CUSTOMIZABLE SINGLE-AXIS SERVO DRIVE

INSTALLATION & USER'S MANUAL

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CHAPTER 1. OVERVIEW

1.1 Introduction

This section gives an overview of the available Customizable Single Axis (CSA) Servo-Drive controller models, ratings and general specifications. Detailed outlines of installation and wiring, functionality, user interfaces and other technical data are given in subsequent sections.

CAUTION: Repairs or modifications to the product by anyone other than a Moog authorized repair facility may create unsafe operating conditions and will invalidate the product warranty.

1.2 CSA Models

The CSA family is available in twelve base models, which cover a range of output current ratings.

Table 1-1 CSA Family Models

CSA Base Model			Amplifier Current Rating		
Code	**Size**	**Power Stage ID**	**Continuous (Arms)**	**Maximum (Arms)**	**Peak (A)**
G362-003	µA	9	3	6.4	11
G362-006	µA	8	6	16	22
G362-x08	A	4	8	16	22
G362-014	B	3	14	29.7	42
G362-020	C	2	20	31.8	45
G362-025	C	1	25	49.5	70
G362-030	C	0	30	63.6	90
G362-050	D	14	50	99.3	140
G362-060	D	13	60	127.6	180
G362-100	E	11	100	212.1	300
G362-140	F	10	140	212.1	300

The CSA family uses a 14 character coding system to identify the unique attributes of each model.

Contact your local Moog sales office or authorized distributor for information on valid part numbers, additional features and available fieldbus interfaces.

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1.3 Environmental Specifications

CSA Electronics

Table 1-2 CSA Electronics

Maximum Temperature	
• **Storage:**	-25 C to 55 C (Class 1K4)
• **Transport:**	-25 C to 70 C (Class 2K3)
• **Surrounding Air**	0 C to 40 C
Relative Humidity:	5 % to 85 %, non-condensing, 1 g/m3 to 25 g/m3, in accordance with EN50178 class 3k3
Elevation:	1000m (3,300 feet); De-rate output 2% per 300m (1000ft) above 1000m (3300ft)
Air Pressure:	86 kPa to 106 kPa
Type Of Protection:	Components must be installed into an enclosure. The enclosure must provide at least IP54 per standard EN60529 or equivalent.
Pollution Degree:	Drive is suitable for installation in a Pollution Degree 2 environment.
Installed Position:	Vertical only.
Overvoltage Protection Class:	Category 2 per standard VDE0110 / IEC664
Noise:	Overall noise depends on the user installation and cabinet.

1.4 Design Standards

The CSA SD is CE-Marked under the EU's Low Voltage Directive. It has been designed to allow easy compliance of customer's machines under the EU's EMC Directive (measures as directed in this manual have to be taken to ensure EMC compliance). The CSA SD is designed to the UL508C standard, A-F sizes are UL listed and the CSA size μA are UL recognised.

The CSA SD has been designed to the following specific standards:-

Table 1-3 CSA Design Standards

IP Code	EN 60529:1991
EMC	EN 61800-3:1996 , EN 61800-3/A11:2012 (Second Environment)
UL	UL508C with reference to UL840

1.5 Power Ratings Specifications

Table 1-4 CSA SD Power Ratings

Model : G362-x	3Amp	6Amp	8Amp	14Amp	20Amp	25Amp	30Amp	50Amp	60Amp	100Amp	140Amp
A.C. Mains Input Range **Minimum** **Maximum**	 66Vac (110Vac -40%) 506Vac (460Vac +10%)										
Frequency Range	50 - 60Hz										
Internal Regeneration Power **Continuous Dissipation** **Peak Dissipation @ 230Vac** **Peak Dissipation @ 400Vac**	50W 1.3KW 4.8kW	100W 1.3kW 4.8kW	150W 2.6kW 10.3kW	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
External Regeneration Power **Continuous Dissipation** **Peak Dissipation @ 230Vac** **Peak Dissipation @ 400Vac**	50W 1.2KW 4.8kW	100W 1.2kW 4.8kW	200W 2.8kW 11.3kW	250W 4.4kW 17.5kW	370W 12.0kW 48.1kW	370W 12.0kW 48.1kW	370W 12.0kW 48.1kW	750W 14.4kW 57.8kW	750W 14.4kW 57.8kW	1kW 37kW 148kW	1.5kW 48kW 192.5kW
Softstart Peak Inrush Current/Phase	30Apk										
Power Supply Fault Detection	D.C. Bus Overvoltage D.C. Bus Undervoltage Bridge Temperature Fault Amplifier Short Circuit Protection 24V Logic Backup Monitoring										
Voltage Discharge after A.C Mains Removal	Bleed Resistors across high voltage section.										

* Contact your local Moog sales office or authorized distributor for information

1.5.1 Optional Control Logic Backup Power

Table 1-5 CSA SD Control Logic Backup Power Ratings

D.C. Bus Minimum Voltage *Below which, 24Vd.c.* *Control Logic Backup supply is needed*	170Vd.c. (Generated from rectified 120Va.c.)
+24Vdc Input Control Voltage *Supply must have a reliable isolation from mains,* *in accordance with EN 50178*	24Vdc ± 10% 2.0A steady state

An auxiliary +24Vdc. control logic backup supply is **MANDATORY** for the (G362-003-XXXX-XXXX or G362-006-XXXX-XXXX) variants of the CSA product family.

The 24V backup supply input is intended for use in the secondary of a Class 1 supply. It should be additionally fitted with a current limiting device, either a fuse rated 3A or circuit breaker (CB) which will cut off the supply to the drive in the event of a safety related fault condition.

1.5.2 Power Amplifier

Table 1-6 CSA SD Power Amplifier Ratings

Power Amplifier Ratings:	
Model	**Rating**
G362-003	3A continuous/11A peak
G362-006	6A continuous/22A peak
G362-x08	8A continuous/22A peak
G362-014	14A continuous/42A peak
G362-020	20A continuous/45A peak
G362-025	25A continuous/70A peak
G362-030	30A continuous/90A peak
G362-050	50A continuous/ 140A peak
G362-060	60A continuous/ 180A peak
G362-100	100A continuous/ 300A peak
G362-140	140A continuous/ 300A peak

The continuous current is shown is Arms and the maximum current is shown in shown as Amps\peak, See Reference, *Table 1-1 CSA Family Models* for details.

Two levels of thermal protection which limit the peak current and the time for which the Peak current is available protect the CSA drives. These are:

- RMS Protection,
- Thermal Foldback.

1.5.4.1 RMS Protection

The RMS protection acts to limit the current provided to the rated continuous current of the drive. Thus, a G362-006 cannot supply, on average, greater than 6Amps continuous RMS to the motor. The current to the motor is averaged and if it exceeds the RMS rating, the drive limits the current command. If the controller continuously demands current greater than the drive capability, the RMS protection will limit the actual current supplied to the drive rating. The time for which peak current can be supplied is dependent on whether the motor is stalled or running.

1.5.4.2 Thermal Foldback

Thermal Foldback is implemented in the CSA drives to prevent the junction temperatures of the amplifier bridge IGBT's exceeding their maximum rated temperature. The thermal Foldback is based on a measure of the heatsink temperature and the mode in which the drive is operating (motor running or stalled). As the heatsink temperature increases, the peak current capability of the drive is reduced to ensure the IGBT die temperature cannot increase above the device maximum rating.

For the CSA D size, a simple thermal shutdown is implemented, as the drive bridge thermal feedback is monitored via a single PTC. These drives will report an overtemperature fault once the measured heatsink temperature exceeds the maximum rating of the drive. For CSA sizes E & F the bridge temperature is monitored via an NTC and a PTC. The NTC will monitor the bridge temperature until a temperature of 80ºC is reached, beyond this threshold a simple thermal shutdown is implemented.

1.6 General Functional Specifications

1.6.1 Optically Isolated Digital Inputs (J2A)

- Maximum of eight user configurable, bipolar, optically isolated digital inputs
- Digital Input 1 - dedicated hardware enable input function
- Digital inputs are optically isolated to a maximum of 2.5kVrms
- Digital inputs operate over a 12Vdc…36V dc input voltage range.
- 2.3kΩ input impedance.

Table 1-7 CSA Digital Inputs Overview: Standard Configuration

STANDARD FUNCTION	**FIELDBUS OR INTERFACE SPECIFIC**
Hardware Enable Input	Hardware Enable Input
Auto / Manual Mode	See Section 5.10.1, Digital Input functionality
Torque / Velocity Mode Switch	*See Section 5.10.1, Digital Input functionality*
Brake Control	*See Section 5.10.1, Digital Input functionality*
CW Limit Switch	*See Section 5.10.1, Digital Input functionality*
CCW limit Switch	*See Section 5.10.1, Digital Input functionality*
Quick Stop	*See Section 5.10.1, Digital Input functionality*
Controlled Disable	*See Section 5.10.1, Digital Input functionality*

Where the CSA is factory configured for use with a digital incremental encoder with support for commutation tracks [G362-XXX-XX (5) X-XXXX or G362-XXX-XX (6) X-XXXX], only four optically isolated digital inputs are available to the user, (digital input 1-4)

1.6.2 Optically Isolated Digital Outputs (J2B)

- Maximum of three user configurable, optically isolated digital outputs
- All outputs are optically isolated.
- Digital outputs operate as low side drivers only i.e. load is connected between V+ and digital output
- Overvoltage protected to 60Vdc for inductive loads
- Nominal ratings of 6V to 32V, 250mA
- Short-circuit & reverse polarity protected
- Off-state leakage current 5μA typical at 0Vdc

Table 1-8 CSA SD Digital Outputs Overview

STANDARD FUNCTION	**FIELDBUS OR INTERFACE SPECIFIC**
Drive Enabled	Hardware Enable Input
Limiting Function	See Section 5.10.2, Digital Output functionality
User Defined	*See Section 5.10.2, Digital Output functionality*

1.6.3 Standard Input and Output Functionality

Table 1-9 Standard Input and Output Functionality

STANDARD FUNCTION	INTERFACE SPECIFIC
Drive Ready (J2C)	Relay output, contact ratings: 36V, 100mA max. • Normally open mechanical contact (NO). • Closed when the drive is in a ‘Ready to Enable’ state, • A ‘0’ is present on the seven segment display
Brake Control (J2D)	2A, 24Vd.c. solid-state high-side drive for motor brake control. Switched under user control or CSA software control
Motor Position Feedback Type (J3/J4)	Supported Resolver & Encoder Types • Serial Synchronous Interface [SSI] • Sick|Stegmann Hiperface® • Analogue Encoders • EnDat 2.1 & EnDat 2.2 Encoders • Digital Incremental Encoders – including support for commutation tracks • MCG LP SSI
Communications Interfaces (J1)	RS232 Interface at 19200…..115200 Baud

The CSA may be factory configured with a solid state relay option [G362-XXX-XX (3) X-XXXX or G362-XXX-XX (4) X-XXXX], in replace of the mechanical option available on the standard CSA, for use in ignition sensitive environments.

Where the CSA is factory configured for use with a digital incremental encoder with support for commutation tracks [G362-XXX-XX (5) X-XXXX or G362-XXX-XX (6) X-XXXX], only four optically isolated digital inputs are available to the user, (digital input 1-4). Commutation tracks are supported via J2A:6-8 and J3:9, *please refer to section 5.6 for details*

1.6.4 Variant Specific I/O

1.6.4.1.1 Refer to the appendix for details on a specific fieldbus variant.

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CHAPTER 2. SAFETY AND EMC INSTRUCTIONS

2.1 General

This user's manual is intended to provide sufficient information on how to install Moog CSA electric motor systems. Section 2.2 covers Safety and System Safeguards. Section 2.3 covers Electromagnetic Compatibility (EMC). This user's guide must be read and understood before applying power and operating the equipment described.

This equipment must be installed and serviced only by duly qualified service personnel. All information in this manual is directed towards such persons only. Individuals responsible for the installation of the equipment described in this user's guide must ensure;

1) only technically qualified individuals are employed to work on the installation,
2) these qualified individuals must have the accompanying documentation available at all times when working on the installation and are obliged to use this documentation in a consistent manner, and
3) work on, or close to, the installation is prohibited for non-technically qualified individuals

Throughout this user's guide may be found ANSI Z535.4-2007 based pictorials indicating **NOTES, CE-Compliance-Required** and safety related **CAUTIONS**, and **WARNINGS** and **DANGER** related symbols. They are defined as follows:

NOTES are general in nature and are intended to emphasise information.

CAUTIONS are to alert personnel to actions that could cause equipment damage, resulting in the equipment becoming unsafe

WARNINGS serve to make personnel aware of potentially hazardous actions that may result in personal injury or death, **Warnings indicating a risk to moving parts**

WARNINGS serve to make personnel aware of potentially hazardous actions that may result in personal injury or death, **Warnings indicating a risk of high voltage**

CE-Compliance indicates where a particular application-related safety or EMC requirement is driven by the need for CE-Compliance of the CSA when installed in the system. Customers who do not need CE-Compliance on their machinery may choose not to implement these features.

The CSA controller contains potentially lethal voltages. Extreme caution shall be observed whenever the equipment is in operation. Incorrect installation of the motor or the controller may cause damage to the equipment, serious personal injury or death. Consequently, the instructions in this user's manual, as well as national and local rules and safety regulations must be complied with.

2.2 Safety Regulations

1. The CSA controller must be disconnected from all power if repair work is to be carried out. Check that the mains supply has been disconnected and that at least 5 minutes has passed to allow the D.C. bus capacitors to discharge, before removing motor and mains connections.
2. Correct protective earthing of the equipment must be established, the user must be protected against high voltage supply, and the motor must be protected against overload in accordance with applicable national and local regulations.
3. Do not remove the connections for the motor and mains supply while the CSA controller is connected to mains power. Check that the mains supply voltage has been turned-off and that the necessary time has passed before removing motor and mains connections.

WARNING AGAINST UNINTENDED START - The installation of safety interlocks, additional control and protection devices must be done in accordance with the relevant local safety requirements. Note that changes made through software can result in the motor starting suddenly.

This user’s manual assumes that the user has a basic working knowledge of servo-drive products and the system motion controller. The user should provide the necessary additional training for ALL personnel working within or around the workcell.

NOTE - These safety precautions are guidelines only and are not claimed to be comprehensive. The Moog Brushless Technology products described herein, in conjunction with the system controller, provide the capability for control of remote devices. Typically, these remote devices move at high speeds and exert considerable force. Like all mechanical systems and most industrial equipment, they must be treated with respect by both the machine integrator and user, and the operator.

NOTE - This user’s guide defines “user” as the responsible person or company and “operator” as a person who starts, stops or monitors workcell operation.

NOTE - This user’s guide should be read by all personnel who operate or who work within or near the workcell.

Individuals responsible for the installation of the equipment described in this user’s guide must ensure that only technically qualified service personnel are employed to work on the installation.

In the context of these safety instructions, skilled technical personnel means people who are familiar with the product, and have the necessary technical qualifications required for the performance of their functions.

2.2.1 System Safeguards

2.2.1.1 General Safety Requirements

Users are required to implement safety measures with all equipment, systems and installations into which the CSA Servo-drive is installed. In addition, safeguards must be an integral part of workcell design, installation, operator training and operator procedures where this equipment is used.

Users are directed to refer to the European Union (EU**) Machine Safety Directive**: 98/37/EC and **EU Low Voltage Directive** 73/23/EEC (as amended by EU Directive 93/68/EEC) for essential health and safety requirements to be met. Furthermore the requirements of the EU EMC Directive: 89/336/EEC (as amended by EU Directive 92/31/EEC and 93/68/EEC) must be met by all equipment, systems and installations into which the CSA Controllers are installed.

Users are recommended to refer to the latest publications of the European Union (EU) commission and to local regulations for further information on the requirements of these directives of the EU.

Users are required to ensure that the drive is only connected to supply network configurations of the following types

- TN Systems including TN-C, TN-S, TN-C-S
- TT Systems

Connection to IT systems or corner-earthed TN systems is not permitted. Users should ensure the nature of the supply system is appropriate before connecting and operating the drive.

2.2.1.2 Specific Safety Requirements

The specific safety measures described below are required to be installed by the user into all equipment, systems and installations into which the CSA Series Controllers are installed.

The user is required to provide safety interlocks to prevent unexpected restart during servicing of the CSA Controller and any equipment attached to or driven by these units.

The CSA Servo-drives themselves must be installed in enclosures or cabinets that provide a degree of ingress protection against liquids and objects of at least IP54. These enclosures or cabinets must be accessible to technically qualified service or maintenance persons only. All external Regen (Regenerative circuit) resistors used with the CSA must be installed in enclosures which provide a degree of ingress protection against liquids and objects of at least IP22 and which are accessible to technically qualified service or maintenance persons only. Protection against electric shock must be maintained when installing these resistors.

The equipment may have a continuous leakage current of more than 3.5 mA A.C. or 10 mA D.C. in normal use. The CSA must be permanently and reliably connected to Earth and all conductive parts in the IP54 rated enclosure or cabinet must be permanently connected to Earth. The impedance between the earth terminal and any accessible part of the enclosure or cabinet should be less than or equal to 0.1ohm.

A dc component can occur in the fault current in the event of a fault connection to earth. Only a residual-current-operated protective device (RCD) of Type B is allowed. When the protection in installations with regard to indirect contact is achieved by means of an RCD, their appropriate function/combination shall be verified.

All electrical supply wires and cables to this equipment must be installed in wireways (cable routings) which are smooth and free from sharp edges.

All external D.C. Supply voltages used with the CSA Series Controllers must be derived from a Safety Extra Low Voltage (SELV) or Protective Extra Low Voltage (PELV) supply as defined by standard EN60950. Such SELV voltages do not exceed a value of 60Vd.c. or 42.4Vac peak under normal conditions and are supplied by circuits which are separated from all hazardous voltage conductors by permitted safety methods such as reinforced insulation.

All external electrical wiring connected to this equipment must be colour coded in accordance with European Standard EN 60204-1 requirements.

All wires and cables entering and leaving the IP54 rated enclosures or cabinets containing the CSA Controllers and Regen resistor(s) must be protected and anchored in accordance with the requirements of EN 60204-1.

As no fuses are provided inside the drive, the CSA SD must be provided with suitable fusing to protect the drive. The fuses required for each CSA SD model are detailed in the following table. It is recommended to use UL certified fuses and fuse blocks.

Table 2-1 Recommended CSA SD Fusing

CSA SD Models	**Size ‘µA’**					**Notes**
Size	3/11			6/22		**-**
Short Circuit Rating	5,000 Arms					-
Power Line Fuse	25A, 660V FWP25-A1F					Semiconductor (Cooper Bussmann)
Recovery Resistor Fuse	Contact Moog Application Engineering for Advice					-
24Vdc Aux. Pwr. Fuse	3A, 250V					Delayed
CSA SD Models	**Size ‘A’**			**Size ‘B’**		**Notes**
Size	8/22			14/42		**-**
Short Circuit Rating	5,000 Arms					-
Power Line Fuse	50-FE 690V					Semiconductor (Cooper Bussmann)
Recovery Resistor Fuse	Contact Moog Application Engineering for Advice					-
24Vdc Aux. Pwr. Fuse	3A, 250V					Delayed
CSA SD Models	**Size ‘C’**			**Size ‘D’**		**Notes**
Size	20/45	25/70	30/90	50/140	60/180	-
Short Circuit Rating	5,000 Arms			10,000 Arms		-
Power Line Fuse	100-FE 690V			160-FEE 690V		Semiconductor (Cooper Bussmann)
Recovery Resistor Fuse	Contact Moog Application Engineering for Advice					-
24Vdc Aux. Pwr. Fuse	3A, 250V					Delayed
CSA SD Models	**Size ‘E’**			**Size ‘F’**		**Notes**
Size	100/300			140/300		-
Short Circuit Rating	10,000 Arms					-
Power Line Fuse	315-FM					Semiconductor (Cooper Bussmann)
Recovery Resistor Fuse	Contact Moog Application Engineering for Advice					-
24Vdc Aux. Pwr. Fuse	3A, 250V					Delayed

2.2.2 Equipment Safety

All persons must observe sound safety practices during the operation and testing of all electrically powered equipment. Prior to first use, power should not be applied to the CSA Servo-drive until all instructions in the Wiring and Installation section of this User's manual have been carried out.

WARNING – In the event of a fuse failure, remove all power; refrain from working on the unit for at least 5minutes to allow all internal voltages to decay to a safe level. Remove all fuses from the system and determine the source of the failure before re-commencing operation of the drive.

WARNING - DO NOT-remove or replace any assemblies, subassemblies or components with power present.

WARNING - Lethal voltages remain present within this equipment when the mains power is removed. It is recommended to refrain from commencing any servicing, maintenance, repair or upgrading of this equipment until at least 5 minute after power shutdown. It is further recommended to measure the voltage level at all high voltage terminals before commencing any such activities, to ensure that no lethal voltages are present.

WARNING – The removable plug-in connectors of the CSA Servo-Drives are for ease of wiring installation. These removable plug-in connectors are not suitable for connection or disconnection under power. All connections must be made with power removed.

WARNING - Repair or internal adjustments to the CSA Series Controllers must not be attempted. All faulty items must be returned to Moog Service Centres for maintenance and repair.

WARNING - Entering the workcell when **HIGH POWER** or **PROGRAM RUNNING** indicators are **ON** may result in severe injury.

WARNING - The equipment described in this user's guide operates at voltage levels, which can exceed 800 volts D.C., and/or 460 volts A.C. These levels are a potential source of severe electrical shock. **DO NOT** remove or replace any assemblies, subassemblies or components with the primary power present. To avoid possible personal injury or equipment damage, always remove power **BEFORE** attempting repair or upgrade procedures. Wait at least 5 minutes after power shutdown to ensure power supply capacitors have discharged. Then using a voltmeter, check for safe levels across all high voltage power terminals.

Safeguards should be an integral part of a work cell design, installation, operator training, and operator procedures. A computer-controlled system may activate remote devices under program control at times not anticipated by personnel. It is critical that safeguards be in place to prevent personnel from entering the work cell whenever equipment power is present. Moog highly recommends the use of work cell safety features such as light curtains, safety gates or safety floor mats to prevent access to the workcell while power is present. Computer controlled systems have various communication features which may aid the user in constructing system safeguards, including:

- Emergency stop circuitry
- binary input and output lines
- spare system-controlled user lines

The emergency power-off circuitry of a computer-controlled system is generally capable of switching external power systems, as well as detecting intrusion signals from safety barriers.

All personnel must observe sound safety practices during the operation and testing of all electrically powered equipment. To avoid injury or damage to equipment, always remove power BEFORE attempting ANY repair or upgrade activity.

2.2.3 Safety Requirements for Cables

User's whose machine installations require CE-Compliance should read this Section.

a) Requirements - Conductors and Cables

All cables and conductors used shall be specified as compliant with the requirements of European Standard EN 60204-1 and other known National and International Standards for the environment in which they are installed and for the voltage and current carried.

Conductors and cables shall be specified and selected so as to be suitable for the operating conditions (e.g. voltage, current, protection against electric shock, grouping of cables) and external influences (e.g. ambient temperature, presence of water or corrosive substances, mechanical stress) which can exist.

The table below details the recommended cable dimensions for all CSA models

Table 2-2 Recommended CSA Cable Dimensions

	CSA Models				Notes
	µA		A	B	
Cable	**3/11** AWG (mm²)	**6/22** AWG (mm²)	**8/22** AWG (mm²)	**14/42** AWG (mm²)	
Line Power	3x14 (2.1)			3x12 (3.3)	
Protective Bonding Cable	1x 6 (13)				
Motor Power Cable	4x14 (2.1)			4x12 (3.3)	Shielded
Regen Resistor Cable	2x14 (2.1)				Shielded
DC Bus Cable	2x14 (2.1)				Shielded
Safety Interlock (If applicable)	2x22 (0.3)				Shielded
24V Power Cable	2x14 (2.1)				Shielded

	CSA Models					Notes
	C			D		
Cable	**20/45** AWG (mm²)	**25/70** AWG (mm²)	**30/90** AWG (mm²)	**50/140** AWG (mm²)	**60/180** AWG (mm²)	
Line Power	3x8 (8.4)			3x 6 (13)	3x 4 (21)	
Protective Bonding Cable	1x 6 (13)			1x6 (13)	1x4 (21)	
Motor Power Cable	4x8 (8.4)			4x6 (13)	4x4 (21)	Shielded
Regen Resistor Cable	2x8 (8.4)			2x 6 (13)	2x4 (21)	Shielded
DC Bus Cable	2x8 (8.4)			2x 6 (13)	2x4 (21)	Shielded
Safety Interlock (If applicable)	2x22 (0.3)					Shielded
24V Power Cable	2x14 (2.1)					Shielded

	CSA Models		Notes
	E	F	
Cable	**100/300** AWG (mm²)	**100/300** AWG (mm²)	
Line Power	3 x 1 (42)	3 x 1 (42)	
Protective Bonding Cable	1 x 1 (42)	1 x 1 (42)	
Motor Power Cable	4 x 1 (42)	4 x 1 (42)	Shielded
Regen Resistor Cable	2 x 2 (34)	2 x 2 (34)	Shielded
DC Bus Cable	2 x 1 (42)	2 x 1 (42)	Shielded
Safety Interlock (If applicable)	2x22 (0.3)		Shielded
24V Power Cable	2 x 14 (2.1)		Shielded

Wherever possible, insulated conductors and cables that have flame-retardant properties shall be used.

Where insulated conductors and cables can constitute a fire hazard due to the propagation of a fire or the emission of toxic or corrosive fumes (e.g. PVC), guidance from the cable supplier should be sought. In particular it is important to maintain the integrity of circuits having a safety function (e.g. emergency stop) for as long as possible under these conditions.

The mechanical strength and thickness of the insulation shall be such that the insulation cannot be damaged in operation or during laying, especially for cables pulled into ducts.

The voltage drops on cables and conductors shall not exceed 5% of the nominal voltage. The current carrying capacity of the conductors and cables is determined by both:

- The maximum allowable conductor temperature under the highest possible steady state current under normal conditions; and
- The ultimate allowable short-time conductor temperature under short circuit conditions.

2.2.3.1 Wiring Practices - Connections and routing

All connections, especially those of the protective bonding circuit, shall be secured against accidental loosening.

2.2.3.2 Wiring Practices - Conductor and cable runs

Conductors and cables shall be run from terminal to terminal without splices or intervening joints

Where it is necessary to connect and disconnect cables and cable assemblies, sufficient extra length shall be provided for this purpose.

The terminations of multicore cables shall be adequately supported where undue strain can be exerted on the terminations of the conductors.

Wherever possible, the protective conductor shall be placed close to the associated live conductors in order to decrease the impedance of the loop.

2.2.3.3 Wiring Practices - Conductors of different circuits

Subject to the constraints for EMC suppression given in this User’s manual, conductors of different circuits may be laid side by side. They may occupy the same duct (e.g. conduit, cable trunking system) and may be in the same multicore cable, provided that the arrangement does not impair the proper functioning of the respective circuits. Where these circuits operate at different voltages, the conductors shall be either separated by suitable barriers or insulated for the highest voltage to which any conductor within the same duct can be subjected.

Circuits which are not switched off by the supply disconnecting device (circuit breaker) shall be either physically separated from other wiring or distinguished by color (or both) so that they can be identified as being live when the supply disconnecting device is in the OFF or OPEN position.

2.2.3.4 Wiring Practices - Identification of conductors

For safety reasons, the color Green or the color Yellow shall not be used where there is a possibility of confusion with the bicolor combination GREEN-AND-YELLOW.

Color identification using combinations of colors may be used provided there can be no confusion and that GREEN or YELLOW is not used, except in the bicolor combination GREEN- AND-YELLOW.

2.2.3.5 Wiring Practices - Identification of the Protective Conductor

The protective conductor shall be readily distinguishable by shape, location, marking or color. When identification is by color alone, the bicolor combination GREEN-AND-YELLOW shall be used throughout the length of the conductor. This color identification is strictly reserved for the protective conductor.

For insulated conductors, the bicolor combination GREEN-AND-YELLOW shall be such that on any 15mm length, one of the colors covers at least 30% and not more than 70% of the surface of the conductor, the other color covering the remainder of the surface.

Where the protective conductor can be easily identified by its shape, position or construction (e.g. braided conductor), or where the insulated conductor is not readily accessible, color coding throughout its length is not necessary. However, the ends or accessible positions shall be clearly identified by the graphical symbol or by the bicolor combination GREEN-AND-YELLOW.

2.2.3.6 Wiring Practices - Identification of the Neutral Conductor

Where a circuit includes a neutral conductor identified by color, the color shall be LIGHT BLUE. LIGHT BLUE shall not be used for identifying any other conductor where confusion is possible.

In the absence of a neutral conductor, a LIGHT BLUE conductor may be used for other purposes except for use as a protective conductor.

Where identification by color is used, bare conductors used as neutral conductors shall be either colored by a LIGHT BLUE stripe, 15 mm to 100 mm wide, in each compartment or unit or at each accessible position, or colored LIGHT BLUE throughout their length.

2.2.3.7 Wiring Practices - Wiring Inside Enclosures

Panel conductors shall be supported where necessary to keep them in place. Non-metallic channels or conduits shall be permitted only when made with a flame-retardant insulating material. Where possible, earthed shielded metal cable ducting should be used to minimise EMC noise coupling.

It is recommended that electrical equipment mounted inside the enclosures be designed and constructed in such a way as to permit modification of the wiring from the front of the enclosure. Where this is not possible and control devices are connected from the rear of the enclosure, access doors or swing-out panels shall be provided.

Connections to devices mounted on doors or to other movable parts shall be made using flexible conductors in accordance with European standard EN 60204-1, to allow for the frequent movement of the part. The conductors shall be anchored to the fixed part and the movable part independently of the electrical connections.

Conductors and cables that do not run in ducts shall be adequately supported.

Terminal blocks or attachment plug/socket combinations shall be used for control wiring that extends beyond the enclosure.

Power cables and cables of measuring circuits may be directly connected to the terminals of the devices for which the connections were intended.

2.2.3.8 Wiring Practices - Wiring Outside Enclosures

The means of introduction of cables or ducts with their individual glands, bushings, etc., into an enclosure shall ensure that the degree of protection is not reduced.

Conductors and their connections external to the electrical equipment IP54 enclosures shall be installed in suitable ducts (i.e. conduit or cable trunking systems) as described in Section 2.2.4, except for suitably protected cables, which may be installed without enclosing ducts and with or without the use of open cable trays or cable support means.

Fittings used with ducts or multi-conductor cable shall be suitable for the physical environment.

Flexible conduit or flexible multi-conductor cable shall be used where it is necessary to employ flexible connections to pendant push-button stations. The weight of pendant stations shall be supported by means other than the flexible conduit or the flexible multi-conductor cable, except where the conduit or cable is specifically designed for that purpose.

Flexible conduit or flexible multi-conductor cable shall be used for connections involving small or infrequent movements. They shall also be permitted to complete the connection to normally stationary motors, to position switches, and to other externally mounted devices.

Connections to frequently moving parts shall be made with conductors suitable for flexing service in accordance with European standard EN 60204-1. Flexible cable and flexible conduit shall be so installed as to avoid excessive flexing and straining particularly at the fittings.

Cables subject to movement shall be supported in such a way that there is no mechanical strain on the connection points or any sharp bending. The loop shall have sufficient length to provide for a bending radius of the cable of at least ten times its outside diameter.

Where cables subject to movement are close to moving parts, precautions shall be taken so that a space of at least 25mm shall be maintained between the moving parts and the cables. Where this distance is not practicable, fixed barriers shall be provided between the cables and the moving parts.

The cable sheath shall be resistant to the normal wear which can be expected from movement, and to the effects of atmospheric contaminants (e.g. oil, water, coolants, and dust).

Where flexible conduit is adjacent to moving parts, the construction and supporting means shall prevent damage to the flexible conduit or cable under all conditions of operation.

Flexible metal conduit shall not be used for rapid or frequent movements, except when specifically designed for that purpose.

2.2.3.9 Wiring Practices - Ducts, Connection and Junction Boxes

All sharp edges, flash, burrs, rough surfaces, or threads, with which the insulation of the conductors may come in contact, shall be removed from ducts and fittings. Wherever necessary, additional protection consisting of flame-retardant oil-resistant insulating material shall be provided to protect the conductor insulation from harsh environments.

Ducts and cable trays shall be rigidly supported and positioned at a sufficient distance from the moving parts and in such a manner so as to minimise the possibility of damage or wear.

Cable trunking systems external to enclosures shall be rigidly supported and clear of all moving or contaminating portions of the machine or equipment into which they are installed.

Note: 2x14 (2.08) = Number of conductors x conductor size
(AWG = American wire gauge).

2.2.4 EMC requirements for cables

User's whose machine installations require CE-Compliance should read this Section.

Avoid close parallel routing of signal cables and power cables. Always use the minimum length of cable necessary and install all cables in a fixed routing.

Data signal cables, motor power and resolver/signal cables, regen resistor cables and power input cables shall have segregated routings. Where cable routings must intersect, it is recommended that they intersect at an angle of 90 degrees, to minimise EMC noise coupling.

Where signal and power cables must run in parallel it is recommended that these cables are separated by at least 20 cm. Where possible, cables shall be routed in earthed shielded cable ducting, to minimise electromagnetic noise coupling.

Use shielded cable to connect the external regen resistor (if installed) to the CSA. The length of this cable shall be as short as possible. The shields of these voltage supply cables shall be earthed to Chassis Earth using the EMC kit or the panel earth bar. Alternatively, if the cable is required to pass through an enclosure panel earthed to Chassis Earth, the shield may be earthed to the panel by use of a 360 degree metal cable gland.

Cables supplying external D.C supply voltages to the CSA Servo-drive (For example, the +24Vd.c. supply) must be as short as possible. The supply wires shall be twisted together or alternatively shielded cable shall be used.

Cables connecting the D.C bus from the CSA Servo-drives must be as short as possible. Shielded cable shall be used.

Motor power cables must be shielded with the cable shield securely connected to Chassis Earth at both ends of the cable. At the CSA end of the cable the shield shall be earthed to Chassis Earth using the EMC kit or the panel earth bar.

Motor resolver/signal cables must be shielded with the cable shield securely connected to Chassis Earth at both ends of the cable.

Signal cables must be shielded with the cable shield securely connected to make a good HF earth bond to Chassis Earth at both ends of the cable.

2.3 Electromagnetic Compatibility (EMC)

User's whose machine installations require CE-Compliance should read this Section.

The CSA Servo-drives are system components which must be installed in a correct manner to ensure that all electromagnetic compatibility (EMC) requirements are met. The requirements of European Union (EU) EMC Directive: 89/336/EEC (as amended by EU Directives 92/31/EEC and 93/68/EEC) must be met by all equipment, systems and installations into which the CSA Servo-drive are installed.

For further information on the requirements of EU EMC Directive the user is recommended to refer to the latest publications of the EU Commission and to local regulations.

The CSA Servo-drives have been tested for compliance with the requirements of the EU EMC Directive in so far as they can be regarded as single functional units. The CSA have been tested in typical configurations and it has been found that these configurations meet the essential requirements of the EU EMC Directive. The EMC standards applied is EN61800-3:

This standard is published by **CENELEC**, European Committee for Electrotechnical Standardisation, Brussels.

2.3.1 Specific Electromagnetic Compatibility (EMC) Requirements:

The EMC measures outlined below are required to be installed by the user into all equipment, systems and installations into which the CSA is installed. Further details are given throughout this User’s Guide.
The CSA Servo-drive must be installed by mounting on a panel in a manner that ensures that EMC earthing requirements are met. (Refer Section 3 of this User’s Guide).

EMC brackets are provided to facilitate earthing of cable shields prior to entering the CSA. Cable shields must be bonded to either the panel earthing bar or the EMC brackets.

For safety reasons the CSA Servo-drive, and the panel on which they are mounted must be installed in enclosures or cabinets which provide a degree of ingress protection against liquids and objects of at least IP54. These enclosures or cabinets must be accessible to technically qualified service or maintenance persons only. For Electrostatic Discharge (ESD) reasons all service or maintenance persons must ground themselves to the chassis of the equipment when performing service functions inside the IP54 rated enclosure or cabinet in which the CSA Servo-drive are installed.

All external D.C supply voltages used with the CSA must be supplied from power supplies which are compliant with the requirements of the EU EMC Directive. All other equipment that is connected to the CSA must be compliant with the EU EMC Directive.

Shielded cable is required to be installed by the user for many external user cable connections to the CSA. Details of areas where shielded cable must be installed and details of earthing arrangements which must be implemented for the shields of such cables are given throughout Section 3 of this User’s Guide.

This equipment is intended to be connected to an industrial low-voltage power supply network, or public network, which does not supply buildings used for domestic purposes (**second environment**, according to EMC Standards). If connected to a low-voltage public network that supplies domestic premises (first environment), this product is expected to cause radio interference in which case supplementary measures may be required.

2.3.2 Recommended EMC Filters

No internal filtering is provided in the CSA. To ensure EMC compliance an external line filter must be installed. The recommended filters for the CSA are detailed below.

Table 2-3 - Recommended EMC Filters for CSA, µA Size

Manufacturer	Rated Current (A) @ 50ºC (40ºC)	Max Voltage	Drive Input
Schaffner Fairite Clamp. Part # 00443164151	-	-	$24V_{dc}$ Input (4 Turns in Common Mode)
Schaffner FN 258-7/07	7 (8.4)	3x480V	3-phase AC Line Input
Schaffner FN 350-12/29	12 (13.8)	1x250V	1-phase AC Line Input (µA 3/11 only)

Table 2-4 - Recommended EMC Filters for CSA, CSA A, B, C, D, E & F Sizes

Manufacturer	Rated Current (A) @ 50ºC (40ºC)	Max Voltage	Drive Input\Size
Schaffner FN2070-3-06	(3)	250V	$24V_{dc}$ Input
Schaffner FN258-7/07	7 (8.4)	3x480V	3-phase AC Line Input (Size A)
Schaffner FN258-16/07	16 (19.2)	3x480V	3-phase AC Line Input (Size B)
Schaffner FN258-30/07	30 (36)	3x480V	3-phase AC Line Input (Size C)
Schaffner FN258-42/07	42 (50.4)	3x480V	3-phase AC Line Input (Size D 50/140)
Schaffner FN258-55/07	55 (66)	3x480V	3-phase AC Line Input (Size D 60/180)
Schaffner FN258-100/07	100 (113)	3x480V	3-phase AC Line Input (Size E 100/300)
Schaffner FN258-130/07	130 (143)	3x480V	3-phase AC Line Input (Size F 140/300)

The following table details the mechanical dimensions of the recommended filters.

Table 2-5 Recommended EMC Filters Mechanical Dimensions

Manufacturer	Dimensions [mm]							Weight
	L1	L2	L3	L4	L5	L6	L7	[kg]
Schaffner FN2070-3-06	85	75	54	0	65	40.3	Fast-on	0.25
Schaffner FN 258-7/07	255	240	50	25	225 ±0.8	126 ±0.8	300	1.1
Schaffner FN350-12/29	99.5	51	105	95	99.5	57	Terminal blocks only	0.9
Schaffner FN258-16/07	3.5	290	55	30	275±0.8	142±0.8	300	1.7
Schaffner FN258-30/07	335	320	60	35	305	150	400	1.8
Schaffner FN258-42/07	329	314	70	45	300	185	500	2.8
Schaffner FN258-55/07	329	314	80	55	300	185	500	3.1
Schaffner FN258-100/35	379	364	90	65	350	220	Terminal blocks only	5.5
Schaffner FN258-130/07	439	414	110	80	400	240	Terminal blocks only	5.5

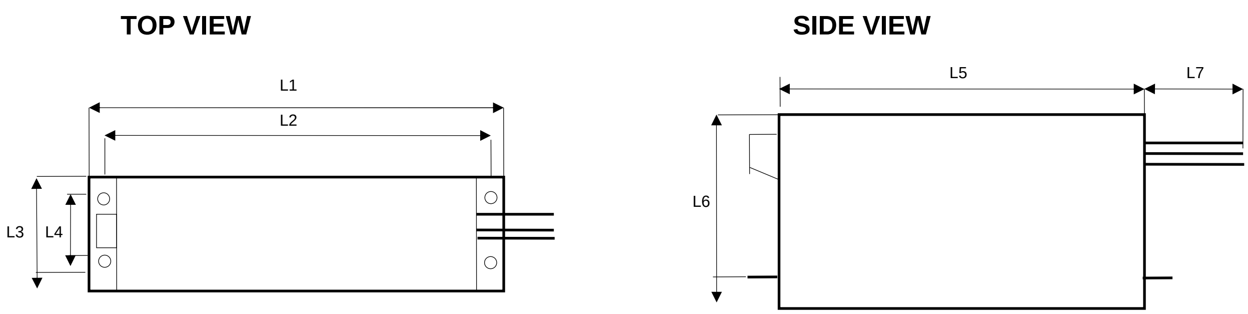

Table 4 - CSA Recommended Filters Mechanical Sizing

Caution: A space of at least 60mm (2.4") must be left around the filter for air circulation when the cabinet does not have forced ventilation.

The filter must be located as close as possible to the drive input. If the separation between filter and drive exceeds 30 cm (1'), then a flat cable (multi-thread copper flat cable) should be used for the RF connection between filter and drive.

Before mounting the drive and the filter to the cabinet, check that the panel surface is conductive. If not, remove any paint and/or other insulating material before mounting the drive and filter.

EMC filter can produce high leakage currents to ground (Protective Earth). The current levels associated with individual filters are detailed in the associated filter datasheet.

CAUTION: The filter must be connected to earth before connecting the supply.

2.3.3 EMC requirements for cables

User's whose machine installations require CE-Compliance should read this Section.

Avoid close parallel routing of signal cables and power cables. Always use the minimum length of cable necessary and install all cables in a fixed routing.

Data signal cables, motor power and resolver/signal cables, regen resistor cables and power input cables shall have segregated routings. Where cable routings must intersect, it is recommended that they intersect at an angle of 90 degrees, to minimise EMC noise coupling.

Where signal and power cables must run in parallel it is recommended that these cables are separated by at least 20 cm. Where possible, cables shall be routed in earthed shielded cable ducting, to minimise electromagnetic noise coupling.

Use shielded cable to connect the external regen resistor (if installed) to the CSA. The length of this cable shall be as short as possible. The shields of these voltage supply cables shall be earthed to Chassis Earth using the EMC kit or the panel earth bar. Alternatively, if the cable is required to pass through an enclosure panel earthed to Chassis Earth, the shield may be earthed to the panel by use of a 360 degree metal cable gland. If this is not possible, a copper strap of minimum length should be used. See Figure 1 Partition Crossing.

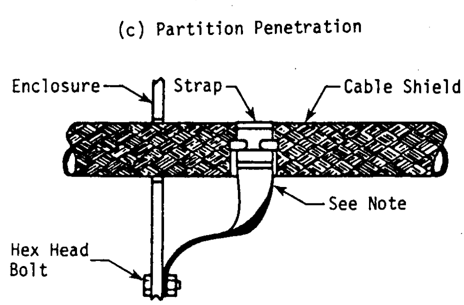

Figure 2-1 Partition Crossing

All external Regen (Regenerative circuit) resistors used with the CSA must be installed in conductive enclosures which provide a degree of ingress protection against liquids and objects of at least IP22. Any paint on the panel or regen resistor enclosure must be removed before the regen resistor enclosure is mounted.

Cables supplying external D.C. supply voltages to the CSA Servo-drive (For example, the +24Vdc. supplies) must be as short as possible. The supply wires shall be twisted together or alternatively shielded cable shall be used. The +24Vdc supply should be routed as far from the motor power cable as possible to ensure EMC compliance.

Cables connecting the D.C. bus from the CSA Servo-drives must be as short as possible. Shielded cable shall be used.

Motor power cables **MUST** be shielded with the cable shield securely connected to Chassis Earth at both ends of the cable. At the CSA end of the cable, the shield shall be earthed to Chassis Earth using the EMC kit or the panel earth bar. The correct method to earth the shield is shown in Figure 2 Correct Cable Preparation Grounding of Shield to Chassis.

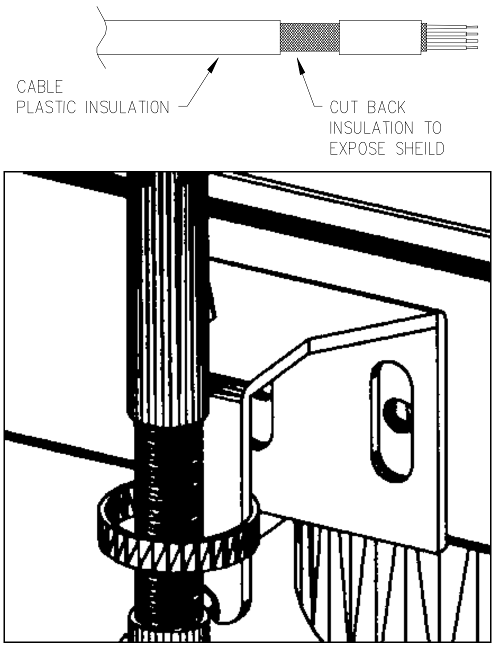

Figure 2-2 - Correct Cable Preparation Grounding of Shield to Chassis

Motor resolver/signal cables must be shielded with the cable shield securely connected to Chassis Earth at both ends of the cable.

Signal cables must be shielded with the cable shield securely connected to make a good HF earth bond to Chassis Earth at both ends of the cable.

Typical cable shield terminations for each of the cables on each CSA size are shown in the following figures.

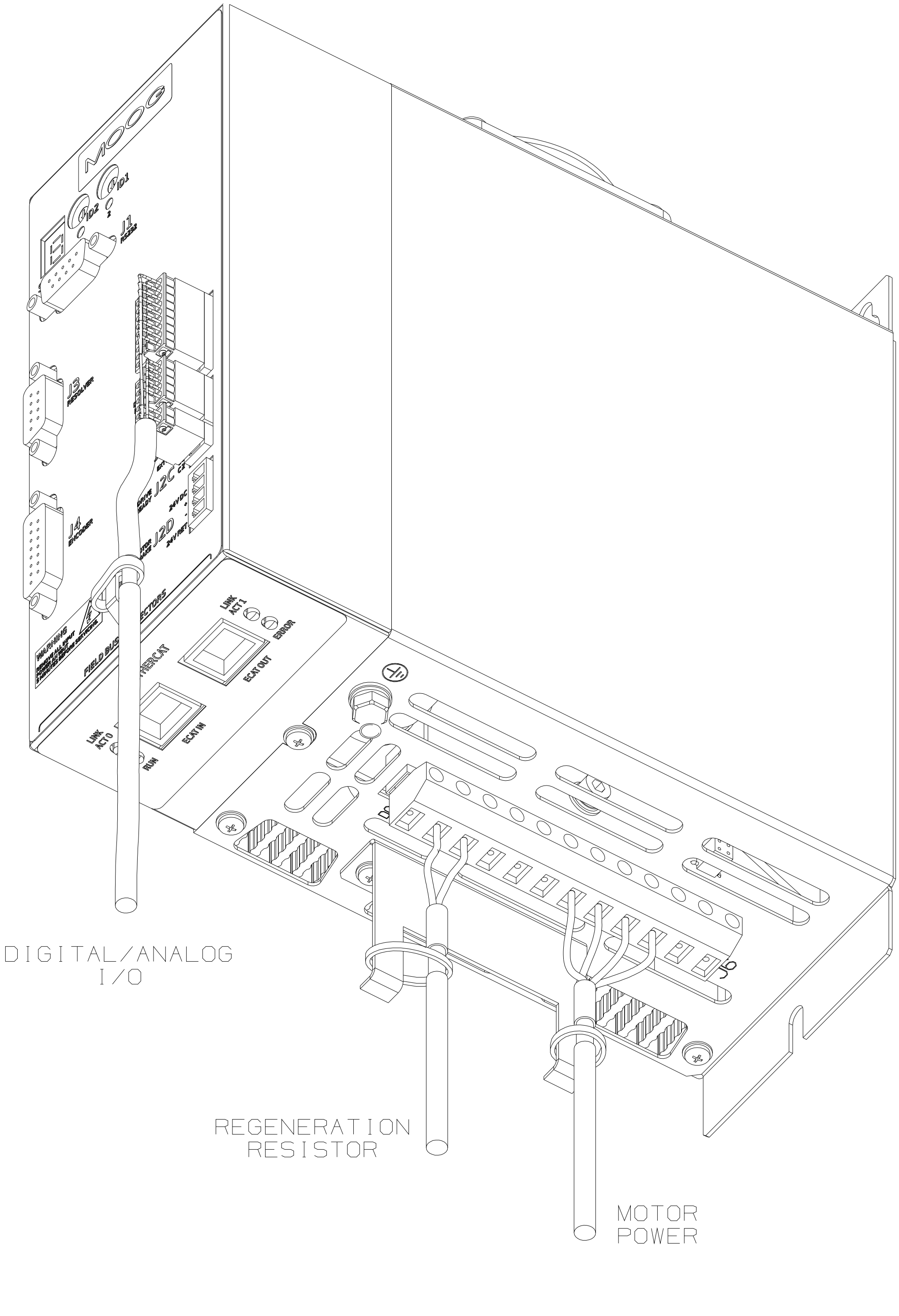

Figure 2-3 - CSA size µA Cable Shield Terminations

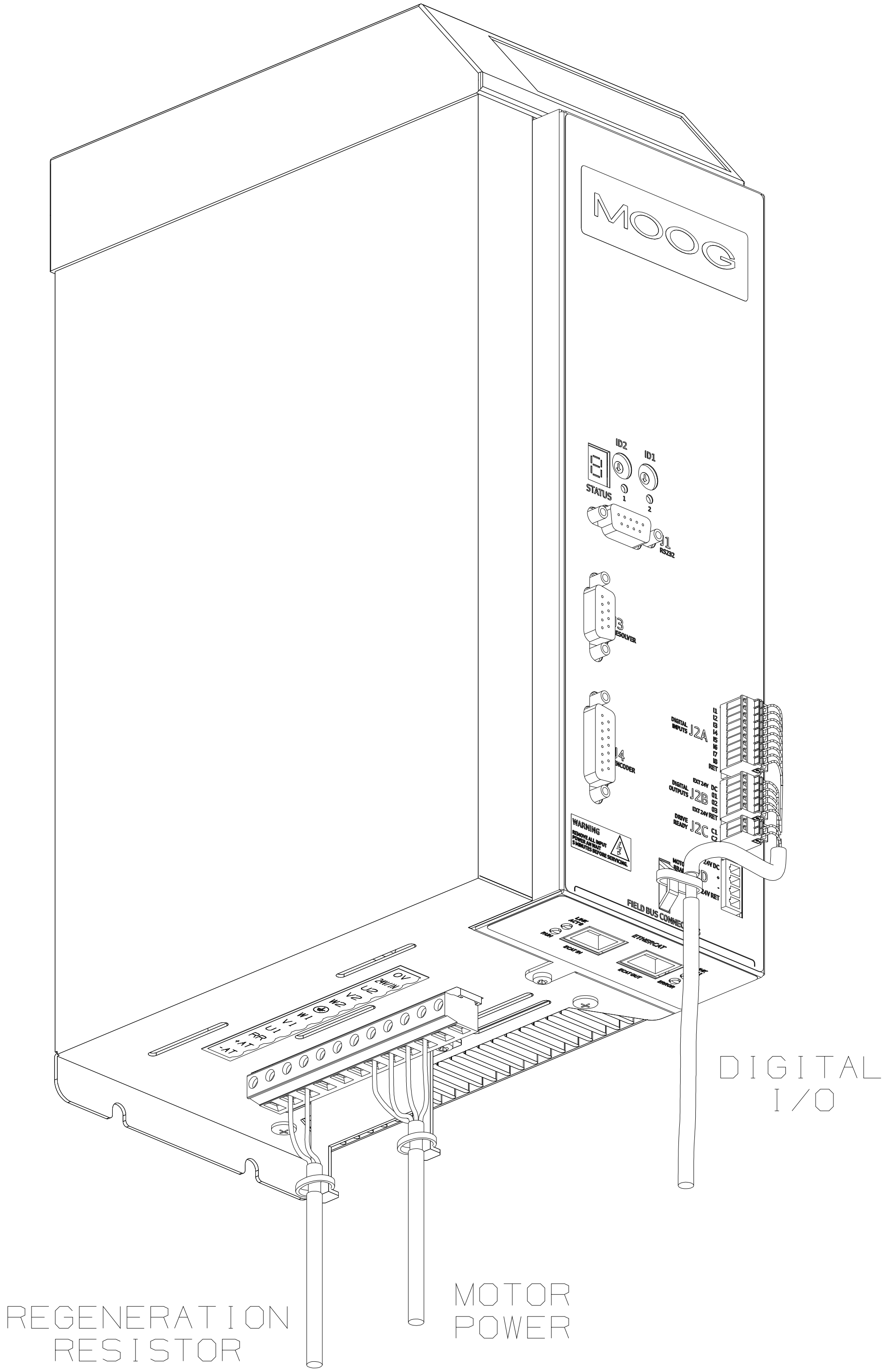

Figure 2-4 - CSA size A & B Cable Shield Terminations

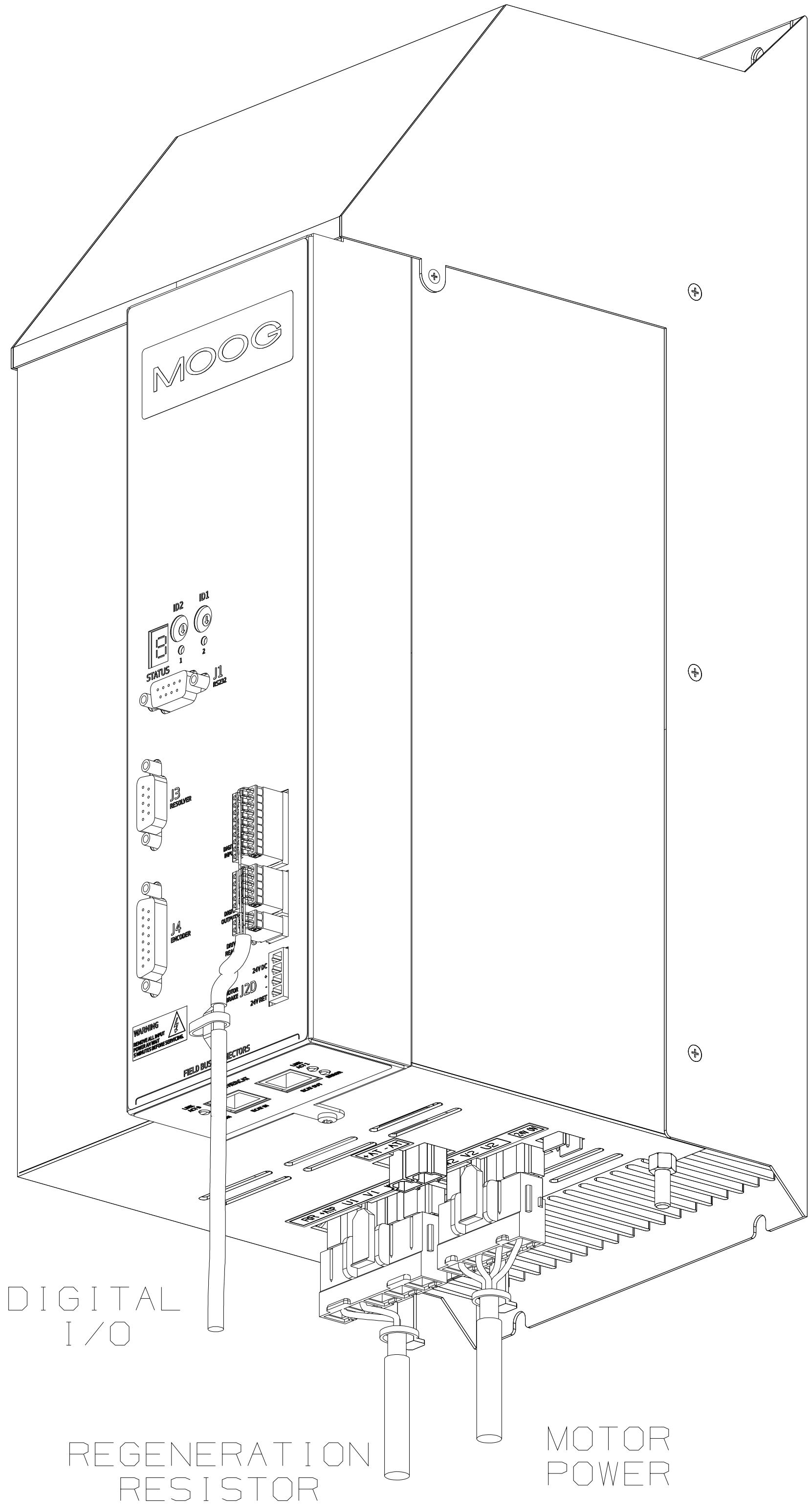

Figure 2-5 - CSA size C Cable Shield Terminations

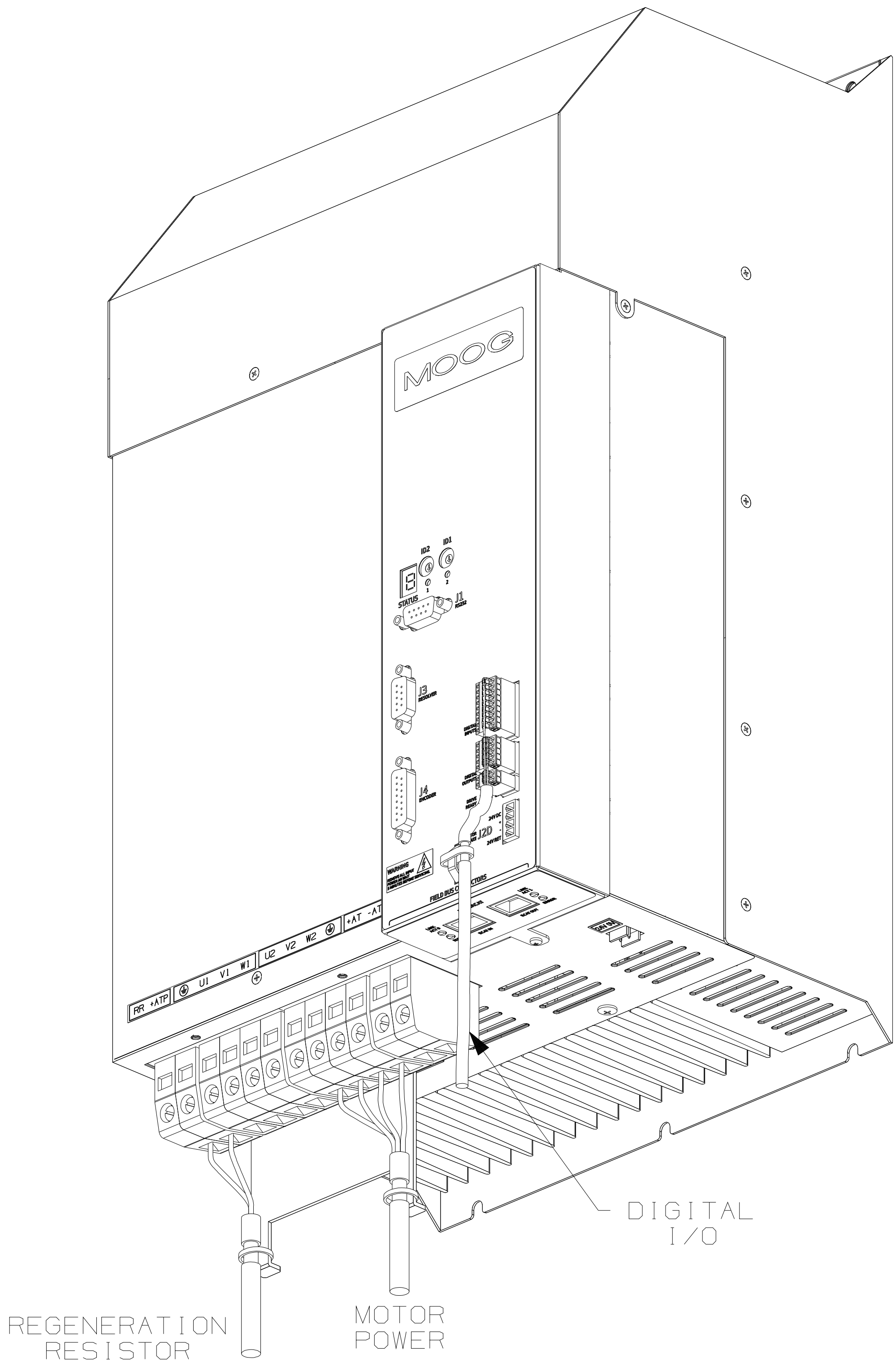

Figure 2-6 - CSA size D Cable Shield Terminations

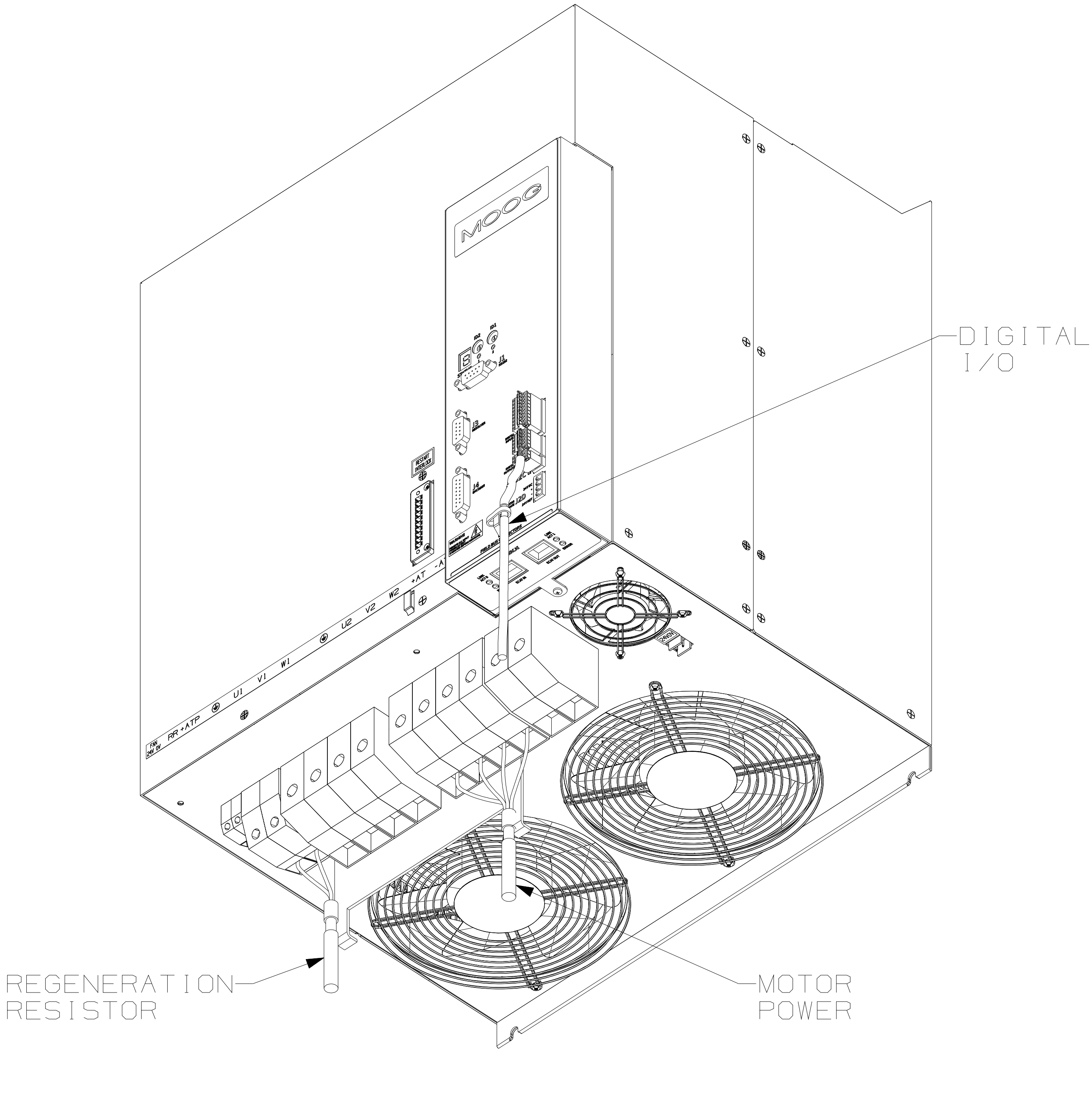

Figure 2-7 - CSA size E Cable Shield Terminations

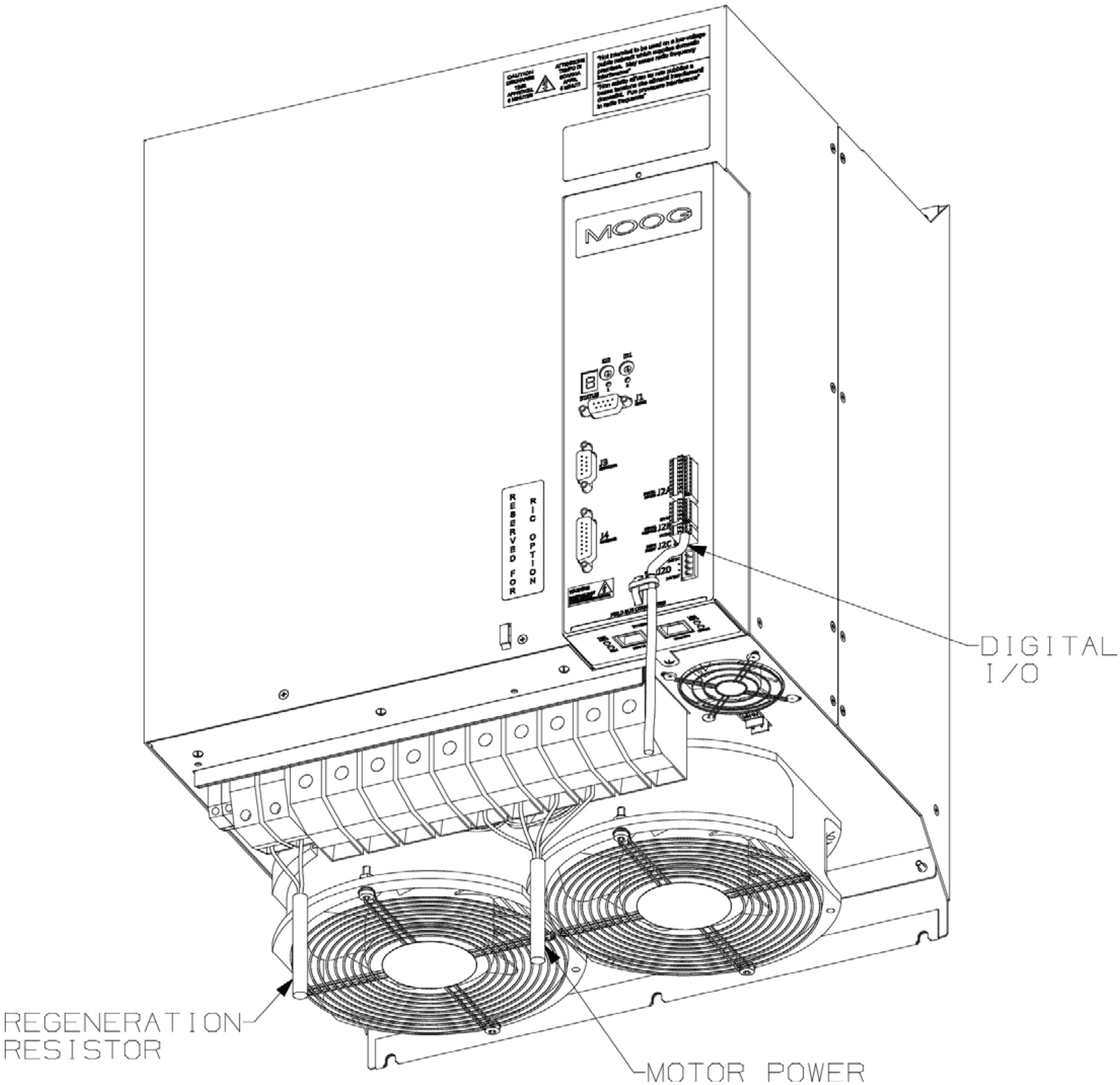

Figure 2-8 - CSA size F Cable Shield Terminations

2.4 UL Requirement

2.4.1 Specific UL Requirements

- **Usage:** The CSA shall be used according to the guidelines given in this manual.
- **Ratings:** The CSA shall be used within the ratings specified in the markings on the equipment.
- **24V Logic Supply:** The 24V supply is intended for use in the secondary of a Class 1 supply. Alternatively, it should be additionally fitted with a listed current limiting fuse, rated 3A on the supply input to the device.
- **Surrounding Air Temperature**: “Maximum Surrounding Air Temperature, 40ºC”.
- **Pollution Degree 2 Installation**: The drive must be installed in a Pollution Degree 2 environment.
- **Equipment Designation**: - Open Type Equipment.
- **Short circuit Ratings**:-
  - CSA 3/11, 6/22, 8/22, 10/42, 14/42, 20/45, 25/70, 30/90, 50/140: “Equipment suitable for use on a circuit capable of delivering not more than 5000Vrms symmetrical Amperes, 460V ac + 10% Max”.
  - CSA 60/180, 100/300, 140/300: “Equipment suitable for use on a circuit capable of delivering not more than 10000Vrms symmetrical Amperes, 460V ac + 10% Maximum”.
- **Branch Circuit Protection**. The Branch Circuit Protection for short circuit protection shall be provided in the end use application by external fuses. Recommended fuses are manufactured by Cooper Bussmann.
  CSA 3/9 & 6/22: ....Fuse Model No. FWP-25A14F Semiconductor Type Fuses,
  CSA 8/22, 10/42, & 14/42: ....Fuse Model No. 50FE Semiconductor Type Fuses.
  CSA 20/45, 25/70 30/90:..........Fuse Model No: 100FE Semiconductor Type Fuses.
  CSA 50/140 & 60/180:............Fuse Model No: 160FEE Semiconductor Type Fuses.
  CSA 100/300:......................Fuse Model No: 315-FM Semiconductor Type Fuses.
  CSA 140/300:......................Fuse Model No: 550-FMM Semiconductor Type Fuses.
- **Wiring**. The drive shall be wired with stranded and \ or solid copper (Cu), 60/75ºC conductors only. The tightening torque for terminal blocks specified in Section 3 of this manual shall be applied. These requirements do not apply to the control circuit terminals.
- **Regeneration Resistor**. The regeneration resistor when external shall be wired with R/C (AVLV2) rated wire or shall be insulated with R/C (YDPU2) or R/C (UZCW2) rated insulation.
- **Field Wiring**. The power connector of the CSA µA (J6) is not rated as a Field Wiring Terminal. This connector may only be used as a Factor Wiring Terminal block.
- **Over-speed Protection**: The CSA incorporates a software-based over-speed protection. See ‘Motor Rating Parameters’ and ‘Velocity Limiting’ in Chapter 5 of this Manual.
- **Motor Overload Protection**: The CSA does not incorporate an internal motor load protection. The drive is intended to be used with motors that have integral thermal protection in the form of an NTC or PTC thermistor. The selections of NTC or PTC and overtemperature fault level are set in software. See ‘Motor Thermal Parameters’ and ‘Motor Thermal Protection Mechanism’ in Section 5 of this manual.
- **Overcurrent Protection:** The CSA is equipped with internal over current protection. See the ‘Cabling and Interconnect Protection Scheme’ detailed in Section 5 of this manual.

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SECTION 3: WIRING AND INSTALLATION

This chapter covers the installation, wiring and cabling of the Moog CSA Servo Drive series. A pictorial diagram of a single-axis system, with typical components included, is shown in *Figure 3-1Typical CSA System Components (µA Size).*

Users are directed to read *Chapter 2, Safety Instructions*, before proceeding with wiring and installation of the CSA Servo Drive.

WARNING - This equipment must be permanently and reliably connected to an approved AC Mains supply Protective Earth (PE) connection. All conductive parts in the IP54 rated enclosure in which the CSA Series Servo-drive is installed must be reliably connected to Protective Earth. A Protective Earth connection must come directly from an approved AC mains network; stranded copper-wire of appropriate wire gauge (*Chapter 2, Table 2 CSA Cable Dimensions*) is recommended to carry the earth.

FAILURE TO PROVIDE AN ADEQUATE EARTH MAY CAUSE SERIOUS PERSONAL INJURY AND EQUIPMENT MALFUNCTION.

3.1 System Components

The following components are required to build a Moog brushless motor digital control system, *Figure 3.1 Typical CSA System Components.* The user supplies all components besides the CSA, EMC-Brackets, motor and other accessory cabling.

3.1.1 A.C. Mains Power Interface

The CSA should be connected to a three-phase AC supply. Operation with a single-phase supply is only allowed with the G362-x003 and G362-x006 variants of the drive. For single-phase operation, the phase supply voltage must be limited to 230V and the input power to the drive limited to 1.1kW.

3.1.2 A.C. Input Line Protection

Details of the recommended Line fuses are given in *Chapter 2, Table1 Typical CSA Fusing* of this manual. Alternatively AC mains Circuit Breaker (Instantaneous Trip Type) can be used as a protective device providing its ratings are equivalent to the recommended fuses.

After a power loss to the servo-drive, the motor will continue running until its stored energy is dissipated through friction alone, or will be stopped by a motor-equipped brake if a brake is available.

It is also recommended to install a contactor rated for the CSA input between the line fuses and the EMC filter at the input of the CSA, *Figure 3-1Typical CSA System Components (µA Size).* This contactor should be controlled directly by user supplied Emergency Stop Buttons and other series connected safety switches to remove AC input power in any situation affecting personnel safety.

WARNING - The supply-disconnecting device (circuit breaker) must be switched to the ‘**OFF’** position and an adequate DC Bus capacitance discharge time allowed before any service or maintenance activity is commenced.

3.1.3 Line Filter Requirements

Details of the recommended line filters for each of the CSA variants are given in *Chapter 2, Table 2 CSA Cable Dimensions,* of this manual.

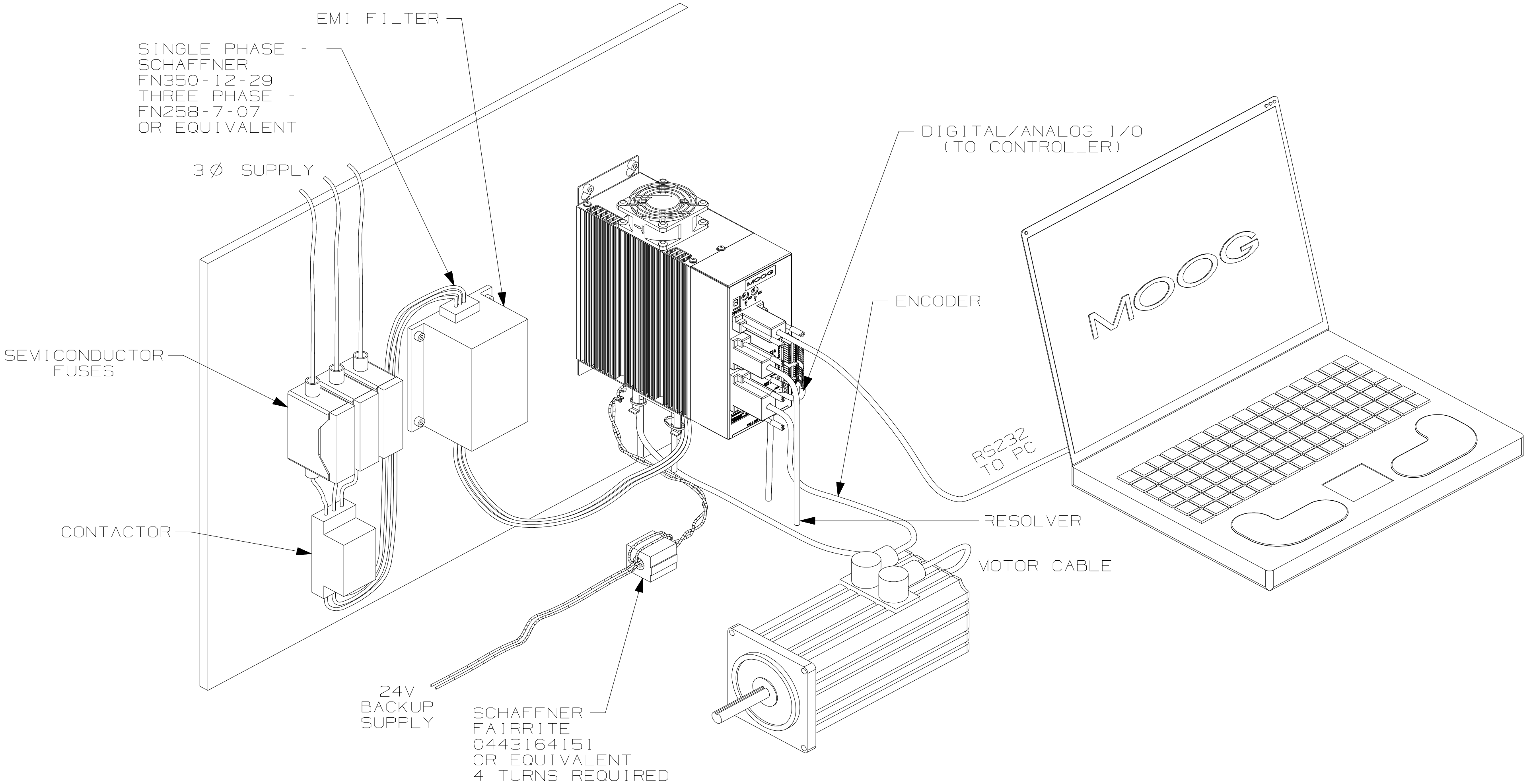

Figure 3-1Typical CSA System Components (µA Size)

3.1.4 Serial Set-up Terminal (User-Supplied)

An RS-232 interface should be established for individual servo-drive communications, using a PC. The PC can run Moog's Windrive Windows-based user-interface program.

The personal computer using Windrive is a service engineering tool only and must be installed so that use of the key sequences which allow control of the machine functions is accessible to authorized, qualified service personnel only. All such service set-up computers must be CE - marked as compliant with the EU EMC Directive.

3.1.5 Control-Backup Power Input (User Supplied)

The CSA requires a control power source to supply backup-power for the control electronics. This control-backup power is useful where the user requires that the CSA does not lose absolute position data or status information when AC mains power is removed from the CSA.

The user is directed to the local Moog sales office or authorized distributor for a recommended list of these control power source devices.

The G362-003 & G362-006 type Servo Drives **MUST** have a +24Vdc logic backup supply connected for the drive to operate. No internal high voltage backup is provided on these smaller models.

The +24Vdc control power option allows high voltage motor power to be removed from a CSA Series Servo-drive without losing control power.

The acceptable voltage range for this supply is +24Vdc ±10% with a minimum current rating of 2Adc per CSA Series Servo-drive connected. A low cost unregulated DC supply is adequate for the control back-up power input to the CSA

The +24Vdc power supply must be compliant with the requirements of the EU EMC Directive. The output from the +24Vdc power supply must be Protective Extra Low Voltage (PELV), as defined by European standard EN 60950).

3.1.6 Brushless Servo motors

The CSA series Servo-drive is compatible with Moog brushless servomotors.

Normal connection to the motor requires two cables - a power and a signal cable. The power cable provides three-phase stator power, protective earth and brake connections. The signal cable carries position transducer feedback signals and motor temperature detection connections.

3.1.6.1 Brushless Motor Brake 24V Power Supply

The motor brake requires a 24Vdc supply for release. This should be rated to cover at least twice the sums of the rated currents of all brakes connected.

3.1.7 Heatsinks and Climatic Control

The need for air conditioning will depend on the duty cycle of the system and the surrounding ambient temperature. The maximum allowable ambient temperature is 40°C (104°F). The humidity range is 5-95% non-condensing.

All CSA Servo-drives incorporate internal cooling fans and integral heat sinks. Other than controlling ambient conditions, additional heat sinking is not required.

3.2 Equipment Mounting

This section details the mechanical dimensions of the CSA chassis, as well as required clearances for cabling etc. The CSA is designed to be panel or cabinet mounted. The CSA must be mounted in a vertical orientation. The CSA must be panel mounted within an enclosure or cabinet that provides a degree of ingress protection against liquids and objects of at least IP54. Such enclosures or cabinets must be accessible to technically qualified service or maintenance persons only.

It is recommended that the cabinet be ventilated using filtered or conditioned air, free of corrosive or electrically conductive contaminants. The accumulation of dust, dirt, etc. on the equipment must be avoided. A minimum clearance above and below each of the CSA drive sizes is required. These distances are detailed in *Table 3 Minimum Clearance around CSA Drives*, below;

Table 3-1 Minimum Clearance around CSA Drives

CSA Size	Minimum Clearance Top (mm)	Minimum Clearance Bottom (mm)
μA & A	60	100
B	60	100
C	80	160
D	100	200
E	200	300
F	200	300

The top mounting screw for size A and B drives should be tightened to a maximum of 2.0 Nm to prevent damaging the plastic fan housing.

If any of the CSA units are mounted in a closed cabinet, allow 100mm clearance at the front for cable bends.

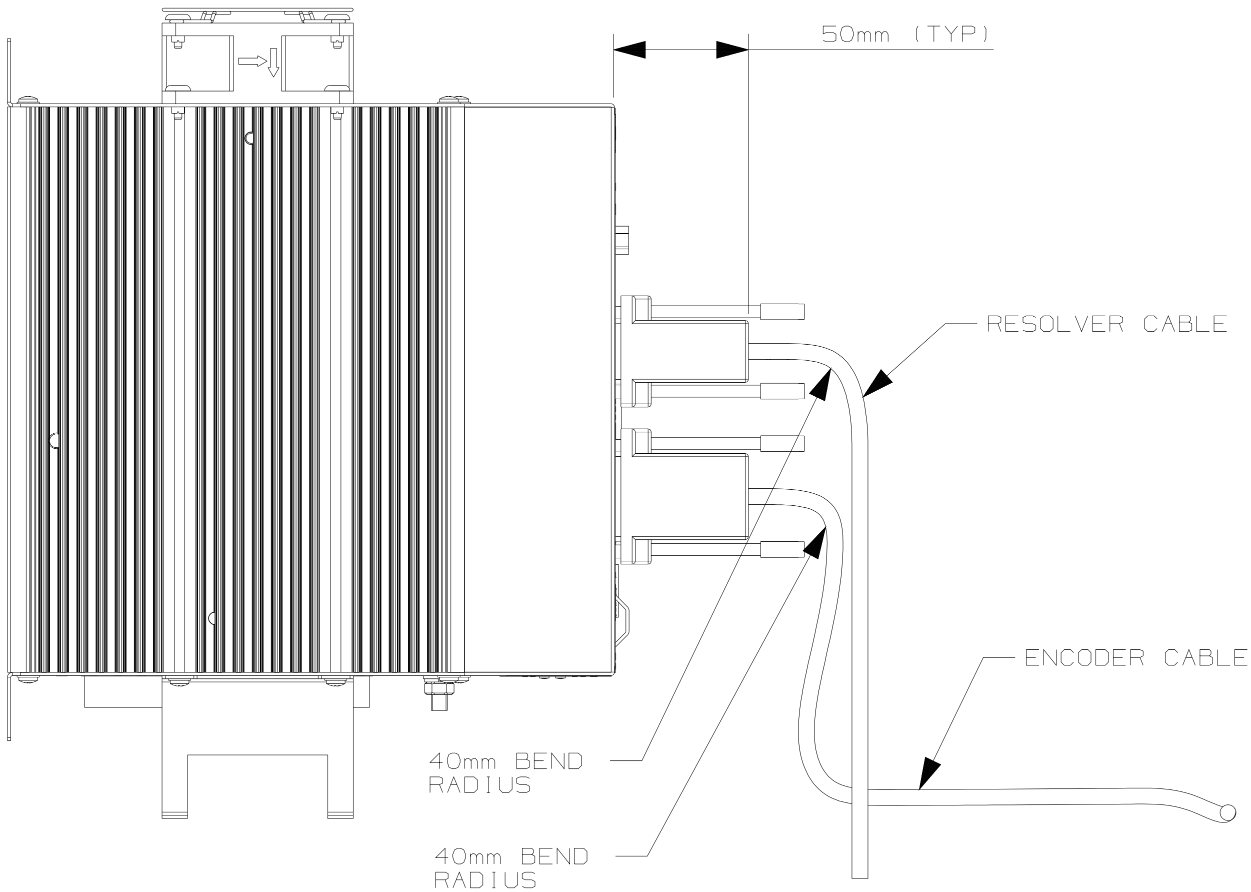

Figure 3-2 Typical CSA Cable Bend Radius Requirements

The CSA must be permanently and reliably connected to AC mains Protective Earth and all conductive parts in the IP54 rated enclosure or cabinet must be permanently connected to protective Earth. The impedance between the earth terminal and any accessible part of the enclosure or cabinet should be less than or equal to 0.1 ohm.

NOTE - The CSA Series Servo-drives are system components that must be installed in the correct manner to ensure that all electromagnetic compatibility (EMC) requirements are met. (Refer to *Chapter 2* of this User's Guide).

The CSA must be mounted on a panel with a flat solid surface in a manner that ensures that EMC earthing requirements are met.

There must be a clean flat conductive surface at all of the mounting points. Remove paint or other insulating materials and provide conductive corrosion protection at the mounting points. It is important that there is good high-frequency bonding between the panel and the CSA Servo-drive. Conductive hex socket head bolts with conductive locking washers should be used.

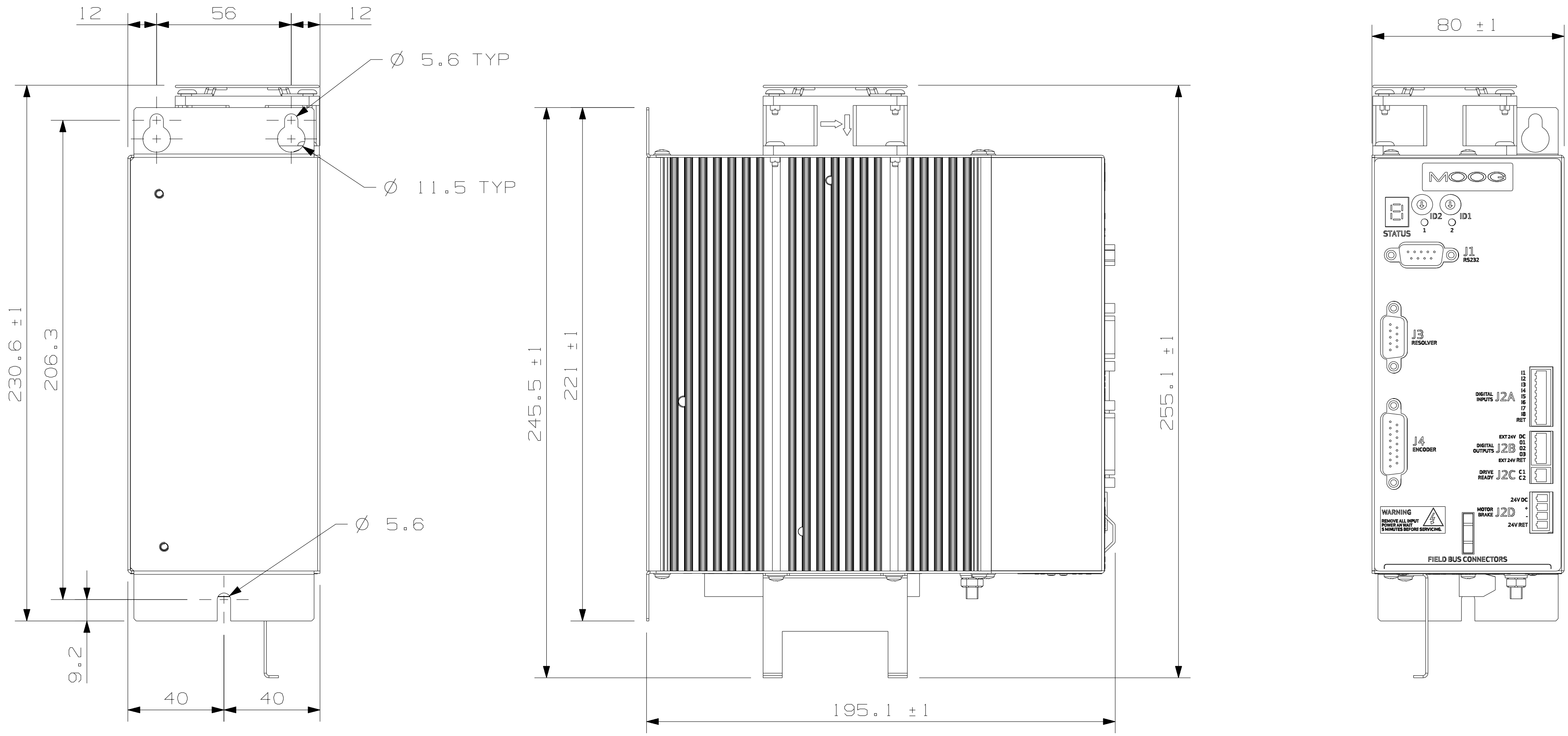

Figure 3-3 CSA Size ‘µA’ Mechanical & Mounting Dimensions

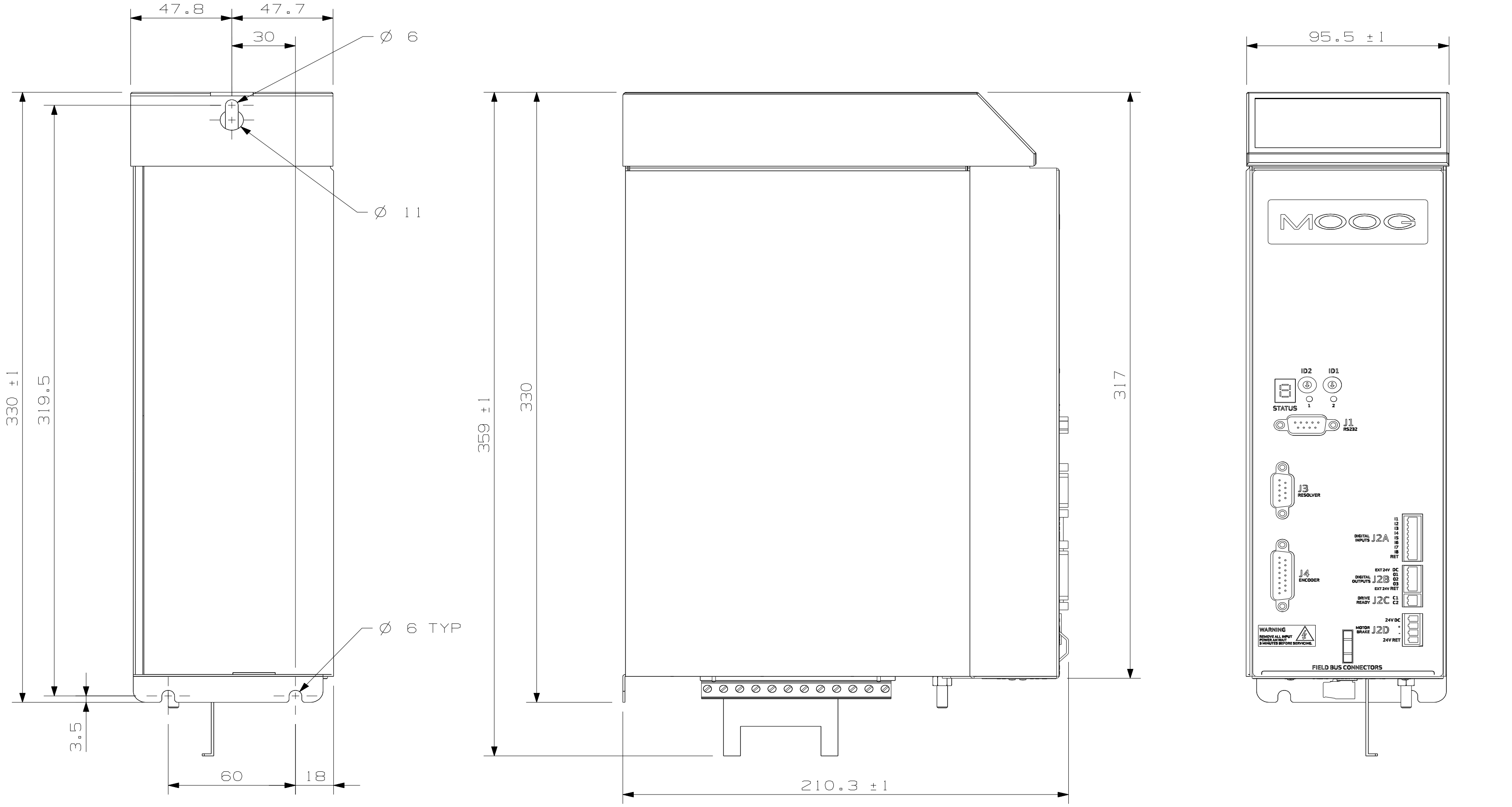

Figure 3-4 CSA Size ‘A’ Mechanical & Mounting Dimensions

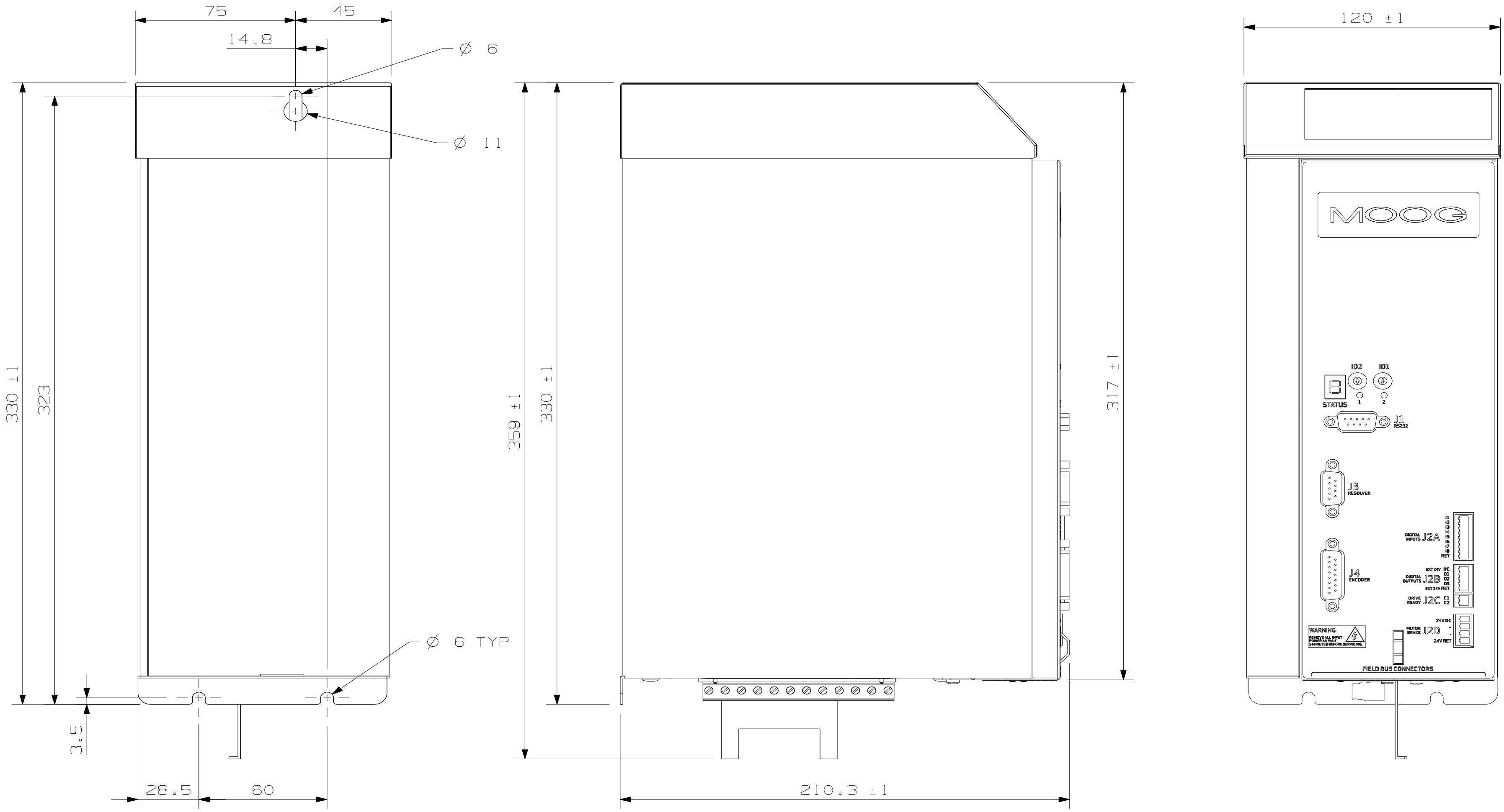

Figure 3-5 CSA Size ‘B’ Mechanical & Mounting Dimensions

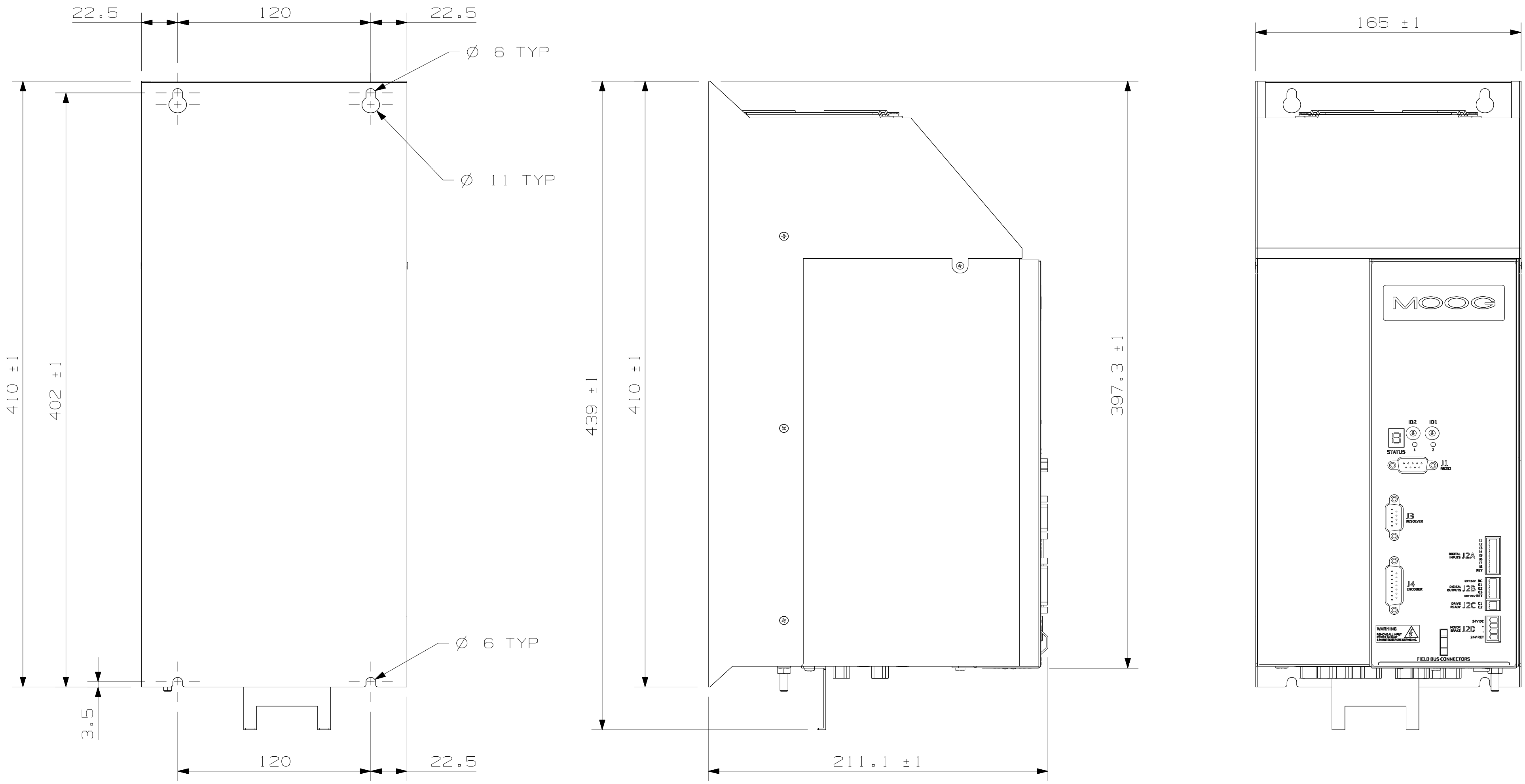

Figure 3-6 CSA Size ‘C’ Mechanical & Mounting Dimensions

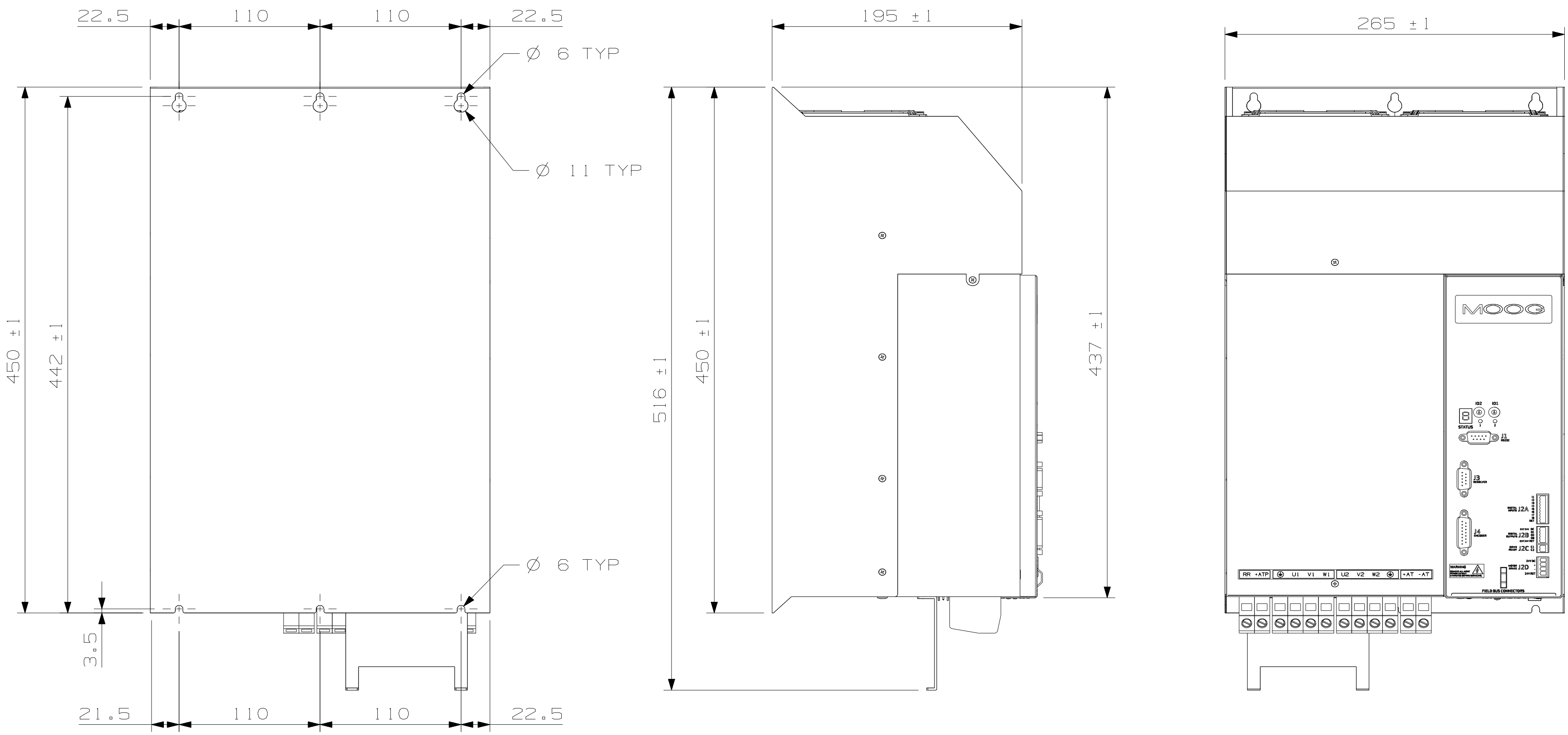

Figure 3-7 CSA Size 'D' Mechanical & Mounting Dimensions

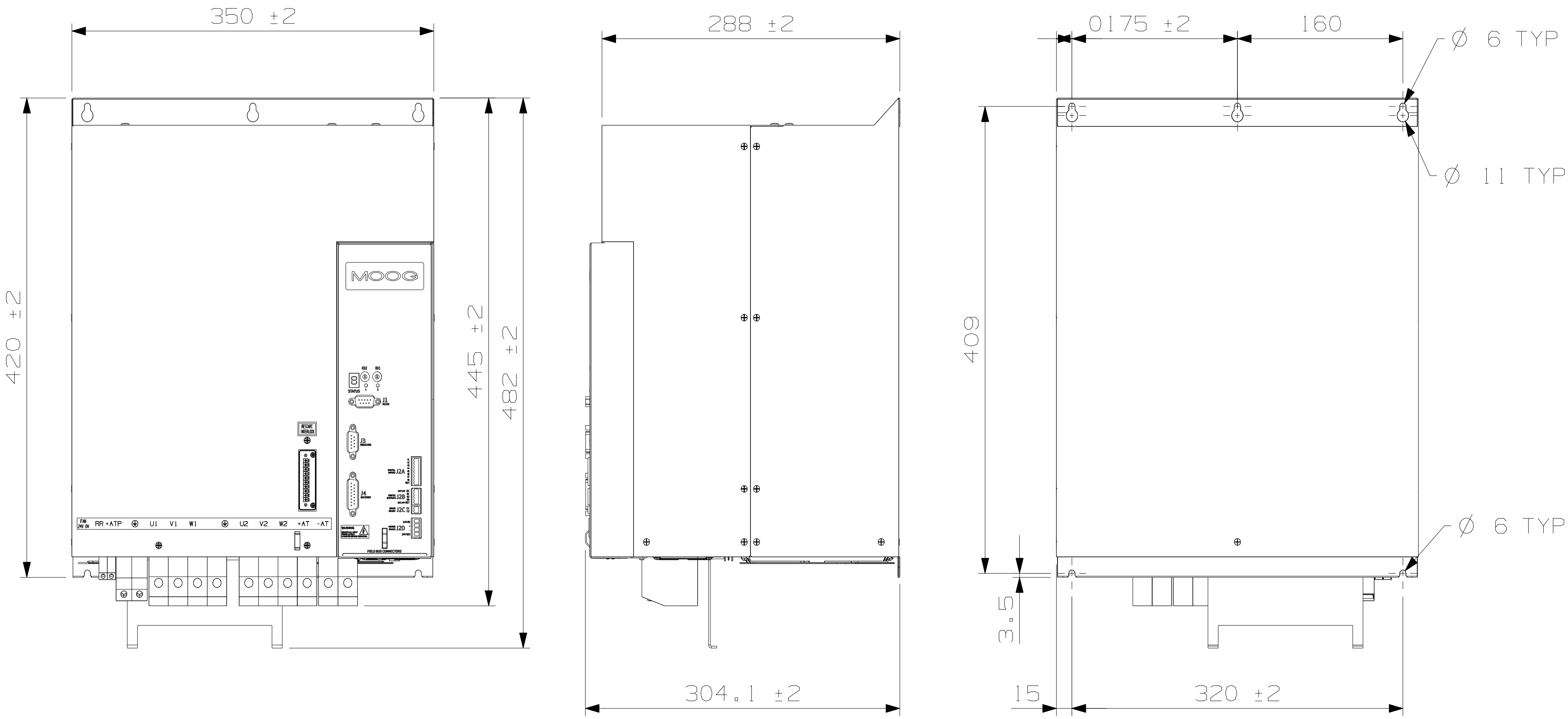

Figure 3-8 CSA Size ‘E’ Mechanical & Mounting Dimensions

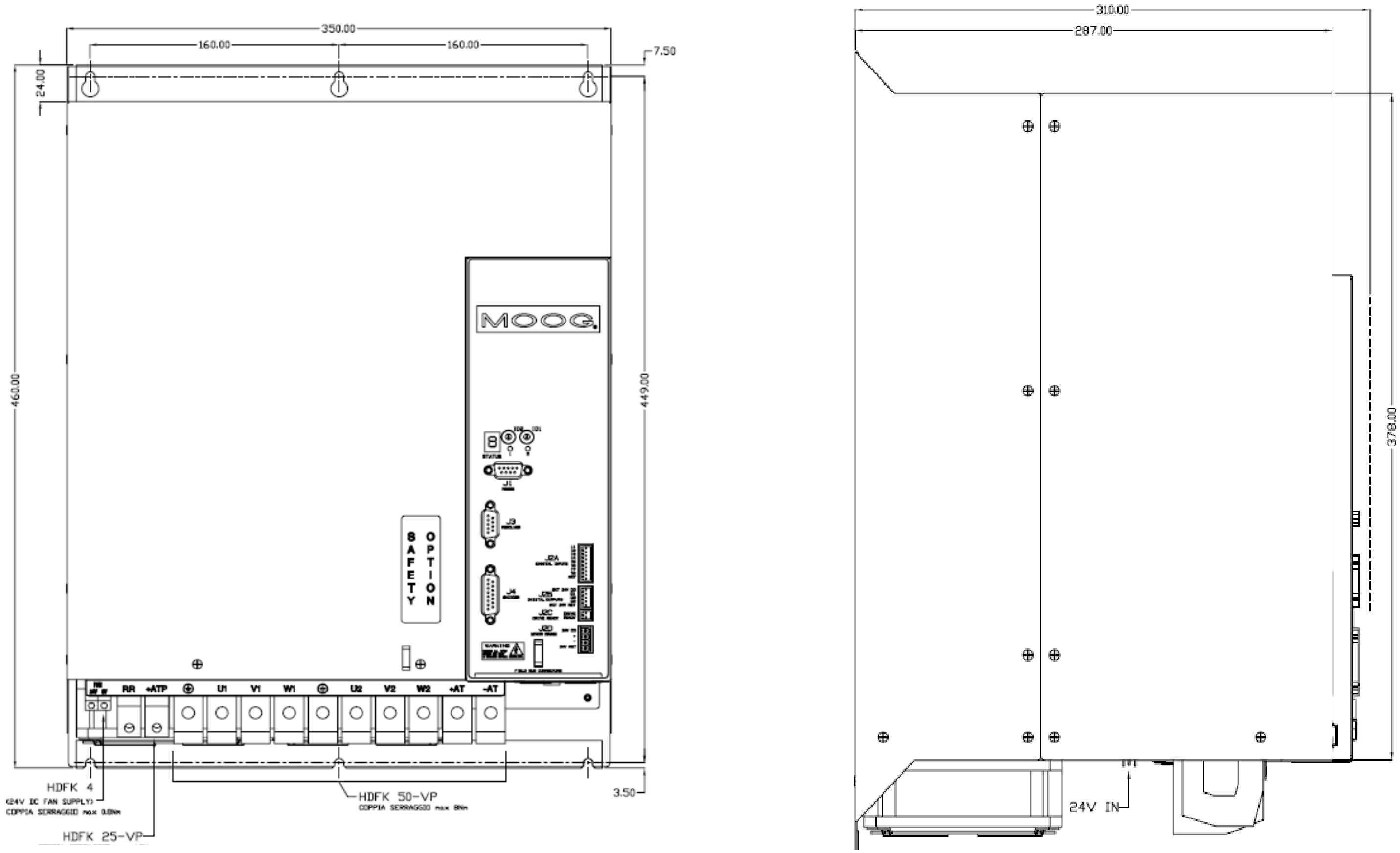

Figure 3-9 CSA Size ‘F’ Mechanical & Mounting Dimensions

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3.2.1 CE Items for Mechanical Installation

Additional electromagnetic compatibility (EMC) measures must be installed on equipment associated with the CSA Servo-drive. The following measures must be implemented:

- All external Regen (Regenerative circuit) resistors used with the CSA must be installed in enclosures which provide a degree of ingress protection against liquids and objects of at least IP22 and which are accessible to technically qualified service or maintenance persons only. Protection against electric shock must be maintained when installing these resistors.
- Use shielded cable to connect the external regen resistor (if installed) to the CSA power supply. The length of this cable should be as short as possible. The shields of these cables should be earthed to Chassis Earth using the optional EMC Bracket kit or the panel earth bar. Alternatively, if the cable is required to pass through an enclosure panel earthed to Chassis Earth, the shield may be earthed to the panel by use of a 360 degree metal cable gland.
- Cables supplying external DC supply voltages to the CSA Series Servo-drives (for example, the 24 Vdc supply) must be as short as possible. The supply wires should be twisted together or alternatively shielded cable should be used.
- Cables connecting the D.C. Bus from the CSA Power Supply to other CSA Servo-drives must be as short as possible. The supply cables should be shielded.
- Motor power cables must be shielded with the cable shield securely connected to Chassis Earth at both ends of the cable. At the CSA Servo-drive end of the cable, the shield should be earthed using the EMC Bracket.
- Motor feedback & signal cables must be shielded with the cable shield securely connected to Chassis Earth at both ends of the cable.
- Signal cables must be shielded with the cable shield securely connected to make a good HF earth bond to Chassis Earth at both ends of the cable.
-

Further details for the correct installation and shielding of cables and conductors are given in *Chapter 2 of this user's manual.*

CAUTION - Enclosure or cabinet temperature control is critical for performance, reliability and the life of electrical components. Maintaining a uniform temperature (check for hot spots) within the specified values for the equipment will prevent premature failure due to temperature stress.

3.3 Dissipation

To facilitate the cabinet cooling requirements *Table 3-2 Estimated Power Dissipation for the CSA Servo-drives* provides approximate equipment power dissipation values. If the application employs regeneration, the regen resistor power dissipation must be added to the numbers quoted in *Table 3-2 Estimated Power Dissipation for the CSA Servo-drives*

Table 3-2 Estimated Power Dissipation for the CSA Servo-drives

	Power Dissipation (@ nom. current)										
CSA	3Amp	6Amp	8Amp	14Amp	20Amp	25Amp	30Amp	50Amp	60Amp	100Amp	140Amp
Watts	60	90	110	180	250	300	400	650	800	1200	TBD

Use the continuous wattage rating of the regen resistor if the actual application regen dissipation is unknown).

3.4 CSA Connector Terminals

Figures 3.9 through 3.14 detail the connectors on the CSA (all sizes).

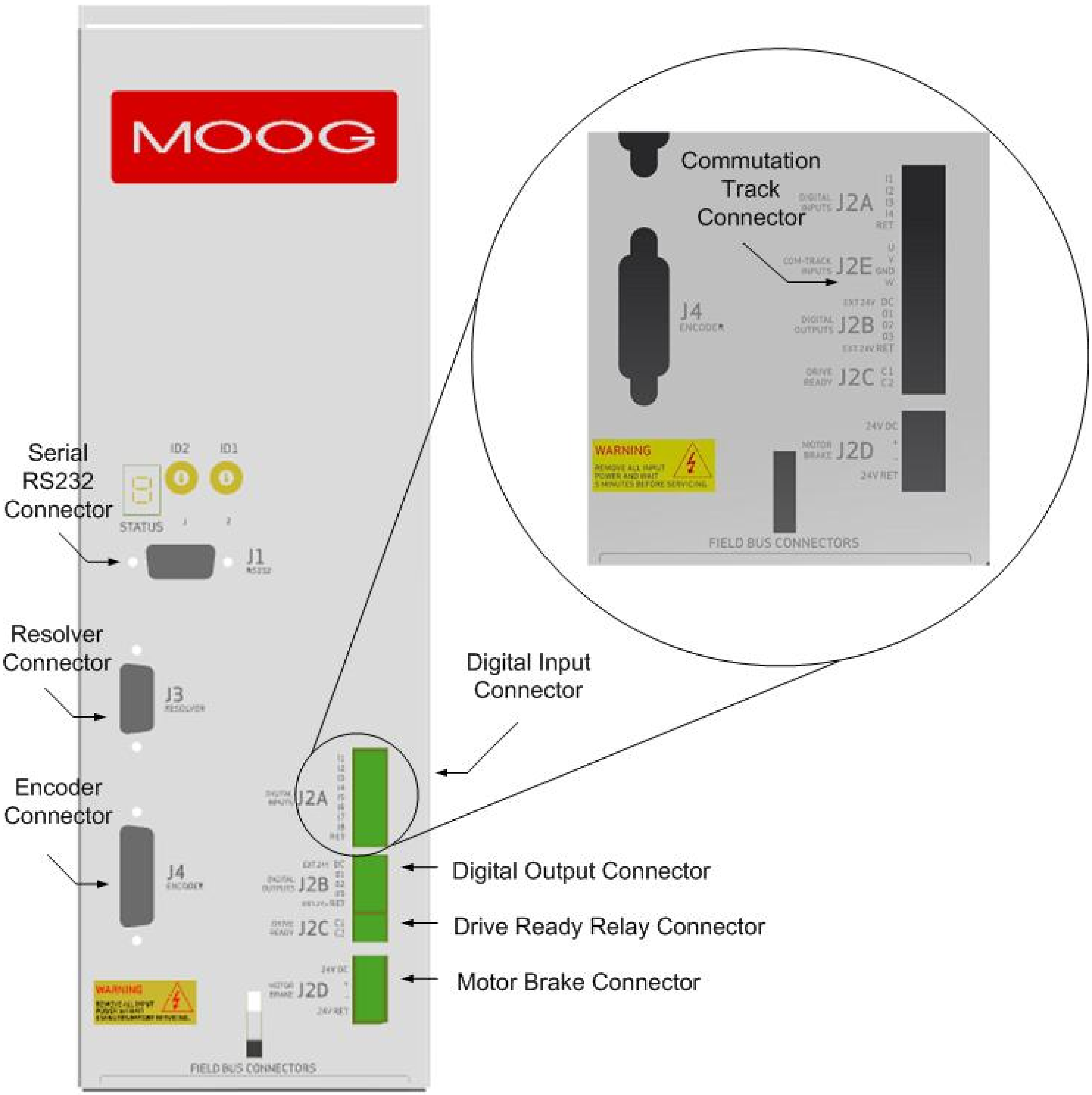


Figure 3-10 CSA Control Card Connector Terminals

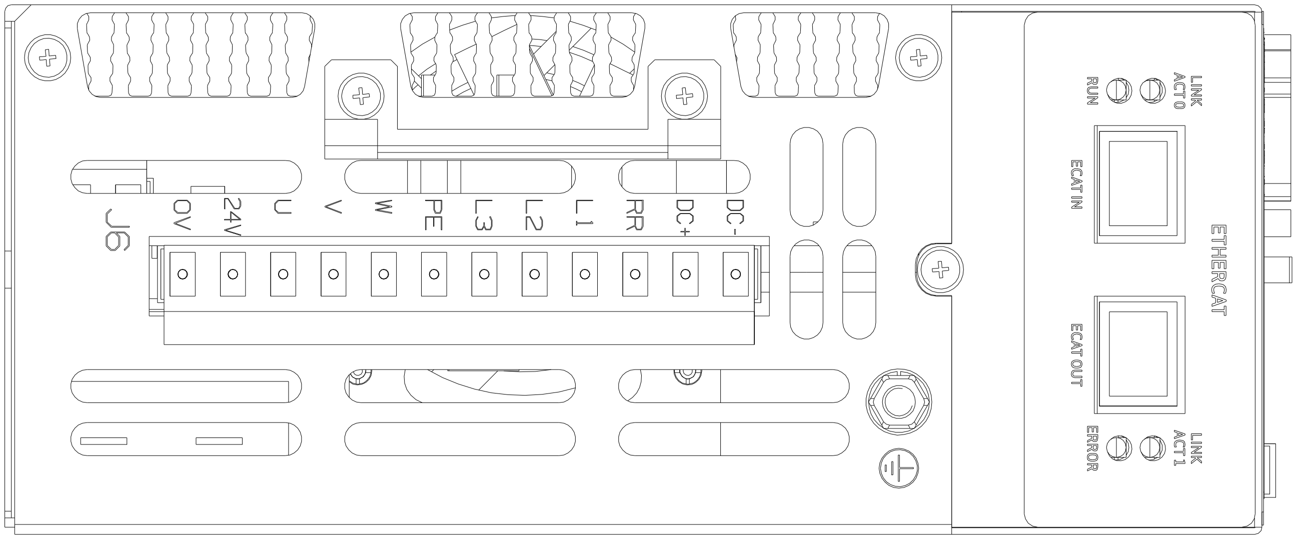


Figure 3-11 CSA Size µA Power Connector Terminals

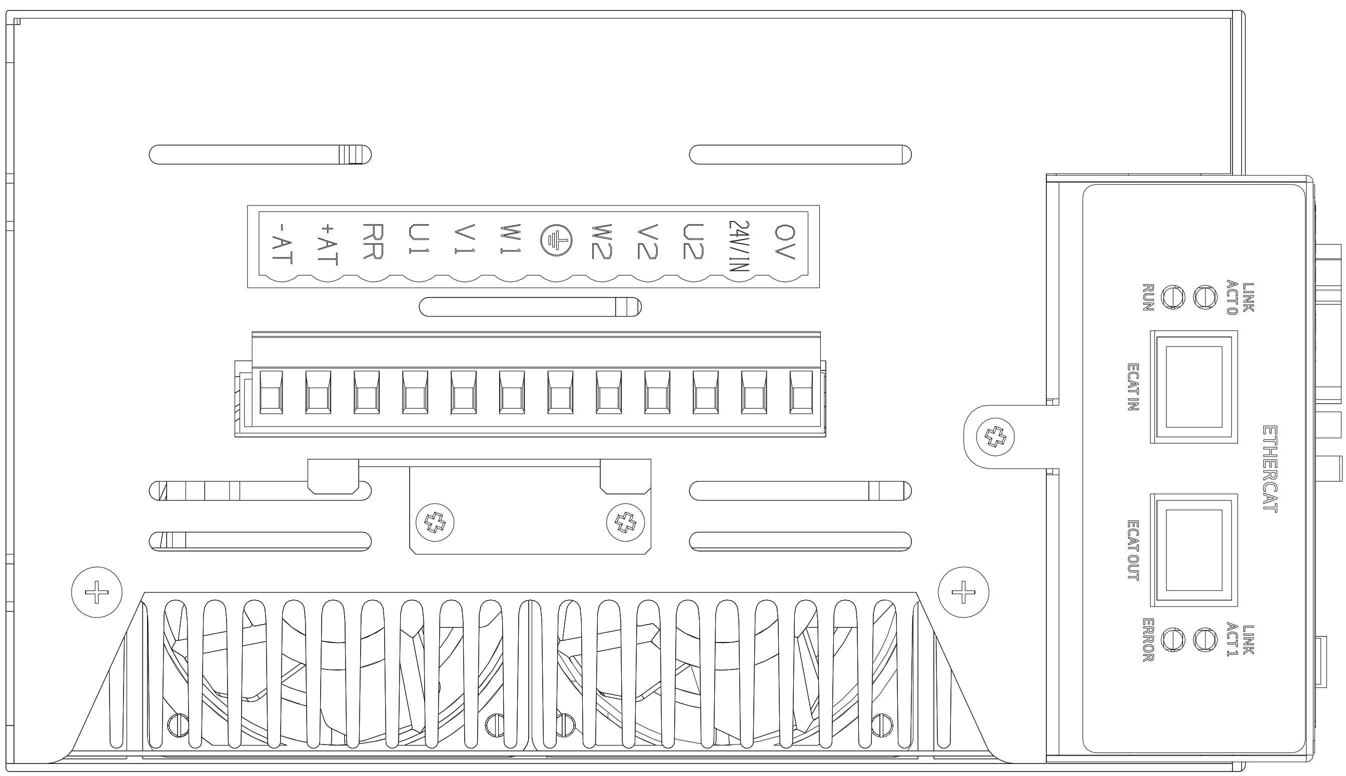


Figure 3-12 CSA Size A & B Power Connector Terminals

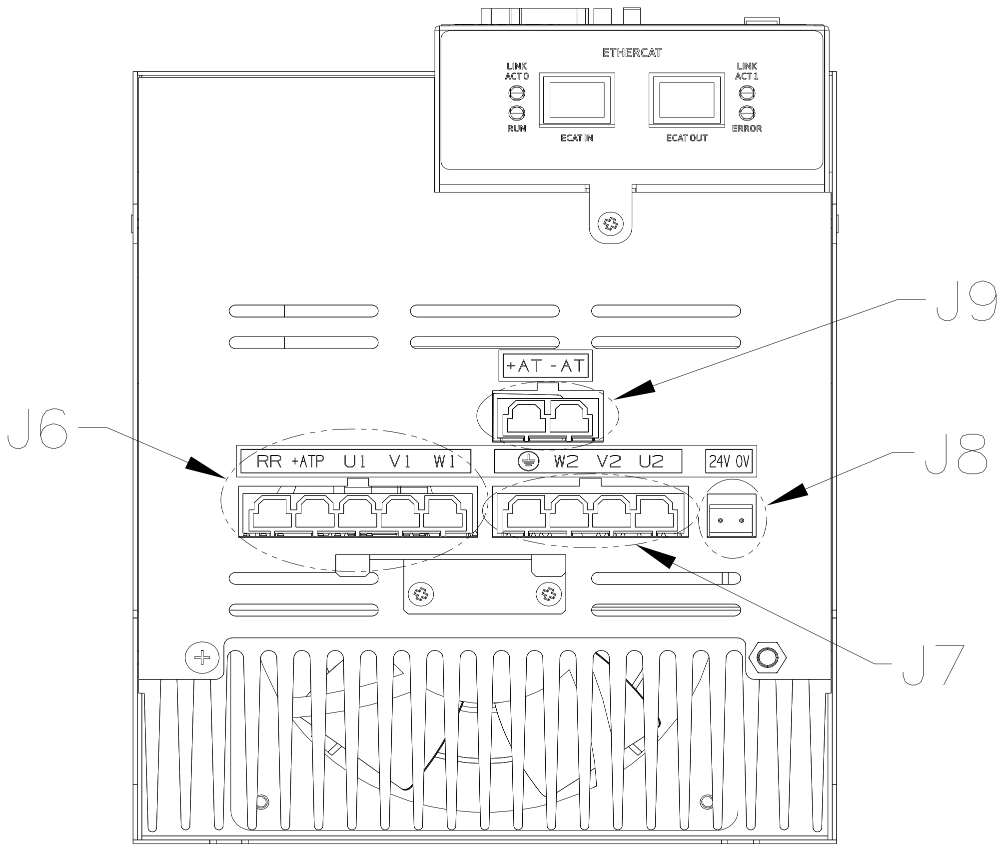


Figure 3-13 CSA Size C Power Connector Terminals

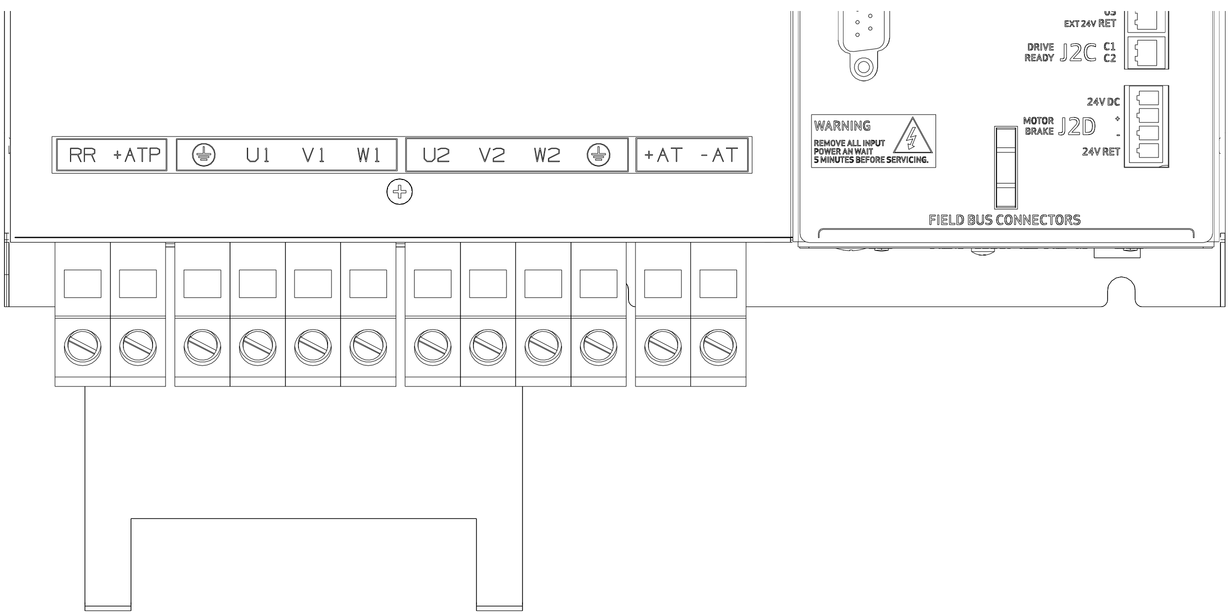


Figure 3-14 CSA Size D Power Connector Terminals

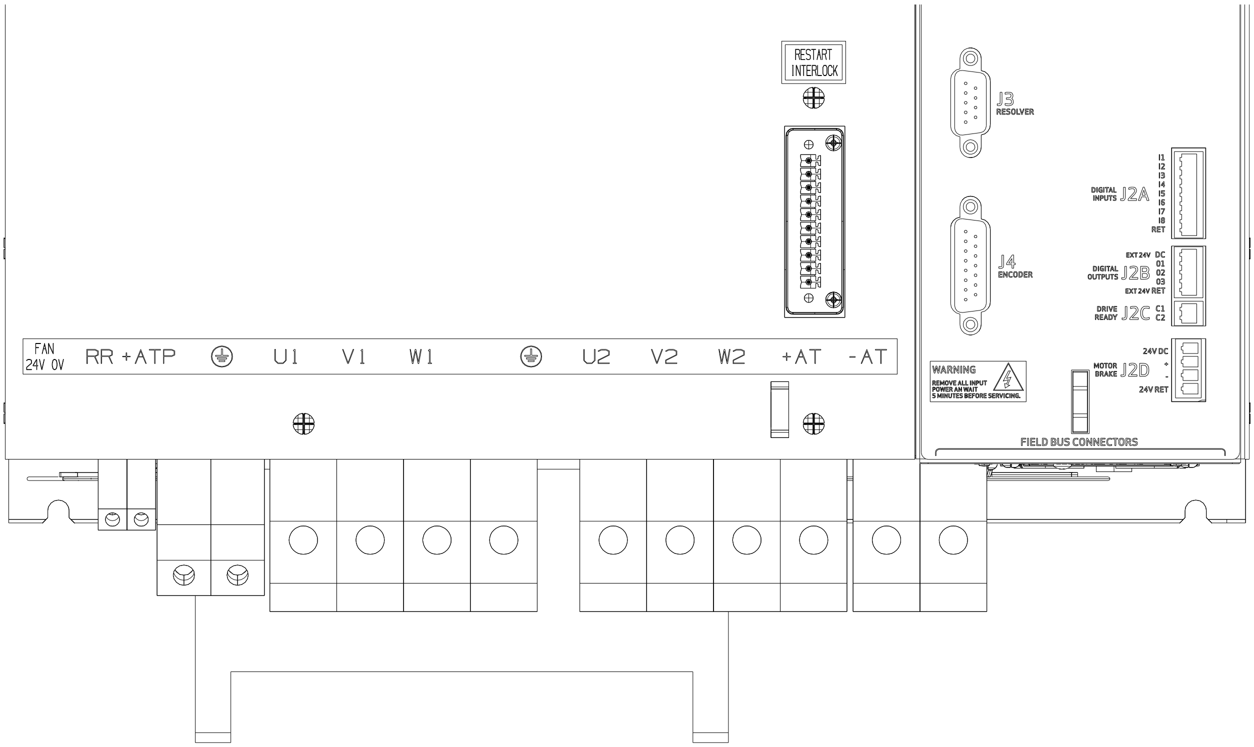


Figure 3-15 CSA Size E Power Connector Terminals

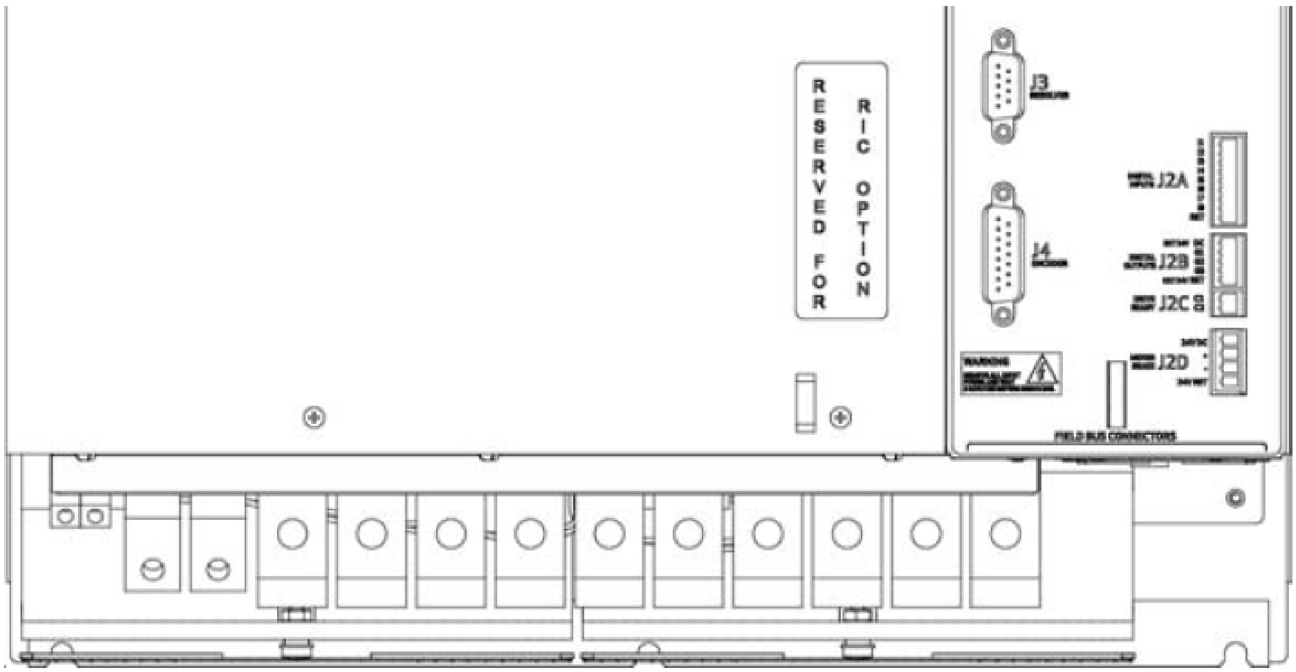


Figure 3-16 CSA Size F Power Connector Terminals

3.5 General System Wiring Guidelines

The following is a general reminder of the cable requirements for the CSA Series Servo-drives and related equipment.

An appropriate wire gauge should be selected in accordance with standard wiring practice and local codes for amperage and wire length requirements. Recommended wire sizes are given in *Chapter 2, Table 2 CSA Cable Dimensions.*

NOTE - Cabling and component wiring is critical in obtaining successful operation of the system. Pay close attention to specified wiring practice, cabling information, earthing and shielding requirements. Improper wiring can result in electrical noise generation and unstable motor performance.

Avoid close parallel routing of signal wires and power wires, both inside and outside of the control cabinet. High voltage bus wires should be shielded and their length should be minimized.

Ensure proper chassis earths on all equipment. Terminate all individual chassis earths from power supply and servo-drives to a single tie point, (i.e. cabinet earth bus). Keep the distance from earth bus to earth ground as short as possible. Similarly, keep distance from servo-drive and power supply chassis earths to the tie point as short as possible. Chassis earth should be run close to D.C. Bus wires to minimize EMI. The impedance between the earth terminal and any accessible part of the equipment enclosure or cabinet should be less than or equal to 0.1 ohm

All terminal screws should be securely tightened to avoid faulty operation and screws torque to the specified values

All power connections to the CSA µA, A, B & C Series Servo-drives are through removable plug-in mating connectors. Do not solder the ends of the cables to be inserted into screw clamp terminals. All power connections to the CSA, E and F are via screw terminal connections.

WARNING – The removable plug-in mating connectors are for ease of wiring and are not suitable for connection or dis-connection when power is applied. All dis-connections must be made with power removed.

WARNING - All electrical supply wires and cables to this equipment must be installed in conduits (cable routings) which are smooth and free from sharp edges.

CAUTION - Shielded cable is required to be installed by the user for many external user cable connections to the CSA Servo-drive. Details of areas where shielded cable must be installed and details of earthing arrangements which must be implemented for the shields of such cables are given in the relevant sections of this user manual.

All external electrical wiring connected to this equipment must be color coded in accordance with European Standard EN 60204-1 requirements.

Additional electromagnetic compatibility (EMC) measures which must be installed on equipment cables associated with the CSA Servo-drive are given in *Chapter 2 Safety and EMC Instructions*, of this User's Guide.

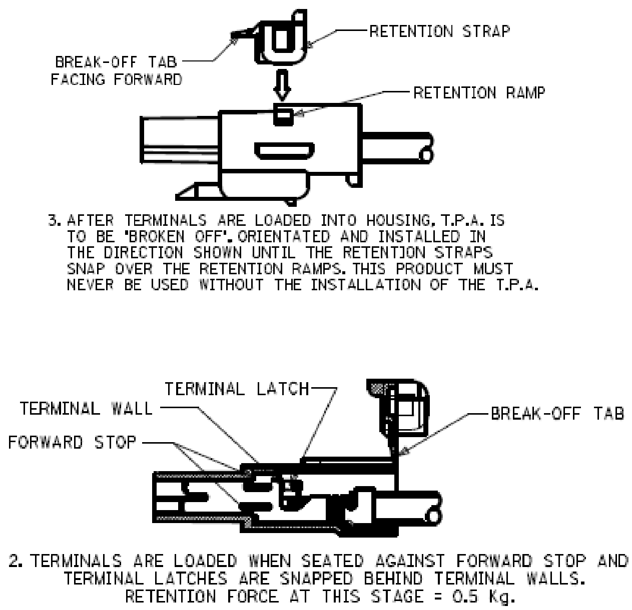
All wires and cables entering and leaving the IP54 rated enclosures or cabinets containing the CSA Servo-drive and the Regen resistor(s) must be protected and anchored in accordance with the requirements of EN 60204-1.

3.5.1 Drive Contactor (User Supplied)

A contactor (suitably rated for the particular CSA) should be installed just before the AC input line filter of the CSA. The contactor acts as a remote switch that may cut off the AC mains supply in the event of an emergency shutdown. This contactor should be sized based on the continuous power of the system.

3.5.2 Wiring notes for J6, J7, J9 connectors (Size C)

The connectors used on the CSA Size C are formed using crimp terminals. The appropriate crimps (Molex type 42815-0031) are supplied together the floating connectors for J6, J7, and J9. These crimps are sized for an 8 AWG (8.4 mm^2) cable with a 10 mm wire stripping. It is recommended to use the appropriate Molex crimping tool (63814-0000, or 63811-1500, or equivalent). After crimping, the contact must be inserted into the floating connector with the correct orientation and should be held in position by the TPA (Terminal Position Assurance) jumper, as shown in *Figure 3-17 CSA Size C Crimp Assembly*.



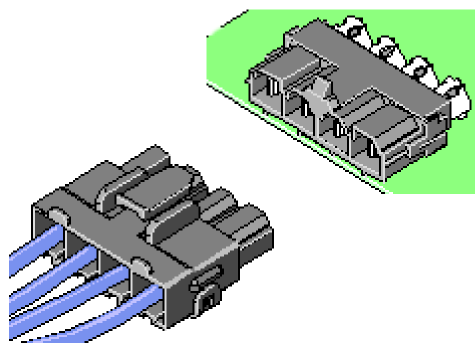


Figure 3-17 CSA Size C Crimp Assembly

3.6 Sequence of Component Wiring Recommendations

The following sequence for wiring is a recommendation. Individual wiring steps are denoted by a box character, which can be used as an installation check off list.

The terminal block layout on all power supplies and servo-drives has been designed to isolate low voltage from high voltage circuits. Cabinet conduits should be arranged to maintain this physical separation.

a) Power Circuit Wiring Sequence

- Wire a +24Vdc logic supply to the drive (Required on µA size drives). Fit a suitable EMC filter on the +24Vdc logic supply and fuse.
- Wire a +24Vdc Logic Supply to the drive for fan external supply, if necessary.
- Wire the AC mains input to user supplied fuses. Make a secure and reliable connection between the chassis of the equipment and Earth.
- Fit a suitable EMC mains line filter after the user supplied fuses and contactor.
- Wire AC mains from the user-supplied contactor to the power input poles of the CSA.

b) Servo-Drive Wiring Sequence

- Plug in Axis I/O cable to J2 and connect other end to user I/O equipment.
- Plug in resolver cable at J3 (or Encoder Cable to J4).
- Connect appropriate communications cabling (RS232 at J1, and/or Field Bus).

c) Motor Wiring Sequence

- Repeat the steps listed in this Section for each motor in the system.
- Plug in and screw tight resolver/encoder cable to motor position connector.
- Plug in and screw tight motor power cable to motor power connector. Also connect the brake terminations at J2D (if provided).
- Connect motor power cable to appropriate drive power terminals.

3.7 Three-Phase A.C. Mains Power Source Configuration

The CSA may be supplied from a three-phase AC. mains input. In this case the following user supplied options are required:-

1. Three-Phase Mains Fusing, ...Refer to *Chapter 2, Table 2-2 Appropriate CSA Fusing*
2. Mains Line Filter, ...Refer to *Chapter 2, Table 2-3 & 2-4 Appropriate CSA Line Filtering*
3. +24Vdc Power Source & Fuse,........Refer to *Chapter 2, Table 2-2 Appropriate CSA Fusing*
4. +24Vdc EMC Filter, ...Refer to *Chapter 2, Table 2-3 & 2-4 Appropriate CSA Line Filtering*

Note that for CSA sizes A, B, C, D, E & F, if the AC mains is still applied, and the control-backup power is removed, then the CSA control section will still operate correctly. Control power can still be generated from the high voltage D.C. Bus.

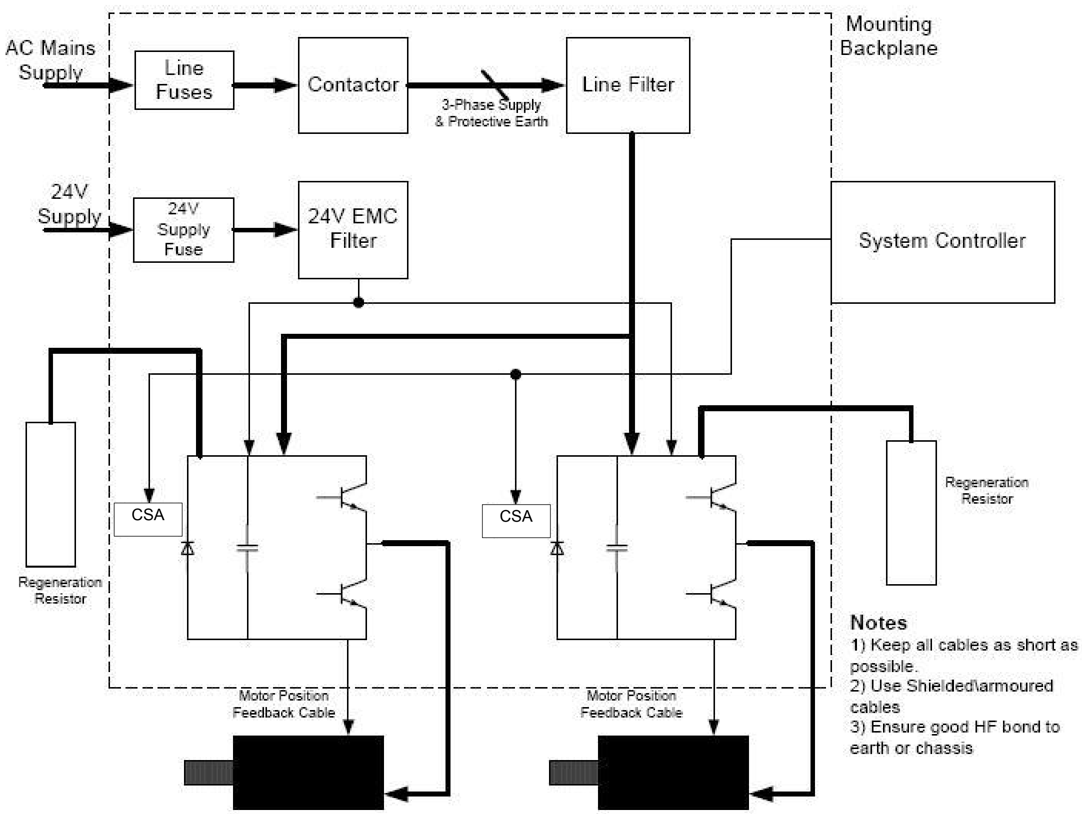


Figure 3-18 CSA Multi-Axis System with 3-Phase A.C. Mains Inputs

3.7.1 AC Mains Power Source Connection

3.7.1.1 Power Source Size µA

(G362- 003-XXXX-XXXX or G362- 006-XXXX-XXXX)

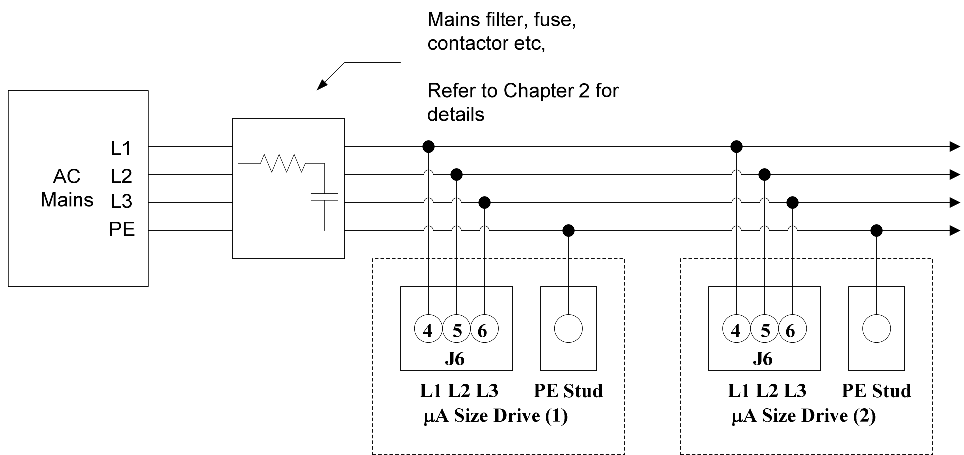


Figure 3-19 µA AC Mains Input Connection

Table 3-3 J6 AC Mains Power connector, µA Size

Pos.	Name	Function
J6.4	L1	Phase "L1", three-phase voltage input 230/460Vac ±10%
J6.5	L2	Phase "L2", three-phase voltage input 230/460Vac ±10%
J6.6	L3	Phase "L3", three-phase voltage input 230/460Vac ±10%
PE	PE	Protective Earth Stud on Chassis

Connector and Mating Part Information

- Fixed connector: 12 pins, male connector
- Mating connector, 12 pins, Female, supplied with the drive.
- Phoenix CombiCon (Part # GMSTB 2.5/12-ST-7.62)

Wire Gauge Information

- µA size wiring: cable 14 AWG (2.1 mm^2). Wire stripping: 7 mm.
- PE Stud wiring: cable 6 AWG (13mm^2)

Torque Information

- Tightening torque: 0.5Nm.

3.7.1.2 Power Source Size A & B

(G362- (X08) or (014)-XXXX-XXXX)

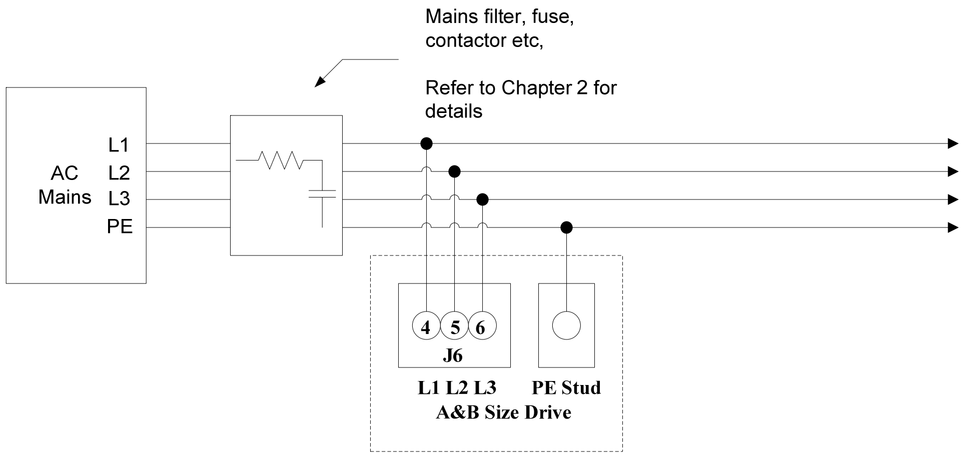


Figure 3-20 A & B AC Mains Input Connection

Table 3-4 J6 AC Mains Power connector, A & B Size

Pos.	Name	Function
J6.4	U1	Phase "L1", three-phase voltage input 230/460Vac ±10%
J6.5	V1	Phase "L2", three-phase voltage input 230/460Vac ±10%
J6.6	W1	Phase "L3", three-phase voltage input 230/460Vac ±10%
PE	PE	Protective Earth Stud on Chassis

Connector and Mating Part Information

- Fixed connector: 12 pins, male connector
- Mating connector, 12 pins, Female, supplied with the drive.
- Phoenix Contact (Part # 1767106)

Wire Gauge Information

- A size wiring: cable 14AWG (2.1 mm^2). Wire stripping: 7 mm
- B size wiring: cable 12AWG (3.3 mm^2). Wire stripping: 7 mm
- PE Stud wiring: cable 6 AWG (13mm^2)

Torque Information

- Tightening torque: 0.5Nm

3.7.1.3 Power Source Size C

(G362- (020), (025) or (030) -XXXX-XXXX)

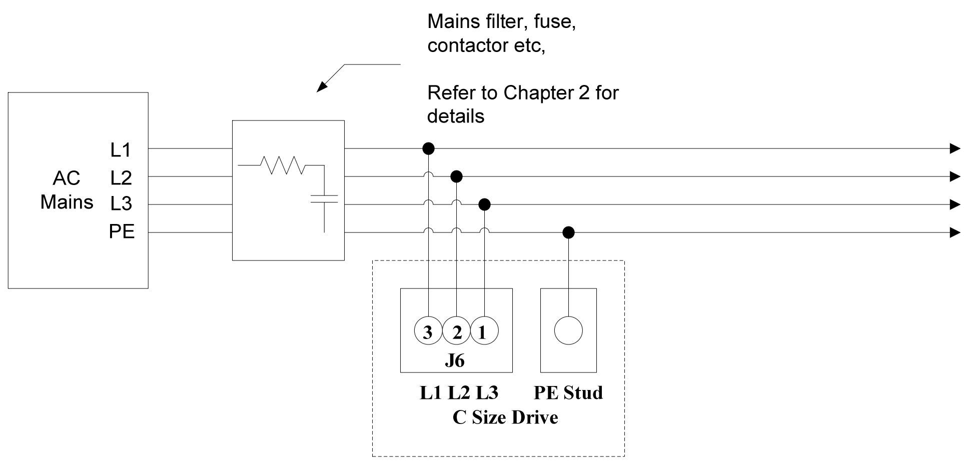


Figure 3-21 Size C AC Mains Input Connection

Table 3-5 J6 AC Mains Power connector, C Size

Pos.	Name	Function
J6.3	U1	Phase "L1", three-phase voltage input 230/460Vac ±10%
J6.2	V1	Phase "L2", three-phase voltage input 230/460Vac ±10%
J6.1	W1	Phase "L3", three-phase voltage input 230/460Vac ±10%
PE	PE	Protective Earth Stud on Chassis

Connector and Mating Part Information

- Fixed connector: 5 pins, male connector
- Mating connector, 5 pin Female, crimped supplied with the drive.
- (Molex 42816-0512)

Wire Gauge Information

- C size wiring: cable 8 AWG (8.4 mm^2).
- PE Stud wiring: cable 6 AWG (13mm^2)

Torque Information

- Tightening torque: 0.5Nm

3.7.1.4 Power Source Size D

(G362-(050) or (060)-XXXX-XXXX)

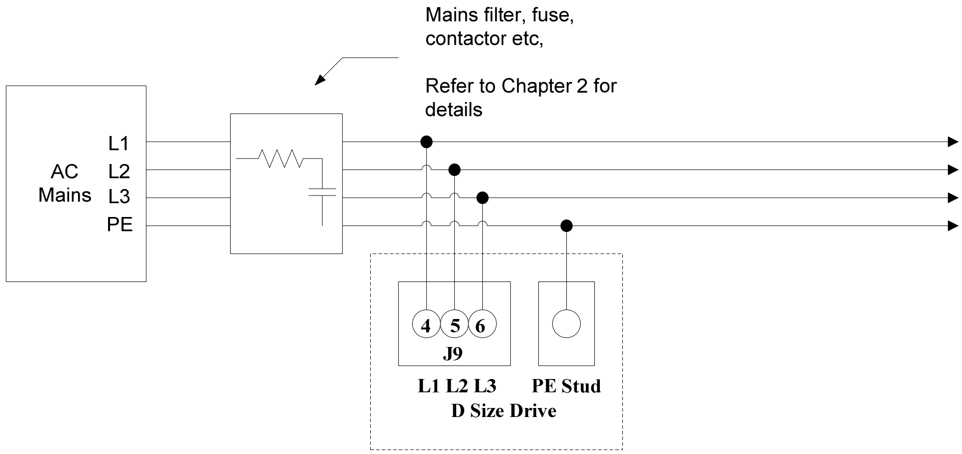


Figure 3-22 Size D AC Mains Input Connection

Connector and Mating Part Information

- Fixed connector: 4 pole, screw terminal

Wire Gauge Information

- D size wiring: cable 6 AWG (13 mm^2) for 50/140
- D size wiring: cable 4 AWG (21 mm^2) for 60/180
- PE Terminal wiring: cable 6 AWG (13 mm^2) for 50/140
- PE Terminal wiring: cable 4 AWG (21 mm^2) for 60/180
- Stripping Length 16mm

Torque Information

- Tightening Torque: 2-2.3Nm

Table 3-6 J9 AC Mains Power connector, D Size

Pos.	Name	Function
J9.3	PE	Protective Earth Screw Terminal
J9.4	U1	Phase "L1", three-phase voltage input 230/460Vac ±10%
J9.5	V1	Phase "L2", three-phase voltage input 230/460Vac ±10%
J9.6	W1	Phase "L3", three-phase voltage input 230/460Vac ±10%

3.7.1.5 Power Source Size E & F

(G362-(100) or (140) -XXXX-XXXX)

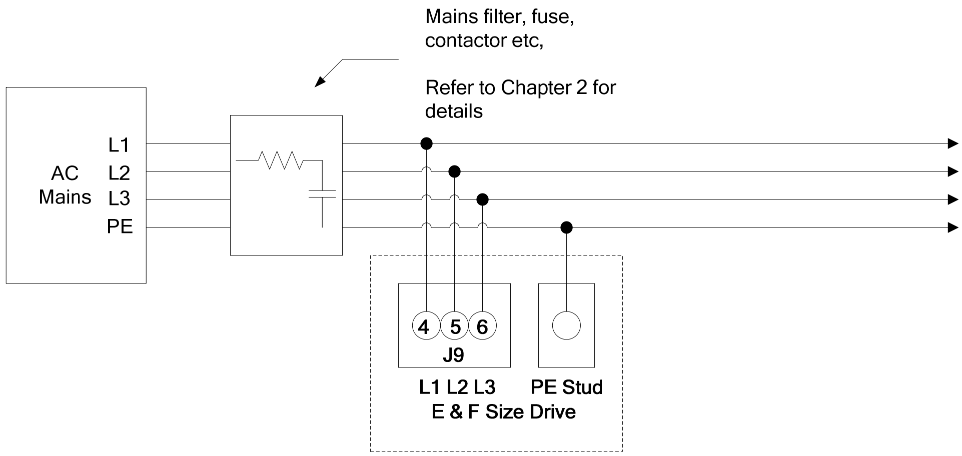


Figure 3-23 Size E & F AC Mains Input Connection

Table 3-7 J9 AC Mains Power connector, E & F Size

Pos.	Name	Function
J9.3	PE	Protective Earth Screw Terminal
J9.4	U1	Phase "L1", three-phase voltage input 230/460Vac ±10%
J9.5	V1	Phase "L2", three-phase voltage input 230/460Vac ±10%
J9.6	W1	Phase "L3", three-phase voltage input 230/460Vac ±10%

Connector and Mating Part Information

- Fixed connector: 4 pole, screw terminal

Wire Gauge Information

- E & F size wiring: cable 1 AWG (42 mm^2)
- PE Terminal wiring: cable 1 AWG (42 mm^2)
- Stripping Length 16mm

Torque Information

- Tightening Torque: 2-2.3Nm

3.7.2 Softstart & Power Cycling Frequency Limits

The CSA contains an internal soft-start function. The soft-start function limits the inrush current into the CSA's D.C. Bus smoothing capacitors after the AC mains has been switched on.

If the frequency of power cycling becomes too high, then the power dissipation in the soft-start resistor can be excessive. In this case the softstart circuitry may become damaged.

CAUTION - The internal softstart resistors are designed to allow an AC application of once every 60 seconds. If this rate is exceeded, then the internal softstart resistors may be damaged

3.8 24V Backup Connection

The CSA is equipped with a 24V logic supply backup. This backup supply provides logic power to the drive when AC mains power is removed.

For the µA size, application of a +24Vdc supply is mandatory for drive operation. Removal of the +24vdc supply will cause the drive to power down and no longer control the motor.

3.8.1 Size µA, A & B 24V Input Connection

(G362-(003) (006), (X08) or 014 - XXXX-XXXX)

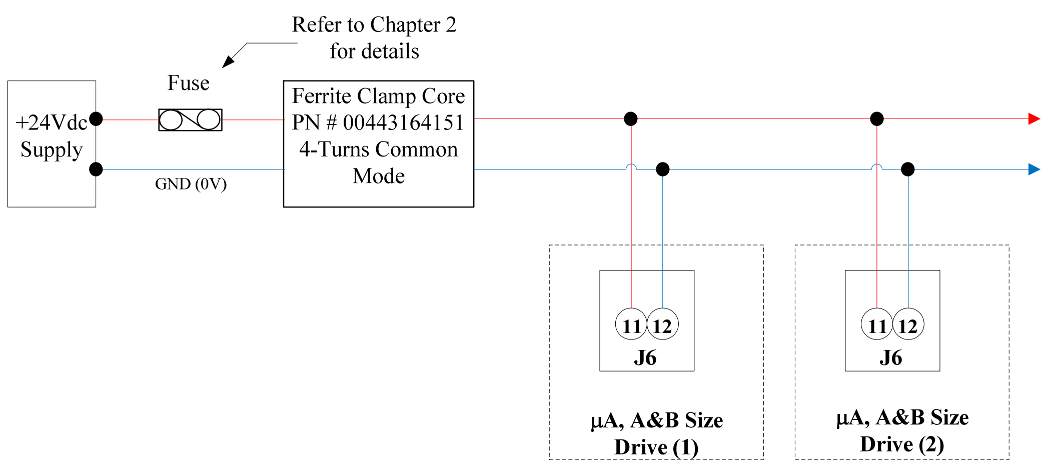


Figure 3-24 Size µA, A & B 24V DC Input Connection

Table 3-8 J6 24V Logic Power connector, µA, A & B Size

Pos.	Name	Function
J6.11	24V	+24V Logic Backup Supply
J6.12	0V	Logic Supply Return (Tied Internally to PE)

Connector and Mating Part Information

- Fixed connector: 12 pins, male connector
- Mating connector, 12 pins, Female, supplied with the drive.
- Phoenix CombiCon (Part # GMSTB 2.5/12-ST-7.62)

Wire Gauge Information

- μA size wiring: cable 14 AWG (2.1 mm^2).
- Stripping Length 7mm

Torque Information

- Tightening torque: 0.5Nm

3.8.2 Size C, D, E & F 24V Input Connection

(G362-(020), (025), (030), (050), (060), (100) or (140) - XXXX-XXXX)

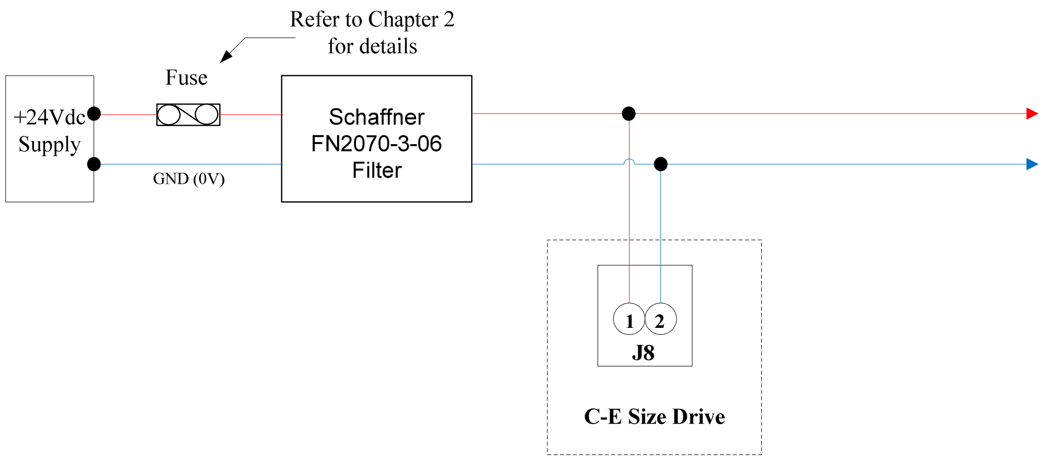


Figure 3-25 Size C, D, E & F 24V DC Input Connection

Table 11 J8 +24Vdc Logic Power connector, C, D, E & F Size

Pos.	Name	Function
J8.1	24V	+24V Logic Backup Supply
J8.2	0V	Logic Supply Return

Connector and Mating Part Information

- Fixed connector: 2 pins, male connector
- Mating connector, 2 pins, Female, supplied with the drive.
- Wago (Part # 231-102/026-000)

Wire Gauge Information

- A, B, C, D & F size wiring: cable 14 AWG (2.1 mm²).
- Stripping Length 8mm

Torque Information

- Tightening torque: 0.5Nm

3.8.3 Auxiliary 24V Fan connection (Size E & F)

(G362- (100) or (140) - XXXX-XXXX)

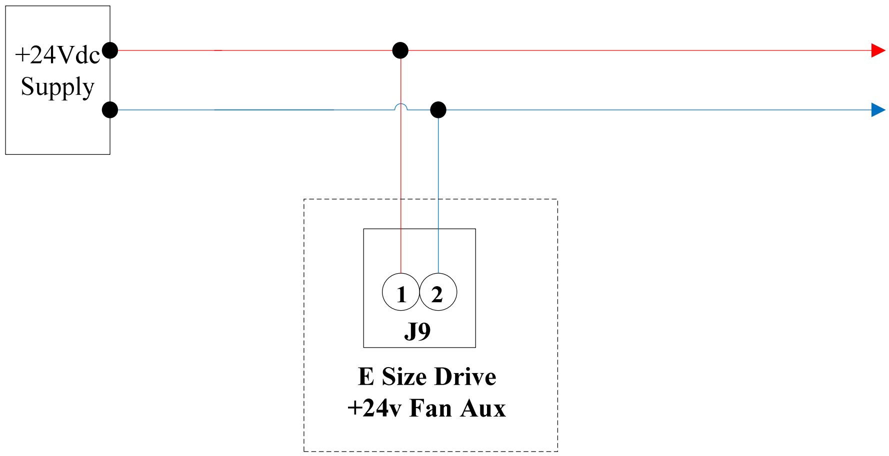


Figure 3-26 Size E & F Auxiliary +24Vdc Fan Supply

Table 3-9 Size E & F J9, Auxiliary +24Vdc Fan Supply

Pos.	Name	Function
J9.1	24V	+24V Logic Backup Supply
J9.2	0V	Logic Supply Return

Connector and Mating Part Information

- Fixed connector: 2 pole, screw terminal

Wire Gauge Information

- Cable 14 AWG (2.1 mm^2)
- Stripping 9mm

Torque Information

- Torque 0.7Nm

3.9 Internal/External Regeneration (Regen) Resistors – Configurations

Regeneration resistors can be fitted to all CSA servo-drives. All external Regen resistors should be mounted to allow adequate heat dissipation and such that heat from the Regen resistor is not directed to air intakes of other equipment. The µA size and 'A' size CSA are the only sizes with internal regen options. All other drive sizes use external regen only.

For EMC purposes, use shielded cable to connect the external Regen resistor to the CSA. The length of this cable should be as short as possible. The shields of these cables should be connected to Chassis Earth using the optional EMC kit or the panel earth bar.

Alternatively, if the cable is required to pass through an enclosure panel earthed to Chassis Earth, the shield may be earthed to the panel by use of a 360 degree metal cable gland.

Refer to *Chapter 2, Safety and EMC Instructions* for further safety and EMC requirements for cable installation.

The regeneration resistors (internal and external) are protected by software. Setting the regen power and resistance parameters, allows the drive to calculate the maximum allowable duty cycle for the regen transistor. The software will clamp the regen duty-cycle at this level. If the drive tries to regen at a greater level, an overvoltage error will occur.

WARNING - External regen resistors are connected to the CSA D.C. Bus voltage that can reach 800 Vdc. Exposed metallic mounting parts of external regen resistors must be connected to protective earth and the electrically conducting parts mechanically shielded for safety. High voltage warning stickers are also recommended.

Table 3-10 Recommended CSA Regeneration Resistors

CSA Regeneration Resistor Options						
Model (Size)	**Internal Regen**			**External Regen**		
	Resistance (Ohms)	**Continuous Power (W)**	**Peak Power (@ 400V$_{AC}$) (kW)**	**Resistance (Ohms)**	**Continuous Power (W)**	**Peak Power (@ 400V$_{AC}$) (kW)**
G362-003 (µA)	120	50	4.8	120	50	4.8
G362-006 (µA)	120	100	4.8	120	100	4.8
G362-x08 (A)	56	150	10.3	51	200	11.3
G362-014 (B)	Internal Regen is **NOT** available in these Sizes.			33	250	17.5
G362-020 (C)				12	370	48.1
G362-025 (C)				12	370	48.1
G362-030 (C)				12	370	48.1
G362-050 (D)				10	750	57.8
G362-060 (D)				10	750	57.8
G362-100 (E)				3.9	1,000	148
G362-140 (F)				3	1,500	192.5

3.9.1 µA Size Regeneration Resistor Connection

(G362- 003-XXXX-XXXX or G362- 006-XXXX-XXXX)

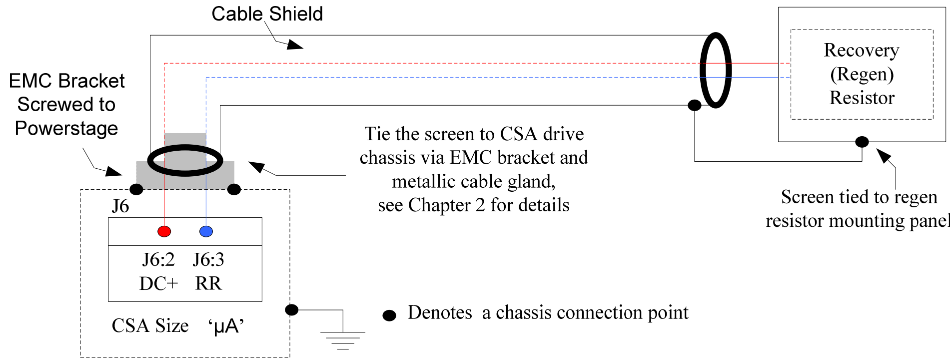


Figure 3-27 CSA Size µA, External Regeneration Connections

Table 3-11 J6, Regeneration Resistor connector, µA Size

Pos.	Name	Function
J6.2	DC+	DC Bus (+)
J6.3	RR	Regeneration Resistor

Connector and Mating Part Information

- Fixed connector: 12 pins, male connector
- Mating connector, 12 pins, Female, supplied with drive.
- Phoenix CombiCon (Part # GMSTB 2.5/12-ST-7.62)

Wire Gauge Information

- µA size wiring: cable 14 AWG (2.1 mm^2). Wire stripping: 7 mm.

Torque Information

- Tightening torque: 0.5Nm

3.9.2 A, B Size Regeneration Resistor Connection

(G362-(X08) or (014)-XXXX-XXXX)

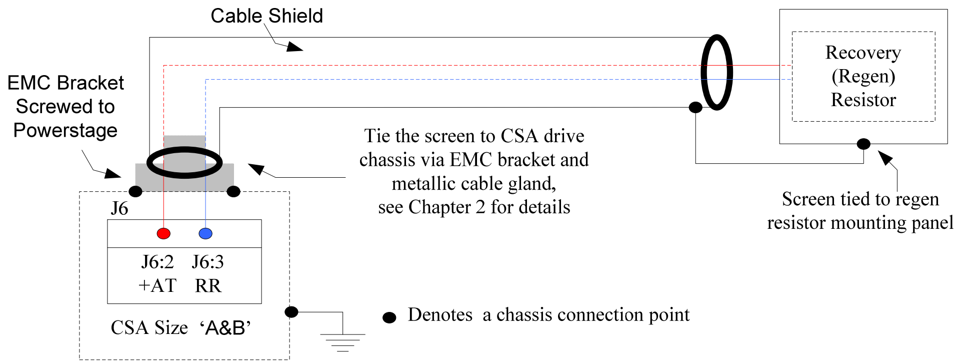


Figure 3-28 CSA Size A, B External Regeneration Connections

Table 3-12 J6, Regeneration Resistor connector, A, B Size

Pos.	Name	Function
J6.2	+AT	DC Bus (+)
J6.3	RR	Regeneration Resistor

Connector and Mating Part Information
- Fixed connector: 10 pins, male connector
- Mating connector, 10 pins, Female, supplied with the drive.
- Phoenix Contact (Part # PC4 HV/10-ST-7.62)

Wire Gauge Information
- A size wiring: cable 14AWG (2.1 mm^2). Wire stripping: 7 mm
- B size wiring: cable 14AWG (2.1 mm^2). Wire stripping: 7 mm

Torque Information
- Tightening torque: 0.5Nm

3.9.3 C Size Regeneration Resistor connection

(G362-(020), (025) or (030) -XXXX-XXXX)

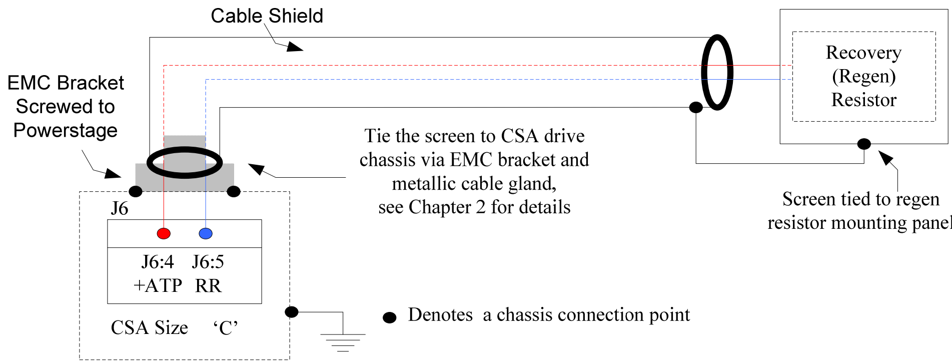


Figure 3-29 CSA Size C External Regeneration Connections

Table 3-13 J6, Regeneration Resistor connector, C Size

Pos.	Name	Function
J6.4	+ATP	DC Bus (+)
J6.5	RR	Regeneration Resistor

Connector and Mating Part Information

- Fixed connector: 5 pins, male connector
- Mating connector, 5 pins Female, crimps supplied with the drive.
- (Molex 42816-0512)

Wire Gauge Information

- C size wiring: cable 8 AWG (8.4 mm^2).

Torque Information

- n/a

3.9.4 D Size Regeneration Resistor connection

(G362-(050) or (060)-XXXX-XXXX)

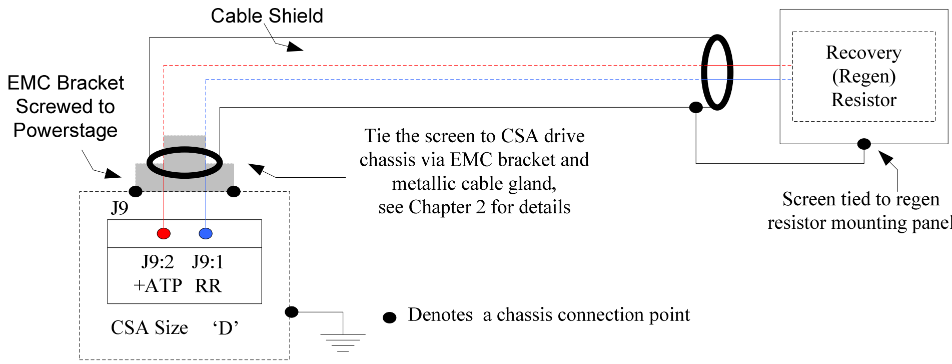


Figure 3-30 CSA Size D External Regeneration Connections

Table 3-14 J9, Regeneration Resistor connector, D Size

Pos.	Name	Function
J9.1	RR	Regeneration Resistor
J9.2	+ATP	DC Bus (+)

Connector and Mating Part Information

- Fixed connector: 2 pole, screw terminal

Wire Gauge Information

- D size wiring: cable 6 AWG (13 mm^2) for 50/140
- D size wiring: cable 4 AWG (21mm^2) for 60/180
- Stripping Length 16mm

Torque Information

- Tightening Torque: 2-2.3Nm

3.9.5 E & F Size Regeneration Resistor connection

(G362-(100) or (140) -XXXX-XXXX)

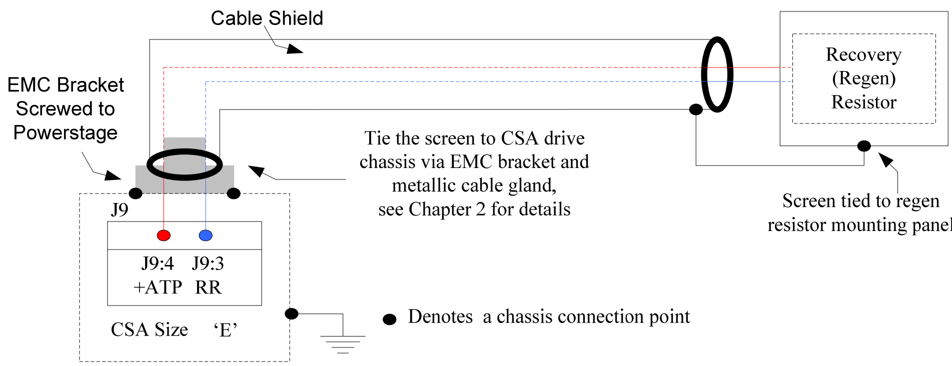


Figure 3-31 CSA Size E & F External Regeneration Connections

Table 3-15 J9, Regeneration Resistor connector, E & F Size

Pos.	Name	Function
J9.3	RR	Regeneration Resistor
J9.4	+ATP	DC Bus (+)

Connector and Mating Part Information
- Fixed connector: 2 pole, screw terminal

Wire Gauge Information
- E & F size wiring: cable 2 AWG (34 mm^{2})
- Stripping Length 19mm

Torque Information
- Tightening Torque: 4Nm

WARNING - When performing any changes to the regen resistor configuration, AC input power must be removed from the CSA. **Wait at least 5 minutes** upon removal of all power, to allow for D.C. Bus capacitors to discharge.

3.10 Motors - Installation

Motors should be sized by qualified personnel. Improper sizing will directly affect performance and reliability.

Motor performance data for Moog motors is shown in separate data sheets. Contact Moog Applications Engineering for detailed motor technical information and application sizing, etc.

Standard motors should not be mounted directly onto a gearbox with the shaft inside the lubrication chamber. Motors may be ordered with an optional shaft seal for these applications. When the motor is mounted, the lubricant level within the gearbox must be below the shaft seal of the motor in order to avoid long term seepage and motor failure.

3.10.1 Assembling Motor Resolver and Power Cables

Use of the made-up cable sets is recommended for connecting the MOOG brushless servomotors. These cable sets are available in standardized lengths.

If MOOG cables are not used, the values specified below with regard to the cable make-up must be maintained **in all cases**. Contact your local Moog sales office or authorized distributor for selection of pre-made motor cables.

The following are listed for convenience:-

Europe and Asia
MOOG GmbH
Hanns-Klemm-Strasse 28
71034 Boeblingen
Germany
Phone: +0049 - 7031 - 622 -0
Fax: +0049 - 7031 - 622 - 100

North America
MOOG.INC
Jamison Road
East Aurora, NY 14052
USA
Phone: +001 - 716 - 652 - 2000
Fax: +001 - 716 - 687 - 4870

3.10.2 Motor Power Cable

Wire the motor power connector in accordance with *Figures 3.30- 3.30 CSA 'Size' Motor Power Connection*. Use wire sizes based on the motor's continuous stall current (rms) and wire length requirements.

Wiring must be in accordance with standard EN 60204-1, refer to *Chapter 2 safety and EMC instructions* of this user's manual

For proper drive commutation of motors, it is required that the motor phase conductors, Phase U, Phase V, and Phase W be wired correctly.

3.10.2.1 Size µA

(G362-(003) or (006)-XXXX-XXXX)

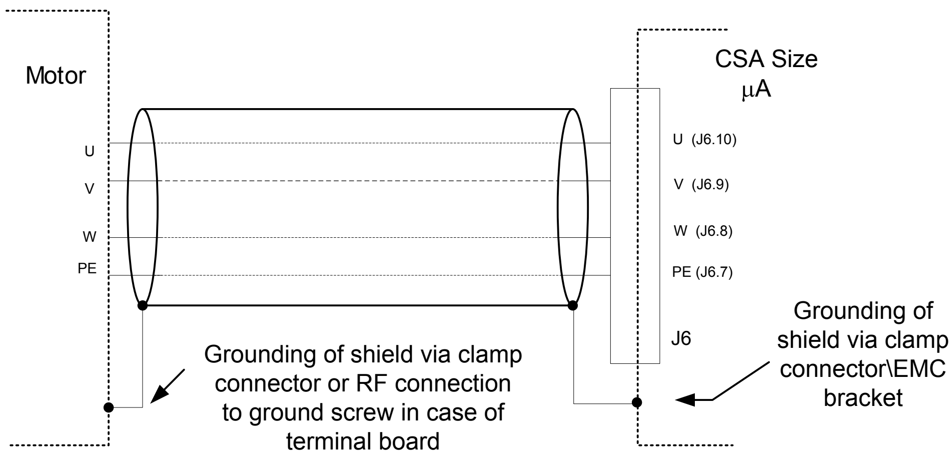


Figure 3-32 µA Motor Power Connection

Table 3-16 J6, Motor connector, µA Size

Pos.	Name	Function
J6.7	PE	Motor Protective Earth
J6.8	W	Motor Phase W
J6.9	V	Motor Phase V
J6.10	U	Motor Phase U

Connector and Mating Part Information

- Fixed connector: 12 pins, male connector
- Mating connector, 12 pins, Female, supplied with the drive.
- Phoenix CombiCon (Part # GMSTB 2.5/12-ST-7.62)

Wire Gauge Information

- µA size wiring: cable 14 AWG (2.1 mm^2).
- Stripping Length 7mm

Torque Information

- Tightening Torque: 0.5Nm

3.10.2.2 Size A & B

(G362-(X08) or (014)-XXXX-XXXX)

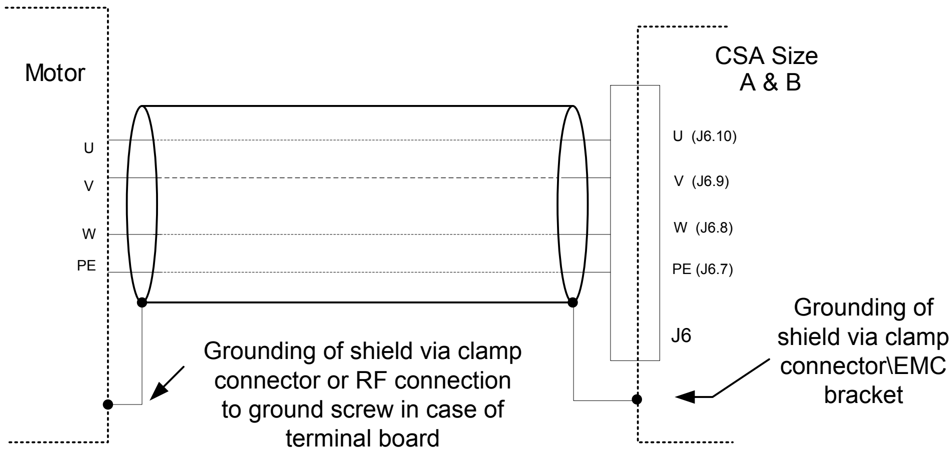


Figure 3-33 A & B Motor Power Connections

Table 3-17 J6, Motor connector, A & B Size

Pos.	Name	Function
J6.7	GND	Motor Protective Earth
J6.8	W2	Motor Phase W
J6.9	V2	Motor Phase V
J6.10	U2	Motor Phase U

Connector and Mating Part Information

- Fixed connector: 10 pins, male connector
- Mating connector, 10 pins, Female, supplied with the drive.
- Phoenix Contact (Part # PC4 HV/10-ST-7.62)

Wire Gauge Information

- A size wiring: cable 14 AWG (2.1 mm^2).
- B size wiring: cable 12 AWG (3.3 mm^2).
- Stripping Length 7mm

Torque Information

- Tightening Torque: 0.5Nm

3.10.2.3 Size C

(G362-(020), (025) or (030) -XXXX-XXXX)

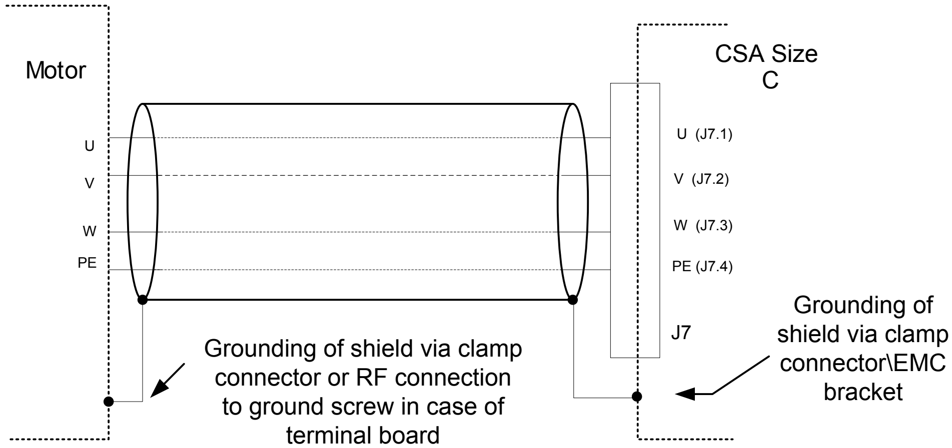


Figure 3-34 C Motor Power Connection

Table 3-18 J7, Motor connector, C Size

Pos.	Name	Function
J7.4	PE	Motor Protective Earth
J7.3	W2	Motor Phase W
J7.2	V2	Motor Phase V
J7.1	U2	Motor Phase U

Connector and Mating Part Information

- Fixed connector: 4 pins, male connector
- Mating connector, 4 pins, Female Crimped, supplied with the drive.
- Molex 42816-0412

Wire Gauge Information

- C size wiring: cable 8 AWG (8.4 mm^2).

3.10.2.4 Size D

(G362-(050) or (060)-XXXX-XXXX)

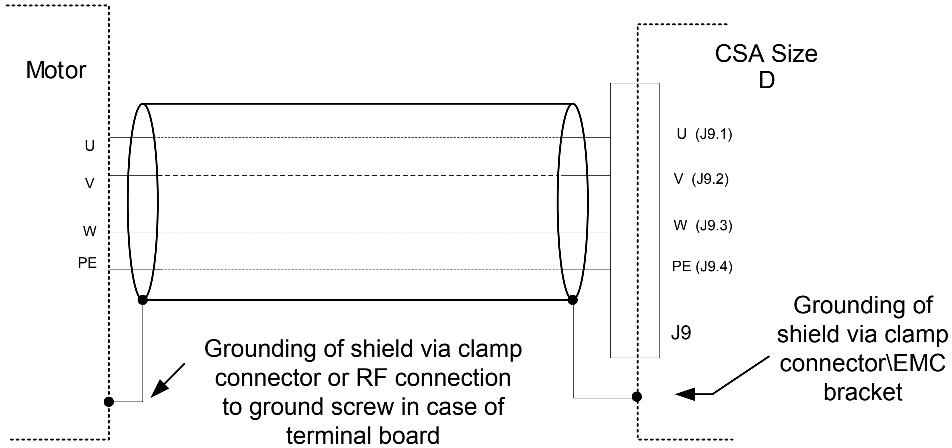


Figure 3-35 D Motor Power Connection

Table 3-19 J9, Motor connector, D Size

Pos.	Name	Function
J9.10	PE	Motor Protective Earth
J9.9	W2	Motor Phase W
J9.8	V2	Motor Phase V
J9.7	U2	Motor Phase U

Connector and Mating Part Information

- Fixed connector: 4 pole, screw terminal

Wire Gauge Information

- D size wiring: cable 6 AWG (13 mm^2) for 50/140
- D size wiring: cable 4 AWG (21mm^2) for 60/180
- Stripping Length 16mm

Torque Information

- Tightening Torque: 2-2.3Nm

3.10.2.5 Size E & F

(G362-(100) or (140) -XXXX-XXXX)

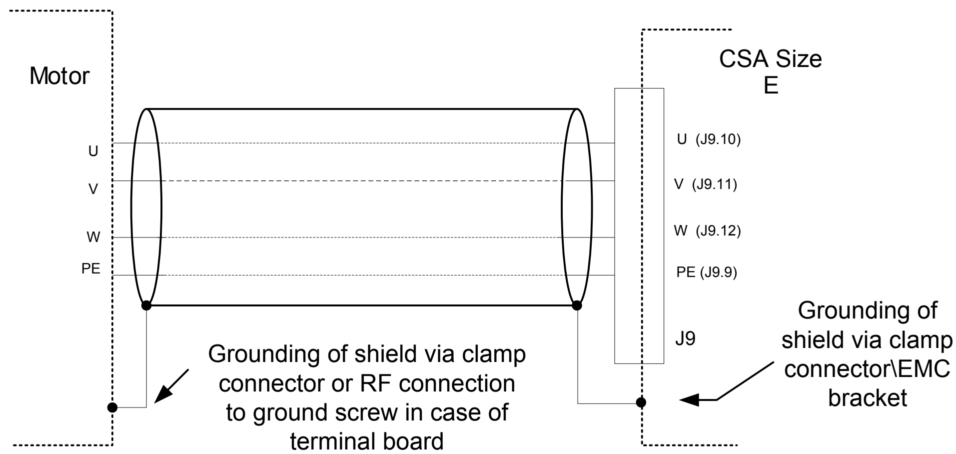


Figure 3-36 CSA E & F Motor Power Connections

Table 3-20 J9, Motor connector, E & F Size

Pos.	Name	Function
J9.9	PE	Motor Protective Earth
J9.12	W2	Motor Phase W
J9.11	V2	Motor Phase V
J9.10	U2	Motor Phase U

Connector and Mating Part Information
- Fixed connector: 4 pole, screw terminal

Wire Gauge Information
- E & F size wiring: cable 1 AWG (42 mm^2)
- Stripping Length 24mm

Torque Information
- Tightening Torque: 8Nm

3.10.3 Motor Brake Connection

The CSA provides a motor break relay at connector J2D (on Control Card Interface). The user supplies a 24Vdc Power Supply Unit for the brake connections. Details of the motor brake current requirements are available from the relevant motor datasheet.

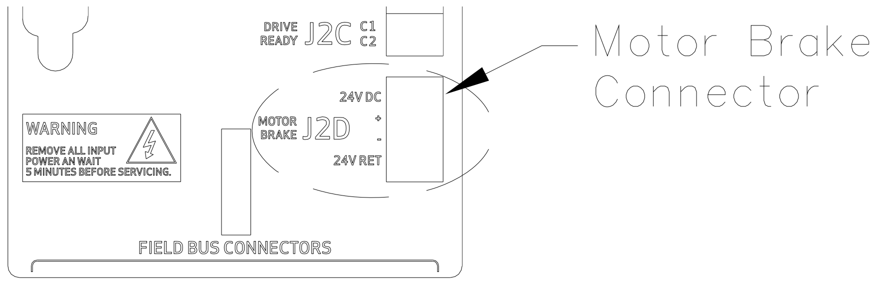


Figure 3-37 Motor Brake Connector Locations

Table 3-21 J2D, CSA Brake connector

Pos.	Name	Function
J2D.1	24V DC	Brake 24V Supply
J2D.2	+	Brake +
J2D.3	-	Brake -
J2D.4	24V RET	Brake 24V Supply Return

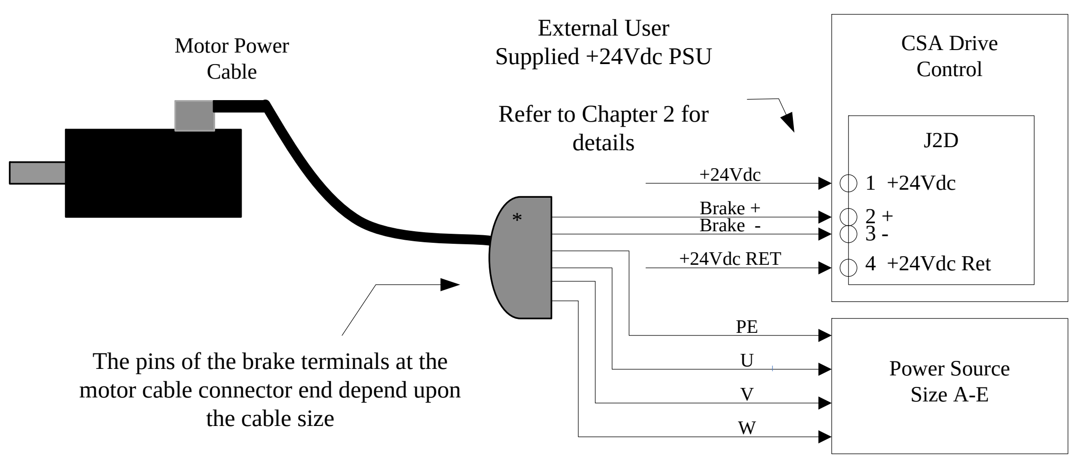


Figure 3-38 Motor Brake Cabling

* The pins of the brake terminals at the motor cable connector end depend upon the cable size

Connector and Mating Part Information

- Fixed connector: 4 pins, male connector
- Mating connector, 4 pins spring cage, Female, supplied with the drive

Wire Gauge Information

- Wiring: cable. 28-16AWG (0.14-1.5mm^2)
- Stripping Length 9mm

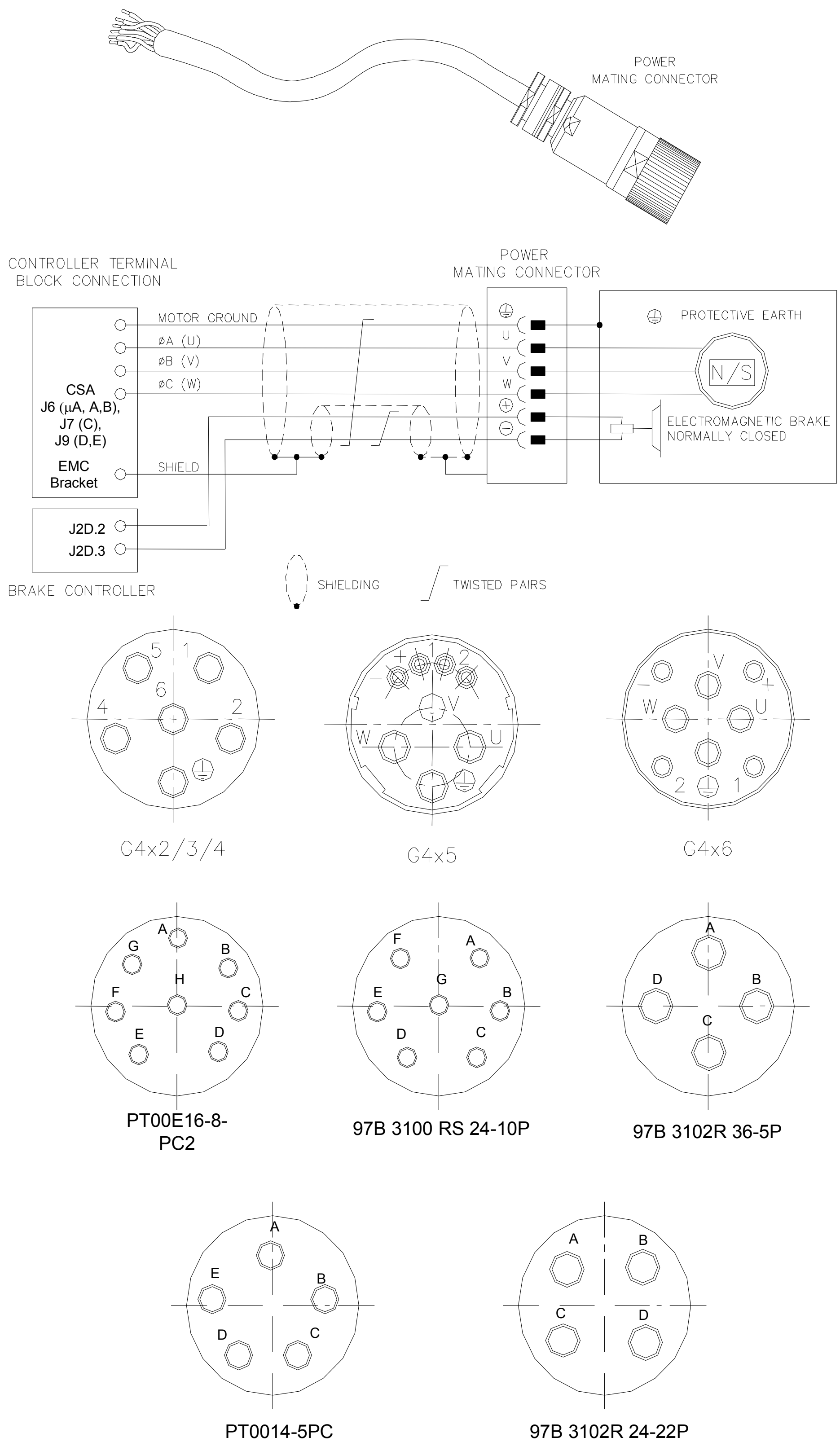


Figure 3-39 Motor Power and Brake Connectors

Table 3-22 Motor Power Connections

CSA	G4x2/3/4	G4x5	G4x6	PT00E 16-8-PC2	97B3100RS 24-10P	97B3102R 36-SP	PT00E 14-5 PC	97B3102RS 24-22P
⏚	⏚	⏚	⏚	D	D	D	D	D
U2	2	U	U	A	A	A	A	A
V2	4	V	V	B	B	B	B	B
W2	1	W	W	C	C	C	C	C
Brake+	5	+	+	E	E	-	-	-
Brake-	6	-	-	F	F	-	-	-

3.10.4 Motor Resolver Connection

Wire the CSA resolver cable in accordance with *Figure 3-41 CSA Resolver Cables and Table 3-23 Resolver to Motor Connections*

For CE compliance, shield should be attached on both sides of resolver cable.

To prevent noise coupling into the resolver signals, avoid running the resolver cable near other high power wiring, especially the motor power cable

Cable Length should not exceed 30m (100 feet).

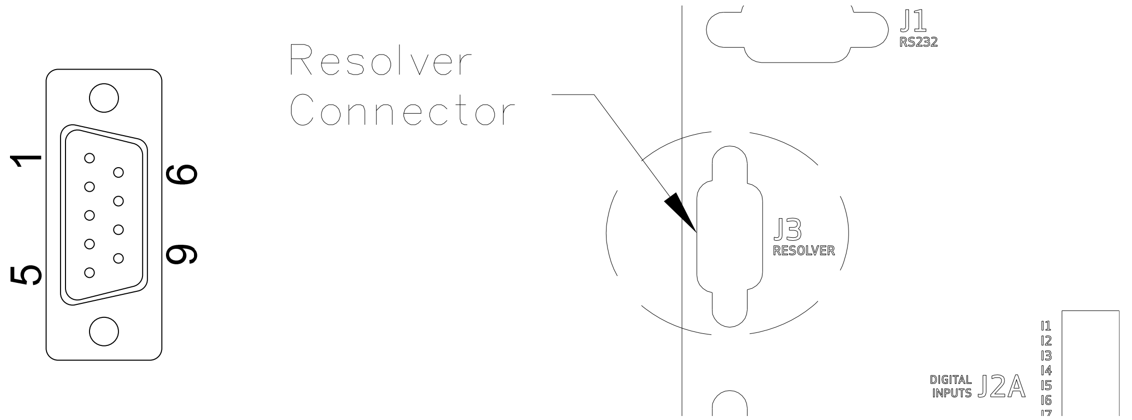


Figure 3-40 Motor Resolver Connector Location and Pin-out

Table 3-23 Resolver to Motor Connections

MOTOR RESOLVER CONNECTOR				
Pos.	**Signal Type**	**FAS T/ FAS K**	**FAS N/ FAS Y**	**G4xx /(FASG)**
J3.1	Cosφ (S2)	C	1	3
J3.2	$\overline{Cos\varphi}$ (S4)	E	2	4
J3.9	V-Ref (R1)	D	10	7
J3.7	0V (R2)	B	7	8
J3.8	PTC\NTC	N	8	6
J3.6	PTC\NTC	A	9	5
J3.4	Sinφ (S1)	G	11	1
J3.5	$\overline{Sin\varphi}$ (S3)	H	12	2
J3.3	Shield	S	3	-

Connector and Mating Part Information

- Fixed connector: 9 pin, Female Sub-D connector
- Mating connector, 9 pin male Sub-D

Wire Gauge Information

- Wiring: cable. 28-18AWG (0.14-0.82mm^2)

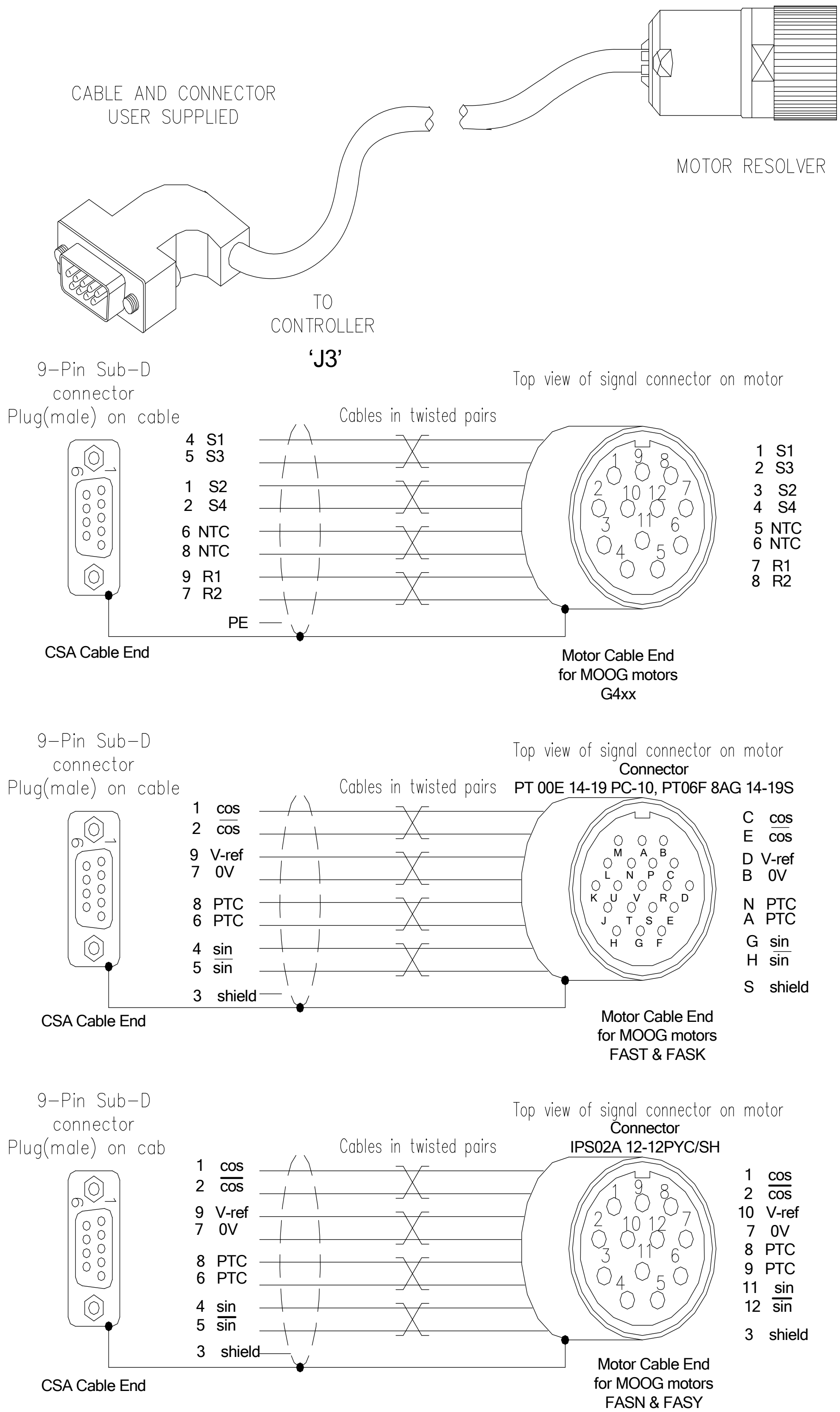


Figure 3-41 CSA Resolver Cables

3.10.5 Motor Encoder Connection

The CSA encoder input supports a variety of encoders. These include Analogue, SSI, Hiperface and Endat. The connections to the drive for each of these encoder types are given in *Table 27 Encoder Cable Input Connections*.

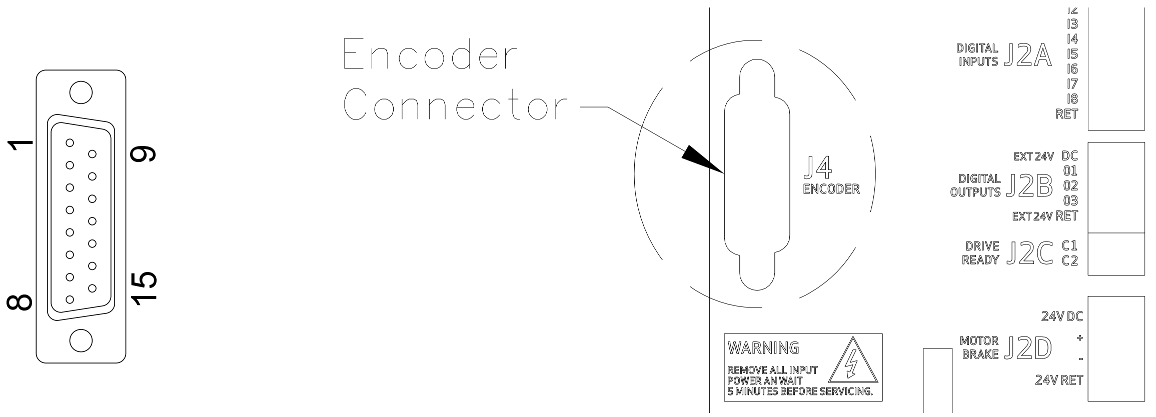


Figure 3-42 Motor Encoder Connector Location and Pinout

Table 3-24 Encoder Cable Input Connections

	Encoder Type					
Pos.	**Analogue**	**SSI**	**Hiperface**	**EnDat2.1**	**EnDat2.2**	**Incremental**
J4.1	Shield	Shield	Shield	Shield	Shield	Shield
J4.2	- Sine	-	- Sine	- Channel B	- Channel B	-
J4.3	- Cosine	-	- Cosine	- Channel A	- Channel A	-
J4.4	0Vdc	0Vdc	0Vdc	0Vdc	0Vdc	0Vdc
J4.5	-	- Clock	-	- Clock	- Clock	- A
J4.6	- Channel Z (Zero)	- Data	RS485 -	- Data	- Data	- B
J4.7	-	-	-	-	-	-
J4.8	NTC/PTC	NTC/PTC	NTC/PTC	NTC/PTC	NTC/PTC	NTC/PTC
J4.9	+ Sine	-	+ Sine	+ Channel B	-	+ Channel Z (Zero)
J4.10	+ Cosine	-	+ Cosine	+ Channel A	-	-
J4.11	+5Vdc to +12Vdc (150 mA max.)	+5Vdc to +12Vdc (150 mA max.)	+5Vdc to +12Vdc (150 mA max.)	+5Vdc to +12Vdc (150 mA max.)	+5Vdc to +12Vdc (150 mA max.)	+5Vdc to +12Vdc (150 mA max.)
J4.12	- Fault	+ Clock	-	+ Clock	+ Clock	+ A
J4.13	+ Channel Z (Zero)	+ Data	RS485 +	+ Data	+ Data	+ B
J4.14	Gnd Supply	Gnd Supply	Gnd Supply	Gnd Supply	Gnd Supply	Gnd Supply
J4.15	NTC/PTC	NTC/PTC	NTC/PTC	NTC/PTC	NTC/PTC	NTC/PTC

Connector and Mating Part Information

- Fixed connector: 15 pin, Female Sub-D connector
- Mating connector, 15 pin male Sub-D

Wire Gauge Information

- Wiring: cable. 28-18AWG (0.14-0.82mm^2)

3.10.5.1 Commutation Track Support

The commutation track inputs operate using RS485/RS422 signals or TTL signals between 0Vdc and +5Vdc. Where the track information is transmitted via RS485/RS422, only the positive referenced signal (U+, V+ or W+) should be connected to the input J2E. Information on the connection of the commutation track to connector J2E is contained with *Table 3-25 Commutation Track Inputs.* The absolute position information (A/A# and B/B#) is connected as per *Table 3-24 Encoder Cable Input Connections*.

Where the CSA is factory configured for use with a digital incremental encoder with support for commutation tracks [C96255-X-X5X-X-XXX & C96255-X-X6X-X-XXX\], only four optically isolated digital inputs are available to the user, (digital input 1-4)

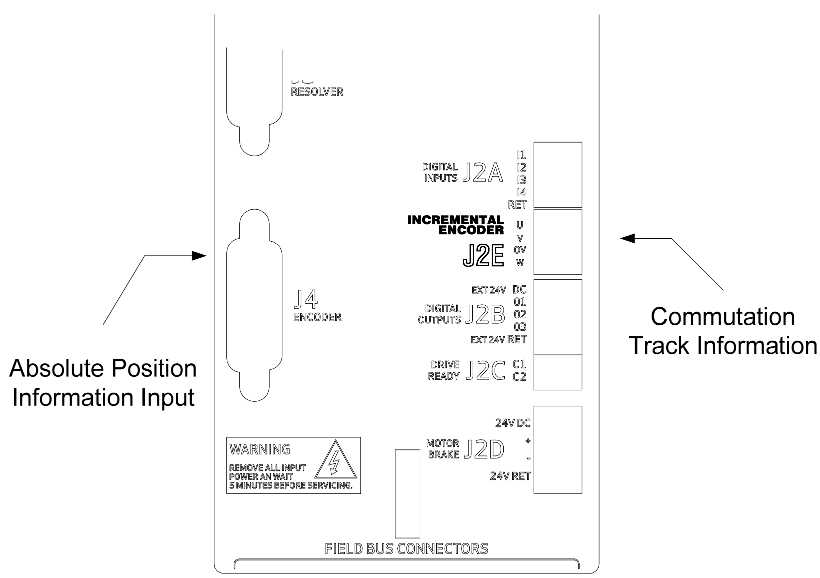


Figure 3-43 Commutation Track Support

Table 3-25 Commutation Track Inputs

Pos.	Commutation Track Input
J2E.1	Phase U+
J2E.2	Phase V+
J2E.3	Gnd\Common
J2E.4	Phase W+

Connector and Mating Part Information

- Fixed connector: 4 pins, male connector
- Mating connector, 4 pins spring cage, Female, supplied with the drive.
- Phoenix Contact (Part # FK-MC 0.5/4-ST-2.5)

Wire Gauge Information

- Wiring: cable. 28-20AWG (0.14-0.5mm^2)
- Wire stripping: 8 mm

For CE compliance, shield should be attached on both sides of resolver cable.

To prevent noise coupling into the resolver signals, avoid running the resolver cable near other high power wiring, especially the motor power cable

Cable Length should not exceed 30m (100 feet).

3.10.6 Motor Rotation Direction

The positive direction of rotation is clockwise, when the motor is viewed from the shaft end, as shown in the diagram below.

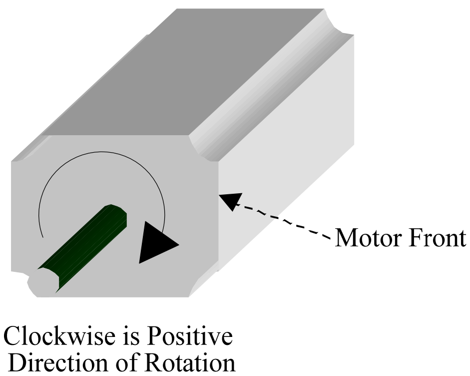


Figure 3-44 Rotational Conventions for Mechanical Process Variables

NOTE:-. For operation with the encoder, positive rotation as defined here corresponds to Channel ‘A’ **leading** Channel ‘B’.

3.11 CSA Control Input and Outputs

The following section contains a description of the control related Input/output (I/O) available to the user. Functionality of this I/O is detailed later in this manual.

NOTE - An external 12Vdc to 32Vdc power source (user supplied) is required for the I/O functions. The amperage rating of this power source will depend on the number of I/O functions used. Supply currents can be calculated as a function of this number and the input and output impedances quoted below.

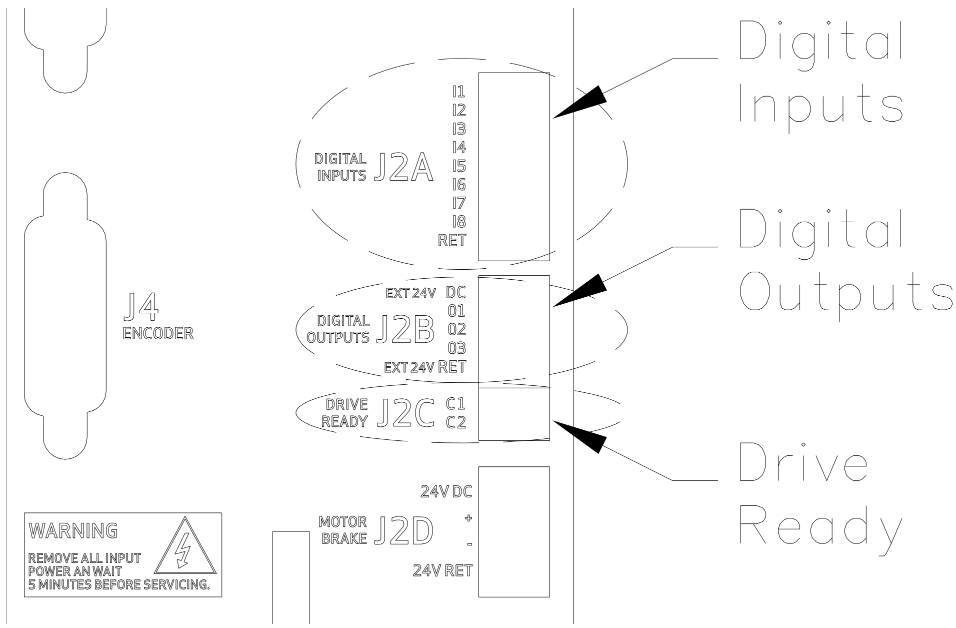


Figure 3-45 CSA I/O Connections

3.11.1 General Purpose Description of the Digital Inputs

The CSA provides 8 digital inputs on connector J2A.

Table 3-26 J2A, CSA Digital Input connector

Pos.	Name	Function	
J2A.1	I1	Digital Input # 1	Drive Enable
J2A.2	I2	Digital Input # 2	User Configurable
J2A.3	I3	Digital Input # 3	User Configurable
J2A.4	I4	Digital Input # 4	User Configurable
J2A.5	I5	Digital Input # 5	User Configurable
J2A.6	I6	Digital Input # 6	User Configurable
J2A.7	I7	Digital Input # 7	User Configurable
J2A.8	I8	Digital Input # 8	User Configurable
J2A.9	RET	Digital Input Ground	

Connector and Mating Part Information
- Fixed connector: 9 pins, male connector
- Mating connector, 9 pins spring cage, Female, supplied with the drive.
- Phoenix Contact (Part # FK-MC 0.5/9-ST-2.5)

Wire Gauge Information
- Wiring: cable. 28-20AWG (0.14-0.5mm^2)
- Wire stripping: 8 mm

Where the CSA is factory configured for use with a digital incremental encoder with support for commutation tracks [G362-XXX-XX (5) X-XXXX or G362-XXX-XX (6) X-XXXX], only four optically isolated digital inputs are available to the user, (digital input 1-4)

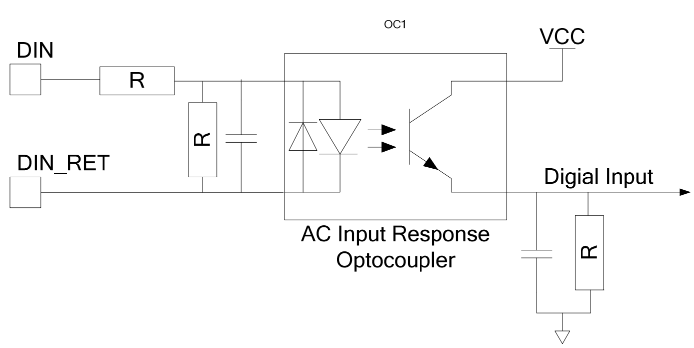


Figure 3-46 General Purpose Digital Input

- All digital inputs are bipolar with an input impedance of ~2.6KΩ, with a voltage Range of 12V to 32V from Digital-Input to the RET line.
- Input voltages whose magnitude is less than 12V with respect to the RET line will not be guaranteed to be recognized as an active signal input.
- Input voltages whose magnitude is more than 5V with respect to the RET line will not be guaranteed to be recognized as an inactive signal input
- All digital inputs are optically isolated for noise immunity purposes. All CSA digital inputs are isolated from high voltage circuitry internally
- Current flowing in the digital input implies the 'safer' of the corresponding active/inactive functions. For example, when current flows in the clockwise limit switch input, then the limit is **NOT** active.

3.11.2 General Purpose Description of the Digital Outputs

The CSA provides 4 digital outputs on connector J2B & J2C. Only the digital outputs on J2B are detailed here.

Table 3-27 J2B, CSA Digital Output Connector

Pos.	Name	Function	
J2B.1	Ext 24V DC	+24V Digital Output Supply	
J2B.2	O1	Digital Output #1	User Configurable
J2B.3	O2	Digital Output #2	User Configurable
J2B.4	O3	Digital Output #3	User Configurable
J2B.5	Ext 24V Ret	Digital Output Return	

Connector and Mating Part Information

- Fixed connector: 5 pins, male connector
- Mating connector, 5 pins spring cage, Female, supplied with the drive.
- Phoenix Contact (Part # FK-MC 0.5/5-ST-2.5)

Wire Gauge Information

- Wiring: cable. 28-20AWG (0.14-0.5mm^2)
- Wire stripping: 8 mm

- Voltage Range is 6Vdc to 32Vdc from Digital-Output to the EXT_24V_RET line.
- Digital outputs switch only DC voltages and are intended for operation as low side drivers. A load must be attached to the digital output for a transition to be detected at the digital output pin on connector J2B. The load must be connected between the V+ supply and the digital output with a maximum current sink capability of 250mA.
- Digital outputs offer an output current ≤ 250 mA with an off-state leakage current ≤ 5 μA at 0 V.
- The digital outputs offer short circuit, reverse polarity and thermal protection and capable of driving inductive loads.
- Digital outputs are protected for supply voltage range of +36Vdc.
- All digital outputs are optically isolated for noise immunity purposes.
- Current flowing in the digital output implies the function is active.

A voltage >12Vdc must be connected between J2D:5\EXT_24V_DC and EXT_24V_RET for the digital outputs to operate refer to *Table 3-44 CSA Digital Input Connections*

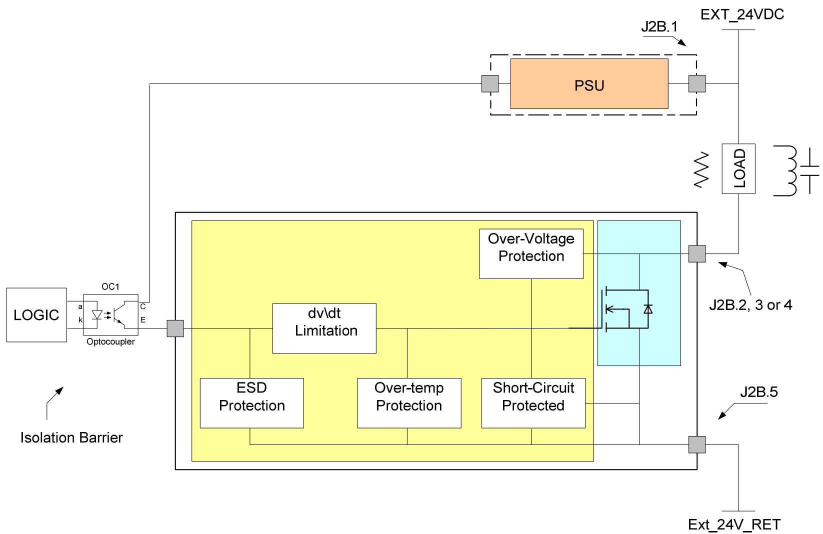


Figure 3-47 General Purpose Digital Outputs

3.11.2.1 Drive Ready Relay

The standard CSA provides one-bipolar mechanical relay output on connector J2C. This relay closes when the drive is in a 'Ready to Enable' state, no faults are present and a '0' is on the 7-segment display.

The CSA may be factory configured with a solid state relay option [C96255-X-X3X-X-XXX or C96255-X-X4X-X-XXX\], in replace of the mechanical option available on the standard CSA, for use in ignition sensitive environments.

The following electrical description applies to both the mechanical and solid-state Drive Ready Relay option

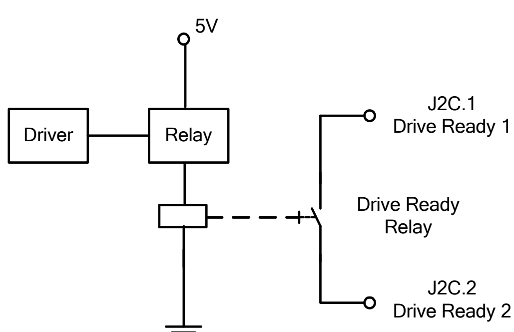


Figure 3-48 Drive Ready Relay Output

Table 3-28 J2B, CSA Digital Output Connector

Pos.	Name	Function	
J2C.1	Drive Ready 1	Drive ready contact pin 1	Drive Ready Relay Contact
J2C.2	Drive Ready 2	Drive ready relay contact pin 1	Drive Ready Relay Contact

Connector and Mating Part Information

- Fixed connector: 2 pins, male connector
- Mating connector, 2 pins spring cage, Female, supplied with the drive.
- Phoenix Contact (Part # FK-MC 0.5/2-ST-2.5)

Wire Gauge Information

- Wiring: cable. 28-20AWG (0.14-0.5mm^2)
- Wire stripping: 8 mm

- **Closed** when drive ready and no faults.
- **Max**. voltage 36 V
- **Max**. contact current 100 mA
-

These operational limits apply to both the mechanical and solid-state option

3.11.2.2 Power Sequencing on Startup

The timing of the digital input ‘Hardware Enable’ and applied power must be considered carefully for proper power-on sequencing.

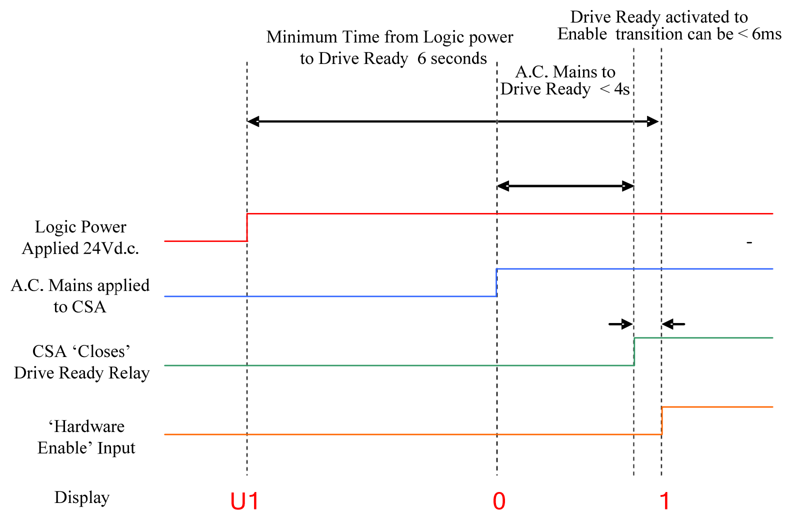


Figure 3-49 Power Sequencing control using Drive Ready Relay and Enable

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WARNING - It is **UNSAFE** to use the ‘Drive Ready’ output as a direct control for the ’Hardware Enable’. The Drive Ready output will switch off when a fault occurs, and will switch on when the fault is cleared. This may result in an inadvertent enable of high power to the CSA high power amplifier, resulting in unexpected high voltage application or motion.

The System Motion Controller should examine the state of the Drive Ready relay output separately, and then enable the CSA high power amplifier if appropriate to do so.

3.12 Communications Interface Wiring and Configuration

The CSA provides one serial interface (RS232) for communication between the drive and the Windrive graphical user interface (GUI).

3.12.1 RS232 Serial Communications Interface

The pin assignment requires use of a 9-pin Sub-D **NULL** modem type cable.

Figure 3-50 RS232 Connector Locations and Pinout

Table 3-29 J1, CSA RS232 Serial Interface Connector

Pos.	CSA Signal	Function	PC Pos.	PC Signal
J1.1	-	connected to pin 4	1	DCD input
J1.2	TxD	Receive Data	3	RxD Input
J1.3	RxD	Transmit Data	2	TxD Output
J1.4	-	Connected to pin 1 and 6	4	DTR output
J1.5	Gnd	Gnd	5	Gnd
J1.6	-	connected to pin 4	6	DSR input
J1.7	-	connected to pin 8	7	RTS output
J1.8	-	connected to pin 7	8	CTS input
J1.9	-	unused	9	RI input

Connector and Mating Part Information

- Fixed connector: 9 pin, Female Sub-D connector
- Mating connector, 9 pin male Sub-D

Wire Gauge Information

- Wiring: cable. 28-18AWG (0.14-0.82mm^2)

* The RS232 Cable shield should be connected to the metal body of the D-Type connector.

3.13 Wiring Summary

3.13.1 µA (G362-(003) or (006)-XXXX-XXXX)

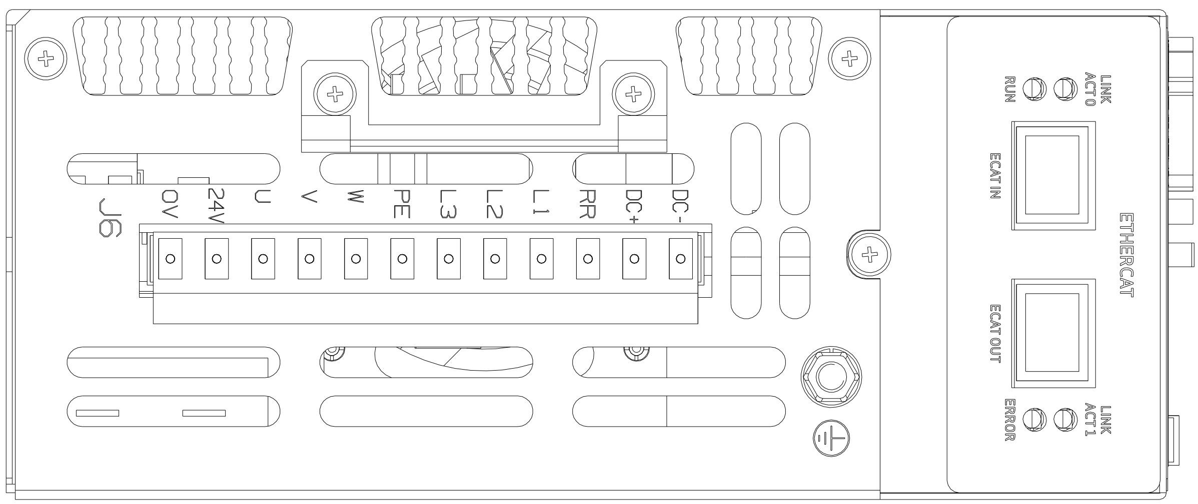

Figure 3-51 µA size Power Stage Connections

Table 3-30 µA size Power Stage Wiring

Pos.	Name	Function
J6.1	DC-	DC Bus (-)
J6.2	DC+	DC Bus (+)
J6.3	RR	Regeneration Resistance
J6.4	L1	Phase "L1", three-phase voltage input 230/460Vac ±10%
J6.5	L2	Phase "L2", ", three-phase voltage input 230/460Vac ±10%
J6.6	L3	Phase "L3", ", three-phase voltage input 230/460Vac ±10%
J6.7	PE	Motor Protective Earth
J6.8	W	Motor Phase W
J6.9	V	Motor Phase V
J6.10	U	Motor Phase U
J6.11	24V	+24V Logic Backup Supply
J6.12	0V	Logic Supply Return

Pos.	Name	Function
PE	PE	Protective Earth Stud on Chassis

Connector and Mating Part Information

- Fixed connector: 12 pins, male connector
- Mating connector, 12 pins, Female, supplied with the drive.
- Phoenix CombiCon (Part # GMSTB 2.5/12-ST-7.62)

Wire Gauge Information

- µA size wiring: cable 14 AWG (2.1 mm^2).
- Wire stripping: 7 mm.
- PE Stud wiring: cable 6 AWG (13mm^2)

Torque Information

- Tightening torque: 0.5Nm

3.13.2 Size A & B (G362-X (08) or (014)-XXXX-XXXX)

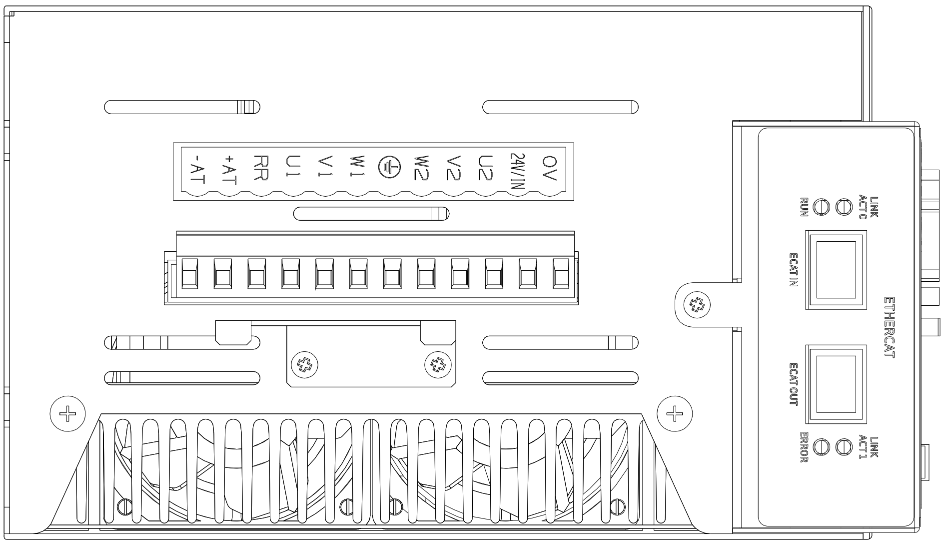

Figure 3-52 A & B size Power Stage Connections

Table 3-31 A & B size Power Stage Wiring

Pos.	Name	Function
J6.1	-AT	DC Bus (-)
J6.2	+AT	DC Bus (+)
J6.3	RR	Regeneration Resistance
J6.4	U1	Phase "L1", three-phase voltage input 230/460Vac ±10%
J6.5	V1	Phase "L2", ", three-phase voltage input 230/460Vac ±10%
J6.6	W1	Phase "L3", ", three-phase voltage input 230/460Vac ±10%
J6.7	PE	Motor Protective Earth
J6.8	W2	Motor Phase W
J6.9	V2	Motor Phase V
J6.10	U2	Motor Phase U
J6.11	24V	+24V Logic Backup Supply
J6.12	0V	Logic Supply Return

Connector and Mating Part Information

- Fixed connector: 12 pins, male connector
- Mating connector, 12 pins, Female, supplied with the drive.
- Phoenix Contact (Part # 1767106)

Wire Gauge Information

- A size wiring: cable 14AWG (2.1 mm^2). Wire stripping: 7 mm
- B size wiring: cable 12AWG (3.3 mm^2). Wire stripping: 7 mm

Torque Information
- Tightening torque: 0.5Nm

Table 3-32 +24Vdc Wiring

Pos.	Name	Function
J8.1	24V	+24V Logic Backup Supply
J8.2	0V	Logic Supply Return

Connector and Mating Part Information
- Fixed connector: 2 pins, male connector
- Mating connector, 2 pins, Female, supplied with the drive.
- Wago (Part # 231-102/026-000)

Wire Gauge Information
- Wiring: cable 14 AWG (2.1 mm^2).
- Stripping Length 8mm

Table 3-33 PE Stud Wiring

Pos.	Name	Function
PE	PE	Protective Earth Stud on Chassis

Wire Gauge Information
- PE Stud wiring: cable 6 AWG (13mm^2)

3.13.3 Size C (G362-(020), (025) or (030) -XXXX-XXXX)

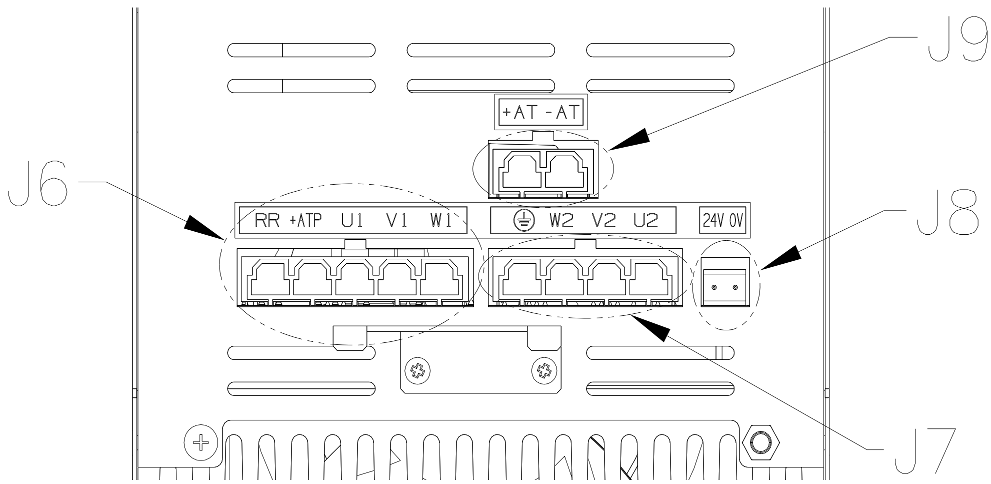

Figure 3-53 C size Power Stage Connections

Table 3-34 C size Power Stage Mains and Regen Wiring

Pos.	Name	Function
J6.1	W1	Phase "L3", ", three-phase voltage input 230/460Vac ±10%
J6.2	V1	Phase "L2", ", three-phase voltage input 230/460Vac ±10%
J6.3	U1	Phase "L1", three-phase voltage input 230/460Vac ±10%
J6.4	+ATP	DC Bus (+) (Regeneration Resistor connection)
J6.5	RR	Regeneration Resistor

Connector and Mating Part Information

- Fixed connector: 5 pins, male connector
- Mating connector, 5 pins, and Female, crimped supplied with the drive.
- (Molex 42816-0512)

Wire Gauge Information

- C size wiring: cable 8 AWG (8.4 mm^2).

Table 3-35 C size Power Stage Motor Wiring

Pos.	Name	Function
J7.1	U2	Motor Phase U
J7.2	V2	Motor Phase V
J7.3	W2	Motor Phase W
J7.4	PE	Motor Protective Earth

Connector and Mating Part Information

- Fixed connector: 4 pins, male connector
- Mating connector, 4 pins, Female, crimped supplied with the drive.
- (Molex 42816-0412)

Wire Gauge Information

- C size wiring: cable 8 AWG (8.4 mm^2).

Table 3-36 Size C +24Vdc Wiring

Pos.	Name	Function
J8.1	24V	+24V Logic Backup Supply
J8.2	0V	Logic Supply Return

Connector and Mating Part Information

- Fixed connector: 2 pins, male connector
- Mating connector, 2 pins, Female, supplied with the drive.
- Wago (Part # 231-102/026-000)

Wire Gauge Information

- C & D size wiring: cable 14 AWG (2.1 mm^2).
- Stripping Length 8mm

Table 3-37 Size C DC Bus Wiring

Pos.	Name	Function
J9.2	+AT	DC Bus (+)
J9.1	-AT	DC Bus (-)

Connector and Mating Part Information

- Fixed connector: 2 pins, male connector
- Mating connector, 2 pins, and Female, crimped supplied with the drive.
- (Molex 42816-0212)

Wire Gauge Information

- C size wiring: cable 8 AWG (8.4 mm^2).

Table 3-38 Size C PE Stud Wiring

Pos.	Name	Function
PE	PE	Protective Earth Stud on Chassis

Wire Gauge Information

- PE Stud wiring: cable 6 AWG (13mm^2)

3.13.4 Size D (G362-(050) or (060)-XXXX-XXXX)

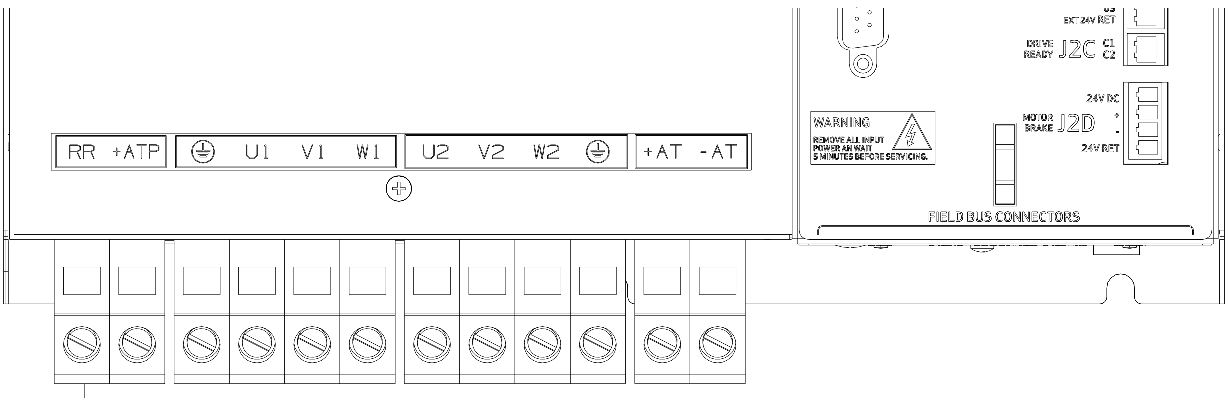

Figure 3-54 D size Power Stage Connections

Table 3-39 Size D Wiring

Pos.	Name	Function
J9.1	RR	Regeneration Resistance
J9.2	+ATP	DC Bus (+)
J9.3	PE	Protective Earth Screw Terminal
J9.4	U1	Phase "L1", three-phase voltage input 230/460Vac ±10%
J9.5	V1	Phase "L2", ", three-phase voltage input 230/460Vac ±10%
J9.6	W1	Phase "L3", ", three-phase voltage input 230/460Vac ±10%
J9.7	U2	Motor Phase U
J9.8	V2	Motor Phase V
J9.9	W2	Motor Phase W
J9.10	PE	Motor Protective Earth
J9.11	+AT	DC Bus (+)
J9.12	-AT	DC Bus (-)

Connector and Mating Part Information

- Fixed connector: 12 pole, screw terminal

Wire Gauge Information

- D size wiring: cable 6 AWG (13 mm^2) for 50/140
- D size wiring: cable 4 AWG (21mm^2) for 60/180
- PE Terminal wiring: cable 6 AWG (13 mm^2) for 50/140
- PE Terminal wiring: cable 4 AWG (21 mm^2) for 60/180
- Stripping Length 16mm

Torque Information

- Tightening torque: 2 to 2.3Nm

Table 3-40 Size D +24Vdc Wiring

Pos.	Name	Function
J8.1	24V	+24V Logic Backup Supply
J8.2	0V	Logic Supply Return

Connector and Mating Part Information

- Fixed connector: 2 pins, male connector
- Mating connector, 2 pins, Female, supplied with the drive.
- Wago (Part # 231-102/026-000)

Wire Gauge Information

- D size wiring: cable 14 AWG (2.1 mm^2).
- Stripping Length 8mm

3.13.5 Size E & F (G362-(100) or (140) -XXXX-XXXX)

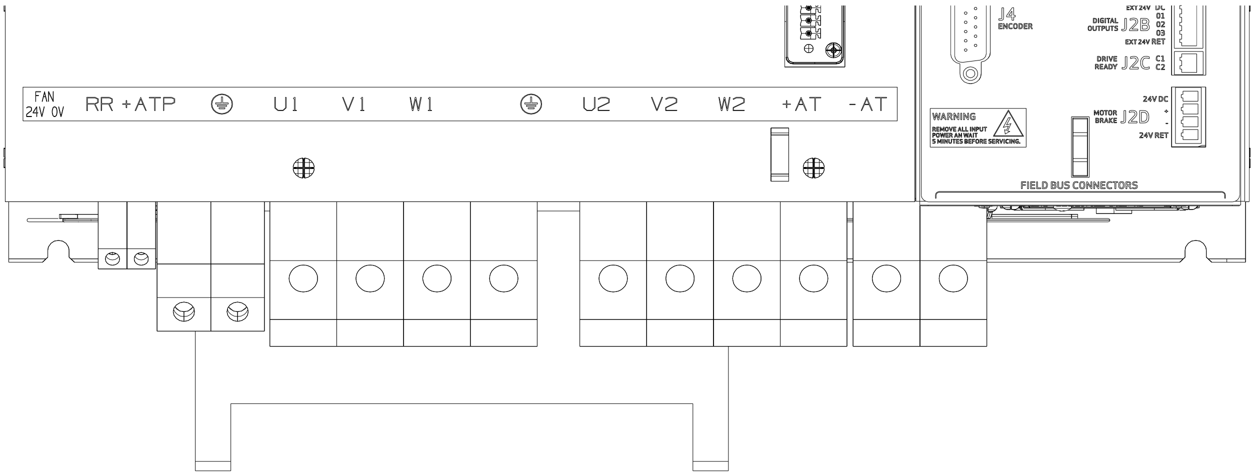

Figure 3-55 E & F size Power Stage Connections

Table 3-41 Size E & F Wiring

Pos.	Name	Function
J9.1	24V fans	Voltage inputs 24Vdc fans ±10%, 2A
J9.2	0V fans	
J9.3	RR	Regeneration Resistance
J9.4	+ATP	DC Bus (+)
J9.5	PE	Protective Earth Screw Terminal
J9.6	U1	Phase "L1", three-phase voltage input 230/460Vac ±10%
J9.7	V1	Phase "L2", ", three-phase voltage input 230/460Vac ±10%
J9.8	W1	Phase "L3", ", three-phase voltage input 230/460Vac ±10%
J9.9	PE	Motor Protective Earth
J9.10	U2	Motor Phase U
J9.11	V2	Motor Phase V
J9.12	W2	Motor Phase W
J9.13	+AT	DC Bus (+)
J9.14	-AT	DC Bus (-)

Connector and Mating Part Information

- Fixed connector: 14 pole, screw terminal

Wire Gauge Information

- Pos. 1,2: Cable 14 AWG (2.1 mm^2) , Stripping 9mm , Torque 0.7Nm
- Pos. 3,4: Cable 2 AWG (34 mm^2) , Stripping 19mm , Torque 4Nm
- Pos. 5-14: Cable 1 AWG (42 mm^2) , Stripping 24mm , Torque 8Nm

Table 3-42 Size E & F +24Vdc Wiring

Pos.	Name	Function
J8.1	24V	+24V Logic Backup Supply
J8.2	0V	Logic Supply Return

Connector and Mating Part Information

- Fixed connector: 2 pins, male connector
- Mating connector, 2 pins, Female, supplied with the drive. Wago
- (Part # 231-102/026-000)

Wire Gauge Information

- E & F size wiring: cable 14 AWG (2.1 mm^2).
- Stripping Length 8mm

3.13.6 CSA Control Card Interface (C96255-X-XXX-X-XXX)

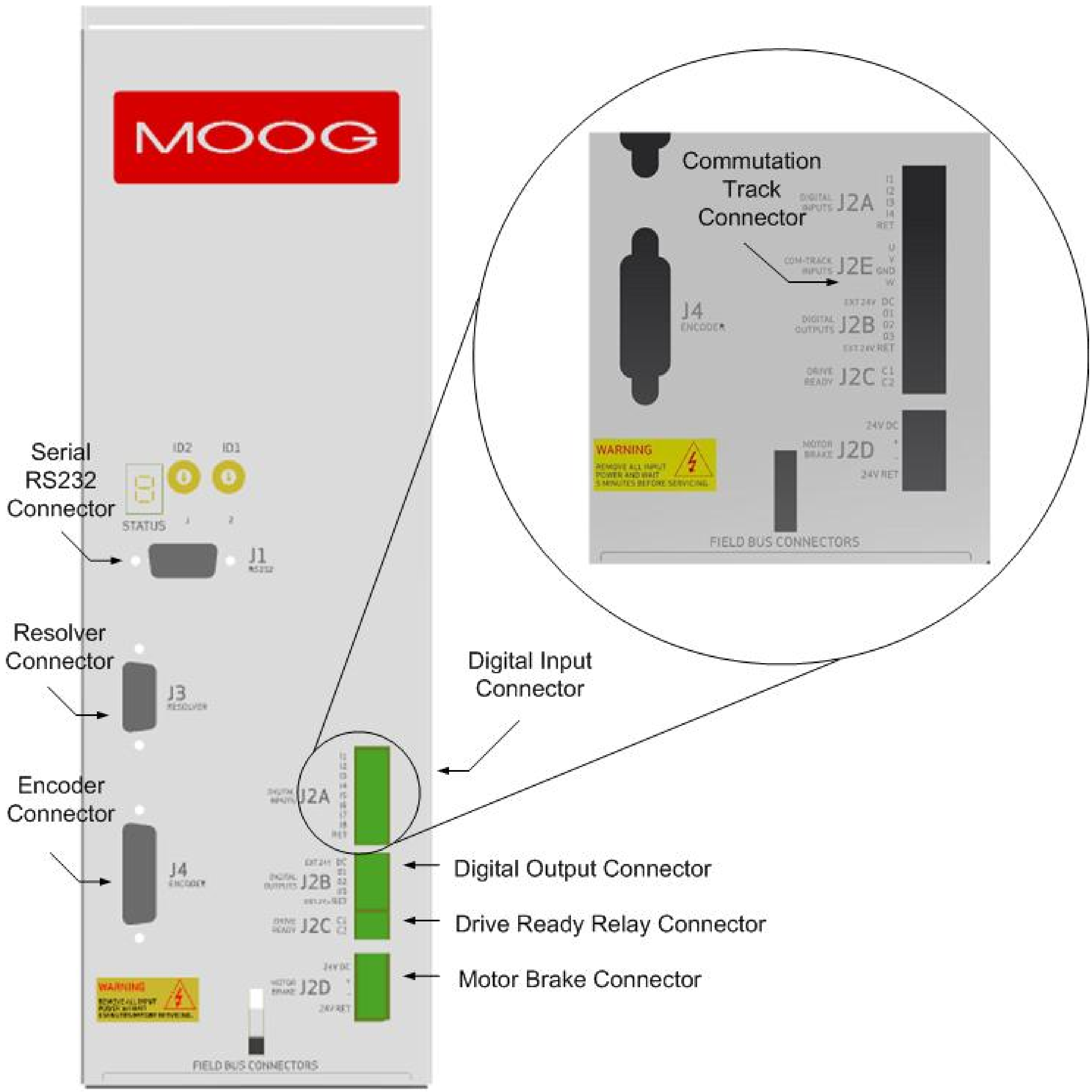

Figure 3-56 CSA Drive Control Card, Standard and Commutation Track Support

3.13.6.1 CSA RS232 Interface

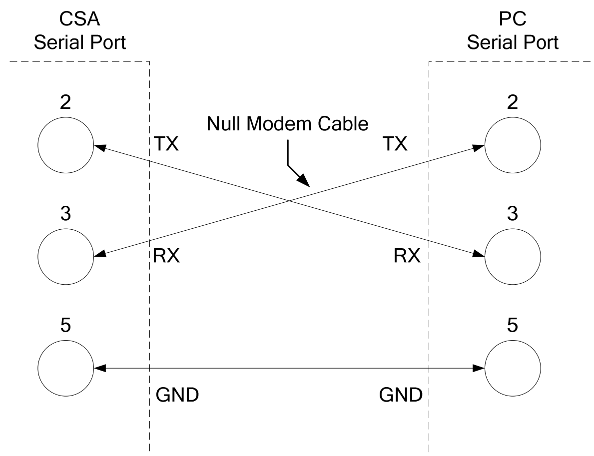

Figure 3-57 CSA RS232 Connections

Table 3-43 CSA RS232 Connections

CSA Connector Pos.	CSA Connector Signal Name	PC Connector Signal Name	PC Connector Signal Function
J1.1	-	DCD Input	Connected to J1:4
J1.2	TxD	TxD Input	Connected to J1:3
J1.3	RxD	RxD Output	Connected to J1:2
J1.4	-	DTR Output	Connected to J1:1 & J1:6
J1.5	Gnd	Gnd	Gnd
J1.6	-	DSR Input	Connected to J1:4
J1.7	-	RTS Output	Connected to J1:8
J1.8	-	CTS Input	Connected to J1:7
J1.9	-	RI Input	Unused

Connector and Mating Part Information

- Fixed connector: 9 pin, Female Sub-D connector
- Mating connector, 9 pin male Sub-D

Wire Gauge Information

- Wiring: cable. 28-18AWG (0.14-0.82mm^2)

The CSA must be connected to the PC RS232 COM port using a null Modem cable

3.13.6.2 Digital Inputs Interface

Table 3-44 CSA Digital Input Connections

Pos.	Name	Standard CSA	Function	C96255-X-X (5)X-X-XXX / C96255-X-X (5)X-X-XXX
J2A.1	I1	Digital Input # 1	Drive Enable	Digital Input # 1
J2A.2	I2	Digital Input # 2	User Configurable	Digital Input # 2
J2A.3	I3	Digital Input # 3	User Configurable	Digital Input # 3
J2A.4	I4	Digital Input # 4	User Configurable	Digital Input # 4
J2A.5	I5	Digital Input # 5	User Configurable	Digital Input Ground
J2A.6	I6	Digital Input # 6	User Configurable	Not Available
J2A.7	I7	Digital Input # 7	User Configurable	Not Available
J2A.8	I8	Digital Input # 8	User Configurable	Not Available
J2A.9	RET	Digital Input Ground		Not Available

Connector and Mating Part Information Standard CSA
- Fixed connector: 9 pins, male connector
- Mating connector, 9 pins spring cage, Female, supplied with the drive.
- Phoenix Contact (Part # FK-MC 0.5/9-ST-2.5)

Connector and Mating Part Information Commutation Track Support CSA
- Fixed connector: 5 pins, male connector
- Mating connector, 5 pins spring cage, Female, supplied with the drive.
- Phoenix Contact (Part # FK-MC 0.5/5-ST-2.5)

Wire Gauge Information
- Wiring: cable. 28-20AWG (0.14-0.5mm^2)
- Wire stripping: 8 mm

3.13.6.3 Digital Outputs Interface

Table 3-45 CSA Digital Output Connections

Pos.	Name	Function	
J2B.1	Ext 24V DC	+24V Digital Output Supply	
J2B.2	O1	Digital Output #1	User Configurable
J2B.3	O2	Digital Output #2	User Configurable
J2B.4	O3	Digital Output #3	User Configurable
J2B.5	Ext 24V Ret	Digital Output Return	

Connector and Mating Part Information
- Fixed connector: 5 pins, male connector
- Mating connector, 5 pins spring cage, Female, supplied with the drive.
- Phoenix Contact (Part # FK-MC 0.5/5-ST-2.5)

Wire Gauge Information
- Wiring: cable. 28-20AWG (0.14-0.5mm^2)
- Wire stripping: 8 mm

3.13.6.4 Drive Ready

Table 3-46 CSA Drive Ready Connections

Pos.	Name	Function	
J2C.1	Drive Ready 1	Drive ready relay contact pin 1	Drive Ready Relay Contact
J2C.2	Drive Ready 2	Drive ready relay contact pin 2	Drive Ready Relay Contact

Connector and Mating Part Information

- Fixed connector: 2 pins, male connector
- Mating connector, 2 pins spring cage, Female, supplied with the drive.
- Phoenix Contact (Part # FK-MC 0.5/2-ST-2.5)

Wire Gauge Information

- Wiring: cable. 28-20AWG (0.14-0.5mm^2)
- Wire stripping: 8 mm

3.13.6.5 Motor Brake

Table 3-47 CSA Motor Brake Connections

Pos.	Name	Function
J2D.1	24V DC	Brake 24V Supply
J2D.2	+	Brake +
J2D.3	-	Brake -
J2D.4	24V RET	Brake 24V Supply Return

Connector and Mating Part Information

- Fixed connector: 4 pins, male connector
- Mating connector, 4 pins spring cage, Female, supplied with the drive.
- Phoenix Contact (Part # FK-MCP 1.5/4-ST-3.81)

Wire Gauge Information

- Wiring: cable. 28-16AWG (0.14-1.5mm^2)
- Wire stripping: 9 mm

3.13.6.6 Fieldbus

- Refer to the appendix for details on a specific Fieldbus connector

3.13.6.7 Encoder Interface

Table 3-48 CSA Encoder Connections

	Encoder Type					
Pos.	**Analogue**	**SSI**	**Hiperface**	**EnDat2.1**	**EnDat2.2**	**Incremental**
J4.1	Shield	Shield	Shield	Shield	Shield	Shield
J4.2	- Sine	-	- Sine	- Channel B	- Channel B	-
J4.3	- Cosine	-	- Cosine	- Channel A	- Channel A	-
J4.4	0Vdc	0Vdc	0Vdc	0Vdc	0Vdc	0Vdc
J4.5	-	- Clock	-	- Clock	- Clock	- A
J4.6	- Channel Z (Zero)	- Data	RS485 -	- Data	- Data	- B
J4.7	-	-	-	-	-	-
J4.8	NTC/PTC	NTC/PTC	NTC/PTC	NTC/PTC	NTC/PTC	NTC/PTC
J4.9	+ Sine	-	+ Sine	+ Channel B	-	+ Channel Z (Zero)
J4.10	+ Cosine	-	+ Cosine	+ Channel A	-	-
J4.11	+5Vdc to +12Vdc (150 mA max.)	+5Vdc to +12Vdc (150 mA max.)	+5Vdc to +12Vdc (150 mA max.)	+5Vdc to +12Vdc (150 mA max.)	+5Vdc to +12Vdc (150 mA max.)	+5Vdc to +12Vdc (150 mA max.)
J4.12	- Fault	+ Clock	-	+ Clock	+ Clock	+ A
J4.13	+ Channel Z (Zero)	+ Data	RS485 +	+ Data	+ Data	+ B
J4.14	Gnd Supply	Gnd Supply	Gnd Supply	Gnd Supply	Gnd Supply	Gnd Supply
J4.15	NTC/PTC	NTC/PTC	NTC/PTC	NTC/PTC	NTC/PTC	NTC/PTC

Connector and Mating Part Information
- Fixed connector: 15 pin, Female Sub-D connector
- Mating connector, 15 pin male Sub-D

Wire Gauge Information
- Wiring: cable. 28-18AWG (0.14-0.82mm^2)

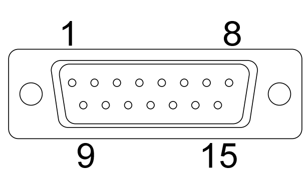

Figure 3-58 CSA Encoder Cable Connections (Harness Connector Front)

3.13.6.8 Commutation Track UVW Interface

Table 3-49 Commutation Track UVW Inputs

Pos.	Name	Standard CSA
J2E.1	U	Commutation Track U+
J2E.2	V	Commutation Track V+
J2E.3	Gnd	Gnd\Common
J2E.4	W	Commutation Track W+

Connector and Mating Part Information

- Fixed connector: 4 pins, male connector
- Mating connector, 4 pins spring cage, Female, supplied with the drive.
- Phoenix Contact (Part # FK-MC 0.5/4-ST-2.5)

Wire Gauge Information

- Wiring: cable. 28-20AWG (0.14-0.5mm^2)
- Wire stripping: 8 mm

3.13.6.9 Resolver Interface

Table 3-50 CSA Resolver Connections

MOTOR RESOLVER CONNECTOR				
Pos.	**Signal Type**	**FAS T/ FAS K**	**FAS N/ FAS Y**	**G4xx /(FASG)**
J3.1	$Cos\varphi$ (S2)	C	1	3
J3.2	$\overline{Cos\varphi}$ (S4)	E	2	4
J3.9	V-Ref (R1)	D	10	7
J3.7	0V (R2)	B	7	8
J3.8	PTC\NTC	N	8	6
J3.6	PTC\NTC	A	9	5
J3.4	$Sin\varphi$ (S1)	G	11	1
J3.5	$\overline{Sin\varphi}$ (S3)	H	12	2
J3.3	Shield	S	3	-

Connector and Mating Part Information

- Fixed connector: 9 pin, Female Sub-D connector
- Mating connector, 9 pin male Sub-D

Wire Gauge Information

- Wiring: cable. 28-18AWG (0.14-0.82mm^2)

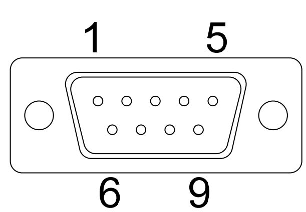

Figure 3-59 CSA Resolver Cable Connections (Harness Connector Front)

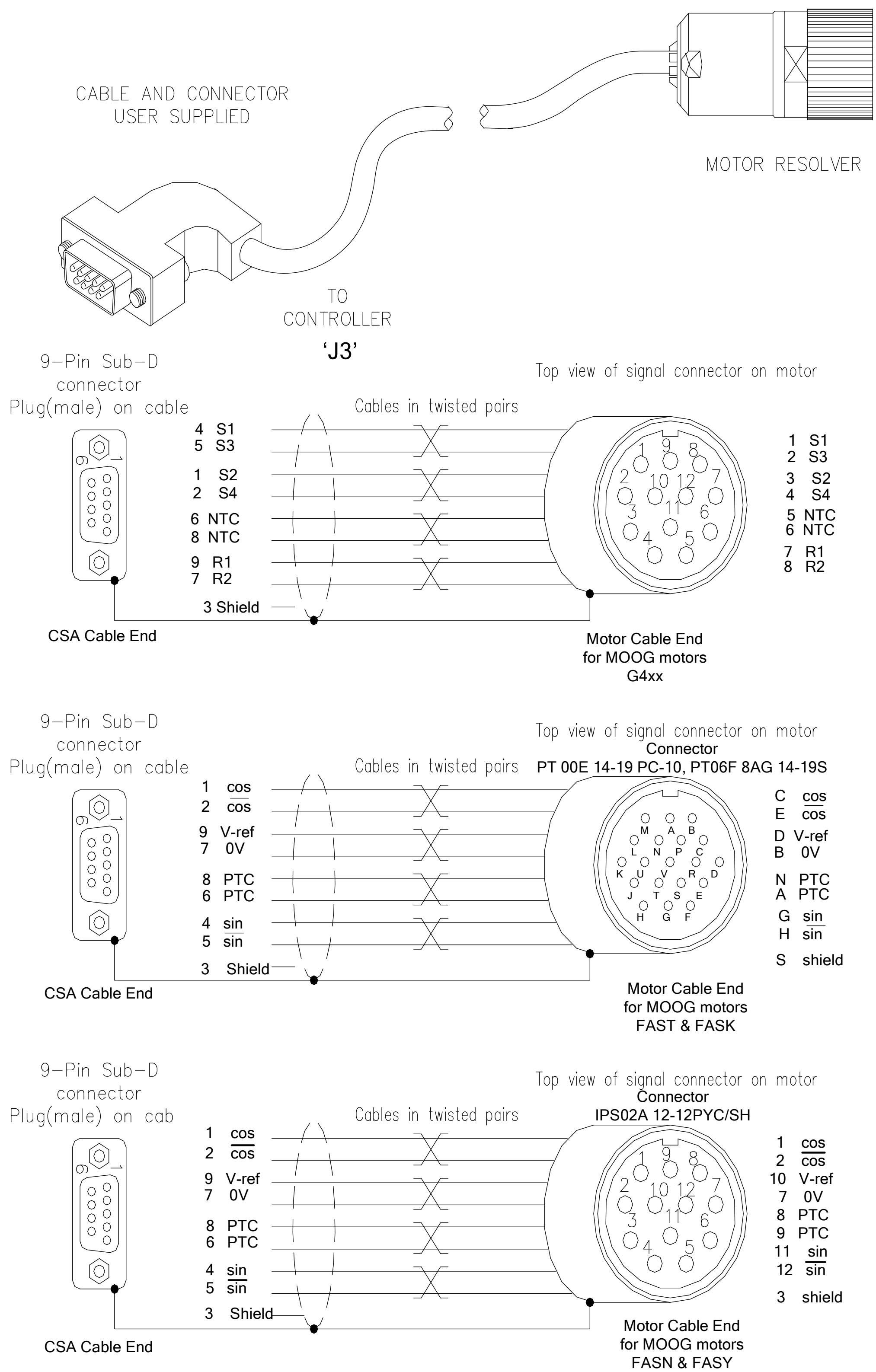

Figure 3-60 CSA Resolver Connections

4.1 Introduction

The getting started guide will provide you with the information needed to get a CSA configured and operational. The guide will show the typical steps required to operate a CSA controller using the Windrive Software.

Before starting this section, the user should become familiar with Sections 1 - Sections 3 of this manual, in particular safety notices and hazard warnings.

After completing this guide, the user will be able to perform basic motor operations using a CSA in both Torque and Velocity Mode.

Note: The example in this chapter demonstrates how to set up and configure a motor with resolver feedback only. To configure a CSA for operation with encoder feedback, please refer to relevant sections of *Chapter 2 Safety and EMC Instructions* and *Chapter 5 Functional Overview*

4.2 Preparation

Install the drive as per *Chapter 3 wiring and Installation* with regards to the safety notices indicated in *Chapter 2 Safety and EMC Instructions*

At a minimum, the items outlined below are required to operate the CSA Servo Drive using the instructions outlined in the sections below.

- A CSA Servo Drive (G362-XXX-XXX).
- A PC Running Windows 98, Windows ME, Windows NT 4.0 (Service Pack 6 or later), Windows 2000, Windows XP or Windows 7 with at least one RS232 serial port
- +24Vdc ±10% supply and/or 230V/400Va.c
- Motor with resolver feedback
- Hardware Drive Enable Input (DIN1), for the purpose of this user guide, a toggle switch is employed.

4.3 Power Supply

The CSA requires a control power source to supply backup-power for the control electronics. This control-backup power is useful where the user requires that the CSA does not lose absolute position data or status information when AC mains power is removed from the CSA.

- Apply a +24Vdc ±10% supply and/or 230V/400Va.c to the relevant connection point for the CSA Servo Drive being operated as indicated in *Chapter 3 wiring and Installation*
- If the CSA is being operated with factory settings employed, the 7-segment display should indicate the following
- ‘F3’, Regen parameters are incorrect or not configured
- ‘F10’, No parameters saved in non-volatile memory
- ‘F11’, Fieldbus not synchronized or not running

- Connect the CSA to an available PC RS232 port using a null modem cable connected to ‘J1’ to the, as instructed in *Chapter 3 wiring and Installation.*

- Connect the CSA using an appropriate resolver cable to connector ‘J3’. Contact your local Moog sales office or authorized distributor for selection of pre-made motor resolver cables.

- If an ‘F8’ is displayed on the 7-segment display, either a ‘Resolver Fault’ is present and the connections should be checked as per *Chapter 3 wiring and Installation* or the *commutation feedback*, parameter 1035, is configured for a Resolver on a motor with an Encoder.

- Connect the CSA using an appropriate motor cable to the relevant connector for the CSA drive in operation as indicated in’ *Chapter 3 wiring and Installation*. Contact your local Moog sales office or authorized distributor for selection of pre-made motor cables.

- To implement the hardware enable switch for a base Host card, connect a toggle (**NOT Momentary**) switch between +24Vdc and J2A:1 (DIN) and 0Vdc and J2A:9 (RET). For the incremental encoder version Host card, connect a toggle (**NOT Momentary**) switch between +24Vdc and J2A:1 (DIN) and 0Vdc and J2A:5 (RET).

At this point the drive is in a state where communication is possible; please proceed to Section 4.4 Installing Windrive below.

For the G362-003 &-006 a 24Vdc logic backup supply is mandatory for the drive to operate. No internal high voltage backup is provided on the smaller µA models.

4.4 Drive Configuration

4.4.1 Configuration User Interfaces

Several User Interface software applications are available for configuring the CSA Servo Drive. The first, Moog WinDrive Software is a low-level application which supports access to the Drive's Parameter Database along with the capability to support firmware upgrades. This software is installed as described in Appendix B, Section B.1, and the Main Window Features are described in Section B.2.

The second User Interface is used with the CSA - MaxForce products and is an Application oriented towards Users. Consult Moog Engineering for the necessary Installation Disk for those products.

For CSA - EtherCAT Flight Simulation systems, the Drive is fully configurable over EtherCAT by the Motion Base Application. Consult Moog Engineering on the details of that User Interface for the particular system.

4.4.1.1 Drive Configuration Using WinDrive

Upon completion of the previous sections the Windrive software should be able to communicate with the CSA controller and the Status bar in the upper right hand corner should be highlighted green and read "*Read Successful (Controller ACK)*" (see Section B.2.4).

If a configuration file is provided, WinDrive can be used to perform a *"Configuration Download"*, the configuration saved, and the Drive restarted and ready to be enabled. If a configuration file is not available, or the drive is not pre-configured, the following startup actions are performed with WinDrive to set User Parameters:

- *"Drive Interface and Loop Configuration"* (Section B.3)
- *"Drive Setup"* (Section B.4)
- *"Motor Setup"* (Section B.5)
- *"Parameter Utilities"*
    - *"Drive Parameter Load/Save*", to save Drive parameters (Section B.3.10.1)
    - *"Encoder Parameter Load/Save*", to save Encoder parameters (Section B.3.10.2)
- *"Status and Faults"* (Section B.3.9)

4.4.1.2 Drive Configuration using the CSA - MaxForce Commissioning GUI

CSA - MaxForce actuators are configured with a Commissioning GUI supplied on a Distribution Disk. After installation of the GUI, the program is run and the User is instructed through the process of configuring the drive.

4.4.1.3 Drive Configuration using the CSA - EtherCAT Motion Systems

The CSA - EtherCAT configuration used in Flight Simulation Motion Systems are configured using CANOpen Over EtherCAT (CoE). Consult Moog Engineering on the details of that User Interface for the particular system.

4.4.2 Regen Resistor Configuration Details

The µA size and select A and B size CSAs are equipped with an internal regeneration resistor. All other A to F size drives will require an external resistor to be attached. The recommended regeneration resistors are detailed in *Section 5.3.5*.

If the CSA is operated for the first time with factory settings or all non-volatile memory has been erased, the CSA will display an 'F3' indicating incorrect or non-configured regen settings

The Regen-on/ Regen-off voltages should be set in accordance with the DC Bus voltage that CSA is intended operating at, *Chapter 5 Functional overview, Table 5.4 Typical Regeneration Turn-on & Turn-off Voltage Levels,* indicates appropriate regen levels for 300dcV and 600Vdc bus voltages. The default DC Bus Voltage is 600Vdc.

These parameters are automatically set when the motor parameters are downloaded to the controller but should be verified to ensure safe operation. Consult End User System documentation for additional information on Regen Resistor sizing.

- Open "*CSA → Drive Setup → Regen Resistor → Regen Parameters"*
  - For a 600Vdc Bus set the "*Regen-On Voltage (V)"* to '760' and "*Regen-Off Voltage (V)"* to '750'
  - For a 300Vdc Bus set the "*Regen-On Voltage (V)"* to '380' and "*Regen-Off Voltage (V)"* to '370'
- Left click the 'Read All' icon and Confirm that values are correct.

Regen on/off voltage are based on 0.95 of the maximum bus voltage of 800Vdc and 400Vdc.

The drive will also display an (F3) if the user inputs data for a regeneration resistor value such that the current, which would flow in the regeneration transistor on turn on, is greater than the Max RR Current level set in the GUI panels "*CSA → Drive Setup → Regen Resistor → Regen Parameters"* (See Section B.3.7.19).

For drives equipped with an internal Regeneration resistor, the parameters associated with that resistor must be set. If the drive has external regeneration capability, all regeneration resistor parameters are set to zero. The drive will display a fault (F3) and will not enable until suitable parameters for regeneration resistors are entered and saved. The resistance and power rating of the regeneration resistor connected to the drive should be entered in either the "*External Regen" or "Internal Regen"* window.

- If a µA size or select A and B size CSA with internal regen is being operated
  - Open "*CSA → Drive Setup → Regen Resistor → Internal Regen*
  - *Set the 'Power' and 'Resistance'* values to the appropriate values for the CSA
- If a µA size or select A and B size CSA is being operated
  - Open "*CSA → Drive Setup → Regen Resistor → External Regen*

- *Set the 'Power' and 'Resistance'* values to the appropriate values for the CSA
- Left click the 'Read All' icon and Confirm that values are correct.

Ensure the regen on/off voltage are set in accordance with the CSA being operated and the voltage levels in use. Failure to configure the regen levels accordingly will cause regeneration faults 'F3' to be presented by the CSA.

The software also checks the value of regeneration resistance entered. If too low a value is entered, such that the current that would flow on turn-on of the regeneration transistor exceeds the ratings of the regeneration, transistor, a regeneration fault (F3) is reported.

4.4.3 Status & Fault Clearing Details

Before high power can be applied all faults must be cleared from the CSA. The prefix "U" on the 7-segment display indicates a warning and an "F" indicates an error on the CSA's. Refer to *Chapter 5 Functional Overview, Section 5.12 Drive Monitoring and Fault Detection* for further information.

After the motor and regeneration parameters have been entered as detailed in the previous sections, all faults should be cleared as follows:

- "*Status and Faults → Clear Faults → Clear Faults*".
  Or
- Using the 'Clear faults' icon on the main toolbar

The CSA should now display a "U1" to indicate "High Power Not Ready". All other errors and warnings should be removed. Should a fault indication remains on the 7-segment display, power-cycle the drive.

If a persistent fault be indicated on the 7-segemnt display, refer to *CSA User's Manual Section 5.12 Drive Monitoring and Fault Detection* for more information on the particular fault. Where applicable, check all connections and parameter settings associated with the particular error.

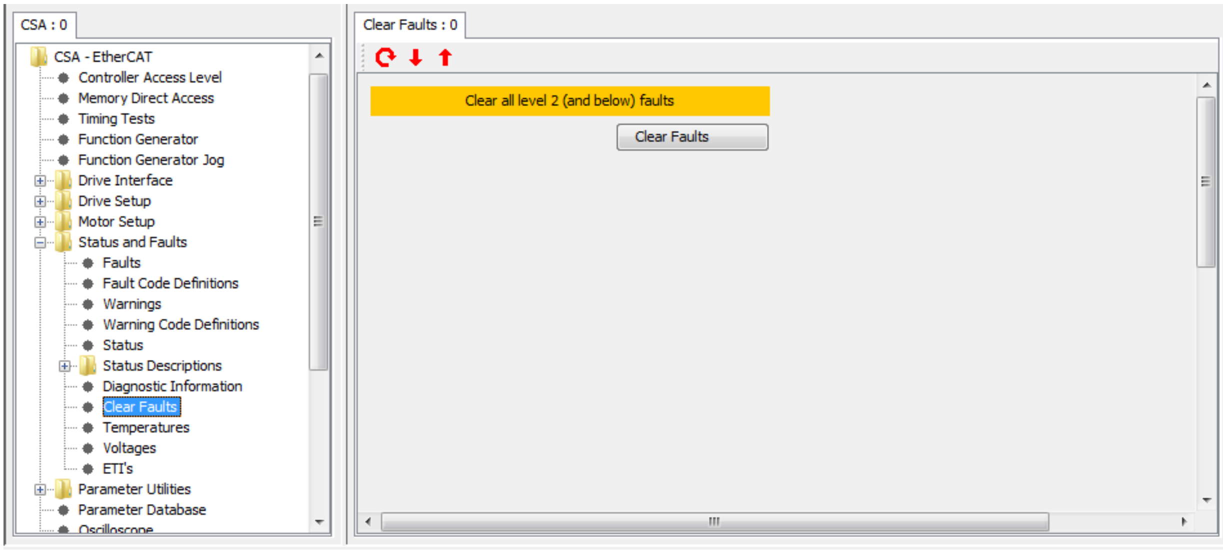

Figure 4-1 Clearing Faults

Failure to remove **ALL** errors before high power is applied will result in the soft start relay remaining open and no DC Bus voltage being applied to the system

4.5 High Power Application

Apply the appropriate 3-phase voltage (230Vac/400Vac) to the CSA controller and allow approximately 1.3 seconds for the Softstart sequence to complete.

If the drive has been set up correctly and all errors removed, the Softstart relay should close to indicate a successful soft start-up, "`buscon.sstfin`" should now indicate a '1'.

"*CSA → Drive Setup → DC Bus Monitoring → Softstart*"

If a size μA, A, B, C or D drive is operation a audible click occurs signifying successful completion of Softstart

The "*Continuous Bus Voltage*" window provides an indication of the "*Detected DC Bus Voltage*", "Over *Voltage Limit*" and "*Under Voltage Limit*"

"*CSA → Drive Setup → DC Bus Monitoring → Continuous Voltage*"

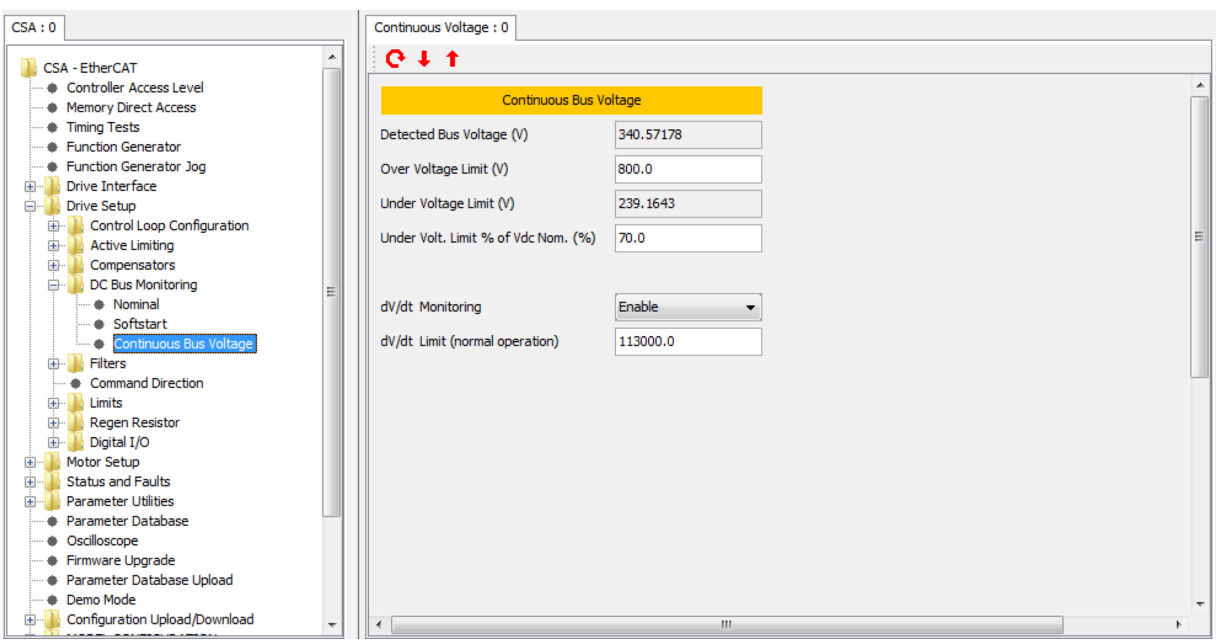

Figure 4-2 DC Bus Voltages

4.6 Autophasing

Once the high power has been applied, the user can then perform an Autophasing operation. For all commutation types, the parameter "`comofs`" contains the mechanical offset angle between the commutation feedback and the motor stator. 16-bit full scale corresponds to one full mechanical revolution.

In certain cases the motor has a resolver or encoder built in that has been adjusted in the factory, this angle can then be obtained from the motor datasheet.

If this information is not available, it is possible to do an automatic adjustment of "`comofs`" using the *Commutation Parameters*" page

- Ensure the hardware drive enable input (DIN1) is set, +24Vdc applied
- Open "*Motor Setup → Commutation Parameters"*
- Left click "*Torque Mode" and then " Start"* in the "*Commutation parameters*" panel
- Left click the Software drive enable button in the toolbar , then save the parameters to NVM once it automatically disables (Section B.3.10.2)

Both the hardware 'Drive Enable' and the Windrive 'Drive Enable' must be enabled in order to enable the drive.

Warning: Ensure that all listed safety precautions are observed when enabling the drive. Ensure that motor is securely mounted on a suitable fixture. Sudden and considerable movement of the motor, with a risk of injury will occur during high speed reversals if the motor is not securely mounted.

4.7 Drive Operation Verification

To verify drive motion and configuration settings, the drive can be enable the drive in torque mode and velocity mode. First, if configured, set the “*Drive Interface->Loop Configuration->Command Reference Source”* to Function Generator

4.7.1 Torque Mode Enable

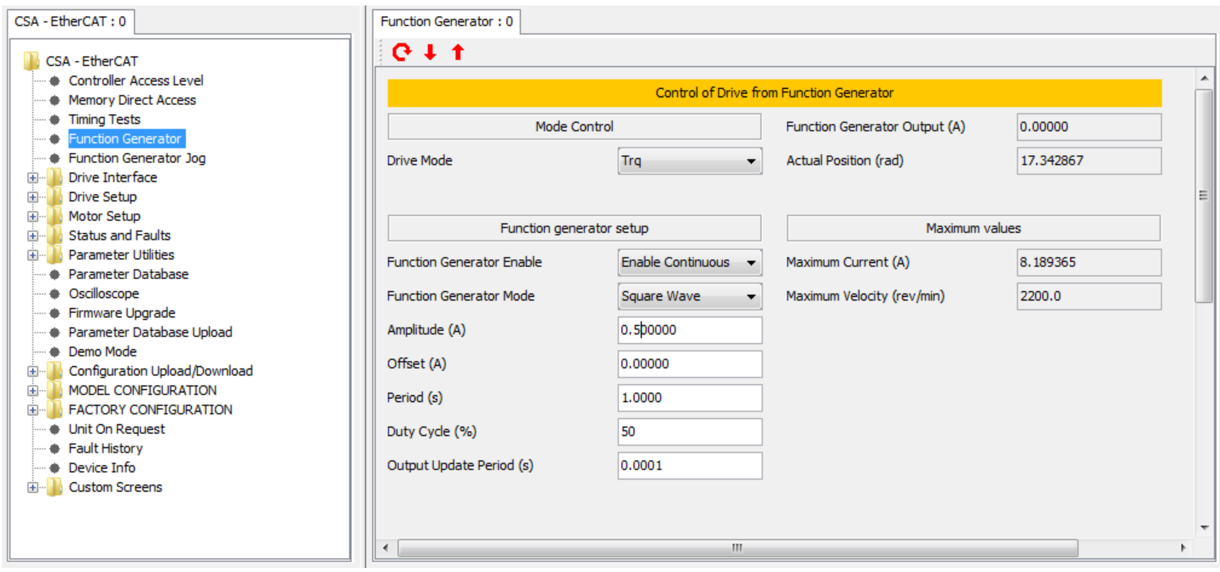

Figure 4-3 Torque Mode Drive Enable

- Open the function generator and set the mode to Torque
  - “CSA → *Function Generator* ”
  - Drive Mode “*Trq*”
  - Left click “*Read All*” to confirm the “*Drive Mode Status*” reads “*Trq*”,
- Give the drive an offset by typing “*0.5*” in the “*Offset*” textbox and click “*Write All*”,
- Left click the software drive enable button Windrive toolbar
- The drive will start to accelerate in a clockwise direction until it reaches maximum velocity.
- Disable the drive using software drive disable button Windrive toolbar

4.7.2 Velocity Mode Enable

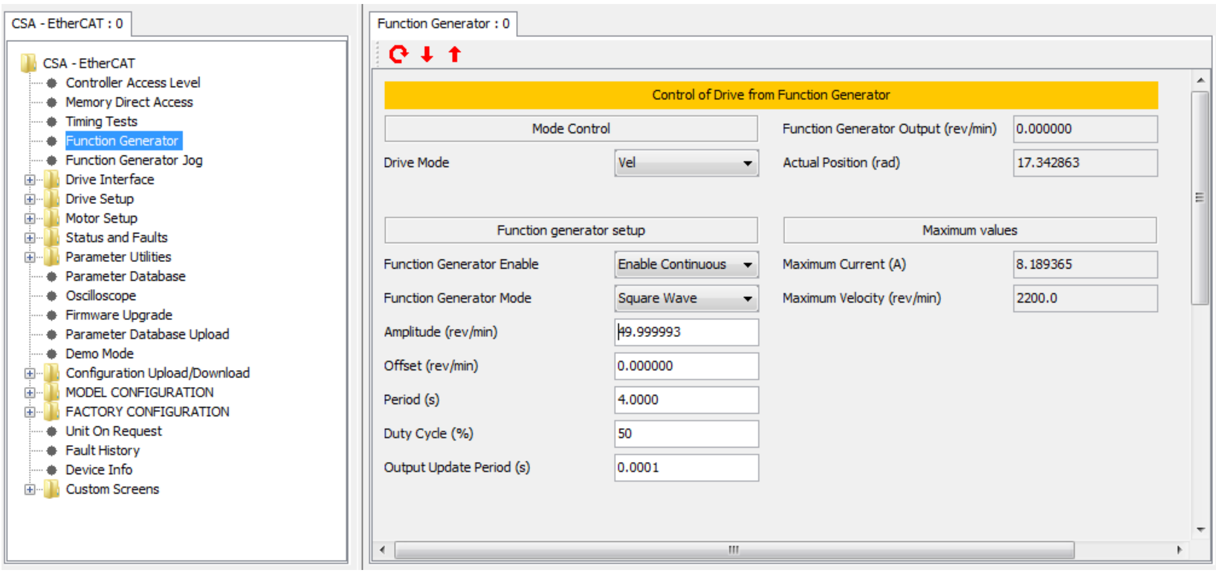

Figure 4-4 Velocity Mode Drive Enable

- Open the function generator and set the mode to Velocity
  - "CSA → *Function Generator* "
  - Drive Mode "*Vel*".
  - Left click "*Read All*" to confirm the "*Drive Mode Status*" reads "*Vel*",
- Give the drive an offset by typing "*50*" (approximately) in the "*Offset*" textbox and by clicking "*Write All*",
- Left click the software drive enable button in the Windrive toolbar
- Check that the drive rotates in a clockwise direction,
- Set the offset back to "*0*" RPM,
- Left click the software drive disable button in the Windrive toolbar
- Set the "*Amplitude*" command to "*100" RPM*, "*Period" "4" s* and left click "*Write all*",
- Left click the software drive enable button in the Windrive toolbar
- Ensure that the motor turns rapidly, changing direction approximately every 2 seconds,
- Left click the software drive disable button in the Windrive toolbar

4.8 Drive Tuning

Drive Tuning is a Controls Engineer task; however, WinDrive provides an Oscilloscope which can be used to very step response and other frequency and stability measurements. The following sections illustrate the use of the Oscilloscope to capture data for the verification of Velocity Loop Performance.

4.8.1 Oscilloscope Set-up

- Open the oscilloscope,
  - *"CSA → Oscilloscope"*
- The Status prompt in the lower right hand corner should be yellow and read "*initializing*"
- Set-up Channels 1-3, Time-based and Trigger as per the table 1 below,

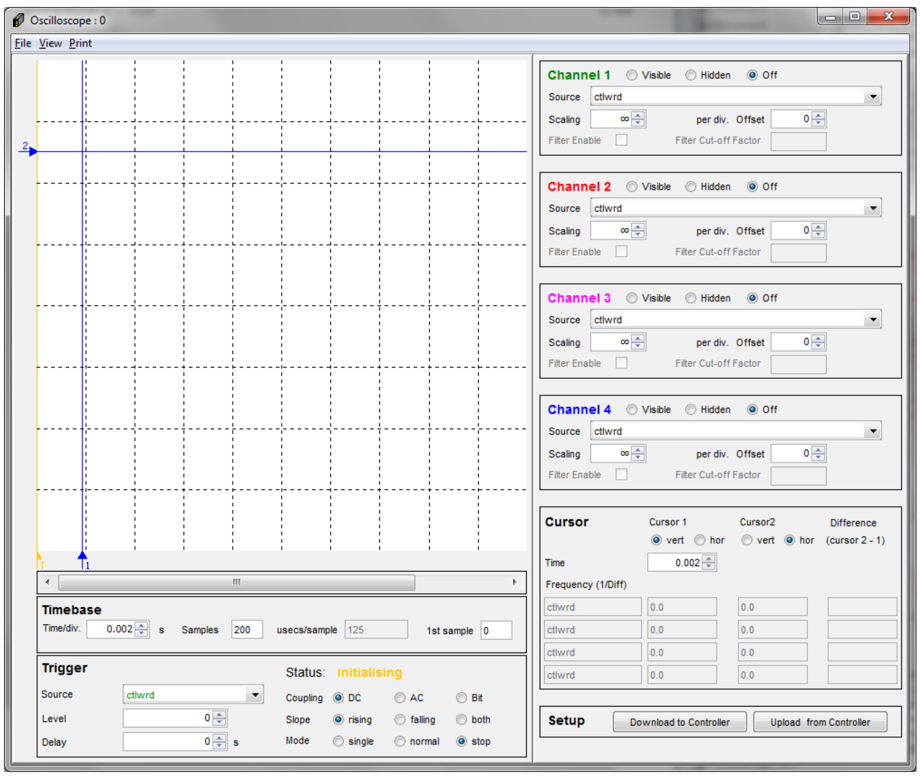

Figure 4-5Windrive Oscilloscope

Table 4-1 Oscilloscope Channel Set-up

	Channel 1	Channel 2	Channel 3	Timebase	Trigger
Status	Visible	Visible	Visible	------------	------------
Source	Demand	Velf	Iqact	------------	Demand
Scaling	200000000 / div	20 / div	5 A / div	0.002 s / div	------------
Delay	------------	------------	------------	------------	Delay - 0.002 s
Coupling	------------	------------	------------	------------	DC
Slope	------------	------------	------------	------------	Rising
Mode	------------	------------	------------	------------	Single

4.8.2 Setting the Velocity Loop Gains

- Open the Velocity Loop Panel,
  - "Drive Setup → Compensators → Velocity Loop Compensators".
- Set the p-gain to an initially low value and the I-gain to '0' and click "*Write*"
  - "*p-gain = 0.01*"
  - "*i-gain = 0*"

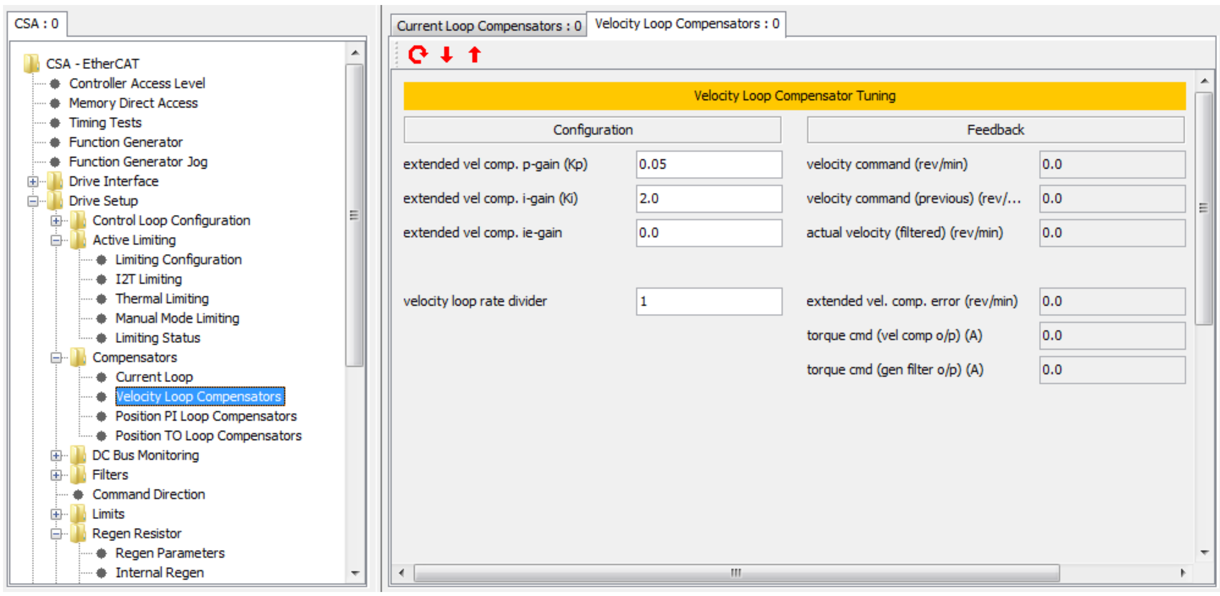

Figure 4-6 Velocity Loop Gains

4.8.3 Step Response With Velocity p-gain = 0.01 & i-gain = 0.0

The following step responses were obtained using a G464-804 Global motor with resolver feedback and under no-load conditions.

- Left click software drive enable button on the on the Windrive toolbar
- The Oscilloscope should trigger and the status prompt should turn red and read "*Stopped*"
- Left click software drive disable button on the on the Windrive toolbar

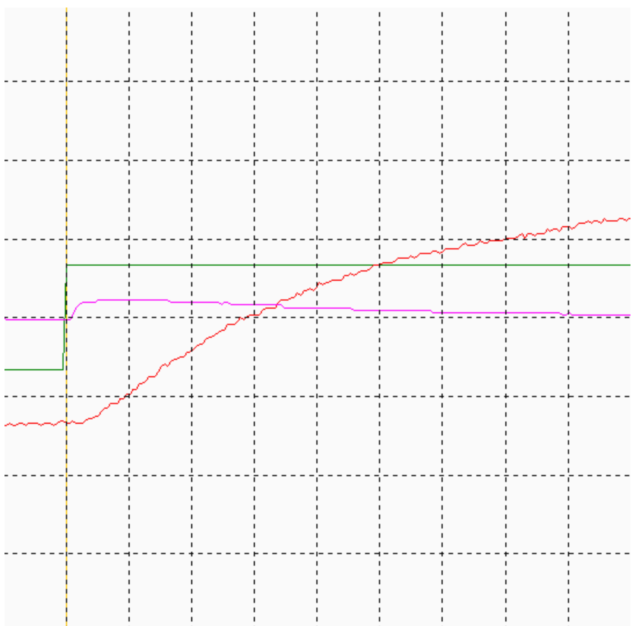

Figure 4-7 CSA Step Response with Initial Velocity Loop Gains

- **Green..............Velocity Demand.....................demand**
- **Red.................Velocity Effective.....................elf**
- **Pink................Actual Current........................iqact**

- Step Response With Velocity p-gain = 0.075 & i-gain = 0.0

▪ Change the Velocity Loop gains “Drive Setup → Compensators → Velocity Loop Compensators” to:

  ▪ “*p-gain = 0.075*”
  ▪ *“i-gain = 0”*

▪ Reset the trigger mode to ‘Normal’, to continuously trigger on an event.

▪ Left click software drive enable button on the Windrive toolbar

▪ The Oscilloscope should trigger and the status prompt should turn red and read “*Stopped”*

▪ Left click software drive disable button on the Windrive toolbar

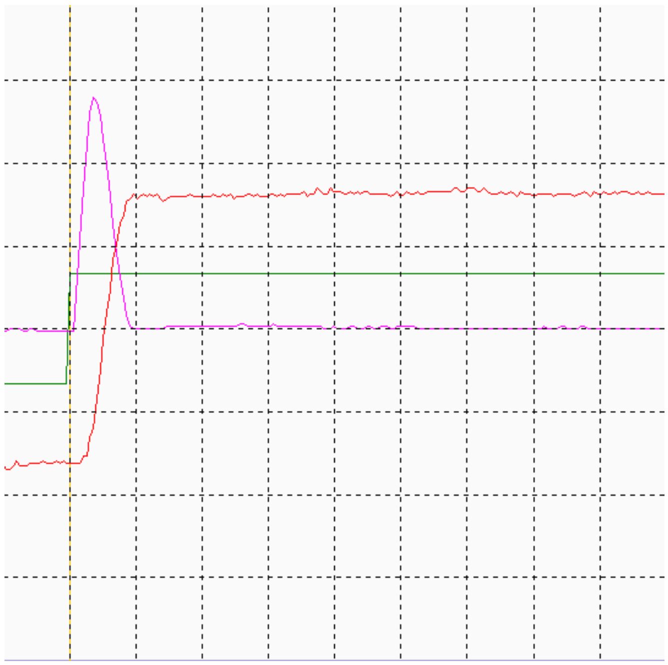

Figure 4-8 CSA Step Response with Increased Velocity Loop Gains

- **Green**..............**Velocity Demand**.....................**demand**
- **Red**.................**Velocity Effective**.....................**elf**
- **Pink**................**Actual Current**........................**iqact**

4.8.4 Step Response With Velocity p-gain = 0.075 & i-gain = 5.0

Change the Velocity Loop gains "Drive Setup → Compensators → Velocity Loop Compensators" to:

- "*p-gain = 0.075*"
- "*i-gain = "5*"

- Reset the trigger mode to Normal
- Left click the software enable button on the Windrive toolbar
- The Oscilloscope should trigger and the status prompt should turn red and read "*Stopped"*
- Left click the software disable button on the Windrive toolbar

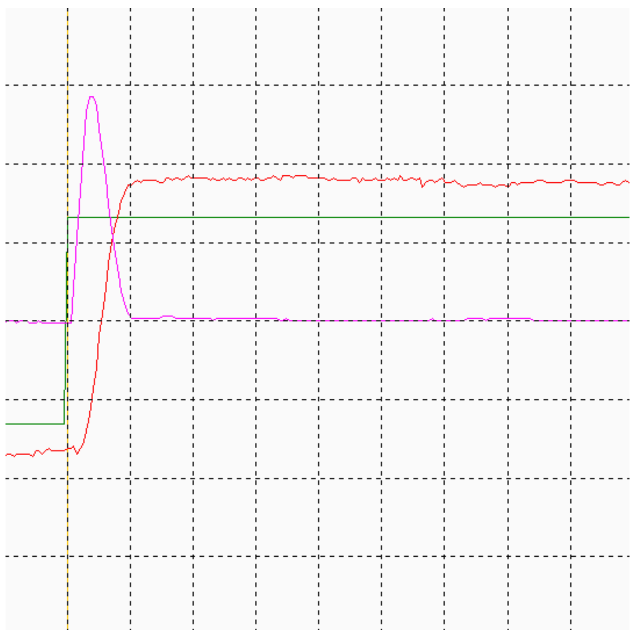

Figure 4-9 CSA Step Response with Maximum Velocity Loop Gains

- **Green..............Velocity Demand.....................demand**
- **Red.................Velocity Effective....................elf**
- **Pink................Actual Current.........................iqact**

4.9 Power-Down Sequence

Ensure the drive is disabled and remove Hi Power (AC mains) from the CSA controller.

Wait until the DC Bus Voltage has decreased to below 50VDC before servicing the controller,

- *"CSA → DC Bus Monitoring → Detected DC Bus Voltage".*

Close the Oscilloscope and the Windrive GUI and remove the 24V DC Logic Back up from the CSA.

The sequence outlined in the preceding sections provides the user with step by step procedure on how to operate a CSA controller using the Windrive software performing basic motoring operations.

For a more in depth analysis of the CSA and Windrive Software please consult the relevant sections of the CSA User's Manual and the GUI User's Manual.

CHAPTER 5 FUNCTIONAL OVERVIEW

5.1 Introduction

This section describes the functionality of the CSA. It details the various modes of operation of the drive. The CSA controller supports communications between drives and to a controller over various fieldbus networks.

Details of particular fieldbus interfaces are given in the appendices of this manual.

5.2 CSA Conventions

This section deals with commonly understood conventions for CSA operation.

5.2.1 Direction of Rotation

The positive direction of rotation is clockwise, when the motor is viewed looking into the shaft end, as outlined below.

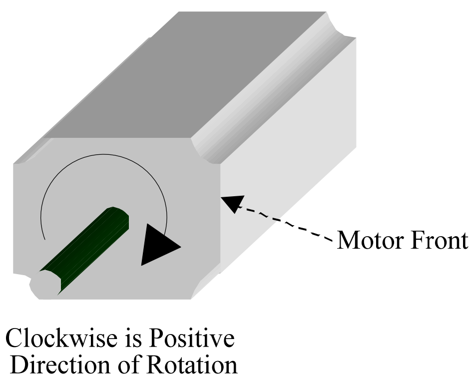

Figure 5.1 Rotational Convention for Mechanical Process Variables

For operation with the encoder, positive rotation as defined here corresponds to Channel A leading Channel B.

The direction convention applies to all torque, velocity and position variables. For example a positive torque command should tend to rotate the motor in a clockwise direction when viewed from the shaft end.

5.3 Power Interface Section

5.3.1 High Power Section Description

The high power supply section has the following features:

- Three Phase AC Operation
- Direct Off-Line 230VACrms to 460VACrms. +10% Operation
- Soft Start Capability (AC Inrush Current Limiting)
- Input MOV Transient Protection
- Internal Regeneration Capability, (µA and A units only)
- Drive Ready Relay
- Provision for External Regeneration Resistor
- Integral Heat Sink and Cooling Fans
- 24V Logic Backup (mandatory on µA size units)

Each of the features above are detailed in the subsequent sections of this manual

WARNING - The high power section contains large capacitors that maintain high voltage on the DC+ to DC- terminals for several minutes after input power is removed, if the regeneration circuit is not operating normally. Wait 5 minutes fter power shutdown for capacitors to discharge. Then use a voltmeter to check for safe voltage from the DC+ terminal to the DC- terminal before contacting terminals or commencing any service or maintenance activities to ensure no lethal voltages are present. Failure to follow this procedure may result in serious personal injury or death.

5.3.1.1 High Power Section Functional Blocks

- High Voltage Rectification and Filtering .... 5.3.2 High Voltage Rectification and Filtering
- Soft-Start of AC Mains Power-On .... 5.3.3 Soft Start
- Low Voltage Control Power Supply .... 5.3.4 Low Voltage Control Power Supply
- Regeneration Circuit .... 5.3.5 Regeneration Control
- Monitoring and Fault Logic Circuits .... 5.12 Drive Monitoring & Fault Detection

5.3.2 High Voltage Rectification and Filtering

The AC mains input is rectified by a three phase diode bridge and filtered by a bank of electrolytic capacitors to generate the internal DC Bus. The high power internal DC supply is unregulated and will vary in direct proportion with the AC mains input voltage magnitude. The dc bus voltage is monitored continuously and is available for user display, parameter *bus_voltage_actual* (Field Number 1232). Once the soft start relay has closed, the nominal DC bus voltage is set in software, parameter *bus_voltage_nominal* (Field Number 1229), which will limit the maximum speed at which a motor can rotate.

The software will generate a fault on both undervoltage (F12) and overvoltage (F2) level being detected. The undervoltage level, parameter *bus_under_voltage_limit* (Field Number 1234) is set, by default, to 70% of the nominal bus voltage. This undervoltage percentage level, parameter *bus_under_voltage_limit_percentage* (Field 1235) can be changed to different levels to suit application requirements..

The overvoltage level parameter *bus_over_voltage_limit* (Field Number 1233) is typically set by the motor configuration and will generally be either 400V or 800V. Bus voltage level is based on equation: AC Mains LL x 1.414 = DC. Bus.

Table 5-1 Magnitude of the DC Bus

AC Mains Type	DC. Bus Voltage Level
230V Three Phase Mains	325VDC.
480V Three Phase Mains	679VDC.

5.3.3 Soft Start

The Soft Start function is used to limit the inrush current to the DC bus capacitor bank on application of AC mains power. This is intended to prevent nuisance tripping of circuit breakers or blowing of line fuses on power-up as a result of inrush current on application of AC mains power.

The soft start relay will close when the monitoring circuit and associated control software determines that the high-voltage DC bus has charged up and the DC bus is at steady state. Softstart will only occur if the DC bus voltage level is above 70V.

5.3.4 Low Voltage Control Power Supply

Control power for the logic circuits is generated by a DC/DC converter, which provides control-circuitry power that is isolated from the mains input. This control voltage also powers the cooling fans on size A-D. Size E and FDrives require separately supplied 24Vdc to power the cooling fans. The DC/DC can generate control power from two sources

1. DC. Bus if it is greater than 120VDC. (Not available on the CSA µA size drives)
2. 24VDC. external supply which is provided by the user specifically for control-backup power

These two sources are diode 'ORed' together to produce the internal 24V logic backup supply.

The state of the internal control electronics logic supplies are available to the user to monitor. If these supplies are out of tolerance the drive will report a fault and react accordingly. The parameters associated with viewing the internal logic supplies are given below.

Table 5-2 Logic Voltage Supply Monitoring Parameters

Parameter Name	**Field Number**	**Description**
supply_+24V	1441	Internal 24V Logic Supply
supply_+3V3	1421	3.3V Logic Supply
supply_-15V	1426	-15V Logic Supply
supply_+15V	1431	+15V Logic Supply
supply_+2.5V_ref	1436	2.5V Reference Level
encoder_supply	1446	Encoder Supply
supply_+5V	1942	+5Vdc Logic Supply
supply_+5VA	1941	5Vdc Analog Logic Supply

If the internal 24V logic supply voltage falls below 20V, the drive will disable and enter a fault status (F9). The drive will automatically perform a power down save which saves certain data to memory such as elapsed time. This save does not however save all parameters to non-volatile memory. Any unsaved parameters will be lost if the internal 24V logic backup is lost.

5.3.5 Regeneration Control

Rapid motor deceleration or an overhauling load creates a situation in which energy is returned back into the DC. Bus. The regeneration energy will charge up the power supply bus capacitors, causing their voltage to increase. To prevent capacitor over voltage, a shunt regulator circuit senses when the bus voltage exceeds the Regeneration cut-in voltage and switches a Regeneration resistor across the DC Bus, (via a Regeneration transistor) to dissipate the Regeneration energy.

The Regeneration resistor is protected by software to limit the power delivered to the internal or external Regeneration resistors. The software will limit the duty cycle of the transistor to protect the component with the lower power ratings.

The Regeneration resistor control software allows the user to enter data for both the internal and external regeneration resistors separately. The software then calculates the appropriate duty cycle for the regeneration transistor. The available and actual regeneration powers are available to the user. If the regeneration power is greater than 90% of the available regeneration power, the drive will display a Regeneration Power Warning (U4) on the 7-segment display to indicate to the user that the drive is close to its maximum regeneration capability.

The Regeneration control can operate in one of five modes:

1. **Regeneration Off**: In this mode, the regeneration transistor is not switched on and therefore the supply must have the capability to absorb the regeneration power so that the bus voltage does not rise above the upper limit.
2. **Duty Cycle controlled**: In this mode, the duty cycle calculated from the regeneration resistor data is used to determine the off times for the regeneration transistor from the on time parameters. The initial on time is used from the first regeneration event until the initial on time has been consumed. After, this the continuous on time is used to determine the regeneration off time. If regeneration is off for sufficient time to allow the initial off time to run out, then the initial on time is used for the next regeneration event.
3. **Duty Cycle Controlled + Power Fault**: In this mode, the regeneration duty cycle is controlled in the same way as above, but a fault is detected if the average power exceeds the maximum power for the regeneration resistor(s). This fault (regen max power exceeded) will cause the drive to disable and transition to a fault mode.
4. **Power Fault Only**: In this mode, the regeneration duty cycle is not controlled. The regeneration transistor is switched on when the bus voltage rises above the regeneration turn-on voltage and is switched off when the bus voltage falls below the turn-off voltage. The regeneration resistor is only protected by the fault detection of the average power exceeding the maximum regeneration power.
5. **Power Warning Only**: In this mode, the regeneration duty cycle is not controlled and the regeneration resistor is not protected by the drive at all. The regeneration transistor is switched on and off as in the ‘power fault only’ mode above, but the fault detection is disabled. Only the regeneration power warning is available to indicate that the regeneration is approaching its maximum capability.

The parameters associated with the regeneration control are given below.

Table 5-3 Regeneration Parameters

Parameter Name	Field Number	Description
regen_enable	1268	Regeneration Control Mode
regen_on_voltage	1249	Regeneration Transistor Turn-on Voltage
regen_off_voltage	1248	Regeneration Transistor Turn-off Voltage
regen_power_filtered	1252	Average Regeneration Power (Measured)
regen_internal_resistance	1258	Internal Regeneration Resistor Resistance
regen_internal_resistor_power	1259	Internal Regeneration Resistor Power
regen_internal_resistor initial_on_time	1261	Internal Regeneration Resistor Initial on-time in ms
regen_internal_resistor_continuous_on_time	1260	Internal Regeneration Resistor Continuous on-time in ms
regen_external_resistance	1262	External Regeneration Resistor Resistance
regen_external_resistor_power	1263	External Regeneration Resistor Power
regen_external_resistor_initial_on_time	1265	External Regeneration Resistor Initial on-time in ms
regen_external_resistor_continuous_on_time	1264	External Regeneration Resistor Continuous on-time in ms
regen_power_capability	1269	Total Regeneration Power Capability
regen_max_current	1266	Maximum Regeneration Current

The Regeneration transistor turn-on and turn-off voltages are set with the motor parameters and DC bus overvoltage level. Typically these voltages are set at follows.

Table 5-4 Typical Regeneration Turn-on & Turn-off Voltage Levels

Motor Voltage (Vdc)	Bus Overvoltage (Vdc)	Regen on Voltage (Vdc)	Regen off Voltage (Vdc)
300V	400V	380V	370V
600V	800V	760V	750V

For drives equipped with an internal Regeneration resistor, the parameters associated with that resistor are set automatically. If the drive has external regeneration capability only, all regeneration resistor parameters are set to zero by default. In this case, the drive will display a fault status (F3) and will not enable until suitable parameters for the external regeneration resistors are entered and saved.

The software also checks the value of regeneration resistance entered. If too low a value is entered, such that the current that would flow on turn-on of the regeneration transistor exceeds the ratings of the regeneration, transistor, a fault (F3) is also reported on the 7-segment display.

5.1.1 Power Interface Parameters

Table 5-5 Power Interface Parameter Access Detail

Parameter Name	Field Number	Data Type	Access	Default Value	Min. Value	Max. Value	Units	Storage Type
HIGH VOLTAGE								
bus_voltage_actual	1232	f32	r	0	-	-	V	N
bus_voltage_nominal	1229	f32	r	-	-	-	V	N
bus_under_voltage_limit	1234	f32	r	-	-	-	V	N
bus_under_voltage_limit_percentage	1235	f32	r/w	70	0	100	%	C
bus_over_voltage_limit	1233	f32	r/w	800	0	1000	V	C
LOW VOLTAGE								
supply_+24V	1441	f32	r	-	-	-	V	N
supply_+3V3	1421	f32	r	-	-	-	V	N
supply_-15V	1426	f32	r	-	-	-	V	N
supply_+15V	1431	f32	r	-	-	-	V	N
supply_+2V_ref.	1436	f32	r	-	-	-	V	N
encoder_supply	1446	f32	r	-	-	-	V	N
supply_+5V	1942	f32	r	-	-	-	V	N
supply_+5VA	1941	f32	r	-	-	-	V	N
REGENERATION CONTROL								
regen_enable	1268	U16	r/w	1	0	4	-	C
regen_on_voltage	1249	f32	r/w	760	10	1000	V	C
regen_off_voltage	1248	f32	r/w	750	0	1000	V	C
regen_power_filtered	1252	f32	r	-	-	-	W	N
regen_internal_resistance	1258	f32	r/w	see note 1	0	-	Ohm	F
regen_internal_resistor_power	1259	f32	r/w	see note 1	0	-	Ohm	F
regen_internal_resistor_initial_on_time	1261	f32	r/w	20	2	1E06	ms	F
regen_internal_resistor_continuous_on_time	1260	f32	r/w	2	1	1E06	ms	F
regen_external_resistance	1262	f32	r/w	0	0	1E06	Ohm	C
regen_external_resistor_power	1263	f32	r/w	0	0	1E06	Ohm	C
regen_external_resistor_initial_on_time	1265	f32	r/w	20	2	1E06	ms	F
regen_external_resistor_continuous_on_time	1264	f32	r/w	2	1	1E06	ms	F
regen_power_capability	1269	f32	r	-	-	-	W	N
regen_max_current	1266	f32	r/w	see note 2	0	-	A	F

Note 1: The internal regeneration capability is automatically determined from the power stage at initialisation

Note 2: The regeneration maximum current capability is automatically determined from the power stage at initialisation

5.4 Motor Configuration

There are a number of parameters that are required when configuring a specific motor for a drive. For standard motors, these parameters will be held in a database on the PC, and downloaded by the GUI. For non-standard motors, the user must enter these parameters.

In addition to the typical electrical motor parameters which are downloaded (e.g. Number of Motor Poles, Resistance, Inductance, etc...), tuning parameters for the current loop, position feedback, commutation, motor thermal characteristics etc., need to be set for the drive, as these parameters will differ for each motor. The following section lists and explains the meaning of each parameter. More detailed descriptions of these parameters are given in the appropriate parts of this section of the manual.
The parameters are grouped as listed below.

5.4.1 Motor Name

Table 5-6 Motor Name

Field No.	Type	Units	Motor Database Name	Name
1074	str	None	Name	motor_name

5.4.2 Electrical Parameters

Table 5-7 Electrical Parameters

Field No.	Type	Units	Motor Database Name	Name
1072	u16	None	Pm	motor_poles
1073	f32	Ohms	Rtt	motor_Rtt
1075	f32	H	Lq	motor_Lq
1076	f32	H	Ld	motor_Ld
1077	f32	V/rad/s	Ke	motor_ke

5.4.3 Current Loop Parameters

Because of the different electrical characteristics of each motor, the current loop must be optimised for the motor to be used with the controller. The control loop structure is described elsewhere, the parameters that must be set are summarised below:

Table 5-8 List of motor (Current Loop) parameters

Field No.	Type	Units	Motor Database Name	Name
1272	F32	V/A/sec	`CSA_di`	*current_loop_d-axis_i-gain*
1274	F32	V/A	`CSA_dp`	*current_loop_d-axis_p-gain*
1277	F32	V/A/sec	`CSA_qi`	*current_loop_q-axis_i-gain*
1279	F32	V/A	`CSA_qp`	*current_loop_q-axis_p-gain*
1284	F32	None	`CSA_calk`	*current_loop_foldback_minimum*
1285	F32	A	`CSA_cali`	*current_loop_foldback_breakpoint*
1288	F32	V/A/sec	`CSA_oap`	*current_loop_alpha_observer_i_gain*
1290	F32	V/A	`CSA_oai`	*current_loop_alpha_observer_p_gain*
1293	F32	V/A/sec	`CSA_obp`	*current_loop_beta_observer_i_gain*
1295	F32	V/A	`CSA_obi`	*current_loop_beta_observer_p_gain*

5.4.4 Feedback and Commutation Parameters

Different sources for the feedback of motor position to the controller are available. The following table lists these options. In the case where no encoder is used (i.e. comfbk = 1), then the encoder parameters may not need to be set. The resolver reference amplitude is in units of 32768/2V, typically the default value for the resolver's reference amplitude is used. The number of resolver poles is required regardless of the feedback source. The values for encoder set-up are listed in the encoder section, and are summarised in the table below:

Table 5-9 List of motor (Feedback and Commutation) parameters

Field No.	Type	Units	Motor Database Name	Name
1042	U16	none	`CSA_rref`	*resolver_amplitude*
1035	U08	none	`CSA_comfbk`	*commutation_feedback*
1036	S16	none	`CSA_comofs`	*commutation_offset*
1037	U16	none	`Pr`	*resolver_poles*
1704	U08	none	`CSA_encsup`	*encoder_supply*
1705	U08	none	`CSA_enctyp`	*encoder_type*
1706	U32	none	`encinc`	*encoder_number_of_increments*
1709	U08	none	`ssibit`	*encoder_ssi_number_bits*
1710	U08	none	`CSA_ssicod`	*encoder_ssi_coding*
1711	U32	none	`CSA_ssimsk`	*encoder_ssi_data_bit_mask*

5.4.5 Bus Parameters

The default value for the bus over-voltage limit is 800, with defaults of 750 and 760 for the regen off and on limit respectively.

Table 5-10 List of motor (Bus) parameters

Field No.	Type	Units	Motor Database Name	Name
1233	F32	V	Vmax	*bus_over_voltage_limit*
1248	F32	V	Vrgnoff	*regen_off_voltage*
1249	F32	V	Vrgnon	regen_on_voltage

5.4.6 Motor Thermal Parameters

The coefficients that characterize the NTC of the motor must be set for each motor. The temperature and span at which the current is Foldback as a function of motor temperature, can also be set, along with the maximum temperature allowed for the motor. Thermal Foldback is only possible where a NTC is present in the motor.

The motor thermal limiting is enabled by default, so the user should not modify the current limit mask setting.

Table 5-11 List of motor (thermal) parameters

Field No.	Type	Units	Motor Database Name	Name
1385	F32	none	CSA_ntca0	*motor_sensor_coefficient_a0*
1386	F32	none	CSA_ntca1	*motor_ sensor _coefficient_a1*
1387	F32	none	CSA_ntca2	*motor_ sensor _coefficient_a2*
1388	F32	none	CSA_ntca3	*motor_ sensor _coefficient_a3*
1389	F32	°C	CSA_ntcmin	*motor_ sensor _min_temperature*
1390	F32	°C	CSA_ntcmax	*motor_ sensor _max_temperature*
1135	U16	none	CSA_tlmena	*current_limit_mask*
1404	F32	°C	Tmax	*motor_maximum_temperature*
1405	F32	°C	CSA_tlmstt	*thermal_limit_motor_start_temperature*
1406	F32	°C	CSA_tlmspn	*thermal_limit_motor_span_temperature*

5.4.7 Motor Rating Parameters

The following parameters for speed and current ratings for the motor must also be set.

Table 5-12 List of motor (ratings) parameters

Field Number	Type	Units	Motor Database Name	Name
1078	F32	A	Imax	*motor_max_current_*
1082	F32	rad/s	Nmax	*motor_max_velocity*
1087	F32	Arms	In	*motor_max_continuous_rms_current*
4226	U32	mNm	Mn	*motor_rated_torque*

5.4.8 Motor Configuration Parameters

Table 5-13 Motor Configuration Parameter Access Details

Parameter Name	Field Number	Data Type	Access	Default Value	Minimum Value	Maximum Value	Units	Storage	Data Group
NAME									
motor_name	1074	str	r/w		-	-	None	C	A
ELECTRICAL									
motor_poles	1072	U16	r/w	12	2	-	None	C	A
motor_Rtt	1073	F32	r/w	2.4	1.0e-9	-	Ohms	C	A
motor_Lq	1075	F32	r/w	5.180e-3	1.0e-9	-	H	C	A
motor_Ld	1076	F32	r/w	4.920e-3	1.0e-9	-	H	C	A
motor_Ke	1077	F32	r/w	1.16	1.0e-9	-	V/rad/s	C	A
CURRENT LOOP									
current_loop_d-axis_i-gain	1272	F32	r/w	6.35404981	0	-	V/A/sec	C	A
current_loop_d-axis_p-gain	1274	F32	r/w	32.02666839	0	-	V/A	C	A
current_loop_q-axis_i-gain	1277	F32	r/w	6.35404981	0	-	V/A/sec	C	A
current_loop_q-axis_p-gain	1279	F32	r/w	32.02666839	0	-	V/A	C	A
current_loop_foldback_minimum	1284	F32	r/w	1.0	0.1	1	None	C	A
current_loop_foldback_breakpoint	1285	F32	r/w	140.0	5.0	-	A	C	A
current_loop_alpha_observer_i-gain	1288	F32	r/w	0.01394492	0	-	V/A/sec	C	A
current_loop_alpha_observer_p-gain	1290	F32	r/w	0.19933257	0	-	V/A	C	A
current_loop_beta_observer_i-gain	1293	F32	r/w	0.01394492	0	-	V/A/sec	C	A
current_loop_beta_observer_p-gain	1295	F32	r/w	0.19933257	0	-	V/A	C	A

FEEDBACK AND COMMUTATION									
resolver_reference_amplitude	1042	U16	r/w	-	0.0	10.0	Vrms	C	A
commutation_feedback	1035	U08	r/w	2	-	2	none	C	A
commutation_offset	1036	S16	r/w	5461	-	-	none	C	A
resolver_poles	1037	U16	r/w	2	2	-	none	C	A
encoder_supply	1704	U08	r/w	5	5	12	none	C	A
encoder_type	1705	U08	r/w	0	-	7	none	C	A
encoder_number_of_increments	1706	U32	r/w	1024	1	-	none	C	A
encoder_ssi_number_bits	1709	U08	r/w	13	2	32	none	C	A
encoder_ssi_coding	1710	U08	r/w	0	-	1	none	C	A
encoder_ssi_data_bit_mask	1711	U32	r/w	0xfffffffc	-	-	none	C	A
BUS									
bus_over_voltage_limit	1233	F32	r/w	800	0	1000	V	C	A
regen_off_voltage	1248	F32	r/w	750	10	1000	V	C	A
regen_on_voltage	1249	F32	r/w	760	0	1000	V	C	A
THERMAL									
motor_ntc_coefficient_a0	1385	F32	r/w	9.74168126	-	-	none	C	A
motor_ntc_coefficient_a1	1386	F32	r/w	0.40921384	-	-	none	C	A
motor_ntc_coefficient_a2	1387	F32	r/w	-6.43817065E-4	-	-	none	C	A
motor_ntc_coefficient_a3	1388	F32	r/w	5.33087836E-7	-	-	none	C	A
motor_ntc_min_temperature	1389	F32	r/w	20.0	-	-	°C	C	A
motor_ntc_max_temperature	1390	F32	r/w	180.0	-	-	°C	C	A
current_limit_mask	1135	U16	r/w	0x47	-	-	none	C	A
motor_maximum_temperature	1404	F32	r/w	155	-	-	°C	C	A
motor_thermal_foldback_start	1405	F32	r/w	145	-	-	°C	C	A
motor_thermal_foldback_span	1406	F32	r/w	10	-	-	°C	C	A
RATING									
motor_max_current_	1078	F32	r/w	24	0.1	-	A	C	A
motor_max_velocity	1082	F32	r/w	1000	0	20000	rad/s	C	A
motor_max_continuous_rms_current	1087	F32	r/w	1000	0.1	1000	Arms	C	A
motor_rated_torque	4226	U32	r/w	1	1	-	mNm	C	A

5.5 Resolver Input

The resolver input allows the connection of various resolvers for drive position feedback, velocity feedback or for motor commutation (rotor angle feedback).

The drive supplies the resolver with a sinusoidal reference signal (R1 - R2). The resolver output signals have the same frequency as the reference but the amplitude changes depending on the rotational angle. The output signals are normally referred to as Sine (S1 - S3) and Cosine (S2 - S4). By measuring the amplitude of both Sine and Cosine Signals and applying an arctan function the drive can determine the rotor angle of the motor.

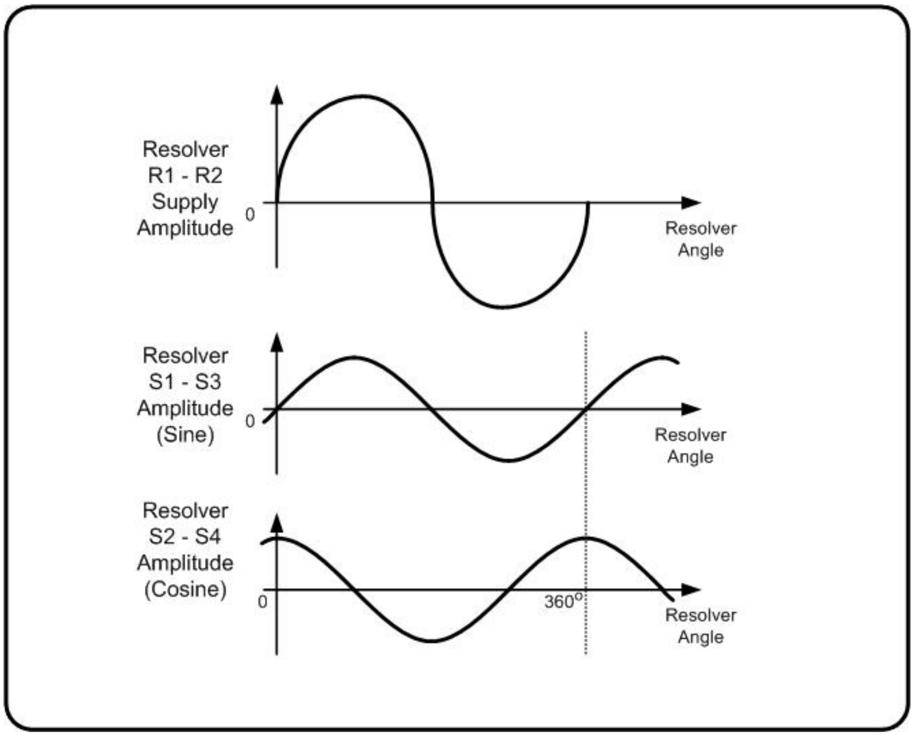

Figure 5.2 Resolver Signal Amplitude

The picture shows the amplitude of the Sine and Cosine signals depending on the rotation angle of the resolver. Normally the reference voltage is about 16Vpp and the maximum Sine or Cosine voltage is about 2 Volts. The frequency is 8 kHz.

5.5.1 Resolver Configuration

5.5.1.1 Number Resolver Poles

The number of resolver pole pairs determines the number of full Sine or Cosine amplitude cycles per full mechanical revolution. In order to function properly, the parameter *resolver_poles* (Field Number 1037) has to be set to the number of resolver poles (pole pairs multiplied by 2). Refer to the motor manufacturer's datasheet for further information. For standard motors in the motor database this parameter is configured as part of the motor parameter download.

5.5.1.2 Resolver Transformer Turns Ratio

The resolver transformer turns ratio determines the required amplitude for the resolver reference output from the CSA. This figure is normally quoted in the resolver data sheet. For standard motors in the motor database this parameter is configured as part of the motor parameter download. Failure to set the parameter *resolver_transformer_ratio* (Field Number 1024) correctly may result in a resolver fault being detected.

5.5.1.3 Resolver Reference Amplitude

The parameter *resolver_amplitude* (Field Number 1042) is the resolver reference amplitude determined from the resolver transformer turns ratio.

5.5.1.4 Resolver Commutation Position

The parameter *resolver_position_(raw)* (Field Number 1057) contains the electrical angle of the resolver. Depending on the pole count of the resolver this value is proportional to the mechanical angle. The scaling is 16-bit full scale change over one electrical cycle of the Sine or Cosine signals. For example a change of 65536 in *resolver_position* corresponds to 360 degrees mechanical for a 2 pole resolver.

5.5.1.5 Resolver Position

The parameter *resolver_position_(multi-turn)* (Field Number 1161) contains a multi-turn version of the resolver commutation position, used in the position loop feedback. The multi-turn resolver position is created by counting the resolver commutation position rollovers.

5.5.1.6 Resolver Reference Frequency

To facilitate the use of the CSA Servo Drive with resolvers requiring different modulation frequencies, the resolver frequency may be set in units of kHz to, 8, 4, or 2, having values of 0, 1, and 2 respectively, using *resolver_tone* (Field Number 1054).

5.5.2 Resolver Parameters

Table 5-14 Resolver Parameter Access Detail

Parameter Name	Field Number	Data Type	Access	Default Value	Minimum Value	Maximum Value	Units	Storage Type	Data Group
RESOLVER									
resolver_poles	1037	u16	r/w	2	2	-	none	C	A
resolver_transformer_ratio	1024	u16	r/w	0.5	0.22	1.34	none	C	A
resolver_amplitude	1042	u16	r/w	-	0	10	Vrms	N	A
resolver_tone	1054	u16	r/w	0 = 8kHz	0	2	none	C	A
resolver_position_(raw)	1057	s16	r	-	-	-	none	N	A
resolver_position_(multi-turn)	1161	S32	r	-	-	-	none	N	A

5.6 Encoder Input

The encoder input allows the connection of various absolute and incremental encoders for drive position feedback, velocity feedback or for motor commutation (rotor angle feedback).

The encoder signals of an encoder with analogue sinusoidal output signals can be used for increased resolution through angle interpolation within one optical increment.

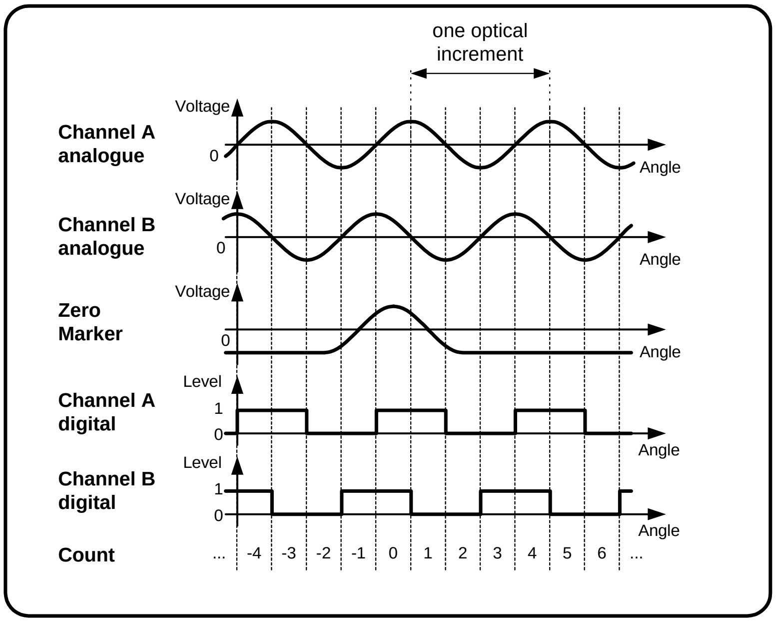

Figure 5.3 Encoder Signals

The picture shows typical analogue encoder signals and the digital signals derived from the analogue signals. The direction of rotation shown is counter-clockwise, so that channel B leads channel A. By counting every digital signal transition, the number of counts per mechanical revolution is four times the number of optical increments. Using the analogue input signals the angle in between the increments can be interpolated to achieve much higher resolution.

5.6.1 Encoder Configuration

5.6.1.1 Encoder Supply Voltage

The supply voltage of the encoder can be selected with the parameter *encoder_supply* (Field Number 1704). It has to be set first to ensure proper operation. The following values are valid for *encoder_supply*:

- '5'..............................+5vdc Encoder Supply voltage
- '8'..............................+8vdc Encoder Supply voltage
- '12'............................+12vdc Encoder Supply voltage

All other values will return an error when written.

5.6.1.2 Encoder Types

There are various encoder types supported. They are selected with the parameter *encoder_type* (Field Number 1705). It can have the following values:

I. 0............................No Encoder Connecter
II. 1............................Digital Incremental Encoder
III. 2............................Analogue Incremental Encoder
IV. 3............................SSI Interface Absolute Singleturn Or Multiturn Encoder
V. 4............................Stegmann Hiperface Interface Absolute Encoder
VI. 5............................Heidenhain Endat 2.1 Interface Absolute Encoders
VII. 6............................Heidenhain EnDat2.2
VIII. 7............................MCG LP SSI Encoder

Depending on the encoder type selected there are more parameters that have to be initialized in order to allow encoder operation.

5.6.1.3 Number of Increments

For normal digital incremental, analogue or SSI interface encoders (*encoder_type* 1..3) the parameter *encoder_number_of_increments* (Field Number 1706) has to be set to the number of increments (optical lines) per mechanical revolution. If the encoder is used for motor commutation only powers of 2 are allowed for *encoder_number_of_increments* (i.e. 512, 1024, etc.). When a Hiperface or Endat encoder is connected this parameter is obtained from the encoder. In this case *encoder_number_of_increments* is read only.

5.6.1.4 Encoder Position

The parameter *encoder_position* (Field Number 1713) contains the 32-bit encoder position. It is assembled using the encoder incremental count value, an interpolated analogue value (only when using encoders with analogue output signals) and an overflow counter that counts the full revolutions of the encoder.

5.6.1.5 Encoder Resolution

For encoders with analogue sinusoidal signals the incremental steps can be interpolated to achieve higher resolution and better velocity signals. The resolution is user selectable using the parameter *encoder_resolution* (Field Number 1708). It determines the bit position of the full encoder increments in the encoder position *encoder_position*. The minimum value is 2 because of 4 incremental steps per optical encoder line using every transition in the quadrature signal. The reasonable maximum for *encoder_resolution* is approximately 12. Values above that can be used to change the scaling of the encoder position value, but it doesn't increase the available resolution any more. Please note that the absolute accuracy still largely depends on the accuracy of the analogue encoder signals. For absolute multi-turn encoders (EnDat2.2) the encoder resolution should be set to ‘2’ so that the encoder position value contains the MSB of information.

5.6.1.6 Encoder Offset

To compensate for a mechanical misalignment between the encoder and the desired encoder position, the parameter *encoder_offset* (Field Number 1712) can be used. Setting it to the value of *encoder_position* will zero the encoder position output value *encoder_position*, which is often done at the home or mid-stroke position.

5.6.1.7 Direction of Rotation

The direction of rotation can be reversed with the parameter *encoder_direction_of_rotation* (Field Number 1707). Normally positive direction is clockwise rotation when looking onto the encoder shaft. In this case, channel A is leading the channel B signals. If the direction has to be changed because of different encoder signals or mounting of the encoder on the motor or machine, *encoder_direction_of_rotation* can be set to 1. This reverses the direction so that positive direction is counter clockwise rotation when looking onto the encoder shaft. The change of direction affects the encoder position, the encoder velocity, and the encoder commutation angle.

0	-	normal direction: positive position count when rotating clockwise looking onto the encoder shaft
1	-	reversed direction: positive position count when rotating counter clockwise looking onto the encoder shaft

5.6.1.8 Number of data stream bits for SSI encoders

For SSI encoders, the number of bits in the data stream has to be set using the parameter *encoder_ssi_number_bits* (Field Number 1709). It contains the number of bits in the raw data stream (not the number of encoder position bits). See encoder manufacturers' manual for further information.

5.6.1.9 Data encoding for SSI encoders

The encoding can be changed between binary and Gray code transmission with the parameter *encoder_ssi_coding* (Field Number 1710). The following values are possible:

0	-	Gray code
1	-	Binary code

See encoder manufacturers' manual for further information.

5.6.1.10 Position bit mask for SSI encoders

Depending on the encoder, not all bits in the SSI data stream contain position information, typically the non-position bits contain error information. To accommodate this, the parameter *encoder_ssi_data_bit_mask* (Field Number 1711) has to be set to mask off the non-position bits in the raw data stream. A one in *encoder_ssi_data_bit_mask* means that the bit contains position information. The least significant bit in *encoder_ssi_data_bit_mask* corresponds to the last bit clocked out of the encoder. Bits above the number set in *encoder_ssi_number_bits* are 'don't care'; they are ignored.

5.6.1.11 Encoder commutation position

The encoder can also be used for commutation of the motor (motor phase current change depending on rotor angle position). The parameter *encoder_commutation_position* (Field Number 1714) contains a 16-bit value that represents a full mechanical revolution independent of the encoder resolution setting *encoder_resolution*. The encoder direction of rotation parameter *encoder_direction_of_rotation* also changes the direction for the encoder commutation position.

5.6.1.12 Set Encoder Position

Encoders with a Hiperface or EnDat digital interface provide the facility to be able to set the datum position from which the absolute position is measured. This feature is supported using the parameter *encoder_set_position*.

5.6.1.13 Incremental Encoder UVW Pattern

The incremental encoder commutation track pattern relative to 0° electrical is entered as a decimal using parameter ‘encincphs’ (Field Number 2202) where ‘U’=LSB, ‘V’=bit 1 and ‘W’=bit 2

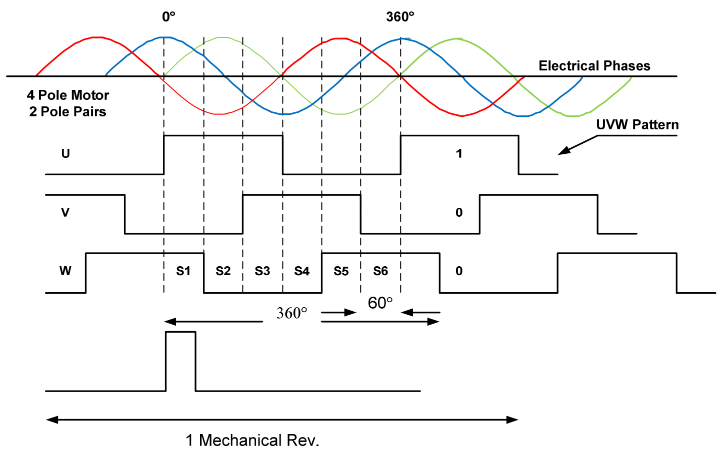

Figure 5.4 Incremental Encoder UVW Pattern

5.6.1.14 Incremental Encoder UVW Phase Offset

Where the mechanical angle and electrical angle are not aligned at 0°, the offset may be entered using parameter ‘encinccom’ (Field Number 2209) in units of electrical degrees.

5.6.1.15 Incremental Encoder Commutation Configuration

The commutation configuration is set using parameter ‘enccomcfg’ (Field Number 2209) for the values: 0=uvw only, 1=uvw_z_marker, 2=z_marker_only, 3=third party only.

5.6.1.16 Z-marker Pulse

Certain encoders may provide a marker channel which produces a single signal pulse per revolution of the encoder shaft and is often used as a reference or Z-marker pulse. The Z-marker pulse is then denoted as a starting position which can resume counting or position tracking. Information regarding the Z-marker pulse is contained within the status word ‘z_marker_status’ (Field Number 2204).

The Z-marker pulse offset from 0° electrical is required in order to generate maximum torque when the CSA switches from UVW commutation to absolute ABZ commutation. The ‘Commutation Offset’ routine supports the measurement of commutation offset relative to Z-marker; the offset is stored in parameter ‘encinczof’ (Field Number 2210)

If the Z-marker has not been passed at the time of the commutation routine, the interface should monitor the Z-marker and establish the relative offset when the marker is passed.

5.6.1.17 Encoder Single-Turn bits

The number of bits of single turn information received from an absolute encoder is set using parameter ‘`encsng`’ (Field Number 10138).

5.6.1.18 Encoder Multi-Turn bits

The number of bits of Multi-turn information received from an absolute encoder is set using parameter ‘`encmul`’ (Field Number 1694). The parameter ‘`encmul`’ must be set to ‘0’ when commutating with an incremental encoder.

5.6.1.19 Encoder bit Rate

When absolute position information is passed from an Endat2.2 encoder to the CSA Servo Drive the bit rate must be set in parameter ‘`encbdr`’ (Field Number 2086) in units of MHz, The allowable values for the encoder bit rate are as follows;

- 1.0
- 1.25
- 1.66
- 2.0
- 2.5

5.6.1.20 CSA EtherCAT Encoder EEPROM Storage

The CSA - EtherCAT is intended to support Hiperface and EnDat encoders which provide onboard EEPROM for parameter storage. This can be used by the CSA to store motor related parameters so that a drive can be replaced while retaining the motor setup. The EEPROM parameter storage is enabled by setting the parameter *encoder_eeprom_enable* to ‘1’ (the default) and by enabling the Encoder Nameplate, *motnpctrl* to ‘1’ (the default). The Encoder Nameplate provides a data format suitable for versioning in future by adding parameters to the encoder while retaining backward compatibility. See Section B.3.10.2 for details on reading and writing the Nameplate along with the definition of its content.

5.6.1.21 CSA MaxForce Encoder EEPROM Storage

The CSA - MaxForce is intended to support Hiperface encoders which provide onboard EEPROM for parameter storage. This can be used by the CSA to store motor related parameters so that a drive can be replaced while retaining the motor setup. The EEPROM parameter storage is enabled by setting the parameter *encoder_eeprom_enable* to ‘1’. See Section B.3.10.3 for details on reading and writing the Encoder Data along with the definition of its content.

5.7 Commutation Module

The commutation module allows the selection of various commutation methods for the motor phase currents. It is possible to use a resolver, an encoder, or a fixed value for the rotor feedback position.

5.7.1 Commutation Configuration

5.7.1.1 Commutation feedback Source

The selection of the rotor position feedback is done through parameter *commutation_feedback* (Field Number 1035). It can have the following values:

0	-	commutation with angle zero
1	-	commutation with resolver feedback
2	-	commutation with encoder feedback

5.7.1.2 Commutation with zero angle

When selecting *commutation_feedback*=0 the feedback angle for the rotor position is fixed at zero. This can be used to determine the phase angle between the rotor and the resolver or encoder. When this mode is selected, the current loop gains may have to be reduced to avoid instabilities.

5.7.1.3 Commutation with resolver

When commutation with resolver is selected, the rotor angle is taken from the resolver commutation position *resolver_position*. 16-bit full scale corresponds to one full mechanical revolution. The number of resolver poles *resolver_poles* and the number of motor poles *motor_poles* has to be set to ensure proper operation of the drive.

5.7.1.4 Commutation with encoder

If the motor is equipped with an encoder, the commutation is done from the encoder commutation angle *encoder_commutation_position*. 16-bit full scale corresponds to one full mechanical revolution. The encoder type and line count have to be set up before. See 'Section 5.6 Encoder' for further information.

5.7.1.5 Commutation offset

In all commutation types the parameter *commutation_offset* (Field Number 1036) contains the offset angle between the commutation feedback and the phase currents. 16-bit full scale corresponds to one full mechanical revolution. When the motor has a resolver or encoder built in that has been adjusted in the factory this angle can be obtained from the motor data. Otherwise it is possible to do an automatic adjustment of this value using the commutation adjustment parameter *commutation_offset_adjustment*.

5.7.2 Commutation offset adjustment

To adjust the offset between the commutation feedback and the phase currents the parameter *commutation_offset_adjustment* can be used.

5.7.2.1 Commutation Angle

The commutation angle is determined in software using the number of motor poles `motor_poles_write_dr1` (Field Number 1072) and the measured angle '`encpos`' (Field Number 1713) \ '`respos`' (Field Number 1161).

5.7.2.2 Commutation Offset Adjustment Procedure

The following steps have to be followed:

1. Make sure the rotor can turn freely.
2. Initialize correct motor parameters.
3. Set *commutation_feedback* (resolver or encoder).
4. Set the drive to torque mode. (parameter *control_loop_mode_requested* (Field Number 1330) = '1301')
5. Set *commutation_offset_adjustment* to '1' to start the adjustment procedure.
6. Enable the drive. The communication adjustment starts.
7. Wait until *commutation_offset_adjustment* reads 0 (after about 2 seconds).

The parameter *commutation_offset* now contains the right value to allow commutation with the feedback device selected. Make sure to **SAVE** the value to EEPROM.

5.7.2.3 Commutation Offset Adjustment with Commutation Tracks

If the CSA Servo Drive is factory configured to support incremental encoders with commutation tracks (G362-XXX-005 or G362-XXX-006), an automatic UVW commutation angle may be determined at power up by setting '`encincuvwena`' to '1' (Field Number 10159).

If the Automatic UVW commutation option is disabled,('`encincuvwena`' = '0') the CSA Servo Drive will **NOT** enable for motion until a successful 'Commutation Offset' procedure has been performed, as described in section *Commutation Offset Adjustment Procedure* has been performed.

5.7.2.4 Commutation Mode Transition

The transition from UVW commutation to Sinusoidal commutation is configurable via parameter '`enccomuvw`' (Field Number 10160) valid writable values are outlined below

- '1'..................Transition from UVW to sinusoidal at first UVW track change only
- '2'..................Transition from UVW to sinusoidal at Z-marker
- '3..................Transition from UVW to sinusoidal at first UVW track change with update at Z-marker
- '4'..................Transition from UVW to sinusoidal upon signal from Fieldbus

The commutation mode being operated by the CSA Servo Drive is reported by parameter 'encinmod' (Field Number TBD)

As the commutation track inputs are only checked at a fixed rate (2ms) a limitation occurs on the maximum velocity in UVW mode, the maximum velocity should be set on power-up using parameter ‘`motvellim`’ (Field Number 10910)

5.7.2.5 Commutation Offset & Z-marker

The ‘Commutation Offset’ routine supports measuring the commutation offset relative to Z-marker. The commutation offset is reported in units of electrical degrees in parameter ‘`encinczof`’ (Field Number 10157).

5.7.3 Commutation Parameters

Table 5-15 Commutation Parameter Access Detail

Parameter Name	Field Number	Data Type	Access	Default Value	Minimum Value	Maximum Value	Units	Storage Type	Data Group
COMMUTATION									
commutation_feedback	1035	u08	r/w	2	-	2	none	C	A
commutation_offset	1036	s16	r/w	5461	-	-	none	C	A
commutation_offset_adjustment	1038	u08	r/w	0	1	1	none	N	A
COMMUTATION RELATED									
control_loop_mode_requested	1330	S32	r/w	0	-	-	none	N	A
motor_poles	1072	u16	r/w	12	2	-	none	C	A
resolver_position	1057	s16	r	-	-	-	none	N	A
encoder_commutation_position	1714	s16	r	-	-	-	none	N	A

5.8 Position Feedback

The feedback signal for the position loop closure can be derived from the resolver input or the encoder input.

5.8.1 Position Feedback Configuration

5.8.1.1 Position feedback

The selection of the position feedback is done through parameter *position_feedback* (Field Number 1168). It can have the following values:

1 - position feedback from resolver

2 - position feedback from encoder

See 'Section 5.5 Resolver' and ''Section 5.6 Encoder ' for further information on how to set up resolvers and encoders.

5.8.2 Position feedback parameters

5.8.2.1 position_feedback (Field Number 1168) (‘posfbk’)

Table 5-16 Position Feedback Parameters

Data type	unsigned 8-bit
Access	read / write
Default value	1
Minimum value	1
Maximum value	2
Storage type	customer settings EEPROM
Data group	application parameter
Field number	1168

5.9 Velocity Feedback

The feedback signal for the velocity loop closure can be derived from the resolver input or the encoder input.

5.9.1 Velocity Feedback Configuration

5.9.1.1 Velocity feedback

The selection of the velocity feedback is done through parameter *velocity_feedback* (Field Number 1169). It can have the following values:

1 - velocity feedback from resolver

2 - velocity feedback from encoder

See 'Section 5.5 Resolver' and 'Section 5.6 Encoder ' for further information on how to set up resolvers and encoders.

5.9.2 Velocity feedback parameters

5.9.2.1 velocity_feedback (Field Number 1169) ('`velfbk`')

Table 5-17 Velocity Feedback Parameters

Data type	unsigned 8-bit
Access	read / write
Default value	1
Minimum value	1
Maximum value	2
Storage type	customer settings EEPROM
Data group	application parameter
Field number	1169

5.10 Digital Input and Output Functional Description

5.10.1 Digital Input Functionality

There are 8 digital inputs on the CSA, numbered I1 to I8 on the CSA front-panel. The first digital input is hardwired to always be used for drive enable, the drive can be enabled when this input is high, and the drive is always disabled when this input is low. This digital input can additionally be configured with a function, but it still retains its hardware enable function as well. The other 7 inputs are user-configurable. The user can configure: -

- Functionality associated with the input (e.g. manual mode input, limit switch input etc.)
- A debounce count, i.e. number of times the input must be seen to be set before functionality is executed
- Invert the logic of the digital input (e.g. if by default manual mode is when input is low can be inverted to occur when input is high).
- Select either edge or level triggering

The parameters associated with inputs follow. Note that the names of the parameters are zero-indexed, but that the numbers on the front-panel start at 1:

Table 5-18 List of Digital Input Parameters

Field No.	Type	Name
1545	U08	hardware_enable_configuration
1546	U08	hardware_enable_debounce_count
1660	U08	hardware_enable_invert
1672	U08	hardware_enable_control
1547	U08	digital_input_1_configuration
1548	U08	digital_input_1_debounce_count
1661	U08	digital_input_1_invert
1673	U08	digital_input_1_control
1549	U08	digital_input_2_configuration
1550	U08	digital_input_2_debounce_count
1662	U08	digital_input_2_invert
1674	U08	digital_input_2_control
1551	U08	digital_input_3_configuration
1552	U08	digital_input_3_debounce_count
1663	U08	digital_input_3_invert
1675	U08	digital_input_3_control

1553	U08	digital_input_4_configuration
1554	U08	digital_input_4_debounce_count
1664	U08	digital_input_4_invert
1676	U08	digital_input_4_control
1555	U08	digital_input_5_configuration
1556	U08	digital_input_5_debounce_count
1665	U08	digital_input_5_invert
1677	U08	digital_input_5_control
1557	U08	digital_input_6_configuration
1558	U08	digital_input_6_debounce_count
1666	U08	digital_input_6_invert
1678	U08	digital_input_6_control
1559	U08	digital_input_7_configuration
1560	U08	digital_input_7_debounce_count
1667	U08	digital_input_7_invert
1679	U08	digital_input_7_control
1542	U08	digital_input_status_word

5.10.1.1 Digital Input Function Assignment

Setting the digital input configuration entry for the digital input, to the appropriate handler function number, configures the functionality of each input. The table below lists the functions that can be assigned. Only the NULL function can be assigned to more than one digital input. If an attempt is made to map a function twice a mapping error is indicated.

For Edge Triggering:
The handler function is not called repetitively, but rather the handler function is called when: -

- Initially setting up the digital input, when no previous function assigned to the input (i.e first time).
- A transition occurs in the digital input.
- Change the setting of the digital input invert.
- On Power-Up (if configuration has been saved to NVM).

For Level Triggering:
The handler function is called repetitively and also when: -

- Initially setting up the digital input, when no previous function assigned to the input (i.e first time).
- The setting of the digital input invert is changed.
- On Power-Up (if configuration has been saved to NVM).

If digital inputs are already configured, and re-configure the input for a different purpose, do not switch any of the digital inputs and do not invert any of the digital inputs as the handler function is not called.

The Table below has the current Digital Input Handler Functions, some of which are supported or reserved for future CSA Applications.

Table 5-19 List of Digital Input Handler Functions

Handler Function	Edge or Level Trigger	Configuration Support (Yes/No)		Input Set	Input Cleared
		CSA - EtherCAT	CSA - MaxForce		
Brake Apply/Release	Edge	Yes	Yes	Release Brake	Enable Brake
Hardware Enable	Edge	Yes	Yes	Enable	Disabled
Positive Limit Switch	Edge	Yes	Yes	Inactive	Active
Negative Limit Switch	Edge	Yes	Yes	Inactive	Active
Home Switch	Edge	Reserved		n/a	n/a
Quickstop (Configurable for enable or disable after stopped)	Edge	Yes	Yes	Quickstop	No Action
Automatic Manual Mode (Auto = normal limits, Manual = reduced power)	Edge	Yes	Yes	Auto. Mode	Manual Mode
Controlled Disable	Edge	Yes	Yes	Disable	No Action
Re-boot	Edge	Yes	Yes	Re-boot	No Action
Safety Circuit Monitor	Edge	Yes	Yes	Assert Condition	De-assert Condition
Safety Circuit Input Monitor	Edge	Yes	No	Generate and Interlock Fault (F17)	No Action
Brake Contact Monitor	Edge	No	Yes	Brake Applied	Brake Released
AC Ready	Edge	No	Yes	AC Power Present	AC Power Not Present
Safety Relay Immediate Open (invokes a Return-To-Home)	n/a	Reserved		n/a	n/a
ESTOP Active Monitor	n/a	Reserved		n/a	n/a
Interlock Active	n/a	Reserved		n/a	n/a
Battery Test Ok	n/a	Reserved		n/a	n/a
AC Power Loss	n/a	Reserved		n/a	n/a
Brake Release Status	n/a	Reserved		n/a	n/a
ESTOP Settle	n/a	Reserved		n/a	n/a
System Fault Settle	n/a	Reserved		n/a	n/a

5.10.1.2 Brake Apply/Release

This handler function releases the brake. The default operation is that setting the digital input (current flowing), will release the brake, and clearing the input will enable the brake. By configuring this digital input, the user takes control of the motor brake. There are two additional parameters that allow configuration of the amount of control the user has over the brake.

- *brake_control* (1603) configures the brake control in normal operation
- *brake_fault_control* (1505) configures the brake control in a fault condition

The default operation is that input not configured by user. Brake is under Drive control so that on enable the brake is released immediately. On disable or in a fault condition, the brake is applied immediately. (e.g. default is *brake_control* = 1 and *brake_fault_control* = ‘1’)

For full user control of the brake in all conditions including fault conditions and during a Quick Stop set both *brake_control* and *brake_fault_control* to ‘0’ in addition to configuring the digital input function .

5.10.1.3 Hardware Enable

The drive can not be enabled unless the Hardware Enable is present on J2A 1.

5.10.1.4 Positive Limit Switch

This handler function is used to configure the input as a positive limit switch. The default operation is that when the input is set the limit switch is inactive. If the input is cleared, and the drive is not performing a homing cycle, the drive will stop. For torque mode operation, torque reference is reduced to zero. For velocity mode operation, the motor is decelerated to zero. For position mode further moves in that direction are prevented. Motion in the opposite direction is possible provided the other limit switch is not also activated. Further movement in the positive direction is prevented, by disabling any torque from being applied in this direction. If the input is cleared, and the drive is performing a homing cycle, the drive will perform a Quickstop, but subsequent moves may occur as part of the homing cycle.
If not in homing mode, the drive can be set up to disable or remain enabled on detection of a limit switch by setting bit 1 of *quickstop_mode* (Field Number 1013). If set to ‘0’ the drive will disable, if set to ‘1’ the drive will remain enabled.

If the drive is configured to disable on a quick stop by setting bit 1 to’0’, the brake is applied (if configured to do so) when the velocity decreases below a programmable level set by *standby_velocity* (Field Number 1138). The drive will then disable a programmable time after the brake is applied set by *brake_lock_to_disable_timeout* (Field Number 1004).
If the velocity does not decrease below *standby_velocity* within a programmable time set by *velocity_rampdown_time_limit* (Field Number 1143), then the drive will disable and the brake will be applied (if configured to do so).

The operation of the brake under a quick stop with disable can be configured to either apply or remain released using the *brake_control* parameter as described in the Brake Release Switch section.

5.10.1.5 Negative Limit Switch

This handler function is used to configure the input as a negative limit switch. The default operation is that when the input is set the limit switch is inactive. If the input is cleared, and the drive is not performing a homing cycle, the drive will stop. For torque mode operation, torque reference is reduced to zero. For velocity mode operation, the motor is decelerated to zero. For position mode further moves in that direction are prevented. Motion in the opposite direction is possible provided the other limit switch is not also activated. Further movement in the negative direction is prevented, by disabling any torque from being applied in this direction. If the input is cleared, and the drive is performing a homing cycle, the drive will quickstop, but subsequent moves may occur as part of the homing cycle.
If not in homing mode, the drive can be set up to disable or remain enabled on detection of a limit switch by setting bit 1 of *quickstop_mode* (1013). If set to ‘0’ the drive will disable, if set to ‘1’ the drive will remain enabled.

If the drive is configured to disable on a quick stop by setting bit 1 to 0, the brake is applied (if configured to do so) when the velocity decreases below a programmable level set by *standby_velocity* (Field Number 1138). The drive will then disable a programmable time after the brake is applied set by *brake_lock_to_disable_timeout* (Field Number 1004).
If the velocity does not decrease below *standby_velocity* within a programmable time set by *velocity_rampdown_time_limit* (Field Number 1143), then the drive will disable and the brake will be applied (if configured to do so).

The operation of the brake under a quick stop with disable can be configured to either apply or remain released using the *brake_control* parameter as described in the Brake Release Switch section.

5.10.1.6 Homing Switch

This handler function is used to configure the input as a homing switch. The homing switch is used when certain homing methods are configured. The default operation is that the homing switch is inactive when the input is cleared and active when the input is set.

5.10.1.7 Quickstop

CAUTION: the user can program the **MANUAL_MODE** torque and velocity limits to be higher than the same limits in the **AUTOMATIC_MODE**. The user should ensure that the correct limits are set-up in the CSA software, so that inadvertently limits are not swapped or used incorrectly in either **MANUAL** or **AUTOMATIC** states.

This handler function is used to configure the input as a Quickstop input. The default operation is to Quickstop the Drive if the input is set, i.e. decelerates at a programmable rate. The drive can be set up to disable or remain enabled once the quick stop is complete by setting bit ‘0’ of *quickstop_mode* (Field Number 1013). If set to ‘1’ the drive will disable, if set to ‘0’ the drive will remain enabled.

If the drive is configured to disable on a quick stop by setting bit 0 to 1, the brake is applied (if configured to do so) when the velocity decreases below a programmable level set by *standby_velocity* (Field Number 1138). The drive will then disable a programmable time after the brake is applied set by *brake_lock_to_disable_timeout* (Field Number 1004).
If the velocity does not decrease below *standby_velocity* within a programmable time *velocity_rampdown_time_limit* (Field Number 1143) then the drive will disable and the brake applied (if configured to do so).

The operation of the brake under a quick stop with disable can be configured to either apply or remain released using the *brake_control* parameter as described in the Brake Release Switch section.

5.10.1.8 Automatic / Manual Mode

This handler function is used to select between automatic (where normal limits apply) and manual mode (reduced power mode). The default operation is to be in manual mode if the input is cleared (i.e. no current flows), and to be in automatic mode if the input is set. In manual mode, the drive operates with Manual mode torque limit and Manual mode velocity limit. The percentage of max torque and max velocity with which the drives operates is set using *manual_mode_limit* (1133) in %. This parameter sets the maximum available torque to a percentage of *current_maximum_physical* (Field Number 1124) and the maximum velocity to a percentage of *velocity_maximum* (Field Number 1085).

5.10.1.9 Controlled Disable

This handler function is the same as the quickstop handler listed above, but configured to always disable when quickstop is complete.

5.10.1.10 Re-Boot

When the input is true this function will force the drive to restart.

5.10.1.11 Safety Circuit Monitor

Asserts or Deasserts a condition monitored by the Safety Circuit Input Monitor Handler.

5.10.1.12 Safety Circuit Input Monitor

If asserted and the Safety Circuit Monitor has been asserted and not cleared, an Interlock Fault (F17) is generated.

5.10.1.13 AC Ready (CSA - MaxForce)

When asserted, an AC Ready Fault (F26) is generated which indicates High Power is available and once the drive disables, it will repeat the softstart process. When deasserted, the Drive switches to battery power if so equipped.

5.10.1.14 Digital Input Debounce Count

The count for all digital input is by default set to ‘1’. The digital inputs are checked at a fixed rate (every 2ms). By setting the count to a higher value, the handler function will only be called, when the input is seen to have settled at a level, for the defined number of counts, each time it is checked.

5.10.1.15 Digital Input Invert Input

This parameter invert the logic associated with a digital input handler function. Default operation for each handler function was listed earlier. If the invert option is set, it will invert this logic. By default the invert option is not set.

For example, the default operation of the automatic/manual input is to set the drive into manual mode if the input is cleared, and into automatic mode if the input is set. By setting the invert parameter for this input, it will set the drive into automatic mode if the input is cleared, and into manual mode if the input is set.

5.10.1.16 Digital Input Status Word

The digital input status word shows the state of the 8 bits of the digital input word. The LSB corresponds to I1, and the MSB corresponds to I8. A bit is shown as 1, if the digital input is set, and shown as 0, if the digital input is cleared. This is the case regardless of the invert option being set.

5.10.2 Digital Output Functionality

There are 3 digital outputs on the CSA, numbered O1 to O3 on the CSA front-panel. All 3 outputs are user-configurable. The user can configure: -

- The bits within a specific parameter that is to be associated with the digital output. This is performed by setting the parameter field number and a mask to select specific bits.
- Invert the logic of the digital output, such that if the selected bit is set, the output is cleared and vice versa.

The parameters associated with outputs are listed below. Note that the names of the parameters and the numbers on the front-panel both start at 1:

Table 5-20 List of Digital Output Parameters

Field Number	Type	Name
1561	U16	digital_output_1_field_number
1562	U32	digital_output_1_mask
1563	U08	digital_output_1_invert
1564	U16	digital_output_2_field_number
1565	U32	digital_output_2_mask

1566	U08	digital_output_2_invert
1567	U16	digital_output_3_field_number
1568	U32	digital_output_3_mask
1569	U08	digital_output_3_invert

5.10.2.1 Digital Output Field and Mask

The user must define specific bits within a specific parameter, which is to be associated with a digital output. The Field value of the parameter (i.e. a unique number identifying a specific parameter) must be entered into the digital output field number parameter, to specify the parameter of interest. This field number is listed in the parameter database, in the utilities panel of the GUI.
The bits within the field are specified by entering the appropriate mask into the digital output mask parameter. This mask is ANDed with the parameter specified by the field number to determine the digital output state.

For example, Bit 7 of the DS402 status word indicates a warning on the drive. If digital_output_1_field_number is set to the field value of the *DS402_status_word* parameter (i.e. 1651), and digital_output_1_mask is set to 0x80, then digital output 1 will be 0 in when no warnings are present, and will be 1 when a warning occurs.

The mask can select a number of bits in a parameter. If any of these bits are set, then the digital output will be 1, otherwise the output will be 0.

5.10.2.2 Digital Output Invert Output

In a similar manner to the digital inputs, this parameter inverts the logic associated with a digital output. Default operation is that if the bit is set in the parameter the output is set to 1, and when the bit is cleared the output is set to 0. If the invert option is set, it will invert this logic, such that clearing the bit will set the digital output to '1' and vice versa.

5.10.2.3 Default Settings

- The default setting for digital output 1 is for the output to be set high when the drive is enabled.
- The default setting for digital output 2 is for the output to be set high when self-protection current limiting is active.
- The default setting for digital output 3 is for no output.

5.10.3 Digital I/O Parameters

Table 5-21 Digital I/O Parameter Access Detail

Parameter Name	Field Number	Data Type	Access	Default Value	Minimum Value	Maximum Value	Units	Storage Type	Data Group
DIGITAL INPUT									
hardware_enable_configuration	1545	u08	r/w	0	-	-	none	C	A
hardware_enable_debounce_count	1546	u08	r/w	1	-	254	none	C	A
hardware_enable_invert	1660	u08	r/w	0	-	1	none	C	A
hardware_enable_control	1672	u08	r/w	0	-	-	none	C	A
digital_input_1_configuration	1547	u08	r/w	0	-	-	none	C	A
digital_input_1_debounce_count	1548	u08	r/w	1	-	254	none	C	A
digital_input_1_invert	1661	u08	r/w	0	0	1	none	C	A
digital_input_1_control	1673	u08	r/w	0	-	-	none	C	A
digital_input_2_configuration	1549	u08	r/w	0	-	254	none	C	A
digital_input_2_debounce_count	1550	u08	r/w	1	-	-	none	C	A
digital_input_2_invert	1662	u08	r/w	0	0	1	none	C	A
digital_input_2_control	1674	u08	r/w	0	-	-	none	C	A
digital_input_3_configuration	1551	u08	r/w	0	-	-	none	C	A
digital_input_3_debounce_count	1552	u08	r/w	1	-	254	none	C	A
digital_input_3_invert	1663	u08	r/w	0	0	1	none	C	A
digital_input_3_control	1675	u08	r/w	0	-	-	none	C	A
digital_input_4_configuration	1553	u08	r/w	0	-	-	none	C	A
digital_input_4_debounce_count	1554	u08	r/w	1	-	254	none	C	A
digital_input_4_invert	1664	u08	r/w	0	0	1	none	C	A
digital_input_4_control	1676	u08	r/w	0	-	-	none	C	A
digital_input_5_configuration	1555	u08	r/w	0	-	-	none	C	A
digital_input_5_debounce_count	1556	u08	r/w	1	-	254	none	C	A
digital_input_5_invert	1665	u08	r/w	0	0	1	none	C	A
digital_input_5_control	1677	u08	r/w	0	-	-	none	C	A
digital_input_6_configuration	1557	u08	r/w	0	-	-	none	C	A
digital_input_6_debounce_count	1558	u08	r/w	1	-	254	none	C	A
digital_input_6_invert	1666	u08	r/w	0	0	1	none	C	A
digital_input_6_control	1678	u08	r/w	0	-	-	none	C	A

digital_input_7_configuration	*1559*	*u08*	*r/w*	*0*	*-*	*-*	*none*	*C*	*A*
digital_input_7_debounce_count	*1560*	*u08*	*r/w*	*1*	*-*	*254*	*none*	*C*	*A*
digital_input_7_invert	*1667*	*u08*	*r/w*	*0*	*0*	*1*	*none*	*C*	*A*
digital_input_7_control	*1679*	*u08*	*r/w*	*0*	*-*	*-*	*none*	*C*	*A*
digital_input_status_word	*1542*	*u08*	*r*	*-*	*-*	*-*	*none*	*N*	*A*
BRAKE RELEASE									
brake_control	1603	u16	r/w	1	-	-	none	C	A
brake_fault_control	1505	u16	r/w	1	-	-	none	C	A
QUICKSTOP									
quickstop_mode	1013	u08	r/w	1	-	-	none	C	A
standby_velocity	1138	f32	r/w	1	0.05	1000	rad/s	C	A
brake_lock_to_disable_timeout	1004	f32	r/w	0.1	0	5	s	C	A
velocity_rampdown_time_limit	1143	f32	r/w	1	0	1000	s	C	A
AUTOMATIC/MANUAL									
manual_mode_limit	1133	f32	r/w	10	0	100	%	C	A
current_maximum_physical	1124	f32	r	-	-	-	A	N	A
motor_max_velocity	1085	f32	r	-	-	-	rad/s	N	A
DIGITAL OUTPUT									
digital_output_1_field_number	1561	u16	r/w	1544	-	-	none	C	A
digital_output_1_mask	1562	u32	r/w	0x80	-	-	none	C	A
digital_output_1_invert	1563	u08	r/w	0	0	1	none	C	A
digital_output_2_field_number	1564	u16	r/w	1132	-	-	none	C	A
digital_output_2_mask	1565	u32	r/w	0xD	-	-	none	C	A
digital_output_2_invert	1566	u08	r/w	0	0	1	none	C	A
digital_output_3_field_number	1567	u16	r/w	1542	-	-	none	C	A
digital_output_3_mask	1568	u32	r/w	0	-	-	none	C	A
digital_output_3_invert	1569	u08	r/w	0	0	1	none	C	A

5.11 Control Loops

There are three loops that can be closed by CSA, depending on the mode of operation of the drive. These torque, velocity and position loops are nested inside each other, with the output of each compensator, being the reference for the next inner loop.

- In torque mode only the torque/current loop is closed, with a torque set-point or demand selected by the user.
- In velocity mode, the velocity compensator output is input to the current loop, with a velocity demand set by the user.
- In position mode, the position compensator output is input to the velocity loop, with the velocity compensator output in turn input to the current loop. Again the user sets the position demand.

The diagram below shows the overall control loop structure.

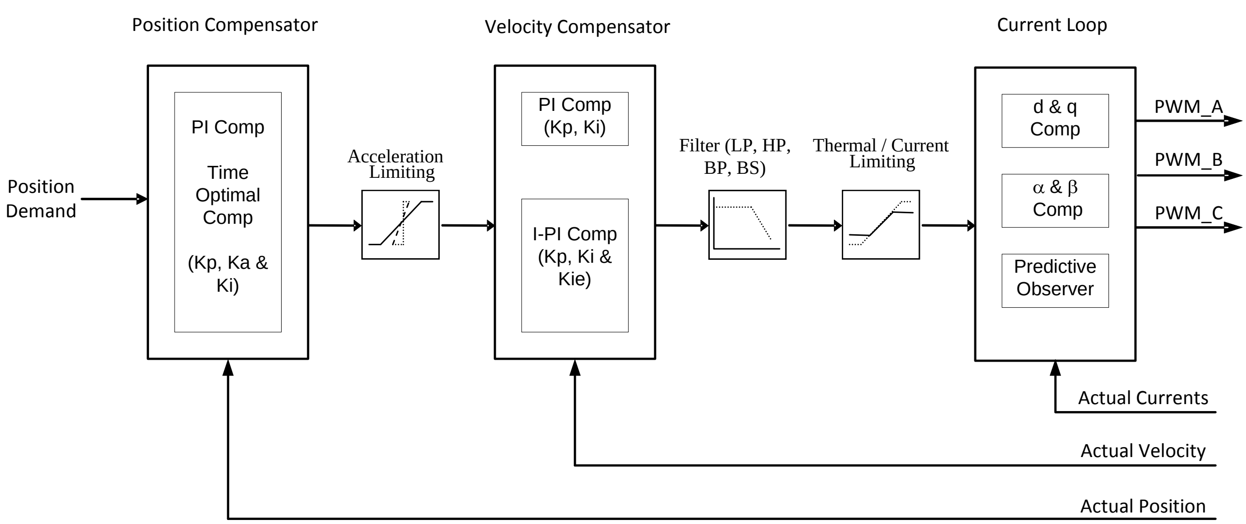

Figure 5.5 Overall Drive Control Loop Structure

The following sections of the manual will describe in more detail each of the blocks listed above, beginning from left to right.

5.11.1 Position Loop Compensator

5.11.1.1 PI Compensator

The outer most control loop in the control structure is the position loop. Two options exist for the position compensator. These are a PI compensator; or a time-optimal compensator.

The PI compensator has a structure as shown in the diagram below:

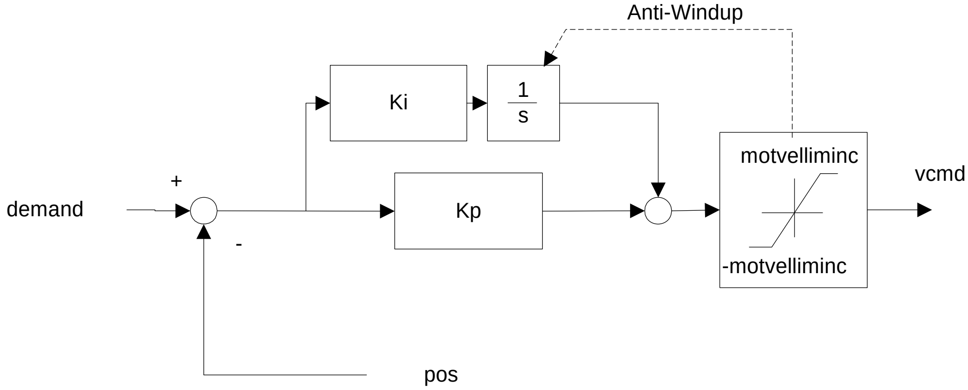

Figure 5.6 Position Loop PI Compensator Structure

The output of the compensator is limited to '`motvelliminc`', a term derived from the motor_max_velocity (Field Number 1085) parameter. The compensator also implements anti-windup for the compensator's integrator. The PI compensator has the gains as listed below.

Table 5-22 List of Position Loop PI Compensator Gains

Field Number	Name	Type	Units
1326	position_PI_loop_p-gain	f32	1/s
1327	position_PI_loop_i-gain	f32	$1/s^2$

Table 5-23 Position Loop PI Compensator Read-only Parameters

Field Number	Name	Type	Units
1328	position_PI_loop_error	f32	radians
1034	internal_loop_demand	f32	Amps
1157	velocity_command_acceleration_limited	f32	RPM

5.11.1.2 Time-Optimal Compensator

The time-optimal compensator is a non-linear compensator that uses a square root function of the position error, to give optimal deceleration performance.

The position error is scaled by parameter thermal_limit_factor (Field Number 1397) to give a scaled position error (i.e. thermal_limit_factor is 1 when no limiting, <1 when limiting),. Dependent on the size (i.e. absolute) of this scaled position error, the output of the compensator will have a linear relationship to the scaled position error, for small position errors, OR will have a square root relationship for larger errors. The cut-off point between the linear and square root relationship depends on $Ka / (Kp^2)$.

In addition, if the absolute value of the position error of the axis is smaller than a programmable limit (*position_TO_enable_velocity_integrator*), then the I part of the velocity compensator, used when in position mode, must be enabled to overcome friction i.e.: -

Abs(position error) <= limit => Activate the I-Term in the velocity compensator.

The compensator has a structure as shown below.

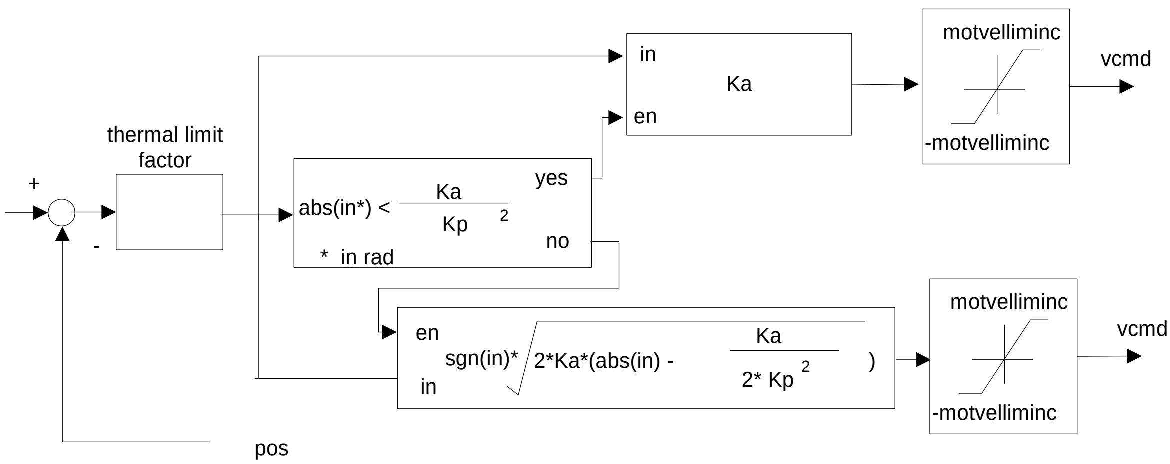

Figure 5.7 Position Loop Time Optimal Compensator Structure

The time-optimal position compensator has gains as listed below.

Table 5-24 List of Position Loop Time Optimal Compensator Gains

Field Number	Name	Type	Units
1340	position_TO_loop_a-gain	f32	rad/s^2
1342	position_TO_loop_p-gain	f32	1/s
1350	position_TO_loop_enable_velocity_i-term	f32	rad

Table 5-25 Position Loop TO Compensator Read-only Parameters

Field Number	Name	Type	Units
1337	position_TO_loop_error	f32	radians
1034	internal_loop_demand	f32	Amps
1157	velocity_command_acceleration_limited	f32	incs/Tsamp

5.11.1.3 Velocity compensator (when in position mode)

When in position mode, the position compensator output is a velocity command, which is input to a PI velocity compensator, to produce the torque demand. Note that the velocity compensator used in position mode is separate to that used in velocity mode, thus allowing different gains to be used in velocity mode to position mode. The PI velocity loop compensator structure is shown following, where `vcmdsav` is the acceleration limited velocity command, in incs/Tsamp. `Velf` is the filtered actual velocity, and `iqdv` is the compensator output, or torque command: -

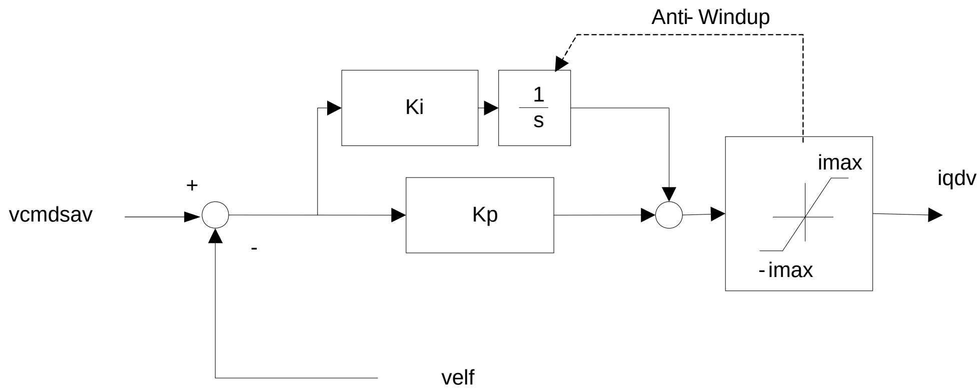

Figure 5.8 Velocity Loop (When in position mode) Compensator Structure

The output of this compensator is limited to ± the maximum current ‘`imax`’ (Field Number 1093), since it is used subsequently as a demand for the current loop. The compensator has parameters are listed below:

Table 5-26 List of Position Loop’s Velocity Loop Compensator Gains

Field Number	Name	Type	Units
1305	*position_mode_velocity_loop_p-gain*	f32	Nm/rad/s
1306	*position_mode_velocity_loop_i-gain*	f32	Nm/rad

Table 5-27 List of Position Loop’s Velocity Loop Read-only Parameters

Field Number	Name	Type	Units
1307	*position_mode_velocity_loop_error*	f32	RPM
1165	*velocity_filtered*	f32	RPM
1120	*current_demand_velocity_comp_output*	f32	Amps.
1093	*current_max*	f32	Amps

5.11.2 Velocity Loop compensator

In velocity mode, the velocity compensator is an I-PI configuration, and has the structure as shown below: -

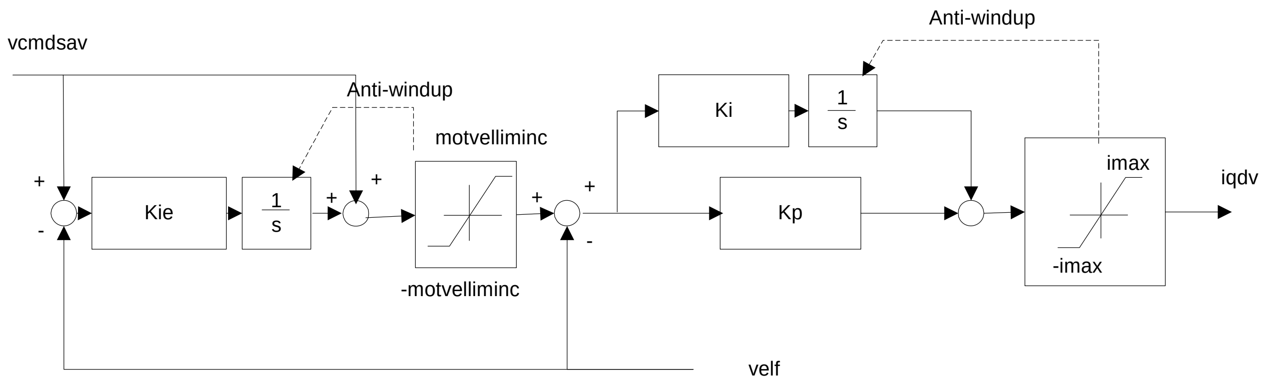

Figure 5.9 Velocity Loop (When in velocity mode) Compensator Structure

The output of this compensator is limited to ± *imax*, and these limits can be read using the upper and lower limit parameters of the compensator. The I-PI velocity loop compensator has gains as listed below.

Table 5-28 List of Velocity Loop Compensator Gains

Field Number	Name	Type	Units
1317	velocity_mode_p-gain	f32	Nm/rad/s
1318	velocity_mode _i-gain	f32	Nm/rad
1319	velocity_mode _ie-gain	f32	none

Table 5-29 List of Velocity Loop Read-only Parameters

Field Number	Name	Type	Units
1320	velocity_mode _error	f32	RPM
1165	velocity_filtered	f32	RPM
1120	current_demand_velocity_comp_output	f32	Amps.

5.11.2.1 Velocity Loop Sample Rate

The velocity loop sample period can be set to any multiple of the current loop sample period (125us) using the parameter velocity_loop_rate_divider (Field Number 1136).

5.11.2.2 Acceleration/Deceleration limiting

The acceleration/deceleration limiting is performed on the velocity command. In position control mode this is the output of the position compensator.

The acceleration limiting parameter is acceleration_limit (Field Number 1335), and has units of rad/s^2.
The deceleration limit can be set separately from the acceleration limit. The deceleration limiting parameter is deceleration_limit (Field Number 1668), and has units of rad/s^2.
The deceleration limits for fault mode and for quickstop can be set separately from the normal deceleration limit. The fault mode deceleration limiting parameter is deceleration_limit_-_fault (Field Number 1671), and has units of rad/s^2.

The quickstop mode deceleration limiting parameter is deceleration_limit_-_quickstop (Field Number 1670), and has units of rad/s^2.

Note that writing to the acceleration limit has the effect of setting all of the deceleration limits to the same value as the acceleration limit, so if a deceleration limit is required to be different then it must be written after the acceleration limit.

Note that writing to the deceleration limit has the effect of setting all of the deceleration limits to the same value as the deceleration limit, so if either the fault or quickstop deceleration limit is required to be different then it must be written after the deceleration limit.

The velocity command input to the acceleration-limiting block is *velocity_command* (Field Number 1156). The output of the acceleration-limiting block is *velocity_command_acceleration_limited* (Field Number 1157). These may both be monitored using the GUI scope to view the effect of acceleration limiting.

These velocity terms have embedded units of “increments/(velocity loop sample period)” and can be converted to rad/s using the expression (where ‘vcmdsav’ = *velocity_command_acceleration_limited*),

$$velocity\ command\ \ (rad/s) = \frac{2\pi}{2^{16}}\ \frac{swifrq}{veldiv}\ vcmdsav$$

This expression can also be used to convert velocity (Field Number 1151), and velocity_filtered (Field Number 1165) to rad/s.

5.11.2.3 Velocity Limiting

There are several ways in which the velocity is limited. These are listed below: -

1. The parameter *velocity_maximum* (Field Number 1800) sets the maximum value for the velocity command. This value is stored in NVM.

2. The parameter *velocity_limit* (Field Number 1802) can be used to limit the velocity temporarily to some value less than the maximum velocity. This parameter can be used in real-time messages, but is not stored to NVM.

3. The velocity of the drive is reduced when in manual mode. This reduces the velocity of the drive to a percentage (default is 10%) of the max velocity. This functionality is outlined earlier in the digital input section of the manual.

4. The velocity of the drive is also reduced/controlled when in torque mode. There is no velocity loop when in torque mode so the following method is applied. A linear de-rating of the torque applied to the motor is implemented when the velocity of the drive exceeds the velocity limit of the drive (i.e. limit in either manual or automatic mode). The de-rating is such that the demand torque is applied when at the velocity limit, but that torque is reduced to zero, when at 5% above the velocity limit. The de-rating gives a smoother profile, than simply zeroing torque if the velocity limit is exceeded. The following diagram shows the implementation:

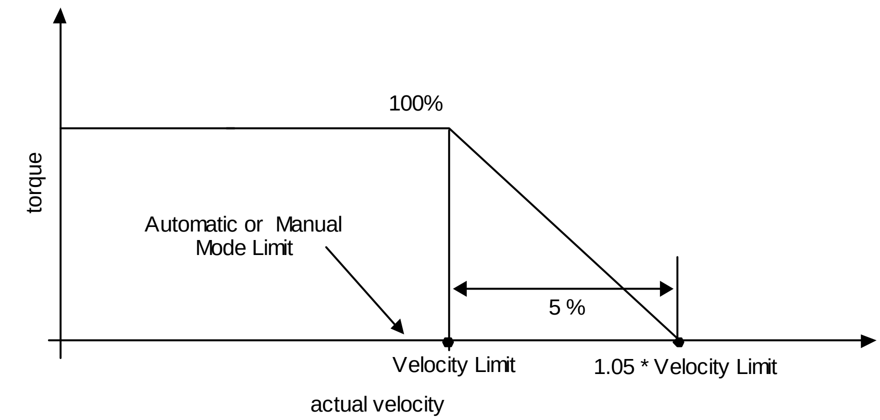

Figure 5.10 Velocity limiting when in Torque Mode

5.11.2.4 Velocity Loop Filter

The generic filter has 9 programmable parameters. Therefore, it may be configured as hi-pass, low-pass, band-pass or band-stop, to allow for maximum flexibility. The output of the velocity compensator becomes the input to the generic filter, denoted by *current_demand_velocity_comp_output* (1120). The output of the generic filter is *current_demand_generic_filter_output* (1122). These two parameters may be monitored on the GUI scope to view the filter activity in real time. The filter may be included/excluded by setting/clearing the appropriate bit in the control loop configuration (see section 5.11.4)

The filter is run at the velocity loop sample rate.

The Generic filter that is implemented is listed below, where $yf(k)$ is the filter output, and $y(k)$ is the filter input at a particular sample instant k.

$$yf(k) = -\left(a_1 \times yf(k-1) + a_2 \times yf(k-2) + a_3 \times yf(k-3) + a_4 \times yf(k-4)\right) + \left(b_0 \times y(k) + b_1 \times y(k-1) + b_2 \times y(k-2) + b_3 \times y(k-3) + b_4 \times y(k-4)\right)$$

The filter has the following set of parameters:

Table 5-30 List of Filter Parameters

Field Number	Name	Type
1351	velocity_loop_filter_coefficient_a1	F32
1352	velocity_loop_filter_coefficient_a2	F32
1353	velocity_loop_filter_coefficient_a3	F32
1354	velocity_loop_filter_coefficient_a4	F32
1355	velocity_loop_filter_coefficient_b0	F32
1356	velocity_loop_filter_coefficient_b1	F32
1357	velocity_loop_filter_coefficient_b2	F32

Field Number	Name	Type
1358	velocity_loop_filter_coefficient_b3	F32
1359	velocity_loop_filter_coefficient_b4	F32
1360	velocity_loop_mode	F32

The mode parameter determines the number of multiplications used to compute the filter output. If *velocity_loop_filter_mode* is set to 1, then only parameters b0, b1, b2, a1, a2 are used to compute the filter output. This configuration is consistent with a second order low-pass or high-pass Butterworth digital filter.

If *velocity_loop_filter_mode* is set to 2, then all 9 parameters are used to compute the filter output. This configuration is consistent with a second order band-pass or band-stop Butterworth digital filter.

Naturally, lower order filter designs are allowed. For example, a first order filter. But in this case the unused parameter must be set to zero.

5.11.2.5 Low-pass filter

For example the coefficients of a second order low-pass butterworth filter with a cut-off frequency of 0.1 time's half the sampling frequency, can be determined as being: -

$b_0 .. b_2 =$ *0.02008336556421 0.04016673112842 0.02008336556421*
$a_0 .. a_2 =$ *1.00000000000000 -1.56101807580072 0.64135153805756*

If the velocity loop rate modulus is 4 and the switching frequency parameter is 9920Hz, Then, the velocity loop sample rate is 400 μs approximately (= 2.5kHz approx).

Hence, the 0.1 filter factor means that the low-pass filter cut-off is 0.1*(Fs / 2) = 0.1*(2.5kHz / 2) = 125Hz.

Setting the filter coefficient parameters of the filter accordingly and setting the mode to '1', implements this filter in the drive. Note that parameter a0 is always 1.0.

5.11.2.6 Band-stop filter (Notch)

The coefficients of a second order band-stop Butterworth filter with a notch between 0.1 time's half the sampling frequency, and 0.2 time's half the sampling frequency, can be determined as being: -

$b_0 .. b_4 =$ *0.80059240346457 -2.88889936383274 4.20729857288451 -2.88889936383274 0.80059240346457*
$a_0 .. a_4 =$ *1.00000000000000 -3.21244081546948 4.16713184175608 -2.56535791219600 0.64135153805756*

If the velocity loop rate modulus is 4 and the switching frequency parameter is 9920Hz, then, the velocity loop sample rate is 400 μs approximately (= 2.5kHz approx).

Hence, the notch entry cut-off is: - 0.1*(Fs / 2) = 0.1*(2.5kHz / 2) = 125Hz.
And, the notch exit cut-off is: - 0.2*(Fs / 2) = 0.2*(2.5kHz / 2) = 250Hz.

Setting the filter coefficient parameters of the filter accordingly and setting the mode to 2, will implement this filter, in the drive. Note that parameter a0 is always 1.0.

5.11.2.7 Velocity feedback filter

A low-pass first order filter is also included on the motor feedback velocity. The feedback velocity is held in the parameter *velocity_actual* (Field Number 1151), with the low-pass filtered velocity held in a parameter called *velocity_filtered* (Field Number 1165). It is this filtered velocity variable that is used to close the velocity loop.

The filter is not a Butterworth, but instead, is a simple Euler approximation filter, characterised by two filter coefficients. The filter cut-off is specified with a filter cut-off factor (FCF), held in a parameter called *velocity_filter_cutoff_factor* *velocity_filter_cutoff_factor* (Field Number 1164). The two filter coefficients (a_1 and b_0) are computed in the embedded software each time the user writes to the cut-off factor

$$a_1 = 1 / (1 + 2*\pi*\textit{velocity\_filter\_cutoff\_factor});$$
$$b_0 = 2*\pi*\textit{velocity\_filter\_cutoff\_factor} / (1 + 2*\pi*\textit{velocity\_filter\_cutoff\_factor});$$

Setting *velocity_filter_cutoff_factor* to 0.5 sets the filter cut-off to half the velocity loop sample rate. Hence, the default speed cut-off factor of 0.25 will set the filter cut-off to 625Hz, when the velocity sample rate is 2.5kHz.

5.11.3 Current / Torque Loop Compensator

The inner most loop is the current or torque loop. The current loop tuning gains are computed from a Matlab simulation. This uses time domain continuous time analysis to compute the Laplace domain gains for the current controller. These are then mapped to the discrete domain using a standard pole placement algorithm. A default set of current loop parameters will be held in the GUI motor database for all standard motors. The general current loop control structure, along with parameter names are illustrated below. The parameters indicated are accessible to the user, and can be plotted on the GUI oscilloscope if required.

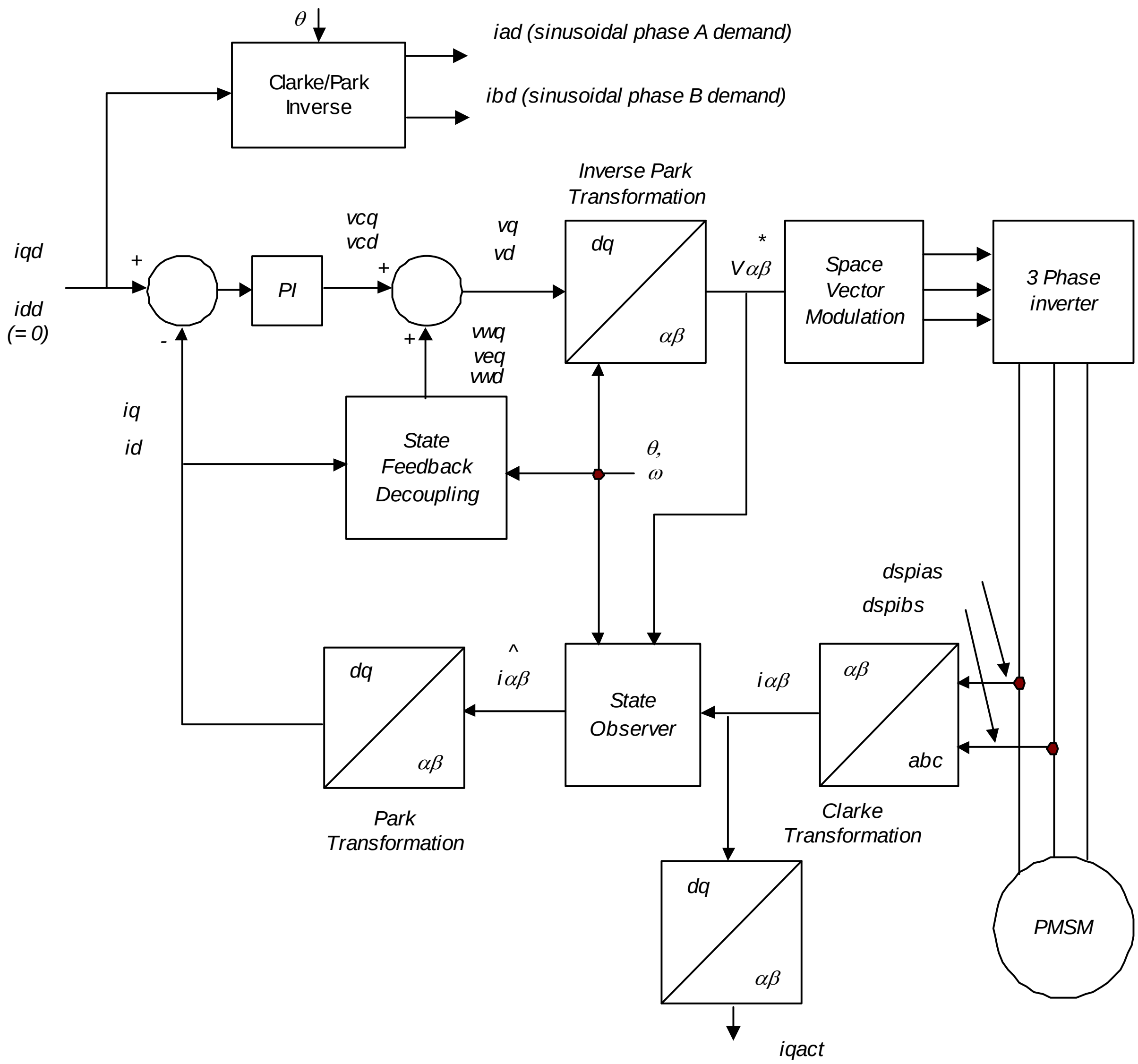

Figure 5.11 General Current Loop Structure

5.11.3.1 Current Loop Components

The current control consists of a pair of compensators, one for the q-axis current control, and the other for d-axis current control. The feedback currents current_q-axis_observer and current_d-axis_observer are output from the predictive current state observers. The predictive observer is used by default for improved performance, by setting the **OBSERVER** bit in the mode request of the drive. The actual q-axis current current_actual, is computed directly from the sampled phase A and phase B motor currents *current_phase_A_feedback, current_phase_B_feedback*, respectively.

For close inspection of torque, the observer predicted current_q-axis_observer, or the actual q-axis feedback, current_actual, can be monitored using the GUI's oscilloscope, as can any of the parameters listed below.

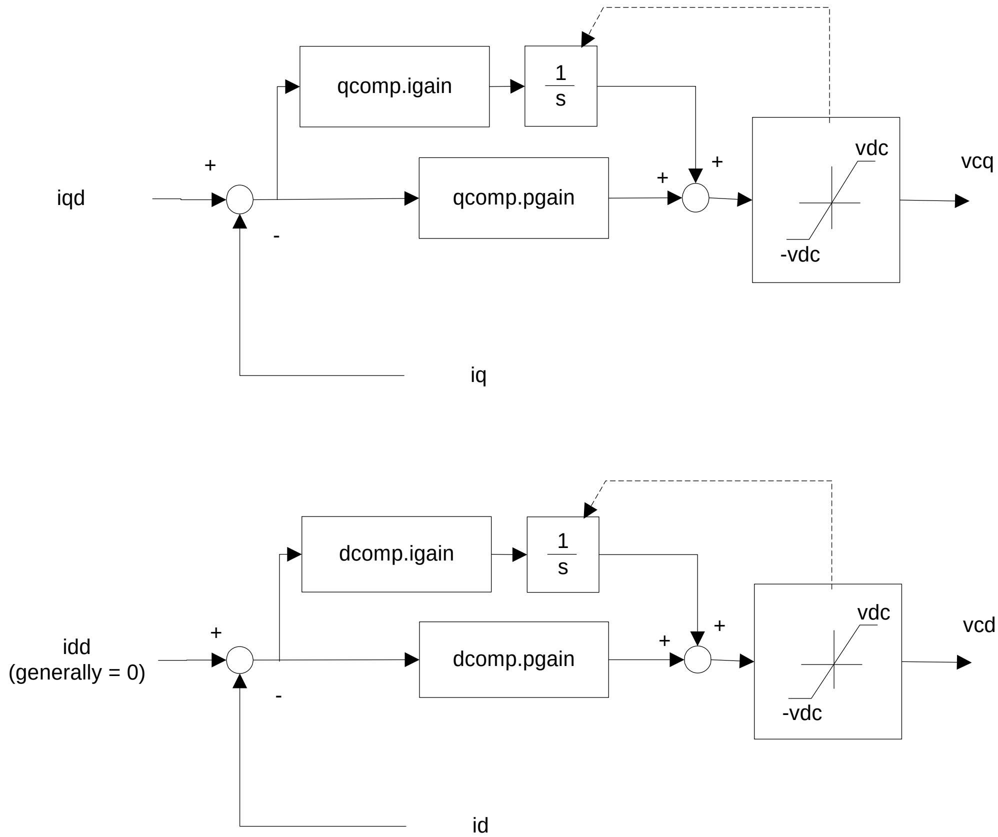

Figure 5.12 d,q current compensator

Gain calibration parameters can be used to back off the current loop gain at high currents to enable the use of motors with high saturation. The current_loop_foldback_breakpoint sets the current at which the current loop gain starts to reduce and current_loop_foldback_minimum sets the fraction of the gain to be used at maximum current. The gains are decreased linearly between the current_loop_foldback_breakpoint and the maximum current. The current loop d and q axis compensators gains, and the observer α and β compensators tuning gains are summarised in the table below.

Table 5-31 List of Current Loop Compensator Gains

Field No.	Name	Type	Units	Comment
1272	*current_loop_d-axis_i-gain*	f32	V/A/sec	dcomp.igain
1274	*current_loop_d-axis_p-gain*	f32	Volts/Amp	dcomp.pgain
1277	*current_loop_q-axis_i-gain*	f32	V/A/sec	qcomp.igain
1279	*current_loop_q-axis_p-gain*	f32	Volts/Amp	qcomp.pgain
1288	*current_loop_alpha_observer_i-gain*	f32	V/A/sec	oacomp.igain
1290	*current_loop_alpha_observer_p-gain*	f32	Volts/Amp	oacomp.pgain
1293	*current_loop_beta_observer_i-gain*	f32	V/A/sec	obcomp.igain
1295	*current_loop_beta_observer_p-gain*	f32	Volts/Amp	obcomp.pgain
1284	*current_loop_foldback_minimum*	f32	none	calkmin
1285	*current_loop_foldback_breakpoint*	f32	Amp	calimin

The table below lists parameter or signals that can be monitored by the GUI, and can be useful during loop tuning.

Table 5-32 List of Current Loop Signal Parameters

Field Number	Name	Type	Units	Comment
1096	current_d-axis_observer	f32	Amps	id
1097	current_q-axis_observer	f32	Amps	iq
1098	current_d-axis_demand	f32	Amps	idd
1099	current_q-axis_demand	f32	Amps	iqd
1104	current_phase_A_demand	s16	Amps	iad
1105	current_phase_B_demand	s16	Amps	ibd
1069	current_phase_A_feedback	s16	see note 1	dspias
1070	current_phase_B_feedback	s16	see note 1	dspibs
1287	current_loop_q-axis_error	f32	Amps	qcomp.error
1286	current_loop_d-axis_error	f32	Amps	dcomp.error
1298	current_loop_alpha_observer_error	f32	Amps	oacomp.error
1299	current_loop_beta_observer_error	f32	Amps	obcomp.error
1119	current_actual	f32	Amps	iqact

WARNING: DANGER OF UNCONTROLLED MOTOR ACCELERATION

The CSA has specialised motor current compensation. For optimum performance the CSA operates a software model of the current loop. The correct motor electrical parameters are required for this software model. Large errors in the motor parameters can result in uncontrolled motion.

Small torque commands can result in a continuous motor acceleration. The velocity of the motor can increase in an uncontrolled way if no counter-balancing torque is present. The user's control system should ensure that the speed of the motor is monitored, and that a compensating torque command is applied to control the motor speed if necessary.

5.11.3.2 Motor Velocity Loop Sample Rate

The motor velocity loop sample period can be set to any multiple of the current loop sample period (125us) using the parameter *motor_velocity_loop_rate_divider* (Field Number 1144).

5.11.3.3 Motor Velocity feedback filter

A low-pass first order filter is also included on the motor feedback velocity. The motor feedback velocity is held in the parameter *motor_velocity_actual* (Field Number 1152), with the low-pass filtered velocity held in a parameter called *motor_velocity_filtered* (Field Number 1163). It is this filtered velocity variable that is used to limit the motor velocity. (See Section B.3.19 for the units on these parameters.)

The filter is a simple Euler approximation filter, characterised by two filter coefficients. The filter cut-off is specified with a filter cut-off factor (FCF), held in a parameter called *motor_velocity_filter_cutoff_factor* (Field Number 1162). The two filter coefficients (a_1 and b_0) are computed in the embedded software each time the user writes to the cut-off factor

$$a_1 = 1 / (1 + 2*\pi* \mathit{motor\_velocity\_filter\_cutoff\_factor});$$
$$b_0 = 2*\pi*\mathit{motor\_velocity\_filter\_cutoff\_factor} / (1 + 2*\pi* \mathit{motor\_velocity\_filter\_cutoff\_factor});$$

Setting *motor_velocity_filter_cutoff_factor* to 0.5 sets the filter cut-off to half the motor velocity loop sample rate. Hence, the default motor speed cut-off factor of 0.25 will set the filter cut-off to 625Hz, when the velocity sample rate is 2.5kHz.

5.11.3.4 Motor Velocity Limiting

The *motor_max_velocity* (Field Number 1082) is set as one of the motor parameters, when a drive is configured for use with a particular motor.

A linear de-rating of the torque applied to the motor is implemented when the velocity of the drive exceeds the motor max velocity. The de-rating is such that the demand torque is applied when at the velocity limit, but that torque is reduced to zero, when at 5% above the velocity limit. The de-rating gives a smoother profile, than simply zeroing torque if the velocity limit is exceeded.

5.11.4 Control Loop Configuration

The control loops are configured by setting/unsetting bits in an internal mode request (Field Number 1330) to switch in/out the various control loop elements. The mode request can be configured for each of the modes of operation: position, velocity and torque, by setting the appropriate mode preset parameter. The table below describes the bits that can be set in the mode request to configure the control loops:

NOTE: Any bit defined as a value (1 or 0) must be always set to that value.

Table 5-33 Mode Request bit Definitions

BIT	Definition
31 (MSB)	0
30	0
29	0
28	0
27	0
26	0
25	0
24	0
23	0
22	0
21	0
20	0
19	0
18	0
17	0
16	0
15	Fieldbus Command Source Enable
14	Reserved
13	ADC Command Source Enable
12	Stabilization Enable
11	Velocity Feed-Forward Enable
10	Acceleration Limiting Enable
9	Command Micro-Interpolation
8	Gain Calibration
7	Time-Optimal Position Loop Enable (Otherwise PI Loop)
6	Position Mode
5	Field Weakening Enable
4	Observer Enable
3	Generic Filter Enable
2	Function Generator Command Source Enable
1	Velocity Mode
0 (LSB)	Torque Mode

5.11.4.1 Torque Mode Preset

The parameter control_loop_torque_mode_preset (Field Number 1334) sets the mode request when a torque control mode is requested. The default value for this parameter is 33041 (8111 hex) indicating that bits 0, 4, 8 and 15 are set.

Note that the bit 0 must always be set in this parameter, bits 1 and 6 must never be set and bits 3, 7 and 10 have no meaning in torque mode.

5.11.4.2 Velocity Mode Preset

The parameter control_loop_velocity_mode_preset (Field Number 1333) sets the mode request when a velocity control mode is requested. The default value for this parameter is 34586 (871A hex) indicating that bits 1, 3, 4, 8, 9, 10 and 15 are set.

Note that the bit 1 must always be set in this parameter, bits 0 and 6 must never be set and bit 7 has no meaning in velocity mode.

5.11.4.3 Position Mode Preset

The parameter control_loop_position_mode_preset (Field Number 1332) sets the mode request when a position control mode is requested. The default value for this parameter is 34776 (87D8 hex) indicating that bits 3, 4, 6, 7, 8, 9, 10 and 15 are set.

Note that the bit 6 must always be set in this parameter, bits 0 and 1 must never be set in position mode.

5.11.5 Control Loop Parameters

Table 5-34 Control Loops Parameter Access Detail

Parameter Name	Field Number	Data Type	Access	Default Value	Minimum Value	Maximum Value	Units	Storage Type	Data Group
POSITION PI COMPENSATOR									
position_PI_loop_p-gain	1326	f32	r/w	2.0	0	-	1/s	C	A
position_PI_loop_i-gain	1327	f32	r/w	0	0	-	$1/s^2$	C	A
position_PI_loop_error	1328	f32	r	-	-	-	radians	N	A
internal_loop_demand	1034	f32	r	-	-	-	Amps	N	A
velocity_command_acceleration_limited	1157	f32	r	-	-	-	RPM	N	A
POSITION TO COMPENSATOR									
position_TO_loop_a-gain	1340	f32	r/w	-	-	-	rad/s^2	C	A
position_TO_loop_p-gain	1342	f32	r/w	-	-	-	1/s	C	A
position_TO_loop_enable_velocity_integrator	1350	f32	r/w	6.28	0	-	rad	C	A
position_TO_loop_error	1337	f32	r	-	-	-	radians	N	A
internal_loop_demand	1034	f32	r	-	-	-	Amps	N	A
velocity_command_acceleration_limited	1157	f32	r	-	-	-	RPM	N	A
POSITION MODE VELOCITY COMPENSATOR									
position_mode_velocity_loop_p-gain	1305	f32	r/w	0.05	0	-	Nm/rad/s	C	A
position_mode_velocity_loop_i-gain	1306	f32	r/w	2.0	0	-	Nm/rad	C	A
position_mode_velocity_loop_error	1307	f32	r	-	-	-	RPM	N	A
velocity_filtered	1165	f32	r	-	-	-	RPM	N	A
current_demand_velocity_comp_output	1120	f32	r	-	-	-	Amps	N	A
current_max	1093	f32	r	-	-	-	Amps	N	A
VELOCITY MODE COMPENSATOR									
velocity_mode_p-gain	1317	f32	r/w	0.05	0	-	Nm/rad/s	C	A
velocity_mode_i-gain	1318	f32	r/w	2	0	-	Nm/rad	C	A
velocity_mode_ie-gain	1319	f32	r/w	0	0	-	none	C	A
velocity_mode_error	1320	f32	r	-	-	-	RPM	N	A
velocity_filtered	1165	f32	r	-	-	-	RPM	N	A

current_demand_velocity_comp_output	*1120*	f32	r	-	-	-	Amps.	N	A

ACCELERATION LIMITING									
acceleration_limit	1335	f32	r/w	1000000	0	-	rad/s^2	C	A
deceleration_limit	1668	f32	r/w	1000000	0	-	rad/s^2	C	A
deceleration_limit_-_quickstop	1670	f32	r/w	1000000	0	-	rad/s^2	C	A
deceleration_limit_-_fault	1671	f32	r/w	1000000	0	-	rad/s^2	C	A
velocity_command_acceleration_limited	1157	f32	r	-	-	-	incs/Tsamp	N	A
velocity	1151	f32	r	-	-	-	RPM	N	A
velocity_filtered	1165	f32	r	-	-	-	RPM	N	A
VELOCITY LIMITING									
velocity_maximum	1800	f32	r/w	1000	0	20000	rad/s	C	A
velocity_limit	1802	f32	r/w	1000	0	20000	rad/s	N	A
VELOCITY LOOP FILTER									
current_demand_velocity_comp_output	1120	f32	r	-	-	-	Amps.	N	A
current_demand_vel_loop_filter_output	1121	f32	r	-	-	-	Amps	N	A
velocity_loop_rate_divider	1136	s16	r/w	1	1	-	none	C	A
switching_frequency	1194	u32	r	-	-	-	Hz	N	A
velocity_loop_filter_coefficient_a1	1351	f32	r/w	0	-	-	none	C	A
velocity_loop_filter_coefficient_a2	1352	f32	r/w	0	-	-	none	C	A
velocity_loop_filter_coefficient_a3	1353	f32	r/w	0	-	-	none	C	A
velocity_loop_filter_coefficient_a4	1354	f32	r/w	0	-	-	none	C	A
velocity_loop_filter_coefficient_b0	1355	f32	r/w	1	-	-	none	C	A
velocity_loop_filter_coefficient_b1	1356	f32	r/w	0	-	-	none	C	A
velocity_loop_filter_coefficient_b2	1357	f32	r/w	0	-	-	none	C	A
velocity_loop_filter_coefficient_b3	1358	f32	r/w	0	-	-	none	C	A
velocity_loop_filter_coefficient_b4	1359	f32	r/w	0	-	-	none	C	A
velocity_loop_filter_mode	1360	u16	r/w	1	1	2	none	C	A
VELOCITY FEEDBACK FILTER									
velocity_filter_cutoff_factor	1164	f32	r/w	0.25	0	100	Hz	C	A
velocity	1151	f32	r	-	-	-	RPM	N	A
velocity_filtered	1165	f32	r	-	-	-	RPM	N	A

CURRENT LOOP									
current_loop_d-axis_i-gain	1272	f32	r/w	6.35404981	0	-	V/A/sec	C	A
current_loop_d-axis_p-gain	1274	f32	r/w	32.02666839	0	-	V/A	C	A
current_loop_q-axis_i-gain	1277	f32	r/w	6.35404981	0	-	V/A/sec	C	A
current_loop_q-axis_p-gain	1279	f32	r/w	32.02666839	0	-	V/A	C	A
current_loop_alpha_observer_i-gain	1288	f32	r/w	0.01394492	0	-	V/A/sec	C	A
current_loop_alpha_observer_p-gain	1290	f32	r/w	0.19933257	0	-	V/A	C	A
current_loop_beta_observer_i-gain	1293	f32	r/w	0.01394492	0	-	V/A/sec	C	A
current_loop_beta_observer_p-gain	1295	f32	r/w	0.19933257	0	-	V/A	C	A
current_loop_foldback_minimum	1284	f32	r/w	0.4	0.1	1	None	C	A
current_loop_foldback_breakpoint	1285	f32	r/w	140.0	5.0	2000	A	C	A
current_d-axis_observer	1096	f32	r	-	-	-	Amps	N	A
current_q-axis_observer	1097	f32	r	-	-	-	Amps	N	A
current_d-axis_demand	1098	f32	r	-	-	-	Amps	N	A
current_q-axis_demand	1099	f32	r	-	-	-	Amps	N	A
current_phase_A_demand	1104	s16	r	-	-	-	Amps	N	A
current_phase_B_demand	1105	s16	r	-	-	-	Amps	N	A
current_phase_A_feedback	1069	s16	r	-	-	-	see note 1	N	A
current_phase_B_feedback	1070	s16	r	-	-	-	see note 1	N	A
current_loop_q-axis_error	1287	f32	r	-	-	-	Amps	N	A
current_loop_d-axis_error	1286	f32	r	-	-	-	Amps	N	A
current_loop_alpha_observer_error	1298	f32	r	-	-	-	Amps	N	A
current_loop_beta_observer_error	1299	f32	r	-	-	-	Amps	N	A
current_actual	1119	f32	r	-	-	-	Amps	N	A
motor_velocity_loop_rate_divider	1144	s16	r/w	1	1	-	None	C	A
motor_velocity_actual	1152	f32	r	-	-	-	Incs/Tsamp	N	A
motor_velocity_filtered	1163	f32	r	-	-	-	Incs/Tsamp	N	A
motor_velocity_filter_cutoff_factor	1162	f32	r/w	0.25	0	100	Hz	C	A
motor_max_velocity	1082	f32	r/w	1000	0	20000	rad/s	C	A
CONTROL LOOP CONFIGURATION									
control_loop_torque_mode_preset	1334	u32	r/w	0x8111 (Note 2)	-	-	none	C	A
control_loop_velocity_mode_preset	1333	u32	r/w	0x871A (Note 2)	-	-	none	C	A
control_loop_position_mode_preset	1332	u32	r/w	0x8758 (Note 2)	-	-	none	C	A

Note 1: units for the *current_loop_phase_x_feedback* parameters are *nominal_sensed_current* / 2^{15}. e.g. the parameters have a physical range of ± *nominal_sensed_current* represented as a signed 16-bit number.

Note 2: The presets for the various modes are as follows:

Option Description	Value	Default Torque Mode Preset (0x8111)	Default Velocity Mode Preset	Default Position Mode Preset
torque mode	0x00000001	Yes	n/a	n/a
velocity mode	0x00000002	n/a	Yes	n/a
Function Generator Control during velocity rampdowns (not a permanent setting)	0x00000004	n/a	n/a	n/a
Generic filter on velocity error	0x00000008	No	Yes	Yes
observer enable bit	0x00000010	Yes	Yes	Yes
field weakening enable bit	0x00000020	No	No	No
position control mode (inc vel loop)	0x00000040	n/a	n/a	Yes
time-optimal pos controller (else PI)	0x00000080	No	No	No
d,q gain calibration	0x00000100	Yes	Yes	Yes
enable command interpolation	0x00000200	No	Yes	Yes
apply accel limiting	0x00000400	No	Yes	Yes
include velocity feed-forward	0x00000800	No	No	No
Stabilisation	0x00001000	No	No	No
use ADC for command generation	0x00002000	No	No	No
use FBS/FGN for command generation	0x00008000	Yes	Yes	Yes

5.12 Drive Monitoring & Fault Detection

5.12.1 Drive Monitoring

The CSA monitors a range on internal and external drive voltages, temperatures, times and powers to ensure that the drive is operating correctly. Depending on the state of these feedback signals, the drive will react appropriately to ensure safe and reliable operation. The parameters monitored are listed below.

Table 5-35 Monitored Temperatures

Parameter Name	Field No./Sub Index	Description
bridge_temperature	1368	Power Amplifier Bridge Temperature
motor_temperature	1373	Motor Winding Temperature
ambient_temperature	1378	Control Electronics Ambient Temperature

Table 5-36 Monitored Voltages

Parameter Name	Field No. / Sub index	Description
supply_+24V	1441	Internal 24V Logic Supply
supply_+3V3	1421	3.3V Logic Supply
supply_-15V	1426	-15V Logic Supply
supply_+15V	1431	+15V Logic Supply
supply_+2.5V_ref.	1436	2.5V Reference Level
encoder_supply	1446	Encoder Supply
bus_voltage_actual	1232	DC Bus Voltage
supply_+5V	1942	+5Vdc Logic Supply
supply_+5VA	1941	5Vdc Analog Logic Supply

Table 5-37 Monitored Times

Parameter Name	Field No. / Subindex	Description
ETI_total_power_on_time	1482	Total powered up time
ETI_power_on_time_since_power_on	1483	Power up time since power up
ETI_number_of_power_downs	1484	Number of power downs
ETI_enabled_time	1485	Total enable time
ETI_enabled_time_since_power_on	1486	Enabled time since power up
ETI_enabled_time_since_enable	1487	Current enabled time

Table 5-38 Monitored Power

Parameter Name	Field No. / Sub index	Description
regen_power_filtered	1252	Average Regeneration Power (Measured)

5.12.2 Faults and User Indication in the CSA

This section outlines the user indication that is present on the CSA. The drive will, depending on its state, indicate via the 7-segment display, various messages to the user. These messages generally reflect the state of operation of the drive and any faults that may be present.

The CSA distinguishes between faults and warnings. Faults are those abnormal conditions that are of a serious enough consequence to cause the CSA to halt operation. This will always result in removal of power from the CSA high power amplifier, and will usually result in application of a motor brake, if present.

Warnings are those abnormal conditions that do not in themselves yet constitute a peril to the equipment or to personnel.

Table 5-39 7-Segment Display Indication

Display Status	Description
0	Logic voltage applied, High voltage applied. No faults present. Drive ready to be enabled
I	Drive Enabled
U* (Table 5.42)	* Warning state & No faults present
F* (Table 5.43)	Fault on drive

Tables 5.42 and 5.43 list the defined warnings and faults that may appear.

Table 5-40 7-Segment Warning Indication

Display U*	Warning Description	Drive Reaction
.	Current limiting Active : Due to: Thermal Foldback, Manual Mode or I^2t limiting	Current limited
U1	High Power Not Ready – soft start mode.	Drive will not enable
U2	Motor Thermal Warning : This warning indicates that the motor winding temperature is within 10% of the motor max temperature.	Current limited
U3	Power Amplifier Thermal Warning: This warning indicates that the power transistor heatsink temperature is within 10% of the bridge maximum temperature.	Current limited
U4	Regeneration Power Warning : This warning indicates that the power dissipated in the regen resistor(s) is within 10% of the continuous capability of the resistor(s).	None
U5	Position Tracking Warning : This warning indicates that the position error has exceeded a pre-set threshold. This error will only be present when the drive is in position mode.	None
U6	Limit Switch Warning : This warning indicates that either clockwise or counter clockwise limit switch has become active.	Cannot move in particular direction.
U7	24V Backup Supply Warning : This warning indicates that Logic supply is below 18 Volts, or greater than 32 Volts.	None

Display U*	Warning Description	Drive Reaction
U8	Manual Mode: This warning indicates that user has switched the drive into manual mode.	Current and velocity limited to limman % of normal limits.
U9	Enable Attempted Warning: This warning indicates that the user has attempted to enable the drive from a no fault state, but with at least one of the conditions for enable false (e.g. H/w enable false, Bus voltage not present).	Drive will not enable. Note that this warning will remain present once set until the drive is truly enabled
U10	Power Amplifier Thermal Limit Warning: This warning indicates that the power transistor heatsink temperature is causing the current to be limited.	Current limited
U11	Motor Thermal Limit Warning: This warning indicates that the motor winding temperature is causing the current to be limited.	Current limited
U12	Ambient Thermal Limit Warning: This warning indicates that the ambient (control card sensor) temperature is causing the current to be limited.	Current limited
U13	Ambient Thermal Warning : This warning indicates that the ambient (control card sensor) temperature is within 10% of the ambient max temperature.	Current limited
U14	Field Bus Warning: Set if the firmware and fieldbus card versions are inconsistent.	Drive will not engage
U15	Model Warning 1	Application Specific when used
U16	Model Warning 2	Application Specific when used
U17	I2T Limit Warning: Set if the absolute value of current demand pre-thermal limiting (Field 1122) is greater than or equal to the I2T current limit (Field 4241) and the drive is enabled.	Current Limited
U18	IT Limit Warning: Set if the IT limit integral current demand (Field 1130) is greater than the IT limit max IT product (Field 1129).	Current Limited

Table 5-41 7-Segment Display Fault Indication

F#	Description	Possible Cause(s)
F1	Power Stage Short Circuit Fault	Defective drive.
F2	DC Bus Over Voltage Fault	Excessive regen power.
F3	Regen Fault	Regen configuration fault/Excessive regen power.
F4	Ambient Over Temperature Fault	Insufficient control electronics cabinet cooling.
F5	Bridge Over Temperature Fault	Insufficient drive cooling.
F6	Motor Over temperature Fault	Motor tuning or power issue.
F7	Encoder Fault	Defective encoder. Defective encoder cable.
F8	Resolver Fault	Drive improperly configured. Resolver cable.
F9	Logic/Analog Supply Fault	External 24VDC power supply. Internal drive power supply.
F10	Database / NVM Fault	Drive improperly configured. Parameters corrupt.
F11	Fieldbus Fault	Motion base application not open. Open Fieldbus communication link.
F12	DC Bus Fault	Bus undervoltage.
F13	Program Fault	Drive internal programming error.
F14	Current Loop Fault	Current offsets. Drive improperly configured.
F15	Board Fault	Defective board in control head.

F#	Description	Possible Cause(s)
F16	Model Fault	Model timing task overrun.
F17	Interlock Fault	Dynamic brake contactor.
F18	Velocity Fault	Maximum feedback velocity exceeded.
F19	Static Position Fault	While stationary, actuator position exceeded tolerance.
F20	Dynamic Position Fault	While moving, actuator position exceeded tolerance.
F21	Reserved for future use	-
F22	Reserved for future use	-
F23	Control System Fault	System initiated fault.
F24	Hall Sensor Fault	Velocity fault.
F25	Homing RTH Fault	A drive fault occurred during the homing process.
F26	Homing Timeout Fault (6DOF2000)	Motion base did not return home in allotted time using RTH.
F26	AC Ready (Barrier)	Ready for AC mains application.
F27	Brake Release Fault	The brake failed to release at engage or indicated an applied condition while engaged.
blank	Undetermined Fault – (should never occur)	

5.12.2.1 Warning Group Descriptions

The following table lists the warnings and the associated action items and status codes

Table 5-42 CSA Warning Groups

Warning Name	Action	Status code
Group 01: DS Bus Inactive	Displayed	62
Group 02: Motor Thermal Warning	Logged & Displayed	100
Group 03: Bridge Thermal Warning	Logged & Displayed	101
Group 04: Regen Power Warning	Logged & Displayed	102
Group 05: Position Tracking Warning	Displayed	93
Group 06: Limit Switch Warning	Displayed	103
Group 07: Plus 24 Volt Warning	Displayed	65
Group 08: Manual Mode Enabled	Displayed	79
Group 09: Enable Attempted	Displayed	80
Group 10: Bridge Thermal Limit Warning	Logged & Displayed	87
Group 11: Motor Thermal Limit Warning	Logged & Displayed	85
Group 12: Ambient Thermal Limit Warning	Logged & Displayed	27
Group 13: Ambient Thermal Warning	Logged & Displayed	28
Group 14: Fieldbus Consistency Warning	Displayed	186
Group 15: Model Application Warning		
Model Application Warning 1 Bit 7	Logged & Displayed	208
Model Application Warning 1 Bit 6	Logged & Displayed	209
Model Application Warning 1 Bit 5	Logged & Displayed	210
Model Application Warning 1 Bit 4	Logged & Displayed	211
Model Application Warning 1 Bit 3	Logged & Displayed	212
Model Application Warning 1 Bit 2	Logged & Displayed	213
Model Application Warning 1 Bit 1	Logged & Displayed	214
Model Application Warning 1 Bit 0	Logged & Displayed	215
Group 16:		
Model Application Warning 2 Bit 7	Logged & Displayed	216
Model Application Warning 2 Bit 6	Logged & Displayed	217
Model Application Warning 2 Bit 5	Logged & Displayed	218
Model Application Warning 2 Bit 4	Logged & Displayed	219
Model Application Warning 2 Bit 3	Logged & Displayed	220
Model Application Warning 2 Bit 2	Logged & Displayed	221
Model Application Warning 2 Bit 1	Logged & Displayed	222
Model Application Warning 2 Bit 0	Logged & Displayed	223
Group 17: I2T Limit Warning	Logged & Displayed	98
Group 18: IT Limit Warning	Logged & Displayed	99
Group 19 through 32: Reserved for future use	Not Applicable	
The following warnings are not displayed and are only logged, they have no display code (Group Number)	Not Displayed	
Power Down NVM Save Error	Logged	16
Analog to Digital Command Offset Fault	Logged	30
COM1 overrun fault	Logged	33

Warning Name	**Action**	**Status code**
COM1 queue overrun fault	Logged	34
COM1 noise flag fault	Logged	35
COM1 framing error fault	Logged	36
COM1 parity flag fault	Logged	37
COM2 overrun fault	Logged	41
COM2 noise flag fault	Logged	42
COM2 framing error fault	Logged	43
COM2 parity flag fault	Logged	44
TPU Initialization Fault	Logged	55
Velocity Rampdown Fault (not a fault)	Logged	78
Drive Start OK	Logged	88
Thermal Limit Active	Logged	95
Programming Warning	Logged	121
Background Task Over-run	Logged	135
COM1 sw rx queue full	Logged	136
COM2 sw rx queue full	Logged	137
RS232 Initialization Fault	Logged	178
RS232 Communication Fault	Logged	179

5.12.3 Drive Fault Reaction

The CSA distinguishes between two types of faults:-

5.12.3.1 Fatal Faults

Faults with which the CSA cannot continue to control the motor, the CSA's reaction to a fatal fault is to immediately disable the switching of the power amplifier. For example, if resolver position sensing is lost, the motor cannot be commutated. The ability to control the motor output torque is therefore lost and the CSA immediately disables high power from the motor.

5.12.3.2 Non-Fatal Faults

Faults which will likely lead to equipment failure or hazards to personnel, but the CSA is still capable of controlling the motor output torque. For example, motor over-temperature is treated as a non-fatal fault, because the CSA can perform a controlled deceleration of the motor. Once the motor stops rotating, the drive can apply the brake and disable the drive.

5.12.3.3 Fatal Fault

If the drive detects a fatal fault, it immediately disables the power stage of the drive. If the drive is set to internal brake control, *brake_control_fault (Field Number* 1505*)* = ‘1’ (default setting), the drive will also apply the brake immediately. If it is set to '0', then the drive will disable the power stage but application of the brake is left to the user. Typically, the user would in this case, control the brake with a digital input.

Table 5-43 Fatal Faults

Fault Type	Drive Reaction	External Brake control	Internal Brake control
Fatal	Immediate Disable	Brake not applied	Brake Applied

5.12.3.4 Non-Fatal Fault

If the drive detects a non-fatal fault, its reaction depends on a number of parameters. The action of the drive is detailed below. On detection of a non-fatal fault, the drive immediately decelerates the drive to zero speed at the drive deceleration limit, *deceleration_limit_-_fault* (Field Number 1671). Once the velocity falls below the level set in parameter f*ault_reaction_velocity* (Field Number 1141), the brake is applied. The drive then disables the power stage after the time set in parameter *brake_bridge_timeout* (Field Number 1004) has elapsed. If the drive does not decelerate to a speed below *fault_reaction_velocity* within the time set by parameter *ramp_down_timeout* (Field Number 1143), the drive will disable anyway and apply the brake.

In each of the cases outlined above, the brake will only be applied if it is under internal control, b*rake_fault_control* set to '1'. As with the fatal fault detailed above, if this parameter is set to '0', then it is up to the user to manage the application and removal of the brake in fault conditions.

Table 5-44 Non-Fatal Faults

Fault Type	Drive Reaction	External Brake control	Internal Brake control
Non-Fatal	Controlled motor deceleration & disable	Brake not applied	Brake Applied

5.12.3.5 Fault Group Descriptions

The following table lists the errors, and the groups to which they will belong. It also lists the faults, as either being fatal or non-fatal, and the status code for the fault in the error log. Fatal requires the drive to be reset or power cycled to clear the fault, while non-fatal faults can be cleared if the condition is no longer present.

Table 5-45 Fault Descriptions

Fault Name	**Severity**	**Status code**
Group 01: Power Stage Short Circuit Fault		
Regeneration short circuit fault	NON-FATAL	61
Short circuit top fault	NON-FATAL	73
Short circuit bottom fault	NON-FATAL	77
Group 02: DC Bus Over-Voltage Fault		
Bus over-voltage fault	NON-FATAL	58
Group 03: Regeneration Fault		
Regeneration initialization fault	NON-FATAL	60
Regeneration Power Fault	NON-FATAL	70
Group 04: Ambient Over Temperature Fault		
Ambient over temperature fault	NON_FATAL	26
Group 05: Bridge Over temperature Fault		
Power stage over temperature fault	NON_FATAL	75
Bridge PTC fault	NON-FATAL	94
Group 06: Motor Over temperature Fault		
Motor over temperature fault	NON_FATAL	76
Group 07: Encoder Fault		
Loss of encoder fault	NON-FATAL	72
Encoder security loop fault	NON_FATAL	81
Encoder parity/gray code fault	NON_FATAL	82
Encoder count fault	NON-FATAL	83
Encoder supply fault	NON-FATAL	84
Group 08: Resolver Fault		
Loss of resolver fault	NON-FATAL	74
Group 09: Logic/Analogue Supply Fault		
3.3V supply fault	NON-FATAL	64
+15V supply fault	NON-FATAL	66
-15V supply fault	NON-FATAL	67
Power down detected (low Vdc)	NON-FATAL	68
2V reference fault	NON-FATAL	71
Group 10: Database/NVM Fault		
Parameter database NVM initialization error	NON_FATAL	168
NVM write fault	NON_FATAL	12
Parameter NVM checksum fault	NON_FATAL for CSA - EtherCAT, FATAL for CSA - MaxForce	13
NVM address out of range	FATAL	123
Group 11: Fieldbus Fault		
Process Data Object (PDO) fault	NON_FATAL	5

Fault Name	Severity	Status code
SYNC timeout fault	NON_FATAL	6
Fieldbus fault	NON_FATAL	184
Fieldbus synchronization fault	NON_FATAL	185
Fieldbus consistency fault	FATAL	187
Fieldbus watchdog fault	NON_FATAL	188
Group 12: DC Bus Fault		
Bus voltage unstable	NON_FATAL	69
Bus under-voltage fault	NON_FATAL	59
Group 13: Program Fault		
Internal programming fault	FATAL	120
Rate task initialization error	FATAL	122
Error handler fault	FATAL	127
Rate task 1 time overrun	FATAL	128
Rate task 2 time overrun	FATAL	129
Rate task 3 time overrun	FATAL	130
Rate task 4 time overrun	FATAL	131
Any reserved exception	FATAL	144
Machine check exception	FATAL	145
Data access exception	FATAL	146
Instruction access exception	FATAL	147
Alignment exception	FATAL	148
Program exception	FATAL	149
Floating point unavailable exception	FATAL	150
System call exception	FATAL	151
Trace exception	FATAL	152
Floating point assist exception	FATAL	153
Software emulation exception	FATAL	154
Instruction protection exception	FATAL	155
Data protection exception	FATAL	156
Data breakpoint exception	FATAL	157
Instruction breakpoint exception	FATAL	158
Maskable external breakpoint exception	FATAL	159
Non-maskable external breakpoint exception	FATAL	160
Returned to exception handler from interrupt	FATAL	161
Failed to rfi for decrementer exception	FATAL	162
Exception handler fault	FATAL	163
System reset and NMI exception fault	FATAL	164
Spurious interrupt fault	FATAL	165
IRQ0 NMI exception fault	FATAL	166
Group 14: Current Loop Fault		
Dead-time generation fault	NON-FATAL	86
Phase A current offset fault	FATAL	96
Phase B current offset fault	ATAL	97
Group 15: Board Fault		
FPGA configuration transmission fault	FATAL	24
QSPI loopback fault	FATAL	29
COM1 loop back fault	FATAL	32
COM1 initialization parameters fault	FATAL	38
COM2 loop back fault	FATAL	40
COM2 initialization parameters fault	FATAL	45
QSPI initialization fault	FATAL	46

Fault Name	Severity	Status code
FPGA test RAM fault	FATAL	15
Group 16: Simulink Model Fault		
Model initialization fault	FATAL	104
Model data fault	FATAL	105
Model timing over-run fault	FATAL	109
Model PWM timing over-run fault	FATAL	138
Group 17: Interlock Fault		
Dynamic brake fault	NON-FATAL	63
RESTART_OUTPUT_FLT	NON-FATAL	115
RESTART_ENABLE_FLT	NON-FATAL	116
BRAKE_MONITOR_FLT	NON-FATAL	117
Group 18: Velocity Fault		
Model velocity fault	NON-FATAL	108
Group 19: Static Position Fault		
Model static position fault	NON-FATAL	107
Group 20: Dynamic Position Fault		
Model dynamic position fault	NON-FATAL	106
Group 21: Model Application Fault 1		
Model Application Fault 1, Bit 7	NON-FATAL	192
Model Application Fault 1, Bit 6	NON-FATAL	193
Model Application Fault 1, Bit 5	NON-FATAL	194
Model Application Fault 1, Bit 4	NON-FATAL	195
Model Application Fault 1, Bit 3	NON-FATAL	196
Model Application Fault 1, Bit 2	NON-FATAL	197
Model Application Fault 1, Bit 1	NON-FATAL	198
Model Application Fault 1, Bit 0	NON-FATAL	199
Group 22: Model Application Fault 2		
Model Application Fault 2, Bit 7	NON-FATAL	200
Model Application Fault 2, Bit 6	NON-FATAL	201
Model Application Fault 2, Bit 5	NON-FATAL	202
Model Application Fault 2, Bit 4	NON-FATAL	203
Model Application Fault 2, Bit 3	NON-FATAL	204
Model Application Fault 2, Bit 2	NON-FATAL	205
Model Application Fault 2, Bit 1	NON-FATAL	206
Model Application Fault 2, Bit 0	NON-FATAL	207
Group 23: Control System Fault		
Control system fault	NON-FATAL	119
Group 24: Hall Sensor Fault		
Hall sensor velocity fault	NON-FATAL	118
Group 25: Homing Fault		
Return To Home homing fault	NON-FATAL	112
Group 26A: Homing Timeout Fault		
Time-out in reaching home position	NON-FATAL	114
Group 26B: Battery System Fault		
AC ready active fault	NON-FATAL	157
Group 27: Dynamic Brake Release Fault		
Dynamic Brake monitor fault	NON-FATAL	117
Group 28: Mechanical Brake Release Fault		
Mechanical Brake monitor fault	NON-FATAL	116

Fault Name	Severity	Status code
Group 29 through 32: Reserved for future use		

Undetermined Fault

If the drive is faulty, but the fault group cannot be determined, F is also displayed.

5.12.4 Fault Clearing

It is possible to clear all faults except for those faults that occur during the initialization process and faults due to microprocessor exceptions. It is possible to determine whether one of these non-clearable faults has occurred by reading the status_controller parameter (1522). If bit '6' of this parameter is '1', then a non-clearable fault has occurred. (i.e. bit 0 is LSB).

To clear faults, the parameter '`errors_clear`' (Field Number 1491) must be written with a value of '1'.

The actions performed when clearing errors are as follows:

1. real-time fault monitoring is disabled
2. fault flags, latched faults and fault counters cleared
3. non-fault state requested in drive state machine
4. when non-fault state achieved then '`errors_clear`' is reset to '0'
5. real-time fault monitoring re-enabled

The completion of the fault clearing process can be verified by reading '`errors_clear`'. Once the process has completed the fault monitoring operates normally and so if a fault is still present it will be detected again.

WARNING: **DELAY IN RE-DETECTING FAULTS**, After the CSA has cleared faults; the time taken to redetect a particular fault depends upon the rate at which it is monitored. Typically, parameters that only change slowly under normal circumstances (such as temperatures) may only be monitored every 100ms. Therefore, a delay of 0.5s should normally be allowed after clearing faults before re-enabling the drive

5.12.5 Fault History

The CSA maintains a non-volatile log of faults and status to aid fault diagnosis. The event log contains the last 850 (approx.) faults that occurred on the drive and is a circular buffer, see Section B.3.20 for further details.

5.12.6 Drive Monitoring & Fault Detection Parameters

Table 5-46 Drive Monitoring and Fault Detection Parameter Access Detail

Parameter Name	Field Number	Data Type	Access	Default Value	Minimum Value	Maximum Value	Units	Storage Type	Data Group
DRIVE MONITORING									
bridge_temperature	1368	f32	r	-	-	-	°C	N	A
motor_temperature	1373	f32	r	-	-	-	°C	N	A
ambient_temperature	1378	f32	r	-	-	--	°C	N	A
supply_+24V	1441	f32	r	-	-	-	V	N	A
supply_+3V3	1421	f32	r	-	-	-	V	N	A
supply_-15V	1426	f32	r	-	-	-	V	N	A
supply_+15V	1431	f32	r	-	-	-	V	N	A
supply_+2V_ref.	1436	f32	r	-	-	-	V	N	A
encoder_supply	1446	f32	r	-	-	-	V	N	A
bus_voltage_actual	1232	f32	r	-	-	-	V	N	A
supply_+5V	1942	f32	r	-	-	-	V	N	A
supply_+5VA	1941	f32	r	-	-	-	V	N	A
ETI_total_power_on_time	1482	u32	r	-	-	-	s	N	A
ETI_power_on_time_since_power_on	1483	u32	r	-	-	-	s	N	A
ETI_number_of_power_downs	1484	u16	r	-	-	-	none	N	A
ETI_enabled_time	1485	u32	r	-	-	-	s	N	A
ETI_enabled_time_since_power_on	1486	u32	r	-	-	-	s	N	A
ETI_enabled_time_since_enable	1487	u32	r	-	-	-	s	N	A
regen_power_filtered	1252	f32	r	-	-	-	W	N	A

FAULT REACTION									
brake_fault_control	1505	u16	r/w	1	-	-	none	C	A
acceleration_limit	1335	f32	r/w	1000	0	-	rad/s^2	C	A
fault_reaction_velocity	1141	f32	r/w	0.5	0.05	1000	rad/s	C	A
brake_lock_to_disable_timeout	1004	f32	r/w	0.0	-	-	s	C	A
velocity_rampdown_time_limit	1143	f32	r/w	0	0	1000	s	C	A
FAULT CLEARING									
status_controller	1522	u08	r	-	-	-	none	N	A
errors_clear	1491	u16	r/w	-	-	-	none	N	A
EVENT LOG									
event_log_timestamp	1499	u32	r	-	-	-	s	N	A
event_log_data1	1500	u32	r	-	-	-	none	N	A
event_log_data2	1501	u32	r	-	-	-	none	N	A
event_log_size	1494	u32	r	-	-	-	none	N	A
event_log_increment	1640	u32	r	-	-	-	none	N	A
event_log_current_position	1495	u16	r	-	-	-	none	N	A
event_log_read_pointer	1498	u16	r/w	-	-	-	none	N	A

5.13 Self-Protection

5.13.1 Power Amplifier Thermal Protection Mechanism

The power amplifier is protected by using a scheme called Thermal-Foldback. The CSA is rated to operate at an ambient temperature of up to 40°C.

- The Foldback scheme is designed to ensure a very conservative temperature margin is maintained between power device manufacturer's rated maximum temperatures (semiconductor junction temperature) and the actual semiconductor junction temperature.
- The running thermal limit applies when the speed of the motor is greater than approximately 50RPM. The stall thermal limit applies for motor shaft speeds of less than approximately 50RPM. The stall limit will become less than the peak current capability of the amplifier only at elevated ambient temperatures and high continuous operating loads.

5.13.2 Motor Thermal Protection Mechanism

- The CSA can measure the temperature of the motor by means of a Negative Temperature Coefficient thermistor (NTC) or a Positive Temperature Coefficient thermistor (PTC) buried within the motor windings. With the motor NTC, temperature is measurable between approximately 25°C and 175°C.

  The PTC acts as a thermal switch so linear temperature measurement of the motor is not possible. When this device changes from a low impedance state to a high impedance state, the software will detect and report a fault.
- Software calculates the motor thermal limit based upon the motor windings temperature. The motor protection scheme is intended to ensure that the temperature of the motor core will not exceed 155°C.

5.13.3 Cabling and Interconnect Protection Scheme

Each CSA model has a continuous current rating. The CSA operates an algorithm that limits the overall RMS level of motor phase current appropriately, over a time window. This is intended to protect the connectors and internal circuitry, which would otherwise be thermally over-stressed.

The CSA measures the motor phase currents at a high frequency. It calculates the remaining amount of current for the next period to ensure that the overall RMS current rating of the drive is not exceeded.

5.13.4 Regeneration Resistor Protection Scheme

The CSA can be equipped, depending on the model size, with an internal or external regeneration resistor. The algorithm controlling the duty cycle of the resistor ensures that the power dissipated by the resistor is maintained at the resistor rating provided by the user.

5.14 Parameter Storage

The saving and loading of parameters to the Non-Volatile Memory (NVM) of the drive is implemented in several ways for the CSA Configurations listed below. WinDrive provides access to screens to save Drive and Encoder data see Appendix B.3.10.

For the CSA - EtherCAT, an NVM save operation will only be performed if the drive is disabled. If a save is commanded while the drive is enabled, the save will not be performed with no error message displayed.

For the CSA - MaxForce, parameter nvm_override (Field 10006) can be set to ‘1’ to allow saving drive parameters while the drive is enabled; it should be used with caution.

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A.1 Data Logger

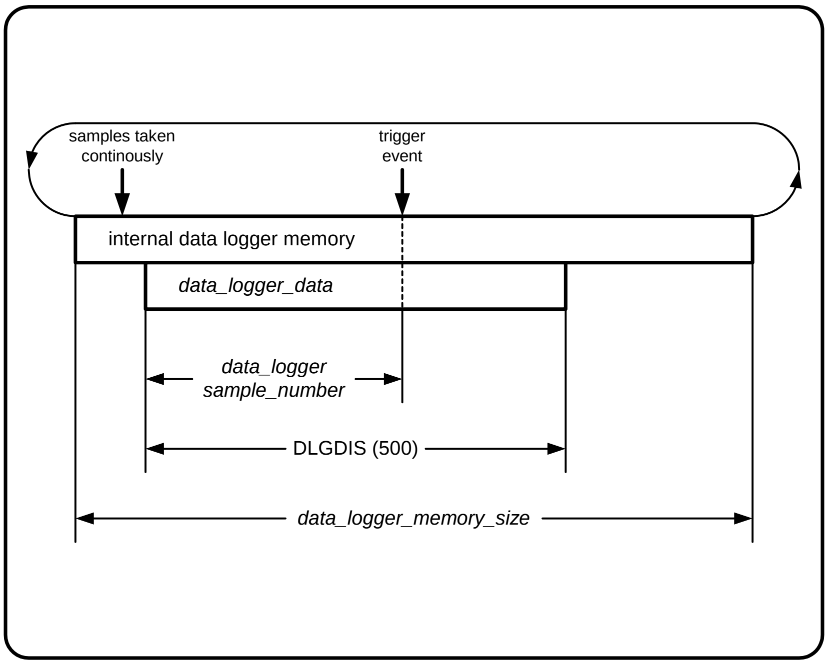
The data logger is an internal storage oscilloscope with up to four input channels,a trigger function and time base. It can be used to store fast events or to store information that caused fault conditions. The sampled data can be downloaded from the embedded controller onto a computer and analyzed.

Normally the data logger functions should be used from within the Moog graphical user interface. The following description is intended for users that want to implement their own data logger front-end.

A.1.1 Input channels

Up to four input channels can be used to sample any internal 8-, 16-, 24- or 32-bit wide integer or 32-bit and 64-bit floating point parameter. The channel is enabled by writing the field number to be sampled into *data_logger_channel* (field number 1754) and setting the *data_logger_enable* (field number 1753) parameter to 0x01, where the index into the array is the channel number (0-3). The number of samples to be taken is the parameter *data_logger_memory_size* (field number 1752). The maximum number of samples that can be taken is limited by the available memory and depends on the parameters sampled.

The samples are written into an internal memory array in sequential order, e.g. 1st sample of first enabled channel, 1st sample of second enabled channel, until all channels are processed and then 2nd sample of first enabled channel 2nd sample of second enabled channel and so on. The data cannot be read directly from the internal memory. There are various parameters available to extract the data from the memory.



FigureA.1: data logger memory and sampling

A.1.2 Time base

The data logger normally runs at the main interrupt frequency of the controller (PWM frequency) or a fraction of this. The main interrupt frequency can be read with the parameter *data_logger_sample_frequency* (field number 1751). The divider ratio can be set with the parameter *data_logger_divider_factor* (field number 1750). The resulting sample frequency is then *data_logger_sample_frequency* / *data_logger_divider_factor*.

A.1.3 Trigger

The trigger controls the sampling of the data syncronized to a trigger input which can be any of the 8-, 16-, 24- or 32-bit integer or 32-bit or 64-bit floating point parameters. It is possible to have a delayed trigger or pre-trigger, which is entered as a negative number. The possible trigger coupling can be dc, ac or bitmap masking, the slope can be rising, falling or both.

A.1.3.1 Trigger modes

The parameter trigger mode *trigger_mode* (field number 1755) controls the trigger and the sampling. There are four different trigger modes available:

0x00	-	free running trigger: always sampling
0x01	-	normal trigger: waiting for trigger event and start sampling, retriggerable after sampling has finished
0x02	-	single shot trigger: after trigger event only one set of samples taken
0x03	-	stopped: no samples taken

A.1.3.2 Trigger status

The actual trigger status can be read back reading parameter *trigger_status* (field number 1767). It has one of the four possible values:

0x00	-	system is being initialized; data logging not possible
0x01	-	waiting for trigger event
0x02	-	sampling
0x03	-	ready, sampled data can be accessed

The samples can be only read from the data logger memory when the trigger status is ready. In single shot triggering the data logger will go automatically into the ready state. In free running mode or normal trigger mode the data trigger mode has to be set to stopped. After finishing the sampling, the data logger will then automatically go into the ready state.

A.1.3.3 Trigger input

The trigger input is selected by setting the trigger channel parameter *trigger_field_number* (field number 1756) to the field number of the parameter that is used for triggering the sampling process. The coupling is selected by setting the *trigger_coupling* (field number 1757) parameter:

0x00	-	ac coupled trigger input
0x01	-	dc coupled trigger input
0x02	-	bitmask trigger

The trigger level can be set with the *trigger_level_xxxxx* parameters. The data type has to match the data type of the parameter sampled. For example, if a 16-bit integer value is used for triggering, then *trigger_level_16-bit* has to be set. The trigger levels also hold the bit mask for the bit mask trigger mode. Only bits that are 1 in the mask are used for triggering. More than one bit can be set to one.

The trigger slope parameter *trigger_slope* (field number 1758) selects if triggering is done on the rising or falling edge of the trigger input. If bit mask trigger is used a 0-1 transition is taken as a rising and a 1-0 transition is taken as a falling input signal.

0x01	-	trigger on rising edge
0x02	-	trigger on falling edge
0x03	-	trigger on both edges

Normally the sampling would start at the trigger event. If the sampling has to be delayed, or if the samples shall be taken before the trigger event, the position of the trigger event within the samples can be selected using the trigger delay parameter *trigger_delay* (field number 1765). It holds the number of the samples before the trigger event.

A.1.4 <u>Data Access</u>

A.1.4.1 Scaled data access

To improve performance and to make the interface easier, there are parameters available that allow the reading of scaled data for each channel with only one byte per channel and sample transmitted.

The offset *data_logger_scaling_offset* (field number 1769) is added to the value and the result is then multiplied with the scaling factor *data_logger_scaling_factor* (field number 1768). The result is then rounded to the nearest signed 8-bit value and can be accessed by reading the parameter *data_logger_channel_x*. The number of bytes displayed, *dlgmax* (field number 1752), is configurable from 200 to 32,000. The transmitted data can be selected from the sampled data by writing to the parameter *data_logger_sample_number* (field number 1770) before reading the data which represents the number of the first data sample to be transmitted relative to the trigger position.

A.1.5 Example

1. set trigger mode to stop (*trigger_mode* = 0x03)
2. wait until trigger status is initialized (*trigger_status*: 0x00)
3. set number of samples to 1000 (*data_logger_memory_size* = 1000)
4. disable channels 1 to 3 (*data_logger_enable*[1-3] = 0x00)
5. enable channel 0 (*data_logger_enable*[0] = 0x01)
6. set channel 0 input to field number of position (*data_logger_channel*[0] = field number actual drive position)
7. set pre divider to 1 (*data_logger_divider_factor* = 1)
8. set trigger input to parameter number of position (*trigger_field_number* = field number actual drive position)
9. set trigger coupling to dc (*trigger_coupling* = 0x01)
10. set trigger slope to rising (*trigger_slope* = 0x01)
11. set trigger level to 0 (*trigger_level_32-bit* = 0)
12. set trigger delay to 0 (*trigger_delay* = 0)
13. set trigger mode to single (*trigger_mode* = 0x02). trigger status should go to waiting for trigger (*trigger_status*: 0x01)
14. move position around zero position trigger status should go to sampling (*trigger_status*: 0x02)
15. wait until trigger status is ready (*trigger_status*: 0x03)
16. read DLGDIS (500) samples from data logger channel data (*data_logger_channel_0*)

A.1.6 Data logger parameters

Parameter Name	Field Number	Data Type	Access	Default Value	Minimum Value	Maximum Value	Units	Storage	Data Group
data_logger_sample_frequency	1751	u32	R	9920	-	-	Freq. units	N	A
data_logger_divider_factor	1750	u16	R/W	1	1	-	None	N	A
data_logger_memory_size	1752	s16	R/W	500	500	8000	None	N	A
data_logger_enable	1753	u08	R/W	0,0,0,0	-	-	None	N	A
data_logger_channel	1754	u16	R/W	1000,1000, 1000,1000	-	-	None	N	A

A.1.7 Trigger parameters

Parameter Name	Field Number	Data Type	Access	Default Value	Minimum Value	Maximum Value	Units	Storage	Data Group
trigger_mode	1755	u08	R/W	0x03	-	0x03	None	N	A
trigger_field_number	1756	fld	R/W	1000	-	-	None	N	A
trigger_coupling	1757	u08	R/W	0x01	-	0x02	None	N	A
trigger_slope	1758	u08	R/W	0x01	0x01	0x03	None	N	A
trigger_level_8-bit	1759	u08	R/W	-	-	-	None	N	A
trigger_level_16-bit	1760	u16	R/W	-	-	-	None	N	A
trigger_level_24-bit	1761	u24	R/W	-	-	-	None	N	A
trigger_level_32-bit	1762	u32	R/W	-	-	-	None	N	A
trigger_level_float	1763	f32	R/W	-	-	-	None	N	A
trigger_level_double	1764	f64	R/W	-	-	-	None	N	A
trigger_delay	1765	s16	R/W	-	-	-	None	N	A
trigger_status	1767	u08	R	-	-	-	None	N	A

A.1.8 Data logger scaling and output parameters

Parameter Name	Field Number	Data Type	Access	Default Value	Minimum Value	Maximum Value	Units	Storage	Data Group
data_logger_scaling_factor	1768	f32	R/W	-	-	-	None	N	A
data_logger_scaling_offset	1769	f32	R/W	-	-	-	None	N	A
data_logger_sample_number	1770	s16	R/W	-	-	-	None	N	A
data_logger_channel_0	1771	s08	R	-	-	-	None	N	A
data_logger_channel_1	1772	s08	R	-	-	-	None	N	A
data_logger_channel_2	1773	s08	R	-	-	-	None	N	A
data_logger_channel_3	1774	s08	R	-	-	-	None	N	A

B.1 WinDrive Introduction

This manual describes the installation and operation of the Moog WinDrive application for Industrial Control Division Customizable Single Axis (CSA) Drive. For application specific usage of WinDrive, refer to supplementary documentation as may be supplied with the system, along with and other sections within this manual the specifically address the parameters and their usage.

B.1.1 System Recommendations

Minimum PC requirement — Any PC capable of running Windows XP or Windows 7

Occasionally laptops with a dedicated serial port may require an external power supply because the battery may not adequately drive the serial port.

Serial Port — A dedicated serial port or a USB to Serial Converter.

Approved USB to Serial Converter devices include the following:

- Easy Sync © "ES-U-1101-M" or "USB2-H-1001-M"
- Keyspan © "USA-19HS"

Minimum Screen Size — 800x600, 1024x768 recommended

B.1.2 Installation of WinDrive

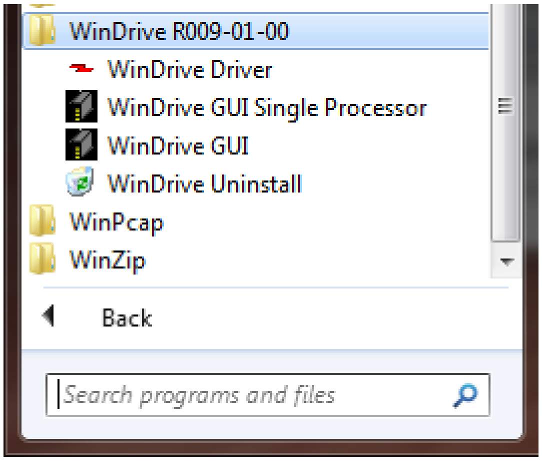
WinDrive can be installed with any of the Installer Files listed below:

Installer File(s)	Description
setup.exe	Customized Installation with step-by-step instruction
setup_silent.exe	Minimal prompting for starting and finishing the installation. Note: The JRE included with WinDrive will automatically be installed.
setup_verysilent.bat	Unassisted installation with no User prompting and automatic finishing of the process, which may be beneficial for remote execution of installations. Note: The JRE included with WinDrive will automatically be installed.

The setup_silent.exe and setup_verysilent.bat Installers are provided as a simplified means of performing the installation process, reducing User intervention and using default installation folders and naming (preferred). Alternately, the installation program setup.exe will take the User through the process step-by-step. Any folders necessary to launch WinDrive will automatically be created in the Start menu. An example of the default installation folder is "C:\Program Files (x86)\WinDrive R009-01-00". The installation program will also attempt to install the Java Runtime Environment (JRE), which is required to run WinDrive. If this is already installed, a notification message will be displayed, which will ask the user whether the JRE is to be uninstalled. The user should cancel this operation completing the installation.

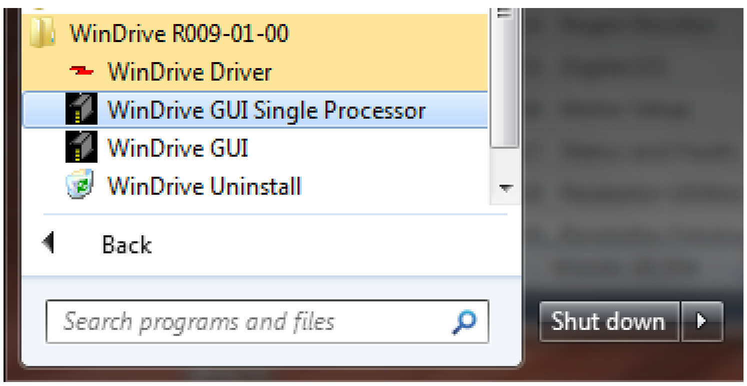
Note that Windows 7 Users may experience a security conflict with installing or running files in folder "C:\Program Files (x86)". If this is the case, use setup.exe and install WinDrive in a root sub-folder, I.E. "C:\Moog".

Installation will create entries on the Windows Program Files Menu; the location may vary with the version of Windows used. An example for Windows 7 is shown below:



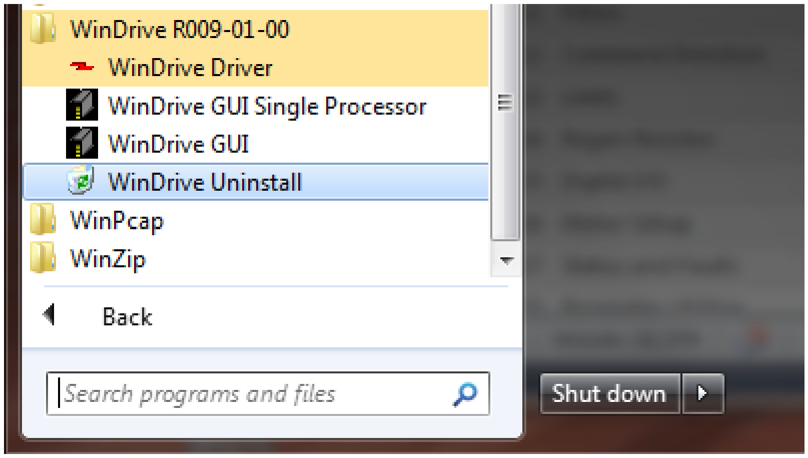
The installation process also creates a desktop icon for launching WinDrive, an example is shown below:

Some multi-core PCs may experience issues with running WinDrive due to the GUI and Serial Driver running on different cores. If that is the case, the "SingleProcessor" version and will set the processor affinity so the 2 programs run on the same core (CPU). Select this version from the Windows Program Menu, an example is shown below:

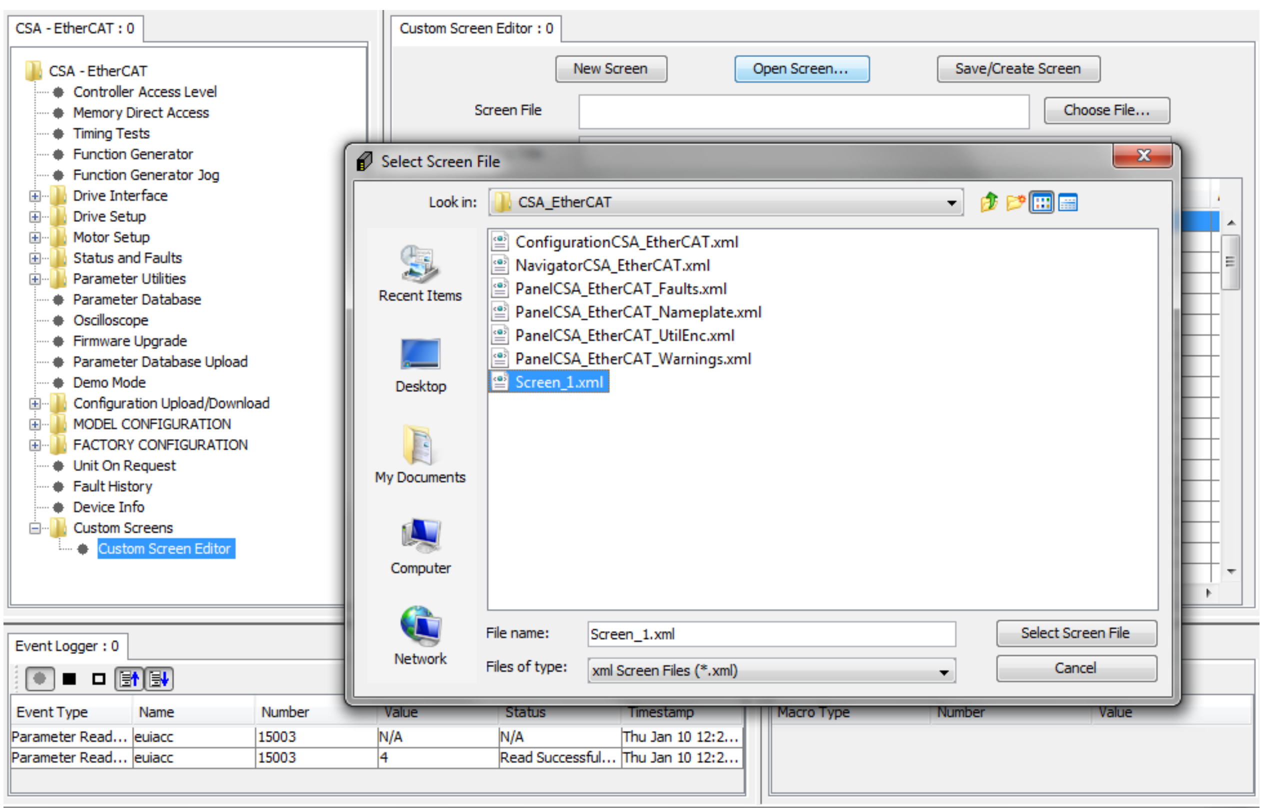


B.1.3 Uninstalling WinDrive

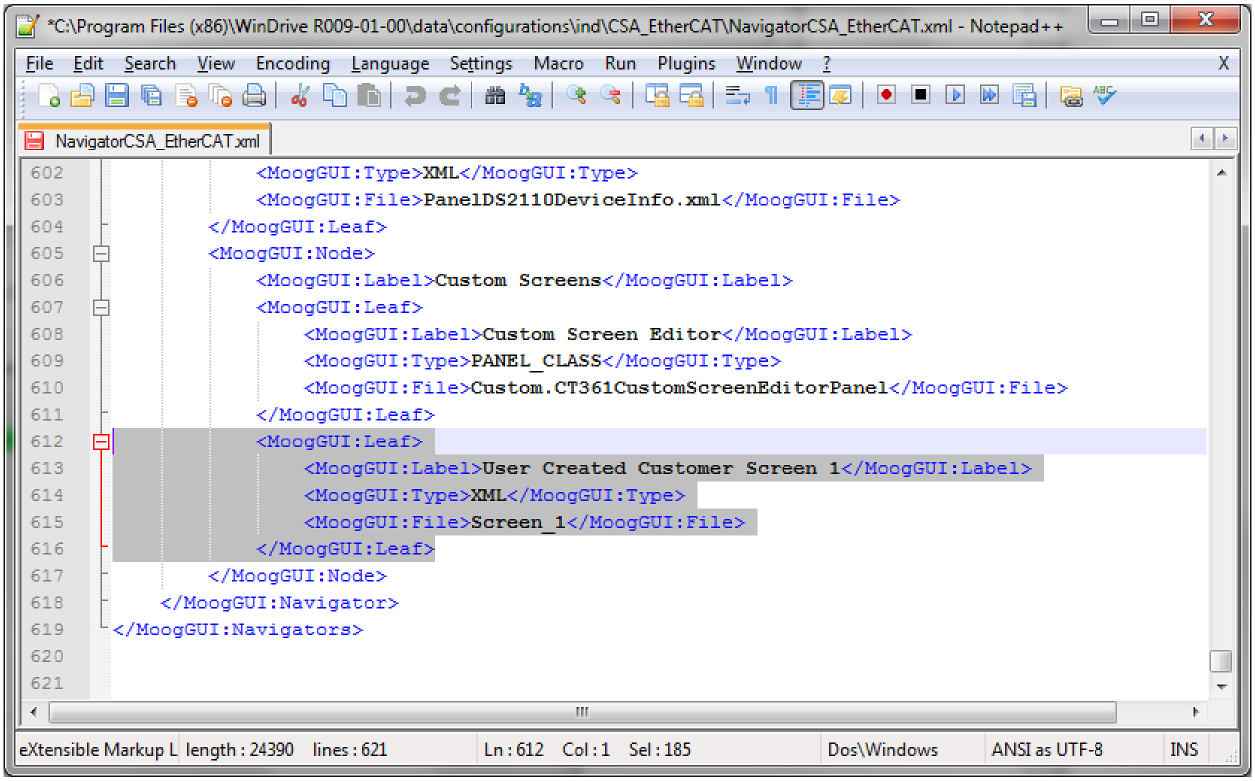
To un-install WinDrive, execute the "WinDrive Uninstall" icon on the Program Menu, an example is shown below.



The un-install process will first make a backup of the program folder ".\data" to ".\data.backup". Any User created or edited files are preserved in the original ".\data" folder. If any installed files were edited, those edits will need to be carefully made to the installed files. The Navigator*.xml files, created in the installation process are also removed. Therefore, any User created screens will need to be added in newly installed Navigator files using the Customer Screen Editor. The sequence of operations would be "Open Screen…", "Select Screen File", then "Save/Create Screen" which adds it under the "Custom Screen Editor" Node; an example is shown below:



A second option is to manually edit the Navigator file itself, an example is shown below, where the Leaf for “Screen_1” is inserted; this method allows the Leaf to be inserted anywhere in the Navigation Pane.



Getting Started

B.1.4 Introduction

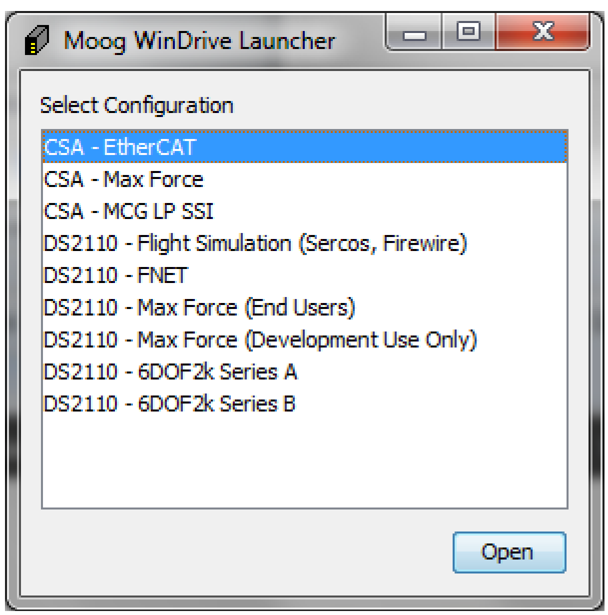
Moog WinDrive is a graphical user interface (GUI) application that is used to configure the Moog CSA Servo-Drives and DS2110 Drives. It has been developed to provide a common "look and feel" for a variety of Moog Drive Application Configurations. A particular configuration corresponding to these applications is chosen at the startup of WinDrive and may have dialogs and panels specific to that configuration.

B.1.5 Starting WinDrive

WinDrive is started using it's icon on the desktop, an example is shown below:

B.1.6 Launcher

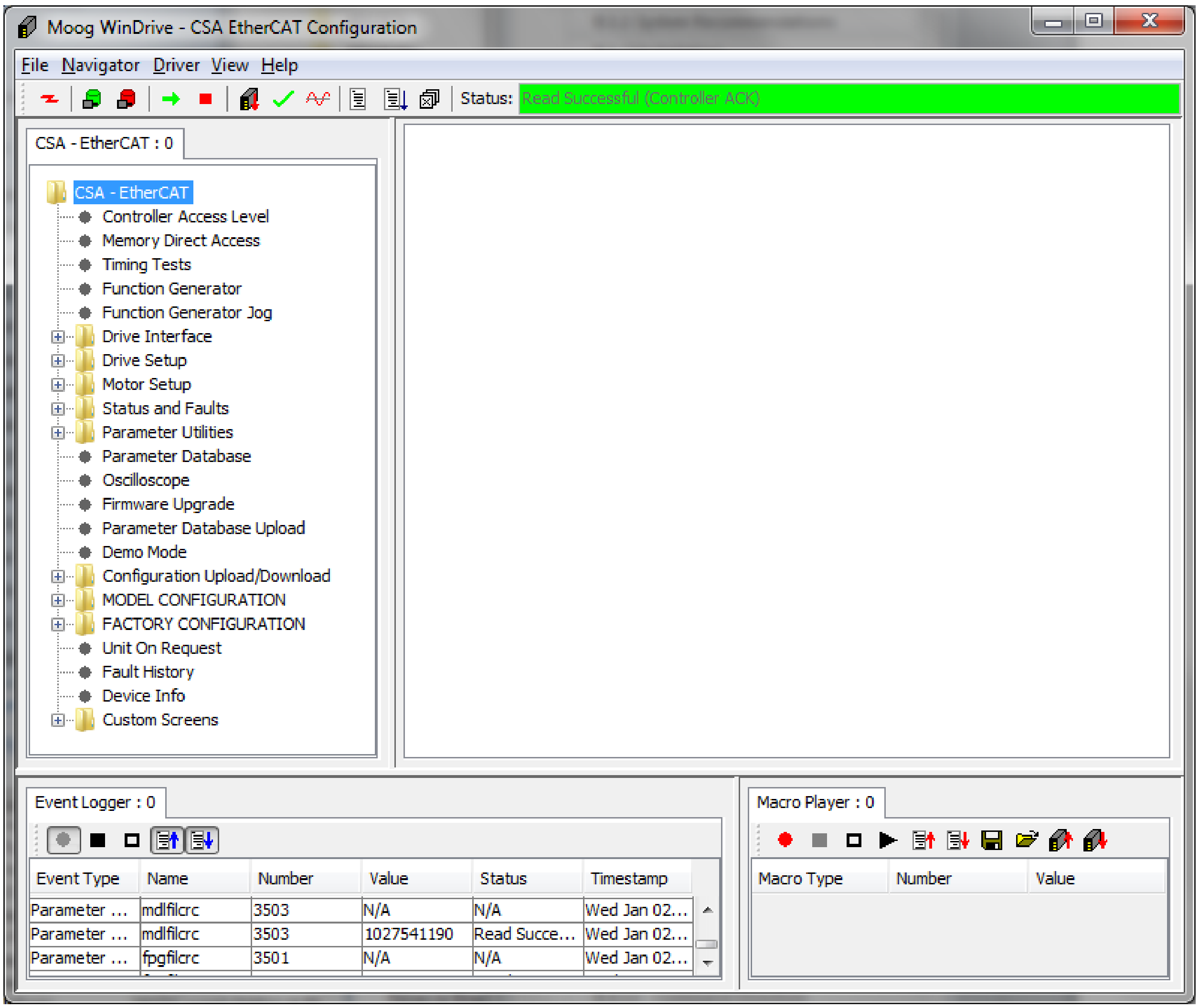
Clicking the icon will display the Launcher dialog box listing the available configurations supported by that version of WinDrive. Note that the list of supported Configurations for given products may change over time, and may vary with the WinDrive shipped with a particular system. The correct configuration can be determined by looking at the model number label on the drive. Select the appropriate configuration and click "Open". The version of WinDrive to be used for a particular Software Boxcar will be listed in the applications Software Configuration Drawing. Note that while the DS2110 configurations appear in the Launcher, only CSA configurations are addressed in this Appendix. Sample screen shots in this Appendix will typically be those of the CSA - EtherCAT configuration. This Launcher will change as more applications are supported.



B.2 Main Window Features

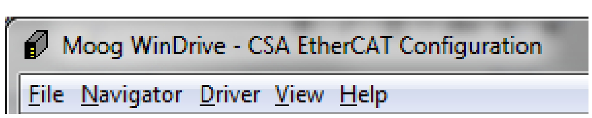
B.2.1 Main Window

The Launcher executes the WinDrive program, displaying the Main Window which consists of a number of components described below. Initial communication status is indicated in the Status Bar. If the status bar is red and reads "*Serial Port Timeout Error*", ensure power is applied and check all serial connections and Port settings and +24vdc is applied to the CSA.



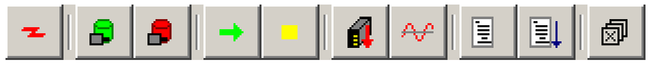
B.2.2 Main Menu

The Main Menu is located at the top of the Main Window.



B.2.3 Toolbar

The Toolbar is located directly under the Main Menu and is used to perform common tasks in the application.

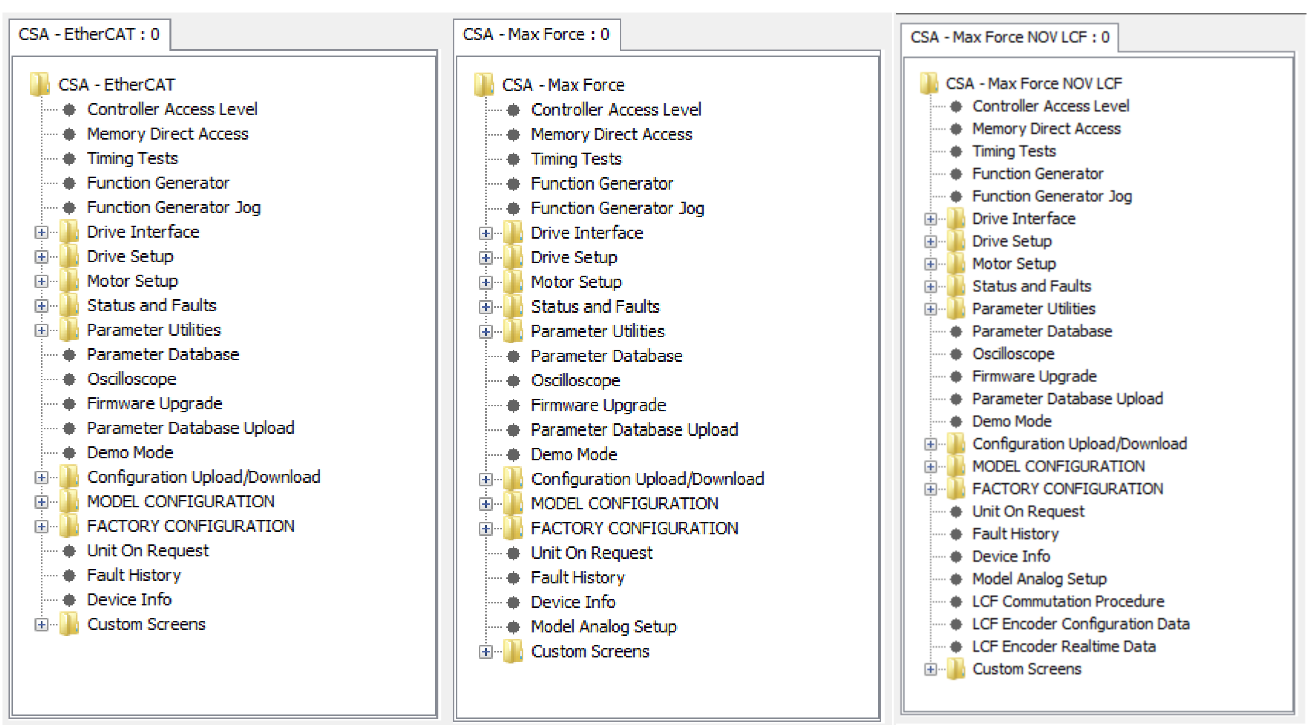


B.2.4 Status Bar

The Status Bar is located to the right of the Toolbar and displays short status messages indicating the result of the last operation performed by WinDrive. Note that the status is not polled or refreshed, it is only updated when an operation between WinDrive and the Drive is attempted. In general, a green background indicates successful communication or operation(s) with the drive. A red background indicates that a fault occurred in the application or in the communications between WinDrive and the application.

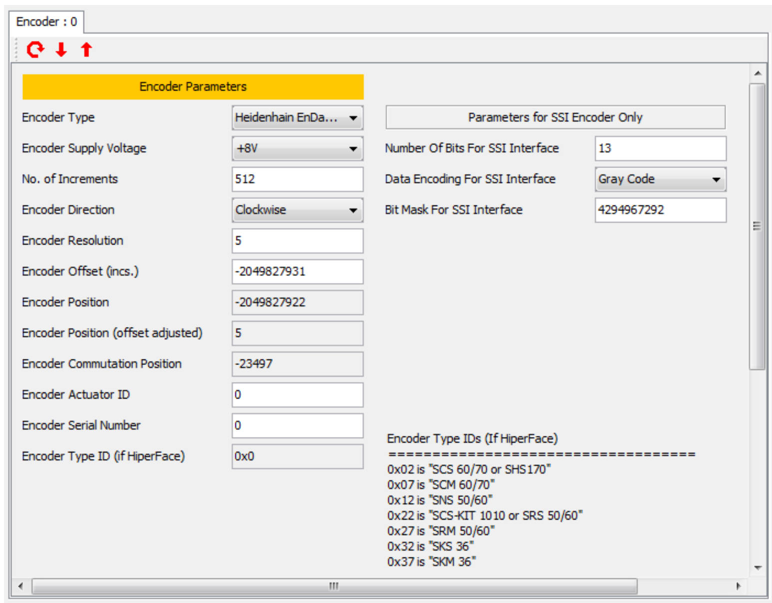
B.2.5 Navigator

The Navigator panel is located at the top left of the Main Window, directly under the Toolbar. It displays a tree which is the principal method for navigating WinDrive. The Navigator for 3 CSA configurations is shown belown. A high degree of commonality exists between the drive configurations. Any relevant differences will be addressed in later sections as necessary. To open a panel in the panel view, click a “leaf” on the tree, such as “Device Info”. To expand a “node” on the tree such as “Motor Setup”, click on the plus sign “+”.



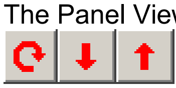
B.2.6 Panel View

The Panel View is located at the top right of the Main Window, directly under the Status Bar. The Panel View can be empty, or contain one or more configuration specific panels. Clicking on leafs within the Navigator tree typically opens these panels. The panels displayed in the Panel View are the main area of interaction between the user and the controller. Panels are typically used to display controller parameters and to modify the values of these parameters. To open panels in the Panel View, use the tree in the Navigator panel, described in the previous section.



B.2.7 Panel View Toolbar

The Panel View Toolbar appears in the upper left hand corner of the panel.



The Panel View Toolbar consists of the following buttons.

Continuous Update

If the Continuous Update toggle button is depressed, all controls within the displayed panel are continuously updated from the controller via a parameter read.

Write All

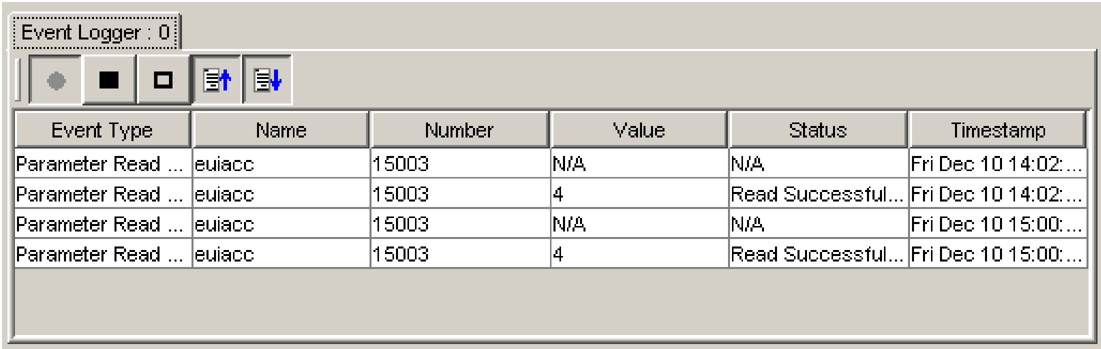
Clicking the Write All button forces a parameter write for each control displayed within the panel.

Read All

Clicking the Read All button forces a parameter read for each control displayed within the panel.

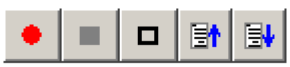
B.2.8 Event Logger

The Event Logger is one of the four large panels in the Main Window. It is located at the bottom left of the Main Window, directly under the Navigator. The purpose of the Event Logger is to allow the user to record any read or write parameter events. Logging events can be useful in order to see what is being read from or written to the controller at the lowest level. For each logged event, the event type, parameter name, parameter number, value, status, and timestamp are logged.



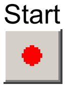
B.2.9 Event Logger Toolbar

The Event Logger Toolbar appears in the upper left hand corner of the panel.



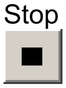
The Event Logger toolbar consists of the following buttons.

Start Logging



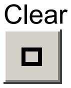
If the Start Logging toggle button is depressed, the Event Logger logs those events whose filter toggle buttons (i.e. Log Read Parameter or Log Write Parameter) also are depressed.

Stop Logging



If the Stop Logging toggle button is clicked, all logging is stopped. Clicking the Start Logging button can recommence logging.

Clear Log



Clicking the Clear Log button completely clears the Event Logger.

Log Read Parameter

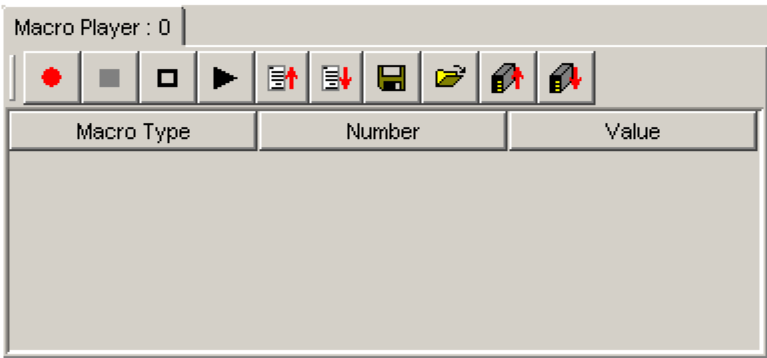
The Log Read Parameter toggle button needs to be depressed if any parameter read events are to be logged.

Log Write Parameter

The Log Write Parameter toggle button needs to be depressed if any parameters write events are to be logged.

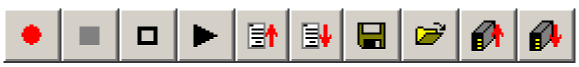
B.2.10 Macro Player

The Macro Player is one of the four large panels in the Main Window. It is located at the bottom right of the Main Window, directly under the Panel View.



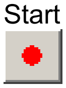
B.2.11 Macro Player Toolbar

The Macro Player Toolbar appears in the upper left hand corner of the panel.



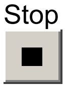
The Macro Player toolbar consists of the following buttons.

Start Recording



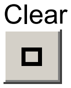
If the Start Recording toggle button is depressed, the Macro Player records those events whose filter toggle buttons (i.e. Record Read Parameter or Record Write Parameter) also are depressed.

Stop Recording



If the Stop Recording toggle button is clicked, all recording is stopped. Clicking the Start Recording button can recommence recording.

Clear Macro



Clicking the Clear Macro button completely clears the Macro Player.

Play Macro

Clicking the Play Macro button commences playing the currently loaded macro.

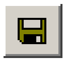
Record Read Parameter

The Record Read Parameter toggle button needs to be depressed if any parameter read events are to be recorded.

Record Write Parameter

The Record Write Parameter toggle button needs to be depressed if any parameters write events are to be recorded.

Save Macro



Clicking the Save Macro button displays a file save dialog box which is used to save the current macro.

Load Macro

Clicking the Load Macro button displays a file open dialog box which is used to load a previously saved macro.

Configuration Upload

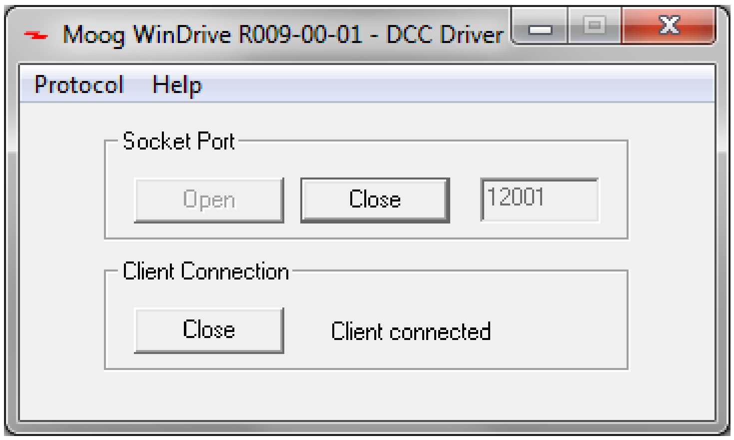
Clicking the Configuration Upload button displays the Save Configuration File dialog box. In this dialog box a file can be specified to which the current controller configuration will be saved. By clicking the Save button in this dialog after having specified a file and directory in which to save the configuration, the configuration upload procedure will be commenced. Once the upload has been completed a message is displayed to the user.

Configuration Download

Clicking the Configuration Download button displays the Load Configuration File dialog box. In this dialog box a previously saved configuration file (see Configuration Upload) can be specified. This configuration can then be downloaded to the controller.

B.2.12 Driver

The Moog WinDrive Driver runs as a separate process from the WinDrive GUI. It is started automatically when WinDrive is opened. To display the driver dialog box, click on the driver's icon on the Windows Task bar. The driver performs all communication with the controller. The DCC Driver is used in ICD drive products, and is displayed in the title bar of the dialog. The WinDrive GUI communicates with the driver via a TCP/IP socket connection.



The Driver Dialog menu consists of the following items:

- Protocol – This menu and any submenus are protocol specific.
- Help / About Driver – Displays the Driver About Box. This dialog contains the driver version information.

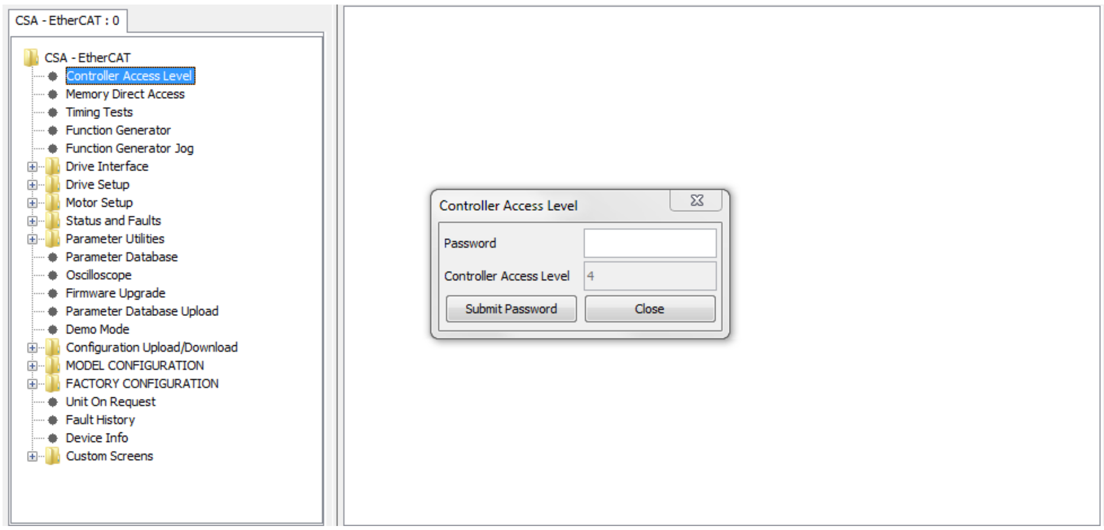
The following controls are part of the Driver Dialog:

- Socket Port – Opens the socket to listen on the specified port for connection requests from the GUI.
- Socket Port – Closes the socket port
- Client Connection / Close – Closes the connection to the WinDrive GUI if it is connected.

B.3 Panel Descriptions

B.3.1 Controller Access Level

The Controller Access Level Dialog is used to set the controller access level. Read and Write access to parameters is password protected, with different access levels required based on the User Role.



The default access level of 4 supports full configuration of a drive and motor received from the factory. Entering a password may set higher levels for greater access. Consult Moog Application Engineering if a higher access level is required to modify Factory Settings such as the commutation offset.

B.3.2 Memory Direct Access

The Memory Direct Access Panel can read any part of the memory map and can write to the whole memory map except flash memory. It requires the highest access level and is only for diagnostic purposes.

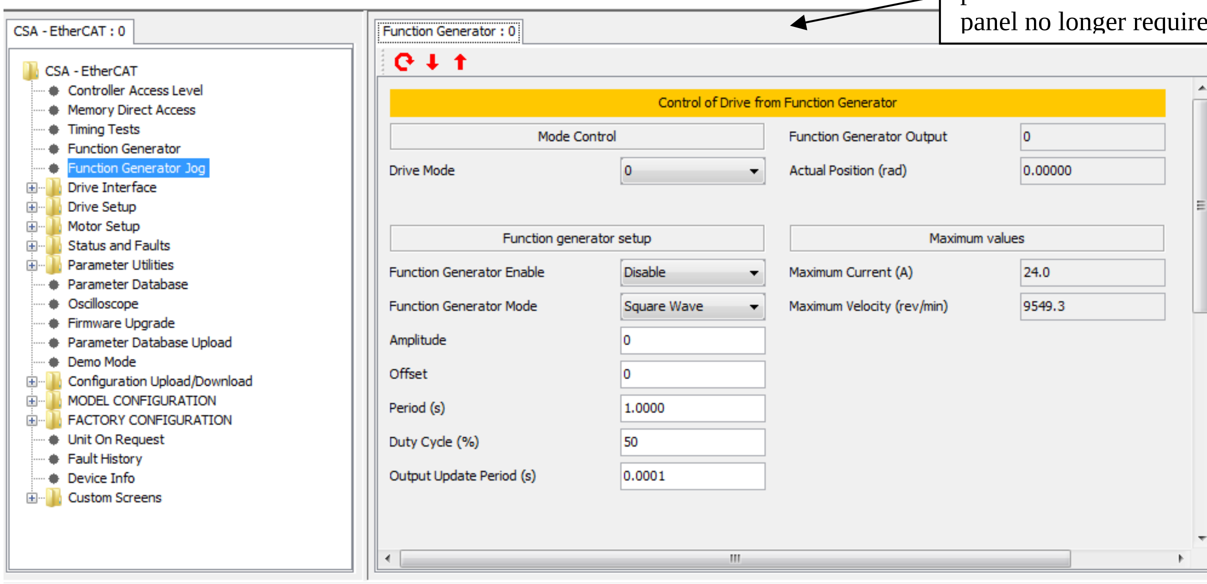
B.3.3 Timing Tests

The Timing Test panel is used to view software execution times and is only used for diagnostic purposes.

B.3.4 Function Generator

The Function Generator panel is used to control the drive directly from the GUI with an internal function generator providing the command to the control loop.

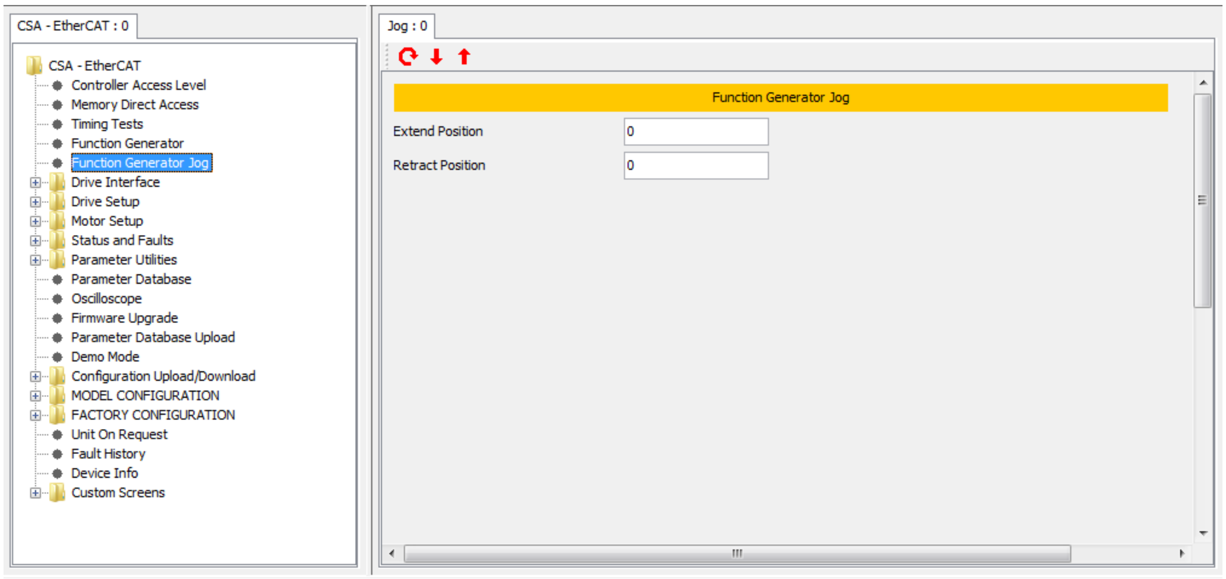
Right click in this area and press "Close" to shut any panel no longer required.



Function Generator	
Section & Parameter	**Description**
Mode Control	
Drive Mode	Options: Torque, Velocity or Position
Function generator setup	
Function Generator Enable	Options: Disable, Enable Single Shot or Enable Continuous
Function Generator Mode	Options: Square Wave, Triangle Wave and Sine Wave
Amplitude	Amplitude, units are changed according to the controller mode (position – rad, velocity – rad/s, torque – Nm)
Offset	Offset, units are changed according to the controller mode (position – rad, velocity – rad/s, torque – Nm)
Period(s)	The time in seconds of 1 cycle of the waveform
Duty Cycle (%)	The percent of "on" time, versus "off" time
Output Update Period (s)	The update period of the Function Generator. Note that a displayed value of 0.0001 corresponds to 125 usec, or 8 kHz
Function Generator Output	The present Function Generator Output in the Drive Mode units
Actual Position	The present Actual Position in Position Mode units
Maximum values	
Maximum Current	The maximum current capability in Amps of the drive/motor system used to assist with using the function generator with the drive in torque mode
Maximum Velocity	The maximum velocity capability in RPMs of the drive/motor system to assist with using the function generator with the drive in velocity mode

B.3.5 Function Generator Jog

The Function Generator Jog Panel is used to move the actuator from one position to another.

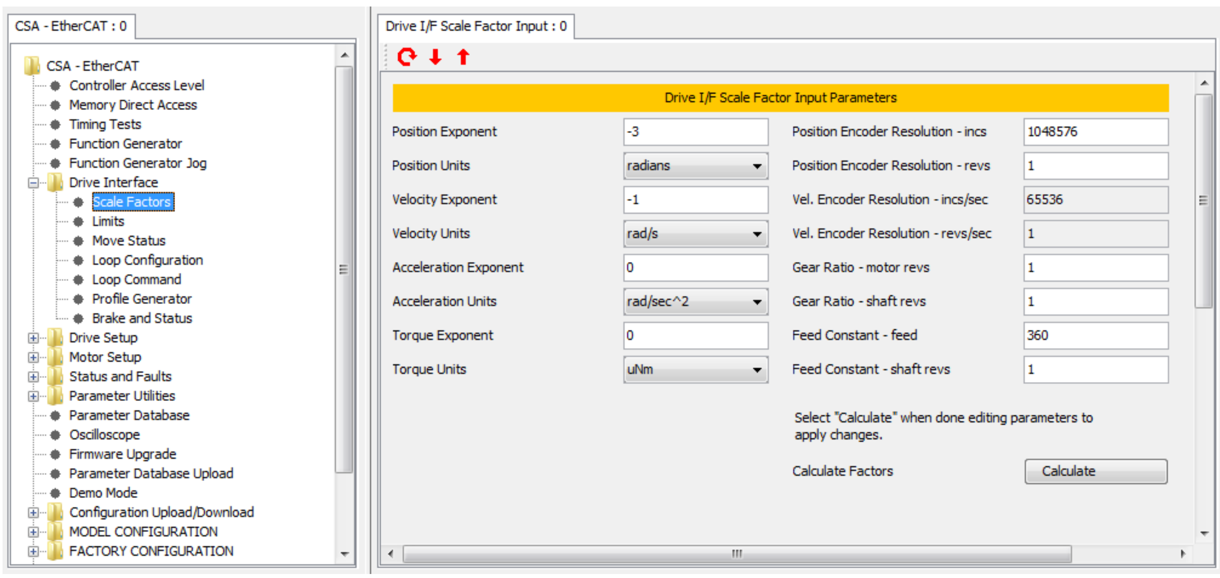


Function Generator Jog	
Section/Parameter	**Description**
Extend Position	Jogs the actuator to an Extended Position
Retract Position	Jogs the actuator to a Retracted Position

B.3.6 Drive Interface

B.3.6.1 Scale Factors

The Drive I/F Scale Factor Input Panel is used to scale the input commands to the Drive Interface into the internal units of the drive. The "Calculate" button should always be used after changing the scale factors in order to re-calculate internal scale factors and have them applied to the Drive Interface.

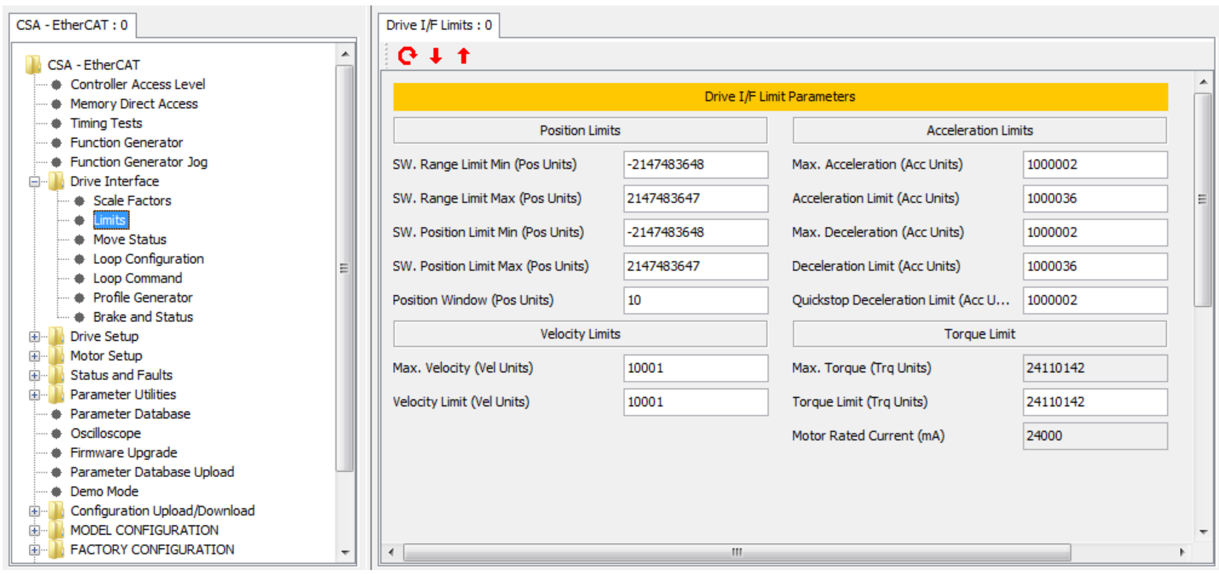


Drive Interface → Scale Factors	
Section & Parameter	**Description**
Position Exponent	Base 10 position decimal exponent applied to drive interface position inputs and outputs. Note that the exponent does not apply to units in increments.
Position Units	Options: increments, meters, radians, seconds, minutes, degrees, revs
Velocity Exponent	Base 10 velocity decimal exponent applied to drive interface velocity inputs and outputs. Note that the exponent does not apply to units in increments
Velocity Units	Options: increments/Tsample,increments/sec,m/sec, m/min, m/hour,rev/sec, rev/min, rev/hour,rad/s
Acceleration Exponent	Base 10 acceleration decimal exponent applied to drive interface acceleration inputs and outputs. Note that the exponent does not apply to units in increments.
Acceleration Units	Options: increments/Ts^2, increments/sec^2, m/sec^2, m/min^2, rev/sec^2, rev/min^2, rad/sec^2, rad/min^2
Torque Exponent	Base 10 torque decimal exponent applied to drive interface torque inputs and outputs. Note that the exponent does not apply to units in increments or uNm.
Torque Units	Options: increments, uNm, Nm,Amps, N/A
Position Encoder Resolution - incs	Position encoder resolution increments represents the dynamic range of the encoder increments before rollover
Position Encoder Resolution - revs	Number of revolutions represented in "position encoder resolution - incs"
Velocity Encoder Resolution - incs/sec	Velocity encoder resolution increments per second
Velocity Encoder Resolution - revs/sec	Number of revolutions represented in "velocity encoder

Drive Interface → Scale Factors	
Section & Parameter	**Description**
	resolution - incs/sec”
Gear Ratio - motor revs	Ratio of gear revolutions to motor revolutions
Feed Constant - feed	Amount of feed displacement in position units
Feed Constant - shaft revs	Number of shaft revolutions represented in the “Feed Constant”
Velocity Command Scale Factor Multiplier	Scalar applied to the velocity command input to the Drive Interface
Velocity Feedback Scale Factor Multiplier	Scalar applied to the velocity feedback output from the Drive Interface
Calculate Factors	Recalculates internal scale factors based on the parameters from this panel.

B.3.6.2 Limits

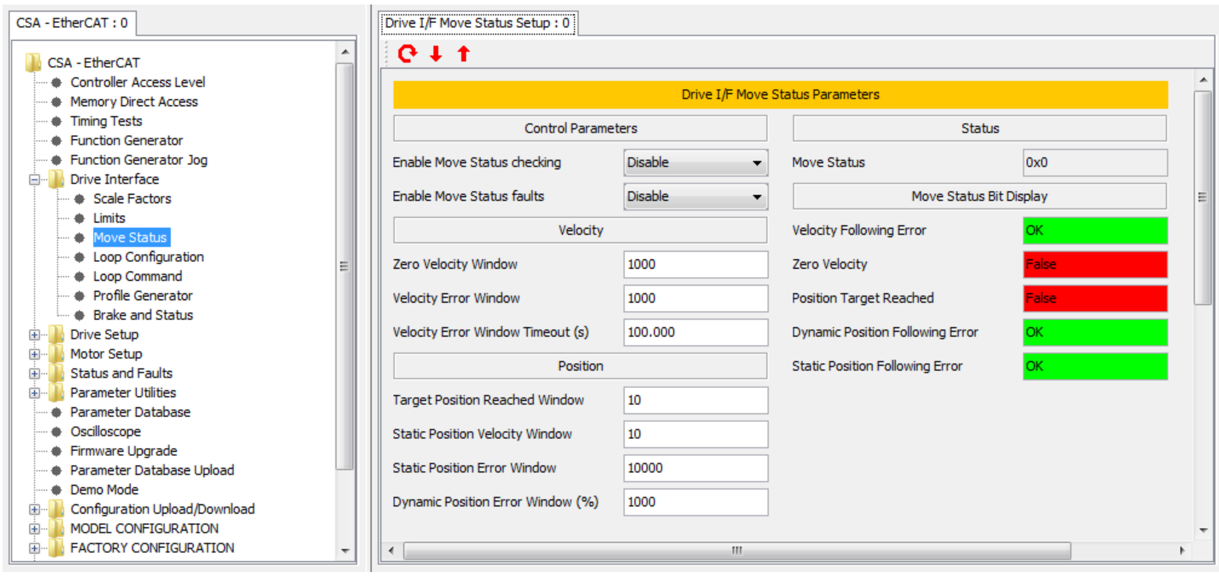
The Drive I/F Limit Parameter Panel is used to limit the Drive Interface (I/F) inputs.



Drive Interface → Limits	
Section & Parameter	**Description**
Position Limits	
SW. Range Limit Min (Pos Units)	The Range limits are applied to the position after the position limiting.
SW. Range Limit Max (Pos Units)	
SW. Position Limit Min (Pos Units)	If the Range limits bound the position limits, then position limiting is applied first.
SW. Position Limit Max (Pos Units)	
Position Window (Pos Units)	In position mode, the value at which a position error fault is detected
Velocity Limits	
Max. Velocity (Vel Units)	Maximum Velocity Capability
Velocity Limit (Vel Units)	Velocity Limit
Acceleration Limits	
Max. Acceleration (Acc Units)	Maximum Acceleration Capability
Acceleration Limit (Acc Units)	Acceleration Limit
Max. Deceleration (Acc Units)	Maximum Acceleration Capability
Deceleration Limit (Acc Units)	Deceleration Limit
Quickstop Deceleration Limit (Acc Units)	Deceleration Limit during a Quickstop Condition
Torque Limit	
Max. Torque (Trq Units)	Maximum Torque Capability
Torque Limit (Trq Units)	Torque Limit
Motor Rated Current (mA)	Motor Rated Current in milli-Amps

B.3.6.3 Move Status

The Drive I/F Move Status Setup Panel is used to configure motion monitoring and optionally faulting if configured options are not met.

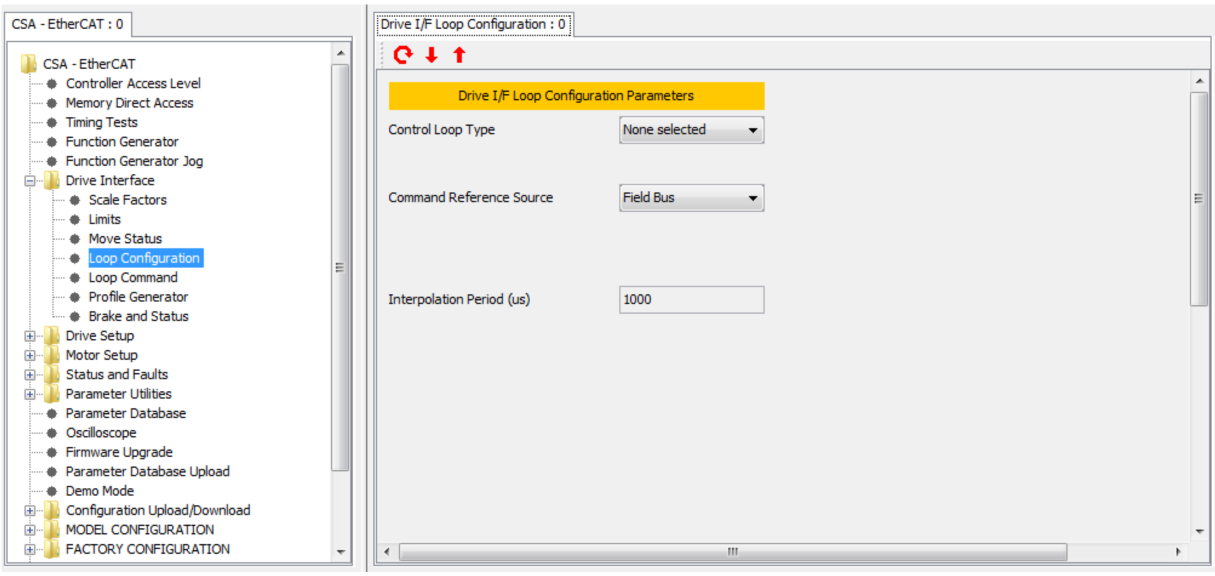


Drive Interface → Move Status	
Section & Parameter	**Description**
Control Parameters	
Enable Move Status Checking	Options: Disable or Enable. If the simulink model is running, it performs Move Status Checking, so this option should be set to 'Disable'
Enable Move Status faults	Options: Disable or Enable. If the simulink model is running, it generates Move Status Faults, so this option should be set to 'Disable'
Velocity	
Zero Velocity Window	Tolerance on the Zero Velocity Check
Velocity Error Window	Tolerance on the Velocity Error Check
Velocity Error Window Timeout (s)	Amount of time exceeding the Velocity Error before generating a fault.
Position	
Targeted Postion Reached Window	Tolerance for determining if the target position was reached.
Static Position Velocity Window	Velocity Window beneath which the Static Position Error is assessed.
Static Position Error Window	Tolerance which if exceeded generates a static following error.
Dynamic Position Error Window (%)	If outside the Static Position Velocity Window and the following error exceeds a percentage of the following error, a Dynamic Position Error is generated.
Status	
Move Status	Move Status has the following bit definitions, where active is logic '1': Bit 0: Static position following error Bit 1: Dynamic position following error Bit 2: Position target reached Bit 3: Speed is equal to 0 Bit 4: Velocity following error

Drive Interface → Move Status	
Section & Parameter	**Description**
Move Status Bit Display	
Velocity Following Error	Values: 'OK' or 'Fault'
Zero Velocity	Values: 'False' or 'True'
Position Target Reached	Values: 'False' or 'True'
Dynamic Position Following Error	Values: 'OK' or 'Fault'
Static Position Following Error	Values: 'OK' or 'Fault'

B.3.6.4 Loop Configuration

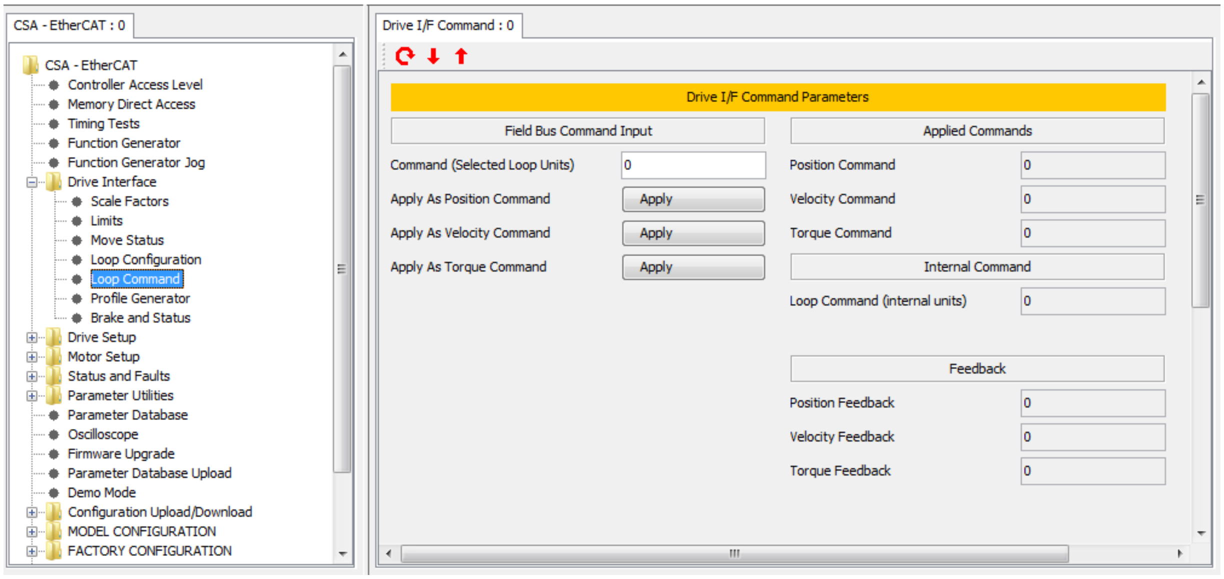
The Drive I/F Loop Configuration Parameter Panel is used to set the control loop options.



Drive Interface → Loop Configuration	
Section & Parameter	**Description**
Control Loop Type	Options: None Selected, Torque, Position or Velocity
Command Reference Source	Options: None, Function Generator, Fieldbus
Interpolation Period (us)	Time between samples. By default, the Function Generator runs at 8kHz, which is 125 usec between samples. Since the control loops run at 8kHz, interpolation is not performed.

B.3.6.5 Loop Command

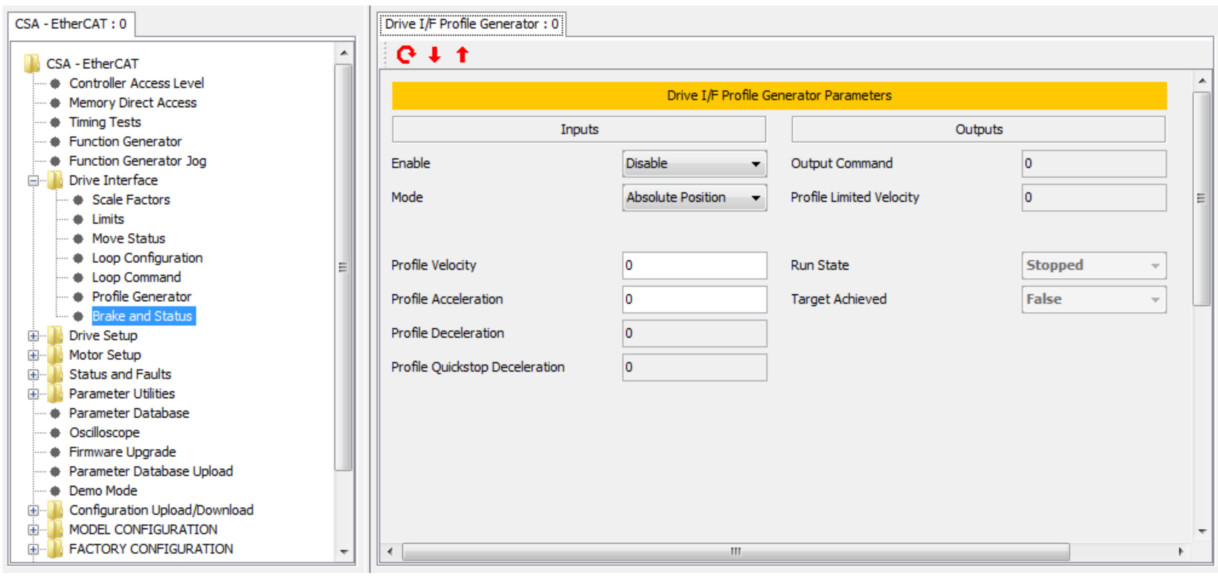
The Drive I/F Command Input Panel is used to set the control loop inputs. The “Command” is in the units selected in the Drive I/F Scale Factor Input Panel.



Drive Interface → Move Status	
Section & Parameter	**Description**
Field Bus Command Input	
Command (Selected Loop Units)	A manually entered fieldbus command value.
Apply as Position Command	Execute to apply the ‘Command’ as a position value.
Apply as Velocity Command	Execute to apply the ‘Command’ as a velocity value.
Apply as Torque Command	Execute to apply the ‘Command’ as a torque value.
Applied Commands	
Position Command	The manually entered ‘Command’ value.
Velocity Command	The manually entered ‘Command’ value.
Torque Command	The manually entered ‘Command’ value.
Internal Command	
Loop Command (internal units)	The internal loop command scaled to the selected loop units.
Feedback	
Position Feedback	Present value of the position feedback.
Velocity Feedback	Present value of the velocity feedback.
Torque Feedback	Present value of the torque feedback.

B.3.6.6 Profile Generator

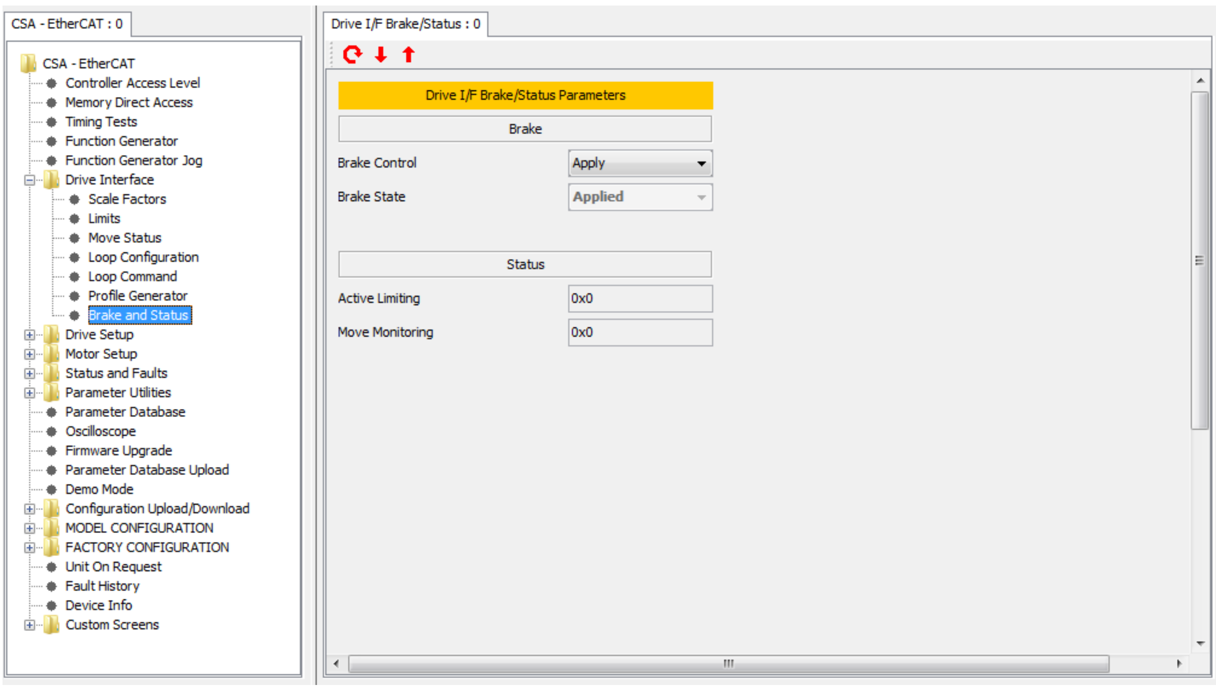
The Drive I/F Profile Generator Panel is used to create profiled moves.



Drive Interface → Profile Generator	
Section & Parameter	**Description**
Inputs	
Enable	Options: Disable or Enable
Mode	Options: Absolute Position, Relative Position or Velocity
Profile Velocity	The Profile Velocity in present Velocity units
Profile Acceleration	The Profile Acceleration in present Acceleration units
Profile Deceleration	Present implementation automatically sets this to the Profile Acceleration
Profile Quickstop Deceleration	Present implementation automatically sets this to the Profile Acceleration
Outputs	
Output Command	Profile Generator Output
Profile Limited Velocity	The Profile Limited Velocity
Run State	Values: Stopped or Running
Target Achieved	Values: False or True

B.3.6.7 Brake and Status

The Drive I/F Brake/Status Panel is used to configure brake behavior and monitor drive and motion status.



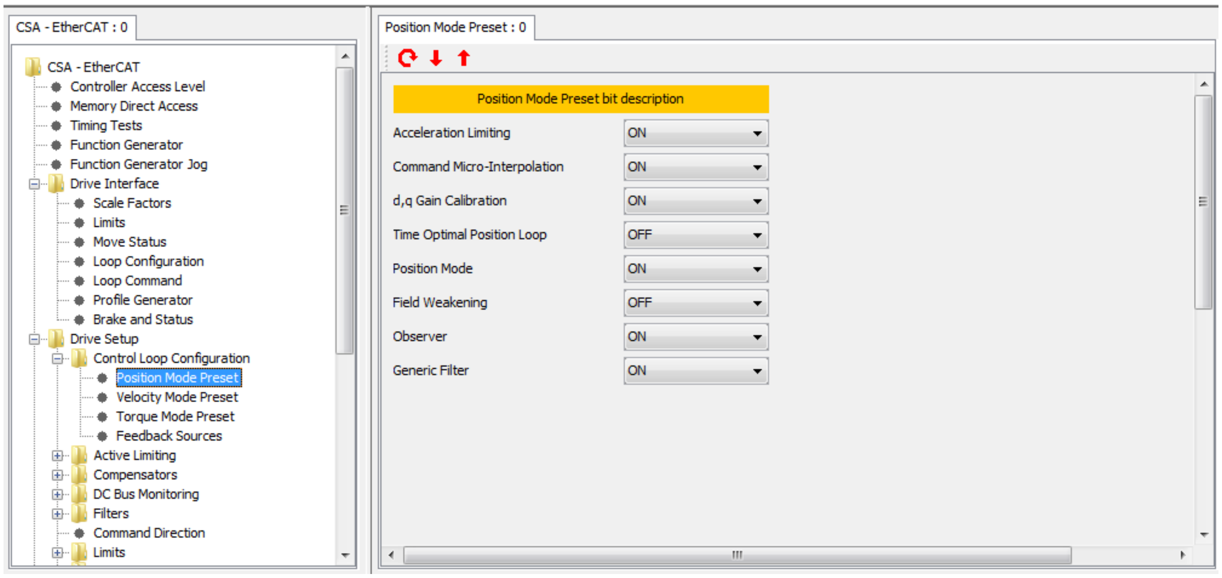
Drive Interface → Brake and Status	
Section & Parameter	**Description**
Brake	
Brake Control	Options: Apply or Release
Brake State	Values: Applied or Released
Status	
Active Limiting	Active Limiting is configured on "Drive Setup → Active Limiting". Limiting Status has the following bit definitions, where active is logic '1': Bit 0: Thermal Limiting Status Bit 1: IT Limiting Status Bit 2: Manual Mode Current Limiting Bit 3: I^2T Limiting
Move Monitoring	Move Monitoring is configured on "Drive Interface → Move Status". Move Status has the following bit definitions, where active is logic '1': Bit 0: Static position following error Bit 1: Dynamic position following error Bit 2: Position target reached Bit 3: Speed is equal to 0 Bit 4: Velocity following error

B.3.7 <u>Drive Setup</u>

B.3.7.1 Control Loop Configuration

B.3.7.1.1 Position Mode Preset

The Position Mode Preset Panel is used to configure the position mode loop options.

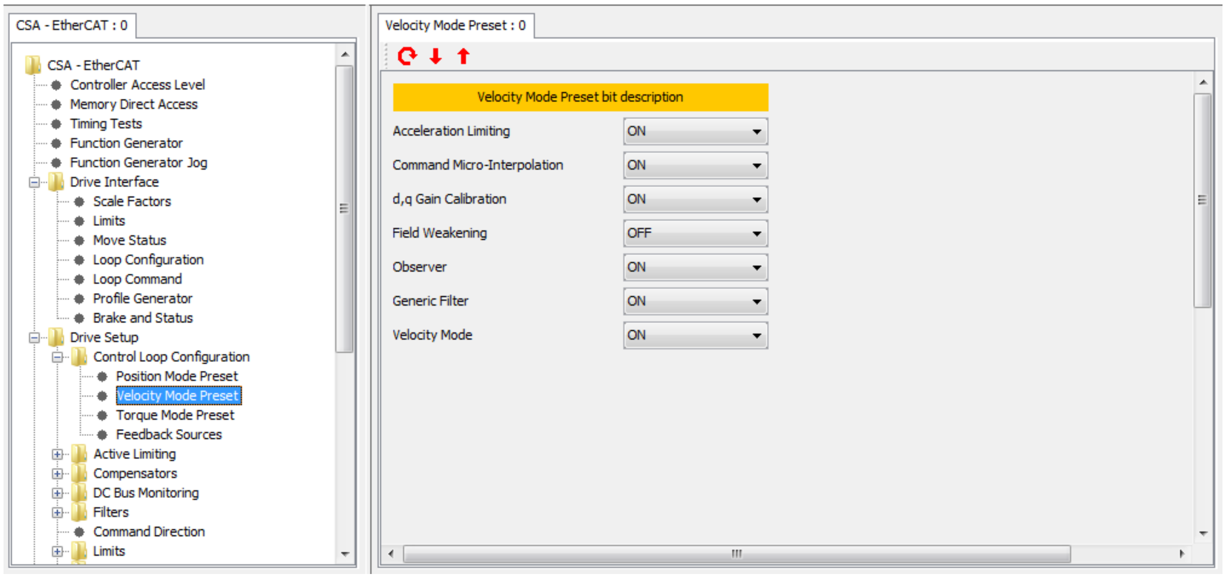


The Position Mode Preset panel is used to set the mode request when a position control mode is requested.

Section & Parameter	Description
Acceleration Limiting	Options: ON (default) or OFF
Command Micro Interpolation	Options: ON (default) or OFF
d,q Gain Calibration	Options: ON (default) or OFF
Time Optimal Position Loop	Options: ON or OFF (default)
Position Mode	Options: ON must be set if position mode, otherwise set to OFF
Field weakening	Options: ON or OFF (default)
Observer	Options: ON (default) or OFF
Generic Filter	Options: ON (default) or OFF

B.3.7.1.2 Velocity Mode Preset

The Velocity Mode Preset Panel is used to configure the velocity mode loop options.

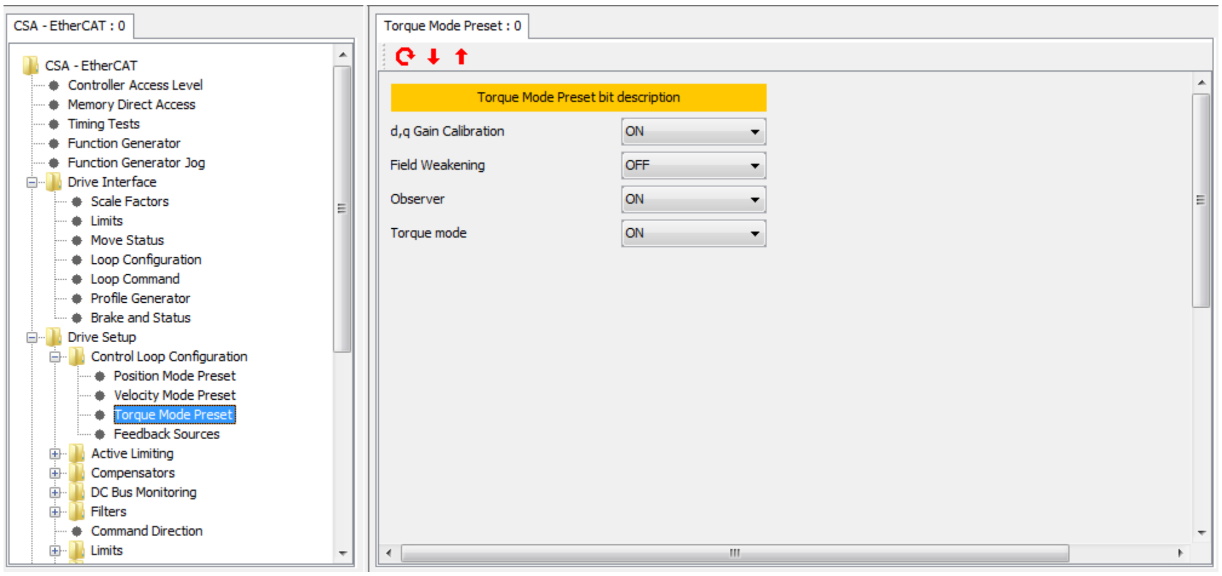


The Velocity Mode Preset panel is used to set the mode request when a velocity control mode is requested.

Section & Parameter	Description
Acceleration Limiting	Options: ON (default) or OFF
Command Micro Interpolation	Options: ON (default) or OFF
d,q Gain Calibration	Options: ON (default) or OFF
Field weakening	Options: ON or OFF (default)
Observer	Options: ON (default) or OFF
Generic Filter	Options: ON (default) or OFF
Velocity Mode	Options: ON must be set if in Velocity Mode, otherwise set to OFF

B.3.7.1.3 Torque Mode Preset

The Torque Mode Preset Panel is used to configure the torque mode loop options.

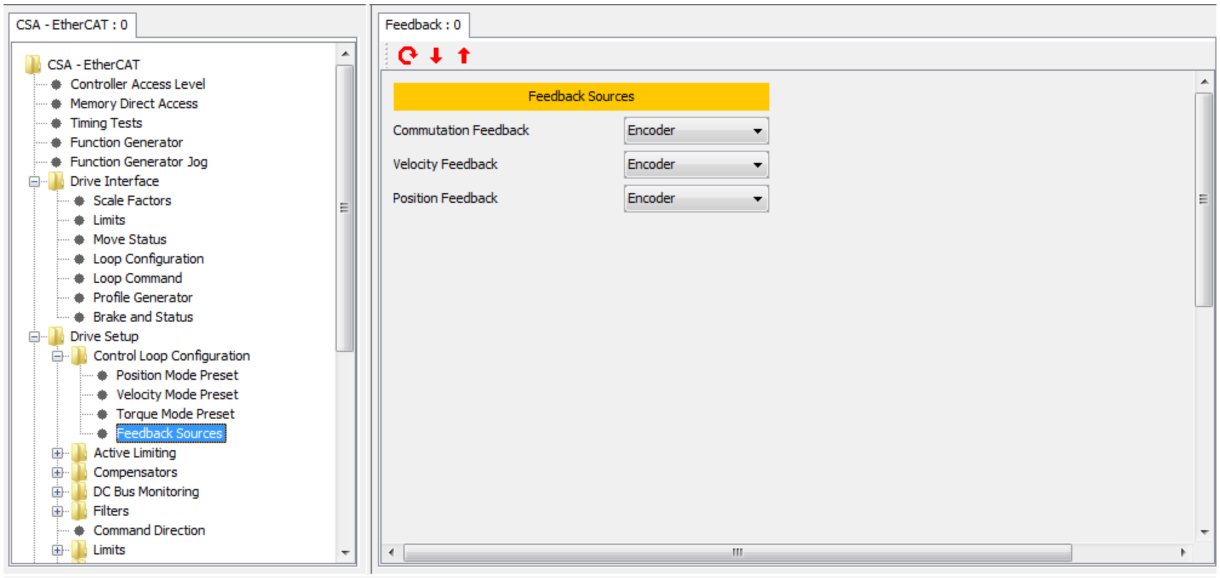


The Torque Mode Preset panel is used to set the mode request when a torque control mode is requested.

Section & Parameter	Description
d,q Gain Calibration	Options: ON (default) or OFF
Field weakening	Options: ON or OFF (default)
Observer	Options: ON (default) or OFF
Torque Mode	Options: ON must be set if in Torque Mode, otherwise set to OFF

B.3.7.1.4 Feedback Sources

The Feedback Panel is used to select the feedback sources for the control loops and motor commutation.



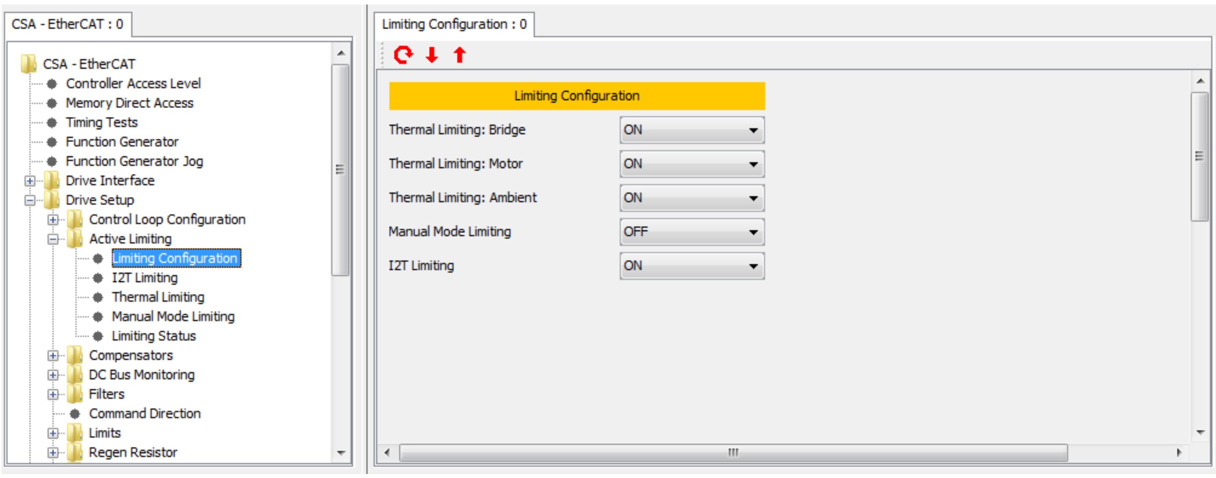
The Feedback Sources panel is used to choose the feedback source used in the position and velocity loops between angle zero, resolver and encoder. Angle zero implies that no commutation feedback source is selected; Moog Application or Design Engineering ONLY should use this value. Customers must select encoder or resolver feedback to turn a motor.

Section & Parameter	Description
Commutation Feedback	Options: Angle Zero, Resolver or Encoder
Velocity Feedback	Options: Angle Zero, Resolver or Encoder
Position Feedback	Options: Angle Zero, Resolver or Encoder

B.3.7.2 Active Limiting

B.3.7.2.1 Limiting Configuration

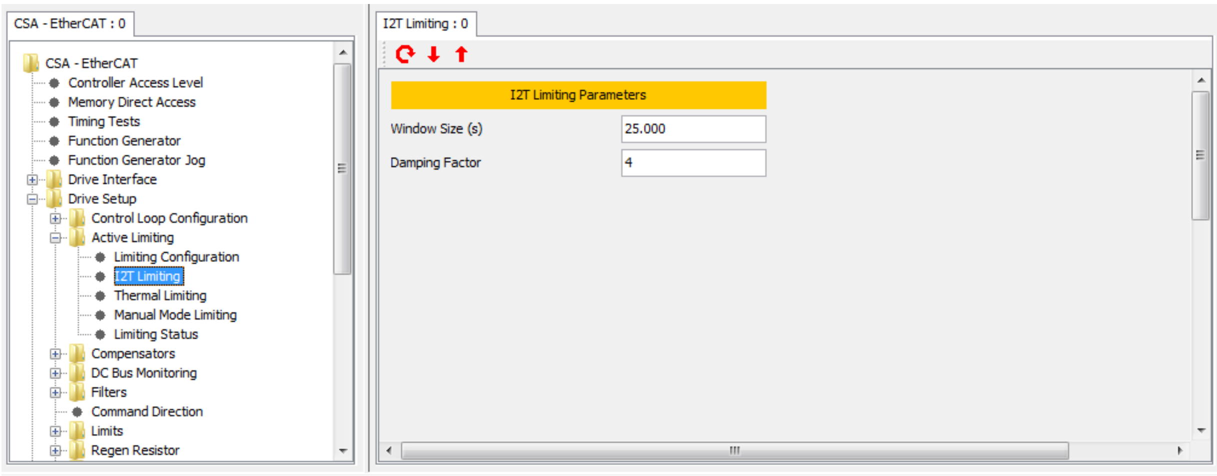
The Limiting Configuration Panel is used to configure the limiting options.



Section & Parameter	Description
Thermal Limiting: Bridge	Options: ON (default) or OFF
Thermal Limiting: Motor	Options: ON (default) or OFF
Thermal Limiting: Ambient	Options: ON (default) or OFF
Manual Mode Limiting	Options: ON (default) or OFF
I2T Limiting	Options: ON (default) or OFF
IT Limiting	IT Limiting is not shown and should never be disabled; it must be enabled in order to protect the drive hardware and motor.

B.3.7.3 I2T Limiting

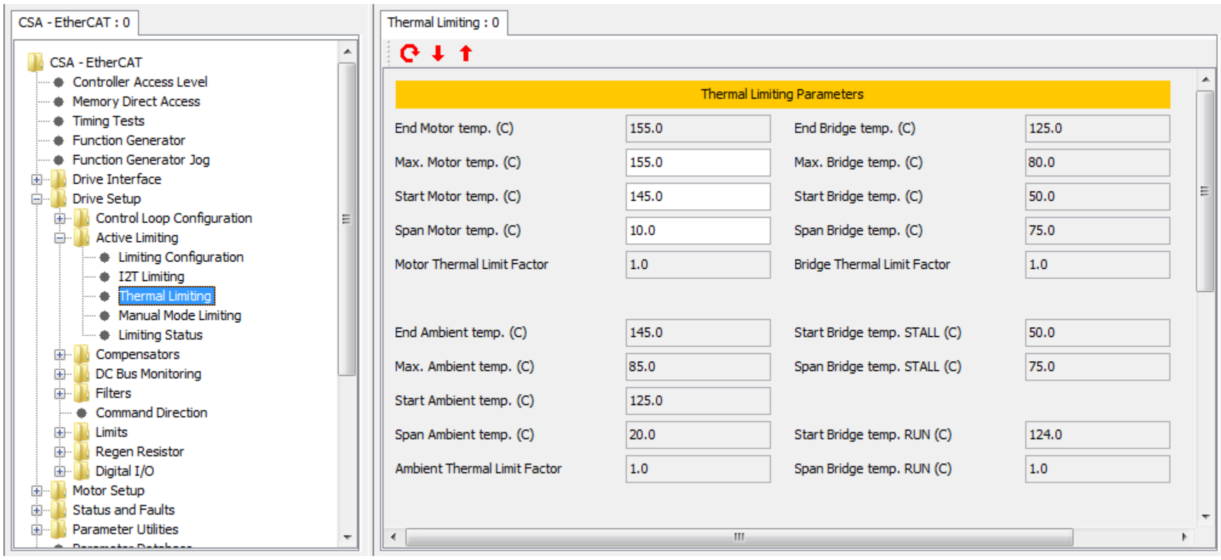
The I2T Limiting Panel is used to set the I2T Limiting parameters.



Section & Parameter	Description
Window Size (s)	Averaging window for I2T limiting
Damping Factor	I2T output smoothing

B.3.7.4 Thermal Limiting

The Thermal Limiting Panel is used to set the motor, bridge and ambient thermal limiting parameters.



Section & Parameter	Description
Motor	
End Motor temp. (C)	Read only value, calculated from start + span. At this temperature the current is reduced to 0.
Max. Motor temp. (C)	The temperature at which an over-temperature fault is indicated
Start Motor temp. (C)	The temperature at which thermal limiting starts to act
Span Motor temp. (C)	The temperature range over which the current is reduced to 0.
Motor Thermal Limit Factor	The actual value of the thermal limit factor (a value between 0 and 1.0)
Ambient	
End Ambient temp. (C)	Read only value, calculated from start + span. At this temperature the current is reduced to 0.
Max. Ambient temp. (C)	The temperature at which an over-temperature fault is indicated
Start Ambient temp. (C)	The temperature at which thermal limiting starts to act
Span Ambient temp. (C)	The temperature range over which the current is reduced to 0.
Ambient Thermal Limit Factor	The actual value of the thermal limit factor (a value between 0 and 1.0)
Bridge	
End Bridge temp. (C)	Read only value, calculated from start + span. At this temperature the current is reduced to 0.
Max. Bridge temp. (C)	The temperature at which an over-temperature fault is indicated
Start Bridge temp. (C)	The temperature at which thermal limiting starts to act
Span Bridge temp. (C)	The temperature range over which the current is reduced to 0.
Bridge Thermal Limit Factor	The actual value of the thermal limit factor (a value between 0 and 1.0)
Bridge Temperature Run and Stall Conditions	
Start Bridge temp. STALL	The temperature at which thermal limiting starts to act for motor speed of ≤50RPM
Span Bridge temp. STALL	The temperature range over which the current is reduced to 0 for motor speed of ≤50RPM
Start Bridge temp. RUN	The temperature at which thermal limiting starts to act for motor speed of >50RPM
Span Bridge temp. RUN	The temperature range over which the current is reduced to 0 for

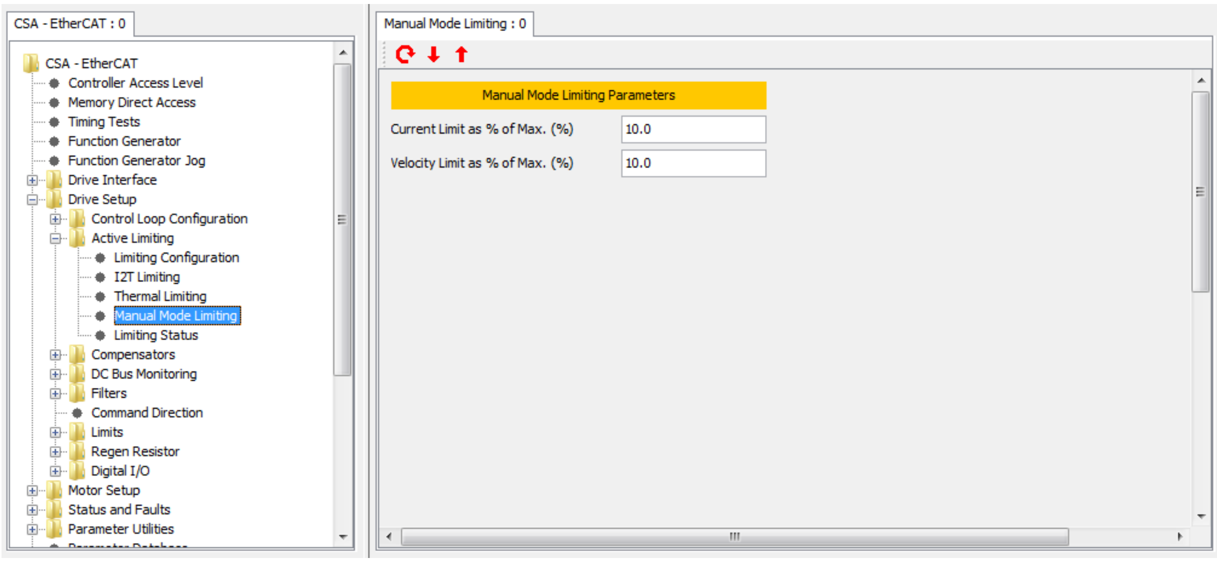
	motor speed of >50RPM

A motor with an NTC sensor supports a measurement range of 25°C to 175°C. A PTC sensor is essentially a thernal switch which acts at approximately 150°C; therefore, thermal limiting is not applicable.

The software calculates the motor thermal limit based upon the motor windings temperature. The motor protection scheme is intended to ensure that the temperature of the motor core will not exceed 155°C.

B.3.7.5 Manual Mode Limiting

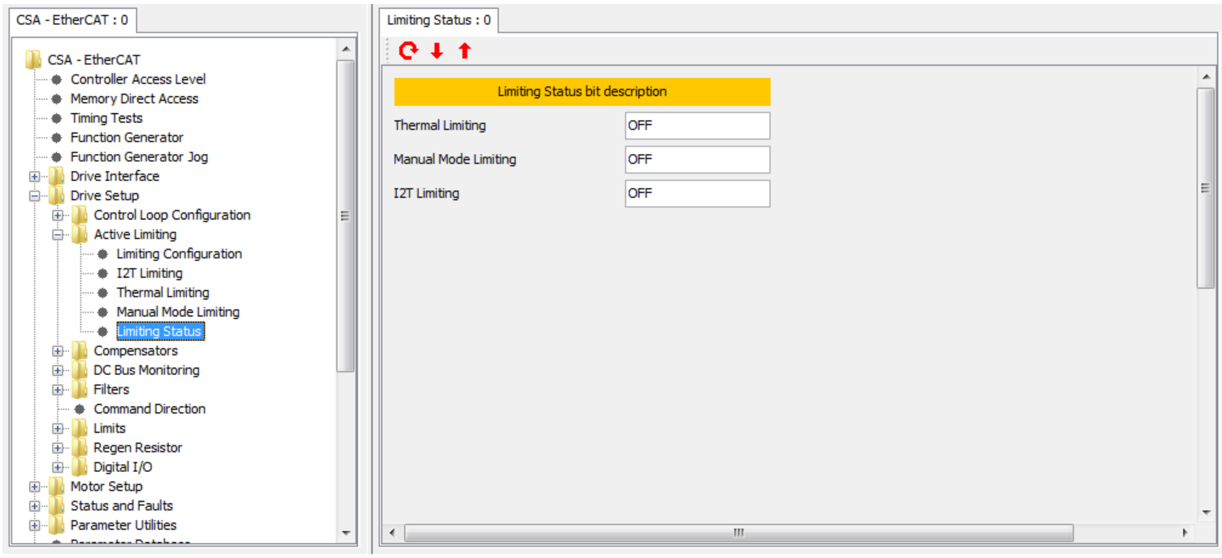
The Manual Mode Limiting Panel is used to set the parameters of this mode.



Section & Parameter	Description
Current Limit as % of Max. (%)	The current limit as a percent of the max value.
Velocity Limit as % of Max. (%)	The velocity limit as a percent of the max value.

B.3.7.6 Limiting Status

The Limiting Status Panel is used to view whether any limiting is active

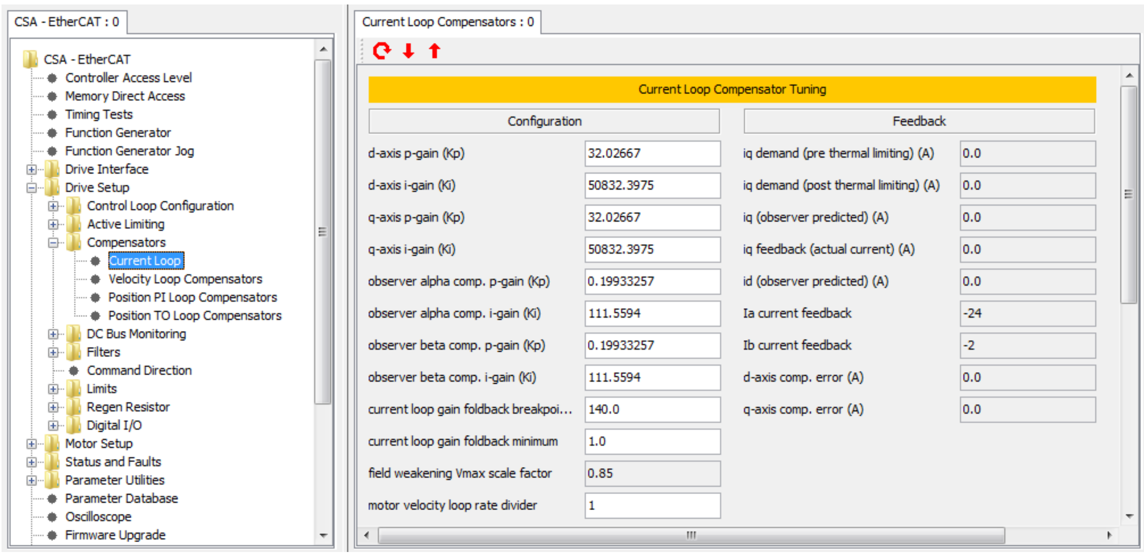


Section & Parameter	Description
Thermal Limiting	Options: ON (default) or OFF
Manual Mode Limiting	Options: ON or OFF (default)
I2T Limiting	Options: ON (default) or OFF

B.3.7.7 Compensators

B.3.7.7.1 Current Loop

The Current Loop Compensators Panel is used to set/read the current loop compensator configuration and to monitor some internal loop variables.



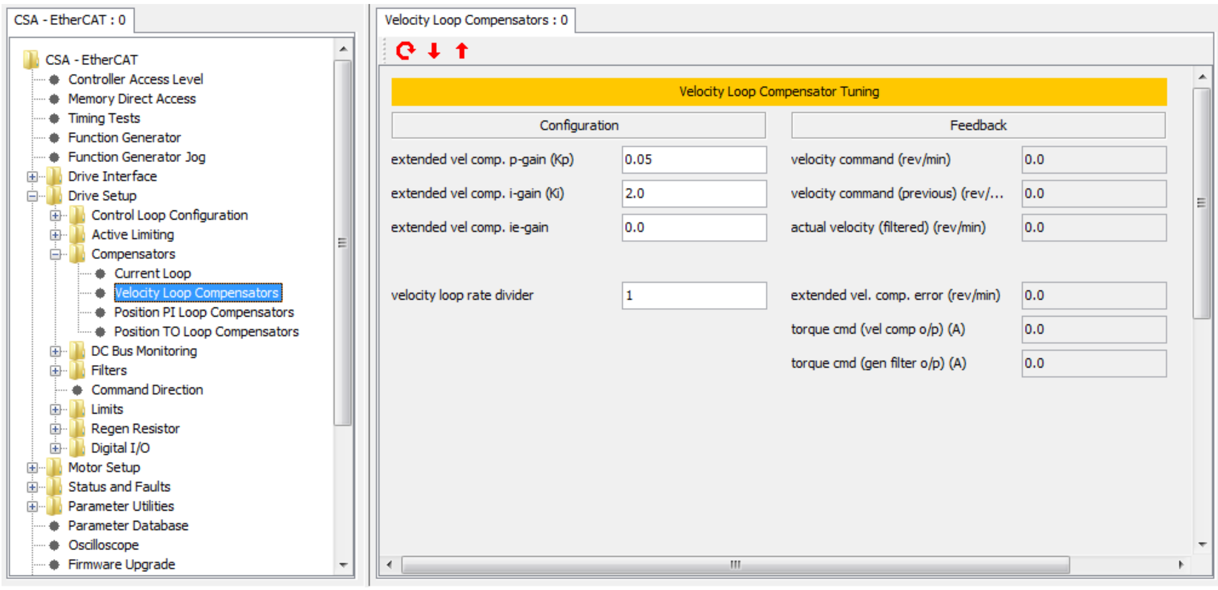
The current control consists of a pair of compensators, one for the q-axis current control and the other for d-axis current control. The feedback currents 'current_q-axis_observer' and 'current_d-axis_observer' are output from the predictive current state observers.

Section & Parameter	Description
Configuration	
d-axis p-gain (Kp)	The p-gain of the d-axis compensator (Volts/Amp).
d-axis i-gain (Ki)	The i-gain of the d-axis compensator (Volts/Amp/Tsamp).
q-axis p-gain (Kp)	The p-gain of the q-axis compensator (Volts/Amp).
q-axis i-gain (Ki)	The i-gain of the q-axis compensator (Volts/Amp/Tsamp).
observer alpha comp. p-gain (Kp)	The p-gain of the observer alpha compensator (Volts/Amp).
observer alpha comp. i-gain (Ki)	The i-gain of the observer alpha compensator (Volts/Amp/Tsamp).
observer beta comp. p-gain (Kp)	The p-gain of the observer beta compensator (Volts/Amp).
observer beta comp. i-gain (Ki)	The i-gain of the observer beta compensator (Volts/Amp/Tsamp).
current loop gain foldback breakpoint (A)	the current at which the current loop gain foldback starts
current loop gain foldback minimum	The minimum value for the current loop gain foldback expressed as a fraction.
Motor velocity loop rate divider	Motor velocity loop rate divider → The rate divider for the motor velocity calculation – the number of current loop samples per motor velocity sample
Feedback	
iq demand (pre thermal limiting) (A)	The requested current on q-axis (before thermal limits setting).
iq demand (post thermal limiting) (A)	The requested current on q-axis (after thermal limits setting).
iq (observer predicted) (A)	The value of the q-axis current predicted by the observer.
iq feedback (actual current) (A)	The actual real value of the q-axis current.
id (observer predicted) (A)	The value of the d-axis current predicted by the observer.
d-axis comp. error (A)	The difference between actual value and demanded value of the d-axis current.

Section & Parameter	Description
q-axis comp. error (A)	The difference between actual value and demanded value of the q-axis current.

B.3.7.8 Velocity Loop Compensators

The Velocity Loop Compensators Panel is used to set the velocity loop compensator configuration and to view the feedback values.

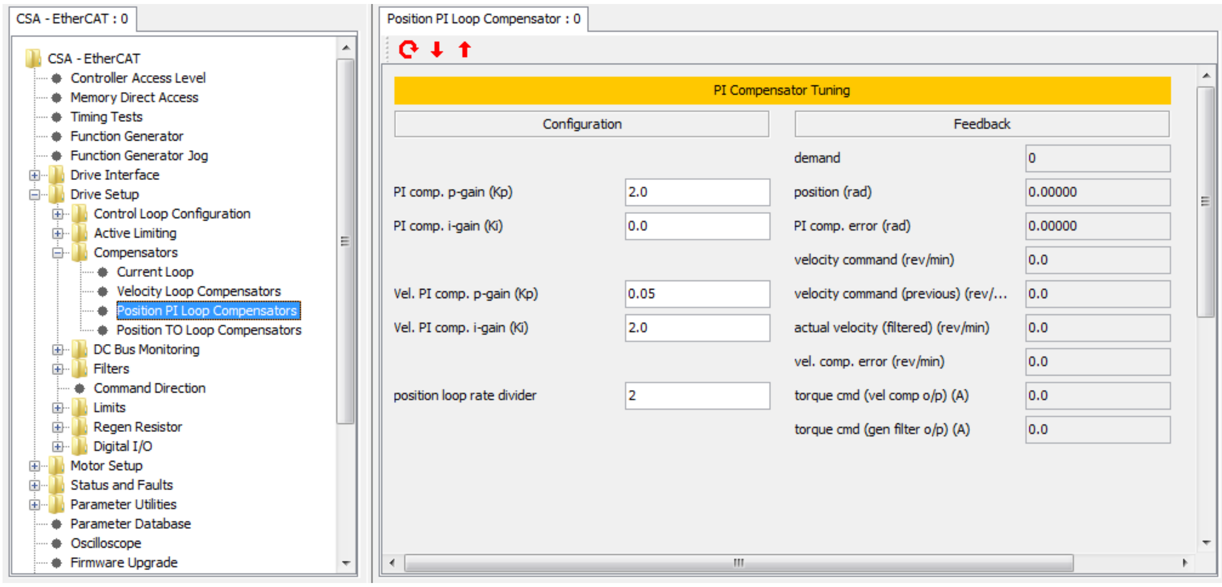


In velocity mode, the velocity compensator is an I-PI configuration. The output of this compensator is limited ±Imax, and these limits can be read using the upper and lower limit parameters of the compensator.

Section & Parameter	Description
Configuration	
extd vel comp. p-gain (Kp)	The p-gain of the velocity compensator (Nm/rad/s).
extd vel comp. i-gain (Ki)	The i-gain of the velocity compensator (Nm/rad).
extd vel comp. ie-gain	The ie-gain of the velocity compensator.
velocity loop rate divider	The rate divider for the velocity loop – the number of current loop samples per velocity loop sample. Set to 1 as the velocity loop normally executes at 8kHz, the same rate as the current loops,
Feedback	
velocity command	Velocity command prior to acceleration limiting
velocity command (previous)	Velocity command after acceleration limiting
actual velocity (filtered) (rad/s)	Low pass filtered velocity
extd vel. comp. error	The difference between actual velocity and demanded velocity
torque cmd (vel comp o/p) (A)	The output from the velocity compensator
torque cmd (gen filter o/p) (A)	The output from the velocity compensator after passing through the generic filter block

B.3.7.9 Position PI Loop Compensators

The Position PI Loop Compensator Panel is used to set the configuration of the PI loop gains and to see the feedback values.

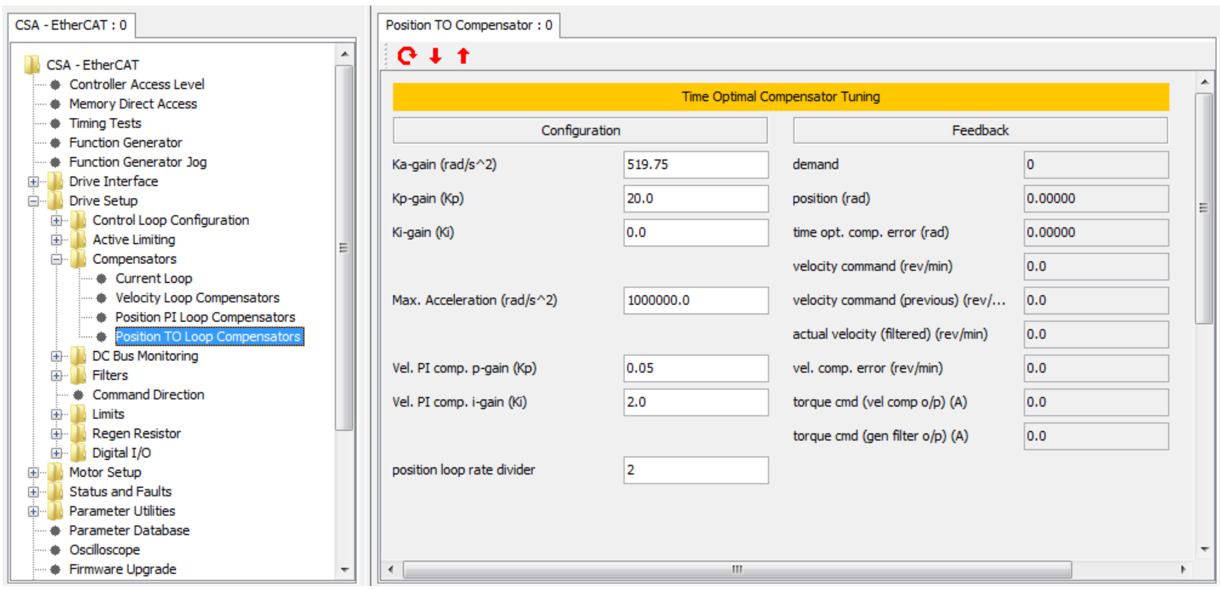


The output of the compensator is limited to motvelliminc, a term derived from the motor_max_velocity parameter. The compensator also implements anti-windup for the compensator's integrator.

Section & Parameter	Description
Configuration	
PI comp. p-gain (Kp)	The p-gain of the PI compensator (1/s).
PI comp. i-gain (Ki)	The i-gain of the PI compensator (1/s^2).
Vel. Pi comp. p-gain (Kp)	The p-gain of the velocity loop PI compensator used in position mode (Nm/rad/s). This is separate to the velocity loop compensator used in velocity mode.
Vel. Pi comp. i-gain (Ki)	The i-gain of the velocity loop PI compensator used in position mode (Nm/rad). This is separate to the velocity loop compensator used in velocity mode.
position loop rate divider	The rate divider of the position loop mode – the number of current loop samples per position loop sample.
Feedback	
demand	The requested value of the position (note that the units for this parameter will only be correct (rad) when the drive is position mode)
position (rad)	The actual value of the position
PI comp. error	The difference between position and demand.
velocity command	Velocity command prior to acceleration limiting (the output from the PI compensator)
velocity command (previous)	Velocity command after acceleration limiting
actual velocity (filtered) (rad/s)	Low pass filtered velocity
vel. comp. error	Difference between actual velocity and demanded velocity
torque cmd (vel comp o/p) (A)	The output from the velocity compensator
torque cmd (gen filter o/p) (A)	The output from the velocity compensator after passing through the generic filter block.

B.3.7.10 Position TO Loop Compensators

The Position TO Loop Compensator Panel is used to set the configuration of the Time Optimal (TO) loop gains and to see the feedback values.



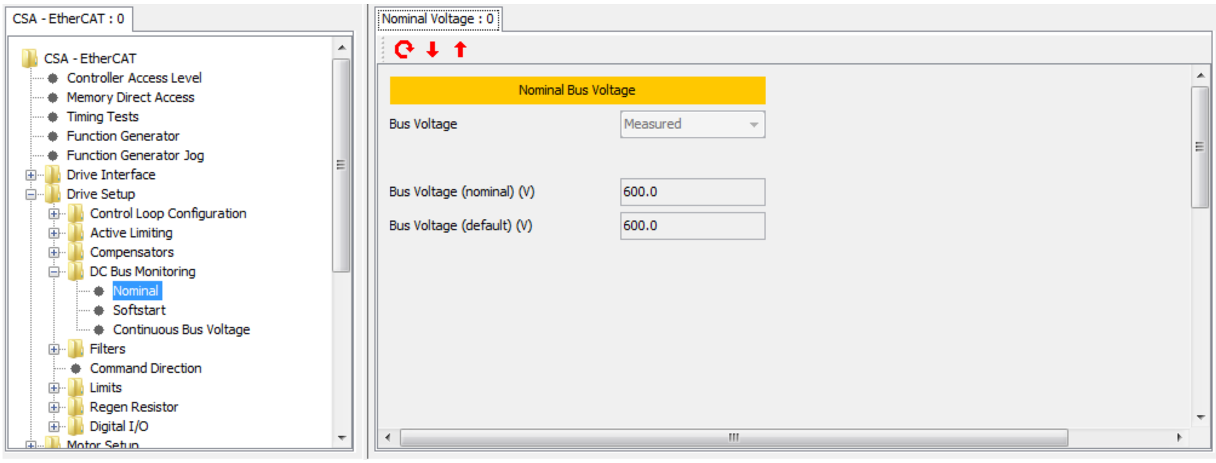
The time-optimal compensator is a non-linear compensator that uses a square root function of the position error, to give optimal deceleration performance.

Section & Parameter	Description
Configuration	
demand	The requested value of the position (note that the units for this parameter will only be correct (rad) when the drive is position mode)
position (rad)	The actual value of the position
PI comp. error	The difference between position and demand.
velocity command	Velocity command prior to acceleration limiting (the output from the PI compensator)
velocity command (previous)	Velocity command after acceleration limiting
actual velocity (filtered) (rad/s)	Vow pass filtered velocity
vel. comp. error	Difference between actual velocity and demanded velocity
Feedback	
demand	The requested value of the position.
position (rad)	The actual value of the position
time opt. comp. error	The difference between position and demand.
velocity command	Velocity command prior to acceleration limiting (the output from the PI compensator)
velocity command (previous)	Velocity command after acceleration limiting
actual velocity (filtered) (rad/s)	Low pass filtered velocity
vel. comp. error	Difference between actual velocity and demanded velocity
torque cmd (vel comp o/p) (A)	The output from the velocity compensator
torque cmd (gen filter o/p) (A)	The output from the velocity compensator after passing through the generic filter block

B.3.7.11 DC Bus Monitoring

B.3.7.11.1 Nominal

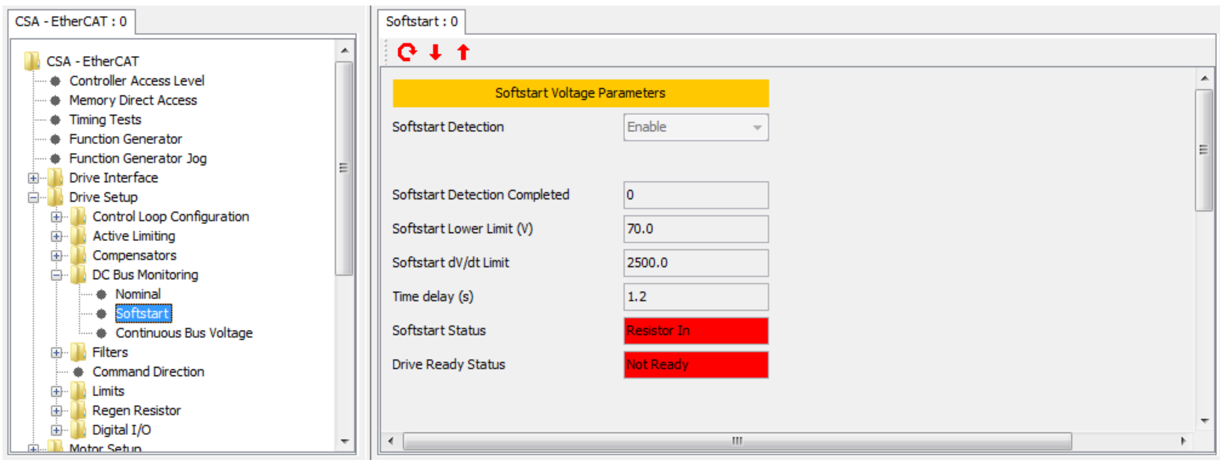
The Nominal Voltage Panel is used to view the nominal value of the DC bus voltage and configure the Bus Monitoring as Measured or Nominal.



Section & Parameter	Description
Bus Voltage	Set to either "Measured" or "Nominal" for the schemes to establish the value of the Bus Voltage. The setting of "Nominal" should never be used with 3 phase power.
Bus Voltage (nominal) (V)	If measured bus voltage is selected then this value is measured once the bus voltage is stable, otherwise this is the default bus voltage
Bus Voltage (default) (V)	The default value of the bus voltage, if the Measured value has not been established (startup)

B.3.7.12 Softstart

The Softstart Panel is used to enable/disable the softstart detection and to set the softstart parameters.

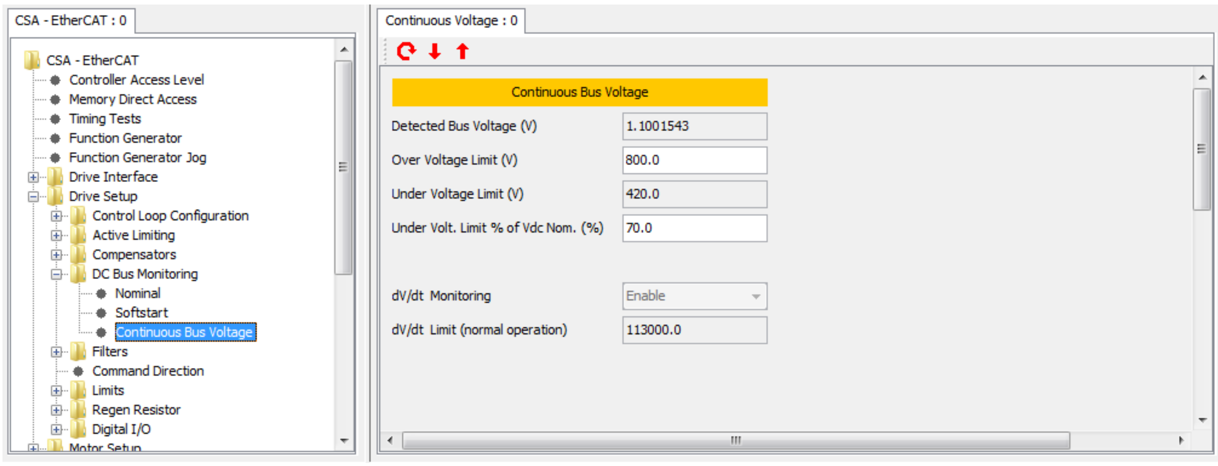


Softstart is used to limit the in-rush current to the DC bus capacitor bank on application of AC mains power. The Softstart Process will only occur if the DC bus voltage level is above the softstart lower limit.

Section & Parameter	Description
Softstart Detection	Set to 'Enable' to detect an in-rush and a stable bus voltage before establishing a nominal bus voltage and a corresponding Under Voltage level. A setting of 'Disable' will employ a time delay before establishing the nominal bus voltage and Under Voltage level.
Softstart Detection Completed	Shows whether the softstart detection has been completed (value of 1).
Softstart Lower Limit (V)	The voltage above which the Softstart process begins.
Softstart dV/dt Limit	Set from the Power Configuration Table if crdpwrid is 1. This is the limit below which the bus voltage is assumed to be stable.
Time delay (s)	If the Softstart Detection is disabled, the drive will delay, and then measure the Bus Voltage, establishing an under-voltage limit and proceeding to the Ready to be Enabled state. If the Softstart Detection is enabled, this delay occurs after the bus is stable, and then the Bus Voltage is measured, establishing an under-voltage limit and proceeding to the Ready to be Enabled state.
Softstart Status	An indication that the Softstart Resistor is either In the circuit (ready to prevent an in-rush of current and an Over-Voltage Fault) or Out of the circuit (ready for enabling and drawing current through the power stage).
Drive Ready Status	An indication that the Drive is either Ready to be enabled or Not Ready to be enabled (typically due to an absence of DC Bus Power or a fault).

B.3.7.13 Continuous Bus Voltage

The Continuous Voltage Panel shows the bus voltage status and allows the voltage limits to be set.

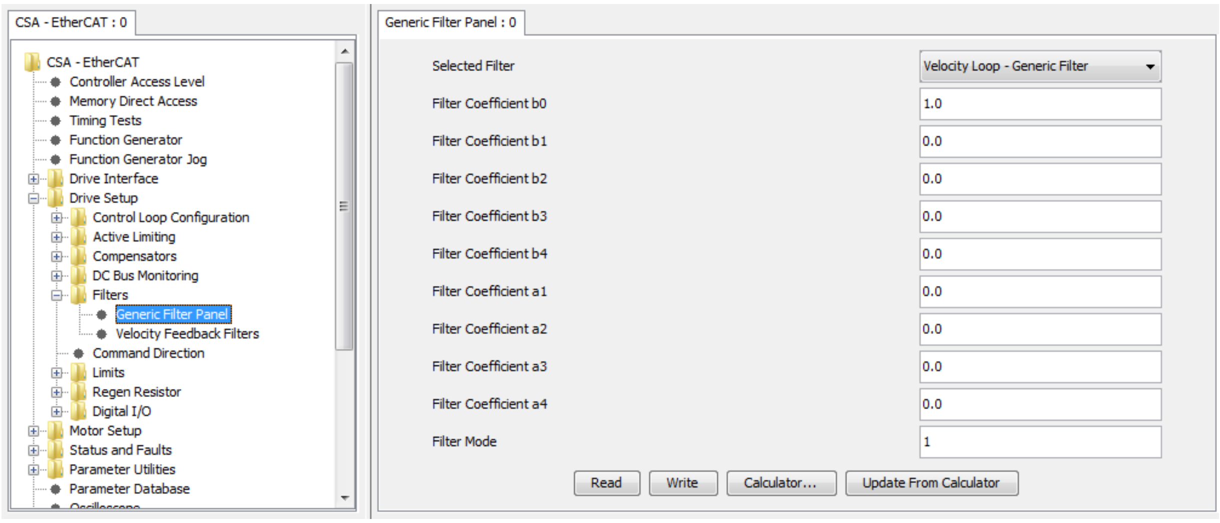


Section & Parameter	Description
Detected Bus Voltage (V)	The actual value of the bus voltage.
Over Voltage Limit (V)	The bus voltage at which a bus over-voltage fault is indicated.
Under Voltage Limit (V)	The bus voltage at which a bus under-voltage fault is indicated. This is read only, the value being set by the percentage parameter.
Under Volt. Limit % of Vdc Nom. (%)	The percentage of the nominal voltage that will be used as the under voltage limit.
dV/dt Monitoring	Options: Enable or Disable
dV/dt Limit (normal operation)	The value at which a fault is generated indicating an unstable bus voltage

B.3.7.14 Filters

B.3.7.14.1 Generic Filter

The Generic Filter Panel is used to set the 9 programmable parameters of the filter on the output of the velocity compensator.

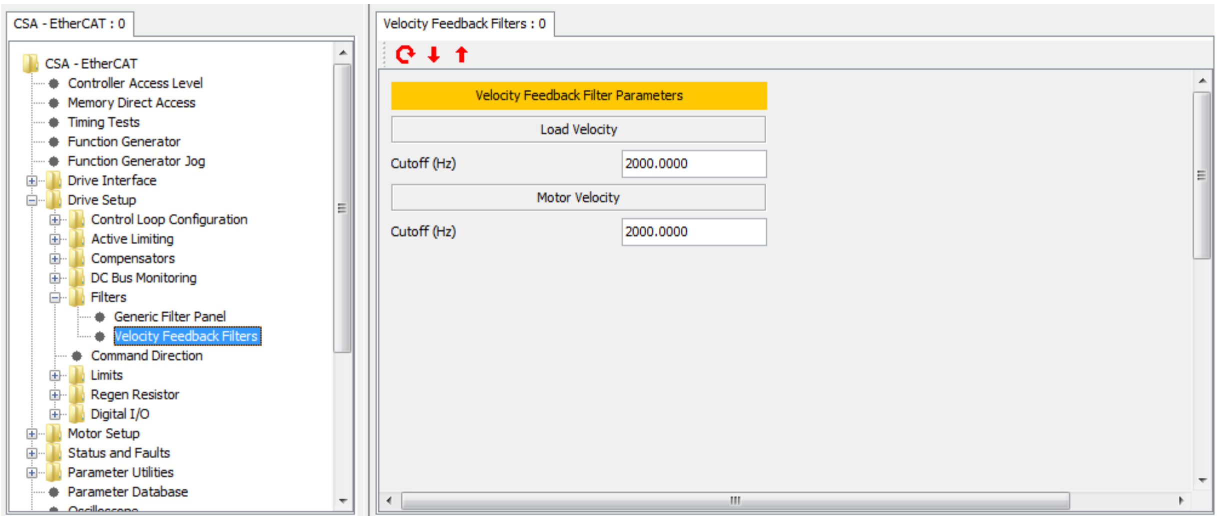


It may be configured as hi-pass, low-pass, band-pass or band-stop, to allow for maximum flexibility.
The filter is used in the velocity loop and the output of the velocity compensator becomes the input to the generic filter.

Section & Parameter	Description
Selected Filter	Option: Velocity Loop - Generic Filter (only supported option)
Filter Coefficients	Set individually or else the filter coefficient calculator can be used to derive the coefficients for a requested filter response.
Filter Mode	Options: Second Order = 1, Fourth Order = 2. Choose the filter mode between high/low pass and band pass/stop for the Calculator. This is used in the drive to reduce the amount of calculation performed when high/low pass is selected.
Filter Type	Options: Low Pass first order, Low Pass second order, Low Pass - second order - poles placed, High Pass first order, High Pass second order, Notch second order, Notch second order + Low Pass first order
Calculator Button	Starts the filter coefficient calculator.
Update From Calculator	Places the values calculated by the filter coefficient calculator into the filter coefficient boxes ready to write to the drive. They will not be written to the drive until drive parameters are saved.

B.3.7.14.2 Velocity Feedback Filters

The Velocity Feedback Filters Panel is used to set the cut-off factor of this filter.

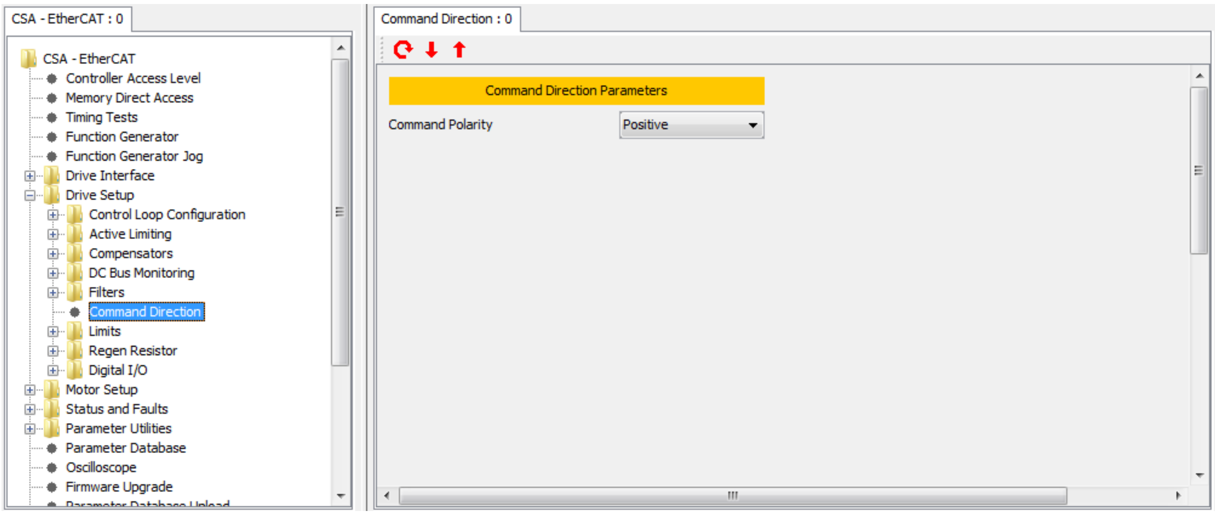


This is a low-pass filter included on the velocity feedback. It's a simple Euler approximation filter characterised by two filter coefficients (a_1 and b_0).

Section & Parameter	Description
Load Velocity	
Cutoiff (Hz)	The cutoff frequency as a fraction of the feedback sample rate of 8kHz, applied to the feedback velocity. Setting this factor to 0.5 sets the filter cut-off to half the feedback sample rate.
Motor Velocity	
Cutoff (Hz)	The cutoff frequency as a fraction of the control loop rate of 8kHz, applied to the motor velocity. Setting this factor to 0.5 sets the filter cut-off to half the control loop rate.

B.3.7.15 Command Direction

The Command Direction Panel is used to set the command polarity.

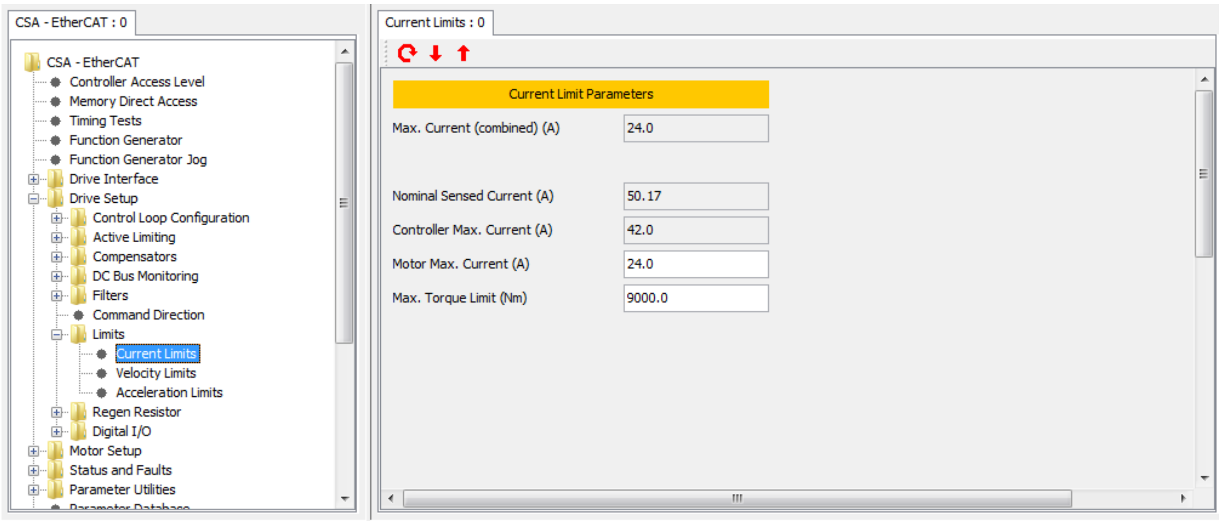


Section & Parameter	Description
Command Polarity	Options: Positive or Negative

B.3.7.16 Limits

B.3.7.16.1 Current Limits

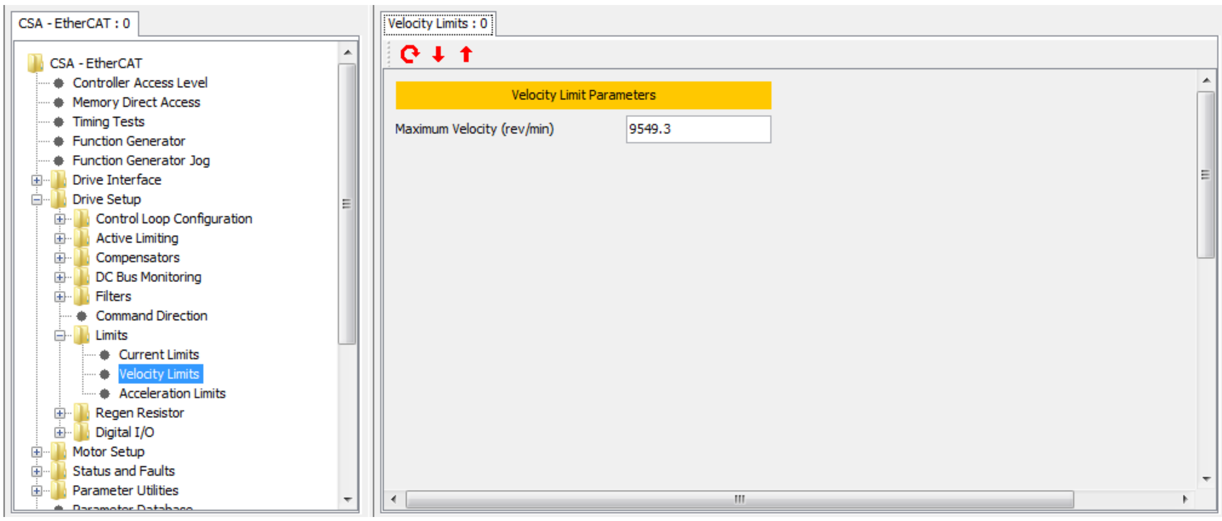
The Current Limits Panel is used to view and set the current limit parameters.



Section & Parameter	Description
Max. Current (combined) (A)	The minimum of all of the maximum currents which are the motor max, controller max, limit max and maximum measurable current. This value is the maximum current demand for the current loop. It is not directly configurable, but is determined at power-up and recalculated if any of the maximum currents is modified.
Nominal Sensed Current (A)	The maximum current that can be sensed by the drive, set automatically at power up for the power stage being used.
Controller Max. Current (A)	The maximum current (peak) available from the drive, set automatically at power up for the power stage being used.
Motor Max. Current (A)	The maximum current that can be used with the attached motor – this is set automatically at power up for the motor being used.
Max. Torque Limit (Nm)	Used to limit the maximum current to a lower value than that obtained from the minimum of the motor and drive maximum currents. If this is not necessary then this parameter should be set to a very high value so that it has no effect.

B.3.7.17 Velocity Limits

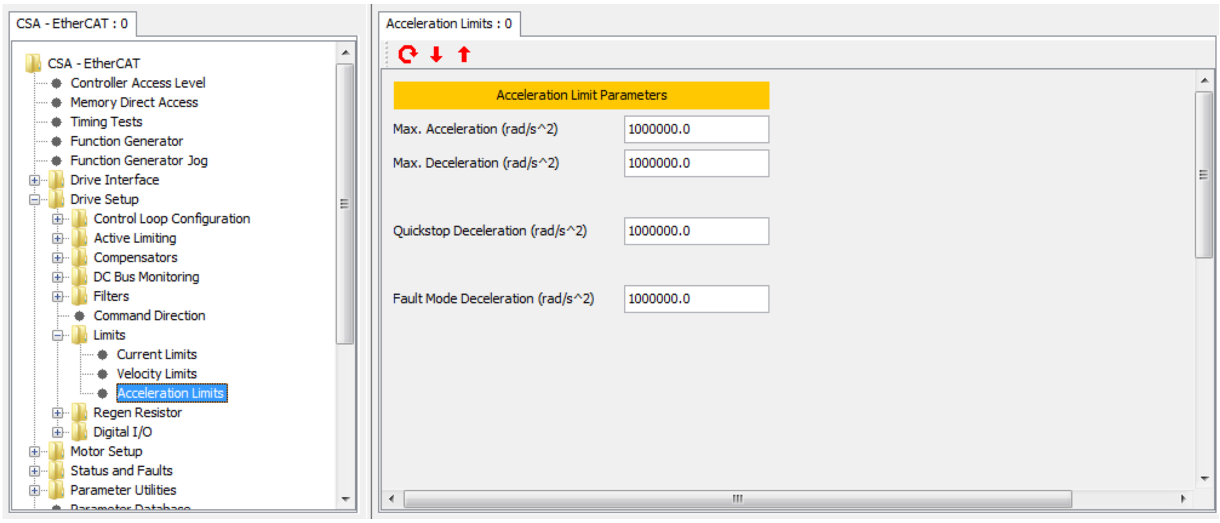
The Velocity Limits Panel is used to set the velocity limit parameters.



Section & Parameter	Description
Maximum Velocity (rad/s)	The maximum velocity value. This is the maximum velocity command and therefore defines the scaling of the internal velocity command.

B.3.7.18 Acceleration Limits

The Acceleration Limits Panel is used to set the acceleration limit parameters.



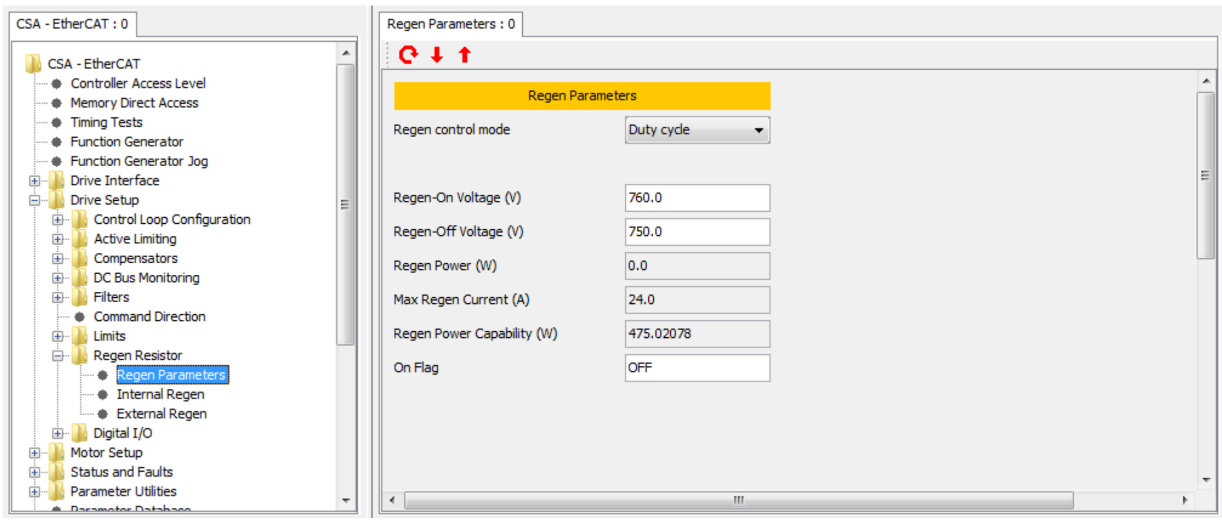
The acceleration limiting is performed on the velocity command and has units of rad/s^2.

Section & Parameter	Description
Max Acceleration (rad/s^2)	The max acceleration value for the velocity loop input.
Max Deceleration (rad/s^2)	The max deceleration value.
Quickstop Deceleration (rad/s^2)	The maximum deceleration value in quickstop mode
Fault Mode Deceleration (rad/s^2)	The maximum deceleration value in fault mode

B.3.7.19 Regen Resistor

B.3.7.19.1 Regen Parameters

The Regen Parameters Panel is used to view and set the regeneration parameters.

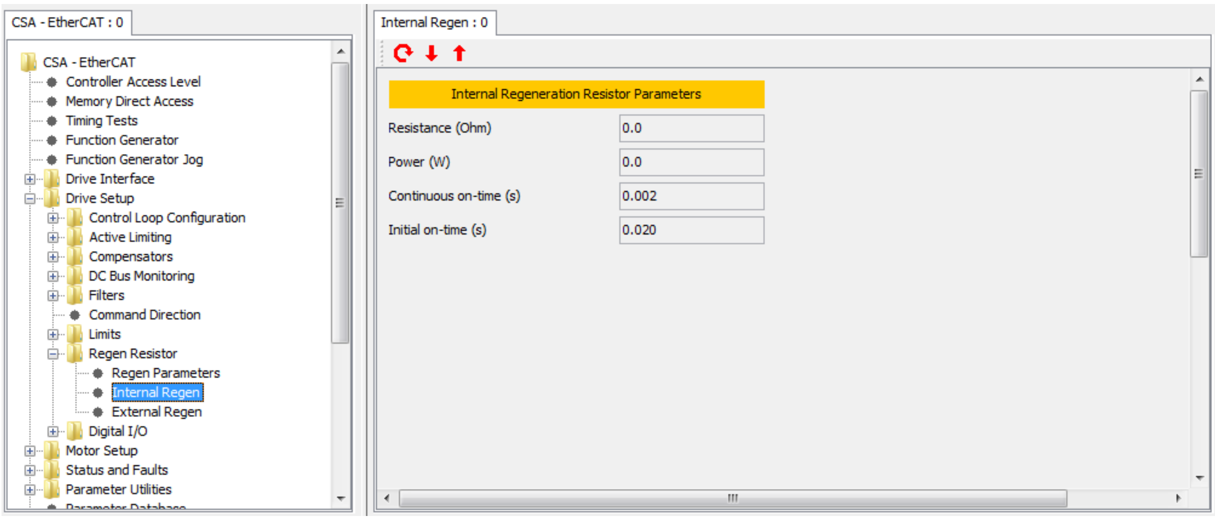


The regeneration control is implemented to prevent the capacitor over voltage caused by the energy that returns back into the D.C. Bus during a rapid motor deceleration or an overhauling load. To prevent it, the software senses when the bus voltage exceeds the Regeneration cut-in voltage and switches a Regeneration resistor across the D.C. Bus, to dissipate the Regeneration energy.

Section & Parameter	Description
Regen control mode	Options: No Regen, Duty-cycle, Duty-cycle + fault, Power fault only, Power warning only
Regen-On Voltage (V)	The regeneration transistor turn-on voltage.
Regen-Off Voltage (V)	The regeneration transistor turn-off voltage.
Regen Power (W)	The average regeneration power (measured).
Max. Regen Current (A)	The maximum regeneration current.
Regen Power Capability (W)	The total regeneration power capability.

B.3.7.20 Internal Regen

The Internal Regen Panel is used to view the internal regeneration resistor parameters.

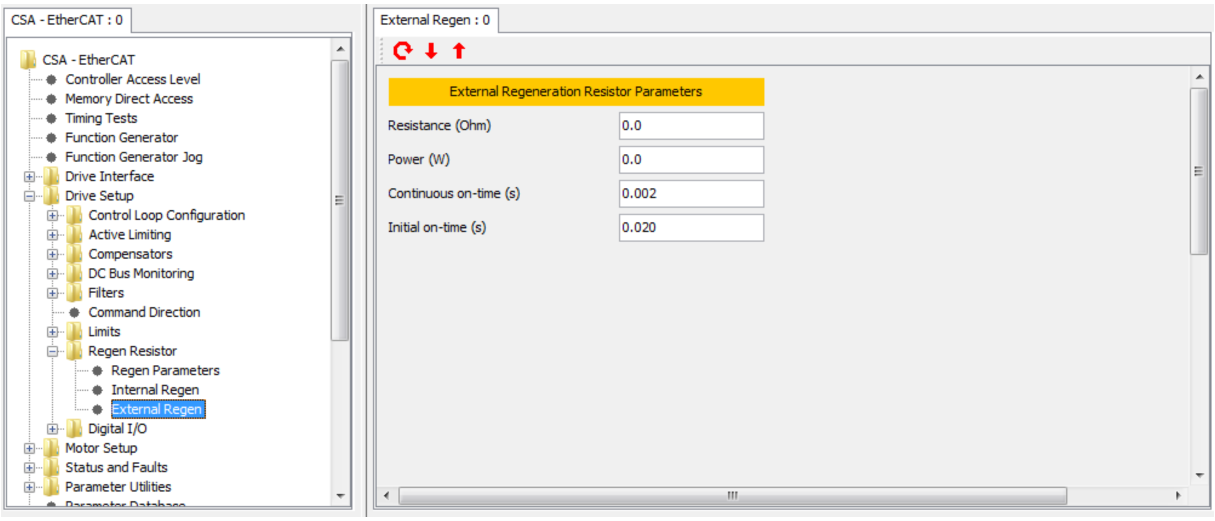


The internal regeneration resistor is effectively connected in parallel with the external one (if connected) because the same transistor controls them.

Section & Parameter	Description
Resistance (Ohm)	The internal regeneration resistor value.
Power (W)	The internal regeneration resistor power.
Continuous/Initial on-time (s)	These values are calculated by the software to set the appropriate duty cycle for the regeneration transistor.

B.3.7.21 External Regen

The External Regen Panel is used to view the external regeneration resistor parameters.

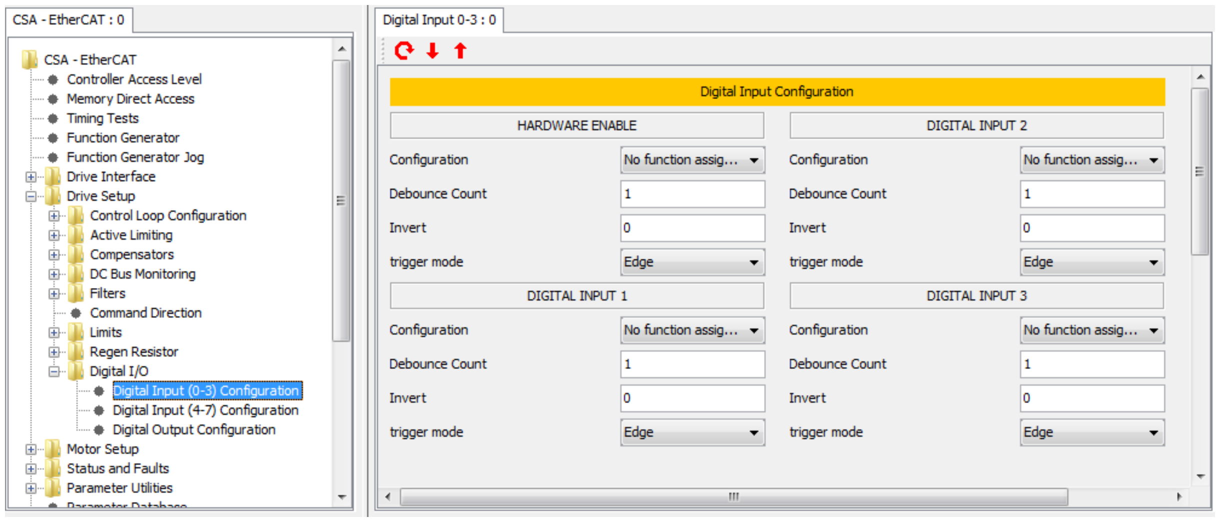


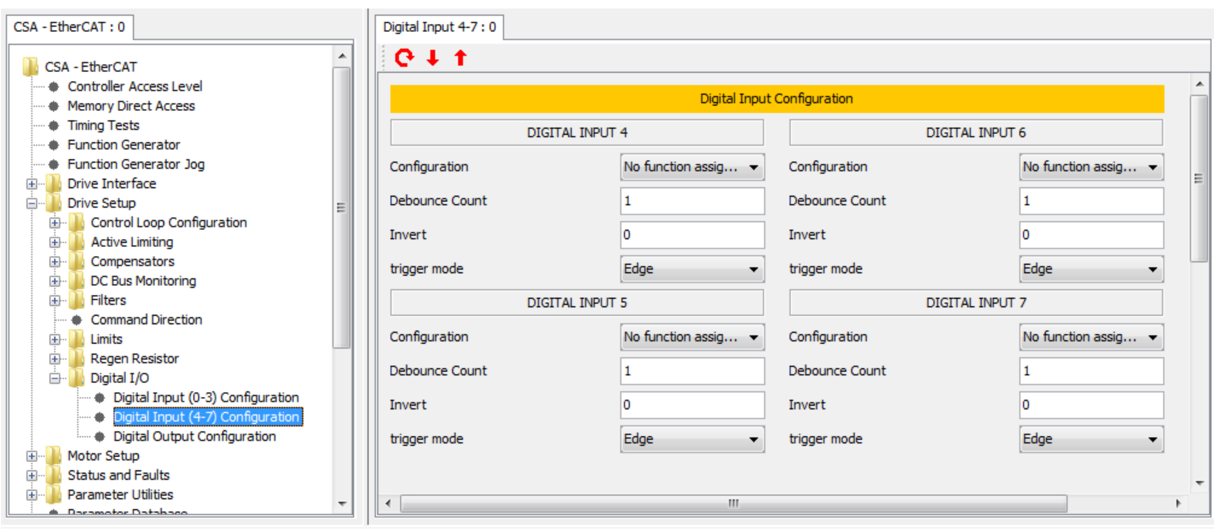
Section & Parameter	Description
Resistance (Ohm)	The external regeneration resistor value.
Power (W)	The external regeneration resistor power.
Continuous/Initial on-time (s)	Values calculated by the software to set the appropriate duty cycle for the regeneration transistor.
Initial on-time (s)	Defines the minimum amount of time that the regeneration transistor is in the circuit on the initial on transition.

B.3.7.22 Digital I/O

B.3.7.22.1 Digital Input Configuration

The Digital Input Configuration panel is used to set digital input parameters, with the panels being the same across all Configurations and supported inputs varying across the configurations.





There are eight digital inputs. The DIGITAL INPUT 1 is dedicated as the drive enable. The drive can be enabled when this input is high, and the drive is always disabled when the input is low. This digital input can additionally be configured with a function, but it retains its hardware enable function as well. The following attributes are configurable for each digital input (excluding hardware enable). Consult System documentation for the values used to configure a particular input.

Section & Parameter	Description
HARDWARE ENABLE	
Configuration	See the table below for a list of configurable functions.
Debounce Count	Number of times the input must be seen to be set before functionally is executed. The sample rate for the digital inputs is in the background task; therefore the sample time is variable.
Invert	Allows the logic of the digital input to be inverted (e.g. If by default manual mode is when input is high it can be inverted to occur when input is low).

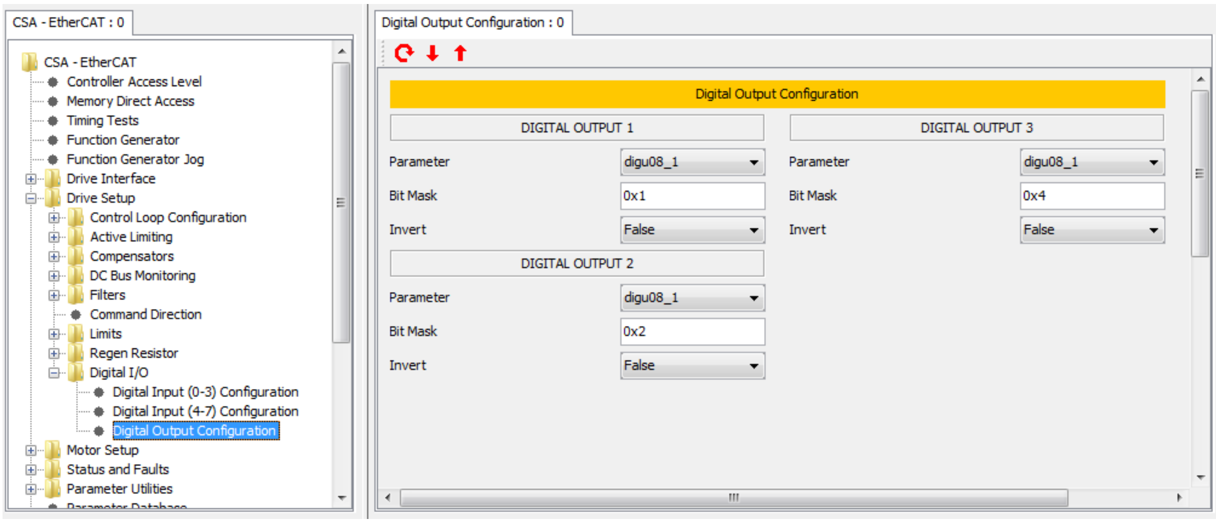
Section & Parameter	Description
trigger mode	Select either edge triggering (the function is only performed when digital input changes state) or level triggering (the function is performed repetitively).
DIGITAL INPUT (1-7)	
Configuration	See the table below for a list of configurable functions.
Debounce Count	Number of times the input must be seen to be set before functionally is executed. The sample rate for the digital inputs is in the background task; therefore the sample time is variable.
Invert	Allows the logic of the digital input to be inverted (e.g. If by default manual mode is when input is high it can be inverted to occur when input is low).
trigger mode	Select either edge triggering (the function is only performed when digital input changes state) or level triggering (the function is performed repetitively).

The lists of Digital Input Functions per CSA configuration are shown in the table below, where 'Yes' is Supported, 'No' is Not Supported, and 'NA' is Not Applicable or Reserved.

Input Function	Edge or Level Trigger	Ether CAT	MaxForce
Brake Apply/Release	Edge	Yes	Yes
Hardware Enable	Edge	Yes	Yes
Positive Limit Switch	Edge	Yes	Yes
Negative Limit Switch	Edge	Yes	Yes
Home Switch	Edge	Yes	Yes
Quickstop (Configurable for enable or disable after stopped)	Edge	Yes	Yes
Auto/Manual (Auto = normal limits, Manual = reduced power)	Edge	Yes	Yes
Controlled Disable	Edge	Yes	Yes
Drive Reboot	Edge	Yes	Yes
Safety Circuit Monitor	Edge	Yes	Yes
Safety Circuit Input Monitor	Edge	Yes	Yes
Brake Contact Monitor	Edge	No	Yes
AC Ready	Edge	No	Yes
Safety Relay Immediate Open (invokes a Return-To-Home)	Reserved		
ESTOP Active Monitor			
Interlock Active			
Battery Test Ok			
AC Power Loss			
Brake Release Status			
ESTOP Settle			
System Fault Settle			

B.3.7.22.2 Digital Output Configuration

The Digital Output Configuration Panel is used to set digital output parameters.



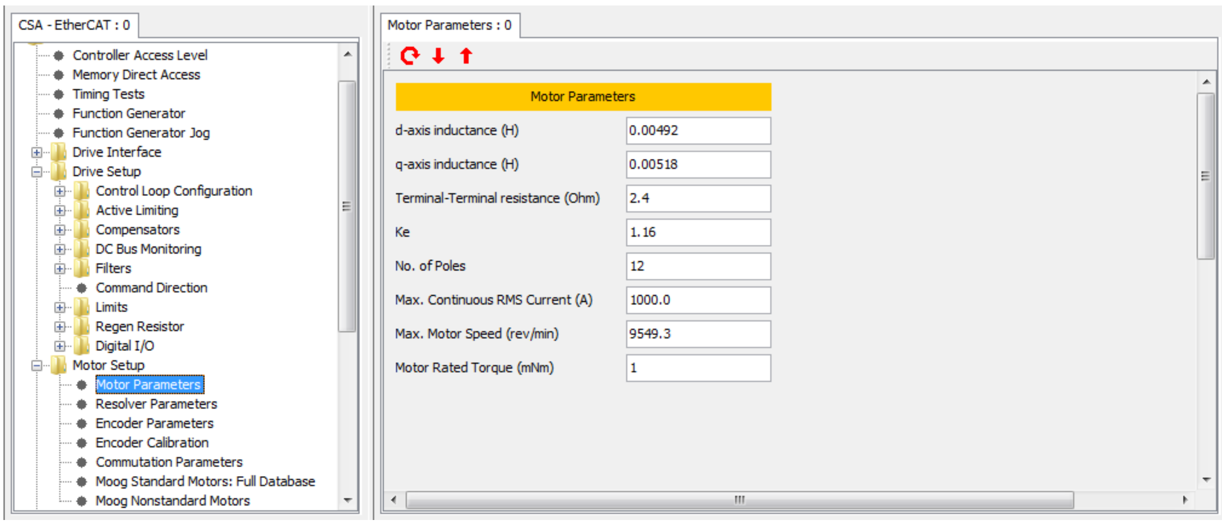
There are 3 digital outputs, which are all user-configurable.

Section & Parameter	Description
DIGITAL OUTPUT 1-3	
Parameter	The parameter to be associated with the digital output. The field value of the parameter must be entered into the digital output field number parameter, to specify the parameter of interest. Defaults: ✓ Digital Output 1 defaults to drvsts ✓ Digital Output 2 defaults to limact ✓ Digital Output 3 defaults to diginp
Bit Mask	Specifies the bits used to determine state of digital output within the parameter. This mask is ANDed with the parameter specified by the field number to determinate the digital output state.
Invert	Invert the logic of the digital output.

B.3.8 Motor Setup

B.3.8.1 Motor Parameters

The Motor Parameters Panel is used to set/read the electrical parameters of the motor.

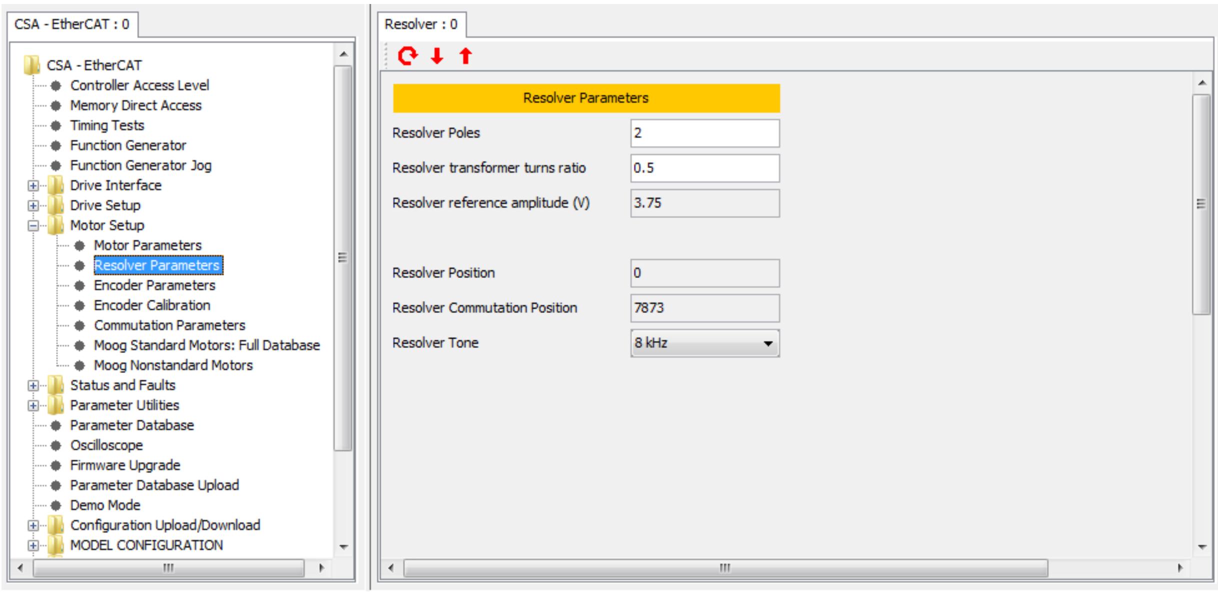


A number of parameters are required when configuring a specific motor drive. For standard motors, these parameters are implemented in the GUI's database. For non-standard motors, the user must enter these parameters. This can be done using this panel but it is preferable to set up the non-standard motor in the non-standard motor database so that it is available for future use.

Section & Parameter	Description
d-axis inductance (H)	The inductance value of d-axis.
q-axis inductance (H)	The inductance value of q-axis.
Terminal-Terminal resistance (Ohm)	The terminal-to-terminal resistance of the motor.
Ke (V/rad/s).	Motor Voltage Constant
No. of Poles	The number of motor poles. It can be set from 2 to 36.
Max. Continuous RMS Current (A)	The maximum continuous RMS current of the motor.
Max. Motor Speed (deg/s)	The maximum speed of the motor.

B.3.8.2 Resolver Parameters

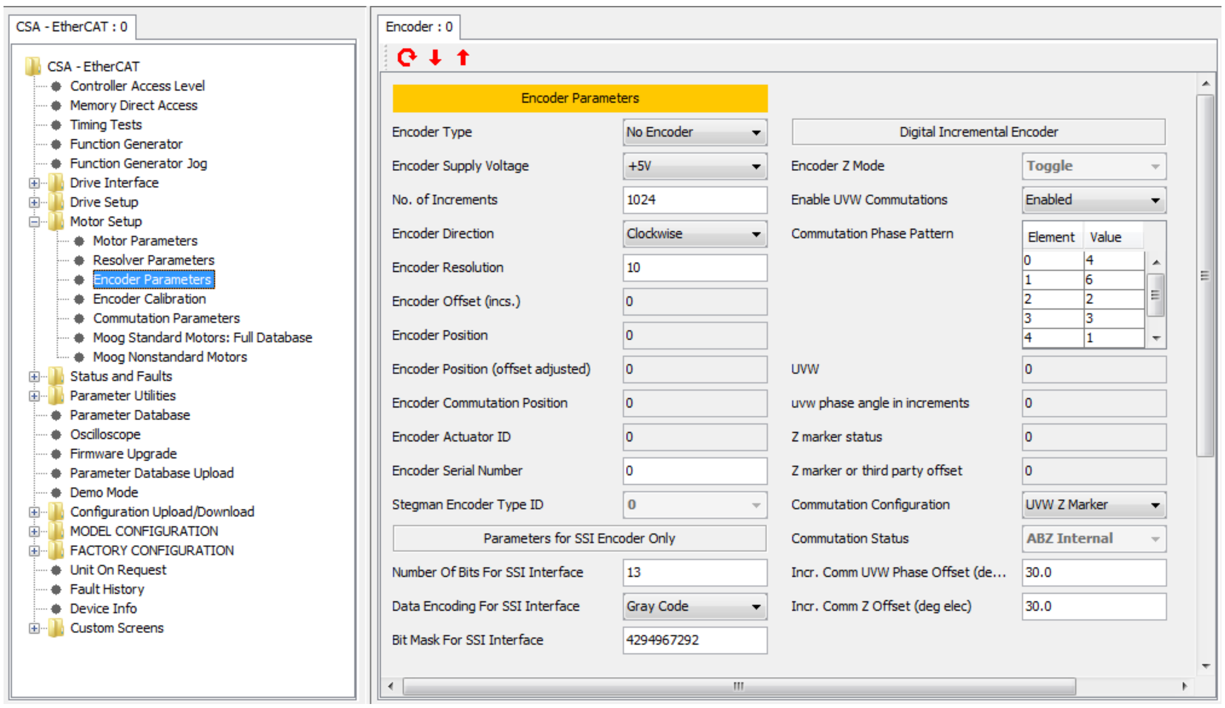
The Resolver Panel is used to set the parameters of this motor position feedback sensor.



Section & Parameter	Description
Resolver Poles	The number of resolver poles.
Resolver Transformer Turns Ratio	A physical characteristic of the resolver, which determines the amplitude of the resolver reference.
Resolver reference amplitude	This is the voltage output required to drive the resolver.
Resolver position	The multi-turn position derived from the resolver input position and used as feedback in the position loop if resolver position is selected for the position loop feedback
Resolver commutation position	The electrical angle of the resolver. Depending on the pole count of the resolver this value is proportional to the mechanical angle.
Resolver Tone	Modulation Frequency of 2kHz, 4kHz or 8kHz

B.3.8.3 Encoder Parameters

The Encoder Panel is used to set the parameters of this motor position feedback sensor.

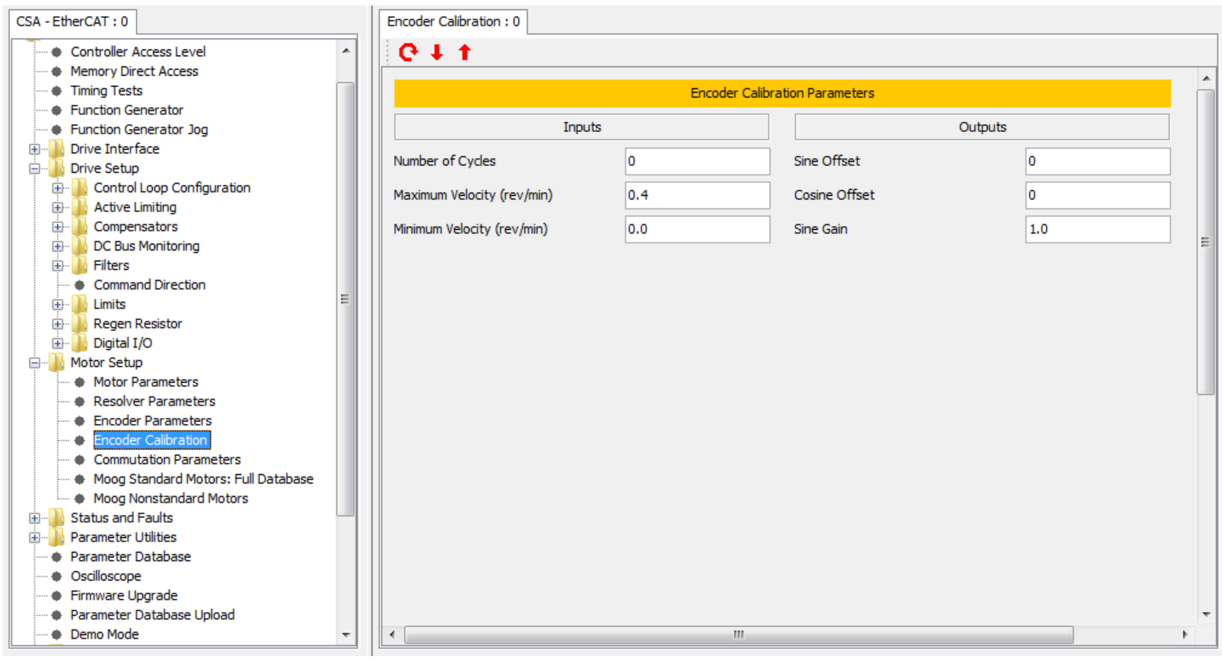


Section & Parameter	Description
Encoder Type	Options: No Encoder, Digital Incremental, Analog Incremental, SSI Interface, Stegmann Hiperface, Heidenhain EnDat2.1, Heidenhain EnDat2.2, MCG LP SSI
Encoder Supply Voltage	Options: +5, +8, +12 Volts.
No. of Increments	For normal digital, analogue or SSI interface encoders, the parameter has to be set to the number of increments (optical lines) per mechanical revolution. In case of Hiperface or Endat encoder this parameter is obtained from the encoder.
Encoder Direction	Select the encoder's direction of rotation between Clockwise and Counter-clockwise.
Encoder Resolution	Fix the bit position of the full encoder increments in the encoder position. It can be set from 2 to 31.
Encoder Offset (incs.)	Subtracted from the encoder raw position value at the designated home position for absolute movements
Encoder Position	The 32-bit encoder position.
Encoder Position (offset adjusted)	The encoder position minus the offset
Encoder Commutation Position	A 16-bit value that represents a full mechanical revolution independent of the encoder resolution setting.
Encoder Actuator ID	The Actuator ID stored on the Encoder
Encoder Serial Number	The Encoder Serial Number
Stegman Encoder Type ID	Various based on the Manufacturer
Parameters for SSI Encoder Only	
Number Of Bits For SSI Interface	The number of bits in the raw data stream (not the number of encoder position bits). It can be set from 2 to 32.
Data Encoding For SSI Interface	Select either binary or Gray code encoding.

Section & Parameter	Description
Bit Mask For SSI Interface	Used to mask off all the unused bits in the raw data stream. A one in the mask means that the bit contains position information.
Digital Incremental Encoder	
Encoder Z Mode	encoder z mode: 0=ignore, 1=single, 2=multi, 3=toggle
Enable UVW Commutations	enable uvw commutation
Commutation Phase Pattern	commutation phase pattern u=bit0,v=bit1, w=bit2
UVW	Present uvw value
uvw phase angle in increments	Present uvw phase angle in increments
Z marker status	Present z marker status
Z marker or third party offset	Present value of z marker or third party offset
Commutation Configuration	0=uvw only, 1=uvw_z_marker, 2=z_marker_only, 3=third party only
Commutation Status	0=abz_int,1=abz_6stp,2=sinsuodial,3=absolute
Incremental Commutation UVW Phase Offset (degrees electrical)	Stored value for incremental commutation UVW phase offset (degrees electrical)
Incremental Commutation Z Offset (degrees electrical)	Stored value for encoder incremental commutation Z offset (degrees electrical)

B.3.8.4 Encoder Calibration

The Encoder Calibration Panel is used to configure the calibration of sine/cosine encoder signals.

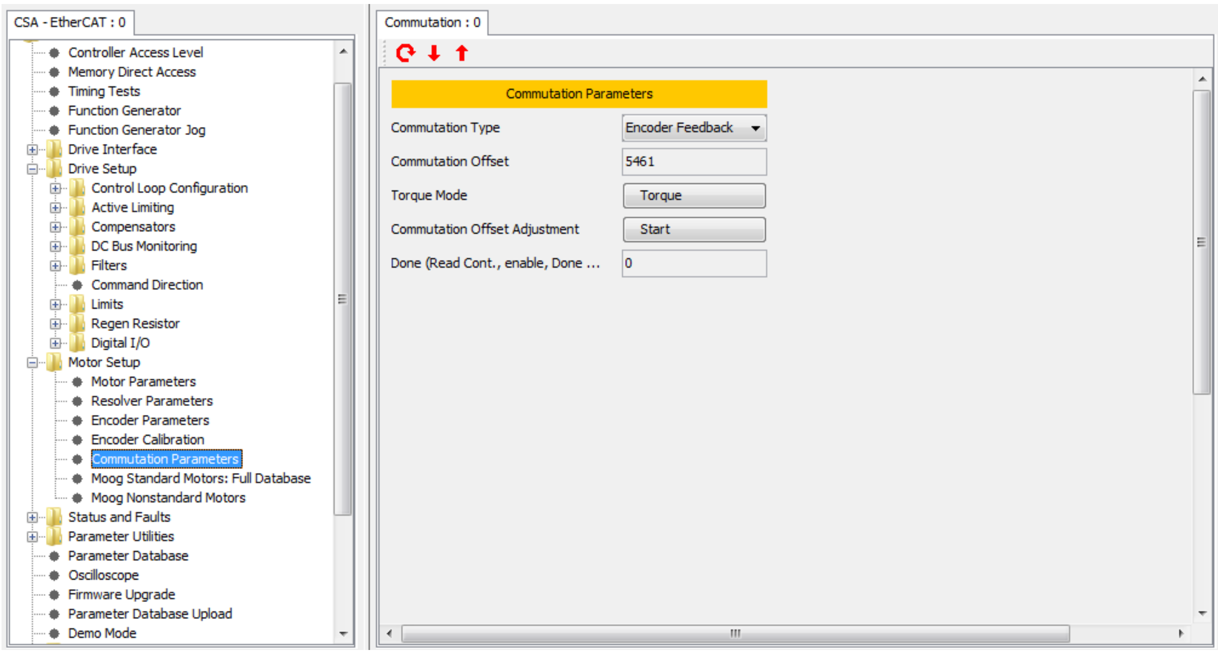


The encoder calibration is performed on the encoder velocity, determined by the delta encoder counts for a Sine/Cosine encoder. A first order filter with fixed coefficients of A1 = 0.4431373, and B0 = 0.5568627 is applied to the encoder velocity

Section & Parameter	Description
Inputs	
Number of Cycles:	The number of samples collected at the loop rate of 8kHz input to the filter. Samples are collected when the encoder velocity is between the Minimum and Maximum Velocity. A value of 0 disabled the calibration. The calibration, if enable runs continually.
Maximum Velocity (rev/min):	The Maximum Velocity under which the encoder velocity samples are collected.
Minimum Velocity (rev/min):	The Minimum Velocity above which the encoder velocity samples are collected.
Outputs	
Sine Offset:	The calculated Sine Offset to be applied by the FPGA to the Encoder Sine Input
Cosine Offset:	The calculated Cosine Offset to be applied by the FPGA to the Encoder Cosine Input
Sine Gain:	The calculated gain to be applied by the FPGA to the Encoder Inputs

B.3.8.5 Commutation Parameters

The Commutation Panel is used to set the commutation parameters.



Various commutation feedback sources may be selected. It is possible to use a resolver, an encoder or a fixed value for the rotor feedback position. The Commutation Adjust Procedure sets the Current Loop Gains to 50%, a torque value of 12.5% of the maximum is applied to shake the rotor free and then a torque value of 25% is applied with an offset electrical angle to determine the commutation offset.

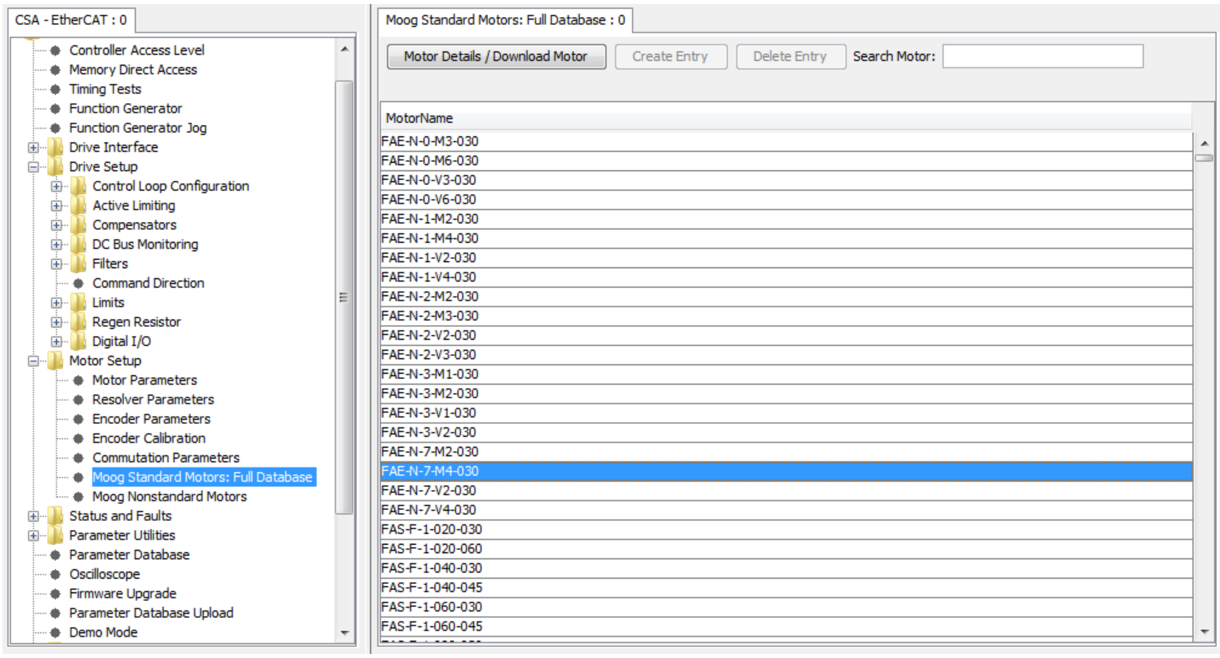
Section & Parameter	Description
Commutation Type	Select the commutation type from: ✓ Angle Zero: the feedback angle for the rotor position is fixed at zero. This can be used to determine the phase angle between the rotor and the resolver or encoder. ✓ Resolver Feedback: the rotor angle is taken from the resolver commutation position. 16-bit full scale corresponds to one full mechanical revolution. ✓ Encoder Feedback: the commutation is done from the encoder commutation angle. 16-bit scale corresponds to one full mechanical revolution.
Commutation Offset	The offset angle between the commutation feedback and the phase currents. In certain cases the motor has a resolver or encoder built in that has been adjusted in the factory, this angle can then be obtained from the motor datasheet.
Torque	Selects Torque mode
Commutation Offset Adjustment	Automatic adjustment of the commutation offset. The following steps have to be followed: Commutation Adjustment Procedure: ✓ Ensure that no faults or warnings are present on the drive. ✓ Ensure that rotor can turn freely.

Section & Parameter	Description
	✓ Ensure that the correct motor parameters have been configured. ✓ Set commutation_feedback (resolver or encoder). ✓ Click the Torque button to set the drive to torque mode. ✓ Click on Start Button to start the procedure. ✓ Enable the drive. The communication adjustment starts. ✓ Wait until display reads 0 (after about 3 seconds). ✓ After a successful execution of this step, the value should be stored to the Drive Head, if Encoder EEPROM storage is not used, by selecting the “Save Drive Parameters” icon on the toolbar. If Encoder EEPROM storage is enabled, the parameters are saved, refer to Section B.3.18.3.

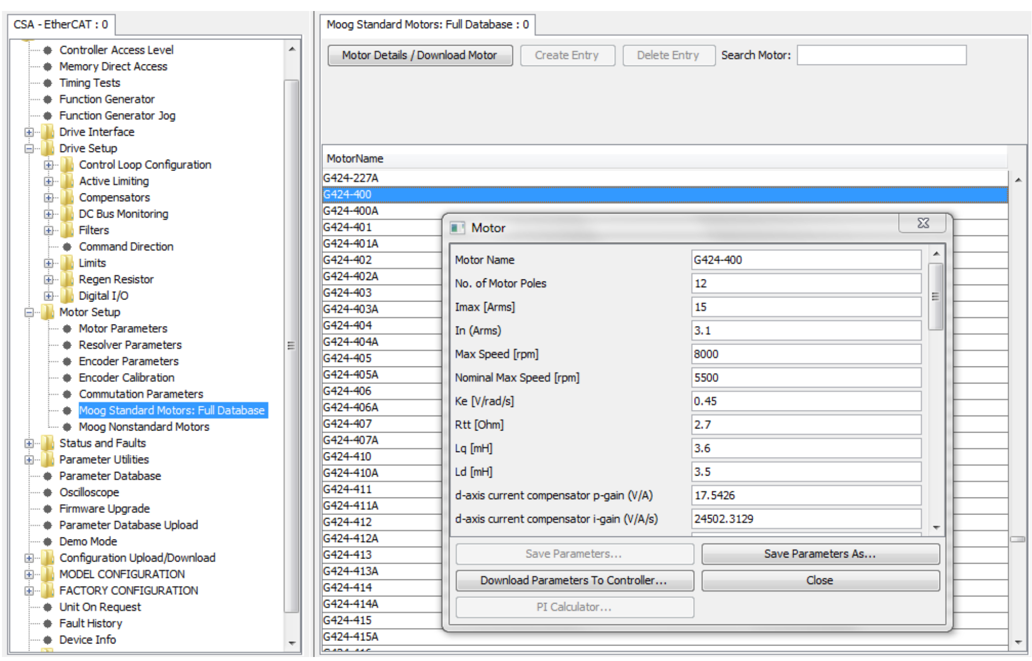
Both the hardware ‘Drive Enable’ and the Windrive ‘Drive Enable’ must be enabled in order to enable the drive.

Warning: Ensure that all listed safety precautions are observed when enabling the drive. Ensure that motor is securely mounted on a suitable fixture. Sudden and considerable movement of the motor, with a risk of injury will occur during high speed reversals if the motor is not securely mounted.

B.3.8.6 Moog Standard Motors: Full Database

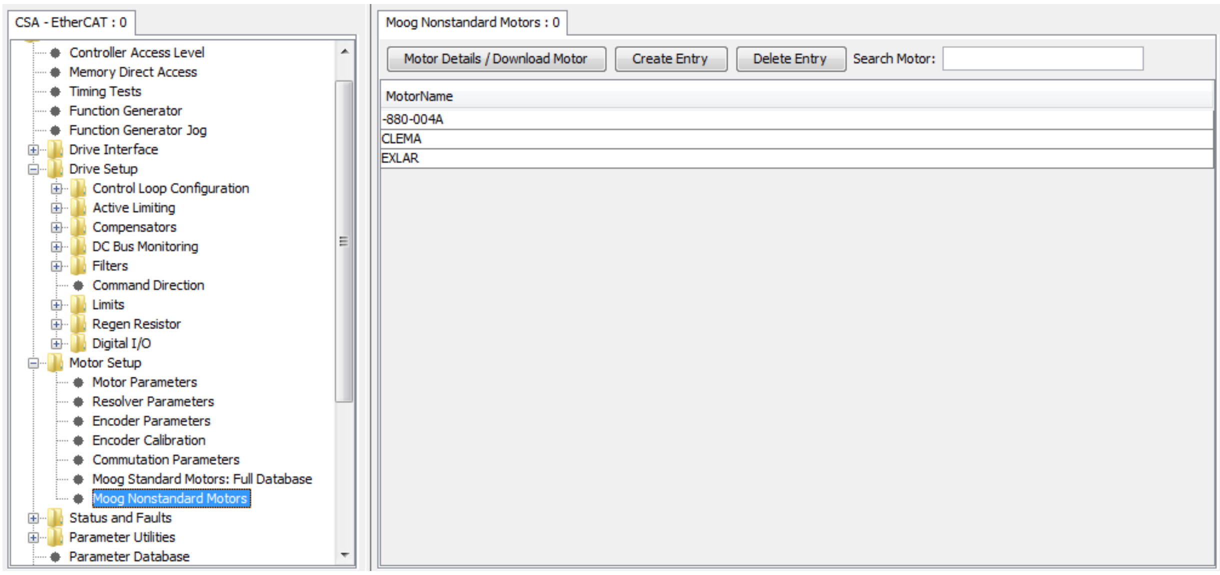


Select a motor (G362-XXX-XXX) from the scrollable motor list by double-clicking on the appropriate motor name.. The nameplate on the motor should be checked for the model and the corresponding motor selected from either of the lists provided.
Use the scrollbars to view the database or enter the motor required in the search textbox.
Once a motor is selected the motor parameters are shown:



Use the scrollbars to view all the parameters. Select "Download Parameters to Controller…" to configure the drive with the motor parameters. All parameters (including motor name) can be changed and, using "Save Parameters As", and selecting the correct database can create a new Non-standard motor.

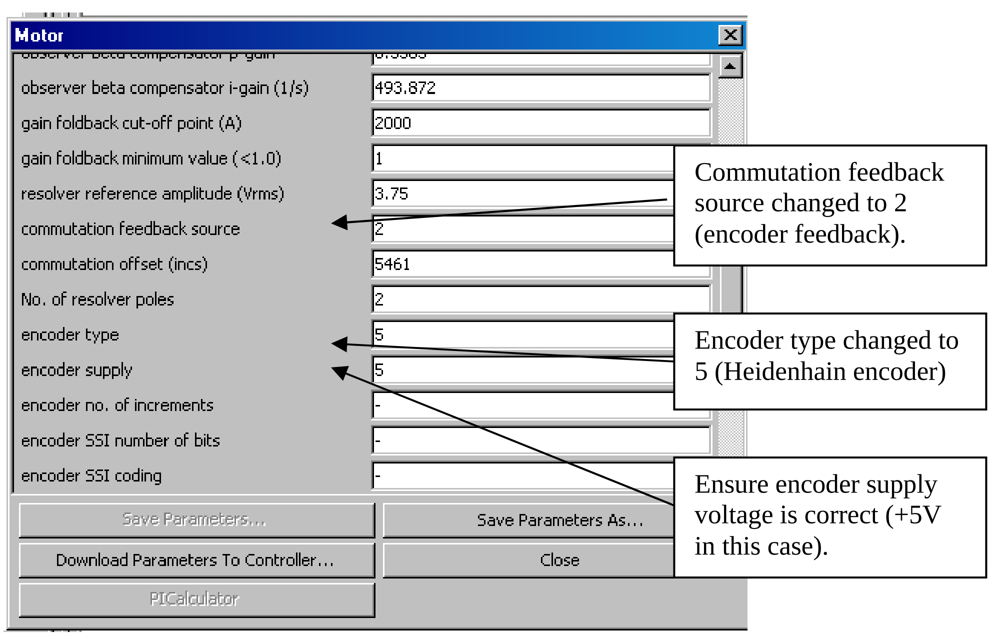
B.3.8.7 Moog Nonstandard Motors



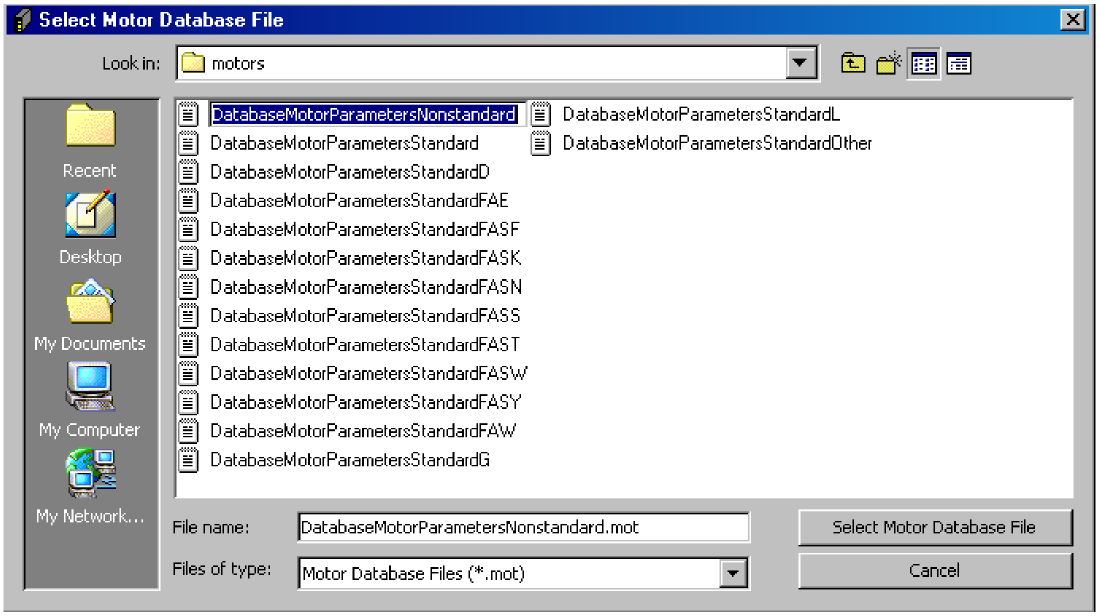
The 'Create Entry' button is used to create a new non-standard motor entry. It opens a panel providing tools for creation of the motor database parameters. Select a motor by double-clicking on the appropriate motor name.

Alternatively, if a standard motor is similar to the motor required, then the standard motor parameters can be altered and saved as a Non-standard motor:

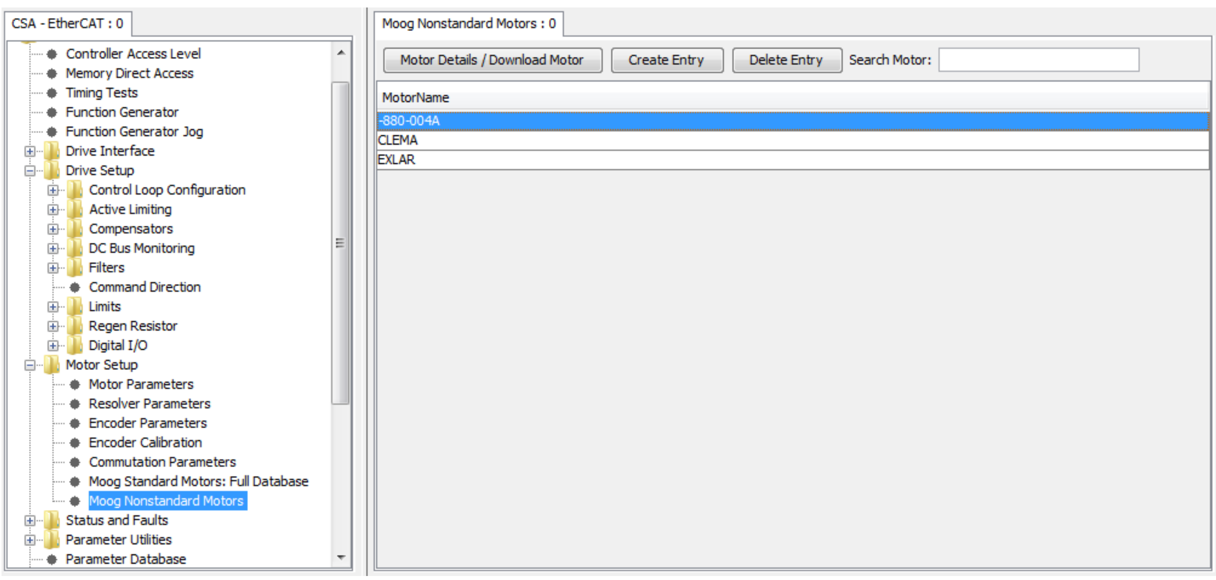
- Select the similar motor e.g. a G424-400, and make the changes required e.g. a Heidenhain encoder feedback is required instead of resolver feedback.
- Change the motor name to an easily recognisable name e.g. G424-400_Enc.
- Change the appropriate parameters:



Click “Save Parameters As…” and save the new motor to the *DatabaseMotorParametersNonstandard.mot* file.



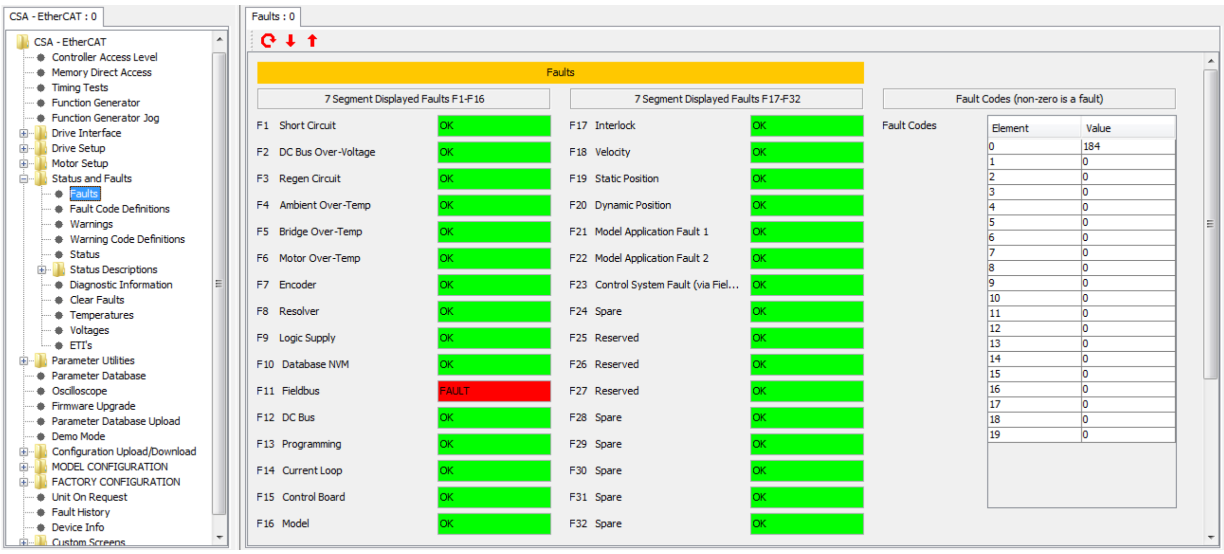
On selecting the Moog Nonstandard Motors tab again, the new non-standard motor is included:



B.3.9 Status and Faults

B.3.9.1 Faults

The Faults Panel is used to view the current state of all Fault indicators and the Fault Codes, with Red being a fault and Green being no fault. Note that faults are latched until cleared. This screen may change with subsequent releases of application software as new faults are defined. Consult the System Documentation for the current definition of these faults.



Faults are latched and must be cleared by either a Control System over the Fieldbus or Digital Input or by a User Interface (WinDrive or other).

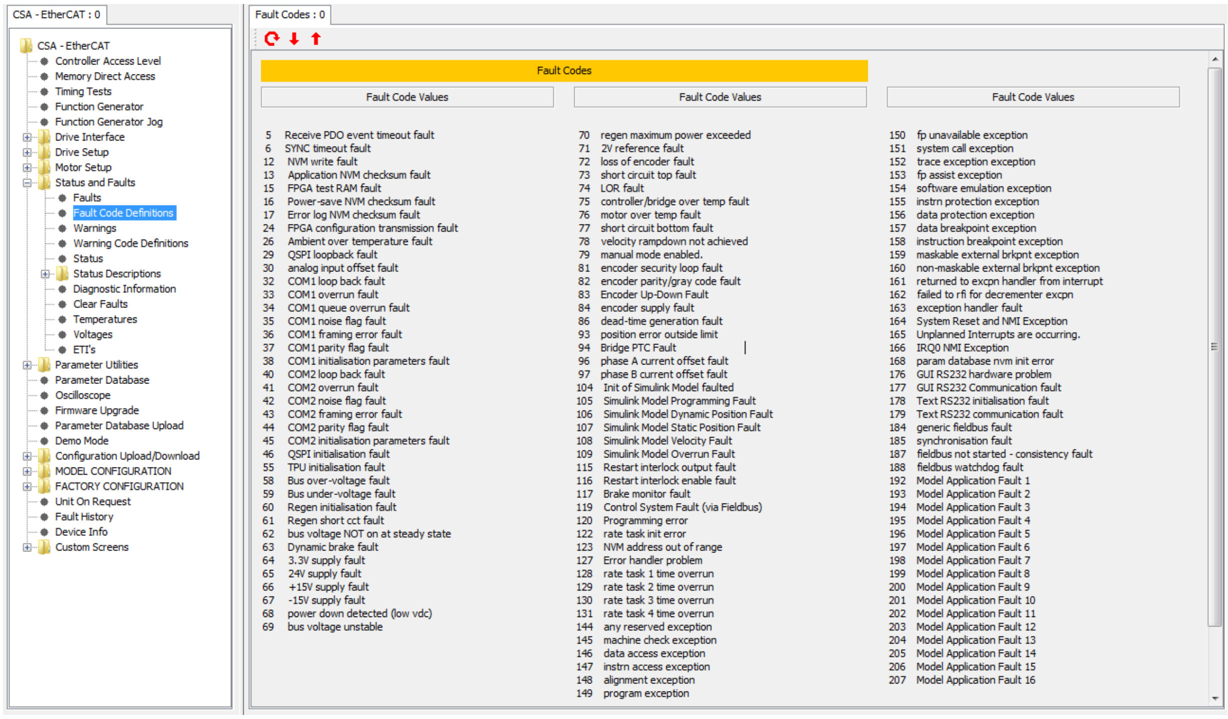
Section & Parameter	Description
7 Segment Displayed Faults F1-F16:	
F1 - Short Circuit	A Regen Short Circuit, or IGBT Short Circuit Top or IGBT Short Circuit Bottom Fault. These signals come from the power stage.
F2 - DC Bus Over-Voltage	Set if the Bus Voltage Actual (Field 1232) exceeds it's limit (Field 1233) for more than 6msec
F3 - Regen Circuit	Regen Initialization Fault, pertains to Regen Parameter values and power calculations or Set if the regen power filtered value (Field 1252) is greater than regen power capability (Field 1269)
F4 - Ambient Over-Temp	Set if the ambient temperature (Field 1378) exceeds it's maximum (Field 1409) for more than 3 seconds
F5 - Bridge Over-Temp	Set if the bridge temperature (Field 1368) exceeds the bridge max temperature (field 1399) for more than 300msec.
F6 - Motor Over-Temp	Set if motor temperature (Field 1373) is greater than the motor max temperature (Field 1404) for more than 300msec.
F7 - Encoder	Various: • Set if the commutation feedback (Field 1035) or position feedback (1168) or velocity feedback (1169) has a value of 2 for encoder and there is an encoder comms fault (Field 1716). The encoder fault is a bit mask of faults, Bit 0 = Communication, Bit 1 = LOE, Bit 2 = Type, Bit 3 = Gain, Bit 4 = Offset. LOE is a sum of squares fault where the voltage levels of the sine and cosine signals is below the encoder fault limit.

Section & Parameter	Description
	• Set if the encoder supply (Field 1446) is +/- 15 percent outside the nominal voltage of 5V, 8V, or 12V based on for more than 30msec.
F8 - Resolver	Set if the commutation feedback (Field 1035) or position feedback (1168) or velocity feedback (1169) has a value of 1 for resolver and there is a resolver fault (Field 1046) equal to 2. A resolver fault is set when the (resolver sine sum (Field 1044) squared plus resolver cosine sum (field 1045)) divided by 2^16 is greater than or equal to 8000.
F9 - Logic Supply	Various: • Set if the Supply +3V3 (Field 1421) is outside the range of 2.88V and 3.67V for more than 30msec. • Set if the Supply +15V (Field 1431) is outside the limits of 12.75V and 17.25V for more than 30msec. • Set if the Supply -15V (Field 1426) is outside the limits of -12.75V and -17.25V for more than 30msec. • Set if Supply +24V (Field 1441) is below supply power down detect limit (Field 1243) for 2msec • Set if the supply +2V5 ref.(Field 1436) is outside the range of 2.25V and 2.75V.
F10 - Database NVM	Various: • Set if an out of range address is accessed. • Set on startup if database initialization fails • Set if database initialization returns an EEPROM or Hardware error. • Set if background database operations return an Access Error or a Version Error
F11 - Fieldbus	Fieldbus Fault
F12 - DC Bus	Various: • Set if the Bus Voltage Actual (Field 1232) is below it's limit (Field 1234) for more than 6msec • Set if the absolute value of the present bus voltage minus the previous bus voltage is greater than the bus dV/dt limit (Field 1240) times 2 msec.
F13 - Programming	Various: • Database error • Software Task initialization error • Software Task Over-runs (exceeded expected execution time) • Various Microprocessor or software exceptions
F14 - Current Loop	Various: • Set if Ia current offset (Field 1065) is outside +/- ADC offset limit (Field 1043). • Set if Ib current offset (Field 1066) is outside +/- ADC offset limit (Field 1043).
F15 - Control Board	Various: • Set if flash verification initialization fails • Set if FPGA initialization fails • Set if the loop-back test on the Queued Serial Peripheral Interface (QSPI) used to access the FPGA fails initialization. • Set if the serial port can not be initialized to 19200 BAUD, 8 bits, No Parity

Section & Parameter	Description
	• Set if the initialization of the QSPI of the Power PC fails
F16 - Model	Various: • Set if the model initialization fails. • Set if the model has a programming fault (database or calculation). • Set if the model overruns it's execution time
7 Segment Displayed Faults F17-F32	
F17 - Interlock	Various: • Set if the phase A current exceeds the Dynamic Brake Test Tolerance (Field 1885) • Set if the phase B current exceeds the Dynamic Brake Test Tolerance (Field 1885) • Set if a digital input is configured for the safety input monitor and the line is high and a SAFETY_CCT_FLT is present. • Set if a digital input is configured for the safety input monitor and the line is low and the FPGA Control has PWM's enabled. • Set if a digital input is configured for the brake monitor and the line is low and the brake is released and the elapsed time in this condition exceeds the brake monitor time delay (Field 1880). The delay units are 0.25 usec. • Set if a digital input is configured for the brake monitor and the line is low and the brake is released and the elapsed time in this condition exceeds the brake monitor time delay (Field 1880). The delay units are 0.25 usec.
F18 - Velocity	Set if the model computes a velocity error
F19 - Static Position	Set if the model computes a static position error Note: To trigger this fault, the following condition needs to be met: (POS_err > Static_pos_err_lim) & (vel_fdbk < dyn_pos_err_vel_threshold).
F20 - Dynamic Position	Set if the model computes a dynamic position error Note: To trigger this fault, the following condition needs to be met: (Pos_err > velfdbk * Dyn_pos_err_percent) &(vel_fdbk > dyn_pos_err_vel_threshold).
F21 - Model Application Fault 1	Set by the model; consult System Documentation for the definition of this fault.
F22 - Model Application Fault 2	Set by the model; consult System Documentation for the definition of this fault.
F23 - Control System Fault (or Reserved)	Control System Fault on select systems and reserved on others. Consult System Documentation for the definition of this fault.
F24 - Spare	Reserved for future use
F25 - F27 Reserved	Reserved for compatibility within application versions
F26 - F32 Spare	Reserved for future use
Fault Codes (non-zero is a fault):	
Value	See the Fault Code Definitions panel for the values definition.

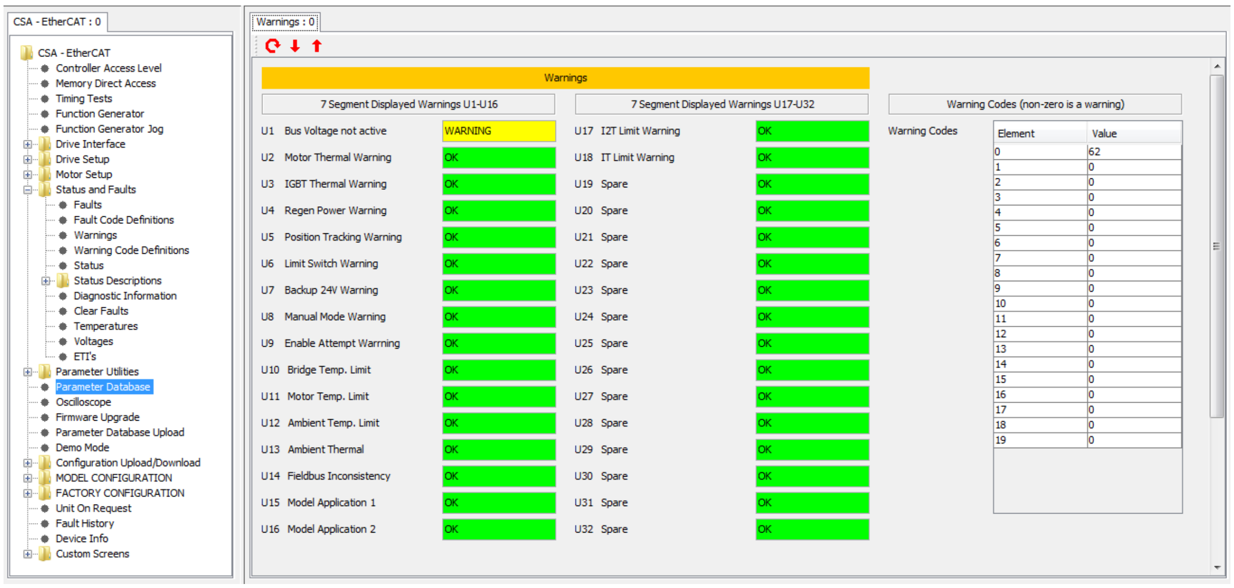
B.3.9.2 Fault Code Definitions

The Fault Codes Panel lists all defined values. Multiple fault codes may correspond to a single fault displayed on the Faults Panel. The codes below are logged in the Fault History. This screen may change with subsequent releases of application software as new faults are defined. Consult the System Documentation for the current definition of these faults.



B.3.9.3 Warnings

The Warnings panel is used to view the current state of all Warning indicators and the Warning Codes, with yellow being an active warning and green being no warning. Note that warnings are not latched. This screen may change with subsequent releases of application software as new warnings are defined. Consult the System Documentation for the current definition of these warnings.



Warnings are not latched and are automatically cleared when the condition is no longer present.

Section & Parameter	Description
7 Segment Displayed Warning U1-U16:	
U1 - Bus Voltage not active	The DC Bus voltage is not present and the Soft Start Process has not completed
U2 - Motor Thermal Warning	Set if the motor temperature (Field 1373) is greater than 0.9 * motor max temperature (Field 1404) for more than 100msec. The warning is cleared if the value is less than 0.88 * motor max temperature.
U3 - IGBT Thermal Warning	Set if current limit mask (1135) has Bit 0 set and the motor temperature (Field 1373) is greater than 0.9 * thermal limit bridge start temperature (Field 1400) for more than 1 second. The warning is cleared if the value is less than 0.88 * thermal limit bridge start temperature.
U4 - Regen Power Warning	Set if regen power filtered (Field 1252) is greater than 0.9 * regen power capability (Field 1269). The warning is cleared if less than or equal to 0.9 * regen power capability.
U5 - Position Tracking Warning	Set if motion monitoring is enabled and a position target has not been reached (I.E. not tracking).
U6 - Limit Switch Warning	Set if pos. or neg. limit switch digital input is high
U7 - Backup 24V Warning	Set if supply +24V (1441) is outside the range of 18V and 36V for 30msec
U8 - Manual Mode Warning	Set if a digital input is configured for Auto/manual mode selection and the line is low and manual mode enable (Field 1134) is non-zero (enabled). The warning is cleared when the line is high regardless of the value of manual mode enable.
U9 - Enable Attempt Warning	Set if the Hardware Enable Digital input is not active or a U1 warning exists and an enable is attempted.
U10 - Bridge Temp. Limit	The Bridge Temperature is within 90% of the fault limit. The

Section & Parameter	Description
	warning is cleared when the temperature falls below 88% of the fault limit.
U11 - Motor Temp. Limit	Set if current limit mask (1135) has Bit 1 set and the motor temperature (Field 1373) is greater than 0.9 * thermal limit motor start temperature (Field 1405) for more than 1 second. The warning is cleared if the value is less than 0.88 * thermal limit motor start temperature.
U12 - Ambient Temp. Limit	Set if current limit mask (1135) has Bit 2 set and the ambient temperature (Field 1378) is greater than 0.9 * thermal limit ambient start temperature (Field 1410) for more than 1 second. The warning is cleared if the value is less than 0.88 * thermal limit ambient start temperature.
U13 - Ambient Thermal	Set if the ambient temperature (Field 1378) is greater than 0.9 * ambient max temperature (Field 1409) for more than 1 second. The warning is cleared if the value is less than 0.88 * ambient max temperature.
U14 - Fieldbus Inconsistency	The application is not consistent with the detected mezzanine card used for the Fieldbus. The Fieldbus capability will not be initialized and will be disabled.
U15 - Model Application 1	A Model Application Fault, defined by the specific Simulink Model used.
U16 - Model Application 2	A Model Application Fault, defined by the specific Simulink Model used.
7 Segment Displayed Warnings U17-U32	
U17 - I2T Limit Warning	The current is greater that the I2T limit. Note that a dot “.” will appear in the lower right hand corner of the 7 Segment Display if current limiting is active.
U18 - IT Limit Warning	The calculated IT value exceeds the IT limit. Note that a dot “.” will appear in the lower right hand corner of the 7 Segment Display if current limiting is active.
U19 - U32 Spare	Reserved for future use
Warning Codes (non-zero is a warning):	
Value	See the Warning Code Definitions panel for a values definition.

B.3.9.4 Warning Code Definitions

The Watning Codes Panel lists all defined values. Multiple warning codes may correspond to a single warning displayed on the Faults Panel. The codes below are logged in the Fault History. This screen may change with subsequent releases of application software as new faults are defined. Consult the System Documentation for the current definition of these faults.

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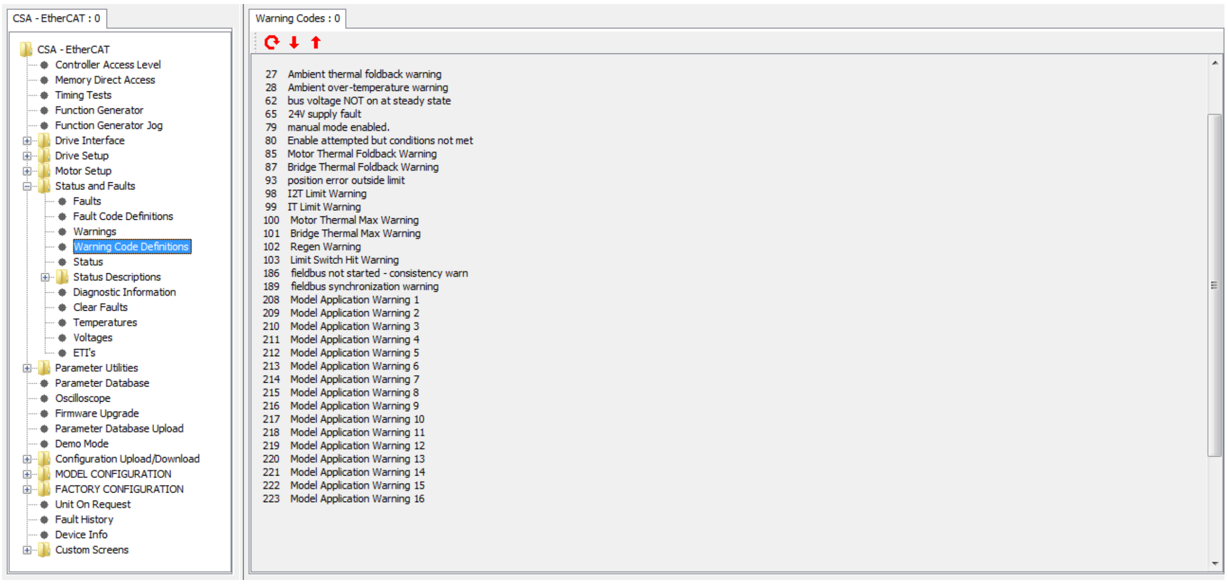
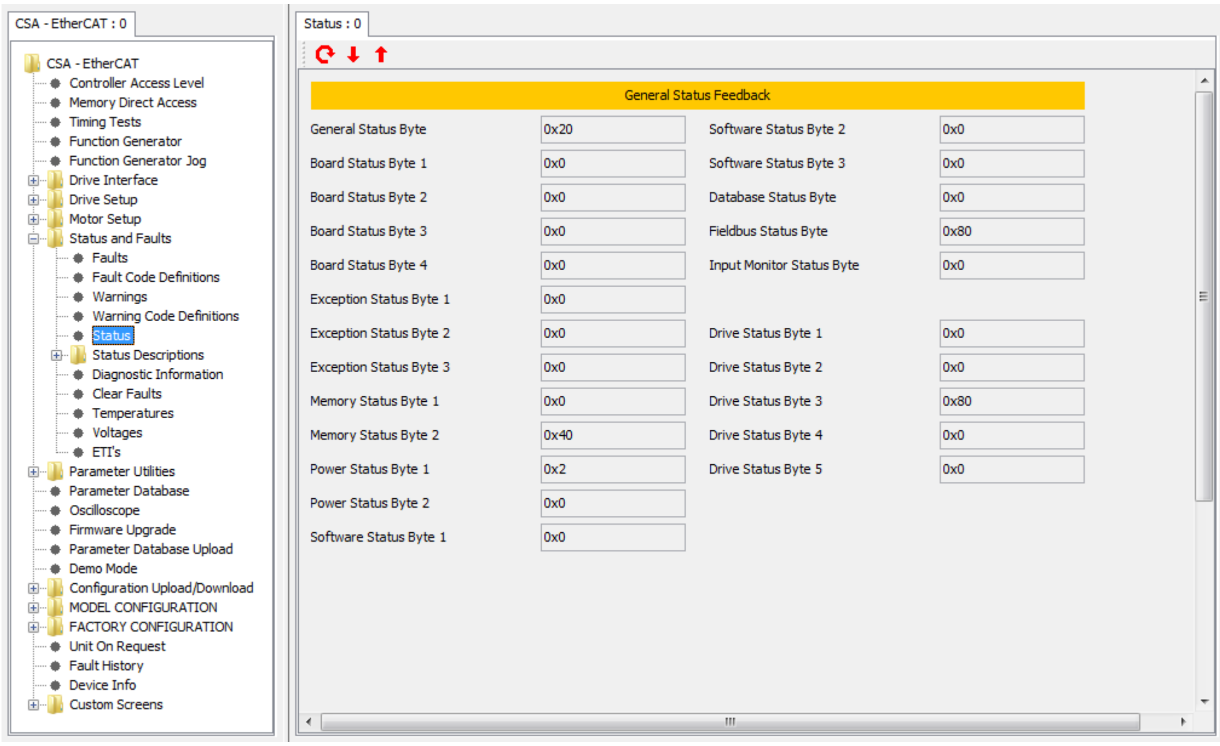


B.3.9.5 Status

The Status Panel is used to view the state of all status bytes.

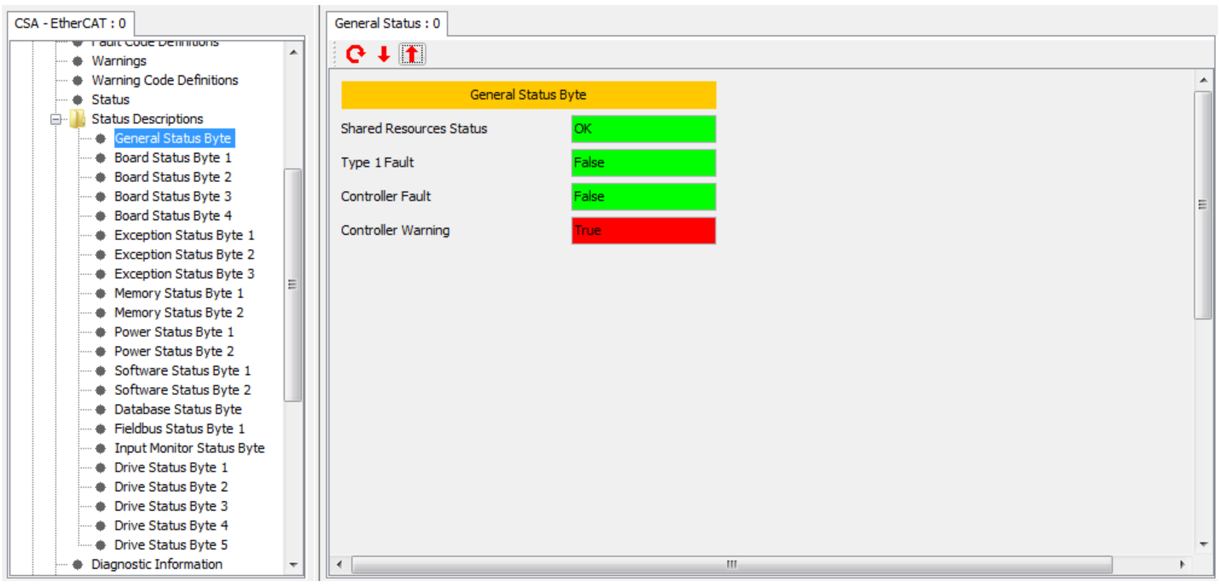


Opening the status description panel for the appropriate status byte shows the definition of the status bits for each of the bytes.

B.3.9.6 Status Descriptions

B.3.9.6.1 General Status Byte

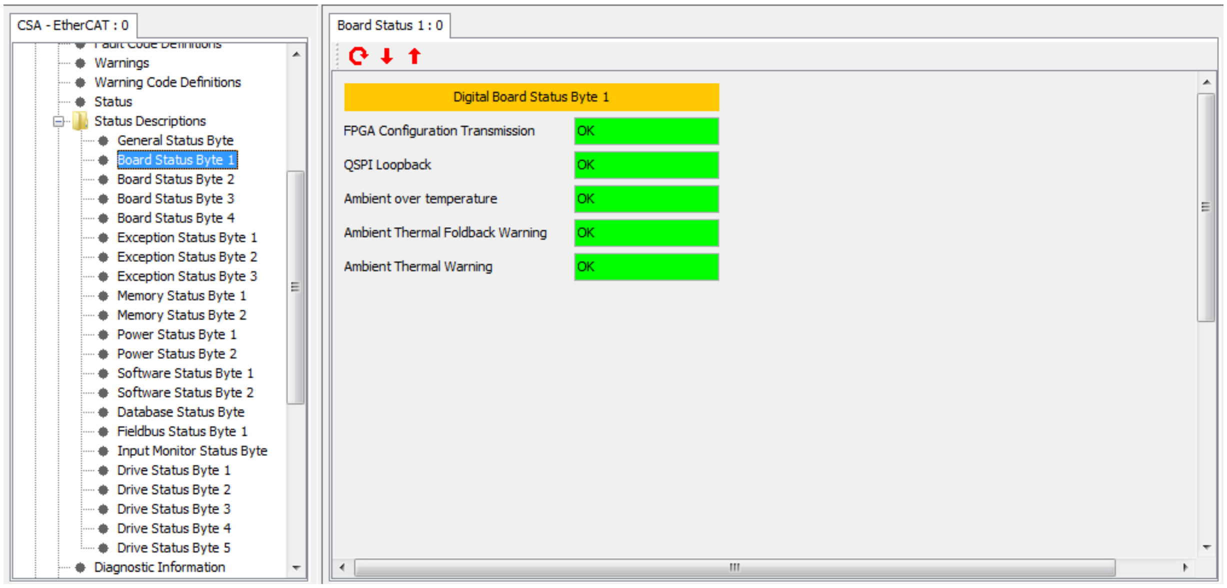
The General Status Panel shows the current status values.



Section & Parameter	Description
Shared Resources Status	Shows the shared resources state. Shared resources are those that would be common to all axes in a multi-axis drive. Values: OK or Fault.
Type 1 Fault	A type 1 fault is one which cannot be cleared except by resetting the drive. Values: True or False
Controller Fault	Shows if a fault is present on the drive. Values: True or False
Controller Warning	Shows if a warning is present on the drive. Values: True or False

B.3.9.6.2 Board Status Byte 1

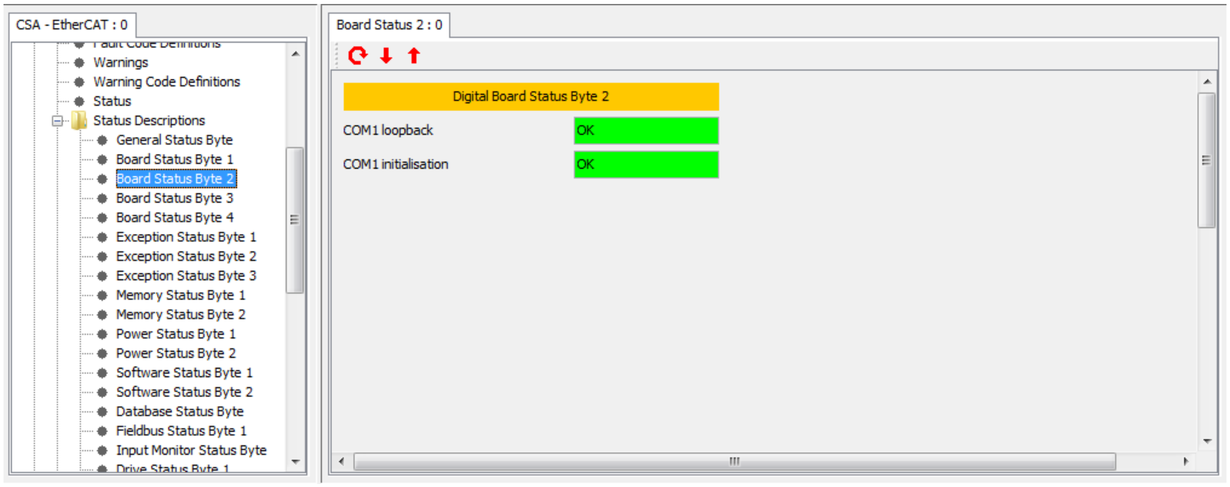
The Board Status 1 Panel shows the current status values.



Section & Parameter	Description
FPGA Configuration Transmission	Indicates if there is a fault in FPGA configuration transmission. Values: OK or Fault.
QSPI Loopback	Indicates there is a QSPI loopback fault. Values: OK or Fault.
Ambient over temperature	Indicates that the ambient temperature is greater than the programmed limit. Values: OK or Fault.
Ambient Thermal Foldback Warning	Indicates that the ambient temperature has reached 90% of the set temperature at which point thermal limiting begins. Values: OK or Fault.
Ambient Thermal Warning	Indicates that the ambient temperature has reached 90% of the set temperature at which a thermal fault occurs. Values: OK or Fault.

B.3.9.6.3 Board Status Byte 2

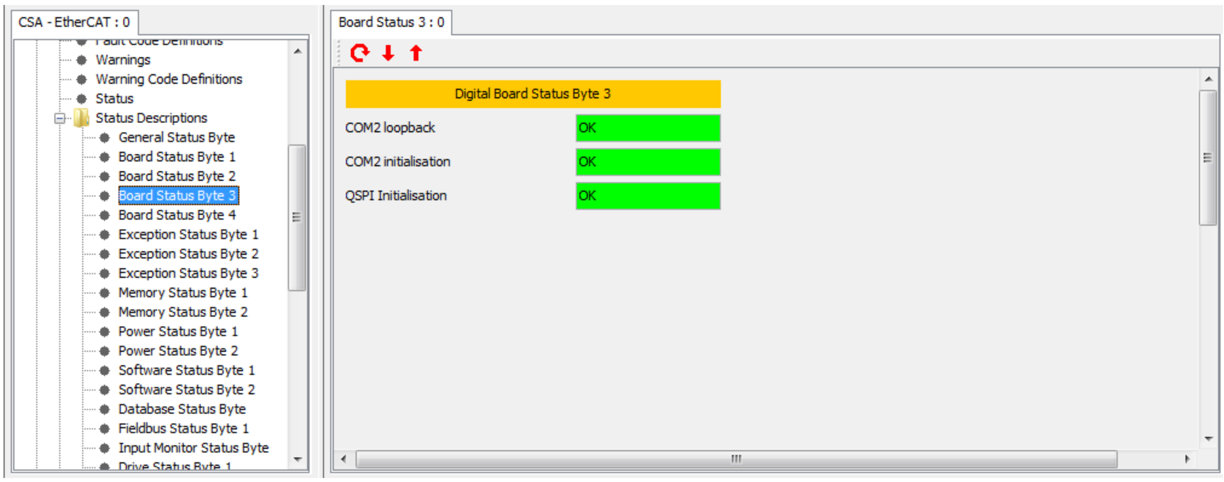
The Board Status 2 Panel shows the current status values.



Section & Parameter	Description
COM1 loopback	The result of the loop back test performed during initialisation of the drive. Values: OK or Fault.
COM1 initialisation	The result of the COM port initialisation. Values: OK or Fault.

B.3.9.6.4 Board Status Byte 3

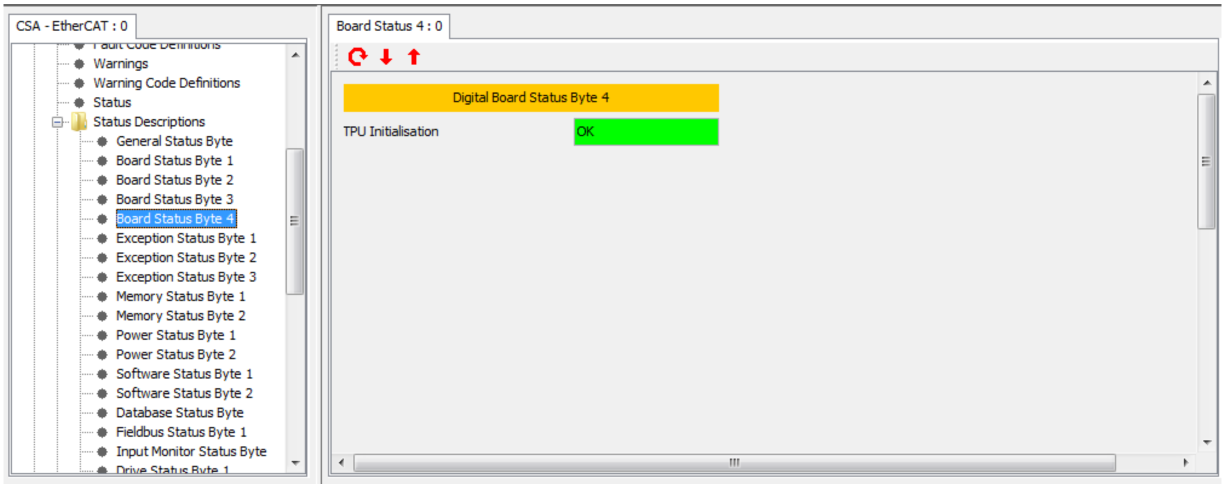
The Board Status 3 Panel shows the current status values.



Section & Parameter	Description
COM2 loopback	The result of the loop back test performed during initialisation of the drive. Values: OK or Fault.
COM2 initialisation	The result of the COM port initialisation. Values: OK or Fault.
QSPI Initialisation	The result of the Queued Serial Peripheral Interface (QSPI) initialisation, which is required to access the FPGA. Values: OK or Fault.

B.3.9.6.5 Board Status Byte 4

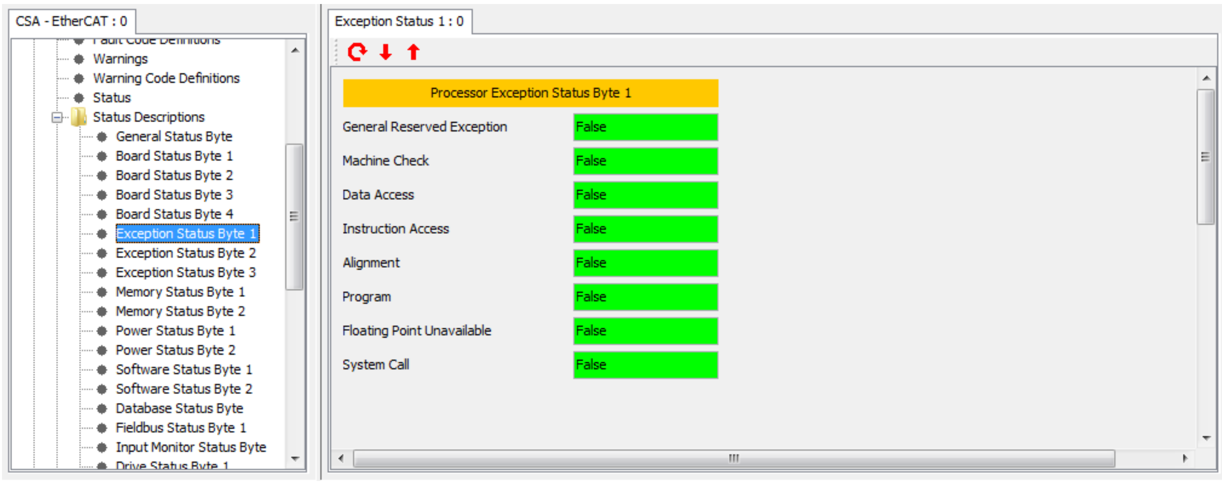
The Board Status 4 Panel shows the current status values.



Section & Parameter	Description
TPU Initialisation	Result of the Power PC Time Processor Unit (TPU) Initialization, used for accessing peripherals through serial channels. Values: OK or Fault.

B.3.9.6.6 Exception Status Byte 1

The Exception Status 1 Panel shows the current status values.

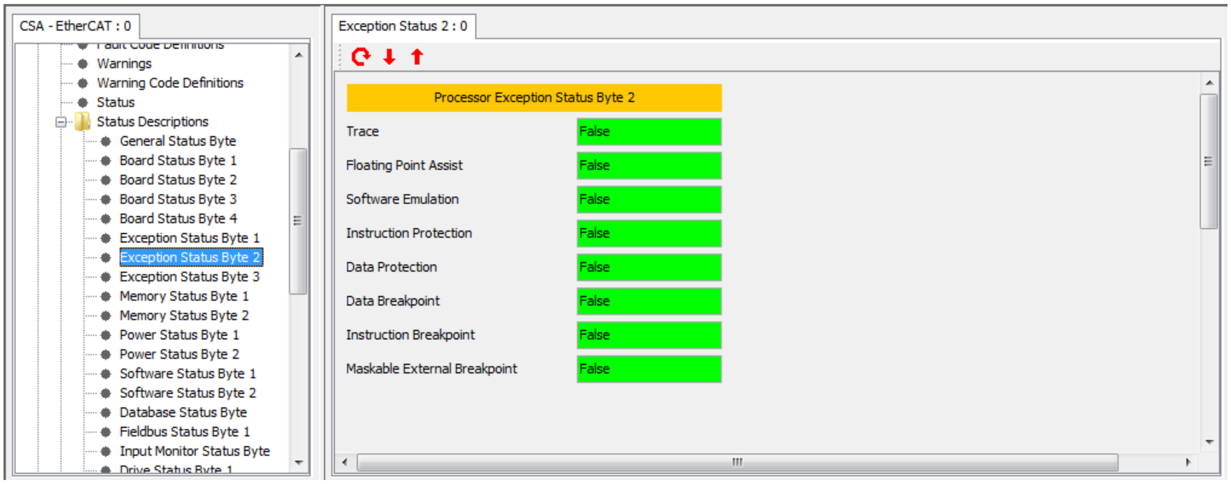


The processor exceptions indicate serious internal faults within the microprocessor on the control card or in the software or its execution. If the control card is programmed with a boot loader and the watchdog enabled, the application will likely fault and restart, these errors may not be observable or even logged in the Fault History.

Section & Parameter	Description
General Reserved Exception	An undefined exception vector was generated. Values: True or False.
Machine Check	Memory access violations such as non-existent addresses, data errors or a violation of the memory protection type. Values: True or False.
Data Access	Mis-aligned or protected data is to be accessed. Values: True or False.
Instruction Access	A protected or invalid instruction is to be accessed. Values: True or False.
Alignment	Non-word aligned data is to be used in a load or store instruction. Values: True or False.
Program	An invalid instruction is to be executed or is not allowed. Values: True or False.
Floating Point Unavailable	An attempt to execute a floating point operation was executed when the Floating Point Unit was disabled. Values: True or False.
System Call	A System Call instruction was executed (should never occur since it is not built into the application). Values: True or False.

B.3.9.6.7 Exception Status Byte 2

The Exception Status 2 Panel shows the current status values.

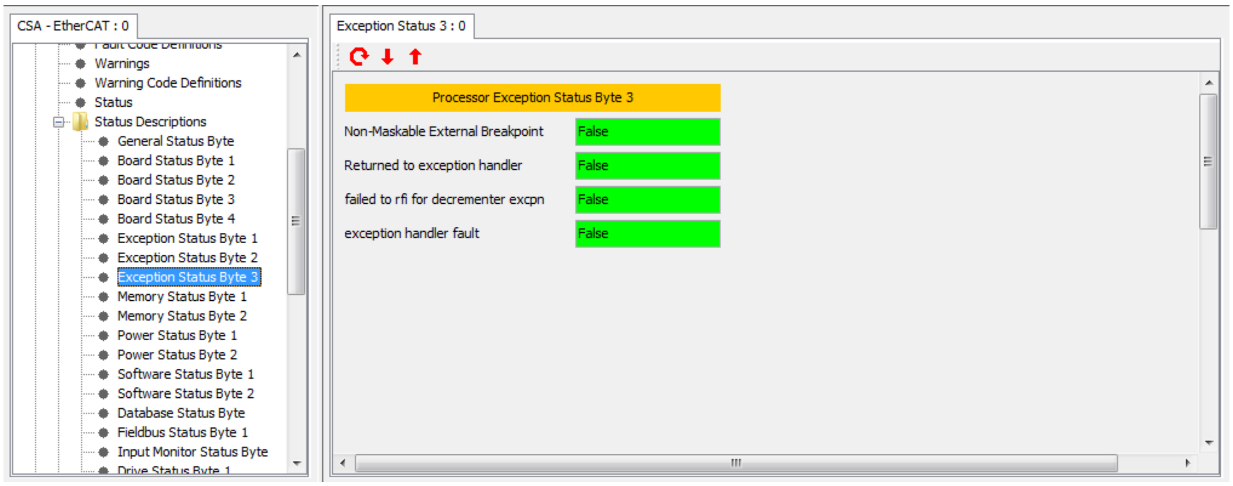


The processor exceptions indicate serious internal faults within the microprocessor on the control card or in the software or its execution. If the control card is programmed with a boot loader and the watchdog enabled, the application will likely fault and restart, these errors may not be observable or even logged in the Fault History.

Section & Parameter	Description
Trace	Trace exceptions occur when the application is being debugged, this should never occur. Values: True or False.
Floating Point Assist	The results of a floating point operation were invalid. Values: True or False.
Software Emulation	Software Emulation exceptions occur when the application is being debugged, this should never occur. Values: True or False.
Instruction Protection	Guarded storage is being accessed by the application. Values: True or False.
Data Protection	Data access violates the defined storage protection. Values: True or False.
Data Breakpoint	A data break point was inserted in the application. This should never happen since the application never debugged when deployed. Values: True or False.
Instruction Breakpoint	A software break point was inserted in the application. This should never happen since the application never debugged when deployed. Values: True or False.
Maskable External Breakpoint	A debug related exception, which should never happen since the application is not being debugged. Values: True or False.

B.3.9.6.8 Exception Status Byte 3

The Exception Status 3 Panel shows the current status values.

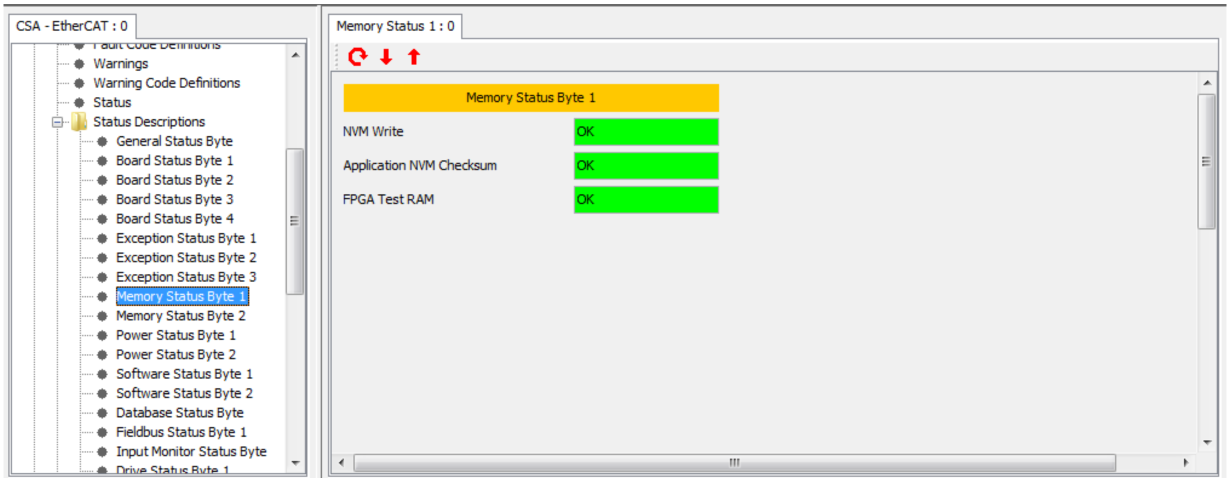


The processor exceptions indicate serious internal faults within the microprocessor on the control card or in the software or its execution. If the control card is programmed with a boot loader and the watchdog enabled, the application will likely fault and restart, these errors may not be observable or even logged in the Fault History.

Section & Parameter	Description
Non-maskable External Breakpoint	A debug related exception, which should never happen since the application is not being debugged. Values: True or False.
Returned to exception handler	An error caused the exception handler to re-execute. Values: True or False.
failed to rfi for decrementer exception	An error occurred with the decrementer register and processing did not return to execute the next instruction correctly. Values: True or False.
exception handler fault	An error occurred in the generation or handling of an exception. Values: True or False.

B.3.9.6.9 Memory Status Byte 1

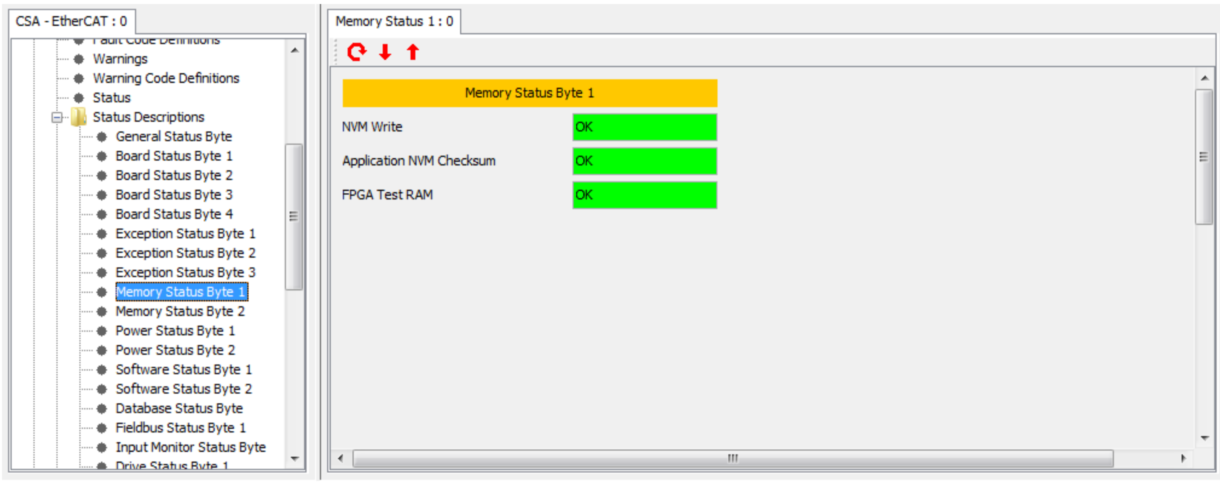
The Memory Status 1 Panel shows the current status values.



Section & Parameter	Description
NVM Write	Indicates a problem writing to the drive internal NVM. Values: OK or Fault.
Application NVM Checksum	Indicates that the checksum for the data in the drive internal parameter NVM is incorrect. Values: OK or Fault.
FPGA Test RAM	Indicates that the FPGA test RAM contains an incorrect value. Values: OK or Fault.

B.3.9.6.10 Memory Status Byte 2

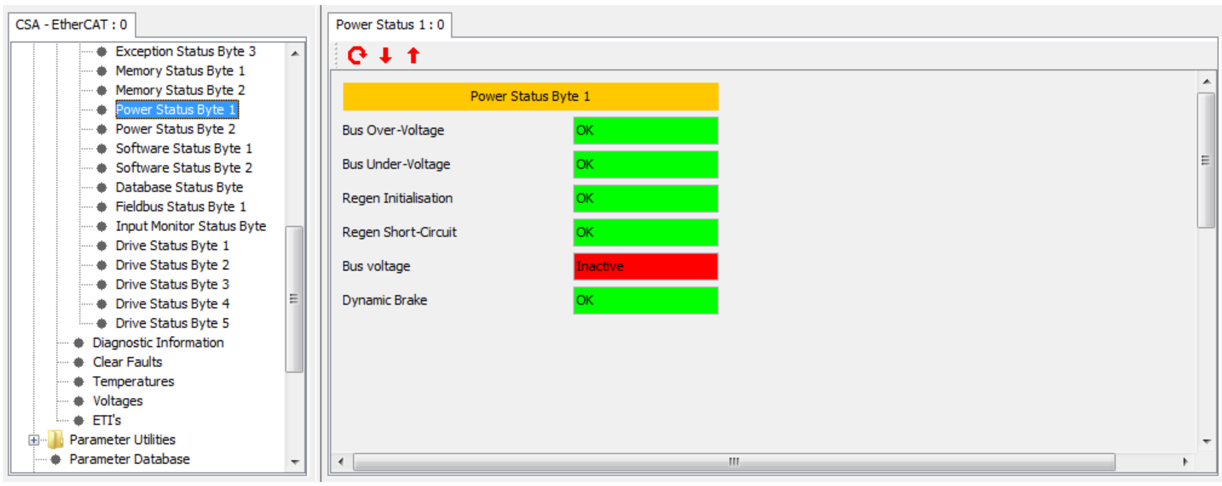
The Memory Status 2 Panel shows the current status values.



Section & Parameter	Description
Power Save NVM Checksum	Indicates that the checksum for the data in the drive internal power save NVM is incorrect. This is for information only and does not cause a fault condition on the drive. Values: OK or Fault.
Error log NVM Checksum	Indicates that the checksum for the data in the drive internal error log NVM is incorrect. This is for information only and does not cause a fault condition on the drive. Values: OK or Fault.

B.3.9.6.11 Power Status Byte 1

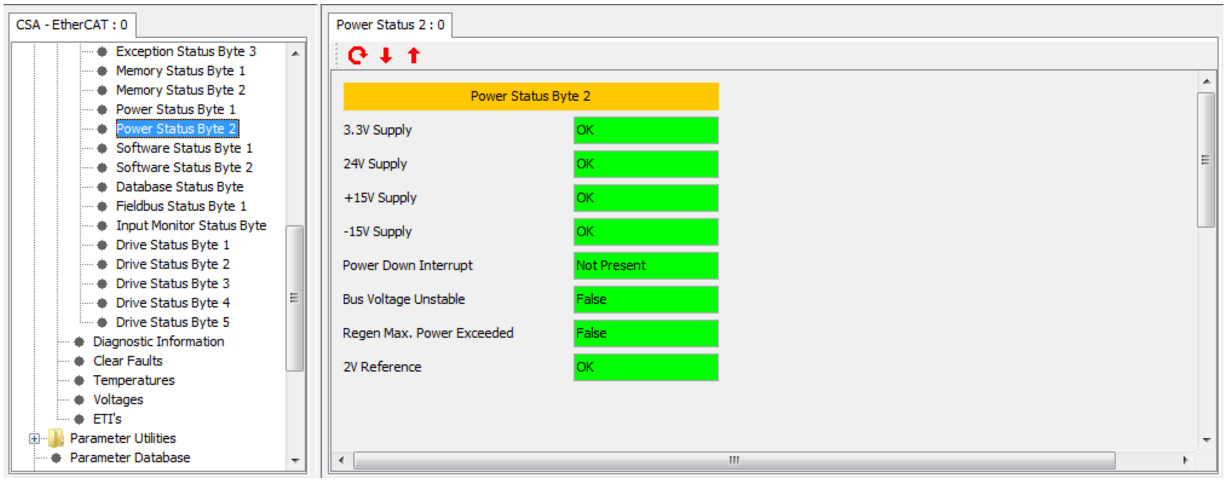
The Power Status 1 Panel shows the current status values.



Section & Parameter	Description
Bus Over-Voltage	Indicates that the bus over-voltage limit is exceeded. Values: OK or Fault.
Bus Under-Voltage	Indicates that the bus under-voltage limit is exceeded. Values: OK or Fault.
Regen Initialisation	Indicates a fault during regeneration initialisation. Values: OK or Fault.
Regen Short-Circuit	Indicates that there is a regeneration short circuit fault. Values: OK or Fault.
Bus Voltage	Indicates whether bus voltage is active. Values: Active or Inactive.
Dynamic Brake	Indicates that there is a dynamic brake fault. Values: OK or Fault.

B.3.9.6.12 Power Status Byte 2

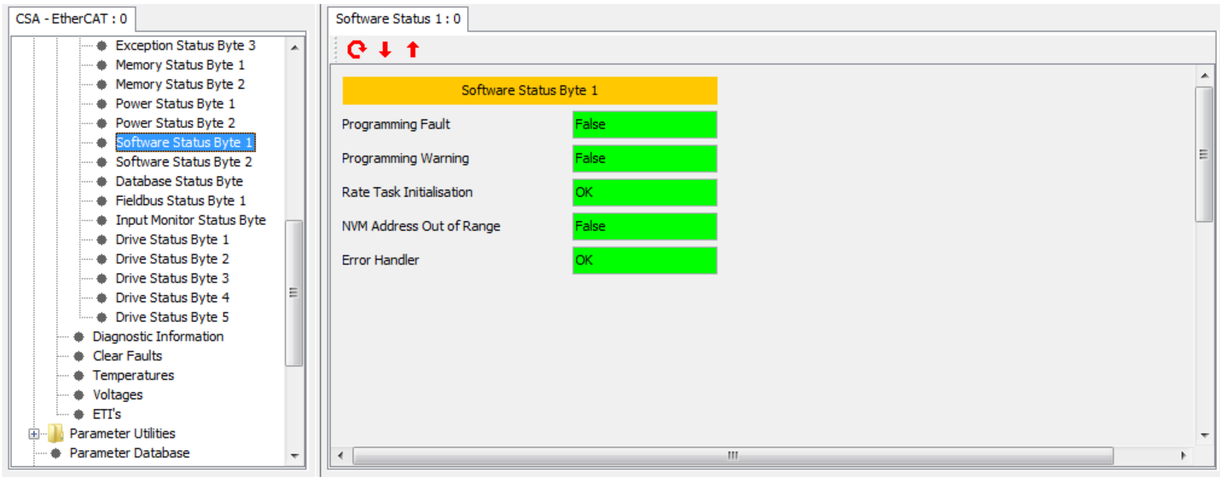
The Power Status 2 Panel shows the current status values.



Section & Parameter	Description
3.3 V Supply	Indicates the 3.3 V supply status. Values: OK or Fault.
24 V Supply	Indicates the 24 V supply status. Values: OK or Fault.
+15 V Supply	Indicates the +15 V supply status. Values: OK or Fault.
-15 V Supply	Indicates the -15 V supply status. Values: OK or Fault.
Power Down Interrupt	Indicates the power down (low VDC) interrupt status. Values: Not Present and Present.
Bus Voltage Unstable	Indicates the bus voltage is unstable. Values: True or False
Regen Max. On Time Exceeded	Indicates whether the regeneration exceeds the max limit on time. Values: True or False
2V Reference	Indicates whether the 2V reference status. Values: OK or Fault.

B.3.9.6.13 Software Status Byte 1

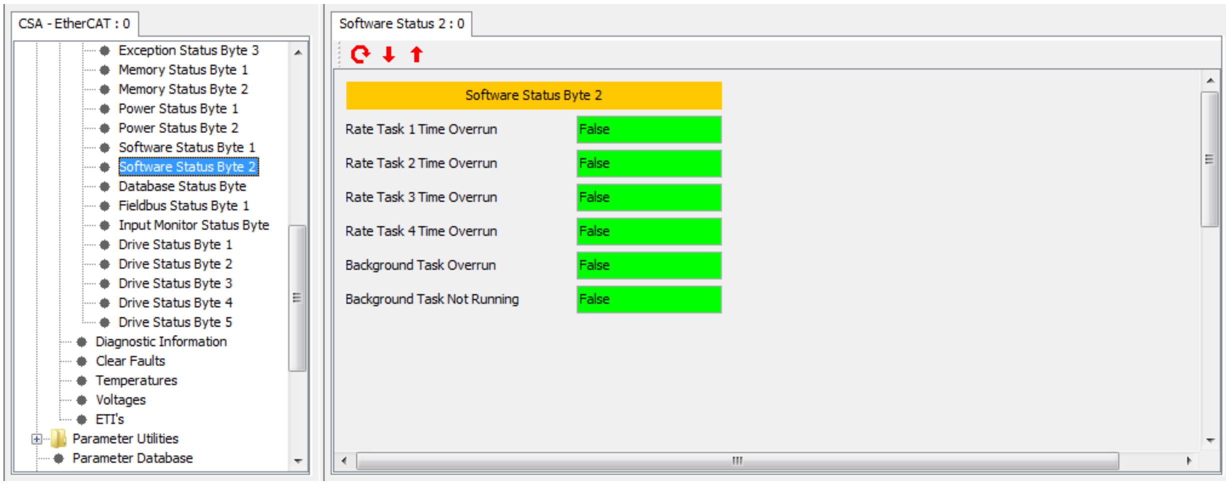
The Software Status 1 Panel shows the current status values.



Section & Parameter	Description
Programming Fault	This is an internal software fault due to invalid data values or states. Values: True or False.
Programming Warning	Indicates a database programming warning. Values: True or False.
Rate Task Initialisation	Indicates that a fault occurred during the initialisation of the periodic tasks. Values: True or False.
NVM Address Out of Range	Indicates that an attempt was made to access an address outside the range of valid NVM addresses. Values: True or False.
Error Handler	Indicates an error initialising the error handler. Values: True or False.

B.3.9.6.14 Software Status Byte 2

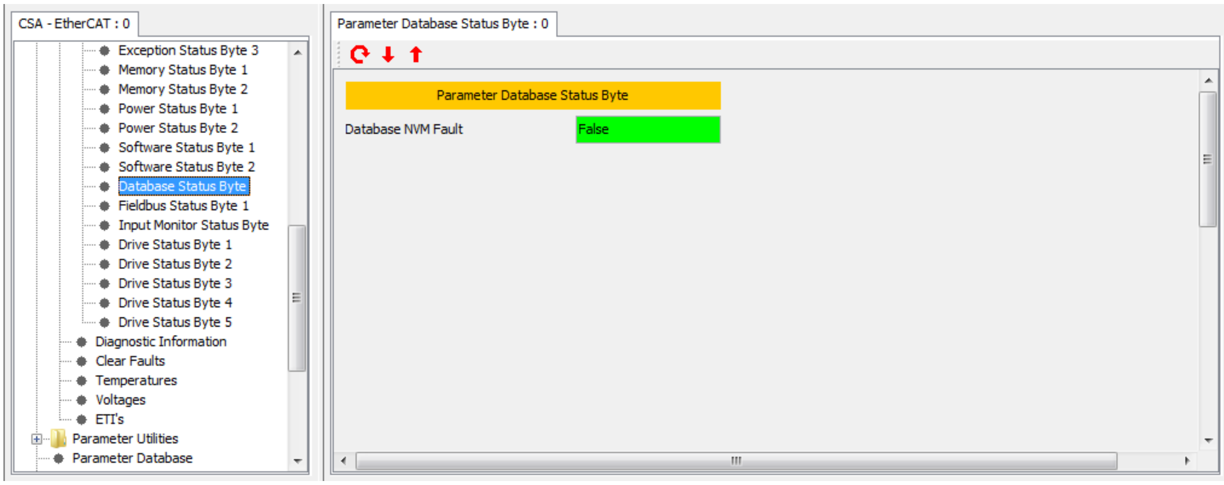
The Memory Status 2 Panel shows the current status values.



Section & Parameter	Description
Rate Task 1 Time Overrun	The Rate Task 1, running every 2 msec, which performs Bus Monitoring, brake control, move monitoring, and hardware related error handling, did not have sufficient time to execute. Values: True or False.
Rate Task 2 Time Overrun	The Rate Task 2, running every 10 msec, which performs logic voltage monitoring, did not have sufficient time to execute. Values: True or False.
Rate Task 3 Time Overrun	The Rate Task 3, running every 100 msec, which performs Motor Temperature Limiting, Bridge Temperature Limiting and Current Limiting, did not have sufficient time to execute. Values: True or False.
Rate Task 4 Time Overrun	The Rate Task 4, running every 1 sec, which performs Ambient Temperature Monitoring, did not have sufficient time to execute. Values: True or False.
Background Task Overrun	The Software Watchdog triggered due to the Background Task not executing in a reasonable amount of time. In general, this is not a significant cause for concern; it merely means the Background task was temporarily delayed. Values: True or False.
Background Task Not Running	All application polling activities are not executing, this includes fieldbus protocols, processing of digital inputs, state machine and error handling. Values: True or False.

B.3.9.6.15 Database Status Byte

The Database Status Byte Panel shows the current status values.



Section & Parameter	Description
Database NVM Fault	Indicates a fault accessing non-volatile data memory from the internal parameter database. Values: True or False.

B.3.9.6.16 Fieldbus Status Byte 1

The Fieldbus Status 1 Panel shows the current status values.

Section & Parameter	Description
Generic fault	Indicates communications failed to initialize, Asynchronous transmissions could not be sent or a Keylock loop error. Values: True or False.
Sync fault	Indicates erroneous bus activity. Values: True or False.

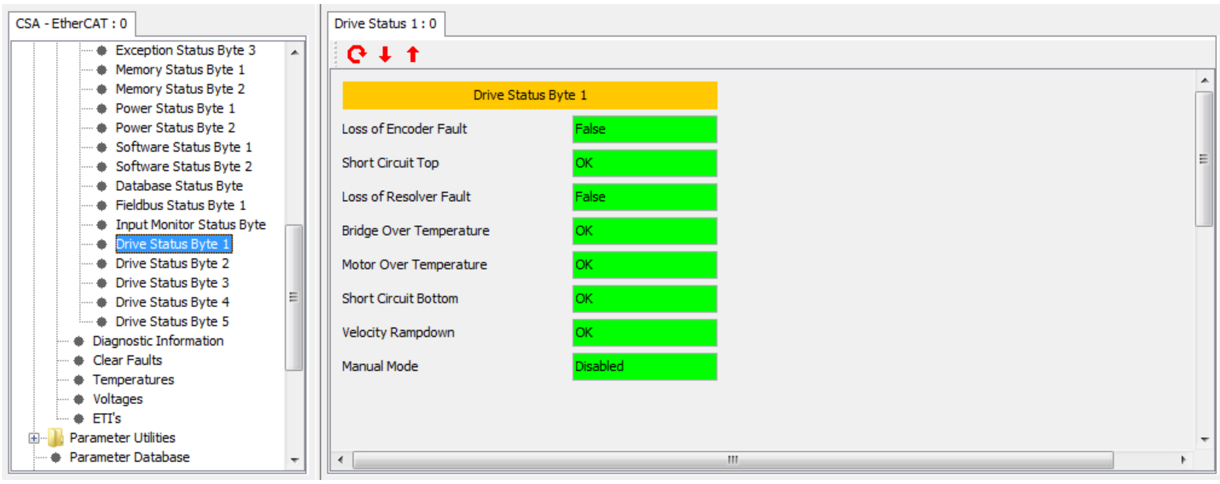
B.3.9.6.17 Input Monitor Status Byte

The Input Monitor Status Panel shows the current status values.

Section & Parameter	Description
Fault Override	Indicates faults have been overidden. Values: ON or Off.
Safety Circuit monitor	Indicates the status of the safety circuit monitor. Values: True or False.
Restart I/L Output fault	Indicates the status of the safety circuit input monitor. Values: True or False.
Restart I/L enable fault	Indicates that a safety circuit input monitor signal was not present when the drive was commanded to be enabled. Values: True or False.
Brake Monitor fault	Indicates that the brake monitor is not consistent with the commanded state of the brake. Values: True or False.

B.3.9.6.18 Drive Status Byte 1

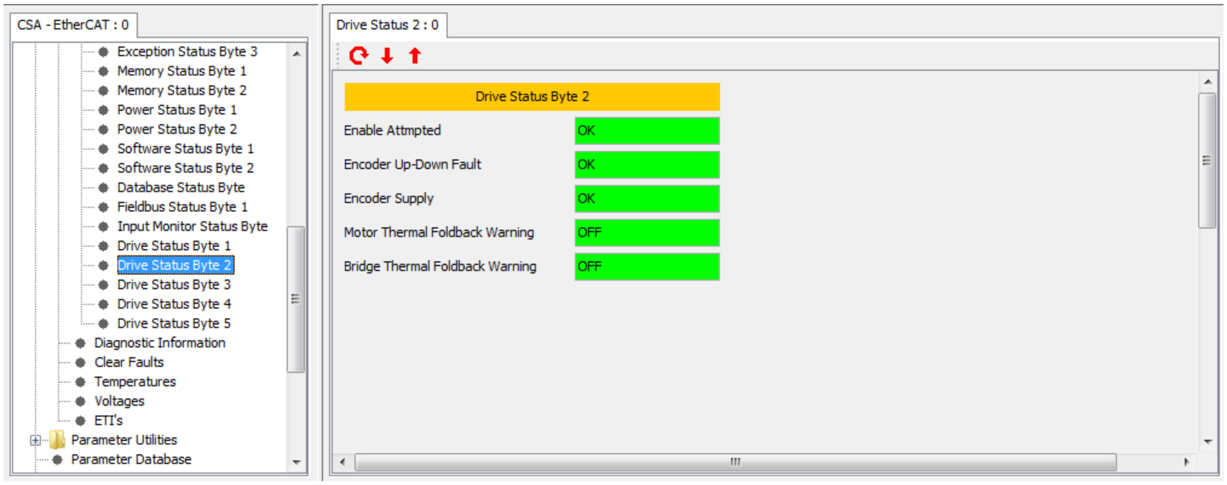
The Drive Status 1 Panel shows the current status values.



Section & Parameter	Description
Loss of Encoder Fault	Indicates that the encoder is disconnected or has failed due to signal or communication related errors, but has been selected as a feedback source. Values: True or False.
Short Circuit Top	Indicates a short circuit fault at the top of the IGBT. Values: OK or Fault.
Loss of Resolver Fault	Indicates that the resolver is disconnected, but has been selected as a feedback source. Values: True or False.
Bridge Over Temperature	Indicates that the bridge temperature has exceeded the upper limit. Values: OK or Fault.
Motor Over Temperature	Indicates that the motor temperature has exceeded the upper limit. Values: OK or Fault.
Short Circuit Bottom	Indicates a short circuit fault at the bottom IGBTs. Values: OK or Fault.
Velocity Rampdown	Indicates a timeout fault during a velocity rampdown (quickstop), the motor/actuator may have been running and abruptly stopped when a fault was processed, instead of coasting to a safe velocity level. Values: OK or Fault.
Manual Mode	A warning ther manual mode is enabled or disabled. Values: Enabled or Disabled.

B.3.9.6.19 Drive Status Byte 2

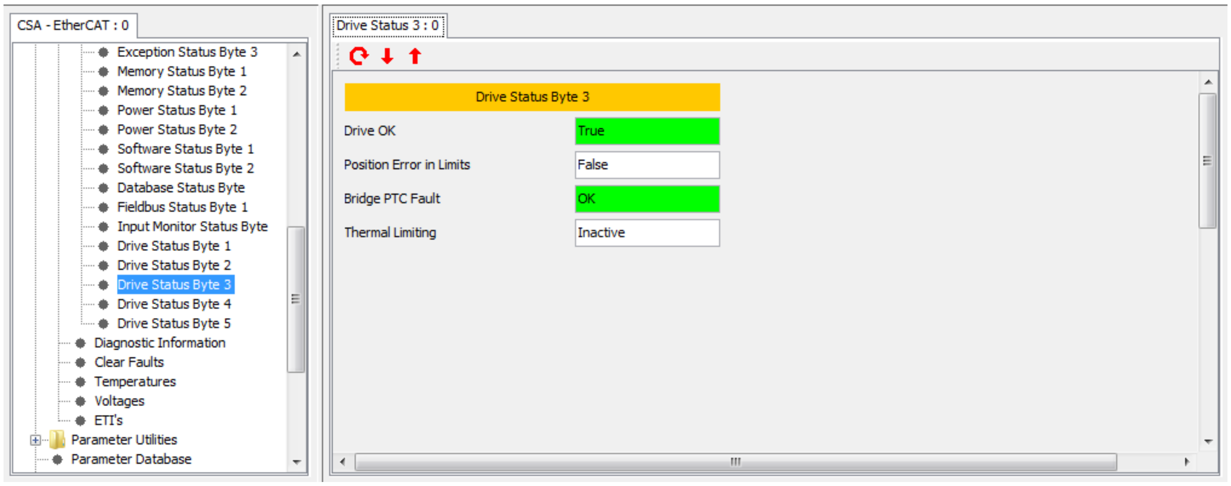
The Drive Status 2 Panel shows the current status values.



Section & Parameter	Description
Enable Attempted	Indicates that an attempt was made to enable the drive when the conditions for enabling were not valid (e.g. hardware enable false). Values: OK or Fault.
Encoder Up-Down Fault	An illegal change in direction was observed. Values: OK or Fault.
Encoder Supply	Indicates an encoder supply fault. Values: OK or Fault.
Motor Thermal Foldback Warning	Indicates that the temperature is within 10% of the start temperature for motor thermal foldback. Values: ON or OFF.
Bridge Thermal Foldback Warning	Indicates that the temperature is within 10% of the start temperature for bridge thermal foldback. Values: ON or OFF.

B.3.9.6.20 Drive Status Byte 3

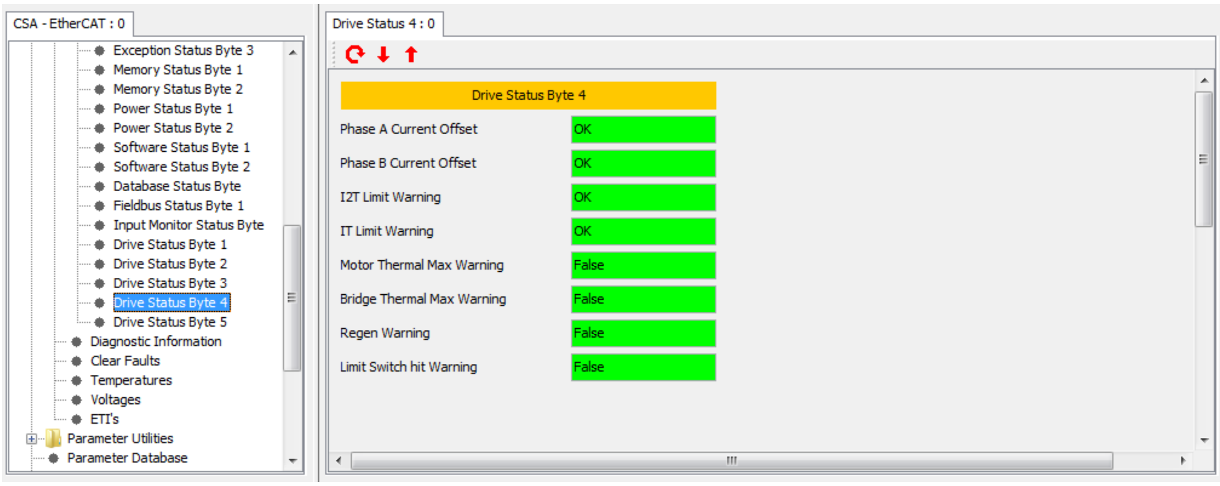
The Drive Status 3 Panel shows the current status values.



Section & Parameter	Description
Drive OK.	Shows the drive resources state. Drive resources are those that would be exclusive to a single axis in a multi-axis drive. Values: True or False.
Position Error in Limits	Indicates that the actual position has attained the target position within a programmable range. Valid in position mode only. Values: True or False.
Bridge PTC Faults	Indicates the PTC sensor below the bridge has exceeded its max temperature, only supported on select versions. Values: OK or Fault.
Thermal Limiting	Indicates whether the thermal limiting is active. Values: Active or Inactive.

B.3.9.6.21 Drive Status Byte 4

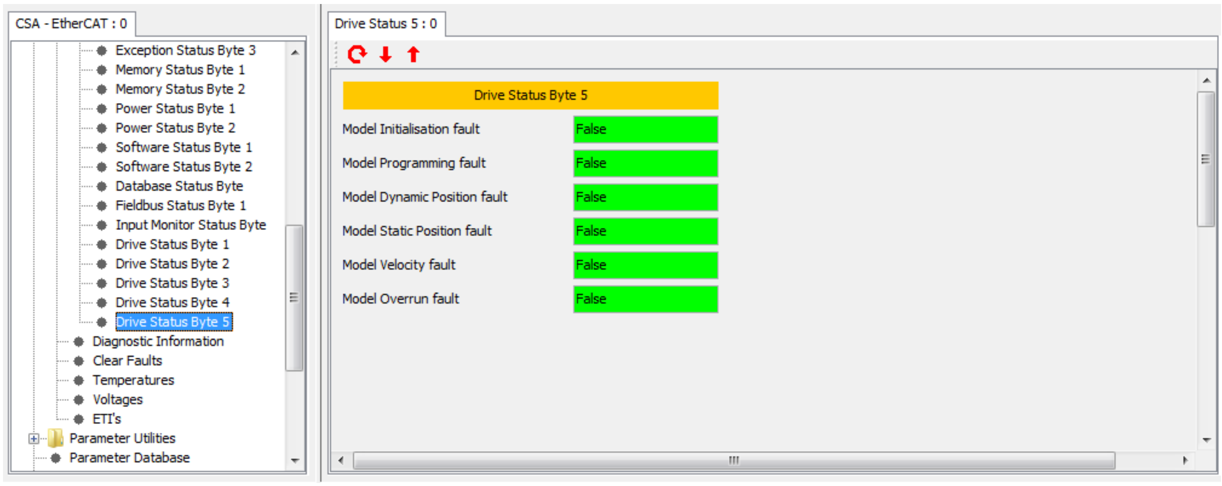
The Drive Status 4 Panel shows the current status values.



Section & Parameter	Description
Phase A Current Offset	Indicates if the phase A current offset is greater than a programmable limit. Values: OK or Fault.
Phase B Current Offset	Indicates if the phase B current offset is greater than a programmable limit. Values: OK or Fault.
I2T Limit Warning	Indicates an I2T limit warning is being exceeded. Values: OK or Fault.
IT Limit Warning	Indicates an IT warning level is being exceeded. Values: OK or Fault.
Motor Thermal Warning.	Indicates that the motor winding temperature is within 10% of the motor max temperature. Values: True or False.
Bridge Thermal Warning	Indicates that the power transistor heatsink temperature is within 10% of the bridge maximum temperature. Values: True or False.
Regen Warning	Indicates that the power dissipated in the regen resistor(s) is within 10% of the continuous capability of the resistor(s). Values: True or False.
Limit Switch hit Warning	Indicates that either clockwise or counter-clockwise limit switch has become active. Values: True or False.

B.3.9.6.22 Drive Status Byte 5

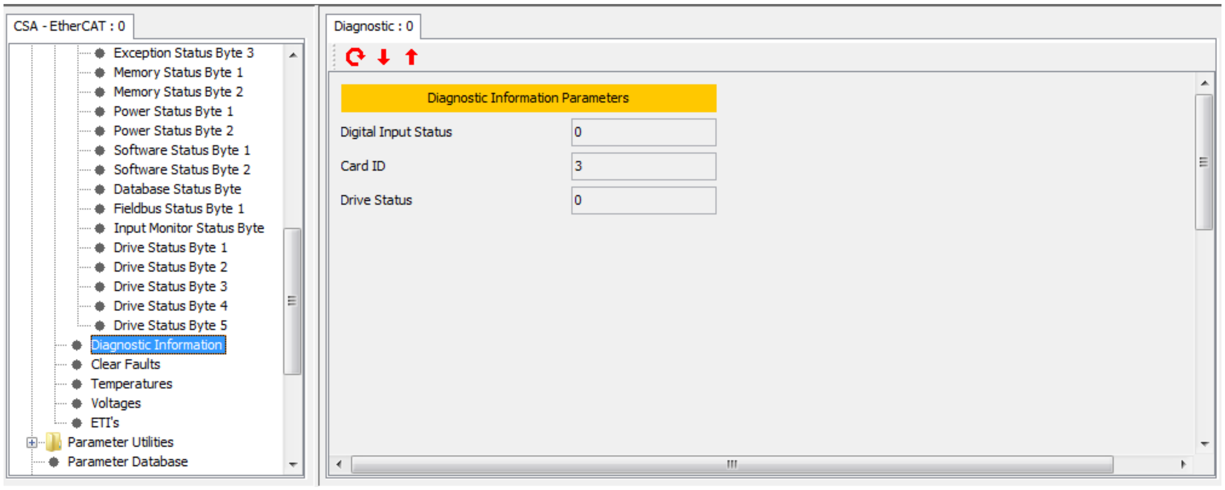
The Drive Status 5 Panel shows the current status values.



Section & Parameter	Description
Model Initialization fault	Indicates the model has failed either the initialization function or parameter access. Values: True or False.
Model Programming fault	Indicates a programming error in the model. Values: True or False.
Model Dynamic Position fault	Indicates a dynamic position error occurred. Values: True or False.
Model Static Position fault	Indicates a static position error occurred. Values: True or False.
Model Velocity fault	Indicates a velocity occurred. Values: True or False.
Model Overrun fault	Indicates the model has exceeded its execution time limit. Values: True or False.

B.3.9.6.23 Diagnostic Information

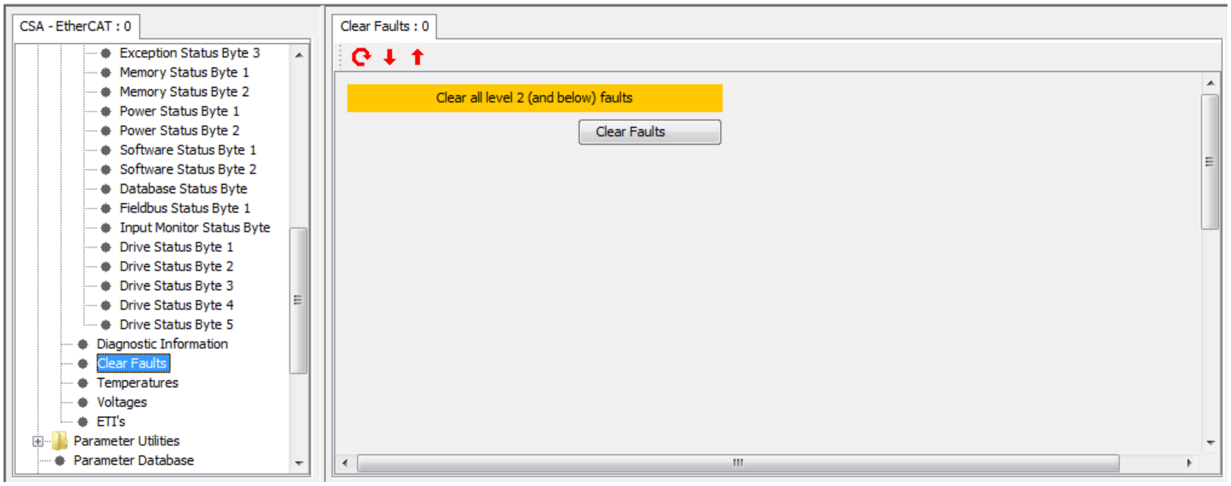
The Diagnostic Panel shows the current values for select parameters helpful for assessing system status.



Section & Parameter	Description
Digital Input Status	Shows the state of the digital inputs. This is a single byte where bit 0 (LSB) corresponds to the hardware enable digital input, bit 1 corresponds to digital input 1,…….., bit 7 corresponds to digital input 7.
Card ID	It shows the ID value of the power stage. See Section 1, Table 1-1.
Drive Status	Shows the state of selected drive status bits. • Bit 7 (MSB) = enable state. • Bit 3 = short circuit (top) fault. • Bit 2 = short circuit (bottom) fault. • Bit 1 = regeneration fault. • Bit 0 (LSB) = PWM dead time generation fault

B.3.9.6.24 Clear Faults

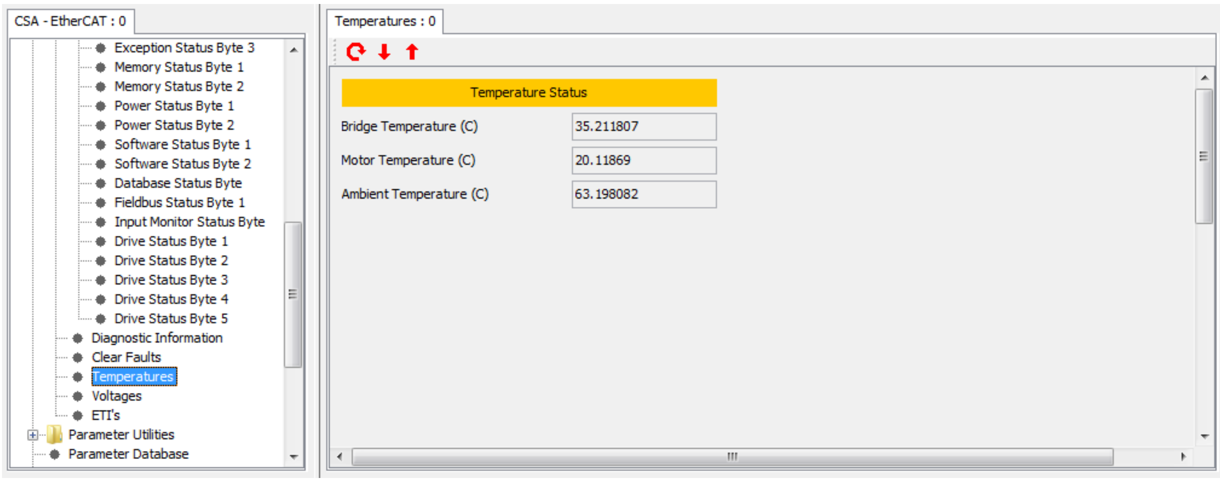
The Clear Faults Panel is used to clear latched drive faults of level 2 and lower.



The Clear Faults panel is used to attempt to clear all the faults. It is possible to clear all faults except for those faults that occur during the initialisation process and faults due to microprocessor exceptions. It is possible to determine whether one of these non-clearable faults has occurred by reading the type 1 fault bit in the status_controller parameter ('General Status' byte) or by referencing the Fault History.

B.3.9.7 Temperatures

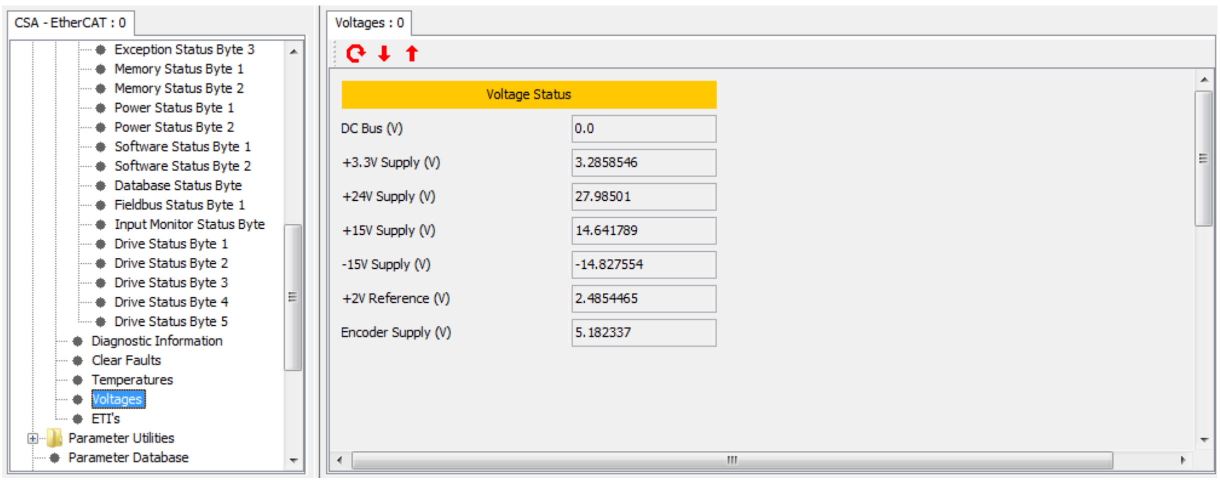
The Temperatures Panel is used to view the values of motor, bridge and ambient temperature.



Section & Parameter	Description
Bridge Temperature (°C)	The power amplifier bridge temperature.
Motor Temperature (°C)	The motor winding temperature.
Ambient Temperature (°C)	The control electronics ambient temperature.

B.3.9.8 Voltages

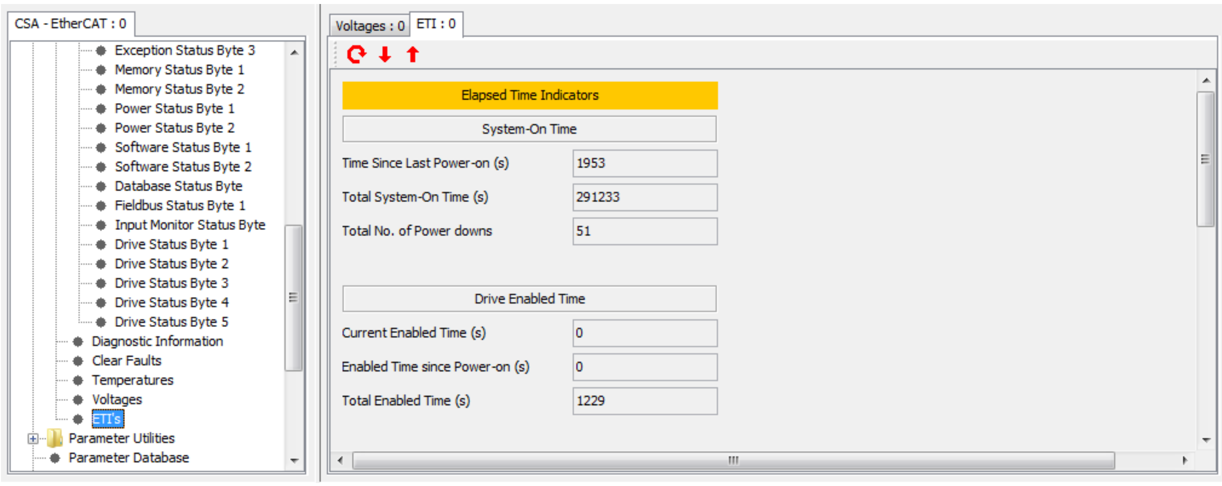
The Voltages Panel displays the actual voltage.



Section & Parameter	Description
DC Bus (V)	The actual value of the DC bus voltage.
+3.3V Supply (V).	The actual value of the +3.3V logic supply.
+24V Supply (V)	The actual value of the internal 24V logic supply.
+15V Supply (V)	The actual value of the +15V logic supply.
-15V Supply (V)	The actual value of the -15V logic supply.
+2V Reference (V)	The actual value of the 2V reference level.
Encoder Supply (V)	The actual value of the encoder supply, nominally 5V, 8V or 12 V.

B.3.9.9 ETI's

The ETI Panel shows the current values of the defined Elapsed Time Indicators (ETI).



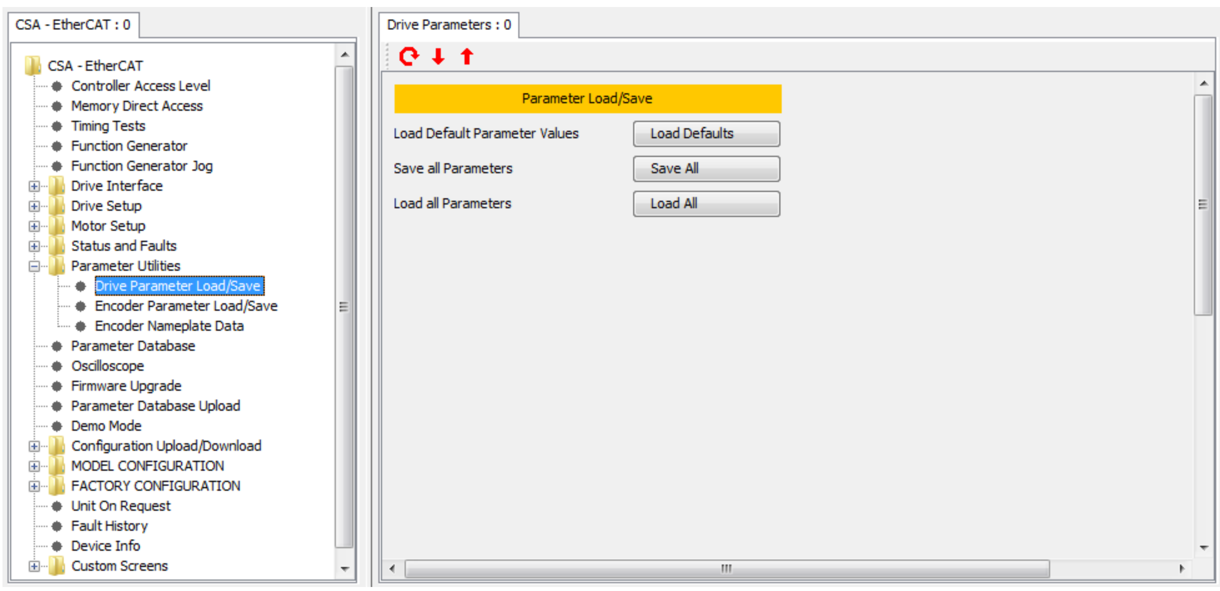
Section & Parameter	Description
System-On Time	
Time Since Last Power-on (s)	The elapsed time since power up.
Total System-On Time (s)	The total powered up time.
Total No. of Power downs	The number of power downs.
Drive Enabled Time	
Current Enabled Time (s)	The enabled time since enable.
Enabled Time since Power-on (s)	The enabled time since power up.
Total Enabled Time (s)	The total enabled time.

B.3.10 Parameter Utilities

The Drive Parameter and Encoder Parameter panels may vary across the supported configurations and are explained in the following sections.

B.3.10.1 Drive Parameter Load/Save (All Configurations)

The Drive Parameters Panel is used to load/save the drive configuration parameters implemented in the software; an example for the "CSA - EtherCAT" configuration is shown below:

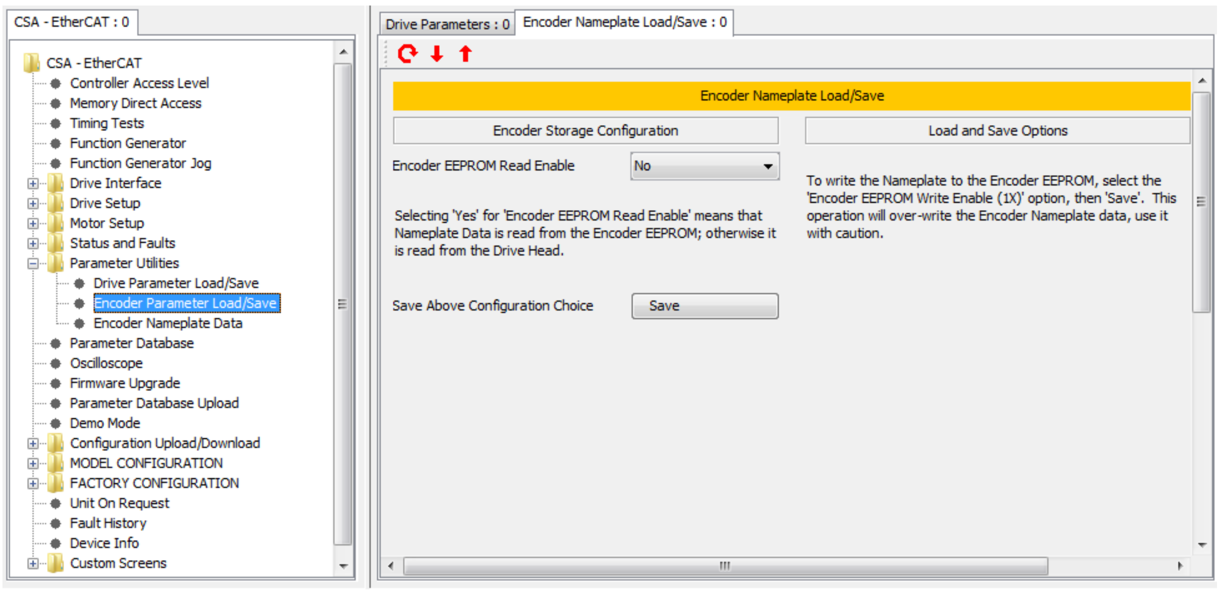


Section & Parameter	Description
Load Default Parameter Values	This is used to load the default values of each drive configuration parameter.
Save all Parameters	This is used to save drive configuration parameters to non-volatile memory.
Load all Parameters	This is used to load drive configuration parameters which have been saved in the non-volatile memory.

B.3.10.2 CSA - EtherCAT Encoder Parameters

B.3.10.2.1 Encoder Parameter Load/Save

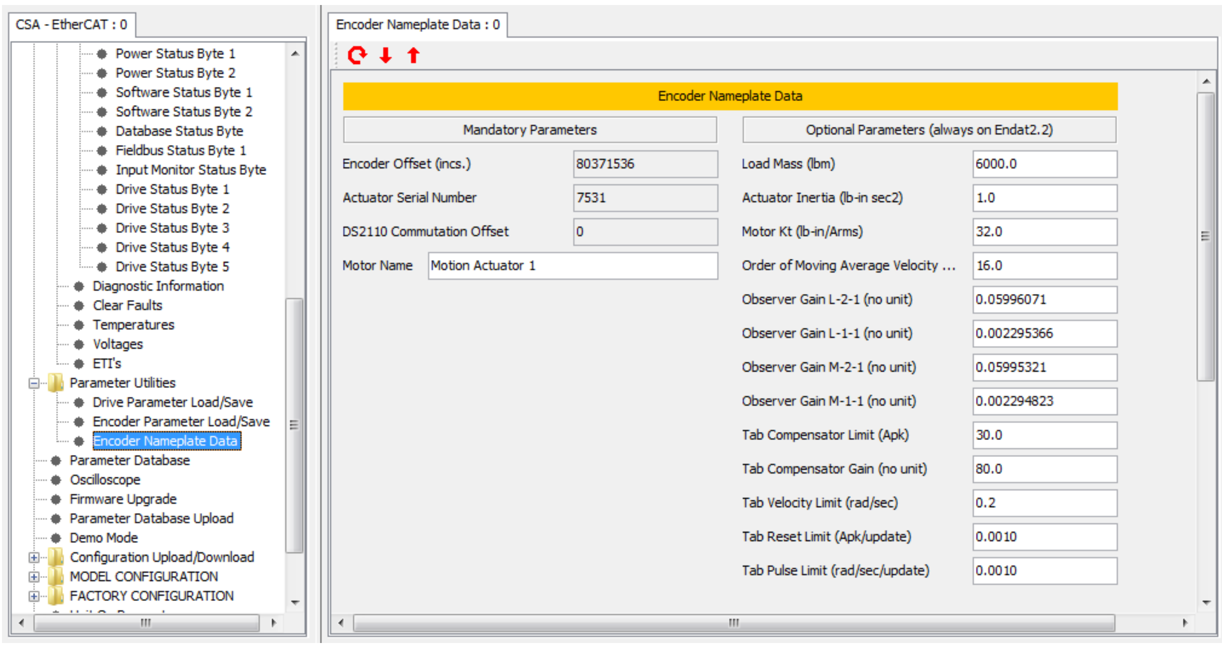
The Encoder Parameter Load/Save Panel is used to load/save Nameplate parameters implemented in the software to the encoder EEPROM.



Section & Parameter	Description
Encoder Data and Storage Configuration	
Encoder EEPROM Read Enable	Options: Yes to read select encoder and motor parameters from the encoder EEPROM or No to read the parameters from the drive.
Save Above Configuration Options	Select to save the Encoder Data and Storage Configuration parameters in the drive.
Load and Save Options	
Load Nameplate from Encoder	Reads the Encoder Nameplate data from the encoder EEPROM
Encoder EEPROM Write Enable (1X)	A safeguard which must be set each time parameters are saved to the encoder EEPROM. This requires the highest Controller Access Level.
Save Parameters to Encoder EEPROM	Select to save select encoder and motor configuration parameters to the encoder EEPROM.

B.3.10.2.2 Encoder Nameplate Data

The Encoder Nameplate Data Panel is used to view or edit mandatory parameters saved in the encoder EEPROM.



The Nameplate capability allows for changes to the parameters with new or updated Application Firmware; therefore, optional parameters are not shown but are listed in the Software Version Description for the Application Firmware.

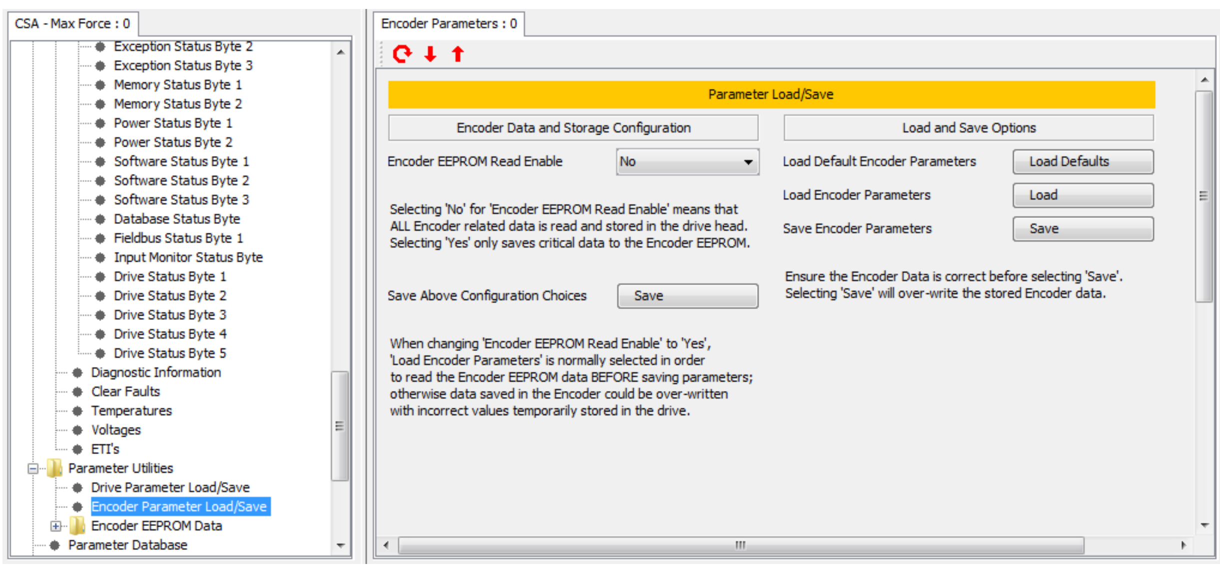
Section & Parameter	Description
Mandatory Parameters	
Encoder Offset (incs.)	Subtracted from the encoder raw position value at the designated home position for absolute movements
Actuator Serial Number:	The serial number of the actuator
DS2110 Commutation Offset	The offset angle between the commutation feedback and the phase currents.
Motor Name	A descriptive name of the actuator, set by the User during Commissioning
Optional Parameters (always on Endat2.2)	
Load Mass (lbm)	The systems load mass
Actuator Inertia (lb-in sec2)	Actuator Inertia used
Motor Kt (lb-in/Arms)	Motor torque constant
Order of Moving Average Velocity Filter (no unit)	Number of samples in the moving window filter
Observer Gain L-2-1 (no unit)	Observer Gain in Matrix L-2-1 for tuning the Kalman Filter
Observer Gain L-1-1 (no unit)	Observer Gain in Matrix L-1-1 for tuning the Kalman Filter
Observer Gain M-2-1 (no unit)	Observer Gain in Matrix M-2-1 for tuning the Kalman Filter
Observer Gain M-1-1 (no unit)	Observer Gain in Matrix M-1-1 for tuning the Kalman

Section & Parameter	Description
	Filter
Tab Compensator Limit (Apk)	The upper limit of the Tab compensation, aftter which the Tab Compensator Output is clipped or clamped
Tab Compensator Gain (no unit)	The Gain applied to the Tab Compensator Output
Tab Velocity Limit (rad/sec)	The velocity below which the Tab Compensator is active
Tab Reset Limit (Apk/update)	The limit after which the Tab integrator is reset
Tab Pulse Limit (rad/sec/update)	Pulse width of the Tab Compensation Current

B.3.10.3 CSA - MaxForce Encoder Parameters

B.3.10.3.1 Encoder Parameter Load/Save

The Encoder Parameter Load/Save Panel is used to load/save encoder parameters to either the Drive or the Encoder EEPROM.



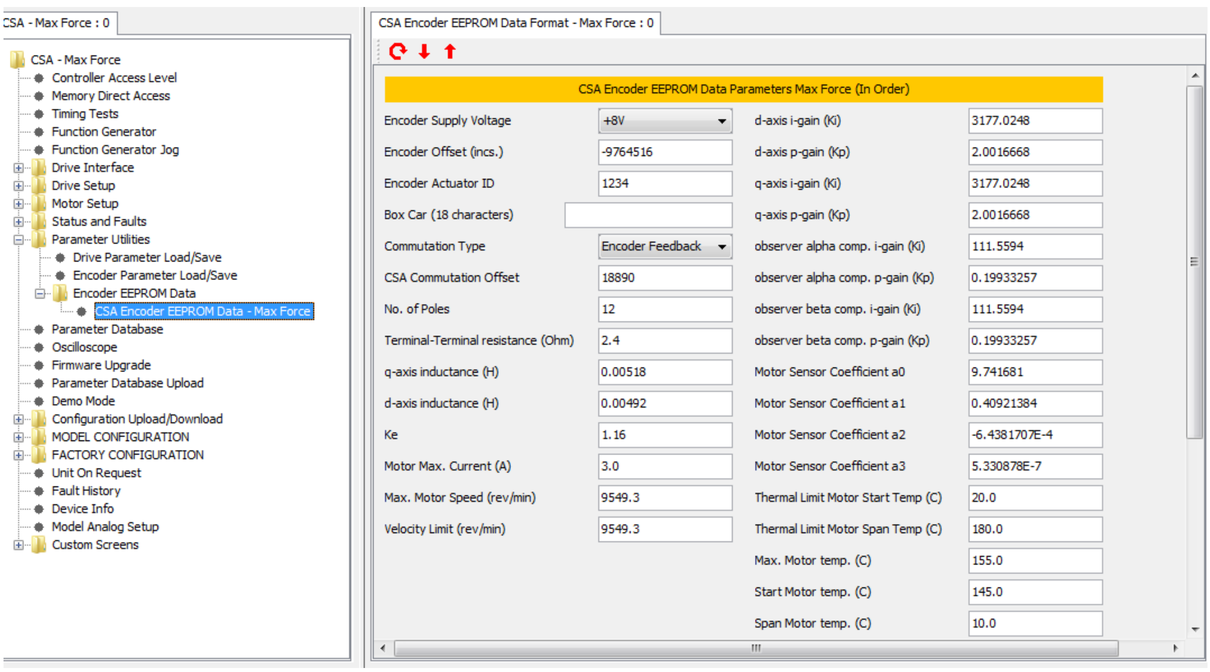
Section & Parameter	Description
Encoder Data and Storage Configuration	
Encoder EEPROM Read Enable	Options: Yes to read select encoder and motor parameters from the encoder EEPROM or No to read the parameters from the drive.
Save Above Configuration Options	Select to save the Encoder Data and Storage Configuration parameters in the drive.
Load and Save Options	
Load Default Encoder Parameters	Writes a default set of encoder parameters to the Drives RAM
Load Encoder Parameters	Reads encoder parameters from the Encoder EEPROM, if enabled, to the Drives RAM.
Save Encoder Parameters	Select to save select encoder and motor configuration parameters to either the encoder EEPROM or Drive NVM.

B.3.10.3.2 Encoder Parameter Load/Save (CSA - MCG LP SSI)

The screen is not required for this configuration since the LP SSI encoder does not have EEPROM accessible to the CSA firmware.

B.3.10.3.3 CSA Encoder EEPROM Data - Max Force

The Encoder Parameters Panel displays the parameters, which if the Encoder EEPROM is enabled, are read or written.

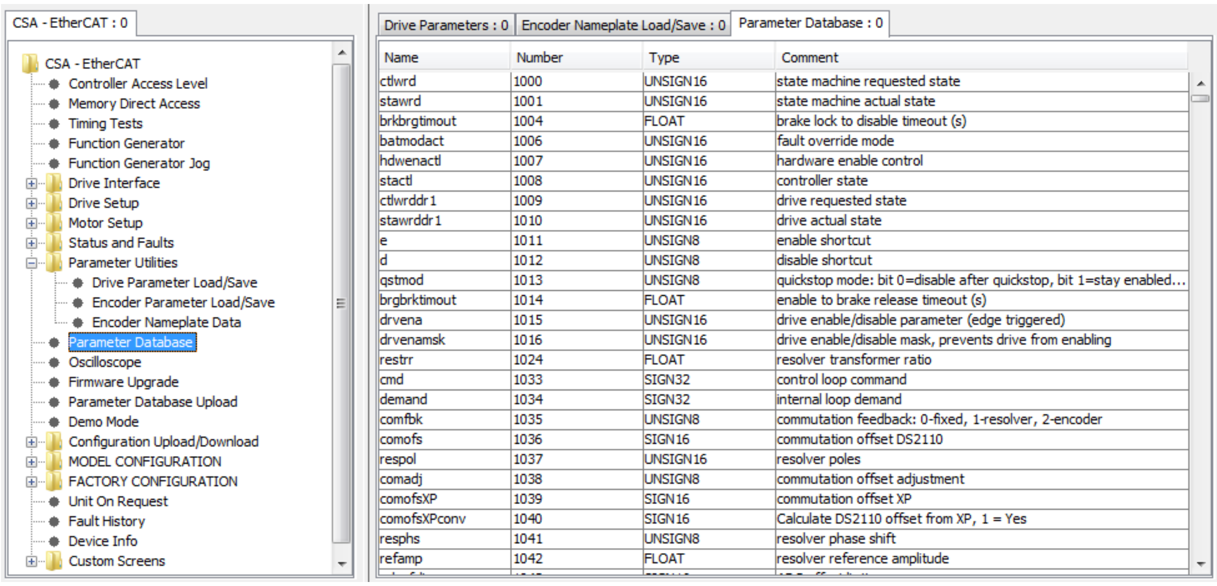


Section & Parameter	Description
CSA Encoder EEPROM Data Parameters Max Force (In Order)	
Encoder Supply Voltage	Options: +5V, +8V, +12V
Encoder Offset (incs)	Subtracted from the encoder raw position value at the designated home position for absolute movements
Encoder Actuator ID	The Actuator ID or S/N
Box Car (18 characters)	Used to identify the kind of actuator during commissioning
Commutation Type	Select the commutation type from: ✓ Angle Zero: the feedback angle for the rotor position is fixed at zero. This can be used to determine the phase angle between the rotor and the resolver or encoder. ✓ Resolver Feedback: the rotor angle is taken from the resolver commutation position. 16-bit full scale corresponds to one full mechanical revolution. ✓ Encoder Feedback: the commutation is done from the encoder commutation angle. 16-bit scale corresponds to one full mechanical revolution.
CSA Commutation Offset	The offset angle between the commutation feedback and the phase currents.
No. of Poles	The number of motor poles. It can be set from 2 to 36.
Terminal-Terminal resistance (Ohm)	The terminal-to-terminal resistance of the motor.
q-axis inductance (H)	The inductance value of q-axis.
d-axis inductance (H)	The inductance value of d-axis.
Ke	Motor Voltage Constant
Motor Max. Current (A)	The maximum continuous RMS current of the motor.
Max. Motor Speed	The maximum speed of the motor.

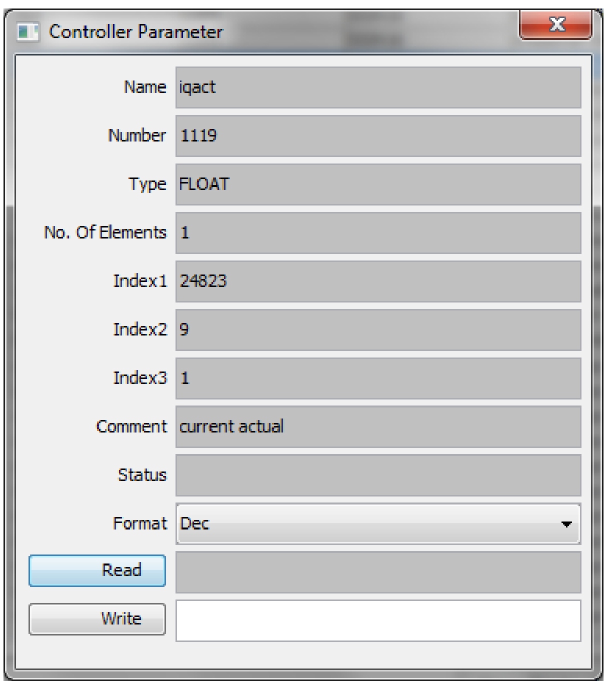
Section & Parameter	Description
(deg/s)	
Velocity Limit (rev/min)	Velocity Limit of the system in RPM
d-axis i-gain (Ki)	The i-gain of the d-axis compensator (Volts/Amp/Tsamp).
d-axis p-gain (Kp)	The p-gain of the d-axis compensator (Volts/Amp).
q-axis i-gain (Ki)	The i-gain of the q-axis compensator (Volts/Amp/Tsamp).
q-axis p-gain (Kp)	The p-gain of the q-axis compensator (Volts/Amp).
observer alpha comp. i-gain (Ki)	The i-gain of the observer alpha compensator (Volts/Amp/Tsamp).
observer alpha comp. p-gain (Kp)	The p-gain of the observer alpha compensator (Volts/Amp).
observer beta comp. i-gain (Ki)	The i-gain of the observer beta compensator (Volts/Amp/Tsamp).
observer beta comp. p-gain (Kp)	The p-gain of the observer beta compensator (Volts/Amp).
Motor Sensor Coefficient a0	Motor Temperature Sensor Polynomial coefficient
Motor Sensor Coefficient a1	Motor Temperature Sensor Polynomial coefficient
Motor Sensor Coefficient a2	Motor Temperature Sensor Polynomial coefficient
Motor Sensor Coefficient a3	Motor Temperature Sensor Polynomial coefficient
Thermal Limit Motor Start Temp (C)	Starting temperature of the Motor Thernal Sensor Profile
Thermal Limit Motor Span Temp (C)	The temperature Span of the Motor Thernm Sensor Profile
Max. Motor temp. (C)	The temperature at which an over-temperature fault is indicated
Start Motor temp. (C)	The temperature at which thermal limiting starts to act
Span Motor temp. (C)	The temperature range over which the current is reduced to 0.

B.3.11 Parameter Database

The Parameter Database Panel lists all parameters implemented in the software. Entry of parameters in to the database requires at minimum, application engineer access.

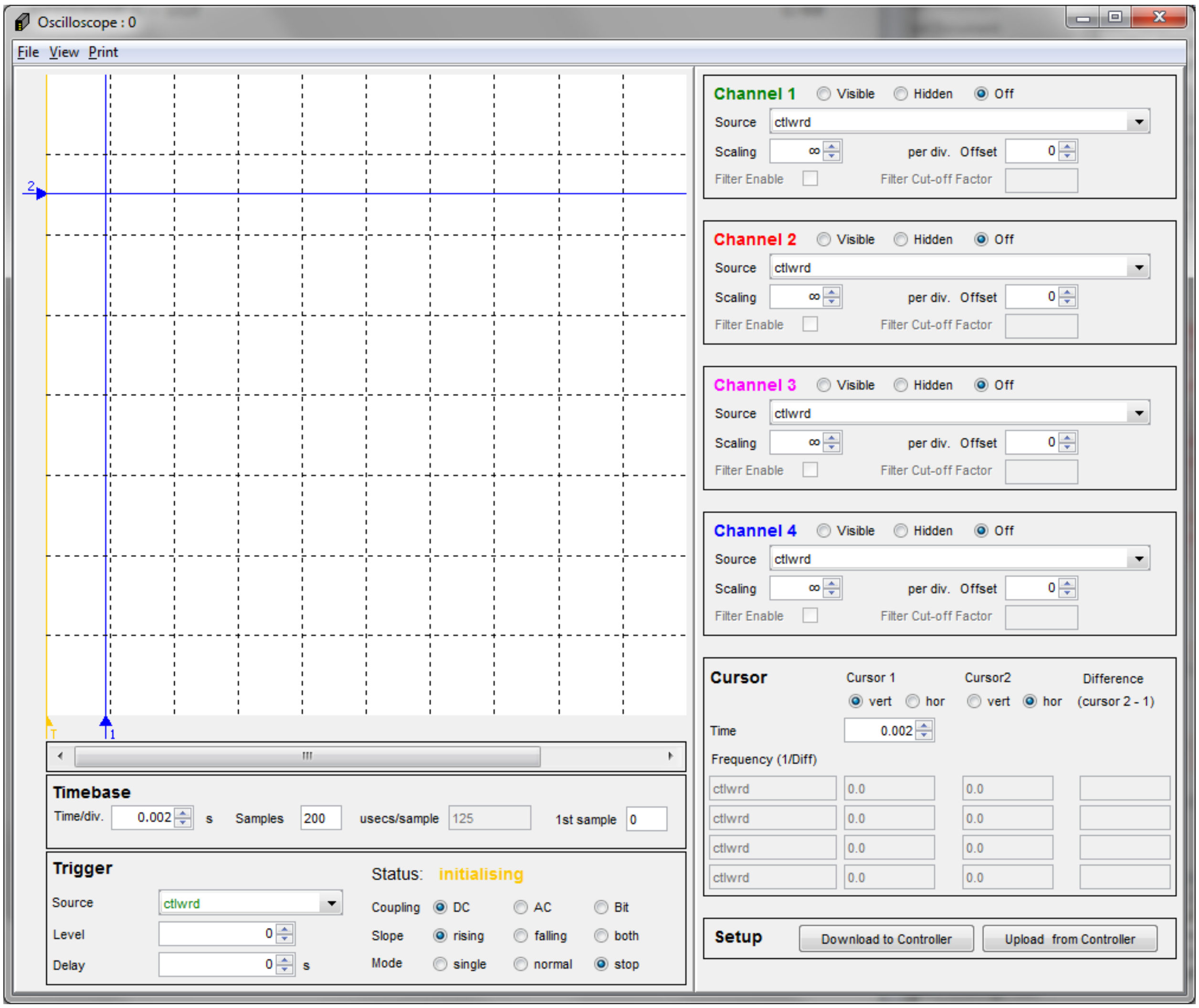


It is possible to sort the database in various ways by right-clicking on the database and selecting the required sort method. Alternatively, click on the Name, Number or Comment title to sort The 'sort by function' option will sort the displayed database in the same order as the master database, so the parameters are grouped together by functionality. A parameter is viewed by double-clicking the row. A dialog box is displayed allowing the User to Read or Write to the parameter.



B.3.12 Oscilloscope

The CSA configuration of WinDrive contains the above **Oscilloscope Panel**. The oscilloscope is an internal storage oscilloscope with up to four input channels, trigger function, and time base. It can be used to store fast events or to store information that caused fault conditions. Up to four input channels can be used to sample any of the controller's internal parameters. The trigger controls the sampling of the data synchronised to a trigger input, which can be any of the controller's internal parameters. It is possible to have a delayed trigger or a pre-trigger by entering a negative time value. The slope can be rising, falling, or both. The details of the Oscilloscope Panel are described in subsequent sections.



B.3.12.1 Display Area

This displays the traces, cursors, and trigger position. Traces are shown in their respective colours (i.e. green, red, pink, or blue). Cursors are shown in blue. The trigger position is shown in orange. At the bottom of the display area there is a horizontal scroll bar, which allows left and right scrolling when the number of samples taken exceeds that at which the trace can be fully displayed in the display with the current settings.

B.3.12.2 Timebase Panel

Time/div.: Sets the time represented by each horizontal division in the display area.
Samples: Sets the number of samples taken before the plot is wrapped around to the beginning. When this occurs, the existing plot is erased. This value can be set to a large number if longer continuous plots are required.

- *usecs/sample*: Displays the sample time in usecs

- *1st sample*: This represents the horizontal offset of the display area with respect to the complete plot. Changing this value has the same effect as moving the timebase scrollbar.

B.3.12.3 Channel Panels

- *Status*: Sets the channel to visible, hidden, or off.
- *Source*: Represents which parameter is logged.
- *Scaling*: Represents the vertical scaling for this channel.
- *Offset*: Represents the vertical offset for this channel.
- *Filter Enable*: Represents signal filtering if supported by the application database, otherwise greyed-out
- *Filter Cut-off Factor*: Represents signal filtering cut-off factor if supported by the application database, otherwise greyed-out

B.3.12.4 Cursor Panel

This section supports 2 cursors to measure on the vertical axis, horizontal axis or a combination of both. Also automatically displays the difference between the cursors in time and frequency.

B.3.12.4.1 Trigger Panel

- *Status*: Displays the current status of the oscilloscope. This can be one of the following:
  - Initialising: The oscilloscope is in the initialization state, waiting for the trigger mode to be set.
  - Stopped: The oscilloscope is currently not logging any data, or has just completed logging data.
  - Waiting: The oscilloscope is currently waiting for the trigger to fire.
  - Sampling: The oscilloscope is currently sampling.
- *Source*: Represents the parameter which is used for triggering.
- *Level*: The value at which the trigger will fire.
- *Delay*: Allows setting of trigger delay or pre-trigger (a negative value).
- *Coupling*: Coupling can be DC, AC, or Bit (a mask on the Source).
- *Slope*: Determines whether to trigger on a rising or falling slope.
- *Mode*: Can be set by the user. This can be one of the following:
  - Continuous: The oscilloscope will sample from firing of trigger continuously.
  - Single: The oscilloscope will sample from firing of trigger for number of samples.
  - Roll: The oscilloscope will sample continuously (ignoring trigger settings).
  - Stop: The oscilloscope will stop sampling.

B.3.12.4.2 Setup Panel

This section supports two buttons:

- ***Download to controller:*** This button allows for a complete download of all scope/datalogger parameters from the PC to the controller. This will allow for re-configuration of the datalogger, in cases where the controller has power-cycled, or a Comms error may have occurred, and not all params are written.
- ***Upload from controller:*** This button allows for a complete upload of all the scope/datalogger parameter from the controller to the PC. This will allow for re-configuration of the scope, in cases where Windrive may have closed, or a Comms error may have occurred. This operation automatically happens when the scope is opened.

B.3.12.4.3 File Menu

This section supports the following options:

- "*Save…"* writes the current scope picture & scope settings to a .scp file.
- "Load*…"* reads the current scope picture & scope settings from a .scp file.
- "*Load and Download to Controller…*" reads the scope file (.scp), updates the scope picture & settings and writes the settings to the drive. This option makes the scope files much more useful as ways of saving/restoring the current scope/datalogger setup, rather than just displaying the trace.
- *"Export Data (dlgdat)…"* exports a scaled representation of the data into a Comma Separated Value (CSV) file suitable for viewing in Microsoft Excel. Generally not recommended if the data ranges exceed values of +/- 256.
- *"Export Data (dlgmem)…"* exports the data, unaltered into a Comma Separated Value (CSV) file suitable for viewing in Microsoft Excel.

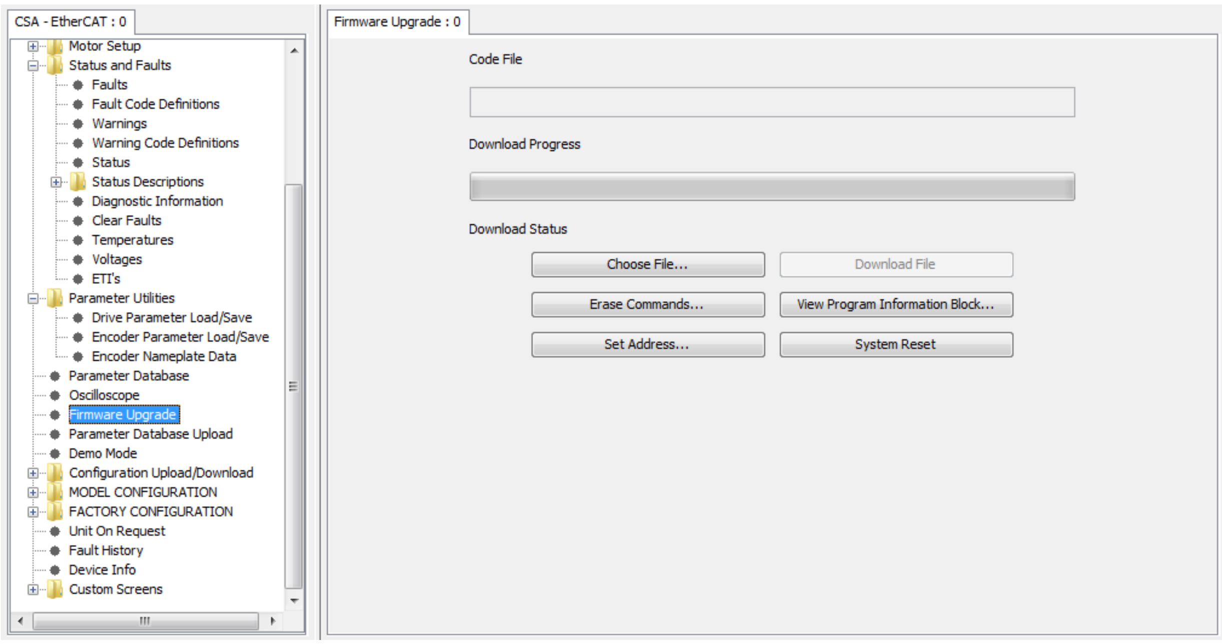
B.3.12.4.4 View Menu

This section supports the following options:

- *List All Parameters**:*** CheckBox Menu Item to list All Parameters in the option to Source Combo-Box for Channel & Trigger. Or alternatively list only signals in these combo-boxes. (Signals are determined as Not saved to NVM, and Number of Element = 1).
- *List By Parameter Name:* CheckBox Menu Item to display parameters in the Source Combo-Box for Channel & Trigger, by Parameter Name. Or alternatively to display the parameters using the Description/Comment Field.

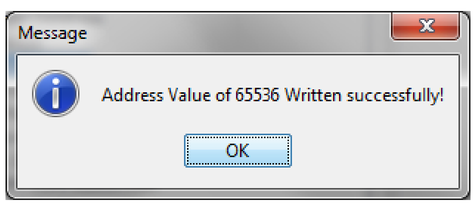
B.3.13 Firmware Upgrade

The Firmware Upgrade Panel provides access to functions that reside in the bootloader for the drive software. Therefore, all of these functions will cause the drive to shut down and reset.

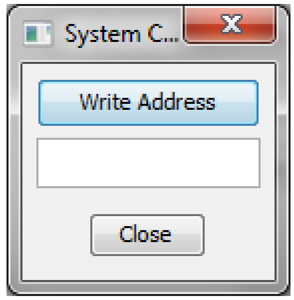


. The options are as follows:

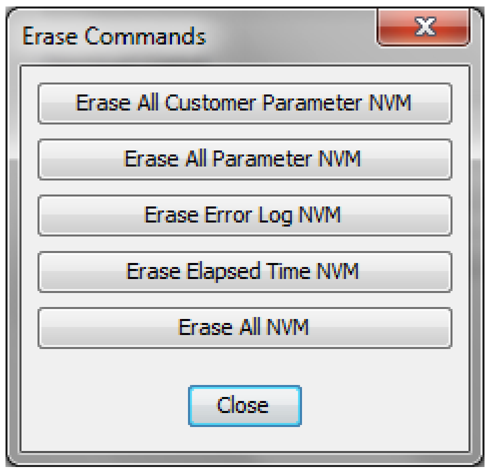
- The '*Choose File…*' button is used to browse for a program file. By default it recognizes program files with the extension of "*.pgm". Additionally, files of the form "*mtn*.pgm", "*mtn_x*.pgm", "*mtnmdl*.pgm", "*mtnmdl_x*.pgm", and "*fpg*.pgm" will automatically have their load addresses set; the "Set Address…" button is not required. An example of the Auto-Address pop-up for "mtnect.pgm", which matches the pattern "*mtn*.pgm" is shown below. Note that the value will be different for the various programs.



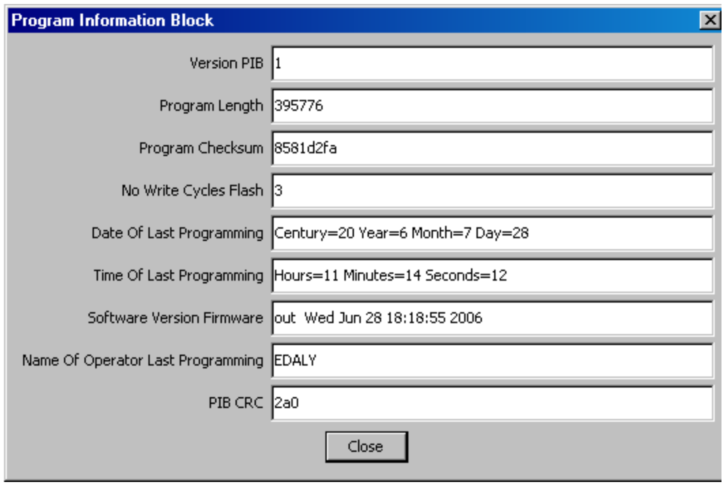
- The "*Set Address…*" button is used if any program with a non-conventional filename is chosen. To complete the action, the *"Write Address"* button must be used. The pop-up is shown below:



- The '*Download File*' button is used to download the program file to the drive.
- The '*Erase Commands*' button provides some NVM erase functions.
- The '*System Reset*' button restarts the drive software.

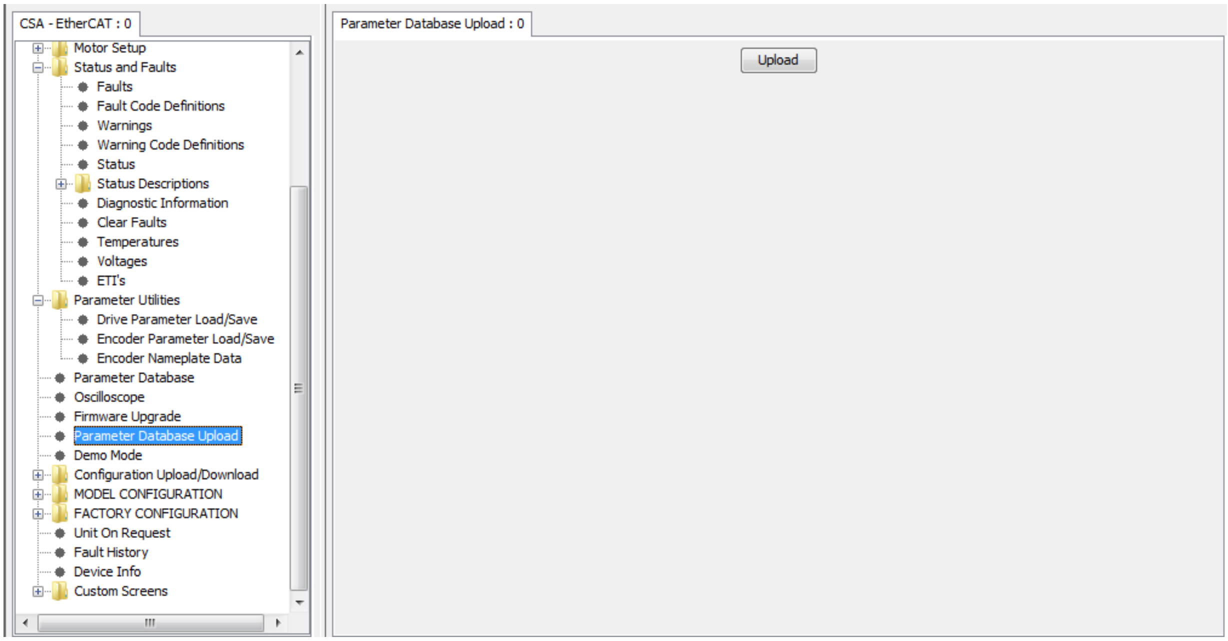


The view program information block is used to view information that was recorded in flash memory when the application firmware was last programmed.



B.3.14 Parameter Database Upload

The Parameter Database Upload Panel used in the GUI is synchronised with the embedded version by uploading the database information from the drive. This upload function is used to ensure that the database held by the GUI is consistent with the database in the drive.



B.3.15 Demo Mode

The Demo Mode Panel is used to review the WinDrive panels without a Drive and turns off serial communication to avoid communication faults.

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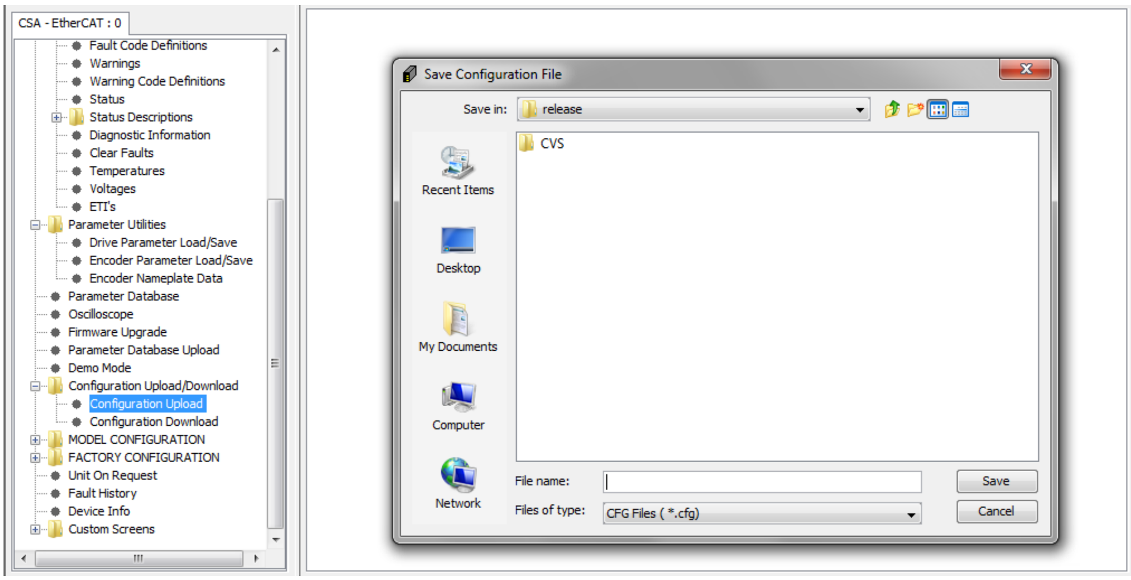
B.3.16 Configuration Upload/Download

B.3.16.1 Configuration Upload

The Save Configuration File Dialog is used to read configuration information from the drive to the PC.



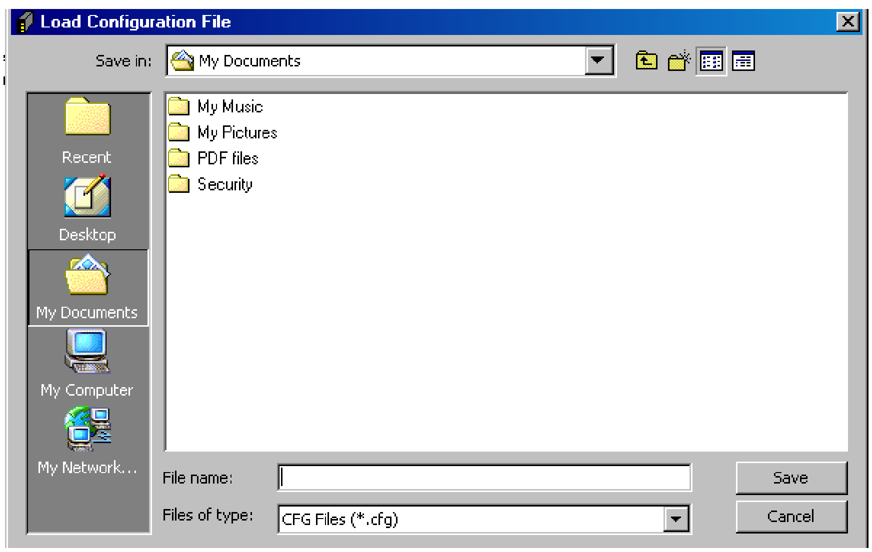
This function is used to upload the values for all of the configuration parameters so that the configuration can be re-used without having to repeat a long set-up procedure. Once the location for the configuration file and filename are selected, click Save. Allow enough time for the full configuration upload to occur. When completed the following message appears:

B.3.16.2 Configuration Download

The Load Configuration Dialog is used to download a configuration (write to the drive) that has previously been uploaded with the configuration upload function.

Note: For safety reasons the drive must be disabled when downloading a new configuration file and a warning message will appear explaining this.

If the drive is enabled it will automatically be disabled if you select Yes.



Browse to the location where the appropriate configuration file is stored, select it and press Save.

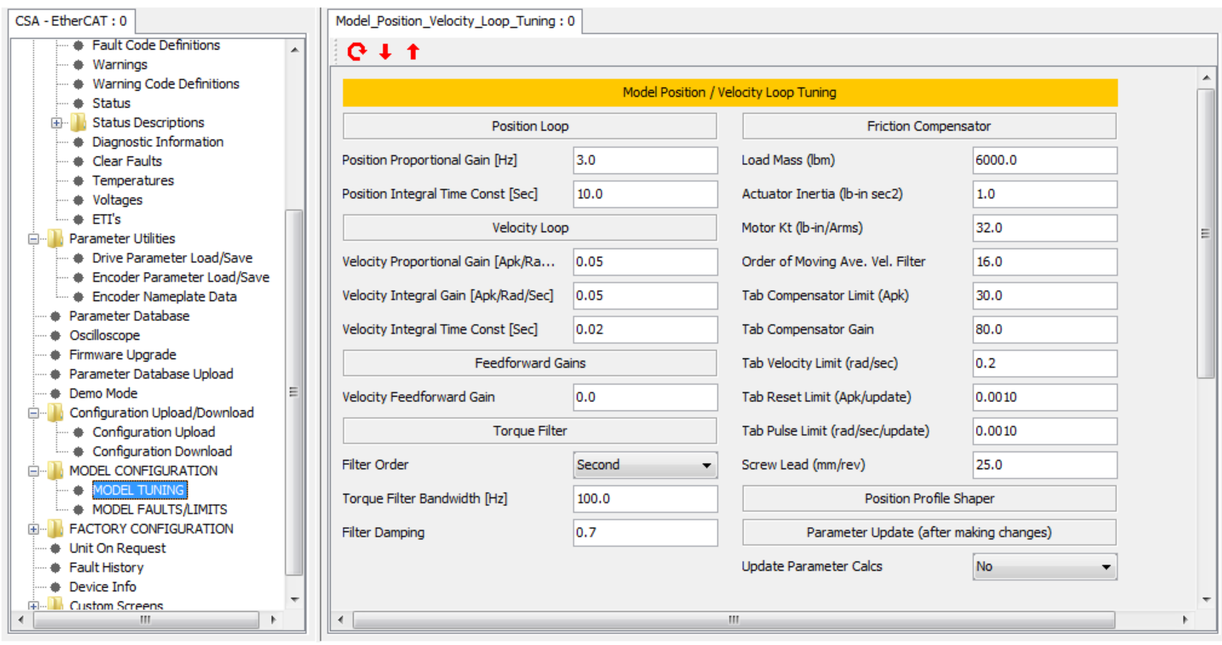
Allow enough time for the download to occur (can be viewed in the Even Logger) and a confirmation message appears

B.3.17 Model Configuration

B.3.17.1 CSA - EtherCAT Configuration

B.3.17.1.1 Model Tuning

The Model_Position_Velocity_Loop_Tuning Panel is used to configure the Model Position and Velocity Loop Tuning parameters. Any changes to the parameters require the User to execute the Update Parameter Calcs to recalculate model scaling parameters.

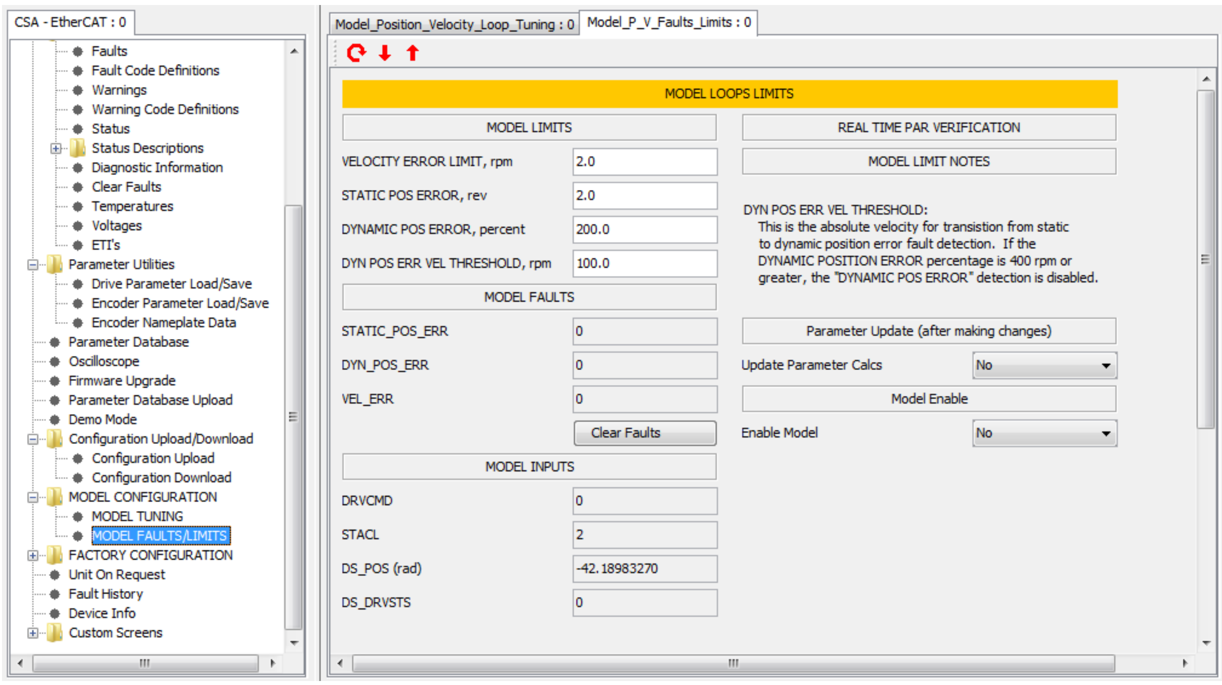


Section & Parameter	Description
Position Loop	
Position Proportional Gain (Hz)	The p-gain of the model position loop
Position Integral Time Const (Sec)	The i-gain of the model position loop
Velocity Loop	
Velocity Proportional Gain (Apk/Rad)	The p-gain of the model velocity loop
Velocity Integral Gain (Apk/Rad/sec)	The i-gain of the model velocity loop
Velocity Integral Time Const (Sec)	The integration period over which the i-gain is applied
Feedforward Gains	
Velocity Feedforward Gain	The gain applied to the feedforward velocity
Torque Filter	
Filter Order	Options: First or Second Order
Torque Filter Bandwidth (Hz)	Defines the torque filter bandwidth
Fitler Damping	Scalar applied to the model torque filter for smoothing the torque ripple
Friction Compensator	
Load Mass (lbM)	The systems load mass
Actuator Inertia (lb-in sec^2)	Actuator Inertia used

Section & Parameter	Description
Motor Kt (lb-in/Arms)	Motor torque constant
Order of Moving Ave. Vel Filter	Number of samples in the moving window filter
Tab Compensator Limit (Apk)	The upper limit of the Tab compensation, aftter which the Tab Compensator Output is clipped or clamped
Tab Compensator Gain	The Gain applied to the Tab Compensator Output
Tab Velocity Limit (rad/sec)	The velocity below which the Tab Compensator is active
Tab Reset Limit (Apk/update)	The limit after which the Tab integrator is reset
Tab Pulse Limit (rad/sec/update)	Pulse width of the Tab Compensation Current
Screw Lead (mm/rev)	Screw lead where 1 motor rotation results in a linear actuation distance
Position Profile Shaper	
Not defined or needed for this application	N/A
Parameter Update	
Update Parameter Calcs	If any parameters are changed, the internal parameters of the model must be recalculated, with the drive disabled, before taking affect. This is a one-shot option.

B.3.17.1.2 Model Faults/limits

The Model_P_V_Faults_Limits Panel is used to configure the Model Loop Limits and review current faults and model inputs.

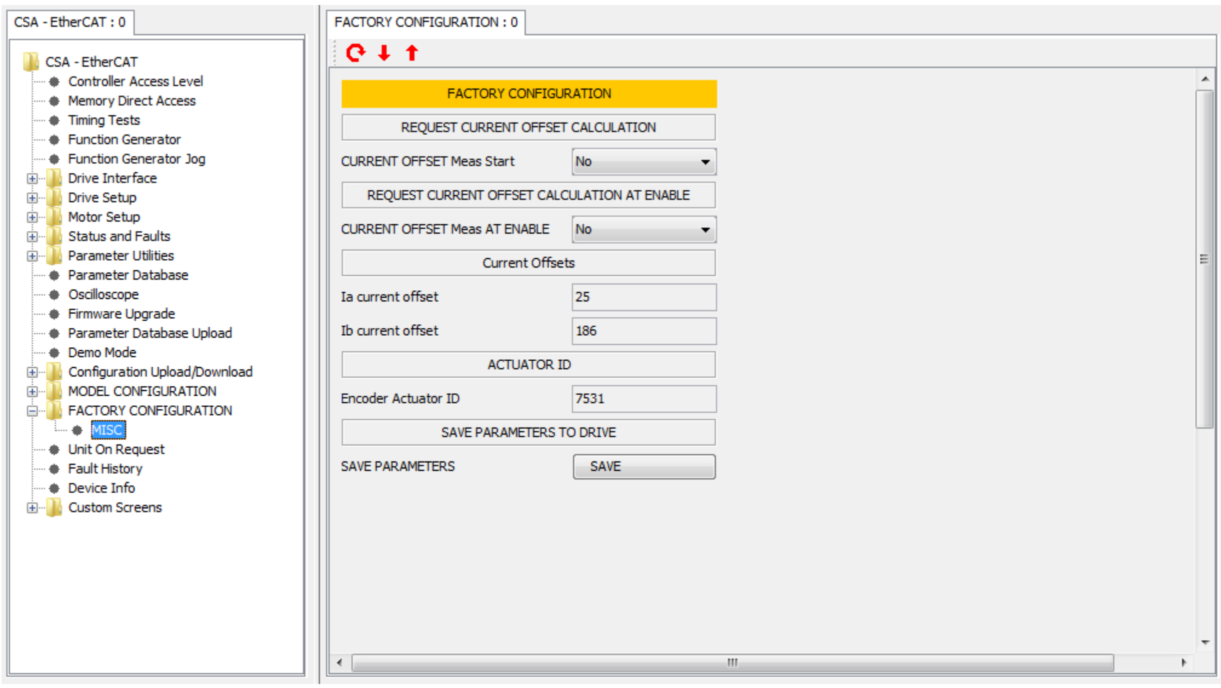


Section & Parameter	Description
MODEL LIMITS	
VELOCITY ERROR LIMIT, rpm	The velocity error limit for the model motion fault checking
STATIC POS ERROR, rev	The position error used in the determination of a static position fault.
DYNAMIC POS ERROR, percent	The percentage of position error allowed in a dynamic condition
DYN POS ERR VEL THRESHOLD, rpm	The Velocity threshold over which a dynamic versus a static position error is determined.
MODEL FAULTS	
STATIC_POS_ERR	Static Position Error indication, 0 = False, 1 = True
DYN_POS_ERR	Dynamic Position Error indication, 0 = False, 1 = True
VEL_ERR	Velocity Error indication, 0 = False, 1 = True
MODEL INPUTS	
DRVCMD (A)	The Position or Velocity Command, an input to the Model Control Loops
STACTL	Controller Status used by the Model to determine the drive state such as Disabled, Enabled or Faulted.
DS_POS (rad)	Feedback Position
DS_DRVSTS	Drive Status used to determine if the drive is enabled and the brake applied status.
REAL TIME PAR VERIFICATION	
Not defined or needed for this application	NA
Parameter Update	
Update Parameter Calcs	Options: No or Yes (one-shot)
Model Enable	
Enable Model	Options: No or Yes

B.3.18 Factory Configuration

B.3.18.1 CSA - EtherCAT Configuration

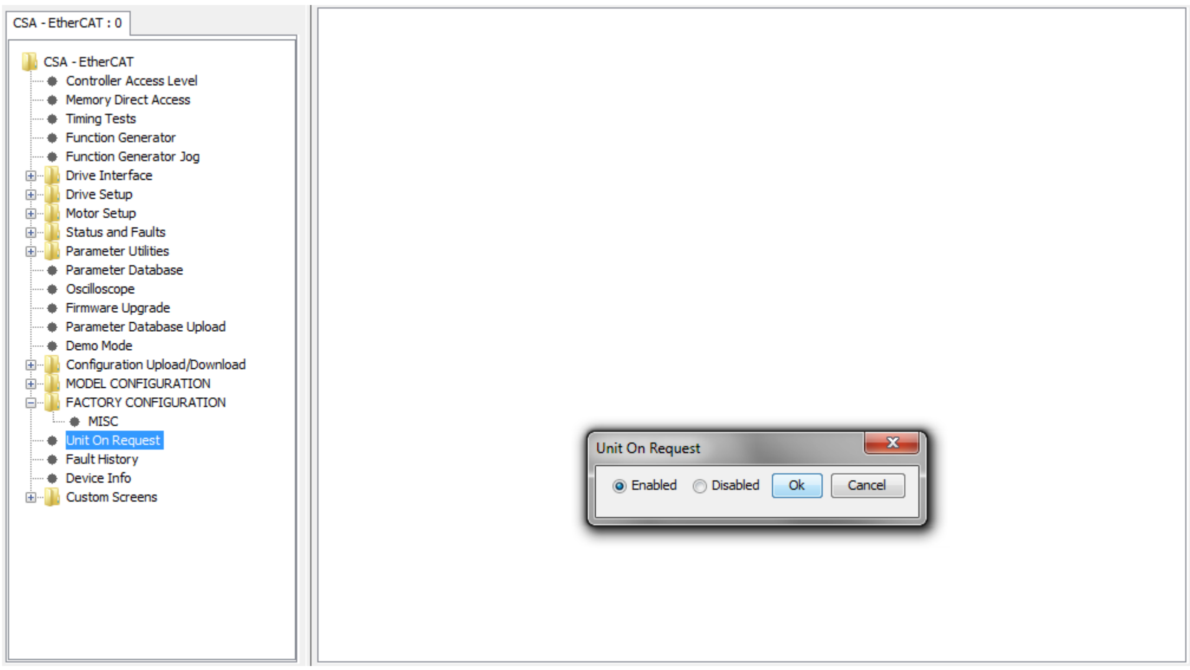
This panel is used to change Factory Configuration of the Current Offsets and when they are calculated.



Section & Parameter	Description
REQUEST CURRENT OFFSET CALCULATION	
CURRENT OFFSET Meas Start	Options: No or Yes. If 'Yes' the current offsets are calculated one time on-demand.
REQUEST CURRENT OFFSET CALCULATION AT ENABLE	
CURRENT OFFSET Meas At Enable	Options: No or Yes. If 'Yes' the current offsets are calculated at the time the drive is enabled.
Current Offsets	
Ia current offset	The present value of the Ia current offset, either calculated or restored from NVM.
Ib current offset	The present value of the Ib current offset, either calculated or restored from NVM.
ACTUATOR ID	
Encoder Actuator ID	Used at commissioning to modify the ID
SAVE PARAMETERS TO DRIVE	
SAVE PARAMETERS	Saves the parameters to the Drive NVM

B.3.19 Unit On Request

This panel is used to select the option of converting parameters from internal units to User units. This option is enabled by default.



The following table describes all parameters which are part of this feature, and would also be logged in Ocsilloscope traces.

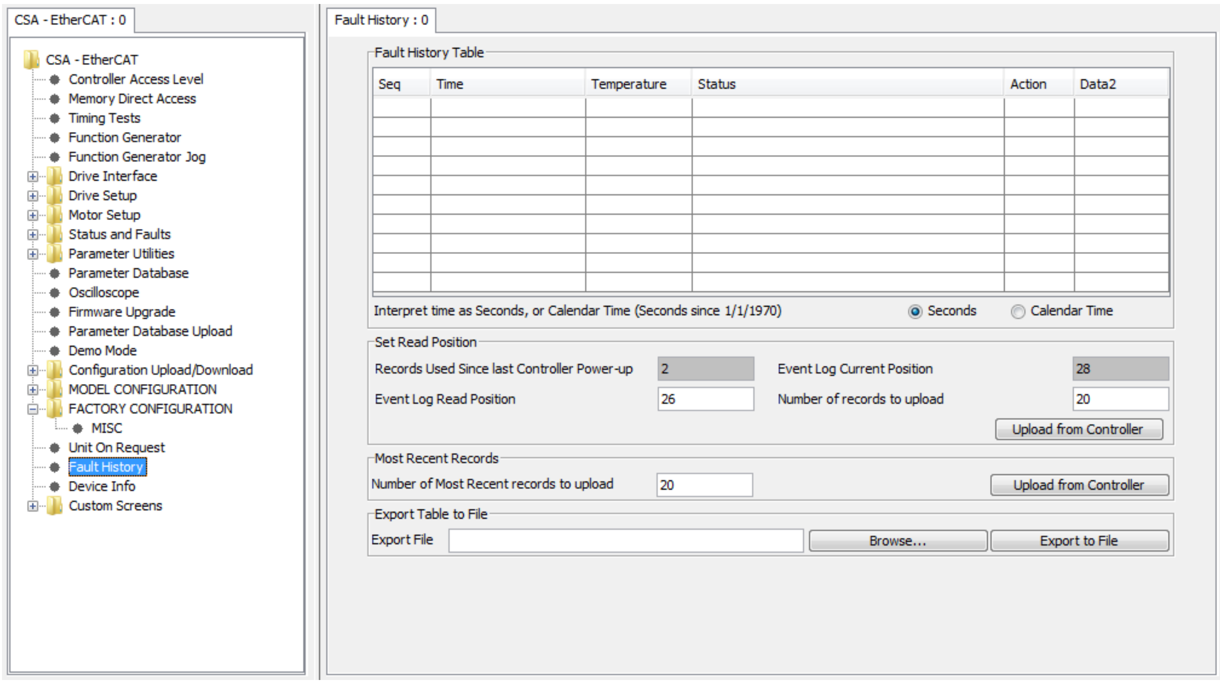
Parameter Name	**Parameter Number**	**Internal Units** ('Unit on Request' is Disabled)	**WinDrive Units** ('Unit on Request' is Enabled)
Motor Velocities			
motor_velocity_actual	1152	radians/Tsample/velocity feedback resolution (p4121)	RPM
motor_velocity_filtered	1163		
Velocity			
velocity	1151	radians/Tsample/velocity feedback resolution (p4121)	RPM
velocity_command	1156		
velocity_command_acceleration_limited	1157		
velocity_feedforward	1158		
velocity_filtered	1165		
velocity_mode_error	1320		
position_mode_velocity_loop_error	1307		

Parameter Name	Parameter Number	Internal Units ('Unit on Request' is Disabled)	WinDrive Units ('Unit on Request' is Enabled)
Position Range and Limits			
position_actual	1154	radians/position feedback resolution	radians
position_PI_loop_error	1328		
position_TO_loop__error	1337		
position_range_min_internal	1646		
position_range_max_internal	1647		
position_range_internal	1648		
position_limit_min_internal	4153		
position_limit_max_internal	4154		
Controller Igain			
current_loop_d-axis_i-gain	1272	V/A/Tsample	V/A/sec
current_loop_q-axis_i-gain	1277		
current_loop_alpha_observer_i-gain	1288		
current_loop_beta_observer_i-gain	1293		
Function Generator Amplitude, Offset and Output			
Postion Mode			
function_generator_amplitude	2002	radians * 10 ^|posexp| (unless the units are increments which has a scalar of the position feedback resolution in increments/rev)	increments meters radians seconds minutes degrees revs
function_generator_offset	2003		
function_generator_output	2006		
function_generator_amplitude_preset	2008		
function_generator_offset_preset	2009		
Function Generator Amplitude, Offset and Output			
Velocity Mode			
function_generator_amplitude	2002	radians/sec * 10 ^|velexp| (Unless the units are increments/Tsample or Increments/sec where the value is normalized to p1800 velocity_max and scaled by 2^31-1),	incr/Tsample incr/second m/sec m/min m/hour rev/sec rev/min rev/hour
function_generator_offset	2003		
function_generator_output	2006		
function_generator_amplitude_preset	2008		
function_generator_offset_preset	2009		

Parameter Name	Parameter Number	Internal Units ('Unit on Request' is Disabled)	WinDrive Units ('Unit on Request' is Enabled)
Function Generator Amplitude, Offset and Output			
Torque Mode			
function_generator_amplitude	2002	amps * 10 ^|trqexp| (Unless the units are Increments where the value is normalized to p1093 current max and scaled by 2^31-1, or uNm)	increments uNm Nm Amps
function_generator_offset	2003		
function_generator_output	2006		
function_generator_amplitude preset	2008		
function_generator_offset_preset	2009		
Demand and Cmd			
control_loop_command	1033	Torque Mode: Normalized to p1093 current max and scaled by 2^31 -1. Velocity Mode: Normalized to p1800 velocity max and scaled by 2^31 -1. Position Mode: radians * position feedback resolution in increments/rev	Amps
internal_loop_demand	1034		
Function Generator Period & Output Update Period			
function_generator_period	2005	Tsample	seconds
function_generator_output_period	2007		
function_generator_period_preset	2011		
function_generator_output_update_period_preset	2012		
Filter_Cutoff_Frequencies			
motor_velocity_filter_cutoff factor	1162	Tsample	Hertz
velocity_filter_cutoff_factor	1164		

B.3.20 Fault History

The Fault History Panel is used to examine the internal event log of the drive.

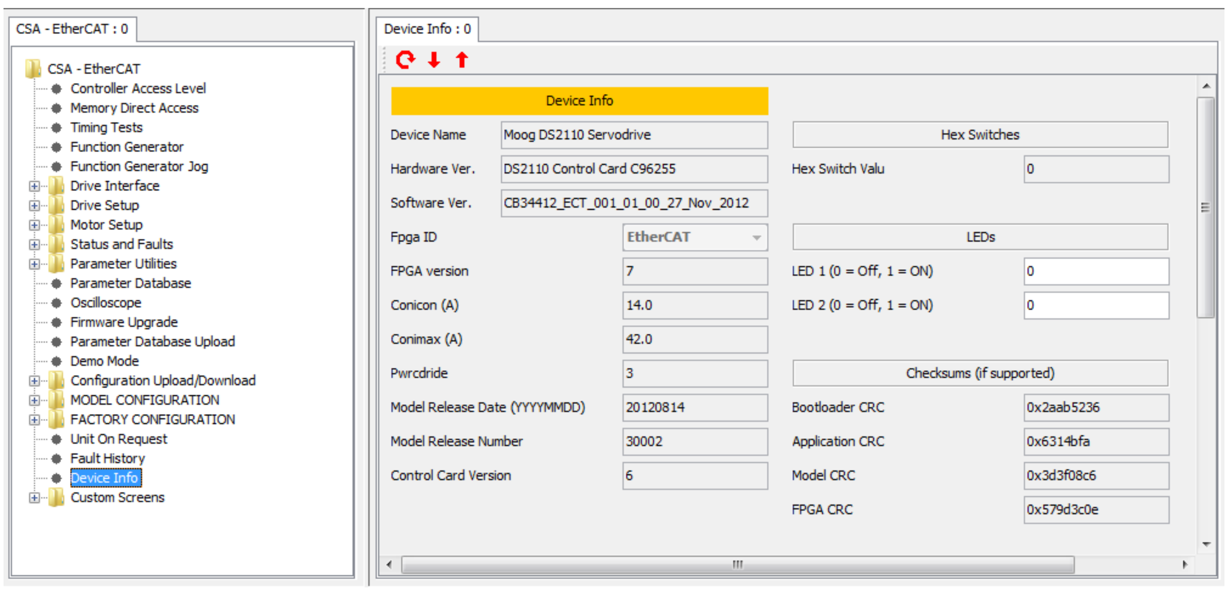


Section & Parameter	Description
Fault History Table	
Time	This is the time recorded from the drive total elapsed time indicator when the event occurred. The time is in seconds and is the total amount of time for which the drive has been powered up until the event occurred. The Time column can be displayed as either '*Seconds*' or '*Calendar Time*'.
Temperature	The ambient temperature at which the event occurred
Status	A description of the event logged
Action	Whether the event was set or cleared
Data2	Diagnostic data for Moog Personnel
Set Read Position	
Records Used Since last Controller Power-up	Lists the number of entries made in the Fault History since the drive was powered on or reset.
Event Log Read Position	Typically set less than the current position
Event Log Current Position	The next record to be written
Number of records to display	Specifies the records to be uploaded
Upload from Controller	Reads the records and displays them.
Most Recent Records	
Number of Most Recent records to display	Specifies the number of recent records to be read, defaults to 20.
Upload from Controller	Reads the records and displays them.
Export Table to File	
Browse…	Selects an output file for the Excel compatible Comma-Separated-Variable (CSV) format.
Export to File	Writes the uploaded records to the file.

B.3.21 Device Info

B.3.21.1 CSA - EtherCAT Configuration

The Device Info Panel displays useful information to identify Version information for the Application Firmware, FPGA Firmware, and Model Firmware along with the Power Stage information. The Checksums will be displayed if they are supported in the Application database.

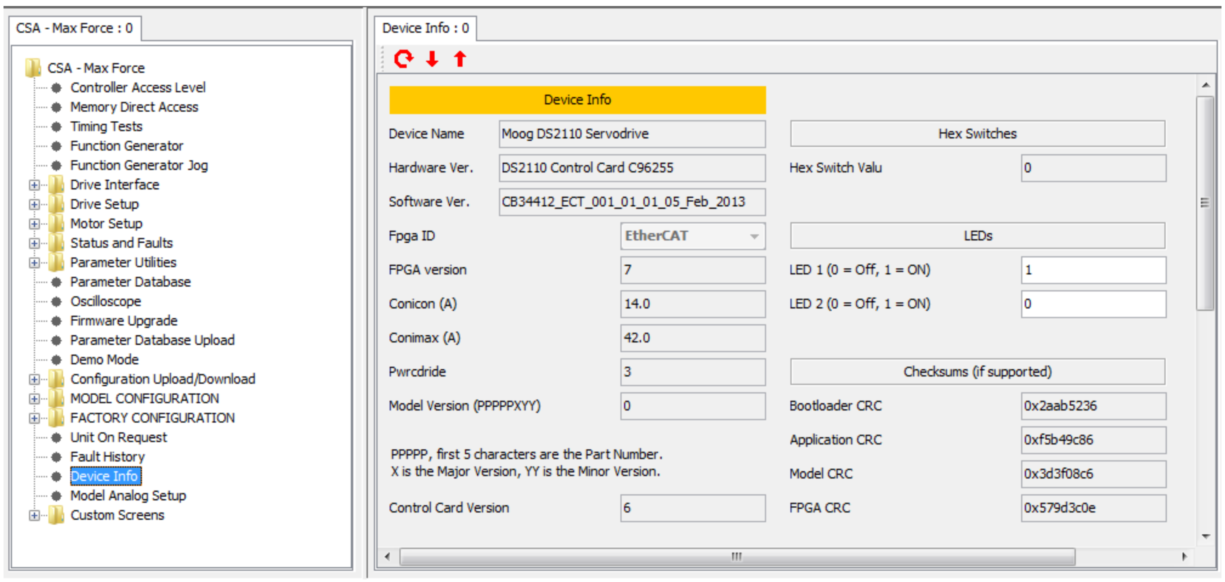


Section & Parameter	Description
Device Name	The type of drive
Hardware Ver.	The control head assembly
Software Ver.	The Software Version number of the application currently loaded and running in the drive. The software version is expressed in the format: **CX12345-FBS-XXX-YY-ZZ-DD-MMM-YYYY** Where: CA12345 is the part number FBS is the Fieldbus (ECT is EtherCAT) XXX is the major version number YY is the minor version number ZZ is the patch release number DD is the day of the month MMM is the month abbreviation YYYY is the year
Fpga ID	The ID for the FPGA can be: EtherCAT, SERCOS or Firewire
FPGA version	The version of the FPGA source
Conicon (A)	The Continious Current rating of the Power Stage
Conimax (A)	The Maximum Current rating of the Power Stage
Pwrcdride	The Power Stage ID used to access the Power Table in the application
Model Release Date (YYYYMMDD)	Model Release Date
Model Release Number	Model Release Number, having a format of Mmmpp where ‘M’ is the major

Section & Parameter	Description
	release number, 'mm' is the minor release number, and 'pp' is the patch release number
Control Card Version	The version number of the Control Card. The initial CSA version is 6.
Hex Switches	
Hex Switch Valu	The Hexidecimal value of the ID switches, the first number is the value of Switch ID1, the second number is the value of ID2, where the values are from 0 to F, which is decimal 0 to 15. If only 1 number is shown, then ID1 is 0 and the digit shown is that of ID2.
LEDs	
LED 1 (0 = Off, 1 = ON)	A value of 1 being ON indicates the drive has latched a fault
LED 2 (0 = Off, 1 = ON)	A changing value from 0 to 1 indicates the Model is running. If the value is 0, the Model is not running.
Checksums (if supported)	
Bootloader CRC	Values vary with the version of the program loaded. Not all applications have this feature implemented in the database. If it is not implemented, the section will be blank.
Application CRC	
Model CRC	
FPGA CRC	

B.3.21.2 CSA - MaxForce and CSA - MCG LP SSI Configurations

The Device Info Panel displays useful information to identify Version information for the Application Firmware, FPGA Firmware, and Model Firmware along with the Power Stage information. The panel is the same for both configurations, “CSA - MaxForce” and “CSA - MCG LP SSI”.

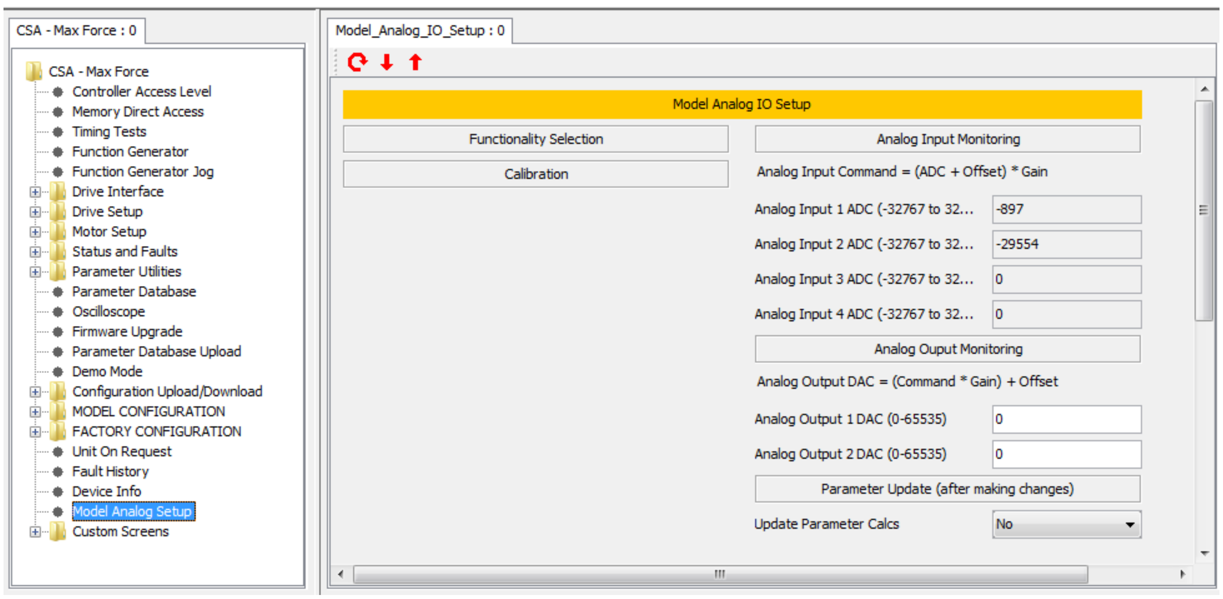


Section & Parameter	Description
Device Name	The type of drive
Hardware Ver.	The control head assembly
Software Ver.	The Software Version number of the application currently loaded and running in the drive. The software version is expressed in the format: **CX12345-FBS-XXX-YY-ZZ-DD-MMM-YYYY** Where: CA12345 is the part number FBS is the Fieldbus if any: DeviceNET is DNT, None is omitted XXX is the major version number YY is the minor version number ZZ is the patch release number DD is the day of the month MMM is the month abbreviation YYYY is the year
Fpga ID	The ID for the FPGA can be: Analog, DeviceNET
FPGA version	The version of the FPGA source
Conicon (A)	The Continious Current rating of the Power Stage
Conimax (A)	The Maximum Current rating of the Power Stage
Pwrcdride	The Power Stage ID used to access the Power Table in the application
Control Card Version	The version number of the Control Card. The initial CSA version is 6.

Section & Parameter	Description
Model Version (PPPPPXYY)	Model Version having a format of PPPPPXYY, where PPPPP is the P/N, X is the Major Version and YY is the Minor Version
Hex Switches	
Hex Switch Valu	The Hexidecimal value of the ID switches, the first number is the value of Switch ID1, the second number is the value of ID2, where the values are from 0 to F, which is decimal 0 to 15. If only 1 number is shown, then ID1 is 0 and the digit shown is that of ID2.
LEDs	
LED 1 (0 = Off, 1 = ON)	A value of 1 being ON indicates the drive has latched a fault
LED 2 (0 = Off, 1 = ON)	A changing value from 0 to 1 indicates the Model is running. If the value is 0, the Model is not running.
Checksums (if supported)	
Bootloader CRC	Values vary with the version of the program loaded. Not all applications have this feature implemented in the database. If it is not implemented, the section will be blank.
Application CRC	
Model CRC	
FPGA CRC	

B.3.22 Model Analog Setup

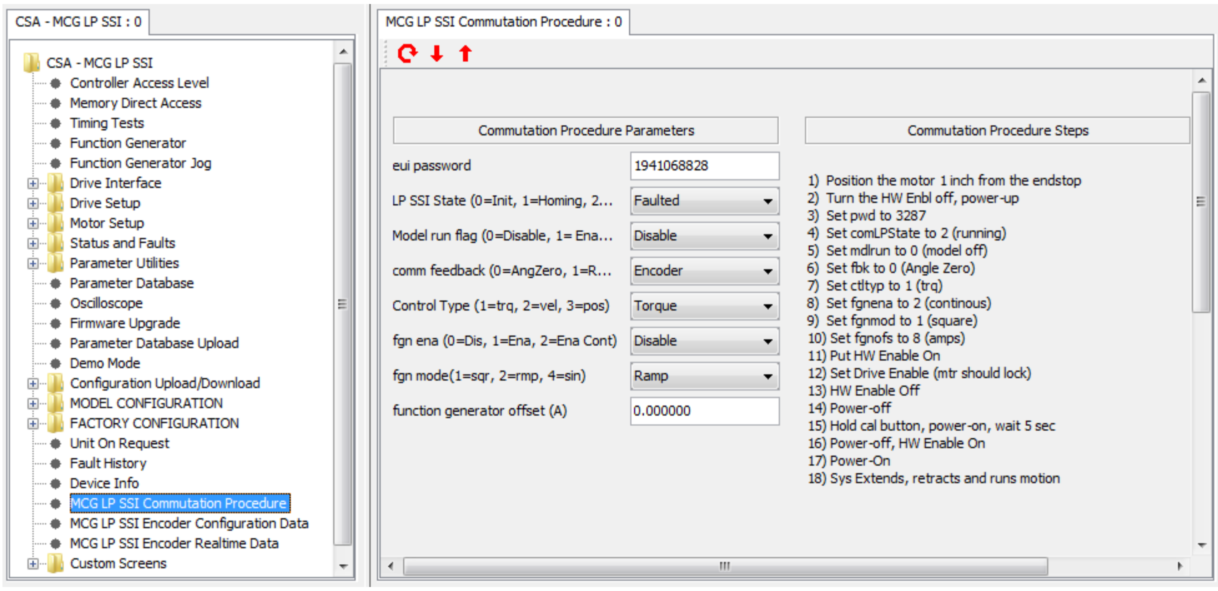
The Model_Analog_IO_Setup Panel supports the display of current Analog inputs and their scaling if an associated Analog Mezzanine Card is used. The Functionality Selection and Calibration sections are supported in select version of the Simulink model and may or may not be present in the Model Database. The panel is the same for both configurations, “CSA - MaxForce” and “CSA - MCG LP SSI”.



Section & Parameter	Description
Functionality Selection	
Supported as necessary by application specific models.	NA
Calibration	
Supported as necessary by application specific models.	NA
Analog Input Monitoring	
Analog Input 1 ADC	The Analog to Digital Conversion of the input, which is +/- 10 Volts corresponds to the range of -32768 to 32767.
Analog Input 2 ADC	
Analog Input 3 ADC	A second set of Analog Inputs is supported on certain Analog Mezzanine Cards.
Analog Input 4 ADC	
Analog Output Monitoring	
Analog Output 1 DAC	The Analog Outputs correspond to a range of 0-65535 which is +/- 10 Volts.
Analog Output 2 DAC	
Parameter Update	
Update Parameter Calcs	If any parameters are changed, the internal parameters of the model must be recalculated, with the drive disabled, before taking affect.

B.3.23 MCG LP SSI Commutation Procedure (CSA - MCG LP SSI)

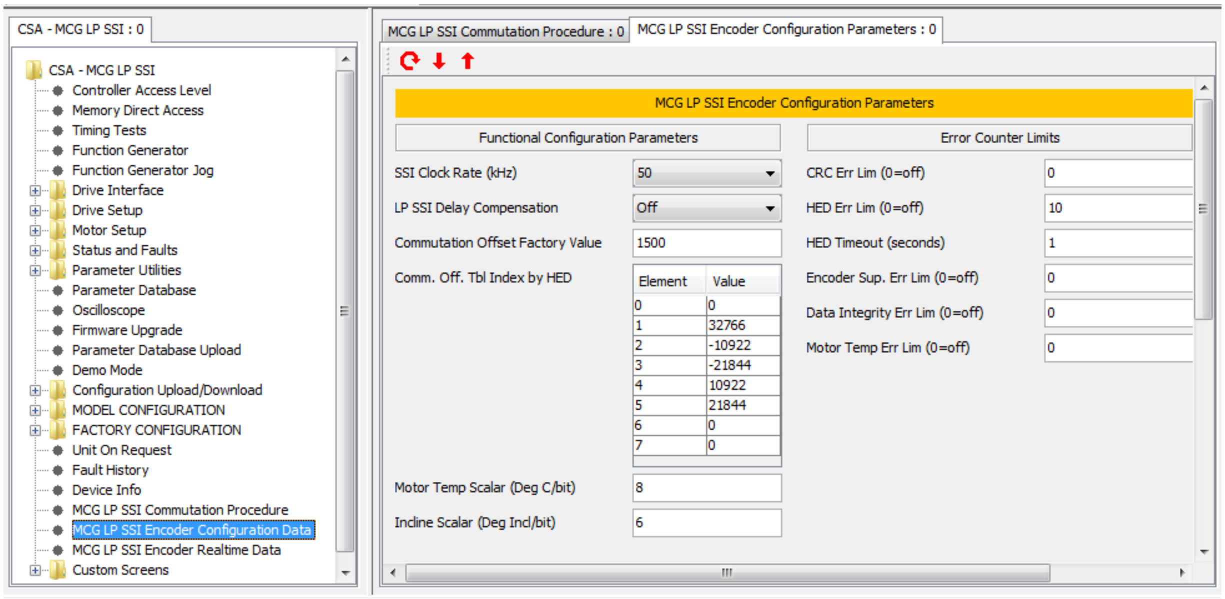
The MCG LP SSI Commutation Procedure Panel is used to support the factory determination of the commutation offset angle.



Section & Parameter	Description
eui password	Consult Moog Application Engineering as this procedure should only be performed at the Factory and requires a higher level of access.
LP State	Options: Init, Homing, Running, Faulted
Model run flag	Options: Disable, Enable
comm feedback	Options: Angle Zero, Resolver, Encoder
Control Type	Options: Torque, Velocity, Position
fgn ena	Options: Disable, Enable 1 shot, Enable Continious
fgn mode	Options: Square, Ramp or Sine Wave
function generator offset(A)	Function Generator Offset in Amps, note that only Torque mode is used for the Commutation Process.
Commutation Procedure Steps	
N/A	Follow the steps in the procedure to perform the Commutation Offset determination.

B.3.24 MCG LP SSIEncoder Configuration Data (CSA - MCG LP SSI)

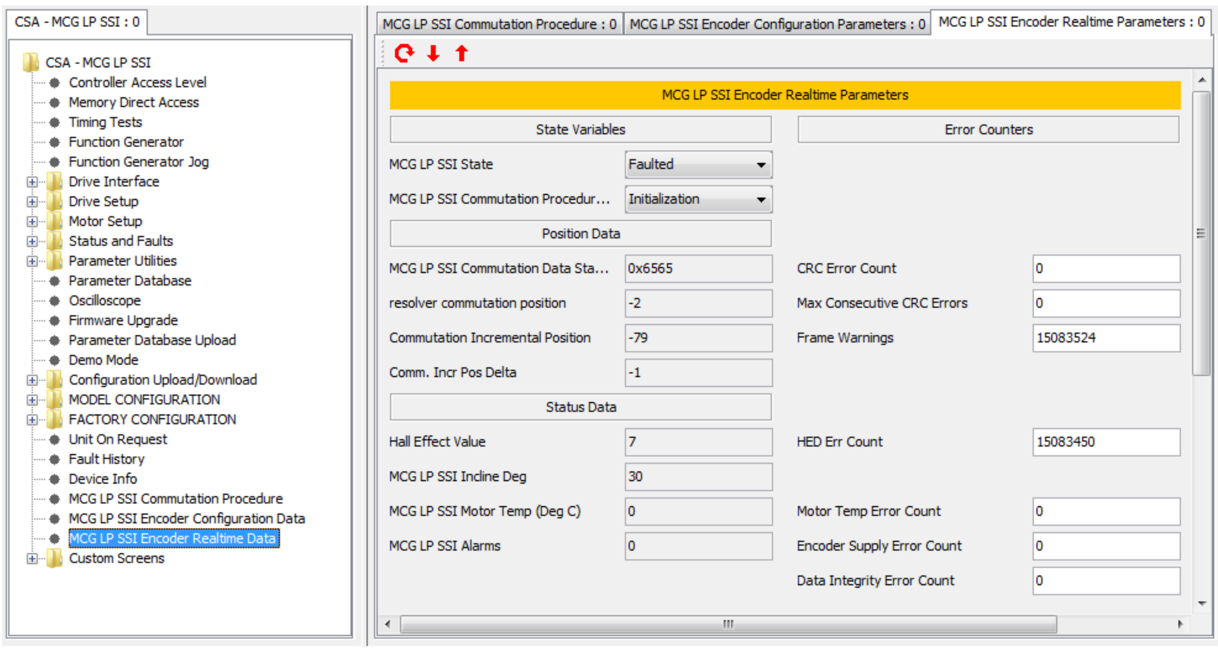
The MCG LP SSI Encoder Configuration Data Panel is used to configure the operation of the MCG LP SSI Encoder used on a Linear Motor.



Section & Parameter	Description
Functionality Configuration Parameters	
SSI Clock Rate (kHz)	Options: 50 (default), 100, 150, 200
LP SSI Delay Compensation	Options: On, Off (default)
Commutation Offset Factory Value	Provided by the Factory
Comm. Off Tbl Index by HED	Provided by the Factory
LP Motor Temp Scalar (Deg C/bit)	LP Motor Temperature Scalar in degrees Celsius/bit (Default = 8)
LP Incline Scalar (Deg Incl/bit)	LP Inclination Angle in degrees/bit (Default = 6)
Error Counter Limits	
CRC Err Lim (0=off)	Cyclical Redundancy Check Error Limit (default = 0 = do not fault)
HED Err Lim (0=off)	Hall Effect Device Error Limit (default = 0 = do not fault)
HED Timeout (seconds)	Hall Effect Device Timeout in seconds (default = 1)
Encoder Sup. Err Lim (0=off)	Encoder Supply Error Limit (default = 0 = do not fault)
Motor Temp Err Lim (0=off)	Motor Temperature Error Limit (default = 0 = do not fault)

B.3.25 MCG LP SSI Encoder Realtime Data (CSA - MCG LP SSI)

The MCG LP SSI Encoder Realtime Data Panel supports

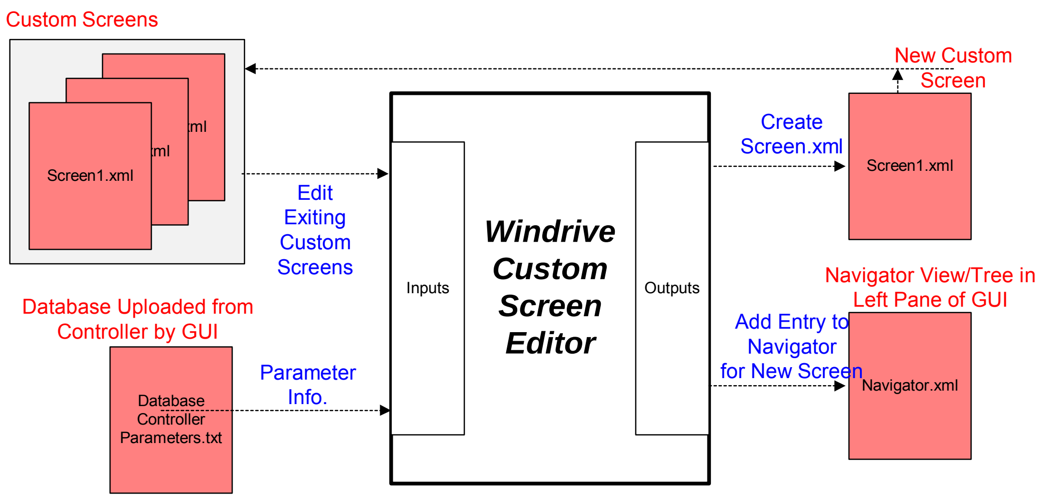


Section & Parameter	Description
State Variables	
MCG LP SSI State	Options: Init, Homing, Running, Faulted
MCG LP SSI Commutation Procedure State	Initialization, Initialize Position, Set Angle, Done
Position Data	
MCG LP SSI Commutation Data Status	The Commutation Data Status: Bit 4: Commutation Data Ready Bit 5: Inclinometer Data Ready Bit 6: Motor Temp Data Ready Bit 7: Alarm Data Ready Bit 8: Position Data Ready Bit 9: Framing Warning Bit 10: Framing Warning Latched
resolver commutation position	The Commutation Position
Commutation Incremental Position	Commutation Incremental Position
Comm. Incr Pos Delta	Commutation Incremental Position Delta
Status Data	
Hall Effect Value	The Hall Effect Device Value, valid values are 1-6, all others are invalid
MCG LP SSI Incline Deg	The Inclination Angle in Degrees
MCG LP SSI Motor Temp (Deg C)	The Motor Temperature in Degrees Celsius
MCG LP SSI Alarms	The Alarm Word, Logic 1 is a fault, Bit 0 = Encoder Supply Fault, Bit 1 = Integrity Data Error, Bit 2 = Reserved, Bit 3 = Reserved
Error Counters	
CRC Error Count	Running total of CRC Errors

Section & Parameter	Description
State Variables	
Max Consecutive CRC Errors	Maximum number of Consecutive CRC Errors
Encoder Supply Error Count	Running total of Encoder Supply Errors
Data Integrity Error Count	Running total of Data Integrity Errors

B.3.26 Custom Screens

The Windrive GUI supports user defined screens, by allowing for XML files to define the parameters displayed, text, controls etc… that are seen in the panels of the GUI. A "Custom Screen Editor" has been added as a user-friendly facility to generate panels. The concept is outlined in the figure below.

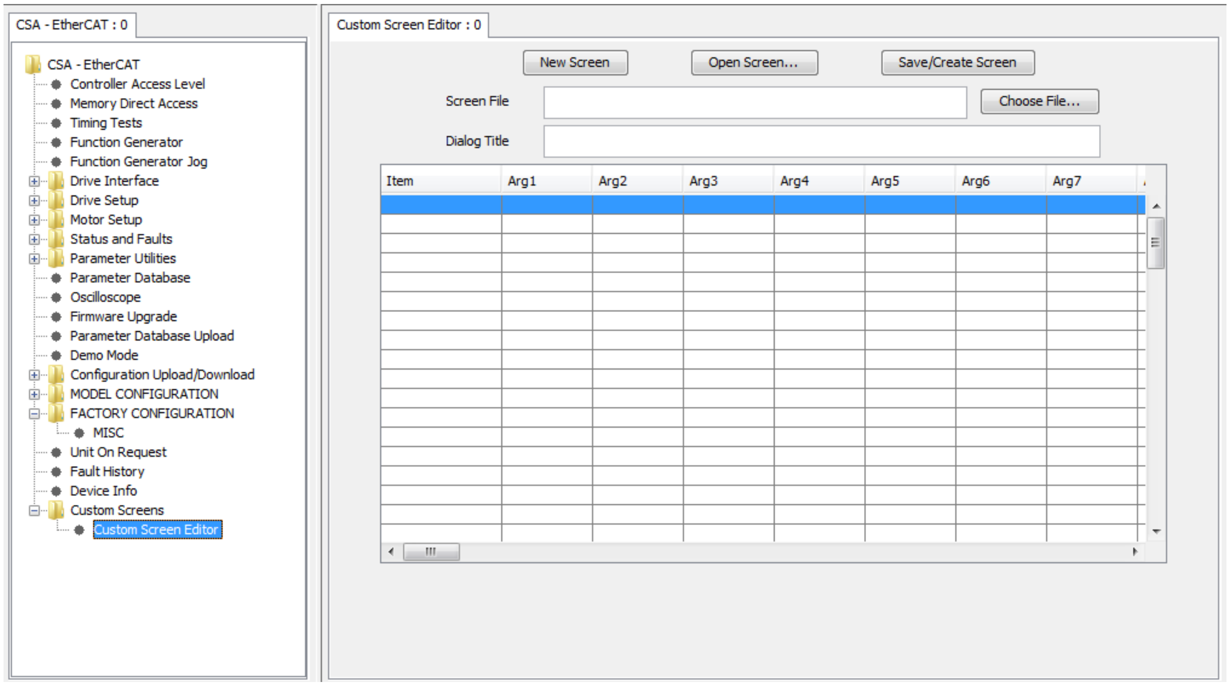


I/O for Custom Screen Editor

B.3.26.1 Navigator

The editor is available as the first entry in a "Custom Screens" folder within the Navigator Pane, as shown below. The screens created by the editor will also be displayed under this folder. When the user selects the "Save/Create Screen" Button in the new editor, the Navigator.xml will be edited to:

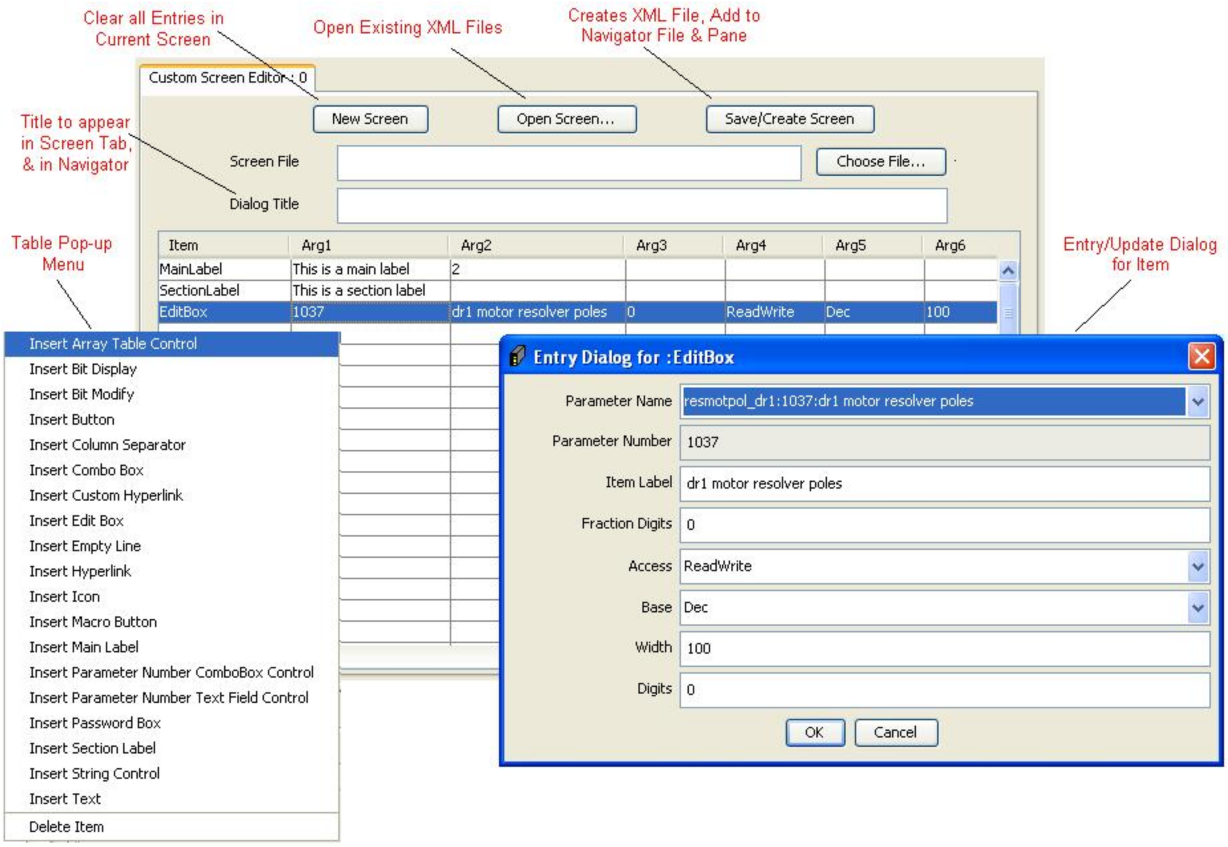
1.) Add the newly created .xml filename, to the list of files within the folder.
2.) Once the Navigator file has been edited, it will be re-loaded by the GUI, to display the new entries in the Navigator Pane, as shown below.



Navigator Support for Custom Screens & Editor

B.3.26.2 Editor

When opened, the editor can be used to add controls (i.e. visual controls, e.g. edit-boxes, combo-boxes, etc in a screen), and their arguments, to a screen by selecting from a table/spreadsheet view.



Custom Editor Screen

B.3.26.3 Inserting and Modifying Controls

Initially the editor table will be empty when the Editor is first opened. The control (e.g. Dialog Title, EditBox, ComboBox, etc…) is selected and the entry dialog is completed with the relevant data. Selecting OK from the entry dialog, the parameters selected will be displayed in the table in the editor, as arguments. In addition to inserting the various items, the drop-down menu also allows for deletion of items, by deleting the selected row in the table. After entering the controls, the parameters can be modified by double clicking on the entry in the table. This will display the entry dialog corresponding to the control.

B.3.26.4 File Handling

When all the required controls have been added, a filename is defined or chosen by browsing to select an existing filename (which will be over-written), in order to define the name of the file that will be created.

When the user selects the “Save/Create Screen” Button, the xml file will be created, and the Navigator.xml file will be updated, and reloaded into Windrive, so that the new screen will be available. The Editor checks that a Title has been assigned to the dialog, and prompts the user to enter one if none is entered. A prompt will be displayed if a filename has not been entered. A warning pop-up is displayed if an existing file will be over-written, allowing for the operation to be cancelled.

All files should reside in the same directory as the Navigator XML file, so that the created screens will be visible/available to the Navigator.

B.3.26.5 Controls

Most Entry Dialogs are self-explanatory, and have tooltips to help with entry of the dialog entries. This section outlines some specific items, in relation to Entry Dialog for various controls.

B.3.26.5.1 Parameter Selection

Most XML screens require a Field Number to uniquely identify the controller parameter. In any item which requires a field number, the field number is not directly editable; instead it is selected using a Parameter Name combo-box. The Combo-box lists all the parameters for the controller. Selection of the appropriate Parameter name, will result in the Parameter number being populated (i.e. Field Number), and the default Item label being set to the parameter description. This item label can be modified subsequently if required.

B.3.26.5.2 Bit Display / Modify

The Bit Display Entry Dialog allows for selection of the Bit Number to which the control relates. After selection of the Parameter Name, the Bit Number should be defined. Each of the setting for this bit should be defined, if different from the default values. As the Bit Number is changed, its associated Label, On/Off, Color etc… are displayed.

Note: For all entries in the control, the “Enter” key should be used when an edit box has been edited to ensure that the new setting is updated.

Note: There is currently no option to delete an entry in Bit Number Combo-Box, once the new values have been entered. The entry of blank lines should be avoided as it may result in confusion.

B.3.26.5.3 Combo-Box

The Combo-Box Entry Dialog allows for entry of the various drop-downs to appear in the control. After selection of the Parameter Name, the entries for the combo-box should be set by entering a “value & string” pair into the combo-box at the bottom of the dialog. The pair should be separated by a colon. (E.g. 0:False, 1:True)

Note: There is currently no option to delete an entry in the Combo-Box, once the new values have been entered. The entry of blank lines should be avoided, as it may result in confusion.

B.3.26.5.4 Edit Box

The EditBox Entry Dialog has three optional parameters, Base, Width & Digits. Modifying the parameter from its default value will result in its entry into the generated XML file.

B.3.26.5.5 Icon, Hyperlink, Macro Files

Certain screens refer to other files for their operation. The filenames typically reside in the same directory as the Navigator XML file. The Macros however, are to be found in a Macros sub-directory of this folder.

B.3.26.5.6 Miscellaneous

The following information describes miscellaneous usage tips for the Custom Screen Editor:

- The Editor supports deletion of controls; hence and an existing XML file may be copied as a starting point and edited to create a customised screen.
- The Dialog Title is displayed in the Tab of the created XML screen along and in the Navigator Window. The title must be entered by the User.

- The Navigator Window is only updated if the name of the created file is not already in the list of customised screens in the Navigator.
- The Navigator does not check if the listed files exist. An error message is displayed when a non-existent file is chosen.
- The Navigator.xml file must be manually edited to delete file(s) from the custom files list.
- The Editor does not display a dialog if the screen, which has been opened, contains field numbers which are not in the selected controller. If Windrive is run from a Batch file, an Exception is displayed.
- When upgrading to a newer version of WinDrive, the custom screen files and the Navigator*.xml must be manually migrated to the new installation folder(s) as necessary.
- Graphic XML Screens (i.e. ones with HotSpots/Links) are not supported.

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C.1 INTENDED APPLICATION

The safety function Restart Interlock is achieved using an internal Restart Interlock Circuit (RIC) option card and can be requested as an option for the 100/300 size drive. This will, in the future, be made available as an option for all other drive sizes. The installation of the card on other drives, or use which is not in accordance with this manual is regarded as inappropriate use.

C.2 RESTART INTERLOCK FUNCTION

The Moog RIC safety function has been validated compliant with the provisions of category 3 as defined in the harmonized standard EN-954-1:1996 by demonstrating that:

- a single fault does not lead to the loss of the safety function
- some, but not all, possible faults can be detected
- Accumulation of undetected faults can lead to the loss of the safety function

The remaining risk is in the case where two errors/faults occur simultaneously in the power section; the motor briefly rotates through a small angle (6-pole motor 60°, 8-pole motor 45°, 12-pole motor 30°, 16-pole motor 22.5°).

The drive controls the movements of an AC three-phase motor via the generation of a rotating magnetic field. To do this, the microprocessor generates a complex model of pulses, which are amplified and used to drive the power semiconductors.

The Restart Interlock function operates via hardware, with a relay which interrupts the auxiliary power supply to the IGBT drivers, and via software by blocking the generation of PWM pulses.

As a result of a risk analysis and evaluation which must be carried out according to the Machinery Directive 98/37/EC modified and referring to standards **EN ISO 12100-1**, **EN ISO 12100-2**, **EN 954-1** (**EN ISO 13849-1**) and EN 1050 and, if it exists, the product standard (e.g. EN 775, safety requirements for robots), the machinery manufacturer must configure the safety circuit for the complete machine taking into account all of the integrated components of the safety chain, including the electric drives.

The approach to achieving category 3 safety is mainly characterized by structure, which is linked to the consequences of the loss of the safety function and to the risk of a specific application.

The more the risk reduction is dependant on the circuit parts, the higher the performance level of these parts is required to be.

To improve the reliability level of the safety function of the drive (one hardware channel and one software channel) or to discriminate between the intervention of different protection systems on the machine by checking the NC contacts, on the RIC board two relays are used, both of which are able to interrupt the auxiliary power supply to the IGBT drivers.

For example, the product standard EN201/A2:2005 related to injection moulding machines with electrical axes, specifies for the axis for the horizontal movement of the plate the use of both the relays in order to have two independent hardware channels in addition to the standard SW channel.

Moreover the architecture of all the circuit parts (external to the drive) which are involved in the safety function must be compliant with category 3 of EN 954-1 (EN ISO 13849-1).

The Restart Interlock function is included in the drive and prevents the need to power-off the drive and to re-do the standard restart procedure.

The Restart Interlock safety function prevents the motor unexpectedly starting from standstill. This circuit can be used in the “Safe Standstill” machine function. When the motor is rotating, the switching-on of the Restart Interlock provides an uncontrolled stop (category 0 according to EN 60204-1:1997).

When a controlled stop of category 1, according to EN 60204-1:1997, is requested, the condition of stopped motor must be assured. The external machine control must be able to stop the motor.

When the intervention time of the safety devices can be set up, appropriate precautions must be adopted to limit the use only to qualified personnel. The intervention time of the restart interlock safety function must be higher than the braking time of the deceleration ramp set by the drive with the maximum speed and the maximum load at the axis.

When active, the restart interlock function removes the output torque and the motor is free to rotate. Adequate protections must be provided when external forces act on the axis (e.g. gravity force on vertical axes), such as a self-locking mechanical system or a weight equalization system.

The restart interlock function does not provide electrical isolation. It does not provide protection against "electric shock". The complete machine or system must always be electrically isolated from the line supply through the main disconnection contactor, secured on the open position, before any work is carried out on the machine or system, e.g. maintenance, service or cleaning work (refer to EN 60204-1:1997, par. 5.3). Personnel must be aware that Bus Bar's can have dangerous voltage even after switching off (capacitive voltage). Discharge time is 5 minutes.

When correctly used, the restart interlock function must be looped in the line contactor circuit in order to switch off the power supply of the axis in case of fault.
The associated drive must be electrically isolated from the supply if the RIC relay function is not consistent (input and output not compatible). Only after the fault has been removed, may the restart interlock and the associated operating mode be used again.

C.3 SAFETY REQUIREMENTS

- Complete Standstill. The Restart Interlock safety function prevents the motor unexpectedly starting from standstill. This circuit can be used in the “Safe Standstill” machine function. When the motor is rotating, the switching-on of the Restart Interlock provides an uncontrolled stop (category 0 according to EN 60204-1:1997). When a controlled stop of category 1, according to EN 60204-1:1997, is requested, the condition of stopped motor must be assured.
  The final machine must be able to stop the motor.

WARNING - The designer must evaluate the machine stopping time during the risk assessment even in the case of failure. The machine can present a dangerous overrun in case of failure of the drive. Other protective measures are needed to achieve a safe condition.

- Environmental Conditions. Equipment intended to operate within the following environmental conditions:
  - Ambient temperature: 0 to +40°C
  - EMC immunity: according to EN 61800-3/A11:2000 (Adjustable speed electrical power drive systems. Part 3: EMC product standard including specific test methods). Second environment (industrial)
  - Vibration immunity: 2 to 12Hz, 1.5 mm amplitude (peak); 12 to 200Hz, 1 g acceleration
  - Shock immunity: 10 g, half sine, 11 ms, according to EN 60721-3-3:1995, Class 3M4

- Enclosure. Electronic Equipment intended for installation in an enclosure providing at least IP54 protection.

- **Pollution Degree 2 or Better.** The equipment shall be installed in a pollution degree 2 environment, where normally only non-conductive pollution occurs. Occasionally, however, a temporary conductivity caused by condensation is to be expected, when the electronic equipment is out of operation.

WARNING - When the Restart Interlock Circuit is activated, the motor can no longer generate a torque. Motors which are not automatically clamped when powered- down (e.g. vertical/inclined axes), must be clamped using a mechanical brake.

C.4 RESTART INTERLOCK CIRCUIT

The restart interlock is provided by redundant interlocking devices acting independently on power control devices.

C.4.1 HARDWARE CHANNELS

The hardware channels (channel 1 and channel 2) interrupt the auxiliary power supply to the IGBT drivers via two relays with forcibly guided contacts.

C.4.1.1 MONITORING CHANNEL 1

For monitoring the interlocking system the input signal “Channel 1” and the output signal “Channel 1 verification” must be checked to have the appropriate status under the following conditions:

Condition 1:	“Channel 1” = 0	“Channel 1 verification” = 1
Condition 2:	“Channel 1” = 1	“Channel 1 verification” = 0

Condition 2 allows for a short circuit on the wiring of the NC contact of the safety relay to be detected. When this check is not available it is necessary to follow the wiring procedures listed in the following pages.

When an incorrect signal status is monitored, the line contactor must disconnect the drive supply, taking care of the release time (max 100 ms) of the signal. An error message must be available to make the malfunction of the safety circuit visible.

C.4.1.2 MONITORING CHANNEL 2

The second hardware channel can be requested by the product standard or can be used to improve the reliability of the safety category.

For monitoring the interlocking system the input signal “Channel 2” and the output signal “Channel 2 verification” must be checked to have the appropriate status under the following conditions:

Condition 1:	“Channel 2” = 0	“Channel 2 verification” = 1
Condition 2:	“Channel 2” = 1	“Channel 2 verification” = 0

Condition 2 allows for a short circuit on the wiring of the NC contact of the safety relay to be detected. When this check is not available it is necessary to follow the wiring procedures listed in the following pages.

When an incorrect signal status is monitored, the line contactor must disconnect the drive supply, taking care of the release time (max 100 ms) of the signal. An error message must be available to make the malfunction of the safety circuit visible.

C.4.2 SOFTWARE CHANNEL

The software channel 2 interrupts the signal path to the IGBT drivers with the standard software procedure. To disable the axis, the input “Drive Enable” of the J2A connector (pinI1 w.r.t. RET) shown in Section 3, must become low (0V).

C.4.2.1 MONITORING SOFTWARE CHANNEL

A failure in the software channel operation cannot be detected by the drive. It is possible to define a cyclic test during the working conditions in order to find the failure of the software channel. For example, at restart it is possible to give the drive a reference signal with Drive Enable OFF and to verify that the motor does not rotate.
In case of fault the motor must be stopped via the hardware channel(s) and via the line contactor. The motor must not restart until the fault has been fixed.

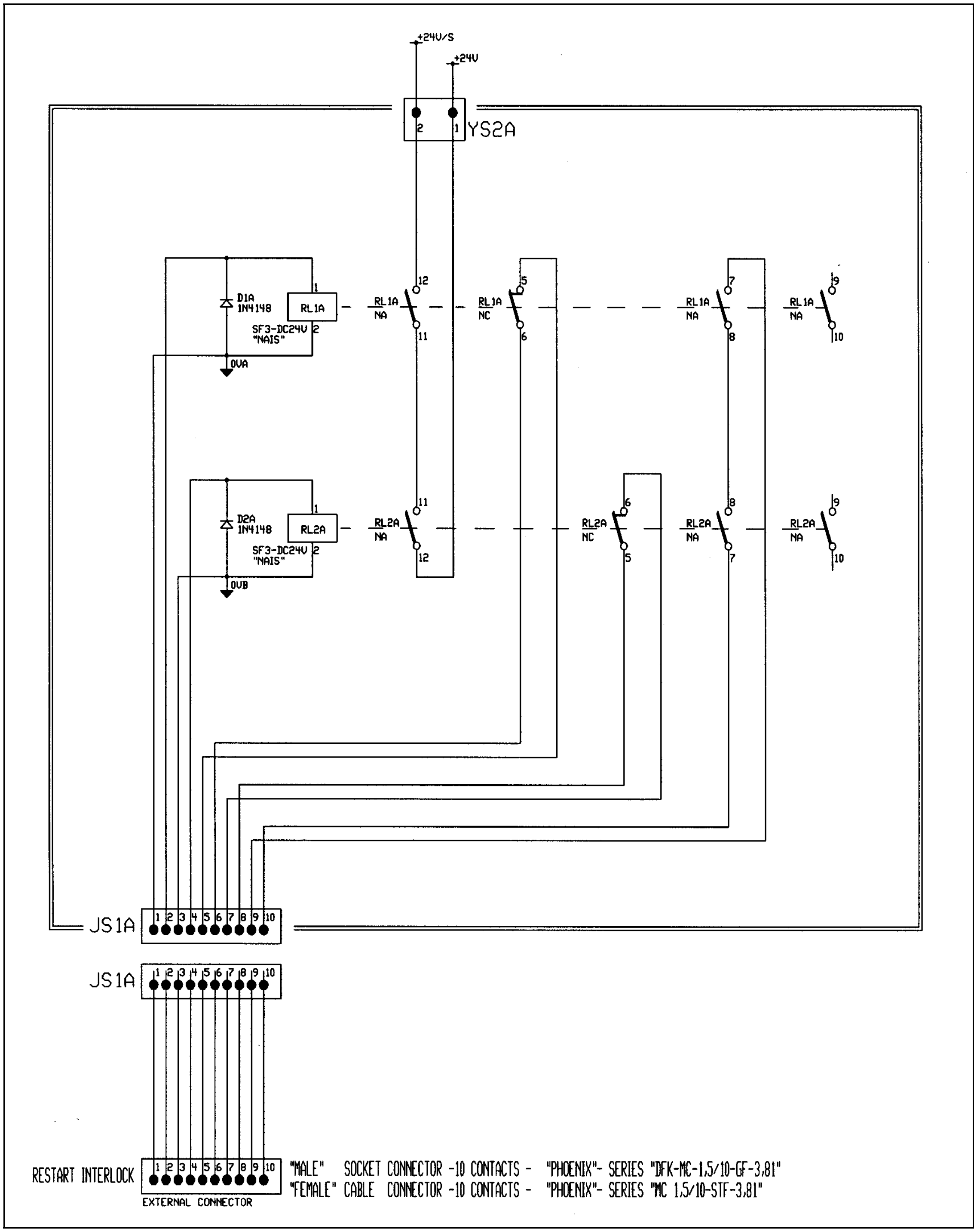


Figure C.1 RESTART INTERLOCK CIRCUIT

C.5 RESTART INTERLOCK CONNECTIONS

The hardware channels of the restart interlock circuit are controlled using the RESTART INTERLOCK connector.

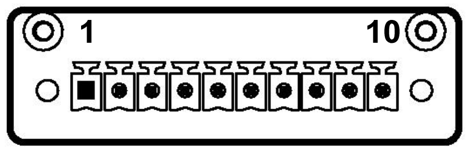


Figure C.2 RESTART INTERLOCK CONNECTOR

Mating connector: 10 contacts, series MC 1,5/10-STF-3,81 by Phoenix

Pin	Name	Function
1	- “Channel 1”	0V input to coil of RL1 Safety Relay Channel 1.
2	+ “Channel 1”	Input to coil of RL1 Safety Relay Channel 1. With the input active this input must be high (+24Vdc). When the input is inactive this input must change to low (0V).
3	- “Channel 2”	0V input to coil of RL2 Safety Relay Channel 2.
4	+ “Channel 2”	Input to coil of RL2 Safety Relay Channel 2. With the input active this input must be high (+24Vdc). When the input is inactive this input must change to low (0V).
5	“Channel 1 verification” NC contact	NC contact of RL1 Safety Relay of Channel 1. Feedback of RIC. When closed (high), the Restart Interlock function is active. The external verification system must monitor this output signal for consistency with its input signal
6		
7	“Channel 2 verification” NC contact	NC contact of RL2 Safety Relay of Channel 2. Feedback of RIC. When closed (high), the Restart Interlock function is active. The external verification system must monitor this output signal for consistency with its input signal
8		
9	NO contact	Series of NO contacts of RL1 and RL2 relays.
10		

Table C-1 Interlock connector pin-out

C.5.1 Wiring practice

The external cable to RESTART INTERLOCK connector must be protected against mechanical damages according to the safety requirements of EN ISO 13849-2:2003, tab. D.4 (prEN 954-2) in order to prevent short circuits.

The Restart Interlock relay of Channel 1 is controlled using the external +24Vdc (pin2 positive terminal, pin1 0V terminal).

When the RL1 relay is de-energized, pins 5-6 are closed and the Restart Interlock Channel 1 is activated.
If “Channel 2” is used, the Restart Interlock relay of Channel 2 is controlled using the external +24Vdc (pin4 positive terminal, pin3 0V terminal).When the RL2 relay is de-energized, pins 7-8 are closed and the Restart Interlock Channel 2 is activated.

If “Channel 2” is not used, the relays (RL2) of “Channel 2” must be always powered using the external +24Vdc (pin4 positive terminal, pin3 0V terminal).

WARNING - The auxiliary functions circuit (NO contacts) must be externally protected using either a delayed fuse rated 2 A or a fast fuse rated 3 A.

WARNING - Pins 1 and 3 must be connected to the protective bonding circuit to prevent malfunctions in case of earth faults.
.

C.6 SAFETY RELAYS - TECHNICAL DATA

Input coil	Pnom = 500 mW Inom = 20.8 mA (±10%) Vnom = 24 Vdc Pick-up voltage = 14.4 Vdc Drop-out Voltage = 2.4 Vdc Resistance = 1.152 Ω Vmax = 28.8 Vdc
Contact	Rmax = 30 mΩ @ 6 Vdc, 1 A Imax = 3 Adc **Vmax = 30 Vdc**

Table C-2 Safety relays specifications

C.7 APPLICATION EXAMPLE

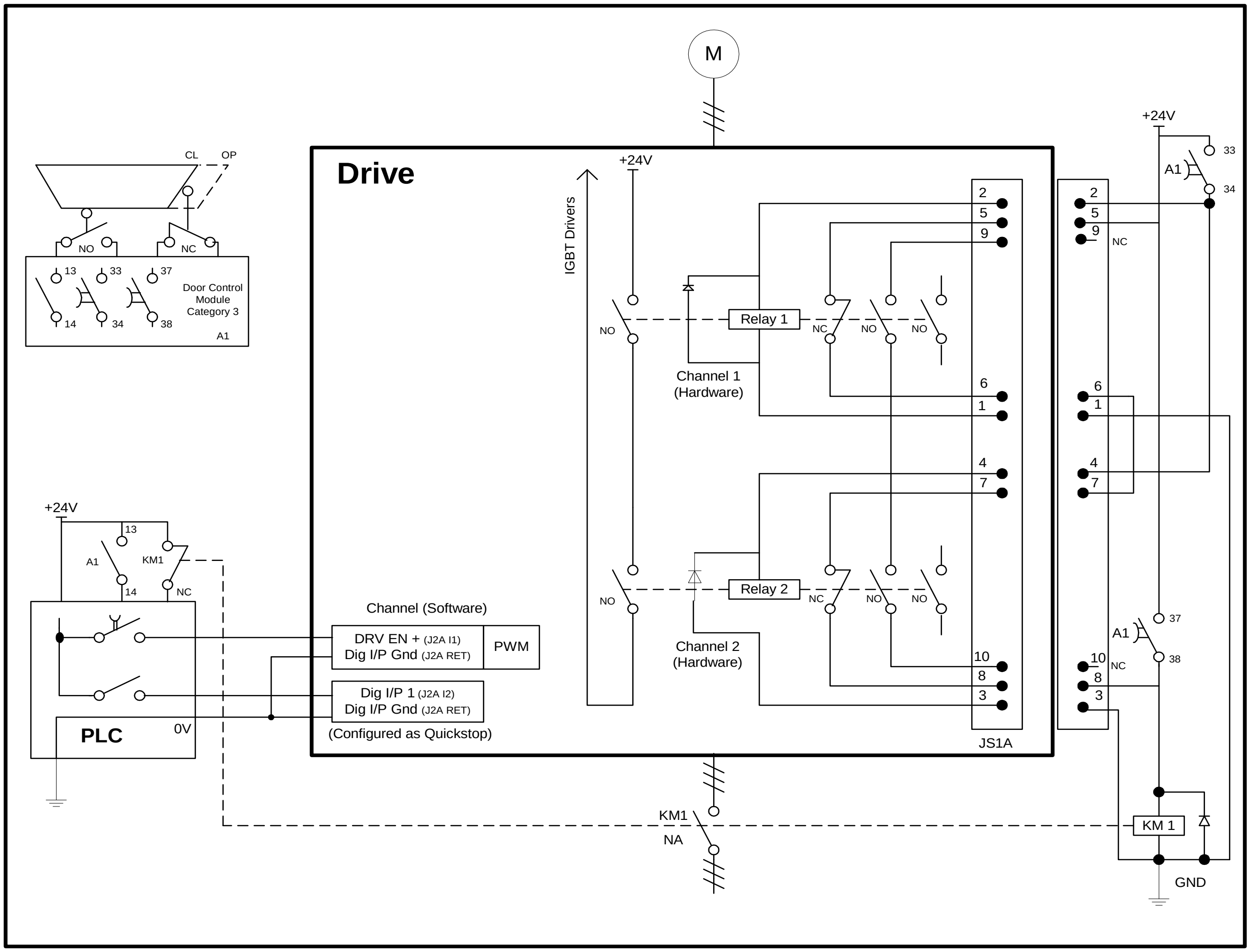


Figure C.3 Example of Restart Interlock with controlled stop Category 1 according to EN 6024-1:1997

C.7.1 Description of the RESTART INTERLOCK FUNCTION

To achieve a controlled stop it is necessary to stop the motor before the activation of the HW and SW safety channels.

Configure digital input 1 as a Quickstop function; refer to *Chapter 5 Functionality Overview - PanelT361DigInp*. Ensure that the Quickstop mode (parameter: '`qstmod`') is set to 1 i.e. the drive disables once the Quickstop is applied. Set the parameter '`velstdby`' to the motor maximum velocity – this ensures that the motor brake, if present, is applied immediately on activation of the Quickstop signal.

Ensure that the digital input invert (parameter: '`diginpinv`' (1)) is set to 1 – this allows a LOW signal to enable the 'Quickstop' input.

By default, when a Quickstop occurs, the motor brake is applied. There is a default delay of 100mS between the brake being applied and the drive disabling (parameter: '`brgbrktimout`').

The drive enable signal is mapped to digital output 1 by default. Once the drive is disabled, this output goes low: see *DS2110_Sec_05 Functionality Overview.doc - PanelT361DigOut*

When the door is opened output 13-14 of the A1 module send
s a stop signal to the PLC. The PLC sets the Quickstop signal LOW in order to stop the motor with the maximum torque available. The drive disables after the 100mS delay and it is then possible to activate the SW and HW channels.
The axis-stopped status can be communicated to the PLC via digital output 'DIG_OUT1', not shown in the figure. This reflects the enable status of the drive in this example.

Software Channel

- When the door is opened, the door control module (output 13-14 of A1) activates the input of the PLC, which, after the 100mS delay, disables the axis according to the sequence of par C.4.2, by removing the DRIVE ENABLE signal (input DRV EN)
- The correct operation of the SW channel cannot be verified.

Hardware Channel

- When the door is opened, the door control module (delayed output 33-34 of A1) opens the inputs of the hardware channels after a 100mS delay.
- If the NC contacts of the safety relays 1 and 2 do not close, the KM1 contactor is de-energized and the power supply to the drive is switched off
- If the drop-out time of the relays 1 and 2 (approx.100 ms) is less than the drop-out time of the KM1 contactor, the KM1 contactor will be de-energized at the opening of the doors. In this case it is possible to add a capacitor in parallel to the coil of KM1 in order to avoid the de-energization when the door is opened.
- The application example checks the status of relays 1 and 2 only at the de-energization (NC contacts closed) and not at the energization (NC contacts opened). In this case it is not possible to detect a short circuit. Thus, the cables must be mechanically protected.

Requirements

- The delayed output of the control module which drives the hardware channels (safety relays) and the PLC output which drives the SW channel must be set ensuring that the intervention of the safety function should occur only with the motor at standstill.
- When personnel are permitted inside the hazardous zone, the restart must be available only after a separate reset following the closure of the protective guards confirming that no personnel is inside the hazardous zone
- The door control module must be compliant with at least category 3 of EN 954-1.

See par C.6 for the technical data.

C.7.2 Sequence and Procedure using the Restart Interlock

The motor must be stopped before the hardware and software channels are inhibited and the Restart Interlock is activated.

WARNING: If a fault occurs on operating the Restart Interlock, then this fault must be removed before the mechanically isolating protective guards to the working zone of the machine or plant are opened. After the fault has been removed, this procedure must be repeated for the Restart Interlock. Under fault conditions, all of the drives, machine and plant must be shut down.

If one of the following faults should occur with the contacts of the “hardware channel verification” opened (0V) and the protective guards withdrawn, then the EMERGENCY STOP must start immediately:

- The acknowledgement contacts “Channel 1 verification” remain open after the intervention of the Restart Interlock.
- If “Channel 2” is also used: the acknowledgement contacts “Channel 2 verification” remain open after the intervention of the Restart Interlock.
- There is a fault in the external control circuit itself.
- There is a fault in the signal lines of the verification contacts.

All of the drives associated with the machine/plant must be disconnected and isolated from the line supply through the line contactor.

WARNING: The line contactor must have a NC contact linked to safety NO contacts.
.

If the Restart Interlock control has been correctly integrated into the external safety-related control and has been checked to ensure correct functioning, then the drives in the separate working zone of the machine are protected against undesirable starting, and personnel can enter or operate in the hazardous zone which has been defined.

CAUTION: Where the equipment requires manual intervention the relevant regulations must be taken into account.
.

C.8 CHECKING THE RESTART INTERLOCK

The following checks must always be made at commissioning and when possible must be repeated at defined intervals during the operating lifetime. A check should also be made after extended production shutdowns. Each individual drive must be checked.

Only qualified personnel, taking into account the necessary safety procedures, must make the following checks:

- Check that the motor is at standstill.
- Inhibit the IGBT drivers by removing the voltage at position 2 (Channel 1) of **RESTART INTERLOCK** connector. The acknowledge contacts 5-6 (Channel 1 verification) of **RESTART INTERLOCK** connector must be closed. The drive must not provide output current.
- If “Channel 2” is also used: inhibit the IGBT drivers by removing the voltage at position 4 (Channel 2) of **RESTART INTERLOCK** connector. The acknowledge contacts 7-8 (Channel 2 verification) of **RESTART INTERLOCK** connector must be closed. The drive must not provide output current.
- Put the drive in the starting condition, with Drive Enable ‘OFF’. Send a reference signal to the motor velocity and verify that the motor does not rotate.
- Disable the protective devices, e.g. by opening the protective doors while the motor is running. If the stop is category 1, check that the motor is braked in a controlled stop and that the Restart Interlock function is activated after the stop. This must not result in a hazardous condition.
- All possible fault situations, which could occur, must be individually simulated in the signal paths between the verification contacts and the external control as well as the signal consistency functions of this control. Example: by disconnecting the Restart Interlock monitoring circuit at positions 5-6 of **RESTART INTERLOCK** connector (condition 1) or by simulating a short circuit within the cable (condition 2) when this cannot be excluded.

For all of the simulated fault situations, the line contactor must disconnect the entire machine or plant drives from the line supply.

C.9 EXTERNAL CONSISTENCY CHECKS

The following consistency checks must be made outside of the drive (e.g. by a PLC).

“Channel 1 verification”

- The external system must monitor this output signal for consistency with its input signal
- Channel 1 (C.4.1.1).

“Channel 2 verification” (if used)

- The external system must monitor this output signal for consistency with its input signal Channel 2 (C.4.1.2).

Monitoring by a standard Programmable Electronic System

Minimum functional requirements

- The automatic monitoring shall, on discovering a fault, disconnect the line contactor and prevent a new start until the fault has been removed. The transition of the monitoring signal shall be checked automatically:
  - o At start up and
  - o During each stopping and starting sequence.

Wiring requirements to avoid common mode failures

- The external cable to RESTART INTERLOCK connector must be protected against mechanical damage according to the safety requirements of EN ISO 13849-2:2003, tab. D.4 (prEN 954-2) in order to prevent short circuits.

Software verification

- Following safety related principles; it is necessary to verify the software and give instructions on following revisions.

Modification of software

- The manufacturer shall write a warning in the software close to the part of program concerning the safety function that this part must not be deactivated or modified for safety reasons
  (see also clause 3.7.7 of EN 292-2)

Other requirements

- The output of the PLC to the line contactor shall be periodically tested by monitoring the consistency of the NC contact of the line contactor.

Protection of program

- The program shall be monitored by e.g. a watchdog
- The program shall be, in permanent memory, protected against electrical interference and shall be equipped with a start-up test procedure.

C.10 INSTALLATION AND ROUTINE TEST

The restart interlock circuit (RIC) is installed and tested at Moog.

Please consult Moog ICD Sales or a Moog Distributor for application specific ordering information.

APPENDIX D. MEZZANINE CARD INSTALLATION

D.1 Introduction

To expand the functionality of the CSA, various fieldbus options are available on mezzanine cards. This document covers the installation of the mezzanine cards in the CSA, with figures being representative of the assembly hardware.

D.2 Installation

If the installation is being carried out in the field, the CSA must be powered down and disconnected from the supply voltage, a ‘wait’ period of **5-minutes** must be recognised before installing the mezzanine card.

The mezzanine card is sensitive to damage from static electricity (ESD). Ensure correct anti-static procedures are observed (e.g. use properly installed earth straps etc.) before installation or removal of a mezzanine card.

1. For size A-F power stages remove the M3 * 8mm Torx screw at the bottom of the drive, connecting the control stage to the power stage. Gently disconnect the ribbon cable from the connector (H2) on the CSA control card.

2. For µA size power stages remove the M3 * 8mm Torx screw at the top and bottom of the drive, connecting the control stage to the power stage. Gently disconnect the ribbon cable from the connector (H2) on the control card.

3. Remove the mezzanine card from the anti-static metallised bag; ensure that ESD precautions are observed.

4. Place the mezzanine card on to the host card, gently pushing the connectors see (*Figure 0-2 CSA Mezzanine Assembly Explosion*) together until the mezzanine card rests evenly on the four standoffs attached to the host card.

5. If using a CSA EtherCAT mezzanine card, position the mounting bracket before inserting the EtherCAT mezzanine card. The EtherCAT mezzanine card should then be placed between the standoff and mounting bracket as shown in *Figure 0-1 CSA EtherCAT Mezzanine Card Mounting Bracket.*

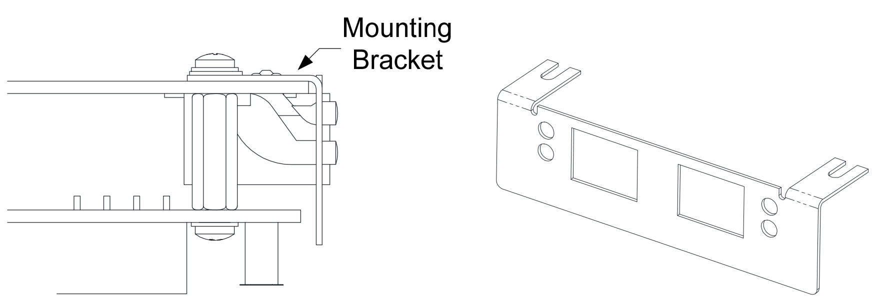


Figure 0-1 CSA EtherCAT Mezzanine Card Mounting Bracket

6. Use the 4 M2.5 * 6mm Torx screws provided, with 4 washers, to secure the mezzanine card to the host controller. Torque to 0.5Nm

7. Place the overlay provided with the mezzanine card centrally on the bottom of the control stage enclosure. This indicates the connectors and/or LEDs for the various mezzanine cards.

8. Press the ribbon cable from power stage back into the connector (H2) on the CSA control card

9. Replace the control stage on the power stage using either 1 or 2 M3 * 8mm Torx screws removed earlier.

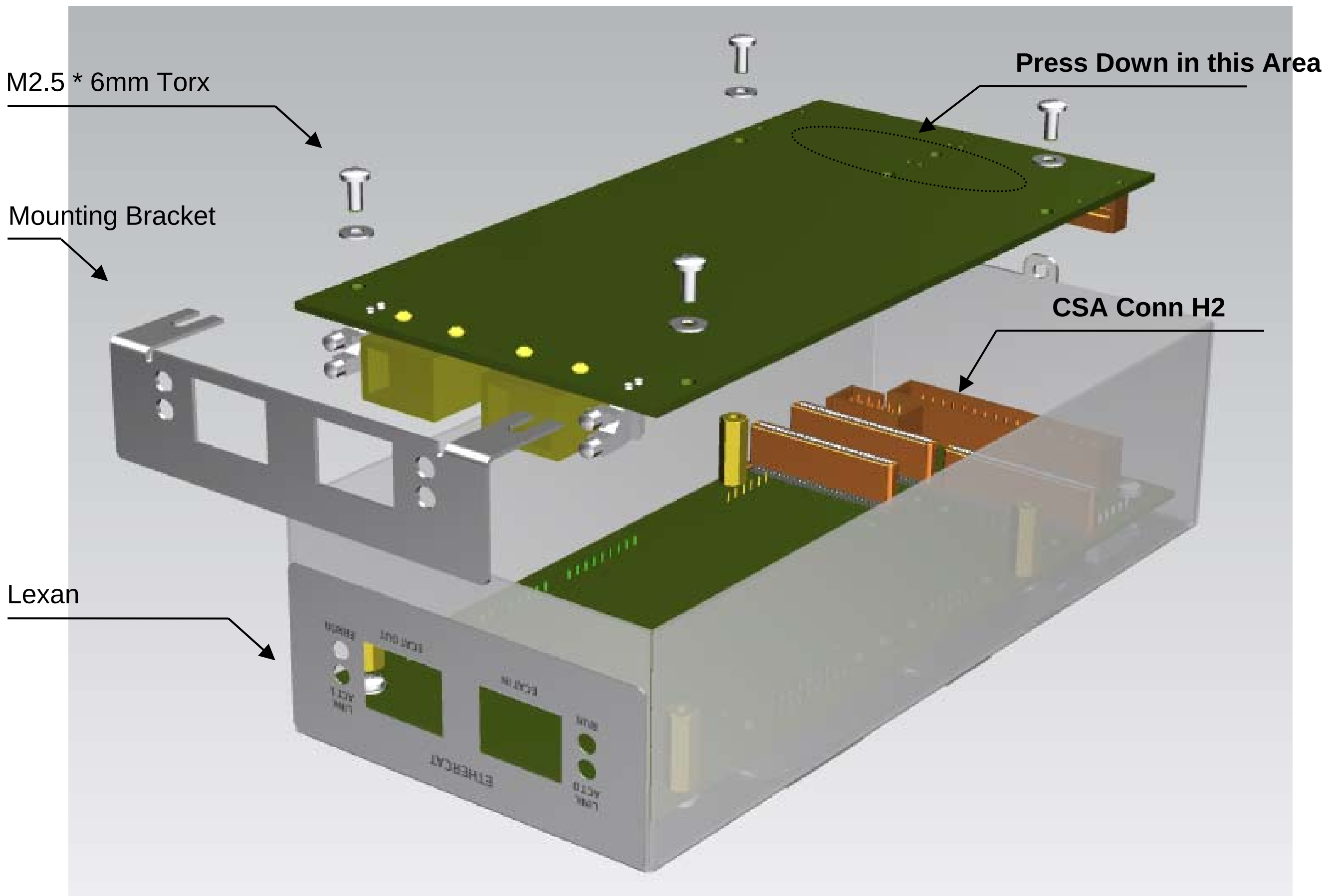


Figure 0-2 CSA Mezzanine Assembly Explosion (μA size)

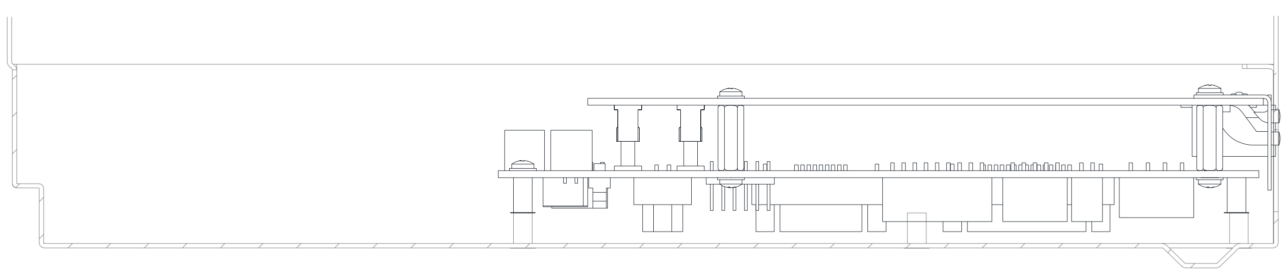


Figure 0-3 CSA Mezzanine Assembly Complete (A-F size)

APPENDIX E. ANALOG I/O MEZZANINE CARD

E.1 Introduction

An Analog Input and Output option of the CSA Control Stage is available. This section will cover the connector details and basic functionality.

E.2 Overview

The Analog I/O option has two analog inputs and outputs available for motion control signals and feedback. The Analog I/O port allows for 2 configurable analog input channels and 2 analog output channels for external control system integration. The simulated encoder interface reproduces encoder data and allows for serial data transfer for master/slave arrangements.

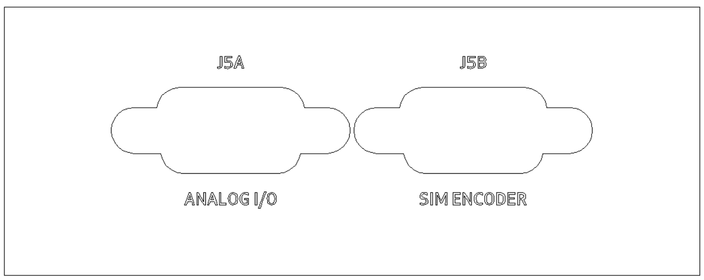


Figure E-1 Picture of Analog Interface

E.3 Configurations

The Analog input and output options are available as follows:

Table E-1 Analog Configurations

Model	Input		Output	
	CH1	CH2	CH1	CH2
5X	±10Vdc	±10Vdc	±10Vdc	±10Vdc
6X	0-20mAdc	0-20mAdc	0-20mAdc	0-20mAdc
7X	±10Vdc	0-20mAdc	±10Vdc	0-20mAdc

Please consult Moog ICD Sales or a Moog Distributor for application specific ordering information.

The maximum input to each channel should not exceed 10 Volts for channels configured for voltage or 20mA for channels configured for current.

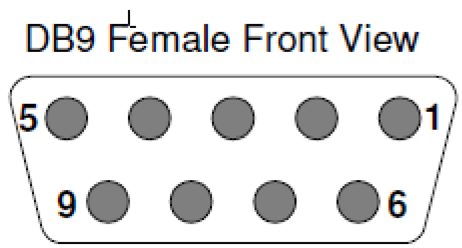
E.4 Analog I/O

E.4.1 Analog I/O Interface

The interface to the Analog I/O is a 9 pin D-sub female connector (J5A). The pinouts are illustrated in Figure E3.

Table E-2 J5A Pin Configuration

Pin	Function
1	Analog Output 1 (+)
2	Analog Output 1 (-)
3	Analog Output 2 (+)
4	Analog Output 2 (-)
5	Chassis GND
6	Analog Input 1 (+)
7	Analog Input 1 (-)
8	Analog Input 2 (+)
9	Analog Input 2 (-)



E.4.2 Assigning Analog I/O

The inputs and outputs are configurable and scalable in order to represent force, position or velocity via the Moog WinDrive GUI software only.

E.4.3 Single-Ended Inputs

A single-ended input measures the voltage between the input signal and ground. In single-ended mode the board measures the voltage between the input channel and ground reference refer to *Figure E-2 Single-Ended Input* .The single-ended input configuration requires only one signal connection (wire) per channel and one ground reference to the external source. Because the board is measuring the input voltage relative to its own ground, single-ended inputs are more susceptible to both electromagnetic interference (EMI) and any ground noise at the signal source.

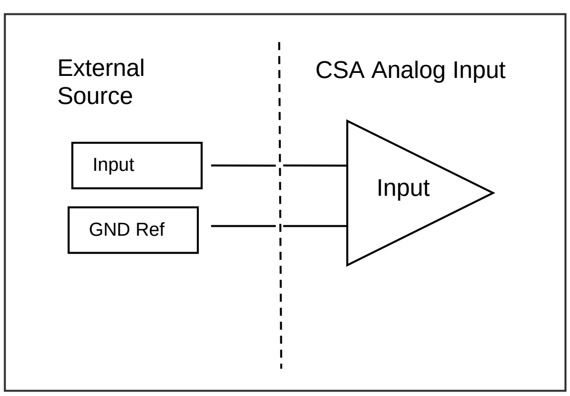


Figure E-2 Single-Ended Input

E.4.4 Differential Inputs

Differential inputs measure the voltage between two distinct input signals. Within a certain range - called the common mode range - measurement is almost independent of signal source to board ground variations. A differential input is also more immune to EMI than a single-ended input. Most EMI noise induced in one lead is also induced in the other. The input measures only the difference between the two leads, and the EMI common to both is ignored. *Figure E-3 Differential Input*, shows the basic differential input configuration.

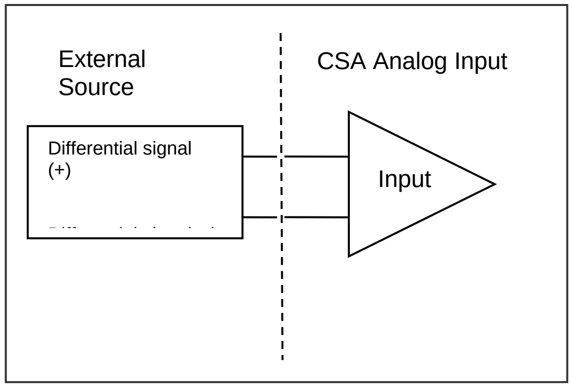


Figure E-3 Differential Input

The common mode noise and input signal between the External Source and the CSA input must not exceed 13.1V / 30mA or the device will not work properly. Excessive voltage/current input will result in damage to the input operational amplifier circuits.

E.5 SSI Interface

The SSI (Synchronous Serial Interface) protocol is a point to point configuration with only transmission capabilities. Its output is configurable via Moog GUI software only. Refer to specific application manual for more details on this topic.

The SSI protocol is asynchronous and stateless. The SSI protocol command structure consists of three parts:

- Header
- Payload
- Optional CRC checksum

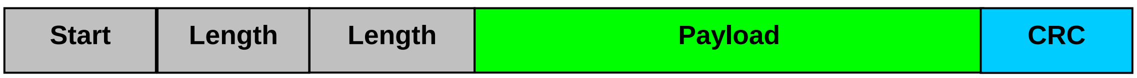


Figure E-4 SSI Protocol

- The SSI protocol byte order is **Big Endian** (most significant byte first).
- The SSI Interface requires a clock pulse from the external controller.
    - o The input frequency of the Clock In pulse determines the rate at which the Data Out will output the serial information.
    - o The data is strobed out on the positive edge of the clock. The format of the message will be in standard binary format.

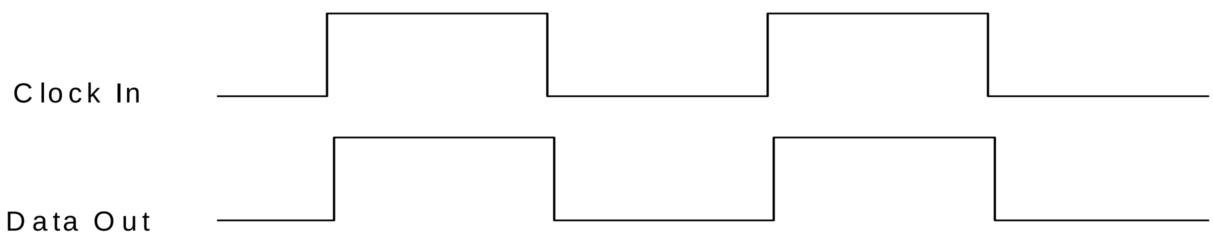


Figure E-5 Clock and Data Out

The frequency of the clock pulse is limited by the length of the conductor used. The following table, *Table E-3 Clock Speed and Cable lengths*, gives a rough estimate of max clock frequency per cable lengths as this may vary with cable type. Please refer to specific controller device manuals for specific information.

Table E-3 Clock Speed and Cable lengths

Clock rate (kHz)	Cable Length (Ft)
150	600
230	400
250	360
375	240

The data bits will be streamed in a word of 32 bits. The controller must be setup for this streaming output.

E.5.1 Interface

See *Table E-4 J5B Pin Configuration* for details,

E.5.2 Assigning SSI

In the following parameter, a number may be entered that will output any internal variable through the SSI interface:

- ‘`mezssivarfld`’ 1894 UNSIGN16 SSI variables field number

For example, the SSI parameter, ‘`mezssivarfld`’, for the Maxforce application is entered as 64078. This represents the ‘**SSIPOS**’ model parameter.

- ‘`ssipos`’ 64078 SIGN32 Position for SSI feedback in counts = Position minus Maxforce Home Offset

Refer to specific application manual for more details on this parameter association.

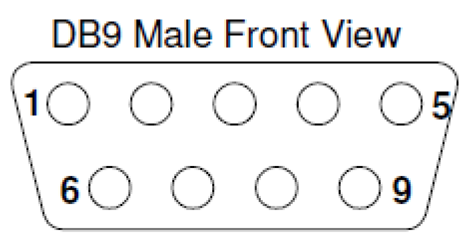
E.6 Simulated Encoder Interface

E.6.1 Interface

The Simulated Encoder is a 9 pin D-sub male connector (J5B). The pinouts are illustrated in Figure E9.

Table E-4 J5B Pin Configuration

Pin	Function
1	Simulated Sine (+)
2	Simulated Cosine (+)
3	Data Out (+)
4	Chassis GND
5	Clock In (+)
6	Simulated Sine (-)
7	Simulated Cosine (-)
8	Data Out (-)
9	Clock In (-)



E.6.2 Parameters

The database parameters related to the Simulated Encoder Signal Generation Feature are shown in *Table E-5 CSA AnalogIO Mezzanine Card Parameters*. To enable the feature, parameter 2031 must be set to ‘1’, the other configuration parameter default values should be sufficient.

Table E-5 CSA AnalogIO Mezzanine Card Parameters

Param Number	Parameter Name	Configuration (stored) or Realtime Parameter	Default Value	Description
2030	`inc_Enc_Config`	Realtime	0	Sim Enc Config Register
2031	`enc_sim_enable`	Configuration	FALSE	Sim Enc Enable (0 = off, 1 = on to enable A & B simulated signals)
2032	`enc_sim_reset`	Realtime	FALSE	Sim Enc Reset (0 = No, 1 = zero accumulator)
2033	`enc_sim_index_typ`	Configuration	FALSE	Sim Enc Index Type (0 = def. for non-simulated generation, 1 = 50/50 index marker)
2034	`fpga_update_freq`	Configuration	20	Sim Enc FPGA Update Freq (multiples of MHz)
2035	`fpga_counter_mod`	Configuration	536870912	Sim Enc FPGA Counter Modulus (MSB)
2036	`encoder_ppr`	Configuration	8192	Sim Enc Encoder pulses per rev (PPR)
2037	`drv_resol`	Configuration	65536	Sim Enc Drive Resolution (counts/rev)
2038	`delta_Pos_mult`	Realtime	3.2768	Sim Enc Delta Position scale multiplier
2039	`enccnt_k`	Realtime	-	Sim Enc Encoder Counts (past position k)
2040	`enccnt_k1`	Realtime	-	Sim Enc Encoder Counts (current position k+1)
2041	`delta_Pos`	Realtime	-	Sim Enc Encoder Counts (current - past)
2042	`delta_Fraction`	Realtime	-	Sim Enc Delta Fraction
2043	`scaled_Delta_Pos`	Realtime	-	Sim Enc Scaled Delta Position
2044	`integer_Delta_Pos`	Realtime	-	Sim Enc Integer Delta Position
2045	`delta_Pos_Output`	Realtime	-	Sim Enc Delta Position Output to FPGA

E.6.3 Simulated Encoder Signal Generation

The Simulated Encoder Signal Generation is collaboration between the firmware and the FPGA. The firmware implements a 16 bit delta value which is an input to the FPGA.

The firmware calculates a delta position count. This count is processed by the control card FPGA into A and B quadrature signals which are output on the AnalogIO Mezzanine Card. The wiring of the AnalogIO Mezzanine Card is as shown below:

Table E-6 CSA DeviceNet Mezzanine Card Simulated Encoder Signals

CSA Connector, Pin, Signal
J5B – 6 – ENCODER_OUT_A(-)
J5B – 7 – ENCODER_OUT_B(-)
J5B – 1 – ENCODER_OUT_A(+)
J5B – 2 – ENCODER_OUT_B(+)

The FPGA takes the 16 bit delta value from the firmware and processes it to generate the A and B quadrature signals and outputs them on the AnalogIO Mezzanine Card.

The simulated sine output will translate the sine information from the encoder to a reconstructed Quadrature Differential signal based on the position of the motor. The simulated cosine output will translate the cosine information from the encoder to a reconstructed analog cosine signal based on the position of the motor.

Encoder resolution is programmable. Typical CSA resolution = 65,536 counts/rev.

E.7 PLC Master – Slave Arrangement

In general, Drives using the AnalogIO option are supported in the CSA - MaxForce applications, in an arrangement as shown below. The drive is configured for motion using a CSA - MaxForce Commissioning GUI (see Section 4.4.1.2 and documentation provided on the Distribution Disk). The parameter database for the CSA - MaxForce applications may vary. Consult End-User documentation or Moog Application Engineering for further details.

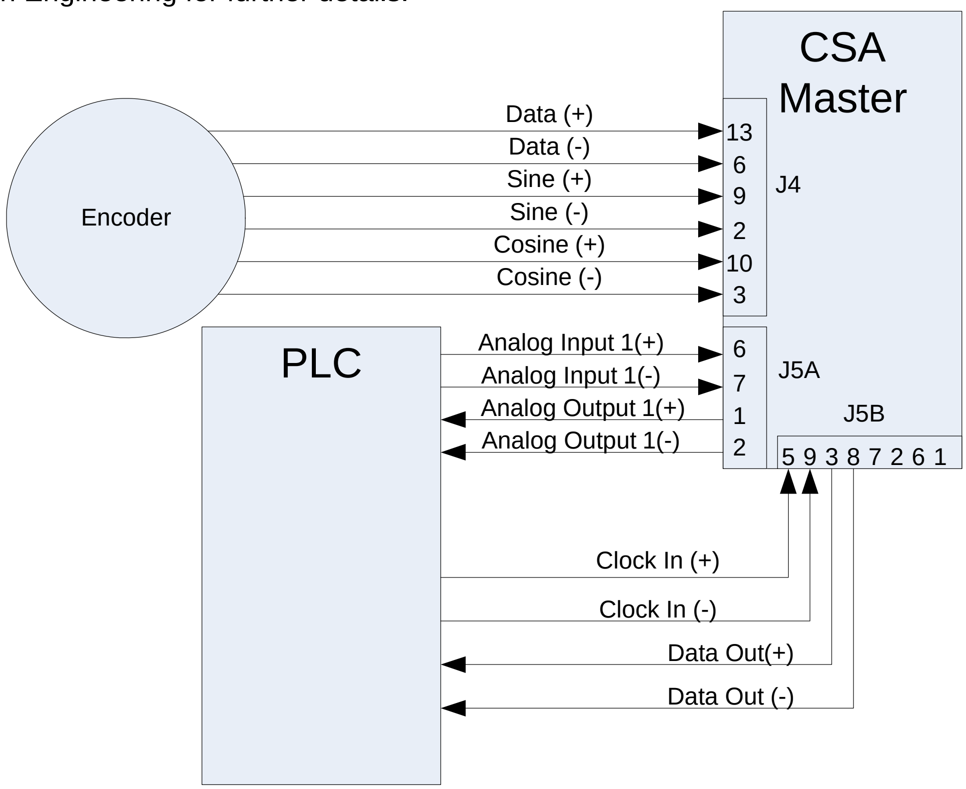


Figure E-6 Block Diagram

Refer to the PLC/Controller manual for descriptions of connectivity as it will vary between devices.

E.8 Noise Reduction

Twisted pair wiring ensures that both wires are subject to virtually identical external influence. This means cancellation of noise. Cable with external braided shielding and 360º termination allows for radiated noise to be conducted to ground via the braid rather than absorbed and conducted by the signal carrying wires. The braid should be terminated at the connector back shells on both ends of the cable.

Moog recommends the use of twisted pair in braided shielded cable for all low voltage wiring. Shields should be terminated at both connector backshells with 360 degree connection.

APPENDIX F. *DEVICENET™ MEZZANINE CARD*

F.1 Introduction

This appendix gives an overview of the capabilities of the DeviceNet^{TM} Mezzanine board for the CSA Servo Drive running the MaxForce application.

NOTE: Wiring a DeviceNet^{TM} Network correctly is not a trivial matter. All DeviceNet^{TM} wiring must be performed according to ODVA specifications to insure functionality and is the responsibility of the installer. Please refer to ODVA publication PUB00027R1 "*ODVA - Planning and Installation Manual - DeviceNet^{TM} Cable System*" for guidance.

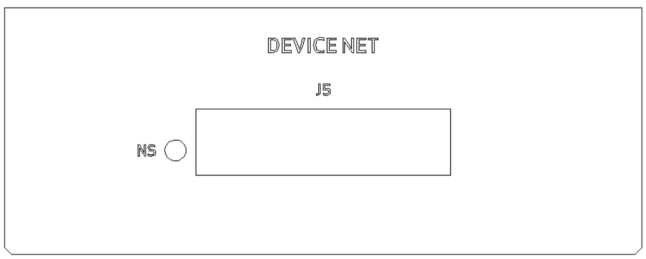


Figure F-1 DeviceNet Overlay

F.2 Connector Pinout

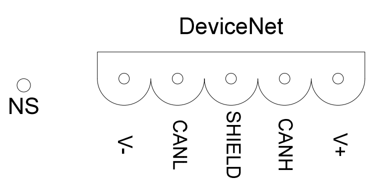


Figure F-2 DeviceNet Pinout

F.3 Network Status (NS) LED

Table F-1 network Status LEDs

LED status	**Description**
LEDs off	Drive Offline
Green LED On	Drive Online
Green LED blinking	Drive Online but no allocated by Master yet.
Red LED On	Error: Drive can not communicate (Duplicate MacID or Bus-Off error).

F.4 Available Objects

Table F-2 Available Objects

Object	Class ID	Instance	Description
Identity	1	1	Device Type, Vendor ID …
Message Router	2	1	-
DeviceNet	3	1	Contains network info of the node. MacID, Baud rate…
Assembly	4	4	Polled I/O info
Connection	5	2	-
MaxForce	0x70-0x78	1	MaxForce parameters. See Parameter list below for Class and Attributes.

F.5 MacID & Baud rate

MacID and Baud rate are software settable through the standard DeviceNet object.

- Default MacID is 63. Supported MacID's are 0-63.
- Default Baud rate is 125. Supported Baud rates are 125, 250 and 500.

F.6 Initial Motion Setup

For the motion to be controlled over the fieldbus the following setup must be done:

- On the 'System Setup' page, DeviceNet must be selected in the Fieldbus window, or the parameter '`fieldbus_interface`' must be set to 1.
- The Fieldbus Scaling Factors (see below) only influence Move 1, so Move 1 must be selected either through the digital inputs or by setting the parameter '`gui_profile_select`' to 1 or by setting the bit 0 in the '`cmnd_word`'.
- To start the motion, a start signal must be given either through the digital inputs, or by setting the parameter '`gui_start_cmnd`' to '1' or by setting bit 7 in the '`cmnd_word`'.
- Note that if the drive is power-cycled, '`gui_profile_select`', '`gui_start_cmnd`' and '`cmnd_word`' will revert back to 0, so these parameters must be set on every power-up.

Note that 'cmnd_word' and 'status_word' are available on the implicit I/O to ease PLC integration and minimize service channel (explicit messaging) traffic.

F.7 Fieldbus Scaling Factors

The 5 field bus scaling factors provides an easy, safe, way to command the drive over the fieldbus.
The scaling factors work on the set points of Move 1 as simple gain factors from 0 to 1.
Example:

- Move 1 Target position has been set to 100mm.
    - By varying the 'fieldbus_pos_scale_factor' between '0' and '1', the drive will position the actuator to any position between 0 and 100mm.

Note that a set point change only takes place if the 'start' command is 1. Leaving the START command at 1 turns the drive in to a command follower. The 'start' command can also be controlled over the fieldbus by writing to the 'gui_start_cmnd' parameter.

F.8 Units

The drive parameters are in engineering units. Based on the value of the UNITS parameter, the values are either interpreted as METRIC (0) or ENGLISH (1). Hence parameters written over the fieldbus must be written in the correct units.

F.9 PARAM_UPDATE_in

Parameters that pertain to the actuator performance, geometry and motion will not take effect on the drive unless the 'param_update_in' parameter is set to '1' and the drive is disabled and the drive is not faulted. This is a safety precaution to avoid unexpected actuator movement. The 'param_update_in' parameter will auto-reset to 0 after the drive has recalculated parameters.

F.10 Implicit I/O

The following parameters are available for Implicit I/O exchange. The parameters take up a total of 16 bytes for input and 16 bytes for output of Polled I/O. See the Parameter List table on the following pages for further detail on the parameters.

Table F-3 CSA DeviceNet Mezzanine Card Implicit I/O

Input to the Drive = Output from Scanner/PLC	Output from the Drive = Input to Scanner/PLC
CMND_WORD	STATUS_WORD
FIELDBUS_POS_SCALE_FACTOR	ACT_POS
FIELDBUS_VEL_SCALE_FACTOR	ACT_VEL
FIELDBUS_FORCE_SCALE_FACTOR	ACT_FORCE

F.11 Parameter Database Interface

The CSA - MaxForce DeviceNET Application(s) have an extensive parameter database. Consult End-User documentation or Moog Application Engineering for details on configuring a Drive for DeviceNET.

APPENDIX G. ETHERNET MEZZANINE CARD

G.1 Introduction

The CSA Servo-drive is available with an Ethernet interface supporting ETHERNET/IP and MODBUS/TCP. This interface can be used to perform the following functions:

- Parameterization and configuration.
- Low frequency, acyclic, control and status monitoring.

Parameterization and configuration is performed by reading or writing drive parameters individually via a request/response type mechanism.

Control and status monitoring are performed by reading or writing specific, pre-defined registers in the drive interface.

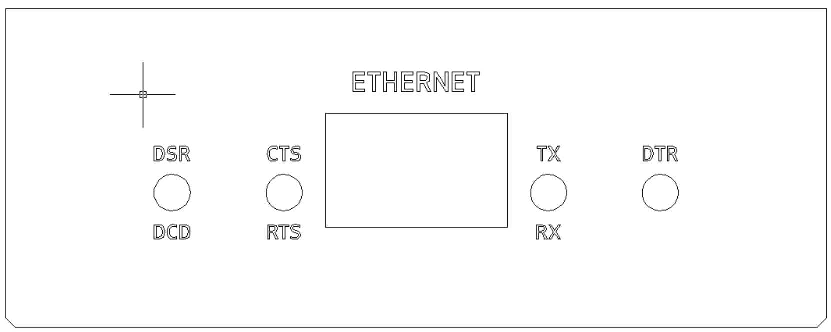


Figure G-1 Ethernet Mezzanine Card Indicators and Connector

- DCD............................Data Carrier Detect
- DSR............................Data Set Ready
- RTS............................Request to Send
- CTS............................Clear To Send
- RX..............................Receive Data
- TX...............................Transmit Data
- DTR............................Data Terminal Ready

G.2 Modes of Operation

There are two distinct modes of operation, configuration mode and IO mode. Only one mode is operational at any given time.

G.2.1 Configuration Mode

Due to the large number of parameters available within the drive, the registers are not mapped directly to all drive parameters but are instead mapped to a number of general purpose registers. In configuration mode the client can read and write data into these buffers over the network. The actual data that the client reads and writes is comprised of a proprietary MOOG protocol. This protocol enables access to all drive parameters via two application data units or packet types.

G.2.2 IO Mode

A subset of the drive parameter set is mapped directly to registers in the interface. A client can read or write this parameter set directly via reads and writes. A client performs a single read or write, to access a parameter or parameters mapped to the interface.

G.3 Changing IP Address for Ethernet Device

The default IP address is 192.168.0.100 when shipped from the factory unless otherwise stated in paperwork accompanying the drive. The Ethernet device uses a Static IP Address. Start-up your browser and access the device at this address, then click the ‘Edit’ button in the ‘Network Settings’ window:

Figure G-2 Changing IP Address

The IP Configuration shows up:

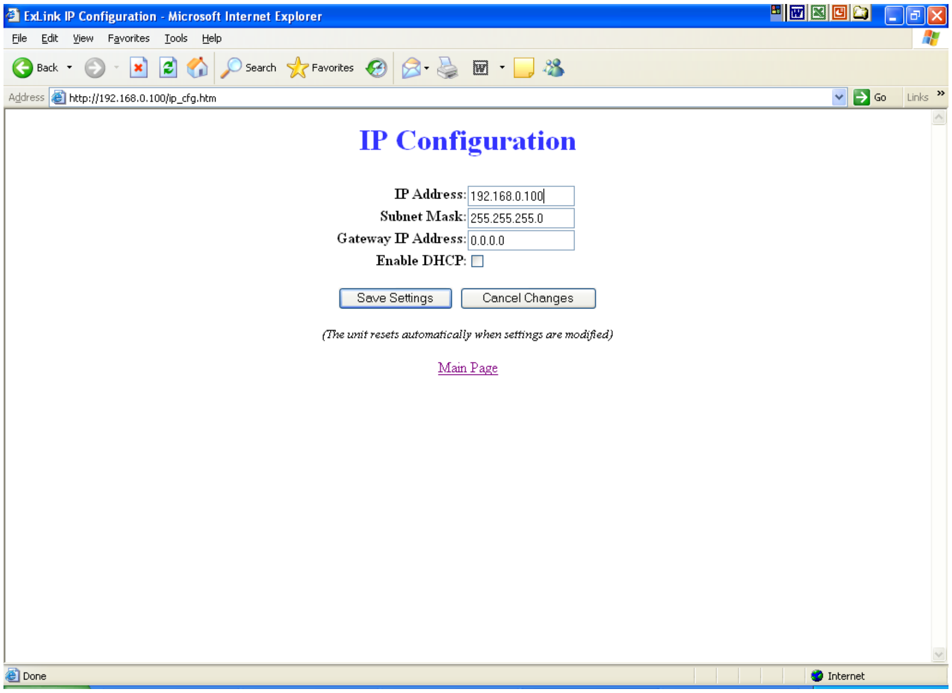


Figure G-3 IP Configuration Screen (1)

Change the IP Address to the desired value, then press the 'Save Settings' button. The unit will automatically reset to the new IP Address. Configuration is complete.

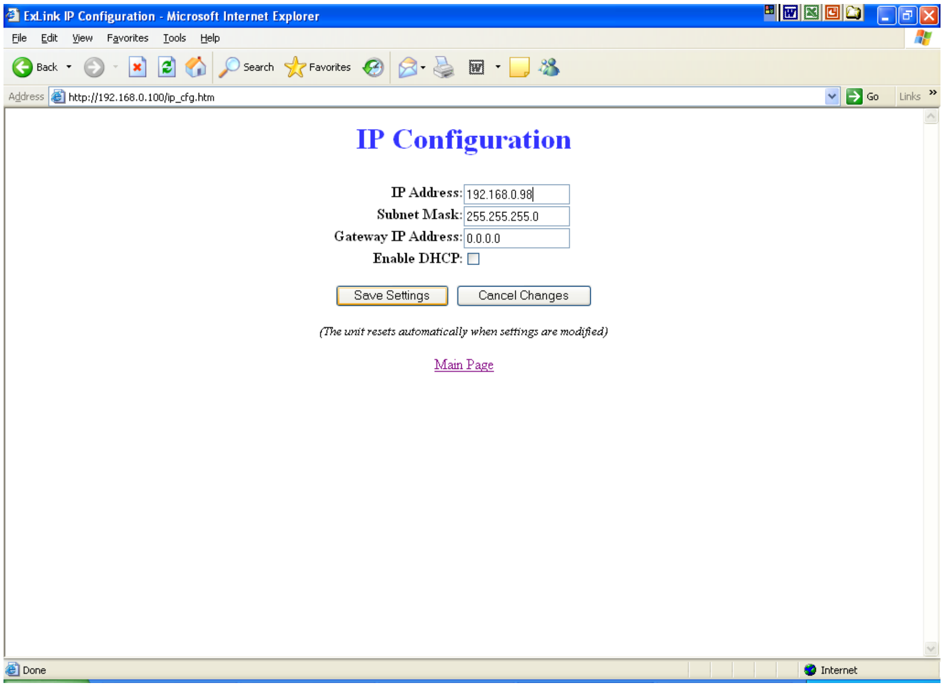


Figure G-4 IP Configuration Screen (1)

G.4 Changing Command and Status Registers

The EMA GUI will setup a default configuration with 4 Commands (inputs) and 4 Status words (outputs). A Maximum of 20 Commands and 20 Status words can be configured.

Access to the parameters is through the Ethernet Mapping page found on the Advanced Diagnostics page:

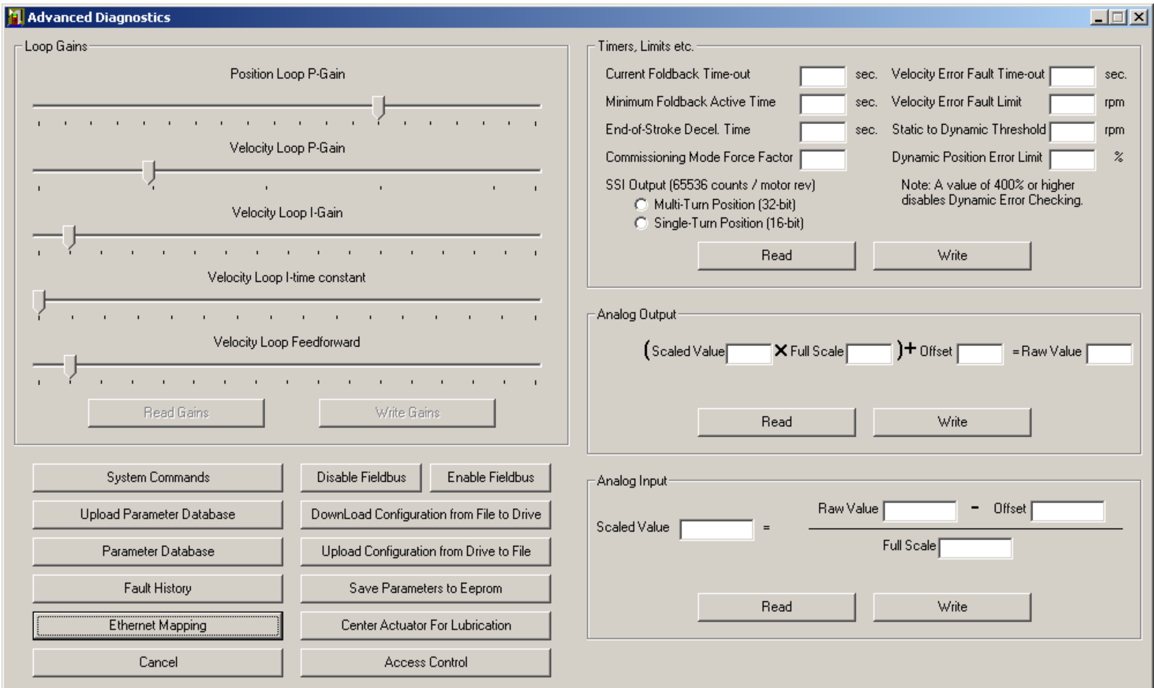


Figure G-5 Mapping Registers

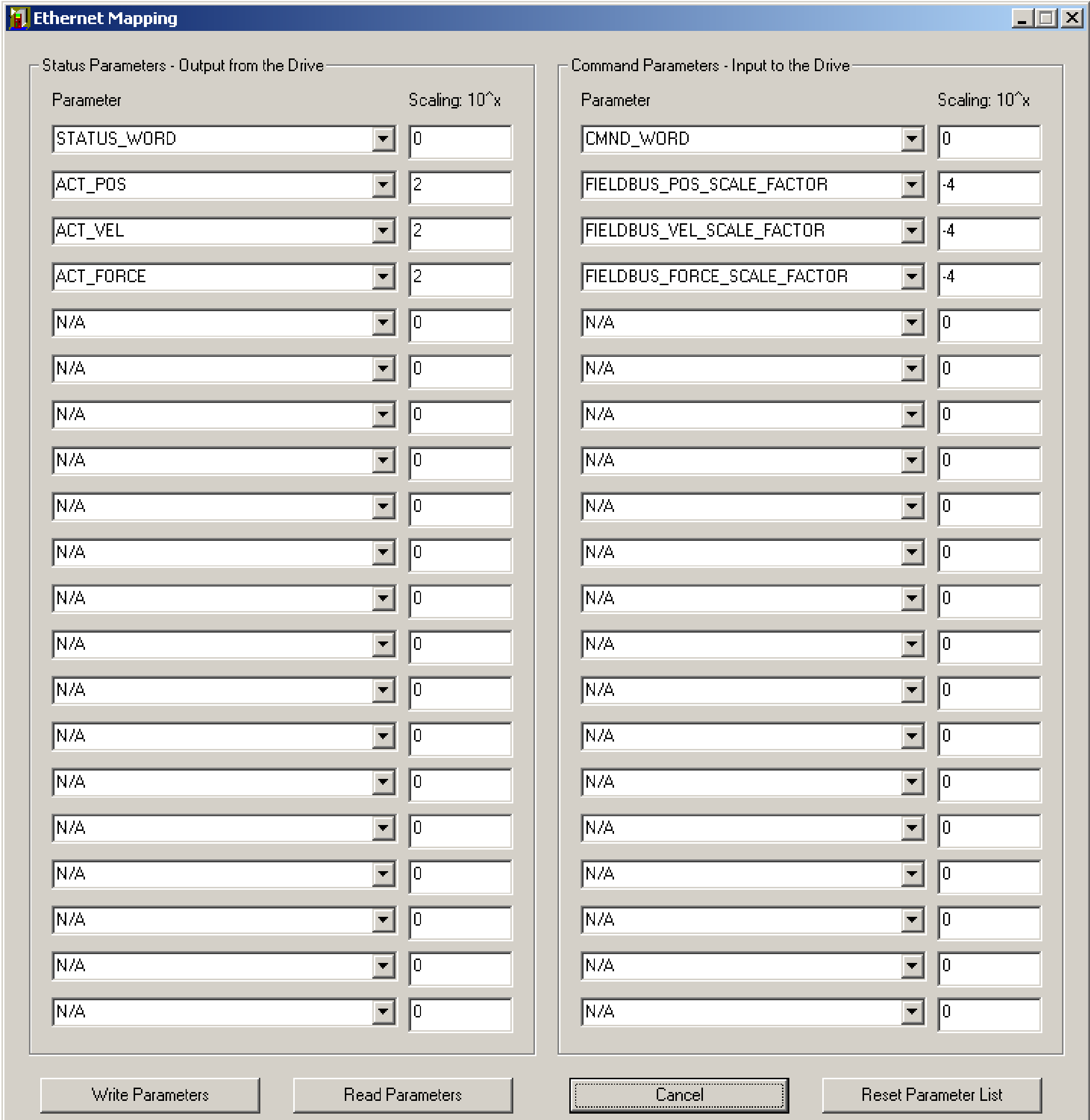


Figure G-6 Command Status Registers

- If you are sending back a floating point value, for example the actual position (ACT_POS - IDN 65300), then the parameter needs to be scaled to fit within the 16-bit boundary of a register.

- The scaling parameter is an exponent, so the resulting scaling factor will become 10 to the power of the value. A value of 2 for example will multiply the floating point value with 10^2 (=100). In other words an actual position of 1.23 would become 123 when sent. The Host or PLC on the receiving end must then divide by the same factor to convert the value back to floating point.

- When changing scaling, it is important to choose a value that does not result in integer overflow, as this might cause a Host/PLC to interpret values incorrectly.

- As can be seen, there is a separate scaling factor for each status parameter. Scaling is applied automatically, but you need to specify the scaling exponent.

- Follow the same recipe for setting or changing the Commands.
- Once configuration is complete the changes must be committed to NVM (Non-Volatile Memory) on the drive.
- The easiest thing to do is to close out the Ethernet Mapping and Advanced Diagnostics pages and press the configuration download button (Green Arrow pointing DOWN) in top-left corner of the GUI. This will download parameter values and perform a NVM save to the drive.

G.5 Allen-Bradley RSLogix Configuration with CSA

When connected to the PLC from RSLogix you should see the Ethernet module in the I/O configuration tree as shown below.

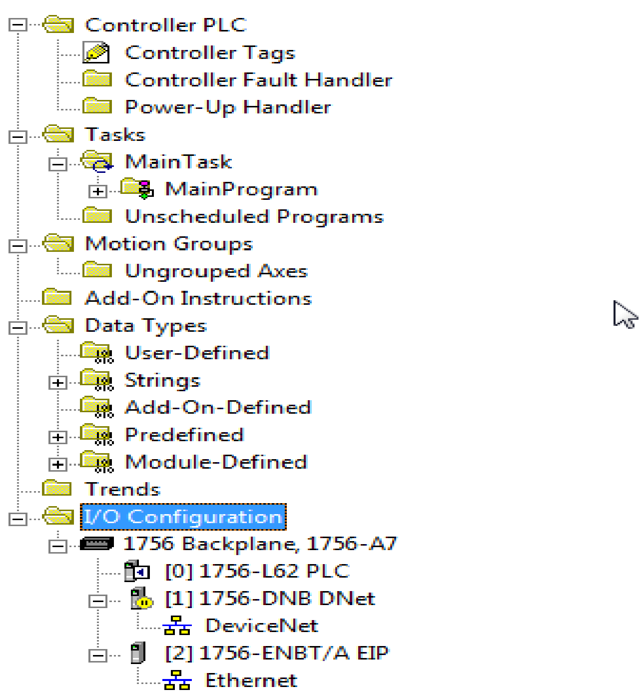


Figure G-7Configuration Tree

- Right click on the Ethernet icon and select new module.

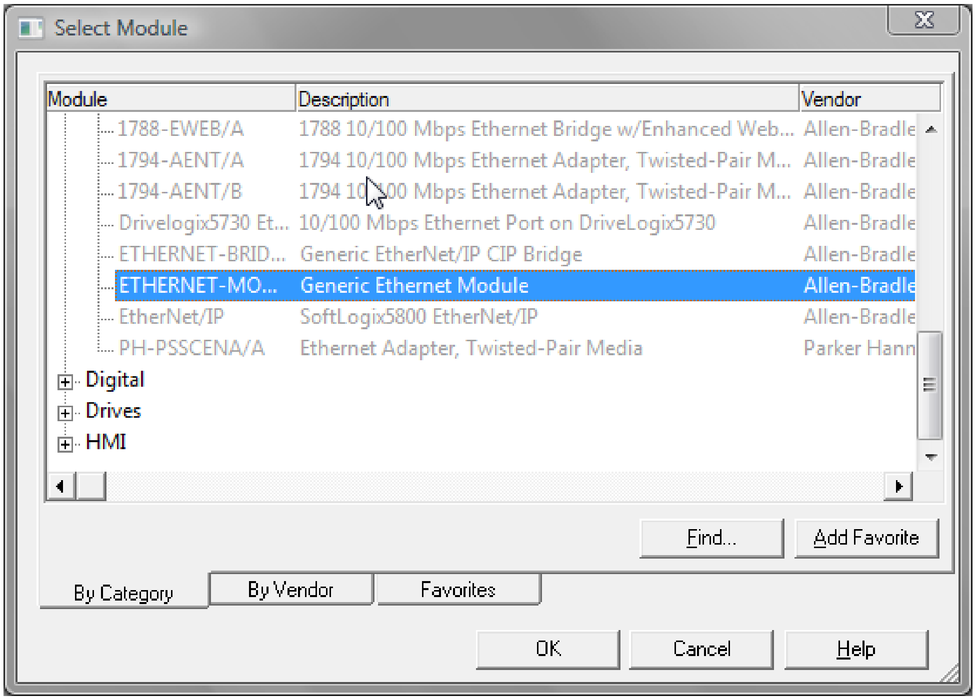


Figure G-8 Module Select

- Select Generic Ethernet Module.
- Set properties exactly as shown, using the actual IP Address of the Ethernet device:

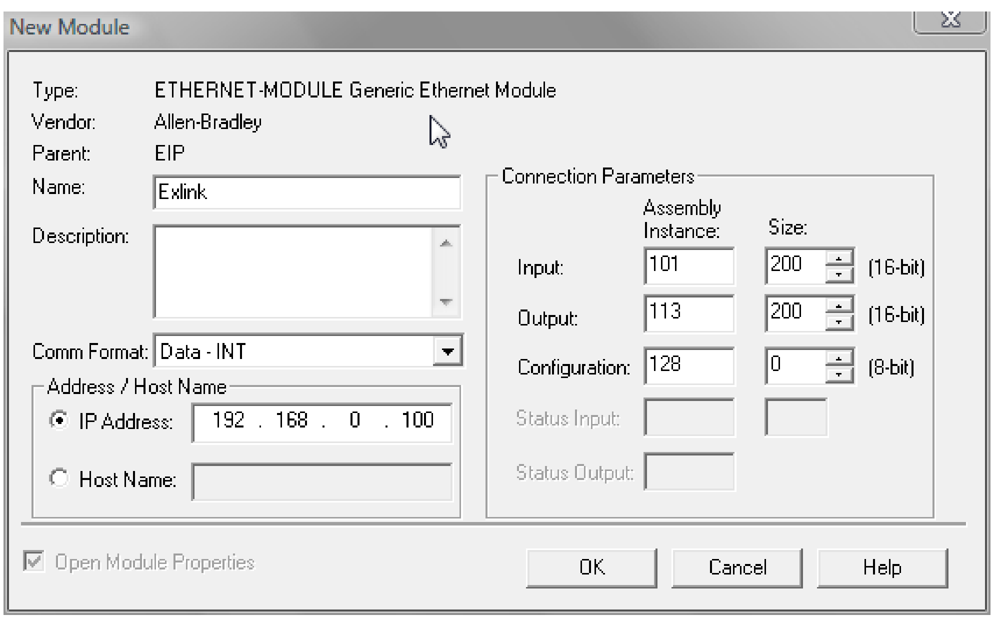


Figure G-9 New Module

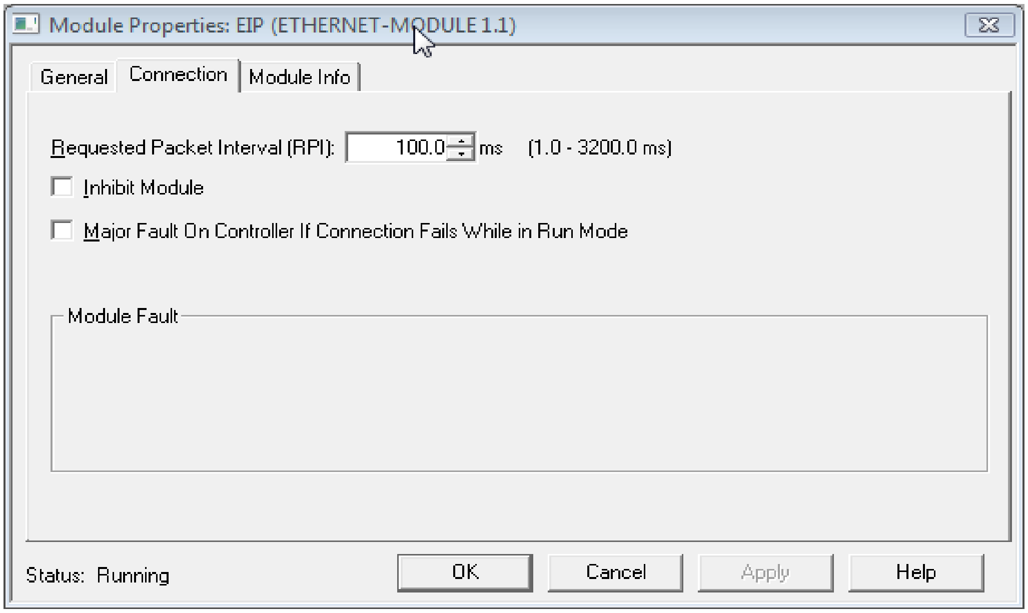


Figure G-10 Module Properties

- Double click on controller tags:

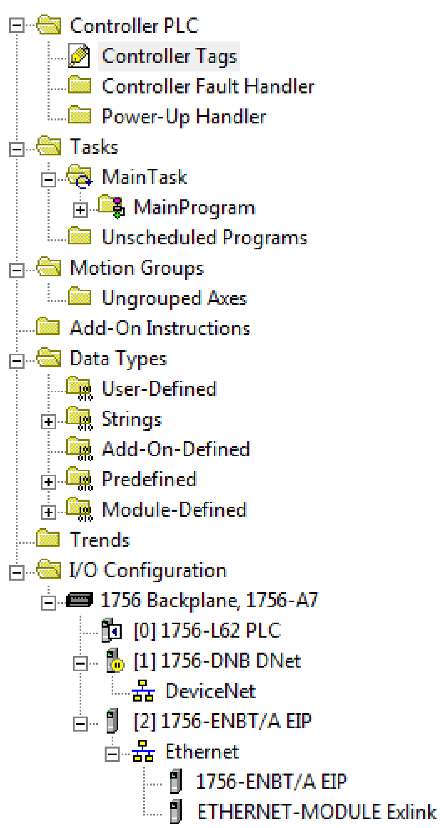
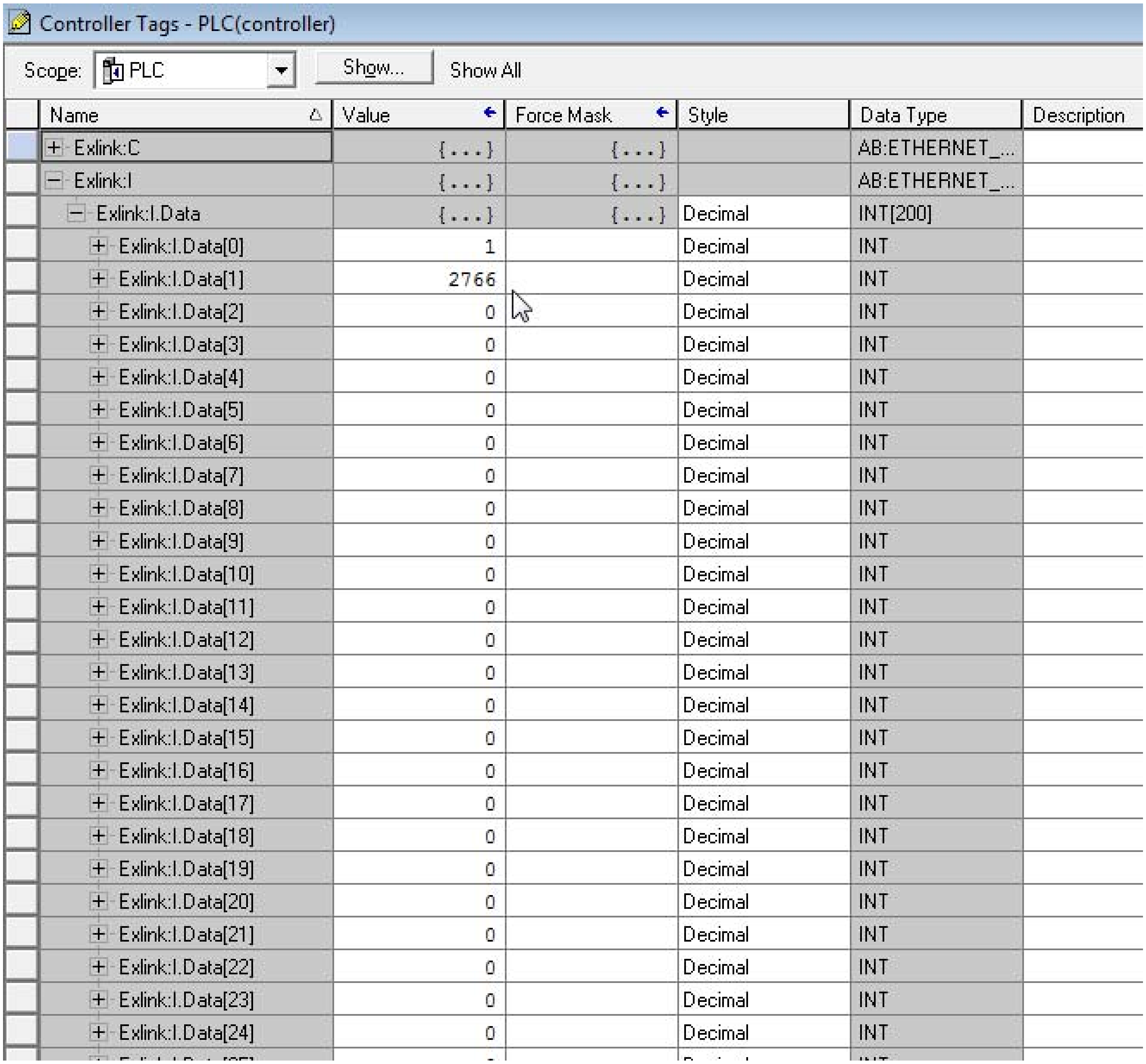


Figure G-11Controller Tags Tree

- You can now see live Ethernet IO data in the tag database as shown:


Controller Tags - PLC(controller)

Scope: PLC Show... Show All

Name	Value	Force Mask	Style	Data Type	Description
+ Exlink:C	{...}	{...}		AB:ETHERNET_...	
− Exlink:I	{...}	{...}		AB:ETHERNET_...	
− Exlink:I.Data	{...}	{...}	Decimal	INT[200]	
+ Exlink:I.Data[0]	1		Decimal	INT	
+ Exlink:I.Data[1]	2766		Decimal	INT	
+ Exlink:I.Data[2]	0		Decimal	INT	
+ Exlink:I.Data[3]	0		Decimal	INT	
+ Exlink:I.Data[4]	0		Decimal	INT	
+ Exlink:I.Data[5]	0		Decimal	INT	
+ Exlink:I.Data[6]	0		Decimal	INT	
+ Exlink:I.Data[7]	0		Decimal	INT	
+ Exlink:I.Data[8]	0		Decimal	INT	
+ Exlink:I.Data[9]	0		Decimal	INT	
+ Exlink:I.Data[10]	0		Decimal	INT	
+ Exlink:I.Data[11]	0		Decimal	INT	
+ Exlink:I.Data[12]	0		Decimal	INT	
+ Exlink:I.Data[13]	0		Decimal	INT	
+ Exlink:I.Data[14]	0		Decimal	INT	
+ Exlink:I.Data[15]	0		Decimal	INT	
+ Exlink:I.Data[16]	0		Decimal	INT	
+ Exlink:I.Data[17]	0		Decimal	INT	
+ Exlink:I.Data[18]	0		Decimal	INT	
+ Exlink:I.Data[19]	0		Decimal	INT	
+ Exlink:I.Data[20]	0		Decimal	INT	
+ Exlink:I.Data[21]	0		Decimal	INT	
+ Exlink:I.Data[22]	0		Decimal	INT	
+ Exlink:I.Data[23]	0		Decimal	INT	
+ Exlink:I.Data[24]	0		Decimal	INT	

Figure G-12 Controller Tags

In this example, you can write data to the “Exlink: O: Data” tags to send data to the “Exlink”.

For a simple example program which is configured to send commands to 3 CSA drives with Ethernet devices, see the MOOG_CSA_3_ETHERNET.ACD Logix program enclosed on the MOOG Maxforce Documentation and Software CD.

For specific implementation, contact Moog Application Engineering.

APPENDIX H. ETHERCAT FIELDBUS OPERATION

H.1 Introduction

The following appendix is intended as an introduction and subsequent overview of the CSA EtherCAT Mezzanine Control Stage (C96255-X-8XX-X-XXX) \ CSA EtherCAT Servo Drive (G362-XXX-8XXX-XXXX).

Please consult Moog ICD Sales or a Moog Distributor for application specific ordering information.

The initial sections outline the EtherCAT mezzanine card connections and indicator LEDs available to the user and conform to EtherCAT Indicator and Labelling specification [ETG.1300.S (R) V1.0.1]
The subsequent sections describe the services provided by the CSA Servo Drive with an EtherCAT mezzanine card attached in compliance with the EtherCAT Application Layer protocol [ETG.1000.6] and the EtherCAT Implementation Guide for CiA402 Drive Profile [ETG.6010 G (D) V0.24].

Explicit Device Identification, as defined in section 18.4.1 of the EtherCAT Protocol Enhancements [ETG.1020 S ® V1.0.0] is supported which allows the master to read the hex rotary switch id value of the drive while in the INIT state.

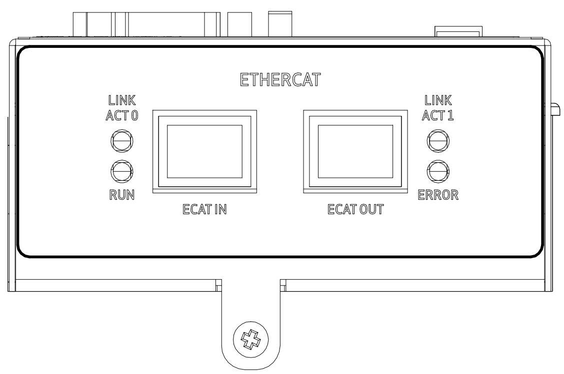


Figure H.1 CSA Servo Drive with EtherCAT Mezzanine card, (End View)

Table H-1 EtherCAT Fieldbus Features

Bus Power Cyclic Redundancy	Maximum Devices	Synchronisation	Sub-Millisecond cycle
Yes	65536	Yes	Yes

H.2 EtherCAT Ports

The EtherCAT interface on the CSA Servo Drive involves the use of two 8 contact RJ45 connectors as Ports without removable connectors that may be interfaced in different topologies (Tree, Star, Ring etc.) with other Servo drives such that their ports contact directly.

The Ports available are outlined in *Table H-2 CSA Servo Drive with EtherCAT Mezzanine card, Connectors*

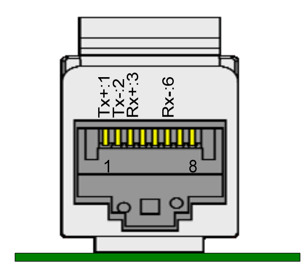
Table H-2 CSA Servo Drive with EtherCAT Mezzanine card, Connectors

Port	Function	Type	Interface	Transmission	Transmission Rate
ECAT IN	*EtherCAT Port ‘0’,	RJ45	4-wire Twisted pair	CAT 5 100-Base-Tx	100MBit\s
ECAT OUT	EtherCAT Port ‘1’	RJ45	4-wire Twisted pair	CAT 5 100-Base-Tx	100MBit\s

* Port directly in front of the EtherCAT processing unit

Table H-3 CSA Servo Drive with EtherCAT Mezzanine card, Connector Pinout

Connector Pin	Function	Interfacing Cable Wire Color
1	EtherCAT Transmit Positive	Orange (Yellow)\White
2	EtherCAT Transmit Negative	Green\White
3	EtherCAT Receive Positive	Orange
4	Common Mode	
5	Common mode	
6	EtherCAT Receive Negative	Green
7	Common Mode	
8	Common mode	
Housing	Shield	-



- Flexible and inexpensive standard Ethernet Cat 5 patch cables in accordance with ‘ANSI/TIA/EIA-568-B.1’ to transfer the signals in Ethernet mode (100BASE-TX).
- Wire colors in *Table H-3 CSA Servo Drive with EtherCAT Mezzanine card, Connector Pinout* are standardised as per IEEE 802.3 for Ethernet.
- Recommended EtherCAT Network Cables, RJ45-RJ45
  - o 0.3 Metres XS5W-T421-AMD-K
  - o 0.5 Metres XS5W-T421-BMD-K
  - o 1 Metres XS5W-T421-CMD-K
  - o 15 Metres XS5W-T421-KMD-K

EtherCAT had been integrated into the international fieldbus standards IEC 61158 and IEC 61784-2 as well as into the drive profile standard IEC 61800-7.

H.3 EtherCAT LED Indicators

The LED indicators on the CSA Servo Drive provide an indication of the Fieldbus status and a means to visually inspect the interface. The LED indicators available to the user are as follows:

- LINK\ACT 0 ....Indicates the activity and status of link 0, Color = Green
- LINK\ACT 1 ....Indicates the activity and status of link 1, Color = Green
- Run ....Indicates the status of the slave controller, Color = Green
- Error ....Indicates watchdog timeouts and unsolicited state changes, Color = Red

The 'ERROR' LED is currently not used on the CSA Servo Drive mezzanine card and all EtherCAT Fieldbus faults are displayed as a fieldbus fault (F11) on the 7-segment display on the host control card

Table H-4 CSA Servo Drive with EtherCAT Mezzanine card, Link LEDs Indicator States

Link	Activity	Condition	Link\Activity Code	Requirement
Yes	No	Port Open	On	Mandatory
Yes	Yes	Port Open	Flickering	Mandatory
No	n/a	Port Closed	Off	Mandatory
Yes	Yes/No	Port Closed (Mode needs manual open)	Inverted Double Flash	Optional
No	No	Local PHY auto negotiation error	Single Flash	Optional
No	No	Remote PHY auto negotiation error	Double Flash	Optional
No	No	Unknown auto negotiation error	Triple Flash	Optional

Table H-5 CSA Servo Drive with EtherCAT Mezzanine card, Run LED Indicator States

Link	Slave State	Condition	Requirement
Off	Initialization	Device is in '**INIT**' State	Mandatory
Blinking	Pre-Operational	Device is in '**Pre-Op**' State	Mandatory
Single Flash	Safe-Operational	Device is in '**Safe-Op'** State	Mandatory
On	Operational	Device is in '**Op'** State	Mandatory
Flickering	Initialization\ Bootstrap	Device is booting and not yet entered the '**INIT**' State, or: the device is in '**BOOTSTRAP**' firmware download operation is in progress	Optional
Triple Flash	Device Identification	User can set this state from the master to locate the specific device	Optional

Table H-6 CSA Servo Drive with EtherCAT Mezzanine card, Error LED Indicator States

ERR State	Error Name	Description	Example	Requirement
On	Application controller failure	A critical communication error has occurred	Application controller is not responding anymore	Optional
N Flashes	Reserved	Reserved	-	Reserved
Triple Flashes	Reserved	Reserved	-	Reserved
Double Flash	Watchdog timeout	Watchdog timeout has occurred	Sync Watchdog timeout	Mandatory
Single Flash	Local Error	Salve device has changed the EtherCAT state Autonomously	Device changes its state from ‘**Op**’ to ‘**Safe-Op-Error’**	Mandatory
Blinking	Invalid Configuration	Configuration error	State change commended by Mater is not possible due to register or object settings	Mandatory
Flickering	Booting Error	‘**INIT**’ state reached but Error indicator bit is still set to ‘1’	Checksum Error	Optional
Off	No Error	EtherCAT communication is in working condition	-	Mandatory

H.4 Communication Services supported

Four separate communication services are supported in the ECAT device,

1. Configuration of communication/device specific parameters in devices’ Object Dictionary’s
2. Reception and Transmission of process data with minimum software overhead
3. Transmission of Emergency Messages from the ECAT device is supported
4. File Transfer to EtherCAT Enabled Drive

H.4.1 EtherCAT Communication

The following protocols, supported by the CSA - EtherCAT Drive software provide the communication services listed above. The File Transfer over EtherCAT (FoE) is only available for firmware and FPGA updates.

- CANopen over EtherCAT (**CoE**)
- File Transfer over EtherCAT (**FoE**)

Particular aspects of the support for these protocols depend on the state of the EtherCAT State Machine in the EtherCAT slave device. These dependencies are detailed below:

H.4.1.1 EtherCAT Communication State Machine

The communication state of the ECAT device is determined by the EtherCAT State Machine. The ECAT device's State Machine is controlled via its AL Control Register. The states of the EtherCAT State Machine are shown below:

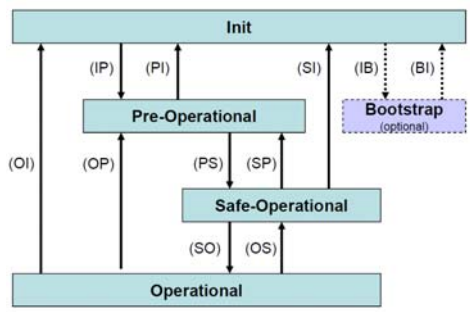


Figure H.2 EtherCAT State Machine

The support for the protocols listed above and their respective dependence on the state of the EtherCAT State Machine are presented in the following sections.

H.5 CANopen Over EtherCAT

CoE is used to support the configuration of communication and device parameters (including, the publication of the object dictionary of the device), the mapping and transfer of process data, the transmission of Emergency Messages. These are detailed in turn in the next sections.

H.5.1 Configuration of Objects

The configuration of the communication and device specific parameters in the ECAT device's Object Dictionary is done using CANopen Service Data Object (SDO) messages embedded in EtherCAT frames. The exchange of these SDO messages is allowed in the following states of the EtherCAT state machine

- Pre-Operational,
- Safe-Operational
- Operational states

CANopen SDO messages are incorporated into EtherCAT frames as shown below:

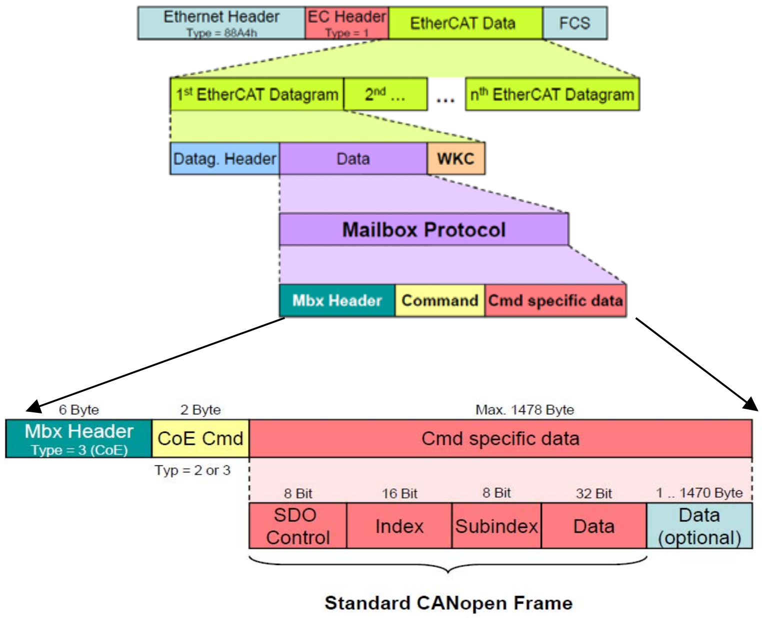


Figure H.3 Location of SDO Frame within an EtherCAT Frame

SDO messages that are sent from to the EtherCAT port using the ‘CoE SDO Request’ protocol. SDO messages message requests are responded to using the ‘CoE SDO Response’ protocol. In the case of an ‘Abort SDO Transfer’ message, the EtherCAT port responds with an ‘SDO Request’ as the CoE type.

The following CANopen SDO protocols are supported and discussed in the subsequent sections:

1) Abort SDO
2) Initiate SDO Download
3) Download SDO Segment
4) Initiate SDO Upload
5) Upload SDO Segment
6) Initiate SDO Block Upload
7) Upload SDO Block Segment

H.5.1.1 Abort SDO

The Abort SDO Transfer Protocol is supported by the CSA Servo Drive. This message is used by both the SDO server and SDO Client that a transfer is being aborted. Within an ‘Abort SDO Transfer’ message an error code contains specific information that can be interpreted by the receiving side to take further action.

This protocol is used to implement the Abort SDO Transfer Service.

Figure 22: Abort SDO Transfer Protocol

- **cs:** command specifier
  4: abort transfer request
- **X:** not used, always 0
- **m:** multiplexor. It represents index and sub-index of the SDO.
- **d:** contains a 4 byte abort code about the reason for the abort.

Figure H.4 Abort SDO Transfer Protocol

When an SDO Protocol message containing a parameter index/sub-index is received, the parameter specified by this index/sub-index is searched for in the SDO Server side's object dictionary parameter database. If a parameter with the specified index cannot be found an Abort SDO message is sent with the error code 0x06020000.

If the parameter with matching index does not have a sub-index corresponding to that specified in the received SDO message an Abort SDO message is sent with the error code 0x08000000, except in the case where the sub-index specified is '0'.

If the received SDO message contains a command byte that is not supported an 'Abort SDO' message is returned with error code 0x05040001.

H.5.1.2 Initiate SDO Download Protocol

The initial SDO download protocol is fully supported in the CSA Servo Drive and outlined below

H.5.1.2.1 General Error Cases

1. Where parameter access not allowed, an Abort SDO message is returned with error code as follows:

   - 0x06020000 – if neither read nor write access is allowed for the parameter being downloaded (i.e. as far as the user is concerned, the parameter is reported as not existing)
   - 0x06010002 – the parameter cannot be written to, with the current controller access level

H.5.1.3 Error Cases for Normal Transfer

Where ''Data Set Size' (S)' is indicated in the SDO request (S = '1') an Abort SDO message with error code 0x06070010 (invalid data type) is returned if the length specified in the message ("d field") does not match the length of the parameter as stored in the SDO server.

H.5.1.3.1 Error Cases for Expedited Transfer

1. Where ‘‘Data Set Size’ (S)’ is indicated in the SDO request (S = 1) an Abort SDO message with error code 0x06070010 (invalid data type) is returned in the following cases:

    - The parameter specified in the received message is larger is size than the number of data bytes that can be accommodated in an expedited transfer
    - The number of data bytes specified by the “n bit” does not match the size of the specified parameter

2. Where an SDO Abort message with another error code is returned if the write to the parameter fails, the error code sent depends on the particular failure of the write to the parameter.

This protocol is used to implement the Initiate SDO Download service for SDOs.

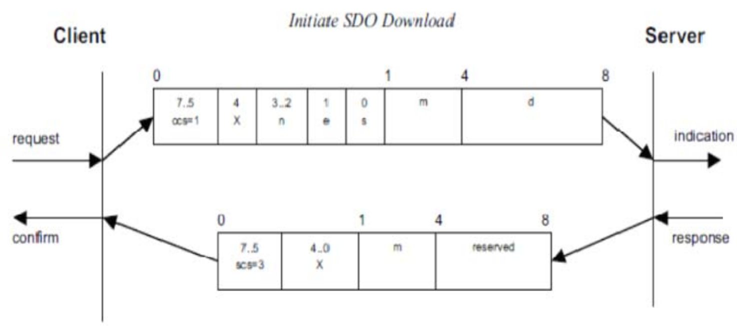


Figure 17: Initiate SDO Download Protocol

- **ccs:** client command specifier
  1: initiate download request
- **scs:** server command specifier
  3: initiate download response
- **n:** Only valid if e = 1 and s = 1, otherwise 0. If valid it indicates the number of bytes in d that do not contain data. Bytes [8-n, 7] do not contain data.
- **e:** transfer type
  0: normal transfer
  1: expedited transfer
- **s:** size indicator
  0: data set size is not indicated
  1: data set size is indicated
- **m:** multiplexor. It represents the index/sub-index of the data to be transfer by the SDO.
- **d:** data
  e = 0, s = 0: d is reserved for further use.
  e = 0, s = 1: d contains the number of bytes to be downloaded.
  Byte 4 contains the lsb and byte 7 contains the msb.
  e = 1, s = 1: d contains the data of length 4-n to be downloaded,
  the encoding depends on the type of the data referenced
  by index and sub-index
  e = 1, s = 0: d contains unspecified number of bytes to be downloaded
- **X:** not used, always 0
- **reserved:** reserved for further use, always 0

Figure H.5 Initiate SDO Download Protocol

H.5.1.4 Download SDO Segment Protocol

The Download SDO Protocol is fully supported in the CSA Servo Drive and outlined below

H.5.1.4.1 Error Cases

1. An Abort SDO message with error code 0x06020000 in following conditions:

   - Where toggle bit in the received message does not match that expected by the SDO Server.
   - Bit 'C' in the received message is set (indicating that this is the last segment) but more data is necessary in order to match the parameter size as stored in the SDO server.

2. An Abort SDO with another error code is sent if the write to the parameter fails following the complete reception of all segments successfully. The error code sent depends on the particular failure of the write to the parameter.

3. If a 'Download SDO Segment Protocol' message is expected from the Master because not all segments comprising the parameter have as yet been received, but an SDO message of another protocol is received, an Abort SDO with error code 0x05040001 (command error) is returned.

This protocol is used to implement the Download SDO Segment service.

Figure 18: Download SDO Segment Protocol

- **ccs:** client command specifier
  0: download segment request
- **scs:** server command specifier
  1: download segment response
- **seg-data:** at most 7 bytes of segment data to be downloaded. The encoding depends on the type of the data referenced by index and sub-index
- **n:** indicates the number of bytes in seg-data that do not contain segment data. Bytes [8-n, 7] do not contain segment data. n = 0 if no segment size is indicated.
- **c:** indicates whether there are still more segments to be downloaded.
  0 more segments to be downloaded
  1: no more segments to be downloaded
- **t:** toggle bit. This bit must alternate for each subsequent segment that is downloaded. The first segment will have the toggle-bit set to 0. The toggle bit will be equal for the request and the response message.
- **X:** not used, always 0
- **reserved:** reserved for further use, always 0

Figure H.6 Download SDO Segment Protocol

H.5.1.5 Initiate SDO Upload Protocol

The Initiate SDO Upload Protocol is fully supported in the CSA Servo Drive and outlined below

H.5.1.5.1 General Error Cases

1. Where parameter access not allowed, an abort SDO is returned with error code as follows:

   - 0x06020000 – if neither read nor write access allowed for the parameter being downloaded to (i.e. as far as the user is concerned, the parameter is reported as not existing)
   - 0x06010001 – parameter cannot be read with current access level

H.5.1.6 Error Cases for Normal Transfer

1. Where the parameter is 4 bytes or less in size, an SDO Abort message with an error code will be sent if the read of the parameter fails. The error code sent depends on the particular failure of the read of the parameter.

This protocol is used to implement the Initiate SDO Upload service.

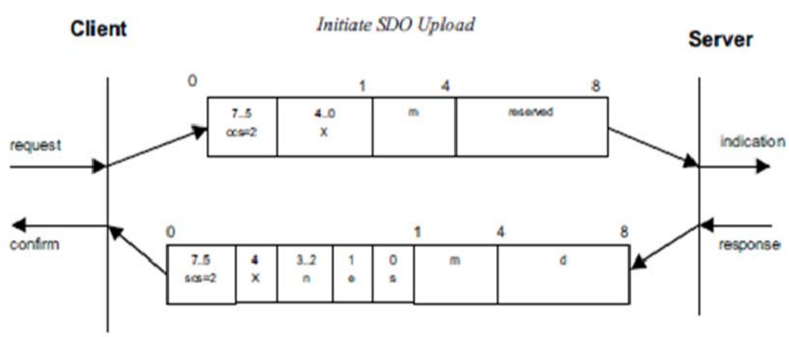


Figure 20: Initiate SDO Upload Protocol

- **ccs:** client command specifier
  2: initiate upload request
- **scs:** server command specifier
  2: initiate upload response
- **n:** Only valid if e = 1 and s = 1, otherwise 0. If valid it indicates the number of bytes in d that do not contain data. Bytes [8-n, 7] do not contain segment data.
- **e:** transfer type
  0: normal transfer
  1: expedited transfer
- **s:** size indicator
  0: data set size is not indicated
  1: data set size is indicated
- **m:** multiplexor. It represents the index/sub-index of the data to be transfer by the SDO.
- **d:** data
  e = 0, s = 0: d is reserved for further use.
  e = 0, s = 1: d contains the number of bytes to be uploaded.
  Byte 4 contains the lsb and byte 7 contains the msb.
  e = 1, s = 1: d contains the data of length 4-n to be uploaded,
  the encoding depends on the type of the data referenced
  by index and sub-index
  e = 1, s = 0: d contains unspecified number of bytes to be uploaded.
- **X:** not used, always 0
- **reserved:** reserved for further use , always 0

Figure H.7 Initiate SDO Upload Protocol

H.5.1.7 Upload SDO Segment Protocol

The Upload SDO Protocol is fully supported in the CSA Servo Drive and outlined below

H.5.1.7.1 General Error Cases

1. If an Upload SDO Segment Protocol message is expected from the Master because not all segments comprising the parameter have as yet been sent, but an SDO message of another protocol is received, an Abort SDO with error code 0x05040001 ('Command Error') is returned.

2. An Abort SDO message with error code 0x06020000 is sent where toggle bit in the received message does not match that expected by the SDO Server.

9.2.2.2.6 Upload SDO Segment Protocol

This protocol is used to implement the Upload SDO Segment service.

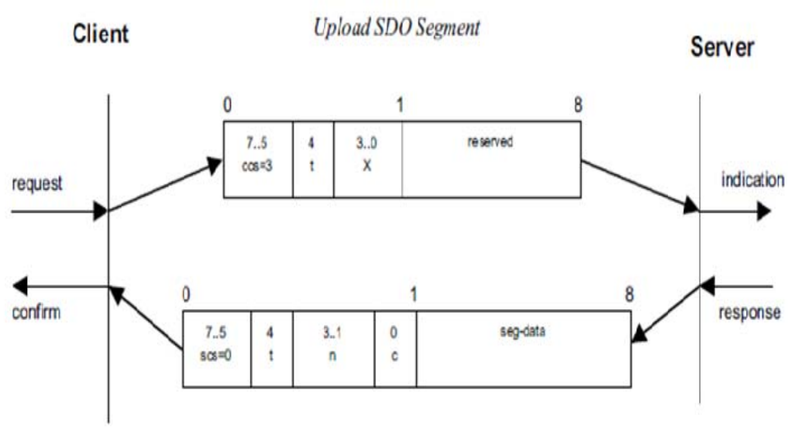


Figure 21: Upload SDO Segment Protocol

- **ccs:** client command specifier
  3: upload segment request
- **scs:** server command specifier
  0: upload segment response
- **t:** toggle bit. This bit must alternate for each subsequent segment that is uploaded. The first segment will have the toggle-bit set to 0. The toggle bit will be equal for the request and the response message.
- **c:** indicates whether there are still more segments to be uploaded.
  0: more segments to be uploaded
  1: no more segments to be uploaded
- **seg-data:** at most 7 bytes of segment data to be uploaded. The encoding depends on the type of the data referenced by index and sub-index
- **n**: indicates the number of bytes in seg-data that do not contain segment data. Bytes [8-n, 7] do not contain segment data. n = 0 if no segment size is indicated.
- **X**: not used, always 0
- **reserved:** reserved for further use, always 0

Figure H.8 Upload SDO Segment Protocol

H.5.1.8 Initiate SDO Block Upload Protocol

The Initiate SDO Block Upload Protocol is fully supported in the CSA Servo Drive and outlined below with the following restrictions:

- The client does not support generating CRC on data.
- No change of transfer protocol is allowed

H.5.1.8.1 General Error Cases

1. Where parameter access not allowed, an abort SDO is returned with error code as follows:

    - 0x06020000 – if neither read nor write access allowed for the parameter being downloaded to (i.e. as far as the user is concerned, the parameter is reported as not existing)

    - 0x06010001 – parameter cannot be read with current access level

2. An Abort SDO message with error code 0x05040001 is sent if the block size specified in the "`blksize`" field is outside the allowed limits (0< '`blksize`' < 128)

This protocol is used to implement the Initiate SDO Block Upload service. If the value of the Protocol Switch Threshold parameter indicated by the client in the first request is less or equal the data set size to be uploaded the server can continue with the SDO Upload Protocol as described in 9.2.2.2.4.

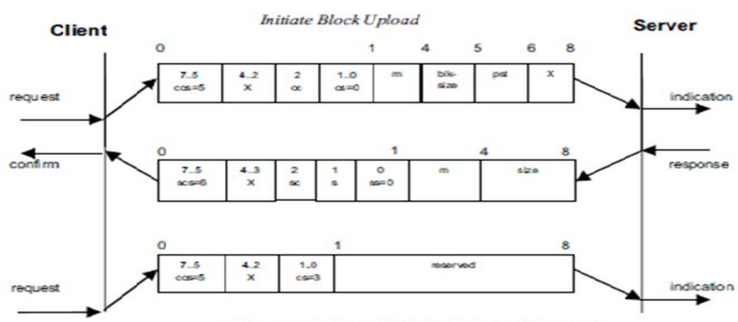


Figure 28: Initiate SDO Block Upload Protocol

- **ccs**: client command specifier
  5: block upload
- **scs:** server command specifier
  6: block upload
- **cs**: client subcommand
  0: initiate upload request
  3: start upload
- **ss**: server subcommand
  0: initiate upload response
- **m**: multiplexor. It represents the index/sub-index of the data to be transfer by the SDO.
- **cc**: client CRC support
  cc = 0: Client does not support generating CRC on data
  cc = 1: Client supports generating CRC on data
- **sc**: server CRC support
  sc = 0: Server does not support generating CRC on data
  sc = 1: Server supports generating CRC on data
- **pst**: Protocol Switch Threshold in bytes to change the SDO transfer protocol
  pst = 0: Change of transfer protocol not allowed.
  pst > 0: If the size of the data in bytes that has to be uploaded is less or equal pst the server can optionally switch to the 'SDO Upload Protocol' by transmitting the server response of the 'SDO Upload Protocol' as described in 9.2.2.2.4.
- **s**: size indicator
  0: data set size is not indicated
  1: data set size is indicated
- **size**: upload size in bytes
  s = 0: size is reserved for further use, always 0
  s = 1: size contains the number of bytes to be downloaded
  Byte 4 contains the lsb and byte 7 the msb
- **blksize:** Number of segments per block with 0 < blksize < 128.
- **X:** not used, always 0
- **reserved:** reserved for further use, always 0

Figure H.9 Initiate SDO Block Upload Protocol

H.5.1.9 Upload SDO Block Segment Protocol

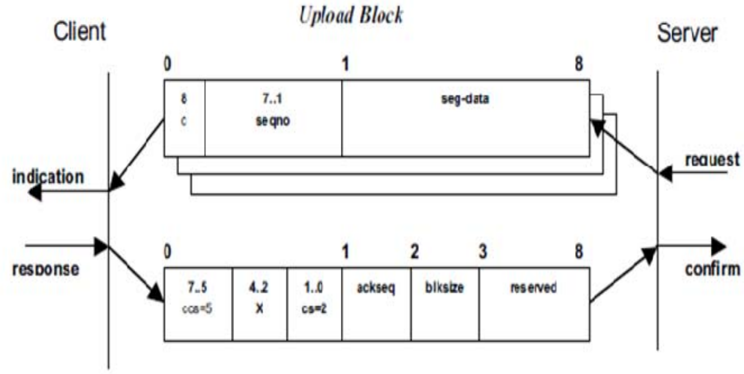
The Upload SDO Block Protocol is fully supported in the CSA Servo Drive and outlined below

H.5.1.9.1 General Error Cases

1. An Abort SDO message with error code 0x05040001 is sent if the block size specified in the ‘ackseq’ field does not match the sequence number of the last segment sent in the last block.

This protocol is used to implement the SDO Block Upload service.

Figure 29: Upload SDO Block Segment Protocol



- **ccs:** client command specifier
  5: block upload
- **cs:** client subcommand
  2: block upload response
- **c:** indicates whether there are still more segments to be downloaded
  0: more segments to be uploaded
  1: no more segments to be uploaded, enter ‘End block upload’ phase
- **seqno**: sequence number of segment 0 < seqno < 128.
- **seg-data:** at most 7 bytes of segment data to be uploaded.
- **ackseq:** sequence number of last segment that was received successfully during the last block upload. If ackseq is set to 0 the client indicates the server that the segment with the sequence number 1 was not received correctly and all segments have to be retransmitted by the server.
- **blksize:** Number of segments per block that has to be used by server for the following block upload with 0 < blksize < 128.
- **X:** not used, always 0
- **reserved:** reserved for further use, always 0

Figure H.10 Upload SDO Block Segment Protocol

H.5.1.10 End SDO Block Upload Protocol

H.5.1.10.1 General Error Cases

There are no general error cases in this protocol in the CSA Servo Drive

9.2.2.2.15 End SDO Block Upload Protocol

This protocol is used to implement the End SDO Block Upload service.

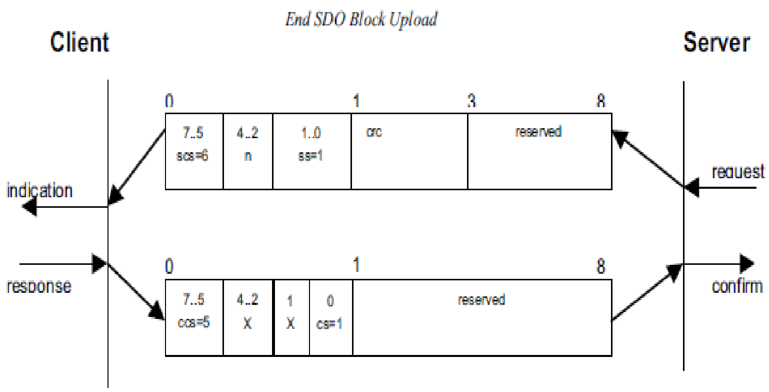


Figure 30: End SDO Block Upload Protocol

- **ccs:** client command specifier

  5: block upload
- **scs:** server command specifier

  6: block upload
- **cs:** client subcommand

  1: end block upload request
- **ss:** server subcommand

  1: end block upload response
- **n**: indicates the number of bytes in the last segment of the last block that do not contain data. Bytes [8-n, 7] do not contain segment data.
- **crc**: 16 bit Cyclic Redundancy Checksum (CRC) for the whole data set. The algorithm for generating the CRC is described in 9.2.2.2.16. CRC is only valid if in Initiate Block Upload cc and sc are set to 1 otherwise crc has to be set to 0.
- **X:** not used, always 0
- **reserved:** reserved for further use, always 0

Figure H.11 End SDO Block Upload Protocol

H.5.1.11 Initiate SDO Block Download Protocol

This protocol is not supported in the CSA Servo Drive

H.5.1.12 Download SDO Block Segment Protocol

This protocol is not supported in the CSA Servo Drive

H.5.1.13 End SDO Block Download Protocol

This protocol is not supported in the CSA Servo Drive

H.5.2 SDO Info Protocol

The ECAT device supports the SDO Info services. These can be used to get details of the Object Dictionary in the ECAT device. The following services are provided by the protocol:

1. Get Object Dictionary List
2. Get Object Description
3. Get Entry Description
4. Error Notification

H.5.3 Get Object Dictionary List

This service allows the uploading of the count and indices of parameters in the ECAT device that match specific criteria. The criteria are:

- Parameters that can be mapped into RX and/or TX Process Data Objects (PDOs),
- Parameters that are stored in non-volatile memory
- Parameters whose value is available for setting after when the system starts.

H.5.4 Get Object Description

This service allows the name and description of any object dictionary entry identified by an index to be read from the ECAT slave.

H.5.5 Get Entry Description

The service allows the following attributes of a parameter identified by an object dictionary index/sub-index to be read from the ECAT device:

- Data Type of the parameter.
- Access Rules for the parameter
- Whether or not it may be mapped into RX and/or TX PDOs
- Whether or not it is stored in non-volatile memory
- Whether or not it is available for settings after start-up
- Min/Max/default value
- Entry Description of the parameter

H.5.6 SDO Info Error Request

An SDO Info Error Request service is used by the ECAT device to indicate that an SDO Info Request failed, the reason being encoded in the SDO Info Error Request message.

H.5.7 Process Data

The mapping of objects into TX and RX PDOs allows the exchange of Process Data with minimal software overhead. This mapping is done using SDO messages sent over EtherCAT. Once the device's EtherCAT State Machine is switched into Operational Mode, the Process Data is exchanged as per the PDO mapping. The PDO messages are incorporated into EtherCAT frames as shown in *Figure H.12 Location of PDO process data frame within an EtherCAT Frame*

EtherCAT frame

Figure H.12 Location of PDO process data frame within an EtherCAT Frame

H.5.8 Emergency Notification

An emergency message is sent by the ECAT device in response to error conditions in the device. This message uses the CANopen Emergency Message format. Refer to [**Error! Reference source not found.**] for details of this format.

The location of the Emergency Message within an EtherCAT frame is shown below:

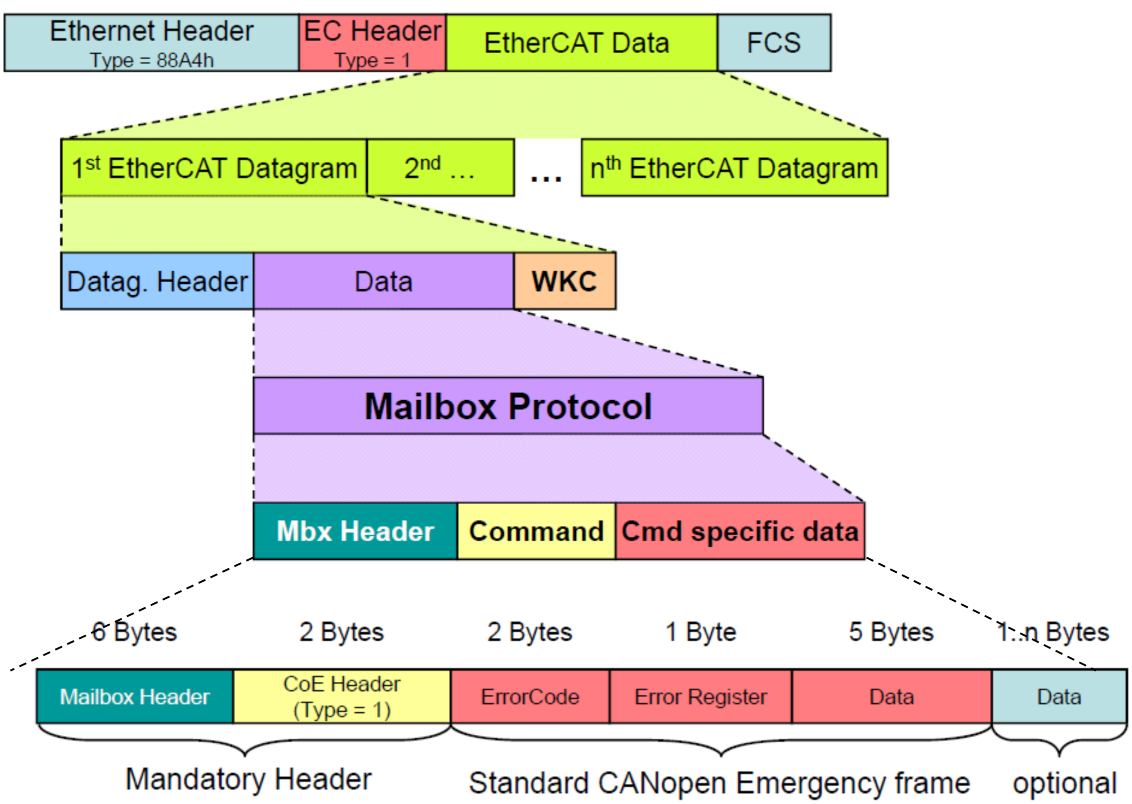


Figure H.13 Location of Emergency within an EtherCAT frame

H.5.9 CoE - Process Data Mapping

The selectable mapping of parameters into Process Data PDO's is supported by the CoE protocol implemented in the ECAT device. There are up to 4 PDO channels available for transmission and 4 PDO channels for reception of process data.

Each PDO channel in turn is capable of mapping up to 8 parameters. Each parameter can be up to 64bits in length with the restriction that the total sum of the lengths of all the parameters in a PDO channel is 256bits. An example valid configuration of mapping into a PDO channel would be as follows:

Table H-7 Example Process Data Mapping Size

PDO Entry	Size/bits
0	32
1	64
2	64
3	16
4	8
5	8
6	32
7	32
Total	**256**

The processing of received process data can be synchronous to a SYNC0 event or it may be free running depending on the configuration of the Slave.

H.6 FoE – File Transfer over EtherCAT

The FoE protocol is supported in the ECAT device. It operates when the EtherCAT State Machine is in Boot Mode. There is no use made of the password functionality in the FoE protocol (the password in the FoE message is simply ignored by the Slave).

H.6.1 File Write

The file write service of FoE supports the transfer of files to the ECAT device. The file is written to internal RAM and then programmed in flash by the bootloader upon an EtherCAT state change request from BOOTSTRAP to INIT. This facilitates efficient in-field updates of functionality. The names of the files that can be downloaded to the ECAT device are fixed as shown below.

Table H-8 Files available in ECAT device

Image	File Name
Bootloader	`botldr.dwn`
Application	`mtnect.dwn`
FPGA image	`fpgect.dwn`
Simulink Programming Model	`mtnmdl.dwn`
Simulink Programming Model (large)	`mtnmdl_lrg.dwn`

H.6.2 File Read

The protocol also supports the uploading of files from the ECAT device. As with the file write service, the files that can be uploaded are restricted to those above in *Table H-8 Files available in ECAT device*.

H.7 Default Configuration of PDO Services in ECAT device

In order to transfer parameters using Process Data In/Out, the following table details the settings that have been configured by default in order to support the use of one PDO transmit channel and one PDO receive channel. Each PDO channel currently supports the transfer of N parameters over the Process Data services.

Figure H.14 Default values for Sync Manager parameters

Parameter Name	Description	Default Value	Parameter Index/subindices
`smntypnum`	sync manager number of used channels	4	0x1C00-0
`smntypchn[4]`	sync manager channel configuration	{1,2,3,4} Mailbox Out(1) Mailbox In(2) Process Data Out(3) Process Data In(4)	0x1C00-1-2-3-4
`smnpd2num`	sync manager rxpdo assign number of objects	1	0x1C12-0
`smnpd2obj[4]`	sync manager rxpdo assign objects	{0x1600,0,0,0}	0x1C12-1-2-3-4
`smnpd3num`	sync manager txpdo assign number of objects	1	0x1C13-0
`smnpd3obj[4]`	sync manager txpdo assign objects	{0x1A00,0,0,0}	0x1C13-1-2-3-4

- Sync Manager 0 is configured as Mailbox Out (for CoE SDO Requests from Master)
- Sync Manager 1 configured as Mailbox (for CoE SDO Reponses from Slave)
- Sync Manager 2 used in to receive Process Data into the ECAT device
  - smntypchn[2] = 3 => configured as Process Data Out (i.e. in to ECAT device)
  - Source and amount of Process Data Out is configured using smnpd2num, smnpd2obj[4]
    - smnpd2num = 1 means only one PDO channel is mapped for TX from slave
    - smnpd2obj[4] = {0x1600,0,0,0} => map of the PDO is available in parameters pdonum0 and pdomap0 – refer to [x] for mapping format of PDO
- Sync Manager 3 used to transmit Process Data from the ECAT device
  - smntypchn[3] = 4 => configured as Process Data In (i.e. out from ECAT device)
  - Source and amount of Process Data Out is configured using smnpd2num, smnpd2obj[4]
    - smnpd2num = 1 means only one PDO channel is mapped for TX from slave
    - smnpd2obj[4] = {0x1A00,0,0,0} => map of the PDO is available in parameters pdonum4 and pdomap4 – refer to [x] for mapping format of PDO

Any changes to PDO mapping are detected in the transition from Pre-Operational to Safe Operational mode in the EtherCAT communication state machine.

H.8 Example Configuration of PDO Mapping

This example shows how to configure the EtherCAT CSA Servo Drive device in order to exchange parameters.

H.8.1 PDO mapping for Data Source → ECAT device

In this example the ECAT device will be configured to receive the following 32bit parameters as Process Data.

Table H-9 example parameters to be sent to ECAT device

Parameter Name	Description	Size
vwd	d-axis speed dependant voltage term	32 bit
vwq	q-axis speed dependant voltage term	32 bit
veq	back emf voltage	32 bit
vcd	d-axis compensator voltage	32 bit
vcq	q-axis compensator voltage	32 bit
vd	d-axis voltage demand	32 bit
vq	q-axis voltage demand	32 bit
va	alpha voltage demand	32 bit
vb	beta voltage demand	32 bit
xq	q-axis reactance	32 bit

There are ten, 32bit parameters to be received by the ECAT device. In DS301, only 8 bytes can be transferred per RX PDO channel but in the ECT device, the length of data that can be transferred in each RX PDO channel has been increased arbitrarily to 32. However, the restriction that only 8 parameters be mapped into an RX PDO channel still remains.

The first 8 parameters in the table above will therefore be mapped into RX PDO channel 0. The last two parameters will be mapped into another RX PDO Channel.

The first RX PDO channel corresponds to Receive PDO Mapping parameter 0x1600 and the second RX PDO channel to RX PDO Mapping parameter 0x1601. In order to activate the second RX PDO in the ECAT device, the following Sync Manager related parameters must be updated:

- `smnpd2num = 2 //` activate two PDO channels
- `smnpd2obj[4] = {0x1600, 0x1601, 0, 0} //` Specify the two PDO Rx Channels

H.8.1.1 Rx PDO Mapping

The RX PDO mapping parameter in CSA Servo Drive is written as follows:

Table H-10 RX PDO Channel mapping

Parameter (idx-subindex)	Value	Description
pdonum0 (0x1600-0)	8	Number of parameters mapped in RX PDO channel 0
pdomap0[8] (0x1600-1to (0x1600-8)	idx(vwd):sub(vwd):32 idx(vwq):sub(vwq):32 idx(veq):sub(veq):32 idx(vcd):sub(vcd):32 idx(vcq):sub(vcq):32 idx(vd):sub(vd):32 idx(vq):sub(vq):32 idx(va):sub(va):32	Map of parameters in format <16bits>:<8bits>:<8bits>
pdonum1 (0x1601-0)	2	Number of parameters mapped in RX PDO channel 1
pdomap1[8] (0x1601-1to (0x1601-8)	<16bits>:<8bits>:<8bits> idx(vb):sub(vb):32 idx(xq):sub(xq):32	Map of parameters in format <16bits>:<8bits>:<8bits>

Other DS301 RX PDO related parameters (e.g. the RX PDO Parameter PDO CommPar), are not used.

H.8.2 Parameters that ECAT device will transmit

In this example the ECAT device will be configured to send the following 32bit parameters as Process Data.

Table H-11 example parameters to be sent from ECAT device

Parameter Name	Description	Size
`stawrd`	State Machine Actual State	16bit
`anaip2raw`	Analogue Input 2, Raw	16bit

In this example, there are two, 16bit parameters to be transmitted. The two parameters will therefore be mapped into TX PDO channel 0 for transmission. No other TX PDO channel is required. Therefore the default values for `smnpd3num` and `smnpd3obj [4]` are as shown in *Table H-12 TX PDO Channel Mapping*.

The TX PDO channel is defined with the TX PDO Mapping parameter. The TX PDO mapping parameter is written as follows:

Table H-12 TX PDO Channel Mapping

Parameter	Value	Description
Pdonum4 (0x1A00-0)	2	Number of parameters mapped in TX PDO channel 0
Pdomap4[8] (0x1A00-1to (0x1A00-8)	idx(vwd):sub(vwd):32 idx(vwq):sub(vwq):32 0 0 0 0 0 0 0 0	Map of parameters in format <16bits>:<8bits>:<8bits>

Other DS301 TX PDO related parameters (e.g. the Receive PDO Parameter PDO CommPar), are not used.

H.9 DS402 Interface

The software in the CSA Servo Drive implements a subset of the DS402 profile

H.9.1 State Machine

The DS402 State Machine is implemented in the ECAT device. This is reproduced here for reference:

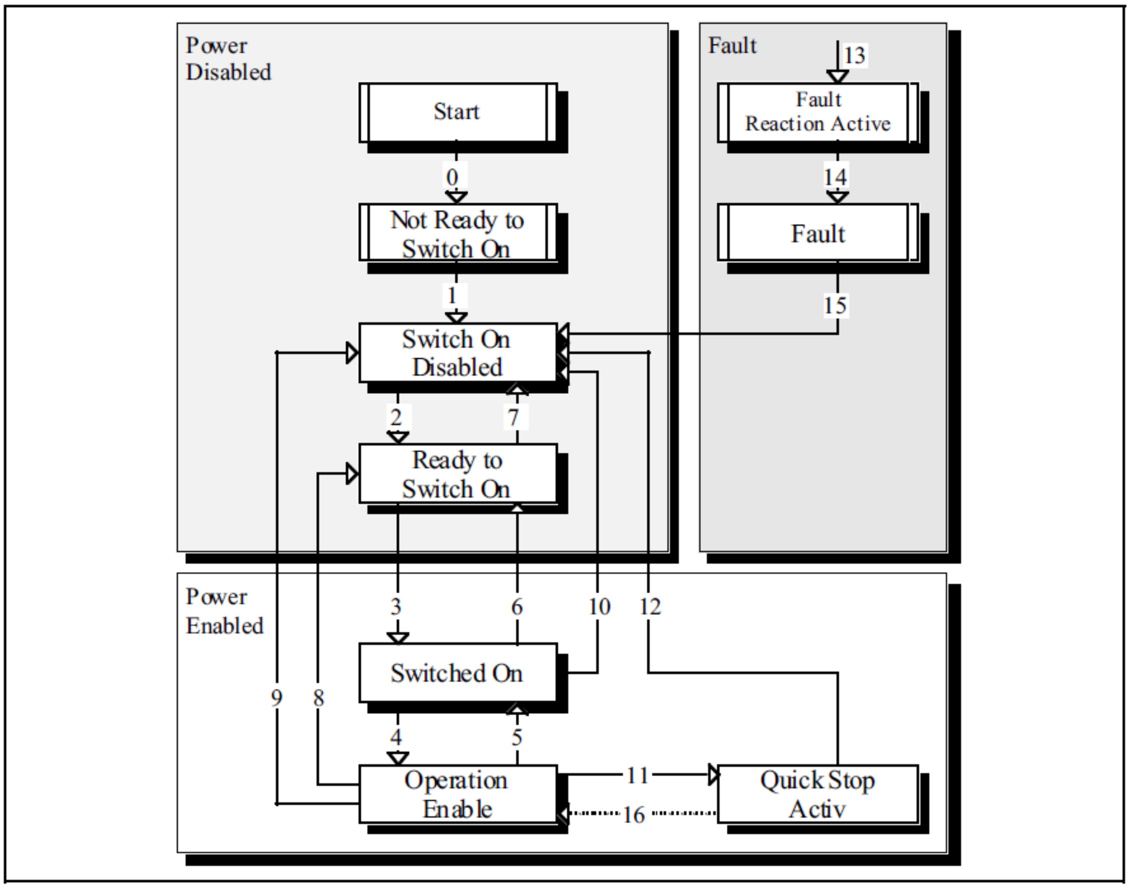


Figure H.15 The DS402 State Machine

Transitions within the DS402 state machine are controlled by the '`ctl402`' parameter. The state machine is available by reading the parameter '`sta402`'.

H.9.2 Supported Modes of Operation

The object definition for the “Supported Drive Modes” (0x6502) object ‘modoprsup’, is shown below. The actual modes supported and be determined by reading the value for this object. The CSA - EtherCAT configuration supports direct torque mode (cst bit 9), direct velocity mode (cst bit 8) and direct position mode (cst bit 7).

31 … 16	15 … 10	9	8	7	6	5	4	3	2	1	0
Manufacturer-specific	*r(eserved)*	*cst*	*csv*	*csp*	*ip*	*hm*	*r*	*tq*	*pv*	*vl*	*pp*
MSB											LSB

Figure H.16 “Supported drive modes” - Extended in 61800-7-201/FDIS object definition of Object 0x6502

H.9.2.1 Switching Modes

While there are no restrictions on switching modes while the device is in the enabled state, it is not recommended **NOT** to change modes while enabled.

H.9.3 Parameter Descriptions

Object	Sub-index	Name	Data Type	Category	Access	Mapping	value range	Unit	Remark	Windrive Name
0x6040	0	Control word	Unsigned 16	M	rw	PDO	refer table H-14 below	-	Drive Enable/Disable, Clear Fault, Quick Stop	ctl402
0x6060	0	Modes of Operation	Integer 8	O	rw	PDO	refer table H-13 below	-	Torque mode : +10, Velocity mode : +9	modopr
0x6071	0	Target torque	Integer 16	M	rw	PDO	-10000 to 10000	-	Current Command	ds4dtmtrqtar
0x6072	0	Max Torque	Unsigned 16	O	rw	PDO	0 to 65535	0.1A	Maximum Current	
0x6080	0	Max motor speed	Unsigned 32	O	rw	PDO	0 to 4294967295	0.001rad/sec	Maximum Velocity	
0x60FF	0	Target velocity	Integer 32	M	rw	PDO		-	Velocity Command	ds4vlmtarvel
0x603F	0	Error code	Unsigned 16	M	ro	SDO	refer table H-16	-		
0x6041	0	Status word	Unsigned 16	M	ro	PDO	refer table H-15	-	Current Fault, Use "FFxxh" for Unique Fault	
0x606C	0	Velocity actual value	Integer 32	M	ro	PDO		-	Drive Ready/Enable, Fault	sta402
0x6077	0	Torque actual value	Integer 16	M	ro	PDO		-	Actual Velocity	ds4vcvelact
0x6410	0	Motor Data		O						
	1	motor name	String	O	rw	SDO	64 characters max (incl term)			motnam
	2	motor poles	Unsigned 16	O	rw	SDO	min 2	-		motpol
	3	motor Rtt: terminal-to-terminal resistance	Float 32	O	rw	SDO	min 1.0e-9	Ohms		motrtt
	4	motor Lq: q-axis inductance	Float 32	O	rw	SDO	min 1.0e-9	henries		motlq
	5	motor Ld: d-axis inductance	Float 32	O	rw	SDO	min 1.0e-9	henries		motld
	6	motor ke: back emf factor	Float 32	O	rw	SDO	min 1.0e-9	volts/Rad/s		motke
	7	motor max current	Float 32	O	rw	SDO	min 0.1	A		motimax
	8	motor max velocity	Float 32	O	rw	SDO	0.0 to 20000.0	rad/s		motvelmax
	9	motor max velocity (increments)	Float 32	O	r	SDO		-		motvelmaxinc
	10	motor velocity limit	Float 32	O	rw	SDO	0.0 to 20000.0	rad/s		motvellim
	11	motor velocity limit (increments)	Float 32	O	r	SDO		-		motvelliminc
	12	motor max continuous rms current	Float 32	O	rw	SDO	0.1 to 1000.0	A		moticon
	13	motor copper mass	Float 32	O	rw	SDO		Kg		motmss
0x6502	0	Supported drive modes	Unsigned 32	O	r	PDO		-		modoprsup
0x6510		Drive data		O						
	1	brake lock to disable timeout (s)	Float 32	O	rw	SDO		s		brkbrgtimout
	2	Quickstop mode: bit 0=disable after Quickstop, bit 1	Unsigned 8	O	rw	SDO		-		qstmod
	3	internal loop demand	Signed 32	O	rw	PDO		unit on request (rqs) from CSA SD		demand
	5	torque max limit	Float 32	O	rw	SDO	0 to 10000	trq		trqmaxlim
	6	manual mode current limit: as percentage of max	Float 32	O	rw	SDO	0 to 100	pct		limmancur
	7	current limit mask	Unsigned 16	O	rw	SDO		-		limmsk
	8	standby velocity	Float 32	O	rw	SDO	0.05 to 1000	avl		velstdby
	9	velocity rampdown time limit (s) – Quickstop	Float 32	O	rw	SDO	0 to 1000.0	s		rmpdwntimqst
	10	velocity actual	Float 32	O	r	PDO		rqs		vel

	11	position actual	Signed 32	O	r	PDO		rqs		pos
	12	velocity command	Float 32	O	r	PDO		rqs		vcmd
	13	velocity command acceleration limited	Float 32	O	r	PDO		rqs		vcmdsav
	14	velocity filter cut-off factor	Float 32	O	rw	SDO	0 to 100.0	rqs		velfcf
	15	velocity filtered	Float 32	O	r	PDO		rqs		velf
	16	position feedback: 1-resolver 2-encoder	Unsigned 8	O	rw	SDO		-		posfbk
	17	acceleration limit	Float 32	O	rw	SDO	min 0	aac		acclimint
	18	brake fault control: bit 1=internal control	Unsigned 16	O	rw	SDO		-		errctl
	21	brake control: bit 1=internal control	Unsigned 16	O	rw	SDO		-		brkctlint
	22	manual mode velocity limit: as percentage of max	Float 32	O	rw	SDO	0 to 100.0	pct		limmanvel
	23	deceleration limit	Float 32	O	rw	SDO	min 0	aac		declimint
	24	velocity feedback: 1-resolver 2-encoder	Unsigned 8	O	rw	SDO	max 3	-		velfbk
	25	deceleration limit - Quickstop	Float 32	O	rw	SDO	min 0	aac		qstlimint
	26	deceleration limit - fault	Float 32	O	rw	SDO	min 0	aac		fltlimint
	27	enable to brake release timeout (s)	Float 32	O	rw	SDO		tim		brgbrktimout
	28	velocity maximum	Float 32	O	rw	SDO	0 to 20000.0	avl		velmaxint
	29	velocity maximum (increments)	Float 32	O	r	SDO		-		velmaxinc
	30	velocity limit	Float 32	O	rw	PDO	0 to 20000.0	avl		vellimint
	31	velocity positive limit (increments)	Float 32	O	r	SDO				vellimposinc
	32	velocity Rampdown time limit (s) - fault	Float 32	O	rw	SDO	0 to 1000.0	tim		rmpdwntimflt
0x6061	0	Modes of operation display	Integer 8	M	r	PDO		-		modoprdis
0x6089	0	Position notation index	Integer 8	O	rw	SDO		-		posexp
0x608A	0	Position dimension index	Unsigned 8	O	rw	SDO		-		posdim
0x608B	0	Velocity notation index	Integer 8	O	rw	SDO		-		velexp
0x608C	0	Velocity dimension index	Unsigned 8	O	rw	SDO		-		veldim
0x608D	0	Acceleration notation index	Integer 8	O	rw	SDO		-		accexp
0x608E	0	Acceleration dimension index	Unsigned 8	O	rw	SDO		-		accdim
0x608F	1	Position Encoder Resolution – Encoder increments	Unsigned 32	O	rw	SDO		-		posencinc
	2	Position Encoder Resolution – Motor revolutions	Unsigned 32	O	rw	SDO	min 1	-		posencrev
0x6090	1	Velocity encoder resolution – encoder increments per second	Unsigned 32	O	rw	SDO		-		velencinc
	2	Velocity encoder resolution – Motor revolutions per second	Unsigned 32	O	rw	SDO	min 1	-		velencrev
0x6091	1	Gear ratio – Motor revolutions	Unsigned 32	O	rw	SDO		-		geamot
	2	Gear ratio – shaft revolutions	Unsigned 32	O	rw	SDO	min 1	-		geasft
0x6092	1	Feed constant – feed	Unsigned 32	O	rw	SDO		-		fedpos
	2	Feed constant – Shaft revolutions	Unsigned 32	O	rw	SDO	min 1	-		fedsft
0x607E	0	Polarity	Integer 8	O	rw	PDO				ds4facpol
0x607A	0	Target position	Integer 32	M	rw	PDO		-		ds4tarpos
0x6064	0	Position actual value	Integer 32	M	r	PDO		-		ds4pcposact
0x6065	0	Following Window Error	Unsigned 8	O	rw	PDO				ds4poserrlim

0x60FB		Position control parameter set		O						
	1	position loop rate divider	Integer 16	O	rw	SDO	min 1	-		posdiv
	2	position PI loop p-gain	Float 32	O	rw	SDO	min 0	ppg		picposkp
	3	position PI loop i-gain	Float 32	O	rw	SDO	min 0	pig		picposki
	4	position PI loop error	Float 32	O	r	PDO		rqs		pcomp.error
	5	position TO loop error	Float 32	O	r	PDO		rqs		ptocomp.error
	6	position TO loop ka-gain	Float 32	O	rw	SDO	min 0	aac		tocposka
	7	position TO loop kp-gain	Float 32	O	rw	SDO	min 0	ppg		tocposkp
	8	position TO loop enable velocity integrator	Float 32	O	rw	SDO	min 0	ang		tocintincdel
0x60F9		Velocity control parameter set		O						
	1	velocity loop rate divider	Integer 16	O	rw	SDO	min 1	-		veldiv
	2	position mode velocity loop p-gain	Float 32	O	rw	SDO	min 0	vpg		picvelkp
	3	position mode velocity loop i-gain	Float 32	O	rw	SDO	min 0	vig		picvelki
	4	position mode velocity loop error	Float 32	O	r	PDO		rqs		vcomp.error
	5	velocity mode p-gain	Float 32	O	rw	SDO	min 0	vpg		pievelkp
	6	velocity mode i-gain	Float 32	O	rw	SDO	min 0	vig		pievelki
	7	velocity mode ie-gain	Float 32	O	rw	SDO	min 0	-		pievelkie
	8	velocity mode error	Float 32	O	r	PDO		rqs		vcompe.error
0x6076	00	Motor rated torque	Unsigned 32	O	rw	SDO		-		mottrq
0x60F7		Power Stage Parameters								
	1	switching frequency	Unsigned 32	O	rw	SDO	1000 to 10000	frq		swifrq
	2	current controller max	Float 32	O	rw	SDO	0.1 to 1000	cur		conimax
	3	imax	Float 32	O	r	SDO		cur		pwmfrq
	4	id	Float 32	O	r	PDO		cur		swifrq
	5	iq	Float 32	O	r	PDO		cur		imax
	6	idd	Float 32	O	r	PDO		cur		id
	7	iqd	Float 32	O	r	PDO		cur		iq
	8	current nominal sensed	Float 32	O	r	PDO		cur		inomsensed
	9	current actual	Float 32	O	r	PDO		cur		iqact
	10	current demand velocity comp output	Float 32	O	r	PDO		cur		iqdv
	11	current demand vel loop filter output	Float 32	O	r	PDO		cur		iqdf
	12	current demand pre thermal limiting	Float 32	O	r	PDO		cur		iqdu
	13	controller continuous rms current	Float 32	O	rw	SDO	0.1 to 1000	cur		conicon
	14	I2T Window size	Unsigned 32	O	rw	SDO		tim		i2ttw
	15	I2T Smoothing Factor	Unsigned 8	O	rw	SDO		-		i2tsmo
	16	I2T current limit	Float 32	O	r	SDO		cur		i2tlim
	17	bus voltage nominal	Float 32	O	rw	SDO		vlt		vdcnom
	18	yes bus voltage actual	Float 32	O	r	PDO		vlt		vdc
	19	pwm freq select 1=1x, 2=2x	Unsigned 32	O	rw	SDO	1 to 2	-		pwmfrq
0x60F6		Torque Control Parameters		O						
	1	current loop d-axis i-gain	Float 32	O	rw	SDO	min 0	rqs		dcomp.igain
	2	current loop d-axis p-gain	Float 32	O	rw	SDO	min 0	cpg		dcomp.pgain

	3	current loop q-axis i-gain	Float 32	O	rw	SDO	min 0	rqs		qcomp.igain
	4	current loop q-axis p-gain	Float 32	O	rw	SDO	min 0	cpg		qcomp.pgain
	5	current loop Foldback minimum	Float 32	O	rw	SDO	0.1 to 1.0	non		calkmin
	6	current loop Foldback breakpoint	Float 32	O	rw	SDO	1 to 2000.0	cur		calimin
	7	current loop d-axis error	Float 32	O	r	PDO		cur		dcomp.error
	8	current loop q-axis error	Float 32	O	r	PDO		cur		qcomp.error
	9	current loop alpha observer i-gain	Float 32	O	rw	SDO	min 0	rqs		oacomp.igain
	10	current loop alpha observer p-gain	Float 32	O	rw	SDO	min 0	cpg		oacomp.pgain
	11	current loop beta observer i-gain	Float 32	O	rw	SDO	min 0	rqs		obcomp.igain
	12	current loop beta observer p-gain	Float 32	O	rw	SDO	min 0	cpg		obcomp.pgain
	13	current loop alpha observer error	Float 32	O	r	PDO		cur		oacomp.error
	14	current loop beta observer error	Float 32	O	r	PDO		cur		obcomp.error
	15	motor velocity loop rate divider	Integer 16	O	rw	SDO	min 0	non		motveldiv
	16	motor velocity actual	Float 32	O	r	PDO		rqs		motvel
	17	motor velocity filter cut-off factor	Float 32	O	rw	SDO	0 to 100.0	rqs		motvelfcf
	18	motor velocity filtered	Float 32	O	r	PDO		rqs		motvelf
0x60B2	0	Torque offset	Integer 16	O	rw	SDO	-10000 to 10000	-		ds4dtmtrqofs
0x2606										
	1	position error limit	Unsigned 32		rw	SDO		-		poserrlim
	2	position limit min	Integer 32		rw	SDO		-		poslimmin
	3	position limit max	Integer 32		rw	SDO		-		poslimmax
	4	position range min	Integer 32		rw	SDO		-		posrngmin
	5	position range max	Integer 32		rw	SDO		-		posrngmax
	6	velocity max	Unsigned 32		rw	SDO		-		velmax
	7	velocity limit	Unsigned 32		rw	SDO		-		vellim
	8	acceleration max	Unsigned 32		rw	SDO		-		accmax
	9	acceleration limit	Unsigned 32		rw	SDO		-		acclim
	10	deceleration max	Unsigned 32		rw	SDO		-		decmax
	11	deceleration limit	Unsigned 32		rw	SDO		-		declim
	12	Quickstop deceleration limit	Unsigned 32		rw	SDO		-		qstlim
	13	torque limit	Unsigned 32		rw	SDO		-		trqlim
	14	motor max current	Unsigned 32		r	SDO		-		trqmax
	15	torque maximum	Unsigned 32		r	SDO		-		motcur
0x2B15										
	1	status1_dr1_g	Unsigned 8		r	PDO		-	Current Warning	
	2	status2_dr1_g	Unsigned 8		r	PDO		-		
	3	status3_dr1_g	Unsigned 8		r	PDO		-	Maximum Bridge Temperature	
	4	status4_dr1_g	Unsigned 8		r	PDO		-		
	5	status5_dr1_g	Unsigned 8		r	PDO		-		
	6	status1_mdl_g	Unsigned 8		r	PDO		-	Board Status Byte 4 - Exception	

									Status Byte 3	
	7	status2_mdl_g	Unsigned 8		r	PDO		-	Memory Status Byte 1 - Power Status Byte 2	
	8	status3_mdl_g	Unsigned 8		r	PDO		-	Software Status Byte 1 - Database Status Byte	
	9	status4_mdl_g	Unsigned 8		r	PDO		-	Fieldbus Status Byte - Interdrive Comms Status Byte	
	10	errfltgrp	Unsigned 32		r	PDO		-	Drive Status Byte 1 - Drive Status Byte 4	
	11	errwrngrp	Unsigned 32		r	PDO		-	Drive Status Byte 5 - Drive Status Byte 6	
	12	status6_dr1_g	Unsigned 8		r	PDO		-	General Status Byte - Board Status Byte 3	

Table H-13 EtherCAT Modes of Operation (only the shaded modes are supported)

Value	Definition
-128 to -1	Manufacturer Specific operation Modes
+0	No Mode/ No Mode Assigned
+1	Profile Position mode
+2	Velocity mode
+3	Profile velocity mode
+4	Torque profile mode
+5	Reserved
+6	Homing mode
+7	Interpolated position mode
+8	Cyclic Sync position mode
+9	Cyclic Sync velocity mode
+10	Cyclic Sync torque mode
+11 to +127	Reserved

Table H-14 EtherCAT Control Word

Command	Bits of Controlword					Transitions
	Bit 7	Bit 3	Bit 2	Bit 1	Bit 0	
Shutdown	0	X	1	1	0	2, 6, 8
Switch on	0	0	1	1	1	3
Switch on\ Enable Opeation	0	1	1	1	1	*3 + 4
Disable Voltage	0	X	X	0	X	7, 9, 10,12
Quickstop	0	X	0	1	X	7, 10, 11
Disable Operation	0	0	1	1	1	5
Enable Operation	0	1	1	1	1	4, 16
Fault Reset	↑	X	X	X	X	15

*Automatic transition to ‘Enable Operation State’ after executing ‘Switched On’ state functionallity

Table H-15 EtherCAT Status Word

Statusword	CSA FDS State
xxxx xxxx x0xx 0000b	Not Ready To Switch On
xxxx xxxx x1xx 0000b	Switch On Disabled
xxxx xxxx x01x 0001b	Ready To Switch On
xxxx xxxx x01x 0011b	Switched On
xxxx xxxx x01x 0111b	Operation Enabled
xxxx xxxx x00x 0111b	Quickstop Active
xxxx xxxx x0xx 1111b	Fault Reaction Active
xxxx xxxx x0xx 1000b	Fault

Emergency Messages are supported in the CSA - EtherCAT configuration and contain an Emergency Error Code, Emergency Error Register and Manufacturer Specific Error Code as shown below:

Table H-16 EtherCAT Emergency Message Contents

Emergency Error Code	**Description**	**Fault Code**	**Error Register** **Bit 0 - Generic Error (set to 1 on any error)** **Bit 1 - Current** **Bit 2 - Voltage** **Bit 3 - Temperature** **Bit 4 - Communication** **Bit 5 - Device Profile Specific** **Bit 6 - Reserved** **Bit 7 - Manufacturer Specific**
0x0000	FLT_NONE	N/A	0x00
0x2340	SHORT_CCT_FLT	F1	0x03
0x3210	DC_BUS_OV_FLT	F2	0x05
0x2310	REGEN_FLT	F3	0x03
0x4110	AMB_OVERTEMP_FLT	F4	0x09
0x4210	BRDG_OVERTEMP_FLT	F5	0x09
0x4310	MOTOR_OVERTEMP_FLT	F6	0x09
0x7305	ENCODER_FLT	F7	0x01
0x7303	RESOLVER_FLT	F8	0x01
0x5100	LOGIC_SUPPLY_FLT	F9	0x01
0x5530	DATABASE_NVM_FLT	F10	0x01
0x8100	FBUS_FLT	F11	0x11
0x3200	DC_BUS_FLT	F12	0x05
0x6100	PROGRAM_FLT	F13	0x01
0x2300	CURR_LOOP_FLT	F14	0x03
0x5200	BOARD_FLT	F15	0x01
0x6100	MODEL_FLT	F16	0x01
0xFF01	INTERLOCK_FLT	F17	0x01
0x8400	VELOCITY_FLT	F18	0x01
0x8500	STATIC_POSITION_FLT	F19	0x01
0x8600	DYNAMIC_POSITION_FLT	F20	0x01
0xFF02	MODEL_APP_FLT_1	F21	0x01
0xFF03	MODEL_APP_FLT_2	F22	0x01
0x8A00	CONTROL_SYSTEM_FLT	F23	0x01
0x7300	HALL_SENSOR_FLT	F24	0x01
0xFF04	RESERVED_F25_FLT	F25	0x01
0xFF05	RESERVED_F26_FLT	F26	0x01
0xFF06	RESERVED_F27_FLT	F27	0x01

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I.1 CSA Cold Plate Servo Drive Overview

This section provides additional information for the CSA Cold Plate Servo Drive. The CSA Cold Plate Servo Drive is an application-specific, higher ambient operating temperature version of the 14/42 A variant of the CSA Servo Drive. The CSA Cold Plate Servo Drive runs application-specific code and has fixed I/O assignments specific to its application. It is designed to operate in conjunction with an actuator to control the position of the main gas metering valve (GMV) (AKA "fuel metering valve," FMV) in gas turbine power generation applications.

Unless noted otherwise within this appendix, features, capabilities and specifications for the CSA Cold Plate Servo Drive are generally as previously described for the 14/42 A variant of the CSA Servo Drive. Consequently, the User should familiarize himself with the main portion of the CSA Servo Drive User's Manual and regard all recommendations and warnings as applicable to the CSA Cold Plate Servo Drive.

Several functional variants of the CSA Cold Plate Servo Drive are available. The drive may be configured to operate with either a 4 – 20 mA Analog I/O interface for commands and feedback data or with a DeviceNet serial, digital communication interface for commands and feedback or with a combination Dual CAN and 4 – 20 mA Analog I/O interface.

The CSA Cold Plate Servo Drive is equipped with an external terminal block option to allow the user to make "flying lead" connections to the drive, eliminating the requirement for specific cable assemblies to match the various I/O port connectors of the base drive unit. The drive can be provided with all required connections between the terminal block and the drive's various ports.

The CSA Cold Plate Servo Drive was designed to operate reliably in ambient air temperatures up to 60° C without the use of a fan in the drive assembly. A fan is available for those applications requiring it. The drive is equipped with over-temperature protection of the motor, the drive power bridge and the control electronics.

This section gives an overview of the available CSA Cold Plate Servo Drive models, ratings and general specifications. Details of functionality, user interfaces and other technical data specific to the Cold Plate drive are provided in subsequent sections. Please note that the terms "G359," "CSA Cold Plate Servo Drive," "Cold Plate drive," "G359 Cold Plate Drive," etcetera may be used interchangeably in this appendix.

Contact Moog Application Engineering for model numbers, installation and wiring details specific to the application.

I.2 CSA Cold Plate Servo Drive Environmental Specifications

Environmental specifications are as previously listed in this manual for the CSA size "B" Servo Drive, with the following exceptions:

Temperature for storage:	-25° C to 85° C
Temperature for transport:	-25° C to 85° C
Operating air temperature:	-20° C to 60° C
Type of protection:	Components must be installed into an enclosure. The enclosure must provide at least IP54 per EN60529 or equivalent. Operating air temperature is the temperature of the air within the enclosure.

I.3 CSA Cold Plate Servo Drive Power Rating Specifications

Power rating specifications are as previously listed in this manual for the CSA size "B" Servo Drive, with the following exceptions:

Output Power Rating:	14 A RMS continuous / 42 A Pk
Input Power Supply:	60 – 300 V DC or 43 – 190 V AC +10%
Internal Regeneration Power Capability:	none
External Regeneration Power Capability*	
Continuous:	250 W
Peak (@200 V DC):	3.0 kW
Power Supply Fault Detection:	D.C. Bus Overvoltage D.C. Bus Undervoltage Bridge Temperature Fault Amplifier Short Circuit Protection
Thermal Protection:	The cold plate drive has the same thermal protection mechanisms described above for the CSA Servo Drive.

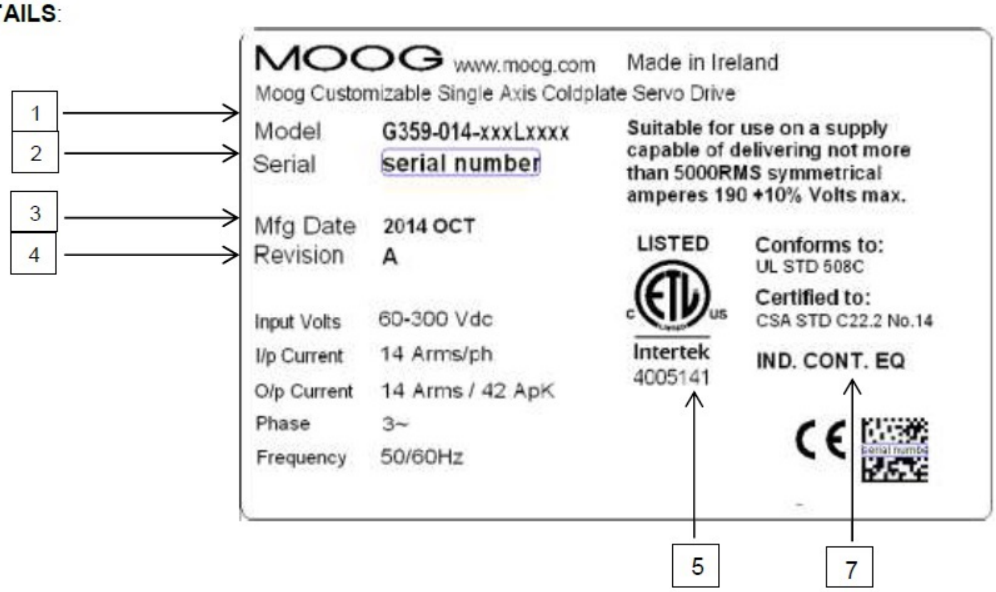
**Note: No power regeneration resistor, neither internal nor external, is provided with the cold plate drive. No power regeneration resistor is required for the GMV application.*

I.4 Labeling and Certifications

The CSA Cold Plate Servo Drive conforms to UL standard 508C and complies with CSA STD C22.2 No. 14. The drive is also certified compliant with requirements for ETL / CETL as well as the CE mark.

Figure I.1, below, illustrates the label template for the cold plate drive.

LABEL DETAILS:



NOTES:

1. **MODEL:** REFERENCE BOXCAR DRAWING CB62588
2. **SERIAL** NUMBER: T000000000 (PROGRESSIVE) SERIAL NUMBER THAT IS ASSIGNED TO THE POWERSTAGE IS USED AND T IS ADDED.
3. **MFG DATE:** DATE OF MANUFACTURE IN THE FORMAT OF **YYYY MMM**
4. **REVISION:** CURRENT REVISION OF THE PRODUCT
5. THIS IS THE MOOG IRELAND CONTROL NUMBER SUPPLIED BY INTERTEK.
6. SEE *MOOG INDUSTRIAL GROUP PRODUCT BRANDING GUIDELINES.PDF* FOR FURTHER DETAILS ON FONTS, TEXT SIZE AND LAYOUT.
7. **IND CONT EQ:** (Industrial Control Equipment) Required by UL file E194181

Figure I.1: CSA Cold Plate Servo Drive labelling details.

Figure I.2, below, provides information relating to the Intertek inspection report leading to the above-referenced certifications for the equipment.

Intertek

Listing Constructional Data Report (CDR)

1.0 Reference and Address

Report Number	100648045LAX-001	Original Issued:	27-Feb-2012	Revised:	31-Jul-2013
Standard(s)	UL 508C Issued:2002/05/03 Ed:3 Rev: 2010/11/09 Standard for Safety Power Conversion Equipment CSA C22.2#14 Issued: 2010/02/01 Ed:11 Industrial Control Equipment - General Instruction No.1: 2010/09/01				

Applicant	MOOG Inc.	Manufacturer	**Moog LTD.**
Address	300 Jamison Road East Aurora, NY 14052	Address	Ringaskiddy, County Cork
Country	USA	Country	Ireland
Contact	Mr. Eugene Monaco	Contact	Michael O'Sullivan
Phone	716-652-2000	Phone	35-30214519064
FAX	716-687-4989	FAX	35-30214519000
Email	gmonaco@moog.com	Email	Mosullivan@moog.com

Manufacturer 2	**Moog Inc., Industrial Controls Division, Plant 11**
Address	300 Jamison Roads East Aurora, NY 14052
Country	USA
Contact	Robert Wojcinski
Phone	(716) 652-2000
FAX	(716) 687-4989
Email	rwojcinski@moog.com

Figure I.2: Listing CDR information for the CSA Cold Plate Servo Drive.

I.5 CSA Cold Plate Servo Drive Dimensions

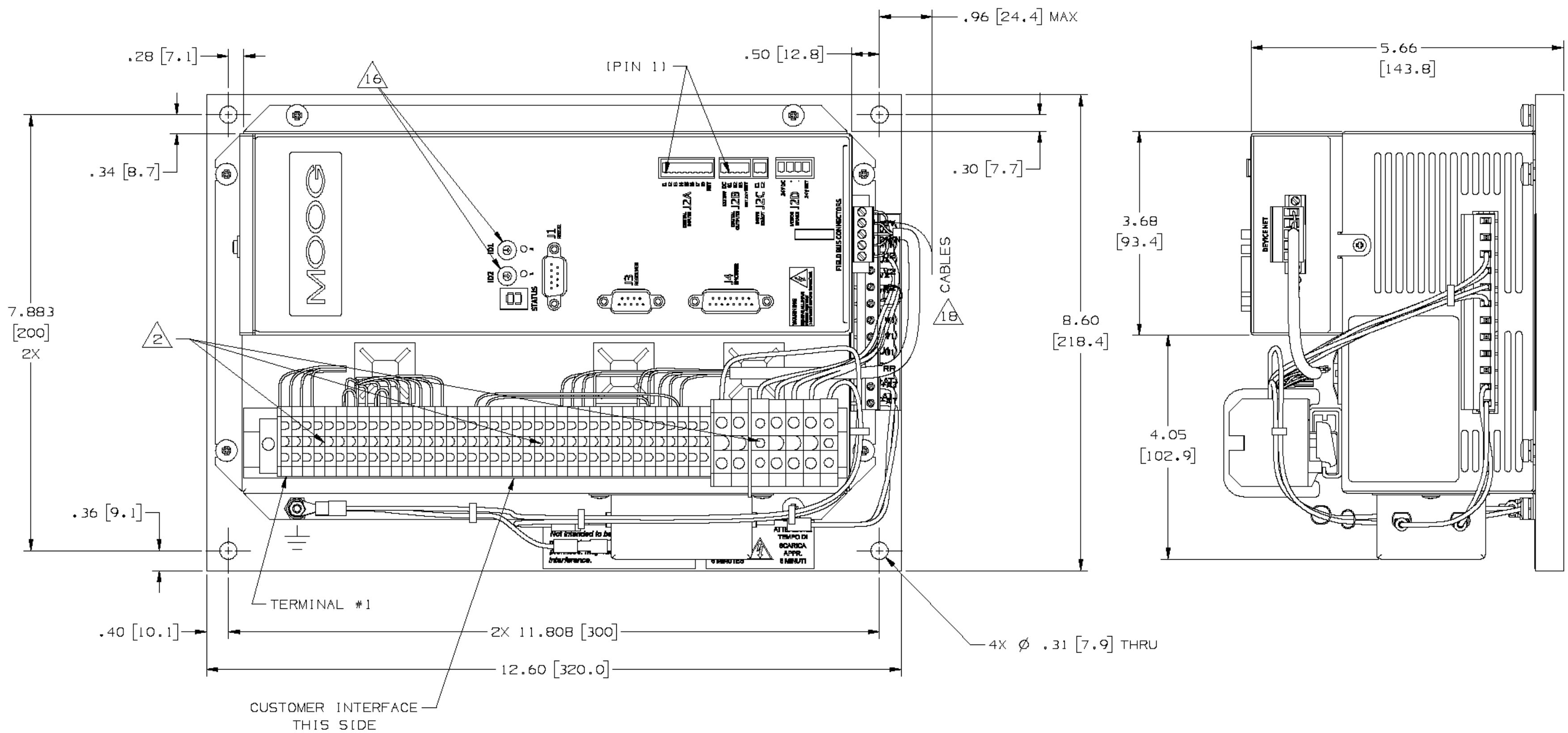


Figure I.3: Front and bottom view of CSA Cold Plate DeviceNet Servo Drive with full terminal strip. Cables are not completely shown.

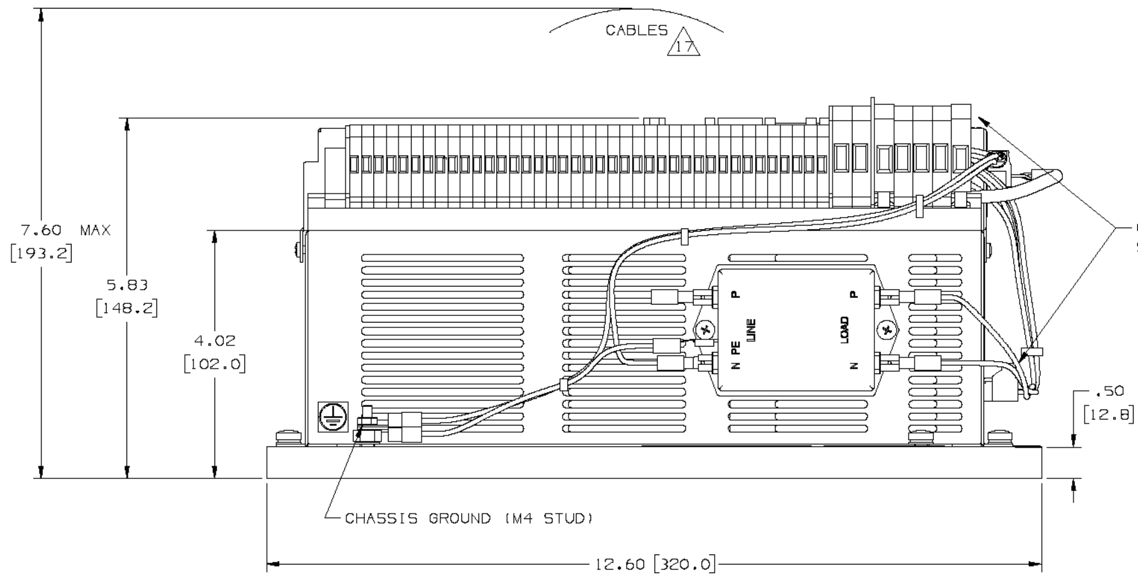


Figure I.4: Side view of CSA Cold Plate Servo Drive with full terminal strip. Cables are not completely shown.

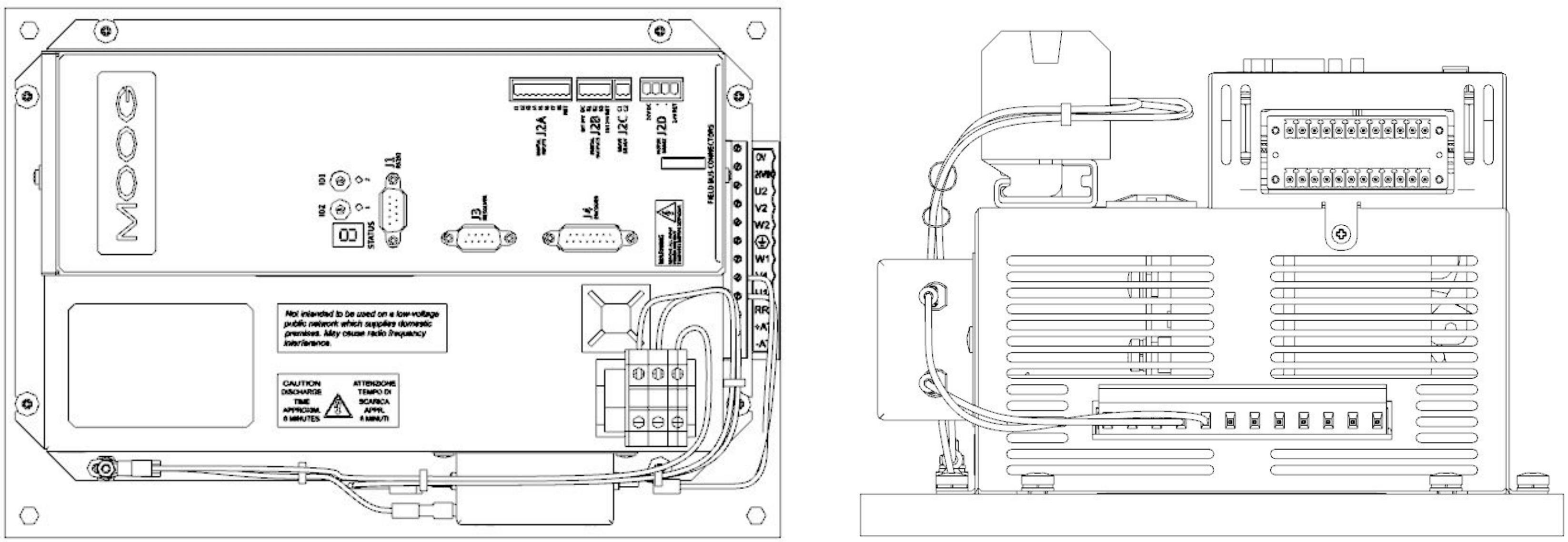


Figure I.5: Front and bottom view of CSA Cold Plate Dual CAN w/ Analog I/O Servo Drive with reduced terminal strip. Cables are not completely shown. (Reference Figure I.3 for dimensions)

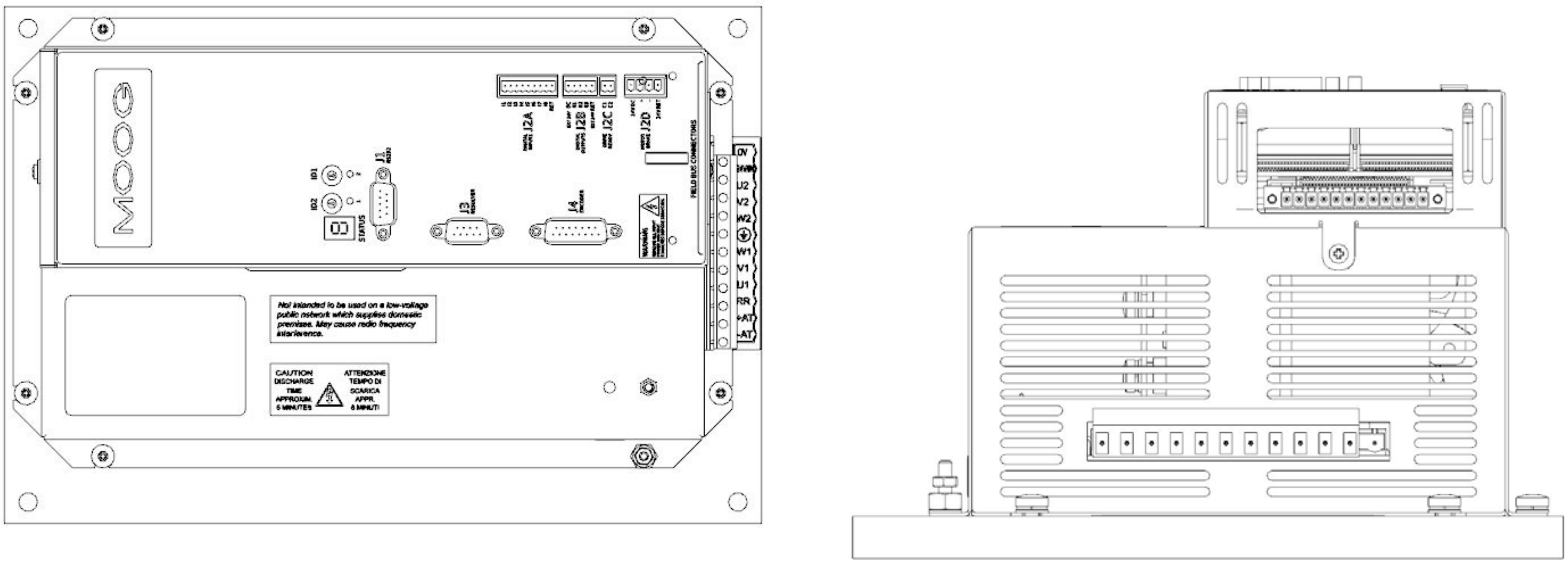


Figure I.6: Front and bottom view of CSA Cold Plate Dual CAN w/o Analog I/O Servo Drive with no terminal strip. Cables are not completely shown. (Reference Figure I.3 for dimensions)

I.6 General Functional Specifications

Reference applicable chapters of the CSA Servo Drive User's Manual for specifics regarding functionality and wiring related to the following sections.

I.6.1 Digital Inputs (J2A)

Digital inputs have the same protections, ratings and operational parameters as described previously for the CSA Servo Drive.

I.6.2 Digital Outputs (J2B)

Digital outputs have the same protections, ratings and operational parameters as described previously for the CSA Servo Drive.

I.6.3 Drive Ready Output (J2C)

Solid-state relay output voltage ratings: 36V, 100mA max. Switches closed when drive has no faults and is in a "Ready to Enable' state. Switches open and the drive will be disabled if a drive fault is detected.

I.6.4 Motor Brake (J2D)

2A, 24V dc solid-state high-side drive for motor brake control. Switched under user control or CSA software control.

I.6.5 Motor Position Feedback Type

- **Resolver (J3)**
- **Encoder (J4)**

I.6.6 Communications and Digital Interfaces

- **RS-232 Interface (J1):** 19.2 kbps (default)
- **DeviceNet Interface (J5):** 125/150/500 kbps (software selectable)
- **CAN OPEN (P8):** 250/500 kbps (software selectable)
- **Ethernet I/P (MODBUS/TCP)** 10/100 Mbps

I.6.7 Drive Variant-Specific I/O

DeviceNet I/O

The Cold Plate drive may be equipped with a DeviceNet card to allow command and feedback via a digital, serial interface. DeviceNet connections may be made to connector J5 of the DeviceNet mezzanine card via the terminal block. J5 is physically located on the bottom of the controller chassis as shown below in Figure I.7.

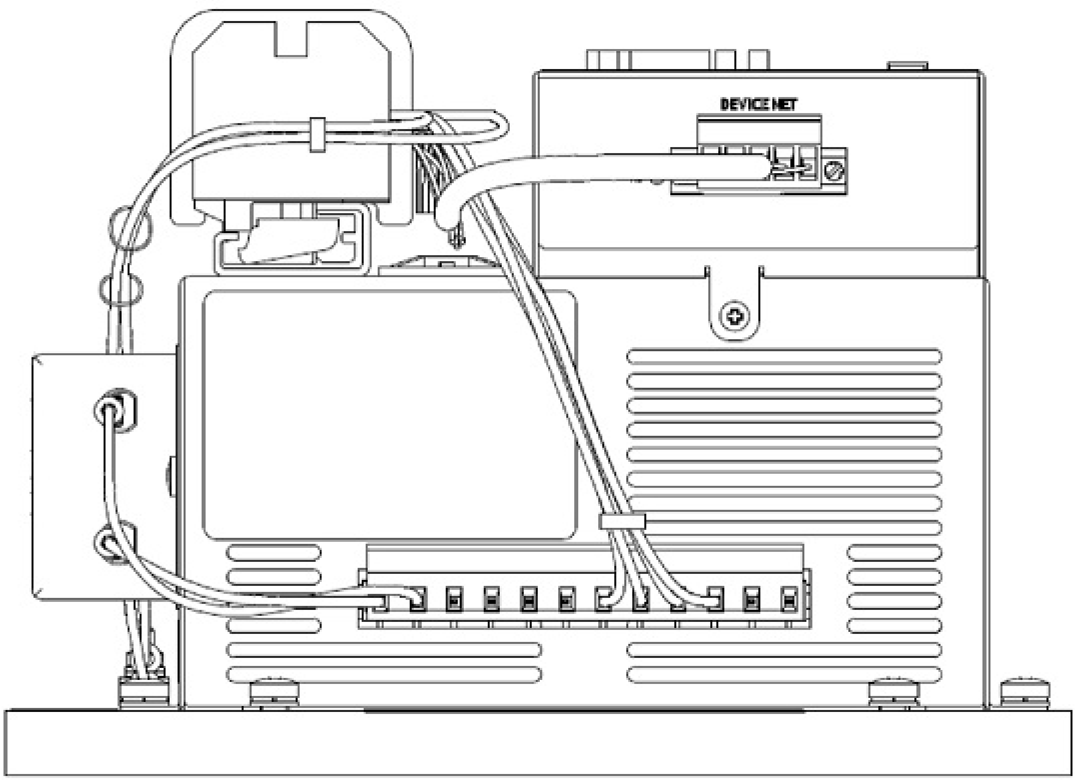


Figure I.7: Bottom view of CSA Cold Plate Servo Drive showing DeviceNet connector.

Analog I/O

The Cold Plate drive may be equipped with an Analog I/O card to receive an input position command and to output actuator position and motor current feedback to the system analog controller. Analog connections may be made to connector J5A of the Analog I/O mezzanine card via the terminal block. J5A is physically located on the bottom of the controller chassis as shown below in Figure I.8.

Inputs and outputs use 4 – 20 mA control loops, corresponding to minimum and maximum values of actuator position or motor current.

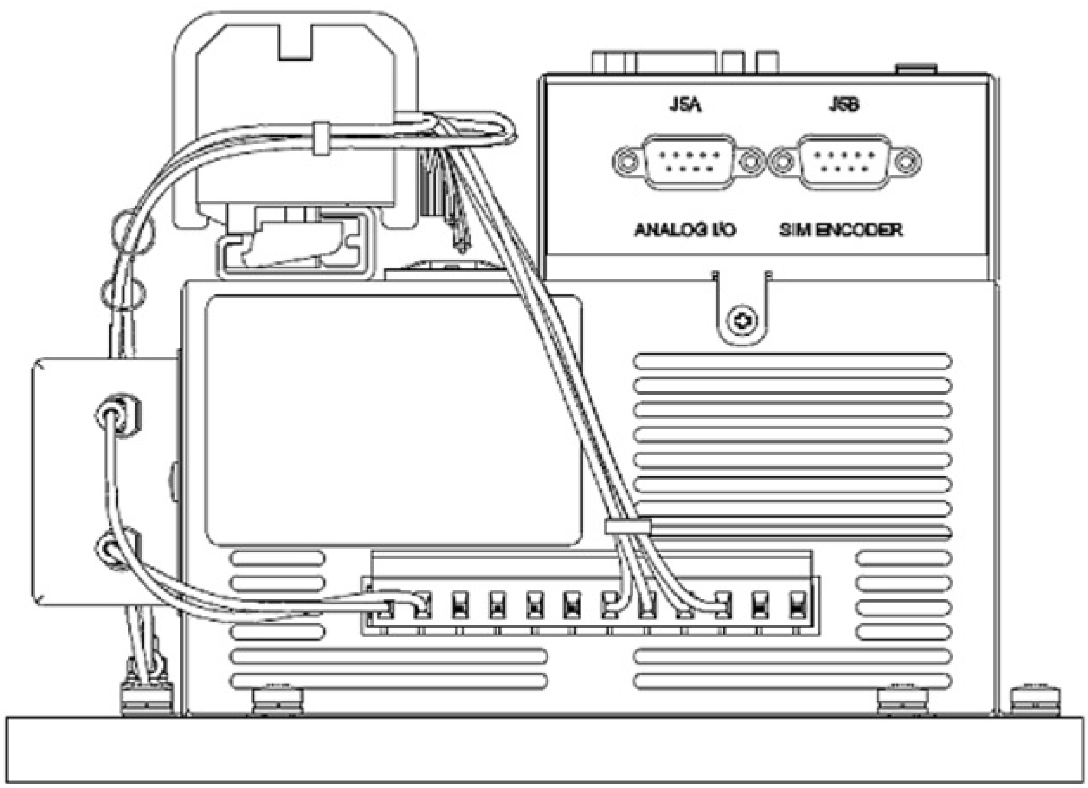


Figure I.8: Bottom view of CSA Cold Plate Servo Drive showing Analog I/O connector.

Ethernet

The Cold Plate drive may be equipped with an Ethernet card supporting ETHERNET I/P and MODBUS/TCP. The interface can be used for parameterization and configuration by reading or writing drive parameters individually via a request/response type mechanism. The interface can also be used for low frequency, acyclic, control and status monitoring by reading or writing specific, pre-defined registers in the drive interface.
Ethernet connections can be made to connector U1 of the Ethernet mezzanine card physically located on the bottom of the controller chassis as shown below in Figure I.9.

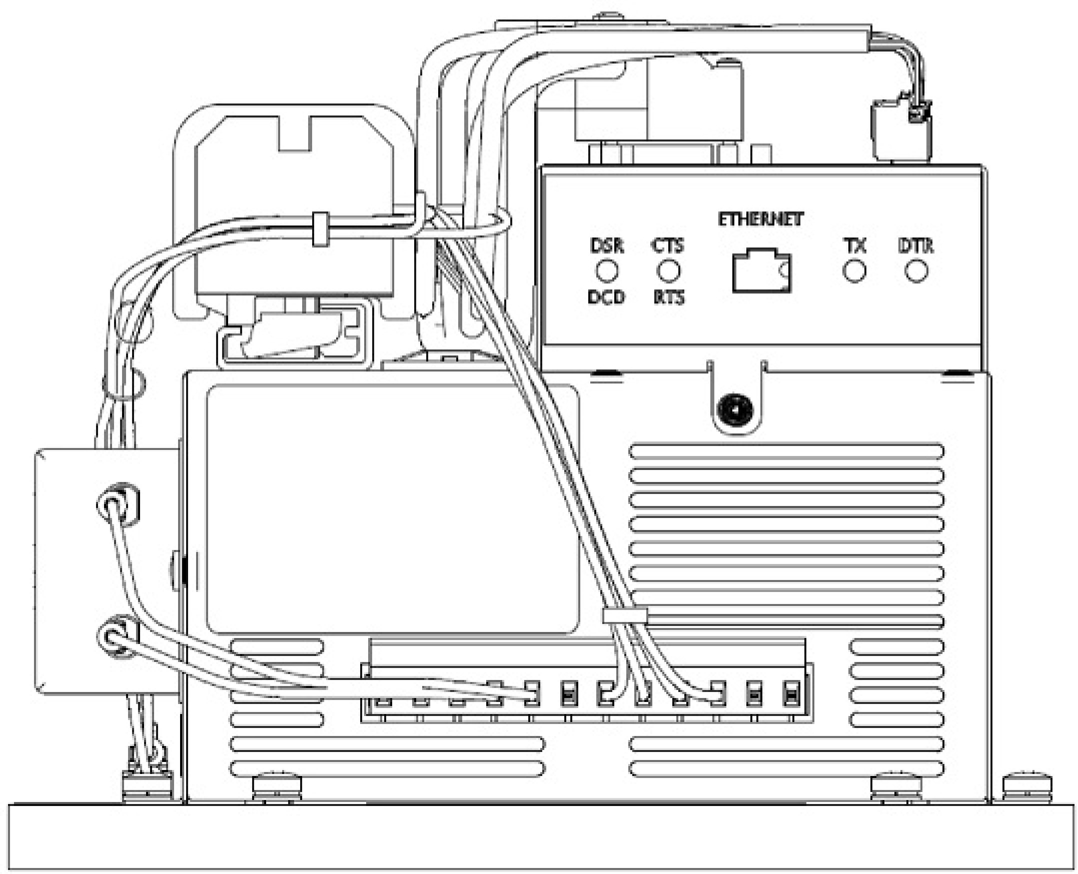


Figure I.9: Bottom view of CSA Cold Plate Servo Drive showing Ethernet connector.

Dual CAN

The Cold Plate drive may be equipped with a Dual CAN mezzanine card. The card is modular in design, presently allowing for variants with two redundant CAN bus interfaces, or two redundant CAN bus interfaces with two 4 to 20 mA Analog I/O channels.

The Analog I/O port allows for 2 configurable analog input channels and 2 analog output channels for external control system integration.

CAN bus and Analog I/O connections can be made to connector P8 of the Dual CAN mezzanine card physically located on the bottom of the controller chassis as shown below in Figures I.10 & I.11

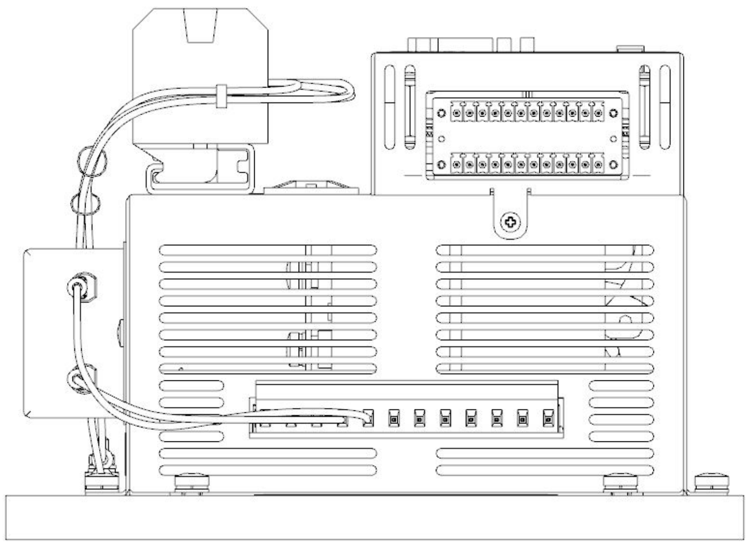


Figure I.10: Bottom view of CSA Cold Plate Servo Drive showing Dual CAN w/Analog IO connector.

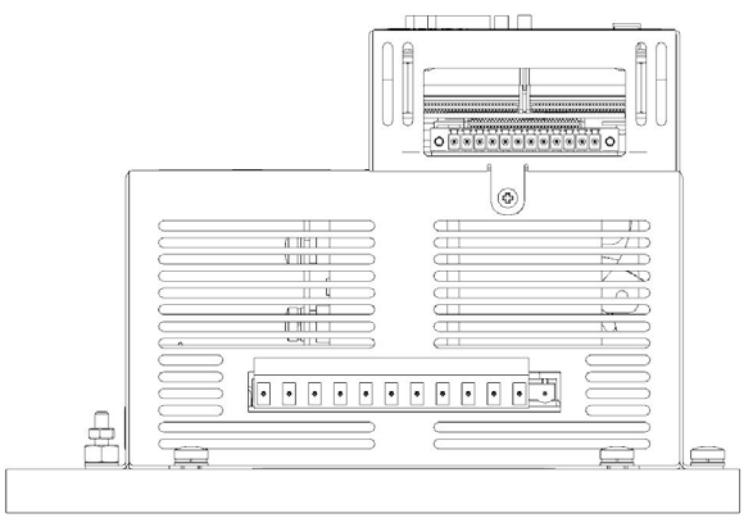


Figure I.11: Bottom view of CSA Cold Plate Servo Drive showing Dual CAN w/o Analog IO connector.

I.7 System Wiring Interconnect

The CSA SD Cold Plate drive offers several variations, each with unique system wiring requirements. Reference the application specific installation drawing for details.

Please contact Moog Application Engineering for assistance with installation and wiring details specific to the application.

I.8 Safety and EMC Instructions

I.8.1 General Safety Instructions

The Safety and EMC Instructions for the CSA Servo Drive in section 2 of this manual apply as well to the CSA SD Cold Plate Servo Drive. The user should review and be familiar with these instructions before applying power and attempting to operate this equipment. Only technically qualified individuals should attempt to install and commission this equipment.

I.8.3 EMC Filter

The CSA SD Cold Plate Servo Drive may come equipped with an EMC filter to reduce the introduction of electrical noise from the drive to the electrical system providing the drive’s power.

I.9 Installation

Please refer to section 3 of this User’s Manual for general wiring information. Wire connections specific to the CSA SD Cold Plate Servo Drive application are shown in Figure 7, above. This section covers the installation, wiring and cabling of the CSA SD Cold Plate Servo Drive. Users are directed to read Section 2 of this manual, Safety Instructions, before proceeding with wiring and installation.

WARNING - This equipment must be permanently and reliably connected to Earth and all conductive parts in the IP54 rated enclosure in which the CSA SD Cold Plate Servo Drive is installed must be reliably connected to Protective Earth. A Protective Earth connection must come directly from an approved AC mains network. Stranded copper-wire is recommended to carry the earth.

FAILURE TO PROVIDE AN ADEQUATE EARTH MAY CAUSE SERIOUS PERSONAL INJURY AND EQUIPMENT MALFUNCTION.

I.9.1 System Components

The following components may be required to build a Moog brushless motor digital control system: (Reference the application specific installation drawing for details.)

I.9.1.1 D.C. and A.C. Mains Power Interface

The CSA Cold Plate Servo Drive may be operated with either DC or AC input power.
The User supplied DC supply should be capable of providing between 60 - 300 V DC at a minimum of 5 A DC in accordance with the application's drive requirements. The AC operating range is 43 – 190 V AC +10%.

I.9.1.2 24 V DC I/O Power Supply

In addition to the D.C. mains power, a separate, User-supplied power supply with a fixed 24 V DC output may be required to supply power for digital inputs and digital outputs. Additionally, a 24 V DC supply would be required to provide power using the DeviceNet fieldbus. This supply may also be used for this purpose, or a separate 24 V DC supply may be used if desired or convenient.

I.9.1.3 Serial Set-up Terminal

An RS-232 interface should be established for cold plate drive communications, using a user-supplied PC. The PC should have a Windows-based user-interface program installed such as Moog's CSA SD PowerGen (provided by Moog) or equivalent. This interface allows for setup and observation of the drive parameters and system variables.

WARNING - The personal computer using the user interface program is a service engineering tool only and must be installed so that use of the key sequences which allow control of the machine functions is accessible to authorized, qualified service personnel only.

I.9.1.4 Brushless Servo Motor

The CSA Cold Plate Servo Drive is compatible with Moog brushless servomotors.

Normal connection to the motor requires two cables - a power and a signal cable. The power cable provides three-phase motor stator power, protective earth and brake connections. The signal cable carries position transducer feedback signals and motor temperature detection connections.

I.9.1.5 Climate Control

The CSA Cold Plate Servo Drive is limited to operation within an ambient air temperature environment of no more than 60° C. *"Ambient temperature," as used here, refers to the temperature within the enclosure in which the drive is mounted*. The drive monitors the temperature of the controller card, the servomotor and the output stage power bridge. Excessive temperature indications in any of these areas will result in a WARNING condition at a value equal to 90% of the FAULT threshold value. Temperatures in any of these areas rising to the level of a FAULT threshold value will immediately result in a FAULT condition and the drive will be disabled. Once activated, the warning indication will remain active until the temperature condition causing the warning is reduced to a value below the warning threshold and a WARNING RESET is issued via the user interface program. Temperature WARNING and FAULT threshold values for the three monitored temperature commodities are fixed at:

I.9.1.6 Enclosure

Some applications require the CSA SD Cold Plate Servo Drive to be installed in an enclosure. The CSA Cold Plate Servo Drive uses thermal conduction to transport heat from the drive's power devices, mounted directly to the cold plate, to the external environment. Heat developed within the output power block is conducted to the thick metal "cold plate" of the drive. When mounted within an enclosure, effective thermal management requires that the cold plate be in intimate contact with a smooth, exterior surface of the enclosure, allowing the enclosure itself to serve as part of the drive's conductive heat dissipation mechanism. Mounting the drive to a suspended panel within an enclosure undermines the thermal management scheme by allowing heat to build up within the panel and the enclosure to a greater degree than directly mounting the drive to an exterior surface would. Such an arrangement imposes an unnecessary thermal limit on the effective power that the drive can provide and the environment in which the enclosed drive can operate. In addition, higher operating temperatures may have a negative impact on drive reliability and service lifetime.

Similarly, mounting the cold plate drive directly to a metal enclosure surface that is not smooth greatly reduces the contact area between the cold plate and the enclosure surface and will not remove heat from the enclosure as effectively as a smooth surface would. The consequences of this are the same as described above, resulting in higher operating temperatures, reduced reliability and reduced service life.

I.9.1.7 Enclosure Mounting Recommendations

Moog recommends that the Cold Plate drive be mounted directly to the interior of an external wall of a metal enclosure. Due to poor thermal characteristics, non-metallic enclosures are not recommended. For effective heat transfer, Moog recommends that the surface roughness of the surface to which the Cold Plate drive is mounted be less than or equal to 3.2 microns (125 microinches) per ANSI B46.1. The use of a light application of heat sink compound on the mounting surface of the Cold Plate drive is recommended to further improve surface contact area and maximize thermal transfer efficiency.

APPENDIX J. DUAL CAN / ANALOG MEZZANINE CARD

J.1 Introduction

The following appendix is intended as an introduction and subsequent overview of the CSA SD Dual CAN/Analog mezzanine card. The Dual CAN mezzanine card functions are implemented by connecting it to the CSA SD controller through the PMC interface.

Please consult Moog ICD Sales or a Moog Distributor for application specific ordering information.

J.2 Overview

The mezzanine card is modular in design, allowing variants with one CAN bus or two redundant CAN bus interfaces, zero, one or two analog input channels capable of accepting 4 to 20 mA signals and zero, one or two analog output channels capable of providing 4 to 20 mA signals and combinations thereof.

The Analog I/O port allows for 2 configurable analog input channels and 2 analog output channels for external control system integration.

J.3 Configurations

Please consult Moog ICD Sales or a Moog Distributor for application specific ordering information.

The following table defines the configurations presently available:

Model	CANopen	Analog Input		Analog Output	
		CH1	CH2	CH1	CH2
xB	Dual	4-20mAdc	4-20mAdc	4-20mAdc	4-20mAdc
xD	Dual	N/A	N/A	N/A	N/A

Table J-1 CAN and Analog Configurations

The maximum input to each channel should not exceed 20mA for channels configured for current.

J.4 External P8 Connection

J.4.1 Dual CAN with Analog I/O

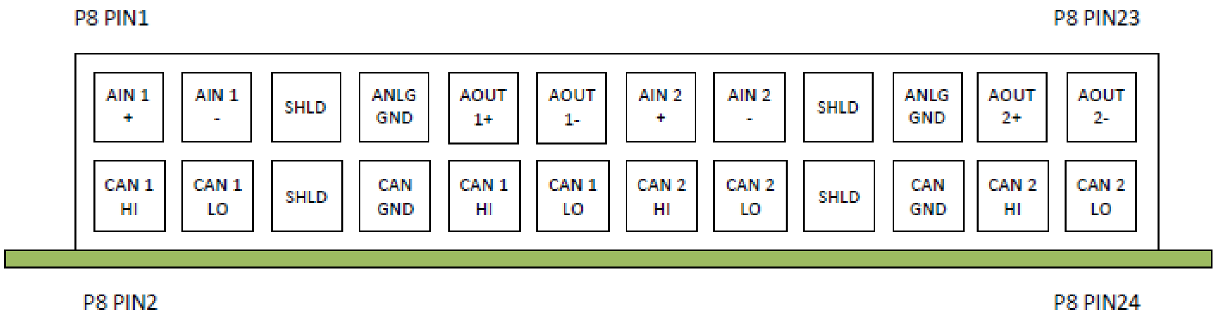


Figure J.1: P8 Dual CAN with Analog I/O Mezzanine Card Terminal Assignments.
View is looking up from the bottom of the drive with the card installed in the drive's control head.

Pos (P8)	Name	Function
1	AIN 1+	Analog input AIN 1+
3	AIN 1-	Analog input AIN 1-
5	SHLD	Shield
7	ANLG GND	Analog 0V common
9	AOUT1+	Analog output AOUT1+
11	AOUT1-	Analog output AOUT1-
13	AIN2+	Analog input AIN 2+
15	AIN2 -	Analog input AIN 2-
17	SHLD	Shield
19	ANLG GND	Analog 0V common
21	AOUT2+	Analog output AOUT2+
23	AOUT2-	Analog output AOUT2-
2	CAN 1 HI	CAN1 High
4	CAN 1 LO	CAN1 Low
6	SHLD	Shield
8	CAN GND	CAN ground (0V)
10	CAN 1 HI	CAN1 High
12	CAN 1 LO	CAN1 Low
14	CAN 2 HI	CAN2 High
16	CAN 2 LO	CAN2 Low
18	SHLD	Shield
20	CAN GND	CAN ground (0V)
22	CAN 2 HI	CAN2 High
24	CAN 2 LO	CAN2 Low

Table J.2: P8 Terminal Connections (Dual CAN w/Analog)

J.4.2 Dual CAN without Analog I/O

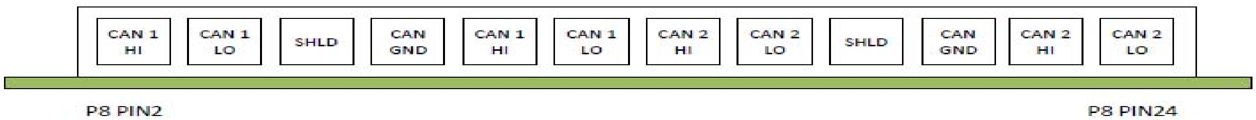


Figure J.2: P8 Dual CAN without Analog I/O Mezzanine Card Terminal Assignments.
View is looking up from the bottom of the drive with the card installed in the drive's control head.

Pos (P8)	Name	Function
2	CAN 1 HI	CAN1 High
4	CAN 1 LO	CAN1 Low
6	SHLD	Shield
8	CAN GND	CAN ground (0V)
10	CAN 1 HI	CAN1 High
12	CAN 1 LO	CAN1 Low
14	CAN 2 HI	CAN2 High
16	CAN 2 LO	CAN2 Low
18	SHLD	Shield
20	CAN GND	CAN ground (0V)
22	CAN 2 HI	CAN2 High
24	CAN 2 LO	CAN2 Low

Table J.3: P8 Terminal Connections (Dual CAN w/o Analog)

J.5 CAN

J.5.1 CAN bus Interface

The mezzanine card has the capability of implementing two, redundant CAN bus interfaces utilizing the CAN protocol.

The mezzanine card provides the necessary I/O terminals to support the implementation of two CAN bus interfaces via pluggable, screw type terminals. Reference Figure J.1 and Table J.2 for pin assignments and signal descriptions.

Model xB – DUAL CAN with Analog IO

Connector and Mating Part Information

- Fixed connector: 24 pin, Male, Weidmuller p/n:1974330000 (Qty. 1 per)
- Mating connectors, 12 pin Female, Weidmuller p/n: 1793020000 (Qty. 2 per)
    - Tightening torque 0.2 – 0.25 Nm
    - Tightening torque for screw flange 0.2 – 0.3 Nm

Wire Gauge Information

- Wiring: cable. 28-16AWG (0.08-1.31mm^2)

Model xD – DUAL CAN without Analog IO

Connector and Mating Part Information

- Fixed connector:12 pin, Female Weidmuller p/n: 1863820000 (Qty. 1 per)
- Mating connector, 12 pin Female, Weidmuller p/n: 1793020000 (Qty. 1 per)
    - Tightening torque 0.2 – 0.25 Nm
    - Tightening torque for screw flange 0.2 – 0.3 Nm

Wire Gauge Information

- Wiring: cable. 28-16AWG (0.08-1.31mm^2)

J.5.2 CAN bus

CANopen Interface

The CSA SD supports a Dual Channel Controller Automation Network (CAN) interface using the CANopen communication protocol and device profile specifications DS301 and DS402, along with Moog defined CANopen Objects. The CAN in Automation (CiA) defines the various specifications, details are found at: http://www.can-cia.de/

Hex Switch ID1 is used to specify a Node ID from 1-15. Configuration options, accessible through WinDrive (see Appendix B of CSA Servo Drive User's Manual), permit the setting of Node ID values higher than 15. Appendix B illustrates the details of configuring the CSA SD to perform the Customer application protocol.

Consult Moog International Sector Services (ISS) Group for details pertaining to the configuration of the CSA SD for the desired protocol.

Hardware Specifications

Circuit power for the user CAN interface is derived from an isolated 5VDC supply referenced to CAN ground.

A differential input voltage (CANH – CANL) from 1.0 to 5.0 V is regarded as the dominant state; differential input voltages between -1.0 and +0.4 V are regarded as the recessive state.

Differential output voltage ranges from 1.5 to 3.0 V for the dominant state and from -500 to +50 mV for the recessive state.

The recommended CAN bus cable should have a twisted pair for the CANH / CANL differential I/O signals plus a ground lead and should be overall braid shielded. Shield connections should be made to the shield terminals of terminal block P8. Due to the high common mode voltage tolerance of the inputs (+/- 36 V), the ground connection may not be required for operation but is highly recommended for the sake of reliability and trouble-free operation as common mode voltages beyond these levels may damage the interface transceiver.

Baud Rate

The CAN bus communication baud rate may be 10, 20, 50, 125, 250, 500, 800 or 1000 kbps selectable via application specific software.

Termination

Use of 120 ohm termination resistors across CANH and CANL at the two terminal positions of the CAN bus is required for noise immunity. For a CSA SD servo drive with dual CAN / analog card in the terminal position, (a) 120 ohm, 0.5 W axial resistor(s) may be mounted to the unused CANx HIGH and CANx LOW terminals on the P8 terminal block.

CAN bus Interconnect

Maximum CAN bus cable length is a function of baud rate, cable resistivity, cable length and the resulting voltage drop. Higher baud rates require a shorter bus as the signal edges are degraded by the increasing effect of the cable's distributed capacitance with increasing length.

The following figure illustrates a five node CAN bus implementation and shows recommended connections.

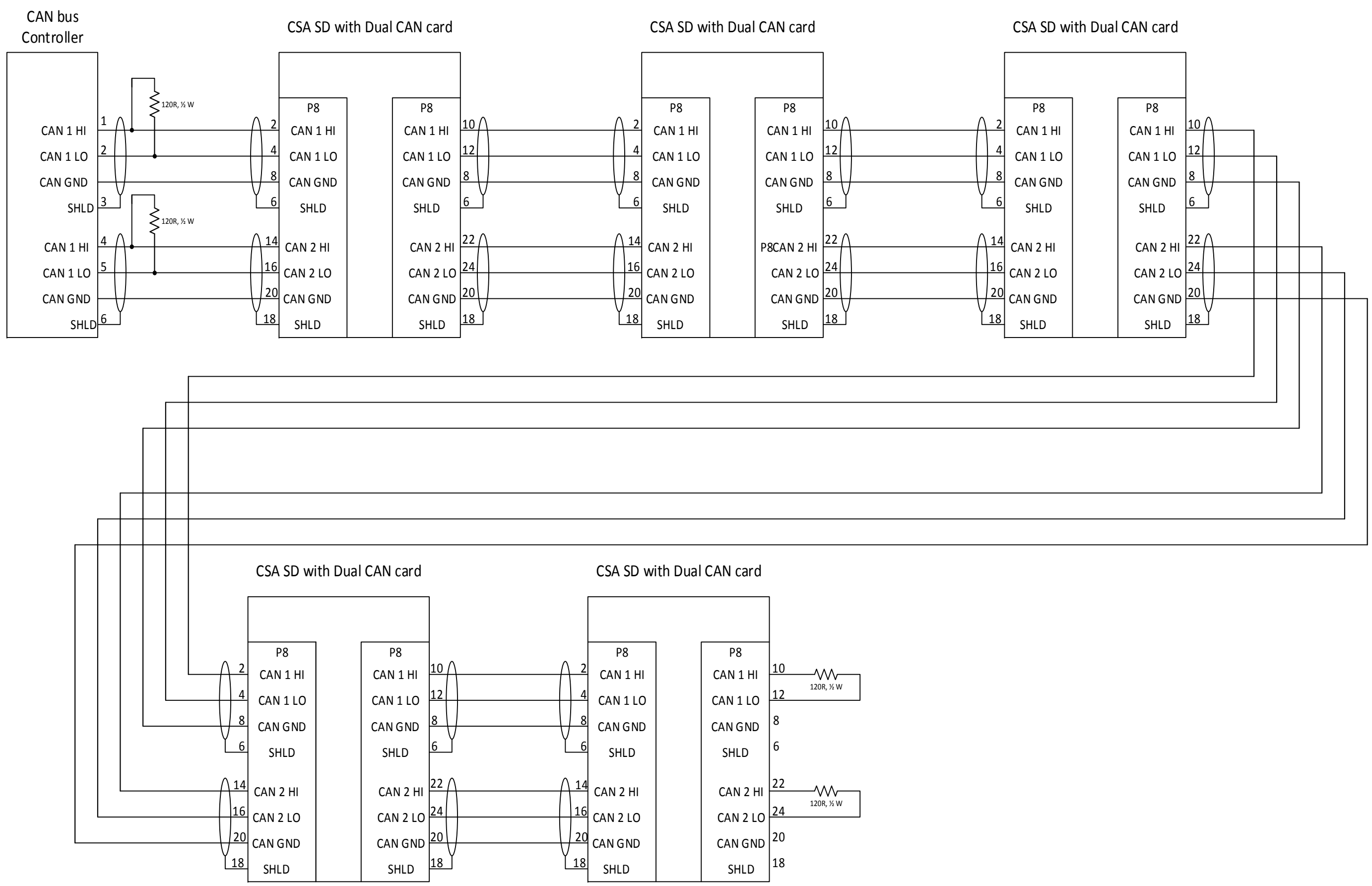


Figure J3: CAN bus with five nodes

J.6 Analog I/O

J.6.1 Analog I/O Interface

The interface to the Analog I/O is via pluggable, screw type terminals. Reference Figure J.1 and Table J.2 for pin assignments and signal descriptions and section J.5.1 for specific connector part numbers.

Moog recommends the use of twisted pair cables with an overall braided shield for all low voltage wiring. Shields should be terminated at both connector backshells with 360 degree connection where possible.

J.6.2 Assigning Analog I/O

Analog inputs and outputs may be required / used in some applications, but general purpose usage is not supported. The use and configuration of analog I/O requires the development of software specific to the application. For further information, consult Moog Applications Engineering.

J.6.3 Analog Inputs

If equipped with analog I/O capability, the card will accept one or two 4 to 20 mA current references. A minimum of 5Vdc source compliance is required to be able to source 20 mA into the card's 250 Ω input resistance.

The common mode noise and input signal between the External Source and the CSA SD input should not exceed 13.1V / 30mA or the device will not work properly. Excessive voltage/current input may result in damage to the input operational amplifier circuits.

J.6.4 Analog Outputs

If equipped with analog I/O capability, the card can provide one or two mA current outputs. The output is capable of sourcing 20 mA into a nominal 500 Ω load (10 V output voltage compliance).