout

Notes ** Combined maximum current from motor and secondary feedback must not exceed 500 mA.

4 Drive Setup

4.1 Setup Overview

Perform the following steps to install and setup a CDHD2 system.

1. Mount the CDHD2.
2. Make all wiring and cable connections, as required by your application:
   - Grounding
   - Controller I/Os and/or Machine I/Os
   - Motor feedback
   - Fieldbus devices, if in use
   - CANopen network: set 120Ω termination resistor switches as required
   - Safe torque off (STO), or bypass using jumpers
   - Motor
   - Regeneration resistor, if required
   - Motor brake, if required
   - MV models: AC input voltage
   - LV models: DC input voltage
3. Connect the drive to the host computer.
4. Power up the drive and the host computer. Refer to *Power Up*.
5. Install ServoStudio 2 software. Refer to the ServoStudio 2 manual.
6. If required, define the drive communication address. Refer to *Drive Addressing*.

4.2 Power Up

After completing all hardware connections, you can turn on power to the drive.

Note If logic and bus AC supplies are separate, it is recommended that logic AC be turned on before bus AC.

Look at the digital display on the CDHD2 front panel.

During power up, the digital display shows 5 dashes (– – – – –).

Upon initial power up, the digital display indicates a Parameter Memory Checksum Failure (Fe). This fault will be cleared once the drive is configured and the parameters are saved in the drive's non-volatile memory.

4.3 Drive Addressing

If only one drive is connected to the host computer, the drive address is set to 0 by default and does not need to be defined.

If more than one drive is connected to the host computer, they must each be assigned a unique communication address. When configuring a daisy-chain, address 0 cannot be used.

- **MV** models: Set the drive address using the operator panel parameter P0003 (refer to the instructions below), or VarCom variable ADDR. Then enter SAVE and power-cycle the drive.
- **LV** models: Set the drive address using the rotary address switch on the front panel. Then power-cycle the drive.

Note The new address will take effect only after (SAVE and) power-cycle of the drive.

Setting the Drive Address

Code	**P0003**
Parameter	Drive Communication Address
VarCom	ADDR
Sequence	Press: Mode Select: (up/down) **P**arameter mode Display: **P0000** Select: (up/down) **P0003** Press: Shift Display: **00000**, flashing digit Select: (up/down) address value; for example: **2** Display: **00002**, flashing **2** Press: Long Shift + Mode (0.5 second) to apply value and execute CONFIG. or Press: Very Long Shift + Mode (2 seconds) for CONFIG and SAVE. Done: **done** Power cycle the drive after changing the address.

Within a CANopen network, a unique node address (identification number) must be allocated to each individual CANopen device.

Within an EtherCAT network, a physical node address (identification number) does not have to be specifically allocated to a device; the EtherCAT controller will assign the address. Two or more drives connected in the EtherCAT network can be set at the same physical address; the EtherCAT controller will automatically set the slave IDs.

4.4 Setup Preparation

4.4.1 Hardware and Tools

All required hardware and tools are specified in the table below.

In addition, you will need:

- **M4** ring or spade terminal for grounding on all models, except CDHD2-033, CDHD2-044, CDHD2-055.
- **M6** ring for grounding on CDHD2-033, CDHD2-044, CDHD2-055.
- **M2** spade terminal for logic connectors on CDHD2-033, CDHD2-044, CDHD2-055.
- A small, slotted screwdriver for setting switches.

Table 4-1. Required Tools (if not using ready-made cable assemblies)

MV Models – 120/240 VAC		
Item	**Model**	**Interface**
	All CDHD2 models	
Crimping tool	Molex 0638190000	P1
	CDHD2-1D5 **CDHD2-003**	
Crimping tool	YRF-1070	P2, P3
Extraction tool	EJ-JFAJ3	P2, P3
Key for spring connector	J-FAT-OT	
	CDHD2-4D5 **CDHD2-006**	
Crimping tool	YRF-1070	P2, P3, P4
Extraction tool	EJ-JFAJ3	P2, P3, P4
Key for spring connector	J-FAT-OT	
	CDHD2-008 **CDHD2-010** **CDHD2-013**	
Crimping tool	YRF-1130	P2, P3, P4
Crimping tool	YRF-1070	P5
Extraction tool	EJ-JFAJ4	P2, P3, P4
Extraction tool	EJ-JFAJ3	P5

For other models, no additional tools are needed.

4.4.2 Cables and Crimping

The various cables required for CDHD2 systems are detailed in the section *Cables*.

Prior to crimping, strip 2 mm at the end of wire, as shown in the following figure.

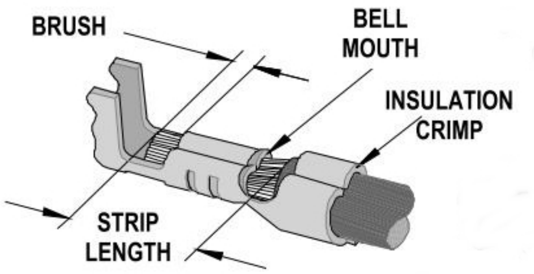


Figure 4-1. Stripped Wire in Crimp Pin

4.4.3 Mating Connectors – Control Board

For cable details, refer to *Cables*.

Table 4-2. Controller Interface C2 Mating Connector

I/F	Mfr.	Item	Manufacturer Part Number	Servotronix Part Number
C2	3M	Solder Plug Connector	10136-3000PE	CONr00000036-01
	3M	Solder Plug Junction Shell	10336-52F0-008	HODr00000036-00

Table 4-3. Machine Interface C3 Mating Connector

I/F	Mfr.	Item	Manufacturer Part Number	Servotronix Part Number
C3	3M	Solder Plug Connector	10120-3000PE	CONr00000020-38
	3M	Solder Plug Junction Shell	10320-52F0-008	HODr00000020-00

Table 4-4. Feedback C4 Mating Connector

I/F	Mfr.	Item	Manufacturer Part Number	Servotronix Part Number
C4	3M	Solder Plug Connector	10126-3000PE	CONr00000026-31
	3M	Solder Plug Junction Shell	10326-52F0-008	HODr00000026-00

Table 4-5. Fieldbus Communication (EtherCAT/CAN) C5/C6 Mating Connector

I/F	Mfr.	Item	Manufacturer Part Number	Servotronix Part Number
C5/C6	Molex	Connector	44915-0011	–

Table 4-6. RS232 Serial Communication C7 Mating Connector

I/F	Mfr.	Item	Manufacturer Part Number	Servotronix Part Number
C7	AIM-Cambridge	Connector	32-5964UL	–

Table 4-7. RS232 Serial Communication C8 Mating Connector

I/F	Mfr.	Item	Manufacturer Part Number	Servotronix Part Number
C8	TE	Connector	1658527-3	CONr00000010-67

4.4.4 Mating Connectors – Power Board

Note All power board mating connectors are supplied with the drive.

Table 4-8. CDHD2-1D5/CDHD2-003 (MV) Mating Connectors

I/F	Function	Mfr.	Manufacturer Part Number	Servotronix Part Number
P1	STO	Molex	Housing: 436450400 Crimp x4: 0430300001	CONr10000004-09 PINr43030000-00
				CONr00000004-AS (STO jumper)
P2	Motor	JST	Spring: 04JFAT-SBXGF-I	CONr10000004-19
			Housing: F32FSS-04V-KX Crimp x4: SF3F-71GF-P2.0	CONr10000004-13 PINrSF3F71GF-00
P3	AC Input and Regen	JST	Spring: 06JFAT-SBXGF-I	CONr10000006-06
			Housing: F32FSS-06V-KX Crimp x6: SF3F-71GF-P2.0	CONr00000006-91 PINrSF3F71GF-00

Table 4-9. CDHD2-4D5/CDHD2-006 (MV) Mating Connectors

I/F	Function	Mfr.	Manufacturer Part Number	Servotronix Part Number
P1	STO	Molex	Housing: 436450400 Crimp x4: 0430300001	CONr10000004-09 PINr43030000-00
				CONr00000004-AS (STO jumper)
P2	Motor	JST	Spring: 04JFAT-SBXGF-I	CONr10000004-19
			Housing: F32FSS-04V-KX Crimp x4: SF3F-71GF-P2.0	CONr10000004-13 PINrSF3F71GF-00
P3	Regen	JST	Housing: F32FSS-02V-KX Crimp x2: SF3F-71GF-P2.0	CONr10000002-10 PINrSF3F71GF-0
P4	AC Input	JST	Spring: 05JFAT-SBXGF-I	CONr10000005-04
			Housing: F32FSS-05V-KX Crimp x5: SF3F-71GF-P2.0	CONr10000005-03 PINrSF3F71GF-00

Table 4-10. CDHD2-008/CDHD2-010/CDHD2-013 (MV) Mating Connectors

I/F	Function	Mfr.	Manufacturer Part Number	Servotronix Part Number
P1	STO	Molex	Housing: 436450400 Crimp x4: 0430300001	CONr10000004-09 PINr43030000-00
				CONr00000004-AS (STO jumper)
P2	Motor	JST	Housing: J43FSS-04V-KX Crimp x4: SJ4F-71GF-M3.0	CONr10000004-18 CRPrSJ4F71GF-00
P3	Regen	JST	Housing: J42FSC-02V-K Crimp x2: SJ4F-71GF-M3.0	CONr10000002-14 CRPrSJ4F71GF-00
P4	Main AC Input	JST	Housing: J43FSS-03V-KX Crimp x3: SJ4F-71GF-M3	CONr10000003-19 CRPrSJ4F71GF-0
P5	Logic AC Input	JST	Housing: F32FSS-02V-KX Crimp x2: SF3F-71GF-P2.0	CONr10000002-10 PINrSF3F71GF-00

Table 4-11. CDHD2-020/CDHD2-024 (MV) Mating Connectors

I/F	Function	Mfr.	Manufacturer Part Number	Servotronix Part Number
P1	STO	Molex	Housing: 436450400 Crimp x4: 0430300001	CONr10000004-09 PINr43030000-00
				CONr00000004-AS (STO jumper)
P2	Motor	Phoenix	Spring: SPC 5/4-STCL-7,62 (1718504)	CONr10000004-2
P3	Regen	Phoenix	Spring: SPC 5/2-STCL-7,62 (1718481)	CONr10000002-16
P4	Main AC Input	Phoenix	Spring: SPC 5/3-STCL-7,62 (1718494)	CONr10000003-21
P5	Logic AC Input	Phoenix	Spring: FKC 2.5/2-STF-5.08 (1873207)	CONr10000002-25

Table 4-12. CDHD2-033/CDHD2-044/CDHD2-055 (MV) Mating Connectors

I/F	Function	Mfr.	Manufacturer Part Number	Servotronix Part Number
P1	STO	Molex	Housing: 436450400 Crimp x4: 0430300001	CONr10000004-09 PINr43030000-00
				CONr00000004-AS (STO jumper)

Table 4-13. CDHD2-003/CDHD2-006/CDHD2-012/CDHD2-015/CDHD2-018 (LV) Mating Connectors

I/F	Function	Mfr.	Manufacturer Part Number	Servotronix Part Number
P2	Motor	Würth	691340500004	CONr10000004-74
P3	Power	Würth	691340500005	CONr10000005-45

Note: LV model CDHD2-018: for future release.

4.4.5 Host Computer System

The following computer system and software are required:

- 2 GHz CPU
- 1 GB RAM
- 1000 MB available on hard drive (after .net 4 is installed)
- Communication interface for connection to the drive; one of the following:
  - USB port
  - USB port and USB-to-RS232 adaptor with ferrite bead
  - RS232 port
- Operating system: Windows 7, Windows 8, Windows 10. 32-bit or 64-bit.
- For ServoStudio 2, the recommended screen resolution is 1280x800;
  minimal resolution is 1024x800.
  It is recommended that Windows display settings be set to **Smaller – 100% (Default)**.
- .Net4 (for details, refer to .NET Framework System Requirements). If .NET 4 is not installed on the computer, ServoStudio 2 will guide you through the installation but will not install it automatically.
- ServoStudio 2, the graphical software interface for configuring and testing the drive.
  Download from the Servotronix website or contact Technical Support.
  Refer to *Software Installation* in the ServoStudio 2 manual.

Note ServoStudio 2, provides compatibility with CDHD2 firmware version 2.0 and later.

Installing ServoStudio 2

1. Download ServoStudio 2 software installation file from the Servotronix website or contact Technical Support.
2. Install ServoStudio 2 software on the host computer.
3. When installation is complete, start ServoStudio 2 from the Windows Start menu or the shortcut on your desktop.

Note If the error message, **The system cannot find the file specified,** is displayed when installing the software, do the following:

- Copy the installation file to the computer hard drive.
- Right-click the installation file, and select Run as Administrator.

Installing USB Device Drivers for CDHD2

The ServoStudio 2 installation attempts to install the USB drivers for CDHD2 automatically, using the driver files in C:\Program Files (x86)\ Servotronix\ServoStudio 2\Drivers\.
Alternately, if the PC is connected to the Internet, and the PC and the CDHD2 are connected by USB cable, Windows will attempt to automatically download and install the USB drivers if does not detect them on the PC.

If neither automatic installation succeeds, install the drivers from the Windows Device Manager, according to the following steps.

1. Open the Windows Device Manager.
2. Under **Ports** or **Universal Serial Bus controllers**, find the device/icon marked as **Unknown**.
3. Right-click on the unknown device and select **Update Driver**.
4. Select **Browse my computer**, and browse to the location:
   C:\Program Files (x86)\ Servotronix\ServoStudio 2\Drivers\
5. Make sure the option **Include subfolders** is selected, and press **Next**.
6. When prompted by Windows, press **Install**.
7. Repeat steps 3 to 6.

Notes

The USB drivers have two layers; therefore, it is recommended to repeat the **Update Driver** procedure twice.

CDHD2 USB drivers are digitally signed.

CDHD2 USB drivers are supported in Windows 7 and 10, 32-bit and 64-bit.

4.4.6 Files for Fieldbus Devices

- EDS file for CDHD2 (if using CAN protocol) on the host computer or PLC controller. Download from the Servotronix website or contact Technical Support.
- XML file for CDHD2 (if using EtherCAT protocol) on the host computer or PLC controller. Download from the Servotronix website or contact Technical Support.

4.5 System Wiring

4.5.1 CDHD2-1D5/CDHD2-003 (MV) System Wiring

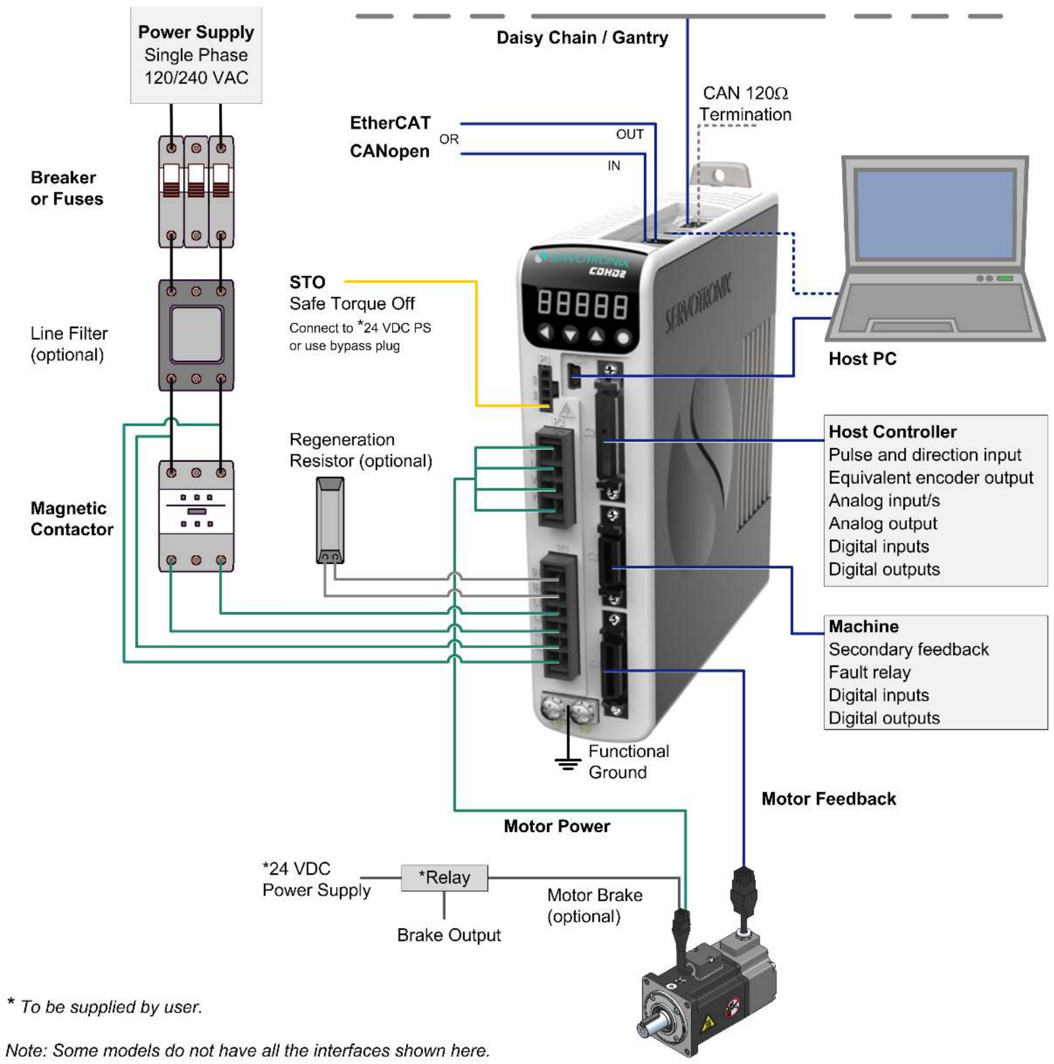


Figure 4-2. Servo System Wiring, Single Phase – CDHD2-1D5/CDHD2-003 (MV)

4.5.2 CDHD2-4D5/CDHD2-006 (MV) System Wiring

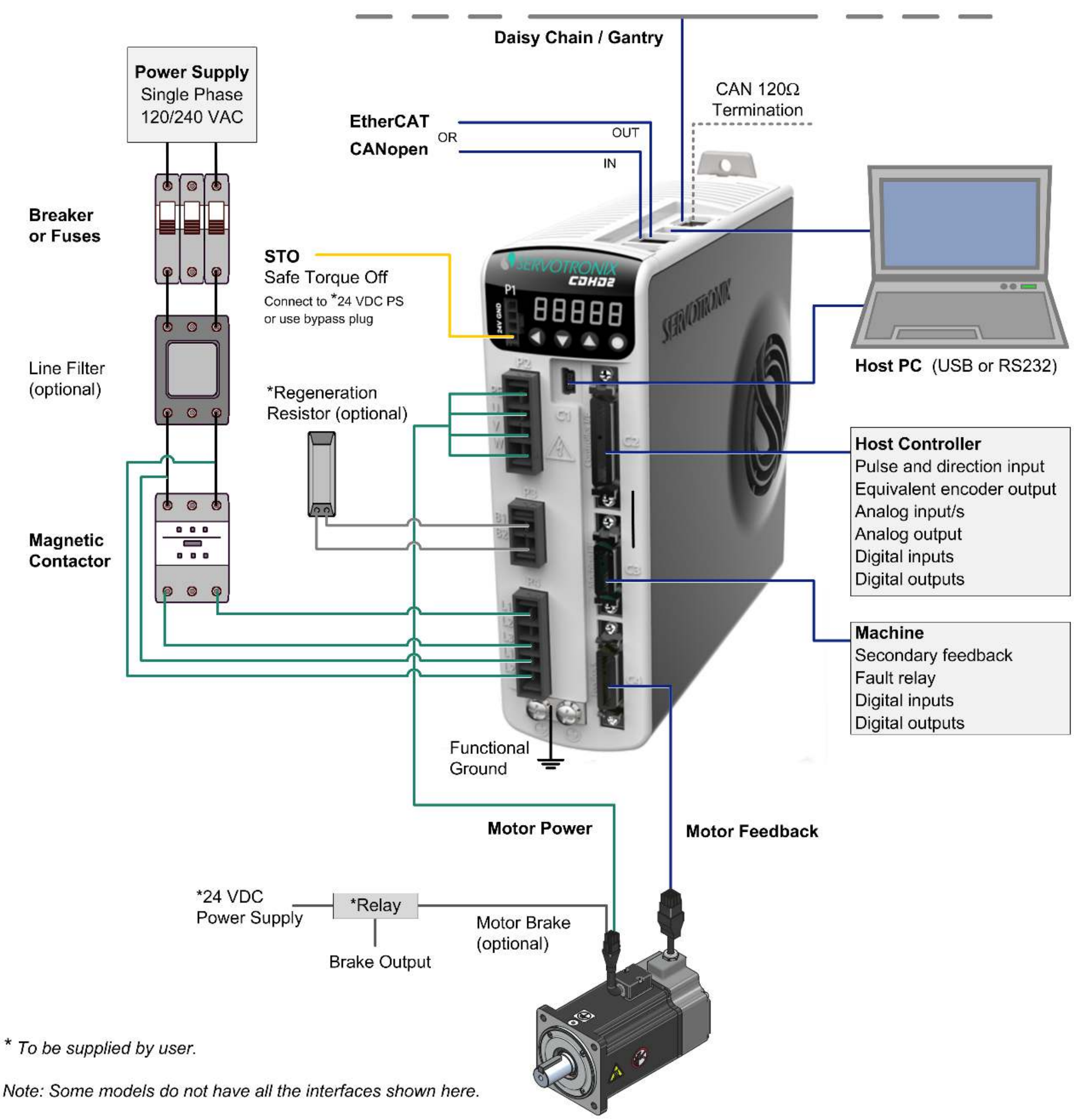


Figure 4-3. Servo System Wiring, Single Phase – CDHD2-4D5/CDHD2-006 (MV)

4.5.3 CDHD2-008/CDHD2-010/CDHD2-013 (MV) System Wiring

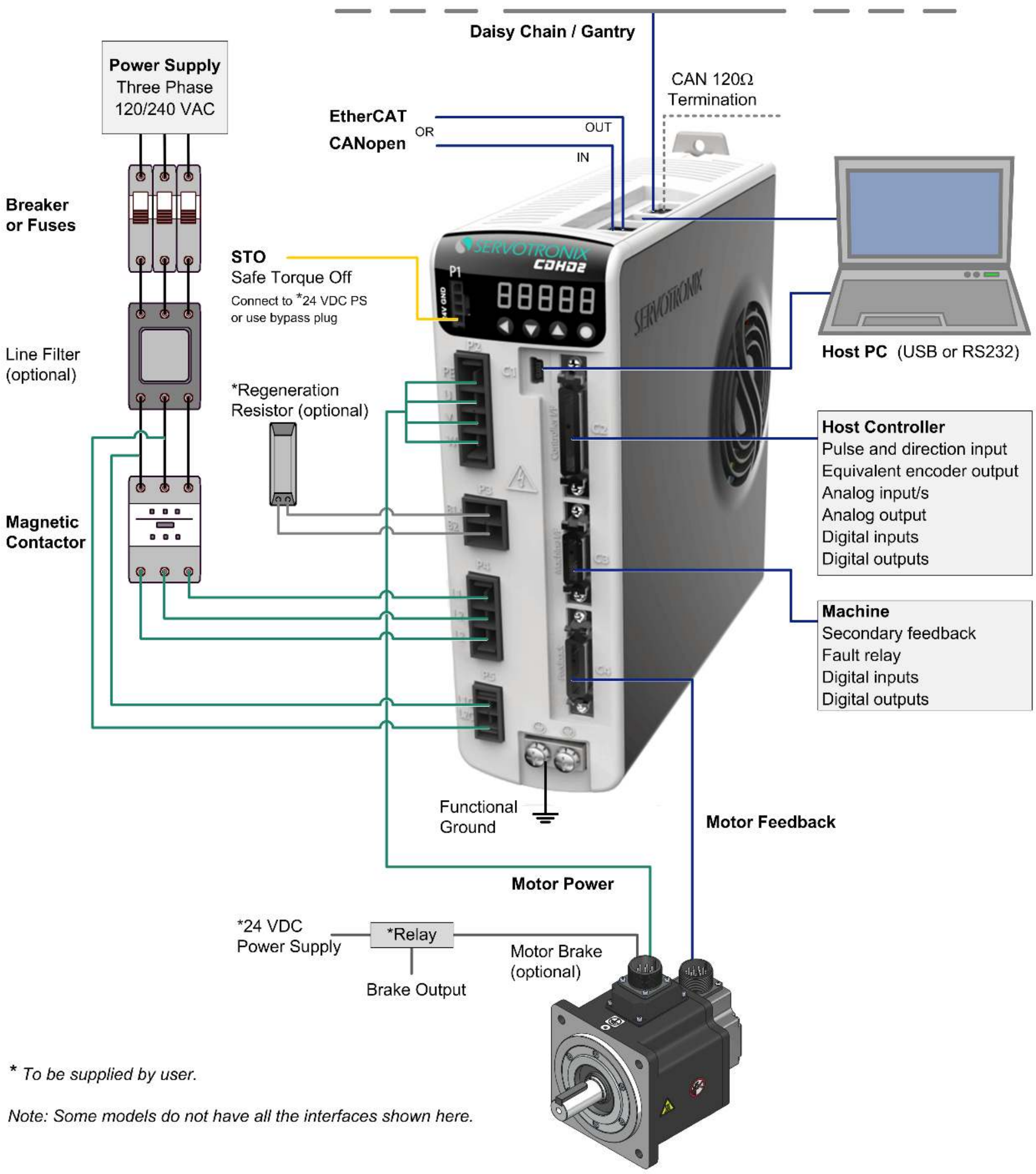
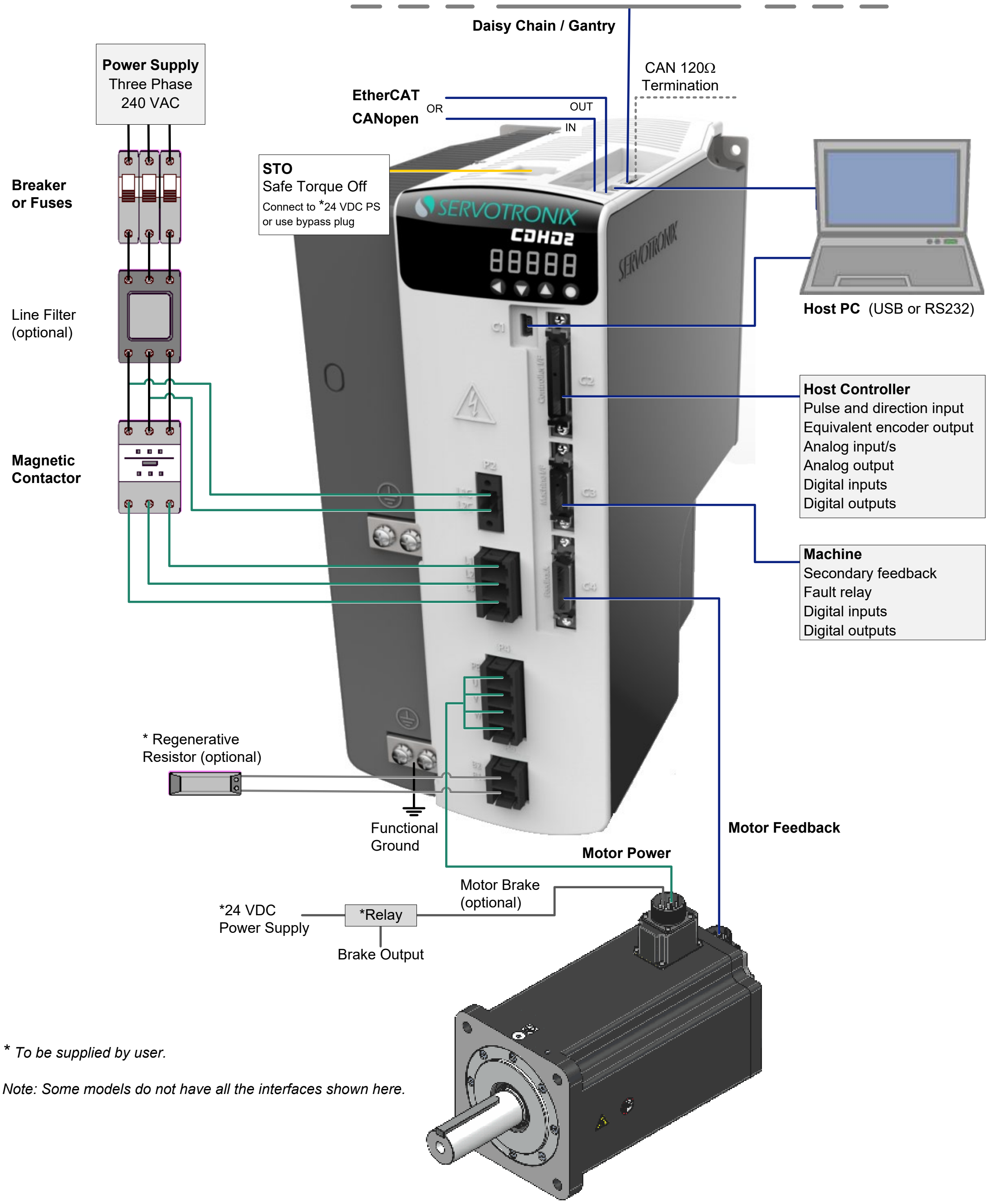


Figure 4-4. Servo System Wiring, Three Phase – CDHD2-008/CDHD2-010/CDHD2-013 (MV)

4.5.4 CDHD2-020/CDHD2-024 (MV) System Wiring



** To be supplied by user.*

Note: Some models do not have all the interfaces shown here.

Figure 4-5. Servo System Wiring, Three Phase – CDHD2-020/CDHD2-024 (MV)

4.5.5 CDHD2-033/CDHD2-044/CDHD2-055 (MV) System Wiring

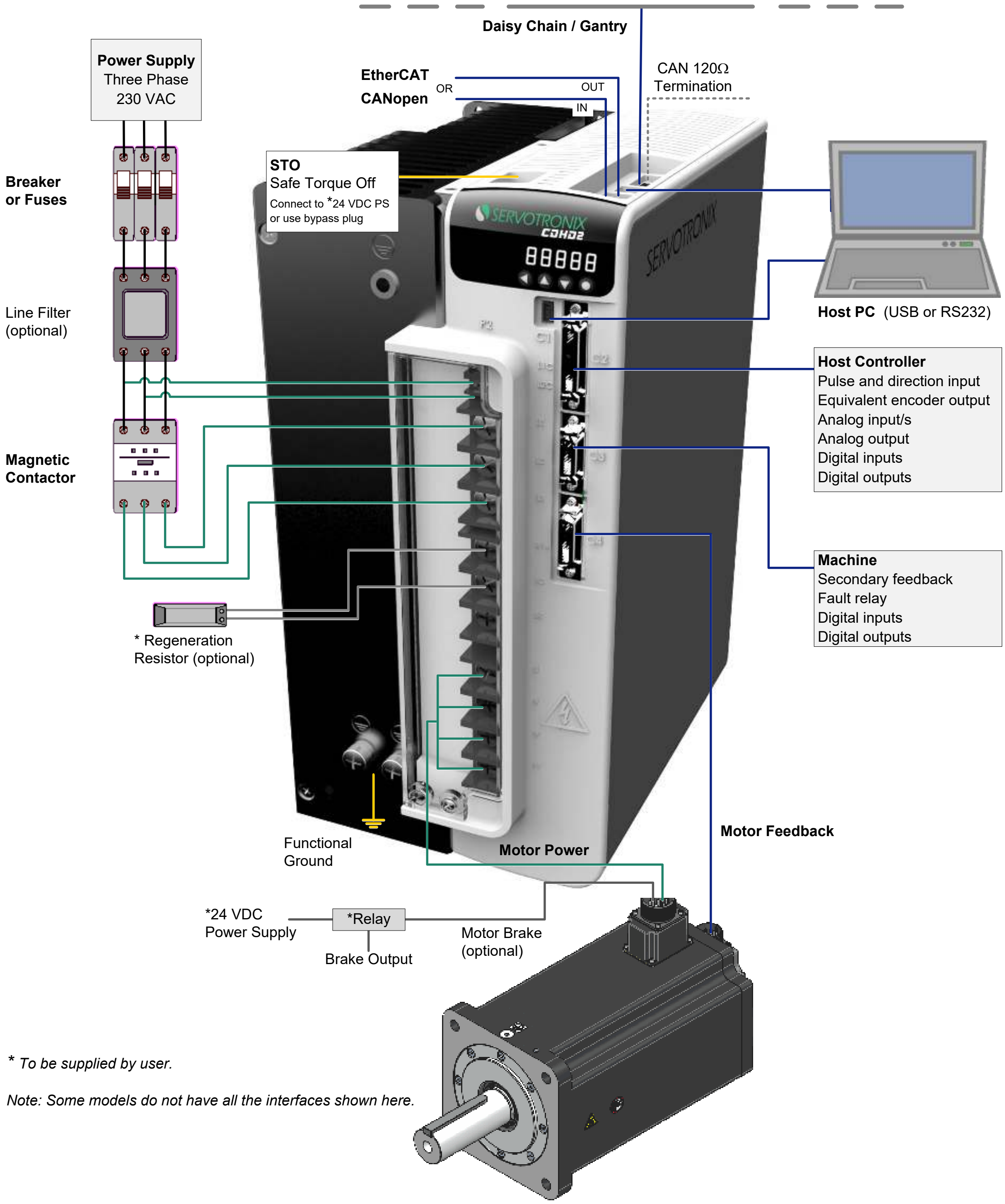


Figure 4-6. Servo System Wiring, Three Phase – CDHD2-033/CDHD2-044/CDHD2-055 (MV)

4.5.6 CDHD2-003/006/012/015/18 (LV) System Wiring

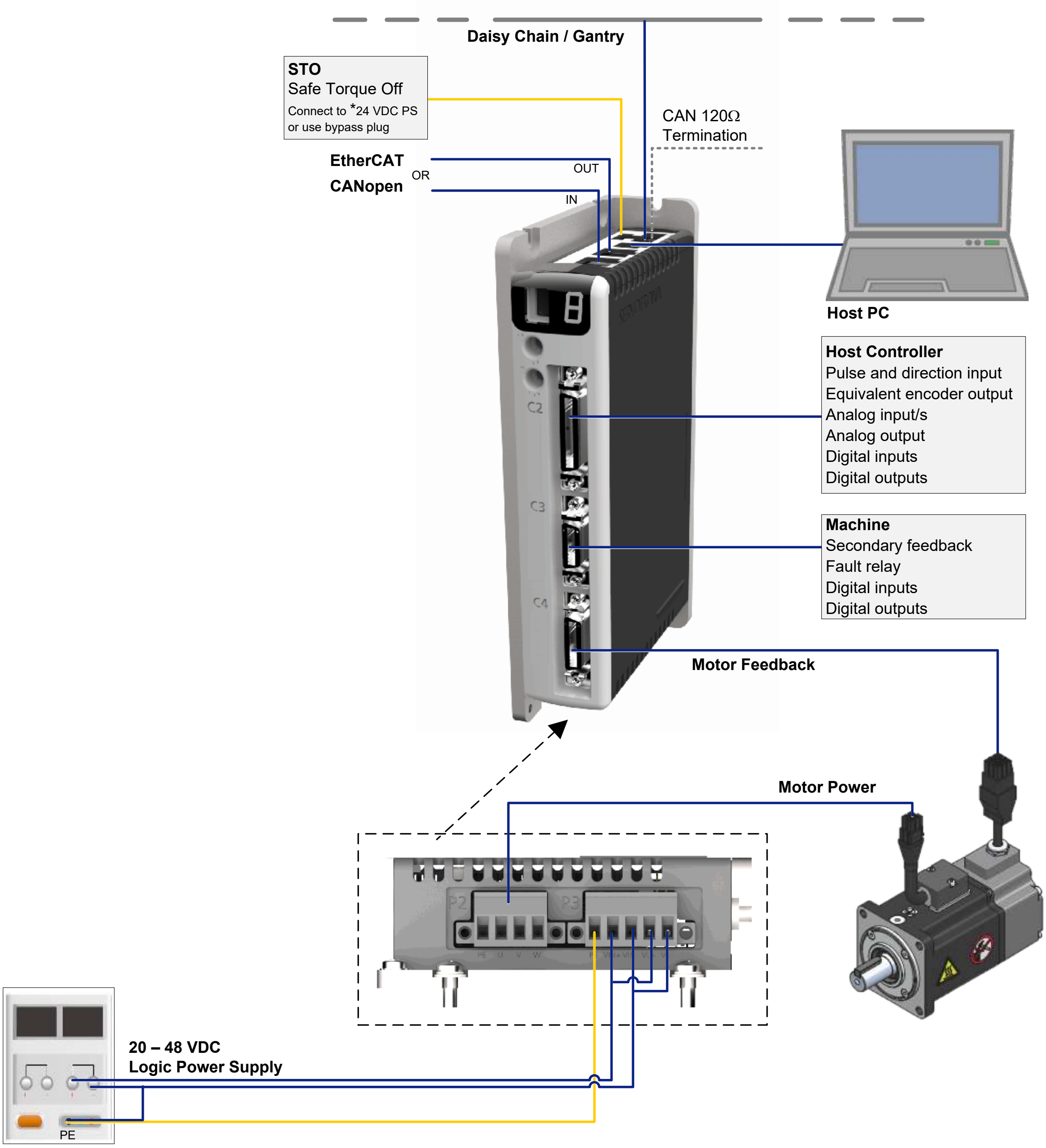


Figure 4-7. CDHD2-003/006/012/015/018 (LV) – System Wiring (1 power supply)

Note: LV model CDHD2-018: for future release.

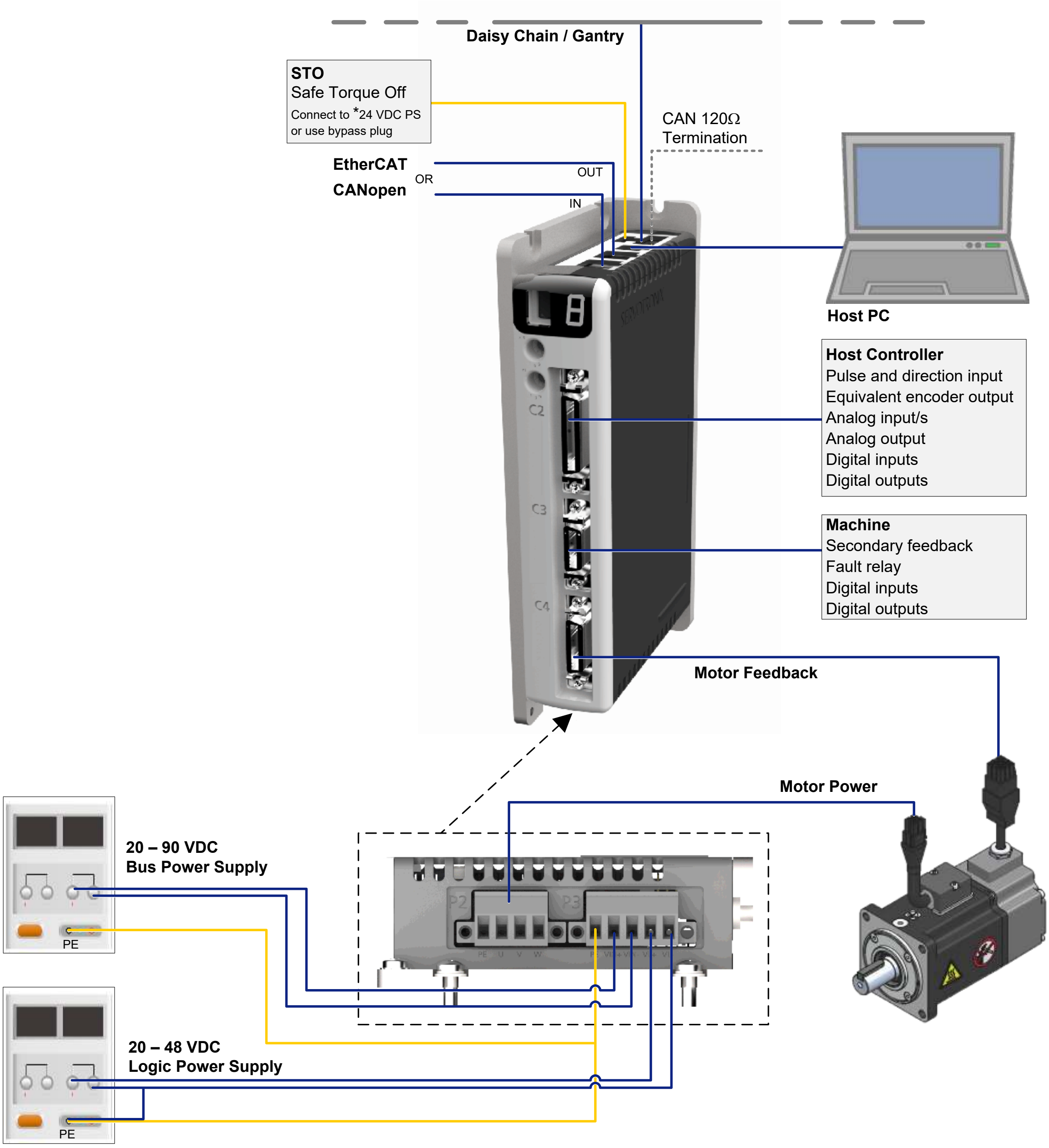


Figure 4-8. CDHD2-003/006/012/015/018 (LV) – System Wiring (2 power supplies)

Note: LV model CDHD2-018: for future release.

4.6 EMI Suppression

4.6.1 CE Filtering Techniques

The CDHD2 drive complies with the CE standards specified in *Standards Compliance*. Proper bonding, grounding and filtering techniques must be applied in order to meet this standard.

Noise currents often occur in two types. The first is conducted emissions that are passed through ground loops. The quality of the system grounding scheme inversely determines the noise amplitudes in the lines. These conducted emissions are of a common-mode nature from line to neutral (or ground). The second is radiated high-frequency emissions usually capacitively coupled from line-to-line and are differential in nature.

To properly mount the EMI filters, the enclosure should have an unpainted metallic surface. This allows for more surface area to be in contact with the filter housing and provides a lower impedance path between this housing and the back plane. The back panel, in turn, has a high frequency ground strap connection to the enclosure or earth ground.

4.6.2 Grounding

When connecting the CDHD2 to other control equipment, be sure to follow two basic guidelines to prevent damage to the drive:

- The CDHD2 must be grounded via the earth ground of the main AC voltage supply.
- Any motion controller, PLC or PC that is connected to the CDHD2 must be grounded to the same earth ground as the CDHD2.

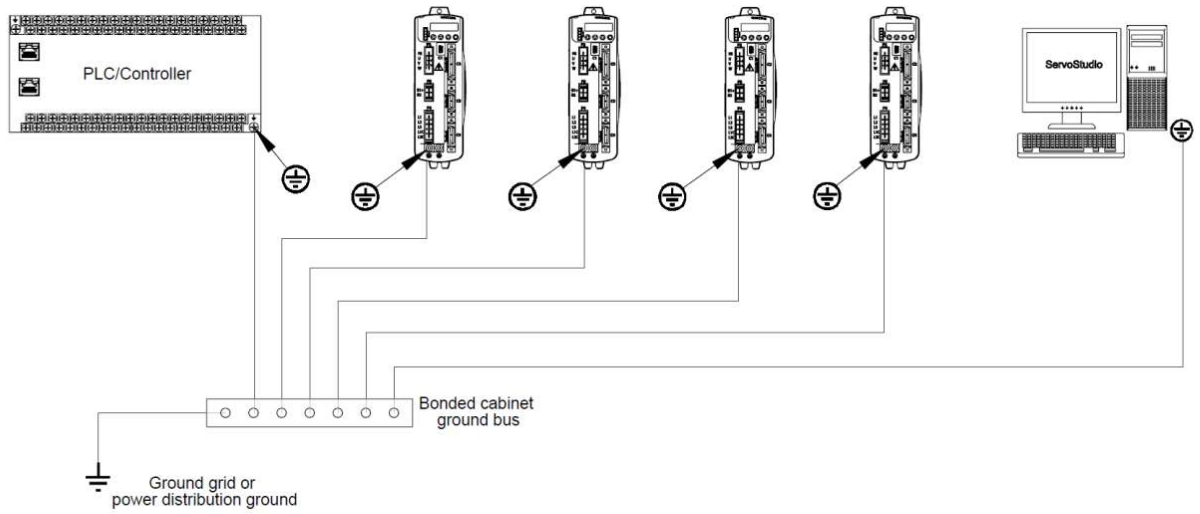


Figure 4-9. CDHD2 System Grounding

System grounding is essential for proper performance of the drive system.

The AC input voltage ground wire must be connected to the PE terminal, located on the CDHD2 front panel. This is necessary for both safety and EMI reduction.

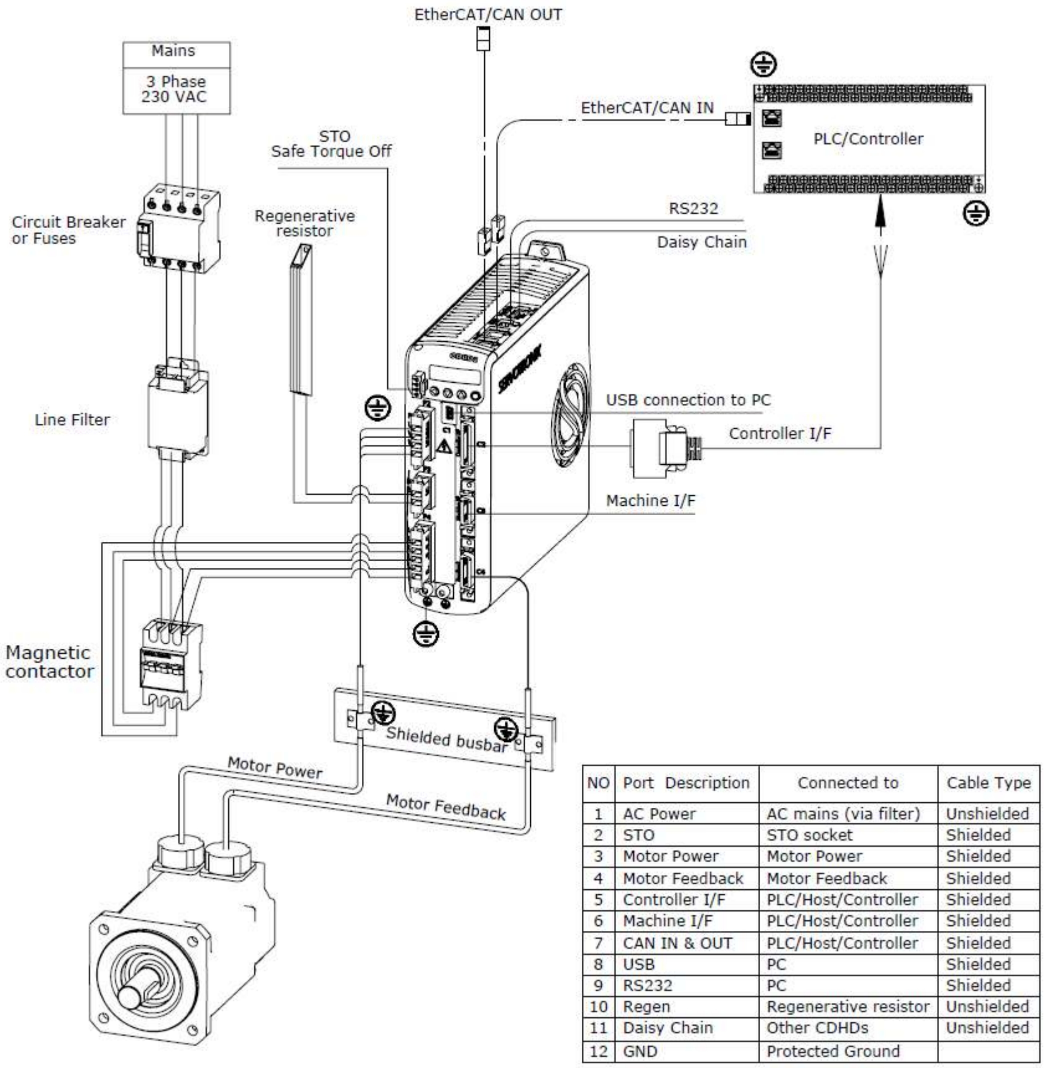
Use a single point ground for the system (start wiring) to avoid ground loops.

It is strongly recommended that the CDHD2 be mounted to a metallic back panel, and that a high frequency ground be provided to connect the back panel to earth ground. Provide an electrical connection across the entire back surface of the drive panel. Electrically-conductive panels such as aluminum or galvanized steel are recommended. For painted and other coated metal panels, remove all coating behind the drive. The objective is to provide an extremely low impedance path between the filters, drives, power supplies, and earth ground for high-frequency signals that might cause EMI. Use a flat braid or copper busbar to achieve high-frequency grounding. Use the shortest braid possible when connecting high frequency grounds.

Ensure good connections between the cabinet components. Connect the back panel and cabinet door to the cabinet body using several conductive braids. Never rely on hinges or mounting bolts for ground connections. Ensure good ground connection from cabinet to proper earth ground. Ground leads should be the same gauge as the leads to main power or one gauge smaller.

The host computer must also be properly grounded.

4.6.3 Shielding and Bonding



NO	Port Description	Connected to	Cable Type
1	AC Power	AC mains (via filter)	Unshielded
2	STO	STO socket	Shielded
3	Motor Power	Motor Power	Shielded
4	Motor Feedback	Motor Feedback	Shielded
5	Controller I/F	PLC/Host/Controller	Shielded
6	Machine I/F	PLC/Host/Controller	Shielded
7	CAN IN & OUT	PLC/Host/Controller	Shielded
8	USB	PC	Shielded
9	RS232	PC	Shielded
10	Regen	Regenerative resistor	Unshielded
11	Daisy Chain	Other CDHDs	Unshielded
12	GND	Protected Ground	

Figure 4-10. CDHD2 Shielding and Bonding

To minimize noise emissions and maximize the immunity levels of the drive system, motor and feedback cables must be shielded and properly bonded to a grounded surface.

The shield must be connected to ground at both ends of the cable. Its effect is to reduce the impedance between the cable shield and the back panel.

It is recommended that all shielded cables be bonded to the back panel.

The motor and feedback shielded cables should be exposed as close as possible to the drive. This exposed cable shield is bonded to the back panel using either non-insulated metallic cable clamps or cable bonding clamps.

It is recommended to use a star point shield connection with a shielding busbar.

4.6.4 Input Power Filtering

The CDHD2 electronic system components require EMI AC line filtering in the input power leads to meet the CE requirements for the industrial environment.

Care must be taken to adequately size the system. The type of filter is determined according to the voltage and current rating of the system and whether the incoming line is single phase or three phase. One input line filter can be used for multi-axis control applications.

For manufacturer names and part numbers of line filters recommended for the CDHD2, refer to *Line Filters*.

Implementation of the input power filter must adhere to the following guidelines:

- Maintain separation of leads entering and exiting the mains filter.
- Filter must be mounted on the same panel as the drive.
- Filter must be mounted as close as possible to the drive, to prevent noise from being capacitively coupled into other signal leads and cables.
- When mounting the filter to the panel, remove any paint or material covering. Use an unpainted metallic back panel, if possible.
- Filters are provided with a ground terminal, which must be connected to ground.
- Filters can produce high leakage currents. Filters must be grounded before connecting the supply.
- Filters should not be touched for 10 seconds after removing the supply.

4.6.5 Additional EMI Suppression Recommendations

Power and control cables should be routed separately. A distance of at least 200 mm is recommended, and improves the interference immunity.

If input power and motor leads need to cross, make sure they cross at a 90° angle.

Feedback lines may not be extended, since this would cause the shielding to be interrupted, and possibly disturb the signal processing.

Splice cables properly. If you need to divide cables, use connectors with metal backshells. Make sure that both shells connect along the circumference of the shields. No portion of the cabling should be unshielded. Never divide a cable across a terminal strip.

For differential inputs for analog signals, use twisted-pair, shielded signal lines, connecting shields on both ends.

4.7 Electrical System Considerations

4.7.1 Fuses

Circuit protection must be compliant with the National Electrical Code and/or the regulations defined by national, state, provincial and/or local authorities.

- US fuses: Class RK5 or CC or J or T, 600 VAC 200 kA, time-delay. The fuse must be UL and CSA listed; UR-recognized is not sufficient.
- EU fuses: Types gRL or gL, 400 V/500 V, time-delay.
- Fuse holders: Standard fuse blocks, or finger-safe fuse holders according to IEC 60529. For example:
  - Bussmann: CH Series modular fuse holders, fuse size up to 30A, class J, 3 poles: CH30J3
  - Ferraz: Ultrasafe fuse holders, fuse size up to 30A, class J, 3 poles: US3J3I

4.7.2 Leakage Current

Leakage current via the PE conductor results from the combination of equipment and cable leakage currents. The leakage current frequency pattern comprises a number of frequencies, whereby the residual-current circuit breakers definitively evaluate the 50 Hz current. For this reason, the leakage current cannot be measured using a conventional multimeter.

As a rule of thumb, the following assumption can be made for leakage current on cables, depending on the PWM frequency of the output stage:

- *Ileak* = *n* x 20 mA + *L* x 1 mA/m at 8 kHz PWM frequency at the output stage
- *Ileak* = *n* x 20 mA + *L* x 2 mA/m at a 16 kHz PWM frequency at the output stage

  (where *Ileak*=leakage current, *n*=number of drives, *L*=length of motor cable)

Since the leakage current to PE is greater than 3.5 mA, compliance with IEC61800-5-1 requires that either the PE connection be doubled or a connecting cable with a cross-section greater than 10 mm² be used. Use the PE terminal and the PE connection screws to meet this requirement.

4.8 Mechanical Installation

4.8.1 Mounting the CDHD2

Using the bracket on the back of the CDHD2, mount the CDHD2 on a grounded conductive metal panel. The panel must be sufficiently rigid.

For mounting dimensions, refer to *Dimensions*.

4.8.2 Mounting Multiple Units

When multiple CDHD2 units are mounted side-by-side within a cabinet or enclosure, the recommended minimum spacing between units is 10 mm. The recommended minimum top and bottom clearance is 50 mm for all CDHD2 models.

It is important to maintain an ambient temperature within the enclosure that does not exceed 45°C. If CDHD2 units are mounted on a backplane, also make sure the backplane temperature does not exceed 45°C. It is recommended that a cooling fan be installed at the bottom of the cabinet for best circulation.

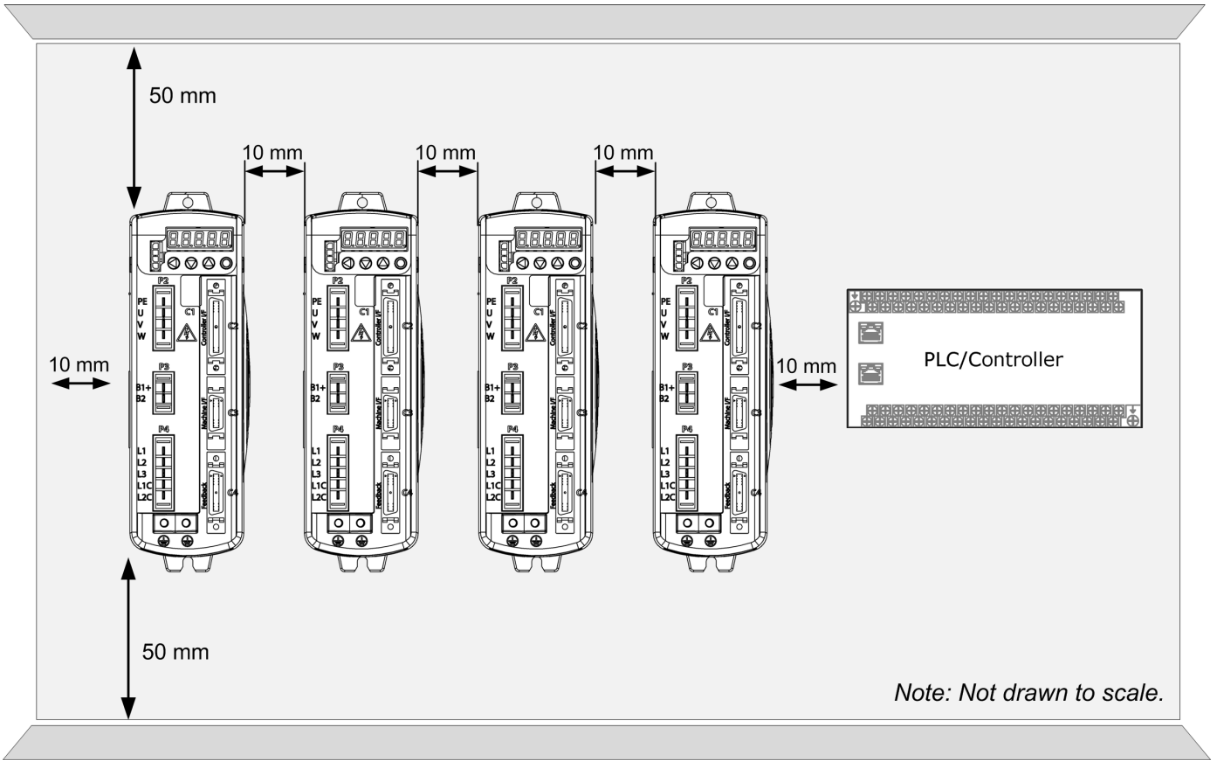


Figure 4-11. Mounting Multiple CDHD2 Units within Cabinet

4.9 Control Board Connections

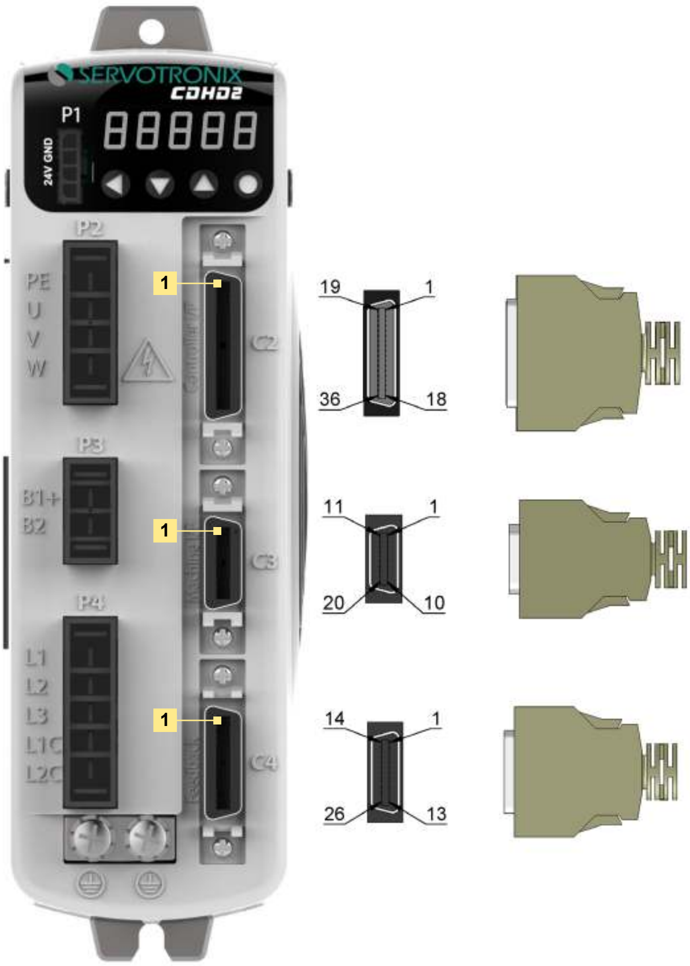
The control board interfaces vary depending on the specific CDHD2 model, as detailed in the following table.

Table 4-14. Controller Board Interfaces

CDHD2 Model		AP	AF	EC	EB
Function	**Interface**				
USB serial communication	**C1**	–	■	■	■
RS232 serial communication	**C7**	■	■	■	–
CANopen communication	**C5 + C6**	–	■	–	–
EtherCAT communication		–	–	■	■
Daisy chain communication	**C8**	■	■	■	■
Controller interface	**C2**	■	■	■	■
Pulse and direction input		■	■	■	–
Equivalent encoder output		■	■	■	–
Analog inputs		1 or 2	1 or 2	1 or 2	2
Analog output		1	1	1	0
Digital inputs	**C2 | C3**	8	8	8	4
Fast digital inputs		3	3	3	1
Digital outputs		6	6	6	3
Fast digital outputs		2	2	2	0
Machine interface	**C3**	■	■	■	–
Secondary feedback		■	■	■	–
Fault relay		■	■	■	–
Motor feedback interface	**C4**	■	■	■	■
Sine encoder		■	■	■	■
Motor temperature sensor		■	■	■	■
Motor feedback 8V supply		–	■	■	–
Motor feedback resolver		■	■	■	–

4.9.1 CDHD2-AP (MV) Control Board Pinouts

I/F	Mfgr	Mating Connector	Manufacturer PN	Servotronix PN
C2	3M	Solder Plug Connector	10136-3000PE	CONr00000036-01
	3M	Solder Plug Junction Shell	10336-52F0-008	HODr00000036-00
C3	3M	Solder Plug Connector	10120-3000PE	CONr00000020-38
	3M	Solder Plug Junction Shell	10320-52F0-008	HODr00000020-00
C4	3M	Solder Plug Connector	10126-3000PE	CONr00000026-31
	3M	Solder Plug Junction Shell	10326-52F0-008	HODr00000026-00



Each type of drive (AP, AF, EC, EB) *has the same control board, regardless of rating.*

Controller I/F **C2**: MDR 36 Plug | 24-28 AWG			
1	Common output	19	Common input
2	Digital output 1	20	Digital input 2
3	Digital input 1	21	
4	Equivalent encoder output A-	22	Equivalent encoder output A+
5	Equivalent encoder output B-	23	Equivalent encoder output B+
6	Equivalent encoder output Z-	24	Equivalent encoder output Z+
7		25	Ground
8	Analog input 1+	26	Analog input 1-
9	Direction input+	27	Direction input-
	Secondary encoder B+		Secondary encoder B-
10	Ground	28	Pulse input+
			Secondary encoder A+
11	Pulse input-	29	Ground
	Secondary encoder A-		
12	Fast digital output 8	30	Fast digital output 7
13	Ground	31	Digital input 3
14	Digital input 4	32	Fast digital input 5
15	Fast digital input 6	33	Digital output 2
16	Digital output 3	34	Fast digital output 24V return
17	Fast digital output 24V	35	* Analog input 2-
18	* Analog input 2+	36	Analog output

* Optional. Refer to *Ordering Options*.

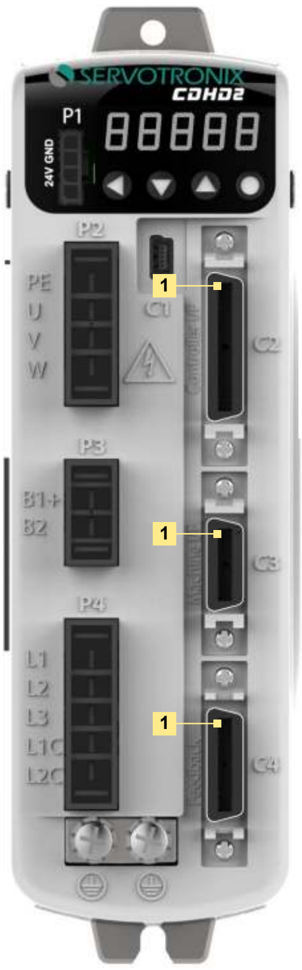
Machine I/F **C3**: MDR 20 Plug | 24-28 AWG			
1	Secondary encoder A+	11	Secondary encoder A-
	Pulse input +		Pulse input -
2	Secondary encoder B+	12	Secondary encoder B-
	Direction input+		Direction input-
3	Secondary encoder Z+	13	Secondary encoder Z-
4	Secondary encoder 5V	14	Secondary encoder ground
5	Digital input 7	15	Digital input 8
6	Digital input 9	16	Digital input 10
7	Fast digital input 11	17	Digital output 4
8	Digital output 5	18	Digital output 6
9	Common input	19	Common output
10	Fault relay 1	20	Fault relay 2

Feedback **C4**: MDR 26 Plug | 24-28 AWG			
1	Incremental encoder A +	14	Incremental encoder A -
	SSI encoder data +		SSI encoder data -
2	Incremental encoder B +	15	Incremental encoder B -
	SSI encoder clock +		SSI encoder clock -
3	Incremental encoder Z +	16	Incremental encoder Z -
4	Hall U +	17	Hall V+
5	Hall W +	18	
6	Resolver sine +	19	Resolver sine -
7	Resolver cosine +	20	Resolver cosine -
8	Resolver reference +	21	Resolver reference -
9	Sine encoder sine +	22	Sine encoder sine -
10	Sine encoder cosine +	23	Sine encoder cosine -
11	5V supply for feedback device	24	Ground (5V return)
12	Motor temperature sensor	25	Motor temperature sensor
13	5V supply for feedback device	26	Shield

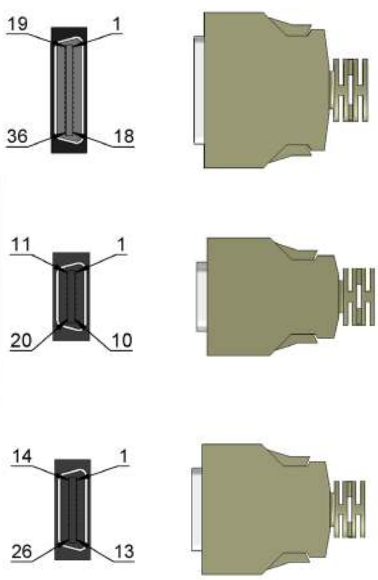
Figure 4-12. CDHD2 (MV) AP Models Control Board Pin Assignments

4.9.2 CDHD2-AF (MV) Control Board Pinouts

I/F	Mfgr	Mating Connector	Manufacturer PN	Servotronix PN
C2	3M	Solder Plug Connector	10136-3000PE	CONr00000036-01
	3M	Solder Plug Junction Shell	10336-52F0-008	HODr00000036-00
C3	3M	Solder Plug Connector	10120-3000PE	CONr00000020-38
	3M	Solder Plug Junction Shell	10320-52F0-008	HODr00000020-00
C4	3M	Solder Plug Connector	10126-3000PE	CONr00000026-31
	3M	Solder Plug Junction Shell	10326-52F0-008	HODr00000026-00



USB	
C1: Mini-B	
1	5V
2	Data -
3	Data +
4	
5	GND



Controller I/F **C2**: MDR 36 Plug | 24-28 AWG			
1	Common output	19	Common input
2	Digital output 1	20	Digital input 2
3	Digital input 1	21	
4	Equivalent encoder output A-	22	Equivalent encoder output A+
5	Equivalent encoder output B-	23	Equivalent encoder output B+
6	Equivalent encoder output Z-	24	Equivalent encoder output Z+
7		25	Ground
8	Analog input 1+	26	Analog input 1-
9	Direction input+	27	Direction input-
	Secondary encoder B+		Secondary encoder B-
10	Ground	28	Pulse input+
			Secondary encoder A+
11	Pulse input-	29	Ground
	Secondary encoder A-		
12	Fast digital output 8	30	Fast digital output 7
13	Ground	31	Digital input 3
14	Digital input 4	32	Fast digital input 5
15	Fast digital input 6	33	Digital output 2
16	Digital output 3	34	Fast digital output 24V return
17	Fast digital output 24V	35	* Analog input 2-
18	* Analog input 2+	36	Analog output
* Optional. Refer to *Ordering Options*.			

Machine I/F **C3**: MDR 20 Plug | 24-28 AWG			
1	Secondary encoder A+	11	Secondary encoder A-
	Pulse input +		Pulse input -
2	Secondary encoder B+	12	Secondary encoder B-
	Direction input+		Direction input-
3	Secondary encoder Z+	13	Secondary encoder Z-
4	Secondary encoder 5V	14	Secondary encoder ground
5	Digital input 7	15	Digital input 8
6	Digital input 9	16	Digital input 10
7	Fast digital input 11	17	Digital output 4
8	Digital output 5	18	Digital output 6
9	Common input	19	Common output
10	Fault relay 1	20	Fault relay 2

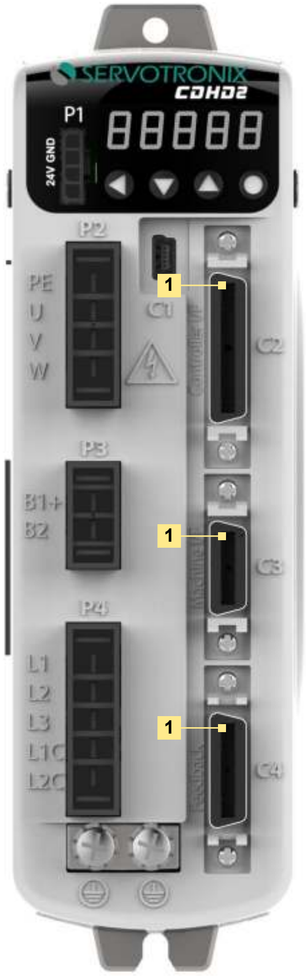
Feedback **C4**: MDR 26 Plug | 24-28 AWG			
1	Incremental encoder A +	14	Incremental encoder A -
	SSI encoder data +		SSI encoder data -
2	Incremental encoder B +	15	Incremental encoder B -
	SSI encoder clock +		SSI encoder clock -
3	Incremental encoder Z +	16	Incremental encoder Z -
4	Hall U +	17	Hall V+
5	Hall W +	18	8V supply
6	Resolver sine +	19	Resolver sine -
7	Resolver cosine +	20	Resolver cosine -
8	Resolver reference +	21	Resolver reference -
9	Sine encoder sine +	22	Sine encoder sine -
10	Sine encoder cosine +	23	Sine encoder cosine -
11	5V/8V supply for feedback device	24	Ground (5V/8V return)
12	Motor temperature sensor	25	Motor temperature sensor
13	5V/8V supply for feedback device	26	Shield

Each type of drive (AP, AF, EC, EB) *has the same control board, regardless of rating.*

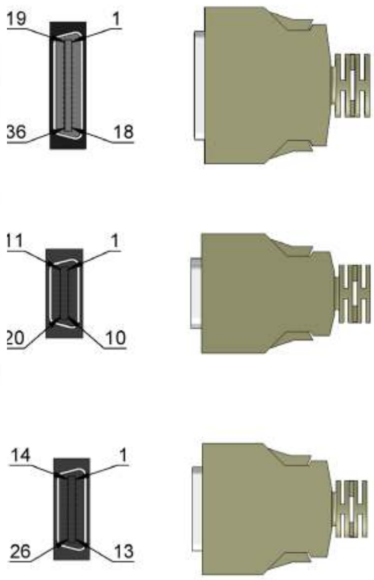
Figure 4-13. CDHD2 (MV) AF Models Control Board Pin Assignments

4.9.3 CDHD2-EC (MV) Control Board Pinouts

I/F	Mfgr	Mating Connector	Manufacturer PN	Servotronix PN
C2	3M	Solder Plug Connector	10136-3000PE	CONr00000036-01
	3M	Solder Plug Junction Shell	10336-52F0-008	HODr00000036-00
C3	3M	Solder Plug Connector	10120-3000PE	CONr00000020-38
	3M	Solder Plug Junction Shell	10320-52F0-008	HODr00000020-00
C4	3M	Solder Plug Connector	10126-3000PE	CONr00000026-31
	3M	Solder Plug Junction Shell	10326-52F0-008	HODr00000026-00



USB C1: Mini-B	
1	5V
2	Data -
3	Data +
4	
5	GND



Controller I/F **C2**: MDR 36 Plug | 24-28 AWG			
1	Common output	19	Common input
2	Digital output 1	20	Digital input 2
3	Digital input 1	21	
4	Equivalent encoder output A-	22	Equivalent encoder output A+
5	Equivalent encoder output B-	23	Equivalent encoder output B+
6	Equivalent encoder output Z-	24	Equivalent encoder output Z+
7		25	Ground
8	Analog input 1+	26	Analog input 1-
9	Direction input+	27	Direction input-
	Secondary encoder B+		Secondary encoder B-
10	Ground	28	Pulse input+
			Secondary encoder A+
11	Pulse input-	29	Ground
	Secondary encoder A-		
12	Fast digital output 8	30	Fast digital output 7
13	Ground	31	Digital input 3
14	Digital input 4	32	Fast digital input 5
15	Fast digital input 6	33	Digital output 2
16	Digital output 3	34	Fast digital output 24V return
17	Fast digital output 24V	35	* Analog input 2-
18	* Analog input 2+	36	Analog output

* Optional. Refer to *Ordering Options*.

Machine I/F **C3**: MDR 20 Plug | 24-28 AWG			
1	Secondary encoder A+	11	Secondary encoder A-
	Pulse input +		Pulse input -
2	Secondary encoder B+	12	Secondary encoder B-
	Direction input+		Direction input-
3	Secondary encoder Z+	13	Secondary encoder Z-
4	Secondary encoder 5V	14	Secondary encoder ground
5	Digital input 7	15	Digital input 8
6	Digital input 9	16	Digital input 10
7	Fast digital input 11	17	Digital output 4
8	Digital output 5	18	Digital output 6
9	Common input	19	Common output
10	Fault relay 1	20	Fault relay 2

Feedback **C4**: MDR 26 Plug | 24-28 AWG			
1	Incremental encoder A +	14	Incremental encoder A -
	SSI encoder data +		SSI encoder data -
2	Incremental encoder B +	15	Incremental encoder B -
	SSI encoder clock +		SSI encoder clock -
3	Incremental encoder Z +	16	Incremental encoder Z -
4	Hall U +	17	Hall V+
5	Hall W +	18	8V supply
6	Resolver sine +	19	Resolver sine -
7	Resolver cosine +	20	Resolver cosine -
8	Resolver reference +	21	Resolver reference -
9	Sine encoder sine +	22	Sine encoder sine -
10	Sine encoder cosine +	23	Sine encoder cosine -
11	5V/8V supply for feedback device	24	Ground (5V/8V return)
12	Motor temperature sensor	25	Motor temperature sensor
13	5V/8V supply for feedback device	26	Shield

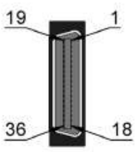
Each type of drive (AP, AF, EC, EB) *has the same control board, regardless of rating.*

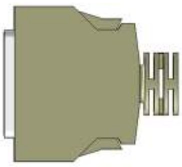
Figure 4-14. CDHD2 (MV) EC Models Control Board Pin Assignments

4.9.4 CDHD2-EB (MV) Control Board Pinouts

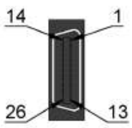
I/F	Mfgr	Mating Connector	Manufacturer PN	Servotronix PN
C2	3M	Solder Plug Connector	10136-3000PE	CONr00000036-01
	3M	Solder Plug Junction Shell	10336-52F0-008	HODr00000036-00
C4	3M	Solder Plug Connector	10126-3000PE	CONr00000026-31
	3M	Solder Plug Junction Shell	10326-52F0-008	HODr00000026-00

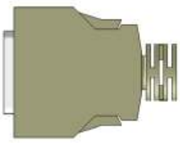
USB C1: Mini-B	
1	5V
2	Data -
3	Data +
4	
5	GND





Controller I/F C2: MDR 36 Plug | 24-28 AWG			
1	Common output	19	Common input
2	Digital output 1	20	Digital input 2
3	Digital input 1	21	
4		22	
5		23	
6		24	
7		25	Ground
8	Analog input 1+	26	Analog input 1-
9		27	
10	Ground	28	
11		29	Ground
12		30	
13	Ground	31	Digital input 3
14	Digital input 4	32	Fast digital input 5
15		33	Digital output 2
16	Digital output 3	34	
17		35	Analog input 2-
18	Analog input 2+	36	





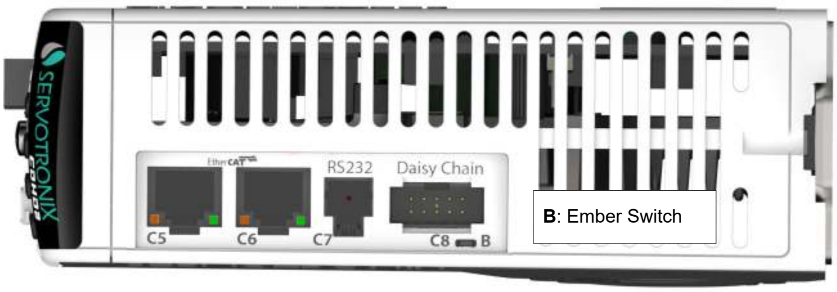
Feedback C4: MDR 26 Plug | 24-28 AWG			
1	Incremental encoder A +	14	Incremental encoder A -
	SSI encoder data +		SSI encoder data -
2	Incremental encoder B +	15	Incremental encoder B -
	SSI encoder clock +		SSI encoder clock -
3	Incremental encoder Z +	16	Incremental encoder Z -
4	Hall U +	17	Hall V+
5	Hall W +	18	
6		19	
7		20	
8		21	
9	Sine encoder sine +	22	Sine encoder sine -
10	Sine encoder cosine +	23	Sine encoder cosine -
11	5V supply for feedback device	24	Ground (5V return)
12	Motor temperature sensor	25	Motor temperature sensor
13	5V supply for feedback device	26	Shield

Each type of drive (AP, AF, EC, EB) *has the same control board, regardless of rating.*

Figure 4-15. CDHD2 (MV) EB Models Control Board Pin Assignments

4.9.5 CDHD2 (MV) Control Board Top Panel Pinouts

Note EB models do not have RS232 port (interface C7).



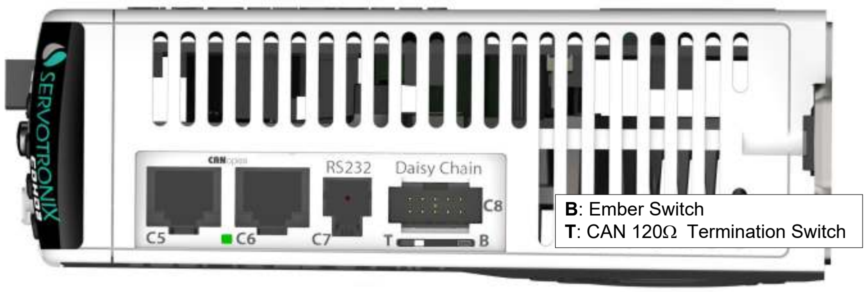
EtherCAT IN **C5**: RJ45	
1	TX +
2	TX -
3	RX +
4	
5	
6	RX -
7	
8	

EtherCAT OUT **C5**: RJ45	
1	TX +
2	TX -
3	RX +
4	
5	
6	RX -
7	
8	

RS232 **C7**: 4p4c	
1	RX
2	GND ISO
3	TX
4	Shield

Daisy Chain / Gantry **C8**: 0.1" IDC Female	
1	DC Shield
2	
3	RX
4	GND
5	TX
6	GND
7	Gantry A+
8	Gantry A-
9	Gantry B+
10	Gantry B-

I/F	Mfgr	Mating Connector	Manufacturer PN	Servotronix PN
C5 **C6**	Molex	Connector	44915-0011	
C7	AIM-Cambridge	Connector	32-5964UL	
C8	TE	Connector	1658527-3	CONr00000010-67



CANopen IN **C5**: RJ45	
1	CANH
2	CANL
3	FGND
4	
5	
6	
7	FGND
8	

CANopen OUT **C6**: RJ45	
1	CANH
2	CANL
3	FGND
4	
5	
6	
7	FGND
8	

RS232 **C7**: 4p4c	
1	RX
2	GND ISO
3	TX
4	Shield

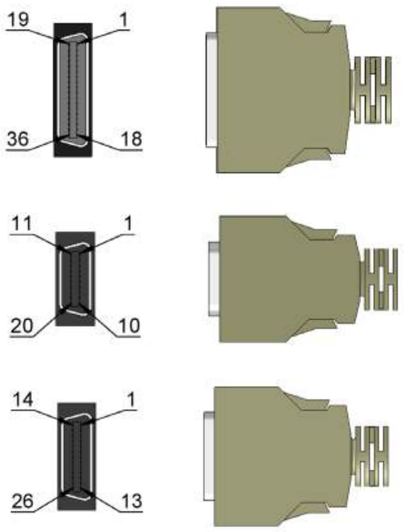
Daisy Chain / Gantry **C8**: 0.1" IDC Female	
1	DC Shield
2	
3	RX
4	GND
5	TX
6	GND
7	Gantry A+
8	Gantry A-
9	Gantry B+
10	Gantry B-

Figure 4-16. CDHD2 (MV) Control Board Pin Assignments – Top Panel

4.9.6 CDHD2-AF/EC (LV) Control Board Pinouts

I/F	Mfgr	Mating Connector	Manufacturer PN	Servotronix PN
C2	3M	Solder Plug Connector	10136-3000PE	CONr00000036-01
	3M	Solder Plug Junction Shell	10336-52F0-008	HODr00000036-00
C3	3M	Solder Plug Connector	10120-3000PE	CONr00000020-38
	3M	Solder Plug Junction Shell	10320-52F0-008	HODr00000020-00
C4	3M	Solder Plug Connector	10126-3000PE	CONr00000026-31
	3M	Solder Plug Junction Shell	10326-52F0-008	HODr00000026-00

USB C1: Mini-B	
1	5V
2	Data -
3	Data +
4	
5	GND



Controller I/F **C2**: MDR 36 Plug | 24-28 AWG			
1	Common output	19	Common input
2	Digital output 1	20	Digital input 2
3	Digital input 1	21	
4	Equivalent encoder output A-	22	Equivalent encoder output A+
5	Equivalent encoder output B-	23	Equivalent encoder output B+
6	Equivalent encoder output Z-	24	Equivalent encoder output Z+
7		25	Ground
8	Analog input 1+	26	Analog input 1-
9	Direction input+	27	Direction input-
	Secondary encoder B+		Secondary encoder B-
10	Ground	28	Pulse input+
			Secondary encoder A+
11	Pulse input-	29	Ground
	Secondary encoder A-		
12	Fast digital output 8	30	Fast digital output 7
13	Ground	31	Digital input 3
14	Digital input 4	32	Fast digital input 5
15	Fast digital input 6	33	Digital output 2
16	Digital output 3	34	Fast digital output 24V return
17	Fast digital output 24V	35	* Analog input 2-
18	* Analog input 2+	36	Analog output
* Optional. Refer to *Ordering Options*.			

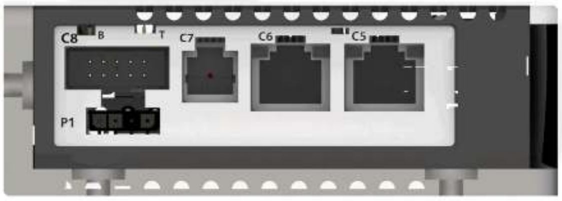
Machine I/F **C3**: MDR 20 Plug | 24-28 AWG			
1	Secondary encoder A+	11	Secondary encoder A-
	Pulse input +		Pulse input -
2	Secondary encoder B+	12	Secondary encoder B-
	Direction input+		Direction input-
3	Secondary encoder Z+	13	Secondary encoder Z-
4	Secondary encoder 5V	14	Secondary encoder ground
5	Digital input 7	15	Digital input 8
6	Digital input 9	16	Digital input 10
7	Fast digital input 11	17	Digital output 4
8	Digital output 5	18	Digital output 6
9	Common input	19	Common output
10	Fault relay 1	20	Fault relay 2

Feedback **C4**: MDR 26 Plug | 24-28 AWG			
1	Incremental encoder A +	14	Incremental encoder A -
	SSI encoder data +		SSI encoder data -
2	Incremental encoder B +	15	Incremental encoder B -
	SSI encoder clock +		SSI encoder clock -
3	Incremental encoder Z +	16	Incremental encoder Z -
4	Hall U +	17	Hall V+
5	Hall W +	18	8V supply
6	Resolver sine +	19	Resolver sine -
7	Resolver cosine +	20	Resolver cosine -
8	Resolver reference +	21	Resolver reference -
9	Sine encoder sine +	22	Sine encoder sine -
10	Sine encoder cosine +	23	Sine encoder cosine -
11	5V/8V supply for feedback device	24	Ground (5V/8V return)
12	Motor temperature sensor	25	Motor temperature sensor
13	5V/8V supply for feedback device	26	Shield

Figure 4-17. CDHD2 (LV) Control Board Pin Assignments (AF and EC Models)

4.9.7 CDHD2-AF/EC (LV) Control Board Top Panel Pinouts

B: Ember Switch
T: CAN 120Ω Termination Switch



Daisy Chain / Gantry **C8**: 0.1" IDC Female	
1	DC Shield
2	
3	RX
4	GND
5	TX
6	GND
7	Gantry A+
8	Gantry A-
9	Gantry B+
10	Gantry B-

RS232 **C7**: 4p4c	
1	RX
2	GND ISO
3	TX
4	Shield

EtherCAT OUT **C5**: RJ45	
1	TX +
2	TX -
3	RX +
4	
5	
6	RX -
7	
8	

EtherCAT IN **C5**: RJ45	
1	TX +
2	TX -
3	RX +
4	
5	
6	RX -
7	
8	

Daisy Chain / Gantry **C8**: 0.1" IDC Female	
1	DC Shield
2	
3	RX
4	GND
5	TX
6	GND
7	Gantry A+
8	Gantry A-
9	Gantry B+
10	Gantry B-

RS232 **C7**: 4p4c	
1	RX
2	GND ISO
3	TX
4	Shield

CANopen OUT **C6**: RJ45	
1	CANH
2	CANL
3	FGND
4	
5	
6	
7	FGND
8	

CANopen IN **C5**: RJ45	
1	CANH
2	CANL
3	FGND
4	
5	
6	
7	FGND
8	

I/F	Mfgr	Mating Connector	Manufacturer PN	Servotronix PN
C5 **C6**	Molex	Connector	44915-0011	
C7	AIM-Cambridge	Connector	32-5964UL	
C8	TE	Connector	1658527-3	CONr00000010-67

Figure 4-18. CDHD2 (LV) Control Board Pin Assignments – Top Panel

4.9.8 USB Serial Communication – C1

For commissioning, the drive can be connected to the host computer through interface C1 (USB port). It is strongly recommended that you use the USB cable supplied by Servotronix, which has been tested and proven for reliability.

Alternately, interface C7 (RS232 port) can be used.

Refer to *Host Computer System*.

Note CDHD2 USB drivers are digitally signed.

4.9.9 RS232 Serial Communication – C7

For commissioning, the drive can be connected to the host computer through interface C7 (RS232 port). Alternately, interface C1 (USB port) can be used.

4.9.10 Fieldbus Communication – C5 and C6

Interfaces C5 and C6 are RJ45 ports that serve as transmitter and receiver for drives operating on a CAN or EtherCAT network.

The LEDs on interfaces C5 and C6 indicate fieldbus status. Refer to *Fieldbus Status – LEDs*.

Refer to the CDHD2 EtherCAT and CANopen Reference Manual for details on installation, configuration and operation of drives being used on CAN and EtherCAT networks.

An adapter is available to enable the connection of a RJ45 port to a D9 interface. Refer to *D9-RJ45 Adapter*.

4.9.11 Daisy Chain and Gantry Communication – C8

The CDHD2 can be addressed and controlled on a daisy-chained RS232 line.

In a daisy-chain RS232 configuration, all drives must be daisy-chained through interface C8. Each drive must have a unique address to enable its identification on the network.

A daisy-chained drive can be assigned an address from 1 to 99 by setting parameter P0003 from the operator panel, or VarCom variable ADDR.

When configuring a daisy-chain, address 0 cannot be used.

4.9.12 Controller Interface – C2

Wire the digital and analog inputs and outputs according to the requirements of your application.

Unused pins must remain unwired.

Common input and common output on the Controller interface (C2) and the Machine interface (C3) are connected internally.

24 VDC supply and return can be connected on either the Controller interface (C2) or the Machine interface (C3), but it is not necessary to connect it on both.

All digital inputs and digital outputs on all CDHD2 models are opto-isolated.

Fast outputs are sink only. All other digital inputs and digital outputs can be connected as either source or sink.

If both the fast and regular digital outputs are configured as sink, one power supply can usually be used for all outputs.

It is recommended to use a fast output (7 or 8) for the motor brake release signal.

A separate power supply is required for the motor brake. An external flywheel diode must be added if the load is inductive (e.g., relay).

Table 4-15. Controller Interface – AP/AF/EC Models

Pin	Function	Description	Pin	Function	Description
1	Common output		19	Common input	
2	Digital output 1	Opto-isolated programmable digital output. Read using OUT1	20	Digital input 2	Opto-isolated programmable digital input. Read using IN2
3	Digital input 1	Opto-isolated programmable digital input. Read using IN1	21		
4	Equivalent encoder output A-	Low side of the equivalent encoder output signal A (RS422)	22	Equivalent encoder output A+	High side of the equivalent encoder output signal A (RS422)
5	Equivalent encoder output B-	Low side of the equivalent encoder output signal B (RS422)	23	Equivalent encoder output B+	High side of the equivalent encoder output signal B (RS422)
6	Equivalent encoder output Z-	Low side of the equivalent encoder output index (RS422)	24	Equivalent encoder output Z+	High side of the equivalent encoder output index (RS422)
7			25	Ground	Digital ground
8	Analog input 1+	High side of the differential analog command input (±10 VDC)	26	Analog input 1-	Low side of the differential analog command input (±10 VDC)
9	Direction input+	High side of the direction signal (RS422), or High side of the down count signal	27	Direction input-	Low side of the direction signal (RS422), or Low side of the down count signal
	Secondary encoder B+	High side of the secondary encoder input signal B (RS422)		Secondary encoder B-	Low side of the secondary encoder input signal B (RS422)
10	Ground	Digital ground	28	Pulse input+	High side of the pulse signal (RS422), or High side of the master encoder signal A, or High side of the up count signal
				Secondary encoder A+	High side of the secondary encoder input signal A (RS422)
11	Pulse input-	Low side of the pulse signal (RS422), or Low side of the master encoder signal A, or Low side of the up count signal	29	Ground	Digital ground

Pin	Function	Description	Pin	Function	Description
	Secondary encoder A-	Low side of the secondary encoder input signal A (RS422)			
12	Fast digital output 8		30	Fast digital output 7	
13	Ground	Digital ground	31	Digital input 3	Opto-isolated programmable digital input. Read using IN3
14	Digital input 4	Opto-isolated programmable digital input. Read using IN4	32	Fast digital input 5	Fast opto-isolated programmable digital input. Read using IN5
15	Fast digital input 6	Fast opto-isolated programmable digital input. Read using IN6	33	Digital output 2	Opto-isolated programmable digital output. Read using OUT2
16	Digital output 3	Opto-isolated programmable digital output. Read using OUT3	34	Fast digital output 24V return	
17	Fast digital output 24V		35	* Analog input 2-	Low side of the second differential analog input (±10 VDC)
18	* Analog input 2+	High side of the second differential analog input (±10 VDC)	36	Analog output	Analog output, referenced to digital ground (0-10 VDC)

Notes

* Optional, see *Ordering Information*.

Blank cells indicate unused pins; these pins must remain unwired.

Table 4-16. Controller Interface – EB Models

Pin	Function	Description	Pin	Function	Description
1	Common output		19	Common input	
2	Digital output 1	Opto-isolated programmable digital output. Read using OUT1	20	Digital input 2	Opto-isolated programmable digital input. Read using IN2
3	Digital input 1	Opto-isolated programmable digital input. Read using IN1	21		
4			22		
5			23		
6			24		
7			25	Ground	Digital ground
8	Analog input 1+	High side of the differential analog command input (±10 VDC)	26	Analog input 1-	Low side of the differential analog command input (±10 VDC)
9			27		
10	Ground	Digital ground	28		
11			29	Ground	Digital ground
12			30		
13	Ground	Digital ground	31	Digital input 3	Opto-isolated programmable digital input. Read using IN3
14	Digital input 4	Opto-isolated programmable digital input. Read using IN4	32	Fast digital input 5	Fast opto-isolated programmable digital input. Read using IN5
			33	Digital output 2	Opto-isolated programmable digital output. Read using OUT2
16	Digital output 3	Opto-isolated programmable digital output. Read using OUT3	34		
17			35	Analog input 2-	Low side of the second differential analog input (±10 VDC)
18	Analog input 2+	High side of the second differential analog input (±10 VDC)	36		

Note Blank cells indicate unused pins; these pins must remain unwired.

Digital and Analog Inputs and Outputs Wiring – C2

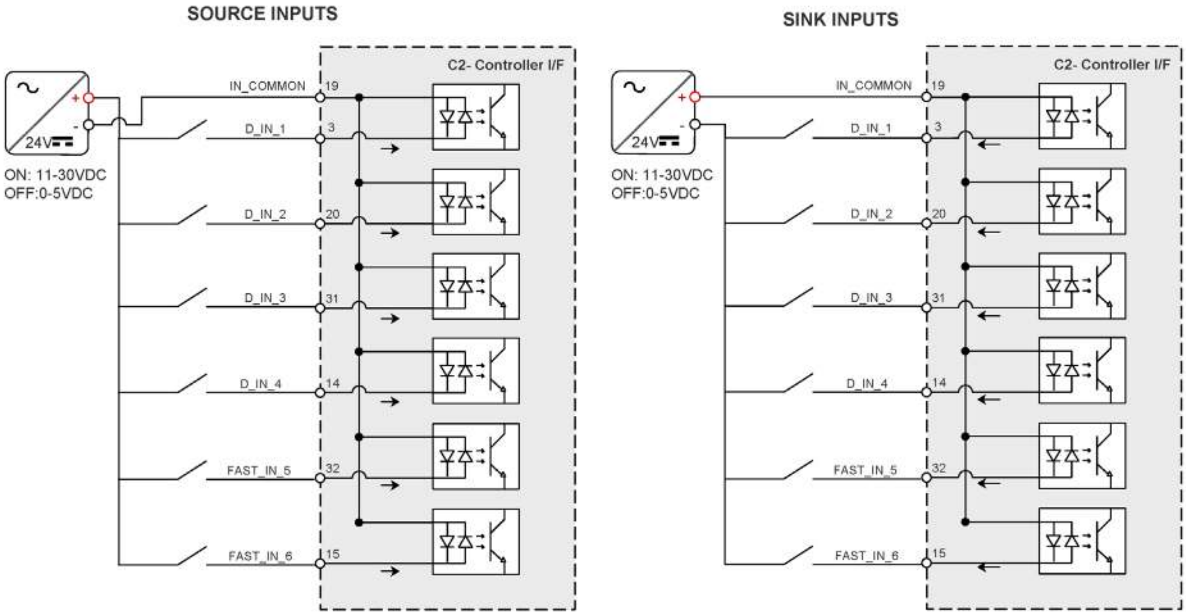


Figure 4-19. Digital Input Wiring – C2

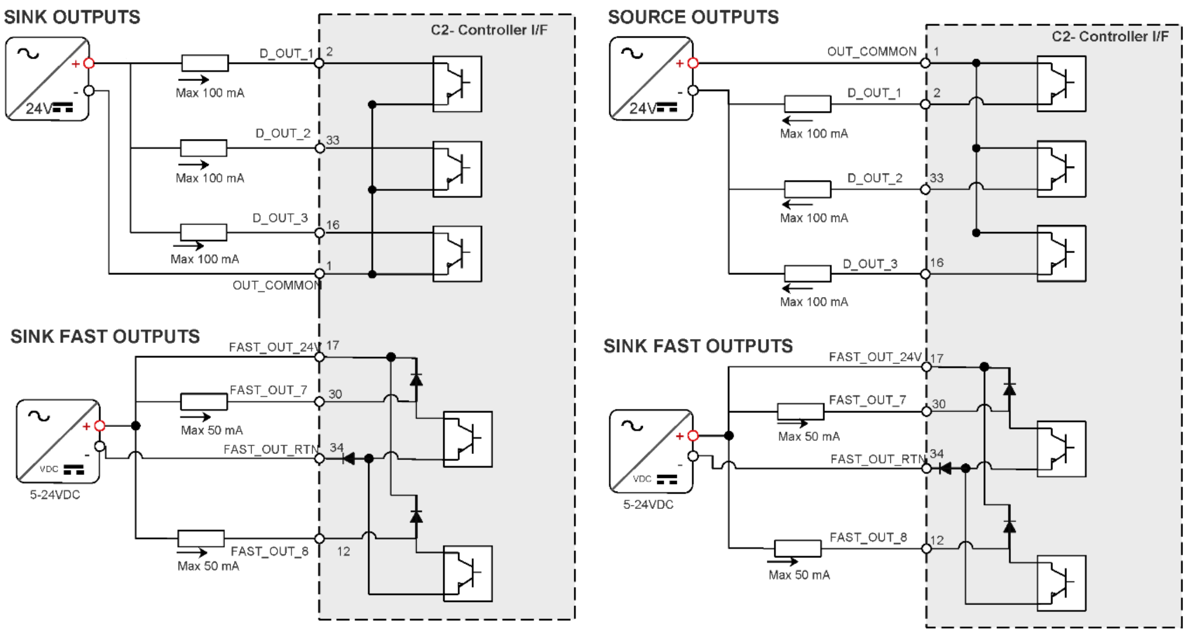


Figure 4-20. Digital Output Wiring – C2

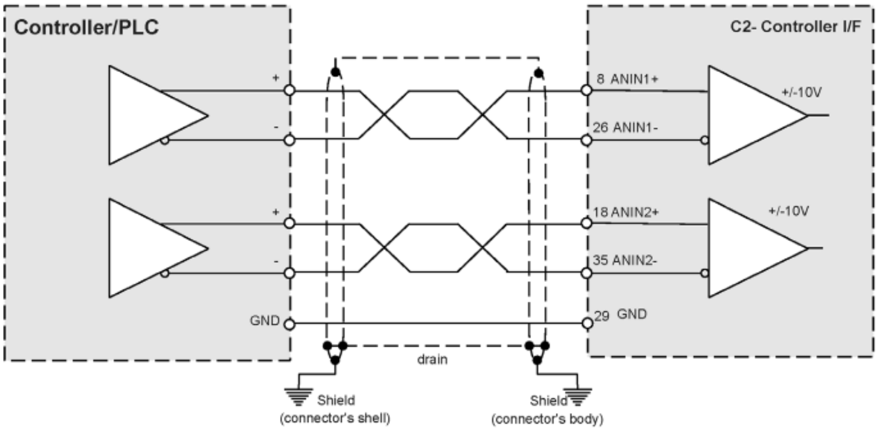


Figure 4-21. Analog Input Wiring – C2

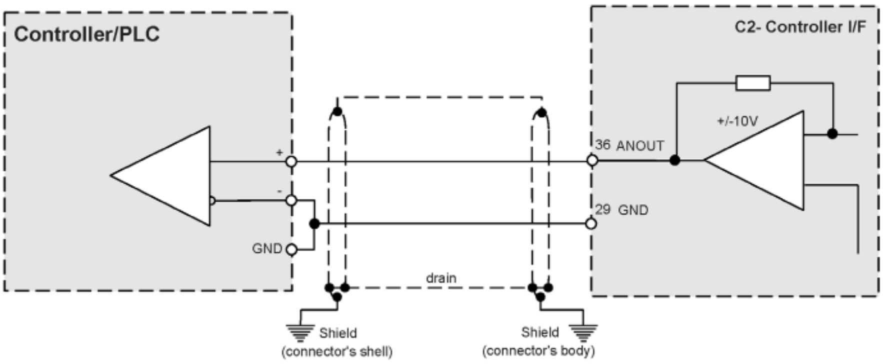


Figure 4-22. Analog Output Wiring – C2

Pulse and Direction Opto-Isolated Wiring – C2

The CDHD2 enables the connection of PLCs with a 24 VDC single-end signal to the drive.

This type of signaling requires the use of the fast digital inputs on the CDHD2 Controller interface (C2).

For this configuration, CDHD2 inputs 5 and 6 must be set to INMODE 17 and 18, respectively. (Applicable/recognized in GEARMODE 0, 1, 2).

- The Pulse signal is connected to fast digital input 5 on pin 32.
- The Direction signal is connected to fast digital input 6 on pin 15.
- The cable shield on the PLC side can be connected to any available shield connector.
- The cable shield on the CDHD2 side can be connected to the shell of the 36-pin connector.

Note The 24 VDC power supply must be provided by the user.

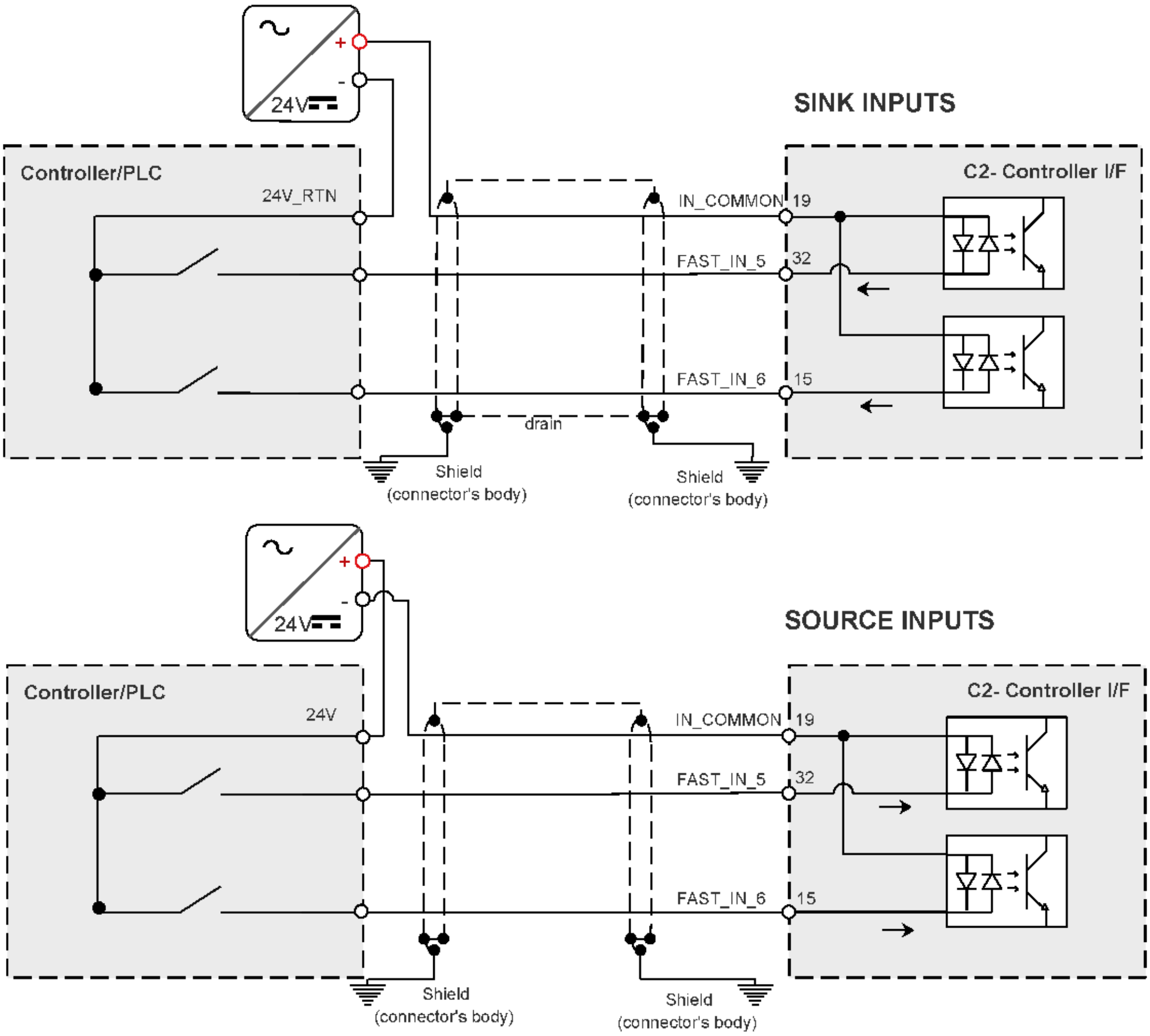


Figure 4-23. Pulse and Direction Opto-Isolated Inputs Wiring – C2

Pulse and Direction Differential Inputs Wiring – C2

When using the CDHD2 Controller interface (C2):

- The Pulse signals are received from the controller or PLC on pins 28 and 11.
- The Directions signals are received from the controller or PLC on pins 9 and 27.

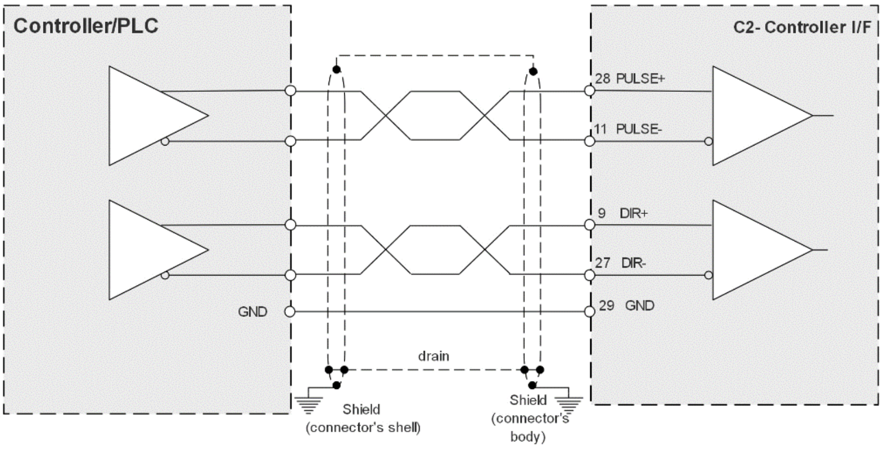


Figure 4-24. Pulse and Direction Differential Inputs Wiring – C2

Simulated Encoder Equivalent Outputs Wiring – C2

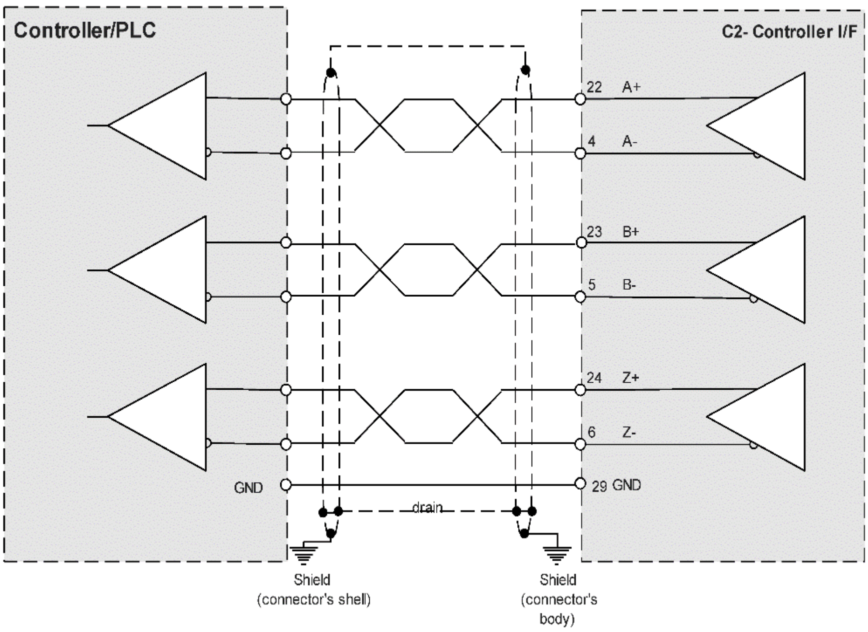


Figure 4-25. Simulated Encoder Equivalent Outputs Wiring – C2

4.9.13 Machine Interface – C3

Note EB Models – CDHD2 EB models do not have a Machine interface.

Wire the machine inputs and outputs according to the requirements of your application.

Unused pins must remain unwired.

Common input and common output on the Controller interface (C2) and the Machine interface (C3) are connected internally.

24 VDC supply and return can be connected on either the Controller interface (C2) or the Machine interface (C3), but it is not necessary to connect it on both.

All digital inputs and digital outputs on all CDHD2 models are opto-isolated.

Fast outputs are sink only. All other digital inputs and digital outputs can be connected as either source or sink.

If both the fast and regular digital outputs are configured as sink, one power supply can usually be used for all outputs.

It is recommended to use a fast output (7 or 8) for the motor brake release signal.

A separate power supply is required for the motor brake. An external flyback diode must be added if the load is inductive (e.g., relay).

Table 4-17. Machine Interface – AP/AF/EC Models

Pin	Function	Description	Pin	Function	Description
1	Secondary encoder A+	High side of the secondary encoder input signal A (RS422)	11	Secondary encoder A-	Low side of the secondary encoder input signal A (RS422)
	Pulse input+	High side of the pulse signal		Pulse input-	Low side of the pulse signal
2	Secondary encoder B+	High side of the Secondary encoder input signal B (RS422)	12	Secondary encoder B-	Low side of the secondary encoder input signal B (RS422)
	Direction input+	High side of the direction signal		Direction input-	Low side of the direction signal
3	Secondary encoder Z+	High side of the secondary encoder input index (RS422)	13	Secondary encoder Z-	Low side of the secondary encoder input index (RS422)
4	Secondary encoder 5V	5 VDC supply for the secondary encoder	14	Secondary encoder ground	Ground of the 5 VDC supply for the secondary encoder.
5	Digital input 7	Opto-isolated programmable digital input. Read using IN7	15	Digital input 8	Opto-isolated programmable digital input. Read using IN8
6	Digital input 9	Opto-isolated programmable digital input. Read using IN9	16	Digital input 10	Opto-isolated programmable digital input. Read using IN10

Pin	Function	Description	Pin	Function	Description
7	Fast digital input 11	Fast opto-isolated programmable digital input. Read using IN11	17	Digital output 4	Opto-isolated programmable digital output. Read using OUT4
8	Digital output 5	Opto-isolated programmable digital output. Read using OUT5	18	Digital output 6	Opto-isolated programmable digital output. Read using OUT6
9	Common input		19	Common output	
10	Fault relay 1	Terminal 1 of the dry contact fault relay	20	Fault relay 2	Terminal 2 of the dry contact fault relay

Digital Inputs and Outputs Wiring – C3

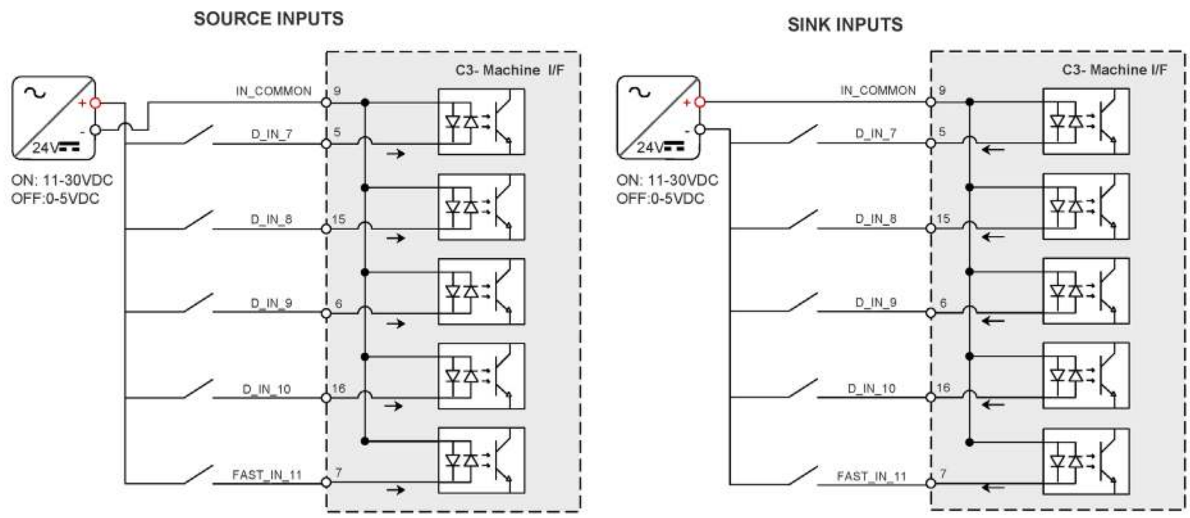


Figure 4-26. Digital Input Wiring – C3

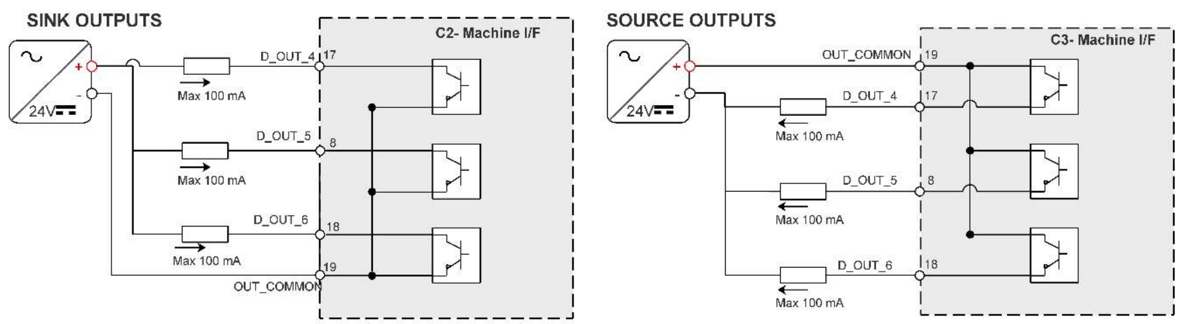


Figure 4-27. Digital Output Wiring – C3

4.9.14 Motor Brake Wiring

The CDHD2 does not have sufficient amperage to activate a motor brake, but can control a motor brake via an external relay. The selection of power supply, relay and diodes depends on the specification of the actual motor brake used in your application.

You can connect the relay to any digital output on the CDHD2 Machine I/F (C3) or Controller interface (C2). It is recommended that you connect to fast digital output 7.

Motor brake wiring requires the following:

- Flyback diodes: D1 and D2 (for example, PN 1N4002)
- Relay: 24 V < 100mA
- Relay coil: > 500 Ω
- External power supply: 24V

When using an inductive load, such as motor brake, be sure to install flyback diodes according to wiring diagram.

When using a DC relay to switch inductive loads, such as a relay sequence circuit, a motor brake, or a DC solenoid, it is important to always absorb surges (e.g., with a diode) to protect the contacts; that is, the drive’s digital inputs and outputs. Switching these inductive loads on and off can generate a counter-electromotive force (Back-EMF) of several hundred to several thousand volts, which can severely damage contacts and greatly shorten product life.

Refer also to *Motor Brake Control via Relay*.

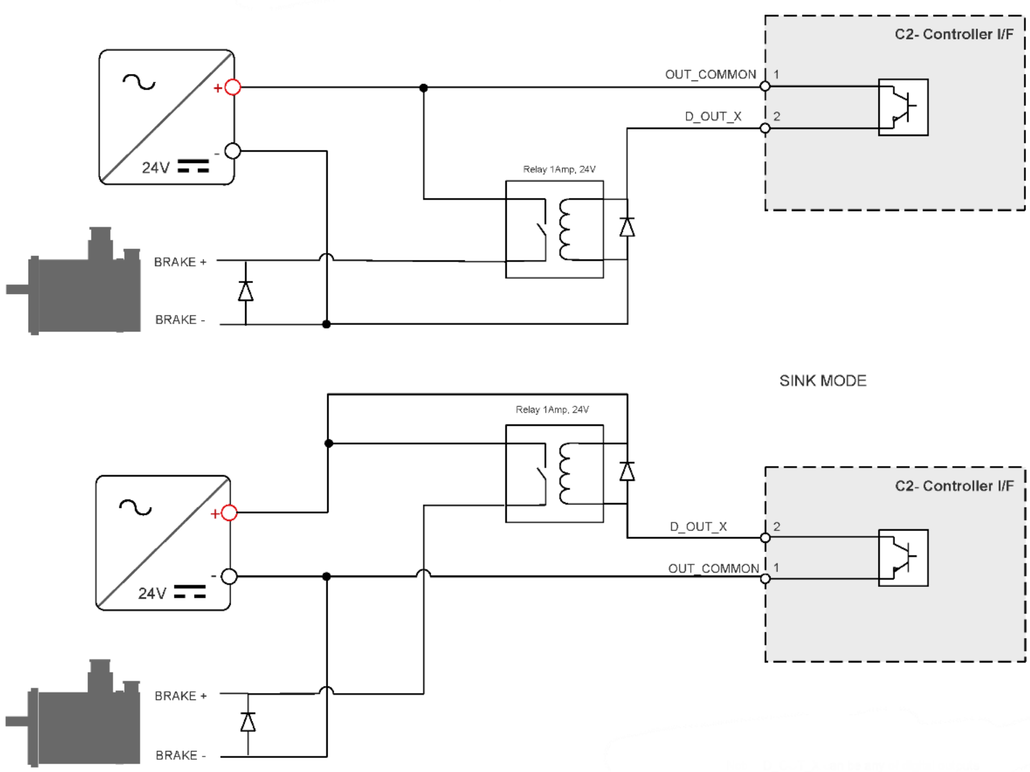


Figure 4-28. Motor Brake Wiring CDHD2 (MV models)

4.9.15 Secondary Feedback Wiring

The following tables show the most common secondary feedback variations. If you need additional information, or your motor feedback does not match any one of the following, contact Technical Support.

Use the User Motor Pin# column in these tables to record the pin numbers of your specific feedback device for future reference.

Wiring – BiSS-C Encoder

Table 4-18. BiSS-C Encoder

Pin #	Twisted Pair	User Encoder Pin#	Signal Description
1	Twisted Pair		Serial Data + (SLO+)
11			Serial Data - (SLO-)
2	Twisted Pair		Serial Clock + (MA+)
12			Serial Clock - (MA-)
4			+5 VDC
14			0 VDC

Wiring – HEIDENHAIN (EnDat 2.x Communication Only)

Table 4-19. Feedback Wiring – HEIDENHAIN (EnDat 2.x Communication Only)

Pin #	Twisted Pair	User Encoder Pin#	Signal Description
1	Twisted Pair		Serial Data +
11			Serial Data -
2	Twisted Pair		Serial Clock +
12			Serial Clock -
4			+5 VDC
14			0 VDC

Wiring – Incremental Encoder A Quad B, Index Pulse and Halls

Table 4-20. Feedback Wiring – Incremental Encoder A Quad B, Index Pulse and Halls

Pin #	Twisted Pair	User Encoder Pin#	Signal Description
1	Twisted Pair		Incremental Encoder A+
11			Incremental Encoder A-
2	Twisted Pair		Incremental Encoder B+
12			Incremental Encoder B-
3	Twisted Pair		Incremental Encoder Z+
13			Incremental Encoder Z-
4			+5 VDC
14			0 VDC

4.9.16 Motor Feedback Interface – C4

Wire the motor feedback interface according to the type of feedback device to be used in your application. Refer to the tables in *Motor Feedback Wiring* for common types of feedback wiring.

Pins 1, 2, 14 and 15 have dual functionality.

Pin 25 for the motor temperature sensor is connected internally in the drive to CDHD2 ground.

Unused pins must remain unwired.

Note

Serial communication encoders, such as Tamagawa and Nikon have the following properties:

- Serial encoder data is bidirectional.
- Serial encoder clock is only output.
- Low-voltage indication comes directly from the encoder; the drive does not have the capability to verify encoder battery voltage.

Table 4-21. Motor Feedback Interface (C4)

Pin	Function	Pin	Function
1	Incremental encoder A +	14	Incremental encoder A -
	SSI encoder data +		SSI encoder data -
2	Incremental encoder B +	15	Incremental encoder B -
	SSI encoder clock +		SSI encoder clock -
3	Incremental encoder Z +	16	Incremental encoder Z -
4	Hall U +	17	Hall V+
5	Hall W +	18	**AF/EC only**: 8V supply
6*	Resolver sine +	19*	Resolver sine -
7*	Resolver cosine +	20*	Resolver cosine -
8*	Resolver reference +	21*	Resolver reference -
9	Sine encoder sine +	22*	Sine encoder sine -
10	Sine encoder cosine +	23	Sine encoder cosine -
11	Power supply to feedback device	24	Ground
12	Motor temperature sensor	25	Motor temperature sensor
13	Power supply to feedback device	26	Shield

** Not on EB model.*

4.9.17 Motor Feedback Wiring

The following tables show the most common feedback variations. If you need additional information, or your motor feedback does not match any one of the following, contact Technical Support.

Use the User Motor Pin# column in these tables to record the pin numbers of your specific motor for future reference.

Use the ServoStudio 2 Motor Setup procedure and the Feedback screens to define motor feedback type, resolution, and other parameters.

Wiring – sensAR Encoder

Table 4-22. Feedback Wiring – sensAR Encoder

Pin #	Twisted Pair	User Motor Pin#	Signal Description
1	Twisted Pair		Serial Data +
14			Serial Data -
11			+5 VDC
24			0 VDC
26			Shield

Wiring – BiSS-C Encoder

Table 4-23. Feedback Wiring – BiSS-C Encoder

Pin #	Twisted Pair	User Motor Pin#	Signal Description
1	Twisted Pair		Serial Data + (SLO+)
14			Serial Data - (SLO-)
2	Twisted Pair		Serial Clock + (MA+)
15			Serial Clock - (MA-)
11			+5 VDC
24			0 VDC
26			Shield

Wiring – Incremental Encoder A Quad B, Index Pulse and Halls

Table 4-24. Feedback Wiring – Incremental Encoder A Quad B, Index Pulse and Halls

Pin #	Twisted Pair	User Motor Pin#	Signal Description
1	Twisted Pair		Incremental Encoder A+
14			Incremental Encoder A-
2	Twisted Pair		Incremental Encoder B+
15			Incremental Encoder B-
3	Twisted Pair		Incremental Encoder Z+

Pin #	Twisted Pair	User Motor Pin#	Signal Description
16			Incremental Encoder Z-
4			Hall U
17			Hall V
5			Hall W
12	Twisted Pair		Motor Temperature Sensor
25			Motor Temperature Sensor
11			+5 VDC
24			0 VDC
26			Shield

Note If the motor does not support a temperature sensor, do not connect pins 12 and 25.

Wiring – Single-Ended Halls

Table 4-25. Feedback Wiring – Single-Ended Halls

Pin #	Twisted Pair	User Motor Pin#	Signal Description
4			Hall U
17			Hall V
5			Hall W
11			+5 VDC
24			0 VDC
12	Twisted Pair		Motor Temperature Sensor
25			Motor Temperature Sensor
26			Shield

Notes

If the motor does not support a temperature sensor, do not connect pins 12 and 25.

Halls are single-ended signals. If you want to use differential Hall signals, refer to the relevant wiring tables.

Wiring – Incremental Encoder A Quad B, Index Pulse and Differential Halls

Table 4-26. Feedback Wiring – Incremental Encoder A Quad B, Index Pulse and Differential Halls

Pin #	Twisted Pair	User Motor Pin#	Signal Description
1	Twisted Pair		Incremental Encoder A+
14			Incremental Encoder A-
2	Twisted Pair		Incremental Encoder B+
15			Incremental Encoder B-
9			Hall U+
22			Hall U-

Pin #	Twisted Pair	User Motor Pin#	Signal Description
10			Hall V+
23			Hall V-
3			Hall W+
16			Hall W-
12	Twisted Pair		Motor Temperature Sensor
25			Motor Temperature Sensor
11			+5 VDC
24			0 VDC
26			Shield

Notes

If the motor does not support a temperature sensor, do not connect pins 12 and 25.

To use differential Halls with A quad B and index, connect the Halls to the Machine interface as follows:
Hall U+ to Machine I/F pin 1, Hall U- to Machine I/F pin 11.
Hall V+ to Machine I/F pin 2, Hall V- to Machine I/F pin 12.
Hall W+ to Machine I/F pin 3, Hall W- to Machine I/F pin 13.
Connect the encoder A, B, I, and power supply to the Motor Feedback connector.

For A/B feedback only (without Halls), phase find (PHASEFIND) must be executed on every power up.

Wiring – Differential Halls Only

Table 4-27. Feedback Wiring – Differential Halls Only

Pin #	Twisted Pair	User Motor Pin#	Signal Description
9			Hall U+
22			Hall U-
10			Hall V+
23			Hall V-
3			Hall W+
16			Hall W-
11			+5 VDC
24			0 VDC
26			Shield

Wiring – Tamagawa Incremental

Table 4-28. Feedback Wiring – Tamagawa Incremental

Pin #	Twisted Pair	User Motor Pin#	Signal Description
1	Twisted Pair		Incremental Encoder A+ / Hall U+

Pin #	Twisted Pair	User Motor Pin#	Signal Description
14			Incremental Encoder A- / Hall U-
2	Twisted Pair		Incremental Encoder B+ / Hall V+
15			Incremental Encoder B- / Hall V-
3	Twisted Pair		Incremental Encoder Z+ / Hall W+
16			Incremental Encoder Z- / Hall W-
12	Twisted Pair		Motor Temperature Sensor
25			Motor Temperature Sensor
11			+5 VDC
24			0 VDC
26			Shield

Notes

If the motor does not support a temperature sensor, do not connect pins 12 and 25.

Incremental encoders with Hall sensors and index pulse.
A, B and Z signals use the same wiring as Hall sensors U, V, and W.
On power up, feedback briefly sends Hall readings, and then continuously sends the A, B and Z signals.

On every power up, phase find (PHASEFIND) must be executed.

Wiring – Sine Encoder

Table 4-29. Feedback Wiring – Sine Encoder

Pin #	Twisted Pair	User Motor Pin#	Signal Description
9	Twisted Pair		Sine Encoder Sine+
22			Sine Encoder Sine-
10	Twisted Pair		Sine Encoder Cosine+
23			Sine Encoder Cosine-
12	Twisted Pair		Motor Temperature Sensor
25			Motor Temperature Sensor
11			+5VDC
24			0VDC
26			Shield

Notes

If the motor does not support a temperature sensor, do not connect pins 12 and 25.

On every power up, phase find (PHASEFIND) must be executed.

Wiring – Sine Encoder with Halls

Table 4-30. Feedback Wiring – Sine Encoder with Halls

Pin #	Twisted Pair	User Motor Pin#	Signal Description
9	Twisted Pair		Sine Encoder Sine+
22			Sine Encoder Sine-
10	Twisted Pair		Sine Encoder Cosine+
23			Sine Encoder Cosine-
4			Hall U
17			Hall V
5			Hall W
12	Twisted Pair		Motor Temperature Sensor
25			Motor Temperature Sensor
11			+5 VDC
24			0 VDC
26			Shield

Note If the motor does not support a temperature sensor, do not connect pins 12 and 25.

Wiring – Sine Encoder with Index

Table 4-31. Feedback Wiring – Sine Encoder with Index

Pin #	Twisted Pair	User Motor Pin#	Signal Description
9	Twisted Pair		Sine Encoder Sine+
22			Sine Encoder Sine-
10	Twisted Pair		Sine Encoder Cosine+
23			Sine Encoder Cosine-
3	Twisted Pair		Sine Encoder Z+
16			Sine Encoder Z-
12	Twisted Pair		Motor Temperature Sensor
25			Motor Temperature Sensor
11			+5 VDC
24			0 VDC
26			Shield

Note If the motor does not support a temperature sensor, do not connect pins 12 and 25.

Wiring – Sine Encoder with Index and Halls

Table 4-32. Feedback Wiring – Sine Encoder with Index and Halls

Pin #	Twisted Pair	User Motor Pin#	Signal Description
9	Twisted Pair		Sine Encoder Sine+
22			Sine Encoder Sine-
10	Twisted Pair		Sine Encoder Cosine+
23			Sine Encoder Cosine-
3	Twisted Pair		Sine Encoder Z+
16			Sine Encoder Z-
4			Hall U
17			Hall V
5			Hall W
12	Twisted Pair		Motor Temperature Sensor
25			Motor Temperature Sensor
11			+5 VDC
24			0 VDC
26			Shield

Note If the motor does not support a temperature sensor, do not connect pins 12 and 25.

Wiring – Sick 5V (HIPERFACE Protocol and Sine Signal)

Table 4-33. Feedback Wiring – Sick 5V (HIPERFACE Protocol and Sine Signal)

Pin #	Twisted Pair	User Motor Pin#	Signal Description
1	Twisted Pair		Serial Data +
14			Serial Data -
9	Twisted Pair		Sine Encoder Sine+
22			Sine Encoder Sine-
10	Twisted Pair		Sine Encoder Cosine+
23			Sine Encoder Cosine-
12	Twisted Pair		Motor Temperature Sensor
25			Motor Temperature Sensor
11			+5 VDC
24			0 VDC
26			Shield

Note If the motor does not support a temperature sensor, do not connect pins 12 and 25.

Wiring – Sick 8V (HIPERFACE Protocol and Sine Signal)

Table 4-34. Feedback Wiring – Sick 8V (HIPERFACE Protocol and Sine Signal)

Pin #	Twisted Pair	User Motor Pin#	Signal Description
1	Twisted Pair		Serial Data +
14			Serial Data -
9	Twisted Pair		Sine Encoder Sine+
22			Sine Encoder Sine-
10	Twisted Pair		Sine Encoder Cosine+
23			Sine Encoder Cosine-
12	Twisted Pair		Motor Temperature Sensor
25			Motor Temperature Sensor
18			+8 VDC
24			0 VDC
26			Shield

Note If the motor does not support a temperature sensor, do not connect pins 12 and 25.

Wiring – HEIDENHAIN (EnDat 2.x Communication Only)

Table 4-35. Feedback Wiring – HEIDENHAIN (EnDat 2.x Communication Only)

Pin #	Twisted Pair	User Motor Pin#	Signal Description
1	Twisted Pair		Serial Data +
14			Serial Data -
2	Twisted Pair		Serial Clock +
15			Serial Clock -
12	Twisted Pair		Motor Temperature Sensor
25			Motor Temperature Sensor
11			+5 VDC
24			0 VDC
26			Shield

Note If the motor does not support a temperature sensor, do not connect pins 12 and 25. Refer to *EnDat 2.x Bidirectional Interface*.

Wiring – HEIDENHAIN (EnDat 2.x with Sine/Cosine)

Table 4-36. Feedback Wiring – HEIDENHAIN (EnDat 2.x with Sine/Cosine)

Pin #	Twisted Pair	User Motor Pin#	Signal Description
1	Twisted Pair		Serial Data +

14			Serial Data -
2	Twisted Pair		Serial Clock +
15			Serial Clock -
9	Twisted Pair		Sine Encoder Sine+
22			Sine Encoder Sine-
10	Twisted Pair		Sine Encoder Cosine+
23			Sine Encoder Cosine-
11			+5 VDC
24			0 VDC
26			Shield

Note If the motor does not support a temperature sensor, do not connect pins 12 and 25. Refer to *EnDat 2.x Bidirectional Interface*.

Wiring – Tamagawa 17/23-bit / Nikon 17/20/24-bit - Single Turn

Table 4-37. Feedback Wiring – Single Turn: Tamagawa 17/23-bit | Nikon 17/20/24-bit

Pin #	Twisted Pair	User Motor Pin#	Signal Description
1	Twisted Pair		Serial Data +
14			Serial Data -
11			+5 VDC
24			0 VDC
26			Shield

Wiring – Tamagawa 17/23-bit / Nikon 17/20/24-bit - Multi-turn

Table 4-38. Feedback Wiring – Multi-turn: Tamagawa 17/23-bit | Nikon 17/20/24-bit

Pin #	Twisted Pair	User Motor Pin#	Signal Description
1	Twisted Pair		Serial Data +
14			Serial Data -
11			+5 VDC
24			0 VDC
26			Shield

Note Encoder backup battery is external to the CDHD2 drive.
Recommended battery is lithium 3.6V, 1000 mAh.
Use the backup battery recommended by the encoder manufacturer.

Wiring – Resolver

Table 4-39. Feedback Wiring – Resolver

Pin #	Twisted Pair	User Motor Pin#	Signal Description
6	Twisted Pair		Resolver Sine +
19			Resolver Sine -
7	Twisted Pair		Resolver Cosine +
20			Resolver Cosine -
8	Twisted Pair		Resolver Reference +
21			Resolver Reference -
12	Twisted Pair		Motor Temperature Sensor
25			Motor Temperature Sensor
24	Ground		Optional: Internal shield of each twisted pair (sine, cosine, reference)
26			Cable Shield

Notes

If the motor does not support a temperature sensor, do not connect pins 12 and 25.

Halls are single-ended signals. If you want to use differential Hall signals, refer to the relevant wiring tables.

4.9.18 Gantry System Wiring

The two drives for the two axes of a CDHD2 gantry system can be connected to each other either through the C8 or the C3 interface.

To ensure noise immunity, it is strongly recommended that the drives be connected through the shielded C3 interface.

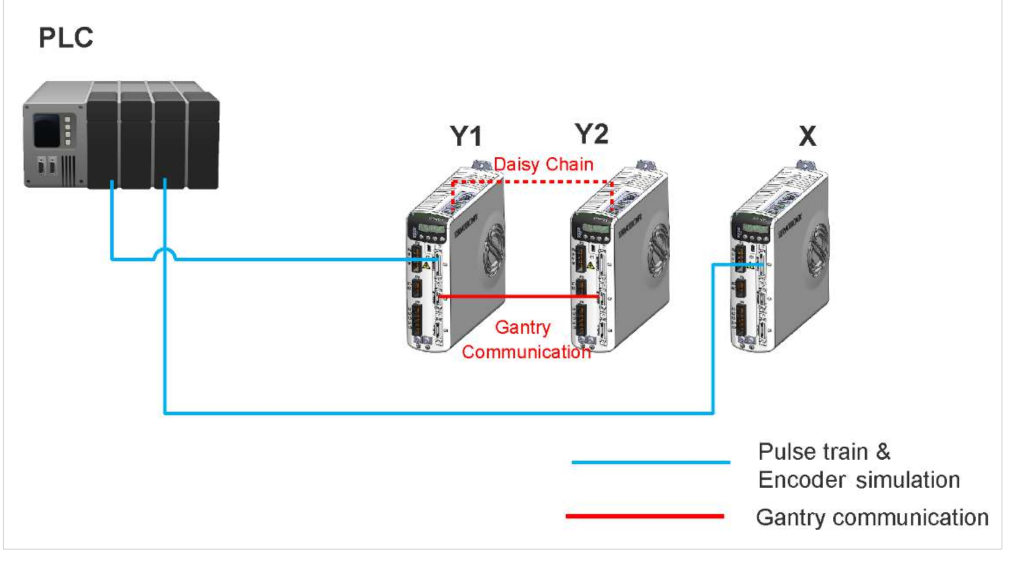


Figure 4-29. Gantry System Wiring – Pulse Train and Serial

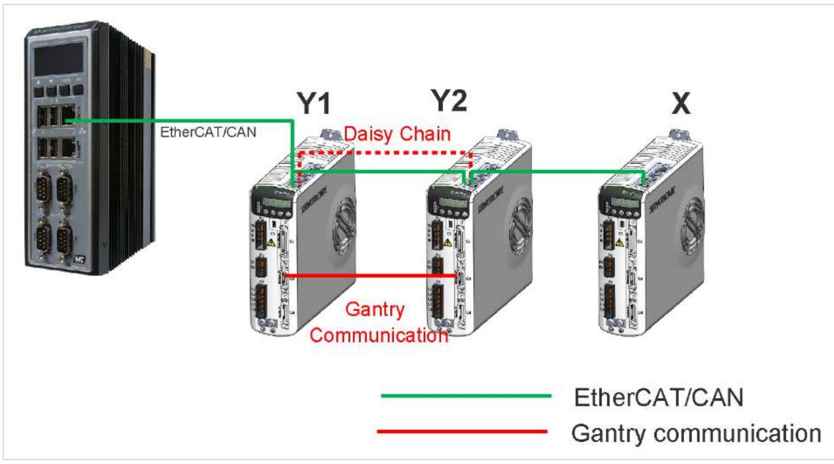


Figure 4-30. Gantry System Wiring – EtherCAT/CAN

Table 4-40. Gantry Daisy Chain C8 Wiring

Gantry Master (Y1) Drive	Gantry Difference (Y2) Drive	Twisted Pair	Signal Description
7	7	Twisted Pair	Serial Data Tx+
8	8		Serial Data Tx-
9	9	Twisted Pair	Serial Data Rx+
10	10		Serial Data Rx-

Table 4-41. Gantry Daisy Chain C3 Wiring

Gantry Master (Y1) Drive	Gantry Difference (Y2) Drive	Twisted Pair	Signal Description
1	1	Twisted Pair	Serial Data Tx+
11	11		Serial Data Tx-
2	2	Twisted Pair	Serial Data Rx+
12	12		Serial Data Rx-

4.10 Power Board Connections

The power board interfaces vary depending on the specific CDHD2 model.

Refer to the Power Board Pinout diagrams.

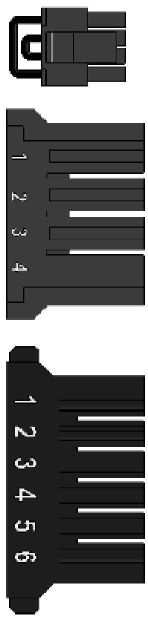
Make sure the main voltage rating matches the drive specification. Applying incorrect voltage may cause drive failure.
Do not apply power until all hardware connections are complete.

4.10.1 CDHD2-1D5/CDHD2-003 (MV) Power Board Pinouts

STO – Safe Torque Off **P1**: Molex | 22-24 AWG	
1	24 VDC (STO enable)
2	Ground (24 VDC return)
3	
4	

Motor **P2**: JST J300 | 18 AWG		
1	PE	Functional Ground
2	U	Motor Phase U
3	V	Motor Phase V
4	W	Motor Phase W

AC Input and Regeneration **P3**: JST J300 | 18 AWG		
1	B1+	DC Bus +
2	B2	Regen Bus -
3	L1	AC Phase 1
4	L2	AC Phase 2
5	L1C	Logic AC Phase 1
6	L2C	Logic AC Phase 2



All drives of the specified rating have the same power board.

Figure 4-31. CDHD2-1D5/CDHD2-003 (MV) Power Board Pin Assignments

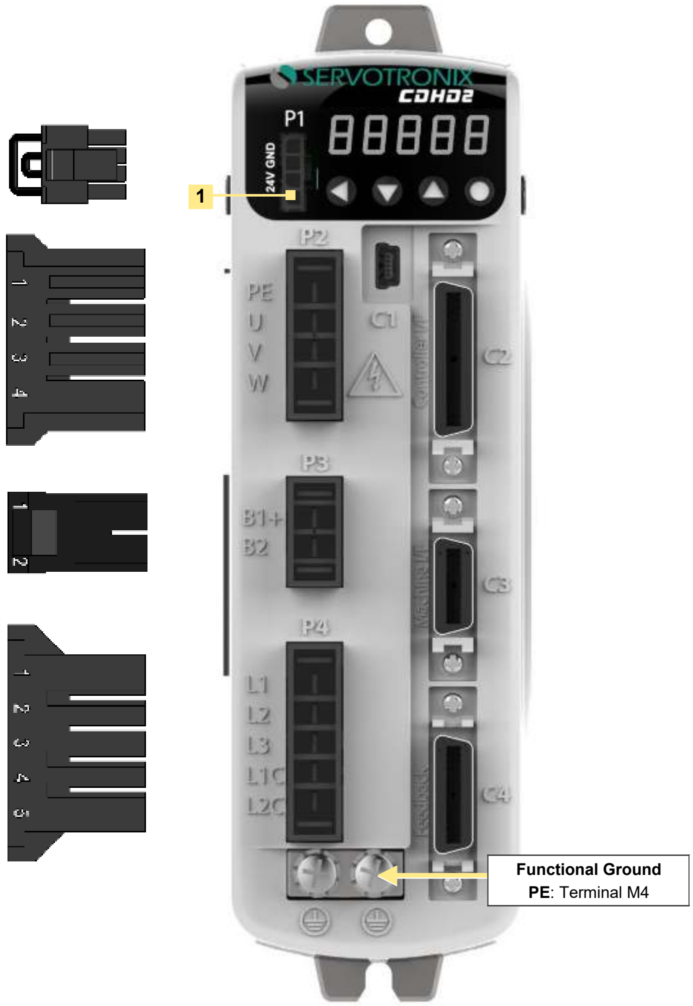
4.10.2 CDHD2-4D5/CDHD2-006 (MV) Power Board Pinouts

STO – Safe Torque Off **P1**: Molex | 22-24 AWG	
1	24 VDC (STO enable)
2	Ground (24 VDC return)
3	
4	

Motor **P2**: JST J300 | 16 AWG		
1	PE	Functional Ground
2	U	Motor Phase U
3	V	Motor Phase V
4	W	Motor Phase W

Regeneration **P3**: JST J300 | 16 AWG		
1	B1+	DC Bus +
2	B2	Regen Bus -

AC Input **P4**: JST J300 | 16 AWG		
1	L1	AC Phase 1
2	L2	AC Phase 2
3	L3	AC Phase 3
4	L1C	Logic AC Phase 1
5	L2C	Logic AC Phase 2



All drives of the specified rating have the same power board.

Figure 4-32. CDHD2-4D5/CDHD2-006 (MV) Power Board Pin Assignments

4.10.3 CDHD2-008/CDHD2-010/CDHD2-013 (MV) Power Board Pinouts

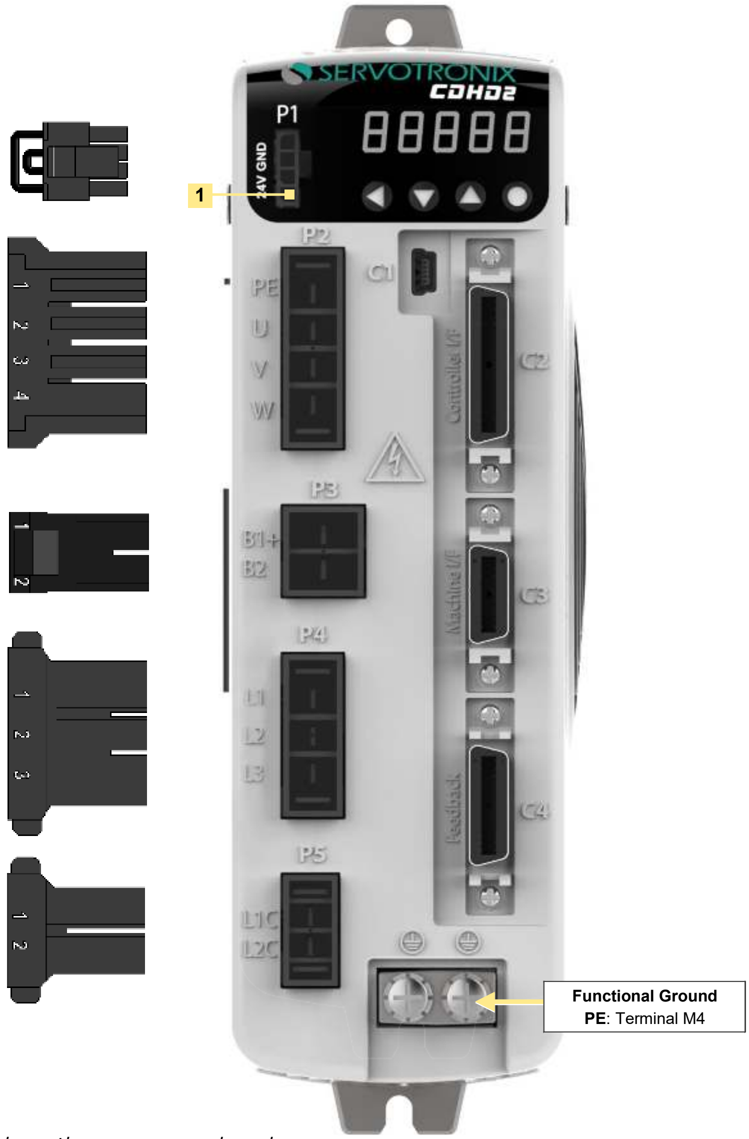
STO – Safe Torque Off **P1**: Molex | 22-24 AWG	
1	24 VDC (STO enable)
2	Ground (24 VDC return)
3	
4	

Motor **P2**: JST J400 | 14 AWG		
1	PE	Functional Ground
2	U	Motor Phase U
3	V	Motor Phase V
4	W	Motor Phase W

Regeneration **P3**: JST J300 | 16 AWG		
1	B1+	DC Bus +
2	B2	Regen Bus -

Main AC Input **P4**: JST J400 | 14 AWG		
1	L1	AC Phase 1
2	L2	AC Phase 2
3	L3	AC Phase 3

Logic Power AC Input **P5**: JST J300 | 16 AWG		
1	L1C	AC Phase 1
2	L2C	AC Phase 2



All drives of the specified rating have the same power board.

Figure 4-33. CDHD2-008/CDHD2-010/CDHD2-013 (MV) Power Board Pin Assignments

4.10.4 CDHD2-020/CDHD2-024 (MV) Power Board Pinouts

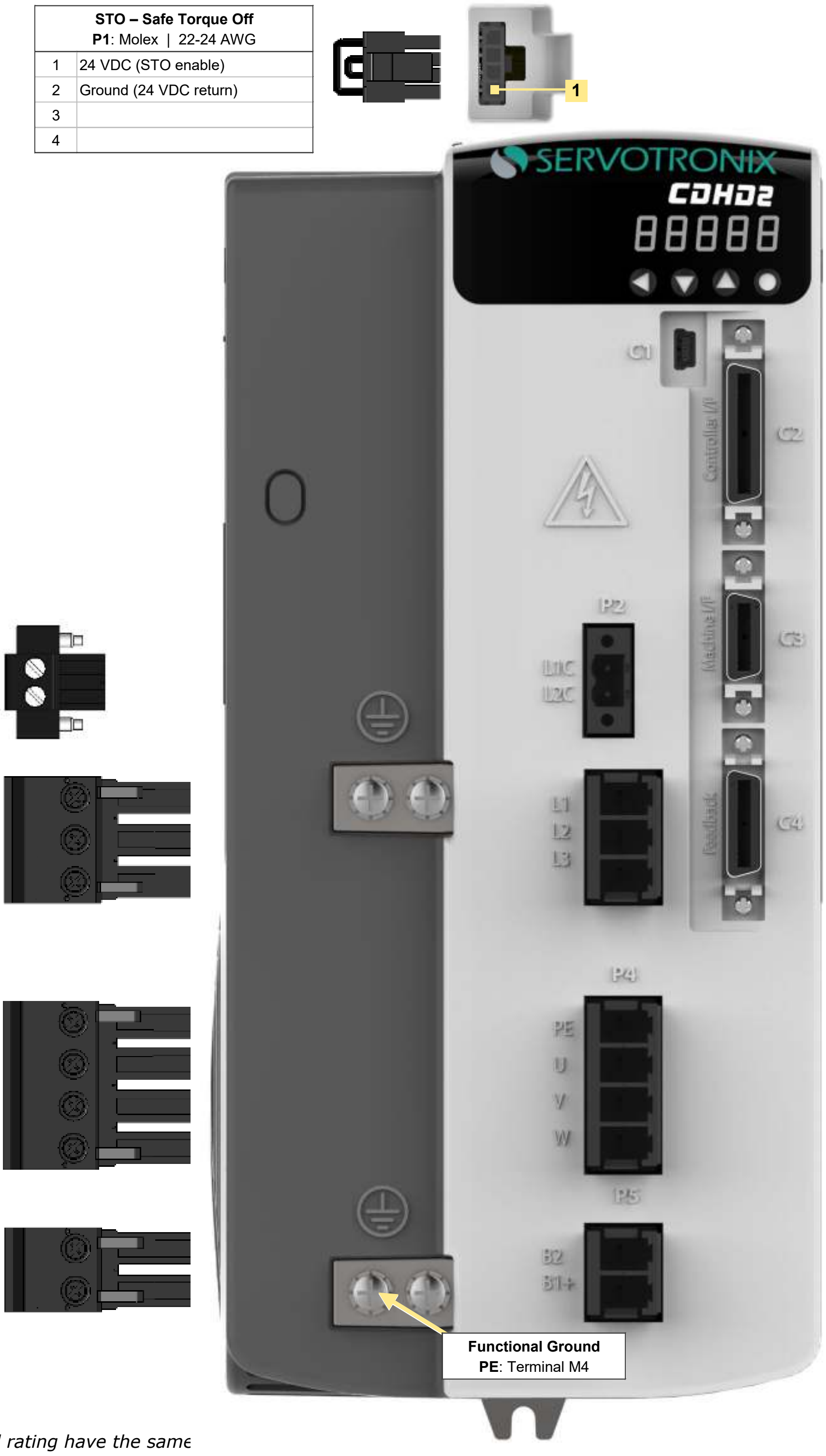
STO – Safe Torque Off **P1**: Molex | 22-24 AWG	
1	24 VDC (STO enable)
2	Ground (24 VDC return)
3	
4	

Logic Power AC Input **P2**: Phoenix | 16 AWG		
1	L1C	AC Phase 1
2	L2C	AC Phase 2

Main AC Input **P3**: Phoenix | 12-13 AWG		
1	L1	AC Phase 1
2	L2	AC Phase 2
3	L3	AC Phase 3

Motor **P4**: Phoenix | 10-11 AWG		
1	PE	Functional Ground
2	U	Motor Phase U
3	V	Motor Phase V
4	W	Motor Phase W

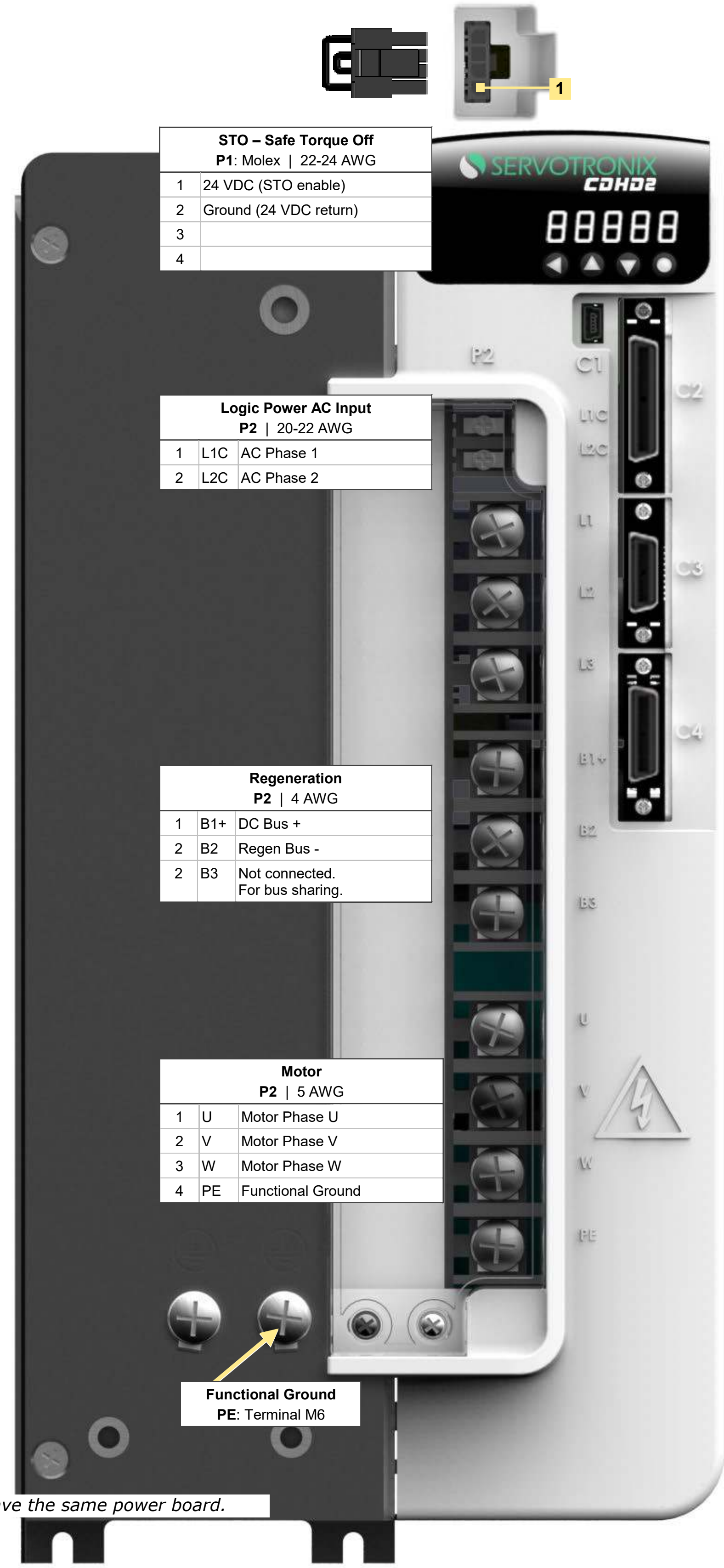
Regeneration **P5**: Phoenix | 14 AWG		
1	B2	Regen Bus -
2	B1+	DC Bus +



All drives of the specified rating have the same

Figure 4-34. CDHD2-020/CDHD2-024 (MV) Power Board Pin Assignments

4.10.5 CDHD2-033/CDHD2-044/CDHD2-055 (MV) Power Board Pinouts



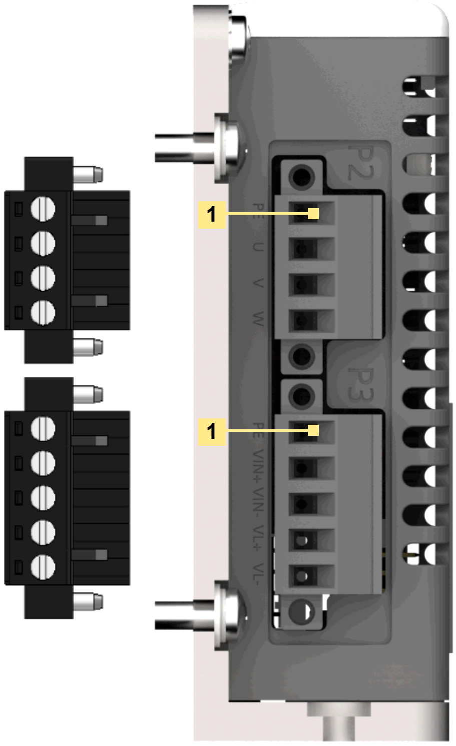
All drives of the specified rating have the same power board.

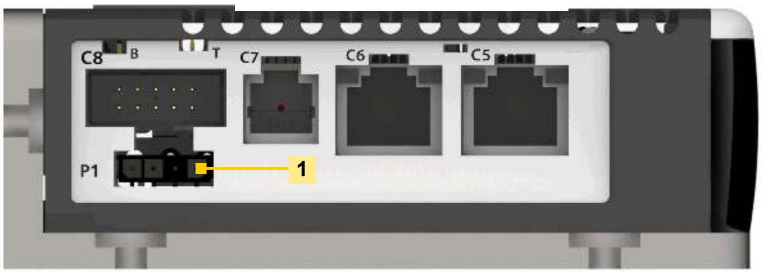
Figure 4-35. CDHD2-033/CDHD2-044/CDHD2-055 (MV) Pin Assignments

4.10.6 CDHD2-003/006/012/015/018 (LV) Power Board Pinouts

Motor **P2**: Wurth | **12-24 AWG**		
1	PE	Functional Ground
2	U	Motor Phase U
3	V	Motor Phase V
4	W	Motor Phase W

Power **P2**: Wurth | **12-24 AWG**		
1	PE	Functional Ground
2	VIN+	Input Voltage + (20-90V)
3	VIN-	Input Voltage Return
4	VL+	Logic Input Voltage (20-48V)
5	VL-	Logic Input Voltage Return





STO – Safe Torque Off **P1**: Molex | **26-28 AWG**	
1	24 VDC (STO enable)
2	Ground (24 VDC return)
3	
4	

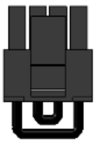


Figure 4-36. CDHD2-003/006/012/015/018 (LV) – Power Board Pin Assignments

Note: LV model CDHD2-018: for future release.

4.10.7 STO – P1

Safe torque off (STO) is a safety function that prevents the drive from delivering power to the motor which can generate torque.

For complete installation and operation details, refer to *Safe Torque Off (STO) Overview*

Table 4-42. STO Interface

Pin	Pin Label	Function
1	24V	STO Power Supply
2	GND	STO Return
3		24V Return, provided by the drive for STO bypass
4		24V Supply, provided by the drive for STO bypass

Note If the application does not require STO control, jumper pin 4 to pin 1, and pin 3 to pin 2, to bypass the STO, using the supplied STO bypass plug.

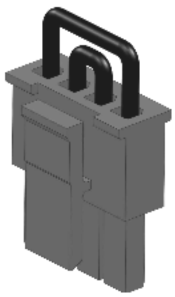


Figure 4-37. STO Bypass Plug

An example of a STO system configuration is shown in the following diagram.

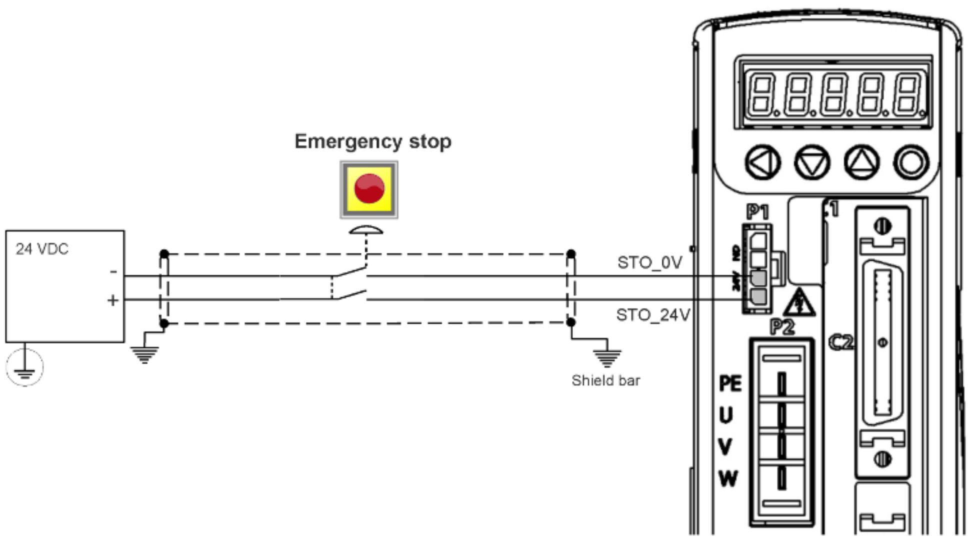


Figure 4-38. STO – Emergency Stop Circuit Wiring – Example

4.10.8 Motor Power – P2, P4

The Motor Power interfaces and connectors vary among CDHD2 models.

Refer to the Power Board Pinouts diagrams.

4.10.9 Regeneration Resistor – P3, P5

The Regeneration Resistor interfaces and connectors vary among CDHD2 models.

Refer to the Power Board Pinouts diagrams.

If the application requires a regeneration (regen) resistor, connect the regen resistor between terminals B1+ and B2.

4.10.10 AC Input - Bus Power and Logic Power – P3, P4, P5

The AC Input interfaces and connectors vary among CDHD2 models.

On CDHD2-1D5 and CDHD2-003, Regen and AC Input Voltage are combined on one connector. Since these models support only single-phase AC, they do not have a L3 terminal for bus power.

Refer to the Power Board Pinouts diagrams.

Make sure the main voltage rating matches the drive specification. Applying incorrect voltage may cause drive failure.

Do not apply power until all hardware connections are complete.

Prevent inrush surge:

Bus Power (L1-L2-L3): After switching off bus power, wait 1 minute before switching on again.

Logic Power (L1C-L2C): After switching off logic power, wait 1 minute before switching on again.

Procedure: Connecting Power

1. Connect the AC input voltage ground wire to the PE terminal, located on the CDHD2 front panel. Use an M4 ring or spade terminal.

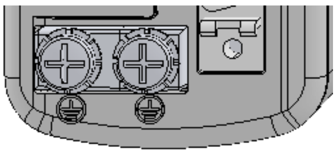


Figure 4-39. Ground Terminals

2. Connect L1, L2 and L3 (for bus power).
   - If the main voltage is from a single-phase source, connect line and neutral to L1 and L3.
   - If the main voltage is from a three-phase source, connect the phases to L1, L2 and L3.
3. Connect L1C and L2C (for logic power).
   - If the main voltage is from a single-phase source, connect line and neutral to L1C and L2C.
   - If the main voltage is from a three-phase source, connect any two phases to L1C and L2C.

4.11 Regeneration

4.11.1 Regenerative Energy Overview

When a motor and load decelerate rapidly, kinetic energy of the load drives the motor shaft energy back to the drive; this is called regenerative energy, or regeneration. This energy must be dissipated or absorbed.

Regenerative energy that is not dissipated is added to the electrical energy already stored in the capacitors of the bus module. If the capacitors are capable of storing the energy, the system does not require a regeneration resistor.

In some cases, often due to a high inertial mismatch between the load and motor, excessive energy is added to the capacitors, causing the voltage on the capacitors to reach the over-voltage threshold, which then disables the drive. To prevent over-voltage, and potential damage to the system, the excessive regenerative energy must be dissipated by a regeneration resistor.

To determine whether a system requires a regeneration resistor, and if so, the level of capacity, refer to Regeneration Resistance Calculations to calculate system properties.

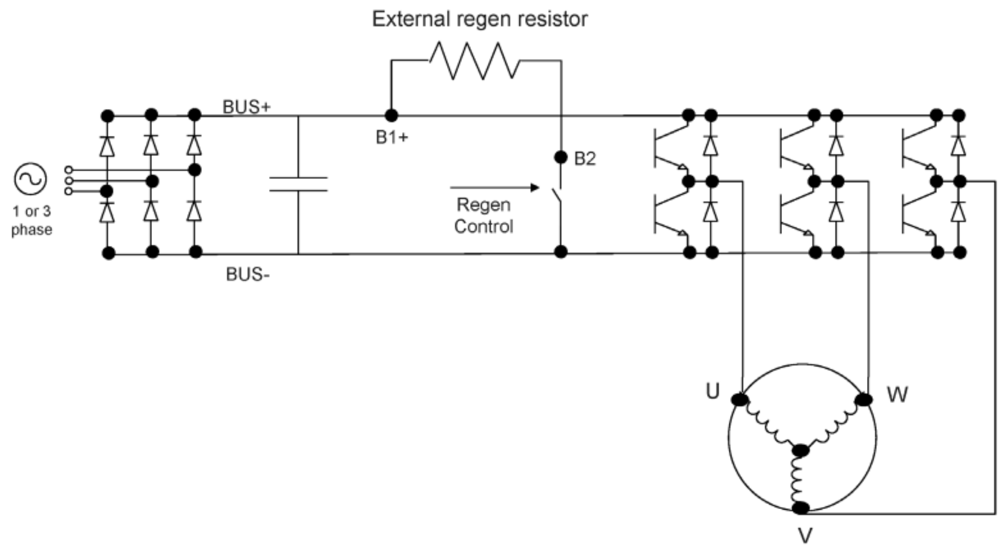


Figure 4-40. Regeneration Resistor Circuit

4.11.2 Regeneration Resistance Calculations

CDHD2 Bus Specifications

Table 4-43. Bus Specifications - Single Phase 120/240 L-L VAC

Drive Model	Capacitance (µF)	VNOM (VDC)	VLow (VDC)	VHigh (VDC)	VMAX (VDC)
CDHD2-1D5	360	170/340	380	400	420
CDHD2-003	660	170/340	380	400	420
CDHD2-4D5	1120	170/340	380	400	420
CDHD2-006	1120	170/340	380	400	420

Table 4-44. Bus Specifications - Three Phase 120/240 L-L VAC

Drive Model	Capacitance (µF)	VNOM (VDC)	VLow (VDC)	VHigh (VDC)	VMAX (VDC)
CDHD2-4D5	1120	170/340	380	400	420
CDHD2-006	1120	170/340	380	400	420
CDHD2-008	2110	170/340	380	400	420
CDHD2-010	2110	170/340	380	400	420
CDHD2-013	2110	170/340	380	400	420
CDHD2-020	3280	170/340	380	400	420
CDHD2-024	3280	170/340	380	400	420

Calculating the Energy Returned for Each Deceleration

$$E_{dec} = \frac{1}{2}(J_M+J_L)\left(\omega_1^2-\omega_2^2\right)$$

Where:

E_{dec} = Energy returned during deceleration (J or ft·lb)

J_M = Rotor inertia (kg·m^2 or lb·ft·sec2)

J_L = Load inertia (kg·m^2 or lb·ft·sec2)

ω_1 = Speed at the start of deceleration (rad/s)

ω_2 = Speed at the end of deceleration (rad/s)

Determining the Amount of Energy Dissipated by the Motor

Due to current flow through the motor winding resistance, some energy is dissipated by the motor:

$$E_{motor} = 3I_M^2 \cdot (R_M/2) \cdot t_d$$

Where:

E_{motor} = Energy dissipated by the motor (J)

R_M = Motor resistance (Ω L-L)

I_M = Current during deceleration (ARMS/phase)

t_d = Time of deceleration (s)

Determining the Amount of Energy Dissipated by Friction

$$E_{friction} = \frac{1}{2} T_f(\omega_1 - \omega_2) t_d$$

Where:

$E_{friction}$	=	Energy dissipated by friction (J or ft·lb)
T_f	=	Friction torque (N·m or lb·ft)
ω_1	=	Speed at the start of deceleration (rad/s)
ω_2	=	Speed at the end of deceleration (rad/s)
t_d	=	Time of deceleration (s)

Determining the Energy to be Dissipated by the Amplifier

$$E_M = E_{dec} - E_{motor} - E_{friction}$$

Where:

E_M	=	Total energy to be dissipated by the amplifier (J or ft·lb)

If this energy is less than that which the bus module can store, no regeneration resistor is needed.

E_M should be expressed in joule. The conversion ratio from ft·lb to joule is:

1 ft·lb = 1.356 J

Determining the Energy the Bus Can Absorb

$$E_{BUS} = \frac{1}{2} C\left(V_M^2 - (V_{NOM})^2\right)$$

E_{BUS}	=	Energy the bus module can absorb (J)
C	=	Bus module capacitance (F); refer to section *Bus Specifications*
V_M	=	Maximum bus voltage (V); refer to section *Bus Specifications*
V_{NOM}	=	Nominal bus voltage = $\sqrt{2}V_{mains}$ (V)

Determine if a regeneration resistor is required

If $E_{BUS} > E_M$	Regeneration resistor is not required.
If $E_{BUS} < E_M$	Regeneration resistor is required.

Determining Resistor Value

The procedure for calculating regeneration requirements is twofold. Both the regeneration resistance value and the resistor wattage must be determined.

Determining the Resistance Value

$$R_{Max} = \frac{V_M^2}{V_B I_M \sqrt{3}}$$

Where:

V_B	=	Motor back EMF less motor losses.

$$V_B = K_B N - \sqrt{3} I_M (R_M/2)$$

V_M	=	Maximum bus voltage (V); refer to section *Bus Specifications*
K_B	=	Back EMF constant (V L-L / rpm)
N	=	motor speed prior to deceleration (rpm)
I_M	=	Current during deceleration (ARMS/phase)
R_M	=	Motor resistance (Ω L-L)

Determining the Average Dissipated Power

$$P_{AV} = \frac{E_M - \frac{1}{2} C (V_{High}^2 - V_{Low}^2)}{t_{cycle}}$$

Where:

E_M	=	Total energy needs to be dissipated by the amplifier (J)
C	=	Bus module capacitance (F); refer to section *Bus Specifications*
V_{High}	=	Hysteresis point: Regen circuit turn on(V); refer to section *Bus Specifications*
V_{Low}	=	Hysteresis point: Regen circuit turn off (V); refer to section *Bus Specifications*
t_{cycle}	=	Time between decelerations + time of deceleration (s)

Determining the Peak Resistor Power

$$P_{PK} = \frac{V_M^2}{R_{Regen}}$$

R_{Regen}	=	Regeneration resistor resistance (Ω L-L)
V_M	=	Maximum bus voltage (V); refer to section *Bus Specifications*

Regeneration Calculation in US Standards Units – Example

Motor and Drive Specifications

CDHD2-006 drive with 240 VAC single phase input

J_{motor} = 0.000484 lb·ft·sec2

R_M = 1.32 Ω

I_{peak} = 18 A

T_M = 19.8 lb·ft

C = 0.001120 F

V_M = 420 V

K_B = 81.2 V/krpm = 0.0812 V/rpm

k_t = 1.188 lb·ft/A

System Specifications

T_f = 1.5 lb·ft

J_{Load} = 0.0015 lb·ft·sec2

V_{Max} = 2,500 rpm => ω_M = 261 rad/s

V_{NOM} = 240 Vrms=340 VDC

Time between decelerations = 5 s

Time of Deceleration Calculation

$$t_d = \frac{(J_{Motor}+J_{Load})\cdot(\omega_M)}{(T_M+T_f)} = (0.000484+0.001)\cdot(261)/(19.8+1.5) = 0.0181 \text{ s}$$

Current During Deceleration Calculation

$$I_M = \frac{(J_{Motor}+J_{Load})}{k_t}\cdot\frac{\omega_1-\omega_2}{t_d} = \frac{0.001+0.000484}{1.188}\cdot\frac{261}{0.0181} = 18 \text{ A}$$

Energy Calculation

$$E_{dec} = \frac{1}{2}(J_M+J_L)(\omega_1^2-\omega_2^2) = \frac{1}{2}(0.0015+0.000484)(261^2-0) = 67.57 \text{ ft}\cdot\text{lb} = 91.63 \text{ J}$$

$$E_{motor} = 3I_M^2\cdot(R_M/2)\cdot t_d = 3\cdot 18^2\cdot\left(\frac{1.32}{2}\right)\cdot 0.0181 = 11.61 \text{ J}$$

$$E_{friction} = \frac{1}{2}T_f(\omega_1-\omega_2)t_d = \frac{1}{2}\cdot 1.5(261-0)\cdot 0.0181 = 3.54 \text{ ft}\cdot\text{lb} = 4.8 \text{ J}$$

$$E_M = E_{dec} - E_{motor} - E_{friction} = 91.633 - 11.611 - 4.8 = 75.22 \text{ J}$$

$$E_{BUS} = \frac{1}{2}C\left(V_M^2-V_{NOM}^2\right) = \frac{1}{2}\cdot 0.001120\left(420^2-340^2\right) = 34.05 \text{ J}$$

Since $E_M > E_{BUS}$, a regeneration resistor is required.

Resistor Specification Calculation

$$V_B = K_B N-\sqrt{3}I_M\left(\frac{R_M}{2}\right) = 0.0812*2500-\sqrt{3}\cdot 18\cdot\left(\frac{1.32}{2}\right) = 182.423 \text{ V}$$

$$R_{MAX} = \frac{V_M^2}{V_B I_M\sqrt{3}} = \frac{420^2}{182.423\cdot 18\cdot\sqrt{3}} = 31.02\ \Omega$$

$$P_{AV} = \frac{E_M-\frac{1}{2}C\left(V_{High}^2-V_{Low}^2\right)}{t_{cycle}} = \frac{75.22-\frac{1}{2}\cdot 0.001120\cdot\left(400^2-380^2\right)}{5.0181} = 13.25 \text{ W}$$

$$P_{PK} = \frac{V_M^2}{R_{Regen}} = \frac{420^2}{1.32} = 5686.65 \text{ W}$$

Regeneration Calculation inMKS Units – Example

Motor and Drive Specifications

CDHD2-006 drive with 240 VAC single phase input

J_{motor} = 0.0006562 kg·m^2

R_M = 1.32 Ω

I_{peak} = 18 A

T_M = 16.08 N·m

C = 0.001120 F

V_M = 420 V

K_B = 81.2 V/krpm = 0.0812 V/rpm

k_t = 1.042 N·m/A

System Specifications

T_f = 2.5 N-m

J_{Load} =0.0015 kg·m^2

V_{Max} = 2,500 RPM => ω_M = 261 rad/s

V_{NOM} = 220 Vrms = 340 VDC

Time between deceleration = 5 s

Time of Deceleration Calculation

$$t_d = \frac{(J_{Motor}+J_{Load})\cdot(\omega_M)}{(T_M+T_f)} = \frac{(0.0006562+0.0015)(261)}{(16.08+2.5)} = 0.03\ s$$

Current During Deceleration Calculation

$$I_M = \frac{(J_{Motor}+J_{Load})}{k_t}\cdot\frac{\omega_1-\omega_2}{t_d} = \frac{0.0006562+0.0015}{1.042}\cdot\frac{261}{0.03} = 18\ A$$

Energy Calculation

$$E_{dec} = \frac{1}{2}(J_M+J_L)(\omega_1^2-\omega_2^2) = \frac{1}{2}(0.0006562+0.0015)(261^2-0) = 73.44\ J$$

$$E_{motor} = 3I_M^2\cdot(R_M/2)\cdot t_d = 3\cdot 18^2\cdot\left(\frac{1.32}{2}\right)\cdot 0.03 = 19.24\ J$$

$$E_{friction} = \frac{1}{2}T_f(\omega_1-\omega_2)t_d = \frac{1}{2}\cdot 2.5\cdot(261-0)\cdot 0.03 = 9.78\ J$$

$$E_M = E_{dec}-E_{motor}-E_{friction} = 73.44-19.24-9.78 = 44.42\ J$$

$$E_{BUS} = \frac{1}{2}C\left(V_M^2-V_{NOM}^2\right) = \frac{1}{2}\cdot 0.001120(420^2-340^2) = 34.05\ J$$

Since $E_M > E_{BUS}$, a regeneration resistor is required.

Resistor Specification Calculation

$$V_B = K_BN-\sqrt{3}I_M\left(\frac{R_M}{2}\right) = 0.0812\cdot 2500-\sqrt{3}\cdot 18\cdot\left(\frac{1.32}{2}\right) = 182.423\ V$$

$$R_{MAX} = \frac{V_M^2}{V_BI_M\sqrt{3}} = \frac{420^2}{182.423\cdot 18\cdot\sqrt{3}} = 31.02\ \Omega$$

$$P_{AV} = \frac{E_M-\frac{1}{2}C\left(V_{High}^2-V_{Low}^2\right)}{t_{cycle}} = \frac{44.42-\frac{1}{2}\cdot 0.001120\cdot\left(400^2-380^2\right)}{5.03} = 7.1\ W$$

$$P_{PK} = \frac{V_M^2}{R_{Regen}} = \frac{420^2}{1.32} = 5686.65\ W$$

4.11.3 Regeneration Resistor Overload Protection

Motor energy regeneration is always active in the CDHD2.

There are two modes for the motor energy regeneration function:

- Regeneration **with** resistor overload protection.

  The regeneration resistor circuitry itself requires overload protection to ensure the resistor functions reliably. In this mode, use the configurable CDHD2 regeneration resistor parameters to apply this protection.

- Regeneration **without** resistor overload protection. This is also referred to as the bang-bang mode.

  In bang-bang mode, when bus voltage exceeds the upper threshold level (400V for medium voltage (MV) drives, 790V for high voltage (HV) drives), the regeneration resister will be activated by the drive; when bus voltage is reduced to the lower threshold level (380V for MV drives, 770V for HV drives), the regeneration resister will be deactivated.

⚠ Use the regeneration resistor protection with caution.
If the motor increases bus voltage, resulting in activation of the protection mechanism, an over-voltage condition may result.

4.11.4 Regeneration Resistor Parameters

The regeneration resistor capacity is defined by several parameters.

To activate the regeneration resistor protection function in the CDHD2, parameter REGENRES and/or parameter REGENPOW must be set to a value other than -1, which is the default value.

VarCom	Description
REGENRES	Resistance of the regeneration resistor, in ohms.
REGENPOW	Power of the regeneration resistor, in watts.
REGENMAXONTIME	The maximum time for which the regeneration resistor may be continually activated (on), in milliseconds.
REGENMAXPOW	The maximum calculated power of the regeneration resistor, in watts.

Note

If the system does not have a regeneration resistor, set REGENRES = -1 and REGENPOW = -1

If the system has a regeneration resistor, a value of -1 for either REGENRES or REGENPOW deactivates the regeneration resistor overload protection algorithm.

4.12 Firmware Update

4.12.1 Firmware Update Preparation

Important: Before updating the firmware, be sure to do the following:

- Refer to the Release Notes and any other documentation supplied with the new firmware.
- Since parameter settings may be lost during the update, backup drive parameters from each drive in the system, and keep these files secure. After the update is completed, the parameters can be reloaded/restored.

  To backup parameters, go the ServoStudio 2 Backup & Restore screen, and press the **Save to Backup** button.

4.12.2 Firmware Update Options

The Download Firmware button in the ServoStudio 2 **Drive Information** screen opens the Firmware Download dialog box.

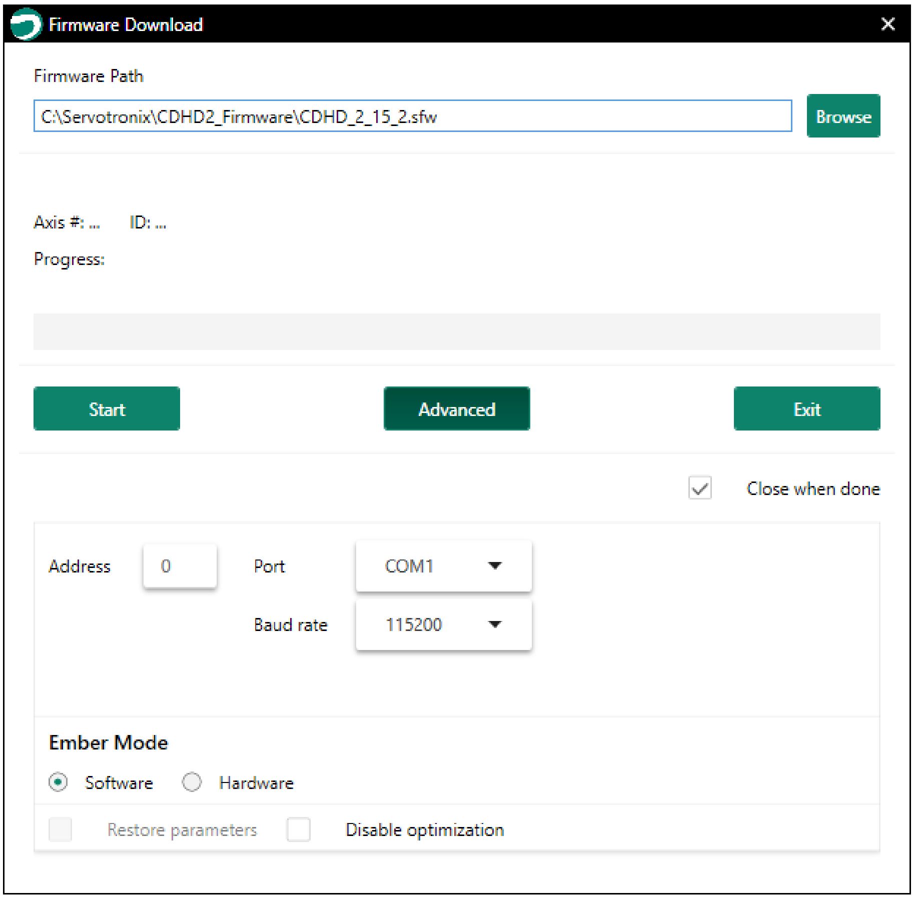


Figure 4-41. Firmware Download

Firmware Path	The path and name of the file containing the firmware update. The file name indicates the firmware version; for example: 2_00_0*.sfw represents firmware version 2.0.x. The default path is \My Documents\ServoStudio 2. Press **Browse** to select another path.
Start	Activates the firmware update.
Advanced	Expands the dialog to show additional options
Close When Done	When selected, the Firmware Download dialog box closes automatically once the procedure is completed.
Address	● When only one drive is connected to the host computer, a drive address is not needed. The software attempts to communicate with the drive that was communicating with the host before the Firmware Download process was activated. Thus, if the drive responds to serial communication, the firmware download process will proceed. ● When multiple drives are connected to the host in a daisy-chain, a drive address must be specified. When a drive address is specified, the software starts by sending the command **** which stops all drives connected to the selected serial port from responding to serial communication. It then issues the command *nn* which instructs only the drive with address *nn* to respond. Then it begins the firmware download.
Port	The COM port of the host computer to which the drive is connected. Make sure this COM port is not being used by any other application.
Baud Rate	The rate must be set to 115200.
Ember Mode	Ember is the process used for burning new firmware on the drive's flash memory. ● **Software**: Normally use the default Software option. ● **Hardware**: If the firmware loading process has been interrupted and you are unable to establish communication with the drive, use this option.
Disable Optimization	The firmware update procedure uses an optimization method to improve performance. In rare instances this optimization may cause the procedure to fail. In such an instance, disable the optimization and restart the firmware update.
Restore Parameters	When selected, the firmware update procedure stores all user parameters to memory before downloading the firmware and restores the parameters after the update. This option can be disabled. This option is not available if host and drive are not communicating. **Note**: Regardless of this option setting, it is strongly recommended that you use the **Save to Backup** option in the Backup & Restore screen to preserve the existing drive parameters before updating the firmware.

4.12.3 Firmware Update over Serial Connection

Procedure: Updating Drive Firmware over Serial Connection

1. Download the drive’s firmware file (*.sfw) from the product web page to a host computer.
2. From the ServoStudio 2 Drive Info screen, press Download Firmware.

   The Firmware Download dialog box opens and allows you to send the firmware file to the drive over a serial communication link.
3. Browse to and select the firmware file.
4. Press Start to download the firmware file to the drive.

   During the firmware update process, the digital display shows (FLOAd):

   The process takes several minutes.

   When the process is complete, the new firmware starts running.
5. Download the drive parameter file to the drive.
6. Execute SAVE to save the parameters in the drive’s non-volatile memory.
7. Cycle power and run the machine.
   If machine behavior has changed, contact Technical Support.
8. Retrieve the parameter file from the drive, and save the file for future reference and backup.
9. Repeat the firmware update procedure for each drive in the machine.

4.12.4 Firmware Update over EtherCAT

Firmware updates can be performed using File over EtherCAT (FoE) download protocol. The CDHD2 runs in a bootloader state to allow firmware download to the host controller via the EtherCAT network. Standardized firmware download to devices is therefore possible, even without the support of TCP/IP.

Note

Drive Resident (Bootloader) must be version 1.3.1 or higher.
The version can be checked in the ServoStudio 2 Terminal screen, by means of the command VER. If the system has a regeneration resistor, a value of -1 for either REGENRES or REGENPOW deactivates the regeneration resistor overload protection algorithm.

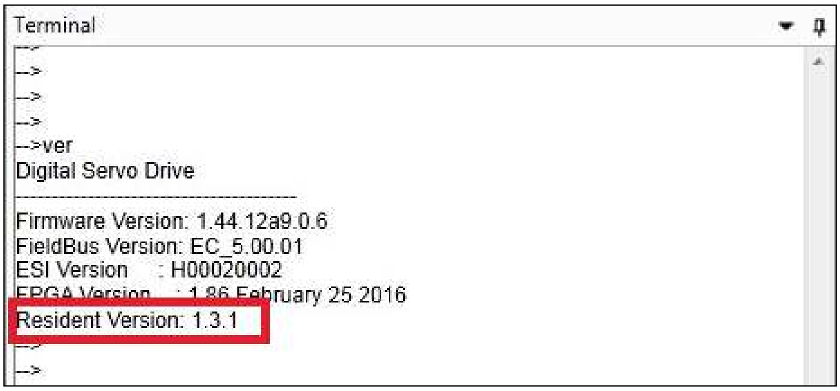


Figure 4-42.

Procedure: Updating Drive Firmware over EtherCAT

1. Install TwinCAT 3.0 on the host PC.

   Follow the instructions provided by Beckhoff.

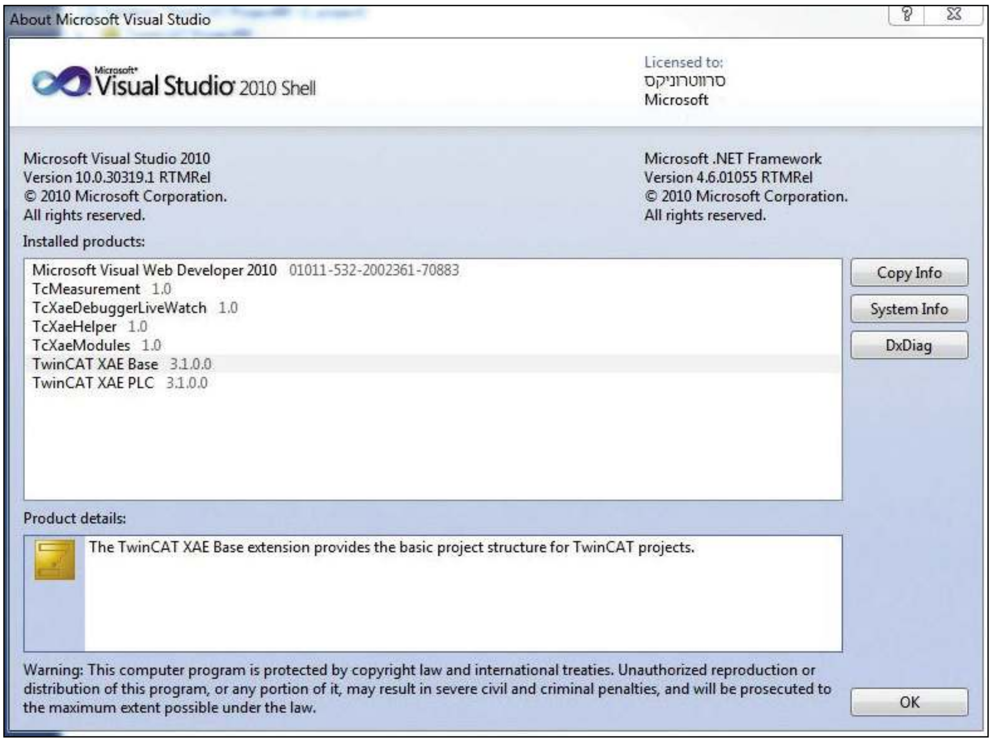


Figure 4-43.

2. In TwinCAT connect to the CDHD2 drive.
3. In the TwinCAT navigation menu, select I/O > Devices ... CDHD2 drive.

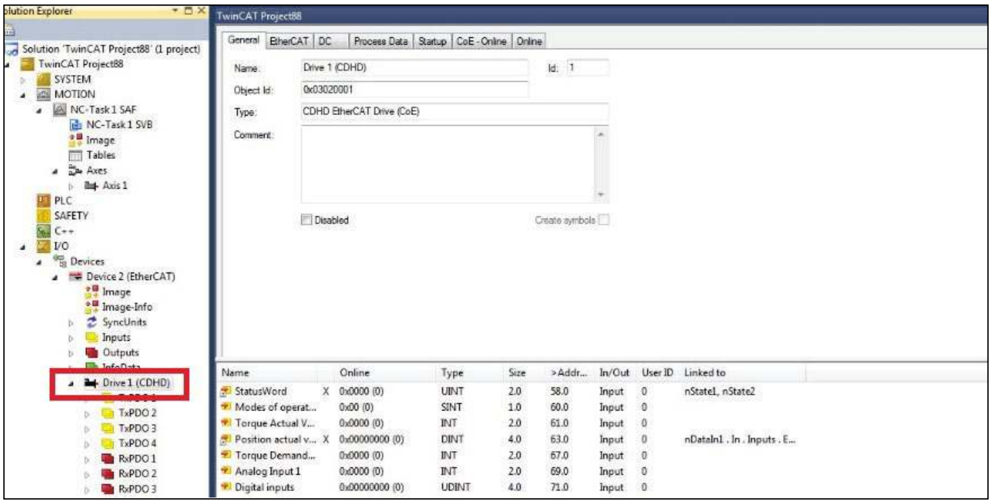


Figure 4-44.

4. Go to the Online tab.

   Press Bootstrap.

   Wait until Current States becomes BOOT.

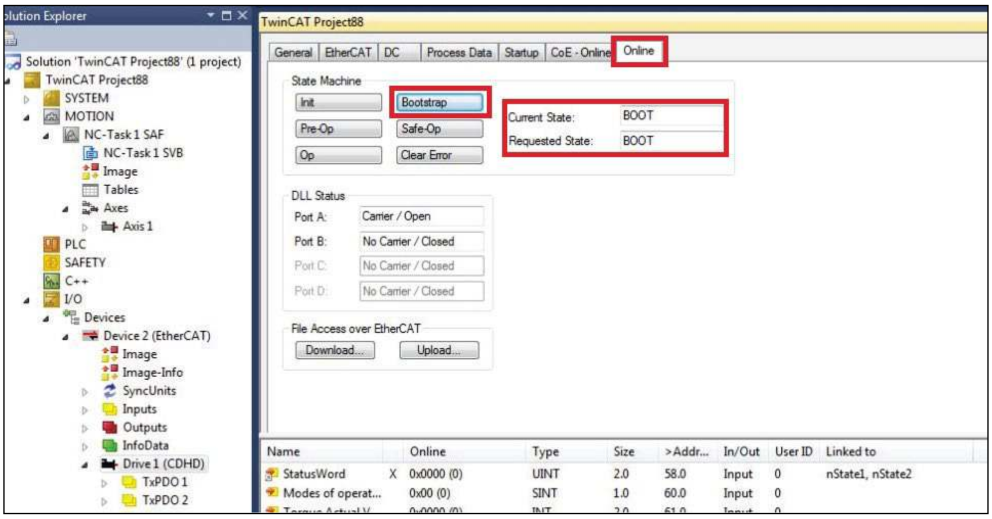


Figure 4-45.

5. Press Download.

6. The File Manager dialog box opens.

   Browse to and select the CDHD2 firmware file (with *.i00 extension).

   Press Open.

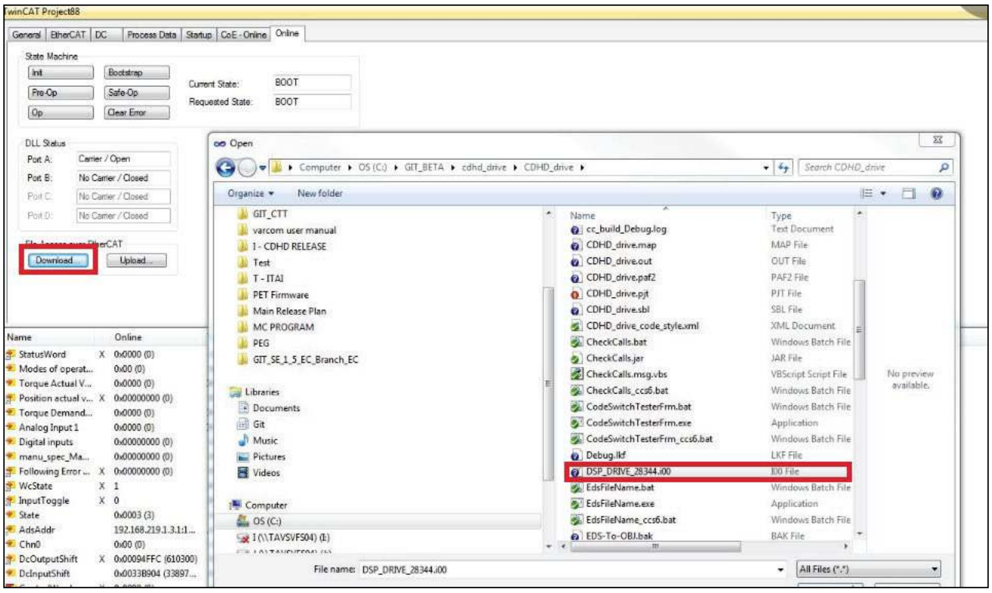


Figure 4-46.

7. The Edit FoE Name dialog box opens.

   Do not change anything in this dialog box. Simply press OK.

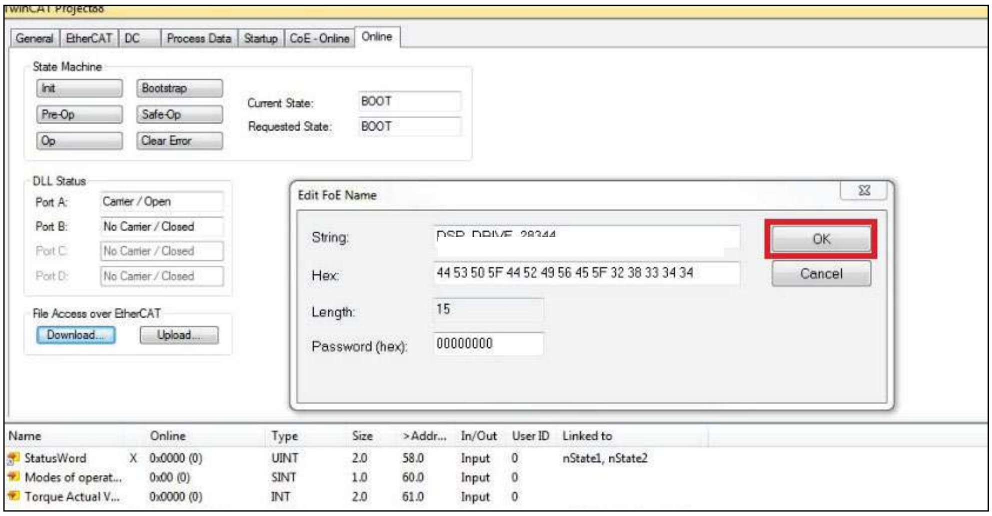


Figure 4-47.

8. The firmware update process begins.

   The digital display shows:

   In the TwinCAT status bar at the bottom of the screen, Downloading is displayed at the left, and a progress bar is displayed at the right.

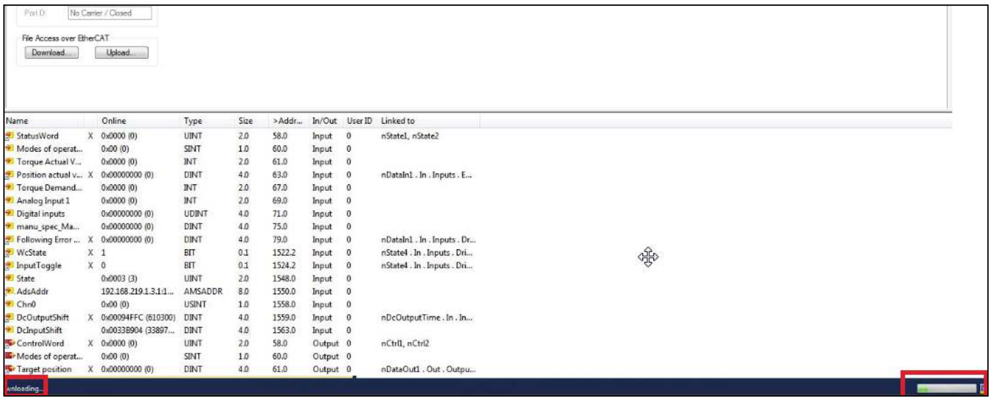


Figure 4-48.

9. When the firmware updated is completed, Current State switches from BOOT to PREOP.

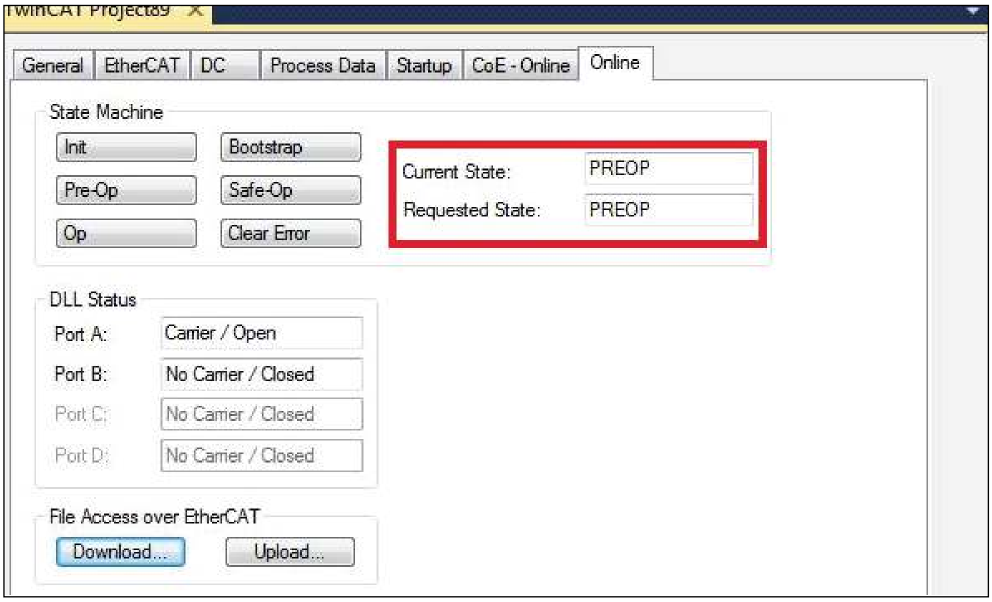


Figure 4-49.

4.12.5 Resuming Operation After Firmware Update

Procedure: Resuming Operation After Firmware Update

1. Go to the ServoStudio 2 **Drive Info** screen in ServoStudio 2, and check the drive firmware version to verify that the new firmware has been loaded.
2. Open the **Backup & Restore** screen, and press the Restore button to reload the previously backed up parameters the drive
3. Check the version release note, and set any parameters that may have been added to the new version.
4. Save the parameters to the non-volatile parameter memory: either execute the serial command SAVE command, or press the Save button on the ServoStudio 2 toolbar, or use the operator panel command C0006 and wait for the display to show done.
5. Cycle power, and run the machine. If machine behavior has changed, contact Technical Support.

4.12.6 Ember Mode

Ember is the process used for burning new firmware on the drive's flash memory. The drive must be in the Ember mode for the firmware to be loaded. The drive has two Ember modes, Software and Hardware.

Normally, you can and should communicate with the drive in Software Ember mode for loading new firmware.

However, if the firmware loading process has been interrupted and you are unable to establish communication with the drive, you need to use the Ember Hardware mode.

To activate the Hardware Ember mode, use a small screwdriver or similar tool to gently press the Hardware Ember switch. This switch is located on the top of the drive next to the daisy chain connector (C8).

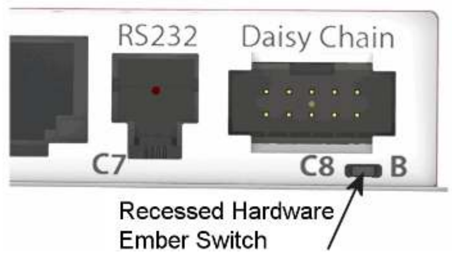


Figure 4-50. Location of Hardware Ember Switch

Pressing the switch sets the drive to serial communication Boot-Up mode.

If the drive has a fan, the fan rotates at maximum speed. The fan speed will revert to normal after the firmware has been downloaded successfully and the drive has restarted.

While in Boot-Up mode, the 5-digit digital display shows five dashes (– – – – –).

4.12.7 Parameter Download over EtherCAT

To automate and simplify the process of downloading parameters to multiple drives, parameters can be downloaded using File over EtherCAT (FoE) download protocol.

Procedure: Downloading Parameters over EtherCAT

1. Use ServoStudio 2, backup the parameters in the drive to an SSV file.

   For example, save to a file called CDHD2_parameters.SSV.

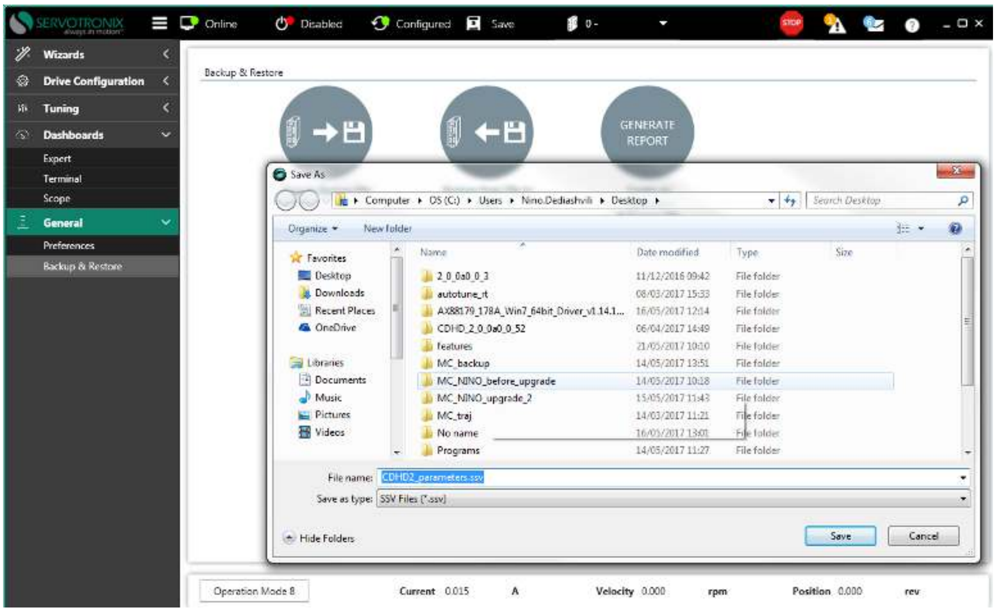


Figure 4-51.

2. Using TwinCAT, connect to CDHD2 drive.

   Be sure the drive is in Init or Pre-Op state.

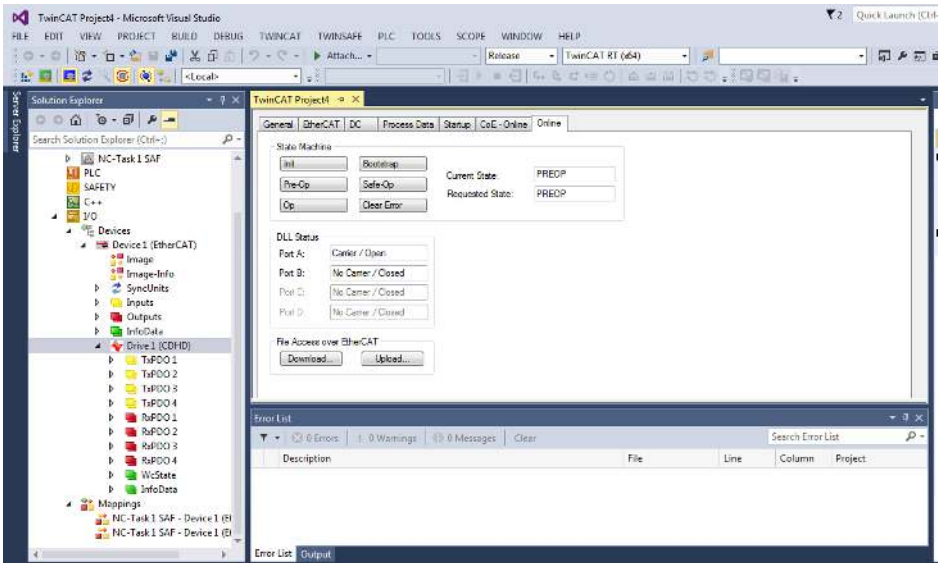


Figure 4-52.

3. Press the Download button, and select the SSV parameter file that you saved in Step 1.

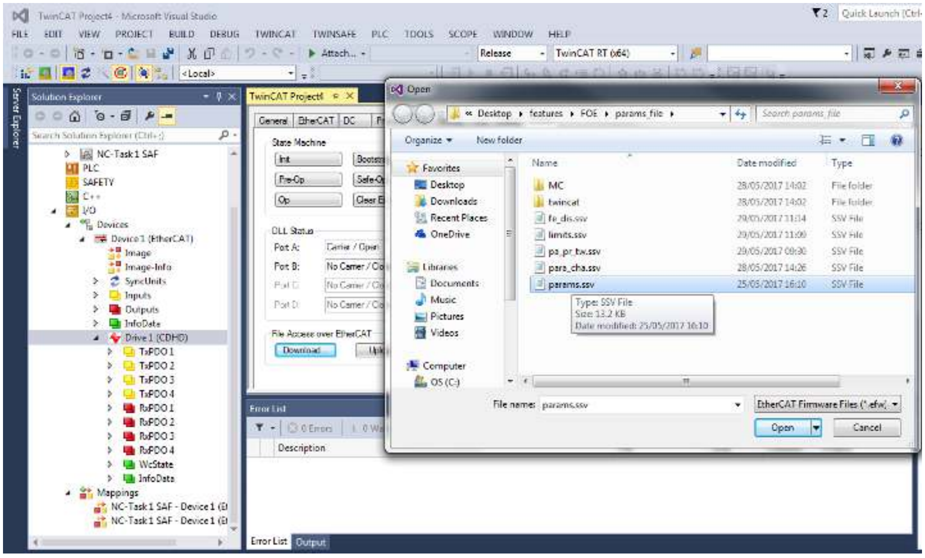


Figure 4-53.

4. Be sure the file name includes the extension .SSV
   (By default, TwinCAT does not add the extension.)

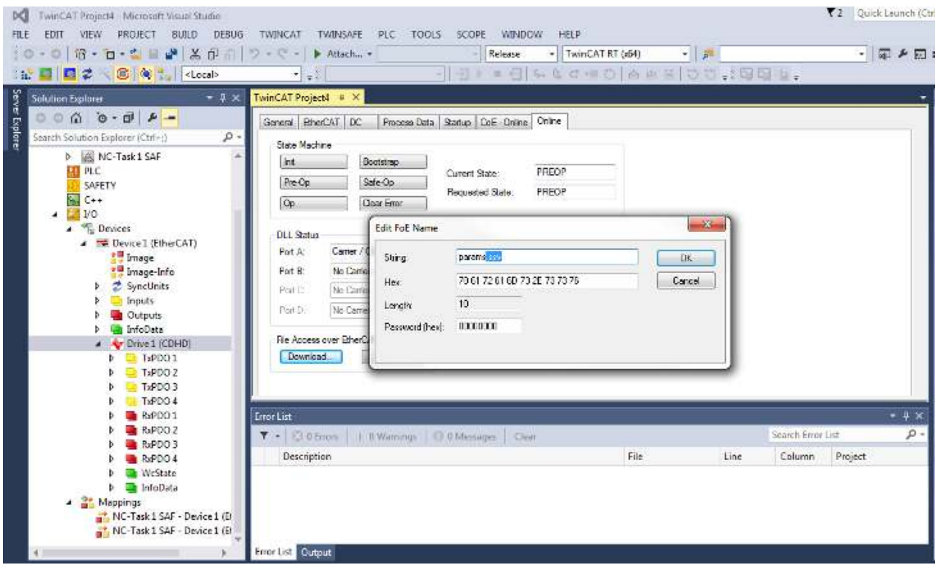


Figure 4-54.

5. Press OK.

   Look at the drive. The digital display shows FoE while the parameters are downloading.

6. Wait about 10 seconds. When the download is complete, the digital display returns to its previous setting.

5 Motor Setup

As of firmware version 1.40.0, the drive attempts to detect a motor feedback device and an electronic motor nameplate (MTP) at power-up. If an MTP is detected, certain motor and feedback parameters are transferred directly to the drive and cannot be manipulated. The electronic nameplate thus makes commissioning very simple and reliable.

If an electronic motor nameplate is not detected at power-up, you can use the **Motor** screen or the **Motor Setup wizard** to select a motor from the ServoStudio 2 databases (motor libraries). You can simply select the motor family and motor part number, and ServoStudio 2 will prepare the appropriate motor and feedback parameters. The screen allows you to modify and send parameters to the drive, read parameters from the drive, and save parameters.

⚠

Disable the drive before manipulating motor and feedback parameters.

Many parameters can be modified while the drive is enabled.
Exercise caution, however, as motor behavior will change.

If a parameter cannot be modified while the drive is enabled, ServoStudio 2 will prompt you to disable the drive.

5.1 Motor Setup Wizard

The ServoStudio 2 Motor Setup wizard provides the quickest and easiest method for getting the drive and motor up and running. It configures the essential parameters and the current control loop for a motor without a load.

It is recommended that you use the Motor Setup wizard when connecting the host computer, drive and motor for the first time.

This chapter describes the functions and parameters that are configured during the setup and initialization of the motor.

Motor Setup – Connection

Typically, the wizard begins with a step to establish communication between the drive and the ServoStudio 2 software.

If ServoStudio 2 is already communicating with the drive, the wizard will skip this step.

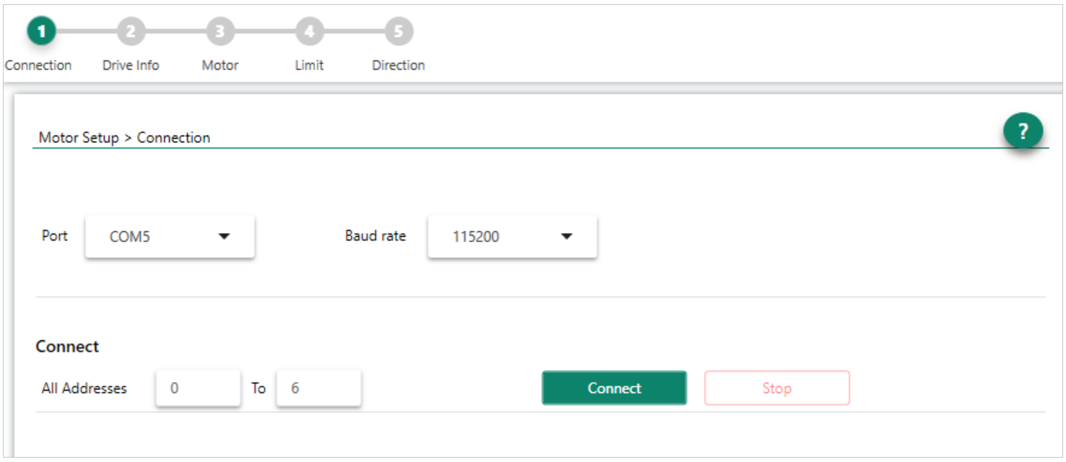


Figure 5-1. Motor Setup Wizard – Connection

1. Select either a specific COM port or Search All.
2. Press Connect.

Refer to *Communication*.

Motor Setup – Drive Identification

If ServoStudio 2 is already communicating with the drive, the wizard will begin at **Drive Information**.

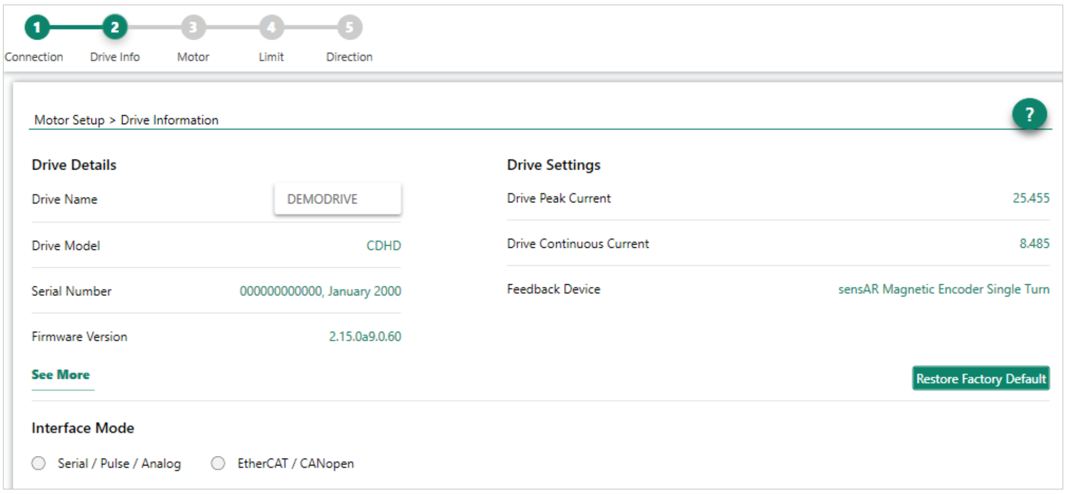


Figure 5-2. Motor Setup Wizard – Drive Information

1. Review the drive information.
2. Enter a name for the drive, and press Enter after typing the name.

   The name field will change from blue to white, indicating the name has been sent to the drive.

This step also includes an option to restore the drive's factory settings: **Restore Factory Default**.

This step also shows and allows setting the Command Interface Mode:

- **Serial/Pulse/Analog** indicates drive is active (Servo On) and motion commands are transmitted via a serial, pulse or analog interface. COMMODE 0.
- **EtherCAT/CANopen** indicates drive is active (Servo On) and motion commands are transmitted via an EtherCAT or CANopen interface. COMMODE 1.

Note For CDHD2 AF, EC, EB models and DDHD AF models, both interface options are available. For CDHD2 AP and DDHD AP models, only the EtherCAT/CANopen option is available.

Motor Setup – Motor Identification and Initialization

If the drive detects an electronic motor nameplate, the parameters in this screen are set automatically and cannot be manipulated. Simply press **Next** to continue to the next step.

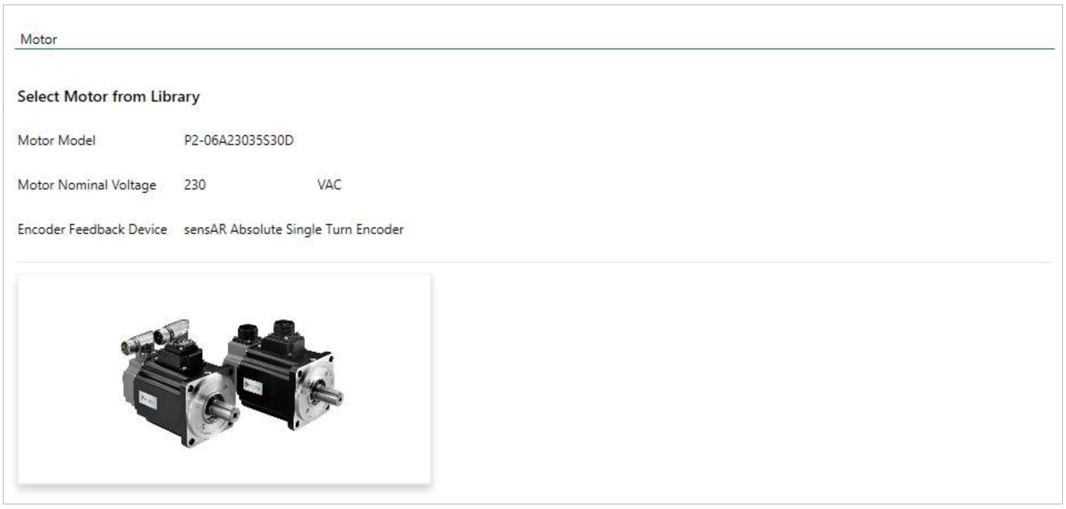


Figure 5-3. Motor Setup Wizard – Automatic Motor Detection

If the drive does not detect an electronic nameplate (or if the software is not communicating with the drive), you can select a motor from the ServoStudio 2 motor libraries.

If your motor is not listed in the default set of motor libraries, press **Define New Motor**, and use the *New Motor Wizard* to enter the parameters for your motor.

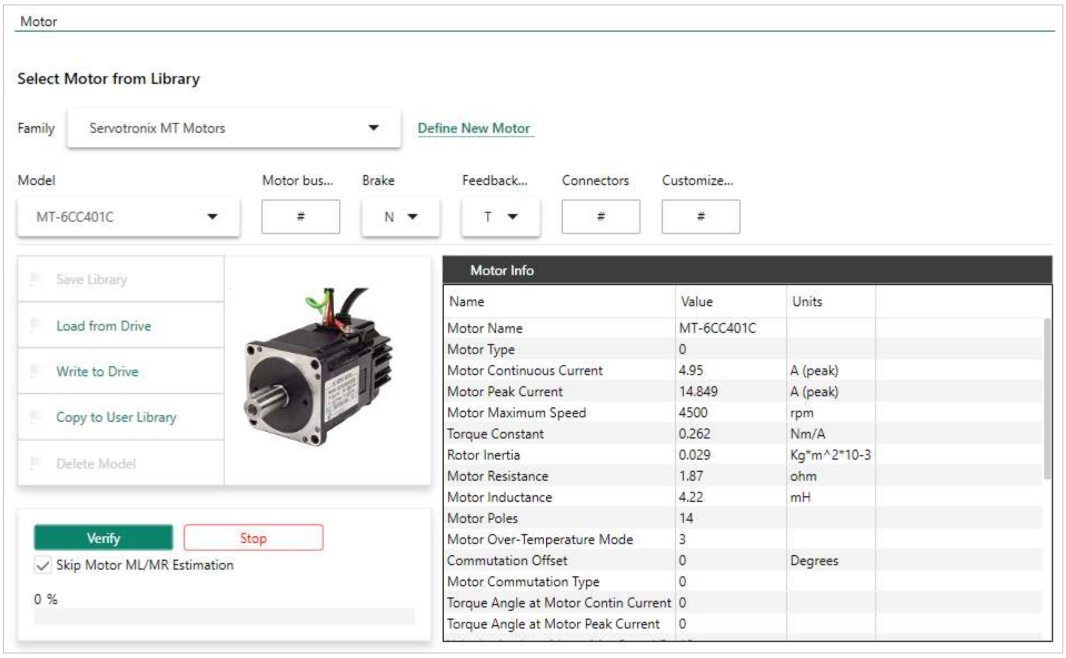


Figure 5-4. Motor Setup Wizard – Motor Selection

1. Select the motor Family
2. Select the motor Model.
3. Select the characters that match the label on the motor (# means the field can be ignored).
4. Press **Verify** to send parameters to the drive and test the motor configuration.

⚠ Verify enables the drive and moves the motor!

Motor Setup – Current, Velocity and Position Limits

The wizard suggests Low, Medium or High limit values for current and velocity. The values are equivalent to 25%, 50% and 100%, respectively, of the maximum range.

Refer to *Current Limits* and *Velocity Limits*.

The wizard also allows you to set the position error threshold level, that is, the maximum value that will not produce a fault.

Refer to VarCom PEMAX.

Note If the limits are set too low, the Autotuning wizard might not produce the optimal result.

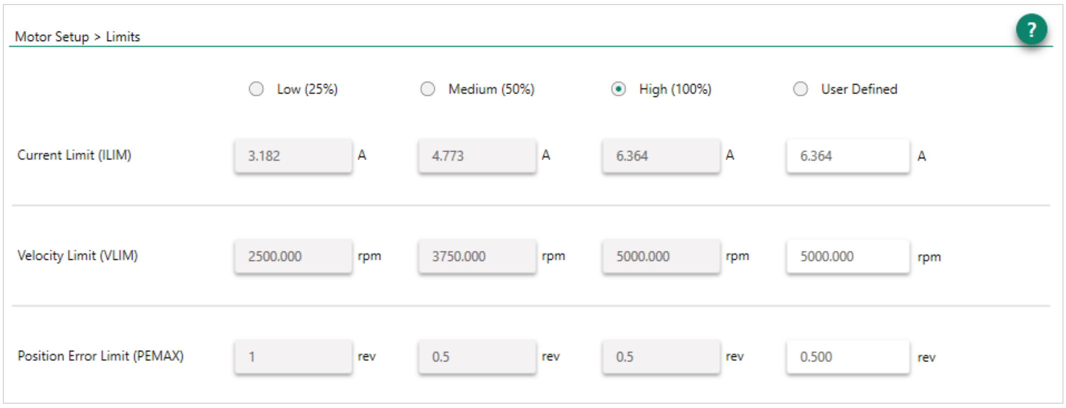


Figure 5-5. Motor Setup Wizard – Limits

1. Do either of the following to set velocity and current limits, and the position error limit:
   - Select the suggested Low, Medium or High values.
   - Select User Defined, and enter your preferred values.
2. Press Approve to send the values to the drive.

If Current Limit or Velocity Limit is set to a user-defined value of 0, it will prevent motion from occurring.

If Position Error Limit is set to a user-defined value of 0, no position error limit is set, and no faults will be produced.

Motor Setup – Motor Direction

The wizard simplifies the process of defining the rotation direction for a movement command. Otherwise, VarCom instructions are required.

Refer to VarCom MPHASE and DIR.

To visually test the direction of motion, press and hold the directional buttons. The test speed is defined as a percentage of Motor Continuous Current. Use a low value so that the direction of motor movement can be easily viewed. By default, it is set to 5.

The Motor Setup wizard simplifies the process of defining the rotation direction for a positive command. Otherwise, VarCom instructions are required.

Figure 5-6. Motor Setup Wizard – Motor Direction

1. To verify motor motion direction, press Negative or Positive.

Negative and Positive enable the drive and move the motor!

2. To reverse the direction to match your system, enable the option **Inverse Direction**.

   Refer to VarCom MPHASE and DIR.

3. To complete the procedure, press SAVE or DONE.

Motor Setup – Save

When the Motor Setup is completed, it is recommended that you save parameters to the drive's non-volatile memory and to a file on the host computer for backup.

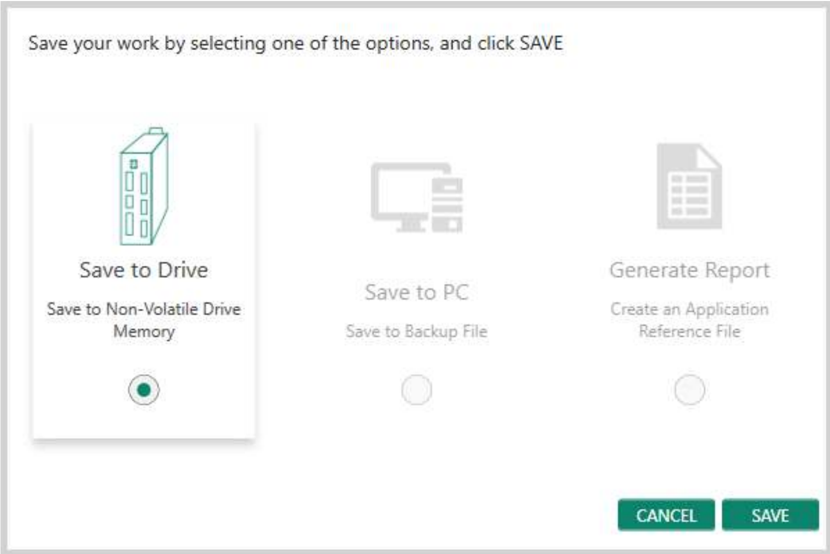


Figure 5-7. Motor Setup Wizard –Save

Do both of the following:

- Press **Save to Drive** to save the parameters from the drive's RAM to the drive's permanent memory.
- Press **Save to PC** to save the parameters in drive RAM to a backup file on the computer. The parameters are saved in a text file with either TXT or SSV extension. The text file can be edited using Notepad or any other text editor.

It is also recommended that you create an application report:

- Press **Generate Report**.

  When activated, the Report Generator opens a dialog box that allows you to enter application and user information. It then generates a set of CSV and TXT files within a zip file. The file can be attached to an email that is automatically addressed to Technical Support. You can change the address and send to a different recipient.

  Refer to *Report Generator* in the ServoStudio 2 manual.

5.2 Drive Identification

Drive information is presented and confirmed in the Motor Setup wizard.

The ServoStudio 2 Drive Info screen allows you to view drive properties and define the drive name.

The following parameters are used to view and configure drive information:

VarCom	Description
INFO	Hardware-defined. Returns the drive model and serial number, and version numbers of firmware, control board, power board and FPGA.
DRIVENAME	Optional, user-defined parameter. It is useful when an application has more than one drive. It is recommended that you provide a name for the drive that reflects the function it performs, such as Axis-1.

5.3 Motor Identification

Motor selection and properties are presented and confirmed in the Motor Setup wizard.

If the drive does not detect an electronic motor nameplate (MTP), the **Motor** screen allows you to define and initialize the motor.

You can select the motor family and motor part number from the ServoStudio 2 databases (motor libraries) and ServoStudio 2 will prepare the appropriate motor and feedback parameters.

If your motor is not listed in the default set of motor libraries, use the **New Motor wizard** to define a new motor.

The following parameter is used to view and configure motor identity:

VarCom	Description
MOTORNAME	If the motor is selected from a library in the ServoStudio 2 database, the name is automatically assigned. Motor names can also be assigned and modified by users. The motor name always begins with a quotation mark ("). For example: "MT-6CC401C

5.4 Motor Initialization

Motor commutation is performed in the Motor Setup wizard.

If the drive does not detect an electronic motor nameplate (MTP), the Motor screen provides the **Verify** and **Stop** buttons to start and stop the MOTORSETUP process.

The command MOTORSETUP initiates a quick commissioning procedure for setting the parameters that define motor commutation.

During the initialization process, the rotary motor moves forward/backward about two mechanical revolutions in forced commutation, which does not require feedback. MOTORSETUP detects the state of Hall switches, index position and polarity, the order of the electrical phases, the direction of motor movement, and the feedback resolution per electrical revolution.

Based on the data collected, the drive updates the parameters MFBDIR, MPHASE, MPOLES, MENCRES and MENCZPOS, making it possible to begin working with the motor and wiring that are connected to the drive.

If the procedure fails, the original values of MFBDIR, MPHASE, MPOLES, MENCRES and MENCZPOS will be restored.

Notes	Not all parameters are updated by the procedure. It depends which parameters are in use, as determined by MENCTYPE. The value of MICONT is very important, since this value sets the limit for the current used during the procedure.

Procedure: MOTORSETUP

To execute the Motor Initialization procedure, do the following:

1. Disable the drive.
2. Clear any faults in the drive.
3. Enter the command MOTORSETUP.
4. Enable the drive (otherwise the process will hang at Stage 5/51).

   The procedure will execute a series of steps.

   Once the Motor Initialization procedure is started (even when the drive is disabled) the digital display shows **A t 1** .
   When the setup finishes successfully, the display returns to its normal state; if the setup fails, the display shows **- 5** .

To cancel the motor setup procedure, enter the command MOTORSETUP 0

Any parameters that were modified by the MOTORSETUP procedure will be restored to their previous values.

To view the status of the procedure, enter the command MOTORSETUPST.

5.5 Current Limits

Current limits are modified and/or confirmed in the Motor Setup.

The **Current Limits** tab in the ServoStudio 2 **Limits** screen allows you to define position limits.

The following parameters are used to define the maximum current for the system and to set the current limits for an application.

VarCom	Description
DIPEAK	The rated peak current of the drive. Hardware defined. Read only.
MIPEAK	The rated peak current of the motor. The value can be manipulated.
IMAX	This value is the maximum current for a drive and motor combination, as calculated by the software. Read only.
ILIM	The current limit for the application. This parameter lets you limit the drive’s peak current to a value lower than DIPEAK.
ILIMACT	The actual drive current limit. Read only.

5.6 Velocity Limits

Velocity limits are modified and/or confirmed in the Motor Setup wizard.

The **Velocity Limits** tab in the ServoStudio 2 **Limits** screen allows you to define position limits.

The maximum speed that the drive can compute is hardware defined.

The following parameters are used to define the maximum velocity for the system and to set the velocity limit for an application.

VarCom	Description
MSPEED	The maximum motor speed, as defined in the motor datasheet.
VMAX	This value is the maximum velocity for a drive and motor combination. VMAX is based on maximum motor speed. Read only.
VLIM	The maximum application velocity. This parameter lets you limit the motor's maximum velocity to a value lower than VMAX.

5.7 Position Limits

Position limits are modified and/or confirmed in the Motor Setup wizard procedure.

The **Position Limits** tab in the ServoStudio 2 **Limits** screen allows you to define position limits.

The following parameters are used to define positioning limit mechanisms and error tolerances.

VarCom	Description
PEMAX	The maximum position error allowed without producing a fault, in counts.
PEINPOS	The window of tolerance for declaring an "in position" state.
INMODE # 5	Defines digital input # as the signal that indicates whether the position limit has been reached in the positive direction.
INMODE # 6	Defines digital input # as the signal that indicates whether the position limit has been reached in the negative direction.
LIMSWITCHPOS LIMSWITCHNEG	Indicate the status of all positive and negative limit events. Read only.
POSLIMMODE	Enables and disables the use of software position limits and/or transient position limits and/or homing limits.
POSLIMPOS POSLIMNEG	The maximum and minimum values, in counts, for the software position limits.

5.8 Motor Direction

When the motion command is positive, the direction of motion can be explicitly reversed. The positive direction for a rotary motor, for example, can be either clockwise or counterclockwise, depending on the application requirements.

Motion direction is tested and/or reversed and/or confirmed in the Motor Setup wizard.

The following parameters are used to define motor direction:

VarCom	Description
DIR	Motor direction. DIR can be used to invert the values of position feedback (PFB), velocity (V) and current (ICMD), thereby inverting the direction of motor movement.
MPHASE	The resolver/encoder phase relative to the standard commutation table. To reverse the direction of rotation, 180 degrees is added to the value of MPHASE.
MFBDIR	Defines several direction and polarity settings. MFBDIR values are set by the MOTORSETUP procedure.

Caution!
The values of DIR and MPHASE must be changed at the same time, before the drive is enabled, otherwise a commutation fault (motor runaway) may occur.

5.9 New Motor Wizard

Note If the drive detects an electronic motor nameplate, the **New Motor** wizard is not available when operating online.

If you are using a motor whose parameters are not available in the default sets of motor libraries in ServoStudio 2, you can use the New Motor wizard to define your motor. Once defined, the new motor is added to the set of User Motors in the motor library.

The wizard can be activated either from the Motor screen, or during the Motor Selection step in the Motor Setup wizard.

Press **Define New Motor** to activate the wizard.

Note It is recommended that you activate the New Motor wizard from the Motor screen, because parameters cannot be saved to the User Motor library when the wizard is activated from Motor Setup.

A series of dialog boxes prompts you to provide motor parameters, which you should be able to extract from the motor datasheet.

The New Motor wizard allows you to select units and enter values according to the information in your motor's datasheet. In addition, the wizard includes a unit conversion function. Once you have entered all data in the wizard, ServoStudio 2 converts the units into the equivalent values used by the drive. These converted values are maintained in the motor library and in the drive.

New Motor – Motor Specification

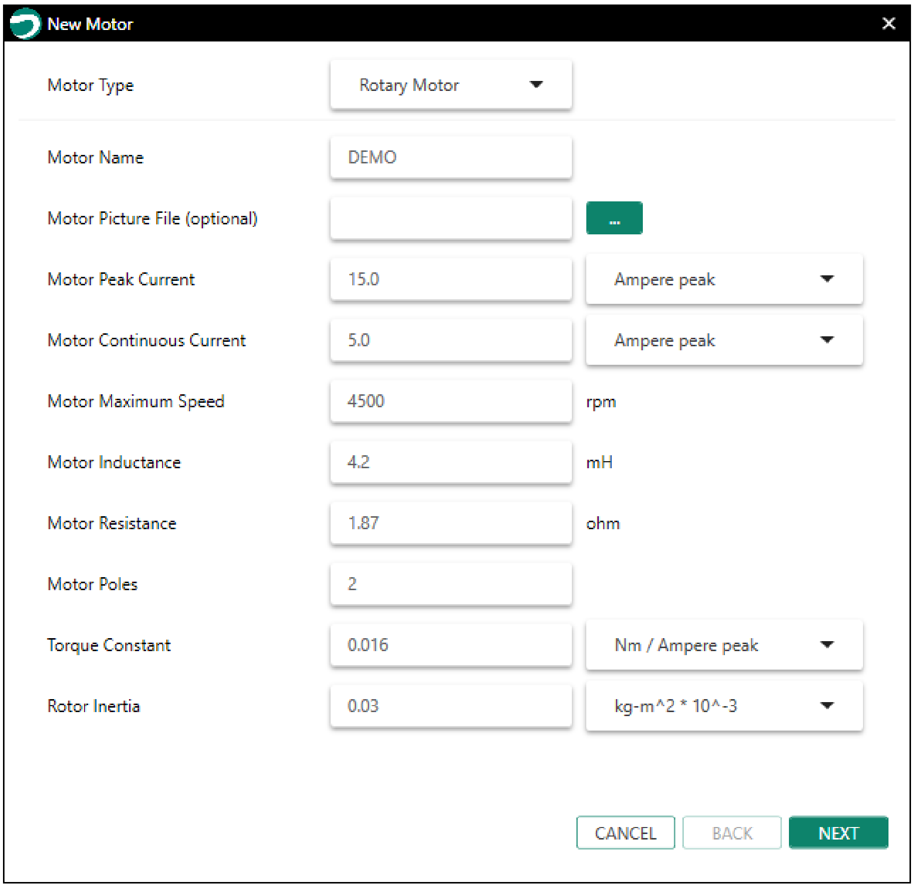


Figure 5-8. New Motor Definition

VarCom	Description
MOTORTYPE	Rotary Motor / Linear Motor
MIPEAK	Motor Peak Current
MICONT	Motor Continuous Current
MSPEED	Motor Maximum Speed
ML	Motor Inductance
MR	Motor Resistance
MPOLES	Motor Poles
MKT	Torque Constant (Rotary Motor)
MJ	Rotor Inertia (Rotary Motor)
MKF	Torque Constant (Linear Motor)
MMASS	Mass of Motor Without Load (Linear Motor)
MPITCH	Motor Pitch (Linear Motor)

New Motor – Motor Feedback Selection

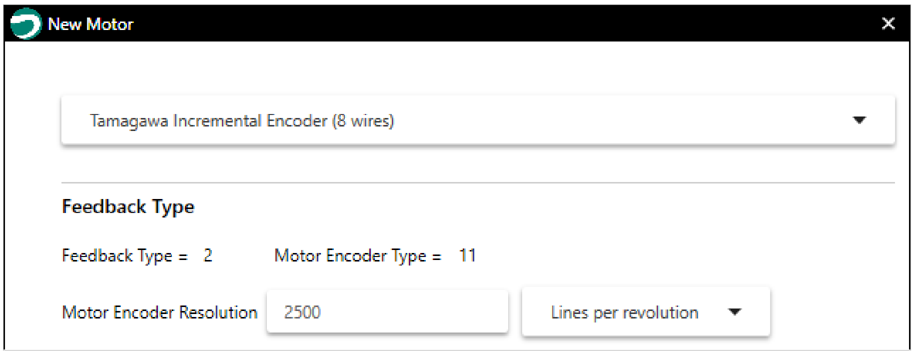


Figure 5-9. New Motor - Feedback

VarCom	Description
FEEDBACKTYPE	Feedback Type
MENCTYPE	Motor Encoder Type
MENCRES	Motor Encoder Resolution

New Motor – Thermal Protection Definition

Figure 5-10. New Motor – Thermal Protection

VarCom	Description
THERMODE	Motor Over-Temperature Mode

New Motor – Verify

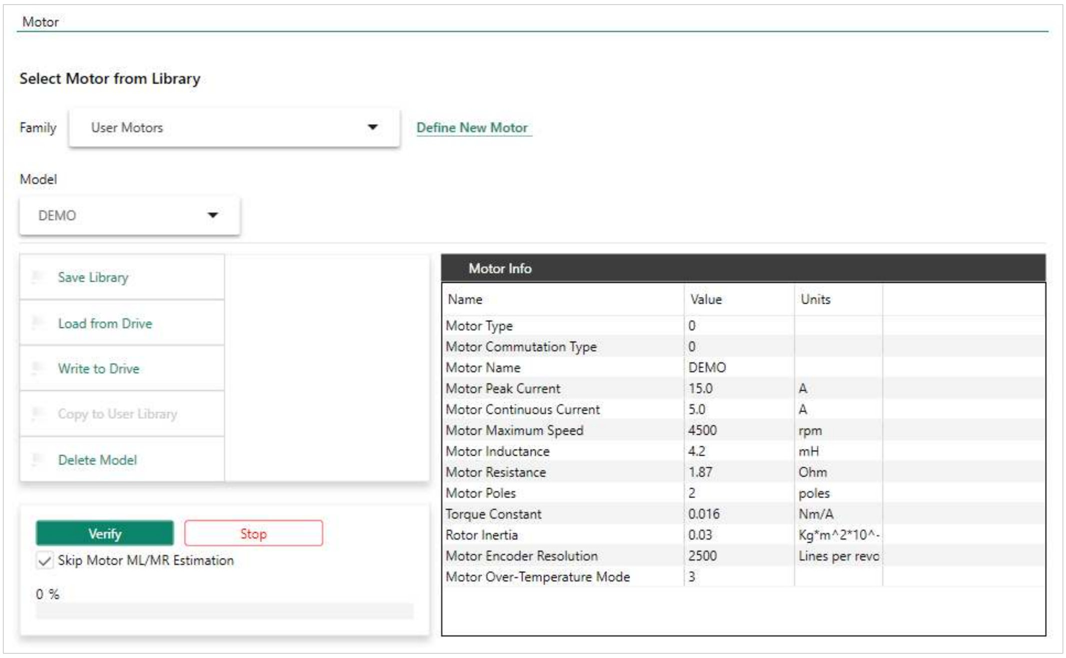


Figure 5-11. New Motor – Verify

Verify enables the drive and moves the motor!

Complete the procedure according to where the New Motor wizard was activated,

- If the New Motor wizard was activated from the Motor screen, press these buttons in the following order:
  - **a.** **Save Library** to save the set of motor parameters to the User Motors library.
  - **b.** **Write to Drive** to send the parameters to the drive.
  - **c.** **Verify** to test the motor configuration.
  - **d.** Wait for the Motor Setup Successful message to appear.
- If the New Motor wizard was activated from the Motor Setup wizard, press **Verify** to send parameters to the drive and test the motor configuration. Wait for the Motor Setup Successful message. (The motor cannot be saved to the User Motors library.)

6 Application Setup

6.1 Parameters

6.1.1 Configuration Parameters

VarCom is a proprietary set of commands and variables, or parameters, used to configure drive functionality when the host and drive are communicating over a serial connection.

VarCom parameters can be accessed and manipulated through ServoStudio 2 software, in either graphical interface screens, or a command-line terminal screen.

While setting parameters, pay close attention to any warning or error messages that appear in ServoStudio 2, and any flashing codes on the drive digital display.

Disable the drive before manipulating motor and feedback parameters.

Many parameters can be modified while the drive is enabled.
Exercise caution, however, as motor behavior may change.

If a parameter cannot be modified while the drive is enabled, a prompt to disable the drive will be displayed.

6.1.2 Managing Parameters - Drive Memory

The CDHD2 drive has two types of memory for storing the drive's parameters:

- **Flash**: Non-volatile memory. It holds the drive's default parameter values (contained within the drive's firmware), as well as the saved set of parameters.
- **RAM**: Volatile memory. The drive's working memory. Parameter values are maintained in RAM while you configure and test the drive and adjust parameters. If power to the drive is disconnected, any unsaved changes in the parameters will be lost.

During power up, the CDHD2 loads parameter values from the non-volatile memory to RAM, and a checksum of these parameter values is calculated. If the checksum is invalid, default parameter values (which are hard-coded in the drive's firmware) are loaded into RAM and a Parameter Memory Checksum Failure fault is set.

Certain parameters may be stored on an electronic motor nameplate (MTP), such as used in the sensAR magnetic encoder. When detected, the values of these parameters are loaded directly from the encoder memory to the drive RAM at power-up.

The following diagram illustrates the relationships among the different types of memory and commands used for managing the drive parameters.

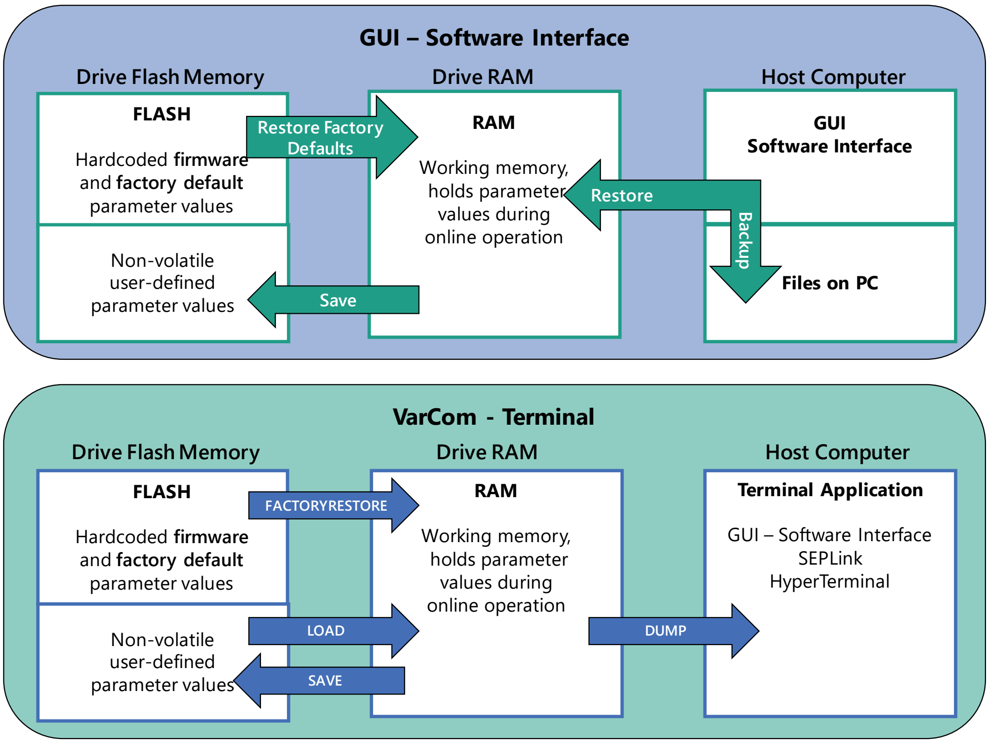


Figure 6-1. Memory and Commands for Managing Parameters

In ServoStudio 2, drive parameters can be saved to non-volatile memory at any time by pressing the Save button on the toolbar.

6.2 Application Setup Wizard

The Application Setup wizard guides you through a procedure that will set drive parameters for your specific application.

The specific Application Setup procedure is determined by the Interface Mode selected in the first step. Subsequent steps may include PDO mapping, definition of position units, gearing ratios, limits, homing, and functionality of inputs and outputs.

Note When the software is offline, all Interface Modes are displayed.
When the software is communicating with the drive, only the relevant modes are shown.

Application Setup – Communication

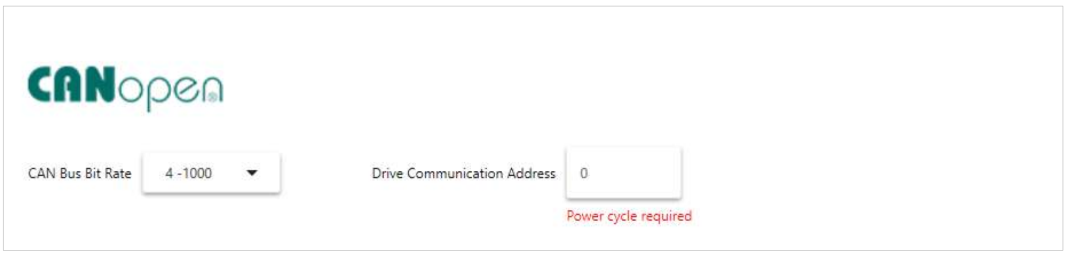


Figure 6-2. ServoStudio 2 – Application Setup Wizard – Communication

Displayed when the Interface Mode is: **CANopen**

Defines the communication settings for a drive system operating in a CANopen network.

Refer to chapter *Communication*.

Application Setup – Operation Mode

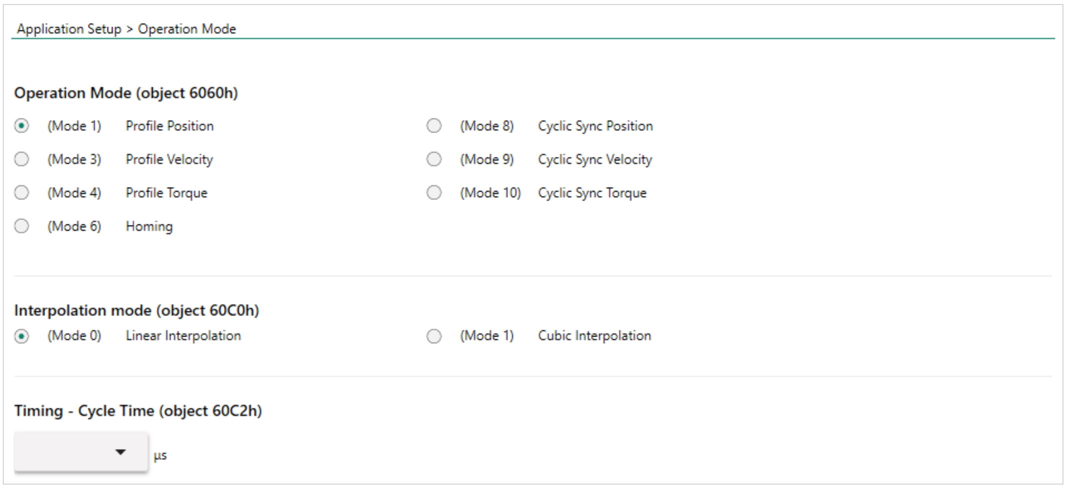


Figure 6-3. ServoStudio 2 – Application Setup Wizard – Operation Mode (CANopen/EtherCAT)

Defines the operation mode for a drive system operating in a CANopen or EtherCAT network.

Refer to the EtherCAT/CANopen Reference Manual.

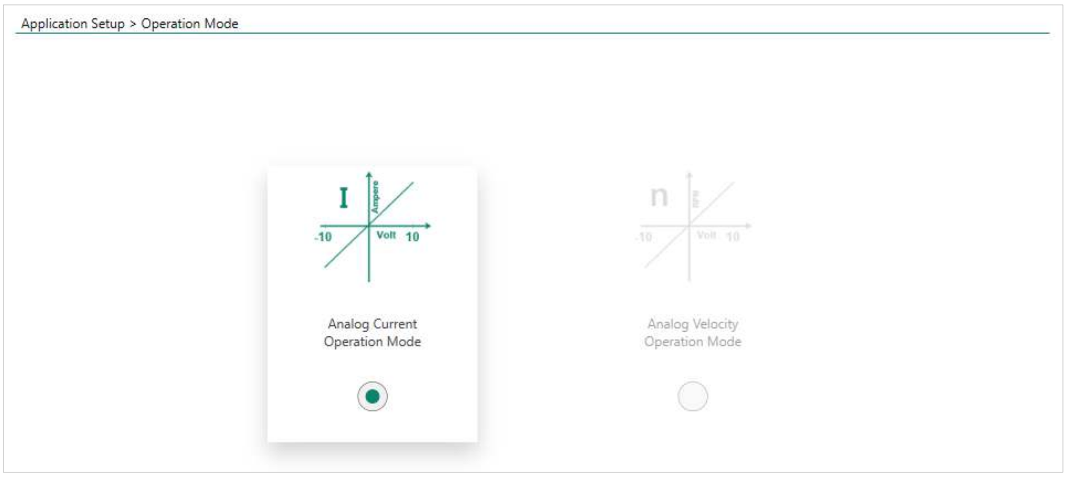


Figure 6-4. ServoStudio 2 – Application Setup Wizard – Operation Mode (Analog Command)

Defines the operation mode for a drive system operating according to analog commands.

Refer to Analog Current Operation Mode and Analog Velocity Operation Mode.

Application Setup – Pulse Train

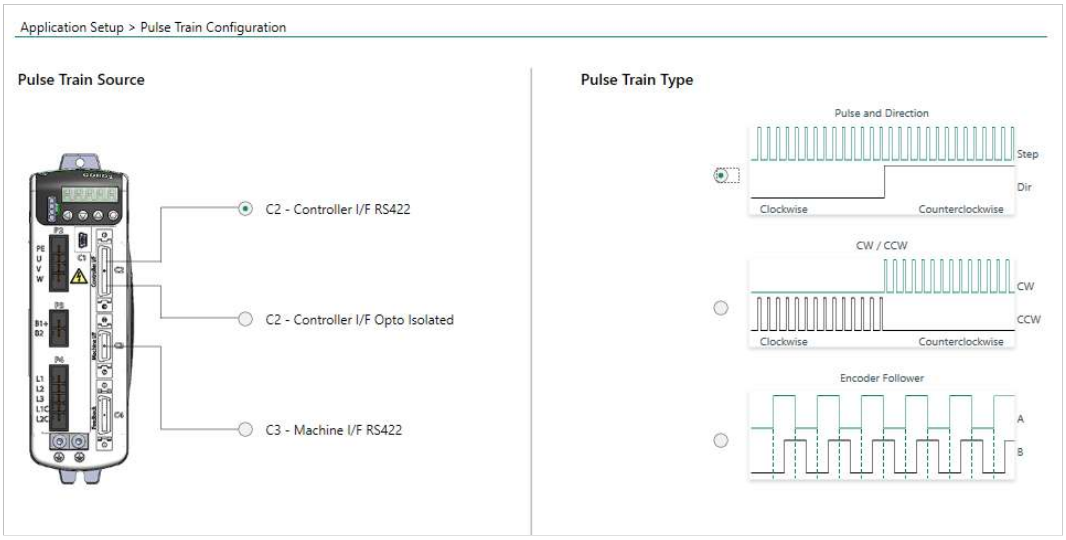


Figure 6-5. ServoStudio 2 – Application Setup Wizard – Pulse Train

Defines the gearing method for a drive system operating according to gearing (pulse train).

Refer to: *Gearing/Pulse Train Operation*

Application Setup – Resolution

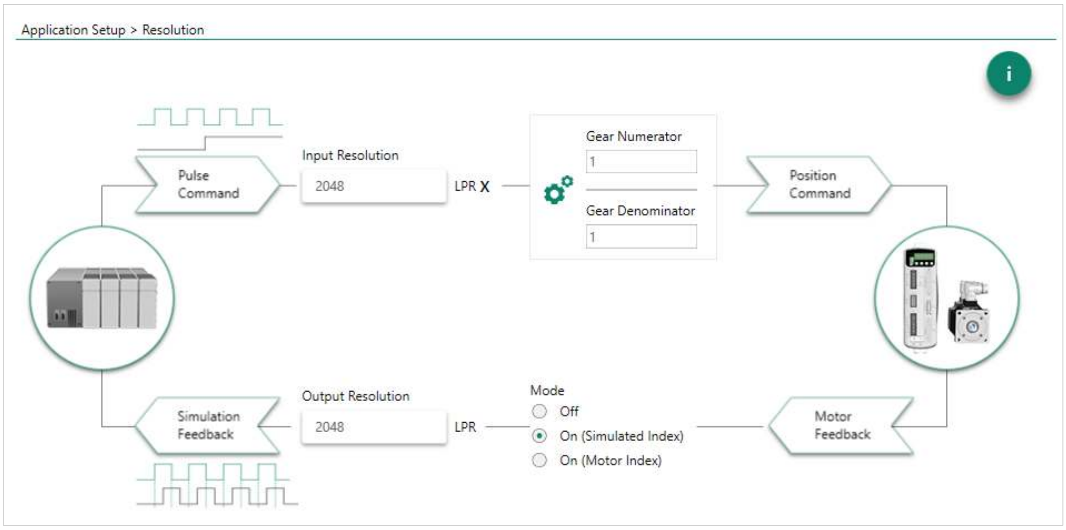


Figure 6-6. ServoStudio 2 – Application Setup Wizard – Resolution (Pulse Train)

Defines the resolution, gearing ratio, and feedback parameters for a drive system operating according to gearing (pulse train).

Refer to: *Gearing/Pulse Train Operation*

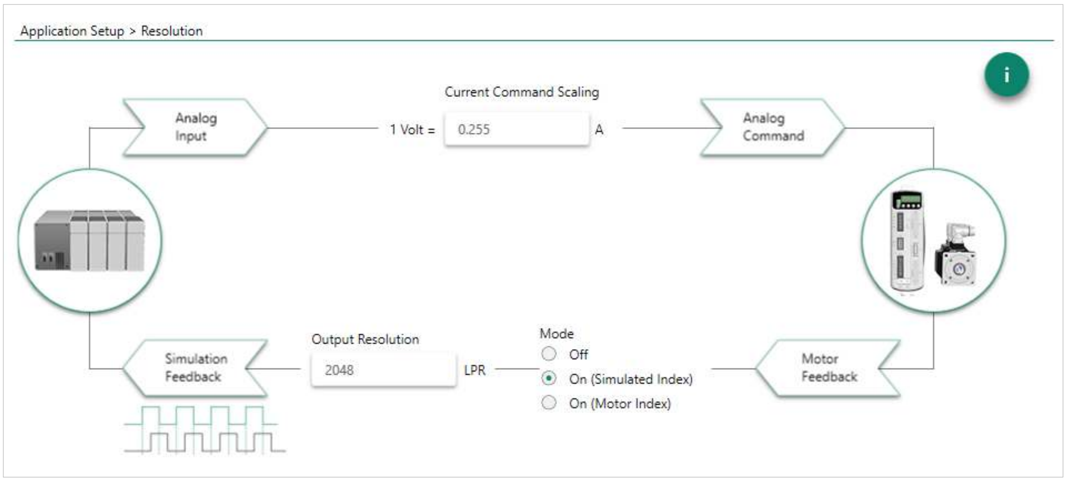


Figure 6-7. ServoStudio 2 – Application Setup Wizard – Resolution (Analog Command)

Defines the resolution, gearing ratio, and feedback parameters for a drive system operating according to analog commands.

Application Setup – Filters

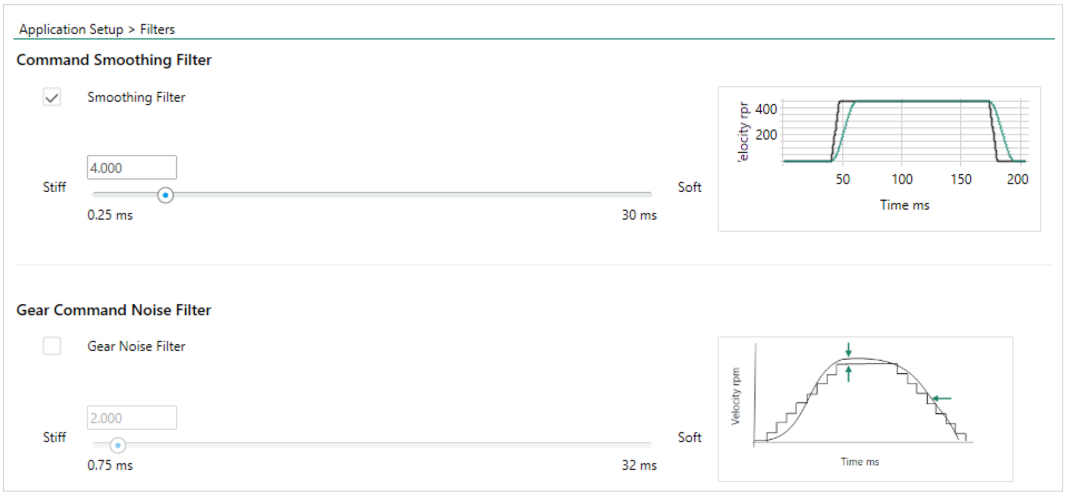


Figure 6-8. ServoStudio 2 – Application Setup Wizard – Filters (Pulse Train)

Defines the resolution, gearing ratio, and feedback parameters for a drive system operating according to gearing (pulse train).

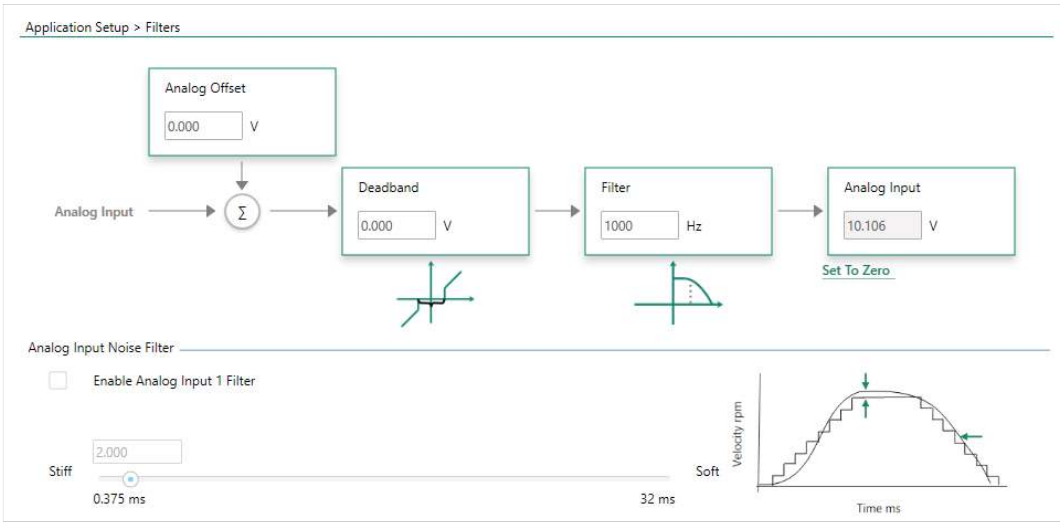


Figure 6-9. ServoStudio 2 – Application Setup Wizard – Filters (Analog Command)

Defines the filtering parameters for a drive system operating according to analog commands.

Application Setup – Limits

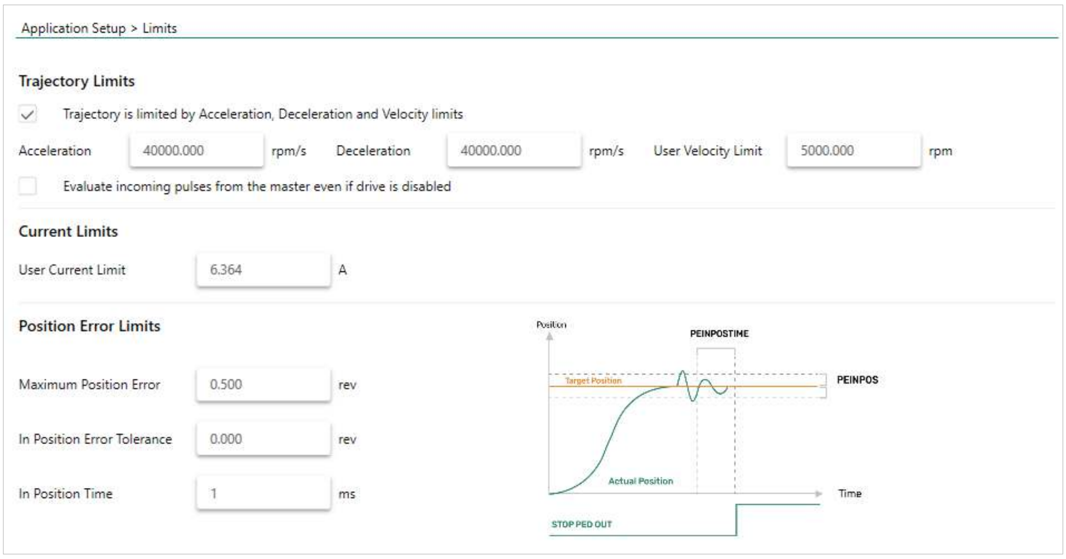


Figure 6-10. ServoStudio 2 – Application Setup Wizard – Limits (Pulse Train)

Defines the limit parameters for a drive system operating according to gearing (pulse train).

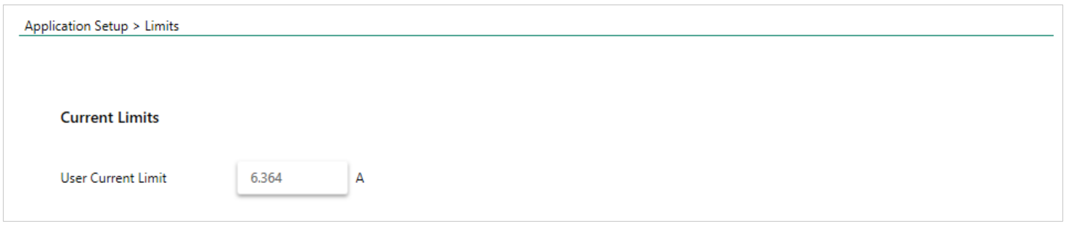


Figure 6-11. ServoStudio 2 – Application Setup Wizard – Limits (Analog Command)

Defines the limit parameters for a drive system operating according to analog commands.

Application Setup – PDO Mapping

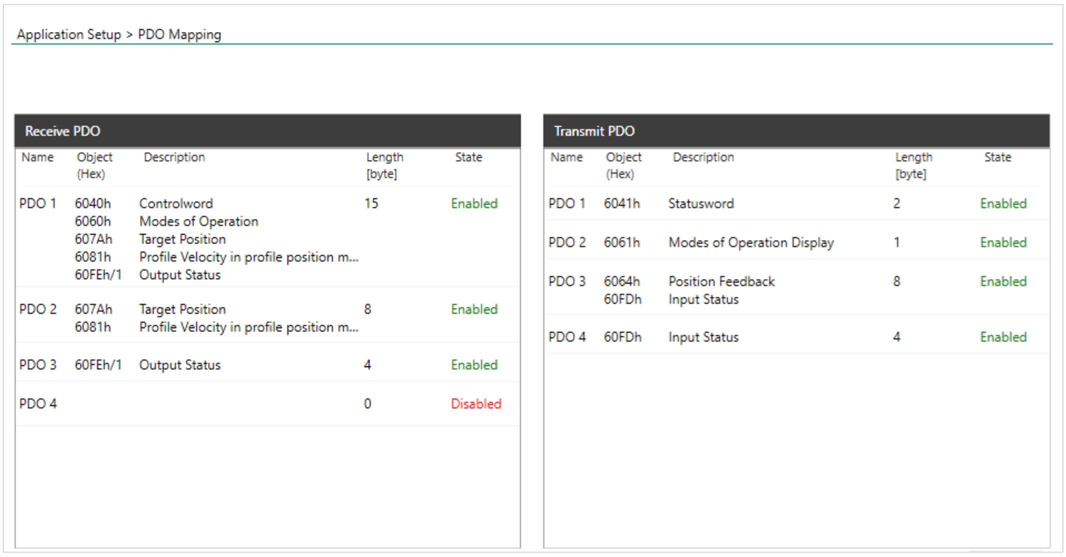


Figure 6-12. ServoStudio 2 – Application Setup Wizard – PDO Mapping (CANopen/EtherCAT)

Displayed when Interface Mode is:

- EtherCAT
- CANopen

Application Setup – Position Units

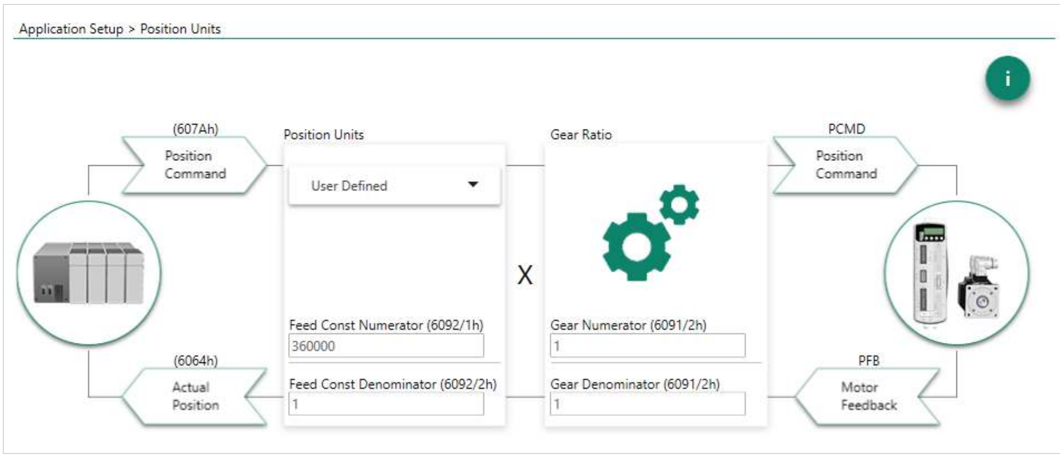


Figure 6-13. ServoStudio 2 – Application Setup Wizard – Position Units

Displayed when Interface Mode is:

- EtherCAT
- CANopen

Application Setup – Inputs/Outputs

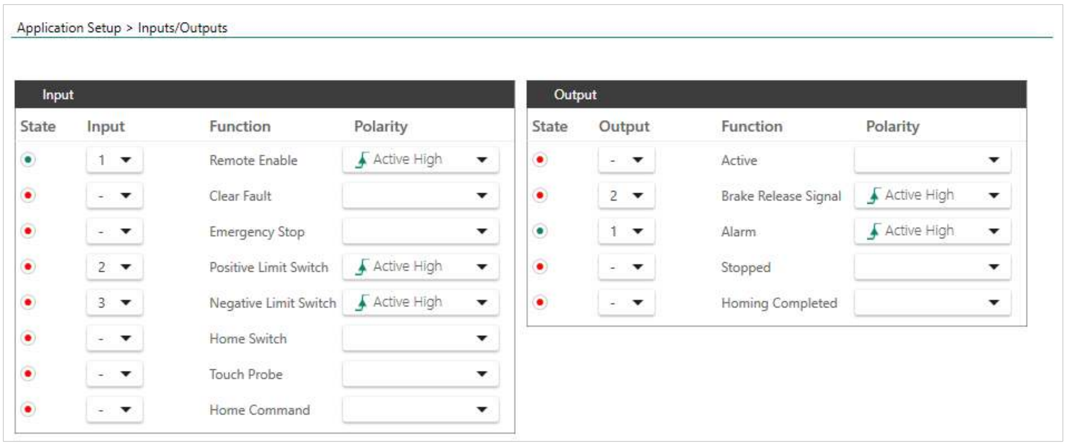


Figure 6-14. ServoStudio 2 – Application Setup Wizard – Inputs/Outputs

Displayed when Interface Mode is:

- EtherCAT
- CANopen
- Pulse train
- Analog Command
- USB/RS232

Application Setup – Homing

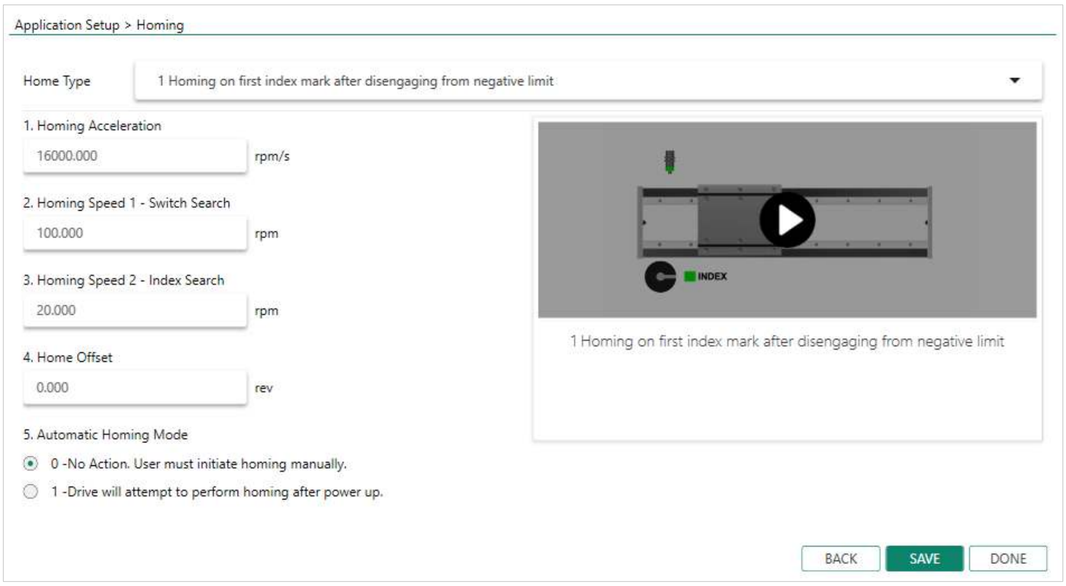


Figure 6-15. ServoStudio 2 – Application Setup Wizard – Homing

Displayed when Interface Mode is:

- EtherCAT

- CANopen
- Pulse train
- USB/RS232

Application Setup – Save

This option appears in the Application Setup – Homing step when the software is communicating with the drive.

6.3 Communication

Commissioning the drive through ServoStudio 2 requires a serial RS232 or USB connection. Once the drive is configured, you can then connect it to a PLC or controller over an EtherCAT or CANopen network.

Note

For communication through serial RS232/USB connections and pulse train/analog interfaces, the drive must be set to COMMODE 0.

For communication over Ethernet or CAN networks, the drive must be set to COMMODE 1. COMMODE 1 is the drive's factory default setting.

The following parameters are used to configure and monitor communication:

VarCom	Description
COMMODE 0	While COMMODE 0 is in effect: • Serial RS232/USB communication is enabled. • EtherCAT/CANopen communication is disabled. • Reference commands are accepted via serial/pulse/analog interfaces only. • The drive can be fully controlled (enabled, motor movement, parameter modification) by both the operator panel and ServoStudio 2 **Note**: Neither the operator panel nor ServoStudio 2 takes precedence.
COMMODE 1	Applicable only for CDHD2 AF, EC and EB models. While COMMODE 1 is in effect: • EtherCAT/CANopen communication is enabled. • Serial RS232/USB communication can be used as a utility for monitoring and changing parameters with limited functionality. • Reference commands cannot be received via serial/ pulse/analog interfaces. • The drive can be fully controlled by a fieldbus device. • The drive cannot be enabled and the motor cannot be moved through ServoStudio 2 or the operator panel. **Note**: Certain functions must be performed by means of ServoStudio 2 or the operator panel. These functions are restricted to parameters that do not interfere with fieldbus operation. If you attempt to set a parameter that interferes with fieldbus operation, the drive will issue an error code in the digital display and/or an error message in ServoStudio 2.
BAUDRATE	Sets the serial communication bit rate between the drive and the host computer.
CANBITRATE	Sets the CAN bus communication bit rate between the drive and the host computer.

The ServoStudio 2 Communication screen allows you to establish communication between the host computer and the drive over a serial connection. Alternately, the first step of the Motor Setup wizard will configure communication between the host computer and the drive.

6.3.1 Serial Baud Rate

The CDHD2 default baud rate is 115200. If the setting is changed and saved in the drive's non-volatile memory, the drive will use the saved baud rate at power up.

In the event of a connectivity problem, for example, you can try using a lower baud rate.

Procedure: Modifying the Serial Baud Rate

To modify baud rate settings, the change must be made in both the drive and ServoStudio 2 software.

1. Change the baud rate in the drive:
   - Go to the Terminal screen.
   - Issue a command to change the baud rate; for example: **BAUDRATE 19200**
   - Press **Enter**.

   Communication is lost as soon as Enter is pressed, and ServoStudio 2 goes offline.
2. Change the baud rate in ServoStudio 2.
   - Go to the Communication screen.
   - Select the same baud rate specified in Terminal for the drive.

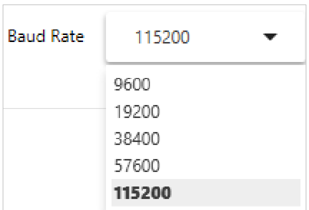


Figure 6-16. Serial Baud Rates

   - Press **Connect**.

   If successful, ServoStudio 2 will reconnect with the drive and go back online.

6.3.2 CANopen Bit Rate

Procedure: Establishing CANopen Communication

To establish, verify and modify CANopen communication, use ServoStudio 2 over a serial connection.

1. Be sure the CANopen interface is installed according to manufacturer instructions.
2. In the ServoStudio 2 Drive Information screen, select the Interface Mode option: EtherCAT/CANopen.
3. In the ServoStudio 2 Terminal screen, make sure the following settings are in effect:

   COMMODE 1
   CANBITRATE 3 (or 4, if required by system)

For the CANBITRATE setting to take effect, a SAVE command followed by a cycle power sequence must be executed.

6.4 Power Rating

When the motor is selected from the ServoStudio 2 Motor Library, power rating parameters are pre-set and written to the drive. These parameters are manufacturer-defined and should not be manipulated by the user; if you want to make any changes to these parameters, contact Technical Support.

Use the ServoStudio 2 Power Rating screen to view current and voltage values, and set some voltage parameters.

The following parameters are used to monitor and manipulate power rating.

VarCom	Description
DICONT	Drive continuous current. Defined in hardware. Read only.
DIPEAK	Drive peak current. Defined in hardware. Read only.
OVTHRESH	The level for detection of bus over-voltage. Defined in hardware. Read only.
UVMODE	Defines how the drive will respond to an under-voltage fault.
UVRECOVER	Defines how the drive will recover from an under-voltage fault.
UVTHRESH	The level for detection of bus under-voltage condition.
UVTIME	The duration of an under-voltage condition before latching a fault.
VBUS	Bus voltage (DC).
VBUSREADOUT	The actual bus voltage of the drive. Defined in hardware. Read only.

6.5 Feedback

When the CDHD2 drive system includes an electronic motor nameplate, certain feedback parameters are transferred directly to the drive after power-up and cannot be manipulated.

When the motor is selected from the ServoStudio 2 Motor Library, motor feedback parameters are pre-set and written to the drive. These parameters are manufacturer-defined and should not be manipulated by the user; if you want to make any changes to these parameters, contact Technical Support.

FEEDBACKTYPE defines the type of motor feedback used in the drive application.

The CDHD2 supports various motor feedback technologies and devices, including:

- BiSS-C encoder
- EnDat encoder
- HIPERFACE encoder
- Incremental A-quad-B encoder, with or without Hall sensors (or commutation tracks)
- Nikon encoder
- Resolver
- sensAR encoder
- Sine encoder
- Tamagawa encoder

6.5.1 Incremental Encoder

Types and Resolution

The CDHD2 supports several types of incremental encoders.

The following parameters are used to configure and monitor incremental encoders.

VarCom	Description
MENCTYPE	The type of encoder being used on the motor.
MENCRES	The resolution of the encoder, in number of lines per revolution of the motor. For an incremental encoder, MENCRES × 4 equals the number of encoder counts per revolution.

The CDHD2 monitors all encoder signal wires, and generates an A/B Line Break fault (digital display: **r4** | **Fr4**) if any wire is broken.

Hall Signals

The CDHD2 supports single-ended (or open-collector) and differential Hall signals.

The following parameters are used to configure and monitor Hall commutation sensors.

VarCom	Description
HALLSTYPE	The type of Hall signals.
HALLS	Reads the state of the Hall signals.
HALLSINV	Inverts the polarity of individual Hall signals associated with motor phases UVW.

The CDHD2 monitors the state of the Hall signals, and will generate an Illegal Halls fault (digital display: **r6** | **Fr6**) if either state 000 or 111 is detected.
It will generate a Differential Halls Line Break fault (digital display: **r38** | **Fr38**) if it fails to detect the differential Hall signals.

Note Differential Hall signals can be used with Incremental A and B signals or as Halls only using the standard motor feedback C4 connector. If your application requires differential Hall signals with incremental A, B and index signals, contact Technical Support.

Encoder Index

Encoders often have an additional channel, referred to as a marker channel, zero pulse, or index channel. This channel outputs one pulse per revolution, and is typically an extremely narrow pulse equal to about one-quarter of the width of an A or B channel pulse, but may be wider. The encoder index can be used for homing (absolute position reference) and for commutation alignment.

You can also use the command Find Index in the ServoStudio 2 Motor Feedback screen to determine the position of the index signal.

The following parameter is used to set and monitor the encoder index.

VarCom	Description
MENCZPOS	The encoder index position.

The CDHD2 monitors the index signal wires, and will generate an Index Line Break fault (digital display: r5 | Fr5) if any wire is broken.

Phase Finding

The Phase Finding procedure is used to initialize commutation for incremental encoder systems.

Note The Phase Finding procedure can be used only on a balanced axis; it cannot be used for unbalanced mechanics, such as a vertical Z-axis. In addition, it cannot be used when gantry mode is in effect.

You can also use the command Find Phase in the ServoStudio 2 Motor Feedback screen to determine the correct commutation.

The following parameters are used to configure phase finding.

VarCom	Description
PHASEFINDMODE	The method to be used for the commutation phase finding.
PHASEFIND	Starts the commutation initialization procedure for incremental encoder systems.
PHASEFINDGAIN	Adjusts the gain of the phase finding mechanism.
PHASEFINDI	Adjusts the current of the phase finding mechanism.
PHASEFINDTIME	The duration of the phase finding mechanism in a soft start.

6.5.2 Sine Encoder

Sine encoders are very similar to incremental encoders. The difference is that sine encoders send the A and B channels to the drive as 1V peak-to-peak sine-waves, while incremental encoders generate digital pulses.

6.5.3 sensAR Absolute Magnetic Encoder

The sensAR series of absolute magnetic encoders was developed by Servotronix.

The sensAR encoder has an electronic motor nameplate (MTP), which means a set of motor parameters is embedded in the encoder’s non-volatile memory.

The CDHD2 attempts to detect an electronic motor nameplate at power-up. If detected, motor and feedback parameters are transferred directly to the drive, and cannot be manipulated by the user.

The Servotronix PRO2 and PRHD2 motors are typically equipped with a sensAR encoder.

The sensAR encoder has two different types:

- Absolute Single Turn (FEEDBACKTYPE=12): After a power cycle the encoder retains its absolute position within one mechanical revolution. The multi-turn absolution position is 0.
- Absolute Multi-turn (FEEDBACKTYPE=19): After a power cycle the encoder retains its absolute position within one mechanical revolution as well as the total number of motor revolutions since the last power cycle. A multi-turn encoder eliminates the need for homing after every power cycle.

  The multi-turn encoder can store up to 65535 revolutions, provided it has an external backup battery. The encoder battery sits in a battery compartment on the cable between the motor and the drive. If the cable between the motor and the battery compartment is disconnected, or if the encoder does not receive voltage from the battery or the drive, the encoder loses the multi-turn number of resolutions; however, the single-turn absolute position is retained.

The following commands are used for configuring and enabling the multi-turn absolute encoder.

VarCom	Description
MTTURNRESET	Resets the position counter of an absolute multi-turn encoder, and clears battery no voltage fault.
IGNOREBATTFLT	IGNOREBATTFLT=1 prevents a multi-turn absolute encoder from issuing a fault due to a dead, disconnected, or missing backup battery, thus allowing the encoder to be used as a single-turn absolute encoder.

Multi-turn Encoder Backup Battery Replacement

The battery voltage level is measured during the power-up sequence only. If the battery voltage drops below the specified values during operation, no warnings or faults are issued until a power cycle is performed.

- If battery power drops below 3.15V, the encoder issues a battery low voltage warning. The battery should be replaced as soon as possible.

  When replacing the battery, keep the drive under power to maintain the multi-turn position in memory during the replacement. Remove the old battery and insert a new one.
- If battery power drops below 3.0V, the encoder issues a battery no voltage fault (**r 4 0**); the drive detects the fault and disables the motor. Multi-turn data is no longer reliable.

  Replace the battery: Shut off power to the drive. Remove the old battery and insert a new one. Power on the drive. Issue the command MTTURNRESET to reset the position counter of the multi-turn encoder. MTTURNRESET also clears the fault.

6.5.4 BiSS-C Interface

BiSS is an open interface for sensors and actuators. The BiSS-C standard allows vendors of such feedback devices to define a small set of commands that will cause the feedback device to perform certain functions. BiSS-C implementation in the drive is fully bidirectional.

The following commands are used to configure and monitor a BISS-C feedback device.

VarCom	Description
BISSCFIELDS	Sets the number of bits allocated for transmission of position data within a BiSS-C packet, and the number of effective bits. It is applicable for both rotary and linear encoders. The values used for the command arguments are taken from the information found in the datasheet provided by the encoder manufacturer.
BISSCINFO	Returns information about the BiSS-C device.

6.5.5 EnDat 2.x Bidirectional Interface

The EnDat interface is a digital, bidirectional interface for encoders. It is capable of transmitting position values from incremental and absolute encoders as well as transmitting or updating information stored in the encoder, or saving new information. The serial transmission method requires only four signal lines. The data is transmitted in synchronism with the clock signal from subsequential electronics. The type of transmission (e.g., position values, parameters, diagnostics) is selected by mode commands that the subsequential electronics send to the encoder.

CDHD2 supports the EnDat 2.1 communication protocol, which is a subset of the EnDat 2.2 protocol. All EnDat 2.2 capable devices support the 2.1 protocol, including the commands and queries that are relevant to CDHD2; accordingly, all EnDat 2.2 capable devices will work with CDHD2.

EnDat 2.x can be used with the CDHD2 in following ways:

- EnDat 2.x Communication Only: for setups in which the drive relies only on the serial data from the feedback device as the source of position information.
- EnDat 2.x with Sine/Cosine: for setups in which (a) the drive performs encoder initialization and uses the serial data for position initialization, and (b) position update during operation is derived from the sine/cosine signals.

Notes

CDHD2 does not support the ability to query and set parameters during position-feedback operations.

CDHD2 communication rate is 2 MHz. (To modify the communication rate, refer to VarCom FEEDBACKBR.)

EnDat 2.x Encoder with Sine Signals: The value of PFB is calculated from the value of HWPOS and the sine/cosine signals during EnDat initialization upon power up, and upon clearing a feedback related fault. Initialization takes a few seconds. During this time, the value of PFB value is undetermined, and therefore the drive cannot be enabled.

Initialization of the EnDat encoder takes about 2.5 seconds; during this process the message “ENDAT initialization incomplete” will be displayed if the drive status is queried (using command ST).

The +5 VDC supply to the EnDat encoder must be switched off during (re)initialization. During the EnDat initialization, the CDHD2 switches off the +5 VDC it supplies to the encoder. However, if the encoder receives +5 VDC from a different source, and it is not switched off, initialization is likely to fail.

6.5.6 Encoder Simulation Output

An encoder simulation output, also referred to as an equivalent encoder output (EEO) or a buffered encoder output, is available on the Controller interface (C2).

The following parameters are used to configure simulation.

VarCom	Description
ENCOUTMODE	Switches the encoder simulation on or off, and sets the functionality.
ENCOUTRES	The resolution, in equivalent lines-per-revolution, of the encoder simulation output.
ENCOUTZPOS	The index offset value of the encoder simulation output.

6.5.7 Resolver

A resolver is a rotary transformer used to measure the motor shaft position.

The resolver has a primary winding, and two secondaries – a sine and cosine in sync with the motor rotation. The level of voltage on the sine and cosine waves correlates to the position of the shaft within one magnetic cycle of the resolver (one pole pair).

Resolvers typically enable slower dynamic tracking than encoders.

The following parameters are used to configure and monitor resolver feedback.

VarCom	Description
RESAMPLRANGE	The acceptable range of resolver sine/cosine signals, expressed as a percentage, around their nominal value.
MRESPOLES	The number of individual poles in the resolver feedback device.
RESFILTMODE	Defines whether feedback position interpolation is performed on the resolver feedback in order to generate a continuous stream of data.
RESBW	The resolver conversion bandwidth. High bandwidth produces better dynamic tracking and less phase lag in high frequencies. Lower bandwidth results in better noise reduction. RESBW sets the most balanced value according to specific application requirements.

Note The automatic tuning of the resolver reference amplitude takes about 3–5 seconds after the drive is powered on. During this time the drive cannot be enabled.

6.5.8 Resolver and Sine Encoder Calibration

Resolver and Sine Encoder Calibration Overview

When the CDHD2 is initially connected to a motor equipped with either a resolver or a sine encoder, CDHD2 parameters must be calibrated. Calibration is required during system assembly. Since analog component values might change over time, it is prudent to repeat the calibration procedure once every two years. Once the calibration procedure is completed, the calibration parameters are saved in the CDHD2.

For the calibration, CDHD2 needs to read 128 sine signals either in one direction or back and forth.

Commonly a resolver will need 128 motor revolutions to generate the necessary 128 sine signals. Therefore, the motor needs to be moved, at a limited speed, by a movement command.

Sine encoders can typically generate 128 sine signals well within one motor revolution. Therefore, the motor may be moved by hand for the calibration.

Resolver and Sine Encoder Parameters

The following parameters are used to configure and monitor resolver/sine encoder calibration.

VarCom	Description
SININITMODE	Enables/disables the automatic calibration of sine encoder or resolver sine and cosine signals at power up.
SININIT	Activates a procedure that calibrates sine encoder or resolver sine and cosine signals. The calibration serves to reduce Harmonic errors in the sine encoder or resolver reading. The procedure averages sine encoder or resolver signals over several motor turns to determine the gain and offset correction.
SININITST	Reports the status of the sine encoder or resolver calibration procedure.
SINPARAM	Returns the parameters that are used for calibrating sine encoder or resolver sine and cosine signals. The parameters are in hexadecimal representation.

Motor Revolutions Required for Calibration

If your application has limited travel, you can run the motor back and forth 128 times. The length of each of these 128 movements must be at least 1.5 sine cycles. If running the motor in one direction, the number of revolutions required for the calibration is calculated as follows:

Resolver: $128 \div \frac{\text{MRESPOLES}}{2}$

Where MENRESPOLES is the number of individual poles in the resolver feedback device.

For example, if MRESPOLES=4, the motor needs to make 64 revolutions for calibration.

Sine encoder: $\frac{\text{MENCRES}}{128}$

Where MENCRES is the number of since cycles per motor revolution or per motor pitch.

Motor Speed Limitations During Calibration

During the calibration procedure, the motor speed must not exceed the following values:

Resolver: $\frac{3750 \bullet 2}{\text{MENCRES}}$ rpm

Sine encoder: $\frac{3750}{\text{MENCRES}}$ rpm

Calibrating Resolver and Sine Encoder

Procedure: Resolver Calibration Using Terminal

1. In the Terminal interface, enter the sine/cosine calibration command:

   SININIT <Enter>

2. Enter a command to run the motor at a low speed, such as 800 rpm,
   for about 10 seconds, according to the operation mode of your application.

3. Enter the sine/cosine calibration status command:

   SININITST <Enter>

4. Wait until SININITST changes to 1, and then reverts to 0.

Example: The motor runs in a velocity control loop at 600 rpm, and the calibration procedure is executed.

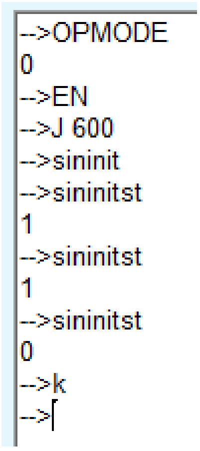


Figure 6-17.

Procedure: Resolver Calibration Using ServoStudio 2

1. In the Feedback screen, select Feedback > Resolver.

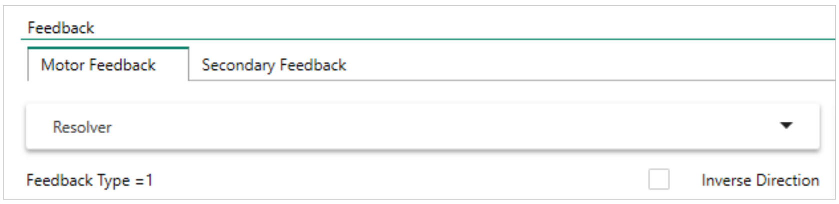


Figure 6-18.

2. In the Motion screen, set the parameters, for example:
   - Select Operation Mode> Serial Velocity.
   - Set Velocity to 600 rpm.

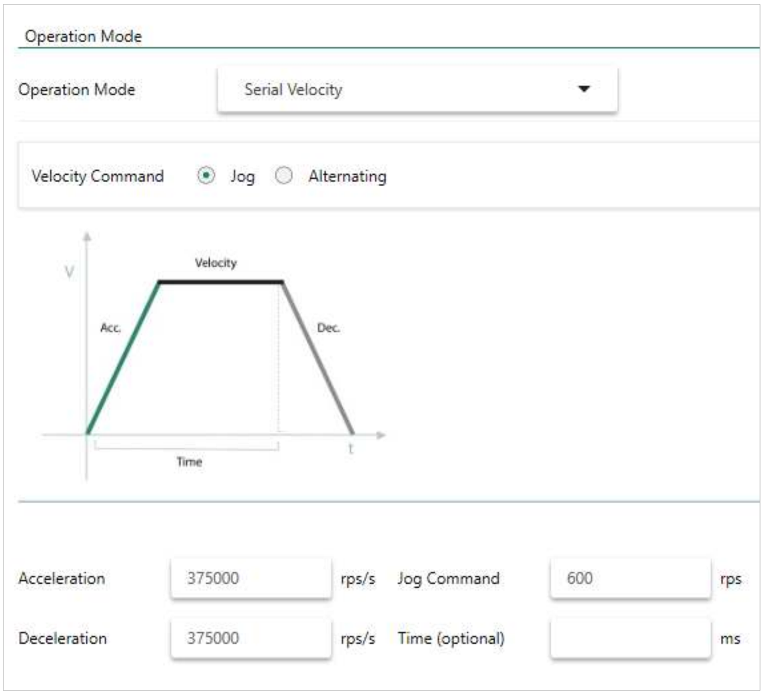


Figure 6-19.

3. In the Feedback screen, set the following:

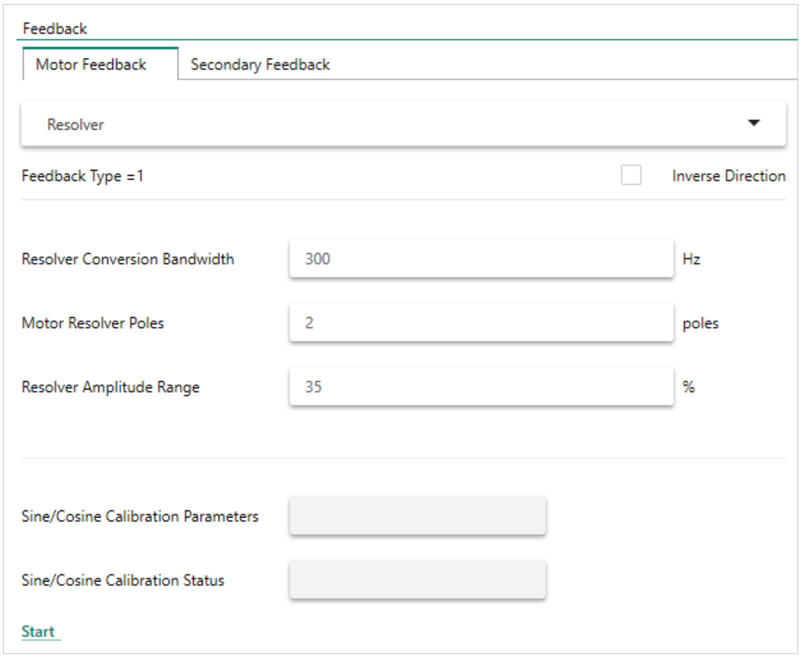


Figure 6-20.

a. Note that Sine/Cosine Calibration Status is 0.

b. Press the Start button to begin the calibration procedure.

c. Note that Sine/Cosine Calibration Status changes to 1.

d. Wait until Sine/Cosine Calibration Status reverts to 0.

Calibration is complete.

Procedure:	Sine Encoder Calibration Using Terminal

1. In the Terminal interface, enter the sine/cosine calibration command:

   SININIT <Enter>

2. Enter a command to run the motor at a low speed, such as 100 rpm, according to the operation mode of your application (current, velocity or position mode). Alternately, move the motor by hand.
3. Enter the sine/cosine calibration status command:

   SININITST <Enter>

4. Wait until SININITST changes to 1, and then reverts to 0.

Example: The motor runs in a velocity control loop at 6 rpm, and the calibration procedure is executed.

```
-->OPMODE
0
-->EN
-->J 6
-->sininit
-->sininitst
1
-->sininitst
1
-->sininitst
0
-->sininitst
0
-->sininitst
0
-->MENCRES
128 [LPR]
-->
```

Figure 6-21.

Procedure:	Sine Encoder Calibration Using ServoStudio 2

ServoStudio 2 does not currently support sine encoder calibration.

Sine Encoder and Resolver Diagnostics

Sine Encoder and Resolver Diagnostics Overview

When working with a sine encoder or a resolver, the CDHD2 measures the levels of the sine and cosine signals, and checks that they are within a certain range. When the signals are out of range, two possible faults can result: **r4** | **Fr4** and **r8** | **Fr8**.
If these faults occur, it is very useful to record the sine and the cosine signals, to determine whether they are valid.

Recording the Signals

The sine and the cosine signals can be recorded by recording particular drive-internal data. A typical RECORD command is as follows:

record 1 1000 "@_AX0_s16_Sine.s16 "@_AX0_s16_Cosine.s16

This command records 1000 samples of the sine and the cosine values, at intervals of 31.25 µs (the drive's basic sampling rate).

A typical recording of a sine encoder might look as shown in the following figure.

The recorded data is presented in internal drive units (counts of the analog-to-digital converter).

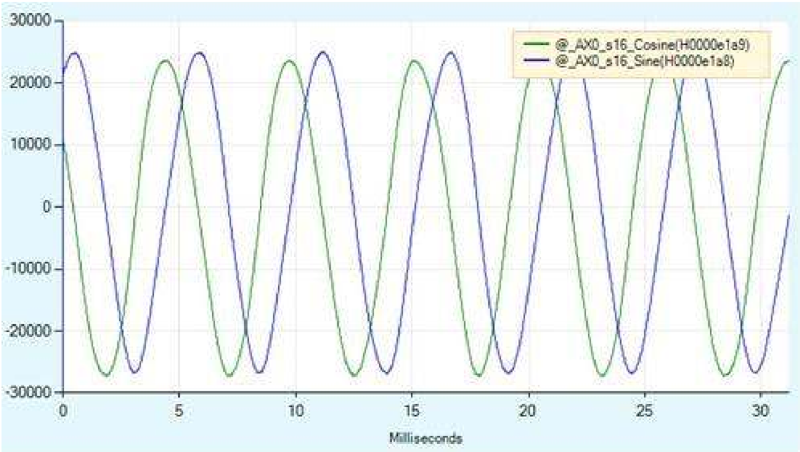


Figure 6-22. Sine Encoder Recording – Example

A typical recording of resolver might look as shown in the following figure.

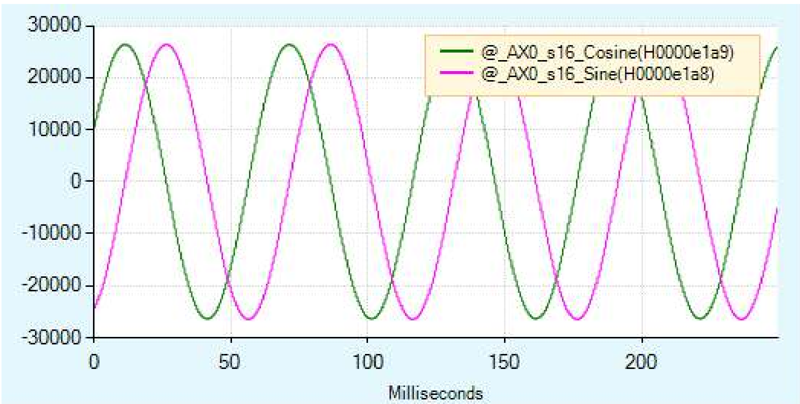


Figure 6-23. Resolver Recording – Example

Converting to Physical Values

The recorded data is in internal drive units, and needs to be converted to physical units; that is, the input voltage to the drive.

Since the physical sine and cosine signals are scaled differently for the sine encoder and the resolver, the following equations are used to convert the recorded data:

$$\text{Sine encoder: Input Voltage} = \frac{\text{Recorded Value}}{32768} \times \frac{10}{16.2}$$

$$\text{Resolver: Input Voltage} = \frac{\text{Recorded Value}}{32768} \times \frac{10}{3.25}$$

Examining the Plot

The recorded data can be scaled in the ServoStudio 2 Scope screen.

When examining the sine and cosine signals from a sine encoder, you need to multiply the signals by 0.00001883 (calculated from 1/32768 x 10/16.2)

The resulting plot in the Scope screen will look like the one shown in the following figure. This plot shows the signal levels of the actual input signal (in volts). As expected, the sine encoder signals are close to 1V peak-to-peak.

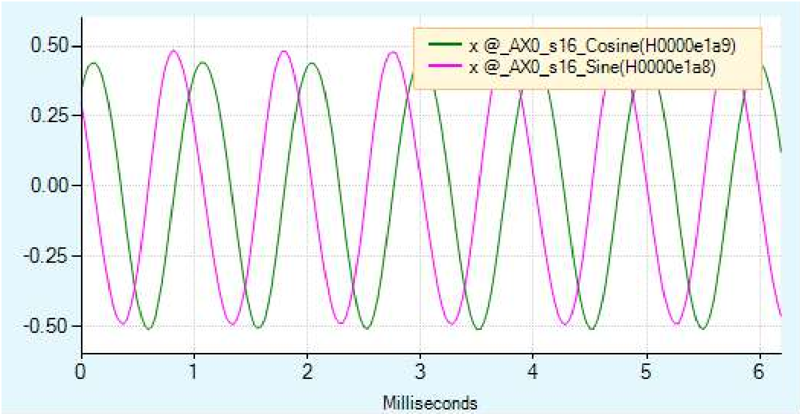


Figure 6-24. Signals from Sine Encoder – Example

When examining the sine and cosine signals from a resolver, you need to multiply the signals by 0.0000939 (calculated from 1/32768 x 10/3.25).

The resulting plot in the Scope screen will look like the one shown in the following figure. This plot shows the signal levels of the actual input signal (in volts).

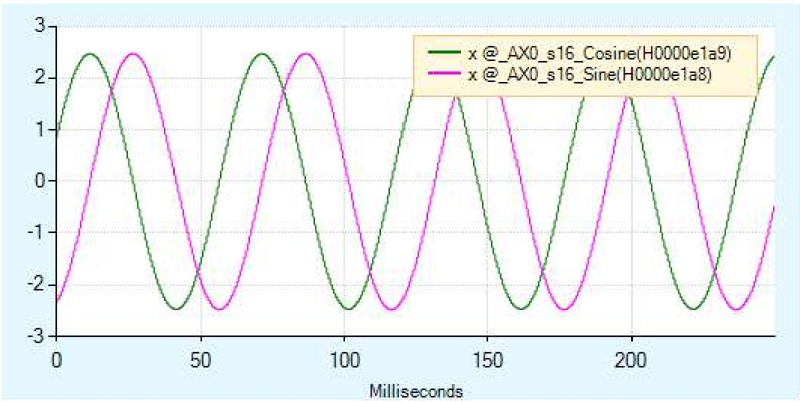


Figure 6-25. Signals from Resolver – Example

6.6 Secondary Feedback

Refer also to Dual Feedback Position Control Loop Tuning.

6.6.1 Secondary Feedback Overview (Dual Loop Control)

The CDHD2 enables correction of positioning errors by means of a secondary feedback device and dual loop control.

In dual loop control, two feedback devices (typically, encoders) are connected to one axis: one feedback device is mounted on the motor and a secondary feedback device is connected to the load. The load feedback device serves to control positioning, while the motor feedback device is used to control velocity and current.

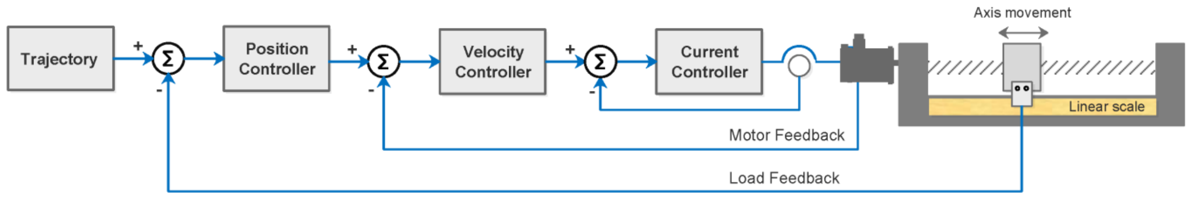


Figure 6-26. Dual Loop Control with Secondary Feedback

In dual loop control, the secondary (load) encoder acts as the main positioning feedback. Thus, the following functions are performed on the load feedback:

- Homing, including homing on index. Refer to *Homing*.
- Encoder simulation output. Refer to *Encoder Simulation Output*.
- AB quadrature encoder interpolation.
- Touch probe capture.

Dual loop control can be used in the following operation modes:

- OPMODE 4 (Gearing/Pulse Train)
- OPMODE 8 (Serial Position)
- CiA 402 mode 1 (Profile Position)
- CiA 402 mode 8 (Cyclic Synchronous Position)

For dual loop control, the motor feedback device is connected to the CDHD2 Feedback interface (C4), and the load feedback device is connected to the Secondary Encoder pins on the CDHD2 Machine interface (C3).

When dual loop control is used, the gearing input must be from the Controller interface (C2); GEARMODE 0, 1 and 2.

Note When the CDHD2 error correction function is used in a dual control loop system, the correction is performed on the secondary (load) encoder value.

6.6.2 Secondary Feedback Devices

CDHD2 dual loop control can be implemented with either rotary motors (MOTORTYPE=0) or linear motors (MOTORTYPE=2).

In addition, secondary feedback devices for dual loop control can be AB quadrature, BiSS-C interface, or EnDat 2.2.

For stable dual loop control, the effective resolution of the motor encoder must be higher than that of the load feedback device. A lower motor encoder resolution will cause the position loop to issue VCMD whose resolution is too high and cannot be executed by the velocity loop. A load encoder with a higher resolution can be used if the load encoder is serving closed position and velocity control loops, and the motor encoder is serving the current control loop.

6.6.3 Secondary Feedback EtherCAT/CANopen

In EtherCAT and CANopen, the drive reports Position Feedback (object 6064h), Velocity Feedback (object 606Ch), and Position Error (Object 60F4h).

- When dual loop is activated, these objects are reported according to the load feedback.
- When dual loop is not activated (default), these objected are reported according to the motor feedback.

6.6.4 Secondary Feedback Units

User Units

Secondary feedback uses the same parameters as motor feedback.

- If the load feedback is a rotary encoder: SFB, SFBVEL are displayed in rotary units: UNITSROTPOS, UNITSROTACC and UNITSROTVEL.
- If the load feedback is a linear encoder: SFB, SFBVEL are displayed in linear units: UNITSLINACC, UNITSLINVEL, UNITSLINPOS.

Secondary Feedback Motor to Load Ratio

[LMUNITSNUM / LMUNITSDEN] is a mechanical ratio, defined as follows:

- For rotary systems: 1 motor revolution per *n* load revolutions.
- For linear systems: 1 motor revolution per *n* millimeters linear movement.

Rotary Motor and Linear Encoder on Load – Example

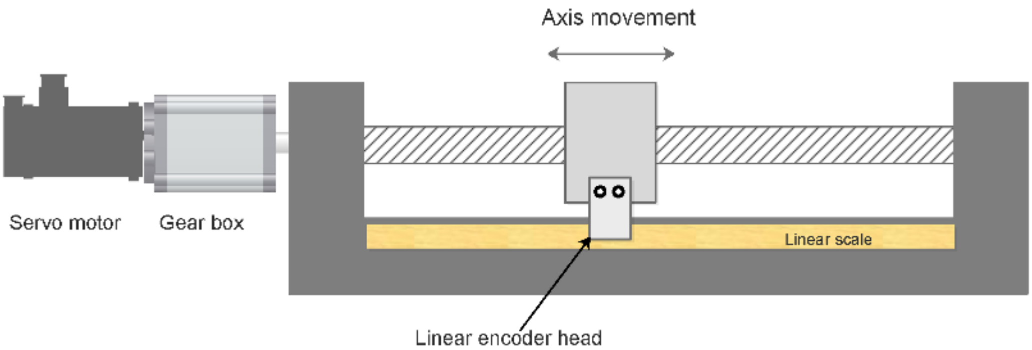


Figure 6-27. Rotary Motor with Gear and Ball Screw and Linear Encoder on Load

Motor reducer ratio: 1:11

Ball screw lead: 20 mm

$$\frac{\text{LMUNITSNUM}}{\text{LMUNITSDEN}} = \frac{1}{11} * \frac{1}{20} = \frac{1}{220}$$

Rotary Motor and Rotary Encoder on Load – Example

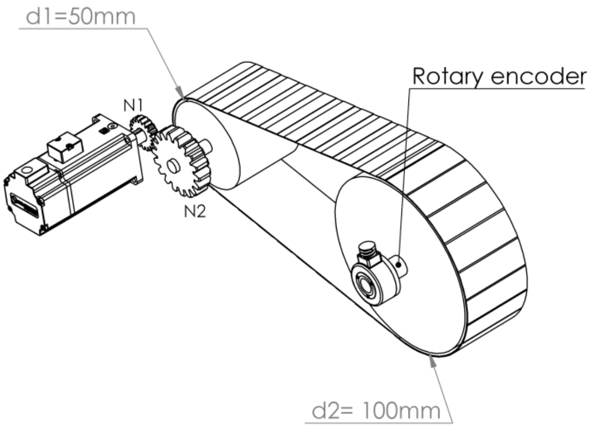


Figure 6-28. Rotary Motor and Rotary Encoder on Load

Pulley diameter on motor side: 50 mm

Pulley diameter on load side: 100 mm

N1: number of teeth on gear N1 (10)

N2: number of teeth on gear N2 (60)

$$\frac{\text{LMUNITSNUM}}{\text{LMUNITSDEN}} = \frac{10\ x\ 100}{60\ x\ 50} = \frac{1}{3}$$

6.6.5 Secondary Feedback Parameters

The following parameters are used to configure and monitor dual-feedback applications.

VarCom	Description	Explained
SFBMODE	Secondary Feedback Mode	Activates/deactivates the dual feedback control mode.
SFBTYPE	Secondary Feedback Type	The type of feedback device (rotary or linear) and communication interface.
SFBENCTYPE	Secondary Feedback Type of AB Quadrature Encoder	The type of AB quadrature encoder on the load.
SFBDIR	Secondary Feedback Direction	The positive direction of feedback from the load.
SFBOFFSET	Secondary Feedback Offset	The offset value added to SFB.
SFBRES	Secondary Feedback Resolution	The resolution of the feedback device on the load, in number of lines per revolution or lines per millimeter.
LMUNITSDEN	Motor to Load Mechanical Ratio Denominator	The denominator of the motor feedback to load feedback scaling ratio.
LMUNITSNUM	Motor to Load Mechanical Ratio Numerator	The numerator of the motor feedback to load feedback scaling ratio.
MFB	Motor Feedback Position (Read only)	The position according to the feedback device on the motor.

VarCom	Description	Explained
SFB	Secondary Feedback Position (Read only)	The position according to the feedback device on the load.
PFB	Feedback Position (Read only)	The position (of motor or load), according to SFBMODE.
MVEL	Motor Velocity (Read only)	The velocity of the motor.
SFBVEL	Secondary Feedback Velocity (Read only)	The velocity of the load.
SFBVLIM	Secondary Feedback Velocity Limit	User-defined maximum velocity for the load.
V	Velocity (Read only)	The velocity (of motor or load), according to SFBMODE.
MACC	Motor Acceleration	The acceleration value according to the feedback device on the motor.
SFBACC	Secondary Feedback Acceleration	The acceleration value according to the feedback device on the load.
ACC	Acceleration	The acceleration value (of motor or load) according to SFBMODE.
MDEC	Motor Deceleration	The deceleration value according to the feedback device on the motor.
SFBDEC	Secondary Feedback Deceleration	The deceleration value according to the feedback device on the load.
DEC	Deceleration	The deceleration value (of motor or load) according to SFBMODE.

6.7 Motion Units

The CDHD2 has configurable units of acceleration, velocity and position, for both linear and rotary motor systems. The unit definitions can be a user preference, or a property of the specific motor being used.

Use the ServoStudio 2 Motion Units screen for viewing and defining motion units.

The following parameters are used to monitor and manipulate motion units.

VarCom	Description
UNITSROTPOS	The units of position variables in a rotary system.
UNITSROTVEL	The units of velocity variables in a rotary system.
UNITSROTACC	The units of acceleration and deceleration variables in a rotary system.
UNITSLINPOS	The units of position variables in a linear system
UNITSLINVEL	The units of velocity variables in a linear system.
UNITSLINACC	The units of acceleration and deceleration variables in a linear system.
PNUM PDEN	Conversion factors of the user-defined unit. They are used to multiply the motor revolution (rotary motors) or the motor pitch (linear motors), according to the type of motor (MOTORTYPE).
FBGDS	The conversion factor of the fieldbus device’s drive shaft revolution.

VarCom	Description
FBGMS	The conversion factor of the fieldbus device's gear shaft revolution.

6.8 Current Foldback

The current foldback is a mechanism used by CDHD2 to protect the drive and motor from overheating due to excessive current. Current foldback is set separately for the drive and for the motor.

Current foldback limits the root mean square (rms) value of current to the drive and/or the motor.

When the motor is selected from the ServoStudio 2 Motor Library, current foldback parameters are pre-set and written to the drive. These parameters are manufacturer-defined and should not be manipulated by the user; if you want to make any changes to these parameters, contact Technical Support.

Use the ServoStudio 2 Current Foldback task screen for viewing and configuring motor and drive foldback parameters.

The following parameters are used to monitor and manipulate foldback properties.

VarCom	Description
IFOLD	Drive foldback current
DICONT	Drive continuous current
IFOLDFTHRESH	Drive foldback fault threshold
IFOLDWTHRESH	Drive foldback warning threshold
DIPEAK	Drive peak current
MIFOLD	Motor foldback current
MICONT	Motor continuous current
MIFOLDFTHRESH	Motor foldback fault threshold
MIFOLDWTHRESH	Motor foldback warning threshold
MIPEAK	Motor peak current
MFOLDD	Motor foldback delay time
MFOLDT	Motor foldback time constant
MFOLDR	Motor foldback recovery time
MFOLDDIS	Motor foldback enabled/disabled

6.9 Digital Inputs

The CDHD2 has both regular and fast opto-isolated digital inputs. The number of inputs varies according to model. Refer to the *I/O Specifications* table.

- Regular digital inputs have a propagation delay up to 1 millisecond.
- Fast digital inputs have a propagation delay up to 1 microsecond.

Use the ServoStudio 2 Digital I/Os screen to configure and view the state of the digital inputs.

The following parameters are used to configure and monitor the digital inputs.

VarCom	Description
IN	Reads the state of a specified digital input.
INPUTS	Reads the state of all digital inputs.
INMODE	Defines the functionality of the digital input.
ININV	Inverts the polarity of a specified input.

ServoStudio 2 includes a Drive Script tool for programming instructions for digital inputs. These scripts can modify drive behavior while a machine is in operation, such as increasing or reducing acceleration, initiating a movement, setting a variable, or switching operation modes. Refer to *Digital Input Activation of Drive Scripts* in the ServoStudio 2 manual.

6.10 Digital Outputs

Most CDHD2 drives have both regular and fast opto-isolated digital outputs. The number of outputs varies according to model. Refer to the *I/O Specifications* table.

- Regular digital outputs have a propagation delay up to 1 millisecond.
- Fast digital outputs have a propagation delay up to 1 microsecond.

Use the ServoStudio 2 Digital I/Os screen to configure and view the state of the digital outputs.

The following parameters are used to configure and monitor the digital outputs.

VarCom	Description
OUT	Reads the state of a specified digital output.
OUTPUTS	Reads the state of all digital outputs
OUTMODE	Defines the functionality of the digital output

6.11 Digital Output Control Using Compare-Match (PCOM)

Note This function is available only in CDHD2 AF (CANopen) and EC (EtherCAT) models.

The drive includes two compare-match modules (PCOM1 and PCOM2) for triggering an output based on a compare-match of position feedback or a timer.

The output is used to activate an external event or device – such as a camera, a pick and place machine, or a measuring device – when the CDHD2 moves through a predefined position or range of positions.

The two PCOM modules have the same functionality, and can be configured to either pulse or toggle the output.

The PCOM modules allow three different configurations for triggering an output.

- **Periodic configuration**: The output is triggered according to a fixed number of feedback counts between positions.
- **Table configuration**: The output is triggered according to a predefined set of positions.
- **Timing configuration:** The output is triggered at time offsets from the SYNC0 signal. The controller updates the times offsets every EtherCAT cycle.

Note When using an incremental feedback device, it must be homed before any of the PCOM module parameters are set.

The following parameters are used for configuring and monitoring the PCOM modules.

VarCom	CANopen/CoE Object	Description
PCOMCNTRL{1|2}	2191h, sub-index 0 2192h, sub-index 0	Configures the Match-Compare Trigger Output (PCOM) module.
PCOMDIR{1|2}	2195h, sub-index 0 2196h, sub-index 0	Defines whether output is triggered during motor movement in negative direction, positive direction, or either direction.
PCOMEND{1|2}	219Dh, sub-index 0 219Eh, sub-index 0	The position at which the PCOM module stops triggering the output.
PCOMN{1|2}	219Fh, sub-index 0 21A0h, sub-index 0	A fixed number of feedback counts between each output trigger position.
PCOMSTART{1|2}	219Bh, sub-index 0 219Ch, sub-index 0	The position at which the PCOM module begins triggering the output.
PCOMSTATUS{1|2}	2193h, sub-index 0 2194h, sub-index 0	The actual state of the PCOM module.
PCOMTABLE{1|2}	21A1h, sub-index 0 21A2h, sub-index 0	A set of positions at which the output will be triggered.
PCOMTABLELEN{1|2}	2197h, sub-index 0 2198h, sub-index 0	The number of positions in the PCOM table.
PCOMWIDTH{1|2}	2199h, sub-index 0 219Ah, sub-index 0	The width of a pulsed output signal.

VarCom	CANopen/CoE Object	Description
DIFPORTMODE	21A3h, sub-index 0	The differential (RS422) digital port hardware and output functionality.
OUTMODE n 27|28	209Ch	The output triggered by PCOM module 1|2.

6.11.1 PCOM Periodic Configuration

The periodic configuration is used to output a pulse, or to toggle the output state, at fixed intervals, defined as number of position feedback counts (PCOMN). In this mode, the PCOM module continuously compares the actual position with the value defined in PCOMN (or the equivalent EtherCAT/CANopen object). Whenever the feedback counter is equivalent to PCOMN, the PCOM module triggers the output.

- Two user-defined positions (PCOMSTART and PCOMEND) define the range of positions in which the position-compare function is active, and output will be triggered.
- A user defined constant (PCOMN) defines the number of encoder counts (interval) between each output trigger.
- The pulse width is defined by PCOMWIDTH.

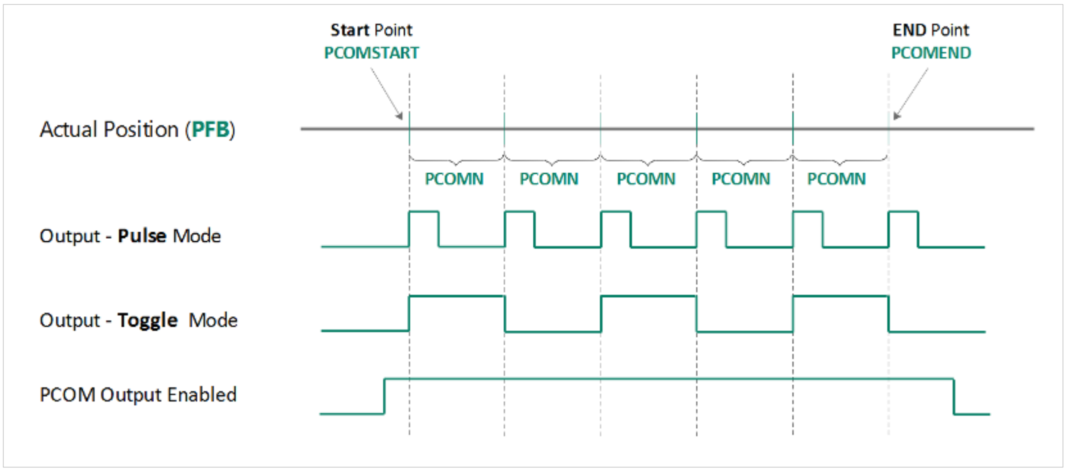


Figure 6-29. Position-Compare Trigger Output – Periodic Configuration

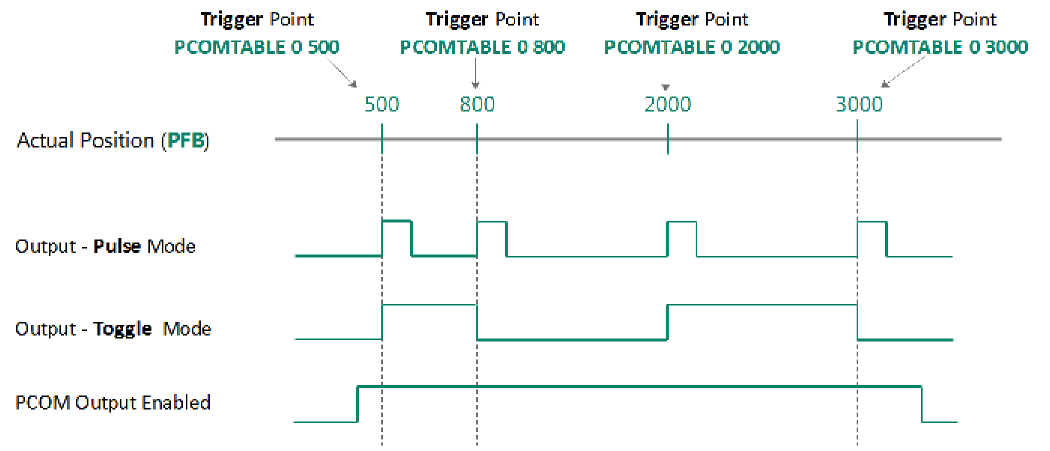
6.11.2 PCOM Table Configuration

The position table configuration is used to output a pulse, or to toggle the output state, at specific positions. In this mode, the PCOM module continuously compares the actual position with the positions defined in PCOMTABLE. Whenever the feedback counter is equivalent to a position in the table, the PCOM module triggers the output.

- For periodic configuration, the pulse width is defined (PCOMWIDTH)
- A user defined constant (PCOMN) defines the number of encoder counts (interval) between each output trigger.

Up to 32 user-defined positions (PCOMTABLE) define the specific positions at which the output will be triggered.

The number of trigger positions in the table is defined by the parameter PCOMTABLELEN.



Index	0	1	2	3	....
Position	500	800	2000	3000	

Figure 6-30. Position-Compare Trigger Output – Table Configuration

6.11.3 PCOM Timing Configuration

Note PCOM timing configuration is applicable only in an EtherCAT Cyclic Synchronous operation mode.

The timing configuration is used to set the output state at time offsets from the **SYNC0** signal.

Within one EtherCAT cycle, up to four time offsets (*TM1*, *TM2*, *TM3*, *TM4*) can for be used for triggering the output. The offsets, and the state of the output, are defined by the four sub-indexes of object 2205h (PCOM 1 module) and 2206h (PCOM 2 module).

TM1 must be the smallest value, and *TM2*, *TM3* and *TM4* must be progressively higher values.

If less than four transitions (*TR*) are required in one cycle – for example, only two – *TR* will be set to 2 by the controller, and the drive will process only *TM1* and *TM2* and ignore *TM3* and *TM4*.

The controller increments the counter to indicate the time offset PDO is valid. If the controller does not increment the counter, the time offset PDO will be ignored, meaning the output state will not change.

Timing resolution is 0.1 µs.

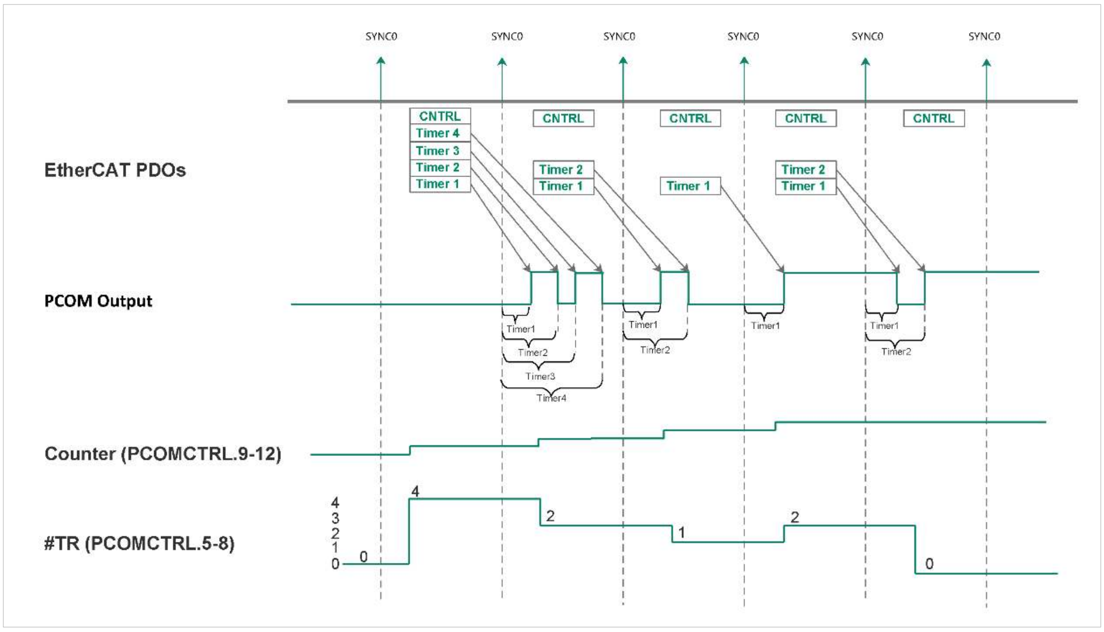


Figure 6-31. Compare-Match Trigger Output – Timing Configuration

6.12 Analog Inputs

The CDHD2 supports either one 16-bit analog input or two 14-bit analog inputs. Both types of inputs are differential.

Note One of the digits in the CDHD2 part number indicates whether the drive supports one or two analog inputs.

The analog input is used to send commands to the drive by means of analog voltage. The analog commands can control the velocity of the motor or the current to the motor. Analog commands can be used when the CDHD2 is operating in Analog Velocity mode (OPMODE 1) or Analog Current mode (OPMODE 3).

Use the ServoStudio 2 Analog Input 1 pane (and Analog Input 2 if available) in the Analog I/Os screen to set the analog input properties and to monitor the input value.

6.12.1 Analog Input 1

Analog Input 1 serves as the analog command for the Analog Velocity (OPMODE 1) and Analog Current (OPMODE 3) operating modes. This functionality cannot be changed.

The following parameters are used to configure and monitor analog input 1.

VarCom	Description
ANIN1OFFSET	The DC voltage offset on the analog input.
ANIN1DB	The deadband range of analog input 1.
ANIN1LPFHZ	A low-pass filter applied to the analog input.
ANIN1	The voltage at the analog input. Read only.
ANIN1ZERO	Causes the value of the analog input 1 signal to become 0 by modifying the analog offset value.

6.12.2 Analog Input 2

Note Analog Input 2 is not available on all drive models.

When a second analog input is available on the drive, Analog Input 2 can be used as an analog current limit. In such a configuration, the parameter ANIN2SCALE is used to set the scaling of the current limit, in units of amperes per volt.

The following parameters are used to configure and monitor analog input 2.

VarCom	Description
ANIN2MODE	Defines the functionality of the second input.
ANIN2LPFHZ	This value is a low-pass filter applied to the analog input. This is useful for filtering high frequency noise from the input, or for limiting the rate of change of that signal.
ANIN2OFFSET	The DC voltage offset on the analog input.
ANIN2	The deadband range of analog input 2. This is useful for preventing the drive from responding to voltage noise near the zero point of the analog input.
ANIN2	The voltage at the analog input. Read only.
ANIN2ZERO	Causes the value of the analog input 2 signal to become 0 by modifying the analog offset value.

6.12.3 Using Analog Inputs for Velocity Command and Current Limit

Procedure: Using Analog Inputs as Velocity Command and Current Limit

Use the following procedure in ServoStudio 2 to configure the CDHD2 to work with analog input 1 as the velocity command and analog input 2 as the current limit.

1. Define the Operation mode.

   Activate the **Motion** screen, and select Operation mode: **Analog Velocity** (OPMODE 1).

   When working in Analog Velocity mode, a signal is applied to analog input 1, and the drive translates it into a velocity command.

2. Define Velocity Scaling.

   Velocity command scaling is a user-defined ratio, which the drive uses to translate the analog input into a velocity command.

   In the example shown here, scaling is set to generate a velocity command of 100 rpm per each volt.

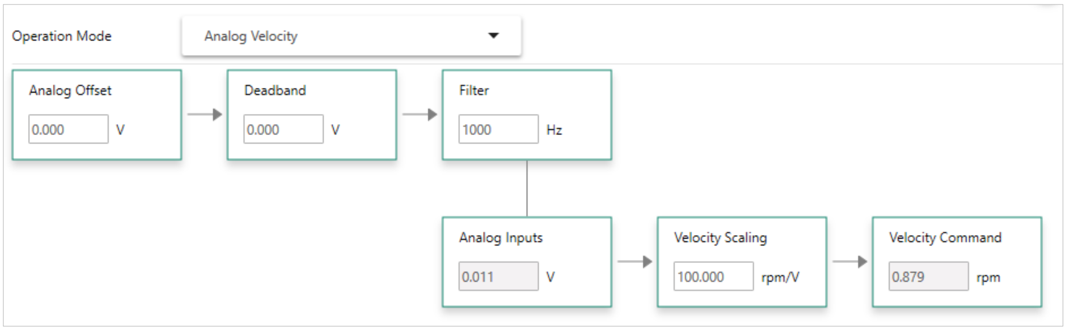


Figure 6-32. Velocity Command Scaling

3. Define the function of Analog Input 2.

   Open Terminal.

   Define analog input 2 as the current limiter by setting the value of parameter ANIN2MODE to 2:

4. Define the scaling of the Analog Current command.

   Set the scaling of the analog current command from input 2 by setting the value of parameter ANIN2ISCALE.

   In the example shown here, scaling is 0.5A per each volt. The drive will calculate the current limit accordingly.

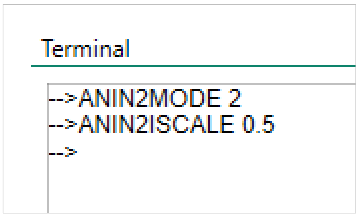


Figure 6-33. Analog Input 2 Parameter Settings

Notes

Since both drive parameter ILIM and analog input 2 define current limit, the drive recognizes the lower value of the two as the current limit at any given time. To read the actual limit, use ILIMACT.

Drive parameters ACC and DEC provide the limits for acceleration and deceleration, respectively. If analog input 1 (when used for velocity commands) generates a rate greater than ACC or DEC, the drive will not exceed the values of ACC and DEC.

6.13 Analog Output

The CDHD2 also has an analog output that can be set to output a voltage equivalent to the value of certain parameters.

Use the ServoStudio 2 Analog Output pane in the Analog I/Os screen to set the analog output properties and to monitor the output value.

The following parameters are used to configure and monitor the analog output.

VarCom	Description
ANOUTMODE	Defines the function of the analog output.
ANOUT	Displays the analog output value (in volts), as set by ANOUTMODE. Read only.
ANOUTCMD	The analog output command (in volts) set by user in ANOUTMODE 0.
ANOUTISCALE	The scaling of the analog output voltage that represents the motor current (I) or the current command (ICMD).
ANOUTLIM	The analog output command voltage limit for all modes.
ANOUTVSCALE	The scaling of the analog output voltage that represents the actual velocity (V) or the velocity error (VE)
OUTMODE	Defines the condition that will activate the specified digital output.

6.14 Disable Mode

The disabling of the drive may be the result of an explicit command from the motion controller or the drive's own response to a fault condition. When the drive becomes disabled, the Disable Mode function can be used in certain cases to bring the motor to a fast stop before power to the motor is shut off. This reduces the amount of motor coasting.

Use the ServoStudio 2 **Emergency Stop** screen to select the methods and parameters to be used for stopping the motor when the drive becomes disabled.

The Disable mode function consists of two mechanisms:

- **Active Disable** brings the motor to a stop by means of a controlled deceleration to zero velocity, and then disables the drive. Active Disable cannot be applied when the drive is operating in a current control mode (OPMODE 2 or OPMODE 3).
- **Dynamic Brake** holds the motor while the drive is disabled by applying only the motor's back-EMF to the stopping current; it can therefore be used even in the event of feedback loss.

VarCom	Description
DISMODE	Defines how the drive will respond when it becomes disabled.
DISMODE 0	No active disabling; no dynamic braking.
DISMODE 1	No active disabling; dynamic braking on fault only.
DISMODE 2	No active disabling; dynamic braking on any disable.
DISMODE 3	Active disabling on fault*; no dynamic braking.
DISMODE 4	Active disabling on fault*; dynamic braking on fault only.
DISMODE 5	Active disabling on fault*; dynamic braking on any disable.

Note Faults that require immediate disable (to prevent drive damage) and feedback faults that might cause a commutation error (runaway motor condition) cannot issue Active Disabling.

Three parameters affect the behavior of the disabling and braking.

VarCom	Description
DISSPEED	Defines the velocity threshold below which the motor is considered stopped and the Active Disable timer starts the countdown to disable. The motor velocity must remain below this threshold for at least 50 ms for the motor to be considered stopped.
DISTIME	Defines the continuous time the motor must remain below DISSPEED before the drive is disabled. The DISTIME counter begins only after motor velocity has been below DISSPEED for at least 50 ms.
DECSTOP	Defines the deceleration rate of the ramp down.

6.14.1 Active Disable

Active Disable prevents motor coasting while the axis is disabled.

The Active Disable mechanism brings the motor to a stop by means of a controlled ramp down to zero velocity, and then disables the drive.

Note Active Disable cannot be applied when the drive is in a current control mode (OPMODE 2 or OPMODE 3); it works in all other operation modes.

Figure 6-34 shows how motor coasting occurs when Active Disable is not used. As soon as the drive is disabled, the velocity command is set to zero. The actual velocity then decreases as a function of the inertia and friction.

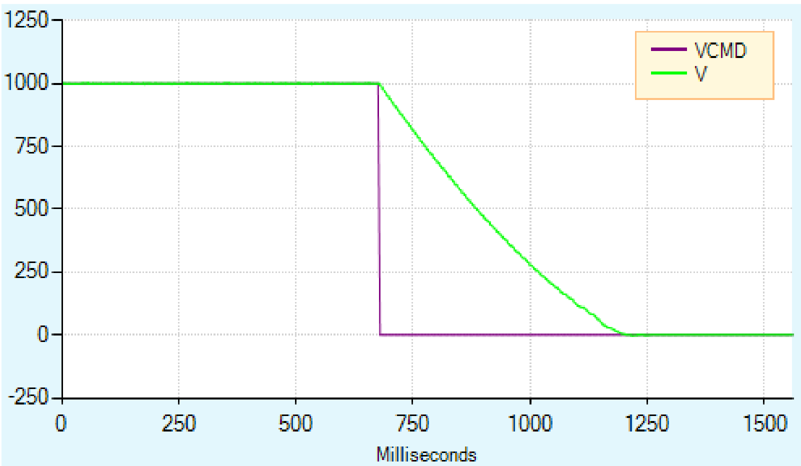


Figure 6-34. Disabling Without Active Disable

Figure 6-35 illustrates what happens when Active Disable is in effect. As soon as the drive receives the disable command, the velocity command is ramped down to zero, and only then is the drive disabled.

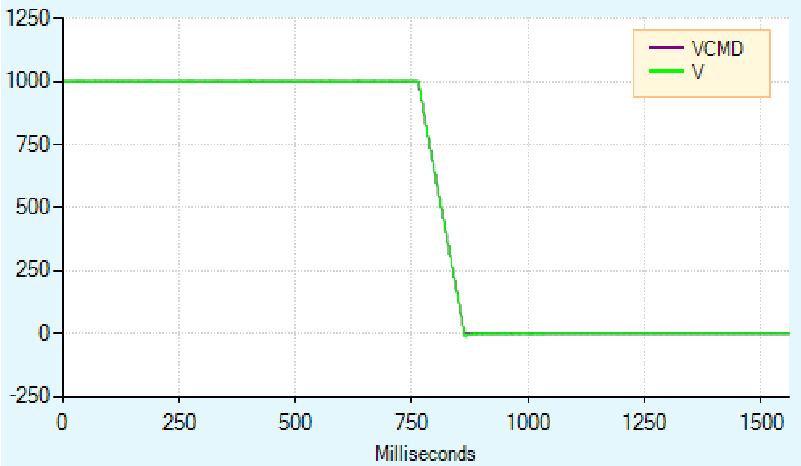


Figure 6-35. Disabling With Active Disable

Figure 6-36 shows the effect of DISSPEED and DISTIME. In this example, DISSPEED is set to 1000, and DISTIME is set to 1 ms. After the motor speed remains below 1000 for 50 ms, and the time defined by DISTIME elapses, the drive is disabled and the motor coasts to a stop.

In this example, approximately 110 ms elapse from the time the motor velocity goes below 1000 and the time the drive is disabled.

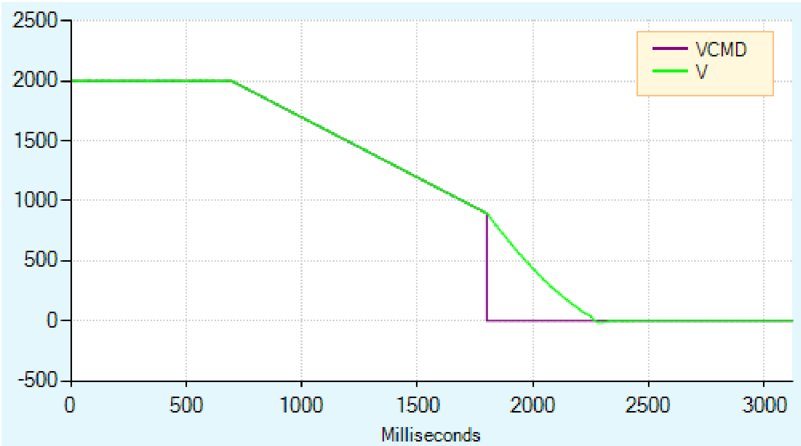


Figure 6-36. Effect of DISSPEED and DISTIME on Active Disable

During the Active Disable ramp down, the drive ignores any new motion commands.

If an additional disable command (VarCom **K**) is issued during the ramp down, the ramp down process is aborted and the drive is immediately disabled.

Figure 6-37 shows the effect of a second disable command. In this example, DISSPEED is set to 1000, and a second disable command is issued before the motor speed has ramped down to that level.

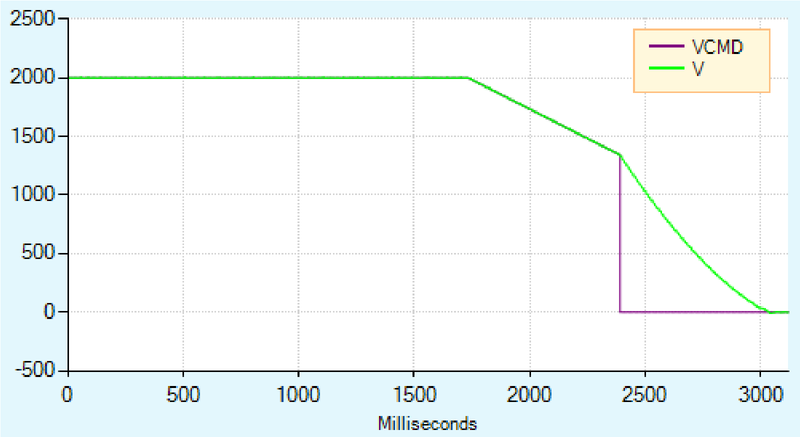


Figure 6-37. Effect of Second Disable Command on Active Disable

The diagram in the ServoStudio 2 Emergency Stop screen illustrates the behavior of Active Disable.

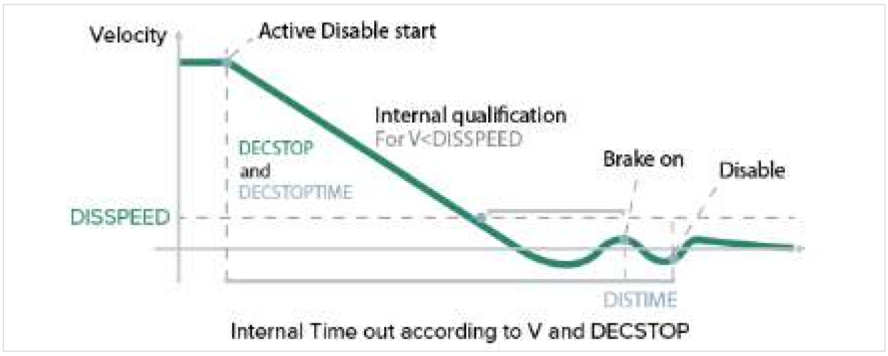


Figure 6-38. Disable Stop

Notes

If one of the digital outputs is configured for brake control, then the brake will be engaged as soon as the DISTIME timer begins counting.

If the internal timeout (which is calculated according to the actual velocity and DECSTOP) expires, the ramp down mechanism will also abort, as indicated by 1 in the Disable Stop diagram.

6.14.2 Dynamic Brake

Dynamic Brake is a mechanism that allows a disabled drive to hold the motor. Only the motor's back-EMF is used to apply the stopping current.

The variable ISTOP is used to set the maximum current allowed during the dynamic braking process.

Figure 6-39 illustrates motor coasting, that is, no Dynamic Brake (and no Active Disable). The velocity command is set to 0 as soon as the drive is disabled. The actual velocity then decreases as a function of the system inertia and friction.

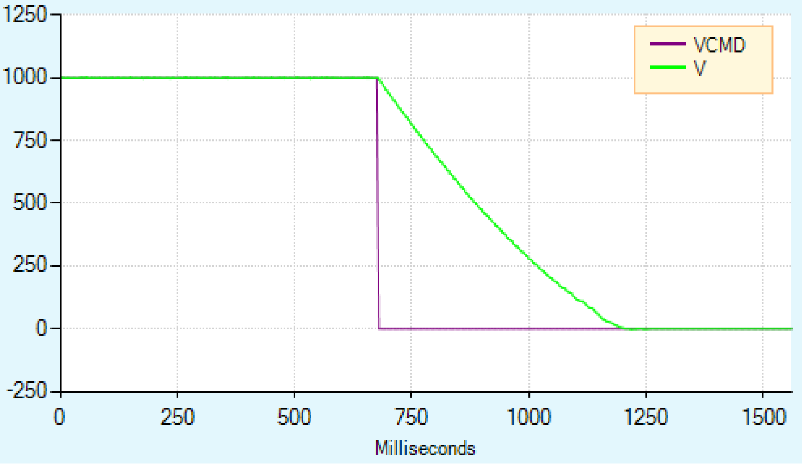


Figure 6-39. Motor Coasting, Without Dynamic Brake

Figure 6-40 shows what happens when Dynamic Brake is in effect. As in the figure above, the velocity command is set to 0 as soon as the drive is disabled. However, the actual velocity ramps down as the braking is applied.

Unlike Active Disable, the velocity does not ramp down according to a motion profile. The ramp down rate is a function of the maximum current allowed (variable ISTOP) and the system inertia and friction.

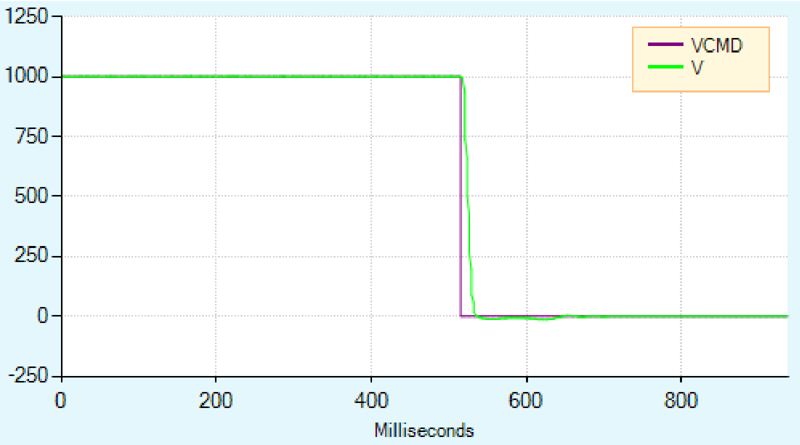


Figure 6-40. Dynamic Brake

Figure 6-41 shows Dynamic Brake with a very low value of ISTOP. In this instance, it takes longer to bring the motor to a stop.

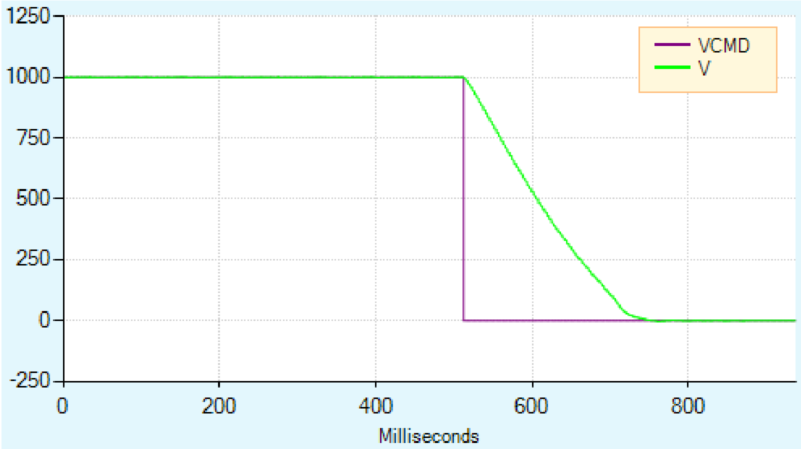


Figure 6-41. Dynamic Brake with Low ISTOP Value

In DISMODE 4 and DISMODE 5 both Active Disable and Dynamic Brake are supported. In these cases, Active Disable is used to bring the motor to a stop, and Dynamic Brake is activated after DISTIME.

6.15 Motor Brake Control via Relay

The CDHD2 can control a motor brake via an external relay. The relay can be connected to any digital output on the CDHD2 Machine I/F (C3) or Controller interface (C2). It is recommended that you connect to digital output 7.

Refer to *Motor Brake Wiring* and to the procedure below.

The polarity of the digital output can be altered to make the drive electronics match those of the motor control circuit.

The CDHD2 disable time is programmable by means of the DISTIME parameter. When the drive receives a Disable command, it first switches off the brake output and then waits for the brake disengage time before becoming disabled.

The brake engage time is not programmable. When the drive receives an Enable command, it simultaneously switches on the brake output and becomes enabled.

The drive needs a maximum of 1.5 milliseconds to become enabled, while a brake typically takes tens of milliseconds to disengage.

Procedure: Configuring Digital Output to Control Brake

To configure the digital output, perform the following procedure in ServoStudio 2.

1. Define the output.

   Go to the Digital I/Os screen, and set an output (e.g., Output 1) to mode 2-Brake Release Signal.

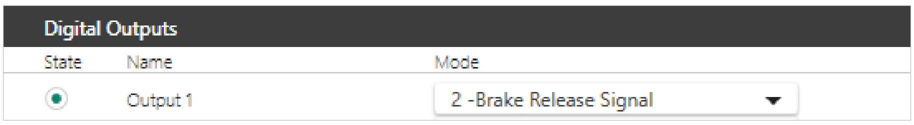


Figure 6-42. Digital Output Settings for Motor Brake Control

By default:

- When CDHD2 is enabled, the brake output is on.
- When CDHD2 is disabled, the brake output is off.

2. Go to the Emergency Stop screen, and set the Active Disable Time (DISTIME).
   For example, set it to 30 ms.

   DISTIME defines the period of time after the motor speed goes below the Active Disable Speed Threshold (DISSPEED) until the drive is disabled by the Active Disable function.

Figure 6-43. Active Disable Time (DISTIME)

Whenever a Disable command is executed, the CDHD2 immediately changes the brake output value, and waits the Active Disable Time (DISTIME) before disabling CDHD2 control.

Whenever a fault such as STO or Feedback Lost occurs, the drive immediately toggles the brake output value and disables CDHD2 control.

6.16 Motor Temperature Sensor

The CDHD2 supports both thermostat (on/off) and thermistor (temperature sensitive resistance) motor temperature sensors.

The following parameters are used to define the type of motor temperature sensor and the drive response to an over-temperature condition.

VarCom	Description
THERM	Indicates whether a motor over-temperature fault exists.
THERMODE	Defines how the drive responds to a motor over-temperature fault. If the motor does not have a temperature sensor, or if the sensor is not wired, set THERMODE=3, so that the drive will ignore this fault.
THERMTYPE	Indicates whether the sensor is type PTC (positive temperature coefficient) or NTC (negative temperature coefficient). When using a thermostat (on/off motor temperature sensor), set THERMTYPE=0 to define type PTC.
THERMREADOUT	Reads the resistance of the temperature sensor.
THERMTRIPLEVEL THERMCLEARLEVEL	The motor over-temperature fault detection and clear mechanism is subject to a hysteresis mechanism. The fault will trip when the resistance passes a certain value, and can be cleared only when the resistance drops below a different value. • For a PTC thermistor, the motor over-temperature fault will trip when the resistance is equal to or greater than the THERMTRIPLEVEL. The fault can be cleared when the resistance is equal to or less than the THERMCLEARLEVEL. • For an NTC thermistor, the motor over-temperature fault will trip when the resistance is equal to or less than the THERMTRIPLEVEL. The fault can be cleared when the resistance is equal to or greater than the THERMCLEARLEVEL. • If the motor temperature sensor is a thermostat, the resistance is zero in normal state and infinite in fault state.

When the drive detects a motor over-temperature condition, the motor over-temperature fault is latched, and the digital display shows **H | FH**.

6.17 Error Correction

6.17.1 Error Correction Overview

The CDHD2 drive has an error correction function that serves to negate repeatable positioning errors.

An external measurement device, such as a laser interferometer, is used to generate an error mapping table. The error mapping is stored in the drive’s non-volatile memory. The drive retrieves correction values in realtime, based on the actual positions, and applies corrections on-the-fly. Once the correction is implemented, the error becomes negligible. As a result, an additional position feedback device is not needed.

6.17.2 Error Correction Table – Example

In this example, the position of the load on a linear axis is measured by a laser interferometer. The axis travel distance is one meter. The drive software sends an instruction to move the motor in intervals of 100 mm, so that the motor moves through a range of 10 positions. As the motor moves the load, the laser system measures the distance traveled by the load, which is compared at each point to the motor encoder position. The difference between the two values is the error correction value.

To ensure smooth motion, the drive performs linear interpolation between points of error table. In this example, to move the stage to a point 275 millimeters from the origin, the controller takes the nearest two data points from the error mapping table (200 and 300 millimeters) and calculates the correction value for the point at 275 millimeters.

Motor Encoder Position	External Measured Position	Correction Value
0	0	0
100	99	1
200	202	-2
300	300	0
400	400	0
500	500	0

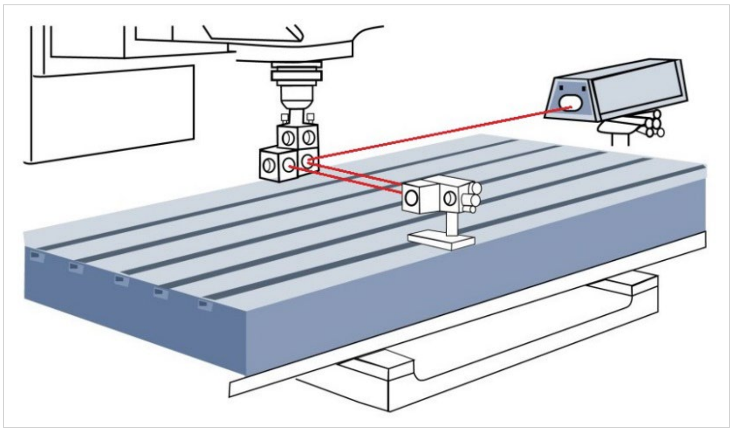


Figure 6-44. Laser Interferometer Measures Distance Traveled

6.17.3 Error Correction Functionality in CDHD2

The CDHD2 error correction function can be applied in various types of motion systems:

- Direct drive linear stages
- Direct drive rotary stages
- Linear stages driven by servo drive (motor is rotary, the error is linear)
- Rotary stages driven by servo motor (motor is rotary, the load is rotary)

The error correction function can be used with all the absolute and incremental encoders that are supported by the CDHD2.

Note Homing is required when using the error correction function in an incremental system.

Note When the CDHD2 error correction function is used in a dual control loop system, the correction is performed on the secondary (load) encoder value.
When CDHD2 error correction is used in a single control loop system, the correction is performed on the primary (motor) encoder value.

6.17.4 Error Correction Parameters and Commands

The following parameters are used to configure and apply the error correction function.

VarCom	Description
ERRCOREN	Defines a user request to activate the error correction function.
ERRCORST	Indicates the state of the error correction function after a user request (ERRCOREN 1) has been issued.
ERRCORSTARTPOS	Defines the position corresponding to the first active entry of the error correction table.
ERRCORACTIVENUM	Defines the number of active entries in the error correction table. Up to 1000 entries can be defined (and active) in the error correction table.
ERRCORINTERVAL	Defines the distance between the positions at which the errors are measured and added to the correction table. Defined in LOAD units.
ERRCORUNITS	Defines the units of the error position data delivered by the error correction table.
ERRCORSTARTOFF	Defines the offset to the first active entry in the error correction table.
LMUNITSNUM	The denominator of the motor feedback to load feedback scaling ratio.
LMUNITSDEN	The numerator of the motor feedback to load feedback scaling ratio.
ERRCORRESET	Used to reset all error correction parameters and table entries to their default values. Reset occurs when ERRCORRESET is set to 1.
ERRCORSETINDEX	Defines a correction value for a specific entry in the correction table.
ERRCORFAILINDEX	Indicates the index of the error correction table entry that failed due to an invalid error size. Error size must not exceed a maximum value of 1 (degree for rotary units/ millimeters for linear units).

VarCom	Description
PFBRAW	The position feedback value, excluding error correction and position modulo. Used for debugging.

6.17.5 Error Correction Feedback Units

Motor to Load Ratio

When using a direct drive linear (DDL) stage or a direct drive rotary (DDR) stage, the mechanical ratio of the motor to load is 1:1.

$$\frac{\mathrm{LMUNITSNUM}}{\mathrm{LMUNITSDEN}} = \frac{1}{1}$$

- In this case, the value and units of PFB are the same for both the motor and the load.

When using a linear stage driven by a servo drive (motor is rotary, the load is linear), the mechanical ratio is 1 motor revolution per *n* millimeters linear movement.

$$\frac{\mathrm{LMUNITSNUM}}{\mathrm{LMUNITSDEN}} = \frac{1}{n}$$

When using a rotary stage driven by a servo motor (motor is rotary, the load is rotary), the mechanical ratio is 1 motor revolution per *n* load revolutions.

$$\frac{\mathrm{LMUNITSNUM}}{\mathrm{LMUNITSDEN}} = \frac{1}{\mathrm{n}}$$

6.17.6 Error Correction Setup

The following diagram shows an example of the parameters used for error correction mapping.

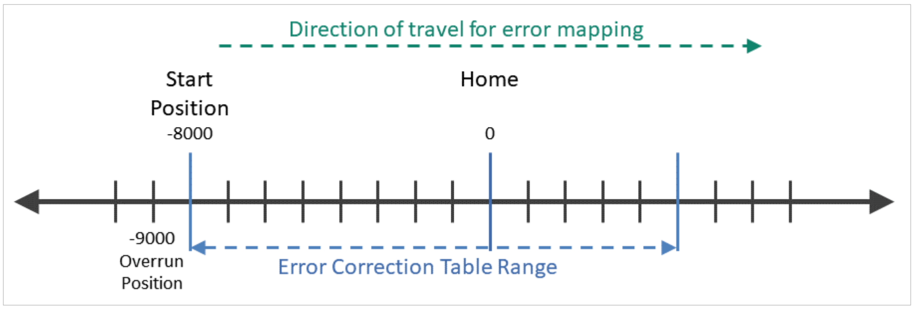


Figure 6-45. Error Correction Mapping – Example

Procedure: Manually Configuring and Generating an Error Correction Table

Using ServoStudio 2 and Any Measuring Device

1. In the ServoStudio 2 Error Correction screen, enter the settings and values that will define the range of positions at which the error sampling and correction will be performed.
   - Start position

- Number of points
- Interval (distance between sampling points)
- Correction units (if needed)
- Load/motor mechanical ratio (if needed)

2. Bring the motor to a position that is at least several millimeters away from the position that will be the first (start) position measured for the error correction table.
3. Send the motor to the start position, and then to a series of positions, corresponding to the positions and intervals defined in ServoStudio 2
4. Using the measuring device, perform error correction measurements at each of the specified positions, and generate a set of error correction values.
5. In the ServoStudio 2 **Correction Table**, the Index and Position values will be displayed according to the values entered on the right side of the screen.

   Manually enter the **Correction** values for each position, calculated as follows:

Encoder Value	Measurement Value	Correction Values
X1	Y1	Y1 – X1 = ERR1
X2	Y2	Y2 – X2 = ERR2
X3	Y2	Y3 – X3 = ERR3

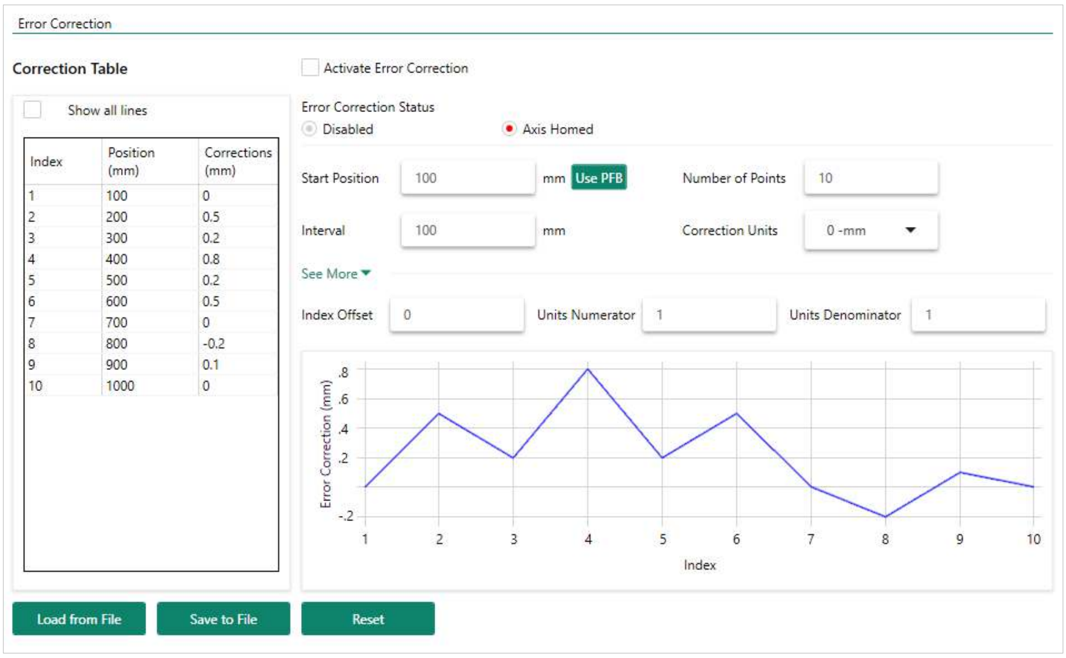


Figure 6-46. Error Correction Table – Example

6. **Save to File** (SSV format)

   Settings and all indexes in the error correction table are saved to an SSV file.

Procedure: Configuring Error Correction Table for Use with Renishaw RTL File

Using ServoStudio 2 and Renishaw Laser Interferometer

Notes This procedure is based on a Renishaw XL=80 laser interferometer and exported RTL file, which is currently the only third-party system supported by the CDHD2 error correction function.

It is assumed that the Renishaw system has been installed according to the manufacturer's instructions, and the user knows how to operate the hardware and software.

CDHD2 - ServoStudio 2

1. Make sure the CDHD2 is operating in serial communication mode (COMMODE 0).
2. Configure the motor and the motor feedback parameters.
3. If using an incremental system, execute homing (HOMECMD).
4. Open the **Error Corrections** screen.

   On the right side of the screen, enter the settings and values that will define the range of positions at which the error sampling and correction will be performed.

   - Start position
   - Number of points
   - Interval between sampled points
   - Correction units (if needed)
   - Index offset (if needed)
   - Load/motor mechanical ratio (if needed)

Note The CDHD2 and the laser system must have the same physical reference (zero) position.

Laser System

5. Use **CARTO Capture – DEFINE** tab to configure the error table.

   Select **Linear** Definition.

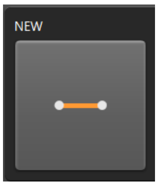


Figure 6-47.

6. **CARTO Capture – DEFINE** tab > **Targets** menu.
   a. Define the following settings. Use the same values as in the configuration defined in ServoStudio 2:
      - **First target** (first point to be measured)
      - **Last target** (last point to be measured)
      - **Interval** (distance between measured points)

- **Targets per run** (total number of points to be measured)

b. Define **unidirectional** travel: the Bidirectional option must be cleared.

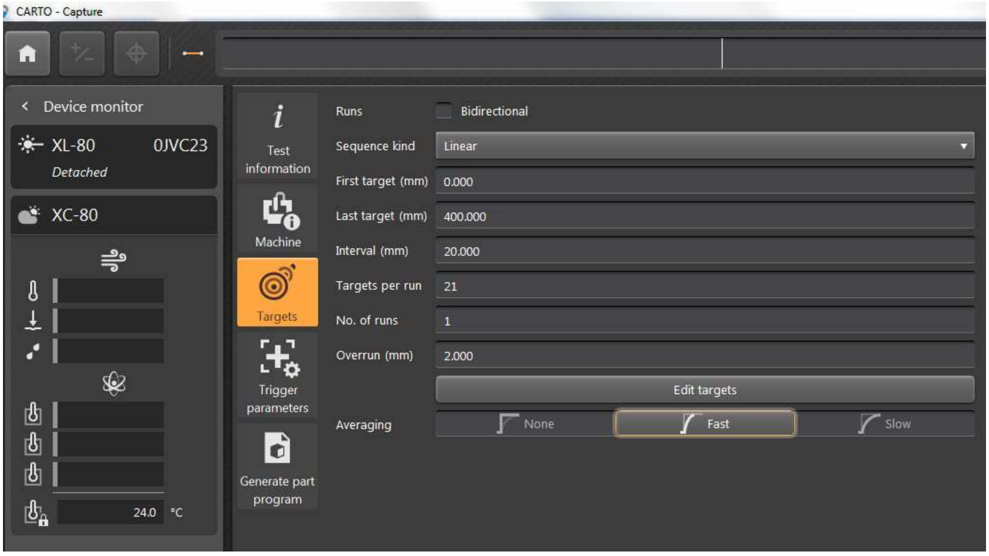


Figure 6-48.

7. **CARTO Capture** – **DEFINE** tab > **Trigger Parameters** menu.

   Use **Position triggering.** This mode automatically captures data by comparing the laser measurement with the target position, and records the error measurement when the machine is within the limits given for Tolerance, Stability Period and Stability Range.

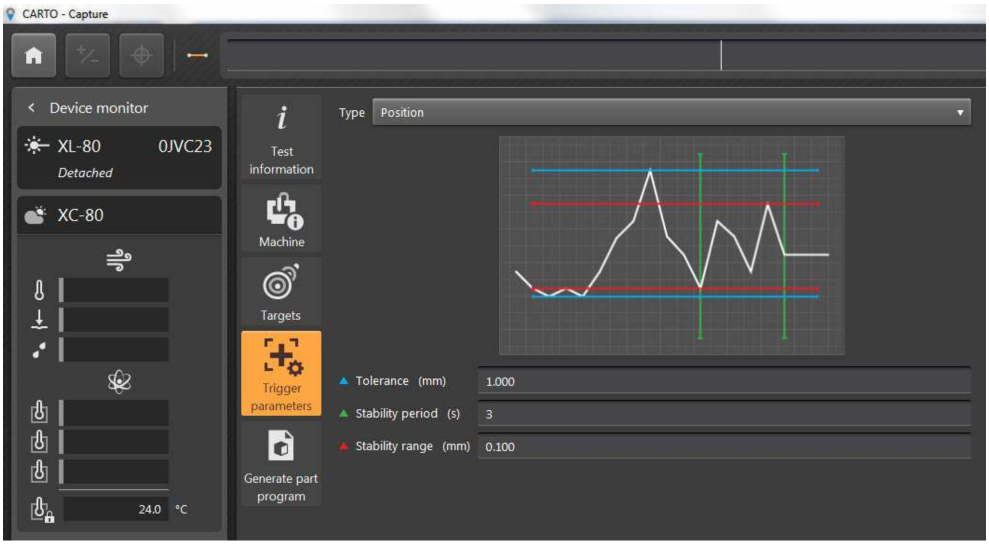


Figure 6-49.

8. **CARTO Capture** – **CAPTURE** tab

   At the bottom of the screen, press **Capture**.

   (The laser resets to 0 when Capture is activated; if it does not reset, use the DATUM function.)

   The laser system will now perform measurement samplings.

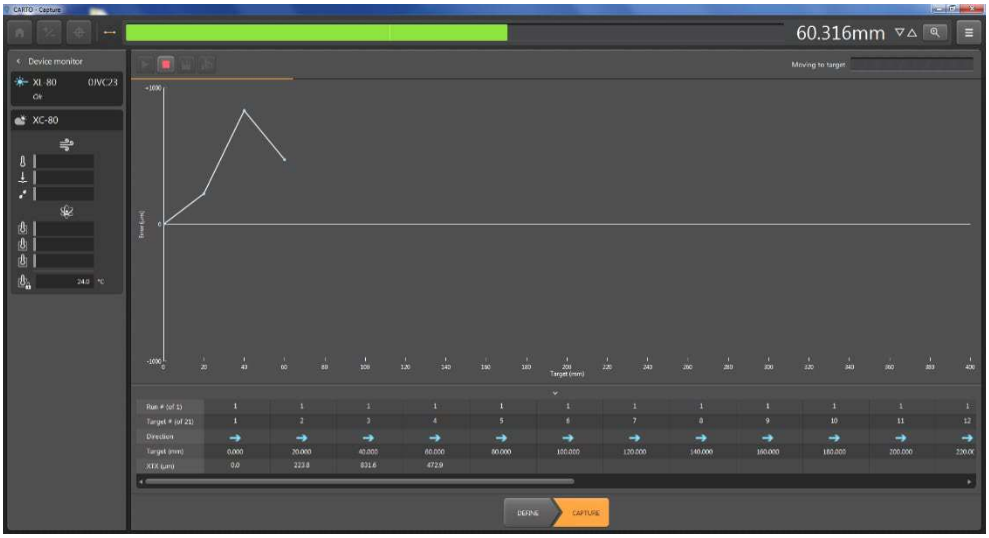


Figure 6-50.

CDHD2 - ServoStudio 2

9. Issue a command to move the axis to an overrun position.

   The overrun position should be at least several millimeters from the start capture position. The overrun position must be defined such that axis movement from the overrun position towards the sampling range is in the direction of movement defined for the laser.

10. Issue a command to move the axis from the overrun position to the first position to be sampled.

11. Issue commands to send the axis to the same positions at which the laser system is programmed to perform measurements.

    A script can be used. See example below.

    The program must include a DELAY command at every measuring point, with a duration that is slightly longer than the one defined for the laser trigger. A recommended value is 5 seconds.

```
#ClearOutput

#Var $start_position=-10
#Var $stop_position=401
#Var $interval=20
#Var $cmd=0
#Var $Vel=80
#Var $index=1
#Var $Corr

en
#Delay 5000
moveabs -10 60
#Delay 5000
moveabs $start_position $vel
#delay 5000
#while $cmd<$stop_position
moveabs $cmd $Vel
#Delay 5000
```

```
#print pfb pfbraw
#Round $index 0
$corr = errcorsetindex $index
#print $corr
$index = $index + 1
$cmd=$cmd+$interval
#End_While
k
```

Laser System

12. **CARTO Capture**.

    Once all sampling is completed, press the **Save** button to save the error correction data.

13. **CARTO Explore**.

    Select **File Open**.

Figure 6-51.

14. From the list, select the data file to be used for the error correction, and press **Export Tests** (first button) at the bottom of the screen.

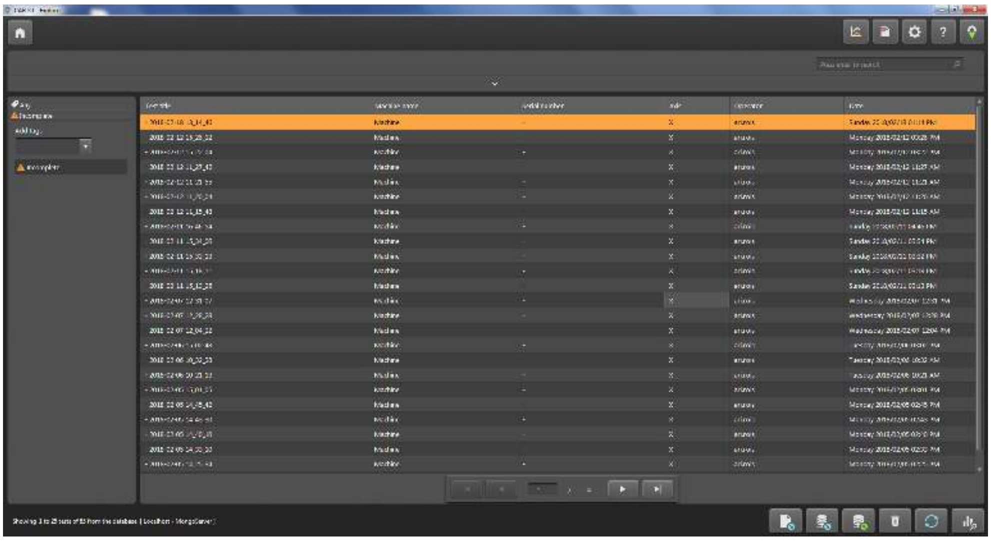


Figure 6-52.

CDHD2 - ServoStudio 2

15. In the **Error Corrections** screen, press **Load from File**, and load the data file saved in CARTO. (*.RTL)

16. The data from the file will now be loaded, and the error correction table will be imported and displayed.

17. Enable the option: **Activate Error Correction**.

18. The yellow line indicates the position for which the error correction value is being applied.

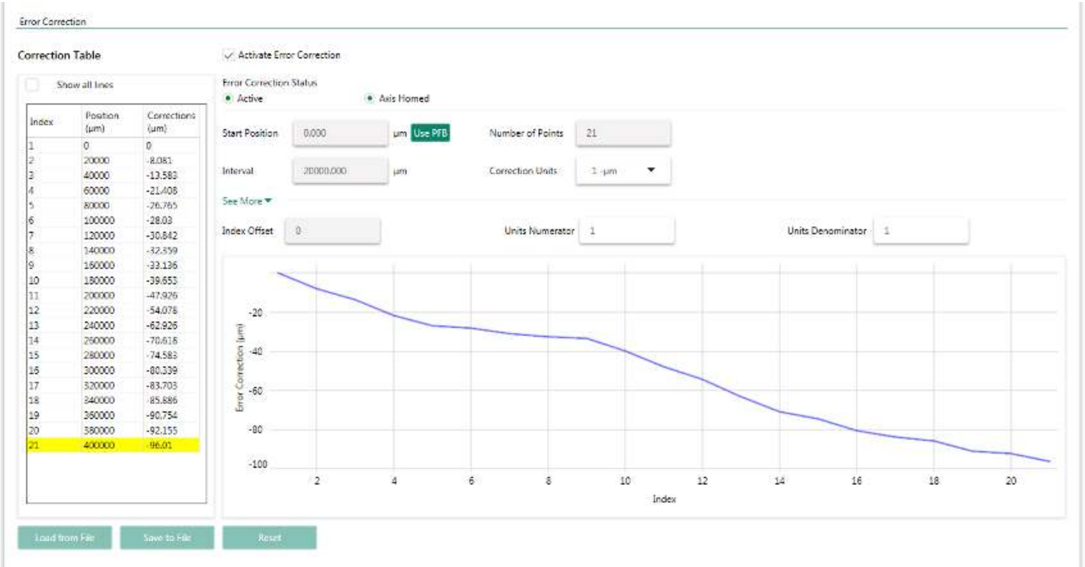


Figure 6-53.

19. Use the SAVE command (**Save** button in menu bar) to save the error correction table to the drive's non-volative memory.

20. It is recommended that you repeat the measurement process using the laser system, and confirm that the error has diminished.

6.18 Gantry System

6.18.1 Gantry System Overview

A gantry system is one in which two parallel axes (Y1 and Y2) are used to control a single linear axis, which is orthogonal (at a right angle) to the system's X-axis.

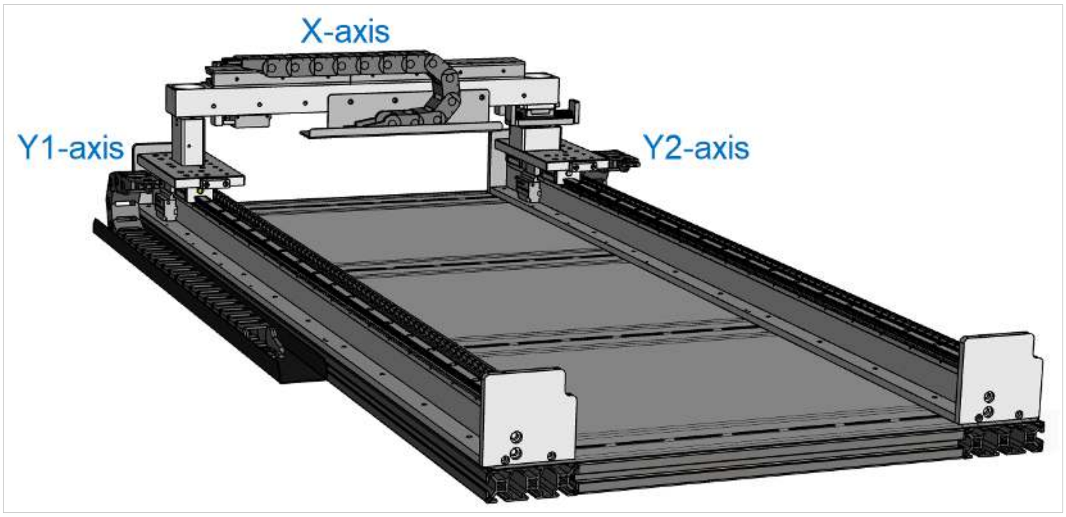


Figure 6-54. Gantry Axes

In many gantry systems, the two parallel linear axes (Y1 and Y2) are controlled independently of each other, which may result in mutual interference, manifested by vibrations, higher current consumption, slower acceleration and speed, and reduced accuracy.

The CDHD2 gantry system synchronizes the two Y axes through two CDHD2 drives working in tandem and using high-speed communication to generate and control movement along the Y axis.

Each of the two Y axes can be driven by either a linear or a rotary motor.

The two Y-axes must have the same type of feedback device with the same resolution.

6.18.2 Gantry Types

The CDHD2 gantry system supports two types of gantry structures: rigid and flexible. The different types indicate the orthogonality of the gantry axes and the amount of flexibility in the coupling of the axes.

The gantry type parameter (GANTRYTYPE) must be defined to ensure proper homing, and to properly compensate for skewing.

Rigid Gantry System

In a rigid gantry structure, the Y and X axes are strictly orthogonal (at right angles to each other) without flexibility in their mechanical coupling to each other.

When one Y axis moves, the other Y axis follows without causing any skewing of the axes.

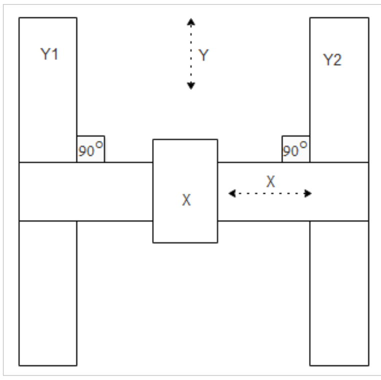


Figure 6-55. Rigid Gantry Structure

Flexible Gantry System

In a flexible gantry structure, one or both Y axes has some flexibility in its mechanical coupling to the X axis.

The differential motion of the two Y axes causes a certain amount of rotational motion about the center of the gantry. This rotational motion (yaw) is considered the **difference** axis by the CDHD2 system.

Therefore, a flexible gantry system requires control of the **difference** between Y1 and Y2 axis positions.

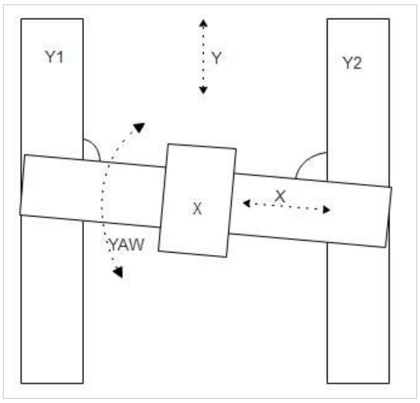


Figure 6-56. Flexible Gantry Structure

Flexible Gantry Yaw Alignment

In a rigid gantry system, the yaw value is 0 and the X and Y axes are aligned orthogonally. Therefore, no yaw alignment is needed.

However, in a flexible gantry system, skewing occurs. The parameter GANTRYOFFSET is used to align the yaw.

The value of GANTRYOFFSET is the difference (in distance) between the Y1 and Y2 reference points. Typically, the reference point is the motor index or home switch.

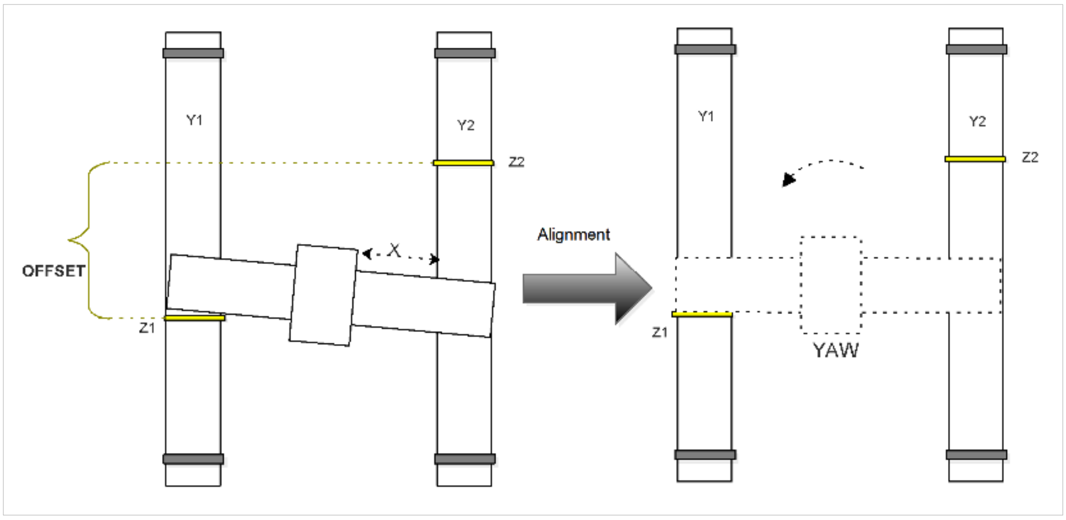


Figure 6-57. Gantry Yaw Alignment

If the motor manufacturer specifications provide the motor index position of Y1 and Y2, then the value of GANTRYOFFSET can be easily calculated as the difference between index position of Y1 and index position of Y2.

If the value of GANTRYOFFSET is not known, one of the following methods can be used to determine its value:

- Manual measurement using a measurement device (laser interferometer, for example) of the offset distance. This is considered the most accurate method, and is recommended.
- Automatic measurement using the parameter GANTRYFINDOFF. The status of the measurement can be monitored using command GANTRYFINDOFFST, whose value changes to 1 when the measurement is completed. Parameter GANTRYOFFSET indicates the value of measurement. Perform this measurement procedure several times to ensure its accuracy. To apply and maintain the GANTRYOFFSET value, set GANTRYOFFSETST=1.

When completed, save the result to the drive memory.

GANTRYOFFSET needs to be defined only once for a system. Subsequently, the homing command will use the correct GANTRYOFFSET value. In addition, at every power up, and when switching from disabled to enabled state, the flexible gantry system will align according to the GANTRYOFFSET value.

6.18.3 Gantry Control Modes

Control of the CDHD2 gantry system is performed by two drives that are paired together by means of communication cable. These drives are called “partner” drives.

The drive for axis Y1 is the **Master** drive. The gantry Master drive receives a position command from the motion controller and performs a position loop on a virtual Y-axis that is calculated as the average of Y1 and Y2.

The drive for axis Y2 is the **Difference** drive. The gantry Difference drive handles the error between the two axes (Y1 and Y2).
In a rigid gantry system, its function is to keep the error between Y1 and Y2 as close as possible to 0.

Note While it is possible to set the error to a non-zero value (to be defined by the controller), gantry applications typically aim for an error of 0 between the Y1 and Y2 axes.

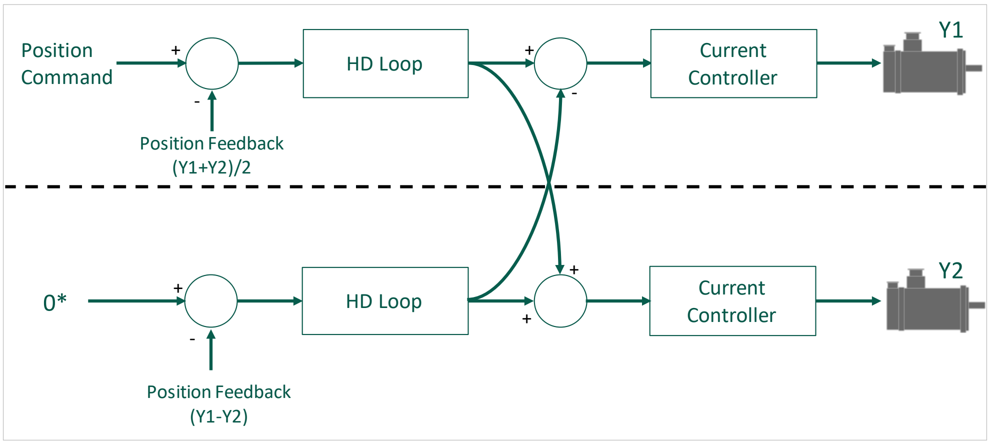


Figure 6-58. Gantry Control Module

Note Master and Difference controllers are both available for rigid and flexible types of gantry. However, for a rigid gantry, the Difference controller it is **not** recommended, and the gain parameters of the Difference controller should be set to 0.

In a flexible gantry system using fieldbus, the motion controller can send non-zero reference commands to the gantry difference axis.

The parameter GANTRYCMDTYPE defines whether the difference command is accepted or ignored (fixed to 0).

6.18.4 Gantry Operation Modes

The CDHD2 gantry drive functions only in a position operation mode.

When COMMODE=0 (serial communication; without fieldbus), operation modes can be either Gearing mode (OPMODE 4) or Serial Positioning mode (OPMODE 8)

When COMMODE=1 (EtherCAT/CANopen communication; with fieldbus), operation modes can be Profile Position (opmode 1), Cyclic Synchronous Position (opmode 8), Homing (opmode 6).

Reference commands can be generated by EtherCAT/CANopen, pulse train, or serial communication devices.

6.18.5 Gantry Parameters and Commands

The following parameters are used to configure and monitor gantry applications.

Some parameters are applicable to both Master and Difference axes, while others are applicable to only one of the gantry axes. For complete details, refer to the VarCom documentation.

VarCom	Description
GANTRYMODE	Defines whether the position loop is applied to the average value or the difference in value of the two gantry motor positions
GANTRYCMDTYPE	Defines how a gantry drive responds to reference commands. Defines which position feedback value the drive will report through EtherCAT/CANopen objects and encoder simulation.
GANTRYALIGNMODE	Defines the alignment method for a flexible gantry system
GANTRYTYPE	Defines whether the gantry structure is rigid or flexible
GANTRYCOMMSTATE	Indicates whether the gantry drives are communicating
GANTRYINTERFACE	Defines the controller interface used for connecting the communication cable between gantry drives.
GANTRYMSTRPFB	Gantry master position feedback value = (Y1+Y2)/2 (Read only)
GANTRYDIFFPFB	Gantry difference position feedback value = (Y1-Y2) (Read only)
GANTRYMSTRVFB	Gantry master velocity feedback value = (V1+V2)/2 (Read only)
GANTRYDIFFVFB	Gantry difference velocity feedback value = (V1-V2) (Read only)
GANTRYMSTRICMD	The current command generated by the gantry master controller. (Read only)
GANTRYDIFFICMD	The current command generated by the gantry difference controller. (Read only)
GANTRYALIGN	Initiates the procedure for aligning the gantry Y axes.
GANTRYALIGNED	Indicates whether the gantry Y axes are aligned. Read only)
GANTRYFINDOFF	Initiates the procedure for finding the value of the difference (in distance) between the Y1 and Y2 reference points.
GANTRYFINDOFFST	Indicates the status of the gantry offset finding procedure.
GANTRYOFFSET	The difference in distance between the Y1 and Y2 reference points. Value required for flexible gantry system.
GANTRYOFFSETST	Indicates whether the stored GANTRYOFFSET value is valid and can be used for alignment procedure
GANTRYPRTNRMFB	The position of the second (partner) gantry motor. (Read only)
GANTRYPRTNRICMD	The current command of the second (partner) gantry axis. (Read only)
GANTRYPRTNRVFB	The velocity of the second (partner) gantry motor. (Read only)

6.18.6 Gantry Setup

To set up the CDHD2 gantry system, perform the following steps:

1. If the gantry system contains limit switches, make sure they are installed as follows:
   - Positive limit switches on Y1 and Y2 must be parallel, with no more than 5 mm difference in their alignment.
   - Negative limit switches on Y1 and Y2 must be parallel, with no more than 5 mm difference in their alignment.
2. Connect the motor of the first gantry axis to the first drive, and the second motor to the second gantry drive.

Make sure each pair of power and feedback cables are connected to the appropriate drive.

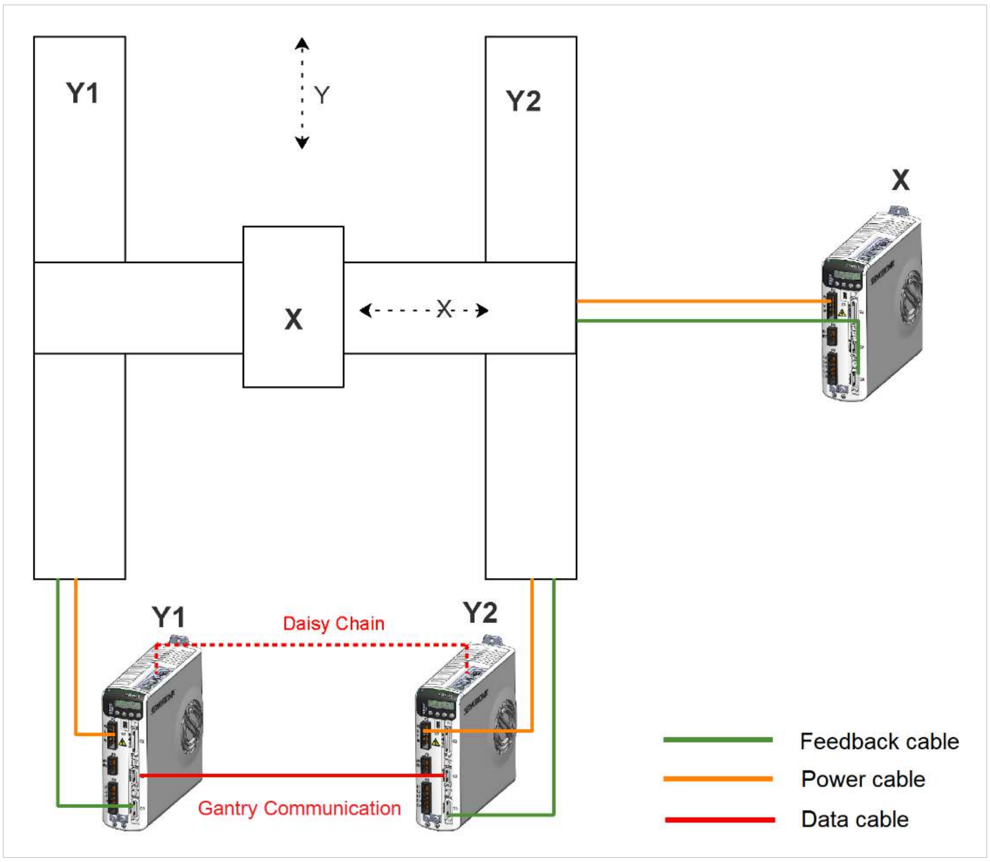


Figure 6-59. Gantry Wiring and Communication

3. Connect the gantry drives to each other via both C3 and C8 interface.
The C3 connection is required for fast communication between the axes' drives.
The C8 daisy chain cabling is required for parameter configuration and tuning.

4. Define an address for each drive. Use the HMI panel (MV models) or the rotary switch (LV models). Refer to the section *Drive Addressing*. Power cycle the drive after setting the address.

Set up and test each axis independently:

Note The ServoStudio 2 Motor Setup **wizard cannot be used** to configure the motors for the two gantry Y-axes.

5. **First** gantry axis:
   a. Configure the motor and feedback device parameters according to the manufacturer's specifications. Use the ServoStudio 2 Motor screen.
   b. Check the current control loop of the first axis.

      Open the ServoStudio 2 Motor screen. Select **Serial Current** operation mode. Select parameters IQ (current Q axis) and ICMD (current command) for recording. Enter a Current Command value. Start the recording.

If motor parameters ML (motor inductance) and MR (motor resistance) are set correctly, the test result should be fine.
If acoustical noise occurs, increase the value of KCD (dead time compensation minimal level) from 1 up to 10 to improve performance.

   c. Test the motor movement.

   Make sure the drive for the second gantry motor is disabled.

   Open the ServoStudio 2 **Operation Mode.** Select **Serial Current** operation mode.

   Enter a Current Command value that is less than 10% of MICONT (motor continuous current).

   While the motor moves, watch the changing values in the ServoStudio 2 status bar.
   Make sure that a positive value generates a positive velocity.
   If not, set MFBDIR to inverse the motor feedback direction, and adjust MPHASE using the ZERO command.

6. **Second** gantry axis: Repeat step **5**.

7. Test the two gantry axes together.

   a. Open the ServoStudio 2 **Gantry** screen.

   b. In the **Configuration** tab: set the drive ID for the **Master Axis** and the **Difference Axis.**

   c. With both drives disabled, manually move the gantry stage, and watch the Position and Speed values in the ServoStudio 2 for both the Master and the Difference axis.

   Make sure Position value increments in the same direction for both axes.

   Make sure the Speed value also reflects the same direction for both axes.

   If directions do not match, modify DIR for one of the axes.

   d. In the **Configuration** tab: Define **Gantry Type** as Rigid or Flexible.

8. Perform homing of the gantry system. Refer to the section *Homing a Gantry System*.
If using a flexible system, you must first set a value for GANTRYOFFSET.

9. Perform tuning of the gantry Master and Difference controllers.
Refer to the section *Gantry Tuning*.

6.19 Homing

The CDHD2 provides numerous methods for homing the motor.

The parameter HOMETYPE defines when direction of motion is reversed during homing, the homing trigger (e.g., switch, index), and other conditions.

Homing types 1–14, 17–30, and 33–35 are standard homing methods, as defined in CiA 402.

Additional homing types have been defined per customer requests.

Use the ServoStudio 2 Homing screen for defining and executing the homing procedure.

The following parameters are used to define and execute the homing procedure.

VarCom	Description
AUTOHOME	Defines whether automatic homing will be performed at power up.
HOMEACC	The value of acceleration and deceleration during the homing process.
HOMECMD	Starts the homing process.
HOMECMD 0	Stops the homing process.
HOMEOFFSET	Sets an offset, in counts, for the Home position.
HOMESPEED1	The initial velocity used in the homing process during the search for limit switches, home switches, and hard stops.
HOMESPEED2	The velocity used in the homing process during the search for the homing trigger, which may be an index pulse, a limit switch transition, a home switch transition, or another source (as defined by HOMETYPE).
HOMESTATE	Displays the current state of system homing.
HOMETYPE	Defines the type of homing process that will be performed.

6.19.1 Home at Index with Motor Resolver

Homing on index pulse can be used with resolver motor feedback.

Homing methods: HOMETYPE 1–14, 33, 34, -8, -12, -33, -34, -40, -44, -65, -66, -97, -98).

The location of the resolver index pulse is where the motor mechanical angle (MECHANGLE) is 0.

To achieve greater accuracy of the homing procedure (i.e., minimum PFB counts from MECHANGLE 0), reduce the value of HOMESPEED2.

6.19.2 Home at Index with Single/Multi-Turn Encoders

Homing on the index pulse can also be used with absolute multi-turn and absolute single-turn feedback devices. The location of the index pulse for the purpose of homing is the zero position of the single-turn data.

Homing methods: HOMETYPE 1–14, 33, 34, -9, -10, -13, -14, -34, -65, -66, -97, -98

In these methods, HOMESPEED1 is used until a limit switch, home switch, or hard stop is detected.

Once the appropriate sequence of events has occurred (such as direction reversal at limit switch), the axis is moved at HOMESPEED2 to detect the index pulse(or its equivalent on absolute encoders).

6.19.3 Home at Positive Edge of Home Switch

Homing methods: HOMETYPE 24, 28

In some instances, the positive edge is reached at HOMESPEED1, which may be too fast, resulting in a less accurate home location.

To improve the homing accuracy for methods 24 and 28, it is recommended to instead use homing methods -24 and -28. These methods include a reversal of movement at HOMESPEED2 until the required event occurs.

6.19.4 Homing a Gantry System

The homing command (HOMECMD) must be sent to the CDHD2 gantry Master drive, which initiates and controls homing for both gantry motors.

In an EtherCAT/CANopen system, each drive must be set to the Homing operation mode (OPMODE 6), and then wait to receive the home command from the motion controller. Homing will be performed first by the gantry Master drive, which will then initiate homing on the gantry Difference drive.

Refer to the sections *Gantry Setup* and *Gantry Tuning*.

Homing a Rigid Gantry System

In a rigid CDHD2 gantry system, homing requirements and methods are as follows:

- Any standard homing method (HOMETYPE) can be used.
- HOMETYPE is defined for the Y1 (master) motor, and is applied to the entire gantry system. HOMETYPE of Y2 (difference) must be set to HOMETYPE=35 (which has no effect on the axis).
- The homing reference (index pulse, home switch, limit switch) is considered only for the Y1 motor; the homing reference for the Y2 motor is ignored.
- If the homing type relies on a limit switch to reverse direction during the home search, the first limit switch detected, either on Y1 or Y2, will cause the direction to change.
- If the homing type relies on a hard stop to change direction during the home search, the first hard stop detected, on either Y1 or Y2, will cause the direction to change.

Homing a Flexible Gantry System

In a flexible CDHD2 gantry system, the homing requirements and method are as follows:

- The two gantry motors must each have either an index or a home switch.
- The same homing type is applied to both Y axes, and can be any one of the following:
  - HOMETYPE 1, 2 (homing on limit switch and index pulse)
  - HOMETYPE 23, 24, 25, 26, 27, 28, 29 or 30 (homing on limit switch and home switch)

- HOMETYPE -33, -34 (homing on index pulse after hard stop)
- HOMETYPE -56, -60 (homing on home switch after hard stop)

When a homing command is issued to the gantry Master, the following occurs:

10. Both axes perform a preliminary, rough alignment. They are closely but not perfectly aligned with each other.
11. Both axes start to move simultaneously toward a limit switch or a hard stop.
12. Both axes simultaneously reverse direction and search for the home reference of axis Y1. The axes move until the opposite limit switch/hard stop (on either axis Y1 or Y2) is reached.
13. The axes simultaneously reverse direction, and search for the home reference of axis Y2.
14. Finally, to align the two axes orthogonally, the homing process moves the Difference axis by the value of GANTRYOFFSET. The gantry is system is homed.

7 Operation

7.1 Drive Enable

Caution! Enabling the drive might cause the motor to move.

Three conditions are required for enabling the CDHD2 drive:

- No faults.
- Software Enable switch must be ON (SWEN=1)
- Remote Enable switch must be ON (REMOTE=1)

Use the ServoStudio 2 Enable & Faults screen to view and control the conditions required for enabling the drive.

The following elements provide visual indications of the drive's enabled or disabled status:

- The Enable|Disable button in the ServoStudio 2 toolbar indicates the state of the drive.

If lit, the drive is enabled (active). Power is being applied to the motor.

If not lit, the drive is disabled.

- Decimal point 1 on the drive's digital display indicates the drive's Enable/Disable state.

If the point is lit when the operation mode is displayed, the drive is enabled, as shown in the example here.

If not lit, the drive is disabled.

7.2 Drive Operation Modes

The CDHD2 can perform in various operation modes. Each operation mode has a primary control loop (current/torque, velocity or position) and a particular type of command input.

When using VarCom instructions, the operation modes are set by the value of OPMODE:

0 = Velocity control, using serial commands

1 = Velocity control, using analog input

2 = Current control, using serial commands

3 = Current control, using analog input

4 = Position control, using pulse/gearing input

8 = Position control, using serial commands

When using CANopen or CANopen over EtherCAT (CoE) communication, the operation modes are set by object 6060h, and reported by object 6061h.

1 = Profile Position

3 = Profile Velocity

4 = Profile Torque

6 = Homing

7 = Interpolated Position

8 = Cyclic Synchronous Position

9 = Cyclic Synchronous Velocity

10 = Cyclic Synchronous Torque

For details, refer to the CDHD2 EtherCAT and CANopen manual.

7.3 Current Operation

7.3.1 Serial Current Operation

In Serial Current mode (OPMODE 2), only the current loop is active, and the drive responds to instructions received via the USB or RS232 ports.

Other than tuning the current loop, no drive variables need to be set in order to operate the drive in this mode.

In the ServoStudio 2 Motion screen, select Operation Mode – Serial Current to modify and test parameters.

7.3.2 Analog Current Operation

When operating in Analog Current mode (OPMODE 3), only the current loop is active, and the drive responds to analog commands from the primary analog input, connected at pins 8 and 26 of the Controller I/F (C2).

In the ServoStudio 2 Motion screen, select Operation Mode – Analog Current to modify and test parameters.

7.3.3 Current Control

Note There is no need to manipulate values in the Current Loop screen, unless instructed to do so by Technical Support.

Current control loop tuning is derived from the motor properties and the bus voltage. The ServoStudio 2 Motor Setup wizard tunes the current control loop.

7.4 Velocity Operation

7.4.1 Serial Velocity Operation

In serial velocity mode (OPMODE 0), the drive's current and velocity loops are active, and the drive responds to instructions received via the USB or RS232 ports. The commanded velocity is subject to programmable acceleration and deceleration limits.

In the ServoStudio 2 Motion screen, select Operation Mode – Serial Velocity to modify and test parameters.

7.4.2 Analog Velocity Operation

When operating in Analog Velocity mode (OPMODE 1), the drive's current and velocity loops are active, and the drive responds to analog commands from the primary analog input, connected at pins 8 and 26 of the Controller interface (C2).

The commanded velocity is subject to a limit on the acceleration, defined by the variable ACC.

7.4.3 Velocity Control

Refer to VarCom VELCONTROLMODE.

- PI controller (uses KVP and KVI)
- PDFF controller(uses KVP, KVI, KVFR)
- Standard pole placement controller (uses MJ, MKT, BW, LMJR, TF)
- HD velocity loop with integrator (uses KNLD, KNLP)

HD Velocity Control with Integrator (Recommended)

Refer to VarCom VELCONTROLMODE 7.

Before using the HD velocity controller, first execute the ServoStudio 2 Autotuning wizard, and then manually adjust the tuning, if necessary.

You can then proceed to use the HD velocity controller.

VELCONTROLMODE 7 provides the advantages of the HD nonlinear controller for velocity control.

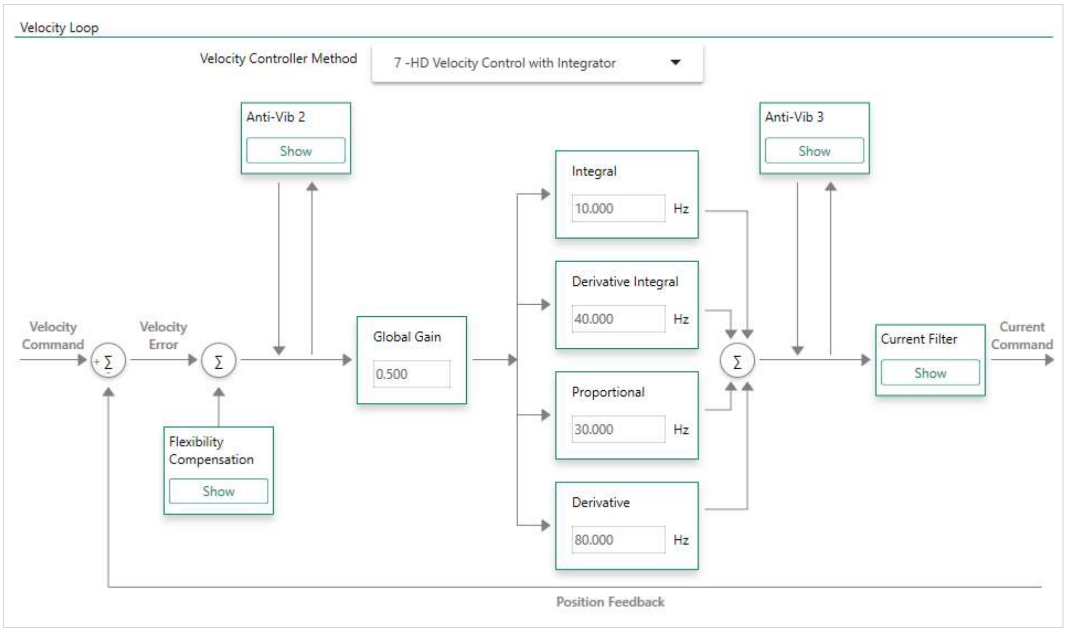


Figure 7-1. Velocity Control Loop – HD Velocity Control with Integrator

Proportional and Integral (PI) Controller

Refer to VarCom VELCONTROLMODE 0.

The following figure shows a PI controller.

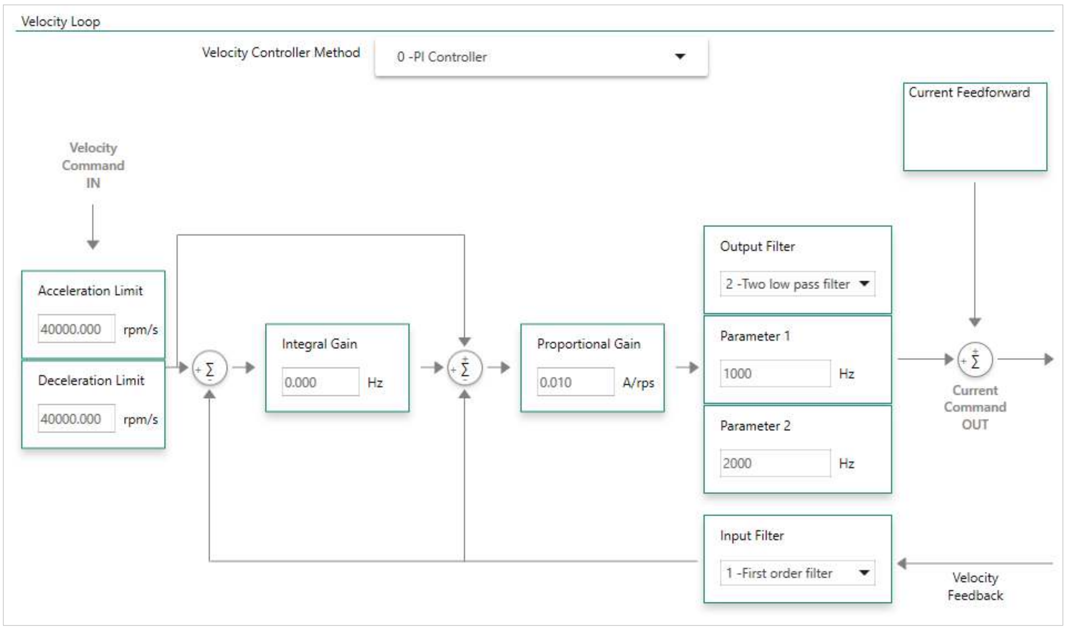


Figure 7-2. Velocity Control Loop – PI Controller

The PI controller is a unity feedback system with no pre-filter. The proportional gain (KVP) stabilizes the system. The integral gain (KVI) compensates for the steady state error.

The controller parameters KVP and KVI and KVFR are tuned by trial and error.

Pseudo Derivative Feedback and Feedforward (PDFF) Controller

Refer to VarCom VELCONTROLMODE 1.

The following figure shows a PDFF controller. Like the PI controller, it has an integral gain (KVI) and a proportional gain (KVP), with the addition of a feedforward, KVFR.

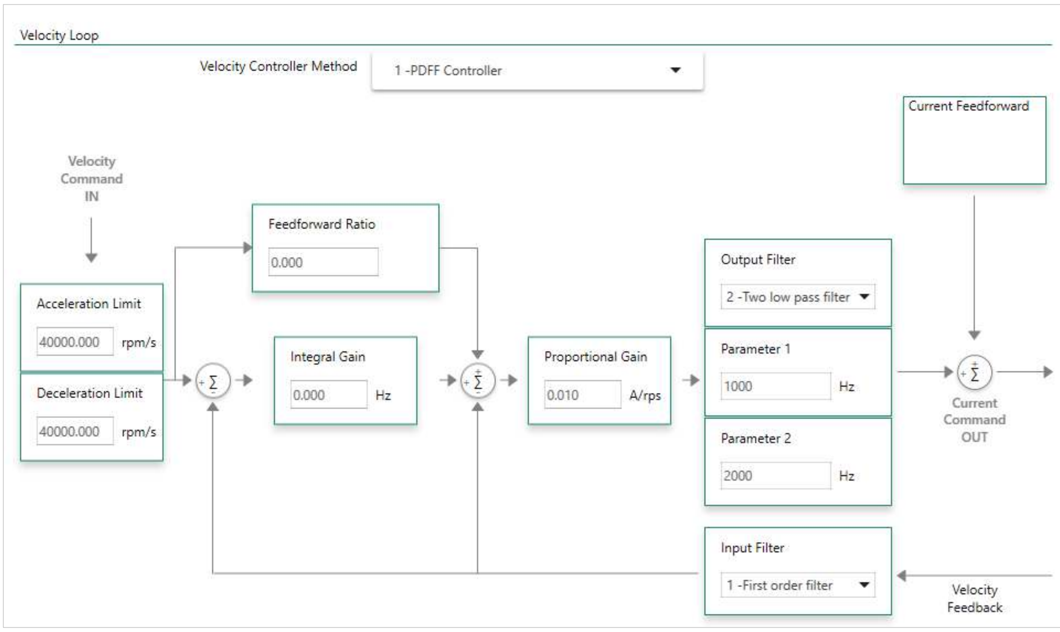


Figure 7-3. Velocity Control Loop – PDFF Controller

When an application requires maximum responsiveness, less integral gain is required, and KVFR can be set to a higher value. When an application requires maximum low-frequency stiffness, KVFR is set to a lower value, which allows much higher integral gain without inducing overshoot. This will also cause the system to be slower in responding to the command. A mid-range KVFR value is usually suitable for motion control applications.

PDFF is a generalized controller. The controller parameters KVP , KVI and KVFR are tuned by trial and error.

Standard Pole Placement (PP) Controller

Refer to VarCom VELCONTROLMODE 2.

For PP controller tuning, only two parameters are needed: load inertia ratio (LMJR) and closed-loop system bandwidth (BW).

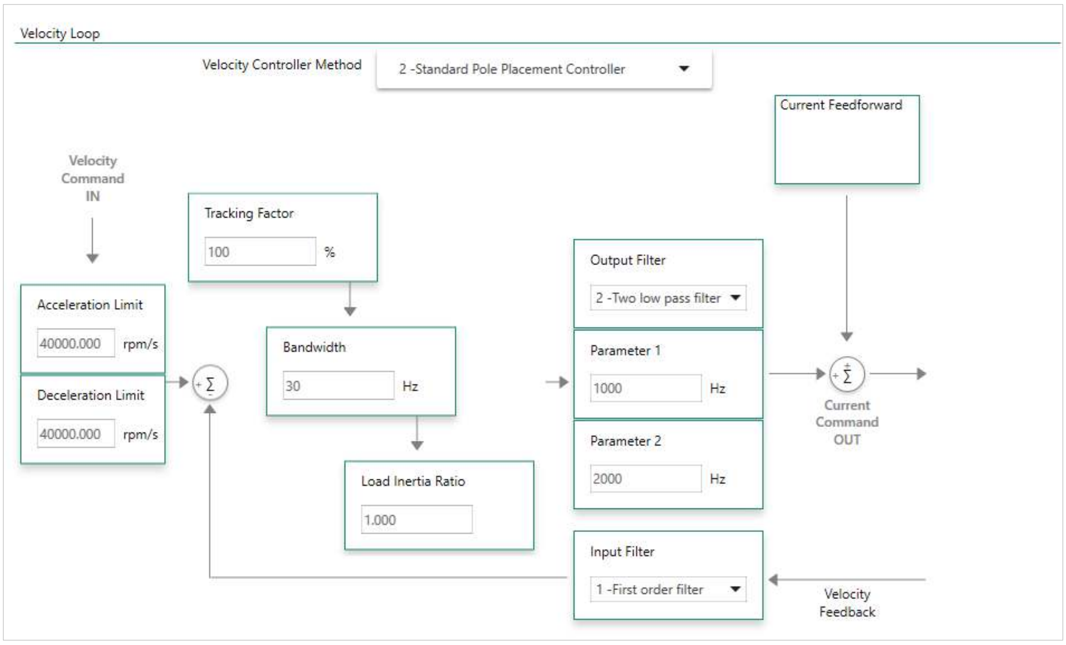


Figure 7-4. Velocity Control Loop – Standard PP Controller

For the controller design, it is not necessary to know the load inertia. The parameter can be easily tuned, as described in the following procedure.

Use the following procedure to manually tune the PP Velocity Controller.

Procedure: Manual Tuning of the PP Velocity Controller

Manual tuning includes the initial steps of load inertia estimation, and the subsequent steps to design the optimum controller.

In ServoStudio 2, go to the Terminal screen or a Terminal tab, and execute the steps using standard ASCII protocol.

Alternately, use the ServoStudio 2 Scope screen to execute and record motion, and evaluate and adjust the parameters.

1. Set the operation mode to serial velocity: OPMODE 0.
2. Set the velocity compensator to standard pole-placement: VELCONTROMODE 2.
3. Enable the drive: EN.
4. Set the desired bandwidth. It is recommended to begin with a low value (10 Hz), and gradually increase it.
5. Set the load inertia ratio to zero: LMJR 0.
   The load inertia value LMJR is expressed as a percentage of the rotor inertia.

   The range for LMJR is 0 to 10,000. It represents a range of load: rotor inertia ratios ranging from 0:1 to 100:1. For example, to set a 10:1 ratio between the load inertia and the motor inertia, use the command LMJR 1000. At this point the step response should have the maximum overshoot, but the control loop should be stable (low gains).
6. Activate the recording mechanism to record the velocity command, the current command, and the actual (feedback) velocity:
   RECORD 1 1024 “VCMD ICMD V

7. Jog the motor at a constant low speed: J [value1]

   For example, start with the command J 150

8. Activate the recording trigger: RECTRIG VCMD [value2] 20 1.

   value2 should be greater than value1 in the previous step; for example: RECTRIG VCMD 200 20 1.

9. Jog the motor at a value higher than specified in the RECTRIG command. This is the step command. The higher the step, the better the results. The step should not be less than 300 (rpm). For example: J 500.

10. The recording takes about half a second. After this period, reduce the motor speed.

11. Verify that the recording process is terminated: RECDONE

12. Display the recorded data by dumping to the serial port: GET

13. Analyze the results.

    If the current command is saturated (gets absolute values of ILIM) during the process, reduce the step or reduce the bandwidth, and return to Step 6.

14. Inspect the feedback velocity:

    - If there is an undershoot or oscillations, reduce LMJR to the mean value of the present LMJR and the last LMJR which had an overshoot, and return to step 6.
    - If there is an overshoot, increase LMJR by 100, and return to Step 6.
    - Repeat the process until the overshoot is reduced to a minimum
      (The estimated load inertia may be queried by LMJR.)

7.5 Position Operation

7.5.1 Serial Position Operation

The CDHD2 has a dedicated mode of operation (OPMODE 8) for simple positioning applications over the serial port. Serial commands are transmitted from a host computer through the serial port. The command specifies the target position and the cruise velocity, while additional motion profile information (such as acceleration, deceleration and profile type) is set up using explicit variables.

In the ServoStudio 2 Motion screen, select Operation Mode – Serial Position to modify and test parameters.

VarCom	Description
ACC	Defines the acceleration.
DEC	Defines the deceleration.
PE	Position error (also called following error). PE is the absolute calculated difference between the values of PCMD and PFB. Read only.
PCMD	The position reference command. Read only.
PFB	The actual position according to the motor feedback. Read only.

Incremental (Relative) Motion

Incremental, or relative, motion moves the motor relative to the current position. Relative motion is always in reference to the current position of the load (and motor shaft), and is useful in indexing applications, such as cut-to-length feeders and rotary tables.

The reference point is the parameter PFB, which is the actual position according to the motor feedback.

Movement can be in either direction, depending on the sign of the position value. For example, if the target position is one revolution, the motor will turn one revolution from the starting point.

VarCom	Description
MOVEINC	Command to execute an incremental position movement according to the acceleration settings in effect.

The value of PFB can be modified, or offset, using the parameter PFBOFFSET. This is useful for manual homing, or simply for testing incremental motion.

Procedure: Setting the Current Position to 0

1. Disable the drive. (PFBOFFSET can be set only when the drive is disabled.)
2. Set PFBOFFSET to 0 (zero).
3. Read PFB
4. Set PFBOFFSET to the negative value of PFB

When using counts as the position units, PFBOFFSET can be set to an integer value only, even though the actual position, PFB, is displayed as a real number, with fractions of a count (as a result of internal interpolation being executed on the encoder signal).

Absolute Motion

Absolute motion is always relative to an absolute reference point.

The reference point is the point at which PFB=0.

VarCom	Description
MOVEABS	Command to execute an absolute position movement according to the acceleration settings in effect.

End of Motion

The following parameters are used to define and indicate the state of the motor at the end of motion.

VarCom	Description
PEMAX	The maximum position error allowed without producing a fault, in counts.
PEINPOS	The window of tolerance for declaring an “in position” state. The motor is considered to be in position when the value of PE (position error) is less than the value of PEINPOS (position-error tolerance). The motor is considered settled when PE (position error) has remained below PEINPOS for the time defined by PEINPOSTIME.

VarCom	Description
INPOS	Indicates Motor In Position state. Read only. When the motor is in position, INPOS=1, regardless of the state of the motion profile. As long as the motor is not in position, INPOS=0.
STOPPED	Indicates Motor Settled state. Read only. STOPPED=-1. Motion was interrupted. STOPPED=0. Motion profile in progress. STOPPED=1. Profile completed. STOPPED=2. Profile completed and INPOS=1.

7.5.2 Position Control

The CDHD2 has two position control loop options – HD (nonlinear) and linear.

HD (Nonlinear) Position Controller

The HD position controller is a proprietary algorithm that is designed to minimize position error during motion and to minimize settling time at the end of motion. This is the recommended controller. Refer to *Tuning*.

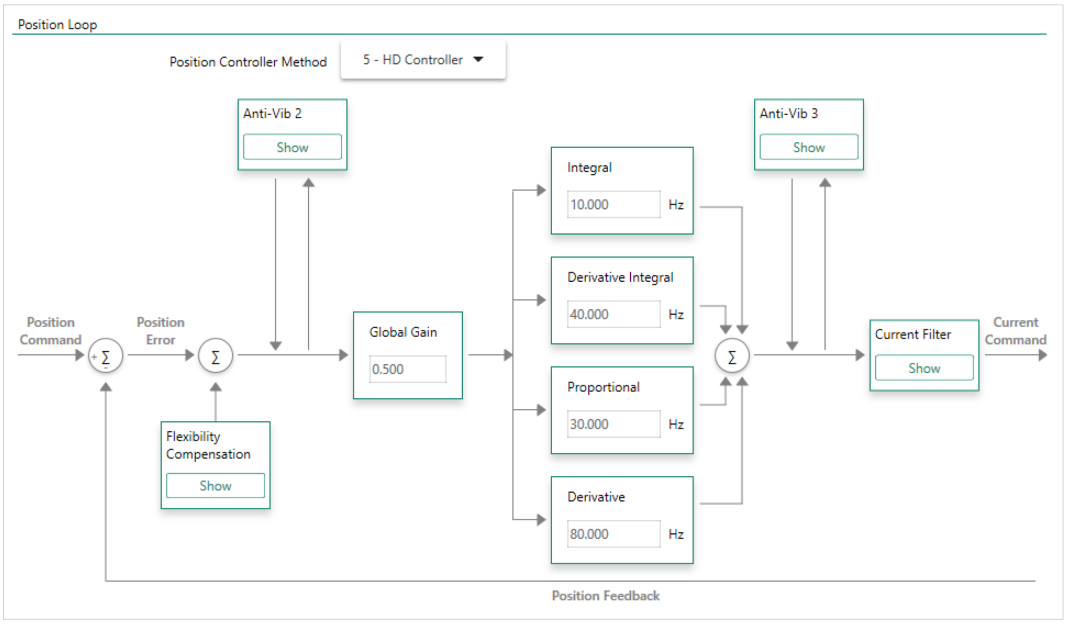


Figure 7-5. Position Control Loop – HD Controller

Linear Position Controller

The Linear position controller is a PID controller with feedforward, and with the option to limit the integral saturation (anti-windup).

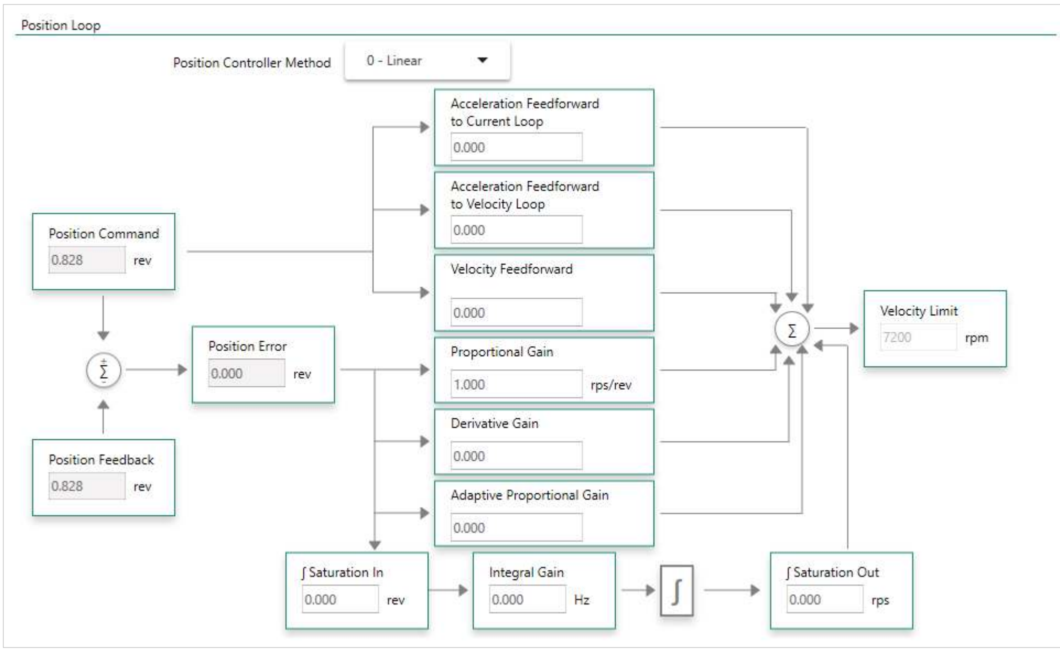


Figure 7-6. Position Control Loop – Linear

7.6 Gearing/Pulse Train Operation

In Gearing/Pulse Train operation mode, the drive's current, velocity and position loops are active, and the drive is synchronized to a master input command signal in the form of a pulse train. The CDHD2 can be configured to read this input signal as an encoder follower, an up/down counter, or a pulse/direction counter.

In the ServoStudio 2 Motion screen, select Operation Mode – **Gearing/Pulse Train** to modify and monitor parameters.

The various methods of gearing are defined by the parameter GEARMODE.

VarCom	Description
GEARMODE 0	Encoder following, signaling through the Controller interface (C2). Signals are received on the Controller interface at pins 28 and 11 (Quadrature A), and pins 9 and 27 (Quadrature B).
GEARMODE 1	Pulse and Direction, signaling through the Controller interface (C2). Signals are received on the Controller interface at pins 28 and 11 (Pulse), and pins 9 and 27 (Direction).
GEARMODE 2	CW/CCW (Up/Down) signaling through the Controller interface (C2). Signals are received on the Controller interface at pins 28 and 11 (CW) and pins 9 and 27 (CCW).
GEARMODE 3	Encoder following (secondary encoder), signaling through the Machine interface (C3). Signals are received on the Machine interface at pins 1 and 11 (Quadrature A) and pins 2 and 12 (Quadrature B).
GEARMODE 4	Pulse and direction (secondary encoder), signaling through the Machine interface (C3). Signals are received on the Machine interface at pins 1 and 11 (Pulse), and pins 2 and 12 (Direction).

Notes

GEARMODE 0:
The Controller interface (C2) cannot supply voltage to the handwheel or the machine master encoder. Only the Machine interface (C3) can supply this voltage.

GEARMODE 0, 1, 2:
If inputs 5 and 6 are set, respectively, to INMODE 17 and 18, signals are received instead from fast inputs 5 and 6 on the Controller interface (C2) at pins 32 and 15.

Regardless of the gearing mode used, the input signal is subject to gearing calculations that allow you to set the ratio of input pulses to encoder counts. Gearing sets up a relationship between the number of input pulses (HWPEXT counts) and the position increments of the motor shaft. The rate at which position increments of the motor shaft (motor speed) occur is determined by the gearing relationship and the line frequency of the pulse train. The gearing relationship is as follows:

$$\frac{GEARIN}{GEAROUT} \times \frac{1}{XENCRES}$$

In addition to tuning the current, velocity and position loops, the following are some of the parameters used to configure and monitor the gearing.

VarCom	Description
GEAR	Activates the gearing function.
GEARIN	Numerator of the gearing ratio. The sign of the GEARIN value determines the direction of rotation.
GEAROUT	Denominator of the gearing ratio.
XENCRES	Resolution of the external pulse source.
HWPEXT	The position measured by an external feedback device.

7.6.1 Pulse and Direction

In Pulse and Direction position control, the drive is synchronized to a master input command signal in the form of a pulse train.

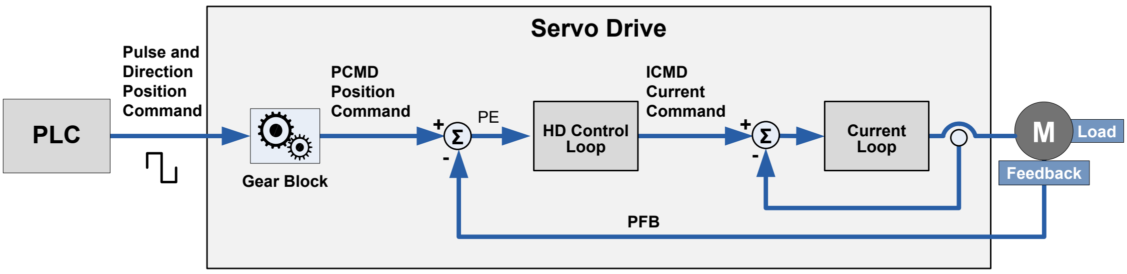


Figure 7-7. Pulse and Direction Position Control

The drive accepts an input pulse train in which the rising edge of each pulse increments (or decrements, depending on the direction) the external input position counter (HWPEXT) of the drive by one position count. This counter value is passed through a gearing block and becomes the position command for the motor.

The position command is compared to the motor position (PFB) to determine the position error (PE). The drive corrects the position error by incrementing the motor to the commanded position.

In Pulse and Direction mode, if the absolute value of GEARIN is equal to GEAROUT, and if XENCRES is equal to 4×MENCRES (that is, the motor encoder resolution after quadrature), then one pulse on the input is equivalent to one count of the motor feedback.

For example, assume that the motor encoder has a resolution of 2500 lines per revolution. Setting GEARIN=1, GEAROUT=1 and XENCRES=10000 will result in the motor making one revolution for every 10000 pulses (assuming the direction is fixed during this time).

Note The drive's homing capabilities remain available in this configuration.

Pulse and Direction Operation

For Pulse and Direction operation, the Pulse signal must be defined on digital input 5 (INMODE 5 17) and the Direction signal must be defined on digital input 6 (INMODE 6 18).

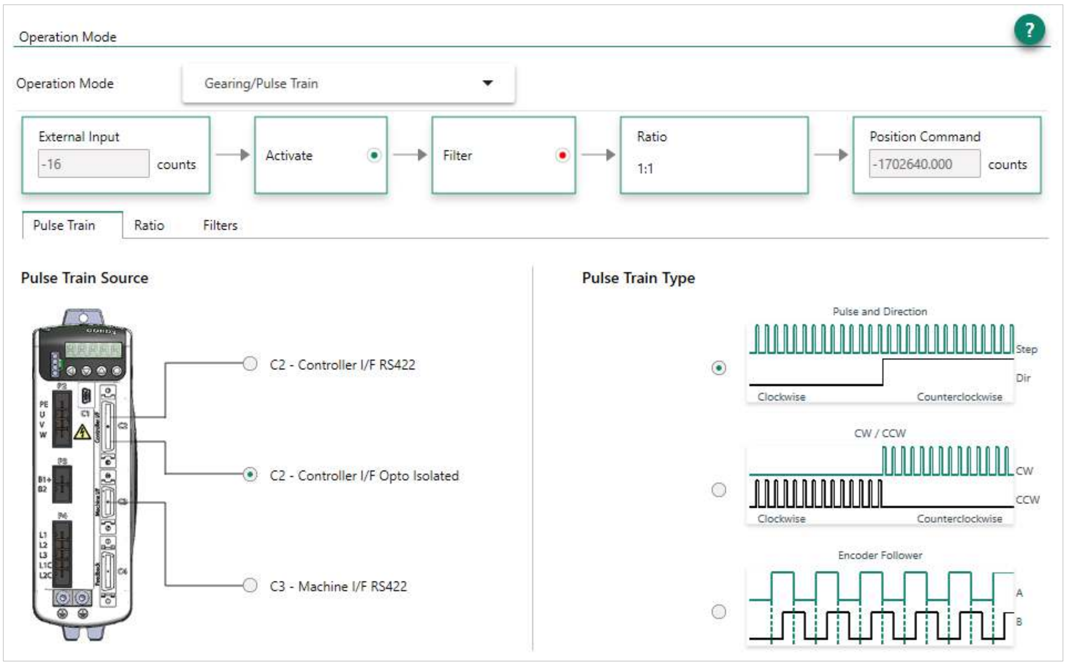


Figure 7-8. Settings for Pulse & Direction Commands Using Opto-Isolated Inputs

Step 1 – Setup and Tuning

1. Run the ServoStudio 2 Motor Setup Wizard, and make sure motor setup is successfully completed.
2. Run the ServoStudio 2 Autotuning Wizard, and make sure autotuning is successfully completed.

Step 2 – Select Pulse and Direction

1. In ServoStudio 2, go to the Operation Mode screen, and select Operation Mode-Gearing/Pulse Train (OPMODE 4)
2. In the **Pulse Train** tab, select the Pulse Train Source and Pulse Train Type:

- If using Differential:
  Select the option Controller I/F RS422 and Pulse & Direction (P&D).
- If using Opto-Isolated:
  Select the option Controller I/F Opto-Isolated and Pulse & Direction (P&D).
  This automatically sets the definitions for digital inputs 5 and 6.

Step 3 – Digital Inputs 5 and 6 Settings (Opto-Isolated inputs only)

1. Go to Drive Configuration > Digital I/Os screen.
2. Make sure digital input 5 is set to 17-Pulse signal.
3. Make sure digital input 6 is set to 18-Direction signal.

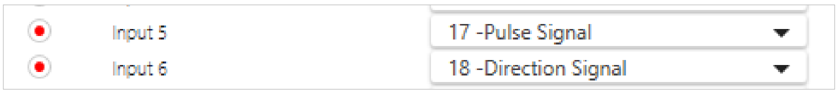


Figure 7-9. Digital Inputs for Pulse and Direction Signals

Step 4 – Set Pulse and Direction Parameters

Figure 7-10. Pulse and Direction Operation Parameters

1. Make sure Gearing mode is enabled (GEAR=1).
2. In the **Ratio** tab, set the Input Resolution and Gearing Ratio.

   The relationship between the number of incoming pulses and the motor shaft movement is determined by the external encoder resolution (HWPEXT), and the gearing ratio (GEARIN/GEAROUT).

   For example: A PLC controller is programmed to provide 1024 line pulses as an input command to a CDHD2 system in order to make the motor rotate two revolutions. The settings are therefore:

   External Encoder Resolution = 1024

   Gear Ratio Multiplier = 2

   Gear Ratio Divider = 1
3. In the **Filters** tab, set adjust the values of the gearing filters and command smoothing filters, as needed.

   Command Smoothing Filter

   - Smoothing Filter (MOVESMOOTHMODE. Select option to activate the filter.
   - Stiff/Soft (MOVESMOOTHAVG). Drag slider to adjust value.

   Gear Command Smoothing Filter

   - Gear Noise Filter (GEARFILTMODE). Select option to activate the filter.
   - Stiff/Soft (GEARFILTDEPTH). Drag slider to adjust value.

7.6.2 CW/CCW (Up/Down) Counting

In CW/CCW (or Up/Down) system, pulses on one signal increment the motor position while pulses on the other signal decrement the motor position. The signals must be connected to the Controller interface (C2).

When the pulse signal is applied to the A channel, the external position counter (PEXT) increments and rotates the motor in a positive direction.

The pulse signal applied to the B channel decrements the external position counter (PEXT) and rotates the motor in a negative direction.

The line frequency and the gearing relationship determine the speed and amount of the shaft movement.

- Set GEARMODE to 2 to indicate to the drive that the signals are received on the Pulse and Direction inputs on the Controller interface (C2).

7.6.3 Encoder Follower (Master/Slave)

In Encoder Follower mode, the drive follows a quadrature encoder signal generated by a master device. The direction of motion is governed by the phase of the quadrature signals (A-lead-B or B-lead-A).

The master device can be, for example, a handwheel, a machine master encoder that is connected to the main camshaft, or the equivalent encoder output of another servo drive.

If the master device is a handwheel or a master encoder, then setting XENCRES equal to the resolution of the encoder (before quadrature) and setting the gear ratio to 1 will result in the motor making one revolution for each revolution on the input.

As an example, assume the handwheel resolution is 120 lines per revolution (that is, 480 counts after quadrature). Setting GEARIN=1, GEAROUT=1 and XENCRES=120 will result in one motor revolution for each turn of the handwheel.

The quadrature signals can be connected to either the Controller interface (C2) or to the Machine interface (C3). The GEARMODE parameter indicates to the drive where the signals are connected to.

- Set GEARMODE to 0 to indicate to the drive that the signals are received on the Pulse and Direction inputs on the Controller interface (C2).
  Note that the Controller interface (C2) cannot supply voltage to the handwheel or the machine master encoder.
- Set GEARMODE to 3 to indicate to the drive that the signals are received on the Secondary Encoder inputs on the Machine interface (C3).

8 Tuning

8.1 CDHD2 HD Controller

The CDHD2 has two user-selectable position control loops – linear and HD (nonlinear).

The HD control loop is a proprietary algorithm that is designed to minimize position error during motion and to minimize settling time at the end of motion.

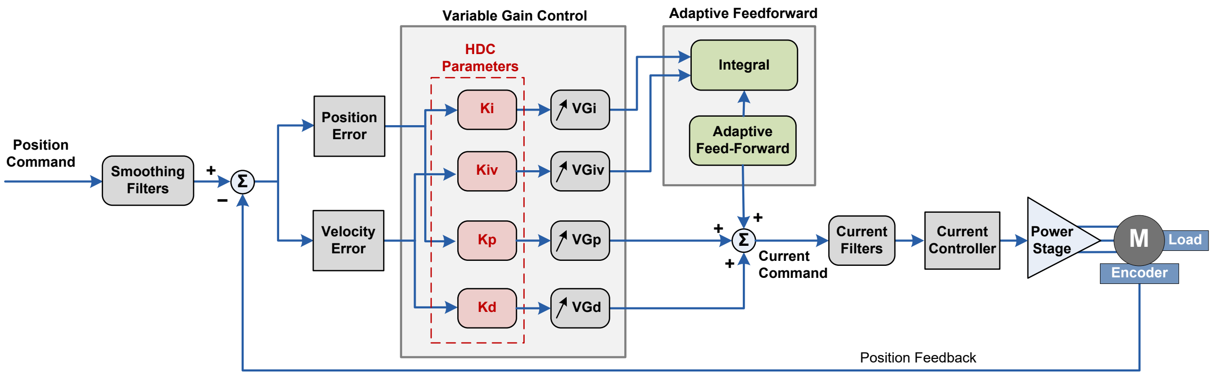


Figure 8-1. CDHD2 HD Controller

The HD algorithm uses a parallel configuration in which all branches are on the same level and executed during the same sampling period. On each branch a variable gain is introduced and automatically optimized for high gain and stability.

The HD controller also includes an adaptive feedforward function that is applied at the end of movement in order to achieve a zero or minimum settling time.

Furthermore, the HD controller provides low pass, notch and other filters to handle flexible and resonant systems.

The ServoStudio 2 Position Control Loop screen provides access to the HD control loop parameters that can be modified by users.

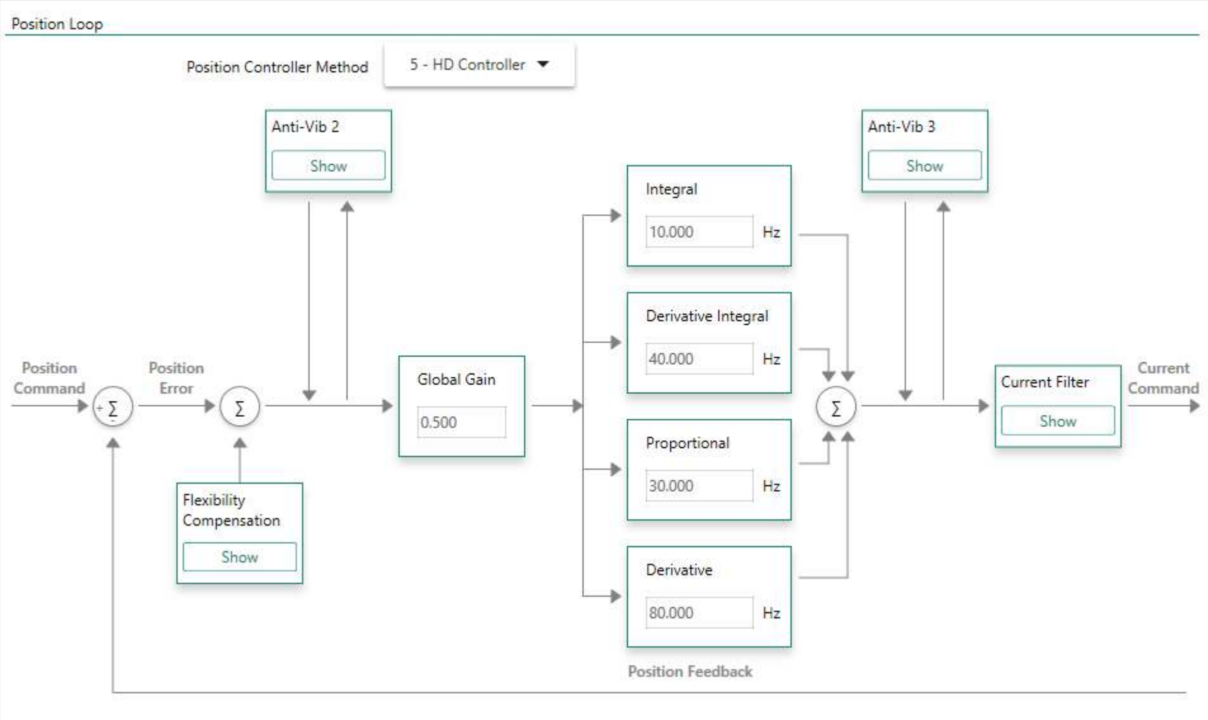


Figure 8-2. CDHD2 HD Control Loop

8.2 CDHD2 HD Controller Autotuning

Caution! Tuning is potentially dangerous. Before starting any tuning routines, make sure no one is within the motion envelope, and the emergency button is within your reach.

Autotuning is performed on the CDHD2's HD control loop. There is no autotuning procedure for the linear control loop.

The HD control loop parameters are initially set using the Autotuning wizard. Drive tuning performed by the wizards is usually sufficient. However, you may need to tune the control parameters manually to optimize them for particular applications. The parameters can be viewed and modified in the ServoStudio 2 **Position Loop - HD Controller** screen.

Automatic and manual tuning use similar methods. During autotuning, the quality of the movement is measured and evaluated by the drive or the software. During manual tuning, the quality of movement is evaluated by the user. In both cases, the servo control parameters are modified progressively and the value that achieves the best performance is selected.

The Autotuning wizard can also be used to optimize drive parameters to produce the most effective motion for a particular task or application.

The setting and optimization of parameters by the Autotuning wizard may be either drive-based on PC-based:

- If an electronic motor nameplate (e.g., PRO2 and PRDH2 motors with sensAR magnetic encoder) is detected at power-up, or if the software is operating offline, ServoStudio 2 will activate the **drive-based** autotuning wizard.
- If an electronic motor nameplate is not detected at power up, ServoStudio 2 will activate the **PC-based** autotuning wizard.

8.3 Drive-Based Autotuning

ServoStudio 2 activates the wizard for Drive-based Autotuning if an electronic motor nameplate with a servo parameter bundle (e.g., PRO2 and PRHD2 motors with sensAR magnetic encoder) is detected at power-up. This wizard is also activated if the software is operating offline.

Drive-based autotuning has four possible routines: **Express/Internal**, **Express/External**, **Advanced/Internal** and **Advanced/External**.

- **Express** autotuning requires no user input except to activate each step.
- **Advanced** autotuning requires user input.
- **Internal Reference** – the motion command used for tuning is generated by the drive.
- **External Reference** – the motion command used for tuning is generated by an external controller, such as a PLC.

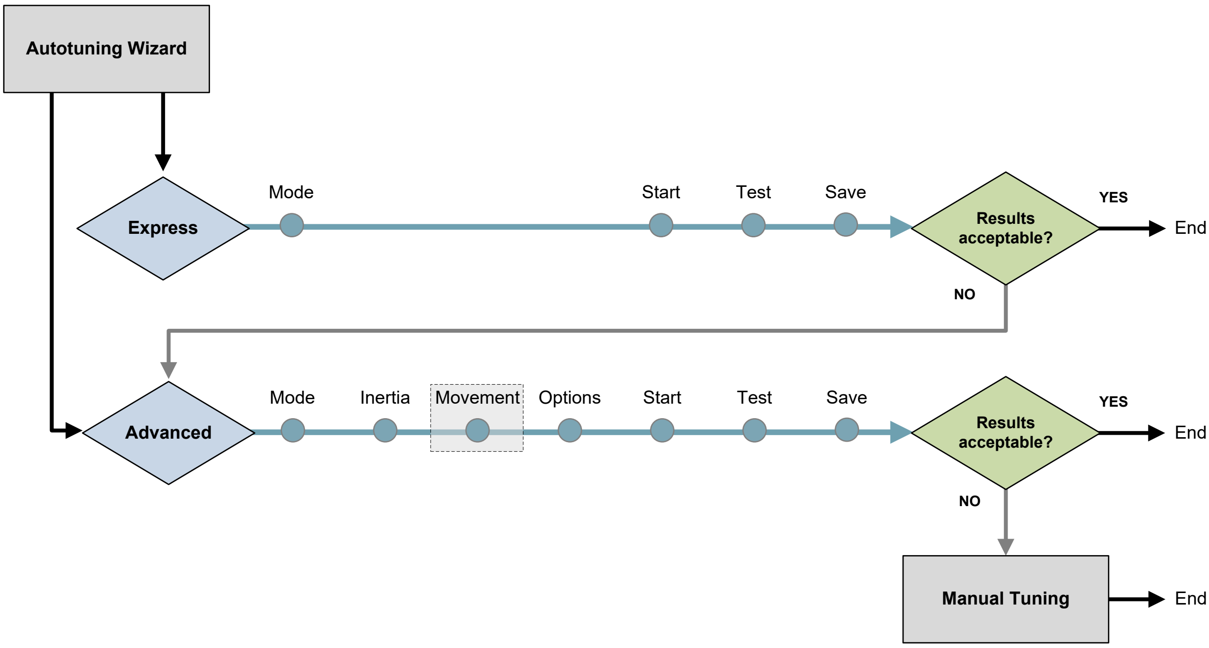


Figure 8-3. Autotuning Wizard for Drive for Motor with Load

8.3.1 Drive-Based Autotuning – Express

The Express autotuning procedure requires no user input except to activate each step.

Express Autotuning consists of the following steps:

1. Select either **Express/Internal** or **Express/External.**
2. **Start** Autotuning.
3. **Test** the result.
4. **Save** the parameters.

For details on each of the steps, refer to *Drive-Based Autotuning – Advanced*.

Table 8-1. Steps in Drive-Based Autotuning Process

	Express	Advanced
Mode	x	x
Inertia		x
Movement		x
Options		x
Start	x	x
Test	x	x
Save	x	x

8.3.2 Drive-Based Autotuning – Advanced

The Advanced autotuning procedure consists of the following steps:

1. Select either **Advanced/Internal** or **Advanced/External.**

   Optional: Manually move the axis to the start position (available when the drive generates the motion). Use the Positive and Negative buttons if needed to bring the load to a position at which the motor can safely make three rotations in each direction.

2. Load/motor inertia ratio estimation.
3. Set motion profile.
4. Set options for parameter optimization.
5. Run autotuning.
6. Test the result.
7. Save the parameters.

Press **Next** to advance to the next screen during the procedure.

Step – Tuning Mode

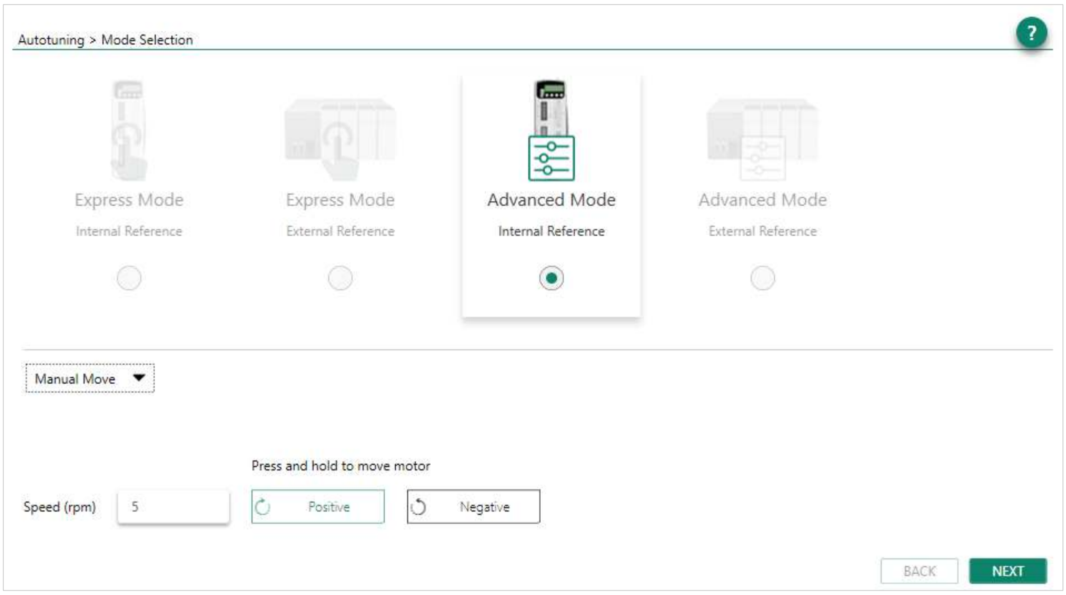


Figure 8-4. Autotuning – Tuning Mode

1. Select **Advanced/External** (or **Advanced/Internal**).
2. Motion testing normally starts at the midpoint of the movement stroke. If a different start position is required by the application, use Manual Move.

   Use the Negative and Positive buttons to bring the load to a position at which the motor can safely make three rotations in each direction. Press and hold the buttons for continuous motion.
3. Press **Next** to continue.

Step – Load/Motor Inertia Ratio

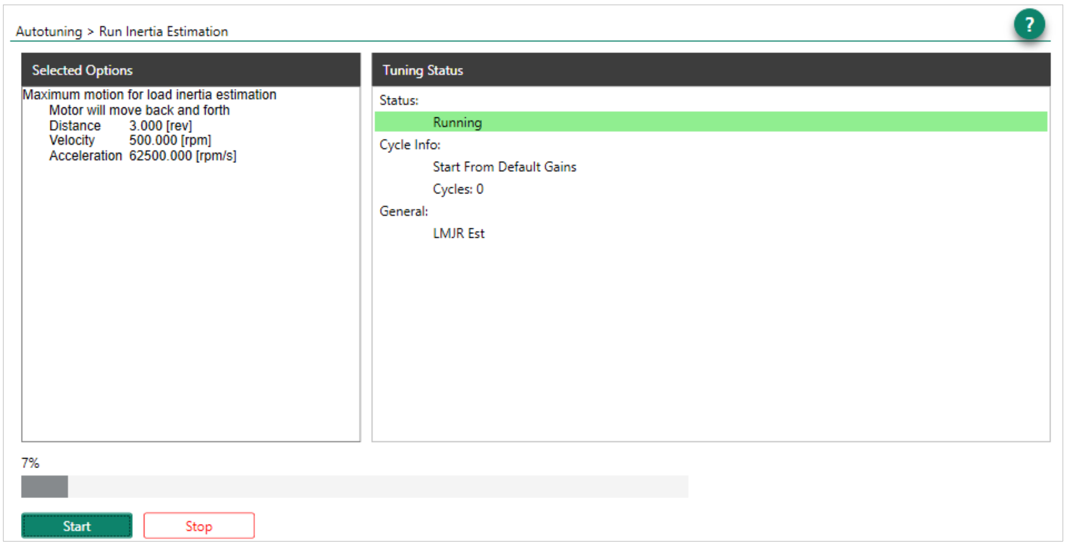


Figure 8-5. Autotuning – Inertia Ratio Estimation

Normally, you should allow the servo drive to estimate the load/motor inertia ratio (LMJR).

You may need to set the moment of inertia manually (Step 4 – Options: LMJR Values) to achieve better performance, in instances such as:

- If the load/motor ratio is very big.
- If you know the exact value of the inertia of the load connected to the motor.
- If the inertia of the load varies.
- If using a multi-axis robot.

Step – Movement

Note Movement step is available only when the drive (internal) is the motion generator.

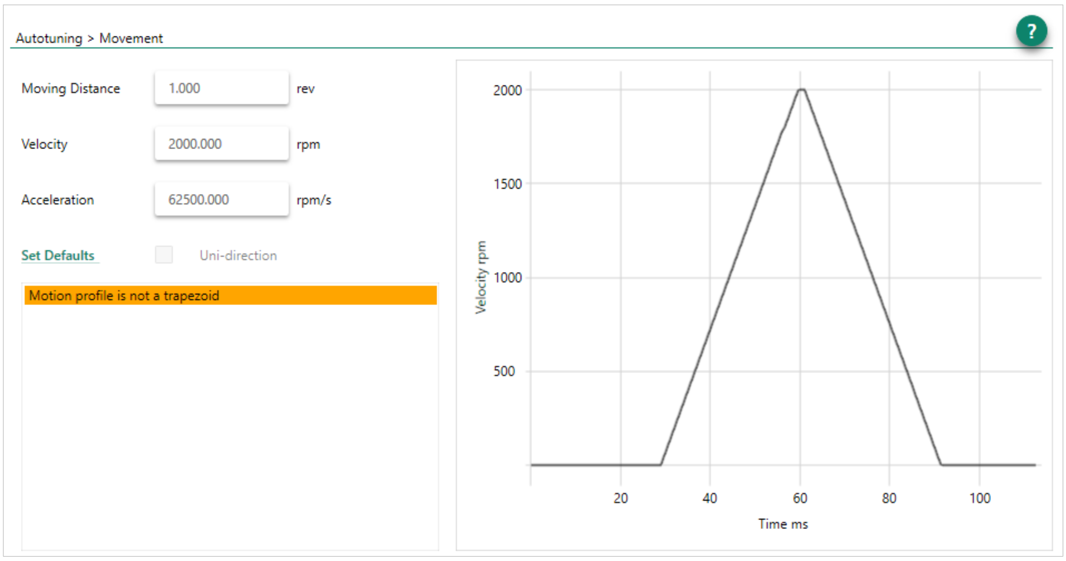


Figure 8-6. Autotuning – Motion Profile. Not Suitable

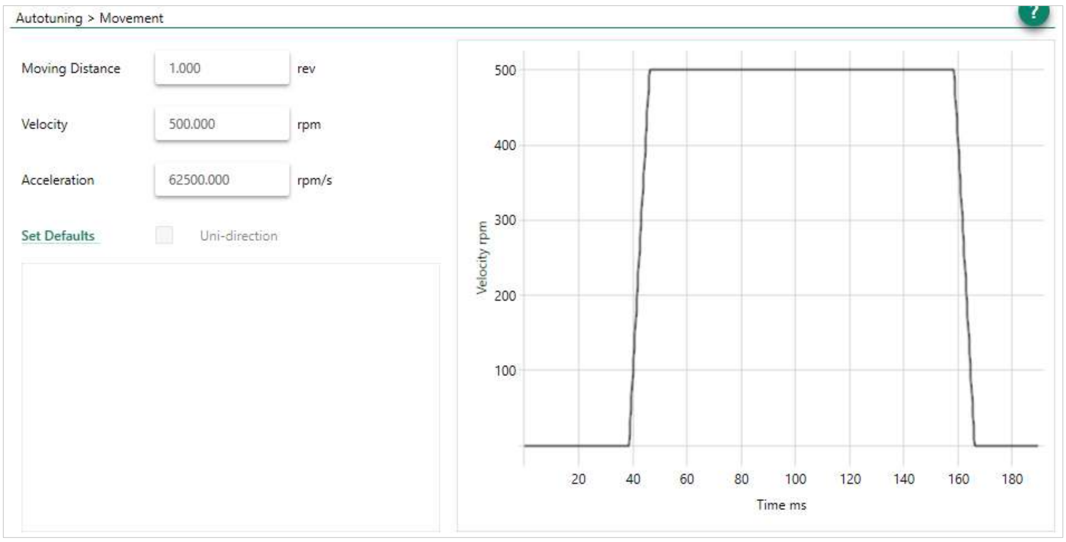


Figure 8-7. Autotuning – Motion Profile. Suitable

Autotuning must be performed using a motion profile that replicates the actual mechanical characteristics of the movement to be performed in the application.

Press **Set Defaults** to set values that produce a good trapezoidal profile on the graph

The software will indicate whether the profile is suitable for the autotuning procedure.

- Highlighted orange: profile is possible, but not recommended
- Highlighted red: profile cannot be used.

Step – Autotuning Options

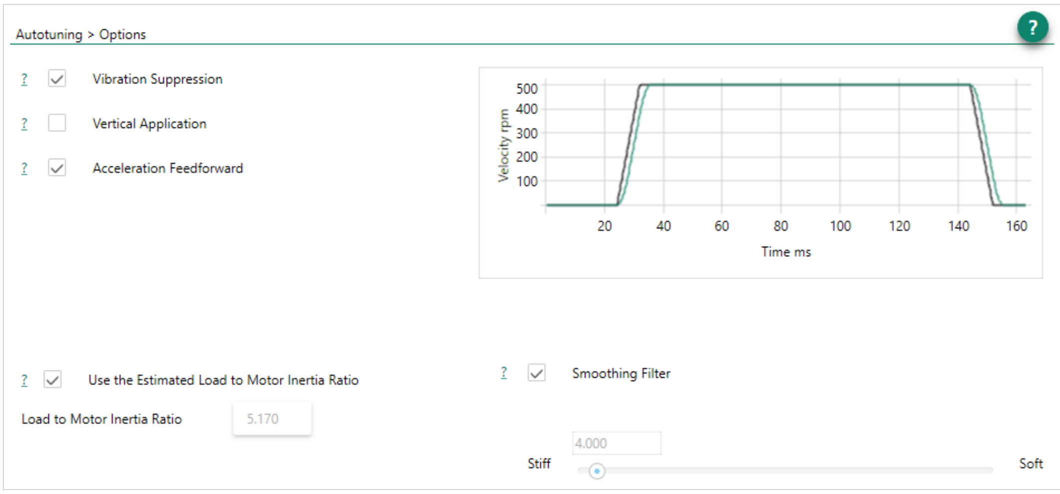


Figure 8-8. Autotuning – Options

Options: Vibration Suppression

Select Vibration Suppression for automatic tuning of the vibration suppression parameter sets (Antivibration2 and Antivibration3).

Clear this option if you want to set vibration suppression parameters manually, or if the application does not require vibration suppression.

Enhanced anti-vibration will have the following effect on performance:

- Will damp oscillations, thereby improving settling time.
- May allow a higher gain of the HD loop.
- May increase the position error of the motor but reduce the position error and oscillation of the end effector.

Options: Vertical Application

Select this option for gravity compensation when axis motion is vertical. If selected, the autotuning sets the value of parameter IGRAV.

Clear this option if axis motion is balanced (non-vertical) in both directions.

Options: Acceleration Feedforward

Select this option to reduce tracking error during motion. If selected, the autotuning sets the value of parameter KNLAFRC.

Clear this option if overshoot is too large.

Options: Smoothing

Select this option for automatic tuning of the input profile command. If selected, the autotuning tunes the Profile Smoothing parameters.

Clear this option if the application is multi-axis and smoothing needs to be the same for all axes.

If cleared, MOVESMOOTHAVG is used, and a value between 1-15 ms is recommended.

Options: LMJR Values

Typically, the autotuning can use the LMJR value calculated in Autotuning step – Inertia Ratio Estimation.

Use this option if you need to change the LMJR value detected by the drive. Enter a value for Load to Motor Inertia Ratio.

Refer to *Step – Load/Motor Inertia Ratio*.

Step – Start

Press **Start** to run the autotuning process.

Start enables the drive and moves the motor repeatedly!

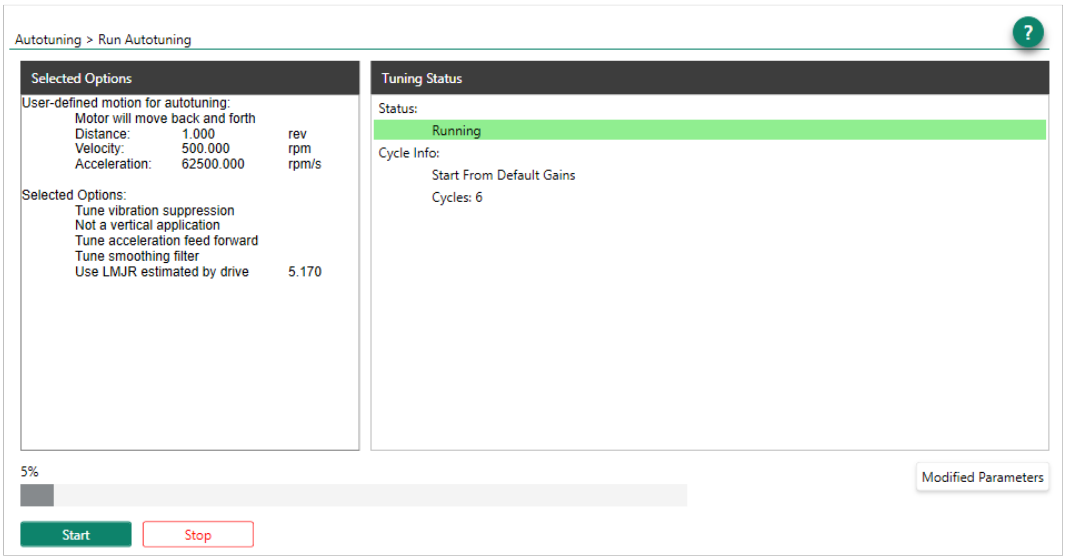
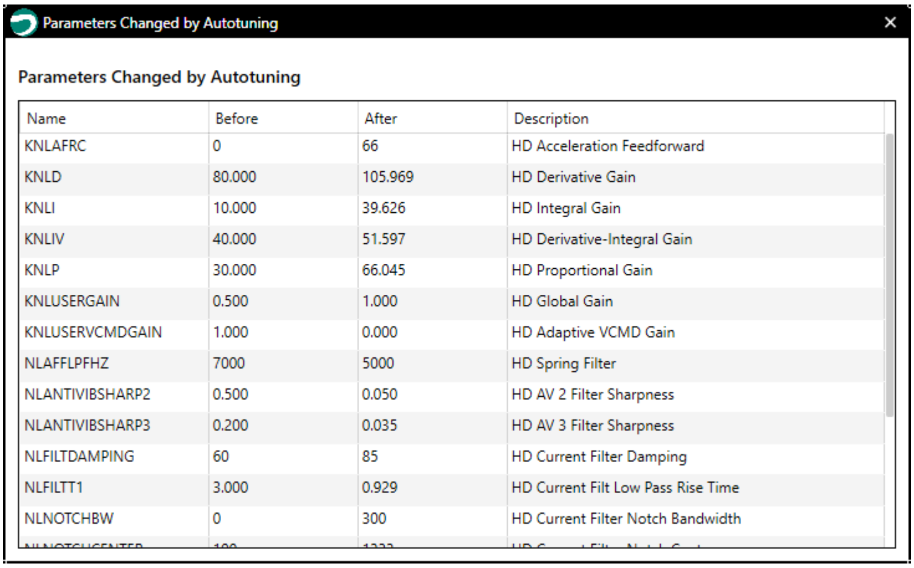


Figure 8-9. Autotuning – Start

The motor moves back and forth continuously while testing values at intervals throughout the range for each of the control loop parameters.

When the autotuning is completed, press **Modified Parameters** to view the new settings.



Name	Before	After	Description
KNLAFRC	0	66	HD Acceleration Feedforward
KNLD	80.000	105.969	HD Derivative Gain
KNLI	10.000	39.626	HD Integral Gain
KNLIV	40.000	51.597	HD Derivative-Integral Gain
KNLP	30.000	66.045	HD Proportional Gain
KNLUSERGAIN	0.500	1.000	HD Global Gain
KNLUSERVCMDGAIN	1.000	0.000	HD Adaptive VCMD Gain
NLAFFLPFHZ	7000	5000	HD Spring Filter
NLANTIVIBSHARP2	0.500	0.050	HD AV 2 Filter Sharpness
NLANTIVIBSHARP3	0.200	0.035	HD AV 3 Filter Sharpness
NLFILTDAMPING	60	85	HD Current Filter Damping
NLFILTT1	3.000	0.929	HD Current Filt Low Pass Rise Time
NLNOTCHBW	0	300	HD Current Filter Notch Bandwidth

Figure 8-10. Autotuning – Modified Parameters

Step – Test

Figure 8-11. Autotuning – Test

4. Press **Move and Plot** to send a current command to the drive and plot the response.

⚠ **Move and Plot** enables the drive and moves the motor!

The resulting graph shows the position command profile in velocity units (PTPVCMD). Options also enable the display of motor velocity measured by the feedback device (V) and the current command (ICMD). A second graph shows the position error (PE).

The wizard also displays the Settling Time and the Position Error Window values calculated by the system.

The toolbar buttons allow you to examine the graph more closely, and to export results to a spreadsheet. These functions are also available in the ServoStudio 2 Scope screen.

5. Optionally, modify the motion settings and/or the gain setting, and repeat the test under different conditions:
   - Target Position
   - Cruise Velocity
   - Acceleration (and Deceleration)
   - HD Global Gain (KNLUSERGAIN); this is the global gain parameter for the HD control loop. A higher gain value results in stiffer control, and a lower value results in softer control.
6. Press **Save** to save the parameters set by the autotuning.

Step – Save

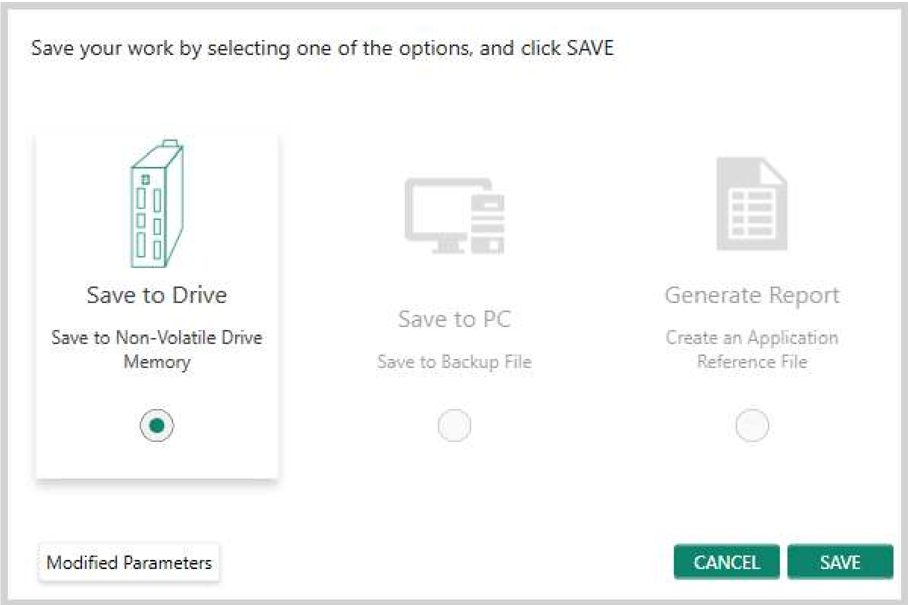


Figure 8-12. Autotuning – Save

To complete the autotuning process, do all the following:

- Press **Save to Drive** to save the parameters in drive RAM to the drive's non-volatile memory.
- Press **Save to PC** to save the parameters in drive RAM to a backup file on the computer. The parameters are saved in a text file with either TXT or SSV extension. The text file can be edited using Notepad or any other text editor.
- Press **Generate Report** to create a record of system settings that can be used for future reference and/or sent to Technical Support should the need arise.

  It is recommended that you create a report whenever you complete configuration of your application, even when the system is functioning properly.

8.4 PC-Based Autotuning

ServoStudio 2 activates the wizard for PC-based autotuning if an electronic motor nameplate is not detected at power-up.

Note

The PC-based Autotuning wizard overrides the user's unit settings and works in the following units:

- Position: counts
- Velocity: rpm/s for rotary motors, and mm/s for linear motors
- Acceleration/deceleration: rpm/s2 for rotary motors, mm/s2 for linear motors

Step – LMJR Estimation

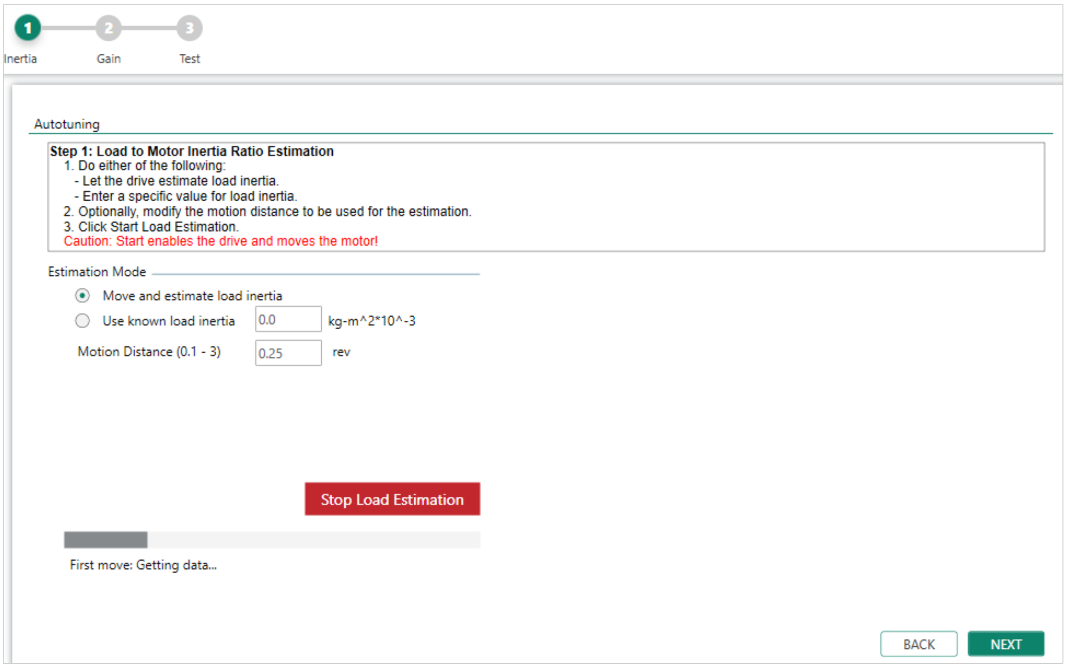


Figure 8-13. PC-Based Autotuning Wizard – LMJR Estimation

1. For automatic estimation, select Move and estimate load inertia.
   or
   If you know the inertia of the load connected to the motor, select Use known load inertia, and enter the value.
2. Optionally, modify the number of motor revolutions to be used as the motion distance during the load estimation.
3. Press Start Load Estimation.

⚠ **Start** enables the drive and moves the motor repeatedly!

   ServoStudio 2 estimates the load currently on the motor, and displays the results.

4. Press OK to send the calculated parameters to the drive.
5. Press **Next** to continue.

Step – Gain Optimization

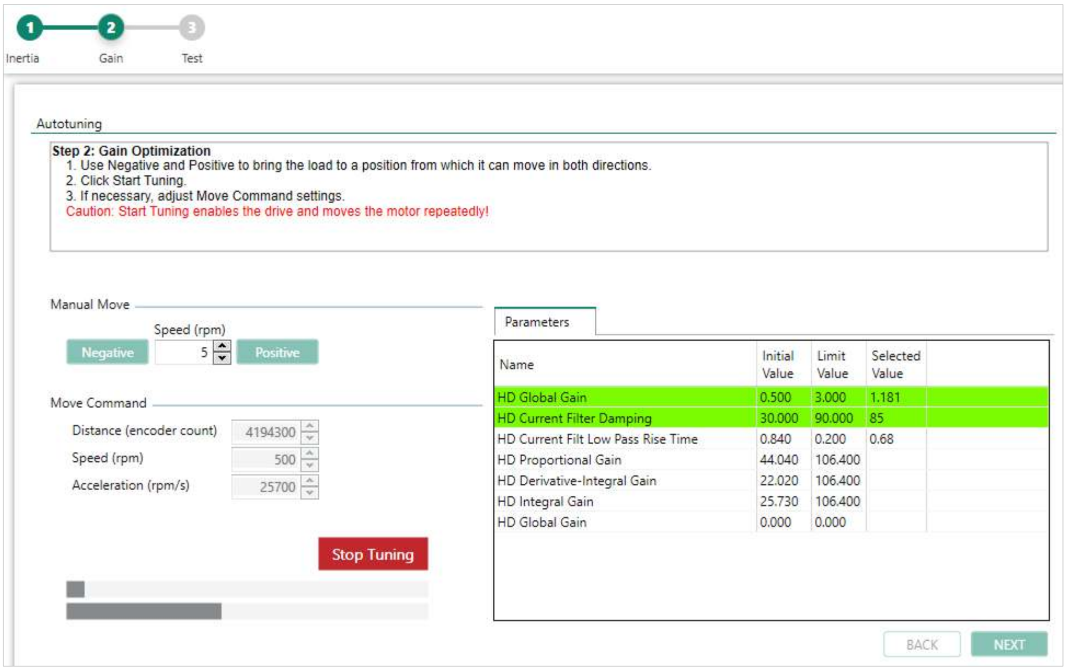


Figure 8-14. PC-Based Autotuning Wizard – Gain Optimization

1. The displayed Move Command values are recommended values; they have been determined according to the motor you defined in the setup. Use the Negative and Positive buttons to bring the load to a position at which the motor can safely make a full rotation in each direction.
2. If necessary, adjust the Manual Move Speed setting.
3. Press **Start**.

⚠ **Start** enables the drive and moves the motor repeatedly!

The motor moves back and forth continuously, while ServoStudio 2 tests values at intervals throughout the range for each of the control loop parameters. Once it achieves the best result, it displays the optimal value in the parameter table.

The top bar shows the progress of the parameter currently being tested.

The lower bar shows the progress of the entire process.

4. If necessary, adjust the Move Command settings, and press Start to repeat the test.

Step – Test Quality of Motion

Figure 8-15. PC-Based Autotuning Wizard – Test Quality of Motion

1. Press **Move and Plot** to send a current command to the drive and plot the response.

⚠ **Move and Plot** enables the drive and moves the motor!

2. A plot appears. The plot shows the velocity command generated by the point-to-point position profile (PTPVCMD), and the position error (PE).

   The wizard also displays the Settling Time and the Position Error Window values calculated by the system.

   The toolbar buttons allow you to examine the graph more closely, and to export results to a spreadsheet. These functions are also available in the ServoStudio 2 Scope screen.

3. Optionally, modify the motion settings and/or the gain setting, and repeat the test under different conditions:
   - Target Position
   - Cruise Velocity
   - Acceleration (and Deceleration)
   - HD Global Gain (KNLUSERGAIN); this is the global gain parameter for the HD control loop. A higher gain value results in stiffer control, and a lower value results in softer control.

Step – Save

To complete the autotuning process, do all the following:

- Press **Save to Drive** to save the parameters in drive RAM to the drive's non-volatile memory.

- Press **Save to PC** to save the parameters in drive RAM to a backup file on the computer. The parameters are saved in a text file with either TXT or SSV extension. The text file can be edited using Notepad or any other text editor.
- Press **Generate Report** to create a record of system settings that can be used for future reference and/or sent to Technical Support should the need arise.

  It is recommended that you create a report whenever you complete configuration of your application, even when the system is functioning properly.

8.5 Autotuning Parameters Summary

The following table lists the parameters that may be optimized and set during the Autotuning procedure.

Not all parameters are modified during the process. The final values of the parameters are determined by the specific options selected by user in the autotuning wizard.

√ Autotuning optimizes the parameter value

Y/N Autotuning sets the parameter, or user can set the value manually

Table 8-2. Parameters Set During the Autotuning Process

Function	Description	Parameter	Express	Adv.
Gearing Filters	Automatically optimized during the Autotuning process. Applicable for Position Gearing operation mode. The gearing filter interpolates the pulse and direction command.	GEARFILTMODE	√	√
		GEARFILTT1	√	√
		GEARFILTT2	√	√
		GEARFILTVELFF	√	√
		GEARFILTAFF	√	√
Move Smoothing Filter	Use Autotuning to optimize parameters for smoothing the input profile command. Do not use Autotuning if the application is multi-axis and smoothing must be the same for all axes. Instead, use MOVESMOOTHAVG with a value between 1–15 ms.	MOVESMOOTHSRC	√	Y/N
		MOVESMOOTHMODE	√	Y/N
		MOVESMOOTHLPFHZ	√	Y/N
		MOVESMOOTHAVG	√	Y/N
HD Control Loop	Automatically optimized during the Autotuning process.	NLPEAFF	√	√
		NLAFFLPFHZ	√	√
		KNLD	√	√
		KNLI	√	√
		KNLIV	√	√
		KNLP	√	√
Current Control Notch Filters	HD control loop parameters.	NLNOTCHBW	√	√
		NLNOTCHCENTER	√	√
		NLNOTCH2BW	√	√
		NLNOTCH2CENTER	√	√

Function	Description	Parameter	Express	Adv.
Current Control Low Pass Filter	HD control loop parameters.	NLFILTT1	√	√
		NLFILTDAMPING	√	√
Acceleration Feedforward	HD control loop parameter. Use Autotuning to optimize parameters for achieving minimal tracking error during motion. Do not use Autotuning if overshoot is too large.	KNLAFRC	√	Y/N
Global Gain	HD control loop parameter. Can be modified at Test stage of Autotuning process.	KNLUSERGAIN	Y/N	Y/N
Anti-Vibration Filters	Use Autotuning to optimize parameters for suppressing vibration. Do not use Autotuning if you want to set vibration suppression parameters manually, or if the application does not require vibration suppression.	NLANTIVIBGAIN2		Y/N
		NLANTIVIBSHARP2		Y/N
		NLANTIVIBHZ2		Y/N
		NLANTIVIBGAIN3		Y/N
		NLANTIVIBSHARP3		Y/N
		NLANTIVIBHZ3		Y/N
		NLANTIVIBQ3		Y/N
Moment of Inertia	Use Autotuning to determine the load's moment of inertia. Do not use Autotuning if the moment of inertia of the load varies (e.g., a multi-axis robot), or if you know the exact inertia. You can enter a value for either Load Inertia or Load Inertia Ratio; the software sets the other parameter accordingly.	LMJR	√	Y/N
Vertical Application	Use Autotuning to compensate for the effect of gravity when axis motion is vertical. Do not use Autotuning if axis motion is balanced (non-vertical) in both directions.	IGRAV		Y/N

8.6 Recording and Evaluating Performance

8.6.1 Diagnostics

After autotuning has been completed, the system may display behavior that is less than optimal, such as:

- Servo motor is audibly noisy.

- Servo motor is very hot.
- Performance is not consistent.
- Foldback occurs; that is, the motor demands a level of current that drive cannot handle continuously.
- Jerk in system.
- Jerky movements.
- Excessive overshoot results in hitting application mechanical limits.

The following diagram outlines the procedures for diagnosing system behavior and applying filters to improve performance.

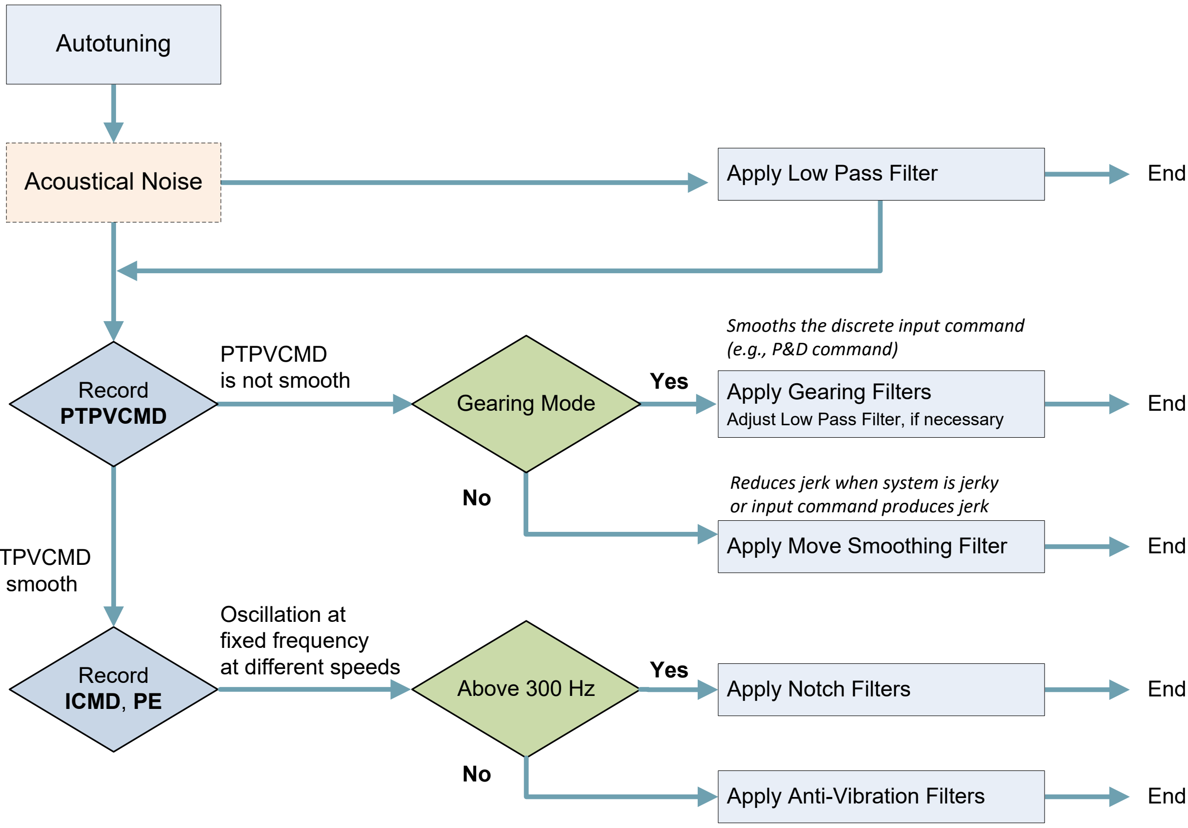


Figure 8-16. Performance Diagnostics

The CDHD2 recording function is used for performance verification, tuning and debugging. ServoStudio 2 provides a full-featured graphic interface for recording, plotting and measuring data. Refer to the ServoStudio 2 Reference Manual for details.

To improve or change performance of the CDHD2 system, refer to the Performance Diagnostics diagram, and manually modify and evaluate the parameters.

Procedure: Modifying and Testing a Parameter

After each modification of a parameter, do the following:

1. Make sure Operation Mode is set to **Serial Position**.
2. Execute a back/forth motion, and record PE, ICMD and PTPVCMD
3. Use the ServoStudio 2 Scope screen to plot and evaluate the recorded values.

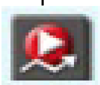
4. Check the settling time of PE.

8.6.2 Recording Data in ServoStudio 2

Procedure: Recording Data in ServoStudio 2 – Example

1. In the ServoStudio 2 Scope screen, select the **Motion** tab.
   - Make sure Operation Mode is set to **Serial Position**.
   - Set the value of the Target Position 3 revolutions.
   - Set the values of the motion parameters to produce a movement at 50% of the motor's maximum speed, and 75% of the maximum acceleration required by the application. Thus, in this example:
     - Maximum speed (Cruise Velocity) is set to 1000
     - Acceleration (and Deceleration) is set to 50000
   - If you need a back and forth motion, select the option Alternating.

   The aim is to achieve a motion profile that has substantial durations for the acceleration, plateau, and deceleration phases.
2. In the Recorder Setup panel, select the following Record Variables:
   - PTPVCMD (Position command velocity)
   - ICMD (Current command)
   - PE (Position error).
3. In the Recorder Setup panel, enter the sampling values and trigger variable:
   - Samples: 1000
   - Time Interval: 16
   - Trigger: IMM
4. Make sure the drive is enabled, and then press the Move Record and Plot button in the Scope toolbar.

   Note that the trace of the Position Error variable shown here is scaled by a factor of 50.

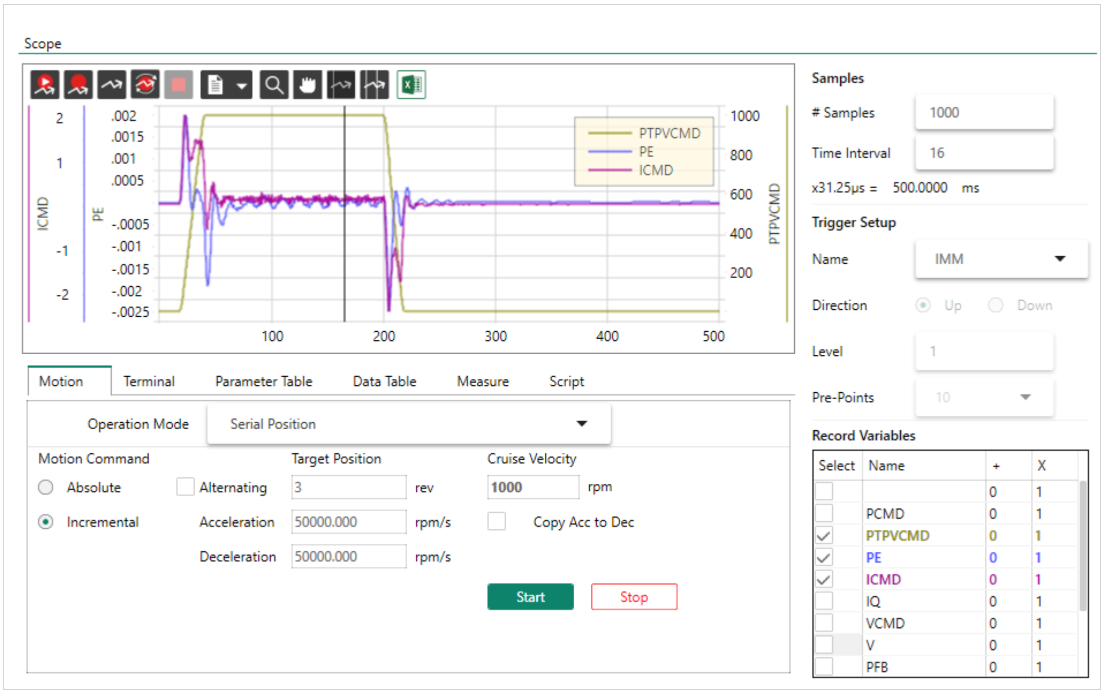


Figure 8-17. Motion Obtained with Default Parameter Values

5. Select the Parameter Table tab.

Motion | Terminal | **Parameter Table** | Data Table | Measure | Script

Parameter	Value	Unit
HD Global Gain	1.000	
HD Derivative Gain	139.691	Hz
HD Proportional Gain	88.593	Hz
HD Derivative-Integral Gain	69.213	Hz
HD Integral Gain	35.436	Hz
HD Flexibility Compensation	5000.000	Hz
HD Spring Filter	5000	Hz
HD Maximum Adaptive Gain	1.600	
HD Current Filter Damping	85	%
HD Current Filt Low Pass Rise Time	0.547	ms
HD Current Filter Notch Center	1333	Hz

Figure 8-18. Parameters – Example

Parameter KNLUSERGAIN (HD Global Gain) is set to 1.000 during autotuning. For additional, manual tuning, you can often begin with this setting. If the gain is too high – as evidenced by vibrations and noise – decreasing the value of KNLUSERGAIN can help achieve a smoother movement.

6. View position error and settling time

Right-click in the recording chart pane, and select Show Settling Time.

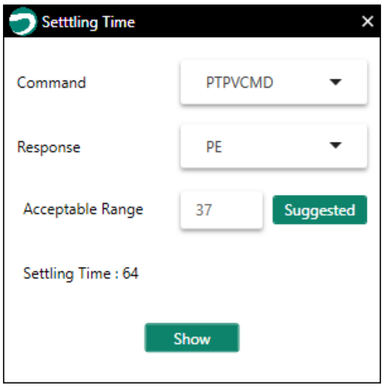


Figure 8-19. Position Error (counts) and Setting Time (ms)

The acceptable range of the response (position error) is the movement (in counts) at the endpoint.

Acceptable range: $\frac{2 \times \pi \times \text{length}}{\text{resolution} \times \text{gear}}$

Example:

Mechanical dimension (joint length) = 0.5 m

Motor resolution: 1 rev = 17 bit = 131072 counts

Gear ratio = 1:100

Acceptable range: $\frac{2 \times \pi \times 0.5}{131072 \times 100}$

If motor moves 100 counts, movement at endpoint is 0.2 x 10-6 meter. Acceptable range: 50–100.

8.6.3 Recording Data in Terminal

Procedure: Recording Data (Terminal)

1. Use the command RECORD to define the variables to be recorded, the recording interval, and the number of points to record.

   The syntax for the recording instruction is:

   RECORD {*sample time*} {*num points*} {*var1*} [*var2*] [*var3*]

   For example: RECORD 32 100 "VCMD "V "ICMD

   Records 100 points for VCMD, V, and ICMD every 1 milliseconds

   Note that variables must be preceded by a quotation mark (").

2. Use the command RECTRIG to define the variable and conditions that triggers the recording.

   The syntax for the recording trigger instruction is:

   RECTRIG {*var*} [*level*] [*pre-trig*] [*above*|*below*]

Note If the specified number of pre-trigger points is greater than the number of points recorded prior to the trigger, the pre-trigger segment of the recording will include the value of the variable before motion began.

For example, record a Jog (J) that goes to 1000 rpm starting from zero with an acceleration of 10000 rps/s; specify the record level at 1 rpm, the direction as Up, 128 pre-trigger points and a time interval of 1. Since there will not be 128 points of pre-trigger motion, the record data will be packed with zeros (zero velocity command before the motion).

3. Use the variable RECDONE (recording finished) and/or RECING (recording in progress) to determine whether recorded data is available.

4. Set variable GETMODE to 0. Then use the command GET to retrieve the recorded data in a comma-separated variable (CSV) ASCII format.

Function	VarCom	Description
Recording Activation Commands	RECORD	Defines the variables to be recorded and the recording time span and sample time.
	RECTRIG	Defines the triggering condition for starting a recording, and pre-trigger duration.
	RECOFF	Turns active recording off.
Recording Utility Information	RECLIST	Lists all the variables that can be recorded by the record function.
	RECTRIGLIST	Lists all the options for triggering the recording.
Status Flags	RECRDY	Indicates that a recording is armed and ready.
	RECING	Indicates that a trigger condition has occurred and that a recording is active.
	RECDONE	Indicates that the recording is completed
Data Retrieval	GETMODE	Defines the format for the recorded data (binary/ASCII)
	GET	Retrieves the recorded data

8.6.4 Evaluating PTPVCMD

Note *Not fully updated for ServoStudio 2.*

Parameter PTPVCMD (position command generator velocity) reports the derivative of the position command profile in velocity units. PTPVCMD is useful for recording and viewing the actual velocity and the velocity command, which is available only as a derivative of the position profile.

PTPVCMD is the trajectory velocity command applicable to all position loops.

Note VCMD is the output velocity command of the linear controller.
VCMD is not used in HD (nonlinear) control.

The following figure shows an example of a PTPVCMD recording that indicates poor performance.

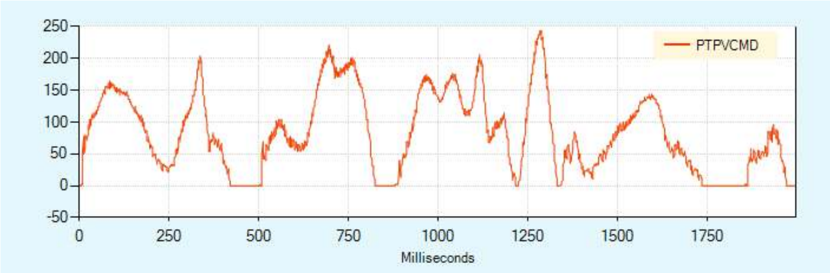


Figure 8-20. PTPVCMD Poor Result

8.6.5 Evaluating ICMD and/or PE Oscillations

Note *Not fully updated for ServoStudio 2.*

The following figure shows an example of oscillations in ICMD (current command) and PE (position error) that indicate poor performance.

Figure 8-21. ICMD and PE Poor Result

To determine whether the oscillations are greater than 300 Hz, use the ServoStudio 2 FFT function on the PE or ICMD recording:

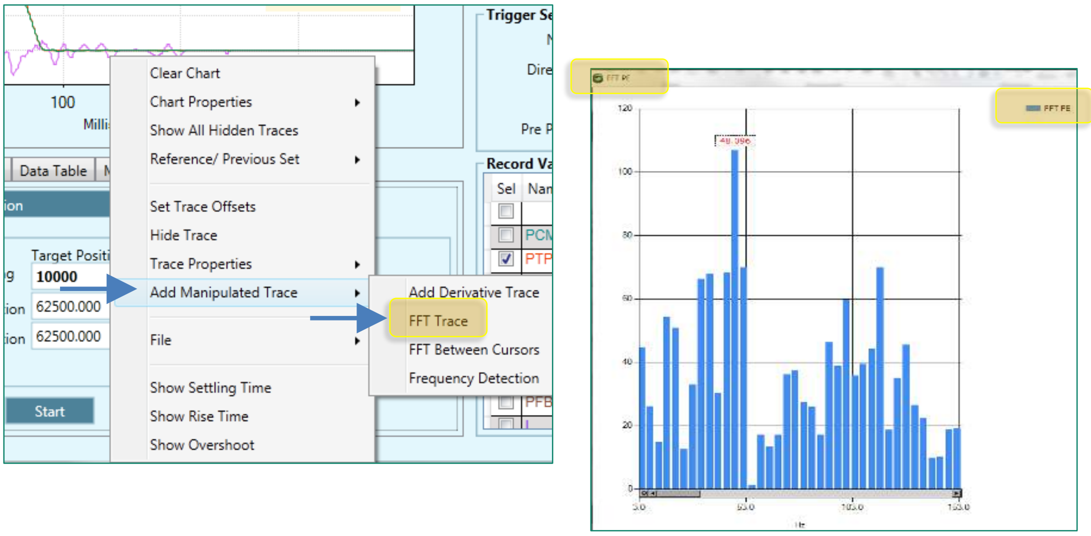


Figure 8-22. FFT Trace Evaluation

8.7 Low Pass Filter on Current Command

Note *Not fully updated for ServoStudio 2.*

The output of the HD control loop is a current command. This current command is low pass filtered before it is transferred to the current controller.

The Autotuning procedure sets the optimal values for the low pass filter parameters during the Load Estimation routine.

- NLFILTDAMPING (HD Current Filter Damping), defined as a percentage, maintains the bandwidth of the filter up to the cutoff frequency.
- NLFILTT1 (HD Current Filter Low Pass Rise Time), defined in milliseconds, defines the inverse of the cutoff frequency.

If acoustical noise occurs, it may be necessary to fine-tune the low pass filter.
Increase NLFILTT1 in incremental steps of 10% until the acoustical noise reaches an acceptable level.

If the system becomes unstable, it may be necessary to reduce global gain (KNLUSERGAIN).

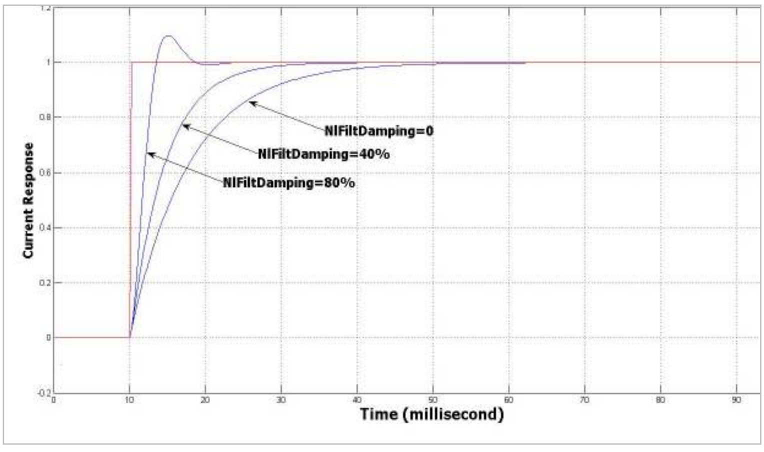
After KNLD is tuned, NLFILTDAMPING and/or NLFILTT1 can undergo further tuning. Refer to *KNLD - Derivative Gain*.

To achieve the fastest response time of the HD control loop, the low pass filter can be adjusted manually. The goal is to use the maximum value for NLFILTDAMPING and the minimum value for NLFILTT1.

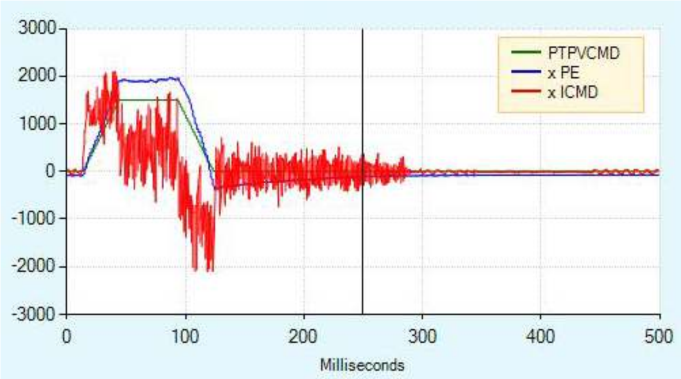
1. Increase NLFILTDAMPING until noise and/or oscillations of ICMD are observed, then reduce by 10%.
2. Decrease NLFILTT1 until noise and/or oscillations of ICMD are observed, then increase by 20% and at least 0.05 ms.

If the plant to be controlled has resonances at relatively high frequencies, NLFILTT1 can be applied on the current output. NLFILTT1 efficiently reduces acoustical noise, but also reduces control bandwidth and the potential stiffness of the system.

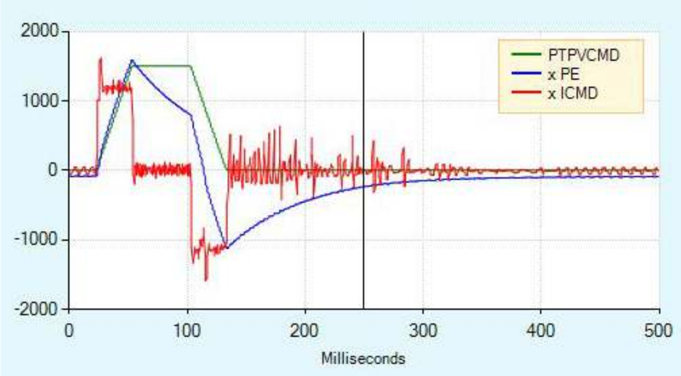
NLFILTDAMPING minimizes the negative effects of the low pass. NLFILTDAMPING may be set independently of NLFILTT1 to provide an overshoot response. Combined with the low pass characteristic of the mechanical system, it helps in achieving a higher bandwidth of the control.



NLFILTDAMPING
at 0% 40% 80%



NLFITT1
value too low



NLFITT1
selected value

Figure 8-23. Low Pass Filters

8.8 Gearing Filters

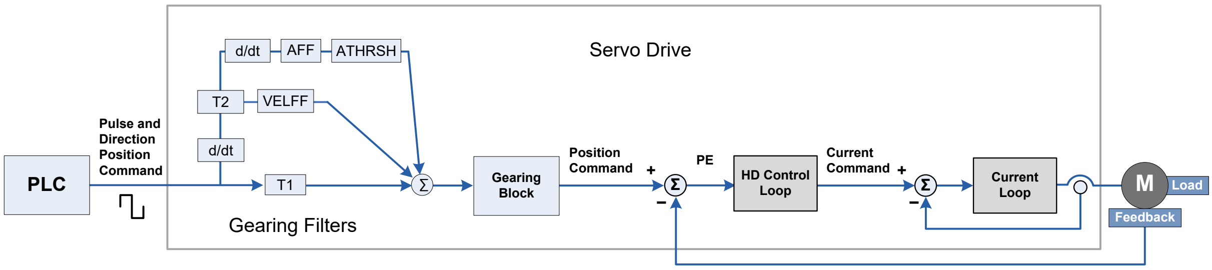
Note *Not fully updated for ServoStudio 2.*

Gearing filters may be useful if the system displays characteristics such as:

- Pulse and direction command has a low resolution
- Coupling between motor and load is not stiff
- Movement is too short
- Motor is noisy after tuning
- Current is very choppy during settling
- Motor temperature is unusually high

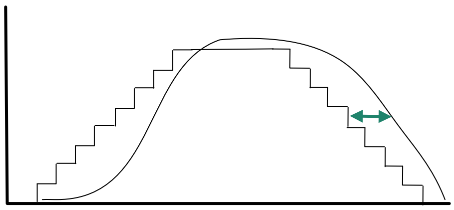
Before applying gearing filters, make sure GEARINMODE = 1

When a system has multiple axes, gearing filter values must be the same for all axes.



T1	GEARFILTT1	Gearing filter depth
T2	GEARFILTT2	Gearing filter velocity and acceleration depth
ATHRSH	GEARACCTHRESH*	Gearing acceleration threshold
VELFF	GEARFILTVELFF*	Gearing filter velocity feedforward
AFF	GEARFILTAFF*	Gearing filter acceleration feedforward
	* Use default values. Contact Technical Support if necessary.	

Figure 8-24. Gearing Filters



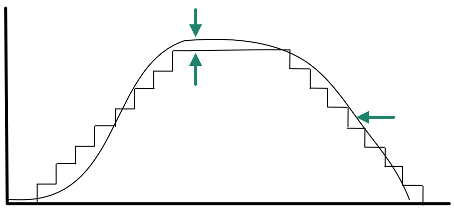
Gearing Filter – Example 1

Increasing GEARFILTT1 smooths the input command PTPVCMD, but adds a delay.

Recommended values:

GEARFILTT1 = ~2 × input step width

GEARFILTT2 = 2 × GEARFILTT1



Gearing Filter – Example 2

Increasing GEARFILTT2 and VELFF compensates for the delay, but adds overshoots.

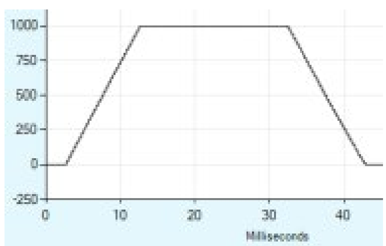
If GEARFILTVELFF = GEARFILTT2, there is no delay.

Figure 8-25. Tuning Gearing Filters

8.9 Move Smoothing Filter

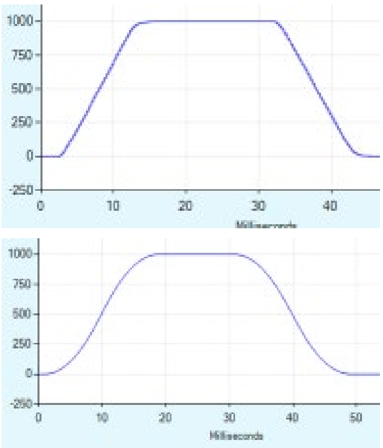
Note *Not fully updated for ServoStudio 2.*

HD control provides three options for smoothing the position command, as defined by the parameter MOVESMOOTHMODE.



MOVESMOOTH 0:

No smoothing of the position command profile.



MOVESMOOTH 1:

Low pass smoothing of profile (in hertz) based on MOVESMOOTHLPFHZ.
The lower the value, the greater the smoothing.

MOVESMOOTH 2:

S-curve by averaging (in ms) based on MOVESMOOTHAVG.
Time extends the average.
Binary values (2, 4, 8, 32, 64, 128, 256)

Figure 8-26. Smoothing Filters

To apply a smoothing filter to an external reference command, such as a pulse train or EtherCAT/CANopen, certain bits in MOVESMOOTHSRC must first be set.

8.10 Notch Filters

Note *Not fully updated for ServoStudio 2.*

Notch filters can be used to eliminate high frequency oscillations that may occur in systems having a flexible link between motor and load, such as:

- Ball screw linear slide with coupling
- Belt drive
- Harmonic drive

Oscillations usually occur during the first steps in tuning (feedback gain). Tuning is done by checking the frequency of the oscillation, and setting the notch accordingly. Once notch parameters are set, the tuning procedure can continue.

HD control notch filters are used at any time during tuning to damp oscillations at a fixed frequency greater than 300 Hz:

- NLNOTCHCENTER (HD Current Filter – Notch Filter Center)
- NLNOTCHBW (HD Current Filter – Notch Filter Bandwidth)

A second set of HD control notch filters (NOTCH2CENTER and NLNOTCH2BW) is available through Terminal, but does not appear in the ServoStudio 2 control loop screen.

8.11 Anti-Vibration Filters

Note *Not fully updated for ServoStudio 2.*

Anti-Vibration Overview

The HD control anti-vibration function is based on proprietary control algorithms and serves to suppress vibrations at constant frequencies.

The vibration suppression function runs in a closed loop, detecting oscillations as they occur, and damping them immediately. Actively damping load oscillations significantly reduces the time it takes for a heavy load or an end effector to settle at the target position. Although the position error at the encoder level may be higher, the overall performance of the system, as evaluated at load position, is significantly improved.

A typical example is a load fixed to a servo controlled motor by means of a shaft that has a certain amount of flexibility. If the servo control of the motor is set for near-zero position error during movement, then the load will oscillate strongly. Every change in the acceleration (jerk) will apply a perturbation, resulting in oscillations of the load. While the stiff HD control loop will overcome these oscillations at motor position level, the load will still oscillate strongly.

The anti-vibration function can handle systems with an oscillation frequency of up to 100 Hz.

The following diagram shows the four phases of the vibration suppression process.

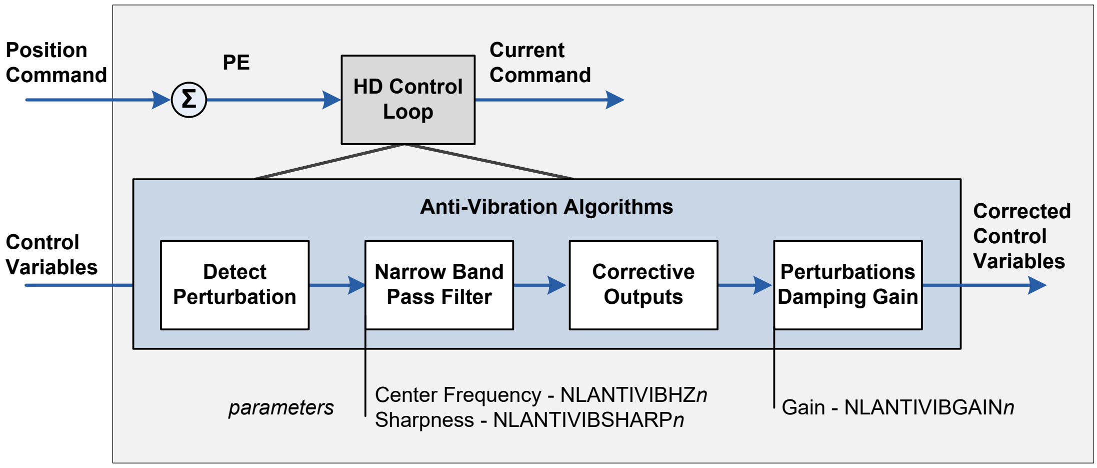


Figure 8-27. Anti-Vibration Filters

Phase 1: The perturbations induced to the system are detected using various control variables, such as position error and current, as input. A perturbation value is calculated for use in the next phase.

Phase 2: The perturbation value is passed through a narrow band pass filter in order to select the perturbations that are induced by the system oscillations. The center frequency and the width of the band pass filter are set, respectively, by the parameters NLANTIVIBHZn and NLANTIVIBSHARP*n*.

Phase 3: Corrective outputs to be added to the control variables are calculated.

Phase 4: Corrective outputs are added to control variables using a damping gain (parameter NLANTIVIBGAIN*n*).

Anti-Vibration Tuning Procedure

After autotuning, more anti-vibration tuning may be required.

If an additional vibration frequency needs to be suppressed, the turning process can be repeated using the second set of anti-vibration filters.

The following table shows the parameters whose values are modified by the tuning procedures.

HD Anti-Vibration Filter	Parameter	Default	Range
Center Frequency 2	NLANTIVIBHZ2	100	5 to 800 [Hz]
Center Frequency 3	NLANTIVIBHZ3	400	5 to 800 [Hz]
Sharpness 2	NLANTIVIBSHARP2	0.5	0.01 to 10
Sharpness 3	NLANTIVIBSHARP3	0.2	0.01 to 10
Damping Gain 2	NLANTIVIBGAIN2	0	0 to 99
Damping Gain 3	NLANTIVIBGAIN3	0	0 to 6

Note Although parameters NLANTIVBHZ, NLANTIVIBSHARP and NLANTIVIBGAIN are still available, they are not recommended for use.

Step 1 – Setting the Narrow Band Filter (NBF)

1. Set the narrow band center frequency.
   - Execute a movement and measure the resonance (oscillation frequency) of the current command (ICMD):
     - In the Scope screen, right-click on the ICMD plot.
     - Select FFT and Derivative.
     - Select FFT Trace.

     The FFT trace will look like this, for example:

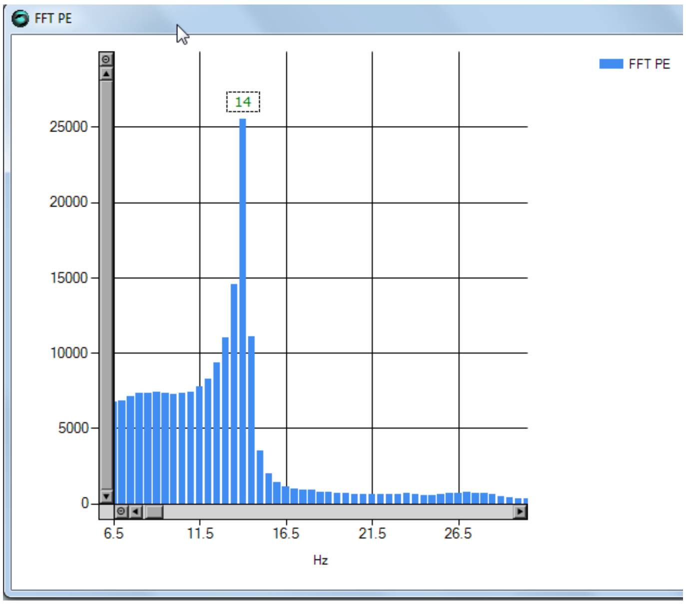


Figure 8-28. FFT Trace

   - Set the value of parameter NLANTIVIBHZn to the peak, or dominant, resonance, in Hertz. In the example shown here, the value is 14 Hz.
2. Set the narrow band center sharpness (width).
   - Set the value of parameter NLANTIVIBSHARPn according to the resonance sharpness (width) of the narrow band filter.

Estimate the width by visually comparing the graph in the FF Trace dialog box to the graph below, which shows the frequency response of the NBF as a function of the value of NLANTIVIBSHARPn. Typical setting values range from 0.1 to 1.0.

The following diagram shows the narrow band filter frequency response.

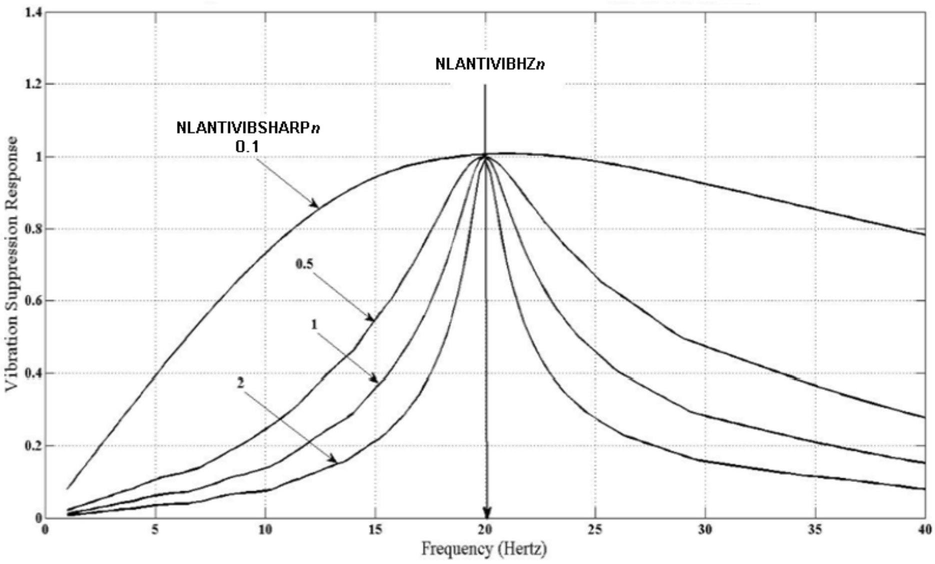


Figure 8-29. Frequency response as a function of NLANTIVIBSHARPn for 20 Hz center frequency

Step 2 – Tuning the Damping Gain

Increase parameter NLANTIVIBGAIN*n* until optimal damping is achieved.

- At each increment, record the current command (ICMD) and check the oscillation damping.

  Optimal damping of the system is obtained for the best damped current oscillations.

Note If, while increasing this parameter, a high frequency vibration appears, slightly reduce the adaptive global gain (KNLUSERGAIN).

Anti-Vibration Tuning – Example

Note Plots of some variables are scaled (indicated by “x”).

Without the vibration suppression tuning, position error and current oscillate, and settling time is very long.

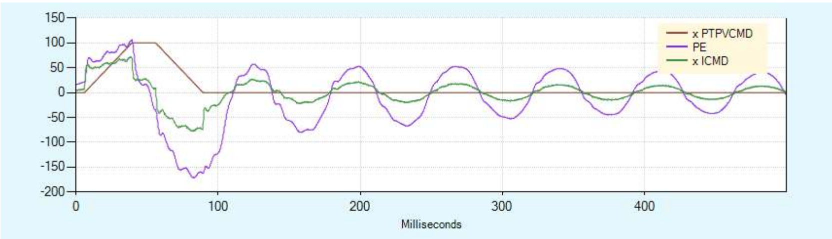


Figure 8-30. Without vibration suppression, oscillation of position error and current

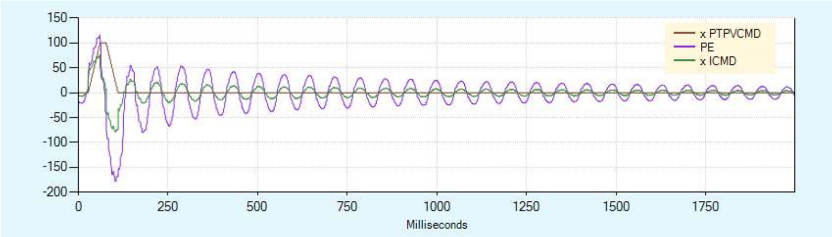


Figure 8-31. Without vibration suppression, long settling time

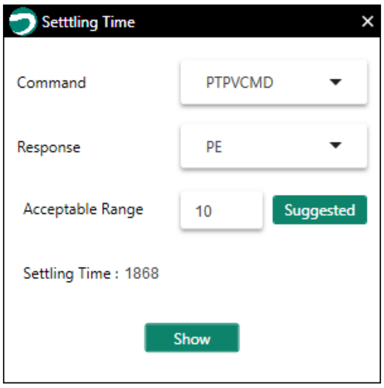


Figure 8-32. Settling time – no anti-vibration tuning

To damp the oscillations and reduce settling time, the following parameters are set:

- NLANTIVIBHZ2 = 14 Hz, frequency of the measured resonance.
- NLANTIVIBSHARP2 = 0.5, width estimated according to the sharpness displayed in the FFT trace.
- NLANTIVIBGAIN2 = 8, determined by manually increasing the value from 0, until best settling time is achieved.

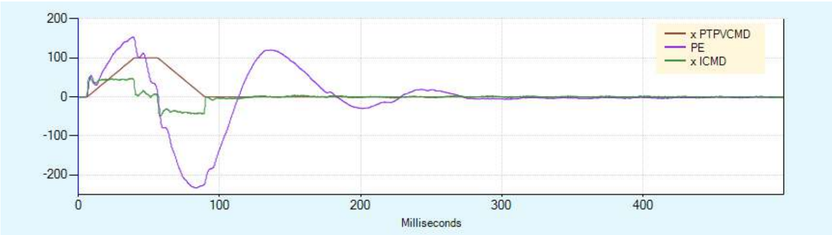


Figure 8-33. Tuning for vibration suppression, less oscillation of position error and current

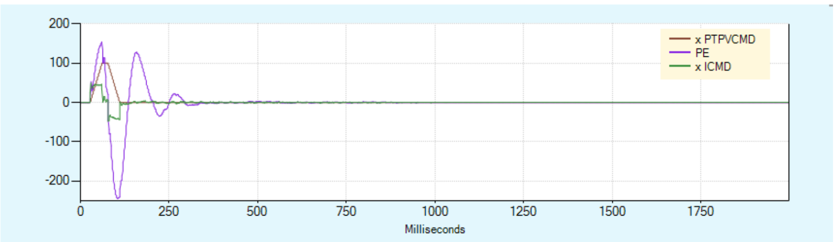


Figure 8-34. Tuning for vibration suppression, faster settling time

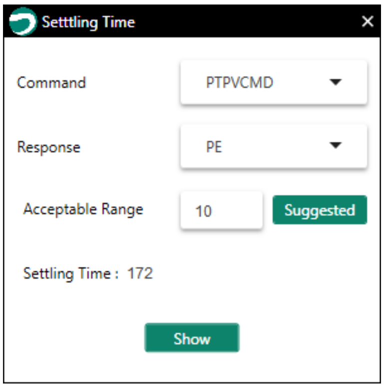


Figure 8-35. Settling time – with anti-vibration tuning

8.12 Gains – Manual Tuning

Note *Not fully updated for ServoStudio 2.*

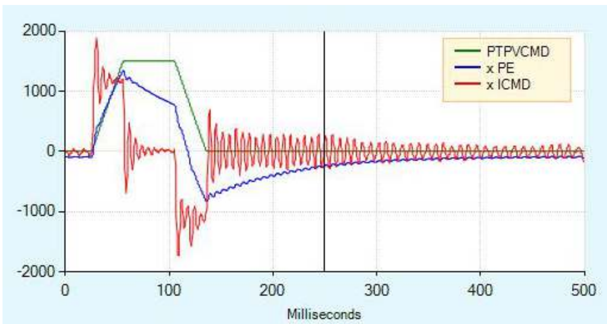
KNLD - Derivative Gain

1. Set KNLP to half the value that was set by default.
2. Set KNLI and KNLIV to zero.
3. Increase KNLD until oscillations of ICMD are observed.

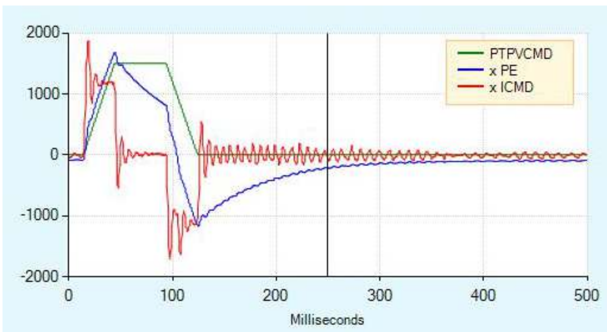
The acceptable level of ICMD ripple depends on the system, primarily the load. It can often be judged by the acoustical noise.

Light loads (LMJR < 2): 5% of rated current may be normal.

Higher loads (LMJR > 2): 10% of rated current may result in acceptable ripple.



KNLD value too high



KNLD selected value

Figure 8-36. Derivative Gain Tuning

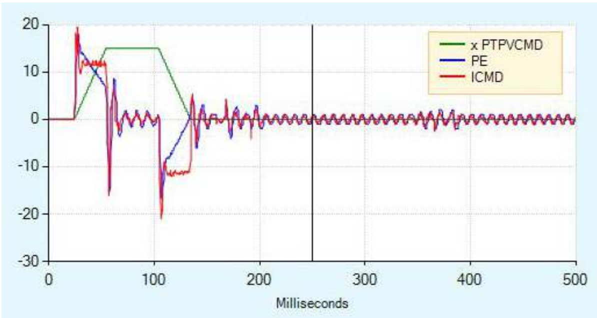
KNLIV - Derivative-Integral Gain

Increase KNLIV until position error (PE) begins to oscillate.

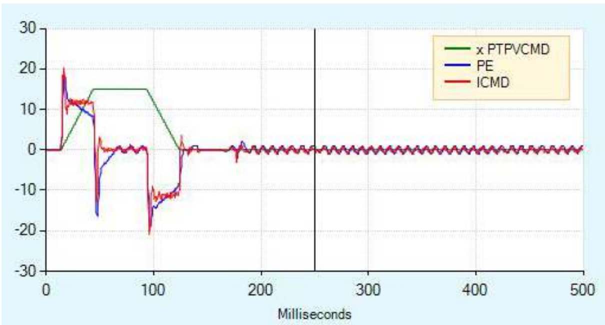
Increasing KNLIV reduces the position error, reduces sensitivity to external perturbations, and reduces the steady state position error at stop (if exists).

Best tuning: Position error decreases as fast as possible after each movement phase transition (jerk), without oscillations during transition between phases; no overshoot of position error; oscillations at stop are acceptable (±1 encoder count).

Best settling time: If possible, increase KNLIV until position error returns to 0 before the end of the deceleration phase.



KNLIV value is too high; vibrations at stop are too strong; overshoot of position error



KNLIV selected value; good settling time

Figure 8-37. Derivative-Integral Gain Tuning

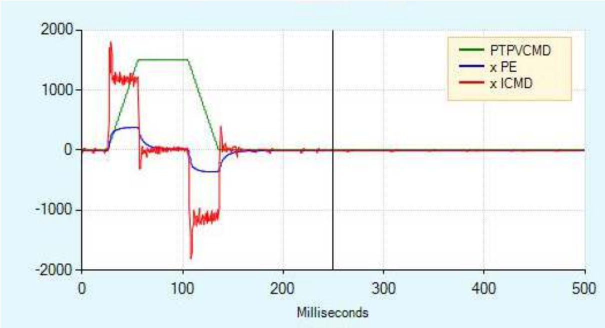
KNLP - Proportional Gain

Increase KNLP until position error (PE) begins to oscillate.

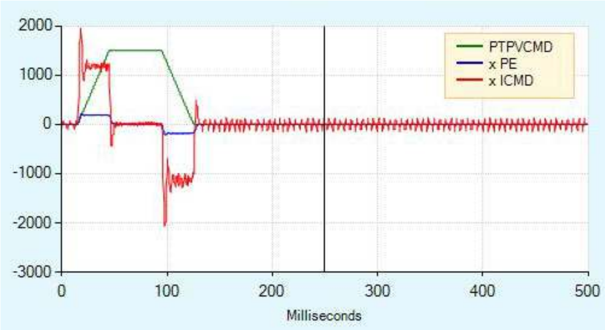
As the value of KNLP increases, the shape of the position error become square, reflecting the constant values during acceleration and deceleration.

As the KNLP proportional gain gets higher, the position error reaches a steady value during each phase of the movement (acceleration, plateau, deceleration).

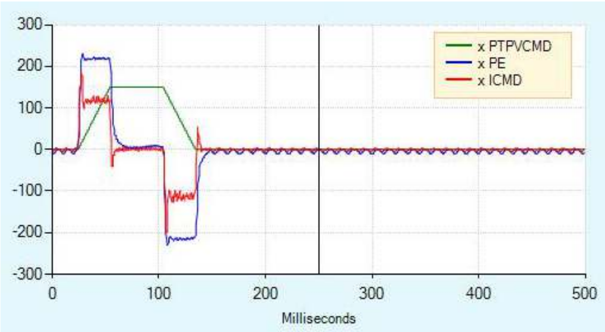
Best tuning: Graph is as square as possible, indicating the position error is constant during each phase of movement, and there are no oscillations during the transition between phases (acceleration to plateau, plateau to deceleration, deceleration to stop).



PE gets flatter during acceleration and deceleration



KNLP value too high; vibrations at stop



KNLP selected value

Figure 8-38. Proportional Gain Tuning

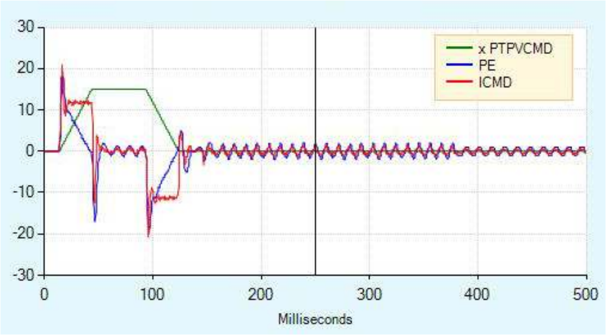
KNLI - Integral Gain

KNLI is used to reduce the position error during movement and at stop.

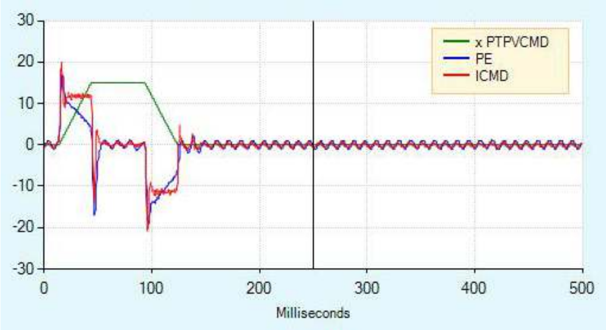
Best tuning: Maximum value that does not create overshoot or oscillations.

Best settling time: If possible, increase KNLI until position error returns to 0 before the end of the deceleration phase.

Result: Position error is slightly reduced; oscillations at stop are acceptable (±1 encoder count); no overshoot of position error at end of deceleration phase (stopping point).



KNLI value too high; position error oscillations at stop; overshoot of position error



KNLI selected value

Figure 8-39. KNLI Tuning

8.13 Flexibility Compensation Tuning

Note *Not fully updated for ServoStudio 2.*

The flexibility compensation parameters reduce the vibrations induced to the load by abrupt changes in acceleration (jerk), and reduce tracking error. They also serve to minimize overshoot and settling time.

- NLPEAFF (HD Flexibility Compensation), defined in Hertz, is set according to the rigidity of the system. Rigid systems require a high value. Systems with high load inertia and flexible couplings require lower values; the normal range is 400 to30 Hz). If not used, set to 5000 Hz.
- NLAFFLPFHZ (HD Spring Filter), defined in Hertz, applies a low pass filter on the acceleration of the command position used to perform the compensation. This acceleration is calculated from the input command position, and may be noisy if the input command position has a relatively low resolution, as for example a pulse train input. Application of the low pass filter NLAFFLPFHZ smooths the calculated acceleration of the command position, and should be used whenever noisy operation is observed while applying the parameter NLPEAFF.

Best tuning: Typically, the highest frequency is 400 Hz. Thus, for heavily loaded and flexible systems, typical range for NLPEAFF is 400 to 30 Hz.

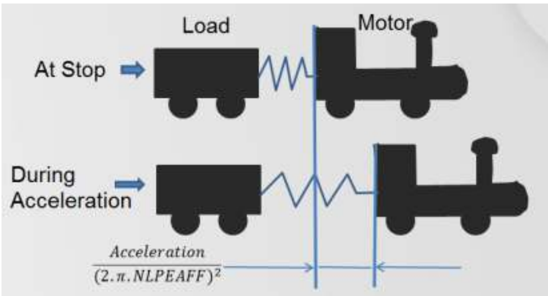


Figure 8-40. Plant Flexibility

Procedure: Flexibility Compensation Tuning

1. Set NLAFFLPFHZ = 3×KNLD
2. Start with highest value of NLPEAFF, and reduce until the best result for the application is achieved. Criteria may be either settling time or position error.

8.14 Dual Feedback Position Control Loop Tuning

Note *Not fully updated for ServoStudio 2.*

When secondary feedback is enabled and used for the control loop (SFBMODE 1), the variable PFB represents the feedback used to control positioning.

The position controller in the dual feedback control system is a dedicated P-gain controller with velocity feedforward and acceleration feedforward. The velocity loop can be either PI or PDFF, and controls the motor using the motor feedback. The current loop also controls the motor using the motor feedback.

The dual feedback position controller includes three gain parameters:

- KNLDUALLOOPKP: Position loop proportional gain.
- KNLDUALLOOPVFF: Position loop velocity feedforward.
- KNLDUALLOOPAFF: Position loop acceleration feedforward.

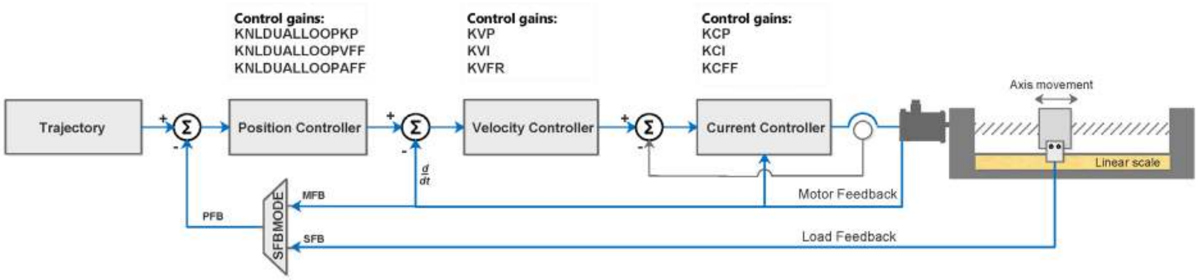


Figure 8-41. Dual Feedback Position Control Loop

Procedure: Tuning the Dual Feedback Position Control Loop

1. Make sure the drive is operating in serial communication mode (COMMODE 0).
2. Configure the motor and the motor feedback parameters.
3. Set the motor to load inertia ratio (LMJR) value.
   If unknown, use the ServoStudio 2 Autotuning to estimate the value.
4. Configure the secondary feedback device parameters.
   Refer to *Secondary Feedback*.
5. Make sure the direction of motor feedback and secondary feedback are the same.
   If not, use SFBDIR to invert the direction.
6. Enable secondary feedback and activate the dual loop mode (SFBMODE 1).
7. Tune the velocity controller:
   a. Switch to Serial Velocity operation mode (OPMODE 0).
   b. Define PDFF velocity controller (VELCONTROLMODE 1).
   c. Select variables for recording: VCMD, MVEL, ICMD
   d. Using these variables, tune the velocity loop for the motor:
      - Tune the velocity proportional gain (KVP).

- Tune the velocity integral gain (KVI).
- Tune the velocity feedforward (KVFR).

Figure 8-42. Dual Feedback – Tuning Velocity Controller – Example

8. Tune the dual-feedback position controller:
   a. Switch to Serial Position operation mode (OPMODE 8).
   b. Select variables for recording: PTPVCMD, V, PE, ICMD.
   c. Using these variables, tune the dual-feedback position loop:
      - Tune the proportional gain (KNLDUALLOOPKP)
      - Tune the velocity feedforward (KNLDUALLOOPVFF)

   Best tuning: Gradually increase KNLDUALLOOPKP until oscillation occurs on ICMD, or acoustical noise is heard. Then decrease KNLDUALLOOPKP by 10%.

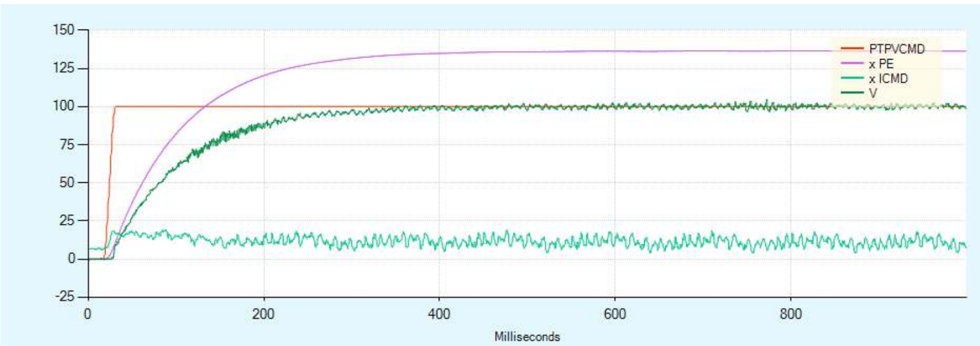


Figure 8-43. Dual Feedback – Tuning Position Controller (KNLDUALLOOPKP) – Example

   d. Set the velocity feedforward to 100% (KNLDUALLOOPVFF):

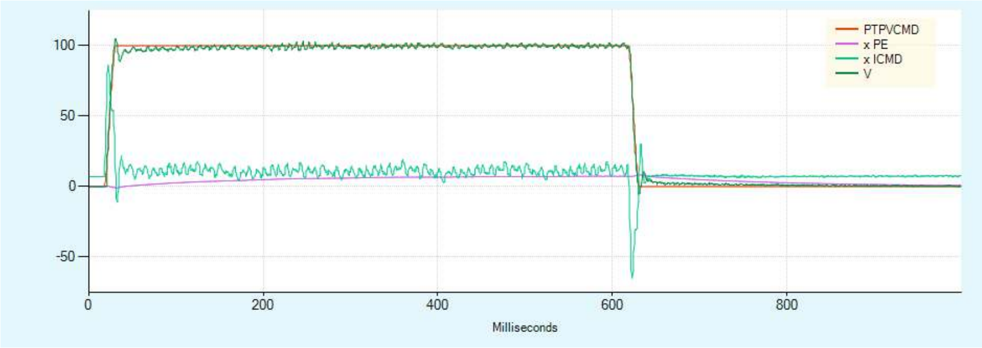


Figure 8-44. Dual Feedback – Tuning Position Controller (KNLDUALLOOPVFF) – Example

8.15 Gantry Tuning

Notes

The tuning procedure (motion/recording) for the gantry system is performed by the gantry Master drive.

All motion commands to the gantry system must be issued by the gantry Master drive.
The gantry Difference drive will reject motion commands.

Procedure: Tuning the Gantry System

1. Make sure you have completed the gantry system setup described in the section *Gantry Setup*.
2. Open the ServoStudio 2 **Operation Mode** screen.
For each drive, select Serial Position (OPMODE 8, COMMODE 0) operation mode.
3. Open the ServoStudio 2 Control>**Position Loop** screen.
For each drive, select Position Controller method **5-HD Controller**.
(POSCONTROLMODE 5)
4. Open the ServoStudio 2 Control>**Scope** screen.
Make sure the selected drive is the gantry Master.
   - Define the parameters to be recorded.
```
PTPVCMD
PE
V
ICMD
```
   - Define a serial position motion command, execute and record. View the resulting plot.

Note ServoStudio 2 will record PE and ICMD of both drives.

5. Gradually increase KNLD (HD derivative gain) until the system generates audible noises.
The goal is to maintain the highest KNLD with the least amount of filtering.
Adjust the gains of the gantry Master drive, as described in the following steps, while continuously testing the system.

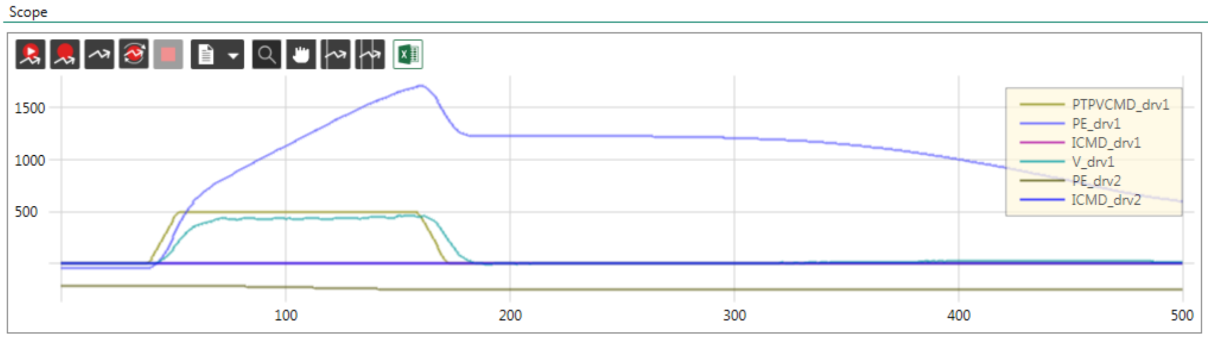


Figure 8-45. KNLD=1

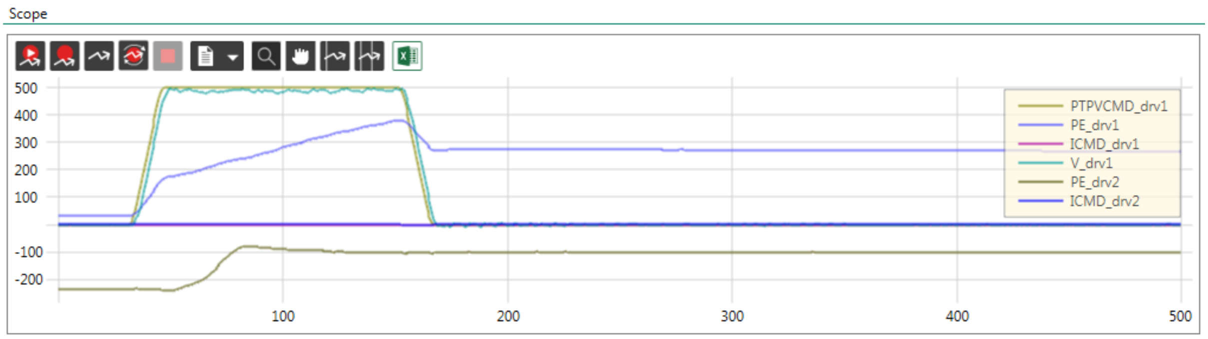


Figure 8-46. KNLD=20

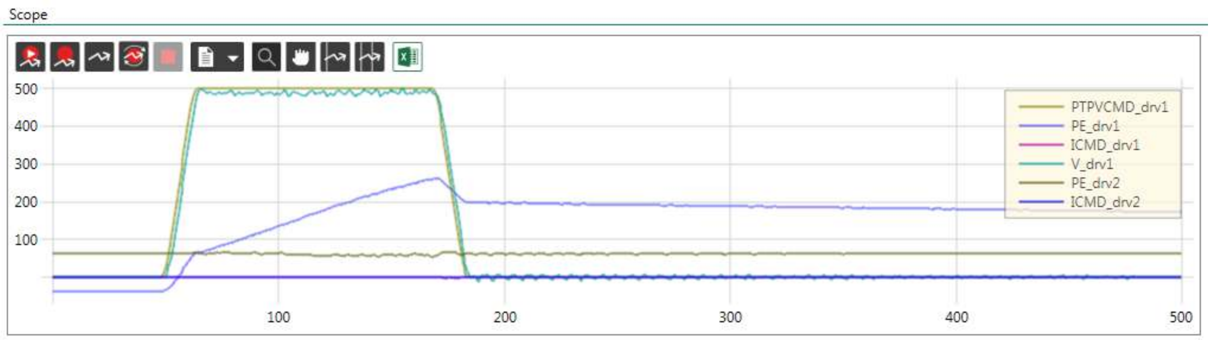


Figure 8-47. KNLD=50

6. Gradually increase KNLP (HD proportional gain) until the position error diminishes.

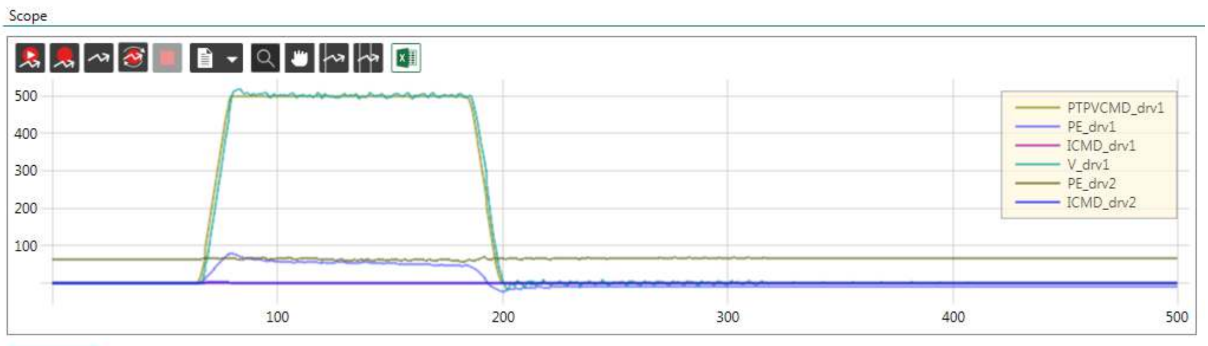


Figure 8-48. KNLD=20

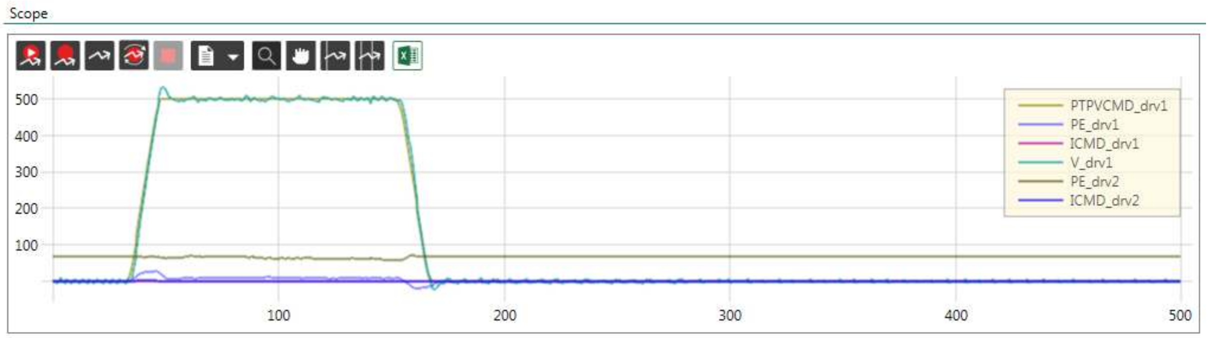


Figure 8-49. KNLD=50

7. Increase KNLI (HD integral gain) to reduce the standstill error.

   The maximum value of KNLI should always be less than $\frac{KNLP}{2}$.

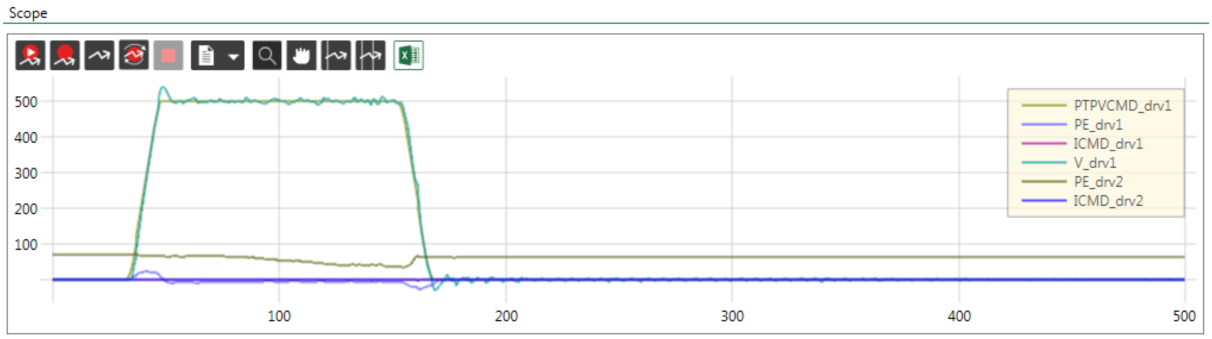


Figure 8-50. KNLD=20

8. If needed, reduce setting time by increasing KNLIV (HD derivative-integral gain).
   If there are vibrations at the end of the movement, reduce KNLIV.
9. Switch the active axis to the gantry **Difference** drive.
10. For a rigid gantry system set the Difference drive HD control loop gain parameter to 0.
    For a flexible gantry system, adjust the Difference drive gain parameters as described in the preceding steps.
    Most likely KNLI and KNIV need to be set to 0 to prevent current rise during standstill.
11. To test performance, switch the active axis to the gantry Master drive, and execute motion/record.

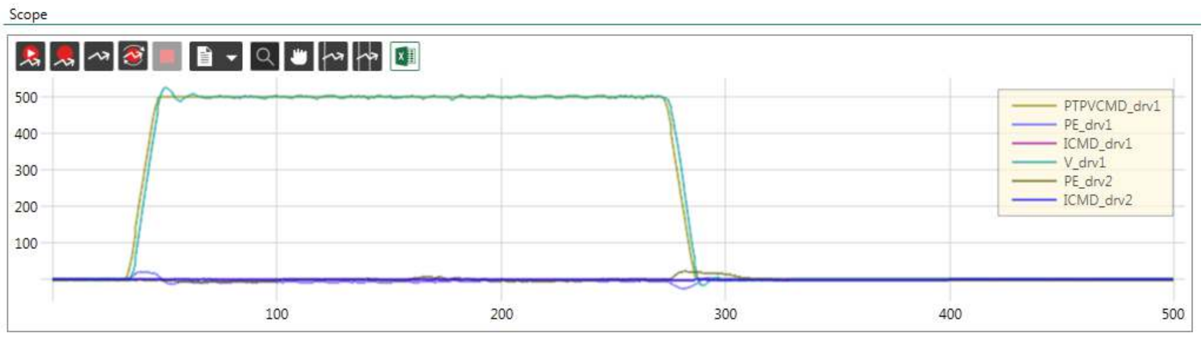


Figure 8-51. Both Axes are Tuned

Using Terminal for Tuning - Example

```
\1
K
#Delay 100
CLEARFAULTS
KNLUSERGAIN 1
NLTFDESIGNMODE 1
NLTFBW 400
KNLD 32
KNLP 16
KNLI 0
KNLIV 0
KNLVFF 1

\2
KNLUSERGAIN 1
NLTFDESIGNMODE 1
NLTFBW 400
KNLD 32
KNLP 8
KNLI 0
KNLIV 0
KNLVFF 1

\1
RECOFF
RECORD 32 2000 "PTPVCMD "PE "GANTRYMSTRVFB "ICMD
RECTRIG "PTPVCMD 10 100 1
ACC 100
DEC 100
MOVEABS 1400000 500
#PLOT
#Delay 4000
MOVEABS 0 250
```

8.16 Tuning Issues – Q&A

When should a notch filter be used?

> If your plant has high frequency vibrations, and produces shrieking or honking sounds when you raise the gain.

Although system performance is good, the system produces a lot of acoustical noise at low speeds. What should be done?

> Tune the system at a high speed, reduce global gain KNLUSERGAIN, increase low pass filter rise time NLFILTT1, and then increase NLMAXGAIN.

The system has flexibility, and overshoots at the end of the movement. How can overshoot be eliminated?

> Use a low value of acceleration filter NLAFFLPFHZ and decrease NLPEAFF. This will create an undershoot before the stop and eliminate the overshoot.

9 Operator Panel (HMI)

The CDHD2 operator panel is an HMI (human-machine interface) that allows you to monitor and edit parameter values, execute commands, and perform drive diagnostics and troubleshooting.

While COMMODE 0 is in effect, the drive can be fully controlled (enabled, motor movement, parameter modification) by both the operator panel and ServoStudio 2. Neither the operator panel nor ServoStudio 2 takes precedence.

Functions performed in the operator panel and in ServoStudio 2 are recognized by each other, but modifications to certain values, states and mode are not automatically displayed in the other. Changes made from the panel might not appear in a ServoStudio 2 screen until the screen in refreshed (exited and reopened).

When COMMODE 1 is in effect, the drive cannot be enabled, and the motor cannot be moved through the operator panel or ServoStudio 2. The operator panel can only be used to manipulate parameters that do not interfere with fieldbus operation. If you attempt to set a parameter that interferes with fieldbus operation, the drive will issue an error code in the operator panel and/or an error message in ServoStudio 2.

The operator panel has a 5-digit 7-segment LED display, and four control keys.

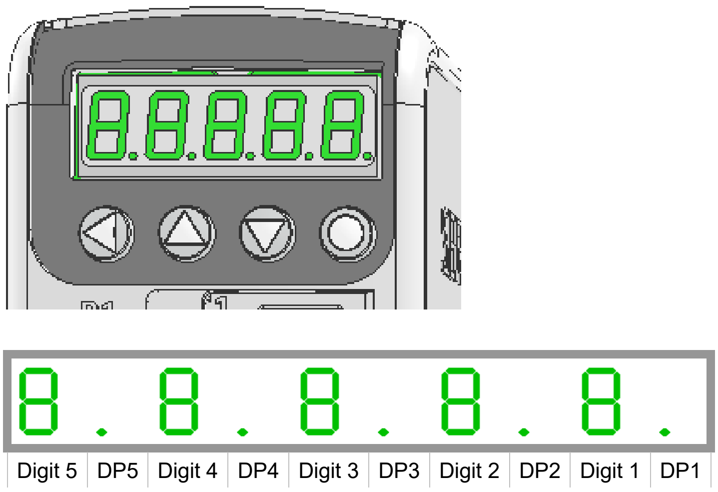


Figure 9-1. Five digit 7-segment display and keypad

Table 9-2. Operator Panel Control Keys

Key	Name	Function
	Mode	• Switches to next panel display mode (Status > Parameter > Command > Monitor > Fault > Status). • While editing, cancels the edited value and returns to mode menu.
	Shift | Enter	• Moves the cursor one digit to the left. • Press short: Shows the value of the currently selected parameter, and enables editing and setting of the parameter value. • Press long: Applies parameter number or value

Key	Name	Function
	Up	Parameter: • Press once: Navigates up to next parameter. • Press continuously: Quickly scrolls through ascending parameter indexes. Speed of scrolling increases the longer the key is pressed. Value: • Increases value by one increment
	Down	Parameter: • Press once: Navigates down to next parameter. • Press continuously: Quickly scrolls through descending parameter indexes. Speed of scrolling increases the longer the key is pressed. Value: • Decreases value by one increment
	Mode	• Scrolls to next panel display mode. • While editing, cancels the edited value and moves to next panel mode.
	Shift + Mode	Long press (>0.5 second) Applies parameter value and executes CONFIG. >> done
	Shift + Mode	Very long press (>2 seconds) Executes CONFIG after one second, then executes SAVE after two seconds. >> done

9.1 Operator Panel Modes

Use the Mode  button to scroll through the five digital display modes.

The operator panel has five modes:

Status (S)	**S**	Mode for displaying drive status, operating mode, warnings and motor movement. Refer to *Operator Panel – Status Mode* and *Digital Display – Warning Codes*.
Parameters	**P**	Mode for reading and writing values of drive parameters. Refer to the VarCom Reference Manual.
Command	**C**	Mode for executing drive commands. Refer to *Operator Panel – Command Mode*.
Monitoring	**d**	Mode for displaying drive and system variables, such as actual speed, position, input and output states. Refer to *Operator Panel – Monitoring Mode*.

Faults & Info	**F**	Mode for displaying fault codes and system information. Refer to *Operator Panel – Faults & Info Mode*.

The drive remembers the last selected setting or value in each mode.

If one or more faults occurs while in Status, Commands or Monitoring mode, the digital display automatically switches to Faults mode, and the most recent fault number is displayed. To resume working, a different display mode must be selected.

While in Parameters mode, an incorrect value will cause an error code to be displayed, but the digital display will not switch modes.

9.2 Operator Panel – Status Mode

The Status mode is indicated by the character **S** in digit 5.

In Status mode, the digital display indicates the state of the drive, the drive operating mode, drive enabled/disabled status, warnings, and motor movement.

The drive always powers up in Status mode, and indicates the operating mode in effect.

While the operating mode is displayed, DP1 is lit if the drive is enabled; DP1 is off if the drive is disabled.

HMI Status Codes

Status codes are shown in the table below.
In addition, refer to *Digital Display – Warning Codes*.

Table 9-3. Digital Display Status Codes

Digit or DP	Display	Description
DP 1	.	Drive enabled
	.	Drive disabled
Digits 1 and 2		Operating mode, depending on COMMODE.
		If COMMODE 0: Serial/Pulse/Analog (OPMODE)
	0 0	0 = Velocity control, using serial commands
	0 1	1 = Velocity control, using analog input
	0 2	2 = Current control, using serial commands
	0 3	3 = Current control, using analog input
	0 4	4 = Position control, using gearing input
	0 8	8 = Position control, using serial commands

Digit or DP	Display	Description
		If COMMODE 1: EtherCAT/CANopen (Object 6061)
	PP	1 = Profile Position mode
	PS	3 = Profile Velocity mode
	Pt	4 = Profile Torque mode
	HH	6 = Homing mode
	SP	8 = Cyclic Synchronous Position mode
	SS	9 = Cyclic Synchronous Velocity mode
	St	10 = Cyclic Synchronous Torque mode
DP 2	.	EtherCAT/CANopen OP mode active
	.	EtherCAT/CANopen INIT mode
Digit 3	r	Motor is moving
	.	Motor is not moving
Digit 4	#	First character of a warning code.
	.	No faults or warnings
Digit 5	S	Status mode. Displays the codes shown in this table.
	P	Parameter mode. Refer to *Operator Panel – Parameter Mode* and to the VarCom Reference Manual.
	C	Command mode. Refer to *Operator Panel – Command Mode*.
	d	Monitoring mode. Refer to *Operator Panel – Monitoring Mode*.
	F	Faults & Information mode Refer to *Operator Panel – Faults & Info Mode*.

HMI Special Status Codes

Power Up

During power up, the digital display shows 5 dashes.

This code is also displayed when the Ember switch is activated, which sets the drive to serial communication Boot-Up mode.

Ember Mode

During the firmware update process, the digital display shows:

9.3 Operator Panel – Parameter Mode

The Parameter mode is indicated by the character **P** in digit 5.

In Parameter mode, the digital display shows the value of drive parameters, and the panel is used to edit the values of drive parameters.

done indicates that a parameter has been set.

In Parameter mode, DP5 is lit to indicate the parameter is read only; for example, the value of Analog Output (P4219):

When editing in Parameter mode, an invalid value will cause an error message code to be displayed. (The panel does not switch to Fault mode.)

Error messages resulting from parameter manipulation are indicated by E followed by a two- or three-digit error code. Refer to *Error Messages*.

If CONFIG is required after a parameter value is entered, the display will flash.

CONFIG can be issued by a long press on Shift + Mode keys, or by command C0005, or through the ServoStudio 2 interface.

Setting a Parameter - Example

Code	**P0018**
Parameter	Motor Direction
VarCom	DIR
Sequence	Press: Mode Select: (up/down) **P**arameter mode Display: **P0000** Select: (up/down) **P0018** Press: Shift Display: **00000**, flashing digit Select: (up/down) parameter value; for example: **3** Display: **00003**, flashing **3** Press: Long Shift + Mode (0.5 second) to apply value and execute CONFIG. or Press: Very Long Shift + Mode (2 seconds) for CONFIG and SAVE. Done: **done**

HMI Parameter Value Manipulation

The digital display can present parameter values up to ±9,223,372,036,854,775,807.000

The first string is displayed by default. To view the second, third and fourth strings, press the Shift key repeatedly, until the display shows the next string.

The string can be recognized by the DPs that are lit:

- DP1: first string (integer value)
- DP1 + DP4: first string (value with 3 decimal places)
- DP1 + DP2: second string
- DP1 + DP2+ DP3: third string
- DP1 + DP2+ DP3 + DP4: fourth string

First string	Second string	Third string	Fourth string
integers up to 99999	numerals in values up to 9,999,999.xxx	numerals in values up to 999,999,999,999.xxx	numerals in values up to 99,999,999,999,999,999.xxx
			
or values up to 99.999			
			

Note that the first string might show 00.000. while the value of the parameter is shown and set in the second string; for example, if acceleration parameter (ACC/P0014) = 40000.000 [rpm/s]:

- First string:

- Shift to second string:

HMI Parameter Codes

Table 9-4. Parameter Groups

Parameter Group	Description
Basic - most frequently used	Starting at index 0000
Gains and Filters	Starting at index 1000
Shaping Filters	Starting at index 1100
Linear Loop Gains	Starting at index 1200
Current Loop Gains	Starting at index 1300
Feedback	Starting at index 2000
Secondary Feedback	Starting at index 2100
Motor	Starting at index 3000
Digital I/Os	Starting at index 4000
Analog I/Os	Starting at index 4100
Limits	Starting at index 5000
Communication/Fieldbus	Starting at index 6000
Drive Parameters and Foldback	Starting at index 7000
Emergency stop	Starting at index 7100
Homing	Starting at index 7200
Faults Modes and Thresholds	Starting at index 7300

Table 9-5. Parameter Codes

Parameter	Description	Code
Basic - most frequently used	**Starting at index 0000**	
COMMODE	Communication Mode	P0000
OPMODE	Drive Operation Mode	P0001
GEARMODE	Gearing Operation Mode	P0002
ADDR	Drive Communication Address	P0003
XENCRES	External Encoder Resolution	P0004
GEARIN	Gear Ratio Numerator	P0005
GEAROUT	Gear Ratio Divider	P0006
ENCOUTRES	Encoder Simulation Line Resolution	P0007
ENCOUTMODE	Encoder Simulation Mode	P0008

Parameter	Description	Code
ANIN1VSCALE	Analog Input 1 Velocity Scaling	P0009
ANIN1ISCALE	Analog Input 1 Current Scaling	P0010
ILIM	User Current Limit	P0011
VLIM	User Velocity Limit	P0012
VBUS	Bus Voltage (DC)	P0013
ACC	Acceleration	P0014
DEC	Deceleration	P0015
DISMODE	Disable Mode	P0016
DECSTOP	Active Disable Deceleration	P0017
DIR	Motor Direction	P0018
MFBDIR	Motor and Feedback Direction	P0019
MPHASE	Commutation Offset	P0020
PFBOFFSET	Position Offset	P0021
UNITSROTPOS	Units Rotary Position	P0022
UNITSROTACC	Units Rotary Acc/Dec	P0023
UNITSROTVEL	Units Rotary Velocity	P0024
UNITSLINPOS	Units Linear Position	P0025
UNITSLINACC	Units Linear Acc/Dec	P0026
UNITSLINVEL	Units Linear Velocity	P0027
Gains and Filters	**Starting at index 1000**	
POSCONTROLMODE	Position Loop Controller Mode	P1000
VELCONTROLMODE	Velocity Loop Controller	P1001
KNLUSERGAIN	HD Global Gain	P1002
KNLD	HD Derivative Gain	P1003
KNLP	HD Proportional Gain	P1004
KNLIV	HD Derivative-Integral Gain	P1005
KNLI	HD Integral Gain	P1006
KNLAFRC	HD Acceleration Feedforward	P1007
NLPEAFF	HD Flexibility Compensation	P1008
NLAFFLPFHZ	HD Spring Filter	P1009
NLFILTT1	HD Current Filter Low Pass Rise Time	P1010
NLFILTDAMPING	HD Current Filter Damping	P1011
NLMAXGAIN	HD Maximum Adaptive Gain	P1012
NLNOTCHCENTER	HD Current Filter Notch Center	P1013
NLNOTCHBW	HD Current Filter Notch Bandwidth	P1014
NLNOTCH2CENTER	HD Current Filter 2nd Notch Center	P1015
NLANTIVIBSHARP	HD AV 1 Filter Sharpness	P1016
NLANTIVIBGAIN2	HD Anti-Vibration 2 Filter ? Gain	P1017

Parameter	Description	Code
NLANTIVIBHZ2	HD AV 2 Filter Center Frequency	P1018
NLANTIVIBSHARP2	HD AV 2 Filter Sharpness	P1019
NLANTIVIBGAIN3	HD Anti-Vibration 3 Filter ? Gain	P1020
NLANTIVIBHZ3	HD AV 3 Filter Center Frequency	P1021
NLANTIVIBSHARP3	HD AV 3 Filter Sharpness	P1022
Shaping Filters	**Starting at index 1100**	
MOVESMOOTHMODE	Position Command Smoothing Mode	P1100
MOVESMOOTHSRC	Position Command Smoothing Source	P1101
MOVESMOOTHAVG	Position Command Moving Avg Filter	P1102
MOVESMOOTHLPFHZ	Position Command Move Low Pass Filter	P1103
GEARFILTMODE	Gearing Filter Mode	P1104
GEARFILTT1	Gearing Filter Depth	P1105
GEARFILTT2	Gearing Filter Vel and Acc Depth	P1106
GEARACCTHRESH	Gearing Acceleration Threshold	P1107
GEARFILTVELFF	Gearing Filter Velocity Feedforward	P1108
GEARFILTAFF	Gearing Filter Acceleration FF	P1109
Linear Loop Gains	**Starting at index 1200**	
KVP	Velocity Proportional Gain	P1200
KVI	Velocity Integral Gain	P1201
KVFR	Velocity Feedforward Ratio	P1202
FILTMODE	Velocity Loop Output Filter Mode	P1203
FILTHZ1	Velocity Loop Output Filter Param 1	P1204
FILTHZ2	Velocity Loop Output Filter Param 2	P1205
VELFILTMODE	Velocity Filter Mode	P1206
KPP	Position Proportional Gain	P1207
KPI	Position Integral Gain	P1208
KPISATIN	Position Integral Saturation Input	P1209
KPISATOUT	Position Integral Saturation Output	P1210
KPD	Position Derivative Gain	P1211
KPE	Position Adaptive Proportional Gain	P1212
KPVFR	Position Velocity Feedforward	P1213
KPAFRC	Position Acc FF to Current Loop	P1214
KPAFRV	Position Acceleration Feedforward	P1215
Current Loop Gains	**Starting at index 1300**	
KCP	Current KP Gain	P1300
KCI	Current KI Gain	P1301
KCD	Dead Time Compensation Min Level	P1302
KCFF	Current KFF Gain	P1303

Parameter	Description	Code
KCBEMF	Current BEMF Compensation Gain	P1304
KCMODE	Current Loop Compatibility Mode	P1305
MLGAINP	Adaptive Gain at Peak Motor Current	P1307
MLGAINC	Adapt Gain at Continuous Motor Current	P1308
MTANGLC	Torque Angle at Motor Continuous Current	P1308
MTANGLP	Torque Angle at Motor Peak Current	P1309
FRICINEG	Friction Compens Negative Current	P1310
FRICIPOS	Friction Compens Positive Current	P1311
FRICNVHYST	Friction Compens Neg Vel Hysteresis	P1312
FRICPVHYST	Friction Compens Neg Vel Hysteresis	P1313
I	Motor Current	P1314
ICMD	Current Command	P1315
ID	Current D Axis	P1316
IFFLPFHZ	Current Feedforward Low Pass Filter	P1317
IGRAV	Gravity Compensation	P1318
IMAX	Drive Current Limit	P1319
IQ	Current Q Axis	P1320
IU	Phase U Actual Current	P1321
IUOFFSET	Phase U Current Offset	P1322
IV	Phase V Actual Current	P1323
IVOFFSET	Phase V Current Offset	P1324
Feedback	**Starting at index 2000**	
FEEDBACKTYPE	Feedback Type	P2000
MENCRES	Motor Encoder Resolution	P2001
MENCTYPE	Motor Encoder Type	P2002
MSININT	Motor Sine Interpolation	P2003
BISSCFIELDS (argument 1)	Multi-turn Data (bits)	P2004
BISSCFIELDS (argument 2)	Effective Multi-turn Data (bits)	P2005
BISSCFIELDS (argument 3)	Single Turn Data (bits)	P2006
BISSCFIELDS (argument 4)	Effective Single Turn Data (bits)	P2007
RESBW	Resolver Conversion Bandwidth	P2008
HALLSINV	Hall Signals Inversion	P2009
HALLSTYPE	Hall Signals Type	P2010
PHASEFINDMODE	Phase Find Mode	P2011
PHASEFINDI	Phase Find Current	P2012
PHASEFINDTIME	Phase Find Duration	P2013
PHASEFINDGAIN	Phase Find Gain	P2014
HALLSCOMMTHRESH	Halls-Only Commutation Source Switch	P2015

Parameter	Description	Code
HALLSONLYCOMM	Halls-Only Commutation Source	P2016
HALLSFILTAFF	Halls-Only MSQ Filter Acc FF	P2017
HALLSFILTT1	Halls-Only MSQ Filter Depth	P2018
HALLSFILTT2	Halls-Only MSQ Filter Vel and Acc	P2019
HALLSFILTVELFF	Halls-Only MSQ Filter Velocity FF	P2020
HWPOS	Hardware Position	P2021
MECHANGLE	Motor Angle	P2023
MENCAQBFILT	Motor Encoder A/B Quadrature Filter	P2024
MENCZPOS	Motor Encoder Index Position	P2025
MFBMODE	Motor Feedback Mode	P2026
MRESPOLES	Motor Resolver Poles	P2027
RESAMPLRANGE	Resolver Amplitude Range	P2028
SININITMODE	Sine/Cosine Calibration Mode	P2029
TMTEMP	Tamagawa Temperature	P2030
INDEXDURATE	Simulated Encoder Index Pulse Duration	P2032
Secondary Feedback	**Starting at index 2100**	
HWPEXT	Hardware Position External	P2100
HWPEXTCNTRLR	Hardware Position External (FPGA)	P2101
HWPEXTMACHN	Hardware Position External (DSP)	P2102
SFB	Secondary Feedback	P2103
SFBMODE	Secondary Feedback Mode	P2107
SFBOFFSET	Secondary Feedback Offset	P2108
SFBTYPE	Secondary Feedback Type	P2113
LMUNITSDEN	Motor to Load Scaling Denominator	P2114
LMUNITSNUM	Motor to Load Scaling Numerator	P2115
Motor	**Starting at index 3000**	
MOTORNAME	Motor Name	P3000
MOTORTYPE	Motor Type	P3001
MICONT	Motor Continuous Current	P3002
MIPEAK	Motor Peak Current	P3003
MSPEED	Motor Maximum Speed	P3004
MPOLES	Motor Poles	P3005
MPITCH	Motor Pitch	P3006
MKT	Torque Constant	P3007
MKF	Torque Constant for Linear Motor	P3008
ML	Motor Inductance	P3009
MR	Motor Resistance	P3010
MOTORCOMMTYPE	Motor Commutation Type	P3011

Parameter	Description	Code
MFOLD	Motor Foldback Status	P3012
MFOLDD	Motor Foldback Delay Time	P3013
MFOLDDIS	Motor Foldback Disable	P3014
MFOLDF	Motor Foldback Factor	P3015
MFOLDR	Motor Foldback Recovery Time	P3016
MFOLDT	Motor Foldback Time Constant	P3017
MIFOLD	Motor Foldback Current	P3018
MIFOLDFTHRESH	Motor Foldback Fault Threshold	P3019
MTPMODE	Electronic Motor Nameplate Mode	P3020
Digital I/Os	**Starting at index 4000**	
INMODE 1	Input Mode (input 1)	P4000
INMODE 2	Input Mode (input 2)	P4001
INMODE 3	Input Mode (input 3)	P4002
INMODE 4	Input Mode (input 4)	P4003
INMODE 5	Input Mode (input 5)	P4004
INMODE 6	Input Mode (input 6)	P4005
INMODE 7	Input Mode (input 7)	P4006
INMODE 8	Input Mode (input 8)	P4007
INMODE 9	Input Mode (input 9)	P4008
INMODE 10	Input Mode (input 10)	P4009
INMODE 11	Input Mode (input 11)	P4010
ININV 1	Input Inversion (input 1)	P4011
ININV 2	Input Inversion (input 2)	P4012
ININV 3	Input Inversion (input 3)	P4013
ININV 4	Input Inversion (input 4)	P4014
ININV 5	Input Inversion (input 5)	P4015
ININV 6	Input Inversion (input 6)	P4016
ININV 7	Input Inversion (input 7)	P4017
ININV 8	Input Inversion (input 8)	P4018
ININV 9	Input Inversion (input 9)	P4019
ININV 10	Input Inversion (input 10)	P4020
ININV 11	Input Inversion (input 11)	P4021
OUTMODE 1	Output Mode (output 1)	P4022
OUTMODE 2	Output Mode (output 2)	P4023
OUTMODE 3	Output Mode (output 3)	P4024
OUTMODE 4	Output Mode (output 4)	P4025
OUTMODE 5	Output Mode (output 5)	P4026
OUTMODE 6	Output Mode (output 6)	P4027

Parameter	Description	Code
OUTMODE 7	Output Mode (output 7)	P4028
OUTINV 1	Output Inversion (output 1)	P4029
OUTINV 2	Output Inversion (output 2)	P4030
OUTINV 3	Output Inversion (output 3)	P4031
OUTINV 4	Output Inversion (output 4)	P4032
OUTINV 5	Output Inversion (output 5)	P4033
OUTINV 6	Output Inversion (output 6)	P4034
OUTINV 7	Output Inversion (output 7)	P4035
ENCOUTZPOS	Encoder Simulation Index Position	P4036
IN32OPMODES	Operation Mode Change Input Level	P4037
IN32SWITCH	Operation Mode Change Resume Motion	P4038
JOGSPD1	Jog Speed 1 Triggered by Input	P4039
JOGSPD2	Jog Speed 2 Triggered by Input	P4040
OUTBRAKE	Manual Brake by Output	P4041
OUTBRAKEINV	Manual Brake by Output Inverse	P4042
OUTBRAKEMODE	Manual Brake by Output Mode	P4043
OUTFLTLVL	Force Digital Output State on Fault	P4044
OUTILVL1	Current 1 Digital Output Definition	P4045
OUTILVL2	Current 2 Digital Output Definition	P4046
OUTINV	Position 1 Digital Output Definition	P4047
OUTPLVL2	Position 2 Digital Output Definition	P4048
OUTVLVL1	Velocity 1 Digital Output Definition	P4049
OUTVLVL2	Velocity 2 Digital Output Definition	P4050
RELAY	Fault Relay Status	P4051
RELAYMODE	Fault Relay Mode	P4052
Analog I/Os	**Starting at index 4200**	
ANIN1DB	Analog Input 1 Deadband	P4200
ANIN1FILTAFF	Analog Input 1 MSQ 2nd Deriv FF	P4201
ANIN1FILTIN	Analog Input 1 Before MSQ Filter	P4202
ANIN1FILTMODE	Analog Input 1 MSQ Filter	P4203
ANIN1FILTT1	Analog Input 1 MSQ Filter Depth	P4204
ANIN1FILTT2	Analog Input 1 MSQ 1st 2nd Deriv	P4205
ANIN1FILTVELFF	Analog Input 1 MSQ 1st Deriv FF	P4206
ANIN1LPFHZ	Analog Input 1 Filter	P4207
ANIN1OFFSET	Analog Input 1 Offset	P4208
ANIN2DB	Analog Input 2 Deadband	P4209
ANIN2ISCALE	Analog Input 2 Current Scaling	P4210
ANIN2LPFHZ	Analog Input 2 Filter	P4211

Parameter	Description	Code
ANIN2MODE	Analog Input 2 Mode	P4212
ANIN2OFFSET	Analog Input 2 Offset	P4213
ANIN2USER	Analog Input 2 Voltage User Units	P4214
ANIN2USERDEN	ANIN2USER Conversion Denominator	P4215
ANIN2USERNUM	ANIN2USER Conversion Numerator	P4216
ANIN2USEROFFSET	ANIN2USER Conversion Offset	P4217
ANIN2ZERO	Analog Input 2 Zero Command	P4218
ANOUT	Analog Output Value	P4219
ANOUTCMD	Analog Output Command	P4220
ANOUTISCALE	Analog Output Current Scaling	P4221
ANOUTLIM	Analog Output Voltage Limit	P4222
ANOUTMODE	Analog Output Mode	P4223
ANOUTVSCALE	Analog Output Velocity Scaling	P4224
Limits	**Starting at index 5000**	
LIMSWITCHNEG	Limit Switch Negative Status	P5000
LIMSWITCHPOS	Limit Switch Positive Status	P5001
GEARLIMITSMODE	Electronic Gearing Mode	P5002
POSLIMHYST	SW Position LS Hysteresis Value	P5003
POSLIMMODE	Position Limiting Mode	P5004
POSLIMNEG	Minimum Software Position Limit	P5005
POSLIMPOS	Maximum Software Position Limit	P5006
ILIMACT	Drive Actual Current Limit	P5007
Communication/Fieldbus	**Starting at index 6000**	
BAUDRATE	Serial Baud Rate	P6000
CANBITRATE	CAN Bus Bit Rate	P6001
CHECKSUM	Checksum	P6002
ECHO	Serial Communication Character Echo	P6003
PNUM	Feed Constant Scaling Numerator	P6004
FBGDS	Fieldbus Gear Driving Shaft Scaling	P6006
FBGMS	Fieldbus Gear Motor Shaft Scaling	P6007
FBITIDX	Fieldbus Interpolation Time Index	P6008
FBITPRD	Fieldbus Interpolation Time	P6009
FBPLIGNORE	Fieldbus Ignore Packet Loss Fault	P6010
FBSCALE	Fieldbus Unit Scaling	P6011
MSGPROMPT	Drive Messages and Prompts	P6012
Drive Parameters and Foldback	**Starting at index 7000**	
DICONT	Drive Continuous Current	P7000
DIPEAK	Drive Peak Current	P7001

Parameter	Description	Code
FOLD	Drive Foldback Status	P7002
IFOLD	Drive Foldback Current Limit	P7003
IFOLDFTHRESH	Drive Foldback Fault Threshold	P7004
IFOLDWTHRESH	Drive Foldback Warning Threshold	P7005
IZERO	Zero Procedure Current	P7006
Emergency Stop	**Starting at index 7100**	
DECSTOPTIME	Active Disable Deceleration Time	P7102
DISSPEED	Active Disable Speed Threshold	P7103
DISTIME	Active Disable Time	P7104
ESTOPILIM	Current Limit During Emergency	P7105
HOLD	Hold Position Command	P7106
ISTOP	Dynamic Braking Current	P7107
COMMERRTTHRESH	Commutation Error Threshold	P7109
COMMERRVTHRESH	Commutation Velocity Deviation	P7110
STALLTIME	Stall Time	P7111
STALLVEL	Stall Velocity	P7112
Homing	**Starting at index 7200**	
HOMETYPE	Homing Type	P7200
HOMECMDST	Homing Process Status	P7202
HOMEIHARDSTOP	Current for Homing on Hard Stop	P7203
HOMEOFFSET	Home Offset	P7204
HOMEOFSTMOVE	Home Offset Move	P7205
HOMESPEED1	Homing Speed 1 - Switch Search	P7206
HOMESPEED2	Homing Speed 2 - Index Search	P7207
HOMESTATE	Homing Status	P7208
Faults Modes and Thresholds	**Starting at index 7300**	
UVMODE	Under-Voltage Mode	P7300
UVRECOVER	Under-Voltage Recovery Mode	P7301
UVTHRESH	Under-Voltage Threshold	P7302
UVTIME	Under-Voltage Time	P7303
IGNOREBRKFLT	Ignore Power Brake Fault	P7304
LINELOSSMODE	Bus AC Supply Line Disconnect Mode	P7305
LINELOSSRECOVER	Bus AC Disconnect Recovery Mode	P7306
LINELOSSTYPE	Bus AC Supply Line Disconnect Type	P7307
OVTHRESH	Over-Voltage Threshold	P7308
PWMFRQ	PWM Frequency	P7309
REGENFLTMODE	Regeneration Resistor Fault Mode	P7310
REGENMAXONTIME	Regeneration Resistor Max On Time	P7311

Parameter	Description	Code
REGENMAXPOW	Regeneration Resistor Maximum Power	P7312
REGENPOW	Regeneration Resistor Power	P7313
REGENRES	Regeneration Resistor Resistance	P7314

9.4 Operator Panel – Command Mode

The Command mode is indicated by the character C in digit 5.

In Command mode, the panel is used to issue commands to the drive.

If an invalid command argument is entered, an error message code will be displayed. Error messages resulting from parameter manipulation are indicated by Er followed by a two- or three-digit error code.

For the full list of error message codes, refer to *Error Messages*.

HMI Command Codes

Command codes are shown in the table below.

The sequences for entering the commands are presented in the sections that follow.

When selecting/entering a command, 0 often flashes once in digit 1. This is standard behavior of the panel, indicating a value can be entered.

Table 9-6. Command Codes

Command - VarCom	Description	Code
HDTUNE	Initiate Drive-based Autotuning	C0000
MOTORSETUP	Motor Setup Command	C0001
CLEARFAULTS	Clear Faults	C0002
EN / K	Enable/Disable	C0003
J	Jog Command	C0004
CONFIG	Configure Drive	C0005
SAVE	Save Parameters	C0006
MTTURNRESET	Encoder Multi-Turn Reset	C0007
FACTORYRESTORE	Restore Factory Settings	C0008
ANIN1ZERO	Analog Input 1 Zero Command	C0009
MOVEABS	Move Absolute Command	C0010
MOVEINC	Move Incremental Command	C0011

Command - VarCom	Description	Code
HOMECMD	Homing Command	C0012
PHASEFIND	Phase Find Command	C0013
SININIT	Sine/Cosine Calibration Command	C0014

Autotuning

<table>
<tr><td>Code</td><td>C0000</td></tr>
<tr><td>Command</td><td>Initiate Drive-based Autotuning</td></tr>
<tr><td>VarCom</td><td>HDTUNE</td></tr>
<tr><td>Sequence</td><td>Make sure the drive is disabled, and has no faults
Select: C0000
Press: Shift
Display: Atune

Press: Shift
Display: Flashing 0. in digit 1
Insert a value that represents the autotuning options:
<table>
<tr><td>0</td><td>Internal Motion Generator – Express, drive-based</td></tr>
<tr><td>1</td><td>Internal Motion Generator – Advanced, drive-based</td></tr>
<tr><td>2</td><td>Internal Motion Generator – Advanced, for vertical applications, drive-based</td></tr>
<tr><td>10</td><td>External Motion Generator – Express, controller-based</td></tr>
<tr><td>11</td><td>External Motion Generator – Advanced, controller-based</td></tr>
<tr><td>12</td><td>External Motion Generator – Advanced, for vertical application, controller-based</td></tr>
<tr><td>13</td><td>External Motion Generator – Advanced, with command smoothing, controller-based</td></tr>
<tr><td>14</td><td>External Motion Generator – Advanced, with command smoothing for vertical application, controller-based</td></tr>
</table>
Press: Long Shift
Display: Autotuning progress in % number (DP1 is lit)
Done: done
(or an error code)</td></tr>
<tr><td>Note</td><td>During autotuning:
A warning will be displayed as S#
A fault will be displayed as F# flashing</td></tr>
</table>

Motor Setup

Code	**C0001**
Command	Motor Setup
VarCom	MOTORSETUP
Sequence	Make sure the drive is disabled, and has no faults Select: C0001 Press: Shift Display: **nnset**  Press: Long Shift Display: Motor setup progress in % number Done: **done** (or an error code)

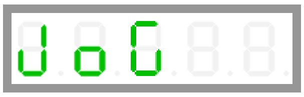
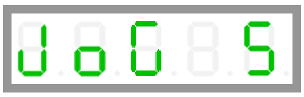
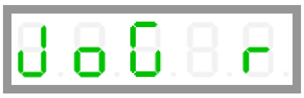
Clear Faults OK

Code	**C0002**
Command	Clear Faults
VarCom	CLEARFAULTS
Sequence	Select: C0002 Press: Shift Display: **00000.** Press: Shift Display: Flashing **0.** in digit 1 Press: Long Shift Display: **00000.** or will continue to show the fault code

Enable / Disable

Code	C0003
Command	Enable/Disable (Toggle)
VarCom	EN / K
Sequence	Select: C0003 Press: Shift Display: 00.000. Press: Long Shift Done: 00.000.
Sequence	Select: C0003 Press: Shift Display: 00.000. Press: Shift Display: Flashing 0. in digit 1 Press: Long Shift Done: 00.000.
Note	The ServoStudio 2 toolbar/status bar might not accurately reflect change in Enable/Disable state. Use the ST command in Terminal to verify.

Jog

Code	**C0004**
Command	Jog
VarCom	J
Note	Jog speed range: 1 rpm to VLIM The jog command from the panel functions in both 0 and 8 modes
Sequence	Make sure drive is in appropriate operating mode. Make sure drive is Enabled. Select: C0004 Press: Shift Display: **joG88**  Press: Shift Display: **00.000.** Press: Shift Display: flashing **0.** in digit 1 For example, set a speed of 300 rpm First string = values up to 99.999. Nothing to set.  Press: Shift until you reach the first digit in the second string. Second string = values up to 9999,9nn.nnn. Press: Up to reach 3  Press: Long Shift Display: joG8S (jog motion stopped)  Press and hold Up key move motor at defined speed in positive direction. Press and hold Down key to move motor at defined speed in negative direction. Display: jog8r (rotating, during motion) 

Config

Code	**C0005**
Command	Configure Drive
VarCom	CONFIG
Sequence	Select: C0005 Show: **config**  Press: Shift Display: Flashing **0.** in digit 1 Press: Long Shift Done: **done** (momentarily), and then **00000.** (or an error code)

Save Parameters

Code	**C0006**
Command	Save Parameters
VarCom	SAVE
Sequence	Select: C0006 Press: Shift Display: **done** (or an error code)

Encoder Multi-Turn Reset

Code	**C0007**
Command	Encoder Multi-turn Reset
VarCom	MTTURNRESET
Sequence	Select: C0007 Press: Shift. Display: **done** (or an error code)

Restore Factory Settings

Code	C0008
Command	Restore Factory Settings
VarCom	FACTORYRESTORE
Sequence	Make sure drive is Disabled. Select: C0008 Display: frstr  Press: Shift Display: Flashing 0. in digit 1 Press: Up (>1) for digits 1 to 4 Display: 0 1 1 1 1. Press: Long Shift Display: done (momentarily), then flashes, and stops.

Analog Input 1 Zero

Code	C0009
Command	Analog Input 1 Zero Command
VarCom	ANIN1ZERO
Sequence	Make sure drive is Disabled. Select: C0008 Press: Shift Display: Flashing 0. in digit 1 Press: Long Shift Display: done (or an error code)

Move Absolute - Distance

Code	**C0010**
Command	Move Absolute - distance
VarCom	MOVEABS {distance} {velocity} Sets the distance argument. Command uses velocity value set by JOGSPD1.
Sequence	Make sure drive is Enabled. Select: C0010 Display: **absnn**  Press: Long Shift Display: Flashing **0.** in digit 1 Press: (for example) Set a value of 15 (revolutions) Press: Long Shift (motor rotates) Display: **abSnn** (during motor movement) Display: **done** (or an error code)

Move Incremental - Distance

Code	**C0011**
Command	Move Incremental - distance
VarCom	MOVEINC {distance} {velocity} Sets the distance argument. Command uses velocity value set by JOGSPD1.
Sequence	Select: C0011 Display: **incnn**  Press: Long Shift Display: flashing **0** Press: (for example) Set a value of 2 (revolutions) Press: Long Shift Display: **incnn** (during movement) Display: **done** (or an error code) Note value of movement = revolution, counts, degrees Sets distance for movement. Speed is set according JOGSPD1

Home

Code	**C0012**
Command	Home
VarCom	HOMECMD
Sequence	Select: C0012 Display: **honne**  Press: Shift Display: Flashing **0.** in digit 1 Press: Set the value of a homing type Press: Long Shift Press: Long Shift Display: (indicates homing progress in a % number) Display: **done** (or an error code)

Phase Find

Code	**C0013**
Command	Phase Find
VarCom	PHASEFIND
Sequence	Select: C0013 Press: Shift. Display: **PhaSe**  Press: Shift Display: Flashing **0.** in digit 1 Press: Long Shift Display: **done** (or an error code)

Sine/Cosine Calibration

Code	**C0014**
Command	Sine/Cosine Calibration
VarCom	SININIT
Sequence	Select: C0014 Display: **sinin**  Press: Shift Display: Flashing **0.** in digit 1 Press: Long Shift Display: **done** (or an error code)

9.5 Operator Panel – Monitoring Mode

The Monitoring mode is indicated by the character **d** in digit 5.

In Monitoring mode, the panel is used to read drive variables, such as speed, position, and current, inputs and outputs.

HMI Monitor Codes

Table 9-7. Monitor Codes

Command - VarCom	Description	Code
V	Actual speed, in rpm	**d0000**
PFB	Actual position, in degrees	**d0001**
PFB	Actual position, in revolutions	**d0002**
I	Current, in amperes	**d0003**
IN	Digital inputs 1 through 10	**d0004**
IN	Digital input 11	**d0005**
OUT	Digital outputs 1 through 7	**d0006**
Not Applicable	CAN statusword	**d0007**
Not Applicable	CAN controlword	**d0008**
ANIN1	Analog input 1	**d0009**
ANIN2	Analog input 2	**d0010**
HWPEXT	Hardware position-external	**d0011**

Actual Speed

Code	d0000
Command	Velocity
Description	Shows the actual speed of the motor, as measured by the primary feedback, in rpm. Speed is shown in digits 4 3 2 1 If motion is in a negative direction, DP5 is lit.
VarCom	V
Sequence	Select: d0000 Press: Shift Display: 00000 Press: Shift (repeatedly), until only DP1 is lit. Start motion.
Examples	0 0 2 5 0. = positive motion 250 rpm 0 0 0 2 0. = positive motion 20 rpm 0.0 2 5 0. = negative motion 250 rpm 0.0 0 2 0. = negative motion 20 rpm

Actual Position (degrees)

Code	d0001
Command	Actual Position, in degrees
Description	Shows the actual position of the motor, as measured by the primary feedback, in degrees. If the position is a negative value, DP5 is lit.
VarCom	PFB
Sequence	Select: d0001 Press: Shift (repeatedly) until only DP2 and DP1 are lit. Start motion.
	Press the Shift key to view the next string.
Examples	Examples of display: 0025.0. during motion 0036.0. (move absolute 36,000 degrees position: 100 revs.) 0360.0. (move absolute 360,000 degrees position: 1000 revs.) 1800.0. (move absolute 1,080,000 degrees position: 3000 revs.) 0.003.6. (move absolute -3,600 degrees position: -10)

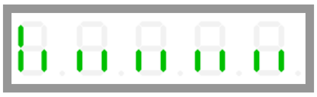
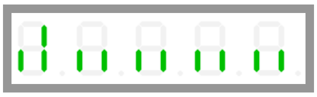
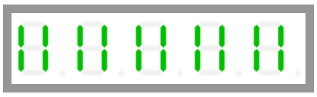
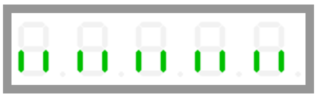
Actual Position (rev)

Code	d0002
Command	Actual Position, in revolutions
Description	Shows the actual position of the motor, as measured by the primary feedback, in revolutions. If the position is a negative value, DP5 is lit.
VarCom	PFB
Sequence	Select: d0002 Press: Shift Start motion.
	If number of revolutions = 1000 – 9999: digits 4 3 2 1 = integer value If number of revolutions <1000: digits 4 3 2 = integer value, digit 1 = decimal value DP1 is lit If number of revolutions <100 digits 4 3 = integer value digits 2 1 = decimal value DP2 and DP1 are lit If number of revolutions <10 digit 4 = integer value digit 3 2 1 = decimal value DP3, DP2 and DP1 are lit If number of revolutions > 10,000, press **Shift** to view the next string.
Examples	Examples of display: If position = 00.000 to 99.999: String 1: 78.123. 78.123 revolutions 97.345 97.345 revolutions If position = 100.000 to 999.999: String 1: 01.789. = 101.789 revolutions 04.367. = 104.367 revolutions Press Shift String 2: 0000.1. = 101.789 0000.1. = 104.367

Actual Current

Code	d0003
Command	Motor Current
Description	Shows the motor current, in amperes. If the current is a negative value, DP5 is lit.
VarCom	I
Sequence	Select: d0003 Press: Shift Display: 0 0. # # #.
Examples	During motion, values change continuously. 00.178. 00.188. 00.192. 00.204.

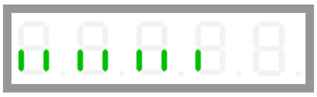
Digital Inputs 1 through 10

Code	**d0004**
Command	Digital Inputs State
Description	Indicates the state of digital inputs 1 through 10. Double height line = on Single height line = off Read from left to right.
VarCom	IN
Sequence	Select: d0004 Press: Shift
Examples	Digital input 1 on. Digital inputs 2 through 10 off.  Digital input 2 on. Digital inputs 1, 3 through 10 off.  Digital inputs 1 through 10 are all on.  Digital inputs 1 through 10 are all off. 

Digital Input 11

Code	**d0005**
Command	Digital Input 11 Status
Description	Indicates the state of digital input 11. Double height line = on Single height line = off
VarCom	IN
Sequence	Press: d0005 Press: Shift
Examples	Digital input 11 is on.  Digital input 11 is off. 

Digital Outputs 1 through 7

Code	**d0006**
Command	Digital Outputs State
Description	Indicates the state of digital outputs 1 through 7. Double height line = on Single height line = off Read from left to right.
VarCom	OUT
Sequence	Press: d0006 Press: Shift
Examples	Digital outputs 1 through 7 are all on.  Digital outputs 1 through 7 are all off. 

Returns CAN Statusword

Code	**d0007**
Command	Returns Statusword
Description	Object 6041h
VarCom	Not Applicable
Sequence	Press: d0007 Press: Shift Display: **h4250** (for example)

Returns CAN Controlword

Code	**d0008**
Command	Returns Controlword
Description	Object 6040h
VarCom	Not Applicable
Sequence	Press: d0008 Press: Shift Display: **h0000** (for example)

Analog Input 1 Value

Code	**d0009**
Command	Analog Input 1 Value
Description	Shows the value of analog input 1, in millivolts
VarCom	ANIN1
Sequence	Press: d0009 Press: Shift Display: **02.286.** (for example)

Analog Input 2 Value

Code	**d0010**
Command	Analog Input 2 Value
Description	Shows the value of analog input 2, in millivolts
VarCom	ANIN2
Sequence	Press: d0010 Press: Shift

Hardware Position External (counts)

Code	d0011
Command	Hardware Position External
Description	Shows the position as measured by an external feedback device, in counts
VarCom	HWPEXT
Sequence	Press: d0011 Press: Shift Display: 00032. (for example)
Examples	-16 counts 0.0016.

9.6 Operator Panel – Faults & Info Mode

The Faults & Info mode is indicated by the character **F** in digit 5.

HMI Fault Codes

If one or more faults occurs while the digital display is in Status, Commands or Monitoring mode, the Faults mode "hijacks" the display, and the code of the most recent fault is displayed.

When faults occur simultaneously, the display shows the code of the fault with the highest priority.

To resume work, after clearing the fault/s, you must select a different display mode.

When the digital display is in Fault mode, the fault codes are displayed as a string, in digits 4, 3, 2 and 1 as needed, and do not flash.

If a fault remains in effect, and a different display mode is selected, the fault code characters will be displayed sequentially in digit 4, with flashing.

For the full list of Fault codes, refer to *Digital Display – Fault Codes*.

HMI Info Codes

The Faults & Info mode is also used to display faults history, warning history, and drive information.

Info codes are shown in the table below.

The sequences for entering codes and viewing information are presented in the sections that follow.

Table 9-8. Info Codes

Command - VarCom	Description	Code
FLTHIST	Faults History	F0001
VER	Firmware Version	F0002
VER	FPGA Version	F0003
Not Applicable	Warnings History	F0004

Faults History

Code	F0001
Command	Faults History
VarCom	FLTHIST
Example	Fe123: TP Read Failure Fr20: Feedback Communication Error Fe: Parameter Memory Checksum Failure Fr25: Pulse and Direction Input Line Break
Sequence	Select: F0001 Press: Shift Display: Fr123 Press: Up Display: Fr2 Press: Up Display: Fe
Note	Since the same fault may have been triggered multiple times, you may need to press the Up or Down key several times before the code changes. Alternately, press and hold the Up or Down key. The longer you press the key, the faster the scrolling.

Firmware Version

Code	**F0002**
Command	Firmware Version
VarCom	VER
Example	Firmware version: 2.0.0a0.0.48
Sequence	Select: F0002 Press: Shift Display:  Press: Shift Display:  Press: Shift Display:  Press: Shift Display: **00000** Press: Shift (display returns to 2 .0 .0)

FPGA Version

Code	**F0002**
Command	Firmware Version
VarCom	VER
Example	FPGA Version: 4.08 March 16 2017
Sequence	Select: F0002 Press: Shift Display:  Press: Shift Display:  Press: Shift Display:  Press: Shift Display: 

Warnings History

Code	**F 0 0 0 4**
Command	Warnings History
VarCom	Not Applicable
Example	**F** : Foldback Warning **n** : STO Warning **L 6** : Software Limit Switches are Tripped
Sequence	Select: F0001 Press: Shift Display: **F** Press: Up Display: **n** Press: Up Display: L6
Notes	When displayed in Status mode, multi-character warning codes are displayed in sequence, in digit 4 only. When displayed in Faults & Info mode, multi-character codes are displayed as strings. Since the same warning may have been triggered multiple times, you may need to press the Up or Down key several times before the code changes. Alternately, press and hold the Up or Down key. The longer you press the key, the faster the scrolling.

10 Functional Safety

10.1 Safe Torque Off (STO) Overview

Functional safety in the CDHD2 servo drive is implemented by means of the safe torque off (STO) function. Activation of the Safe Torque Off (STO) function causes the drive to stop providing power which controls the motor movement. STO ensures that no torque-generating energy can continue to act upon a motor, and prevents unintentional starting or motor rotation while the drive remains connected to a power supply.

The advantage of the integrated STO safety function over standard safety technology using electromechanical switchgear is the elimination of separate components and the effort required to wire and service them.

In addition, the function has a shorter switching time than the electromechanical components in conventional safety solutions.

Note When the STO function is active, power to the STO circuit is removed, and power to the motor is inhibited.

The STO function is defined in standard EN/IEC 61800-5-2, and relates to an uncontrolled stop as per stop category 0 of IEC 60204-1.

Standard EN/IEC 61800-5-2 defines the functional safety requirements for adjustable speed electrical power drive systems. According to this standard, when the STO function is active, power that can cause motion is not applied to the motor.

The STO function may be used where power removal is required to prevent an unexpected startup.

Warning: Drives with a suspended load must have an additional mechanical safety block (such as a motor-holding brake) since the drive cannot hold the load when STO is in effect. Serious injury could result if the load is not properly safeguarded.

The STO function in the CDHD2 removes power from the gate drivers of the power module, effectively inhibiting PWM pulses from driving the IGBTs, as shown in the following figure.

10.2 STO Modules in CDHD2 Servo Drives

Several types of STO modules are currently in use in the various CDHD2 servo drives:

- STO_A3, STO_A4 and STO_A5 generate only positive supply voltages to the gate drivers.
- STO_B generates both positive and negative supply voltages to the gate drivers.

Product Family	Size	Input Voltage	Nominal Output Current	STO Circuit	STO Compliance
CDHD2	2A	120/240 VAC	1.5A, 3A	STO_A3	Yes*
CDHD2	2B	120/240 VAC	4.5A, 6A	STO_A3	Yes*
CDHD2	2C	120/240 VAC	8A, 10A, 13A	STO_A3	Yes*
CDHD2	2D	120/240 VAC	20A, 24A	STO_B	Yes*

Product Family	Size	Input Voltage	Nominal Output Current	STO Circuit	STO Compliance
CDHD2	2E	120/240 VAC	55A	STO_A5	Yes*
CDHD2	1D	20/90 VDC	3A, 6A, 12A, 15A	STO_A4	Yes*

* Certification pending

10.3 STO Functional Safety Specifications

Note STO certification is currently pending for all CDHD2 models.

Table 10-1. STO/Functional Safety Specifications – All CDHD2 Models

Feature	Specification					
Performance Level	Compliant with Category 3 PL e (ISO 13849-1)					
Safety Integrity Level	Compliant with SIL 3 (IEC 61508 / IEC 62061 / 61800-5-2)					
Reliability Data	**SFF**	**MTTFd**	**PFH***	**PFDAVG****	**PL**	**Cat.**
	99.0%	59924	1.90E-9	1.67E-5	e	3
	* Probability of failure per hour ** Probability of failure on demand, calculated as one demand per year					

Additional Safety Parameters:

Operation mode: PFH=1.7E-9, HFT=0, SFF=98.9%, PTI, Systematic capability SIL 3, Type A, MTTR, MTTFd=67949 years, PFDavg=1.5E-5.

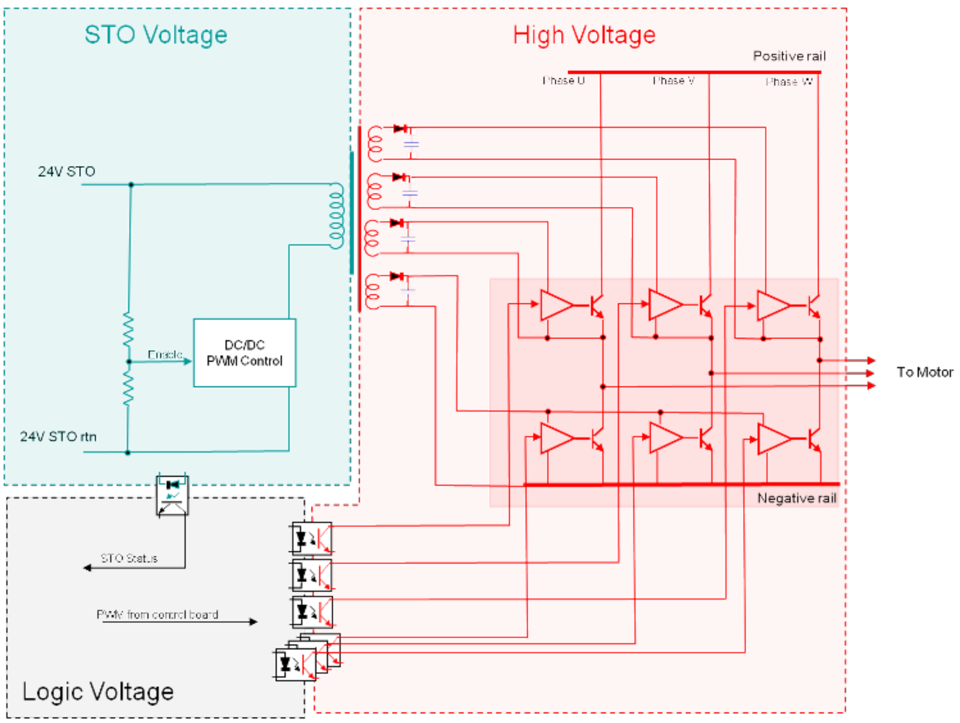


Figure 10-1. STO Circuit Wiring

10.4 STO System Requirements

STO Power Supply

To avoid a high voltage level at the STO input, a low voltage must be used for safety related parts.

A voltage supply unit of 24 volts must be used. This voltage supply unit must comply with PELV/SELV, as per EN 60204-1 (Safety of Machinery - Electrical Equipment of Machines – Part 1: General Requirements).

Note The CDHD2 internal 24 VDC supply is not approved for use in safety applications, and is thus prohibited for use as the STO power supply.

STO Cable

The STO cable must be less than 30 meters in length to conform to EN 61800-5-2.

Shielded and double insulated cables must be used. Double insulation refers to the need for a cable jacket on the wire that supplies the power.

The cable shield must be connected to the ground of the power supply.

The ideal gauge for the cable wire is 22 AWG (0.34 mm^2). Since current drain by the STO circuit is less than 0.25A, 24 AWG (0.25 mm^2) is also suitable.

The STO cable must be spatially separated from any sources of environmental stress, be it mechanical, electrical, thermal or chemical.

Note A fault exclusion must be carried out for the STO input wiring according to EN 61800-5-2 Table D.1 and D.3 / EN ISO 13849-2, Table D.5.

10.5 Using STO

STO Behavior

The STO function serves exclusively to provide a safe stop of the motion system according to the STO specification in IEC 61800-5-2. Triggering the STO function results in power being removed from the motor control circuits, and, as a result the motor is without control. When STO is triggered while the motor is in motion, the motor shaft and its linked mechanical elements coast until brought to a stop by their own friction.

The immediate effect of STO is that the drive cannot supply any torque-generating energy. STO can be used in applications where the motor is expected to reach a standstill within a sufficiently short time based on the load and friction, and when coasting down of the motor will not have any impact on safety.

The following figure illustrates what happens to the motor when the STO function is in effect. The graph depicts a motor being driven in constant velocity mode, and the coasting of the motor to a stop when the power to the STO circuit is removed.

The graph shows motor speed as a function of time. It compares the behavior of the motor when brought to a controlled stop (STO function not in effect – VCMD and V traces) and when coasting to a stop (STO function in effect – Ref traces).

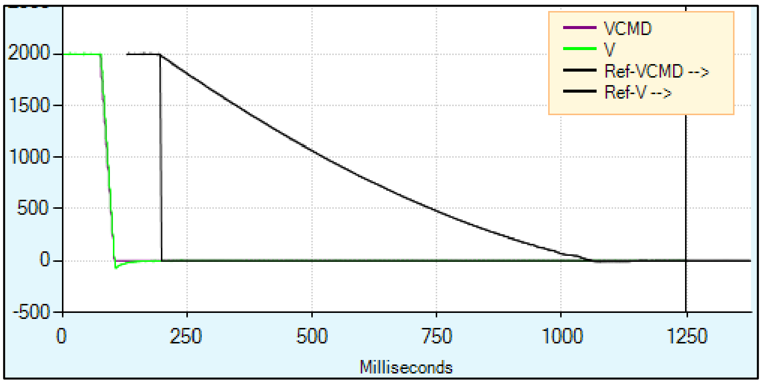


Figure 10-2. Motor Coasting to Stop when STO Function in Effect

STO Indicators

STO status and diagnostic information is available in the following ways.

Digital Display

If the drive is disabled and STO is in effect (STO power is removed), a warning condition occurs, indicated by a steadily lit **n** when the panel is in Status mode. (08 indicates the operation mode in this example.)

If the drive is enabled and STO is in effect (STO power is removed), a fault condition occurs, and the digital display automatically switches to Fault mode.

If the panel mode is switched back to Status mode while the fault condition still exists, the display shows **S n** with a flashing **n** (in accordance with panel mode behavior).

Serial Communication

Using serial communications (terminal), the query ST returns a list of status reports. The status varies slightly when the STO is in effect (STO power is removed), depending on whether the drive is enabled or disabled at time STO power was removed.

If the drive is disabled and the STO is in effect (STO power is removed), a Warning condition occurs, and the status report shows the warning:

```
Drive Inactive
Drive not ready:
   No SW enable
Warnings Exist:
   WRN 1  STO Signal Not Connected
```

If the drive is enabled and the STO power is removed, this is a fault condition, and the status report indicates a fault.

```
Drive Inactive
Drive not ready:
   No SW enable
   Fault exists
```

```
Fault exists:
   FLT 4  STO Fault
```

Since the drive was enabled and a fault occurred, the Fault Recovery procedure must be performed.

CANopen and EtherCAT

If the drive is enabled and the STO power is removed, a fault condition occurs.

Object 603Fh sub-index 0 provides the error code for the current errors.

The STO fault code is 12673 (decimal).

Recovery from an STO Event

If the drive is disabled while the STO function is in effect, no recovery procedure is required. Once the STO power is restored, the drive is functional as usual.

An unexpected restart is possible and must be prevented by the control system if it is required by the application.

If the drive is enabled while the STO function is in effect, the drive enters a Fault state. A fault recovery procedure is required since the drive fault status is latched, and the drive cannot be enabled until the fault status is explicitly cleared.

After the STO power is restored, a Fault Clear command must be executed. After a successful Fault Clear, the drive is again functional.

Fault Clear can be performed in any of the following ways:

- Toggling Drive Enable. This is done either by executing a drive disable command (K) followed by the enabled (EN) command, or by toggling the Remote Enable line (REMOTE).
- In some systems a specific drive input is defined as Alarm Clear. In such a system, toggling the input clears the fault.
- Executing the clear faults command (CLEARFAULTS)

If the STO fault condition no longer exists, the drive is reenabled.

Prohibited Use of STO

The STO function must not be used in conditions where external influences will create a hazard when the function is in effect, as for example, the dropping of a suspended load.

The STO function is specifically prohibited for use in elevator applications. In these cases, additional measures (such as mechanical brakes) are required to prevent any hazard.

Exceptional STO Circumstance

A short circuit of two non-adjacent IGBTs within a brief time can produce a movement of up to 120 electrical degrees, even if the STO function is in effect. Such an event is highly unlikely but possible. An unexpected movement has to be considered.

10.6 STO Maintenance

Users must perform a manual test of the STO function at least once every three months.

The diagnostic test entails removing the STO supply voltage and verifying that the drive is indeed in the STO Fault state, and that motion is inhibited.

The maintenance procedure is performed as follows:

Set up the system such that nominal STO voltage is supplied to the drive, and the drive is enabled.

1. Remove (or switch off) the STO power supply. Verify that:
   - The drive is in a Fault state, and the STO Fault is indicated.
   - The drive cannot be enabled.
2. Restore the STO voltage, and clear the fault. Verify that the drive can be enabled.

11 Troubleshooting

11.1 Report Generator

Before contacting Technical Support, create a report of application settings by means of the Report Generator in ServoStudio 2. The information contained in the report files will enable Technical Support to troubleshoot your problem and provide assistance.

In general, it is strongly recommended that you create a report whenever you complete configuration of your application, even when the system is functioning properly.

The Report Generator option can be accessed in ServoStudio 2 in two locations:

- Autotuning wizard (final step)
- Backup & Restore screen

11.2 Faults and Warnings

If the CDHD2 is connected to a host computer via a serial connection, it communicates fault codes to the computer by means of a text message. This message is saved in a fault history log (FLTHIST) in the drive's non-volatile memory, so that the fault history is not lost when power is removed from the drive.

- Warnings are not considered faults and do not disable operation. The system automatically clears the warning state when the condition that generated the warning no longer exists.
- Faults occur when settings or conditions may cause improper operation of the drive/motor and/or equipment damage. Faults automatically disable the drive, and a fault status is indicated on the drive's display and in the software interface.

  The drive fault status is generally latched, and the drive cannot be enabled until the fault status is explicitly cleared. Only if the fault condition no longer exists can the fault status be cleared. It is done by either of the following:

  - Toggling the drive enable. This is done either by executing a drive disable command (K) followed by the enabled (EN) command or by toggling the Remote Enable input.
  - In some systems, a specific drive input is defined as Alarm Clear. In this case, toggling the input will clear the fault.

  When the fault condition no longer exists, the drive is reenabled.
- Fatal faults. Some faults are referred to as fatal faults since they disable almost all drive functions (including communications) and prevent the drive from being enabled. This condition is typical of faults due to internal failures, such as a watchdog event or a failure of an internal power source. Fatal faults require intervention by Technical Support.

VarCom	Description
CLEARFAULTS	Clears all latched faults.
FLT	Returns a list of faults latched by the drive.
FLTHIST	Returns the contents of the fault buffer.
K | EN	Disable drive | Enable drive
READY	Indicates whether drive is ready to be enabled.
REMOTE	Indicates the state of the external hardware enable input.
ST	Returns detailed drive status messages.

11.3 Digital Display – Warning Codes

Note Warning codes appear only while the operator panel is in Status mode.

A warning is indicated by the character in digit 4 of the digital display:

The character is steadily lit.

If the warning code is two or more characters (such as L2), the characters are displayed sequentially without flashing.

When scrolling through the Warning history (using F0004), the warning codes are displayed as strings; for example:

u8888

L2888

51888

_ Realtime Overload Warning

Definition	Realtime Overload Warning
Type	Warning
Message #	WRN 36
Description	Drive has detected that CPU is close to its computational limit.
Action required	

b Multi-turn Encoder Battery Low Voltage

Definition	Absolute Multi-turn Encoder Battery Low Voltage Warning
Type	Warning
Message #	WRN 22
Description	The voltage level of the absolute multi-turn encoder backup battery has dropped below 3.15V.
Action required	Replace the battery as soon as possible. If the battery is replaced while drive power is on, encoder position information is retained. If power to the battery is shut off before the battery is replaced, issue the command MTTURNRESET to reset the multi-turn position after battery power is restored.

c Regen Resistor Overload

Definition	Regen Resistor Overload
Type	Warning
Message #	WRN 34
Description	Regeneration resistor is overloaded.
Action required	

F Drive Foldback Warning
Motor Foldback Warning

Definition	Drive Foldback Warning Motor Foldback Warning
Type	Warning
Message #	WRN 2 WRN 3
Description	Drive foldback current dropped below the drive foldback current warning threshold (MIFOLDWTHRESH). Or, motor foldback current dropped below the motor foldback current warning threshold (IFOLDWTHRESH).
Action required	Check the drive-motor sizing. This warning can occur if the drive is under-sized (under-powered) for the application.

H Motor Over-Temperature

Definition	Motor Over-Temperature
Type	Warning
Message #	WRN 6
Description	Motor is overheated.
Action required	

L1 Hardware Positive Limit Switch is Open

Definition	Hardware Positive Limit Switch is Open
Type	Warning
Message #	WRN 15
Description	Positive hardware limit switch is activated.
Action required	

L2 Hardware Negative Limit Switch is Open

Definition	Hardware Negative Limit Switch is Open
Type	Warning
Message #	WRN 16
Description	Negative hardware limit switch is activated.
Action required	

L3 Hardware Positive and Negative Limit Switches are Open

Definition	Hardware Positive and Negative Limit Switches are Open
Type	Warning
Message #	WRN 17
Description	Positive and negative hardware limit switches are both activated.
Action required	

L4 Software Positive Limit Switch is Tripped

Definition	Software Positive Limit switch is Tripped
Type	Warning
Message #	WRN 18
Description	Positive software limit switch is activated. PFB > POSLIMPOS and POSLIMMODE = 1
Action required	

L5 Software Negative Limit Switch is Tripped

Definition	Software Negative Limit Switch is Tripped
Type	Warning
Message #	WRN 19
Description	Negative software limit switch is activated. PFB < POSLIMNEG and POSLIMMODE = 1
Action required	

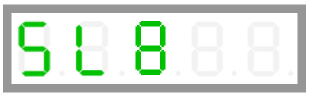
L6 Software Limit Switches are Tripped

Definition	Software Limit Switches are Tripped
Type	Warning
Message #	WRN 20
Description	Positive and negative software limit switches are activated. PFB > POSLIMPOS and PFB < POSLIMNEG and POSLIMMODE = 1
Action required	

L7 Gantry Partner Axis Positive Limit Switch

Definition	Gantry Partner Axis Positive Limit Switch
Type	Warning
Message #	WRN 60
Description	The second gantry axis has reached a positive hardware or software limit switch.
Action required	

L8 Gantry Partner Axis Negative Limit Switch



Definition	Gantry Partner Axis Negative Limit Switch
Type	Warning
Message #	WRN 61
Description	The second gantry axis has reached a negative hardware or software limit switch.
Action required	

n STO Warning

Definition	STO Warning
Type	Warning
Message #	WRN 1
Description	The STO signal is not connected when drive disabled.
Action required	Check that the STO connector (P1) is wired correctly.

o Bus AC Supply Line Disconnected

Definition	Bus AC Supply Line Disconnected
Type	Warning
Message #	WRN 32
Description	At least one phase of the main power for the bus supply is not connected.
Action required	

r Offset and/or Gain Adjustment Values Detected After SININIT

Definition	Offset and/or Gain Adjustment Values Detected After SININIT
Type	Warning
Message #	WRN 27
Description	Significant offset and/or gain adjustment values were detected after SININIT. The values that trigger this warning are half the value of those used to declare a fault. Although the system may continue to function, these values indicate the existence of a problem, which may worsen over time.
Action required	Check the encoder and associated hardware. These values suggest some degradation in either electronics (e.g., encoder, drive) or wiring (e.g., increased wire resistance, increased leakage between wires). The problem must be analyzed and repaired.

S1 Cannot Use SFBTYPE 1 with Analog OPMODE

Definition	Cannot Use SFBTYPE 1 with Analog OPMODE
Type	Warning
Message #	WRN 37
Description	Cannot use the specified type of secondary feedback with analog operation modes (i.e., OPMODE 1, OPMODE 3)
Action required	

t **Power Stage Over-Temperature**
Control Board Over-Temperature
Integrated Power Module Over-Temperature

Definition	Power Stage Over-Temperature Control Board Over-Temperature Integrated Power Module Over-Temperature
Type	Warning
Message #	WRN 5 WRN 9 WRN 38
Description	The temperature on the power board and/or on the control board and/or the power module (IPM) has exceeded the preset limit.
Action required	Check if the ambient temperature exceeds the drive specification. Otherwise contact Technical Support.

u **Under-Voltage**

Definition	Under-Voltage
Type	Warning
Message #	WRN 4
Description	The bus voltage is below the minimum value. If the value of variable UVMODE is 1 or 2, and the drive is enabled, an under-voltage warning is issued.
Action required	Check that the main AC voltage supply is connected to the drive and is switched on. The under-voltage limit can be read with the UVTHRESH command.

11.4 Digital Display – Fault Codes

For more information about the digital display Faults mode, refer to *Operator Panel – Faults & Info Mode*.

The fault codes are presented here in alphanumerical order, using the following format:

Definition	Short name. Used in ServoStudio 2.
Type	*Specifies Fault or Fatal fault. Types of faults are explained in Faults and Warnings.*
Active disable	Indicates whether the Active Disable function can be triggered by the fault. Refer to *Disable Mode*.
Message #	The fault message number displayed in Terminal.
Description	Describes the status or fault indicated by the code.
Action required	Describes the recommended steps for correcting the fault.

-5 Motor Setup Failed

Definition	Motor Setup Failed
Type	Fault
Active disable	No
Message #	FLT 44
Description	Motor Setup procedure failed. MOTORSETUPST will show the cause. This fault disables the drive.
Action required	Check phase and motor wiring. Make sure the correct feedback type is selected. Check MOTORSETUPST for hints.

-1 Not Configured

Definition	Not Configured
Type	Fault
Active disable	Not applicable
Message #	FLT 12
Description	Drive configuration required. CONFIG is required after the value of any of certain parameters is modified. CONFIG is also required after certain parameters are sent to the drive, even if their value has not been changed.
Action required	Set drive parameters and/or and execute CONFIG.

_ Realtime Overload Fault

Definition	Realtime Overload Fault
Type	Fault
Active disable	No
Message #	FLT 89
Description	CPU has exceeded its computational limit. Realtime execution takes longer than 31.25 µs. This fault disables the drive.
Action required	Contact Technical Support

≡ [3 bars] Watchdog Fault

Definition	Watchdog Fault
Type	Fault
Active disable	No
Message #	FLT 38
Description	Typically occurs due to an unforeseen circumstance. The drive is inoperable until power is cycled.
Action required	Switch the drive off and on again. If the detected error persists, contact Technical Support.

A4 CAN Supply Fault

Definition	CAN Supply Fault
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 32
Description	A problem with the internal voltage supply for the CAN bus. This fault disables the drive.
Action required	The drive probably needs repair. Contact Technical Support.

b Drive Locked

Definition	Drive Locked
Type	Fatal fault
Active disable	Not applicable
Message #	FLT 1
Description	Security code and key do not match. Drive cannot be enabled.
Action required	Contact Technical Support.

b1 PLL Synchronization Failed

Definition	PLL (Phase-Locked Loop) Synchronization Failed
Type	Fault
Active disable	No
Message #	FLT 48
Description	Controller synchronization signal is missing or not stable. The fault is detected only when synchronization is enabled by SYNCSOURCE command. This fault disables the drive.
Action required	Check for controller synchronization signal. Check the cable connection and wiring.

C1 CAN Heartbeat Lost

Definition	CAN Heartbeat Lost
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 50
Description	Drive detected disconnection between CAN master and drive. This fault disables the drive.
Action required	Reconnect master and slave, and power cycle the drive.

e **Parameter Memory Checksum Failure**

Definition	Parameter Memory Checksum Failure
Type	Fault
Active disable	Not applicable
Message #	FLT 2
Description	The non-volatile memory used to store drive parameters is empty or the data is corrupted. This fault is displayed upon initial power up. The fault will be cleared once the drive is configured and the parameters are saved in the drive's non-volatile memory. This fault may also occur during power off if SAVE operation has not completed.
Action required	Reconfigure the drive, or download the parameter set, and save the parameters. If problem persists, contact Technical Support.

E **Failure Writing to Flash Memory**

E	Flashing
Definition	Failure Writing to Flash Memory
Type	Fatal fault
Active disable	Not applicable
Message #	FLT 13
Description	An internal problem accessing the flash memory. Drive cannot be enabled.
Action required	Contact Technical Support.

e101 FPGA Config Failed

Definition	FPGA Config Failed
Type	Fatal fault
Active disable	Not applicable
Message #	FLT 5
Description	The code for the FPGA did not load. Drive cannot be enabled.
Action required	Contact Technical Support.

e105 Self-Test Failed

Definition	Self-Test Failed
Type	Fatal fault
Active disable	Not applicable
Message #	FLT 33
Description	The power-up self-test failed. Drive cannot be enabled.
Action required	Contact Technical Support.

e106 Control EEPROM Fault

Definition	Control EEPROM Fault
Type	Fatal fault
Active disable	Not applicable
Message #	FLT 6
Description	A problem accessing the EEPROM on the control board. Drive cannot be enabled.
Action required	Contact Technical Support.

e107 Power EEPROM Fault

Definition	Power EEPROM Fault
Type	Fatal fault
Active disable	Not applicable
Message #	FLT 7
Description	A problem accessing the EEPROM on the power board. Drive cannot be enabled.
Action required	Contact Technical Support.

e108 Vbus Measure Circuit Failed

Definition	Vbus Measure Circuit Failed
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 8
Description	A failure occurred in the circuit that measures bus voltage. This fault disables the drive.
Action required	Reset faults. If the fault persists, the drive probably needs repair. Contact Technical Support.

e109 Current-Sensors Offset Invalid

Definition	Current-Sensors Offset Invalid
Type	Fault
Active disable	No
Message #	FLT 43
Description	The calculated offsets for the current sensors are out of range. This fault disables the drive.
Action required	Reset faults. If the fault persists, the drive probably needs repair. Contact Technical Support.

e120 FPGA Version Mismatch

Definition	FPGA Version Mismatch
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 47
Description	FPGA version does not match the firmware version. This fault disables the drive.
Action required	Update either FPGA version or drive version.

e121 Internal Error

Definition	Internal Error
Type	Fault
Active disable	No
Message #	FLT 70
Description	Internal error due to an endless while loop or a numerical issue. This fault disables the drive.
Action required	Contact Technical Support.

e123 MTP Read Failure

Definition	Motor Plate Read Failed
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 85
Description	Motor type nameplate data cannot be read. This fault disables the drive.
Action required	Reconnect the feedback device. Make sure the motor type nameplate data is present.

e124 SAVE and Power Cycle Required

Definition	SAVE and Power Cycle Required
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 86
Description	Parameter was changed, and requires SAVE and power cycle to take effect. This fault disables the drive.
Action required	SAVE and then cycle power to the drive.

e125 Fieldbus Version Mismatch

Definition	Fieldbus Version Mismatch
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 93
Description	EtherCAT - the Microblaze version does not match the version specified by drive. This fault disables the drive.
Action required	Make sure the correct version has been downloaded to the drive.

e126 ESI Version Mismatch

Definition	ESI Version Mismatch
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 94
Description	EtherCAT - the ESI version does not match the version specified by drive. This fault disables the drive.
Action required	Make sure the correct version has been downloaded to the drive.

e127 Digital Output Over-Current Fault

Definition	Digital Output Over-Current Detected
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 96
Description	Over-current detected on one of the digital outputs. This fault disables the drive.
Action required	Verify correct wiring of the digital outputs. Make sure the output circuit is not shorted.

e129 Feedback Type Auto-Detect Failed

Definition	Feedback type auto-detection failed.
Type	Fault
Active disable	Not Applicable
Message #	FLT 106
Description	Automatic detection of feedback type on power-up failed because neither sensAR nor HIPERFACE feedback device was detected. Feedback device is either disconnected or a different type. This fault disables the drive.
Action required	Verify the connection. Manually configure the actual type of feedback.

e130 EnDat Excessive Resolution Fault

Definition	The EnDat encoder in-turn resolution detected during initialization exceeds 32 bits.
Type	Fault
Active disable	Not Applicable
Message #	FLT 107
Description	EnDat high resolution feedback cannot be handled by the drive. This fault disables the drive.
Action required	

e131 MOTORNAME/MTP Data Mismatch

Definition	MOTORNAME and MTP data are not compatible.
Type	Fault
Active disable	Not Applicable
Message #	FLT 108
Description	Drive may have been configured previously for another, different motor. This fault disables the drive.
Action required	Clear MOTORNAME and clear faults. Perform tuning with parameters for the connected motor.

e132 Firmware Version is Not Supported by this Drive

Definition	The drive firmware is not supported on this drive model.
Type	Fault
Active disable	Not Applicable
Message #	FLT 109
Description	Firmware version higher than 1.44.X cannot run on this drive. This fault disables the drive.
Action required	Download a compatible firmware version to the drive.

e134 ESI Vendor Mismatch

Definition	ESI Vendor Mismatch
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 110
Description	On EtherCAT. The ESI vendor data does not match the data specified by the drive. This fault disables the drive.
Action required	Make sure the correct vendor data is downloaded to drive.

F1 Drive Foldback

Definition	Drive Foldback
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 16
Description	Drive average current exceeds rated drive continuous current. It occurs after the Foldback warning has occurred.
Action required	Check motor-drive sizing. This fault can occur if the drive is under-sized (under-powered) for the application. Check that the commutation angle is correct (i.e., commutation is balanced).

F2 Motor Foldback

Definition	Motor Foldback
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 17
Description	Motor average current exceeds rated motor continuous current. It occurs after the Foldback warning has occurred.
Action required	Check the drive-motor sizing. This fault can occur if the motor is under-sized (under-powered) for the application.

F2H Pulse Train Frequency Too High

Definition	Pulse Train Frequency Too High
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 76
Description	The external pulse train frequency has exceeded the maximum specified input frequency. This fault disables the drive.
Action required	Reduce the frequency of the gearing pulses commanded from the controller.

F3 Stall Fault

Definition	Stall Fault
Type	Fault
Active disable	No
Message #	FLT 59
Description	A stall condition occurs when [I > MICONT] and [I > 0.9×ILIM] and [V < STALLVEL]. A stall fault occurs whenever a stall condition persists for a duration greater than STALLTIME. This fault disables the drive.
Action required	Remove the stall condition, and take care to prevent stall conditions.

Fb1 Fieldbus Velocity Limit Exceeded

Definition	Fieldbus Velocity Limit Exceeded
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 30
Description	A target position command from controller was rejected because it would cause motor to exceed the velocity limit. This fault disables the drive.
Action required	Enable the drive and send valid position commands.

Fb12 Fieldbus Interpolation Cycle Exceeds Sync Time

Definition	Fieldbus Interpolation Cycle Exceeds Sync Time
Type	Fault
Active disable	
Message #	FLT 120
Description	The fieldbus interpolation cycle exceeds the defined sync time.
Action required	Adjust the cycle time setting.

Fb13 Received Object Index Exceed Objects Array Size

Definition	Received Object Index Exceed Objects Array Size
Type	Fault
Active disable	No
Message #	FLT 122
Description	This fault disables the drive.
Action required	Reset the drive.

Fb2 Command Exceeds Acc/Dec Limits

Definition	Command Exceeds Acc/Dec Limits
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 66
Description	A new target position command from controller is about to cause the motor acceleration/deceleration to exceed the limits. Therefore, the command is rejected and the drive faults. This fault disables the drive.
Action required	Enable the drive and send valid position commands.

Fb3 Fieldbus Cable Disconnected

Definition	Fieldbus Cable Disconnected
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 65
Description	The connection between controller and drive was removed. This fault disables the drive.
Action required	Reestablish the connection between controller and drive.

Fb4 Fieldbus Target Command Lost

Definition	Fieldbus Target Command Lost
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 69
Description	The fieldbus controller has not sent a target command in 3 consecutive instances. This fault disables the drive.
Action required	Clear the fault and allow the controller to send new commands.

Fb7 CAN is in Bus-Off State

Definition	CAN is in Bus-Off State
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 88
Description	The drive has disconnected from the CAN bus due to communication errors, and is no longer sending/receiving communication packets. This fault disables the drive. This fault can be masked in object 1029h.
Action required	Check CAN cabling and verify the CAN network is functioning properly.

Fb8 EtherCAT Packet Loss

Definition	EtherCAT Packet Loss
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 91
Description	EtherCAT packets have been lost. This fault disables the drive.
Action required	Make sure the EtherCAT master (controller) sends the packets within the time defined (by the master).

Fb9 CAN/EtherCAT State Not Operational

Definition	CAN/EtherCAT State Not Operational
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 92
Description	Drive was enabled and in an operational state prior to receiving a command to move to a lower state of communication. This fault disables the drive.
Action required	Make sure the controller does not switch to a lower state of communication while the drive is enabled.

G1 Gantry Difference Axis Fault (Active Disable)

Definition	Gantry Difference Axis Fault (Active Disable)
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 129
Description	The gantry difference axis has reported a fault that requires active disable to be handled by the master axis. This fault disables the drive.
Action required	Correct the fault on the gantry difference axis, and use GANTRYCLRFLT.

G2 Gantry Difference Axis Fault (not Active Disable)

Definition	Gantry Difference Axis Fault (not Active Disable)
Type	Fault
Active disable	No
Message #	FLT 130
Description	The gantry difference axis has reported a fault that cannot be handled by active disable. This fault disables the drive.
Action required	Correct the fault on the gantry difference axis, and use GANTRYCLRFLT.

G3 Inter-Drive Communication Fault

Definition	Inter-Drive Communication Fault
Type	Fault
Active disable	
Message #	FLT 131
Description	There is a sync loss or timeout error in the inter-drive communication layer. This fault disables the drive.
Action required	Check the physical connection of the inter-drive communication cable.

G4 Gantry Alignment Process Failed

Definition	Gantry Alignment Process Failed
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 132
Description	The gantry alignment failed due to a timeout or a fault or drive disabling during the alignment process. This fault disables the drive.
Action required	

G5 Gantry Difference Controller is Saturated

Definition	Gantry Difference Controller is Saturated
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 133
Description	The gantry controller current command is saturated. This fault disables the drive.
Action required	

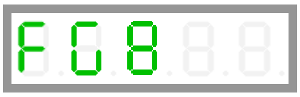
G6 Gantry Did Not Receive PFB Ack from Partner Axis

Definition	Gantry Did Not Receive PFB Ack from Partner Axis
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 134
Description	The axis sent position feedback data to the partner axis, but the partner axis did not acknowledge receipt. This fault disables the drive.
Action required	Check the physical connection of the inter-drive communication cable.

G7 Gantry FIFO Buffer is Higher than Expected

Definition	Gantry FIFO Buffer is Higher than Expected
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 135
Description	The FIFO buffer counter indicates a number of frames that is higher than expected. This fault disables the drive.
Action required	--

G8 Too Many Communication Errors



Definition	Too Many Communication Errors
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 136
Description	There are too many consecutive or parity or timeout errors. This fault disables the drive.
Action required	--

G9 High Rate of Gantry Communication Errors

Definition	High Rate of Gantry Communication Errors
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 137
Description	The number of communication errors has exceeded the acceptable rate. This fault disables the drive.
Action required	

G10 Gantry Did Not Receive Home Offset Ack from Partner

Definition	Gantry Did Not Receive Home Offset Ack from Partner
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 138
Description	The axis sent home offset data to the partner axis, but the partner axis did not acknowledge receipt. This fault disables the drive.
Action required	Check the physical connection of the inter-drive communication cable.

G11 Gantry Partner Axis Did Not Enable

Definition	Gantry Partner Axis Did Not Enable
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 139
Description	The gantry partner axis did not become enabled during gantry enabling. This fault disables the drive.
Action required	Check the gantry partner drive.

G12 Gantry Partner Axis Reported a Fault

Definition	Gantry Partner Axis Reported a Fault
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 140
Description	The gantry partner axis reported a fault. This fault disables the drive.
Action required	Correct and clear the faults.

G13 Gantry Homing Failed

Definition	Gantry Homing Failed
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 141
Description	Gantry homing failed. This fault disables the drive.
Action required	Correct and clear the faults.

H Motor Over-Temperature

Definition	Motor Over-Temperature
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 23
Description	Either the motor has overheated, or the drive is not set up correctly for the motor temperature sensor. This fault disables the drive.
Action required	Check that the drive is configured properly (using THERMODE, THERMTYPE, THERMTRIPLEVEL and THERMTIME), and that the motor temperature sensor is properly connected to the drive if needed. If the drive is configured and wired properly, check whether the motor is under-sized for the application.

J Velocity Over-Speed Exceeded

Definition	Velocity Over-Speed Exceeded
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 14
Description	Actual velocity exceeded 1.2 times the velocity limit. The velocity limit is set using VLIM. This fault disables the drive.
Action required	Check that VLIM is set to match the application requirements. Using velocity loop tuning, check for excessive overshoot.

J1 Exceeded Maximum Position Error

Definition	Exceeded Maximum Position Error
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 45
Description	The position error (PE) has exceeded the position error limit (PEMAX). This fault disables the drive.
Action required	Change drive tuning to improve position tracking, or increase PEMAX to allow a greater position error.

J2 Exceeded Maximum Velocity Error

Definition	Exceeded Maximum Velocity Error
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 67
Description	The velocity error (VE) has exceeded the velocity error limit (VEMAX). This fault disables the drive.
Action required	Change drive tuning to improve velocity tracking, or increase VEMAX to allow a greater velocity error.

J3 Excessive PE Value

Definition	Excessive PE Value
Type	Fault
Active disable	No
Message #	FLT 87
Description	The position error (PE) has reached the software numerical limit. This fault disables the drive.
Action required	Check tuning.

J4 Commutation Error (Motor Runaway) Condition Detected

Definition	Commutation Error (Motor Runaway) Condition Detected
Type	Fault
Active disable	No
Message #	FLT 77
Description	The motor moves in negative direction although the commanded current is positive. Commutation is incorrect. (Algebraic signs of actual current, acceleration and velocity do not match.) This fault disables the drive.
Action required	Correct MPHASE setting. Activate and improve the phase find process.

J5 Secondary Feedback Position Mismatch

Definition	Secondary Feedback Position Mismatch
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 90
Description	Position deviation between motor and load is too great. This fault disables the drive.
Action required	Improve position tuning.

n STO Fault

Definition	STO Fault
Type	Fault
Active disable	No
Message #	FLT 4
Description	The STO signal is not connected when drive enabled. This fault disables the drive.
Action required	Check that the STO connector (P1) is wired correctly.

n1 Regen Over-Current

Definition	Regen Over-Current
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 29
Description	The preset current limit for regen current has been exceeded. This fault disables the drive.
Action required	Increase the value of the regen resistor.

n3 Emergency Stop Issued

Definition	Emergency Stop Issued
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 57
Description	Input defined as Emergency Stop indicator has been activated. This fault disables the drive.
Action required	Turn off the input.

n41 Power Brake Open Load

Definition	Power Brake Open Load
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 63
Description	Open load on the power brake output. This fault prevents drive from being enabled.
Action required	Make sure the power brake load cables are connected properly and are not damaged.

n42 Power Brake Short

Definition	Power Brake Short
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 64
Description	Short circuit on the power brake output. This fault disables the drive.
Action required	Replace the motor brake or the entire motor.

n45 Power Brake Fault

Definition	Power Brake Fault
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 98
Description	A fault occurred on the power brake. This fault disables the drive.
Action required	Replace the motor brake.

o Over-Voltage

o	Flashing
Definition	Over-Voltage
Type	Fault
Active disable	No
Message #	FLT 9
Description	The bus voltage exceeded the maximum value. This fault disables the drive.
Action required	Check whether a regeneration resistor is required for the application.

o15 Plus 15V Out of Range

Definition	Plus 15V Out of Range
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 36
Description	The internal +15 V supply is out of range. This fault disables the drive.
Action required	The drive probably needs repair. Contact Technical Support.

o-15 Minus 15V Out of Range

Definition	Minus 15V Out of Range
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 37
Description	The internal -15 V supply is out of range. This fault disables the drive.
Action required	The drive probably needs repair. Contact Technical Support.

o5 5V Out of Range

Definition	5V Out of Range
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 52
Description	5V is low or powering off. This fault disables the drive.
Action required	May occur during power off. If it occurs under other conditions, contact Technical Support.

o6 Logic AC Power Failure

Definition	Logic AC Power Failure
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 72
Description	The main power for the logic supply is off. This fault disables the drive.
Action required	No Action required. This is a normal response when logic power is turned off.

o7 Bus AC Supply Line Disconnect

Definition	Bus AC Supply Line Disconnect
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 78
Description	At least one phase of the main power for the bus supply is not connected. This fault disables the drive.
Action required	Check the connection of the bus AC supply. Make sure the supply is on. Refer to LINELOSSMODE and related parameters.

o8 Regen Resistor Overload

Definition	Regen Resistor Overload
Type	Fault
Active disable	No
Message #	FLT 83
Description	The regen resistor load exceeds its allowed power. This fault disables the drive.
Action required	Check whether the regen resistor properties are suited to the application.

o9 Digital Output Over-Current Fault

Definition	Digital Output Over-Current Fault
Type	Fault
Active disable	No
Message #	FLT 105
Description	Over-current at the digital output has been detected. This fault disables the drive.
Action required	Check the digital output connections.

P Over-Current

Definition	Over-Current
Type	Fault
Active disable	No
Message #	FLT 3
Description	Over-current at the drive output has been detected. This fault disables the drive. The drive allows this fault to occur up to three times in succession. When the fault occurs for the fourth time, the drive forces a delay of 1 minute before it can be reenabled.
Action required	Check for a short circuit on the motor connection. Check for excessive overshoot in the current loop.

P2 Unstable Current Loop

Definition	Unstable Current Loop
Type	Fault
Active disable	No
Message #	FLT 100
Description	An unexpected high current overshoot has been detected. This fault disables the drive.
Action required	Check and modify current controller settings.

P3 High IQ Current Detected

Definition	High IQ Current Detected
Type	Fault
Active disable	No
Message #	FLT 104
Description	The detected IQ current is greater than 120% of ILIM. This fault disables the drive.
Action required	Check and modify current controller settings.

r10 Sine Feedback Communication Fail

Definition	Sine Feedback Communication Fail
Type	Fault
Active disable	No
Message #	FLT 21
Description	Communication problem between the drive and an EnDat or HIPERFACE encoder. This fault disables the drive.
Action required	Check that the data and clock signals to the EnDat or HIPERFACE encoder are connected properly. The cable must be shielded.

r14 Sine Encoder Quadrature Fault

Definition	Sine Encoder Quadrature Fault
Type	Fault
Active disable	No
Message #	FLT 24
Description	Mismatch between calculated and actual encoder quadrature information. This fault disables the drive.
Action required	Check the feedback device wiring. Make sure the correct encoder type (MENCTYPE) is selected.

r15 Sin/Cos Calibration Invalid

Definition	Sin/Cos Calibration Invalid
Type	Fault
Active disable	No
Message #	FLT 25
Description	The sine/cosine calibration parameters are out of range. This fault is related to resolver and sine encoder feedback. This fault disables the drive.
Action required	Re-execute the sine/cosine calibration process.

r16 Feedback 5V Over-Current

Definition	Feedback 5V Over-Current
Type	Fault
Active disable	No
Message #	FLT 26
Description	The current supplied by the drive on the 5V primary encoder supply has exceeded the preset current limit. The drive allows this fault to occur up to 3 times in succession. After 3 faults, the drive forces a delay of 1 minute before it can be reenabled. This fault disables the drive.
Action required	The CDHD2 can source a maximum current of 320 mA to the primary encoder. Check for a short-circuit at the encoder. Check if the encoder is drawing more than the current limit

r17 Secondary Feedback Index Break

Definition	Secondary Feedback Index Break
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 27
Description	Secondary encoder index line not connected. This fault disables the drive.
Action required	Check whether the drive is configured for working with the index signal on the secondary encoder, and check if the index signal is connected.

r18 Secondary Feedback A/B Line Break

Definition	Secondary Feedback A/B Line Break
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 28
Description	One of the secondary feedback signals is not connected. This fault disables the drive.
Action required	Check that all signals from the secondary encoder are properly connected to the drive.

r19 Secondary Encoder 5V Over-Current

Definition	Secondary Encoder 5V Over-Current
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 31
Description	The preset current limit for current supplied by the drive on the 5 V secondary encoder supply has been exceeded. This fault disables the drive.
Action required	The CDHD2 can source a maximum current of 320 mA to the secondary encoder. Check for a short-circuit at the encoder. Check if the encoder is drawing more than the current limit.

r20 Feedback Communication Error

Definition	Feedback Communication Error
Type	Fault
Active disable	No
Message #	FLT 34
Description	Communication with the feedback device did not initialize correctly. This fault disables the drive.
Action required	Check that the feedback device is wired correctly. Check that the correct encoder type (MENCTYPE) is selected.

r21 Nikon Encoder Operational Fault

Definition	Nikon Encoder Operational Fault
Type	Fault
Active disable	No
Message #	FLT 35
Description	Communication with the Nikon feedback device did not initialize correctly. This fault disables the drive.
Action required	Check that the feedback device is wired correctly. Check that the correct encoder type (MENCTYPE) is selected.

r22 Secondary Feedback Communication Error

Definition	Secondary Feedback Communication Error
Type	Fault
Active disable	No
Message #	FLT 121
Description	Communication with the secondary feedback device did not initialize correctly. This fault disables the drive.
Action required	Make sure the secondary feedback device is wired correctly. Make sure the correct secondary encoder type (SFBTYPE) is selected.

r23 Phase Find Failed

Definition	Phase Find Failed
Type	Fault
Active disable	No
Message #	FLT 41
Description	Commutation initialization has failed. This fault occurs in systems that do not have commutation information (e.g., Hall signals) in the motor feedback device. This fault disables the drive.
Action required	Check whether the motor feedback type and the phase-finding parameters are set correctly for the application.

r24 Tamagawa Init Failed

Definition	Tamagawa Init Failed
Type	Fault
Active disable	No
Message #	FLT 42
Description	The initialization process with the Tamagawa feedback device has failed. This fault disables the drive.
Action required	Check that the wiring to the encoder is correct.

r25 Pulse and Direction Input Line Break

Definition	Pulse and Direction Input Line Break
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 46
Description	One of the Pulse & Direction signals is not connected. This fault disables the drive.
Action required	Check that all signals to the P&D inputs are properly connected to the drive.

r26 Tamagawa Abs Operational Fault

Definition	Tamagawa Abs Operational Fault
Type	Fault
Active disable	No
Message #	FLT49
Description	Several faults are indicated by the feedback device and include one or more of the following: battery low/error, over-speed, counting error, multi-turn error. This fault disables the drive.
Action required	Check the battery voltage and feedback wiring. Make sure the motor did not move at a high velocity during encoder initialization.

r27 Motor Phases Disconnected

Definition	Motor Phases Disconnected
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 51
Description	One of the motor phases is disconnected. The current of one of the motor phases is effectively zero for more than 160 electrical degrees while the current command is greater than 100. This fault disables the drive.
Action required	Check the wiring of the motor phases.

r28 Resolver Initialization Failed

Definition	Resolver Initialization Failed
Type	Fault
Active disable	No
Message #	FLT 55
Description	The drive could not detect the proper gain setting or sampling point for the sine/cosine signals. This fault disables the drive.
Action required	Check resolver wiring and gain value.

r29 Multi-turn Encoder Battery Low Voltage

Definition	Absolute Multi-turn Encoder Battery Low Voltage Fault
Type	Fault
Active disable	No
Message #	FLT 56
Description	The voltage level of the absolute multi-turn encoder backup battery has dropped below 3.0V. This fault disables the drive.
Action required	Replace the encoder battery. If battery power is cut off before the battery is replaced, issue the command MTURNRESET to reset the multi-turn position after battery power is restored.

r32 Endat2X Feedback Fault

Definition	Endat2X Feedback Fault
Type	Fault
Active disable	No
Message #	FLT 58
Description	CRC error occurred while drive was communicating with EnDat encoder. Also caused by EnDat encoder setting Alarm bit/s to indicate an encoder problem. This fault disables the drive.
Action required	Reset the encoder including encoder power off.

r33 Custom Absolute Encoder Operational Fault

Definition	Custom Absolute Encoder Internal Faults
Type	Fault
Active disable	No
Message #	FLT 95
Description	Several possible issues are indicated by this feedback device fault: battery low or error; over-speed; counting error; multi-turn error. This fault disables the drive.
Action required	Check the battery voltage and feedback wiring. Make sure the motor did not move at a high velocity during encoder initialization.

r34 PFB Off Checksum Invalid

Definition	PFB Off Checksum Invalid
Type	Fault
Active disable	No
Message #	FLT 60
Description	The calculated checksum of the PFB backup data does not match the expected checksum. This fault disables the drive.
Action required	If required by the application, home the machine.

r35 PFB Off Data Mismatch

Definition	PFB Off Data Mismatch
Type	Fault
Active disable	No
Message #	FLT 61
Description	Multi-turn data of the PFB cannot be restored due to axis movement. This fault disables the drive.
Action required	If required by the application, home the machine.

r36 No PFB Off Data

Definition	No PFB Off Data
Type	Fault
Active disable	No
Message #	FLT 62
Description	PFB backup memory is empty. This fault disables the drive.
Action required	If required by the application, home the machine.

r37 Encoder Phase Error

Definition	Encoder Phase Error
Type	Fault
Active disable	No
Message #	FLT 68
Description	In normal incremental encoder operation, quadrature inputs A and B are 90 degrees out of phase. The phase error occurs when edge transition is detected simultaneously on the A and B signals. This fault disables the drive. This fault disables the drive.
Action required	Set MENCAQBFILT to 0 to remove the filter on A and B signals. If problem persists, it may be due to a faulty encoder.

r38 Differential Halls Line Break

Definition	Differential Halls Line Break
Type	Fault
Active disable	No
Message #	FLT 71
Description	Line break in differential Hall sensors. This fault disables the drive.
Action required	Make sure HALLSTYPE matches the Hall sensors in use (single-ended or differential). Check whether all signals from the differential Hall sensors are properly connected to the drive.

r39 AB Quad Commutation Fault

Definition	AB Quadrature Commutation Fault
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 80
Description	Loss of commutation/encoder counts for AB quadrature encoder. The index signal serves as a reference position for detecting loss of commutation/pulses. The AB quadrature encoder counter is compared at different index positions. Between index position captures the count must be exactly MENCRESx4 (or 0 counts if moved back to same index location). This fault disables the drive.
Action required	If a fault occurs shortly after motion begins, check MENCRES settings. If a fault occurs after some time it is likely due to EMI noise. Improve the installation. Make sure ground is connected. Make sure shield is connected on feedback and motor cables.

r4 A/B Line Break

Definition	A/B Line Break
Type	Fault
Active disable	No
Message #	FLT 18
Description	One of the primary feedback signals is not connected. This fault occurs in incremental encoder, resolver and sine encoder feedback types. This fault disables the drive.
Action required	Refer to *Sine Encoder and Resolver Diagnostics*. Check whether all signals from the primary feedback device are properly connected to the drive.

r40 sensAR Encoder Fault

Definition	sensAR Encoder Fault
Type	Fault
Active disable	No
Message #	FLT 82
Description	The drive has detected an internal fault on the sensAR encoder through communication. This fault disables the drive.
Action required	Use command SRVSNSINFO to identify the fault. Replace the battery: Shut off power to the drive. Remove the old battery and insert a new one. Power on the drive. Issue the command MTTURNRESET to reset the position counter of the multi-turn encoder. MTTURNRESET also clears the fault. Refer to *sensAR Absolute Magnetic Encoder*.

r41 Sankyo Absolute Encoder Fault

Definition	Sankyo Absolute Encoder Fault
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 99
Description	One or more faults are indicated by the feedback device, including: battery low or error, over-speed, counting error, multi-turn error. This fault disables the drive.
Action required	Check the battery voltage and feedback wiring. Make sure the motor did not move at a high velocity during encoder initialization.

r42 BiSS-C Encoder Indicates an Internal Fault

Definition	BiSS-C encoder indicates an internal fault.
Type	Fault
Active disable	No
Message #	FLT 102
Description	This fault disables the drive.
Action required	Refer to the BiSS-C encoder manufacturer specific documentation.

r43 HIPERFACE Data Error

Definition	HIPERFACE encoder data error.
Type	Fault
Active disable	No
Message #	FLT 103
Description	This fault disables the drive.
Action required	Enter the command HSAVE 1.

r45 MENCZPOS Mismatch with Halls

Definition	MENCZPOS Does Not Match Halls
Type	Fault
Active disable	No
Message #	FLT 111
Description	Either an incorrect MENCZPOS value was saved or the encoder has a different index location. The fault is declared when the difference between the electrical angle based on MENCZPOS and the electrical angle of the Hall sensors is greater than 30 degrees. This fault disables the drive.
Action required	Run Motor Setup wizard and save the new value of MENCZPOS.

r46 sensAR Encoder Position Fault

Definition	sensAR Encoder Position Fault
Type	Fault
Active disable	No
Message #	FLT 112
Description	The returned position values are no longer considered reliable. This fault disables the drive.
Action required	Restart the drive.

r47 sensAR Over-Temperature Fault

Definition	sensAR Over-Temperature Fault
Type	Fault
Active disable	No
Message #	FLT 113
Description	The device temperature is too high. This fault disables the drive.
Action required	

r48 sensAR Power Supply Insufficient for Operation

Definition	sensAR Power Supply Insufficient for Operation
Type	Fault
Active disable	No
Message #	FLT 114
Description	The voltage supply to the device has dropped below operational value. This fault disables the drive.
Action required	Check the encoder power supply.

r49 sensAR Battery Voltage is Below Threshold

Definition	sensAR Battery Voltage is Below Threshold
Type	Fault
Active disable	No
Message #	FLT 115
Description	The battery voltage is less than the threshold value. This fault disables the drive.
Action required	Replace the encoder battery.

r50 sensAR Requires Reset Command

Definition	sensAR Requires Configuration Command
Type	Fault
Active disable	No
Message #	FLT 116
Description	sensAR requires the reset command MTTURNRESET. This fault disables the drive.
Action required	

r5 Index Line Break

Definition	Index Line Break
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 20
Description	Encoder index line is not connected. This fault disables the drive.
Action required	Check that the drive is configured for working with the index signal (using MENCTYPE), and check if the index signal is connected.

r51 Internal Position Synchronization Failure

Definition	Internal Position Synchronization Failure
Type	Fault
Active disable	No
Message #	FLT 117
Description	Internal position synchronization of the multi-turn and single-turn modules is not functioning properly. This fault disables the drive.
Action required	Restart the drive.

r52 Multi-Turn Encoder General Failure

Definition	Multi-Turn Encoder General Failure
Type	Fault
Active disable	No
Message #	FLT 118
Description	The multi-turn module is not functioning properly. This fault disables the drive.
Action required	Restart the drive.

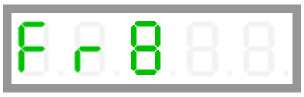
r53 sensAR Firmware-Hardware Mismatch

Definition	sensAR Firmware Not Compatible with sensAR Hardware
Type	Fault
Active disable	No
Message #	FLT 119
Description	The firmware version is not compatible with the sensAR hardware. This fault disables the drive.
Action required	Contact Technical Support.

r6 Invalid Halls

Definition	Invalid Halls
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 19
Description	The drive has detected either 000 or 111 state on the Hall feedback signals. This fault disables the drive.
Action required	Check that the Hall signals are all properly connected. While turning the motor, read the Halls state (using HALLS) to see which signal is not connected. If the feedback type is Tamagawa, check that the feedback wiring is correct

r8 A/B Out of Range



Definition	A/B Out of Range
Type	Fault
Active disable	No
Message #	FLT 22
Description	Feedback analog signal is out of range. This fault is related to resolver and sine encoder feedback. The drive checks that the amplitudes of the sine and cosine signals are correct, based on the calculation sin2 + cos2 = 1 This fault disables the drive.
Action required	Refer to *Sine Encoder and Resolver Diagnostics*. Check the amplitudes of the sine and cosine signals.

r9 Encoder Simulation Frequency Too High

Definition	Encoder Simulation Frequency Too High
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 15
Description	The computed equivalent encoder output frequency exceeds the upper limit for this signal, which is 4 MHz. This fault disables the drive.
Action required	Check the parameters used for setting up the equivalent encoder output. If using a sine encoder, check the ENCOUTRES parameter settings.

t1 Power Stage Over-Temperature

Definition	Power Stage Over-Temperature
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 10
Description	The temperature on the power board has exceeded the preset limit. This fault disables the drive.
Action required	Check if the ambient temperature exceeds the drive specification. Otherwise contact Technical Support.

t2 Integrated Power Module Over-Temperature

Definition	Integrated Power Module Over-Temperature
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 39
Description	The temperature within the integrated power module has exceeded the preset limit. This fault disables the drive.
Action required	Check if the ambient temperature exceeds the drive specification. Otherwise contact Technical Support.

t3 Control Board Over-Temperature

Definition	Control Board Over-Temperature
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 40
Description	The temperature on the control board has exceeded the preset limit. This fault disables the drive.
Action required	Check if the ambient temperature exceeds the drive specification. Otherwise contact Technical Support.

t4 Temperature Sensor Failure

Definition	Temperature Sensor Failure
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 73
Description	Temperature sensor malfunction. This fault disables the drive.
Action required	Cycle power. If problem persists, contact Technical Support.

u Under-Voltage

Definition	Under-Voltage
Type	Fault
Active disable	This fault can trigger the Active Disable function.
Message #	FLT 11
Description	The bus voltage is below the minimum value. If the value of variable UVMODE is 3, and the drive is enabled, an under-voltage fault is issued. This fault disables the drive.
Action required	Check that the main AC voltage supply is connected to the drive and is switched on. The under-voltage limit can be read with the UVTHRESH command.

11.5 Warning, Error and Fault Messages

The following tables present the fault, warning and error codes that may be displayed when working in Terminal.

All faults, and many warnings, are also indicated by the drive's digital display. Certain conditions generate on-screen warning messages only.

11.5.1 Warning Messages

CDHD2 drive warnings are reported in object **2011h**.

Since CDHD2 warnings are 64 bits, they have two 32-bit segments.

Table 11-1. Warning Codes and Messages

WRN #	Warning Message (click description for more info)	Warning Code
WRN 1	STO Warning	00000000 00000001h
WRN 2	Drive Foldback Warning	00000000 00000002h
WRN 3	Motor Foldback Warning	00000000 00000004h
WRN 4	Under-Voltage	00000000 00000008h
WRN 5	Power Stage Over-Temperature	00000000 00000010h
WRN 6	Motor Over-Temperature	00000000 00000020h
WRN 9	Control Board Over-Temperature	00000000 00000100h
WRN 10	Phase Find Required Phase difference is required to initialize the commutation angle.	00000000 00000200h
WRN 11	PLL Not Synchronized Phase locked loop (PLL) has not been synchronized (SYNCSOURCE>0).	00000000 00000400h
WRN 15	Hardware Positive Limit Switch is Open	00000000 00004000h
WRN 16	Hardware Negative Limit Switch is Open	00000000 00008000h
WRN 17	Hardware Positive and Negative Limit Switches are Open	00000000 00010000h
WRN 18	Software Positive Limit Switch is Tripped	00000000 00020000h
WRN 19	Software Negative Limit Switch is Tripped	00000000 00040000h
WRN 20	Software Limit Switches are Tripped	00000000 00080000h
WRN 21	HIPERFACE Encoder Resolution Mismatch Encoder resolution determined from the detected HIPERFACE device is not the same as the MENCRES settings currently in effect.	00000000 00100000h
WRN 22	Multi-turn Encoder Battery Low Voltage	00000000 00200000h
WRN 24	EnDat Encoder Resolution Mismatch Mismatch between MENCRES and encoder resolution as read during initialization process.	00000000 00800000h
WRN 25	PFB Backup Not Read PFBBACKUP data has not yet been received.	00000000 01000000h

WRN #		Warning Message (click description for more info)	Warning Code
WRN	27	Offset and/or Gain Adjustment Values Detected After SININIT	00000000 04000000h
WRN	32	Bus AC Supply Line Disconnected	00000000 80000000h
WRN	34	Regen Resistor Overload	00000002 00000000h
WRN	35	SensAR: Encoder Warning Drive detected a warning on SensAR.	00000004 00000000h
WRN	36	Realtime Overload Warning	00000008 00000000h
WRN	37	Cannot Use SFBTYPE 1 with Analog OPMODE	00000010 00000000h
WRN	38	Integrated Power Module Over-Temperature	00000020 00000000h
WRN	40	Online LMJR Estimation Active Online LMJR estimation active.	00000080 00000000h
WRN	41	PDO Packet is Not the Expected Length (too long) PDO packet is not the expected length according to PDO mapping. It is too long.	00000100 00000000h
WRN	42	Data in RPDO is Out of Range Data in RPDO is out of range or exceeds minimum/maximum limits.	00000200 00000000h
WRN	43	Data Cannot Be Written When Drive is Enabled RPDO data cannot be written when drive is enabled.	00000400 00000000h
WRN	44	Command is Toward Positive Software Limit Command is toward negative software limit.	00000800 00000000h
WRN	45	Command is Toward Negative Software Limit Command is toward positive software limit.	00001000 00000000h
WRN	47	CAN Communication Entered Passive State CAN communication error on bus	00004000 00000000h
WRN	48	Default Drive Configuration The drive configuration is the default factory setting	00008000 00000000h
WRN	49	Fieldbus Target Command Lost The fieldbus controller has not sent a target command in 3 consecutive instances.	00010000 00000000h
WRN	50	I2C Failed To Read Temp Sensor	00020000 00000000h
WRN	51	BiSS-C Encoder Indicates an Internal Warning	00040000 00000000h
WRN	52	Motor Compatibility Warning.	00080000 00000000h
WRN	53	Conflicting Digital Inputs On	00100000 00000000h
WRN	54	Fan Circuit Warning Fan circuit is either overloaded or disconnected	
WRN	55	Excessive Electrical Noise Warning System is generating excessive electrical noise	
WRN	56	Feedback Type Mismatch Configured feedback type and connected encoder do not match	
WRN	57	sensAR Encoder Over-Temperature Warning sensAR encoder over-temperature warning	

WRN #	Warning Message (click description for more info)	Warning Code
WRN 58	sensAR Encoder Internal Flash Failure sensAR internal flash malfunction	
WRN 59	Excessive Shaft Displacement Detected The device has detected unusually high shaft displacement	
WRN 60	Gantry Partner Axis Positive Limit Switch The second gantry axis has reached a positive hardware or software limit switch	
WRN 61	Gantry Partner Axis Negative Limit Switch The second gantry axis has reached a negative hardware or software limit switch	
WRN 62	Internal Axis Sync Loss (no HMI) Issue with internal FPGA comm sync	

11.5.2 Error Messages – Manufacturer-Specific

Table 11-2. Error Codes and Messages – Manufacturer-Specific

ERR #	Error Message	Digital Display	Error Code
ERR 20	Unknown command	E0020	0800 0000h
ERR 21	Unknown variable	E0021	0800 0000h
ERR 22	Checksum error	E0022	0800 0000h
ERR 23	Drive active	E0023	0800 0000h
ERR 24	Drive inactive	E0024	0800 0000h
ERR 25	Value out of range	E0025	0609 0030h
ERR 26	Value too low	E0026	0609 0032h
ERR 27	OPMODE invalid	E0027	0800 0000h
ERR 28	Syntax error	E0028	0800 0000h
ERR 29	Value too high	E0029	0609 0031h
ERR 36	Not programmable	E0036	0601 0002h
ERR 37	Not Configured	E0037	0800 0000h
ERR 38	N/A	E0038	0800 0000h
ERR 42	Flash invalid	E0042	0606 0000h
ERR 43	Recording active	E0043	0800 0000h
ERR 44	Recorded data not available	E0044	0800 0000h
ERR 45	NVRAM empty	E0045	0800 0000h
ERR 46	Value must be an even number	E0046	0800 0000h
ERR 49	Value must be a multiple of 0.25	E0049	0800 0000h
ERR 50	SAVE to flash failed	E0050	0800 0000h
ERR 51	Not available	E0051	0606 0000h
ERR 54	Command towards limit switch	E0054	0800 0000h

ERR #	Error Message	Digital Display	Error Code
ERR 55	Zeroing mode active	E0055	0800 0000h
ERR 60	Motor in motion	E0060	0800 0000h
ERR 62	Communication error	E0062	0800 0000h
ERR 63	EnDat not ready	E0063	0800 0000h
ERR 64	EnDat CRC error	E0064	0800 0000h
ERR 65	EnDat busy	E0065	0800 0000h
ERR 66	Password protected	E0066	0800 0000h
ERR 67	TM Write to EEPROM Failed	E0067	0606 0000h
ERR 68	TM communication CRC failed	E0068	0504 0004h
ERR 71	Homing type not in use	E0071	0800 0000h
ERR 72	Homing type invalid	E0072	0800 0000h
ERR 73	Homing trigger input source not set	E0073	0800 0000h
ERR 74	Homing already in progress	E0074	0800 0000h
ERR 75	Homing direction-reversal input not set. Refer to CiA402.	E0075	0800 0000h
ERR 82	Functionality already defined	E0082	0800 0000h
ERR 94	Command exceeds software limits	E0094	0800 0000h
ERR 95	Feedback invalid	E0095	0800 0000h
ERR 96	Variable is not recordable	E0096	0800 0000h
ERR 97	Value must be an integer	E0097	0800 0000h
ERR 98	I/O not supported	E0098	0800 0000h
ERR 99	Active Disable in progress	E0099	0800 0000h
ERR 100	I2C bus is busy	E0100	0800 0000h
ERR 102	Another procedure is running	E0102	0800 0000h
ERR 103	Clear faults before procedure	E0103	0800 0000h
ERR 104	Motion pending	E0104	0800 0000h
ERR 105	Invalid PTP mode	E0105	0800 0000h
ERR 106	Checksum invalid	E0106	0800 0000h
ERR 107	Analog output mode invalid	E0107	0800 0000h
ERR 108	Hold mode active	E0108	0800 0000h
ERR 109	Motor commutation type invalid	E0109	0800 0000h
ERR 113	HC actual velocity out of range	E0113	0800 0000h
ERR 114	Not supported on this hardware	E0114	0800 0000h
ERR 115	Value must be a multiple of 0.125	E0115	0800 0000h
ERR 116	Fieldbus mode (COMMODE=1) active	E0116	0800 0000h
ERR 201	Current loop design failed	E0201	0800 0000h
ERR 202	MENCRES out of range	E0202	0800 0000h
ERR 204	MSPEED out of range	E0204	0800 0000h

ERR #	Error Message	Digital Display	Error Code
ERR 206	MVANGLF out of range	E0206	0800 0000h
ERR 210	VLIM out of range	E0210	0800 0000h
ERR 212	MVANGLH out of range	E0212	0800 0000h
ERR 213	DICONT greater than DIPEAK	E0213	0800 0000h
ERR 214	MENCTYPE mismatch	E0214	0800 0000h
ERR 215	DIPEAK out of range	E0215	0800 0000h
ERR 216	MIPEAK out of range	E0216	0800 0000h
ERR 217	MICONT greater than MIPEAK	E0217	0800 0000h
ERR 218	VBUS out of range	E0218	0800 0000h
ERR 219	ML out of range	E0219	0800 0000h
ERR 220	MPOLES out of range	E0220	0800 0000h
ERR 221	Velocity loop design failed	E0221	0800 0000h
ERR 222	Internal dual gain present	E0222	0800 0000h
ERR 223	PHASEFIND required	E0223	0800 0000h
ERR 224	Value is not allowed	E0224	0609 0030h
ERR 225	Internal dual gain not present	E0225	0800 0000h
ERR 226	MENCTYPE invalid for linear motor	E0226	0800 0000h
ERR 227	ENCOUTRES*VLIM too high	E0227	0800 0000h
ERR 228	Function invalid for this input	E0228	0800 0000h
ERR 229	MJ out of range	E0229	0800 0000h
ERR 230	MMASS out of range	E0230	0800 0000h
ERR 232	Autotuning active	E0232	0800 0000h
ERR 233	Internal config failed	E0233	0800 0000h
ERR 234	Feedback type mismatch	E0234	0800 0000h
ERR 250	Velocity config failed	E0250	0800 0000h
ERR 254	Cycle identification active	E0254	0800 0000h
ERR 255	Phase find mode invalid	E0255	0800 0000h
ERR 256	Feedback device disconnected	E0256	0800 0000h
ERR 257	Feedback device initializing	E0257	0800 0000h
ERR 260	No input assigned to touch probe	E0260	0800 0000h
ERR 261	COMMERRVTHRESH exceeds VLIM	E0261	0800 0000h
ERR 263	SensAR: The device is busy	E0263	0800 0000h
ERR 264	SensAR: Request timeout	E0264	0800 0000h
ERR 265	SensAR: Flash save failed	E0265	0800 0000h
ERR 266	SensAR: Protocol error	E0266	0800 0000h
ERR 267	SensAR: Illegal request	E0267	0800 0000h
ERR 268	SensAR: Address not aligned	E0268	0800 0000h
ERR 269	Cannot read motor nameplate data	E0269	0800 0000h

ERR #	Error Message	Digital Display	Error Code
ERR 270	Cannot be set when MTPMODE>0	E0270	0800 0000h
ERR 271	Cannot be set when COMMODE>0	E0271	0800 0000h
ERR 272	POSCONTROLMODE not supported	E0272	0800 0000h
ERR 274	Cannot be issued when SFBMODE>0	E0274	0800 0000h
ERR 275	HDTUNE profile is not trapezoidal	E0275	0800 0000h
ERR 276	Not supported on this feedback	E0276	0800 0000h
ERR 277	Feedback returned too much data	E0277	0800 0000h
ERR 278	HDTUNEAVMODE invalid	E0278	0800 0000h
ERR 279	SensAR: Internal request error	E0279	0800 0000h
ERR 280	SensAR driver is occupied	E0280	0800 0000h
ERR 281	SensAR driver failed	E0281	0800 0000h
ERR 282	SensAR driver acquire timeout	E0282	0800 0000h
ERR 283	Drive is not homed	E0283	0800 0000h
ERR 284	SensAR address is out of range	E0284	0800 0000h
ERR 285	SensAR CRC error occurred	E0285	0800 0000h
ERR 286	Autotune activation failed	E0286	0800 0000h
ERR 287	Zero failed. Cannot zero if ILIM=0	E0287	0800 0000h
ERR 288	Comm feedback defaults undefined	E0288	0800 0000h
ERR 289	Feedback memory not partitioned	E0289	0800 0000h
ERR 290	Cannot change in modulo mode	E0290	0800 0000h
ERR 291	Mismatch in EnDat stamp value	E0291	0800 0000h
ERR 292	EnDat 2.X not supported	E0292	0800 0000h
ERR 293	MENCRES too high for this drive	E0293	0800 0000h
ERR 294	HDTUNE Vcruise too low	E0294	0800 0000h
ERR 295	HDTUNE distances not equal	E0295	0800 0000h
ERR 296	Failed to store data on flash	E0296	0800 0000h
ERR 297	Failed to read data from flash	E0297	0800 0000h
ERR 298	CANopen internal error	E0298	0800 0000h
ERR 299	CANopen: object index not found	E0299	0602 0000h
ERR 300	CANopen: object sub index not found	E0300	0609 0011h
ERR 301	CANopen: object size incorrect	E0301	0607 0010h
ERR 302	CANopen: drive in wrong NMT state	E0302	0800 0000h
ERR 303	SFBMODE unsupported in nonlinear	E0303	0800 0000h
ERR 304	Use different sign for Pos and Neg	E0304	0800 0000h
ERR 305	Use same sign for Pos and Neg	E0305	0800 0000h
ERR 306	PHASEFINDMODE=4 with old KCMODE	E0306	0800 0000h
ERR 307	CANopen: Cannot transfer data	E0307	0800 0020h
ERR 308	Positive limit switch is active	E0308	0800 0000h

ERR #	Error Message	Digital Display	Error Code
ERR 309	Negative limit switch is active	E0309	0800 0000h
ERR 310	Home switch in opposite state	E0310	0800 0000h
ERR 311	Motion stopped abruptly	E0311	0800 0000h
ERR 312	BiSS-C: address out of range	E0312	0800 0000h
ERR 313	BiSS-C: the device is busy	E0313	0800 0000h
ERR 314	BiSS-C: Illegal request	E0314	0800 0000h
ERR 315	BiSS-C: EEPROM save failed	E0315	0800 0000h
ERR 316	BiSS-C: busy timeout	E0316	0800 0000h
ERR 317	BiSS-C: internal error	E0317	0800 0000h
ERR 318	BiSS-C: protocol error	E0318	0800 0000h
ERR 319	BiSS-C: driver error	E0319	0800 0000h
ERR 320	BiSS-C: driver acquisition timeout	E0320	0800 0000h
ERR 321	BiSS-C: driver is occupied	E0321	0800 0000h
ERR 322	BiSS-C: request CRC error	E0322	0800 0001h
ERR 324	HIPERFACE data error. Use HSAVE 1.	E0324	0800 0000h
ERR 325	Predefined and set automatically	E0325	0800 0000h
ERR 326	Not allowed in DDHD	E0326	0800 0000h
ERR 328	No serial Enable in COMMODE=1	E0328	0800 0050h
ERR 329	Command for specific customer ID	E0329	0800 0050h
ERR 330	VLIM is less than VCRUISE	E0330	0x08000000
ERR 331	Total cycle time greater than 1 sec	E0331	0x08000000
ERR 332	Motor parameters estimation active	E0332	0x08000000
ERR 333	Uni-direction not allowed in P&D	E0333	0x08000000
ERR 334	DECSTOP less than autotune deceler	E0334	0x08000000
ERR 335	Cannot change when PCOM is enabled	E0335	0x08000000
ERR 336	PCOM output not configured	E0336	0x08000000
ERR 337	PCOM periodic data incorrect	E0337	0x08000000
ERR 338	PCOM output frequency exceeded	E0338	0x08000000
ERR 339	PCOM motor moved during initialize	E0339	0x08000000
ERR 340	PCOM table order incorrect	E0340	0x08000000
ERR 341	PCOM feedback invalid	E0341	0x08000000
ERR 342	PCOM drive is not homed	E0342	0x08000000
ERR 343	PCOM type does not exist	E0343	0x08000000
ERR 344	PCOM output mode not defined	E0344	0x08000000
ERR 345	Dual loop invalid VELCONTROLMODE	E0345	0x08000000
ERR 346	Dual loop invalid ENCOUTMODE	E0346	0x08000000
ERR 347	Dual loop invalid GEARMODE	E0347	0x08000000
ERR 348	Dual loop invalid POSCONTROLMODE	E0348	0x08000000

ERR #	Error Message	Digital Display	Error Code
ERR 349	Invalid SFBTYPE-SFBMODE combination	E0349	0x08000000
ERR 350	MOVESMOOTHAVG 128 max value	E0350	0x08000000
ERR 351	FOE in progress. Value not allowed	E0351	0x08000000
ERR 352	Drive is not set to the correct gantry mode	E0352	0800 0000h
ERR 353	The gantry system is not aligned	E0353	0800 0000h
ERR 354	Requested operation mode is not available in gantry mode	E0354	0800 0000h
ERR 355	Gantry clear faults procedure is active	E0355	0800 0000h
ERR 356	Gantry system is not ready to be enabled	E0356	0800 0000h
ERR 357	Gantry alignment procedure is active	E0357	0800 0000h
ERR 358	Operation not allowed when gantry difference controller PEMAX = 0	E0358	0800 0000h
ERR 359	Position command rejected per GANTRYCMDTYPE	E0359	0800 0000h
ERR 360	Rigid gantry difference controller must use HOMETYPE 35	E0360	0800 0000h
ERR 361	Gantry partner axis tripped a limit switch	E0361	0800 0000h
ERR 362	PCOM error on previous cycle	E0362	0800 0000h
ERR 363	PCOM counter was reset	E0363	0800 0000h
ERR 364	PCOM type not assignable as PDO	E0364	0800 0000h
ERR 365	PCOM time-based not available when position-based active	E0365	0800 0000h
ERR 366	PCOM position-based not available when time-based active	E0366	0800 0000h
ERR 367	Not supported with linear control	E0367	0800 0000h
ERR 368	Not available in DDHD CAN when gantry mode is active	E0368	0800 0000h
ERR 369	GANTRYMODE and SFBMODE cannot be configured simultaneously	E0369	0800 0000h
ERR 370	PCOM TM value exceeded limits	E0370	0800 0000h
ERR 371	Identification process active	E0371	0800 0000h
ERR 372	Function invalid for this output	E0372	0800 0000h
ERR 373	The gantry system is not homed	E0373	0800 0000h
ERR 374	Modification not allowed on error correction enabled request	E0374	0800 0000h

11.5.3 Fault Messages

Table 11-3. Fault Codes and Messages

FLT #	Fault Message (click description for more info)	Emergency (Fault) Error Code
FLT 1	Drive Locked	8180h
FLT 2	Parameter Memory Checksum Failure	5585h
FLT 3	Over-Current	2214h
FLT 4	STO Fault	3181h
FLT 5	FPGA Config Failed	6581h
FLT 6	Control EEPROM Fault	5581h
FLT 7	Power EEPROM Fault	5530h
FLT 8	Vbus Measure Circuit Failed	3182h
FLT 9	Over-Voltage	3110h
FLT 10	Power Stage Over-Temperature	4310h
FLT 11	Under-Voltage	3120h
FLT 12	Not Configured	6381h
FLT 13	Failure Writing to Flash Memory	5586h
FLT 14	Velocity Over-Speed Exceeded	8481h
FLT 15	Encoder Simulation Frequency Too High	7387h
FLT 16	Drive Foldback	2311h
FLT 17	Motor Foldback	2310h
FLT 18	A/B Line Break	7383h
FLT 19	Invalid Halls	7384h
FLT 20	Index Line Break	7111h
FLT 21	Sine Feedback Communication Fail	738Eh
FLT 22	A/B Out of Range	738Fh
FLT 23	Motor Over-Temperature	4410h
FLT 24	Sine Encoder Quadrature Fault	7391h
FLT 25	Sin/Cos Calibration Invalid	7392h
FLT 26	Feedback 5V Over-Current	7393h
FLT 27	Secondary Feedback Index Break	7180h
FLT 28	Secondary Feedback A/B Line Break	7181h
FLT 29	Regen Over-Current	3180h
FLT 30	Fieldbus Velocity Limit Exceeded	6380h
FLT 31	Secondary Encoder 5V Over-Current	2189h
FLT 32	CAN Supply Fault	5582h
FLT 33	Self-Test Failed	5583h
FLT 34	Feedback Communication Error	7380h
FLT 35	Nikon Encoder Operational Fault	7381h

FLT #	Fault Message (click description for more info)	Emergency (Fault) Error Code
FLT 36	Plus 15V Out of Range	5111h
FLT 37	Minus 15V Out of Range	5111h
FLT 38	Watchdog Fault	—
FLT 39	Integrated Power Module Over-Temperature	4080h
FLT 40	Control Board Over-Temperature	4081h
FLT 41	Phase Find Failed	7082h
FLT 42	Tamagawa Init Failed	7382h
FLT 43	Current-Sensors Offset Invalid	2380h
FLT 44	Motor Setup Failed	7081h
FLT 45	Exceeded Maximum Position Error	8611h
FLT 46	Pulse and Direction Input Line Break	7182h
FLT 47	FPGA Version Mismatch	7090h
FLT 48	PLL Synchronization Failed	7386h
FLT 49	Tamagawa Abs Operational Fault	7388h
FLT 50	CAN Heartbeat Lost	8130h
FLT 51	Motor Phases Disconnected	2381h
FLT 52	5V Out of Range	5180h
FLT 55	Resolver Initialization Failed	7394h
FLT 56	Multi-turn Encoder Battery Low Voltage	7385h
FLT 57	Emergency Stop Issued	7091h
FLT 58	Endat2X Feedback Fault	7395h
FLT 59	Stall Fault	7121h
FLT 60	PFB Off Checksum Invalid	FF8Dh
FLT 61	PFB Off Data Mismatch	FF8Eh
FLT 62	No PFB Off Data	FF8Fh
FLT 63	Power Brake Open Load	7112h
FLT 64	Power Brake Short	7113h
FLT 65	Fieldbus Cable Disconnected	7580h
FLT 66	Command Exceeds Acc/Dec Limits	7581h
FLT 67	Exceeded Maximum Velocity Error	8482h
FLT 68	Encoder Phase Error	738Bh
FLT 69	Fieldbus Target Command Lost	7582h
FLT 70	Internal Error	FF01h
FLT 71	Differential Halls Line Break	738Ah
FLT 72	Logic AC Power Failure	—
FLT 73	Temperature Sensor Failure	4096h
FLT 76	Pulse Train Frequency Too High	FF97h

FLT #		Fault Message (click description for more info)	Emergency (Fault) Error Code
FLT	77	Commutation Error (Motor Runaway) Condition Detected	7198h
FLT	78	Bus AC Supply Line Disconnect	3183h
FLT	80	AB Quad Commutation Fault	738Ch
FLT	82	sensAR Encoder Fault	738Dh
FLT	83	Regen Resistor Overload	3199h
FLT	85	MTP Read Failure	FF02h
FLT	86	SAVE and Power Cycle Required	FF03h
FLT	87	Excessive PE Value	8689h
FLT	88	CAN is in Bus-Off State	—
FLT	89	Realtime Overload Fault	FF04h
FLT	90	Secondary Feedback Position Mismatch	8688h
FLT	91	EtherCAT Packet Loss	818Dh
FLT	92	CAN/EtherCAT State Not Operational	F080h
FLT	93	Fieldbus Version Mismatch	7093h
FLT	94	ESI Version Mismatch	7094h
FLT	95	Custom Absolute Encoder Operational Fault	7389h
FLT	96	Digital Output Over-Current Fault	2382h
FLT	98	Power Brake Fault	718Fh
FLT	99	Sankyo Absolute Encoder Fault	7390h
FLT	100	Unstable Current Loop	8380h
FLT	102	BiSS-C Encoder Indicates an Internal Fault	7097h
FLT	103	HIPERFACE Data Error.	7098h
FLT	104	High IQ Current Detected	8381h
FLT	105	Digital Output Over-Current Fault	2382h
FLT	106	Feedback Type Auto-Detect Failed	7396h
FLT	107	EnDat Excessive Resolution Fault	7397h
FLT	108	MOTORNAME/MTP Data Mismatch	FF14h
FLT	109	Firmware Version is Not Supported by this Drive	FF16h
FLT	110	ESI Vendor Mismatch	7099h
FLT	111	MENCZPOS Mismatch with Halls	70A0h
FLT	112	sensAR Encoder Position Fault	7398h
FLT	113	sensAR Over-Temperature Fault	4380h
FLT	114	sensAR Power Supply Insufficient for Operation	3184h
FLT	115	sensAR Battery Voltage is Below Threshold	3185h
FLT	116	sensAR Requires Reset Command	7399h
FLT	117	Internal Position Synchronization Failure	3186h
FLT	118	Multi-Turn Encoder General Failure	3187h

FLT #	Fault Message (click description for more info)	Emergency (Fault) Error Code
FLT 119	sensAR Firmware-Hardware Mismatch	FF15h
FLT 120	Fieldbus Interpolation Cycle Exceeds Sync Time	7583h
FLT 121	Secondary Feedback Communication Error	7380h
FLT 122	Received Object Index Exceed Objects Array Size	—
FLT 129	Gantry Difference Axis Fault (Active Disable)	FF98h
FLT 130	Gantry Difference Axis Fault (not Active Disable)	FF99h
FLT 131	Inter-Drive Communication Fault	FF9Ah
FLT 132	Gantry Alignment Process Failed	FF9Bh
FLT 133	Gantry Difference Controller is Saturated	FF9Ch
FLT 134	Gantry Did Not Receive PFB Ack from Partner Axis	FF9Dh
FLT 135	Gantry FIFO Buffer is Higher than Expected	FF9Eh
FLT 136	Too Many Communication Errors	FF9Fh
FLT 137	High Rate of Gantry Communication Errors	FFA0h
FLT 138	Gantry Did Not Receive Home Offset Ack from Partner	FFA1h
FLT 139	Gantry Partner Axis Did Not Enable	FFA2h
FLT 140	Gantry Partner Axis Reported a Fault	FFA3h
FLT 141	Gantry Homing Failed	FFA4h
FLT 143	Drive Parameters Set to Default Values	—

11.6 Fieldbus Status – LEDs

11.6.1 Status LEDs – CANopen

Interfaces C5 and C6 (on AF models) share a LED that indicates the fieldbus status when communicating on a CANopen network.

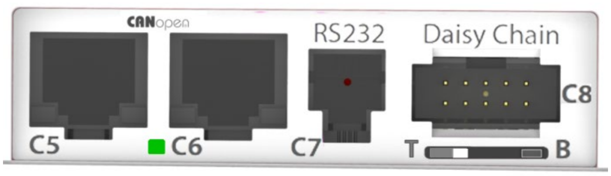


Figure 11-1. Top Panel Interfaces and LEDs on CANopen models

Green	Steadily lit – Operational (OP) state
	Fast flashing – Pre-Operational (PREOP) state
	Slow flashing – Stopped state
Red	Flashing – Error
Not Lit	Drive is not set to EtherCAT/CANopen command interface mode. Refer to VarCom COMMODE

11.6.2 Status LEDs – EtherCAT

Interfaces C5 and C6 (on EB and EC models) each have two LEDs that indicate the fieldbus status when communicating on an EtherCAT network.

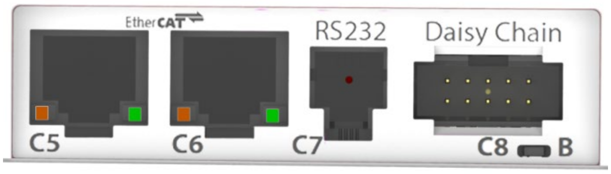


Figure 11-2. Top Panel Interfaces and LEDs on EtherCAT models

Green	Flashing – Communication activity
	Not lit – No communication activity
Orange	Steadily lit – Operational (OP) state
	Slow flashing – Safe-Operation (SAFEOP) state
	Fast flashing – Pre-Operational (PREOP) state
	Very fast flashing – Bootstrap (BOOT) state
	Not lit – Initial (INIT) state

12 CDHD2 Accessories

12.1 Mating Connector Kits

Description	Servotronix Part Number
CDHD2 (MV) Power mating 1.5A 3A 120/240 VAC, Spring	KIT-2A-PWSPR-00
CDHD2 (MV) Power mating 4.5A 6A 120/240 VAC, Spring	KIT-2B-PWSPR-00
CDHD2 (MV) Power mating 8A 10A 13A 120/240 VAC, Crimp	KIT-2C-POWER-00
CDHD2 (MV) Power mating 20A 24A 240 VAC, Spring	KIT-2D-PWSPR-00
CDHD2 (LV) Power mating 3A, 6A, 12A, 15A, 18A 20/90 VAC	KIT-1D-POWER-00
CDHD2 C2 – Controller interface MDR 36 pins	KIT-C2MDR36 0 0 0
CDHD2 C3 – Machine interface MDR 20 pins	KIT-C3MDR20 0 0 0
CDHD2 C4 – Feedback MDR 26 pins	KIT-C4MDR26 0 0 0
CDHD2 STO connector	KIT-00P1000-00

12.2 Cables

Table 12-1. C1 – USB 2.0 A to Mini-B Cable

Note It is strongly recommended that you use the USB cable supplied by Servotronix, which has been tested and proven for reliability.

Item	Specification	Servotronix Part Number
USB 2.0 A to Mini-B Cable		CBLr0000USBA-00
Shield	85% copper braid shield coverage	
Twisted pair	Required	
Maximum length	3 m	
Wire gauge	20–28 AWG	
EMI filtering	2 ferrite cores, located near each connector	

Table 12-2. C2 – Controller Interface Cable

Item	Specification	Servotronix Part Number
C2 Flying Leads Cable	Cable 1 meter, flying leads	CBL-MDR2-36-01
	Cable 2 meter, flying leads	CBL-MDR2-36-02
	Cable 3 meter, flying leads	CBL-MDR2-36-03
	Cable 5 meter, flying leads	CBL-MDR2-36-05
	Cable 10 meter, flying leads	CBL-MDR2-36-10

Table 12-3. C3 – Machine Interface Cable

Item	Specification	Servotronix Part Number
C2 Flying Leads Cable	Cable 1 meter, flying leads Cable 2 meter, flying leads Cable 3 meter, flying leads Cable 5 meter, flying leads Cable 10 meter, flying leads	CBL-MDR2-20-01 CBL-MDR2-20-02 CBL-MDR2-20-03 CBL-MDR2-20-05 CBL-MDR2-20-10

Table 12-4. C4 – Feedback Cable

Item	Specification	Servotronix Part Number
C2 Flying Leads Cable	Cable 1 meter, flying leads Cable 2 meter, flying leads Cable 3 meter, flying leads Cable 5 meter, flying leads Cable 10 meter, flying leads	CBL-MDR2-26-01 CBL-MDR2-26-02 CBL-MDR2-26-03 CBL-MDR2-26-05 CBL-MDR2-26-10

Table 12-5. C5 | C6 – RJ45 Industrial Ethernet/EtherCAT Cat 5e Cable

Item	Specification	Servotronix Part Number
RJ45 CAT5E Cable	Length: 0.5 meter Length: 1 meter Length: 2 meter Length: 10 meter	CBLr00400100-00 CBLr00400180-00 CBLr00400110-00 CBLr00400140-00
Shield	85% copper braid shield coverage	
Twisted pair	Required	
Maximum length	10 m	
Wire gauge	26-27 AWG	

Table 12-6. C7 – RS232 Cable

Item	Specification	Servotronix Part Number
RS232 Cable		CBLrRS232AS0-01
Shield	85% copper braid shield coverage	
Maximum length	10 m	
Wire gauge	24–28 AWG	

Table 12-7. USB to RS232 Adapter Cable

Item	Specification	Servotronix Part Number
USB to RS232 Converter		CBLr000UT880-00
Shield	85% copper braid shield coverage	
Maximum length	1.5 m	

Table 12-8. C8 – Daisy Chain

Item	Specification	Servotronix Part Number
Cable		--
Shield	85% copper braid shield coverage	
Twisted pair	Required	
Maximum length	0.5 m	
Wire gauge	24–28 AWG	

Table 12-9. C3<>C3 – Gantry Cable

Item	Specification	Servotronix Part Number
Gantry Cable	Cable 0.5 meter Cable 1 meter Cable 2 meter	CBL-00C3GAN-005 CBL-00C3GAN-010 CBL-00C3GAN-020
Twisted pair	Required	
Wire gauge	24–28 AWG	

12.3 D9-RJ45 Adapter

Many PLC devices use D9 type interfaces for CAN connections.

To enable the connection of the CDHD2 RJ45 port to a D9 interface, Servotronix offers an adapter, as shown below.

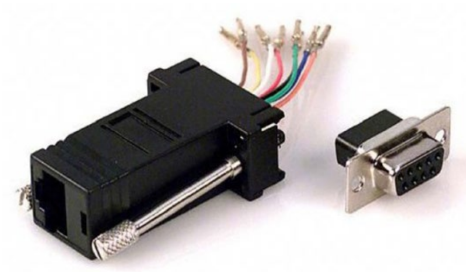


Figure 12-1. D9-RJ45 Adapter

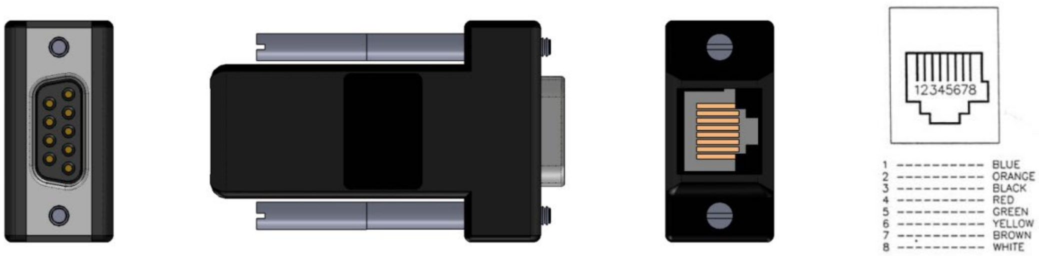


Figure 12-2. D9-RJ45 Adapter Interfaces

Table 12-10. D9-RJ45 Adapter Wiring

Function	CDHD2 RJ45 Pin	D9 Connector Pin
CAN High	1	7
CAN Low	2	2
Functional Ground	3	3
CAN Shield	6	5
Functional Ground	7	6

Table 12-11. D9-RJ45 Adapter

Description	Servotronix Part Number
CDHD2 Adapter CAN, D9 to RJ45	ADPrCAN_D9-RJ45
CDHD2 Adapter DB95, RJ45/ Female 8 Contact	ADPr0AMK0001-00

12.4 Line Filters

The manufacturers and part numbers of line filters recommended for the CDHD2 are listed in the following tables.

Table 12-12. Recommended Line Filters for CDHD2 MV Models

MV Models	**CDHD2-1D5-2A** **CDHD2-003-2A**	**CDHD2-4D5-2A** **CDHD2-006-2A**	**CDHD2-4D5-2A** **CDHD2-006-2A**
Mains	**Single Phase**	**Single Phase**	**Three Phase**
Manufacturer Part Number	High & Low 04SS4-2NC2-x-Q	LCR 0923.01021.00	LCR 096B.01001.00
Manufacturer Part Number	LCR 055M.80601.00	LCR 092.01023.00	Schaffner FN3258
Manufacturer Part Number	LCR 092.00423.00	LCR 055.81011.00	
Manufacturer Part Number	Schaffner FN2070	Schaffner FN2070	
MV Models	**CDHD2-008-2A** **CDHD2-010-2A** **CDHD2-013-2A**	**CDHD2-020-2A** **CDHD2-024-2A**	**CDHD2-033-2A** **CDHD2-044-2A** **CDHD2-055-2A**
Mains	**Three Phase**	**Three Phase**	**Three Phase**
Manufacturer Part Number	LCR 096B.02001.00	LCR 096.03501.00	TBD
Manufacturer Part Number	LCR 097.01601.00	LCR 096B.03001.00	TBD
Manufacturer Part Number	Schaffner FN3258	Schaffner FN3258	TBD

12.5 Regeneration Resistors

Resistance values (Ohms, Ω) are defined by the CDHD2 servo drive. Required power is defined by the application. Therefore, each drive has several regeneration resistor options.

The manufacturers and part numbers of regen resistors recommended for the CDHD2 are listed in the following tables.

Refer to *Regeneration* .

Table 12-13. Recommended Regen Resistors for CDHD2 MV Models

	CDHD2-1D5-2A CDHD2-003-2A	CDHD2-4D5-2A CDHD2-006-2A CDHD2-008-2A CDHD2-010-2A CDHD2-013-2A	CDHD2-020-2A CDHD2-024-2A	CDHD2-033-2A CDHD2-044-2A CDHD2-055-2A
Power (W)	**Minimum Resistance 100 Ω**	**Minimum Resistance 33 Ω**	**Minimum Resistance 15 Ω**	**Minimum Resistance TBD Ω**
150	ISOTEK ULH150 N 100 K FL500	ISOTEK ULH150 N 33 K FL500	ISOTEK ULH150 N 15 K FL500	TBD
300	ISOTEK ULH300 N 100 K FL500	ISOTEK ULH300 N 33 K FL500	ISOTEK ULH150 N 15 K FL500	TBD
600	FRIZLEN FZECU400x65-100	FRIZLEN FZECU400x65-33	ISOTEK ULV600 N 15 K FL500	TBD
1000	X	ISOTEK ULV1000 N 33 K FL500	ISOTEK ULV1000 N 15 K FL500	TBD
2000	X	FRIZLEN FZZCU600x65-33	ISOTEK ULM2000 N 15 K	TBD
3000	X	FRIZLEN FGFKU3100602-33	FRIZLEN FGFKU3100602-15	TBD
4000	X	X	FRIZLEN FGFKU3100802-15	