MOOG

DS2100
Digital Controller

Installation &
User's Manual

D	Added motor thermal protection notes following UL508C review. Updated boxcar drawing.	Apr 2012	IRL024545
C	Significant re-write prior to release	Nov 2007	IRL21767
B	Added getting started section	Jan 2005	
A	DS2100 Preliminary Installation & User's Manual	23-April-2004	
Revision	**Description**	**Date**	**EO**

C27750-001 DS2100 Installation & User's Manual

SECTION 1: DS2100 OVERVIEW

TABLE OF CONTENTS

1.1 Introduction

This section gives an overview of the available DS2100 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 authorised repair facility may create unsafe operating conditions and will invalidate the product warranty.

1.2 DS2100 Models

The DS2100 family is available in nine base models, which cover a range of output current ratings.

DS2100 Base Model		**Amplifier Current Rating**		
Code	Size	Continuous (Arms)	Maximum (Arms)	Peak (A)
G361-xx03	µA	3	8	11
G361-xx06	µA	6	16	22
G361-xx08	A	8	16	22
G361-xx14	B	14	29.7	42
G361-xx20	C	20	31.8	45
G361-xx25	C	25	49.5	70
G361-xx30	C	30	63.6	90
G361-xx50	D	50	99.3	140
G361-xx60	D	60	127.6	180
G361-xx1x	E	100	212.7	300

Table 1.1 DS2100 Family Models

The DS2100 family uses a 13 character coding system to identify the unique attributes of each model. The coding system is shown in Figure 1.1.

G361 X X X XX X - XX - XXX

Model Series Designator

Current Model Design Status

Letter
E (E model)
- (dash)

Fieldbus / command reference

No.	Option Description	Status
0	Reserved	-
1	CAN	Available
2	Reserved	
3	Reserved	-
4	Reserved	-

Safety Interlock

No.	Option
0	No Safety Interlock
1	Safety Interlock installed.

Power Rating Section

No.	Arms / Apk	Power Stage	Control Stage	Packing Kit
03	3/11	C25699-003	C27740-001	C27745-003
06	6/22	C25699-006	C27740-001	C27745-003
08	8/22	CA18516-503-000R	C27741-001	C27745-008
14	14/42	CA18517-508-000R	C27741-001	C27745-014
20	20/45	C25699-020	C27741-001	C27745-020
25	25/70	C25699-025	C27741-001	C27745-020
30	30/90	C25699-030	C27741-001	C27745-020
50	50/140	C25699-050	C27741-001	C27745-050
60	60/180	C25699-060	C27741-001	C27745-050
10	100/300	C25699-010	C27741-001	C27745-100
10[4]	100/300	C25699-110	C27741-001	C27745-100
11[5]	100/300	C25699-011	C27741-001	C27745-100
11[4, 5]	100/300	C25699-111	C27741-001	C27745-100

Current Hardware Version

Letter
A

Software Version

Version	Description	P/N
03	Standard CAN Software	C27735-001

Reserved

Number	Description
XXX	See form 757 for valid configurations (Default 000)

Valid Controller Model Numbers: Reference Form 757

1)Users must be experienced/qualified in the use of this product range before building products from this drawing.

2)3Amp and 6Amp drive options are provided with a 120Ohm Internal Regen Resistor

3)External regen resistors are to be ordered and supplied separately.

4)These power stages contain a safety interlock.

5)These power stages contain an AC mains/ 24V PSU to directly feed fans, when high-voltage is present.

Figure 1.1 DS2100 Box Car

Moog also provides and recommends a variety of accessories for the DS2100. Examples include:

- EMC cable brackets for securing cable and grounding shields at the DS2100. (Supplied as standard with DS2100).
- Pre-configured motor cables.
- Fuses & circuit breakers for use with the DS2100 drives.
- Filters to achieve EMC compliance.
- Graphical User Interface (GUI) for drive configuration and diagnostics.

Please consult your local Moog sales office or authorised distributor for part number and availability of these or other products.

1.3 Environmental Specifications

DS2100 Electronics

Temperature for storage:	-25 °C to 55 °C (Class 1K4)
Temperature for transport:	-25 °C to 70 °C (Class 2K3)
Maximum surrounding air temperature:	0 °C to 40 °C
Relative Humidity:	5 % to 85 %, non-condensing, 1 g/m^3 to 25 g/m^3, in accordance with EN50178 class 3k3
Elevation:	1000m (3,300 feet) Derate output 2% per 300m (1000 feet) above 1000m (3300 feet)
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 DS2100 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). It is designed to the UL508C standard. The µA size DS2100 units are UL Recognised. The DS2100 A-D sizes are UL listed.

The DS2100 has been designed to the following specific standards:-

IP Code	EN 60529:1991
EMC	EN 61800-3:1996 , EN 61800-3/A11:2000 (Second Environment)
UL	UL508C with reference to UL840

Table 1.2 DS2100 Design Standards

1.5 Power Ratings Specifications

Model : G361-x	3Amp	6Amp	8Amp	14Amp	20Amp	25Amp	30Amp	50Amp	60Amp	100Amp
A.C. Mains Input Range **Minimum** **Maximum**	65Vac (110Vac -40%) 506Vac (440Vac +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	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 1.3Kw 4.8kW	100W 1.3kW 4.8kW	200W 3.1kW 12.5kW	250W 4.85kW 19.4kW	370W 13.3kW 53.3kW	370W 13.3kW 53.3kW	370W 13.3kW 53.3kW	750W 16kW 64kW	750W 16kW 64kW	1kW 36kW 146kW
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.									

Table 1.3 DS2100 Power Ratings

1.5.1 Optional Control Logic Backup Power

D.C. Bus Minimum Voltage (below which 24Vd.c. Control Logic Backup supply is needed)	170Vd.c. (Generated from rectified 120Va.c.)
24V Input	24Vd.c.± 10% 2.0A steady state

Table 1.4 DS2100 Control Logic Backup Power Ratings

An auxiliary 24V d.c. control logic backup supply is **MANDATORY** for the –x003 & -x006 variants of the DS2100 product family.

The 24V Backup supply input is intended for use in the secondary of a Class 2 supply. Alternatively, it should be additionally fitted with a Listed Current limiting type fuse, rated 3A on the supply input to the device.

1.5.2 Power Amplifier

All current ratings are specified in ampere r.m.s. unless otherwise stated.

Power Amplifier Ratings:	
G361-xx03	$3A_{continuous}/11A_{peak}$
G361-xx06	$6A_{continuous}/22A_{peak}$
G361-xx08	$8A_{continuous}/22A_{peak}$
G361-xx14	$14A_{continuous}/42A_{peak}$
G361-xx20	$20A_{continuous}/45A_{peak}$
G361-xx25	$25A_{continuous}/70A_{peak}$
G361-xx30	$30A_{continuous}/90A_{peak}$
G361-xx50	$50A_{continuous}/ 140A_{peak}$
G361-xx60	$60A_{continuous}/ 180A_{peak}$
G361-xx1x	$100A_{continuous}/ 300A_{peak}$

Table 1.5 DS2100 Power Amplifier Ratings

Two levels of thermal protection which limit the peak current and the time for which it is available protect the DS2100 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 G361-x006 cannot supply, on average, greater than $6A_{continuous}$ 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 DS2100 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 DS2100 D size, a simple thermal shutdown is implemented. These drives will report an overtemperature fault once the measured heatsink temperature exceeds the maximum rating of the drive.

1.6 General Functional Specifications

1.6.1 Digital Inputs (J2A)

- 8 Digital Inputs, user configurable
- Digital Input 1 Dedicated to High Power Enable
- All Optically Isolated, 12…36V Input Range.
- 5kΩ input impedance.

Standard Function	**FIELDBUS OR INTERFACE SPECIFIC**
High Power Enable Input	High Power Enable Input
Auto / Manual Mode	See Section 5.9
Torque / Velocity Mode Switch	See Section 5.9
Brake Control	See Section 5.9
CW Limit Switch	See Section 5.9
CCW limit Switch	See Section 5.9
Quick Stop	See Section 5.9
Controlled Disable	See Section 5.9

Table 1.6 DS2100 Digital Inputs Overview : Standard Configuration

1.6.2 Digital Outputs (J2B)

- 3 Digital outputs, user configurable
- All outputs are Optically Isolated.
- Nominal ratings of 6V to 32V, 250mA
- Protected for supply range of –40V to 40V
- Short-circuit & reverse polarity protected
- Off-state leakage current <100µA at 0V

Standard Function
Drive Enabled
Limiting Function
User defined

Table 1.7 DS2100 Digital Outputs Overview

1.6.3 Standard I/O

Brake Control (J2D)	2A, 24Vd.c. solid-state high-side drive for motor brake control. Switched under user control or DS2100 software control
Motor Position Feedback Type (J4/J5)	Resolver Encoder Types • SSI • Hiperface • Analogue encoders • Endat
Communications Interfaces (J1)	RS232 Interface at 19200Baud

Table 1.8 DS2100 Standard I/O Summary

1.6.4 Variant Specific I/O

CAN Variant (J3A, J3B)

Communications Interfaces	**Controller Area Interface** CAN High speed (ISO11898-2) hardware-interface. Optically Isolated (internally supplied power) 5kBaud to 1MBaud programmable CANopen DS301 V4.01 CANopen DSP402 V2.0 Device Profile

Table 1.9 DS2100 CANopen

Page Intentionally Blank

SECTION 2: SAFETY & EMC INSTRUCTIONS

TABLE OF CONTENTS

2.1 General

This user's manual is intended to provide sufficient information on how to install Moog DS2100 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 **NOTES, CAUTIONS**, and **WARNINGS** and **CE-Compliance-Required**. They are defined as follows:

i

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.

CE-Compliance indicates where a particular application-related safety or EMC requirement is driven by the need for CE-Compliance of the DS2100 when installed in the system. Customers who do not need CE-Compliance on their machinery may choose not to implement these features.

The DS2100 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 DS2100 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 for the µA size (6 minutes for A-E sizes), to allow for 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 supply voltage, 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 DS2100 controller is connected to mains power. Check that the mains supply has been disconnected 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.

i

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.

i

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.

i

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

a) General Safety Requirements

Users are required to implement safety measures with all equipment, systems and installations into which the DS2100 Servo-drive are installed. In addition, safeguards must be an integral part of workcell design, installation, operator training and operator procedures where this equipment is used.

Required for CE-Compliance

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 DS2100 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.

Required for CE-Compliance

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 allowed. Users should ensure the nature of the supply system is appropriate before connecting and operating the drive.

b) 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 DS2100 Series Controllers are installed.

The user is required to provide safety interlocks to prevent unexpected restart during servicing of the DS2100 Controller and any equipment attached to or driven by these units.

The DS2100 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 DS2100 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 DS2100 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 0.1Ω.

A D.C 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 DS2100 Series Controllers must be derived from a Safety Extra Low Voltage (SELV) supply as defined by standard EN60950. Such SELV voltages do not exceed a value of 60 Vd.c. or 42.4 Va.c. 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 DS2100 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 DS2100 must be provided with suitable fusing to protect the drive. The fuses required for each DS2100 model are detailed in the following table It is recommended to use UL certified fuses and fuse blocks

DS2100 Models	**Size μA**					**Notes**
Size	3/11		6/22			**Notes**
Short Circuit Rating	5,000 Amps_{rms}					
Power Line Fuse	25A, 660V FWP25-A1F					Semiconductor (Cooper Bussmann)
Recovery Resistor Fuse	Contact Moog Application Engineering for Advice					
24Vdc Auxiliary Power Supply Fuse	3A, 250V					Delayed
DS2100 Models	**Size A**		**Size B**			
Size	8/22		14/42			**Notes**
Short Circuit Rating	5,000 Amps_{rms}					
Power Line Fuse	50-FE 690V					Semiconductor (Cooper Bussmann)
Recovery Resistor Fuse	Contact Moog Application Engineering for Advice					
24Vdc Auxiliary Power Supply Fuse	3A, 250V					Delayed
DS2100 Models	**Size C**			**Size D**		**Notes**
Size	20/45	25/70	30/90	50/140	60/180	
Short Circuit Rating	5,000 Amps_{rms}			10,000 Amps_{rms}		
Power Line Fuse	100-FE 690V			160-FEE 690V		Semiconductor (Cooper Bussmann)
Recovery Resistor Fuse	Contact Moog Application Engineering for Advice					
24Vdc Auxiliary Power Supply Fuse	3A, 250V					Delayed
DS2100 Models	**Size E**					**Notes**
Size	100/300					
Short Circuit Rating	10,000 Amps_{rms}					
Power Line Fuse	315-FM					Semiconductor (Cooper Bussmann)
Recovery Resistor Fuse	Contact Moog Application Engineering for Advice					
24Vdc Auxiliary Power Supply Fuse	3A, 250V					Delayed

Table 2.1 Recommended DS2100 Fusing

WARNING – In the event of a fuse failure, remove all power, refrain from working on the unit for at least 5minutes for the μA size (6 minutes for the A-E sizes) to allow all internal voltages to decay to a safe level. Remove all fuses from the system. Determine the source of the failure before re-commencing operation of the drive.

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 DS2100 Servo-drive until all instructions in the Wiring and Installation section of this User's manual have been carried out.

WARNING - DO NOT remove or replace any assemblies, subassemblies or components with primary 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 for the µA size (6 minutes for the A-E sizes) 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 DS2100 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 DS2100 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 for the µA size (6 minutes for the A-E sizes) 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

Required for CE-Compliance

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 following table details the recommended cable dimensions for all DS2100 models

	DS2100 Models				**Notes**
	µA		**A**	**B**	
Cable	**3/11 AWG (mm^2)**	**6/22 AWG (mm^2)**	**8/22 AWG (mm^2)**	**14/42 AWG (mm^2)**	
Line Power	3x14 (2.1)	3x14 (2.1)	3x14 (2.1)	3x12 (3.3)	
Protective Bonding Cable	1x 6 (13)	1x 6 (13)	1x 6 (13)	1x 6 (13)	
Motor Power Cable	4x14 (2.1)	4x14 (2.1)	4x14 (2.1)	4x12 (3.31)	Shielded
Regen Resistor Cable	2x14 (2.1)	2x14 (2.1)	2x14 (2.1)	2x14 (2.1)	Shielded
DC Bus Cable	2x14 (2.1)	2x14 (2.1)	2x14 (2.1)	2x14 (2.1)	Shielded
Safety Interlock (If applicable)	2x22 (0.3)				Shielded
24V Power Cable	2x14 (2.1)				Shielded

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

	DS2100 Models					**Notes**
	C			**D**		
Cable	**20/45 AWG (mm^2)**	**25/70 AWG (mm^2)**	**30/90 AWG (mm^2)**	**50/140 AWG (mm^2)**	**60/180 AWG (mm^2)**	
Line Power	3x8 (8.4)	3x8 (8.4)	3x8 (8.4)	3x 6 (13)	3x 4 (21)	
Protective Bonding Cable	1x 6 (13)	1x 6 (13)	1x 6 (13)	1x6 (13)	1x4 (21)	
Motor Power Cable	4x8 (8.4)	4x8 (8.4)	4x8 (8.4)	4x6 (13)	4x4 (21)	Shielded
Regen Resistor Cable	2x8 (8.4)	2x8 (8.4)	2x8 (8.4)	2x 6 (13)	2x4 (21)	Shielded
DC Bus Cable	2x8 (8.4)	2x8 (8.4)	2x8 (8.4)	2x 6 (13)	2x4 (21)	Shielded
Safety Interlock (If applicable)	2x22 (0.3)					Shielded
24V Power Cable	2x14 (2.1)					Shielded

	DS2100 Models	**Notes**
	E	
Cable	**100/300 AWG (mm^2)**	
Line Power	3 x 1 (42)	
Protective Bonding Cable	1 x 1 (42)	
Motor Power Cable	4 x 1 (42)	Shielded
Regen Resistor Cable	2 x 2 (34)	Shielded
DC Bus Cable	2 x 1 (42)	Shielded
Safety Interlock (If applicable)	2x22 (0.3)	Shielded
24V Power Cable	2 x 14 (2.1)	Shielded

Table 2.2 DS2100 Cable Dimensions

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.

b) Wiring Practices - Connections and routing

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

c) 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.

d) 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 colour (or both) so that they can be identified as being live when the supply disconnecting device is in the OFF or OPEN position.

e) Wiring Practices - Identification of conductors

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

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

f) Wiring Practices - Identification of the protective conductor

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

For insulated conductors, the bicolour combination GREEN-AND-YELLOW shall be such that on any 15mm length, one of the colours covers at least 30% and not more than 70% of the surface of the conductor, the other colour 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, colour coding throughout its length is not necessary. However, the ends or accessible positions shall be clearly identified by the graphical symbol or by the bicolour combination GREEN-AND-YELLOW.

g) Wiring Practices - Identification of the neutral conductor

Where a circuit includes a neutral conductor identified by colour, the colour 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 colour is used, bare conductors used as neutral conductors shall be either coloured by a LIGHT BLUE stripe, 15 mm to 100 mm wide, in each compartment or unit or at each accessible position, or coloured LIGHT BLUE throughout their length.

h) 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.

i) 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 nor 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, 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.

j) 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. Where necessary, additional protection consisting of a flame-retardant, oil-resistant insulating material shall be provided to protect conductor insulation.

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.

2.2.4 EMC requirements for cables

User's whose machine installations require for 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 DS2100. 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 DS2100 Servo-drive (For example, the 24 Vd.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 DS2100 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 DS2100 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 are intended for CE-Compliance should read this Section.

The DS2100 Servo-drive 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 DS2100 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 DS2100 Servo-drive 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 DS2100 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, the 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 DS2100 is installed. Further details are given throughout this User's Guide.

The DS2100 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 DS2100. Cable shields must be bonded to either the panel earthing bar or the EMC brackets.

For safety reasons the DS2100 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 DS2100 Servo-drive are installed.

All external d.c. supply voltages used with the DS2100 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 DS2100 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 DS2100. 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 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 DS2100. To ensure EMC compliance an external line filter must be installed. The recommended filters for the DS2100 are detailed below.

DS2100 µA Size

Moog Order Code	Manufacturer	Rated Current (A) @ 50°C (40°C)	Max Voltage	Drive Input
-	Schaffner Fairite Clamp. Part # 00443164151	-	-	$24V_{dc}$ Input (4 Turns in Common Mode)
AT6009	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)

DS2100 A,B,C,D, E Sizes

Moog Order Code	Manufacturer	Rated Current (A) @ 50°C (40°C)	Max Voltage	Drive Input\Size
AT6017[1]	Schaffner FN2070-3-06	(3)	250V	$24V_{dc}$ Input
AT6009	Schaffner FN258-7/07	7 (8.4)	3x480V	3-phase AC Line Input (Size A)
AT6010	Schaffner FN258-16/07	16 (19.2)	3x480V	3-phase AC Line Input (Size B)
AT6011	Schaffner FN258-30/07	30 (36)	3x480V	3-phase AC Line Input (Size C)
AT6012	Schaffner FN258-42/07	42 (50.4)	3x480V	3-phase AC Line Input (Size D 50/140)
AT6013	Schaffner FN258-55/07	55 (66)	3x480V	3-phase AC Line Input (Size D 60/180)
AT6015	Schaffner FN258-100/35	100 (113)	3x480V	3-phase AC Line Input (Size D 100/300)

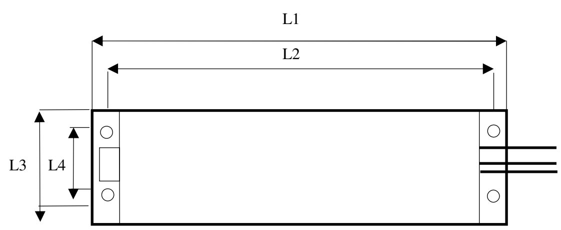
Table 2.3 Recommended EMC Filters for DS2100

[1] The 24Vdc filter can be used with two DS2100 drives. If more than two DS2100 drives are in use on a machine, a filter from the same series can be used with a higher current rating.

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

Moog Order Code	Manufacturer	Dimensions [mm]							Weight
		L1	L2	L3	L4	L5	L6	L7	[kg]
AT6017	Schaffner FN2070-3-06	85	75	54	0	65	40.3	Fast-on	0.25
AT6009	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
AT6010	Schaffner FN258-16/07	3.5	290	55	30	275±0.8	142±0.8	300	1.7
AT6011	Schaffner FN258-30/07	335	320	60	35	305	150	400	1.8
AT6012	Schaffner FN258-42/07	329	314	70	45	300	185	500	2.8
AT6013	Schaffner FN258-55/07	329	314	80	55	300	185	500	3.1
AT6015	Schaffner FN258-100/35	379	364	90	65	350	220	Terminal blocks only	5.5

TOP VIEW



SIDE VIEW

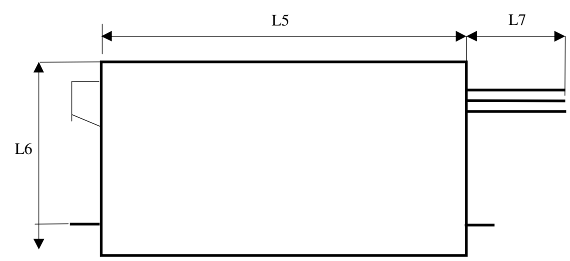


Table 2.4 DS2100 Recommended Filters Mechanical Sizing

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.

WARNING: High voltage –Internal filter capacitors discharge time: approx. 10 seconds.

2.3.3 EMC requirements for cables

User's whose machine installations require for 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 DS2100. 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 2.1 **Partition Crossing**

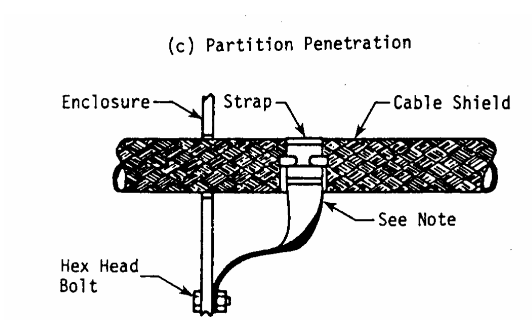


Figure 2.1 Partition Crossing

All external Regen (Regenerative circuit) resistors used with the DS2100 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 DS2100 Servo-drive (For example, the 24 $V_{d.c.}$ supply) must be as short as possible. The supply wires shall be twisted together or alternatively shielded cable shall be used. The 24 $V_{d.c.}$ 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 DS2100 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 DS2100 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 2.2 Correct Cable Preparation Grounding of Shield to Chassis**

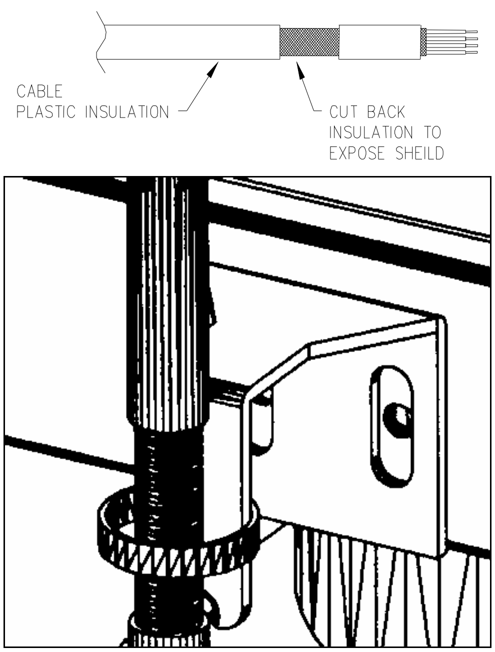


Figure 2.2 Correct Cable Preparation Grounding of Shield to Chassis

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 DS2100 size are shown in the following figures.

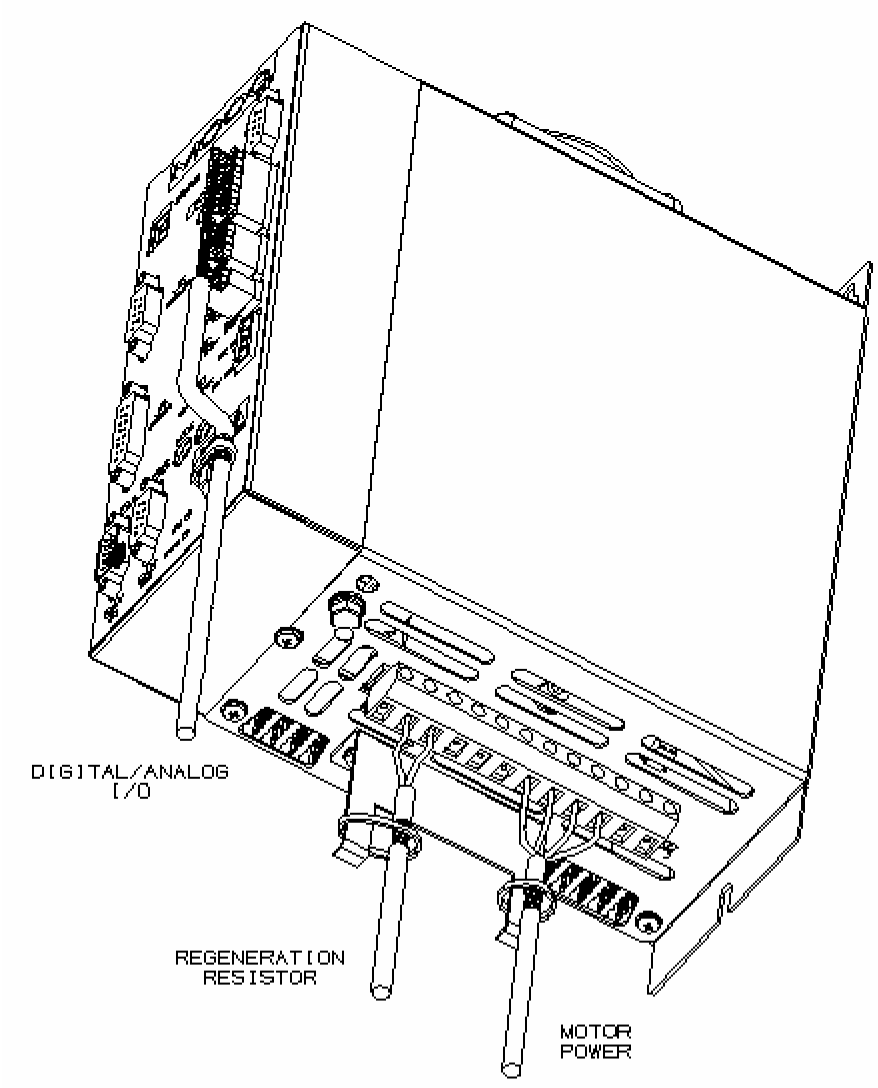


Figure 2.3 DS2100 µA Cable Shield Terminations

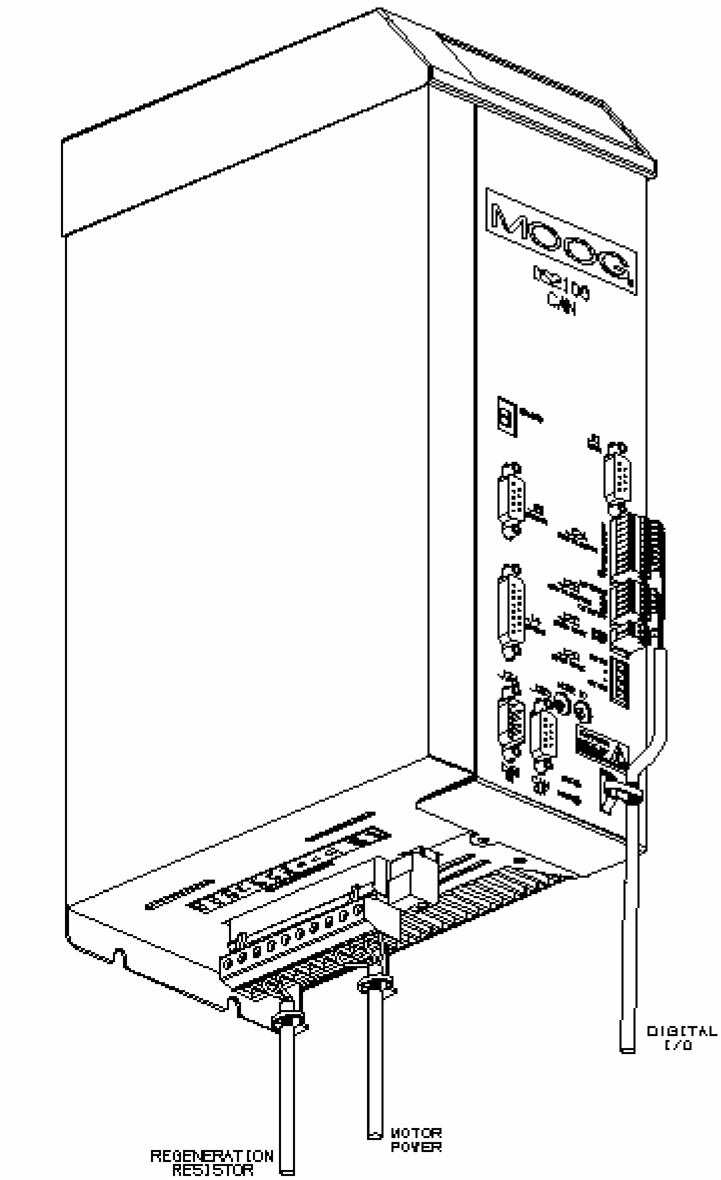


Figure 2.4 DS2100 A & B Cable Shield Terminations

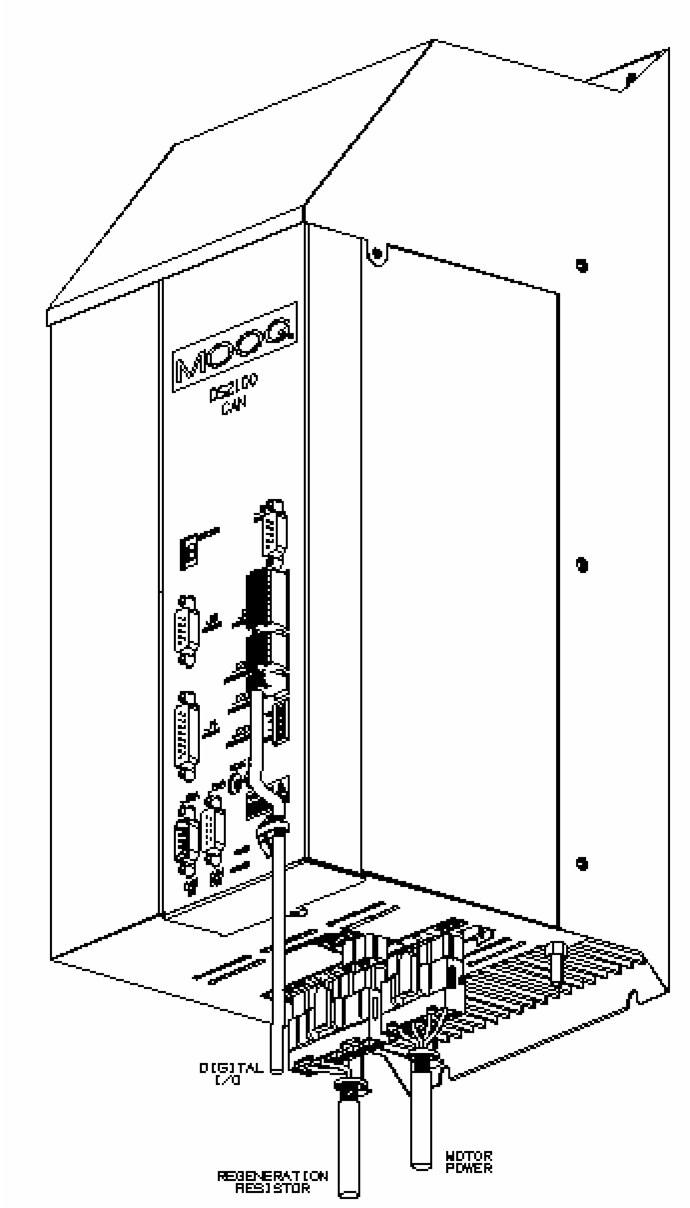


Figure 2.5 DS2100 C Cable Shield Terminations

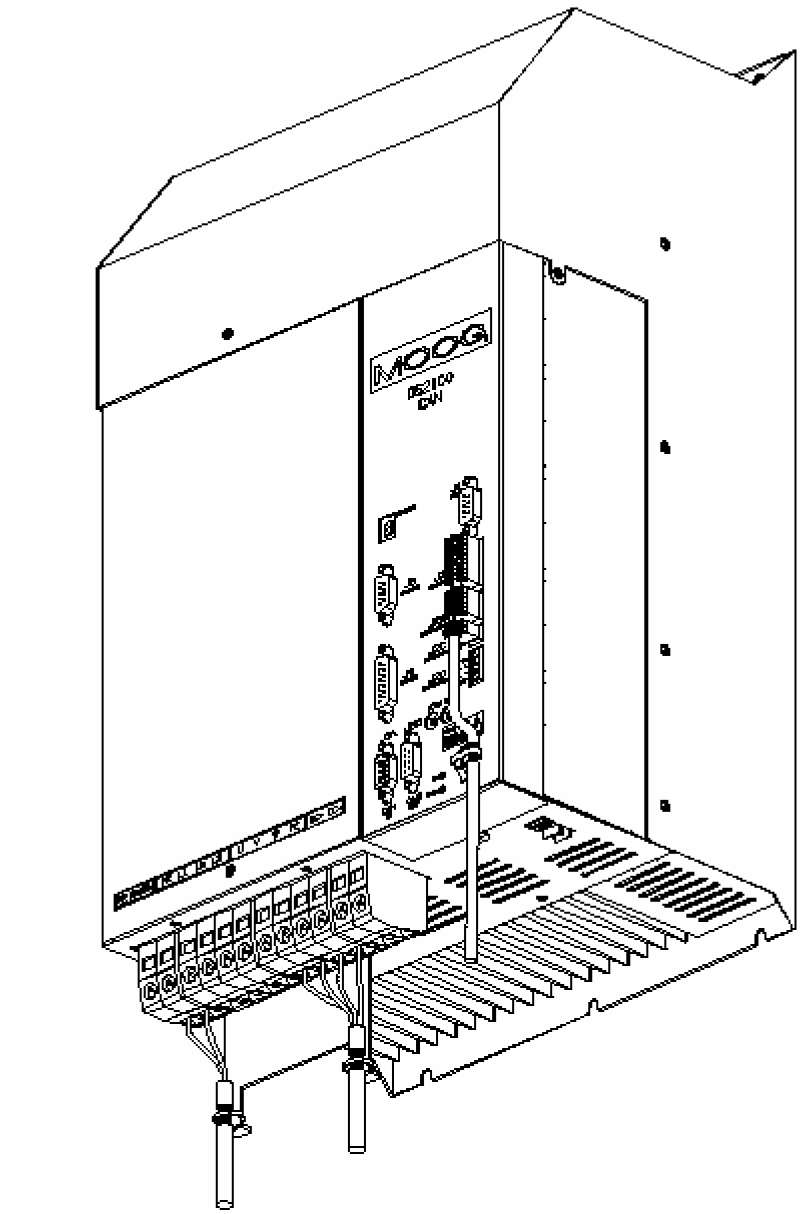


Figure 2.6 DS2100 D Cable Shield Terminations

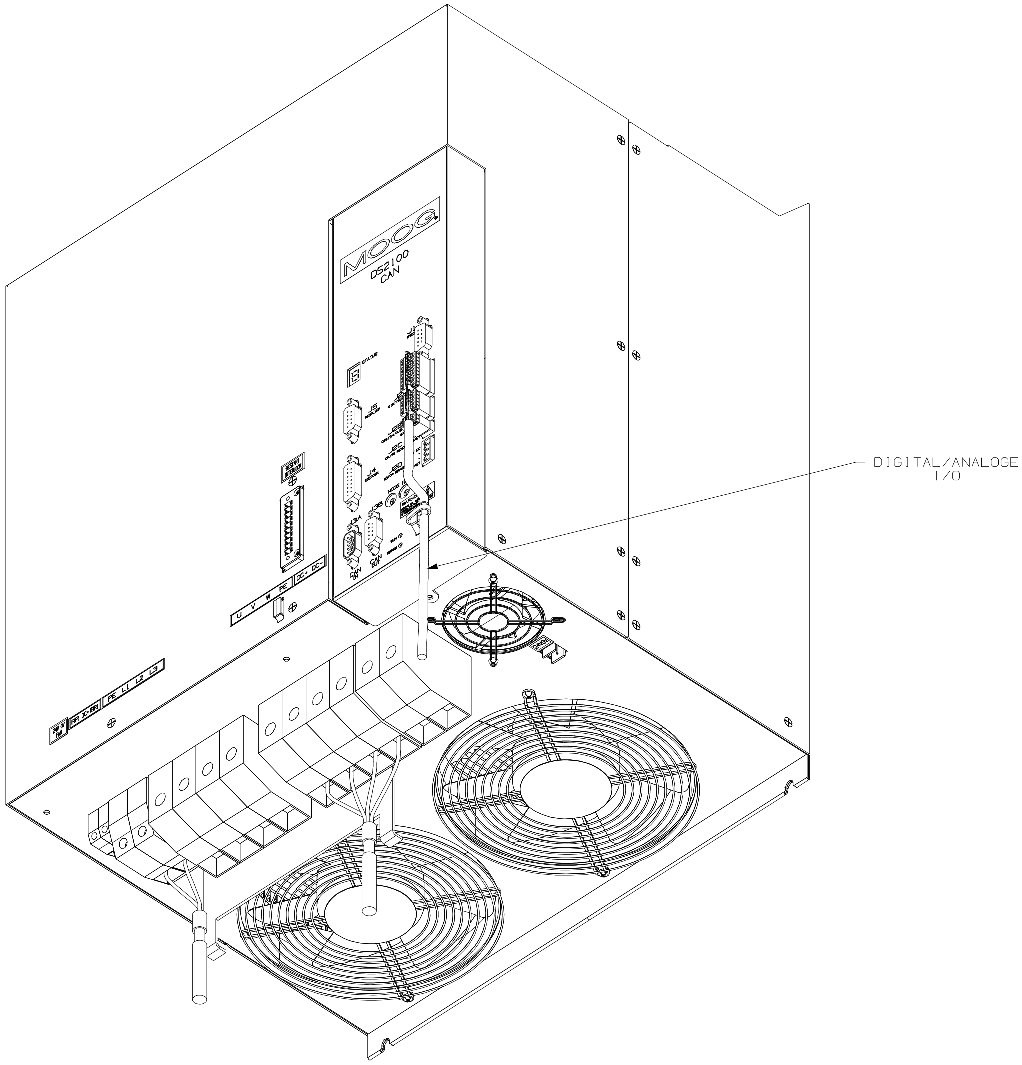


Figure 2.7 DS2100 E Cable Shield Terminations

2.4 UL Requirements

Detailed below are the specific UL requirements for the DS2100.

2.4.1 Specific UL Requirements

- **Usage:** The DS2100 shall be used according to the guidelines given in this manual.

- **Ratings:** The DS2100 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 2 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, 40°C".

- **Pollution Degree 2 Installation**:- The drive must be installed in a Pollution Degree 2 environment.

- **Equipment Designation**: - Open Type Equipment.

- **Short circuit Ratings**:-

  DS2100 3/11, 6/22, 8/22, 14/42, 20/45, 25/70, 30/90, 50/140: "Equipment suitable for use on a circuit capable of delivering not more than 5000 rms symmetrical Amperes, 460V ac + 10% Maximum".

  DS2100 60/180, 100/300: "Equipment suitable for use on a circuit capable of delivering not more than 10000 rms 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.

DS2100 3/11 & 6/22:	Fuse Model No. FWP-25A14F Semiconductor Type Fuses.
DS2100 8/22 & 14/42:	Fuse Model No. 50FE Semiconductor Type Fuses.
DS2100 20/45, 25/70 30/90:	Fuse Model No: 100FE Semiconductor Type Fuses.
DS2100 50/140 & 60/180:	Fuse Model No: 160FEE Semiconductor Type Fuses.
DS2100 100/300 :	Fuse Model No: 315-FM Semiconductor Type Fuses.

- **Wiring**. The drive shall be wired with stranded and \ or solid copper (Cu), 60/75°C 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 DS2100 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 DS2100 incorporates a software-based over-speed protection. See 'Motor Rating Parameters' and 'Velocity Limiting' in Section 5 of this Manual.

- **Motor Overload Protection**: The DS2100 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 DS2100 is equipped with internal over current protection. See the ‘Cabling and Interconnect Protection Scheme’ detailed in Section 5 of this manual.

- The **Integral Motor Thermal Protection** signal shall be connected on the equipment, on G361 connectors J4/J5 (PIN 8-15/6-8), which accepts signals maximum 5.5 Vdc ±10%, 400 µA. The ultimate result of this signal is to "Switch-OFF" the output of the Solid State Motor Controller and thereby "No-Power" is transmitted to the Motor connected to the Motor-Drive.

Page Intentionally Blank

SECTION 3: WIRING AND INSTALLATION

TABLE OF CONTENTS

This section covers the installation, wiring and cabling of the Moog DS2100 Servo-drive series. A pictorial diagram of a single-axis system, with typical components included, is shown in Figure 3.1. Users are directed to read Section 2, 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 DS2100 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 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 (refer to Figure 3.1). The user supplies all components besides the DS2100, EMC-Brackets, motor and other accessory cabling.

3.1.1 A.C. Mains Power Interface

The DS2100 should be connected to a three-phase AC supply. Operation with a single-phase supply is only allowed with the G361-x003 and G361-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 Section 2 of this manual. Alternatively an 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 DS2100 input between the line fuses and the EMC filter at the input of the DS2100 (refer to Figure 3.1). 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 before any service or maintenance activity is commenced.

3.1.3 Line Filter Requirements

Details of the recommended line filters for each of the DS2100 variants are given in Section 2 of this manual.

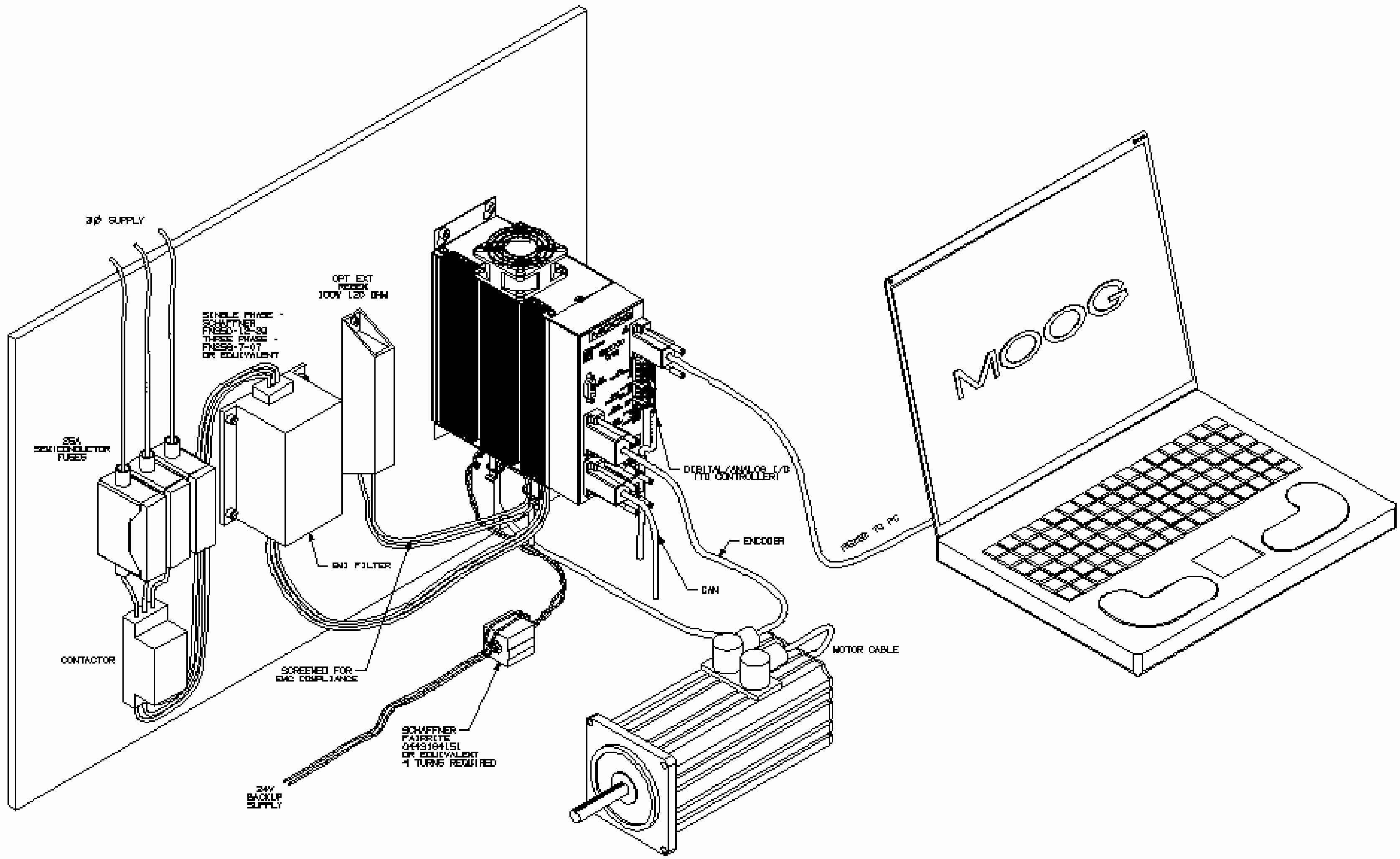


Figure 3.1Typical DS2100 System Components (µA Size)

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.

Required for CE-Compliance

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 authorised 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 DS2100 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 DS2100 does not lose absolute position data or status information when AC mains power is removed from the DS2100.

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

The G361-x003 &-x006 **MUST** have a $24V_{dc}$ logic backup supply connected for the drive to operate. No internal high voltage backup is provided on these smaller models.

The $24V_{dc}$ control power option allows high voltage motor power to be removed from a DS2100 Series Servo-drive without losing control power.

The acceptable voltage range for this supply is $24V_{dc}$ ±10% with a minimum current rating of $2A_{dc}$ per DS2100 Series Servo-drive connected. A low cost unregulated DC supply is adequate.

Required for CE-Compliance

NOTE - The $24V_{dc}$ power supply must be compliant with the requirements of the EU EMC Directive. The $24V_{dc}$ output from the power supply must be Safety Extra Low Voltage (SELV - as defined by European standard EN 60950).

3.1.6 Brushless Servo motors

The DS2100 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 $24V_{dc}$ 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 DS2100 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 DS2100 chassis, as well as required clearances for cabling etc. The DS2100 is designed to be panel or cabinet mounted. The DS2100 must be mounted in a vertical orientation. The DS2100 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 DS2100 drive sizes is required. These distances are detailed in Table 3.3-1.

DS2100 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

Table 3.3-1 Minimum Clearance around DS2100 Drives

If any of the DS2100 units are mounted in a closed cabinet, allow 100mm clearance at the front for cable bends.

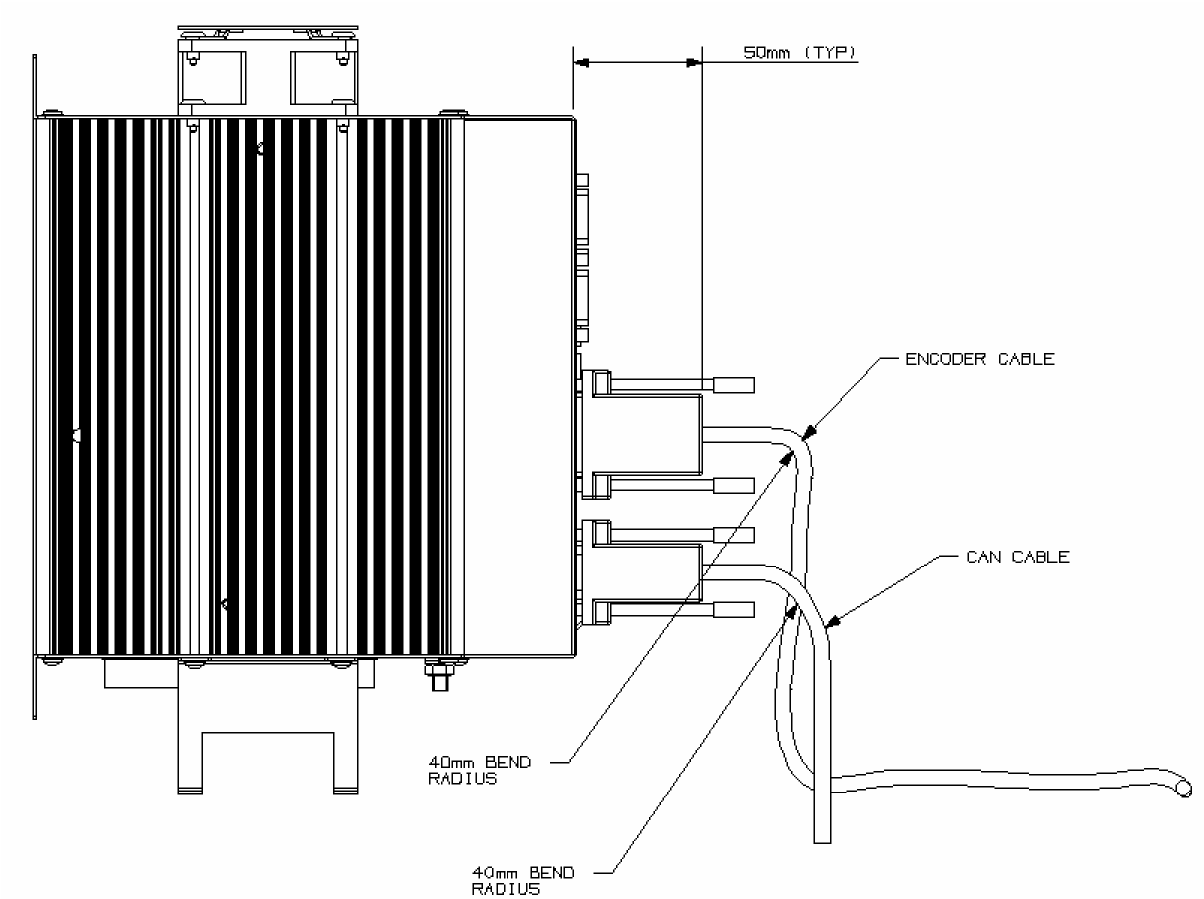


Figure 3.2 Typical DS2100 Cable Bend Radius Requirements

The DS2100 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 0.1 Ω.

Required for CE-Compliance

NOTE - The DS2100 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 Section 2 of this User's Guide).

The DS2100 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 DS2100 Servo-drive. Conductive hex socket head bolts with conductive locking washers should be used.

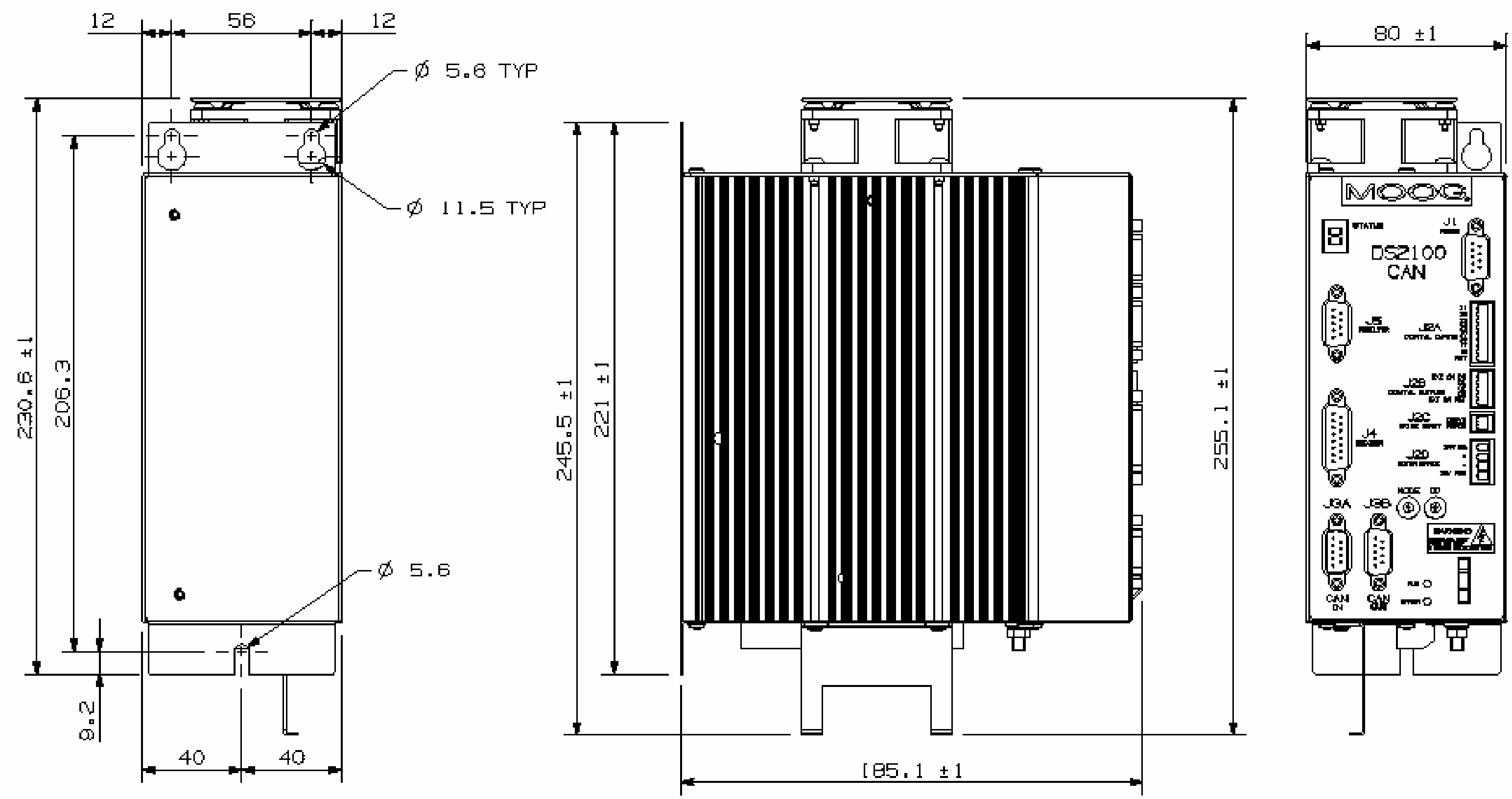


Figure 3.3 DS2100 µA Mechanical & Mounting Dimensions

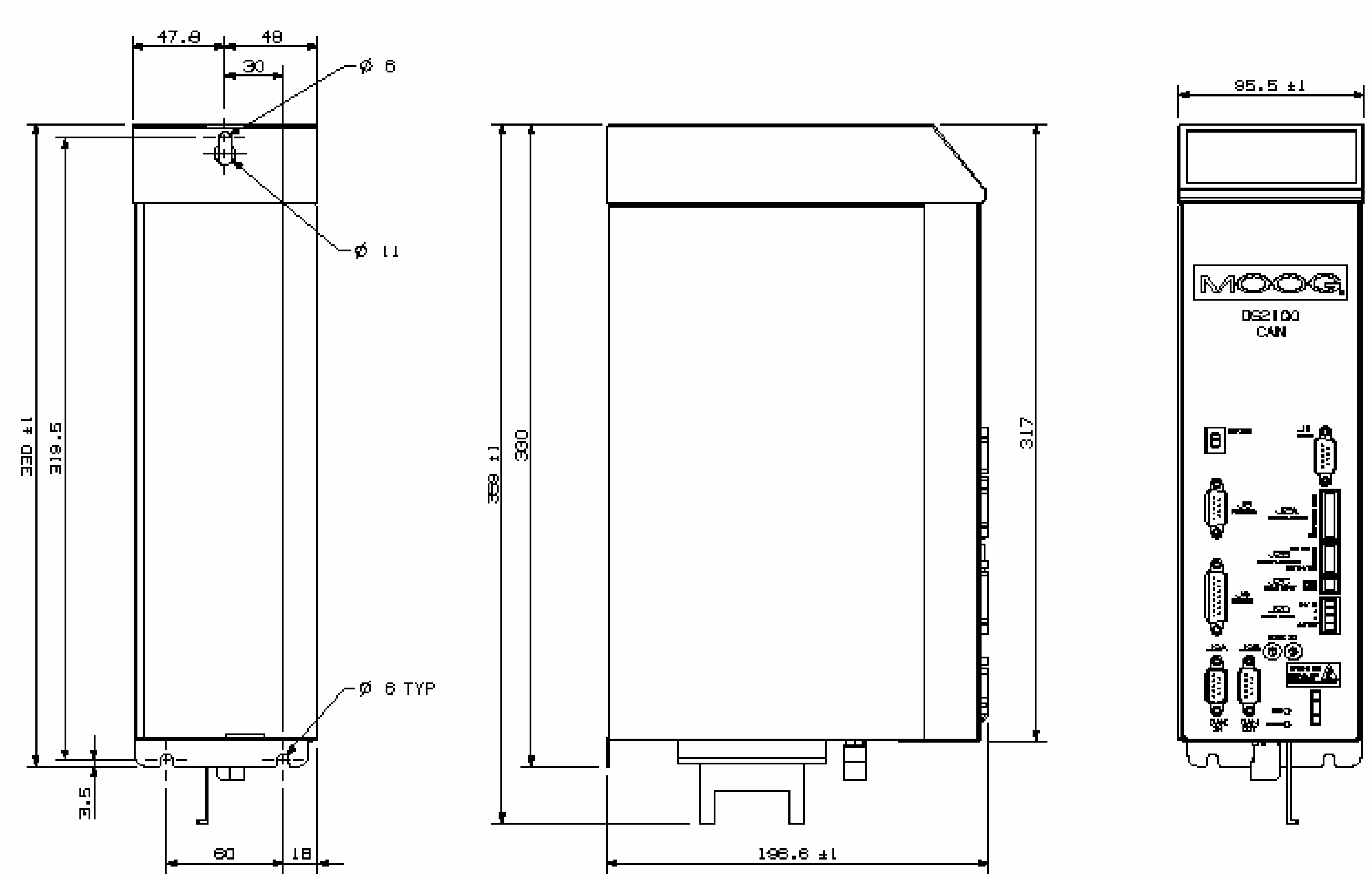


Figure 3.4 DS2100 A Mechanical & Mounting Dimensions

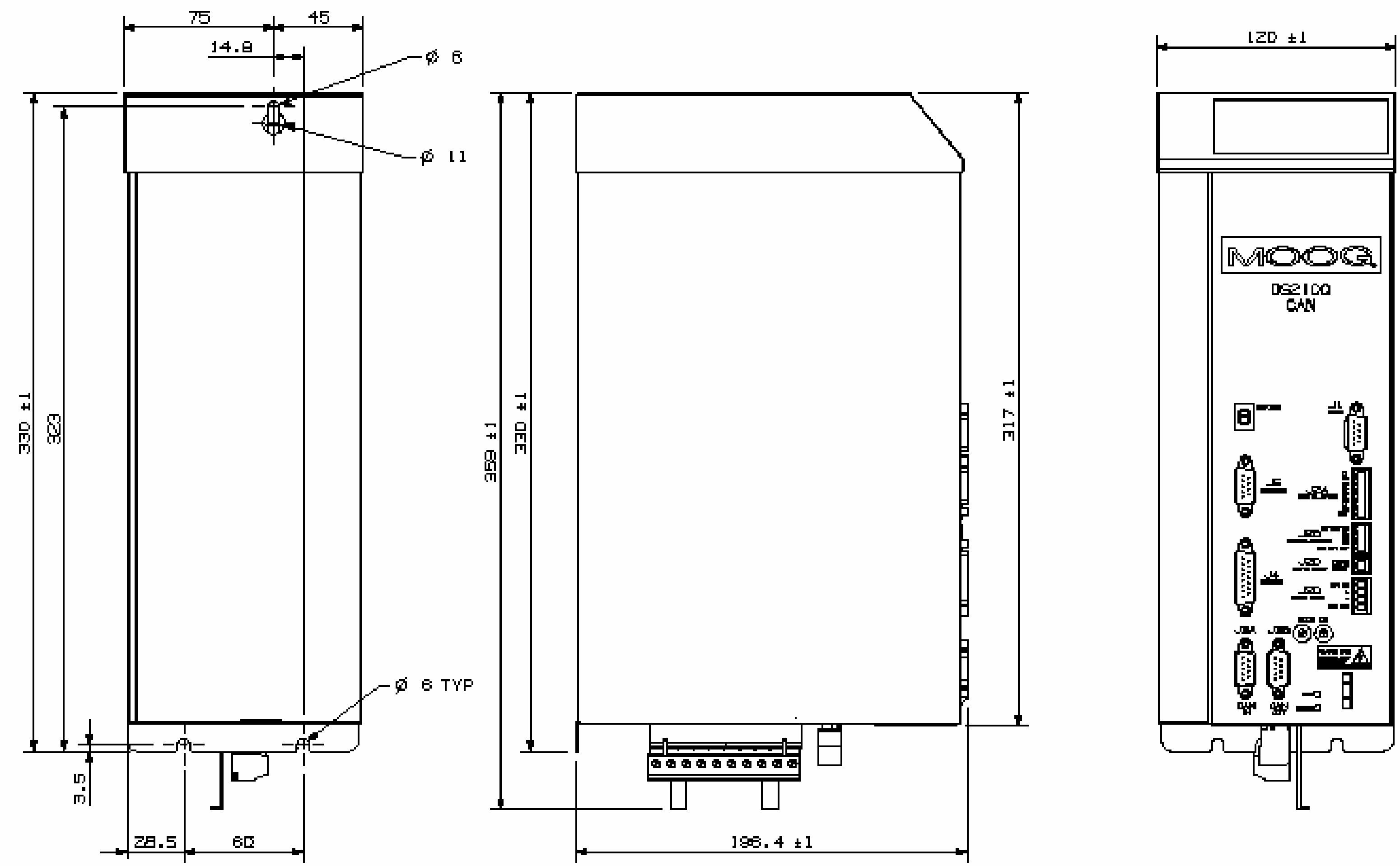


Figure 3.5 DS2100 B Mechanical & Mounting Dimensions

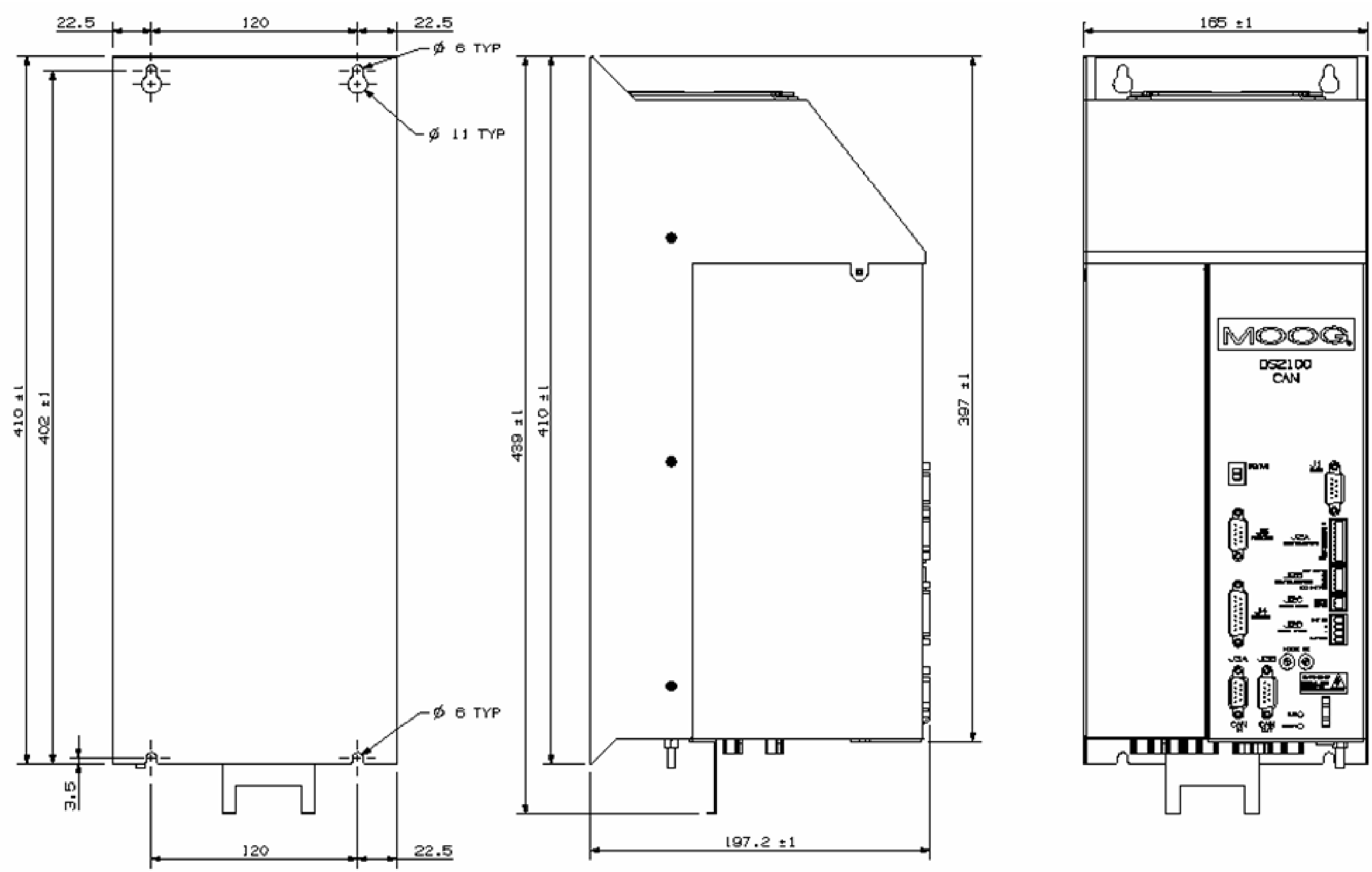


Figure 3.6 DS2100 C Mechanical & Mounting Dimensions

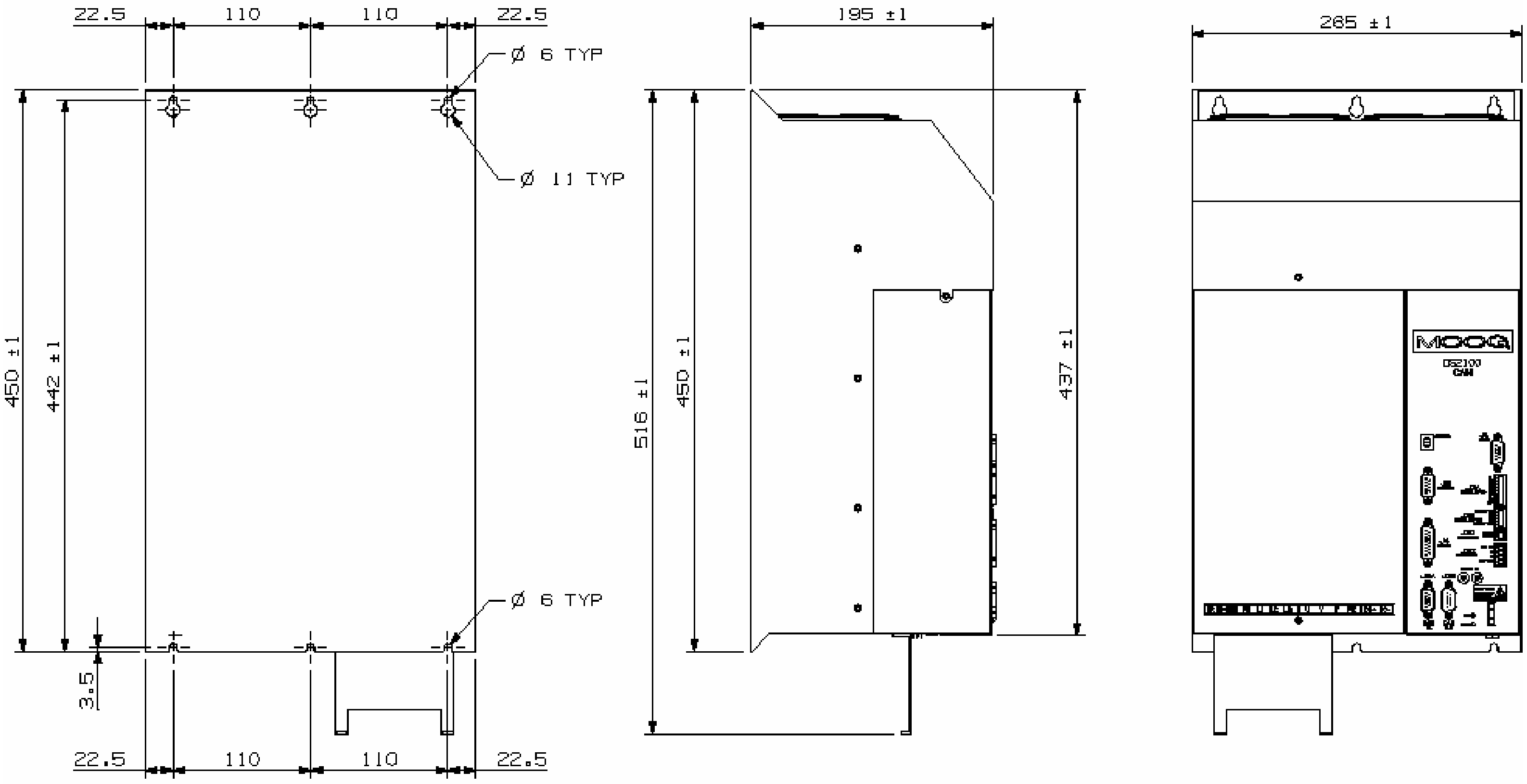


Figure 3.7 DS2100 D Mechanical & Mounting Dimensions

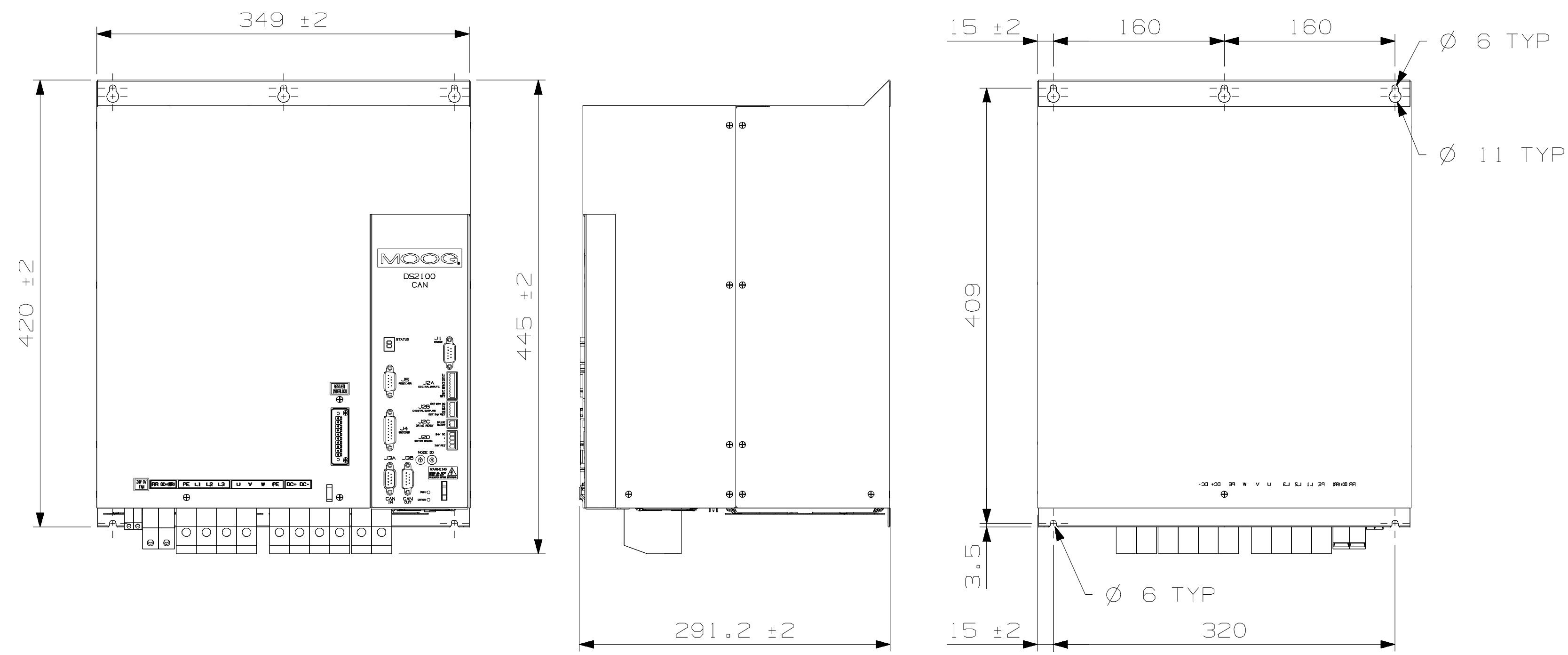


Figure 3.8 DS2100 E Mechanical & Mounting Dimensions

3.2.1 CE Items for Mechanical Installation

Required for CE-Compliance

Additional electromagnetic compatibility (EMC) measures must be installed on equipment associated with the DS2100 Servo-drive. The following measures must be implemented:

- All external Regen (Regenerative circuit) resistors used with the DS2100 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 DS2100 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 d.c. supply voltages to the DS2100 Series Servo-drives (for example, the 24 Vd.c. 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 DS2100 Power Supply to other DS2100 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 DS2100 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 Section 2.

CAUTION - Enclosure or cabinet temperature control is critical for performance, reliability and 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 Power Dissipation

To calculate cabinet cooling requirements, Table 3.3-2 provides approximate equipment power dissipation values. If the application employs regeneration, be sure to add the regen resistor power dissipation to the numbers quoted in Table 3.3-2 below, (use the continuous wattage rating of the regen resistor if the actual application regen dissipation is unknown).

	Power Dissipation								
DS2100	**3Amp**	**6Amp**	**8Amp**	**14Amp**	**25Amp**	**30Amp**	**50Amp**	**60Amp**	**100Amp**
(Watts)	53	100	110	180	300	400	650	800	1200

Table 3.3-2 Estimated Power Dissipation for the DS2100 Servo-drives

3.4 DS2100 Connector Terminals

Figure 3.9 to Figure 3.14 below detail the connectors on the DS2100 (all sizes).

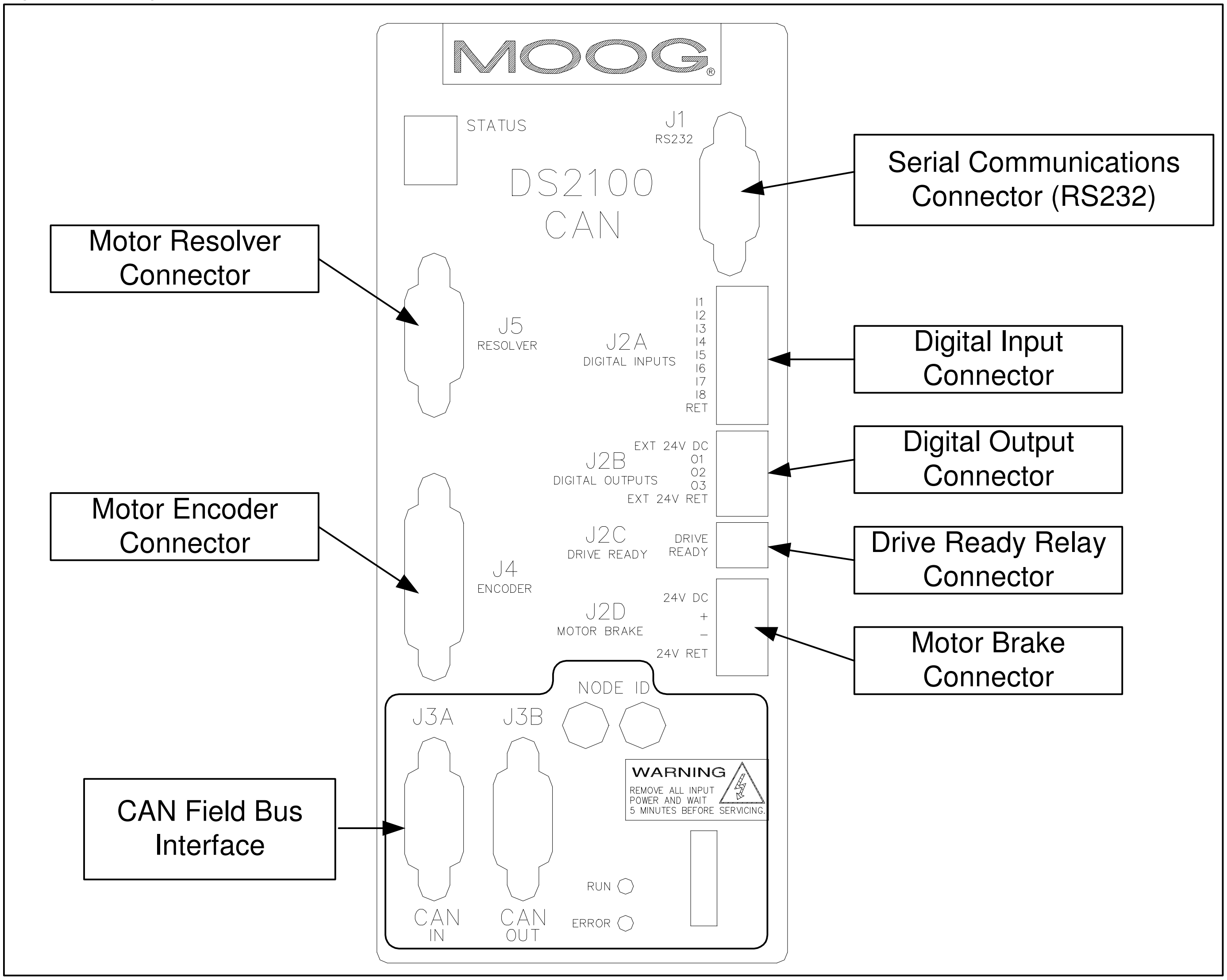


Figure 3.9 DS2100 Control Card Connector Terminals

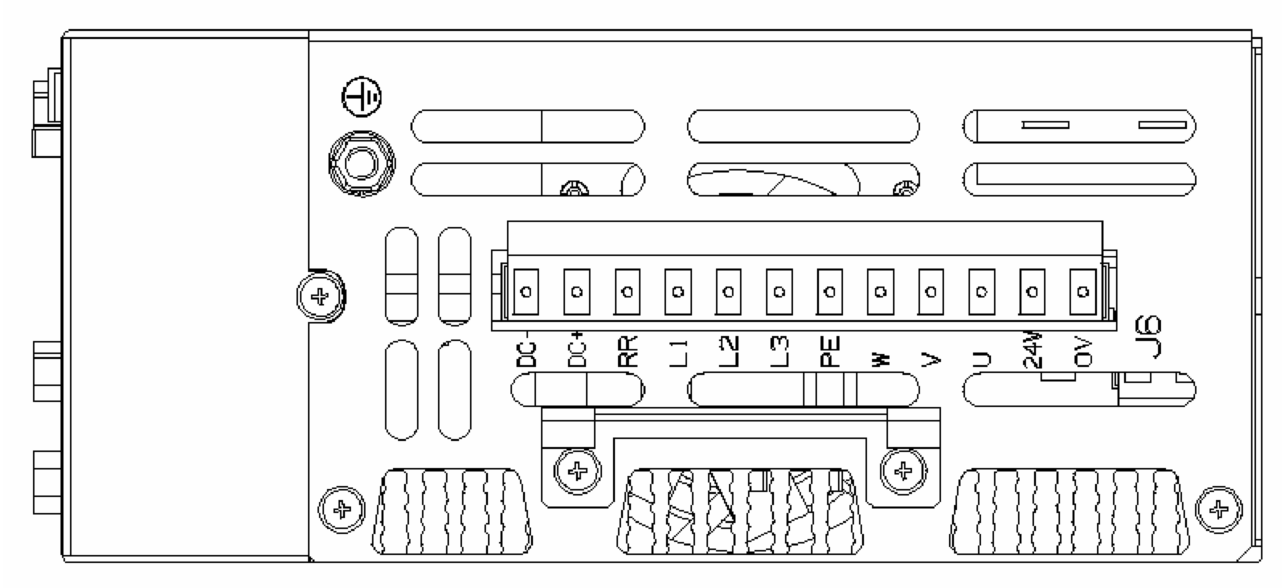


Figure 3.10 DS2100 Size µA Power Connector Terminals

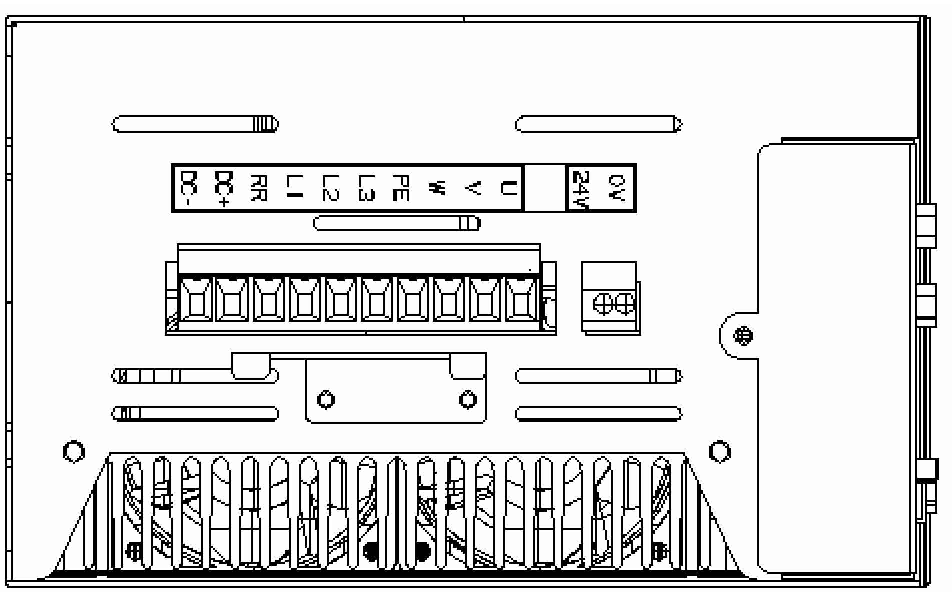


Figure 3.11 DS2100 Size A & B Power Connector Terminals

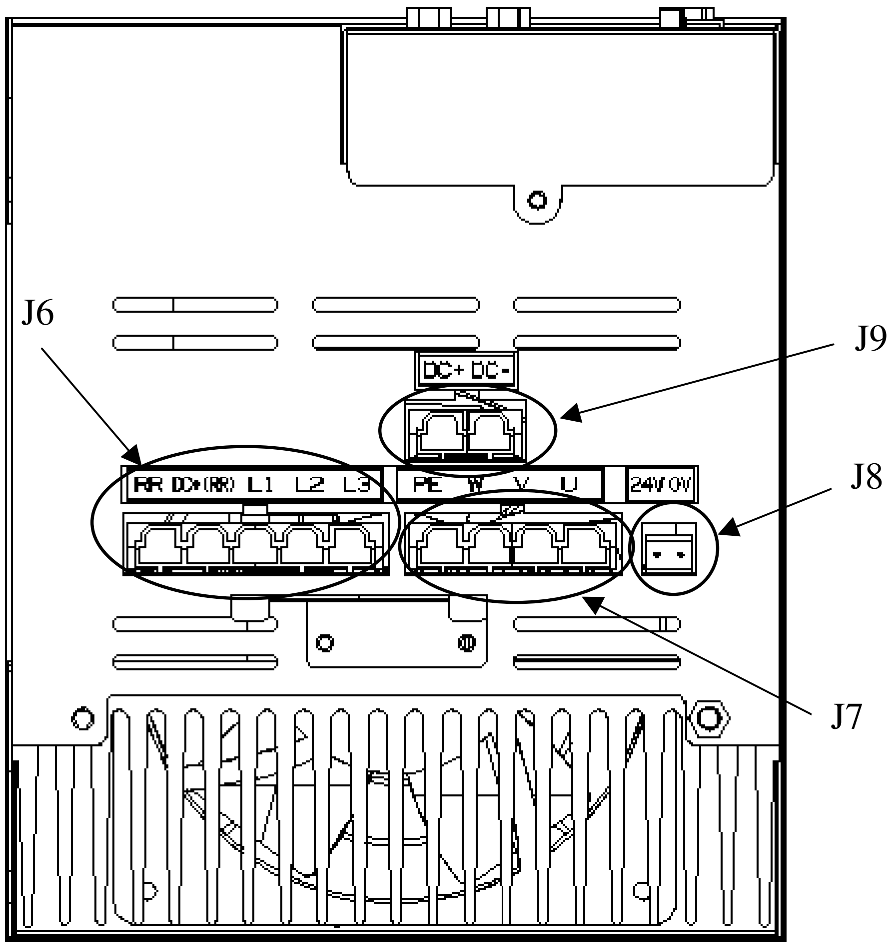


Figure 3.12 DS2100 Size C Power Connector Terminals

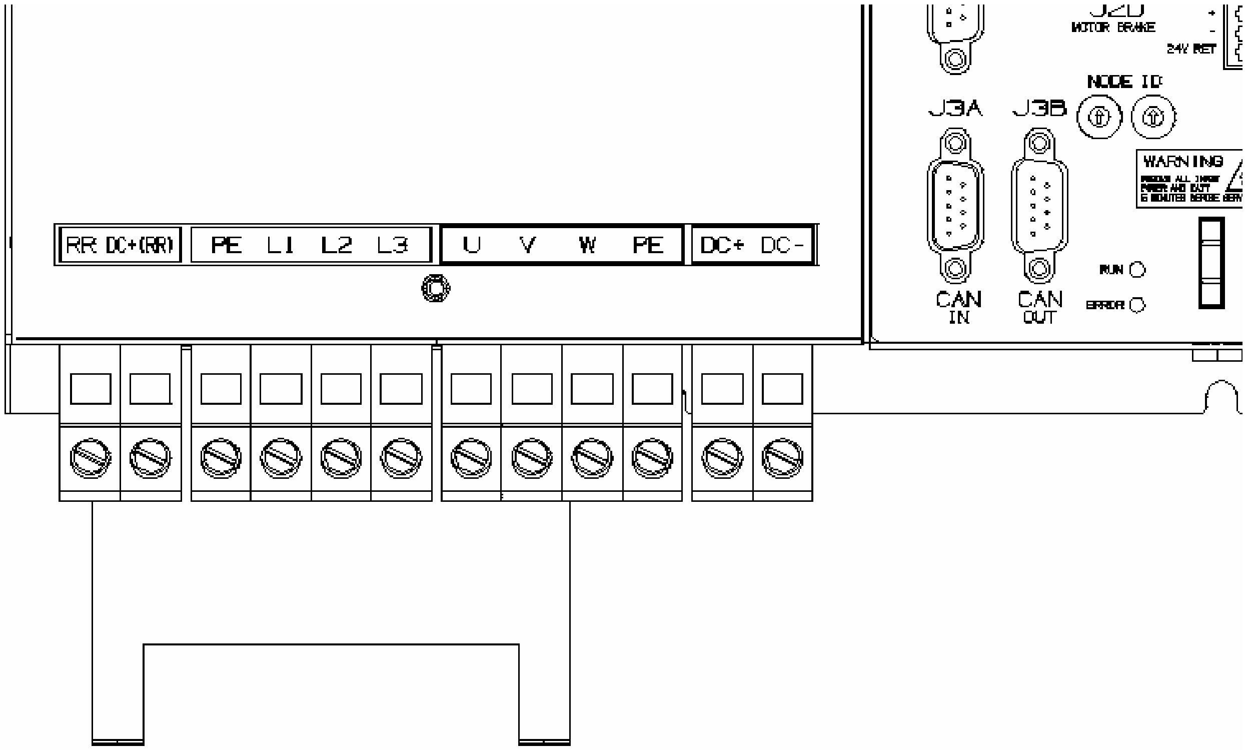


Figure 3.13 DS2100 Size D Power Connector Terminals

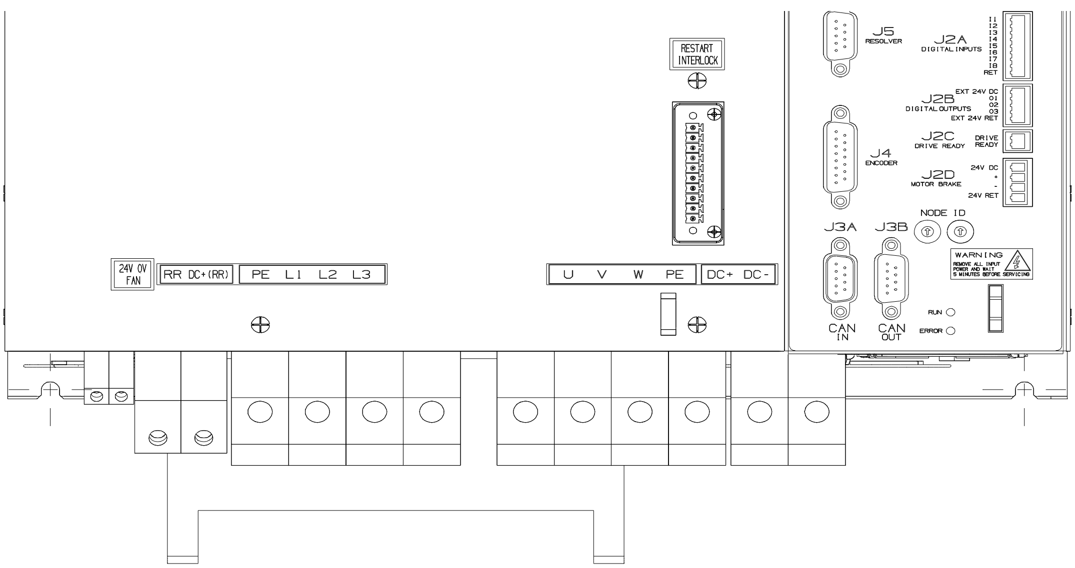


Figure 3.14 DS2100 Size E Power Connector Terminals

3.5 General System Wiring Guidelines

The following is a general reminder of the cable requirements for the DS2100 Series Servo-drives and related equipment.

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.

Size wire in accordance with standard wiring practice and local codes for amperage and wire length requirements. Recommended wire sizes are given in Section 2.

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 minimised.

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 minimise EMI. The impedance between the earth terminal and any accessible part of the equipment enclosure or cabinet should be less than or equal to 0.1Ω

Tighten all terminal screws securely to avoid faulty operation. Torque screws to the specified values

All power connections to the DS2100 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 DS2100 D & E 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 DS2100 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.

Required for CE-Compliance

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

CAUTION - Additional electromagnetic compatibility (EMC) measures which must be installed on equipment cables associated with the DS2100 Servo-drive are given in Section 2 of this User's Guide.

CAUTION - All wires and cables entering and leaving the IP54 rated enclosures or cabinets containing the DS2100 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 DS2100) should be installed just before the AC input line filter of the DS2100. 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 DS2100 Size C are 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 **Error! Reference source not found.**.

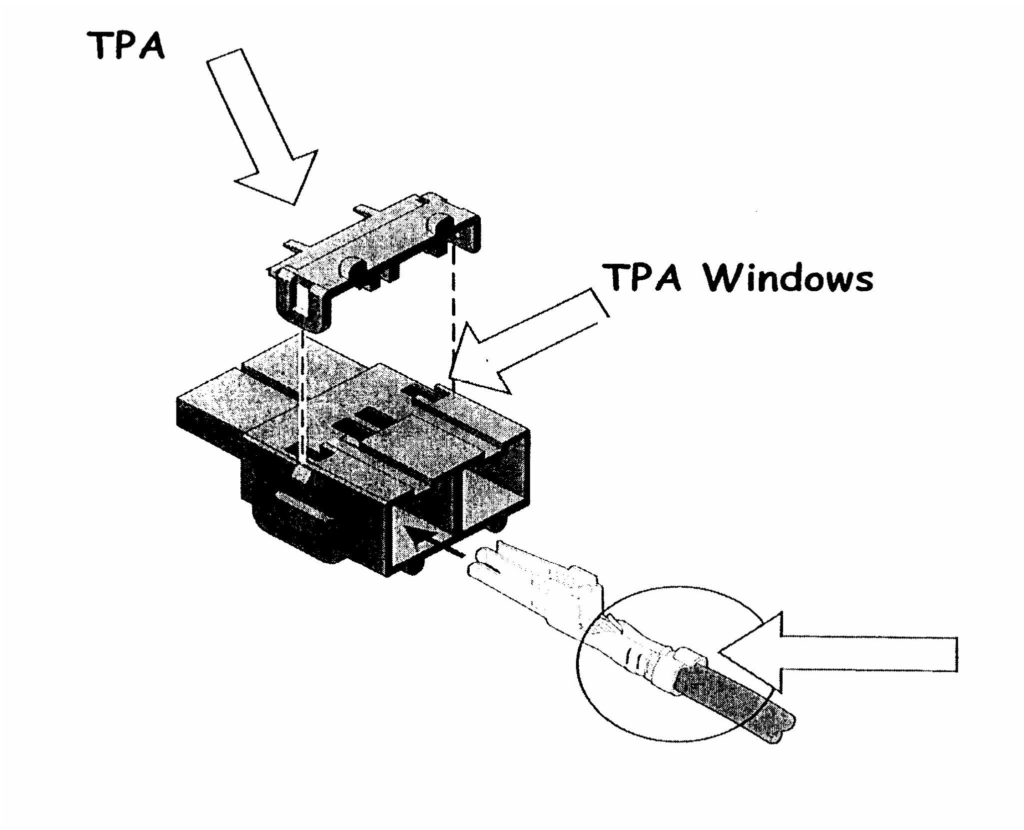


Figure 3.15 DS2100 Size C Crimp Assembly

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

- ❑ Wire a 24V Logic Supply to the drive (Required on µA size drives). Fit a suitable EMC filter on the 24V logic Supply and fuse.
- ❑ Wire a 24V Logic Supply to the drive for fan external supply, if necessary.
- ❑ Wire a.c. mains input to a 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 a.c. mains from the user-supplied contactor to the power input poles of the DS2100.

b) Servo-drive Wiring

- ❑ Plug in Axis I/O cable to J2 and connect other end to user I/O equipment.
- ❑ Plug in resolver cable at J5 (or Encoder Cable to J4).
- ❑ Connect appropriate communications cabling (RS232 at J1, and/or Field Bus).

c) Motor Wiring

- ❑ 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 DS2100 may be supplied from a three-phase a.c. mains input. In this case the following user supplied options are required:-

1. Three-Phase Mains Fusing
2. Mains Line Filter
3. 24Vd.c. Power Source & Fuse
4. 24V d.c. EMC Filter

Note that for DS2100 sizes A,B,C, D & E, if the a.c. mains is still applied, and the control-backup power is removed, then the DS2100 control section will still operate correctly. Control power can still be generated from the high voltage D.C. Bus.
below outlines typical interconnect in a multi-axis DS2100 system, which is powered by 3-phase a.c. mains supply.

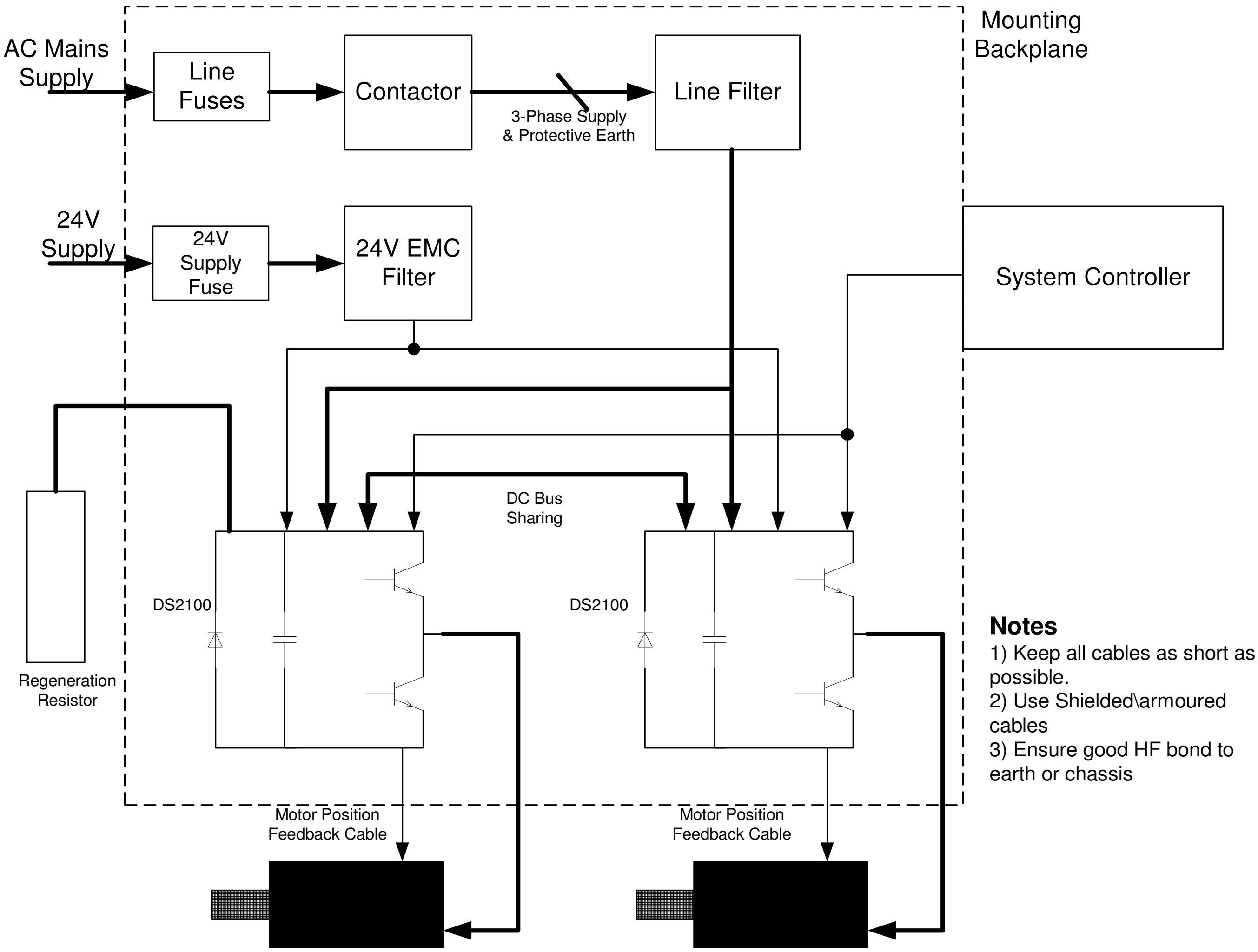


Figure 3.16 DS2100 Multi-Axis system with 3-Phase A.C. Mains Inputs

3.7.1 AC Mains Power Source Connection

3.7.1.1 Size µA

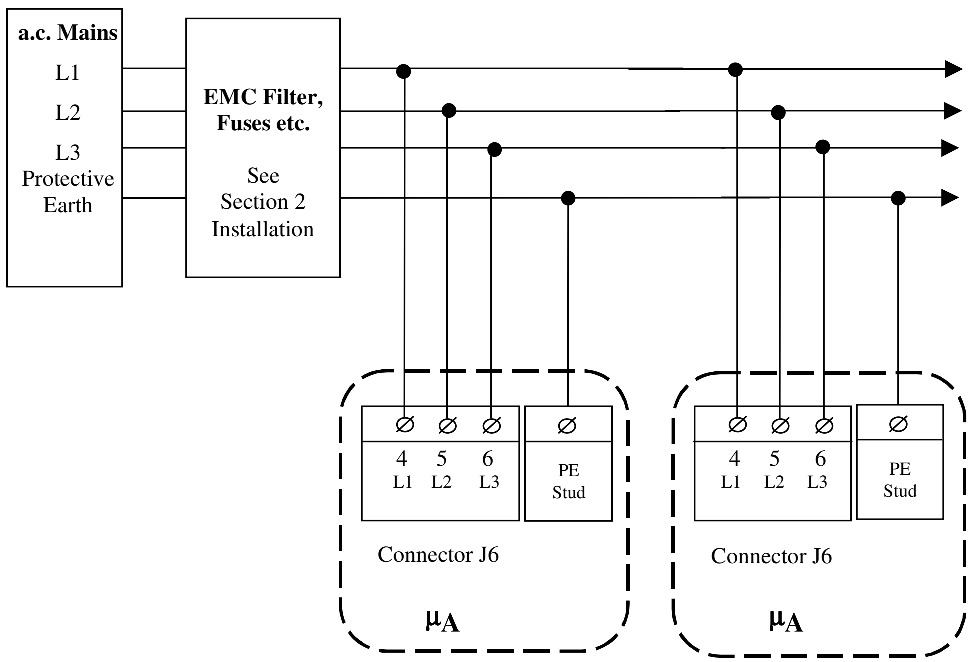


Figure 3.17 µA AC Mains Input Connection

- 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)
- µA size wiring: cable 14 AWG (2.1 mm^2). Wire stripping: 7 mm.
- PE Stud wiring: cable 6 AWG (13mm^2)
- Tightening torque: 0.5Nm.

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

Table 3.3-3 J6 AC Mains Power connector, µA Size

3.7.1.2 Size A & B

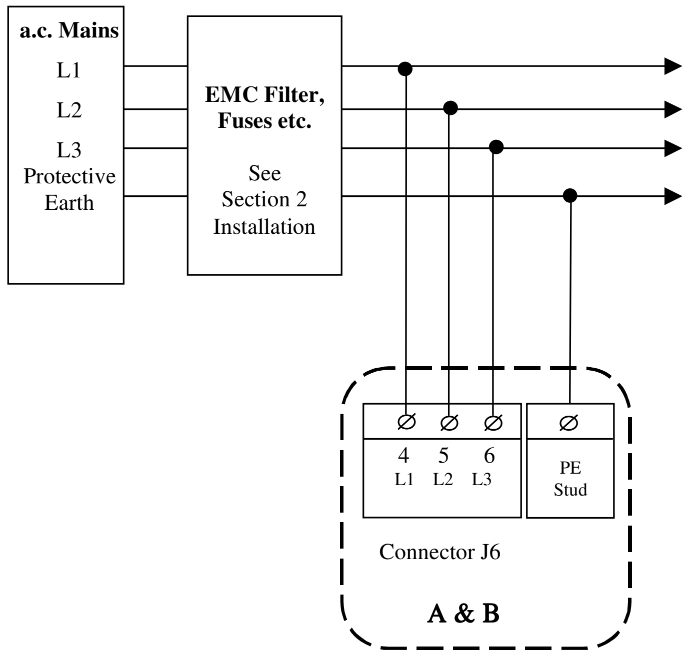


Figure 3.18 A & B AC Mains Input Connection

- Fixed connector: 10 pins, male connector
- Mating connector, 10 pins, female, supplied with the drive. Phoenix Contact (Part # PC4 HV/10-ST-7.62)
- 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)
- Tightening torque: 0.5Nm.

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

Table 3.3-4 J6 AC Mains Power connector, A & B Size

3.7.1.3 Size C

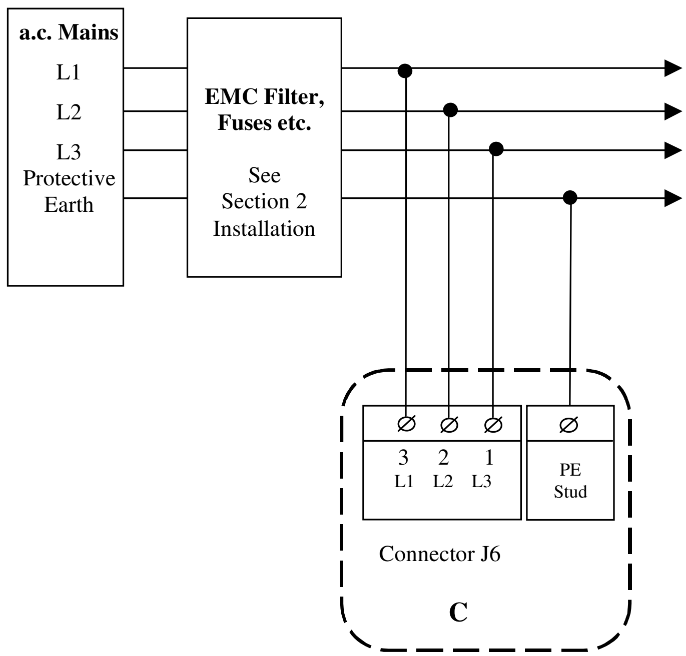


Figure 3.19 Size C AC Mains Input Connection

- Fixed connector: 5 pins, male connector
- Mating connector, 5 pins, female, crimped supplied with the drive. (Molex 42816-0512)
- C size wiring: cable 8 AWG (8.4 mm^2).
- PE Stud wiring: cable 6 AWG (13mm^2)

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

Table 3.3-5 J6 AC Mains Power connector, C Size

3.7.1.4 Size D

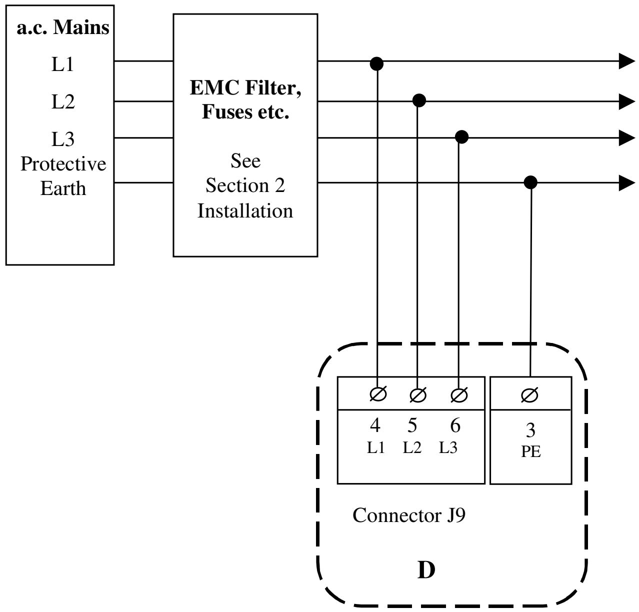


Figure 3.20 Size D AC Mains Input Connection

- Fixed connector: 4 pole, screw terminal
- 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
- Tightening Torque: 2-2.3Nm

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

Table 3.3-6 J9 AC Mains Power connector, D Size

3.7.1.5 Size E

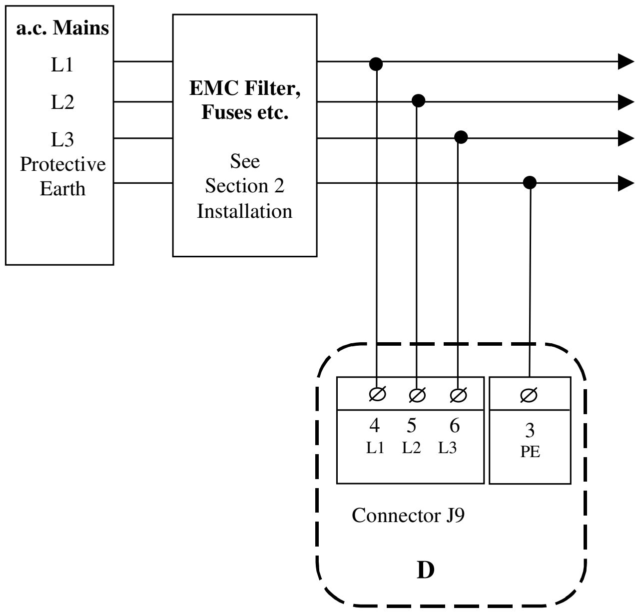


Figure 3.21 Size E AC Mains Input Connection

- Fixed connector: 4 pole, screw terminal
- E size wiring: cable 1 AWG (42 mm^2) for 310/300
- PE Terminal wiring: cable 1 AWG (42 mm^2) for 100/300
- Stripping Length 16mm
- Tightening Torque: 2-2.3Nm

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

3.7.2 Softstart & Power Cycling Frequency Limits

The DS2100 contains an internal soft-start function. The soft-start function limits the inrush current into the DS2100's D.C. Bus smoothing capacitors after the a.c. 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 DS2100 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, this backup is mandatory for drive operation.

3.8.1 Size µA 24V Input Connection

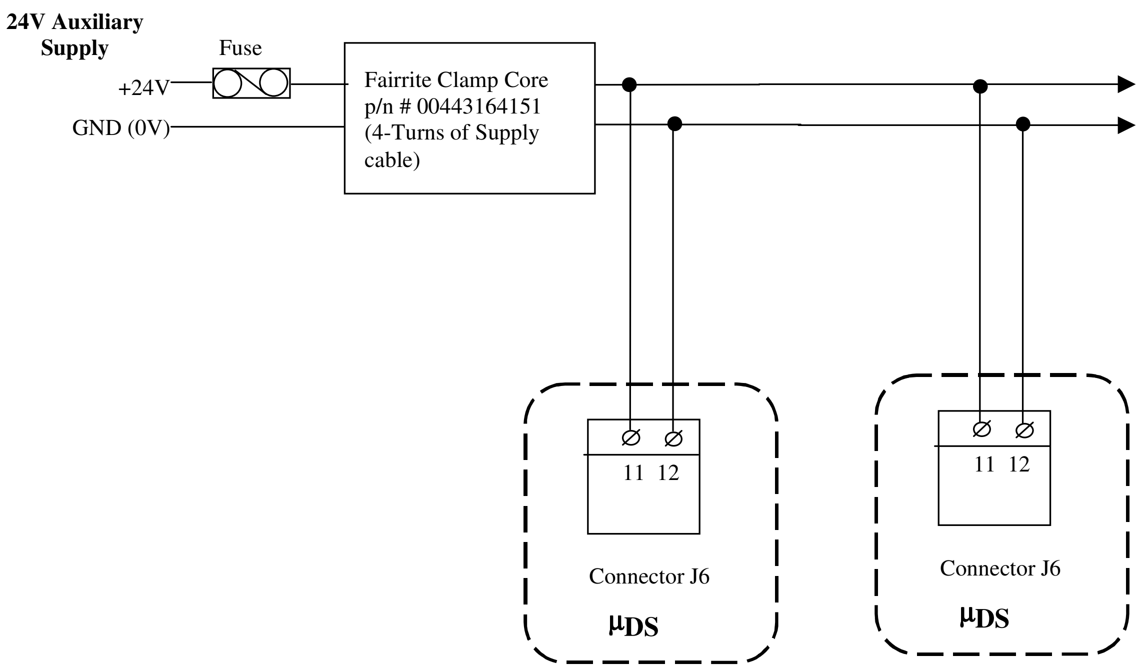


Figure 3.22 Size µA 24V DC Input Connection

- 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)
- µA size wiring: cable 14 AWG (2.1 mm^2).
- Stripping Length 7mm
- Tightening torque: 0.5Nm.

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

Table 3.3-7 J6 24V Logic Power connector, µA Size

3.8.2 Size A,B,C, D & E 24V Input Connection

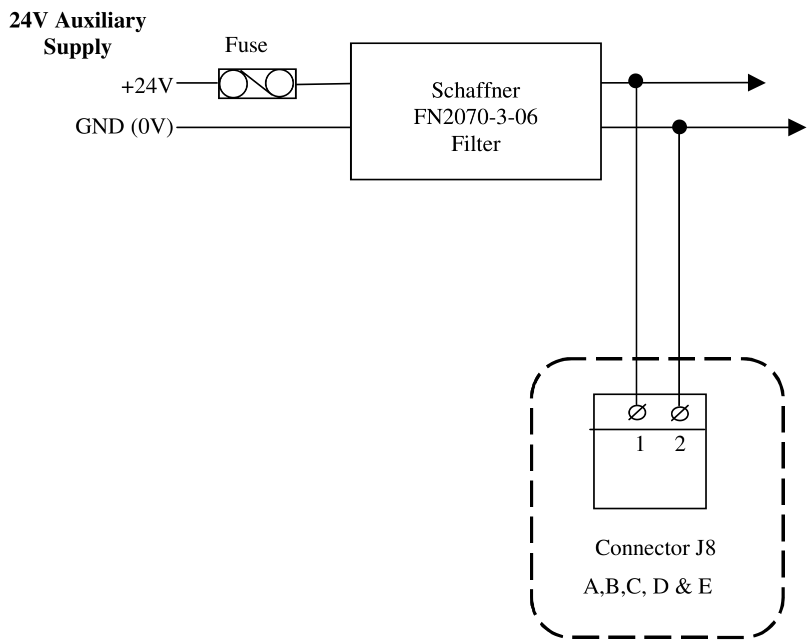


Figure 3.23 Size A,B, C, D & E 24V DC Input Connection

- Fixed connector: 2 pins, male connector
- Mating connector, 2 pins, female, supplied with the drive. Wago (Part # 231-102/026-000)
- A,B,C & D size wiring: cable 14 AWG (2.1 mm^2).
- Stripping Length 8mm

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

Table 3.3-8 J8 24V Logic Power connector, A,B,C & D Size

3.8.3 Auxiliary 24V Fan connection (Size E)

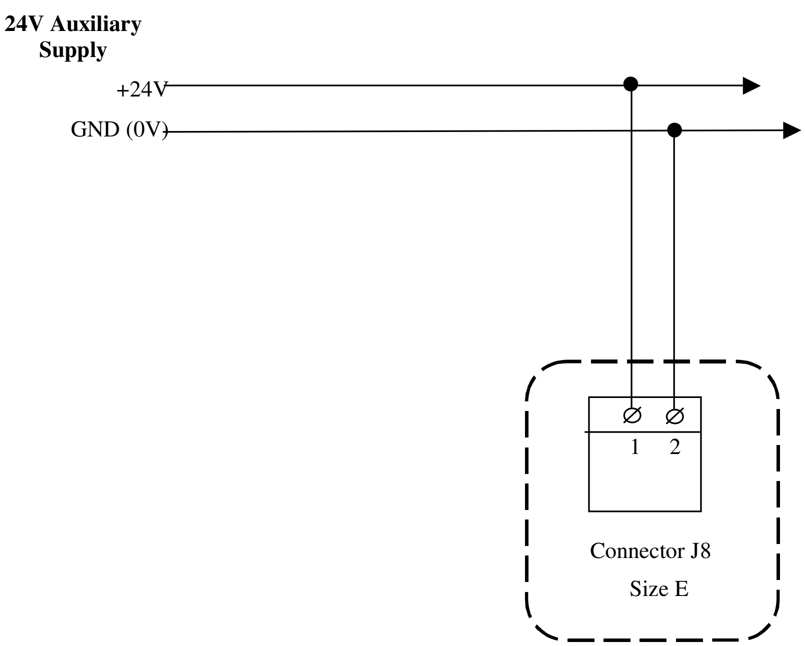


Figure 3.24 Size E auxiliary 24V fan supply

- Fixed connector: 2 pole, screw terminal
- Cable 14 AWG (2.1 mm^2)
- Stripping 9mm
- Torque 0.7Nm

3.9 Paralleling DS2100 Units through the D.C. Bus

DS2100 units can be paralleled via the D.C. Bus, in order to share regeneration power.

To comply with the EMC Directive, the DC Bus cable must be shielded and the shield must be connected to the housing with a 360^{o} connection at both ends.

CAUTION – To connect drives through the DC bus, please contact Moog application engineering for advice.

3.9.1 µA Size DC Bus Inter-connection

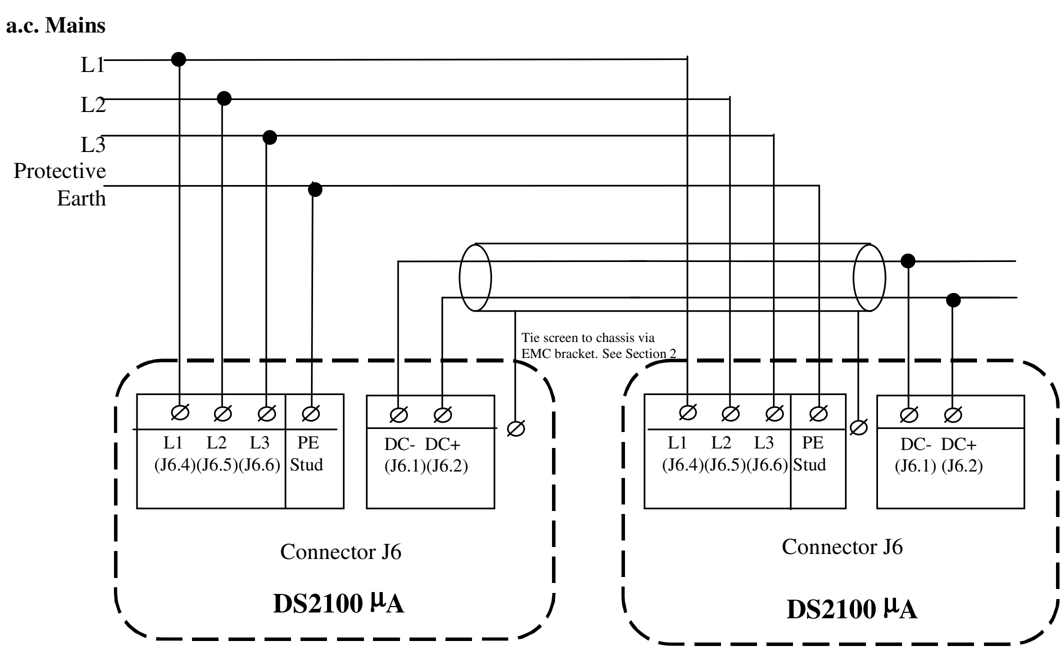


Figure 3.25 Size µA DC Bus Inter-connection

- 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)
- µA size wiring: cable 14 AWG (2.1 mm^2). Wire stripping: 7 mm.
- PE Stud wiring: cable 6 AWG (13mm^2)
- Tightening torque: 0.5Nm.

Pos.	Name	Function
J6.1	DC-	DC Bus (-)
J6.2	DC+	DC Bus (+)

Table 3.3-9 J6, DC Bus connector, µA Size

3.9.2 A & B Size DC Bus Inter-connection

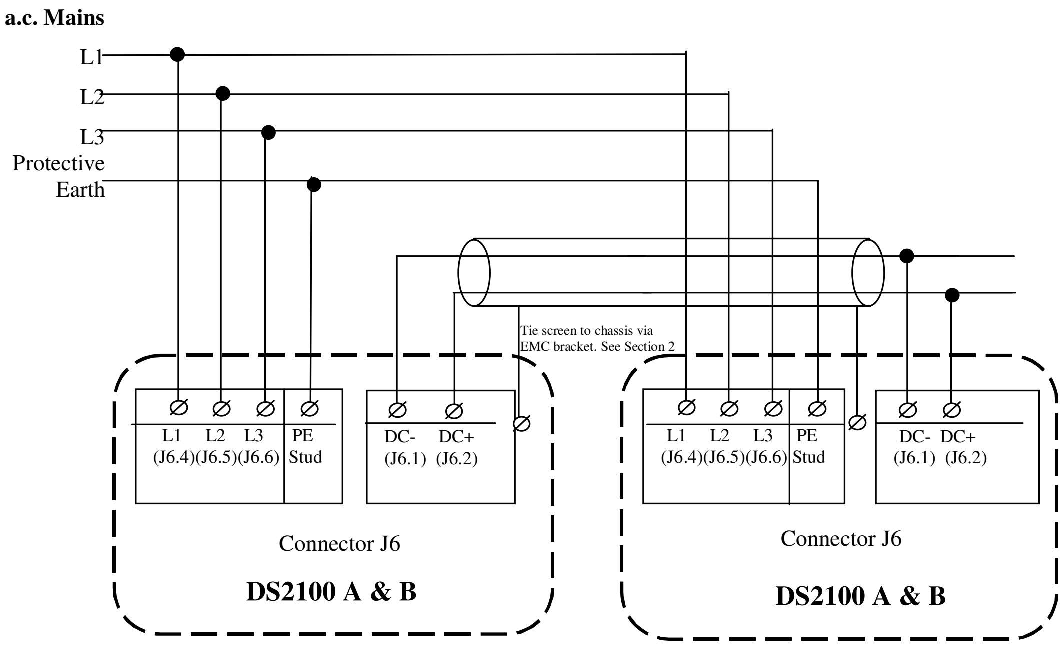


Figure 3.26 Size A & B DC Bus Inter-connection

- Fixed connector: 10 pins, male connector
- Mating connector, 10 pins, female, supplied with the drive. Phoenix Contact (Part # PC4 HV/10-ST-7.62)
- 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
- PE Stud wiring: cable 6 AWG (13mm^2)
- Tightening torque: 0.5Nm.

Pos.	Name	Function
J6.1	DC-	DC Bus (-)
J6.2	DC+	DC Bus (+)

Table 3.3-10 J6, DC Bus connector, A,B Size

3.9.3 C Size DC Bus Inter-connection

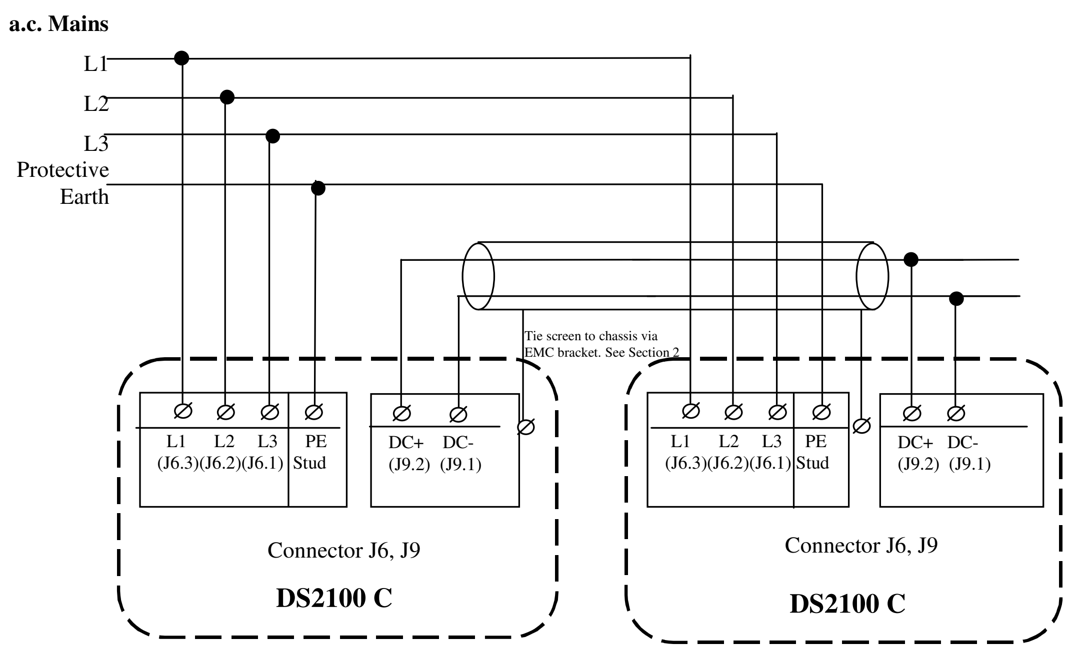


Figure 3.27 Size C DC Bus Inter-connection

J6
- Fixed connector: 5 pins, male connector
- Mating connector, 5 pins, female, crimped supplied with the drive. (Molex 42816-0512)
- C size wiring: cable 8 AWG (8.4 mm^2).
- PE Stud wiring: cable 6 AWG (13mm^2)

J9
- Fixed connector: 2 pins, male connector
- Mating connector, 2 pins, female, crimped supplied with the drive. (Molex 42816-0212)
- C size wiring: cable 8 AWG (8.4 mm^2).

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

Table 3.3-11 J9, DC Bus connector, C Size

3.9.4 D Size DC Bus Inter-connection

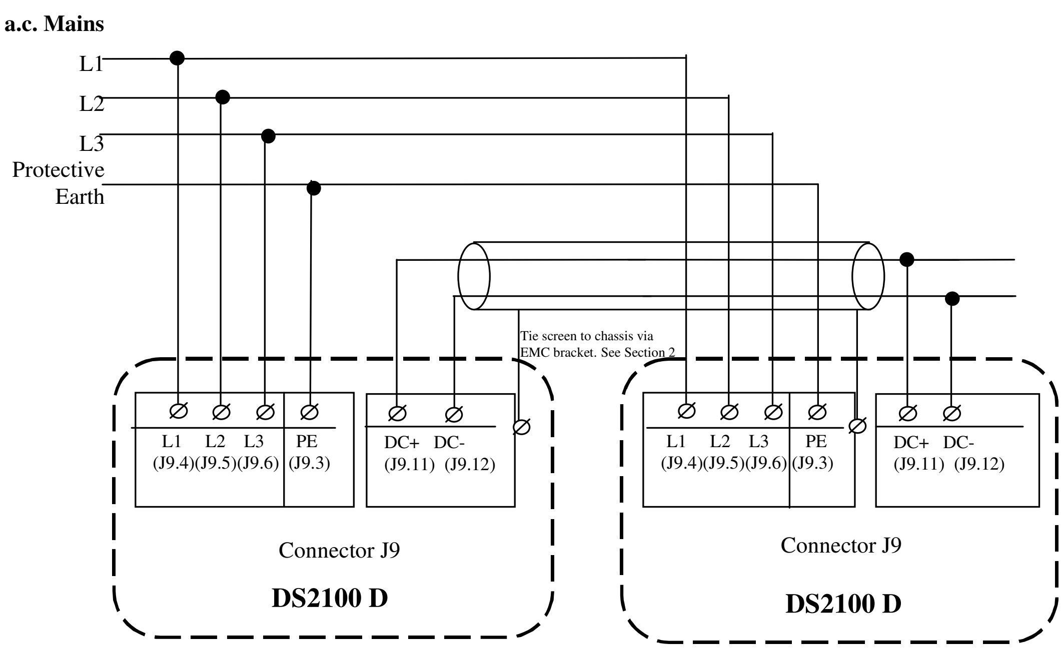


Figure 3.28 Size D DC Bus Inter-connection

J9

- Fixed connector: 2 pole, screw terminal
- 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 (13mm^2) for 50/140
- PE Terminal wiring: cable 4 AWG (21 mm^2) for 60/180
- Stripping Length 16mm
- Tightening Torque: 2-2.3Nm

Pos.	Name	Function
J9.11	DC+	DC Bus (+)
J9.12	DC-	DC Bus (-)

Table 3.3-12 J9, DC Bus connector, D Size

3.9.5 E Size DC Bus Inter-connection

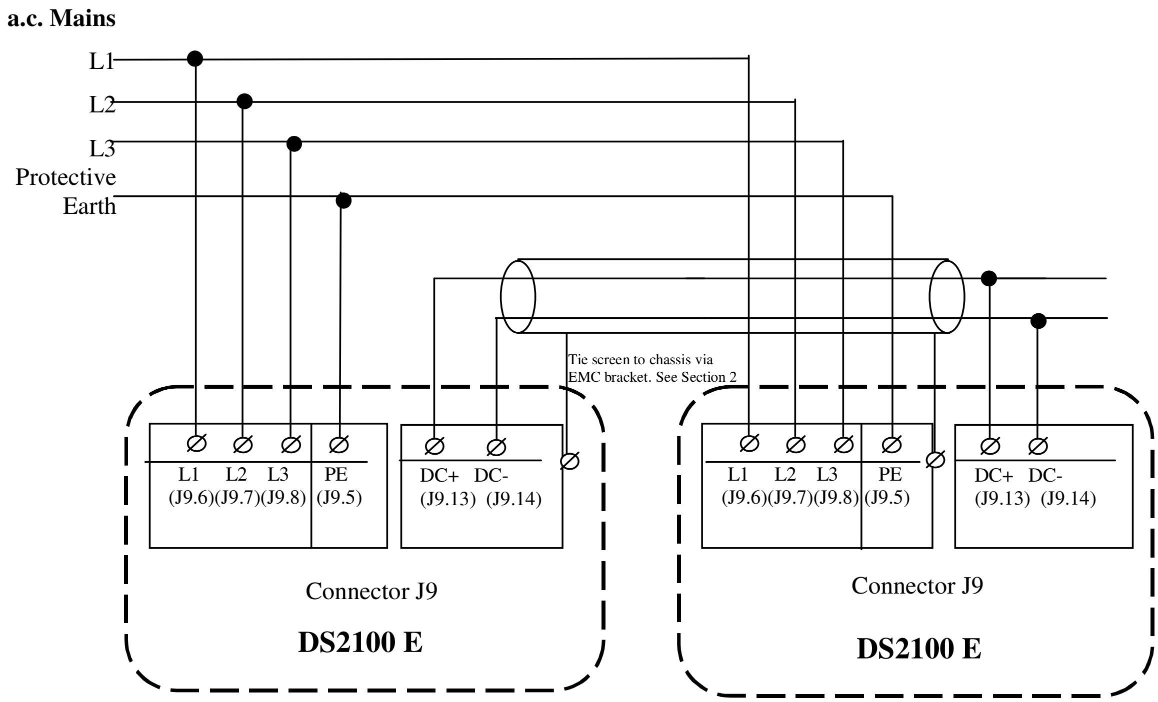


Figure 3.29 Size D DC Bus Inter-connection

J9

- Fixed connector: 2 pole, screw terminal
- E size wiring: cable 1 AWG (42 mm^2)
- PE Terminal wiring: cable 1 AWG (42 mm^2)
- Stripping Length: 24mm
- Tightening Torque: 8Nm

Pos.	**Name**	**Function**
J9.13	DC+	DC Bus (+)
J9.14	DC-	DC Bus (-)

Table 3-13 J9, DC Bus connector, E Size

3.10 Internal/External Regeneration (Regen) Resistors – Configurations

Regeneration resistors can be fitted to all DS2100 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 DS2100 is the only size with internal regen. All other drive sizes use external regen only.

For EMC purposes, use shielded cable to connect the external Regen resistor to the DS2100. 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 Section 2 for further safety and EMC requirements for cable installation.

NOTE - The regeneration resistor (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 DS2100 D.C. Bus voltage that can reach 800 V d.c. 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.

DS2100 Regeneration Resistor Options						
Model (Size)	Internal Regen			External Regen		
	Resistance (Ω)	Continuous Power (W)	Peak Power (@ 400V_{AC}) (kW)	Resistance (Ω)	Continuous Power (W)	Peak Power (@ 400V_{AC}) (kW)
G361-xx03 (µA)	120	50	4.8	120	50	4.8
G361-xx06 (µA)	120	100	4.8	120	100	4.8
G361-xx08 (A)	Internal Regen is available only on the DS2100 µA Size.			51	200	12.5
G361-xx14 (B)				33	250	19.4
G361-xx20 (C)				12	370	53.3
G361-xx25 (C)				12	370	53.3
G361-xx30 (C)				12	370	53.3
G361-xx50 (D)				10	750	64
G361-xx60 (D)				10	750	64
G361-xx1x (E)				3.9	1,000	146

Table 3.3-14 Recommended Regeneration Resistors

3.10.1 μA Size Regeneration Resistor Connection

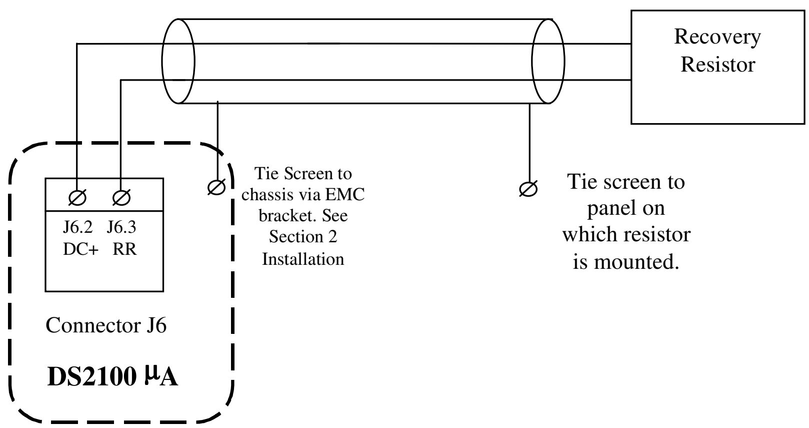


Figure 3.3.30 DS2100 Size μA External Regeneration Connections

- 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)
- μA size wiring: cable 14 AWG (2.1 mm^2). Wire stripping: 7 mm.
- Tightening torque: 0.5Nm.

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

Table 3.3-15 J6, Regeneration Resistor connector, μA Size

3.10.2 A, B Size Regeneration Resistor connection

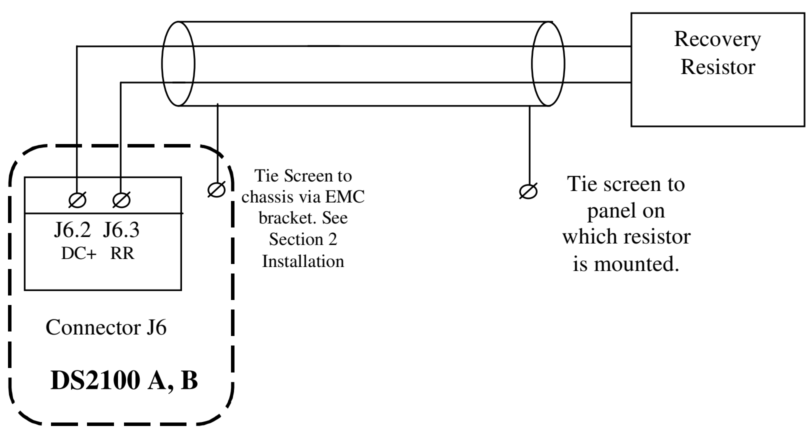


Figure 3.3.31 DS2100 Size A,B External Regeneration Connections

- Fixed connector: 10 pins, male connector
- Mating connector, 10 pins, female, supplied with the drive. Phoenix Contact (Part # PC4 HV/10-ST-7.62)
- 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
- Tightening torque: 0.5Nm.

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

Table 3.3-16 J6, Regeneration Resistor connector, A,B Size

3.10.3 C Size Regeneration Resistor connection

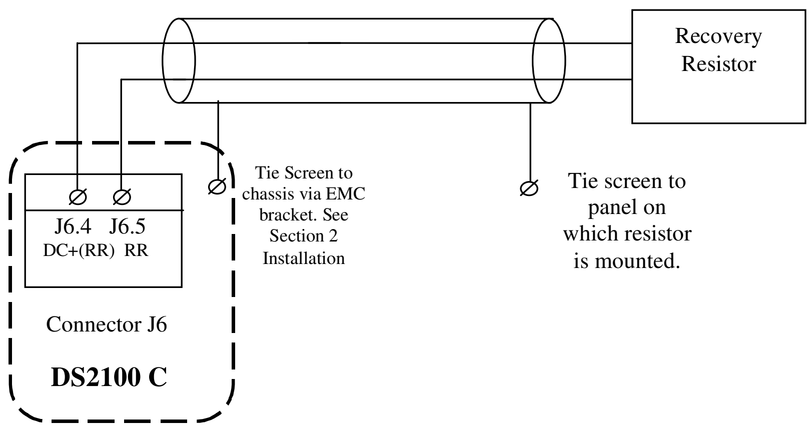


Figure 3.3.32 DS2100 Size C External Regeneration Connections

- Fixed connector: 5 pins, male connector
- Mating connector, 5 pins, female, crimped supplied with the drive. (Molex 42816-0512)
- C size wiring: cable 8 AWG (8.4 mm^2).

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

Table 3.3-17 J6, Regeneration Resistor connector, C Size

3.10.4 D Size Regeneration Resistor connection

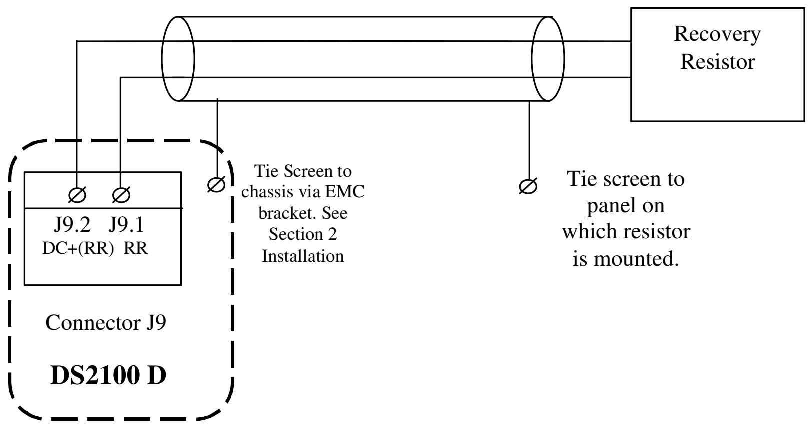


Figure 3.3.33 DS2100 Size D External Regeneration Connections

J9

- Fixed connector: 2 pole, screw terminal
- 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
- Tightening Torque: 2-2.3Nm

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

Table 3.3-18 J9, Regeneration Resistor connector, D Size

3.10.5 E Size Regeneration Resistor connection

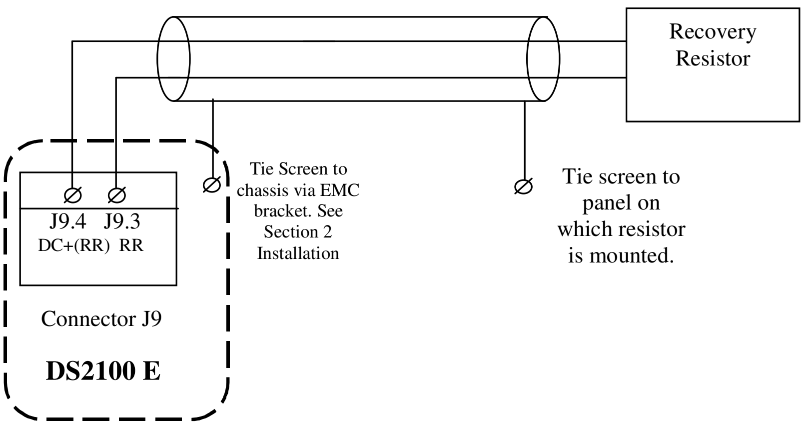


Figure 3.3.34 DS2100 Size E External Regeneration Connections

J9

- Fixed connector: 2 pole, screw terminal
- E size wiring: cable 2 AWG (34 $mm^{2)}$
- Stripping Length 19mm
- Tightening Torque: 4Nm

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

Table 3.3-19 J9, Regeneration Resistor connector, E Size

WARNING - When performing any changes to the regen resistor configuration, a.c. input power must be removed from the DS2100. Wait at least 5 minutes for the µA sizes (6 minutes for the A-E sizes) upon removal of all power, to allow for D.C. Bus capacitors to discharge.

3.11 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.

3.11.1 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 authorised 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

Italy
MOOG Italiana S.r.l.
Electric Division
Via Avossa 94
16015 Casella (Gevova)
Italy
phone: +0039 - 010 - 96711
fax: +0039 - 010 - 9671280

3.11.2 Motor Power Cable

Wire the motor power connector in accordance with Figure 3.3.35 to Figure 3.3.42.

Use wire sizes based on the motor's continuous stall current (r m s) and wire length requirements.

Required for CE-Compliance

Wiring must be in accordance with standard EN 60204-1 (See Section 2 of this Users Manual.)

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

3.11.2.1 Size µA

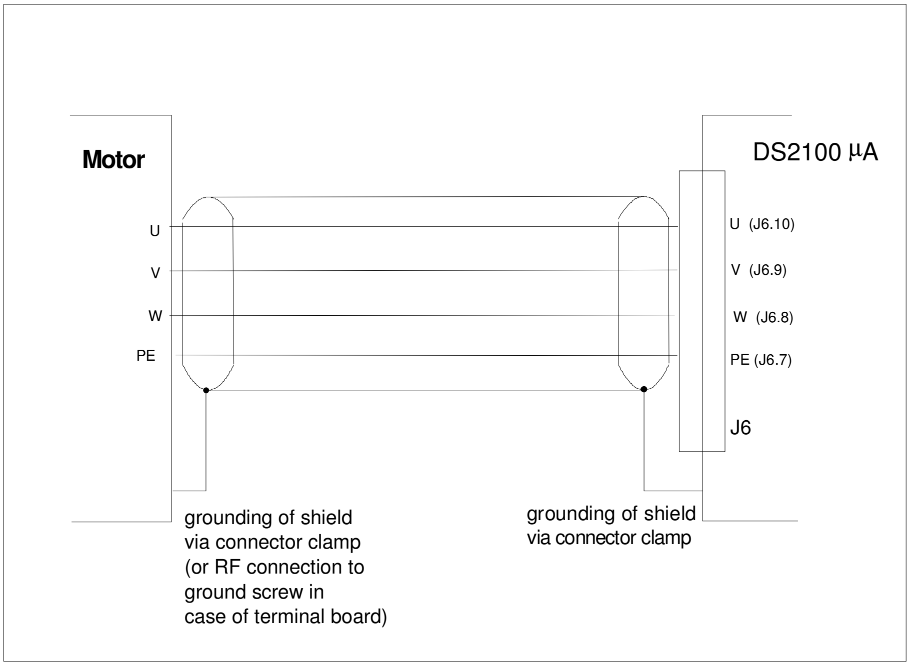


Figure 3.3.35 DS2100 µA Motor Power Connection

- 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)
- µA size wiring: cable 14 AWG (2.1 mm^2). Wire stripping: 7 mm.
- Tightening torque: 0.5Nm.

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

Table 3.3-20 J6, Motor connector, µA Size

3.11.2.2 Size A & B

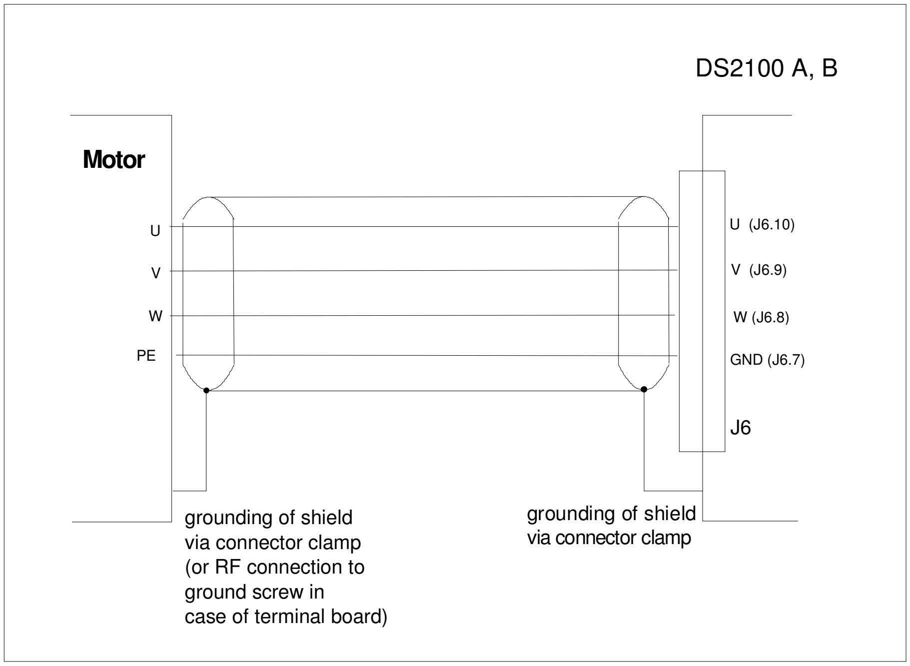


Figure 3.3.36 DS2100 A & B Motor Power Connection

- Fixed connector: 10 pins, male connector
- Mating connector, 10 pins, female, supplied with the drive. Phoenix Contact (Part # PC4 HV/10-ST-7.62)
- 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
- Tightening torque: 0.5Nm.

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

Table 3.3-21 J6, Motor connector, A & B Size

3.11.2.3 Size C

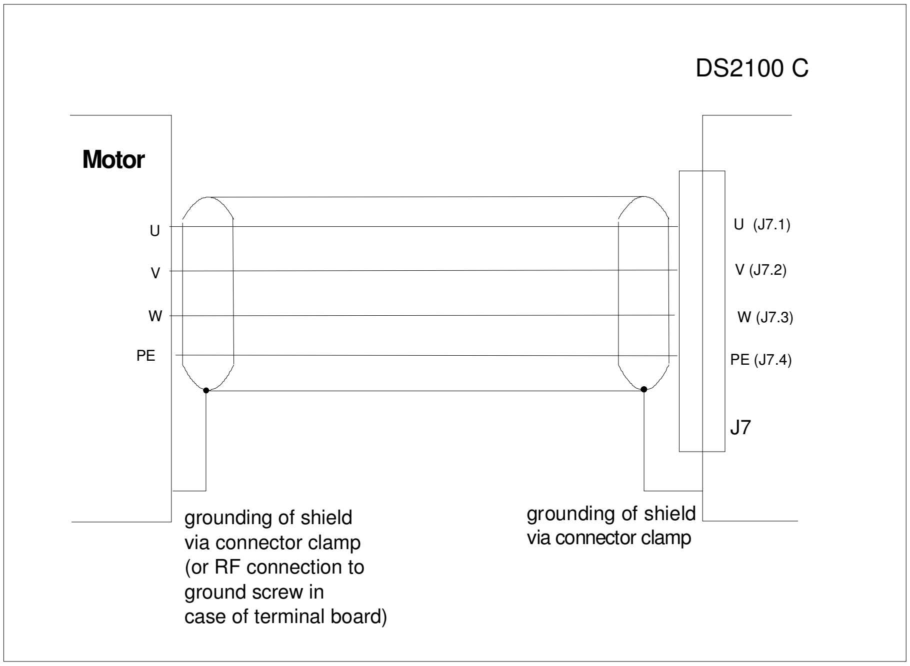


Figure 3.3.37 DS2100 C Motor Power Connection

- Fixed connector: 4 pins, male connector
- Mating connector, 4 pins, female, crimped supplied with the drive. (Molex 42816-0412)
- C size wiring: cable 8 AWG (8.4 mm^2).

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

Table 3.3-22 J7, Motor connector, C Size

3.11.2.4 Size D

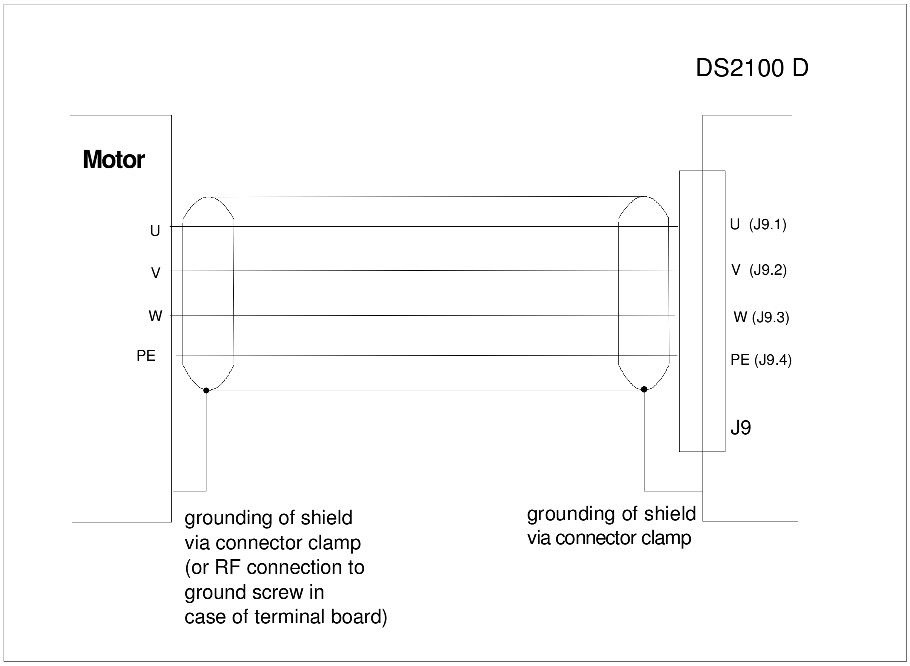


Figure 3.3.38 DS2100 D Motor Power Connection

J9
- Fixed connector: 4 pole, screw terminal
- 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
- Tightening Torque: 2-2.3Nm

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

Table 3.3-23 J9, Motor connector, D Size

3.11.2.5 Size E

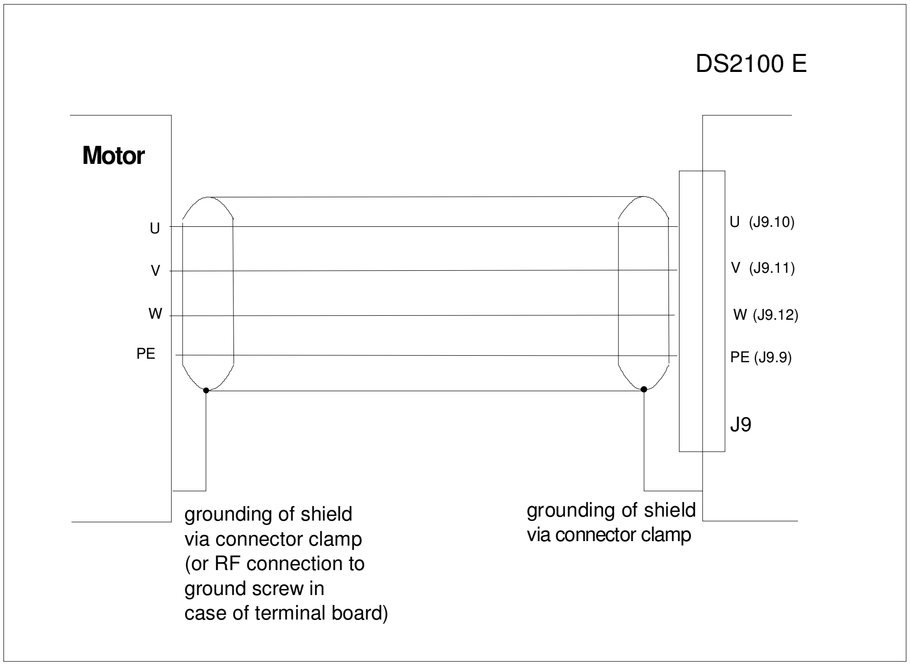


Figure 3.3.39 DS2100 E Motor Power Connection

J9

- Fixed connector: 4 pole, screw terminal
- E size wiring: cable 1 AWG (42 mm^2)
- Stripping Length 24mm
- Tightening Torque: 8Nm

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

Table 3.3-24 J9, Motor connector, E Size

3.11.3 Motor Brake Connection

The DS2100 provides a motor break relay at connector J2D (on Control Card Interface). The user supplies a 24Vd.c., Power Supply Unit for the brake connections. Details of the motor brake current requirements are available from the relevant motor datasheet.

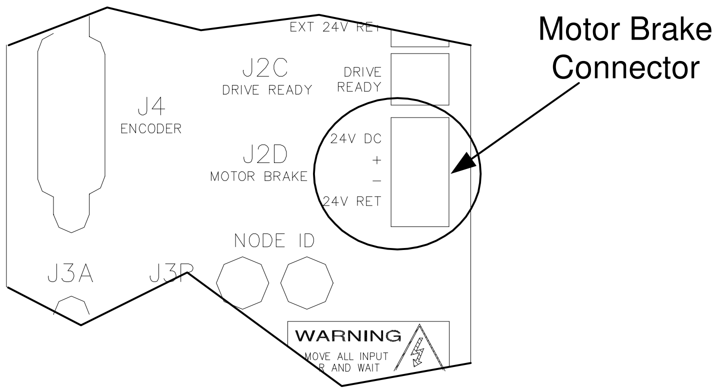


Figure 3.3.40 Motor Brake Connector Location

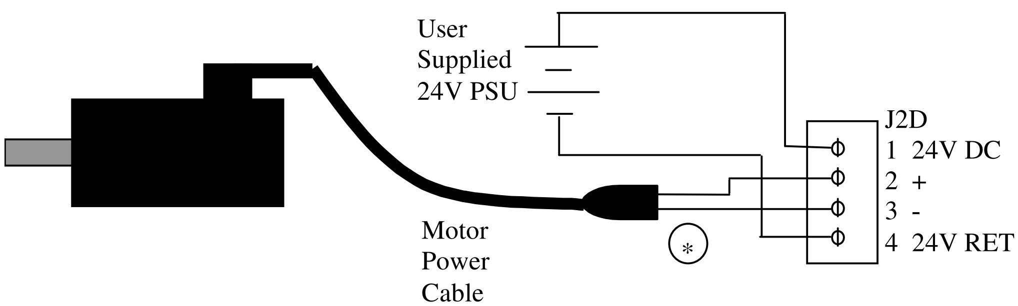


Figure 3.3.41 Motor Brake Cabling

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

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

Table 3.3-25 J2D, DS2100 Brake connector

* The pins of the brake terminals at the motor cable connector end depend upon the cable size. Refer to Figure 3.3.42 for details.

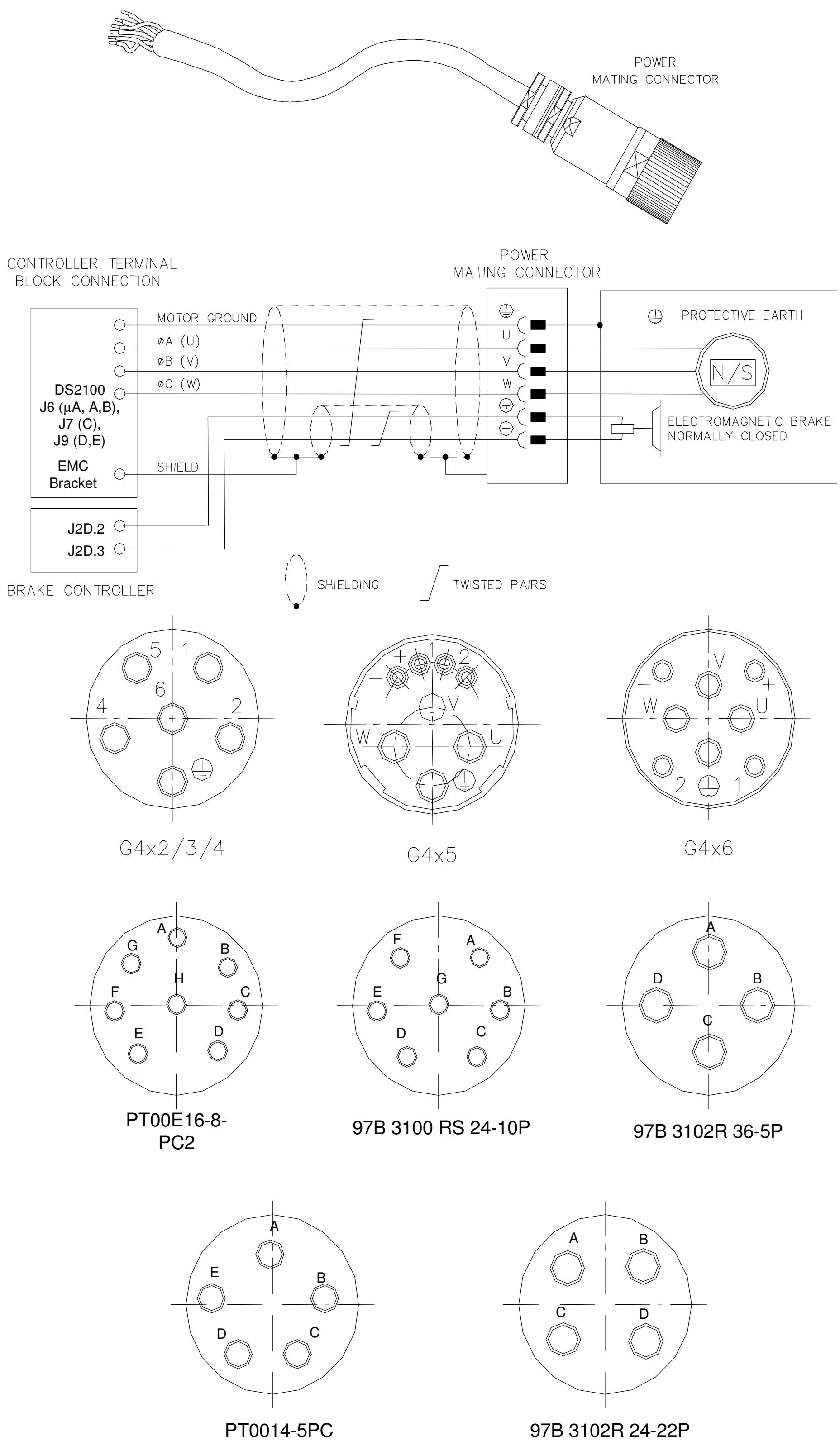


Figure 3.3.42 Motor Power and Brake Connectors

DS2100	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
U	2	U	U	A	A	A	A	A
V	4	V	V	B	B	B	B	B
W	1	W	W	C	C	C	C	C
Brake+	5	+	+	E	E	-	-	-
Brake-	6	-	-	F	F	-	-	-

Table 3.3-26 Motor Power Connections

3.11.4 Motor Resolver Connection

Wire the DS2100 resolver cable in accordance with Figure 3.3.44 and Table 3.3-27.

Required for CE-Compliance

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

NOTE:- Avoid running the resolver cable near other high power wiring, especially the motor power cable, if possible.

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

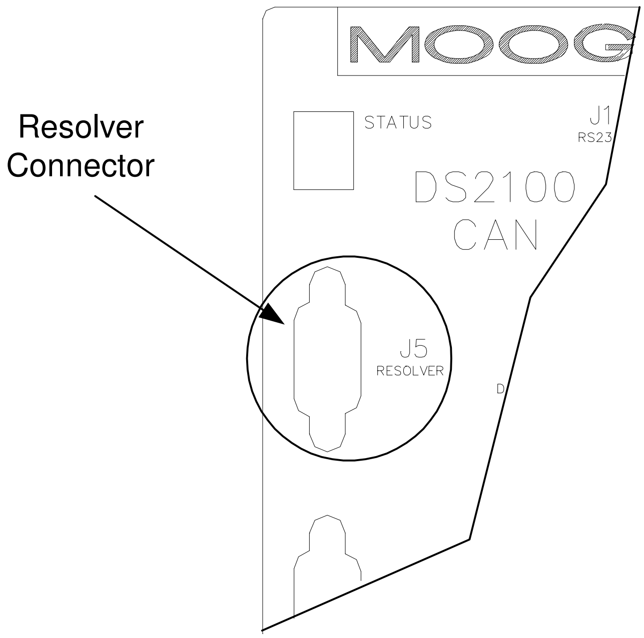


Figure 3.3.43 Motor Resolver Connector Location

- Fixed connector: 9 pin, female Sub-D connector
- Mating connector, 9 pin male Sub-D
- Wiring: cable. 28-18AWG (0.14-0.82mm^2)

MOTOR RESOLVER CONNECTOR				
Pos	**Signal Type**	**FAS T/ FAS K**	**FAS N/ FAS Y**	**G4xx (FASG)**
J5.1	Cosφ (S2)	C	1	3
J5.2	$\overline{\text{Cos}\,\varphi}$ (S4)	E	2	4
J5.9	V-Ref (R1)	D	10	7
J5.7	0V (R2)	B	7	8
J5.8	PTC\NTC	N	8	6
J5.6	PTC\NTC	A	9	5
J5.4	Sinφ (S1)	G	11	1
J5.5	$\overline{\text{Sin}\,\varphi}$ (S3)	H	12	2
J5.3	Shield	S	3	-

Table 3.3-27 Resolver connections to motor

- Resolver Connector (J5)
  "Motor Resolver port" for the "Motor Resolver Signals" and for the "Motor Integral NTC/PTC Temperature Control (PIN 6-8). This Auxiliary-connector is referred to Limited Voltage / Current circuits (rated max 5.5 Vdc ±10%, 400 μA).

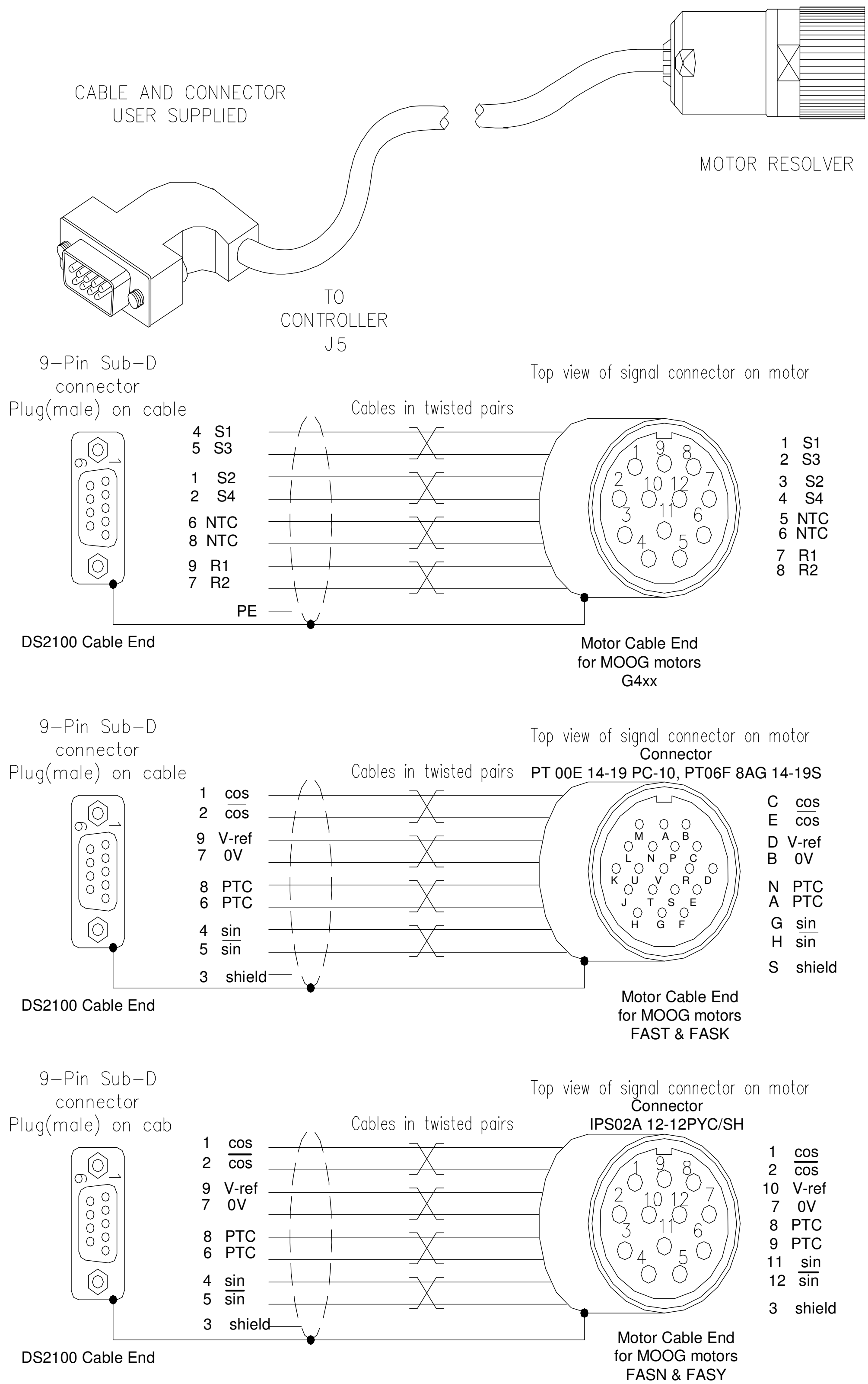


Figure 3.3.44 DS2100 Resolver Cables

3.11.5 Motor Encoder Connection

The DS2100 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 3.3-28.

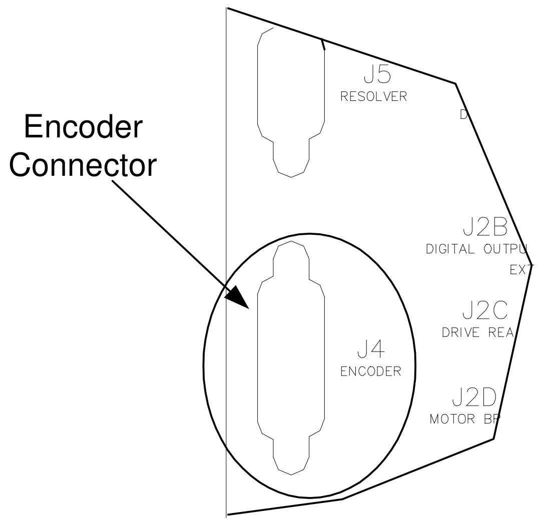


Figure 3.3.45 Motor Encoder Connector Location

- Fixed connector: 15 pin, female Sub-D connector
- Mating connector, 15pin male Sub-D
- Wiring: cable. 28-18AWG (0.14-0.82mm^2)

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

Table 3.3-28 Encoder Cable Input Connections

- Encoder Connector (J4)
  “Motor Encoder port” for the “Motor Encoder Channels” and for the “Motor Integral NTC/PTC Temperature Control (PIN 8-15). This Auxiliary-connector is referred to Limited Voltage / Current circuits (rated max 5.5 Vdc ±10%, 400 μA).

Required for CE-Compliance

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

NOTE:- Avoid running the encoder cable near other high power wiring, especially the motor power cable, if possible.

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

3.11.6 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.

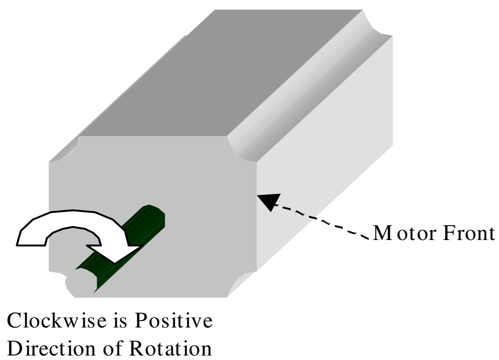


Figure 3.3.46 Rotational Convention for Mechanical Process Variables

i

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

3.12 DS2100 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 12Vd.c. to 32Vd.c. 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.

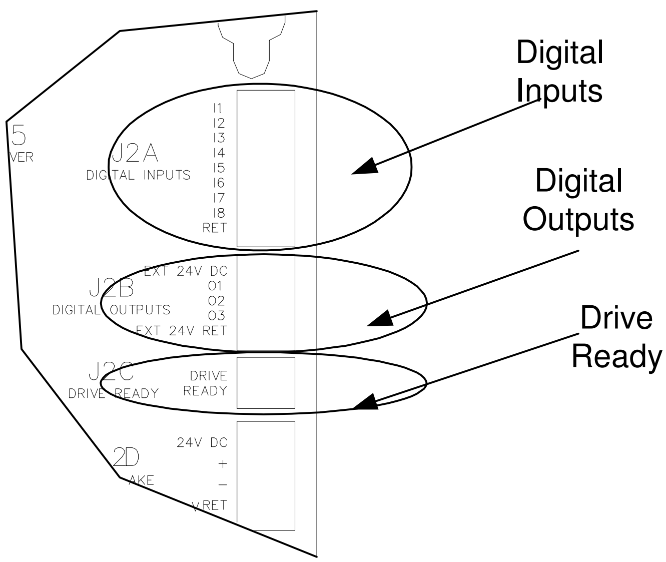


Figure 3.3.47 DS2100 I/O Connections

3.12.1 General Purpose Description of the Digital Inputs

The DS2100 provides 8 digital inputs on connector J2A.

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

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	

Table 3.3-29 J2A, DS2100 Digital Input connector

The following electrical description applies to all the digital inputs of the DS2100.

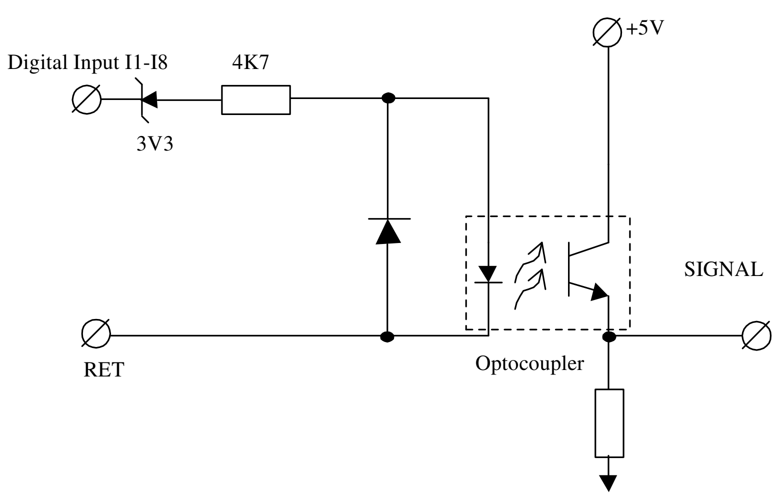


Figure 3.3.48 DS2100 Generic Digital Inputs

Note that:-

- Input Impedance **> 5k Ω**.
- Voltage Range is **12V to 32V** from Digital-Input to the I_COMMON line. Inputs are protected for input voltages from –40V to +40V
    - Input voltages whose magnitude is less than 12V with respect to the I_COMMON line will not be guaranteed to be recognised as an **active** signal input.
    - Input voltages whose magnitude is more than 5V with respect to the I_COMMON line will not be guaranteed to be recognised as an **inactive** signal input
- **All digital inputs are optically isolated** for noise immunity purposes. All DS2100 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.

3.12.2 General Purpose Description of the Digital Outputs

The DS2100 provides 4 digital outputs on connector J2B & J2C. Only the digital outputs on J2B are detailed here.

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

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	

Table 3.3-30 J2B, DS2100 Digital Output connector

The following electrical description applies to all, except one, of the digital outputs of the DS2100. (One digital output, Drive Ready, uses a relay rather than an opto-coupler).

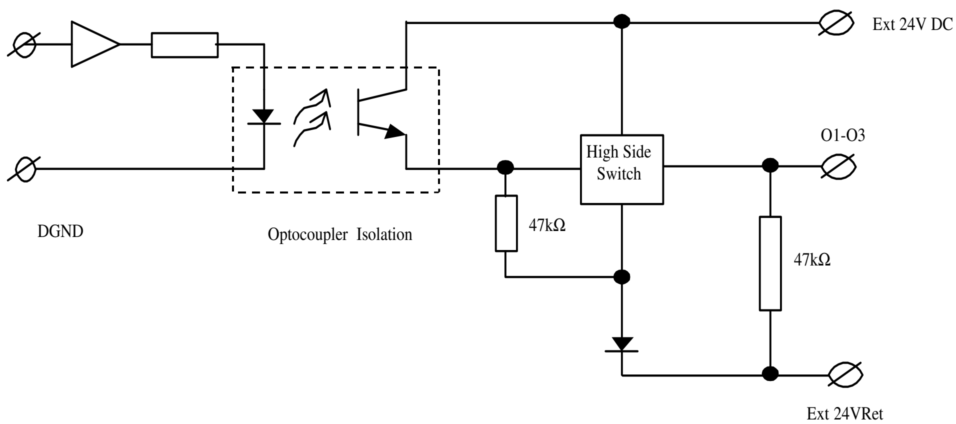


Figure 3.3.49 DS2100 Generic Digital Outputs

Note that:-

- **Voltage Range** is **6V to 32V** from Digital-Output to the O_COMMON line. Digital outputs switch only DC voltages.
- **Output current** ≥ 250 mA, off state leakage current ≤ 100 µA at 0 V.
- **Short circuit** protected, inductive load driving capability, reverse polarity protected. Protected for supply voltage range of -40 V to +40 V.
- **All digital outputs are optically isolated** for noise immunity purposes. All DS2100 digital outputs are isolated from high voltage circuitry.
- **Current flowing** in the digital output implies the function is active.

3.12.2.1 Drive Ready Relay

The DS2100 provides 1 relay output on connector J2C. This relay closes when the drive is ready and no faults are present.

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

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

Table 3.3-31 J2B, DS2100 Digital Output connector

The following electrical description applies to the Drive ready relay of the DS2100.

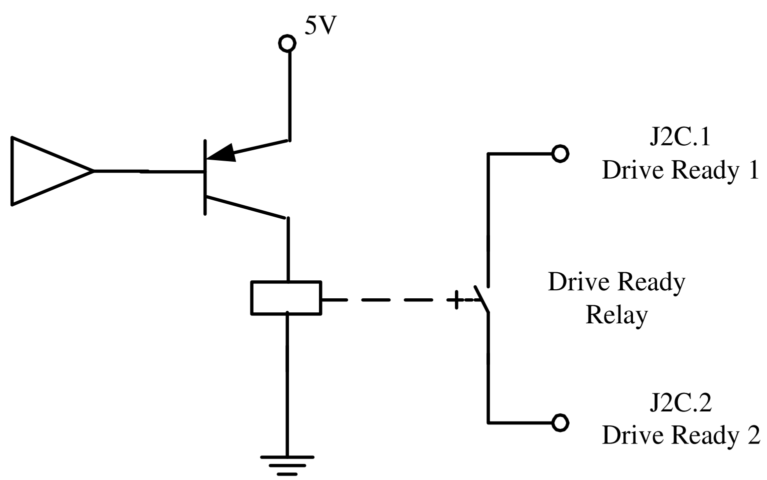


Figure 3.3.50 Drive Ready Relay Output

Note that:-

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

3.12.3 Power Sequencing on Startup

The timing of the digital inputs ENABLE and PWR_RDY must be considered carefully for proper power-on sequencing.

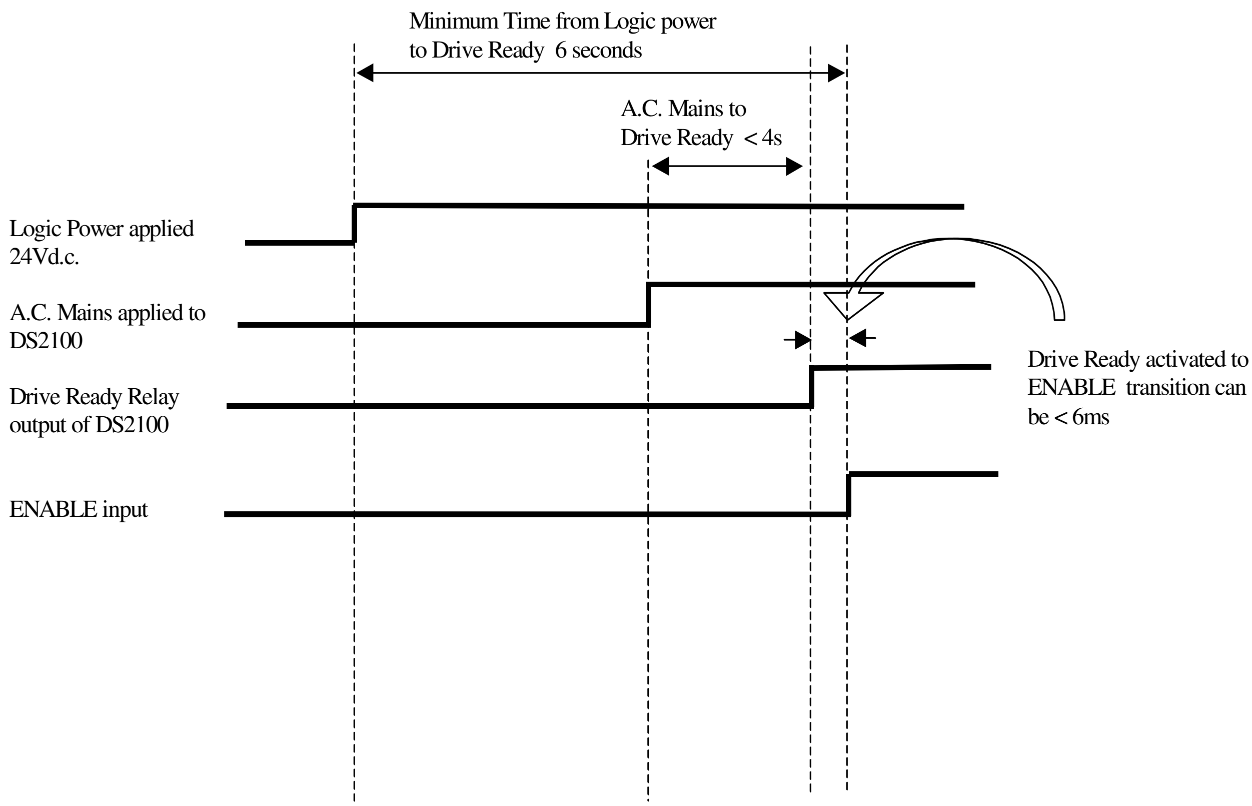


Figure 3.3.51 Power Sequencing control using Drive Ready Relay and ENABLE

WARNING - It is UNSAFE to use the Drive Ready output as a direct control for the 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 DS2100 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 DS2100 high power amplifier if appropriate

3.13 Communications Interface Wiring and Configuration

The DS2100 provides one serial interface (RS232) for communication between the drive and the Windrive graphical user interface (GUI).

The drive also provides a CAN High speed (ISO11898-2) hardware-interface for higher bandwidth communications between one System Motion Controller and many DS2100's (which can handle motion commands between the System Motion Controller and DS2100's)

3.13.1 RS232 Serial Communications Interface

The pin assignment enables use of a 9-pin Sub-D cable with all signals connected straight through.

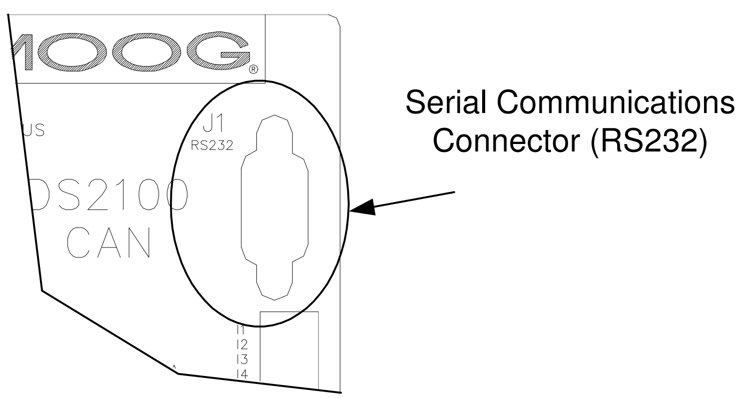


Figure 3.3.52 RS232 Connector Location

- Fixed connector: 9 pin, female Sub-D connector
- Mating connector, 9 pin male Sub-D
- Wiring: cable. 28-18AWG (0.14-0.82mm^2)

Pos.	DS2100 Signal	Function	PC Signal
J1.1	-	connected to pin 4	DCD input
J1.2	TxD	Transmit Data	RxD input
J1.3	RxD	Receive Data	TxD output
J1.4	-	connected to pin 1 and 6	DTR output
J1.5	Gnd	Gnd	Gnd
J1.6	-	connected to pin 4	DSR input
J1.7	-	connected to pin 8	RTS output
J1.8	-	connected to pin 7	CTS input
J1.9	-	unused	RI input

Table 3.3-32 J1, DS2100 RS232 Serial Interface Connector

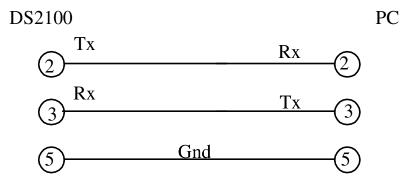


Figure 3.3.53 DS2100's J1 RS232 Wire Pin-out

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

3.13.2 CAN Cable Wiring

The CAN-In and CAN-Out ports at J3A and J3B of the DS2100 provide the means to daisy-chain the CAN cabling between DS2100 units and system controller. The CAN interface is equipped with driver and receiver for 24V systems. These are optically isolated from the internal drive electronics for noise immunity. Internal supply of the isolated side of the CAN is provided. No user supplied voltage is required. Two daisy chained 9-way D-Sub connectors, one male, one female are also provided for ease of wiring.

Please refer to CAN Draft Standard 303, 'Cabling and Connector Pin Assignment' for further details of the CAN cabling requirements.

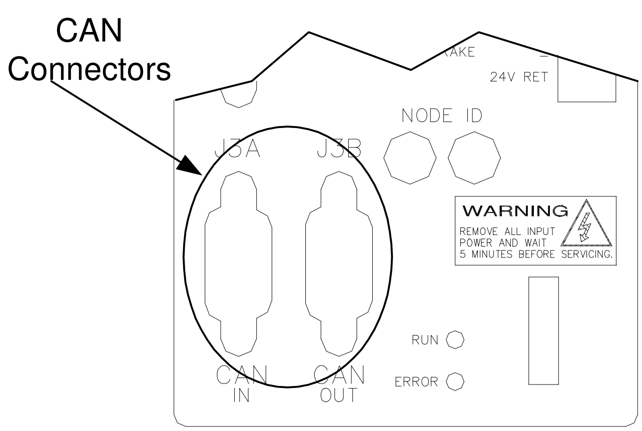


Figure 3.3.54 CAN Connector Location

- Fixed connector: 9 pin, male & female Sub-D connector
- Mating connector, 9 pin male & female Sub-D
- Wiring: cable. 28-18AWG (0.14-0.82mm^2)

Pos (x=A,B)	Signal	Description
J3x.1	-	not connected
J3x.2	CAN_L	CAN_L bus line (dominant low)
J3x.3	CAN_GND	CAN Ground
J3x.4	-	not connected
J3x.5	CAN_SHLD	Chassis Ground
J3x.6	CAN_GND	CAN Ground
J3x.7	CAN_H	CAN_H bus line (dominant high)
J3x.8	-	not connected
J3x.9	-	Optional CAN external positive supply, not connected.

Table 3.3-33 CAN Connector Pin Description

Note:-

- CAN lines must be terminated in a 120Ohm resistance, between the positive and negative terminals (CAN-High and CAN-Low) at both ends of the CAN network for correct operation.
- All pins of J3A and J3B are wired straight through the connectors of the DS2100.

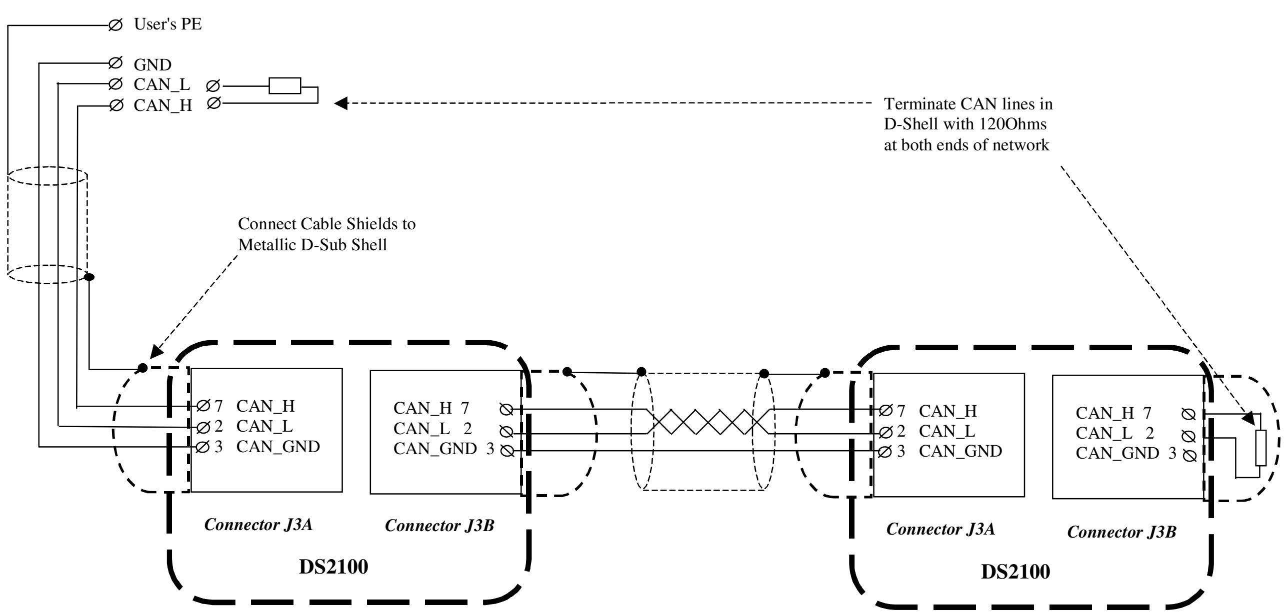
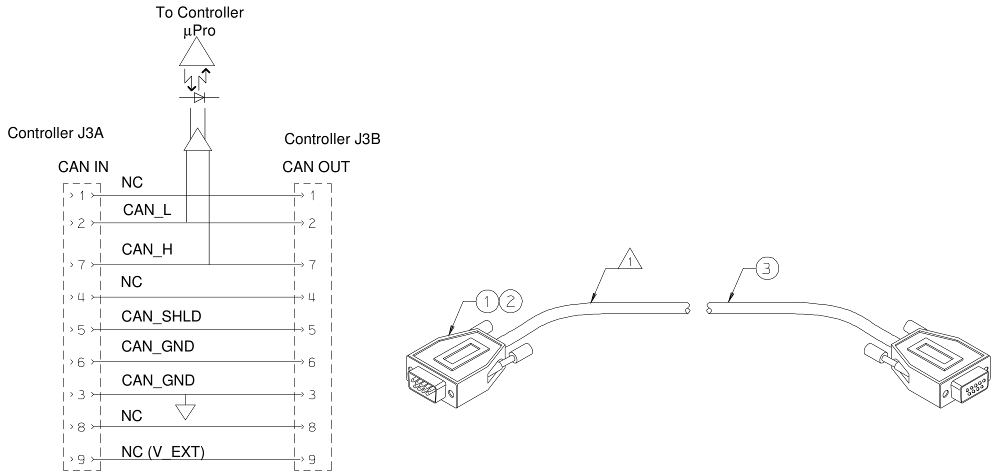


Figure 3.3.55 DS2100 CAN Wiring and Termination



Notes

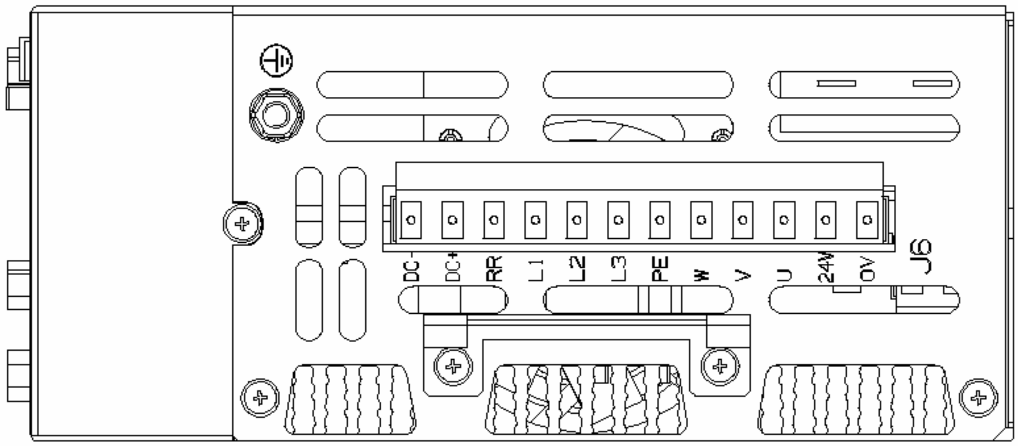
1. CABLE LENGTH NOT TO EXCEED 40 METERS FOR 1MBAUD OPERATION.
CABLE SHOULD NOT EXCEED 100 METERS FOR 500KBAUD OPERATION.

FIND NO.	MOOG PART NO.	DESCRIPTION	QUANTITY
1	MAKE ITEM	CONNECTOR 9 WAY D TYPE MALE	USER SPLY
2	MAKE ITEM	CONNECTOR 9 WAY D TYPE FEMALE	USER SPLY
3	MAKE ITEM	CABLE BELDEN 9842	USER SPLY

Figure 3.3.56 CAN_L/CAN_H Connector (J3A and J3B) Wiring

3.14 Wiring Summary

3.14.1 µA Size Power Stage



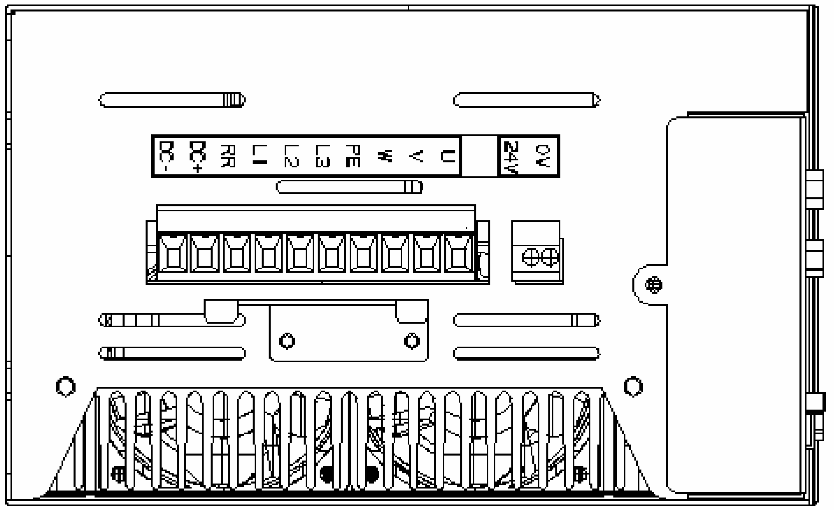
- Fixed connector: 12 pins, male connector
- Mating connector, 12 pins, female, supplied with the drive. Phoenix Combicon (Part # GMSTB 2.5/12-ST-7.62)
- µA size wiring: cable 14 AWG (2.1 mm^2). Wire stripping: 7 mm.
- Tightening torque: 0.5Nm.

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

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

Pos.	Name	Function
PE	PE	Protective Earth Stud on Chassis

3.14.2 A & B Size Power Stage



- Fixed connector: 10 pins, male connector
- Mating connector, 10 pins, female, supplied with the drive. Phoenix Contact (Part # PC4 HV/10-ST-7.62)
- 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
- Tightening torque: 0.5Nm.

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

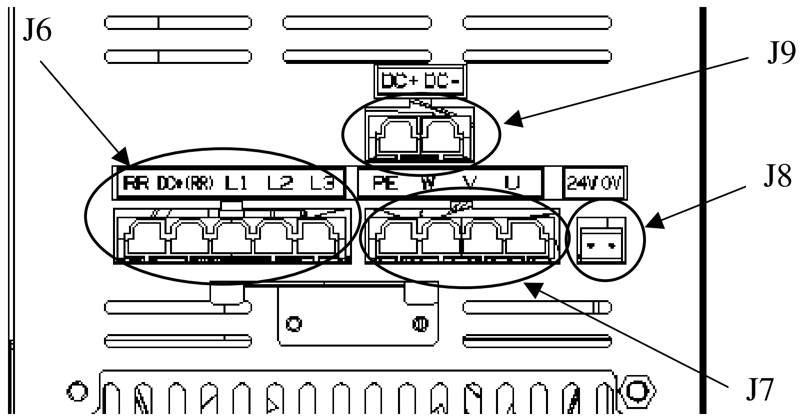
- Fixed connector: 2 pins, male connector
- Mating connector, 2 pins, female, supplied with the drive. Wago (Part # 231-102/026-000)
- C & D size wiring: cable 14 AWG (2.1 mm^2).
- Stripping Length 8mm

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

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

Pos.	Name	Function
PE	PE	Protective Earth Stud on Chassis

3.14.3 C Size Power Stage



- Fixed connector: 5 pins, male connector
- Mating connector, 5 pins, female, crimped supplied with the drive. (Molex 42816-0512)
- C size wiring: cable 8 AWG (8.4 mm^2).

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

- Fixed connector: 4 pins, male connector
- Mating connector, 4 pins, female, crimped supplied with the drive. (Molex 42816-0412)
- C size wiring: cable 8 AWG (8.4 mm^2).

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

- Fixed connector: 2 pins, male connector
- Mating connector, 2 pins, female, supplied with the drive. Wago (Part # 231-102/026-000)
- C & D size wiring: cable 14 AWG (2.1 mm^2).
- Stripping Length 8mm

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

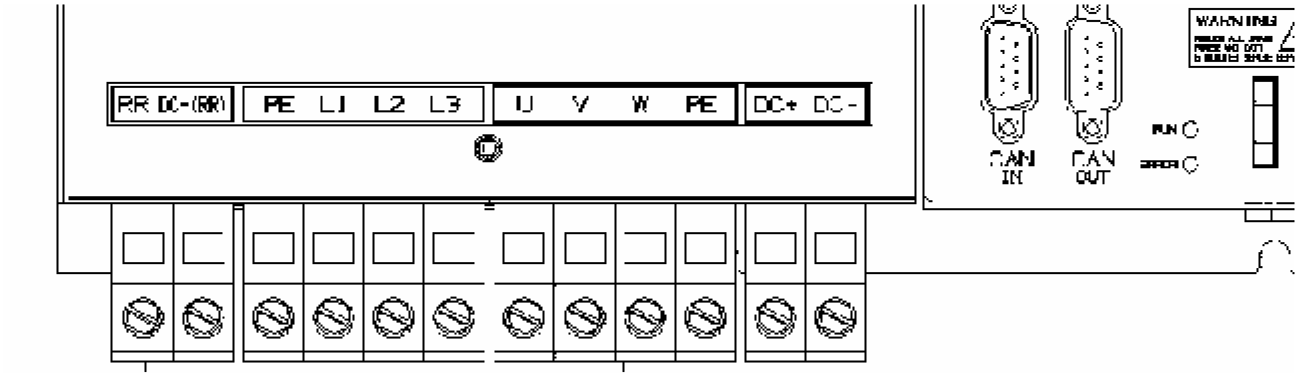
- Fixed connector: 2 pins, male connector
- Mating connector, 2 pins, female, crimped supplied with the drive. (Molex 42816-0212)
- C size wiring: cable 8 AWG (8.4 mm^2).

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

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

Pos.	Name	Function
PE	PE	Protective Earth Stud on Chassis

3.14.4 D Size Power Stage



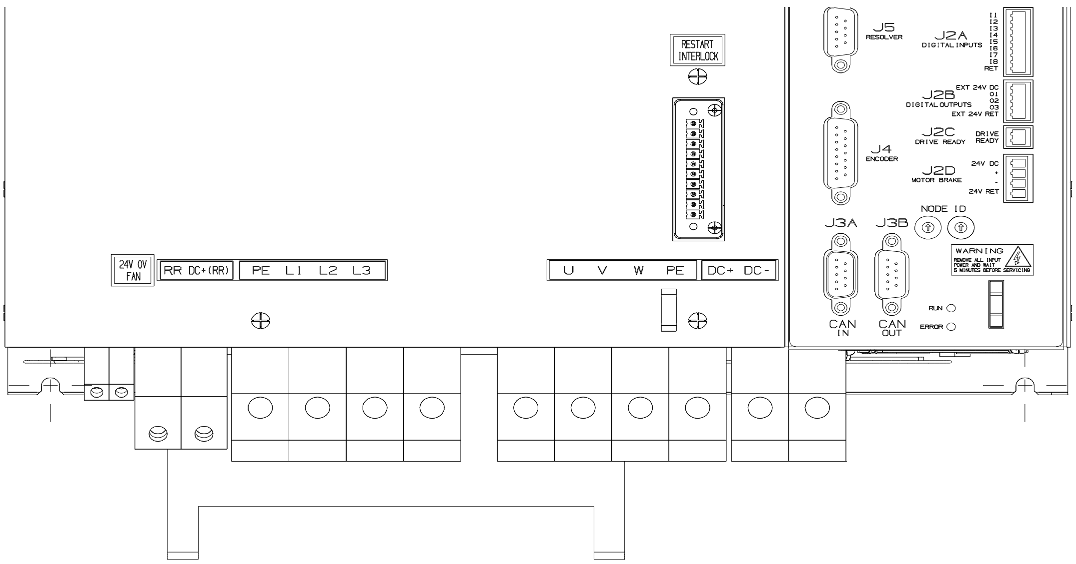
- Fixed connector: 12 pole, screw terminal
- D size wiring: cable 6 AWG (13 mm^2) for 50/140
- D size wiring: cable 4 AWG (21mm^2) for 60/180
- PE Terminal wiring: cable 6 AWG (13 mm^2) for 50/140
- PE Terminal wiring: cable 4 AWG (21 mm^2) for 60/180
- Stripping Length 16mm
- Tightening Torque: 2-2.3Nm

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

- Fixed connector: 2 pins, male connector
- Mating connector, 2 pins, female, supplied with the drive. Wago (Part # 231-102/026-000)
- D size wiring: cable 14 AWG (2.1 mm^2).
- Stripping Length 8mm

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

3.14.5 E Size Power Stage



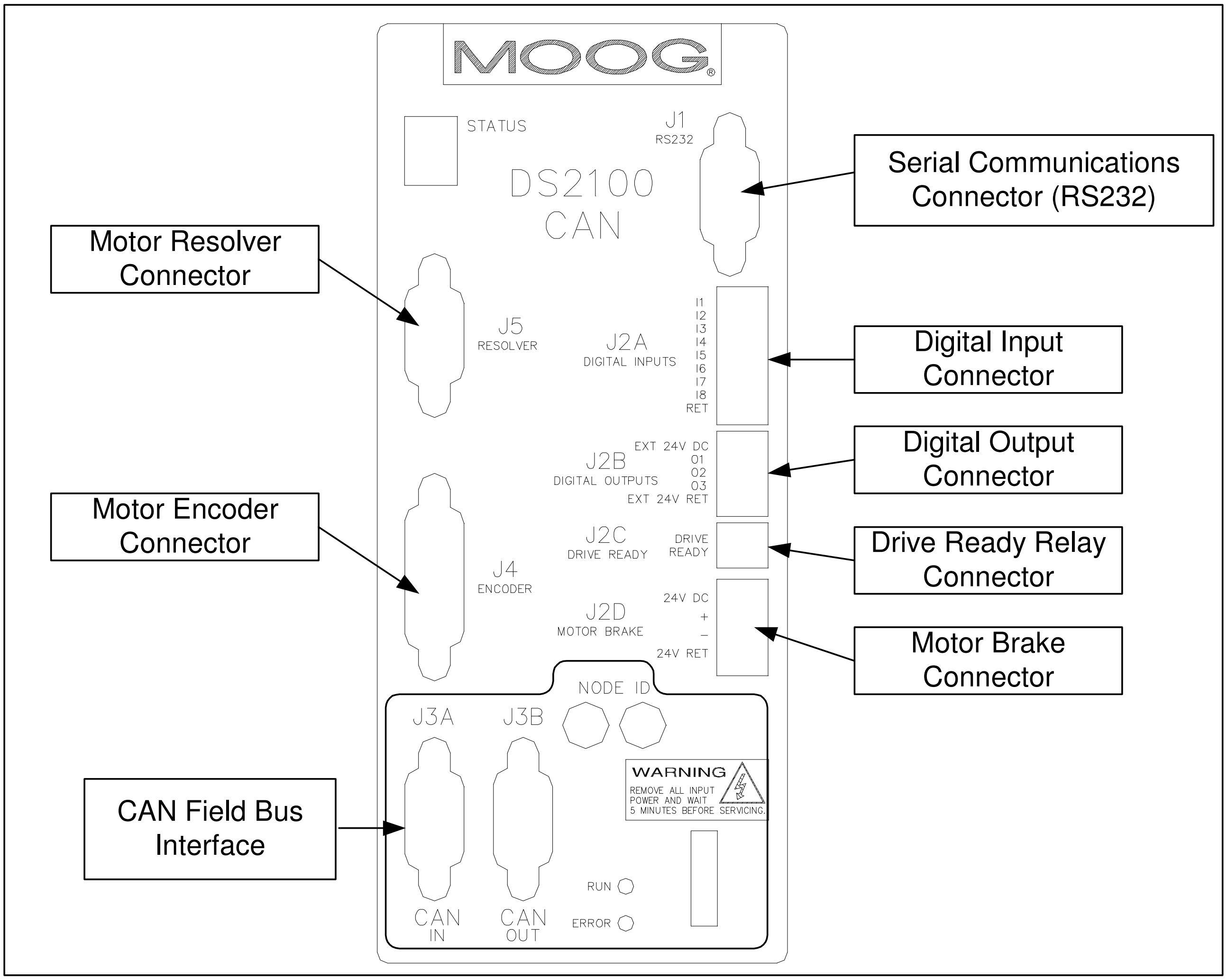
- Fixed connector: 14 pole, screw terminal
- Pos 1,2: Cable 14 AWG (2.1 mm^2) , Stripping 9mm , Torque 0.7Nm
- Pos 3,4: Cable 2 AWG (34 mm^2) , Stripping 19mm , Torque 4Nm
- Pos 5-14: Cable 1 AWG (42 mm^2) , Stripping 24mm , Torque 8Nm

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

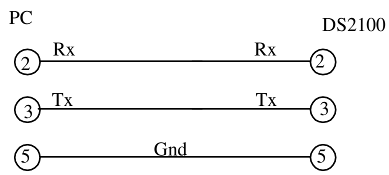
- Fixed connector: 2 pins, male connector
- Mating connector, 2 pins, female, supplied with the drive. Wago (Part # 231-102/026-000)
- E size wiring: cable 14 AWG (2.1 mm^2).
- Stripping Length 8mm

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

3.14.6 Control Card



3.14.6.1 RS232



- Fixed connector: 9 pin, female Sub-D connector
- Mating connector, 9 pin male Sub-D
- Wiring: cable. 28-18AWG (0.14-0.82mm^2)

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

3.14.6.2 Digital Inputs

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

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	

3.14.6.3 Digital Outputs

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

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	

3.14.6.4 Drive Ready

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

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 1	Drive Ready Relay Contact

3.14.6.5 Motor Brake

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

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

3.14.6.6 CAN

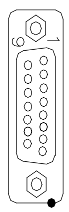
- Fixed connector: 9 pin male & female, Sub-D connector
- Mating connector, 9 pin male & female Sub-D
- Wiring: cable. 28-18AWG (0.14-0.82mm^2)

Pos (x=A,B)	Signal	Description
J3x.1	-	not connected
J3x.2	CAN_L	CAN_L bus line (dominant low)
J3x.3	CAN_GND	CAN Ground
J3x.4	-	not connected
J3x.5	CAN_SHLD	Chassis Ground
J3x.6	CAN_GND	CAN Ground
J3x.7	CAN_H	CAN_H bus line (dominant high)
J3x.8	-	not connected
J3x.9	-	Optional CAN external positive supply, not connected.

3.14.6.7 Encoder

- Fixed connector: 15 pin, female Sub-D connector
- Mating connector, 15pin male Sub-D
- Wiring: cable. 28-18AWG (0.14-0.82mm^2)

15-Pin Sub-D Connector
Plug (male) on cable



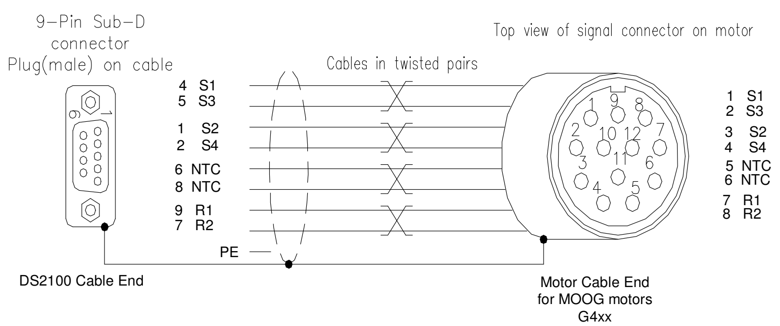
DS2100 Cable End
J4

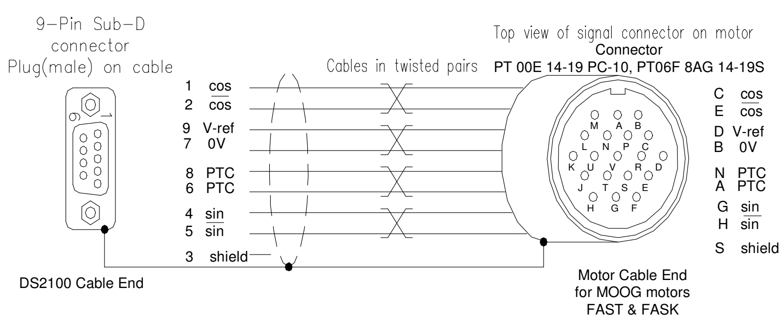
	Encoder Type			
Pos	**Analogue**	**SSI**	**Hiperface**	**Endat**
J4.1	Shield	Shield	Shield	Shield
J4.2	- Sine	-	- Sine	- Channel B
J4.3	- Cosine	-	- Cosine	- Channel A
J4.4	Gnd Supply	Gnd Supply	Gnd Supply	Gnd Supply
J4.5	-	- Clock	-	- Clock
J4.6	- Channel Z (Zero)	- Data	RS485 -	- Data
J4.7	-	-	-	-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

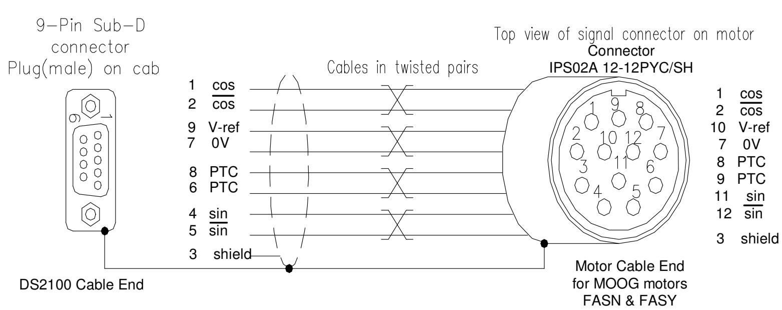
3.14.6.8 Resolver

- Fixed connector: 9 pin, female Sub-D connector
- Mating connector, 9 pin male Sub-D
- Wiring: cable. 28-18AWG (0.14-0.82mm^2)

MOTOR RESOLVER CONNECTOR				
Pos	Signal Type	FAS T/ FAS K	FAS N/ FAS Y	G4xx (FASG)
J5.1	Cosφ (S2)	C	1	3
J5.2	$\overline{\mathrm{Cos}\,\varphi}$ (S4)	E	2	4
J5.9	V-Ref (R1)	D	10	7
J5.7	0V (R2)	B	7	8
J5.8	PTC\NTC	N	8	6
J5.6	PTC\NTC	A	9	5
J5.4	Sinφ (S1)	G	11	1
J5.5	$\overline{\mathrm{Sin}\,\varphi}$ (S3)	H	12	2
J5.3	Shield	S	3	-







SECTION 4: GETTING STARTED

TABLE OF CONTENTS

TABLE OF FIGURES

4.1 Introduction

The getting started guide will provide you with the information needed to get a DS2100 configured and operational. The guide will show the typical steps required to operate a DS2100 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 DS2100 in both Torque and Velocity Mode.

Note: The example in this chapter demonstrates how to set up and configure a motor with **resolver** feedback.

4.2 Initial Preparation

Install the drive as per *Section 3* with regards to the safety notices indicated in section 2. As a minimum the following items are required before getting started:

- A DS2100 Controller.
- A PC Running Windows 98, Windows ME, Windows NT 4.0 (Service Pack 6 or later), Windows 2000, Windows XP with at least one RS232 serial port
- 24Vd.c and/or 230V/400Va.c
- Motor with resolver feedback
- Drive Enable Input

4.3 Power Supply

The DS2100 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 DS2100 does not lose absolute position data or status information when AC mains power is removed from the DS2100.

For the G361-x003 &-x006 a $24V_{dc}$ logic backup supply is mandatory for the drive to operate. No internal high voltage backup is provided on the smaller µA models.

4.4 Installing Windrive

WinDrive should be installed by running setup.exe from the File Manager or from the Program Manager.
The installation program will take the user through all the necessary installation steps. Any necessary folders to launch WinDrive will automatically be created in the Start menu.
For a more detailed account of setting up and installing the Windrive software refer to the “Readme” file which accompanies the GUI software.

From the Windows Start menu, select the “windrive” executable jar file to launch the application.
The Launcher dialog box is displayed after starting WinDrive. It displays the available configurations available for the particular release of WinDrive.
To determine which version is required look at the model number label on the drive:
For a drive named G361-xxxxA-0**0**-000 or G361-xxxxA-0**1**-000 select DS2100v0.1.
For a drive named G361-xxxxA-0**2**-000 select DS2100v0.2.
Click “Open”.

Figure 4.4.1Main Window

4.5 Controller Access

At this stage the Windrive software should be able to communicate with the DS2100 controller and the Status bar in the upper right hand corner should be green and read "*Read Successful (Controller ACK)*"

If the status bar is red and reads "*Serial Port Timeout Error*", ensure the +24V Backup power is applied and check all serial connections and Port settings.

The user does not need to input any password to set up and configure a drive and motor combination. Controller Access is for use by Moog Application Engineering and Moog Design Engineering.

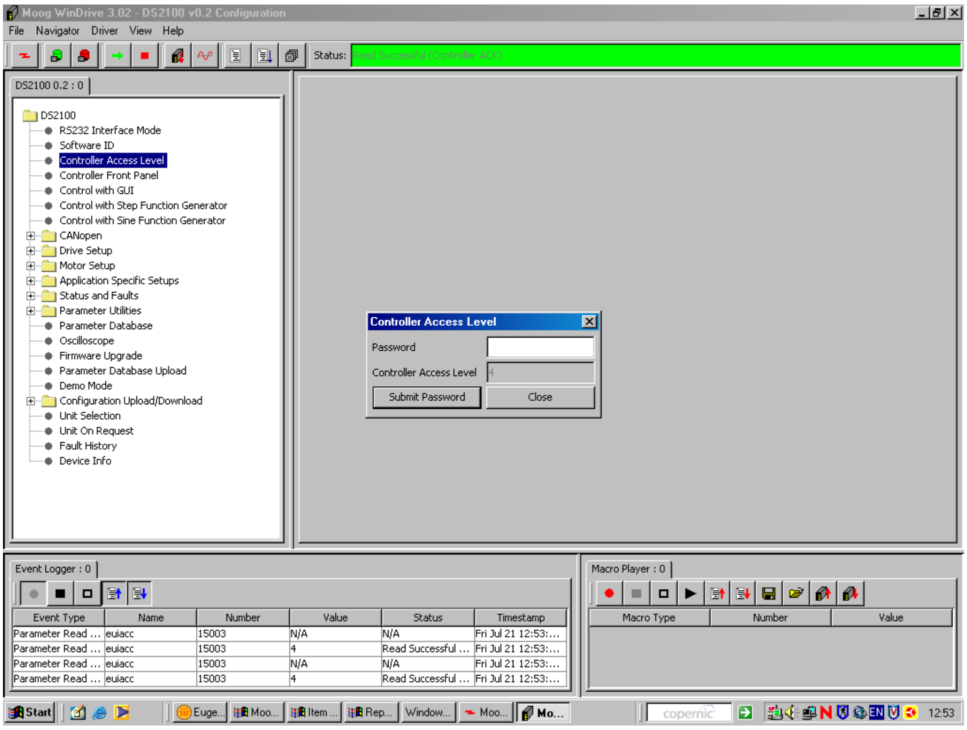


Figure 4.3 Access level Password

The WinDrive Software should now be functional and DS2100 Controller ready to be configured with the users particular parameters.

4.6 Motor Selection

The user may select to download the appropriate motor settings using one of the supplied Moog Motor libraries

- Moog Standard library "*Motor Setup → Moog Standard Motors (Full Database)*"
- Moog Non-standard Motor Library "*Motor Setup → Moog Nonstandard Motors*".

The motor may be selected by a choice of model (Gxxx-xxx) or electrical type (GxLxx) from the scrollable motor list. The nameplate on the motor should be checked for either the model or electrical type and the corresponding motor selected from either of the lists provided.
A search bar is also provided to help identify the corresponding motor in the list.

- Double click on the appropriate motor name to display a list of the current motor parameters.
- Left Click "*Download Parameters to Controller*".
- Select "*Yes*" at the prompt
- Select "*Close*" to close the list of motor parameters.

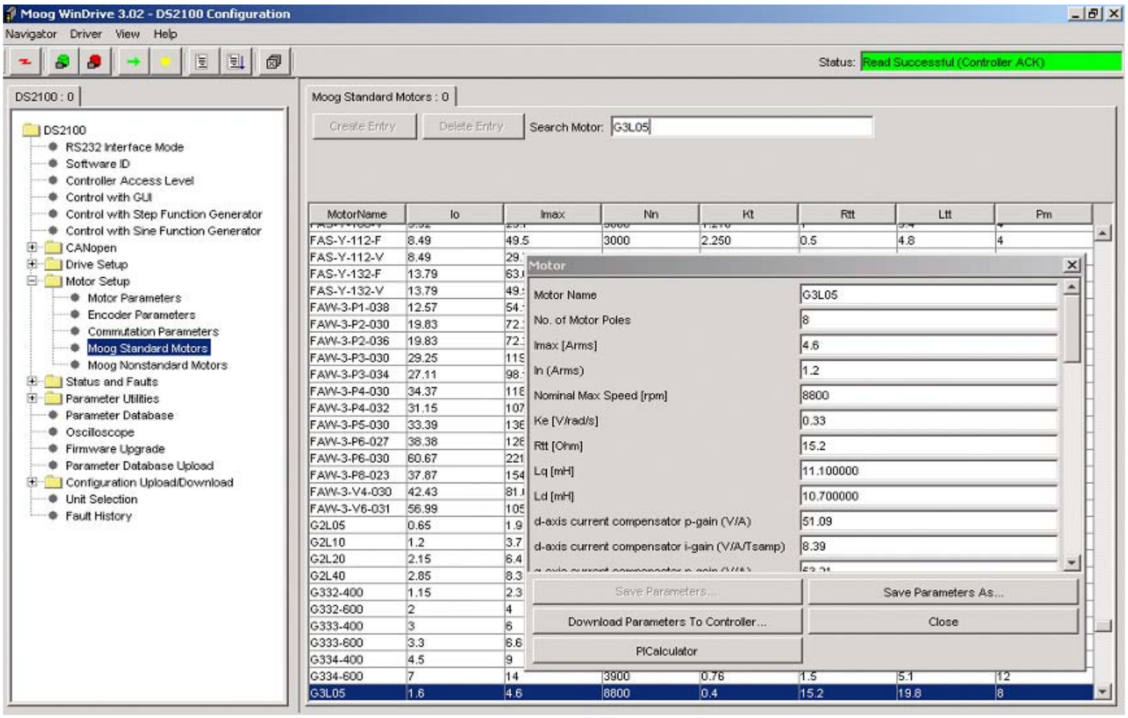


Figure 4.5 Downloading Motor Parameters

Open the parameter database *DS2100 → Parameter Database*. Click on the "Name" column header and all parameters will be sorted alphabetically.

- Ensure the commutation feedback parameter "comfbk" is set to 1 (resolver feedback),
  - *DS2100 → Parameter Database → comfbk*
- Ensure the Position feedback parameter "posfbk" is set to 1 (resolver feedback),,
  - *DS2100 → Parameter Database → posfbk*

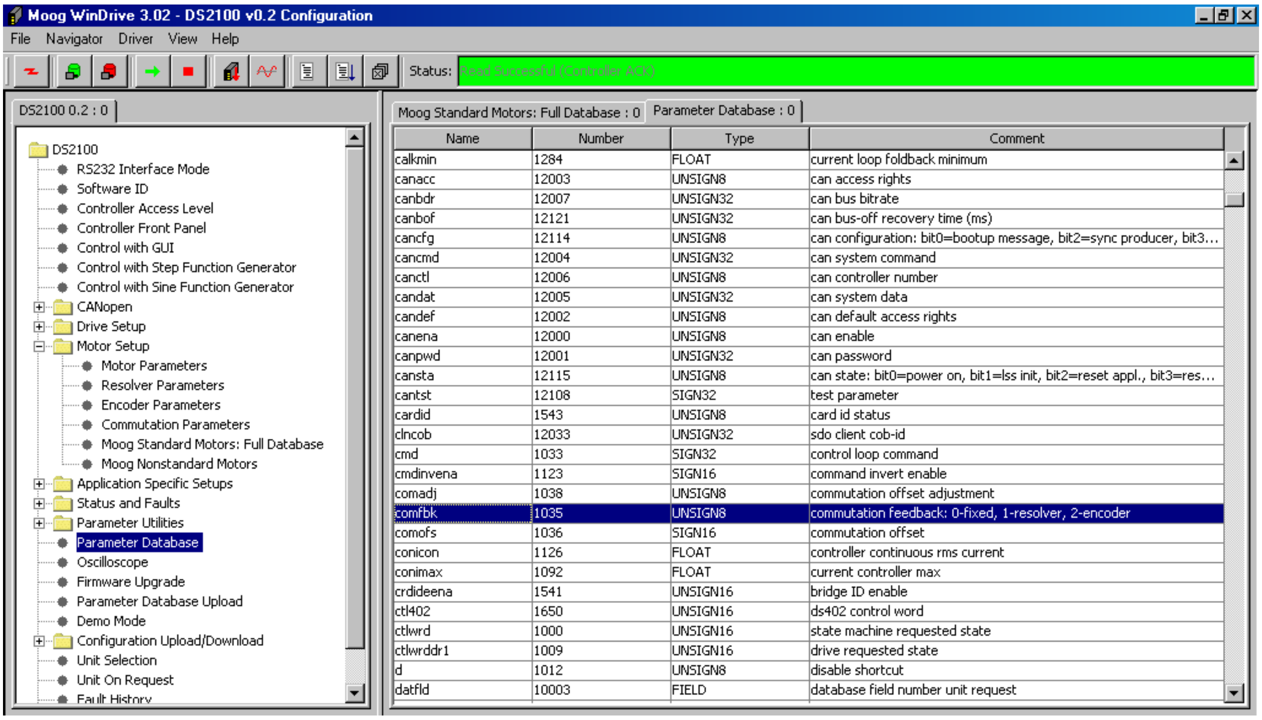


Figure 4.7 Parameter Database

4.7 Regen Resistor Configuration

Only the µA size DS2100 is equipped with an internal regeneration resistor. The larger sizes (A-D) require an external resistor to be attached. The recommended regeneration resistors are detailed in *Section 5.3.5*.

The Regen-on/ Regen-off voltages should be set in accordance with the DC Bus voltage, *Table 5.4 Typical Regeneration Turn-on & Turn-off Voltage Levels.* These parameters are automatically set when the motor parameters are downloaded to the controller but should be verified to ensure safe operation.

- Open *"DS2100 → Drive Setup → Regen Resistor → Regen Parameters"* and ensure that the *"Regen-On Voltage (V)"* and *"Regen-Off Voltage (V)"* are set correctly
- Select Write All.
- Confirm that values are correct.

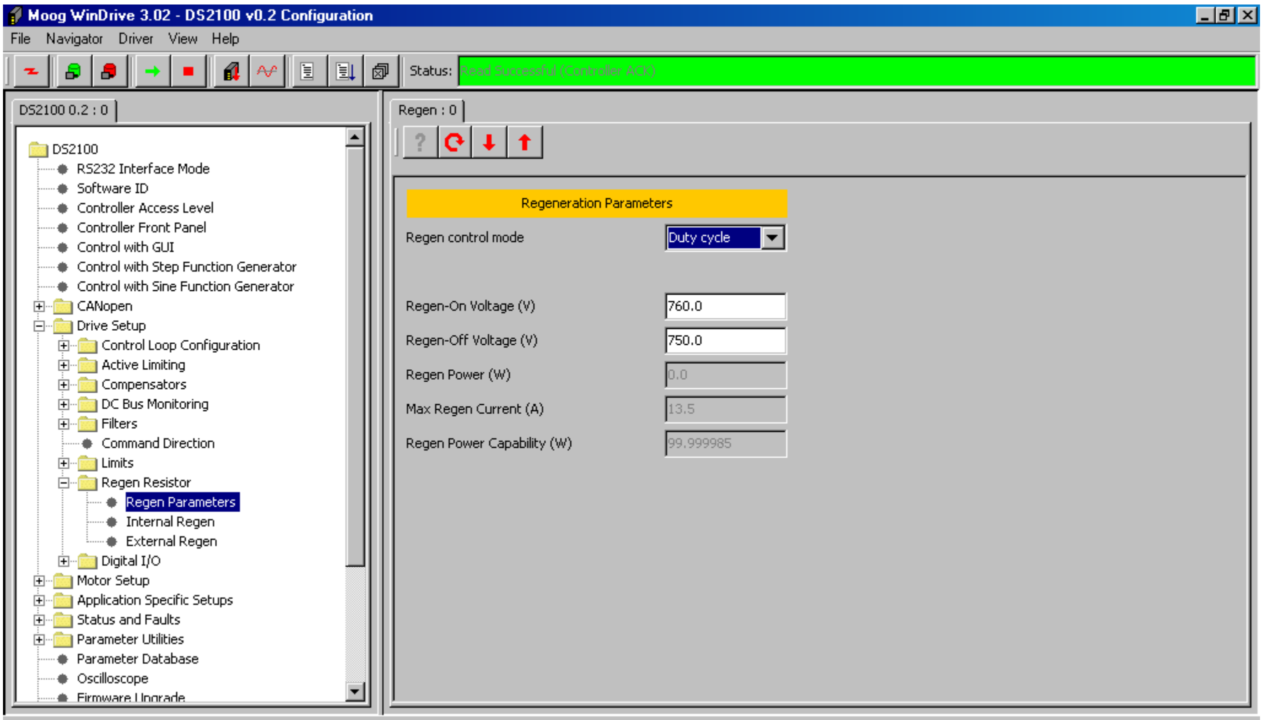


Figure 4.8 Regeneration Parameters

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. In this case, the drive will display a fault (F3) and will not enable until suitable parameters for the external regeneration resistors are entered and saved. The resistance and power rating of the external regeneration resistor connected to the drive should be entered in the "*External Regen*" window.

- Open "*Drive Setup → Regen Resistor → External Regen*" and enter the correct resistance and power ratings for the externally connected Regen Resistor (RR).
- Select Write All.
- Confirm that values are correct.

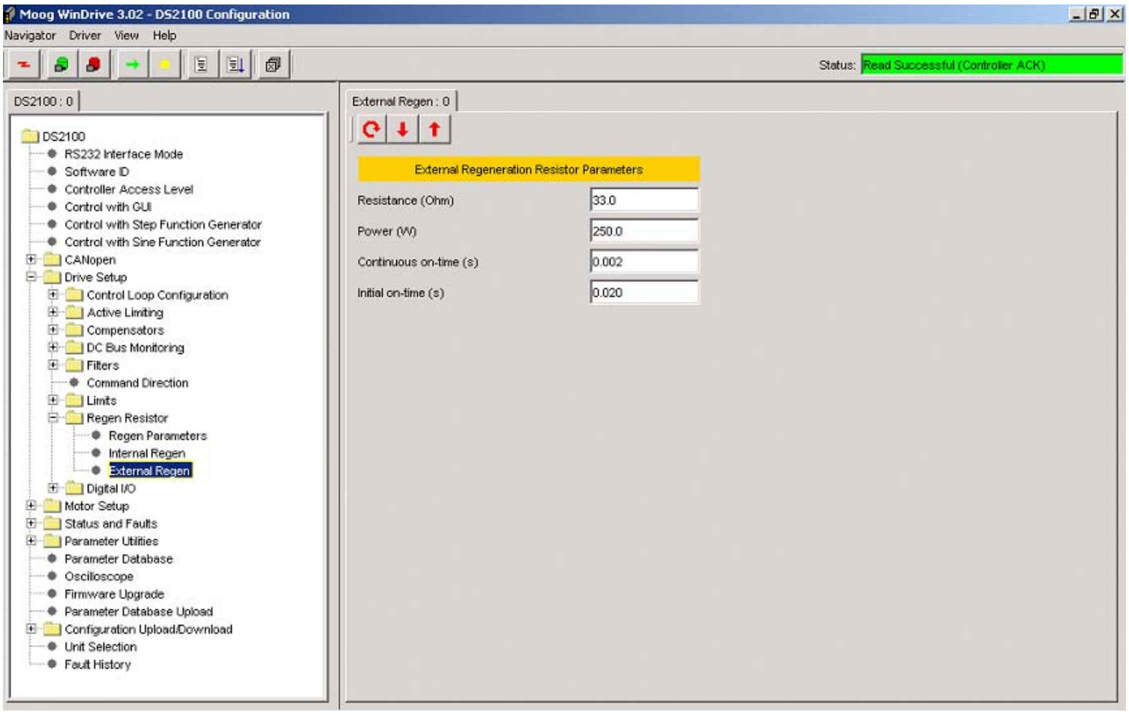


Figure 4.10 External Regen Parameters

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.

The drive will also display an F3 if the user inputs data for a regeneration resistor 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 "*DS2100 → Drive Setup → Regen Resistor → Regen Parameters*".

4.8 Acceleration Limits

The acceleration limiting is performed on the velocity command. The deceleration limits can be set separately to the acceleration limit, but writing to the acceleration limit will always set all of the deceleration limits to the same value as the acceleration limit.

- Set the Acceleration limits accordingly using the Drive Set-up panel
  "*Drive Setup* → *Limits* → *Acceleration Limits*"
- E.g. Set the Acceleration limits to "*10,000*" rad/s2

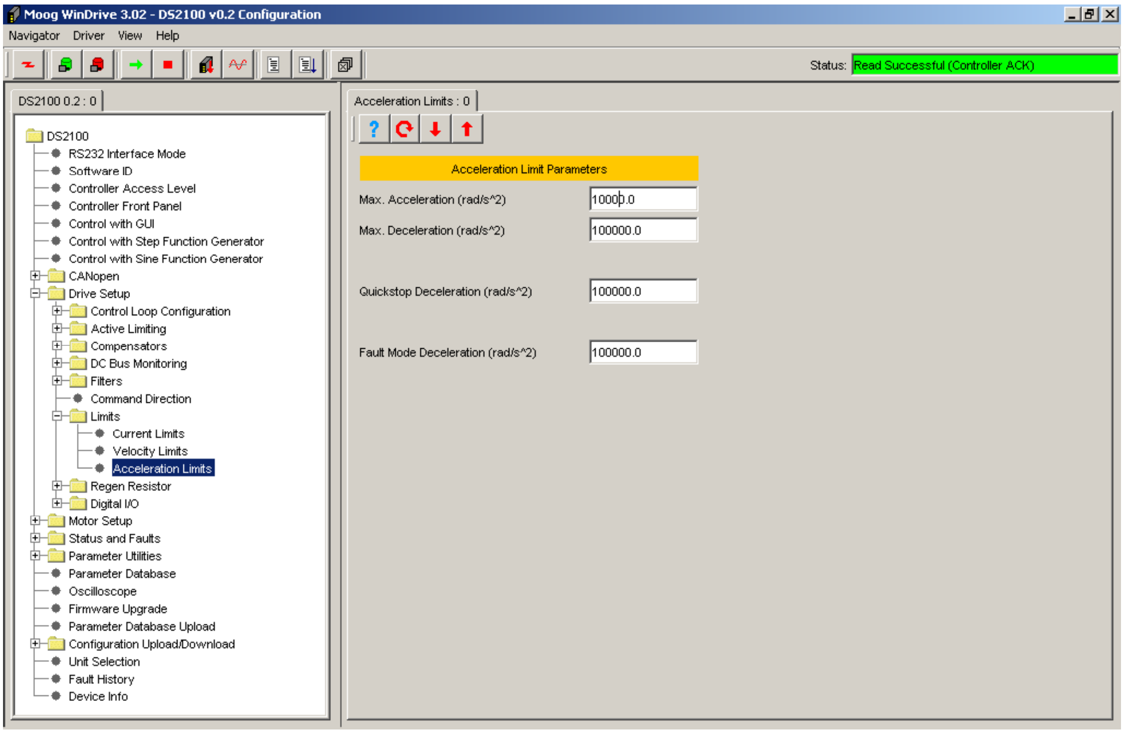


Figure 4.12 Acceleration Limits

4.9 Parameter Utilities

The user's parameters should now be saved to the non-volatile memory, such that when the drive is power cycled, the DS2100 is initialised with the user's parameters and not the default parameters.

- Open "*Parameter Utilities Drive Parameter Load/Save*" and left click "*Save Al Parameters*" to save all parameters to the non-volatile memory.

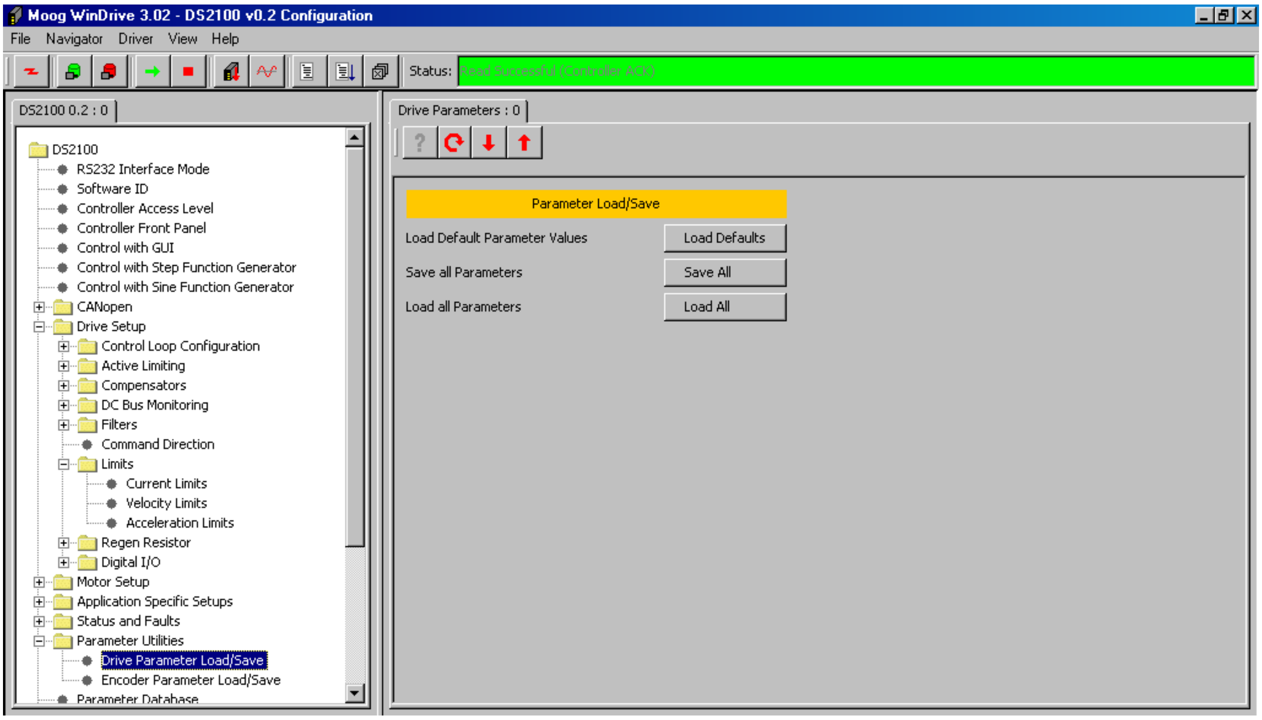


Figure 4.14 Parameter Utilities

4.10 Status & Faults

Before high power can be applied all faults must be cleared from the DS2100. The prefix “U” indicates a warning and an “F” indicates an error on the DS2100’s 7-segment display. *Refer Section 5.11 Drive Monitoring and Fault Detection.* 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*”.

The DS2100 should now display a “U1” to indicate “High Power Not Ready”. All other errors and warnings should be removed. Should an error indication remain, power-cycle the drive.
Should a persistent error occur *Refer to DS2100 User’s Manual Section 5.11 Drive Monitoring and Fault Detection* to identify the error. Where applicable check all connections and parameter settings associated with the particular error.

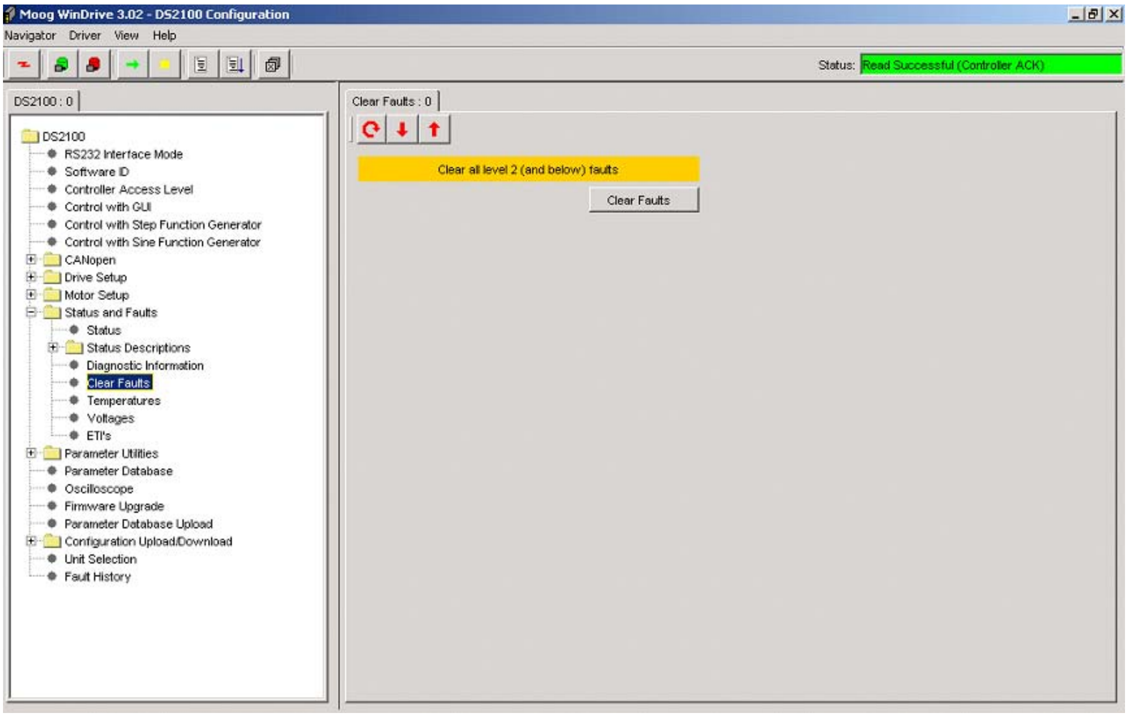


Figure 4.16 Clearing Faults

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

4.11 High Power Application

Apply the appropriate 3-phase voltage *(230Vac/400Vac)* to the DS2100 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.

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

"DS2100 → Drive Setup → DC Bus Monitoring → Continuous Voltage"

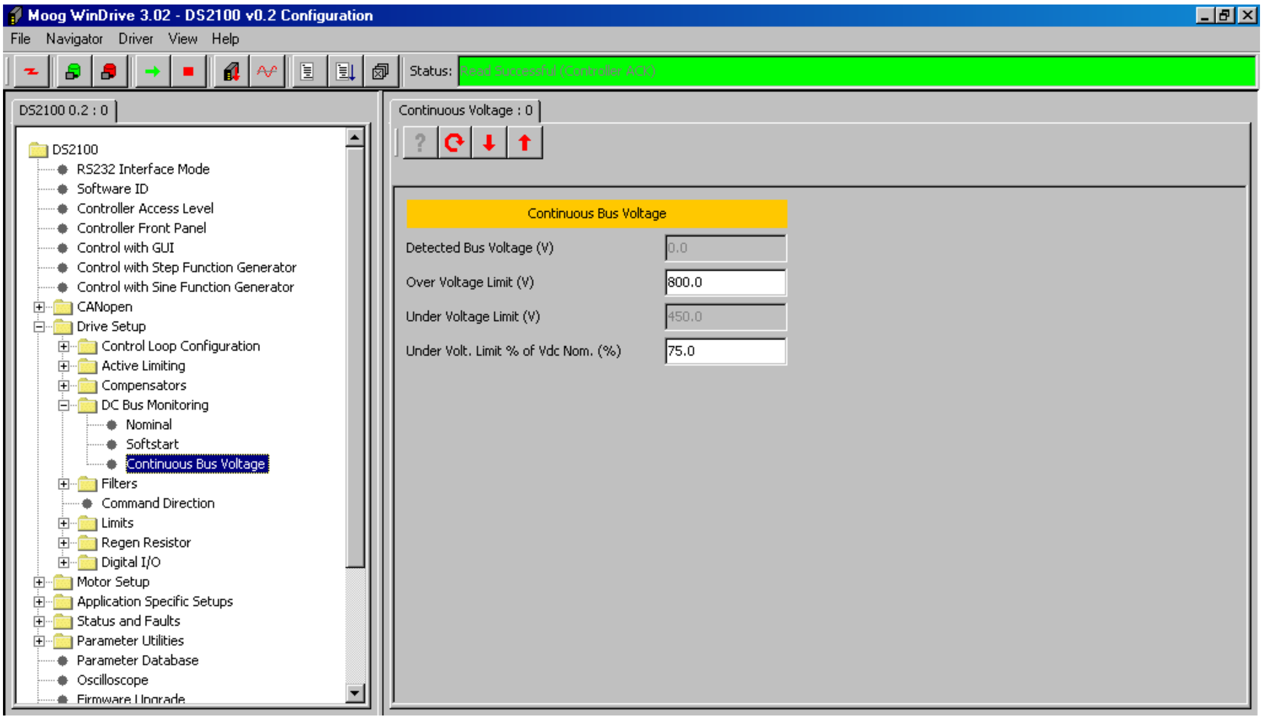


Figure 4.18 DC Bus Voltages

4.12 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.
Otherwise it is possible to do an automatic adjustment of this value using “*Commutation Parameters*”

- Open the ‘*Commutation Parameters’* panel in the *Motor Setup* menu item
- Select ‘*Torque Mode’*
- Select “*Start*” in the “*Commutation parameters*” panel
- Ensure that hardware drive enable input has +24V applied and enable the drive using the enable button ( ) in the toolbar.
- When the function has completed, save the parameters to NVM using the *Save All* parameters command in the Parameter Utilities “*Full Parameters Load/Save → Save all Parameters → Save All*”.

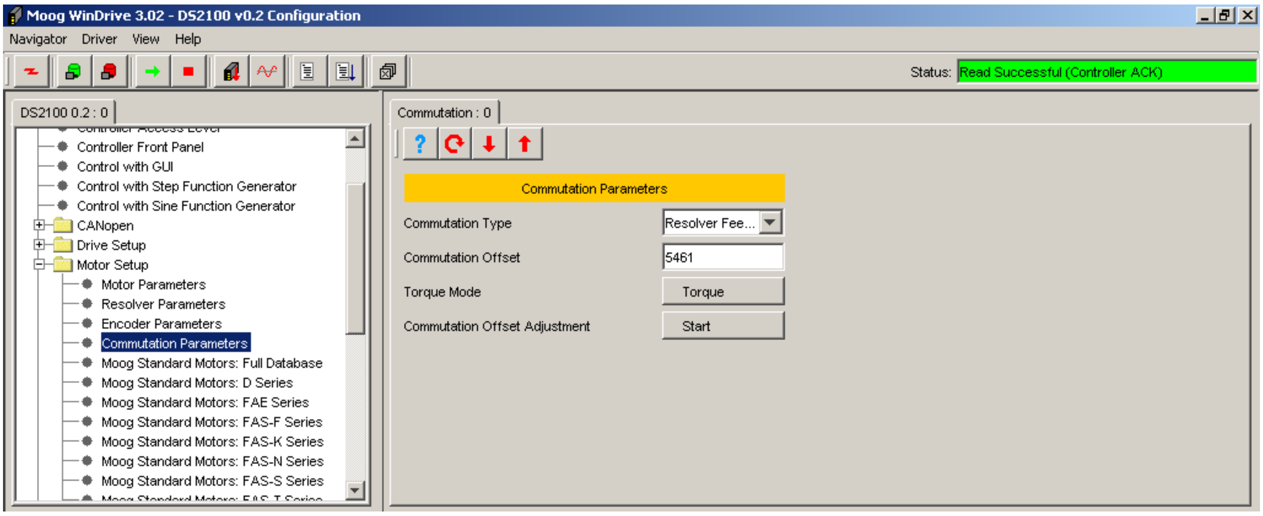


Figure 4.21 Commutation Parameters

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.

4.13 Torque Mode Enable

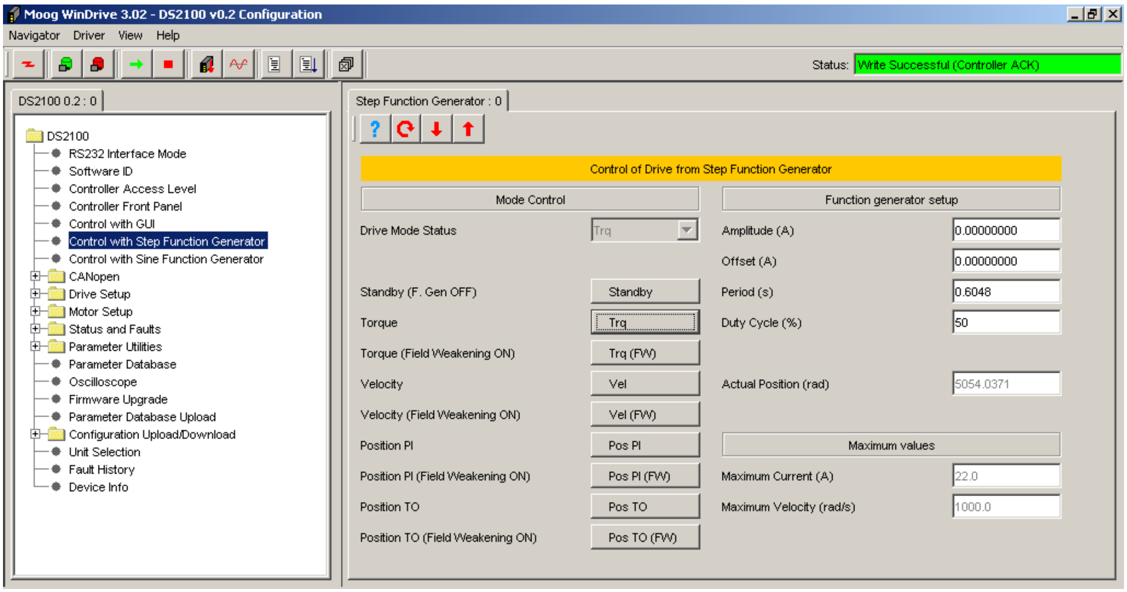
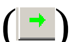
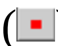


Figure 4.23 Torque Mode Drive Enable

- Open "*Control with Step Function Generator*", and click "*Trq*".
- 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*",
- Click enable button ().
- The Drive will start to accelerate in a clockwise direction until it reaches maximum velocity.
- Disable drive using disable button ().

4.14 Velocity Mode Enable

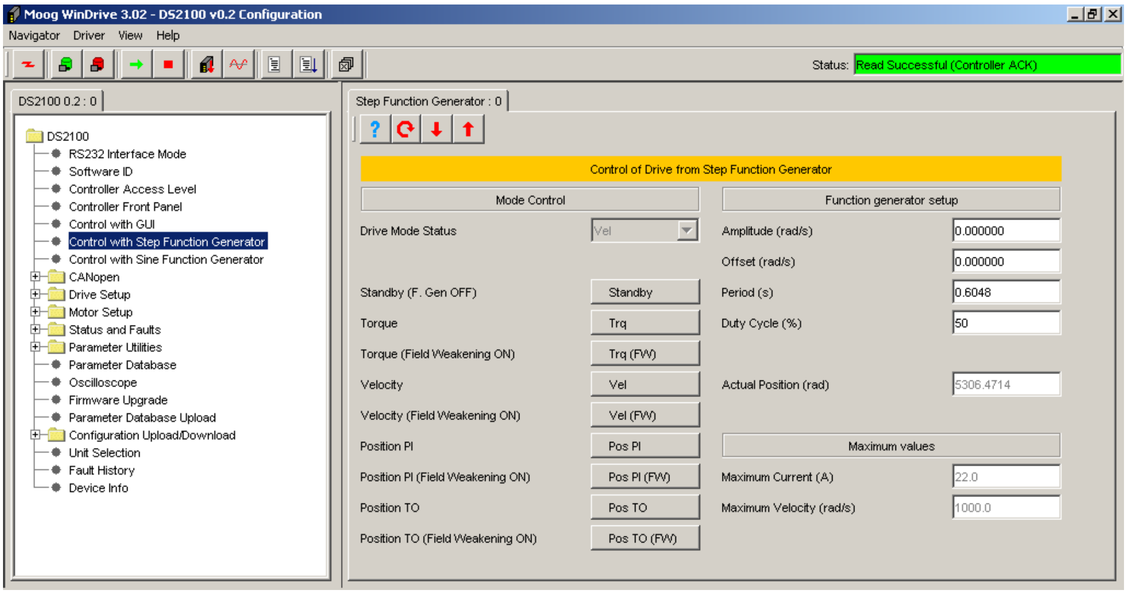


Figure 4.25 Velocity Mode Drive Enable

- Open "*Step Function Generator*", and click "*Vel*".
- Click "*Read All*" to confirm the "*Drive Mode Status*" reads "*Vel*".
- Give the drive an offset by typing "*50*" in the "*Offset*" textbox and by clicking "*Write All*",
- Click enable button ( ) and check that the drive rotates in a clockwise direction,
- Set the offset back to "*0*" rad/s,
- Disable drive using disable button ( ).
- Give the drive an "*Amplitude*" of "*100" rad/s*, a "*Period" "4" s* and click "*Write all*",
- Enable Drive and ensure that the motor turns rapidly, changing direction approximately every 2 seconds,
- Disable drive using disable button ( ).

4.15 Oscilloscope

4.15.1 Oscilloscope Set-up

- Open the oscilloscope, *"DS2100 → Oscilloscope"*
- The Status prompt in the lower right hand corner should be yellow and read "*initialising"*
- Set-up Channels 1-3, Timebase and Trigger as per the table 1 below,

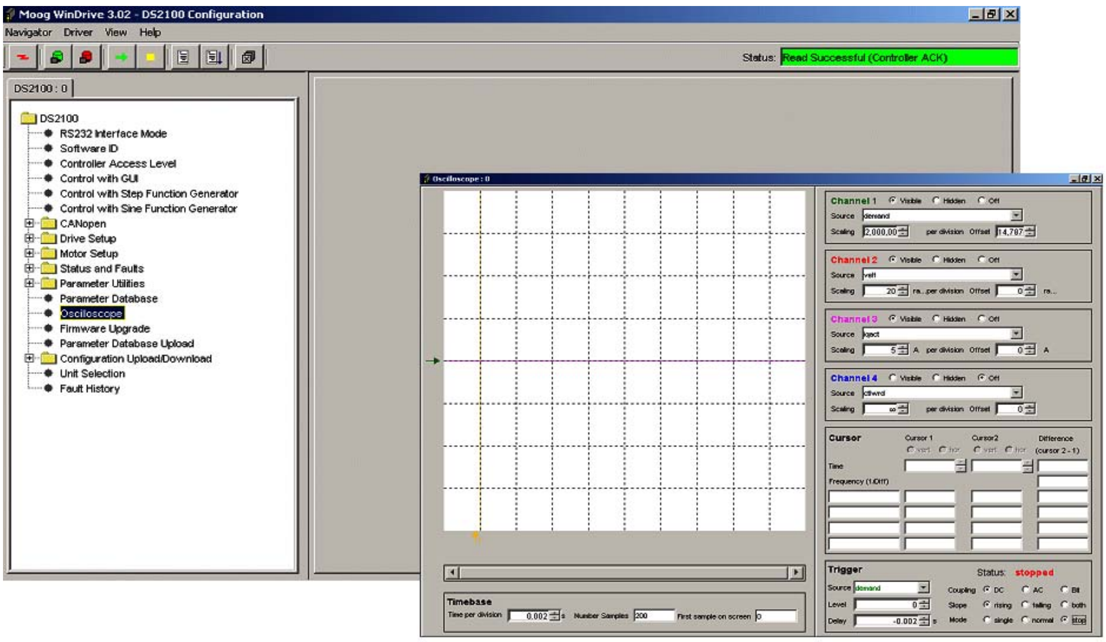


Figure 4.27 Oscilloscope

	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

Table 1 Oscilloscope Channel Set-up

4.15.2 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"*

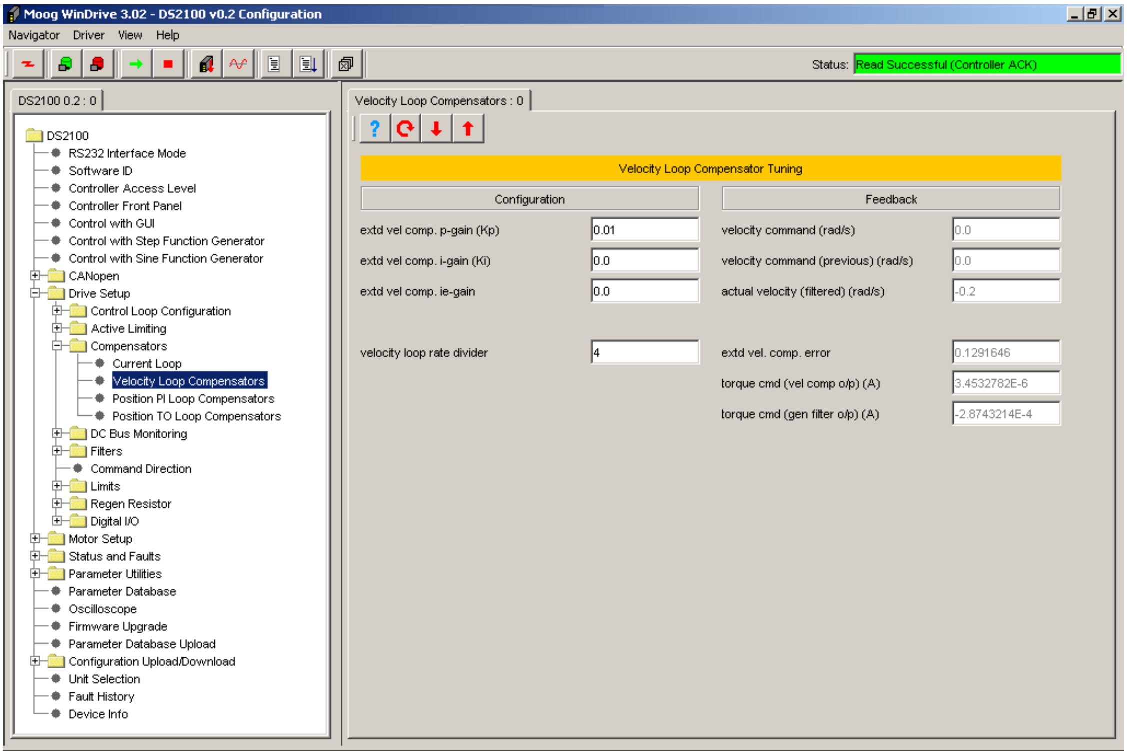
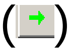
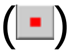


Figure 4.29 Velocity Loop Gains

4.15.3 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.

- Click enable button ()
- The Oscilloscope should trigger and the status prompt should turn red and read "*Stopped*"
- Disable drive using disable button ().

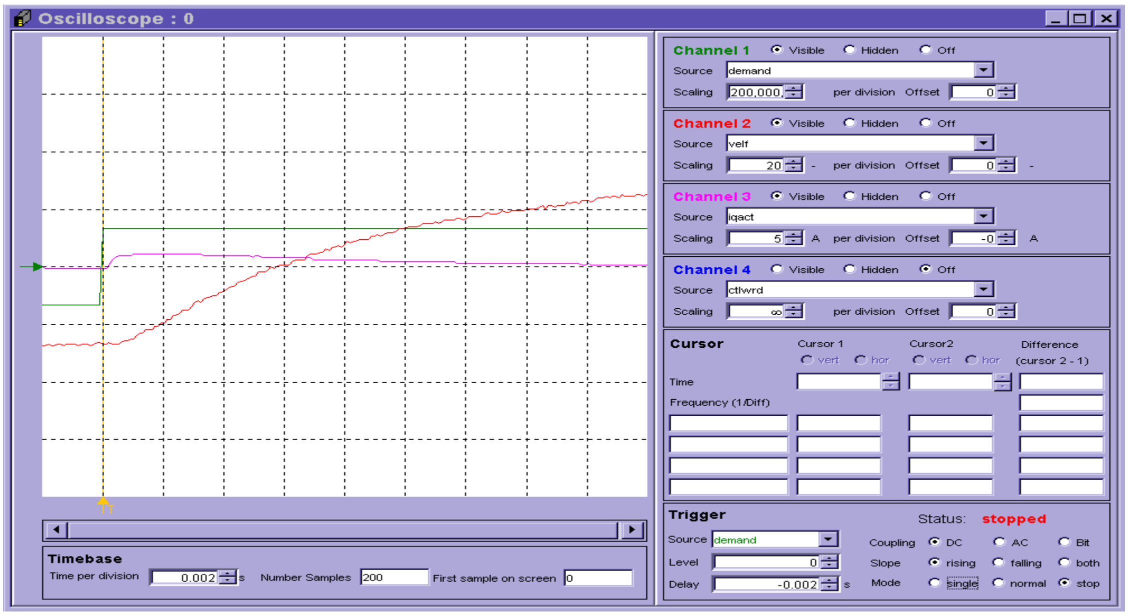
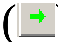
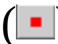


Figure 4.31 Step Response With Velocity p-gain = 0.01 & i-gain = 0.0

4.15.4 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
- Click enable button ()
- The Oscilloscope should trigger and the status prompt should turn red and read “*Stopped*”
- Disable drive using disable button ().

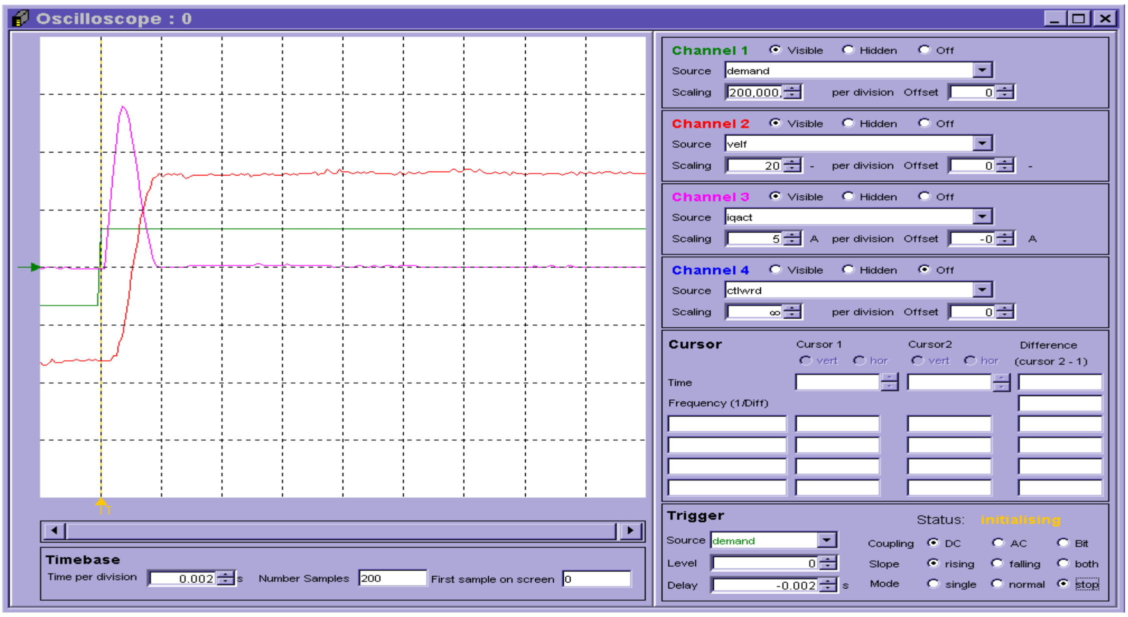
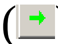
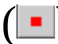


Figure 4.33 Step Response With Velocity p-gain = 0.075 & i-gain = 0.0

4.15.5 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
- Click enable button ().
- The Oscilloscope should trigger and the status prompt should turn red and read "*Stopped*"
- Disable drive using disable button ().

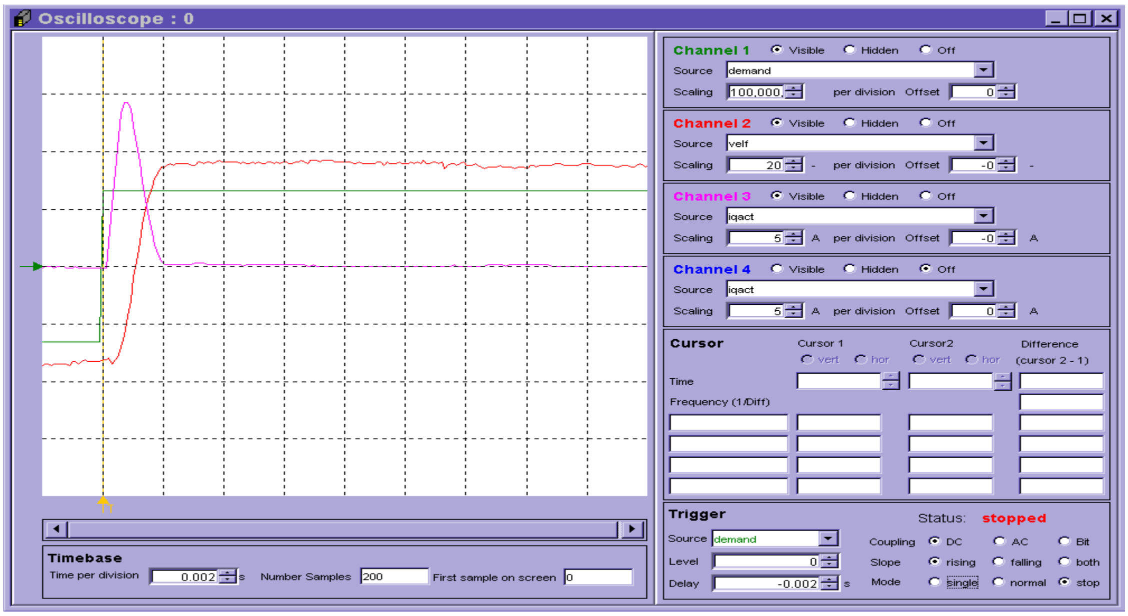


Figure 4.35 Step Response With Velocity p-gain = 0.075 & i-gain = 5

4.16 Power-Down Sequence

Ensure the drive is disabled and remove Hi Power (AC mains) from the DS2100 controller. Wait until the DC Bus Voltage has decreased to below 50VDC before servicing the controller, "*DS2100 → DC Bus Monitoring → Detected DC Bus Voltage*".

Close the Oscilloscope and the Windrive GUI and remove the 24V DC Logic Back up from the DS2100.

The sequence outlined in the preceding sections provides the user with step by step procedure on how to operate a DS2100 controller using the Windrive software performing basic motoring operations.

For a more in depth analysis of the DS2100 and Windrive Software please consult the relevant sections of the DS2100 User's Manual and the GUI User's Manual.

SECTION 5: DS2100 FUNCTIONAL OVERVIEW

TABLE OF CONTENTS

5.1 Introduction

This section describes the functionality of the DS2100. It details the various modes of operation of the drive. The DS2100 CAN controller supports communications between drives and to a controller over a CAN network. Details of the CAN interface are given in Sections 6 and Section 7 of this manual.

5.2 DS2100 Conventions

This section deals with commonly understood conventions for DS2100 operation.

5.2.1 Direction of Rotation

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

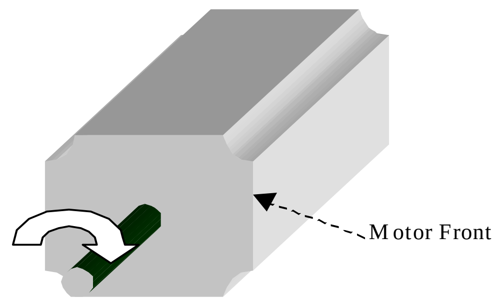


Figure 5.1 Rotational Convention for Mechanical Process Variables

i

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

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 a.c Operation
- Direct Off-Line 230 V r.m.s to 460V r.m.s. +10% Operation
- Soft Start (a.c. Inrush Current Limiting)
- Input MOV Transient Protection
- Internal Regeneration capability (µA units only)
- Drive Ready Relay
- Provision for External Regeneration Resistor
- Integral Heat Sink and Cooling Fans
- 24V Logic Backup (mandatory on µA size units)

These features are described in the next sections.

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 at least 5 minutes for the µA sizes (6 minutes for the A-D sizes) after 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.

The high power supply section may be divided into functional blocks:

- High voltage rectification and filtering
- Soft-start of a.c. mains power-on
- Low voltage control power supply
- Regeneration circuit
- Monitoring and fault logic circuits

5.3.2 High Voltage Rectification and Filtering

The a.c. mains input is rectified by a three phase diode bridge and filtered by a bank of electrolytic capacitors to generate the internal DC Bus. This high power d.c. supply is unregulated and will vary in direct proportion with the a.c. mains input voltage magnitude. The dc bus voltage is monitored continuously and is available for user display, parameter *bus_voltage_actual* (index 0x60F7, subindex18). Once the softstart relay has closed, the nominal DC bus, voltage is set in software, parameter *bus_voltage_nominal* (index 0x60F7, subindex 17), 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* (index 0x24A0, subindex 6) is set, by default, to 75% of the nominal bus voltage. This undervoltage percentage level, parameter *bus_under_voltage_limit_percentage* (index 0x24A0, subindex 7) can be changed to different levels to suit application requirements..

The overvoltage level, parameter *bus_over_voltage_limit* (index 0x24A0, subindex 5) is typically set by the motor configuration and will generally be either 400V or 800V.

A.C. Mains Type	D.C. Bus Voltage Level
230V Three Phase Mains	325Vd.c.
400Va.c. Mains	565Vd.c.

Table 5.1 Magnitude of the D.C. Bus

5.3.3 Soft Start

Soft start is used to limit the inrush current to the d.c. bus capacitor bank on application of a.c. mains power. This is intended to prevent nuisance tripping of circuit breakers or blowing of line fuses on power-up.

The soft start relay will close when the monitoring circuit and associated control software determines that the high-voltage d.c. 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. The DC/DC can generate control power from two sources

1. D.C. Bus if it is greater than 120Vd.c. (Not available on the DS2100 μA size drives)
2. 24Vd.c. external supply which is provided by the user specially 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.

Parameter Name	**Index / Subindex**	**Description**
supply_+24V	0x2810 / 25	Internal 24V Logic Supply
supply_+3V3	0x2810 / 5	3.3V Logic Supply
supply_-15V	0x2810 / 10	-15V Logic Supply
supply_+15V	0x2810 / 15	+15V Logic Supply
supply_+2V_ref	0x2810 / 20	2V Reference Level
encoder_supply	0x2810 / 30	Encoder Supply

Table 5.2 Logic Voltage Supply Monitoring Parameters

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 D.C. 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 D.C..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. As the DS2100 uses only one Regeneration transistor, both the internal and external Regeneration resistors are effectively connected in parallel. Thus, 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 use 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 detemine 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.:

Parameter Name	Index / Subindex	Description
regen_enable	0x24A4 / 21	Regeneration Control Mode 0 - Regeneration Off 1 - Duty cycle controlled 2 - Duty cycle controlled + power fault 3 - Power fault only 4 - Power warning only
regen_on_voltage	0x24A4 / 2	Regeneration Transistor Turn-on Voltage
regen_off_voltage	0x24A4 / 1	Regeneration Transistor Turn-off Voltage
regen_power_filtered	0x24A4 / 5	Average Regeneration Power (Measured)
regen_internal_resistance	0x24A4 / 11	Internal Regeneration Resistor Resistance
regen_internal_resistor_power	0x24A4 / 12	Internal Regeneration Resistor Power
regen_internal_resistor initial_on_time	0x24A4 / 14	Internal Regeneration Resistor Initial on-time in ms
regen_internal_resistor_contin uous_on_time	0x24A4 / 13	Internal Regeneration Resistor Continuous on-time in ms
regen_external_resistance	0x24A4 / 15	External Regeneration Resistor Resistance
regen_external_resistor_power	0x24A4 / 16	External Regeneration Resistor Power
regen_external_resistor_initial _on_time	0x24A4 / 18	External Regeneration Resistor Initial on-time in ms
regen_external_resistor_contin uous_on_time	0x24A4 / 17	External Regeneration Resistor Continuous on-time in ms
regen_power_capability	0x24A4 / 22	Total Regeneration Power Capability
regen_max_current	0x24A4 / 19	Maximum Regeneration Current

Table 5.3 Regeneration Parameters

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.

Motor Voltage	Bus Overvoltage	Regen on Voltage	Regen off Voltage
300V	400V	390V	380V
600V	800V	780V	760V

Table 5.4 Typical Regeneration Turn-on & Turn-off Voltage Levels

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 (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.

5.3.6 Power Interface Parameters

Parameter Name	CANopen Index	CANopen sub-index	PDO mapping	Data Type	Access	Default Value	Minimum Value	Maximum Value	Units	Storage Type	Data Group	Field Number
HIGH VOLTAGE												
bus_voltage_actual	0x60F7	18	yes	f32	r	-	-	-	V	N	A	1232
bus_voltage_nominal	0x60F7	17	no	f32	r	-	-	-	V	N	A	1229
bus_under_voltage_limit	0x24A0	6	no	f32	r	-	-	-	V	N	A	1234
bus_under_voltage_limit_percentage	0x24A0	7	no	f32	r/w	75	0	100	%	C	A	1235
bus_over_voltage_limit	0x24A0	5	no	f32	r/w	800	0	1000	V	C	A	1233
LOW VOLTAGE												
supply_+24V	0x2810	25	yes	f32	r	-	-	-	V	N	A	1441
supply_+3V3	0x2810	5	yes	f32	r	-	-	-	V	N	A	1421
supply_-15V	0x2810	10	yes	f32	r	-	-	-	V	N	A	1426
supply_+15V	0x2810	15	yes	f32	r	-	-	-	V	N	A	1431
supply_+2V_ref.	0x2810	20	yes	f32	r	-	-	-	V	N	A	1436
encoder_supply	0x2810	30	yes	f32	r	-	-	-	V	N	A	1446
REGENERATION CONTROL												
regen_enable	0x24A4	21	no	U16	r/w	1	0	4	-	C	A	1268
regen_on_voltage	0x24A4	2	no	f32	r/w	780	10	-	V	C	A	1249
regen_off_voltage	0x24A4	1	no	f32	r/w	760	0	-	V	C	A	1248
regen_power_filtered	0x24A4	5	yes	f32	r	-	-	-	W	N	A	1252
regen_internal_resistance	0x24A4	11	no	f32	r/w	see note 1	0	-	Ohm	F	A	1258
regen_internal_resistor_power	0x24A4	12	no	f32	r/w	see note 1	0	-	Ohm	F	A	1259
regen_internal_resistor_initial_on_time	0x24A4	14	no	f32	r/w		20	-	ms	F	A	1261
regen_internal_resistor_continuous_on_time	0x24A4	13	no	f32	r/w		2	-	ms	F	A	1260
regen_external_resistance	0x24A4	15	no	f32	r/w	0	0	-	Ohm	C	A	1262
regen_external_resistor_power	0x24A4	16	no	f32	r/w	0	0	-	Ohm	C	A	1263
regen_external_resistor_initial_on_time	0x24A4	18	no	f32	r/w		20	-	ms	F	A	1265
regen_external_resistor_continuous_on_time	0x24A4	17	no	f32	r/w		2	-	ms	F	A	1264

regen_power_capability	0x24A4	22	no	f32	r	-	-	-	W	N	A	1269
regen_max_current	0x24A4	19	no	f32	r/w	see note 2	0	-	A	F	A	1266

Table 5.5 Power Interface Parameter Access Detail

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. These parameters are held in the GUI, and downloaded by selecting the appropriate motor from the motor set-up folder, in the T361 navigator panel. 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 shown below.

5.4.1 Motor Name

Index	*Type*	*Units*	*Motor Database Name*	*Name*
0x6410/1	str	None	Name	motor_name

5.4.2 Electrical Parameters

Index	*Type*	*Units*	*Motor Database Name*	*Name*
0x6410/2	u16	None	Pm	*motor_poles*
0x6410/3	f32	Ohms	Rtt	*motor_Rtt*
0x6410/4	f32	H	Lq	*motor_Lq*
0x6410/5	f32	H	Ld	*motor_Ld*
0x6410/6	f32	V/rad/s	Ke	*motor_ke*

Table 5.6 List of motor (Electrical) parameters

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: -

Index	*Type*	*Units*	*Motor Database Name*	*Name*
0x60F6/1	F32	V/A/Tsamp	DS2100_di	*current_loop_d-axis_i-gain*
0x60F6/2	F32	V/A	DS2100_dp	*current_loop_d-axis_p-gain*
0x60F6/3	F32	V/A/Tsamp	DS2100_qi	*current_loop_q-axis_i-gain*
0x60F6/4	F32	V/A	DS2100_qp	*current_loop_q-axis_p-gain*
0x60F6/5	F32	None	DS2100_calk	*current_loop_foldback_minimum*
0x60F6/6	F32	A	DS2100_cali	*current_loop_foldback_breakpoint*
0x60F6/9	F32	V/A/Tsamp	DS2100_oap	*current_loop_alpha_observer_i_gain*

0x60F6/10	F32	V/A	DS2100_oai	*current_loop_alpha_observer_p_gain*
0x60F6/11	F32	V/A/Tsamp	DS2100_obp	*current_loop_beta_observer_i_gain*
0x60F6/12	F32	V/A	DS2100_obi	*current_loop_beta_observer_p_gain*

Table 5.7 List of motor (Current Loop) parameters

5.4.4 Feedback and Commutation Parameters

Different sources for the feedback of motor position to the controller are available. The following tables 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: -

Index	***Type***	***Units***	***Motor Database Name***	***Name***
0x2200/4	U16	none	DS2100_rref	*resolver_amplitude*
0x2171/1	U08	none	DS2100_comfbk	*commutation_feedback*
0x2171/2	S16	none	DS2100_comofs	*commutation_offset*
0x2171/3	U16	none	Pr	*resolver_poles*
0x2e20/1	U08	none	DS2100_encsup	*encoder_supply*
0x2e20/2	U08	none	DS2100_enctyp	*encoder_type*
0x2e20/3	U32	none	encinc	*encoder_number_of_increments*
0x2e20/6	U08	none	ssibit	*encoder_ssi_number_bits*
0x2e20/7	U08	none	DS2100_ssicod	*encoder_ssi_coding*
0x2e20/8	U32	none	DS2100_ssimsk	*encoder_ssi_data_bit_mask*

Table 5.8 List of motor (Feedback and Commutation) parameters

5.4.5 Bus Parameters

The default value for the bus over-voltage limit is 800, with defaults of 760 and 780 for the regen. off and on limit respectively.

Index	***Type***	***Units***	***Motor Database Name***	***Name***
0x24a0/5	F32	V	Vmax	*bus_over_voltage_limit*
0x24a4/1	F32	V	Vrgnoff	*regen_off_voltage*
0x24a4/2	F32	V	Vrgnon	regen_on_voltage

Table 5.9 List of motor (Bus) parameters

5.4.6 Motor Thermal Parameters

The coefficients that characterise 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.

Index	***Type***	***Units***	***Motor Database Name***	***Name***
0x2805/1	F32	none	DS2100_ntca0	*motor_sensor_coefficient_a0*

0x2805/2	F32	none	DS2100_ntca1	*motor_ sensor _coefficient_a1*
0x2805/3	F32	none	DS2100_ntca2	*motor_ sensor _coefficient_a2*
0x2805/4	F32	none	DS2100_ntca3	*motor_ sensor _coefficient_a3*
0x2805/5	F32	°C	DS2100_ntcmin	*motor_ sensor _min_temperature*
0x2805/6	F32	°C	DS2100_ntcmax	*motor_ sensor _max_temperature*
0x6510/7	U16	none	DS2100_tlmena	*current_limit_mask*
0x280A/8	F32	°C	Tmax	*motor_maximum_temperature*
0x280A/9	F32	°C	DS2100_tlmstt	*thermal_limit_motor_start_temperature*
0x280A/10	F32	°C	DS2100_tlmspn	*thermal_limit_motor_span_temperature*

Table 5.10 List of motor (thermal) parameters

5.4.7 Motor Rating Parameters

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

Index	***Type***	***Units***	***Motor Database Name***	***Name***
0x6410/6	F32	A	Imax	*motor_max_current_*
0x6410/8	F32	rad/s	Nmax	*motor_max_velocity*
0x6410/12	F32	Arms	In	*motor_max_continuous_rms_current*
0x6076/0	U32	mNm	Mn	*motor_rated_torque*

Table 5.11 List of motor (ratings) parameters

5.4.8 Motor Configuration Parameters

Parameter Name	CANopen Index	CANopen sub-index	PDO mapping	Data Type	Access	Default Value	Minimum Value	Maximum Value	Units	Storage Type	Data Group	Field Number
NAME												
motor_name	0x6410	1	no	str	r/w	?	-	-	None	C	A	?
ELECTRICAL												
motor_poles	0x6410	2	no	U16	r/w	12	2	36	None	C	A	1072
motor_Rtt	0x6410	3	no	F32	r/w	2.4	1.0e-9	-	Ohms	C	A	1073
motor_Lq	0x6410	4	no	F32	r/w	5.180e-3	1.0e-9	-	H	C	A	1075
motor_Ld	0x6410	5	no	F32	r/w	4.920e-3	1.0e-9	-	H	C	A	1076
motor_Ke	0x6410	5	no	F32	r/w	1.16	1.0e-9	-	V/rad/s	C	A	1077
CURRENT LOOP												
current_loop_d-axis_i-gain	0x60F6	1	no	F32	r/w	6.35404981	0	-	V/A/Tsamp	C	A	1272
current_loop_d-axis_p-gain	0x60F6	2	no	F32	r/w	32.02666839	0	-	V/A	C	A	1274
current_loop_q-axis_i-gain	0x60F6	3	no	F32	r/w	6.35404981	0	-	V/A/Tsamp	C	A	1277
current_loop_q-axis_p-gain	0x60F6	4	no	F32	r/w	32.02666839	0	-	V/A	C	A	1279
current_loop_foldback_minimum	0x60F6	5	no	F32	r/w	0.4	0.1	1	None	C	A	1284
current_loop_foldback_breakpoint	0x60F6	6	no	F32	r/w	140.0	0	-	A	C	A	1285
current_loop_alpha_observer_i-gain	0x60F6	9	no	F32	r/w	0.01394492	0	-	V/A/Tsamp	C	A	1288
current_loop_alpha_observer_p-gain	0x60F6	10	no	F32	r/w	0.19933257	0	-	V/A	C	A	1290
current_loop_beta_observer_i-gain	0x60F6	11	no	F32	r/w	0.01394492	0	-	V/A/Tsamp	C	A	1293
current_loop_beta_observer_p-gain	0x60F6	12	no	F32	r/w	0.19933257	0	-	V/A	C	A	1295
FEEDBACK AND COMMUTATION												
resolver_reference_amplitude	0x2200	4	no	U16	r/w	30000	10000	65535	Vrms/3861.7	C	A	1042
commutation_feedback	0x2171	1	no	U08	r/w	1	-	2	none	C	A	1035
commutation_offset	0x2171	2	no	S16	r/w	5461	-	-	none	C	A	1036
resolver_poles	0x2171	3	no	U16	r/w	2	2	12	none	C	A	1037
encoder_supply	0x2e20	1	no	U08	r/w	5	5	12	none	C	A	1704
encoder_type	0x2e20	2	no	U08	r/w	0	-	5	none	C	A	1705
encoder_number_of_increments	0x2e20	3	no	U32	r/w	1024	1	-	none	C	A	1706

encoder_ssi_number_bits	0x2e20	6	no	U08	r/w	13	2	32	none	C	A	1709
encoder_ssi_coding	0x2e20	7	no	U08	r/w	0	-	1	none	C	A	1710
encoder_ssi_data_bit_mask	0x2e20	8	no	U32	r/w	0xfffffffc	-	-	none	C	A	1711
BUS												
bus_over_voltage_limit	0x24a0	5	no	F32	r/w	800	0	1000	V	C	A	1233
regen_off_voltage	0x24a4	1	no	F32	r/w	760	0	1000	V	C	A	1248
regen_on_voltage	0x24a4	2	no	F32	r/w	780	0	1000	V	C	A	1249
THERMAL												
motor_ntc_coefficient_a0	0x2805	1	no	F32	r/w	9.74168	-	-	none	C	A	1385
motor_ntc_coefficient_a1	0x2805	2	no	F32	r/w	0.409214	-	-	none	C	A	1386
motor_ntc_coefficient_a2	0x2805	3	no	F32	r/w	-6.43817E-4	-	-	none	C	A	1387
motor_ntc_coefficient_a3	0x2805	4	no	F32	r/w	5.33088E-7	-	-	none	C	A	1388
motor_ntc_min_temperature	0x2805	5	no	F32	r/w	20.0	-	-	°C	C	A	1389
motor_ntc_max_temperature	0x2805	6	no	F32	r/w	180.0	-	-	°C	C	A	1390
current_limit_mask	0x6510	7	no	U16	r/w	0x27	-	-	none	C	A	1135
motor_maximum_temperature	0x280A	8	no	F32	r/w	155	-	-	°C	C	A	1404
motor_thermal_foldback_start	0x280A	9	no	F32	r/w	145	-	-	°C	C	A	1405
motor_thermal_foldback_span	0x280A	10	no	F32	r/w	10	-	-	°C	C	A	1406
RATING												
motor_max_current_	0x6410	6	no	F32	r/w	24	0.1	-	A	C	A	1078
motor_max_velocity	0x6410	8	no	F32	r/w	10000	0	20000	rad/s	C	A	1082
motor_max_continuous_rms_current	0x6410	12	no	F32	r/w	1000	0.1	-	Arms	C	A	1087
motor_rated_torque	0x6076	0	no	U32	r/w	1	1	-	mNm	C	A	4226

Table 5.12 Motor Configuration Parameter Access Details

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.

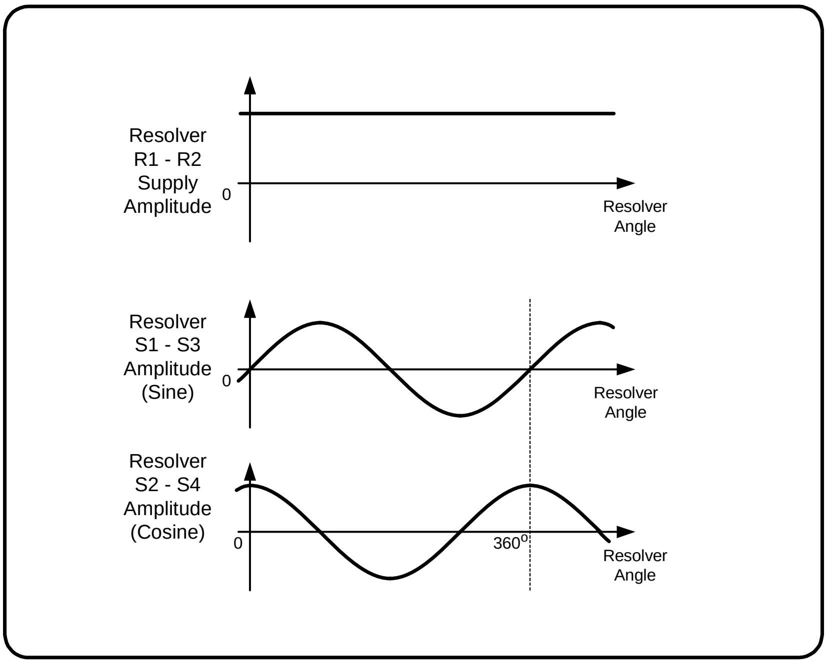


Figure 5.2: Resolver Signal Amplitude

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 4 Volts and the maximum Sine or Cosine voltage is about 2 Volts. The frequency is 5 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* (index 0x2171, subindex 3) has to be set to the number of resolver poles (pole pairs multiplied by 2). Refer to the motor manufacturers 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 DS2100. 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* (index 0x2171, subindex 5) correctly may result in a resolver fault being detected.

5.5.1.3 Resolver reference amplitude

The parameter *resolver_amplitude* (index 0x2200, subindex 4) is the resolver reference amplitude determined from the resolver transformer turns ratio.

5.5.1.4 Resolver commutation position

The parameter *resolver_position_(raw)* (index 0x6510, subindex 4) 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)* (index 0x2421, subindex 18) 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.

5.5.2 Resolver Parameters

Parameter Name	CANopen Index	CANopen sub-index	PDO mapping	Data Type	Access	Default Value	Minimum Value	Maximum Value	Units	Storage Type	Data Group	Field Number
RESOLVER												
resolver_poles	0x2171	3	no	u16	r/w	2	2	-	none	C	A	1037
resolver_transformer_ratio	0x2171	5	no	u16	r/w	0.5	0.22	1.34	none	C	A	1024
resolver_amplitude	0x2200	4	no	u16	r/w	-	10000	65535	none	N	A	1042
resolver_position_(raw)	0x6510	4	yes	s16	r	-	-	-	none	N	A	1057
resolver_position_(multi-turn)	0x2421	18	yes	S32	r	-	-	-	none	N	A	1161

Table 5.13 Resolver Parameter Access Detail

5.6 Encoder Input

The encoder input allows the connection of various 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.

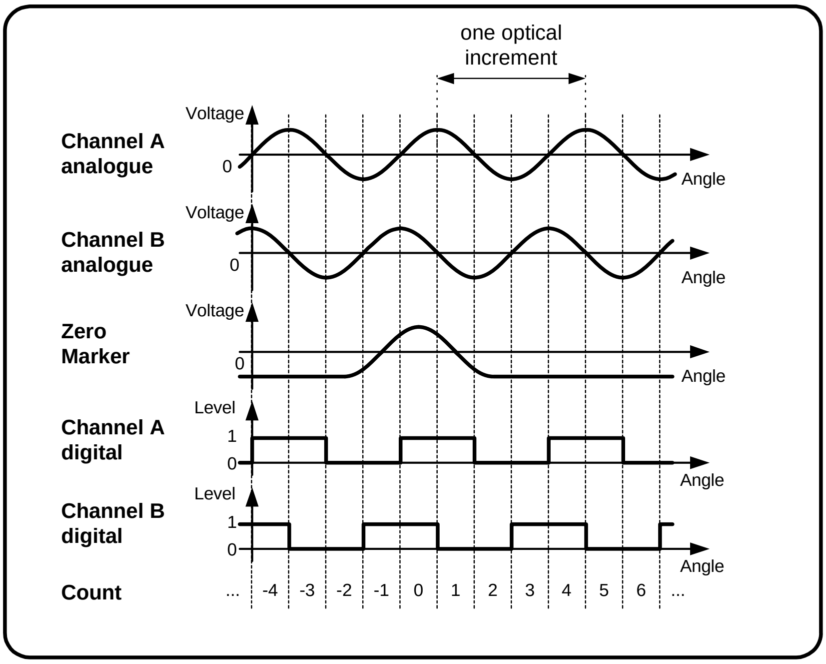


Figure 5.3: encoder signals

The picture shows typical analogue encoder signals and the digital signals derived from the analogue signals. The direction of rotation shown is positive, so that channel B leads channel A. By counting every digital signal transistion, 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* (index 0x2e20, subindex 1). It has to be set first to ensure proper operation. The following values are valid for *encoder_supply*:

5	-	+5 Volts supply voltage
8	-	+8 Volts supply voltage
12	-	+12 Volts 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* (index 0x2e20, subindex 2). It can have the following values:

0	-	no encoder connected
1	-	Digital incremental encoder
2	-	Analogue incremental encoder with two analogue sinusoidal quadrature output signals with 1 Vpp amplitude
3	-	SSI interface absolute singleturn or multiturn encoder
4	-	Stegmann Hiperface interface absolute encoder
5	-	Heidenhain EnDat 2.1 interface absolute encoders

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

5.6.1.3 Number of increments

For normal digital, analogue or SSI interface encoders (*encoder_type* 1..3) the parameter *encoder_number_of_increments* (index 0x2e20, subindex 3) 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, ...). 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* (index 0x2e20, subindex 10) 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* (index 0x2e20, subindex 5). 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 about 12. Values above that can be used to change the scaling of the encoder position value but 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.

5.6.1.6 Encoder Offset

To compensate for a mechanical misalignment between the encoder and the desired encoder position, the parameter *encoder_offset* (index 0x2e20, subindex 9) can be used. Setting it to the value of *encoder_position* at a certain position will zero the encoder position output value *encoder_position*.

5.6.1.7 Direction of rotation

The direction of rotation can be reversed with the parameter *encoder_direction_of_rotation* (index 0x2e20, subindex 4). Normally positive direction is clockwise rotation when looking onto the encoder shaft. In this case is channel B leading the channel A 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* (index 0x2e20, subindex 6). 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* (index 0x2e20, subindex 7). 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. To accommodate this, the parameter *encoder_ssi_data_bit_mask* (index 0x2e20, subindex 8) has to be set to mask off all the unused 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* (index 0x2e20, subindex 11) 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 Encoder EEPROM Enable

Encoders with a Hiperface or EnDat digital interface provide onboard EEPROM for parameter storage. This can be used by the DS2100 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. This parameter is set to 0 by default.

The parameters stored in the encoder EEPROM are:

encoder supply
encoder offset
commutation feedback source
commutation offset
motor number of poles
motor Rtt
motor Lq
motor Ld
motor Ke
motor maximum current
motor maximum velocity
motor velocity limit
current limit mask
bus over-voltage limit
regen off voltage
regen on voltage
current loop d-axis i-gain
current loop d-axis p-gain
current loop q-axis i-gain
current loop q-axis p-gain
current loop alpha observer i-gain
current loop alpha observer p-gain
current loop beta observer i-gain
current loop beta observer p-gain
motor sensor coefficient a0
motor sensor coefficient a1
motor sensor coefficient a2
motor sensor coefficient a3
motor sensor minimum temperature
motor sensor maximum temperature
motor max temperature
thermal limit motor start temperature
thermal limit motor span temperature

5.6.2 Encoder Parameters

Parameter Name	CANopen Index	CANopen sub-index	PDO mapping	Data Type	Access	Default Value	Minimum Value	Maximum Value	Units	Storage Type	Data Group	Field Number
ENCODER CONFIGURATION												
encoder_supply	0x2e20	1	no	u08	r/w	5	5	12	V	C	A	1704
encoder_type	0x2e20	2	no	u08	r/w	0	-	5	none	C	A	1705
encoder_number_of_increments	0x2e20	3	no	u32	r/w	1024	1	-	none	C	A	1706
encoder_direction_of_rotation	0x2e20	4	no	u08	r/w	0	-	1	none	C	A	1707
encoder_resolution	0x2e20	5	no	u08	r/w	10	2	31	none	C	A	1708
encoder_ssi_number_bits	0x2e20	6	no	u08	r/w	13	2	32	none	C	A	1709
encoder_ssi_coding	0x2e20	7	no	u08	r/w	0	-	1	none	C	A	1710
encoder_ssi_data_bit_mask	0x2e20	8	no	u32	r/w	0xfffffffc	-	-	none	C	A	1711
encoder_offset	0x2e20	9	yes	s32	r/w	0	-	-	none	C	A	1712
encoder_position	0x2e20	10	yes	s32	r	-	-	-	none	N	A	1713
encoder_commutation_position	0x2e20	11	yes	s16	r	-	-	-	none	N	A	1714
encoder_set_position	0x2e20	15	no	s32	r/w	-	-	-	none	N	A	1718
encoder_eeprom_enable	0x2e20	14	no	u08	r/w	0	-	-	none	C	A	1717

Table 5.14 Encoder Parameter Access Detail

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

The selection of the rotor position feedback is done through parameter *commutation_feedback* (index 0x2171, subindex 1). 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 insure 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 'Encoder Module' for further information.

5.7.1.5 Commutation offset

In all commutation types the parameter *commutation_offset* (index 0x2171, subindex 2) 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. The following steps have to be followed:

1. Make sure the rotor can turn freely.
2. Initialise correct motor parameters.
3. Set *commutation_feedback* (resolver or encoder).
4. Set the drive to torque mode. (set parameter *control_loop_mode_requested* (index 0x2581, sub-index 2) to 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.

5.7.3 Commutation Parameters

Parameter Name	CANopen Index	CANopen sub-index	PDO mapping	Data Type	Access	Default Value	Minimum Value	Maximum Value	Units	Storage Type	Data Group	Field Number
COMMUTATION												
commutation_feedback	0x2171	1	yes	u08	r/w	1	-	2	none	C	A	1035
commutation_offset	0x2171	2	yes	s16	r./w	5461	-	-	none	C	A	1036
commutation_offset_adjustment	0x2171	4	no	u08	r/w	0	1	1	none	N	A	1038
COMMUTATION RELATED												
control_loop_mode_requested	0x2581	2	No	S32	r/w	-	-	-	None	N	A	1330
motor_poles	0x6410	1	no	u16	r/w	12	2	-	none	C	A	1072
resolver_position	0x2210	1	yes	s16	r	-	-	-	none	N	A	1057
encoder_commutation_position	0x2e20	11	yes	s16	r	-	-	-	none	N	A	1714

Table 5.15 Commutation Parameter Access Detail

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* (index 0x6510, subindex 16). It can have the following values:

1 - position feedback from resolver
2 - position feedback from encoder

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

5.8.2 Position feedback parameters

position_feedback

CANopen index	0x6510
CANopen subindex	16
PDO mapping	no
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* (index 0x6510, subindex 24). It can have the following values:

1 - velocity feedback from resolver
2 - velocity feedback from encoder

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

5.9.2 Velocity feedback parameters

velocity_feedback

CANopen index	0x6510
CANopen subindex	24
PDO mapping	No
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

5.10 Digital Input and Output Functional Description

5.10.1 Digital Input Functionality

There are 8 digital inputs on the DS2100, numbered I1 to I8 on the DS2100 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 are listed below. Note that the names of the parameters are zero-indexed, but that the numbers on the front-panel start at 1: -

Index	*Type*	*Name*
0x2C2E/1	U08	hardware_enable_configuration
0x2C2E/2	U08	hardware_enable_debounce_count
0x2C2E/3	U08	hardware_enable_invert
0x2C2E/25	U08	hardware_enable_control
0x2C2E/4	U08	digital_input_1_configuration
0x2C2E/5	U08	digital_input_1_debounce_count
0x2C2E/6	U08	digital_input_1_invert
0x2C2E/26	U08	digital_input_1_control
0x2C2E/7	U08	digital_input_2_configuration
0x2C2E/8	U08	digital_input_2_debounce_count
0x2C2E/9	U08	digital_input_2_invert
0x2C2E/27	U08	digital_input_2_control
0x2C2E/10	U08	digital_input_3_configuration
0x2C2E/11	U08	digital_input_3_debounce_count
0x2C2E/12	U08	digital_input_3_invert
0x2C2E/28	U08	digital_input_3_control
0x2C2E/13	U08	digital_input_4_configuration
0x2C2E/14	U08	digital_input_4_debounce_count
0x2C2E/15	U08	digital_input_4_invert
0x2C2E/29	U08	digital_input_4_control
0x2C2E/16	U08	digital_input_5_configuration
0x2C2E/17	U08	digital_input_5_debounce_count
0x2C2E/18	U08	digital_input_5_invert
0x2C2E/30	U08	digital_input_5_control
0x2C2E/19	U08	digital_input_6_configuration
0x2C2E/20	U08	digital_input_6_debounce_count
0x2C2E/21	U08	digital_input_6_invert
0x2C2E/31	U08	digital_input_6_control
0x2C2E/22	U08	digital_input_7_configuration
0x2C2E/23	U08	digital_input_7_debounce_count
0x2C2E/24	U08	digital_input_7_invert
0x2C2E/32	U08	digital_input_7_control
0x2C2D/1	U08	digital_input_status_word

Table 5.16 List of Digital Input Parameters

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).

NOTE :- 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. The handler function is not called

Handler	*Handler Function*	*Input Set*	*Input Cleared*
0	NULL	-	-
3	Brake Release Switch	Release Brake	Enable Brake
6	Positive Limit Switch	Inactive	Active
7	Negative Limit Switch	Inactive	Active
8	Homing Switch	Active	Inactive
9	Quickstop	Quickstop	-
10	Automatic Manual Mode	Auto. Mode	Manual Mode
11	Controlled Disable	Disable	-
17	CAN Enable/Disable	Disable	Enable
18	CAN Re-enable	Enable	-
19	Re-boot	Re-boot	-

Table 5.17 List of Digital Input Handler Functions

5.10.1.1.1 Brake Release Switch

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 (0x6510/21) configures the brake control in normal operation
brake_fault_control (0x6510/18) 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 .

5.10.1.1.2 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 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* (0x6510/2). If set to 0 then the drive will disable, if set to 1 then 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* (0x6510/8). The drive will then disable a programmable time after the brake is applied set by *brake_lock_to_disable_timeout* (0x6510/1).
If the velocity does not decrease below *standby_velocity* within a programmable time set by *velocity_rampdown_time_limit* (0x6510/9), 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.

5.10.1.1.3 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* (0x6510/2). If set to 0 then the drive will disable, if set to 1 then 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* (0x6510/8). The drive will then disable a programmable time after the brake is applied set by *brake_lock_to_disable_timeout* (0x6510/1).
If the velocity does not decrease below *standby_velocity* within a programmable time set by *velocity_rampdown_time_limit* (0x6510/9), 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.

5.10.1.1.4 Homing Switch

This handler function is used to configure the input as a homing switch. The homing switch is used 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.

5.10.1.1.5 Quickstop

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* (0x6510/2). If set to 1 then the drive will disable, if set to 0 then 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* (0x6510/8). The drive will then disable a programmable time after the brake is applied set by *brake_lock_to_disable_timeout* (0x6510/1).
If the velocity does not decrease below *standby_velocity* within a programmable time *velocity_rampdown_time_limit* (0x6510/10) 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.

> **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 DS2100 software, so that inadvertently limits are not swapped or used incorrectly in either MANUAL or AUTOMATIC states.

5.10.1.1.6 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* (0x6510 /6) in %. This parameter sets the maximum available torque to a percentage of *current_maximum_physical* (0x2410 /33) and the maximum velocity to a percentage of *velocity_maximum* (0x6510 /28).

5.10.1.1.7 Controlled Disable

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

5.10.1.1.8 CAN Enable/Disable

This function enables the CAN bus handling if the input is false and disables the CAN bus if the input is true. When the CAN bus is switched from the disabled to the enabled state there is a full initialisation of the CAN protocol.

5.10.1.1.9 CAN Re-Enable

This function will enable the CAN bus handling if the input is true. When the CAN bus is switched from the disabled to the enabled state there is a full initialisation of the CAN protocol.

5.10.1.1.10 Re-Boot

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

5.10.1.2 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.

5.10.1.3 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.

5.10.1.4 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 DS2100, numbered O1 to O3 on the DS2100 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: -

Index	***Type***	***Name***
0x2C2C/1	U16	digital_output_1_field_number
0x2C2C/2	U32	digital_output_1_mask
0x2C2C/3	U08	digital_output_1_invert
0x2C2C/4	U16	digital_output_2_field_number
0x2C2C/5	U32	digital_output_2_mask
0x2C2C/6	U08	digital_output_2_invert
0x2C2C/7	U16	digital_output_3_field_number
0x2C2C/8	U32	digital_output_3_mask
0x2C2C/9	U08	digital_output_3_invert

Table 5.18 List of Digital Output Parameters

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 ouptut 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

Parameter Name	CANopen Index	CANopen sub-index	PDO mapping	Data Type	Access	Default Value	Minimum Value	Maximum Value	Units	Storage Type	Data Group	Field Number
DIGITAL INPUT												
hardware_enable_configuration	0x2C2E	1	no	u08	r/w	0	-	-	none	C	A	1545
hardware_enable_debounce_count	0x2C2E	2	no	u08	r/w	1	-	254	none	C	A	1546
hardware_enable_invert	0x2C2E	3	no	u08	r/w	0	-	1	none	C	A	1660
hardware_enable_control	0x2C2E	25	no	u08	r/w	0	-	-	none	C	A	1672
digital_input_1_configuration	0x2C2E	4	no	u08	r/w	0	-	-	none	C	A	1547
digital_input_1_debounce_count	0x2C2E	5	no	u08	r/w	1	-	254	none	C	A	1548
digital_input_1_invert	0x2C2E	6	no	u08	r/w	0	0	1	none	C	A	1661
digital_input_1_control	0x2C2E	26	no	u08	r/w	0	-	-	none	C	A	1673
digital_input_2_configuration	0x2C2E	7	no	u08	r/w	0	-	254	none	C	A	1549
digital_input_2_debounce_count	0x2C2E	8	no	u08	r/w	1	-	-	none	C	A	1550
digital_input_2_invert	0x2C2E	9	no	u08	r/w	0	0	1	none	C	A	1662
digital_input_2_control	0x2C2E	27	no	u08	r/w	0	-	-	none	C	A	1674
digital_input_3_configuration	0x2C2E	10	no	u08	r/w	0	-	-	none	C	A	1551
digital_input_3_debounce_count	0x2C2E	11	no	u08	r/w	1	-	254	none	C	A	1552
digital_input_3_invert	0x2C2E	12	no	u08	r/w	0	0	1	none	C	A	1663
digital_input_3_control	0x2C2E	28	no	u08	r/w	0	-	-	none	C	A	1675
digital_input_4_configuration	0x2C2E	13	no	u08	r/w	0	-	-	none	C	A	1553
digital_input_4_debounce_count	0x2C2E	14	no	u08	r/w	1	-	254	none	C	A	1554
digital_input_4_invert	0x2C2E	15	no	u08	r/w	0	0	1	none	C	A	1664
digital_input_4_control	0x2C2E	29	no	u08	r/w	0	-	-	none	C	A	1676
digital_input_5_configuration	0x2C2E	16	no	u08	r/w	0	-	-	none	C	A	1555
digital_input_5_debounce_count	0x2C2E	17	no	u08	r/w	1	-	254	none	C	A	1556
digital_input_5_invert	0x2C2E	18	no	u08	r/w	0	0	1	none	C	A	1665
digital_input_5_control	0x2C2E	30	no	u08	r/w	0	-	-	none	C	A	1677
digital_input_6_configuration	0x2C2E	19	no	u08	r/w	0	-	-	none	C	A	1557
digital_input_6_debounce_count	0x2C2E	20	no	u08	r/w	1	-	254	none	C	A	1558

digital_input_6_invert	0x2C2E	21	no	u08	r/w	0	0	1	none	C	A	1666
digital_input_6_control	0x2C2E	31	no	u08	r/w	0	-	-	none	C	A	1678
digital_input_7_configuration	0x2C2E	22	no	u08	r/w	0	-	-	none	C	A	1559
digital_input_7_debounce_count	0x2C2E	23	no	u08	r/w	1	-	254	none	C	A	1560
digital_input_7_invert	0x2C2E	24	no	u08	r/w	0	0	1	none	C	A	1667
digital_input_7_control	0x2C2E	32	no	u08	r/w	0	-	-	none	C	A	1679
digital_input_status_word	0x2C2D	1	yes	u08	r	-	-	-	none	N	A	1542
BRAKE RELEASE												
brake_control	0x6510	21	no	u16	r/w	1	-	-	none	C	A	1603
brake_fault_control	0x6510	18	no	u16	r/w	1	-	-	none	C	A	1505
QUICKSTOP												
quickstop_mode	0x6510	2	no	u08	r/w	1	-	-	none	C	A	1013
standby_velocity	0x6510	8	no	f32	r/w	1	0.05	1000	rad/s	C	A	1138
brake_lock_to_disable_timeout	0x6510	1	no	f32	r/w	0.1	0	5	s	C	A	1004
velocity_rampdown_time_limit	0x6510	9	no	f32	r/w	1	0	1000	s	C	A	1143
AUTOMATIC/MANUAL												
manual_mode_limit	0x6510	6	no	f32	r/w	10	0	100	%	C	A	1133
current_maximum_physical	0x2410	33	no	f32	r	-	-	-	A	N	A	1124
motor_max_velocity	0x6410	10	no	f32	r	-	-	-	rad/s	N	A	1085
DIGITAL OUTPUT												
digital_output_1_field_number	0x2C2C	1	no	u16	r/w	1544	-	-	none	C	A	1561
digital_output_1_mask	0x2C2C	2	no	u32	r/w	0x80	-	-	none	C	A	1562
digital_output_1_invert	0x2C2C	3	no	u08	r/w	0	0	1	none	C	A	1563
digital_output_2_field_number	0x2C2C	4	no	u16	r/w	1132	-	-	none	C	A	1564
digital_output_2_mask	0x2C2C	5	no	u32	r/w	0xD	-	-	none	C	A	1565
digital_output_2_invert	0x2C2C	6	no	u08	r/w	0	0	1	none	C	A	1566
digital_output_3_field_number	0x2C2C	7	no	u16	r/w	1542	-	-	none	C	A	1567
digital_output_3_mask	0x2C2C	8	no	u32	r/w	0	-	-	none	C	A	1568
digital_output_3_invert	0x2C2C	9	no	u08	r/w	0	0	1	none	C	A	1569

Table 5.19 Digital I/O Parameter Access Detail

5.11 Control Loops

There are three loops that can be closed by DS2100, 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.

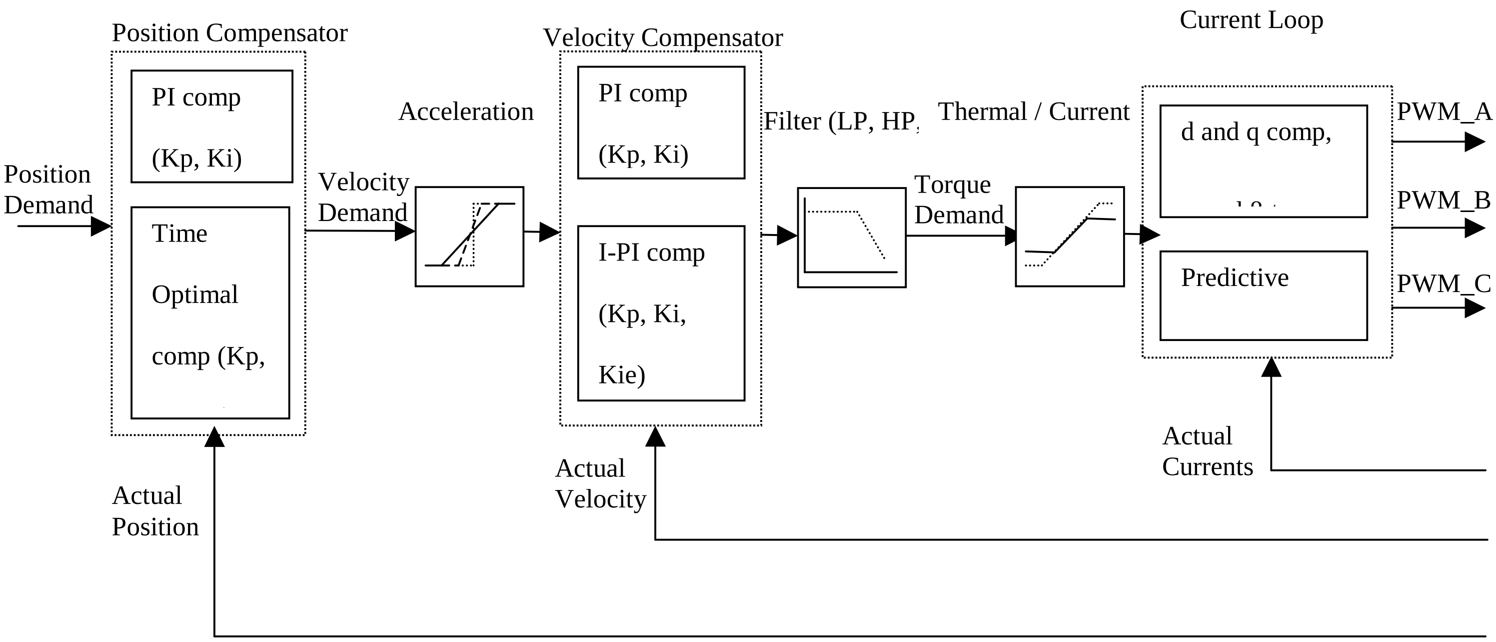


Figure 5.4 : Overall Drive Control Loop Structure

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 loop 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: -

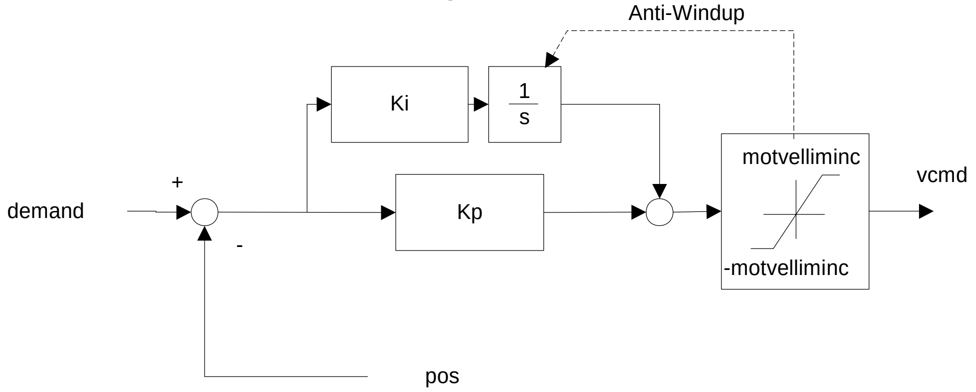


Figure 5.5 : Position Loop PI Compensator Structure

The output of the compensator is limited to *motvelliminc*, a term derived from the motor_max_velocity (0x6410/10) parameter. The compensator also implements anti-windup for the compensator's integrator. The PI compensator has the gains as listed below.

Index	*Name*	*Type*	*Units*
0x60FB/2	position_PI_loop_p-gain	f32	1/s
0x60FB/3	position_PI_ loop_i-gain	f32	$1/s^2$

Table 5.20 List of Position Loop PI Compensator Gains

Index	*Name*	*Type*	*Units*
0x60FB/4	position_PI_loop_error	f32	increments
0x6510/3	internal_loop_demand	f32	increments.
0x6510/13	velocity_command_acceleration_limited	f32	incs/Tsamp

Table 5.21 Position Loop PI Compensator Read-only Parameters

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 (0x280A 1) 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.

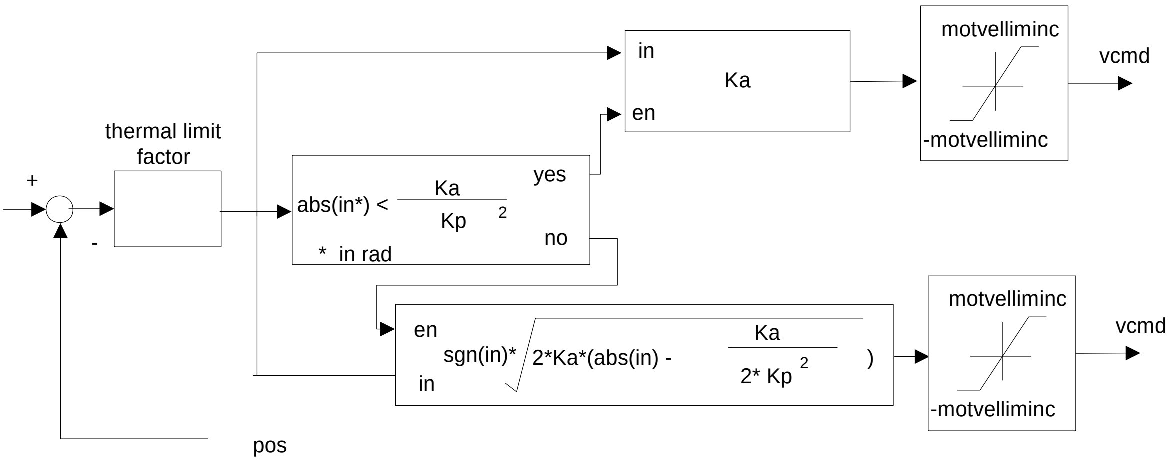


Figure 5.6 : Position Loop Time Optimal Compensator Structure

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

Index	*Name*	*Type*	*Units*
0x60FB/6	position_TO_loop_a-gain	f32	rad/s^2
0x60FB/7	position_TO_loop_p-gain	f32	1/s
0x60FB/8	position_TO_loop_enable_velocity_i-term	f32	rad

Table 5.22 List of Position Loop Time Optimal Compensator Gains

Index	*Name*	*Type*	*Units*
0x60FB/5	position_TO_loop_error	f32	increments
0x6510/3	internal_loop_demand	f32	increments.
0x6510/13	velocity_command_acceleration_limited	f32	incs/Tsamp

Table 5.23 Position Loop TO Compensator Read-only Parameters

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 below, 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.: -

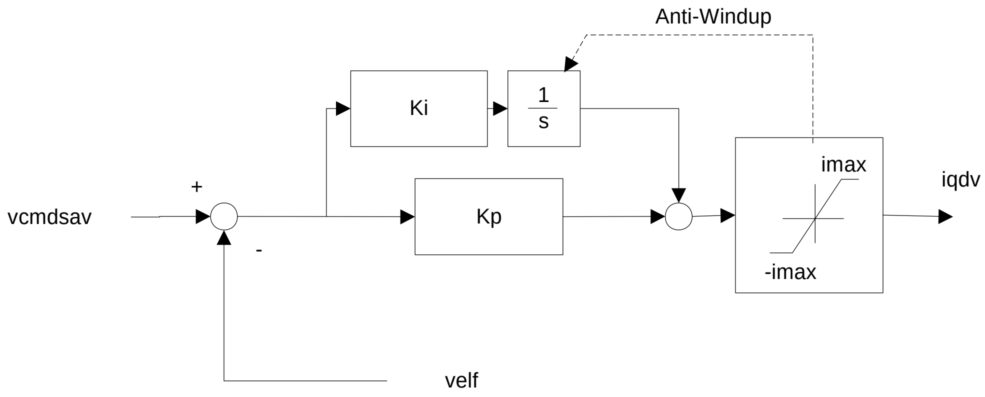


Figure 5.7 : Velocity Loop (When in position mode) Compensator Structure

The output of this compensator is limited to ± *current_max* (0x60F7/3), since it is used subsequently as a demand for the current loop. The compensator has parameters are listed below:

Index	*Name*	*Type*	*Units*
0x60F9/2	position_mode_velocity_loop_p-gain	f32	Nm/rad/s
0x60F9/3	position_mode_velocity_loop_i-gain	f32	Nm/rad

Table 5.24 List of Position Loop's Velocity Loop Compensator Gains

Index	*Name*	*Type*	*Units*
0x60F9/4	position_mode_velocity_loop_error	f32	incs/Tsamp
0x6510/15	velocity_filtered	f32	incs/Tsamp
0x60F7/10	current_demand_velocity_comp_output	f32	Amps.
0x60F7/3	current_max	f32	Amps

Table 5.25 List of Position Loop's Velocity Loop Read-only Parameters

5.11.1.4 Position Loop Tuning

TBA

5.11.2 Velocity Loop compensator

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

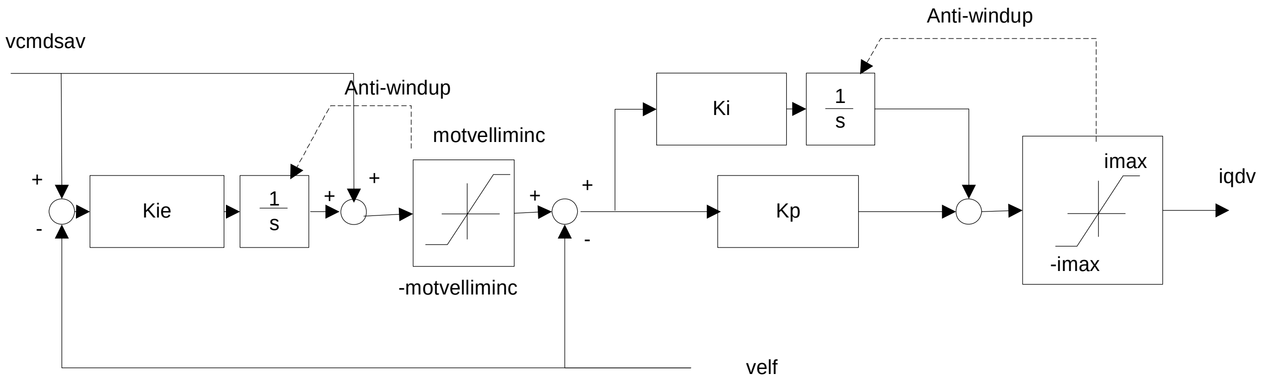


Figure 5.8 : Velocity Loop (When in velocity mode) Compensator Structure

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

Index	***Name***	***Type***	***Units***
0x60F9/5	velocity_mode_p-gain	f32	Nm/rad/s
0x60F9/6	velocity_mode _i-gain	f32	Nm/rad
0x60F9/7	velocity_mode _ie-gain	f32	none

Table 5.26 List of Velocity Loop Compensator Gains

Index	***Name***	***Type***	***Units***
0x60F9/8	velocity_mode _error	f32	incs/Tsamp
0x6510/15	velocity_filtered	f32	incs/Tsamp
0x60F7/10	current_demand_velocity_comp_output	f32	Amps.

Table 5.27 List of Velocity Loop Read-only Parameters

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 (~100us) using the parameter *velocity_loop_rate_divider* (0x60F9/1).

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 (0x6510/18), 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 (0x6510/23), 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 (0x6510/26), and has units of rad/s^2.
The quickstop mode deceleration limiting parameter is deceleration_limit_-_quickstop (0x6510/25), 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* (0x6510/12). The output of the acceleration-limiting block is *velocity_command_acceleration_limited* (0x6510/13). 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 (0x6510/10), and velocity_filtered (0x6510/15) 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* (0x6510/28) sets the maximum value for the velocity command. This value is stored in NVM.

2. The parameter *velocity_limit* (0x6510/30) 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 diagram below show the implementation: -

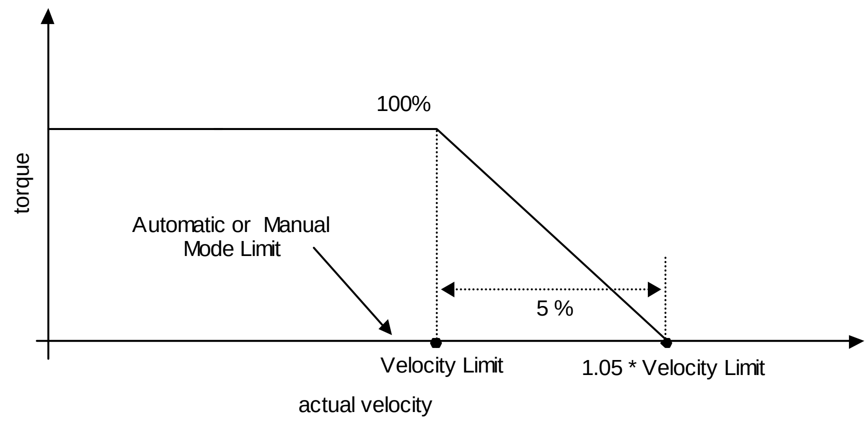


Figure 5.9 : Velocity limiting when in Torque Mode

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*. The output of the generic filter is *current_demand_generic_filter_output* (0x60F7/11). 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)

NOTE: The default filter operating period is *velocity_loop_rate_divider / switching_frequency* = 4/9920 = (approx 400 µs).

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: -

Index	***Name***	***Type***
0x25C1/ 1	velocity_loop_filter_coefficient_a1	F32
0x25C1/ 2	velocity_loop_filter_coefficient_a2	F32
0x25C1/ 3	velocity_loop_filter_coefficient_a3	F32
0x25C1/ 4	velocity_loop_filter_coefficient_a4	F32
0x25C1/ 5	velocity_loop_filter_coefficient_b0	F32
0x25C1/ 6	velocity_loop_filter_coefficient_b1	F32
0x25C1/ 7	velocity_loop_filter_coefficient_b2	F32
0x25C1/ 8	velocity_loop_filter_coefficient_b3	F32
0x25C1/ 9	velocity_loop_filter_coefficient_b4	F32
0x25C1/ 10	velocity_loop_mode	F32

Table 5.28 List of Filter Parameters

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.

5.11.2.4.1 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, will implement this filter, in the drive. Note that parameter a0 is always 1.0.

5.11.2.4.2 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.

5.11.2.5 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* (0x6510/10), with the low-pass filtered velocity held in a parameter called *velocity_filtered* (0x6510/15). 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 (0x6510/14). 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*π* *velocity_filter_cutoff_factor*);
b_0 = 2*π**velocity_filter_cutoff_factor* / (1 + 2*π* *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.

5.11.2.6 Velocity LoopTuning

TBA

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.

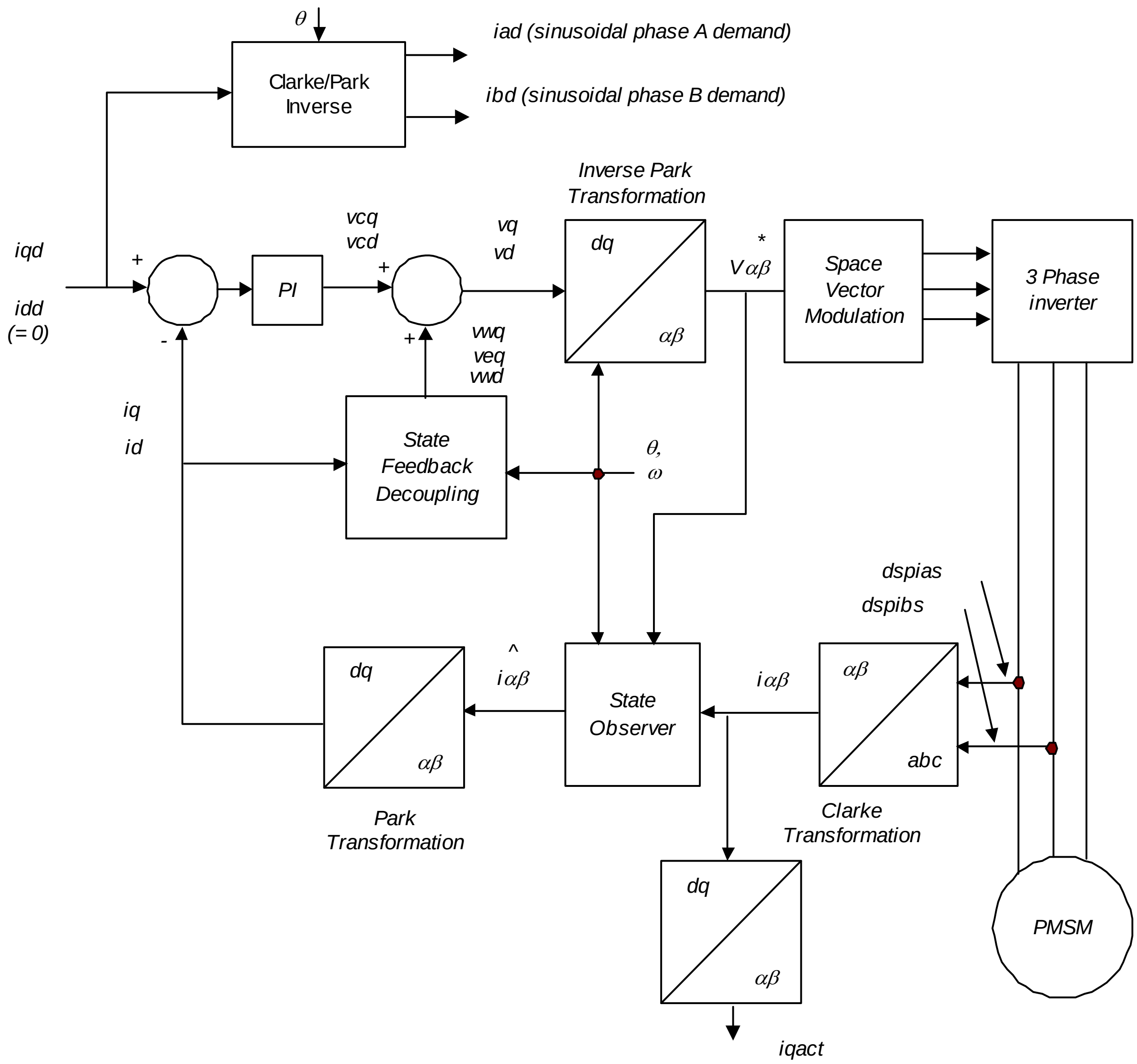


Figure 5.10 : General Current Loop Structure

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.

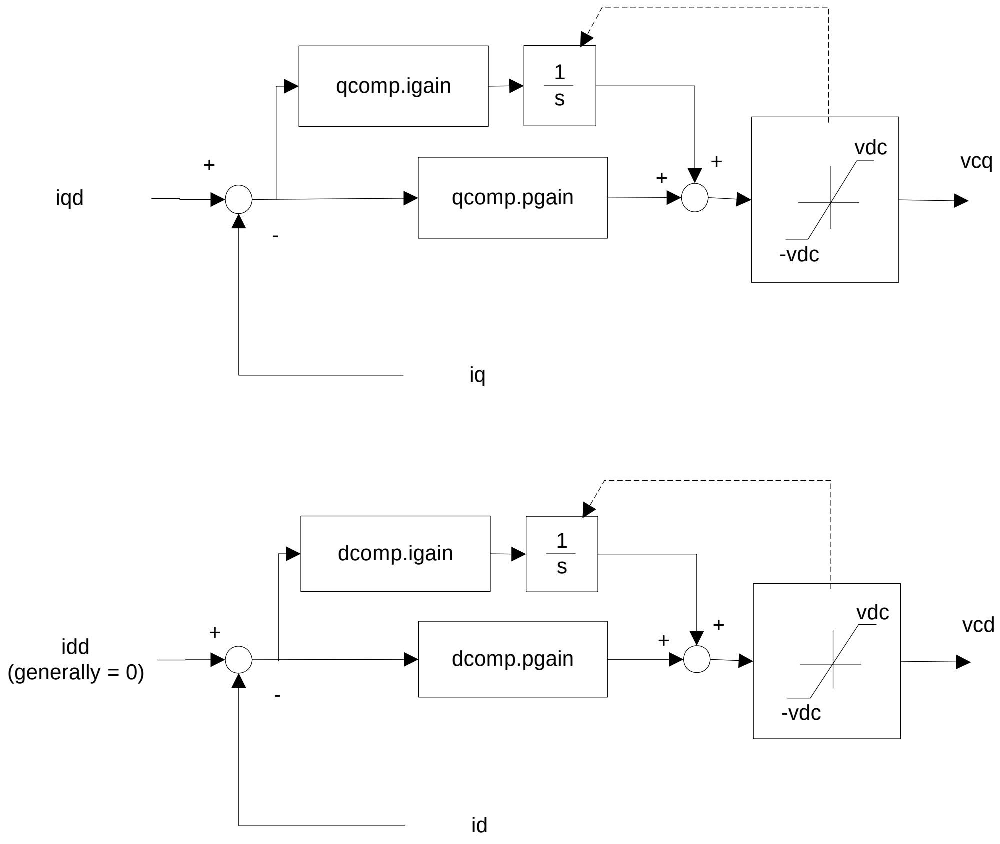


Figure 5.11 : d,q current compensator

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.

Index	*Name*	*Type*	*Units*	*Comment*
0x60F6/1	current_loop_d-axis_i-gain	f32	Volts/Amp/Tsamp	dcomp.igain
0x60F6/2	current_loop_d-axis_p-gain	f32	Volts/Amp	dcomp.pgain
0x60F6/3	current_loop_q-axis_i-gain	f32	Volts/Amp/Tsamp	qcomp.igain
0x60F6/4	current_loop_q-axis_p-gain	f32	Volts/Amp	qcomp.pgain
0x60F6/9	current_loop_alpha_observer_i-gain	f32	Volts/Amp/Tsamp	oacomp.igain
0x60F6/10	current_loop_alpha_observer_p-gain	f32	Volts/Amp	oacomp.pgain
0x60F6/11	current_loop_beta_observer_i-gain	f32	Volts/Amp/Tsamp	obcomp.igain
0x60F6/12	current_loop_beta_observer_p-gain	f32	Volts/Amp	obcomp.pgain
0x60F6/5	current_loop_foldback_minimum	f32	none	calkmin

0x60F6/6	current_loop_foldback_breakpoint	f32	Amp	calimin

Table 5.29 List of Current Loop Compensator Gains

The table below lists parameter or signals that can be monitored by the GUI, and can be useful during loop tuning.

Index	*Name*	*Type*	*Units*	*Comment*
0x60F7/4	current_d-axis_observer	f32	Amps	id
0x60F7/5	current_q-axis_observer	f32	Amps	iq
0x60F7/6	current_d-axis_demand	f32	Amps	idd
0x60F7/7	current_q-axis_demand	f32	Amps	iqd
0x2410/13	current_phase_A_demand	s16	Amps	iad
0x2410/14	current_phase_B_demand	s16	Amps	ibd
0x2210/ 14	current_phase_A_feedback	s16	see note 1	dspias
0x2210/ 15	current_phase_B_feedback	s16	see note 1	dspibs
0x60F6/6	current_loop_q-axis_error	f32	Amps	qcomp.error
0x60F6/7	current_loop_d-axis_error	f32	Amps	dcomp.error
0x60F6/13	current_loop_alpha_observer_error	f32	Amps	oacomp.error
0x60F6/14	current_loop_beta_observer_error	f32	Amps	obcomp.error
0x60F7/9	current_actual	f32	Amps	iqact

Table 5.30 List of Current Loop Signal Parameters

WARNING - **DANGER OF UNCONTROLLED MOTOR ACCELERATION**

The DS2100 has specialised motor current compensation. For optimum performance the DS2100 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 (~100us) using the parameter *motor_velocity_loop_rate_divider* (0x60F6/15).

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* (0x60F6/16), with the low-pass filtered velocity held in a parameter called *motor_velocity_filtered* (0x60F6/18). It is this filtered velocity variable that is used to limit the motor velocity.

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* (0x60F6/17). 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

$a_1 = 1 / (1 + 2*\pi*$ *motor_velocity_filter_cutoff_factor*);
$b_0 = 2*\pi*$*motor_velocity_filter_cutoff_factor* / $(1 + 2*\pi*$ *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* (0x6410/8) 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.

5.11.3.5 Field Weakening

The field weakening function extends the torque-speed performance of the drive/motor combination. There are two parameters available to configure the field weakening performance, but in general these parameters can be left at their default values.
current_scaling_factor_field_weakening (0x2410/24) is the fraction of the maximum current used in the field weakening algorithm.
field_weakening_vmax_scaling_factor (0x2450/3) is the fraction of the maximum bus voltage used in the field weakening algorithm to allow for bus voltage variation due to dead-time compensation, on-state voltage drop, acceleration effects, etc.

WARNING - DANGER OF REDUCED DRIVE MONITORING FUNCTIONALITY AND/OR INTERMITTENT SOFTWARE WATCHDOG TIMEOUT

The DS2100 cannot be guaranteed to run with field weakening enabled when the profile generator is also enabled and by extension the drive cannot be operated in the DS402 profile position mode while field weakening is enabled.
If field weakening is enabled then the parameter *profile_generator_bypass_ switch (0x2E40/0)* must be set to 0 (default value is 1) and profile position mode not used.

5.11.3.6 Current Loop Tuning

TBA

5.11.4 Control Loop Configuration

The control loops are configured by setting/unsetting bits in an internal mode request 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.

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	1
14	0
13	0
12	0
11	0
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	0
1	velocity mode
0 (LSB)	torque mode

Table 5.31 mode request bit definitions

5.11.4.1 Torque Mode Preset

The parameter control_loop_torque_mode_preset (0x2581 /6) 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 (0x2581 /6) 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 (0x2581 /6) 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 1 must always be set in this parameter, bits 0 and 1 must never be set in position mode.

5.11.5 Control Loop Parameters

Parameter Name	CANopen Index	CANopen sub-index	PDO mapping	Data Type	Access	Default Value	Minimum Value	Maximum Value	Units	Storage Type	Data Group	Field Number
POSITION PI COMPENSATOR												
position_PI_loop_p-gain	0x60FB	2	no	f32	r/w	2.0	0	-	1/s	C	A	1326
position_PI_loop_i-gain	0x60FB	3	no	f32	r/w	0	0	-	$1/s^2$	C	A	1327
position_PI_loop_error	0x60FB	4	yes	f32	r	-	-	-	increments	N	A	1328
internal_loop_demand	0x6510	3	yes	f32	r	-	-	-	increments	N	A	1034
velocity_command_acceleration_limited	0x6510	13	yes	f32	r	-	-	-	incs/Tsamp	N	A	1157
POSITION TO COMPENSATOR												
position_TO_loop_a-gain	0x60FB	6	no	f32	r/w	1000	0	-	rad/s^2	C	A	1340
position_TO_loop_p-gain	0x60FB	7	no	f32	r/w	20	0	-	1/s	C	A	1342
position_TO_loop_enable_velocity_integrator	0x60FB	8	no	f32	r/w	6.28	0	6.28	rad	C	A	1350
position_TO_loop_error	0x60FB	5	yes	f32	r	-	-	-	increments	N	A	1337
internal_loop_demand	0x6510	3	yes	f32	r	-	-	-	increments	N	A	1034
velocity_command_acceleration_limited	0x6510	13	yes	f32	r	-	-	-	incs/Tsamp	N	A	1157
POSITION MODE VELOCITY COMPENSATOR												
position_mode_velocity_loop_p-gain	0x60F9	2	no	f32	r/w	0.05	0	-	Nm/rad/s	C	A	1305
position_mode_velocity_loop_i-gain	0x60F9	3	no	f32	r/w	2.0	0	-	Nm/rad	C	A	1306
position_mode_velocity_loop_error	0x60F9	4	yes	f32	r	-	-	-	incs/Tsamp	N	A	1307
velocity_filtered	0x6510	15	yes	f32	r	-	-	-	incs/Tsamp	N	A	1165
current_demand_velocity_comp_output	0x60F7	10	yes	f32	r	-	-	-	Amps.	N	A	1120
current_max	0x60F7	3	yes	f32	r	-	-	-	Amps	N	A	1093
VELOCITY MODE COMPENSATOR												
velocity_mode_p-gain	0x60F9	5	no	f32	r/w	0.05	0	-	Nm/rad/s	C	A	1317
velocity_mode_i-gain	0x60F9	6	no	f32	r/w	2	0	-	Nm/rad	C	A	1318
velocity_mode_ie-gain	0x60F9	7	no	f32	r/w	0	0	-	none	C	A	1319
velocity_mode_error	0x60F9	8	yes	f32	r	-	-	-	incs/Tsamp	N	A	1320
velocity_filtered	0x6510	15	yes	f32	r	-	-	-	incs/Tsamp	N	A	1165
current_demand_velocity_comp_output	0x60F7	10	yes	f32	r	-	-	-	Amps.	N	A	1120

ACCELERATION LIMITING												
acceleration_limit	0x6510	17	no	f32	r/w	1000000	0	-	rad/s^2	C	A	1335
deceleration_limit	0x6510	23	no	f32	r/w	1000000	0	-	rad/s^2	C	A	1668
deceleration_limit_-_quickstop	0x6510	25	no	f32	r/w	1000000	0	-	rad/s^2	C	A	1670
deceleration_limit_-_fault	0x6510	26	no	f32	r/w	1000000	0	-	rad/s^2	C	A	1671
velocity_command_acceleration_limited	0x6510	13	yes	f32	r	-	-	-	incs/Tsamp	N	A	1157
velocity	0x6510	10	yes	f32	r	-	-	-	incs/Tsamp	N	A	1151
velocity_filtered	0x6510	15	yes	f32	r	-	-	-	incs/Tsamp	N	A	1165
VELOCITY LIMITING												
velocity_maximum	0x6510	28	no	f32	r/w	1000	0	20000	rad/s	C	A	1800
velocity_limit	0x6510	30	yes	f32	r/w	1000	0	20000	rad/s	N	A	1802
VELOCITY LOOP FILTER												
current_demand_velocity_comp_output	0x60F7	10	yes	f32	r	-	-	-	Amps.	N	A	1120
current_demand_vel_loop_filter_output	0x60F7	11	yes	f32	r	-	-	-	Amps	N	A	1122
velocity_loop_rate_divider	0x60F9	1	no	s16	r/w	4	1	10	none	C	A	1136
switching_frequency	0x60F7	1	no	u32	r	-	-	-	Hz	N	A	1194
velocity_loop_filter_coefficient_a1	0x25C1	1	no	f32	r/w	0	-	-	none	C	A	1351
velocity_loop_filter_coefficient_a2	0x25C1	2	no	f32	r/w	0	-	-	none	C	A	1352
velocity_loop_filter_coefficient_a3	0x25C1	3	no	f32	r/w	0	-	-	none	C	A	1353
velocity_loop_filter_coefficient_a4	0x25C1	4	no	f32	r/w	0	-	-	none	C	A	1354
velocity_loop_filter_coefficient_b0	0x25C1	5	no	f32	r/w	1	-	-	none	C	A	1355
velocity_loop_filter_coefficient_b1	0x25C1	6	no	f32	r/w	0	-	-	none	C	A	1356
velocity_loop_filter_coefficient_b2	0x25C1	7	no	f32	r/w	0	-	-	none	C	A	1357
velocity_loop_filter_coefficient_b3	0x25C1	8	no	f32	r/w	0	-	-	none	C	A	1358
velocity_loop_filter_coefficient_b4	0x25C1	9	no	f32	r/w	0	-	-	none	C	A	1359
velocity_loop_filter_mode	0x25C1	10	no	u16	r/w	1	1	2	none	C	A	1360
VELOCITY FEEDBACK FILTER												
velocity_filter_cutoff_factor	0x6510	14	no	f32	r/w	0.25	0	100	none	C	A	1164
velocity	0x6510	10	yes	f32	r	-	-	-	incs/Tsamp	N	A	1151
velocity_filtered	0x6510	15	yes	f32	r	-	-	-	incs/Tsamp	N	A	1165
CURRENT LOOP												
current_loop_d-axis_i-gain	0x60F6	1	no	f32	r/w	6.35404981	0	-	V/A/Tsamp	C	A	1272
current_loop_d-axis_p-gain	0x60F6	2	no	f32	r/w	32.02666839	0	-	V/A	C	A	1274
current_loop_q-axis_i-gain	0x60F6	3	no	f32	r/w	6.35404981	0	-	V/A/Tsamp	C	A	1277
current_loop_q-axis_p-gain	0x60F6	4	no	f32	r/w	32.02666839	0	-	V/A	C	A	1279
current_loop_alpha_observer_i-gain	0x60F6	9	no	f32	r/w	0.01394492	0	-	V/A/Tsamp	C	A	1288
current_loop_alpha_observer_p-gain	0x60F6	10	no	f32	r/w	0.19933257	0	-	V/A	C	A	1290

current_loop_beta_observer_i-gain	0x60F6	11	no	f32	r/w	0.01394492	0	-	V/A/Tsamp	C	A	1293
current_loop_beta_observer_p-gain	0x60F6	12	no	f32	r/w	0.19933257	0	-	V/A	C	A	1295
current_loop_foldback_minimum	0x60F6	5	no	f32	r/w	0.4	0.1	1	None	C	A	1284
current_loop_foldback_breakpoint	0x60F6	6	no	f32	r/w	140.0	0	-	A	C	A	1285
current_d-axis_observer	0x60F7	4	yes	f32	r	-	-	-	Amps	N	A	1096
current_q-axis_observer	0x60F7	5	yes	f32	r	-	-	-	Amps	N	A	1097
current_d-axis_demand	0x60F7	6	yes	f32	r	-	-	-	Amps	N	A	1098
current_q-axis_demand	0x60F7	7	yes	f32	r	-	-	-	Amps	N	A	1099
current_phase_A_demand	0x2410	13	yes	s16	r	-	-	-	Amps	N	A	1104
current_phase_B_demand	0x2410	14	yes	s16	r	-	-	-	Amps	N	A	1105
current_phase_A_feedback	0x2210	14	yes	s16	r	-	-	-	see note 1	N	A	1069
current_phase_B_feedback	0x2210	15	yes	s16	r	-	-	-	see note 1	N	A	1070
current_loop_q-axis_error	0x60F6	7	yes	f32	r	-	-	-	Amps	N	A	1287
current_loop_d-axis_error	0x60F6	8	yes	f32	r	-	-	-	Amps	N	A	1286
current_loop_alpha_observer_error	0x60F6	13	yes	f32	r	-	-	-	Amps	N	A	1298
current_loop_beta_observer_error	0x60F6	14	yes	f32	r	-	-	-	Amps	N	A	1299
current_actual	0x60F7	9	yes	f32	r	-	-	-	Amps	N	A	1119
motor_velocity_loop_rate_divider	0x60F6	15	no	s16	r/w	1	1	-	None	C	A	1144
motor_velocity_actual	0x60F6	16	yes	f32	r	-	-	-	Incs/Tsamp	N	A	1152
motor_velocity_filtered	0x60F6	18	yes	f32	r	-	-	-	Incs/Tsamp	N	A	1163
motor_velocity_filter_cutoff_factor	0x60F6	17	no	f32	r/w	0.25	0	100	none	C	A	1162
motor_max_velocity	0x6410	8	no	f32	r/w	1000	0	20000	rad/s	C	A	1082
current_scaling_factor_field_weakening	0x2410	24	no	f32	r/w	1.0	0	1.0	none	C	A	1115
field_weakening_vmax_scaling_factor	0x2450	3	no	f32	r/w	0.85	0	1.0	none	C	A	1193
CONTROL LOOP CONFIGURATION												
control_loop_torque_mode_preset	0x2581	6	no	u32	r/w	0x8111	-	-	none	C	A	1334
control_loop_velocity_mode_preset	0x2581	5	no	u32	r/w	0x871A	-	-	none	C	A	1333
control_loop_position_mode_preset	0x2581	4	no	u32	r/w	0x87D8	-	-	none	C	A	1332

Table 5.32 Control Loops Parameter Access Detail

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.

5.12 Drive Monitoring & Fault Detection

5.12.1 Drive Monitoring

The DS2100 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 of the drive. The parameters monitored are listed below.

Temperatures

Parameter Name	Index / Subindex	Description
bridge_temperature	0x2802 / 5	Power Amplifier Bridge Temperature
motor_temperature	0x2802 / 10	Motor Winding Temperature
ambient_temperature	0x2802 / 15	Control Electronics Ambient Temperature

Table 5.33 Monitored Temperatures

Voltages

Parameter Name	Index / Subindex	Description
supply_+24V	0x2810 / 25	Internal 24V Logic Supply
supply_+3V3	0x2810 / 5	3.3V Logic Supply
supply_-15V	0x2810 / 10	-15V Logic Supply
supply_+15V	0x2810 / 15	+15V Logic Supply
supply_+2V_ref.	0x2810 / 20	2V Reference Level
encoder_ supply	0x2810 / 30	Encoder Supply
bus_voltage_actual	0x60F7 / 18	DC Bus Voltage

Table 5.34 Monitored Voltages

Times (Elapsed time Indicator)

Parameter Name	Index / Subindex	Description
ETI_total_power_on_time	0x2A03 / 1	Total powered up time
ETI_power_on_time_since_power_on	0x2A03 / 2	Power up time since power up
ETI_number_of_power_downs	0x2A03 / 3	Number of power downs
ETI_enabled_time	0x2A03 / 4	Total enable time
ETI_enabled_time_since_power_on	0x2A03 / 5	Enabled time since power up
ETI_enabled_time_since_enable	0x2A03 / 6	Current enabled time

Table 5.35 Monitored Times

Power

Parameter Name	Index / Subindex	Description
regen_power_filtered	0x24A4 / 5	Average Regeneration Power (Measured)

Table 5.36 Monitored Powers

5.12.2 Faults and User Indication in the DS2100

This section outlines the user indication that is present on the DS2100. 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 DS2100 distinguishes between faults and warnings. Faults are those abnormal conditions that are of a serious enough consequence to cause the DS2100 to halt operation. This will always result in removal of power from the DS2100 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.

Display Status	**Description**
0	Logic voltage applied, High voltage applied. No faults present. Drive ready to be enabled
I	Drive Enabled
U* (Table 5.38)	U* Warning state & No faults present
F* (Table 5.39)	Fault on drive

Table 5.37 7-Segment Display Indication

A list of warnings and faults that should be indicated are detailed in Table 5.38 and Table 5.39.

Display	Warning Description	Drive Reaction
•	Current limiting Active : due to Thermal Foldback Manual Mode I^2t limiting	Current limited
U1	High Power Not Ready – softstart 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
U8	Manual Mode: This warning indicates that user has switch 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

Table 5.38 7-Segment Warning Idication

F#	***Description***	***F#***	***Description***
1	Power Stage Short Circuit Fault	2	DC Bus Over Voltage Fault
3	Regen. Fault	4	Ambient Over temperature Fault
5	Bridge Over temperature Fault	6	Motor Over temperature Fault
7	Encoder Fault	8	Resolver Fault
9	Logic/Analog Supply Fault	10	Database / NVM Fault
11	CAN Fault	12	DC Bus Fault
13	Program Fault	14	Current Loop Fault
15	Board Fault		Undetermined Fault – (should never occur)

Table 5.39 7-Segment Display Fault Indication

5.12.3 Drive Fault Reaction

The DS2100 distinguishes between two types of faults:-

- **Fatal Faults** are those faults with which the DS2100 cannot continue to control the motor. The DS2100'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 DS2100 immediately disables high power from the motor.
- **Non-Fatal Faults** are those faults which will likely lead to equipment failure or hazards to personnel, but the DS2100 is still capable of controlling the motor output torque. For example, motor over-temperature is treated as a non-fatal fault, because the DS2100 can perform a controlled deceleration of the motor. Once the motor stops rotating, the drive can apply the brake and disable the drive.

5.12.3.1 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 (index* 0x6510*, subindex 19)* = 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.

Fault Type	**Drive Reaction**	**External Brake control**	**Internal Brake control**
Fatal	Immediate Disable	Brake not applied	Brake Applied

5.12.3.2 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 (index 0x6510 subindex 26). Once the velocity falls below the level set in parameter f*ault_reaction_velocity* (index 0x2420 subindex 6), the brake is applied. The drive then disables the power stage after the time set in parameter *brake_bridge_timeout* (index 0x6510 subindex 1) has elapsed. If the drive does not decelerate to a speed below *fault_reaction_velocity* within the time set by parameter *ramp_down_timeout* (index 0x6510, subindex 9), 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.

Fault Type	**Drive Reaction**	**External Brake control**	**Internal Brake control**
Non-Fatal	Controlled motor deceleration & disable	Brake not applied	Brake Applied

5.12.3.3 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.

Fault Name	Severity	Status code
Group 01: Power Stage Short Circuit Fault		
Regeneration short circuit fault	FATAL	61
short circuit top fault	FATAL	73
short circuit bottom fault	FATAL	77
Group 02: DC Bus Over-Voltage Fault		
Bus over-voltage fault	FATAL	58
Group 03: Regeneration Fault		
Regeneration initialisation fault	FATAL	60
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
Group 06: Motor Over temperature Fault		
motor over temperature fault	NON_FATAL	76
Group 07: Encoder Fault		
loss of encoder fault	FATAL	72
encoder security loop fault	NON_FATAL	81
encoder parity/gray code fault	NON_FATAL	82
encoder supply fault	FATAL	84
DSP ADC2 input out-of-range	FATAL	106
DSP ADC6 input out-of-range	FATAL	110
Group 08: Resolver Fault		
loss of resolver fault	FATAL	74
DSP ADC0 input out-of-range	FATAL	104
DSP ADC3 input out-of-range	FATAL	107
DSP ADC4 input out-of-range	FATAL	108
DSP ADC7 input out-of-range	FATAL	111
Group 09: Logic/Analogue Supply Fault		
3.3V supply fault	FATAL	64
+15V supply fault	FATAL	66
-15V supply fault	FATAL	67
power down detected (low vdc)	FATAL	68
2V reference fault	FATAL	71
Group 10: Database/NVM Fault		
parameter database NVM initialisation error	FATAL	168
NVM write fault	NON_FATAL	12
Parameter NVM checksum fault	FATAL	13
NVM address out of range	FATAL	123
Group 11: CAN Fault		
SYNC timeout fault	NON_FATAL	6
CAN gone bus off	NON_FATAL	176
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 initialisation 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
Group 14: Current Loop Fault		
dead-time generation fault	FATAL	86
phase A current offset fault	NON-FATAL	96
phase B current offset fault	NON-FATAL	97
DSP ADC1 input out-of-range	FATAL	105
DSP ADC5 input out-of-range	FATAL	109
Group 15: Board Fault		
FPGA configuration transmission fault	FATAL	24
DSP programming fault	FATAL	25
QSPI loopback fault	FATAL	29
COM1 loop back fault	FATAL	32
COM1 initialisation parameters fault	FATAL	38
COM2 loop back fault	FATAL	40
COM2 initialisation parameters fault	FATAL	45
QSPI initialisation fault	FATAL	46
FPGA test RAM fault	FATAL	15
Warnings logged to error log		
+24V supply under-voltage	-	65
thermal limit active	-	95
Status logged but not displayed		
ETI NVM checksum fault	-	16
Error Log NVM checksum fault	-	17
LED display initialisation fault	-	55
velocity ramp down fault	-	78

Undetermined Fault

If the drive is faulty, but the fault group cannot be determined, F is also displayed.

5.12.4 Fault Messages - CAN

These faults are also used to group faults that are sent out as emergency messages over CAN.

F#	*Description*	*Emer. Msg*	*Meaning*
1	Power Stage Short Circuit Fault	0x2340	Current on output side: Short Circuit
2	DC Bus Over Voltage Fault	0x3210	Voltage: DC Link Over-voltage
3	Regen. Fault	0x2310	Device Hardware: Power Section
4	Ambient Over temperature Fault	0x4110	Temperature: Excess Ambient Temp.
5	Bridge Over temperature Fault	0x4210	Temperature: Excess Temp. Device
6	Motor Over temperature Fault	0x4310	Temperature: Excess Temp. Drive
7	Encoder Fault	0x7305	Add Modules: Sensor: Incremental sensor 1 fault.
8	Resolver Fault	0x7303	Add Modules: Sensor: Resolver 1 Fault
9	Logic/Analog Supply Fault	0x5100	Device Hardware: Supply
10	Database / NVM Fault	0x5530	Device Hardware: Non-volatile data memory
11	CAN Fault	0x8100	Monitoring : Communication
12	DC Bus Fault	0x3200	Voltage: DC link voltage
13	Program Fault	0x6100	Device Software: internal software
14	Current Loop Fault	0x2300	Current on device output side
15	Board Fault	0x5200	Device Hardware: Control

Table 5.40 CAN Fault Error Codes

5.12.5 Fault Clearing

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 status_controller parameter (0x2B10 /15). If bit 6 of this parameter is 1 then a non-clearable fault has occurred. (where bit 0 is LSB).

To clear faults, the parameter errors_clear (0x2B00 /1) 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 DS2100 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

5.12.6 Event Log

The DS2100 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. The data recorded for each fault entry in the event log is as follows:

Index	*Type*	*Name*	*Description*
0x2B00 /9	U32	event_log_timestamp	total power on time in seconds as a 32-bit unsigned integer
0x2B00 /10	U32	event_log_data1	top 16 bits: status code defining event logged next 8 bits: 1=status set, 2=status cleared low 8 bits: ambient temperature as 8-bit signed integer
0x2B00 /11	U32	event_log_data2	additional event information

Table 5.41 Event log data parameters

When retrieving event log information, there are some additional parameters that give information on how many events have been logged and to allow the user to retrieve the required part of the event log. These parameters are described in the table below:

Index	*Type*	*Name*	*Description*

0x2B00 /4	U32	event_log_size	number of bytes used in event log since last power on
0x2B00 /16	U32	event_log_increment	number of bytes used per entry in event log (currently 12)
0x2B00 /5	U16	event_log_current_position	byte pointer to current position in event log
0x2B00 /8	U16	event_log_read_pointer	byte pointer to position to read from in event log

Table 5.42 Error log access parameters

In order to read the data from the event log it is first necessary to find out the current position in the event log by reading event_log_current_position. This indicates the address at which the next event log entry will be written. The read pointer must then be set to a multiple of the event log increment less than the current position. Then the event log data may be read. The time stamp must always be read before reading the data1 and data2 values since the timestamp read is used to set up the data values to be read.
Successive entries may be read from the event log without setting the read pointer each time.

For example, to read the event log entries since the last power on:

1. read event_log_size
2. read event_log_increment
3. read event_log_position
4. set event_log_read_pointer to be (position – size)
5. read event_log_timestamp
6. read event_log_data1
7. read event_log_data2
8. repeat steps 5,6,7 (size / increment) times

To read the last 10 event log entries:

1. read event_log_increment
2. read event_log_position
3. set event_log_read_pointer to be (position – (10 * increment))
4. read event_log_timestamp
5. read event_log_data1
6. read event_log_data2
7. repeat steps 10 times

5.12.7 Drive Monitoring & Fault Detection Parameters

Parameter Name	CANopen Index	CANopen sub-index	PDO mapping	Data Type	Access	Default Value	Minimum Value	Maximum Value	Units	Storage Type	Data Group	Field Number
DRIVE MONITORING												
bridge_temperature	0x2802	5	yes	f32	r	-	-	-	°C	N	A	1368
motor_temperature	0x2802	10	yes	f32	r	-	-	-	°C	N	A	1373
ambient_temperature	0x2802	15	yes	f32	r	-	-	--	°C	N	A	1378
supply_+24V	0x2810	25	yes	f32	r	-	-	-	V	N	A	1441
supply_+3V3	0x2810	5	yes	f32	r	-	-	-	V	N	A	1421
supply_-15V	0x2810	10	yes	f32	r	-	-	-	V	N	A	1426
supply_+15V	0x2810	15	yes	f32	r	-	-	-	V	N	A	1431
supply_+2V_ref.	0x2810	20	yes	f32	r	-	-	-	V	N	A	1436
encoder_supply	0x2810	30	yes	f32	r	-	-	-	V	N	A	1446
bus_voltage_actual	0x60F7	18	yes	f32	r	-	-	-	V	N	A	1232
ETI_total_power_on_time	0x2A03	1	yes	u32	r	-	-	-	s	N	A	1482
ETI_power_on_time_since_power_on	0x2A03	2	yes	u32	r	-	-	-	s	N	A	1483
ETI_number_of_power_downs	0x2A03	3	yes	u16	r	-	-	-	none	N	A	1484
ETI_enabled_time	0x2A03	4	yes	u32	r	-	-	-	s	N	A	1485
ETI_enabled_time_since_power_on	0x2A03	5	yes	u32	r	-	-	-	s	N	A	1486
ETI_enabled_time_since_enable	0x2A03	6	yes	u32	r	-	-	-	s	N	A	1487
regen_power_filtered	0x24A4	5	yes	f32	r	-	-	-	W	N	A	1252
FAULT REACTION												
brake_fault_control	0x6510	18	no	u16	r/w	1	-	-	none	C	A	1505
acceleration_limit	0x6510	18	no	f32	r/w	1000	0	-	rad/s^2	C	A	1335
fault_reaction_velocity	0x2420	6	no	f32	r/w	0.5	0.05	1000	rad/s	C	A	1141
brake_lock_to_disable_timeout	0x6510	1	no	f32	r/w	0.1	0	5	s	C	A	1004

velocity_rampdown_time_limit	0x6510	9	no	f32	r/w	1	0	1000	s	C	A	1143
FAULT CLEARING												
status_controller	0x2B10	15	yes	u08	r	-	-	-	none	N	A	1522
errors_clear	0x2B00	1	yes	u16	r/w	0	-	-	none	N	A	1491
EVENT LOG												
event_log_timestamp	0x2B00	9	no	u32	r	-	-	-	s	N	A	1499
event_log_data1	0x2B00	10	no	u32	r	-	-	-	none	N	A	1500
event_log_data2	0x2B00	11	no	u32	r	-	-	-	none	N	A	1501
event_log_size	0x2B00	4	no	u32	r	-	-	-	none	N	A	1494
event_log_increment	0x2B00	16	no	u32	r	-	-	-	none	N	A	1640
event_log_current_position	0x2B00	5	no	u16	r	-	-	-	none	N	A	1495
event_log_read_pointer	0x2B00	8	no	u16	r/w	-	-	-	none	N	A	1498

Table 5.43 Drive Monitoring and Fault Detection Parameter Access Detail

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 DS2100 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 DS2100 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 DS2100 model has a continuous current rating. The DS2100 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 DS2100 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 DS2100 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

5.14.1 Command Parameters

The saving and loading of parameters to the Non-Volatile Memory (NVM) of the drive is implemented using three parameters, and a number of bit fields. The three relevant parameters are listed below: -

Index	*Type*	*Name*
0x2141/0	U08	nvm_load_parameters
0x2142/0	U08	nvm_save_parameters
0x2143/0	U08	load_default_parameters

Table 5.44 List of NVM related parameters

5.14.2 Storage Types

Each parameter is assigned a storage type that defines the area of NVM to which it is stored. The storage types are: -

- None: - parameter is not saved to NVM
- Fac: - Factory types are used to hold parameters which are set during drive manufacture, not for general user.
- Ext:- Extended types are used to hold baud rates, parity etc
- Cus: General / Customer types are placed in a general area used to hold parameters set by the user.
- Enc: Encoder types are stored in the encoder EEPROM and also in the 'Cus' storage area

When a load or save is performed, the user defines the storage type of the parameters to be saved or loaded, by setting the appropriate bit(s) in the parameter.

5.14.3 Data Group

Each parameter is assigned to a particular data group. The two groups are: -

- App : Application profile parameters
- Com :- Communication parameters

When a load or save is performed, the user defines the data group of the parameters to be saved or loaded, by setting the appropriate bit(s) in the parameter. The bit mask for selecting the appropriate storage type, and data group is shown below :-

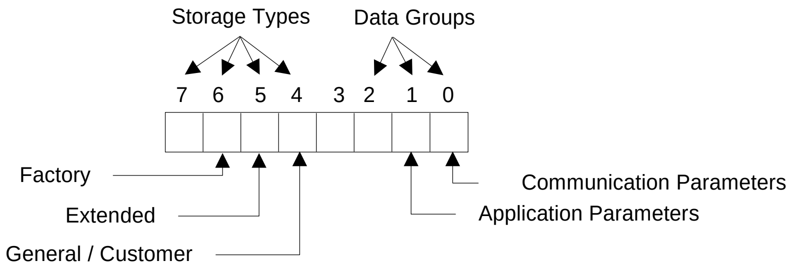


Figure 5.12 : Bit Masks for Storage type and data group

- If the user wishes to save all parameters, (i.e. of all type and all groups) to NVM, set *nvm_save_parameters* to 0xFF
- If the user wishes to load the saved value of all customer parameters, set *nvm_load_parameters* to 0x17
- If the user wishes to load the default ROM values, for all communication parameters, set load_default_parameters to 0x71
- If the user wishes to save only application parameters, set nvm_save_parameters to 0x72
- If the user wishes to load all factory settings, set nvm_load_parameters to 0x47

The parameters and bit-masks are required to load and save parameters using CAN. The GUI has parameters load/save panels , in the utilities sub-folder, for saving different groups of parameters, so the user does not need to know the bitmasks, and parameters required.

Note: The 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, but there will be no error message to indicate that this is the case.

5.14.4 Parameter Storage Parameters

Parameter Name	CANopen Index	CANopen sub-index	PDO mapping	Data Type	Access	Default Value	Minimum Value	Maximum Value	Units	Storage Type	Data Group	Field Number
PARAMETER STORAGE												
nvm_load_parameters	0x2141	0	no	u08	r/w	0	-	-	none	N	A	10000
nvm_save_parameters	0x2142	0	no	u08	r/w	0	-	-	none	N	A	10001
load_default_parameters	0x2143	0	no	u08	r/w	0	-	-	none	N	A	10002

Table 5.45 Parameter Storage Parameter Access Data

Page Intentionally Blank

SECTION 6: DS2100 CANOPEN INTERFACE

TABLE OF CONTENTS

6.1 Introduction

This section describes the CANopen Interface of the DS2100. It details the DS2100 implementation of the CAN in Automation CANopen Draft Standard 301, the CANopen Objects supported and the Moog specific additions to that.

CAN is an abbreviation for the Controller Area Network. This is a high speed serial interface which was designed for use in Automotive and Industrial applications.

Users are directed to read Section 2, Safety Instructions of the DS2100 User's Manual, before proceeding with installation.

The DS2100 provides two hexadecimal switches to set the CAN node ID of the drive. Two LEDs (RUN & ERROR) are provided to indicate the status of operation of the CAN network

6.2 Reference Documentation

For further information please refer to the following specifications from CAN in Automation:

- CiA Draft Standard 301: Application Layer and Communication Profile (referred to in this documentation as 'DS 301')
- CiA Draft Recommendation 303-3: Indicator Specification (referred to in this documentation as 'DS 303')

The CAN standards refer to parameters as 'objects'. Because of all parameters not only being available via CAN but also via the Man Machine Interface (MMI) they are referred to as 'parameters' in this documentation.

CAN Cable Wiring

The CAN-In and CAN-Out ports at J3A and J3B of the DS2100 provide the means to daisy-chain the CAN cabling between DS2100 units and system conroller. The CAN interface is equipped with driver and receiver for 24 V systems. These are optically isolated from the internal drive electronics for noise immunity. Internal supply of the isolated side of the CAN is provided. No user supplied voltage is required. Two daisy chained 9-way D-Sub connectors, one male, one female are also provided for ease of wiring.

Please refer to CAN Draft Standard 303, 'Cabling and Connector Pin Assignment' for further details of the CAN cabling requirements.

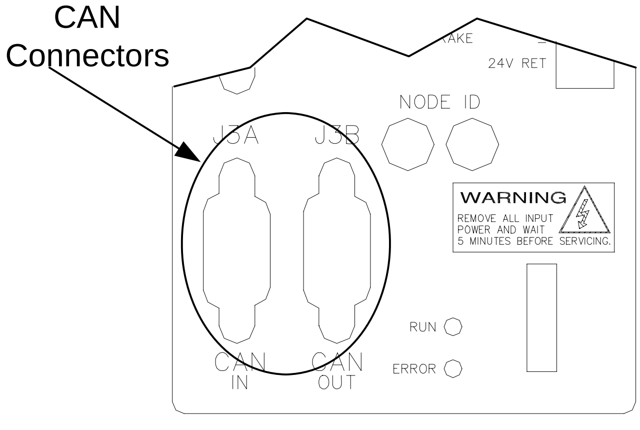


Figure 6.1 CAN Connector Location

Pos (x=A,B)	Signal	Description
J3x.1	-	not connected
J3x.2	CAN_L	CAN_L bus line (dominant low)
J3x.3	CAN_GND	CAN Ground
J3x.4	-	not connected
J3x.5	CAN_SHLD	Chassis Ground
J3x.6	CAN_GND	CAN Ground
J3x.7	CAN_H	CAN_H bus line (dominant high)
J3x.8	-	not connected
J3x.9	-	Optional CAN external positive supply, not connected.

Table 6.1 CAN Connector Pin Description

Note:-

- CAN lines must be terminated in a 120Ohm resistance, between the positive and negative terminals (CAN-High and CAN-Low) at both ends of the CAN network for correct operation.

- All pins of J3A and J3B are wired straight through the connectors of the DS2100.

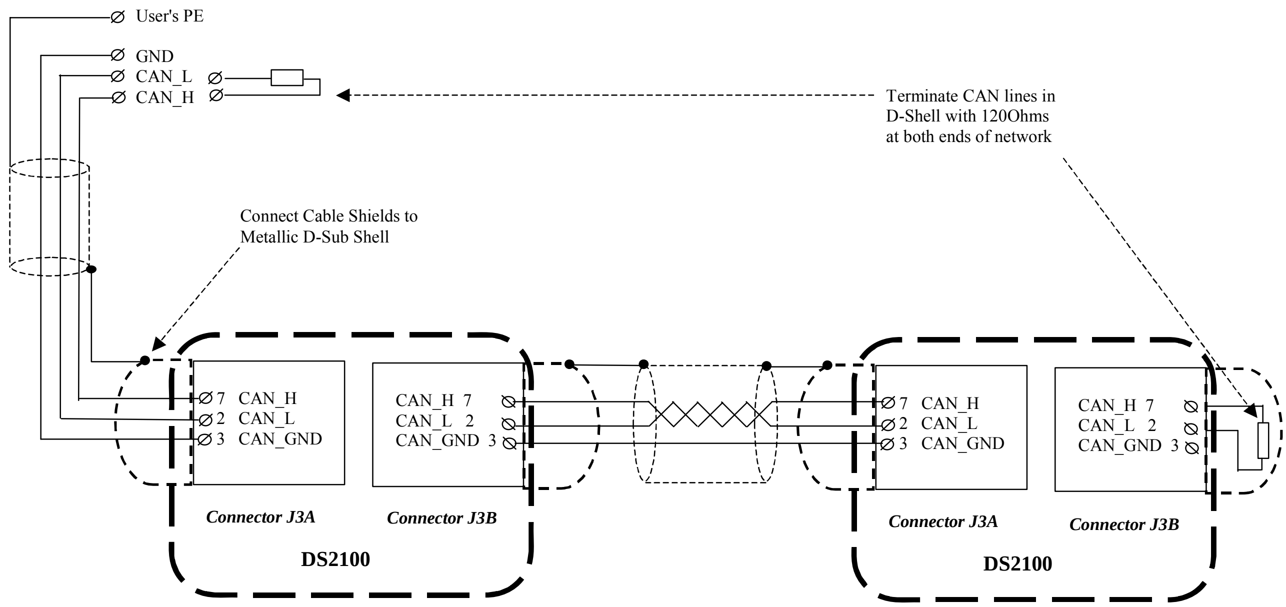
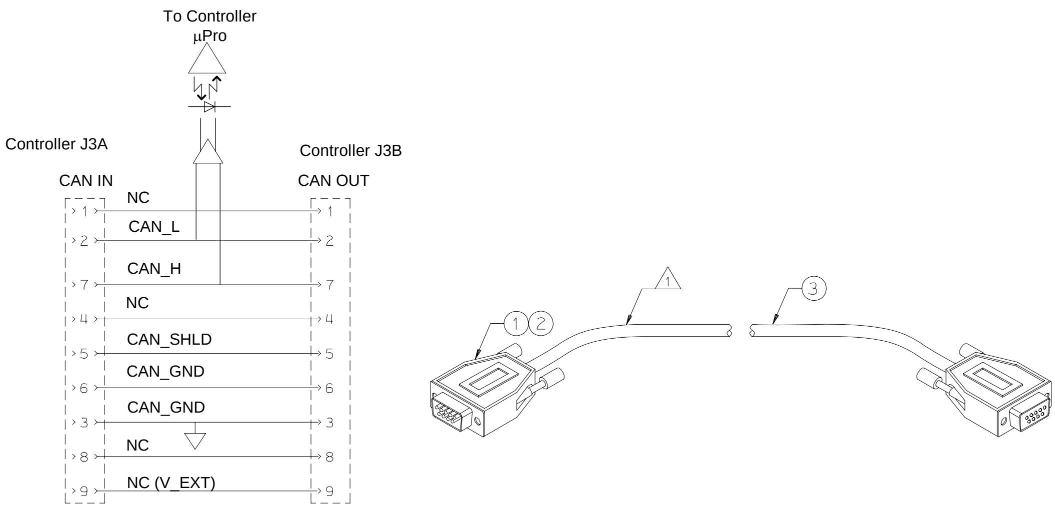


Figure 6.2 DS2100 CAN Wiring and Termination



Notes

1 CABLE LENGTH NOT TO EXCEED 40 METERS FOR 1MBAUD OPERATION.
CABLE SHOULD NOT EXCEED 100 METERS FOR 500KBAUD OPERATION.

FIND NO.	MOOG PART NO.	DESCRIPTION	QUANTITY
1	MAKE ITEM	CONNECTOR 9 WAY D TYPE MALE	USER SPLY
2	MAKE ITEM	CONNECTOR 9 WAY D TYPE FEMALE	USER SPLY
3	MAKE ITEM	CABLE BELDEN 9842	USER SPLY

Figure 6.3 CAN_L/CAN_H Connector (J3A and J3B) Wiring

6.3 CAN node identifier

The node identifier (node-id) within a CANopen network is set with the two hex switches at the front panel. Each node within the network (drives, peripherals ...) needs its own unique number. The switches have to be set to the node-id in hexadecimal. Valid node-ids are 0x01 to 0x7f (1 - 127 decimal). Any other setting will be treated as invalid node-id. This is indicated through both the run and error LED flickering.

Please note that once the drive has recognised an invalid node-id, a power cycle or 'Reset Communication' is required after setting the hex switches to a valid node-id. Refer to 'Network Initialisation and System Bootup' for further information.

6.4 CAN Controller Configuration

6.4.1 CAN Enable

The CAN bus can be enabled /disabled by using the parameter *can_enable* (index 0x3000, sub-index 1). When this parameter is set to 0 the CAN bus is disabled. When this parameter is non-zero the CAN bus is enabled.
The default value for this parameter is 1.

6.4.2 CAN bus bitrate

The bit rate for the CAN bus can be set using the parameter *can_bus_bitrate* (index 0x200b, subindex 0). When changing the bit rate, the new value has to saved to EEPROM and then a reset communication (or power cycle) is required to enable the new bit rate. The following bit rates are supported:

- 10000 bits per second
- 20000 bits per second
- 50000 bits per second
- 125000 bits per second
- 250000 bits per second
- 500000 bits per second
- 800000 bits per second
- 1000000 bits per second

6.4.3 CAN Controller Parameters

Parameter Name	CANopen Index	CANopen sub-index	PDO mapping	Data Type	Access	Default Value	Minimum Value	Maximum Value	Units	Storage Type	Data Group	Field Number
CAN Enable												
can_enable	0x3000	1	No	U8	rw	1	-	-	-	F	C	12000
BIT RATE												
can_bus_bitrate	0x200B	0	no	U32	rw	1000000	-	-	-	C	C	12007

Table 6.2 CAN Controller Parameter Access Detail

6.5 Data Types

The following simple CANopen data types are supported:

- unsigned 8-bit integer
- signed 8-bit integer
- unsigned 16-bit integer
- signed 16-bit integer
- unsigned 24-bit integer
- signed 24-bit integer
- unsigned 32-bit integer
- signed 32-bit integer
- visible string
- 32-bit single precision floating point
- 64-bit double precision floating point

The following complex CANopen data types are supported:

- pdo communication parameter
- pdo mapping
- sdo parameter
- identity object

6.6 Network Initialisation and System Bootup

CAN draft standard 301 defines the various CAN node states and the state transitions.

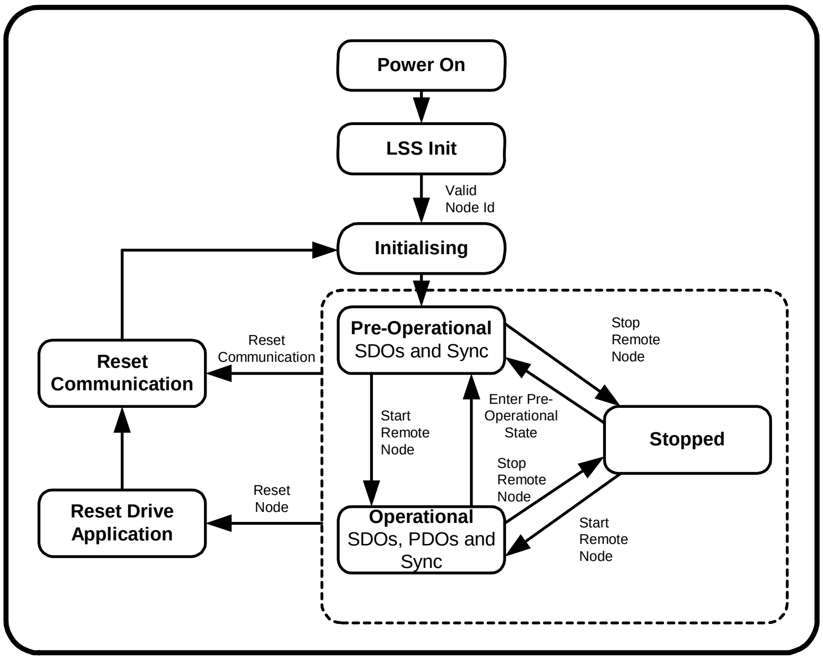


Figure 6.4 CANopen node states

After power up the drive checks for a valid node identifier (node-id). Note that changing the hex switches once the drive has reached the LSS Init state has no effect any more. Changes of the node-id setting will only be recognised after a new power cycle.

All internal variables are initialised then and the drive automatically enters the Pre-Operational state after sending a bootup complete message. In the Pre-Operational state the drive can be configured using Service Data Objects (SDO). After configuring the drive it can be set into the Operational state using Network Management services (NMT). Please refer to DS 301 for further information.

6.6.1 CAN state

The current CAN state is available through the parameter *can_state* (index 0x2009, subindex 0). It contains the following values depending on the CAN state:

0x01	-	Power on state
0x02	-	LSS Init state
0x04	-	Reset Application state
0x08	-	Reset Communication state
0x10	-	Initialisation state
0x20	-	Pre_Operational state
0x40	-	Stopped state
0x80	-	Operational state

The CAN state is also indicated through the RUN LED at the front panel. See 'CAN Indicators' or DS 303 for further information.

6.6.2 Network Initialisation and System Bootup Parameters

Parameter Name	CANopen Index	CANopen sub index	PDO mapping	Data Type	Access	Default Value	Minimum Value	Maximum Value	Units	Storage Type	Data Group	Field Number
CAN STATE												
can_state	0x2009	0	no	U8	rw	1000000	-	-	-	N	C	12115

Table 6.3 Network Initialisation and System Bootup Parameter Access Detail

6.7 Service Data Objects (SDO)

For basic asynchronous communication Service Data Objects (SDO) are supported. The following SDO protocols are available:

- SDO expedited upload
- SDO expedited download
- SDO segmented upload
- SDO segmented download
- SDO block upload
- SDO block download

6.7.1 SDO communication object identifier

Depending on the drive node-id setting, the SDO client and server communication object identifiers (cob-id) are set according to the pre defined connection set. The client cob-id *sdo_client_cob-id* (index 0x1200, subindex 1) is set to 0x600 + node-id and the server cob-id *sdo_server_cob-id* (index 0x1200, subindex 2) is set to 0x580 + node-id.

6.7.2 SDO timeout

Although not explicitly specified in the DS 301 Standard a programmable timeout, *sdo_timeout_ms* (index 0x200A, sub-index 0) is implemented in the communication protocol. The default value for the timeout is 1 second. In case of segmented or block transfers the drive aborts the transfer and waits for a new SDO command. An emergency message is not sent.

6.7.3 SDO abort codes

The following SDO abort codes are used by the drive:

0x05040001	-	invalid command specifier
0x06010000	-	access not allowed
0x06010001	-	no read access right
0x06010002	-	no write access right
0x06020000	-	object not found error
0x06040041	-	PDO mapping error
0x06040042	-	invalid PDO size
0x06060000	-	hardware error
0x06070010	-	invalid data type
0x06090011	-	subindex out of range
0x06090030	-	value out of range
0x06090031	-	value too big
0x06090032	-	value too small
0x08000000	-	generic error
0x08000020	-	EEPROM save error (signature)
0x08000022	-	access not possible due to drive state

6.7.4 SDO Parameters

Parameter Name	CANopen Index	CANopen sub index	PDO mapping	Data Type	Access	Default Value	Minimum Value	Maximum Value	Units	Storage Type	Data Group	Field Number
SDO Communication Object Identifier												
sdo_client_cob-id	0x1200	1	no	U32	r	0x62A[1]	-	0x1fffffff	-	N	C	12033
sdo_server_cob-id	0x1200	2	no	U32	r	0x5AA[1]	-	0x1fffffff	-	N	C	12034
SDO Timeout												
sdo_timeout_ms	0x200A	0	No	U16	rw	1000	-	-	ms	C	C	12008

Table 6.4 SDO Parameter Access Detail

Notes:

1. The client COB ID is set to 0x600 + node ID on power up or reset. The node ID is read from the hex switches on the front panel of the controller.
2. The server COB ID is set to 0x580 + node ID on power up or reset. The node ID is read from the hex switches on the front panel of the controller.

6.8 Process Data Objects (PDO)

The drive supports up to 4 receive and up to 4 transmit Process Data Objects (PDOs). The contents can be specified using PDO mapping. The granularity of the PDO mapping is a byte.

All the PDO settings can only be changed in the pre-operational state. See 'Network Initialisation and System Bootup' for further information.

6.8.1 Communication Object Identifier

The communication object identifier (cob-id) of the PDO can be modified using the parameters *pdo_xxxx_cob-id*. After setting the node-id, all PDOs have a default cob-id according to the DS 301 pre defined connection set. The receive PDO cob-ids have a value of 0x200 + n * 0x100, where n is the number of the PDO from 0..3. The transmit PDO cob-ids have a value of 0x180 + n * 0x100, where n is the number of the PDO from 0..3.

Note that when changing the cob-id, the PDO has to be disabled first by setting the highest bit before the cob-id can be modified. When changing the node-id, all values are reset to the pre defined connection set settings.

6.8.2 Transmission Type

The behaviour of the PDO can be set using the parameters *pdo_xxxx_transmission_type*. Normally values between 1 and 240 are synchronous PDOs that are transmitted every *pdo_xxxx_transmission_type* synchronisation events (see 'Synchronisation Objects' for further information).

Remote Request PDO transmission types 252 and 253 are not supported.

Asynchronous receive PDOs are possible using transmission type 255. In this case, the new data values in the PDO are in effect immediately after reception.

For transmit PDOs the transmission type 255 is event driven, that means that any change in the drive status word will trigger the PDO transmission.

6.8.3 PDO Inhibit Time

The inhibit time can only be set for transmit PDO’s. The parameter *pdo_xxxx_inhibit_time* specifies the minimum time interval between successive transmissions of the PDO message in multiples of 100µs. If this parameter is 0 then there is no minimum time interval between successive transmissions.
The default value for this parameter is 0.

6.8.4 PDO Event Time

The event time is valid for transmit and receive PDO’s. The parameter *pdo_xxxx_event_time* is specified in multiples of 1ms and has a default value of 0.

For receive PDO's, the event time specifies the maximum time allowed between successive receptions of the PDO. If the event time expires before the next receive event for the PDO then a 'RPDO fault' is detected and the drive transitions to a level 2 fault state. If this parameter is 0 then there is no maximum time enforced.

For transmit PDO's, the event time specifies the maximum time between successive transmissions of the PDO. This maximum time is enforced for all types of transmit PDO. If this parameter is 0 then there is no maximum time enforced.

6.8.5 PDO mapping

The PDO mapping is the mechanism that allows the user to change the contents of the process data objects. To change the PDO mapping, the parameter *pdo_xxxx_number_elements* should be set to 0, then the new parameters that should be mapped written in the *pdo_xxxx_mapping* array and then the number of mapped parameters should be written into *pdo_xxxx_number_elements*. Make sure that not more than 8 bytes are used up in this mapping process. If trying to map more than 8 bytes into one PDO, writing of *pdo_xxxx_number_elements* will cause an error.

6.8.6 PDO Parameters

Parameter Name	CANopen Index	CANopen sub-index	PDO mapping	Data Type	Access	Default Value	Minimum Value	Maximum Value	Units	Storage Type	Data Group	Field Number
Receive PDO 1												
pdo_1st_receive_cob-id	0x1400	1	no	U32	rw	0x4000022A	-	-	-	C	C	12035
pdo_1st_receive_transmission_type	0x1400	2	no	U8	rw	255	-	-	-	C	C	12036
pdo_1st_receive_event_time	0x1400	5	no	U16	rw	0	-	-	-	C	C	12039
pdo_1st_receive_number_elements	0x1600	0	no	U8	rw	1	0	7	-	C	C	12040
pdo_1st_receive_mapping	0x1600	1-8	no	U32	rw	0x60400010,0,0,0,0,0,0,0	-	-	-	C	C	12041
Receive PDO 2												
pdo_2nd_receive_cob-id	0x1401	1	no	U32	rw	0xC000032A	-	-	-	C	C	12042
pdo_2nd_receive_transmission_type	0x1401	2	no	U8	rw	255	-	-	-	C	C	12043
pdo_2nd_receive_event_time	0x1401	5	no	U16	rw	0	-	-	-	C	C	12046
pdo_2nd_receive_number_elements	0x1601	0	no	U8	rw	1	0	7	-	C	C	12047
pdo_2nd_receive_mapping	0x1601	1-8	no	U32	rw	0x60400010,0x60600008,0,0,0,0,0,0	-	-	-	C	C	12048
Receive PDO 3												
pdo_3rd_receive_cob-id	0x1402	1	no	U32	rw	0xC000042A	-	-	-	C	C	12049
pdo_3rd_receive_transmission_type	0x1402	2	no	U8	rw	255	-	-	-	C	C	12050
pdo_3rd_receive_event_time	0x1402	5	no	U16	rw	0	-	-	-	C	C	12053
pdo_3rd_receive_number_elements	0x1602	0	no	U8	rw	1	0	7	-	C	C	12054
pdo_3rd_receive_mapping	0x1602	1-8	no	U32	rw	0x60400010,0x607A0020,0,0,0,0,0,0	-	-	-	C	C	12055
Receive PDO 4												
pdo_4th_receive_cob-id	0x1403	1	no	U32	rw	0xC000042A	-	-	-	C	C	12056
pdo_4th_receive_transmission_type	0x1403	2	no	U8	rw	255	-	-	-	C	C	12057
pdo_4th_receive_event_time	0x1403	5	no	U16	rw	0	-	-	-	C	C	12060
pdo_4th_receive_number_elements	0x1603	0	no	U8	rw	1	0	7	-	C	C	12061
pdo_4th_receive_mapping	0x1603	1-8	no	U32	rw	0x60400010,0x60FF0020,0,0,0,0,0,0	-	-	-	C	C	12062

Transmit PDO 1												
pdo_1st_transmit_cob-id	0x1800	1	no	U32	rw	0x400001AA	-	-	-	C	C	12063
pdo_1st_transmit_transmission_type	0x1800	2	no	U8	rw	255	-	-	-	C	C	12064
pdo_1st_transmit_inhibit_time	0x1800	3	no	U16	rw	0	-	-	-	C	C	12065
pdo_1st_transmit_event_time	0x1800	5	no	U16	rw	0	-	-	-	C	C	12067
pdo_1st_transmit_number_elements	0x1A00	0	no	U8	rw	1	0	7	-	C	C	12068
pdo_1st_transmit_mapping	0x1A00	1-8	no	U32	rw	0x60410010,0,0,0,0,0,0,0	-	-	-	C	C	12069
Transmit PDO 2												
pdo_2nd_transmit_cob-id	0x1801	1	no	U32	rw	0xC00002AA	-	-	-	C	C	12070
pdo_2nd_transmit_transmission_type	0x1801	2	no	U8	rw	255	-	-	-	C	C	12071
pdo_2nd_transmit_inhibit_time	0x1801	3	no	U16	rw	0	-	-	-	C	C	12072
pdo_2nd_transmit_event_time	0x1801	5	no	U16	rw	0	-	-	-	C	C	12074
pdo_2nd_transmit_number_elements	0x1A01	0	no	U8	rw	1	0	7	-	C	C	12075
pdo_2nd_transmit_mapping	0x1A01	1-8	no	U32	rw	0x60410010,0x60610008,0,0,0,0,0	-	-	-	C	C	12076
Transmit PDO 3												
pdo_3rd_transmit_cob-id	0x1802	1	no	U32	rw	0xC00003AA	-	-	-	C	C	12077
pdo_3rd_transmit_transmission_type	0x1802	2	no	U8	rw	255	-	-	-	C	C	12078
pdo_3rd_transmit_inhibit_time	0x1802	3	no	U16	rw	0	-	-	-	C	C	12079
pdo_3rd_transmit_event_time	0x1802	5	no	U16	rw	0	-	-	-	C	C	12081
pdo_3rd_transmit_number_elements	0x1A02	0	no	U8	rw	1	0	7	-	C	C	12082
pdo_3rd_transmit_mapping	0x1A02	1-8	no	U32	rw	0x60410010,0x60640020,0,0,0,0,0	-	-	-	C	C	12083
Transmit PDO 4												
pdo_4th_transmit_cob-id	0x1803	1	no	U32	rw	0xC00003AA	-	-	-	C	C	12084
pdo_4th_transmit_transmission_type	0x1803	2	no	U8	rw	255	-	-	-	C	C	12085
pdo_4th_transmit_inhibit_time	0x1803	3	no	U16	rw	0	-	-	-	C	C	12086
pdo_4th_transmit_event_time	0x1803	5	no	U16	rw	0	-	-	-	C	C	12088
pdo_4th_transmit_number_elements	0x1A03	0	no	U8	rw	1	0	7	-	C	C	12089
pdo_4th_transmit_mapping	0x1A03	1-8	no	U32	rw	0x60410010,0x606C0020,0,0,0,0,0	-	-	-	C	C	12090

Table 6.5 PDO Parameter Access Detail

6.9 Synchronisation

The synchronisation method in CANopen is implemented through synchronisation messages that are sent by a sync producer (normally a PLC controller) and that are received by the drive(s).

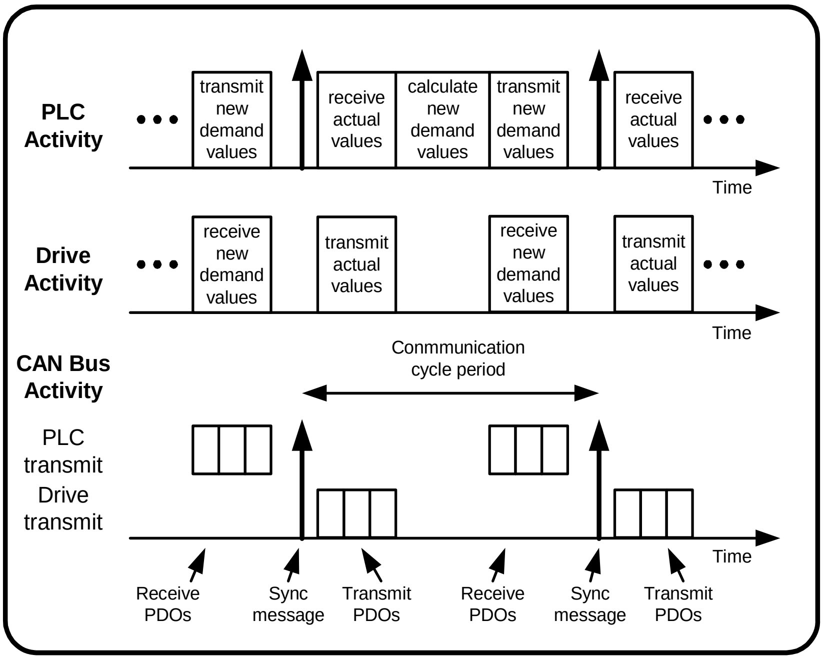


Figure 6.5 Typical CAN system

The picture shows a typical CAN system in Operational state with the PDOs and synchronisation messages sent in a cyclic manner. In every cycle the PLC controller receives the actual values, calculates the new demand values and transmits the new demand values to the drive(s). Then the synchronisation message enables the new demand values in the drive(s) and the new actual values are sampled and transmitted via the bus.

The communication identifier (cob-id) of the synchronisation messages can be changed with the parameter *sync_message_cob-id* (index 0x1005, subindex 0). The time in between sync messages is called communication cycle period. It can be changed by writing to the parameter *sync_communication_cycle_period* (index 0x1006, subindex 0). It contains the synchronisation time in microseconds. The maximum allowed timeout between synchronisation messages is *sync_communication_cycle_period* multiplied by 1.5. If a different timeout value is desired, the parameter *sync_maximum_number_missing* (index 0x2005, subindex 0) can be used. If it is set to a non-zero value, the synchronisation timeout is *sync_communication_cycle_period* multiplied by *sync_maximum_number_missing*. If *sync_maximum_number_missing* is set to zero, the timeout is *sync_communication_cycle_period* multiplied by 1.5

6.9.1 Synchronisation Parameters

Parameter Name	CANopen Index	CANopen sub index	PDO mapping	Data Type	Access	Default Value	Minimum Value	Maximum Value	Units	Storage Type	Data Group	Field Number
Synchronisation												
sync_message_cob_id	0x1005	0	no	U32	rw	128	-	0x000007FF	-	C	C	12115
sync_communication_cycle_period	0x1006	0	no	U32	rw	0	-	-	µs	C	C	12110
sync_maximum_number_missing	0x2005	0	no	U8	rw	0	-	-	-	C	C	12111

Table 6.6 Synchronisation Parameter Access Detail

6.10 Communication Profile Objects

6.10.1 Error reporting

Any errors in the drive are reported using emergency messages. The cob-id can be modified using the parameter *emergency_message_cob-id* (index 0x1014, subindex 0). The last error is available in the parameter *error_register* (index 0x1001, subindex 0).

A list of errors can be read using the parameter *pre-defined_error_field* (index 0x1003, subindex 1 - 8). The number of stored errors can be read through *maximum_saved_errors* (index 0x1003, subindex 0). By writing a 0 to *maximum_saved_errors*, the error list can be deleted. See CiA Draft Standard 301 for further information.

6.10.2 Heartbeat Protocol

For protection purposes in case of a non functioning CAN network the heartbeat producer protocol is implemented. By writing a non zero time value in milliseconds to the parameter *heartbeat_producer_time* (index 0x1017, subindex 0) the transmission of heartbeat messages is enabled.

6.10.3 Storing and restoring Parameters

The drive supports storing and restoring of parameter settings to and from EEPROM. This is done by writing a signature to certain parameters.

Storing parameters to EEPROM is done by writing 0x65766173 (signature 'save') to the parameter *store_all_parameters* (index 0x1010, subindex 1). This saves all parameters to EEPROM. In order to only save the communication parameters or only the drive parameters to EEPROM, the parameters *store_communication_parameters* (index 0x1010, subindex 2) and *store_application_parameters* (index 0x1010, subindex 3) can be used.

In order to restore parameters to default values the value 0x64616f6c (signature 'load') has to be written to *restore_all_parameters* (index 0x1011, subindex 1). To restore only communication or drive parameters the *restore_communication_parameters* (index 0x1011, subindex 2) and *restore_application_parameters* (index 0x1011, subindex 3) can be used. Please not that a 'Reset Commmunication' or 'Reset Node' is necessary in order to restore the default values after writing the signatures. Refer to 'Network Initialisation and System Bootup' for further information.

6.10.4 Drive Identification

For identification purposes in a CAN network various parameters are provided. The parameter *device_type* (index 0x1000, subindex 0) contains the value 0x00020192 which means servo drive (0x0002) according to draft standard 402 (0x0192 in hexadecimal). *manufacturer_device_name* (index 0x1008, subindex 0) contains the device name, *manufacturer_hardware_version* (index 0x1009, subindex 0) the hardware revision and *manufacturer_software_version* (index 0x100a, subindex 0) the software version as visible strings.

6.10.5 Identity Object

The array *identity_object* (index 0x1018, subindex 1 - 4) contains the vendor id (0x28 for Moog), the product code, the revision number and the serial number of the drive.

6.10.6 Communication Profile Parameters

Parameter Name	CANopen Index	CANopen sub-index	PDO mapping	Data Type	Access	Default Value	Minimum Value	Maximum Value	Units	Storage Type	Data Group	Field Number
Error reporting												
emergency_message_cob-id	0x1014	0	no	U32	rw	0xAA	-	-	-	C	C	12029
error_register	0x1001	0	no	U8	r	-	-	-	-	N	C	12011
pre-defined_error_field	0x1003	1-8	no	U32	r	-	-	-	-	N	C	12014
maximum_saved_errors	0x1003	0	no	U8	rw	0	-	-	-	C	C	12013
Heartbeat Protocol												
heartbeat_producer_time	0x1017	0	no	U16	rw	0	-	-	ms	C	C	12030
Storing and restoring Parameters												
store_all_parameters	0x1010	1	no	U32	rw	1	-	-	-	N	C	12021
store_communication_parameters	0x1010	2	no	U32	rw	1	-	-	-	N	C	12022
store_application_parameters	0x1010	3	no	U32	rw	1	-	-	-	N	C	12023
restore_all_parameters	0x1011	1	no	U32	rw	1	-	-	-	N	C	12024
restore_communication_parameters	0x1011	2	no	U32	rw	1	-	-	-	N	C	12025
restore_application_parameters	0x1011	3	no	U32	rw	1	-	-	-	N	C	12026
Drive Identification												
device_type	0x1000	0	no	U32	r	0x00020192	-	-	-	F	C	12010
manufacturer_device_name	0x1008	0	no	string	r	Moog DS2100 CANopen Servodrive	-	-	-	F	C	12016
manufacturer_hardware_version	0x1009	0	no	string	r	G361 CAN Control Card C27440-001	-	-	-	F	C	12017
manufacturer_software_version	0x100A	0	no	string	r	G361_CAN_Vx.x dd.mmm.yyyy	-	-	-	N	C	12018
Identity Object												
identity_object	0x1018	1-4	no	U32	rw	0x00000028,0,1,1	-	-	-	F	C	12032

Table 6.7 Communication Profile Parameter Access Detail

6.11 CAN Indicators

Two LEDs are provided for CAN state and error information.

6.11.1 Run Indicator

The green Run indicator changes its blinking pattern depending on the CAN state.

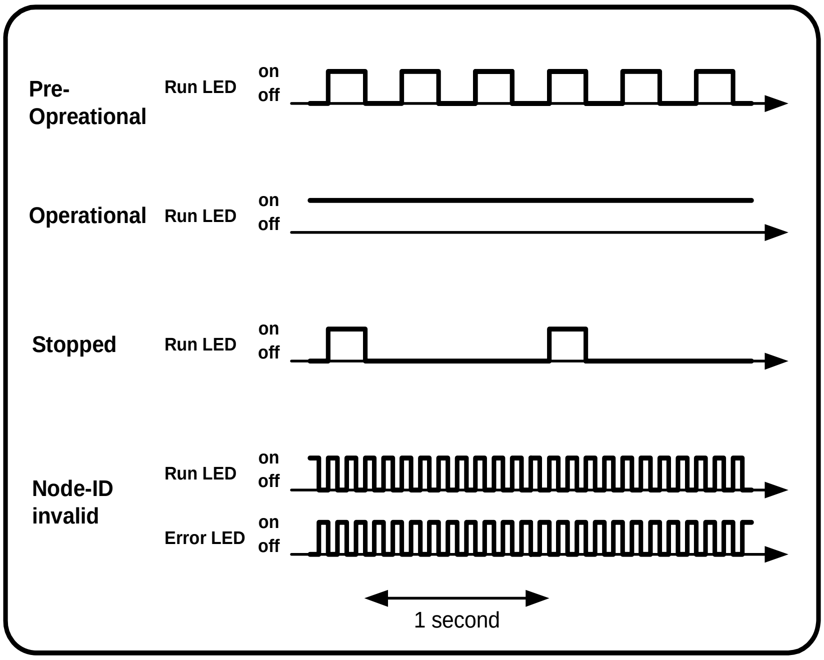


Figure 6.6 CANopen Run indicator

When operational the Run indicator is on continuously, when the drive is in the Pre-Operational state it blinks with about 2.5 Hertz and in the Stopped state there is a short flash about every second. In every other state the Run indicator is off.

6.11.2 Error Indicator

The red Error indicator supplies information on errors on the CAN bus.

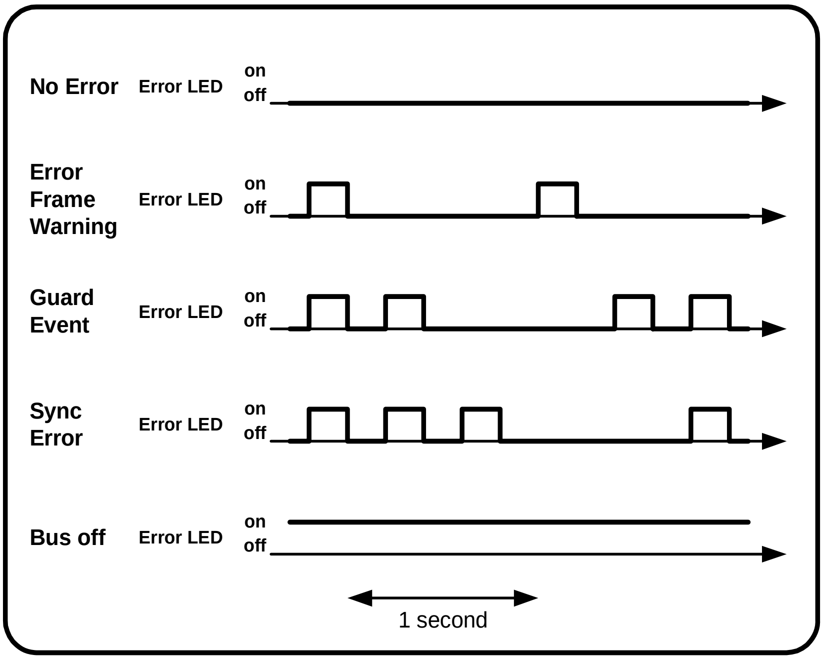


Figure 6.7 CANopen Error indicator

When the Error indicator is off the drive is CAN bus is working with no problems. When the number of error frames on the CAN bus has reached the warning level there is one short flash with a one second pause on the Error indicator. When the controller suspects it is the source of the error frames it goes bus off automatically. This is indicated by the Error indicator on continuously.

In case of a guard event or a heartbeat event the Error indicator is flashing twice with a one second pause.

When a Synchronisation message hasn't been received in time this is indicated with a triple flash and a one second pause.

6.12 Data Type Parameters

For reference purposes and for mapping of dummy entries into PDOs, the following parameters are available:

6.12.1 Data Type Parameters

Parameter Name	CANopen Index	CANopen sub index	PDO mapping	Data Type	Access	Default Value	Minimum Value	Maximum Value	Units	Storage Type	Data Group	Field Number
data_type_u08	0x0005	0	yes	U32	r	-	-	-	-	N	C	12093
data_type_s08	0x0002	0	yes	U32	r	-	-	-	-	N	C	12094
data_type_u16	0x0006	0	yes	U32	r	-	-	-	-	N	C	12095
data_type_s16	0x0003	0	yes	U32	r	-	-	-	-	N	C	12096
data_type_u24	0x0016	0	yes	U32	r	-	-	-	-	N	C	12097
data_type_s24	0x0010	0	yes	U32	r	-	-	-	-	N	C	12098
data_type_u32	0x0007	0	yes	U32	r	-	-	-	-	N	C	12099
data_type_s32	0x0004	0	yes	U32	r	-	-	-	-	N	C	12100
data_type_str	0x0009	0	yes	U32	r	-	-	-	-	N	C	12101
data_type_f32	0x0008	0	yes	U32	r	-	-	-	-	N	C	12102
data_type_f64	0x0011	0	yes	U32	r	-	-	-	-	N	C	12103
data_type_pdo_communication	0x0020	0	No	U8	r	-	-	-	-	N	C	12104
data_type_pdo_mapping	0x0021	0	No	U8	r	-	-	-	-	N	C	12105
data_type_sdo_parameter	0x0022	0	No	U8	r	-	-	-	-	N	C	12106
data_type_identity_object	0x0023	0	No	U8	r	-	-	-	-	N	C	12107

Table 6.8 Data Type Parameter Access Detail

6.13 Additional Functionality Configuration

The additional functionality described in this section is not specified in the CANopen standard DS301.

6.13.1 CAN Configuration Parameter

The parameter *can_configuration* (index 0x2008, sub_index 0) is used to configure the additional functionality. The parameter is a bit mask with the individual bit definitions as shown in the table below:

Bit	Description
7 (MSB)	Reserved
6	Reserved
5	Transmit type 254/255 PDO's only if data has changed
4	Calculate SYNC period
3	Auto-start (transition to Operational state without start node command)
2	Transmit SYNC message
1	Reserved
0 (LSB)	Transmit Boot-Up Complete message

The default value for the parameter *can_configuration* is 1.
The following sections describe the effects of setting the configuration bits.

6.13.2 Boot-Up Complete

If bit 0 of parameter *can_configuration* is set to 0 then the Boot-Up Complete message is not transmitted.

If bit 0 of parameter *can_configuration* is set to 1 then the Boot-Up Complete message is transmitted. This is the default state because the boot-up complete message is specified in DS301 as mandatory.

6.13.3 SYNC Transmit

In some applications it may be necessary for the DS2100 to be the SYNC master. This can be achieved by setting bit 1 of parameter *can_configuration* to 1.
The time period for the transmitted SYNC message is programmable using the parameter *sync_pre_divider_for_sync_transmission* (index 0x2007, sub-index 0). This parameter specifies the SYNC period in multiples of 2ms. The default value for this parameter is 5 (10ms).

Note that the SYNC will only be transmitted if the CANopen state machine is in Operational mode.

6.13.4 Auto-Start

If the application does not have a NMT master then the drive CANopen state machine can be configured to transition directly to Operational mode after power-up or reset. This can be achieved by setting bit 3 of parameter *can_configuration* to 1.

6.13.5 Calculate SYNC Period

This feature enables the drive to calculate the SYNC period from the first *n* SYNC messages received by the DS2100. The number of SYNC messages used to calculate the SYNC period is programmable via the parameter *sync_number_pulses_measured* (index 0x2006, sub-index 0). The default value for this parameter is 5.

This feature is enabled by setting bit 4 of parameter *can_configuration* to 1.

6.13.6 Check for PDO Data Changed

This feature is only used for type 254 and 255 transmit PDO's and enables the frequency of transmit PDO's to be reduced by checking for a change in the data content before transmitting the PDO. When enabled, by setting bit 5 of parameter *can_configuration* to 1, this feature is used for all type 254 and 255 PDO's configured in the drive.
The data content is compared to the data the last time the PDO was transmitted and the PDO is only transmitted if the data has changed.

6.13.7 Recovery From Bus-Off

This allows automatic recovery from a CAN controller bus-off condition by waiting for a programmable period of time from the bus-off event before re-enabling the CAN bus on the drive. The time before re-enabling is set by parameter *can_bus-off_recovery_time_(ms)* which is defined in multiples of 1ms. If this parameter is set to 0 then the bus-off recovery function is inactive. The default value for this parameter is 0.

6.13.8 Additional Functionality Configuration Parameters

Parameter Name	CANopen Index	CANopen sub-index	PDO mapping	Data Type	Access	Default Value	Minimum Value	Maximum Value	Units	Storage Type	Data Group	Field Number
CAN Configuration												
can_configuration	0x2008	0	no	U8	rw	1	-	-	-	C	C	12114
sync_pre_divider_for_sync_transmission	0x2007	0	no	U8	rw	5	1	-	-	C	C	12113
sync_number_pulses_measured	0x2006	0	no	U8	rw	5	2	-	-	C	C	12112
can_bus-off_recovery_time_(ms)	0x200D	0	no	U32	rw	0	-	2000000	ms	C	C	12121

Table 6.9 Additional Functionality Configuration Parameter Access Detail

PAGE INTENTIONALLY BLANK

SECTION 7: CANOPEN DRIVE PROFILE: DS402

TABLE OF CONTENTS

7.1 Introduction

CAN is an abbreviation for the Controller Area Network. This is a high-speed serial interface that was designed for use in Automotive and Industrial applications.

The DS2100 CAN implementation is based on standards from the CANOpen group within the CiA (CAN in Automation) organisation. The two standards of particular relevance are: -

- DS301 – CANOpen Application Layer and Communication Profile Version 4.0.2, 13-Feb-2002
- DS402- CANOpen Device Profile Drives and Motion Control Version 2.0, 26-July-2002.

These standards are available from the CiA at www.can-cia.de

This DS301 implementation has been outlined in the previous section. The section outlines the DS402 implementation. The chapter does not aim to duplicate all the information that is contained in the CANOpen standards, but rather will outline the functionality and parameter sets which have been implemented, with specific emphasis on the areas where the implementation differs from the standard. Each of these standards outline a profile (i.e. a definition of parameters, values, functionality, etc...), which outlines what is required to configure and use drive functions over CAN.

- The DS301 standard is particularly concerned with set-up of the parameters relating to the CAN itself, in order to provide communication to the drive, and has already been outlined.
- The DS402 standard builds on top of this standard to implement a drive profile, by outlining functionality (e.g. homing mode, position mode, etc….), and the parameters relating to these drive functions. The main advantage of such a profile is with regard to system integration and device standardisation, since by implementing a profile, standard drive functionality, parameter numbers, etc.. is implemented on the Moog drive.

The subsections of this manual are in a similar order to their corresponding sections in the CiA standard, allowing for easy comparison and cross-referencing by the user.

7.2 References

Ref Number	Description	Rev
1	CiA Draft Standard 301. CANOpen Application Layer and Communication Profile	Version 4.0.2, 13-Feb-2002
2	CiA Draft Standard Proposal 402. CANOpen Device Profile Drives and Motion Control	Version 2.0, 26-July-02

7.3 Acronyms and Abbreviations

CAN	Controller Area Network; Internally standardized serial bus system,
CiA	CAN in Automation
COB	Communication Object; A unit of transportation in a CAN network
COB-ID	Communication Object Identifier; Used to uniquely identify each COB in a CAN Network.
DTM	Direct Torque Mode
PDO	Process Data Object
RPDO	Receive Process Data Object
SDO	Service Data Object
TPDO	Transmit Process Data Object

7.4 Naming /Format Conventions

- Each section includes an "*issues*" sub-section. This sections highlights assumptions made on items not defined in DS402, interpretations of DS402 issues, manufacturer specific parameters, minor items of information, etc…
- When referring to parameters these are indicated by name, and their parameter number. If the parameter number is such that it has a non-zero sub index this is also included.

  e.g. *ds402 position range min* (0x607B/1)

  The Type of the various parameters is indicated by abbreviations, e.g. U32 corresponds to an unsigned 32 bit quantity, S08 corresponds to a signed 8 bit quantity, etc….

7.5 Revision History

Number	*Description*	*Version*	*Date*
1	First Draft of Document	0.1	28-11-03
2	Second Draft of Document, update CAN wiring, remove 301 section, Add DPM, Add Sequence move Diagrams, Update with DVT issues.	0.2	4-3-04
3	Third Draft of Document, Remove wiring section, update with parameter sets, remove homactlow	0.3	17-3-04
4	Fourth Draft of Document, Add Factor error table, rename parameters, remove comments, fix minor errors.	0.4	22-3-04
5	Add DPM without trigger, removed index pulse set up, Add motor name, home error window, landscape tables, Factors examples and formulae, and interpolation diagram.	0.5	13-4-04
6	Minor Updates (changing modopr, Not saving modopr, etc..)	0.6	21-4-04

7.6 Overview

DS402 particularly focuses on the demand generation aspects of motion control. The standard does not define parameters for motor or drive configuration, nor does it define parameters for control loop configuration. These manufacturer specific parameters are contained in manufacturer specific records or parameter sets, with a parameter number assigned by DS402. The diagram below shows the DS402 modes that are implemented for the DS2100 drive.

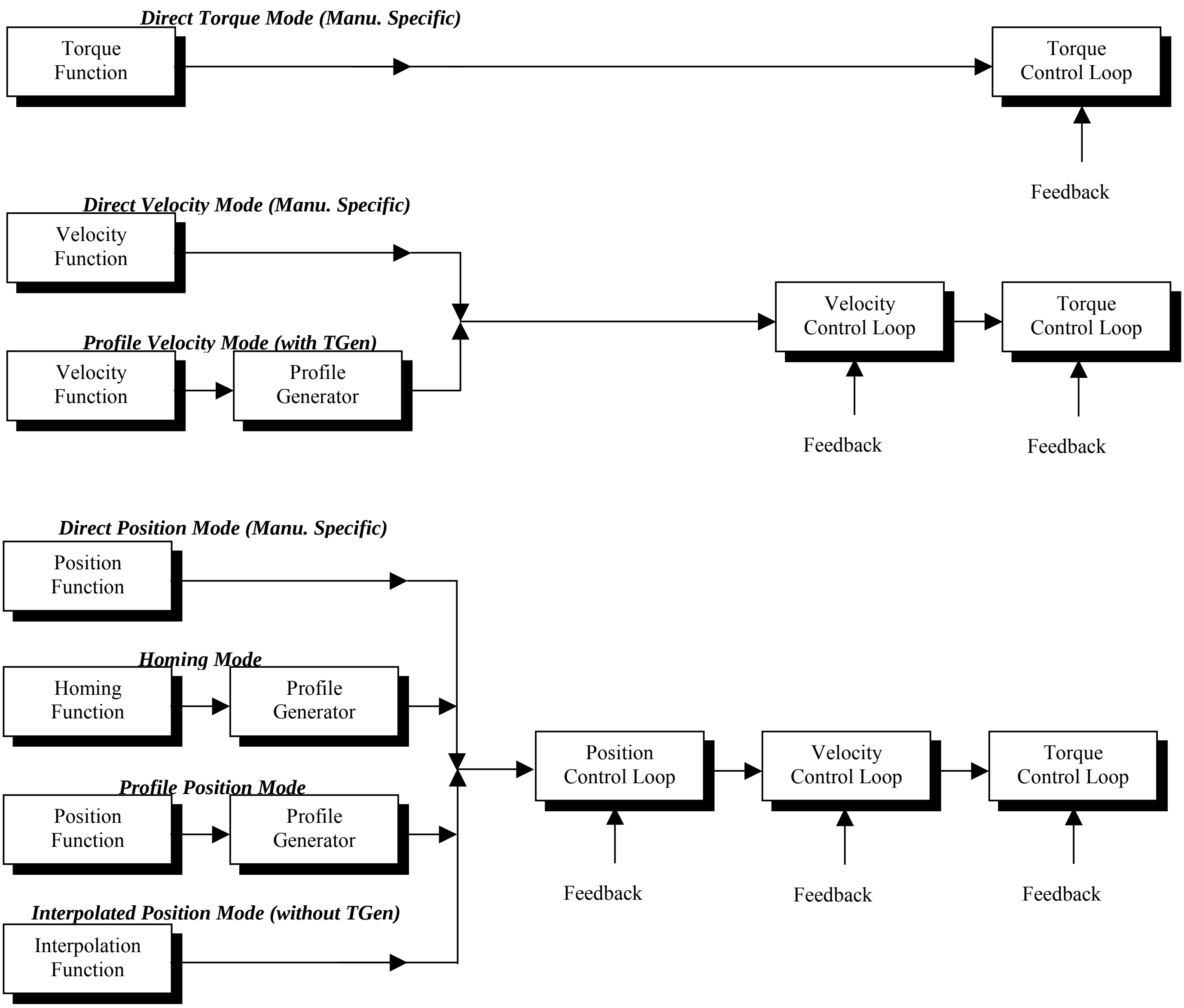


Figure 7.1 Functional DS402 Architecture.

7.7 Emergency Messages

Error messages are triggered by internal errors in the Drive. An Error Code field within an error message defines the cause of the error. DS402 extends the list of error codes listed in DS301 to more specific drive related errors. The following Emergency messages will be sent, when drive faults, corresponding to F1..F15 occur.

Emer. Msg	*ErrReg*	*DS402 Meaning*	*Description*
0x2340	0x03	Current on output side: Short Circuit	Power Stage Short Circuit Fault
0x3210	0x05	Voltage: DC Link Over-voltage	DC Bus Over Voltage Fault
0x2310	0x03	Device Hardware: Power Section	Regen. Fault
0x4110	0x09	Temperature: Excess Ambient Temp.	Ambient Over temperature Fault
0x4210	0x09	Temperature: Excess Temp. Device	Bridge Over temperature Fault
0x4310	0x09	Temperature: Excess Temp. Drive	Motor Over temperature Fault
0x7305	0x01	Add Modules: Sensor: Incremental sensor 1 fault.	Encoder Fault
0x7303	0x01	Add Modules: Sensor: Resolver 1 Fault	Resolver Fault
0x5100	0x01	Device Hardware: Supply	Logic/Analog Supply Fault
0x5530	0x01	Device Hardware: Non-volatile data memory	Database / NVM Fault
0x8100	0x11	Monitoring : Communication	CAN Fault
0x3200	0x05	Voltage: DC link voltage	DC Bus Fault
0x6100	0x01	Device Software: internal software	Program Fault
0x2300	0x03	Current on device output side	Current Loop Fault
0x5200	0x01	Device Hardware: Control	Board Fault

Table 7.1 List of 402 Emergency Messages

7.8 Predefined Objects

Some default values for communication objects that are not listed in the communication profile [1] are defined by DS402 [2]. The mandatory mappings of the Control Word into the Receive PDO, and the Status Word into the Transmit PDO have been implemented. In addition since 4 RPDO and 4 TPDO are implemented, the mappings for this Objects are also implemented, however only the first RPDO and TPDO are not inhibited, the other PDO's are inhibited by default. The following table lists the predefined object parameters that are implemented :-

Index	Name	Comment
0x1000	device type	Value =0x20192, (servo drive + profile = 0x192 = 402)
0x1001	error register	Bit 5 the device profile specific bit is not used.
0x1400 /	rpdo Comm. Set-up	
0x1400 / 1	pdo 1st receive cob-id	0x40000201 (No RTR, 200 + Nodide)
0x1400 / 2	pdo 1st receive transmission type	255 (Profile Specific)
0x1401 / 1	pdo 2nd receive cob-id	0xC0000301 (Inhibit, No RTR, 300 + Nodide)
0x1401 / 2	pdo 2nd receive transmission type	255 (Profile Specific)
0x1402 / 1	pdo 3rd receive cob-id	0xC0000401 (Inhibit,No RTR, 400 + Nodide)
0x1402 / 2	pdo 3rd receive transmission type	255 (Profile Specific)
0x1403 / 1	pdo 4th receive cob-id	0xC0000501 (Inhibit,No RTR, 500 + Nodide)
0x1403 / 2	pdo 4th receive transmission type	255 (Profile Specific)
0x1600 /	rpdo mapping	
0x1600/0	pdo 1st receive number elements	Default value = 1
0x1600 / 1	pdo 1st receive mapping	0x60,40,00,10 (ctl402)
0x1601 / 0	pdo 2nd receive number elements	2
0x1601 / 1+2	pdo 2nd receive mapping	0x60,40,00,10 (ctl402) 0x60,60,00,08 (modopr)
0x1602 / 0	pdo 3rd receive number elements	2
0x1602 / 1+2	pdo 3rd receive mapping	0x60,40,00,10 (ctl402) 0x60,7a,00,20 (ds4tarpos)
0x1603 / 0	pdo 4th receive number elements	2
0x1603 / 1+2	pdo 4th receive mapping	0x60,40,00,10 (ctl402) 0x60,ff,00,20 (vlmtarvel)
0x1800 /	tpdo Comm. Set-up	
0x1800 / 1	pdo 1st transmit cob-id	0x40000181 (No RTR, 180 + Nodide)
0x1800 / 2	pdo 1st transmit transmission type	255 (Profile Specific)
0x1801 / 1	pdo 2nd transmit cob-id	0xC0000281 (Inhibit, No RTR, +280 + Nodide)
0x1801 / 2	pdo 2nd transmit transmission type	255 (Profile Specific)
0x1802 / 1	pdo 3rd transmit cob-id	0xC0000381 (Inhibit, No RTR, + 381 + Nodide)
0x1802 / 2	pdo 3rd transmit transmission type	255 (Profile Specific)
0x1803 / 1	pdo 4th transmit cob-id	0xC0000481 (Inhibit, No RTR, 480 + Nodide)
0x1803 / 2	pdo 4th transmit transmission type	255 (Profile Specific)
0x1A00 /	tpdo mapping	
0x1A00 / 0	pdo 1st transmit number elements	1
0x1A00 / 1	pdo 1st transmit mapping	0x60,41,00,10 (sta402)
0x1A01 / 0	pdo 2nd transmit number elements	2
0x1A01 / 1	pdo 2nd transmit mapping	0x60,41,00,10 (sta402) 0x60610008 (modoprdis)
0x1A02 / 0	pdo 3rd transmit number elements	2
0x1A02 / 1	pdo 3rd transmit mapping	0x60,41,00,10 (sta402) 0x60,64,00,20 (pcposact)
0x1A03 / 0	pdo 4th transmit number elements	2
0x1A03 / 1	pdo 4th transmit mapping	0x60,41,00,10 (sta402) 0x60,6c,00,20 (vcvelact)

Table 7.2 List of predefined objects

GENERAL ISSUES

1. The standard lists all four RPDO's and TPDO's as being enabled. This is considered to be potentially confusing and also redundant, and so only the first PDO is enabled, the others, though configured, are inhibited by setting the inhibit bit in the COB-ID field.

2. The transmission type of 255, causes the PDO to be transmitted from the drive, whenever the status word changes.

7.9 Motor/Drive Parameters

All DS402 motor parameters are optional. An Error code, that corresponds to the lower 16 Bits of the pre-defined error field (0x1003), has been implemented.

Index	***Type***	***Name***
0x603F	U16	Error Code

The manufacturer specific motor data record has been implemented and is outlined in the Motor/Drive parameter table on the next page. The user should refer to the relevant section of the manual, for detailed information on each parameter.

All DS402 drive parameters are optional. The "Supported Drive Modes" parameter has been implemented, with the following modes supported.

Index	***Type***	***Name***	***Comment***
0x6502	U32	ds402 Supported Drive Modes	Support 4 standard modes + 4 manufacturer specific.

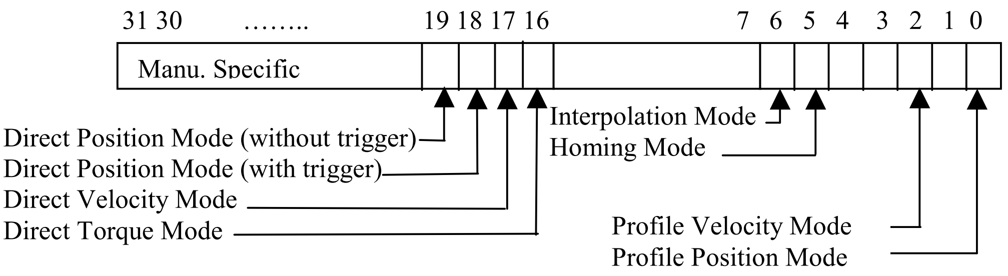


Figure 7.2 Supported Drive Modes

The drive catalog address has been implemented as shown below. The manufacturer specific drive data record has been implemented and is outlined in the Motor/Drive parameter table on the next page. The user should refer to the relevant section of the manual, for detailed information on each parameter.

Index	***Name***	***Type***	***Comment***
0x6505	http drive catalog address	String	Default value of www.moog.com

7.9.1 Motor / Drive Parameters

Parameter Name	CANopen Index	CANopen sub-index	PDO mapping	Data Type	Access	Default Value	Minimum Value	Maximum Value	Units	Storage Type	Data Group	Field Number
COMMON ENTRIES												
ds402 error code	0x603F	0	yes	u16	r	0	-	-	none	N	A	4234
MOTOR DATA RECORD												
motor name	0x6410	1	no	string	r/w	-	-	-	none	C	A	1074
motor poles	0x6410	2	no	u16	r/w	12	2	-	none	E	A	1072
motor Rtt	0x6410	3	no	f32	r/w	2.4	1.0e-9	-	Ohms	E	A	1073
motor Lq	0x6410	4	no	f32	r/w	5.180e-3	1.0e-9	-	H	E	A	1075
motor Ld	0x6410	5	no	f32	r/w	4.920e-3	1.0e-9	-	H	E	A	1076
motor ke	0x6410	6	no	f32	r/w	1.16	1.0e-9	-	V/rad/s	E	A	1077
motor max current	0x6410	7	no	f32	r/w	24.0	0.1	-	A	E	A	1078
motor max velocity	0x6410	8	no	f32	r/w	1000.0	0.0	20000.0	rad/s	E	A	1082
motor max continuous rms current	0x6410	12	no	f32	r/w	1000.0	0.1	1000.0	A	C	A	1087
DRIVE DATA												
ds402 supported drive modes	0x6502	0	yes	u32	r	0xF0065 MOD402SUP	-	-	none	N	A	1649
ds402 http drive catalog address	0x6505	0	no	string	r/w	"www.moog.com"	-	-	none	F	A	4235
DRIVE DATA RECORD												
brake lock to disable timeout	0x6510	1	no	f32	r/w	0.0	0.0	100.0	S	C	A	1004
enable to brake release timeout	0x6510	27	no	f32	r/w	0.0	0.0	100.0	s	C	A	1014
quickstop mode	0x6510	2	no	u08	r/w	1 (i.e. disable)	-	-	none	C	A	1013
internal loop demand	0x6510	3	yes	s32	r	-	-	-	inc	N	A	1034
resolver position	0x6510	4	yes	s16	r	-	-	-	inc	N	A	1057
torque max limit	0x6510	5	no	f32	r/w	9000	0	10000	Nm	C	A	1118
manual mode current limit	0x6510	6	no	f32	r/w	10.0	0.0	100.0	%	C	A	1133

manual mode velocity limit	0x6510	22	no	f32	r/w	10.0	0.0	100.0	%	C	A	4248
current limit mask	0x6510	7	no	u16	r/w	Brg,Mot,Amb,I^2T	-	-	none	E	A	1135
standby velocity	0x6510	8	no	f32	r/w	1.0	0.05	1000.0	rad/s	C	A	1138
velocity rampdown time limit	0x6510	9	no	f32	r/w	1.0	0	1000.0	s	C	A	1143
velocity actual	0x6510	10	yes	f32	r	-	-	-	inc/T_{samp}	N	A	1151
position actual	0x6510	11	yes	s32	r	-	-	-	inc	N	A	1154
velocity command	0x6510	12	yes	f32	r	-	-	-	inc/T_{samp}	N	A	1156
velocity command acceleration limited	0x6510	13	yes	f32	r	0	-	-	inc/T_{samp}	N	A	1157
velocity filter cutoff factor	0x6510	14	no	f32	r/w	0.25	0.0	100.0	none	C	A	1164
velocity filtered	0x6510	15	yes	f32	r	-	-	-	inc/T_{samp}	N	A	1165
position feedback	0x6510	16	no	u08	r/w	1	0	2	none	C	A	1168
velocity feedback	0x6510	24	no	u08	r/w	1	0	2	none	C	A	1169
velocity maximum	0x6510	28	no	f32	r/w	1000	0	20000	rad/s	C	A	1800
velocity limit	0x6510	30	no	f32	r/w	1000	0	20000	rad/s	C	A	1802
acceleration limit	0x6510	17	no	f32	r/w	1000000	0	-	rad/s^2	C	A	1335
deceleration limit	0x6510	23	no	f32	r/w	1000000	0	-	rad/s^2	C	A	1669
deceleration limit – quickstop	0x6510	25	no	f32	r/w	1000000	0	-	rad/s^2	C	A	1670
deceleration limit - fault	0x6510	26	no	f32	r/w	1000000	0	-	rad/s^2	C	A	1671
torque limit	0x6510	19	yes	u16	r/w	-	0	0xFFFF	none	N	A	1581
actual torque in Nm	0x6510	20	yes	f32	r	-	-	-	Nm	N	A	1583
brake control	0x6510	21	no	u16	r/w	1 (internal control)	-	-	none	C	A	1603
brake fault control	0x6510	18	no	u16	r/w	1 (brake if fault)	-	-	none	C	A	1505

7.10 Device Control

The following table lists the parameters that are implemented in the device control section of the device profile.

Index	*Type*	*Name*
0x6040	U16	ds402 Control word
0x6041	U16	ds402 Status word
0x6060	S08	ds402 Modes of Operation
0x6061	S08	ds402 Modes of Operation Display

Table 7.3 Table of drive control related parameters

The state machine as defined in DS402 has been implemented. The state machine is as shown below: -

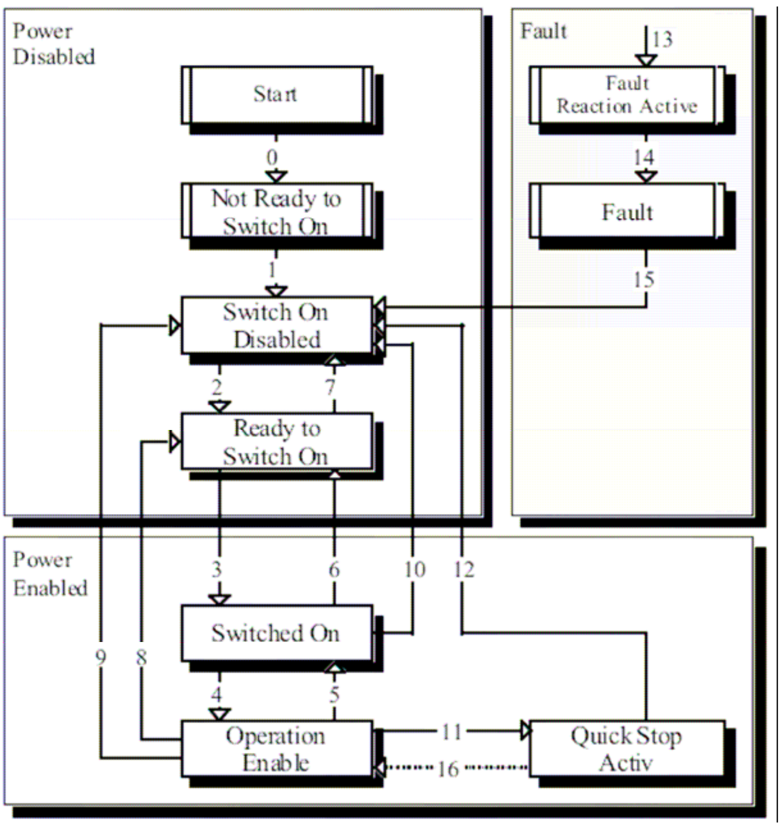


Figure 7.3 State Machine.

The control word has a number of bits that depend on the mode of operation that has been selected for the drive, and a number of bits that control the transitions of the state machine. The bits of the control word are outlined below: -

MSB 15	14 11	10 9	8	7	6 4	3	2	1	LSB 0
Brake control	Not used	Reserved	halt	Fault reset	Operation mode specific	Enable operation	Quick stop	Enable voltage	Switch on

Figure 7.4 Control Word Bits

Bits 0…3, and Bit 7 in the control word control the transitions between the drive states. The table below lists the commands that are issued by setting the appropriate control word bits.

Command	Bit of the control word						Transitions
	Brake control	Fault Reset	Enable operation	Quick stop	Enable voltage	Switch on	
Shutdown	X	0	X	1	1	0	2,6,8
Switch on	X	0	0	1	1	1	3*
Switch on	X	0	1	1	1	1	3**
Disable voltage	X	0	X	X	0	1	7,9,110,12
Quick stop	X	0	X	0	1	X	7,10,11
Disable operation	X	0	0	1	1	1	5
Enable operation	X	0	1	1	1	1	4,16
Fault reset	X	↑	X	X	X	X	15
Apply Brake	↑	X	X	X	X	X	In any state***
Release Brake	↓	X	X	X	X	X	In any state***

Figure 7.5 Control Word Commands/Transitions

Bits marked X are irrelevant except that a transition on ‘brake control’ will always cause the indicated action
* … In the state SWITCHED ON the drive executes the functionality of this state
** … No functionality in the state SWITCHED ON
*** .. The brake control will cause the indicated action except in the START or NOT READY TO SWITCH ON

The status word describes the state of the drive. The tables below lists the meaning of each bit, with later sections outlining the operation mode specific bits, and the state of the drive, indicated by the settings of these bits.

Bit	Description
0	Ready to switch on
1	Switched on
2	Operation enabled
3	Fault
4	Voltage enabled
5	Quick stop
6	Switch on disabled
7	Warning
8	Not used
9	Remote
10	Target reached
11	Internal limit active
12 – 13	Operation mode specific
14	Not used
15	Brake applied

Value (binary)	State
xxxx xxxx x0xx 0000	Not ready to switch on
xxxx xxxx x1xx 0000	Switch on disabled
xxxx xxxx x01x 0001	Ready to switch on
xxxx xxxx x01x 0011	Switched on
xxxx xxxx x01x 0111	Operation enabled
xxxx xxxx x00x 0111	Quick stop active
xxxx xxxx x0xx 1111	Fault reaction active
xxxx xxxx x0xx 1000	Fault

Figure 7.6 Status Word Bits

The modes of operation reflect the supported drive modes listed earlier, and can have the following values.

Value	*Description*
-4	Direct Position Mode (without trigger)
-3	Direct Position Mode (with trigger)
-2	Direct Velocity Mode
-1	Direct Torque Mode
1	Profile Position Mode
3	Profile Velocity Mode
6	Homing Mode
7	Interpolated Position Mode

Table 7.4 Table of modes of operation values

GENERAL ISSUES

1. The Mode of operation is not saved to Non-Volatile Memory, and must be set after power-up/reset.

2. Changing the mode of operation, changes the demand value for the loop, dependent on the mode of operation selected :-
   - Switching to Position Mode, the current position is sampled.The demand (not target value) is set to this value, to avoid large jumps in demand value. Start new move, by setting set-point bit, or changing target.
   - Switching to Velocity Mode, the demand (not target value) is set to zero. Must write to target to set velocity.
   - Switch to Torque Mode, the demand (not target value) is set to zero. Must write to target to set torque.

3. An additional transition directly from Ready to Switch-On to Operation Enable is allowed, and is listed as transition 17.

   NOTE:- Upon request of a transition to the operation-enabled state, the drive checks if an enable is allowed (e.g. Hardware enable is set, and Bus is active), otherwise the transition does not occur.

4. Default operation of the quickstop is to transition to switch on disabled state, since the default value of quickstop_mode=1. By setting quickstop_mode=0, this can be altered to remain in the quickstop state, after quickstop, and thus Transition 16 listed in DS402 can occur, if after/during quickstop ctl402 is set to 0xF

5. The warning bit is set in the status word, whenever warnings occur in the drive (i.e. U1..U8) as displayed on the drives 7 segment display.

6. The manufacturer specific bits are not used or set in the control or status words.

7. The remote bit indicates if the device is in local or remote operation. Local mode being where commands / Inputs sent over CAN are ignored by the drive, but status information is still sent by the drive. This bit is set constantly in the DS2100 implementation since CAN is always used to command the drive.

8. The internal limit active bit is set only in the case of current limiting.

9. The bits that are dependent on mode of operation are outlined in their appropriate relevant sections.

10. Enabling/Disabling of the drive via the serial text interface, GUI toolbar, should not be mixed with control of the drive via the 402 state machine. As serial text modifications will not affect the 402 state machine.

7.10.1 Device Control Parameters

Parameter Name	CANopen Index	CANopen sub-index	PDO mapping	Data Type	Access	Default Value	Minimum Value	Maximum Value	Units	Storage Type	Data Group	Field Number
COMMON ENTRIES												
ds402 control word	0x6040	0	yes	u16	r/w	0	-	-	none	N	A	1650
ds402 status word	0x6041	0	yes	u16	r	0	-	-	none	N	A	1651
ds402 modes of operation	0x6060	0	yes	s08	r/w	0	-	-	none	N	A	1652
ds402 modes of operation display	0x6061	0	yes	s08	r	0	-	-	none	N	A	1653

7.11 Factors Group

A group of parameters are defined in DS402 for scaling between physical units used by the user, and the internal units of the drive. The group consists of two sets of parameters. These consist of a set of input parameters, which when combined, generate a set of output factors / parameters. The input parameters include notation and dimension indices, position and velocity encoder resolutions, feed constant, and gear ratio.

- A notation index indicates the power of ten, relating to the specific index. (e.g. 2 => 10^2)
- A dimension indicates the SI unit relating to the specific index. (e.g. radians, degrees, etc...)

The outputs factors are used to scale from various physical units to internal units, as shown in the diagram below: -

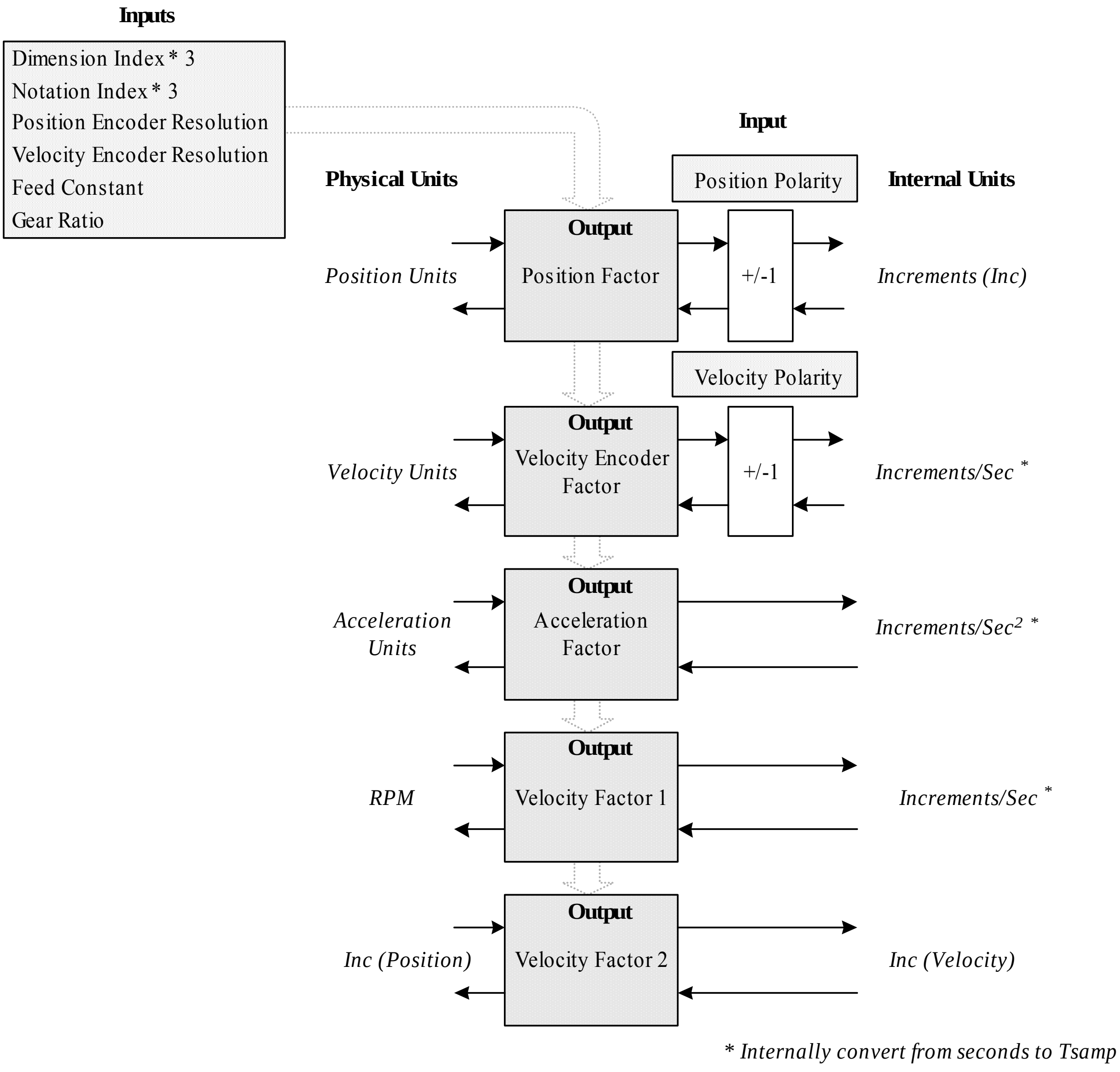


Figure 7.7 Factor Group overview.

Fractional types are implemented as arrays consisting of unsigned 32 values for numerator and denominator. The input parameters are listed below: -

Index	***Name***	***Type***	***Comment***
0x6089	ds402 position notation index	S08	Default value = 0
0x608A	ds402 position dimension index	U08	Default value = 0x41, i.e. degrees.
0x608B	ds402 velocity notation index	S08	Default value = 0
0x608C	ds402 velocity dimension index	U08	Default value = 0xA4, i.e. rpm
0x608D	ds402 acceleration notation index	S08	Default value = 0
0x608E	ds402 acceleration dimension index	U08	Default value = 0xAF, i.e. rev/sec^2
0x608F	ds402 position encoder resolution	Fraction	Inc. per Rev
0x608F/0	number of entries	U08	Fixed value =2
0x608F/1	increments	U32	Default value = 65536
0x608F/2	revolutions	U32	Default value = 1
0x6090	ds402 velocity encoder resolution	Fraction	Inc/sec per Rev/sec
0x6090/0	number of entries	U08	Fixed value = 2
0x6090/1	increments per second	U32	Read-Only with fixed value of 65536
0x6090/2	revs per second	U32	Read-Only with fixed value of 1
0x6091	ds402 gear ratio	Fraction	Motor revs per driving revs
0x6091/0	number of entries	U08	Fixed value = 2
0x6091/1	motor revs	U32	Default value = 1
0x6091/2	shaft revs	U32	Default value = 1
0x6092	ds402 feed constant	Fraction	Feed pos. per driving revs
0x6092/0	number of entries	U08	Fixed value = 2
0x6092/1	Feed	U32	Default value = 360, (pos dimension=degrees)
0x6092/2	shaft revs	U32	Default value = 1
0x607E	ds402 polarity	Unsigned8	Bits to invert demand/actual position/velocity.
0x2861/1	ds402 factor calculate	Unsigned8	Calculate scale factors from factor group input

Table 7.5 Table of input parameters for the factors group

When values are written to the parameters above, the output parameters of the group, (i.e. the factors themselves) are not calculated until the *ds402_factor_calculate* parameter is written (any value) or the *ds402_polarity* is written. This is necessary to prevent errors occurring when changing the factor group. These output factors are used to convert from the user specific units of position, velocity, or acceleration units, to internal units of increments, incs/sec (and incs/T_{samp}), and incs/sec^2 (and incs/T_{samp}^2), as shown previously

Index	***Name***	***Type***	***Comment***
0x6093	ds402 position factor	Fraction	Position units to increments
0x6093/0	number of entries	U08	Fixed value = 2
0x6093/1	numerator	U32	Default value = 1
0x6093/2	denominator	U32	Default value = 1
0x6094	ds402 velocity encoder factor	Fraction	Velocity units to incs./sec
0x6094/0	number of entries	U08	Fixed value = 2
0x6094/1	numerator	U32	Default value = 1
0x6094/2	denominator	U32	Default value = 1
0x6095	ds402 velocity factor 1	Fraction	Velocity units to RPM
0x6095/0	number of entries	U08	Fixed value = 2
0x6095/1	numerator	U32	Default value = 1
0x6095/2	denominator	U32	Default value = 1
0x6096	ds402 velocity factor 2	Fraction	Pos enc res. / vel. enc. res. (fixed at 1/1)
0x6096/0	number of entries	U08	Fixed value = 2
0x6096/1	numerator	U32	Default value = 1
0x6096/2	denominator	U32	Default value = 1
0x6097	ds402 acceleration factor	Fraction	Accel units to incs./sec^2
0x6097/0	number of entries	U08	Fixed value = 2
0x6097/1	numerator	U32	Default value = 1
0x60972	Denominator	U32	Default value = 1
0x2861/0	ds402 factor error	U08	Most Recent Factors Error Code

Table 7.6 Table of output parameters for the factors group

The formulae used to generate the factors are different for linear and rotational cases. The following two sections list the formulae used, and show examples of their use for both rotational and linear cases.

ROTATIONAL EXAMPLE

Consider the case of a rotational example as shown below. Consider for example that the position encoder resolution (feedback) is 65536 increments/rev (e.g. using resolver), the gear ratio is 1:2, and that the position units are in .1 of a degree, velocity units are in rpm, and acceleration units are in rev/sec^2.

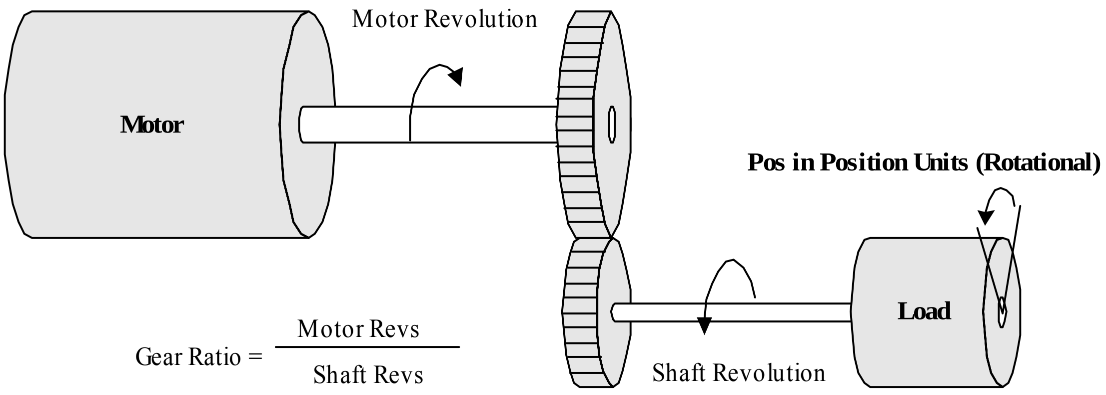


Figure 7.8: - Rotational Factor Example.

The following input values, will result in the output factors listed below: -

ds402 position notation index = -1	ds402 acceleration dimension index 0xAF (rev/sec^2)
ds402 position dimension index = 0x41 (degrees)	ds402 position encoder resolution = 65536 / 1
ds402 velocity notation index = 0	ds402 velocity encoder resolution = 65536 / 1 (Fixed)
ds402 velocity dimension index = 0xA4 (rpm)	ds402 gear ratio = 1/2
ds402 acceleration notation index = 0	ds402 feed constant = 360 / 1

$$Position\ Factor = \left(\frac{position\_encoder\_resolution \times gear\_ratio}{feed\_const.}\right) \times 10^{PosNotIndex}$$

$$= \left(\frac{65536/1 \times 1/2}{360/1}\right) \times 10^{-1} = \frac{65536}{7200}\ \textit{incs per position unit}$$

$$Velocity\ Encoder\ Factor = \left(\frac{velocity\_encoder\_resolution \times gear\_ratio}{vel\_units\ (in\, rev/\sec)}\right) \times 10^{VelNotIndex}$$

$$= \left(\frac{65536/1 \times 1/2}{60}\right) \times 10^{0} = \frac{65536}{120}\ \textit{incs/sec per velocity unit}$$

$$Acceleration\ Factor = \left(\frac{velocity\_encoder\_resolution \times gear\_ratio}{accel\_units\ (in/\sec^2)}\right) \times 10^{AccNotIndex}$$

$$= \left(\frac{65536/1 \times 1/2}{1/1}\right) \times 10^{0} = \frac{65536}{2}\ \textit{incs/sec2 per acceleration unit}$$

$$Velocity\ Factor\ 1 = \left(\frac{vel\_units(in\ rev/\sec)}{60 \times gear\_ratio}\right) \times \frac{1}{10^{VelNotIndex}}$$

$$= \left(\frac{60}{60 \times 1/2} \right) \times \frac{1}{10^0} = \frac{2}{1} \text{ velocity unit per motor rpm}$$

$$Velocity\ Factor\ 2 = \left(\frac{position\_encoder\_resolution}{velocity\_encoder\_resolution} \right) = \frac{65536}{65536} \text{ pos and vel. resolution same}$$

These factors are used as shown in each of the subsequent sections to scale from the units specified by the user, to the correct internal value to be used internally in the drive. This allows the user to work in the preferred units, while the drive implements the correct scaling.

NOTE:- Due to the fixed point nature of the factors (i.e. U32 / U32), and the 2^{32} range of their resolution, position units of radians require a scaling of a floating point number (i.e. 2π). For example, if the Position Dimensions is in radians (i.e. 0x10), and the encoder resolution is 65536, then the Position Factor is 65536/2π. This is implemented in fixed point, by setting the numerator to nearly it's full numerical range of 2^{32} , and setting the denominator accordingly. :-

$$Position\ Factor = \left(\frac{65536}{1} \times \frac{65535}{(U32)65535 * 2\pi} \right) = \frac{4294901760}{411768} = 10430.39$$

This compares to a value of 10430.37, when floating point arithmetic is used.

LINEAR EXAMPLE

Consider the case of a linear example as shown below. Consider for example that the position encoder resolution (feedback) is 2^{20} i.e. 1048576 increments/rev (e.g. using encoder encinc = 2048, and encres = 9), the gear ratio is 1:1, and the feed constant is 50000 µm/rev. The velocity should be in µm/sec, and acceleration in µm/sec^2.

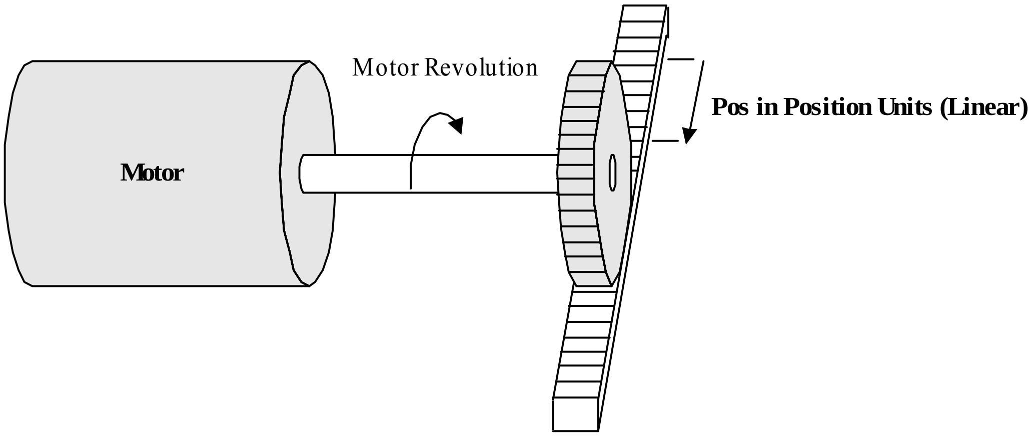


Figure 7.9 Linear Factor Example.

The following input values, will result in the output factors listed below: -

ds402 position notation index = -6	ds402 acceleration dimension index 0x55 (m/sec^2)
ds402 position dimension index = 0x01 (metres)	ds402 position encoder resolution = 1048576 / 1
ds402 velocity notation index = -6	ds402 velocity encoder resolution = 65536 / 1 (Fixed)
ds402 velocity dimension index = 0xA6 (m/sec)	ds402 gear ratio = 1/1
ds402 acceleration notation index = -6	ds402 feed constant = 50000 / 1

$$Position\ Factor = \left(\frac{position\_encoder\_resolution \times gear\_ratio}{feed\_const}\right)$$

$$= \left(\frac{1048576/1 \times 1/1}{50000/1}\right) = \frac{1048576}{50000}\ \textit{incs per position unit}$$

$$Velocity\ Encoder\ Factor = \left(\frac{vel\_enc\_res \times gear\_ratio \times \left(Pos\_units/\sec\right)}{feed\_const \times vel\_units}\right) \times 10^{(VelNotIndex - PosNotIndex)}$$

$$= \left(\frac{65536/1 \times 1/1}{50000/1}\right) \times 10^{(-6-(-6))} = \frac{65536}{50000}\ \textit{incs/sec per velocity unit}$$

$$Acceleration\ Factor = \left(\frac{Vel\ Enc\ Factor \times vel\_units}{accel\_units \times \sec}\right) \times 10^{(AccNotIndex - VelNotIndex)}$$

$$= \left(\frac{65536/50000}{1}\right) \times 10^{(-6-(-6))} = \frac{65536}{50000}\ \textit{incs/sec2 per acceleration unit}$$

$$Velocity\ Factor\ 1 = \left(\frac{feed\_const \times vel\_units}{60 \times gear\_ratio \times \left({pos\_units}/{\sec} \right)} \right) \times 10^{(PosNotIndex - VelNotIndex)}$$

$$= \left(\frac{{50000}/{1}}{60} \right) \times 10^{(-6-(-6))} = \frac{50000}{60}\ \textit{velocity unit per motor rpm}$$

$$Velocity\ Factor\ 2 = \left(\frac{position\_encoder\_resolution}{velocity\_encoder\_resolution} \right)$$

$$= \left(\frac{{1048576}/{1}}{{65536}/{1}} \right) = \frac{1048576}{65536}\ \textit{pos and vel. resolution same}$$

NOTE:- It is recommended that the notations for position, velocity, and acceleration, be in a similar region. If the user were to select m/sec rather than um/sec for velocity, this would result in an additional factor of 1000000 in the velocity encoder, and acceleration factors. To avoid an overflow in the numerator the divisor is reduced, to compensate, with the numerator being set to nearly it's full numerical range of 2^{32}. This has the effect of causing a minor error in the velocity, and acceleration scaling (e.g. 0.02 % in this example). The larger the difference is in notation, the larger the error effect.

$$Velocity\ Encoder\ Factor = \left(\frac{65536}{50000} \right) \times 10^{(0-(-6))} = \frac{65536 \times 1000000}{50000} = 1310720$$

$$= \left(\frac{65536}{50000} \right) \times 10^{(0-(-6))} = \frac{65536 \times 65535}{50000 \times {65535}/{1000000}} = \frac{4294901760}{3276} = 1311020$$

NOTE:- The indices of notation and dimension selected for a particular unit, should be for the smallest unit of interest (e.g. if set units to 1mm, then cannot set any position parameter, that is in position units to smaller than 1mm.)

GENERAL ISSUES

1) The current draft of DS402 standard does not list all valid dimension types (e.g. no acceleration units defined). The following table lists the supported dimensions

Physical Dimension	***Units***	***Dimension Index***	***Linear / Rotational***
Angle/Length/Position	m.	0x01	Linear
	rad.	0x10	Rotational
	sec.	0x43	Rotational
	min	0x42	Rotational
	deg	0x41	Rotational
	revs	0xB4	Rotational
Velocity	m/sec	0xA6	Linear
	m/min	0xA7	Linear
	m/hr	0xA8	Linear
	rev/sec	0xA3	Rotational
	rev/min	0xA4	Rotational
	rev/hr	0xA5	Rotational
Acceleration	m/sec^2	0x55	Linear
	m/min^2	0xB1	Linear
	rev/sec^2	0xAF	Rotational
	rev/min^2	0xB0	Rotational

Table 7.7 Table of factor dimensions

2) Velocity Encoder Resolution is read only, and set to a fixed value of 65536/1, since internally the velocity is always scaled to correspond to 65536 increments/rev. DS402 indicates that this parameter should be writeable.

3) Velocity Factor 1 is incorrect in DS402, since it lists vel units instead of position units in denominator. The velocity factor 1 is implemented as shown earlier.

4) Acceleration Factor is incorrect in DS402, since it does not include acceleration or velocity notation indices. The factor is implemented as shown earlier.

5) Sub-Index 2 of the Position Factor is incorrectly listed as Feed Constant, when it should read divisor.

6) A mix of rotational (e.g. rev/sec) and linear units (e.g. m) is not allowed. The position, velocity and acceleration units must all be either all rotational or all linear. An error is not returned when they are not the same, since this would prevent them from ever being changed.

7) If the dimensions are rotational, the feed is set to a fixed value (e.g. always 360 degrees per rev), and will return an error if attempt to set feed when dimension is rotational.

8) When any of the inputs to the factors change, the outputs, and their dependencies are all updated.

9) The output parameters are read only, being set implicitly from the input values, they cannot be explicitly set.

10) The standard does not explicitly state if rounding should occur, or return an error, when the inputs to the factor group, cause the output values to exceed the size of fixed point 32-bit numerator or denominator. Similarly, it doesn't specify what should happen if scaling a parameter by a factor, could result in an overflow. What is implemented in both cases is that an error is returned, and a parameter called *factor error* is set to indicate the reason for the most recent error. It is recommended that factors be set initially upon configuration, and not altered subsequently. The table below lists the factors error code values, with the first 4 indicating errors in setting up the output of the factors group, and the remainder indicating errors, setting up parameters which depend/use the factors. : -

Value	*Error Code*	*Comment*
1	POS_2_INC_ERROR	Error Setting up Position Factor.
2	VEL_2_INC_PER_SEC_ERROR	Error Setting up Velocity Encoder Factor.
3	RPM_2_VEL_ERROR	Error Setting up Velocity Factor 1.
4	ACC_2_INC_PER_SEC2_ERROR	Error Setting up Acceleration Factor.
5	HOMOFF_ERROR	Error Setting up the Home Offset Value
6	POSLIMMIN_ERROR	Error Setting up the Software Position Limit Minimum
7	POSLIMMAX_ERROR	Error Setting up the Software Position Limit Maximum
8	POSRNGMIN_ERROR	Error Setting up the Position Range Limit Minimum
9	POSRNGMAX_ERROR	Error Setting up the Position Range Limit Maximum
10	TARPOS_ERROR	Error Setting up the Target Position.
11	PROVEL_ERROR	Error Setting up the Profile Velocity.
12	PROACC_ERROR	Error Setting up the Profile Acceleration.
13	HOMSWT_ERROR	Error Setting up the Homing Switch Speed.
14	HOMZER_ERROR	Error Setting up the Homing Zero Speed.
15	HOMACC_ERROR	Error Setting up the Homing Acceleration.
16	TARVEL_ERROR	Error Setting up the Target Velocity.
17	VELWIN_ERROR	Error Setting up the Velocity Window.
18	VELTHR_ERROR	Error Setting up the Velocity Threshold.
19	POSWIN_ERROR	Error Setting up the Position Window.
20	FOLERR_ERROR	Error Setting up the Following Error.

Table 7.8 Table of factors error codes

11) The gear ratio is the number of motor shaft revolutions per driving shaft revolutions. The gear ratio is not included in the feed constant.

12) The velocity encoder factor converts from velocity units to incs/sec. This is incorrectly listed as incs in DS402

13) The acceleration factor converts from acceleration units into incs/sec2. This is incorrectly listed in DS402.

14) The polarity parameter is used for both position and velocity polarities. Setting the position polarity bit will multiply the position demand value and position actual value by –1. Setting the velocity polarity bit will multiply the velocity demand value and velocity actual value by –1. The MSB (Bit 7) sets the position polarity, while Bit 6 sets the velocity polarity.

15) The encoder resolution for the factors group is set dependent on the value of encoder parameters. The resolution is set from encinc << encres. If the factor encoder resolution is changed, encres (0x2e20/5) is set-up accordingly (encinc will not change.).

7.11.1 Factor Group Parameters

Parameter Name	CANopen Index	CANopen sub-index	PDO mapping	Data Type	Access	Default Value	Minimum Value	Maximum Value	Units	Storage Type	Data Group	Field Number
NOTATION / DIMENSION												
ds402 position notation index	0x6089	0	yes	s08	r/w	0	-	-	none	C	A	4111
ds402 position dimension index	0x608A	0	yes	u08	r/w	deg	-	-	none	C	A	4112
ds402 velocity notation index	0x608B	0	yes	s08	r/w	0	-	-	none	C	A	4113
ds402 velocity dimension index	0x608C	0	yes	u08	r/w	rpm	-	-	none	C	A	4114
ds402 acceleration notation index	0x608D	0	yes	s08	r/w	0	-	-	none	C	A	4115
ds402 acceleration dimension index	0x608E	0	yes	u08	r/w	rev/sec^2	-	-	none	C	A	4116
INPUT PARAMETERS												
ds402 position encoder resolution increments (see note 1)	0x608F	1	yes	u32	r/w	65536	-	-	inc	N	A	4118
ds402 position encoder resolution revs	0x608F	2	yes	u32	r/w	1	1	-	none	C	A	4119
ds402 velocity encoder resolution increments/sec	0x6090	1	yes	u32	r	-	-	-	inc/sec	N	A	4121
ds402 velocity encoder resolution revs/sec	0x6090	2	yes	u32	r	1	1	-	rev/sec	N	A	4122
ds402 gear ratio motor revs	0x6091	1	yes	u32	r/w	1	-	-	none	C	A	4124
ds402 gear ratio shaft revs	0x6091	2	yes	u32	r/w	1	1	-	none	C	A	4125
ds402 feed constant feed	0x6092	1	yes	u32	r/w	360	-	-	none	C	A	4127
ds402 feed constant shaft revs	0x6092	2	yes	u32	r/w	1	1	-	none	C	A	4128
ds402 polarity	0x607E	0	yes	u08	r/w	0	-	-	none	C	A	4144
ds402 calculate_factors	0x2861	1	no	u08	r/w	0	-	-	none	N	A	4238
OUTPUT PARAMETERS												
ds402 positon factor numerator	0x6093	1	yes	u32	r	1	-	-	none	N	A	4130
ds402 positon factor denominator	0x6093	2	yes	u32	r	1	1	-	none	N	A	4131
ds402 velocity encoder factor numerator	0x6094	1	yes	u32	r	1	-	-	none	N	A	4133

ds402 velocity encoder factor denominator	0x6094	2	yes	u32	r	1	1	-	none	N	A	4134
ds402 velocity factor1 numerator	0x6095	1	yes	u32	r	1	-	-	none	N	A	4136
ds402 velocity factor1 denominator	0x6095	2	yes	u32	r	1	1	-	none	N	A	4137
ds402 velocity factor2 numerator	0x6096	1	yes	u32	r	1	-	-	none	N	A	4139
ds402 velocity factor2 denominator	0x6096	2	yes	u32	r	1	1	-	none	N	A	4140
ds402 acceleration factor numerator	0x6097	1	yes	u32	r	1	-	-	none	N	A	4142
ds402 acceleration factor denominator	0x6097	2	yes	u32	r	1	1	-	none	N	A	4143
ds402 factor error	0x2861	0	no	u08	r	0	-	-	none	N	A	4236

Note 1: ds402 position encoder resolution is derived from encoder increments and encoder resolution, and therefore need not be save to NVM. Setting the ds402 encoder resolution, will set the encoder resolution, but will not change the encoder increments value.

7.12 Direct Torque Mode (Manufacturer Specific)

A manufacturer specific mode for torque has been implemented, and uses parameters similar to those used in DS402's profile torque mode. The units for torque are also similar to those of profile torque mode, and are listed as per thousand for motor rated torque. The diagram below shows the parameters, and their use.

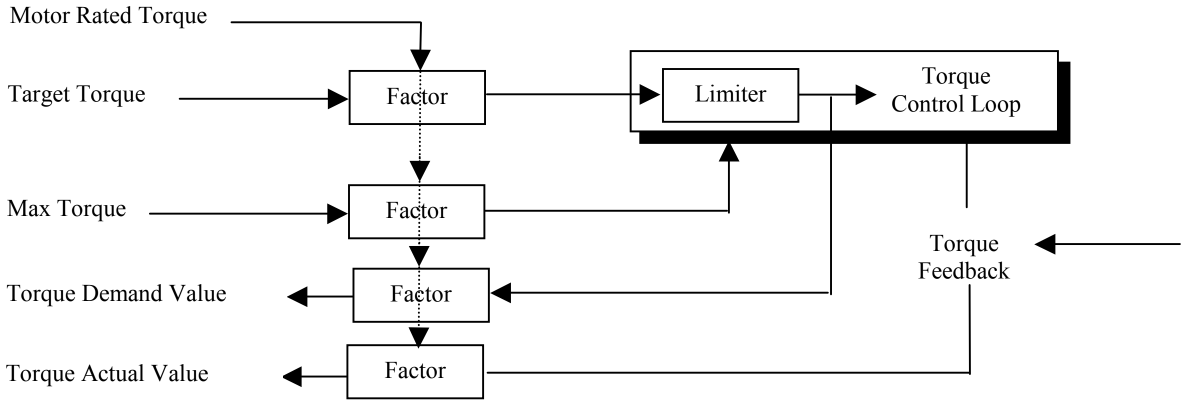


Figure 7.10 Direct Torque Mode implementation.

Index	***Name***	***Type***	***Comment***
0x6071	ds402 target torque	S16	Set-Point for Torque, in units of per thousand of rated torque (Default = 0)
0x6072	ds402 max torque	U16	Max permissible Torque, in units of per thousand of rated torque (Default = 0)
0x6074	ds402 torque demand value	S16	Output of torque limiting function, in units of per thousand of rated torque (Default = 0)
0x6076	ds402 motor rated torque	U32	In units of mNm. (rotational), or mN. (linear) (Default = 1)
0x6077	ds402 torque actual value	S16	Instantaneous Torque in the drive motor, in units of per thousand of rated torque (Default = 0)

Table 7.9 Table of direct torque mode parameters

CONTROL WORD

1. The control word implements the halt bit, as per profile torque mode. Clearing the halt bit will enable/gate the target torque. Setting the halt bit will, in effect, set torque demand to zero.

15 9	8	7	6 4	3 0
(see 10.3.1)	Halt	(see 10.3.1)	reserved	(see 10.3.1)

MSB LSB

Name	Value	Description
Halt	0	Execute motion
	1	Stop axle

Figure 7.11 Direct Torque Mode Control Word.

STATUS WORD

1. None of the operation mode specific bits in the status word are set or cleared when in Direct Torque Mode.

GENERAL ISSUES

1. Motor Rated Torque is not derived from a Motor Current Limit, and so must be set explicitly by the user. It has a default value of 1. Motor Rated Torque = Rated Current * sqrt(3)/2 * motke *1000 mNm.

2. Max Torque is a programmable limit, internal to the torque control loops, and will apply regardless of the mode of operation, since torque/current is the innermost loop.

3. Other limits such as thermal limiting, I^2T limiting, controller current limit, motor current limit, may also limit the Torque Demand Values.

4. In addition, because of the velocity limiting implemented in torque mode, the torque demand may be reduced, or set to zero, to maintain the drives speed at the velocity limit.

5. In addition two parameter sets relating to torque are defined (Torque Control, and Power stage parameter records).0 These parameters are a grouping of drive parameters into a single DS402 record. The two records are in the table on the following page. For detailed information on the meaning of the parameters, see the relevant sections.

SAMPLE SETUP

The following section gives an example of a typical setup for a direct torque move.

Index/Sub Index	*Name*	*Value*	*Comment*
0x6040	ds402 control word	0x06	Shutdown command
0x6060	ds402 modes of operation	-1	Set mode to Profile Position Mode
0x6076	dtm motor rated torque	3724	Based on motke=0.43, Rated Current = 10A.
0x6072	dtm max torque	20	Max torque = 20/1000 of rated torque = 74.48 mNm
0x6071	dtm target torque	10	Set Target Torque = 10/1000 of rated torque.
0x6040	ds402 control word	0x0F	Enable Drive command
0x6077	dtm torque actual		Read Actual Toque as approx. 10 during move
0x6041	ds402 status word		Read as 0x0237 during move
0x6040	ds402 control word	0x10F	Halt command
0x6041	ds402 status word		Read as 0x0237 when halted.

Table 7.10 Sample set-up for direct torque mode

7.12.1 Direct Torque Mode Parameters

Parameter Name	CANopen Index	CANopen sub-index	PDO mapping	Data Type	Access	Default Value	Minimum Value	Maximum Value	Units	Storage Type	Data Group	Field Number
INPUT PARAMETERS												
ds402 motor rated torque	0x6076	0	yes	u32	r/w	1	1	4294967295	0.001Nm	C	A	4226
ds402 target torque	0x6071	0	yes	s16	r/w	0	-	-	Per 1000 rated torque	N	A	4223
ds402 max torque (See note 1)	0x6072	0	yes	u16	r/w	0	-	-	Per 1000 rated torque	N	A	4224
FEEDBACK VALUES												
ds402 torque demand value	0x6074	0	yes	s16	r	0	-	-	Per 1000 rated torque	N	A	4225
ds402 torque actual value	0x6077	0	yes	s16	r	0	-	-	Per 1000 rated torque	N	A	4227
TORQUE CONTROL PARAM. SET												
current loop d-axis i-gain	0x60F6	1	no	f32	r/w	6.35404981	0.0	-	V/A/Tsamp	E	A	1272
current loop d-axis p-gain	0x60F6	2	no	f32	r/w	32.02666839	0.0	-	V/A	E	A	1274
current loop q-axis i-gain	0x60F6	3	no	f32	r/w	6.35404981	0.0	-	V/A/Tsamp	E	A	1277
current loop q-axis p-gain	0x60F6	4	no	f32	r/w	32.02666839	0.0	-	V/A	E	A	1279
current loop foldback minimum	0x60F6	5	no	f32	r/w	0.4	0.1	1.0	None	C	A	1284
current loop foldback breakpoint	0x60F6	6	no	f32	r/w	140.0	5.0	2000.0	Amp	C	A	1285
current loop d-axis error	0x60F6	7	yes	f32	r	-	-	-	A	N	A	1286
current loop q-axis error	0x60F6	8	yes	f32	r	-	-	-	A	N	A	1287
current loop alpha observer i-gain	0x60F6	9	no	f32	r/w	0.01394492	0.0	-	V/A/Tsamp	E	A	1288
current loop alpha observer p-gain	0x60F6	10	no	f32	r/w	0.19933257	0.0	-	V/A	E	A	1290
current loop beta observer i-gain	0x60F6	11	no	f32	r/w	0.01394492	0.0	-	V/A/Tsamp	E	A	1293
current loop beta observer p-gain	0x60F6	12	no	f32	r/w	0.19933257	0.0	-	V/A	E	A	1295
current loop alpha observer error	0x60F6	13	yes	f32	r	-	-	-	A	N	A	1298
current loop beta observer error	0x60F6	14	yes	f32	r	-	-	-	A	N	A	1299
POWER STAGE PARAMETER SET												

switching frequency	0x60F7	1	no	u32	r	-	-	-	Hz	N	A	1194
current controller max	0x60F7	2	no	f32	r/w	22.0	0.1	1000.0	A	F	A	1092
current max	0x60F7	3	no	f32	r	-	-	-	A	N	A	1093
current d-axis observer	0x60F7	4	yes	f32	r	-	-	-	A	N	A	1096
current q-axis observer	0x60F7	5	yes	f32	r	-	-	-	A	N	A	1097
current d-axis demand	0x60F7	6	yes	f32	r	-	-	-	A	N	A	1098
current q-axis demand	0x60F7	7	yes	f32	r	-	-	-	A	N	A	1099
current nominal sensed	0x60F7	8	no	f32	r/w	25.08	0.1	1000.0	A	F	A	1116
current actual	0x60F7	9	yes	f32	r	-	-	-	A	N	A	1119
current demand velocity comp output	0x60F7	10	yes	f32	r	-	-	-	A	N	A	1120
current demand vel loop filter output	0x60F7	11	yes	f32	r	-	-	-	A	N	A	1121
current demand pre thermal limiting	0x60F7	12	yes	f32	r	-	-	-	A	N	A	1122
controller continuous rms current	0x60F7	13	no	f32	r/w	6.0	0.1	1000.0	A	C	A	1126
I2T Window size	0x60F7	14	no	u32	r/w	25000	-	-	mSec	C	A	4239
I2T Smoothing Factor.	0x60F7	15	no	u08	r/w	4	1	49	none	C	A	4240
I2T current limit	0x60F7	16	no	f32	r	-	-	-	A	N	A	4241
bus voltage nominal	0x60F7	17	no	f32	r/w	-	-	-	V	N	A	1229
bus voltage actual	0x60F7	18	yes	f32	r	0	-	-	V	N	A	1232
GENERAL PARAMETERS												
ds402 control word	0x6040	0	yes	u16	r/w	0	-	-	none	N	A	1650
ds402 status word	0x6041	0	yes	u16	r	0	-	-	none	N	A	1651
ds402 modes of operation	0x6060	0	yes	s08	r/w	0	-	-	none	N	A	1652
ds402 modes of operation display	0x6061	0	yes	s08	r	0	-	-	none	N	A	1653
ds402 error code	0x603F	0	yes	u16	r	-	-	-	none	N	A	4234

Note 1: ds402 max torque is derived from (and can set) torque max limit and therefore need not be saved to NVM.

7.13 Direct Velocity Mode (Manufacturer Specific)

A manufacturer specific mode for velocity has been implemented, and uses parameters similar to the profile velocity mode, with the exception that the target velocity is not profiled or shaped, but rather a set-point value is used as the demand. The Velocity Control Function is required for this mode, and is outlined in section Velocity Control Function

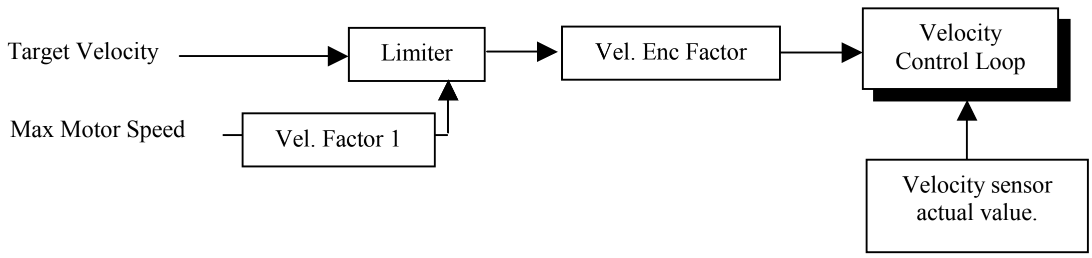


Figure 7.12 Direct Velocity Mode implementation.

Index	*Name*	*Type*	*Comment*
0x6080	ds402 max motor speed	U32	Maximum allowable speed of motor, in rpm.
0x60FF	ds402 target velocity	S32	Input / Set point for velocity, in velocity units.
0x6510/32	ds402 max_load_speed	U32	Maximum allowable speed of load in velocity units

Table 7.11 Table of direct velocity mode parameters

CONTROL WORD

1. The control word implements the halt bit, as per profile velocity mode. Clearing the halt bit will enable/gate the target velocity. Setting the halt bit will, in effect, set velocity demand to zero.

15 9	8	7 6	4 3	0
(see 10.3.1)	Halt	(see 10.3.1)	reserved	(see 10.3.1)
MSB				LSB

Name	Value	Description
Halt	0	Execute motion
	1	Stop axle

Figure 7.13 Direct Velocity Mode Control Word.

STATUS WORD

1. A target reached bit is implemented; indicating that the target velocity has been reached, within the velocity window (See Section 7.19 Velocity Control Function). If the Halt bit is set, it will indicate if the drive has stopped or not.

2. A "Speed=0" bit is implemented; indicating that the speed is at zero (less than the velocity threshold), see Section 7.19 Velocity Control Function.

15 14	13	12	11	10	9 … 0
(see 10.3.2)		Speed	(see 10.3.2)	Target reached	(see 10.3.2)
MSB					LSB

Name	Value	Description
Target reached	0	Halt = 0: *Target velocity* not (yet) reached Halt = 1: Axle decelerates
	1	Halt = 0: *Target velocity* reached Halt = 1: Axle has velocity 0
Speed	0	Speed is not equal 0
	1	Speed is equal 0

Figure 7.14 Direct Velocity Mode Status Word.

GENERAL ISSUES

1. The ds402 Max Load Speed is derived from *velocity_maximum*, and so setting either value will setup the other automatically.

2. Setting ds402 Max Load Speed, or *velocity_maximum* should be done initially at configuration, and not changed during moves, as it changes the internal scaling of the drive.

3. In the case of the drive being halted; to determine if axle has velocity 0, it is compared against a standby velocity in rads./sec. If the value is less than this value then it is considered stopped.

4. The acceleration limit is set by the acceleration limit of the drive.

SAMPLE SETUP

The following section gives an example of a typical setup for a direct velocity move.

Index/Sub Index	*Name*	*Value*	*Comment*
0x6040	ds402 control word	0x06	Shutdown command
0x6060	ds402 mode of operation	-2	Set mode to Direct Velocity Mode
0x6510/32	ds402 max load speed	6000	Set Max load speed = 6000 rpm
0x606D	ds402 velocity window	40	Set velocity window = 40 rpm
0x606F	ds402 velocity threshold	20	Set velocity threshold = 20 rpm
0x60FF	ds402 target velocity	1000	Set target velocity = 1000 rpm
0x6040	ds402 control word	0x0F	Enable Drive command
0x606C	ds402 velocity actual		Read as 1000 during move
0x6041	ds402 status word		Read as 0x637 during move
0x6040	ds402 control word	0x10F	Halt command
0x6041	ds402 status word		Read as 0x1637 when halted.

Table 7.12 Sample set-up for direct velocity mode

7.13.1 Direct Velocity Mode Parameters

Parameter Name	CANopen Index	CANopen sub-index	PDO mapping	Data Type	Access	Default Value	Minimum Value	Maximum Value	Units	Storage Type	Data Group	Field Number
INPUT PARAMETERS												
ds402 max motor speed (Note 1)	0x6080	0	yes	u32	r/w	0	-	-	rpm	N	A	4161
ds402 target velocity	0x60FF	0	yes	s32	r/w	0	-	-	vel units	N	A	4228
ds402 max load speed (Note 2)	0x6510	32	yes	u32	r/w	0	-	-	vel units	N	A	4178
FEEDBACK VALUES												
ds402 velocity sensor actual value	0x6069	0	yes	s32	r	0	-	-	incs/sec	N	A	4233
ds402 velocity demand value	0x606B	0	yes	s32	r	0	-	-	vel. units	N	A	4231
ds402 velocity actual value	0x606C	0	yes	s32	r	0	-	-	vel. units	N	A	4232
GENERAL PARAMETERS												
ds402 control word	0x6040	0	yes	u16	r/w	0	-	-	none	N	A	1650
ds402 status word	0x6041	0	yes	u16	r	0	-	-	none	N	A	1651
ds402 modes of operation	0x6060	0	yes	s08	r/w	0	-	-	none	N	A	1652
ds402 modes of operation display	0x6061	0	yes	s08	r	0	-	-	none	N	A	1653
ds402 error code	0x603F	0	yes	u16	r	-	-	-	none	N	A	4234

Note 1: ds402 max motor speed is derived from (and can set) motor max velocity and therefore need not be saved to NVM.
Note 2: ds402 max load speed is derived from (and can set) velocity_maximum and therefore need not be saved to NVM.

7.14 Profile Velocity Mode

In this mode, a target velocity is input to a profile generator. It generates a velocity demand profile for the velocity control loops, with further inputs to the profile generator rate limiting its output (e.g. max acceleration, etc…). The parameters below are used in this mode along with the parameters of the velocity control function as outlined in Section 7.19 Velocity Control Function.

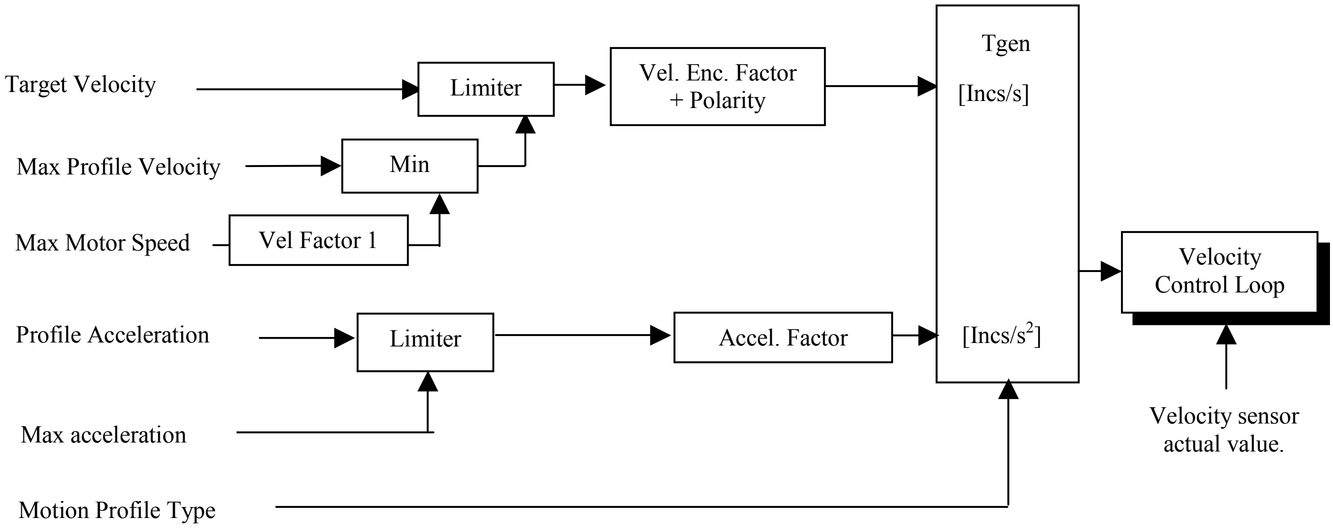


Figure 7.15 Profile Velocity Mode implementation.

Index	*Name*	*Type*	*Comment*
0x607F	ds402 max profile velocity	U32	Maximum speed allowed during a profile move, in velocity units.
0x6080	ds402 max motor speed	U32	Maximum allowable speed of motor, in rpm.
0x6510/32	ds402 max_load_speed	U32	Maximum allowable speed of load in velocity units
0x6083	ds402 profile acceleration	U32	Used to define acceleration of moves, in acceleration units.
0x6086	ds402 motion profile type	S16	Used to select the type of motion profile to perform. Only linear ramp (trapezoidal profile) is implemented.
0x60C5	ds402 max acceleration	U32	The max acceleration can be used to limit the profile acceleration. It is defined in acceleration units.
0x60FF	ds402 target velocity	S32	Input / Set point for velocity, in velocity units.

Table 7.13 Table of profile velocity mode parameters

CONTROL WORD

1. The control word implements the halt bit. Clearing the halt bit will enable/gate the target velocity. Setting the halt bit will, in effect, set velocity demand to zero. The drive will accelerate/decelerate at the profile acceleration. The location of the halt bit is the same as that shown previously for direct velocity mode.

STATUS WORD

1. A target reached bit is implemented, indicating that the target velocity has been reached, within the velocity window. If the Halt bit is set, it will indicate if the drive has stopped or not.

2. A "Speed=0" bit is implemented; indicating that the speed is at zero (i.e. less than the velocity threshold), see Section 7.19 Velocity Control Function

3. The location of the bits is the same as that shown previously for direct velocity mode.

GENERAL ISSUES

1. An internal limit in the drive may further limit the acceleration further. This *acceleration limit* parameter in rads./sec has a default value of 1000000 rads./sec. This limit is also used for quick stopping the drive.

2. If drive is enabled and moving and switch mode to profile velocity (e.g. from direct velocity mode), and if profile/maximum acceleration is set at zero, then the drive will not respond to changes in the target value, since the drive is not allowed to accelerate or decelerate.

3. Setting ds402 Max Load Speed, or *velocity_maximum* should be done initially at configuration, and not changed during moves, as it changes the internal scaling of the drive

4. The default and only value which Motion Profile Type can have is 0, (i.e. Linear ramp/ trapezoidal profile.)

5. The Max Slippage Error is not implemented, nor is the max slippage parameter, as their functionality is not clearly defined in the DS402 standard.

SAMPLE SETUP

The following section gives an example of a typical setup for a profile velocity move.

Index/Sub Index	*Name*	*Value*	*Comment*
0x6040	ds402 control word	0x06	Shutdown command
0x6060	ds402 modes of operation	3	Set mode to Profile Velocity Mode
0x60C5	ds402 max acceleration	200	Set maximum acceleration=200 rev/sec^2
0x6083	ds402 profile acceleration	100	Set profile acceleration=100 rev/sec^2
0x6510/32	ds402 max load speed	6000	Set Max load speed = 6000 rpm
0x607F	ds402 max pro velocity	6000	Set Max profile speed = 6000 rpm
0x606D	ds402 velocity window	40	Set velocity window = 40 rpm
0x606F	ds402 velocity threshold	20	Set velocity threshold = 20 rpm
0x60FF	ds402 target velocity	1000	Set target velocity = 1000 rpm
0x6040	ds402 control word	0x0F	Enable Drive command
0x606C	ds402 velocity actual		Read as 1000 during move
0x6041	ds402 status word		Read as 0x637 during move
0x6040	ds402 control word	0x10F	Halt command
0x6041	ds402 status word		Read as 0x1637 when halted.

Table 7.14 Sample set-up for profile velocity mode

7.14.1 Profile Velocity Mode Parameters

Parameter Name	CANopen Index	CANopen sub-index	PDO mapping	Data Type	Access	Default Value	Minimum Value	Maximum Value	Units	Storage Type	Data Group	Field Number
INPUT PARAMETERS												
ds402 max profile velocity	0x607F	0	yes	u32	r/w	0	-	-	vel. units	C	A	4160
ds402 max motor speed (Note 1)	0x6080	0	yes	u32	r/w	0	-	-	rpm	N	A	4161
ds402 max load speed (Note 2)	0x6510	32	yes	u32	r/w	0	-	-	vel units	N	A	4178
ds402 profile acceleration	0x6083	0	yes	u32	r/w	0	-	-	acc. units	C	A	4164
ds402 motion profile type (Note 3)	0x6086	0	yes	s16	r/w	0	-	-	none	N	A	4166
ds402 max acceleration	0x60C5	0	yes	u32	r/w	0	-	-	acc. units	C	A	4163
ds402 target velocity	0x60FF	0	yes	s32	r/w	0	-	-	vel. units	N	A	4228
ds402 velocity window	0x606D	0	yes	u16	r/w	0	-	-	vel. units	C	A	4229
ds402 velocity threshold	0x606F	0	yes	u16	r/w	0	-	-	vel. units	C	A	4230
FEEDBACK VALUES												
ds402 velocity sensor actual value	0x6069	0	yes	s32	r	0	-	-	incs/sec	N	A	4233
ds402 velocity demand value	0x606B	0	yes	s32	r	0	-	-	vel. units	N	A	4231
ds402 velocity actual value	0x606C	0	yes	s32	r	0	-	-	vel. units	N	A	4232
GENERAL PARAMETERS												
ds402 control word	0x6040	0	yes	u16	r/w	0	-	-	none	N	A	1650
ds402 status word	0x6041	0	yes	u16	r	0	-	-	none	N	A	1651
ds402 modes of operation	0x6060	0	yes	s08	r/w	0	-	-	none	N	A	1652

ds402 modes of operation display	0x6061	0	yes	s08	r	0	-	-	none	N	A	1653
ds402 error code	0x603F	0	yes	u16	r	-	-	-	none	N	A	4234

Note 1: ds402 max motor speed is derived from (and can set) motor max velocity and therefore need not be saved to NVM.
Note 2: ds402 max load speed is derived from (and can set) velocity_maximum and therefore need not be saved to NVM.
Note 3: ds402 motion profile type can only have a value of 0 (i.e. linear /trapezoidal profile)

7.15 Direct Position Mode (Manufacturer Specific)

In this mode, a target position is set and limited to create a position demand. No profile generator is used. There are two different modes of operation for direct position mode. If mode of operation is set to –3, then a trigger for the move must be set by a 0 to 1 transition in the new set-point bit of the control word (similar to profile position mode). If the mode of operation is set to –4, then no trigger is required, and simply changing the set point will cause the new set point to be assumed. In both modes the "change immediately" bit can be set or cleared to interrupt or follow the current move.

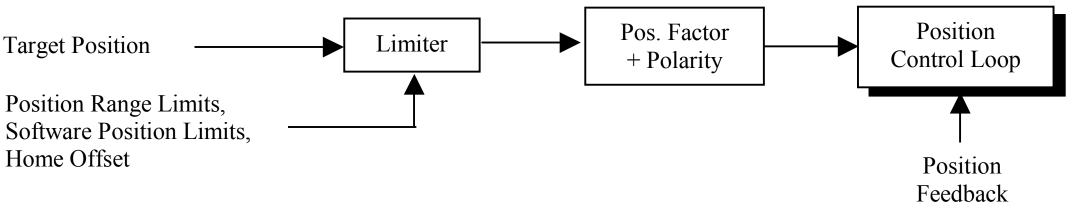


Figure 7.16 Block Diagram of Direct Position Mode

Index	*Name*	*Type*	*Comment*
0x607A	ds402 target position	U32	Input position for absolute move, in position units.
0x607B	ds402 software range limit	Array	Range limiting on demand, in position units.
0x607B/0	number of entries	U08	Fixed value = 2
0x607B/1	min	S32	Default value = -2^{31}
0x607B/2	max	S32	Default value = $2^{31}-1$
0x607D	ds402 software position limit	Array	Limit on demand in position units, relative to home position.
0x607D/0	number of entries	U08	Fixed value = 2
0x607D/1	min	S32	Default value = -2^{31}
0x607D/2	max	S32	Default value = $2^{31}-1$

CONTROL WORD

1. The control word is implemented as specified in the DS402 standard, with the following mode specific bits.

15 9	8	7	6	5	4	3 0
(see 10.3.1)		(see 10.3.1)		Change set immediately	New set-point	(see 10.3.1)
MSB						LSB

Name	Value	Description
New set-point	0	Does not assume *target position*
	0 -> 1	Assume *target position*
Change set immediately	0	Finish the actual positioning and then start the next positioning
	1	Interrupt the actual positioning and start the next positioning

Figure 7.17 Direct Position Mode Control Word

2. If mode of operation = -3 (i.e. triggered), then the "new set point" bit must see a 0 to 1 transition in order for a move to occur. If the mode of operation = -4 (i.e. non-triggered), then the "new set point" bit is ignored, and a move is triggered by changing the target position.

3. Setting the "Change Set Immediately bit", will interrupt the actual positioning, and start the next positioning. Clearing the bit will finish the actual positioning, before starting the next positioning.

STATUS WORD

1. The status word is implemented as specified in the DS402 standard, with the following mode specific bits.

15	14 13	12	11	10	9 … 0
(see 10.3.2)		Set-point acknowledge	(see 10.3.2)	Target reached	(see 10.3.2)
MSB					LSB

Name	Value	Description
Target reached	0	Halt = 0: *Target position* not reached Halt = 1: Axle decelerates
	1	Halt = 0: *Target position* reached Halt = 1: Velocity of axle is 0
Set-point acknowledge	0	Trajectory generator has not assumed the positioning values (yet)
	1	Trajectory generator has assumed the positioning values

Figure 7.18 Direct Poition Mode Status Word

2. The "target reached bit" indicates that the target position has been reached (within position window). See Section 7.20 Position Control Function.

3. The "Set point acknowledge bit" indicates if the Drive has assumed the positioning values or not. This value should be read when the new-set-point is cleared, to indicate if a subsequent move is queued or not.

GENERAL ISSUES

1. This mode supports only absolute moves. It does not support relative moves.

2. The halt bit is not used in this mode, rather the generic quickstop bit should be used.

3. The "following error bit" is not used in this mode since there is no intermediate demand value which changes over time, as there is in the case of a profile position move.

4. The speed at which the move is performed is limited by motor max velocity.

5. The purpose of the set-point acknowledge bit is to allow for sequencing of moves, when used in conjunction with the immediate bit. If the change immediate bit is set, then no sequencing of moves occurs, instead the current move is interrupted, and the new move is applied immediately, as shown below.

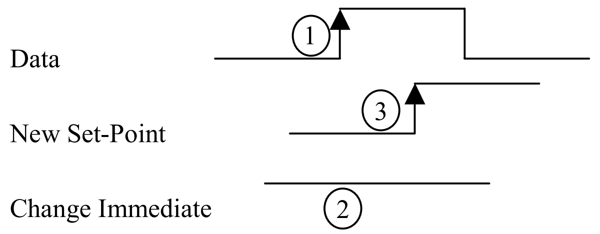


Figure 7.19 Non-Sequenced Move

1. The user downloads target position for move (velocities etc in case of profile position mode).
2. The user sets the immediate bit in the control word to cause the move to occur immediately.
3. The user sets the new set-point bit from 0 to 1, to cause move to occur.

If the immediate bit is cleared, is allows for a request-response mechanism between host and drive, to indicate when more data can be written.

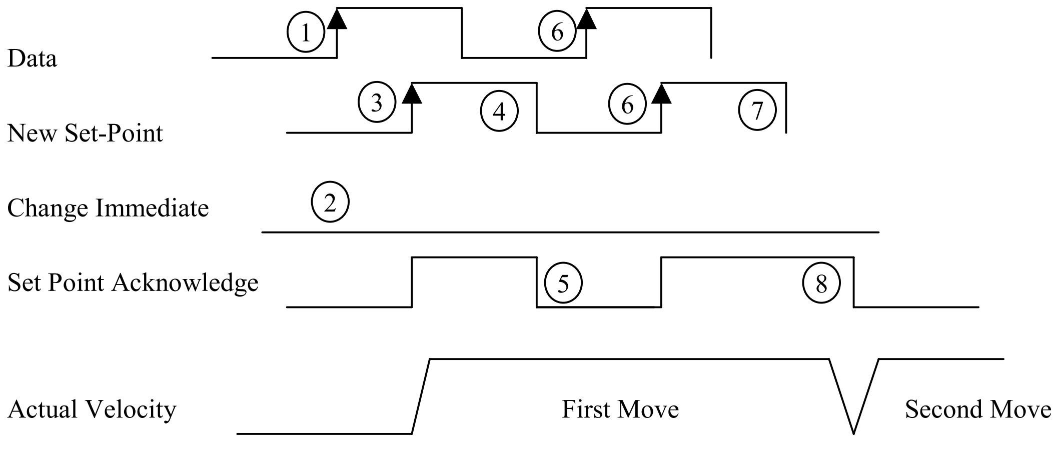


Figure 7.20 Sequenced Move

1. The user downloads a target position for a move (velocities etc in case of profile position mode).
2. The user clears the immediate bit in the control word to allow for sequencing of moves.
3. The user sets the new set-point bit from 0 to 1, to cause move to occur.
4. The user then clears the new-set point bit in the control word.
5. The user checks the set-point acknowledge is low, before writing new target parameters for a new move.
6. The user sets a new set-point, and sets the set-point bit from 0 to 1, to queue the move.
7. The user then clears the new-set point bit in the control word.
8. The Drive will clear the set-point acknowledge when the drive is ready to accept new data, i.e. when first move of sequence is complete, since in effect set of set-points is only 2 deep.

SAMPLE SETUP

The following section gives an example of a typical setup for a direct position move. It performs a move to 36000 degrees.

Index/Sub Index	*Name*	*Value*	*Comment*
0x6040	ds402 control word	0x06	Shutdown command
0x6060	ds402 mode of operation	-3	Set mode to Direct Position Mode
0x607A	ds402 target position	36000	Target Position, pos dim=degrees
0x6067	ds402 position window	2	Set position window = 2 degrees
0x6065	ds402 following error window	10	Set following error window = 10 degrees
0x6040	ds402 control word	0x0F	Enable Drive
0x6040	ds402 control word	0x3F	Set New-Set point, with immediate bit set.
0x6040	ds402 control word	0x0F	Clear New-Set point,
0x6064	ds402 position actual		Actual Position, Read at end of move = 36000
0x6063	ds402 position actual inc		Actual Position in incs = 65536000
0x6041	Ds402 status word		Read at end of move = 0x0637 (i.e. target reached bit is set.)

Table 7.15 Sample set-up for direct position mode

7.15.1 Direct Position Mode Parameters

Parameter Name	CANopen Index	CANopen sub-index	PDO mapping	Data Type	Access	Default Value	Minimum Value	Maximum Value	Units	Storage Type	Data Group	Field Number
INPUT PARAMETERS												
ds402 target position	0x607A	0	yes	s32	r/w	0	-	-	pos units	N	A	4146
ds402 position range min	0x607B	1	yes	s32	r/w	-2147483648	-	-	pos units	C	A	1644
ds402 position range max	0x607B	2	yes	s32	r/w	2147483647	-	-	pos units	C	A	1645
ds402 software position limit min	0x607D	1	yes	s32	r/w	-2147483648	-	-	pos units	C	A	4149
ds402 software position limit max	0x607D	2	yes	s32	r/w	2147483647	-	-	pos units	C	A	4150
ds402 home offset	0x607C	0	yes	s32	r/w	0	-	-	pos units	C	A	4147
ds402 following error window (Note 1)	0x6065	0	yes	u32	r/w	0	-	-	pos units	N	A	4171
ds402 position window	0x6067	0	yes	u32	r/w	0	-	-	pos units	C	A	4172
FEEDBACK VALUES												
ds402 position demand value	0x6062	0	yes	s32	r	0	-	-	pos units	N	A	4167
ds402 position demand value increments	0x60FC	0	yes	s32	r	0	-	-	incs	N	A	4168
ds402 position actual value	0x6064	0	yes	s32	r	0	-	-	pos units	N	A	4169
ds402 position actual value increments	0x6063	0	yes	s32	r	0	-	-	incs	N	A	4170
GENERAL PARAMETERS												
ds402 control word	0x6040	0	yes	u16	r/w	0	-	-	none	N	A	1650
ds402 status word	0x6041	0	yes	u16	r	0	-	-	none	N	A	1651
ds402 modes of operation	0x6060	0	yes	s08	r/w	0	-	-	none	N	A	1652
ds402 modes of operation display	0x6061	0	yes	s08	r	0	-	-	none	N	A	1653
ds402 error code	0x603F	0	yes	u16	r	-	-	-	none	N	A	4234

Note 1: ds402 following error is derived from (and can set) position error limit and therefore need not be saved to NVM.

7.16 Profile Position Mode

In this mode, a target position is input to a profile generator. It generates a position demand profile for the position control loops, with further inputs to the profile generator shaping its output (e.g. velocity, acceleration limits…)

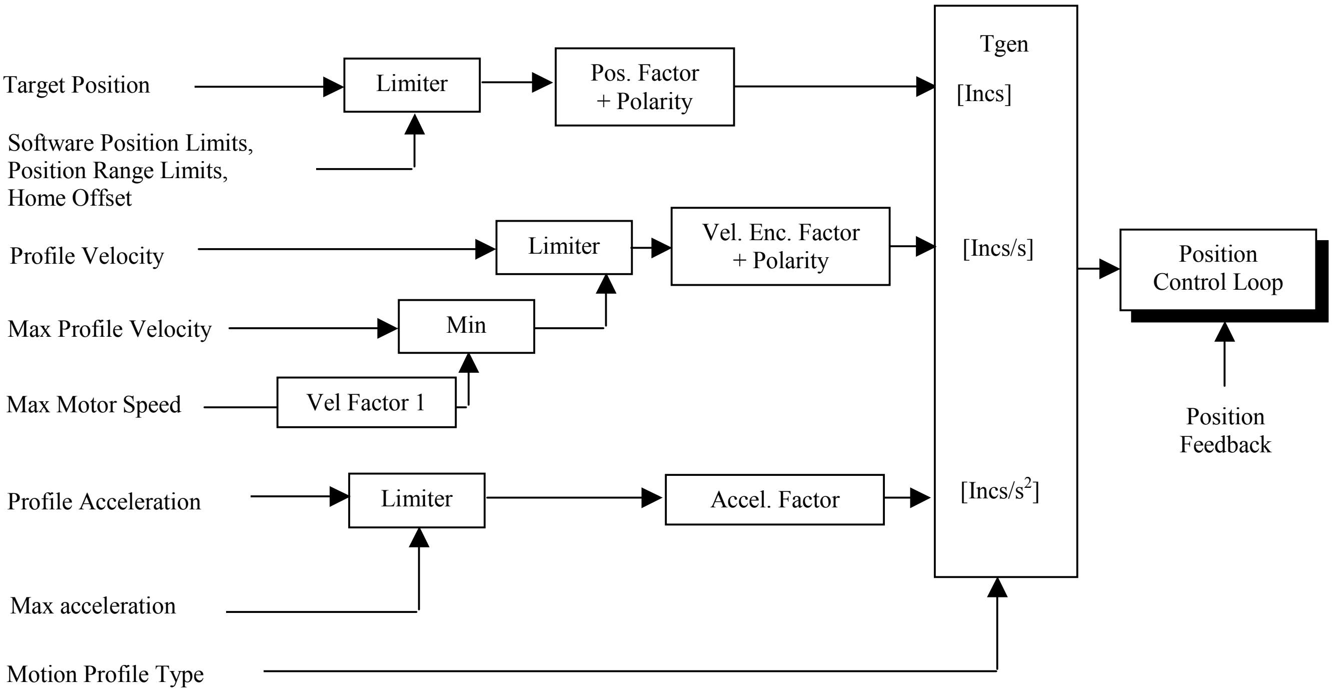


Figure 7.21 Profile Position Mode implementation.

Index	***Name***	***Type***	***Comment***
0x607A	ds402 target position	S32	Input to profile generator in position units.
0x607B	ds402 software range limit	Array	Range limiting on demand, in position units.
0x607B/0	number of entries	U08	Fixed value = 2
0x607B/1	min	S32	Default value = -2^{31}
0x607B/2	max	S32	Default value = $2^{31}-1$
0x607D	ds402 software position limit	Array	Limit on demand in position units, relative to home position.
0x607D/0	number of entries	U08	Fixed value = 2
0x607D/1	min	S32	Default value = -2^{31}
0x607D/2	max	S32	Default value = $2^{31}-1$
0x607F	ds402 max profile velocity	U32	Max. speed allowed during a profile move, in velocity units.
0x6080	ds402 max motor speed	U32	Maximum allowable speed of motor, in rpm.
0x6510/32	ds402 max_load_speed	U32	Maximum allowable speed of load in velocity units
0x6081	ds402 profile velocity	U32	Normally attained at end of accel. ramp, in velocity units.
0x6083	ds402 profile acceleration	U32	Used to define acceleration of moves, in acceleration units.
0x6086	ds402 motion profile type	S16	Only linear ramp (trapezoidal profile) is implemented.
0x60C5	ds402 max acceleration	U32	Used to limit the profile acceleration, in acceleration units.

Table 7.16 Table of profile position mode parameters

CONTROL WORD

1. The control word is implemented as specified in the DS402 standard, with the following mode specific bits.

15 … 9	8	7	6	5	4	3 … 0
(see 10.3.1)	Halt	(see 10.3.1)	abs / rel	Change set immediately	New set-point	(see 10.3.1)
MSB						LSB

Name	Value	Description
New set-point	0	Does not assume *target position*
	0 -> 1	Assume *target position*
Change set immediately	0	Finish the actual positioning and then start the next positioning
	1	Interrupt the actual positioning and start the next positioning
abs / rel	0	*Target position* is an absolute value
	1	*Target position* is a relative value
Halt	0	Execute positioning
	1	Stop axle with *profile deceleration* (if not supported with *profile acceleration*)

Figure 7.22 Profile Position Mode Control Word

2. The "new set point" bit must see a 0 to 1 transition in order for a move to occur.

3. In the control word, if the "Change immediately" bit is set, and the drive is in the middle of a move, since the Profile Generator does not support changing acceleration on the fly, the acceleration cannot be changed.

4. If during a relative move, you set the control word with the "Change immediately" bit set, this extends the existing move by the target position value.

STATUS WORD

1. The status word is implemented as specified in the DS402 standard, with the following mode specific bits.

15 … 14	13	12	11	10	9 … 0
(see 10.3.2)	Following error	Set-point acknowledge	(see 10.3.2)	Target reached	(see 10.3.2)
MSB					LSB

Name	Value	Description
Target reached	0	Halt = 0: *Target position* not reached Halt = 1: Axle decelerates
	1	Halt = 0: *Target position* reached Halt = 1: Velocity of axle is 0
Set-point acknowledge	0	Trajectory generator has not assumed the positioning values (yet)
	1	Trajectory generator has assumed the positioning values
Following error	0	No following error
	1	Following error

Figure 7.23 Profile Position Mode Status Word

2. The "target reached bit" indicates that the target position has been reached (within position window). If the Halt bit is set, it will indicate if the drive has stopped or not. See Section 7.20 Position Control Function

3. The "Set point acknowledge bit" indicates if the Profile Generator has assumed the positioning values or not. This operates the same as outlined earlier for direct position mode.

4. The "following error bit" indicates if a following error exists. (Delta between demand and actual position is greater than following error window). See Section 7.20 Position Control Function

5. The target reached bit is set for both relative and absolute moves, when the final position is reached.

GENERAL ISSUES

1. The New-Set Point has been implemented as a 0->1 transition (similar to homing mode), and as shown in Figure 17 of DS402. Whereas table 9 of DS402 indicates it as levels

2. DS402 has Set-Point Acknowledge values set incorrectly. What has been implemented is that value 0 indicates the profile generator has assumed the value, and value 1 indicates they have not been assumed.

3. In the control word, if the "Change immediately bit" is set, and the drive is in the middle of a move, and the new target position is such as to cause a reversal in direction of the drive, then the profile generator will quick-stop the drive.

4. An internal limit in the drive may further limit the acceleration further. This acceleration limit parameter in rads./sec has a default value of 1000 rads./sec. This limit is also used for quick stopping the drive.

5. If the drive is disabled via the serial text interface, the Profile generator still generates the profile, which can result in high speeds, when drive is enabled, due to large position errors.

6. If the drive is enabled, and outside a position limit, when a new position limit is set, the drive will move to this new limit, regardless of the "new-set point" bit in the control word.

7. The following error window, and position window are not implemented with a timer function, (i.e. duration for which limit must be exceeded). Instead a direct test of the absolute position versus the window value is used.

8. In the case of a relative move, the software limits, limit the size of the relative move.

9. Setting the immediate bit, and changing only the target velocity can increase the velocity during a move.

SAMPLE SETUP
The following section gives an example of a typical setup for a profile position move. It performs an absolute move of 36000 degrees, at a speed of 2000 rpm.

Index/Sub Index	*Name*	*Value*	*Comment*
0x6040	ds402 control word	0x06	Shutdown command
0x6060	ds402 mode of operation	1	Set mode to Profile Position Mode
0x607A	ds402 target position	36000	Target Position, pos dim=degrees
0x6510/32	ds402 max load speed	6000	Set Max load speed = 6000 rpm
0x607F	ds402 max profile velocity	6000	Set max. profile speed = 6000 rpm
0x6081	ds402 profile velocity	2000	Set profile speed = 2000 rpm
0x6083	ds402 profile acceleration	50	Set profile acceleration = 50 rec/sec^2
0x60C5	ds402 max acceleration	50	Set max. acceleration = 50 rec/sec^2
0x6067	ds402 position window	2	Set position window = 2 degrees
0x6065	ds402 following error window	10	Set following error window = 10 degrees
0x6040	ds402 control word	0x3F	Enable Drive, Set New-Setpoint, Set change immed bit, and absolute move
0x606C	ds402 velocity actual		Actual Velocity, Read during move = 2000
0x6064	ds402 position actual		Actual Position, Read at end of move = 36000
0x6063	ds402 position actual inc		Actual Position in incs = 65536000
0x6041	ds402 status word		Read at end of move = 0x1637

Table 7.17 Sample set-up for profile position mode

7.16.1 Profile Position Mode Parameters

Parameter Name	CANopen Index	CANopen sub-index	PDO mapping	Data Type	Access	Default Value	Minimum Value	Maximum Value	Units	Storage Type	Data Group	Field Number
INPUT PARAMETERS												
ds402 target position	0x607A	0	yes	s32	r/w	0	-	-	pos units	N	A	4146
ds402 position range min	0x607B	1	yes	s32	r/w	-2147483648	-	-	pos units	C	A	1644
ds402 position range max	0x607B	2	yes	s32	r/w	2147483647	-	-	pos units	C	A	1645
ds402 software position limit min	0x607D	1	yes	s32	r/w	-2147483648	-	-	pos units	C	A	4149
ds402 software position limit max	0x607D	2	yes	s32	r/w	2147483647	-	-	pos units	C	A	4150
ds402 home offset	0x607C	0	yes	s32	r/w	0	-	-	pos units	C	A	4147
ds402 max profile velocity	0x607F	0	yes	u32	r/w	0	-	-	vel units	C	A	4160
ds402 max motor speed (Note 1)	0x6080	0	yes	u32	r/w	0	-	-	rpm	N	A	4161
ds402 max load speed (Note 2)	0x6510	32	yes	u32	r/w	0	-	-	vel units	N	A	4178
ds402 profile velocity	0x6081	0	yes	u32	r/w	0	-	-	vel units	C	A	4162
ds402 max acceleration	0x60C5	0	yes	u32	r/w	0	-	-	acc units	C	A	4163
ds402 profile acceleration	0x6083	0	yes	u32	r/w	0	-	-	acc units	C	A	4164
ds402 motion profile type	0x6086	0	yes	s16	r/w	0	-	-	none	N	A	4166
ds402 following error window (Note 3)	0x6065	0	yes	u32	r/w	0	-	-	pos units	N	A	4171
ds402 position window	0x6067	0	yes	u32	r/w	0	-	-	pos units	C	A	4172
FEEDBACK VALUES												
ds402 position demand value	0x6062	0	yes	s32	r	0	-	-	pos units	N	A	4167
ds402 position demand value increments	0x60FC	0	yes	s32	r	0	-	-	incs	N	A	4168
ds402 position actual value	0x6064	0	yes	s32	r	0	-	-	pos units	N	A	4169
ds402 position actual value increments	0x6063	0	yes	s32	r	0	-	-	incs	N	A	4170

GENERAL PARAMETERS												
ds402 control word	0x6040	0	yes	u16	r/w	0	-	-	none	N	A	1650
ds402 status word	0x6041	0	yes	u16	r	0	-	-	none	N	A	1651
ds402 modes of operation	0x6060	0	yes	s08	r/w	0	-	-	none	N	A	1652
ds402 modes of operation display	0x6061	0	yes	s08	r	0	-	-	none	N	A	1653
ds402 error code	0x603F	0	yes	u16	r	-	-	-	none	N	A	4234

Note 1: ds402 max motor speed is derived from (and can set) motor max velocity and therefore need not be saved to NVM.
Note 2: ds402 max load speed is derived from (and can set) velocity_maximum and therefore need not be saved to NVM.
Note 3: ds402 following error is derived from (and can set) position error limit and therefore need not be save to NVM.

7.17 Interpolated Position Mode

The Interpolated Position Mode is used to control multiple coordinated axles or a single axle with the need for time-interpolation of set-point data. The Interpolated Position Mode uses the sync object as a synchronization mechanism for coordination of the related drive units. For each interpolation cycle, the drive will calculate a position demand value by interpolating positions over a period of time.

Due to real-time requirements, the scaling and limiting of the interpolation data record is done when placing the data in the input buffer. This differs from the diagram in the DS402 standard that suggests that the scaling and limiting is done in real-time. The mode is implemented using linear interpolation only, and does not include the optional limit functions for speed, acceleration and deceleration. Instead the buffer can be seen as a set of position set points for the position loop.

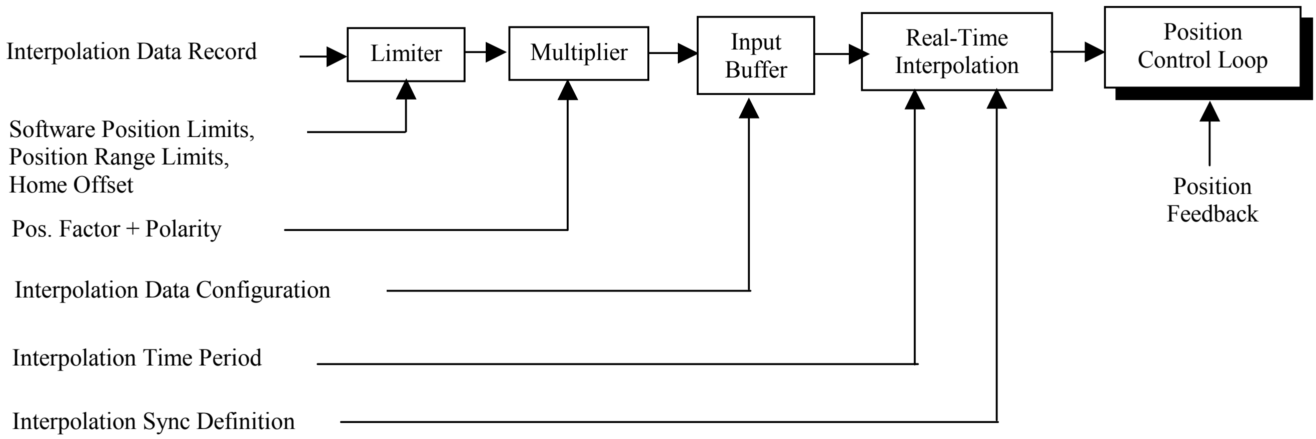


Figure 7.24 Interpolated Position Mode implementation.

The mode is implemented by writing data records into a buffer. The user writes into the data records, which in turn are written into the buffer. The data records can either have 1 or 2 entries. Single entries contain the position set points. Records with 2 entries contain set point, and a time period. In the case of single entry records, the interpolation period is defined in the interpolation period parameter. In the case of records with 2 entries, the interpolation unit is defined in the data record, but the interpolation index (e.g. 10^{-3}, or 10^{-2}, is still read from the interpolation period parameter.)

The buffer can be organised in 2 different ways, as either Ring buffer or FIFO queue, as shown in the diagram below.

- In the case of a FIFO queue, data is written into the queue (buffer position is ignored), and is read out on a first-in-first-out basis. However data is only read on the occurrence of a Synchronisation trigger, (i.e. on every n^{th} occurrence of a CAN sync message). Upon the trigger occurring, all data is read. If additional triggers occur during the resultant move, the triggers are ignored until all data is read.

- The ring buffer is where data can be written in any order into a buffer, using the buffer position parameter, and a ring pointer circularly read the contents of the buffer. There is no synchronisation to read new data from the buffer, but rather, is constantly read. This results in a periodic waveform, with the period of the waveform dependent on the size of the buffer.

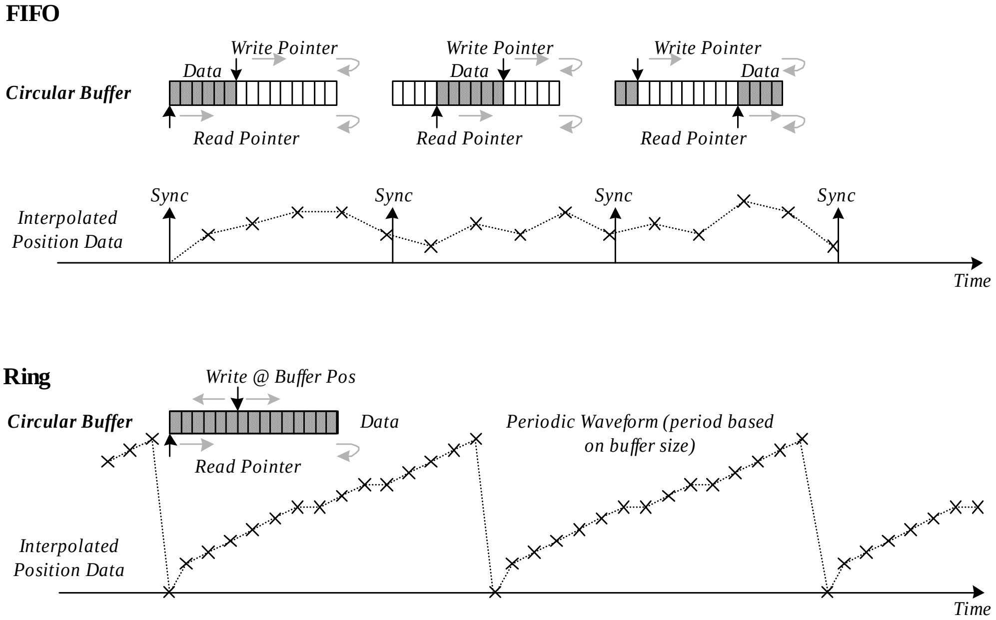


Figure 7.25 FIFO and Ring Organisation.

The following table lists the parameters relating to Interpolated Position Mode.

Index	***Name***	***Type***	***Comment***
0x60C1	interpolation data record.	Array	The input data words that are necessary to perform the interpolation algorithm
0x60C1/0	number of entries	S32	1 or 2, depending on record size (0x60C4/5)
0x60C1/1	set point	S32	Target position for the velocity loop.
0x60C1/2	period.	S32	Interpolation period if record size=2. In units of time period index (0x60C2/2).
0x60C2	interpolation time period	Record	Interpolation period in terms of time units, and index.
0x60C2/0	number of entries	U08	Fixed Value = 2
0x60C2/1	units	U08	Default value = 1
0x60C2/2	index	S08	Default value = -3
0x60C3	interpolation sync definition	Array	Configure synchronization of drives, on every nth occurrence of a Sync Object.
0x60C3/0	number of entries	U08	Fixed Value = 2
0x60C3/1	synchronize on	U08	Default value = 0, (i.e. General Sync is used)
0x60C3/2	sync every	U08	Default value = 1, used in FIFO mode.
0x60C4	interpolation data configuration	Record	Configures Max./Actual Buffer Size, Organisation, Position, size of record, etc.
0x60C4/0	number of entries	U08	Fixed Value = 6
0x60C4/1	max buffer size	U32	Default value = 256
0x60C4/2	actual buffer size	U32	Default value = 256 (DS402 indicates 0)
0x60C4/3	buffer organisation	U08	Default value = 0 (0=FIFO, 1=Ring)
0x60C4/4	buffer position	U16	Default value = 0
0x60C4/5	size of data record	U08	Default value = 1
0x60C4/6	buffer clear	U08	Default value = 0. (0=clear buffer, disable access, 1= enable access to input buffer)
0x2855	interpolation buffer	Array of S32	Internal array, which holds the data records that are written by user.
0x2856/2	interpolation sync count	U32	Counter of Syncs received, since buffer cleared or organisation set.

Table 7.18 Table of interpolated position mode parameters

CONTROL WORD

1. The control word is implemented as specified in the DS402 standard, with the following mode specific bits

15 ... 9	8	7	6 ... 5	4	3 ... 0
(see 10.3.1)	Halt	(see 10.3.1)	reserved	Enable ip mode	(see 10.3.1)
MSB					LSB

Name	Value	Description
Enable ip mode	0	Interpolated position mode inactive
	1	Interpolated position mode active
Halt	0	Execute the instruction of bit 4
	1	Stop axle

Figure 7.26 Interpolated Position Mode Control Word.

2. Setting the halt bit will stop the axle, by fixing the position demand (i.e. hold the read pointer at its current location in the input buffer).

STATUS WORD

1. The status word is implemented as specified in the DS402 standard, with the following mode specific bits

15 … 14	13	12	11	10	9 … 0
(see 10.3.2)	reserved	ip mode active	(see 10.3.2)	Target reached	(see 10.3.2)
MSB					LSB

Name	Value	Description
Target reached	0	Halt = 0: Position not (yet) reached Halt = 1: Axle decelerates
	1	Halt = 0: Position reached Halt = 1: Axle has velocity 0
ip mode active	0	Interpolated position mode inactive
	1	Interpolated position mode active

Figure 7.27 Interpolated Position Mode Status Word

2. The "target reached bit" indicates that the target position has been reached (within position window). If the Halt bit is set, it will indicate if the drive has stopped or not. See Section 7.20 Position Control Function

3. The "IP Mode active" bit indicates whether the mode is active or not.

GENERAL ISSUES

1. The Sub-Mode Select parameter has not been implemented since only linear interpolation is supported.

2. The interpolation time period is scaled internally to the number of position loops periods within this period, and is limited to 1...255. This limits the largest interpolation time period to 255 mSecs. This reduces the range that is specified in DS402, that in theory could go from $1x10^{-128}$…$255x10^{63}$ Seconds

3. In the case of the Ring Buffer no synchronisation occurs, instead the read pointer constantly cycles through the data. In the case of the FIFO, the Synchronisation event (i.e. every X Syncs), causes the drive to read all the data in its buffer. When the end of the data is reached it waits for the next synchronisation trigger.

4. Default Actual Buffer Size is set to Max Buffer Size, although standard says it should be 0.

5. Units of time period, if in data record, are determined using the interpolation time period index.

6. The default value of time period of 1mSec, matches the position loop rate, which means that in effect no interpolation is done, and the buffer contains set points applied to the position loop every position loop period.

7. In the case of buffer organisation = FIFO, the queue size is actually one less than the actual buffer size. In this case there will always be one buffer entry which cannot be accessed, since buffer is considered empty if read pointer = write pointer. The buffer is considered full, if incrementing write pointer, would make both pointers equal.

8. Since scaling/limiting is done when data is written into the buffer,
   - If the user changes the scaling related parameters such as position factor, position dimension etc… it will have no effect until new data is written into the buffer.
   - If the home position is changed, the data in the buffer will be relative to the home position, when the records were written, not any new home position.
   - If no data has been written to the buffer it contains all zeros. To prevent the drive moving to zero, the position loop reference is set to the current position when the user sets the mode of operation.

9. In the case of 2 entries in the data record, the user must write the second entry, before the whole record is written into the buffer. It is not sufficient to write only the first entry, even if the second entry is unchanged

10. In the case of a Ring Buffer, disabling the IP Enabled bit in the control word is recommended while the buffer is being reorganised, or its buffer is being updated. If the drive is enabled, the set points will be moved to as the buffer reads them, but this will include both new and old set-points, until the buffer is completely written.

11. The contents of the input buffer are not saved to non-volatile memory.

12. Modifying the record size in the data configuration record can change the value of actual buffer size, (e.g. if record size is increased to 2, and there is not now enough space for the actual buffer size records, then set actual buffer size to max buffer size.). So changing record size before setting actual buffer size is recommend.

13. The Buffer position is zero indexed, (i.e. 0...actual buffer size –1).

14. The record size and buffer clear parameters in the data configuration record should be write-only parameters, but instead have been implemented as read-write parameters.

15. The internal input buffer is an array of 256 signed32 integers, which can be read from the interpolation buffer parameter (0x2855).

16. The count of the received Syncs, which are used for FIFO synchronisation, is reset when the buffer organisation is changed, or when its contents are cleared. A manufacturer specific U32 parameter called *interpolation sync count* (0x2856 / 2) displays the sync count.

SAMPLE SETUP
The following section gives an example of a typical setup for an interpolated position move. It fills the buffer with 5 set-point position of 0,20,40,60, and 80 degrees, and in a ring buffer, cycles through these set-points :-

Index/Sub Index	*Name*	*Value*	*Comment*
0x6040	ds402 control word	0x06	Shutdown command
0x6060	ds402 mode of operation	7	Set Interpolated Position Mode
0x60C2/1	interpolation time period units	250	interpolation period = 250mS
0x60C2/2	interpolation time period index	-3	
0x60C4/5	interpolation data configuration record size	1	
0x60C4/2	interpolation data configuration actual buffer size	5	Only 5 entries in the buffer
0x60C4/3	interpolation data configuration buffer organisation	1	Set-up for Ring Buffer
0x60C4/6	interpolation data configuration buffer clear	0	Clear out the buffer
0x60C4/6	interpolation data configuration buffer clear	1	Enable access to input buffer
0x60C4/4	interpolation data configuration buffer position	0	Set buffer position
0x60C1/1	interpolation data record set point	0	Write set-point
0x60C4/4	interpolation data configuration buffer position	1	Move buffer position
0x60C1/1	interpolation data record set point	20	Write Position = 20^0
0x60C4/4	interpolation data configuration buffer position	2	Move buffer position
0x60C1/1	interpolation data record set point	40	Write Position=40^0
0x60C4/4	interpolation data configuration buffer position	3	Move buffer position
0x60C1/1	interpolation data record set point	60	Write Position=60^0
0x60C4/4	interpolation data configuration buffer position	4	Move buffer position
0x60C1/1	interpolation data record set point	80	Write Position=80^0
0x6040	ds402 control word	0x1F	Enable the drive and the mode.

Table 7.19 Sample set-up for interpolated position mode

7.17.1 Interpolated Position Mode Parameters

Parameter Name	CANopen Index	CANopen sub-index	PDO mapping	Data Type	Access	Default Value	Minimum Value	Maximum Value	Units	Storage Type	Data Group	Field Number
INPUT PARAMETERS												
ds402 interp. data record size	0x60C1	0	no	s32	r	1	-	-	None	N	A	4173
ds402 interp. data record position	0x60C1	1	yes	s32	r/w	0	-	-	Pos units	N	A	4174
ds402 interp. data record time	0x60C1	2	yes	s32	r/w	0	-	-	$10^{\text{ip time period}}$ Sec	N	A	4175
ds402 interp. data config max buffer size	0x60C4	1	yes	u32	r	256	-	-	None	N	A	4180
ds402 interp. data config actual buffer size	0x60C4	2	yes	u32	r/w	256	-	-	None	C	A	4181
ds402 interp. data config buffer organisation	0x60C4	3	yes	u08	r/w	0	0	1	None	C	A	4182
ds402 interp. data config buffer position	0x60C4	4	yes	u16	r/w	0	-	-	None	N	A	4183
ds402 interp. data config size of data record	0x60C4	5	yes	u08	r/w	1	1	2	None	C	A	4184
ds402 interp. data config buffer clear	0x60C4	6	yes	u08	r/w	0	-	-	None	C	A	4185
ds402 interp. time period units	0x60C2	1	yes	u08	r/w	1	-	-	$10^{\text{ip time period}}$ Sec	C	A	4189
ds402 interp. time period index	0x60C2	2	yes	s08	r/w	-3	-128	63	None	C	A	4190
ds402 interp. sync definition sync on group	0x60C3	1	yes	u08	r/w	0	0	0	None	N	A	4193

ds402 interp. sync definition every nth event	0x60C3	2	yes	u08	r/w	1	-	-	Counts	C	A	4194
ds402 interp. data buffer.	0x2855	0	no	s32	r	-	-	-	None	N	A	4198
ds402 interp. sync count	0x2856	2	no	s32	r	0	-	-	Counts	N	A	4201
ds402 position range min	0x607B	1	yes	s32	r/w	-2147483648	-	-	pos units	C	A	1644
ds402 position range max	0x607B	2	yes	s32	r/w	2147483647	-	-	pos units	C	A	1645
ds402 software position limit min	0x607D	1	yes	s32	r/w	-2147483648	-	-	pos units	C	A	4149
ds402 software position limit max	0x607D	2	yes	s32	r/w	2147483647	-	-	pos units	C	A	4150
ds402 home offset	0x607C	0	yes	s32	r/w	0	-	-	pos units	C	A	4147
ds402 following error window (Note 2)	0x6065	0	yes	u32	r/w	0	-	-	pos units	N	A	4171
ds402 position window	0x6067	0	yes	u32	r/w	0	-	-	pos units	C	A	4172
FEEDBACK VALUES												
ds402 position demand value	0x6062	0	yes	s32	r	0	-	-	pos units	N	A	4167
ds402 position demand value increments	0x60FC	0	yes	s32	r	0	-	-	incs	N	A	4168
ds402 position actual value	0x6064	0	yes	s32	r	0	-	-	pos units	N	A	4169
ds402 position actual value increments	0x6063	0	yes	s32	r	0	-	-	incs	N	A	4170
GENERAL PARAMETERS												
ds402 control word	0x6040	0	yes	u16	r/w	0	-	-	none	N	A	1650
ds402 status word	0x6041	0	yes	u16	r	0	-	-	none	N	A	1651
ds402 modes of operation	0x6060	0	yes	s08	r/w	0	-	-	none	N	A	1652
ds402 modes of operation display	0x6061	0	yes	s08	r	0	-	-	none	N	A	1653
ds402 error code	0x603F	0	yes	u16	r	-	-	-	none	N	A	4234

Note 1: ds402 max motor speed is derived from (and can set) motor max velocity and therefore need not be saved to NVM.
Note 2: ds402 following error is derived from (and can set) position error limit and therefore need not be saved to NVM.

7.18 Homing Mode

The homing method is used to determine the home position (also called datum or zero position) of a system, using various methods, and different digital inputs. Profile and interpolated position mode moves are relative to this zero position. The DS2100 supports a numbers of the homing methods specified in DS402, and also implements 4 manufacturer specific modes.

Homing methods 1...4, consist of two phases. The first phase consists of an initial movement, at a "switch search speed", in a direction determined by the method selected and the state of certain digital inputs. The velocity profile of this move is trapezoidal (i.e. ramp from standstill to steady velocity, using a linear ramp, at user defined acceleration). On finding the switch, the drive quick-stops, and does an absolute move to the position of the switch (determined using position registration). When at the switch, the drive starts a second phase, moving at a slower speed, (i.e. "zero search speed"), to find the encoder index pulse. On finding the zero position, the drive quick stops, and does an absolute move to this zero position (again determined using position registration), and sets the home position. A sample of homing method 1 is shown in the diagram below.

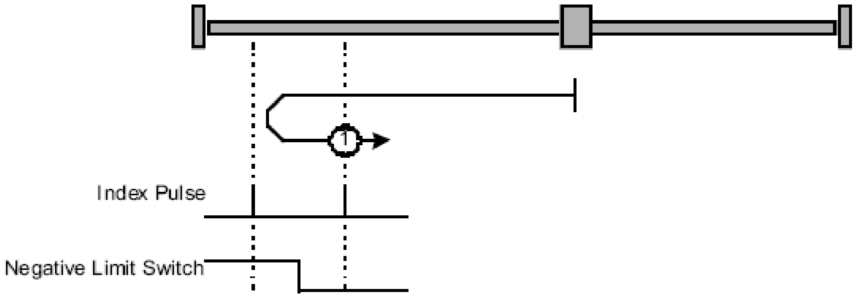


Figure 7.28 Homing on the negative limit switch and index pulse.

Homing methods 17...20, consist of only one phase. This phase is similar to that of methods 1...4, (i.e. the faster search for the switch). In the case of these methods, the drive will quick stop, and move to the switch, and does not search for an index pulse.

Homing method 35 simply sets the current position to be the homing position.

Homing methods –1…-4, are similar to methods 1…4, except that they are used when no encoder is present, and the resolver zero position is used instead. In this case, reading the resolver position when the first digital input is hit, and performing an absolute move to the resolver zero position, determines the zero position. No index pulse is required.

Three different digital inputs relate to the homing mode, although all three inputs are not used in any individual method, rather a subset is used. These digital inputs are, positive limit switch, negative limit switch, and homing switch, and need to be configured before using the relevant homing mode. The index pulse is determined internally from the encoder signals.

Index	*Name*	*Type*	*Comment*
0x607C	home offset	S32	Difference between the zero position and the home position (found during homing), in position units.
0x6098	homing method	U08	Select the method to be used for homing. Methods supported are listed above.
0x6099	homing speed	Array	Defines the speeds used when searching for switch, and searching for zero.
0x6099/0	number of entries	U08	Fixed Value = 2
0x6099/1	switch	U32	Speed during search for switch, Default value = 0
0x6099/2	zero	U32	Speed during search for zero ,Default value = 0
0x609A	homing acceleration	U32	Sets acceleration and deceleration used with all homing modes, in acceleration units.
0x2857/2	home position	S32	Home Position in increments.
0x2858/0	home logical switch status	U08	Home Digital input Logical Status.
0x2859/2	home error state	U16	Home State drive was in when error occurred.
0x2862/0	home error window	S32	Position window between switch and zero, that causes error, in fractions of a rev.

Table 7.20 Table of homing mode parameters

The table below lists the methods supported, and are detailed in DS402.

Method	*Phase 1*		*Phase 2*		*Comment*
	Dig. Input	*Direction*	*Dig. Input*	*Direction*	
-4	Home ↑	Clockwise	-	Clockwise	Home position set at resolver/encoder zero.
-4	Home ↓	Anti-Clk	-	Clockwise	Home position set at resolver/encoder zero.
-3	Home ↑	Clockwise	-	Anti-Clk	Home position set at resolver/encoder zero.
-3	Home ↓	Anti-Clk	-	Anti-Clk	Home position set at resolver/encoder zero.
-2	Pos Lim	Clockwise	-	Anti-Clk	Home position set at resolver/encoder zero.
-1	Neg Lim	Anti-Clk	-	Clockwise	Home position set at resolver/encoder zero.
0	-	-	-	-	Drive Doesn't Move, Home Pos. unchanged
1	Neg Lim	Anti-Clk	Index Pulse	Clockwise	Home position set when index pulse set.
2	Pos Lim	Clockwise	Index Pulse	Anti-Clk	Home position set when index pulse set.
3	Home ↑*	Clockwise	Index Pulse	Anti-Clk	Home position set when index pulse set.
3	Home ↓	Anti-Clk	Index Pulse	Anti-Clk	Home position set when index pulse set.
4	Home ↑	Clockwise	Index Pulse	Clockwise	Home position set when index pulse set.
4	Home ↓	Anti-Clk	Index Pulse	Clockwise	Home position set when index pulse set.
17	Neg Lim	Anti-Clk	-	-	Home position set when Negative Limit hit,
18	Pos Lim	Clockwise	-	-	Home position set when Positive Limit hit,
19	Home ↑	Clockwise	-	-	Home position set when Home Sw hit.
19	Home ↓	Anti-Clk	-	-	Home position set when Home Sw hit.
20	Home ↑	Clockwise	-	-	Home position set when Home Sw hit.
20	Home ↓	Anti-Clk	-	-	Home position set when Home Sw hit.
35	-	-	-	-	Drive Doesn't Move, Home Pos = current pos.

* The ↑ is used to indicate an initially inactive state, changing to an active state, and ↓ is the reverse.

Table 7.21 Table of supported homing methods

CONTROL WORD

1. The control word is implemented as specified in the DS402 standard, with the following mode specific bits

15 … 9	8	7	6 … 5	4	3 … 0
(see 10.3.1)	Halt	(see 10.3.1)	reserved	Homing operation start	(see 10.3.1)
MSB					LSB

Name	Value	Description
Homing operation start	0	Homing mode inactive
	0 → 1	Start homing mode
	1	Homing mode active
	1 → 0	Interrupt homing mode
Halt	0	Execute the instruction of bit 4
	1	Stop axle with homing acceleration

Figure 7.29 Homing mode Control Word

STATUS WORD

1. The status word is implemented as specified in the DS402 standard, with the following mode specific bits

15 … 14	13	12	11	10	9 … 0
(see 10.3.2)	Homing error	Homing attained	(see 10.3.2)	Target reached	(see 10.3.2)
MSB					LSB

Name	Value	Description
Target reached	0	Halt = 0: Home position not reached Halt = 1: Axle decelerates
	1	Halt = 0: Home position reached Halt = 1: Axle has velocity 0
Homing attained	0	Homing mode not yet completed
	1	Homing mode carried out successfully
Homing error	0	No homing error
	1	Homing error occurred; Homing mode carried out not successfully; The error cause is found by reading the error code

Figure 7.30 Homing Mode Status Word

2. The following events set the Homing Error Bit in the Status Word.
   - Interrupt Homing using control word, (Halt Bit, or Homing Start Bit 1->0).
   - Limit Switches are active at start of move.
   - Digital Inputs required for method have not been configured.
   - If index pulse is within home error window revs (default 45 degrees) of switch position.
   - If the speed is too fast when searching for the zero position.
   - If invalid entry in homing state table (i.e. Internal Software Error executing NULL).

   The Home Error State (0x2859/2) parameter can be used to determine which state the state machine is in when the error occurs, and thus determine the cause of the error, as outlined in the following table.

Val.	*State*	*Description*
2	Check neg. limit switch	Error since neg. limit switch set, before move
3	Check pos. limit switch	Error since pos. limit switch set, before move
5	Set up neg. limit switch	Error since no digital input set up for neg. limit switch
6	Set up pos. limit switch	Error since no digital input set up for pos. limit switch
7	Set up index pulse	Error since pos. feedback != encoder, or Enc. Inc. = 16384.
8	Set up home switch	Error since no digital input set up for home switch
18,23,24	Check zero registration	Error since zero pos. is with error window revs. of switch pos.
-	-	If set halt bit in control word.
-	-	If Homing start bit in control word, 1->0, during homing.
-	-	Homing attempts to execute NULL function.

Table 7.22 Table of homing error state values

GENERAL ISSUES

1. If the drive is disabled via the serial text interface the profile generator can still generate the profile, which can result in high speeds, when the drive is enabled, due to large position errors.

2. An internal limit in the drive may limit the acceleration further. This drive acceleration limit parameter (in rads/sec) has a default value of 1000000rads/sec. This limit is also used for quick-stopping the drive.

3. In the case of 1, 2, 17 and 18, if the limit switch is active at the start, no movement occurs and the error bit is indicated in the status word.

4. Changing homing method during a homing move is not recommended, it may only lead to confusion. The method is sampled at the start of the homing move.

5. The user must configure the digital inputs so that the correct digital input handler function is associated with the required digital input. This is achieved by writing the number of the digital input handler function to the relevant correct element in the "diginpcfg" entry. The array is zero indexed, with entry 0 always configured for the enable input. The DS402 Digital inputs parameter (0x60FD) has not been implemented since the digital inputs are user configurable. The following are the function numbers

Digital Input	**Handler**	**Example**
Positive Limit Switch	6	Diginpcfg[1] 6 (i.e. 0x2C2E/3) sets input 1 to positive limit switch
Negative Limit Switch	7	Diginpcfg[2] 7 (i.e. 0x2C2E/5) sets input 2 to negative limit switch
Homing Switch	8	Diginpcfg[3] 8 (i.e. 0x2C2E/7) sets input 3 to homing switch

Table 7.23 Table of digital input configuration values

6. The default operation of the limit switches is to be active low. This can be inverted by inverting the associated digital input. In addition a parameter called home logical switch status word (0x2858/0) contains the logical status of these digital inputs, and be can used to see which inputs are set, regardless of the digital input mapping.

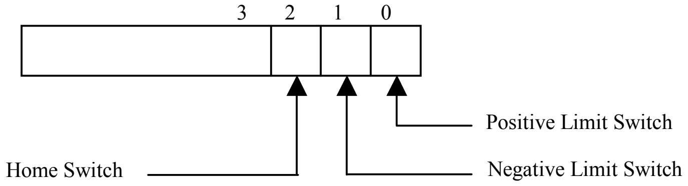


Figure 7.31 Home logical switch status parameter

7. A non-DS402 parameter called home position can be read to display the home position. This value is in increments, and is the value of "position actual" sampled when the homing cycle is complete.

8. The Position Polarity is not used during homing mode. This is not explicitly stated in the DS402 standard, but similar modes are available for left and right moves (e.g. method 1, and 2.)

9. The user can set a home offset that defines the position of the "zero position" relative to this home position. Profile and Interpolated Position moves are relative to this zero position. Position Limits are however relative to the home position. Parameters such as Position Actual Value (0x6064), Position Demand (0x6062) etc, are also relative to the zero position.

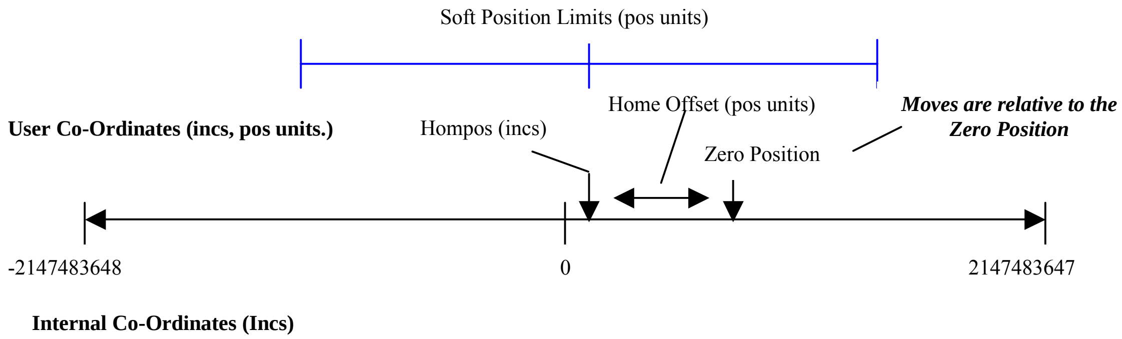


Figure 7.32 Homing position co-ordinates

10. The DS402 standard indicates that as well as setting the error bit in the status word, that an error code could be written. This is not done; instead the home error state can be used.

11. The home position is NOT saved to non-volatile memory, since it is assumed that a homing cycle is done initially on power-up.

12. The home offset is saved to non-volatile memory. This means that following power-up, if this value is non-zero, a move with a target position of zero, would still result in the movement of the axis, by the home offset amount.

13. In case where large velocities are used during homing. There may be a noticeable reversal of direction when switch or zero position is hit, due to the requirement to return to the registered position when the switch or zero was hit.

14. If the homing cycle is interrupted e.g. by causing a shutdown, instead of clearing the "start operation bit", no error is indicated, since mode specific bits are only examined when in enabled state.

15. The operation of the homing method requires on certain positions being reached (e.g. switch and index pulse locations). This requires that there be some integral term in the position control loop, to pull the position error to zero.

SAMPLE SETUP
The following section gives an example of a typical setup for a homing cycle.

Index/Sub Index	*Name*	*Value*	*Comment*
0x2C2E/4	digital input config. [2]	7	Set-up Negative Limit Switch
0x6060	ds402 mode of operation	6	Set-up for Homing Mode
0x6098	homing method	-1	Set-up Homing Method
0x6099/1	homing speed switch	1000	Set Switch Speed=1000 rpm
0x6099/2	homing speed zero	60	Set Zero Speed=60rpm
0x609A	homing acceleration	100	Set homing acceleration=100 rev/sec^2
0x2857/2	home position		Read home position initially=0
0x6041	ds402 status word		Read Status=0x270
0x6040	ds402 control word	0x06	Shutdown command
0x6040	ds402 control word	0x1F	Start the homing cycle
Hit the negative limit switch, drive will search and stop at zero position.			
0x6510/10	position resolver		Read dsprespos=0
0x2857/2	home position		Read home position (e.g. = -3145709)
0x6041	ds402 status word		Read Status=0x1687
0x6064	ds402 position actual		Read actual position=0.

Table 7.24 Sample set-up for homing mode

7.18.1 Homing Mode Parameters

Parameter Name	CANopen Index	CANopen sub-index	PDO mapping	Data Type	Access	Default Value	Minimum Value	Maximum Value	Units	Storage Type	Data Group	Field Number
INPUT PARAMETERS												
ds402 home offset	0x607C	0	yes	s32	r/w	0	-	-	pos units	C	A	4147
ds402 homing method	0x6098	0	yes	s08	r/w	0	-	-	none	C	A	4204
ds402 homing speeds switch search	0x6099	1	yes	u32	r/w	0	-	-	vel units	C	A	4206
ds402 homing speeds zero search	0x6099	2	yes	u32	r/w	0	-	-	vel units	C	A	4207
ds402 homing acceleration	0x609A	0	yes	u32	r/w	0	-	-	acc units	C	A	4208
OUTPUT PARAMETERS												
ds402 home position	0x2857	2	no	s32	r	0	-	-	incs	N	A	4203
ds402 homing logical switch status	0x2858	0	no	u08	r	0	-	-	none	N	A	4209
ds402 homing error state	0x2859	2	no	u16	r	0	-	-	none	N	A	4218
ds402 homing error window	0x2862	0	no	f32	r/w	0.125	0.0	0.5	none	C	A	4221
FEEDBACK VALUES												
ds402 position demand value	0x6062	0	yes	s32	r	0	-	-	pos units	N	A	4167
ds402 position demand value increments	0x60FC	0	yes	s32	r	0	-	-	incs	N	A	4168
ds402 position actual value	0x6064	0	yes	s32	r	0	-	-	pos units	N	A	4169
ds402 position actual value increments	0x6063	0	yes	s32	r	0	-	-	incs	N	A	4170
GENERAL PARAMETERS												
ds402 control word	0x6040	0	yes	u16	r/w	0	-	-	none	N	A	1650
ds402 status word	0x6041	0	yes	u16	r	0	-	-	none	N	A	1651
ds402 modes of operation	0x6060	0	yes	s08	r/w	0	-	-	none	N	A	1652
ds402 modes of operation display	0x6061	0	yes	s08	r	0	-	-	none	N	A	1653
ds402 error code	0x603F	0	yes	u16	r	-	-	-	none	N	A	4234

7.19 Velocity Control Function

The DS402 standard defines a number of parameters related to velocity, which are particularly relevant when in velocity mode. In addition it also defines a windowing function that is used to determine if a target velocity has been reached, or if the actual velocity is below a certain threshold value. Parameters for configuration and tuning of the velocity loop are manufacturer specific. The DS402 parameters that are defined are listed below: -

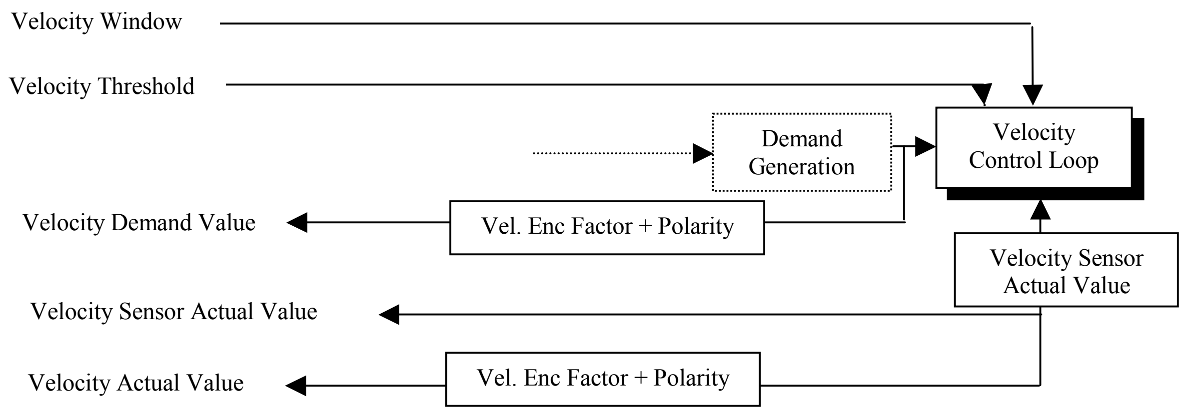


Figure 7.33 Velocity control function

Index	*Name*	*Type*	*Comment*
0x6069	ds402 velocity sensor actual value	S32	Value read from resolver in (incs/sec)
0x606B	ds402 velocity demand value	S32	Output of velocity demand function, in velocity units.
0x606C	ds402 velocity actual value	S32	Sensor Value scaled to be in velocity units
0x606D	ds402 velocity window	U16	Limits (in velocity units) within which target velocity reached bit can be set, in status word.
0x606F	ds402 velocity threshold	U16	If velocity actual value is less than or equal to this value (in velocity units), Speed=0 bit can be set, in status word.

Table 7.25 Table of velocity control function parameters

In addition a velocity control parameter set has been defined. It is a grouping of existing drive parameters, into a single ds402 record, (under parameter number 0x60F9). This record is included in the velocity control table of parameters on the following page.

GENERAL ISSUES

1. Velocity Window and Velocity Threshold are only used in velocity modes.

2. The Velocity Sensor Actual Value, is derived from the velocity in units of incs/Tsamp, and includes the negation of the Velocity Polarity Bit, if the bit is set.

3. The velocity window and velocity threshold functions do not implement a window time. There is no duration for which the actual velocity must be within the window, before the target reached bit is set in the status word. Instead if the actual velocity is within the window, the target reached bit is set. Similarly if the actual velocity is less than the threshold, the Speed=0 bit is set and there is no duration involved.

4. The standard lists the velocity control record as an array, rather than a record, this is incorrect, and inconsistent, and a record has been implemented, as shown above.

7.19.1 Velocity Control Parameters

Parameter Name	CANopen Index	CANopen sub-index	PDO mapping	Data Type	Access	Default Value	Minimum Value	Maximum Value	Units	Storage Type	Data Group	Field Number
INPUT PARAMETERS												
ds402 velocity window	0x606D	0	yes	u16	r/w	0	-	-	Vel units	C	A	4229
ds402 velocity threshold	0x606F	0	yes	u16	r/w	0	-	-	Vel units	C	A	4230
OUTPUT PARAMETERS												
ds402 velocity demand value	0x606B	0	yes	s32	r	0	-	-	Vel units	N	A	4231
ds402 velocity actual value	0x606C	0	yes	s32	r	0	-	-	Vel units	N	A	4232
ds402 velocity sensor actual value	0x6069	0	yes	s32	r	0	-	-	Incs/sec	N	A	4233
VELOCITY CONTROL PARAMETER SET												
velocity loop rate divider	0x60F9	1	no	s16	r/w	1	1	-	none	C	A	1136
position mode velocity loop p-gain	0x60F9	2	no	f32	r/w	0.05	0.0	-	Nm/rad/s	C	A	1305
position mode velocity loop i-gain	0x60F9	3	no	f32	r/w	2.0	0.0	-	Nm/rad	C	A	1306
position mode velocity loop error	0x60F9	4	yes	f32	r	-	-	-	Inc/Tsamp	N	A	1307
velocity mode p-gain	0x60F9	5	no	f32	r/w	0.05	0.0	-	Nm/rad/s	C	A	1317
velocity mode i-gain	0x60F9	6	no	f32	r/w	2.0	0.0	-	Nm/rad	C	A	1318
velocity mode ie-gain	0x60F9	7	no	f32	r/w	0.0	0.0	-	none	C	A	1319
velocity mode error	0x60F9	8	yes	f32	r	-	-	-	Inc/Tsamp	N	A	1320

7.20 Position Control Function

The DS402 standard defines a number of parameters related to position, which are particularly relevant when in position mode. In addition it also defines windowing functions that are used to determine if a target position has been reached (actual position is within a certain window of the target position), or if a following error exists (actual position is within a certain window of the demand position). Parameters for configuration and tuning of the position loop are manufacturer specific. The DS402 parameters that are defined are listed below:

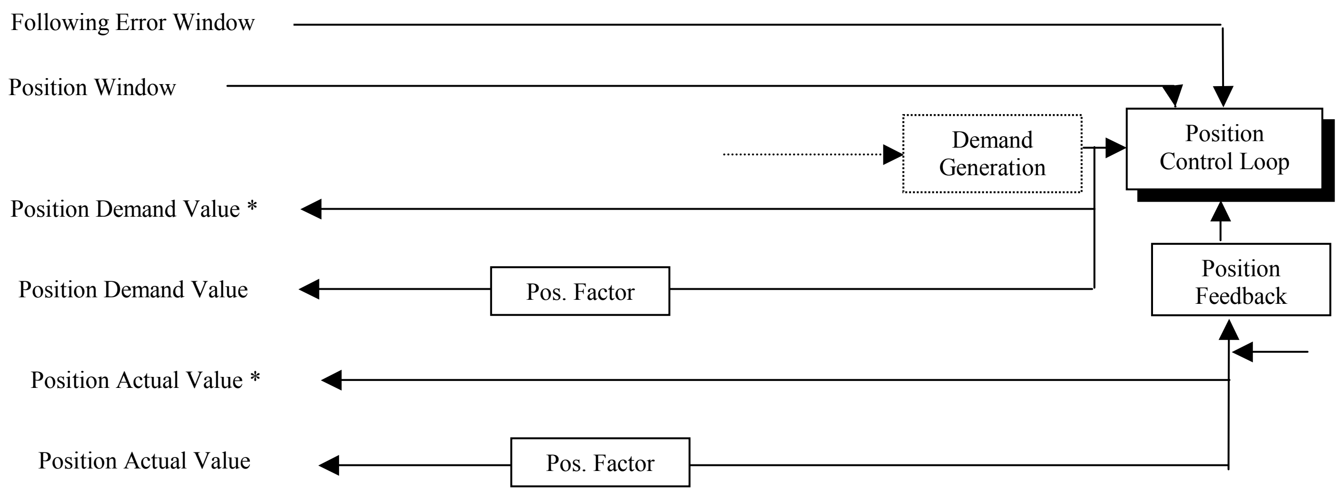


Figure 7.34 Position control function

Index	*Name*	*Type*	*Comment*
0x6062	ds402 position demand value	S32	Output from Demand Block in position units.
0x6063	ds402 position actual value inc*	S32	Actual value from the position measurement device, in incs.
0x6064	ds402 position actual value	S32	Actual value from the position measurement device, in pos. units.
0x6065	ds402 following error window	U32	The Delta between demand and actual position, if greater than this window (in position units), will set the following error bit in the status word.
0x6067	ds402 position window	U32	The Delta between target and actual position, if less than or equal to this window, (in position units) it will set the target reached bit in the status word.
0x60FC	ds402 position demand value inc*	S32	Output from Demand Block in units of increments.

* Is used in DS402 to indicate it is in increments rather than position units.

Table 7.26 Table of position control function parameters

In addition a position control parameter set has been defined. It is a grouping of existing drive parameters, into a single ds402 record, (under parameter number 0x60FB). This record is included in the position control table of parameters on the following page.

GENERAL ISSUES

1. Position Window and Following Error Window are only used in position modes.

2. Position Actual Value and Position Actual Value* are both relative to the home/zero position.

3. The position window and following error window functions do not implement a window time. There is no duration for which the actual position must be within the window, before the target reached bit is set in the status word. Instead if the actual position is within the window, the target reached bit is set. Similarly, if the following error is within the window, the following error bit is set and there is no duration involved.

4. The ds402 following error window, is tied to the position error limit (in radians) parameter of the drive. The resolution of the position error limit, is limited to that of the ds402 position units. Therefore rounding may occur when the position error limit is set, to accommodate a corresponding fixed point ds402 following error window. For example, with default settings of position units of degrees, if the user sets a position error limit of 0.01 rads, it is actually set to a value of 0.01745 rads, corresponding to a ds402 following error of 1 degree.

7.20.1 Position Control Parameters

Parameter Name	CANopen Index	CANopen sub-index	PDO mapping	Data Type	Access	Default Value	Minimum Value	Maximum Value	Units	Storage Type	Data Group	Field Number
INPUT PARAMETERS												
ds402 following error window	0x6065	0	yes	u32	r/w	0	-	-	pos units	N	A	4171
ds402 position window	0x6067	0	yes	u32	r/w	0	-	-	pos units	C	A	4172
OUTPUT PARAMETERS												
ds402 position demand value	0x6062	0	yes	s32	r	0	-	-	pos units	N	A	4167
ds402 position demand value increments	0x60FC	0	yes	s32	r	0	-	-	inc	N	A	4168
ds402 position actual value	0x6064	0	yes	s32	r	0	-	-	pos units	N	A	4169
ds402 position actual value increments	0x6063	0	yes	s32	r	0	-	-	inc	N	A	4170
POSITION CONTROL PARAMETER SET												
position loop rate divider	0x60FB	1	no	s16	r/w	2	1	-	none	C	A	1137
position PI loop p-gain	0x60FB	2	no	f32	r/w	2.0	0.0	-	1/s	C	A	1326
position PI loop i-gain	0x60FB	3	no	f32	r/w	0.0	0.0	-	$1/s^2$	C	A	1327
position PI loop error	0x60FB	4	yes	f32	r	-	-	-	inc	N	A	1328
position TO loop error	0x60FB	5	yes	f32	r	-	-	-	inc	N	A	1337
position TO loop ka-gain	0x60FB	6	no	f32	r/w	519.75	0.0	-	$rads/s^2$	C	A	1347
position TO loop kp-gain	0x60FB	7	no	f32	r/w	20.0	0.0	-	1/s	C	A	1349
position TO loop enable velocity integrator	0x60FB	8	no	f32	r/w	6.28	0.0	-	rad	C	A	1350

PAGE INTENTIONALLY BLANK

APPENDIX A DATA LOGGER

TABLE OF CONTENTS

A.1 Data Logger

The data logger 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. The sampled data can be downloaded from the embedded controller onto a computer and analysed.

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* (index 0x2f02, subindex 1 - 4) and setting the *data_logger_enable* (index 0x2f01, subindex 1 - 4) 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* (index 0x2f00, subindex 3). 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.

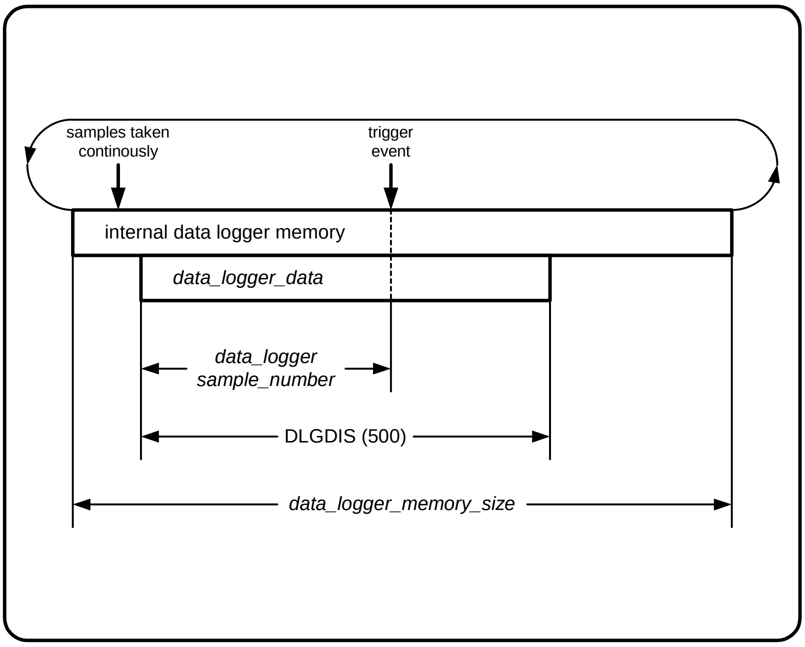


Figure A.1: data logger memory and sampling

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* (index 0x2f00, subindex 2). The divider ratio can be set with the parameter *data_logger_divider_factor* (index 0x2f00, subindex 1). 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. 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* (index 0x2f04, subindex 1) 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* (index 0x2f04, subindex 13). It has one of the four possible values:

0x00	-	system is beeing initialised; 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* to the field number of the parameter that is used for triggering the sampling process. The coupling is selected by setting the *trigger_coupling* (index 0x2f04, subindex 3) 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* (index 0x2f04, subindex 4) 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* (index 0x2f04, subindex 11). It holds the number of the samples before the trigger event.

A.1.4 Data Access

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* (index 0x2f06, subindex 1 - 4) is added to the value and the result is then multiplied with the scaling factor *data_logger_scaling_factor* (index 0x2f05, subindex 1 - 4). 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 transmitted is always DLGDIS (500). The transmitted data can be selected from the sampled data by writing to the parameter *data_logger_sample_number* (index 0x2f07, subindex 1) 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 initialised (*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	CANopen Index	CANopen sub-index	PDO mapping	Data Type	Access	Default Value	Minimum Value	Maximum Value	Units	Storage Type	Data Group	Field Number
data_logger_sample_frequency	0x2f00	2	no	u32	R	9920	-	-	Freq. units	N	A	1751
data_logger_divider_factor	0x2f00	1	no	u16	R/W	1	1	-	None	N	A	1750
data_logger_memory_size	0x2f00	3	no	s16	R/W	500	500	8000	None	N	A	1752
data_logger_enable	0x2f01	1-4	no	u08	R/W	0,0,0,0	-	-	None	N	A	1753
data_logger_channel	0x2f02	1-4	no	u16	R/W	1000,1000, 1000,1000	-	-	None	N	A	1754

A.1.7 Trigger parameters

Parameter Name	CANopen Index	CANopen sub-index	PDO mapping	Data Type	Access	Default Value	Minimum Value	Maximum Value	Units	Storage Type	Data Group	Field Number
trigger_mode	0x2f04	1	no	u08	R/W	0x03	-	0x03	None	N	A	1755
trigger_field_number	0x2f04	2	no	fld	R/W	1000	-	-	None	N	A	1756
trigger_coupling	0x2f04	3	no	u08	R/W	0x01	-	0x02	None	N	A	1757
trigger_slope	0x2f04	4	no	u08	R/W	0x01	0x01	0x03	None	N	A	1758
trigger_level_8-bit	0x2f04	5	no	u08	R/W	-	-	-	None	N	A	1759
trigger_level_16-bit	0x2f04	6	no	u16	R/W	-	-	-	None	N	A	1760
trigger_level_24-bit	0x2f04	7	no	u24	R/W	-	-	-	None	N	A	1761
trigger_level_32-bit	0x2f04	8	no	u32	R/W	-	-	-	None	N	A	1762
trigger_level_float	0x2f04	9	no	f32	R/W	-	-	-	None	N	A	1763
trigger_level_double	0x2f04	10	no	f64	R/W	-	-	-	None	N	A	1764
trigger_delay	0x2f04	11	no	s16	R/W	-	-	-	None	N	A	1765
trigger_status	0x2f04	13	no	u08	R	-	-	-	None	N	A	1767

A.1.8 Data logger scaling and output parameters

Parameter Name	CANopen Index	CANopen sub-index	PDO mapping	Data Type	Access	Default Value	Minimum Value	Maximum Value	Units	Storage Type	Data Group	Field Number
data_logger_scaling_factor	0x2f05	1-4	no	f32	R/W	-	-	-	None	N	A	1768
data_logger_scaling_offset	0x2f06	1-4	no	f32	R/W	-	-	-	None	N	A	1769
data_logger_sample_number	0x2f07	1	no	s16	R/W	-	-	-	None	N	A	1770
data_logger_channel_0	0x2f08	0	no	s08	R	-	-	-	None	N	A	1771
data_logger_channel_1	0x2f09	0	no	s08	R	-	-	-	None	N	A	1772
data_logger_channel_2	0x2f0a	0	no	s08	R	-	-	-	None	N	A	1773
data_logger_channel_3	0x2f0b	0	no	s08	R	-	-	-	None	N	A	1774

Page Intentionally Blank

APPENDIX B GUI

B.1 Contents

B.2 Introduction

This manual describes the installation and operation of the Moog WinDrive application.

B.2.1 System Requirements

Minimum PC requirement	586 / Pentium processor 16MB RAM (128MB recommended) 30MB free space on hard disk
Operating System	Windows 98, Windows ME, Windows NT 4.0 (Service Pack 6 or later), Windows 2000, Windows XP
Minimum Screen Size	800x600, 1024x768 recommended

B.2.2 Installation

WinDrive should be installed by running setup.exe from the File Manager or from the Program Manager. In Program Manager you can do this from Run... under the File menu item. Type D:\setup.exe in the command line (if your CD drive is drive E, type E:\setup.exe, etc.). Alternatively, you can double-click setup.exe in File Manager.
The installation program will take the user through all the necessary installation steps. Any necessary folders to launch WinDrive will automatically be created in the Start menu. 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. The installation process will then complete.

B.3 Getting Started / Common Features

B.3.1 Introduction

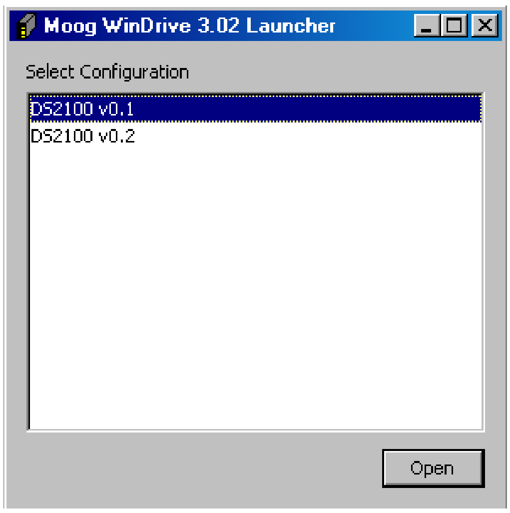
Moog WinDrive is a graphical user interface (GUI) application that is used to configure Moog Servo-Drives. It has been developed to provide a common “look and feel” for configuring a wide range of Moog controllers. For each controller or controller family there is a corresponding configuration within WinDrive. A particular configuration is chosen on startup of WinDrive. The chosen configuration will determine which controller specific dialogs and panels are displayed within WinDrive and which protocol is used to communicate with the controller.

B.3.2 Starting WinDrive

From the Windows Start menu, select Start/Programs/WinDrive/WinDrive GUI to launch the application.

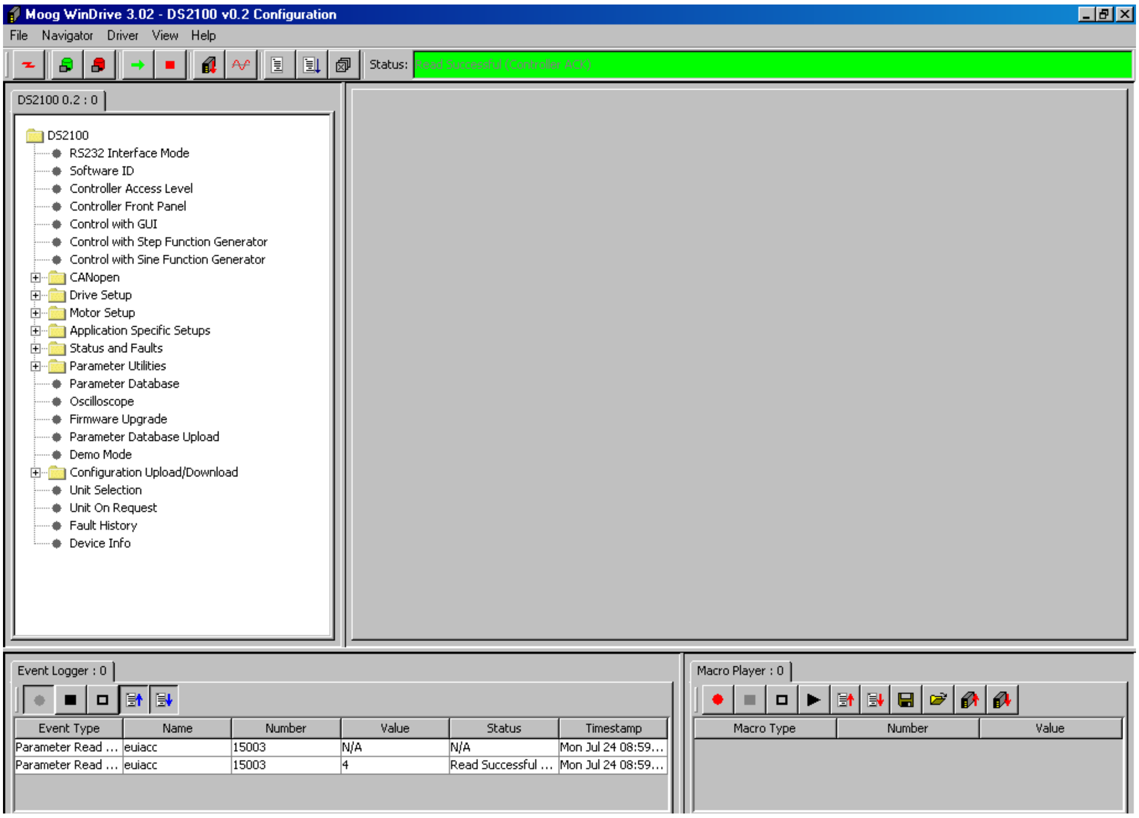
B.3.3 Launcher

The Launcher dialog box is displayed after starting WinDrive. It displays the available configurations available for the particular release of WinDrive. Note that depending on what Moog product WinDrive was shipped with, the list of available configurations may differ. When the Launcher dialog is displayed, select the required configuration.
To determine which version is required look at the model number label on the drive:
For a drive named G361-xxxxA-0**0**-000 or G361-xxxxA-0**1**-000 select DS2100v0.1.
For a drive named G361-xxxxA-0**2**-000 select DS2100v0.2.
Click “Open”.



B.3.4 Main Window

The Main Window is displayed after selecting a controller configuration and clicking Open in the Launcher dialog box. The Main Window consists of a number of components described below.

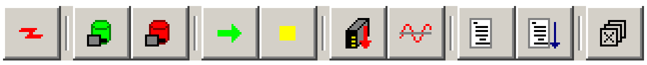


B.3.5 Main Menu

The Main Menu is located at the top of the Main Window.

B.3.6 Toolbar

The Toolbar is located directly under the Main Menu. The toolbar is used to perform common tasks in the application. Parts of the toolbar are configuration specific and are described in the relevant section of each particular configuration. An example toolbar is given in the figure below.

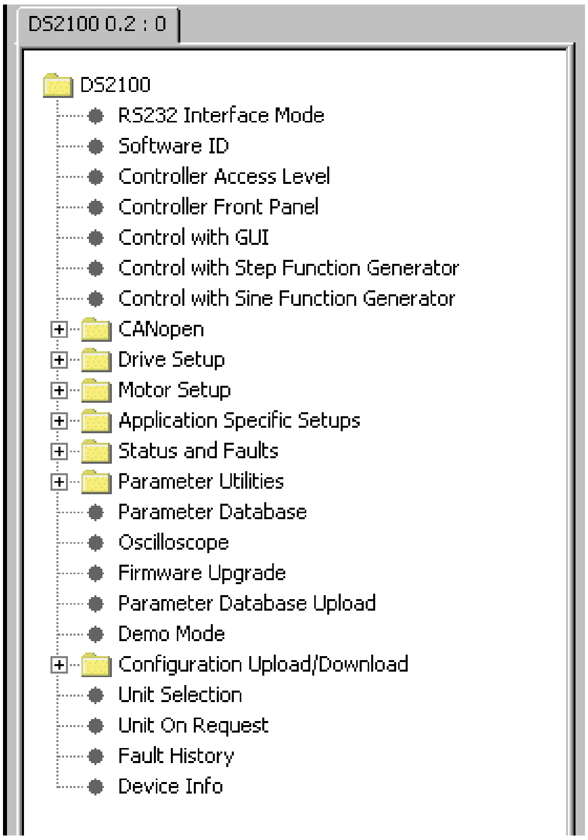


B.3.7 Status Bar

The Status Bar is located to the right of the Toolbar. The Status Bar displays short status messages that indicate the current state of WinDrive. Generally, a green background indicates that no fault occurred while a red background indicates that a fault occurred in the application.

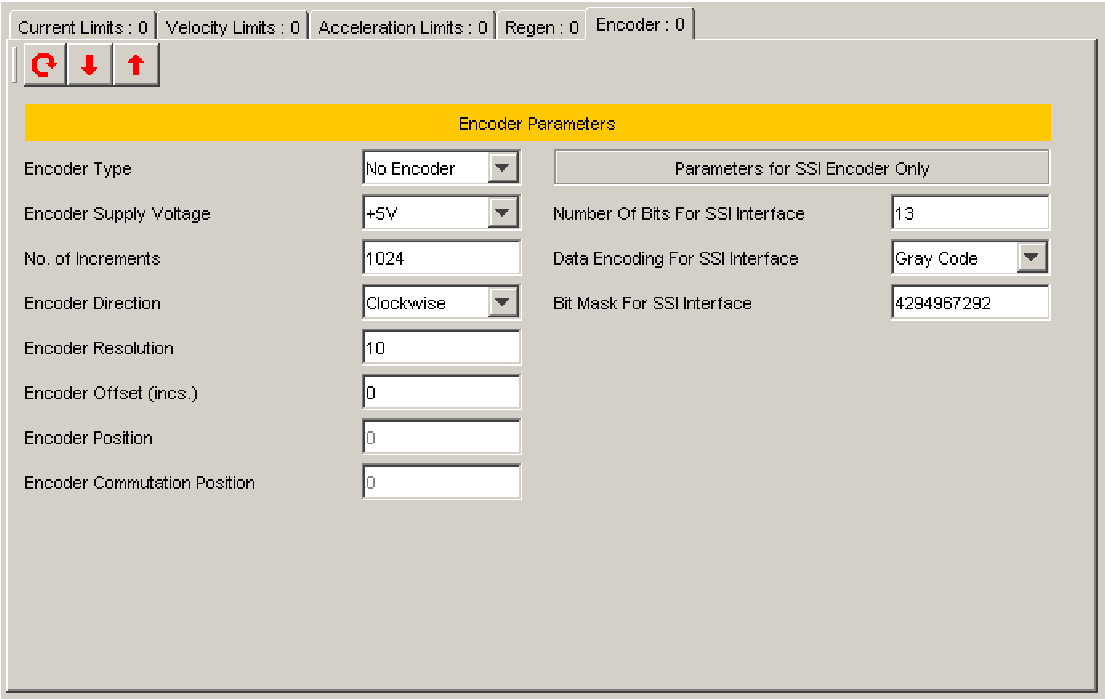
B.3.8 Navigator

The Navigator is one of the four large panels in the Main Window. It is located at the top left of the Main Window, directly under the Toolbar. The Navigator panel contains one or more navigator tabbed panels. These panels display a tree. The tree is the principal method of navigating around WinDrive. The tree is configuration specific and thus may differ between different configurations. To open a panel in the panel view, click on the corresponding node in the tree. The panel will then be opened in the panel view.

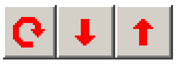


B.3.9 Panel View

The Panel View is one of the four large panels in the Main Window. It 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 nodes 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. They 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.

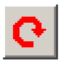


B.3.10 Panel View Toolbar



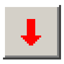
The Panel View Toolbar consists of the following buttons.

Continuous Update



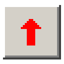
If the Continuous Update toggle button is depressed, all controls within the displayed panel are continuously updated from the controller via a parameter read.

Write All



Clicking the Write All button forces a parameter write for each control displayed within the panel.

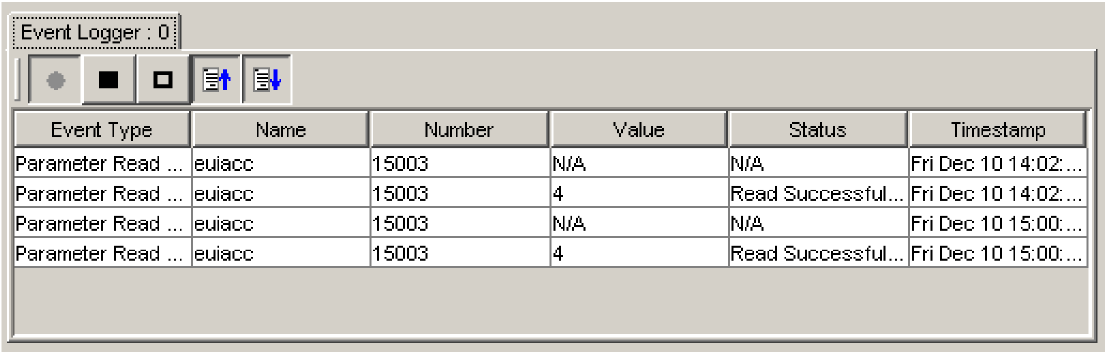
Read All



Clicking the Read All button forces a parameter read for each control displayed within the panel.

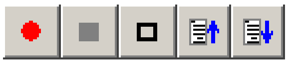
B.3.11 Event Logger

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 parameter read and / or parameters write 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.



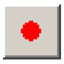
Event Type	Name	Number	Value	Status	Timestamp
Parameter Read ...	euiacc	15003	N/A	N/A	Fri Dec 10 14:02:...
Parameter Read ...	euiacc	15003	4	Read Successful...	Fri Dec 10 14:02:...
Parameter Read ...	euiacc	15003	N/A	N/A	Fri Dec 10 15:00:...
Parameter Read ...	euiacc	15003	4	Read Successful...	Fri Dec 10 15:00:...

B.3.12 Event Logger Toolbar



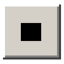
The Event Logger toolbar consists of the following buttons.

Start Logging



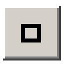
If the Start Logging toggle button is depressed, the Event Logger logs those events whose filter toggle buttons (i.e. Log Read Parameter or Log Write Parameter) also are depressed.

Stop Logging



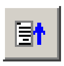
If the Stop Logging toggle button is clicked, all logging is stopped. Clicking the Start Logging button can recommence logging.

Clear Log



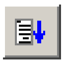
Clicking the Clear Log button completely clears the Event Logger.

Log Read Parameter



The Log Read Parameter toggle button needs to be depressed if any parameter read events are to be logged.

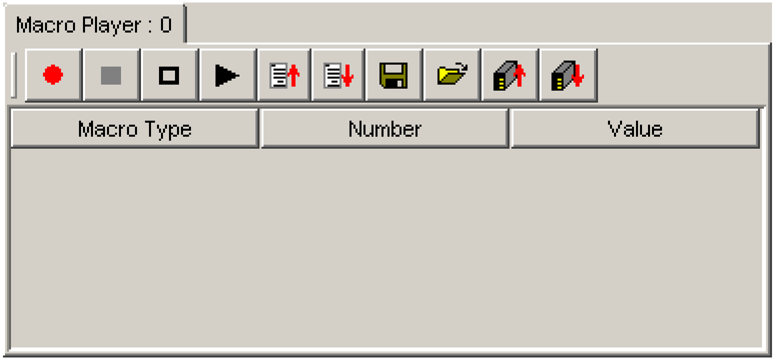
Log Write Parameter



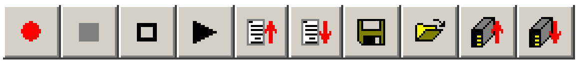
The Log Write Parameter toggle button needs to be depressed if any parameters write events are to be logged.

B.3.13 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.

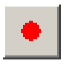


B.3.14 Macro Player Toolbar



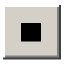
The Macro Player toolbar consists of the following buttons.

Start Recording



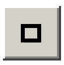
If the Start Recording toggle button is depressed, the Macro Player records those events whose filter toggle buttons (i.e. Record Read Parameter or Record Write Parameter) also are depressed.

Stop Recording



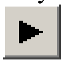
If the Stop Recording toggle button is clicked, all recording is stopped. Clicking the Start Recording button can recommence recording.

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.

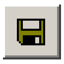
Record Read Parameter

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



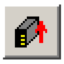
Clicking the Save Macro button displays a file save dialog box, which allows the user to save the current macro.

WARNING – Only SI units are supported when downloading parameters using the Macro Player. Changing parameter units in a saved macro and downloading to a drive may result in unexpected motor performance.

Load Macro

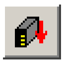
Clicking the Load Macro button displays a file open dialog box, which allows the user to load a previously saved macro.

Configuration Upload



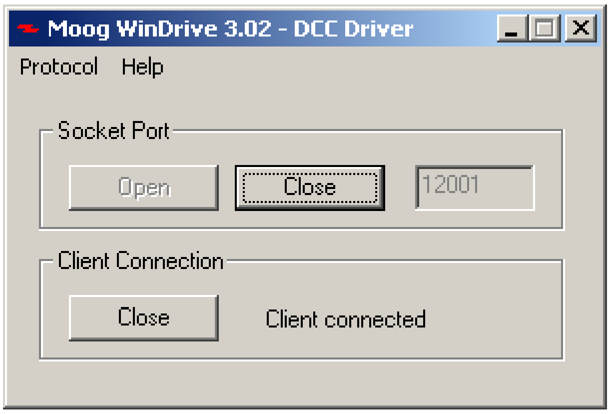
Clicking the Configuration Upload button displays the Save Configuration File dialog box. In this dialog box a file can be specified to which the current controller configuration will be saved. By clicking the Save button in this dialog after having specified a file and directory in which to save the 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.3.15 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. Its purpose is to implement various protocols that are used to communicate with various controllers. Depending on which protocol is used, the protocol name 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:

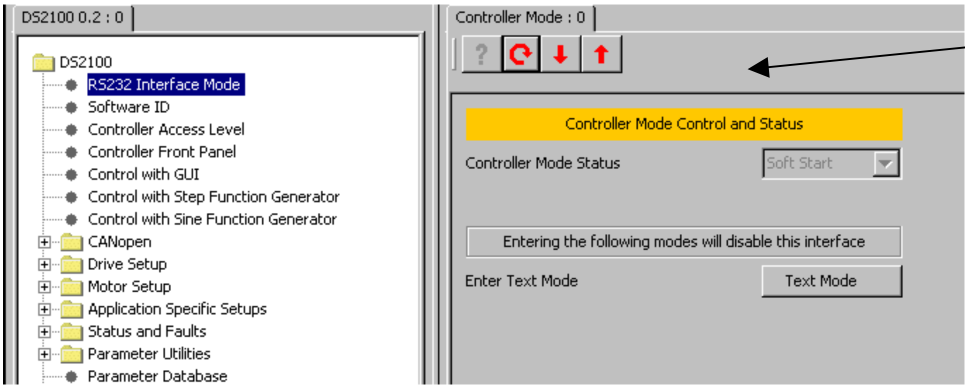
Protocol – This menu and any submenus are protocol specific.
Help / About Driver – Displays the Driver About Box. This dialog contains the driver version information.

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.3.16 Panel Descriptions

B.3.16.1 RS232 Interface Mode

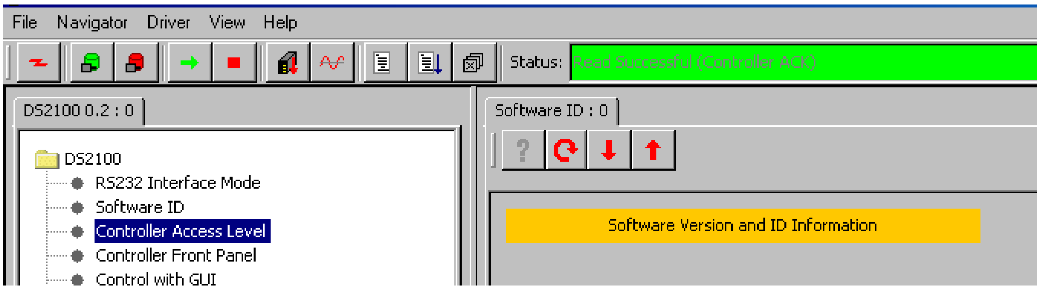


Right click in this area and press “Close” to shut any panel no longer required.

- Controller Mode Control & Status → This parameter allows the user to view the Controller Mode Status.
- Enter Text Mode → This parameter allows the user to switch the controller from the GUI interface to the text interface. After this switch the GUI cannot communicate with the controller until the controller interface is reset.

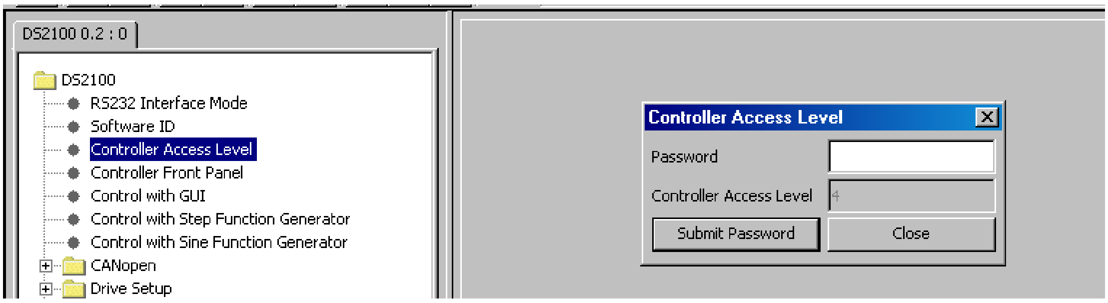
B.3.16.2 Software ID

The Software ID panel allows the user to see embedded software version and FPGA version information. **This information is only available at higher access levels.**



B.3.16.3 Controller Access Level –

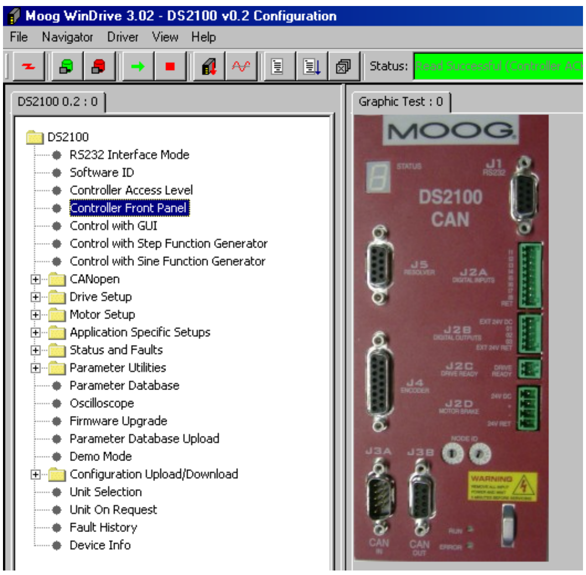
The Controller Access Level dialog allows the user to set the controller access level.



The default access level is 4, but entering a password may set higher levels. Full configuration of a drive and motor is possible at access level 4. Consult Moog Application Engineering if higher level access is required.

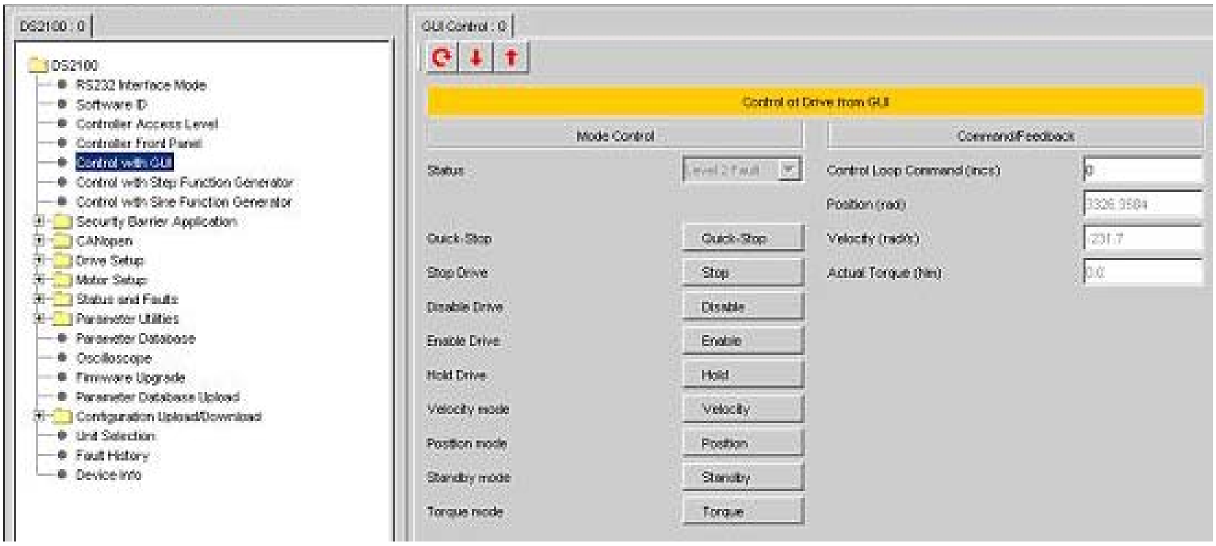
B.3.16.4 Controller Front Panel

The Controller Front Panel contains a picture of the DS2100 front panel (µA Size)



B.3.16.5 Control with GUI

The Control with GUI panel allows the user to control the drive directly from the GUI and set the command into the appropriate control loop.



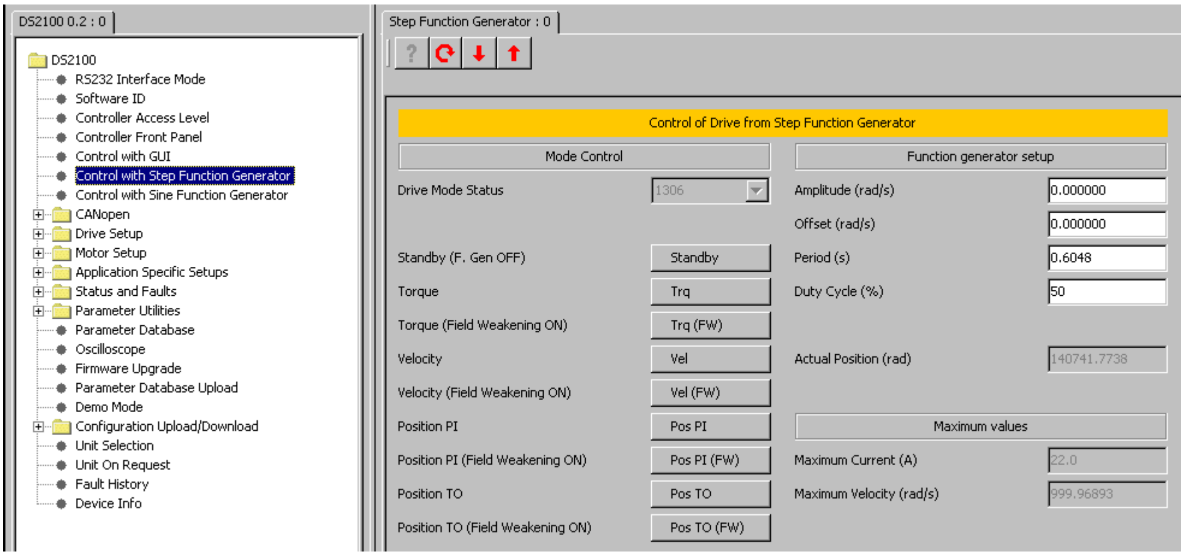
- Status → This displays the current mode of the drive. This may be blank if the drive is not being controlled using this panel.
- Mode Control → These buttons allow the user to set the drive mode.

Command/Feedback

- Control Loop Command – The input to the control loop in internal increments. The command is interpreted according to the mode of the controller – in position mode this is a position command; in velocity mode, a velocity command; in torque mode, a torque command.
- Position → The actual position in radians
- Velocity → The actual velocity in rad/s
- Torque → The actual torque in Nm.

B.3.16.6 Control with Step Function Generator

The Control of Drive with Step Function Generator panel allows the user to control the drive directly from the GUI and use the internal step function generator to set the command into the loop.

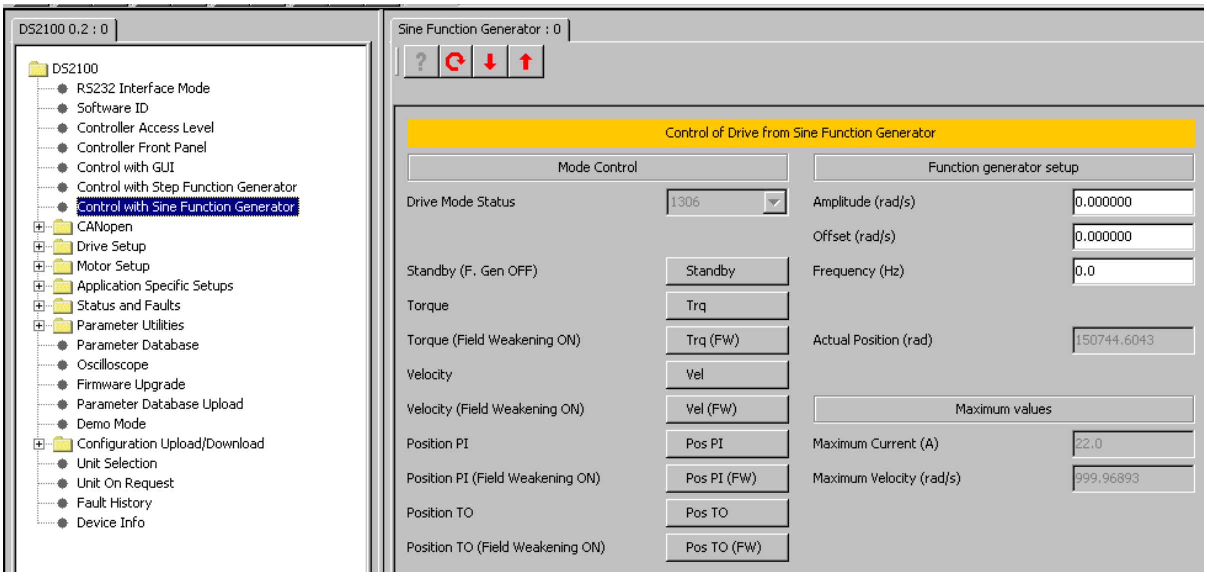


- Drive Mode Status → This displays the current mode of the drive. This may be blank if the drive is not being controlled using this panel. On start-up the drive defaults to standby mode (1306).
- Mode Control → These buttons allow the user to set the drive mode.

- Function Generator Setup → This allows the user to set the function generator Amplitude, Offset, Period and Duty Cycle commands. The units of amplitude and offset are changed according to the controller mode (position – rad, velocity – rad/s, torque – Nm).
- Maximum current → This parameter allows the user to see the maximum current capability of the drive/motor system to assist with using the function generator with the drive in torque mode.
- Maximum velocity → This parameter allows the user to see the maximum velocity capability of the drive/motor system to assist with using the function generator with the drive in velocity mode.

B.3.16.7 Control with Sine Function Generator

The Control of Drive with Sine Function Generator panel allows the user to control the drive directly from the GUI and use the internal sine function generator to set the command into the loop.



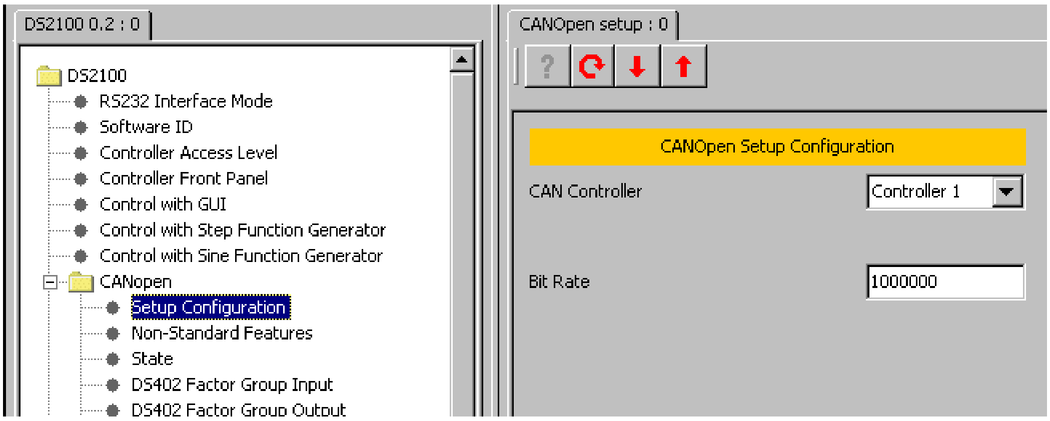
- Drive Mode Status → This displays the current mode of the drive. This may be blank if the drive is not being controlled using this panel. On start-up the drive defaults to standby mode (1306).
- Mode Control → These buttons allow the user to set the drive mode.

- Function Generator Setup → This allows the user to set the function generator Amplitude, Offset, Period and Duty Cycle commands.
- Maximum current → This parameter allows the user to see the maximum current capability of the drive/motor system to assist in using the function generator with the drive in torque mode.

B.3.16.8 CANOpen Setup Configuration

The CANOpen Setup Configuration panel allows the user to set fundamental CAN communication parameters.

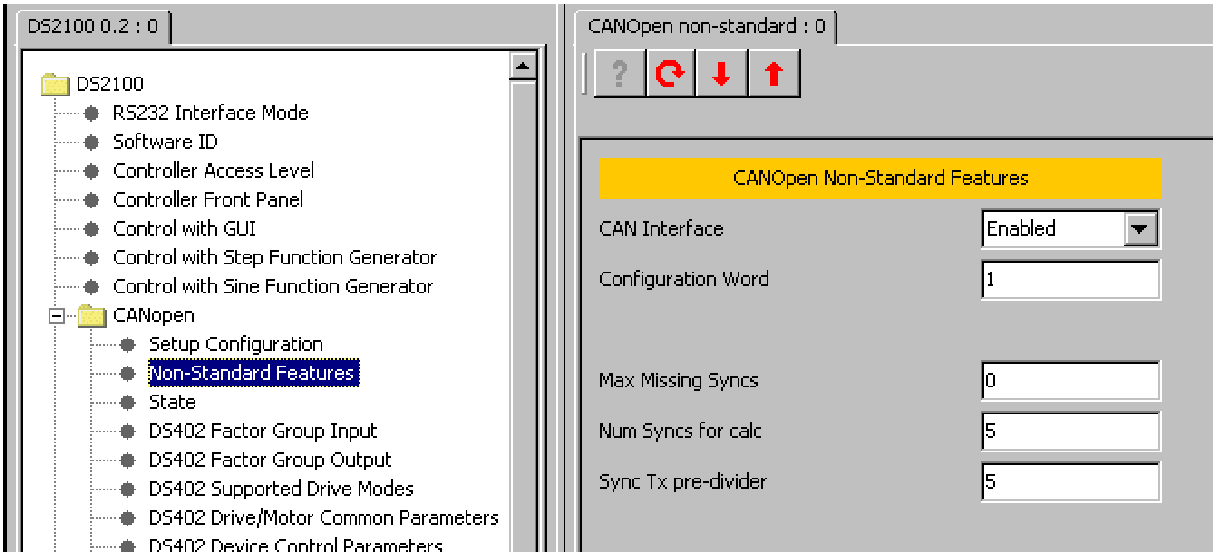
NOTE: For further CANOpen information see Section 7 of this manual.



- CAN Controller → This parameter allows the user to choose CAN controller between Controller 1 and Controller 2. This should always remain at Controller 1.
- Bit Rate → This parameter allows the user to set the bit rate for the CAN bus. The following bit rates are supported:
  - 10000 bits per second
  - 20000 bits per second
  - 50000 bits per second
  - 125000 bits per second
  - 250000 bits per second
  - 500000 bits per second
  - 800000 bits per second
  - 1000000 bits per second

B.3.16.9 CANOpen Non-Standard Features

This panel provides access to some additional functionality beyond the CANOpen standard.

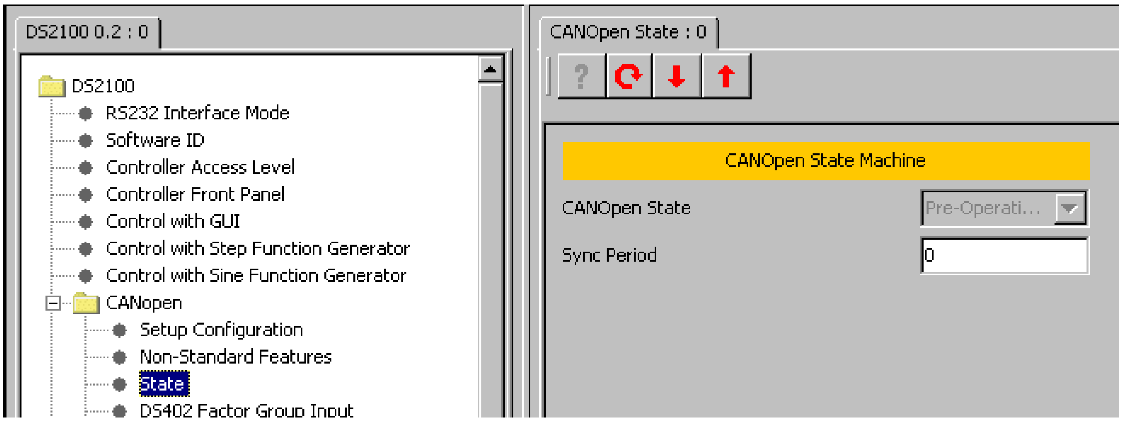


- CAN Interface → This parameter allows the user to enable or disable CAN interface.
- Configuration Word → This is a bit mask that provides some alternative CANOpen startup modes. The bits in this parameter arte defined as follows:

BIT	**ACTION** (when bit is true in configuration word)
0	transmit boot-up complete message
1	none
2	transmit SYNC messages from controller
3	auto start – transition through to CANOpen ‘operational’ mode without waiting for node start command
4	auto calculate SYNC period
5	none
6	none
7	none

- Max missing syncs → A fault is detected after this number of sync periods passes with no SYNC message being received
- Num syncs for calc → the number of sync messages used for the auto calculate function
- Sync Tx pre-divider → the multiple of 2ms at which the sync is transmitted if this function is enabled

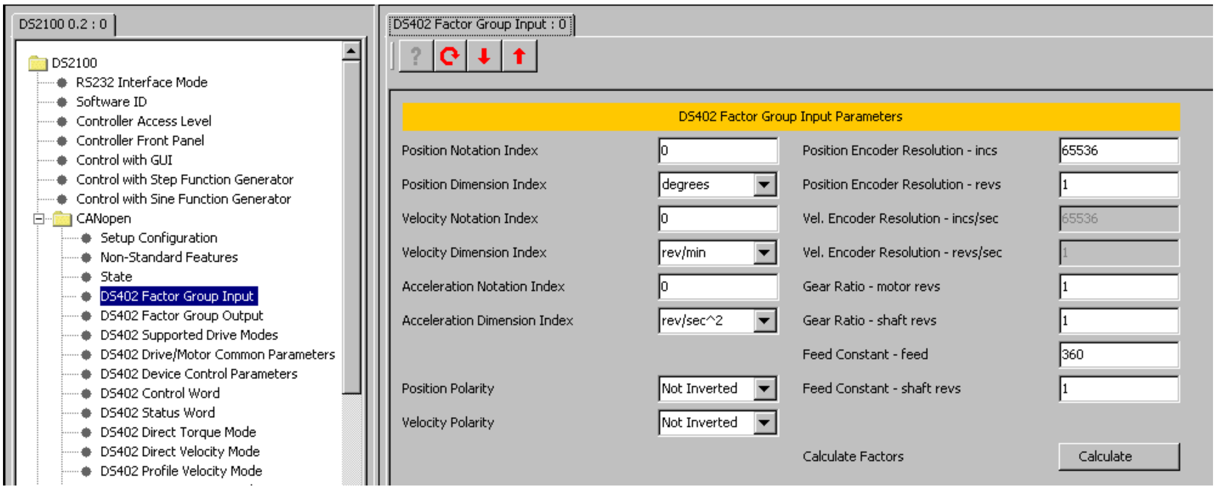
B.3.16.10 CANOpen State



- CANOpen State → This parameter allows the user to view the CANOpen state.
- Sync period → The sync period can be set manually.

B.3.16.11 DS402 Factor Group Input

The DS402 Factor Group Input Parameters panel allows the user to set factor group input parameters for scaling between physical units used by the user, and internal units of the drive.



- Position Notation Index→ This parameter allows the user to select the position notation index (the power of 10 for the position units).
- Position Dimension Index→ This parameter allows the user to select the position dimension unit type between meters ,radians ,seconds, minutes, degrees and revs.
- Velocity Notation Index→ This parameter allows the user to select the velocity notation index (the power of 10 for the velocity units).
- Velocity Dimension Index → This parameter allows the user to select the velocity dimension unit type between m/sec, m/min, m/hour, rev/sec, rev/min and rev/hour.
- Acceleration Notation Index→ This parameter allows the user to select the acceleration notation index (the power of 10 for the acceleration units).
- Acceleration Dimension Index→ This parameter allows the user to select the acceleration unit type between m/sec^2, m/min^2, rev/sec^2 and rev/min^2.

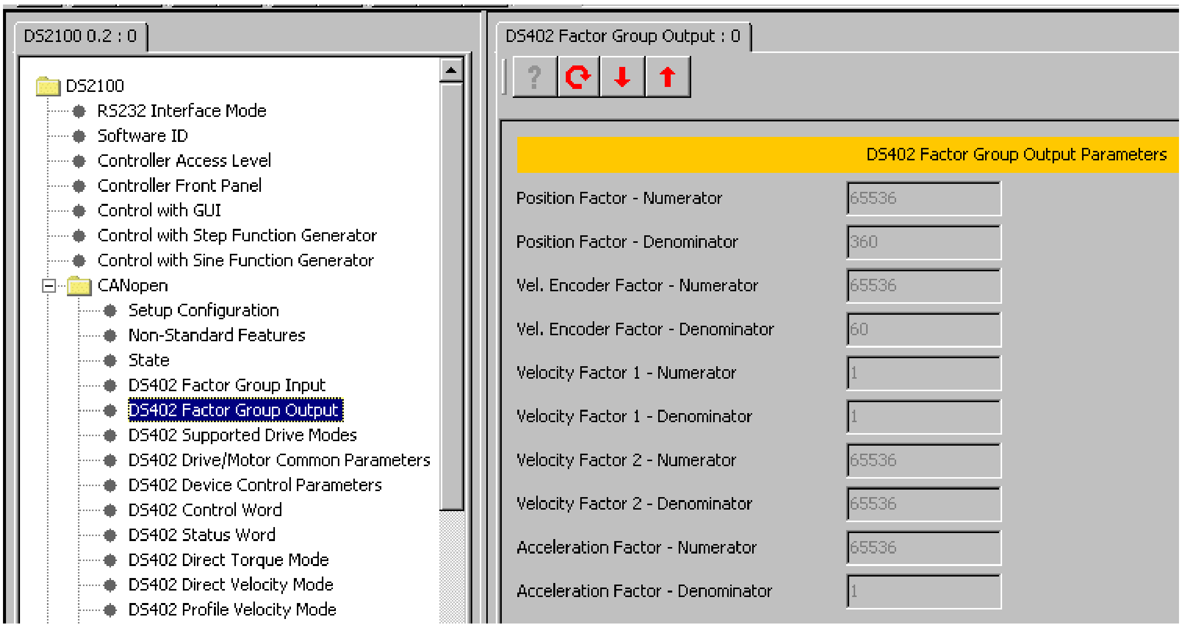
- Position Polarity→ This parameter allows the user to invert the position polarity.
- Velocity Polarity→ This parameter allows the user to invert the velocity polarity.
- Position Encoder Resolution - incs→ Used in conjunction with the 'position encoder resolution – revs' parameter to set the position encoder resolution.
- Position Encoder Resolution – revs→ Used in conjunction with the 'position encoder resolution – incs' parameter to set the position encoder resolution. Resolution = incs/rev
- Vel. Encoder Resolution – incs/sec→ Used in conjunction with the 'position encoder resolution – revs/sec' parameter to set the position encoder resolution.
- Vel. Encoder Resolution – revs/sec→ Used in conjunction with the 'position encoder resolution – incs/sec' parameter to set the position encoder resolution. Resolution = (incs/sec)/(revs/sec)

- Gear Ratio – motor revs → Used in conjunction with the 'Gear Ratio – shaft revs to set the gear ratio.
- Gear Ratio – shaft revs → Used in conjunction with the 'Gear Ratio – motor revs' parameter to set the gear ratio. Gear Ratio = motor revs/shaft revs.

- Feed Constant - feed → Used in conjunction with the 'Feed Constant – shaft revs to set the feed constant.
- Feed Constant – shaft revs → Used in conjunction with the 'Feed Constant - feed' parameter to set the feed constant. Feed Constant = feed/shaft revs.

B.3.16.12 DS402 Factor Group Output

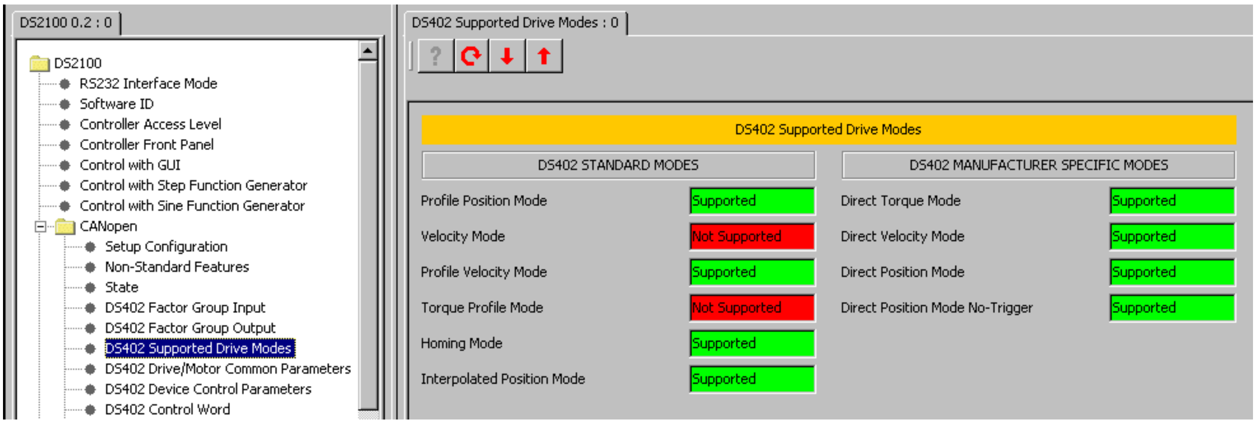
The DS402 Factor Group Output panel allows the user to view factor group output parameters for scaling between physical units used by the user , and internal units of the drive.



- Position Factor - Numerator/Denominator (position units to increment) → This parameter allows the user to see the position factor fraction. The fraction's value depends on input parameters.
- Vel. Encoder Factor - Numerator/Denominator (velocity units to incs./sec) → This parameter allows the user to see the vel.encoder factor fraction. The fraction's value depends on input parameters.
- Velocity Factor 1 - Numerator/Denominator (velocity units to RPM) → This parameter allows the user to see the velocity factor 1 fraction. The fraction's value depends on input parameters.
- Velocity Factor 2 - Numerator/Denominator (pos.enc.res./vel.enc.res.) → This parameter allows the user to see the velocity factor 2 fraction. The fraction's value depends on input parameters.
- Acceleration Factor – Numerator/Denominator (Accel. units to incs./sec^2) → This parameter allows the user to see the acceleration factor fraction. The fraction's value depends on input parameters.

B.3.16.13 DS402 Supported Drive Modes

The DS402 Supported Drive Modes panel allows the user to see which DS402 modes are supported.

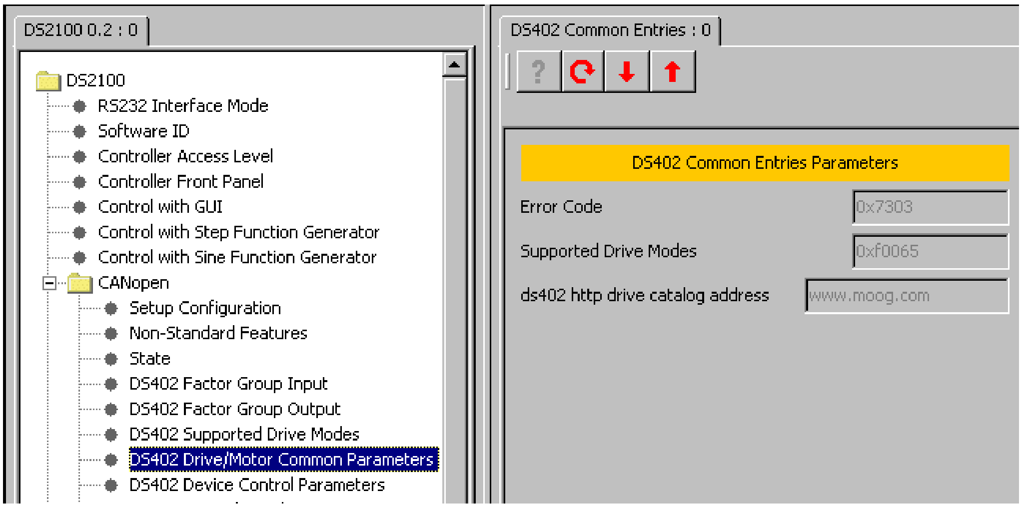


DS402 STANDARD MODES → This parameter allows the user to see a list of supported standard DS402 modes.

DS402 MANUFACTURER SPECIFIC MODES → This parameter allows the user to see a list of supported manufacturer (Moog) specific modes.

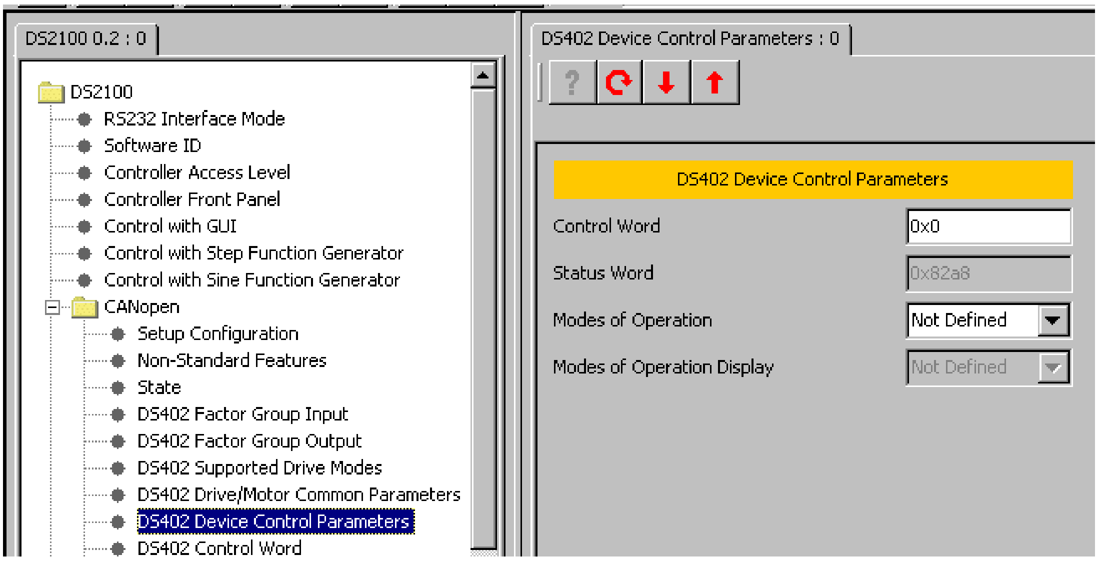
B.3.16.14 DS402 Common Entries

This panel displays parameters that are common to all DS402 modes



- Error Code → This parameter corresponds to the lower 16 Bits of the pre-defined error field (0*1003).
- Supported Drive Modes → This parameter is a numerical code of supported modes which are 4 standard modes + 4 manufacturer specific.
- DS402 HTTP drive catalog address → This parameter allows the user to see the default value of www.moog.com.

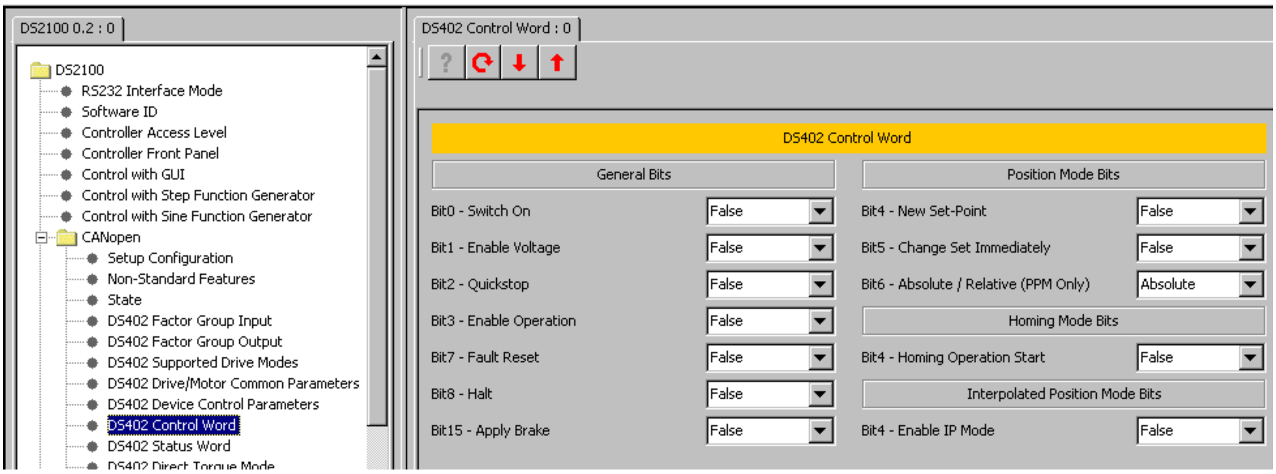
B.3.16.15 DS402 Device Control Parameters



- Control Word → This parameter allows the user to control the transitions between the drive states by setting the bits in the DS402 control word.
- Status Word → This parameter allows the user to see the status of the drive by the settings of specific bits in the DS402 status word.
- Modes of Operation → This parameter allows the user to select one of the eight supported drive models.
- Modes of Operation Display → The actual mode of operation of the drive

B.3.16.16 DS402 Control Word

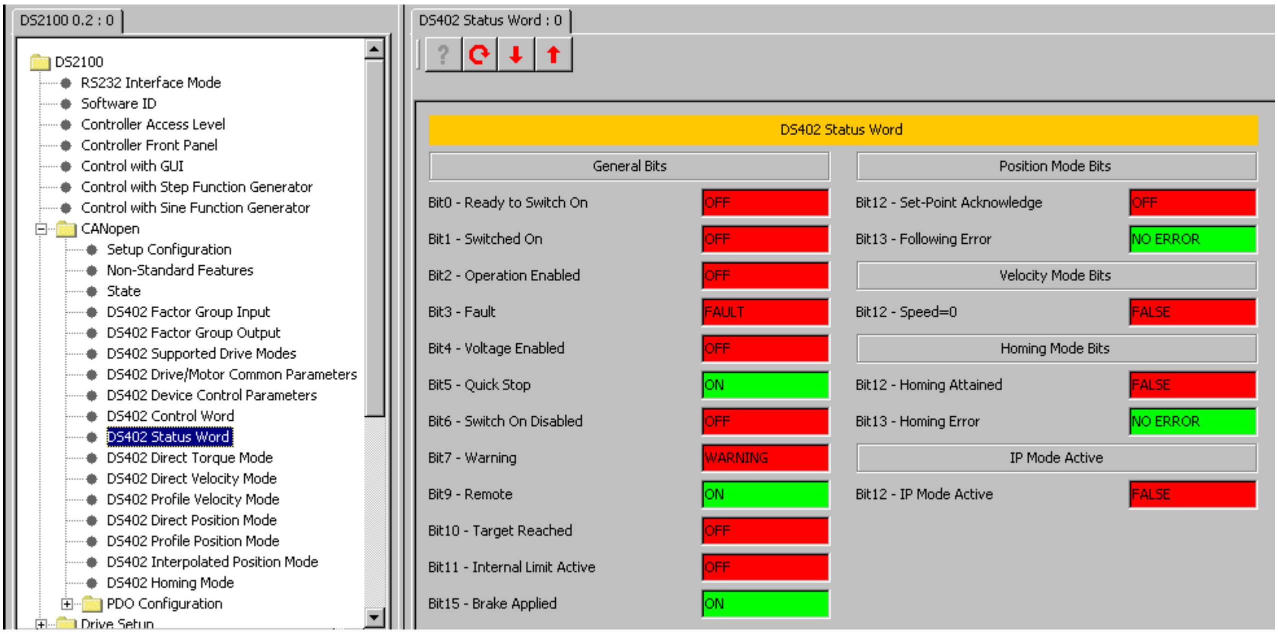
The DS402 Control Word panel allows the user to set control word bits individually.



- General Bits → These are used in all DS402 modes
- Position Mode Bits → Used only in Profile and Direct position modes
- Homing Mode Bits → Used only in Homing mode
- Interpolated Position Mode Bits → Used only in Interpolated position mode

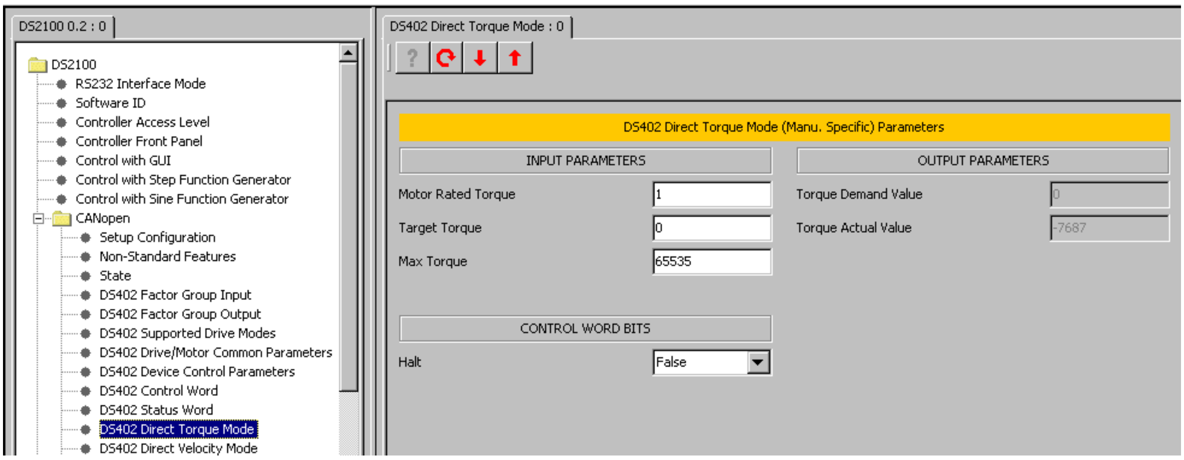
B.3.16.17 DS402 Status Word

The DS402 Status Word panel allows the user to see the state of the drive.



- General Bits → Valid in all modes
- Position Mode Bits → Valid only in profile and direct position modes
- Velocity Mode Bits → Valid only in velocity mode
- Homing Mode Bits → Valid only in homing mode
- IP Mode Active → Valid only in interpolated position mode

B.3.16.18 DS402 Direct Torque Mode



INPUT PARAMETERS → Allows the user to setup the input parameters of direct torque mode. The parameters are:

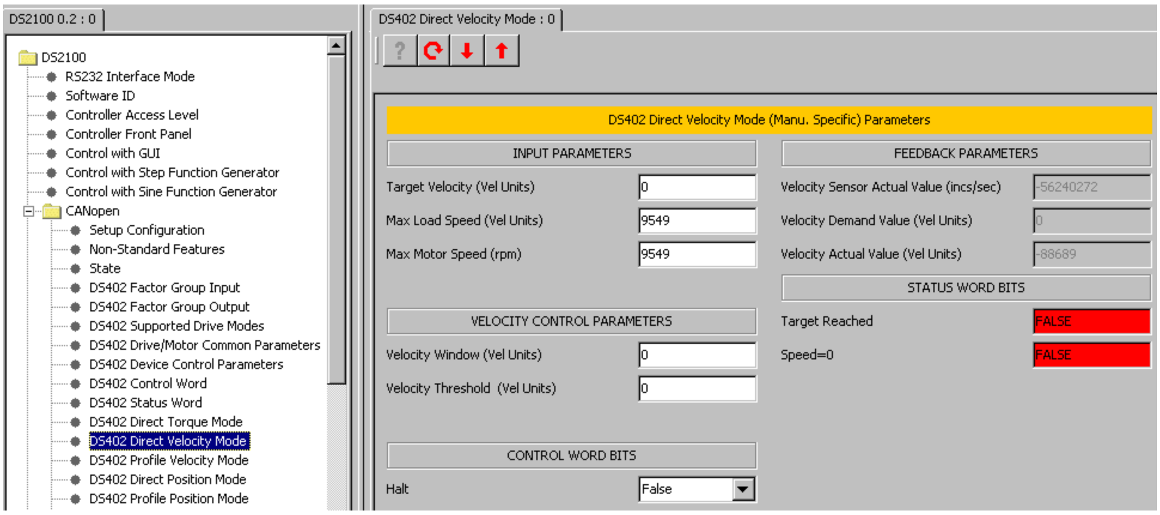
- Motor Rated Torque → In units of Nm. (rotational).
- Target Torque → Set-Point for Torque, in units of per thousand of rated torque.
- Max Torque → Max permissible Torque, in units of per thousand of rated torque.

OUTPUT PARAMETERS → Allows the user to see the value of the two output parameters. The parameters are:

- Torque Demand Value → Output of torque limiting function, in units of per thousand of rated torque.
- Torque Actual Value → Instantaneous Torque in the drive motor, in units of per thousand of rated torque.

CONTROL WORD BITS → Allows the user to set/clear the halt bit.

B.3.16.19 DS402 Direct Velocity Mode



INPUT PARAMETERS → Allows the user to setup the input parameters of direct velocity mode. The parameters are:

- Target Velocity → Input/Set-Point for velocity, in velocity units.
- Max Load Speed → Maximum system speed for velocity loop, in rpm.
- Max Motor Speed→ Maximum allowable speed of motor, in rpm.

FEEDBACK PARAMETERS → Allows the user to see the value of the three feedback parameters. The parameters are:

- Velocity Sensor Actual Value → Value read from resolver in (incs/sec).
- Velocity Demand Value → Output of velocity demand function, in velocity units.
- Velocity Actual Value → Sensor Value scaled to be in velocity units.

VELOCITY CONTROL PARAMETERS → Allows the user to setup the velocity control parameters. The parameters are:

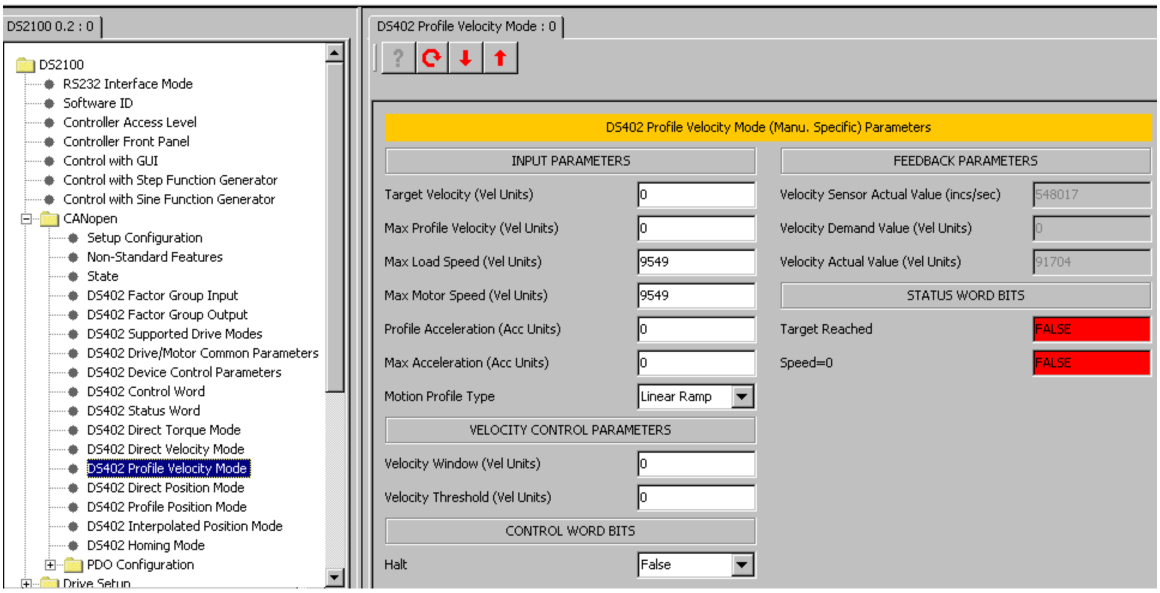
- Velocity Window → Limits (in velocity units) within which target velocity reached bit can be set, in status word.
- Velocity Threshold → If velocity actual value is less than or equal to this value (in velocity units), Speed=0 bit will be set in status word.

STATUS WORD BITS → Allows the user to see the status word bits.

- Target Reached → Indicates that the target velocity has been reached, within the velocity window.
- Speed=0 → Indicates that the speed is at zero (less than the velocity threshold).

CONTROL WORD BITS → Allows the user to set/clear the halt bit.

B.3.16.20 DS402 Profile Velocity Mode



In this mode, a target velocity is input to a profile generator. It generates a velocity demand profile for the velocity control loops, with further inputs to the profile generator limiting its output.

INPUT PARAMETERS → This parameter allows the user to setup the input parameters of profile velocity mode. The parameters are:

- Target Velocity → Input/Set-Point for velocity, in velocity units.
- Max Profile Velocity → Maximum speed allowed during a profile move, in velocity units. This value is limited to the lower value of the following 2 parameters (Max Load Speed and Max Motor Speed)
- Max Load Speed → Maximum speed of the system, used in the velocity loop.
- Max Motor Speed → Maximum allowable speed of motor, in rpm.
- Profile Acceleration → Used to define acceleration of moves, in acceleration units.
- Max Acceleration → The max acceleration can be used to limit the profile acceleration, in acceleration units.
- Motion Profile Type → Used to select the type of motion profile to perform. Only linear ramp (trapezoidal profile) is implemented.

FEEDBACK PARAMETERS → This parameter allows the user to see the value of the three feedback parameters. The parameters are:

- Velocity Sensor Actual Value → Value read from resolver in (incs/sec).
- Velocity Demand Value → Output of velocity demand function, in velocity units.
- Velocity Actual Value → Sensor Value scaled to be in velocity units.

VELOCITY CONTROL PARAMETERS → This parameter allows the user to set up the velocity control parameters. The parameters are:

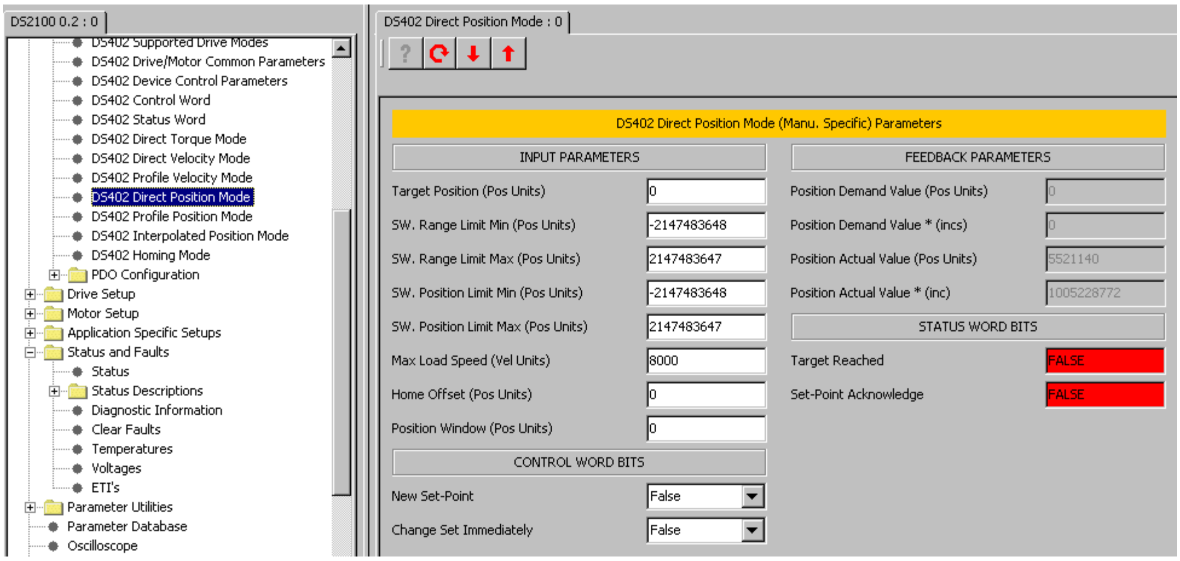
- Velocity Window → Limits (in velocity units) within which target velocity reached bit can be set, in status word.
- Velocity Threshold → If velocity actual value is less than or equal to this value (in velocity units), Speed=0 bit can be set, in status word.

STATUS WORD BITS → This parameter allows the user to see the status word bits.

- Target Reached → Indicates that the target velocity has been reached, within the velocity window.
- Speed=0 → Indicates that the speed is at zero (less than the velocity threshold).

CONTROL WORD BITS → Allows the user to set/clear the halt bit.

B.3.16.21 DS402 Direct Position Mode



In this mode, a target position is set and limited to create a position demand. No profile generator is used.

INPUT PARAMETERS → Allows the user to setup the input parameters of direct position mode. The parameters are:

- Target Position → Input Position for absolute move, in position units.
- SW. Range Limit Min/Max → Range limiting on demand, in position units. The extreme fixed values are –2^31 and 2^31 –1.
- SW. Position Limit Min/Max→ Limit on demand in position units, relative to home position. The extreme fixed values are –2^31 and 2^31-1.
- Max Load Speed → Maximum speed of the system, used in the velocity loop.
- Home Offset → Delta between the zero position and the home position (found during homing), in position units.
- Position Window → Delta between target and actual position, if less than or equal to this window, (in position units) it will set the target reached bit in the status word.

FEEDBACK PARAMETERS → Allows the user to see the value of the four feedback parameters. The parameters are:

- Position Demand Value → Output from Demand Block in position units.
- Position Demand Value* → Output from Demand Block in units of increments.
- Position Actual Value → Actual value from the position measurement device, in position units.
- Position Actual Value* → Actual value from the position measurement device, in incs.

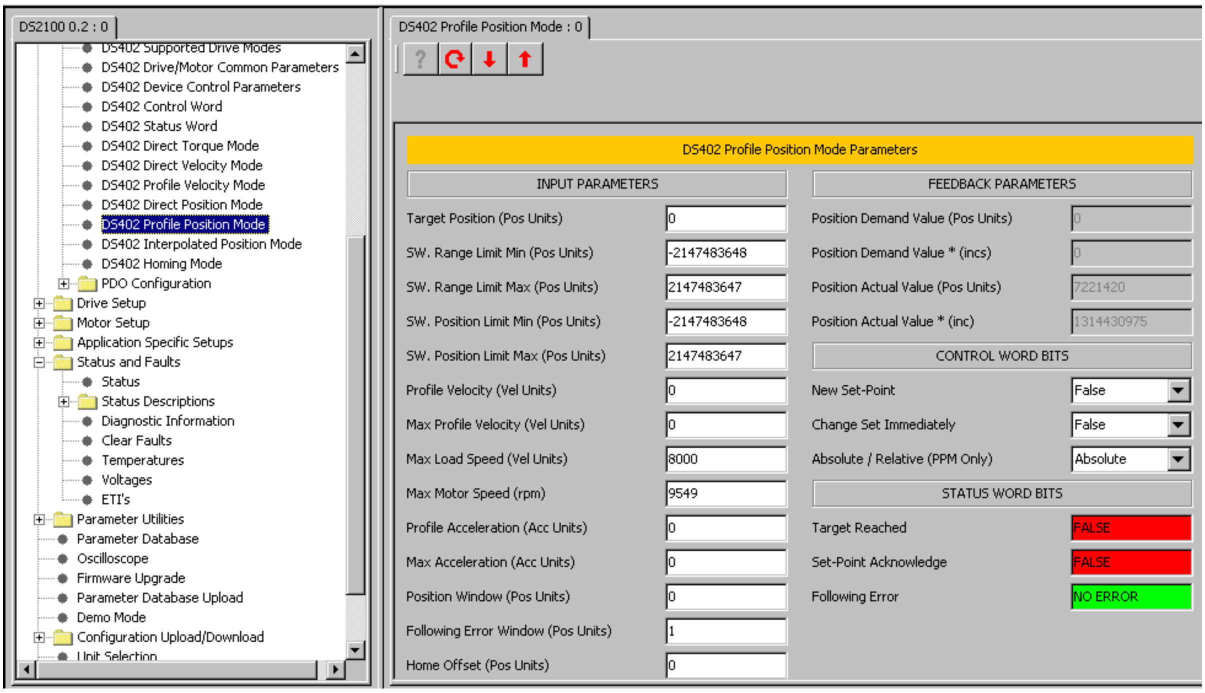
STATUS WORD BITS → Allows the user to see the status word bits.

- Target Reached → Indicates that the target velocity has been reached, within the velocity window.
- Set Point Acknowledge → Indicates if the Drive has assumed the positioning values or not.

CONTROL WORD BITS → Allows the user to set the control word bits.

- New Set – Point → Set the next target position.
- Change Set Immediately → Interrupt the actual positioning and then start the next positioning.

B.3.16.22 DS402 Profile Position Mode



In this mode, a target position is input to a profile generator. It generates a position demand profile for the position control loops, with further inputs to the profile generator shaping is output.

INPUT PARAMETERS → Allows the user to setup the input parameters of profile position mode. The parameters are:

- Target Position → Input to profile generator in position units.
- SW. Range Limit Min/Max → Range limiting on demand, in position units. The extreme fixed values are –2^31 and 2^31 –1.
- SW. Position Limit Min/Max→ Limit on demand in position units, relative to home position. The extreme fixed values are –2^31 and 2^31-1.
- Profile Velocity → Used to define acceleration of moves, in acceleration units.
- Max Profile Velocity→ Max speed allowed during a profile move, in velocity units. This value is limited to the lower value of the following 2 parameters (Max Load Speed and Max Motor Speed)
- Max Load Speed → Maximum speed of the system, used in the velocity loop.
- Max Motor Speed→ Maximum allowable speed of motor, in rpm.
- Profile Acceleration → Used to define acceleration of moves, in acceleration units.
- Max Acceleration → Used to limit the profile acceleration, in acceleration units.
- Position Window → The Delta between target and actual position, if less than or equal to this window, (in position units) it will set the target reached bit in the status word.
- Following Error Window → Allows the user to set the size of the window for the position following error. If the following error is outside this window then a position following error will be flagged.
- Home offset → This shows the offset measured in the homing mode. The user can also set it without performing a homing sequence if required.
- Motion Profile Type → This indicates the type of profile used. Only a 'linear ramp' type is available currently.

FEEDBACK PARAMETERS → Allows the user to see the value of the three feedback parameters. The parameters are:

- Position Demand Value → Output from Demand Block in position units.
- Position Demand Value* → Output from Demand Block in units of increments.
- Position Actual Value → Actual value from the position measurement device, in position units.
- Position Actual Value* → Actual value from the position measurement device, in incs.

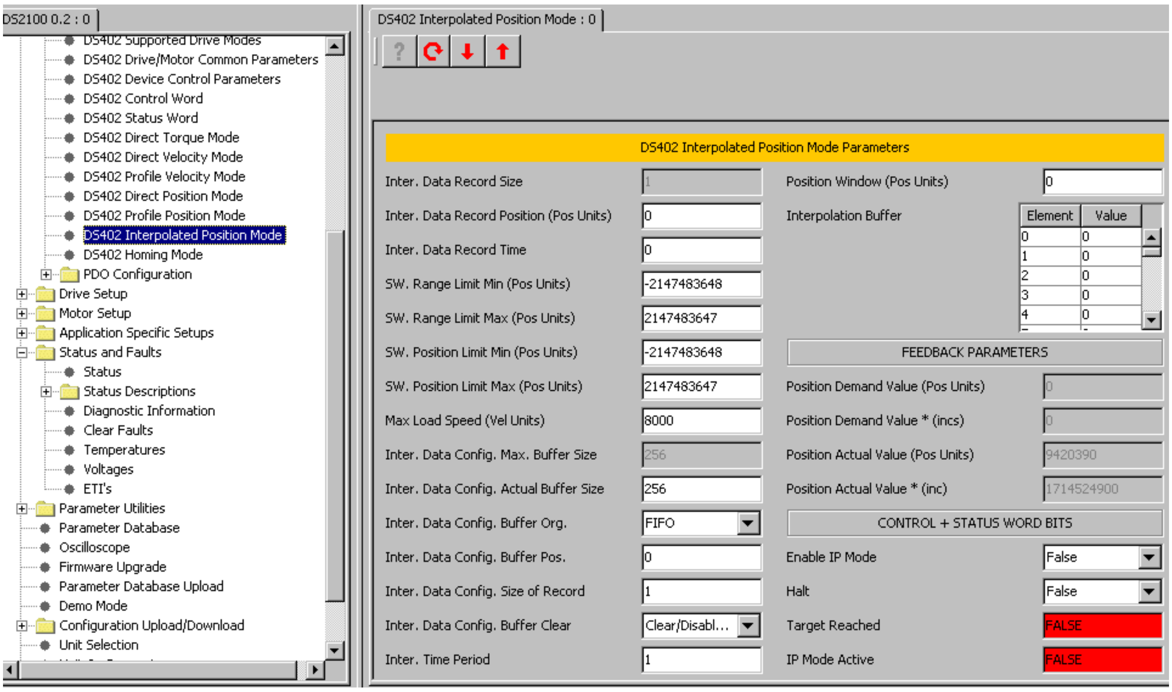
CONTROL WORD BITS → Allows the user to set the control word bits.

- New Set – Point → Set the next target position.
- Change Set Immediately → Interrupt the actual positioning and then start the next positioning.
- Absolute/Relative (PPM Only) → Select whether target value is absolute or relative.

STATUS WORD BITS → Allows the user to see the state of word bits.

- Target Reached → Indicates that the target position has been reached.
- Set Point Acknowledge → Indicates if the Drive has assumed the positioning values.

B.3.16.23 DS402 Interpolated Position Mode



This mode is used to control multiple coordinated axles or a single axle with the need for time-interpolation of set-point data. The IP Mode uses the sync object as a synchronization mechanism for coordination of the related drive units. For each interpolation cycle, the drive will calculate a position demand value by interpolating positions over a period.

IMPUT PARAMETERS → Allows the user to setup the input parameters of interpolated position mode.

The parameters are:

- Inter. Data Record Size/Position/Time → The input data words that are necessary to perform the interpolation algorithm.
- SW. Range Limit Min/Max → Range limiting on demand, in position units. The extreme fixed values are –2^31 and 2^31 –1.
- SW. Position Limit Min/Max→ Limit on demand in position units, relative to home position. The extreme fixed values are –2^31 and 2^31-1.
- Max Load Speed → Maximum speed of the system, used in the velocity loop.
- Inter. Data Config. Max. Buffer Size → Shows the maximum interpolation buffer size
- Inter. Data Config. Actual Buffer Size → Allows the user to set the required interpolation buffer size.
- Inter. Data Config. Buffer Org. → Allows the user to select the interpolation buffer type (FIFO or Ring).
- Inter. Data Config. Buffer Pos. → The position in the interpolation buffer.
- Inter. Data Config. Size of Record → The size of each record in the interpolation buffer.
- Inter. Data Config. Buffer Clear → Clear/disable or else enable the interpolation buffer.
- Inter. Time Period Units → The size of the interpolation time period. This is defined in units of 'Inter. Time Period Index' seconds.
- Inter. Time Period Index → The seconds power of 10 per unit used for the interpolation time period.
- Inter. Sync Defn Sync on → The signal used for interpolation synchronisation – this can only be set to 'general sync'

- Inter. Sync Defn every nth event → interpolation synchronization performed at this number of sync's
- Position Window→ The Delta between target and actual position, if less than or equal to this window, (in position units) it will set the target reached bit in the status word.
- Interpolation Buffer → The interpolation buffer is an internal array, which holds the data records that are written by user.

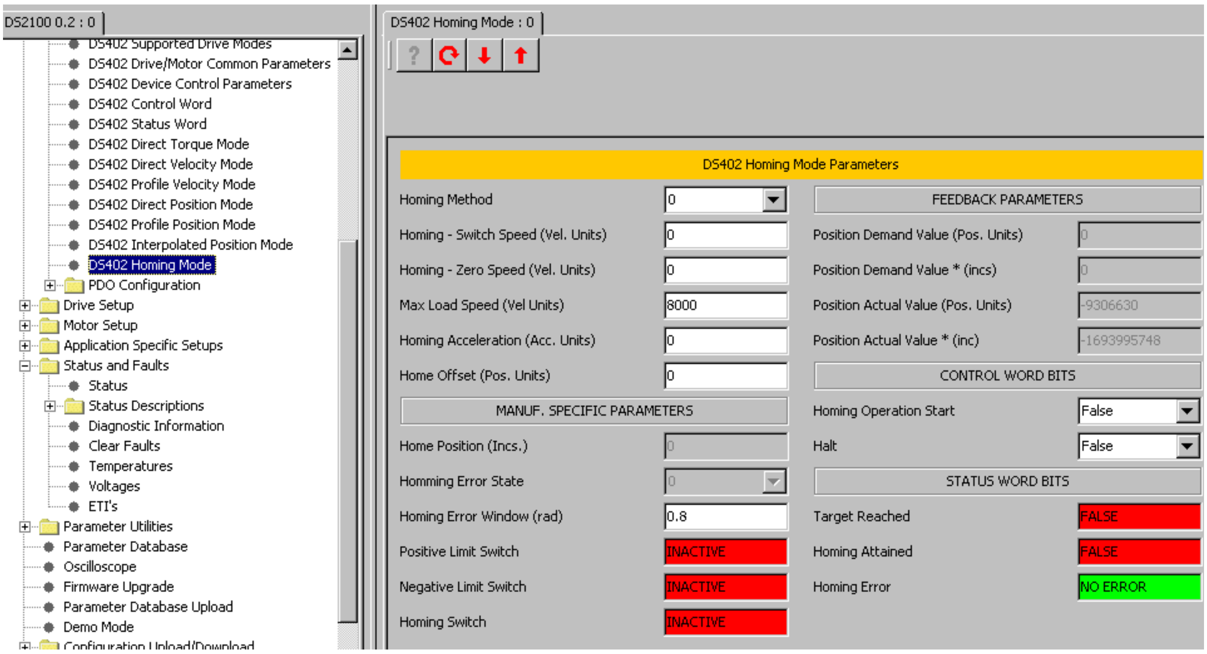
FEEDBACK PARAMETERS → Allows the user to see the value of the four feedback parameters. The parameters are:

- Position Demand Value → Output from Demand Block in position units.
- Position Demand Value* → Output from Demand Block in units of increments.
- Position Actual Value → Actual value from the position measurement device, in position units.
- Position Actual Value* → Actual value from the position measurement device, in incs.

CONTROL + STATUS WORD BITS

- Enable IP Mode → It allows the IP Mode to be enabled or disabled
- Halt → Allows the user to set/clear the halt bit.
- Target Reached → Indicates that the target position has been reached
- IP mode active → Indicates that interpolated position mode is active

B.3.16.24 DS402 Homing Mode



This method is used to determine the home position (also called datum or zero position) of a system, using various methods, and different digital inputs.

- Homing Method → Select the method to be used for homing. There are 4 manufacturer specific modes.
- Homing - Switch Speed → Speed during search for switch
- Homing - Zero Speed → Speed during search for zero
- Homing Acceleration→ Sets acceleration and deceleration used with all homing modes, in acceleration units.
- Home Offset → Difference between the zero position and the home position (found during homing), in position units

MANUF. SPECIFIC PARAMETERS → Allows the user to see the value of the six manufacturer specific parameters.

The parameters are:

- Home Position → Home Position in increments.
- Homing Error State → Home State drive was in when error occurred.
- Homing Error Window → Position window between switch and zero, that causes error, in fractions of a rev.
- Positive Limit Switch → Indicates if positive limit is active or not.
- Negative Limit Switch → Indicates if negative limit is active or not.
- Homing Switch→ Home Digital input Logical Status.

FEEDBACK PARAMETERS → Allows the user to see the value of the four feedback parameters.

The parameters are:

- Position Demand Value → Output from Demand Block in position units.
- Position Demand Value* → Output from Demand Block in units of increments.
- Position Actual Value → Actual value from the position measurement device, in position units.

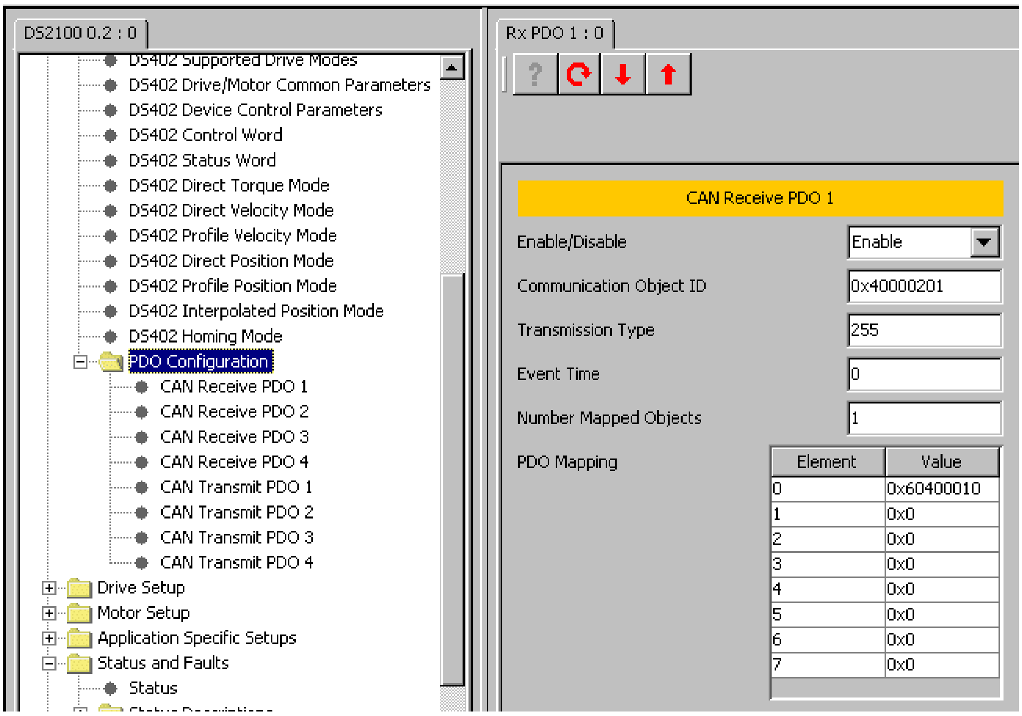
CONTROL WORD BITS

- Homing Operation Start → Activate the homing mode.
- Halt → Allows the user to set/clear the halt bit.

STATUS WORD BITS

- Target Reached → It shows if Home position is reached.
- Homing Attained → It shows if Homing mode is successfully completed.
- Homing Error → It shows if a Homing error has occurred.

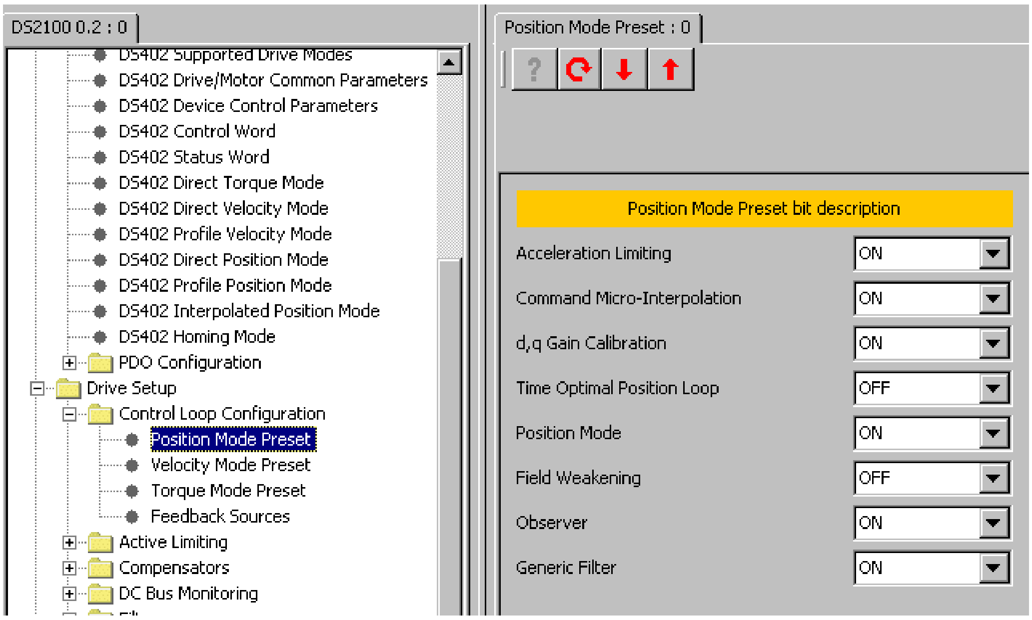
B.3.16.25 CAN Receive/Transmit PDO 1 - PDO 2 – PDO 3 – PDO 4



The drive supports up to 4 receive and up to 4 transmit Process Data Objects (PDOs)
The contents can be specified using PDO mapping. The granularity of the PDO mapping is a byte.

- Enable/Disable → Enable or disable the CAN Receive or Transmit PDO. A PDO should be disabled before changes are made to its configuration (ID, transmission type or mapping)
- Communication Object ID → the 11 LSB's of this parameter are set to the COB ID. Bit 30 is always 1 and bit 29 is always 0
- Transmission Type → The transmission type as defined by CANOpen standard DS301. (For example, 255 is an asynchronous event driven transmission type.)
- PDO Mapping → The PDO mapping is the mechanism that allows the user to change the contents of the process data objects. To change the PDO mapping, the parameter 'Number Mapped Objects' should be set to 0, then the new parameters to be mapped written in the 'PDO_Mapping' array and then the number of mapped parameters should be written into 'Number Mapped Objects'. Make sure that not more than 8 bytes are used up in this mapping process. If trying to map more than 8 bytes into one PDO, writing of 'Number Mapped Objects' will cause an error.

B.3.16.26 Position Mode Preset

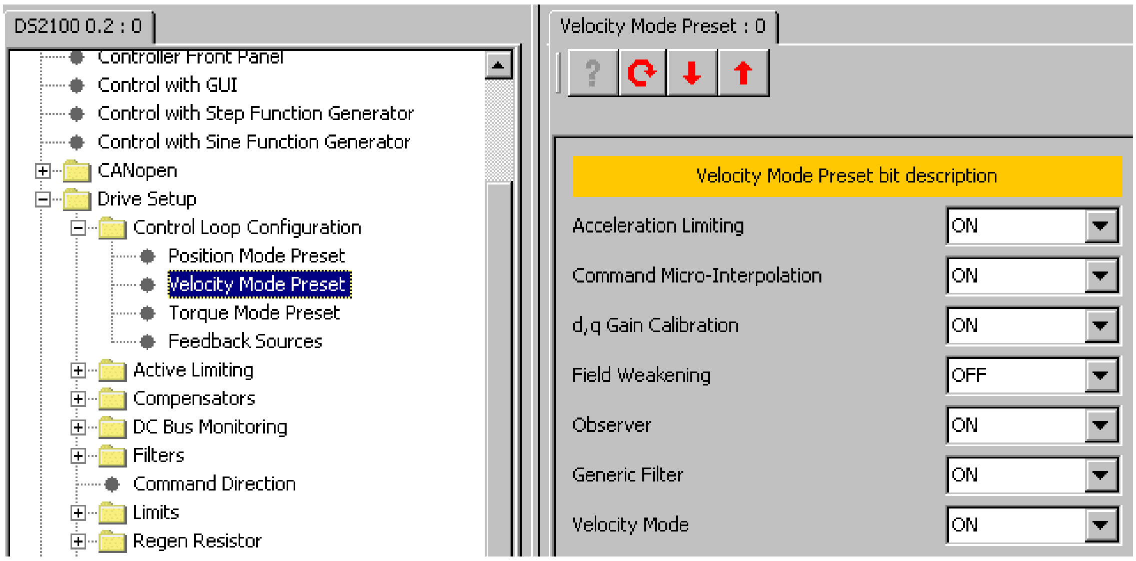


The Position Mode Preset panel allows the user to set the mode request when a position control mode is requested. The default value for this parameter is 34776 (87D8 hex) indicating that bits 3, 4, 6, 7, 8, 9, 10 and 15 are set. Note that bit 6 must always be set in this parameter; bits 0 and 1 must never be set in position mode.

The user can set the following commands:

- Acceleration Limiting → ON/OFF (bit 10)
- Command Micro Interpolation → ON/OFF (bit 9)
- d,q Gain Calibration → ON/OFF (bit 8)
- Time Optimal Position Loop → ON/OFF (bit 7)
- Position Mode → ON/OFF (bit 6)
- Field weakening → ON/OFF (bit 5)
- Observer → ON/OFF (bit 4)
- Generic Filter → ON/OFF (bit 3)

B.3.16.27 Velocity Mode Preset

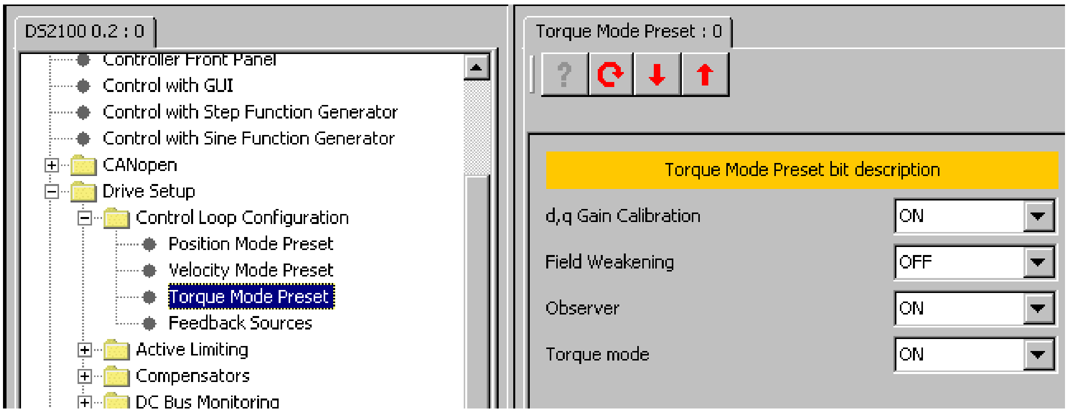


The Velocity Mode Preset panel allows the user to set the mode request when a velocity control mode is requested. The default value for this parameter is 34586 (871A hex) indicating that bits 1, 3, 4, 8, 9, 10 and 15 are set. Note that bit 1 must always be set in this parameter, bits 0 and 6 must never be set and bit 7 has no meaning in velocity mode.

The user can set the following commands:

- Acceleration Limiting → ON/OFF (bit 10)
- Command Micro Interpolation → ON/OFF (bit 9)
- d,q Gain Calibration → ON/OFF (bit 8)
- Field weakening → ON/OFF (bit 5)
- Observer → ON/OFF (bit 4)
- Generic Filter → ON/OFF (bit 3)
- Velocity Mode → ON/OFF (bit 1)

B.3.16.28 Torque Mode Preset

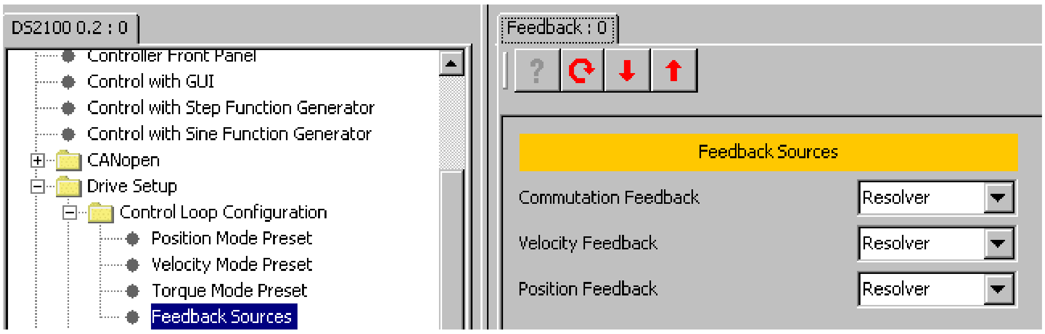


The Torque Mode Preset panel allows the user to set the mode request when a torque control mode is requested. The default value for this parameter is 33041 (8111 hex) indicating that bits 0, 4, 8 and 15 are set. Note that bit 0 must always be set in this parameter, bits 1 and 6 must never be set and bits 3, 7 and 10 have no meaning in torque mode.

The user can set the following commands:

- d,q Gain Calibration → ON/OFF (bit 8)
- Field weakening → ON/OFF (bit 5)
- Observer → ON/OFF (bit 4)
- Torque Mode → ON/OFF (bit 0)

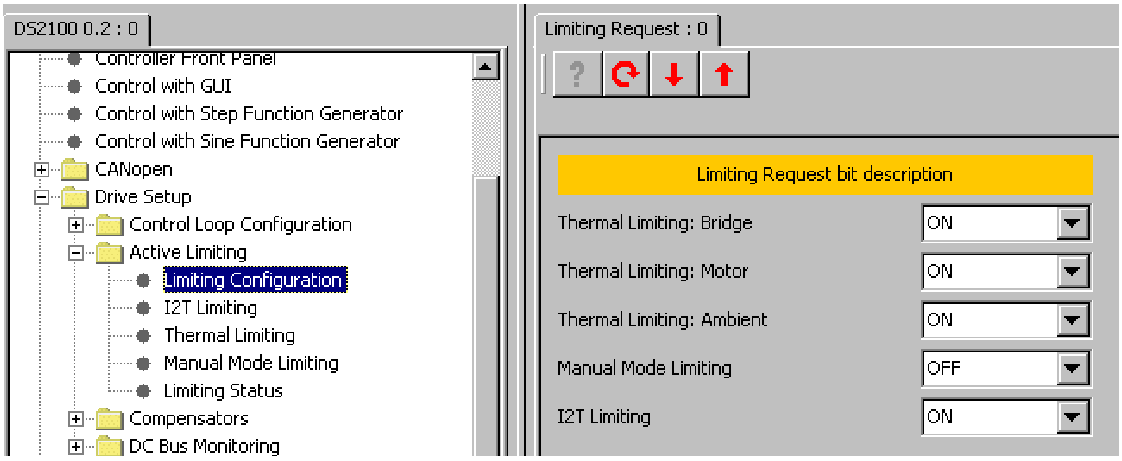
B.3.16.29 Feedback Sources



The Feedback Sources panel allows the user 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 uses this parameter. Customers have to select encoder or resolver feedback to turn a motor.

- Commutation Feedback → Angle Zero/Resolver/Encoder
- Velocity Feedback → Angle Zero/Resolver/Encoder
- Position Feedback → Angle Zero/Resolver/Encoder

B.3.16.30 Limiting Configuration

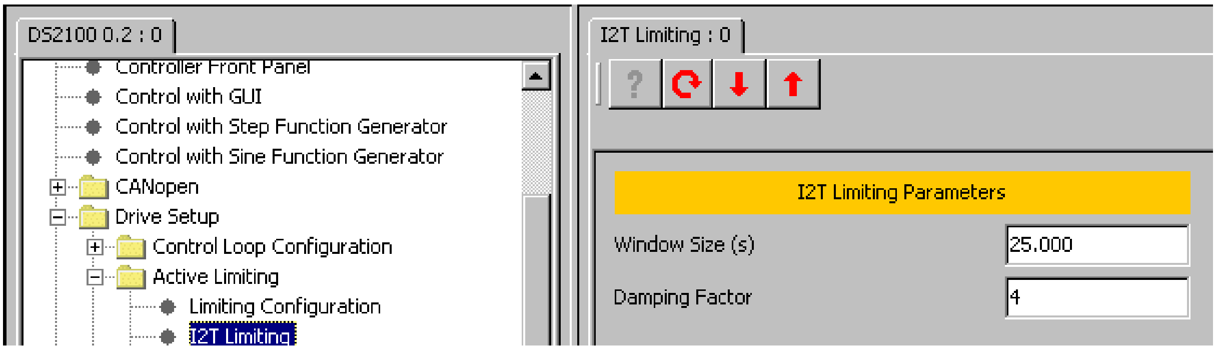


The Limiting Configuration panel allows the user to set the limits using the following commands:

- Thermal Limiting Bridge → Thermal limit of the power amplifier bridge (ON/OFF).
- Thermal Limiting Motor → Thermal winding limit of the motor (ON/OFF).
- Thermal Limiting Ambient → Thermal limit of the control electronics ambient (ON/OFF).
- Manual Mode Limiting → Enables the manual mode limiting (ON/OFF).
- I2T Limiting → Enables the I2T limiting (ON/OFF).

B.3.16.31 I2T Limiting

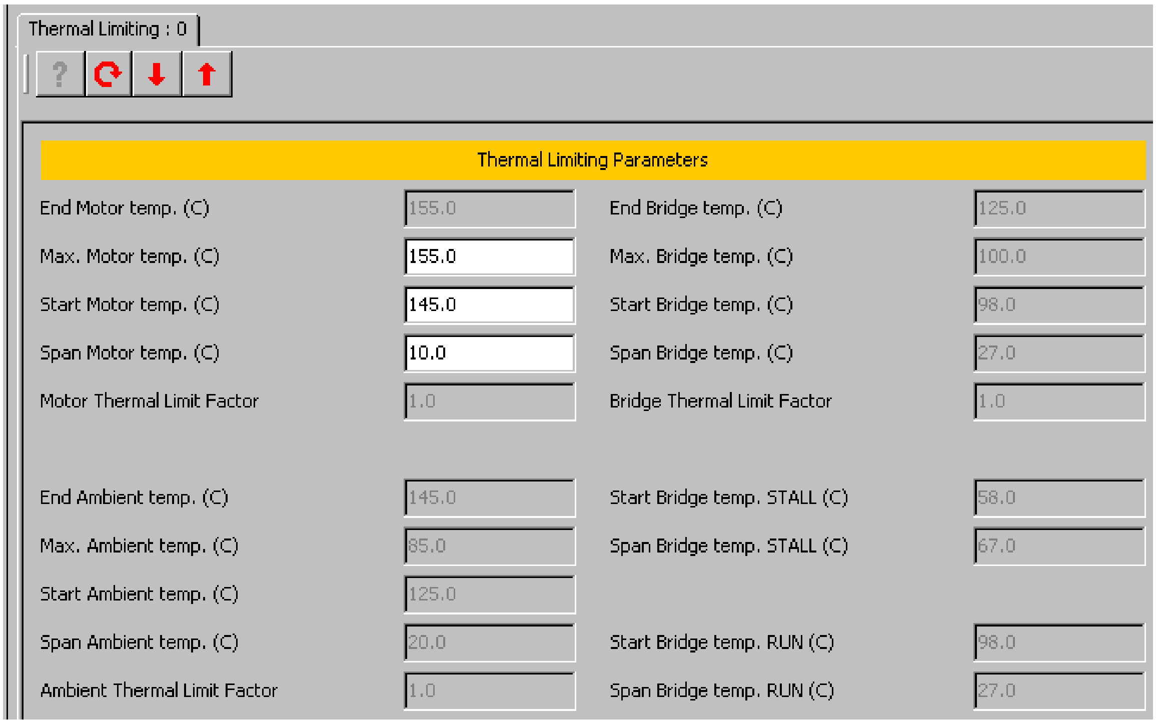
The I2T Limiting panel allows the user to set the I2T Limiting parameters.



- Window Size (s) → averaging window for I2T limiting
- Damping Factor → I2T output smoothing

B.3.16.32 Thermal Limiting

The Thermal Limiting panel allows the user to set the motor, bridge and ambient thermal limiting parameters .



For the motor the parameters are:

- End Motor temp. → read only value, calculated from start + span. At this temperature the current is reduced to 0.
- Max. Motor temp. → the temperature at which an over-temperature fault is indicated
- Start Motor temp. → the temperature at which thermal limiting starts to act
- Span Motor temp. → 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)

The motor's temperature is measurable approximately between 25°C and 175°C.
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.

For the ambient the parameters are:

- End Ambient temp. → read only value, calculated from start + span. At this temperature the current is reduced to 0.
- Max. Ambient temp. → the temperature at which an over-temperature fault is indicated
- Start Ambient temp. → the temperature at which thermal limiting starts to act
- Span Ambient temp. → 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)

For the bridge the parameters are:

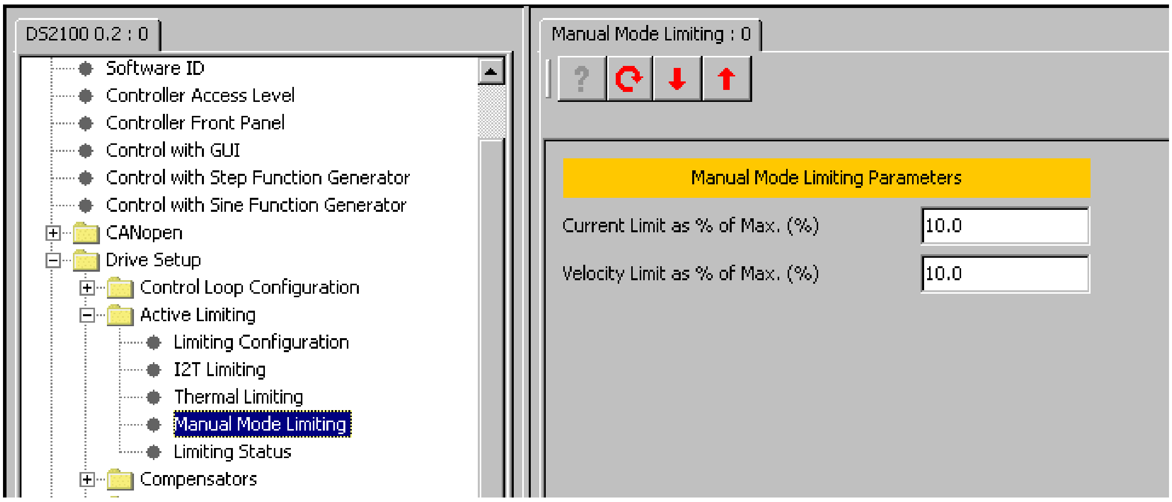
- End Bridge temp. → read only value, calculated from start + span. At this temperature the current is reduced to 0.
- Max. Bridge temp.→ the temperature at which an over-temperature fault is indicated
- Start Bridge temp. → read only value, which takes the value of 'Start Bridge temp. STALL' if the motor speed is less than 50RPM and otherwise takes the value of Start Bridge temp. RUN
- Span Bridge temp. → read only value, which takes the value of 'Span Bridge temp. STALL' if the motor speed is less than 50RPM and otherwise takes the value of Span Bridge temp. RUN
- Bridge Thermal Limit Factor → the actual value of the thermal limit factor (a value between 0 and 1.0)

- 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

B.3.16.33 Manual Mode Limiting

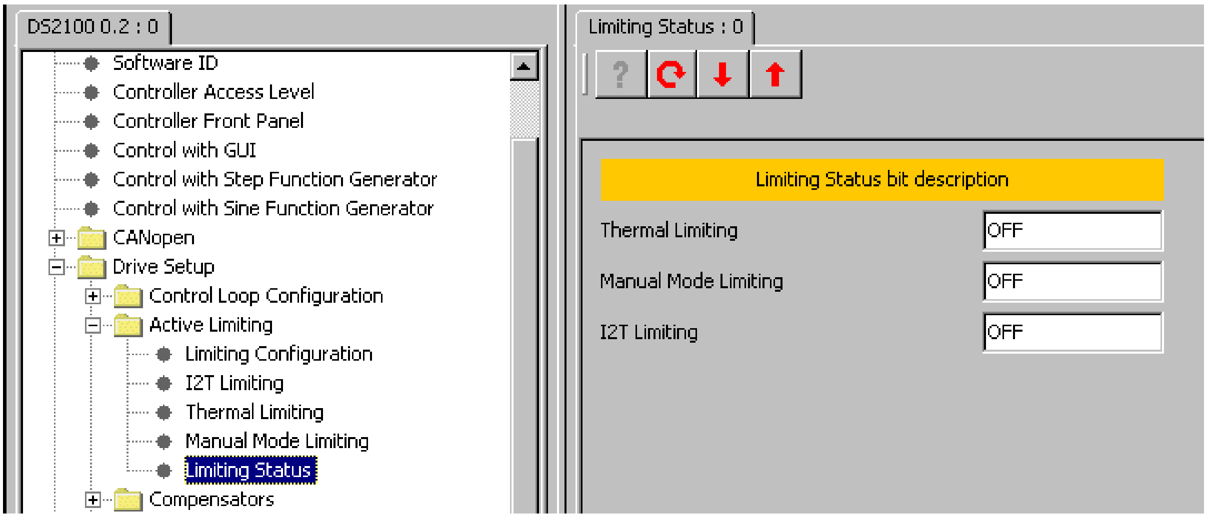
The Manual Mode Limiting panel allows the user to set the parameters of this mode.



- Current/Velocity Limit as % of Max. (%) → it allows the user to set the current/velocity limit as a percent of the max value.

B.3.16.34 Limiting Status

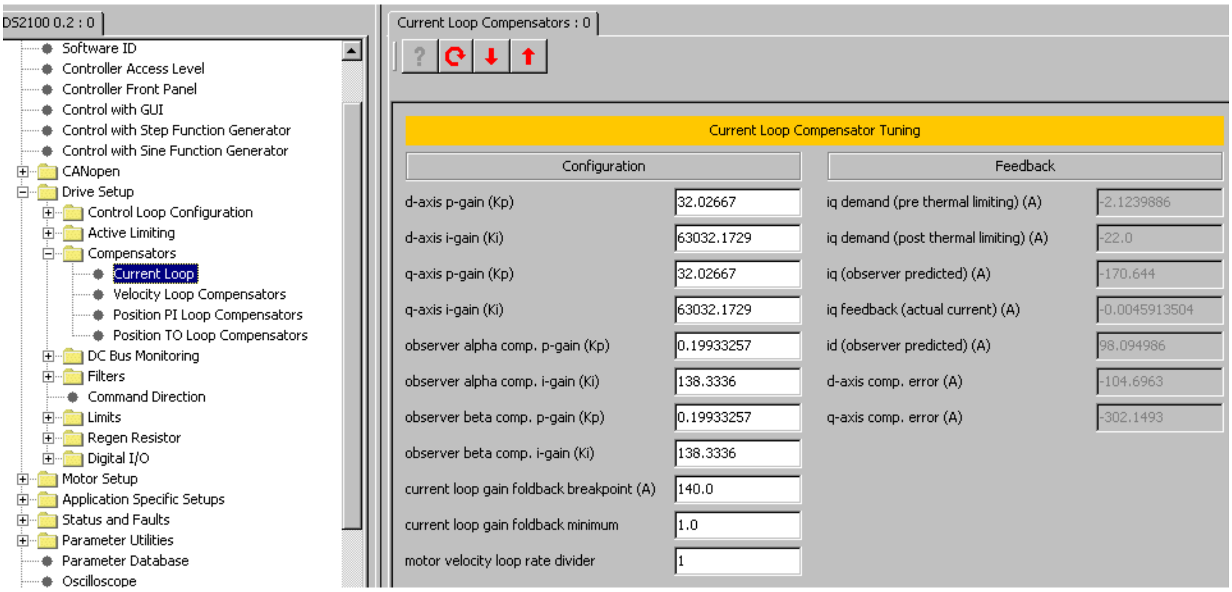
The Limiting Status panel allows the user to see whether any limiting is active



- Thermal Limiting → (ON/OFF)
- Manual Mode Limiting → (ON/OFF)
- I2T Limiting → (ON/OFF)

B.3.16.35 Current Loop

The Current Loop panel allows the user 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.

CONFIGURATION:

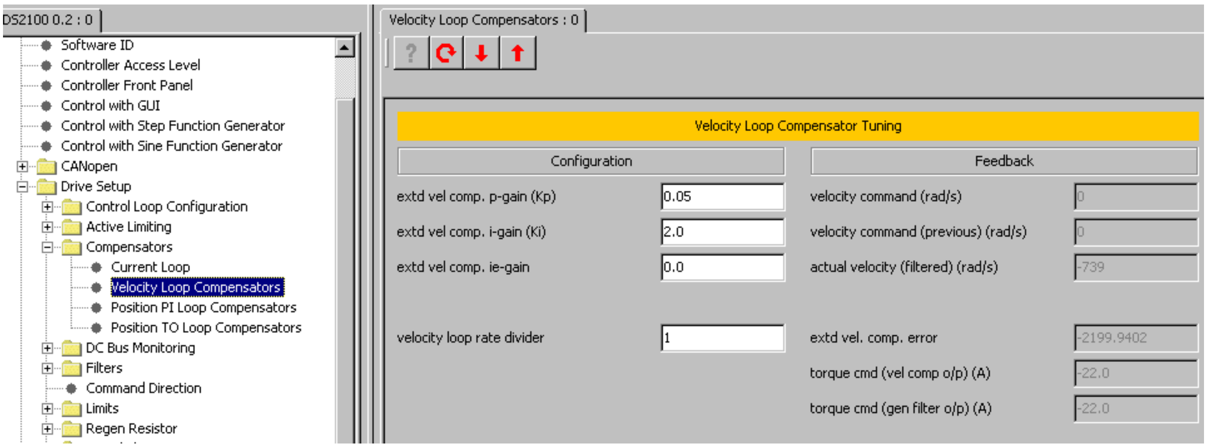
- d-axis p-gain (Kp) → The p-gain of the d-axis compensator (Volts/Amp).
- d-axis i-gain (Ki) → The i-gain of the d-axis compensator (Volts/Amp/Tsamp).
- q-axis p-gain (Kp) → The p-gain of the q-axis compensator (Volts/Amp).
- q-axis i-gain (Ki) → The i-gain of the q-axis compensator (Volts/Amp/Tsamp).
- 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) → v 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 → 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.
- q-axis comp. error (A) → The difference between actual value and demanded value of the q-axis current.

B.3.16.36 Velocity Loop Compensators

The Velocity Loop Compensators panel allows the user to set the velocity loop compensator configuration and to see 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.

CONFIGURATION

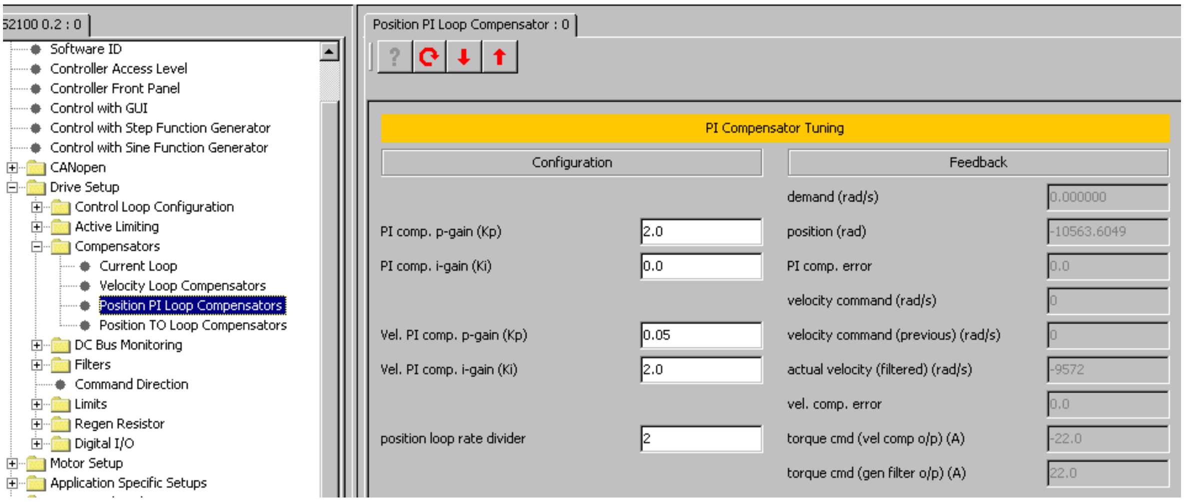
- extd vel comp. p-gain (Kp) → The p-gain of the velocity compensator (Nm/rad/s).
- extd vel comp. i-gain (Ki) → The i-gain of the velocity compensator (Nm/rad).
- extd vel comp. ie-gain → The ie-gain of the velocity compensator.
- velocity loop rate divider → The rate divider for the velocity loop – the number of current loop samples per velocity loop sample.

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 → 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.3.16.37 Position PI Loop Compensators

The Position PI Loop Compensators panel allows the user 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.

CONFIGURATION

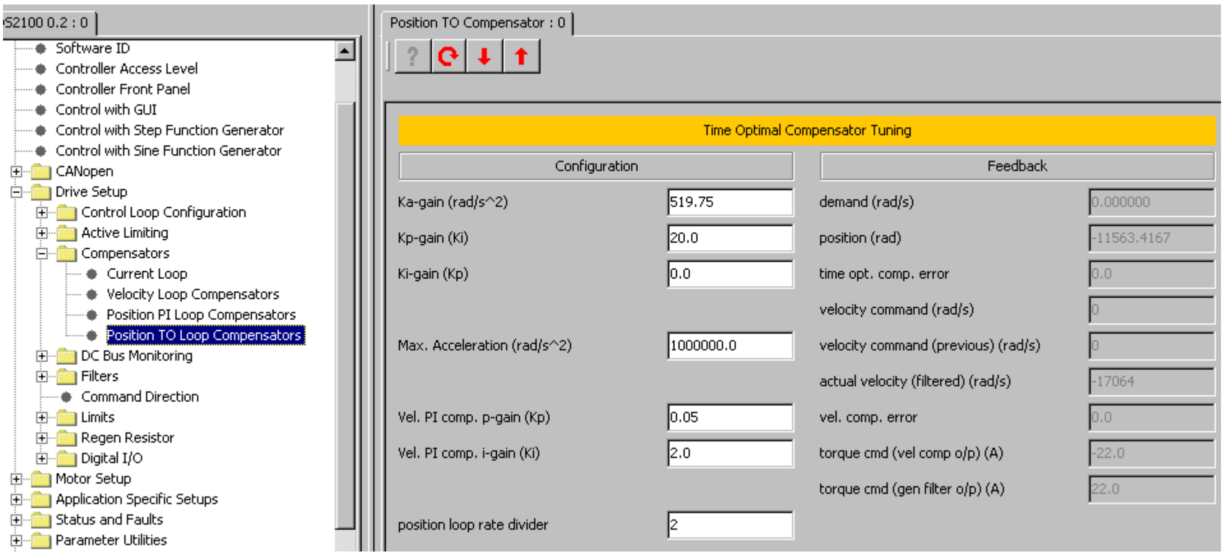
- PI comp. p-gain (Kp) → The p-gain of the PI compensator (1/s).
- PI comp. i-gain (Ki) → The i-gain of the PI compensator (1/s^2).
- Vel. Pi comp. p-gain (Kp) → The p-gain of the velocity loop PI compensator used in position mode (Nm/rad/s). This is separate to the velocity loop compensator used in 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
- extd 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.3.16.38 Position TO Loop Compensators

The Position TO Loop Compensators panel allows the user to set the configuration of the 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.

CONFIGURATION

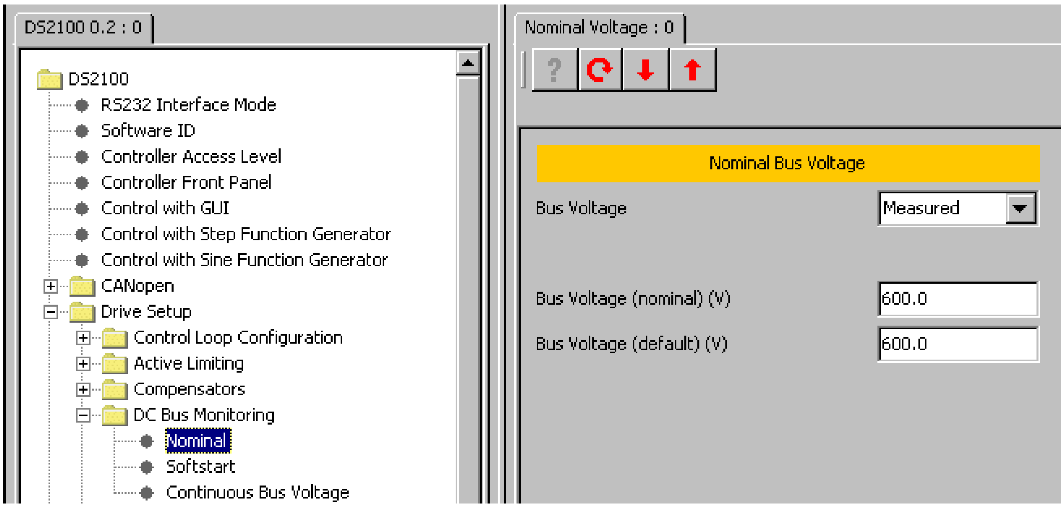
- Ka-gain (rad/s^2) → The a-gain of the TO compensator (rad/s^2).
- Kp-gain (Ki) → The p-gain of the TO compensator (1/s).
- K i-gain (Kp) → The i-gain of the TO compensator (1/s^2).
- Vel. Pi comp. p-gain (Kp) → The p-gain of the velocity loop PI compensator used in position mode (Nm/rad/s). This is 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.
- 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
- extd 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.3.16.39 Nominal Bus Voltage

The Nominal Bus Voltage panel allows the user see the nominal value of the DC bus voltage.

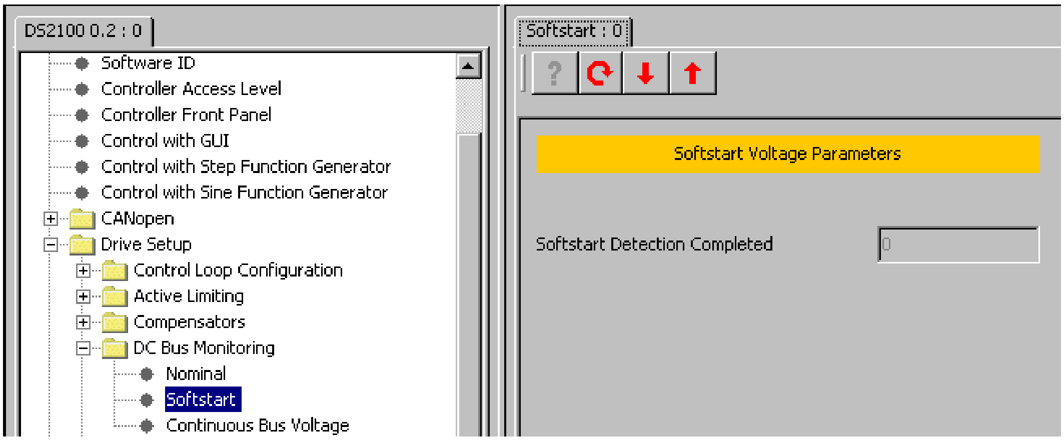


NOMINAL BUS VOLTAGE:

Bus Voltage (nominal) (V) → The nominal value of the bus voltage. If measured bus voltage is selected then this value is measured once the bus voltage is stable, otherwise this is the default bus voltage

B.3.16.40 SOFTSTART VOLTAGE PARAMETERS

The Softstart panel allows the user to enable/disable the softstart detection and to set the softstart parameters.



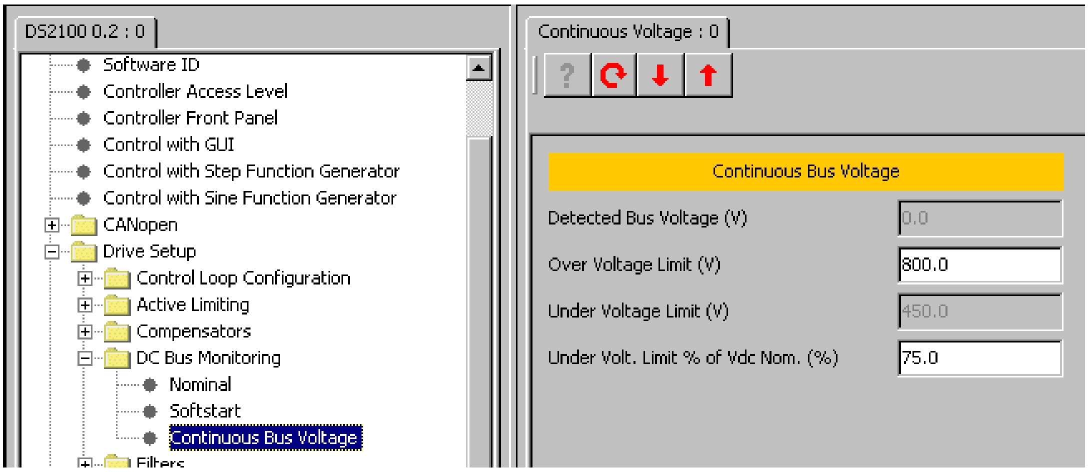
Softstart is used to limit the inrush current to the d.c. bus capacitor bank on application of a.c. mains power.
Softstart will only occur if the DC bus voltage level is above the softstart lower limit.

SOFTSTART VOLTAGE PARAMETERS :

- Softstart Detection Completed → Shows whether the softstart detection has been completed.

B.3.16.41 Continuous Bus Voltage

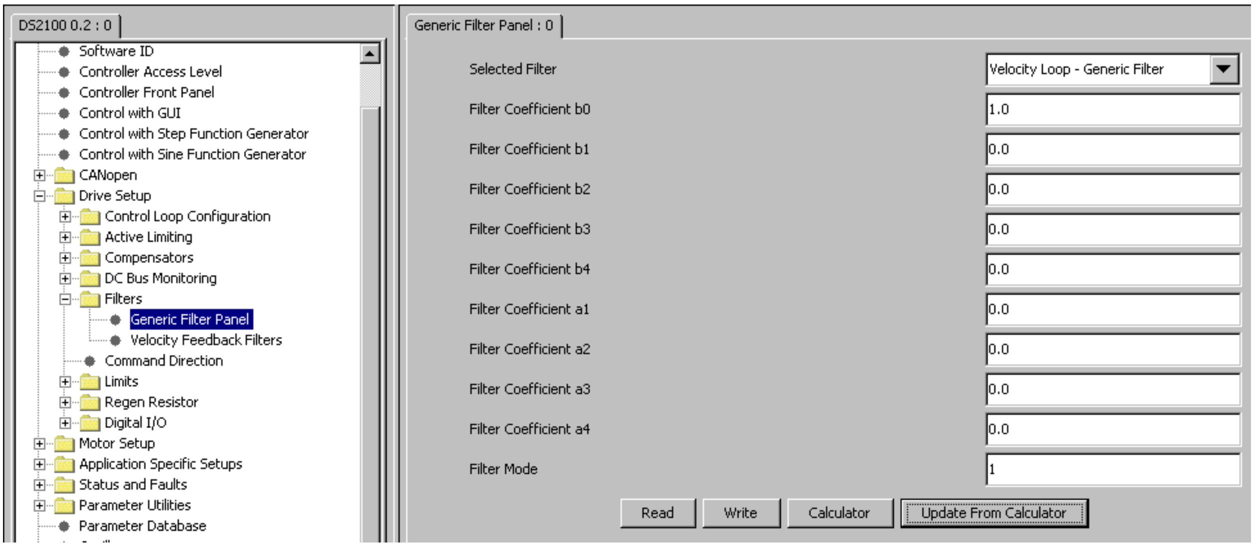
The Continuous Bus Voltage panel shows the bus voltage status and allows the voltage limits to be set.



- 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 over-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.

B.3.16.42 Generic Filters

The Generic Filters panel allows the user 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.

GENERIC FILTER PARAMETERS :

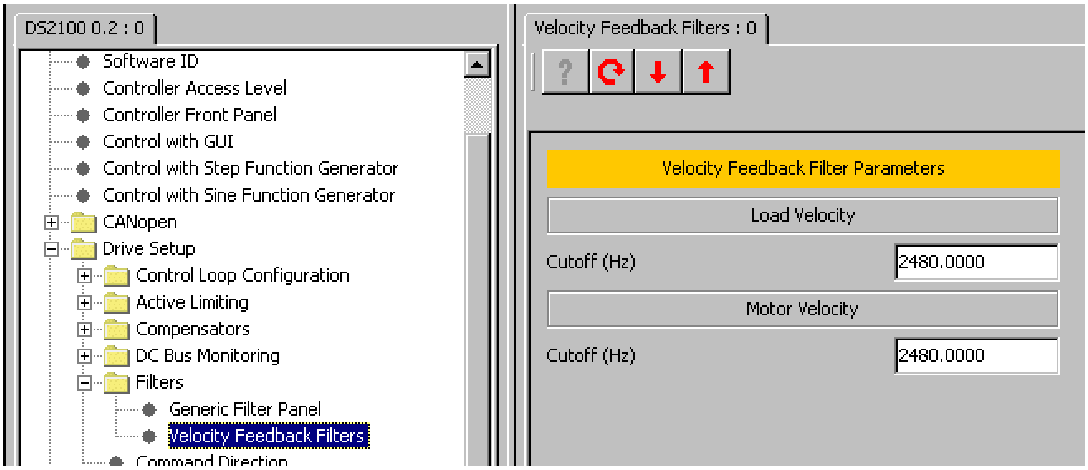
- Filter Coefficients → these can be set individually or else the filter coefficient calculator can be used to derive the coefficients for a requested filter response.
- Filter Mode → Allows the user to choose the filter mode between high/low pass and band pass/stop. This is used in the drive to reduce the amount of calculation performed when high/low pass is selected.

The ‘Calculator’ button starts the filter coefficient calculator

The ‘Update from calculator’ button will place 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 explicitly requested.

B.3.16.43 Velocity Feedback Filters

The Velocity Feedback Filters panel allows the user to set the cut-off factor of this filter.



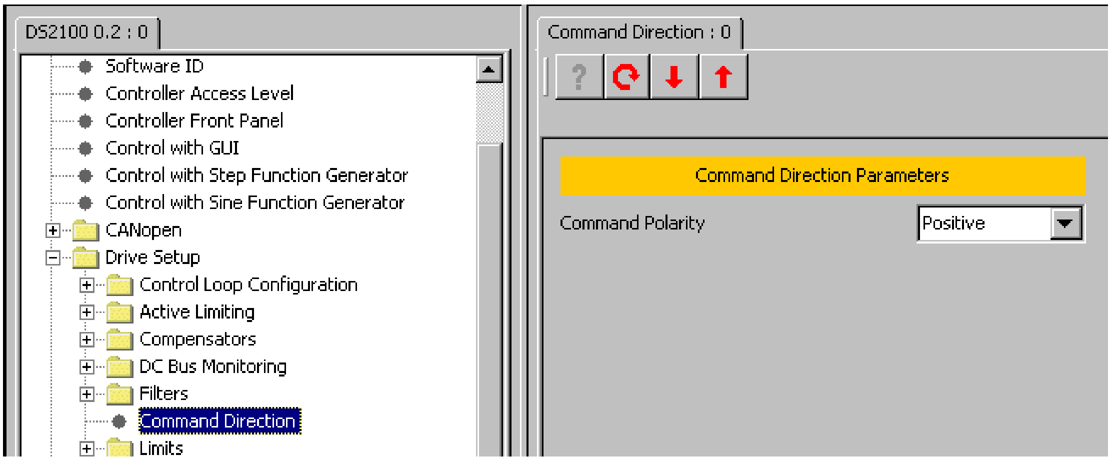
This is a low-pass filter included on the motor feedback velocity. It's a simple Euler approximation filter characterised by two filter coefficients (a_1 and b_0).

VELOCITY FEEDBACK FILTER PARAMETERS :

- Cutoff → The cutoff frequency as a fraction of the velocity loop sample rate. Setting this factor to 0.5 sets the filter cut-off to half the velocity loop sample rate.

B.3.16.44 Command Direction

The Command Direction panel allows the user to set the command polarity.

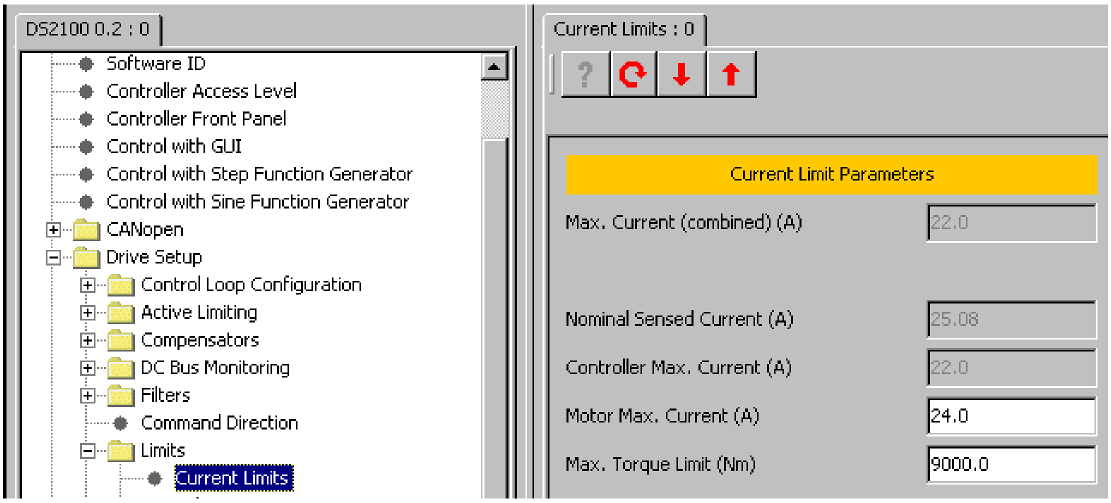


COMMAND DIRECTION PARAMETERS :

- Command Polarity → Allows the user to choose the command polarity to be either positive or negative.

B.3.16.45 Current Limits

The Current Limits panel allows the user to see and set the current limit parameters.



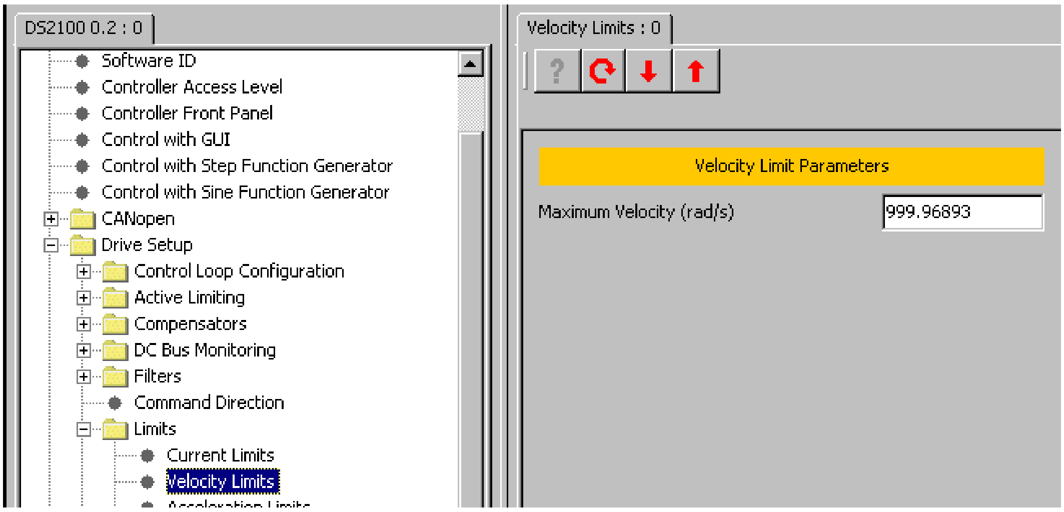
CURRENT LIMIT PARAMETERS :

- Max. Current (combined) (A) → This is the minimum of all of the maximum currents set for the application. This is the current used as the maximum current demand for the current loop.

- Nominal Sensed Current (A) → This is the maximum current that can be sensed by the drive – this is set automatically at power up for the power stage being used.
- Controller Max. Current (A) → This is the maximum current (peak) available from the drive – this is 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) → This can be 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.3.16.46 Velocity Limits

The Velocity Limits panel allows the user to set the velocity limit parameters.

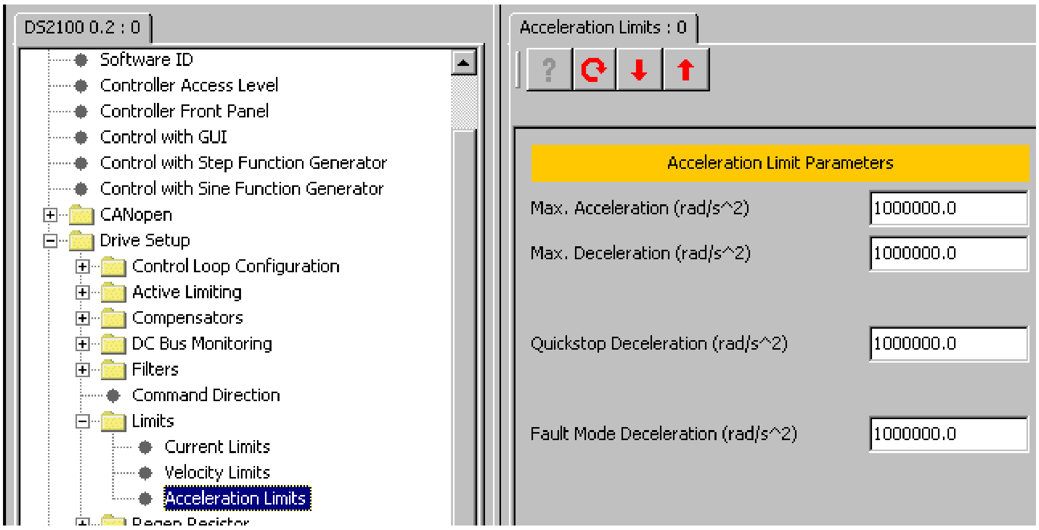


VELOCITY LIMIT PARAMETERS:

- Maximum Velocity (rad/s) → Allows the user to set the maximum velocity value. This is the maximum velocity command and therefore defines the scaling of the internal velocity command.

B.3.16.47 Acceleration Limits

The Acceleration Limits panel allows the user to set the acceleration limit parameters.



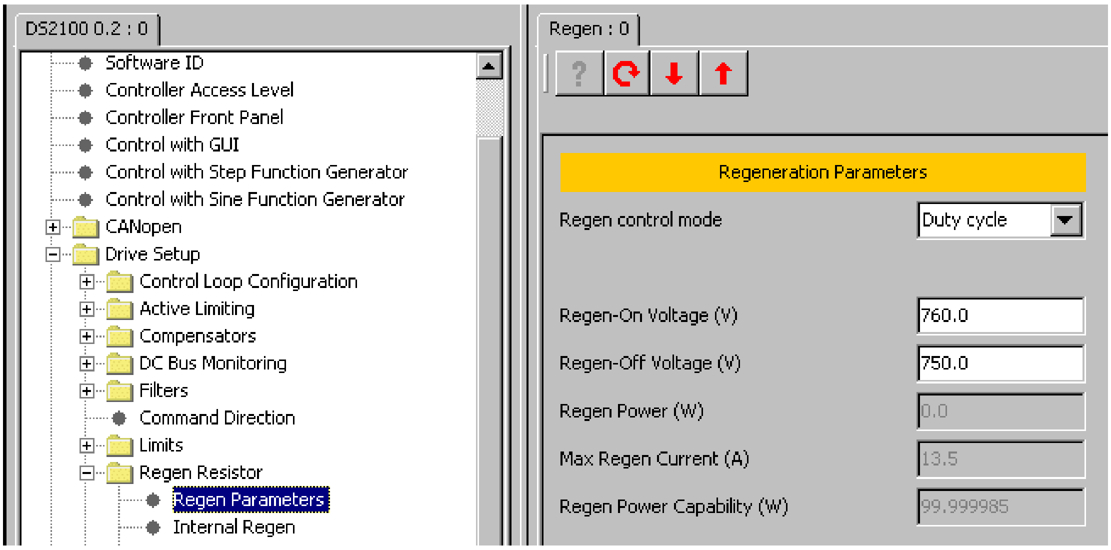
The acceleration limiting is performed on the velocity command and has units of rad/s^2.

ACCELERATION LIMIT PARAMETERS :

- Max Acceleration → The max acceleration value for the velocity loop input.
- Max Deceleration → The max deceleration value.
- Quickstop Deceleration → The maximum deceleration value in quickstop mode
- Fault Mode Deceleration → The maximum deceleration value in fault mode

B.3.16.48 Regen Parameters

The Regen Parameters panel allows the user to see and set the regeneration parameters.



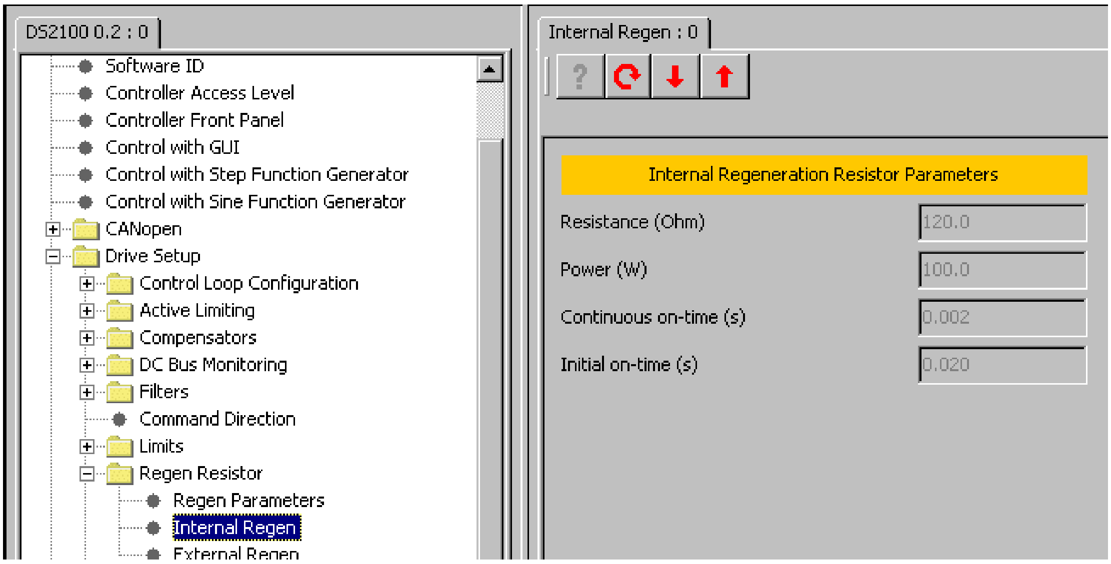
The regeneration control is implemented to prevent the capacitor over voltage caused by the energy that returns back into the D.C. Bus during a rapid motor deceleration or an overhauling load.
To prevent it, a shunt regulator circuit senses when the bus voltage exceeds the Regeneration cut-in voltage and switches a Regeneration resistor across the D.C. Bus, to dissipate the Regeneration energy.

REGENERATION PARAMETERS :

- Regen control mode → Allows user to select between:
  - 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.3.16.49 Internal Regen

The Internal Regen panel allows the user to see the internal regeneration resistor parameters.



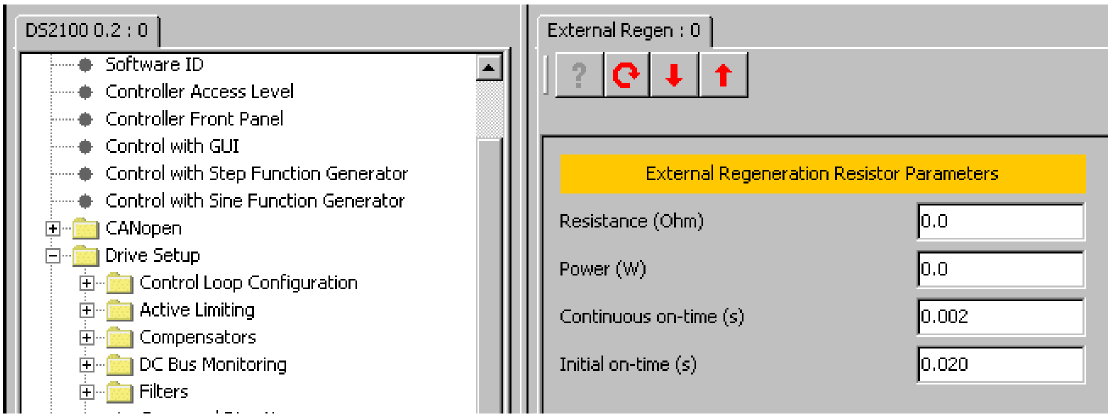
The internal regeneration resistor is effectively connected in parallel with the external one (if connected) because the same transistor controls them.

INTERNAL REGENERATION RESISTOR PARAMETERS :

- 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.3.16.50 External Regen

The External Regen panel allows the user to see the external regeneration resistor parameters.

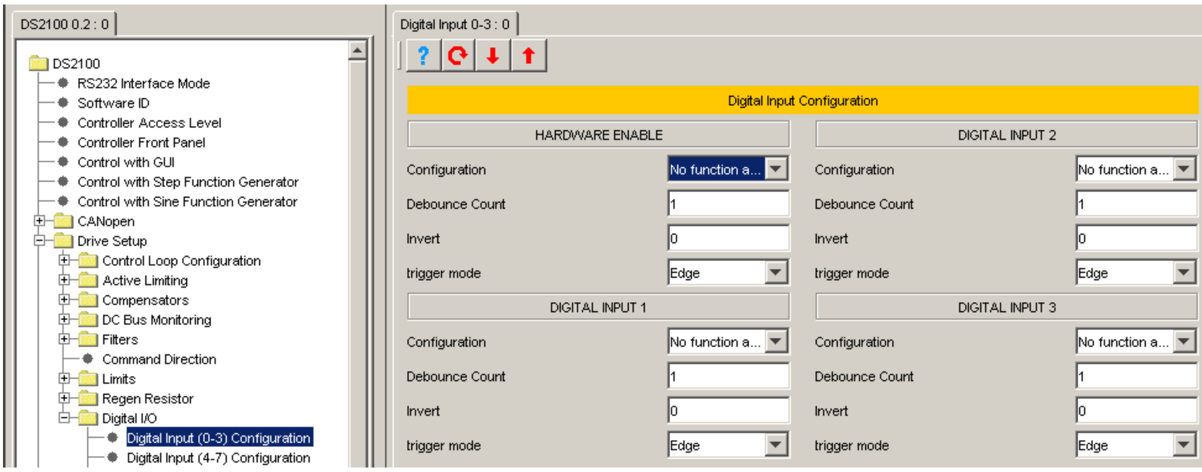


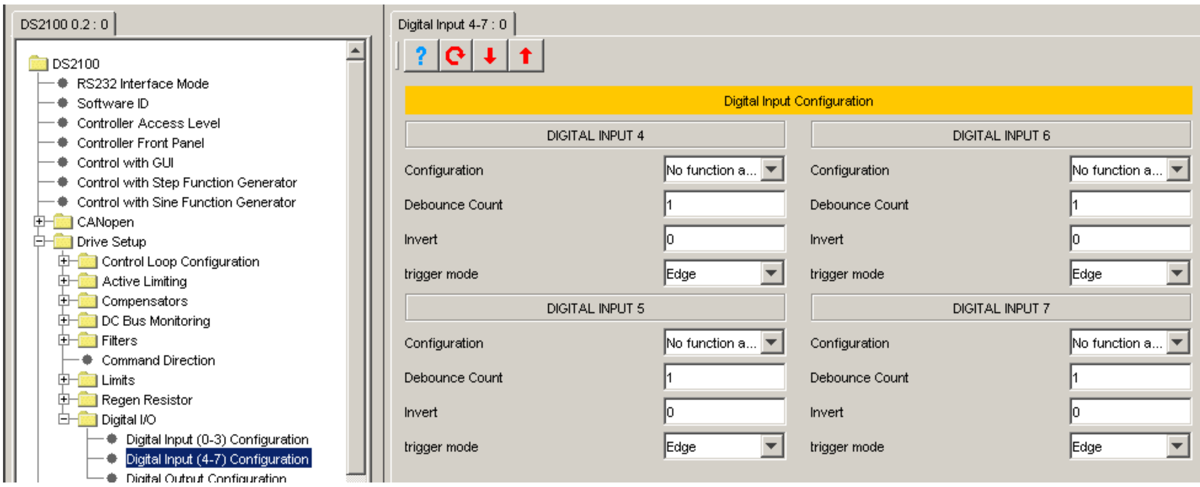
EXTERNAL REGENERATION RESISTOR PARAMETERS :

- Resistance (Ohm) → The external regeneration resistor value.
- Power (W) → The external 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.3.16.51 Digital Input Configuration

The Digital Input Configuration panel allows the user to set digital input parameters.





There are 8 digital inputs on the DS2100. 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 the input is low. This digital input can additionally be configured with a function, but it retains its hardware enable function as well. The other 7 inputs are user-configurable.

DIGITAL INPUT CONFIGURATION :
Digital input 0 (the drive enable input) is not available for configuration on this panel

DIGITAL INPUT (1, 2, 3, 4, 5, 6, 7)

- Configuration → Associate a function to the input. The implemented functions are:
-
    - Brake Apply/Release: this handler function releases the brake.
    - Positive Limit Switch: this handler function is used to configure the input as a positive limit switch.
    - Negative Limit Switch: this handler function is used to configure the input as a negative limit switch.
    - Home Switch: : this handler function is used to configure the input as a homing switch.
    - Quickstop: this handler function is used to configure the input as a quickstop input.
    - Auto/Manual: this handler function is used to select between automatic (where normal limits apply) and manual mode (reduced power mode).
    - Controlled Disable: this handler function is the same as the quickstop handler listed above, but configured to always disable when quickstop is complete.

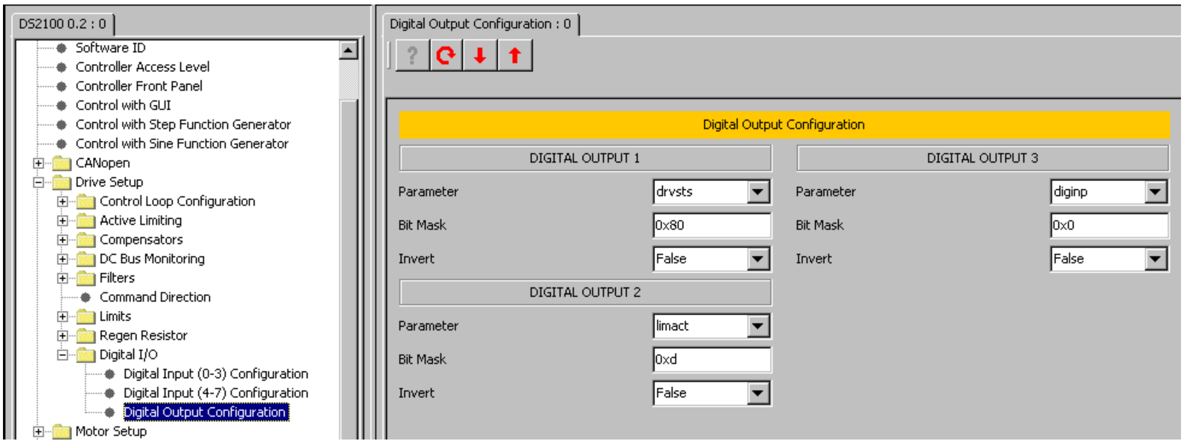
- Debounce Count → Number of times the input must be seen to be set before functionally is executed. The sample rate for the digital inputs is 2ms.

- 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).

B.3.16.52 Digital Output Configuration

The Digital Output Configuration panel allows the user to set digital output parameters.



There are 3 digital outputs on the DS2100. All 3 outputs are user-configurable.

DIGITAL OUTPUT CONFIGURATION :

DIGITAL OUTPUT (1, 2, 3)

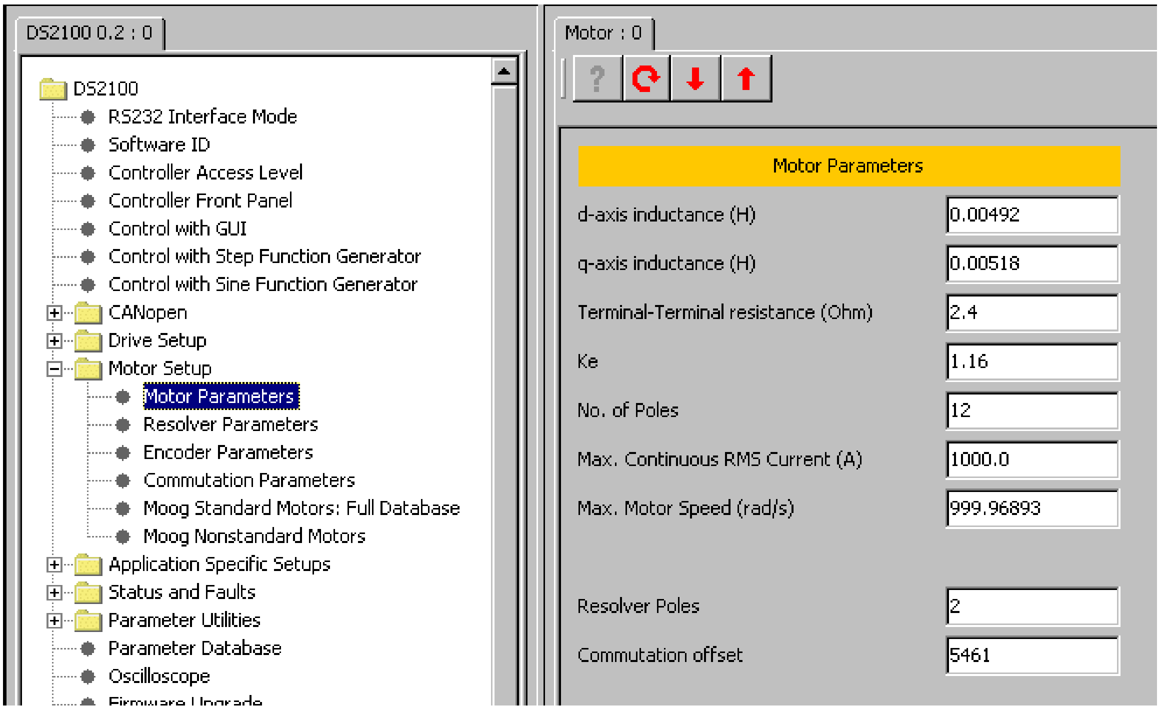
- Parameter Number → The specific parameter that is to be associated with the digital output. The field value of the parameter must be entered into the digital output field number parameter, to specify the parameter of interest.
  - Digital Output 1 defaults to drvsts
  - Digital Output 2 defaults to limact
  - Digital Output 3 defaults to diginp

- Bit Mask → Specify 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.3.16.53 Motor Parameters

The Motor Parameters panel allows the user to set/read the electrical parameters of the motor.



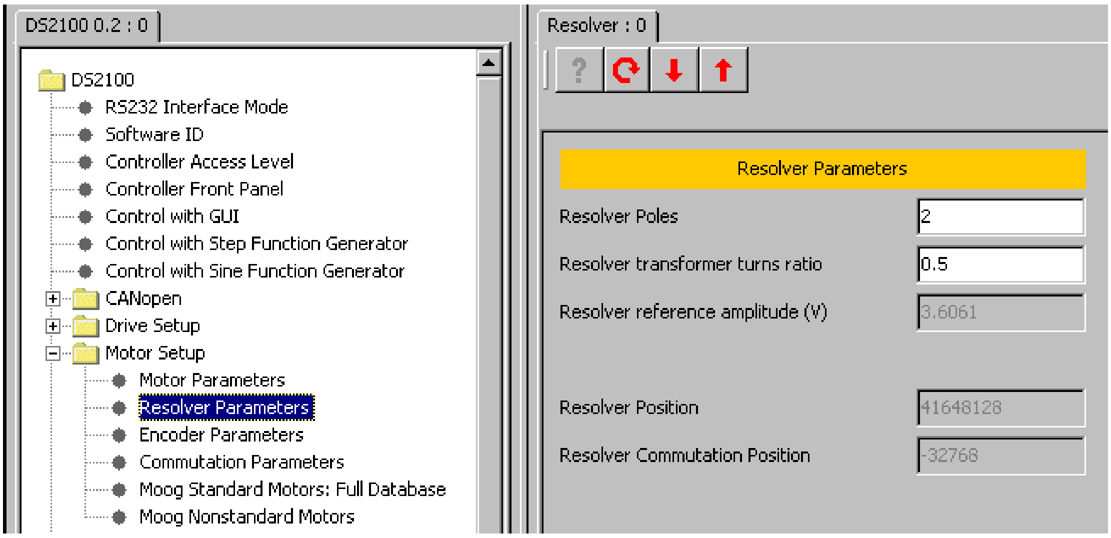
A number of parameters are required when configuring a specific motor drive. For standard motors, these parameters are implemented in the GUI's database.
For non-standard motors, the user must enter these parameters. This can be done using this panel but it is preferable to set up the non-standard motor in the non-standard motor database so that it is available for future use.

MOTOR PARAMETERS

- 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) → The Ke factor of the motor.
- 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.
- Resolver Poles → The number of resolver poles.
- Commutation offset → The value of the commutation offset.

B.3.16.54 Resolver Parameters

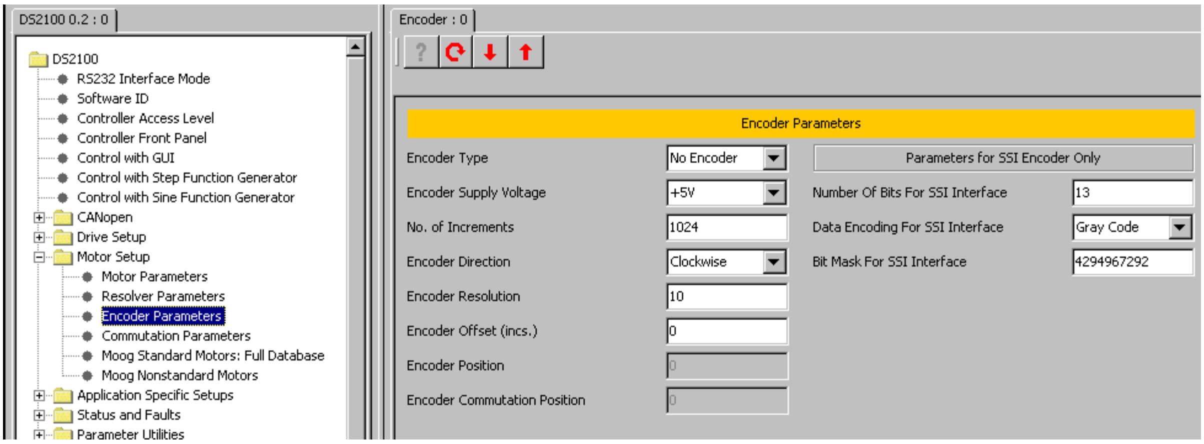
The Resolver Parameters panel allows the user to set the parameters of this motor position feedback sensor.



- 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 from the DS2100 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.

B.3.16.55 Encoder Parameters

The Encoder Parameters panel allows the user to set the parameters of this motor position feedback sensor.



ENCODER PARAMETERS :

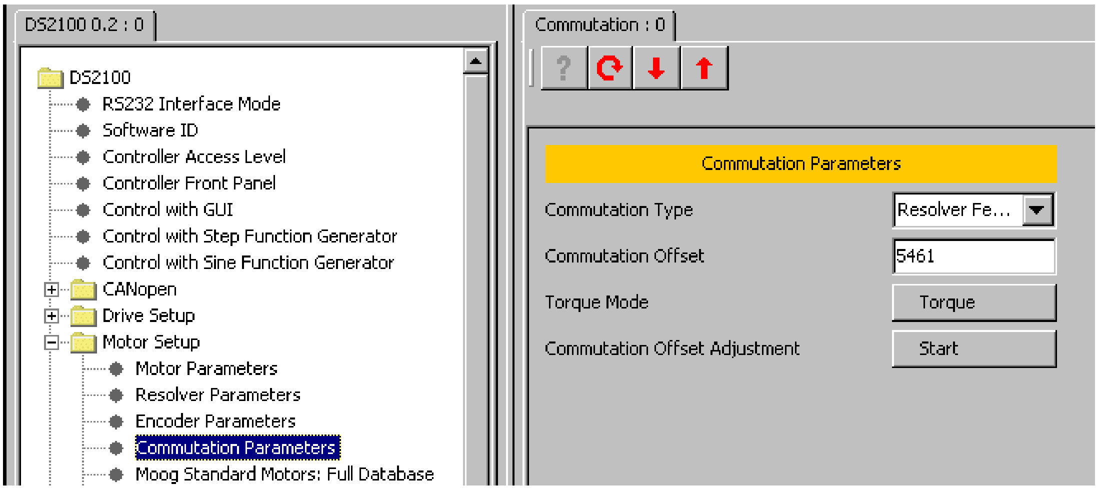
- Encoder Type → Select the encoder type from a list of various types:
  - No Encoder
  - Digital Incremental
  - Analog Incremental
  - SSI Interface
  - Stegmann Hiperface
  - Heidenhain EnDat
- Encoder Supply Voltage → Choose the encoder supply voltage. There are 3 options: +5, +8, +12 Volts.
- No. 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.) → This can be used to compensate for a mechanical misalignment between the encoder and the desired encoder position.
- Encoder Position → The 32-bit encoder position.
- Encoder Commutation Position → A 16-bit value that represents a full mechanical revolution independent of the encoder resolution setting.

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.
- 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`

B.3.16.56 Commutation Parameters

The Commutation Parameters panel allows the user to set the commutation parameters.



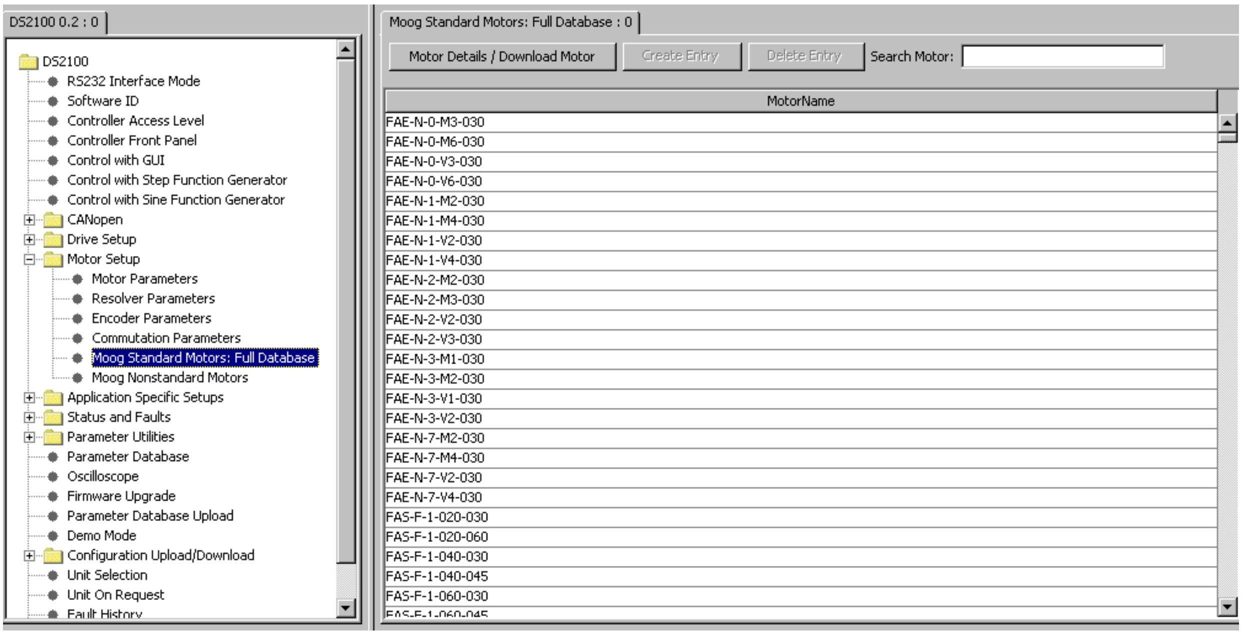
The commutation module allows the selection of various commutation methods for the motor phase currents. It is possible to use a resolver, an encoder or a fixed value for the rotor feedback position.

COMMUTATION PARAMETERS :

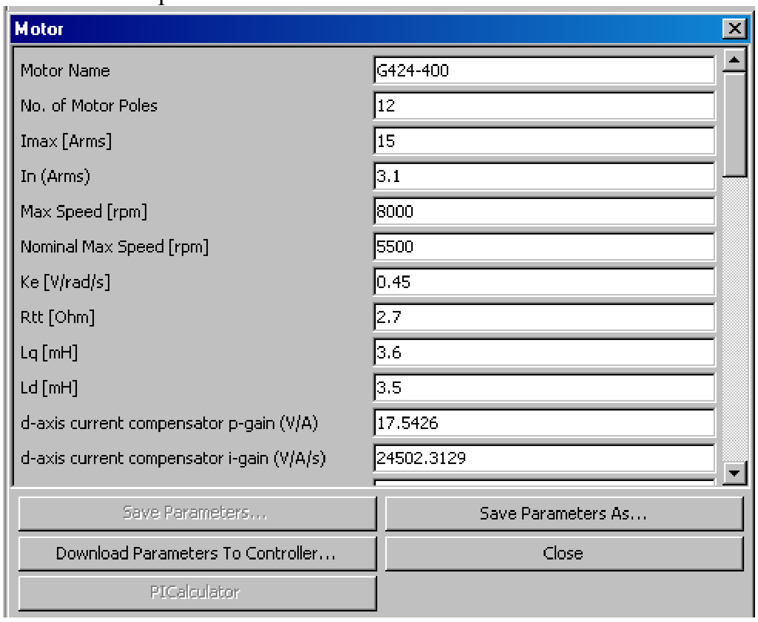
- Commutation Type → Select the commutation type from:
    - Angle Zero: the feedback angle for the rotor position is fixed at zero. This can be used to determine the phase angle between the rotor and the resolver or encoder.
    - Resolver Feedback: the rotor angle is taken from the resolver commutation 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.
- 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.
    - Ensure that the correct motor parameters have been configured.
    - Set commutation_feedback (resolver or encoder).
    - Set the drive to torque mode.
    - Set Comm. Off. Adj. To 1 to start the procedure.
    - Enable the drive. The communication adjustment starts.
    - Wait until reads 0 (after about 2 seconds).

B.3.16.57 Moog Standard Motors: Full Database

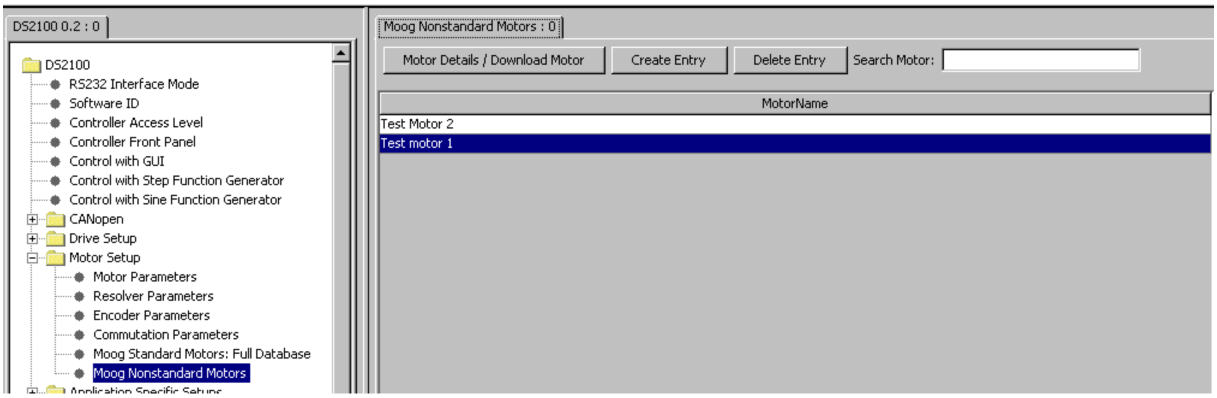


Select a motor by double-clicking on the appropriate motor name.
Use the scrollbars to view the database or enter the motor required in the search textbox.
Once a motor is selected the motor parameters are shown:



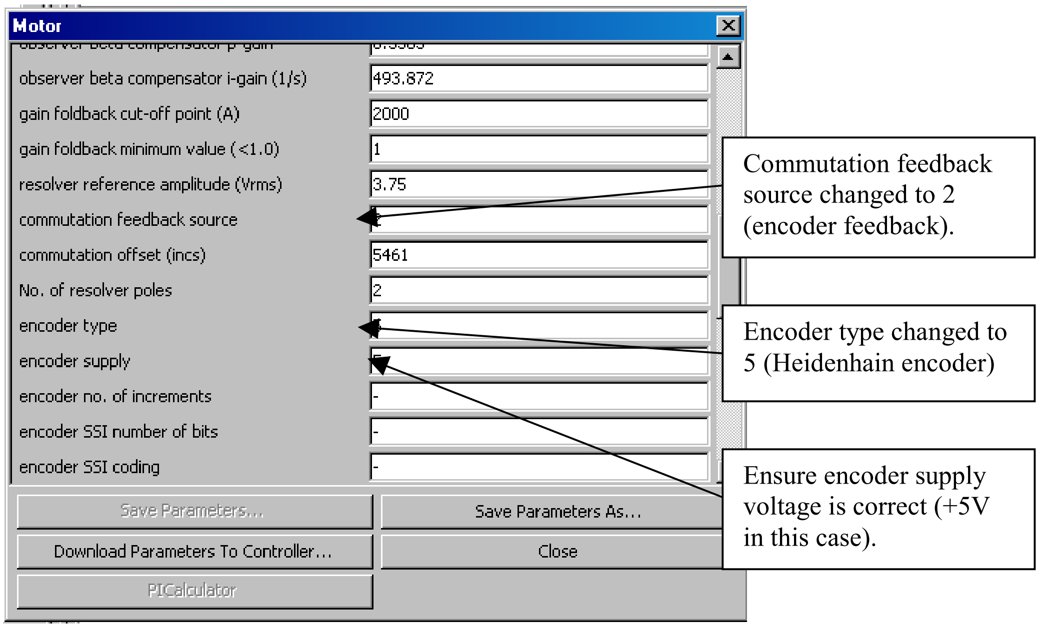
Use the scrollbars to view all the parameters.
Select "Download Parameters to Controller…" to configure the drive with the motor parameters.
All parameters (including motor name) can be changed and, using "Save Parameters As", and selecting the correct database can create a new Non-standard motor.

B.3.16.58 Moog Nonstandard Motors

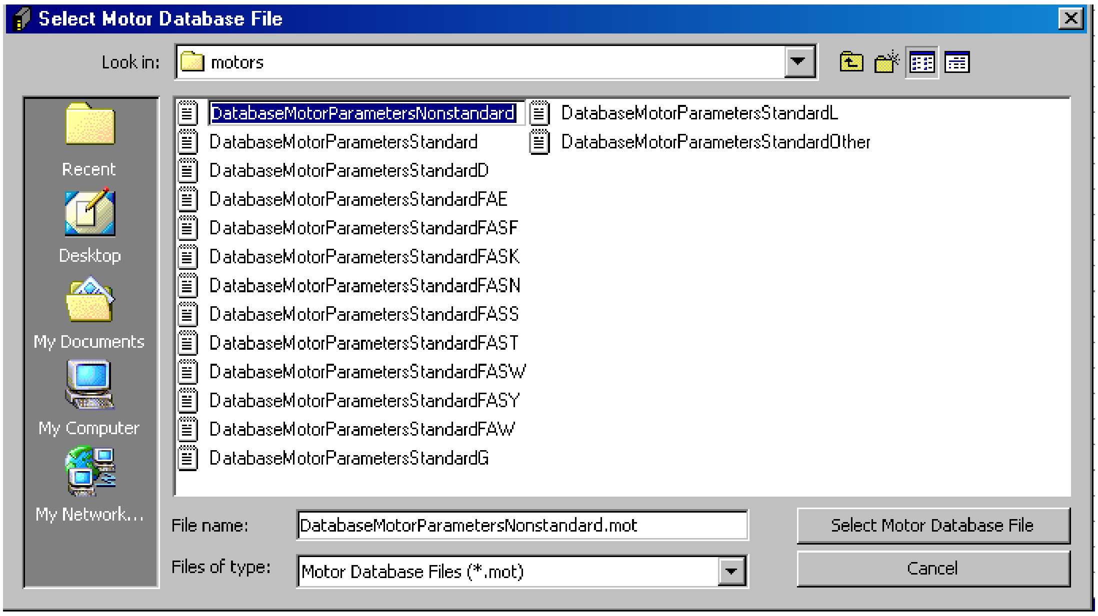


The ‘Create Entry’ button allows the user to create a new non-standard motor entry. It opens a panel providing tools for creation of the motor database parameters.
Select a motor by double-clicking on the appropriate motor name.

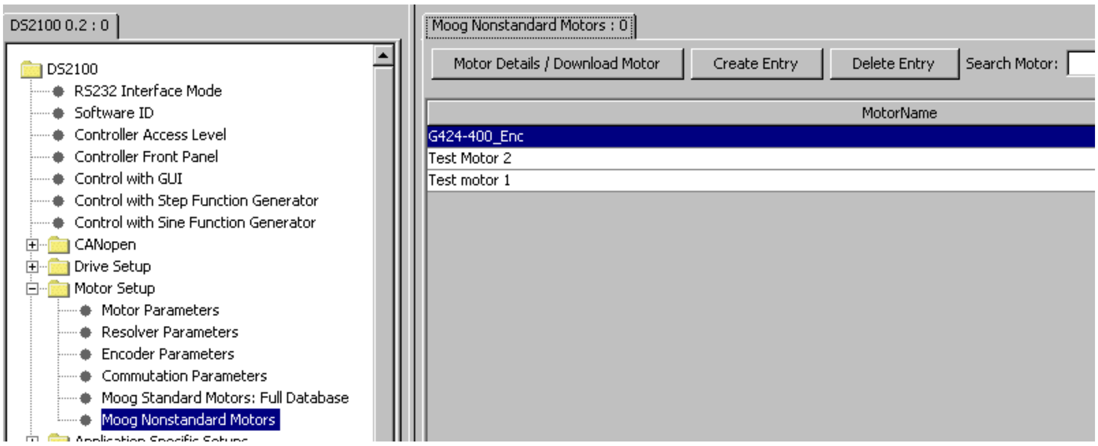
Alternatively, if a standard motor is similar to the motor required, then the standard motor parameters can be altered and saved as a Non-standard motor:
Select the similar motor e.g. a G424-400, and make the changes required e.g. a Heidenhain encoder feedback is required instead of resolver feedback.
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.

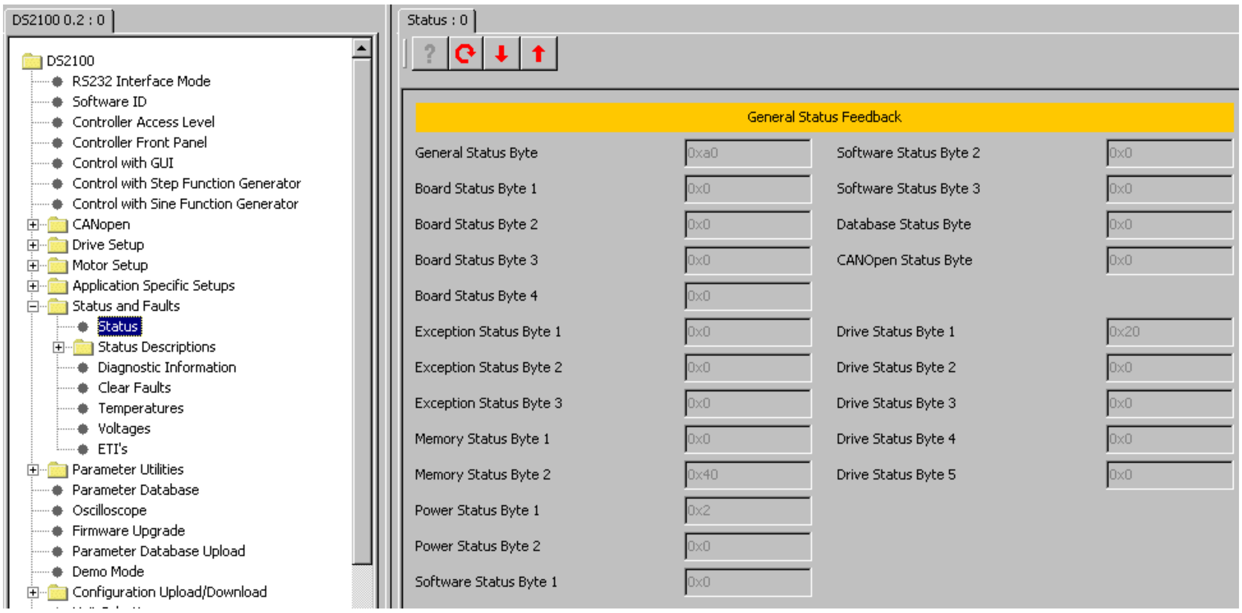


On selecting the Moog Nonstandard Motors tab again, the new non-standard motor is included:



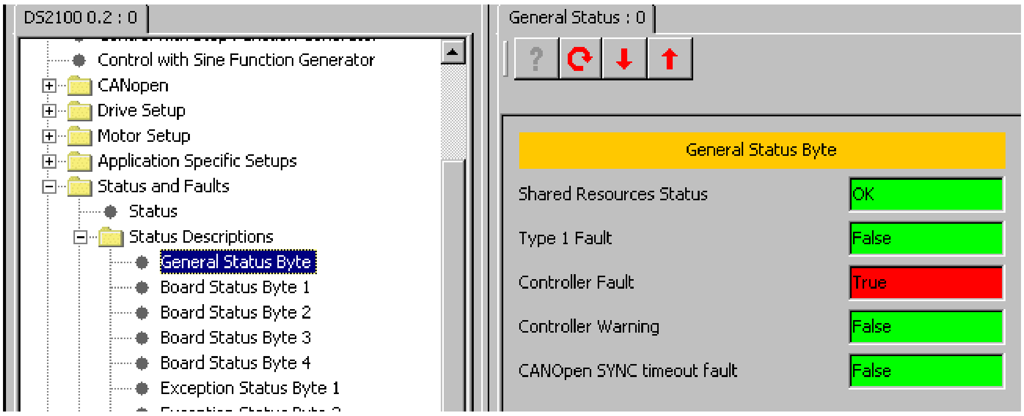
B.3.16.59 Status

The Status panel allows the user to see 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.

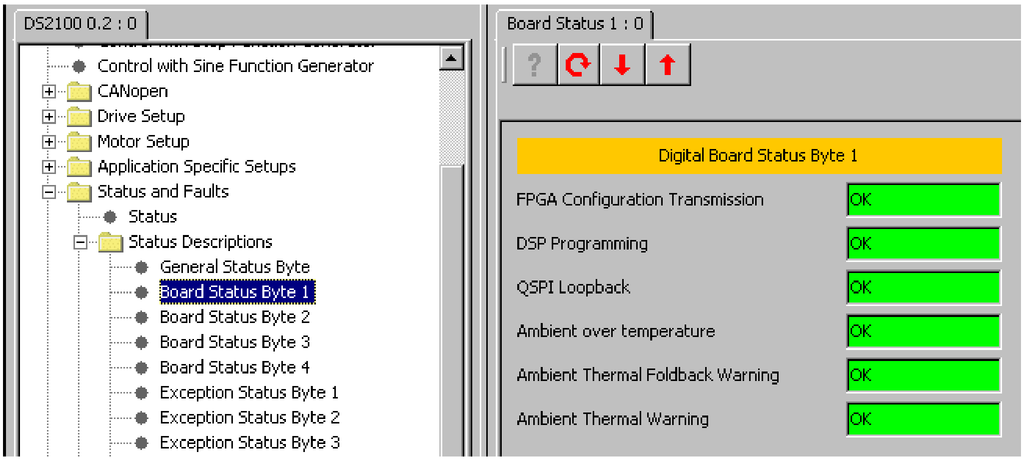
B.3.16.60 General Status Byte



GENERAL STATUS BYTE :

- Shared Resources Status → Shows the shared resources state. Shared resources are those that would be common to all axes in a multi-axis drive.
- Type 1 Fault → A type 1 fault is one which cannot be cleared except by resetting the drive.
- Controller Fault → shows if a fault is present on the drive
- Controller Warning → shows if a warning is present on the drive
- CANOpen SYNC timeout fault → Indicates that the SYNC message is no longer being received.

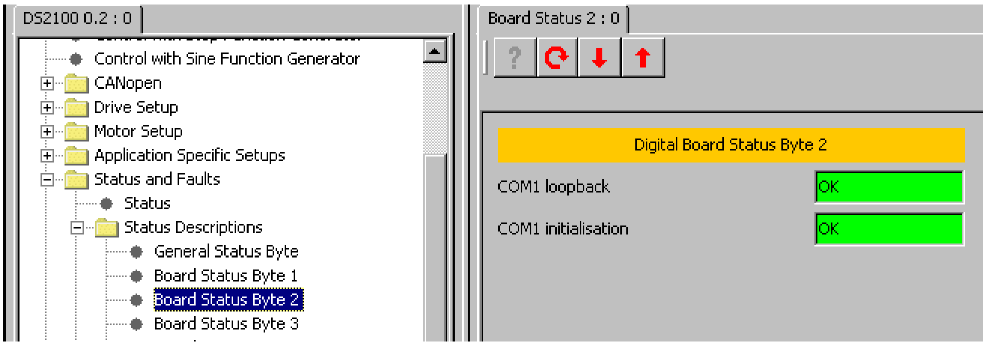
B.3.16.61 Board Status Byte 1



DIGITAL BOARD STATUS BYTE 1 :

- FPGA Configuration Transmission → Indicates if there is a fault in FPGA configuration transmission.
- DSP Programming → Indicates there is a DSP programming fault.
- QSPI Loopback → Indicates there is a QSPI loopback fault.
- Ambient over temperature → Indicates that the ambient temperature is greater than the programmed limit.
- Ambient Thermal Foldback Warning → Indicates that the ambient temperature has reached 90% of the set temperature at which point thermal limiting begins.
- Ambient Thermal Warning → Indicates that the ambient temperature has reached 90% of the set temperature at which a thermal fault occurs.

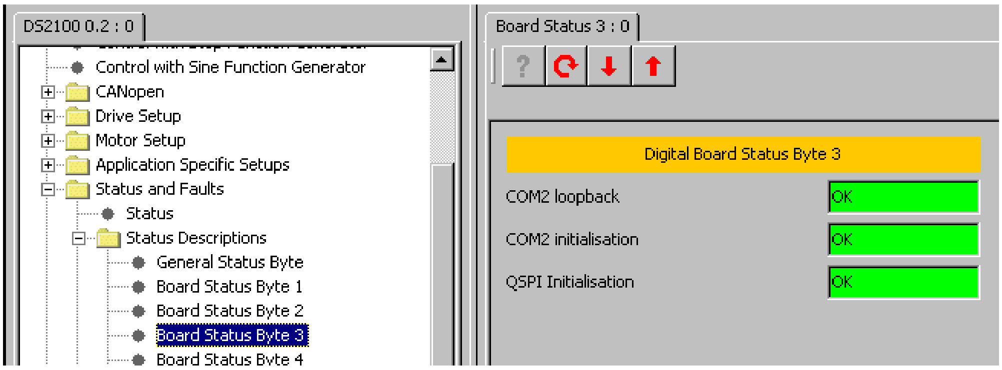
B.3.16.62 Board Status Byte 2



DIGITAL BOARD STATUS BYTE 2 :

- COM1 loopback → The result of the loop back test performed during initialisation of the drive.
- COM1 initialisation → The result of the COM port initialisation

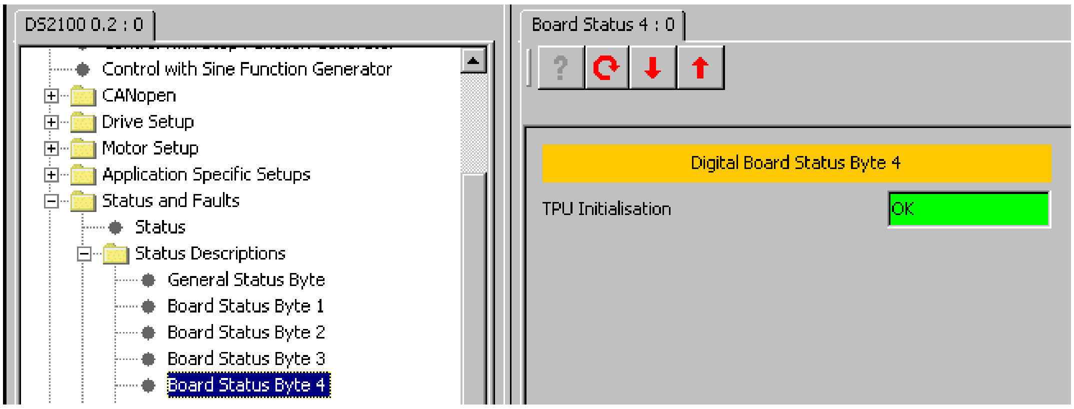
B.3.16.63 Board Status Byte 3



DIGITAL BOARD STATUS BYTE 3 :

- COM2 loopback → The result of the loop back test performed during initialisation of the drive.
- COM2 initialisation → The result of the COM port initialisation
- QSPI Initialisation → The result of the QSPI initialisation

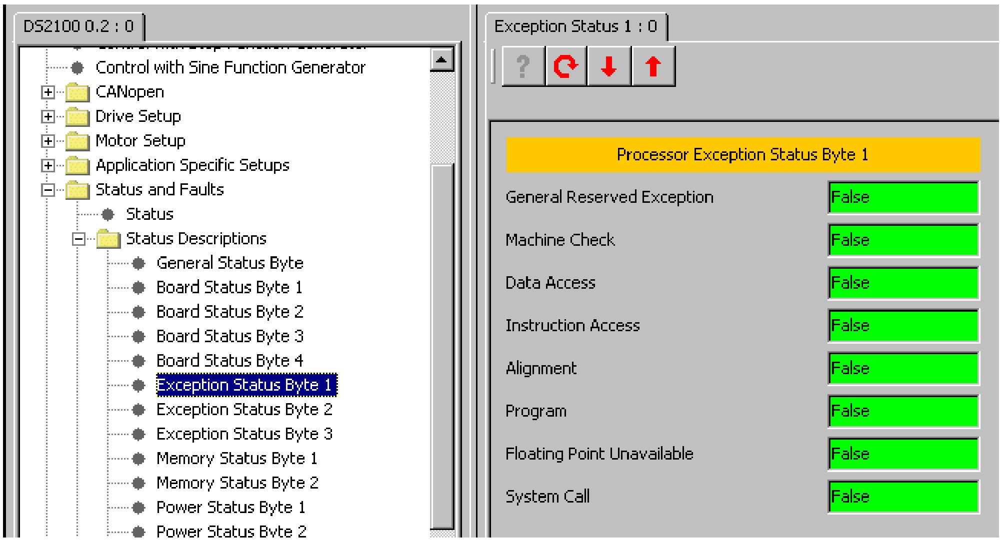
B.3.16.64 Board Status Byte 4



DIGITAL BOARD STATUS BYTE 4 :

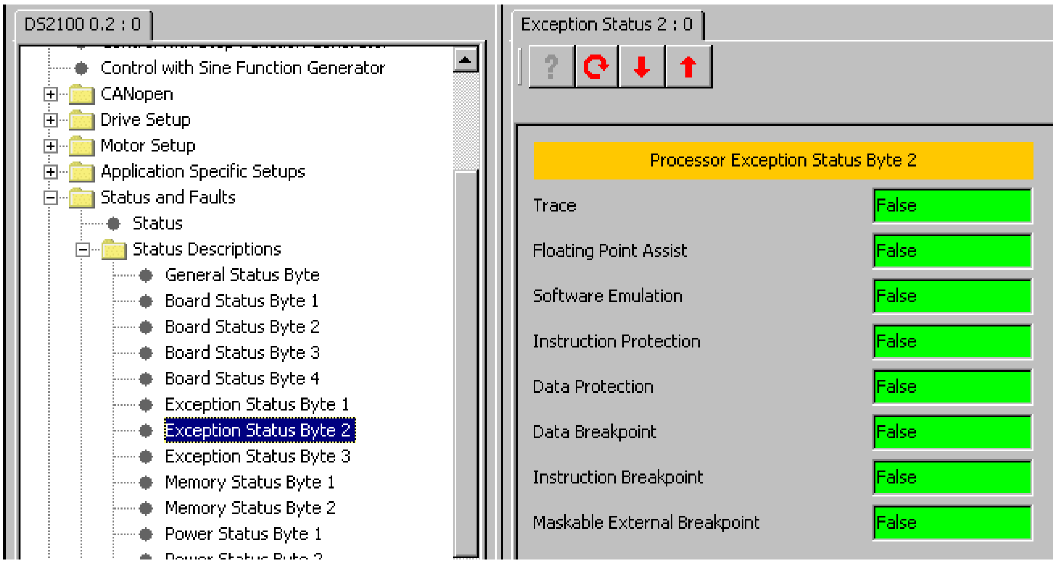
- TPU Initialisation → The result of the TPU initialisation.

B.3.16.65 Exception Status Byte 1



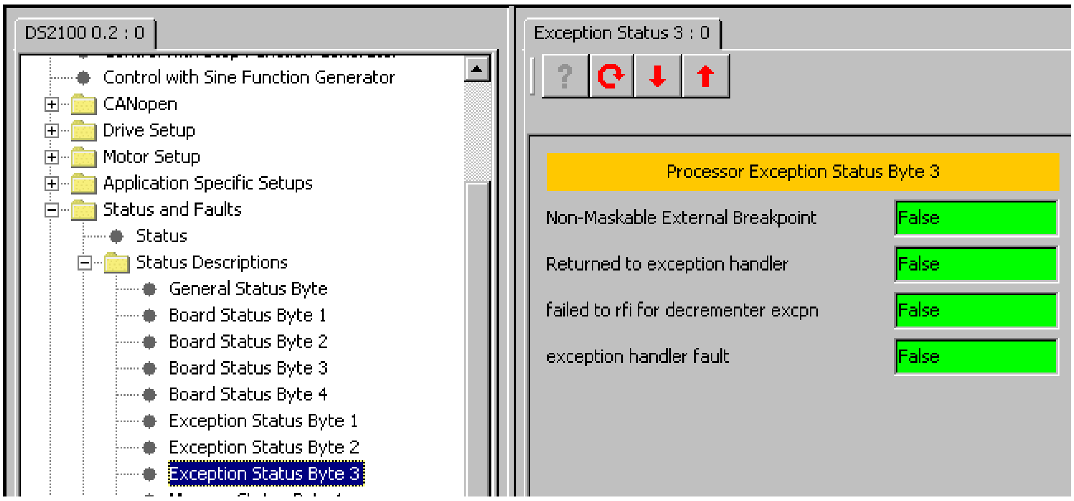
The processor exceptions indicate serious internal faults in the drive.

B.3.16.66 Exception Status Byte 2



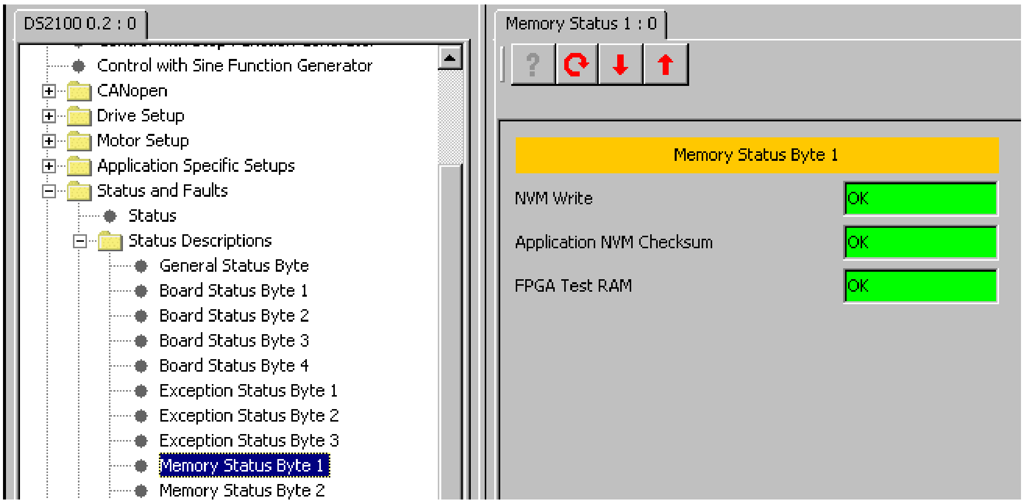
The processor exceptions indicate serious internal faults in the drive.

B.3.16.67 Exception Status Byte 3



The processor exceptions indicate serious internal faults in the drive.

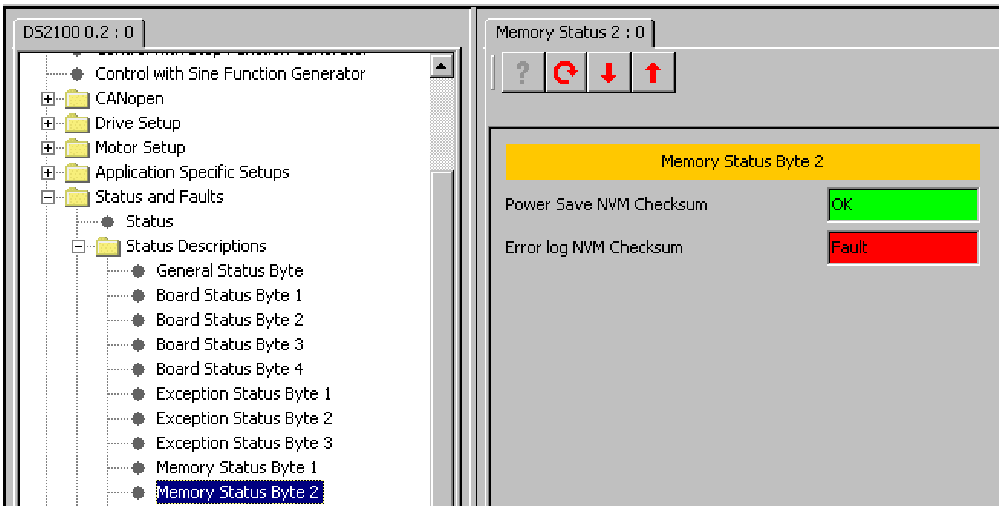
B.3.16.68 Memory Status Byte 1



MEMORY STATUS BYTE 1 :

- NVM Write → Indicates a problem writing to the drive internal NVM
- Application NVM Checksum → Indicates that the checksum for the data in the drive internal parameter NVM is incorrect
- FPGA Test RAM → Indicates that the FPGA test RAM contains an incorrect value

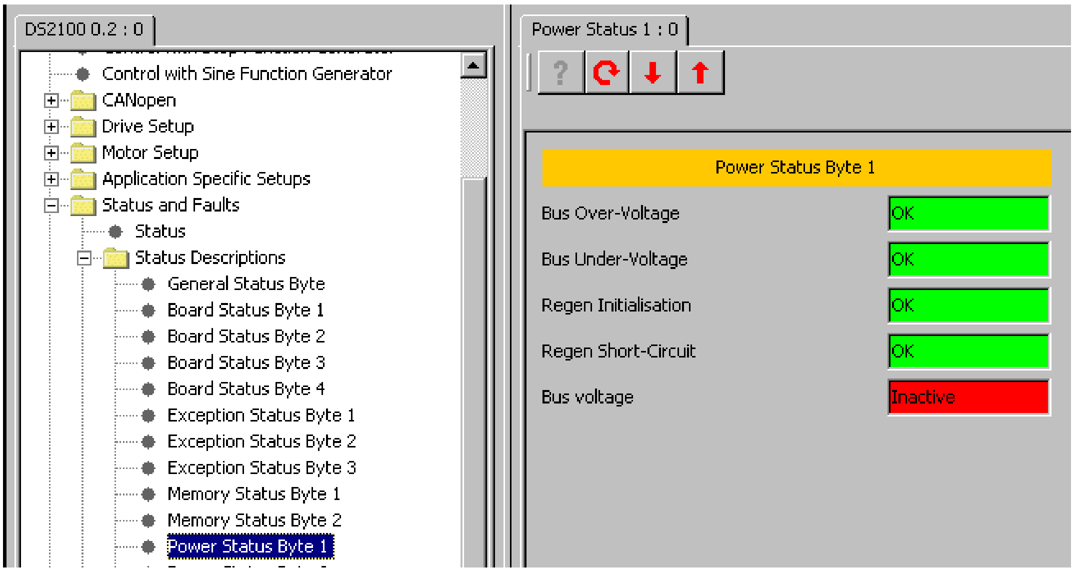
B.3.16.69 Memory Status Byte 2



MEMORY STATUS BYTE 2 :

- 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, it does not cause a fault condition on the drive.
- 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, it does not cause a fault condition on the drive.

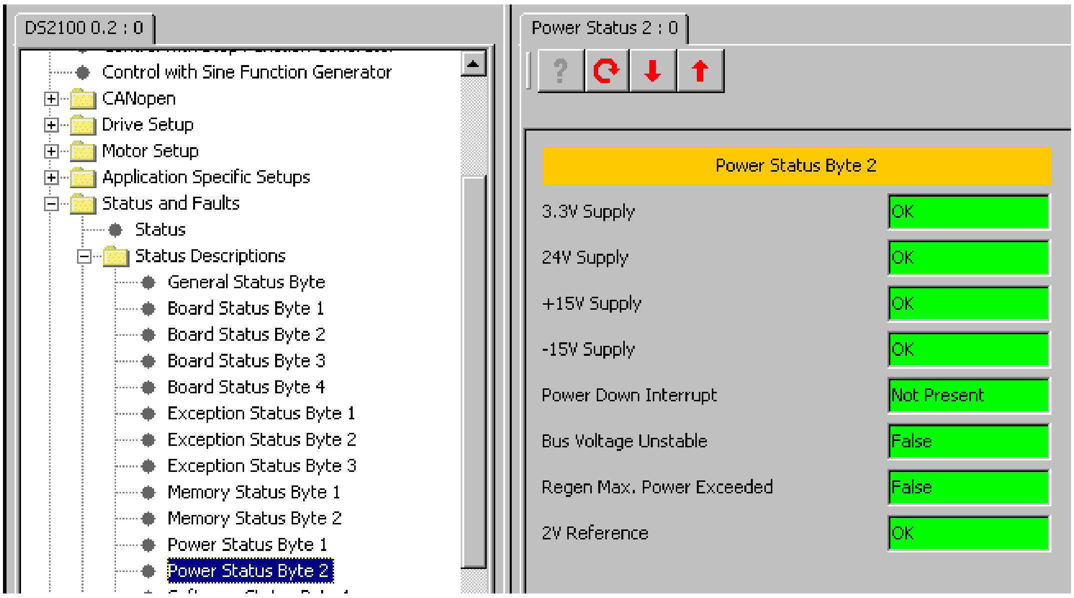
B.3.16.70 Power Status Byte 1



POWER STATUS BYTE 1 :

- Bus Over-Voltage → Indicates that the bus over-voltage limit is exceeded.
- Bus Under-Voltage → Indicates that the bus under-voltage limit is exceeded.
- Regen Initialisation → Indicates a fault during regeneration initialisation.
- Regen Short-Circuit → Indicates that there is a regeneration short circuit fault.
- Bus Voltage → Indicates whether bus voltage is active.

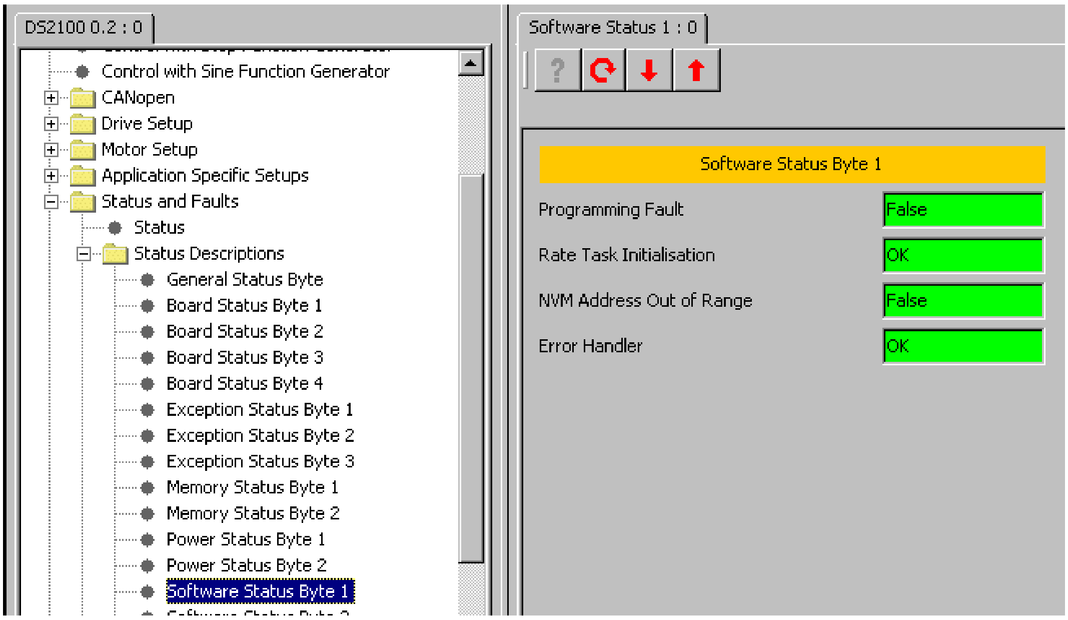
B.3.16.71 Power Status Byte 2



POWER STATUS BYTE 2 :

- 3.3 V Supply → Indicates whether the 3.3 V supply is OK.
- 24 V Supply → Indicates whether the 24 V supply is OK.
- +15 V Supply → Indicates whether the +15 V supply is OK.
- -15 V Supply → Indicates whether the -15 V supply is OK.
- Power Down Interrupt → Indicates whether the power goes down (low V_{DC}).
- Bus Voltage Unstable → Indicates whether the bus voltage is unstable.
- Regen Max. On Time Exceeded → Indicates whether the regeneration exceeds the max limit on time
- 2V Reference → Indicates whether the 2V reference is OK.

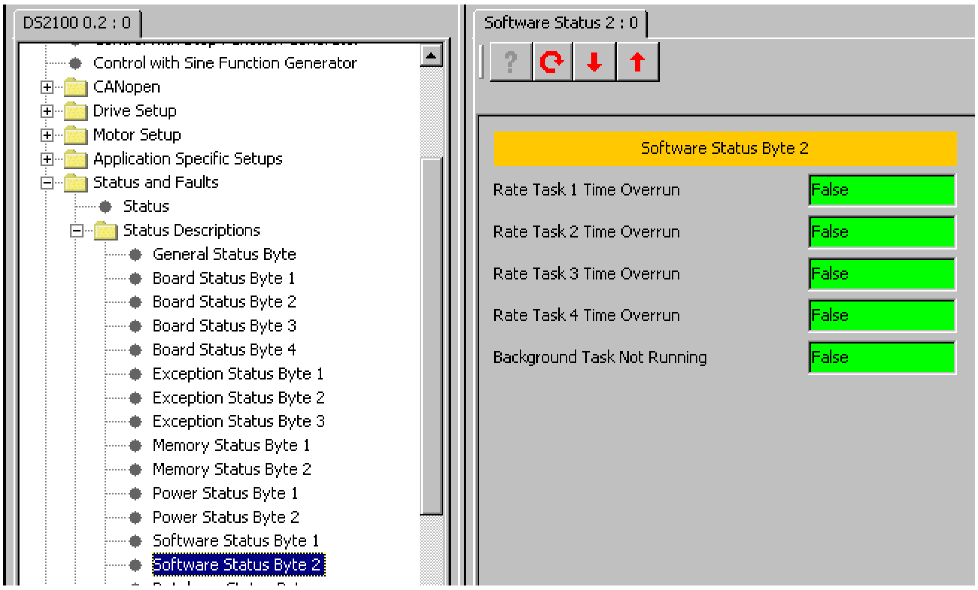
B.3.16.72 Software Status Byte 1



SOFTWARE STATUS BYTE 1 :

- Programming Fault → This is an internal software fault and should never occur
- Rate Task Initialisation → Indicates that a fault occurred during the initialisation of the periodic tasks
- NVM Address Out of Range → Indicates that an attempt was made to access an address outside the range of valid NVM addresses
- Error Handler → Indicates an error initialising the error handler

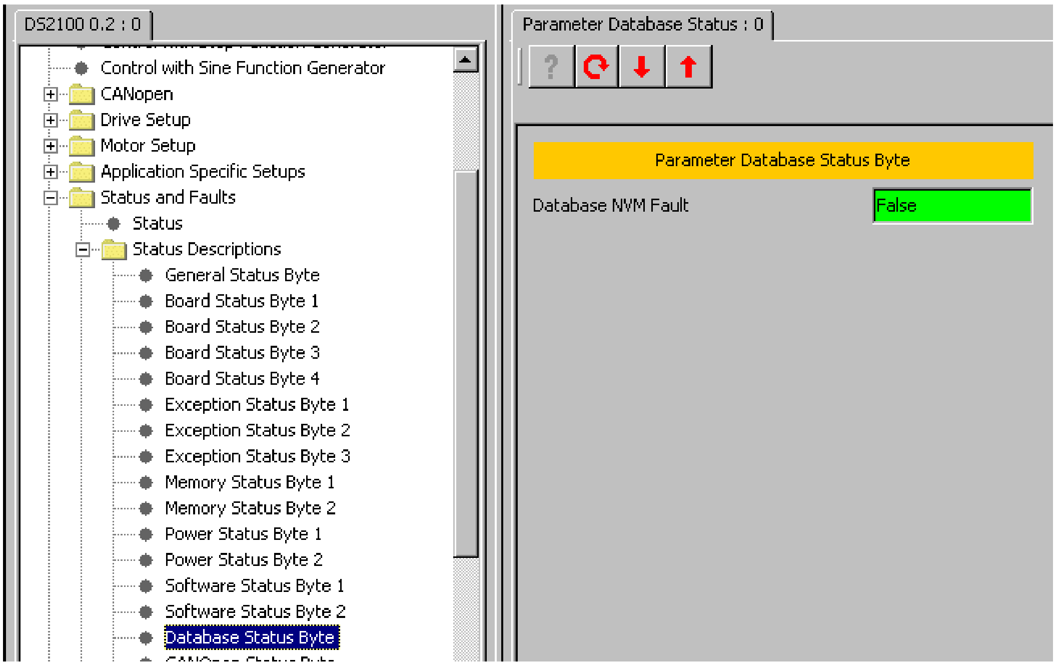
B.3.16.73 Software Status Byte 2



SOFTWARE STATUS BYTE 2 :

- Rate Task 1 Time Overrun → Indicates the rate task code has taken longer than allowed to execute
- Rate Task 2 Time Overrun→ Indicates the rate task code has taken longer than allowed to execute
- Rate Task 3 Time Overrun→ Indicates the rate task code has taken longer than allowed to execute
- Rate Task 4 Time Overrun→ Indicates the rate task code has taken longer than allowed to execute
- Background Task Not Running→ Indicates the background task has not been executed for at least 1s. This is for indication only and does not cause a drive fault.

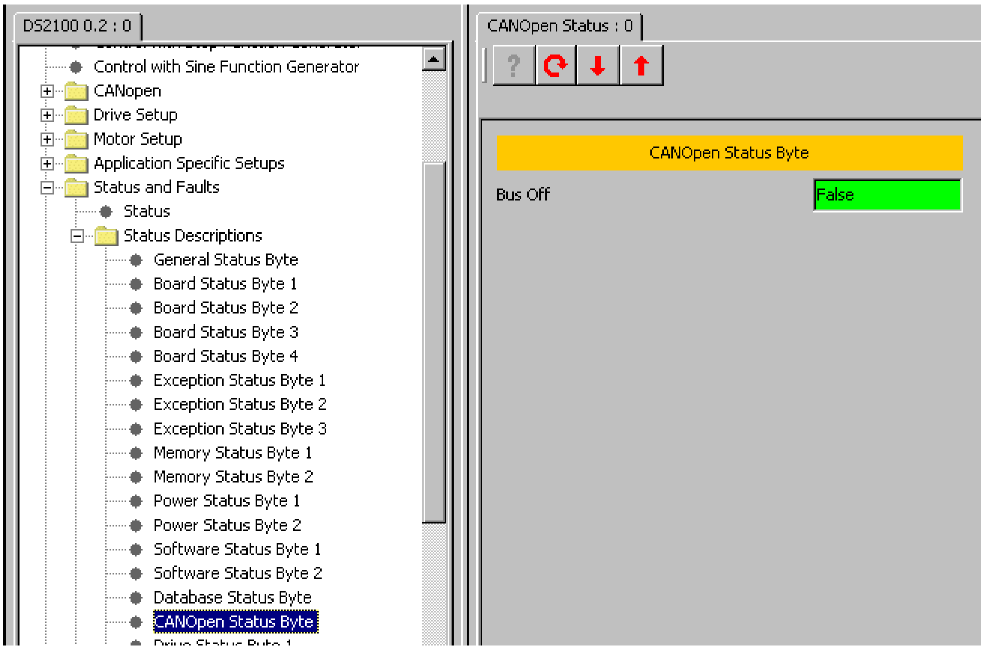
B.3.16.74 Database Status Byte



PARAMETER DATABASE STATUS BYTE :

- Database NVM Fault → Indicates a fault accessing non-volatile data memory from the internal parameter database.

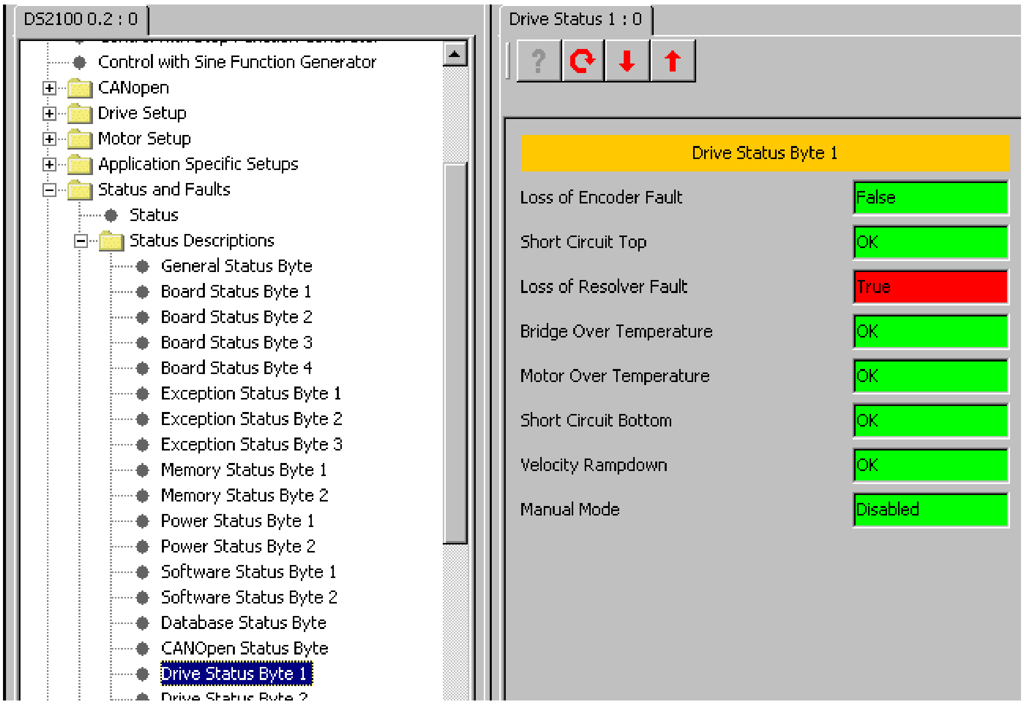
B.3.16.75 CANOpen Status Byte



CANOPEN STATUS BYTE :

- Bus Off → Indicates that the drive CAN controller is in the bus off state due to a fault on the system CAN bus.

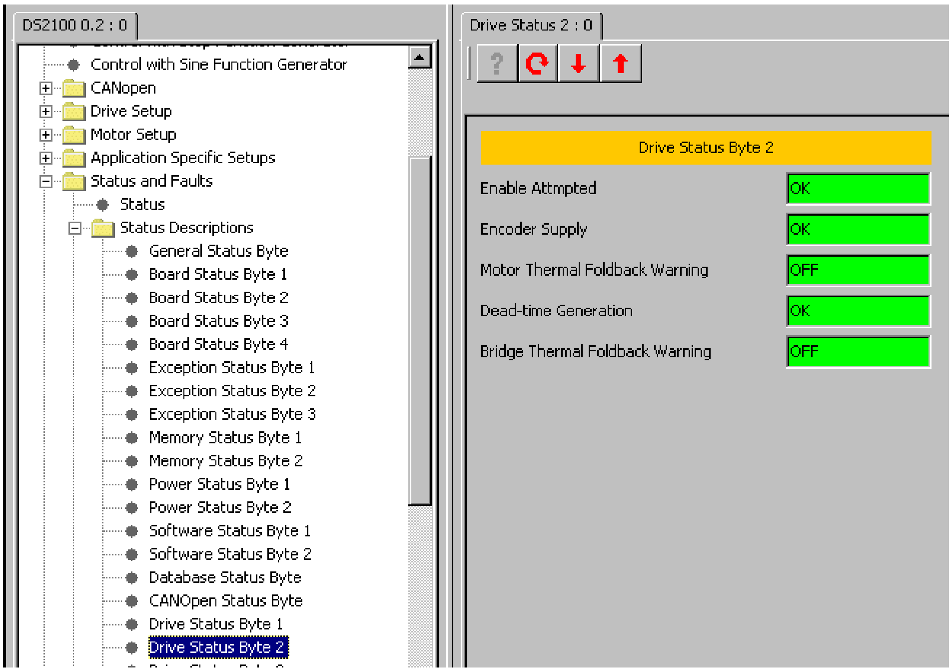
B.3.16.76 Drive Status Byte 1



DRIVE STATUS BYTE 1 :

- Loss of Encoder Fault → Indicates that the encoder is disconnected, but has been selected as a feedback source.
- Short Circuit Top → Indicates a short circuit fault
- Loss of Resolver Fault → Indicates that the resolver is disconnected, but has been selected as a feedback source.
- Bridge Over Temperature → Indicates that the bridge temperature has exceeded the upper limit.
- Motor Over Temperature → Indicates that the motor temperature has exceeded the upper limit.
- Short Circuit Bottom → Indicates a short circuit fault
- Velocity Rampdown → Indicates a timeout fault during a velocity rampdown (quickstop).
- Manual Mode → Indicates whether manual mode is enabled. This is a warning only.

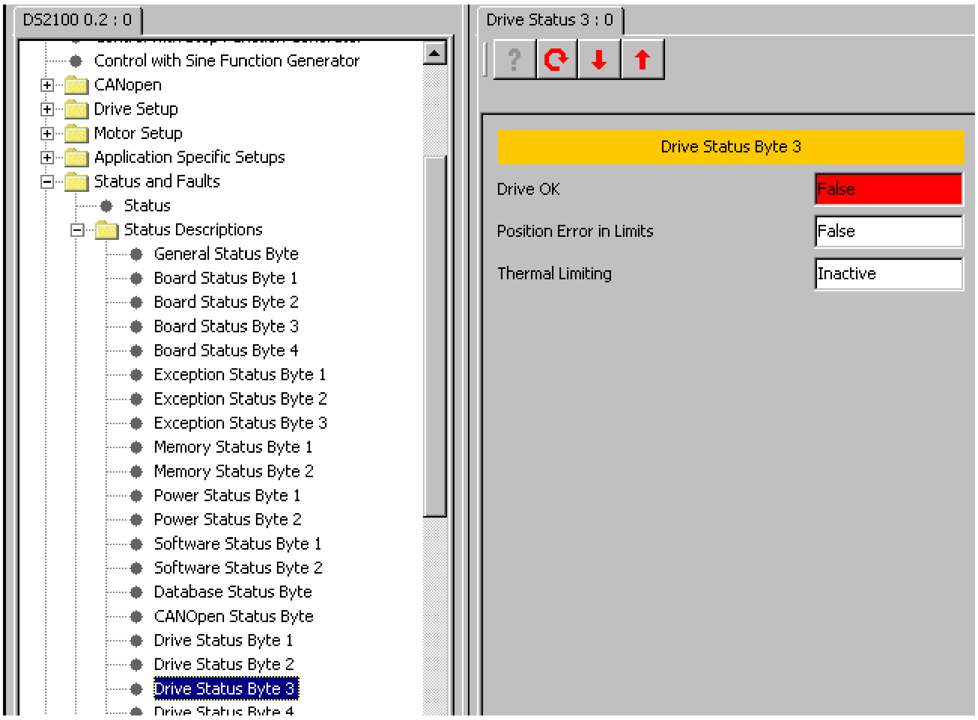
B.3.16.77 Drive Status Byte 2



DRIVE STATUS BYTE 2 :

- 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).
- Encoder Supply → Indicates an encoder supply fault.
- Motor Thermal Foldback Warning → Indicates that the temperature is within 10% of the start temperature for motor thermal foldback
- Dead-time Generation → Indicates a fault in the PWM dead-time generation.
- Bridge Thermal Foldback Warning → Indicates that the temperature is within 10% of the start temperature for bridge thermal foldback

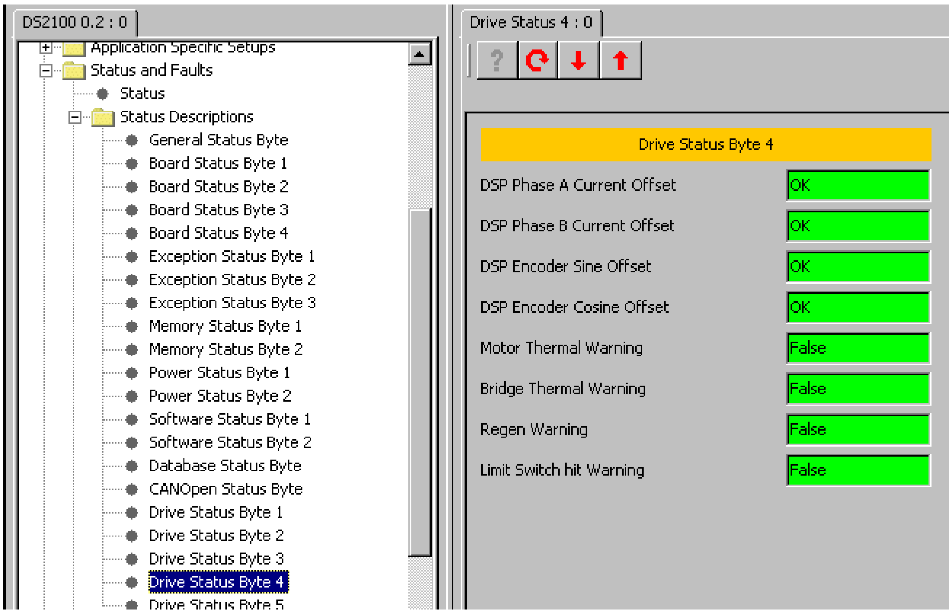
B.3.16.78 Drive Status Byte 3



DRIVE STATUS BYTE 3 :

- Drive OK→ Shows the drive resources state. Drive resources are those that would be exclusive to a single axis in a multi-axis drive.
- Position Error in Limits → Indicates that the actual position has attained the target position within a programmable range. Valid in position mode only.
- Thermal Limiting → Indicates whether the thermal limiting is active.

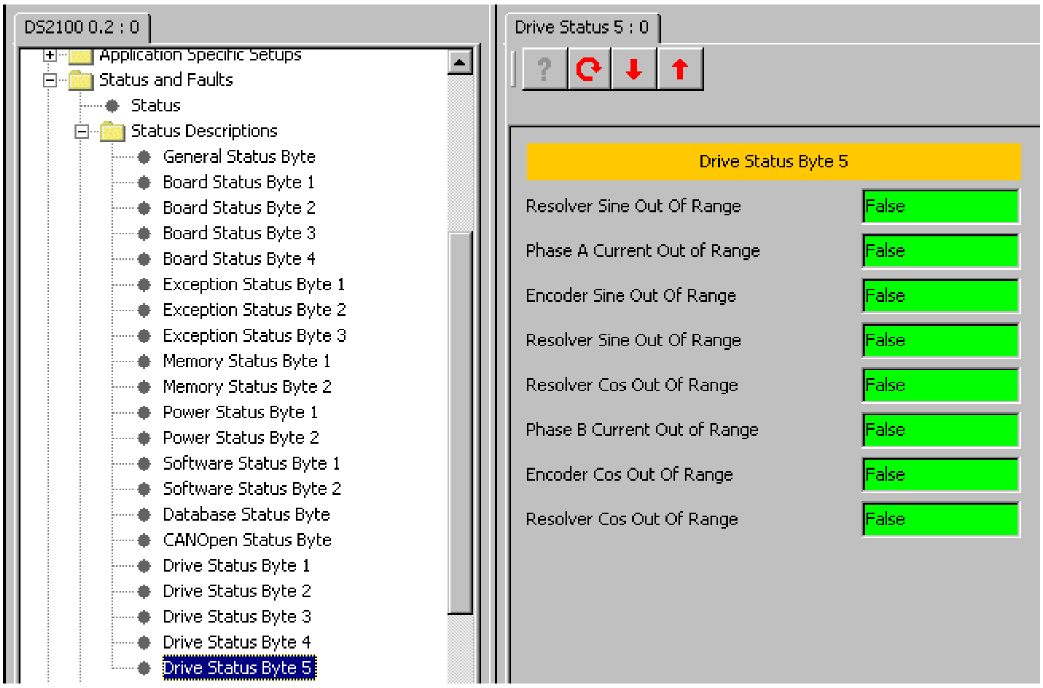
B.3.16.79 Drive Status Byte 4



DRIVE STATUS BYTE 4 :

- DSP Phase A Current Offset → Indicates if the DSP phase A current offset is greater than a programmable limit.
- DSP Phase B Current Offset → Indicates if the DSP phase B current offset is greater than a programmable limit.
- DSP Encoder Sine Offset → Indicates if the DSP encoder sine offset is greater than a programmable limit.
- DSP Encoder Cosine Offset → Indicates if the DSP encoder cosine offset is greater than a programmable limit.
- Motor Thermal Warning → indicates that the motor winding temperature is within 10% of the motor max temperature.
- Bridge Thermal Warning → Indicates that the power transistor heatsink temperature is within 10% of the bridge maximum temperature.
- Regen Warning → Indicates that the power dissipated in the regen resistor(s) is within 10% of the continuous capability of the resistor(s).
- Limit Switch hit Warning → Indicates that either clockwise or counter-clockwise limit switch has become active.

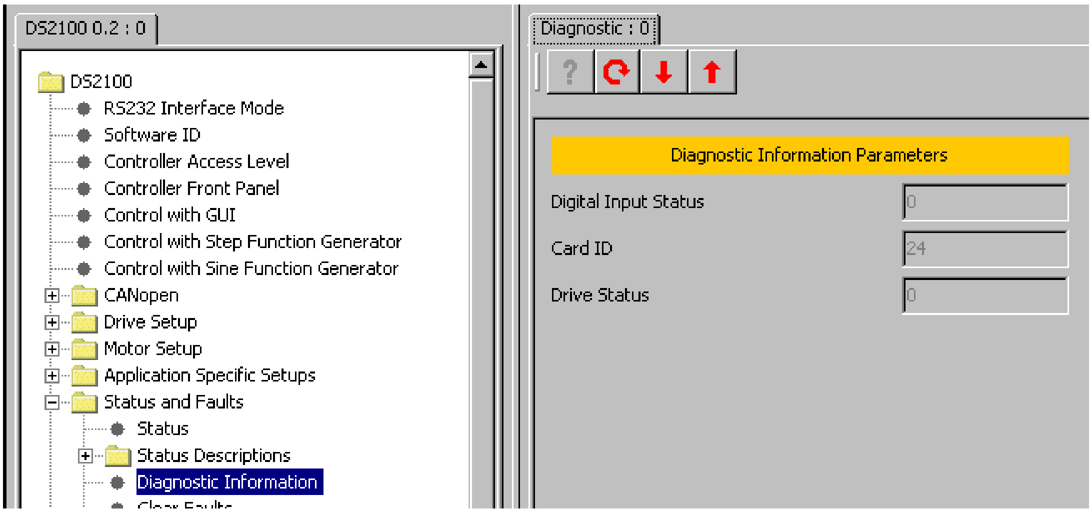
B.3.16.80 Drive Status Byte 5



DRIVE STATUS BYTE 5 :

- Resolver Sine Out Of Range → the DSP A-D input is outside the valid range of 0V to 4V
- Phase A Current Out Of Range → the DSP A-D input is outside the valid range of 0V to 4V
- Encoder Sine Out Of Range → the DSP A-D input is outside the valid range of 0V to 4V
- Resolver Sine Out Of Range → the DSP A-D input is outside the valid range of 0V to 4V
- Resolver Cos Out Of Range → the DSP A-D input is outside the valid range of 0V to 4V
- Phase B Current Out Of Range → the DSP A-D input is outside the valid range of 0V to 4V
- Encoder Cos Out Of Range → the DSP A-D input is outside the valid range of 0V to 4V

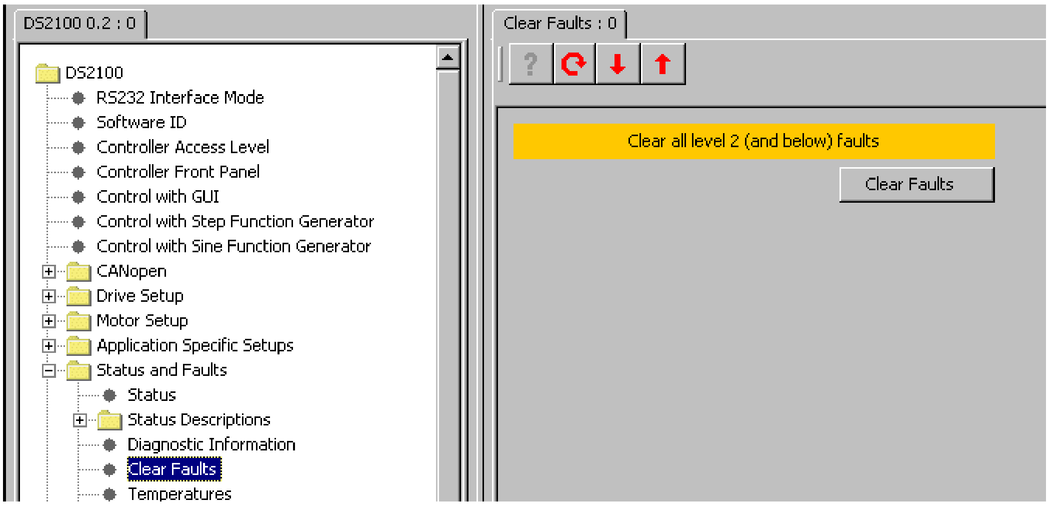
B.3.16.81 Diagnostic Information



DIAGNOSTIC INFORMATION PARAMETERS :

- 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.
- 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

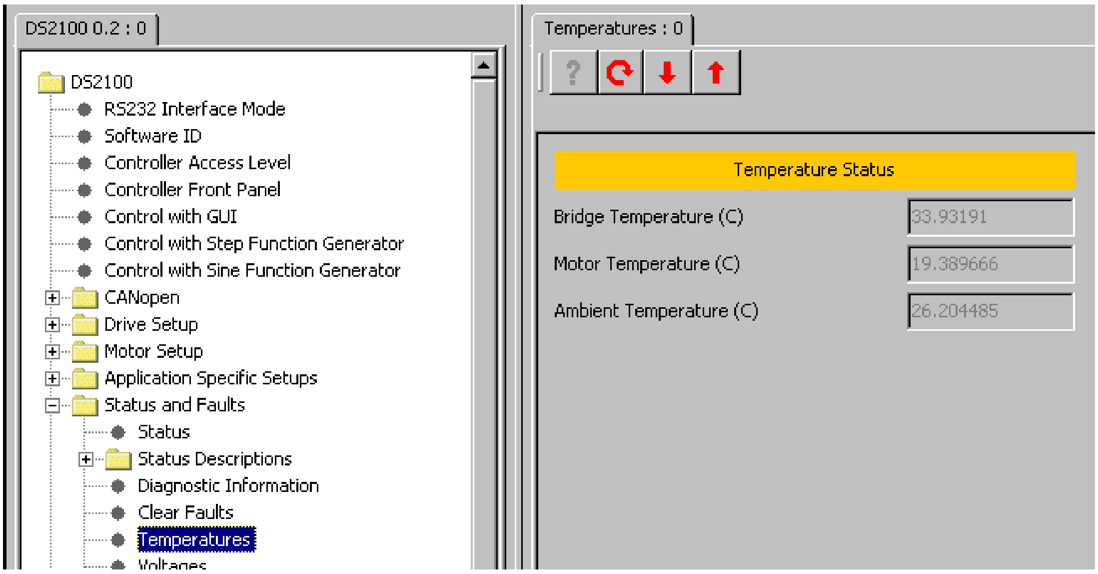
B.3.16.82 Clear Faults



The Clear Faults panel allows the user 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).

B.3.16.83 Temperatures

The Temperature panel allows the user to see the values of motor, bridge and ambient temperature.

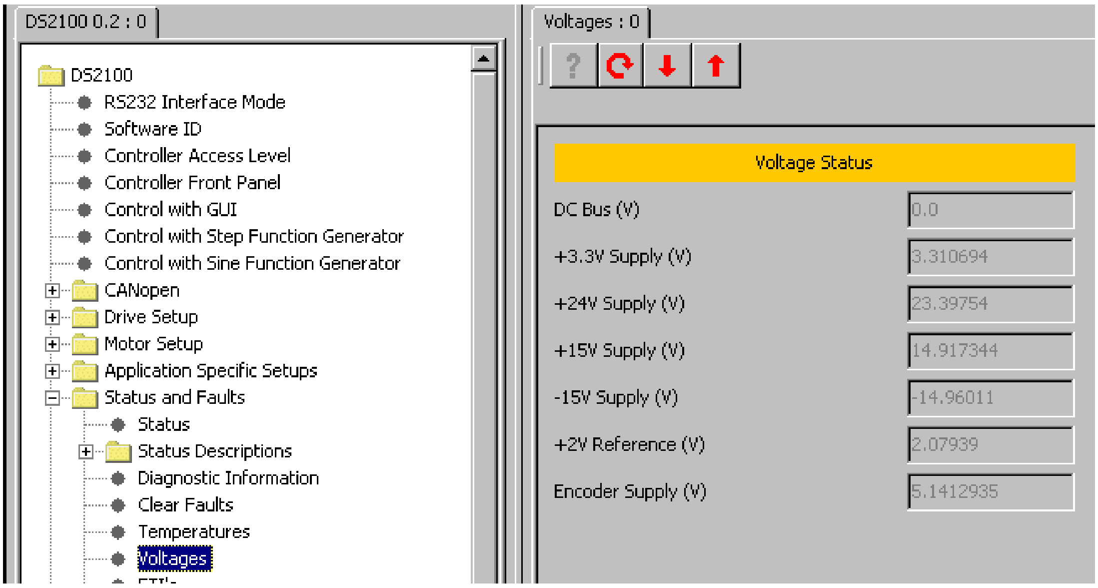


TEMPERATURE STATUS :

- Bridge Temperature (°C) → The power amplifier bridge temperature.
- Motor Temperature (°C) → The motor winding temperature.
- Ambient Temperature (°C) → The control electronics ambient temperature.

B.3.16.84 Voltages

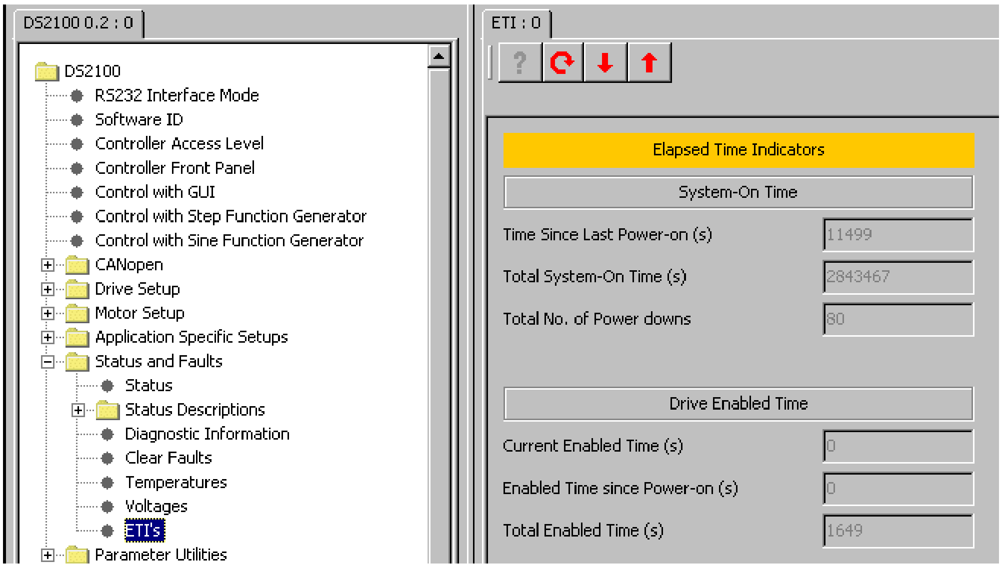
The Voltages panel displays the actual voltage.



VOLTAGE STATUS :

- 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.

B.3.16.85 ETI's



The ETI panel allows the user to see the Elapsed Time Indicators.

ELAPSED TIME INDICATORS :

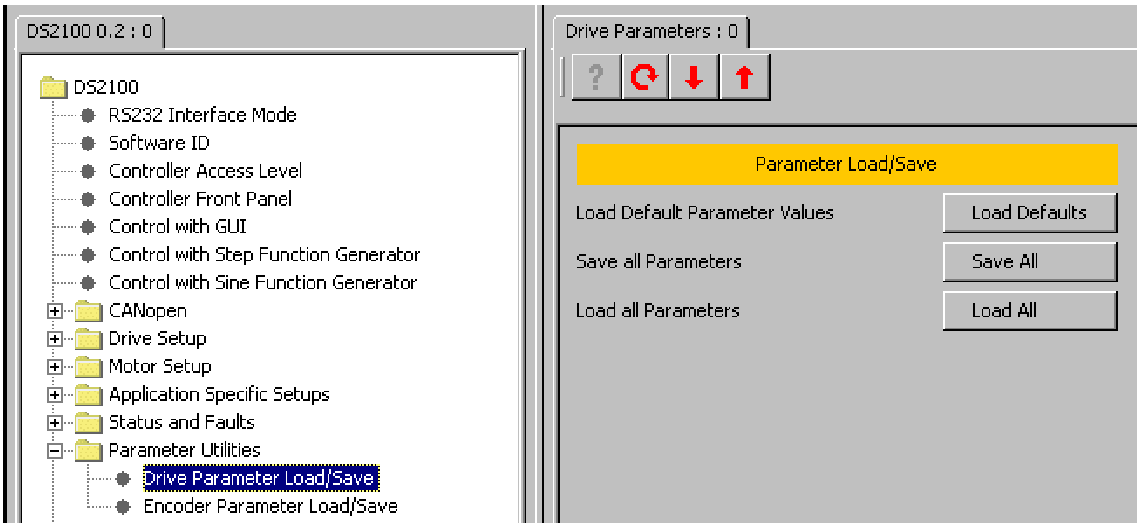
System-On Time:

- 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.3.16.86 Drive Parameter Load/Save

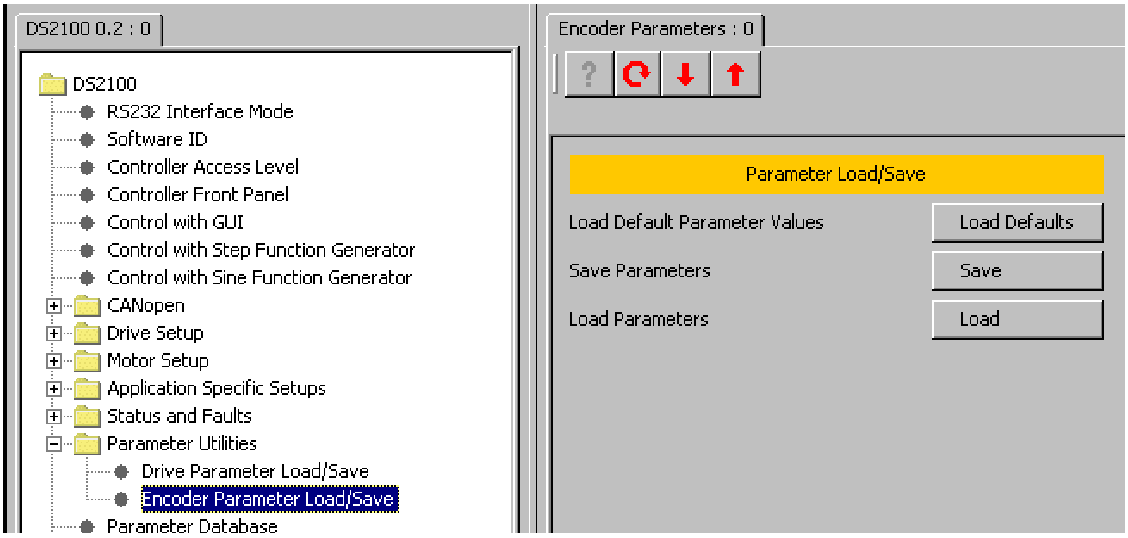


The Drive Parameter Load/Save panel allows the user to load/save the drive configuration parameters implemented in the software.

PARAMETER LOAD/SAVE :

- Load Default Parameter Values → This allows the user to load the default values of each drive configuration parameter.
- Save all Parameters → This allows the user to save drive configuration parameters to non-volatile memory.
- Load all Parameters → This allows the user to load drive configuration parameters which have been saved in the non-volatile memory.

B.3.16.87 Encoder Parameter Load/Save



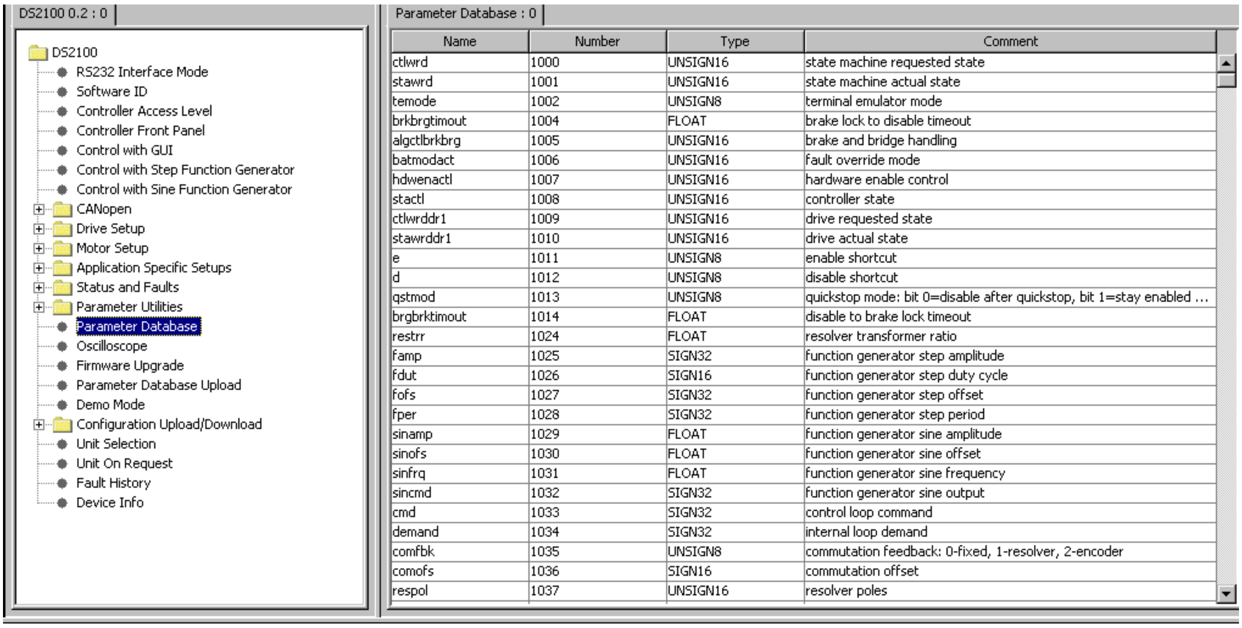
The Encoder Parameter Load/Save panel allows the user to load/save the motor configuration parameters implemented in the software to the encoder EEPROM.

PARAMETER LOAD/SAVE :

- Load Default Parameter Values → This allows the user to load the default values of the motor configuration parameters to the drive.
- Save all Parameters → This allows the user to save drive configuration parameters to the encoder EEPROM.
- Load all Parameters → This allows the user to load motor configuration parameters which have been saved in the encoder EEPROM.

B.3.16.88 Parameter Database

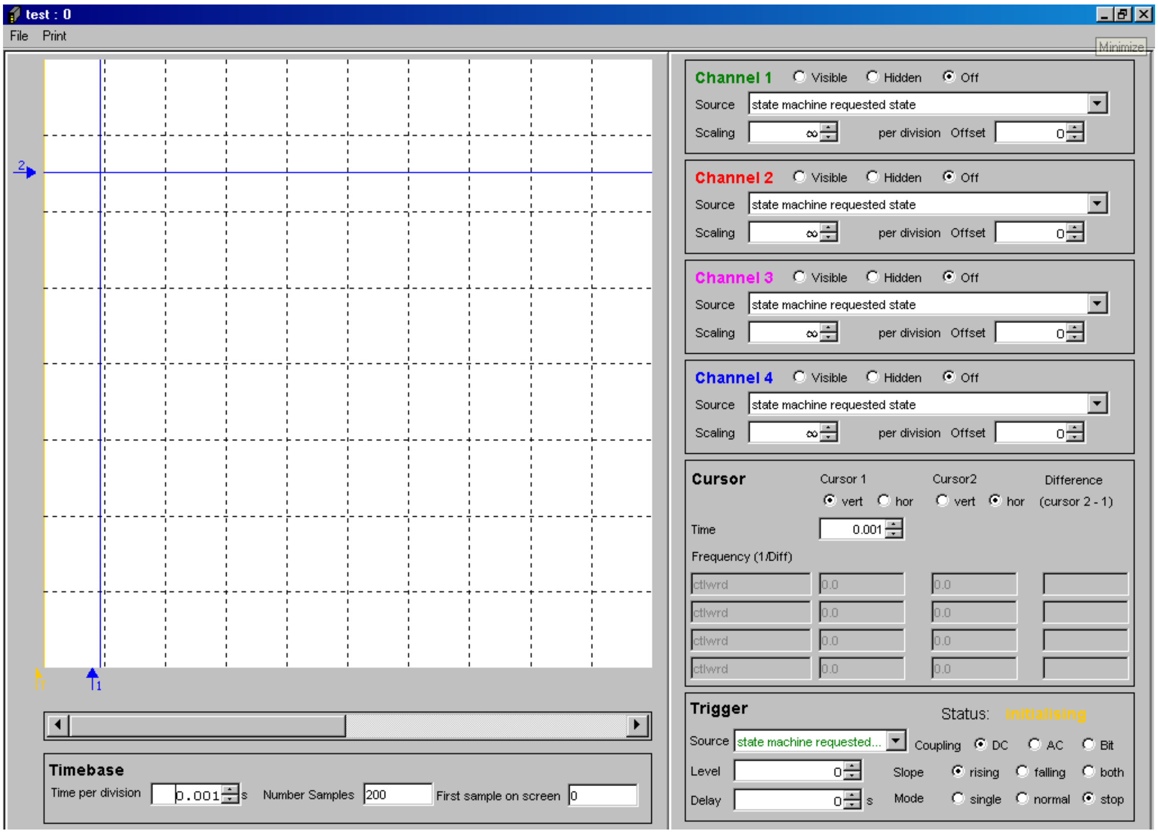
This is the database of all parameters implemented in the software.
Entry of parameters in to the database requires at minimum, application engineer access.



Name	Number	Type	Comment
ctlwrd	1000	UNSIGN16	state machine requested state
stawrd	1001	UNSIGN16	state machine actual state
temode	1002	UNSIGN8	terminal emulator mode
brkbrgtimout	1004	FLOAT	brake lock to disable timeout
algctlbrkbrg	1005	UNSIGN16	brake and bridge handling
batmodact	1006	UNSIGN16	fault override mode
hdwenactl	1007	UNSIGN16	hardware enable control
stactl	1008	UNSIGN16	controller state
ctlwrddr1	1009	UNSIGN16	drive requested state
stawrddr1	1010	UNSIGN16	drive actual state
e	1011	UNSIGN8	enable shortcut
d	1012	UNSIGN8	disable shortcut
qstmod	1013	UNSIGN8	quickstop mode: bit 0=disable after quickstop, bit 1=stay enabled ...
brgbrktimout	1014	FLOAT	disable to brake lock timeout
restrr	1024	FLOAT	resolver transformer ratio
famp	1025	SIGN32	function generator step amplitude
fdut	1026	SIGN16	function generator step duty cycle
fofs	1027	SIGN32	function generator step offset
fper	1028	SIGN32	function generator step period
sinamp	1029	FLOAT	function generator sine amplitude
sinofs	1030	FLOAT	function generator sine offset
sinfrq	1031	FLOAT	function generator sine frequency
sincmd	1032	SIGN32	function generator sine output
cmd	1033	SIGN32	control loop command
demand	1034	SIGN32	internal loop demand
comfbk	1035	UNSIGN8	commutation feedback: 0-fixed, 1-resolver, 2-encoder
comofs	1036	SIGN16	commutation offset
respol	1037	UNSIGN16	resolver poles

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.

B.3.16.89 Oscilloscope



The DS2100 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. The slope can be rising, falling, or both.

The Oscilloscope Panel is divided into the following sections:

B.3.16.89.1 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.3.16.89.2 Timebase Panel

Time per division: Sets the time represented by each horizontal division in the display area.
Number of 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.

First Sample On Screen: 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.3.16.89.3 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.

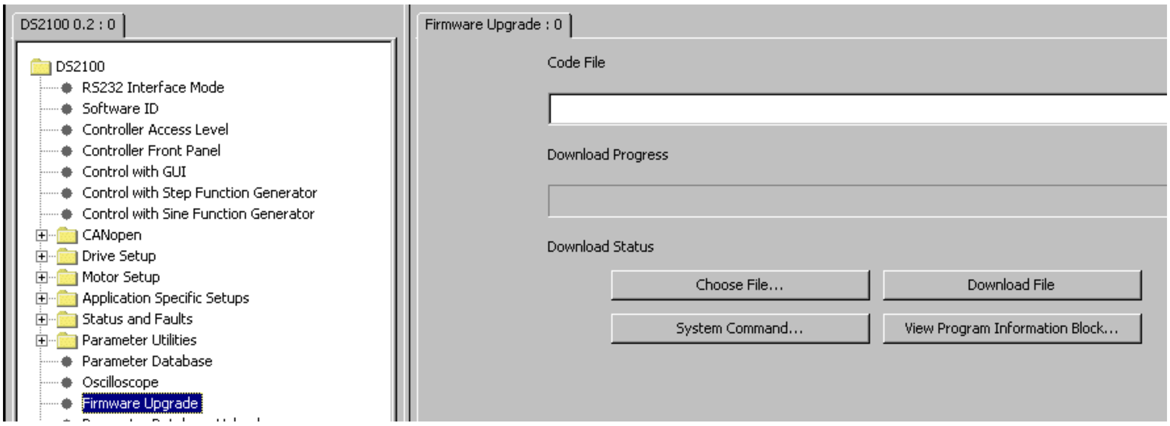
B.3.16.89.4 Cursor Panel

Allows 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.

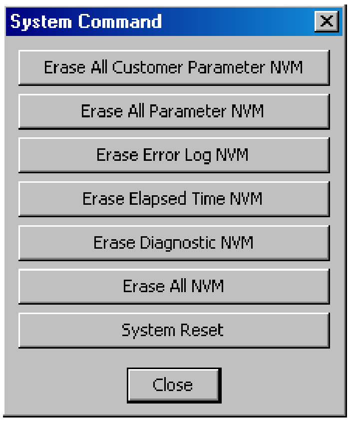
B.3.16.89.5 Trigger Panel

- *Status*: Displays the current status of the oscilloscope. This can be one of the following:
  - Stopped: The oscilloscope is currently not logging any 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.
- *Coupling*: Coupling can be dc, ac, or bitmap masking.
- *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.

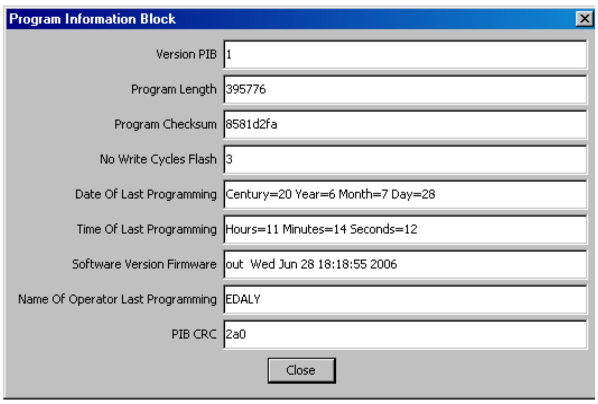
B.3.16.90 Firmware Upgrade



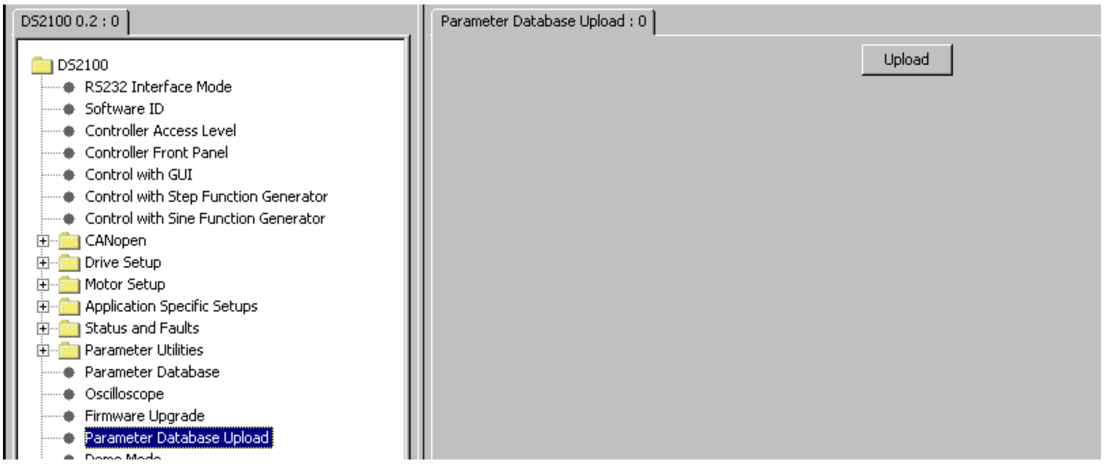
The firmware upgrade panel provides access to functions that reside in the bootloader for the drive software. Therefore, all of these functions will cause the drive to shut down and reset.
The ‘choose file’ and ‘download file’ buttons are used to change the application firmware in the drive.
The ‘system command’ button provides some NVM erase functions and a system reset.



The view program information block allows the user to view information that was recorded in flash memory when the application firmware was last programmed.



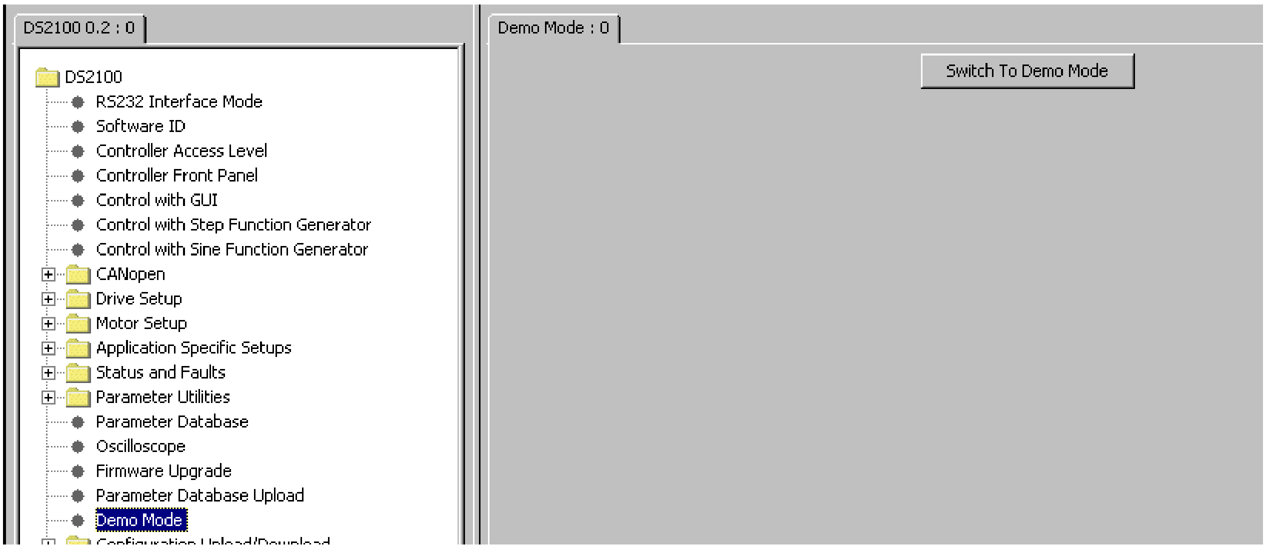
B.3.16.91 Parameter Database Upload



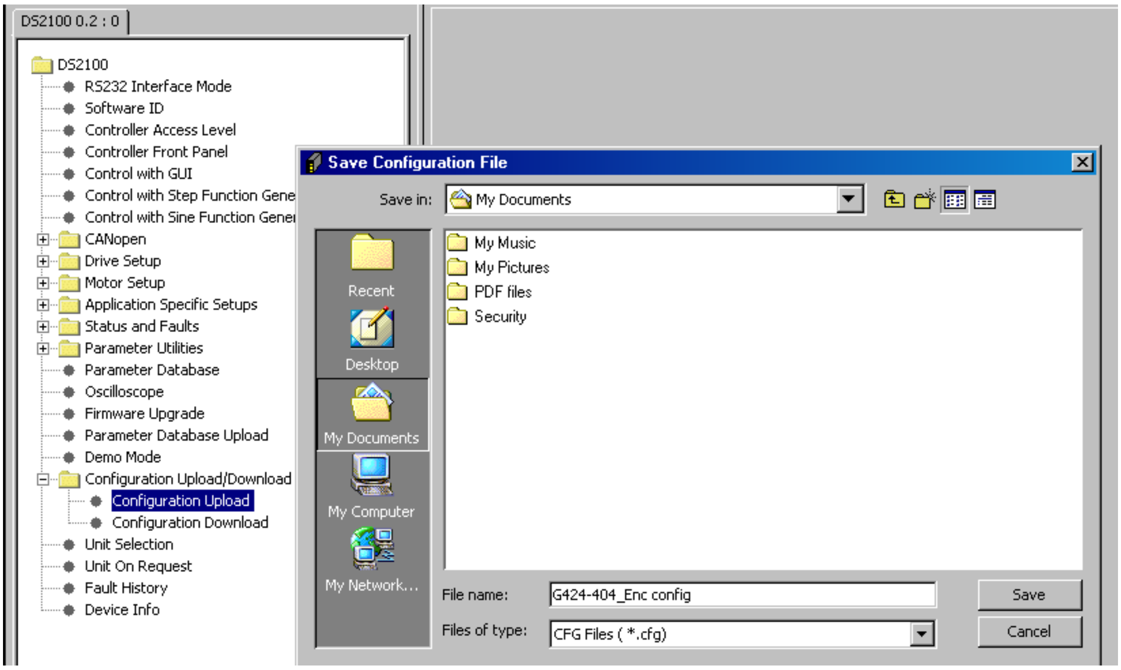
The parameter database used in the GUI is synchronised with the embedded version by uploading the database information from the drive. This upload function allows the user to ensure that the database held by the GUI is consistent with the database in the drive.

B.3.16.92 Demo Mode

Switches the GUI into demonstration mode – no communications with the drive are possible in this mode.



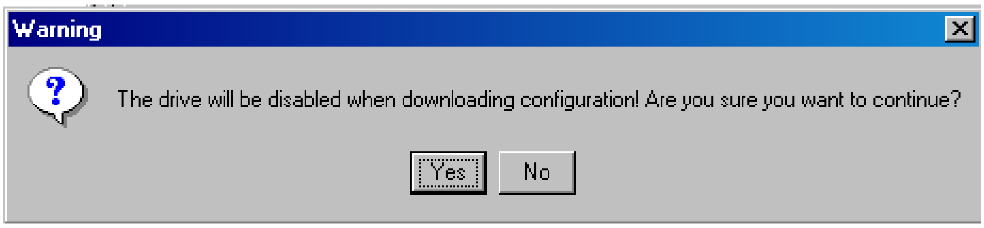
B.3.16.93 Configuration Upload



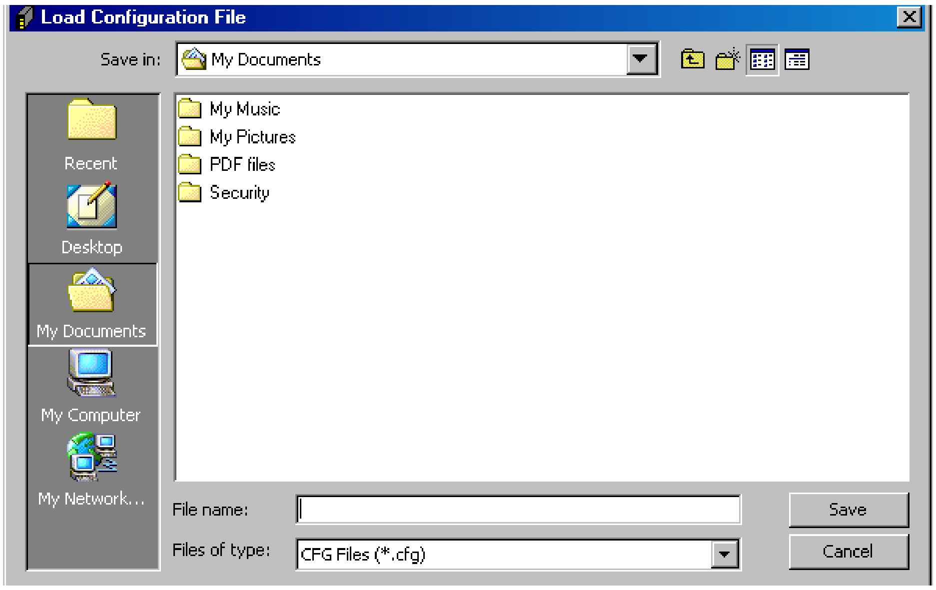
This function allows the user to upload the values for all of the configuration parameters so that the configuration can be re-used without having to repeat a long set-up procedure.
Once the location for the configuration file and filename are selected, click Save.
Ensure enough time is allowed for the full configuration upload to occur. Once upload is complete the following message appears:

B.3.16.94 Configuration Download

This function allows the user to download a configuration 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.

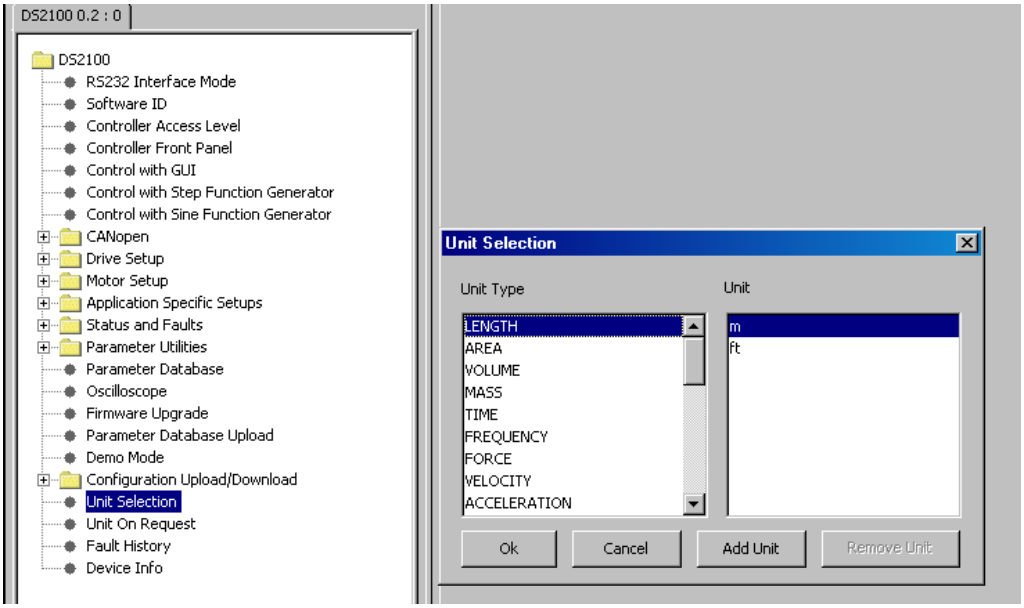


Browse to the location where the appropriate configuration file is stored, select it and press Save.

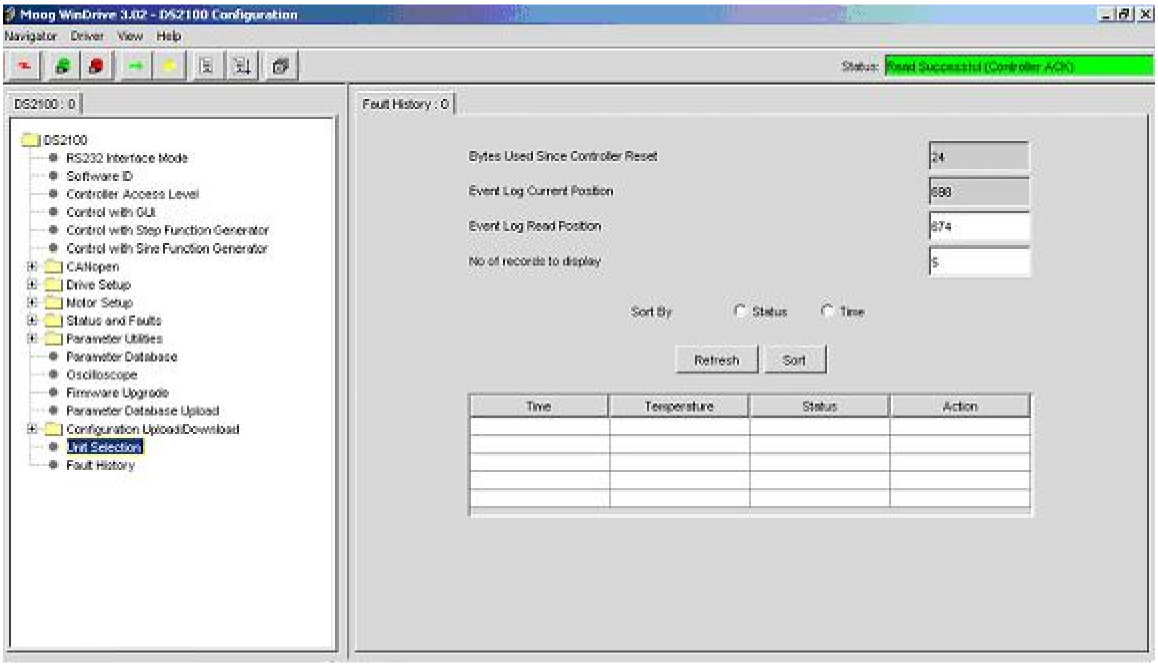
Allow enough time for the download to occur (can be viewed in the Even Logger) and a confirmation message appears

B.3.16.95 Unit Selection

This panel allows the user to select the units to be used for each physical attribute.


DS2100 0.2 : 0
DS2100
RS232 Interface Mode
Software ID
Controller Access Level
Controller Front Panel
Control with GUI
Control with Step Function Generator
Control with Sine Function Generator
CANopen
Drive Setup
Motor Setup
Application Specific Setups
Status and Faults
Parameter Utilities
Parameter Database
Oscilloscope
Firmware Upgrade
Parameter Database Upload
Demo Mode
Configuration Upload/Download
Unit Selection
Unit On Request
Fault History
Device Info
Unit Selection
Unit Type
Unit
LENGTH
AREA
VOLUME
MASS
TIME
FREQUENCY
FORCE
VELOCITY
ACCELERATION
m
ft
Ok
Cancel
Add Unit
Remove Unit

B.3.16.96 Fault History



This panel allows the user to examine the internal event log of the drive.

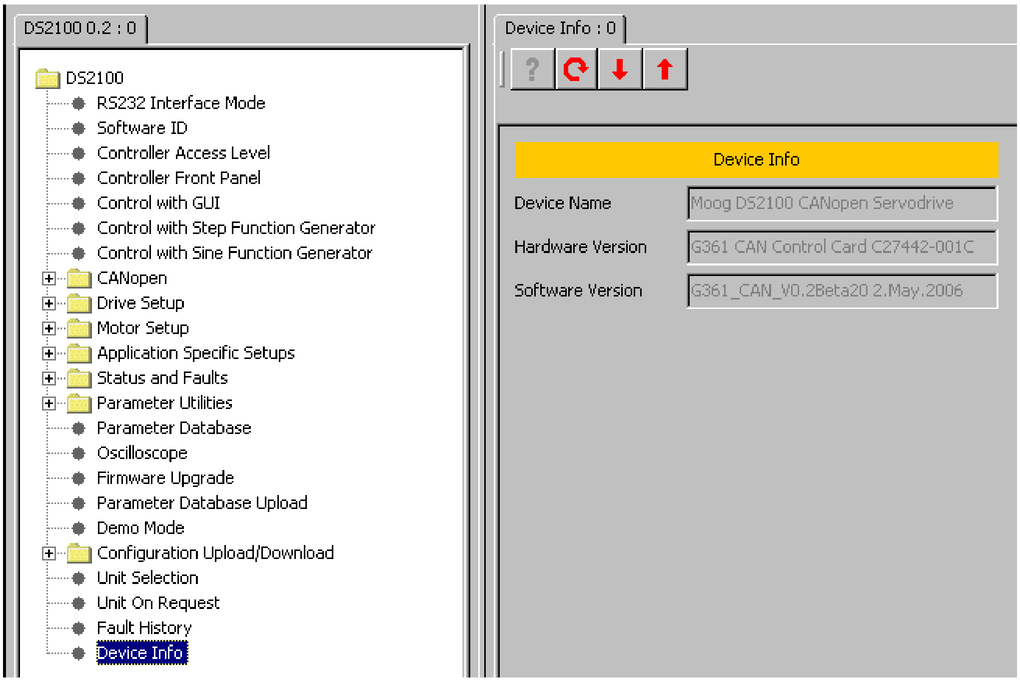
Event Log Current Position – the next byte position that will be written in the event log.

Event Log Read Position – the first byte position that will be read from the event log when the refresh button is selected. This number will be automatically re-adjusted to the start of a record. After a refresh has completed, this number will be set to the end of the block of bytes that have been read

No of records to display – this is the number of event log records that will be read when the refresh button is selected. Each event log record has a length of 12 bytes.

In the event log display the columns are defined as follows:
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.
Temperature – the temperature at which the event occurred
Status – a description of the event logged
Action – whether the event was set or cleared

B.3.16.97 Device Information



This panel displays useful information:

Device Name – Moog DS2100 CANopen Servodrive
Hardware version – contains the revision of the CAN digital control card
Software version – contains the name of the embedded firmware on the drive.

PAGE INTENTIONALLY BLANK