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User Guide

CSD100

Model size 4 to 6

Variable Speed AC drive for
permanent magnet motors

Part Number: 0478-0107-03
Issue: 3

Copeland Scroll™

www.emersonclimate.com/CommercialScroll

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Original Instructions

For the purposes of compliance with the EU Machinery Directive 2006/42/EC:

General information

The manufacturer accepts no liability for any consequences resulting from inappropriate, negligent or incorrect installation or adjustment of the optional operating parameters of the equipment or from mismatching the variable speed drive with the motor.

The contents of this guide are believed to be correct at the time of printing. In the interests of a commitment to a policy of continuous development and improvement, the manufacturer reserves the right to change the specification of the product or its performance, or the contents of the guide, without notice.

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Drive firmware version

This product is supplied with the latest firmware version. If this drive is to be connected to an existing system or machine, all drive firmware versions should be verified to confirm the same functionality as drives of the same model already present. This may also apply to drives returned from a Service Centre or Repair Centre. If there is any doubt please contact the supplier of the product.

The firmware version of the drive can be checked by looking at Pr **11.029**.

CSD100 Software version

This product is supplied with the latest software version. The software version can be verified in Pr **00.056** {20.003}.

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Issue Number: 3

Drive Firmware: 01.07.01.00 onwards

CSD100 Software: 01.06 onwards

How to use this guide

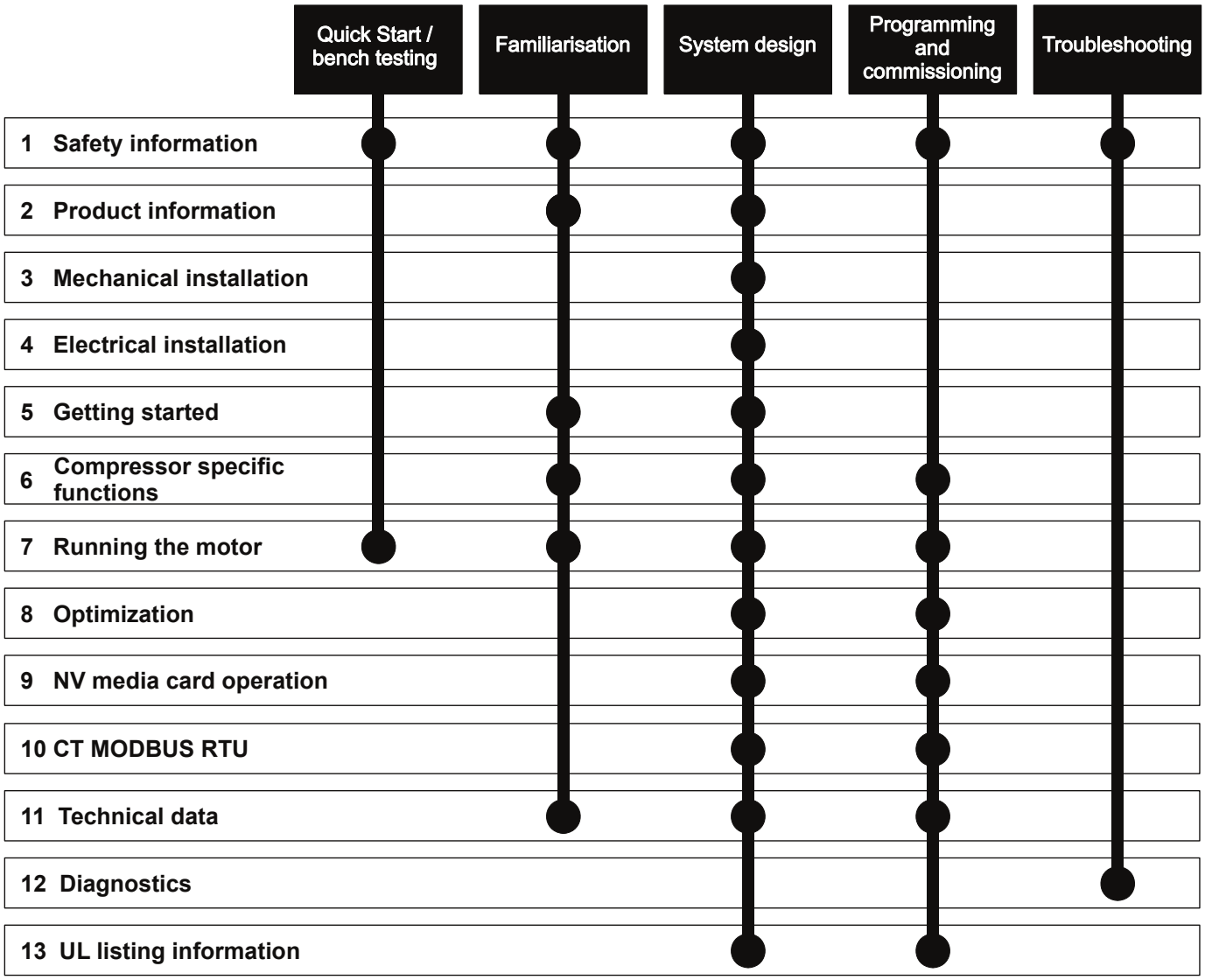
This user guide provides complete information for installing and operating the drive from start to finish.

The information is in logical order, taking the reader from receiving the drive through to fine tuning the performance.

NOTE

There are specific safety warnings throughout this guide, located in the relevant sections. In addition, Chapter 1 *Safety information* contains general safety information. It is essential that the warnings are observed and the information considered when working with or designing a system using the drive.

This map of the user guide helps to find the right sections for the task you wish to complete, but for specific information, refer to *Contents* on page 4:



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Declaration of Conformity

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Boulevard Marcellin Leroy
CS10015
16915 Angoulême Cedex 9
France

This declaration applies to CSD100 variable speed drive products, comprising model numbers as shown below:

CSD100-*bbbbbbbbb* Valid characters:	
bbbbbbbbb	04400240A 05400300A 06200500A, 06200580A, 06400380A, 06500220A, 06500270A

The AC variable speed drive products listed above have been designed and manufactured in accordance with the following European harmonized standards:

EN 61800-5-1:2007	Adjustable speed electrical power drive systems - safety requirements - electrical, thermal and energy
EN 61800-3:2004	Adjustable speed electrical power drive systems. EMC product standard including specific test methods
EN 61000-6-2:2005	Electromagnetic compatibility (EMC). Generic standards. Immunity standard for industrial environments
EN 61000-6-4:2007	Electromagnetic compatibility (EMC). Generic standards. Emission standard for industrial environments
EN 61000-3-2:2006	Electromagnetic compatibility (EMC), Limits, Limits for harmonic current emissions (equipment input current <16 A per phase)
EN 61000-3-3:2008	Electromagnetic compatibility (EMC), Limits, Limitation of voltage fluctuations and flicker in low-voltage supply systems for equipment with rated current <16 A

EN 61000-3-2:2006 Applicable where input current <16 A. No limits apply for professional equipment where input power >1 kW.

These products comply with the requirements of the Restriction of Hazardous Substances Directive 2011/65/EU, the Low Voltage Directive 2006/95/EC and the Electromagnetic Compatibility Directive 2004/108/EC.

T. Alexander

Control Techniques Vice President, Technology

Newtown

Date: 10th December 2014

These electronic drive products are intended to be used with appropriate motors, controllers, electrical protection components and other equipment to form complete end products or systems. Compliance with safety and EMC regulations depends upon installing and configuring drives correctly, including using the specified input filters. The drives must be installed only by professional assemblers who are familiar with requirements for safety and EMC. The assembler is responsible for ensuring that the end product or system complies with all the relevant laws in the country where it is to be used. Refer to the User Guide. An EMC Data Sheet is also available giving detailed EMC information.

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1 Safety information

1.1 Warnings, Cautions and Notes

A Warning contains information which is essential for avoiding a safety hazard.

WARNING

A Caution contains information which is necessary for avoiding a risk of damage to the product or other equipment.

CAUTION

NOTE

A Note contains information which helps to ensure correct operation of the product.

1.2 Electrical safety - general warning

The voltages used in the drive can cause severe electrical shock and/or burns, and could be lethal. Extreme care is necessary at all times when working with or adjacent to the drive.

Specific warnings are given at the relevant places in this User Guide.

1.3 System design and safety of personnel

The drive is intended as a component for professional incorporation into complete equipment or a system. If installed incorrectly, the drive may present a safety hazard.

The drive uses high voltages and currents, carries a high level of stored electrical energy, and is used to control equipment which can cause injury.

Close attention is required to the electrical installation and the system design to avoid hazards either in normal operation or in the event of equipment malfunction. System design, installation, commissioning/ start-up and maintenance must be carried out by personnel who have the necessary training and experience. They must read this safety information and this User Guide carefully.

The STOP and SAFE TORQUE OFF functions of the drive do not isolate dangerous voltages from the output of the drive or from any external option unit. The supply must be disconnected by an approved electrical isolation device before gaining access to the electrical connections.

With the sole exception of the SAFE TORQUE OFF function, none of the drive functions must be used to ensure safety of personnel, i.e. they must not be used for safety-related functions.

Careful consideration must be given to the functions of the drive which might result in a hazard, either through their intended behavior or through incorrect operation due to a fault. In any application where a malfunction of the drive or its control system could lead to or allow damage, loss or injury, a risk analysis must be carried out, and where necessary, further measures taken to reduce the risk.

The SAFE TORQUE OFF function may be used in a safety-related application. The system designer is responsible for ensuring that the complete system is safe and designed correctly according to the relevant safety standards.

1.4 Environmental limits

Instructions in this User Guide regarding transport, storage, installation and use of the drive must be complied with, including the specified environmental limits. Drives must not be subjected to excessive physical force.

1.5 Access

Drive access must be restricted to authorized personnel only. Safety regulations which apply at the place of use must be complied with.

1.6 Compliance with regulations

The installer is responsible for complying with all relevant regulations, such as national wiring regulations, accident prevention regulations and electromagnetic compatibility (EMC) regulations. Particular attention must be given to the cross-sectional areas of conductors, the selection of fuses or other protection, and protective ground (earth) connections.

This User Guide contains instruction for achieving compliance with specific EMC standards.

Within the European Union, all machinery in which this product is used must comply with the following directives:

2006/42/EC Safety of machinery.
2004/108/EC: Electromagnetic Compatibility.

1.7 Motor

Ensure the motor is installed in accordance with the manufacturer's recommendations. Ensure the motor shaft is not exposed.

1.8 Adjusting parameters

Some parameters have a profound effect on the operation of the drive. They must not be altered without careful consideration of the impact on the controlled system. Measures must be taken to prevent unwanted changes due to error or tampering.

1.9 Electrical installation

1.9.1 Electric shock risk

The voltages present in the following locations can cause severe electric shock and may be lethal:

AC supply cables and connections

Output cables and connections

Many internal parts of the drive, and external option units

Unless otherwise indicated, control terminals are single insulated and must not be touched.

1.9.2 Stored charge

The drive contains capacitors that remain charged to a potentially lethal voltage after the AC supply has been disconnected. If the drive has been energized, the AC supply must be isolated at least ten minutes before work may continue.

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2 Product information

2.1 Introduction

Variable speed compressor drive

The CSD100 delivers maximum machine performance with sensorless permanent magnet motor control, for dynamic and efficient machine operation.

Features

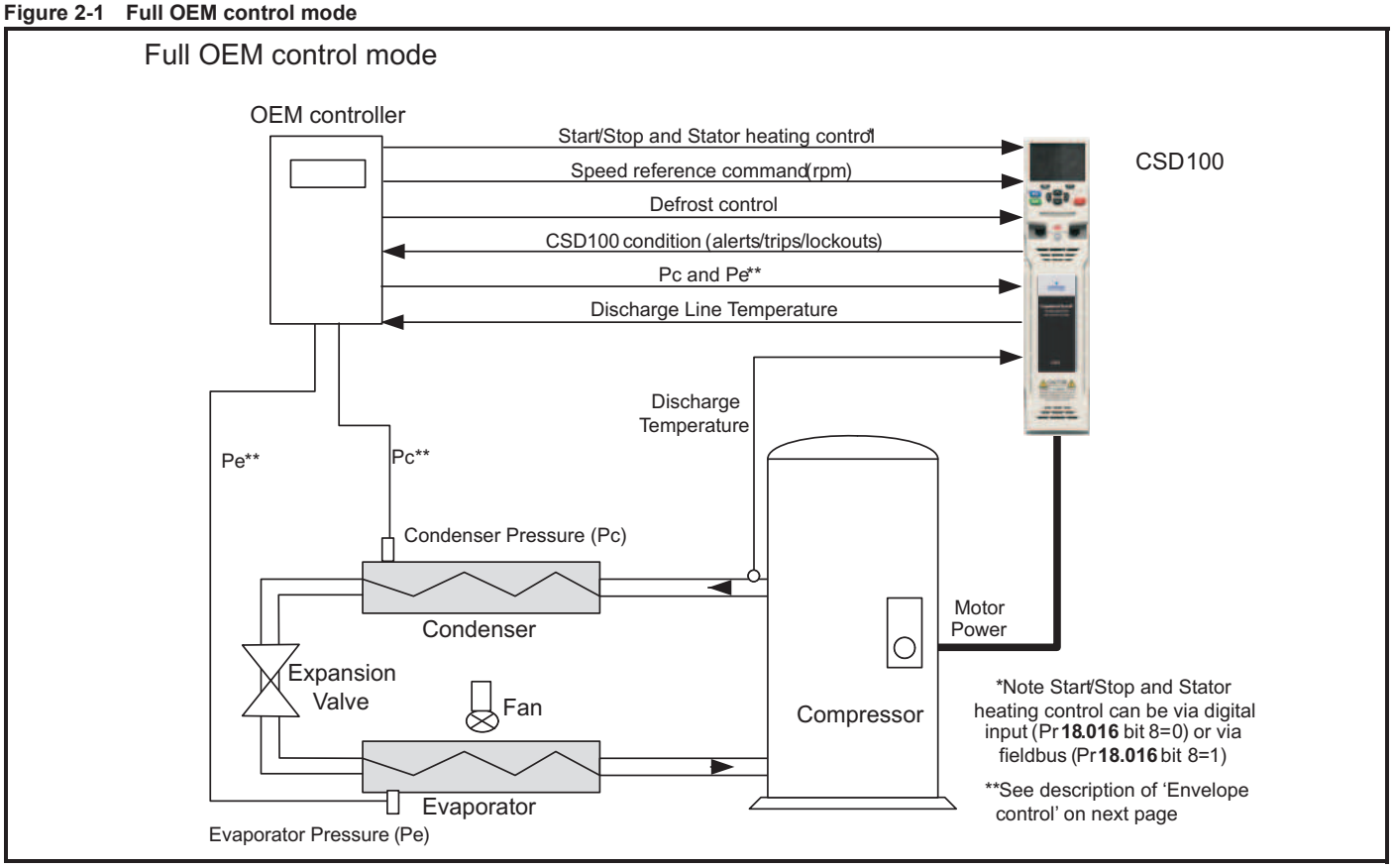
- Universal high performance drive for sensorless permanent magnet motors.
- Onboard IEC 61131-3 programmable automation
- 485 serial communications interface
- Single channel SAFE TORQUE OFF (STO) input

Optional features

- Select up to three option modules
- NV Media Card for parameter copying and data storage
- Keypad
- EMC filter
- Input line reactor

The CSD100 compressor drive is designed to be used in the configuration shown below.

Figure 2-1 Full OEM control mode



Compressor functionality provided by the dedicated CSD100 software

The dedicated CSD100 compressor related functionality includes:

- **Soft start**

The initial start of the compressor, where the motor is accelerated to a predetermined dwell speed.

- **Locked rotor**

During a mechanical failure of compressor or associated system, a condition can occur where the motor cannot turn even with maximum current, this is the locked rotor condition. It is detected by the software during soft start if the estimating motor speed is below 20% of the soft-start dwell speed.

- **Motor phase loss detection**

The drive will detect and trip if a phase connection to the motor is missing during soft-starting. After 5 minutes the trip is automatically reset and the soft-start can begin once more. The system will lockout after 10 trips within 24 hours [the count of trips is reset on lockout].

- **Reverse rotation**

Reverse rotation of the compressor can occur if the motor has been miss-wired (phase order error). The software detects this condition by monitoring the torque profile during soft start. This is only checked on the first soft start after power up.

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- **Envelope control**

The compressor has a speed envelope in which normal operation takes place. Envelope control is used to keep the compressor operating within this envelope. The software function receives both the condenser and evaporator pressures and limits the speed reference to keep the compressor operating within its envelope. If operation outside the outer envelope is detected, a trip will occur to protect the compressor.

- **Resonance avoidance**

This is to avoid running at motor speeds that cause mechanical resonance effects.

- **Defrost cycle**

During this mode of operation the compressor motor is changed to a defined speed for a period of time. This is to raise the temperature of the evaporator and defrost it.

- **Oil boost**

If the compressor is running at a speed that is insufficient to guarantee lubrication (for a defined time) oil boost mode is entered. During oil boost the motor speed is increased for a period of time to ensure the compressor is correctly lubricated.

- **Lost rotor trip prevent**

The drive automatically reduces the compressor speed under conditions where the speed error is greater than expected to avoid nuisance trips.

- **Controlled shut down**

A controlled shut down avoids compressor issues that would be caused by simply turning off the power. During a controlled shut down, the motor decelerates to a defined speed for a dwell time and then slows to zero speed at a controlled rate.

- **Anti short cycling**

Excessive short duration cycles can cause damage to the compressor and system. The short-cycle prevention scheme detects if there have been too many short-cycles. It will alert the user and impose a restart lockout time to prevent further short-cycles.

- **Discharge Line Temperature**

The drive monitors the level of the discharge line temperature sensor and trips if it is outside of the permitted range.

- **Stator Heating**

This function feeds DC current through the motor stator windings in order to heat the compressor while the compressor is not spinning.

- **Field-bus communications watchdog timer**

This function may be used to protect the system from a long term loss of field-bus communications.

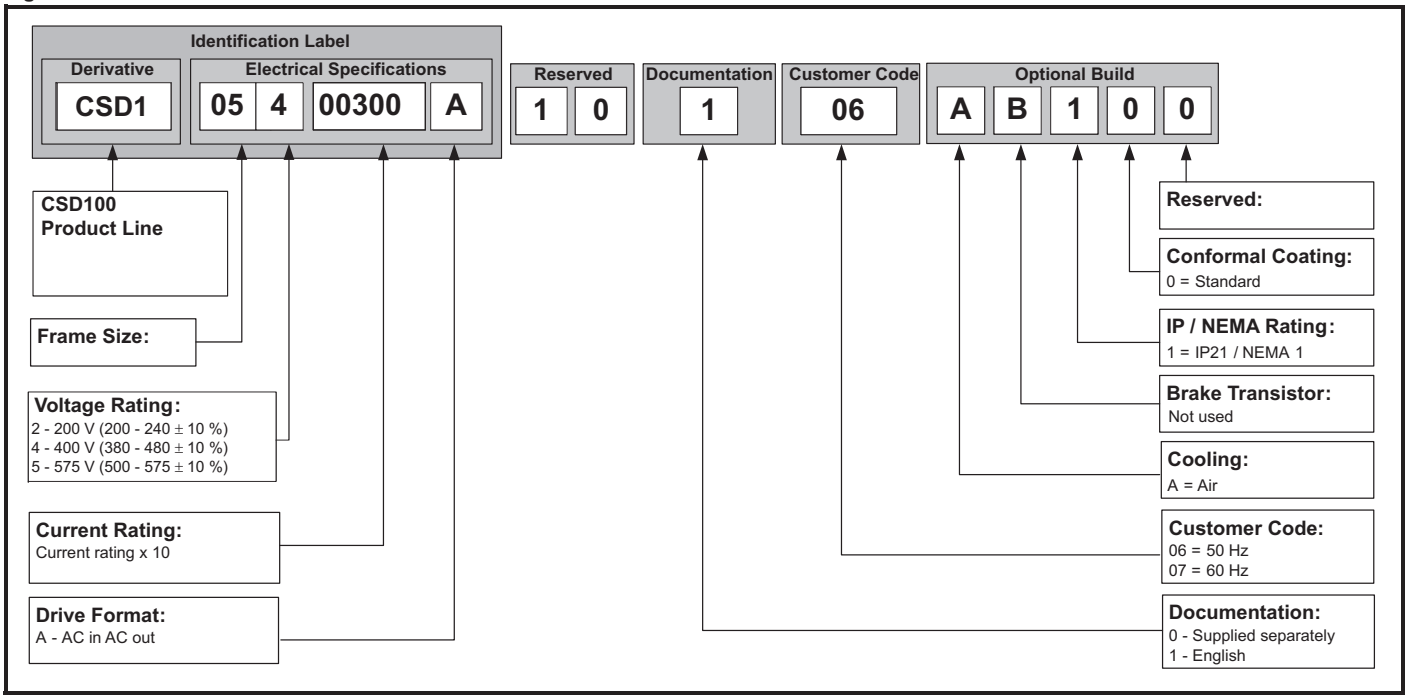
- **Alert log**

The last 20 alerts occurring within the last 7 days are logged for diagnostic purposes

2.2 Model number

The way in which the model numbers for the CSD100 range are formed is illustrated below:

Figure 2-2 Model number



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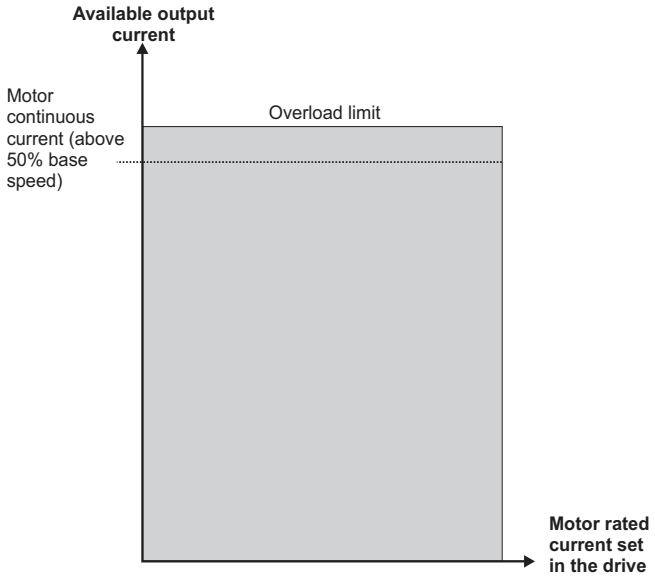
2.3 Ratings

Ratings are compatible with motors designed to IEC60034.

The graph aside illustrates the relationship between continuous current rating and short term overload limits.



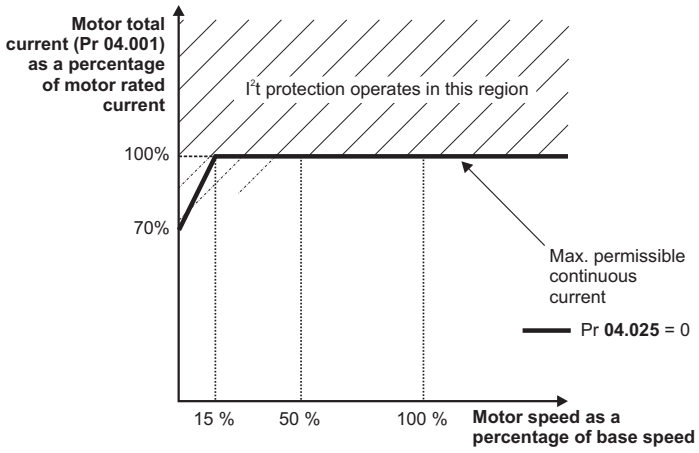
To provide the correct level of protection the I^2t software operates at a level which is speed dependent. This is illustrated in the graph below.

NOTE

The speed at which the low speed protection takes effect can be changed by the setting of *Low Speed Thermal Protection Mode* (04.025). The protection starts when the motor speed is below 15 % of base speed when Pr **04.025** = 0 (default) and below 50 % when Pr **04.025** = 1.

Operation of motor I^2t protection

Motor I^2t protection is fixed as shown below.



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The continuous current ratings given are for maximum 40 °C (104 °F), 1000 m altitude and 3.0 kHz switching. Derating is required for higher switching frequencies, ambient temperature >40 °C (104 °F) and high altitude. For further information, refer to Chapter 11 *Technical data* on page 102.

Table 2-1 200 V drive ratings (200 V to 240 V ±10 %)

Model		Nominal rating		Maximum permissible continuous output current (A) for the following ambient temperatures	
		kW	hp	(40°C)	(60°C)
Frame size 6	06200500	11	15	50	27
	06200580	15	20	58	43

Table 2-2 400 V drive ratings (380 V to 480 V ±10 %)

Model		Nominal rating		Maximum permissible continuous output current (A) for the following ambient temperatures	
		kW	hp	(40°C)	(60°C)
Frame size 4	04400240	11	15	24	15
Frame size 5	05400300	15	20	30	24
Frame size 6	06400380	18.5	25	38	38

Table 2-3 575 V drive ratings (500 V to 575 V ±10 %)

Model		Nominal rating		Maximum permissible continuous output current (A) for the following ambient temperatures	
		kW	hp	(40°C)	(60°C)
Frame size 6	06500220	11	15	22	
	06500270	15	20	27	24

2.3.1 Typical short term overload limits

The maximum percentage overload limit changes depending on the selected motor. Variations in motor characteristics can result in changes in the maximum possible overload. The exact value for a specific motor can be calculated using the equations detailed in Menu 4 in the *Parameter Reference Guide*.

Typical values are shown in the table below for RFC-S.

Table 2-4 Typical overload limits

Operating mode	RFC from cold	RFC from 100 %
Overload with motor rated current = drive rated current	110 % for 165 s	110 % for 9 s

Generally the drive rated current is higher than the matching motor rated current allowing a higher level of overload than the default setting.

The time allowed in the overload region is proportionally reduced at very low output frequency on some drive ratings.

NOTE

The maximum overload level which can be attained is independent of the speed.

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2.4 Operating modes

The CSD100 drive is designed to operate in the following mode:

1. RFC - S
   Without position feedback sensor (Sensorless)

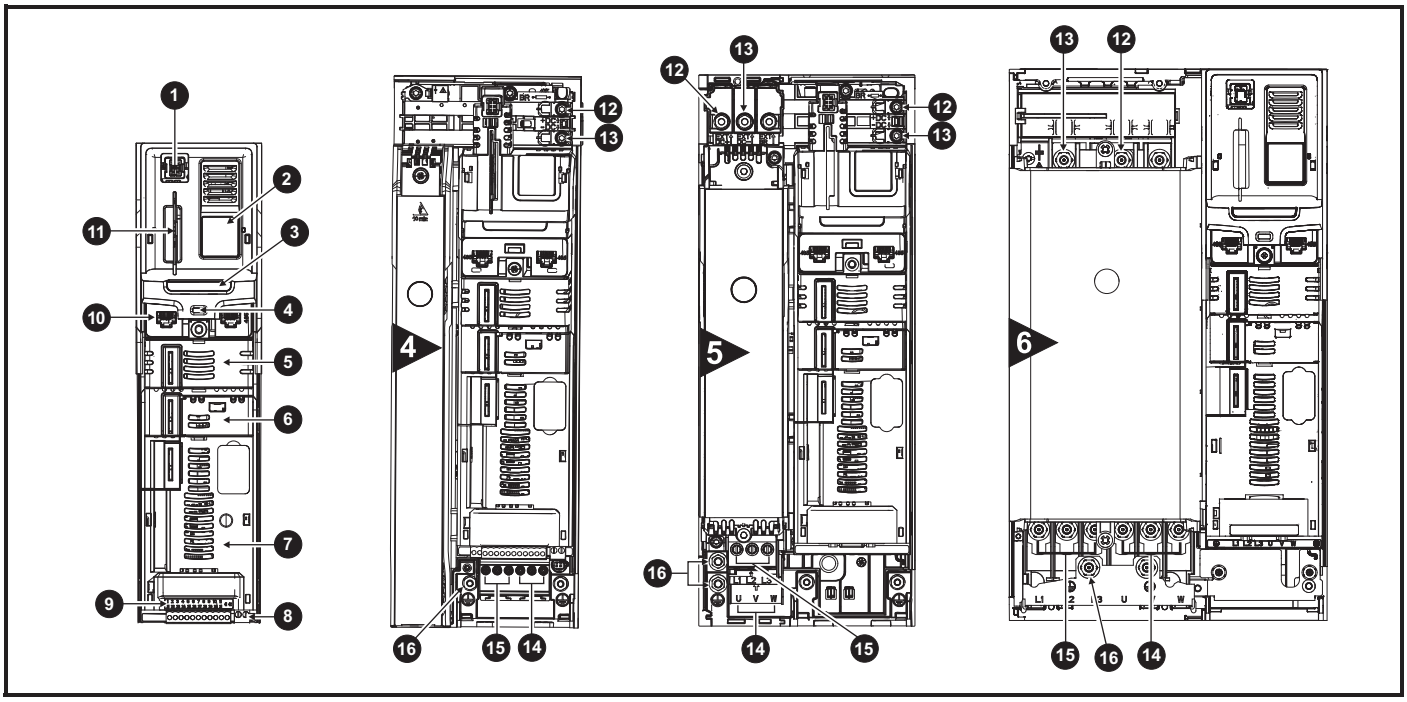
2.4.1 RFC- S mode

Without position feedback sensor (Sensorless)

RFC-S sensorless mode provides closed loop control without the need for position feedback by using current, voltages and key motor parameters to estimate the motor speed.

2.5 Drive features

Figure 2-3 Features of the drive



Key

1. Keypad connection
2. Rating label
3. Identification label
4. Status LED
5. Option module slot 1
6. Option module slot 2
7. Option module slot 3
8. Relay connections
9. Control connections
10. Communications port
11. NV media card slot
12. DC bus +
13. DC bus -
14. Motor connections
15. AC supply connections
16. Ground connections

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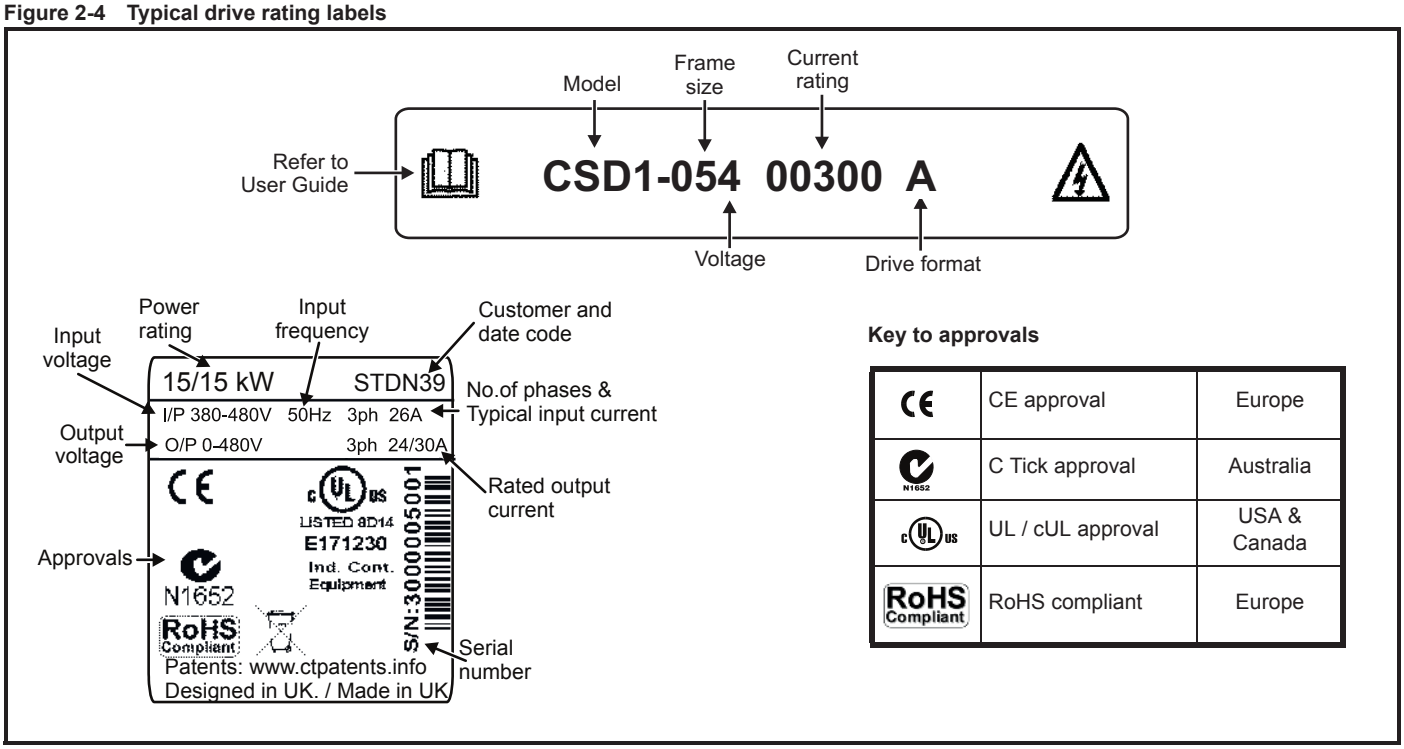
2.6 Nameplate description

See Figure 2-3 for location of rating labels.

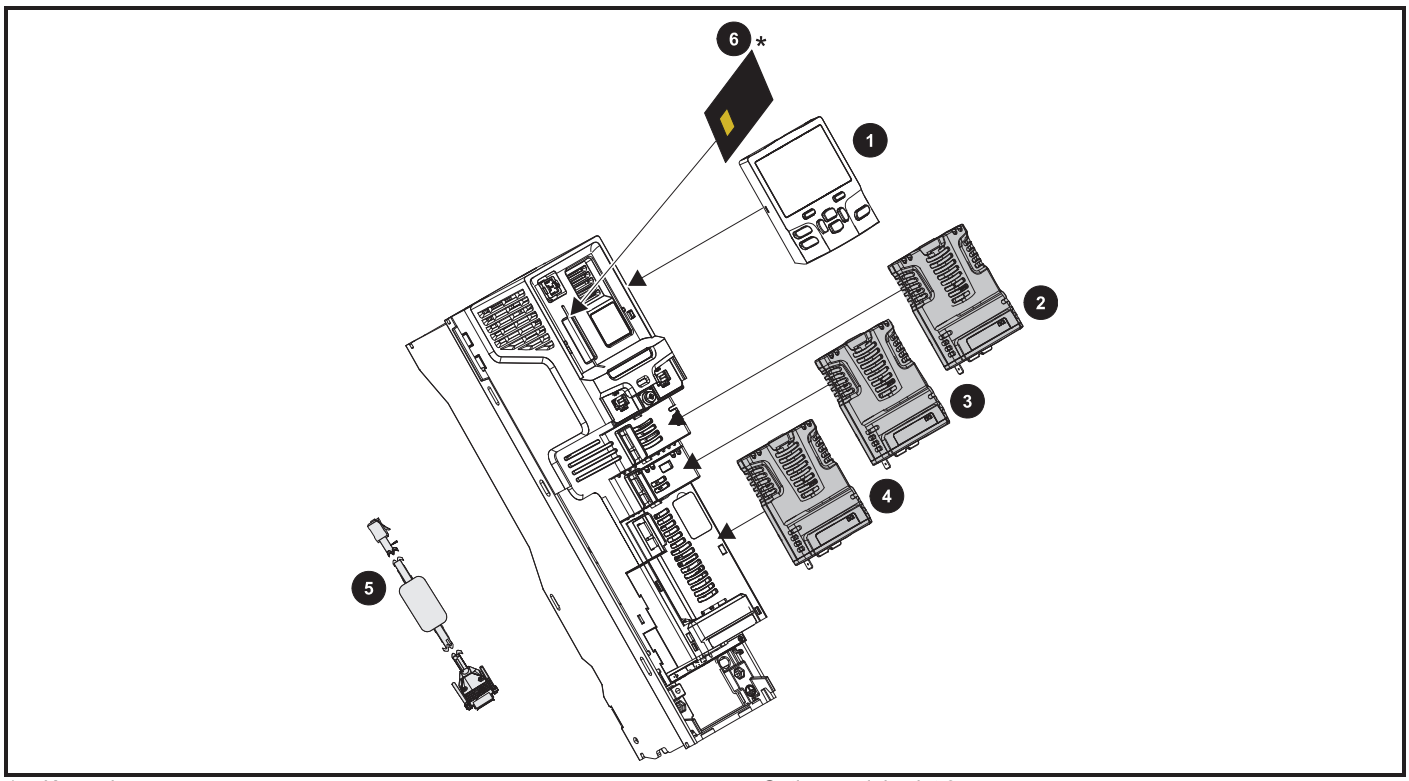
Figure 2-4 Typical drive rating labels



Refer to Figure 2-2 *Model number* on page 9 for further information relating to the labels.

2.7 Options

Figure 2-5 Options available with the drive



1. Keypad
2. Option module slot 1
3. Option module slot 2
4. Option module slot 3
5. CT Comms cable
6. NV media card

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WARNING

Be aware of possible live terminals when inserting or removing the NV media card.

All standard option modules are color-coded in order to make identification easy. All modules have an identification label on top of the module. Standard option modules can be installed to any of the available option slots on the drive. The following tables shows the color-code key and gives further details on their function.

Table 2-5 Option module identification (standard modules)

Type	Option module	Color	Name	Further Details
Fieldbus		Purple	SI-PROFIBUS	**Profibus option** PROFIBUS adapter for communications with the drive
		Medium Grey	SI-DeviceNet	**DeviceNet option** DeviceNet adapter for communications with the drive
		Light Grey	SI-CANopen	**CANopen option** CANopen adapter for communications with the drive
Automation (I/O expansion)		Orange	SI-IO	**Extended I/O** Increases the I/O capability by adding the following combinations: • Digital I/O • Digital Inputs • Analog Inputs (differential or single ended) • Analog Output • Relays

Table 2-6 Keypad identification

Type	Keypad	Name	Further Details
Keypad		HOA-Keypad	**LCD keypad option** Keypad with a LCD display
		HOA-Keypad RTC	**LCD keypad option** Keypad with a LCD display and real time clock

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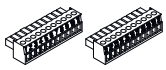
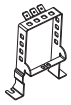
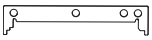
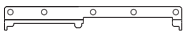
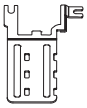
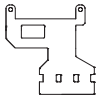
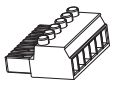
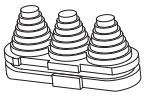
2.8 Items supplied with the drive

The drive is supplied with a copy of the *Getting Started Guide*, a safety information booklet, the Certificate of Quality and an accessory kit box including the items shown in Table 2-7.

Table 2-7 Parts supplied with the drive

Description	Size 4	Size 5	Size 6
Control connectors		 x 1 x 1	
Relay connector		 x 1	
24 V power supply connector			 x 1
Grounding bracket		 x 1	
Surface mounting brackets	 x 2	 x 2	 x 2
Grounding clamp	 x 1	 x 1	 x 1
DC terminal cover grommets	 x 2		
Terminal nuts			 M6 x 11
Supply and motor connector	 x 1	 x 1 x 1	
Finger guard grommets		 x 3	 x 2

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3 Mechanical installation

This chapter describes how to use all mechanical details to install the drive. The drive is intended to be installed in an enclosure. Key features of this chapter include:

- Through-hole mounting
- High IP as standard or through-panel mounting
- Enclosure sizing and layout
- Option module installing
- Terminal location and torque settings

3.1 Safety information

WARNING

Follow the instructions
The mechanical and electrical installation instructions must be adhered to. Any questions or doubt should be referred to the supplier of the equipment. It is the responsibility of the owner or user to ensure that the installation of the drive and any external option unit, and the way in which they are operated and maintained, comply with the requirements of the Health and Safety at Work Act in the United Kingdom or applicable legislation and regulations and codes of practice in the country in which the equipment is used.

WARNING

Competence of the installer
The drive must be installed by professional assemblers who are familiar with the requirements for safety and EMC. The assembler is responsible for ensuring that the end product or system complies with all the relevant laws in the country where it is to be used.

WARNING

Enclosure
The drive is intended to be mounted in an enclosure which prevents access except by trained and authorized personnel, and which prevents the ingress of contamination. It is designed for use in an environment classified as pollution degree 2 in accordance with IEC 60664-1. This means that only dry, non-conducting contamination is acceptable.

3.2 Planning the installation

The following considerations must be made when planning the installation:

3.2.1 Access

Access must be restricted to authorized personnel only. Safety regulations which apply at the place of use must be complied with.

The IP (Ingress Protection) rating of the drive is installation dependent. For further information, refer to section 3.9 *Enclosing standard drive for high environmental protection* on page 29.

3.2.2 Environmental protection

The drive must be protected from:

- Moisture, including dripping water or spraying water and condensation. An anti-condensation heater may be required, which must be switched off when the drive is running.
- Contamination with electrically conductive material
- Contamination with any form of dust which may restrict the fan, or impair airflow over various components
- Temperature beyond the specified operating and storage ranges
- Corrosive gasses

NOTE

During installation it is recommended that the vents on the drive are covered to prevent debris (e.g. wire off-cuts) from entering the drive.

3.2.3 Cooling

The heat produced by the drive must be removed without its specified operating temperature being exceeded. Note that a sealed enclosure gives much reduced cooling compared with a ventilated one, and may need to be larger and/or use internal air circulating fans.

For further information, refer to section 3.6 *Enclosure for standard drives* on page 27.

3.2.4 Electrical safety

The installation must be safe under normal and fault conditions. Electrical installation instructions are given in Chapter 4 *Electrical installation on page 37*.

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3.2.5 Electromagnetic compatibility

Variable speed drives are powerful electronic circuits which can cause electromagnetic interference if not installed correctly with careful attention to the layout of the wiring.

Some simple routine precautions can prevent disturbance to typical industrial control equipment.

If it is necessary to meet strict emission limits, or if it is known that electromagnetically sensitive equipment is located nearby, then full precautions must be observed. In-built into the drive, is an internal EMC filter, which reduces emissions under certain conditions. If these conditions are exceeded, then the use of an external EMC filter may be required at the drive inputs, which must be located very close to the drives. Space must be made available for the filters and allowance made for carefully segregated wiring. Both levels of precautions are covered in section 4.6 *EMC (Electromagnetic compatibility) on page 43*.

3.2.6 Hazardous areas

The drive must not be located in a classified hazardous area unless it is installed in an approved enclosure and the installation is certified.

3.3 Terminal cover removal

WARNING

Isolation device

The AC and / or DC power supply must be disconnected from the drive using an approved isolation device before any cover is removed from the drive or before any servicing work is performed.

WARNING

Stored charge

The drive contains capacitors that remain charged to a potentially lethal voltage after the AC and / or DC power supply has been disconnected. If the drive has been energized, the power supply must be isolated at least ten minutes before work may continue.

Normally, the capacitors are discharged by an internal resistor. Under certain, unusual fault conditions, it is possible that the capacitors may fail to discharge, or be prevented from being discharged by a voltage applied to the output terminals. If the drive has failed in a manner that causes the display to go blank immediately, it is possible the capacitors will not be discharged. In this case, consult Control Techniques or their authorized distributor.

3.3.1 Removing the terminal covers

Figure 3-1 Location and identification of terminal covers

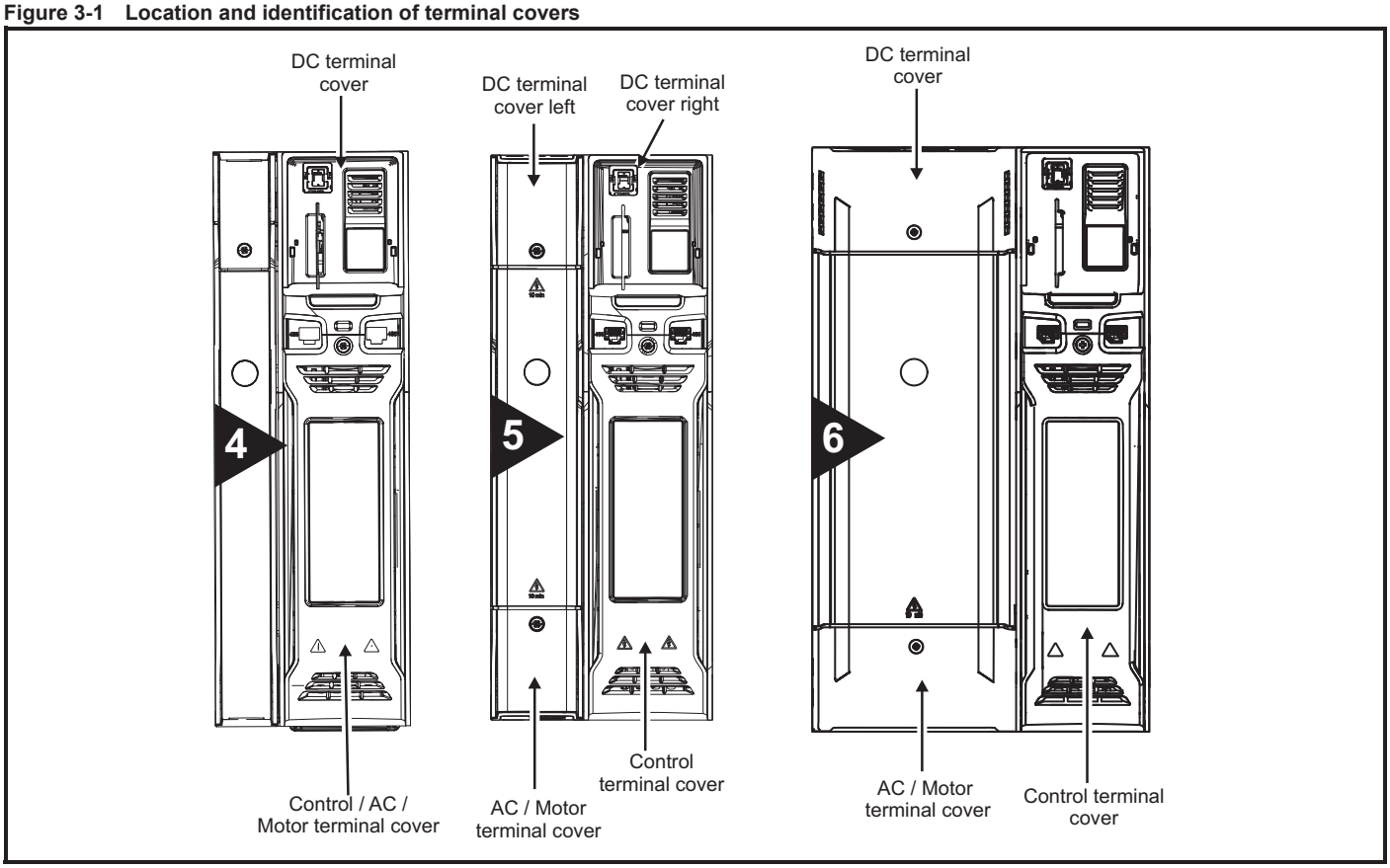

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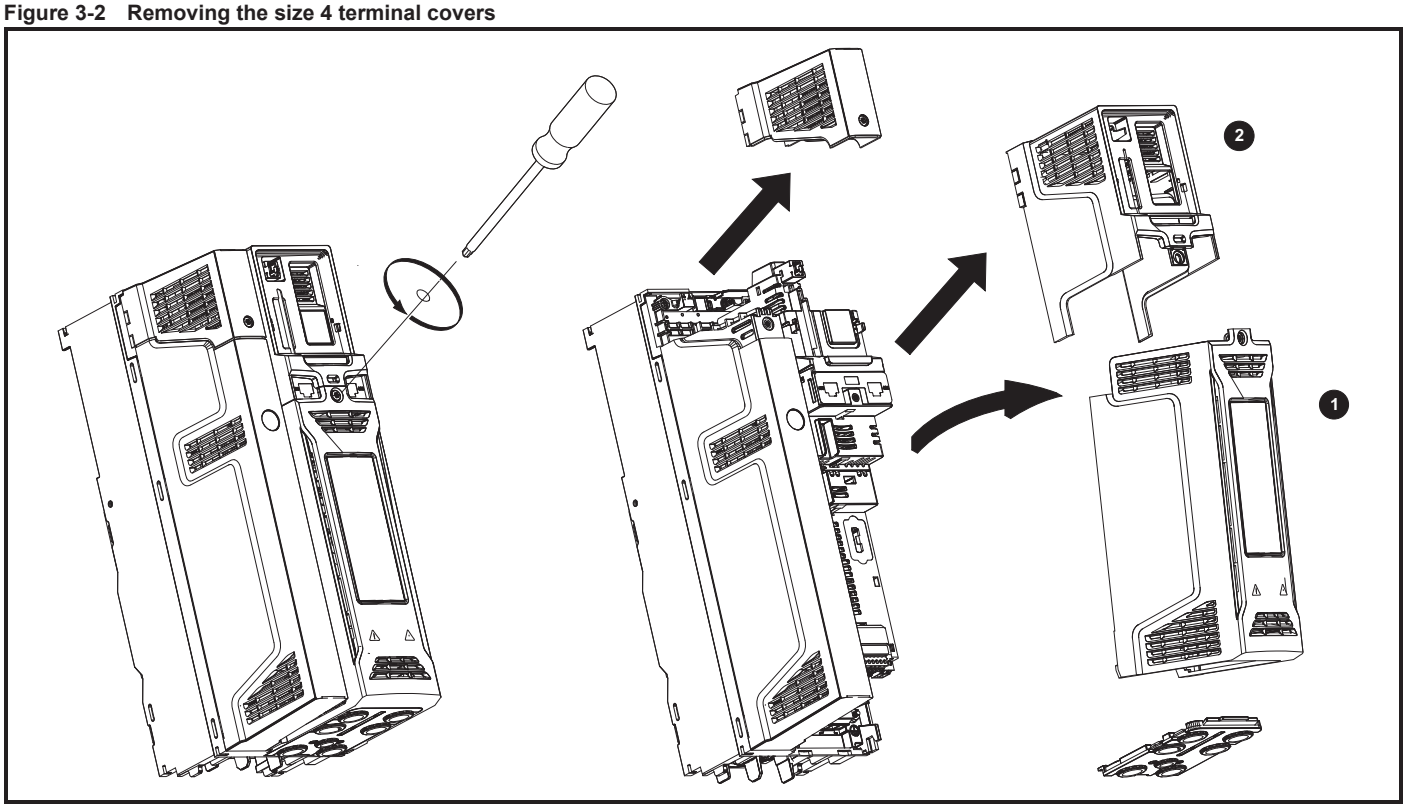
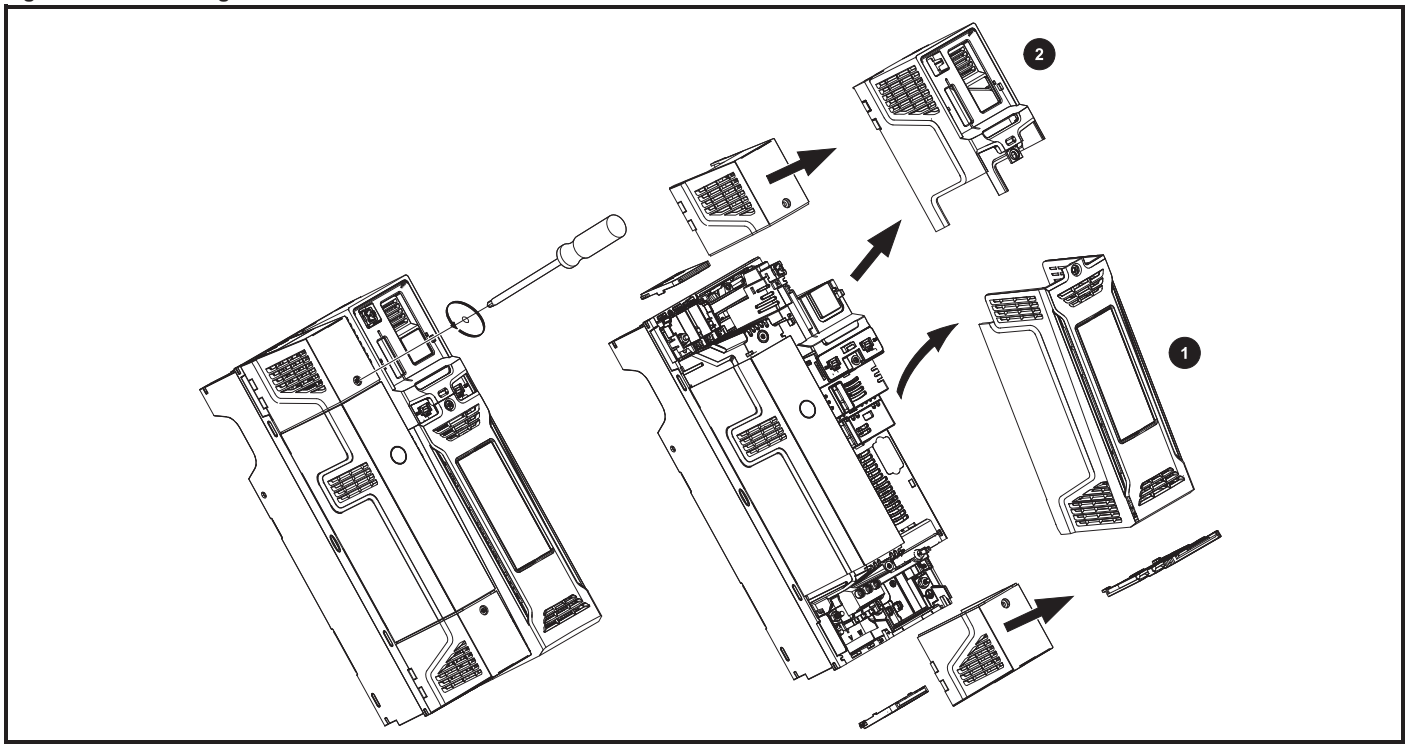
Figure 3-2 Removing the size 4 terminal covers



1. Control / AC / Motor terminal cover
2. DC terminal cover

On size 4 drives, the Control / AC / Motor terminal cover must be removed before removal of the DC terminal cover. When replacing the terminal covers, the screws should be tightened to a maximum torque of 1 N m (0.7 lb ft).

Figure 3-3 Removing the size 5 terminal covers



1. Control terminal cover
2. DC terminal cover right

On size 5 drives, the Control terminal cover must be removed before removal of the DC terminal cover right. When replacing the terminal covers the screws should be tightened to a maximum torque of 1 N m (0.7 lb ft).

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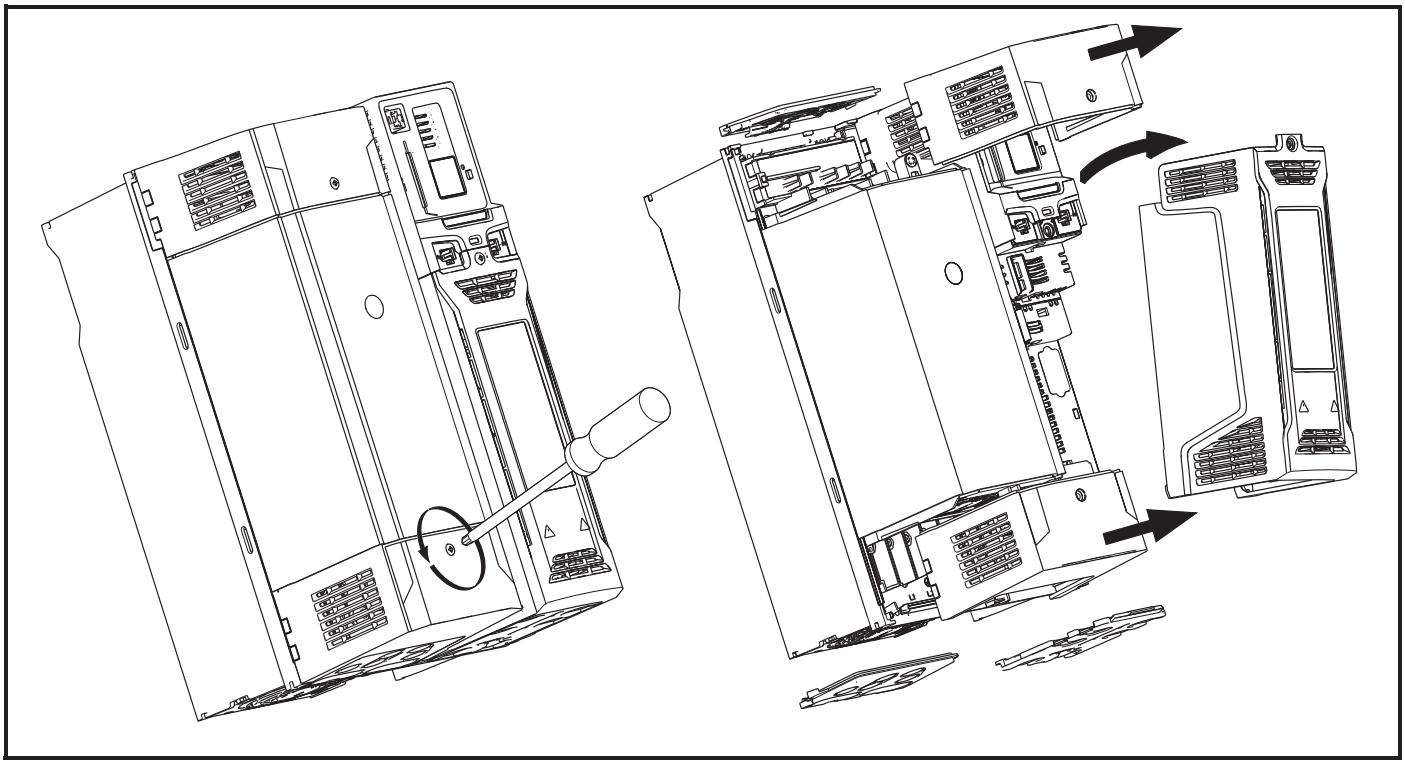
Figure 3-4 Removing the size 6 terminal covers



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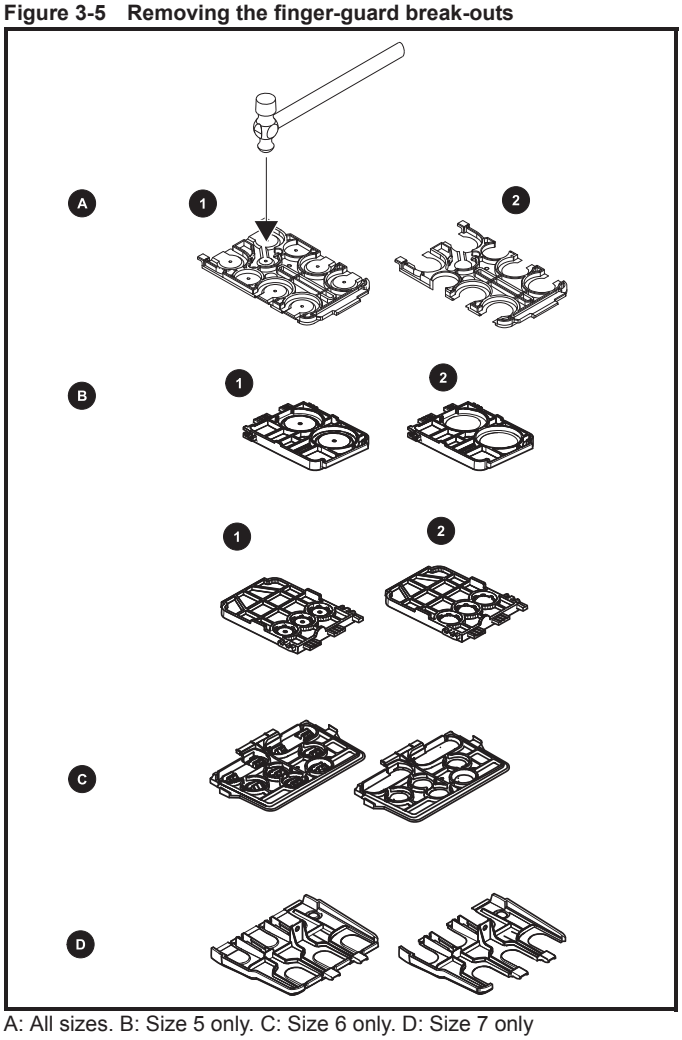
3.3.2 Removing the finger-guard and DC terminal cover break-outs

Figure 3-5 Removing the finger-guard break-outs



A: All sizes. B: Size 5 only. C: Size 6 only. D: Size 7 only

Place finger-guard on a flat solid surface and hit relevant break-outs with hammer as shown (1). Continue until all required break-outs are removed (2). Remove any flash / sharp edges once the break-outs are removed.

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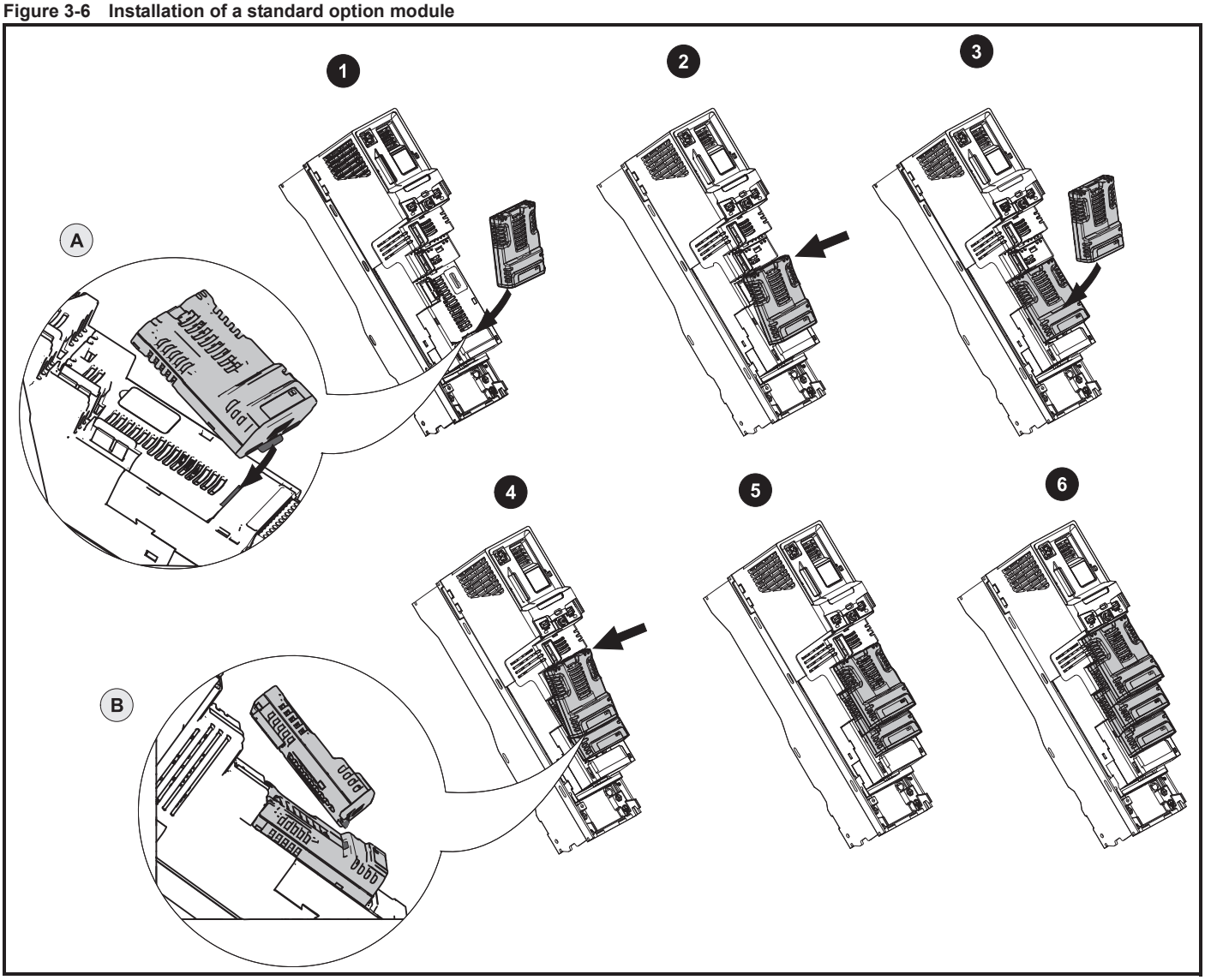
3.4 Installing / removing option modules and keypads

CAUTION

Power down the drive before installing / removing the option module. Failure to do so may result in damage to the product.

Figure 3-6 Installation of a standard option module



Installing the first option module

NOTE

Option module slots must be used in the following order: slot 3, slot 2 and slot 1 (refer to Figure 2-3 *Features of the drive* on page 12 for slot numbers).

- Move the option module in direction shown (1).
- Align and insert the option module tab in to the slot provided (2), this is highlighted in the detailed view (A).
- Press down on the option module until it clicks into place.

Installing the second option module

- Move the option module in direction shown (3).
- Align and insert the option module tab in to the slot provided on the already installed option module (4), this is highlighted in the detailed view (B).
- Press down on the option module until it clicks into place. Image (5) shows two option modules fully installed.

Installing the third option module

- Repeat the above process.

The drive has the facility for all three option module slots to be used at the same time, image (6) shows the three option modules installed.

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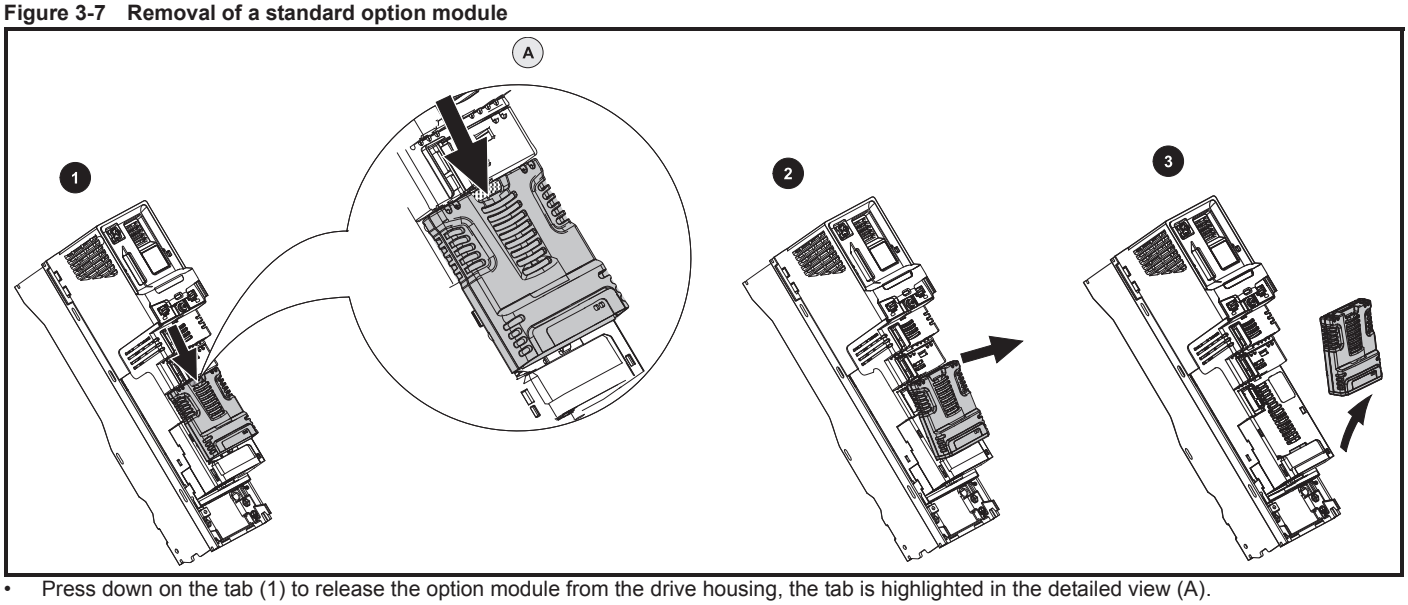
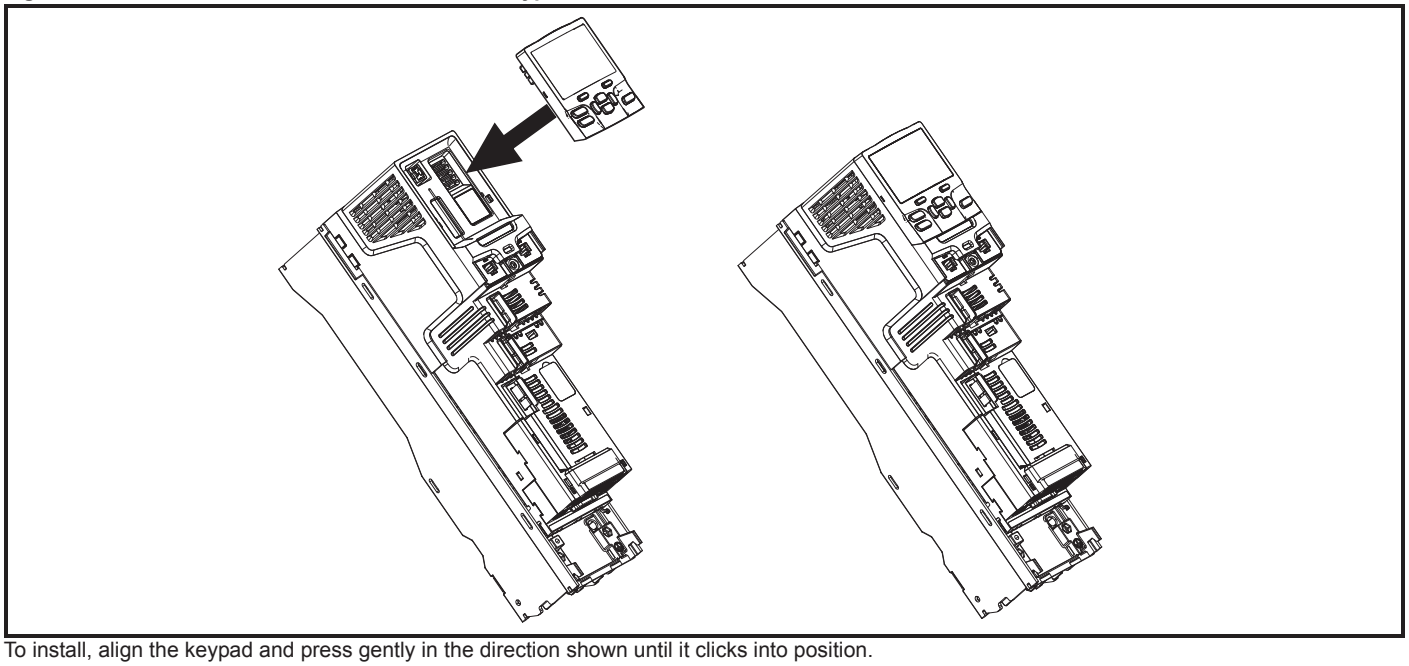
Figure 3-7 Removal of a standard option module



- Press down on the tab (1) to release the option module from the drive housing, the tab is highlighted in the detailed view (A).
- Tilt the option module towards you as shown (2).
- Totally remove the option module in direction shown (3).

Figure 3-8 Installation and removal of the HOA-Keypad



To install, align the keypad and press gently in the direction shown until it clicks into position.

To remove, reverse the installation instructions.

NOTE

The keypad can be installed / removed while the drive is powered up and running a motor, providing that the drive is not operating in keypad mode.

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3.5 Dimensions and mounting methods

The drive can be either surface or through-panel mounted using the appropriate brackets. The following drawings show the dimensions of the drive and mounting holes for each method to allow a back plate to be prepared.

The Through-panel mounting kit is not supplied with the drive and can be purchased separately, below are the relevant part numbers:

Size	CT part number
4	3470-0056
5	3470-0067
6	3470-0055

WARNING

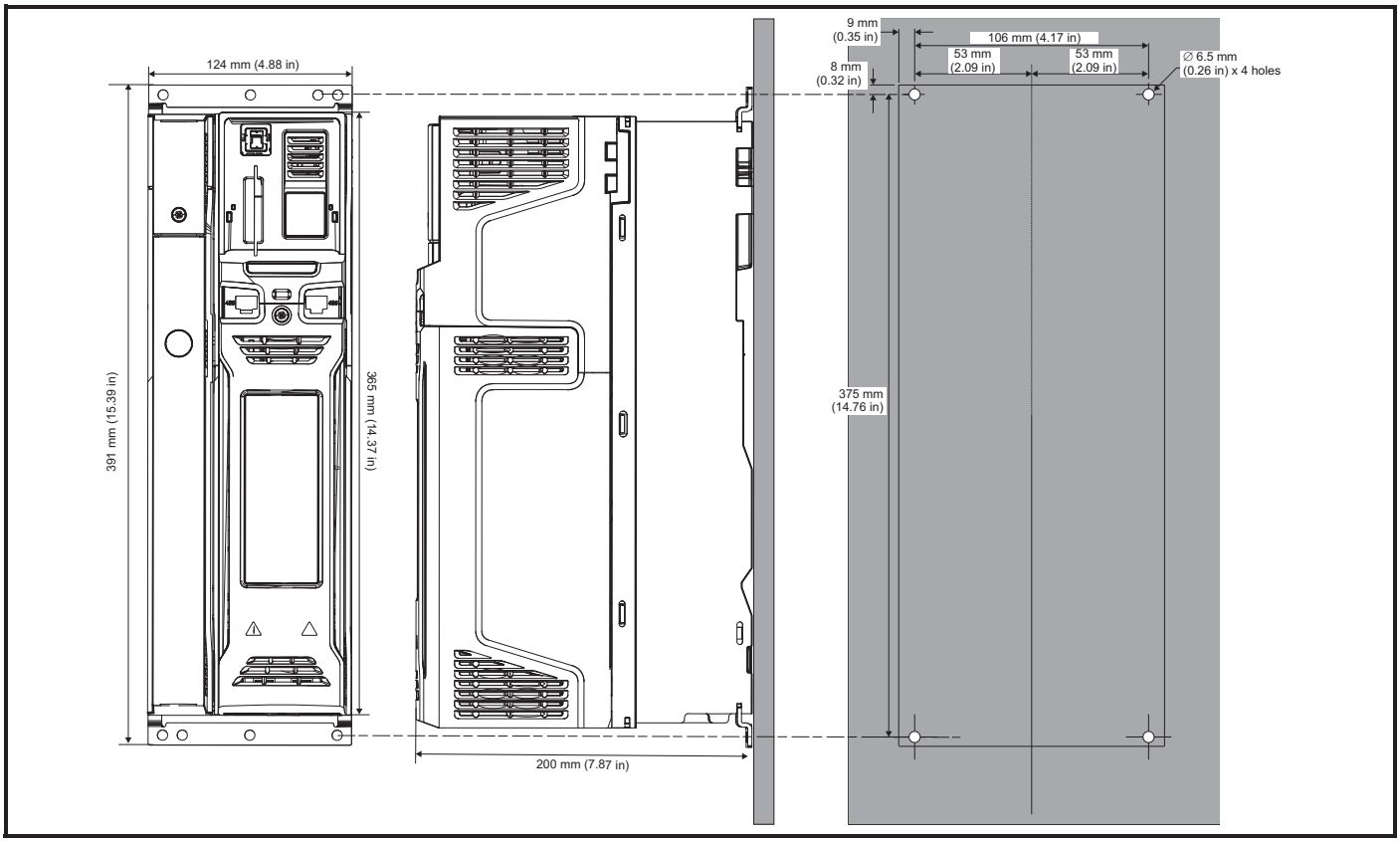
If the drive has been used at high load levels for a period of time, the heatsink can reach temperatures in excess of 70 °C (158 °F). Human contact with the heatsink should be prevented.

WARNING

Many of the drives in this product range weigh in excess of 15 kg (33 lb). Use appropriate safeguards when lifting these models. A full list of drive weights can be found in section 11.1.19 *Weights* on page 104.

3.5.1 Surface mounting

Figure 3-9 Surface mounting the size 4 drive



NOTE

The outer holes in the mounting bracket are to be used for surface mounting. See Table 3-1 for further information.

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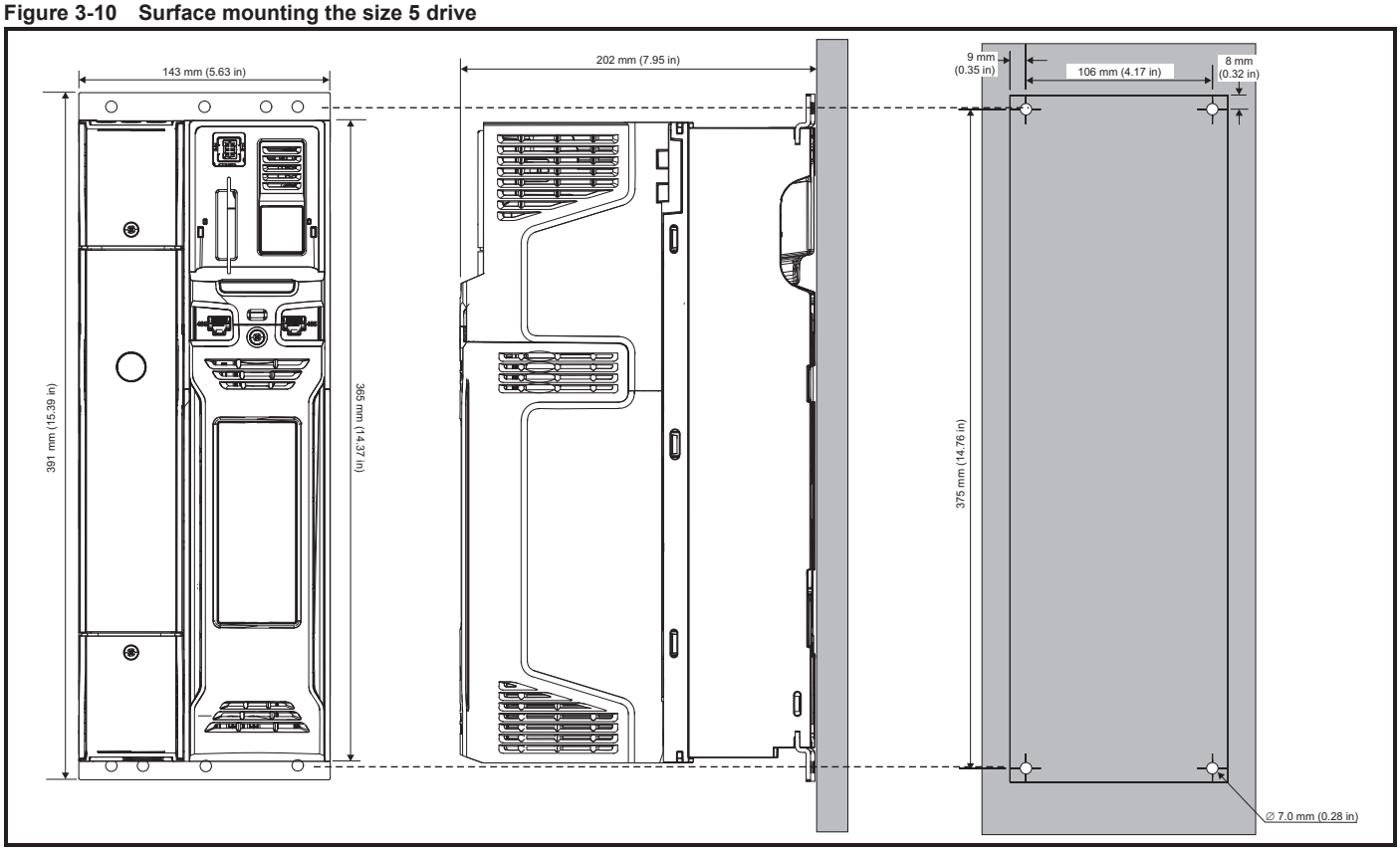
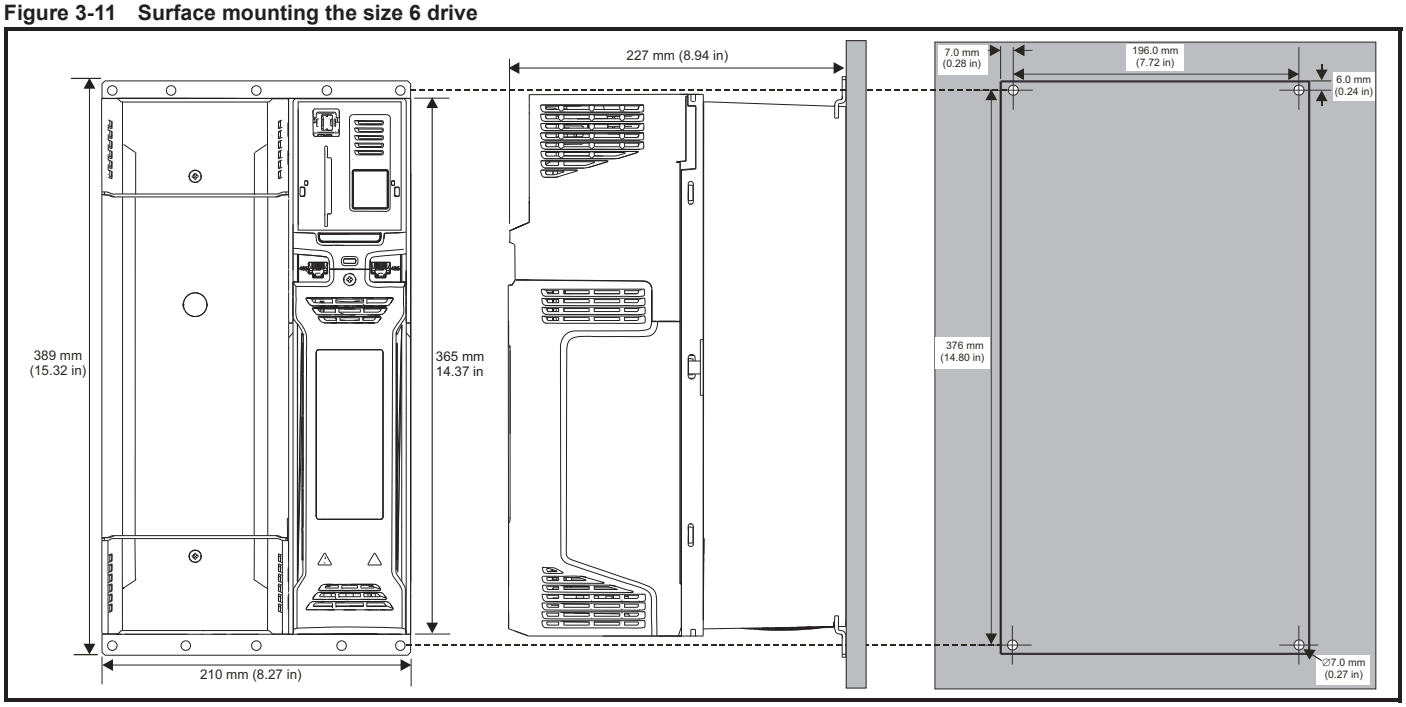
Figure 3-10 Surface mounting the size 5 drive



NOTE

The outer holes in the mounting bracket are to be used for surface mounting. See Table 3-1 for further information.

Figure 3-11 Surface mounting the size 6 drive



NOTE

The outer holes in the mounting bracket are to be used for surface mounting. See Table 3-1 for further information.

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3.5.2 Through-panel mounting

Figure 3-12 Through panel mounting the size 4 drive

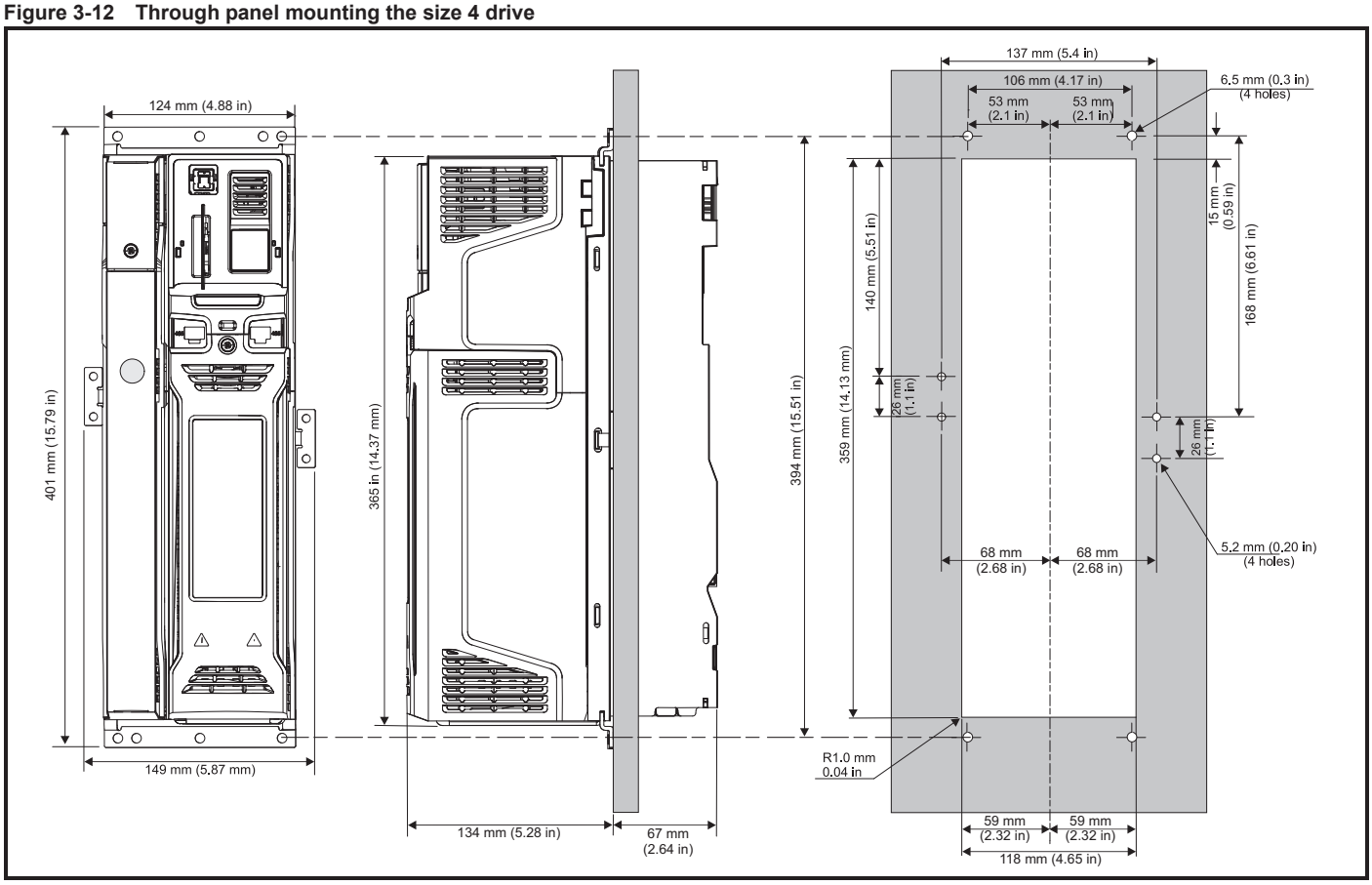

Figure 3-13 Through panel mounting the size 5 drive

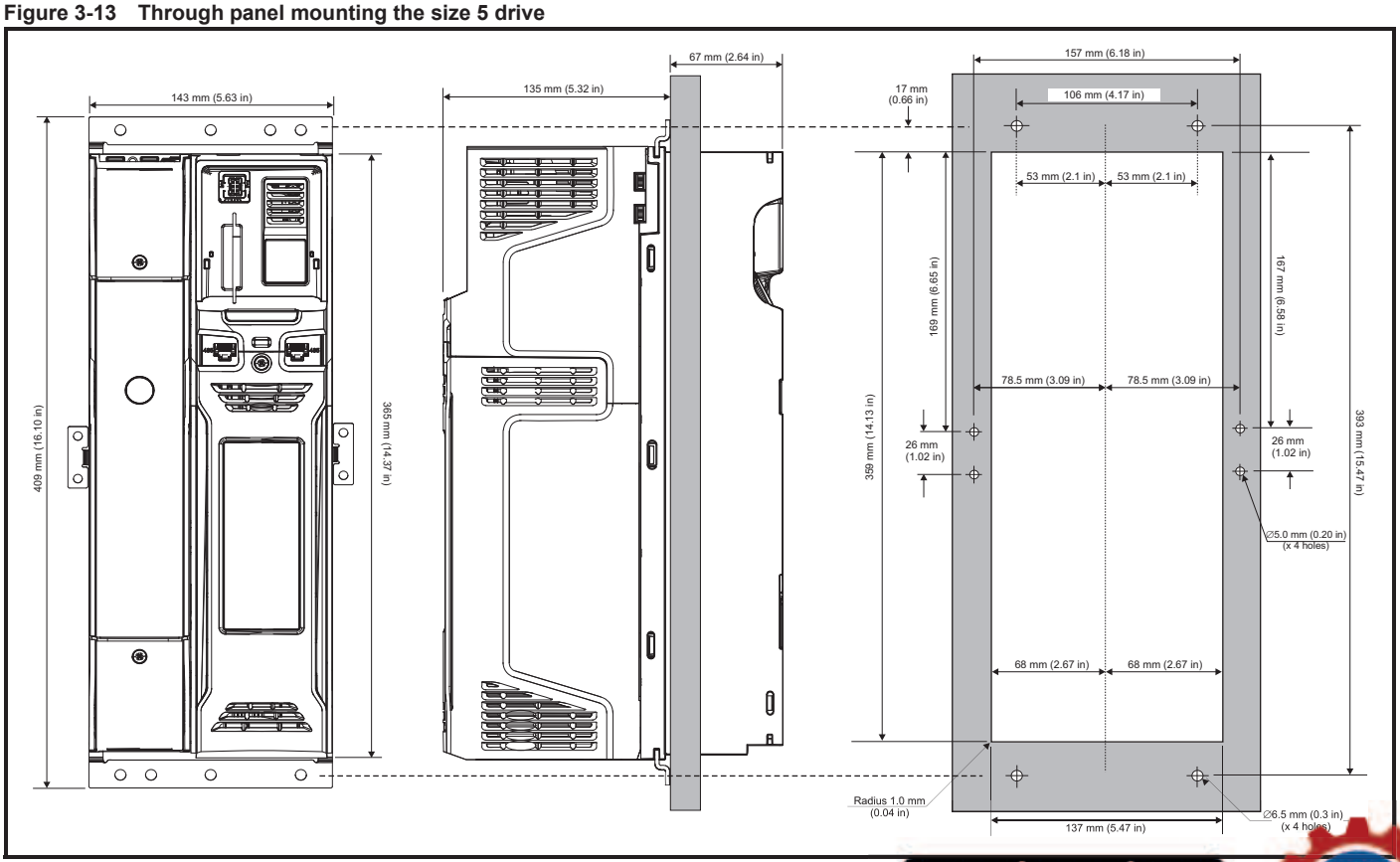

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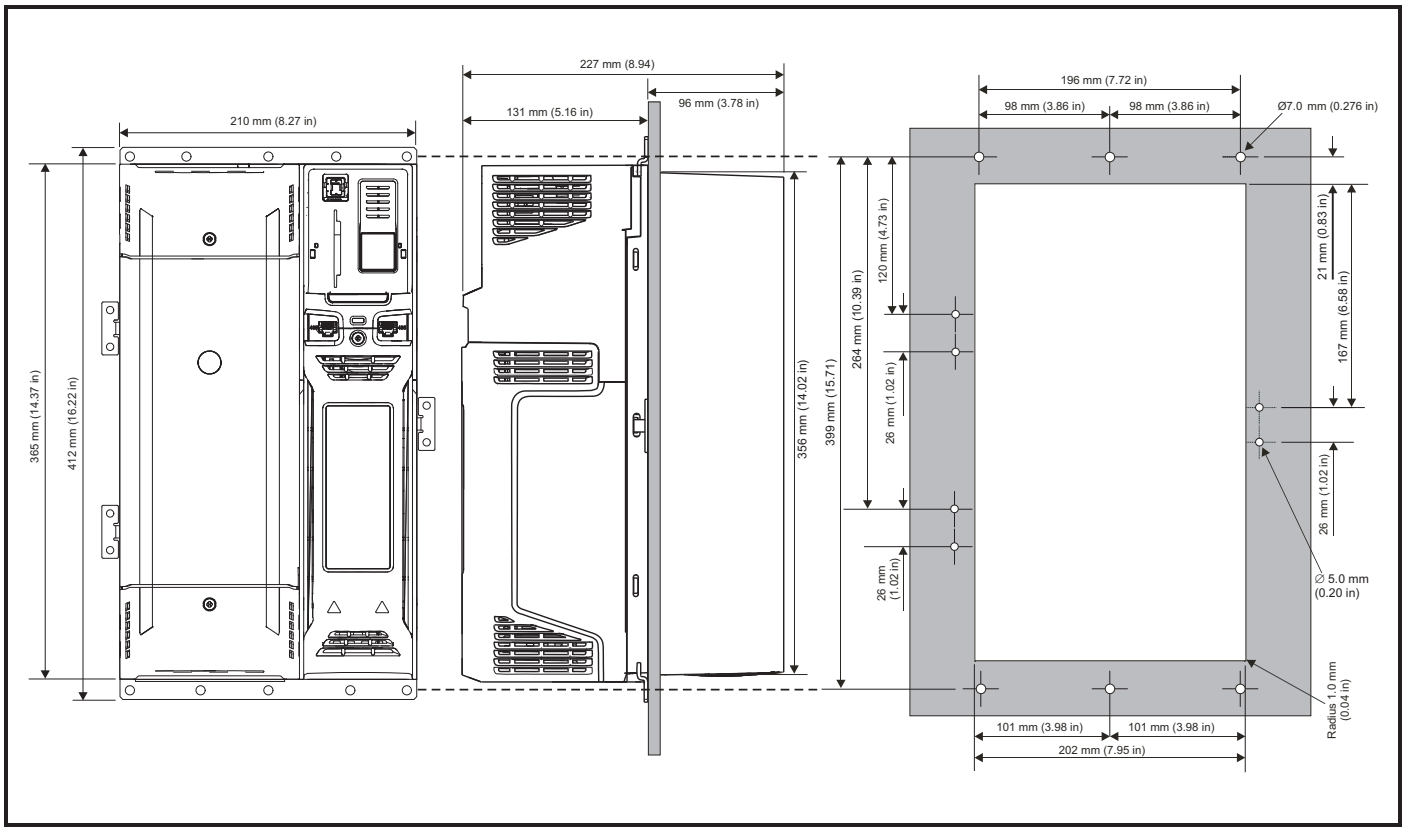
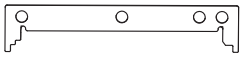
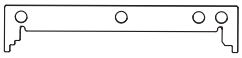
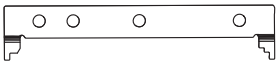
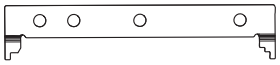
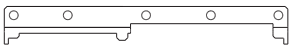
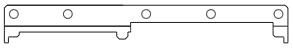
Figure 3-14 Through panel mounting the size 6 drive



NOTE

The outer holes plus the hole located in the center of the bracket are to be used for through panel mounting.

Table 3-1 Mounting brackets

Frame size	Surface	Qty	Through-panel	Qty
4	 Hole size: 6.5 mm (0.26 in)	x 2	 Hole size: 5.2 mm (0.21 in)	x 3
			 Hole size: 6.5 mm (0.26 in)	x 2
5	 Hole size: 6.5 mm (0.26 in)	x 2	 Hole size: 5.2 mm (0.21 in)	x 2
			 Hole size: 6.5 mm (0.26 in)	x 2
6	 Hole size: 6.5 mm (0.26 in)	x 2	 Hole size: 5.2 mm (0.21 in)	x 3
			 Hole size: 6.5 mm (0.26 in)	x 2

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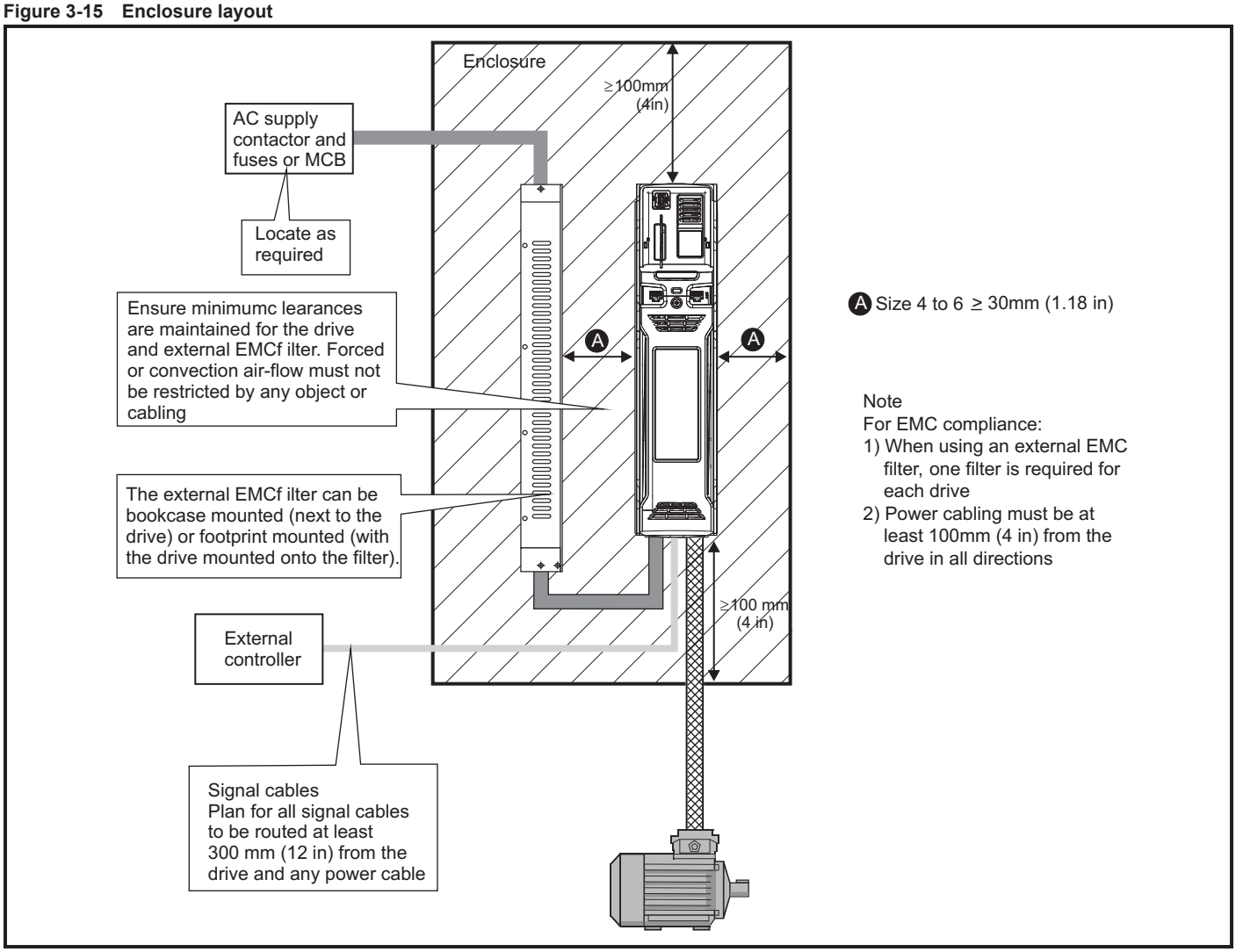
3.6 Enclosure for standard drives

3.6.1 Enclosure layout

Please observe the clearances in the diagram below taking into account any appropriate notes for other devices / auxiliary equipment when planning the installation.

Figure 3-15 Enclosure layout



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3.6.2 Enclosure sizing

1. Add the dissipation figures from section on page 102 for each drive that is to be installed in the enclosure.
2. If an external EMC filter is to be used with each drive, add the dissipation figures from section 11.2.1 *EMC filter ratings* on page 110 for each external EMC filter that is to be installed in the enclosure.
3. If the braking resistor is to be mounted inside the enclosure, add the average power figures from for each braking resistor that is to be installed in the enclosure.
4. Calculate the total heat dissipation (in Watts) of any other equipment to be installed in the enclosure.
5. Add the heat dissipation figures obtained above. This gives a figure in Watts for the total heat that will be dissipated inside the enclosure.

Calculating the size of a sealed enclosure

The enclosure transfers internally generated heat into the surrounding air by natural convection (or external forced air flow); the greater the surface area of the enclosure walls, the better is the dissipation capability. Only the surfaces of the enclosure that are unobstructed (not in contact with a wall or floor) can dissipate heat.

Calculate the minimum required unobstructed surface area $\mathbf{A_e}$ for the enclosure from:

$$\mathbf{A_e} = \frac{\mathbf{P}}{\mathbf{k}(\mathbf{T_{int}} - \mathbf{T_{ext}})}$$

Where:

$\mathbf{A_e}$	Unobstructed surface area in m^2 (1 m^2 = 10.9 ft^2)
$\mathbf{T_{ext}}$	Maximum expected temperature in ^oC *outside* the enclosure
$\mathbf{T_{int}}$	Maximum permissible temperature in ^oC *inside* the enclosure
P	Power in Watts dissipated by *all* heat sources in the enclosure
k	Heat transmission coefficient of the enclosure material in $W/m^2/^oC$

Example

To calculate the size of an enclosure for the following:

- Two drives operating at the Normal Duty rating
- External EMC filter for each drive
- Braking resistors are to be mounted outside the enclosure
- Maximum ambient temperature inside the enclosure: 40°C
- Maximum ambient temperature outside the enclosure: 30°C

For example, if the power dissipation from each drive is 187 W and the power dissipation from each external EMC filter is 9.2 W.

Total dissipation: 2 x (187 + 9.2) =392.4 W

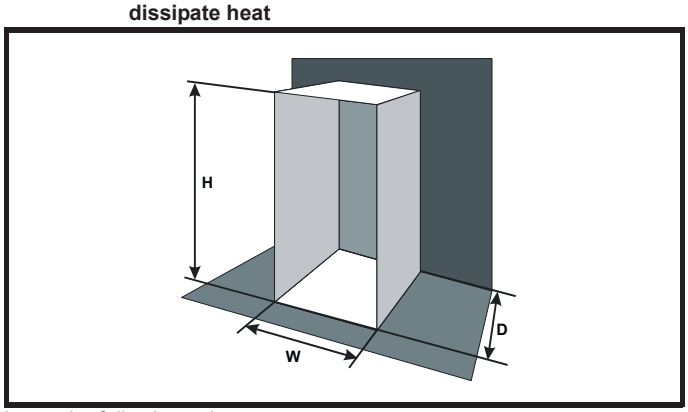
NOTE

Power dissipation for the drives and the external EMC filters can be obtained from Chapter 11 *Technical data* on page 102.

The enclosure is to be made from painted 2 mm (0.079 in) sheet steel having a heat transmission coefficient of 5.5 $W/m^2/^oC$. Only the top, front, and two sides of the enclosure are free to dissipate heat.

The value of 5.5 $W/m^2/^oC$ can generally be used with a sheet steel enclosure (exact values can be obtained by the supplier of the material). If in any doubt, allow for a greater margin in the temperature rise.

Figure 3-16 Enclosure having front, sides and top panels free to dissipate heat



Insert the following values:

$\mathbf{T_{int}}$	40 °C
$\mathbf{T_{ext}}$	30 °C
k	5.5
P	392.4 W

The minimum required heat conducting area is then:

$$\mathbf{A_e} = \frac{\mathbf{392.4}}{\mathbf{5.5(40-30)}}$$

$\mathbf{= 7.135\ m^2\ (77.8\ ft^2)}$ (1 m^2 = 10.9 ft^2)

Estimate two of the enclosure dimensions - the height (H) and depth (D), for instance. Calculate the width (W) from:

$$\mathbf{W} = \frac{\mathbf{A_e - 2HD}}{\mathbf{H + D}}$$

Inserting **H** = 2m and **D** = 0.6 m, obtain the minimum width:

$$\mathbf{W} = \frac{\mathbf{7.135 - (2 \times 2 \times 0.6)}}{\mathbf{2 + 0.6}}$$

=1.821 m (71.7 in)

If the enclosure is too large for the space available, it can be made smaller only by attending to one or all of the following:

- Using a lower PWM switching frequency to reduce the dissipation in the drives
- Reducing the ambient temperature outside the enclosure, and/or applying forced-air cooling to the outside of the enclosure
- Reducing the number of drives in the enclosure
- Removing other heat-generating equipment

Calculating the air-flow in a ventilated enclosure

The dimensions of the enclosure are required only for accommodating the equipment. The equipment is cooled by the forced air flow.

Calculate the minimum required volume of ventilating air from:

$$\mathbf{V} = \frac{\mathbf{3kP}}{\mathbf{T_{int} - T_{ext}}}$$

Where:

V	Air-flow in m^3 per hour (1 m^3/hr = 0.59 ft^3/min)
$\mathbf{T_{ext}}$	Maximum expected temperature in °C *outside* the enclosure
$\mathbf{T_{int}}$	Maximum permissible temperature in °C *inside* the enclosure
P	Power in Watts dissipated by *all* heat sources in the enclosure
k	Ratio of $\frac{\mathbf{P_o}}{\mathbf{P_l}}$

Where:

$\mathbf{P_0}$ is the air pressure at sea level

$\mathbf{P_l}$ is the air pressure at the installation

Typically use a factor of 1.2 to 1.3, to allow also for pressure-drops in dirty air-filters.

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Example

To calculate the size of an enclosure for the following:

- Three drives operating at the Normal Duty rating
- External EMC filter for each drive
- Braking resistors are to be mounted outside the enclosure
- Maximum ambient temperature inside the enclosure: 40 °C
- Maximum ambient temperature outside the enclosure: 30 °C

For example, dissipation of each drive: 101 W and dissipation of each external EMC filter: 6.9 W (max).

Total dissipation: 3 x (101 + 6.9) = 323.7 W

Insert the following values:

T_{int} 40 °C
T_{ext} 30 °C
k 1.3
P 323.7 W

Then:

$$V = \frac{3 \times 1.3 \times 323.7}{40 - 30}$$

= 126.2 m^3/hr (74.5 ft^3 /min) (1 m^3/ hr = 0.59 ft^3/min)

3.7 Enclosure design and drive ambient temperature

Drive derating is required for operation in high ambient temperatures

Totally enclosing or through panel mounting the drive in either a sealed cabinet (no airflow) or in a well ventilated cabinet makes a significant difference on drive cooling.

The chosen method affects the ambient temperature value (T_{rate}) which should be used for any necessary derating to ensure sufficient cooling for the whole of the drive.

The ambient temperature for the four different combinations is defined below:

1. Totally enclosed with no air flow (<2 m/s) over the drive
   T_{rate} = T_{int} + 5 °C
2. Totally enclosed with air flow (>2 m/s) over the drive
   T_{rate} = T_{int}
3. Through panel mounted with no airflow (<2 m/s) over the drive
   T_{rate} = the greater of T_{ext} +5 °C, or T_{int}
4. Through panel mounted with air flow (>2 m/s) over the drive
   T_{rate} = the greater of T_{ext} or T_{int}

Where:

T_{ext} = Temperature outside the cabinet
T_{int} = Temperature inside the cabinet
T_{rate} = Temperature used to select current rating from tables in Chapter 11 *Technical data* on page 102.

3.8 Heatsink fan operation

The drive is ventilated by an internal heatsink mounted fan. The fan housing forms a baffle plate, channelling the air through the heatsink chamber. Thus, regardless of mounting method (surface mounting or through-panel mounting), the installing of additional baffle plates is not required.

Ensure the minimum clearances around the drive are maintained to allow air to flow freely.

The heatsink fan on all sizes is a variable speed fan. The drive controls the speed at which the fan runs based on the temperature of the heatsink and the drive's thermal model system. The maximum speed at which the fan operates can be limited in Pr **06.045**. This could incur an output current derating. Refer to section 3.12.2 *Fan removal procedure* on page 35 for information on fan removal. The size 6 and 7 is also installed with a variable speed fan to ventilate the capacitor bank.

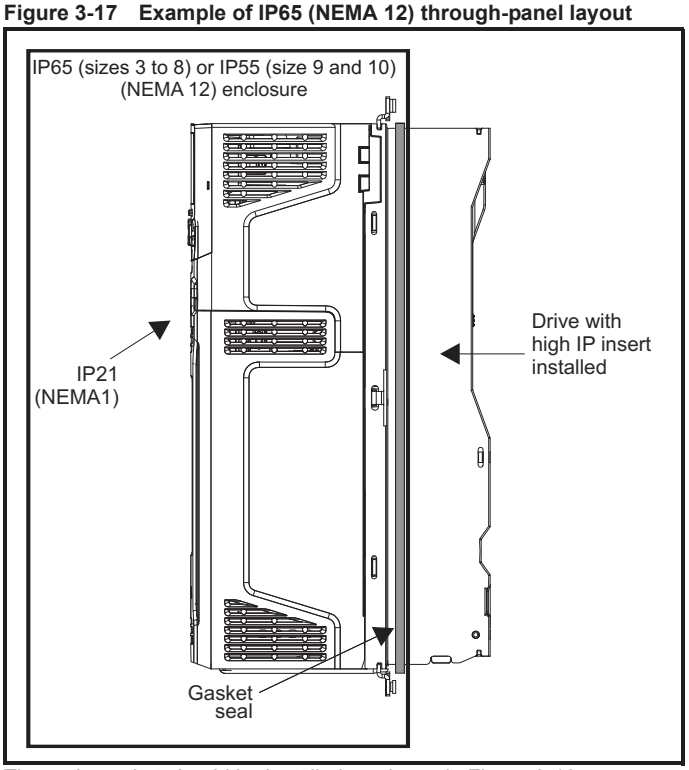
3.9 Enclosing standard drive for high environmental protection

An explanation of environmental protection rating is provided in section 11.1.9 *IP / UL Rating* on page 103.

The standard drive is rated to IP21 pollution degree 2 (dry, non-conductive contamination only) (NEMA 1). However, it is possible to configure the drive to achieve IP65 rating (NEMA 12) at the rear of the heatsink for through-panel mounting (some current derating is required). Refer to Table on page 102.

This allows the front of the drive, along with various switchgear, to be housed in a high IP enclosure with the heatsink protruding through the panel to the external environment. Thus, the majority of the heat generated by the drive is dissipated outside the enclosure maintaining a reduced temperature inside the enclosure. This also relies on a good seal being made between the heatsink and the rear of the enclosure using the gaskets provided.

Figure 3-17 Example of IP65 (NEMA 12) through-panel layout



The main gasket should be installed as shown in Figure 3-18.

On drive sizes 4 and 5, in order to achieve the high IP rating at the rear of the heatsink it is necessary to seal a heatsink vent by installing the high IP insert as shown in Figure 3-20 and Figure 3-21.

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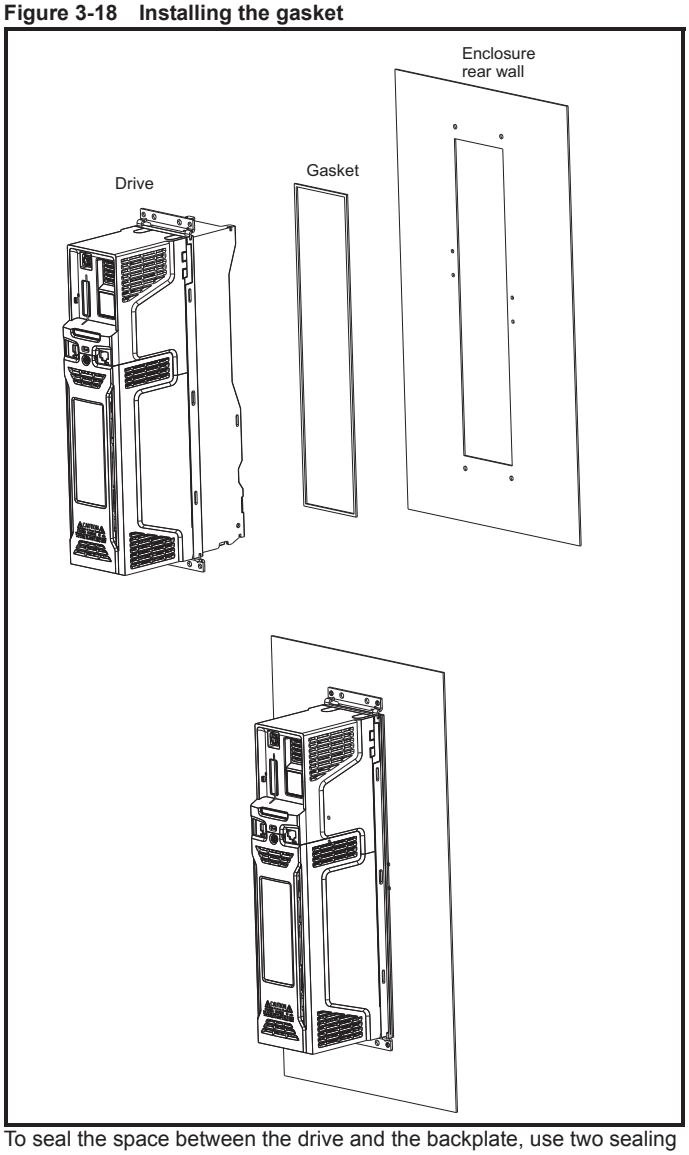
Figure 3-18 Installing the gasket



To seal the space between the drive and the backplate, use two sealing brackets as shown in Figure 3-19. The sealing brackets are included in the accessories kitbox supplied with the drive.

Figure 3-19 Through panel mounting

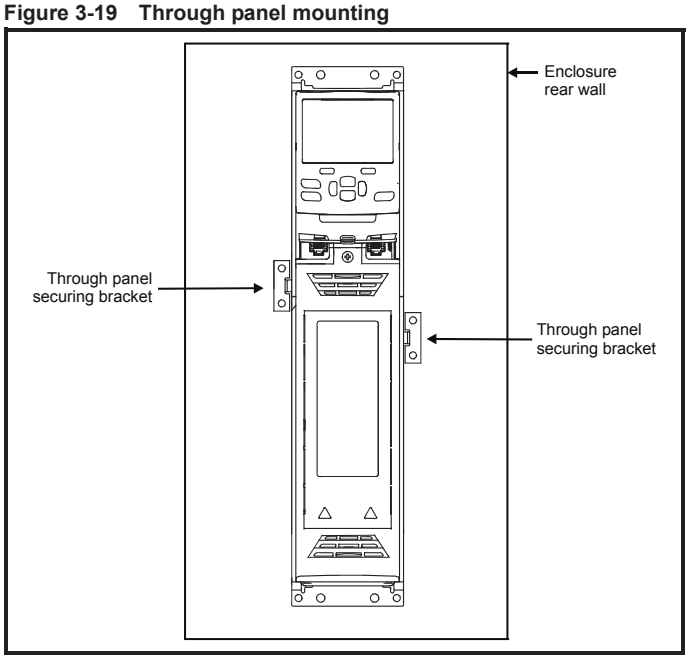
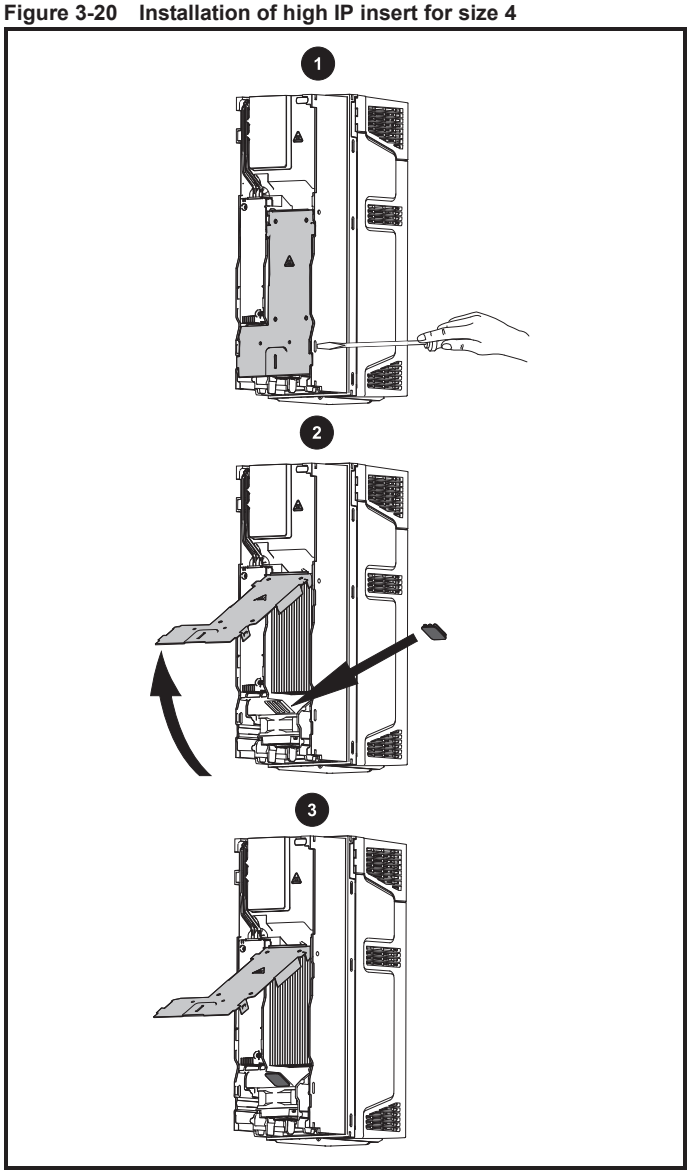


Figure 3-20 Installation of high IP insert for size 4



1. To install the high IP insert, firstly place a flat head screwdriver into the slot highlighted (1).
2. Pull the hinged baffle up to expose the ventilation hole, install the high IP insert into the ventilation hole in the heatsink (2).
3. Ensure the high IP insert is securely installed by firmly pressing it into place (3).
4. Close the hinged baffle as shown (1).

To remove the high IP insert, reverse the above instructions.

The guidelines in Table 3-2 should be followed.

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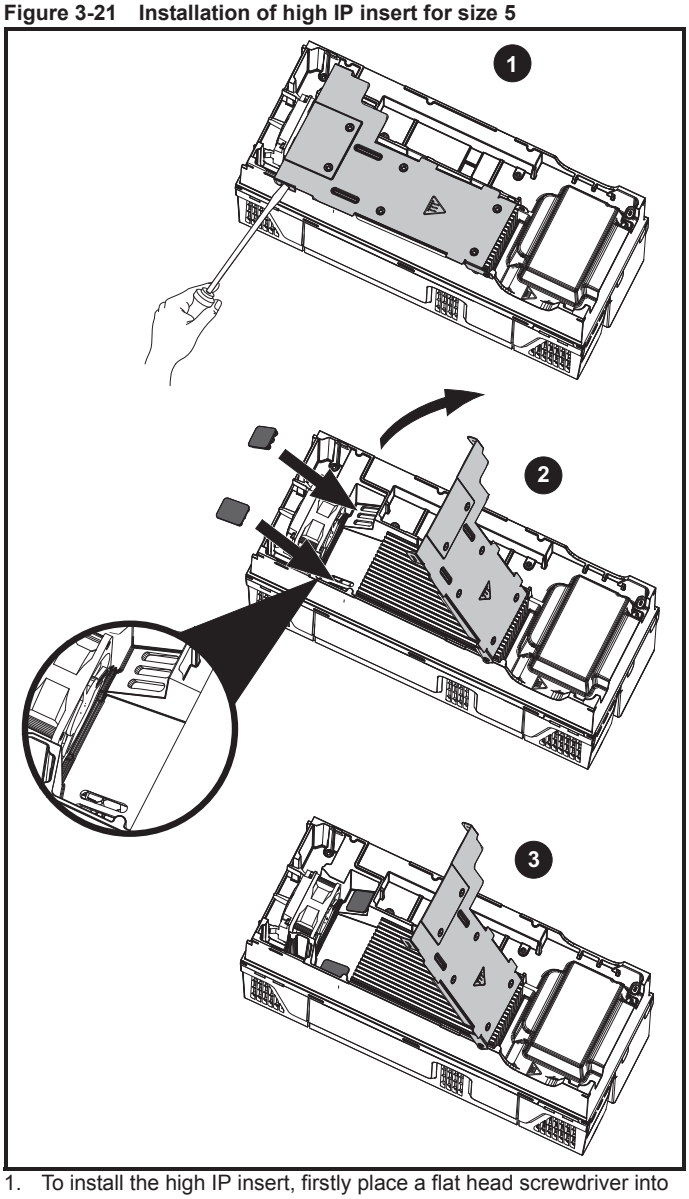
Figure 3-21 Installation of high IP insert for size 5



1. To install the high IP insert, firstly place a flat head screwdriver into the slot highlighted (1).
2. Pull the hinged baffle up to expose the ventilation holes, install the high IP inserts into the ventilation holes in the heatsink (2).
3. Ensure the high IP inserts are securely installed by firmly pressing them into place (3).
4. Close the hinged baffle as shown (1).

To remove the high IP insert, reverse the above instructions.

Table 3-2 Environment considerations

Environment	High IP insert	Comments
Clean	Not installed	
Dry, dusty (non-conductive)	Installed	Regular cleaning recommended
Dry, dusty (conductive)	Installed	
IP65 compliance	Installed	

NOTE

A current derating must be applied to the drive if the high IP insert is installed. Derating information is provided in section 11.1.1 *Power and current ratings* on page 102.

Failure to do so may result in nuisance tripping.

When designing an IP65 (NEMA 12) enclosure (Figure 3-17 *Example of IP65 (NEMA 12) through-panel layout* on page 29), consideration should be made to the dissipation from the front of the drive.

Table 3-3 Power losses from the front of the drive when through-panel mounted

Frame size	Power loss
4	≤75 W
5	≤100 W
6	≤100 W

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3.10 External EMC filter

The external EMC filter details for each drive rating are provided in the table below

Table 3-4 External EMC filter data

Model	CT part number	Weight	
		kg	lb
200 V			
06200500 to 06200580	4200-2300	6.5	14.3
400 V			
04400240	4200-0252	4.1	9.04
05400300	4200-0402	5.5	12.13
06400380	4200-4800	6.7	14.8
575 V			
06500220 to 06500270	4200-3690	7.0	15.4

The external EMC filters for size 4, 5 and 6 can be footprint or bookcase mounted, see Figure 3-22 and Figure 3-23.

Mount the external EMC filter following the guidelines in section 4.6.5 *Compliance with generic emission standards* on page 48.

Figure 3-22 Footprint mounting the EMC filter

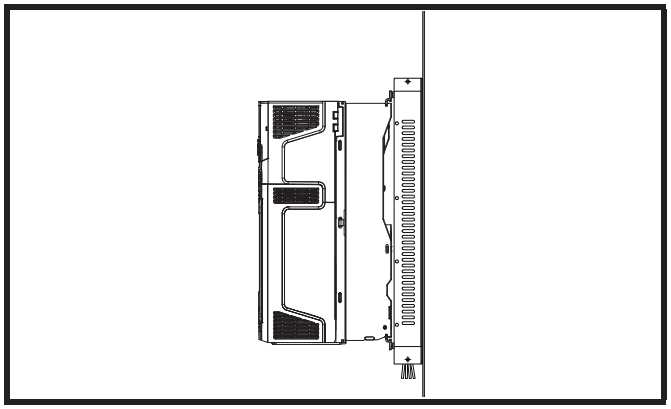


Figure 3-23 Bookcase mounting the EMC filter

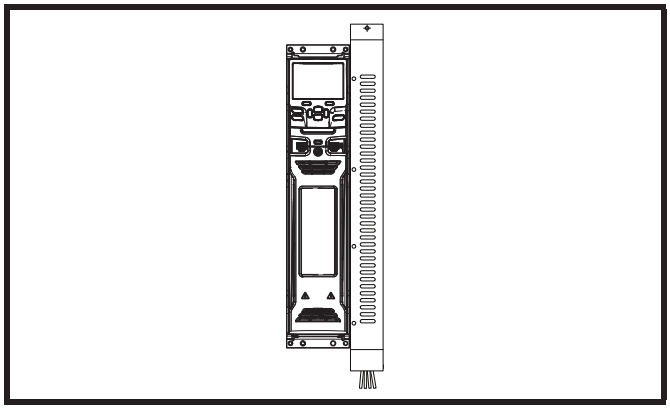
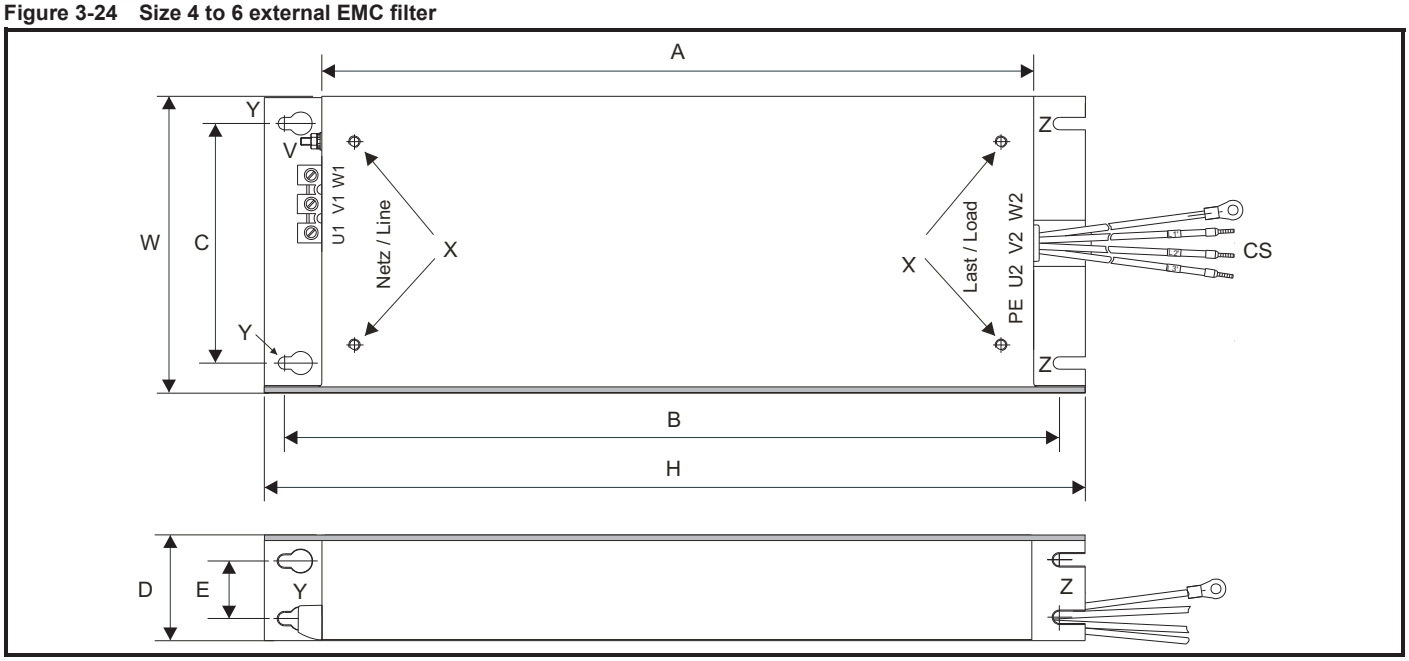


Figure 3-24 Size 4 to 6 external EMC filter



V: Ground stud

X: Threaded holes for footprint mounting of the drive

Y: Footprint mounting hole diameter

Z: Bookcase mounting slot diameter.

CS: Cable size

Table 3-5 Size 4 external EMC filter dimensions

CT part number	A	B	C	D	E	H	W	V	X	Y	Z	CS
4200-0252	395 mm (15.55 in)	425 mm (16.73 in)	100 mm (3.94 in)	60 mm (2.36 in)	33 mm (1.30 in)	437 mm (17.2 in)	123 mm (4.84 in)			6.5 mm	6.5 mm	6 mm (10

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Table 3-6 Size 5 external EMC filter dimensions

CT part number	A	B	C	D	E	H	W	V	X	Y	Z	CS
4200-0402	395 mm (15.55 in)	425 mm (16.73 in)	106 mm (4.17 in)	60 mm (2.36 in)	33 mm (1.30 in)	437 mm (17.2 in)	143 mm (5.63 in)	M6	M6	6.5 mm (0.26 in)	6.5 mm (0.26 in)	10 mm^2 (8 AWG) 2.5 mm^2 (14 AWG)

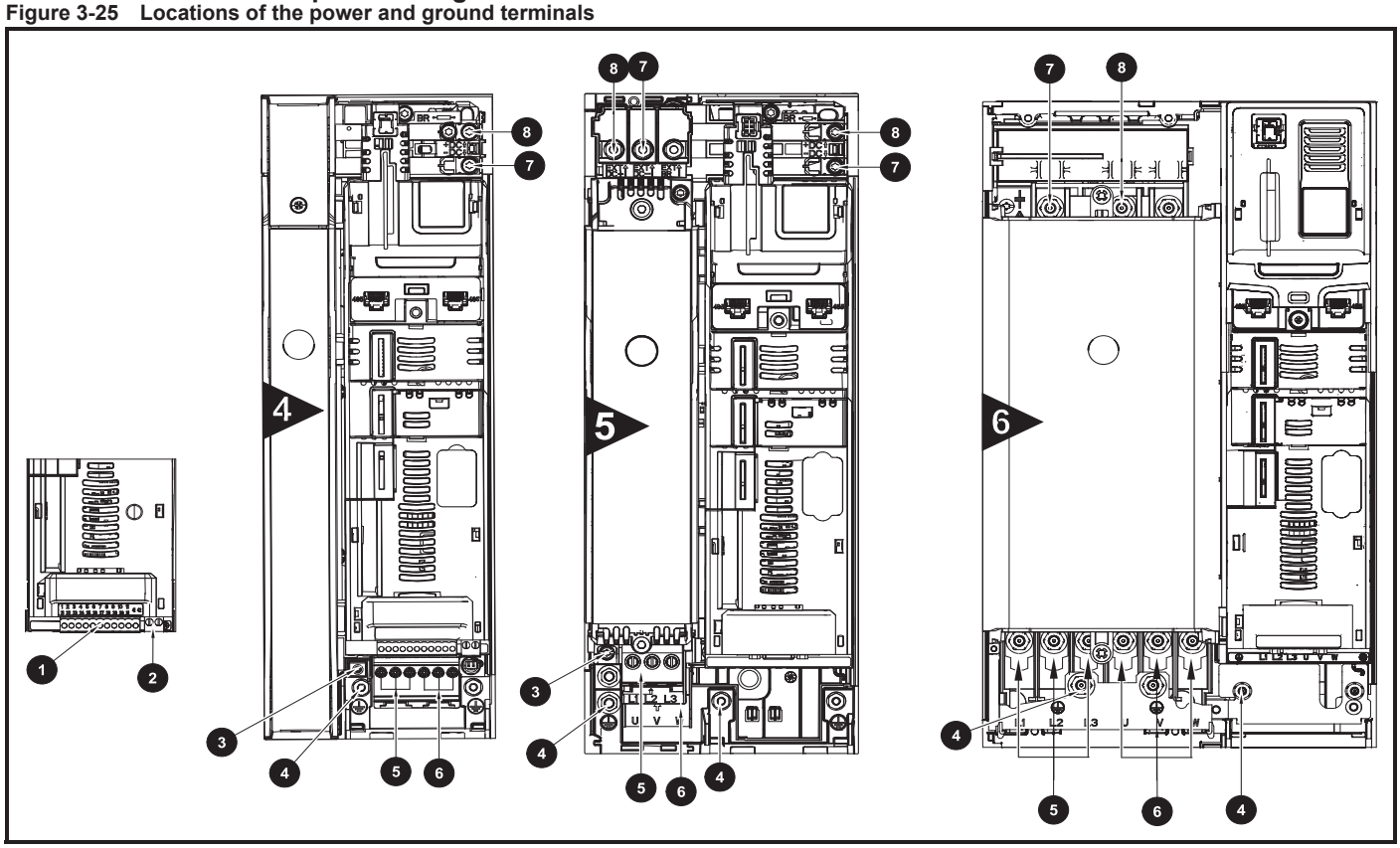
Table 3-7 Size 6 external EMC filter dimensions

CT part number	A	B	C	D	E	H	W	V	X	Y	Z	CS
4200-2300 4200-3690 4200-4800	392 mm (15.43 in)	420 mm (16.54 in)	180 mm (7.09 in)	60 mm (2.36 in)	33 mm (1.30 in)	434 mm (17.09 in)	210 mm (8.27 in)	M6	M6	6.5 mm (0.26 in)	6.5 mm (0.26 in)	16 mm^2 (6 AWG)

3.11 Electrical terminals

3.11.1 Location of the power and ground terminals

Figure 3-25 Locations of the power and ground terminals



Key

1. Control terminals
2. Relay terminals
3. Additional ground connection
4. Ground connections
5. AC power terminals
6. Motor terminals
7. DC bus -
8. DC bus +

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3.11.2 Terminal sizes and torque settings

To avoid a fire hazard and maintain validity of the UL listing, adhere to the specified tightening torques for the power and ground terminals. Refer to the following tables.

Table 3-8 Drive control and relay terminal data

Model	Connection type	Torque setting
All	Plug-in terminal block	0.5 N m (0.4 lb ft)

Table 3-9 Drive power terminal data

CSD100 frame size	AC and motor terminals		Ground terminal	
	Recommended	Maximum	Recommended	Maximum
4	Plug-in terminal block		T20 Torx (M4) / M4 Nut (7 mm AF)	
	0.7 N m (0.5 lb ft)	0.8 N m (0.6 lb ft)	2.0 N m (1.4 lb ft)	2.5 N m (1.8 lb ft)
5	Plug-in terminal block		M5 Nut (8 mm AF)	
	1.5 N m (1.1 lb ft)	1.8 N m (1.3 lb ft)	2.0 N m (1.4 lb ft)	5.0 N m (3.7 lb ft)
6	M6 Nut (10 mm AF)		M6 Nut (10 mm AF)	
	6.0 N m(4.4 lb ft)	8.0 N m(6.0 lb ft)	6.0 N m(4.4 lb ft)	8.0 N m(6.0 lb ft)

Table 3-10 Plug-in terminal block maximum cable sizes

Model size	Terminal block description	Max cable size
All	11 way control connectors	1.5 mm^2 (16 AWG)
	2 way relay connector	2.5 mm^2 (12 AWG)
4	6 way AC power connector	6 mm^2 (10 AWG)
5	3 way AC power connector 3 way motor connector	8 mm^2 (8 AWG)
6	2 way low voltage power 24 V supply connector	1.5 mm^2 (16 AWG)

Table 3-11 External EMC filter terminal data

CT part number	Power connections		Ground connections	
	Max cable size	Max torque	Ground stud size	Max torque
4200-0252	16 mm^2 (6 AWG)	1.8 N m (1.4 lb ft)	M6	5.0 N m (3.7 lb ft)
4200-0402				
4200-2300	16 mm^2 (6 AWG)	2.3 N m (1.70 lb ft)	M6	5.0 N m (3.7 lb ft)
4200-3690				

3.12 Routine maintenance

The drive should be installed in a cool, clean, well ventilated location. Contact of moisture and dust with the drive should be prevented. Regular checks of the following should be carried out to ensure drive / installation reliability are maximized:

Environment	
Ambient temperature	Ensure the enclosure temperature remains at or below maximum specified
Dust	Ensure the drive remains dust free – check that the heatsink and drive fan are not gathering dust. The lifetime of the fan is reduced in dusty environments.
Moisture	Ensure the drive enclosure shows no signs of condensation
Enclosure	
Enclosure door filters	Ensure filters are not blocked and that air is free to flow
Electrical	
Screw connections	Ensure all screw terminals remain tight
Crimp terminals	Ensure all crimp terminals remains tight – check for any discoloration which could indicate overheating
Cables	Check all cables for signs of damage

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3.12.1 Real time clock battery replacement

Those keypads which have the real time clock feature contain a battery to ensure the clock works when the drive is powered down. The battery has a long life time but if the battery needs to be replaced or removed, follow the instructions below.

Low battery voltage is indicated by low battery symbol on the keypad display.

Figure 3-26 HOA-Keypad RTC (rear view)

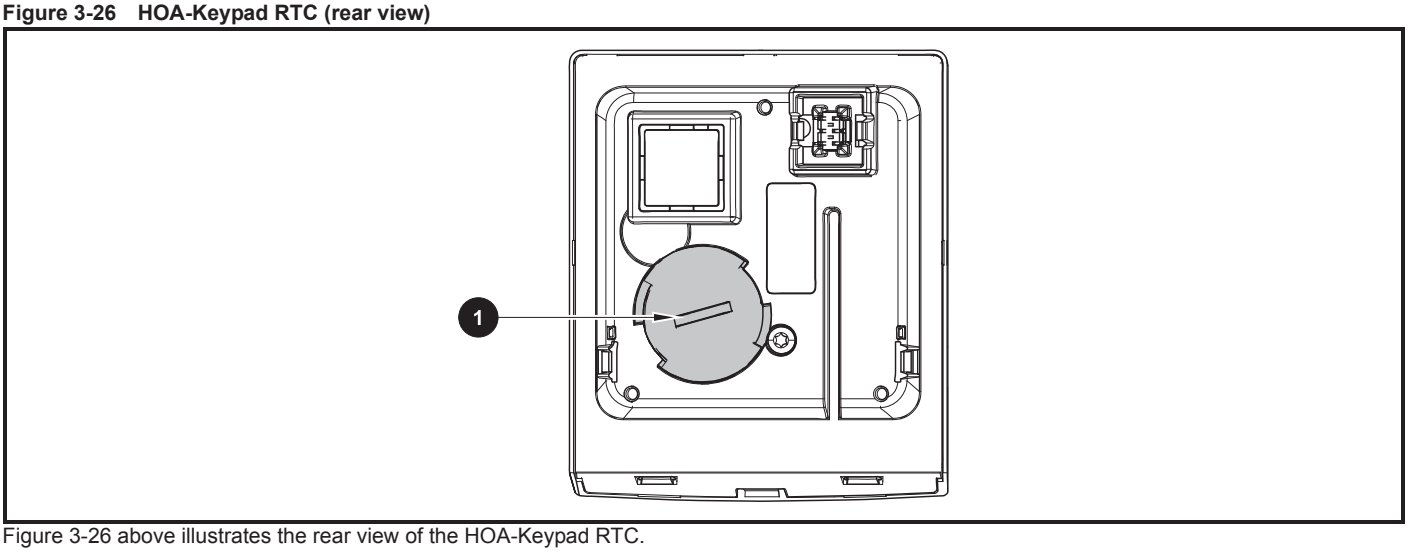


Figure 3-26 above illustrates the rear view of the HOA-Keypad RTC.

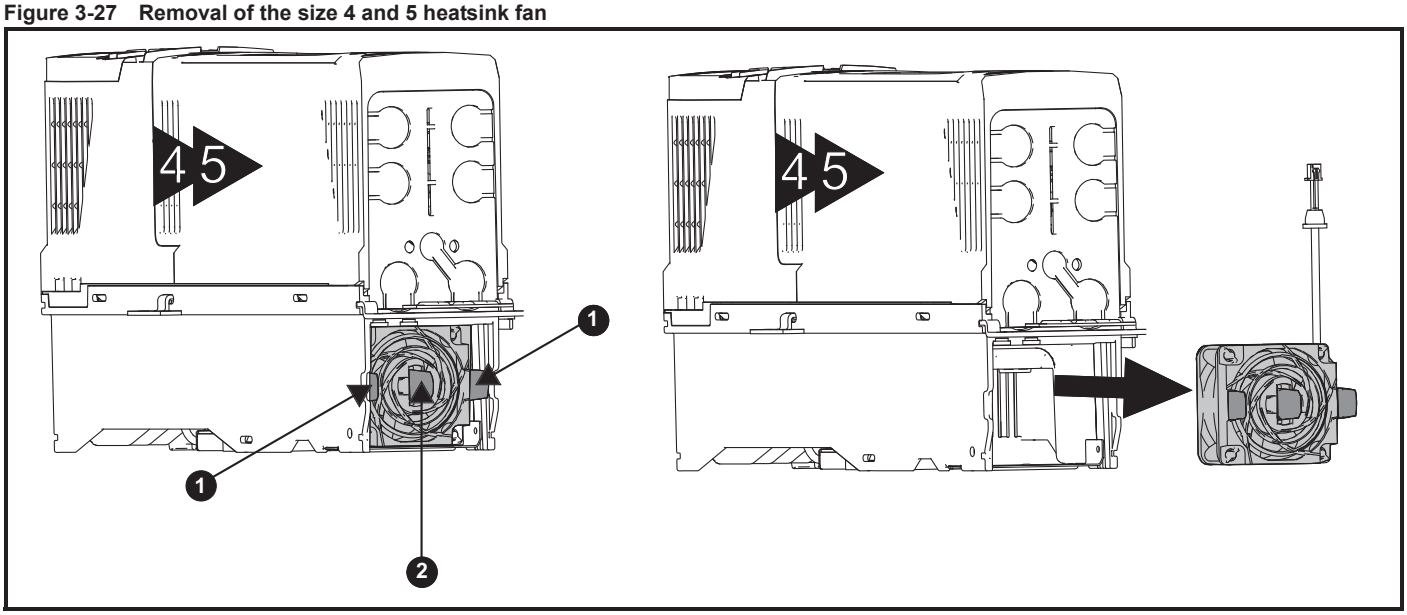
1. To remove the battery cover insert a flat head screwdriver into the slot as shown (1), push and turn anti-clockwise until the battery cover is released.
2. Replace the battery (the battery type is: CR2032).
3. Reverse point 1 above to replace battery cover.

NOTE

Ensure the battery is disposed of correctly.

3.12.2 Fan removal procedure

Figure 3-27 Removal of the size 4 and 5 heatsink fan



1. Ensure the fan cable is disconnected from the drive prior to attempting fan removal.
2. Press the two tabs (1) inwards to release the fan from the drive frame.
3. Using the central fan tab (2), withdraw the fan assembly from the drive housing.

Replace the fan by reversing the above instructions.

NOTE

If the drive is surface mounted using the outer holes on the mounting bracket, then the heatsink fan can be replaced without removing the drive from the backplate.

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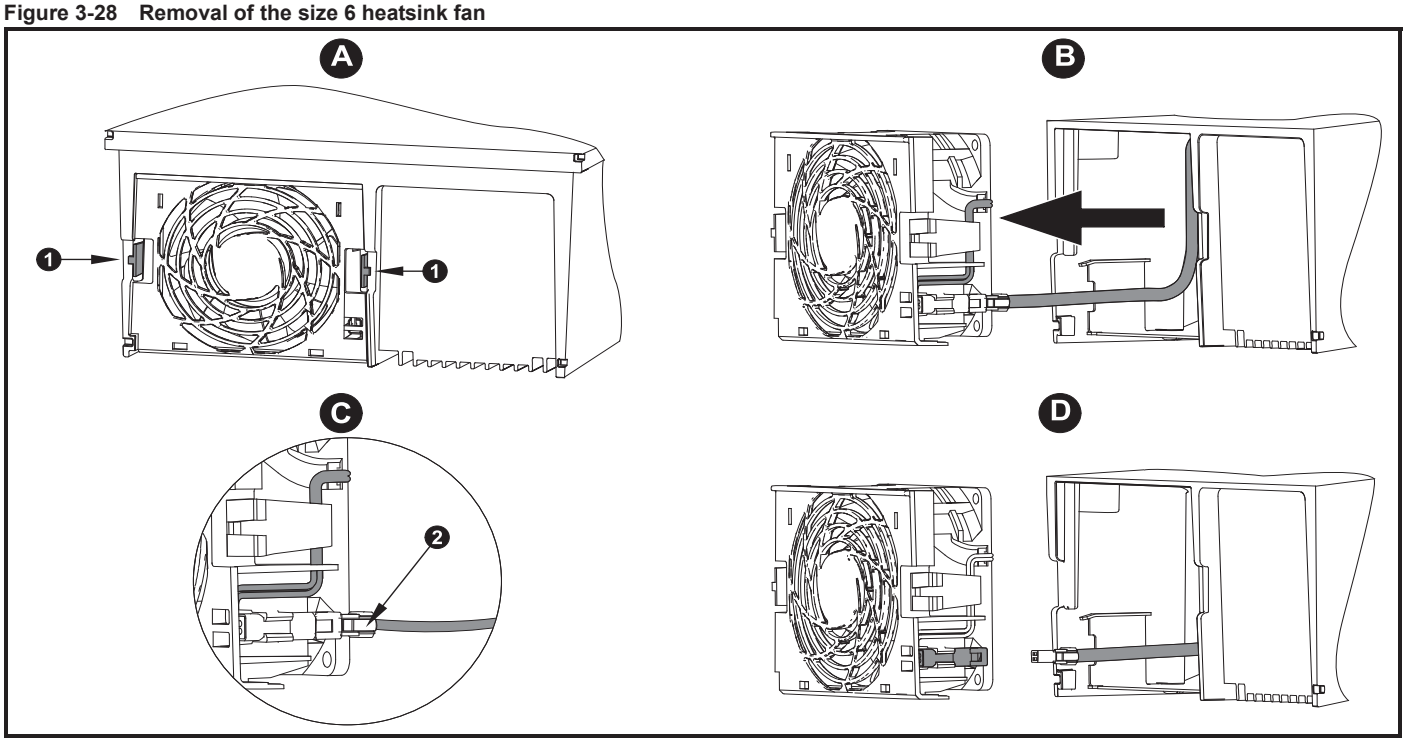
Figure 3-28 Removal of the size 6 heatsink fan



A: Press the tabs (1) inwards to release the fan assembly from the underside of the drive.

B: Use the tabs (1) to withdraw the fan by pulling it away from the drive.

C: Depress and hold the locking release on the fan cable lead as shown (2).

D: With the locking release depressed (2), take hold of the fan supply cable and carefully pull to separate the connectors.

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4 Electrical installation

Many cable management features have been incorporated into the product and accessories, this chapter shows how to optimize them. Key features include:

- SAFE TORQUE OFF function
- Internal EMC filter
- EMC compliance with shielding / grounding accessories
- Product rating, fusing and cabling information

WARNING

Electric shock risk
The voltages present in the following locations can cause severe electric shock and may be lethal:

- AC supply cables and connections
- DC and brake cables, and connections
- Output cables and connections
- Many internal parts of the drive, and external option units

Unless otherwise indicated, control terminals are single insulated and must not be touched.

WARNING

Isolation device
The AC and / or DC power supply must be disconnected from the drive using an approved isolation device before any cover is removed from the drive or before any servicing work is performed.

WARNING

STOP function
The STOP function does not remove dangerous voltages from the drive, the motor or any external option units.

WARNING

SAFE TORQUE OFF function
The SAFE TORQUE OFF function does not remove dangerous voltages from the drive, the motor or any external option units.

WARNING

Stored charge
The drive contains capacitors that remain charged to a potentially lethal voltage after the AC and / or DC power supply has been disconnected. If the drive has been energized, the AC and / or DC power supply must be isolated at least ten minutes before work may continue. Normally, the capacitors are discharged by an internal resistor. Under certain, unusual fault conditions, it is possible that the capacitors may fail to discharge, or be prevented from being discharged by a voltage applied to the output terminals. If the drive has failed in a manner that causes the display to go blank immediately, it is possible the capacitors will not be discharged. In this case, consult Control Techniques or their authorized distributor.

WARNING

Equipment supplied by plug and socket
Special attention must be given if the drive is installed in equipment which is connected to the AC supply by a plug and socket. The AC supply terminals of the drive are connected to the internal capacitors through rectifier diodes which are not intended to give safety isolation. If the plug terminals can be touched when the plug is disconnected from the socket, a means of automatically isolating the plug from the drive must be used (e.g. a latching relay).

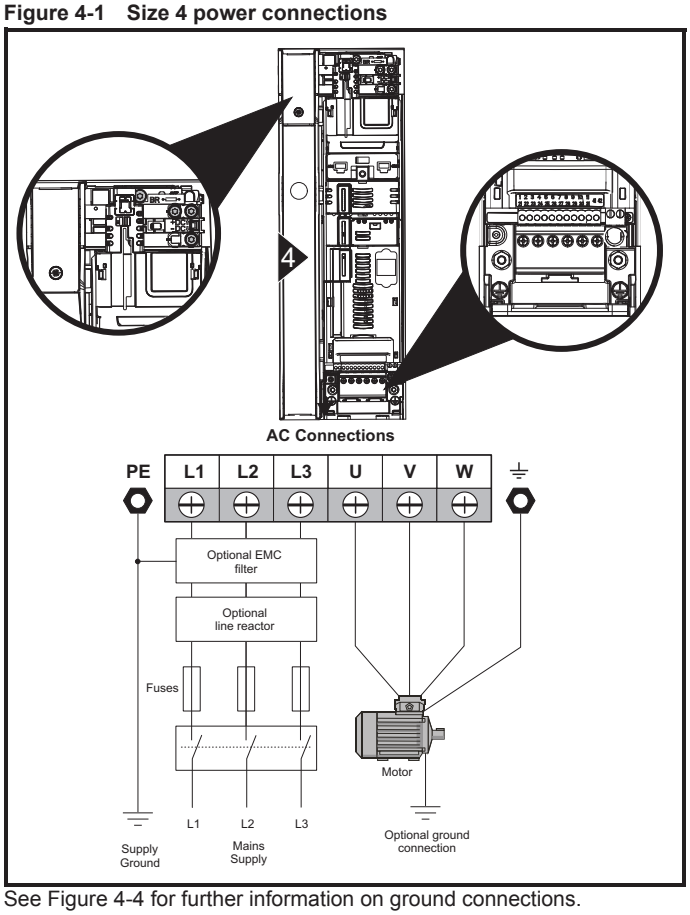
WARNING

Permanent magnet motors
Permanent magnet motors generate electrical power if they are rotated, even when the supply to the drive is disconnected. If that happens then the drive will become energized through its motor terminals.
If the motor load is capable of rotating the motor when the supply is disconnected, then the motor must be isolated from the drive before gaining access to any live parts.

4.1 Power connections

4.1.1 AC connections

Figure 4-1 Size 4 power connections



See Figure 4-4 for further information on ground connections.

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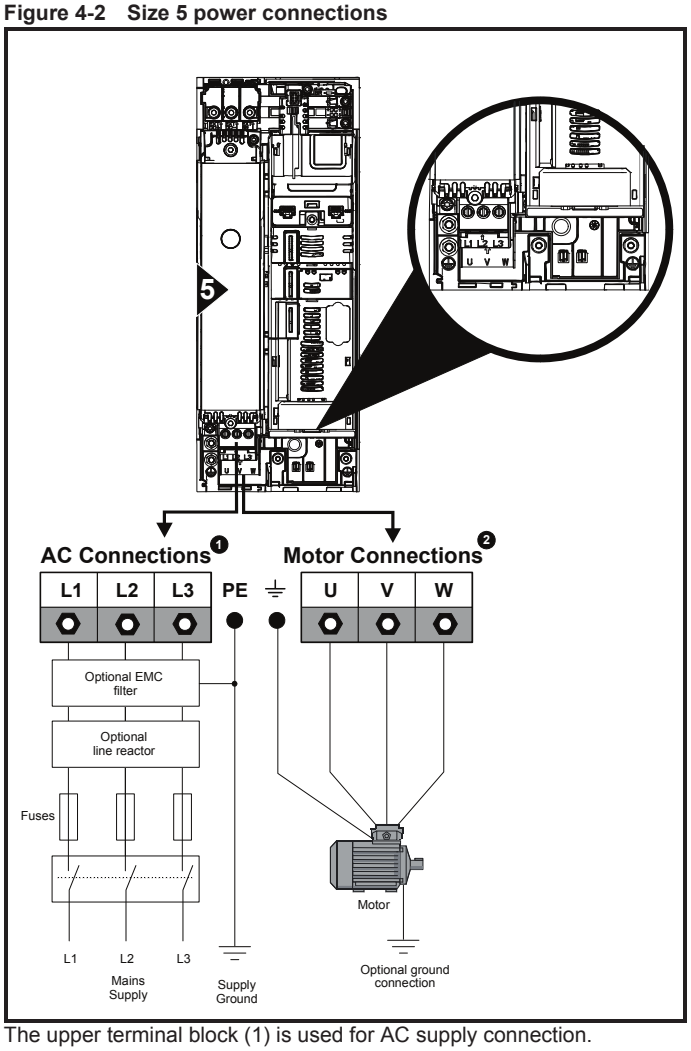
Figure 4-2 Size 5 power connections

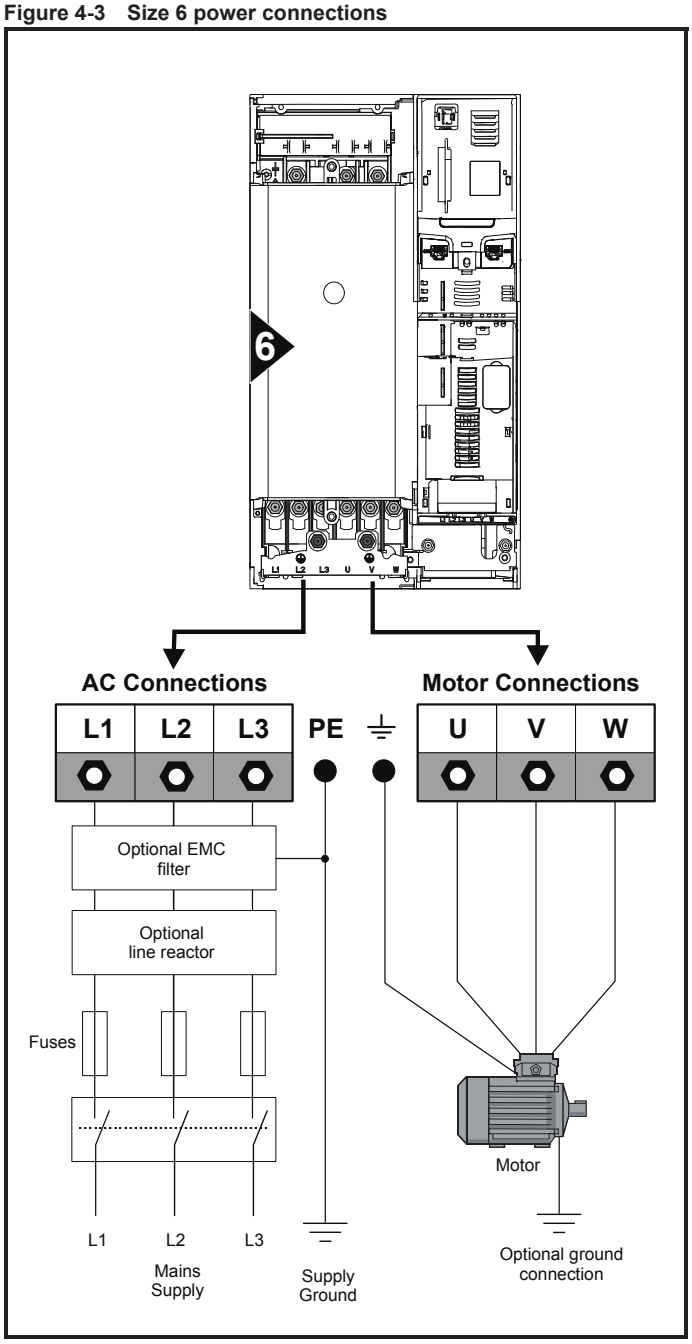


The upper terminal block (1) is used for AC supply connection.

The lower terminal block (2) is used for the Motor connection.

See Figure 4-5 for further information on ground connections.

Figure 4-3 Size 6 power connections



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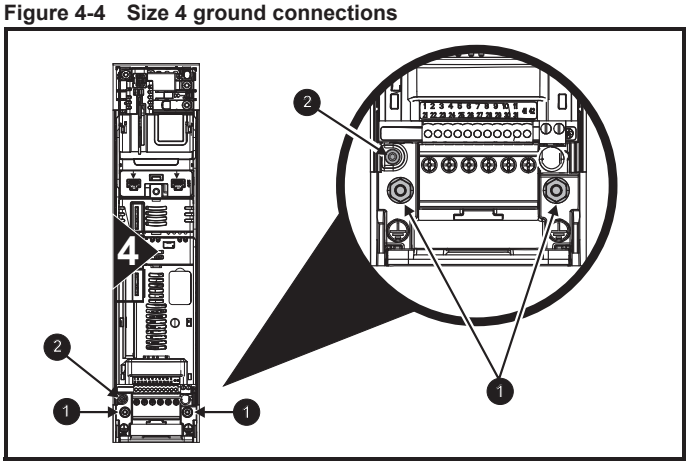
4.1.2 Ground connections

Electrochemical corrosion of grounding terminals
Ensure that grounding terminals are protected against corrosion i.e. as could be caused by condensation.

Size 4

On size 4, the supply and motor ground connections are made using the M4 studs located either side of the drive near the plug-in power connector. Refer to Figure 4-4 for additional ground connection.

Figure 4-4 Size 4 ground connections

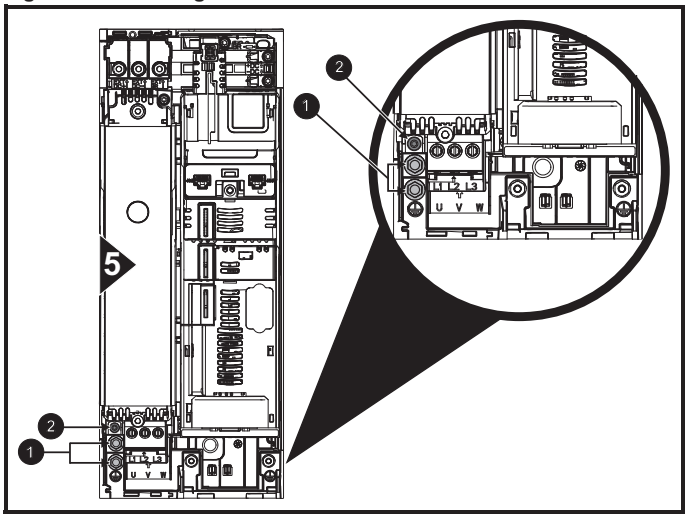


1. Ground connection studs.
2. Additional ground connection.

Size 5

On size 5, the supply and motor ground connections are made using the M5 studs located near the plug-in power connector. Refer to Figure 4-5 for additional ground connection.

Figure 4-5 Size 5 ground connections

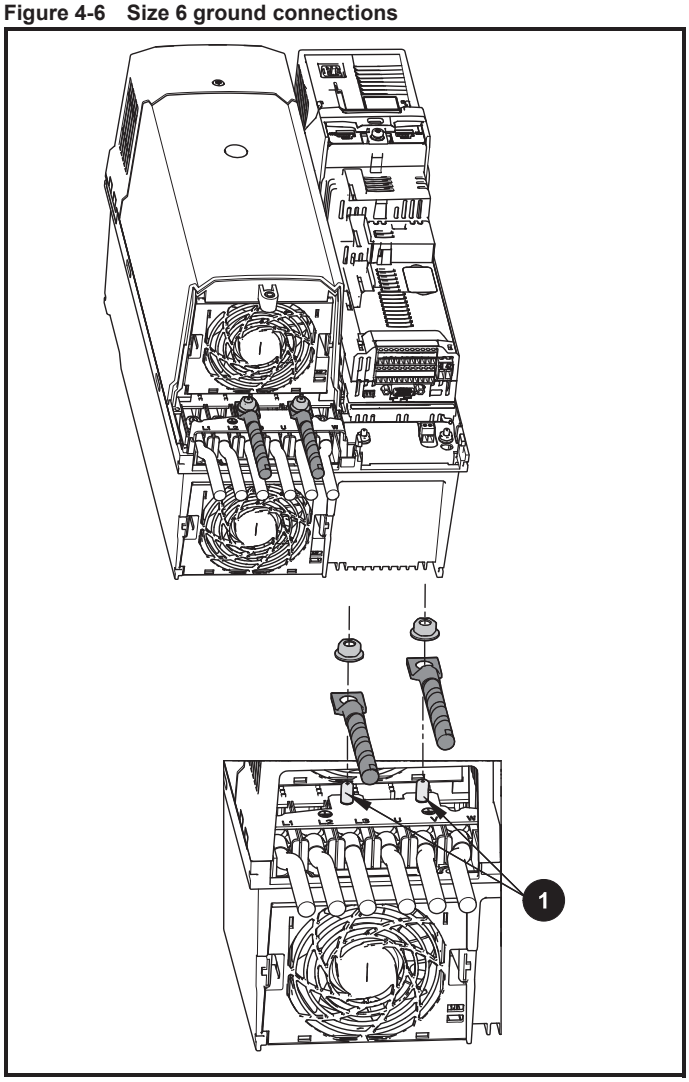


1. Ground connection studs.
2. Additional ground connection.

Size 6

On a size 6, the supply and motor ground connections are made using the M6 studs located above the supply and motor terminals. Refer to Figure 4-6 below.

Figure 4-6 Size 6 ground connections



The ground loop impedance must conform to the requirements of local safety regulations.

The drive must be grounded by a connection capable of carrying the prospective fault current until the protective device (fuse, etc.) disconnects the AC supply.

The ground connections must be inspected and tested at appropriate intervals.

Table 4-1 Protective ground cable ratings

Input phase conductor size	Minimum ground conductor size
≤ 10 mm^2	Either 10 mm^2 or two conductors of the same cross-sectional area as the input phase conductor (an additional ground connection is provided on sizes 3, 4 and 5 for this purpose).
> 10 mm^2 and ≤ 16 mm^2	The same cross-sectional area as the input phase conductor
> 16 mm^2 and ≤ 35 mm^2	16 mm^2
> 35 mm^2	Half of the cross-sectional area of the input phase conductor

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4.2 AC supply requirements

Voltage:

200 V drive: 200 V to 240 V ±10 %
400 V drive: 380 V to 480 V ±10 %
575 V drive: 500 V to 575 V ±10 %

Number of phases: 3

Maximum supply imbalance: 2 % negative phase sequence (equivalent to 3 % voltage imbalance between phases).

Frequency range: 45 to 66 Hz

For UL compliance only, the maximum supply symmetrical fault current must be limited to 100 kA

4.2.1 Supply types

All drives are suitable for use on any supply type i.e TN-S, TN-C-S, TT and IT.

- Supplies with voltage up to 600 V may have grounding at any potential, i.e. neutral, centre or corner (“grounded delta”)
- Supplies with voltage above 600 V may not have corner grounding

Drives are suitable for use on supplies of installation category III and lower, according to IEC60664-1. This means they may be connected permanently to the supply at its origin in a building, but for outdoor installation additional over-voltage suppression (transient voltage surge suppression) must be provided to reduce category IV to category III.

Operation with IT (ungrounded) supplies:
Special attention is required when using internal or external EMC filters with ungrounded supplies, because in the event of a ground (earth) fault in the motor circuit the drive may not trip and the filter could be over-stressed. In this case, either the filter must not be used (removed), or additional independent motor ground fault protection must be provided. For instructions on removal, refer to section 4.6.2 *Internal EMC filter* on page 45. For details of ground fault protection contact the supplier of the drive.

A ground fault in the supply has no effect in any case. If the motor must continue to run with a ground fault in its own circuit then an input isolating transformer must be provided and if an EMC filter is required it must be located in the primary circuit.

Unusual hazards can occur on ungrounded supplies with more than one source, for example on ships. Contact the supplier of the drive for more information.

4.2.2 Supplies requiring line reactors

Input line reactors reduce the risk of damage to the drive resulting from poor phase balance or severe disturbances on the supply network.

Where line reactors are to be used, reactance values of approximately 2 % are recommended. Higher values may be used if necessary, but may result in a loss of drive output (reduced torque at high speed) because of the voltage drop.

For all drive ratings, 2 % line reactors permit drives to be used with a supply unbalance of up to 3.5 % negative phase sequence (equivalent to 5% voltage imbalance between phases).

Severe disturbances may be caused by the following factors, for example:

- Power factor correction equipment connected close to the drive.
- Large DC drives having no or inadequate line reactors connected to the supply.
- Across the line (DOL) started motor(s) connected to the supply such that when any of these motors are started, the voltage dip exceeds 20 %.

Such disturbances may cause excessive peak currents to flow in the input power circuit of the drive. This may cause nuisance tripping, or in extreme cases, failure of the drive.

Drives of low power rating may also be susceptible to disturbance when connected to supplies with a high rated capacity.

CSD drive model sizes have an internal DC choke so they do not require AC line reactors except for cases of excessive phase unbalance or extreme supply conditions.

When required, each drive must have its own reactor(s). Three individual reactors or a single three-phase reactor should be used.

Reactor current ratings
The current rating of the line reactors should be as follows:

Continuous current rating:
Not less than the continuous input current rating of the drive

Repetitive peak current rating:
Not less than twice the continuous input current rating of the drive

4.2.3 Input inductor calculation

To calculate the inductance required (at **Y**%), use the following equation:

$$\mathbf{L} = \frac{\mathbf{Y}}{\mathbf{100}} \times \frac{\mathbf{V}}{\sqrt{\mathbf{3}}} \times \frac{\mathbf{1}}{\mathbf{2\pi f I}}$$

Where:
I = drive rated input current (A)
L = inductance (H)
f = supply frequency (Hz)
V = voltage between lines

4.3 Ratings

The input current is affected by the supply voltage and impedance.

Typical input current

The values of typical input current are given to aid calculations for power flow and power loss.

The values of typical input current are stated for a balanced supply.

Maximum continuous input current

The values of maximum continuous input current are given to aid the selection of cables and fuses. These values are stated for the worst case condition with the unusual combination of stiff supply with bad balance.

The value stated for the maximum continuous input current would only be seen in one of the input phases. The current in the other two phases would be significantly lower.

The values of maximum input current are stated for a supply with a 2 % negative phase-sequence imbalance and rated at the supply fault current given in Table 4-2 .

Table 4-2 Supply fault current used to calculate maximum input current

Model	Symmetrical fault level
All	100

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WARNING

Fuses

The AC supply to the drive must be installed with suitable protection against overload and short-circuits. Table 4-3 shows recommended fuse ratings. Failure to observe this requirement will cause risk of fire.

Table 4-3 AC Input current and fuse ratings (200 V)

Model	Typical input current	Maximum continuous input current	Maximum overload input current	Fuse rating			
				IEC gG		Class CC or Class J	
				Nominal	Maximum	Nominal	Maximum
	A	A	A	A	A	A	A
06200550	42	48	64	63	63	60	70
06200580	49	56	85			70	

Table 4-4 AC Input current and fuse ratings (400 V)

Model	Typical input current	Maximum continuous input current	Maximum overload input current	Fuse rating			
				IEC gG		Class CC or Class J	
				Nominal	Maximum	Nominal	Maximum
	A	A	A	A	A	A	A
04400240	22	24	35	32	32	30	30
05400300	26	29	58	40	40	35	35
06400380	32	36	67	63	63	40	60

Table 4-5 AC Input current and fuse ratings (575 V)

Model	Typical input current	Maximum continuous input current	Maximum overload input current	Fuse rating			
				IEC gG		Class CC or Class J	
				Nominal	Maximum	Nominal	Maximum
	A	A	A	A	A	A	A
06500220	22	24	41	40	40	30	30
06500270	26	29	50	50	63	35	50

NOTE

Ensure all cables used suit local wiring regulations.

CAUTION

The nominal cable sizes below are only a guide. The mounting and grouping of cables affects their current-carrying capacity, in some cases smaller cables may be acceptable but in other cases a larger cable is required to avoid excessive temperature or voltage drop. Refer to local wiring regulations for the correct size of cables.

Table 4-6 Cable ratings (200 V)

Model	Cable size (IEC) mm^2				Cable size (UL) AWG			
	Input		Output		Input		Output	
	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum
06200500	16	25	16	25	4	3	4	3
06200580	25		25		3		3	

Table 4-7 Cable ratings (400 V)

Model	Cable size (IEC) mm^2				Cable size (UL) AWG			
	Input		Output		Input		Output	
	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum
04400240	6	6	6	6	8	8	8	8
05400300	6	6	6	6				
06400380	10	25	10	25	6	3	6	

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Table 4-8 Cable ratings (575 V)

Model	Cable size (IEC) mm²				Cable size (UL) AWG			
	Input		Output		Input		Output	
	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum
06500220	6	25	6	25	10	3	10	3
06500270	10		10		8		8	

NOTE
PVC insulated cable should be used.

NOTE
Cable sizes are from IEC60364-5-52:2001 table A.52.C with correction factor for 40°C ambient of 0.87 (from table A52.14) for cable installation method B2 (multicore cable in conduit).

Installation class (ref: IEC60364-5-52:2001)
B1 - Separate cables in conduit.
B2 - Multicore cable in conduit.
C - Multicore cable in free air.
Cable size may be reduced if a different installation method is used, or if the ambient temperature is lower.

NOTE
The nominal output cable sizes assume that the motor maximum current matches that of the drive. Where a motor of reduced rating is used the cable rating may be chosen to match that of the motor. To ensure that the motor and cable are protected against overload, the drive must be programmed with the correct motor rated current.
A fuse or other protection must be included in all live connections to the AC supply.

Fuse types
The fuse voltage rating must be suitable for the drive supply voltage.

Ground connections
The drive must be connected to the system ground of the AC supply. The ground wiring must conform to local regulations and codes of practice.

NOTE
For information on ground cable sizes, refer to Table 4-1 *Protective ground cable ratings* on page 39.

4.3.1 Main AC supply contactor
The recommended AC supply contactor type for size 4, 5 and 6 is AC1.

4.4 Output circuit and motor protection
The output circuit has fast-acting electronic short-circuit protection which limits the fault current to typically no more than five times the rated output current, and interrupts the current in approximately 20 µs. No additional short-circuit protection devices are required.

The drive provides overload protection for the motor and its cable. For this to be effective, *Rated Current* (Pr **05.007**) must be set to suit the motor.

WARNING
Rated Current (Pr **05.007**) must be set correctly to avoid a risk of fire in the event of motor overload.

There is also provision for the use of a motor thermistor to prevent over-heating of the motor, e.g. due to loss of cooling.

4.4.1 Cable types and lengths
Since capacitance in the motor cable causes loading on the output of the drive, ensure the cable length does not exceed the values given in Table 4-9, Table 4-10 and Table 4-11.

Use 105 °C (221 °F) (UL 60/75 °C temp rise) PVC-insulated cable with copper conductors having a suitable voltage rating, for the following power connections:

- AC supply to external EMC filter (when used)
- AC supply (or external EMC filter) to drive
- Drive to motor
- Drive to braking resistor

Table 4-9 Maximum motor cable lengths (200 V drives)

200 V Nominal AC supply voltage							
Model	Maximum permissible motor cable length for each of the following switching frequencies						
	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
06200500	300 m (984 ft)	200 m (660 ft)	150 m (490 ft)	100 m (330 ft)	75 m (245 ft)	50 m (165 ft)	
06200580							

Table 4-10 Maximum motor cable lengths (400 V drives)

400 V Nominal AC supply voltage							
Model	Maximum permissible motor cable length for each of the following switching frequencies						
	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
04400240	200 m (660 ft)		150 m (330 ft)	100 m (330 ft)	75 m (245 ft)	50 m (165 ft)	37 m (120 ft)
05400300							
06400380	300 m (984 ft)	200 m (660 ft)	150 m (330 ft)	100 m (330 ft)	75 m (245 ft)	50 m (165 ft)	

Table 4-11 Maximum motor cable lengths (575 V drives)

575 V Nominal AC supply voltage							
Model	Maximum permissible motor cable length for each of the following switching frequencies						
	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
06500270	300 m (984 ft)	200 m (660 ft)	150 m (490 ft)	100 m (330 ft)	75 m (245 ft)	50 m (165 ft)	
06500270							

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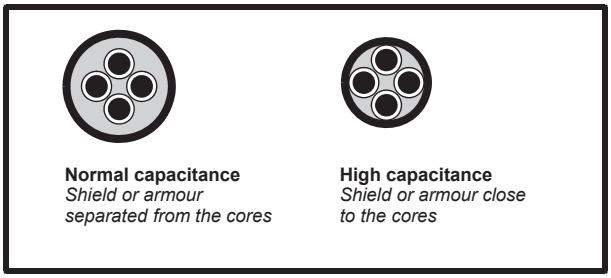
4.4.2 High-capacitance / reduced diameter cables

The maximum cable length is reduced from that shown in section 4.4.1 *Cable types and lengths* on page 42 if high capacitance or reduced diameter motor cables are used.

Most cables have an insulating jacket between the cores and the armor or shield; these cables have a low capacitance and are recommended. Cables that do not have an insulating jacket tend to have high capacitance; if a cable of this type is used, the maximum cable length is half that quoted in the tables, (Figure 4-7 shows how to identify the two types).

Figure 4-7 Cable construction influencing the capacitance



The maximum motor cable lengths specified in Section 4.4.1 *Cable types and lengths* , are shielded and contain four cores. Typical capacitance for this type of cable is 130 pF/m (i.e. from one core to all others and the shield connected together).

4.4.3 Motor winding voltage

The PWM output voltage can adversely affect the inter-turn insulation in the motor. This is because of the high rate of change of voltage, in conjunction with the impedance of the motor cable and the distributed nature of the motor winding.

For normal operation with AC supplies up to 500 Vac and a standard motor with a good quality insulation system, there is no need for any special precautions. In case of doubt the motor supplier should be consulted. Special precautions are recommended under the following conditions, but only if the motor cable length exceeds 10 m:

- AC supply voltage exceeds 500 V
- DC supply voltage exceeds 670 V
- Operation of 400 V drive with continuous or very frequent sustained braking
- Multiple motors connected to a single drive

For multiple motors, the precautions given in section on page 43 should be followed.

For the other cases listed, it is recommended that an inverter-rated motor be used taking into account the voltage rating of the inverter. This has a reinforced insulation system intended by the manufacturer for repetitive fast-rising pulsed voltage operation.

Users of 575 V NEMA rated motors should note that the specification for inverter-rated motors given in NEMA MG1 section 31 is sufficient for motoring operation but not where the motor spends significant periods braking. In that case an insulation peak voltage rating of 2.2 kV is recommended.

If it is not practical to use an inverter-rated motor, an output choke (inductor) should be used. The recommended type is a simple iron-cored component with a reactance of about 2 %. The exact value is not critical. This operates in conjunction with the capacitance of the motor cable to increase the rise-time of the motor terminal voltage and prevent excessive electrical stress.

4.4.4 Output contactor

WARNING If the cable between the drive and the motor is to be interrupted by a contactor or circuit breaker, ensure that the drive is disabled before the contactor or circuit breaker is opened or closed. Severe arcing may occur if this circuit is interrupted with the motor running at high current and low speed.

A contactor is sometimes required to be installed between the drive and motor for safety purposes.

The recommended motor contactor is the AC3 type.

Switching of an output contactor should only occur when the output of the drive is disabled.

Opening or closing of the contactor with the drive enabled will lead to:

1. OI ac trips (which cannot be reset for 10 s)
2. High levels of radio frequency noise emission
3. Increased contactor wear and tear

The Drive Enable terminal (T31) when opened provides a SAFE TORQUE OFF function. This can in many cases replace output contactors.

For further information see section 4.10 *SAFE TORQUE OFF (STO)* on page 56.

4.5 Ground leakage

The ground leakage current depends upon whether the internal EMC filter is installed or not. The drive is supplied with the filter installed. Instructions for removing the internal filter are given in section 4.6.2 *Internal EMC filter* on page 45.

WARNING When the internal filter is installed the leakage current is high. In this case a permanent fixed ground connection must be provided, or other suitable measures taken to prevent a safety hazard occurring if the connection is lost.

4.5.1 Use of residual current device (RCD)

There are three common types of ELCB / RCD:

1. AC - detects AC fault currents
2. A - detects AC and pulsating DC fault currents (provided the DC current reaches zero at least once every half cycle)
3. B - detects AC, pulsating DC and smooth DC fault currents
   - Type AC should never be used with drives.
   - Type A can only be used with single phase drives
   - Type B must be used with three phase drives

WARNING Only type B ELCB / RCD are suitable for use with 3 phase inverter drives.

If an external EMC filter is used, a delay of at least 50 ms should be incorporated to ensure spurious trips are not seen. The leakage current is likely to exceed the trip level if all of the phases are not energized simultaneously.

4.6 EMC (Electromagnetic compatibility)

The requirements for EMC are divided into three levels in the following three sections:

Section4.6.3, General requirements for all applications, to ensure reliable operation of the drive and minimise the risk of disturbing nearby equipment. The immunity standards specified in Chapter 11 *Technical data* on page 102 will be met, but no specific emission standards are applied. Note also the special requirements given in *Surge immunity of control circuits - long cables and connections outside a building* on page 50 for increased surge immunity of control circuits where control wiring is extended.

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Section 4.6.4, Requirements for meeting the EMC standard for power drive systems, IEC61800-3 (EN 61800-3:2004).

Section 4.6.5, Requirements for meeting the generic emission standards for the industrial environment, IEC61000-6-4, EN 61000-6-4:2007.

The recommendations of section 4.6.3 will usually be sufficient to avoid causing disturbance to adjacent equipment of industrial quality. If particularly sensitive equipment is to be used nearby, or in a non-industrial environment, then the recommendations of section 4.6.4 or section 4.6.5 should be followed to give reduced radio-frequency emission.

In order to ensure the installation meets the various emission standards described in:

- The EMC data sheet available from the supplier of the drive
- The Declaration of Conformity at the front of this manual
- Chapter 11 *Technical data* on page 102

The correct external EMC filter must be used and all of the guidelines in section 4.6.3 *General requirements for EMC* on page 47 and section 4.6.5 *Compliance with generic emission standards* on page 48 must be followed.

Table 4-12 Drive and EMC filter cross reference

Model	CT Part number
200 V	
06200500 to 06200580	4200-2300
400 V	
04400240	4200-0252
05400300	4200-0402
06400380	4200-4800
575 V	
06500220 to 06500270	4200-3690

WARNING

High ground leakage current
When an EMC filter is used, a permanent fixed ground connection must be provided which does not pass through a connector or flexible power cord. This includes the internal EMC filter.

NOTE

The installer of the drive is responsible for ensuring compliance with the EMC regulations that apply in the country in which the drive is to be used.

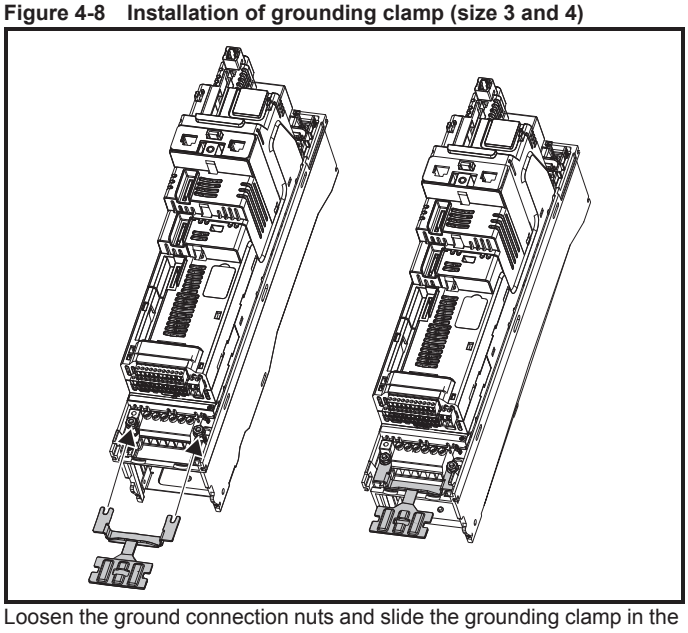
4.6.1 Grounding hardware

The drive is supplied with a grounding bracket and grounding clamp to facilitate EMC compliance. They provide a convenient method for direct grounding of cable shields without the use of "pig-tails". Cable shields can be bared and clamped to the grounding bracket using metal clips or clamps[1] (not supplied) or cable ties. Note that the shield must in all cases be continued through the clamp to the intended terminal on the drive, in accordance with the connection details for the specific signal.

[1] A suitable clamp is the Phoenix DIN rail mounted SK14 cable clamp (for cables with a maximum outer diameter of 14 mm).

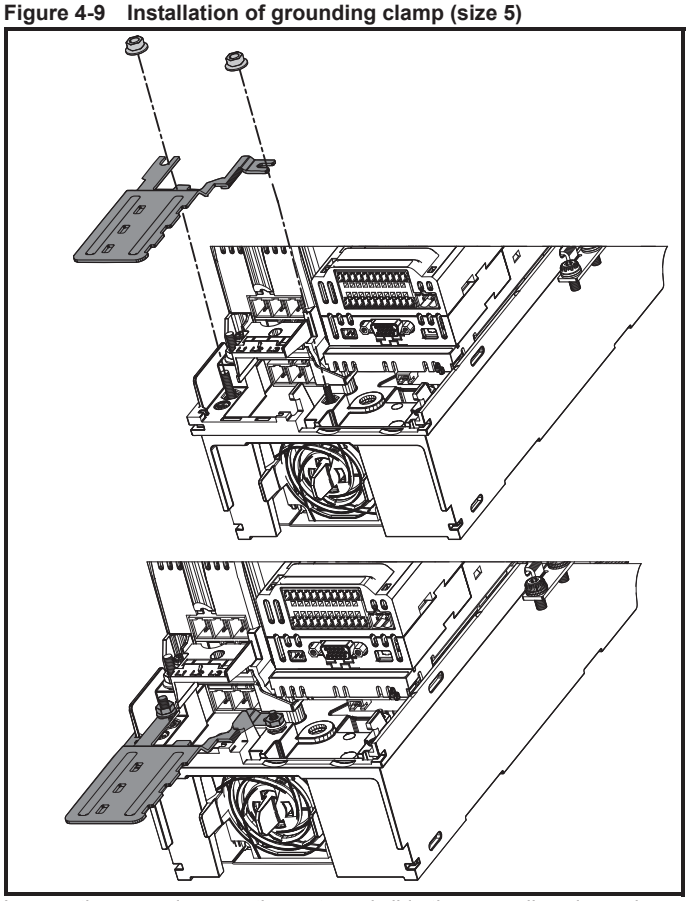
- See Figure 4-8 to Figure 4-10 for details on installing the grounding clamp.
- See Figure 4-11 for details on installing the grounding bracket.

Figure 4-8 Installation of grounding clamp (size 3 and 4)



Loosen the ground connection nuts and slide the grounding clamp in the direction shown. Once in place, the ground connection nuts should be tightened with a maximum torque of 2 N m (1.47 lb ft).

Figure 4-9 Installation of grounding clamp (size 5)



Loosen the ground connection nuts and slide the grounding clamp down onto the pillars in the direction shown. Once in place, the ground connection nuts should be tightened with a maximum torque of 2 N m (1.47 lb ft).

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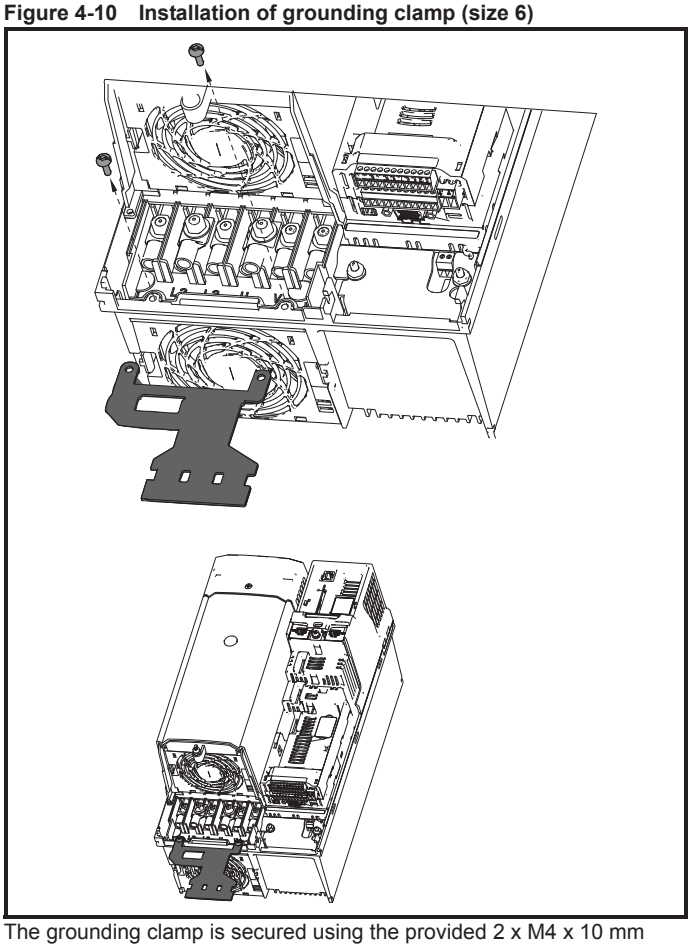
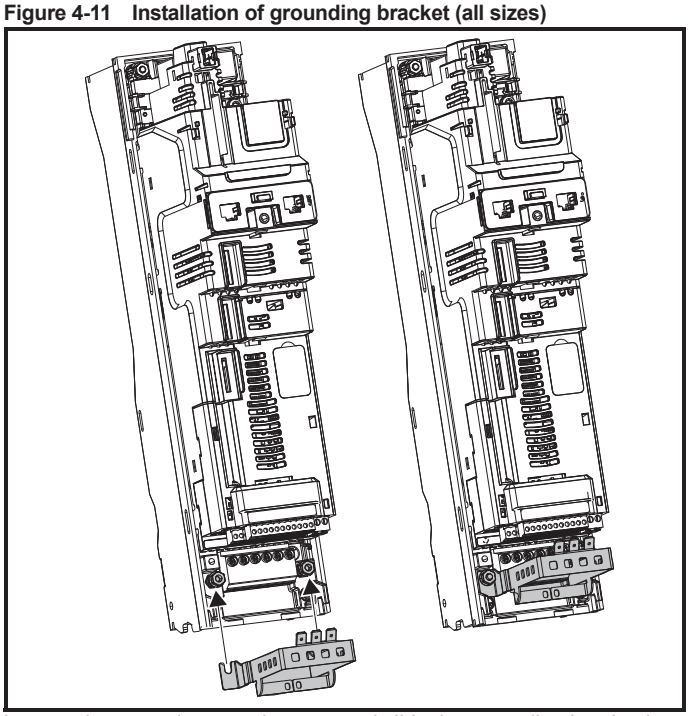
Figure 4-10 Installation of grounding clamp (size 6)



The grounding clamp is secured using the provided 2 x M4 x 10 mm fasteners. The fasteners should be tightened with the maximum torque of 2 N m (1.47 lb ft).

Figure 4-11 Installation of grounding bracket (all sizes)



Loosen the ground connection nuts and slide the grounding bracket in the direction shown. Once in place, the ground connection nuts should be tightened with a maximum torque of 2 N m (1.47 lb ft).

A faston tab is located on the grounding bracket for the purpose of connecting the drive 0 V to ground should the user require to do so.

4.6.2 Internal EMC filter

It is recommended that the internal EMC filter be kept in place unless there is a specific reason for removing it.

WARNING

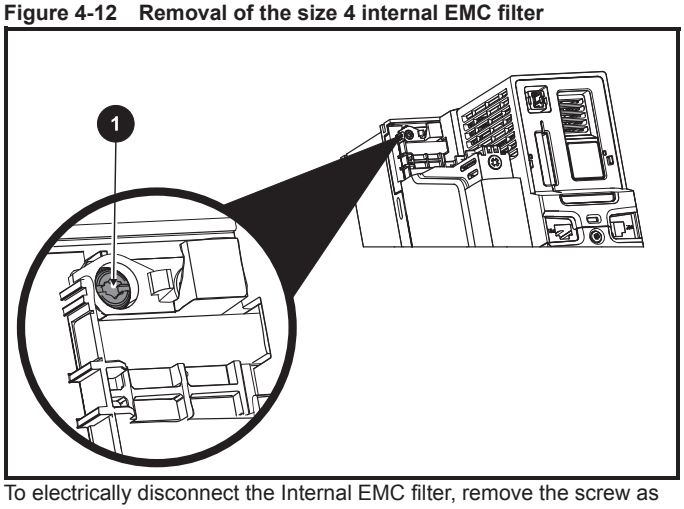
If the drive is used with ungrounded (IT) supplies, the internal EMC filter must be removed unless additional motor ground fault protection is installed.
For instructions on removal refer to section 4.6.2.
For details of ground fault protection contact the supplier of the drive.

The internal EMC filter reduces radio-frequency emission into the line power supply. Where the motor cable is short, it permits the requirements of EN 61800-3:2004 to be met for the second environment - see section 4.6.4 *Compliance with EN 61800-3:2004 (standard for Power Drive Systems)* on page 48 and section 11.1.25 *Electromagnetic compatibility (EMC)* on page 108. For longer motor cables the filter continues to provide a useful reduction in emission levels, and when used with any length of shielded motor cable up to the limit for the drive, it is unlikely that nearby industrial equipment will be disturbed. It is recommended that the filter be used in all applications unless the instructions given above require it to be removed. See Figure 4-12 or Figure 4-14 on page 46 for details of removing and installing the internal EMC filters.

WARNING

The supply must be disconnected before removing the internal EMC filter.

Figure 4-12 Removal of the size 4 internal EMC filter



To electrically disconnect the Internal EMC filter, remove the screw as highlighted above (1).

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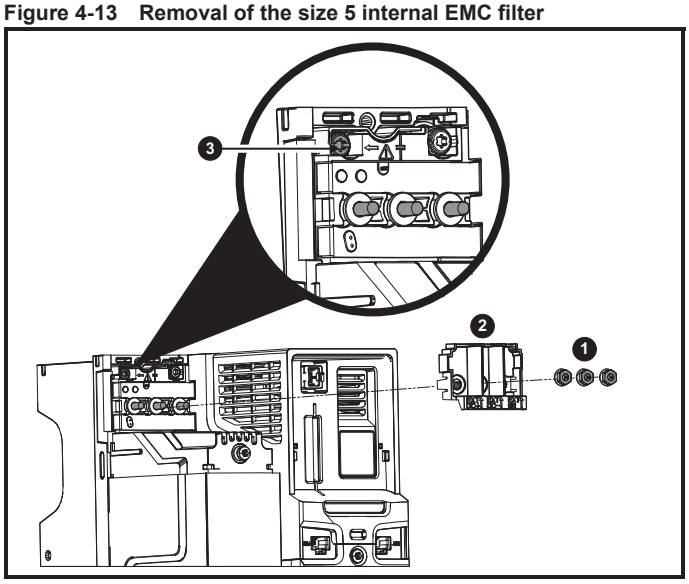
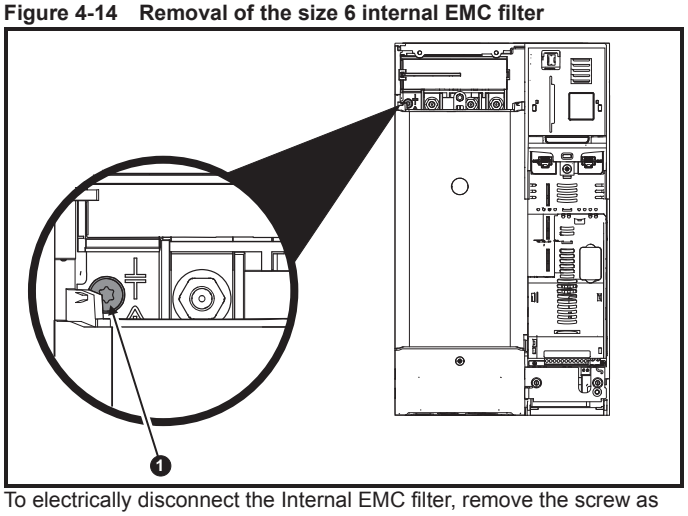
Figure 4-13 Removal of the size 5 internal EMC filter



Remove the three M5 terminal nuts (1). Lift away the cover (2) to expose the M4 Torx internal EMC filter removal screw. Finally remove the M4 Torx internal EMC filter removal screw (3) to electrically disconnect the internal EMC filter.

Figure 4-14 Removal of the size 6 internal EMC filter



To electrically disconnect the Internal EMC filter, remove the screw as highlighted above (1).

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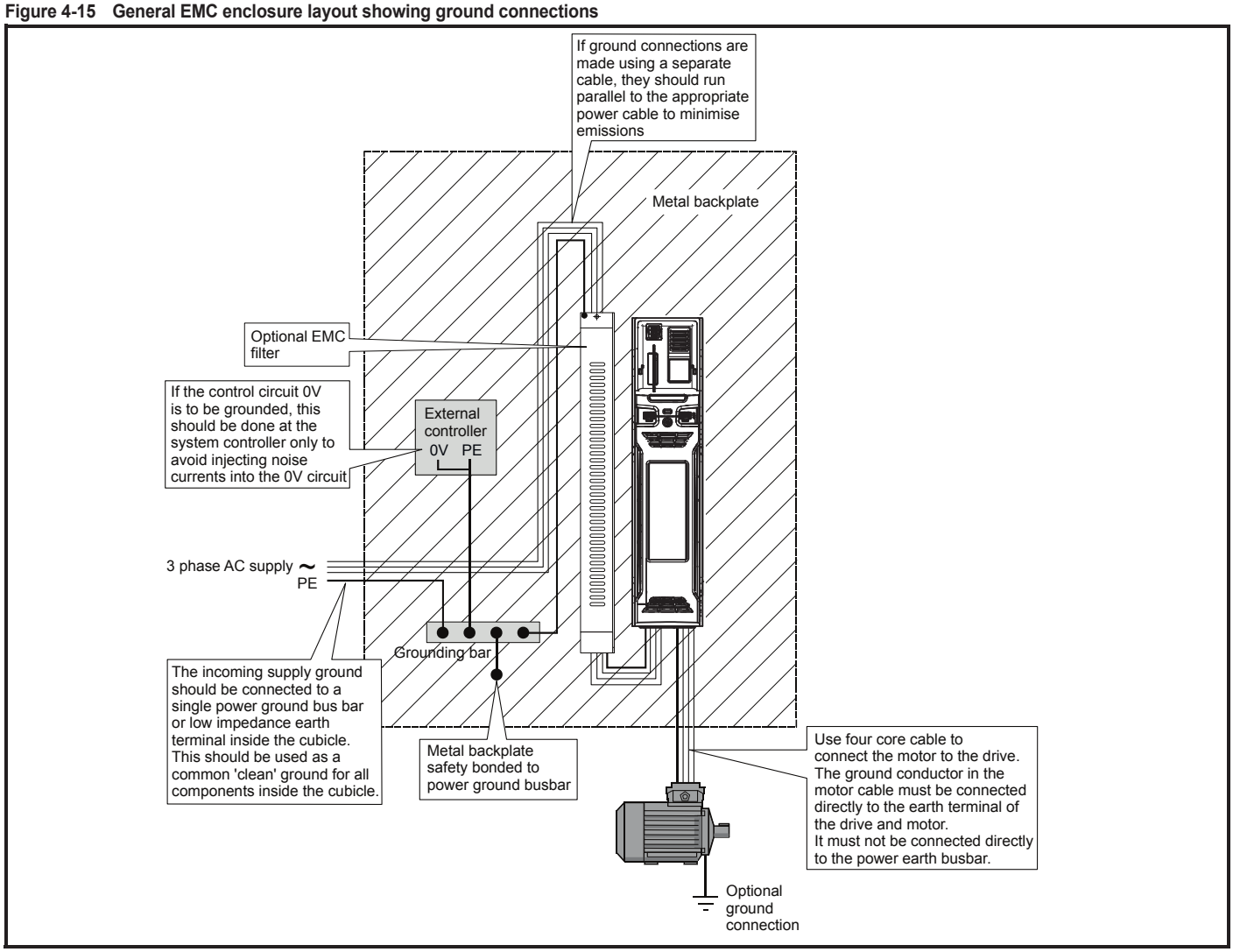
4.6.3 General requirements for EMC

Ground (earth) connections

The grounding arrangements should be in accordance with Figure 4-15, which shows a single drive on a back-plate with or without an additional enclosure.

Figure 4-15 shows how to configure and minimise EMC when using unshielded motor cable. However shielded cable is a better option, in which case it should be installed as shown in section 4.6.5 *Compliance with generic emission standards* on page 48.

Figure 4-15 General EMC enclosure layout showing ground connections



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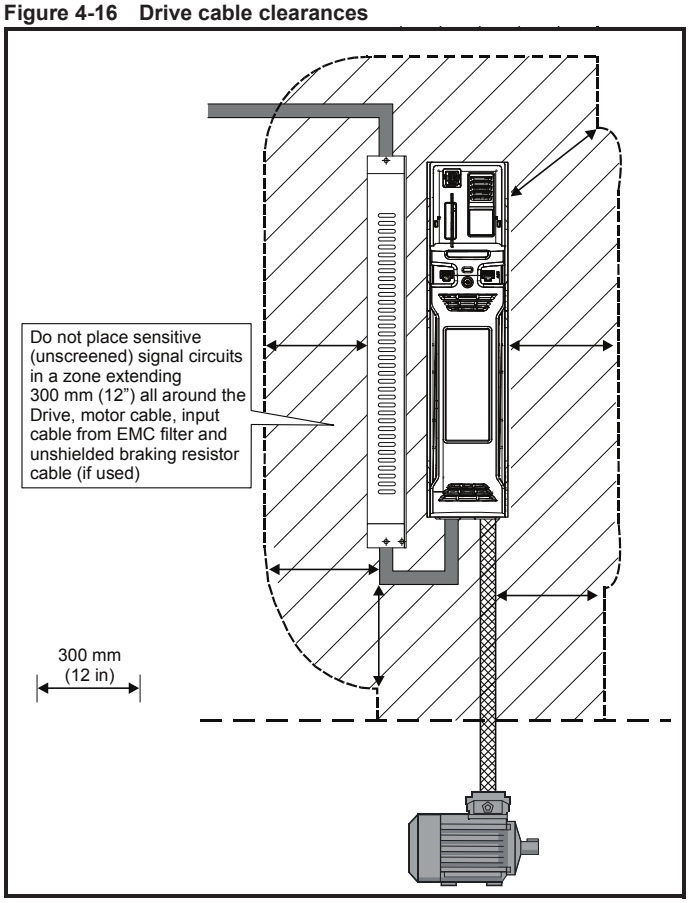
Cable layout

Figure 4-16 indicates the clearances which should be observed around the drive and related 'noisy' power cables by all sensitive control signals / equipment.

Figure 4-16 Drive cable clearances



NOTE

Any signal cables which are carried inside the motor cable (i.e. motor thermistor, motor brake) will pick up large pulse currents via the cable capacitance. The shield of these signal cables must be connected to ground close to the motor cable, to avoid this noise current spreading through the control system.

4.6.4 Compliance with EN 61800-3:2004 (standard for Power Drive Systems)

Meeting the requirements of this standard depends on the environment that the drive is intended to operate in, as follows:

Operation in the first environment

Observe the guidelines given in section 4.6.5 *Compliance with generic emission standards* on page 48. An external EMC filter will always be required.

CAUTION

This is a product of the restricted distribution class according to IEC 61800-3

In a residential environment this product may cause radio interference in which case the user may be required to take adequate measures.

Operation in the second environment

In all cases a shielded motor cable must be used, and an EMC filter is required for all drives with a rated input current of less than 100 A.

The drive contains an in-built filter for basic emission control. In some cases feeding the motor cables (U, V and W) once through a ferrite ring can maintain compliance for longer cable lengths.

For longer motor cables, an external filter is required. Where a filter is required, follow the guidelines in Section 4.6.5 *Compliance with generic emission standards* .

Where a filter is not required, follow the guidelines given in section 4.6.3 *General requirements for EMC* on page 47.

CAUTION

The second environment typically includes an industrial low-voltage power supply network which does not supply buildings used for residential purposes. Operating the drive in this environment without an external EMC filter may cause interference to nearby electronic equipment whose sensitivity has not been appreciated. The user must take remedial measures if this situation arises. If the consequences of unexpected disturbances are severe, it is recommended that the guidelines in Section 4.6.5 *Compliance with generic emission standards* be adhered to.

Refer to section 11.1.25 *Electromagnetic compatibility (EMC)* on page 108 for further information on compliance with EMC standards and definitions of environments.

Detailed instructions and EMC information are given in the *EMC Data Sheet* which is available from the supplier of the drive.

4.6.5 Compliance with generic emission standards

The following information applies to frame sizes 3 to 8.

Use the recommended filter and shielded motor cable. Observe the layout rules given in Figure 4-17.

Figure 4-17 Supply and ground cable clearance (sizes 4, 5 and 6)

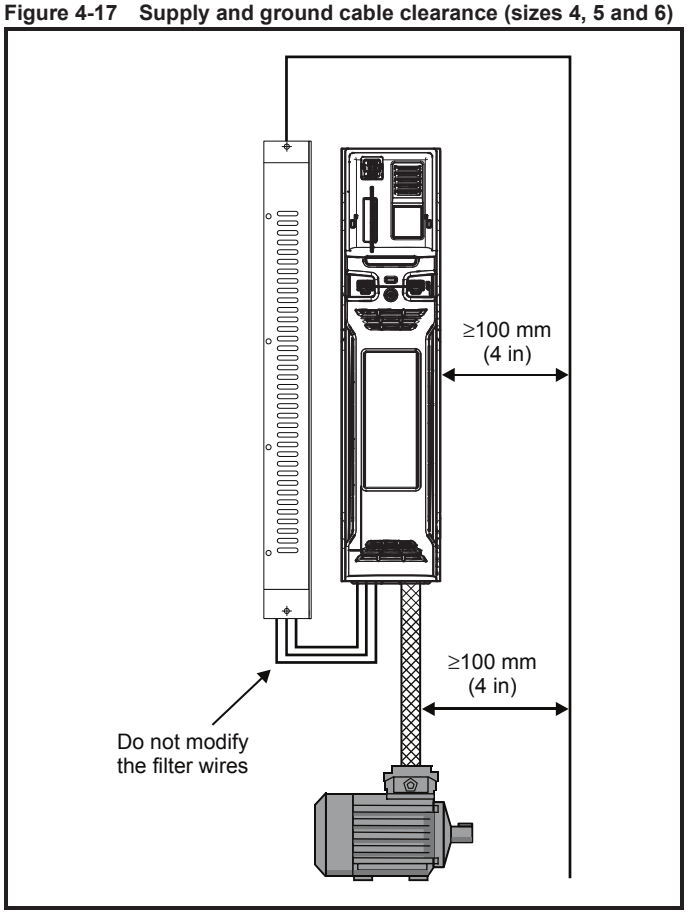


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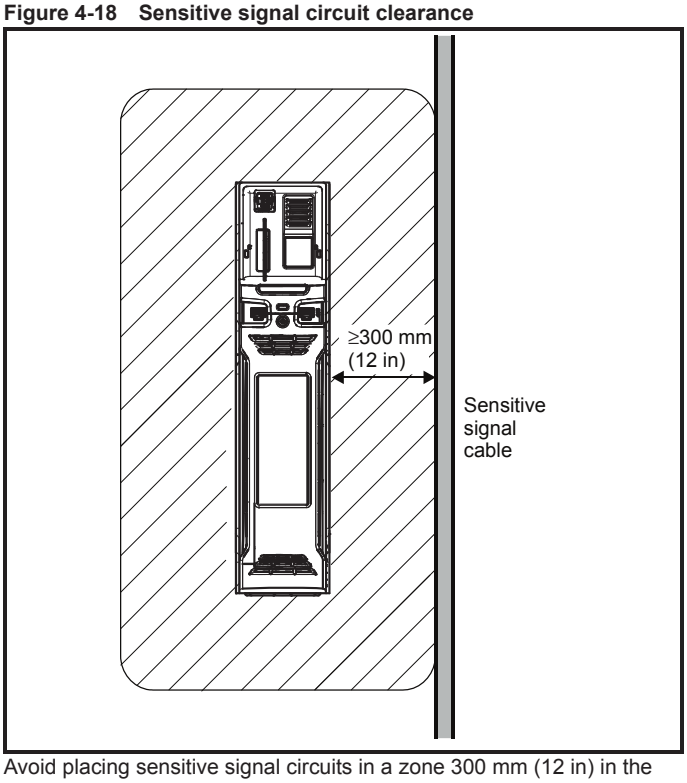
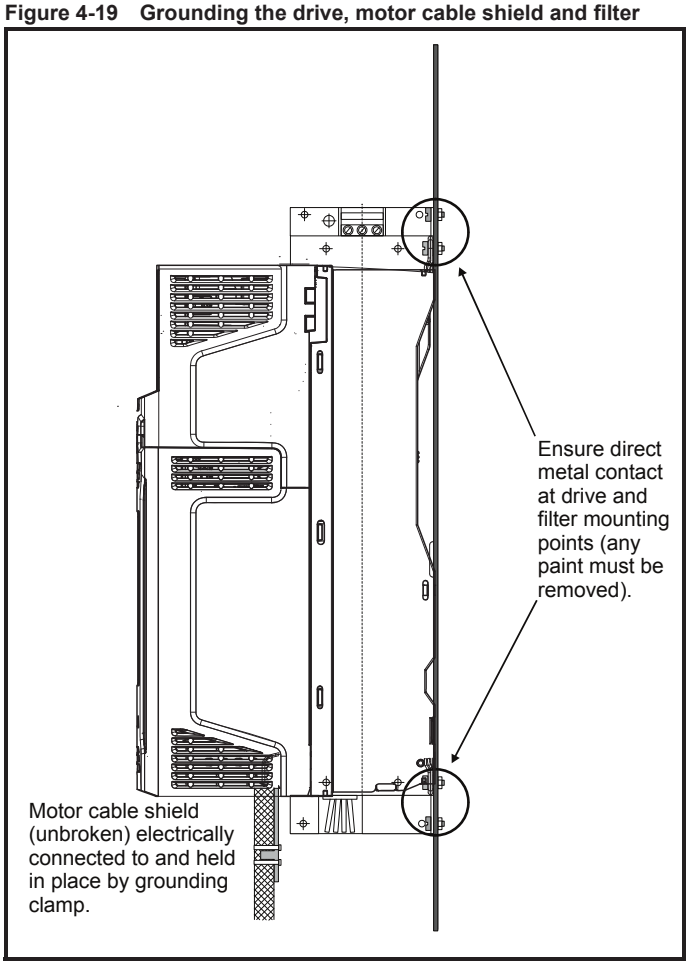
Figure 4-18 Sensitive signal circuit clearance



Avoid placing sensitive signal circuits in a zone 300 mm (12 in) in the area immediately surrounding the power module. Ensure good EMC grounding.

Figure 4-19 Grounding the drive, motor cable shield and filter

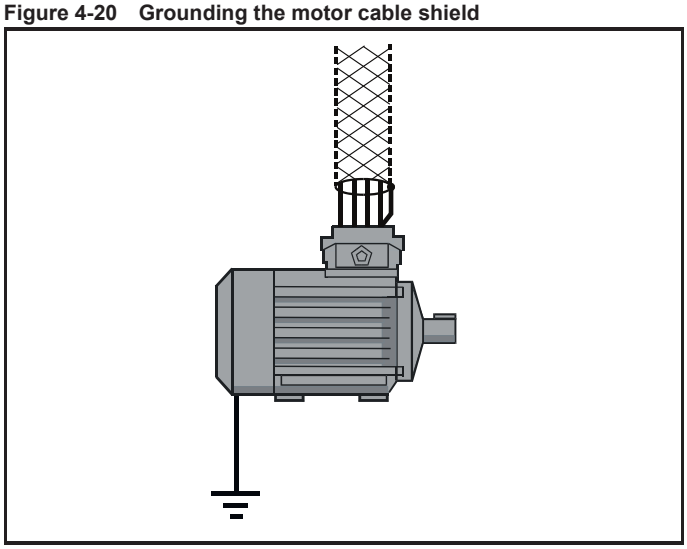


Connect the shield of the motor cable to the ground terminal of the motor frame using a link that is as short as possible and not exceeding 50 mm (2 in) long.

A complete 360° termination of the shield to the terminal housing of the motor is beneficial.

From an EMC consideration it is irrelevant whether the motor cable contains an internal (safety) ground core, or if there is a separate external ground conductor, or where grounding is through the shield alone. An internal ground core will carry a high noise current and therefore it must be terminated as close as possible to the shield termination.

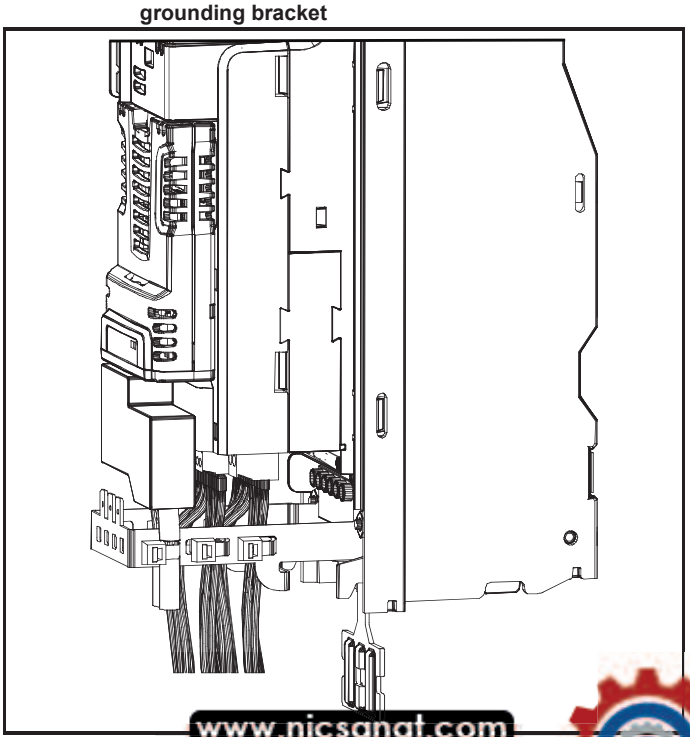
Figure 4-20 Grounding the motor cable shield



If the control wiring is to exit the enclosure, it must be shielded and the shield(s) clamped to the drive using the grounding bracket as shown in Figure 4-21. Remove the outer insulating cover of the cable to ensure the shield(s) make direct contact with the bracket, but keep the shield(s) intact until as close as possible to the terminals.

Alternatively, wiring may be passed through a ferrite ring, part number 3225-1004.

Figure 4-21 Grounding of signal cable shields using the grounding bracket



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4.6.6 Variations in the EMC wiring

Interruptions to the motor cable

The motor cable should ideally be a single length of shielded or armored cable having no interruptions. In some situations it may be necessary to interrupt the cable, as in the following examples:

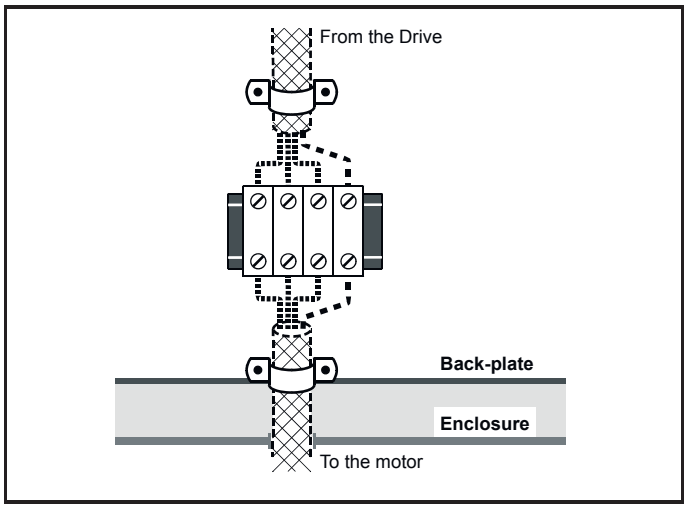
- Connecting the motor cable to a terminal block in the drive enclosure
- Installing a motor isolator / disconnect switch for safety when work is done on the motor

In these cases the following guidelines should be followed.

Terminal block in the enclosure

The motor cable shields should be bonded to the back-plate using uninsulated metal cable-clamps which should be positioned as close as possible to the terminal block. Keep the length of power conductors to a minimum and ensure that all sensitive equipment and circuits are at least 0.3 m (12 in) away from the terminal block.

Figure 4-22 Connecting the motor cable to a terminal block in the enclosure



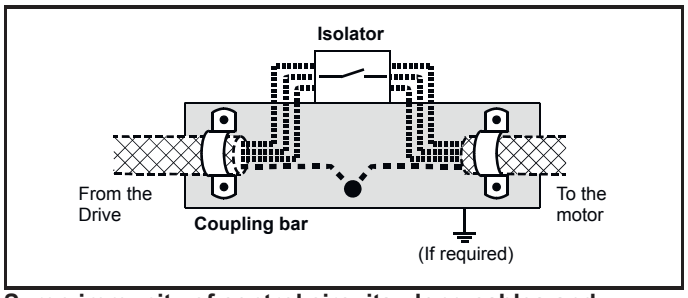
Using a motor isolator / disconnect-switch

The motor cable shields should be connected by a very short conductor having a low inductance. The use of a flat metal coupling-bar is recommended; conventional wire is not suitable.

The shields should be bonded directly to the coupling-bar using uninsulated metal cable-clamps. Keep the length of the exposed power conductors to a minimum and ensure that all sensitive equipment and circuits are at least 0.3 m (12 in) away.

The coupling-bar may be grounded to a known low-impedance ground nearby, for example a large metallic structure which is connected closely to the drive ground.

Figure 4-23 Connecting the motor cable to an isolator / disconnect switch



Surge immunity of control circuits - long cables and connections outside a building

The input/output ports for the control circuits are designed for general use within machines and small systems without any special precautions.

These circuits meet the requirements of EN 61000-6-2:2005 (1 kV surge) provided the 0 V connection is not grounded.

In applications where they may be exposed to high-energy voltage surges, some special measures may be required to prevent malfunction or damage. Surges may be caused by lightning or severe power faults in association with grounding arrangements which permit high transient voltages between nominally grounded points. This is a particular risk where the circuits extend outside the protection of a building.

As a general rule, if the circuits are to pass outside the building where the drive is located, or if cable runs within a building exceed 30 m, some additional precautions are advisable. One of the following techniques should be used:

1. Galvanic isolation, i.e. do not connect the control 0 V terminal to ground. Avoid loops in the control wiring, i.e. ensure every control wire is accompanied by its return (0 V) wire.
2. Shielded cable with additional power ground bonding. The cable shield may be connected to ground at both ends, but in addition the ground conductors at both ends of the cable must be bonded together by a power ground cable (equipotential bonding cable) with cross-sectional area of at least 10 mm^2, or 10 times the area of the signal cable shield, or to suit the electrical safety requirements of the plant. This ensures that fault or surge current passes mainly through the ground cable and not in the signal cable shield. If the building or plant has a well-designed common bonded network this precaution is not necessary.
3. Additional over-voltage suppression - for the analog and digital inputs and outputs, a zener diode network or a commercially available surge suppressor may be connected in parallel with the input circuit as shown in Figure 4-24 and Figure 4-25.

If a digital port experiences a severe surge its protective trip may operate (I/O Overload trip). For continued operation after such an event, the trip can be reset automatically by setting Pr **10.034** to 5.

Figure 4-24 Surge suppression for digital and unipolar inputs and outputs

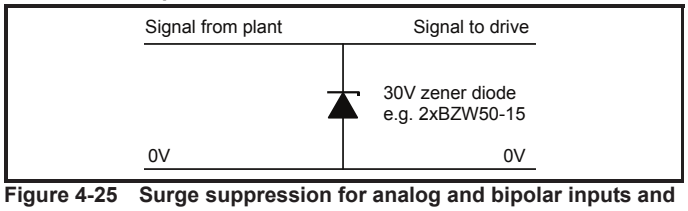
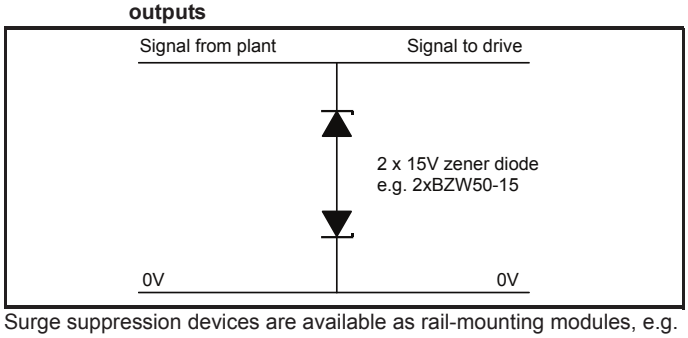


Figure 4-25 Surge suppression for analog and bipolar inputs and outputs



Surge suppression devices are available as rail-mounting modules, e.g. from Phoenix Contact:

Unipolar TT-UKK5-D/24 DC
Bipolar TT-UKK5-D/24 AC

These devices are not suitable for encoder signals or fast digital data networks because the capacitance of the diodes adversely affects the signal. Most encoders have galvanic isolation of the signal circuit from the motor frame, in which case no precautions are required. For data networks, follow the specific recommendations for the particular network.

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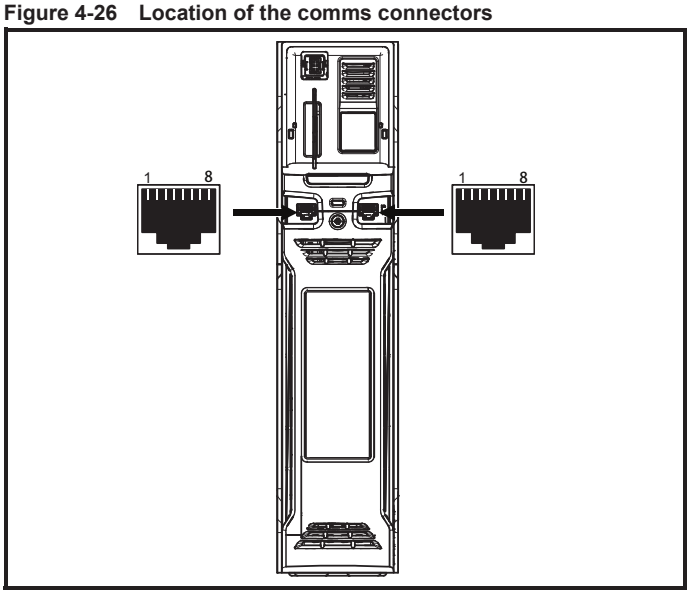
4.7 Communications connections

The drive offers a 2 wire 485 interface. This enables the drive set-up, operation and monitoring to be carried out with a PC or controller if required.

Figure 4-26 Location of the comms connectors



The 485 option provides two parallel RJ45 connectors are provided allowing easy daisy chaining. The drive only supports MODBUS RTU protocol. See Table 4-13 for the connection details.

NOTE

Standard Ethernet cables are not recommended for use when connecting drives on a 485 network as they do not have the correct twisted pairs for the pinout of the serial comms port.

Table 4-13 Serial communication port pin-outs

Pin	Function
1	120 Ω Termination resistor
2	RX TX (Receive / transmit line - positive)
3	Isolated 0 V
4	+24 V (100 mA)
5	Isolated 0 V
6	TX enable
7	RX\ TX\ (Receive / transmit line - negative)
8	RX\ TX\ (if termination resistors are required, link to pin 1)
Shell	Isolated 0 V

Minimum number of connections are 2, 3, 7 and shield.

4.7.1 Isolation of the 485 serial communications port

The serial PC communications port is double insulated and meets the requirements for SELV in EN 50178:1998.

WARNING

In order to meet the requirements for SELV in IEC60950 (IT equipment) it is necessary for the control computer to be grounded. Alternatively, when a lap-top or similar device is used which has no provision for grounding, an isolation device must be incorporated in the communications lead.

An isolated serial communications lead has been designed to connect the drive to IT equipment (such as laptop computers), and is available from the supplier of the drive. See below for details:

Table 4-14 Isolated serial comms lead details

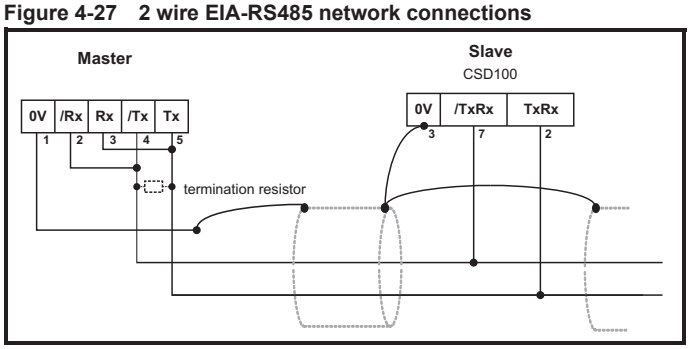
Part number	Description
4500-0096	CT USB Comms cable

The “isolated serial communications” lead has reinforced insulation as defined in IEC60950 for altitudes up to 3,000 m.

4.7.2 2 wire EIA-RS485 network

The diagram below shows the connections required for a 2 wire EIA-RS485 network, using a master controller with an EIA-RS485 port.

Figure 4-27 2 wire EIA-RS485 network connections



NOTE

If more than one drive is connected to a host computer / PLC etc, each drive must have a unique serial address see Section 10.2 *Slave address* and Section 5.10 *Communications*

Any number in the permitted range 1 to 247 may be used.

4.7.3 Routing of the cable

A data communications cable should not run parallel to any power cables, especially ones that connect drives to motors. If parallel runs are unavoidable, ensure a minimum spacing of 300 mm (1 ft) between the communications cable and the power cable.

Cables crossing one another at right-angles are unlikely to give trouble. The maximum cable length for a EIA-RS485 jumper (link) is 1200 metres (4,000 ft). This is at low baud rates only. The higher the baud rate the lower the maximum cable length.

4.7.4 Termination

When a long-distance multi-drop EIA-RS485 system is used, the transmit and receive pairs should have a termination resistor of 120 W installed across them in order to reduce signal reflections. However, at the lower data rates this is not so critical.

4.8 Control connections

4.8.1 General

Table 4-15 The control connections consist of:

Function	Qty	Control parameters available	Terminal number
Differential analog input	1	Mode, offset, invert, scaling	5, 6
Single ended analog input	2	Mode, offset, invert, scaling, destination	7, 8
Analog output	2	Source, mode, scaling,	9, 10
Digital input	3	Destination, invert, logic select	27, 28, 29
Digital input / output	3	Input / output mode select, destination / source, invert, logic select	24, 25, 26
Relay	1	Source, invert	41, 42
Drive enable (SAFE TORQUE OFF)	1		31
+10 V User output	1		4
+24 V User output	1	Source, invert	22
0V common	6		1, 3, 11, 21, 23, 30
+24V External input	1	Destination, invert	2

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Key:

Destination parameter:	Indicates the parameter which is being controlled by the terminal / function
Source parameter:	Indicates the parameter being output by the terminal
Mode parameter:	Analog - indicates the mode of operation of the terminal, i.e. voltage 0-10 V, current 4-20 mA etc. Digital - indicates the mode of operation of the terminal, i.e. positive / negative logic (the Drive Enable terminal is fixed in positive logic), open collector.

All analog terminal functions can be programmed in menu 7.
All digital terminal functions (including the relay) can be programmed in menu 8.

WARNING

The control circuits are isolated from the power circuits in the drive by basic insulation (single insulation) only. The installer must ensure that the external control circuits are insulated from human contact by at least one layer of insulation (supplementary insulation) rated for use at the AC supply voltage.

WARNING

If the control circuits are to be connected to other circuits classified as Safety Extra Low Voltage (SELV) (e.g. to a personal computer), an additional isolating barrier must be included in order to maintain the SELV classification.

CAUTION

If any of the digital inputs (including the drive enable input) are connected in parallel with an inductive load (i.e. contactor or motor brake) then suitable suppression (i.e. diode or varistor) should be used on the coil of the load. If no suppression is used then over voltage spikes can cause damage to the digital inputs and outputs on the drive.

CAUTION

Ensure the logic sense is correct for the control circuit to be used. Incorrect logic sense could cause the motor to be started unexpectedly.
Positive logic is the default state for the drive.

NOTE

Any signal cables which are carried inside the motor cable (i.e. motor thermistor, motor brake) will pick up large pulse currents via the cable capacitance. The shield of these signal cables must be connected to ground close to the point of exit of the motor cable, to avoid this noise current spreading through the control system.

NOTE

The SAFE TORQUE OFF drive enable terminal is a positive logic input only. It is not affected by the setting of *Input Logic Polarity* (08.029).

NOTE

The common 0 V from analog signals should, wherever possible, not be connected to the same 0 V terminal as the common 0 V from digital signals. Terminals 3 and 11 should be used for connecting the 0 V common of analog signals and terminals 21, 23 and 30 for digital signals. This is to prevent small voltage drops in the terminal connections causing inaccuracies in the analog signals.

4.9 CSD100 specific Input/Output and control

4.9.1 Analog signals

A discharge Line Temperature signal must be present and its range checked to prove that it is not short circuit.

- Analog input 2. [Optional] (Terminal 7 on drive). Analog speed reference input (0 to 10 V).
- Analog input 3. [Optional] (Connected between terminals 8 and 11 on drive) DLT sensor input.

NOTE

To use the analogue speed reference input:-

- Set parameter Pr **07.012** to equal 0.220 to provide a scaling of 10 V gives 7200 rpm.
- Set parameter Pr **07.014** to equal 18.011 to route the scaled reference to the "User speed reference in RPM"
- Save and press the reset (red) button to action this change.

4.9.2 Digital signals

Digital signals are used in controlling and resetting the drive:

- Drive hardware enable [Required] (Terminal 31 on drive)
- Reset (triggered on transition from low to high) [optional] Digital input 2 (Terminal 25 on drive)
- Start/Run [optional] Digital input 3 (Terminal 26 on drive)
- Stator heating during idle enable [optional] (Terminal 27 on drive)

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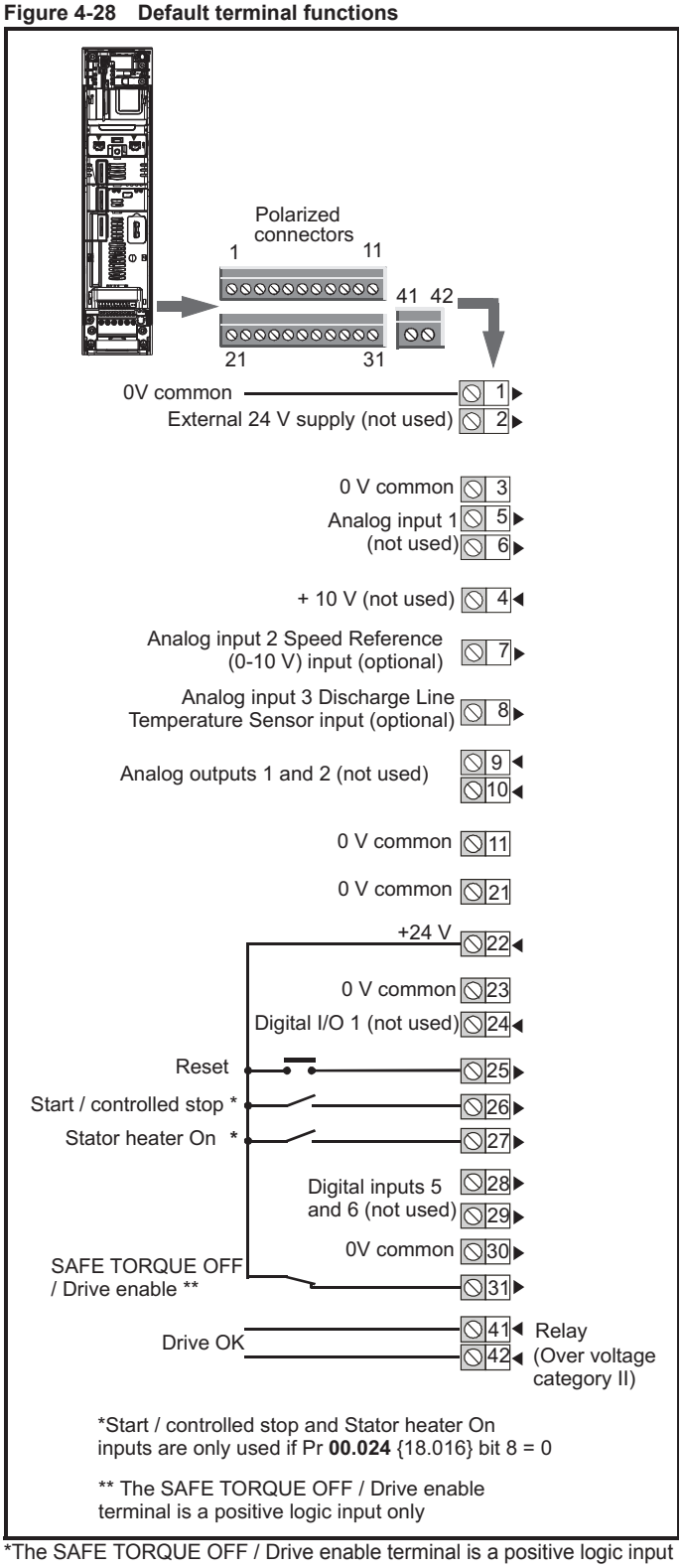
4.9.3 Control terminal configuration diagram

Figure 4-28 Default terminal functions



*The SAFE TORQUE OFF / Drive enable terminal is a positive logic input only.

4.9.4 Control terminal specification

1	0V common
Function	**Common connection for all external devices**

2	+24V external input
Function	**To supply the control circuit without providing a supply to the power stage**
Programmability	Can be switched on or off to act as a digital input by setting the source Pr **08.063** and input invert Pr **08.053**
Nominal voltage	+24.0 Vdc
Minimum continuous operating voltage	+19.2 Vdc
Maximum continuous operating voltage	+30.0 Vdc
Minimum start-up voltage	21.6 Vdc
Recommended power supply	40 W 24 Vdc nominal
Recommended fuse	3 A, 50 Vdc

3	0V common
Function	**Common connection for all external devices**

4	+10V user output
Function	**Supply for external analog devices**
Voltage	10.2 V nominal
Voltage tolerance	±1 %
Nominal output current	10 mA
Protection	Current limit and trip @ 30 mA

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	Precision reference Analog input 1
5	Non-inverting input
6	Inverting input

Default function	Not used
Type of input	Bipolar differential analog voltage or current, thermistor input
Mode controlled by:	Pr **07.007**
Operating in Voltage mode	
Full scale voltage range	±10 V ±2 %
Maximum offset	±10 mV
Absolute maximum voltage range	±36 V relative to 0 V
Working common mode voltage range	±13 V relative to 0 V
Input resistance	≥100 kΩ
Monotonic	Yes (including 0 V)
Dead band	None (including 0 V)
Jumps	None (including 0 V)
Maximum offset	20 mV
Maximum non linearity	0.3% of input
Maximum gain asymmetry	0.5 %
Input filter bandwidth single pole	~3 kHz
Operating in current mode	
Current ranges	0 to 20 mA ±5 %, 20 to 0 mA ±5 %, 4 to 20 mA ±5 %, 20 to 4 mA ±5 %
Maximum offset	250 µA
Absolute maximum voltage (reverse biased)	±36 V relative to 0 V
Equivalent input resistance	≤300 Ω
Absolute maximum current	±30 mA
Operating in thermistor input mode (in conjunction with analog input 3)	
Internal pull-up voltage	2.5 V
Trip threshold resistance	User defined in Pr **07.048**
Short-circuit detection resistance	50 Ω ± 40 %
Common to all modes	
Resolution	12 bits (11 bits plus sign)
Sample / update period	250 µs with destinations Pr **01.036**, Pr **01.037**, Pr **03.022** or Pr **04.008** in RFC-A and RFC-S modes. 4 ms for open loop mode and all other destinations in RFC-A or RFC-S modes.

7	Analog input 2

Default function	Speed reference
Type of input	Bipolar single-ended analog voltage or unipolar current
Mode controlled by...	Pr **07.011**
Operating in voltage mode	
Full scale voltage range	±10 V ±2 %
Maximum offset	±10 mV
Absolute maximum voltage range	±36 V relative to 0 V
Input resistance	≥100 k Ω
Operating in current mode	
Current ranges	0 to 20 mA ±5 %, 20 to 0 mA ±5 %, 4 to 20 mA ±5 %, 20 to 4 mA ±5 %
Maximum offset	250 µA
Absolute maximum voltage (reverse bias)	±36 V relative to 0V
Absolute maximum current	±30 mA
Equivalent input resistance	≤ 300 Ω
Common to all modes	
Resolution	12 bits (11 bits plus sign)
Sample / update	250 µs with destinations Pr **01.036**, Pr **01.037** or Pr **03.022,** Pr **04.008** in RFC-A or RFC-S. 4ms for open loop mode and all other destinations in RFC-A or RFC-S mode.

8	Analog input 3

Default function	Discharge line temperature sensor input
Type of input	Bipolar single-ended analog voltage, or thermistor input
Mode controlled by...	Pr **07.015**
Operating in Voltage mode (default)	
Voltage range	±10 V ±2 %
Maximum offset	±10 mV
Absolute maximum voltage range	±36 V relative to 0 V
Input resistance	≥100 k Ω
Operating in thermistor input mode	
Supported thermistor types	Din 4408, KTY 84, PT100, PT 1000, PT 2000
Internal pull-up voltage	2.5 V
Trip threshold resistance	User defined in Pr **07.048**
Reset resistance	User defined in Pr **07.048**
Short-circuit detection resistance	50 Ω ± 40 %
Common to all modes	
Resolution	12 bits (11 bits plus sign)
Sample / update period	250 µs with destinations Pr **01.036**, Pr **01.037**, Pr **03.022** or Pr **04.008** in RFC-A and RFC-S modes. 4ms for open loop mode and all other destinations in RFC-A or RFC-S mode.

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9	**Analog output 1**
10	**Analog output 2**
Terminal 9 default function	**Not used**
Terminal 10 default function	**Not used**
Type of output	Bipolar single-ended analog voltage
Operating in Voltage mode (default)	
Voltage range	±10 V ±5 %
Maximum offset	±120 mV
Maximum output current	±20 mA
Load resistance	≥1 k Ω
Protection	20 mA max. Short circuit protection
Common to all modes	
Resolution	10-bit
Sample / update period	250 µs (output will only change at update the rate of the source parameter if slower)

11	**0V common**
Function	**Common connection for all external devices**

21	**0V common**
Function	**Common connection for all external devices**

22	**+24 V user output (selectable)**
Terminal 22 default function	**+24 V user output**
Programmability	Can be switched on or off to act as a fourth digital output (positive logic only) by setting the source Pr **08.028** and source invert Pr **08.018**
Nominal output current	100 mA combined with DIO3
Maximum output current	100 mA 200 mA (total including all Digital I/O)
Protection	Current limit and trip
Sample / update period	2 ms when configured as an output (output will only change at the update rate of the source parameter if slower)

23	**0V common**
Function	**Common connection for all external devices**

24	**Digital I/O 1**
25	**Digital I/O 2**
26	**Digital I/O 3**
Terminal 24 default function	**Not used**
Terminal 25 default function	**DRIVE RESET input**
Terminal 26 default function	**Start / Controlled stop**
Type	Positive or negative logic digital inputs, positive logic voltage source outputs
Input / output mode controlled by...	Pr **08.031**, Pr **08.032** and Pr **08.033**
Operating as an input	
Logic mode controlled by...	Pr **08.029**
Absolute maximum applied voltage range	-3 V to +30 V
Impedance	>2 mA @15 V from IEC 61131-2, type 1, 6.6 k Ω
Input thresholds	10 V ±0.8 V from IEC 61131-2, type 1
Operating as an output	
Nominal maximum output current	100 mA (DIO1 & 2 combined) 100 mA (DIO3 & 24 V User Output Combined)
Maximum output current	100 mA 200 mA (total including all Digital I/O)
Common to all modes	
Voltage range	0 V to +24 V
Sample / Update period	250 µs when configured as an input with destinations Pr **06.035** or Pr **06.036**. 2 ms when configured as an output (output will only change at the update rate of the source parameter

27	**Digital Input 4**
28	**Digital Input 5**
Terminal 27 default function	**Stator heater on**
Terminal 28 default function	**Not used**
Type	Negative or positive logic digital inputs
Logic mode controlled by...	Pr **08.029**
Voltage range	0 V to +24 V
Absolute maximum applied voltage range	-3 V to +30 V
Impedance	>2 mA @15 V from IEC 61131-2, type 1, 6.6 k Ω
Input thresholds	10 V ±0.8 V from IEC 61131-2, type 1
Sample / Update period	250 µs when configured as an input with destinations Pr **06.035** or Pr **06.036**. 600 µs when configured as an input with destination Pr **06.029**. 2 ms in all other cases.

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29	Digital Input 6
Terminal 29 default function	**Not used**
Type	Negative or positive logic digital inputs
Logic mode controlled by...	Pr **08.029**
Voltage range	0 V to +24 V
Absolute maximum applied voltage range	-3 V to +30 V
Impedance	>2 mA @15 V from IEC 61131-2, type 1, 6.6 k Ω
Input thresholds	10 V ±0.8 V from IEC 61131-2, type 1
Sample / Update period	250 µs when configured as an input with destinations Pr **06.035** or Pr **06.036**. 2 ms in all other cases.

30	0V common
Function	**Common connection for all external devices**

Refer to section 4.10 *SAFE TORQUE OFF (STO)* on page 56 for further information.

31	SAFE TORQUE OFF function (drive enable)
Type	Positive logic only digital input
Voltage range	0 V to +24 V
Absolute maximum applied voltage	30 V
Logic Threshold	10 V ± 5 V
Low state maximum voltage for disable to SIL3 and PL e	5 V
Impedance	>4 mA @15 V from IEC 61131-2, type 1, 3.3 k Ω
Low state maximum current for disable to SIL3 and PL e	0.5 mA
Response time	Nominal: 8 ms Maximum: 20 ms
The SAFE TORQUE OFF function may be used in a safety-related application in preventing the drive from generating torque in the motor to a high level of integrity. The system designer is responsible for ensuring that the complete system is safe and designed correctly according to the relevant safety standards. If the SAFE TORQUE OFF function is not required, this terminal is used for enabling the drive.	

41 42	Relay contacts
Default function	**Drive OK indicator**
Contact voltage rating	240 Vac, Installation over-voltage category II
Contact maximum current rating	2 A AC 240 V 4 A DC 30 V resistive load 0.5 A DC 30 V inductive load (L/R = 40 ms)
Contact minimum recommended rating	12 V 100 mA
Contact type	Normally open
Default contact condition	Closed when power applied and drive OK
Update period	4 ms

51 52	0 V +24 Vdc
Nominal operating voltage	24.0 Vdc
Minimum continuous operating voltage	18.6 Vdc
Maximum continuous operating voltage	28.0 Vdc
Minimum startup voltage	18.4 Vdc
Maximum power supply requirement	40 W
Recommended fuse	4 A @ 50 Vdc

WARNING To prevent the risk of a fire hazard in the event of a fault, a fuse or other over-current protection must be installed in the relay circuit.

4.10 SAFE TORQUE OFF (STO)

The SAFE TORQUE OFF function provides a means for preventing the drive from generating torque in the motor, with a very high level of integrity. It is suitable for incorporation into a safety system for a machine. It is also suitable for use as a conventional drive enable input.

The safety function is active when the STO input is in the logic-low state as specified in the control terminal specification. The function is defined according to EN 61800-5-2 and IEC 61800-5-2 as follows. (In these standards a drive offering safety-related functions is referred to as a PDS(SR)):

'Power, that can cause rotation (or motion in the case of a linear motor), is not applied to the motor. The PDS(SR) will not provide energy to the motor which can generate torque (or force in the case of a linear motor)'.

This safety function corresponds to an uncontrolled stop in accordance with stop category 0 of IEC 60204-1.

The SAFE TORQUE OFF function makes use of the special property of an inverter drive with an induction motor, which is that torque cannot be generated without the continuous correct active behavior of the inverter circuit. All credible faults in the inverter power circuit cause a loss of torque generation.

The SAFE TORQUE OFF function is fail-safe, so when the SAFE TORQUE OFF input is disconnected the drive will not operate the motor, even if a combination of components within the drive has failed. Most component failures are revealed by the drive failing to operate. SAFE TORQUE OFF is also independent of the drive firmware. This meets the requirements of the following standards, for the prevention of operation of the motor.

Data as verified by TÜV Rheinland:

According to EN ISO 13849-1:

PL = e

Category = 4

$MTTF_D$ = High

DC_{av} = High

Mission Time and Proof Test Interval = 20 years

The calculated $MTTF_D$ for the complete STO function is:

STO1 2574 yr

According to EN 61800-5-2:

SIL = 3

PFH = 4.21 x 10^{-11} h^{-1}

The SAFE TORQUE OFF input also meets the requirements of EN 81-1 (clause 12.7.3 b) as part of a system for preventing unwanted operation of the motor in a lift (elevator).

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SAFE TORQUE OFF can be used to eliminate electro-mechanical contactors, including special safety contactors, which would otherwise be required for safety applications.

The function can be used in safety-related machines or systems which have been designed according to IEC 62061 or IEC 61508, or other standards which are compatible with IEC 61508, since the analysis and the integrity metrics used in EN 61800-5-2 are the same.

Note on response time of SAFE TORQUE OFF, and use with safety controllers with self-testing outputs.
SAFE TORQUE OFF has been designed to have a response time of greater than 1 ms, so that it is compatible with safety controllers whose outputs are subject to a dynamic test with a pulse width not exceeding 1 ms.

Note on the use of servo motors, other permanent-magnet motors, reluctance motors and salient-pole induction motors.
When the drive is disabled through SAFE TORQUE OFF, a possible (although highly unlikely) failure mode is for two power devices in the inverter circuit to conduct incorrectly.

This fault cannot produce a steady rotating torque in any AC motor. It produces no torque in a conventional induction motor with a cage rotor. If the rotor has permanent magnets and/or saliency, then a transient alignment torque may occur. The motor may briefly try to rotate by up to 180° electrical, for a permanent magnet motor, or 90° electrical, for a salient pole induction motor or reluctance motor. This possible failure mode must be allowed for in the machine design.

WARNING
The design of safety-related control systems must only be done by personnel with the required training and experience. The SAFE TORQUE OFF function will only ensure the safety of a machine if it is correctly incorporated into a complete safety system. The system must be subject to a risk assessment to confirm that the residual risk of an unsafe event is at an acceptable level for the application.

WARNING
SAFE TORQUE OFF inhibits the operation of the drive, this includes inhibiting braking. If the drive is required to provide both braking and SAFE TORQUE OFF in the same operation (e.g. for emergency stop) then a safety timer relay or similar device must be used to ensure that the drive is disabled a suitable time after braking. The braking function in the drive is provided by an electronic circuit which is not fail-safe. If braking is a safety requirement, it must be supplemented by an independent fail-safe braking mechanism.

WARNING
SAFE TORQUE OFF does not provide electrical isolation. The supply to the drive must be disconnected by an approved isolation device before gaining access to power connections.

With SAFE TORQUE OFF there are no single faults in the drive which can permit the motor to be driven. Therefore it is not necessary to have a second channel to interrupt the power connection, nor a fault detection circuit.

It is important to note that a single short-circuit from the SAFE TORQUE OFF input to a DC supply of approximately +24 V would cause the drive to be enabled. This can be excluded under EN ISO 13849-2 by the use of protected wiring. The wiring can be protected by either of the following methods:

- By placing the wiring in a segregated cable duct or other enclosure.

or

- By providing the wiring with a grounded shield in a positive-logic grounded control circuit. The shield is provided to avoid a hazard from an electrical fault. It may be grounded by any convenient method; no special EMC precautions are required.

WARNING
It is essential to observe the maximum permitted voltage of 5 V for a safe low (disabled) state of SAFE TORQUE OFF. The connections to the drive must be arranged so that voltage drops in the 0 V wiring cannot exceed this value under any loading condition. It is strongly recommended that the SAFE TORQUE OFF circuit be provided with a dedicated 0 V conductor which should be connected to terminal 30 at the drive.

SAFE TORQUE OFF over-ride

The drive does not provide any facility to over-ride the SAFE TORQUE OFF function, for example for maintenance purposes.

For more information regarding the SAFE TORQUE OFF input, please see the *Control Techniques Safe Torque Off Engineering Guide* available for download from www.controltechniques.com.

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5 Getting started

This chapter introduces the user interfaces, menu structure and security levels of the drive.

5.1 Understanding the display

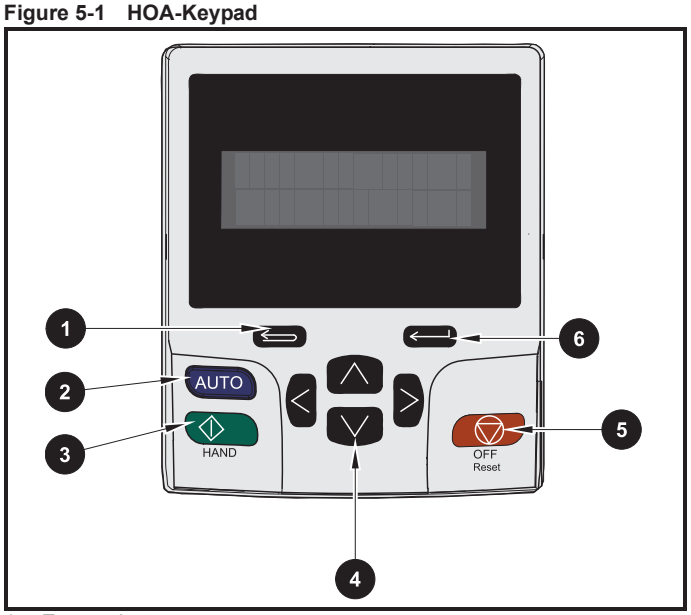
The keypad can only be mounted on the drive.

5.1.1 HOA-Keypad

The HOA-Keypad display consists of two rows of text. The upper row shows the drive status or the menu and parameter number currently being viewed. The lower row of the display line shows the parameter value or the specific trip type. The last two characters on the first row may display special indications. If more than one of these indications is active then the indications are prioritized as shown in Table 5-2.

When the drive is powered up the lower row will show the power up parameter defined by *Parameter Displayed At Power-Up* (11.022).

Figure 5-1 HOA-Keypad



1. Escape button
2. Auto (blue) button
3. Hand (green)
4. Navigation keys (x4)
5. Stop / Reset / OFF (red) button
6. Enter button

NOTE

The red stop button is also used to reset the drive.

The parameter value is correctly displayed in the lower row of the keypad display, see table below.

Table 5-1 Keypad display formats

Display formats	Value
IP Address	127.000.000.000
MAC Address	01ABCDEF2345
Time	12:34:56
Date	31-12-11 or 12-31-11
Version number	01.02.02.00
Character	ABCD
32 bit number with decimal point	21474836.47
16 bit binary number	0100001011100101

Table 5-2 Active action icon

Active action icon	Description	Row (1=top)	Priority in row
	Accessing non-volatile media card	1	1
	Alarm active	1	2
	Keypad real-time clock battery low	1	3
or	Drive security active and locked or unlocked	1	4

5.2 Keypad operation

5.2.1 Control buttons

The keypad consists of:

- Navigation Keys - Used to navigate the parameter structure and change parameter values.
- Enter / Mode button - Used to toggle between parameter edit and view mode.
- Escape / Exit button - Used to exit from parameter edit or view mode. In parameter edit mode, if parameter values are edited and the exit button pressed the parameter value will be restored to the value it had on entry to edit mode.
- Hand button - Not used.
- Auto button - Not used.
- Stop / Reset / OFF button - Used to reset the drive.

NOTE

Low battery voltage is indicated by low battery symbol on the keypad display. Refer to section 3.12.1 *Real time clock battery replacement* on page 35 for information on battery replacement.

Figure 5-2 overleaf shows an example on moving between menus and editing parameters.

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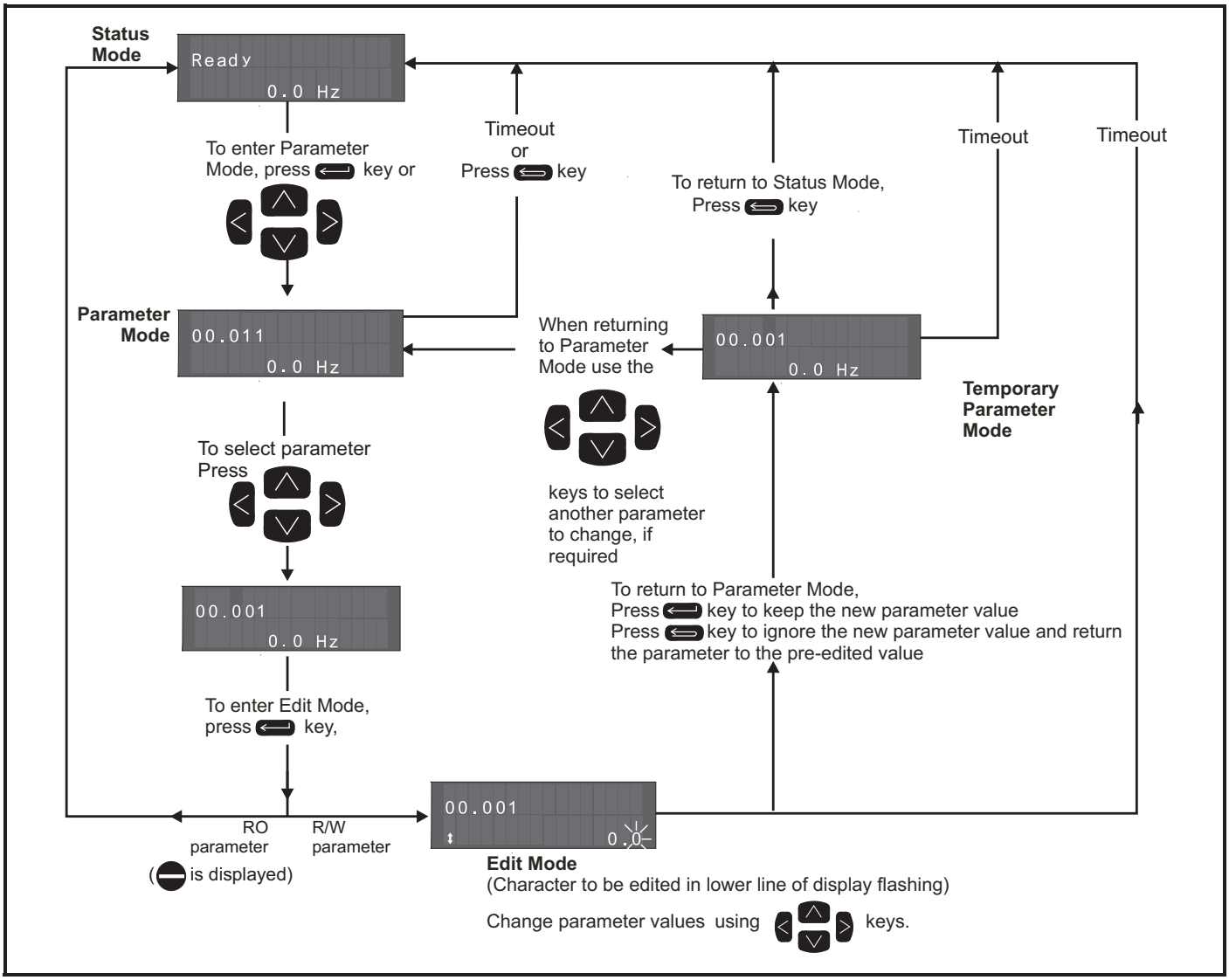
Figure 5-2 Display modes



NOTE

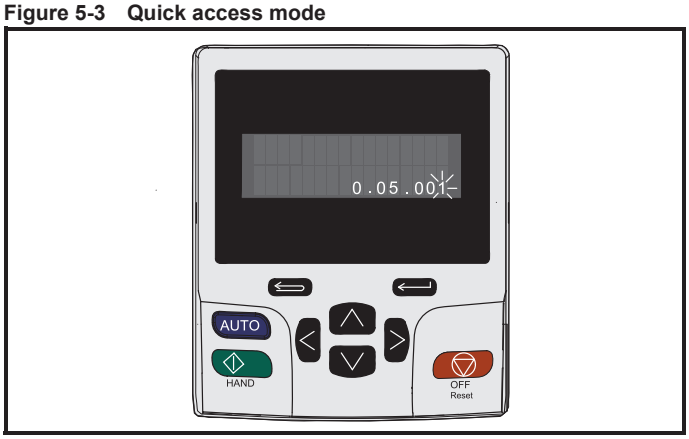
The navigation keys can only be used to move between menus if Pr **00.049** has been set to show 'All Menus'. Refer to section 5.7 *Parameter access level and security* on page 62.

5.2.2 Quick access mode

The quick access mode allows direct access to any parameter without scrolling through menus and parameters.

To enter the quick access mode, press and hold the Enter button on the keypad while in 'parameter mode'.

Figure 5-3 Quick access mode



5.2.3 Keypad shortcuts

In 'parameter mode':

- If the up and down keypad buttons are pressed together, then the keypad display will jump to the start of the parameter menu being viewed, i.e. Pr **05.005** being viewed, when the above buttons pressed together will jump to Pr **05.000**.
- If the left and right keypad buttons are pressed together, then the keypad display will jump to the last viewed parameter in Menu 0.

In 'parameter edit mode':

- If the up and down keypad buttons are pressed together, then the parameter value of the parameter being edited will be set to 0.
- If the left and right keypad buttons are pressed together, the least significant digit (furthest right) will be selected on the keypad display for editing.

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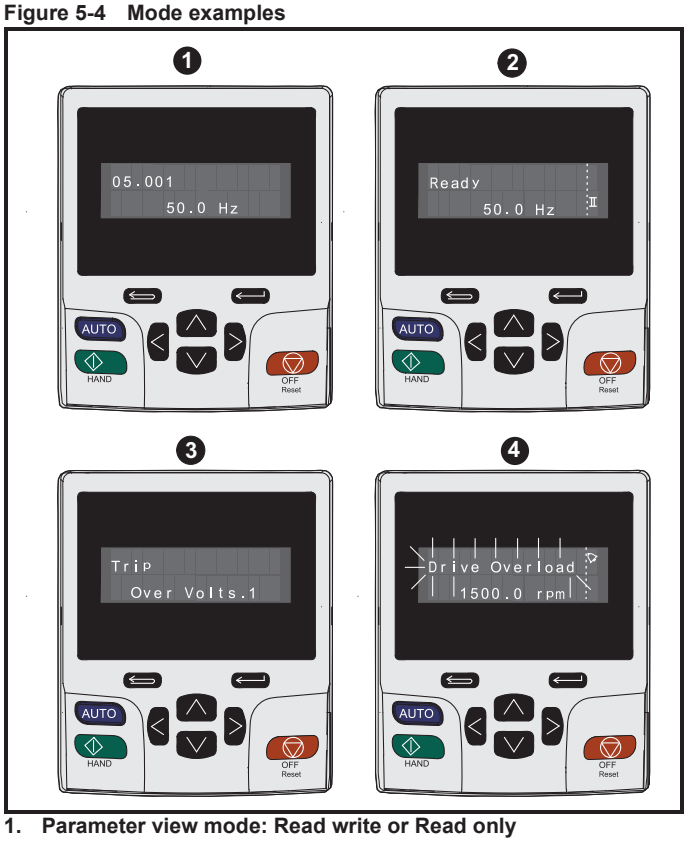
Figure 5-4 Mode examples



1. **Parameter view mode: Read write or Read only**
2. **Status mode: Drive OK status**

If the drive is ok and the parameters are not being edited or viewed, the upper row of the display will show one of the following:

- 'Inhibit', 'Ready' or 'Run'.

3. **Status mode: Trip status**

When the drive is in trip condition, the upper row of the display will indicate that the drive has tripped and the lower row of the display will show the trip code. For further information regarding trip codes. refer to Table 12-10 *Trip indications* on page 117.

4. **Status mode: Alarm status**

During an 'alarm' condition the upper row of the display flashes between the drive status (Inhibit, Ready or Run, depending on what is displayed) and the alarm.

WARNING

Do not change parameter values without careful consideration; incorrect values may cause damage or a safety hazard.

NOTE

When changing the values of parameters, make a note of the new values in case they need to be entered again.

NOTE

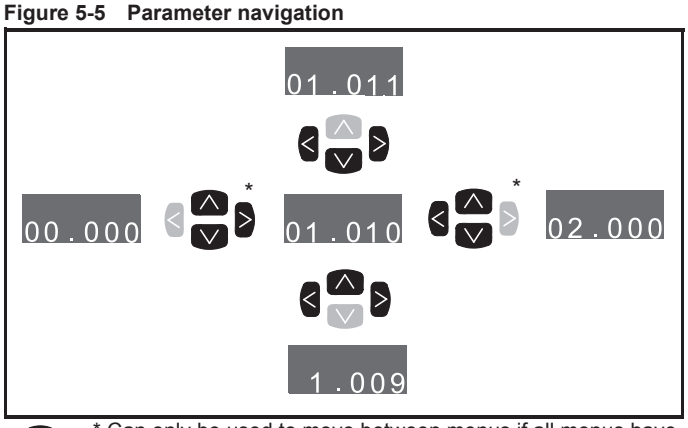
For new parameter-values to apply after the line power supply to the drive is interrupted, new values must be saved. Refer to section 5.6 *Saving parameters* on page 62.

5.3 Menu structure

The drive parameter structure consists of menus and parameters.

The drive initially powers up so that only Menu 0 can be viewed. The up and down arrow buttons are used to navigate between parameters and once Pr **00.049** has been set to 'All Menus' the left and right buttons are used to navigate between menus. For further information, refer to section 5.7 *Parameter access level and security* on page 62

Figure 5-5 Parameter navigation



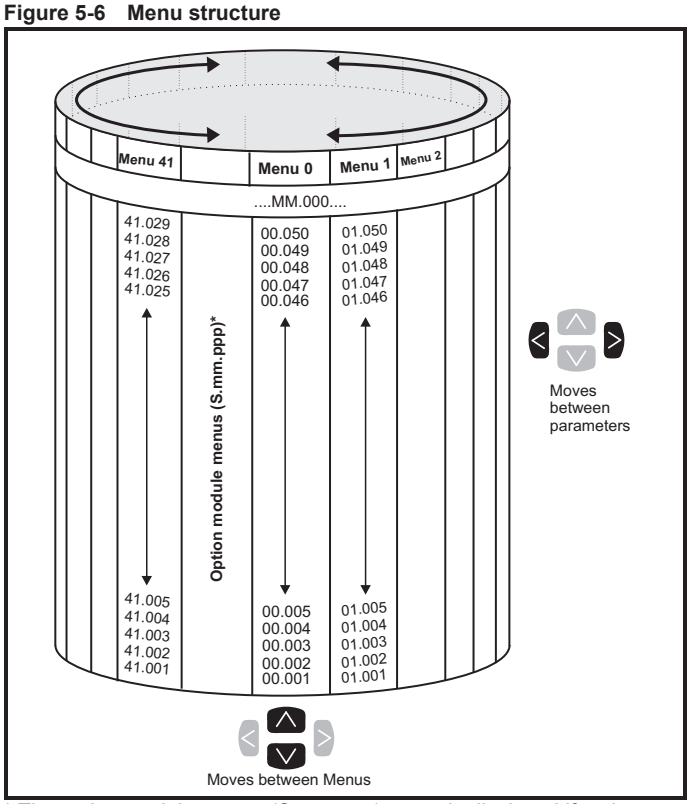
* Can only be used to move between menus if all menus have been enabled (Pr **00.049**). Refer to section 5.7 *Parameter access level and security* on page 62.

The menus and parameters roll over in both directions.

i.e. if the last parameter is displayed, a further press will cause the display to rollover and show the first parameter.

When changing between menus the drive remembers which parameter was last viewed in a particular menu and thus displays that parameter.

Figure 5-6 Menu structure



* The option module menus (S.mm.ppp) are only displayed if option modules are installed. Where S signifies the option module slot number and the mm.ppp signifies the menu and the parameter number of the option module's internal menus and parameter.

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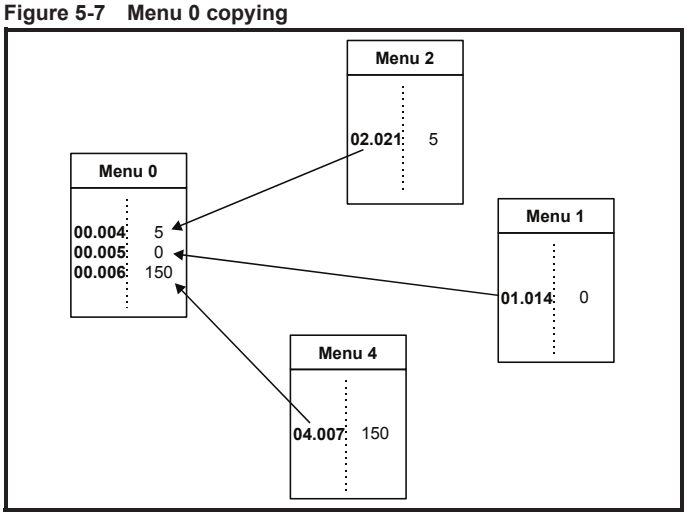
5.4 Menu 0

Menu 0 is used to bring together various commonly used parameters for basic easy set up of the drive. The parameters displayed in Menu 0 can be configured in Menu 22.
Appropriate parameters are copied from the advanced menus into Menu 0 and thus exist in both locations.

For further information, refer to Chapter 6 *Compressor specific functions* on page 65.

Figure 5-7 Menu 0 copying



5.5 Advanced menus

The advanced menus consist of groups or parameters appropriate to a specific function or feature of the drive. Menus 0 to 41 can be viewed on the HOA-Keypad. The option module menus (S.mm.ppp) are only displayed if option modules are installed. Where S signifies the option module slot number and the mm.ppp signifies the menu and parameter number of the option module's internal menus and parameter.

Table 5-3 Advanced menu descriptions

Menu	Description
0	Commonly used basic set up parameters for quick / easy programming
1	Frequency / Speed reference
2	Ramps
3	Frequency slaving, speed feedback and speed control
4	Torque and current control
5	Motor control
6	Sequencer and clock
7	Analog I/O
8	Digital I/O
10	Status and trips
11	Drive set-up and identification, serial communications
15	Option module slot 1 set-up menu
16	Option module slot 2 set-up menu
17	Option module slot 3 set-up menu
18	General option module application menu 1
19	General option module application menu 2
20	General option module application menu 3
22	Menu 0 set-up
23	Not allocated
28	Reserved menu
29	Reserved menu
Slot 1	Slot 1 option menus*
Slot 2	Slot 2 option menus*
Slot 3	Slot 3 option menus*

*Only displayed when the option modules are installed.

5.5.1 HOA-Keypad set-up menu

To enter the keypad set-up menu press and hold the escape button on the keypad from status mode. All the keypad parameters are saved to the keypad non-volatile memory when exiting from the keypad set-up menu.

To exit from the keypad set-up menu press the escape or or button. Below are the keypad set-up parameters.

Table 5-4 HOA-Keypad set-up parameters

Parameters		Range	Type
Keypad.01	Language selection	English (1)	RW
Keypad.02	Show parameter units	OFF (0), On (1)	RW
Keypad.03	Backlight level	0 to 100 %	RW
Keypad.04*	Keypad real-time clock date	01.01.10 to 31.12.99	RO
Keypad.05*	Keypad real-time clock time	00:00:00 to 23:59:59	RO
Keypad.06	Keypad software version	00.00.00.00 to 99.99.99.99	RO

* These parameters are only displayed on the HOA-Keypad RTC.

NOTE
It is not possible to access the keypad parameters via any communications channel.

5.5.2 Display messages

The following tables indicate the various possible mnemonics which can be displayed by the drive and their meaning.

Table 5-5 Status indications

Upper row string	Description	Drive output stage
Inhibit	The drive is inhibited and cannot be run. The SAFE TORQUE OFF signal is not applied to SAFE TORQUE OFF terminals or Pr **06.015** is set to 0. The other conditions that can prevent the drive from enabling are shown as bits in *Enable Conditions* (06.010)	Disabled
Ready	The drive is ready to run. The drive enable is active, but the drive inverter is not active because the final drive run is not active	Disabled
Stop	The drive is stopped / holding zero speed	Enabled
Run	The drive is active and running	Enabled
Supply Loss	Supply loss condition has been detected	Enabled
Deceleration	The motor is being decelerated to zero speed / frequency because the final drive run has been deactivated	Enabled
Trip	The drive has tripped and no longer controlling the motor. The trip code appears in the lower display	Disabled
Active	The Regen unit is enabled and synchronized to the supply	Enabled
Under Voltage	The drive is in the under voltage state either in low voltage or high voltage mode	Disabled
Heat	The motor pre-heat function is active	Enabled

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5.5.3 Alarm indications

An alarm is an indication given on the display by alternating the alarm string with the drive status string on the upper row and showing the alarm symbol in the last character in the upper row. Alarms strings are not displayed when a parameter is being edited, but the user will still see the alarm character on the upper row.

Table 5-6 Alarm indications

Alarm string	Description
Motor Overload	*Motor Protection Accumulator* (04.019) in the drive has reached 75.0 % of the value at which the drive will trip and the load on the drive is >100 %.
Ind Overload	Regen inductor overload. *Inductor Protection Accumulator* (04.019) in the drive has reached 75.0 % of the value at which the drive will trip and the load on the drive is >100 %.
Drive Overload	Drive over temperature. *Percentage Of Drive Thermal Trip Level* (07.036) in the drive is greater than 90 %.
Auto Tune	The autotune procedure has been initialized and an autotune in progress.
Limit Switch	Limit switch active. Indicates that a limit switch is active and that is causing the motor to be stopped.

Table 5-7 Option module and NV media card and other status indications at power-up

First row string	Second row string	Status
Booting	**Parameters**	Parameters are being loaded
Drive parameters are being loaded from a NV Media Card		
Booting	**User Program**	User program being loaded
User program is being loaded from a NV Media Card to the drive		
Booting	**Option Program**	User program being loaded
User program is being loaded from a NV Media Card to the option module in slot X		
Writing To	**NV Card**	Data being written to NV Media Card
Data is being written to a NV Media Card to ensure that its copy of the drive parameters is correct because the drive is in Auto or Boot mode		
Waiting For	**Power System**	Waiting for power stage
The drive is waiting for the processor in the power stage to respond after power-up		
Waiting For	**Options**	Waiting for an option module
The drive is waiting for the options modules to respond after power-up		
Uploading From	**Options**	Loading parameter database
At power-up it may be necessary to update the parameter database held by the drive because an option module has changed or because an applications module has requested changes to the parameter structure. This may involve data transfer between the drive an option modules. During this period 'Uploading From Options' is displayed		

5.6 Saving parameters

When changing a parameter in Menu 0, the new value is saved when pressing the ⏎ Enter button to return to parameter view mode from parameter edit mode.

If parameters have been changed in the advanced menus, then the change will not be saved automatically. A save function must be carried out.

Procedure

See section 6.2.6 *Housekeeping functions* on page 70 .

5.7 Parameter access level and security

The parameter access level determines whether the user has access to Menu 0 only or to all the advanced menus (Menus 1 to 41) in addition to Menu 0.

The User Security determines whether the access to the user is read only or read write.

Both the User Security and Parameter Access Level can operate independently of each other as shown in table Table 5-8.

Table 5-8 Parameter access level and security

User security status (11.044)	Access level	User security	Menu 0 status	Advanced menu status
0	Menu 0	Open	RW	Not visible
		Closed	RO	Not visible
1	All Menus	Open	RW	RW
		Closed	RO	RO
2	Read-only Menu 0	Open	RO	Not visible
		Closed	RO	Not visible
3	Read-only	Open	RO	RO
		Closed	RO	RO
4	Status only	Open	Not visible	Not visible
		Closed	Not visible	Not visible
5	No access	Open	Not visible	Not visible
		Closed	Not visible	Not visible

The default settings of the drive are Parameter Access Level Menu 0 and user Security Open i.e. read / write access to Menu 0 with the advanced menus not visible.

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5.7.1 User Security Level / Access Level

The drive provides a number of different levels of security that can be set by the user via *User Security Status* (11.044); these are shown in the table below.

User Security Status (Pr 11.044)	Description
Menu 0 (0)	All writable parameters are available to be edited but only parameters in Menu 0 are visible
All menus (1)	All parameters are visible and all writable parameters are available to be edited
Read- only Menu 0 (2)	Access is limited to Menu 0 parameters only. All parameters are read-only
Read-only (3)	All parameters are read-only however all menus and parameters are visible
Status only (4)	The keypad remains in status mode and no parameters can be viewed or edited
No access (5)	The keypad remains in status mode and no parameters can be viewed or edited. Drive parameters cannot be accessed via a comms/ fieldbus interface in the drive or any option module

5.7.2 Changing the User Security Level /Access Level

The security level is determined by the setting of Pr **00.059** or Pr **11.044**. The Security Level can be changed through the keypad even if the User Security Code has been set.

5.7.3 User Security Code

The User Security Code, when set, prevents write access to any of the parameters in any menu.

Setting User Security Code

Enter a value between 1 and 2147483647 in Pr **11.030** and press the button; the security code has now been set to this value. In order to activate the security, the Security level must be set to desired level in Pr **00.059**. When the drive is reset, the security code will have been activated and the drive returns to Menu 0 and the symbol is displayed in the right hand corner of the keypad display. The value of Pr **11.030** will return to 0 in order to hide the security code.

Unlocking User Security Code

Select a parameter that need to be edited and press the button, the upper display will now show ‘Security Code’. Use the arrow buttons to set the security code and press the button. With the correct security code entered, the display will revert to the parameter selected in edit mode.

If an incorrect security code is entered, the following message ‘Incorrect security code’ is displayed, then the display will revert to parameter view mode.

Disabling User Security

Unlock the previously set security code as detailed above. Set Pr **11.030** to 0 and press the button. The User Security has now been disabled, and will not have to be unlocked each time the drive is powered up to allow read / write access to the parameters.

5.8 Displaying parameters with non-default values only

By selecting 'Show non-default' in Pr **mm.000** (Alternatively, enter 12000 in Pr **mm.000**), the only parameters that will be visible to the user will be those containing a non-default value. This function does not require a drive reset to become active. In order to deactivate this function, return to Pr **mm.000** and select 'No action' (alternatively enter a value of 0). Please note that this function can be affected by the access level enabled, refer to section 5.7 *Parameter access level and security* on page 62 for further information regarding access level.

5.9 Displaying destination parameters only

By selecting 'Destinations' in Pr **mm.000** (Alternatively enter 12001 in Pr **mm.000**), the only parameters that will be visible to the user will be destination parameters. This function does not require a drive reset to become active. In order to deactivate this function, return to Pr **mm.000** and select 'No action' (alternatively enter a value of 0).

Please note that this function can be affected by the access level enabled, refer to section 5.7 *Parameter access level and security* on page 62 for further information regarding access level.

5.10 Communications

The CSD100 drive offers a 2 wire EIA485 interface. This enables the drive set-up, operation and monitoring to be carried out with a PC or controller if required.

5.10.1 485 Serial communications

The EIA485 option provides two parallel RJ45 connectors allowing easy daisy chaining. The drive only supports MODBUS RTU protocol.

The serial communications port of the drive is a RJ45 socket, which is isolated from the power stage and the other control terminals (see section 4.7 *Communications connections* on page 51 for connection and isolation details).

The communications port applies a 2 unit load to the communications network.

USB/EIA232 to EIA485 Communications

An external USB/EIA232 hardware interface such as a PC cannot be used directly with the 2-wire EIA485 interface of the drive. Therefore a suitable converter is required.

Suitable USB to EIA485 and EIA232 to EIA485 isolated converters are available as follows:

- CT USB Comms cable (CT Part No. 4500-0096)
- CT EIA232 Comms cable (CT Part No. 4500-0087)

NOTE

When using the CT EIA232 Comms cable the available baud rate is limited to 19.2 k baud.

When using one of the above converters or any other suitable converter with the drive, it is recommended that no terminating resistors be connected on the network. It may be necessary to 'link out' the terminating resistor within the converter depending on which type is used. The information on how to link out the terminating resistor will normally be contained in the user information supplied with the converter.

Serial communications set-up parameters

The following parameters need to be set according to the system requirements.

Serial Address (Pr 11.023)

This parameter defines the serial address and an addresses between 1 and 247 are permitted.

Changing the parameters does not immediately change the serial communications settings. See note below for more details.

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Serial Mode (Pr 11.024)

This parameter defines the data format used by the EIA485 comms port on the drive.

Value	Text
0 (Default)	8 2 NP
1	8 1 NP
2	8 1 EP
3	8 1 OP
4	8 2 NP M
5	8 1 NP M
6	8 1 EP M
7	8 1 OP M
8	7 2 NP
9	7 1 NP
10	7 1 EP
11	7 1 OP
12	7 2 NP M
13	7 1 NP M
14	7 1 EP M
15	7 1 OP M

The bits in the value of *Serial Mode* (Pr **11.024**) define the data format as follows.:

Bits	3	2	1 and 0
Format	Number of data bits 0 = 8 bits 1 = 7 bits	Register mode 0 = Standard 1 = Modified	Stop bits and Parity 0 = 2 stop bits, no parity 1 = 1 stop bit, no parity 2 = 1 stop bit, even parity 3 = 1 stop bit, odd parity

Bit 3 is always 0 in the core product as 8 data bits are required for MODBUS RTU.

Bit 2 selects either standard or modified register mode. The menu and parameter numbers are derived for each mode as given in the table below. Standard mode is the default setting and allows up to 99 parameters to be accessed within a menu. Modified mode is provided to allow register numbers up to 255 to be addressed.

Register mode	Register address
Standard	(mm x 100) + ppp - 1 where mm ≤ 162 and ppp ≤ 99
Modified	(mm x 256) + ppp - 1 where mm ≤ 63 and ppp ≤ 255

This parameter can be changed via the drive keypad, or via the comms interface itself. Changing the parameters does not immediately change the serial communications settings. See note below for more details.

Serial Baud Rate (Pr 11.025)

This parameter defines the baud rate used by the serial comms interface.

Value	Text
0	300
1	600
2	1200
3	2400
4	4800
5	9600
6 (Default)	19200
7	38400
8	57600
9	76800
10	115200

Changing the parameters does not immediately change the serial communications settings. See note below for more details.

Minimum Comms Transmit Delay (Pr 11.026)

There will always be a finite delay between the end of a message from the host (master) and the time at which the host is ready to receive the response from the drive (slave). The drive does not respond until at least 1ms after the message has been received from the host allowing 1ms for the host to change from transmit to receive mode. This initial delay can be extended using *Minimum Comms Transmit Delay* (Pr **11.026**) if required.

Value	Action
0	The transmitters are turned on and data transmission begins immediately after the initial delay (≥1 ms)
1	The transmitters are turned on after the initial delay (≥1ms) and data transmission begins 1ms later
2 or more	The transmitters are turned on after a delay of at least the time specified by *Minimum Comms Transmit Delay* (Pr **11.026**) and data transmission begins 1ms later

The drive holds its own transmitters active for up to 1 ms after it has transmitted data before switching to the receive mode; the host should not send any data during this time.

Changing the parameters does not immediately change the serial communications settings See note below for more details.

Silent Period (Pr 11.027)

The silent period defines the idle time required to detect the end of a received data message. If *Silent Period* (Pr **11.027**) = 0 then the silent period is at least 3.5 characters at the selected baud rate. This is the standard silent period for MODBUS RTU. If *Silent Period* (Pr **11.027**) is non-zero it defines the minimum silent period in milliseconds.

Changing the parameters does not immediately change the serial communications settings. See note below for more details.

NOTE

When *Serial Address* (Pr **11.023**), *Serial Mode* (Pr **11.024**), *Serial Baud Rate* (Pr **11.025**), M*inimum Comms Transmit Delay* (Pr **11.026**) or *Silent Period* (Pr **11.027**) are modified the changes do not have an immediate effect on the serial communications system. The new values are used after the next power-up or if *Reset Serial Communications* (Pr **11.020**) is set to one. *Reset Serial Communications* (Pr **11.020**) is automatically cleared to zero after the communications system is updated.

This does not save any changes made and a separate parameter save is required.

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6 Compressor specific functions

6.1 Menu 0 - compressor specific parameters

Menu 0 is used to bring together all the compressor specific parameters for easy basic setup of the CSD100. All of the parameters in menu 0 appear in other menus in the CSD (denoted by {…}). Where control is via 485 serial communications, a MODBUS address is given for each parameter (assumes 32-bit access).

Table 6-1 Menu 0: Compressor specific parameters

Parameter			Range(⇳)	Default(⇨)	Data size (bits)	MODBUS Address (hex)	See section
00.001	User soft-start dwell speed	**{01.021}**	1500.0 to 7200.0 rpm	3600.0 rpm	32	4000	6.4.1
00.002	Normal running final reference	**{01.022}**	0.0 to 7200.0 rpm	0.0 rpm	32	4001	6.4.2
00.003	Controlled shutdown final reference	**{01.023}**	0.0 to 7200.0 rpm	3600.0 or envelope minimum	32	4002	6.4.3
00.004	Stop reference	**{01.024}**	0.0 rpm	0.0 rpm	32	4003	6.4.3
00.005	Defrost final reference	**{01.025}**	1500.0 to 7200.0 rpm	1500.0 or envelope minimum	32	4004	6.4.4
00.006	Oil boost reference	**{01.026}**	3600.0 to 7200.0 rpm	3600.0 rpm	32	4005	6.3.5
00.007	Skip Reference 1	**{01.029}**	0 to 7200 rpm	0 rpm [no filter]	16	4006	6.4.5
00.008	Skip Reference Band 1	**{01.030}**	0 to 250 rpm	0 rpm	8	4007	6.4.5
00.009	Soft-start acceleration rate	**{02.011}**	1.000 to 2.500 s/1000 rpm	1.000 s/1000 rpm	32	4008	6.4.1
00.010	Normal running acceleration rate	**{02.012}**	5.000 to 1000.000 s/1000 rpm	5.000 s/1000 rpm	32	4009	6.4.2
00.011	Defrost acceleration rate	**{02.015}**	2.000 to 20.000 s/1000 rpm	2.000 s/1000 rpm	32	400A	6.4.4
00.012	Oil boost acceleration rate	**{02.016}**	2.000 to 20.000 s/1000 rpm	5.000 s/1000 rpm	32	400B	6.3.5
00.013	Normal running deceleration rate	**{02.022}**	5.000 to 1000.000 s/1000 rpm	5.000 s/1000 rpm	32	400C	6.4.2
00.014	Controlled shutdown deceleration rate	**{02.023}**	2.000 to 20.000 s/1000 rpm	5.000 s/1000 rpm	32	400D	6.4.3
00.015	Stop deceleration rate	**{02.024}**	2.000 to 20.000 s/1000 rpm	2.000 s/1000 rpm	32	400E	6.4.3
00.016	Defrost deceleration rate	**{02.025}**	2.000 to 20.000 s/1000 rpm	2.000 s/1000 rpm	32	400F	6.4.4
00.017	Oil boost deceleration rate	**{02.026}**	2.000 to 20.000 s/1000 rpm	5.000 s/1000 rpm	32	4010	6.3.5
00.018	Total number of trips	**{18.001}**	0 to 10000	0	16	4011	12
00.019	User speed reference in RPM	**{18.011}**	0 to 7200 rpm	0 rpm	16	4012	6.4.2
00.020	System control word	**{18.012}**	0 to 32767	0	16	4013	6.2.2
00.021	Trip/Lockout number	**{18.013}**	0 to 255	0	16	4014	12
00.022	Condition alerts	**{18.014}**	0 to 255	0	16	4015	12
00.023	Condition warnings	**{18.015}**	0 to 255	0	16	4016	12
00.024	Configuration control parameter	**{18.016}**	0 to 32767	0	16	4017	6.2.1
00.025	Condenser pressure	**{18.017}**	0 to 650 psig	250 psig	16	4018	6.3.3
00.026	Evaporator pressure	**{18.018}**	0 to 650 psig	80 psig	16	4019	6.3.3
00.027	Soft-start dwell time	**{18.019}**	120 to 300 s	120 s	16	401A	6.4.1
00.028	Locked Rotor Failure start count	**{18.020}**	0 to 10	0	16	401B	6.2.12
00.029	Locked rotor idle time	**{18.021}**	30 to 300 s	35 s	16	401C	6.2.12
00.030	Number of reverse rotation detection events	**{18.023}**	0 to 2	0	16	401D	6.2.11
00.031	DLT (Discharge line temperature)	**{18.024}**	-40 to 330 degrees F	0	16	401E	6.3.2
00.032	DLT over temperature fault count	**{18.025}**	0 to 4	0	16	401F	6.3.2
00.033	Time between reverse wiring checks	**{18.029}**	30 to 300 s	30 s	16	4020	6.2.11
00.034	Trigger a save of the parameters	**{18.031}**	0 to 1	0	1	4021	6.2.6
00.035	Short cycle count	**{19.011}**	0 to 4	0	16	4022	6.3.1
00.036	Short cycle limit	**{19.012}**	1 to 144 cycles	48 cycles	16	4023	6.3.1
00.037	Short cycle time	**{19.013}**	60 to 600 s	60 s	16	4024	6.3.1
00.038	Running log of alerts entry number	**{19.014}**	0 to 20	0	16	4025	12
00.039	Running log alert ID number and days and hours	**{19.015}**	0 to 32767			26	

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Parameter			Range(⇳)	Default(⇨)	Data size (bits)	MODBUS Address (hex)	See section
00.040	Return to application defaults	**{19.016}**	0 to 1	0	16	4027	6.2.6
00.041	Stator heating wattage	**{19.017}**	10 W to 150 W	100 W	16	4028	6.3.4
00.042	Compressor missing a phase counter	**{19.018}**	0 to 10	0	16	4029	6.2.10
00.043	Oil boost threshold speed	**{19.019}**	1800 to 3600 rpm	3600 rpm	16	402A	6.3.5
00.044	Oil boost threshold time	**{19.020}**	1 to 120 minutes	120 minutes	16	402B	6.3.5
00.045	Oil boost solution time	**{19.021}**	5 to 30 minutes	5 minutes	16	402C	6.3.5
00.046	Reverse rotation indicator threshold	**{19.022}**	1 to 100 %	35 %	16	402D	6.2.11
00.047	Lost rotor ride-through dynamic threshold	**{19.023}**	30 to 400 rpm	200 rpm	16	402E	6.2.13
00.048	Lost rotor ride-through constant threshold	**{19.024}**	30 to 400 rpm	100 rpm	16	402F	6.2.13
00.049	Controlled shutdown dwell time	**{19.027}**	0 to 300 s	120 s	16	4030	6.4.3
00.050	Number of soft-start attempts	**{19.028}**	0 to 3	0	16	4031	6.4.1
00.051	User defrost speed reference	**{19.029}**	1500 to 7200 rpm	1500 rpm	16	4032	6.4.4
00.052	Defrost cycle end dwell time	**{19.030}**	30 to 300	60 s	16	4033	6.4.4
00.053	Stator heating control mode	**{19.032}**	0 to 1	0	1	4034	6.3.4
00.054	Fieldbus comms monitor	**{20.001}**	0 to 300s	0 s	16	4035	6.4.6
00.055	Active CSD100 trip number	**{20.002}**	0 to 255	0	16	4036	12
00.056	CSD100 software version	**{20.003}**	0 to 255	Current software version	16	4037	6.2.6
00.057	Software system state	**{20.004}**	0 to 20	0	16	4038	6.2.4
00.058	Speed reference after envelope control	**{20.005}**	0 to 7200 rpm	0	16	4039	6.3.3
00.059	User security level	**{11.044}**	0 to 5	1 (all menus visible)	8	403A	5.7

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6.2 Detailed compressor function descriptions

6.2.1 Configuration parameter

To allow simple configuration via communications, all functions are enabled / disabled with a single bitwise parameter: Pr **00.024** {Pr **18.016**}.
For example:
If Pr **00.024** {Pr **18.016**} contained a decimal value of 197, this is 0000000011000101 in binary meaning that bits 0, 2, 6 and 7 are set (at a value of 1)

Table 6-2 Key to the configuration parameter (first bit is on the right):

Pr **00.024** {Pr **18.016**} Bit	Name	Function	Default
0 (1st)	Enable the CSD100 motor thermal model	1: Enable 0: Disable	0 (Disabled)
1 (2nd)	Reserved	N/A	N/A
2 (3rd)	Disable short cycle protection	1: Disable 0: Enable	0 (Enabled)
3 (4th)	Disable CSD100 envelope control	1: Disable 0: Enable	0 (Enabled)
4 (5th)	Temperature unit	0 = Fahrenheit, 1 = Celsius	0 (°F)
5 (6th)	Pressure unit	0 = Psig, 1 = Bar	0 (Psig)
6 (7th)	Enable oil control	1: Disable 0: Enable	0 (Enabled)
7 (8th)	Enable defrost cycle control	1: Enable 0: Disable	0 (Disabled)
8 (9th)	Select control source for Start/run and stator heater	1: Start and stator heater are by system control word parameter (Pr **18.012**). 0: Start and stator heater enable are from digital input.*	0 (Digital)
9 (10th)	Disable DLT protection	1: Disable 0: Enable	0 (Enabled)
10 (11th)	Disable locked rotor on start indicator	1: Disable 0: Enable	0 (Enabled)
11 (12th)	Disable reversed rotation indicator	1: Disable 0: Enable	0 (Enabled)
12 (13th)	Disable lost rotor ride-through	1: Disable 0: Enable	0 (Enabled)
13 (14th)	OEM updates the DLT temperature	1: Disable 0: Enable	0 (Enabled)
Bits 14 to 15	Reserved	N/A	N/A

NOTE

Note when digital inputs are used as the control source (Pr **00.024** bit 8=0), if the logic level returns to zero, the CSD100 will move to the controlled shut down state if currently in the normal running state. When the system control word is selected (Pr **00.024** bit 8=1), the start bit starts the CSD100 but the drive will not stop the motor if the bit is reset. To stop using a controlled shut down, a separate control word bit is used.

6.2.2 System control word parameter

To allow simple control via communications, all functions are controlled with a single bitwise parameter: Pr **00.020** {Pr **18.012**}.

For example:

If Pr **00.020** {Pr **18.012**} contained a decimal value of 9, this is 0000000000001001 in binary, meaning that bits 0 and 3 are set (at a value of 1).

Key to the System Control Word Parameter (first bit is on the right):

Pr **00.020** {Pr **18.012**} Bit	Name	Function	Default
0 (1st)	Start	1: Start 0: No action	0
1 (2nd)	Controlled shutdown	1: Shut down the compressor 0: No action	0
2 (3rd)	Stator heating control	1: Turn on the stator heater 0: No action	0
3 (4th)	Defrost cycle trigger	1: Trigger the defrost cycle on transition 0: No action	0
4 (5th)	Reset trips if possible	1: Reset trips on transition 0: No action	0
5 (6th)	Trip on communication loss	1: Enable the communication watchdog 0: No action	0
Bits 6 to 15	Reserved	N/A	N/A

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6.2.3 Preset speeds

The preset speed parameters and acceleration/deceleration rates are defaulted to basic values but can be modified and saved by the user.

Function	CSD100 Preset speed parameter	Default speed value (rpm)	CSD100 acceleration parameter	CSD100 deceleration parameter	Default accel/decel value (s/1000rpm)
Soft-start	Pr **00.001 {01.021}**	3600.0	Pr **00.009 {02.011}**	N/A	1.000
Normal running	Pr **00.019** {**18.011**} User speed reference	1500	Pr **00.010** {**02.012**}	Pr **00.013 {2.022}**	5.000 / 5.000
	Pr **00.002 {01.022}** Final reference controlled by the software	0	Pr **00.010** {**02.012**}	Pr **00.013 {2.022}**	5.000 / 5.000
Controlled shutdown	Pr **00.003 {01.023}**	3600 (or envelope minimum)	N/A	Pr **00.014 {02.023}**	5.000
Stop	Pr **00.004 {01.024}**	0	N/A	Pr **00.015 {02.024}**	2.000
Defrost speed	Pr **00.051 {19.029}** User defrost speed reference	1500	Pr **00.011 {02.015}**	Pr **00.016 {02.025}**	2.000 / 2.000
	Pr **00.005 {01.025}** Final defrost speed reference controlled by the software	1500 (or envelope minimum)	Pr **00.011 {02.015}**	Pr **00.016 {02.025}**	2.000 / 2.000
Oil boost solution speed	Pr **00.006 {01.026}** Final oil boost speed reference controlled by the software	1500.0	Pr **00.012 {02.016}**	Pr **00.017 {02.026}**	5.000 / 5.000

6.2.4 State machine

The CSD100 software operates as a state machine in which each state provides a specific set of functions. This approach permits the sequencing of functions to be presented in a simple manner.

Table 6-3 Key to the software system state

Numerical state shown in Pr **00.057 {20.004}**	Name	Function active														
		Motor over current	Max load and low voltage fold back	Missing phase	Miswire detection	Locked rotor detection	Lost rotor	Short cycle detection	Discharge line temperature	Envelope control & protection	Stator heating	Defrost control	Skip frequencies	Oil boost	Controlled shut down	Fieldbus monitoring
0	IDLE	X	X						X	X						X
1	IDLE WITH STATOR HEATING	X	X						X	X	X					X
2	SOFT-START	X	X	X	X	X		X	X	X			X			X
3	NORMAL RUNNING	X	X				X		X	X			X			X
4	DEFROST CYCLE	X	X						X	X		X	X			X
5	OIL BOOST	X	X						X	X			X	X		X
6	CONTROLLED SHUT DOWN	X	X						X	X			X		X	X
20	TRIPPED															

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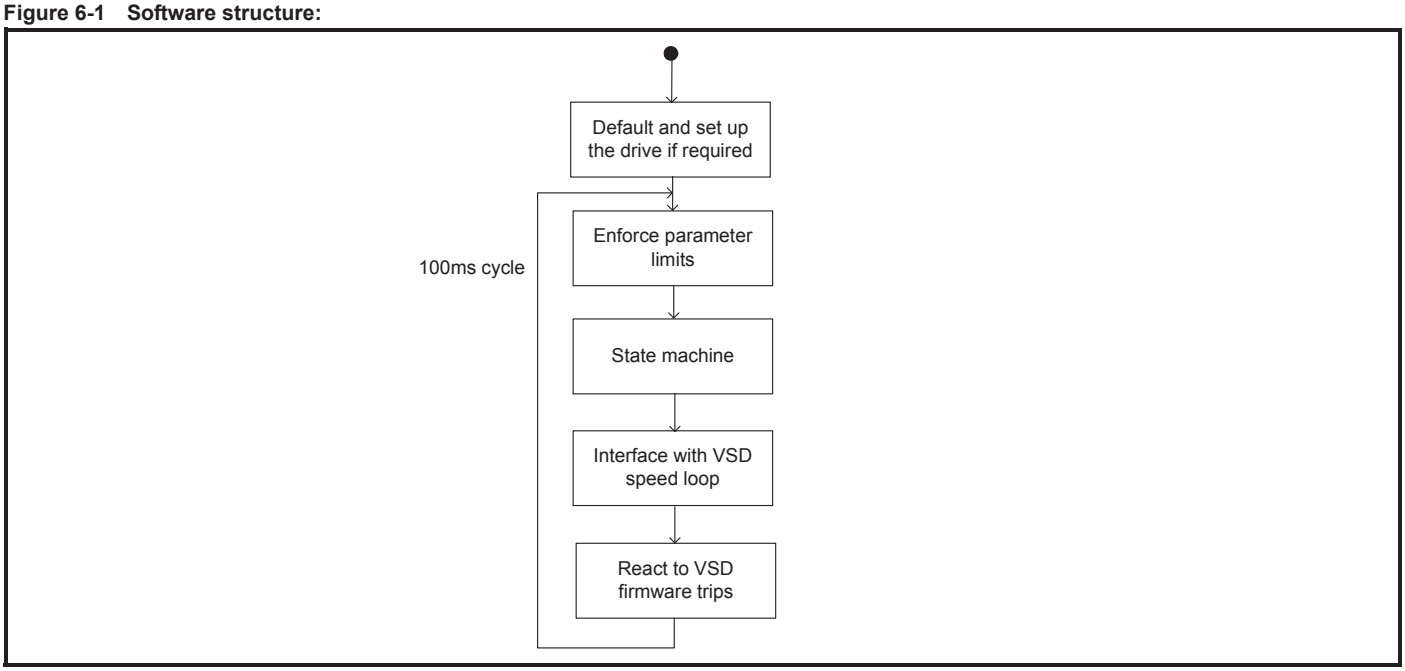
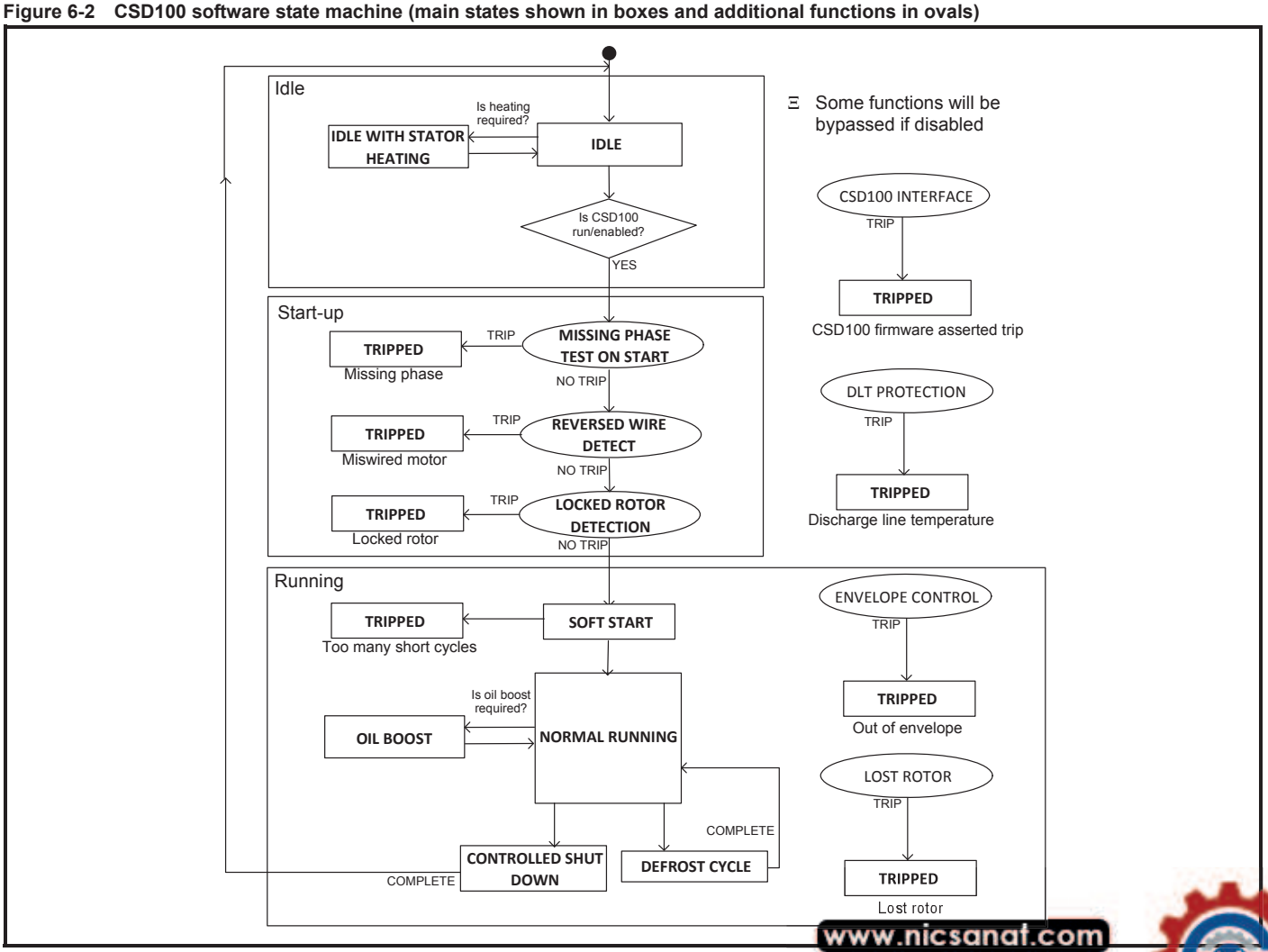
The software structural diagram below presents the top level groups of functions and how they are sequenced from the time of power up of the CSD100. Details of the individual groups of tasks and functions are given later in this section.

Figure 6-1 Software structure:



The state machine is a top level block within the software structural diagram and numerically represents the CSD100 specific functions. Figure 6-2 shows the process flow through the state machine and thus how the individual CSD100 specific software functions are sequenced.

Figure 6-2 CSD100 software state machine (main states shown in boxes and additional functions in ovals)



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The states are arranged in three groups:

- Idle

This group includes stator heating and occurs when the compressor is not active.

- Start-up

This state includes the motor/compressor wiring and direction checks.

- Running

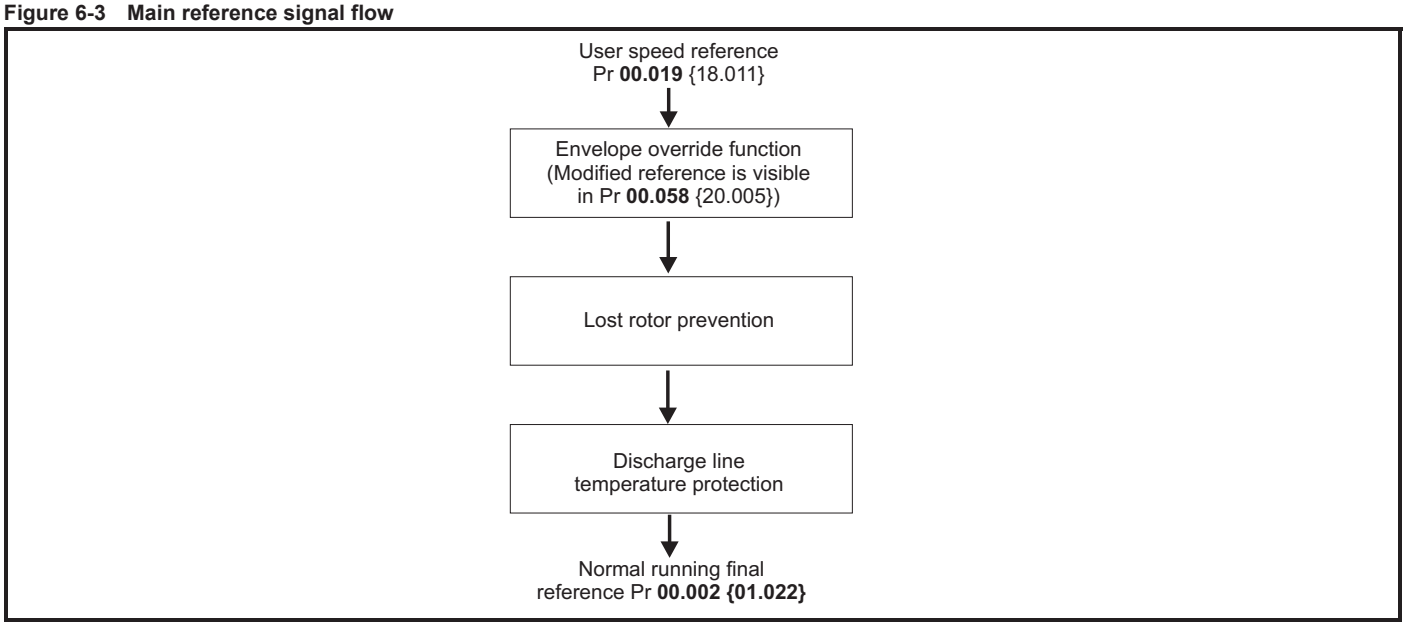
This group contains the running, defrost, oil boost and the controlled shut down functions. The envelope and lost rotor protection is run in all of the states contained in this group.

The CSD100 interface function and the discharge line protection functions are running all of the time irrespective of the current state or group of states.

6.2.5 Speed reference

The main reference signal flow diagram below defines how the speed reference is modified/limited/controlled within the CSD100 software - from receipt from the OEM controller to the speed demand passed to the standard drive speed loop and motor control.

Figure 6-3 Main reference signal flow



NOTE

In the case of the CSD100, the envelope override function can limit the speed reference before it enters the state machine functions and that the final modification is under the control of the discharge line temperature protection function.

6.2.6 Housekeeping functions

Parameter	Parameter name	Description	Units	Range	Default
00.034 {18.031}	Trigger a save of the parameters	Only operates during idle with no heating active. Resets to off (0) when complete.	none	0 to 1	0
00.056 {20.003}	CSD100 software version	Displays the CSD100 software version where V01.12 = 112	none	0 to 9999	0
00.057 {20.004}	Software system state	Current software state	none	0 to 20	0 [Idle]
00.040 {19.016}	Return to application defaults	If saved to zero, the CSD100 will load the application defaults on the next power-up. The application will set to 1 whenever application defaults have been loaded.	none	0 to 1	0

The user can trigger a save of the parameters and have the ability of returning the CSD100 specific parameters to their default values.

The CSD100 software version and the system state can be viewed.

To return the CSD100 specific parameters to their default values, set Return to application defaults Pr **00.040 {19.016}** to zero and save the parameters using Trigger a save of the parameters Pr **00.034 {18.031}**. Power cycle the CSD100, the defaults are loaded during the initialization.

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6.2.7 Compressor motor protection

The motor protection heading brings together all of the CSD100 software motor protection functions.

6.2.8 Motor over current

Motor over current protection is provided by the CSD100 protection and motor overload protection model. The over current trip is provided to prevent motor demagnetization. This trip cannot be reset during the first 10 s after the trip occurred.

- A power cycle or reset command, via MODBUS keypad or digital input is required to clear the lockout.

NOTE

The motor over current protection is similar to CoreSense 1379 Alert/Lockout Code 9 - Over-Current Protection

6.2.9 Missing phase connection

Function runs in the following state(s):	Description
Soft-start	Missing phase on start

Parameter	Parameter Name	Function area	Description	Units	Range	Default
00.042 {19.018}	Compressor missing a phase counter	Compressor missing a phase	Increments with every missing phase event detected up to 10 in 24 hrs	None	0 to 10	0

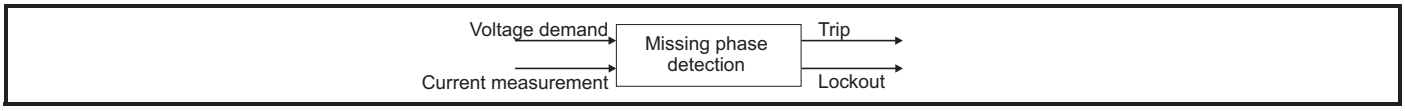
This feature is set up by the CSD100 software and implemented in the standard drive firmware.

- The standard drive firmware will trip Out Phase Loss.1. The CSD100 software will trip "Compressor Missing Phase" and move to the TRIPPED state.
- After 5 minutes the trip is automatically reset.
- The system will lockout after 10 trips within 24 hours [the count of trips is reset on lock-out].
- A power cycle or reset command, via MODBUS keypad or digital input is required to clear the lockout.

NOTE

The missing phase detection is similar to CoreSense 1384 Alert/Lockout Code 6 - Missing Phase

Figure 6-4 Missing phase detection function block



Sub-trip	Reason
1	U phase detected as disconnected when drive enabled to run
2	V phase detected as disconnected when drive enabled to run
3	W phase detected as disconnected when drive enabled to run

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6.2.10 Miswire/Reverse phase run prevention

Function runs in the following state(s):	Description
Soft-start	Miswire detection

Parameter	Parameter Name	Function area	Description	Units	Range	Default
00.030 {18.023}	Number of reverse rotation detection events	Reversed rotation indicator	This shows the number of reverse rotation events that have been detected. A trip is generated as the 2nd event is detected	none	0 to 2	0
00.033 {18.029}	Time between reverse wiring checks	Reversed rotation indicator	Defines the time between start attempts.	s	30 to 300 s	30 s
00.046 {19.022}	Reverse rotation indicator threshold	Reversed rotation indicator	Threshold at which reverse rotation is detected.	% of Pr 4.020	1 to 100 %	35 %

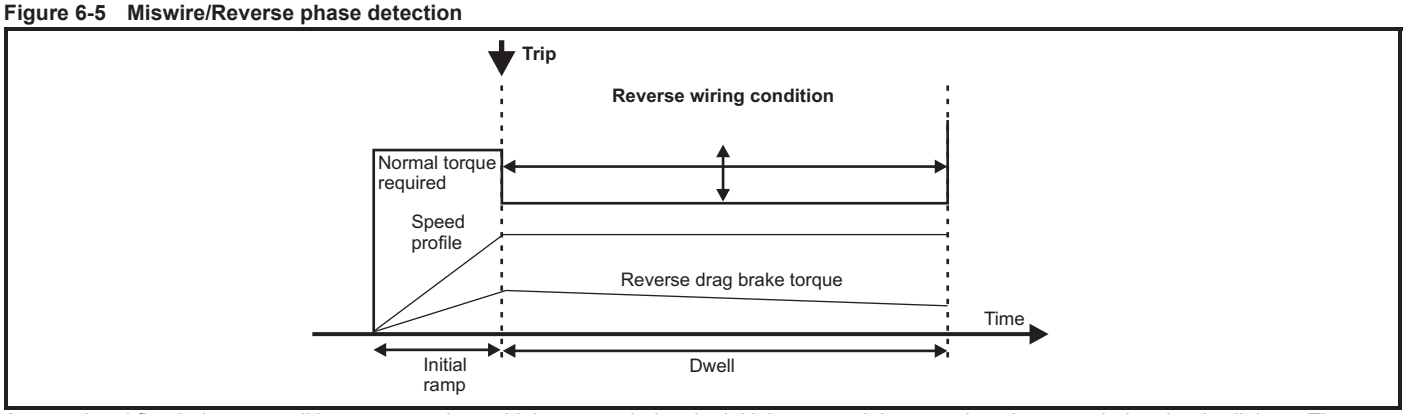
- Detection is only required on first compressor start after module power-up.

If the input to the compressor is miswired (phase rotation) then the compressor may run in reverse. When the compressor runs in reverse operation, a Fluid Brake is applied.

Miswire/Reverse phase detection

Reverse rotation is detected using a torque profile method as shown in Figure 6-5 below:

Figure 6-5 Miswire/Reverse phase detection



A normal and flooded start condition start, requires a high current during the initial ramp and then a reduced current during the dwell time. The reversed condition requires a torque demand that is approximately proportional to the speed.

The torque profile detection system filters the current load demand (Pr **04.020**) to reduce the effect of measurement noise but with a time constant shorter than the shortest normal start high torque period. The maximum current load demand is stored during the initial ramp soft-start. If this is below a default 35 % [user configurable] threshold, a reversed motor condition is detected.

The reverse wiring (reversed mechanical direction) test is only performed on the first run after power-up to reduce the possibility of refrigerant or oil swirl effects.

The detection is started from when the estimated speed becomes positive to prevent initial magnetic synchronisation affecting the detection.

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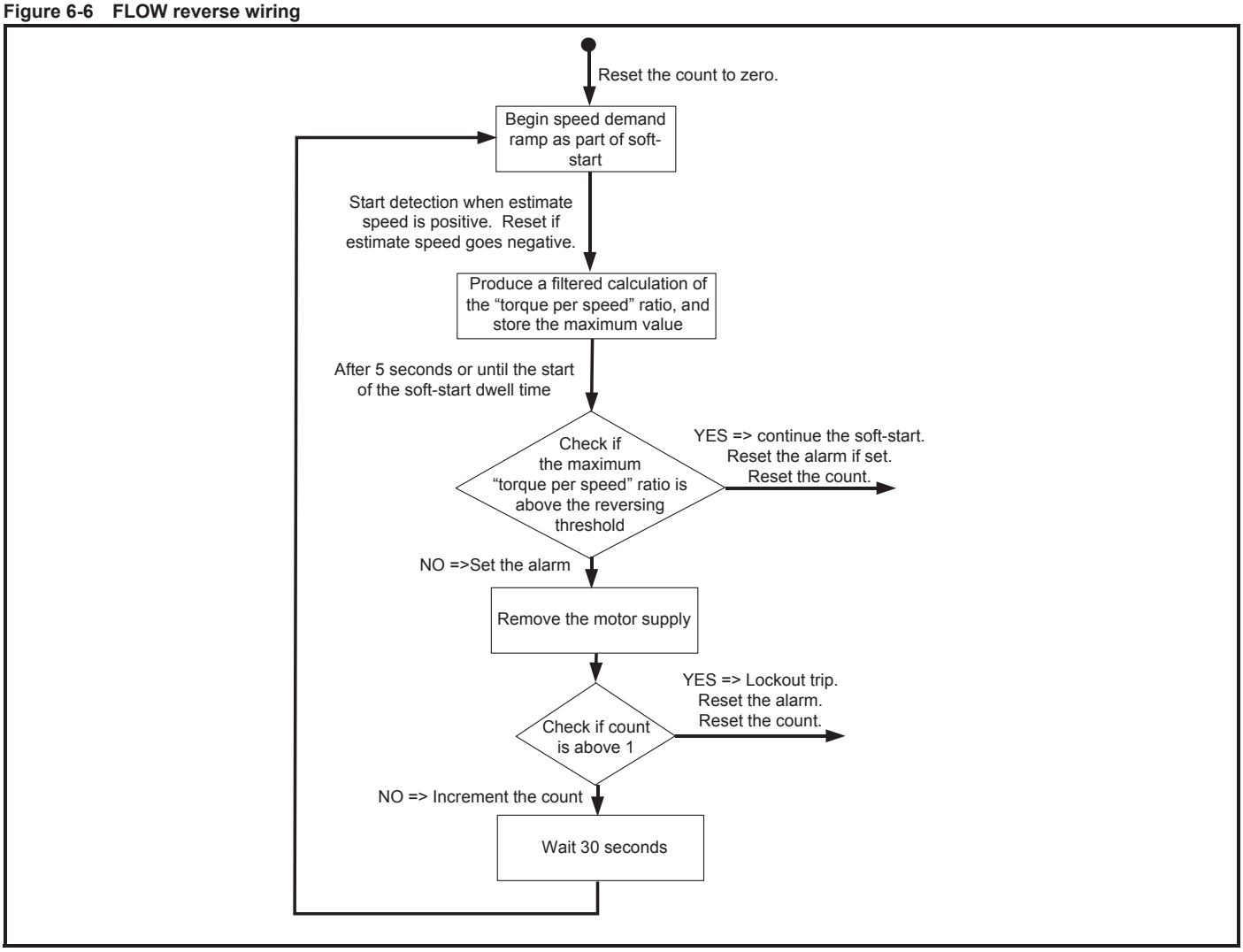
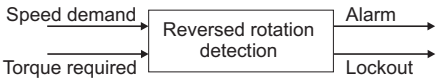
Figure 6-6 FLOW reverse wiring



NOTE

The miswire detection function is similar to CoreSense 1384 Alert/Lockout Code 7 - Reverse Phase

Table 6-4 Miswire detection function block



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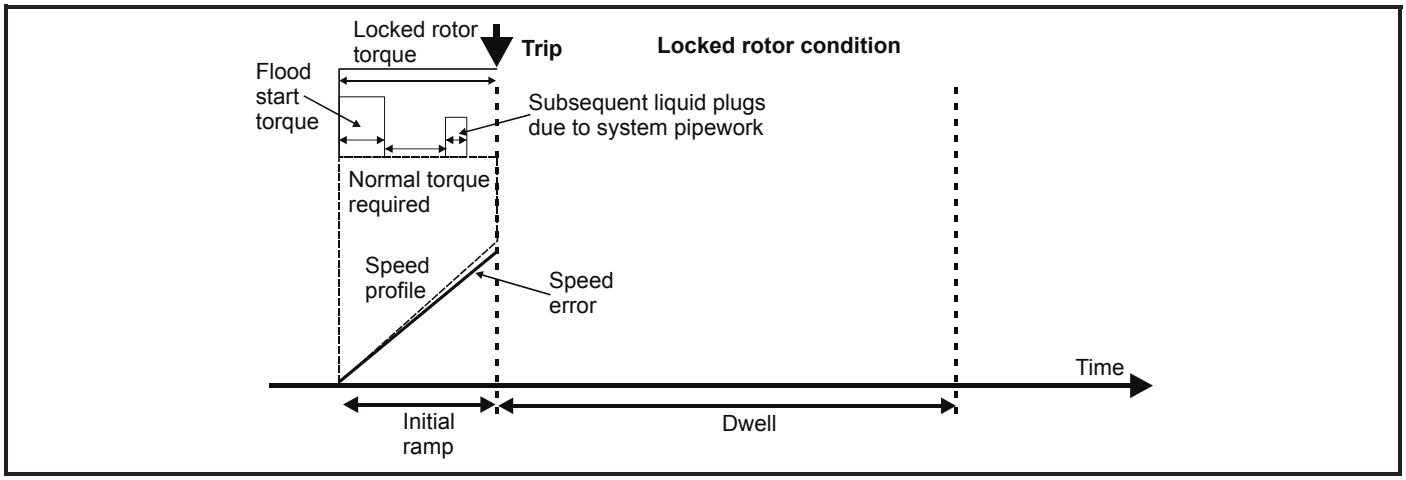
6.2.11 Locked rotor condition

Function runs in the following state(s):	Description
Soft-start	Locked rotor detection

Table 6-5 Parameters associated with the locked rotor detection function:

Parameter	Parameter Name	Function area	Description	Units	Range	Default
00.028 {18.020}	Locked Rotor Failure start count	Locked Rotor Indicator	Records number of failed starts due to Locked Rotor protection	none	0 to 10	0
00.029 {18.021}	Locked rotor idle time	Locked Rotor Indicator	After a failed start, the drive has to wait for a period of idle time before attempting to start the motor again	s	30 to 300	35



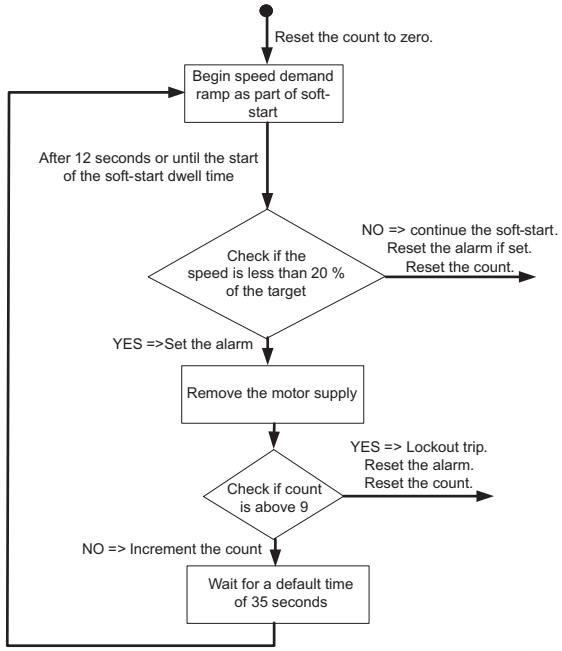
- The locked rotor condition is detected if the speed is less than 20% of the target speed at the end of the initial soft-start ramp.

During the detection phase the "locked rotor" condition warning flag is set.

After a failed start, the drive will wait for a default idle time of 35 s before restarting the compressor. After 10 consecutive Locked Rotor Starts have occurred, the drive will disable itself and produce a "locked rotor" condition trip and the software state is set to TRIPPED.

NOTE

A power cycle is required before the next batch of restarts is attempted (This is to satisfy the UL requirement for a manual reset device).



NOTE

The locked rotor detection function is similar to CoreSense 1379 Alert/Lockout Code 4 - Locked Rotor [illegible]

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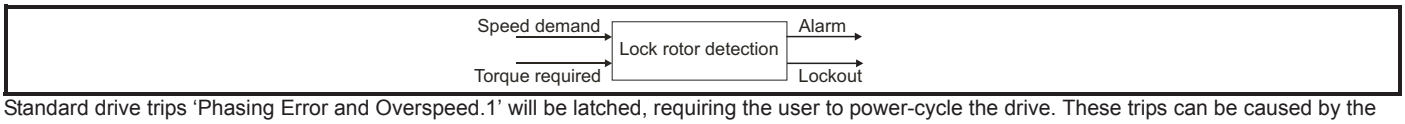
Figure 6-7 Locked rotor detection function block diagram



Standard drive trips 'Phasing Error and Overspeed.1' will be latched, requiring the user to power-cycle the drive. These trips can be caused by the drive being unable to synchronize to the motor due to the locked rotor condition. UL requires a power-cycle reset to permit the UL test to be the '50 test' method rather than the '15 day test' method.

6.2.12 Lost Rotor Trip Prevention, Detection, Retry and Ride-Through Control

Function runs in the following state(s):	Description
Normal running	Lost rotor condition management

Parameter	Parameter Name	Function area	Description	Units	Range	Default
00.047 {19.023}	Lost rotor ride-through dynamic threshold	Lost rotor ride-through	Speed error	rpm	30 to 400 rpm	100 rpm
00.048 {19.024}	Lost rotor ride-through constant threshold	Lost rotor ride-through	Speed error	rpm	30 to 400 rpm	50 rpm

- The aim is to avoid nuisance trips by either riding through, or by dealing with the issue and then automatically restarting.
- Operates in the RUNNING state not during soft-start or controlled stop.

The lost rotor detection system detects conditions where the speed error is greater than expected which could be due to a locked or stalling rotor while running. The detection method must not trip during normal operation when speed error would be expected. During dynamic drive output frequency demand change the expected speed error is higher than during constant drive output frequency demand so two sets of limits are used.

The limits during dynamic drive output frequency demand change must permit the completion of flood starting (after the soft-start is complete) where there is liquid in the scroll rather than vapor. The limits during constant drive output frequency demand, must allow for small slugs of liquid produced by isolated cooling in the system pipe work, to pass through the compressor.

- Constant drive output frequency demand is defined as less than a 2 % rated frequency change in the last 10 s.

Limits during dynamic drive output frequency demand change:

The "lost rotor" condition is detected if the modulus of the speed error (Pr **03.003**) is greater than 100 rpm [user configurable] for longer than 4 s. The aim is to keep the compressor running.

Limits during constant drive output frequency demand:

The "lost rotor" condition is detected if the modulus of the speed error (Pr **03.003**) is greater than 50 rpm [user configurable] for longer than 4 s.

Action if lost rotor detected

If a lost rotor condition is detected the speed demand is lowered by 200 rpm (at the normal running deceleration rate where it remains for a 10 s dwell while the lost rotor condition is again checked. The "lost rotor" alert is set.

This is repeated until the speed demand is at the minimum envelope speed or 1000 rpm if the envelope protection is not enabled. The supply is removed and the drive waits for 60 s before the "lost rotor" alert is reset and the soft-start begins again.

If the lost rotor condition is not detector during one of the 10 s dwell periods, the speed demand is increased by 200 rpm or to the OEM speed demand level (which every is lowest) at 200 rpm per s. The "lost rotor" alert is reset.

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Figure 6-8 Lost rotor alert

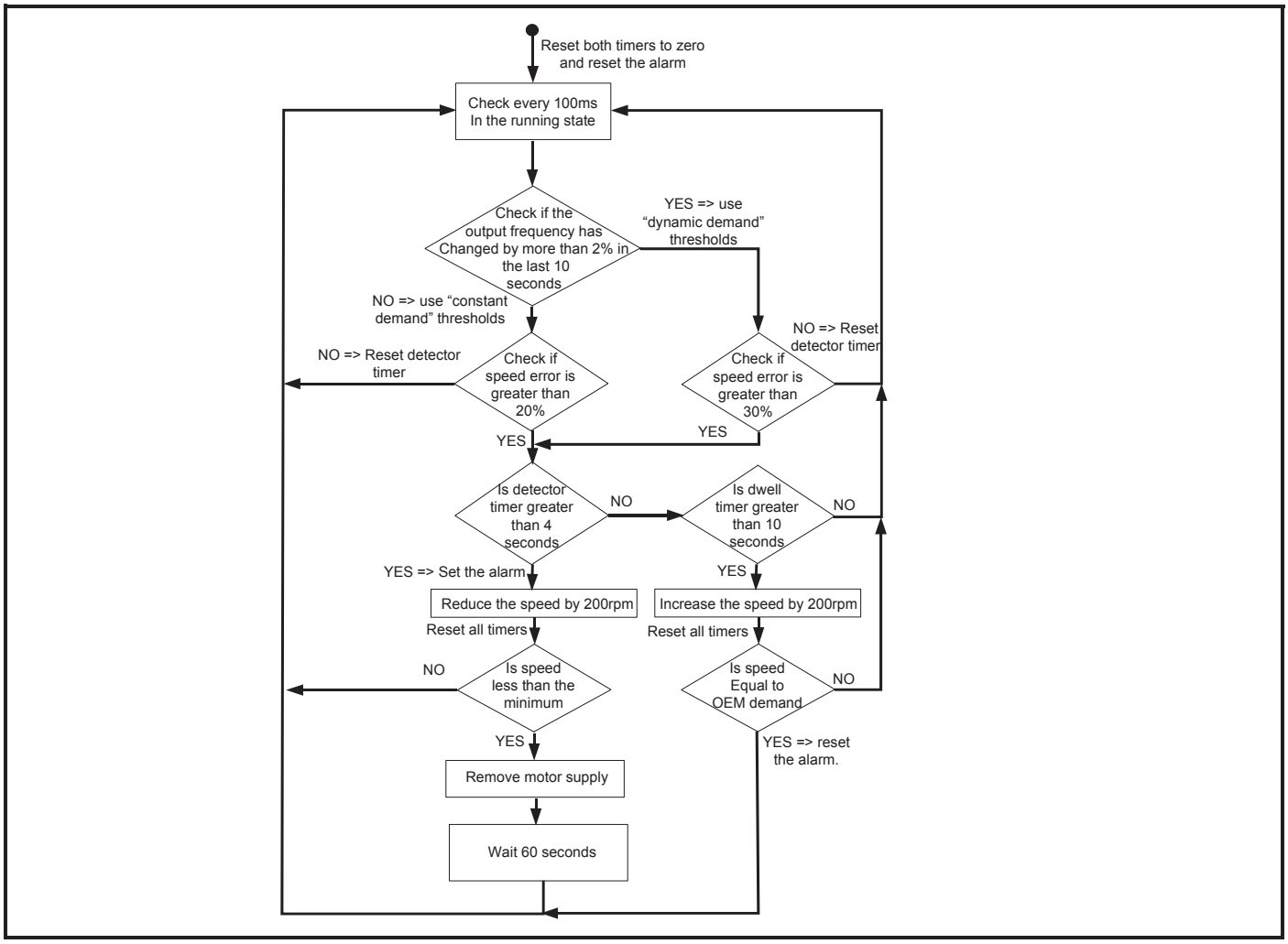
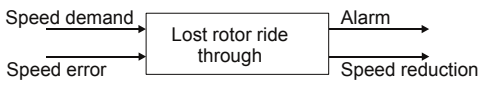


Figure 6-9 Lost rotor function block



6.2.13 Max-load and Low-Voltage fold back management

The aim of this is to avoid nuisance trips and keep the motor running.

- No values for user configuration.
- Uses the drives standard motor current/load and dc bus voltage foldback/limit method.

Fold back the current/torque and speed under the following circumstances:

- Reaching the motor current limit
- If the drive thermal protection is active
- Reaching the motor voltage limit
- Operating with a low voltage supply

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6.3 Compressor protection

The system protection heading brings together all of the compressor system protection functions.

6.3.1 Anti short cycling (Short cycle prevention)

Function runs in the following state(s):	Description
Soft-start	Short cycle detection

Parameter	Parameter Name	Function area	Description	Units	Range	Default
00.035 {19.011}	Short cycle count	Anti-short cycle	Number of short cycles that have occurred	none	0 to Pr **19.012**	0
00.036 {19.012}	Short cycle limit	Anti-short cycle	Maximum allowed short cycles in a day	none	1 to 144	48
00.037 {19.013}	Short cycle time	Anti-short cycle	Short cycle duration	s	60-600	60 s

Excessive short duration cycles can cause damage to the compressor. The short-cycle prevention scheme detects if there have been too many short-cycles. It will then alert the user and impose a restart lockout time to prevent further short-cycles.

Short cycling can occur if control limits are set too tight. This can cause damage to the compressor as correct oil lubrication may not be achieved. This can also occur as a result of problems with the system control: for example, fluctuating loads and sensor faults.

- A short cycle is defined by a start to stop time of less than the setting of Pr **00.037 {19.013}**.
- The start time begins when the system starts the soft-start.

The short-cycle prevention scheme uses an accumulator to detect if there have been too many short-cycles and an alert and restart lockout time to manage and thus prevent further short-cycles.

Detection of the short-cycle event

A timer is started at the beginning of the soft-start and is checked when the compressor next shuts down.

- If the time between the beginning of the start-up and completion of the shut-down is less than the short cycle duration Pr **00.037 {19.013}** an event has been detected.

Accumulator

- The accumulator is incremented whenever a short-cycle event has been detected.
- The accumulator is decremented every "minimum time between short-cycles" which is the 24 hours divided by the user parameter "maximum allowed short cycles in a day".
- The accumulator is never permitted to go negative.

Minimum time between short-cycles" = 24hours / "maximum allowed short cycles in a day".

If the time between short-cycles is greater than or equal to the "minimum time between short-cycles", the accumulator value will reduce to zero. If however, the time between short-cycles is less than the "minimum time between short-cycles", the accumulator will increase.

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Management of the short cycle event

- If the accumulator is equal to or greater than 4 the prevention management is activated.
- The value of 4 has been chosen to permit a number of short-cycles to take place in the short term while providing protection long term.
- While the prevention management is active, the next start is delayed until the accumulator value has reduced from 4. The accumulator is reduced every "minimum time between short-cycles", and thus the starts are restricted to the "minimum time between short-cycles".
- The short-cycle prevention alert is set when the accumulator value is equal to 4 and reset when the accumulator value is equal to 2.

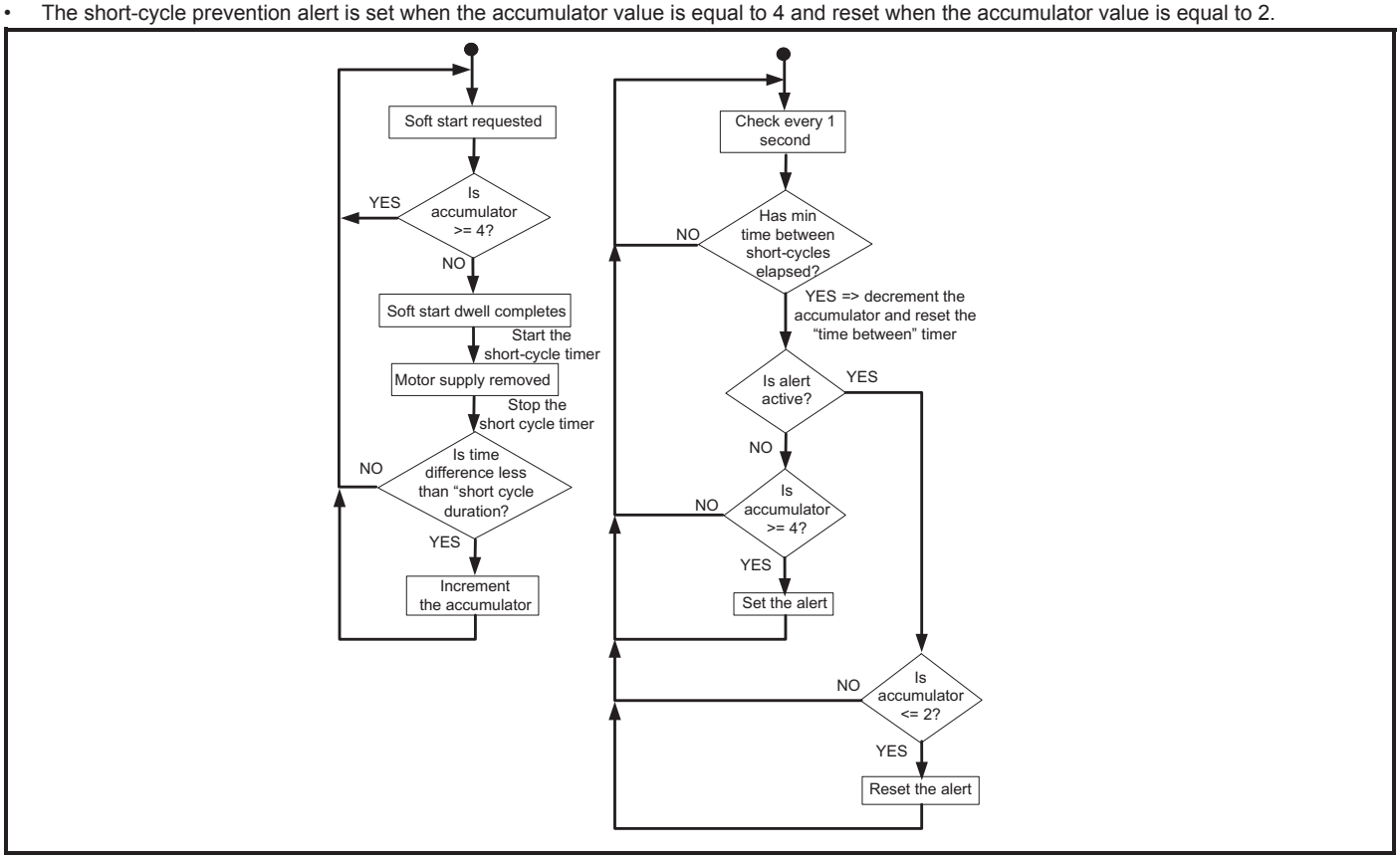
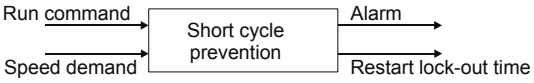


Figure 6-10 Short cycle prevention block



6.3.2 Discharge Line Temperature (DLT)

Function runs in the following state(s):	Description
Idle and all running states	Over temperature protection

Parameter	Parameter Name	Function area	Description	Units	Range	Default
00.031 {18.024}	DLT (Discharge line temperature)	Discharge line temperature	Temperature protection/control	° F	- 40° to 330° F	0
00.032 {18.025}	DLT over temperature fault count	Discharge line temperature	Number of over temperature faults	none	0 to 4	0

If configuration parameter bit 13 (14th) is set to zero, the DLT signal is measured directly by the drive with a range check to detect if the signal is short circuit.

If configuration parameter bit 13 (14th) is set to one, the DLT temperature (in° F) is written to the drive by the OEM controller.

This function is designed to prevent the compressor from running in an over-temperature situation. This situation can occur anywhere, but the key area is at the top left of the operating envelope. An over-temperature event can also be indicative of system transients / faults: locked rotor, blocked suction, blocked discharge, condensing fan failure, system loss of refrigerant charge, improper field charging of the system.

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Over temperature protection

- The temperature is checked every 1 second.
- If the temperature is above the fault level, an alert is set.
- If the DLT temperature is below the trip level, the alert is reset.
- If the temperature is above the trip level for more than 3 samples each taken at 60 second intervals, the drive is disabled, the "DLT" trip set (Pr **00.021** = 42) and the software state set to TRIPPED.
- The trips will automatically be cleared if the DLT temperature is below the trip level for 10 minutes. The trip log will still log that the trip has occurred.
- The DLT over temperature feature can be disabled using the disable function flag for field charging, system setup and commissioning.

Figure 6-11 Over temperature protection

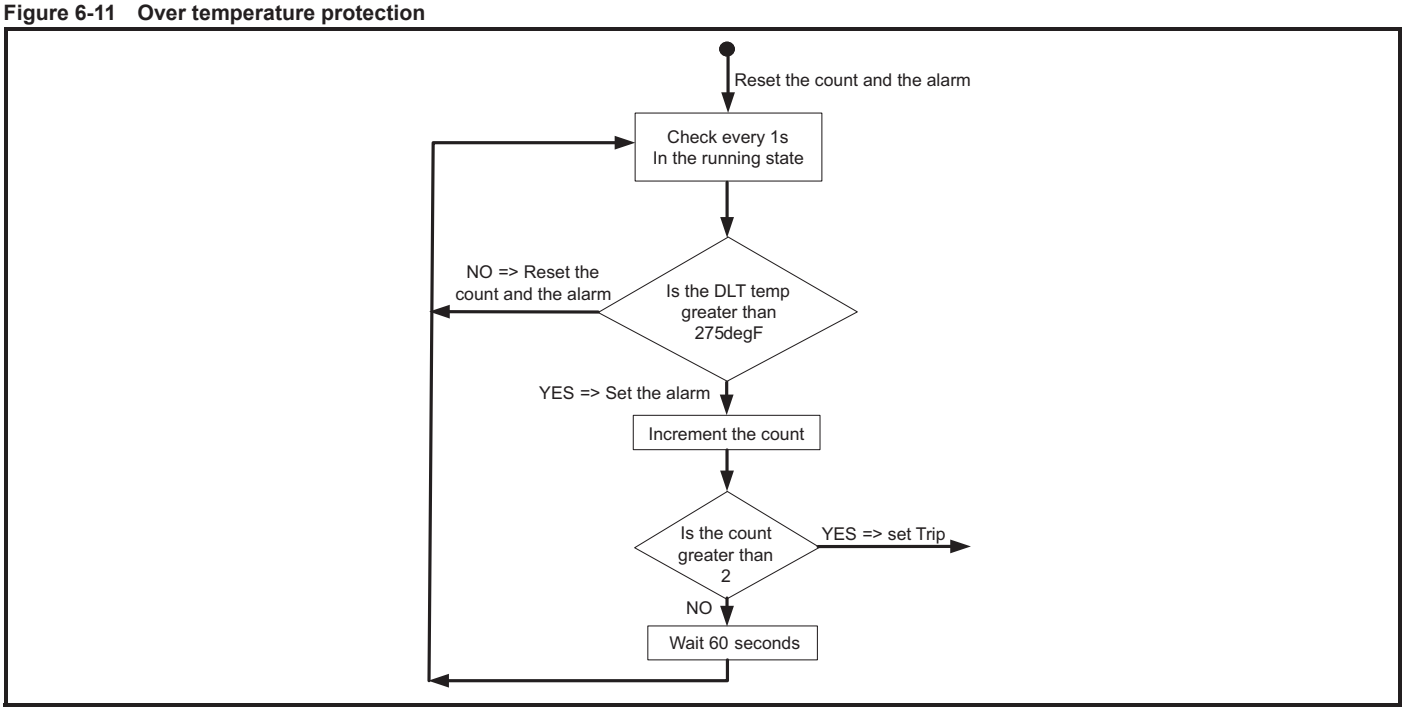

Figure 6-12 DLT protection function block

6.3.3 Envelope control

Function runs in the following state(s):	Description
Running states	Envelope control

Parameter	Parameter Name	Function area	Description	Units	Range	Default
00.025 {18.017}	Condenser pressure	Envelope control	Condenser pressure	Pressure	0 to 650 psig	250 psig
00.026 {18.018}	Evaporator pressure	Envelope control	Evaporator pressure	Pressure	0 to 650 psig	80 psig
00.058 {20.005}	Speed reference after envelope control	Envelope control	Speed reference after envelope control	rpm	0 to 7200 rpm	0 rpm

- If the envelope is not enabled, the frequency minimum is 1000 rpm.

This functionality will prevent the compressor from being used outside of its design limits (Envelope). The benefit to the customer of this functionality is a control simplification for the OEM (design time).

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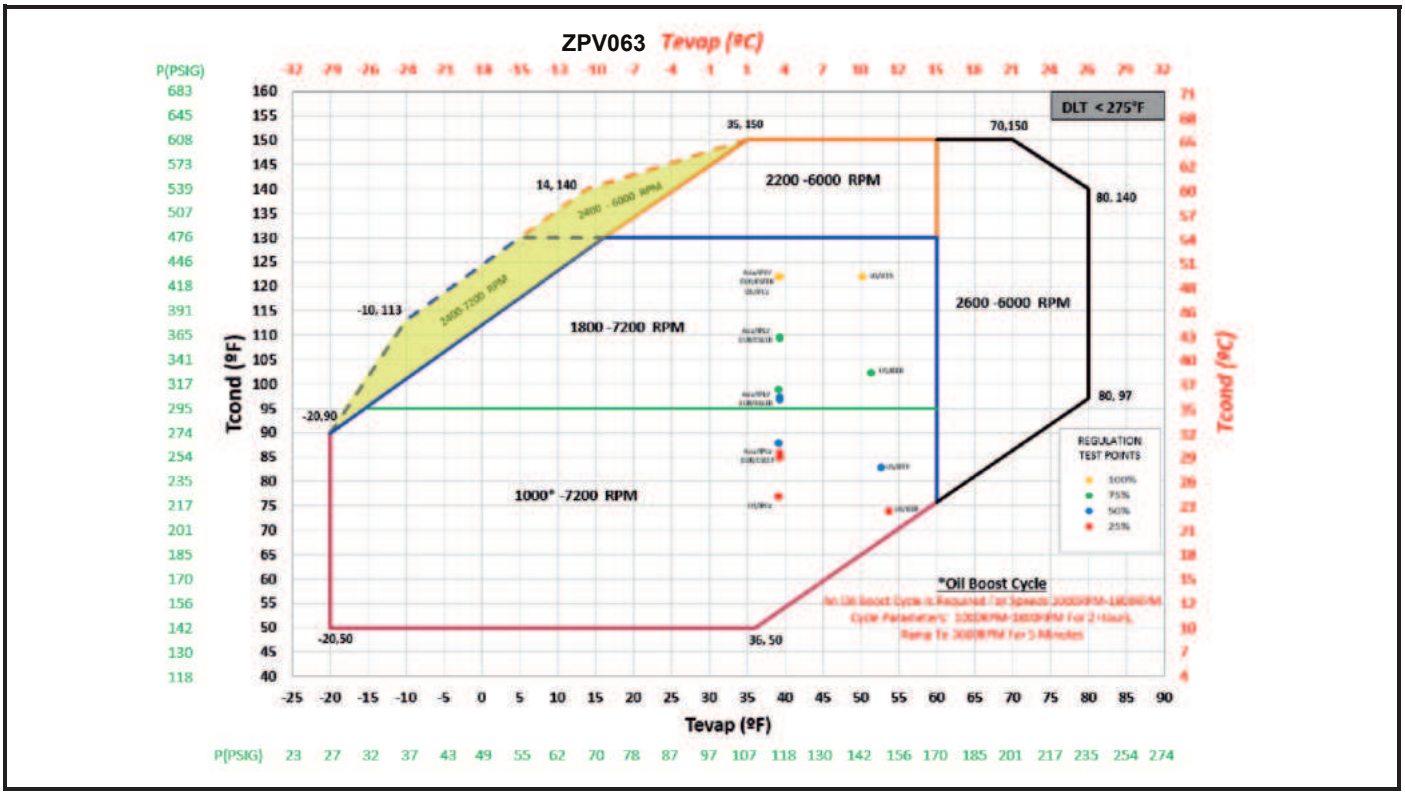
Figure 6-13 Preliminary operating envelope



- Pressure out to the Condenser Pc (Pr **18.017**)
- Pressure in from the Evaporator Pe (Pr **18.018**)

The shape of the envelope and regions are shown in Figure 6-13 *Preliminary operating envelope* above.

The control system has two stages:-

- Out of outer envelope detection
- Speed limits within an envelope sub-region

Out of outer envelope detection

The outer envelope is defined based on a set of points which are used within a straight line formula to detect whether a pressure point is in or out of the outer envelope. The quantisation is to 1psig. When rounding is required, this is performed "into" the envelope (so round down if the value is just above, and round up if the value is just below) to avoid rogue trips.

- The CSD100 will trip "out of envelope" if the pressure point is out of the outer envelope for more than 10 minutes. If the pressures are within the envelope for 10 minutes, the trip is cleared automatically.
- If Condensing / Evaporation pressures are out of envelope for 15 s, an alert is set.

Speed limits within an envelope sub-region

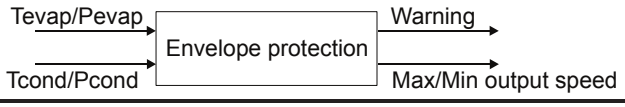
The sub-region is determined if the pressure points are within the outer envelope

Given the two pressure inputs, this function will provide a maximum range for the speed which is applied to the reference.

The software will set the "Envelope Override Active" alert flag when the speed reference is being limited by this function.

The CSD100 will act as an override on the speed reference signal, preventing over/under speed at the operating envelope point. The envelope override limits both the minimum and maximum speed. Envelope override is only active during the running group of states and affects the input speed reference before the other functions modify the reference.

Figure 6-14 Envelope protection function block



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6.3.4 Stator heating

Function runs in the following state(s):	Description
IDLE WITH STATOR HEATING	Controlled stator heating if there is a sump/outdoor sensor
TIMED STATOR HEATING	Timed stator heating if no sump/outdoor sensor

Parameter	Parameter Name	Function area	Description	Units	Range	Default
00.053 {19.032}	Stator heating control mode	Stator heating	0 => Off [default] 1 => OEM (digital or comms) control	none	0 to 1	0 [off]
00.041 {19.017}	Stator heating wattage	Stator heating	Controls the heating current [Default to 100 W]	Watts	10 to 150 W	100 W

A user parameter is provided to alter the stator heating power with a default setting of 100 Watts.

OEM (digital or comms) control mode:

- The field-bus/comms control is through the System control word Pr **00.020 {18.012}**.
- The digital control is through digital input 4 (CSD100 control terminal 27).
- The stator heater is activated if the software is in the idle state and the command bit or the digital signal is active by the OEM controller.
- The stator heater is deactivated if the command bit or the digital signal is not active.

6.3.5 Oil boost

Function runs in the following state(s):	Description
Oil boost	

Parameter	Parameter Name	Function area	Description	Units	Range	Default
00.006 {01.026}	Oil boost speed	Oil boost	Boost speed used if oil boost required	0.1 rpm	1500.0 to 7200.0	1500.0 rpm
00.012 {02.016}	Oil boost acceleration rate		Oil boost acceleration rate	0.000 s per 1000 rpm	0.500 to 20.000	5.000 s
00.017 {02.026}	Oil boost deceleration rate		Oil boost deceleration rate	0.000 s per 1000 rpm	0.500 to 20.000	5.000 s
00.043 {19.019}	Oil boost threshold speed		Oil boost threshold speed	rpm	0 to 7200	1000 rpm
00.044 {19.020}	Oil boost threshold time		Period of time for oil boost mode to be entered	minutes	1 to 120	120
00.045 {19.021}	Oil boost solution time		Period of time that the motor will be run at the oil boost speed if oil boost mode is entered	minutes	5 to 30 s	5

If the compressor is running at a speed that is insufficient to guarantee lubrication (for a defined time), oil boost mode is entered. During oil boost, the motor speed is increased for a period of time to ensure the compressor is correctly lubricated.

The function is active in all run conditions except for soft-start. The function's logic is as follows:

- If the motor speed is higher than the user configured threshold for 5 minutes, reset the timing.
- Otherwise start timing.
- If the compressor is turned off, stop the counter and store the value ready for when the compressor turns on again.
- If the threshold time (user configurable) has elapsed, ramp to the oil boost speed (user defined in Pr **00.006 {01.026}** but can only be higher than the default) at 200 rpm per second default. Set the oil boost warning.
- Hold for the solution time (user defined in Pr **00.045 {19.021**} but cannot be less than the default 60 s).
- Once the time has elapsed, return to the previous state ramping if necessary at 200 rpm per s. Reset the oil boost warning.

The purpose of the oil boost is to ensure adequate lubrication of the compressor components, and to return oil from the system to the compressor.

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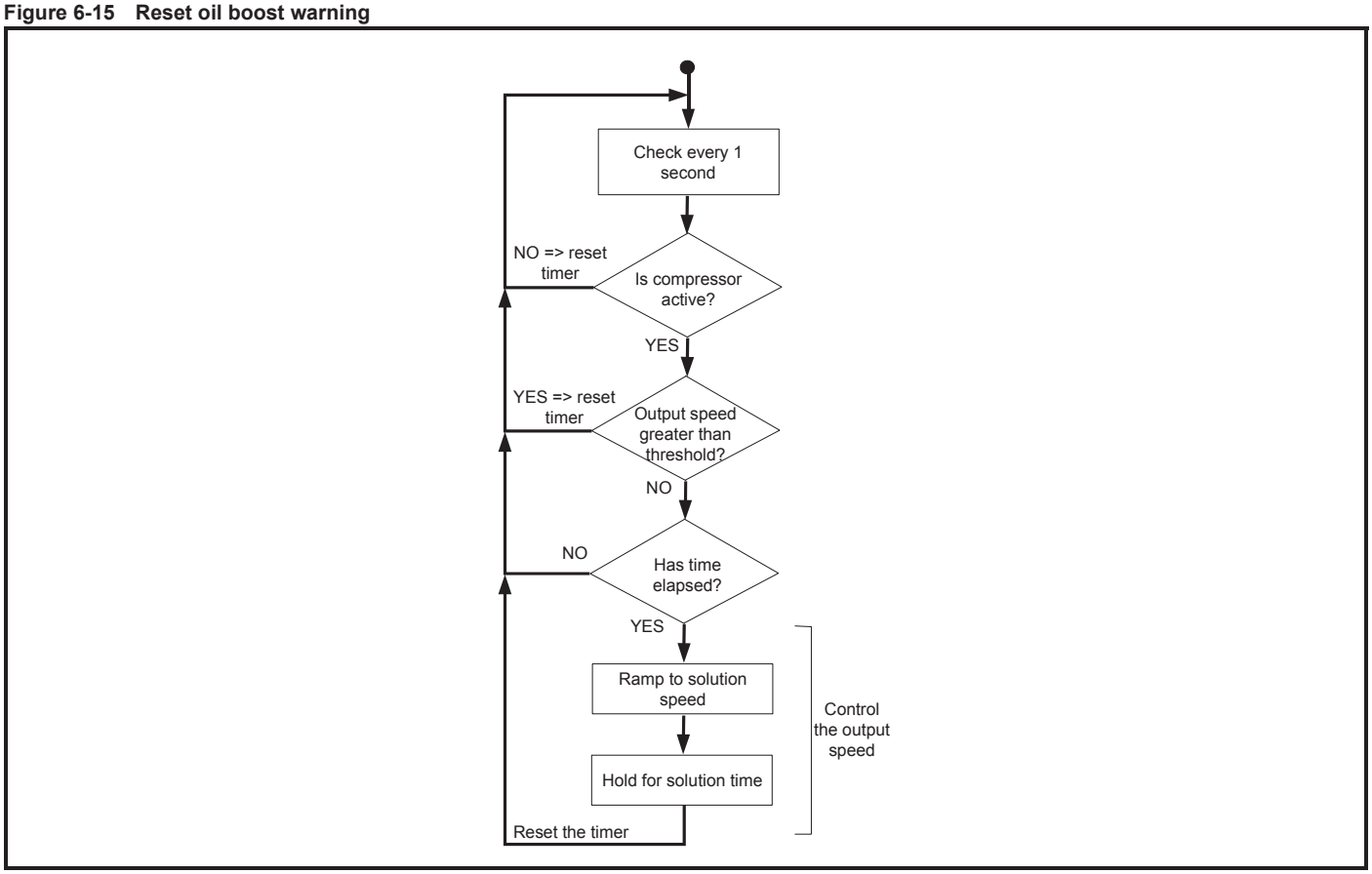
Figure 6-15 Reset oil boost warning



6.4 System control

This section heading brings together all of the control functions provided by the CSD100 software.

6.4.1 Start and Shut down procedures

Soft-start

- The soft-start and controlled stop modes override the OEM speed reference.

Function runs in the following state(s):	Description
SOFT-START	Start-up

Parameter	Parameter Name	Function area	Description	Units	Range	Default
00.001 {01.021}	User soft-start dwell speed	Soft-start	User soft-start dwell speed	0.1 rpm	1500.0 to 7200.0	3600.0 rpm
00.009 {02.011}	Soft-start acceleration rate		Soft-start acceleration rate	0.000 s per 1000 rpm	0.500 to 2.500	1.000 s
00.027 {18.019}	Soft-start dwell time		Soft-start dwell time	s	120 to 300	120 s
00.050 {19.028}	Number of soft-start attempts		Number of soft-start attempts	none	0 to 3	0

The drive controls the starting routine of the variable speed scroll compressor. The routine allows soft-starting, an advantage over traditional on-off control of non variable speed compressors.

- On a call for operation from the system controller, the drive will start the compressor and ramp its speed up to the soft start dwell speed (default 3600 rpm). The default acceleration rate is 1000 rpm per second. This acceleration rate can be set using the soft start acceleration parameter- Pr **00.009 {02.022}** but it should be noted that the initial acceleration rate up to a speed of 300 rpm is fixed at 1000 rpm per second.
- The final motor speed may be affected by the loading conditions and fold back. The speed estimation is checked 1 second after the soft-start demand should have reached 3600 rpm. If the torque loading (Pr **04.020**) is greater than 90 %, the soft-start demand is reduced to zero at 1000rpm per second and an alert is set. When the demand has reached 0 rpm the system waits for 1 s (for the rotor speed to meet the demand) before the motor supply is removed. The system waits 10 s before re-starting the soft-start.
- If there are three consecutive soft-start failures, the drive will trip and lockout the compressor. A power cycle, MODBUS reset command, reset signal to T25 or keypad reset is required to clear the lockout.
- The drive will maintain the 3600 rpm command for a user defined time (range 2.0 to 5.0 minutes with a default of 2.0 minutes [120 seconds]) and then ramp the speed up or down to the speed requested by the system controller at a rate of 200 rpm per second. This applies to all start up conditions.

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Figure 6-16 Soft start sequence

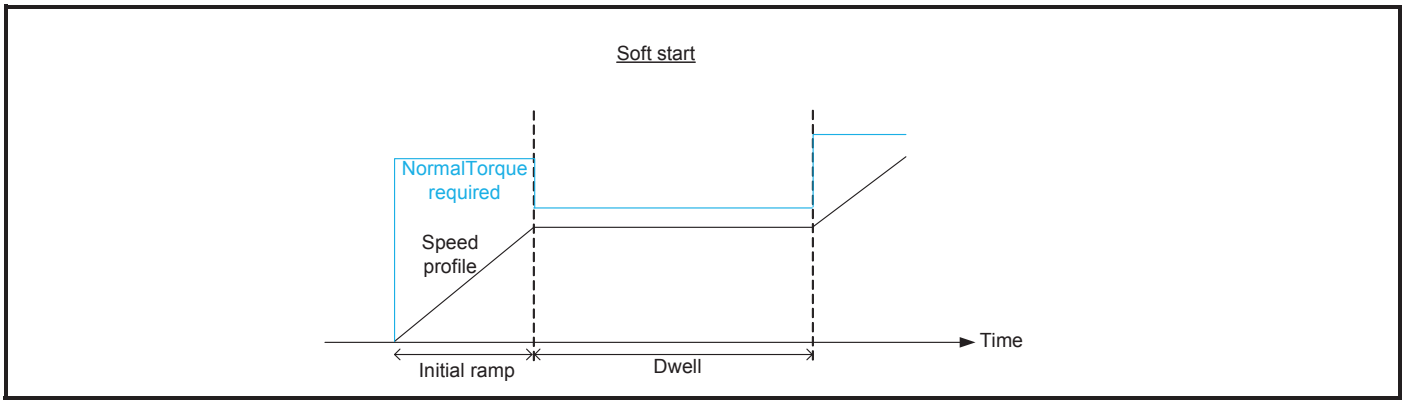
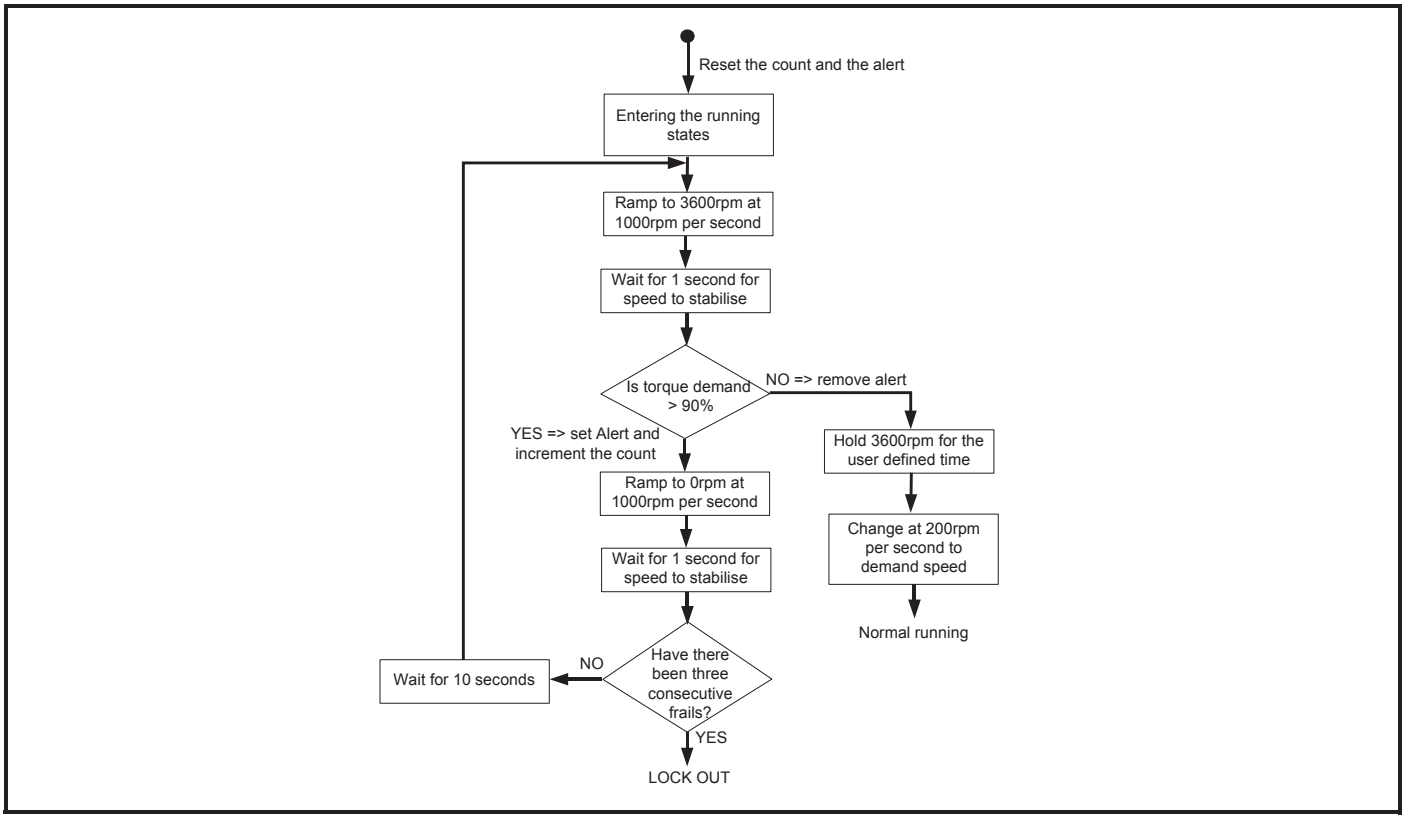


Figure 6-17 Soft start function block

Figure 6-18 Soft start function flow chart



6.4.2 Normal running

During normal running, the change in the OEM speed reference is internally limited to +/-200 rpm.

Parameter	Parameter Name	Function area	Description	Units	Range	Default
00.002 {01.022}	Normal running reference	Reference after limits and protection	Set by the software	0.1 rpm	0 to 7200.0	0 rpm
00.010 {02.012}	Normal running acceleration rate	Normal running	Normal running acceleration rate	0.000 s per 1000 rpm	5.000 to 1000.000	5.000 s
00.013 {02.022}	Normal running deceleration rate	Normal running	Normal running deceleration rate	0.000 s per 1000 rpm	5.000 to 1000.000	5.000 s
00.019 {18.011}	User speed reference in RPM	Reference	From OEM controller			

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6.4.3 Controlled shut down

Function runs in the following state(s):	Description
CONTROLLED SHUTDOWN	Shut down

Parameter	Parameter Name	Function area	Description	Units	Range	Default
00.003 {01.023}	Controlled shut down final reference	Controlled shut down	Controlled shut down final reference	0.1 rpm	0 to 7200.0	3600 or envelope minimum
00.004 {01.024}	Stop reference	Controlled shut down	Held at zero	0.1 rpm	0	0
00.014 {02.023}	Controlled shutdown deceleration rate	Controlled shut down	Controlled stop deceleration rate	0.000 s per 1000 rpm	0.500 to 20.000	5.000 s
00.015 {02.024}	Stop deceleration rate	Controlled shut down	Stop reference deceleration rate	0.000 s per 1000 rpm	0.500 to 20.000	2.000 s
00.049 {19.027}	Controlled shutdown dwell time	Controlled shut down	Controlled shutdown dwell time	s	0 to 300	120 s

This function requires the compressor to complete a shutdown and stop before starting up again. When the system controller signals for the compressor to stop, by sending controlled shut down command, the controlled shut down is triggered.

If the envelope protection **is active**:

- If 70 % of the final speed reference, Pr **03.001** (which is the OEM reference subjected to the acceleration and deceleration limits) is still higher than the minimum operating speed envelope condition, reduce the speed by 30 % to 70 % of the final speed reference.
- Else, stay at the current speed.
- Hold for 3 minutes and then check the reference.
- If the command is no longer there, go back to normal running state.
- Else, ramp to minimum envelope speed at 200 rpm per second.
- Shutdown (remove the supply) for 10 s then go to the idle state.

If the envelope control is **not active**:

- If the estimated speed is above 3600 rpm, ramp down to 3600 rpm at 200 rpm per second.
- Else if the estimated speed is below 3600 rpm, remain at the current speed.
- Hold for 3 minutes and then check the reference.
- If the command is no longer there, go back to normal running state.
- Else, shutdown (remove the supply) for 10 s then go to the idle state.

If a minor fault condition occurs during operation the drive will perform a controlled shutdown triggered by the OEM controller.

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Figure 6-19 Entering controlled shut-down

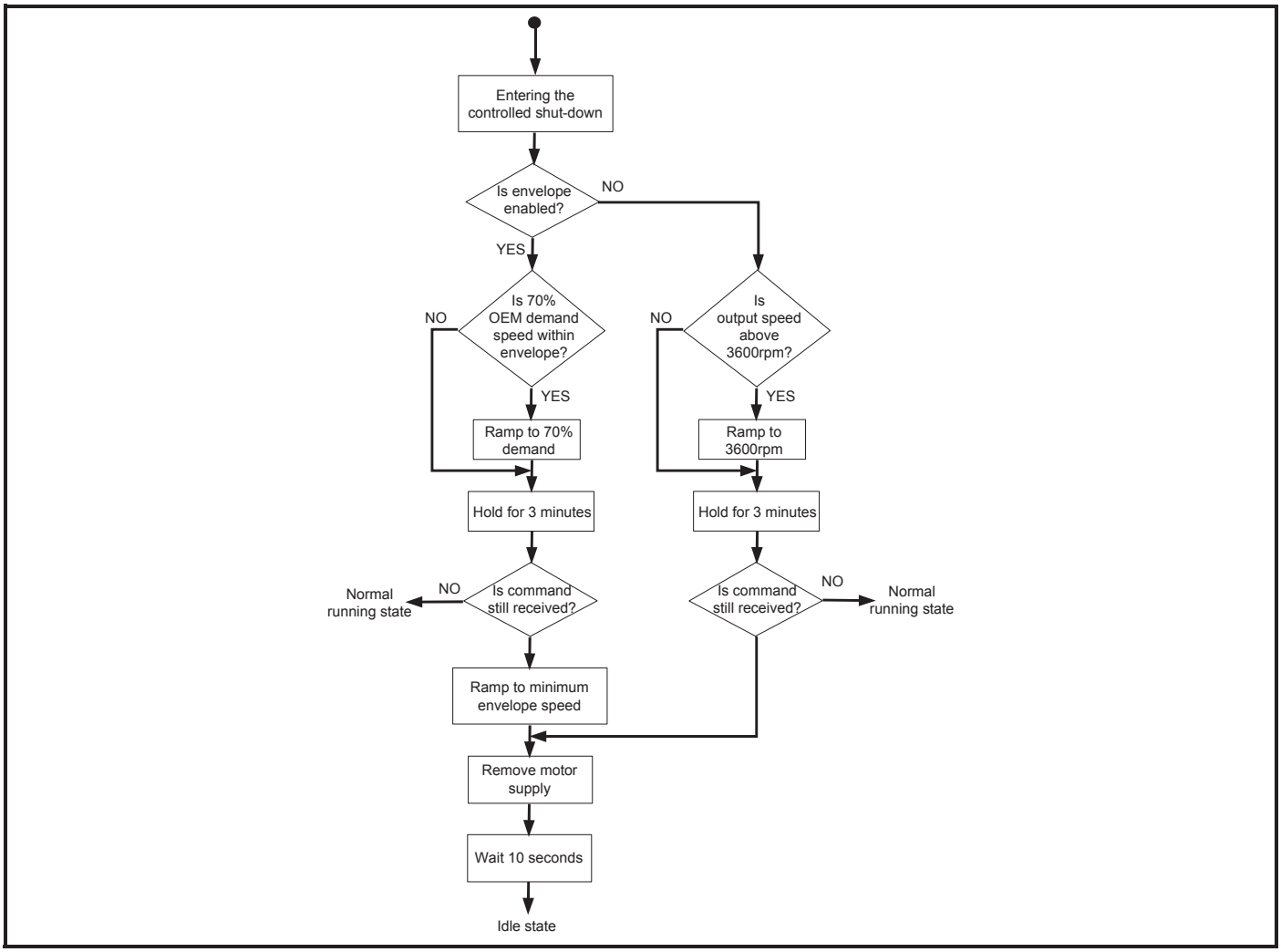
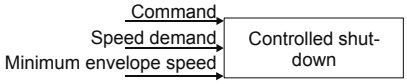


Figure 6-20 Controlled shut-down function block



6.4.4 Defrost control/procedure

Function runs in the following state(s):	Description
DEFROSTCYCLE	Defrosting

Parameter	Parameter Name	Function area	Description	Units	Range	Default
00.005 {01.025}	Final defrost speed reference	Defrost cycle	Speed during defrost dwell	0.1 rpm	1500.0 to 7200.0	1500.0 or envelope minimum
00.011 {02.015}	Defrost acceleration rate	Defrost cycle	Defrost acceleration rate	0.000 s per 1000 rpm	0.500 to 20.000	2.000 s
00.016 {02.025}	Defrost deceleration rate	Defrost cycle	Defrost deceleration rate	0.000 s per 1000 rpm	0.500 to 20.000	2.000 s
00.051 {19.029}	User defrost speed reference	Defrost cycle	User defrost speed reference	rpm	1500 to 7200	1500 rpm
00.052 {19.030}	Defrost cycle end dwell time	Defrost cycle	Defrost cycle end dwell time	s	30 to 300	60 s

Once triggered, through the System control word Pr **00.020 {18.012}**, the defrost cycle will operate until complete. During operation the defrost flag is set high in the condition warnings parameter Pr **00.023 {18.015}** bit 4.

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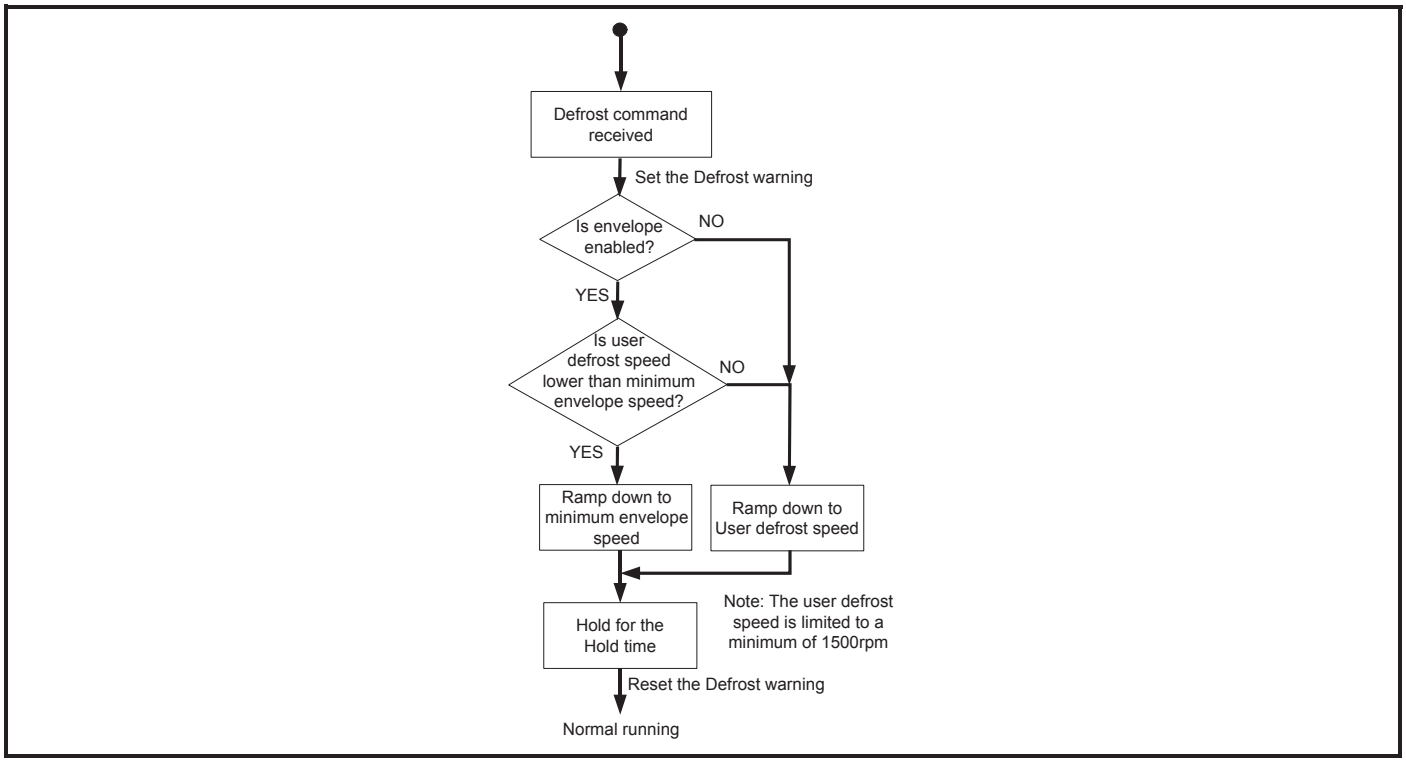
- If the envelope protection is active, the minimum speed is used. If envelope protection is not active 1500 rpm (default - user defined by Pr **00.051 {19.029}**) is used as the minimum speed.
- The drive will slow the compressor to 1500 rpm (user defined by Pr **00.051 {19.029}**) (or the minimum speed from the envelope condition) at a default rate of 2 s per 1000 rpm - user defined by Pr **00.016 {02.025}**.
- The compressor will remain at this speed for 60 s (default- user defined in Pr **00.052 {19.030}**) to let the suction and discharge pressures stabilize.
- After the hold time, the system will return to the normal running state, changing the speed at a default rate of 2 s per 1000 rpm (user defined by Pr **00.011 {02.015}**).

Figure 6-21 Defrost command



6.4.5 Resonance avoidance

Function runs in the following state(s):	Description
Running states	Use the standard skip frequencies function available in the CSD100 firmware

Parameter	Parameter Name	Function area	Description	Units	Range	Default
00.007 {01.029}	Skip Reference 1	Resonance avoidance	Skip Reference	rpm	0 to 7200	0 rpm [no filter]
00.008 {01.030}	Skip Reference Band 1	Resonance avoidance	Defines the range either side of Pr **01.029**	rpm	0 to 250	0 rpm
01.031	Skip Reference 2	Resonance avoidance	Skip Refeence	rpm	0 to 7200	0 rpm [no filter]
01.032	Skip Reference Band 2	Resonance avoidance	Defines the range either side of Pr **01.031**	rpm	0 to 250	0 rpm
01.033	Skip Reference 3	Resonance avoidance	Skip Refeence	rpm	0 to 720	0 rpm [no filter]
01.034	Skip Reference Band 3	Resonance avoidance	Defines the range either side of Pr **01.033**	rpm	0 to 250	0 rpm

This function is provided to avoid running at motor speeds which cause mechanical resonance effects. In the default state no filter is applied, however it can be configured if required.

Skip Reference Band 1 (**01.030**) defines the range either side of *Skip Reference 1* over which references are rejected in either direction. The actual rejection band is therefore twice that defined by *Skip Reference Band 1* (**01.030**) with *Skip Reference 1* (**01.029**) as the centre of the band. When the selected reference is within the rejection band the lower limit of the band is passed through the filter so that reference is always less than demanded.

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6.4.6 Fieldbus (MODBUS) over RS485

The OEM controller can read all of the available standard drive parameters. Certain trips and lock out conditions are resettable through the Fieldbus link using the System control word Pr **00.020 {18.012}**.

Parameter	Parameter Name	Function area	Description	Units	Range	Default
00.054 {20.001}	Fieldbus comms monitor	Fieldbus comms monitor	If zero [default] the comms monitoring is disabled.	none	0 to 300	0

If this parameter is set to 0 (default) Fieldbus comms monitoring is disabled.

If a value greater than 1 is written by the OEM to this parameter, the software will begin to increment the parameter every 1 second. If the parameter reaches a value larger than 300 (5 minutes), the system will move to the trip state (Pr **00.021** = 45) and stop the compressor using a controlled stop.

This parameter is therefore designed to be periodically reset to a non zero value (in a watchdog type fashion) by the OEM controller. If a Fieldbus communication problem occurs, this reset will not occur and the system will trip within 300 s. It should be noted that the OEM can select the timeout: for example writing 1 to the parameter provides the full five minutes, writing 240 would give 1 minute.

NOTE

This function is similar to CoreSense 1384 Warning Code 1 - Loss of Communication].

6.5 Parameter descriptions

6.5.1 Pr mm.000

Pr **mm.000** is available in all menus, commonly used functions are provided as text strings in Pr **mm.000** shown in Table 6-6.

Table 6-6 Commonly used functions in xx.000

Value	Equivalent value	String	Action
0	0	**[No Action]**	
1000	1	**[Save parameters]**	Save parameters when under voltage is not active and low voltage threshold is not active
6001	2	**[Load file 1]**	Load the drive parameters or user program file from NV media card file 001
4001	3	**[Save to file 1]**	Transfer the drive parameters to parameter file 001
6002	4	**[Load file 2]**	Load the drive parameters or user program file from NV media card file 002
4002	5	**[Save to file 2]**	Transfer the drive parameters to parameter file 002
6003	6	**[Load file 3]**	Load the drive parameters or user program file from NV media card file 003
4003	7	**[Save to file 3]**	Transfer the drive parameters to parameter file 003
12000	8	**[Show non-default]**	Displays parameters that are different from defaults
12001	9	**[Destinations]**	Displays parameters that are set

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7 Running the motor

This chapter takes the new user through all the essential steps to running a motor for the first time.

NOTE

Motor parameters are pre-configured to suit an individual compressor, hence no setting of these parameters or motor autotuning is required.

WARNING

Ensure that no damage or safety hazard could arise from the motor starting unexpectedly.

WARNING

If the intended maximum speed affects the safety of the machinery, additional independent over-speed protection must be used.

7.1 Quick start connections

7.1.1 Basic requirements

This section shows the basic connections which must be made for the drive to run. When the basic connections shown in Figure 7-2 *Minimum connections to get the motor running (size 5)* on page 90 have been made, the CSD100 is started as described below:

- Turn on the power supply.
- Set Pr **00.024 {18.016}** Configuration Control Parameter appropriately (see section 6.2.1 *Configuration parameter* on page 67).
- Provide a user speed reference in Pr **00.019 {18.011}**.
- Apply an enable signal to control terminal T31
- Apply a start signal to T26 (if configured Pr **00.024 {18.016}** bit 8 = 0), or apply the control word start/run bit (if configured **00.024 {18.016}** bit 8 = 0).

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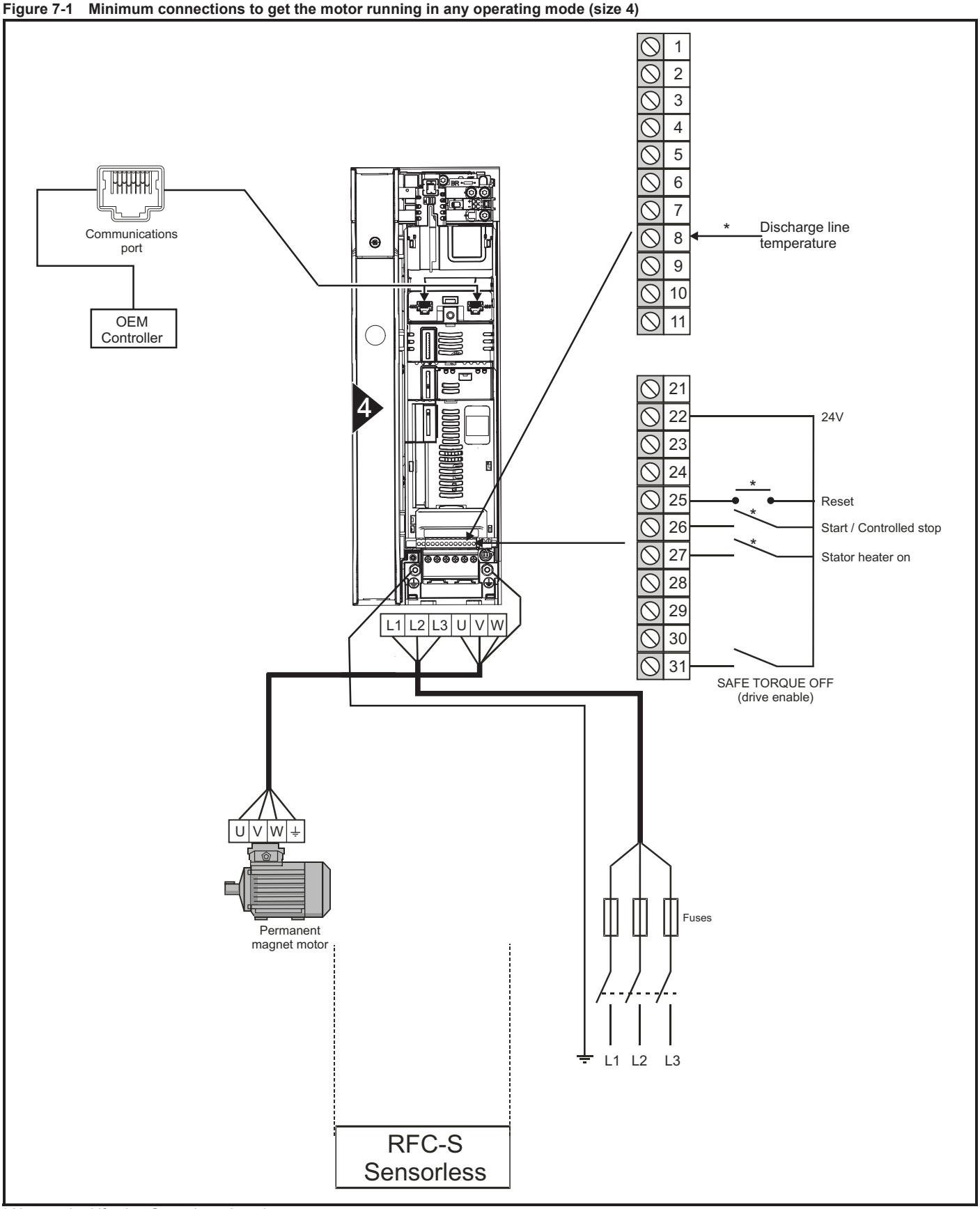
Figure 7-1 Minimum connections to get the motor running in any operating mode (size 4)



* Not required if using Control word mode.

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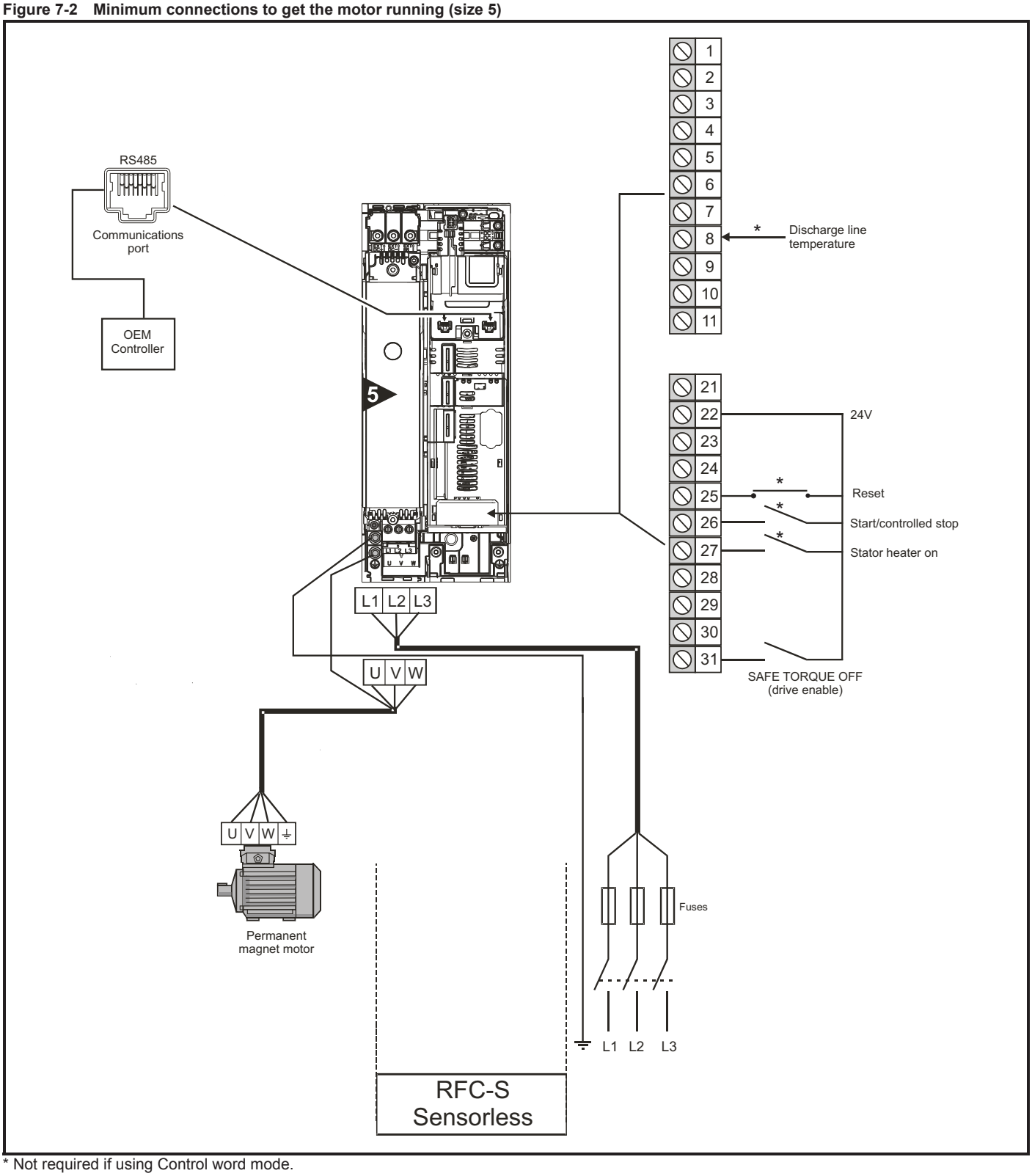
Figure 7-2 Minimum connections to get the motor running (size 5)



* Not required if using Control word mode.

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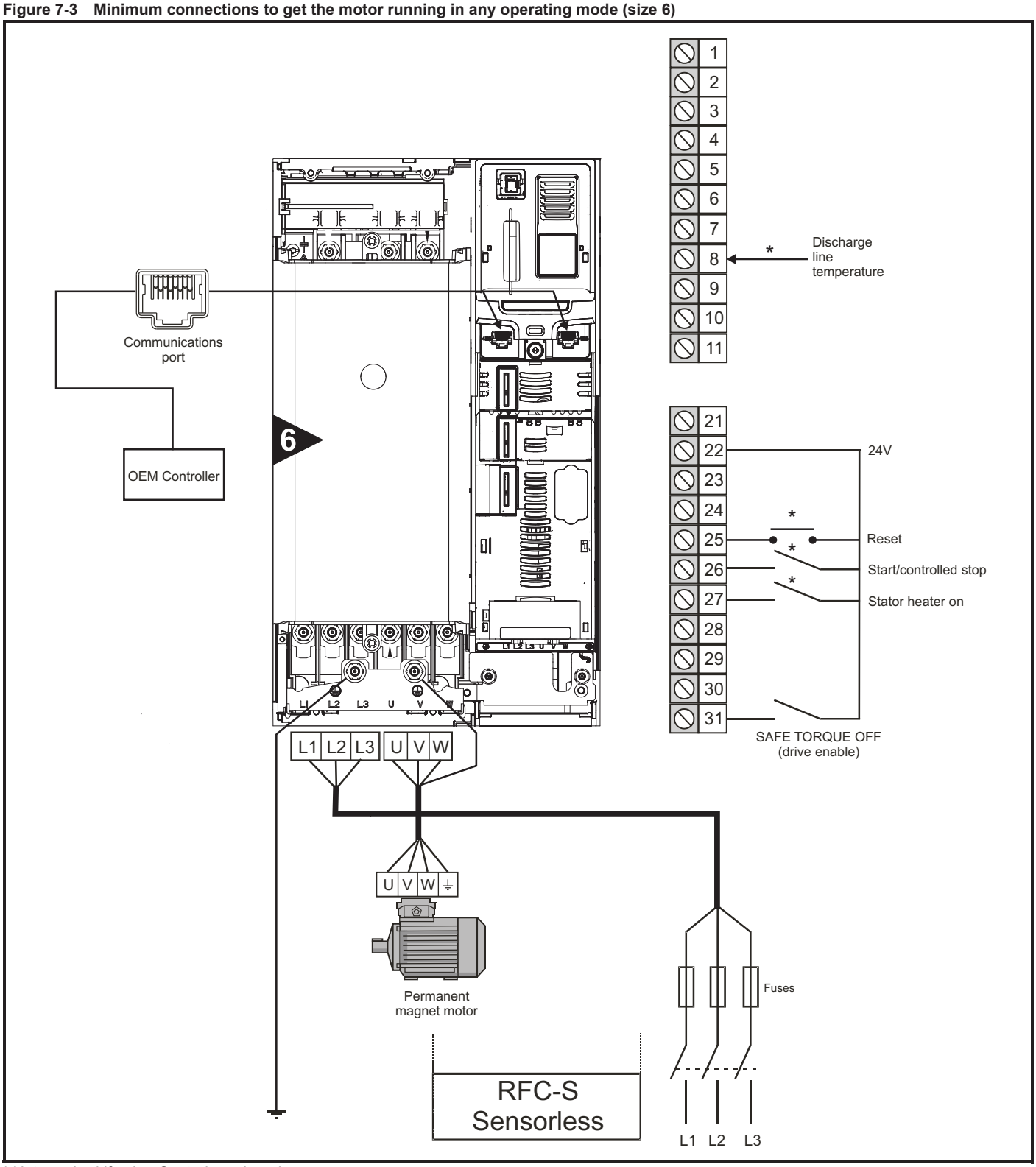
Figure 7-3 Minimum connections to get the motor running in any operating mode (size 6)



* Not required if using Control word mode.

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8 Optimization

This chapter takes the user through methods of optimizing the drive set-up and maximize the performance.

8.1 Motor thermal protection

A dual time constant thermal model is provided to estimate the motor temperature as a percentage of its maximum allowed temperature.

The motor thermal protection is modelled using losses in the motor. The losses in the motor are calculated as a percentage value, so that under these conditions the *Motor Protection Accumulator* (04.019) would eventually reach 100 %.

Percentage losses = 100 % x [Load related losses + Iron losses]
Where:

Load related losses = $(1 - K_{fe}) \times (I / (K_1 \times I_{Rated})^2$

Iron losses = $K_{fe} \times (w / w_{Rated})^{1.6}$

Where:

I = *Current Magnitude* (04.001)

I_{Rated} = *Rated Current* (05.007)

K_{fe} = *Rated Iron Losses As Percentage Of Losses* (04.039) / 100 %

The *Motor Protection Accumulator* (04.019) is given by:

Pr **04.019** = Percentage Losses x $[(1 - K_2) (1 - e^{-t/\tau 1}) + K_2 (1 - e^{-t/\tau 2})]$

Where:

T = *Motor Protection Accumulator* (04.019)

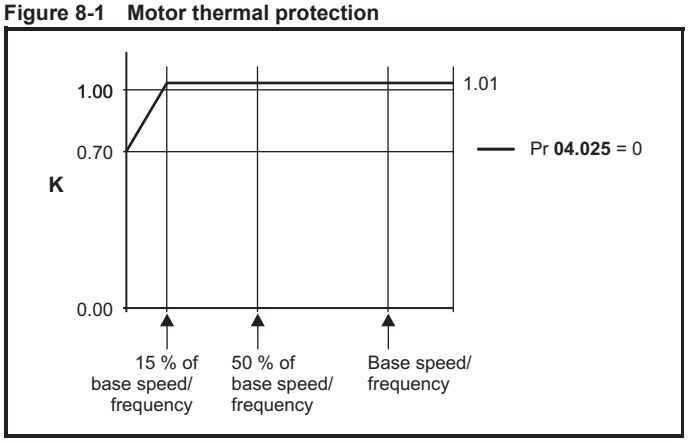
K_2 = *Motor Thermal Time Constant 2 Scaling* (04.038) / 100 %

$\tau 1$ = *Motor Thermal Time Constant 1* (04.015)

$\tau 2$ = *Motor Thermal Time Constant 2* (04.037)

K_1 = Varies, see below

Figure 8-1 Motor thermal protection



The characteristic is intended for motors where the cooling effect reduces with motor speed below 15 % of base speed/frequency. The maximum value for K1 is 1.01, so that above the knee of the characteristics the motor can operate continuously up to 101 % current.

When the estimated temperature in Pr **04.019** reaches 100 % the drive trips.

The thermal model temperature accumulator is reset to zero at power-up and accumulates the temperature of the motor while them drive remains powered-up.

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9 NV Media Card Operation

9.1 Introduction

The Non-Volatile Media Card feature enables simple configuration of parameters, parameter back-up, storing / reading PLC programs and drive copying using a SMARTCARD or SD card storing / reading PLC programs. The drive offers backward compatibility for a Unidrive SP SMARTCARD.

The NV Media Card can be used for:

- Parameter copying between drives
- Saving drive parameter sets
- Saving an onboard user program

The NV Media Card is located at the top of the module under the drive display (if installed) on the left-hand side.

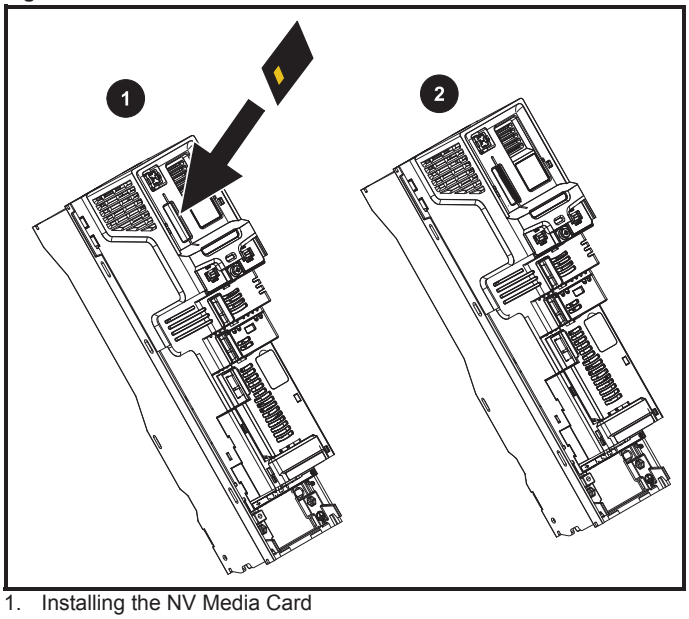
Ensure the NV Media Card is inserted with the contacts facing the left-hand side of the drive.

The drive only communicates with the NV Media Card when commanded to read or write, meaning the card may be "hot swapped".

WARNING

Beware of possible live terminals when installing the NV Media Card.

Figure 9-1 Installation of the NV Media Card



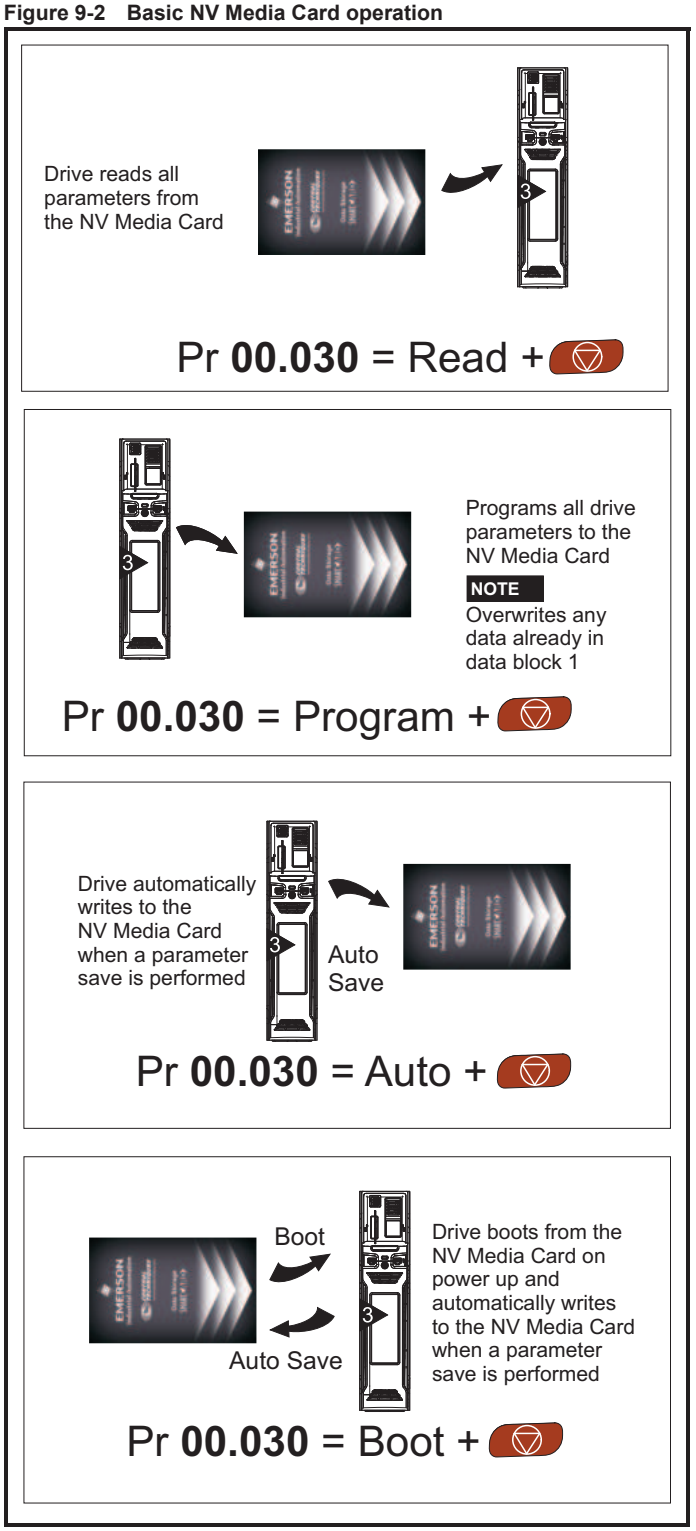
1. Installing the NV Media Card
2. NV Media Card installed

NV Media Card	Part number
SD Card Adaptor (memory card not included)	3130-1212-03
8 kB SMARTCARD	2214-4246-03
64 kB SMARTCARD	2214-1006-03

9.2 NV Media Card support

The NV Media Card can be used to store drive parameter sets from the CSD100 in data blocks 001 to 499 on the card.

Figure 9-2 Basic NV Media Card operation



The whole card may be protected from writing or erasing by setting the read-only flag as detailed in section 9.3.9 *9888 / 9777 - Setting and clearing the NV Media Card read only flag* on page 95.

The card should not be removed during data transfer, as the drive will produce a trip. If this occurs then either the transfer should be reattempted or in the case of a card to drive transfer, default parameters should be loaded.

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9.3 Transferring data

Data transfer, erasing and protecting the information is performed by entering a code in Pr **mm.000** and then resetting the drive as shown in Table 9-1.

Table 9-1 SMARTCARD and SD card codes

Code	Operation	SMARTCARD	SD card
2001	Transfer the drive parameters to parameter file 001 and sets the block as bootable. This will include the parameters from attached option modules.	✓	✓
4yyy	Transfer the drive parameters to parameter file yyy. This will include the parameters from attached option modules.	✓	✓
6yyy	Load the drive parameters from parameter file yyy.	✓	✓
7yyy	Erase file yyy.	✓	✓
8yyy	Compare the data in the drive with file yyy. If the files are the same then *Pr **mm.000*** (**mm.000**) is simply reset to 0 when the compare is complete. If the files are different a 'Card Compare' trip is initiated. All other NV media card trips also apply.	✓	✓
9555	Clear the warning suppression flag	✓	✓
9666	Set the warning suppression flag	✓	✓
9777	Clear the read-only flag	✓	✓
9888	Set the read-only flag	✓	✓
9999	Erase and format the NV media card	✓	

Where yyy indicates the block number 001 to 999.

NOTE

If the read only flag is set then only codes 6yyy or 9777 are effective.

9.3.1 Writing to the NV Media Card

4yyy - Writes defaults differences to the NV Media Card

The data block only contains the parameter differences from the last time default settings were loaded.

All parameters except those with the NC (Not copied) coding bit set are transferred to the NV Media Card. In addition to these parameters all menu 20 parameters (except Pr **20.000**), can be transferred to the NV Media Card.

Writing a parameter set to the NV Media Card (Pr 11.042 = Program (2))

Setting Pr **11.042** to Program (2) and resetting the drive will save the parameters to the NV Media Card, i.e. this is equivalent to writing 4001 to Pr **mm.000**. All NV Media Card trips apply except 'Card Change'. If the data block already exists it is automatically overwritten. When the action is complete this parameter is automatically reset to None (0).

9.3.2 Reading from the NV Media Card

6yyy - Reading from NV Media Card

When the data is transferred back to the drive, using 6yyy in Pr **mm.000**, it is transferred to the drive RAM and the EEPROM. A parameter save is not required to retain the data after-power down. Set up data for any option modules installed stored on the card are transferred to the drive. If the option modules installed are different between source and destination drives, the menus for the option module slots where the option module categories are different are not updated from the card and will contain their default values after the copying action. The drive will produce a 'Card Option' trip if the option module installed to the source and the destination drives are different or are in different slots. If the data is being transferred to the drive with different voltage or current rating a 'Card Rating' trip will occur.

The following drive rating dependant parameters (RA coding bit set) will not be transferred to the destination drive by a NV Media Card when the voltage rating of the destination drive is different from the source drive and the file is a parameter file.

However, drive rating dependent parameters will be transferred if only the current rating is different. If drive rating dependant parameters are not transferred to the destination drive they will contain their default values.

Pr **02.008** *Standard Ramp Voltage*

Pr **04.005** to Pr **04.007** *Motoring Current Limits*

Pr **04.024**, *User Current Maximum Scaling*

Pr **05.007** *Rated Current*

Pr **05.009** *Rated Voltage*

Pr **05.017** *Stator Resistance*

Pr **05.018** *Maximum Switching Frequency*

Pr **05.024** *Ld*

Pr **06.048** *Supply Loss Detection Level*

Pr **06.065** *Standard Under Voltage Threshold*

Pr **06.066** *Low Under Voltage Threshold*

Reading a parameter set from the NV Media Card (Pr 11.042 = Read (1))

Setting Pr **11.042** to Read (1) and resetting the drive will transfer the parameters from the card into the drive parameter set and the drive EEPROM, i.e. this is equivalent to writing 6001 to Pr **mm.000**.

All NV Media Card trips apply. Once the parameters are successfully copied this parameter is automatically reset to None (0). Parameters are saved to the drive EEPROM after this action is complete.

9.3.3 Auto saving parameter changes (Pr 11.042 = Auto (3))

This setting causes the drive to automatically save any changes made to menu 0 parameters on the drive to the NV Media Card. The latest menu 0 parameter set in the drive is therefore always backed up on the NV Media Card. Changing Pr **11.042** to Auto (3) and resetting the drive will immediately save the complete parameter set from the drive to the card, i.e. all parameters except parameters with the NC coding bit set. Once the whole parameter set is stored only the individual modified menu 0 parameter setting is updated.

Advanced parameter changes are only saved to the NV Media Card when Pr **mm.000** is set to 'Save Parameters' or a 1000 and the drive reset.

All NV Media Card trips apply, except 'Card Change'. If the data block already contains information it is automatically overwritten.

If the card is removed when Pr **11.042** is set to 3 Pr **11.042** is then automatically set to None (0).

When a new NV Media Card is installed Pr **11.042** must be set back to Auto (3) by the user and the drive reset so the complete parameter set is rewritten to the new NV Media Card if auto mode is still required.

When Pr **11.042** is set to Auto (3) and the parameters in the drive are saved, the NV Media Card is also updated, and therefore the NV Media Card becomes a copy of the drives stored configuration.

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At power up, if Pr **11.042** is set to Auto (3), the drive will save the complete parameter set to the NV Media Card. The drive will display 'Card Write' during this operation. This is done to ensure that if a user puts a new NV Media Card in during power down the new NV Media Card will have the correct data.

NOTE

When Pr **11.042** is set to Auto (3) the setting of Pr **11.042** itself is saved to the drive EEPROM but not the NV Media Card.

9.3.4 Booting up from the NV Media Card on every power up (Pr 11.042 = Boot (4))

When Pr **11.042** is set to Boot (4) the drive operates the same as Auto mode except when the drive is powered-up. The parameters on the NV Media Card will be automatically transferred to the drive at power up if the following are true:

- A card is inserted in the drive
- Parameter data block 1 exists on the card
- The data in block 1 is type 1 to 4 (as defined in Pr **11.038**)
- Pr **11.042** on the card set to Boot (4)

The drive will display 'Booting Parameters during this operation. If the drive mode is different from that on the card, the drive gives a 'Card Drive Mode' trip and the data is not transferred.

If 'Boot' mode is stored on the copying NV Media Card this makes the copying NV Media Card the master device. This provides a very fast and efficient way of re-programming a number of drives.

NOTE

'Boot' mode is saved to the card, but when the card is read, the value of Pr **11.042** is not transferred to the drive.

9.3.5 Booting up from the NV Media Card on every power up (Pr mm.000 = 2001)

It is possible to create a bootable parameter data block by setting Pr **mm.000** to 2001 and initiating a drive reset. This data block is created in one operation and is not updated when further parameter changes are made.

Setting Pr **mm.000** to 2001 will overwrite the data block 1 on the card if it already exists.

9.3.6 8yyy - Comparing the drive full parameter set with the NV Media Card values

Setting 8yyy in Pr **mm.000**, will compare the NV Media Card file with the data in the drive. If the compare is successful Pr **mm.000** is simply set to 0. If the compare fails a 'Card Compare' trip is initiated.

9.3.7 7yyy / 9999 - Erasing data from the NV Media Card values

Data can be erased from the NV Media Card either one block at a time or all blocks in one go.

- Setting 7yyy in Pr **mm.000** will erase NV Media Card data block yyy
- Setting 9999 in Pr **mm.000** will erase all the data blocks on a SMARTCARD, but not on an SD Card.

9.3.8 9666 / 9555 - Setting and clearing the NV Media Card warning suppression flag

If the option modules installed to the source and destination drive are different or are in different slots the drive will produce a 'Card Option' trip. If the data is being transferred to a drive of a different voltage or current rating a 'Card Rating' trip will occur. It is possible to suppress these trips by setting the warning suppression flag. If this flag is set the drive will not trip if the option module(s) or drive ratings are different between the source and destination drives. The options module or rating dependent parameters will not be transferred.

- Setting 9666 in Pr **mm.000** will set the warning suppression flag
- Setting 9555 in Pr **mm.000** will clear the warning suppression flag

9.3.9 9888 / 9777 - Setting and clearing the NV Media Card read only flag

The NV Media Card may be protected from writing or erasing by setting the read only flag. If an attempt is made to write or erase a data block when the read only flag is set, a 'Card Read Only' trip is initiated. When the read only flag is set only codes 6yyy or 9777 are effective.

- Setting 9888 in Pr **mm.000** will set the read only flag
- Setting 9777 in Pr **mm.000** will clear the read only flag

9.4 Data block header information

Each data block stored on a NV Media Card has header information detailing the following:

- *NV Media Card File Number* (11.037)
- *NV Media Card File Type* (11.038)
- *NV Media Card File Version* (11.039)
- *NV Media Card File Checksum* (11.040)

The header information for each data block which has been used can be viewed in Pr **11.038** to Pr **11.040** by increasing or decreasing the data block number set in Pr **11.037**. If there is no data on the card Pr **11.037** can only have a value of 0.

9.5 NV Media Card parameters

Table 9-2 Key to parameter table coding

RW	Read / Write	ND	No default value
RO	Read only	NC	Not copied
Num	Number parameter	PT	Protected parameter
Bit	Bit parameter	RA	Rating dependant
Txt	Text string	US	User save
Bin	Binary parameter	PS	Power-down save
FI	Filtered	DE	Destination

11.036 {00.029}	NV Media Card File Previously Loaded									
RO	Num					NC	PT			
OL / RFC-A / RFC-S	⇳	0 to 999			⇨	0				

This parameter shows the number of the data block last transferred from a NV Media Card to the drive. If defaults are subsequently reloaded this parameter is set to 0.

11.037	NV Media Card File Number									
RW	Num									
OL / RFC-A / RFC-S	⇳	0 to 999			⇨	0				

This parameter should have the data block number which the user would like the information displayed in Pr **11.038**, Pr **11.039** and Pr **11.040**.

11.038	NV Media Card File Type									
RO	Txt				ND	NC	PT			
OL / RFC-A / RFC-S	⇳	RFC-S (3)			⇨					

Displays the type/mode of the data block selected with Pr **11.037**.

Pr 11.038	String	Type / mode
3	RF	aramet

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11.039	NV Media Card File Version								
RO	Num				ND	NC	PT		
OL / RFC-A / RFC-S	⇳	0 to 9999			⇨				

Displays the version number of the file selected in Pr **11.037**.

11.040	NV Media Card File Checksum								
RO	Num				ND	NC	PT		
OL / RFC-A / RFC-S	⇳	--2147483648 to 2147483647			⇨				

Displays the checksum of the data block selected in Pr **11.037**.

11.042	Parameter Cloning								
RW	Txt					NC		US*	
OL / RFC-A / RFC-S	⇳	None (0), Read (1), Program (2), Auto (3), Boot (4)			⇨	None (0)			

* Only a value of 3 or 4 in this parameter is saved.

NOTE

If Pr **11.042** is equal to 1 or 2, this value is not transferred to the drive or saved to the EEPROM. If Pr **11.042** is set to 3 or 4 the value is saved to the EEPROM

None (0) = Inactive

Read (1) = Read parameter set from the NV Media Card

Program (2) = Program a parameter set to the NV Media Card

Auto (3) = Auto save

Boot (4) = Boot mode

11.073	NV Media Card Type								
RO	Txt				ND	NC	PT		
OL / RFC-A / RFC-S	⇳	None (0), SMART Card (1), SD Card (2)			⇨				

This will display the type of media card inserted; it will contain one of the following values:

"None" (0) - No NV Media Card has been inserted.

"SMART Card" (1) - A SMARTCARD has been inserted.

"SD Card" (2) - A FAT formatted SD card has been inserted.

11.075	NV Media Card Read-only Flag								
RO	Bit				ND	NC	PT		
OL / RFC-A / RFC-S	⇳	Off (0) or On (1)			⇨				

NV Media Card Read-only Flag (11.075) shows the state of the read-only flag for the currently installed card.

11.076	NV Media Card Warning Suppression Flag								
RO	Bit				ND	NC	PT		
OL / RFC-A / RFC-S	⇳	Off (0) or On (1)			⇨				

NV Media Card Warning Suppression Flag (11.076) shows the state of the warning flag for the currently installed card.

11.077	NV Media Card File Required Version								
RW	Num				ND	NC	PT		
OL / RFC-A / RFC-S	⇳	0 to 9999			⇨				

The value of *NV Media Card File Required Version* (11.077) is used as the version number for a file when it is created on an NV Media Card. *NV Media Card File Required Version* (11.077) is reset to 0 when the file is created or the transfer fails.

9.6 NV Media Card trips

After an attempt to read, write or erase data from a NV Media Card a trip is initiated if there has been a problem with the command.

See Chapter 13 *Diagnostics* on page 258 for more information on NV Media Card trips.

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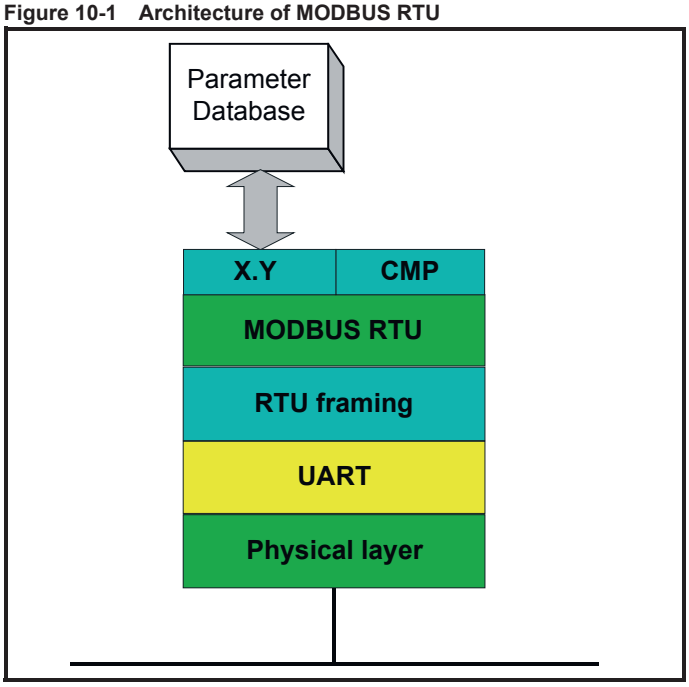
10 CT MODBUS RTU

This section describes the adaptation of the MODBUS RTU protocol offered on Control Techniques' products. The portable software class which implements this protocol is also defined.

MODBUS RTU is a master slave system with half-duplex message exchange. The Control Techniques (CT) implementation supports the core function codes to read and write registers. A scheme to map between MODBUS registers and CT parameters is defined. The CT implementation also defines a 32-bit extension to the standard 16-bit register data format.

Figure 10-1 Architecture of MODBUS RTU



10.1 MODBUS RTU

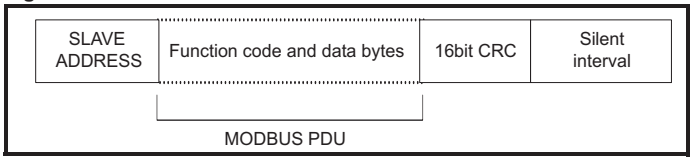
Physical layer

Attribute	Description
Normal physical layer for multi-drop operation	RS285 2-wire
Bit stream	Standard UART asynchronous symbols with Non Return to Zero (NRZ)
Symbol	Each symbol consists of:- 1 start bit 8 data bits (transmitted least significant bit first) 2 stop bits
Baudrates	300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 76800, 115200

RTU framing

The frame has the following basic format:

Figure 10-2 MODBUS RTU format



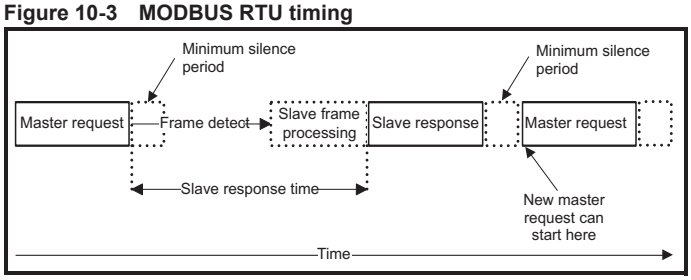
The frame is terminated with a minimum silent period of 3.5 character times (for example, at 19200 baud the minimum silent period is 2 ms). Nodes use the terminating silence period to detect the end of frame and begin frame processing. All frames must therefore be transmitted as a continuous stream without any gaps greater or equal to the silence period. If an erroneous gap is inserted then receiving nodes may start frame processing early in which case the CRC will fail and the frame will be discarded. See description of Silent Period (Pr **11.027**) in section 5.10.1 *485 Serial communications* on page 63.

MODBUS RTU is a master slave system. All master requests, except broadcast requests, will lead to a response from an individual slave. The slave will respond (i.e. start transmitting the response) within the quoted maximum slave response time (this time is quoted in the data sheet for all drive products). The minimum slave response time is also quoted but will never be less than the minimum silent period defined by 3.5 character times.

If the master request was a broadcast request then the master may transmit a new request once the maximum slave response time has expired.

The master must implement a message time out to handle transmission errors. This time out period must be set to the maximum slave response time + transmission time for the response.

Figure 10-3 MODBUS RTU timing



10.2 Slave address

The first byte of the frame is the slave node address. Valid slave node addresses are 1 through 247 decimal. In the master request this byte indicates the target slave node; in the slave response this byte indicates the address of the slave sending the response.

Global addressing

Address zero addresses all slave nodes on the network. Slave nodes suppress the response messages for broadcast requests.

10.3 MODBUS registers

The MODBUS register address range is 16-bit (65536 registers) which at the protocol level is represented by indexes 0 through 65535.

PLC registers

Modicon PLCs typically define 4 register 'files' each containing 65536 registers. Traditionally, the registers are referenced 1 through 65536 rather than 0 through 65535. The register address is therefore decremented on the master device before passing to the protocol.

File type	Description
1	Read only bits
2	Read / write bits
3	Read only 16-bit register
4	Read / write 16-bit register

The register file type code is NOT transmitted by MODBUS and all register files can be considered to map onto a single register address space. All parameters in the drive are holding registers.

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CT parameter mapping

The drive is parameterized using the **mm.ppp** notation. Indexes '**mm**' and '**ppp**' are in the range 0 through 99. Parameters are mapped into the MODBUS register space in standard addressing mode as:

Protocol register = (mm x 100) + ppp - 1

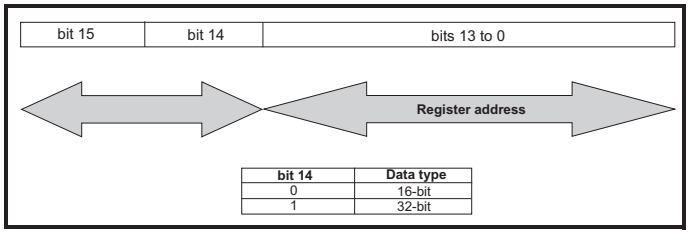
To correctly map the parameters at the application layer, the slave device increments the received register address. The consequence of this behavior is that Pr **00.000** cannot be accessed.

Data types

The MODBUS protocol specification defines registers as 16-bit signed integers. Each drive parameter is internally mapped to a single 16-bit MODBUS register, all MODBUS function codes access 16-bit registers only so to access a 32-bit parameter, two contiguous MODBUS registers must be specified in the request and the 32-bit data access scheme must be used.

32-bit data access

Standard MODBUS registers are 16 bits in size and reference a single drive parameter. To access a 32-bit data value the multiple read/write services must be used to transfer a contiguous array of 16-bit registers. Selection between either 16-bit or 32-bit access is specified using bit 14 of the register address. Note: Bit 15 of the register address is reserved for future use.



If 32-bit data type is selected then this effectively adds 16384 (0x4000) to the start register address.

e.g. For drive parameter Pr **01.021** in standard addressing mode, the start register value is 16384 + 120 = 16504 (0x4078)

If a 32-bit data type is selected then the drive uses two consecutive 16-bit MODBUS registers (in 'big endian'). The master must also set the correct 'number of 16-bit registers' in the request.

Example: read Pr **00.001** (Pr **01.021**) as a 32-bit parameter, using FC03 from node 1:

Master request

Byte	Value	Description
0	0x01	Slave destination node address
1	0x03	Function code 0x03
2	0x40	Start register Pr **00.001** (16384 + (100 x 0) + 1 – 1) = 16384 = 0x4000
3	0x00	
4	0x00	Number of 16-bit registers to read Pr **00.001** is 1 x 32-bit register = 2 x 16-bit registers
5	0x02	
6	0xD1	CRC LSB
7	0xCB	CRC MSB

Slave response

Byte	Value	Description
0	0x01	Slave destination node address
1	0x03	Function code 0x03
2	0x04	Length of data (bytes) = 1 x 32-bit register = 4 bytes
3		Pr **00.001** data
4		
5		
6		
7		CRC LSB
8		CRC MSB

Reads when actual parameter type is different from selected

The slave will send the least significant word of a 32-bit parameter if that parameter is read as part of a 16-bit access.

The slave will sign extend the least significant word if a 16-bit parameter is accessed as a 32-bit parameter. The number of 16-bit registers must be even during a 32-bit access.

Writes when actual parameter type is different from selected

The slave will allow writing a 32-bit value to a 16-bit parameter as long as the 32-bit value is within the normal range of the 16-bit parameter.

The slave will allow a 16-bit write to a 32-bit parameter. The slave will sign extend the written value, therefore, the effective range of this type of write will be ±32767.

10.4 Data encoding

MODBUS RTU uses a 'big-endian' representation for addresses and data items (except the CRC, which is 'little-endian'). This means that when a numerical quantity larger than a single byte is transmitted, the MOST significant byte is sent first. So for example:

16-bits 0x1234 would be 0 x12 0 x34

32-bits 0x12345678 would be 0 x12 0 x34 0 x56 0 x78

There is no facility to encode a decimal point, therefore values must be written and read raw (e.g. a value of 2.000 is written or read as 2000).

10.5 Function codes

The function code determines the context and format of the message data. Bit 7 of the function code is used in the slave response to indicate an exception.

The following function codes are supported:

Code	Description
03	Read multiple 16-bit registers
06	Write single register
16	Write multiple 16-bit registers
23	Read and write multiple 16-bit registers

FC03 Read multiple registers

Read a contiguous array of registers. The drive imposes an upper limit on the number of registers (16 in the case of CSD100), which can be read. If this is exceeded the drive will issue an exception code 2.

The normal response includes the function code, number of data bytes in the read block followed by the register data (unless an exception occurs).

If 32-bit parameter addressing is used, then for each parameter read:

- Two 16-bit registers must be used in the request
- The register data in the response will contain 4 bytes of data

Master request

Byte	Description
0	Slave destination node address (1 – 247, 0 is global)
1	Function code 0x03
2	Start register address MSB
3	Start register address LSB
4	Number of 16-bit registers to read MSB
5	Number of 16-bit registers to read LSB
6	CRC LSB
7	CRC MSB

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Slave response

Byte	Description
0	Slave destination node address
1	Function code 0x03
2	Length of data in read block (bytes)
3	Register data 0 MSB
4	Register data 0 LSB
3+byte count	CRC LSB
4+byte count	CRC MSB

Example

Read Pr **00.011** to Pr **00.014** with 32-bit data access

Master request

Byte	Value	Description
0	0x01	Slave destination node address
1	0x03	Function code 0x03
2	0x40	Start register Pr **00.011** (16384 + (100 x 0) + 11 – 1) = 16394 = 0x400A
3	0x0A	
4	0x00	Number of 16-bit registers to read 4 x 32-bit register = 8 x 16-bit registers
5	0x08	
6	0x71	CRC LSB
7	0xCE	CRC MSB

Slave response

Byte	Value	Description
0	0x01	Slave destination node address
1	0x03	Function code 0x03
2	0x10	Length of data (bytes) = 4 x 32-bit registers = 16 bytes
3-6		Pr **00.011** data
7-10		Pr **00.012** data
11-14		Pr **00.013** data
15-18		Pr **00.014** data
19		CRC LSB
20		CRC MSB

FC06 Write single register

Writes a single 16-bit value to a register. The normal response is an echo of the request (unless an exception occurs) returned after the parameter has been written.

The register address can correspond to a 32-bit parameter, but only the lower 16-bits of the value will be written.

Master request

Byte	Description
0	Slave destination node address (1 – 247, 0 is global)
1	Function code 0x06
2	Start register address MSB
3	Start register address LSB
4	Register data MSB
5	Register data LSB
6	CRC LSB
7	CRC MSB

Slave response

Byte	Description
0	Slave destination node address
1	Function code 0x06
2	Start register address MSB
3	Start register address LSB
4	Register data MSB
5	Register data LSB
6	CRC LSB
7	CRC MSB

Example

Write the value 0x0000 to Pr **00.020** (Pr **18.012**)

Master request

Byte	Value	Description
0	0x01	Slave destination node address
1	0x06	Function code 0x06
2	0x00	Start register Pr **00.020** (100 x 0) + 20 – 1) = 19 = 0x0013
3	0x13	
4	0x00	Register data MSB
5	0x00	Register data LSB
6	0x78	CRC LSB
7	0x0F	CRC MSB

Slave response

Byte	Value	Description
0	0x01	Slave destination node address
1	0x06	Function code 0x06
2	0x00	Start register MSB
3	0x13	Start register LSB
4	0x00	Register data MSB
5	0x00	Register data LSB
6	0x78	CRC LSB
7	0x0F	CRC MSB

FC16 - Write multiple registers

This function code allows a contiguous series of registers to be written. The drive imposes an upper limit on the number of registers to be written (16 in the case of CSD100), and if this is exceeded the drive will issue an exception response code 2.

The normal response includes the function code, start register address and number of 16-bit registers written (unless an exception occurs), returned after the parameters have been written.

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If 32-bit parameter addressing is used, then for each parameter written:

- Two 16-bit registers must be used in the request
- Four bytes must be specified in the request
- The number of registers written in the response will be twice the number of parameters written

Master request

Byte	Description
0	Slave destination node address (1 – 247, 0 is global)
1	Function code 0x10
2	Start register address MSB
3	Start register address LSB
4	Number of 16-bit registers to write MSB
5	Number of 16-bit registers to write LSB
6	Length of register data to write (bytes)
7	Register data 0 MSB
8	Register data 0 LSB
7+byte count	CRC LSB
8+byte count	CRC MSB

Slave response

Byte	Description
0	Slave destination node address
1	Function code 0x10
2	Start register address MSB
3	Start register address LSB
4	Number of 16-bit registers written MSB
5	Number of 16-bit registers written LSB
6	CRC LSB
7	CRC MSB

Example

Write the value 2000 to Pr **00.011** and 3000 to Pr **00.012** with 32-bit data access

Master request

Byte	Value	Description
0	0x01	Slave destination node address
1	0x10	Function code 0x10
2	0x40	Start register Pr **00.011** 16384 + (100 x 0) + 11 – 1) = 16394 = 0x400A
3	0x0A	
4	0x00	Number of 16-bit registers MSB
5	0x04	Number of 16-bit registers LSB
6	0x08	Length of register data to write (bytes)
7-10	0x00 0x00 0x07 0xD0	Register data 0
11-14	0x00 0x00 0x0B 0xB8	Register data 1
15	0x97	CRC LSB
16	0x85	CRC MSB

Slave response

Byte	Value	Description
0	0x01	Slave destination node address
1	0x10	Function code 0x10
2	0x40	Start register address MSB
3	0x0A	Start register address LSB
4	0x00	Number of 16-bit registers written MSB
5	0x04	Number of 16-bit registers written LSB
6		CRC LSB
7		CRC MSB

FC23 - Read/Write multiple registers

This function code allows a contiguous series of registers to be written and another contiguous series of registers to be read. The drive imposes an upper limit on the number of registers to be written (16 in the case of CSD100), and if this is exceeded the drive will issue an exception response code 2.

The normal response includes the function code, number of data bytes in the read block followed by the register data (unless an exception occurs).

If 32-bit parameter addressing is used:

- For each parameter read or written, two 16-bit registers must be used in the request
- For each parameter written, four bytes must be specified in the request
- For each parameter read, four bytes of data will be used in the response

It should be noted that the FC23 request is effectively an FC03 (read multiple) request followed by an FC16 (write multiple) request. The write is performed first and continues until any of the errors given for FC16 occur. Some parameters may have been written when an error is detected, but no indication is given about how many parameters have been written successfully. The read is always performed even if an error is detected during writing. Any of the errors given for FC03 can occur and the exception response is the same as for FC03.

Master request

Byte	Description
0	Slave destination node address (1 – 247, 0 is global)
1	Function code 0x17
2	Start register address to read MSB
3	Start register address to read LSB
4	Number of 16-bit registers to read MSB
5	Number of 16-bit registers to read LSB
6	Start register address to write MSB
7	Start register address o write LSB
8	Number of 16-bit registers to write MSB
9	Number of 16-bit registers to write LSB
10	Length of register data to write (bytes)
11	Register data 0 MSB
12	Register data 0 LSB
11+byte count	CRC LSB
12+byte count	CRC MSB

Slave response

Byte	Description
0	Slave destination node address
1	Function code 0x10
2	Length of register data in read block (bytes)
3	Register data 0 MSB
4	Register data 0 LSB
3+byte count	CRC LSB
4+byte count	CRC MSB

Example

Write the value 200 to Pr **00.054** and read Pr **00.057** with 32-bit data access

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Master request

Byte	Value	Description
0	0x01	Slave destination node address
1	0x17	Function code 0x17
2	0x40	Start register Pr **00.057** 16384 + (100 x 0) + 57 – 1) = 16440 = 0x4038
3	0x38	
4	0x00	Number of 16-bit registers MSB
5	0x02	Number of 16-bit registers LSB
6	0x40	Start register Pr **00.054** 16384 + (100 x 0) + 54 – 1) = 16437 = 0x4035
7	0x35	
	0x00	Number of 16-bit registers to write MSB
	0x02	Number of 16-bit registers to write LSB
	0x04	Length of register data to write (bytes)
8-11	0x00 0x00 0x00 0xC8	Register data 0
16	0x6B	CRC LSB
17	0x61	CRC MSB

Slave response

Byte	Value	Description
0	0x01	Slave destination node address
1	0x17	Function code 0x10
2	0x04	Length of register data in read block (bytes)
3-6	0x00 0x00 0x00 0x00	Register data 0
7		CRC MSB
8		CRC MSB

10.6 Exceptions

The slave will respond with an exception response if an error is detected in the master request. If a message is corrupted and the frame is not received or the CRC fails then the slave will not issue an exception. In this case, the master device will time out. If a write multiple (FC16 or FC23) request exceeds the slave maximum buffer size then the slave will discard the message. No exception will be transmitted in this case and the master will time out.

Exception message format

The slave exception message has the following format:

Byte	Description
0	Slave source node address
1	Original function code with bit7 set (e.g. FC 0x03 will be returned as 0x83)
2	Exception code
3	CRC LSB
4	CRC MSB

Exception codes

The following exception codes are supported:

Byte	Description
1	Function code not supported
2	Register address out of range, or request to read too many registers

10.7 CRC

The CRC is a 16-bit cyclic redundancy check using the standard CRC-16 polynomial x16 + x15 + x2 + 1. The 16-bit CRC is appended to the message and transmitted LSB first.

The CRC is calculated on ALL the bytes in the frame.

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11 Technical data

11.1 Drive technical data

11.1.1 Power and current ratings

Table 11-1 Maximum permissible continuous output current

Model	Nominal rating		Maximum permissible continuous output current (A) for the following ambient temperatures	
	kW	hp	(40°C)	(60°C)
200 V				
06200500	11	15	50	27
06200580	15	20	58	43
400 V				
04400240	11	15	24	15
05400300	15	20	30	24
06400380	18.5	25	38	38
500 V				
06500220	11	15	22	
06500270	15	20	27	24

11.1.2 Power dissipation

Table 11-2 Losses @ 40°C (104°F) ambient

Model	Nominal rating		Drive losses (W) taking into account any current derating for the given conditions	
	kW	hp	3 kHz	6 kHz
200 V				
06200500	11	15	394	452
06200580	15	20	463	528
400 V				
04400240	11	15	283	325
05400300	15	20	332	434
06400380	18.5	25	417	532
575 V				
06500220	15	20	362	484
06500270	18.5	25	448	596

Table 11-3 Losses @ 40°C (104°F) ambient with high IP insert installed

Model	Nominal rating		Drive losses (W) taking into account any current derating for the given conditions	
	kW	hp	3 kHz	6 kHz
400 V				
04400240	11	15	101	131
05400300	15	20	218	284

Table 11-4 Power losses from the front of the drive when through-panel mounted

Frame size	Power loss
4	≤75 W
5	≤100 W
6	

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11.1.3 Supply requirements

AC supply voltage:

200 V drive: 200 V to 240 V ±10 %
400 V drive: 380 V to 480 V ±10 %
575 V drive: 500 V to 575 V ±10 %

Number of phases: 3

Maximum supply imbalance: 2 % negative phase sequence (equivalent to 3 % voltage imbalance between phases).

Frequency range: 45 to 66 Hz

For UL compliance only, the maximum supply symmetrical fault current must be limited to 100 kA

11.1.4 Line reactors

Input line reactors reduce the risk of damage to the drive resulting from poor phase balance or severe disturbances on the supply network.

Where line reactors are to be used, reactance values of approximately 2 % are recommended. Higher values may be used if necessary, but may result in a loss of drive output (reduced torque at high speed) because of the voltage drop.

For all drive ratings, 2 % line reactors permit drives to be used with a supply unbalance of up to 3.5 % negative phase sequence (equivalent to 5 % voltage imbalance between phases).

Severe disturbances may be caused by the following factors, for example:

- Power factor correction equipment connected close to the drive.
- Large DC drives having no or inadequate line reactors connected to the supply.
- Across the line (DOL) started motor(s) connected to the supply such that when any of these motors are started, the voltage dip exceeds 20 %

Such disturbances may cause excessive peak currents to flow in the input power circuit of the drive. This may cause nuisance tripping, or in extreme cases, failure of the drive.

Drives of low power rating may also be susceptible to disturbance when connected to supplies with a high rated capacity.

CSD drive model sizes have an internal DC choke so they do not require AC line reactors except for cases of excessive phase unbalance or extreme supply conditions.

When required each drive must have its own reactor(s). Three individual reactors or a single three-phase reactor should be used.

Reactor current ratings

The current rating of the line reactors should be as follows:

Continuous current rating:

Not less than the continuous input current rating of the drive

Repetitive peak current rating:

Not less than twice the continuous input current rating of the drive

11.1.5 Motor requirements

No. of phases: 3

Maximum voltage:

200 V drive: 240 V
400 V drive: 480 V
575 V drive: 575 V

11.1.6 Temperature, humidity and cooling method

Ambient temperature operating range:

- 20 °C to 50 °C (- 4 °F to 122 °F).
Output current derating must be applied at ambient temperatures >40 °C (104 °F).

Cooling method: Forced convection

Maximum humidity: 95 % non-condensing at 40 °C (104 °F)

11.1.7 Storage

-40 °C (-40 °F) to +50 °C (122 °F) for long term storage, or to +70 °C (158 °F) for short term storage.

Storage time is 2 years.

Electrolytic capacitors in any electronic product have a storage period after which they require reforming or replacing.

The DC bus capacitors have a storage period of 10 years.

The low voltage capacitors on the control supplies typically have a storage period of 2 years and are thus the limiting factor.

Low voltage capacitors cannot be reformed due to their location in the circuit and thus may require replacing if the drive is stored for a period of 2 years or greater without power being applied.

It is therefore recommended that drives are powered up for a minimum of 1 hour after every 2 years of storage.

This process allows the drive to be stored for a further 2 years.

11.1.8 Altitude

Altitude range: 0 to 3,000 m (9,900 ft), subject to the following conditions:

1,000 m to 3,000 m (3,300 ft to 9,900 ft) above sea level: de-rate the maximum output current from the specified figure by 1% per 100 m (330 ft) above 1,000 m (3,300 ft)

For example at 3,000 m (9,900 ft) the output current of the drive would have to be de-rated by 20 %.

11.1.9 IP / UL Rating

The drive is rated to IP20 pollution degree 2 (dry, non-conductive contamination only) (NEMA 1). However, it is possible to configure the drive to achieve IP65 rating (NEMA 12) at the rear of the heatsink for through-panel mounting (some current derating is required).

In order to achieve the high IP rating at the rear of the heatsink with the drive size 4 and 5, it is necessary to seal a heatsink vent by installing the high IP insert.

The IP rating of a product is a measure of protection against ingress and contact to foreign bodies and water. It is stated as IP XX, where the two digits (XX) indicate the degree of protection provided as shown in Table 11-5.

Table 11-5 IP Rating degrees of protection

First digit		Second digit	
Protection against contact and ingress of foreign bodies		Protection against ingress of water	
0	No protection	0	No protection
1	Protection against large foreign bodies ϕ > 50 mm (large area contact with the hand)	1	Protection against vertically falling drops of water
2	Protection against medium size foreign bodies ϕ > 12 mm (finger)	2	Protection against spraywater (up to 15 ° from the vertical)
3	Protection against small foreign bodies ϕ > 2.5 mm (tools, wires)	3	Protection against spraywater (up to 60 ° from the vertical)
4	Protection against granular foreign bodies ϕ > 1mm (tools, wires)	4	Protection against splashwater (from all directions)
5	Protection against dust deposit, complete protection against accidental contact.	5	Protection against heavy splash water (from all directions, at high pressure)
6	Protection against dust ingress, complete protection against accidental contact.	6	Protection against deckwater (e.g. in heavy seas)
7		7	Protection against immersion
8		8	Protection against submersion

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Table 11-6 UL enclosure ratings

UL rating	Description
Type 1	Enclosures are intended for indoor use, primarily to provide a degree of protection against limited amounts of falling dirt.
Type 12	Enclosures are intended for indoor use, primarily to provide a degree of protection against dust, falling dirt and dripping non-corrosive liquids.

11.1.10 Corrosive gasses

Concentrations of corrosive gases must not exceed the levels given in:

- Table A2 of EN 50178:1998
- Class 3C2 of IEC 60721-3-3

This corresponds to the levels typical of urban areas with industrial activities and/or heavy traffic, but not in the immediate neighborhood of industrial sources with chemical emissions.

11.1.11 RoHS compliance

The drive meets EU directive 2002-95-EC for RoHS compliance.

11.1.12 Vibration

Maximum recommended continuous vibration level 0.14 g r.m.s. broad-band 5 to 200 Hz.

NOTE

This is the limit for broad-band (random) vibration. Narrow-band vibration at this level which coincides with a structural resonance could result in premature failure.

Bump Test

Testing in each of three mutually perpendicular axes in turn.
Referenced standard:IEC 60068-2-29: Test Eb:
Severity: 18 g, 6 ms, half sine
No. of Bumps: 600 (100 in each direction of each axis)

Random Vibration Test

Testing in each of three mutually perpendicular axes in turn.
Referenced standard:IEC 60068-2-64: Test Fh:
Severity: 1.0 m^2/s^3 (0.01 g^2/Hz) ASD from 5 to 20 Hz
-3 dB/octave from 20 to 200 Hz
Duration: 30 minutes in each of 3 mutually perpendicular axes.

Sinusoidal Vibration Test

Testing in each of three mutually perpendicular axes in turn.
Referenced standard: IEC 60068-2-6: Test Fc:
Frequency range: 5 to 500 Hz
Severity: 3.5 mm peak displacement from 5 to 9 Hz
10 m/s^2 peak acceleration from 9 to 200 Hz
15 m/s^2 peak acceleration from 200 to 500 Hz
Sweep rate: 1 octave/minute
Duration: 15 minutes in each of 3 mutually perpendicular axes.

EN 61800-5-1:2007, Section 5.2.6.4. referring to IEC 60068-2-6

Frequency range: 10 to 150 Hz
Amplitude: 10 to 57 Hz at 0.075 mm pk
57 to 150 Hz at 1g p
Sweep rate: 1 octave/minute
Duration: 10 sweep cycles per axis in each of 3 mutually perpendicular axes

11.1.13 Starts per hour

By electronic control: unlimited

By interrupting the AC supply: ≤20 (equally spaced)

11.1.14 Start up time

This is the time taken from the moment of applying power to the drive, to the drive being ready to run the motor:

Sizes 4, 5 and 6:

11.1.15 Output frequency / speed range

The maximum output frequency is limited to 550 Hz.

11.1.16 Accuracy and resolution

Speed:

The absolute frequency and speed accuracy depends on the accuracy of the crystal used with the drive microprocessor. The accuracy of the crystal is 100 ppm, and so the absolute frequency/speed accuracy is 100 ppm (0.01 %) of the reference, when a preset speed is used. If an analog input is used the absolute accuracy is further limited by the absolute accuracy of the analog input.

The following data applies to the drive only; it does not include the performance of the source of the control signals.

Open loop resolution:
Preset frequency reference: 0.1 Hz
Precision frequency reference: 0.001 Hz

Closed loop resolution
Preset speed reference: 0.1 rpm
Precision speed reference: 0.001 rpm
Analog input 1: 11 bit plus sign
Analog input 2: 11 bit plus sign

Current:

The resolution of the current feedback is 10 bit plus sign.

Accuracy: typical 2 %
worst case 5 %

11.1.17 Acoustic noise

The heatsink fan generates the majority of the sound pressure level at 1 m produced by the drive. The heatsink fan on size 4, 5 and 6 is a variable speed fan. The drive controls the speed at which the fan runs based on the temperature of the heatsink and the drive's thermal model system.

Table 11-7 gives the sound pressure level at 1 m produced by the drive for the heatsink fan running at the maximum and minimum speeds.

Table 11-7 Acoustic noise data

Size	Max speed dBA	Min speed dBA
4	40	35
5		
6	48	40

11.1.18 Overall dimensions

H Height including surface mounting brackets
W Width
D Projection forward of panel when surface mounted
F Projection forward of panel when through-panel mounted
R Projection rear of panel when through-panel mounted

Table 11-8 Overall drive dimensions

Size	Dimension				
	H	W	D	F	R
4	391 mm (15.39 in)	124 mm (4.88 in)	200 mm (7.87 in)	134 mm (5.28 in)	67 mm (2.64 in)
5		143 mm (5.63 in)	202 mm (7.95 in)	135 mm (5.32 in)	
6		210 mm (8.27 in)	227 mm (8.94 in)	131 mm (5.16 in)	96 mm (3.78 in)

11.1.19 Weights

Table 11-9 Overall drive weights

Size	Model	kg	lb
4	All variants	6.5	14.30
5		7.4	16.30
6		14	30.90

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11.1.20 SAFE TORQUE OFF data

Data as verified by TÜV Rheinland:

According to EN ISO 13849-1:

PL = e

Category = 4

$MTTF_D$ = High

DC_{av} = High

Mission Time and Proof Test Interval = 20 years

The calculated $MTTF_D$ for the complete STO function is:

STO1 2574 yr

According to EN 61800-5-2:

SIL = 3

PFH = 4.21 x 10^{-11} h^{-1}

Logic levels comply with IEC 61131-2:2007 for type 1 digital inputs rated at 24 V. Maximum level for logic low to achieve SIL3 and PL e 5 V and 0.5 mA.

11.1.21 Input current, fuse and cable size ratings

The input current is affected by the supply voltage and impedance.

Typical input current

The values of typical input current are given to aid calculations for power flow and power loss.

The values of typical input current are stated for a balanced supply.

Maximum continuous input current

The values of maximum continuous input current are given to aid the selection of cables and fuses. These values are stated for the worst case condition with the unusual combination of stiff supply with bad balance. The value stated for the maximum continuous input current would only be seen in one of the input phases. The current in the other two phases would be significantly lower.

The values of maximum input current are stated for a supply with a 2 % negative phase-sequence imbalance and rated at the maximum supply fault current given in Table 11-10.

Table 11-10 Supply fault current used to calculate maximum input currents

Model	Symmetrical fault level (kA)
All	100

WARNING

Fuses

The AC supply to the drive must be installed with suitable protection against overload and short-circuits. Table 11-11, Table 11-12 and Table 11-13 show the recommended fuse ratings. Failure to observe this requirement will cause risk of fire.

Table 11-11 AC Input current and fuse ratings (200 V)

Model	Typical input current	Maximum continuous input current	Maximum overload input current	Fuse rating			
				IEC gG		Class CC or Class J	
				Nominal	Maximum	Nominal	Maximum
	A	A	A	A	A	A	A
06200500	42	48	64	63	63	60	70
06200580	49	56	85			70	

Table 11-12 AC Input current and fuse ratings (400 V)

Model	Typical input current	Maximum continuous input current	Maximum overload input current	Fuse rating			
				IEC gG		Class CC or Class J	
				Nominal	Maximum	Nominal	Maximum
	A	A	A	A	A	A	A
04400240	22	24	35	32	32	30	30
05400300	27	30	58	40	40	35	35
06400380	32	36	67	63	63	40	60

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Table 11-13 AC Input current and fuse ratings (575 V)

Model	Typical input current	Maximum continuous input current	Maximum overload input current	Fuse rating			
				IEC gG		Class CC or Class J	
				Nominal	Maximum	Nominal	Maximum
	A	A	A	A	A	A	A
06500220	22	24	41	40	40	30	30
06500270	26	29	50	50	63	35	50

NOTE
Ensure cables used suit local wiring regulations.

CAUTION
The nominal cable sizes below are only a guide. The mounting and grouping of cables affects their current-carrying capacity, in some cases smaller cables may be acceptable but in other cases a larger cable is required to avoid excessive temperature or voltage drop. Refer to local wiring regulations for the correct size of cables.

Table 11-14 Cable ratings (200 V)

Model	Cable size (IEC) mm^2				Cable size (UL) AWG			
	Input		Output		Input		Output	
	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum
06200500	16	25	16	25	4	3	4	3
06200580	25		25		3		3	

Table 11-15 Cable ratings (400 V)

Model	Cable size (IEC) mm^2				Cable size (UL) AWG			
	Input		Output		Input		Output	
	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum
04400240	6	6	6	6	10	8	10	8
05400300					8		8	
06400380	10	25	10	25	6	3	6	3

Table 11-16 Cable ratings (575 V)

Model	Cable size (IEC) mm^2				Cable size (UL) AWG			
	Input		Output		Input		Output	
	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum
06500220	6	25	6	25	10	3	10	3
06500270	10		10		8		8	

11.1.22 Protective ground cable ratings

Table 11-17 Protective ground cable ratings

Input phase conductor size	Minimum ground conductor size
≤ 10 mm^2	Either 10 mm^2 or two conductors of the same cross-sectional area as the input phase conductor (an additional ground connection is provided on sizes 3, 4 and 5 for this purpose).
> 10 mm^2 and ≤ 16 mm^2	The same cross-sectional area as the input phase conductor
> 16 mm^2 and ≤ 35 mm^2	16 mm^2
> 35 mm^2	Half of the cross-sectional area of the input phase conductor

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11.1.23 Maximum motor cable lengths

Table 11-18 Maximum motor cable lengths (200 V drives)

200 V Nominal AC supply voltage							
Model	Maximum permissible motor cable length for each of the following switching frequencies						
	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
06200500 06200580	300 m (984 ft)	200 m (660 ft)	150 m (490 ft)	100 m (330 ft)	75 m (245 ft)	50 m (165 ft)	

Table 11-19 Maximum motor cable lengths (400 V drives)

400 V Nominal AC supply voltage							
Model	Maximum permissible motor cable length for each of the following switching frequencies						
	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
04400240 05400300	200 m (660 ft)		150 m (490 ft)	100 m (330 ft)	75 m (245 ft)	50 m (165 ft)	37 m (120 ft)

Table 11-20 Maximum motor cable lengths (575 V drives)

575 V Nominal AC supply voltage							
Model	Maximum permissible motor cable length for each of the following switching frequencies						
	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
06500220 06500270	300 m (984 ft)	200 m (660 ft)	150 m (490 ft)	100 m (330 ft)	75 m (245 ft)	50 m (165 ft)	

- Cable lengths in excess of the specified values may be used only when special techniques are adopted; refer to the supplier of the drive.
- The default switching frequency is 6 kHz for RFC-S mode.

The maximum cable length is reduced from that shown in Table 11-18, Table 11-19 and Table 11-20 if high capacitance or reduced diameter motor cables are used. For further information, refer to section 4.4.2 *High-capacitance / reduced diameter cables* on page 43.

11.1.24 Torque settings

Table 11-21 Drive control and relay terminal data

Model	Connection type	Torque setting
All	Plug-in terminal block	0.5 N m (0.4 lb ft)

Table 11-22 Drive power terminal data

CSD100 frame size	AC and motor terminals		Ground terminal	
	Recommended	Maximum	Recommended	Maximum
4	Plug-in terminal block		T20 Torx (M4) / M4 Nut (7 mm AF)	
	0.7 N m (0.5 lb ft)	0.8 N m (0.6 lb ft)	2.0 N m (1.4 lb ft)	2.5 N m (1.8 lb ft)
5	Plug-in terminal block		T20 Torx (M4) / M4 Nut (7 mm AF)	
	1.5 N m (1.1 lb ft)	1.8 N m (1.3 lb ft)	2.0 N m (1.4 lb ft)	5.0 N m (3.7 lb ft)
6	M6 Nut (10 mm AF)		M6 Nut (10 mm AF)	
	6.0 N m (4.4 lb ft)	8.0 N m (6.0 lb ft)	6.0 N m (4.4 lb ft)	8.0 N m (6.0 lb ft)

Table 11-23 Plug-in terminal block maximum cable sizes

Model size	Terminal block description	Max cable size
All	11 way control connectors	1.5 mm^2 (16 AWG)
	2 way relay connector	2.5 mm^2 (12 AWG)
4	6 way AC power connector	6 mm^2 (10 AWG)
5	3 way AC power connector 3 way motor connector	8 mm^2 (8 AWG)
6	2 way low voltage power 24 V supply connector	1.5 mm^2 (16 AWG)

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11.1.25 Electromagnetic compatibility (EMC)

This is a summary of the EMC performance of the drive. For full details, refer to the *EMC Data Sheet* which can be obtained from the supplier of the drive.

Table 11-24 Immunity compliance

Standard	Type of immunity	Test specification	Application	Level
IEC61000-4-2 EN61000-4-2	Electrostatic discharge	6 kV contact discharge 8 kV air discharge	Module enclosure	Level 3 (industrial)
IEC61000-4-3 EN61000-4-3	Radio frequency radiated field	10 V/m prior to modulation 80 - 1000 MHz 80 % AM (1 kHz) modulation	Module enclosure	Level 3 (industrial)
IEC61000-4-4 EN61000-4-4	Fast transient burst	5/50 ns 2 kV transient at 5 kHz repetition frequency via coupling clamp	Control lines	Level 4 (industrial harsh)
		5/50 ns 2 kV transient at 5 kHz repetition frequency by direct injection	Power lines	Level 3 (industrial)
IEC61000-4-5 EN61000-4-5	Surges	Common mode 4 kV 1.2/50 µs waveshape	AC supply lines: line to ground	Level 4
		Differential mode 2 kV 1.2/50 µs waveshape	AC supply lines: line to line	Level 3
		Lines to ground	Signal ports to ground [1]	Level 2
IEC61000-4-6 EN61000-4-6	Conducted radio frequency	10V prior to modulation 0.15 - 80 MHz 80 % AM (1 kHz) modulation	Control and power lines	Level 3 (industrial)
IEC61000-4-11 EN61000-4-11	Voltage dips and interruptions	-30 % 10 ms +60 % 100 ms -60 % 1 s <-95 % 5 s	AC power ports	
IEC61000-6-1 EN61000-6-1:2007	Generic immunity standard for the residential, commercial and light - industrial environment			Complies
IEC61000-6-2 EN61000-6-2:2005	Generic immunity standard for the industrial environment			Complies
IEC61800-3 EN61800-3:2004	Product standard for adjustable speed power drive systems (immunity requirements)		Meets immunity requirements for first and second environments	

[1] See section *Surge immunity of control circuits - long cables and connections outside a building* on page 50 for control ports for possible requirements regarding grounding and external surge protection

Emission

The drive contains an in-built filter for basic emission control. An additional optional external filter provides further reduction of emission. The requirements of the following standards are met, depending on the motor cable length and switching frequency.

Table 11-25 Size 4 emission compliance (400 V drives)

Motor cable length (m)	Switching Frequency (kHz)						
	2	3	4	6	8	12	16
Using internal filter:							
0 – 4	C3			C4			
Using internal filter and ferrite ring (2 turns):							
0 – 10	C3		C4				
Using external filter:							
0 – 20	R (C1)	R (C1)	I (C2)	I (C2)	I (C2)	I (C2)	I (C2)
20 – 100	I (C2)	I (C2)	C3	C3	C3	C3	C3

Table 11-26 Size 5 emission compliance (400 V drives)

Motor cable length (m)	Switching Frequency (kHz)						
	2	3	4	6	8	12	16
Using internal filter:							
0 – 4	C3			C4			
0 – 10	C3	C4					
No advantage to using ferrite ring							
Using external filter:							
0 – 20	R (C1)	R (C1)	I (C2)	I (C2)	I (C2)	I (C2)	I (C2)
20 – 100	I (C2)	I (C2)	C3	C3	C3	C3	C3

Table 11-27 Size 6 emission compliance (200 V drives)

Motor cable length (m)	Switching Frequency (kHz)						
	2	3	4	6	8	12	16
Using internal filter:							
0 – 2	C3		C4				
Using internal filter and ferrite ring (1 turn – no advantage to 2 turns):							
0 – 2	C3					C4	
0 – 5	C3			C4			
0 – 7	C3		C4				
0 – 10	C3	C4					
Using external filter:							
0 – 20	R (C1)	R (C1)	I (C2)	I (C2)	I (C2)	I (C2)	I (C2)
20 – 100	I (C2)	I (C2)	C3	C3	C3	C3	C3

Table 11-28 Size 6 emission compliance (575 V drives)

Motor cable length (m)	Switching Frequency (kHz)						
	2	3	4	6	8	12	16
Using internal filter:							
-	C4						
Using internal filter and ferrite ring (2 turns):							
0 – 4	C3			C4			
0 – 2	C3					C4	
Using external filter:							
0 – 20	R (C1)	R (C1)	I (C2)	I (C2)	I (C2)	I (C2)	I (C2)
20 – 100	I (C2)	I (C2)	C3	C3	C3	C3	C3

Key (shown in decreasing order of permitted emission level):

E2R EN 61800-3:2004 second environment, restricted distribution (Additional measures may be required to prevent interference)

E2U EN 61800-3:2004 second environment, unrestricted distribution

I Industrial generic standard EN 61000-6-4:2007
EN 61800-3:2004 first environment restricted distribution (The following caution is required by EN 61800-3:2004)

CAUTION This is a product of the restricted distribution class according to IEC 61800-3. In a residential environment this product may cause radio interference in which case the user may be required to take adequate measures.

R Residential generic standard EN 61000-6-3:2007
EN 61800-3:2004 first environment unrestricted distribution

EN 61800-3:2004 defines the following:

- The first environment is one that includes residential premises. It also includes establishments directly connected without intermediate transformers to a low-voltage power supply network which supplies buildings used for residential purposes.
- The second environment is one that includes all establishments other than those directly connected to a low-voltage power supply network which supplies buildings used for residential purposes.

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- Restricted distribution is defined as a mode of sales distribution in which the manufacturer restricts the supply of equipment to suppliers, customers or users who separately or jointly have technical competence in the EMC requirements of the application of drives.

IEC 61800-3:2004 and EN 61800-3:2004

The 2004 revision of the standard uses different terminology to align the requirements of the standard better with the EC EMC Directive.

Power drive systems are categorized C1 to C4:

Category	Definition	Corresponding code used above
C1	Intended for use in the first or second environments	R
C2	Not a plug-in or movable device, and intended for use in the first environment only when installed by a professional, or in the second environment	I
C3	Intended for use in the second environment, not the first environment	E2U
C4	Rated at over 1000 V or over 400 A, intended for use in complex systems in the second environment	E2R

Note that category 4 is more restrictive than E2R, since the rated current of the PDS must exceed 400 A or the supply voltage exceed 1000 V, for the complete PDS.

11.2 Optional external EMC filters

Table 11-29 EMC filter cross reference

Model	CT Part number
200 V	
06200500 to 06200580	4200-2300
400 V	
04400240	4200-0252
05400300	4200-0402
06400380	4200-4800
575 V	
06500220 to 06500270	4200-3690

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11.2.1 EMC filter ratings

Table 11-30 Optional external EMC filter details

CT part number	Maximum continuous current		Voltage rating		IP rating	Power dissipation at rated current		Ground leakage		Discharge resistors
	@ 40 °C (104 °F)	@ 50 °C (122 °F)	IEC	UL		@ 40 °C (104 °F)	@ 50 °C (122 °F)	Balanced supply phase-to-phase and phase-to-ground	Worst case	
	A	A	V	V		W	W	mA	mA	MΩ
4200-2300	55	51	250	300	20	41	35	4.2	69	1.68
4200-0252	25	23	528	600		28	24	11.1	182	
4200-0402	40	36.8	528	600		47	40	18.7	197	
4200-3690	42	39	760	600		45	39	12	234	

11.2.2 Overall EMC filter dimensions

Table 11-31 Optional external EMC filter dimensions

CT part number	Dimension (mm)						Weight	
	H		W		D			
	mm	inch	mm	inch	mm	inch	kg	lb
4200-2300	434	17.09	210	8.27	60	2.36	6.5	14.30
4200-0252	437	17.20	123	4.84			4.1	9.04
4200-0402			143	5.63			5.5	12.13
4200-3690	434	17.09	210	8.27			7.0	15.40

11.2.3 EMC filter torque settings

Table 11-32 Optional external EMC Filter terminal data

CT part number	Power connections				Ground connections		
	Max cable size		Max torque		Ground stud size	Max torque	
	mm^2	AWG	N m	lb ft		N m	lb ft
4200-0252	16	6	1.8	1.4	M6	4.8	2.8
4200-0402							
4200-2300	16	6	2.3	1.70	M6	4.8	2.8
4200-3690							

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12 Diagnostics

The keypad display on the drive gives various information about the status of the drive. The keypad display provides information on the following categories:

- Trip indications
- Alarm indications
- Status indications

WARNING

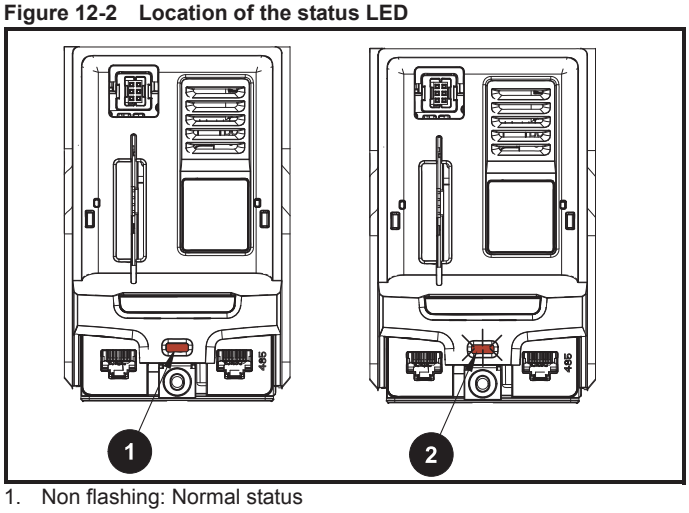
Users must not attempt to repair a drive if it is faulty, nor carry out fault diagnosis other than through the use of the diagnostic features described in this chapter.
If a drive is faulty, it must be returned to an authorized Control Techniques distributor for repair.

12.1 Status modes (Keypad and LED status)

Figure 12-1 Keypad status modes

1. Drive OK status
2. Trip status
3. Alarm status

Figure 12-2 Location of the status LED



1. Non flashing: Normal status
2. Flashing: Trip status

12.2 Trip indications

The output of the drive is disabled under any trip condition so that the drive stops controlling the motor. If the motor is running when the trip occurs it will coast to a stop.

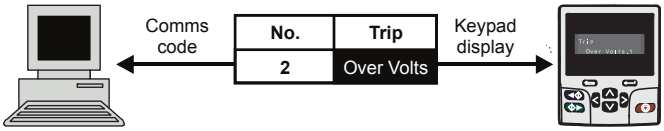
During a trip condition, where a HOA-Keypad is being used, the upper row of the display indicates that a trip has occurred and the lower row of the keypad display will display the trip string. Some trips have a sub-trip number to provide additional information about the trip. If a trip has a sub-trip number, the sub-trip number is flashed alternately with the trip string unless there is space on the second row for both the trip string and the sub-trip number in which case both the trip string and sub-trip information is displayed separated by a decimal place.

The back-light of the HOA-Keypad display will also flash during a trip condition. If a display is not being used, the drive LED Status indicator will flash with 0.5 s duty cycle if the drive has tripped. Refer to Figure 12-2.

Trips are listed alphabetically in Table 12-10 based on the trip indication shown on the drive display. Alternatively, the drive status can be read in Pr **10.001** 'Drive OK' using communication protocols. The most recent trip can be read in Pr **10.020** providing a trip number. It must be noted that the hardware trips (HF01 to HF20) do not have trip numbers. The trip number must be checked in Table 12-11 to identify the specific trip.

Example

1. Trip code 2 is read from Pr **10.020** via serial communications.
2. Checking Table 12-10 shows Trip 2 is an Over Volts trip.



3. Look up Over Volts in Table 12-10.
4. Perform checks detailed under *Diagnosis*.

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12.3 Identifying a trip / trip source

Some trips only contain a trip string whereas some other trips have a trip string along with a sub-trip number which provides the user with additional information about the trip.

A trip can be generated from a control system or from a power system. The sub-trip number associated with the trips listed in Table 12-1 is in the form xxyzz and used to identify the source of the trip.

Table 12-1 Trips associated with xxyzz sub-trip number

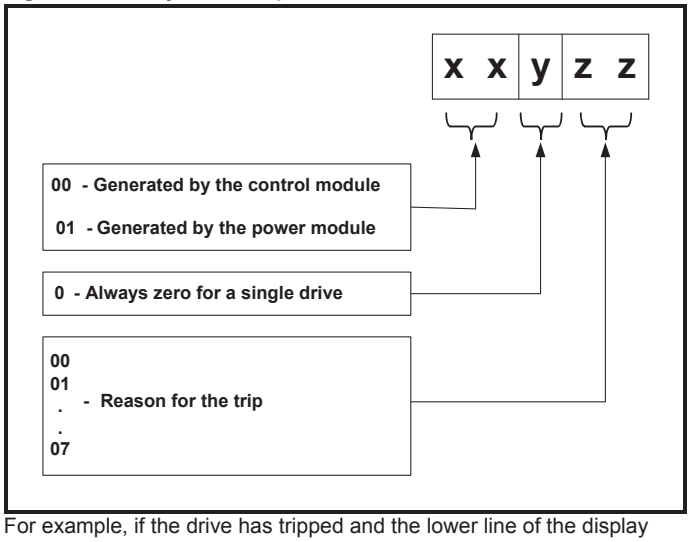
Over Volts	OHt dc bus
OI ac	Phase Loss
Power Data	Power Comms
PSU	OI Snubber
OHt Inverter	OHt Rectifier
OHt Power	Temp Feedback
OHt Control	

The digits xx are 00 for a trip generated by the control system. For a single drive (not part of a multi-power module drive), if the trip is related to the power system then xx will have a value of 01, when displayed the leading zeros are suppressed.

The y digit is used to identify the location of a trip which is generated by a rectifier module connected to a power module (if xx is non zero). For a control system trip (xx is zero), the y digit, where relevant is defined for each trip. If not relevant, the y digit will have a value of zero.

The zz digits give the reason for the trip and are defined in each trip description.

Figure 12-3 Key to sub-trip number



For example, if the drive has tripped and the lower line of the display shows 'OHt Control.2', with the help Table 12-2 the trip can be interpreted as; an over temperature has been detected; the trip was generated by fault in the control module, the control board thermistor 2 over temperature.

Table 12-2 Sub-trip identification

Source	xx	y	zz	Description
Control system	00	0	01	Control board thermistor 1 over temperature
Control system	00	0	02	Control board thermistor 2 over temperature
Control system	00	0	03	Control board thermistor 3 over temperature

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12.4 Compressor specific diagnostics

12.4.1 Definitions

Warnings - are indicators of tests/functions stages and are not logged or counted.

Alerts/alarms - are logged and counted towards trips or lockouts.

Trips - remove the motor supply, and are permanently logged and may auto-reset.

Lockouts - are triggered directly or after a number of trips or alerts. Lockouts remove the motor supply and are permanently logged. They have to be reset by the user.

The keypad can be used to reset certain trips and lock out conditions (see detailed function descriptions).

Certain trips and lock out conditions, are resettable through the Fieldbus link using the **System control word**.

Table 12-3 Parameters involved in diagnostic functions

Parameter	Parameter Name	Function area	Description	Units	Range	Default
00.018 {18.001}	Total number of trips	Diagnostics	Counts the trips. User can reset to zero.	none	0 to 10000	0
00.020 {18.012}	System control word	Diagnostics	See table below for key.	none	0 to 32767	0
00.021 {18.013}	Trip/Lockout number	Diagnostics	Compressor related trip status. [Zero is no trip] See logging section.	none	0 to 255	0
00.022 {18.014}	Condition alerts	Diagnostics	System related alerts.	none	0 to 255	0
00.023 {18.015}	Condition warnings	Diagnostics	System related warnings.	none	0 to 255	0
00.024 {18.016}	Configuration control parameter	Diagnostics	See table below for key.	none	0 to 32767	0
00.038 {19.014}	Running log of alerts entry number	Diagnostics	User set 1 to 20.	none	0 to 20	0
00.039 {19.015}	Running log alert ID number and days and hours	Diagnostics	iidhh format. Id is the ii, day is the d and hours are the hh.	none	0 to 32767	0
00.055 {20.002}	CSD100 trip number	Diagnostics	Active CSD100 trip number (clone of Pr **10.020**) with zero denoting no trip.	none	0 to 255	0

Table 12-4 Key to the trip/lockout parameter 00.021 {18.013}:

Trip number 00.021 {18.013}	Fault Condition	Code fault Description	Code Reset Description
32	Drive voltage imbalance fault	The drive has detected an input phase loss or large supply imbalance.	Automatic reset after 60 s unless more than 5 in one hour
42	Discharge line temperature	DLT temperature has been too high too often.	Automatic reset below the trip level for 10 minutes
44	Out of envelope condition	Out of master envelope condition even after envelope control.	Automatic reset after 10 minutes if the condition is becomes within the envelope.
45	Fieldbus communication loss	The communication watchdog timer. (of up to 5 minutes) has detected the absence of communications.	Once communication is re-established
46	Drive low input voltage fault	The drive is in the under voltage state (with a 10 second timeout).	Automatic reset [See function description]
48	DLT sensor fault	Detection of a sensor fault for more than 60 s.	
98	Compressor missing a phase	Phase loss has been detected at the drive output at start-up.	After 5 minutes the trip is automatically reset. The system will lockout after 10 trips within 24 hours.

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Table 12-5 Key to trip/lockout parameter 00.021 {18.013}

Lockout number 00.021 {18.013}	Fault Condition	Code fault Description	Code Reset Description
3	OI.Ac	The instantaneous drive output current has exceeded the drive over current threshold.	Power-cycle or through the reset command (MODBUS, keypad or digital input)
9	Internal 24 V PSU	The otal user load of the drive has exceeded the internal 24 V power supply limit.	Power-cycle or through the reset command (MODBUS, keypad or digital input)
5	Internal general PSU	One or more internal power supply rails are outside limits or overloaded.	Power-cycle or through the reset command (MODBUS, keypad or digital input)
40	Locked rotor detected	A locked or lost rotor trip condition had been detected.	Power-cycle
41	Incorrectly wired motor	Reverse rotation condition due to motor miss wiring detected.	Power-cycle required
47	Soft-start did not succeed	The soft-start did not achieve the soft-start dwell speed after three attempts.	Power-cycle or through the reset command (MODBUS, keypad or digital input)
50	Compressor missing a phase	Phase loss has been detected at the drive output at start-up.	Power-cycle or through the reset command (MODBUS, keypad or digital input)
51	Missing input phase	Input phase loss has detected more than 5 trips in 1 hour.	Power-cycle or through the reset command (MODBUS, keypad or digital input)

Table 12-6 Key to the condition warning parameter 00.023 {18.015}

Warning Number Pr 00.023 {18.015} Bit	Condition	Condition Description
0 (1st)	Locked rotor retrying	A locked rotor condition has been detected and the VSD is retrying or waiting between retries.
1 (2nd)	Motor being run in opposite direction	A reversed motor connection was detected. The drive has changed the direction to test.
2 (3rd)	Stator heating active	Current is being passed through the motor stator windings to provide heating.
3 (4th)	Envelope Override Active	The user speed reference is outside of the limits imposed by the systems operating condition within the envelope and so the final compressor speed has been limited.
4 (5th)	Defrost cycle active	The system is providing a defrost cycle. This bit will change to low when the defrost cycle is complete.
5 (6th)	Motor thermal model over 75 % of the accumulator trip level	Warns that the motor/compressor is above the 75 % level (according to the motor model) where 100 % represents the trip level.
6 (7th)	Oil boost active	The oil boost function is active.
Bits 7 to 15	Reserved	Reserved for future functionality.

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Table 12-7 Key to the condition alerts parameter 00.022 {18.014}

Alert/alarm Number Pr 00.022 {18.014} Bit	Condition	Condition Description	Further Actions
0 (1st)	DLT OT Protection	DLT temperature is too high.	Trip if more than 3 samples each taken at 60 s intervals
1 (2nd)	DLT sensor fault	The DLT sensor is not within the expected range.	Trip if error persists for more than 60 s
2 (3rd)	Soft-start did not succeed	The last soft-start attempt did not achieve the soft-start dwell speed.	Lockout after 3 consecutive alerts
3 (4th)	Motor Overload Alarm (**10.017**)	Indicates that the motor overload accumulator is above 75 % and the output current is high.	Trip at 100 %
4 (5th)	Lost rotor	For dynamic speed demand: Speed error is greater than 100 rpm [user set] for longer than 4 s. For constant speed demand: Speed error is greater than 50 rpm [user set] for longer than 4 s.	Will fold back
5 (6th)	Foldback active	See section description. May affect the motor current overload limit.	May trip on motor thermal model or drive thermal model
6 (7th)	Short-cycle lockout active	Prevents short-cycling by delaying the next start up.	
7 (8th)	Out of envelope	The compressor is operating outside of the envelope	Will trip after 10 minutes if operation does not return to inside the envelope
Bits 8 to 15	Reserved	Reserved for future functionality.	Reserved

The condition alerts and warnings parameter should be viewed as a binary value where each bit within the value is associated with an individual condition alert and warning. The use of a single parameter provides fast access to the trip/status through a single parameter read transfer.

12.4.2 Fault history/logging

- The last 10 trips and lockouts are stored by the standard DRIVE firmware with a time stamp (based on the powered-up timer). They remain stored even if the power to the CSD100 is cycled.
- *Date* (06.016), *Time* (06.017) and *Day Of Week* (06.018) show the date and time since the drive was power-up.
- The days have a minimum value of 0 and roll over after 30, the months have a minimum value of 0 and roll over after 11, and *Day Of Week* (06.018) is always 0 (Sunday).

The value of this parameter as seen over communications as follows.

Value = (day[1..31] x 10000) + (month[1..12] x 100) + year[0..99]

Table 12-8 CSD100 specific permanent alert log

Parameter	Parameter Name	Function area	Size
00.028 {18.020}	Locked Rotor Failure start count	Records number of failed starts due to Locked Rotor protection	INT16
00.032 {18.025}	DLT OT fault count	Number of over temperature faults	INT16
00.035 {19.011}	Short cycle count	Number of short cycles that have occurred	INT16
00.042 {19.018}	Compressor missing a phase counter	Lockout after 10 “compressor missing a phase “ trips within 24 hours	INT16
00.050 {19.028}	Number of soft-start attempts	Number of failed soft start attempts that have occurred (a trip is generated on the 3rd failed attempt)	INT16
00.030 {18.023}	Number of reverse rotation detection events	Number of reverse rotation events detected (a trip is generated on the 2nd)	INT16
00.018 {18.001}	Total number of trips	Counts the number of CSD100 specific and drive trips. User can reset to zero.	INT16

The "total number of trips" is saved automatically on power down. The user can reset this by writing zero to the parameter.

12.4.3 Status/alarm indicator

The purpose of this parameter is to provide a way to communicate the system status, warnings and alerts via the CSD100 to a service technician.

1. The drive will send the status/alarm to the system controller. The system controller can decide how to handle the information from the system side.
2. For drives sold with a Keypad, the status/alarm information with other information (such as compressor speed) is displayed on the LCD.
3. For drives sold without a Keypad, the LED can be used to indicate the system status (flashing LED indicates trip condition).

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12.4.4 Running alert log

Table 12-9 Key to the running alert log Pr 00.039 {19.015}:

ID	Condition	Condition Description
1	DLT over temperature protection	DLT temperature is too high
2	DLT sensor fault	The DLT sensor is not within range.
3	Soft-start did not succeed	The soft-start did not achieve the initial speed.
4	*Motor Overload Alarm* (**10.017**)	Indicates that the motor overload accumulator is above 75 % and the output current is high
5	Lost rotor	Dynamic speed demand: Speed error is greater than 30 % [user set] for longer than 4 s. Constant speed demand: Speed error is greater than 20 % [user set] for longer than 4 s.
6	Foldback active	See section description. May affect the motor current overload limit.
7	Short-cycle lockout active	Prevents short-cycling by delaying the next start up

Alerts logged with a time stamp sampled on the activation of the alert.

- The time stamp is quanti sized to 1 hour.
- The data/time is in hours ago (and thus is updated every hour that passes).
- The log shows the last 20 alerts.
- An event is removed after 7 days.
- Up to 31 alert Id's can be defined.

Pr **00.038 {19.014}**	Running log of alerts entry number	User set 1 to 20	INT16
Pr **00.039 {19.015}**	Running log alert ID number and days and hours	iidhh format. The alert ID is the ii, day is the d and hour is the hh.	INT16

The user sets the alert entry number (1 to 20) and then reads the Alert ID and hour parameter and the Alert date parameter.

Example, a DLT sensor fault that occurred 4 days and 12 hours ago would read 2412.

The time is given by two parameters, Pr **6.016** for the date and Pr **6.017** for the time.

This is converted internally into an elapsed hours using:

Elapsed hours = (Years * 8640) + (Months * 720) + (Days * 24) + Hours.

12.4.5 CSD100 input (supply) low voltage

The standard CSD100, has detection and trip functions for monitoring the input supply and the supply rails that the CSD100 provides.

- The drive will ride through supply voltage dips given the level of stored energy.
- The drive cannot start with a spinning rotor, as this effects the missing phase detection on start up.

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12.5 Trips, Sub-trip numbers

Table 12-10 Trip indications

Trip	Diagnosis
An Input 1 Loss	**Analog input 1 current loss**
28	*An Input 1 Loss* trip indicates that a current loss was detected in current mode on Analog input 1 (Terminal 5, 6). In 4-20 mA and 20-4 mA modes loss of input is detected if the current falls below 3 mA. **Recommended actions:** • Check control wiring is correct • Check control wiring is undamaged • Check the *Analog Input 1 Mode* (07.007) • Current signal is present and greater than 3 mA
An Input 2 Loss	**Analog input 2 current loss**
29	*An Input 2 Loss* indicates that a current loss was detected in current mode on Analog input 2 (Terminal 7). In 4-20 mA and 20-4 mA modes loss of input is detected if the current falls below 3 mA. **Recommended actions:** • Check control wiring is correct • Check control wiring is undamaged • Check the *Analog Input 2 Mode* (07.011) • Current signal is present and greater than 3 mA
An Output Calib	**Analog output calibration failed**
219	The *An output Calib* trip indicates that one or both of the Analog outputs have failed during the zero offset calibration**.** The failed output can be identified by the sub-trip number. **Sub-trip** / **Reason**: 1 – Output 1 failed (Terminal 9); 2 – Output 2 failed (Terminal 10) **Recommended actions:** • Check the wiring associated with analog outputs • Remove all the wiring that is connected to analog outputs and perform the calibration • If trip persists replace the drive
App Menu Changed	**Customization table for an application module has changed**
217	The *App Menu Changed* trip indicates that the customization table for an application menu has changed. The menu that has been changed can be identified by the sub-trip number. **Sub-trip** / **Reason**: 1 – Menu 18; 2 – Menu 19; 3 – Menu 20 **Recommended actions:** • Reset the trip and perform a parameter save to accept the new settings
Card Access	**NV Media Card Write fail**
185	The *Card Access* trip indicates that the drive was unable to access the NV Media Card. If the trip occurs during the data transfer to the card then the file being written may be corrupted. If the trip occurs when the data being transferred to the drive then the data transfer may be incomplete. If a parameter file is transferred to the drive and this trip occurs during the transfer, the parameters are not saved to non-volatile memory, and so the original parameters can be restored by powering the drive down and up again. **Recommended actions:** • Check NV Media Card is installed / located correctly • Replace the NV Media Card
Card Boot	**The Menu 0 parameter modification cannot be saved to the NV Media Card**
177	Menu 0 changes are automatically saved on exiting edit mode. The *Card Boot* trip will occur if a write to a Menu 0 parameter has been initiated via the keypad by exiting edit mode and Pr **11.042** is set for auto or boot mode, but the necessary boot file has not been created on the NV Media Card to take the new parameter value. This occurs when Pr **11.042** is changed to Auto (3) or Boot (4) mode, but the drive is not subsequently reset. **Recommended actions:** • Ensure that Pr **11.042** is correctly set, and then reset the drive to create the necessary file on the NV Media Card • Re-attempt the parameter write to the Menu 0 parameter

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Trip	Diagnosis
Card Busy	**NV Media Card cannot be accessed as it is being accessed by an option module**
178	The *Card Busy* trip indicates that an attempt has been made to access a file on NV Media Card, but the NV Media Card is already being accessed by an option module, such as one of the Applications modules. No data is transferred. **Recommended actions:** • Wait for the option module to finish accessing the NV Media Card and re-attempt the required function
Card Data Exists	**NV Media Card data location already contains data**
179	The *Card Data Exists* trip indicates that an attempt has been made to store data on a NV Media Card in a data block which already contains data. **Recommended actions:** • Erase the data in data location • Write data to an alternative data location
Card Compare	**NV Media Card file/data is different to the one in the drive**
188	A compare has been carried out between a file on the NV Media Card, a Card Compare trip is initiated if the parameters on the NV Media Card are different to the drive. **Recommended actions:** • Set Pr **mm.000** to 0 and reset the trip • Check to ensure the correct data block on the • NV Media Card has been used for the compare
Card Drive Mode	**NV Media Card parameter set not compatible with current drive mode**
187	The *Card Drive Mode* trip is produced during a compare if the drive mode in the data block on the NV Media Card is different from the current drive mode. This trip is also produced if an attempt is made to transfer parameters from a NV Media Card to the drive if the operating mode in the data block is outside the allowed range of operating modes. **Recommended actions:** • Ensure the destination drive supports the drive operating mode in the parameter file. • Clear the value in Pr **mm.000** and reset the drive • Ensure destination drive operating mode is the same as the source parameter file
Card Error	**NV Media Card data structure error**
182	The *Card Error* trip indicates that an attempt has been made to access a NV Media Card but an error has been detected in the data structure on the card. Resetting the trip will cause the drive to erase and create the correct folder structure. The cause of the trip can be identified by the sub-trip. **Sub-trip** / **Reason** 1 – The required folder and file structure is not present 2 – The HEADER.DAT file is corrupted 3 – Two or more files in the GT8DATA\DRIVE folder have the same file identification number **Recommended actions:** • Erase all the data block and re-attempt the process • Ensure the card is located correctly • Replace the NV Media Card
Card Full	**NV Media Card full**
184	The *Card Full* trip indicates that an attempt has been made to create a data block on a NV Media Card, but there is not enough space left on the card. **Recommended actions:** • Delete a data block or the entire NV Media Card to create space • Use a different NV Media Card
Card No Data	**NV Media Card data not found**
183	The *Card No Data* trip indicates that an attempt has been made to access non-existent file or block on a NV Media Card. **Recommended actions:** • Ensure data block number is correct

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Trip	Diagnosis
Card Option	**NV Media Card trip; option modules installed are different between source drive and destination drive**
180	The *Card Option* trip indicates that parameter data or default difference data is being transferred from a NV Media Card to the drive, but the option module categories are different between source and destination drives. This trip does not stop the data transfer, but is a warning that the data for the option modules that are different will be set to the default values and not the values from the card. This trip also applies if a compare is attempted between the data block and the drive. **Recommended actions:** • Ensure the correct option modules are installed. • Ensure the option modules are in the same option module slot as the parameter set stored. • Press the red reset button to acknowledge that the parameters for one or more of the option modules installed will be at their default values • This trip can be suppressed by setting Pr **mm.000** to 9666 and resetting the drive.
Card Product	**NV Media Card data blocks are not compatible with the drive derivative**
175	The *Card Product* trip is initiated either at power-up or when the card is accessed, If *Drive Derivative* (11.028) is different between the source and target drives. This trip can be reset and data can be transferred in either direction between the drive and the card. **Recommended actions:** • Use a different NV Media Card • This trip can be suppressed by setting Pr **mm.000** to 9666 and resetting the drive
Card Rating	**NV Media Card Trip; The voltage and / or current rating of the source and destination drives are different**
186	The Card Rating trip indicates that parameter data is being transferred from a NV Media Card to the drive, but the current and / or voltage ratings are different between source and destination drives. This trip also applies if a compare (using Pr **mm.000** set to 8yyy) is attempted between the data block on a NV Media Card and the drive. The Card Rating trip does not stop the data transfer but is a warning that rating specific parameters with the RA attribute may not be transferred to the destination drive. **Recommended actions:** • Reset the drive to clear the trip • Ensure that the drive rating dependent parameters have transferred correctly
Card Read Only	**NV Media Card has the Read Only bit set**
181	The *Card Read Only* trip indicates that an attempt has been made to modify a read-only NV Media Card or a read-only data block. A NV Media Card is read-only if the read-only flag has been set. **Recommended actions:** • Clear the read only flag by setting Pr **mm.000** to 9777 and reset the drive. This will clear the read-only flag for all data blocks in the NV Media Card
Card Slot	**NV Media Card Trip; Option module application program transfer has failed**
174	The *Card Slot* trip is initiated, if the transfer of an option module application program to or from an application module failed because the option module does not respond correctly. If this happens this trip is produced with the sub-trip indicating the option module slot number. **Recommended actions:** • Ensure the source / destination option module is installed on the correct slot
Configuration	**The number of power modules installed is different from the modules expected**
111	The *Configuration* trip indicates that the *Number Of Power Modules Detected* (11.071) does not match the previous value stored. **Recommended actions:** • Ensure that all the power modules are correctly connected / simultaneously • Ensure all the power modules have powered up correctly • Ensure that the value in Pr **11.071** is set to the number of power modules connected • Set Pr **11.035** to 0 to disable the trip if it is not required
Control Word	**Trip initiated from the *Control Word* (06.042)**
35	The Control Word trip is initiated by setting bit 12 on the control word in Pr **06.042** when the control word is enabled (Pr **06.043** = On). **Recommended actions:** • Check the value of Pr **06.042.** • Disable the control word in *Control Word Enable* (Pr **06.043**) Bit 12 of the control word set to a one causes the drive to trip on Control Word When the control word is enabled, the trip can only be cleared by setting bit 12 to zero
Current Offset	**Current feedback offset error**
225	The *Current Offset* trip indicates that the current offset is too larger to be trimmed. **Recommended actions:** • Ensure that there is no possibility of current flowing in the output phases of the drive when the drive is not enabled • Hardware fault – Contact the supplier of the drive

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Trip	Diagnosis
Data Changing	**Drive parameters are being changed**
97	A user action or a file system write is active that is changing the drive parameters and the drive has been commanded to enable, i.e. *Drive Active* (10.002) = 1. **Recommended actions:** • Ensure the drive is not enabled when one of he following is being carried out Loading defaults Changing drive mode Transferring data from NV Media Card or position feedback device Transferring user programs
Destination	**Two or more parameters are writing to the same destination parameter**
199	The Destination trip indicates that destination output parameters of two or more logic functions (Menus 3, 7, 8, 9, 12 or 14) within the drive are writing to the same parameter. **Recommended actions:** • Set Pr **mm.000** to 'Destinations' or 12001 and check all visible parameters in all menus for parameter write conflicts
Drive Size	**Power stage recognition: Unrecognized drive size**
224	The *Drive Size* trip indicates that the control PCB has not recognized the drive size of the power circuit to which it is connected. **Recommended action:** • Ensure the drive is programmed to the latest firmware version • Hardware fault - return drive to supplier
Derivative Image	**Derivative Image error**
248	The *Derivative Image* trip indicates that an error has been detected in the derivative image. **Recommended action:** Contact the supplier of the drive
EEPROM Fail	**Default parameters have been loaded**
31	The *EEPROM Fail* trip indicates that default parameters have been loaded. The exact cause/reason of the trip can be identified from the sub-trip number. **Sub-trip** / **Reason** 1 – The most significant digit of the internal parameter database version number has changed 2 – The CRC's applied to the parameter data stored in internal non-volatile memory indicate that a valid set of parameters cannot be loaded 3 – The drive mode restored from internal non-volatile memory is outside the allowed range for the product or the derivative image does not allow the previous drive mode 4 – The drive derivative image has changed 5 – The power stage hardware has changed 6 – The internal I/O hardware has changed 7 – The position feedback interface hardware has changed 8 – The control board hardware has changed 9 – The checksum on the non-parameter area of the EEPROM has failed **Recommended actions:** • Default the drive and perform a reset • Allow sufficient time to perform a save before the supply to the drive is removed • If the trip persists - return drive to supplier
External Trip	**An External trip is initiated**
6	An *External Trip* has occurred. The cause of the trip can be identified from the sub trip number displayed after the trip string. See table below. An external trip can also be initiated by writing a value of 6 in Pr **10.038**. **Sub-trip** / **Reason** 1 – *External Trip Mode* (08.010) = 1 or 3 and SAFE TORQUE OFF input 1 is low 2 – *External Trip Mode* (08.010) = 2 or 3 and SAFE TORQUE OFF input 2 is low 3 – *External Trip* (10.032) = 1 **Recommended actions:** • Check the SAFE TORQUE OFF signal voltage on terminal 31 equals to 24 V • Check the value of Pr **08.009** which indicates the digital state of terminal 31, equates to 'on'. • If external trip detection of the SAFE TORQUE OFF input is not required, set Pr **08.010** to OFF (0). • Check the value of Pr **10.032**. • Select 'Destinations' (or enter 12001) in Pr **mm.000** and check for a pa • Ensure Pr **10.032** or Pr **10.038** (= 6) is not being controlled by serial comm

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Trip	Diagnosis
HF01	**Data processing error: CPU address error**
	The *HF01* trip indicates that a CPU address error has occurred. This trip indicates that the control PCB on the drive has failed. **Recommended actions:** • Hardware fault – Contact the supplier of the drive
HF02	**Data processing error: DMAC address error**
	The *HF02* trip indicates that a DMAC address error has occurred. This trip indicates that the control PCB on the drive has failed. **Recommended actions:** • Hardware fault – Contact the supplier of the drive
HF03	**Data processing error: Illegal instruction**
	The *HF03* trip indicates that an illegal instruction has occurred. This trip indicates that the control PCB on the drive has failed. **Recommended actions:** • Hardware fault – Contact the supplier of the drive
HF04	**Data processing error: Illegal slot instruction**
	The *HF04* trip indicates that an illegal slot instruction has occurred.This trip indicates that the control PCB on the drive has failed. **Recommended actions:** • Hardware fault – Contact the supplier of the drive
HF05	**Data processing error: Undefined exception**
	The *HF05* trip indicates that an undefined exception error has occurred. This trip indicates that the control PCB on the drive has failed. **Recommended actions:** • Hardware fault – Contact the supplier of the drive
HF06	**Data processing error: Reserved exception**
	The *HF06* trip indicates that a reserved exception error has occurred. This trip indicates that the control PCB on the drive has failed. **Recommended actions:** • Hardware fault – Contact the supplier of the drive
HF07	**Data processing error: Watchdog failure**
	The *HF07* trip indicates that a watchdog failure has occurred. This trip indicates that the control PCB on the drive has failed. **Recommended actions:** • Hardware fault – Contact the supplier of the drive
HF08	**Data processing error: CPU Interrupt crash**
	The *HF08* trip indicates that a CPU interrupt crash has occurred. This trip indicates that the control PCB on the drive has failed. **Recommended actions:** • Hardware fault – Contact the supplier of the drive
HF09	**Data processing error: Free store overflow**
	The *HF09* trip indicates that a free store overflow has occurred. This trip indicates that the control PCB on the drive has failed. **Recommended actions:** • Hardware fault – Contact the supplier of the drive
HF10	**Data processing error: Parameter routing system error**
	The *HF10* trip indicates that a Parameter routing system error has occurred. This trip indicates that the control PCB on the drive has failed. **Recommended actions:** • Hardware fault – Contact the supplier of the drive
HF11	**Data processing error: Access to EEPROM failed**
	The *HF11* trip indicates that access to the drive EEPROM has failed. This trip indicates that the control PCB on the drive has failed. **Recommended actions:** • Hardware fault – Contact the supplier of the drive

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Trip	Diagnosis
HF12	**Data processing error: Main program stack overflow**
	The *HF12* trip indicates that the main program stack over flow has occurred. The stack can be identified by the sub-trip number. This trip indicates that the control PCB on the drive has failed. **Sub-trip** / **Stack** 1 – Freewheeling tasks 2 – Clock tasks 3 – Main system interrupts **Recommended actions:** • Hardware fault – Contact the supplier of the drive
HF13	**Data processing error: Firmware incompatible with hardware**
	The *HF13* trip indicates that the drive firmware is not compatible with the hardware. This trip indicates that the control PCB on the drive has failed. **Recommended actions:** • Re-program the drive with the latest version of the drive firmware • Hardware fault – Contact the supplier of the drive
HF14	**Data processing error: CPU register bank error**
	The *HF14* trip indicates that a CPU register bank error has occurred. This trip indicates that the control PCB on the drive has failed. **Recommended actions:** • Hardware fault – Contact the supplier of the drive
HF15	**Data processing error: CPU divide error**
	The *HF15* trip indicates that a CPU divide error has occurred. This trip indicates that the control PCB on the drive has failed. **Recommended actions:** • Hardware fault – Contact the supplier of the drive
HF16	**Data processing error: RTOS error**
	The *HF16* trip indicates that a RTOS error has occurred. This trip indicates that the control PCB on the drive has failed. **Recommended actions:** • Hardware fault – Contact the supplier of the drive
HF17	**Data processing error: Clock supplied to the control board is out of specification**
	The *HF17* trip indicates that the clock supplied to the control board logic is out of specification. This trip indicates that the control PCB on the drive has failed. **Recommended actions:** • Hardware fault – Contact the supplier of the drive
HF18	**Data processing error: Internal flash memory has failed**
	The *HF18* trip indicates that the internal flash memory has failed when writing option module parameter data. The reason for the trip can be identified by the sub-trip number. **Sub-trip** / **Reason** 1 – Option module initialization timed out 2 – Programming error while writing menu in flash 3 – Erase flash block containing setup menus failed 4 – Erase flash block containing application menus failed 5 – Incorrect setup menu CRC contained in flash 6 – Incorrect application menu CRC contained in flash 7 – Incorrect common application menu 18 CRC contained in flash 8 – Incorrect common application menu 19 CRC contained in flash 9 – Incorrect common application menu 20 CRC contained in flash **Recommended actions:** • Hardware fault - Contact the supplier of the drive.
HF19	**Data processing error: CRC check on the firmware has failed**
	The *HF19* trip indicates that the CRC check on the drive firmware has failed. **Recommended actions:** • Re-program the drive • Hardware fault - Contact the supplier of the drive

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Trip	Diagnosis
HF20	**Data processing error: ASIC is not compatible with the hardware**
	The *HF20* trip indicates that the ASIC version is not compatible with the drive firmware. The ASIC version can be identified from the sub-trip number. **Recommended actions:** • Hardware fault - Contact the supplier of the drive
Inductor Too Hot	**The regen inductor has overloaded**
93	In Regen mode, this trip indicates a regen inductor thermal overload based on the *Rated Current* (Pr **05.007**) and the *Inductor Thermal Time Constant* (Pr **04.015**). Pr **04.019** displays the inductor temperature as a percentage of the maximum value. The drive will trip on *Inductor Too Hot* when Pr **04.019** gets to 100 %. **Recommended actions:** • Check the load / current through the inductor has not changed. • Ensure the *Rated Current* (Pr **05.007**) is not zero.
I/O Overload	**Digital output overload**
26	The *I/O Overload* trip indicates that the total current drawn from 24 V user supply or from the digital output has exceeded the limit. A trip is initiated if one or more of the following conditions: • Maximum output current from one digital output is 100 mA. • The combined maximum output current from outputs 1 and 2 is 100 mA • The combined maximum output current from output 3 and +24 V output is 100 mA **Recommended actions:** • Check total loads on digital outputs • Check control wiring is correct • Check output wiring is undamaged
Low Load	**The load on the drive has fallen below the low load detection level**
38	When the low load detector is active, the low load condition is detected when the *Percentage Load* (Pr **04.020**) falls below the threshold defined by the *Low Load Detection Level* (Pr **04.027**). *Enable Trip On Low Load* (Pr **04.029**) defines the action taken when low load is detected. If *Enable Trip On Low Load* (Pr **04.029**) = 0, a Low Load warning is displayed and *Low Load Detected Alarm* (Pr **10.062**) = 1. If *Enable Trip On Low Load* (Pr **04.029**) = 1 no warning is given, but a Low Load trip is initiated. **Recommended actions:** • Check the load on the motor has not changed
Motor Too Hot	**Output current overload timed out (I^2t)**
20	The *Motor Too Hot* trip indicates a motor thermal overload based on the output current (Pr **05.007**) and motor thermal time constant (Pr **04.015**). Pr **04.019** displays the motor temperature as a percentage of the maximum value. The drive will trip on *Motor Too Hot* when Pr **04.019** gets to 100 %. **Recommended actions:** • Ensure the load is not jammed / sticking • Check the load on the motor has not changed • If seen during an auto-tune test in RFC-S mode, ensure the motor rated current in Pr **05.007** is ≤ Heavy duty current rating of the drive • Tune the rated speed parameter (RFC-A mode only) • Check feedback signal for noise • Ensure the motor rated current is not zero
OHt Control	**Control stage over temperature**
23	This *OHt Control* trip indicates that a control stage over-temperature has been detected. From the sub-trip 'xxyzz', the Thermistor location is identified by 'zz'.

Source	xx	y	zz	Description
Control system	00	0	01	Control board thermistor 1 over temperature
Control system	00	0	02	Control board thermistor 2 over temperature
Control system	00	0	03	I/O board thermistor over temperature

Recommended actions:

- Check enclosure / drive fans are still functioning correctly
- Check enclosure ventilation paths
- Check enclosure door filters
- Increase ventilation
- Reduce the drive switching frequency
- Check ambient temperature

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Trip	Diagnosis
OHt dc bus	**DC bus over temperature**
27	The *OHt dc bus* trip indicates a DC bus component over temperature based on a software thermal model. The drive includes a thermal protection system to protect the DC bus components within the drive. This includes the effects of the output current and DC bus ripple. The estimated temperature is displayed as a percentage of the trip level in Pr **07.035**. If this parameter reaches 100 % then an *OHt dc bus* trip is initiated. The drive will attempt to stop the motor before tripping. If the motor does not stop in 10 s the drive trips immediately. **Source** | **xx** | **y** | **zz** | **Description** Control system | 00 | 2 | 00 | DC bus thermal model gives trip with sub-trip 0 **Recommended actions:** • Check the AC supply voltage balance and levels • Check DC bus ripple level • Reduce duty cycle • Reduce motor load • Check the output current stability. If unstable; Check the motor map settings with motor nameplate (Pr **05.006**, Pr **05.007**, Pr **05.008**, Pr **05.009**, Pr **05.010**, Pr **05.011**) – (All Modes) Disable slip compensation (Pr **05.027** = 0) – (Open loop) Disable dynamic V to F operation (Pr **05.013** = 0) - (Open loop) Select fixed boost (Pr **05.014** = Fixed) – (Open loop) Select high stability space vector modulation (Pr **05.020** = 1) – (Open loop) Disconnect the load and complete a rotating autotune (Pr **05.012**) – (RFC-A, RFC-S) Auto-tune the rated speed value (Pr **05.016** = 1) – (RFC-A, RFC-S) Reduce speed loop gains (Pr **03.010**, Pr **03.011**, Pr **03.012**) – (RFC-A, RFC-S) Add a speed feedback filter value (Pr **03.042)** – (RFC-A, RFC-S) Add a current demand filter (Pr **04.012**) – (RFC-A, RFC-S) Check encoder signals for noise with an oscilloscope (RFC-A, RFC-S) Check encoder mechanical coupling - (RFC-A, RFC-S)
OHt Inverter	**Inverter over temperature based on thermal model**
21	This trip indicates that an IGBT junction over-temperature has been detected based on a software thermal model. **Source** | **xx** | **y** | **zz** | **Description** Control system | 00 | 1 | 00 | Inverter thermal model gives {OHt Inverter} trip with sub-trip 0 **Recommended actions:** • Reduce the selected drive switching frequency • Ensure *Auto-switching Frequency Change Disable* (05.035) is set to OFF • Reduce duty cycle • Decrease acceleration / deceleration rates • Reduce motor load • Check DC bus ripple • Ensure all three input phases are present and balanced
OHt Power	**Power stage over temperature**
22	This trip indicates that a power stage over-temperature has been detected. From the sub-trip ‘xxyzz’, the Thermistor location is identified by ‘zz’. **Source** | **xx** | **y** | **zz** | **Description** Power system | 01 | 0 | zz | Thermistor location in the drive defined by zz **Recommended actions:** • Check enclosure / drive fans are still functioning correctly • Force the heatsink fans to run at maximum speed • Check enclosure ventilation paths • Check enclosure door filters • Increase ventilation • Reduce the drive switching frequency • Reduce duty cycle • Decrease acceleration / deceleration rates • Reduce motor load • Check the derating tables and confirm the drive is correctly sized for the application. • Use a drive with larger current / power rating

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<table>
<tr><th>Trip</th><th>Diagnosis</th></tr>
<tr><td>OHt Rectifier</td><td>Rectifier over temperature</td></tr>
<tr><td>102</td><td>The OHt Rectifier indicates that a rectifier over-temperature has been detected. The thermistor location can be identified from the sub-trip number.
<table>
<tr><th>Source</th><th>xx</th><th>y</th><th>zz</th><th>Description</th></tr>
<tr><td>Power system</td><td>Power module number</td><td>Rectifier number</td><td>zz</td><td>Thermistor location defined by zz</td></tr>
</table>
Recommend actions:
• Check the motor and motor cable insulation with an insulation tester
• Fit an output line reactor or sinusoidal filter
• Force the heatsink fans to run at maximum speeds by setting Pr 06.045 = 11
• Check enclosure / drive fans are still functioning correctly
• Check enclosure ventilation paths
• Check enclosure door filters
• Increase ventilation
• Decrease acceleration / deceleration rates
• Reduce duty cycle
• Reduce motor load</td></tr>
<tr><td>OI ac</td><td>Instantaneous output over current detected</td></tr>
<tr><td>3</td><td>The instantaneous drive output current has exceeded above VM_DRIVE_CURRENT_MAX.
<table>
<tr><th>Source</th><th>xx</th><th>y</th><th>zz</th><th>Description</th></tr>
<tr><td>Control system</td><td>00</td><td>Rectifier number</td><td rowspan="2">00</td><td rowspan="2">Instantaneous over-current trip when the measured a.c. current exceeds VM_DRIVE_CURRENT[MAX].</td></tr>
<tr><td>Power system</td><td>Power module number</td><td>0</td></tr>
</table>
Recommended actions:
• Acceleration/deceleration rate is too short
• If seen during auto-tune reduce the voltage boost
• Check for short circuit on the output cabling
• Check integrity of the motor insulation using an insulation tester
• Check feedback device wiring
• Check feedback device mechanical coupling
• Check feedback signals are free from noise
• Is motor cable length within limits for the frame size
• Reduce the values in the speed loop gain parameters - (Pr 03.010, 03.011, 03.012) or (Pr 03.013, 03.014, 03.015)
• Has the phase angle autotune been completed? (RFC-S mode only)
• Reduce the values in current loop gain parameters (RFC-A, RFC-S modes only)</td></tr>
<tr><td>OI dc</td><td>Power module over current detected from IGBT on state voltage monitoring</td></tr>
<tr><td>109</td><td>The OI dc trip indicates that the short circuit protection for the drive output stage has been activated.
Recommended actions:
• Disconnect the motor cable at the drive end and check the motor and cable insulation with an insulation tester
• Replace the drive</td></tr>
</table>

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<table>
<tr><th>Trip</th><th>Diagnosis</th></tr>
<tr><td>OI Snubber</td><td>Snubber over-current detected</td></tr>
<tr><td>92</td><td>The OI Snubber trip indicates that an over-current condition has been detected in the rectifier snubber circuit. The reason for the trip can be identified by the sub-trip number.
<table>
<tr><th>Source</th><th>xx</th><th>y</th><th>zz</th><th>Description</th></tr>
<tr><td>Power system</td><td>Power module number</td><td>Rectifier number</td><td>00</td><td>Rectifier snubber over-current trip detected.</td></tr>
</table>
Recommended actions:
• Ensure the internal EMC Filter is installed
• Ensure the motor cable length does not exceed the maximum for selected switching frequency
• Check for supply voltage imbalance
• Check for supply disturbance such as notching from a DC drive
• Check the motor and motor cable insulation with an insulation tester
• Fit an output line reactor or sinusoidal filter</td></tr>
<tr><td>Option Disable</td><td>Option module does not acknowledge during drive mode changeover</td></tr>
<tr><td>215</td><td>The Option Disable trip indicates that the option module did not acknowledge notifying the drive that communications with the drive has been stopped during the drive mode changeover with in the allocated time.
Recommended trip:
• Reset the trip
• If the trip persists replace the option module</td></tr>
<tr><td>Out Phase Loss</td><td>Output phase loss detected</td></tr>
<tr><td>98</td><td>The Out Phase Loss trip indicates that a phase loss has been detected at the drive output. If Output Phase Loss Detection Enable (06.059) = 1 then output phase loss is detected as follows:
1. When the drive is enabled short pulses are applied to make sure each output phase is connected.
2. During running the output current is monitored and the output phase loss condition is detected if the current contains more than TBD % negative phase sequence current for TBDs.
Recommended action:
• Check motor and drive connections
• To disable the trip set Output Phase Loss Detection Enable (06.059) = 0</td></tr>
<tr><td>Over Frequency</td><td>Output frequency has exceeded the maximum frequency threshold</td></tr>
<tr><td>222</td><td>The Over Frequency trip indicates that the output frequency has exceeded 560 Hz for more than 4 ms.</td></tr>
<tr><td>Over Speed</td><td>Motor speed has exceeded the over speed threshold</td></tr>
<tr><td>7</td><td>If the Speed Feedback (03.002) exceeds the Over Speed Threshold in Pr 03.008 an Over Speed trip is produced. If Pr 03.008 is set to 0.0 the threshold is then equal to 1.2 x the value set in Pr 01.006.
For compressor applications, the Over Speed trip can occur if the rotor is locked and thus the speed estimator is not valid.
The trip is latched and requires a power-cycle to reset in order to conform to UL testing.
The above description relates to a standard over speed trip, however in RFC-S mode it is possible to produce an Over Speed trip with sub-trip 1. This is caused if the speed is allowed to exceed the safe level in RFC-S mode with flux weakening. See Enable High Speed Mode (05.022) for details.
Recommended actions:
• Reduce the Speed Controller Proportional Gain (03.010) to reduce the speed overshoot (RFC-A, RFC-S modes only)</td></tr>
</table>

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Trip	Diagnosis
Over Volts	**DC bus voltage has exceeded the peak level or maximum continuous level for 15 s**
2	The *Over Volts* trip indicates that the DC bus voltage has exceeded the VM_DC_VOLTAGE[MAX] or VM_DC_VOLTAGE_SET[MAX] for 15 s. The trip threshold varies depending on voltage rating of the drive as shown below.

Voltage rating	VM_DC_VOLTAGE[MAX]	VM_DC_VOLTAGE_SET[MAX]
200	415	410
400	830	815
575	990	970
690	1190	1175

Sub-trip Identification

Source	xx	y	zz
Control system	00	0	01: Instantaneous trip when the DC bus voltage exceeds VM_DC_VOLTAGE[MAX].
Control system	00	0	02: Time delayed trip indicating that the DC bus voltage is above VM_DC_VOLTAGE_SET[MAX].
Power system	Power module number	0	00: Instantaneous trip when the DC bus voltage exceeds VM_DC_VOLTAGE[MAX].

Recommended actions:

- Increase deceleration ramp (Pr **00.004**)
- Decrease the braking resistor value (staying above the minimum value)
- Check nominal AC supply level
- Check for supply disturbances which could cause the DC bus to rise
- Check motor insulation using a insulation tester

Phase Loss	**Supply phase loss**
32	The *Phase Loss* trip indicates that the drive has detected an input phase loss or large supply imbalance. The drive will attempt to stop the motor before this trip is initiated. If the motor cannot be stopped in 10 s the trip occurs immediately. The *Phase Loss* trip works by monitoring the ripple voltage on the DC bus of the drive, if the DC bus ripple exceeds the threshold, the drive will trip on Phase Loss. Potential causes of the DC bus ripple are input phase loss, Large supply impedance and severe output current instability.

Source	xx	y	zz
Control system	00	0	00: Phase loss detected based on control system feedback. The drive attempts to stop the drive before tripping unless bit 2 of *Action On Trip Detection* (10.037) is set to one.
Power system	Power module number	Rectifier number	00: Phase loss has been detected by the rectifier module
Control system			01: Mains loss has been detected by the rectifier module in a multi-power module system, where this must be treated as a phase loss condition to prevent damage to the drive.

Input phase loss detection can be disabled when the drive is required to operate from the DC supply or from a single phase supply in *Input Phase Loss Detection Mode* (06.047).

Recommended actions:

- Check the AC supply voltage balance and level at full load
- Check the DC bus ripple level with an isolated oscilloscope
- Check the output current stability
- Reduce the duty cycle
- Reduce the motor load
- Disable the phase loss detection, set Pr **06.047** to 2.

Phasing Error	**RFC-S mode phasing failure due to incorrect phase angle**
198	For compressor applications, the phasing error trip can occur if the rotor is locked and thus the rotor cannot be synchronized. This trip is latched and requires a power-cycle to reset to conform to UL testing.

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Trip	Diagnosis
Power Comms	**Communication has been lost / errors detected between power, control and rectifier modules**
90	The *Power Comms* trip is initiated if there is no communications between power, control or the rectifier module or if excessive communication errors have been detected. The reason for the trip can be identified by the sub-trip number.

Source	xx	y	zz
Control system	00	0	01: No communications between the control system and the power system
			02: Excessive communication errors between the control system and power system
	Power module number	Rectifier number	00: Excessive communications errors detected by the rectifier module

Recommended actions:

- Hardware fault – Contact the supplier of the drive

Trip	Diagnosis
Power Data	**Power system configuration data error**
220	The *Power Data* trip indicates that there is an error in the configuration data stored in the power system.

Source	xx	y	zz	Description
Control system	00	0	01	No data was obtained from the power board.
Control system	00	0	02	There is no data table in node 1.
Control system	00	0	03	The power system data table is bigger than the space available in the control pod to store it.
Control system	00	0	04	The size of the table given in the table is incorrect.
Control system	00	0	05	Table CRC error.
Control system	00	0	06	The version number of the generator software that produced the table is too low.
Power system	Power module number	0	00	The power data table used internally by the power module has an error.
Power system	Power module number	0	01	The power data table that is uploaded to the control system on power up has an error.
Power system	Power module number	0	02	The power data table used internally by the power module does not match the hardware identification of the power module.

Recommended actions:

- Hardware fault – Contact the supplier of the drive

Trip	Diagnosis
Power Down Save	**Power down save error**
37	The *Power Down Save* trip indicates that an error has been detected in the power down save parameters saved in non-volatile memory.

Recommended actions:

- Perform a 1001 save in Pr **mm.000** to ensure that the trip doesn't occur the next time the drive is powered up.

Trip	Diagnosis
PSU	**Internal power supply fault**
5	The *PSU* trip indicates that one or more internal power supply rails are outside limits or overloaded.

Source	xx	y	zz	Description
Control system	00	0	00	Internal power supply overload.
Power system	Power module number	Rectifier number		

Recommended actions:

- Remove any option modules and perform a reset
- Remove encoder connection and perform a reset
- Hardware fault within the drive – return the drive to the supplier

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Trip	Diagnosis
PSU 24V	**24V internal power supply overload**
9	The total user load of the drive and option modules has exceeded the internal 24 V power supply limit. The user load consists of the drive digital outputs and main encoder supply. **Recommended actions:** • Reduce the load and reset • Provide an external 24 V power supply on control terminal 2 • Remove all option modules
Reserved	**Reserved trips**
01 **94 -95** **103 – 108** **161** **164 – 197** **170 – 173** **228 - 247**	These trip numbers are reserved trip numbers for future use. These trips should not be used by the user application programs. **Trip Number** / **Description** 01 – Reserved resettable trip 94 -95 – Reserved resettable trip 103 - 108 – Reserved resettable trip 161 – Reserved resettable trip 164 – 197 – Reserved resettable trip 170 - 173 – Reserved resettable trip 228 - 247 – Reserved non-resettable trip
Resistance	**Measured resistance has exceeded the parameter range**
33	The Resistance trip indicates that the measured stator resistance during an auto-tune test has exceeded the maximum possible value of *Stator Resistance* (05.017). The stationary auto-tune is initiated using the auto-tune function (Pr **05.012**) or in open loop vector mode (Pr **05.014**) on the first run command after power up in mode 4 (Ur_I) or on every run command in modes 0 (Ur_S) or 3 (Ur_Auto). This trip can occur if the motor is very small in comparison to the rating of the drive. **Recommended actions:** • Check the motor cable / connections • Check the integrity of the motor stator winding using a insulation tester • Check the motor phase to phase resistance at the drive terminals • Check the motor phase to phase resistance at the motor terminals • Ensure the stator resistance of the motor falls within the range of the drive model • Select fixed boost mode (Pr **05.014** = Fixed) and verify the output current waveforms with an oscilloscope • Replace the motor
Slot4 Not Fitted	**Interface in slot 4 has been removed**
253	The *Slot4 Not Fitted* trip indicates that the interface in slot 4 on the drive has been removed since the last power-up. **Recommended actions:** • Hardware fault - Contact the supplier of the drive.
Slot App Menu	**Application menu Customization conflict error**
216	The Slot App Menu trip indicates that more than one option slot has requested to customize the application menus 18, 19 and 20. The sub-trip number indicates which option slot has been allowed to customize the menus. **Recommended actions:** • Ensure that only one of the Application modules is configured to customize the application menus 18, 19 and 20
SlotX Different	**Option module in option slot X has changed**
204 **209** **214**	The *SlotX Different* trip indicates that the option module in option slot X on the drive is a different type to that installed when parameters were last saved on the drive. The reason for the trip can be identified by the sub-trip number. **Sub-trip** / **Reason** 1 – No module was installed previously 2 – A module with the same identifier is installed, but the set-up menu for this option slot has been changed, and so default parameters have been loaded for this menu. 3 – A module with the same identifier is installed, but the applications menu for this option slot has been changed, and so default parameters have been loaded for this menu. 4 – A module with the same identifier is installed, but the set-up and applications menu for this option slot have been changed, and so default parameters have been loaded for these menus. >99 – Shows the identifier of the module previously installed. **Recommended actions:** • Turn off the power, ensure the correct option modules are installed in the correct option slots and re-apply the power • Confirm that the currently installed option module is correct, ensure option module parameters are set correctly and perform a user save in Pr **mm.000.**

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Trip	Diagnosis
SlotX Error	**Option module in option slot X has detected a fault**
202 **207** **212**	The *SlotX Error* trip indicates that the option module in option slot X on the drive has detected an error. The reason for the error can be identified by the sub-trip number. **Recommended actions:** • See relevant *Option Module User Guide* for details of the trip
SlotX HF	**Option module X hardware fault**
200 **205** **210**	The *SlotX HF* trip indicates that the option module in option slot X on the drive has indicated a hardware fault. The possible causes of the trip can be identified by the sub-trip number. **Sub-trip** / **Reason** 1 – The module category cannot be identified 2 – All the required customized menu table information has not been supplied or the tables supplied are corrupt 3 – There is insufficient memory available to allocate the comms buffers for this module 4 – The module has not indicated that it is running correctly during drive power-up 5 – Module has been removed after power-up or it has stopped working 6 – The module has not indicated that it has stopped accessing drive parameters during a drive mode change 7 – The module has failed to acknowledge that a request has been made to reset the drive processor 8 – The drive failed to correctly read the menu table from the module during drive power up 9 – The drive failed to upload menu tables from the module and timed out (5 s) **Recommended actions:** • Ensure the option module is installed correctly • Replace the option module • Replace the drive
SlotX Not installed	**Option module in option slot X has been removed**
203 **208** **213**	The *SlotX Not installed* trip indicates that the option module in option slot X on the drive has been removed since the last power up. **Recommended actions:** • Ensure the option module is installed correctly. • Re-install the option module. • To confirm that the removed option module is no longer required perform a save function in Pr **mm.000**.
SlotX Watchdog	**Option module watchdog function service error**
201 **206** **211**	The *SlotX Watchdog* trip indicates that the option module installed in Slot X has started the option watchdog function and then failed to service the watchdog correctly. **Recommended actions:** • Replace the option module
Soft Start	**Soft start relay failed to close, soft start monitor failed**
226	The *Soft Start* trip indicates that the soft start relay in the drive failed to close or the soft start monitoring circuit has failed. **Recommended actions:** • Hardware fault – Contact the supplier of the drive
Stored HF	**Hardware trip has occurred during last power down**
221	The Stored HF trip indicates that a hardware trip (HF01 –HF17) has occurred and the drive has been power cycled. The sub-trip number identifies the HF trip i.e. stored HF.17. **Recommended actions:** • Enter 1299 in Pr **mm.000** and press reset to clear the trip

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Trip	Diagnosis
Sub-array RAM	**RAM allocation error**
227	The Sub-array RAM indicates that an option module, derivative image or user program image has requested more parameter RAM than is allowed. The RAM allocation is checked in order of resulting sub-trip numbers, and so the failure with the highest sub-trip number is given. The sub-trip is calculated as (parameter size) + (parameter type) + sub-array number.

Parameter size	Value
1-bit	1000
8-bit	2000
16-bit	3000
32-bit	4000
64-bit	5000

Parameter type	Value
Volatile	0
User save	100
Power-down save	200

Sub-array	Menus	Value
Applications menus	18-20	1
Derivative image	29	2
User program image	30	3
Option slot 1 set-up	15	4
Option slot 1 applications	25	5
Option slot 2 set-up	16	6
Option slot 2 applications	26	7
Option slot 3 set-up	17	8
Option slot 3 applications	27	9
Option slot 4 set-up	24	10
Option slot 4 applications	28	11

Temp Feedback	**Internal thermistor has failed**
218	The *Temp Feedback* trip indicates that an internal thermistor has failed. The thermistor location can be identified by the sub-trip number.

Source	xx	y	zz
Power system	Power module number	0	Always zero
Power system	Power module number	Rectifier number	Always zero

Recommended actions:

- Hardware fault – Contact the supplier of the drive

Th Short Circuit	**Motor thermistor short circuit**
25	The *Th Short Circuit* trip indicates that the motor thermistor connected to terminal 8 (analog input 3) on the control connections or terminal 15 on the encoder terminal (15-way D-type connector) is short circuit or low impedance. The cause of the trip can be identified by the sub-trip number.

Sub-trip	Reason
1	*P1 Thermistor Short Circuit Detect* (03.123) = 1 and the resistance of the thermistor connected to the drive P1 position feedback interface is less than 50 Ω.
2	*Analog Input 3 Mode* (07.015) = 7 and the resistance of the thermistor connected to analog input 3 is less than 50 Ω.

Recommended actions:

- Check thermistor continuity
- Replace motor / motor thermistor

Thermistor	**Motor thermistor over-temperature**
24	The *Thermistor* trip indicates that the motor thermistor connected to terminal 8 (analog input 3) on the control connections or terminal 15 on the encoder terminal (15 way D-type connector) has indicated a motor over temperature. The cause of the trip can be identified by the sub-trip number

Sub-trip	Reason
1	Trip initiated from P1 position feedback interface
2	Trip initiated from analog input 3

Recommended actions:

- Check motor temperature
- Check thermistor continuity

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Trip	Diagnosis
Undefined	**Drive has tripped and the cause of the trip is Undefined**
110	The *Undefined* trip indicates that the power system has generated but did not identify the trip the power system. The cause of the trip is unknown. **Recommended actions:** • Hardware fault – return the drive to the supplier
User 24V	**User 24 V supply is not present on control terminals (1,2)**
91	A *User 24 V* trip is initiated, if *User Supply Select* (Pr **06.072**) is set to 1 or *Low Under Voltage Threshold Select* (06.067) = 1 and no user 24 V supply is present on control terminals 1 and 2. **Recommended actions:** • Ensure the user 24 V supply is present on control terminals 1 (0 V) and 2 (24 V)

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Trip	Diagnosis
User Program	**On board user program error**

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The *User Program* trip indicates that an error has been detected in the onboard user program image. The reason for the trip can be identified by the sub-trip number.

Sub-trip	Reason	Comments
1	Divide by zero	
2	Undefined trip	
3	Attempted fast parameter access set-up with non-existent parameter	
4	Attempted access to non-existent parameter	
5	Attempted write to read-only parameter	
6	Attempted and over-range write	
7	Attempted read from write-only parameter	
30	The image has failed because either its CRC is incorrect, or there are less than 6 bytes in	Occurs when the drive powers-up or the image is programmed. The image tasks will not run
31	The image requires more RAM for heap and stack than can be provided by the drive.	As 30
32	The image requires an OS function call that is higher than the maximum allowed	As 30
33	The ID code within the image is not valid	As 30
34	The derivative image has been changed for an image with a different derivative number.	As 30
40	The timed task has not completed in time and has been suspended	
41	Undefined function called, i.e. a function in the host system vector table that has not been	As 40
51	Core menu customization table CRC check failed	As 30
52	Customized menu table CRC check failed	As 30
53	Customized menu table changed	Occurs when the drive powers-up or the image is programmed and the table has changed. Defaults are loaded for the derivative menu and the trip will keep occurring until drive parameters are saved.
61	The option module installed in slot 1 is not allowed with the derivative image	As 30
62	The option module installed in slot 2 is not allowed with the derivative image	As 30
63	The option module installed in slot 3 is not allowed with the derivative image	As 30
64	The option module installed in slot 4 is not allowed with the derivative image	As 30
70	An option module that is required by the derivative image is not installed in any slot.	As 30
71	An option module specifically required to be installed in slot 1 not present	As 30
72	An option module specifically required to be installed in slot 2 not present	As 30
73	An option module specifically required to be installed in slot 3 not present	As 30
74	An option module specifically required to be installed in slot 4 not present	As 30
80	Image is not compatible with the control board	Initiated from within the image code
81	Image is not compatible with the control board serial number	As 80

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Trip	Diagnosis
User Prog Trip	**Trip generated by an onboard user program**
96	This trip can be initiated from within an onboard user program using a function call which defines the sub-trip number. **Recommended actions:** • Check the user program
User Save	**User Save error / not completed**
36	The *User Save* trip indicates that an error has been detected in the user save parameters saved in non-volatile memory. For example, following a user save command, If the power to the drive was removed when the user parameters were being saved. **Recommended actions:** • Perform a user save in Pr **mm.000** to ensure that the trip doesn't occur the next time the drive is powered up. • Ensure that the drive has enough time to complete the save before removing the power to the drive.
User Trip	**User generated trip**
40 -89 **112 -159**	These trips are not generated by the drive and are to be used by the user to trip the drive through an application program. **Recommended actions:** • Check the user program
Watchdog	**Control word watchdog has timed out**
30	The *Watchdog* trip indicates that the control word has been enabled and has timed out **Recommended actions:**

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Table 12-11 Serial communications look up table

No	Trip	No	Trip	No	Trip
1	Reserved 001	92	OI Snubber	198	Phasing Error
2	Over Volts	93	Inductor Too Hot	199	Destination
3	OI ac	94 - 95	Reserved 94 -95	200	Slot1 HF
4	Not used	96	User Prog Trip	201	Slot1 Watchdog
5	PSU	97	Data Changing	202	Slot1 Error
6	External Trip	98	Out Phase Loss	203	Slot1 Not installed
7	Over Speed	99	Not used	204	Slot1 Different
8	Reserved 008	100	Reset	205	Slot2 HF
9	PSU24	101	Not used	206	Slot2 Watchdog
10	Not used	102	OHt Rectifier	207	Slot2 Error
11	Not used	103 - 108	Reserved 103 - 108	208	Slot2 Not installed
12	Not used	109	OI dc	209	Slot2 Different
13	Not used	110	Undefined	210	Slot3 HF
14	Not used	111	Configuration	211	Slot3 Watchdog
15	Not used	112 - 167	User Trip 112 - 167	212	Slot3 Error
16	Not used	168	Not used	213	Slot3 Not installed
17	Not used	169	Not used	214	Slot3 Different
18	Not used	170 - 173	Reserved 170 - 173	215	Option Disable
19	Not used	174	Card Slot	216	Slot App Menu
20	Motor Too Hot	175	Card Product	217	App Menu Changed
21	OHt Inverter	176	Not used	218	Temp Feedback
22	OHt Power	177	Card Boot	219	An Output Calib
23	OHt Control	178	Card Busy	220	Power Data
24	Thermistor	179	Card Data Exists	221	Stored HF
25	Th Short Circuit	180	Card Option	222	Over Frequency
26	I/O Overload	181	Card Read Only	223	Not used
27	OHt dc bus	182	Card Error	224	Drive Size
28	An Input Loss 1	183	Card No Data	225	Current Offset
29	An Input Loss 2	184	Card Full	226	Soft Start
30	Watchdog	185	Card Access	227	Sub-array RAM
31	EEPROM Fail	186	Card Rating	228 - 247	Reserved 228 - 247
32	Phase Loss	187	Card Drive Mode	248	Derivative Image
33	Resistance	188	Card Compare	249	User Program
34	Not used	189	Not used	250	Slot4 HF
35	Control Word	190	Not used	251	Slot4 Watchdog
36	User Save	191	Not used	252	Slot4 Error
37	Power Down Save	192	Not used	253	Slot4 Not installed
38	Low Load	193	Not used	254	Slot4 Different
39	Not used	194	Not used	255	Reset Logs
40 -89	User Trip 40 - 89	195	Not used		
90	Power Comms	196	Not used		
91	User 24V	197	Not used		

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The trips can be grouped into the following categories. It should be noted that a trip can only occur when the drive is not tripped or is already tripped but with a trip with a lower priority number.

Table 12-12 Trip categories

Priority	Category	Trips	Comments
1	Internal faults	HF01, HF02, HF03, HF04, HF05, HF06, HF07, HF08, HF09, HF10, HF11, HF12, HF13, HF14, HF15, HF16, HF17, HF18, HF19, HF20	These indicate internal problems and cannot be reset. All drive features are inactive after any of these trips occur. If an HOA-Keypad is installed it will show the trip, but the keypad will not function.
1	Stored HF trip	{Stored HF}	This trip cannot be cleared unless 1299 is entered into *Parameter* (**mm.000**) and a reset is initiated.
2	Non-resettable trips	Trip numbers 218 to 247, {Slot1 HF}, {Slot2 HF}, {Slot3 HF} or {Slot4 HF}	These trips cannot be reset.
3	Volatile memory failure	{EEPROM Fail}	This can only be reset if Parameter **mm.000** is set to 1233 or 1244, or if *Load Defaults* (11.043) is set to a non-zero value.
3	Internal 24 V power supply	{PSU 24}	
4	NV Media Card trips	Trip numbers 174, 175 and 177 to 188	These trips are priority 5 during power-up.
5	Trips with extended reset times	{OI ac}, {OI Brake}, and OI dc}	These trips cannot be reset until 10 s after the trip was initiated.
5	Phase loss and d.c. link power circuit protection	{Phase Loss} and {Oht dc bus}	The drive will attempt to stop the motor before tripping if a {Phase Loss}. 000 trip occurs unless this feature has been disabled (see *Action On Trip Detection* (10.037). The drive will always attempt to stop the motor before tripping if an {Oht dc bus} occurs.
5	Standard trips	All other trips	

12.6 Internal / Hardware trips

Trips {HF01} to {HF20} are internal faults that do not have trip numbers. If one of these trips occurs, the main drive processor has detected an irrecoverable error. All drive functions are stopped and the trip message will be displayed on the drive keypad. If a non permanent trip occurs this may be reset by power cycling the drive. On power up after it has been power cycled the drive will trip on Stored HF. Enter 1299 in **mm.000** to clear the Stored HF trip.

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12.7 Alarm indications

In any mode, an alarm is an indication given on the display by alternating the alarm string with the drive status string on the first row and showing the alarm symbol in the last character in the first row. If an action is not taken to eliminate any alarm except "Auto Tune and Limit Switch" the drive may eventually trip. Alarms are not displayed when a parameter is being edited, but the user will still see the alarm character on the upper row.

Table 12-13 Alarm indications

Alarm string	Description
Motor Overload	*Motor Protection Accumulator* (04.019) in the drive has reached 75.0 % of the value at which the drive will trip and the load on the drive is >100 %.
Ind Overload	Regen inductor overload. *Inductor Protection Accumulator* (04.019) in the drive has reached 75.0 % of the value at which the drive will trip and the load on the drive is >100 %.
Drive Overload	Drive over temperature. *Percentage Of Drive Thermal Trip Level* (07.036) in the drive is greater than 90 %.
Auto Tune	The autotune procedure has been initialized and an autotune in progress.
Limit Switch	Limit switch active. Indicates that a limit switch is active and that is causing the motor to be stopped.

12.8 Status indications

Table 12-14 Status indications

Upper row string	Description	Drive output stage
Inhibit	The drive is inhibited and cannot be run. The SAFE TORQUE OFF signal is not applied to SAFE TORQUE OFF terminals or Pr **06.015** is set to 0	Disabled
Ready	The drive is ready to run. The drive enable is active, but the drive inverter is not active because the final drive run is not active	Disabled
Stop	The drive is stopped / holding zero speed.	Enabled
Run	The drive is active and running	Enabled
Supply Loss	Supply loss condition has been detected	Enabled
Deceleration	The motor is being decelerated to zero speed / frequency because the final drive run has been deactivated.	Enabled
Trip	The drive has tripped and no longer controlling the motor. The trip code appears in the lower display	Disabled
Active	The regen unit is enabled and synchronized to the supply	Enabled
Under Voltage	The drive is in the under voltage state either in low voltage or high voltage mode	Disabled
Heat	The motor pre-heat functions inactive	Enabled

Table 12-15 Option module and NV Media Card and other status indications at power-up

First row string	Second row string	Status
Booting	**Parameters**	Parameters are being loaded
Drive parameters are being loaded from a NV Media Card		
Booting	**User Program**	User program being loaded
User program is being loaded from a NV Media Card to the drive		
Booting	**Option Program**	User program being loaded
User program is being loaded from a NV Media Card to the option module in slot X		
Writing To	**NV Card**	Data being written to NV Media Card
Data is being written to a NV Media Card to ensure that its copy of the drive parameters is correct because the drive is in Auto or Boot mode		
Waiting For	**Power System**	Waiting for power stage
The drive is waiting for the processor in the power stage to respond after power-up		
Waiting For	**Options**	Waiting for an option module
The drive is waiting for the Options Modules to respond after power-up		
Uploading From	**Options**	Loading parameter database
At power-up it may be necessary to update the parameter database held by the drive because an option module has changed or because an applications module has requested changes to the parameter structure. This may involve data transfer between the drive an option modules. During this period ‘Uploading From Options’ is displayed		

12.9 Displaying the trip history

The drive retains a log of the last ten trips that have occurred. *Trip 0* (10.020) to *Trip 9* (10.029) store the most recent 10 trips that have occurred where *Trip 0* (10.020) is the most recent and *Trip 9* (10.029) is the oldest. When a new trip occurs it is written to *Trip 0* (10.020) and all the other trips move down the log, with oldest being lost. The date and time when each trip occurs are also stored in the date and time log, i.e. *Trip 0 Date* (10.041) to *Trip 9 Time* (10.060). The date and time are taken from *Date* (06.016) and *Time* (06.017). The date / time source can be selected with *Date / Time Selector* (06.019). Some trips have sub-trip numbers which give more detail about the reason for the trip. If a trip has a sub-trip number its value is stored in the sub-trip log, i.e. *Trip 0 Sub-trip Number* (10.070) to *Trip 9 Sub-trip Number* (10.079). If the trip does not have a sub-trip number then zero is stored in the sub-trip log.

If any parameter between Pr **10.020** and Pr **10.029** inclusive is read by serial communication, then the trip number in Table 12-10 is the value transmitted.

NOTE

The trip logs can be reset by writing a vale of 255 in Pr **10.038**.

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12.10 Behaviour of the drive when tripped

If the drive trips, the output of the drive is disabled so the load coasts to a stop. If any trip occurs the following read only parameters are frozen until the trip is cleared. This is to help in diagnose the cause of the trip.

Parameter	Description
01.001	Frequency / speed reference
01.002	Pre-skip filter reference
01.003	Pre-ramp reference
02.001	Post-ramp reference
03.001	Frequency slaving demand / Final speed ref
03.002	Speed feedback
03.003	Speed error
03.004	Speed controller output
04.001	Current magnitude
04.002	Active current
04.017	Reactive current
05.001	Output frequency
05.002	Output voltage
05.003	Power
05.005	DC bus voltage
07.001	Analog input 1
07.002	Analog input 2
07.003	Analog input 3

If the parameters are not required to be frozen then this can be disabled by setting bit 4 of Pr **10.037**.

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13 UL listing information

At the time of writing the CSD100 is not currently UL listed and UL listing is being pursued.

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