Nidec

All for dreams

Getting Started Guide

Powerdrive F300

Frame Sizes 3 to 11

Part Number: 0479-0002-07
Issue: 7

Original Instructions

For the purposes of compliance with the EU Machinery Directive 2006/42/EC, the English version of this manual is the Original Instructions. Manuals in other languages are Translations of the Original Instructions.

Documentation

Manuals are available to download from the following locations: **http://www.drive-setup.com/ctdownloads**

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Registered Office

Nidec Control Techniques Ltd
The Gro
Newtown
Powys
SY16 3BE
UK
Registered in England and Wales. Company Reg. No. 01236886.

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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.

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

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

1.2 Important safety information. Hazards. Competence of designers and installers

This guide applies to products which control electric motors either directly (drives) or indirectly (controllers, option modules and other auxiliary equipment and accessories). In all cases the hazards associated with powerful electrical drives are present, and all safety information relating to drives and associated equipment must be observed.

Specific warnings are given at the relevant places in this guide.

Drives and controllers are intended as components for professional incorporation into complete systems. If installed incorrectly they 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 competence. They must read this safety information and this guide carefully.

1.3 Responsibility

It is the responsibility of the installer to ensure that the equipment is installed correctly with regard to all instructions given in this guide. They must give due consideration to the safety of the complete system, so as to avoid the risk of injury both in normal operation and in the event of a fault or of reasonably foreseeable misuse.

The manufacturer accepts no liability for any consequences resulting from inappropriate, negligent or incorrect installation of the equipment.

1.4 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 guide contains instructions for achieving compliance with specific EMC standards.

All machinery to be supplied within the European Union in which this product is used must comply with the following directives:

2006/42/EC Safety of machinery.

2014/30/EU: Electromagnetic Compatibility.

1.5 Electrical hazards

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. Hazardous voltage may be present in any of the following locations:

- AC and DC 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.

The supply must be disconnected by an approved electrical isolation device before gaining access to the electrical connections.

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 drive must be installed in accordance with the instructions given in this guide. Failure to observe the instructions could result in a fire hazard.

1.6 Stored electrical 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.

1.7 Mechanical hazards

Careful consideration must be given to the functions of the drive or controller which might result in a hazard, either through their intended behaviour 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 - for example, an over-speed protection device in case of failure of the speed control, or a fail-safe mechanical brake in case of loss of motor braking.

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.

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.

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.

1.8 Access to equipment

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

1.9 Environmental limits

Instructions in this guide regarding transport, storage, installation and use of the equipment must be complied with, including the specified environmental limits. This includes temperature, humidity, contamination, shock and vibration. Drives must not be subjected to excessive physical force.

1.10 Hazardous environments

The equipment must not be installed in a hazardous environment (i.e. a potentially explosive environment).

1.11 Motor

The safety of the motor under variable speed conditions must be ensured.

To avoid the risk of physical injury, do not exceed the maximum specified speed of the motor.

Low speeds may cause the motor to overheat because the cooling fan becomes less effective, causing a fire hazard. The motor should be installed with a protection thermistor. If necessary, an electric forced vent fan should be used.

The values of the motor parameters set in the drive affect the protection of the motor. The default values in the drive must not be relied upon. It is essential that the correct value is entered in the Motor Rated Current parameter.

1.12 Mechanical brake control

Any brake control functions are provided to allow well co-ordinated operation of an external brake with the drive. While both hardware and software are designed to high standards of quality and robustness, they are not intended for use as safety functions, i.e. where a fault or failure would result in a risk of injury. In any application where the incorrect operation of the brake release mechanism could result in injury, independent protection devices of proven integrity must also be incorporated.

1.13 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.

1.14 Electromagnetic compatibility (EMC)

Installation instructions for a range of EMC environments are provided in the relevant Power Installation Guide. If the installation is poorly designed or other equipment does not comply with suitable standards for EMC, the product might cause or suffer from disturbance due to electromagnetic interaction with other equipment. It is the responsibility of the installer to ensure that the equipment or system into which the product is incorporated complies with the relevant EMC legislation in the place of use.

2 Product information

This guide covers the *Powerdrive F300* product.

Table 2-1 Supported operating modes

Product	Supported operating modes		
	Open-Loop	RFC-A Sensorless	RFC-S Sensorless
Powerdrive F300	✓	✓	✓

2.1 Drive firmware version

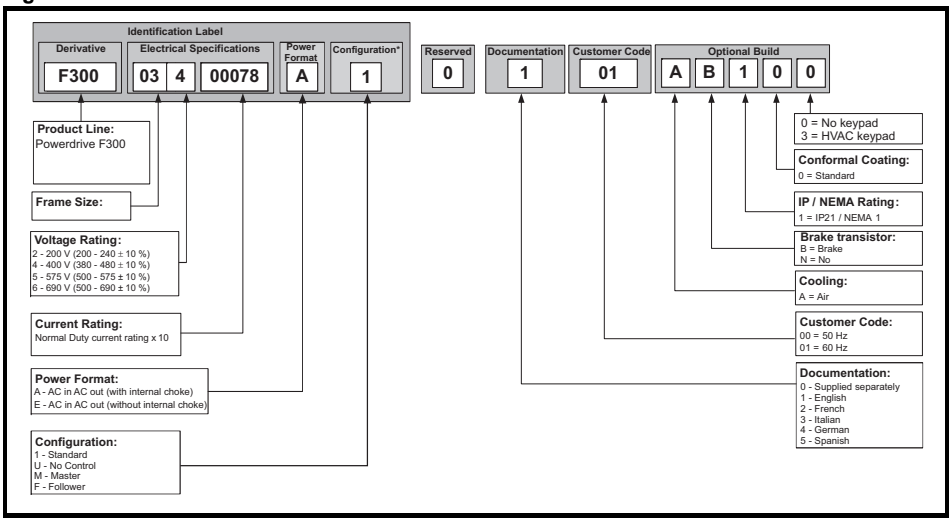
This product is supplied with the latest firmware version. If this drive is to be connected to an existing system or machine, all drive firmware versions should be verified to confirm the same functionality as drives of the same model already present. This may also apply to drives returned from an Industrial Automation 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 **00.050** {**11.029**}

2.2 Model number

The way in which the model numbers for the *Powerdrive F300* product range are formed is illustrated below:

Figure 2-1 Model number



* Only shown on frame size 9 and above identification label.

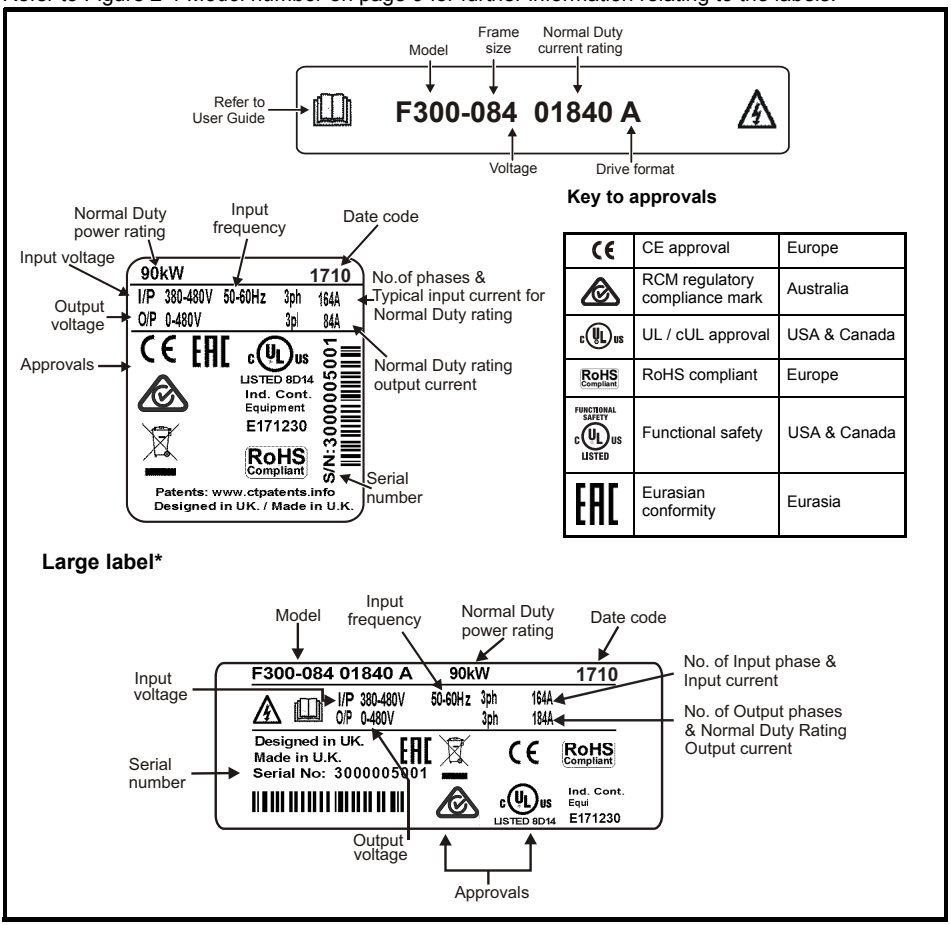
NOTE

For simplicity a Frame 9 drive with no internal choke (i.e. Model 09xxxxxE) is referred to as a Frame 9E and a Frame 9 drive with an internal choke (i.e. Model 09xxxxxA) is referred to as a Frame 9A. Any reference to Frame 9 is applicable to both sizes 9E and 9A. All Frame size 10 and 11 drives are supplied with no internal choke.

2.3 Nameplate description

Figure 2-2 Typical drive rating labels

Refer to Figure 2-1 *Model number* on page 9 for further information relating to the labels.



* This label is only applicable to Size 7 and above.

Refer to Figure 2-1 *Model number* on page 9 for further information relating to the labels.

NOTE **Date code format**

The date code is four numbers. The first two numbers indicate the year and the remaining numbers indicate the week of the year in which the drive was built.

Example:

A date code of **1710** would correspond to week 10 of year 2017.

2.4 Ratings

Fuses

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

NOTE Nominal cables sizes below are based on cable installation method B2 (ref: IEC60364-5-52:2001) unless otherwise specified, and are provided as a guide only. Ensure cables used suit local wiring regulations.

Table 2-2 200 V drive ratings, cable sizes and fuse ratings

Model	Max. cont. input current	Fuse				Nominal cable size				Normal Duty		
		IEC		UL		European		USA				
	3ph	Nom	Class	Nom	Class	Input	Output	Input	Output	Max. cont. output current	Nom power @ 230 V	Motor power @ 230 V
	A	A		A		mm^2	mm^2	AWG	AWG	A	kW	hp
03200066	10.4	16	gG	20	CC, J or T*	1.5	1.5	14	14	6.6	1.1	1.5
03200080	12.6	20		20		1.5	1.5	14	14	8	1.5	2
03200110	17	20		25		4	4	12	12	11	2.2	3
03200127	20	25		25		4	4	12	12	12.7	3	3
04200180	20	25	gG	25	CC, J or T*	6	6	10	10	18	4	5
04200250	28	32		30		8	8	8	8	25	5.5	7.5
05200300	31	40	gG	40	CC, J or T*	10	10	8	8	30	7.5	10
06200500	48	63	gG	60	CC, J or T*	16	16	4	4	50	11	15
06200580	56	63		70		25	25	3	3	58	15	20
07200750	67	80	gG	80	CC, J or T*	35	35	2	2	75	18.5	25
07200940	84	100		100		35	35	1	1	94	22	30
07201170	105	125		125		70	70	1/0	1/0	117	30	40
08201490	137	200	gR	200	HSJ	95	95	3/0	3/0	149	37	50
08201800	166	200		225		2 x 70	2 x 70	2 x 1	2 x 1	180	45	60
09202160	205	250	gR	250	HSJ	2 x 70 (B1)	2 x 95 (B2)	2 x 2/0		216	55	75
09202660	260	315		300		2 x 95 (B1)	2 x 120 (B2)	2 x 4/0		266	75	100
10203250	305	400	gR	400	HSJ	2 x 120 (B1)	2 x 120 (B2)	2 x 250		325	90	125
10203600	361	450		450		2 x 150 (C)		2 x 300		360	110	150

* These fuses are fast acting.

Table 2-3 400 V drive ratings, cable sizes and fuse ratings

Model	Max. cont. input current	Fuse				Nominal cable size				Normal Duty		
		IEC		UL		European		USA				
	3ph	Nom	Class	Nom	Class	Input	Output	Input	Output	Max. cont. output current	Nom power @ 400 V	Motor power @ 460 V
	A	A		A		mm^2	mm^2	AWG / kcmil		A	kW	hp
03400034	5	10	gG	10	CC, J or T*	1.5	1.5	18	18	3.4	1.1	2
03400045	7	10		10		1.5	1.5	16	16	4.5	1.5	2
03400062	9	10		10		1.5	1.5	14	14	6.2	2.2	3
03400077	13	20		20		2.5	2.5	14	14	7.7	3	5
03400104	13	20		20		2.5	2.5	14	14	10.4	4	5
03400123	16	20		20		2.5	2.5	12	12	12.3	5.5	7.5
04400185	19	25	gG	25	CC, J or T*	4	4	10	10	18.5	7.5	10
04400240	24	32		30		6	6	8	8	24	11	15
05400300	29	40	gG	35	CC, J or T*	6	6	8	8	30	15	20
06400380	36	63	gR	40	CC, J or T*	10	10	6	6	38	18.5	25
06400480	46	63		50		16	16	4	4	48	22	30
06400630	60	63		60		25	25	3	3	63	30	40
07400790	74	100	gG	80	CC, J or T*	35	35	1	1	79	37	60
07400940	88	100		100		50	50	2	2	94	45	60
07401120	105	125		125		70	70	1/0	1/0	112	55	75
08401550	155	250	gR	225	HSJ	2 x 50	2 x 50	2 x 1	2 x 1	155	75	100
08401840	177	250		225		2 x 70	2 x 70	2 x 1/0	2 x 1/0	184	90	150
09402210	232	315	gR	300	HSJ	2 x 70 (B1)	2 x 95 (B2)	2 x 3/0	2 x 2/0	221	110	150
09402660	267			350		2 x 95 (B1)	2 x 120 (B2)	2 x 4/0	2 x 4/0	266**	132	200
10403200	332	400	gR	400	HSJ	2 x 120 (C)	2 x 120 (B2)	2 x 300	2 x 250	320	160	250
10403610	397	450		450		2 x 150 (C)	2 x 150 (B2)	2 x 350	2 x 300	361	200	300
11404370	449	500	gR	600	HSJ	4 x 95 (C)	2 x 185 (C)	4 x 3/0	2 x 400	437	225	350
11404870	492	500					2 x 240 (C)	4 x 4/0		487**	250	400
11405070	539	630								507**	280	450

* These fuses are fast acting.

** These ratings are for 2 kHz switching frequency. For ratings at 3 kHz switching frequency refer to the Power and current ratings in the *Drive User Guide*.

Table 2-4 575 V drive ratings, cable sizes and fuse ratings

Model	Max. cont. input current	Fuse				Nominal cable size				Normal Duty		
		IEC		UL		European		USA				
	3ph	Nom	Class	Nom	Class	Input	Output	Input	Output	Max. cont. output current	Nom power @ 575 V	Motor power @ 575 V
	A	A		A		mm^2	mm^2	AWG	AWG	A	kW	hp
05500039	4	10	gG	10	CC, J or T*	0.75	0.75	16	16	3.9	2.2	3
05500061	7	10		10		1	1	14	14	6.1	4	5
05500100	11	20		20		1.5	1.5	14	14	10	5.5	7.5
06500120	13	20	gG	20	CC, J or T*	2.5	2.5	14	14	12	7.5	10
06500170	19	32		25		4	4	10	10	17	11	15
06500220	24	40		30		6	6	10	10	22	15	20
06500270	29	50		35		10	10	8	8	27	18.5	25
06500340	37	50		40		10	10	6	6	34	22	30
06500430	47	63		50		16	10	6	6	43	30	40
07500530	45	50	gG	50	CC, J or T*	16	16	4	4	53	45	50
07500730	62	80		80		25	25	3	3	73	55	60
08500860	83	125	gR	100	HSJ	35	35	1	1	86	75	75
08501080	104	160		150		50	50	1	1	108	90	100
09501250	166	150	gR	150	HSJ	2 x 70 (B2)	2 x 35 (B2)	2 x 1	2 x 3	125	110	125
09501500	166	200		175			2 x 50 (B2)		2 x 1	150	110	150
10502000	197	250	gR	250	HSJ	2 x 70 (B2)		2 x 2/0		200	150	200
11502480	265	400	gR	400	HSJ	2 x 70 (C)		2 x 3/0		248	185	250
11502880	310					2 x 95 (C)		2 x 4/0		288**	225	300
11503150	338					2 x 120 (C)		2 x 250		315**	250	350

* These fuses are fast acting.

** These ratings are for 2 kHz switching frequency. For ratings at 3 kHz switching frequency refer to the Power and current ratings in the *Drive User Guide*.

Table 2-5 690 V drive ratings, cable sizes and fuse ratings

Model	Max. cont. input current	Fuse				Nominal cable size				Normal Duty		
		IEC		UL		European		USA				
	3ph	Nom	Class	Nom	Class	Input	Output	Input	Output	Max. cont. output current	Nom power @ 690 V	Motor power @ 690 V
	A	A		A		mm^2	mm^2	AWG	AWG	A	kW	hp
07600230	20	25	gG	25	CC, J or T*	10	10	8	8	23	18.5	25
07600300	26	32		30		10	10	6	6	30	22	30
07600360	31	40		35		10	10	6	6	36	30	40
07600460	39	50		50		16	16	4	4	46	37	50
07600520	44	50		50		16	16	4	4	52	45	60
07600730	62	80		80		25	25	3	3	73	55	75
08600860	83	125	gR	100	HSJ	50	50	2	2	86	75	100
08601080	104	160		150		70	70	1/0	1/0	108	90	125
09601250	149	150	gR	150	HSJ	2 x 50 (B2)	2 x 35 (B2)	2 x 1	2 x 3	125	110	150
09601550	171	200		200		2 x 70 (B2)	2 x 50 (B2)	2 x 1/0	2 x 1	155	132	175
10601720	202	225	gR	250	HSJ	2 x 70 (B2)	2 x 70 (B2)	2 x 2/0	2 x 1/0	172	160	200
10601970	225	250	gR	250		2 x 95 (B2)		2 x 3/0	2 x 2/0	197	185	250
11602250	256	400	gR	400	HSJ	2 x 70 (C)		2 x 3/0		225	200	250
11602750	302					2 x 95 (C)		2 x 4/0		275**	250	300
11603050	329					2 x 95 (C)		2 x 250		305**	280	400

* These fuses are fast acting.

** These ratings are for 2 kHz switching frequency. For ratings at 3 kHz switching frequency refer to the Power and current ratings in the *Drive User Guide*.

Table 2-6 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.
> 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

Typical short term overload limits

The maximum percentage overload limit changes depending on the selected motor. Variations in motor rated current, motor power factor and motor leakage inductance all result in changes in the maximum possible overload. Typical values are shown in the table below:

Table 2-7 Typical overload limits

Operating mode	RFC from cold	RFC from 100 %	Open loop from cold	Open loop from 100 %
Normal Duty overload with motor rated current = drive rated current	110 % for 165 s	110 % for 9 s	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.

Output current

The continuous output current ratings given on the rating label are for maximum 40 °C (104 °F), 1000 m altitude and 3 kHz switching frequency (except where shown). Derating is required for higher switching frequencies, ambient temperatures >40 °C (104 °F) and higher altitude. For derating information, refer to the *Drive User Guide*.

Input current

The input current is affected by the supply voltage and impedance. The input current given on the rating label is the typical input current and is stated for a balanced supply.

Input line reactor (Frame 9E, 10E and 11E)

A line reactor must be used with Frame 9E, 10E and 11E. Failure to provide sufficient reactance could damage or reduce the service life of the drive. Refer to Table 2-8.

Table 2-8 Size 9E, 10E and 11E Model and Line reactor part number

Size	Drive model	Inductor model	Line reactor part number
9E	09202160, 09202660, 09402210, 09402660	INL 401	4401-0181
	09501250, 09501500, 09601720, 09601970	INL 601	4401-0183
10E	10203250, 10203600, 10403200, 10403610	INL 402	4401-0182
	10502000, 10601720, 10601970	INL 602	4401-0184
11E	11404370	INL 403L**	4401-0274
	11404370, 11404870, 11405070	INL 403*	4401-0259
	11502480, 11502880, 11503150, 11602250, 11602750, 11603050	INL 603*	4401-0261

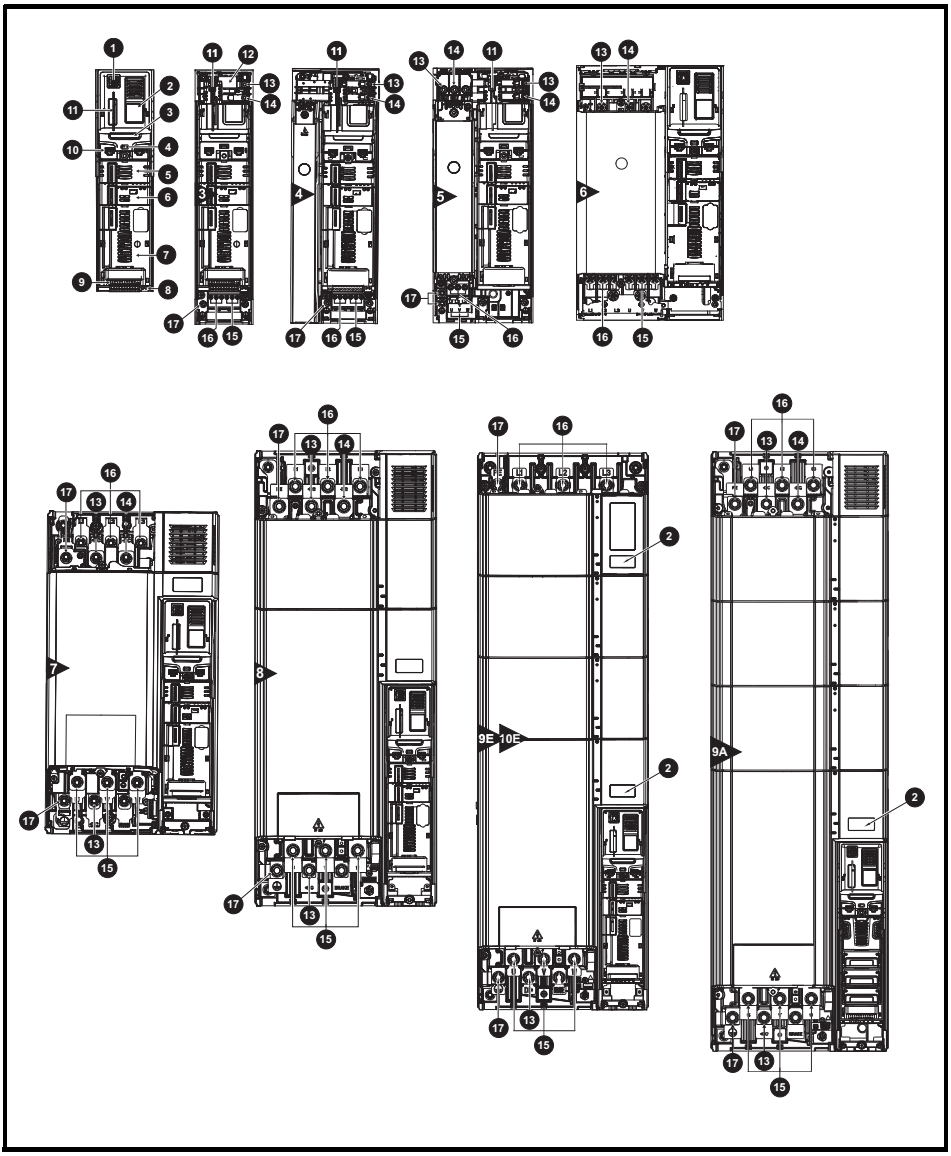
* Natural cooling.

** May represent a more economic solution when operating below 420 A.

NOTE Input line reactors are also available for other *Powerdrive* models for use when poor phase balance or severe severe supply disturbances are present, please refer to the *Drive User Guide* for further details.

2.5 Drive features

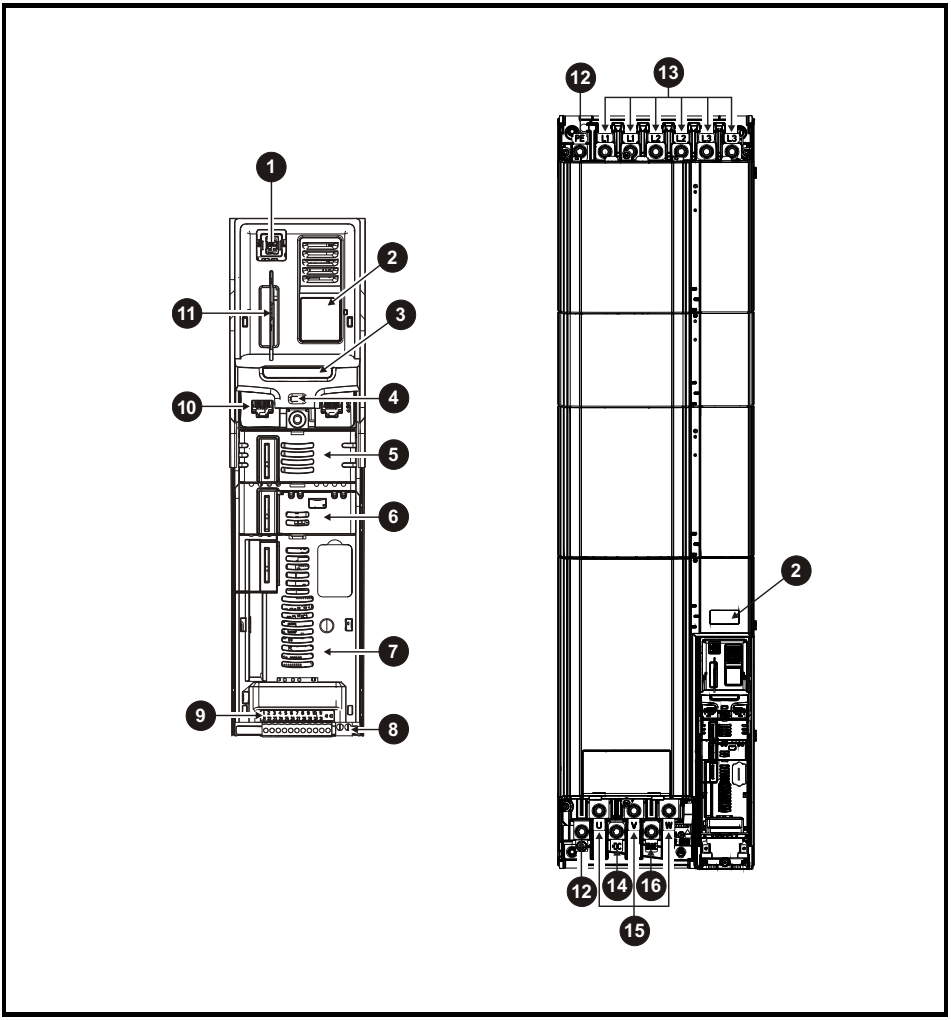
Figure 2-3 Features of the drive (size 3 to 10)



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. Internal EMC filter
13. DC bus +
14. DC bus -
15. Motor connections
16. AC supply connections
17. Ground connections
18. Braking terminal

Figure 2-4 Features of the drive (size 11)



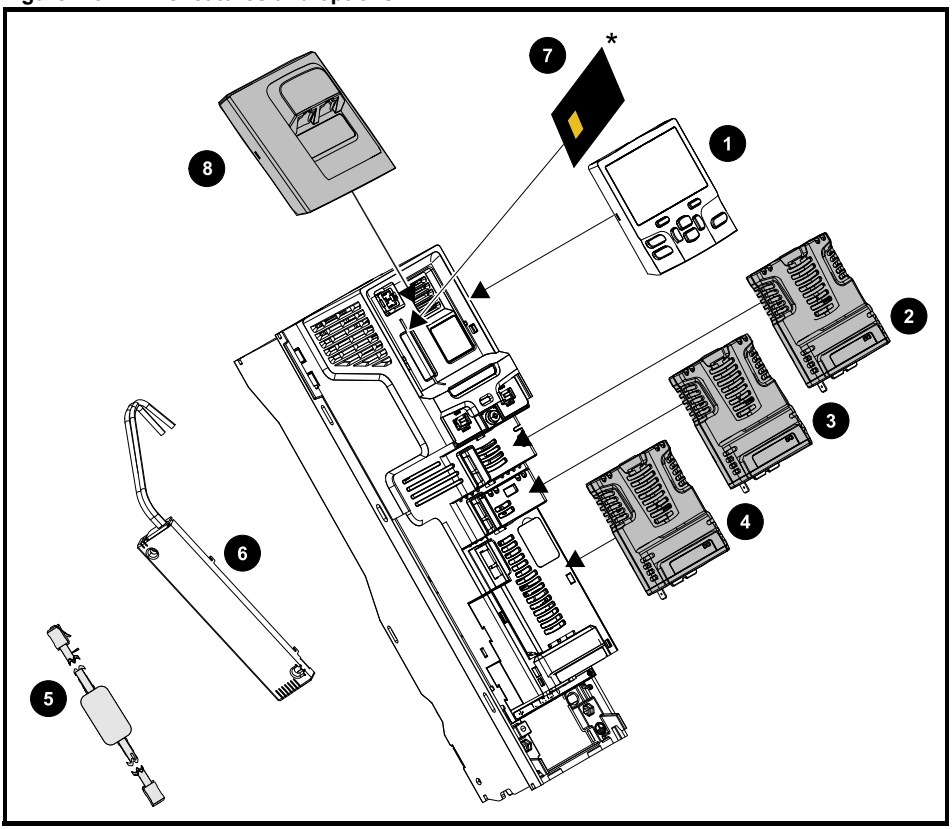
Key

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

* Common AC supply connections are internally linked on the 11E 6 pulse drive.

2.6 Options / Accessories

Figure 2-5 Drive features and options



1. Keypad
2. Option module slot 1
3. Option module slot 2
4. Option module slot 3
5. CT USB Comms cable
6. Heatsink mounted braking resistor (size 3, 4 and 5 only)
7. NV media card
8. KI-485 comms adaptor

* For further information refer to Chapter 9 *NV Media Card Operation* on page 101

WARNING

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

Table 2-9 Option modules, Keypad and additional options available

Type	Name	Further details
Fieldbus	KI-485 Adaptor	**485 Comms Adaptor** 485 Comms adaptor provides 485 communication interface. This adaptor supports 115 k Baud, node addresses between 1 to 16 and 8 1 NP M serial mode.
	SI-PROFIBUS	**Profibus option** PROFIBUS adapter for communications with the drive.
	SI-DeviceNet	**DeviceNet option** DeviceNet adapter for communications with the drive.
	SI-CANopen	**CANopen option** CANopen adapter for communications with the drive.
	SI-Ethernet	**Ethernet option** External Ethernet module that supports EtherNet/IP and Modbus TCP/IP
	SI-PROFINET V2	**PROFINET option** PROFINET adapter for communications with the drive.
Automation (I/O expansion)	SI-I/O	**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.
Keypad	KI-HOA Keypad RTC	**LCD keypad option** Keypad with an LCD display, Hand / Off / Auto buttons and real time clock
	HOA Keypad RTC	**LCD keypad option** Remotely mounted keypad with an LCD display, Hand / Off / Auto buttons and real time clock
Back-up	SD Card Adaptor	**SD Card Adaptor** Allows the drive to use an SD card for drive back-up.
	SMARTCARD	**SMARTCARD** Used for parameter back-up with the drive.

For more information refer to the *Drive User Guide* and the relevant option module user guide.

2.6.1 Parts supplied with the drive

Items such as control terminals, relay connector, 24 V power supply connector, grounding bracket, surface mount brackets, grounding clamp, DC terminal cover grommets, terminal nuts, supply and motor connector and finger guard grommets are provided with the drive. For more information refer to the label on the accessory kit box supplied with the drive.

3 Mechanical installation

3.1 Safety information

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.

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.

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.

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.

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 Fire protection

The drive enclosure is not classified as a fire enclosure. A separate fire enclosure must be provided.

For installation in the USA, a NEMA 12 enclosure is suitable.

For installation outside the USA, refer to the *Drive User Guide*.

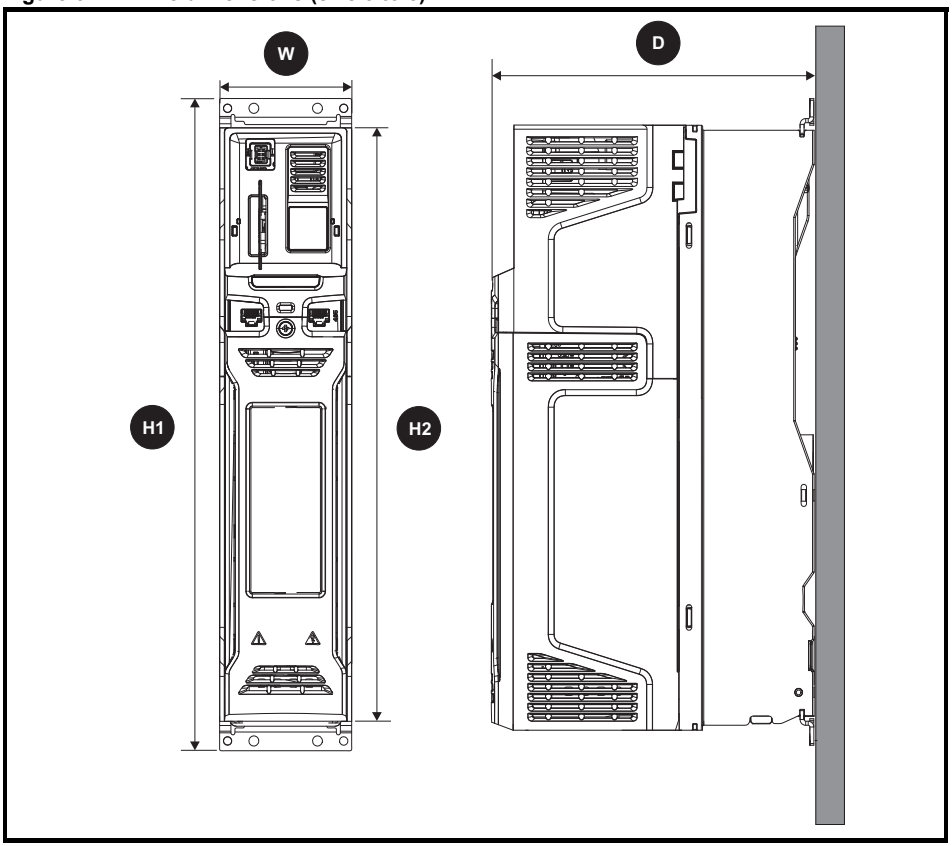
3.3 Mounting methods

All drive sizes can be either surface or through-panel mounted using the appropriate brackets.

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.

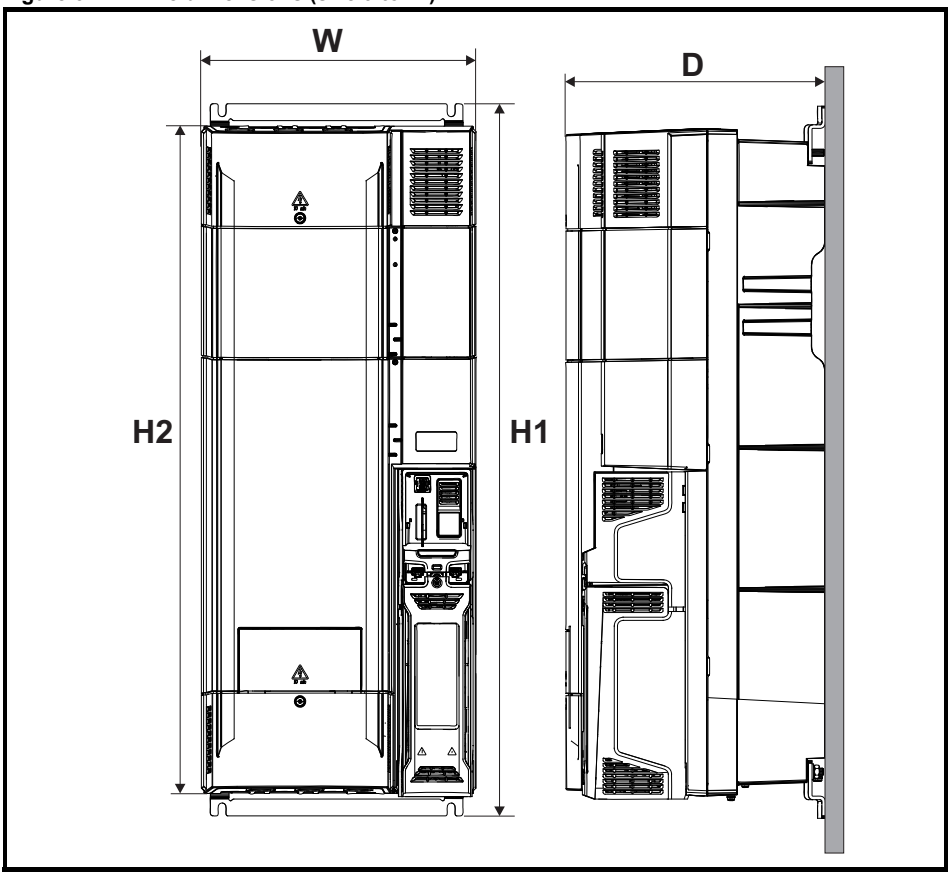
3.4 Drive dimensions

Figure 3-1 Drive dimensions (size 3 to 8)



Size	H1		H2		W		D	
	mm	in	mm	in	mm	in	mm	in
3	382	15.04	365	14.37	83	3.27	200	7.87
4	391	15.39			124	4.88		
5	391	15.39			143	5.63	200	7.87
6	391	15.39			210	8.27	227	8.94
7	557	21.93	508	20	270	10.63	280	11.02
8	804	31.65	753	29.65	310	12.21	290	11.42

Figure 3-2 Drive dimensions (size 9 to 11)



Size	H1		H2		W		D	
	mm	in	mm	in	mm	in	mm	in
9A	1108	43.6	1049	41.3	310	12.2	290	11.4
9E and 10E	1069	42.1	1010	39.7	310	12.2	290	11.4
11E	1242	48.9	1189	46.8	310	12.2	313	12.3

3.5 Surface mounting

Figure 3-3 Surface mounting dimensions (size 3 to 7)

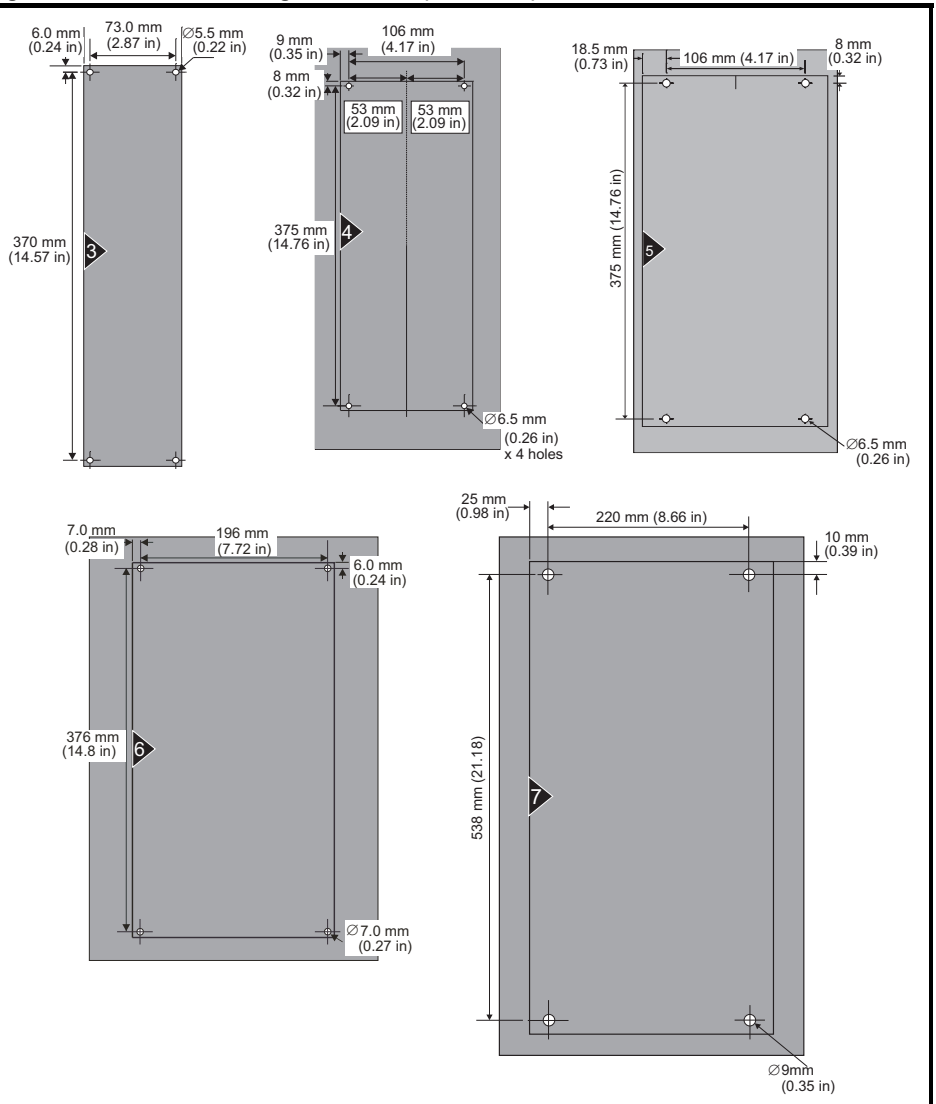


Figure 3-4 Surface mounting dimensions (size 9A)

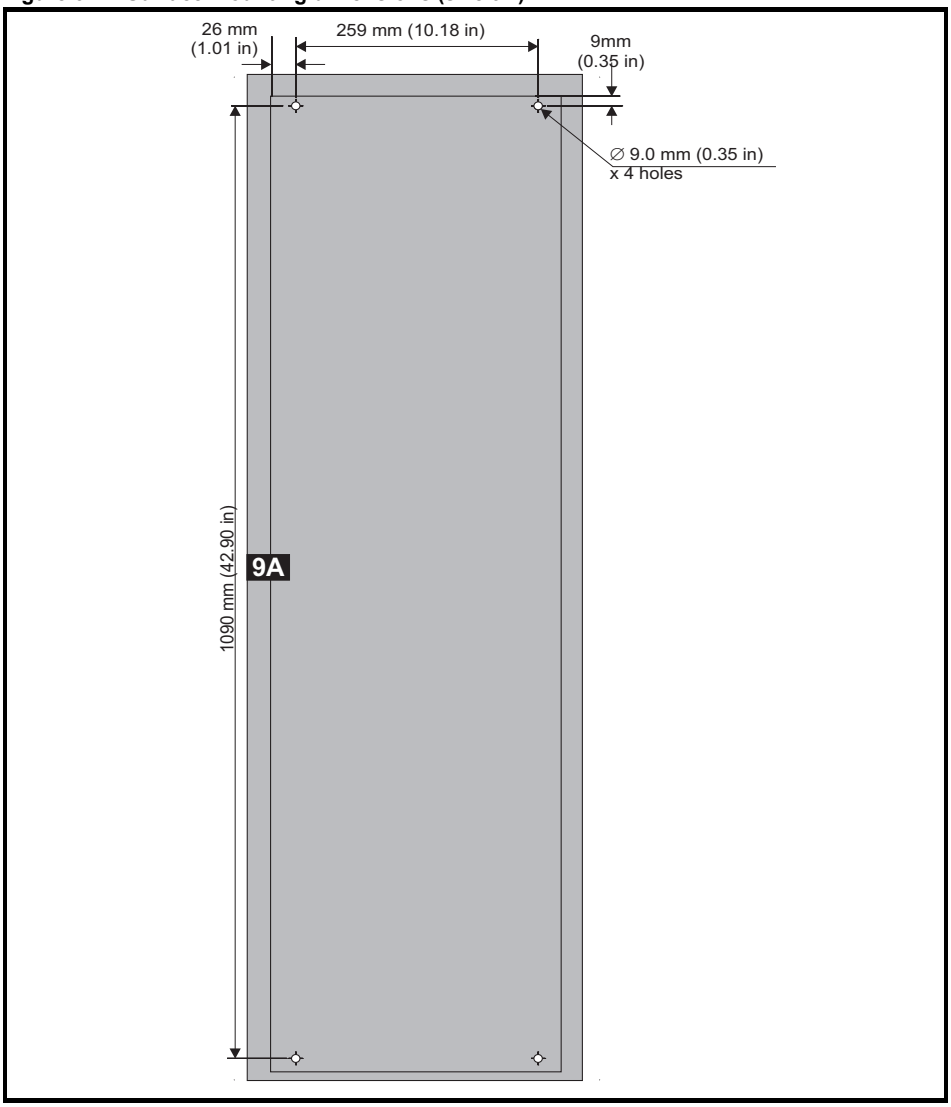


Figure 3-5 Surface mounting dimensions (size 8, 9E and 10E)

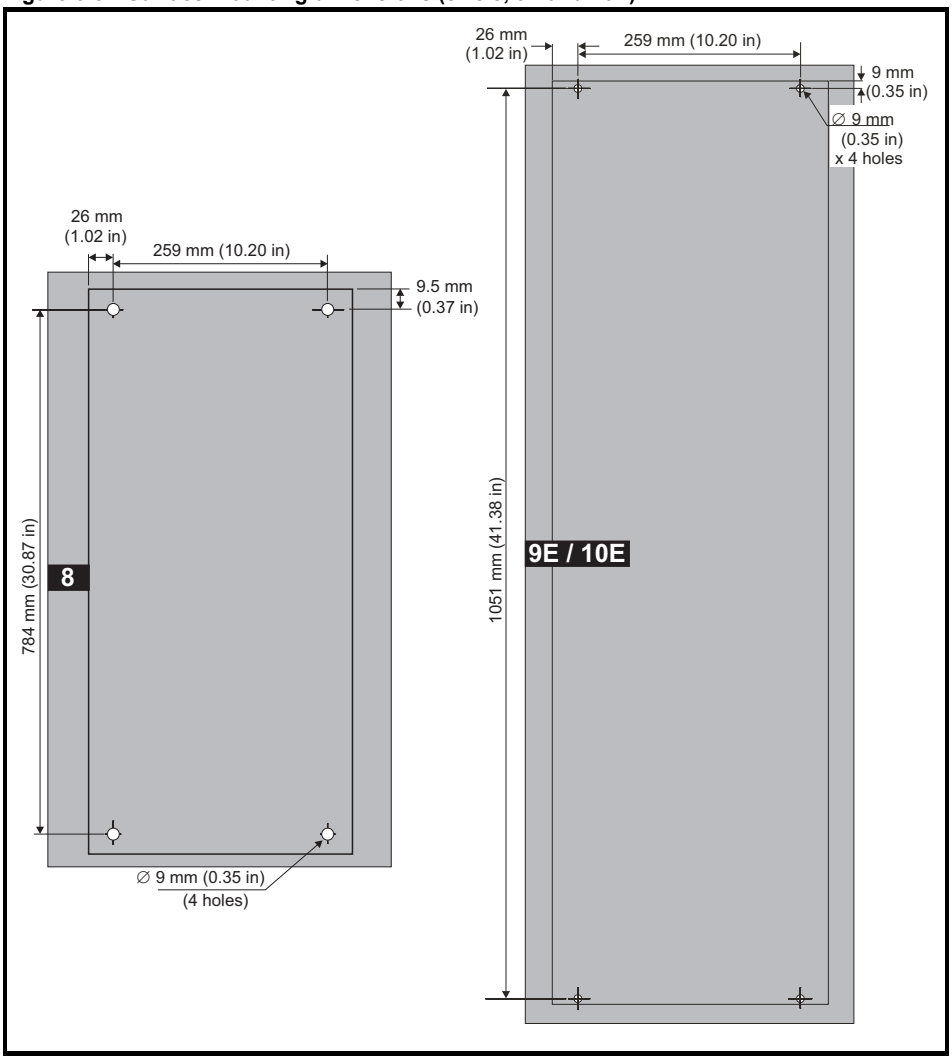
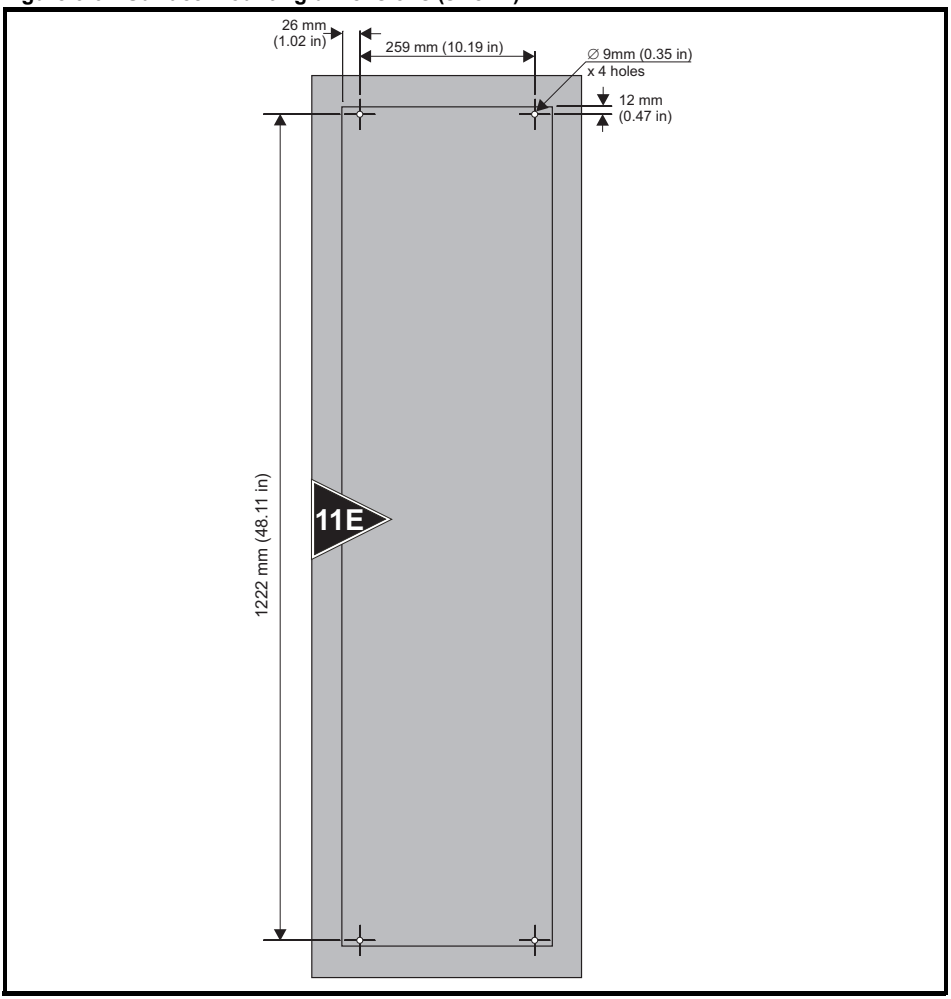


Figure 3-6 Surface mounting dimensions (size 11)



3.6 Terminal size and torque settings

Table 3-1 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 3-2 Drive power terminal data

Model size	AC terminals	DC and braking	Ground terminal
	Recommended		
3 and 4	Plug-in terminal block	T20 Torx (M4)	T20 Torx (M4) / M4 Nut (7 mm AF)
	0.7 N m (0.5 lb ft)	2.0 N m (1.47 lb ft)	2.0 N m (1.47 lb ft)
5	Plug-in terminal block	T20 Torx (M4) / M4 Nut (7 mm AF)	M5 Nut (8 mm AF)
	1.5 N m (1.1 lb ft)	1.5 N m (1.1 lb ft)	2.0 N m (1.47 lb ft)
6	M6 Nut (10 mm AF)		
	6.0 N m (4.42 lb ft)		
7	M8 Nut (13 mm AF)		
	12.0 N m (8.85 lb ft)		
8 to 11	M10 Nut (17 mm AF)		
	15 N m (11.1 lb ft)		

3.7 Enclosure

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 3-7 Enclosure layout (size 3 to 8)

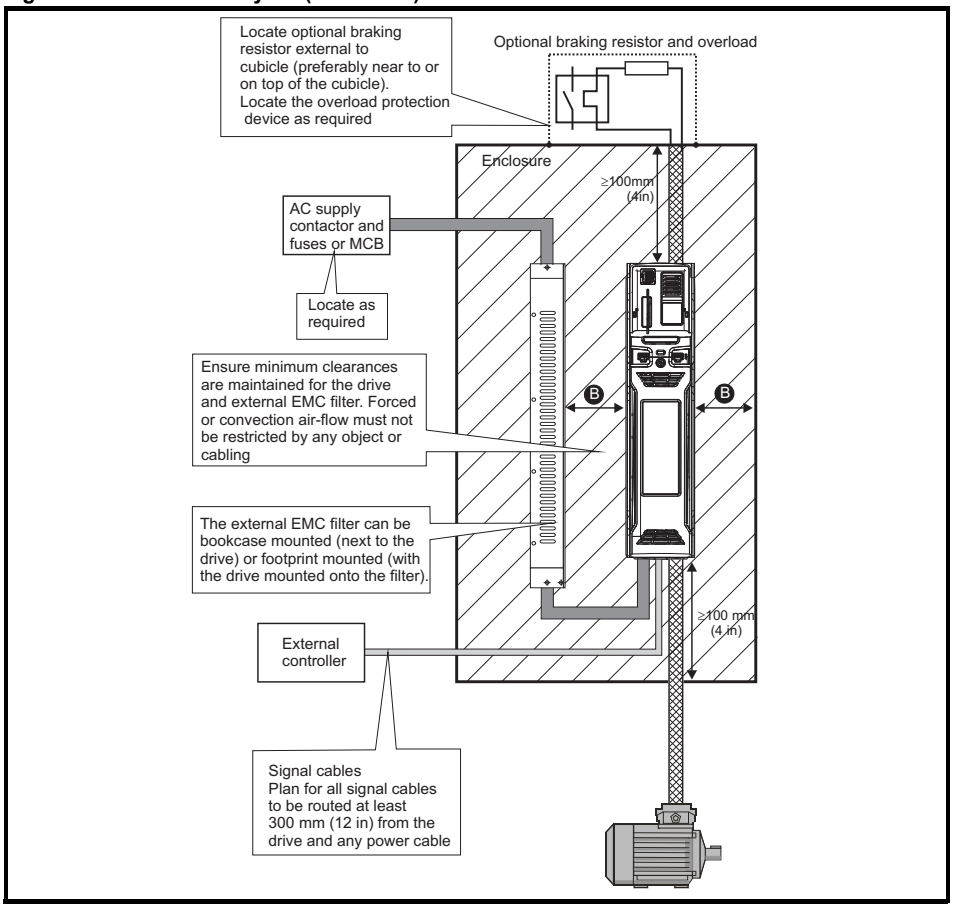
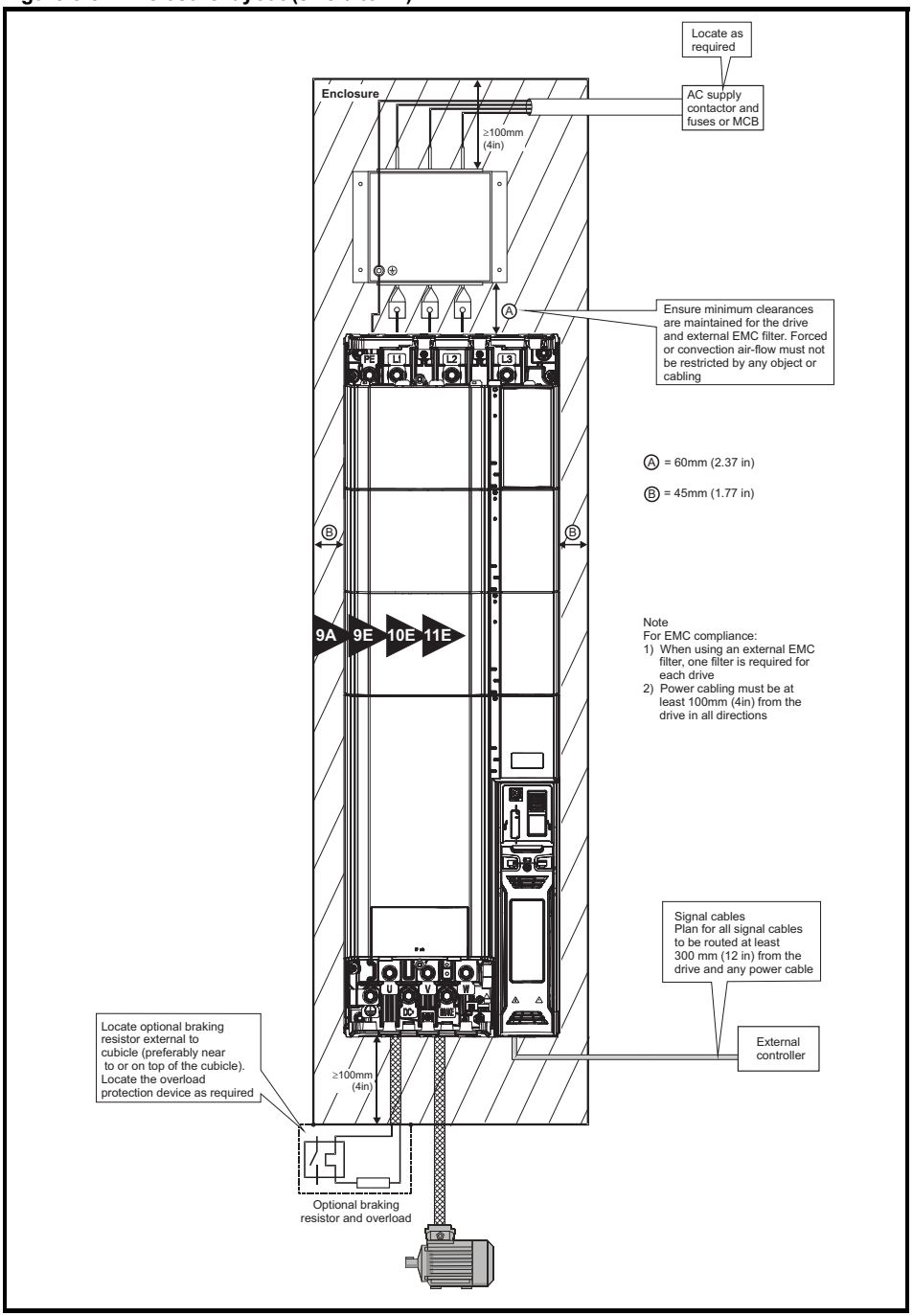


Figure 3-8 Enclosure layout (size 9 to 11)

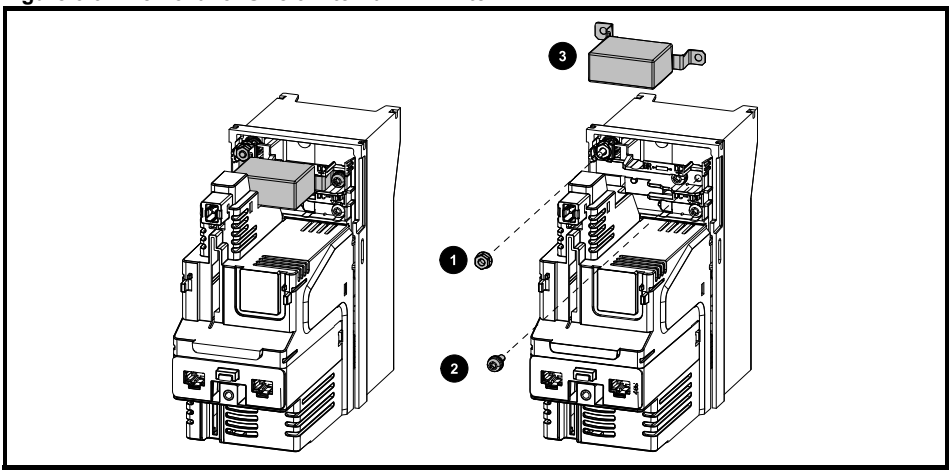


3.8 EMC filters

3.8.1 Internal filter

It is recommended that the internal EMC filter be kept in place unless there is a specific reason for removing it. If the drive is part of a regen system or it is connected to an IT supply then the internal EMC filter must be removed. 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 - for further information see the *Drive User Guide*. For longer motor cables the filter continues to provide a useful reduction in emission level, 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 or the ground leakage current of the drive is unacceptable.

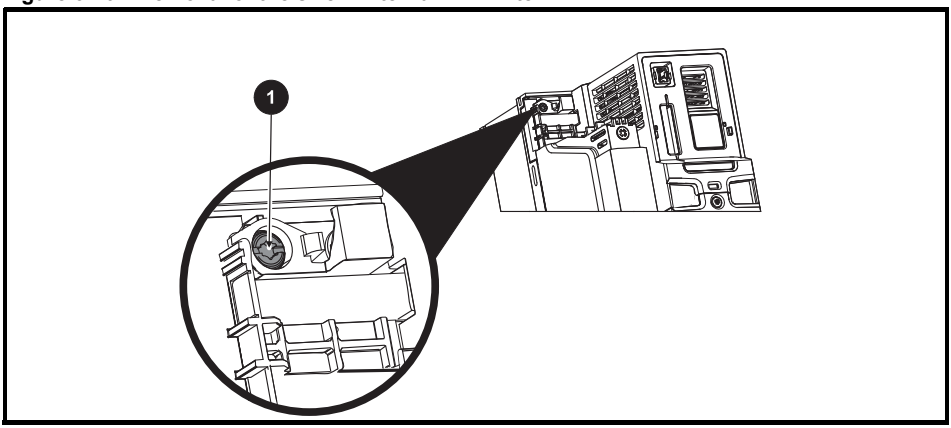
Figure 3-9 Removal of Size 3 internal EMC filter



Loosen / remove the screw and nut as shown (1) and (2).

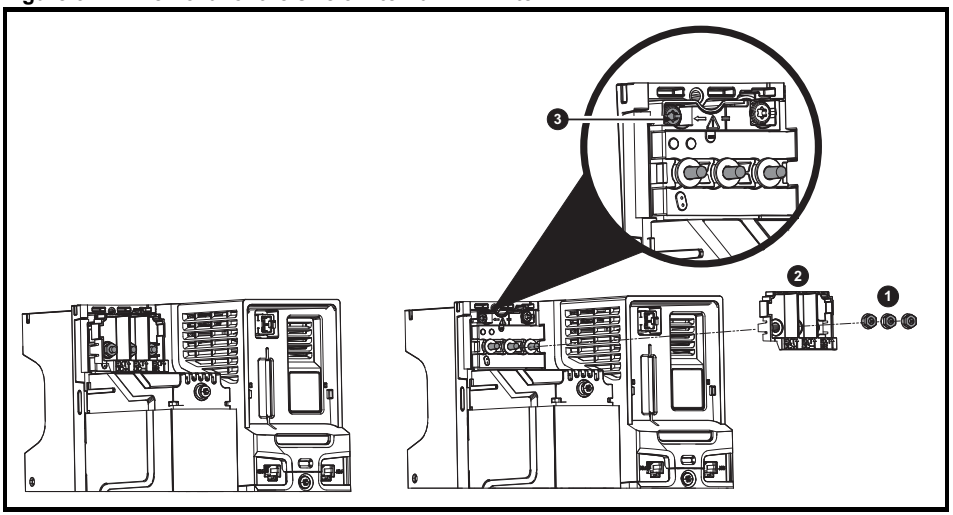
Lift away from securing points and then rotate away from the drive. Ensure the screw and nut are replaced and re-tightened with a maximum torque of 2 N m (1.47 lb ft).

Figure 3-10 Removal of the size 4 internal EMC filter



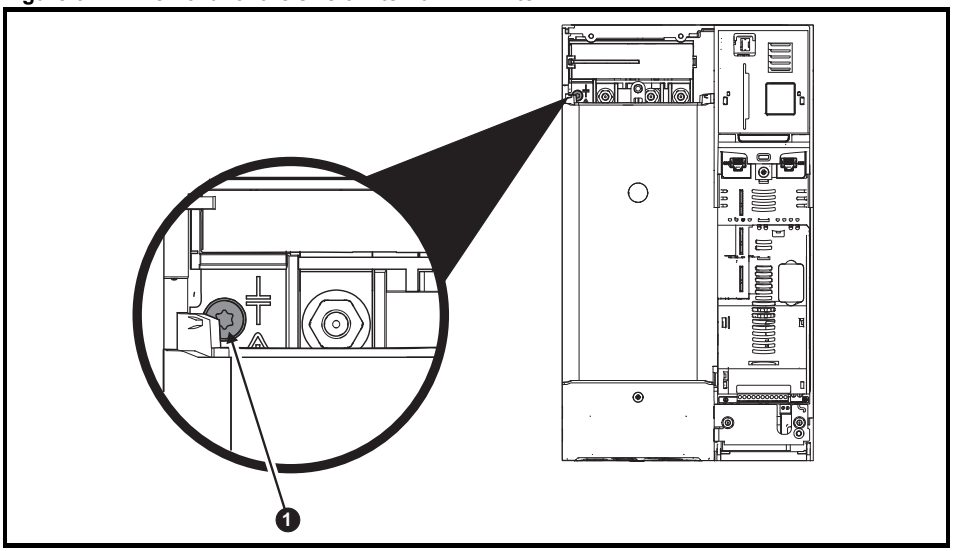
To electrically disconnect the Internal EMC filter, remove the screw (1) as highlighted above.

Figure 3-11 Removal of the size 5 internal EMC filter



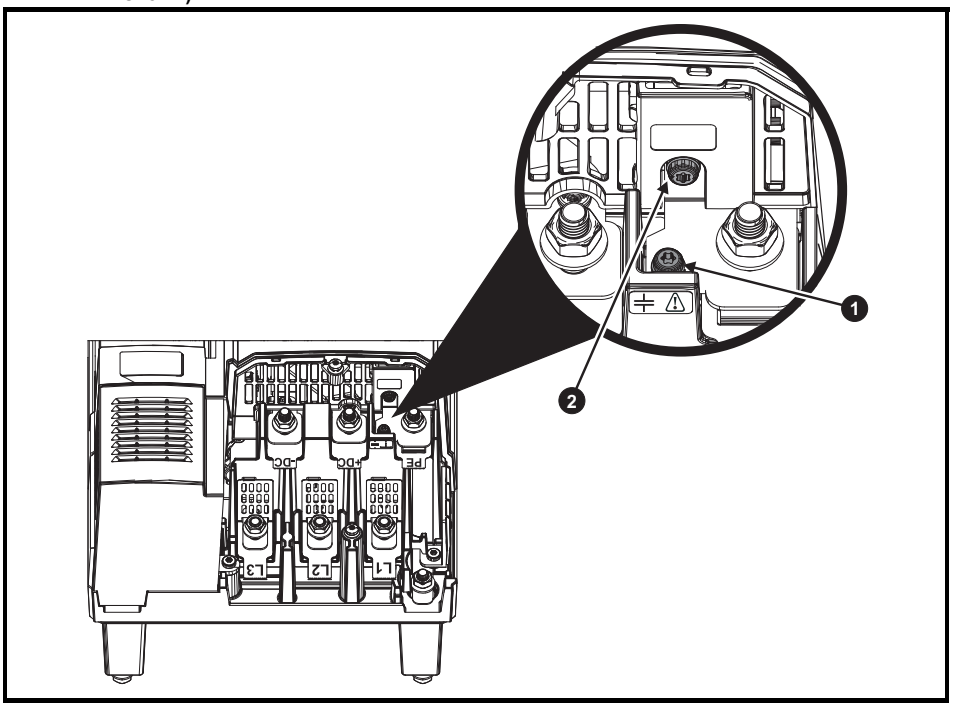
Remove the three M5 terminal nuts (1). Lift away the cover (2) to expose the M4 Torx internal EMC filter removal screw. Finally remove the M4 Torx internal EMC filter removal screw (3) to electrically disconnect the internal EMC filter.

Figure 3-12 Removal of the size 6 internal EMC filter



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

Figure 3-13 Removal of the size 7, 8 and 9A internal EMC filter and line to ground varistors (size 7 shown)



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

To electrically disconnect the line to ground varistors, remove the screw as highlighted above (2).

NOTE

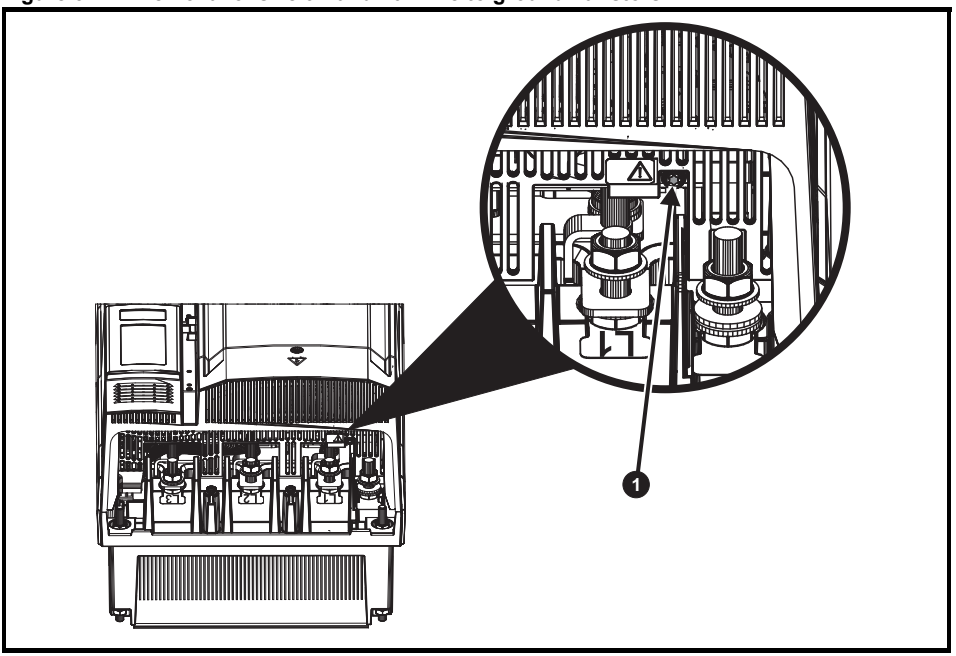
The Internal EMC filter on size 9E, 10E and 11E cannot be removed.

3.8.2 Line to ground varistors

WARNING

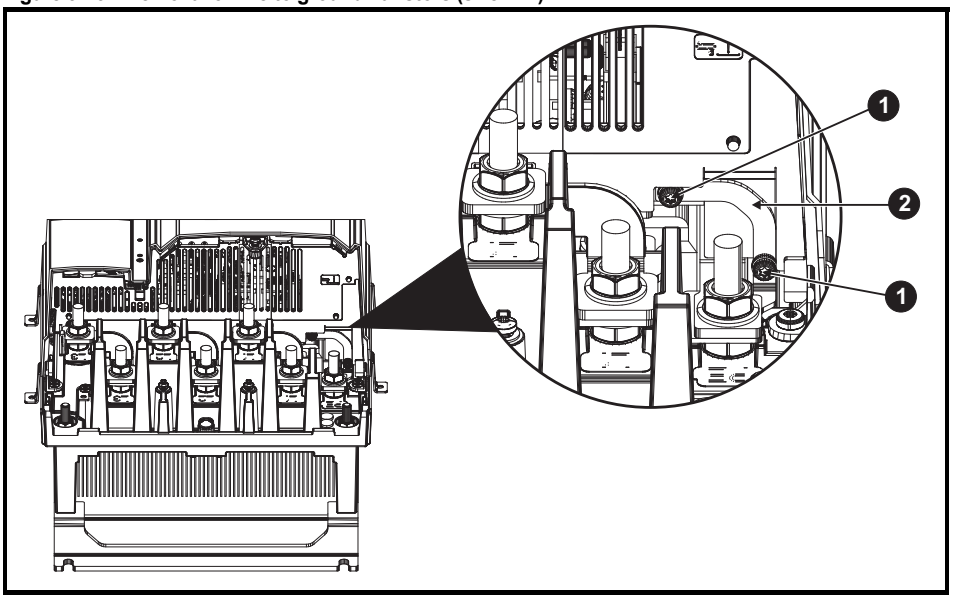
The line to ground varistors should only be removed in special circumstances such as ungrounded supplies with more than one source, for example on ships. Where the line to ground varistors are removed, ensure that line to ground transients are limited to values of category II. This is to ensure that line to ground transients do not exceed 4 kV as the drive insulation system from power to ground is designed to category II.Contact the supplier of the drive for more information.

Figure 3-14 Removal of size 9E and 10E line to ground varistors



To electrically disconnect the line to ground varistors, remove the screw as highlighted above (1).

Figure 3-15 Removal of line to ground varistors (size 11E)



To electrically disconnect the line to ground varistors, remove the two screws highlighted (1) above and remove the bracket (2).

3.8.3 External filter

The external EMC filter for size 3, 4, 5 and 6 can be footprint or bookcase mounted.

For information on drive and EMC filter cross reference, refer to the *Drive User Guide*.

WARNING

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

For further information refer to the *Drive User Guide*.

4 Electrical installation

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.

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.

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

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

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.

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).

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 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 IEC 60664-1. 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.

NOTE If the drive is to be used on an IT (ungrounded) supply, refer to the *Drive User Guide* for more information.

4.2 Ratings

See section 2.4 *Ratings* on page 11.

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 high imbalance. 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 section 2.4 *Ratings* on page 11.

The nominal cable sizes given in section 2.4 *Ratings* on page 11 are only a guide. Refer to local wiring regulations for the correct size of cables. In some cases a larger cable is required to avoid excessive voltage drop.

NOTE The nominal output cable sizes in section 2.4 *Ratings* on page 11 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 over-load, the drive must be programmed with the correct motor rated current.

Fuses
The AC supply to the drive must be installed with suitable protection against overload and short-circuits. Nominal fuse ratings are shown in section 2.4 *Ratings* on page 11. Failure to observe this requirement will cause risk of fire.

A fuse or other protection must be included in all live connections to the AC supply. An MCB (miniature circuit breaker) or MCCB (moulded-case circuit-breaker) with type C may be used in place of fuses for size 3 under the following conditions:

- The fault-clearing capacity must be sufficient for the installation.

Fuse types

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

4.3 Power connections

Figure 4-1 Size 3 power and ground connections

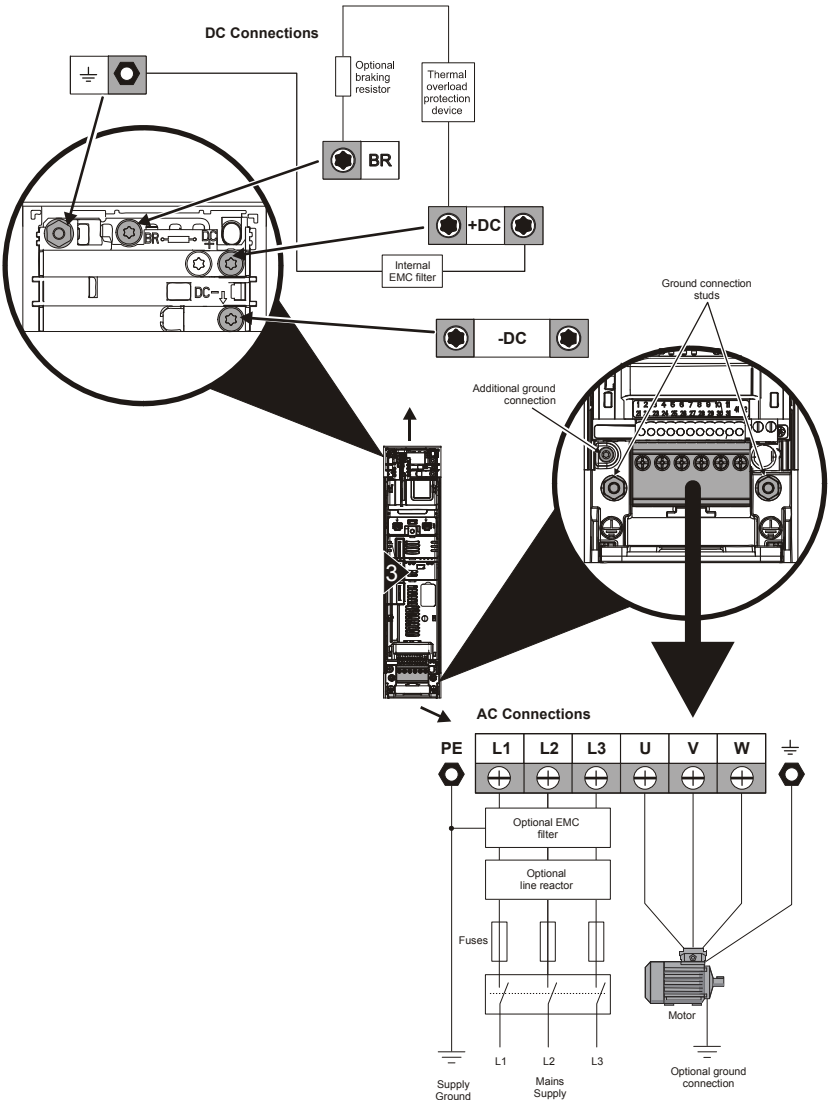


Figure 4-2 Size 4 power and ground connections

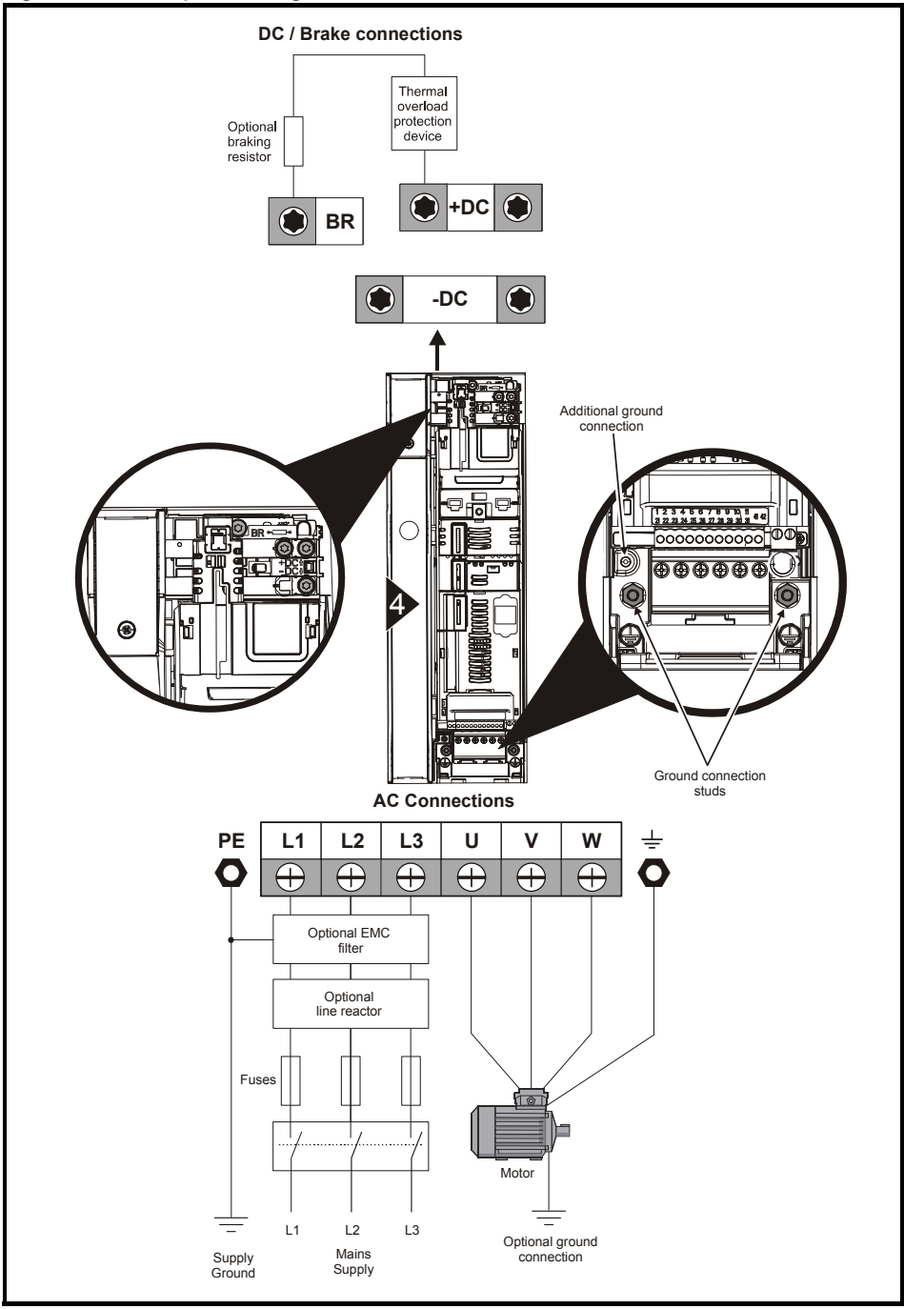
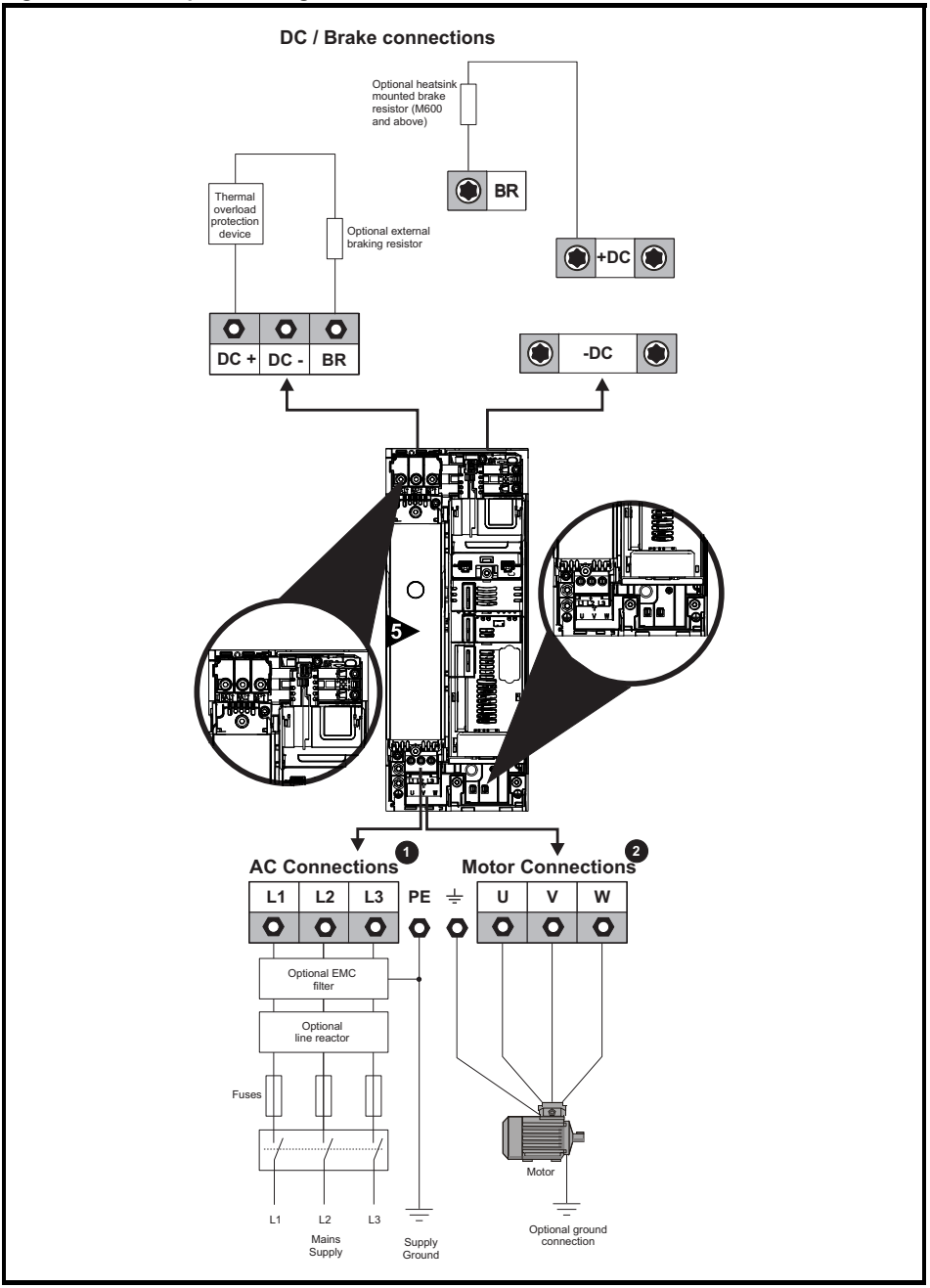


Figure 4-3 Size 5 power and ground connections



❶The upper terminal block is used for AC supply connection.

❷The lower terminal block is used for Motor connection.

Figure 4-4 Size 6 power and ground connections

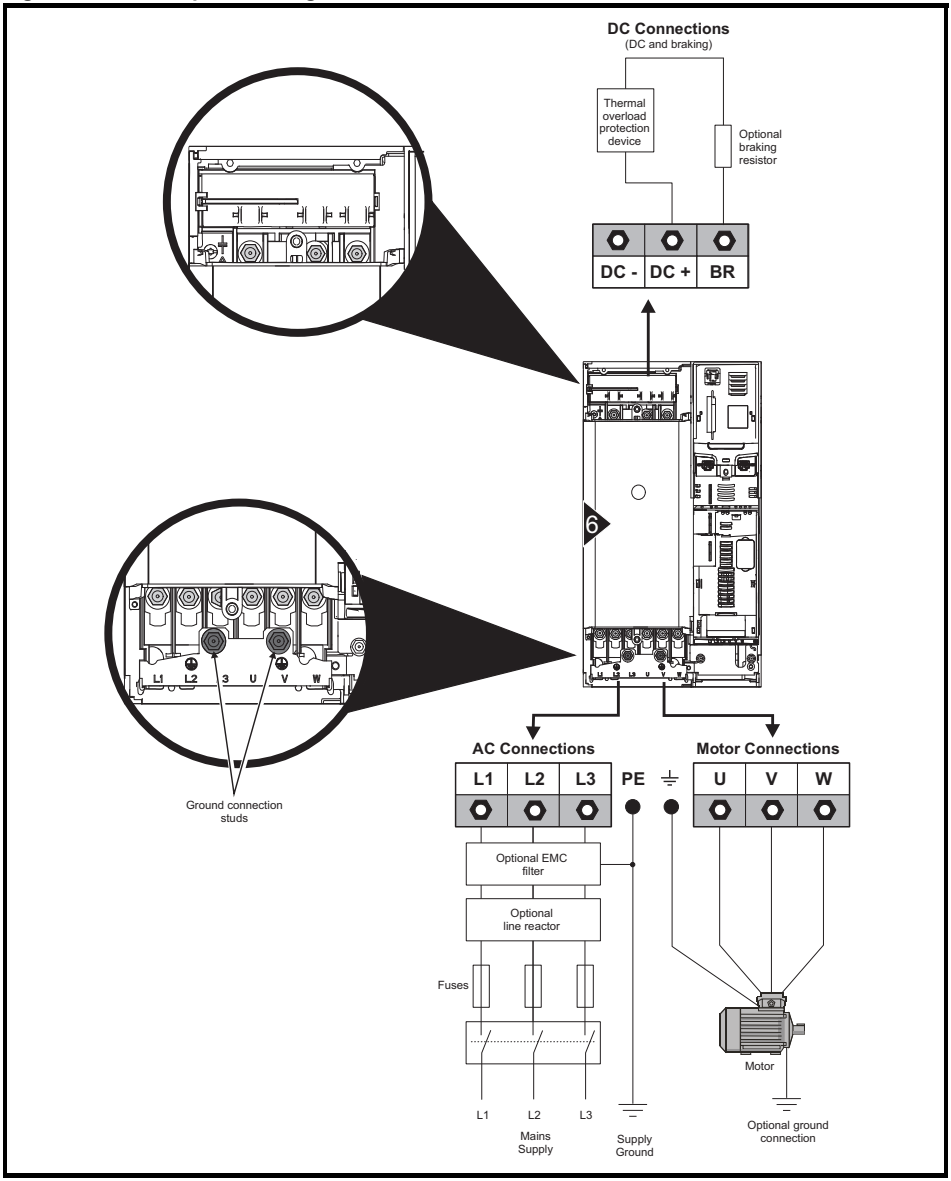


Figure 4-5 Size 7 and 8 power and ground connections (size 7 shown)

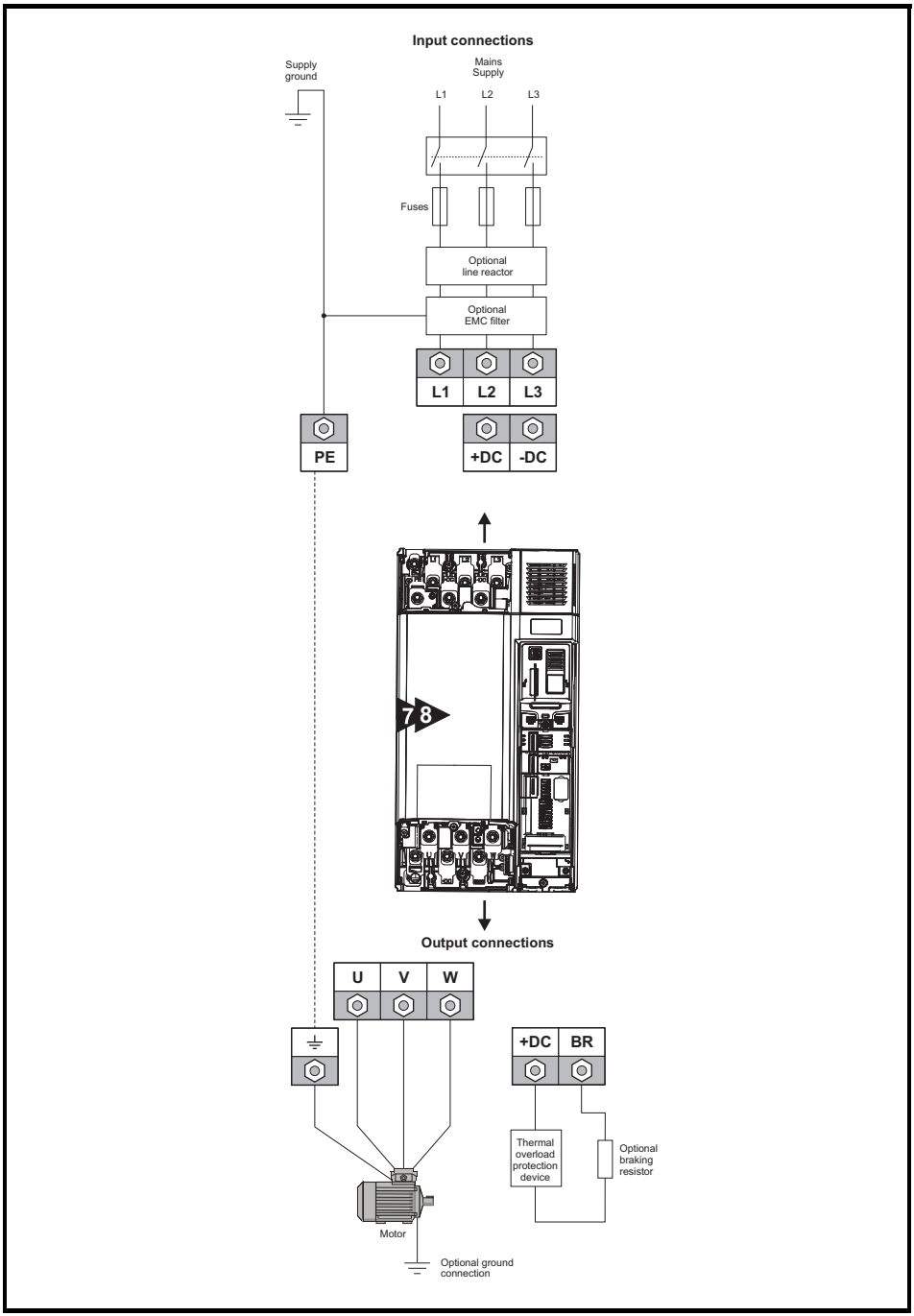


Figure 4-6 Size 9A power and ground connections

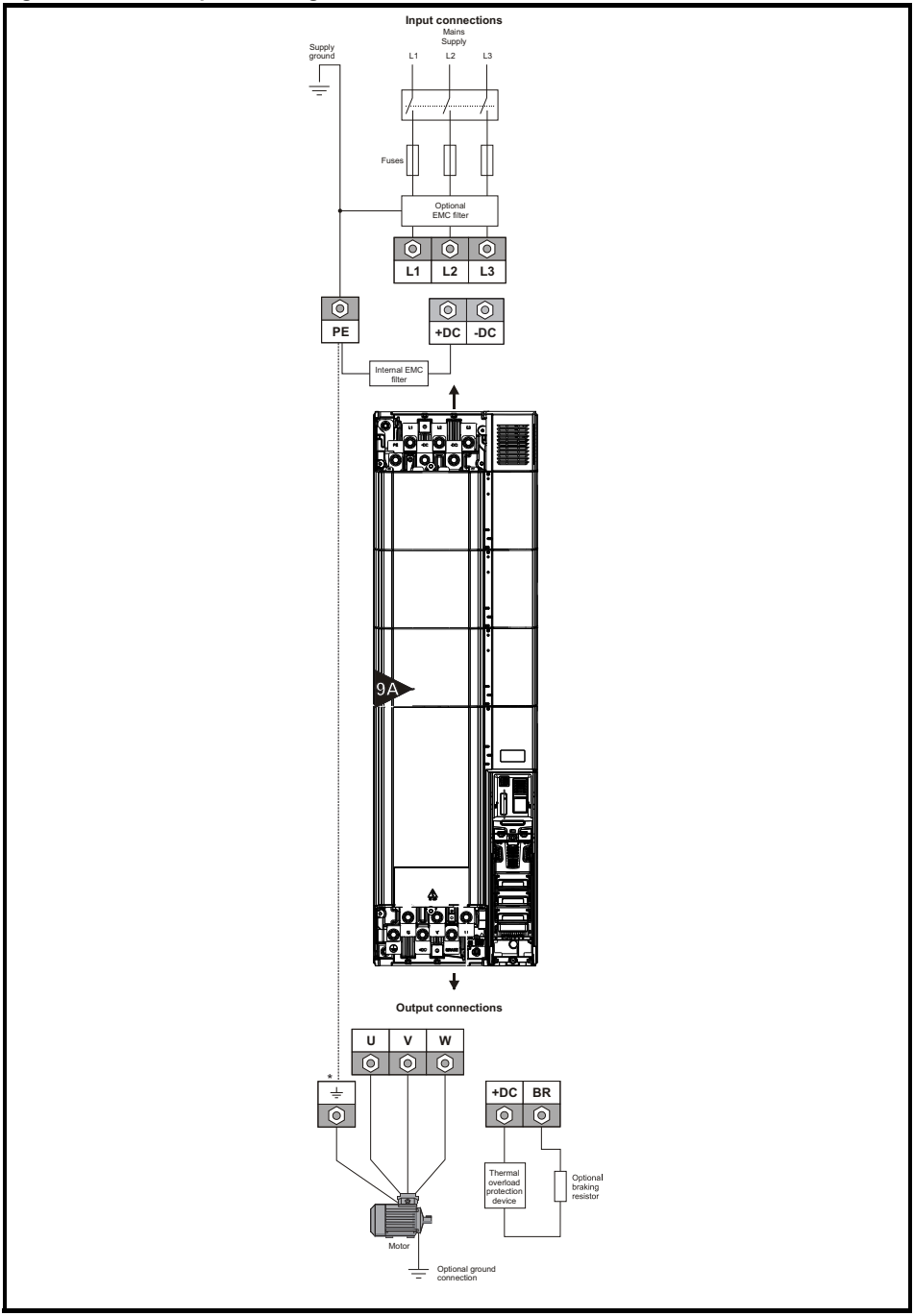


Figure 4-7 Size 9E and 10E power and ground connections

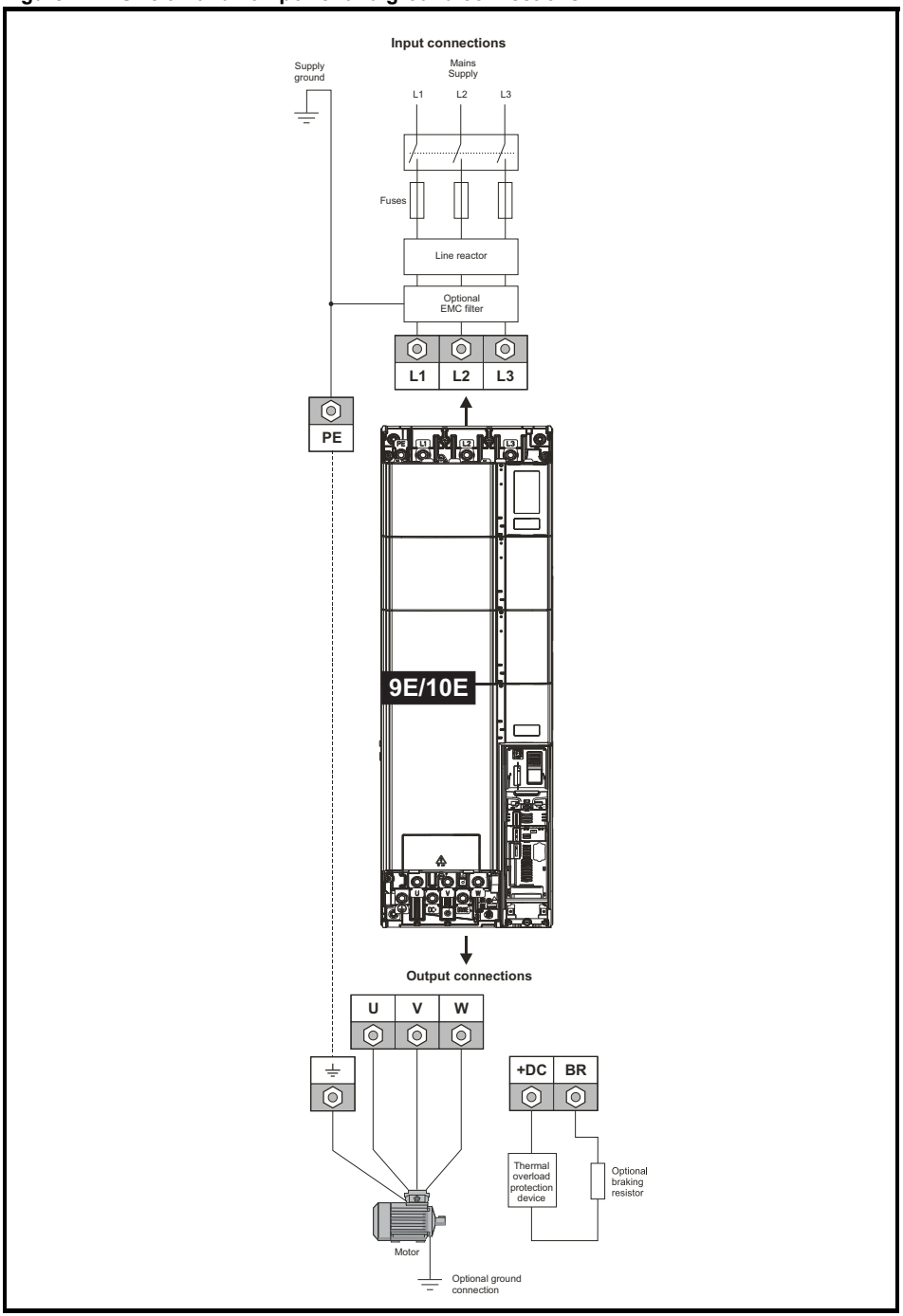
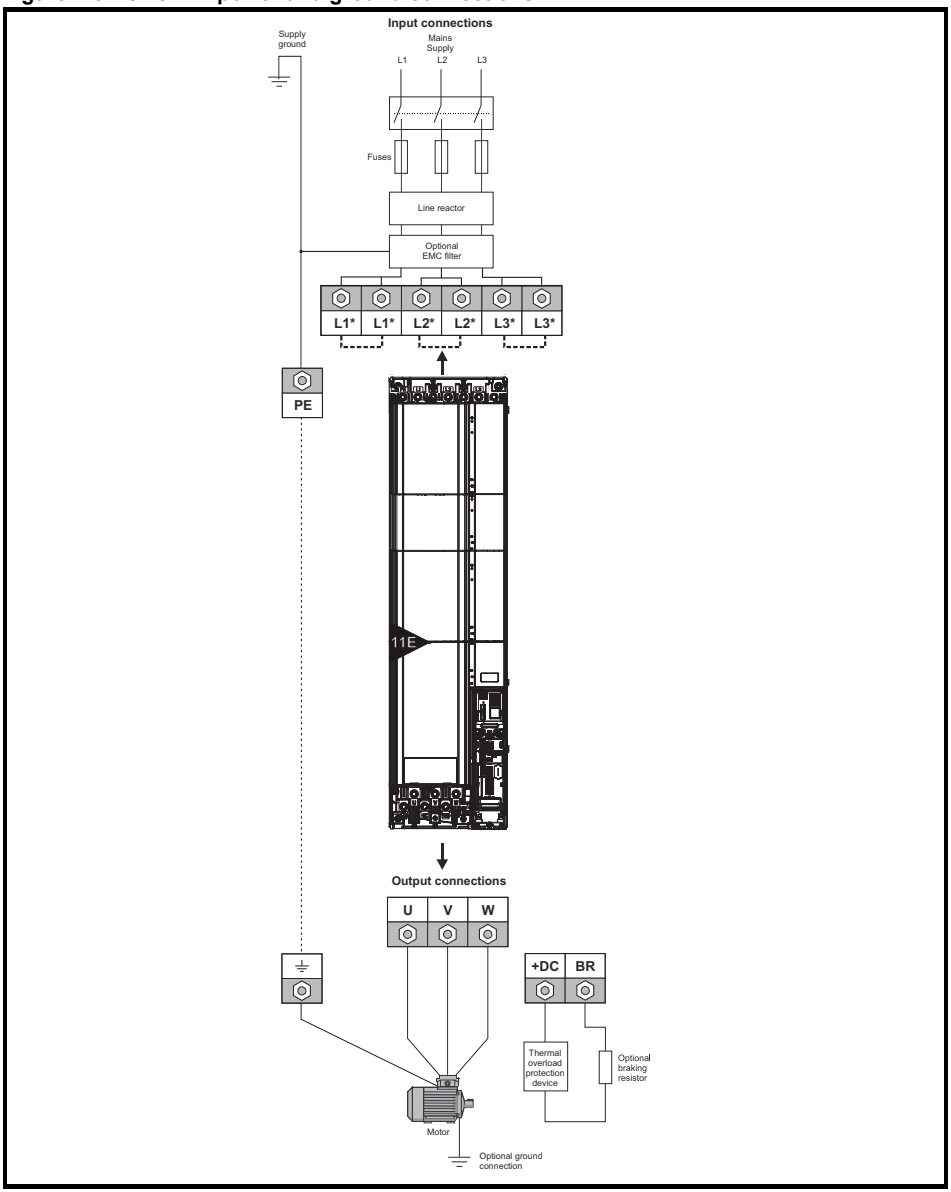


Figure 4-8 Size 11E power and ground connections



* Connect to either terminal.

CAUTION

A separate line reactor (INLXXX) must be used for size 9E,10E and 11E. Failure to provide sufficient reactance could damage or reduce the service life of the drive. Refer to Table 2-8 *Size 9E, 10E and 11E Model and Line reactor part number* on page 15.

4.4 Ground connections

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

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 further information on ground cable sizes, refer to Table 2-6 *Protective ground cable ratings* on page 14.

On size 3 and 4, the supply and motor ground connections are made using the M4 studs located either side of the drive near the plug-in power connectors. See Figure 4-1 and Figure 4-2 for details.

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 4-3.

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 4-4.

On size 7, the supply and motor ground connections are made using the M8 studs located by the supply and motor connection terminals. Refer to Figure 4-5.

On size 8, the supply and motor ground connections are made using the M10 studs located by the supply and motor connection terminals. Refer to Figure 4-5.

On size 9A, the supply and motor ground connections are made using the M10 studs located by the supply and motor connection terminals. Refer to Figure 4-6

On size 9E and 10E, the supply and motor ground connections are made using the M10 studs located by the supply and motor connection terminals. Refer to Figure 4-7.

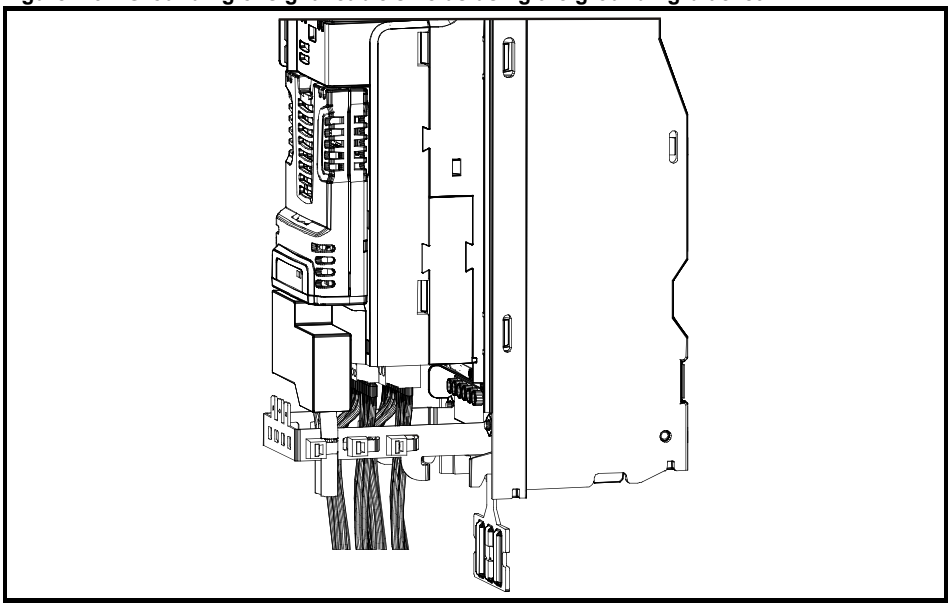
On size 11E, the supply and motor ground connections are made using the M10 studs located by the supply and motor connection terminals. Refer to Figure 4-8.

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.

4.5 Shield connections

The following guidelines should be followed to ensure suppression of radio-frequency emission and good noise immunity**.** Use the grounding bracket and grounding clamp supplied with the drive to terminate the shields at the drive.

Figure 4-9 Grounding of signal cable shields using the grounding bracket



Motor cable: Use a motor cable with an overall shield. 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 full 360 ° termination of the shield to the terminal housing of the motor is beneficial.

Brake resistor cable: The optional braking resistor should also be wired with shielded cable. If unshielded wire is required refer to the *Drive User Guide* for guidance.

Control cables: If the control wiring is to leave the enclosure, it must be shielded and the shield(s) clamped to the drive using the grounding bracket. Remove the outer insulating cover of the cable to ensure the shield(s) make contact with the bracket, but keep the shield(s) intact until as close as possible to the terminals.

4.6 Communications connections

The drive offers a 2 wire 485 serial interface. This enables the drive set-up, operation and monitoring to be carried out with a PC or controller if required. The drive provides two parallel RJ45 connectors allowing easy daisy chaining. The drive supports the Modbus RTU protocol. See Table 4-1 for the connection details.

Table 4-1 Serial communication port pin-outs

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

4.7 Control connections

For information on control connections, refer to the back cover of this guide.

5 Getting started

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

5.1 Understanding the display

The KI-HOA Keypad RTC can only be mounted on the drive. The HOA Keypad RTC can be mounted on the drive or remotely mounted.

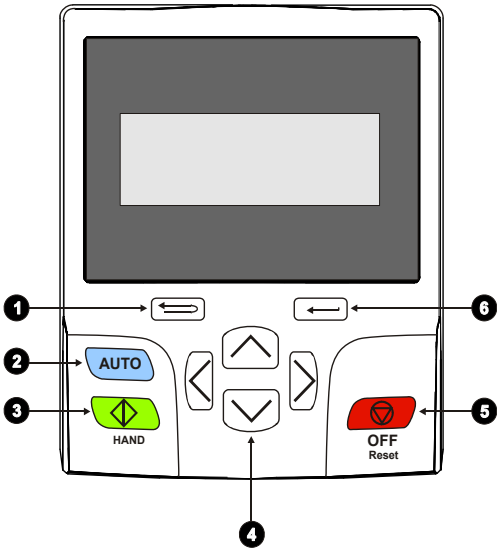
5.1.1 Keypad details

The display of both keypads 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 5-1

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

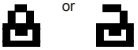
Figure 5-1 KI-HOA Keypad RTC / HOA Keypad RTC

1. Escape button
2. Auto
3. Hand button
4. Navigation keys (x4)
5. Off / Reset
6. Enter button



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

Table 5-1 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
	Drive security active and locked or unlocked	1	4
	User program running	3	1
	Keypad reference active	4	1

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.
- Three control buttons - used to select Hand / Off / Auto modes (see section 5.2.2 below).

5.2.2 Hand / Off / Auto

Hand / Off / Auto functions are enabled if Pr **01.052** is set to a non-zero value, otherwise the keypad buttons are allocated as follows:

- Blue 

- Forward/Reverse
- Green  - Run
- Red  - Reset

When Hand / Off / Auto functions are enabled (Pr **01.052** set to either 1, 2 or 3), then the keypad buttons will be allocated as follows:

- Blue 

- Auto
- Green  - Hand
- Red  - Off/Reset

The value in Pr **01.052** selects Hand/Off/Auto mode on power-up as shown in Table 5-2.

Table 5-2 Hand/Off/Auto mode

Pr 01.052	Power up
0	Hand/Off/Auto disabled
1	Auto Mode
2	Off Mode
3	See Table 5-3

Table 5-3 Power-up modes if Pr 01.052 = 3

Power-down	Power-up
Hand	Off
Off	Off
Auto	Auto

Auto

In Auto mode, the reference for the motor speed/frequency will be selected by the value set in Pr **00.005**.

Hand

The speed/frequency reference Pr **00.005** is automatically set to keypad reference. The motor speed is determined by the value in the keypad control mode reference Pr **01.017**, which can be adjusted by pressing the Up/Down arrows on the keypad.

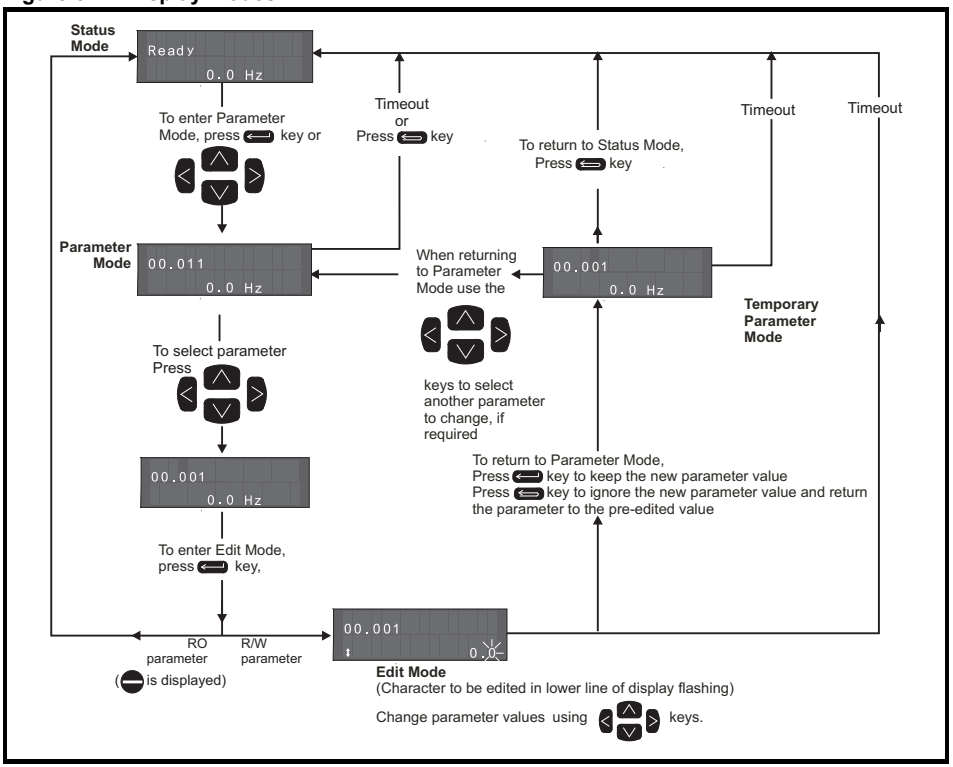
When Hand is selected from Auto, Pr **01.017** will be set to the value of the *Pre-ramp reference* (Pr **01.003**) on mode transition, so the current motor speed is maintained.

If Hand mode is selected from Off mode, the motor will ramp up to the speed determined by the value in Pr **01.017**.

Off

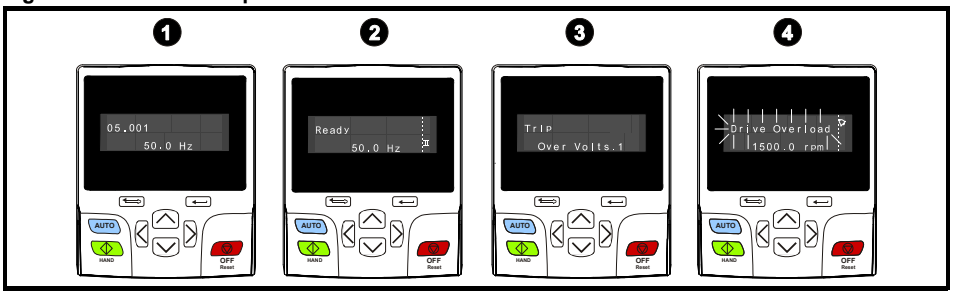
In Off mode, the motor will be stopped. The speed/frequency reference (Pr **00.005**) is automatically set to keypad reference allowing the value in the *keypad control mode reference* (Pr **01.017**) to be modified by pressing the Up/Down arrow keys. If Hand mode is then selected, the motor will ramp up to the speed determined by the value in Pr **01.017**.

Figure 5-2 Display modes



The navigation keys can only be used to move between menus if Pr **00.049** has been set to show 'All Menus'

Figure 5-3 Mode examples



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 AC supply to the drive is interrupted, new values must be saved. Refer to section 5.7 *Saving parameters* on page 54.

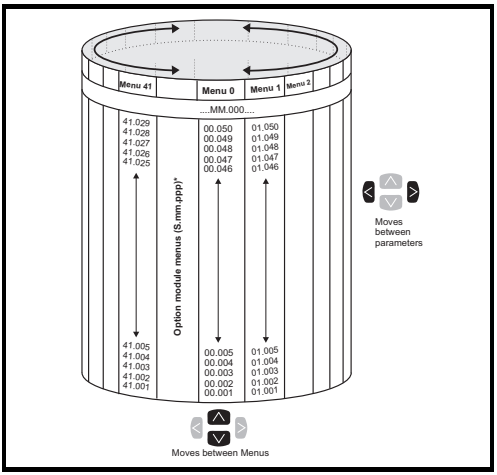
5.3 Menu 0

Menu 0 is used to bring together various commonly used parameters for basic easy set up of the drive. Appropriate parameters are copied from the advanced menus into menu 0 and thus exist in both locations. For further information, refer to Chapter 6 *Basic parameters (Menu 0)* on page 56.

5.4 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 5.11 *Parameter access level and security* on page 55.

Figure 5-4 Menu structure



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.

* 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.

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 keypad.

Table 5-4 Advanced menu descriptions

Menu	Description
0	Commonly used basic set-up parameters for quick / easy programming
1	Frequency / speed reference
2	Ramps
3	Speed feedback and speed control
4	Torque and current control
5	Motor control
6	Sequencer and clock
7	Analog I/O, Temperature monitoring
8	Digital I/O
9	Programmable logic, motorized pot, binary sum, timers and scope
10	Status and trips
11	Drive set-up and identification, serial communications
12	Threshold detectors and variable selectors
14	User PID controller
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	Not allocated
29	Reserved - menu pumping functions
30	Onboard user programming application 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.

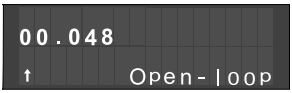
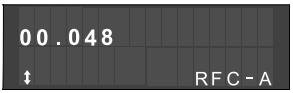
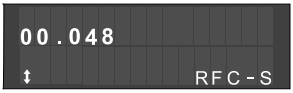
5.6 Changing the operating mode

Changing the operating mode returns all parameters to their default value, including the motor parameters. *User security status* (00.049) and *User security code* (00.034) are not affected by this procedure).

Procedure

Use the following procedure only if a different operating mode is required:

1. Ensure the drive is not enabled, i.e. terminal 29 is open or Pr **06.015** is OFF (0)
2. Enter either of the following values in Pr **mm.000**, as appropriate:
   1253 (50 Hz AC supply frequency)
   1254 (60 Hz AC supply frequency)
3. Change the setting of Pr **00.048** as follows:

Pr 00.048 setting		Operating mode
	1	Open-loop (Induction motor)
	2	RFC-A (Induction motor without position feedback)
	3	RFC-S (Permanent magnet motor without position feedback)

The figures in the second column apply when serial communications are used.

4. Either:

- Press the red reset button
- Toggle the reset digital input
- Carry out a drive reset through serial communications by setting Pr **10.038** to 100.

NOTE Entering 1253 or 1254 in Pr **mm.000** will only load defaults if the setting of Pr **00.048** has been changed.

5.7 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

1. Select 'Save Parameters'* in Pr **mm.000** (alternatively enter a value of 1001 in Pr **mm.000**)
2. Either:

- Press the red reset button
- Toggle the reset digital input, or
- Carry out a drive reset through serial communications by setting Pr **10.038** to 100

5.8 Restoring parameter defaults

Restoring parameter defaults by this method saves the default values in the drives memory. *User security status* (00.049) and *User security code* (00.034) are not affected by this procedure).

Procedure

1. Ensure the drive is not enabled, i.e. terminal 29 is open or Pr **06.015** is OFF (0)
2. Select 'Reset 50 Hz Defs' or 'Reset 60 Hz Defs' in Pr **mm.000**. (alternatively, enter 1233 (50 Hz settings) or 1244 (60 Hz settings) in Pr **mm.000**).
3. Either:

- Press the red  reset button
- Toggle the reset digital input
- Carry out a drive reset through serial communications by setting Pr **10.038** to 100

5.9 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 5.11 *Parameter access level and security* on page 55 for further information regarding access level.

5.10 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 5.11 *Parameter access level and security* for further information regarding access level.

5.11 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 5-5.

Table 5-5 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.

6 Basic parameters (Menu 0)

Parameter			Range			Default			Type					
			OL	RFC-A	RFC-S	OL	RFC-A	RFC-S						
00.001	Minimum Reference Clamp	**{01.007}**	VM_NEGATIVE_REF_CLAMP1 Hz / rpm			0 Hz / rpm			RW	Num				US
00.002	Maximum Reference Clamp	**{01.006}**	VM_POSITIVE_REF_CLAMP1 Hz / rpm			50 Hz default: 50.0 Hz 60 Hz default: 60.0 Hz	50 Hz default: 1500.0 rpm 60 Hz default: 1800.0 rpm		RW	Num				US
00.003	Acceleration Rate 1	**{02.011}**	0.0 to VM_ACCEL_RATE s to Pr **01.006**	0.000 to VM_ACCEL_RATE s to Pr **01.006**		20.0 s to Pr **01.006**	20.000 s to Pr **01.006**		RW	Num				US
00.004	Deceleration Rate 1	**{02.021}**	0.0 to VM_ACCEL_RATE s to Pr **01.006**	0.000 to VM_ACCEL_RATE s to Pr **01.006**		20.0 s to Pr **01.006**	20.000 s to Pr **01.006**		RW	Num				US
00.005	Reference Selector	**{01.014}**	A1 A2 (0),A1 Preset (1), A2 Preset (2), Preset (3), Keypad (4), Reserved(5), Keypad Ref (6)			A1 A2 (0)			RW	Txt				US
00.006	Symmetrical Current Limit	**{04.007}**	0.0 to VM_MOTOR1_CURRENT_LIMIT %			110 %	110 %		RW	Num		RA		US
00.007	Open-loop Control Mode	**{05.014}**	Ur S (0),Ur (1), Fixed (2), Ur Auto (3), Ur I (4), Square (5)			Ur I (4)			RW	Txt				US
	Speed Controller Proportional Gain Kp1	**{03.010}**		0.0000 to 200.000 s/rad			0.0300 s/rad		RW	Num				US
00.008	Low Frequency Voltage Boost	**{05.015}**	0.0 to 25.0 %			3.0 %			RW	Num				US
	Speed Controller Integral Gain Ki1	**{03.011}**		0.00 to 655.35 s^2/rad			0.10 s^2/rad		RW	Num				US
00.009	Dynamic V to F Select	**{05.013}**	Off (0) or On (1)			On (1)			RW	Bit				US
	Speed Controller Differential Feedback Gain Kd 1	**{03.012}**		0.00000 to 0.65535 1/rad			0.00000 1/rad		RW	Num				US
00.010	Motor Rpm	**{05.004}**	±180000 rpm						RO	Num	ND	NC	PT	FI
	Speed Feedback	**{03.002}**		VM_SPEED rpm					RO	Num	ND	NC	PT	FI
00.011	Output Frequency	**{05.001}**	VM_SPEED_FREQ_REF Hz						RO	Num	ND	NC	PT	FI
00.012	Current Magnitude	**{04.001}**	0.000 to VM_DRIVE_CURRENT_ UNIPOLAR A						RO	Bit	ND	NC	PT	FI
00.013	Torque Producing Current	**{04.002}**	VM_DRIVE_CURRENT A						RO	Bit	ND	NC	PT	FI
00.015	Ramp Mode	**{02.004}**	Fast (0), Standard (1), Std boost (2)	Fast (0), Standard (1)		Standard (1)			RW	Txt				US
00.017	Digital Input 6 Destination	**{08.026}**	0.000 to 59.999			0.000			RW	Num	DE		PT	US
	Current Reference Filter 1 Time Constant	**{04.012}**		0.0 to 25.0 ms			1.0 ms	2.0 ms	RW	Num				US
00.019	Analog Input 1 Mode	**{07.007}**	4-20mA Low (-4), 20-4mA Low (-3), 4-20mA Hold (-2), 20-4mA Hold (-1), 0-20mA (0), 20-0mA (1), 4-20mA Trip (2), 20-4mA Trip (3), 4-20mA (4), 20-4mA (5), Volt (6), Therm Short Cct (7), Thermistor (8), Therm No Trip (9)			4-20mA (4)			RW	Txt				US
00.020	Analog Input 1 Destination	**{07.010}**	00.000 to 59.999			01.036			RW	Num	DE		PT	US
00.021	Analog Input 2 Mode	**{07.011}**	4-20mA Low (-4), 20-4mA Low (-3), 4-20mA Hold (-2), 20-4mA Hold (-1), 0-20mA (0), 20-0mA (1), 4-20mA Trip (2), 20-4mA Trip (3), 4-20mA (4), 20-4mA (5), Volt (6), Therm Short Cct (7), Thermistor (8), Therm No Trip (9)			Volt (6)			RW	Txt				US

Parameter			Range			Default			Type					
			OL	RFC-A	RFC-S	OL	RFC-A	RFC-S						
00.022	Bipolar Reference Enable	**{01.010}**	Off (0) or On (1)			Off (0)			RW	Bit				US
00.024	Preset Reference 1	**{01.021}**	VM_SPEED_FREQ_REF Hz / rpm			0.0 Hz / rpm			RW	Num				US
00.025	Preset Reference 2	**{01.022}**	VM_SPEED_FREQ_REF Hz / rpm			0.0 Hz / rpm			RW	Num				US
00.026	Preset Reference 3	**{01.023}**	VM_SPEED_FREQ_REF Hz			0.0 Hz			RW	Num				US
	Overspeed Threshold	**{03.008}**		0 to 40000 rpm			0 rpm		RW	Num				US
00.027	Preset Reference 4	**{01.024}**	VM_SPEED_FREQ_REF Hz			0.0 Hz			RW	Num				US
00.029	NV Media Card Data Previously Loaded	**{11.036}**	0 to 999			0			RO	Num		NC	PT	
00.030	Parameter Cloning	**{11.042}**	None (0), Read (1), Program (2), Auto (3), Boot (4)			None (0)			RW	Txt		NC		US
00.031	Drive Rated Voltage	**{11.033}**	200 V (0), 400 V (1), 575 V (2), 690 V (3)						RO	Txt	ND	NC	PT	
00.033	Catch A Spinning Motor	**{06.009}**	Disable (0), Enable (1), Fwd Only (2), Rev Only (3)			Disable (0)			RW	Txt				US
00.034	User Security Code	**{11.030}**	0 to 2147483647			0			RW	Num	ND	NC	PT	US
00.035	Serial Mode	**{11.024}**	8 2 NP (0), 8 1 NP (1), 8 1 EP (2), 8 1 OP (3), 8 2 NP M (4), 8 1 NP M (5), 8 1 EP M (6), 8 1 OP M (7), 7 2 NP (8), 7 1 NP (9), 7 1 EP (10), 7 1 OP (11), 7 2 NP M (12), 7 1 NP M (13), 7 1 EP M (14), 7 1 OP M (15)			8 2 NP (0)			RW	Txt				US
00.036	Serial Baud Rate	**{11.025}**	300 (0), 600 (1), 1200 (2), 2400 (3), 4800 (4), 9600 (5), 19200 (6), 38400 (7), 57600 (8), 76800 (9), 15200 (10)			19200 (6)			RW	Txt				US
00.037	Serial Address	**{11.023}**	1 to 247			1			RW	Num				US
00.038	Current Controller Kp Gain	**{04.013}**	0 to 30000			20	150		RW	Num				US
00.039	Current Controller Ki Gain	**{04.014}**	0 to 30000			40	2000		RW	Num				US
00.040	Auto-tune	**{05.012}**	0 to 2		0, 1, 2, 6	0			RW	Num		NC		
00.041	Maximum Switching Frequency	**{05.018}**	2 kHz (0), 3 kHz (1), 4 kHz (2), 6 kHz (3), 8 kHz (4), 12 kHz (5), 16 kHz (6)			3 kHz (1)			RW	Txt		RA		US
00.042	Number Of Motor Poles	**{05.011}**	Automatic (0) to 480 Poles (240)			Automatic (0)		8 Poles (4)	RW	Num				US
00.043	Rated Power Factor*	**{05.010}**	0.000 to 1.000			0.850			RW	Num		RA		US
00.044	Rated Voltage	**{05.009}**	0 to VM_AC_VOLTAGE_SET V			200V drive: 230V 50Hz default 400V drive: 400V 60Hz default 400V drive: 460V 575V drive: 575V 690V drive: 690V			RW	Num		RA		US
00.045	Rated Speed	**{05.008}**	0 to 33000 rpm	0.00 to 33000.00 rpm		Eur - 1500 rpm USA - 1800 rpm	Eur - 1450.00 rpm USA - 1750.00 rpm	3000.00 rpm	RW	Num				US
00.046	Rated Current	**{05.007}**	0.000 to VM_RATED_CURRENT A			Maximum rated current (Pr **11.060**) A			RW	Num		RA		US
00.047	Rated Frequency	**{05.006}**	0.0 to 550.0 Hz			50 Hz: 50.0 60 Hz: 60.0			RW	Num				US
	Volts per 1000 rpm	**{05.033}**			0 to 10000 V / 1000 rpm			98 V / 1000 rpm	RW	Num				US
00.048	User Drive Mode	**{11.031}**	Open-loop (1), RFC-A (2), RFC-S (3)			Open-loop (1)	RFC-A (2)	RFC-S (3)	RW	Txt	ND	NC	PT	
00.049	User Security Status	**{11.044}**	Menu 0 (0), All Menus (1), Read-only Menu 0 (2), Read-only (3), Status Only (4), No Access (5)			Menu 0 (0)			RW	Txt	ND		PT	

Parameter			Range			Default			Type					
			OL	RFC-A	RFC-S	OL	RFC-A	RFC-S						
00.050	Software Version	**{11.029}**	0 to 99999999						RO	Num	ND	NC	PT	
00.051	Action On Trip Detection	**{10.037}**	00000 to 11111			00000			RW	Bin				US
00.052	Reset Serial Communications	**{11.020}**	Off (0) or On (1)			Off (0)			RW	Bit	ND	NC		
00.053	Motor Thermal Time Constant 1	**{04.015}**	1.0 to 3000.0 s			89.0 s			RW	Num				US
00.054	RFC Low Speed Mode	**{05.064}**			Injection (0), Non salient (1), Current (2), Current No Test (3), Current Step (4), Current Only (5)			Non-salient (1)	RW	Txt				US
00.055	Low Speed Sensorless Mode Current	**{05.071}**			0.0 to 1000.0 %			20.0 %	RW	Num		RA		US
00.056	No-load Lq	**{05.072}**			0.000 to 500.000 mH			0.000 mH	RW	Num		RA		US
00.057	Iq Test Current or Inductance Measurement	**{05.075}**			0 to 200 %			100 %	RW	Num				US
00.058	Phase Offset At Iq Test Current	**{05.077}**			±90.0 °			0.0 °	RW	Num		RA		US
00.059	Lq At The Defined Iq Test Current	**{05.078}**			0.000 to 500.000 mH			0.000 mH	RW	Num		RA		US
00.060	Id Test Current for Inductance Measurement	**{05.082}**			-100 to 0 %			-50 %	RW	Num				US
00.061	Lq At The Defined Id Test Current	**{05.084}**			0.000 to 500.000 mH			0.000 mH	RW	Num		RA		US

*Following a rotating autotune Pr **00.043** {05.010} is continuously written by the drive, calculated from the value of Stator Inductance (Pr **05.025**). To manually enter a value into Pr **00.043** {05.010}, Pr **05.025** will need to be set to 0. Please refer to the description of Pr **05.010** in the *Parameter Reference Guide* for further details.

RW	Read / Write	RO	Read only	Num	Number parameter	Bit	Bit parameter	Txt	Text string	Bin	Binary parameter	FI	Filtered
ND	No default value	NC	Not copied	PT	Protected parameter	RA	Rating dependent	US	User save	PS	Power-down save	DE	Destination

6.1 Parameter descriptions

6.1.1 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 6-1. The functions in Table 6-1 can also be selected by entering the appropriate numeric values (as shown in Table 6-2) in Pr **mm.000**. For example, enter 7001 in Pr **mm.000** to erase the file in NV media card location 001.

Table 6-1 Commonly used functions in Pr mm.000

String	Action
Save parameters	Save parameters under all conditions
Load file 1	Load the drive parameters or user program file from NV media card file 001
Save to file 1	Transfer the drive parameters to parameter file 001
Load file 2	Load the drive parameters or user program file from NV media card file 002
Save to file 2	Transfer the drive parameters to parameter file 002
Load file 3	Load the drive parameters or user program file from NV media card file 003
Save to file 3	Transfer the drive parameters to parameter file 003
Show non-default	Displays parameters that are different from defaults
Destinations	Displays parameters that are set
Reset 50Hz Defs	Load parameters with standard (50 Hz) defaults
Reset 60Hz Defs	Load parameters with US (60 Hz) defaults
Reset modules	Reset all option modules
Read Enc.NP P1	No function on F300
Read Enc.NP P2	No function on F300

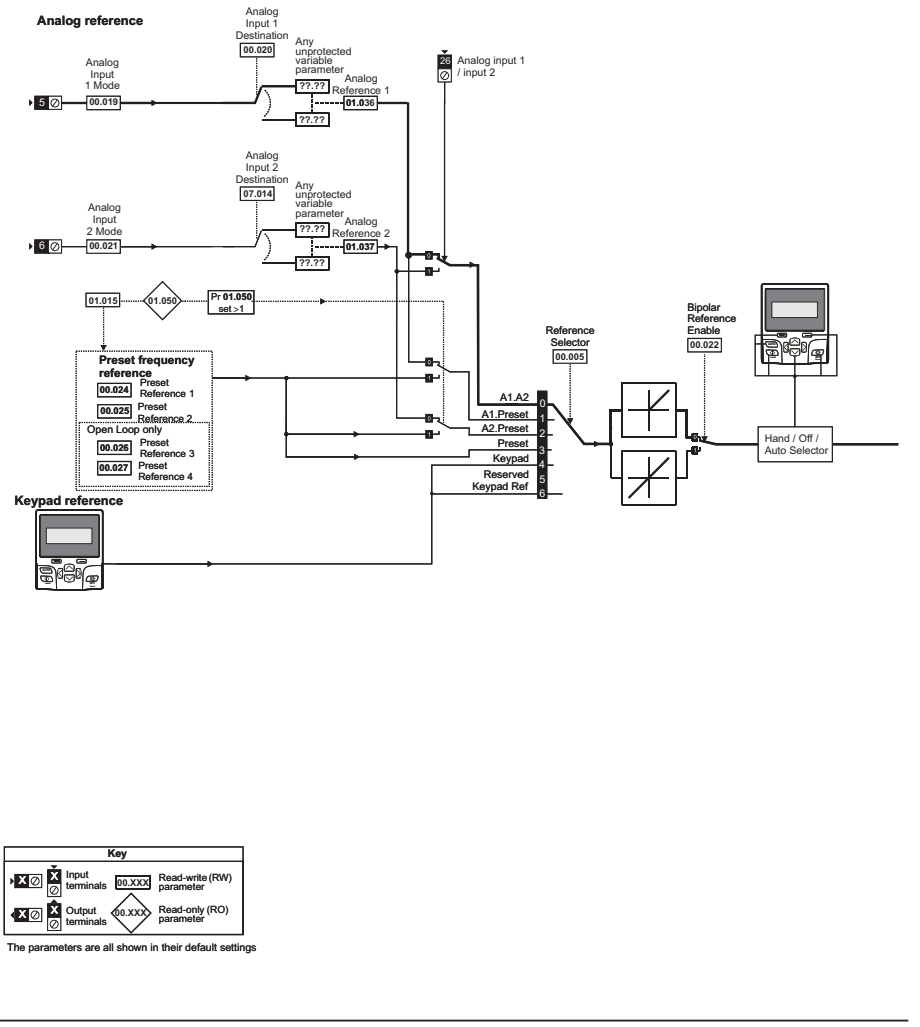
Table 6-2 Functions in Pr mm.000

Value	Action
1000	Save parameters when *Under Voltage Active* (Pr **10.016**) is not active and *Low Under Voltage Threshold Select* mode (Pr **06.067** = Off) is not active.
1001	Save parameter under all conditions
1070	Reset all option modules
1233	Load standard (50 Hz) defaults
1234	Load standard (50 Hz) defaults to all menus except option module menus (i.e 15 to 20 and 24 to 28)
1244	Load US (60 Hz) defaults
1245	Load US (60 Hz) defaults to all menus except option module menus (i.e 15 to 20 and 24 to 28)
1253	Change drive mode and load standard (50 Hz) defaults
1254	Change drive mode and load US (60 Hz) defaults
1255	Change drive mode and load standard (50 Hz) defaults except for menus 15 to 20 and 24 to 28
1256	Change drive mode and load US (60 Hz) defaults except for menus 15 to 20 and 24 to 28
1299	Reset {Stored HF} trip.
2001*	Create a boot file on a non-volatile media card based on the present drive parameters including all Menu 20 parameters
4yyy*	NV media card: Transfer the drive parameters to parameter file xxx
5yyy*	NV media card: Transfer the onboard user program to onboard user program file xxx
6yyy*	NV media card: Load the drive parameters from parameter file xxx or the onboard user program from onboard user program file xxx
7yyy*	NV media card: Erase file xxx
8yyy*	NV Media card: Compare the data in the drive with file xxx
9555*	NV media card: Clear the warning suppression flag
9666*	NV media card: Set the warning suppression flag
9777*	NV media card: Clear the read-only flag
9888*	NV media card: Set the read-only flag
9999*	NV media card: Erase and format the NV media card
12000**	Only display parameters that are different from their default value. This action does not require a drive reset.
12001**	Only display parameters that are used to set-up destinations (i.e. DE format bit is 1). This action does not require a drive reset.

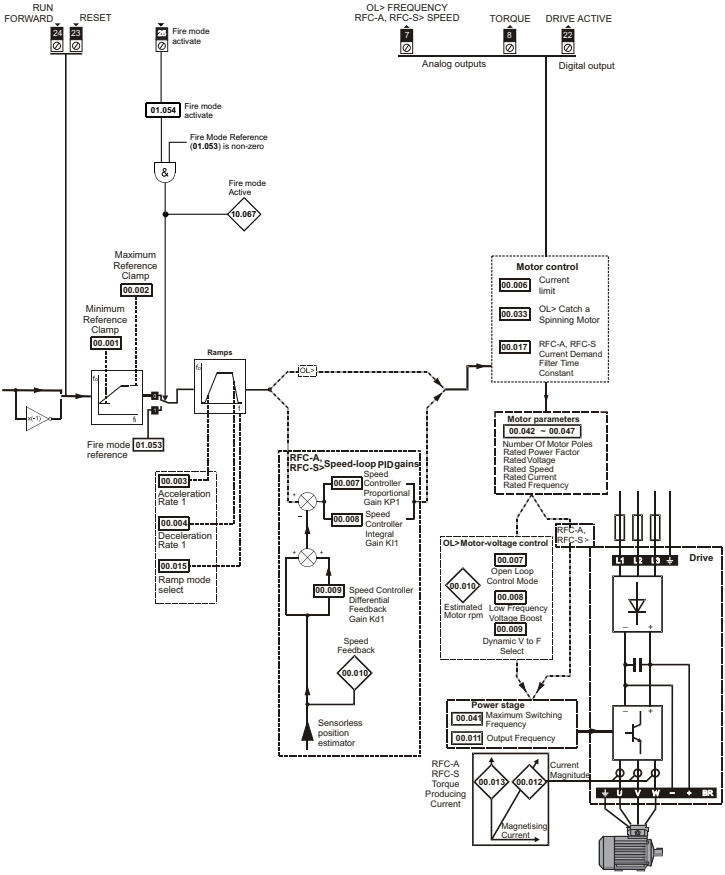
* See section 9 *NV Media Card Operation* on page 101 for more information on these functions.

** These functions do not require a drive reset to become active. All other functions require a drive reset to initiate the function.

Figure 6-1 Menu 0 logic diagram



The parameters are all shown in their default settings


RUN FORWARD
RESET
24
23
Fire mode activate
26
01.054
Fire mode activate
Fire Mode Reference (01.053) is non-zero
&
Fire mode Active
10.067
OL> FREQUENCY RFC-A, RFC-S> SPEED
TORQUE
DRIVE ACTIVE
7
8
22
Analog outputs
Digital output
Maximum Reference Clamp
00.002
Minimum Reference Clamp
00.001
Ramps
OL>
Motor control
00.006 Current limit
00.033 OL> Catch a Spinning Motor
00.017 RFC-A, RFC-S Current Demand Filter Time Constant
Motor parameters
00.042 ~ 00.047
Number Of Motor Poles
Rated Power Factor
Rated Voltage
Rated Speed
Rated Current
Rated Frequency
Fire mode reference
01.053
00.003 Acceleration Rate 1
00.004 Deceleration Rate 1
00.015 Ramp mode select
RFC-A RFC-S> Speed-loop PID gains
00.007 Speed Controller Proportional Gain KP1
00.008 Speed Controller Integral Gain KI1
00.009 Speed Controller Differential Feedback Gain Kd1
Speed Feedback
00.010
Sensorless position estimator
RFC-A, RFC-S>
OL> Motor-voltage control
00.007 Open Loop Control Mode
00.010 Estimated Motor rpm
00.008 Low Frequency Voltage Boost
00.009 Dynamic V to F Select
Power stage
00.041 Maximum Switching Frequency
00.011 Output Frequency
RFC-A RFC-S Torque Producing Current
00.013
00.012
Current Magnitude
Magnetising Current
L1 L2 L3
Drive
U V W
BR

7 Running the motor

This chapter takes the new user through all the essential steps to running a motor for the first time, in each of the possible operating modes.

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

The values of the motor parameters affect the protection of the motor.
The default values in the drive should not be relied upon.
It is essential that the correct value is entered in Pr **00.046** *Rated Current*. This affects the thermal protection of the motor.

If the drive is started using the keypad it will run to the speed defined by the keypad reference (Pr **01.017**). This may not be acceptable depending on the application. The user must check in Pr **01.017** and ensure that the keypad reference has been set to 0.

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 in the required mode. For minimal parameter settings to run in each mode please see the relevant part of section 7.2 *Quick Start / start-up* on page 69.

Table 7-1 Minimum control connection requirements for each control mode

Drive control method	Requirements
Terminal mode	Drive enable Speed / Torque reference Run forward / Run reverse
Keypad mode	Drive enable
Communications	Drive enable Communications link

Table 7-2 Minimum control connection requirements for each mode of operation

Operating mode	Requirements
Open loop mode	Induction motor
RFC - A sensorless (without feedback position)	Induction motor
RFC - S sensorless (without position feedback)	Permanent magnet motor

Figure 7-1 Minimum connections to get the motor running in any operating mode (size 3 and 4)

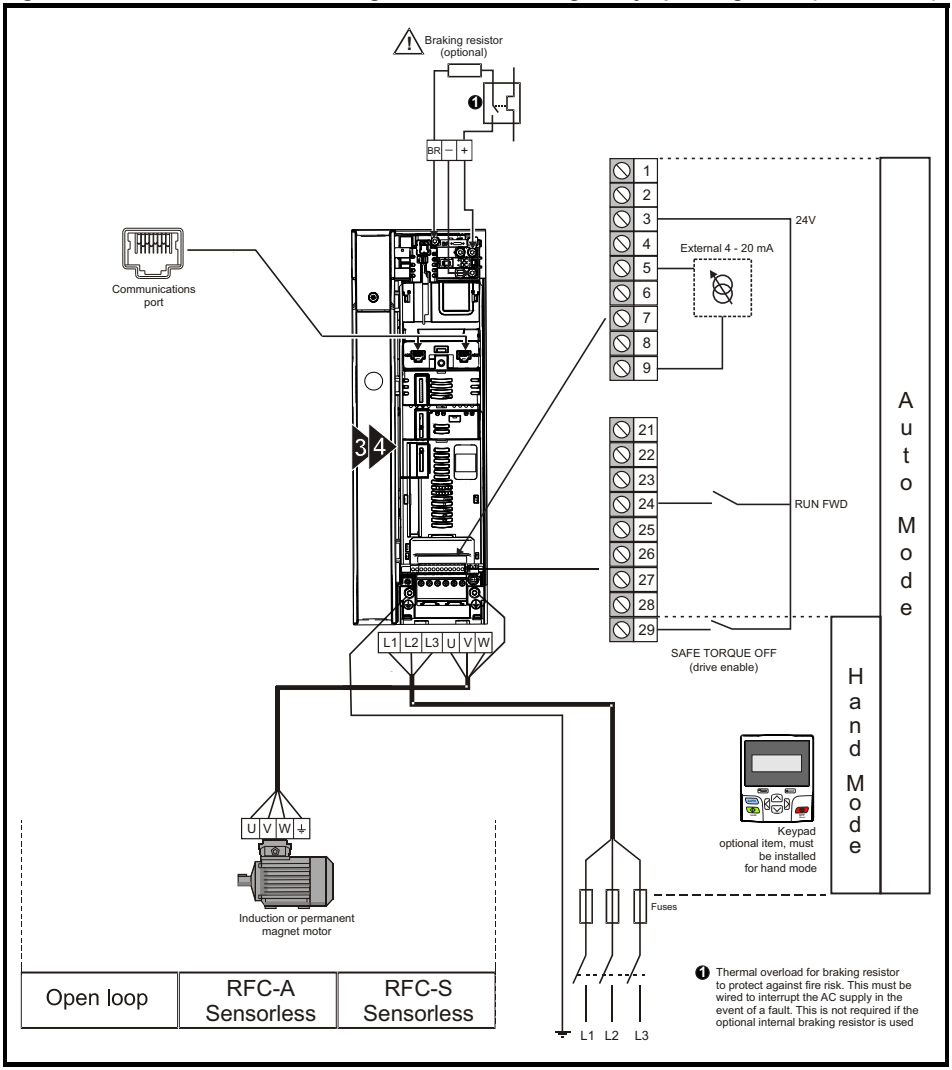


Figure 7-2 Minimum connections to get the motor running in any operating mode (size 5)

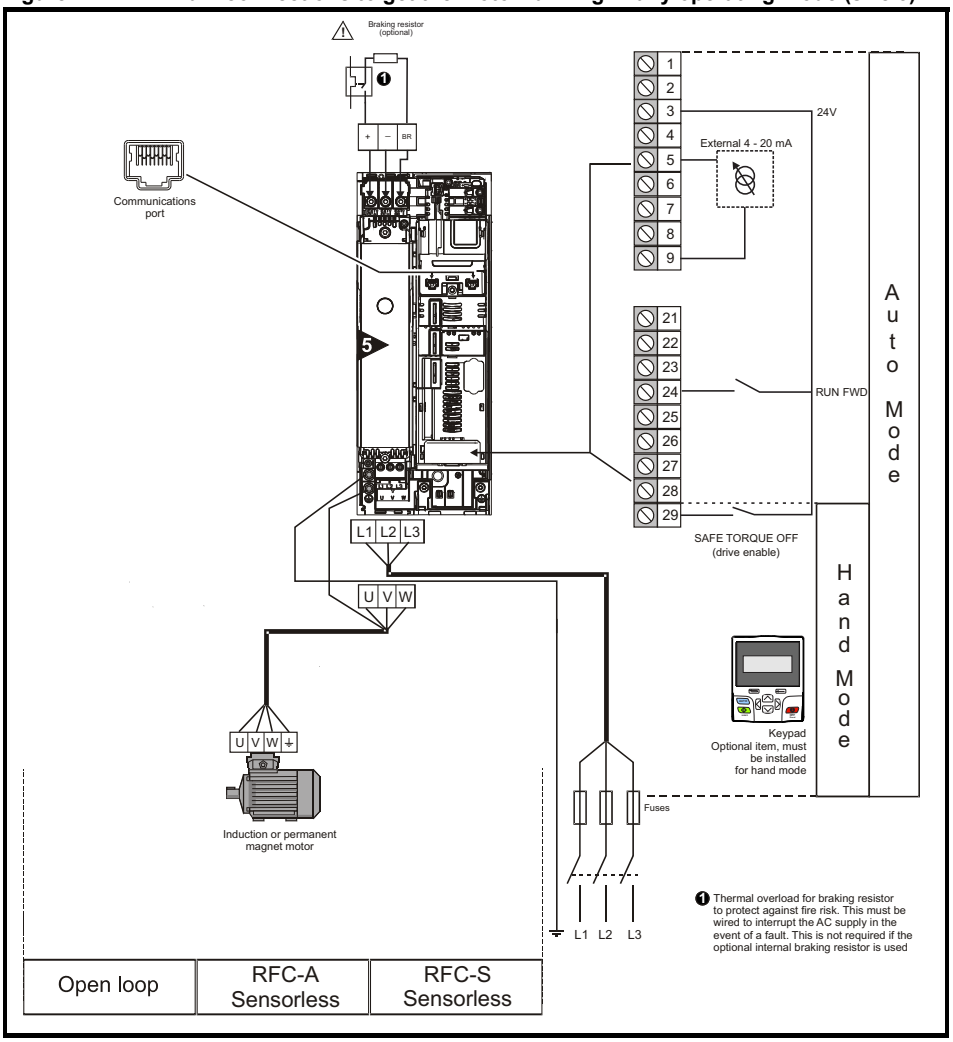


Figure 7-3 Minimum connections to get the motor running in any operating mode (size 6)

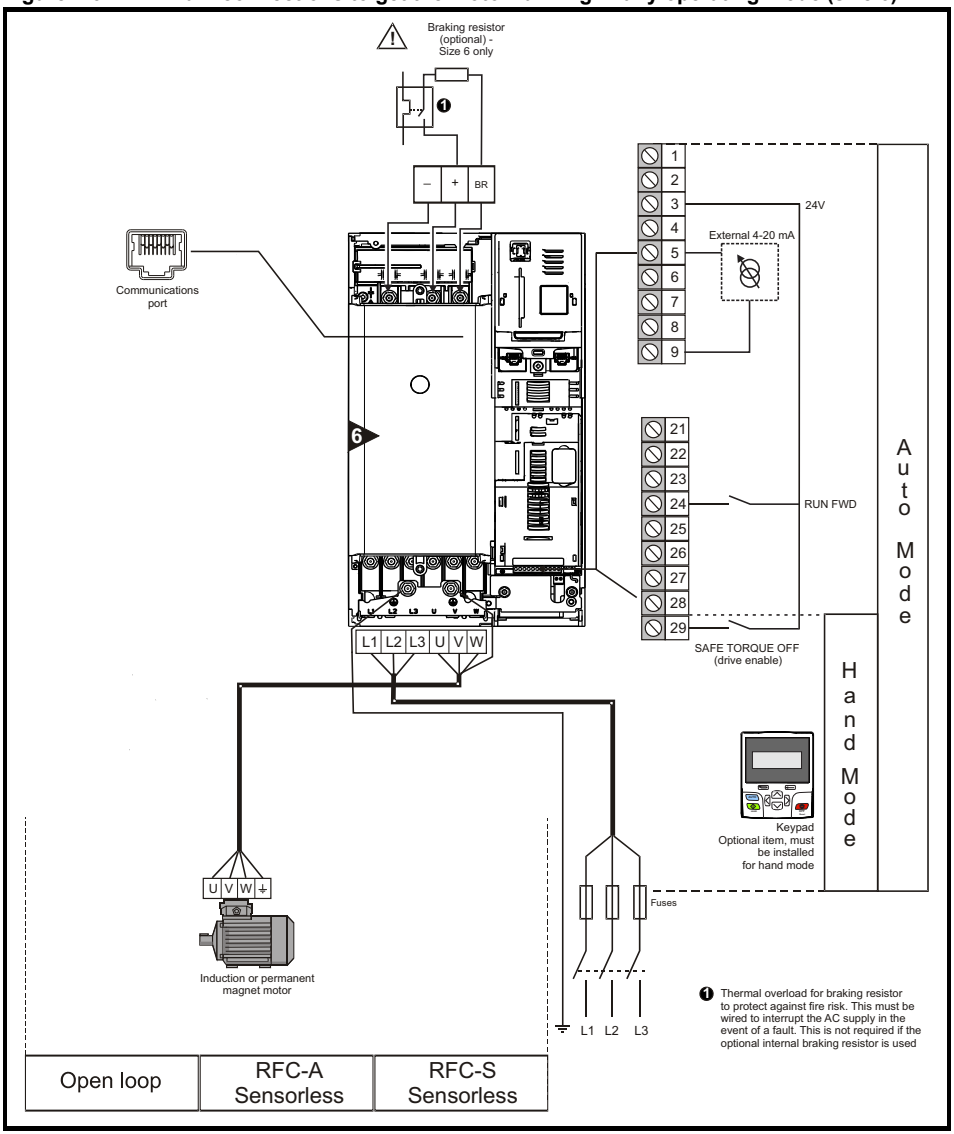
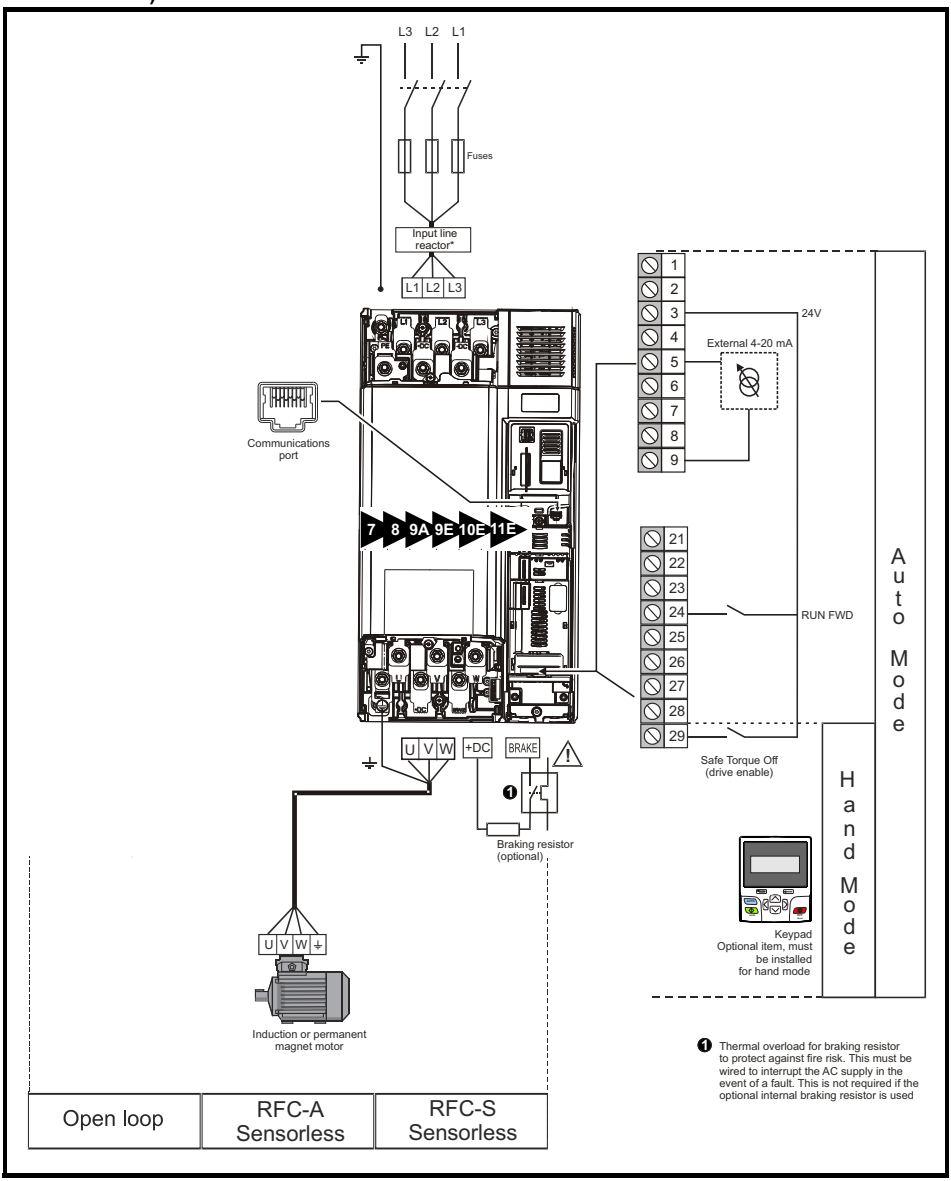


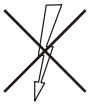
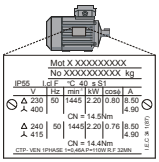
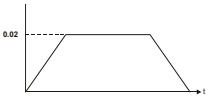
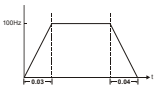
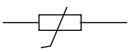
Figure 7-4 Minimum connections to get the motor running in any operating mode (size 7 to 11)

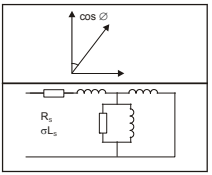


*Required for size 9E,10E and 11E.

7.2 Quick Start / start-up

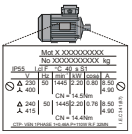
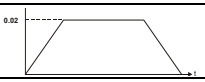
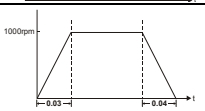
7.2.1 Open loop

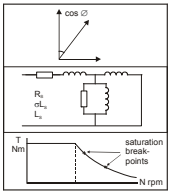
Action	Detail	
Before power-up	Ensure: • The drive enable signal is not given (terminal 29) • Run signal is not given • Motor is connected	
Power-up the drive	Verify that Open Loop mode is displayed as the drive powers up. If the mode is incorrect see section 5.6 *Changing the operating mode* on page 54. Ensure that the drive displays 'Inhibit'	
Enter motor nameplate details	Enter: • Motor rated frequency in Pr **00.047** (Hz) • Motor rated current in Pr **00.046** (A) • Motor rated speed in Pr **00.045** (rpm) • Motor rated voltage in Pr **00.044** (V) - check if ⅄ or △ connection	
Set maximum frequency	Enter: • Maximum frequency in Pr **00.002** (Hz)	
Set acceleration / deceleration rates	Enter: • Acceleration rate in Pr **00.003** (s to Pr **1.006**) • Deceleration rate in Pr **00.004** (s to Pr **1.006**) (If braking resistor installed, set Pr **00.015** = Fast. Also ensure Pr **10.030** and Pr **10.031** and Pr **10.061** are set correctly, otherwise premature 'Brake R Too Hot' trips may be seen).	
Motor thermistor set-up	The motor thermistor can be selected in Pr **07.011**. Refer to Pr **07.011** for further information.	

Action	Detail	
Autotune	The drive is able to perform either a stationary or a rotating autotune. The motor must be at a standstill before an autotune is enabled. A rotating autotune should be used whenever possible so the measured value of power factor of the motor is used by the drive. **WARNING** A rotating autotune will cause the motor to accelerate up to $^2/_3$ base speed in the direction selected regardless of the reference provided. Once complete the motor will coast to a stop. The enable signal must be removed before the drive can be made to run at the required reference. The drive can be stopped at any time by removing the run signal or removing the drive enable. • A stationary autotune can be used when the motor is loaded and it is not possible to uncouple the load from the motor shaft. A stationary autotune measures stator resistance and transient inductance of the motor and values relating to deadtime compensation from the drive. These are required for good performance in vector control modes. A stationary autotune does not measure the power factor of the motor so the value on the motor nameplate must be entered into Pr **00.043**. • A rotating autotune should only be used if the motor is uncoupled. A rotating autotune first performs a stationary autotune before rotating the motor at $^2/_3$ base speed in the direction selected. The rotating autotune measures the power factor of the motor. To perform an autotune: • Set Pr **00.040** = 1 for a stationary autotune or set Pr **00.040** = 2 for a rotating autotune • Close the Drive Enable signal (terminal 29). The drive will display 'Ready'. • Close the run signal (terminal 24). The upper row of the display will flash 'Auto Tune' while the drive is performing the autotune. • Wait for the drive to display 'Inhibit' and for the motor to come to a standstill. • Remove the drive enable and run signal from the drive.	
Save parameters	Select 'Save Parameters' in Pr **mm.000** (alternatively enter a value of 1001 in Pr **mm.000**) and press the red reset button or toggle the reset digital input.	
Run	Drive is now ready to run	

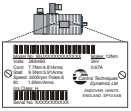
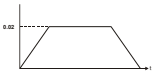
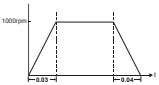
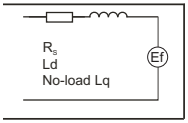
7.2.2 RFC-A mode (Sensorless)

Induction motor with sensorless control

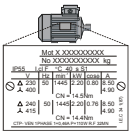
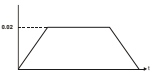
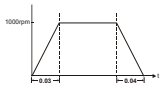
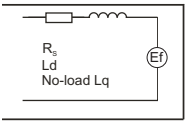
Action	Detail	
Before power-up	Ensure: • The drive enable signal is not given (terminal 29) • Run signal is not given • Motor is connected	
Power-up the drive	Verify that RFC-A mode is displayed as the drive powers up. If the mode is incorrect see section 5.6 *Changing the operating mode* on page 54, otherwise restore parameter defaults (see *section 5.8 Restoring parameter defaults* on page 55.) Ensure that the drive displays 'Inhibit'	
Enter motor nameplate details	Enter: • Motor rated frequency in Pr **00.047** (Hz) • Motor rated current in Pr **00.046** (A) • Motor rated speed in Pr **00.045** (rpm) • Motor rated voltage in Pr **00.044** (V) - check if ⅄ or Δ connection	
Set maximum speed	Enter: • Maximum speed in Pr **00.002** (rpm)	
Set acceleration / deceleration rates	Enter: • Acceleration rate in Pr **00.003** (s to Pr **01.006**) • Deceleration rate in Pr **00.004** (s to Pr **01.006**) (If braking resistor installed, set Pr **00.015** = Fast. Also ensure Pr **10.030** and Pr **10.031** and Pr **10.061** are set correctly, otherwise premature 'Brake R Too Hot' trips may be seen).	

Action	Detail	
Autotune	The drive is able to perform either a stationary or a rotating autotune. The motor must be at a standstill before an autotune is enabled. A stationary autotune will give moderate performance whereas a rotating autotune will give improved performance as it measures the actual values of the motor parameters required by the drive. **NOTE** It is highly recommended that a rotating autotune is performed (Pr **00.040** set to 2). **WARNING** A rotating autotune will cause the motor to accelerate up to $^{2}/_{3}$ base speed in the direction selected regardless of the reference provided. Once complete the motor will coast to a stop. The enable signal must be removed before the drive can be made to run at the required reference.The drive can be stopped at any time by removing the run signal or removing the drive enable. • A stationary autotune can be used when the motor is loaded and it is not possible to uncouple the load from the motor shaft. The stationary autotune measures the stator resistance and transient inductance of the motor and values relating to deadtime compensation from the drive. Measured values are used to calculate the current loop gains, and at the end of the test the values in Pr **00.038** and Pr **00.039** are updated. A stationary autotune does not measure the power factor of the motor so the value on the motor nameplate must be entered into Pr **00.043**. • A rotating autotune should only be used if the motor is uncoupled. A rotating autotune first performs a stationary autotune before rotating the motor at 2/3 base speed in the direction selected. The rotating autotune measures the stator inductance of the motor and calculates the power factor. To perform an autotune: • Set Pr **00.040** = 1 for a stationary autotune or set Pr **00.040** = 2 for a rotating autotune • Close the drive enable signal (terminal 29). The drive will display 'Inhibit'. • Close the run signal (terminal 24). The lower display will flash 'Autotune' while the drive is performing the autotune. • Wait for the drive to display 'Inhibit' and for the motor to come to a standstill. • Remove the drive enable and run signal from the drive.	
Save parameters	Select 'Save Parameters' in Pr **mm.000** (alternatively enter a value of 1001 in Pr **mm.000**) and press red reset button or toggle the reset digital input.	
Run	Drive is now ready to run	

7.2.3 RFC-S mode (Sensorless) Permanent magnet motor without position feedback

Action	Detail	
Before power-up	Ensure: • The drive enable signal is not given (terminal 29). • Run signal is not given • Motor is connected	
Power-up the drive	Verify that RFC-S mode is displayed as the drive powers up. If the mode is incorrect see section 5.6 *Changing the operating mode* on page 54, otherwise restore parameter defaults (see section 5.8 *Restoring parameter defaults* on page 55). Ensure that the drive displays 'inhibit'	
Enter motor nameplate details	Enter: • Motor rated current in Pr **00.046** (A) • Number of poles in Pr **00.042** • Motor rated voltage in Pr **00.044** (V)	
Set maximum speed	Enter: • Maximum speed in Pr **00.002** (rpm)	
Set acceleration / deceleration rates	Enter: • Acceleration rate in Pr **00.003** (s to Pr **01.006**) • Deceleration rate in Pr **00.004** (s to Pr **01.006**) (If braking resistor installed, set Pr **00.015** = Fast. Also ensure Pr **10.030** and Pr **10.031** and Pr **10.061** are set correctly, otherwise premature 'Brake R Too Hot' trips may be seen).	
Autotune	The drive is able to perform a stationary autotune. The motor must be at a standstill before an autotune is enabled. A stationary autotune will give moderate performance. • A stationary autotune is performed to locate the flux axis of the motor. The stationary autotune measures the stator resistance, inductance in flux axis, inductance in torque axis with no load on the motor and values relating to deadtime compensation from the drive. Measured values are used to calculate the current loop gains, and at the end of the test the values in Pr **00.038** and Pr **00.039** are updated. To perform an autotune: • Set Pr **00.040** = 1 or 2 for a stationary autotune. (Both perform the same tests). • Close the run signal (terminal 24). • Close the drive enable signal (terminal 29). The upper row of the display will flash 'Auto Tune' while the drive is performing the test. • Wait for the drive to display 'Inhibit'. • Remove the drive enabled and run signal from the drive.	
Check Saliency	In sensorless mode, when the motor speed is below Pr **00.045** / 10, a special low speed algorithm must be used to control the motor. There are two modes available, with the mode chosen based on the saliency of the motor. The ratio No-load Lq (Pr **00.056**) / Ld (Pr **05.024**) provides a measure of the saliency. If this value is > 1.1, then injection (0) mode may be used (this is the default). Non-salient (1) mode may be used (but with limitations). If this value is < 1.1, then Non-salient (1) mode must be used. Set Pr **00.054** for the selected mode: Injection (0) or Non-salient (1).	
Save parameters	Select 'Save Parameters' in Pr **mm.000** (alternatively enter a value of 1001 in Pr **mm.000**) and press red reset button or toggle the reset digital input.	
Run	Drive is now ready to run	

7.2.4 RFC-S mode (Sensorless) Dyneo LSRPM motor set-up with V01.12.02.00 onwards firmware

Action	Detail	
Before power-up	Ensure: • The drive enable signal is not given (terminal 29). • Run signal is not given • Motor is connected	
Power-up the drive	Verify that RFC-S mode is displayed as the drive powers up. If the mode is incorrect see section 5.6 *Changing the operating mode* on page 54, otherwise restore parameter defaults (see section 5.8 *Restoring parameter defaults* on page 55). Ensure that the drive displays 'inhibit'	
Enter motor nameplate details	Enter: • Motor rated current in Pr **00.046** (A)* • Rated speed in Pr **00.045** (rpm) • Volts per 1000 rpm in Pr **00.047** (V / 1000 rpm) Motor rated voltage Pr **00.044** and number of motor poles Pr **00.042** are also required but the default values in RFC-S mode for the Powerdrive F300 are set to match those required by the Dyneo LSRPM motor. From firmware version 01.12.xx.xx onwards, the rated current from the motor nameplate is entered into Pr **05.007** / Pr **00.046** and will be updated automatically to the sensorless value after an autotune.	
Enter motor thermal data and switching frequency	Enter: • Motor Thermal Time Constant value into Pr **00.053** (s) from the values specified inTable 7-3 to Table 7-9. • Switching frequency value into Pr **00.041** (kHz) from the values specified in Table 7-3 to Table 7-9.	
Set maximum speed	Enter: • Maximum speed in Pr **00.002** (rpm)	
Set acceleration / deceleration rates	Enter: • Acceleration rate in Pr **00.003** (s to Pr **01.006**) • Deceleration rate in Pr **00.004** (If braking resistor installed, set Pr **00.015** = Fast. Also ensure Pr **10.030** and Pr **10.031** and Pr **10.061** are set correctly, otherwise premature 'Brake R Too Hot' trips may be seen).	
Autotune	Perform a stationary autotune. The motor must be at a standstill before an autotune is enabled. To perform an autotune: • Set Pr **00.040** = 1 or 2 for a stationary autotune. (Both perform the same tests). • Close the run signal (terminal 24). • Close the drive enable signal (terminal 29). • The upper row of the display will flash 'Auto Tune' during the test. • Wait for the drive to display 'Inhibit'. If the drive trips it cannot be reset until the drive enable signal (terminal 29) has been removed. • Remove the drive enable from the drive. If no trip occurs during or after the autotune then this indicates that the drive has been correctly set-up and is ready to run the Dyneo LSRPM motor. If a User Trip 40 occurs, then this indicates that the motor rated current or motor rated speed was not recognized as being a valid value for a Dyneo LSRPM motor. Check the Rated Speed (Pr **00.045**) and Rated Current (Pr **00.046**) entered in the drive against the Dyneo LSRPM motors listed in Table 7-3 to Table 7-9. Correct the values and perform an autotune again.	

Action	Detail	
Check Saliency	In sensorless mode, when the motor speed is below Pr **00.045** / 10, a special low speed algorithm must be used to control the motor. There are five modes available, with the mode chosen based on the saliency of the motor. The Dyneo LSRPM motors have little or no saliency so require the non-salient low speed mode to be used. Set Pr **00.054** to: Non-salient (1). Non-salient mode requires the ramp rate to be no slower than 5 s / 1000 rpm when operating in the region below Rated Speed Pr **00.045** / 10. The drive contains a feature to ensure that the ramp rate during the low speed region is at least 4 s / 1000 rpm. This feature is enabled automatically after a successful set-up of the Dyneo LSRPM motor.	
Save parameters	Select 'Save Parameters' in Pr **mm.000** (alternatively enter a value of 1001 in Pr **mm.000**) and press red  reset button or toggle the reset digital input.	
Run	Drive is now ready to run**	

* When using V01.11.01.00 firmware the Sensorless motor rated current must be used rather than the nameplate value (see Table 7-3 to Table 7-9 on page 81).

** Under certain supply conditions instability may be seen at high speeds and high load.

If instability is experienced then the Current Loop P Gain (Pr **04.013**) should be reduced to half the original value.

Table 7-3 Dyneo LSRPM 1500 rpm motors

Dyneo LSRPM Motor model	Motor rated current (nameplate value) Pr 00.046* A	Sensorless motor rated current after autotune* A	Switching frequency Pr 00.041 kHz	Ke Pr 00.047 V / 1000 rpm	Motor Thermal Time Constant Pr 00.053 s
1500 LSRPM 90SL 3 kW	5.9	6.0	3	212	850
1500 LSRPM 100L 4.5 kW	8.6	8.6	3	223	850
1500 LSRPM 100L 6 kW	10.9	10.9	3	237	850
1500 LSRPM 132M 8.2 kW	16.0	17.3	3	232	1050
1500 LSRPM 132M 10.2 kW	19.9	20.6	3	234	1050
1500 LSRPM 132M 12 kW	23.0	23.6	3	237	1050
1500 LSRPM 160MP 15.6 kW	30.0	30.0	3	241	1050
1500 LSRPM 160MP 19.2 kW	37.0	37.0	3	242	1050
1500 LSRPM 160LR 22.8 kW	43.0	43.0	3	245	1050
1500 LSRPM 200L 25 kW	56.0	60.8	3	204	900
1500 LSRPM 200L 33 kW	65.5	69.0	3	218	900
1500 LSRPM 200L / 225ST1 40 kW	82.9	82.9	3	215	900
1500 LSRPM 200LU / 250MY 55 kW	110	110	3	221	900
1500 LSRPM 225MR1 70 kW	142	142	3	218	900
1500 LSRPM 250ME / 280SCM 85 kW	175	175	3	208	1150
1500 LSRPM 280SC 105 kW	215	215	3	210	1150
1500 LSRPM 280SD / 315SN 125 kW	245	245	3	228	1150
1500 LSRPM 280MK1 / 315MP1 145 kW	265	273	3	219	2600
1500 LSRPM 315SP1 175 kW	350	350	3	213	2600
1500 LSRPM 315MR1 220 kW	415	415	3	226	2600
1500 LSRPM 315MR1 250 kW	490	490	3	226	2600

* From firmware version 01.12.xx.xx onwards, the rated current from the motor nameplate is entered into Pr **05.007** / Pr **00.046** and will be updated automatically to the sensorless value after an autotune.

Table 7-4 Dyneo LSRPM 1800 rpm motors

Dyneo LSRPM Motor model	Motor rated current (nameplate value) Pr 00.046* A	Sensorless motor rated current after autotune* A	Switching frequency Pr 00.041 kHz	Ke Pr 00.047 V/1000 rpm	Motor Thermal Time Constant Pr 00.053 s
1800 LSRPM 132M 9.8 kW	19.0	19.8	3	188	1050
1800 LSRPM 132M 12.3 kW	24.0	24.7	3	197	1050
1800 LSRPM 132M 14.4 kW	28.0	28.0	3	191	1050
1800 LSRPM 160MP 18.7 kW	36.0	36.0	3	206	1050
1800 LSRPM 160MP 23 kW	42.9	42.9	3	204	1050
1800 LSRPM 160LR 27.3 kW	52.0	52.0	3	205	1050
1800 LSRPM 200L 33 kW	79.0	80.3	3	170	900
1800 LSRPM 200L 40 kW	82.5	85.0	3	172	900
1800 LSRPM 200L 55 kW	120	124	3	181	900
1800 LSRPM 225ST1 70 kW	145	145	3	182	900
1800 LSRPM 225MR1 85 kW	172	172	3	187	900
1800 LSRPM 250ME 100 kW	204	207	3	195	1150
1800 LSRPM 280SC 125 kW	248	248	3	183	1150
1800 LSRPM 280SD 150 kW	295	295	3	195	1150
1800 LSRPM 280MK1 175 kW	330	330	3	196	2600
1800 LSRPM 315SP1 195 kW	370	370	3	206	2600
1800 LSRPM 315MR1 230 kW	425	425	3	201	2600

* From firmware version 01.12.xx.xx onwards, the rated current from the motor nameplate is entered into Pr **05.007** / Pr **00.046** and will be updated automatically to the sensorless value after an autotune.

Table 7-5 Dyneo LSRPM 2400 rpm motors

Dyneo LSRPM Motor model	Motor rated current (nameplate value) Pr 00.046*	Sensorless motor rated current after autotune*	Switching frequency Pr 00.041	Ke Pr 00.047	Motor Thermal Time Constant Pr 00.053
	A	A	kHz	V/1000 rpm	s
2400 LSRPM 90SL 4.8 kW	9.1	9.4	4	145	850
2400 LSRPM 100L 7.2 kW	13.4	13.4	4	146	850
2400 LSRPM 100L 9.5 kW	17.7	17.7	4	151	850
2400 LSRPM 132M 13.1 kW	25.0	27.2	8	149	1050
2400 LSRPM 132M 16.3 kW	31.0	32.1	8	140	1050
2400 LSRPM 132M 19.2 kW	37.0	37.1	8	152	1050
2400 LSRPM 160MP 25 kW	47.0	47.0	8	153	1050
2400 LSRPM 160MP 31 kW	58.0	58.0	8	156	1050
2400 LSRPM 160LR 36 kW	69.0	69.0	8	156	1050
2400 LSRPM 200L 50 kW	110	110	4	136	900
2400 LSRPM 200L1 65 kW	137	137	4	128	900
2400 LSRPM 200L1 80 kW	160	164	4	145	900
2400 LSRPM 225MR1 100 kW	200	201	4	142	900
2400 LSRPM 250SE 125 kW	235	240	4	146	1150
2400 LSRPM 250ME 150 kW	285	288	4	146	1150
2400 LSRPM 280SD1 190 kW	350	361	4	152	1150
2400 LSRPM 280MK1 230 kW	429	429	4	147	2600

* From firmware version 01.12.xx.xx onwards, the rated current from the motor nameplate is entered into Pr **05.007** / Pr **00.046** and will be updated automatically to the sensorless value after an autotune.

Table 7-6 Dyneo LSRPM 3000 rpm motors

Dyneo LSRPM Motor model	Motor rated current (nameplate value) Pr 00.046* A	Sensorless motor rated current after autotune* A	Switching frequency Pr 00.041 kHz	Ke Pr 00.047 V/1000 rpm	Motor Thermal Time Constant Pr 00.053 s
3000 LSRPM 90SL 5.8 kW	11.0	11.1	4	120	850
3000 LSRPM 100L 8.7 kW	16.2	16.2	4	131	850
3000 LSRPM 100L 11.6 kW	21.0	21.0	4	134	850
3000 LSRPM 132M 15.8 kW	30.0	31.8	8	121	1050
3000 LSRPM 132M 19.7 kW	38.0	38.0	8	121	1050
3000 LSRPM 132M 23 kW	44.0	44.0	8	126	1050
3000 LSRPM 160MP 30 kW	57.0	57.0	8	127	1050
3000 LSRPM 160MP 37 kW	67.8	67.8	8	128	1050
3000 LSRPM 160LR 44 kW	82.0	82.0	8	129	1050
3000 LSRPM 200L 50 kW	111	116	4	109	900
3000 LSRPM 200L1 65 kW	126	136	4	118	900
3000 LSRPM 200L1 85 kW	170	170	4	125	900
3000 LSRPM 225ST2 110 kW	215	219	4	118	900
3000 LSRPM 250SE 145 kW	285	285	4	114	1150
3000 LSRPM 250ME1 170 kW	338	344	4	111	1150
3000 LSRPM 280SD1 200 kW	365	365	4	126	1150
3000 LSRPM 280SD1 220 kW	370	398	4	130	1150

* From firmware version 01.12.xx.xx onwards, the rated current from the motor nameplate is entered into Pr **05.007** / Pr **00.046** and will be updated automatically to the sensorless value after an autotune.

Table 7-7 Dyneo LSRPM 3600 rpm motors

Dyneo LSRPM Motor model	Motor rated current (nameplate value) Pr 00.046*	Sensorless motor rated current after autotune*	Switching frequency Pr 00.041	Ke Pr 00.047	Motor Thermal Time Constant Pr 00.053
	A	A	kHz	V/1000 rpm	s
3600 LSRPM 132M 17.6 kW	33.0	33.7	8	103	1050
3600 LSRPM 132M 22 kW	39.4	41.2	8	103	1050
3600 LSRPM 132M 26 kW	48.0	48.0	8	106	1050
3600 LSRPM 160MP 34 kW	63.0	63.0	8	106	1050
3600 LSRPM 160MP 41 kW	77.0	77.0	8	107	1050
3600 LSRPM 160LR 49 kW	91.0	91.0	8	110	1050
3600 LSRPM 200L1 70 kW	129	137	4	100	900
3600 LSRPM 200L1 85 kW	162	162	4	100	900
3600 LSRPM 200LU2 115 kW	217	232	4	103	900
3600 LSRPM 225SG 132 kW	250	250	4	103	1150
3600 LSRPM 250SE1 165 kW	330	330	4	96	1150
3600 LSRPM 250SE1 190 kW	350	360	4	106	1150
3600 LSRPM 280SD1 240 kW	420	429	4	108	1150

* From firmware version 01.12.xx.xx onwards, the rated current from the motor nameplate is entered into Pr **05.007** / Pr **00.046** and will be updated automatically to the sensorless value after an autotune.

Table 7-8 Dyneo LSRPM 4500 rpm motors

Dyneo LSRPM Motor model	Motor rated current (nameplate value) Pr 00.046*	Sensorless motor rated current after autotune*	Switching frequency Pr 00.041	Ke Pr 00.047	Motor Thermal Time Constant Pr 00.053
	A	A	kHz	V/1000 rpm	s
4500 LSRPM 132M 18.6 kW	35.0	35.0	8	86	1050
4500 LSRPM 132M 23 kW	44.0	44.0	8	84	1050
4500 LSRPM 132M 27 kW	51.0	51.0	8	83	1050
4500 LSRPM 160MP 35 kW	67.0	67.0	8	90	1050
4500 LSRPM 160MP 44 kW	81.0	81.0	8	92	1050
4500 LSRPM 160LR 52 kW	97.0	97.0	8	86	1050
4500 LSRPM 200L1 65 kW	130	142	8	82	900
4500 LSRPM 200L1 80 kW	160	172	8	82	900
4500 LSRPM 200L1 100 kW	200	200	8	79	900
4500 LSRPM 200L2 120 kW	230	230	8	82	900
4500 LSRPM 200LU2 135 kW	258	260	8	84	900
4500 LSRPM 225SR2 150 kW	262	281	8	91	900

* From firmware version 01.12.xx.xx onwards, the rated current from the motor nameplate is entered into Pr **05.007** / Pr **00.046** and will be updated automatically to the sensorless value after an autotune.

Table 7-9 Dyneo LSRPM 5500 rpm motors

Dyneo LSRPM Motor model	Motor rated current (nameplate value) Pr 00.046*	Sensorless motor rated current after autotune*	Switching frequency Pr 00.041	Ke Pr 00.047	Motor Thermal Time Constant Pr 00.053
	A	A	kHz	V/1000 rpm	s
5500 LSRPM 132M 18.6 kW	35.0	35.0	8	74	1050
5500 LSRPM 132M 23 kW	44.0	44.0	8	74	1050
5500 LSRPM 132M 27 kW	52.0	52.0	8	77	1050
5500 LSRPM 160MP 35 kW	67.0	67.0	8	76	1050
5500 LSRPM 160MP 44 kW	82.0	82.0	8	77	1050
5500 LSRPM 160LR 52 kW	97.0	97.0	8	77	1050
5500 LSRPM 200L1 70 kW	140	141	8	68	900
5500 LSRPM 200L1 85 kW	170	170	8	64	900
5500 LSRPM 200L1 100 kW	210	210	8	64	900
5500 LSRPM 200L2 140 kW	265	296	8	67	900

* From firmware version 01.12.xx.xx onwards, the rated current from the motor nameplate is entered into Pr **05.007** / Pr **00.046** and will be updated automatically to the sensorless value after an autotune.

7.3 Quick start commissioning / start-up using Powerdrive Connect (V02.00.00.00 onwards)

Powerdrive Connect is a Windows™ based software commissioning / start-up tool for Powerdrive F300. Powerdrive Connect can be used for commissioning / start-up and monitoring, drive parameters can be uploaded, downloaded and compared and simple or custom menu listings can be created. Drive menus can be displayed in standard list format or as live block diagrams. Powerdrive Connect is able to communicate with a single drive or a network. Powerdrive Connect can be downloaded from www.controltechniques.com (file size approximately 100 MB).

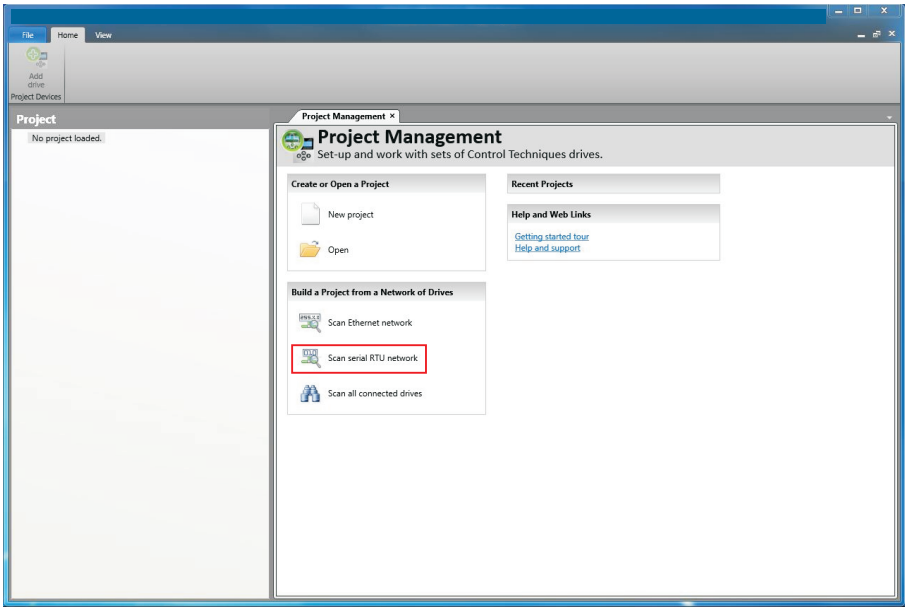
Powerdrive Connect system requirements

- Windows 8, Windows 7 SP1, Windows Vista SP2, Windows XP SP3
- Minimum of 1280 x 1024 screen resolution with 256 colours
- Microsoft.Net Frameworks 4.0 (this is provided in the downloaded file)
- Note that you must have administrator rights to install Powerdrive Connect

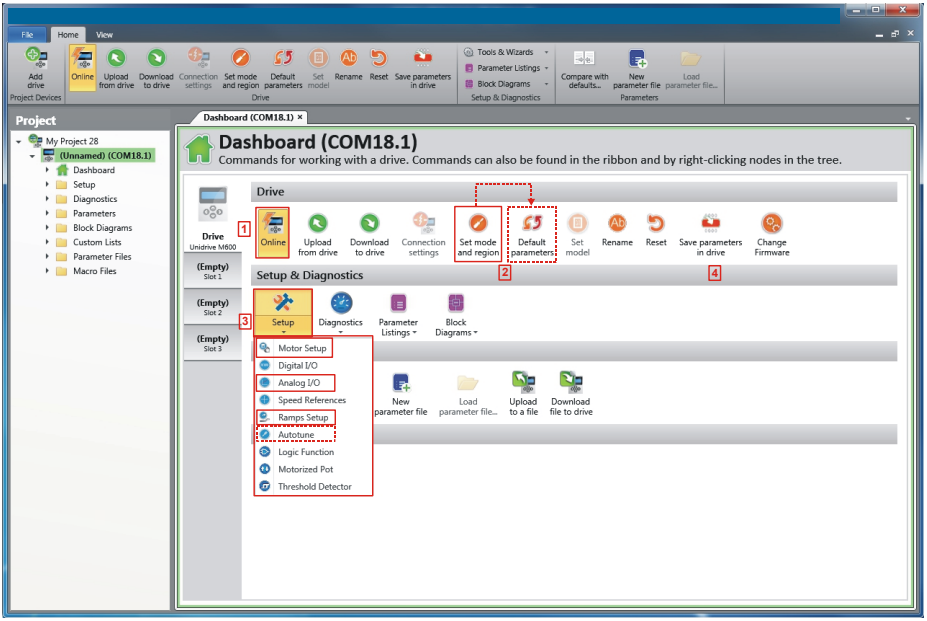
Any previous copy of Powerdrive Connect should be un-installed before proceeding with the installation (existing projects will not be lost). Included within Powerdrive Connect is the *Parameter Reference Guide* for Powerdrive.

7.3.1 Power-up the drive

1. Start Powerdrive Connect, and on the ‘Project Management’ screen select 'Scan serial RTU network' or 'Scan all connected drives’.



7.3.2 Select the discovered drive



1. Select the 'Online' icon to connect with the drive. When a successful connection is made the icon will be highlighted orange.
2. Select 'Set mode and region'.
   If the required control mode is highlighted in the 'Drive Settings' dialog, then:
   - Change the supply frequency, if required and select 'Apply', otherwise select 'Cancel'.
   - Select 'Default parameters' from the Dashboard and in the 'Default Parameters' dialogue, select 'Apply'

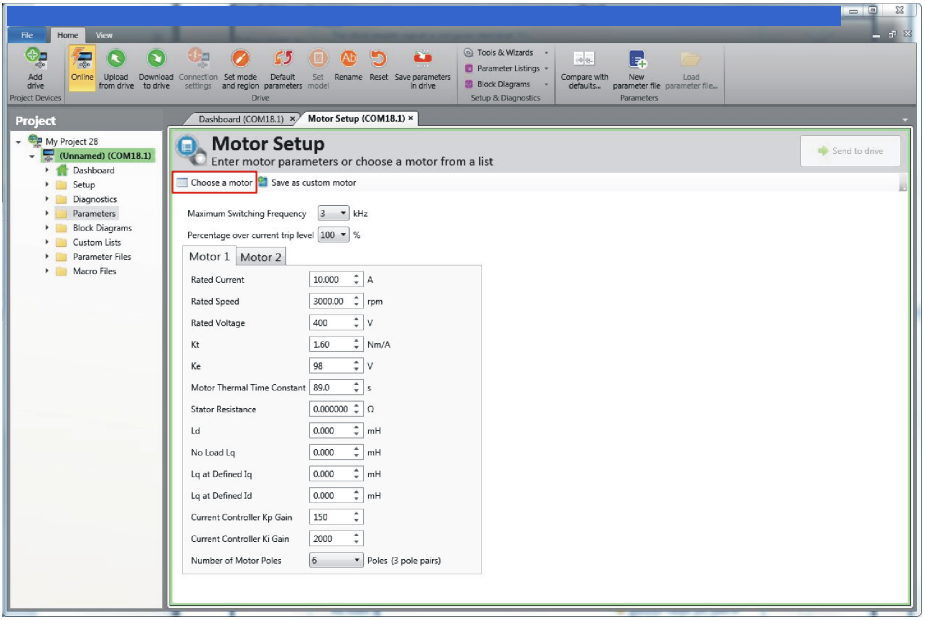
   If the required control mode is not highlighted in the 'Drive Settings' dialog then:
   - Select the required mode and supply frequency.
   - Select 'Apply'.
3. Select 'Set-up' and perform the steps highlighted (dotted lines indicate a step which may not need to be performed (see below):

Action	Detail
Motor Set-up	Powerdrive Connect contains a database for induction motors and permanent magnet motors. Provision is also made to enter motor nameplate data. The next section describes the use of the motor database for a Leroy Somer Dyneo LSRPM motor used in RFC-S Sensorless mode.
Analog I/O	The motor thermistor can be selected in Pr **07.011**. Refer to the parameter help for Pr **07.011** for further information.
Ramps Set-up	Enter the required Acceleration rate and Deceleration rate
Autotune	Not required when using data from the motor database for a Leroy Somer Dyneo LSRPM motor used in RFC-S Sensorless mode.

4. Select 'Save parameters in drive' to perform a parameter save. The drive is now ready to run.

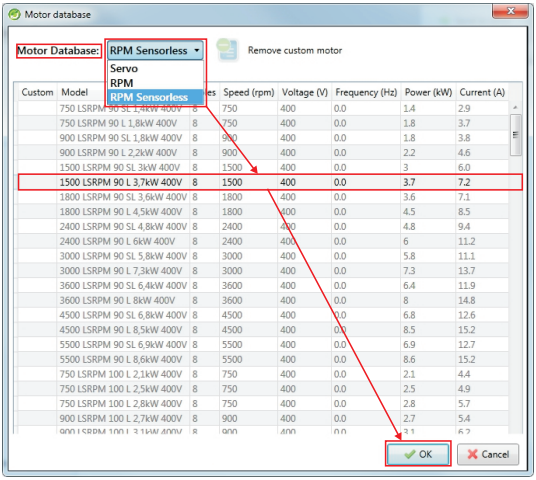
7.3.3 Use of the motor database for a Leroy Somer Dyneo LSRPM motor for use in RFC-S Sensorless mode

- Select 'Motor Set-up' from the 'Dashboard'.
- On the 'Motor Set-up' screen, select 'Choose a motor'.

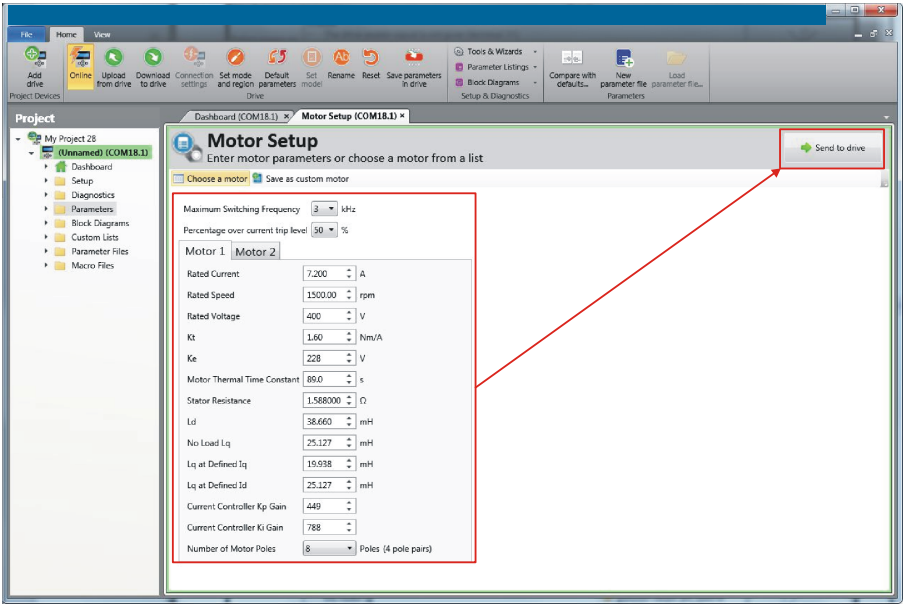


Select the required motor database:

7.3.4 Select the required motor from the list and click 'OK'



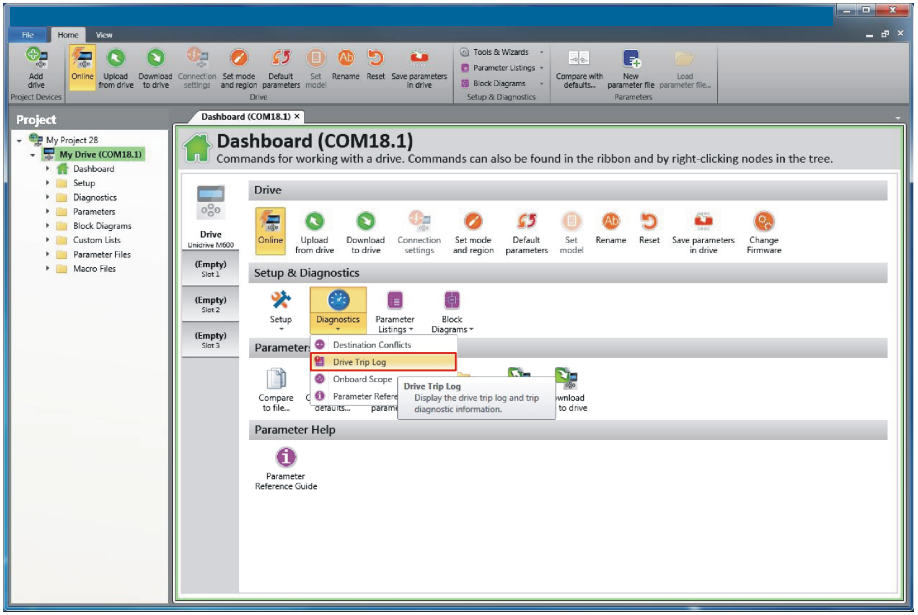
The data for the selected motor is displayed on the 'Motor Set-up' screen. Click 'Send to drive' to set the associated parameters.



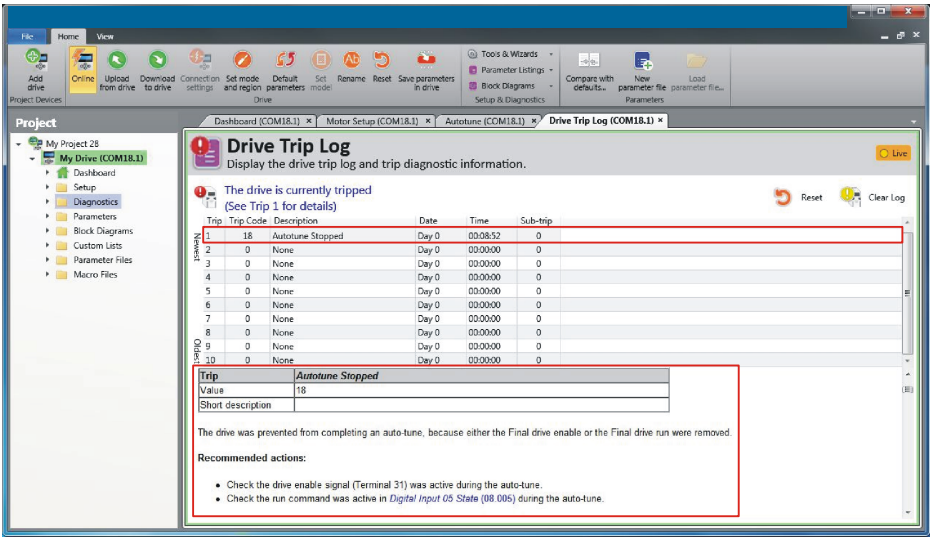
7.4 Diagnostics

If the drive trips, it is possible to interrogate the trip log from within Powerdrive Connect.

Select 'Drive Trip Log' from the 'Dashboard'.



The drive trip log shows the trip responsible for stopping the autotune and a description of the trip.



8 Optimization

This chapter takes the user through methods of optimizing the drive set-up and maximize the performance. The auto-tuning features of the drive simplify the optimization tasks

8.1 Motor map parameters

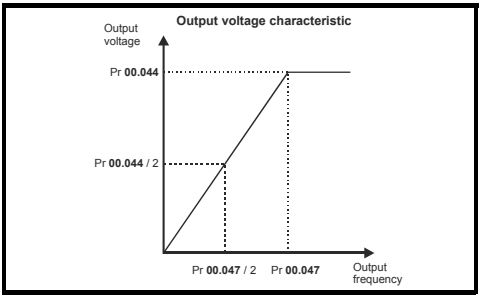
8.1.1 Open loop motor control

Pr 00.046 {05.007} ***Rated Current***	**Defines the maximum continuous motor current**

- The rated current parameter must be set to the maximum continuous current of the motor. The motor rated current is used in the following:
- Current limits (see section 8.3 *Switching frequency* on page 98, for more information).
- Motor thermal overload protection (see section 8.2 *Motor thermal protection* on page 97, for more information)
- Vector mode voltage control (see *Open Loop Control Mode* (00.007), later in this table)
- Slip compensation (see *Enable Slip Compensation* (05.027), later in this table)
- Dynamic V/F control

Pr 00.044 {05.009} ***Rated Voltage***	**Defines the voltage applied to the motor at rated frequency**
Pr 00.047 {05.006} ***Rated Frequency***	**Defines the frequency at which rated voltage is applied**

The *Rated Voltage* (00.044) and the *Rated Frequency* (00.047) are used to define the voltage to frequency characteristic applied to the motor (see *Open Loop Control Mode* (00.007), later in this table). The *Rated Frequency* (00.047) is also used in conjunction with the motor rated speed to calculate the rated slip for slip compensation (see *Rated Speed* (00.045), later in this table).



Pr 00.045 {05.008} ***Rated Speed***	**Defines the full load rated speed of the motor**
Pr 00.042 {05.011} ***Number Of Motor Poles***	**Defines the number of motor poles**

The motor rated speed and the number of poles are used with the motor rated frequency to calculate the rated slip of induction machines in Hz.

Rated slip (Hz) = Motor rated frequency - (Number of pole pairs x [Motor rated speed / 60]) =

$$\mathbf{00.047} = \left(\frac{\mathbf{00.042}}{\mathbf{2}} \times \frac{\mathbf{00.045}}{\mathbf{60}}\right)$$

If Pr **00.045** is set to 0 or to synchronous speed, slip compensation is disabled. If slip compensation is required this parameter should be set to the nameplate value, which should give the correct rpm for a hot machine. Sometimes it will be necessary to adjust this when the drive is commissioned because the nameplate value may be inaccurate. Slip compensation will operate correctly both below base speed and within the field-weakening region. Slip compensation is normally used to correct for the motor speed to prevent speed variation with load. The rated load rpm can be set higher than synchronous speed to deliberately introduce speed droop. This can be useful to aid load sharing with mechanically coupled motors.

Pr **00.042** is also used in the calculation of the motor speed display by the drive for a given output frequency. When Pr **00.042** is set to 'Automatic', the number of motor poles is automatically calculated from the rated frequency Pr **00.047**, and the motor rated speed Pr **00.045**.

Number of poles = 120 x (*Rated Frequency* (00.047) / *Rated Speed* (00.045)) rounded to the nearest even number.

Pr 00.043 {05.010} ***Rated Power Factor***	**Defines the angle between the motor voltage and current**

The power factor is the true power factor of the motor, i.e. the angle between the motor voltage and current. The power factor is used in conjunction with the *Rated Current* (00.046), to calculate the rated active current and magnetising current of the motor. The rated active current is used extensively to control the drive, and the magnetising current is used in vector mode stator resistance compensation. It is important that this parameter is set up correctly. The drive can measure the motor rated power factor by performing a rotating autotune (see Autotune (Pr **00.040**), below).

Pr 00.040 {05.012} Autotune	

There are two autotune tests available in open loop mode, a stationary and a rotating test. A rotating autotune should be used whenever possible so the measured value of power factor of the motor is used by the drive.

- A stationary autotune can be used when the motor is loaded and it is not possible to remove the load from the motor shaft. The stationary test measures the *Stator Resistance* (05.017) and *Transient Inductance* (05.024) which are required for good performance in vector control modes (see *Open Loop Control Mode* (00.007), later in this table). The stationary autotune does not measure the power factor of the motor so the value on the motor nameplate must be entered into Pr **00.043**. To perform a Stationary autotune, set Pr **00.040** to 1, and provide the drive with both an enable signal (on terminal 29) and a run signal (on terminal 24).

- A rotating autotune should only be used if the motor is unloaded. A rotating autotune first performs a stationary autotune, as above, then a rotating test is performed in which the motor is accelerated with currently selected ramps up to a frequency of *Rated Frequency* (05.006) x $^{2}/_{3}$, and the frequency is maintained at that level for 4 seconds. *Stator Inductance* (05.025) is measured and this value is used in conjunction with other motor parameters to calculate *Rated Power Factor* (05.010). To perform a Rotating autotune, set Pr **00.040** to 2, and provide the drive with both an enable signal (on terminal 29) and a run signal (on terminal 24).

Following the completion of an autotune test the drive will go into the inhibit state. The drive must be placed into a controlled disable condition before the drive can be made to run at the required reference. The drive can be put in to a controlled disable condition by removing the Safe Torque Off signal from terminal 29, setting the *Drive Enable* (06.015) to OFF (0) or disabling the drive via the *Control Word* (06.042) and *Control Word Enable* (06.043).

Pr 00.007 {05.014} *Open Loop Control Mode*

There are several voltage modes available which fall into two categories, vector control and fixed boost.

Vector control

Vector control mode provides the motor with a linear voltage characteristic from 0 Hz to motor *Rated Frequency* (00.047), and then a constant voltage above motor rated frequency. When the drive operates between motor rated frequency/50 and motor rated frequency/4, full vector based stator resistance compensation is applied. When the drive operates between motor rated frequency/4 and motor rated frequency/2 the stator resistance compensation is gradually reduced to zero as the frequency increases. For the vector modes to operate correctly the *Rated Power Factor* (00.043) and *Stator Resistance* (05.017) are required to be set up accurately. The drive can be made to measure these by performing an autotune (see Pr 00.040 *Autotune*). The drive can also be made to measure the stator resistance automatically every time the drive is enabled or the first time the drive is enabled after it is powered up, by selecting one of the vector control voltage modes.

(0) **Ur S =** The stator resistance is measured and the parameter for the selected motor map are over-written each time the drive is made to run. This test can only be done with a stationary motor where the flux has decayed to zero. Therefore this mode should only be used if the motor is guaranteed to be stationary each time the drive is made to run. To prevent the test from being done before the flux has decayed there is a period of 1 second after the drive has been in the ready state during which the test is not done if the drive is made to run again. In this case, previously measured values are used. Ur S mode ensures that the drive compensates for any change in motor parameters due to changes in temperature. The new value of stator resistance is not automatically saved to the drive's EEPROM.

(4) **Ur I =** The stator resistance is measured when the drive is first made to run after each power-up. This test can only be done with a stationary motor. Therefore this mode should only be used if the motor is guaranteed to be stationary the first time the drive is made to run after each power-up. The new value of stator resistance is not automatically saved to the drive's EEPROM.

(1) **Ur =** The stator resistance is not measured. The user can enter the motor and cabling resistance into the *Stator Resistance* (05.017). However this will not include resistance effects within the drive inverter. Therefore if this mode is to be used, it is best to use an autotune test initially to measure the stator resistance.

(3) **Ur_Auto =** The stator resistance is measured once, the first time the drive is made to run. After the test has been completed successfully the *Open Loop Control Mode* (00.007) is changed to Ur mode. The *Stator Resistance* (05.017) parameter is written to, and along with the *Open Loop Control Mode* (00.007), are saved in the drive's EEPROM. If the test fails, the voltage mode will stay set to Ur Auto and the test will be repeated next time the drive is made to run.

Fixed boost

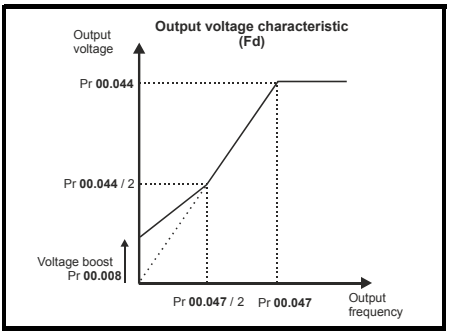
Neither the stator resistance nor the voltage offset are used in the control of the motor, instead a fixed characteristic with low frequency voltage boost as defined by Pr **00.008**, is used. Fixed boost mode should be used when the drive is controlling multiple motors. There are two settings of fixed boost available:

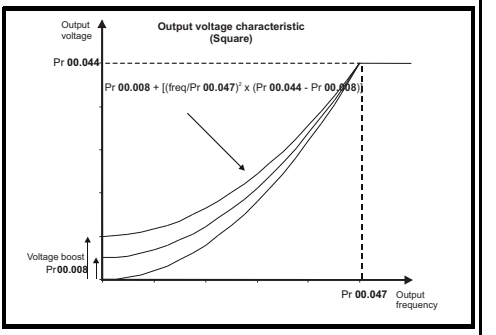
(2) **Fixed** = This mode provides the motor with a linear voltage characteristic from 0 Hz to *Rated Frequency* (00.047), and then a constant voltage above rated frequency.

(5) **Square** = This mode provides the motor with a square law voltage characteristic from 0 Hz to *Rated Frequency* (00.0 47), and then a constant voltage above rated frequency. This mode is suitable for variable torque applications like fans and pumps where the load is proportional to the square of the speed of the motor shaft. This mode should not be used if a high starting torque is required.

Pr 00.007 {05.014} *Open Loop Control Mode (cont)*

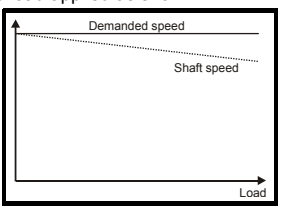
For both these modes, at low frequencies (from 0 Hz to ½ x Pr **00.047**) a voltage boost is applied defined by Pr **00.008** as shown below:





Pr 05.027 *Enable Slip Compensation*

When a motor, being controlled in open loop mode, has load applied a characteristic of the motor is that the output speed droops in proportion to the load applied as shown:



In order to prevent the speed droop shown above slip compensation should be enabled. To enable slip compensation Pr **05.027** must be set to a 1 (this is the default setting), and the motor rated speed must be entered in Pr **00.045** (Pr **05.008**).

The motor rated speed parameter should be set to the synchronous speed of the motor minus the slip speed. This is normally displayed on the motor nameplate, i.e. for a typical 18.5 kW, 50 Hz, 4 pole motor, the motor rated speed would be approximately 1465 rpm. The synchronous speed for a 50 Hz, 4 pole motor is 1500 rpm, so therefore the slip speed would be 35 rpm. If the synchronous speed is entered in Pr **00.045**, slip compensation will be disabled. If too small a value is entered in Pr **00.045**, the motor will run faster than the demanded frequency. The synchronous speeds for 50 Hz motors with different numbers of poles are as follows:

2 pole = 3000 rpm, 4 pole = 1500 rpm, 6pole =1000 rpm, 8 pole = 750 rpm

8.1.2 RFC-A Sensorless mode

Induction motor without position feedback

Pr 00.046 {05.007} ***Motor Rated Current***	**Defines the maximum motor continuous current**
The motor rated current parameter must be set to the maximum continuous current of the motor. The motor rated current is used in the following: • Motor thermal overload protection (see section 8.2 *Motor thermal protection* on page 97, for more information) • Vector control algorithm	
Pr 00.044 {05.009} ***Rated Voltage***	**Defines the voltage applied to the motor at rated frequency**
Pr 00.047 {05.006} ***Rated Frequency***	**Defines the frequency at which rated voltage is applied**
The motor rated voltage Pr **00.044** and the motor rated frequency Pr **00.047** are used to define the relationship between the voltage and frequency applied to the motor. The motor rated voltage is used by the field controller to limit the voltage applied to the motor. Normally this is set to the nameplate value. To allow current control to be maintained, it is necessary for the drive to leave some 'headroom' between the motor terminal voltage and the maximum available drive output voltage. For good transient performance at high speed, the motor rated voltage should be set below 95 % of the minimum supply voltage to the drive. The motor rated voltage and motor rated frequency are also used during the rotating autotune test (see Autotune Pr **00.040** later in this table) therefore, it is important that the correct value for motor rated voltage is used.	
Pr 00.045 {05.008} ***Rated Speed***	**Defines the full load rated speed of the motor**
Pr 00.042 {05.011} ***Number Of Motor Poles***	**Defines the number of motor poles**
The motor rated speed and motor rated frequency are used to determine the full load slip of the motor which is used by the vector control algorithm. Incorrect setting of this parameter has the following effects: • Reduced efficiency of motor operation • Reduction of maximum torque available from the motor • Reduced transient performance • Inaccurate control of absolute torque in torque control modes The nameplate value is normally the value for a hot motor; however, some adjustment may be required when the drive is commissioned if the nameplate value is inaccurate. When Pr **00.042** is set to 'Automatic', the number of motor poles is automatically calculated from the motor *Rated Frequency* (00.047), and the motor *Rated Speed* (00.045). Number of poles = 120 x (Motor *Rated Frequency* (00.047 / Motor *Rated Speed* (00.045) rounded to the nearest even number.	
Pr 00.043 {05.010} ***Rated Power Factor***	**Defines the angle between the motor voltage and current**
The power factor is the true power factor of the motor, i.e. the angle between the motor voltage and current. If the *Stator Inductance* (05.025) is set to zero then the power factor is used in conjunction with the motor *Rated Current* (00.046) and other motor parameters to calculate the rated active and magnetising currents of the motor, which are used in the vector control algorithm. If the stator inductance has a non-zero value this parameter is not used by the drive, but is continuously written with a calculated value of power factor. The stator inductance can be measured by the drive by performing a rotating autotune (see *Autotune* (Pr 00.040), later in this table).	

Pr 00.040 {05.012} *Autotune*

There are two autotune tests available in RFC-A mode, a stationary test, and a rotating test. A stationary autotune will give moderate performance whereas a rotating autotune will give improved performance as it measures the actual values of the motor parameters required by the drive.

It is highly recommended that a rotating autotune is performed (Pr **00.040** set to 2).

Autotune test 1:

- A stationary autotune can be used when the motor is loaded and it is not possible to remove the load from the motor shaft. The stationary autotune measures the *Stator Resistance* (05.017) and *Transient Inductance* (05.024) of the motor. These are used to calculate the current loop gains, and at the end of the test the values in Pr **04.013** and Pr **04.014** are updated. A stationary autotune does not measure the power factor of the motor so the value on the motor nameplate must be entered into Pr **00.043**. To perform a stationary autotune, set Pr **00.040** to 1, and provide the drive with both an enable signal (on terminal 29) and a run signal (on terminal 24).

Autotune test 2:

- A rotating autotune should only be used if the motor is unloaded. A rotating autotune first performs a stationary autotune, a rotating test is then performed in which the motor is accelerated with currently selected ramps up to a frequency of *Rated Frequency* (05.006) x 2/3, and the frequency is maintained at the level for up to 40 s. During the rotating autotune the *Stator Inductance* (05.025) is modified by the drive. The power factor is also modified for user information only, but is not used after this point as the stator inductance is used in the vector control algorithm instead. To perform a Rotating autotune, set Pr **00.040** to 2, and provide the drive with both an enable signal (on terminal 29) and a run signal (on terminal 24).

Following the completion of an autotune test the drive will go into the inhibit state. The drive must be placed into a controlled disable condition before the drive can be made to run at the required reference. The drive can be put in to a controlled disable condition by removing the Safe Torque Off signal from terminal 29, setting the *Drive Enable* (06.015) to OFF (0) or disabling the drive via the control word (Pr **06.042** & Pr **06.043**)

Pr 00.038 {04.013} / Pr 00.039 {04.014} *Current Loop Gains*

The current loop gains proportional (Kp) and integral (Ki) gains control the response of the current loop to a change in current (torque) demand. The default values give satisfactory operation with most motors. However, for optimal performance in dynamic applications it may be necessary to change the gains to improve the performance. The *Current Controller Kp Gain* (04.013) is the most critical value in controlling the performance. The values for the current loop gains can be calculated by performing a stationary or rotating autotune (see *Autotune* Pr **00.040**, earlier in this table) the drive measures the *Stator Resistance* (05.017) and *Transient Inductance* (05.024) of the motor and calculates the current loop gains.

This will give a step response with minimum overshoot after a step change of current reference. The proportional gain can be increased by a factor of 1.5 giving a similar increase in bandwidth; however, this gives a step response with approximately 12.5 % overshoot. The equation for the integral gain gives a conservative value. In some applications where it is necessary for the reference frame used by the drive to dynamically follow the flux very closely (i.e. high speed Sensorless RFC-A induction motor applications) the integral gain may need to have a significantly higher value.

***Speed Loop Gains* (Pr 00.007 {03.010}, Pr 00.008 {03.011}, Pr 00.009 {03.012})**

The speed loop gains control the response of the speed controller to a change in speed demand. The speed controller includes proportional (Kp) and integral (Ki) feed forward terms, and a differential (Kd) feedback term.

Speed Controller Proportional Gain (Kp), Pr **00.007** {**03.010**}

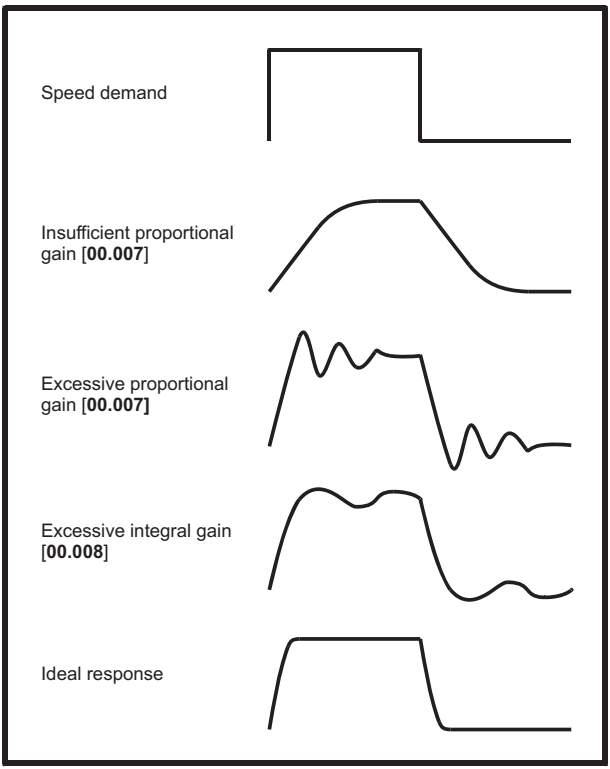
If the proportional gain has a value and the integral gain is set to zero the controller will only have a proportional term, and there must be a speed error to produce a torque reference. Therefore as the motor load increases there will be a difference between the reference and actual speeds. This effect, called regulation, depends on the level of the proportional gain, the higher the gain the smaller the speed error for a given load. If the proportional gain is too high either the acoustic noise produced by speed feedback quantization becomes unacceptable, or the stability limit is reached.

Speed Controller Integral Gain (Ki), Pr **00.008** {**03.011**}

The integral gain is provided to prevent speed regulation. The error is accumulated over a period of time and used to produce the necessary torque demand without any speed error. Increasing the integral gain reduces the time taken for the speed to reach the correct level and increases the stiffness of the system, i.e. it reduces the positional displacement produced by applying a load torque to the motor. Unfortunately increasing the integral gain also reduces the system damping giving overshoot after a transient. For a given integral gain the damping can be improved by increasing the proportional gain. A compromise must be reached where the system response, stiffness and damping are all adequate for the application. For RFC-A Sensorless mode, it is unlikely that the integral gain can be increased much above 0.50.

Differential Gain (Kd), Pr **00.009** {**03.012**}

The differential gain is provided in the feedback of the speed controller to give additional damping. The differential term is implemented in a way that does not introduce excessive noise normally associated with this type of function. Increasing the differential term reduces the overshoot produced by under-damping, however, for most applications the proportional and integral gains alone are sufficient.



8.1.3 RFC-S Sensorless mode

Permanent magnet motor without Position feedback

Pr 00.046 {05.007} *Rated Current*	**Defines the maximum motor continuous current**

The motor rated current parameter must be set to the maximum continuous current of the motor. The motor rated current is used in the following:

- Motor thermal overload protection (see section 8.2 *Motor thermal protection* on page 97, for more information)

Pr 00.042 {05.011} *Number Of Motor Poles*	**Defines the number of motor poles**

The number of motor poles parameter defines the number of electrical revolutions in one whole mechanical revolution of the motor. This parameter must be set correctly for the control algorithms to operate correctly. When Pr **00.042** is set to "Automatic" the number of poles is 6.

Pr 00.040 {05.012} *Autotune*	

There are three autotune tests available in RFC-S sensorless mode, a stationary autotune and a locked rotor test.

- Auto tune test 1: Stationary Autotune

The stationary autotune can be used to measure all the necessary parameters for basic control. The tests measures *Stator Resistance* (05.017), *Ld* (05.024) and *No Load Lq* (05.072). *The Stator Resistance* (05.017) and *Ld* (05.024) are then used to set up *Current controller Kp Gain* (04.013) and *Current Controller Ki Gain* (04.014). To perform a Stationary autotune, set Pr **00.040** to 1, and provide the drive with both an enable signal (on terminal 29) and a run signal (on terminal 24).

- Autotune test 2: Rotating Autotune

In sensorless mode, if Rotating autotune is selected (Pr **00.040** = 2), then a stationary autotune is performed.

Following the completion of an autotune test the drive will go into the inhibit state. The drive must be placed into a controlled disable condition before the drive can be made to run at the required reference. The drive can be put in to a controlled disable condition by removing the Safe Torque Off signal from terminal 29, setting the drive Enable Parameter (**06.015**) to OFF (0) or disabling the drive via the control word (Pr **06.042** & Pr **06.043**).

- Autotune test 6: Locked rotor test for load dependant parameters

This test is not implemented at the time of writing.

Pr 03.079 *Sensorless Mode Filter*	

When RFC-S sensorless mode is active the measured speed can include some ripple, which increases as the drive passes into field weakening. A filter is applied to the estimated speed and *Sensorless Mode Filter* (03.079) defines the time constant. The default time constant is 4 ms, but this can be extended to improve the filtering. This is particularly useful when using standard ramp or spinning start with a low friction high inertia load, and can prevent over voltage trips when the drive has no braking resistor.

Pr 05.064 *RFC Low Speed Mode* /
Pr 05.071 *Low Speed Sensorless Mode Current*

(0) Injection mode

For low speed sensorless operation with signal injection (*RFC Low Speed Mode* (05.064) = 0) it is necessary to have a ratio of Lq/Ld = 1.1. Even if a motor has a larger ratio on no load, this ratio normally reduces as the q axis current is increased from zero. *Low Speed Sensorless Mode Current* (05.071) should be set at a level that is lower than the point where the inductance ratio falls to 1.1. The value of this parameter is used to define the drive current limits when signal injection is active and prevent loss of control of the motor.

(1) Non-salient mode

For low speed sensorless operation for non-salient motors (*RFC Low Speed Mode* (05.064) = 1) this defines a current applied in the d axis to aid starting. For most motors and application requiring up to 60 % torque on starting the default value is suitable. However the level of current may need to be increased to make the motor start.

(2) Current

This method, which applies a rotating current vector at the frequency defined by the speed reference, can be used with any motor with no saliency or moderate saliency. It should only be used with motors where more of the torque is produced in conjunction with the magnet flux rather than from saliency torque. This mode does not provide the same level of control at low speed as injection mode, but is easier to set up and more flexible than "Non-salient" mode. The following should be considered:

1. A current specified by *Low Speed Sensorless Mode Current* (05.071) is applied when low speed mode is active. This current should be sufficient to start the motor with the highest expected load. If the motor has some saliency with no-load applied, and a suitable saturation characteristic, the drive can detect the rotor position and apply the current at the correct angle to avoid starting transient. If the motor is non-salient as defined by the conditions for Inductance trip then the drive will not attempt to detect the rotor position and the current will be applied at an arbitrary angle. This could cause a starting transient if the level of current applied is high, and so *Low Speed Sensorless Mode Current* (05.071) should not be set to a higher level than necessary. To minimise the movement as a result of applying the current, it is increased over the period defined by *Sensorless Mode Current Ramp* (05.063) in the form of a squared characteristic (i.e. it is increased with a low rate of change at the beginning and the rate of change is gradually increased).
2. As the level of current when low speed mode is active is not dependent on the applied load, but is as defined by *Low Speed Sensorless Mode Current* (05.071), and so the motor may become too hot if low speed mode is active for a prolonged period of time.
3. Generally *Low Speed Sensorless Mode Current* (05.071) should be set to a level higher than the expected maximum load, and can be set to a much higher level than the load if the saliency and saturation characteristic allow the position of the rotor to be detected on starting. However, *Low Speed Sensorless Mode Current* (05.071) should be matched more closely to the expected load under the following conditions: the load inertia is high compared to the motor interia, or there is very little damping/loss in the load system, or where the q axis inductance of the motor changes significantly with load.

(3) Current no test

The "Current" method is used, but no attempt is made to determine the position of the rotor before applying the current. This can be selected for example, if the motor does not have a suitable saturation characteristic to allow the rotor position to be determined during starting, or if faster starting is required. The initial current vector angle will be at an arbitary position with respect to the actual rotor position. As the vector sweeps round it must make the rotor start to rotate. If the ramp rate is too high the rotor may not keep up with the current vector and the motor may not start. If this is the case then the ramp rate should be reduced and/or the current used to start the motor should be increased.

(4) Current step

The current starting modes normally provide a smooth transition between the low speed current mode and normal running at higher speeds. If the drive accelerates very rapidly and only spends short periods of time in each mode the transition smoothing can malfunction. "Current step" mode is similar to "Current no test" mode except that the transition smoothing is disabled. It is not advisable to use this mode unless it is necessary as torque current and torque transients will occur when changing between low speed and normal running operation.

(5) Current only

The "Current" method is used, but no attempt is made to determine the position of the rotor before applying the current. The system remains in this starting mode at all speeds and does not change to the normal operating algorithms. This provides a very basic open-loop control method, that is not recommended for most applications. Flux weakening is not possible, and so this method will not operate correctly when the motor voltage approaches the maximum voltage avaialble from the drive.

Pr 00.017 {04.012} *Current Reference Filter 1 Time Constant*

Current Reference Filter 1 Time Constant (00.017 / 04.012) defines the time constant of a first order filter that can be applied to the *Final Current Reference* (04.004). The filter is provided to reduce acoustic noise and vibration produced as a result of position feedback quantisation. The filter introduces a lag in the speed controller loop, and so the speed controller gains may need to be reduced to maintain stability as the filter time constant is increased.

Pr 00.038 {04.013} / Pr 00.039 {04.014} *Current Loop Gains*

The current loop gains proportional (Kp) and integral (Ki) gains control the response of the current loop to a change in current (torque) demand. The default values give satisfactory operation with most motors. The proportional gain (Pr **04.013**) is the most critical value in controlling the performance. The values for the current loop gains can be calculated by performing a stationary or rotating autotune (see *Autotune* Pr **00.040**, earlier in this table) the drive measures the *Stator Resistance* (05.017) and *Transient Inductance* (05.024) of the motor and calculates the current loop gains.

***Speed Loop Gains* (Pr 00.007 {03.010}, Pr 00.008 {03.011}, Pr 00.009 {03.012})**

The speed loop gains control the response of the speed controller to a change in speed demand. The speed controller includes proportional (Kp) and integral (Ki) feed forward terms, and a differential (Kd) feedback term. **NOTE: In sensorless mode, the speed controller bandwidth may need to be limited to 10 Hz or less for stable operation.**

Speed Controller Proportional Gain (Kp), Pr **00.007** {**03.010**}

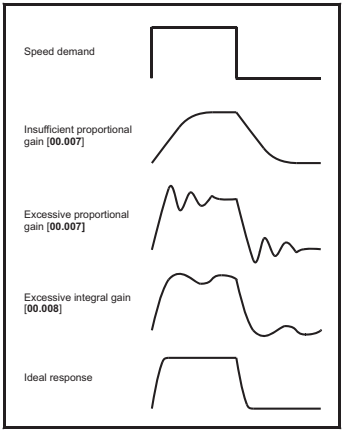
If the proportional gain has a value and the integral gain is set to zero the controller will only have a proportional term, and there must be a speed error to produce a torque reference. Therefore as the motor load increases there will be a difference between the reference and actual speeds. This effect, called regulation, depends on the level of the proportional gain, the higher the gain the smaller the speed error for a given load. If the proportional gain is too high either the acoustic noise produced by speed feedback quantization becomes unacceptable, or the stability limit is reached.

Speed Controller Integral Gain (Ki), Pr **00.008** {**03.011**}

The integral gain is provided to prevent speed regulation. The error is accumulated over a period of time and used to produce the necessary torque demand without any speed error. Increasing the integral gain reduces the time taken for the speed to reach the correct level and increases the stiffness of the system, i.e. it reduces the positional displacement produced by applying a load torque to the motor. Unfortunately increasing the integral gain also reduces the system damping giving overshoot after a transient. For a given integral gain the damping can be improved by increasing the proportional gain. A compromise must be reached where the system response, stiffness and damping are all adequate for the application. For RFC-A Sensorless mode, it is unlikely that the integral gain can be increased much above 0.50.

Differential Gain (Kd), Pr **00.009** {**03.012**}

The differential gain is provided in the feedback of the speed controller to give additional damping. The differential term is implemented in a way that does not introduce excessive noise normally associated with this type of function. Increasing the differential term reduces the overshoot produced by under-damping, however, for most applications the proportional and integral gains alone are sufficient.



8.2 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)

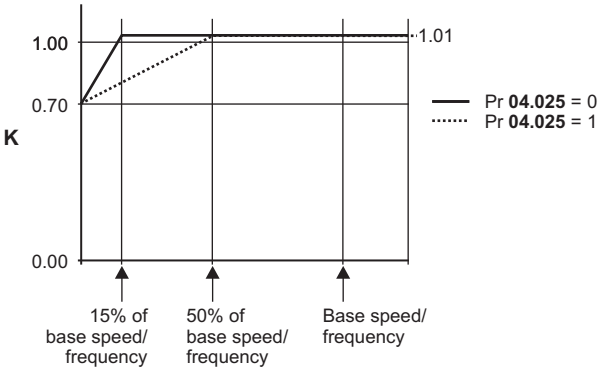
K_2 = *Motor Thermal Time Constant 2 Scaling* (04.038) / 100 %

$\tau 1$ = *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 (Normal Duty)



Both settings of Pr **04.025** are intended for motors where the cooling effect of the motor fan reduces with reduced motor speed, but with different speeds below which the cooling effect is reduced. If Pr **04.025** is 0 the characteristic is intended for motors where the cooling effect reduces with motor speed below 15 % of base speed/frequency. If Pr **04.025** is 1 the characteristic is intended for motors where the cooling effect reduces with motor speed below 50 % 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 takes some action depending on the setting of Pr **04.016**. If Pr **04.016** is 0, the drive trips when Pr **04.019** reaches 100 %. If Pr **04.016** is 1, the current limit is reduced to (K - 0.05) x 100 % when Pr **04.019** reaches 100 %.

The current limit is set back to the user defined level when Pr **04.019** falls below 95 %. 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. If the rated current defined by Pr **05.007** is altered, the accumulator is reset to zero.

The default setting of the thermal time constant (Pr **04.015**) is 89 s which is equivalent to an overload of 110 % for 165 s from cold.

Fire Mode - Important Warning.
When Fire Mode is active the motor overload and thermal protection are disabled, as well as a number of drive protection functions. Fire Mode is provided for use only in emergency situations where the safety risk from disabling protection is less than the risk from the drive tripping - typically in smoke extraction operation to permit evacuation of a building. The use of Fire Mode itself causes a risk of fire from overloading of the motor or drive, so it must only be used after careful consideration of the balance of risks.

Care must be taken to prevent inadvertent activation or de-activation of Fire Mode. Fire Mode is indicated by a flashing display text warning "Fire mode active".

Care must be taken to ensure that parameters Pr **01.053** or Pr **01.054** are not inadvertently re-allocated to different inputs or variables. It should be noted that, by default, Pr **01.054** is controlled from digital input 4 and changing Pr **08.024** can re-allocate this digital input to another parameter. These parameters are at access level 2 in order to minimize the risk of inadvertent or unauthorized changes. It is recommended that User Security be applied to further reduce the risk (see section 5.11 *Parameter access level and security* on page 55). These parameters may also be changed via serial communications so adequate precautions should be taken if this functionality is utilized.

8.3 Switching frequency

The default switching frequency is 3 kHz, however this can be increased up to a maximum of 16 kHz by Pr **05.018** (dependent on drive size). The available switching frequencies are shown below.

Table 8-1 Available switching frequencies

Drive size	Model	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
3	All	✓	✓	✓	✓	✓	✓	✓
4								
5								
6								
7								
8								
9A								
9E								
10E								
11E	400 V	✓	✓	✓	✓	✓		
11E	575 and 690 V	✓	✓	✓				

If the switching frequency is increased from 3 kHz the following apply:

1. Increased heat loss in the drive, which means that derating to the output current must be applied. See the derating tables for switching frequency and ambient temperature in the *Drive User Guide*.
2. Reduced heating of the motor - due to improved output waveform quality.
3. Reduced acoustic noise generated by the motor.
4. Increased sample rate on the speed and current controllers.

A trade off must be made between motor heating, drive heating and the demands of the application with respect to the sample time required.

Table 8-2 Sample rates for various control tasks at each switching frequency

	3, 6, 12 kHz	2, 4, 8, 16 kHz	Open loop	RFC-A / RFC-S
Level 1	3 kHz = 167µs 6 kHz = 83 µs 12 kHz = 83 µs	2 kHz = 250 µs 4 kHz = 125 µs 8 kHz = 62.5 µs 16 kHz = 62.5 µs	Peak limit	Current controllers
Level 2	250 µs	2 kHz -500 µs 4 kHz - 250 µs 8 kHz - 125 µs 16 kHz - 125 µs	Current limit and ramps	Speed controller and ramps
Level 3	1 ms		Voltage controller	
Level 4	4 ms		Time critical user interface	
Background			Non-time critical user interface	

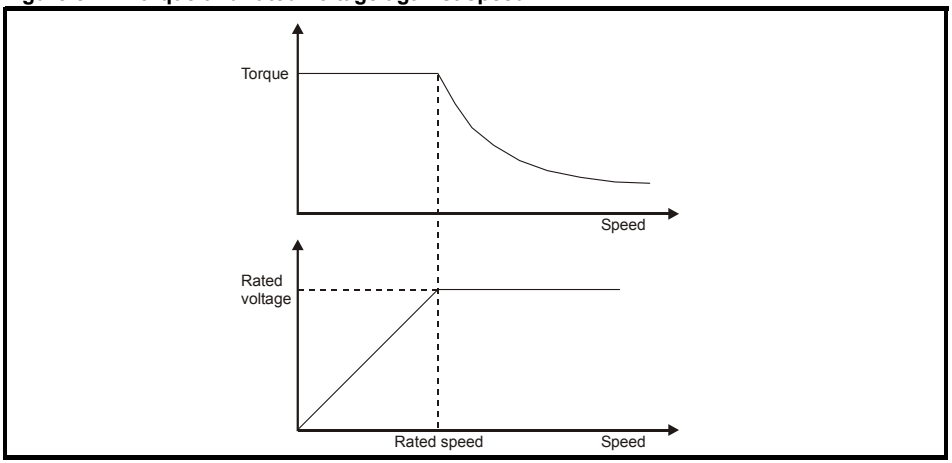
8.4 High speed operation

8.4.1 Field weakening (constant power) operation

(Open loop and RFC-A mode only)

The drive can be used to run an induction machine above synchronous speed into the constant power region. The speed continues to increase and the available shaft torque reduces. The characteristics below show the torque and output voltage characteristics as the speed is increased above the rated value.

Figure 8-2 Torque and rated voltage against speed



Care must be taken to ensure the torque available above base speed is sufficient for the application to run satisfactorily.

8.4.2 Permanent magnet motor high speed operation

High speed servo mode is enabled by setting Pr **05.022** =1. Care must be taken when using this mode with permanent magnet motor to avoid damaging the drive. The voltage produced by the permanent magnet motor magnets is proportional to speed. For high speed operation the drive must apply currents to the motor to counter-act the flux produced by the magnets. It is possible to operate the motor at very high speeds that would give a very high motor terminal voltage, but this voltage is prevented by the action of the drive.

If however, the drive is disabled (or tripped) when the motor voltages would be higher than the rating of the drive without the currents to counter-act the flux from the magnets, it is possible to damage the drive. If high speed mode is enabled the motor speed must be limited to the levels given in the table below unless an additional hardware protection system is used to limit the voltages applied to the drive output terminals to a safe level.

Drive voltage rating	Maximum motor speed (rpm)	Maximum safe line to line voltage at the motor terminals (V rms)
200	400 x 1000 / (Ke x √2)	400 / √2
400	800 x 1000 / (Ke x √2)	800 / √2
575	955 x 1000 / (Ke x √2)	955 / √2
690	1145 x 1000 / (Ke x √2)	1145 / √2

Ke is the ratio between r.m.s. line to line voltage produced by the motor and the speed in V/1000 rpm. Care must also be taken not to de-magnetize the motor. The motor manufacturer should always be consulted before using this mode.

By default, high speed operation is disabled (Pr **05.022** = 0).

It is also possible to enable high speed operation, and allow the drive to automatically limit the motor speed to the levels specified in the tables and generate an Overspeed. 1 trip if the levels are exceeded (Pr **05.022** = -1)

8.4.3 Maximum speed / frequency

In all operating modes (Open loop, RFC-A and RFC-S) the maximum output frequency is limited to 550 Hz. However, in RFC-S mode the speed is also limited by the voltage constant (Ke) of the motor. Ke is a specific constant for the servo motor being used. It can normally be found on the motor data sheet in V/k rpm (volts per 1,000 rpm).

8.4.4 Quasi-Square wave (open-loop only)

The maximum output voltage level of the drive is normally limited to an equivalent of the drive input voltage minus voltage drops within the drive (the drive will also retain a few percent of the voltage in order to maintain current control). If the motor rated voltage is set at the same level as the supply voltage, some pulse deletion will occur as the drive output voltage approaches the rated voltage level. If Pr **05.020** (Quasi-square wave enable) is set to 1 the modulator will allow over modulation, so that as the output frequency increases beyond the rated frequency the voltage continues to increase above the rated voltage. The modulation depth will increase beyond unity; first producing trapezoidal and then quasi-square waveforms.

This can be used for example:

- To obtain high output frequencies with a low switching frequency which would not be possible with space vector modulation limited to unity modulation depth,

or

- In order to maintain a higher output voltage with a low supply voltage.

The disadvantage is that the machine current will be distorted as the modulation depth increases above unity, and will contain a significant amount of low order odd harmonics of the fundamental output frequency. The additional low order harmonics cause increased losses and heating in the motor.

9 NV Media Card Operation

9.1 Introduction

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

The NV Media Card can be used for:

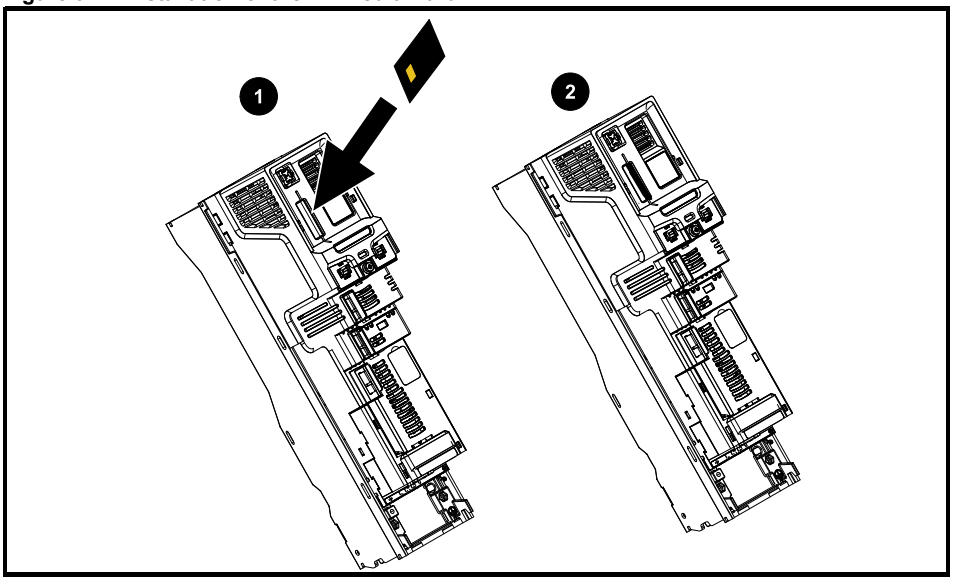
- Parameter copying between drives
- Saving drive parameter sets
- Saving a program

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

Ensure 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".

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
8 kB SMARTCARD	2214-4246
64 kB SMARTCARD	2214-1006

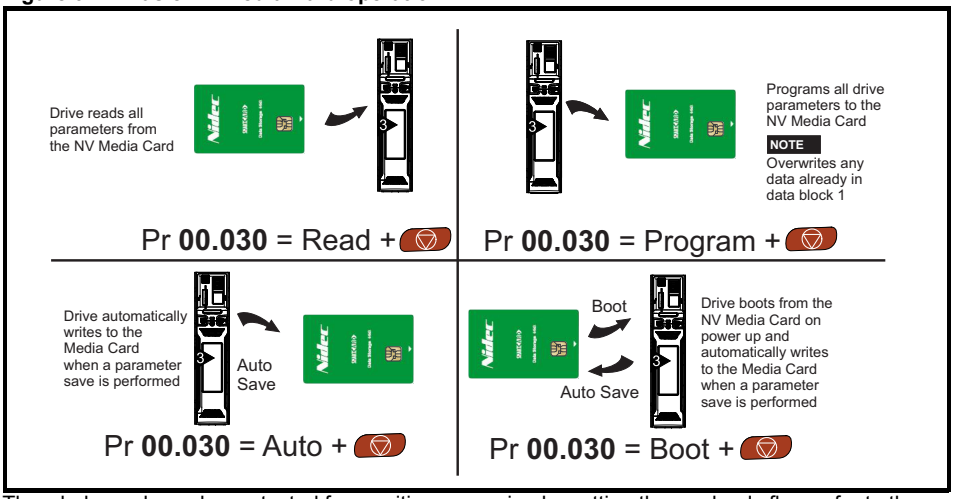
9.2 NV Media Card support

The NV Media Card can be used to store drive parameters and / or PLC programs set from the Powerdrive in data blocks 001 to 499.

The Powerdrive is compatible with Unidrive SP SMARTCARD and is able to read and translate the Unidrive SP parameter set into a compatible parameter set for Powerdrive. This is only possible if the Unidrive SP parameter set was transferred to the SMARTCARD using the difference from defaults transfer method (i.e. 4yyy transfer). The Powerdrive is not able to read any other type of Unidrive SP data block on the card. Although it is possible to transfer difference from default data blocks from a Unidrive SP into the Powerdrive, the following should be noted:

1. If a parameter from the source drive does not exist in the target drive then no data is transferred for that parameter.
2. If the data for the parameter in the target drive is out of range then the data is limited to the range of the target parameter.
3. If the target drive has a different rating to the source drive then the normal rules for this type of transfer apply.

Figure 9-2 Basic NV Media Card operation



The whole card may be protected from writing or erasing by setting the read-only flag, refer to the *Drive User Guide* for further information.

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.

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.	✓	✓
5yyy	Transfer the onboard user program to onboard user program file yyy.	✓	✓
6yyy	Load the drive parameters from parameter file yyy or the onboard user program from onboard user program 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	✓	

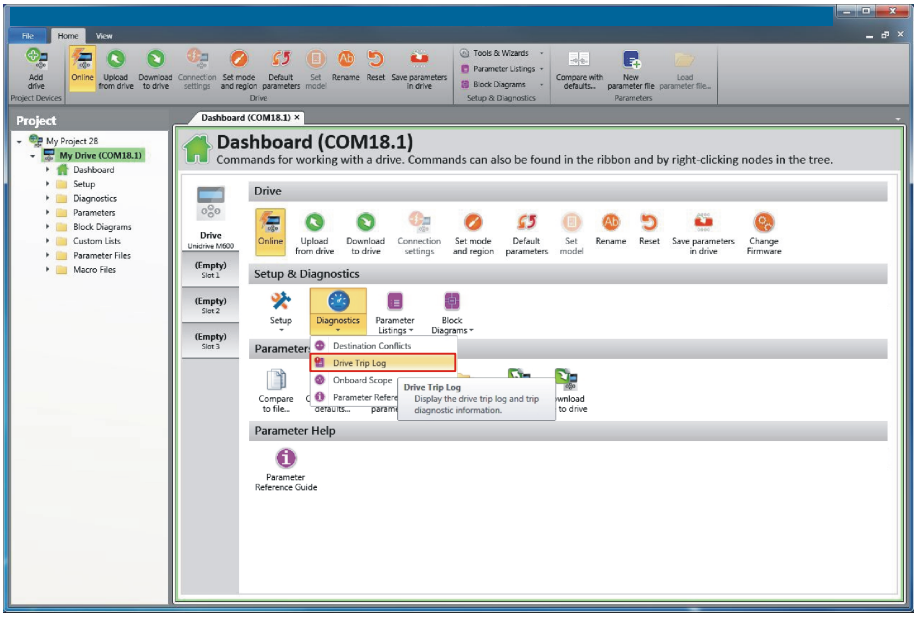
10 Further information

10.1 Diagnostics

For further information on diagnostics including trips and alarms, refer to the *Drive User Guide*.

If the drive trips, it is possible to interrogate the trip log from within Powerdrive Connect.

Select 'Drive Trip Log' from the 'Dashboard'.



11 UL listing information

11.1 UL file reference

All products covered by this Guide are UL Listed to both Canadian and US requirements. The UL file reference is: NMMS/7.E171230.

Products that incorporate the Safe Torque Off function have been investigated by UL. The UL file reference is: FSPC.E171230.

11.2 Option modules, kits and accessories

All Option Modules, Control Pods and Installation Kits supplied by Nidec Industrial Automation for use with these drives are UL Listed.

11.3 Enclosure ratings

Drives are UL Open Type as supplied.

Drives fitted with a conduit box are UL Type 1.

Drives that are capable of through-hole mounting are UL Type 12 when installed with the high-IP insert (where provided), and the Type 12 sealing kit to prevent ingress of dust and water.

Remote Keypads are UL Type 12.

11.4 Mounting

Drives can be mounted directly onto a vertical surface. This is known as 'surface' or 'standard' mounting. Refer to section 3.5 *Surface mounting* on page 23 for further information.

Drives can be installed side by side with recommended spacing between them. This is known as 'bookcase' mounting. Refer to the *Drive User Guide* for further information.

Drives fitted with a conduit box can be mounted directly onto a wall or other vertical surface without additional protection. Suitable conduit boxes are available from Nidec Industrial Automation.

Some drives may be through-hole mounted. Mounting brackets and sealing kits are available from Nidec Industrial Automation. Refer to the *Drive User Guide* for further information.

Remote Keypads can be mounted on the outside of a UL Type 12 enclosure. A sealing and mounting kit is provided with the keypad.

11.5 Environment

Drives must be installed in a Pollution Degree 2 environment or better (dry, non-conductive pollution only). All drives are capable of delivering full rated output current at surrounding air temperatures up to 40 °C.

Drives may be operated in surrounding air temperatures up to 50 °C or 55 °C at de-rated current, depending on the model number. Refer to the *Drive User Guide* for further information.

11.6 Electrical Installation

TERMINAL TORQUE

Terminals must be tightened to the rated torque as specified in the Installation Instructions. Refer to section 3.6 *Terminal size and torque settings* on page 27 for further information.

WIRING TERMINALS

Drives must be installed using cables rated for 75 °C operation, copper wire only.

UL Listed closed-loop connectors sized according to the field wiring shall be used for all field wiring connections. Refer to section 3.6 *Terminal size and torque settings* on page 27 for further information.

BRANCH CIRCUIT PROTECTION

The fuses and circuit breakers required for branch circuit protection are contained in the Installation Instructions. Refer to section 2.4 *Ratings* on page 11

OPENING OF BRANCH CIRCUIT

Opening of the branch-circuit protective device may be an indication that a fault has been interrupted. To reduce the risk of fire or electric shock, the equipment should be examined and replaced if damaged. If burnout of the current element of an overload relay occurs, the complete overload relay must be replaced.

Integral solid state short circuit protection does not provide branch circuit protection. Branch circuit protection must be provided in accordance with the National Electrical Code and any additional local "codes".

11.7 Motor overload protection and thermal memory retention

All drives incorporate internal overload protection for the motor load that does not require the use of an external or remote overload protection device.

The protection level is adjustable and the method of adjustment is provided in section 8.2 *Motor thermal protection* on page 97. Maximum current overload is dependent on the values entered into the current limit parameters (motoring current limit, regenerative current limit and symmetrical current limit entered as percentage) and the motor rated current parameter (entered in amperes).

The duration of the overload is dependent on motor thermal time constant. The time constant is programmable. The default overload protection is set such that the product is capable of 150 % of the current value entered into the motor rated current parameter for 60 seconds.

The drives are provided with user terminals that can be connected to a motor thermistor to protect the motor from high temperature, in the event of a motor cooling fan failure.

The method of adjustment of the overload protection is provided in the Installation Instructions shipped with the product.

All models are provided with thermal memory retention.

11.8 Electrical supply

The drives are suitable for use on a circuit capable of delivering not more than 100,000 RMS Symmetrical Amperes, at rated voltage when protected by fuses as specified in the Installation Instructions.

Some smaller drives are suitable for use on a circuit capable of delivering not more than 10,000 RMS Symmetrical Amperes, at rated voltage when protected by circuit breakers as specified in the Installation Instructions.

11.9 External Class 2 supply

The external power supply used to power the 24 V control circuit shall be marked: "UL Class 2". The power supply voltage shall not exceed 24 Vdc.

11.10 Requirement for Transient Surge Suppression

This requirement applies to drives with rated input voltage = 575 V, Frame Size 7 only.

TRANSIENT SURGE SUPPRESSION SHALL BE INSTALLED ON THE LINE SIDE OF THIS EQUIPMENT AND SHALL BE RATED 575 Vac (PHASE TO GROUND), 575 Vac (PHASE TO PHASE), SUITABLE FOR OVERVOLTAGE CATEGORY III, AND SHALL PROVIDE PROTECTION

FOR A RATED IMPULSE VOLTAGE TO WITHSTAND VOLTAGE PEAK OF 6 kV AND A CLAMPING VOLTAGE OF MAXIMUM 2400 V.

11.11 Group Installation and Modular Drive Systems

Drives with DC+ and DC- supply connections, with 230 V or 480 V supply voltage rating, are UL approved for use in modular drive systems as inverters when supplied by the converter sections: Mentor MP25A, 45A, 75A, 105A, 155A or 210A range manufactured by Nidec Industrial Automation.

Alternatively, the inverters may be supplied by converters from the *Powerdrive-F300* range manufactured by Nidec Industrial Automation.

In these applications the inverters are required to be additionally protected by supplemental fuses.

Drives have not been evaluated for other Group Installation applications, for example where a single inverter is wired directly to two or more motors. In these applications, additional thermal overload protection is needed. Contact Nidec Industrial Automation for further details.

Figure 11-1 Default terminal functions