



EMERSONTM
Industrial Automation



Installation Guide

Unidrive M / Unidrive HS Modular

Model sizes 9 to 11

Universal Variable Speed AC drive
Modular Solutions for induction and
permanent magnet motors

Part Number: 0478-0141-05
Issue: 5

Original Instructions

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

General information

This guide covers the basic information that is required to install the drive, in applications where a drive malfunction does not result in a mechanical hazard. When the drive is used in a safety related application, i.e. where a malfunction might result in a hazard, it is essential to refer to this guide and the *Control User Guide*. The *Control User Guide* is available for download from:

<http://www.emersonindustrial.com/en-EN/controltechniques/downloads/userguidesandsoftware/Pages/downloads.aspx>

or

www.emersonindustrial.com/en-EN/leroy-somer-motors-drives/downloads/Pages/manuals.aspx

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

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

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Drive firmware version

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

Environmental statement

Emerson Industrial Automation is committed to minimising the environmental impacts of its manufacturing operations and of its products throughout their life cycle. To this end, we operate an Environmental Management System (EMS) which is certified to the International Standard ISO 14001. Further information on the EMS, our Environmental Policy and other relevant information is available on request, or can be found at:

<http://www.emersonindustrial.com/en-EN/controltechniques/aboutus/environment/Pages/environment.aspx>.

The electronic variable-speed drives manufactured by Emerson Industrial Automation have the potential to save energy and (through increased machine/process efficiency) reduce raw material consumption and scrap throughout their long working lifetime. In typical applications, these positive environmental effects far outweigh the negative impacts of product manufacture and end-of-life disposal. Nevertheless, when the products eventually reach the end of their useful life, they must not be discarded but should instead be recycled by a specialist recycler of electronic equipment. Recyclers will find the products easy to dismantle into their major component parts for efficient recycling. Many parts snap together and can be separated without the use of tools, while other parts are secured with conventional fasteners. Virtually all parts of the product are suitable for recycling.

Product packaging is of good quality and can be re-used. Large products are packed in wooden crates, while smaller products come in strong cardboard cartons which themselves have a high recycled fibre content. If not re-used, these containers can be recycled. Polythene, used on the protective film and bags for wrapping product, can be recycled in the same way. Emerson Industrial Automation's packaging strategy prefers easily-recyclable materials of low environmental impact, and regular reviews identify opportunities for improvement.

When preparing to recycle or dispose of any product or packaging, please observe local legislation and best practice.

REACH legislation

EC Regulation 1907/2006 on the Registration, Evaluation, Authorisation and restriction of Chemicals (REACH) requires the supplier of an article to inform the recipient if it contains more than a specified proportion of any substance which is considered by the European Chemicals Agency (ECHA) to be a Substance of Very High Concern (SVHC) and is therefore listed by them as a candidate for compulsory authorisation.

For current information on how this requirement applies in relation to specific Emerson Industrial Automation's products, please approach your usual contact in the first instance. Emerson Industrial Automation's position statement can be viewed at:

www.emersonindustrial.com/en-EN/controltechniques/aboutus/environment/reachregulation/Pages/reachregulation.aspx.

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Moteurs Leroy-Somer SAS. Headquarters: Bd Marcellin Leroy, CS 10015, 16915 Angoulême Cedex 9, France. Share Capital: 65 800 512 €, RCS Angoulême 338 567 258.

Issue Number: 5

Drive Firmware: 01.13.02.00

How to use this guide

This installation guide provides complete information for installing and operating the drive from start to finish. The information is in logical order, taking the reader from receiving the drive through to fine tuning the performance.

NOTE

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

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

	Quick Start / bench testing	Familiarisation	System design	Programming and commissioning	Troubleshooting
1 Safety information	●	●	●	●	●
2 Introduction					
3 Product information		●	●		
4 System configuration	●		●	●	●
5 Mechanical Installation			●		
6 Electrical installation			●		
7 Technical data		●	●	●	
8 UL information			●	●	

Contents

EU Declaration of Conformity	5	6	Electrical Installation	85
EU Declaration of Conformity		6.1	Power connections	86
(including 2006 Machinery Directive)	6	6.2	AC supply requirements	92
1 Safety information	8	6.3	Output sharing choke specification	95
1.1 Warnings, Cautions and Notes	8	6.4	Supplying the Unidrive M/Unidrive HS size 9A, 9D, 10D and 11D drives with DC / DC bus paralleling	96
1.2 Electrical safety - general warning	8	6.5	Heatsink fan supply	96
1.3 System design and safety of personnel	8	6.6	24 Vdc supply	96
1.4 Environmental limits	8	6.7	Low voltage operation	98
1.5 Access	8	6.8	Status LED	98
1.6 Fire protection	8	6.9	Ratings	99
1.7 Compliance with regulations	8	6.10	Output circuit and motor protection	103
1.8 Motor	8	6.11	Braking	105
1.9 Mechanical brake control	8	6.12	Ground leakage	107
1.10 Adjusting parameters	8	6.13	EMC (Electromagnetic compatibility)	108
1.11 Electrical installation	9	6.14	Communication connections	116
2 Introduction	10	6.15	Control connections	117
2.1 Rectifier	10	6.16	M70X/HS7X Position feedback connections	124
2.2 Size 9A drives	11	6.17	Safe Torque Off (STO)	131
2.3 Size 9E, 10E and 11E drives	12	7 Technical data	133	
2.4 Size 9D, 10D and 11D inverters	13	7.1	Drive technical data	133
2.5 Size 9T, 10T and 11T drives	13	7.2	Optional external EMC filters	151
2.6 Input line reactor	14	8 UL Information	153	
2.7 Output sharing choke	14	8.1	UL file reference	153
2.8 Model number	15	8.2	Option modules, kits and accessories	153
3 Product information	16	8.3	Enclosure ratings	153
3.1 Ratings	16	8.4	Mounting	153
3.2 Operating modes	19	8.5	Environment	153
3.3 Nameplate description	22	8.6	Electrical Installation	153
3.4 Supplied items	25	8.7	Motor overload protection and thermal memory retention	154
4 System configuration	27	8.8	Electrical supply	154
5 Mechanical Installation	39	8.9	External Class 2 supply	154
5.1 Safety information	39	8.10	Requirement for Transient Surge Suppression	154
5.2 Planning the installation	39	8.11	Group Installation and Modular Drive Systems	154
5.3 Terminal cover removal	40	Index	155	
5.4 Mounting of the control master/follower/ standard pod	44			
5.5 Dimensions and mounting methods	47			
5.6 Enclosure	61			
5.7 Heatsink fan operation	67			
5.8 Enclosing drive for high environmental protection	68			
5.9 External EMC filter	70			
5.10 Line reactor mounting dimensions	74			
5.11 Electrical terminals	77			
5.12 Routine maintenance	79			

EU Declaration of Conformity

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This declaration is issued under the sole responsibility of the manufacturer. The object of the declaration is in conformity with the relevant Union harmonization legislation. The declaration applies to the variable speed drive products shown below:

Model number	Interpretation	Nomenclature aaaa - bbc ddddde
aaaa	Basic series	M100, M101, M200, M201, M300, M400, M600, M700, M701, M702, F300, H300, E200, E300, HS30, HS70, HS71, HS72, M000, RECT
bb	Frame size	01, 02, 03, 04, 05, 06, 07, 08, 09, 10, 11
c	Voltage rating	1 = 100 V, 2 = 200 V, 4 = 400 V, 5 = 575 V, 6 = 690 V
dddd	Current rating	Example 01000 = 100 A
e	Drive format	A = 6P Rectifier + Inverter (internal choke), D = Inverter, E = 6P Rectifier + Inverter (external choke), T = 12P Rectifier + Inverter (external choke)

The model number may be followed by additional characters that do not affect the ratings.

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

EN 61800-5-1:2007	Adjustable speed electrical power drive systems - Part 5-1: Safety requirements - Electrical, thermal and energy
EN 61800-3: 2004+A1:2012	Adjustable speed electrical power drive systems - Part 3: EMC requirements and specific test methods
EN 61000-6-2:2005	Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity for industrial environments
EN 61000-6-4: 2007+ A1:2011	Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments
EN 61000-3-2:2014	Electromagnetic compatibility (EMC) - Part 3-2: Limits for harmonic current emissions (equipment input current ≤16 A per phase)
EN 61000-3-3:2013	Electromagnetic compatibility (EMC) - Part 3-3: Limitation of voltage changes, voltage fluctuations and flicker in public, low voltage supply systems, for equipment with rated current ≤16 A per phase and not subject to conditional connection

EN 61000-3-2:2014 Applicable where input current < 16 A. No limits apply for professional equipment where input power ≥1 kW.

These products comply with the Restriction of Hazardous Substances Directive (2011/65/EU), the Low Voltage Directive (2014/35/EU) and the Electromagnetic Compatibility Directive (2014/30/EU).



G Williams
Vice President, Technology
Date: 17th March 2016

These electronic drive products are intended to be used with appropriate motors, controllers, electrical protection components and other equipment to form complete end products or systems. Compliance with safety and EMC regulations depends upon installing and configuring drives correctly, including using the specified input filters.

The drives must be installed only by professional installers who are familiar with requirements for safety and EMC. Refer to the Product Documentation. An EMC data sheet is available giving detailed information. 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.

EU Declaration of Conformity (including 2006 Machinery Directive)

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This declaration is issued under the sole responsibility of the manufacturer. The object of the declaration is in conformity with the relevant Union harmonization legislation. The declaration applies to the variable speed drive products shown below:

Model No.	Interpretation	Nomenclature aaaa - bbc ddddde
aaaa	Basic series	M300, M400, M600, M700, M701, M702, F300, H300, E200, E300, HS30, HS70, HS71, HS72, M000, RECT
bb	Frame size	01, 02, 03, 04, 05, 06, 07, 08, 09, 10, 11
c	Voltage rating	1 = 100 V, 2 = 200 V, 4 = 400 V, 5 = 575 V, 6 = 690 V
dddd	Current rating	Example 01000 = 100 A
e	Drive format	A = 6P Rectifier + Inverter (internal choke), D = Inverter, E = 6P Rectifier + Inverter (external choke), T = 12P Rectifier + Inverter (external choke)

The model number may be followed by additional characters that do not affect the ratings.

This declaration relates to these products when used as a safety component of a machine. Only the Safe Torque Off function may be used for a safety function of a machine. None of the other functions of the drive may be used to carry out a safety function.

These products fulfil all the relevant provisions of the Machinery Directive 2006/42/EC and the Electromagnetic Compatibility Directive (2014/30/EU). EC type examination has been carried out by the following notified body:

TUV Rheinland Industrie Service GmbH
Am Grauen Stein
D-51105 Köln
Germany

EC type-examination certificate numbers:
01/205/5270.01/14 dated 2014-11-11
01/205/5387.01/15 dated 2015-01-29
01/205/5383.02/15 dated 2015-04-21

Notified body identification number: 0035

The harmonized standards used are shown below:

EN 61800-5-1:2007	Adjustable speed electrical power drive systems - Part 5-1: Safety requirements - Electrical, thermal and energy
EN 61800-5-2:2007	Adjustable speed electrical power drive systems - Part 5-2: Safety requirements - Functional
EN ISO 13849-1:2008	Safety of Machinery, Safety-related parts of control systems, General principles for design
EN ISO 13849-2:2008	Safety of machinery, Safety-related parts of control systems. Validation
EN 61800-3: 2004+A1:2012	Adjustable speed electrical power drive systems - Part 3: EMC requirements and specific test methods
EN 62061:2005	Safety of machinery, Functional safety of safety related electrical, electronic and programmable electronic control systems

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Vice President, Technology

Date: 17th March 2016

Place: Newtown, Powys, UK

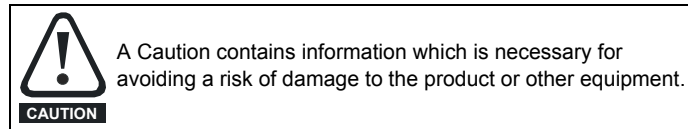
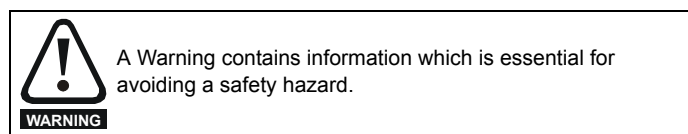
IMPORTANT NOTICE

These electronic drive products are intended to be used with appropriate motors, controllers, electrical protection components and other equipment to form complete end products or systems. Compliance with safety and EMC regulations depends upon installing and configuring drives correctly, including using the specified input filters.

The drives must be installed only by professional installers who are familiar with requirements for safety and EMC. Refer to the Product Documentation. An EMC data sheet is available giving detailed information. 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.

1 Safety information

1.1 Warnings, Cautions and Notes



NOTE

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

1.2 Electrical safety - general warning

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

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

1.3 System design and safety of personnel

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

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

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

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

With the sole exception of the Safe Torque Off function, none of the drive functions should be used to ensure safety of personnel, i.e. they must not be used for safety-related functions.

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

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

1.4 Environmental limits

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

1.5 Access

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

1.6 Fire protection

The drive enclosure is not classified as a fire enclosure. A separate fire enclosure must be provided. For further information, refer to section 5.2.5 *Fire protection* on page 39.

1.7 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 Installation Guide contains instruction for achieving compliance with specific EMC standards.

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

- Safety of Machinery 2006/42/EC
- Electromagnetic Compatibility (EMC) Directive 2014/30/EU

1.8 Motor

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

Standard squirrel cage induction motors are designed for single speed operation. If it is intended to use the capability of the drive to run a motor at speeds above its designed maximum, it is strongly recommended that the manufacturer is consulted first.

Low speeds may cause the motor to overheat because the cooling fan becomes less effective. 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 should not be relied upon.

It is essential that the correct value is entered in Pr **00.046** motor rated current. This affects the thermal protection of the motor.

1.9 Mechanical brake control

The 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.

1.10 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.

1.11 Electrical installation

1.11.1 Electric shock risk

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

AC supply cables and connections

Output cables and connections

Many internal parts of the drive, and external option units

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

1.11.2 Stored charge

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

2 Introduction

The Unidrive M / Unidrive HS modular drive offers the possibility of implementing many custom power systems with a wide range of power modules. The power range is 110 kW to 2.8 MW and the modular design of input and output stages enables a wide range of very compact and efficient systems to be realized. These include:

- Parallel output stages for higher power motors:
 - Size 9 and 10:**
Up to a maximum of 20 modules
(1 master module with up to 19 follower modules, OR
1 remote mounted control master pod controlling up to 20 followers. This allows the user to place all control circuitry in one low voltage cabinet)
 - Size 11:**
Up to a maximum of 10 modules
(1 master module with up to 9 follower modules OR 1 remote mounted control master pod controlling up to 10 followers).
- Common DC bus multi-drive systems for:
 - Connection to larger existing power supplies
 - Energy sharing between motoring and regenerating drives
- Active front end drive systems for:
 - Minimizing supply current harmonics
 - Four quadrant motor control
- Multiple controlled rectifier bridges for:
 - Minimizing supply current harmonics by drawing 6, 12 or 18 pulse supply load currents.

2.1 Rectifier



CAUTION

A separate input line reactor (INLXXX) of at least the value shown in Table 6-2 *Model and line reactor part numbers* on page 93 must be used with the rectifiers. Failure to provide sufficient reactance could damage or reduce the service life of the rectifier or inverter.

The Unidrive M / Unidrive HS rectifier is a half controlled SCR/thyristor bridge and is used as a front end to the size 9, size 10 or size 11 inverter module. The rectifier cannot be used as a stand alone rectifier for several smaller drives.

Figure 2-1 Frame 10 single half controlled SCR/thyristor

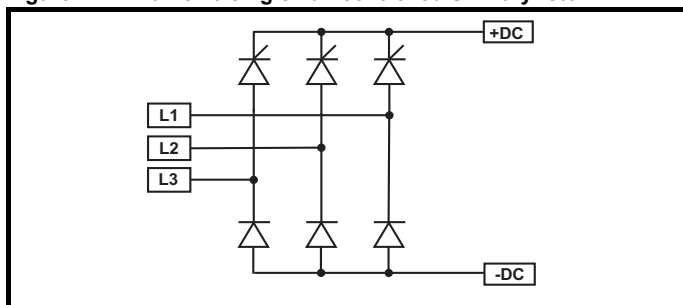


Figure 2-2 Frame 11 single half controlled SCR/thyristor

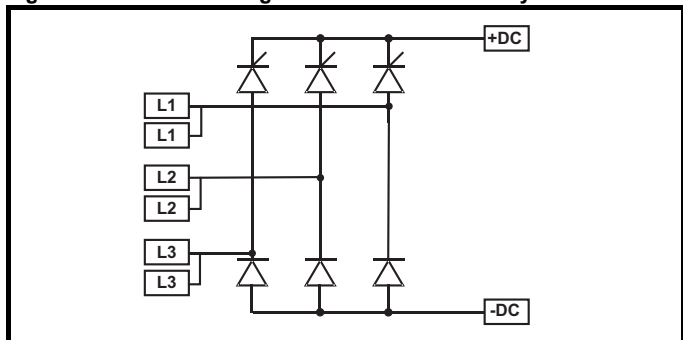
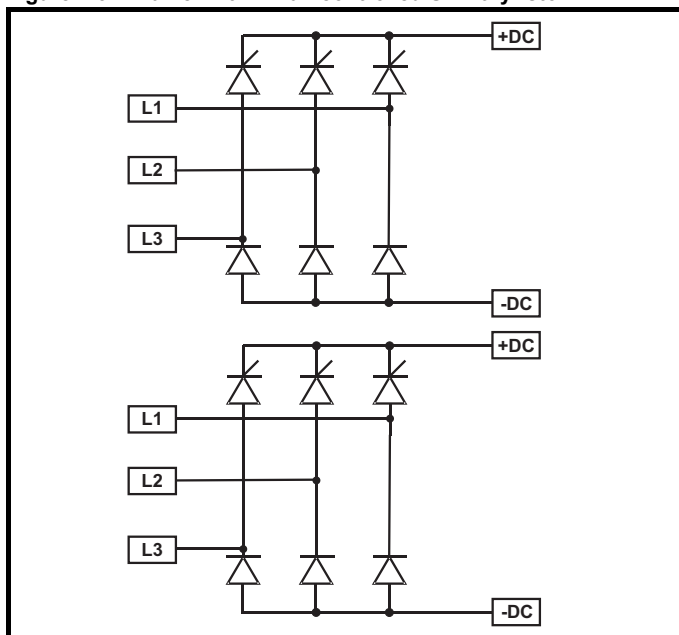


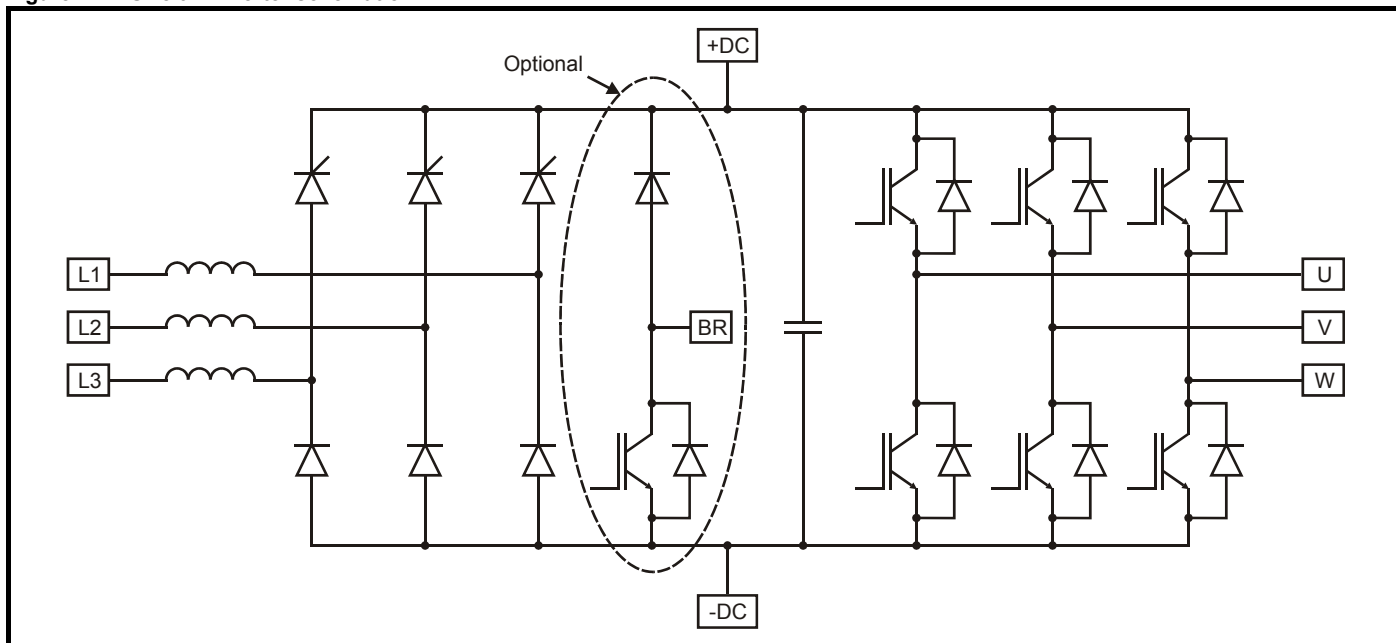
Figure 2-3 Frame 11 twin half controlled SCR/thyristor



2.2 Size 9A drives

The size 9A is a complete drive with internal rectifier and AC input line chokes (AC in to AC out). It can provide a maximum continuous output current of 266 A (400 V drive). DC connections are available for use in regen and bus-parallel applications. The size 9A is available with or without a braking IGBT installed.

Figure 2-4 Size 9A inverter schematic



2.3 Size 9E, 10E and 11E drives

The size 9E, 10E and 11E are complete drives with internal rectifier (AC in to AC out). External AC line chokes are required.

Figure 2-5 Size 9E and 10E inverter schematic

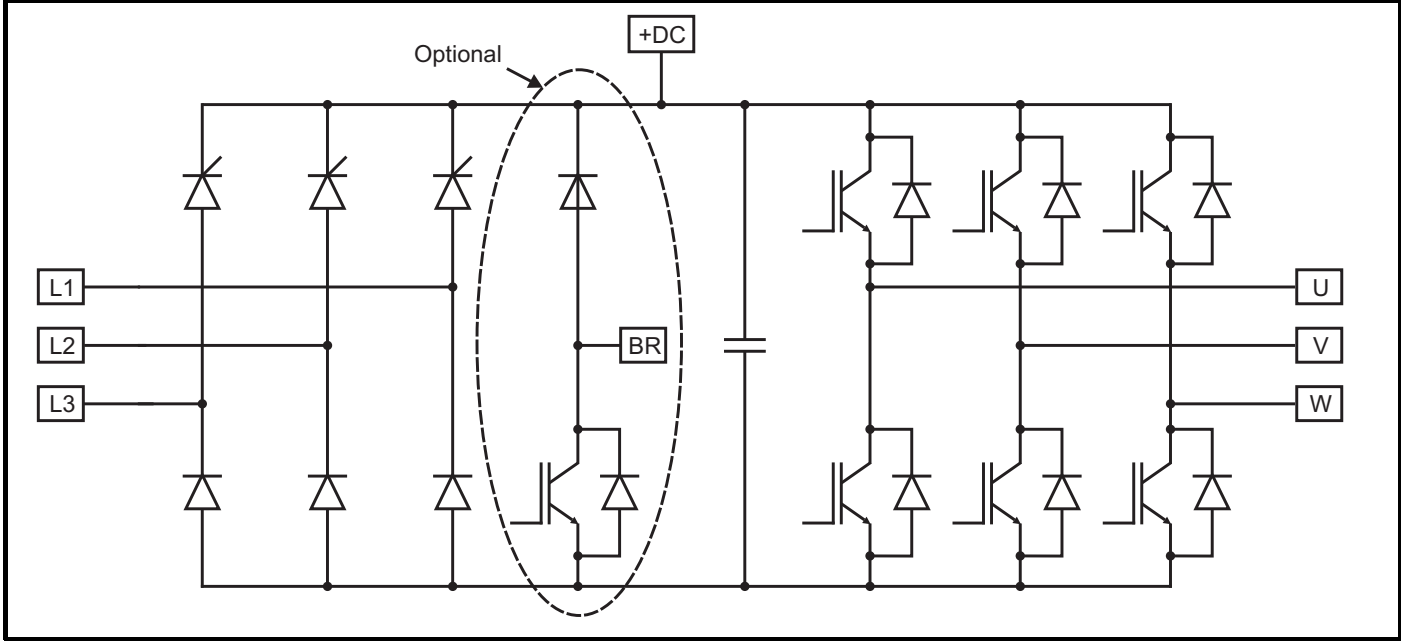
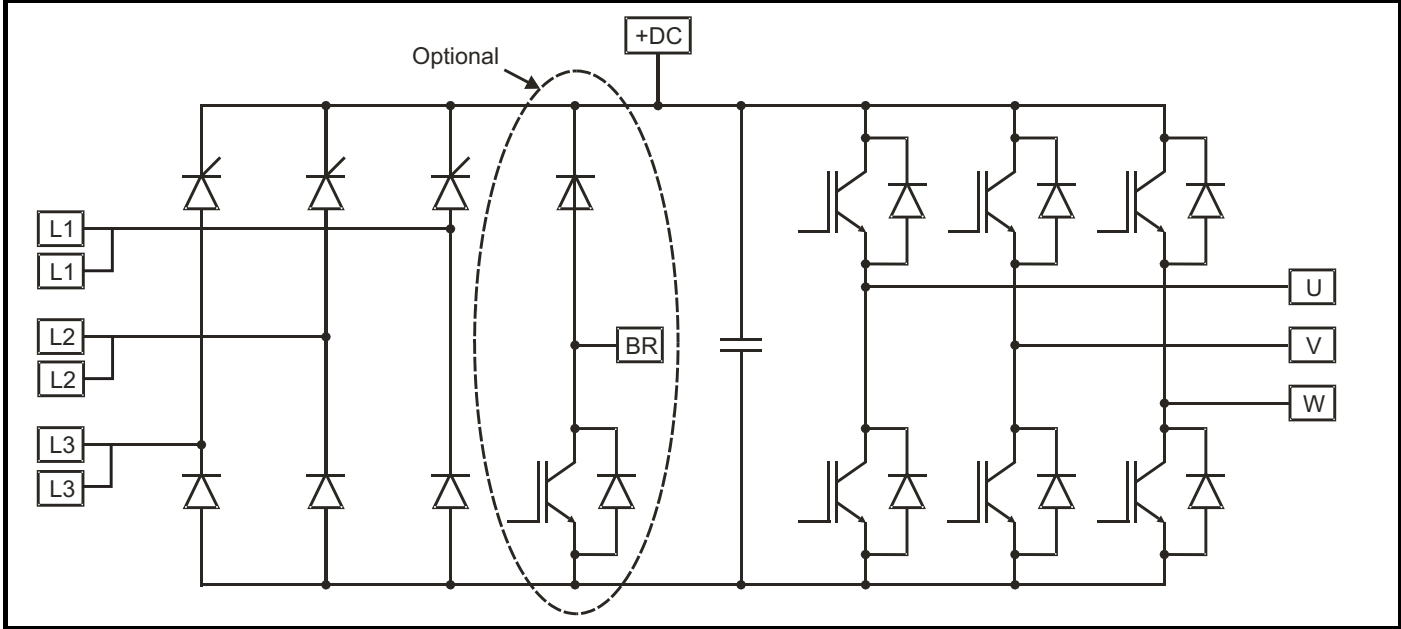


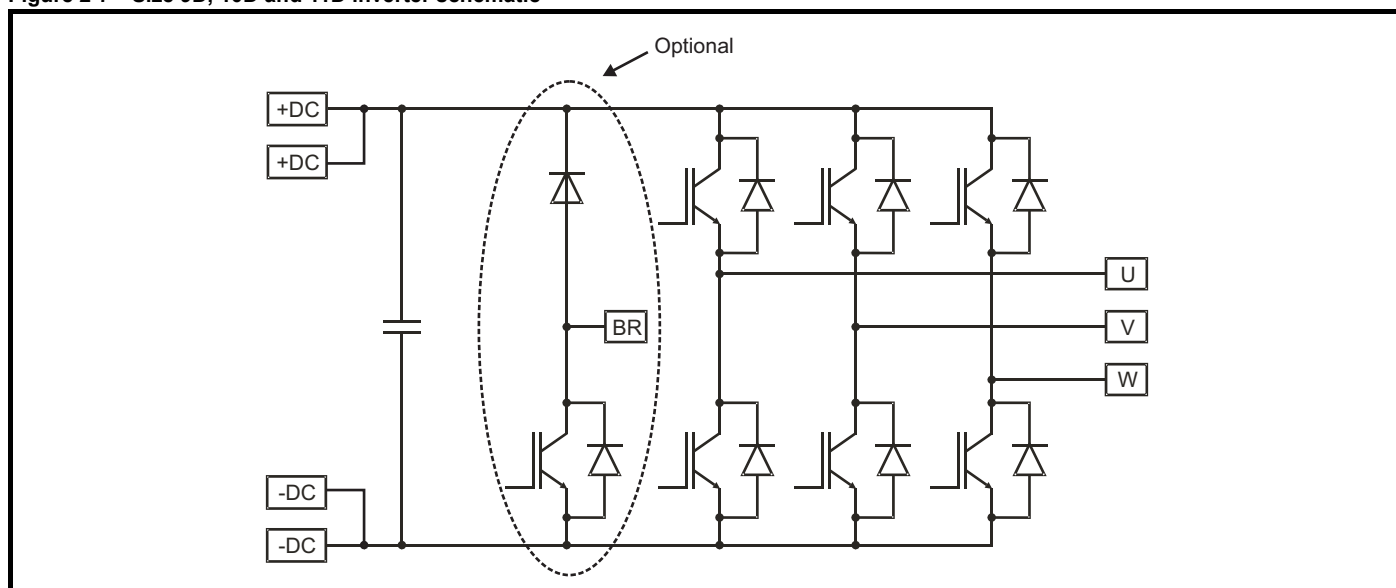
Figure 2-6 Size 11E inverter schematic



2.4 Size 9D, 10D and 11D inverters

Size 9D, 10D and 11D are inverter stage only (DC in to AC out). If a rectifier is required, then an AC input line reactor must also be installed. DC connections can be used for regen and bus-parallel applications. Size 9D, 10D and 11D are available with or without a braking IGBT installed.

Figure 2-7 Size 9D, 10D and 11D inverter schematic



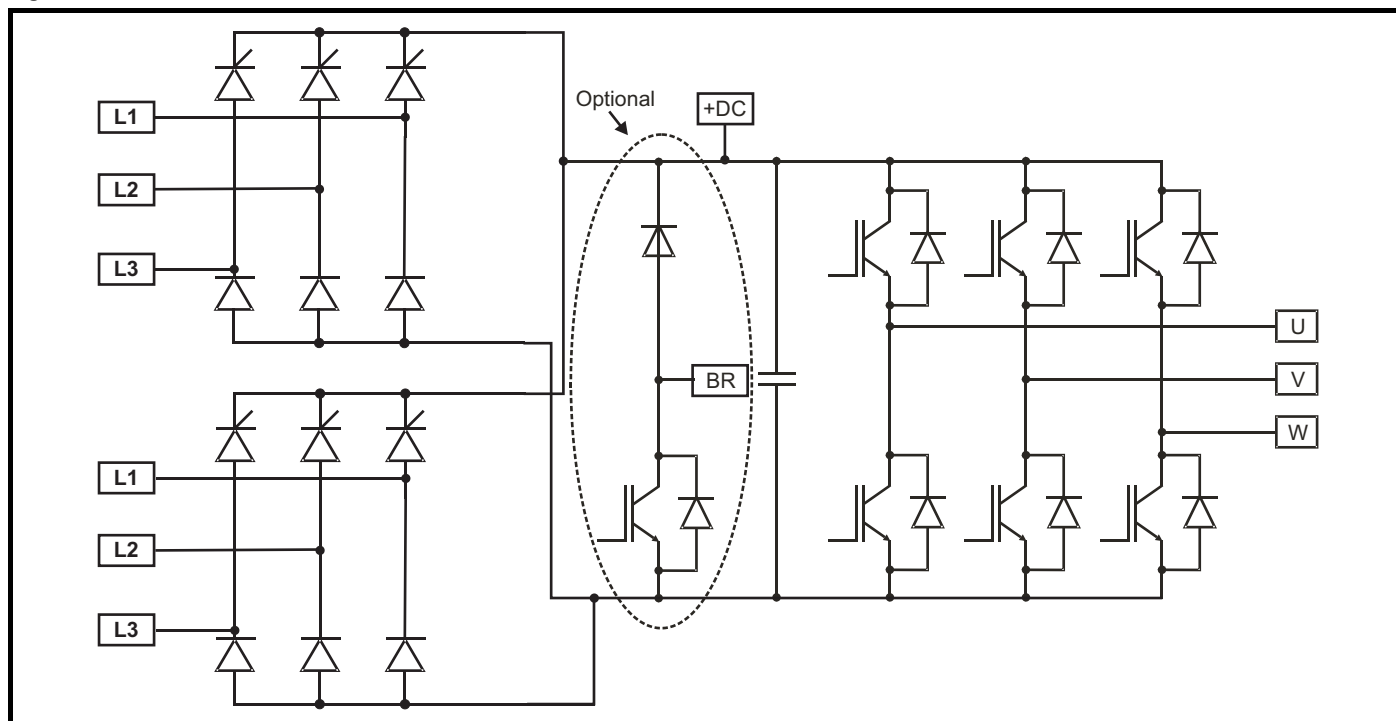
NOTE

The above diagram shows size 11D which has double DC terminals, size 9D and 10D have single DC terminals.

2.5 Size 9T, 10T and 11T drives

Size 9T, 10T and 11T are complete drives with internal 12 pulse rectifier (AC in to AC out). External AC line chokes are required unless the required reactance is incorporated into a 12 pulse transformer.

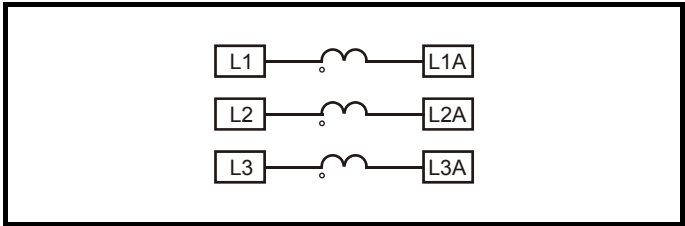
Figure 2-8 Size 9T, 10T and 11T inverter schematic



2.6 Input line reactor

The INL line reactor must be used in conjunction with the Unidrive M / Unidrive HS rectifiers. See section 6.2.2 *Input line reactor specifications* on page 93 for further information.

Figure 2-9 Single input line reactor (INLX0X)/force cooled (INLX0XW)



2.7 Output sharing choke

The OTL output sharing choke must be used on the output of Unidrive M / Unidrive HS when more than one module is paralleled together.

Figure 2-10 Single output sharing choke (OTLX0X) - two chokes shown

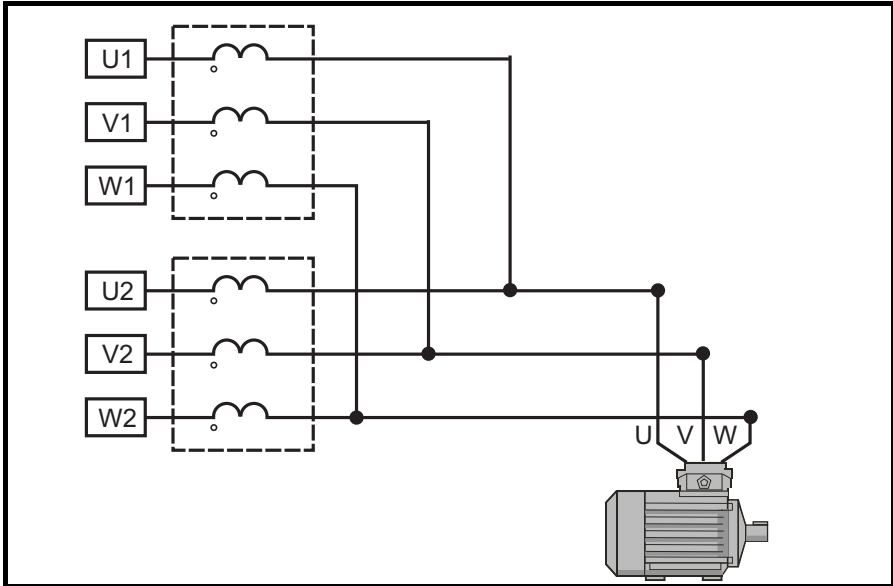
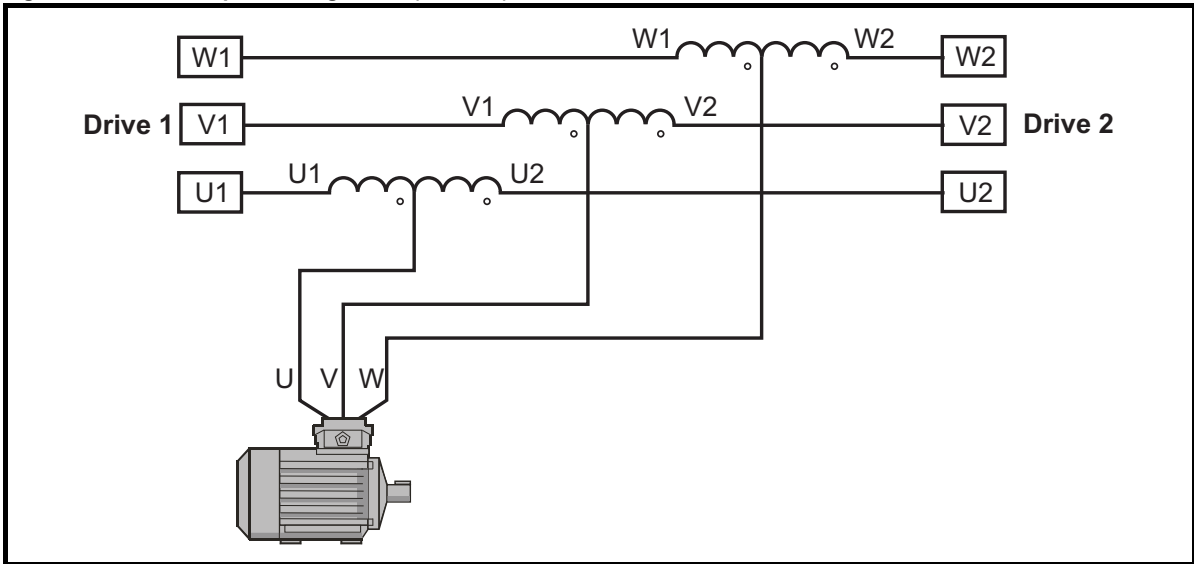


Figure 2-11 Dual output sharing choke (OTLX1X)



For a physical representation of the input line reactors and output sharing chokes, see section 2.6 and section 2.7 *Output sharing choke* on page 14.

2.8 Model number

The model numbers for the Unidrive M / Unidrive HS range are formed as illustrated below.

Figure 2-12 Rectifier model number

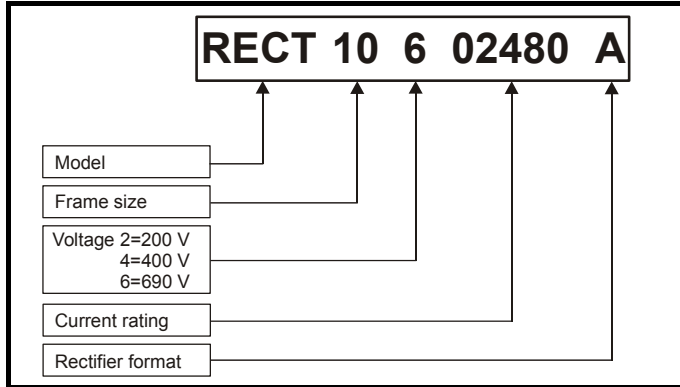


Figure 2-13 Drive model number

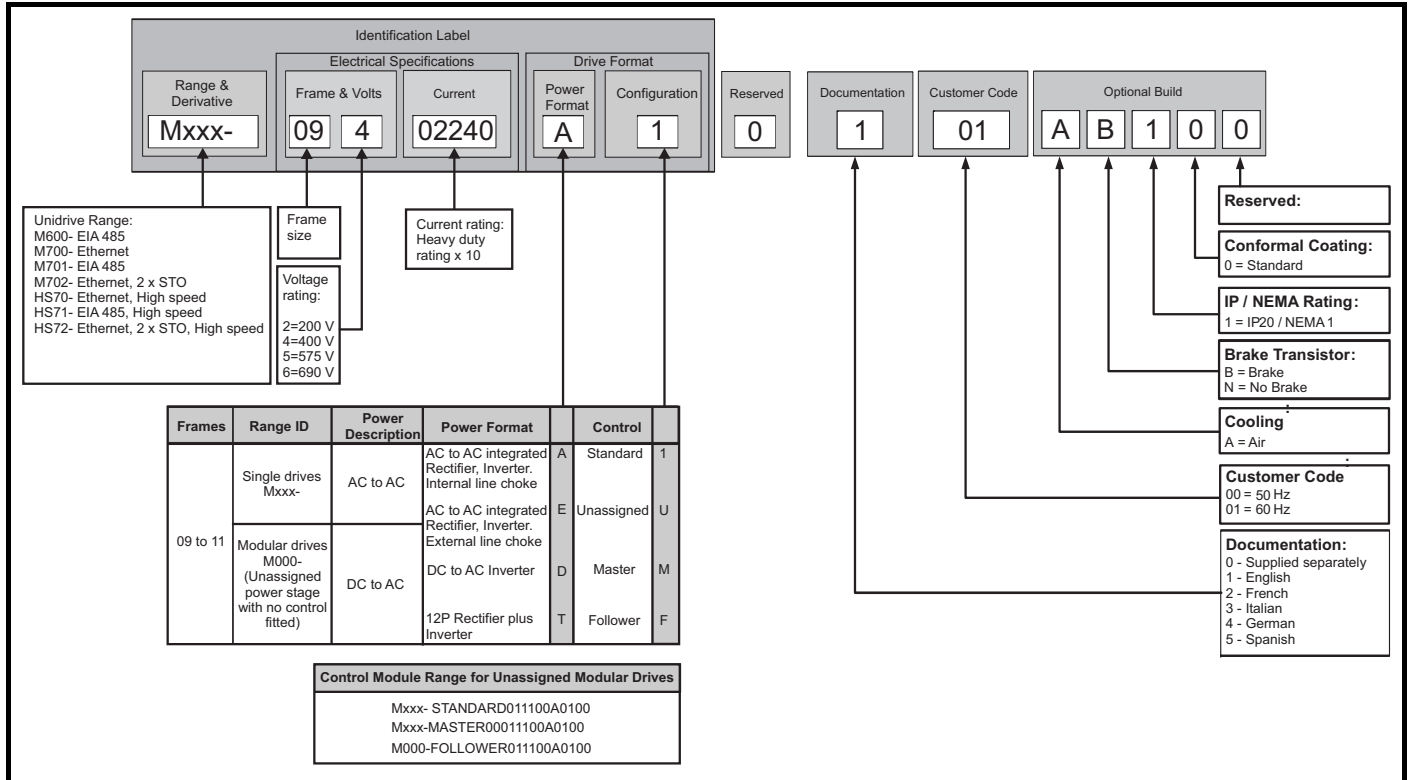
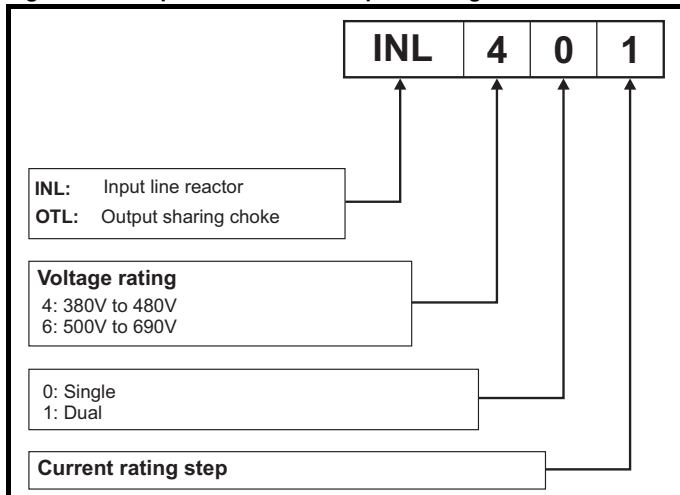


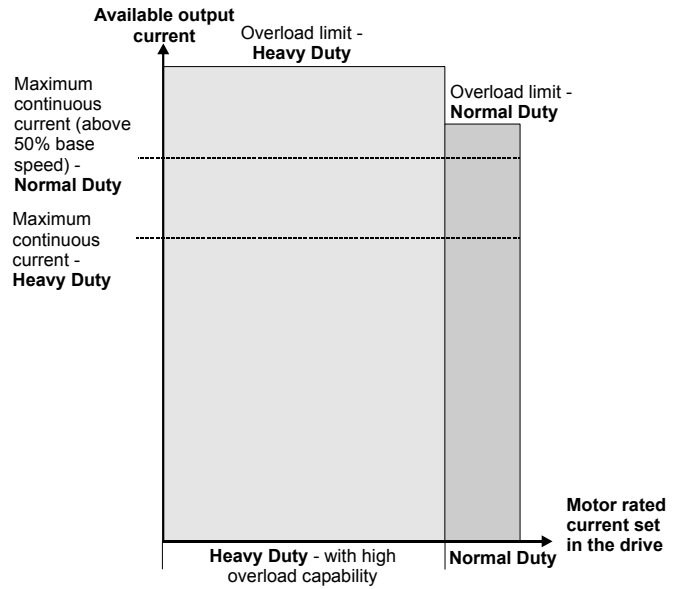
Figure 2-14 Input line reactor / output sharing choke



3 Product information

3.1 Ratings

The drive is dual rated.
 The setting of the motor rated current determines which rating applies - Heavy Duty or Normal Duty.
 The two ratings are compatible with motors designed to IEC60034.
 The graph aside illustrates the difference between Normal Duty and Heavy Duty with respect to continuous current rating and short term overload limits.



Normal Duty	Heavy Duty (default)
--------------------	-----------------------------

For applications which use Self ventilated (TENV/TEFC) induction motors and require a low overload capability, and full torque at low speeds is not required (e.g. fans, pumps).
 Self ventilated (TENV/TEFC) induction motors require increased protection against overload due to the reduced cooling effect of the fan at low speed. To provide the correct level of protection the I^2t software operates at a level which is speed dependent. This is illustrated in the graph below.

NOTE

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

For constant torque applications or applications which require a high overload capability, or full torque is required at low speeds (e.g. winders, hoists).
 The thermal protection is set to protect force ventilated induction motors and permanent magnet servo motors by default.

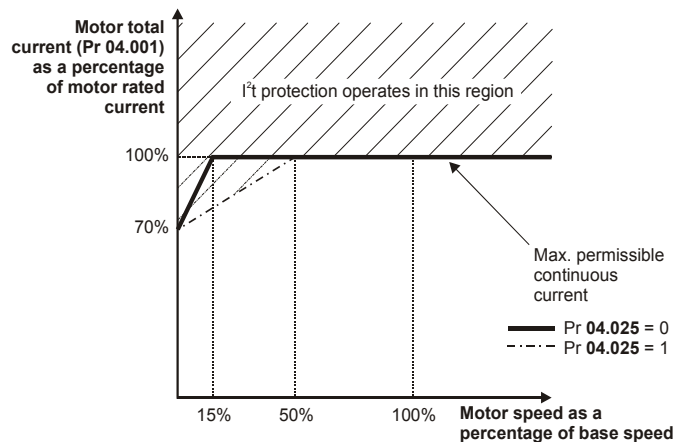
NOTE

If the application uses a self ventilated (TENV/TEFC) induction motor and increased thermal protection is required for speeds below 50 % base speed, then this can be enabled by setting *Low Speed Thermal Protection Mode* (04.025) = 1.

Operation of motor I^2t protection	
--	--

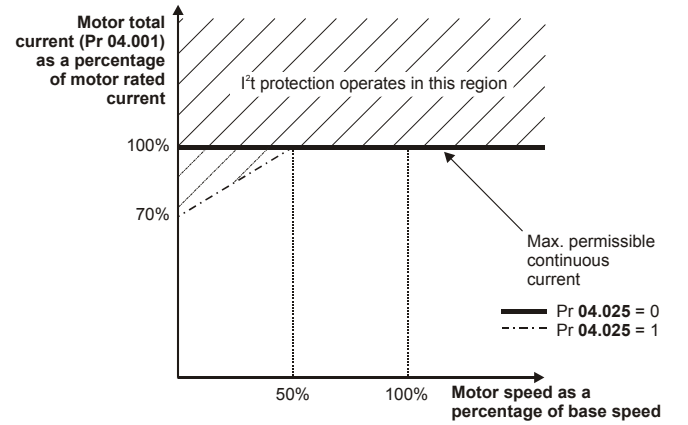
Motor I^2t protection is fixed as shown below and is compatible with:

- Self ventilated (TENV/TEFC) induction motors



Motor I^2t protection defaults to be compatible with:

- Forced ventilation induction motors
- Permanent magnet servo motors



The continuous current ratings given are for maximum 40 °C (104 °F), 1000 m altitude and 2 kHz switching frequency. Derating is required for higher switching frequencies, ambient temperature >40 °C (104 °F), high altitude and parallel applications. For further information, refer to section 7.1.1 Power and current ratings (Derating for switching frequency and temperature) on page 133, **5 % derating should be applied when paralleling two or more inverters.**

Table 3-1 Size 9 and 10 200 V drive ratings (200 V to 240 V ±10 %)

Model		Normal Duty				Heavy Duty				
		Maximum continuous output current	Nominal power at 230 V	Motor power at 230 V	Peak current	Maximum continuous output current	Open loop peak current	RFC peak current	Nominal power at 230 V	Motor power at 230 V
		A	kW	hp	A	A	A	A	kW	hp
9A / 9E / 9D	09201760	216	55	75	238	176	264	308	45	60
	09202190	266	75	100	293	219	328	383	55	75
10D / 10E	10202830	325	90	125	357	283	424	495	75	100
	10203000	360	110	150	396	300	450	525	90	125

Table 3-2 Size 9, 10 and 11 400 V drive ratings (380 V to 480 V ±10 %)

Model		Normal Duty				Heavy Duty				
		Maximum continuous output current	Nominal power at 400 V	Motor power at 460 V	Peak current	Maximum continuous output current	Open loop peak current	RFC peak current	Nominal power at 400 V	Motor power at 460 V
		A	kW	hp	A	A	A	A	kW	hp
9A / 9E / 9D / 9T	09402000	221	110	150	243	200	300	350	90	150
	09402240	266	132	200	293	224	336	392	110	150
10D / 10E / 10T	10402700	320	160	250	352	270	405	472	132	200
	10403200	361	200	300	397	320	480	560	160	250
11D / 11E / 11T	11403770	437	225	350	481	377	565	660	185	300
	11404170	487	250	400	536	417	625	730	200	350
	11404640	507	280	450	558	464	696	812	250	400

Table 3-3 Size 9, 10 and 11 575 V drive ratings (500 V to 575 V ±10 %)

Model		Normal Duty				Heavy Duty				
		Maximum continuous output current	Nominal power at 575 V	Motor power at 575 V	Peak current	Maximum continuous output current	Open loop peak current	RFC peak current	Nominal power at 575 V	Motor power at 575 V
		A	kW	hp	A	A	A	A	kW	hp
9A / 9E / 9D / 9T	09501040	125	110	125	137	104	156	182	75	100
	09501310	150	110	150	165	131	196	229	90	125
10D / 10E / 10T	10501520	200	130	200	220	152	228	266	110	150
	10501900	200	150	200	220	190	285	332	132	200
11D / 11E / 11T	11502000	248	185	250	273	200	300	350	150	200
	11502540	288	225	300	317	254	381	444	185	250
	11502850	315	250	350	346	285	427	499	225	300

Table 3-4 Size 9, 10 and 11 690 V drive ratings (500 V to 690 V ±10 %)

Model		Normal Duty				Heavy Duty				
		Maximum continuous output current	Nominal power at 690 V	Motor power at 690 V	Peak current	Maximum continuous output current	Open loop peak current	RFC peak current	Nominal power at 690 V	Motor power at 690 V
		A	kW	hp	A	A	A	A	kW	hp
9A / 9E / 9D / 9T	09601040	125	110	150	137	104	156	182	90	125
	09601310	155	132	175	170	131	196	229	110	150
10D / 10E / 10T	10601500	172	160	200	189	150	225	262	132	175
	10601780	197	185	250	217	178	267	311	160	200
11D / 11E / 11T	11602100	225	200	250	247	210	315	367	185	250
	11602380	275	250	300	302	238	357	416	200	250
	11602630	305	280	400	335	263	394	460	250	300

Table 3-5 Rectifier ratings at 40° C (104° F)

Model	Voltage rating	Typical input current	Maximum continuous input current	Maximum overload input current	Typical continuous DC output current	Maximum DC output current
	V	A	A	A	A	A
10204100	200	333	361	494	409	413
10404520	400	370	396	523	452	455
10502430	575	202	218	313	243	246
10602480	690	202	225	313	247	251
11406840	400	557	594	752	684	689
11503840	575	313	338	473	384	387
11604060	690	331	362	465	406	411
1142X400*	400	2 x 326	2 x 358	2 x 397	2 x 395	2 x 400
1162X380*	690	2 x 308	2 x 339	2 x 375	2 x 375	2 x 380

* Twin rectifier

3.1.1 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. The exact value for a specific motor can be calculated using the equations detailed in Menu 4 in the *Parameter Reference Guide*.

Typical values are shown in the table below for RFC (RFC-A or RFC-S) and open loop (OL) modes:

Table 3-6 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
Heavy Duty overload with motor rated current = drive rated current (size 9, 10 and 11)	175 % for 42 s	175 % for 5 s	150 % for 60 s	150 % for 7 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.

3.2 Operating modes

The drive is designed to operate in any of the following modes:

1. Open loop mode
 - Open loop vector mode
 - Fixed V/F mode (V/Hz)
 - Quadratic V/F mode (V/Hz)
2. RFC - A mode
 - With position feedback sensor
 - Without position feedback sensor (Sensorless)
3. RFC - S mode
 - With position feedback sensor
 - Without position feedback sensor (Sensorless)
4. Regen mode

3.2.1 Open loop mode

The drive applies power to the motor at frequencies varied by the user. The motor speed is a result of the output frequency of the drive and slip due to the mechanical load. The drive can improve the speed control of the motor by applying slip compensation. The performance at low speed depends on whether V/F mode or open loop vector mode is selected.

Open loop vector mode

The voltage applied to the motor is directly proportional to the frequency except at low speed where the drive uses motor parameters to apply the correct voltage to keep the flux constant under varying load conditions.

Typically 100 % torque is available down to 1 Hz for a 50 Hz motor.

Fixed V/F mode

The voltage applied to the motor is directly proportional to the frequency except at low speed where a voltage boost is provided which is set by the user. This mode can be used for multi-motor applications.

Typically 100 % torque is available down to 4 Hz for a 50 Hz motor.

Quadratic V/F mode

The voltage applied to the motor is directly proportional to the square of the frequency except at low speed where a voltage boost is provided which is set by the user. This mode can be used for running fan or pump applications with quadratic load characteristics or for multi-motor applications. This mode is not suitable for applications requiring a high starting torque.

3.2.2 RFC-A mode

Rotor Flux Control for **A**synchronous (induction) motors (**RFC-A**) encompasses closed loop vector control with a position feedback device

With position feedback

For use with induction motors with a feedback device installed. The drive directly controls the speed of the motor using the feedback device to ensure the rotor speed exactly as demanded. Motor flux is accurately controlled at all times to provide full torque all the way down to zero speed.

Without position feedback (Sensorless)

Sensorless mode provides closed loop control without the need for position feedback by using current, voltages and key motor parameters to estimate the motor speed. It can eliminate instability traditionally associated with open loop control such as operating large motors with light loads at low frequencies.

3.2.3 RFC-S mode

Rotor Flux Control for **S**ynchronous (permanent magnet brushless) motors (**RFC-S**) provides closed loop control with position feedback device.

With position feedback

For use with permanent magnet brushless motors with a feedback device installed.

The drive directly controls the speed of the motor using the feedback device to ensure the rotor speed is exactly as demanded. Flux control is not required because the motor is self excited by the permanent magnets which form part of the rotor.

Absolute position information is required from the feedback device to ensure the output voltage is accurately matched to the back EMF of the motor. Full torque is available all the way down to zero speed.

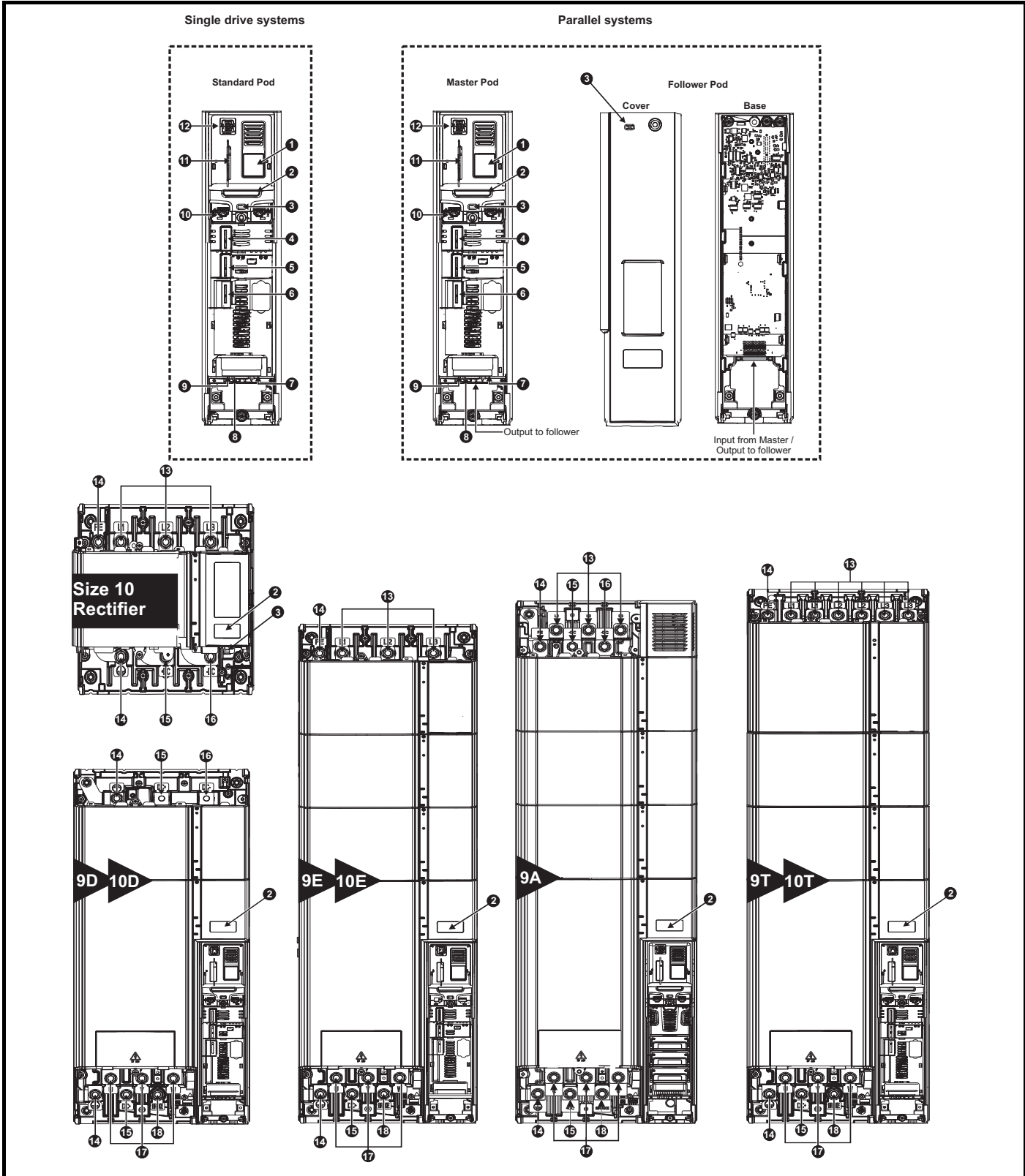
3.2.4 Regen mode

For use as a regenerative front end for four quadrant operation.

Regen operation allows bi-directional power flow to and from the AC supply. This provides far greater efficiency levels in applications which would otherwise dissipate large amounts of energy in the form of heat in a braking resistor.

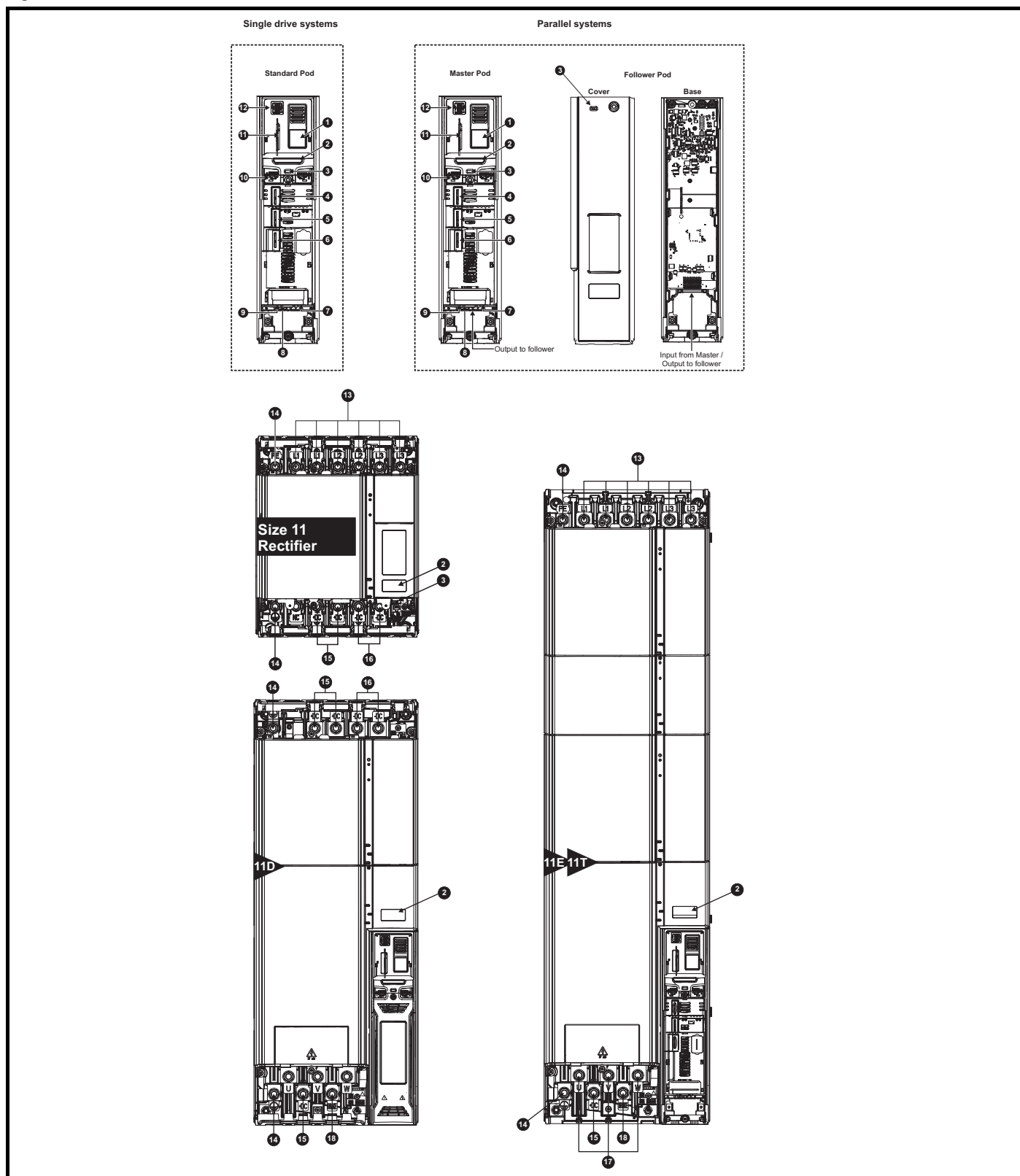
The harmonic content of the input current is negligible due to the sinusoidal nature of the waveform when compared to a conventional bridge rectifier or SCR/thyristor front end.

Figure 3-1 Features of the Unidrive M / Unidrive HS size 9 and 10



- Key**
- | | | | |
|-------------------------|----------------------------------|---------------------------|-----------------------|
| 1. Rating label | 6. Option module slot 3 | 11. NV media card slot | 16. DC bus - |
| 2. Identification label | 7. Relay connections | 12. Keypad connection | 17. Motor connections |
| 3. Status LED | 8. Position feedback connections | 13. AC supply connections | 18. Braking terminal |
| 4. Option module slot 1 | 9. Control connections | 14. Ground connections | |
| 5. Option module slot 2 | 10. Communications port | 15. DC bus + | |

Figure 3-2 Features of the Unidrive M / Unidrive HS size 11



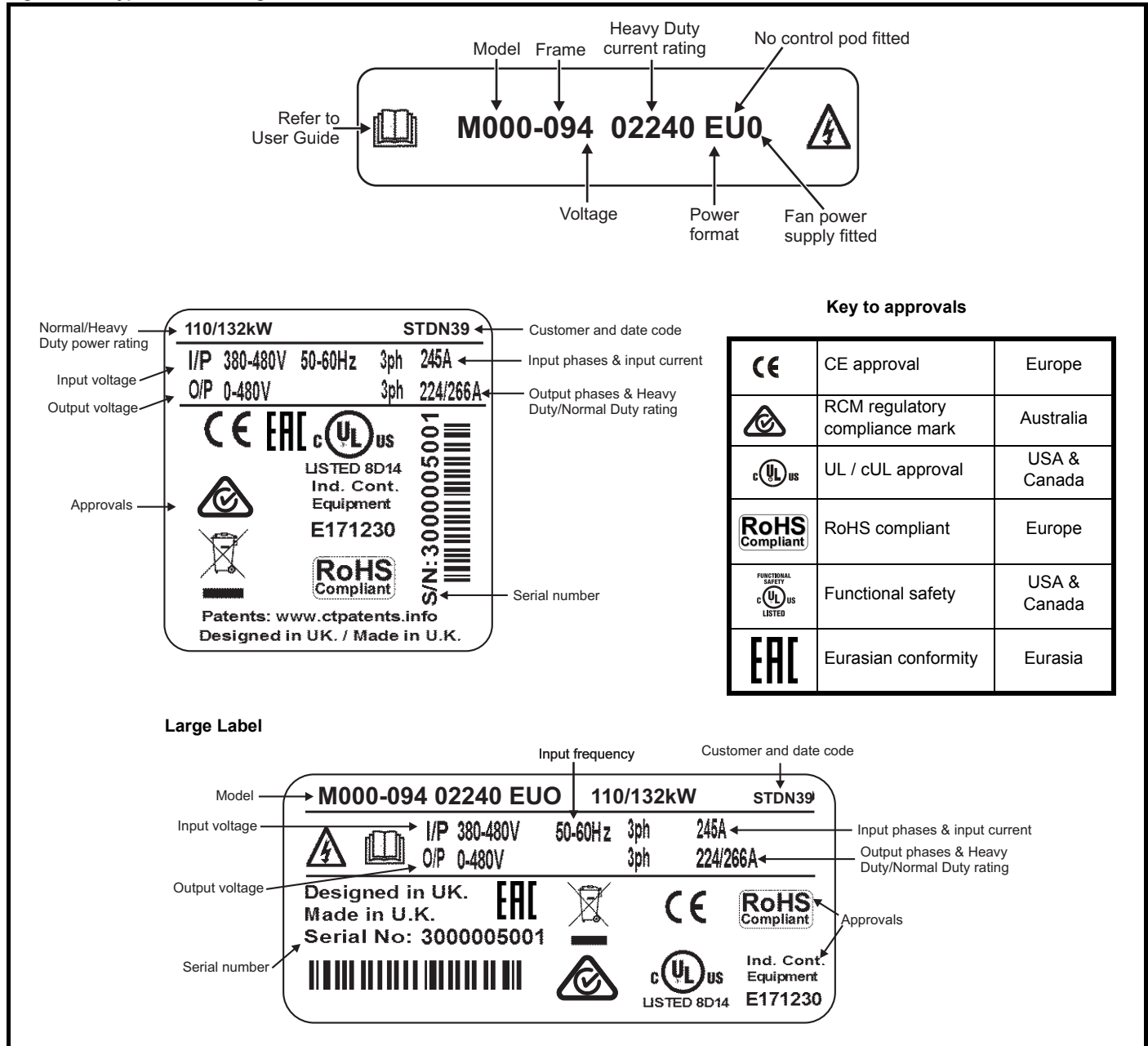
Key

- | | | | |
|-------------------------|----------------------------------|---------------------------|-----------------------|
| 1. Rating label | 6. Option module slot 3 | 11. NV media card slot | 16. DC bus - |
| 2. Identification label | 7. Relay connections | 12. Keypad connection | 17. Motor connections |
| 3. Status LED | 8. Position feedback connections | 13. AC supply connections | 18. Braking terminal |
| 4. Option module slot 1 | 9. Control connections | 14. Ground connections | |
| 5. Option module slot 2 | 10. Communications port | 15. DC bus + | |

3.3 Nameplate description

Figure 3-3 illustrates typical nameplate and rating labels.

Figure 3-3 Typical drive rating labels



Refer to Figure 2-13 Drive model number on page 15 for further information relating to the labels.

NOTE

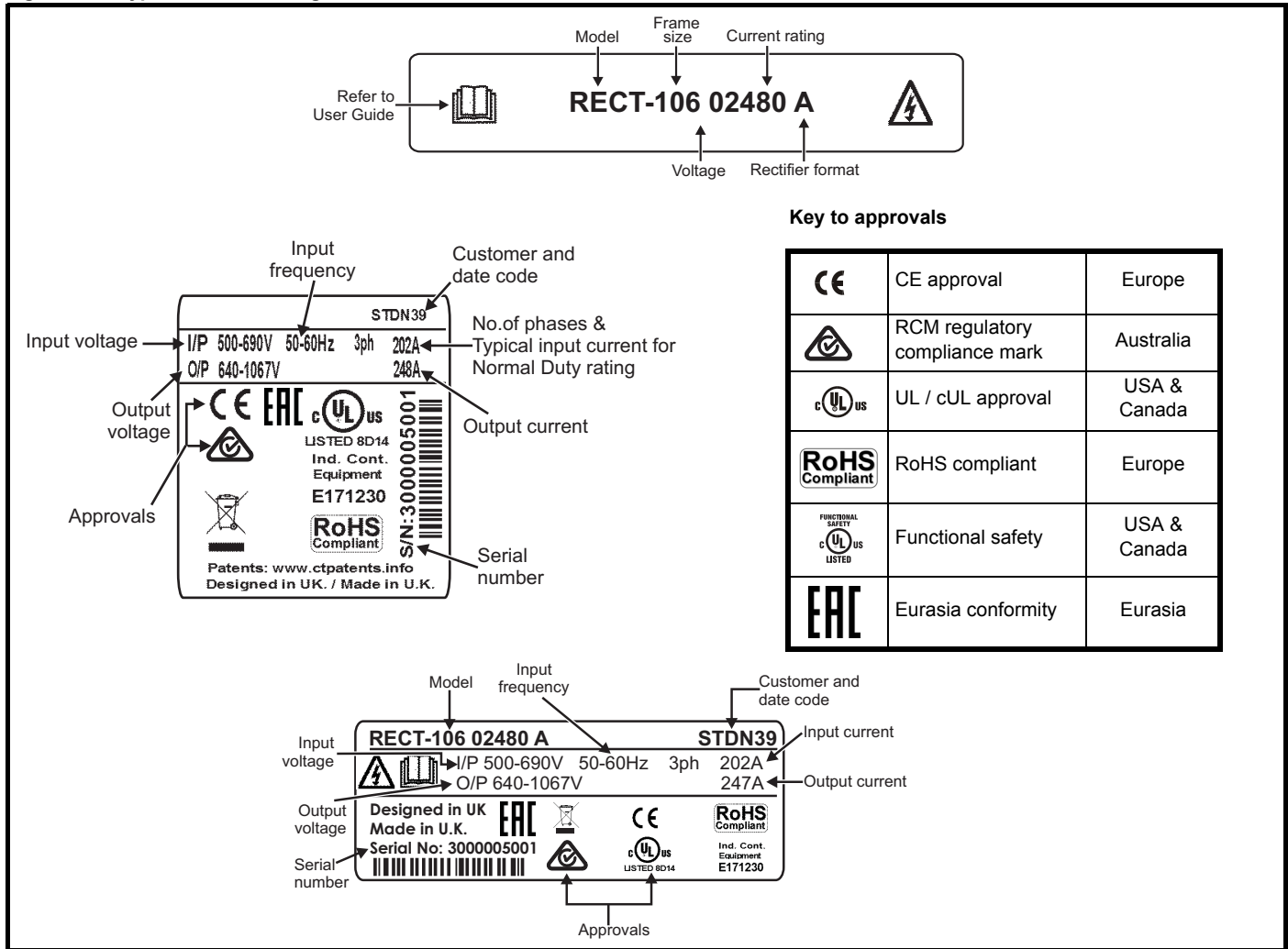
Date code format

The date code is split into two sections: a letter followed by a number. The letter indicates the year, and the number indicates the week number (within the year) in which the drive was built. The letters go in alphabetical order, starting with A in 1991 (B in 1992, C in 1993 etc).

Example:

A date code of **W28** would correspond to week 28 of year 2013.

Figure 3-4 Typical rectifier rating labels



Refer to Figure 2-12 *Rectifier model number* on page 15 for further information relating to the labels.

Figure 3-5 Typical master pod rating labels

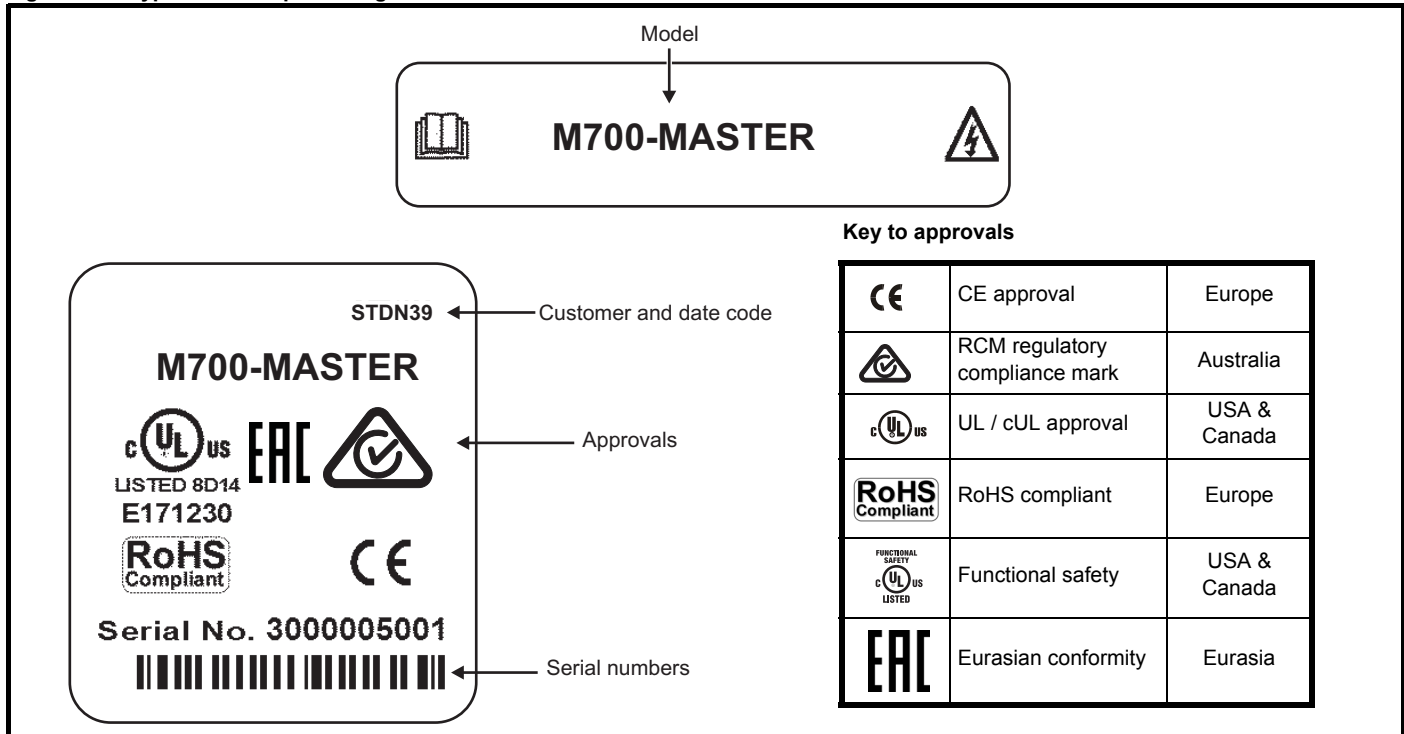


Figure 3-6 Typical follower pod rating label

Key to approvals

	CE approval	Europe
	RCM regulatory compliance mark	Australia
	UL / cUL approval	USA & Canada
	RoHS compliant	Europe
	Functional safety	USA & Canada
	Eurasian conformity	Eurasia

Figure 3-7 Options available for Unidrive M/HS modular drives

<p>Size 9 and 10 single input line reactor (INLX0X)</p>	<p>Size 9 and 10 single output sharing choke (OTLX0X) for parallel module drives</p>	<p>Size 9 and 10 dual output sharing chokes (OTLX1X) for parallel module drives *</p>	<p>Size 11 single input line reactor (INLX0X)</p>
<p>Finger-guard grommet double entry kit 3470-0107 x 8</p>	<p>Size 11 single output sharing choke (OTLX0X) for parallel module drives.</p>	<p>EMC filter</p>	
<p>Size 11D Lifting tool 7778-0031</p>	<p>Size 9E/D/T, 10E/D/T and size 10 Rectifier Lifting tool 7778-0016</p>	<p>Size 11E/T and size 11 single/twin Rectifier Lifting tool 7778-0030</p>	<p>Size 9A Lifting tool 7778-0045</p>








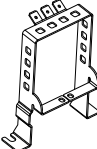




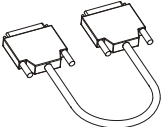
* Limit drive output current to rating of dual output sharing choke.

A separate input line reactor of at least the value shown in Table 6-2 on page 93 must be used with all modular drives other than size 9A (which has an internal line reactor). Failure to provide sufficient reactance could damage or reduce the service life of the rectifier or inverter.

3.4 Supplied items

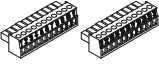









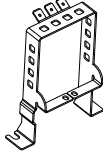



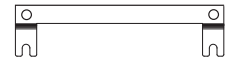



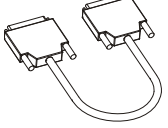
The drive/rectifier/pod is supplied with a safety information booklet, the Certificate of Quality and an accessory kit box including the items shown in Table 3-7 (frame 9 and 10), and Table 3-8 (frame 11).

Table 3-7 Parts supplied with the size 9A/E/T, 10E/D

Description	Standard / Master Pod	Follower Pod	Size 10 rectifier	Size 9 and 10 inverter
Control connections	 x 1 x 1 x 1			
Relay connector	 x 1			
24 V power supply	 x 1	 x 1	 x 1	 x1  x1
Grounding bracket	 x 1			
Surface mounting bracket			 x 2	 x 2
Paralleling cable management bracket	 x 1	 x 1		
Paralleling cable (2m)*		 x 1		

NOTE * A two meter paralleling cable is supplied with each follower pod, 1m, 2m and 5m cables are also available separately. Please see section 4.1.2 *Paralleling cable* on page 38 for further details.

Table 3-8 Parts supplied with the size 11E/D/T

Description	Standard / Master Pod	Follower Pod	Size 11 rectifier	Size 11E	Size 11D
Control connections	 x 1 x 1  x 1				
Relay connector	 x 1				
24 V power supply	 x 2	 x 1	 x 1	 x1  x1	 x1  x1
Grounding bracket	 x 1				
Surface mounting bracket			 x 1  x 1	 x 2  x 1	 x 2
Paralleling cable management bracket	 x 1	 x 1			
Paralleling cable (2m)		 x 1			

NOTE * A two meter paralleling cable is supplied with each follower pod, 1m, 2m and 5m cables are also available separately. Please see section 4.1.2 *Paralleling cable* on page 38 for further details.

4 System configuration

This chapter describes the various Unidrive M / Unidrive HS size 9, 10 and 11 system configurations.

Figure 4-1 Layout for a Unidrive M / Unidrive HS size 9A module operating on a 3-phase AC supply

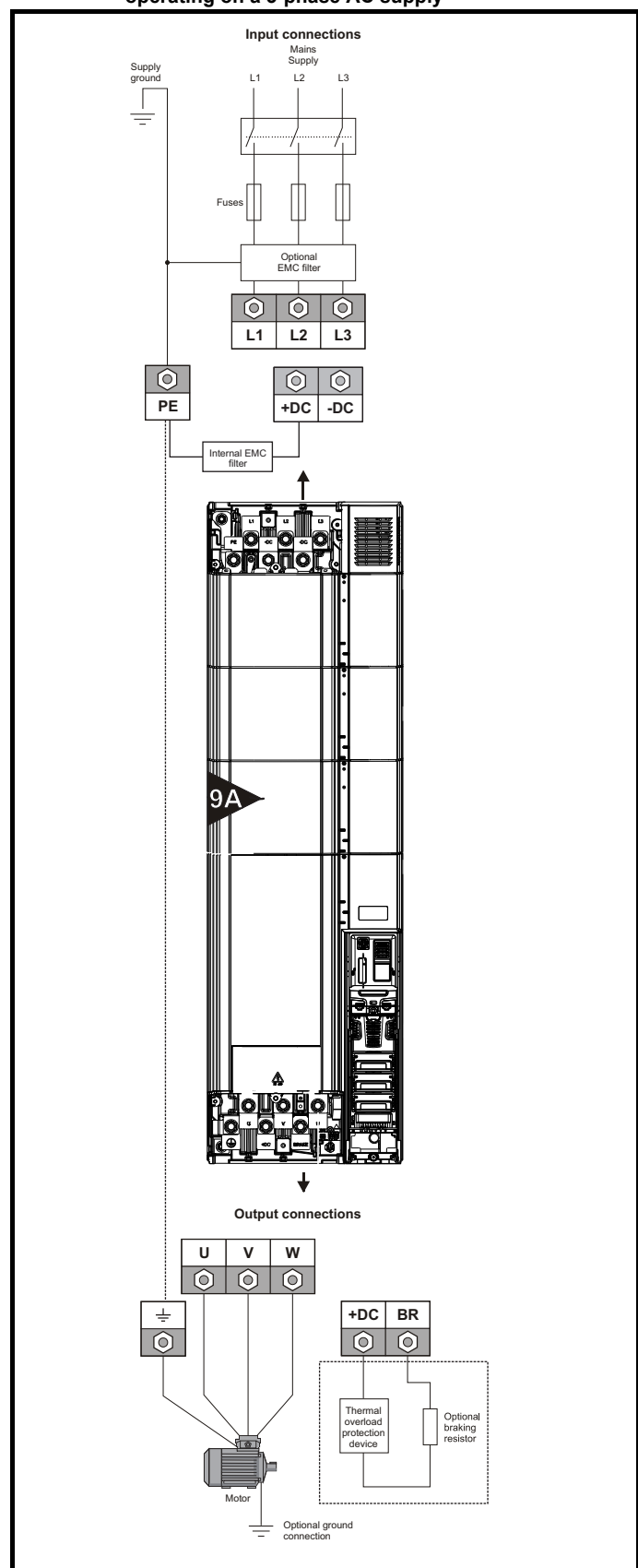


Figure 4-2 Layout for a Unidrive M / Unidrive HS size 9E or 10E module operating on a 3-phase AC supply

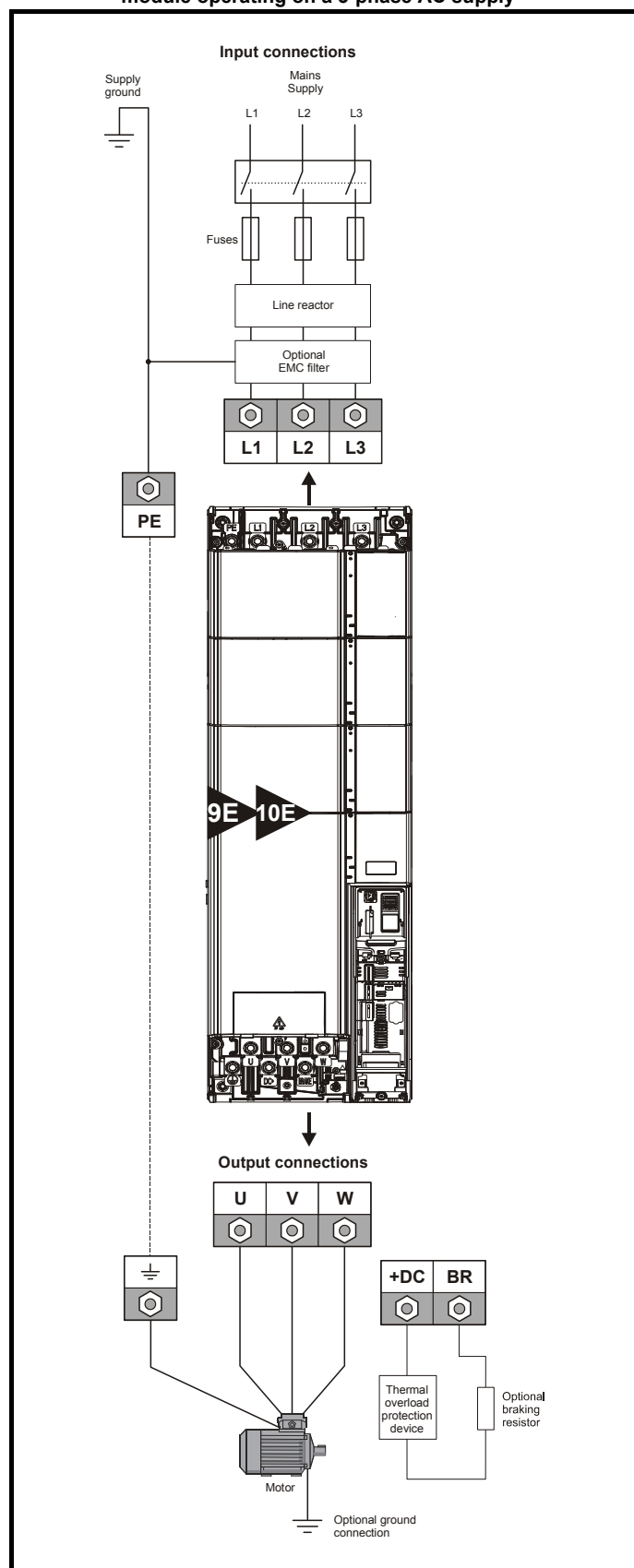
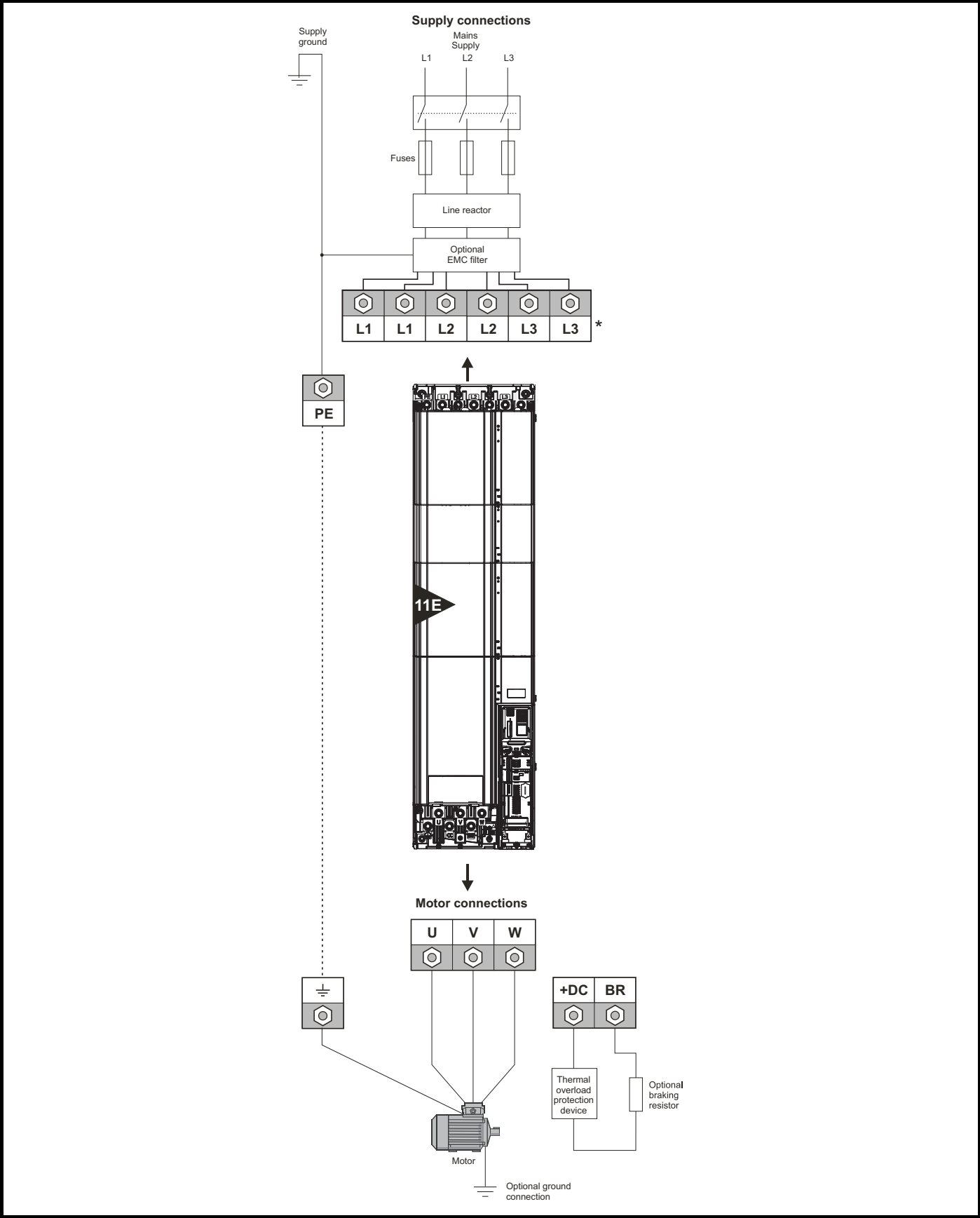


Figure 4-3 Layout for a Unidrive M / Unidrive HS size 11E module operating on a 3-phase AC supply



* Connect to either terminal.

Figure 4-4 Layout for a Unidrive M / Unidrive HS size 9D and 10D module operating on a 3-phase supply

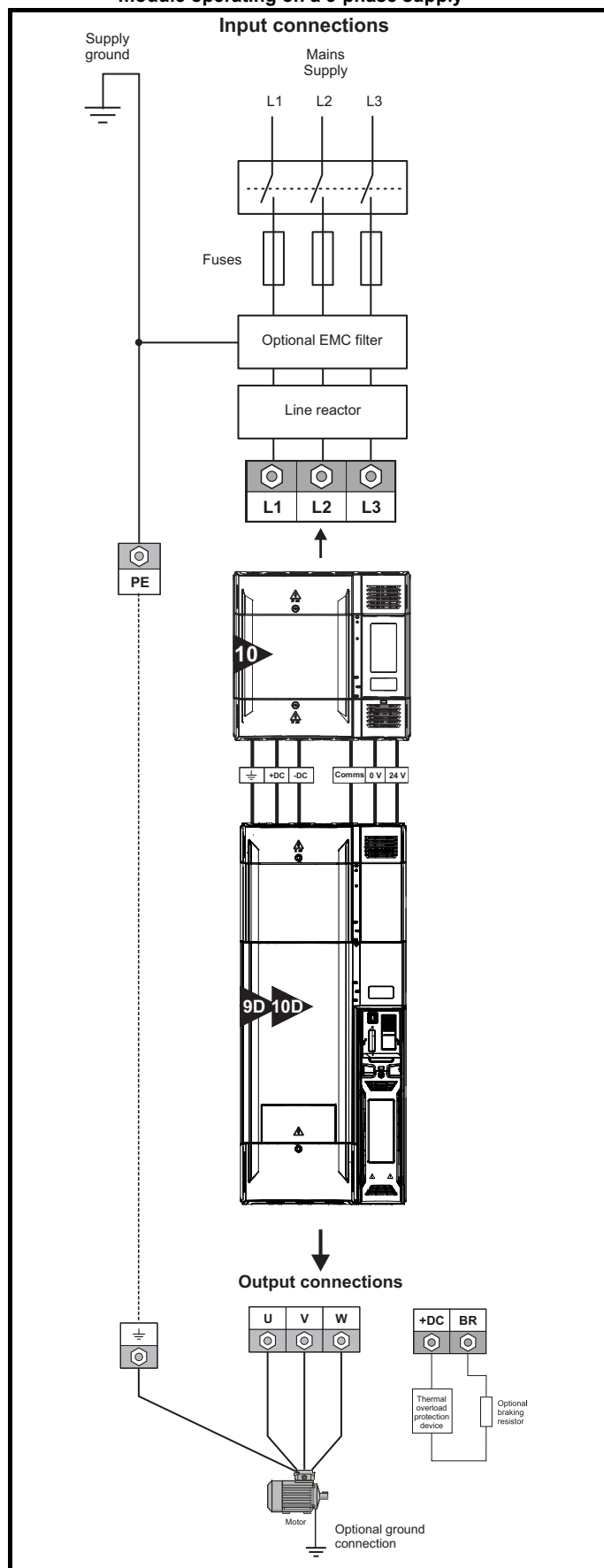
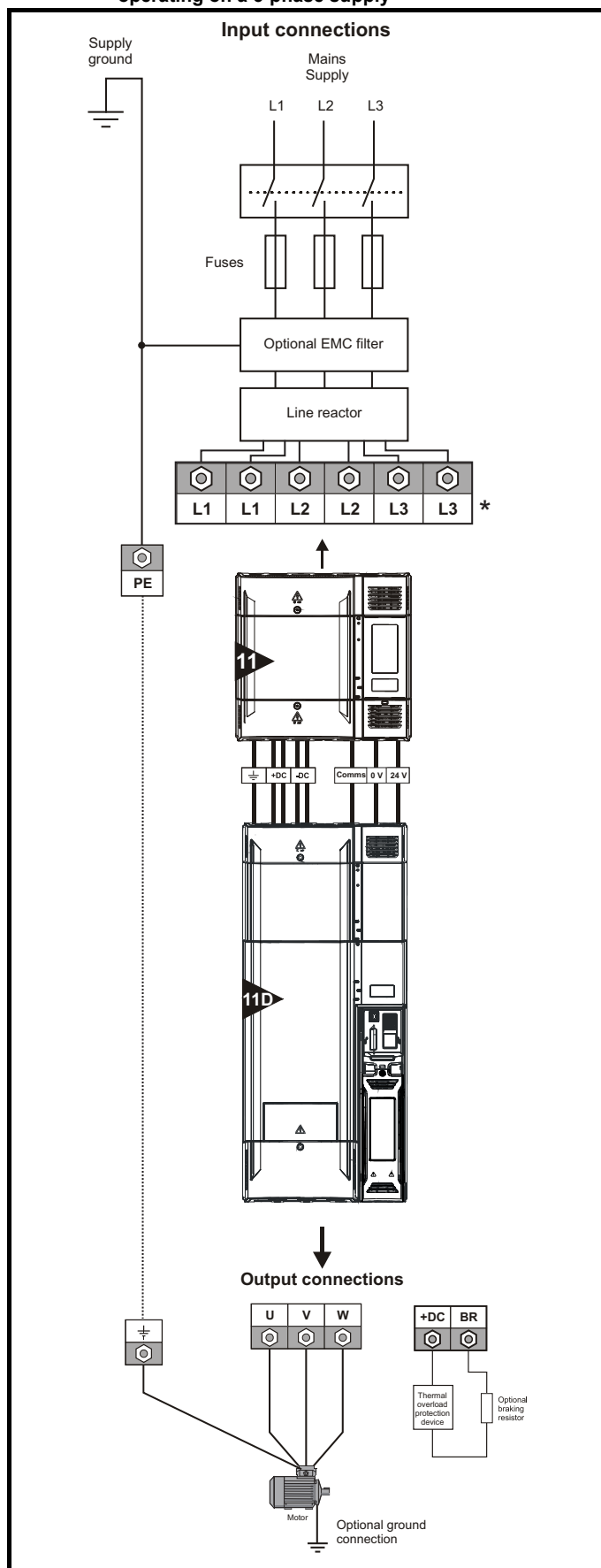
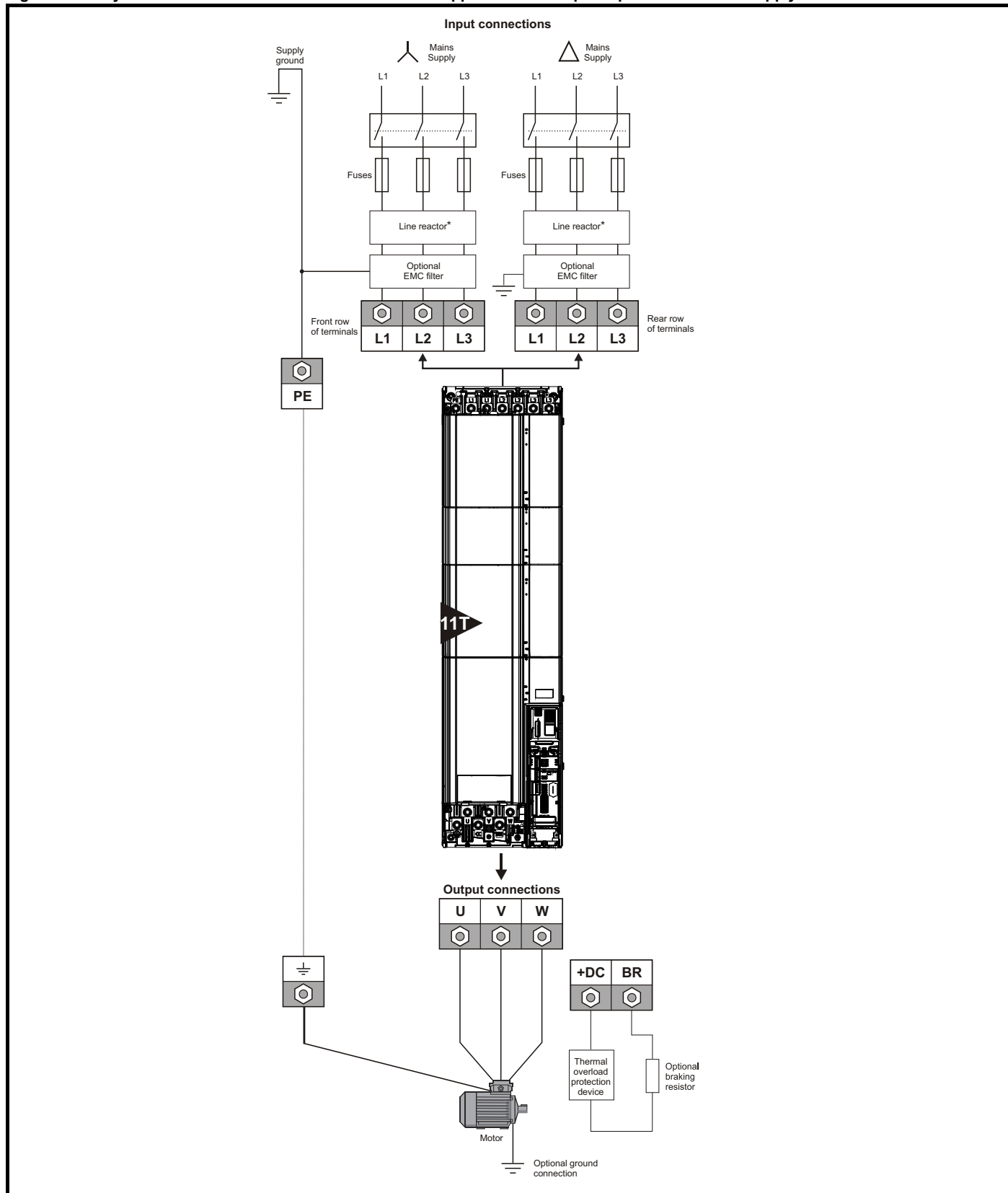


Figure 4-5 Layout for a Unidrive M / Unidrive HS size 11D operating on a 3-phase supply



* Connect to either terminal.

Figure 4-6 Layout for a Unidrive M / Unidrive HS size 11T supplied from a 12 pulse phase shifted AC supply



* INL chokes may be omitted if:

1. The transformer is dedicated to the drive i.e. not shared with other equipment.
2. The transformer has reactances from primary to secondary and between secondaries of at least 4 % based on the drive rating. This represents a fully wound transformer with loosely coupled secondaries whose rating (kVA) does not match the drive rating.

Figure 4-7 Layout for two Unidrive M / Unidrive HS size 9A modules operating on a 6 pulse 3-phase AC supply

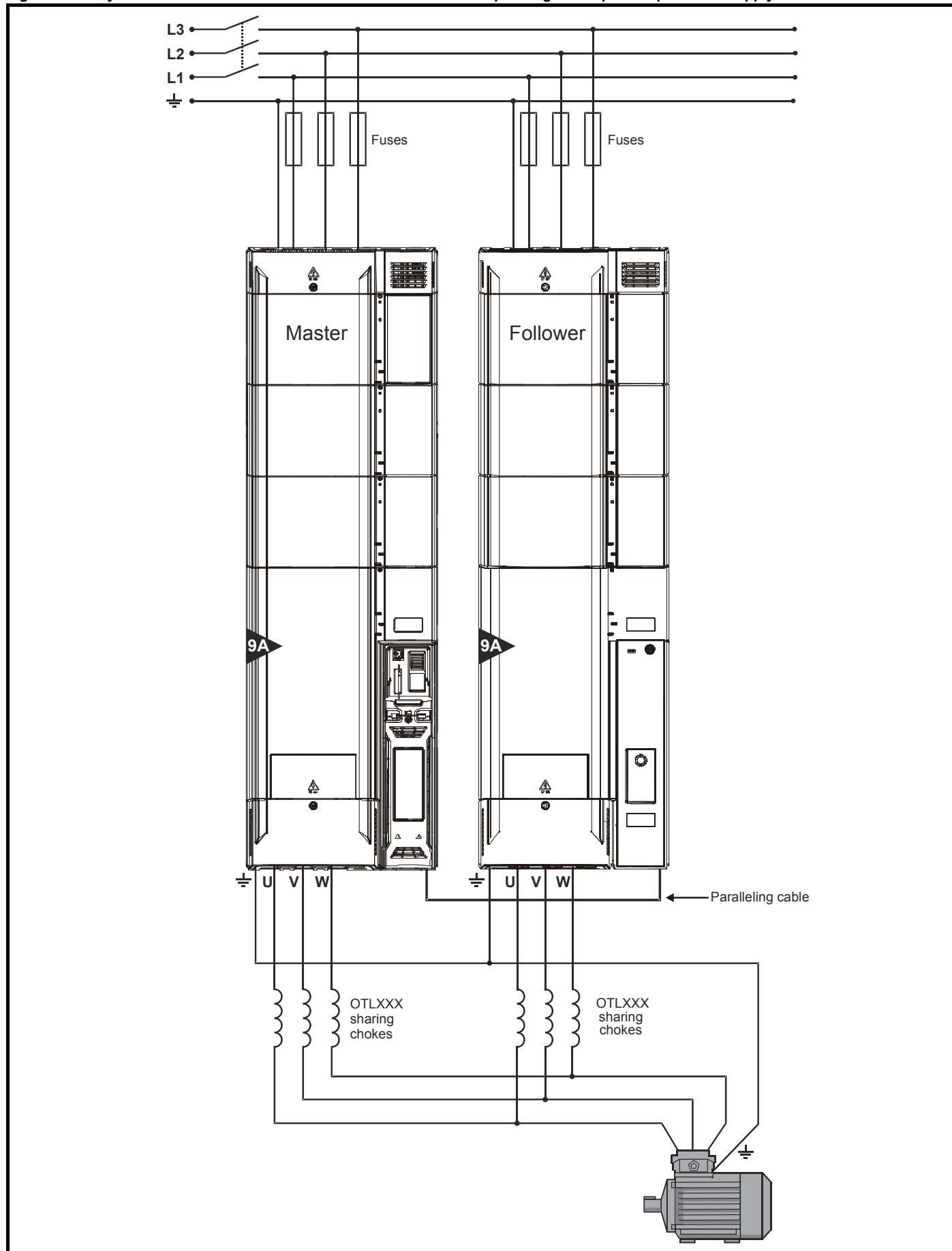


Figure 4-8 Layout for two Unidrive M / Unidrive HS size 9E, 10E or 11E modules operating on a 6 pulse 3-phase AC supply

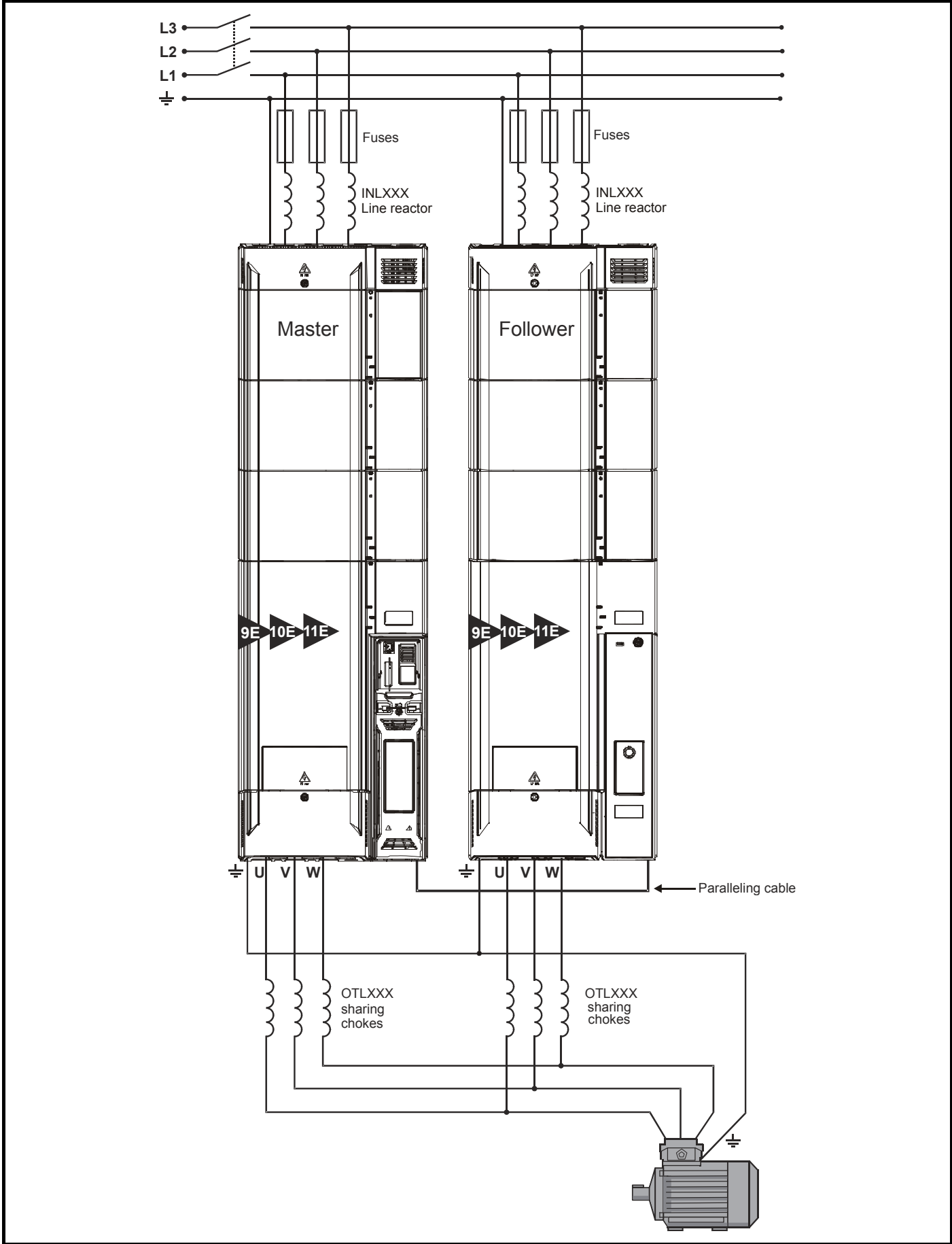


Figure 4-9 Layout for two or more Unidrive M / Unidrive HS size 9D, 10D or 11D with single size 10 or 11 rectifiers operating on a 6 pulse 3-phase AC supply

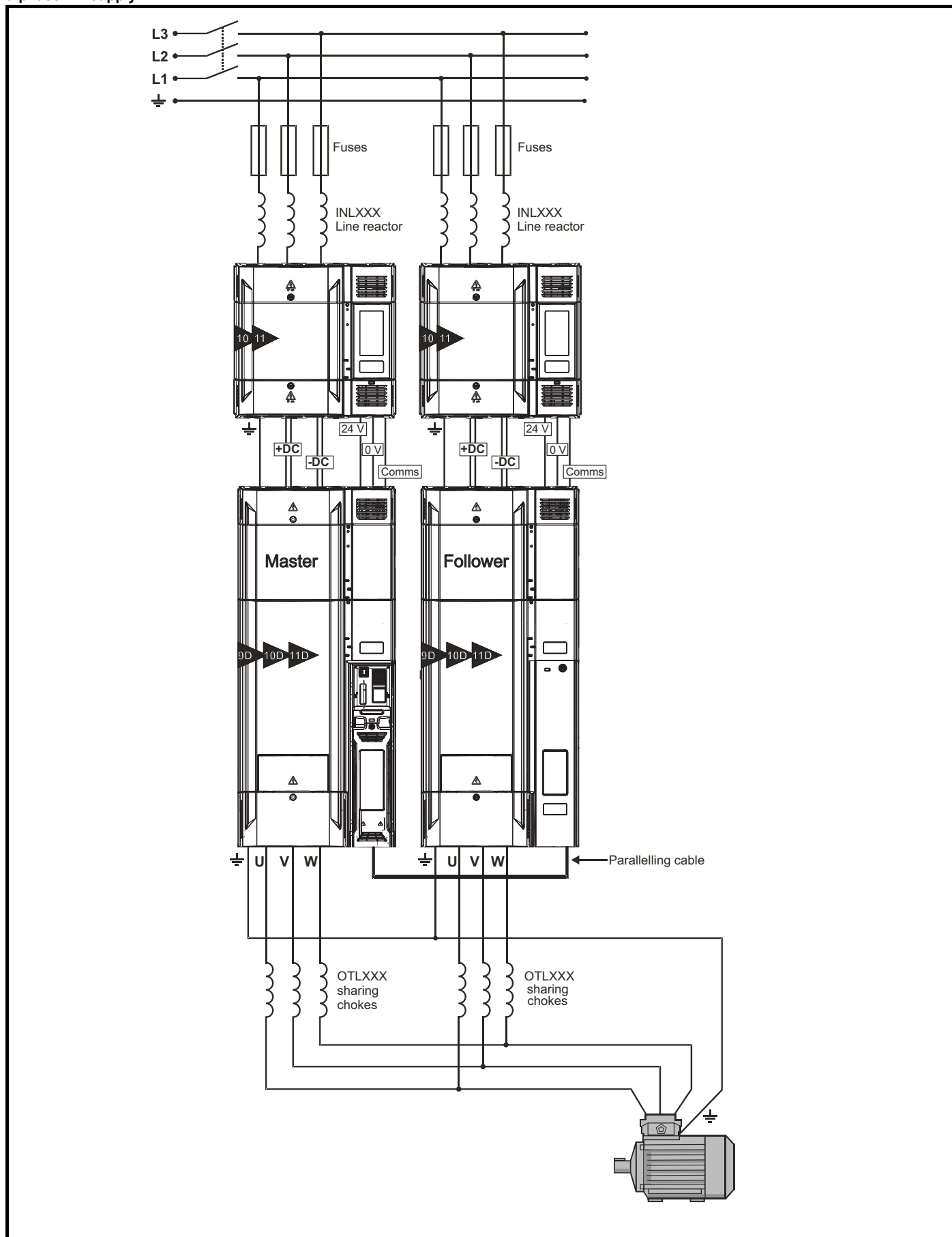
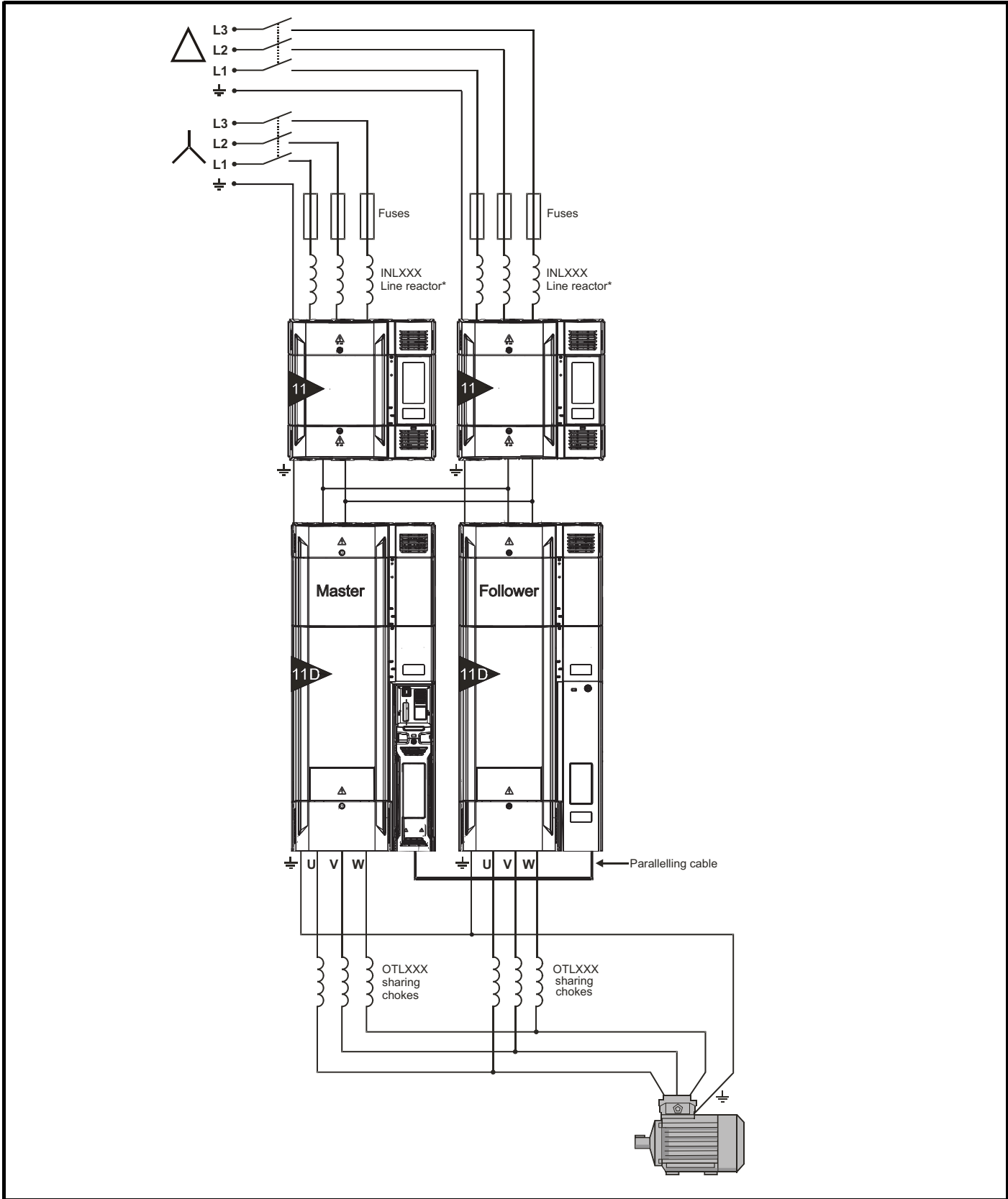


Figure 4-10 Layout for two Unidrive M / Unidrive HS size 11D with single size 11 rectifiers operating on a 12 pulse phase shifted AC supply



* INL chokes may be omitted if:

1. The transformer is dedicated to the drive i.e. not shared with other equipment.
2. The transformer has reactances from primary to secondary and between secondaries of at least 4% based on the drive rating. This represents a fully-wound transformer with loosely-coupled secondaries whose rating (kVA) does not much exceed the drive rating.

Figure 4-11 Layout for two Unidrive M / Unidrive HS size 9D/10D with twin size 11 rectifier on a 6 pulse 3-phase supply

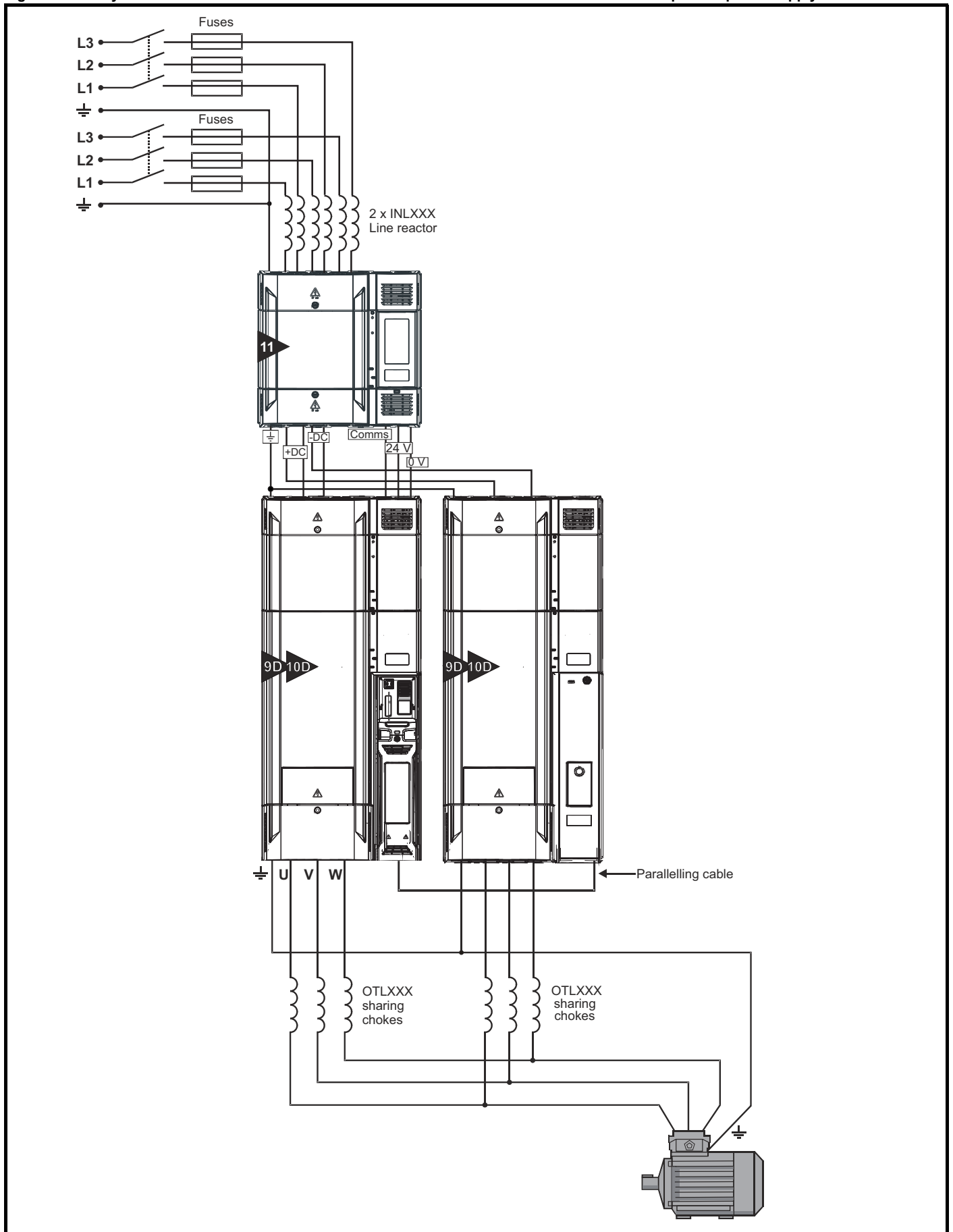
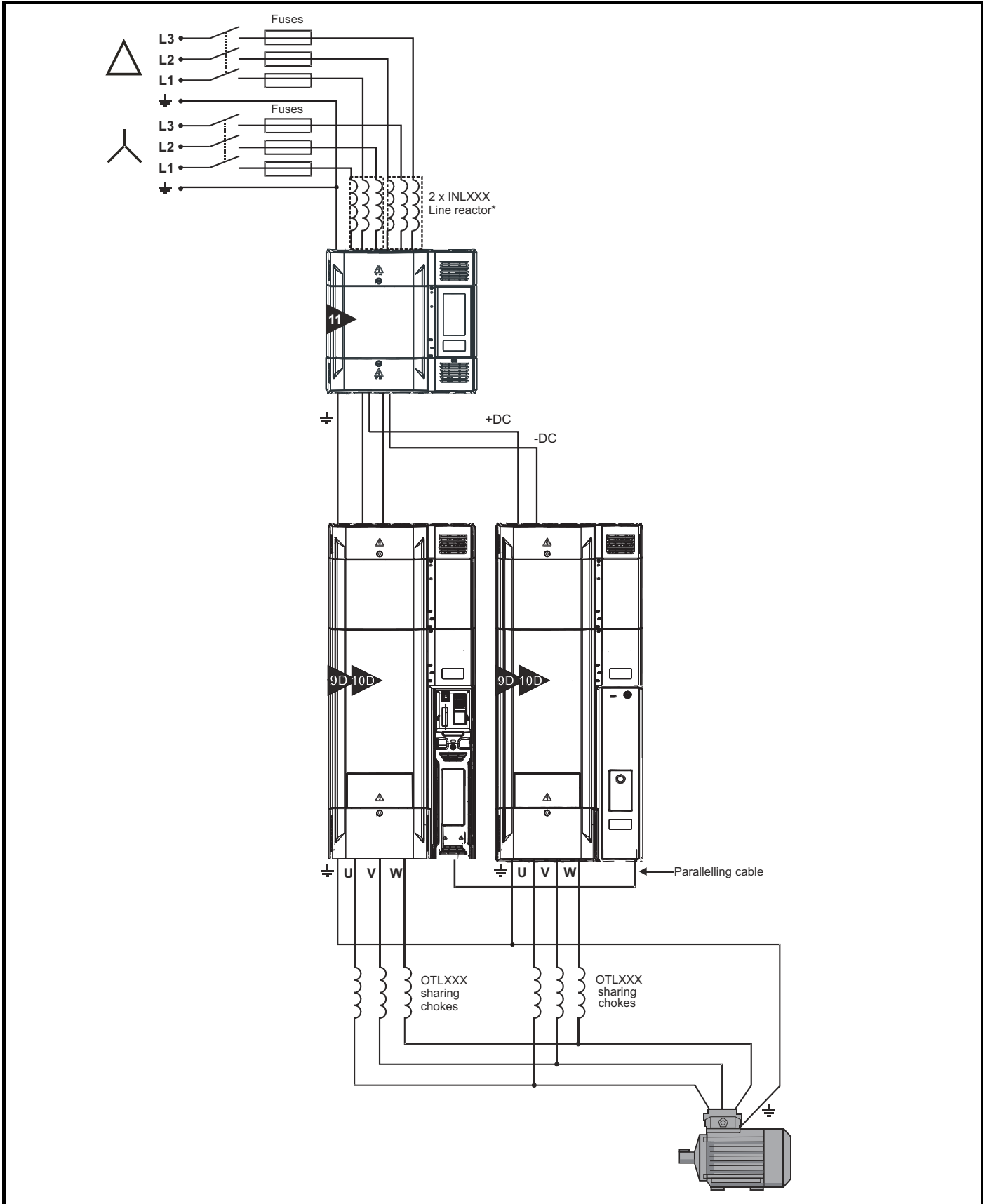


Figure 4-12 Layout for two Unidrive M / Unidrive HS size 9D/10D with twin size 11 rectifier operating on a 12 pulse phase shifted AC supply



* INL chokes may be omitted if:

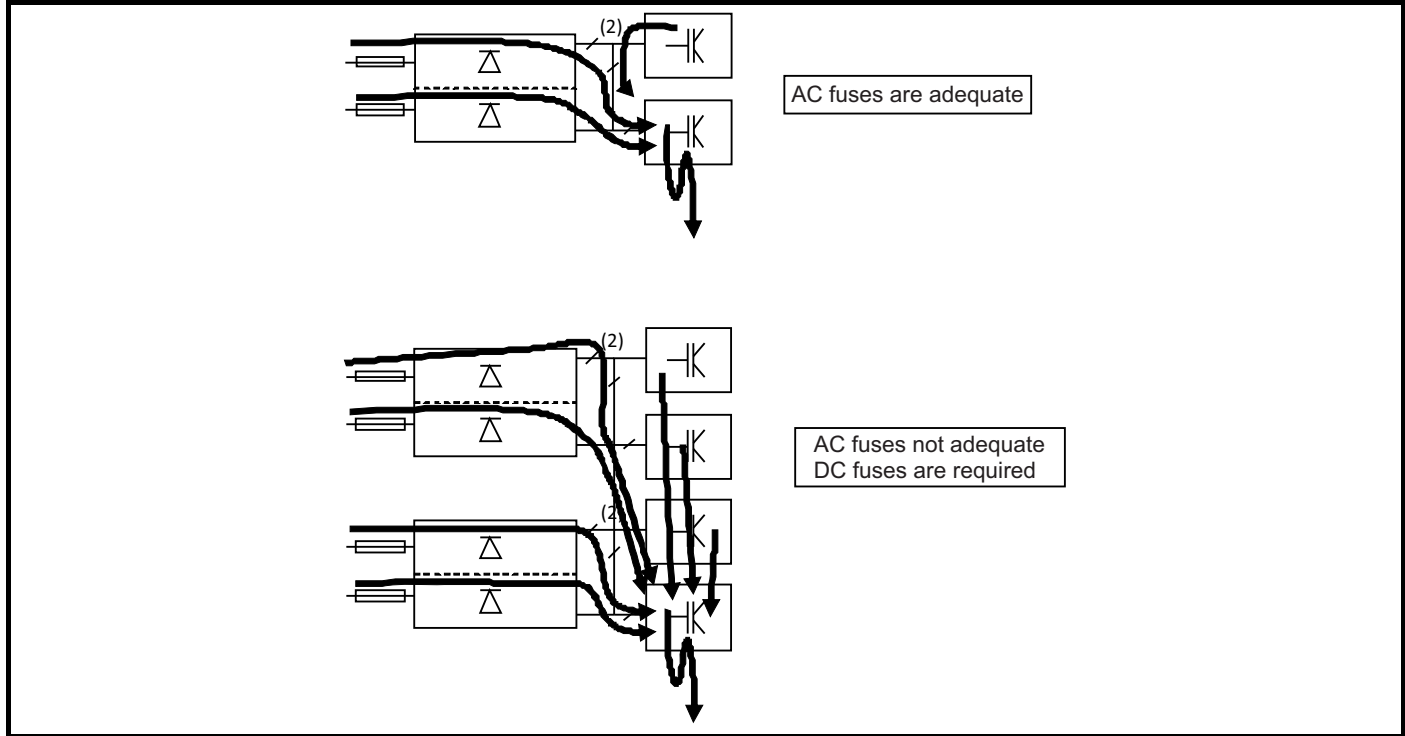
1. The transformer is dedicated to the drive i.e. not shared with other equipment.
2. The transformer has reactances from primary to secondary and between secondaries of at least 4% based on the drive rating. This represents a fully-wound transformer with loosely-coupled secondaries whose rating (kVA) does not much exceed the drive rating.

4.1.1 DC fusing

The *Unidrive M/HS* modular system has undergone safety testing and proving when using the specified AC input fuses, including the case where the size 11 twin rectifier is used to supply two D type modules. A fault in any module is cleared by the AC input fuses.

If more rectifiers or inverters are connected to the DC bus then the prospective fault current and the energy delivered before a fault is cleared are increased because of the multiple sources and the increased stored energy in the inverter capacitors. It then becomes necessary to provide fuses in the DC bus. This is illustrated in Figure 4-13.

Figure 4-13 Fault current contributions

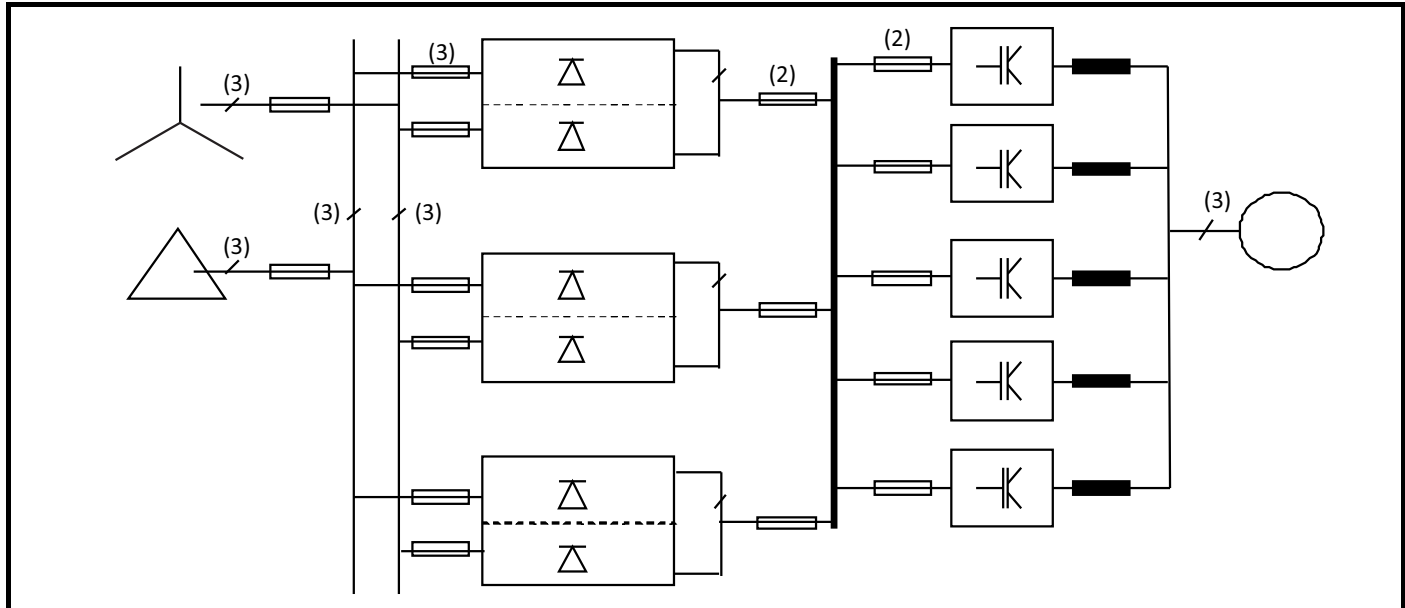


As shown in Figure 4-14 when DC fuses are required they must be placed in the rectifier output circuits as well as the inverter inputs, since they are also exposed to the total fault-current infeed. For the size 11 twin rectifier, only one fuse pair is needed for the complete module.

The only exception to this rule is where the rectifier input fuses are reduced in rating so that the total i^2t let-through for all of the phases is no greater than that for the standard recommended fuses for the 6-pulse arrangement. This will be the case for some of the lower-power multi-pulse arrangements. This needs to be verified on a case-by-case basis.

All DC fuses are in pairs, i.e. one in each pole, to provide protection against earth faults.

Figure 4-14 12-pulse system using twin rectifiers and 6-phase AC distribution with odd number of inverter modules



NOTE

Please see Table 6-15 *DC fuse and cable ratings for Unidrive M / HS size 9, 10 and 11 inverters* on page 102 for DC fuse ratings.

4.1.2 Paralleling cable

Part numbers

A single two meter paralleling cable is supplied with each follower pod. 1 m, 2 m and 5 m cables are also available separately (see Table 4-1 for part numbers)

Table 4-1 Paralleling cable part numbers

Description	Part number
1 m paralleling cable	3471-9842
2 m paralleling cable	3471-0013
5 m paralleling cable	3471-6850

Maximum lengths


Individual links between modules should be nominally 2 m in length however a maximum of two 5 m lengths can be used in a parallel system. The maximum combined paralleling cable length can not exceed 40 m.


5 Mechanical Installation


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


- Surface and through-panel mounting
- Remote mounting of control master pod
- Enclosure sizing and layout
- Terminal location and torque settings

5.1 Safety information

Follow the instructions

WARNING
 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.

Competence of the installer

WARNING
 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.

Many of the drives in this product range weigh in excess of 15 kg (33 lb). Use appropriate safeguards when lifting these models.

WARNING

Enclosure

WARNING
 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.

5.2 Planning the installation

The following considerations must be made when planning the installation:

5.2.1 Access

Access must be restricted to authorized personnel only. Safety regulations which apply at the place of use must be complied with. The IP (Ingress Protection) rating of the drive is installation dependent.

5.2.2 Environmental protection

The drive must be protected from:

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

NOTE

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

5.2.3 Cooling

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

For further information, please refer to section 5.6.4 *Enclosure sizing* on page 64.

5.2.4 Electrical safety

The installation must be safe under normal and fault conditions. Electrical installation instructions are given in Chapter 6 *Electrical Installation* on page 85.

5.2.5 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.

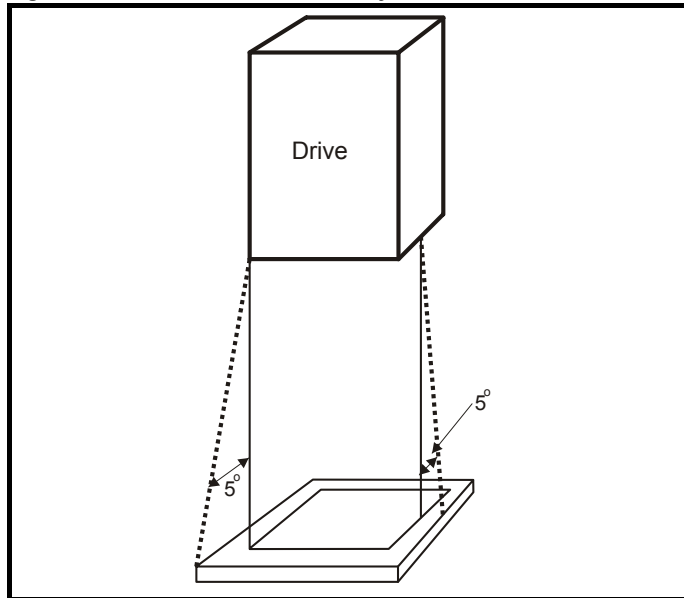
For installation outside the USA, the following (based on IEC 62109-1, standard for PV inverters) is recommended.

Enclosure can be metal and/or polymeric, polymer must meet requirements which can be summarized for larger enclosures as using materials meeting at least UL 94 class 5VB at the point of minimum thickness.

Air filter assemblies to be at least class V-2.

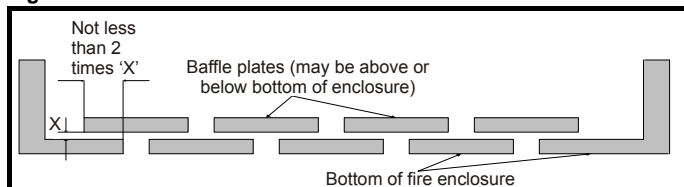
The location and size of the bottom shall cover the area shown in Figure 5-1. Any part of the side which is within the area traced out by the 5° angle is also considered to be part of the bottom of the fire enclosure.

Figure 5-1 Fire enclosure bottom layout



The bottom, including the part of the side considered to be part of the bottom, must be designed to prevent escape of burning material - either by having no openings or by having a baffle construction. This means that openings for cables etc. must be sealed with materials meeting the 5VB requirement, or else have a baffle above. See Figure 5-2 for acceptable baffle construction. This does not apply for mounting in an enclosed electrical operating area (restricted access) with concrete floor.

Figure 5-2 Fire enclosure baffle construction



5.2.6 Electromagnetic compatibility

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


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


If it is necessary to meet strict emission limits, or if it is known that electromagnetically sensitive equipment is located nearby, then full precautions must be observed. In-built into the drive, is an internal EMC filter, which reduces emissions under certain conditions. If these conditions are exceeded, then the use of an external EMC filter may be required at the drive inputs, which must be located very close to the drives. Space must be made available for the filters and allowance made for carefully segregated wiring. Both levels of precautions are covered in section 6.13 *EMC (Electromagnetic compatibility) on page 108.*

5.2.7 Hazardous areas

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

5.3 Terminal cover removal

	<p>Isolation device</p> <p>The AC 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.</p>
	<p>WARNING</p>

	<p>Stored charge</p> <p>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.</p> <p>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.</p>
	<p>WARNING</p>

5.3.1 Removing the terminal covers

Unidrive M / Unidrive HS size 9/10/11 D and E are installed with three terminal covers: Control, input and output terminal covers.

Unidrive M / Unidrive HS rectifiers are installed with two terminal covers: Input and output terminal covers. The terminal covers must be removed to gain access to all the terminals.

Figure 5-3 Location and identification of terminal covers

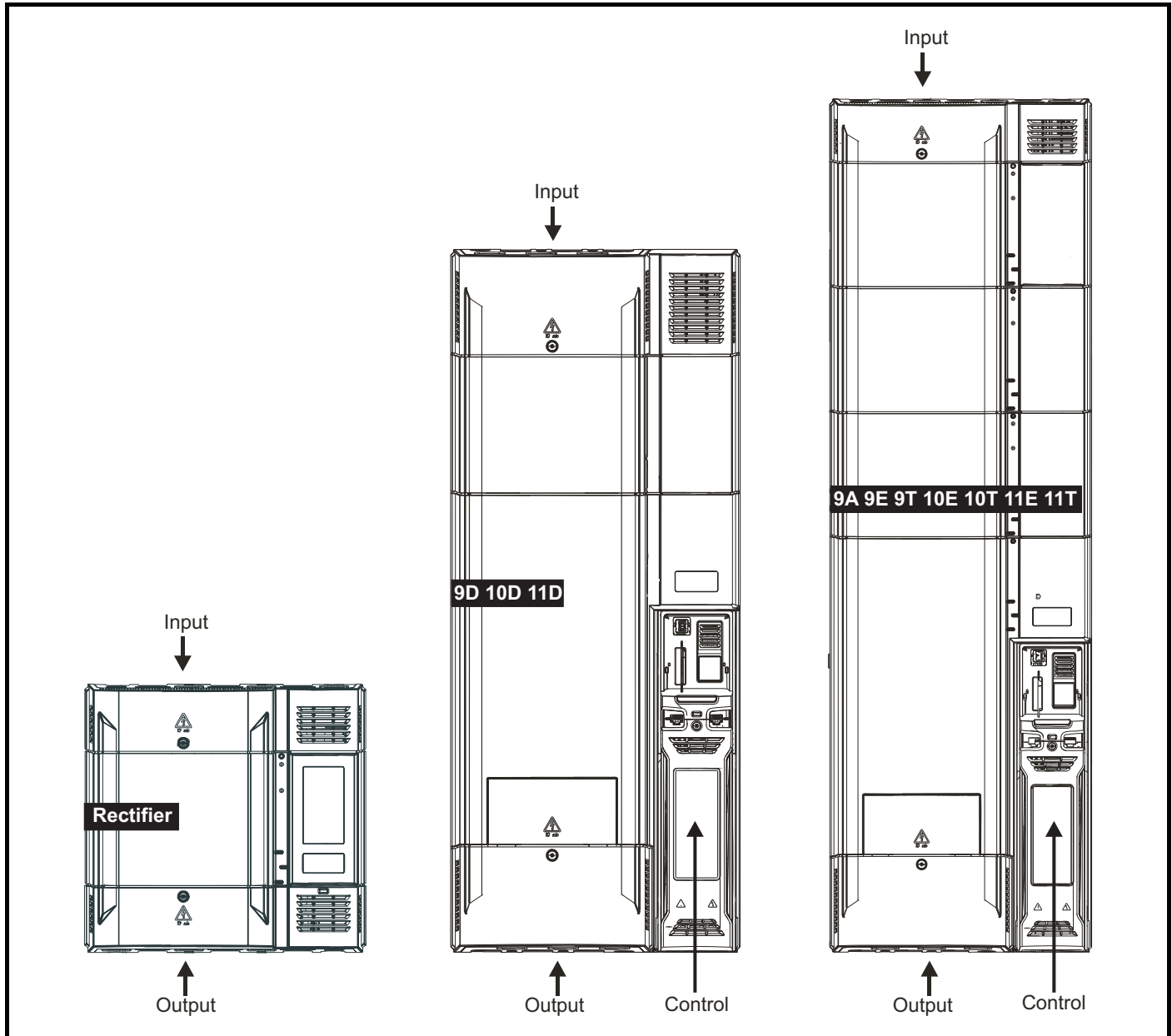
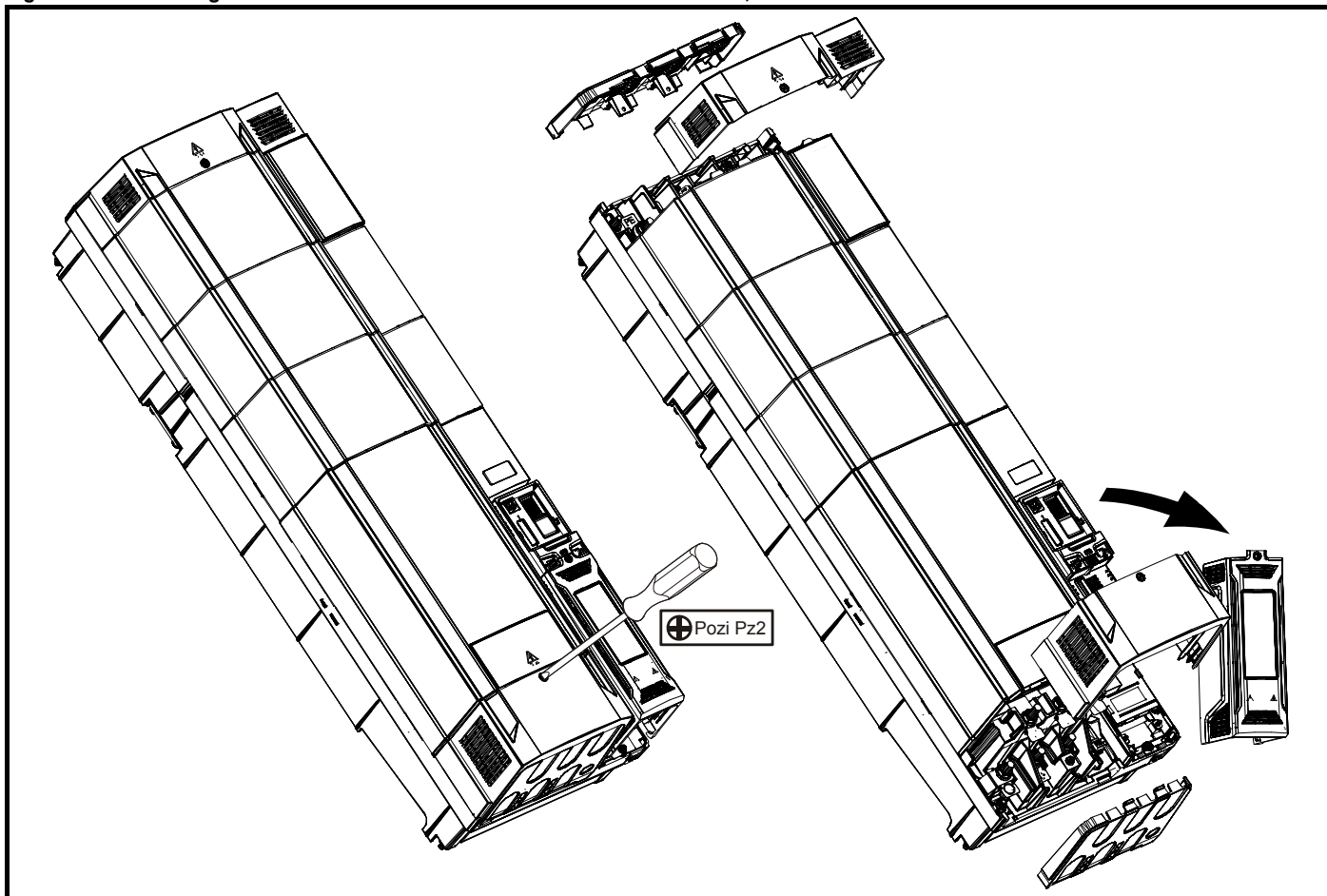
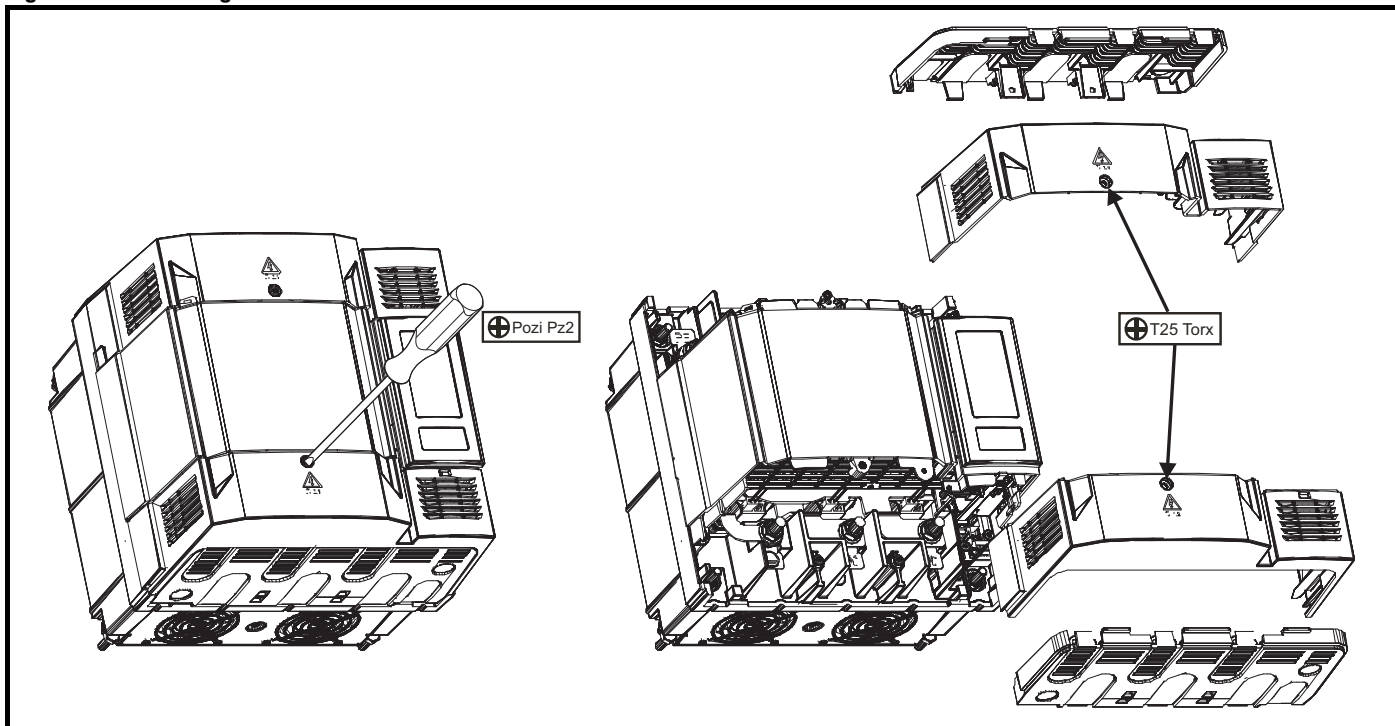


Figure 5-4 Removing the terminal covers on Unidrive M / Unidrive HS size 9, 10 and 11

To remove a terminal cover, undo the screw and lift the terminal cover off as shown.

When replacing the terminal covers the screws should be tightened with a maximum torque of 1 N m (0.7 lb ft).

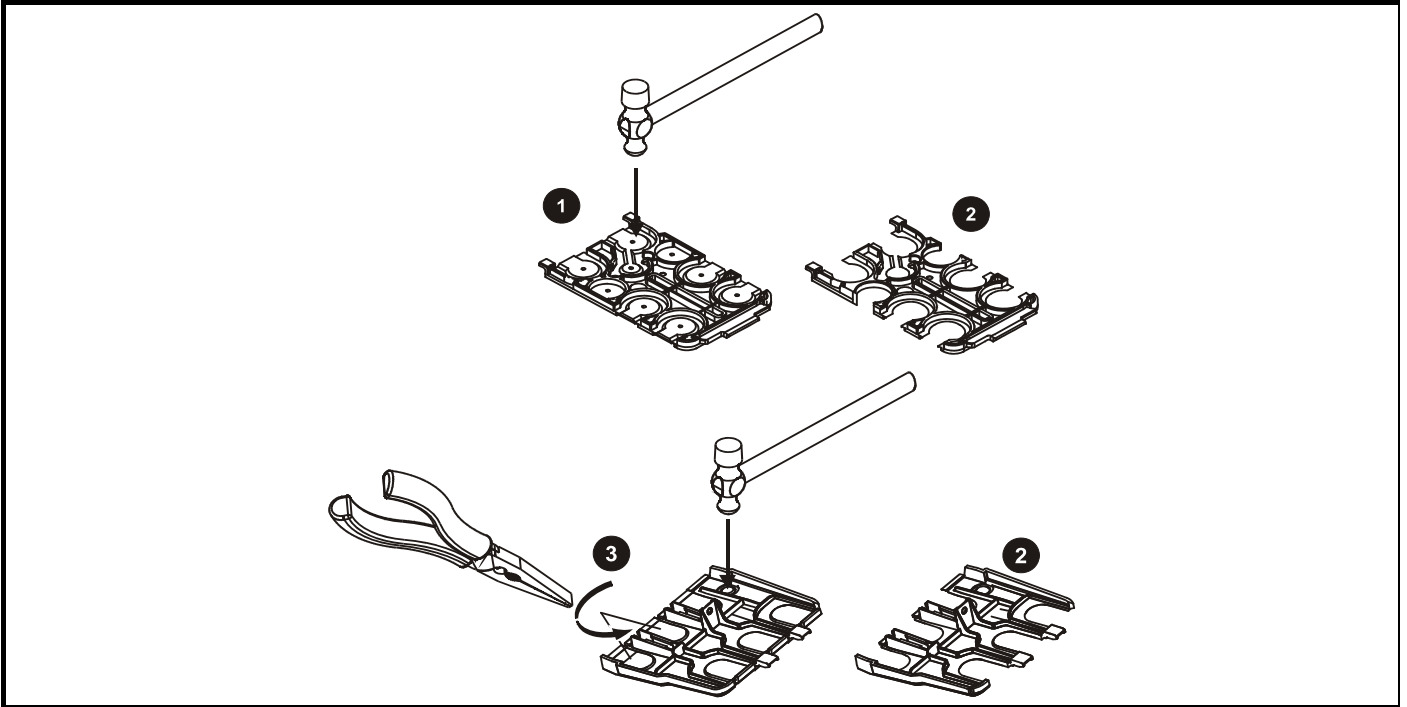
Figure 5-5 Removing the Unidrive M / Unidrive HS size 10 and 11 rectifier terminal covers

To remove a terminal cover, undo the screw and lift the terminal cover off as shown.

When replacing the terminal covers the screws should be tightened with a maximum torque of 1 N m (0.7 lb ft).


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

Figure 5-6 Removing the finger-guard break-outs



All sizes:

Place the finger-guard on a flat solid surface and hit relevant break-outs with hammer as shown (1). Pliers can be used to remove the breakouts, grasp the relevant break-out with pliers and twist it as shown (3). Continue until all the required break-outs have been removed (2). Remove any flash / sharp edges once the break-outs have been removed.

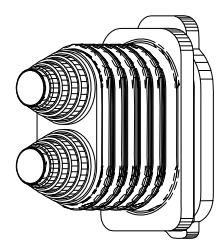


The grommets must be installed to ensure ingress protection to IP20 and to avoid the risk of fire in the event of a major internal failure.

WARNING

Grommet kits are available for size 9, 10 and 11 power terminal finger guards.

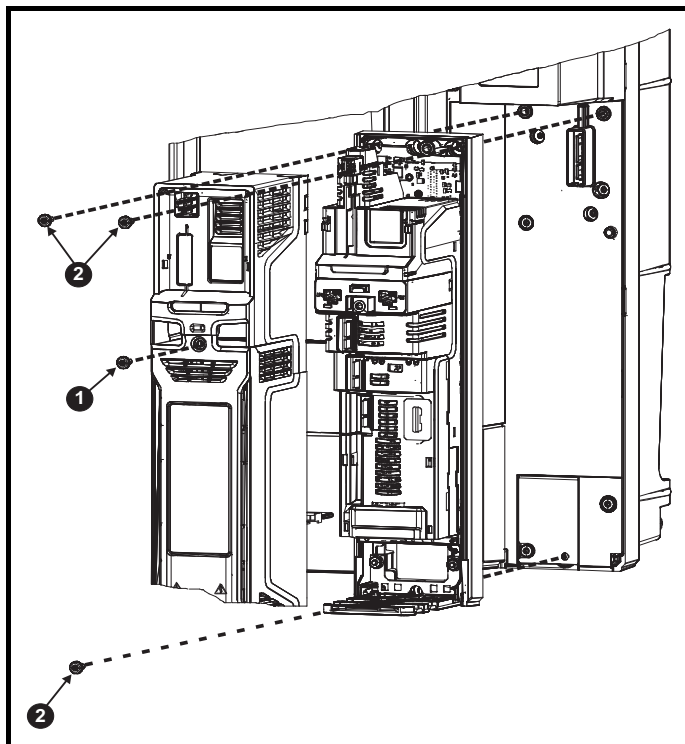
Table 5-1 Grommet kits for power terminal finger guards

Drive size	Quantity of kits	Part number	Picture
Size 9 and 10 - Kit of 8 x double entry grommets	1	3470-0107	
Size 11 - Kit of 8 x double entry grommets	2	3470-0107	

5.4 Mounting of the control master/ follower/standard pod

For control master/follower pod paralleling connections, refer to Figure 5-9 *Parallel control connections* on page 45.

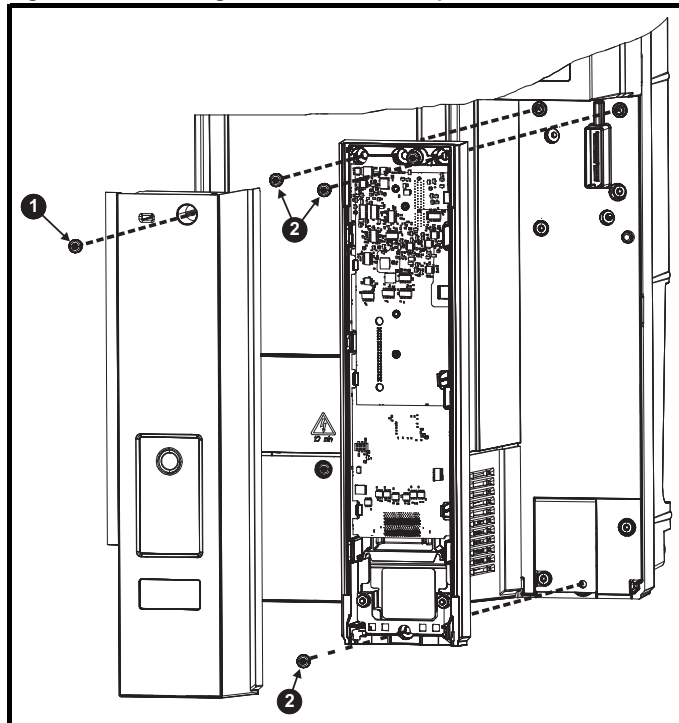
Figure 5-7 Mounting the control master or standard pod on the drive



1. In order to expose the control master/follower mounting holes, the terminal covers need to be removed. This is done by undoing the terminal cover screw highlighted and then removing the two plastic covers.
2. Care must be taken when installing master control pod. Line up the connector on the back of the master control pod with the respective connector on the power module. Use the 3 x M5 screws to mount the control master pod to the drive in the position shown.

The terminal covers can then be re-installed.

Figure 5-8 Mounting the control follower pod on the drive



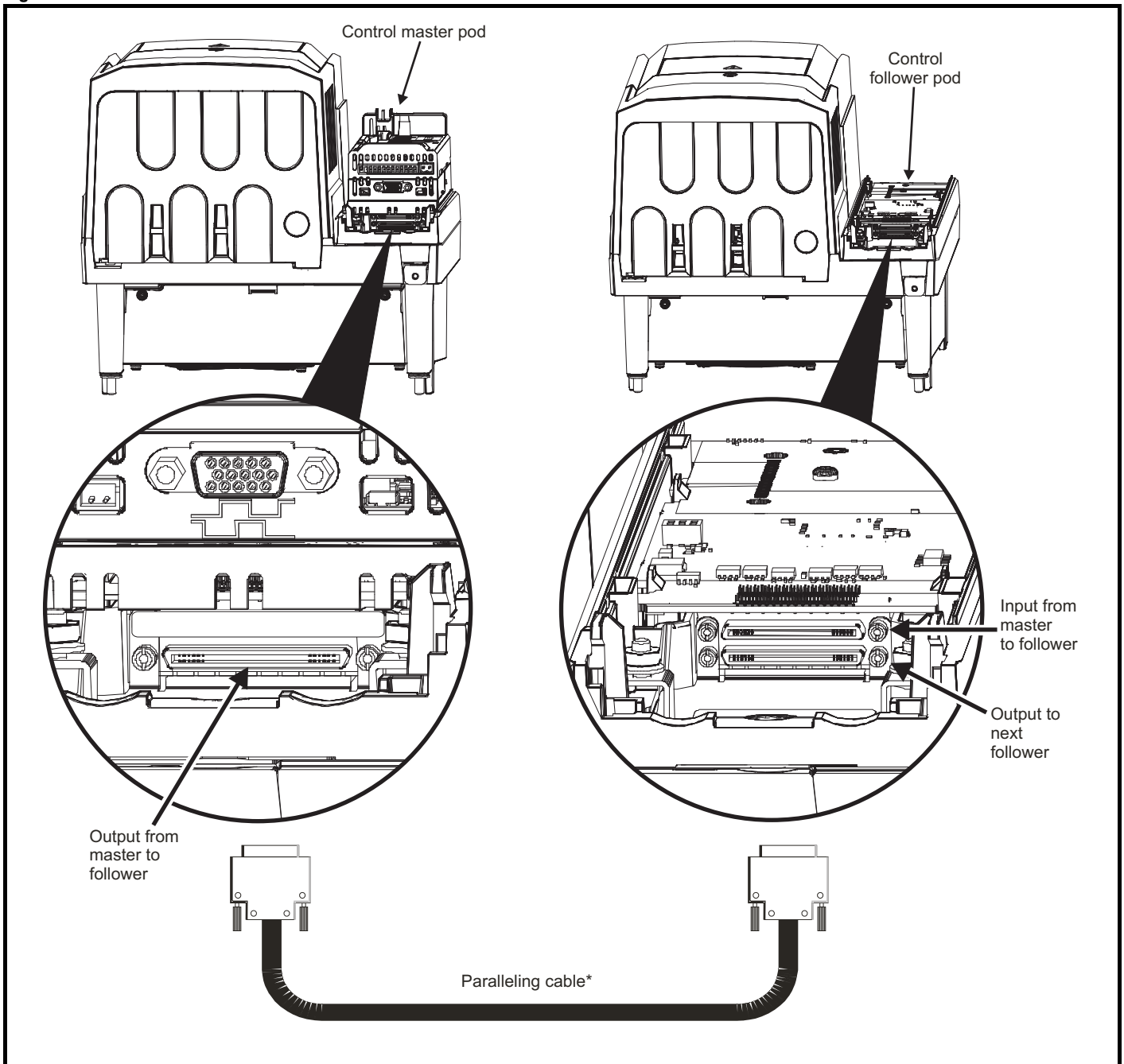
1. In order to expose the mounting holes, remove the control follower pod cover. This is done by undoing the screw highlighted and removing the cover.
2. Care must be taken when installing follower control pod. Line up the connector on the back of the follower control pod with the respective connector on the power module. Use the 3 x M5 screws to mount the control master pod to the drive in the position shown.

The cover can then be re-installed.

NOTE

The control master pod can also be remotely mounted and connected to the first follower with a parallel cable, see Figure 5-19 *Control master pod dimensions and remote surface mounting diagram* on page 53 for mounting information.

Figure 5-9 Parallel control connections



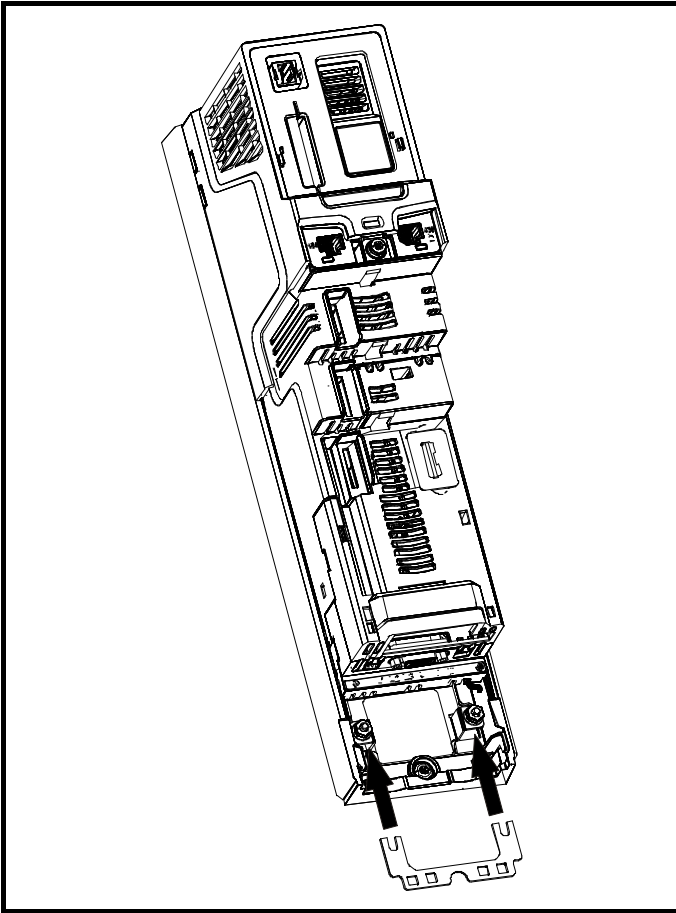
*Only supplied with follower drive.

NOTE

The parallel cable should be routed according to the rules shown in Figure 6-29 *Sensitive signal circuit clearance* on page 113 for the control cable.

The screw locks on the parallel cable must be fully tightened.

The orientation of the parallel cable ports on Unidrive M / Unidrive HS are opposite to Unidrive SP.

Figure 5-10 Installation of parallel cable management bracket

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

5.5 Dimensions and mounting methods

Unidrive M / Unidrive HS size 9, 10, 11 and rectifier can be either surface or through-panel mounted using the appropriate brackets.

Surface mounting is where the drive is simply secured to the enclosure wall/backplate.

Through-panel mounting is where the drive is secured with the heatsink protruding through the enclosure panel to the external environment. This has the effect of reducing the temperature within the enclosure.

The following drawings show the dimensions of the drive and mounting holes for each method to allow a back plate to be prepared.



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.



Many of the drives in this product range weigh in excess of 15 kg (33 lb). Use appropriate safeguards when lifting these models. Use the appropriate lifting bracket as shown in Figure 3-7 *Options available for Unidrive M/HS modular drives* on page 24.

5.5.1 Surface mounting

Figure 5-11 Surface mounting the Unidrive M / Unidrive HS size 9A

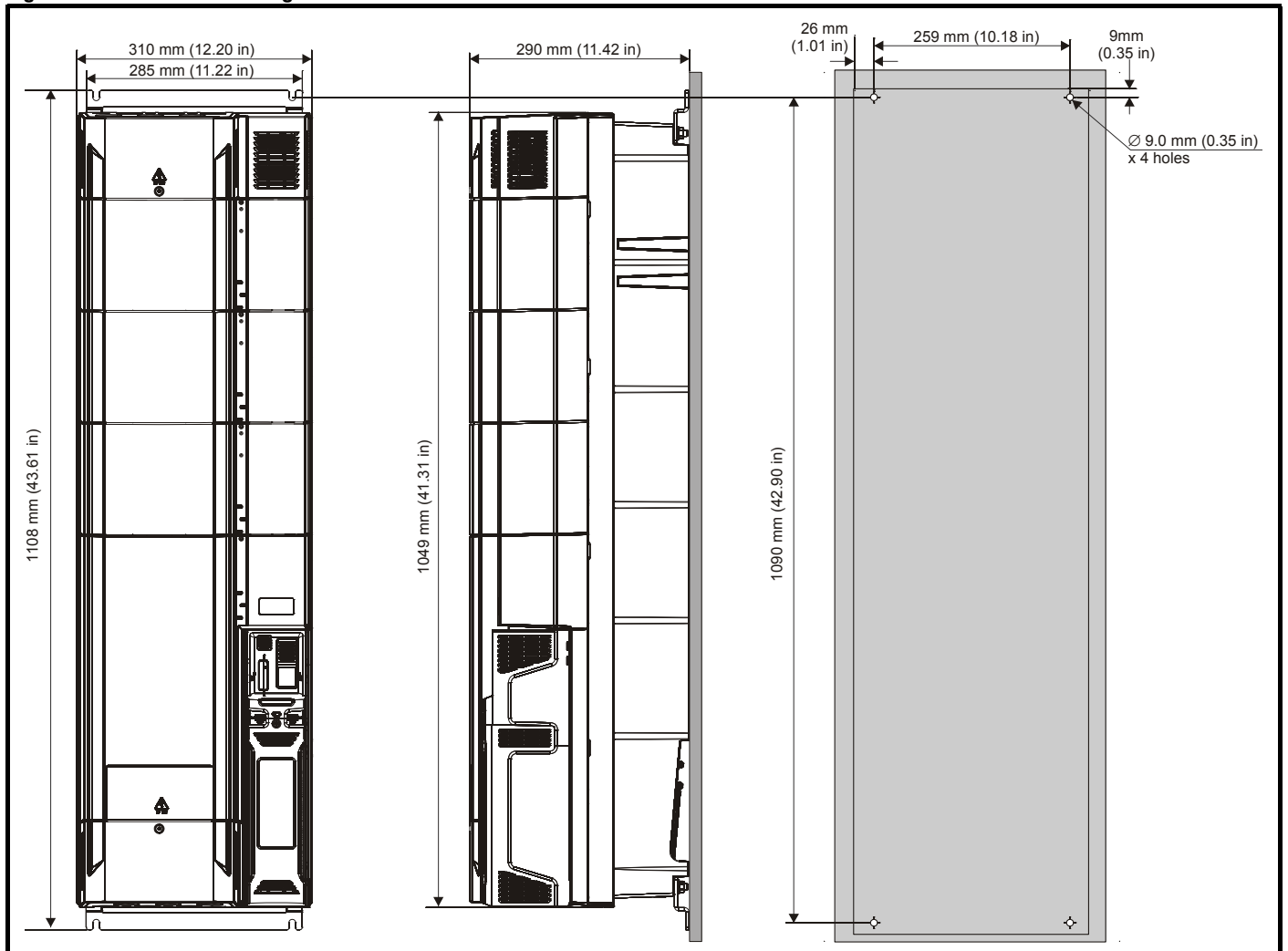


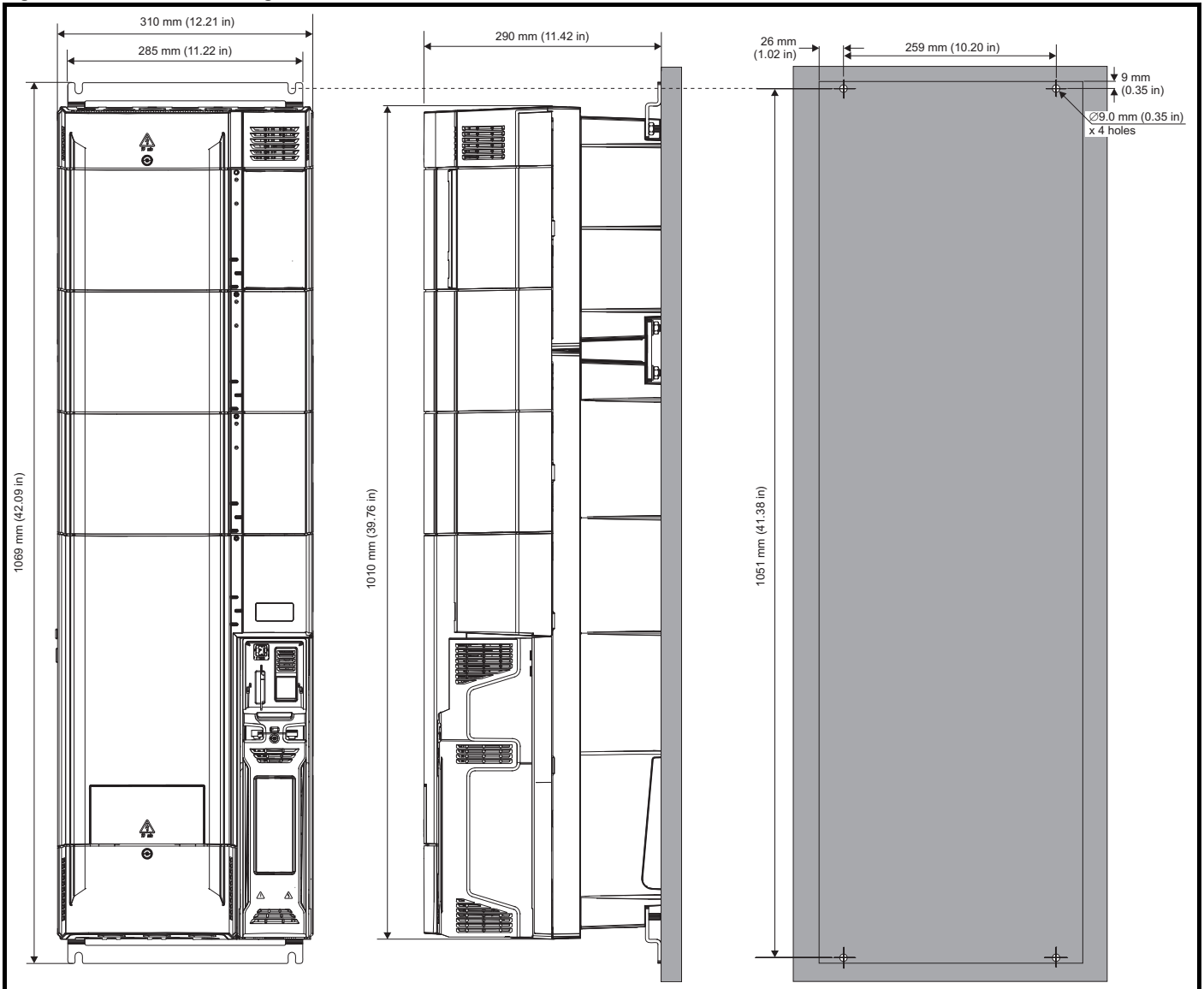
Figure 5-12 Surface mounting the Unidrive M / Unidrive HS size 9E/10E

Figure 5-13 Surface mounting the Unidrive M / Unidrive HS size 9T/10T

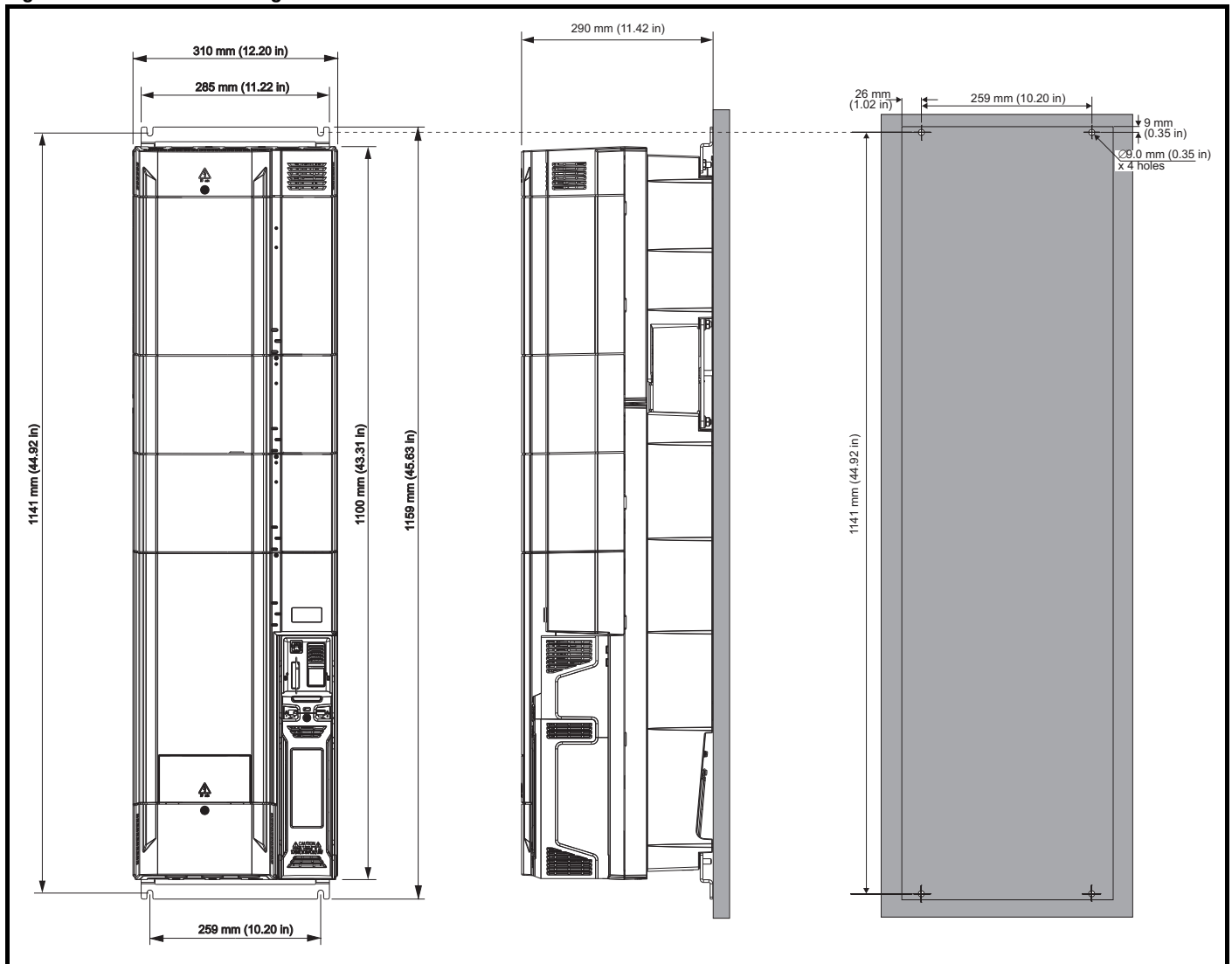


Figure 5-14 Surface mounting the Unidrive M / Unidrive HS size 11E / 11T

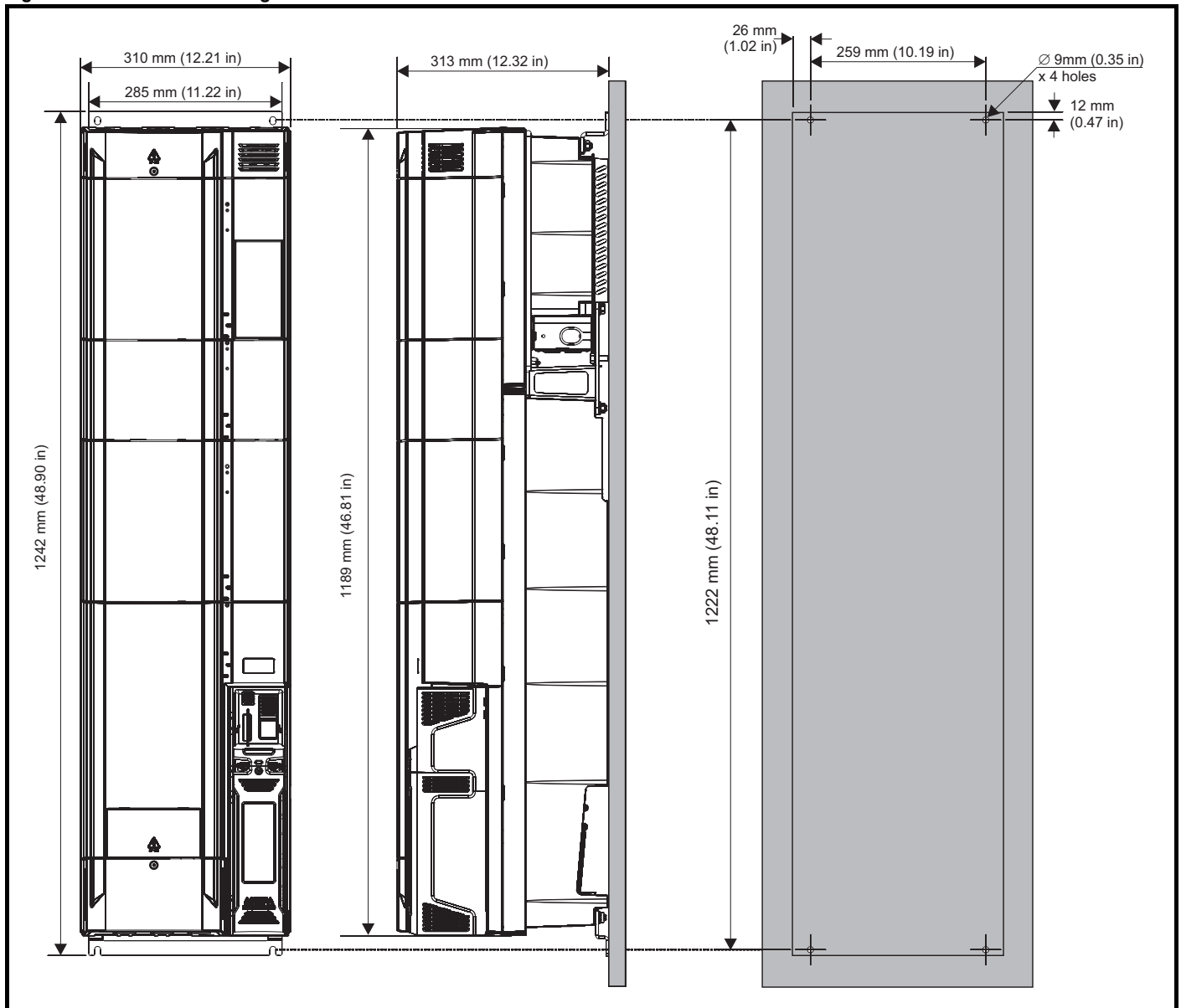


Figure 5-15 Surface mounting the Unidrive M / Unidrive HS size 9D/10D

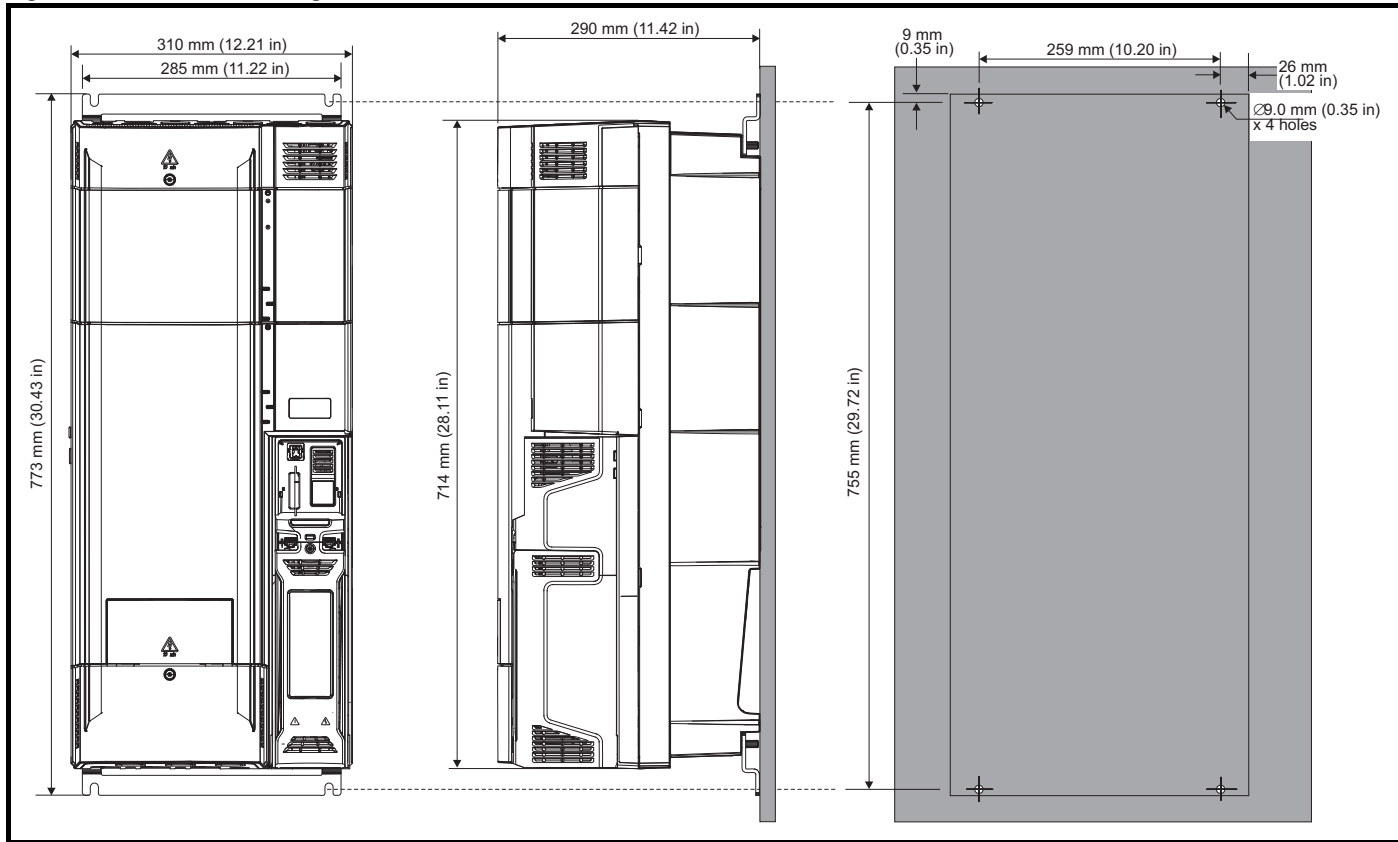


Figure 5-16 Surface mounting the Unidrive M / Unidrive HS size 11D

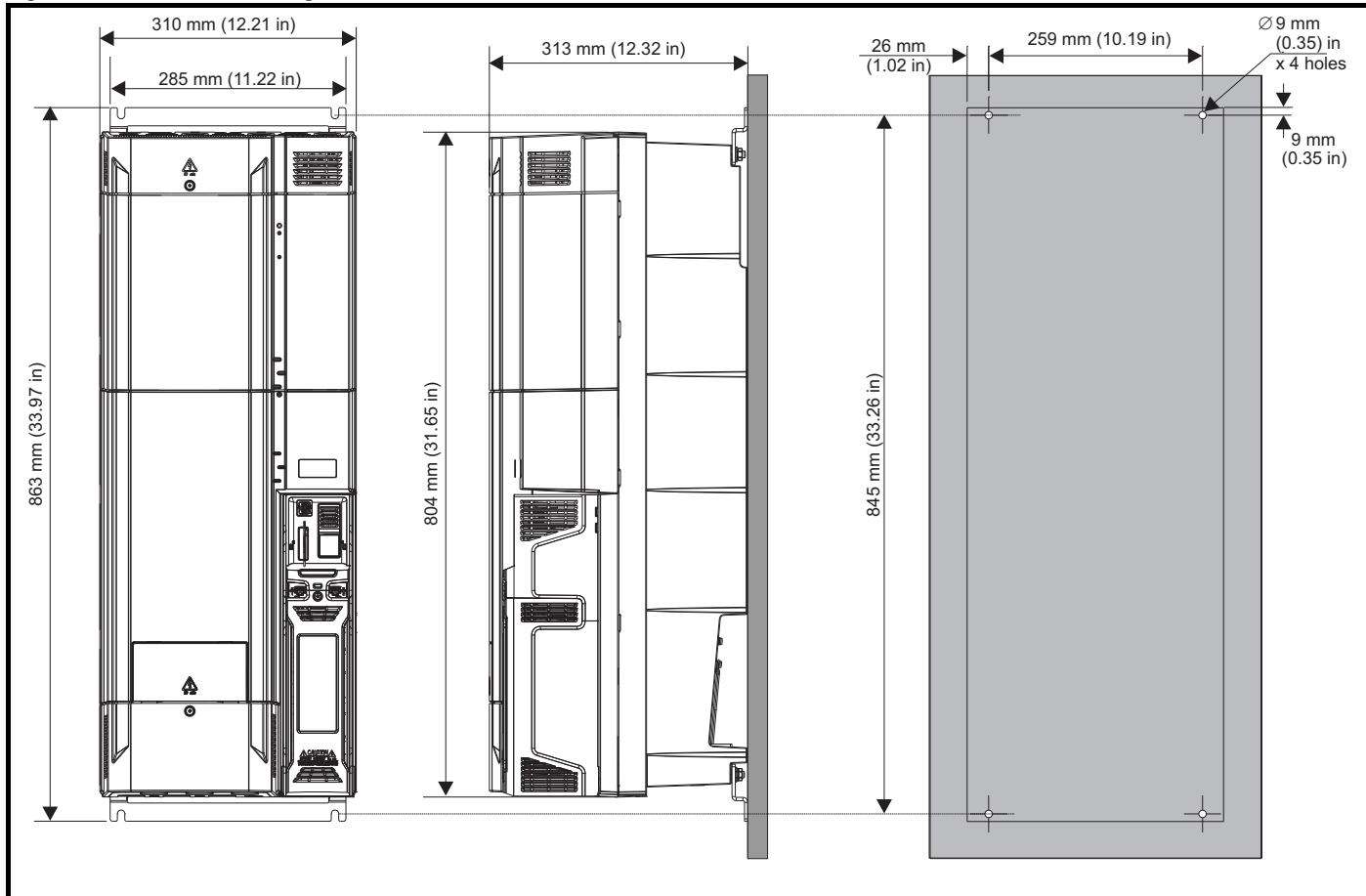


Figure 5-17 Surface mounting the Unidrive M / Unidrive HS size 10 rectifier

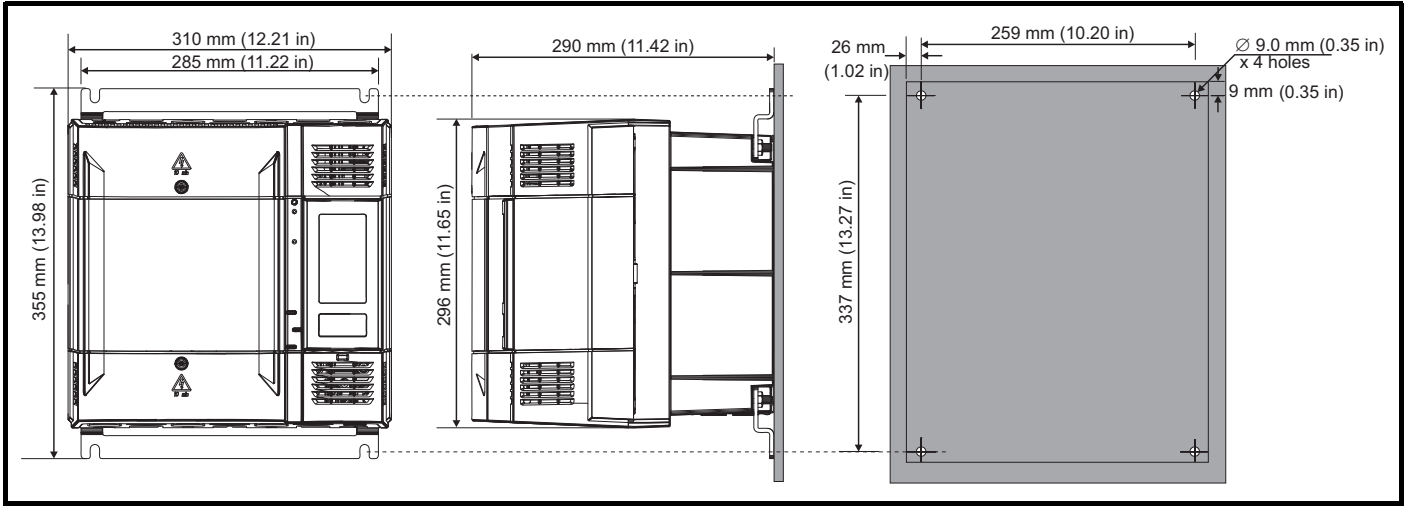


Figure 5-18 Surface mounting the Unidrive M / Unidrive HS size 11 rectifier

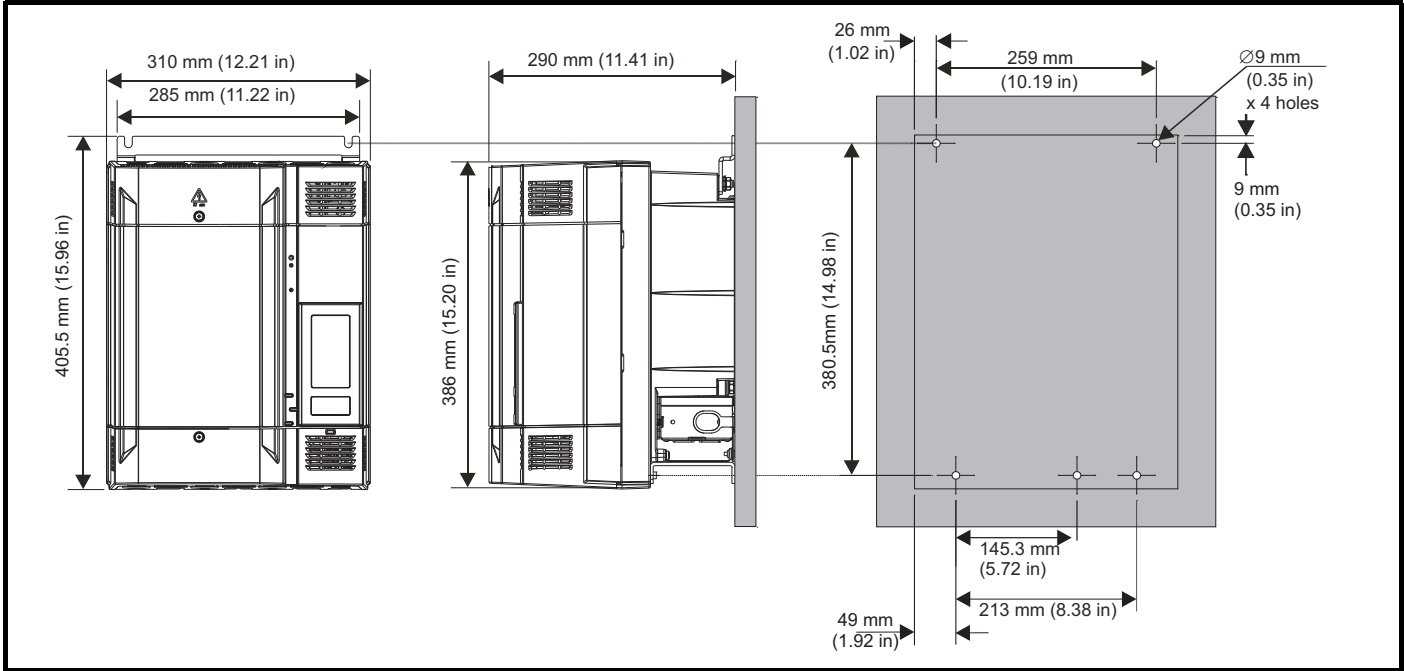
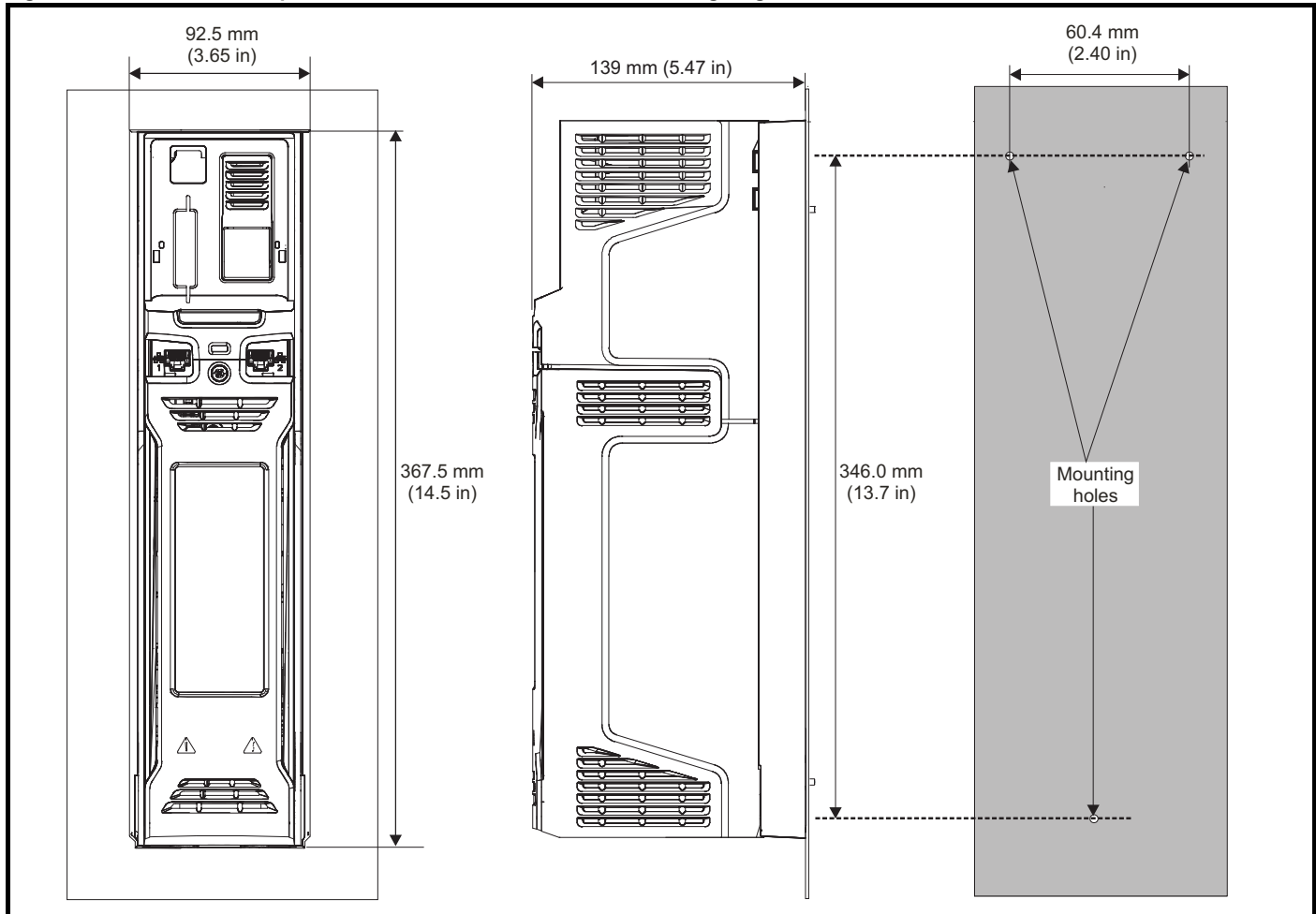


Figure 5-19 Control master pod dimensions and remote surface mounting diagram



5.5.2 Through-panel mounting

The Through-panel mounting kits are not supplied with the drive and can be purchased separately, using the part numbers shown below:

Table 5-2 Through panel mounting kits

Part number	Description
3470-0105	Size 9E/10E
3470-0106	Size 10 rectifier only
3470-0108	Size 9D and 10D inverter only
3470-0119	Size 9A
3470-0127	Size 9T/10T
3470-0126	Size 11E/11T
3470-0130	Size 11D inverter only
3470-0123	Size 11 rectifier only

Figure 5-20 Through-panel mounting the Unidrive M / Unidrive HS size 9A

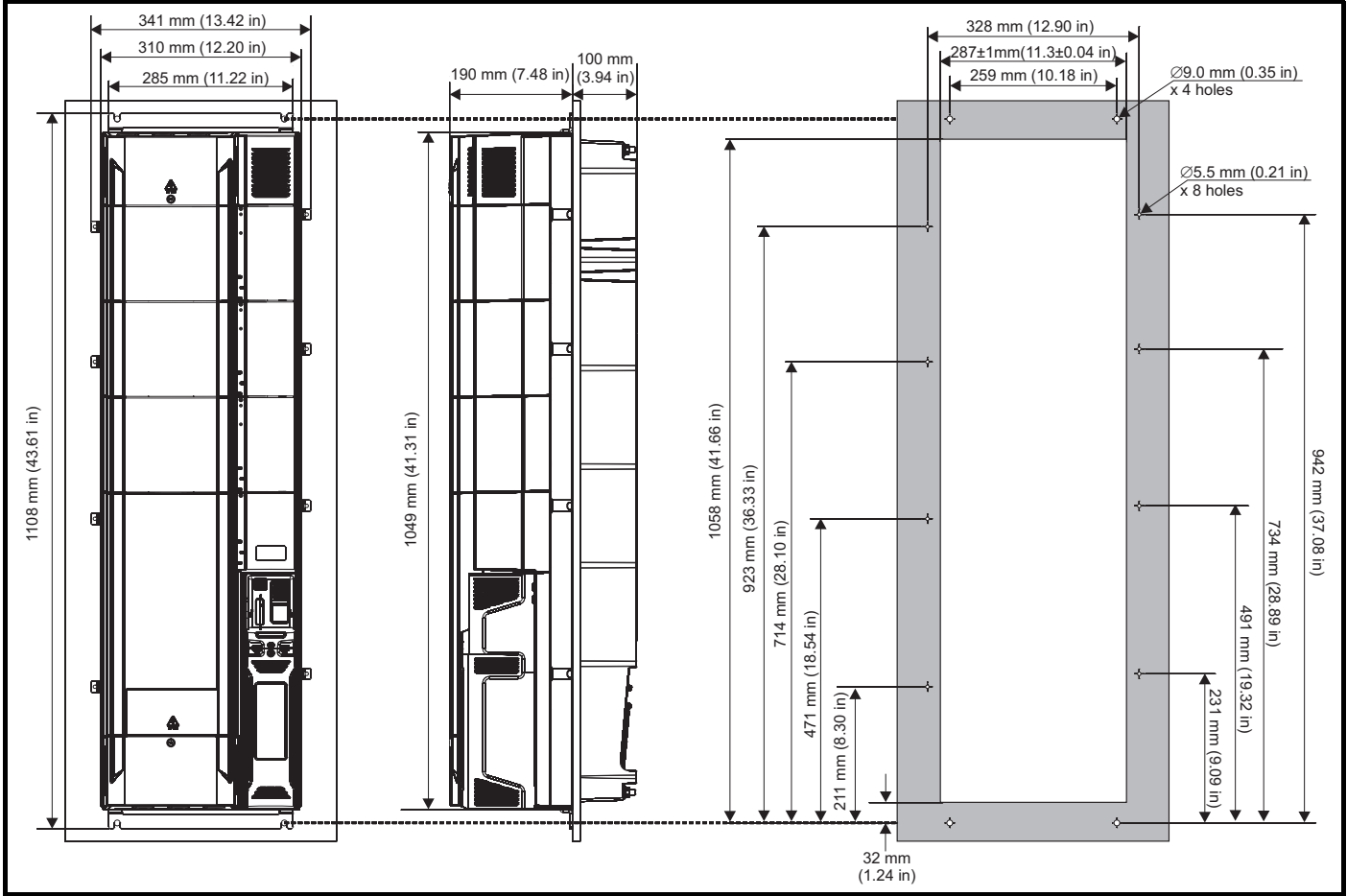


Figure 5-21 Through-panel mounting the Unidrive M / Unidrive HS size 9E/10E

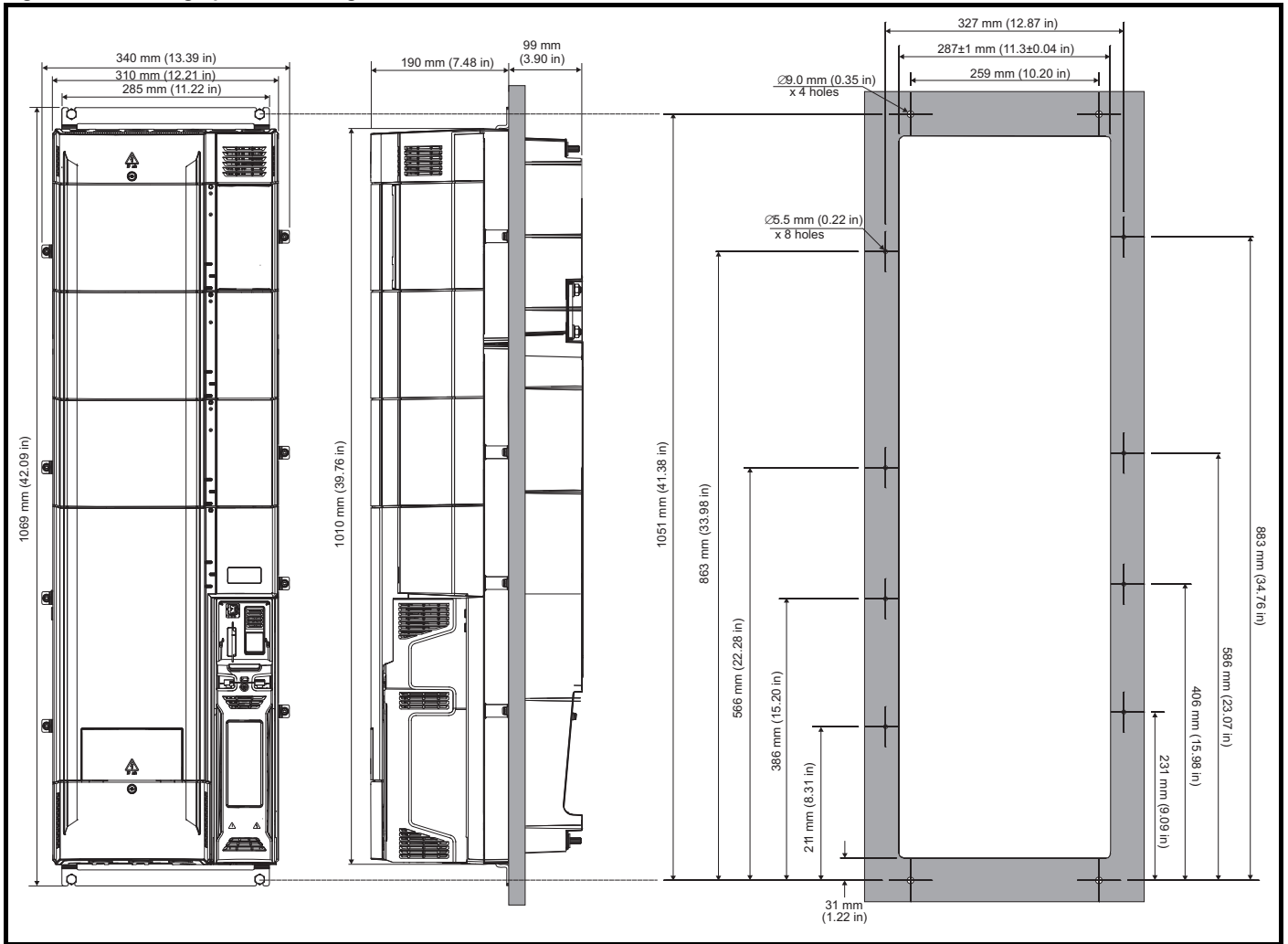


Figure 5-22 Through-panel mounting the Unidrive M / Unidrive HS size 9T/10T

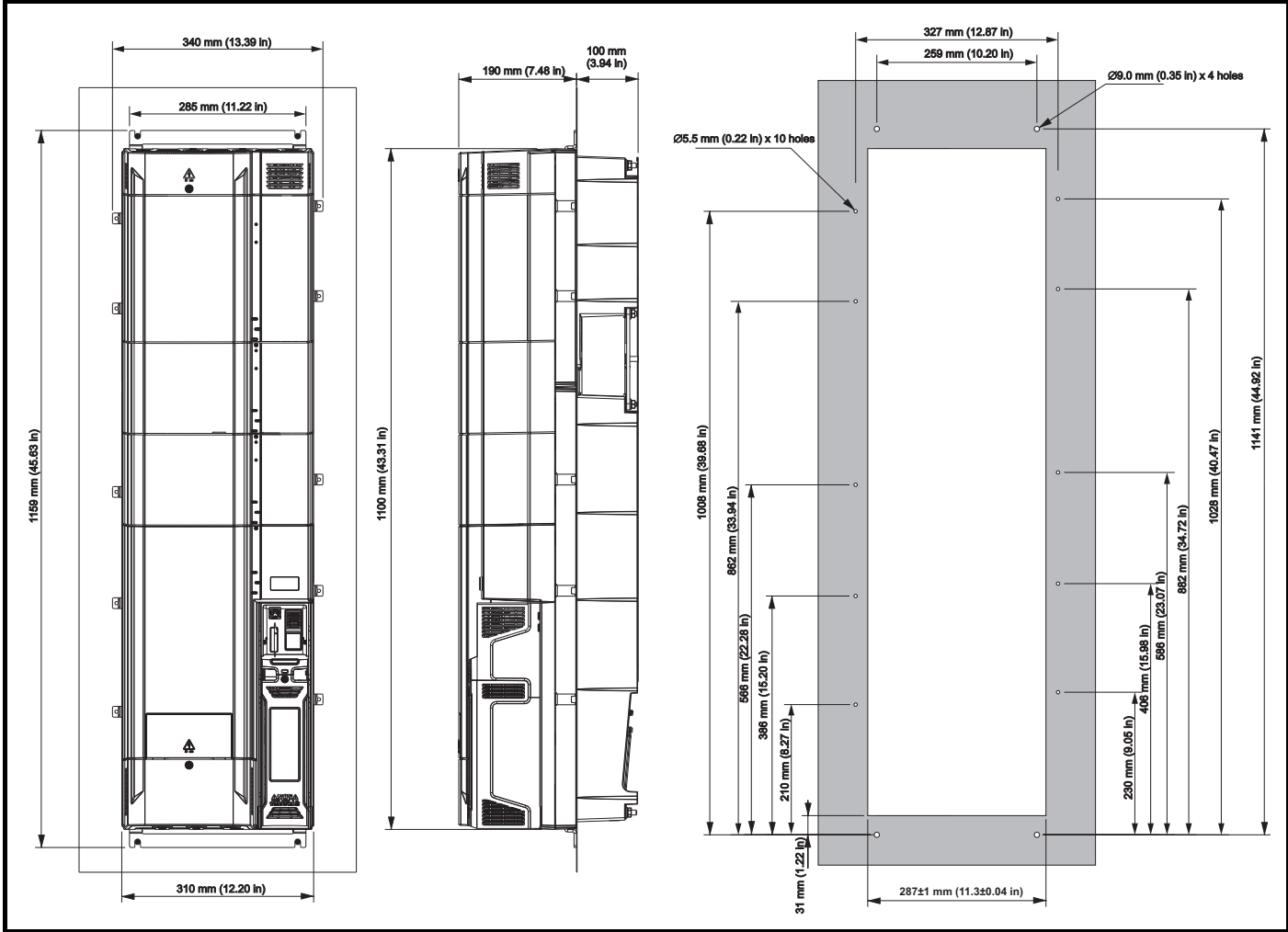


Figure 5-23 Through-panel mounting the Unidrive M / Unidrive HS size 11E/11T

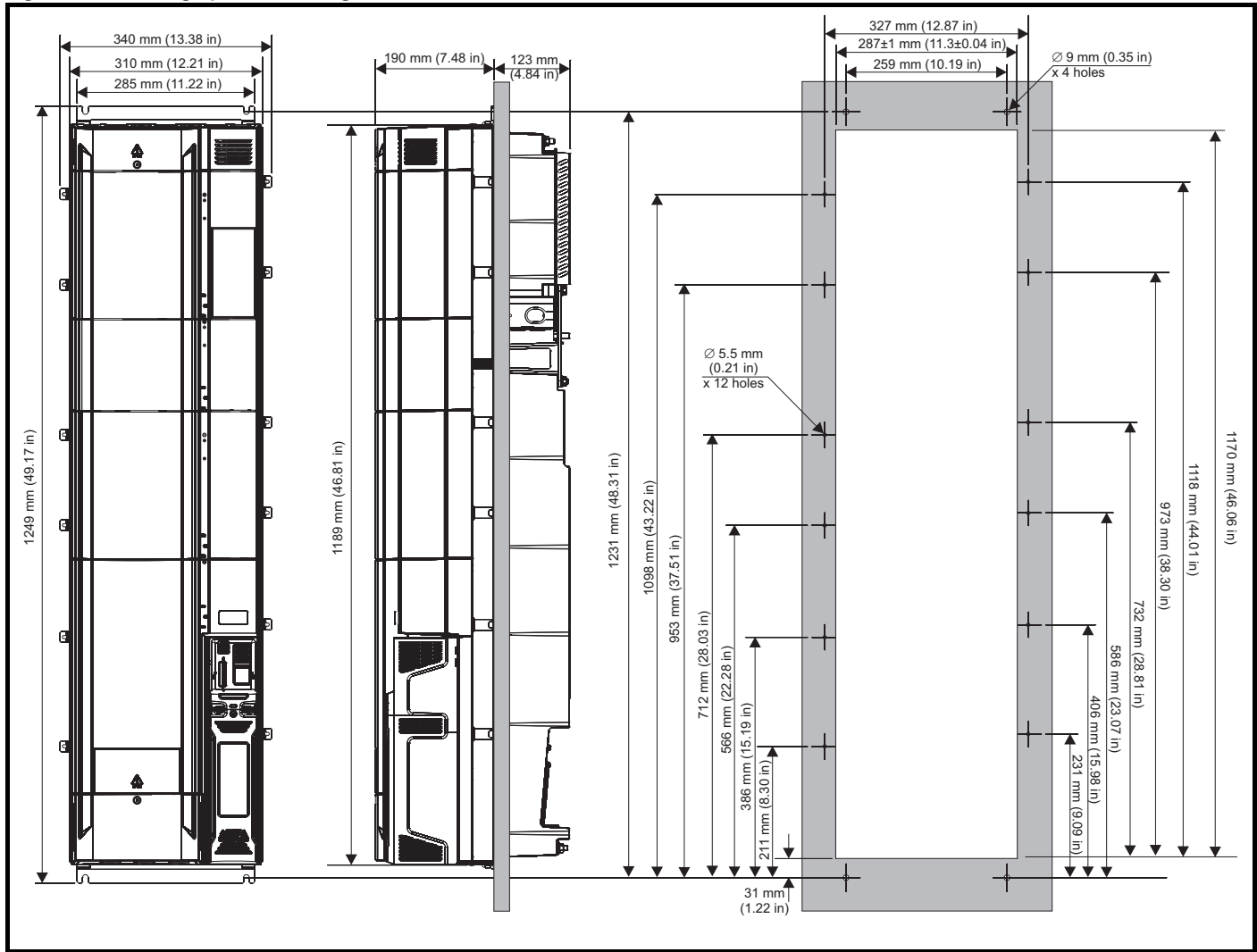


Figure 5-24 Through-panel mounting the Unidrive M / Unidrive HS size 9D/10D

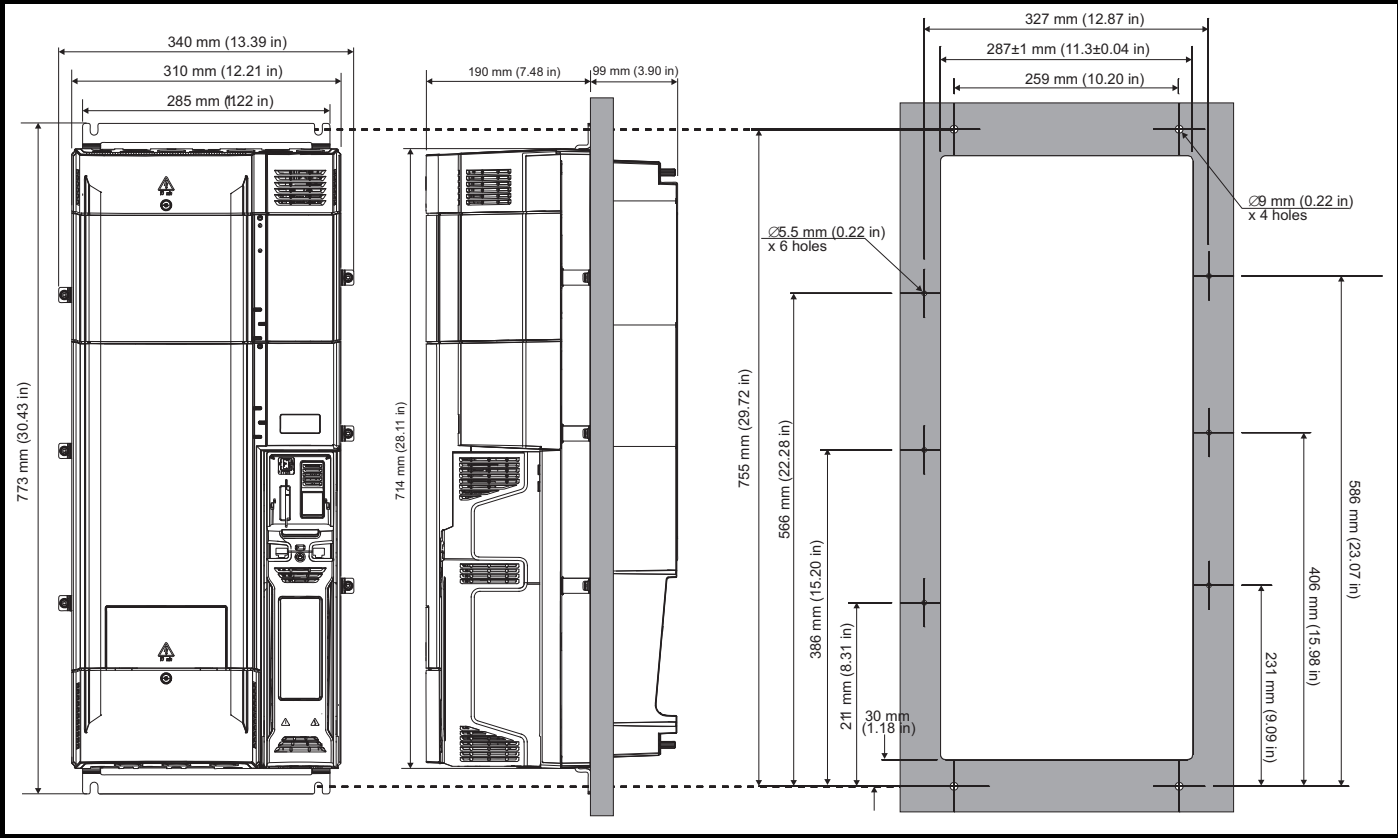


Figure 5-25 Through-panel mounting the Unidrive M / Unidrive HS size 11D

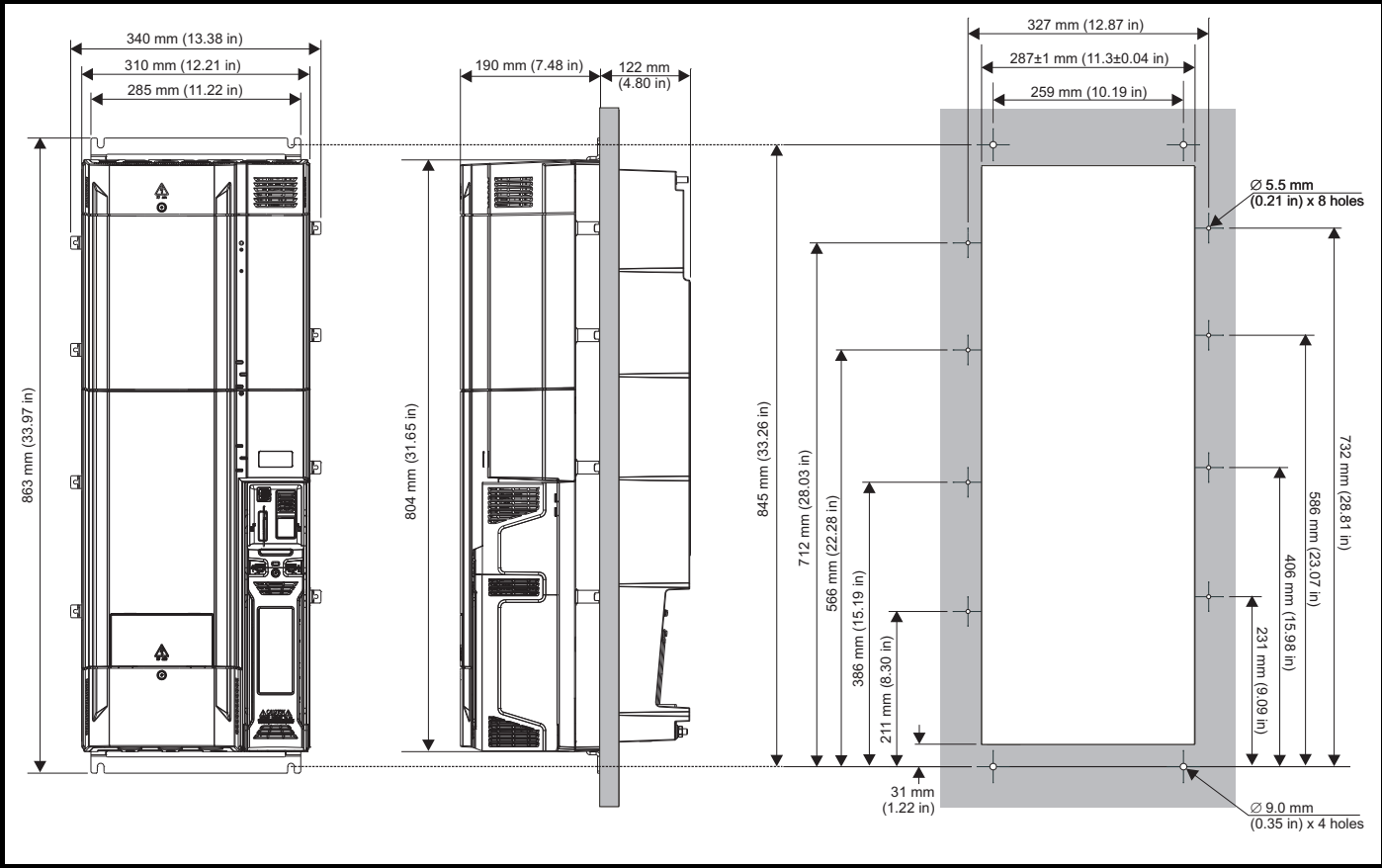


Figure 5-26 Through-panel mounting the Unidrive M / Unidrive HS size 10 rectifier

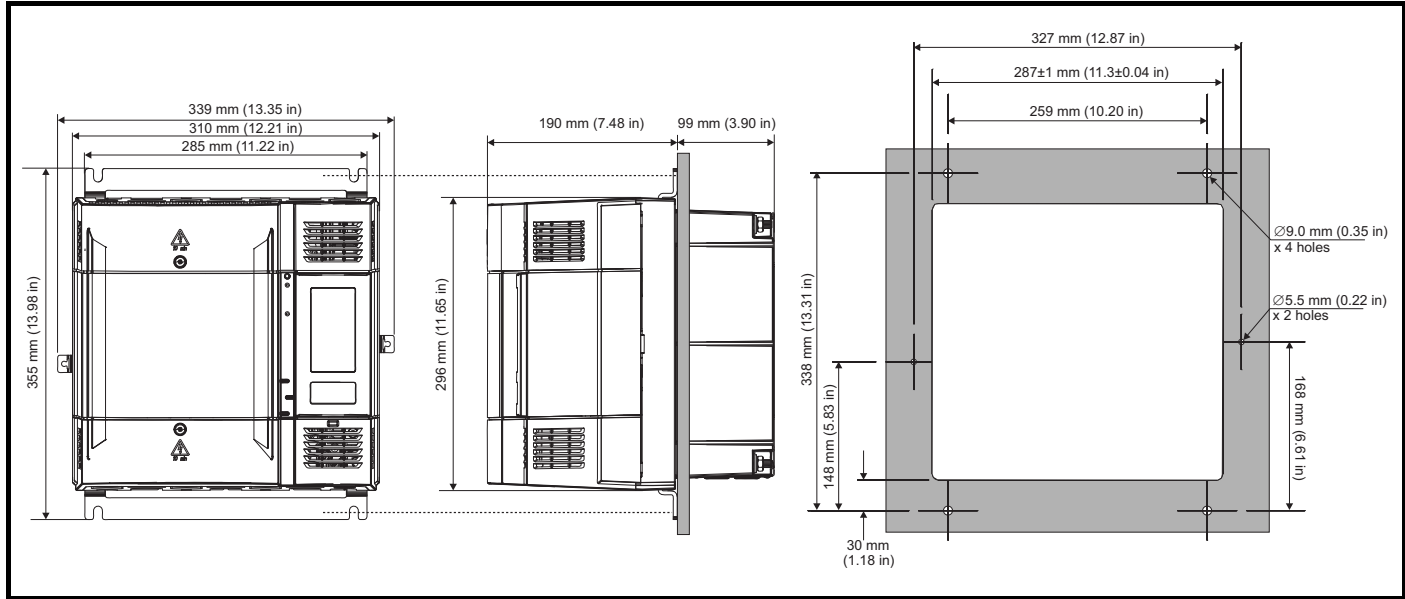
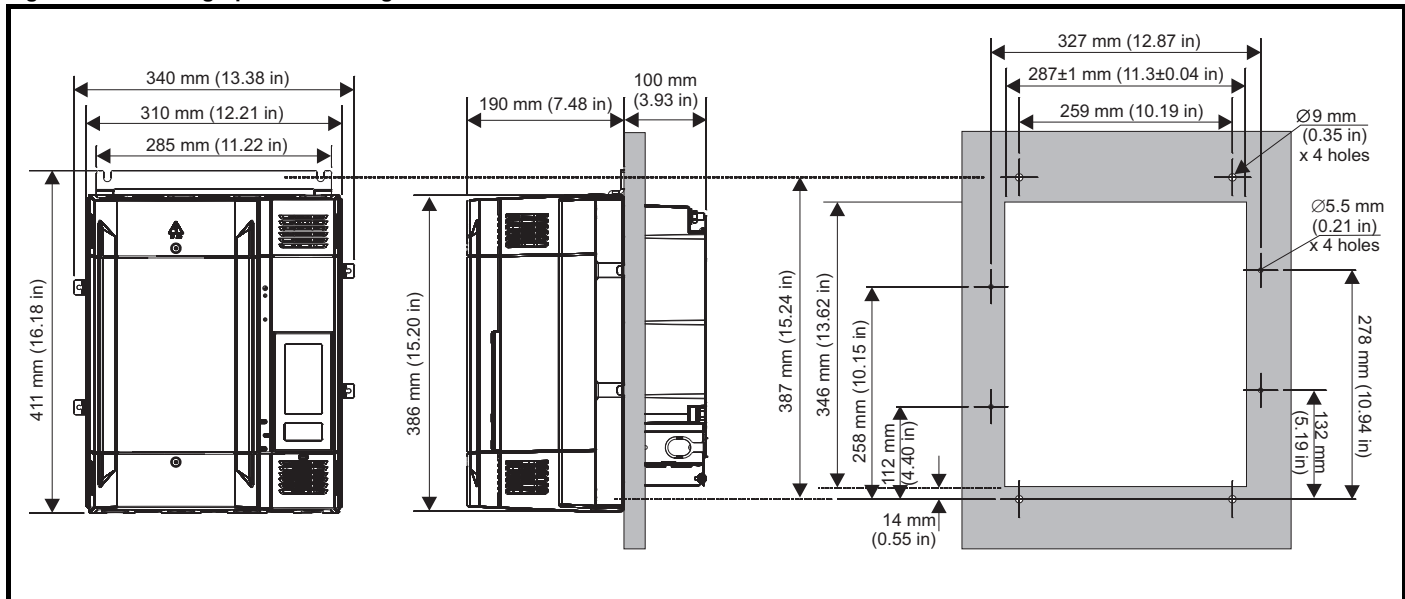
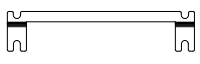


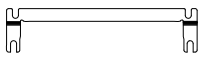


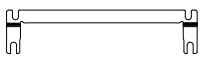















Figure 5-27 Through-panel mounting the Unidrive M / Unidrive HS size 11 rectifier



5.5.3 Mounting brackets

Table 5-3 Mounting brackets

Frame size	Surface mounting kit (supplied with drive)	Qty	Optional through-panel mounting kit	Qty
10 (rectifier)	 Hole size: 9 mm (0.35 in)	x 2*	 Hole size: 5.5 mm (0.22 in)	x 2
				x 1
9A / 9E and 10E (inverter)	 Hole size: 9 mm (0.35 in)	x 2*	 Hole size: 5.5 mm (0.22 in)	x 8
				x 1
9D and 10D (inverter)	 Hole size: 9 mm (0.35 in)	x 2*	 Hole size: 5.5 mm (0.22 in)	x 6
				x 1
11 (rectifier)	 Hole size: 9 mm (0.35 in)	x 1	 Hole size: 5.5 mm (0.22 in)	x 4
	 Hole size: 9 mm (0.35 in)	x 1*		x 1
11E/T	 Hole size: 9 mm (0.35 in)	x 2*	 Hole size: 5.5 mm (0.22 in)	x 12
	 Hole size: 9 mm (0.35 in)	x 1		x 1
11D	 Hole size: 9 mm (0.35 in)	x 2*	 Hole size: 5.5 mm (0.22 in)	x 8
				x 1

* Surface mounting brackets are also used when through-panel mounting.

The through-panel mounting kits are not supplied with the drive and can be purchased separately, using the part numbers shown below:

Table 5-4 Through panel mounting kits

Part number	Description
3470-0105	Size 9E/10E
3470-0106	Size 10 rectifier only
3470-0108	Size 9D and 10D inverter only
3470-0119	Size 9A
3470-0127	Size 9T/10T
3470-0126	Size 11E/11T
3470-0130	Size 11D inverter only
3470-0123	Size 11 rectifier only

5.6 Enclosure

5.6.1 Enclosure layout

Observe the clearances in Figure 5-28 taking into account any appropriate notes for other devices / auxiliary equipment when planning the installation.

Figure 5-28 Unidrive M / Unidrive HS size 9A/9E/10E and 11E enclosure layout

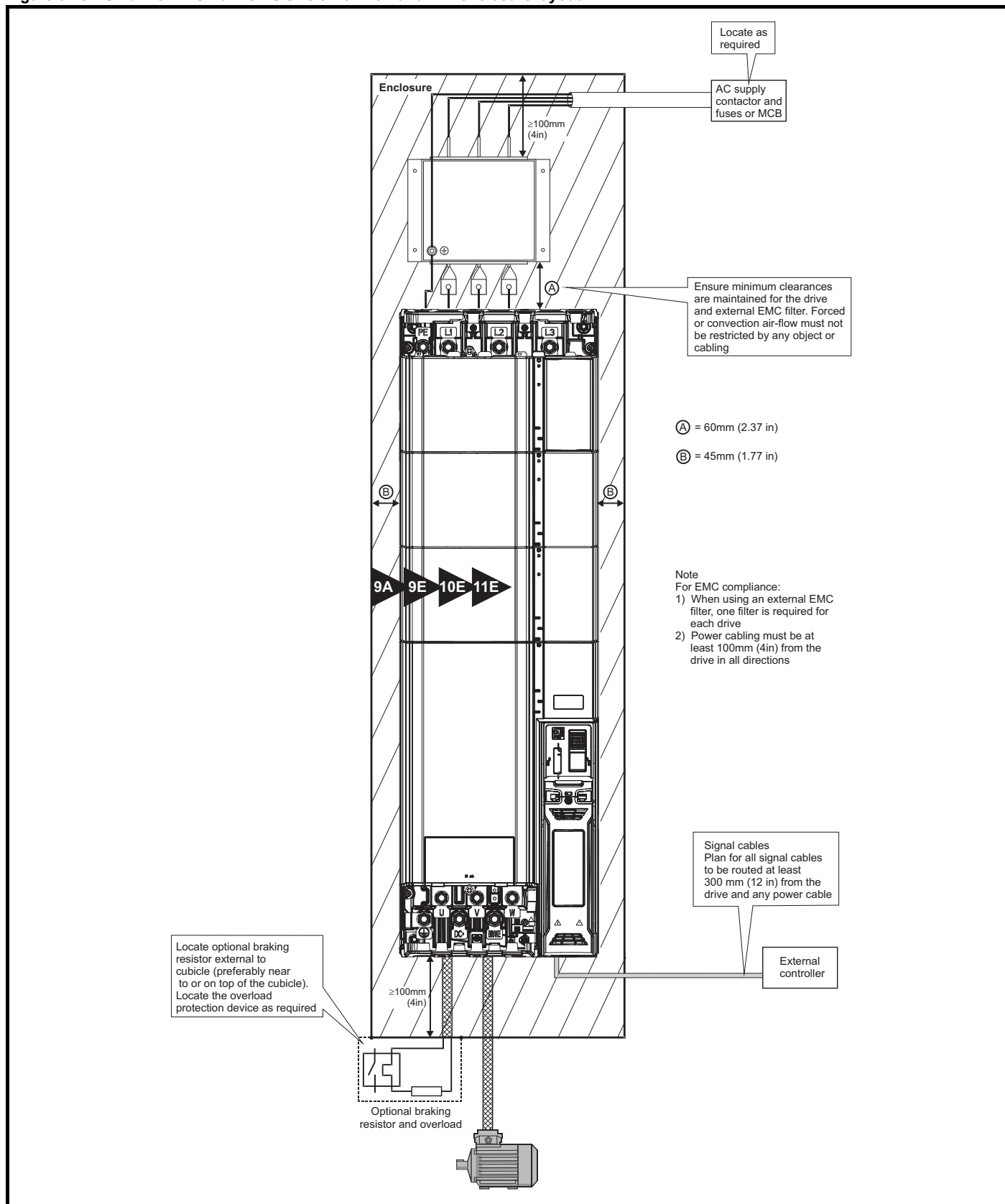


Figure 5-29 Unidrive M / Unidrive HS size 9D/10D and 11D enclosure layout

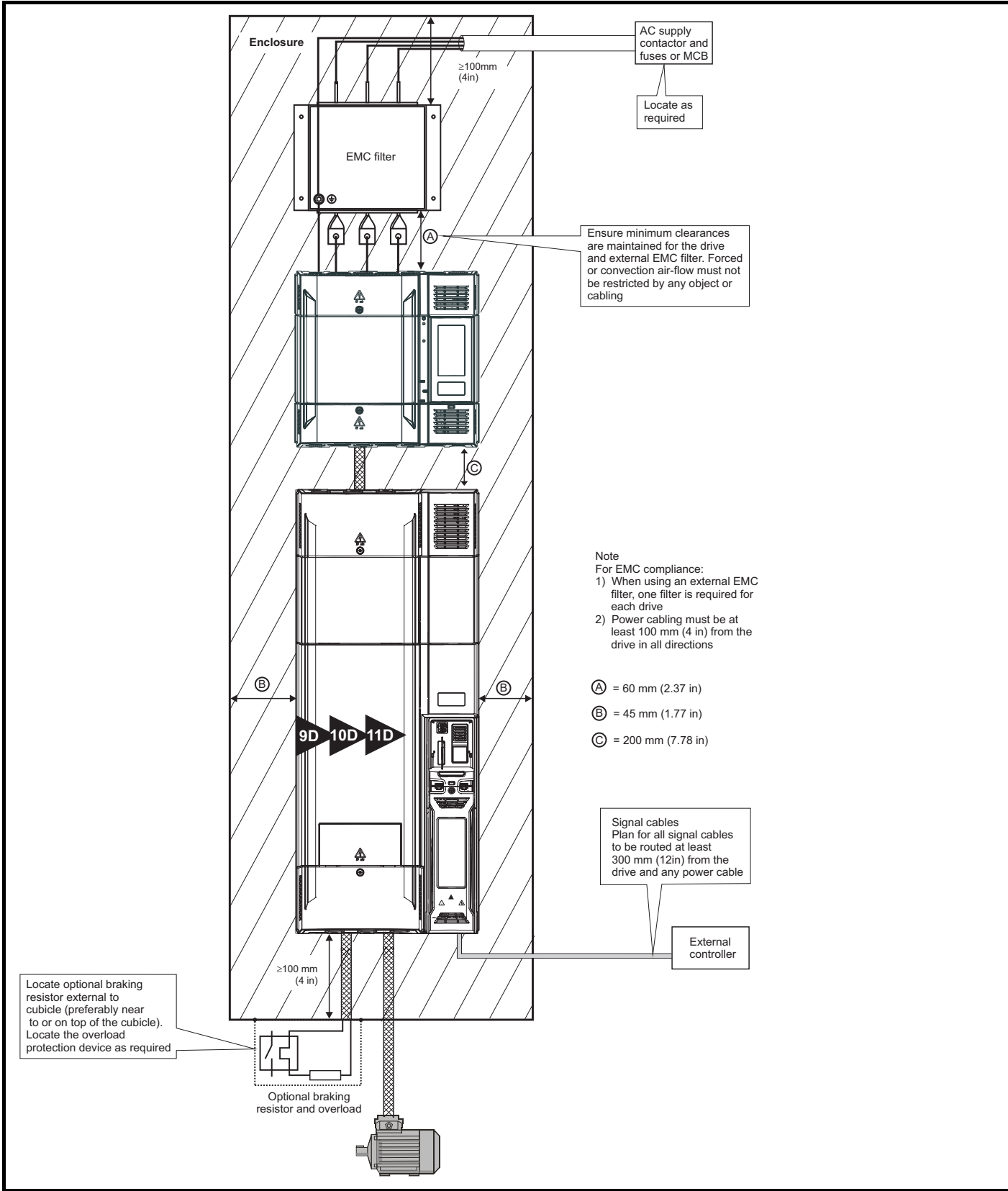
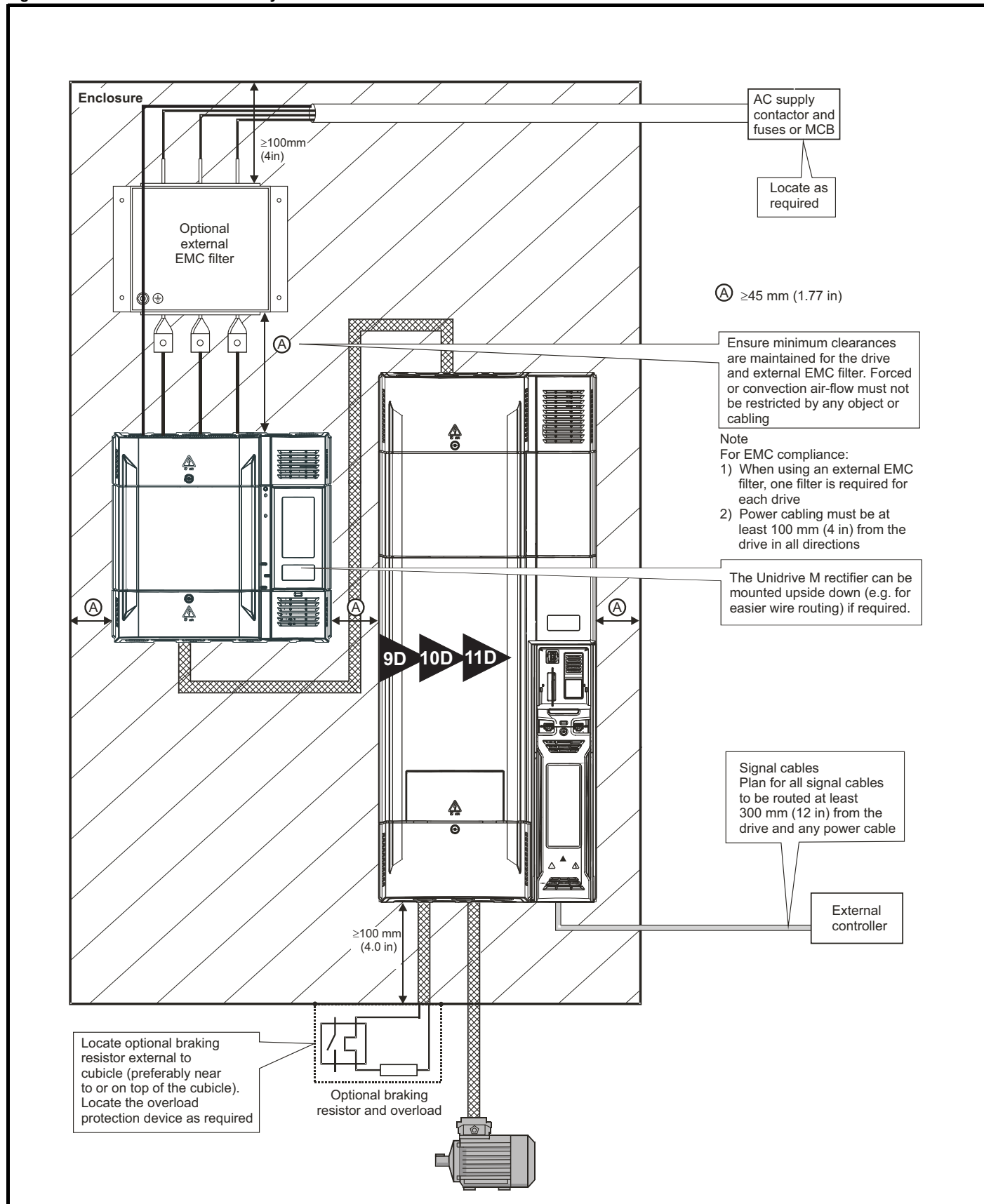


Figure 5-30 Alternative enclosure layout: rectifier and size 9D/10D and 11D



5.6.2 Enclosure ambient temperature

Drive derating is required for operation in high ambient temperatures

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

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

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

- Totally enclosed with no air flow (<2 m/s) over the drive
 $T_{rate} = T_{int} + 5^{\circ} C$
- Totally enclosed with air flow (>2 m/s) over the drive
 $T_{rate} = T_{int}$
- Through panel mounted with no airflow (<2 m/s) over the drive
 $T_{rate} = \text{the greater of } T_{ext} + 5^{\circ}C, \text{ or } T_{int}$
- Through panel mounted with air flow (>2 m/s) over the drive
 $T_{rate} = \text{the greater of } T_{ext} \text{ or } T_{int}$

Where:

T_{ext} = Temperature outside the cabinet

T_{int} = Temperature inside the cabinet

T_{rate} = Temperature used to select current rating

5.6.3 Altitude derating

Multiply the maximum rated output current by the derate factor (Df) in Figure 5-31 and the ambient correction factor (Cf) in Figure 5-32.

$$\text{Rated output current} = Df \times Cf \times Oc$$

Figure 5-31 Altitude derate factor

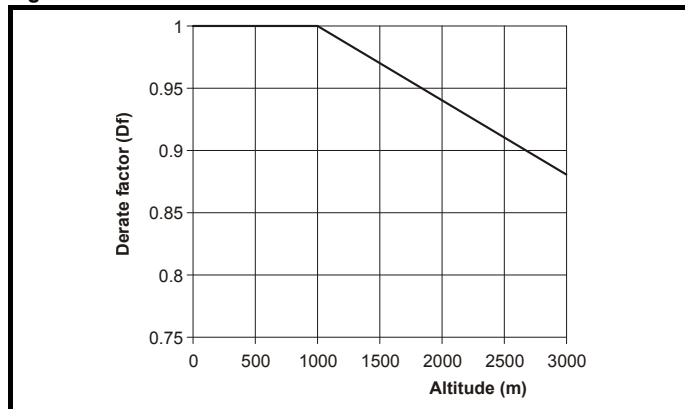
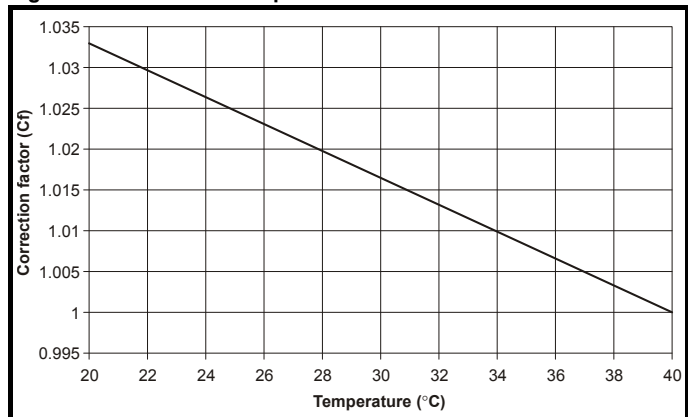


Figure 5-32 Ambient temperature correction factor



NOTE

- The ambient temperature correction factor used is for altitude calculation only. If the ambient is less than 40°C the drive cannot be over rated. The maximum permissible output currents should remain the same as those given at 40 °C.
- If the drive is required to operate above 40 °C the derates at 50 °C should be applied.
- The same applies for altitude below 1000 m. There should be no over rating at lower altitude

NOTE

For applications over 3000 m, contact the supplier of the drive.

5.6.4 Enclosure sizing

This section looks at a method for cooling a medium power density enclosure. By running through a worked example it brings out the issues associated with cooling the drives when they are completely mounted inside an enclosure.

This example only considers one possible method of enclosing the drives and tries to highlight and solve thermal issues created by hot air recirculating inside an enclosure. Other methods of enclosure design are also possible, such as through panel mounting, which removes many of the issues discussed in this chapter. Refer to section 5.5.2 *Through-panel mounting* on page 54.

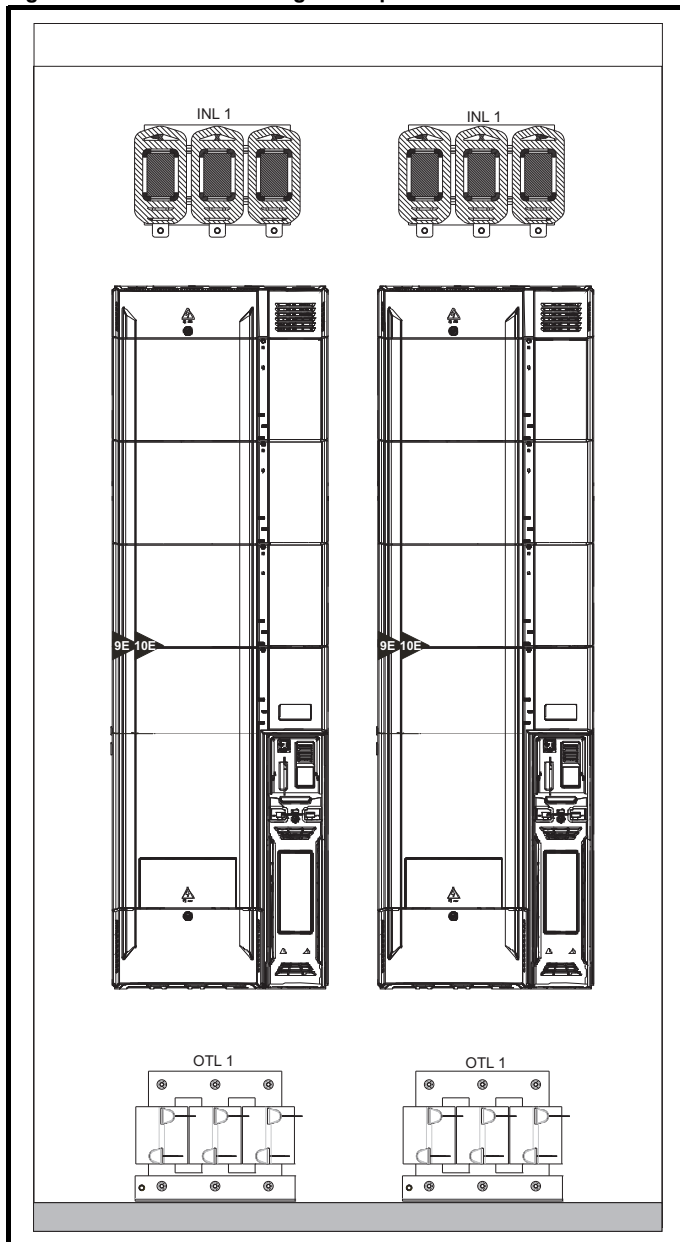
The enclosure design example will use the following conditions:

- Enclosure placed in a room with a 30°C ambient and an altitude <1000 m
- Continuous output current requirement from the system = 650 A

Parts used in system model:

- 1800 mm (70.87 in) x 800 mm (31.5 in) x 500 mm (19.69 in) enclosure with input and output ventilation
- 2 x 10402700
- 2 x input line reactors (L1)
- 2 x output sharing chokes (L2)

Figure 5-33 Enclosure design example

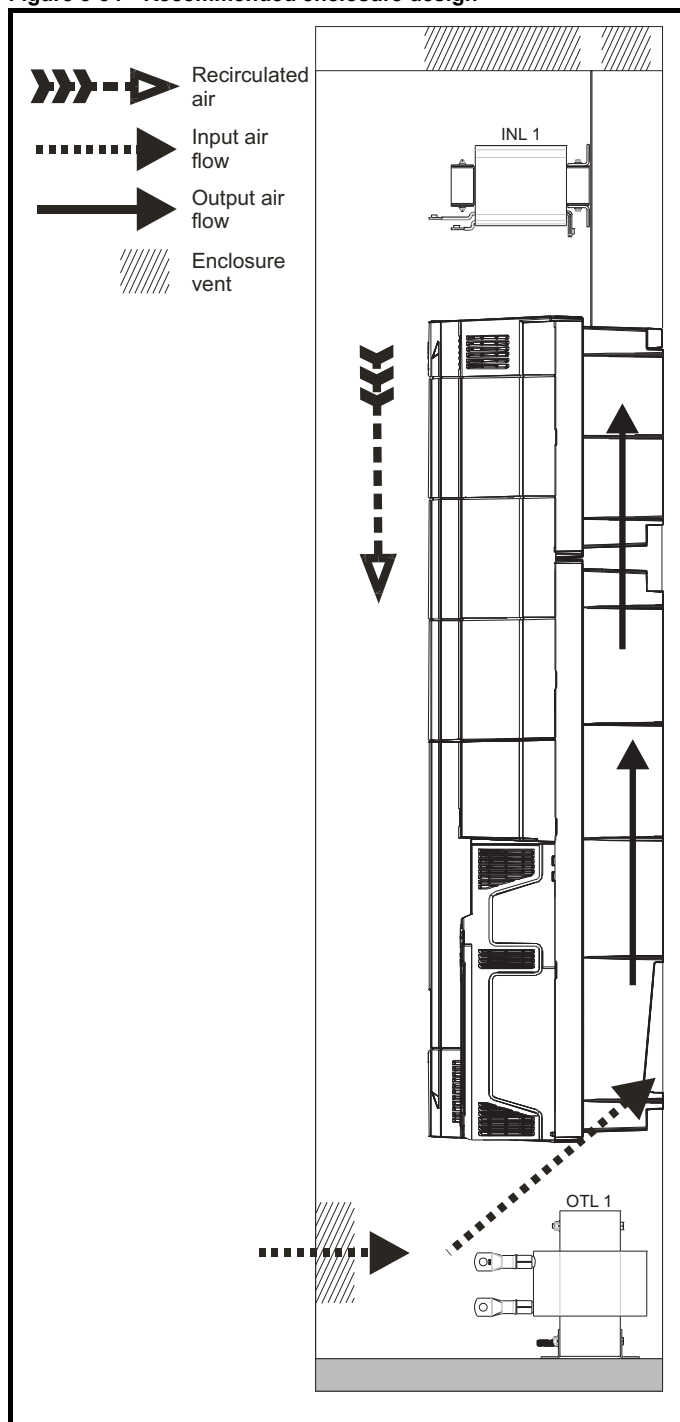


Drive selection

Select drives necessary to achieve desired output current based on altitude calculation and other drive derates (e.g. paralleling derates, switching frequency derates, ambient derate etc).

Enclosure design to prevent recirculation of hot air

Figure 5-34 Recommended enclosure design



For front view of enclosure, refer to Figure 5-33.

Spacing between units and sides of enclosure: >60 mm

Calculation of temperature rise in enclosure inputs

Table 5-5 Example data

Output sharing choke loss under single unit (OTL 1)	250 W
Total loss of single drive	4290 W
Number of drives in enclosure	2
Width of enclosure	0.8 m
Depth of enclosure	0.5 m
Open area of roof vent (outlet)	0.27 m ²
Open area of inlet vent	0.15 m ²
External ambient	30 °C
Altitude derate factor (Cf x Df)	1

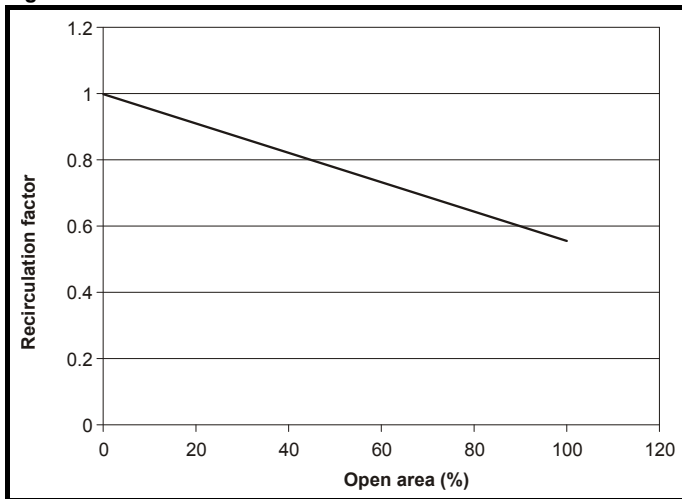
For this example it is assumed the drive is in an altitude below 1000 m and the enclosure it is mounted in has input and output ventilation.

Calculate open area % of venting and recirculation factor

$$\begin{aligned} \text{Open area of venting \%} &= \frac{\text{Open area of roof} + \text{open area of inlet} \times 100}{2 \times \text{cubicle width} \times \text{cubicle depth}} \\ &= \frac{(0.27 + 0.15) \times 100}{(2 \times 0.8 \times 0.5)} \\ &= 52.5 \% \end{aligned}$$

From Figure 5-35 the re-circulation factor = 0.76.

Figure 5-35 Recirculation factor



This is an approximation of the amount of air that is re-circulated within the enclosure due to inlet and outlet venting restrictions. The factor has a safety factor built in to it to ensure a safe result. The factor has been calculated using CFD software, testing the amount of heat flow back into the drive when different vent restrictions are given. The factor can also be applied to an Unidrive M / Unidrive HS size 9/10 E and separated Unidrive M / Unidrive HS size 9/10 D.

Calculate loss which affects the drive inlet air temperature

$$\begin{aligned} \text{Loss affecting drive temperature (Pr)} &= \text{Lower choke Loss (Pc)} + \\ &(\text{Total loss of single drive (Dp)} \times \text{Recirculation factor (Rf)}) \\ &= 250 + (4290 \times 0.76) \\ &= 3510 \text{ W} \end{aligned}$$

NOTE

This is the loss from 1 drive unit only as simulations have shown that with drives mounted inline and in a symmetric system the losses are shared equally.

Calculate temperature rise

Table 5-6 Air flow rates

Modules	Flow rate (m ³ /hr)
Inverter	402
Rectifier	266

Calculating temperature rise in enclosure

$$dT = 3kPr/V$$

Where:

V = Airflow in m³/hr (Unidrive flow rate = 305)

dT = Temperature rise

Pr = Loss affecting drive temp

k = 1 / Altitude de-rate

Therefore ambient temperature rise (dT):

$$\begin{aligned} &= (3 \times 1 \times 3510.4) / 305 \\ &= 34.5 \text{ °C} \end{aligned}$$

So,

Ambient temperature inside enclosure = External ambient + temperature rise = 64.5 °C

This shows that with the maximum allowable ambient drive temperature of 40 °C, the enclosure will overheat.

Processing results

Option 1: If the absolute temperature inside the enclosure is still less than 50 °C, select a drive with the correct rating at 50 °C.

Option 2: Add more venting, if possible, to reduce the recirculation and recalculate.

Option 3: Add an enclosure fan.

Option 4: Redesign the enclosure so that the drives can be through panel mounted. This means that most of the heat can escape outside the main enclosure, and the input air into the heat sinks will remain at the external ambient and not be affected by recirculation. Refer to section 5.5.2 *Through-panel mounting* on page 54.

NOTE

Heat loss through the front of the drive still needs to be considered.

Adding enclosure fan

Calculate required flow rate

- Fan needs to remove the effect of re-circulation and the added choke loss.
- Loss affecting drive temp (Pr) = 3510.4 W
- The above Loss of 3510.4 W is for one drive only, so with an enclosure of 2 units the total loss to remove = 7020.8 W

Calculate the temperature rise allowed in the enclosure:

$$\text{Temperature rise (dT)} = (\text{Allowable drive ambient} - 5 \{\text{safety factor}\}) - \text{External ambient}$$

$$= (40 - 5) - 30$$

$$= 5 \text{ °C}$$

Then using:

$$V = 3kPr / (dT)$$

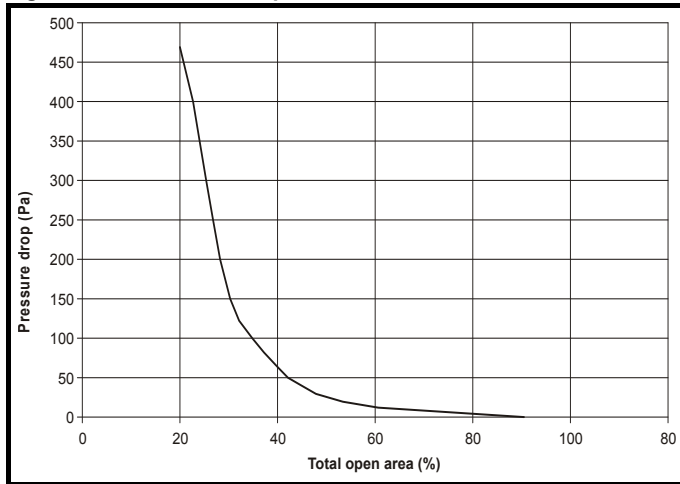
$$\text{Flow rate required to remove loss} = (3 \times 1 \times 7020.8) / 5$$

$$= 4212.5 \text{ m}^3/\text{hr}$$

Calculate back pressure on fan

$$\text{Open area of venting \%} = \frac{\text{Open area of roof} + \text{open area of inlet} \times 100}{2 \times \text{cubicle width} \times \text{cubicle depth}}$$

Figure 5-36 Pressure drop



Best practice: Size the enclosure air inlet and exit vents at least as large as the venturi opening of the fan used. This will ensure a negligible back pressure.




With 52.5 % open area: **Pressure drop = 34**

Selecting fan

Considerations when selecting fan:

- Dimensions and space limitation
- Required flow rate
- Static pressure
- Noise level
- Power supply

Table 5-7 Type of fan

<p>Backward curved Blower (Centrifugal)</p> <ul style="list-style-type: none"> • Outward flow perpendicular to inward flow • Good at high + low back pressures • Good resistance to dust and dirt due to impeller design • Do not need cowling • Relatively small diameters required for high airflow 	
<p>Forward curved blower (Centrifugal)</p> <ul style="list-style-type: none"> • Requires cowling • Good at directing flow 	
<p>Axial Fan</p> <ul style="list-style-type: none"> • Not good at high pressure but good for low pressure applications such as room venting and ducting • Inward flow and outward flow is in same direction • Good in straight line duct applications. • Large diameters required for high air flows 	

Fan curves

Once the type of fan has been selected the next step is to match the system characteristics of your enclosure to the fan performance curve.

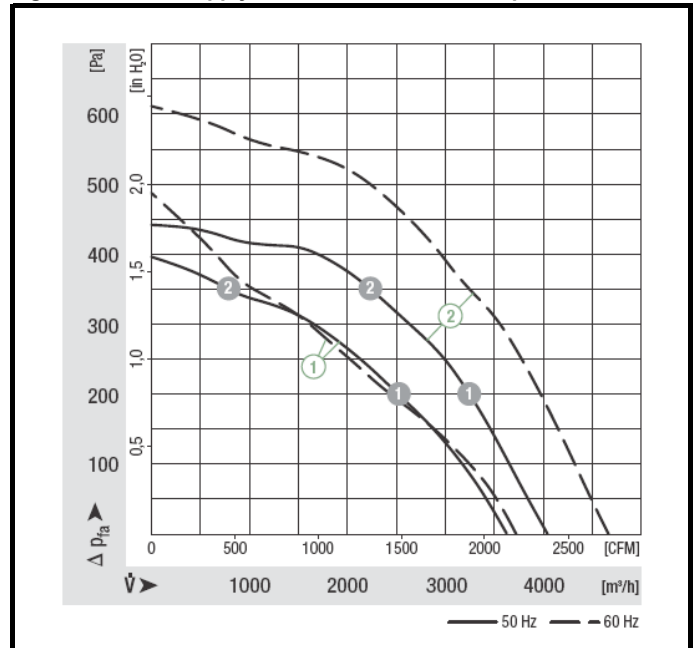
System operating point is:

Static pressure = 34 Pa

Flow rate= 4212.5 m³/hr

Selected fan is a Backward curved centrifugal blower to place in the roof and take advantage of the perpendicular flow and high flow rate properties.

Figure 5-37 AC supply 400 mm diameter blower performance



Final summary

1. Enclosure fans can be placed on inlet and outlet depending on system limitations.
2. Considerations with fan on outlet:
 - Higher Ambient temperature surrounding fan, can affect fan life.
 - Depressurisation of enclosure which may draw in dust through any apertures.
3. Considerations with fan on inlet:
 - Proximity of dust filter to fan, can create excess back pressure on fan
 - Non-uniform flow across internal components
4. Dust filters:
 - Use the largest filter possible, in order to:
 - a. Increase dust capacity
 - b. Reduce pressure drop
5. Make sure Drive inlets are as close to the enclosure air inlet as possible
6. Do not block the inlet and outlets of the drive airflow. Keep to best practice spacing between drives and other parts in enclosure.
7. Beware of blocking air inlets or outlets with cable routing.

5.7 Heatsink fan operation

The Unidrive M / Unidrive HS size 9, 10, 11 and the rectifier are ventilated by a heatsink mounted fan and an auxiliary fan to ventilate the drive box. The fan housing forms a baffle plate, channelling the air through the heatsink chamber. Thus, regardless of mounting method (surface mounting or through-panel mounting), the installation of additional baffle plates is not required.

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

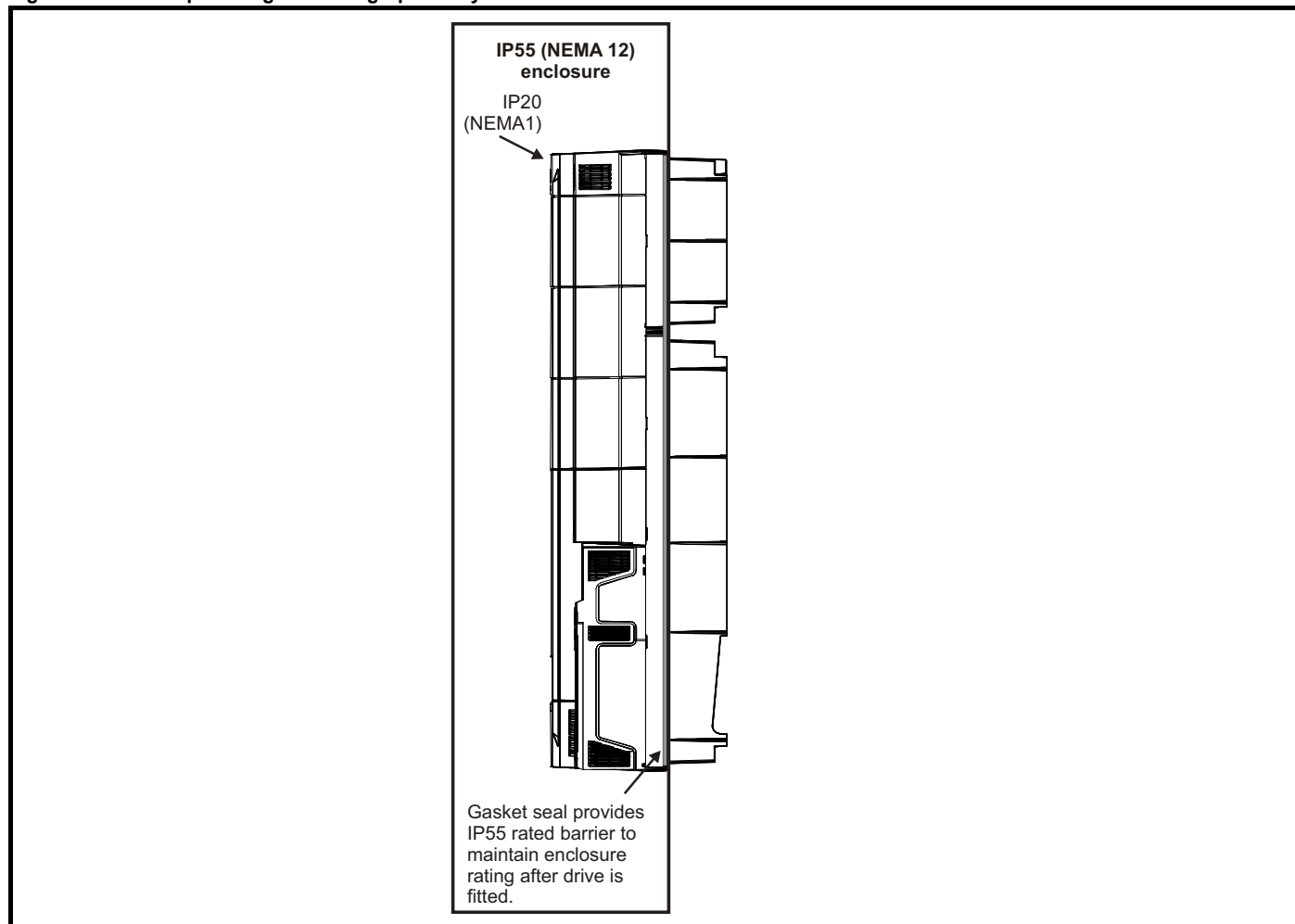
The heatsink fan on Unidrive M / Unidrive HS size 9, 10, 11 and the rectifier is a variable speed device. The drive controls the speed at which the fan runs based on the temperature of the heatsink and the drive's thermal model system. The Unidrive M / Unidrive HS size 9, 10 and 11 are also installed with variable speed fans to ventilate the capacitor bank.

5.8 Enclosing drive for high environmental protection

The standard drive is rated to IP20 pollution degree 2 (dry, non-conductive contamination only) (NEMA 1). However, it is possible to configure the drive to achieve a higher IP rating at the rear of the heatsink when through-panel mounted.

This allows the front of the drive, along with various switchgear, to be housed in an IP55 (NEMA 12) enclosure with the heatsink protruding through the panel to the external environment. Thus, the majority of the heat generated by the drive is dissipated outside the enclosure maintaining a reduced temperature inside the enclosure. This also relies on a good seal being made between the heatsink and the rear of the enclosure using the gaskets provided.

Figure 5-38 Example of high IP through-panel layout

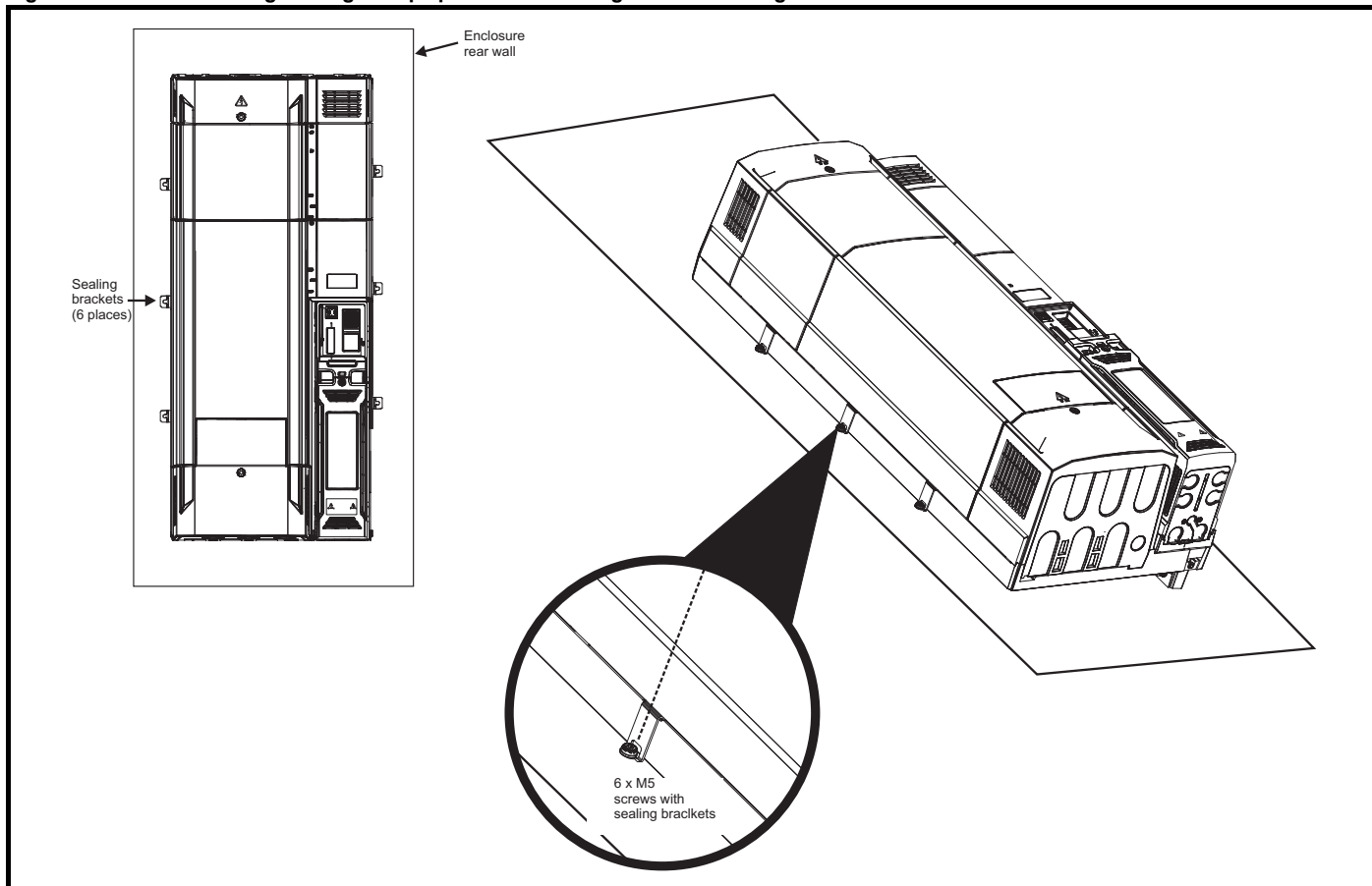


The main gasket should be installed as shown in Figure 5-38. Any screws / bolts that are used for mounting should be installed with M8 flat nylon washers to maintain a seal around the screw hole.

See Figure 5-39 on page 69, sealing clamps are supplied in the through panel mounting kit to aid compression of the gasket.

NOTE

The heatsink fans have conformal coated PCBs and have sealant at cable entry points. Dripping, splashing or sprayed water can impede the operation of the fan, therefore if the environment is such that the fan may be subjected to more than occasional dripping or sprayed water while operational, then suitable drip protection covers should be employed.

Figure 5-39 View showing sealing clamps provided in through hole mounting kit**NOTE**

For detailed information regarding high IP through panel mounting see Figure 5-24 *Through-panel mounting the Unidrive M / Unidrive HS size 9D/10D* on page 58.

NOTE

When designing an IP55 (NEMA 12) enclosure (Figure 5-38 *Example of high IP through-panel layout* on page 68), consideration should be given to the dissipation from the front of the drive.

Table 5-8 Power losses from the front of the drive when through-panel mounted

Frame size	Power loss
All sizes	≤ 480 W
Rectifier (all models)	≤ 50 W

5.9 External EMC filter

In order to provide our customers with a degree of flexibility, external EMC filters have been sourced from two manufacturers: Schaffner & Fuss. Filter details for each drive rating are provided in the tables below. Both the Schaffner and Fuss filters meet the same specifications.

Table 5-9 Single drive EMC filter details

Model	CT part number	Weight	
		kg	lb
400 V			
09402000 to 09402240 (9A)	4200-3021	11	24.25
09402000 to 09402240 (9E)	4200-4460	12	26.46
10402700 to 10403200	4200-4460	12	26.46
11403770 to 11404640	4200-0400	14.7	32.41
575 V			
09501040 to 09501310 (9A)	4200-1660	5.2	11.46
09501040 to 09501310 (9E)	4200-2210	10.3	22.71
10501520 to 10501900	4200-2210	10.3	22.71
11502000 to 11502850	4200-0690	16.75	36.9
690 V			
09601040-09601310 (9A)	4200-1660	5.2	11.46
09601040 to 09601310 (9E)	4200-2210	10.3	22.71
10601500 to 1061780	4200-2210	10.3	22.71
11602100 to 11602630	4200-0690	16.75	36.9

The external EMC filters for Unidrive M / Unidrive HS Modular drives are designed to be mounted above the drive, as shown in Figure 5-40.

Figure 5-40 Mounting the external EMC filter

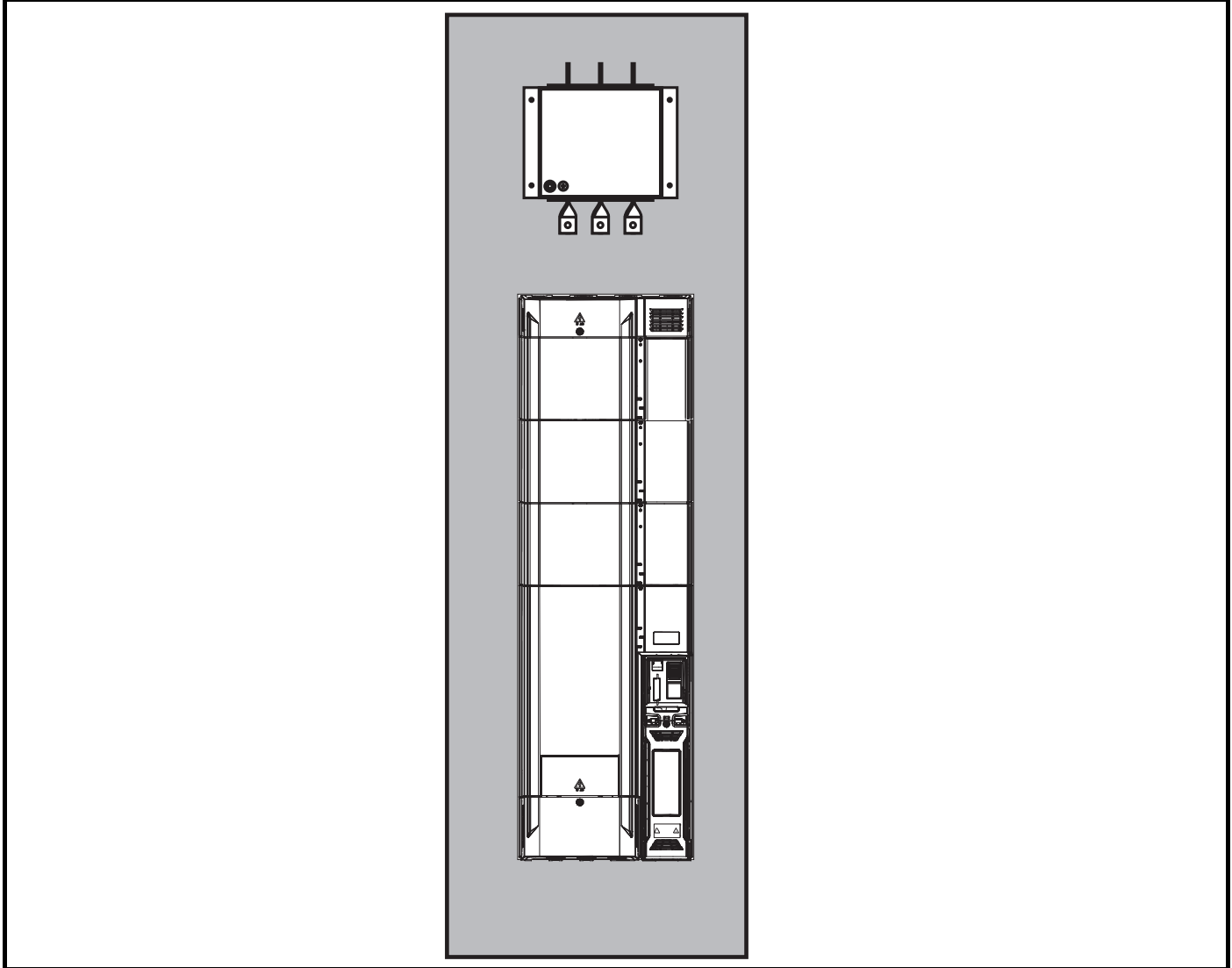


Figure 5-41 External EMC filter Unidrive M / Unidrive HS (size 9A)

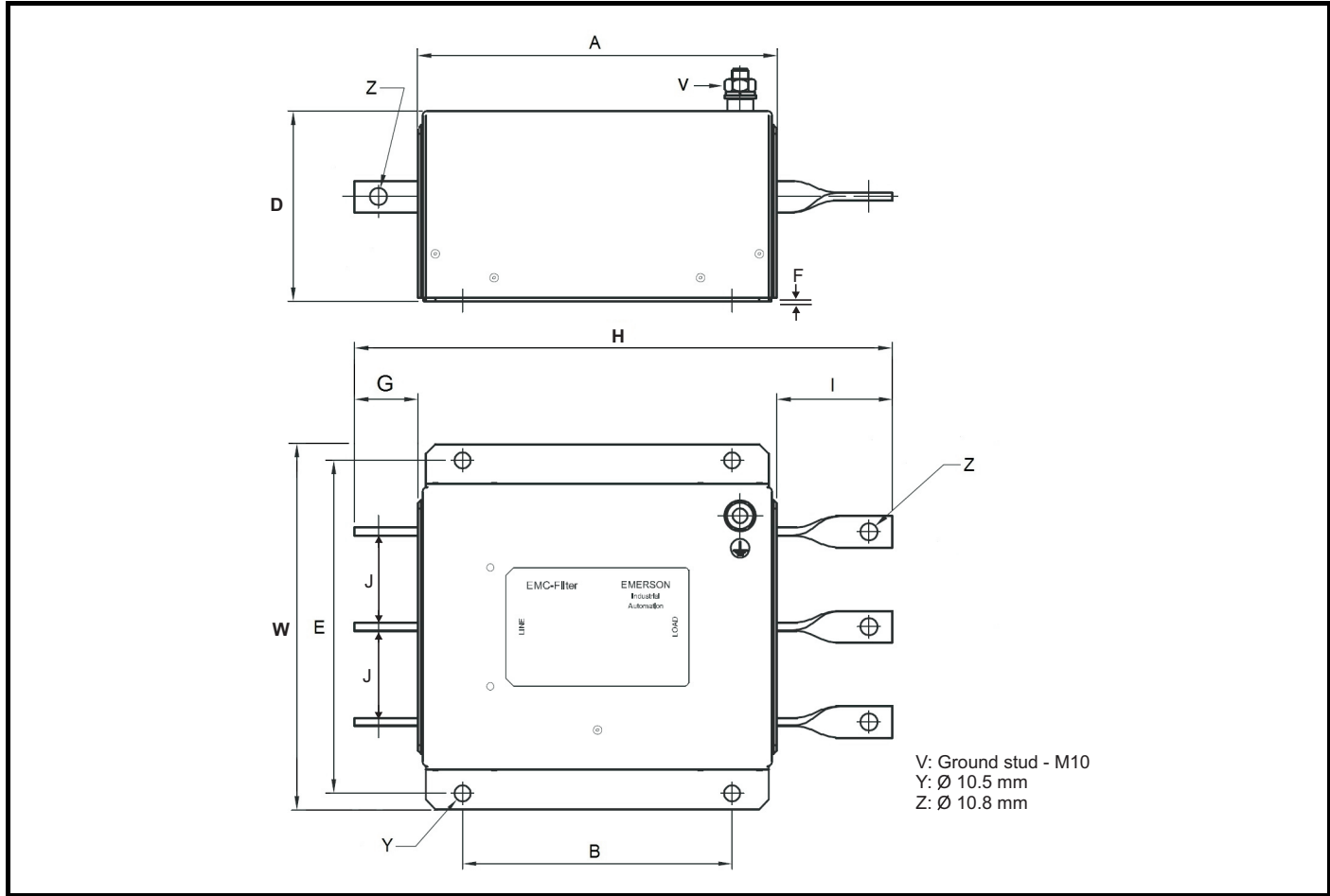


Table 5-10 Size 9A external EMC filter dimensions

CT part number	A	B	D	E	F	G	H	I	J	W
4200-3021	220 mm (8.66 in)	170 mm (6.70 in)	120 mm (4.72 in)	210 mm (8.27 in)	2 mm (0.08 in)	40 mm (1.57 in)	339 mm (13.34)	73 mm (2.87 in)	60 mm (2.36 in)	230 mm (9.06 in)
4200-1660	280 mm (11.02 in)	180 mm (7.09 in)	105 mm (4.13 in)	225 mm (8.86 in)	2 mm (0.08 in)	40 mm (1.57 in)	360 mm (14.17 in)	73 mm (2.87 in)	60 mm (2.36 in)	245 mm (9.65 in)

Figure 5-42 External EMC filter (size 9E and 10)

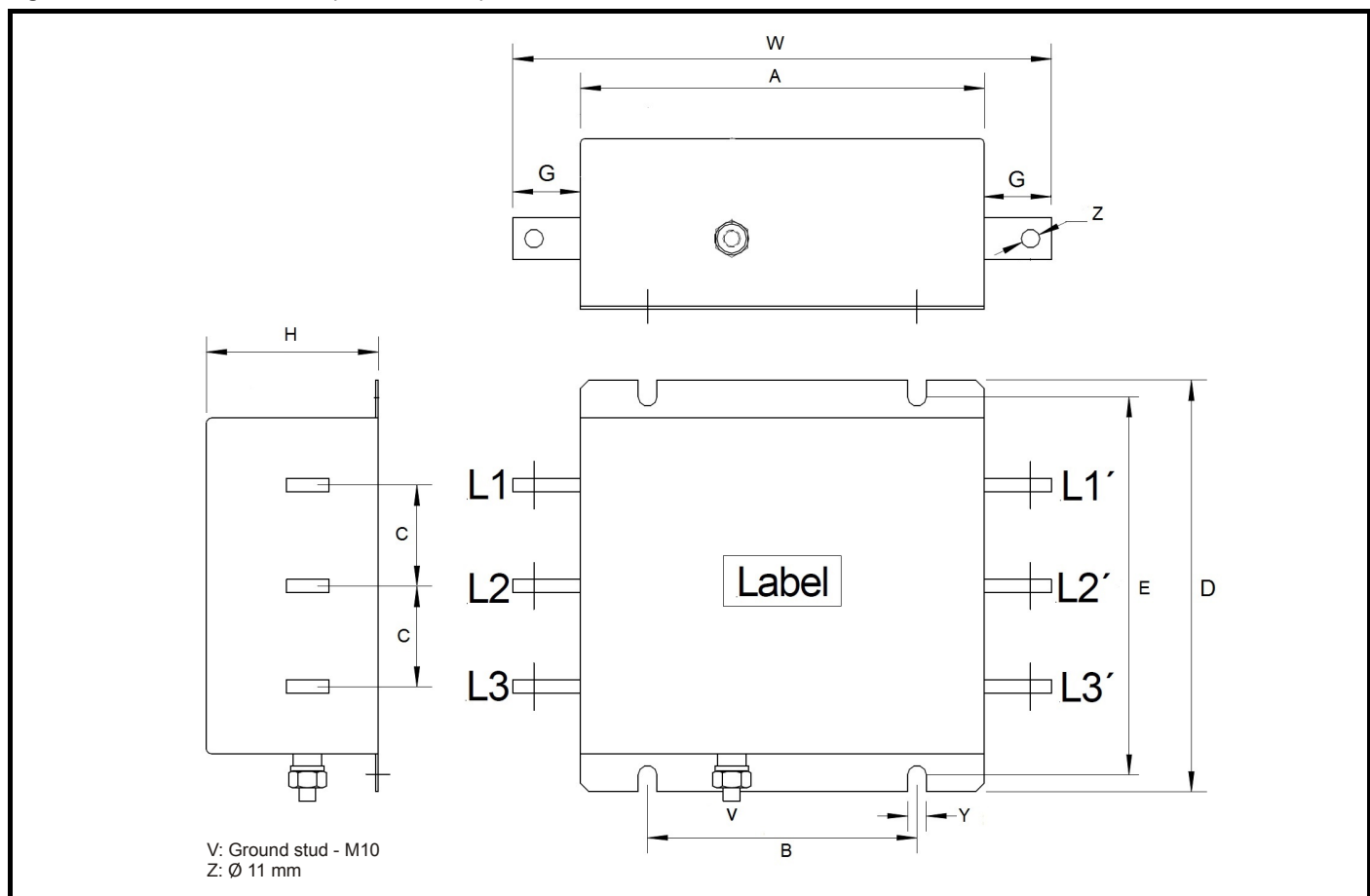
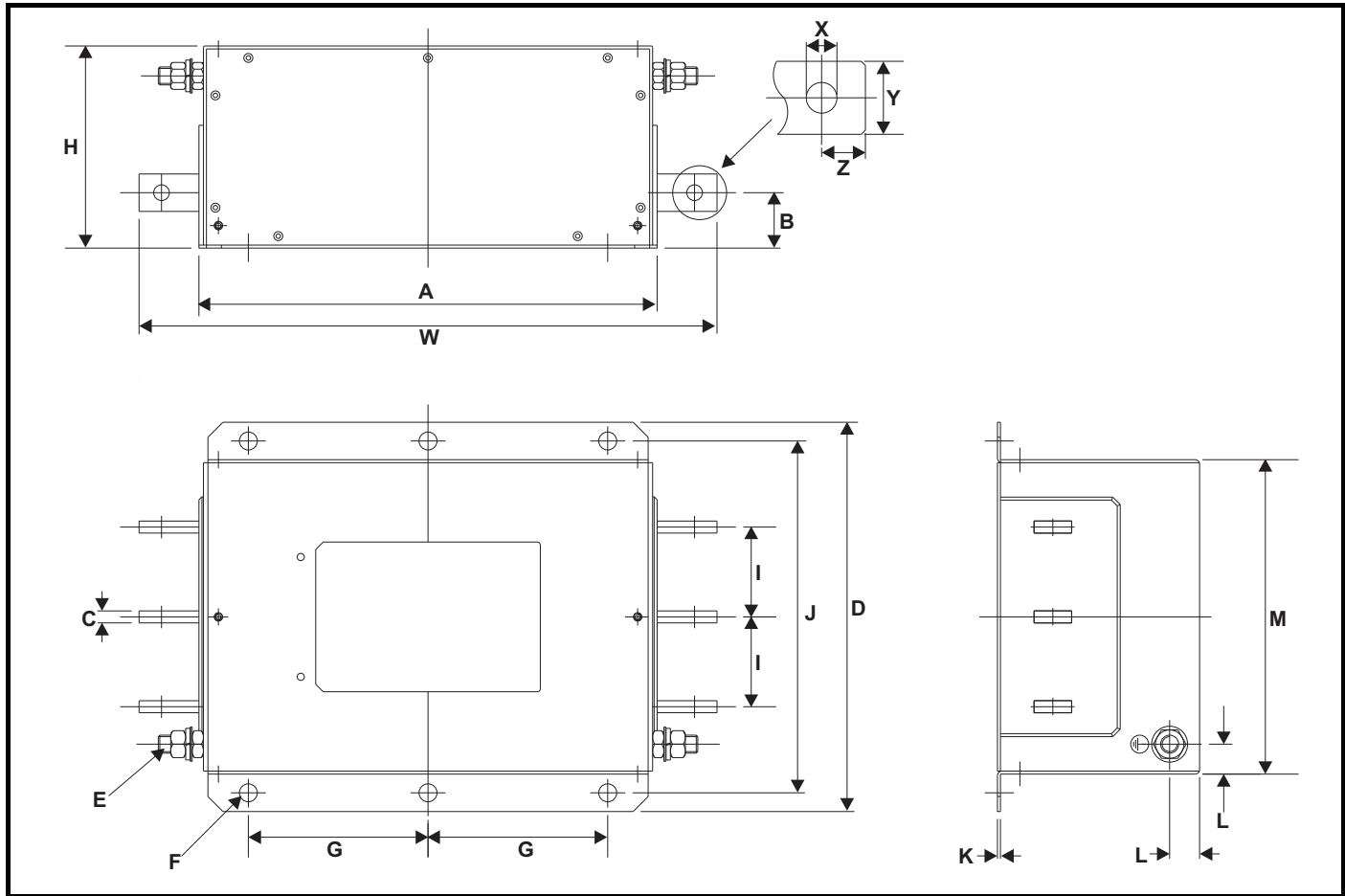


Table 5-11 Unidrive M / Unidrive HS size 9E and 10 external EMC filter dimensions

CT part number	A	B	C	D	E	G	H	W	Y
4200-4460	280 mm	180 mm	57 mm	245 mm	225 mm	40 mm	105 mm	360 mm	11 mm
4200-2210	(11.02)	(7.09)	(2.24 mm)	(9.65 in)	(8.86 in)	(1.57 in)	(4.13 in)	(14.7 in)	(0.43 in)

Figure 5-43 External Unidrive M / Unidrive HS size 11 EMC External EMC filter



5.9.1 EMC filter dimensions

Table 5-12 Unidrive M / Unidrive HS size 11 external EMC filter dimensions

CT part number	A	B	C	D	E	F	G	H	I	J	K	L	M	X	Y	Z	W
4200-0400	306 mm	37 mm	8 mm	260 mm	M12	12 mm	120 mm	135 mm	60 mm	235 mm	2 mm	20 mm	210 mm	10.5 mm	25 mm	15 mm	386 mm
4200-0690	(12.05 in)	(1.46 in)	(0.32 in)	(10.2 in)		(0.47 in)	(4.72 in)	(5.32 in)	(2.36 in)	(9.25 in)	(0.08 in)	(0.79 in)	(8.27 in)	(0.41 in)	(0.98 in)	(0.59 in)	(15.20 in)

5.10 Line reactor mounting dimensions

5.10.1 Input line reactors

Figure 5-44 Unidrive M / Unidrive HS size 9 and 10 single input line reactor (INLX0X)

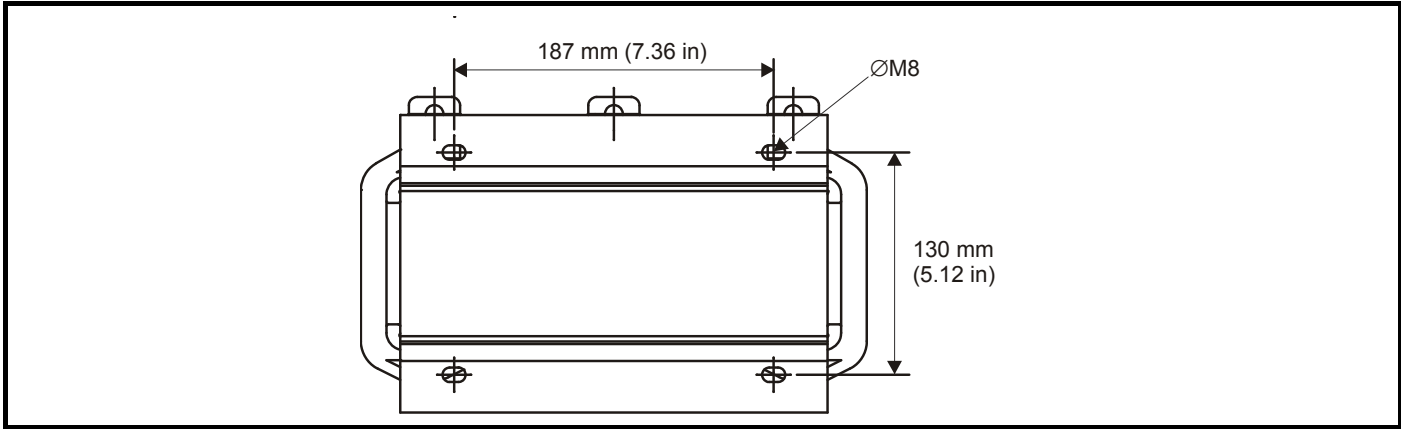
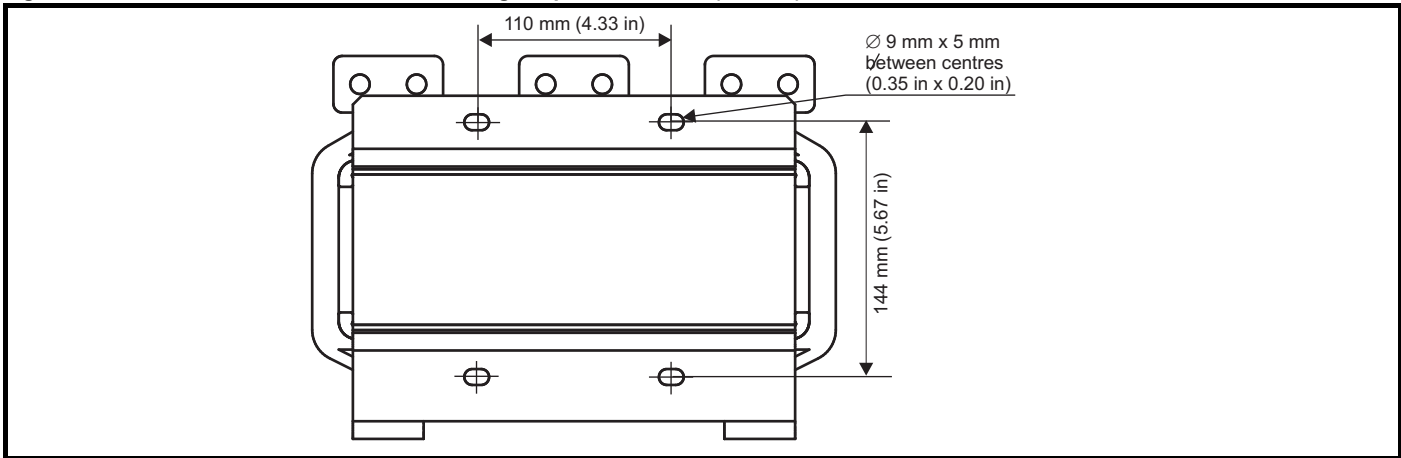


Figure 5-45 Unidrive M / Unidrive HS size 11 single input line reactor (INLX0X)



5.10.2 Output sharing chokes

Figure 5-46 Unidrive M / Unidrive HS size 9 and 10 single output sharing choke (OTL401 - OTL404)

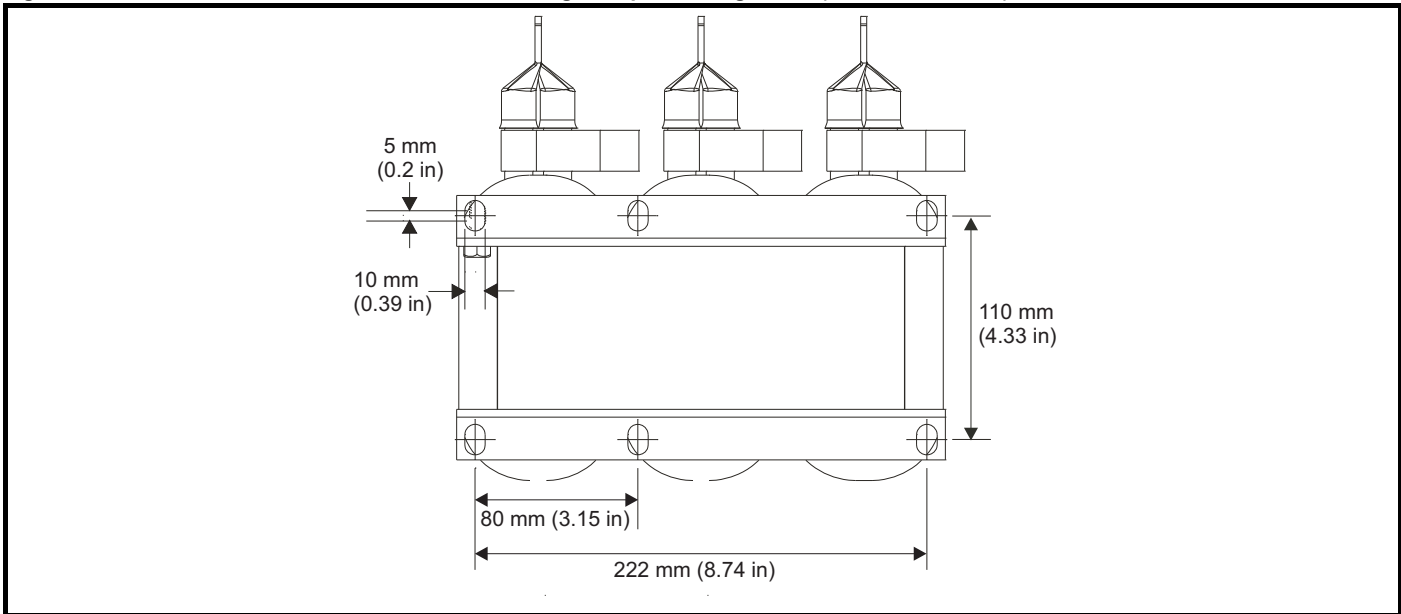


Figure 5-47 Unidrive M / Unidrive HS size 11 single output sharing choke (OTL405 and OTL607)

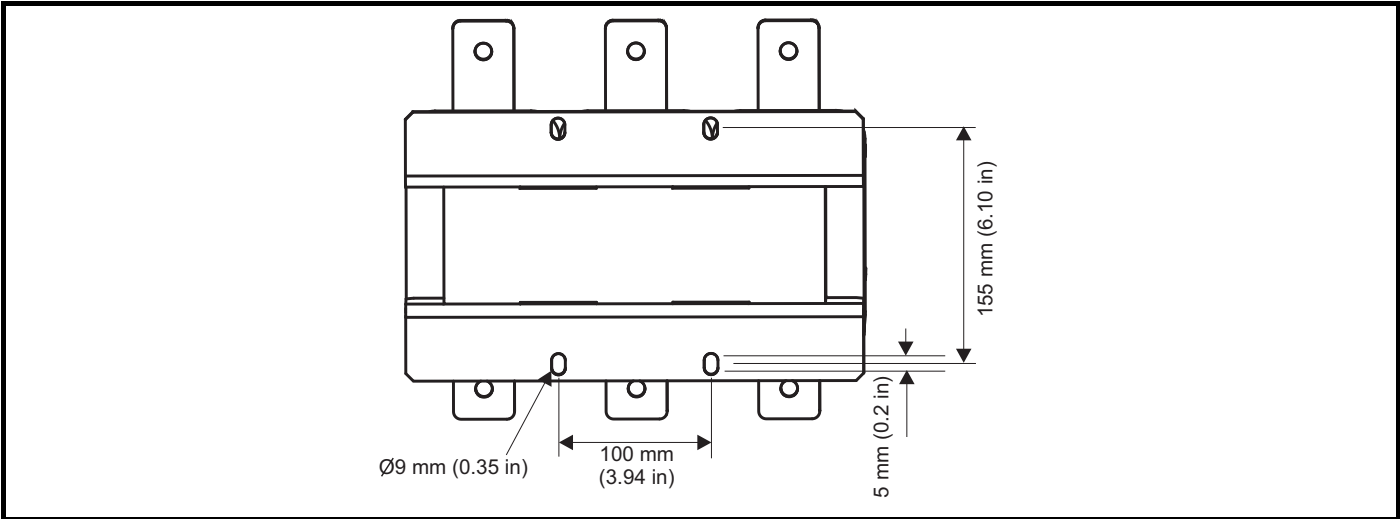


Figure 5-48 Unidrive M / Unidrive HS size 11 single output sharing choke (OTL407)

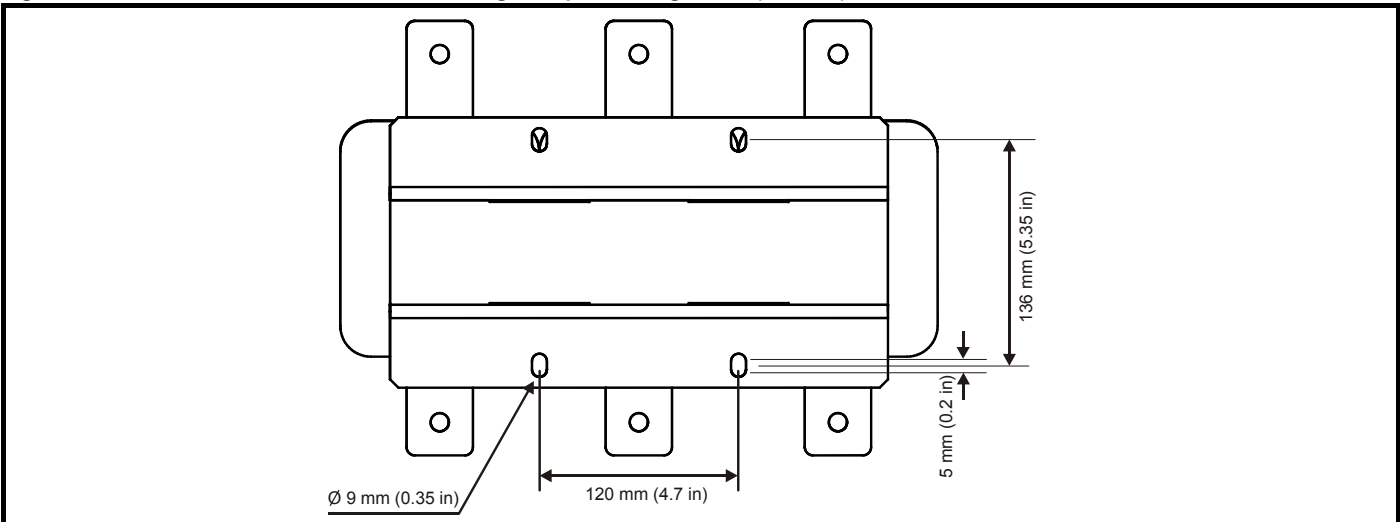


Figure 5-49 Unidrive M / Unidrive HS size 11 single output sharing choke (OTL605)

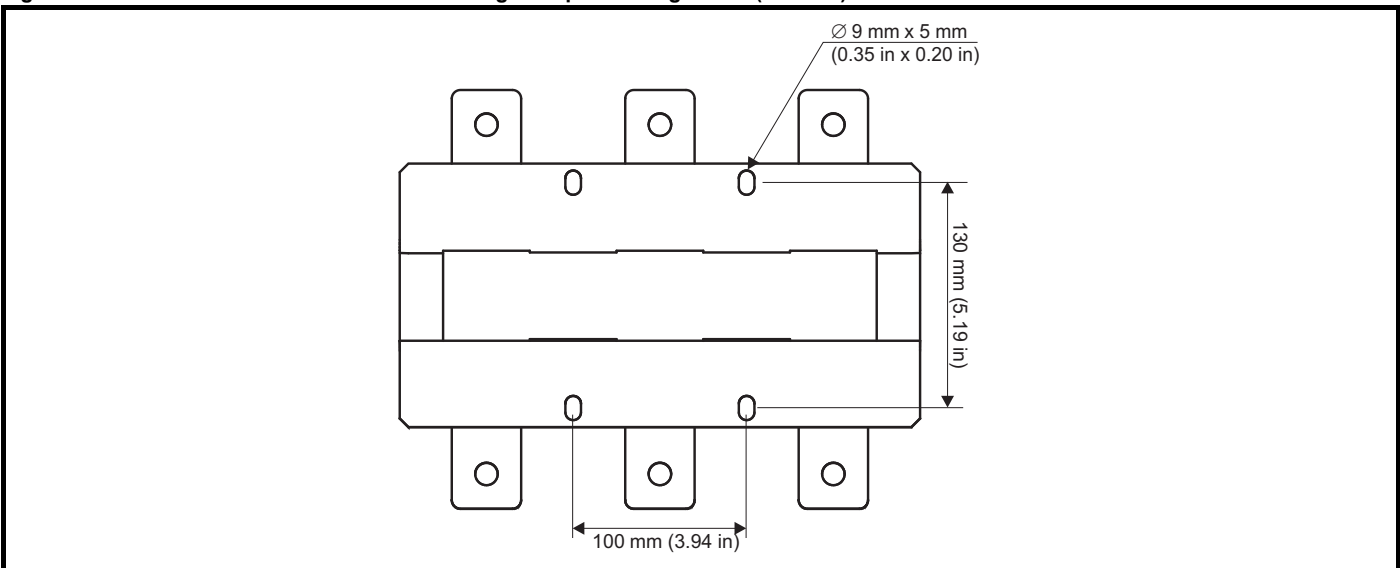
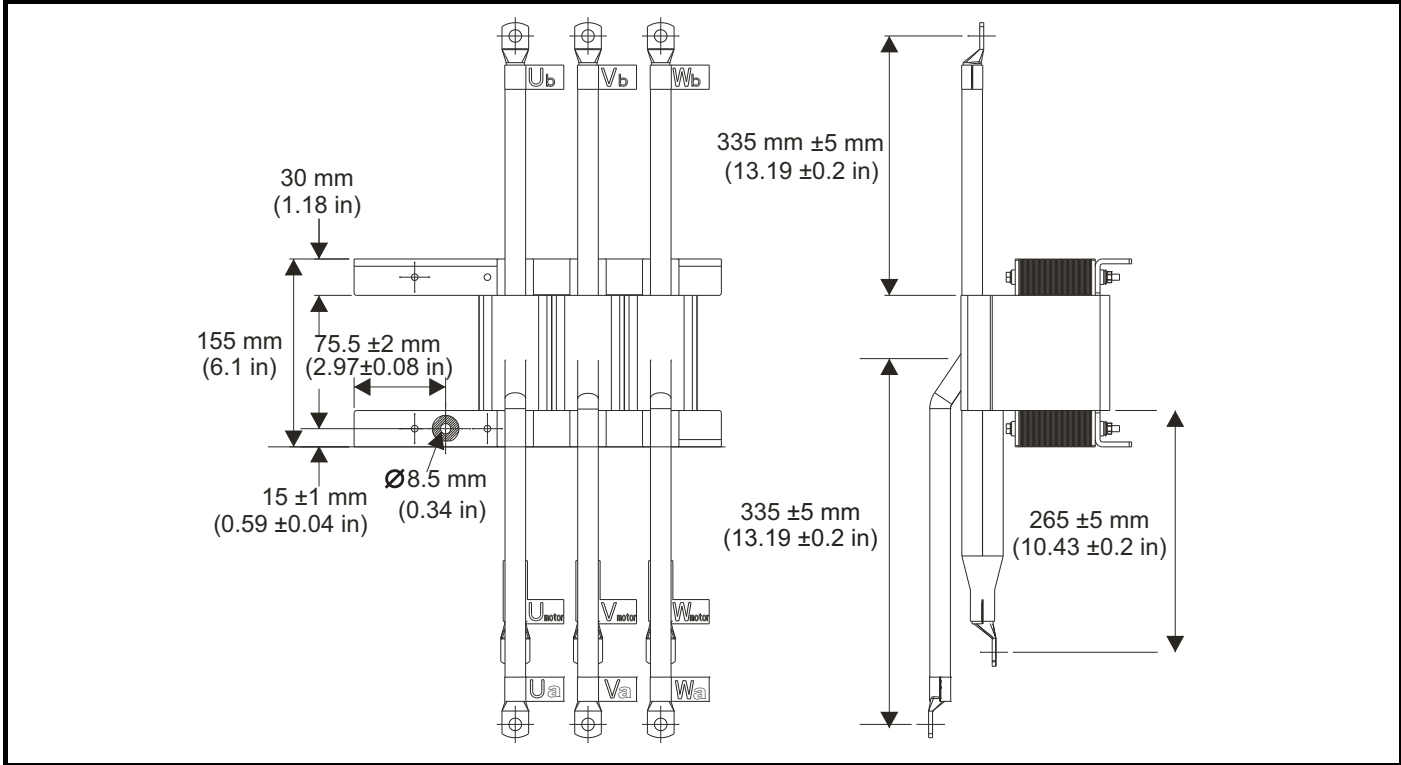


Figure 5-50 Unidrive M / Unidrive HS size 9 and 10 dual output sharing choke (OTLX1X)

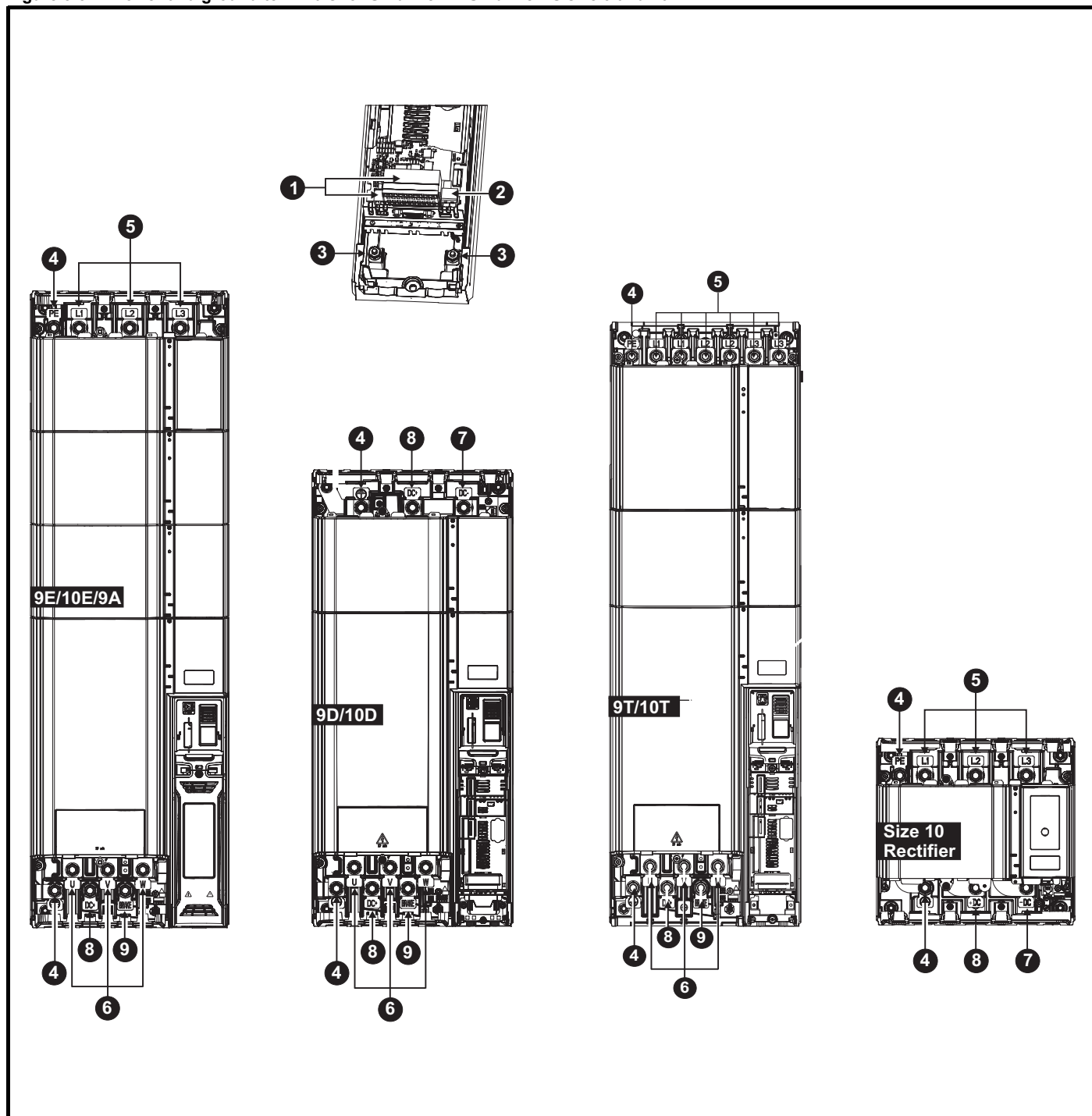


For overall dimensions and other details, refer to section 6.3 *Output sharing choke specification* on page 95.

5.11 Electrical terminals

5.11.1 Location of the power, control and ground terminals

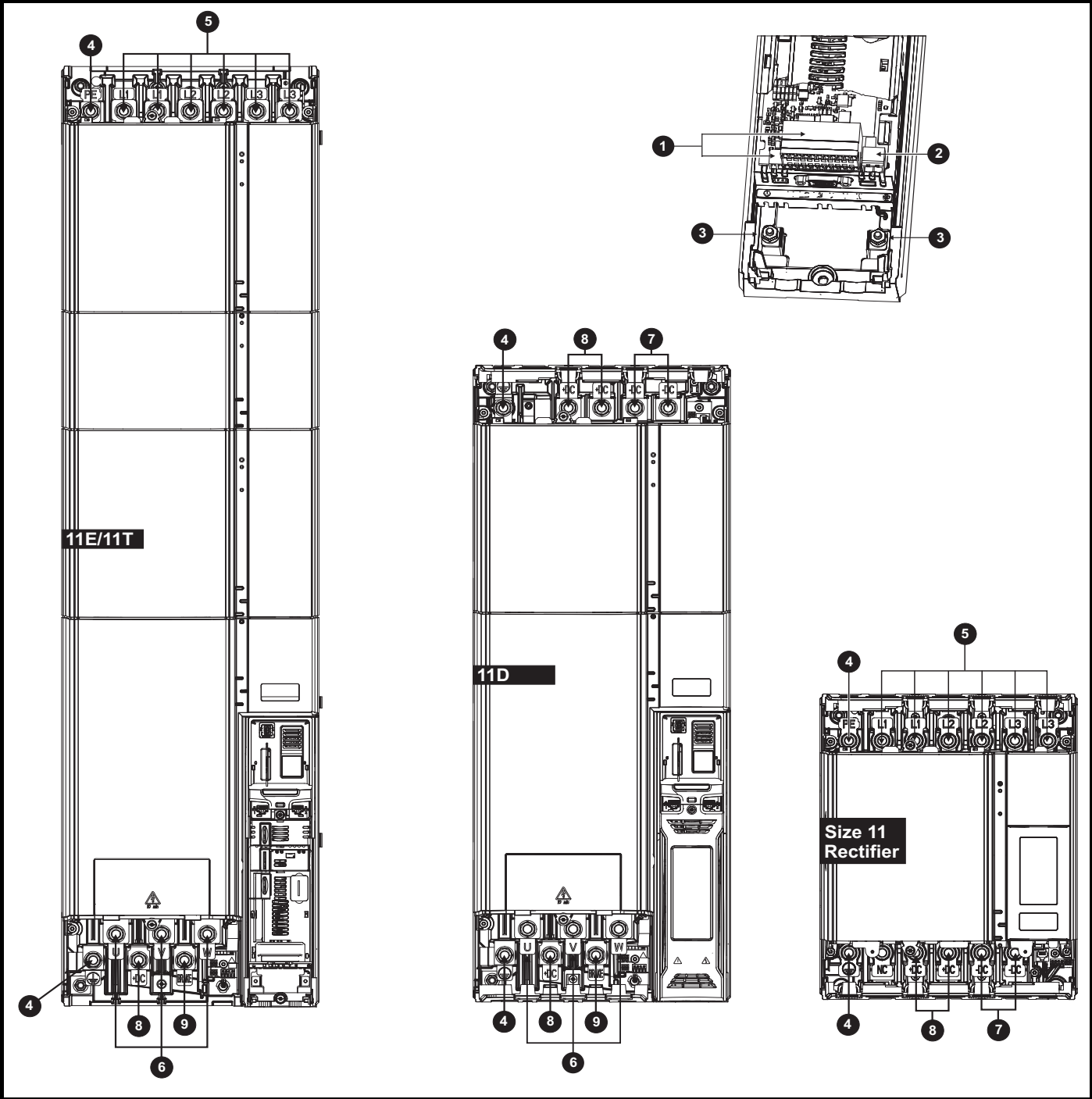
Figure 5-51 Power and ground terminals for Unidrive M / Unidrive HS size 9 and 10



Key

- | | | |
|--------------------------------|-----------------------|-------------------|
| 1. Control terminals | 4. Ground connections | 7. DC bus - |
| 2. Relay terminals | 5. AC power terminals | 8. DC bus + |
| 3. Additional ground terminals | 6. Motor terminals | 9. Brake terminal |

Figure 5-52 Power and Ground terminals for Unidrive M / Unidrive HS size 11



Key:

- | | | |
|--------------------------------|-----------------------|-------------------|
| 1. Control terminals | 4. Ground connections | 7. DC bus - |
| 2. Relay terminals | 5. AC power terminals | 8. DC bus + |
| 3. Additional ground terminals | 6. Motor terminals | 9. Brake terminal |

5.11.2 Terminal sizes and torque settings



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

Table 5-13 Master control and relay terminal data

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

Table 5-14 Drive power terminal data

Model size	AC and motor terminals		DC and braking		Ground terminal	
	Recommended	Maximum	Recommended	Maximum	Recommended	Maximum
All	M10 Nut (17 mm AF)		M10 Nut (17 mm AF)		M10 Nut (17 mm AF)	
	15 N m (11.1 lb ft)	20 N m (14.8 lb ft)	15 N m (11.1 lb ft)	20 N m (14.8 lb ft)	15 N m (11.1 lb ft)	20 N m (14.8 lb ft)

Table 5-15 Plug-in terminal block maximum cable sizes

Model size	Terminal block description	Max cable size
All	2 way low voltage power / 24 V supply connector	1.5 mm ² (16 AWG)

Table 5-16 Optional external EMC Filter terminal data

CT part number	Power connections		Ground connections	
	Bar hole diameter	Max torque	Ground stud size	Max torque
4200-3021	10.8 mm	30 N m (22.1 lb ft)	M10	18 N m (13.3 lb ft)
4200-4460	11 mm			
4200-1660	10.8 mm			
4200-2210	11 mm			
4200-0400	10.5 mm		M12	25 N m (18.4 lb ft)
4200-0690	10.5 mm			

5.12 Routine maintenance

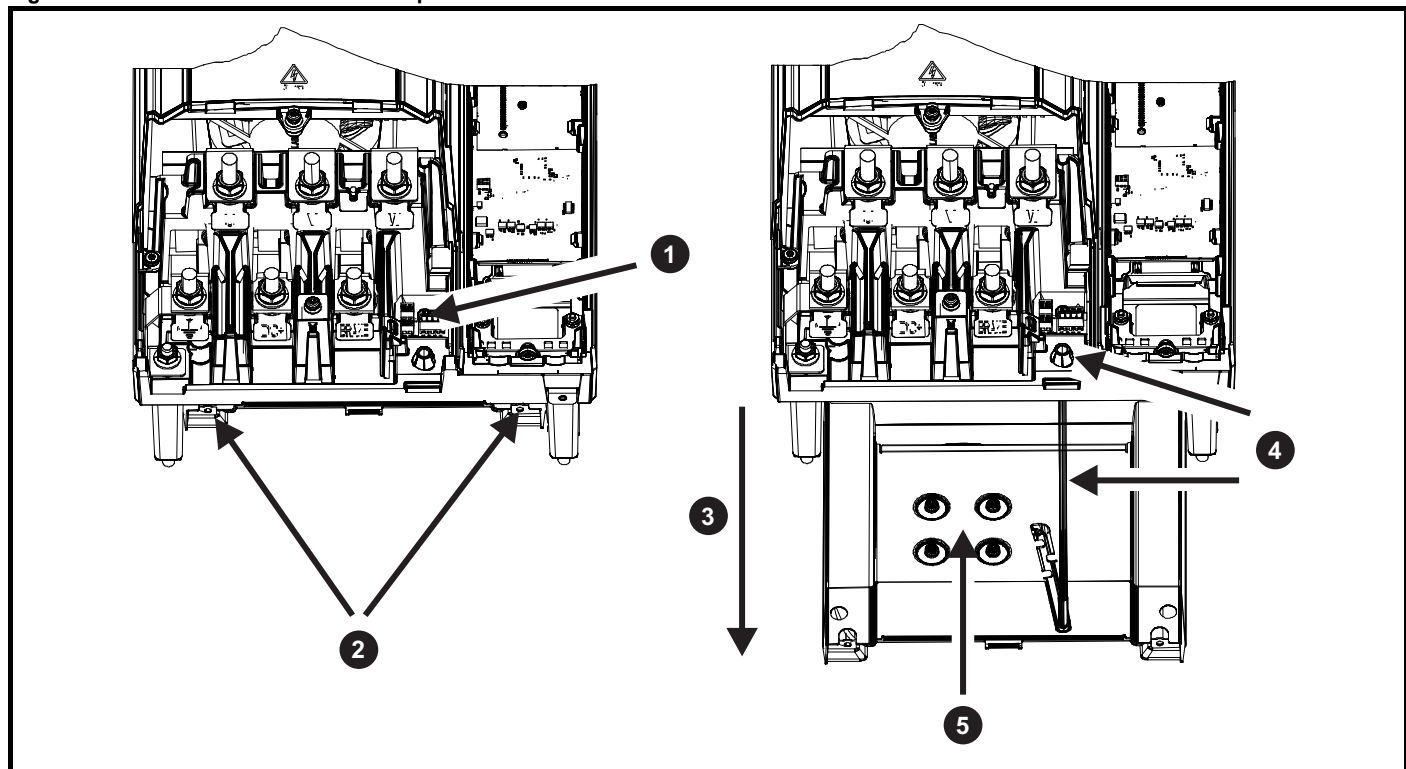
The drive should be installed in a cool, clean, well ventilated location. Contact of moisture and dust with the drive should be prevented.

Regular checks of the following should be carried out to ensure drive / installation reliability are maximized:

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

5.12.1 Size 9 to 11 heatsink fan replacement

Figure 5-53 Size 9 to 11 Heatsink fan replacement



Heatsink fan removal procedure

- 1) Using a flat screwdriver remove the fan wires from the fan connector (making a note of the order).
- 2) Using a T20 Torque driver remove the two screws that retain the heatsink fan housing
- 3) Withdraw the heatsink fan housing from the drive in the direction shown
- 4) Pull the fan cable through the fan cable gland
- 5) Using a T20 Torque driver remove the four screws that retain the fan in the housing

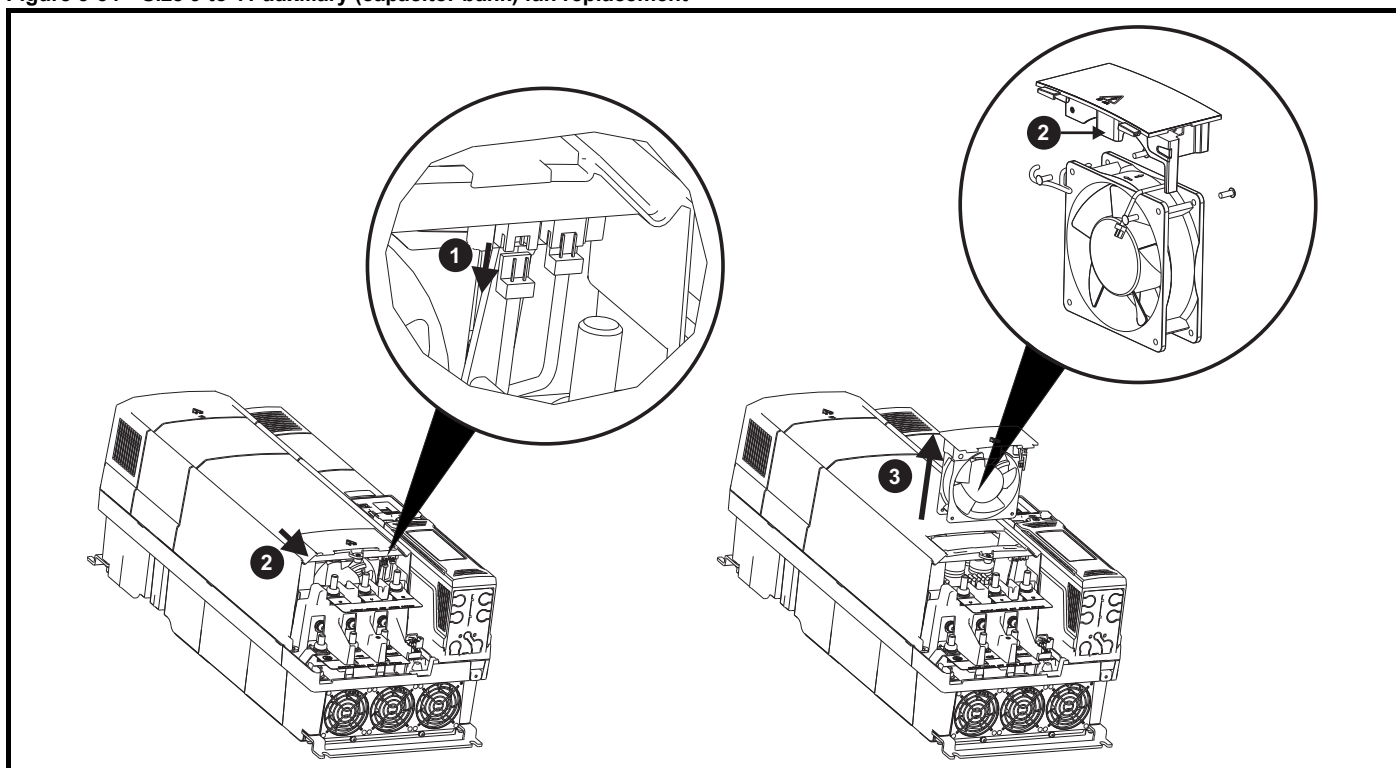
After fan has been replaced, reverse the above steps to refit.

Table 5-17 Heatsink fan part number

Drive model	Heatsink fan part number
Size 9 to 11	3251-1750

5.12.2 Size 9 to 11 auxiliary (capacitor bank) fan replacement

Figure 5-54 Size 9 to 11 auxiliary (capacitor bank) fan replacement



Auxiliary fan removal procedure

- 1) Disconnect the fan wiring connector shown
- 2) Slide fan housing in the direction shown using tongue shown in enlarged diagram of fan
- 3) Withdraw fan housing from the drive

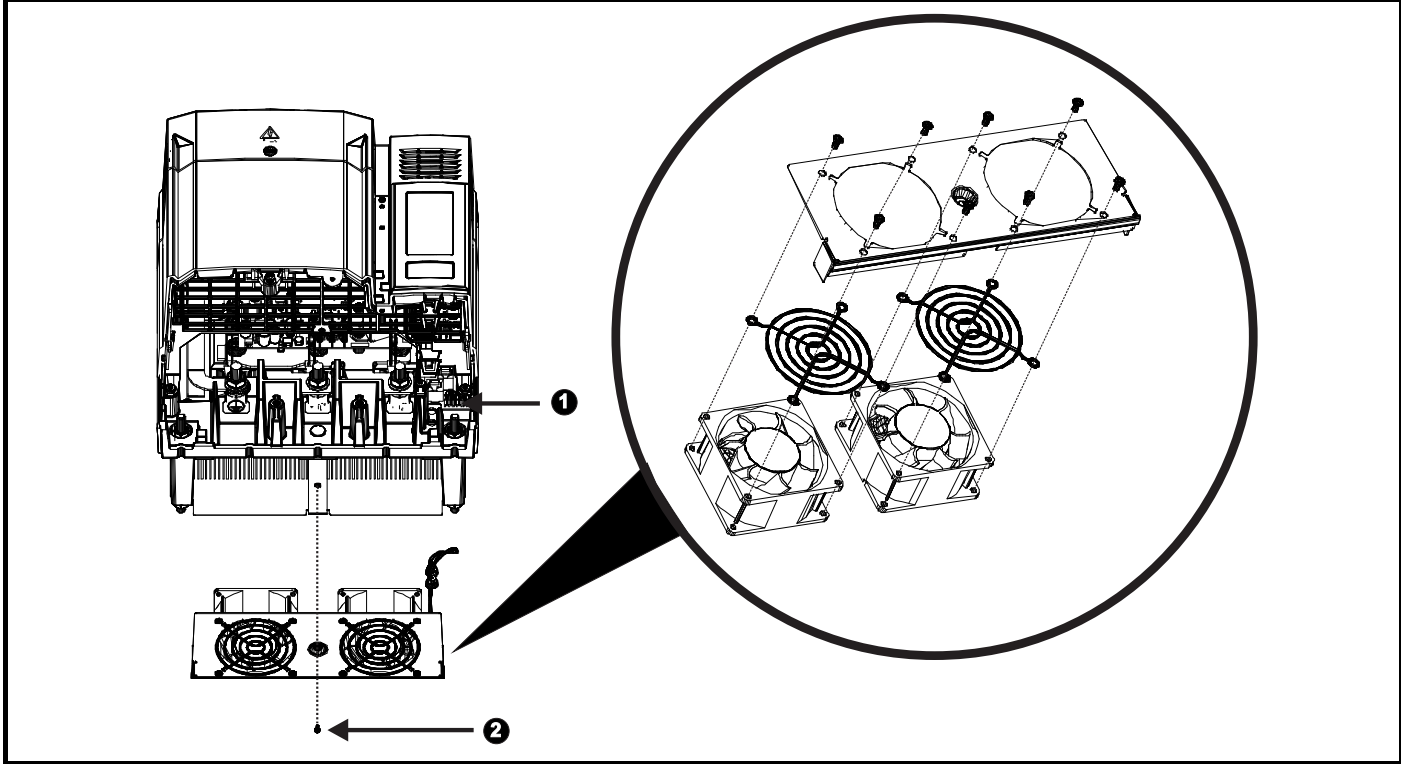
After fan has been replaced, reverse the above steps to refit.

Table 5-18 Auxiliary (capacitor bank) fan part numbers

Drive model	Auxiliary (capacitor bank fan part number
Size 9, 10 and 11 (575V and 690V)	3251-0042
Size 11 (400V)	3251-1202

5.12.3 Size 10 rectifier fan replacement

Figure 5-55 Size 10 rectifier fan replacement



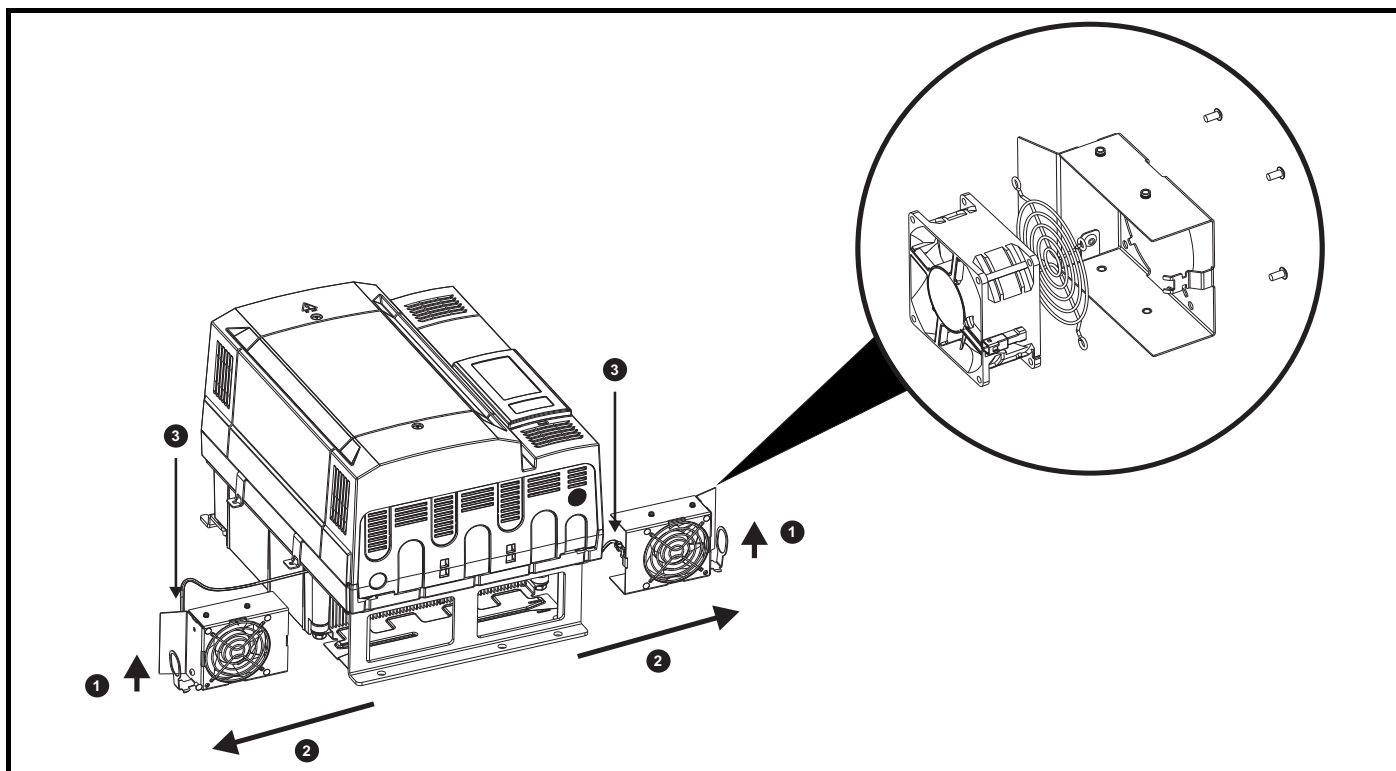
Size 10 rectifier fan removal procedure

- 1) Using a flat screwdriver remove the fan wires from the fan connector (making a note of the order).
- 2) Using a T20 Torque driver remove the screw that retains the fan housing and pull fan housing away from the rectifier
- 3) Pull fan wiring through cable gland

After fans have been replaced, reverse the above steps to refit the fan housing in the rectifier.

Table 5-19 Size 10 rectifier fan part number

Rectifier model	Rectifier fan part number
Size 10 rectifier	3251-8241

5.12.4 Size 11 rectifier fan replacement**Figure 5-56** Size 11 rectifier fan replacement**Size 11 rectifier fan removal procedure**

- 1) Lift the ring eye provided
- 2) Pull the fan housing in the direction shown
- 3) Disconnect the fan wiring at the connector shown

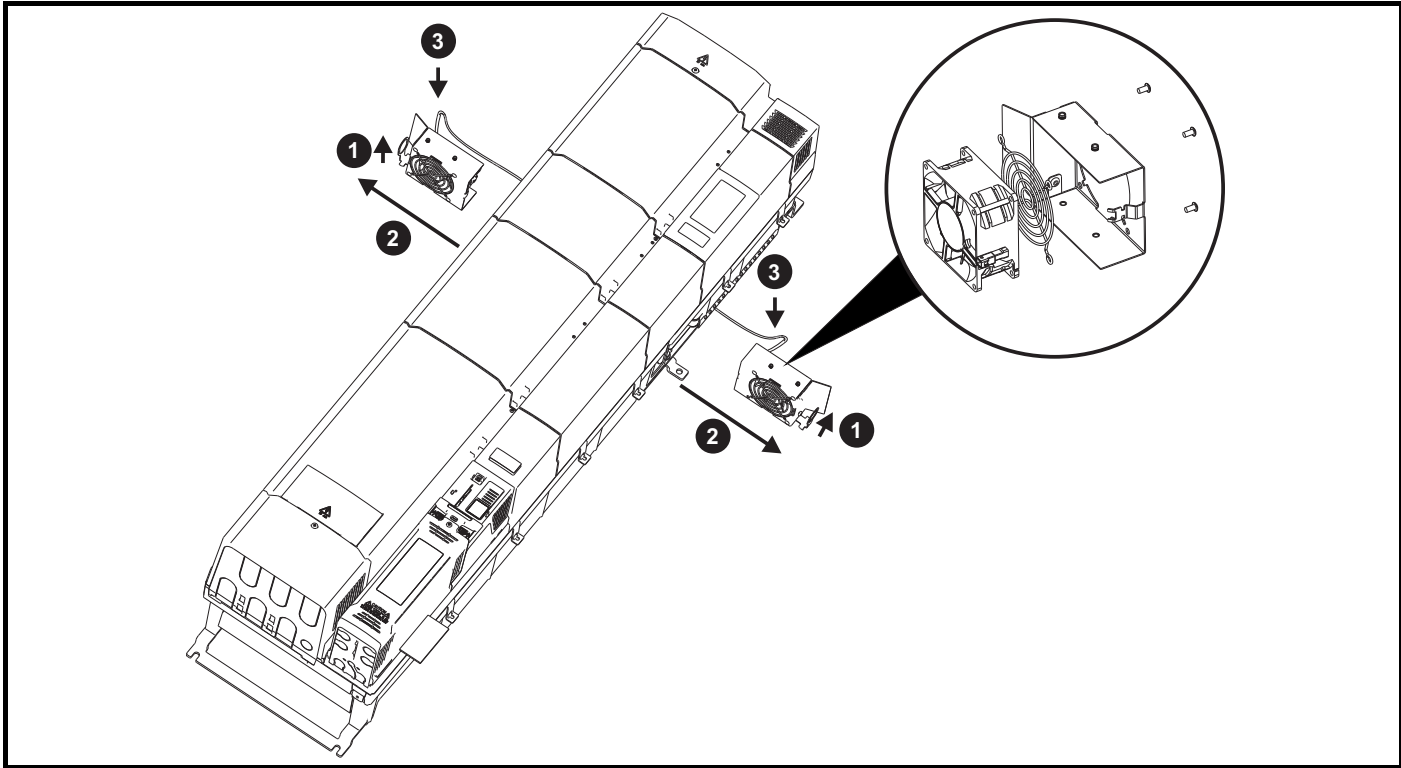
After fans have been replaced, reverse the above steps to refit the fan housing in the rectifier (making sure the fan housing aligns correctly in the slots top and bottom).

Table 5-20 Rectifier fan part numbers

Rectifier model	Rectifier fan part number
Size 11 rectifier	3251-0030

5.12.5 Size 11E rectifier fan replacement

Figure 5-57 Size 11E rectifier fan replacement



Size 11 rectifier fan removal procedure

- 1) Lift the ring eye provided
- 2) Pull the fan housing in the direction shown
- 3) Disconnect the fan wiring at the connector shown

After fans have been replaced, reverse the above steps to refit the fan housing in the rectifier (making sure the fan housing aligns correctly in the slots top and bottom).

Table 5-21 Rectifier fan part number

Drive model	Rectifier fan part number
Size 11E rectifier	3251-0030

6 Electrical Installation

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

- Safe Torque Off function
- Internal EMC filter
- EMC compliance with shielding / grounding accessories
- Product rating, fusing and cabling information
- Brake resistor details (selection / ratings)



Electric shock risk

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

WARNING

- 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 supply must be disconnected from the drive using an approved isolation device before any cover is removed from the drive or before any servicing work is performed.

WARNING



STOP function

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

WARNING



Safe Torque Off function

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

WARNING



Stored charge

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

WARNING

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).

WARNING



Permanent magnet motors

Permanent magnet motors generate electrical power if they are rotated, even when the supply to the drive is disconnected. If that happens then the drive will become energized through its motor terminals.

WARNING

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.



WARNING

Use of rectifiers other than Unidrive M / Unidrive HS - rectifier

If a rectifier other than Unidrive M / Unidrive HS Rectifier is used with Unidrive M / Unidrive HS size 9D/10D/11D, then it must be installed with line to ground varistors which are capable of reducing overvoltage transients from category III to values of category II. (ref. EN61800-5-1). This is to ensure L-E transients do not exceed 4 kV because there are no varistors installed in a D module, and the insulation system from power to ground is designed to category II.

Any non Control Techniques rectifier must be installed with AC line fuses that correspond to those specified for the Unidrive M / Unidrive HS rectifier. If this is not possible then DC fuses should be specified for the Unidrive M / Unidrive HS size 9D/10D/11D. This is to ensure validity of the safety testing carried out to complete the safety file and for UL certification, especially in the event of a short circuit bus cap in the DC bus.



CAUTION

0V control connections on both Unidrive M / Unidrive HS sizes 9, 10 and 11 drives are internally earthed and cannot be disconnected. Ensure that there is adequate equipotential bonding between parts of a system with interconnected control wiring.

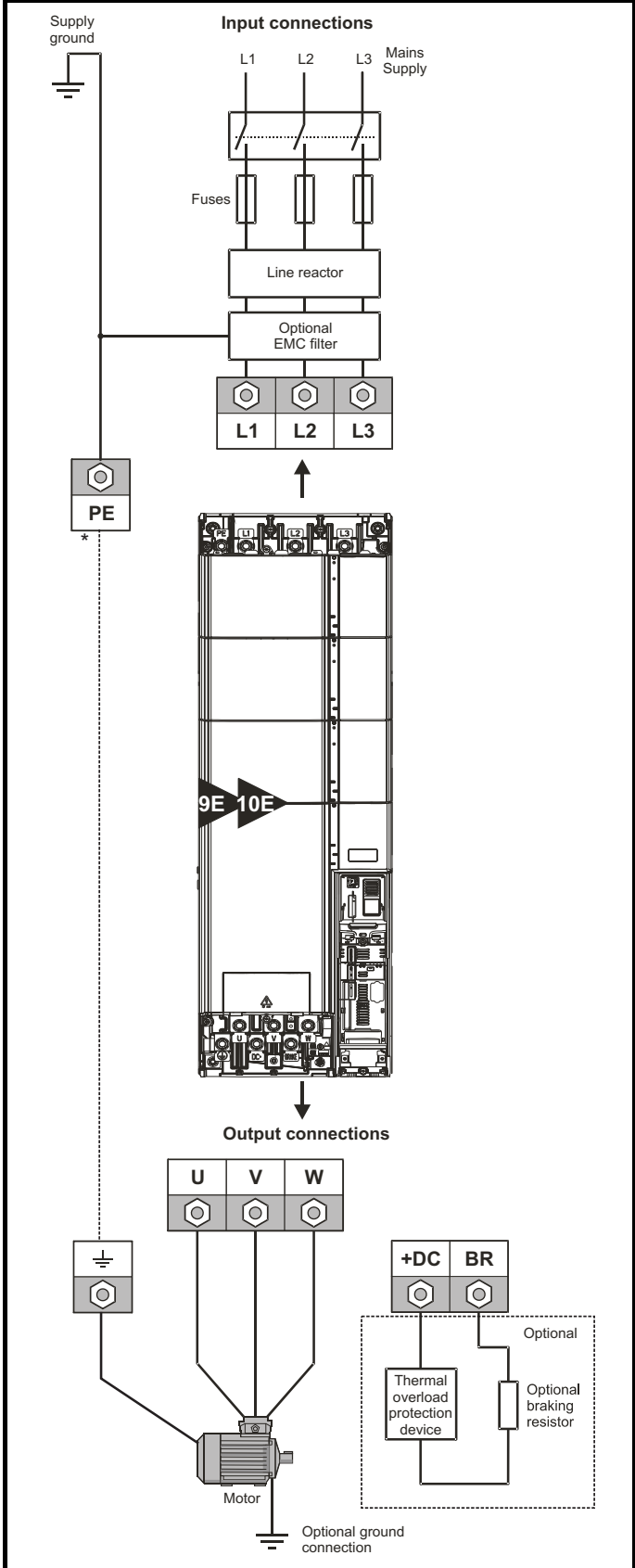
NOTE

The power supply to all modules in a multi-module system should be applied at the same time, to ensure the drive powers-up correctly. Otherwise the drive may power-up with a hardware fault (HF) trip code.

6.1 Power connections

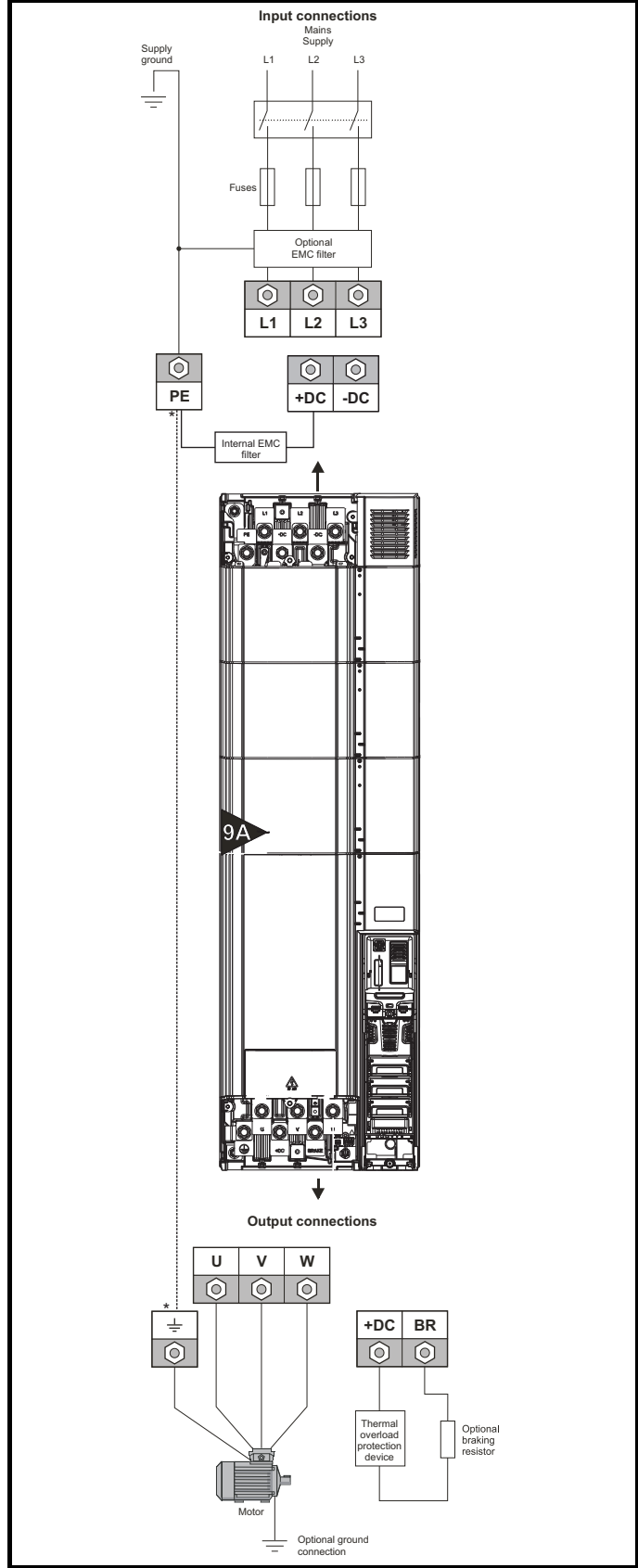
6.1.1 AC and DC connections

Figure 6-1 Unidrive M/Unidrive HS size 9E/10E power connections



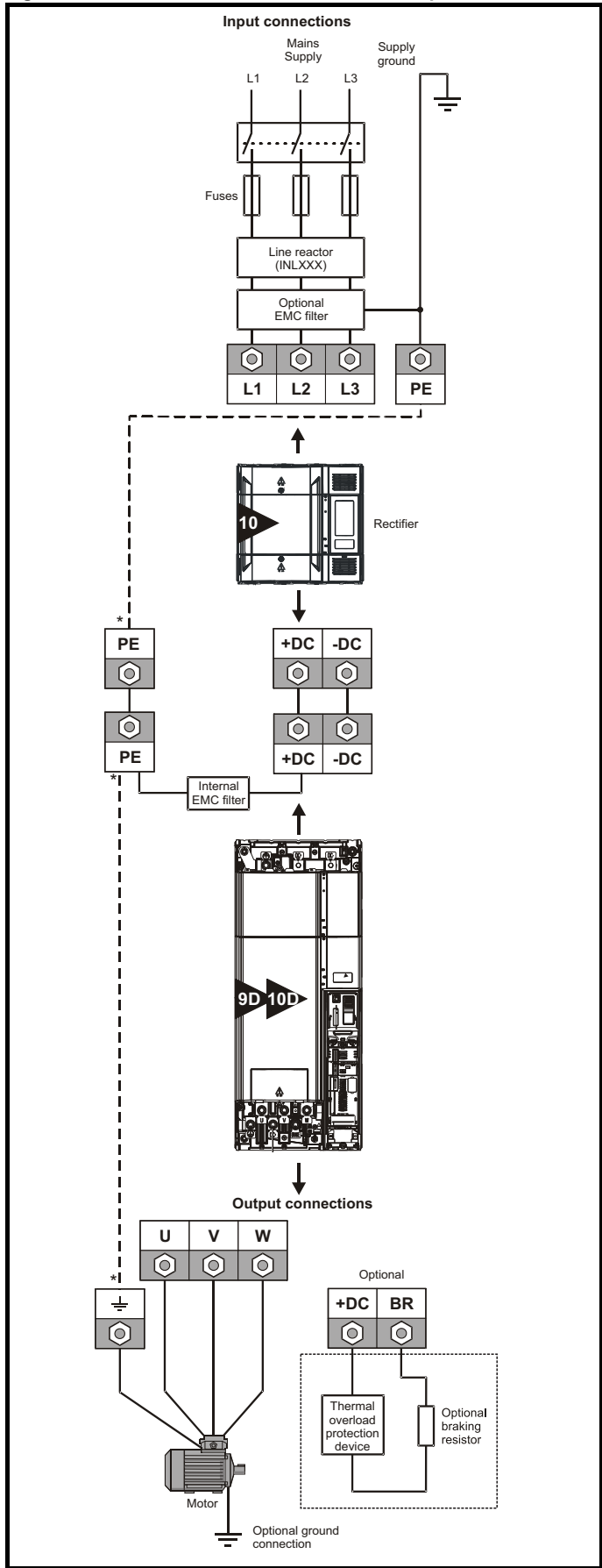
* See section 6.1.3 Ground connections .

Figure 6-2 Unidrive M/Unidrive HS size 9A power connections



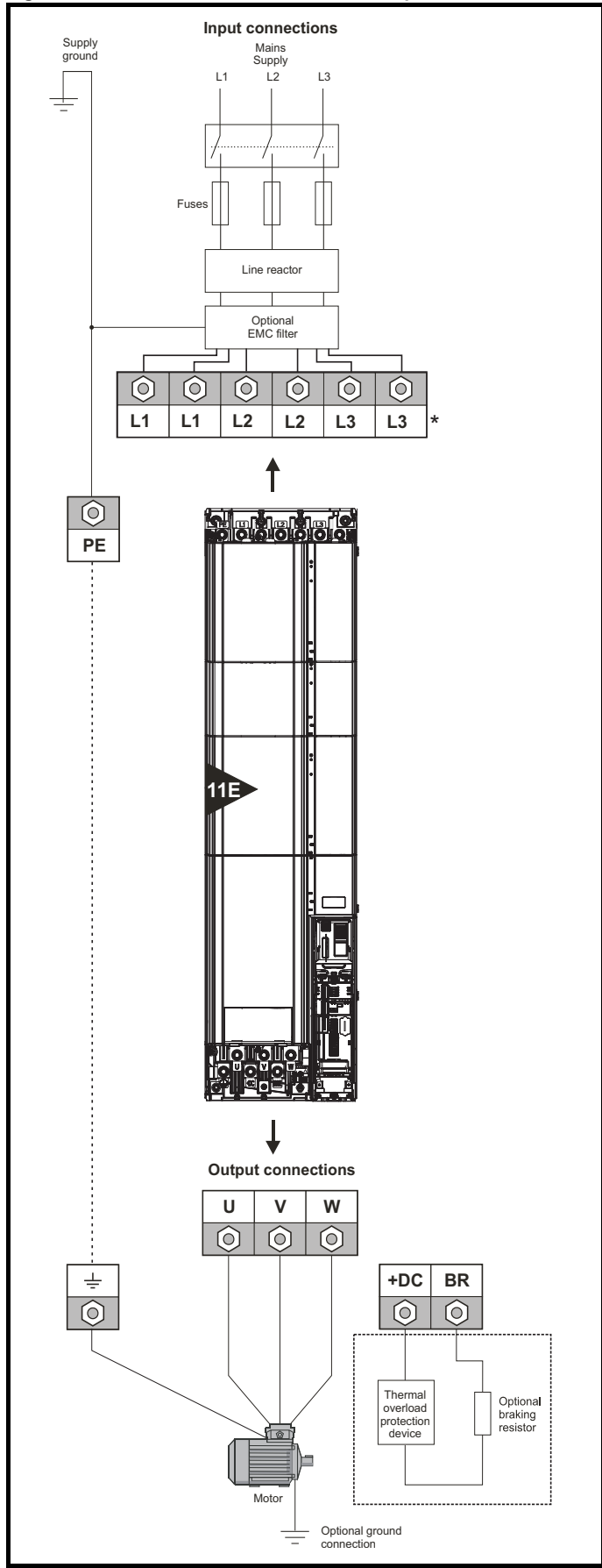
* See section 6.1.3 Ground connections .

Figure 6-3 Unidrive M/Unidrive HS size 9D/10D power connections



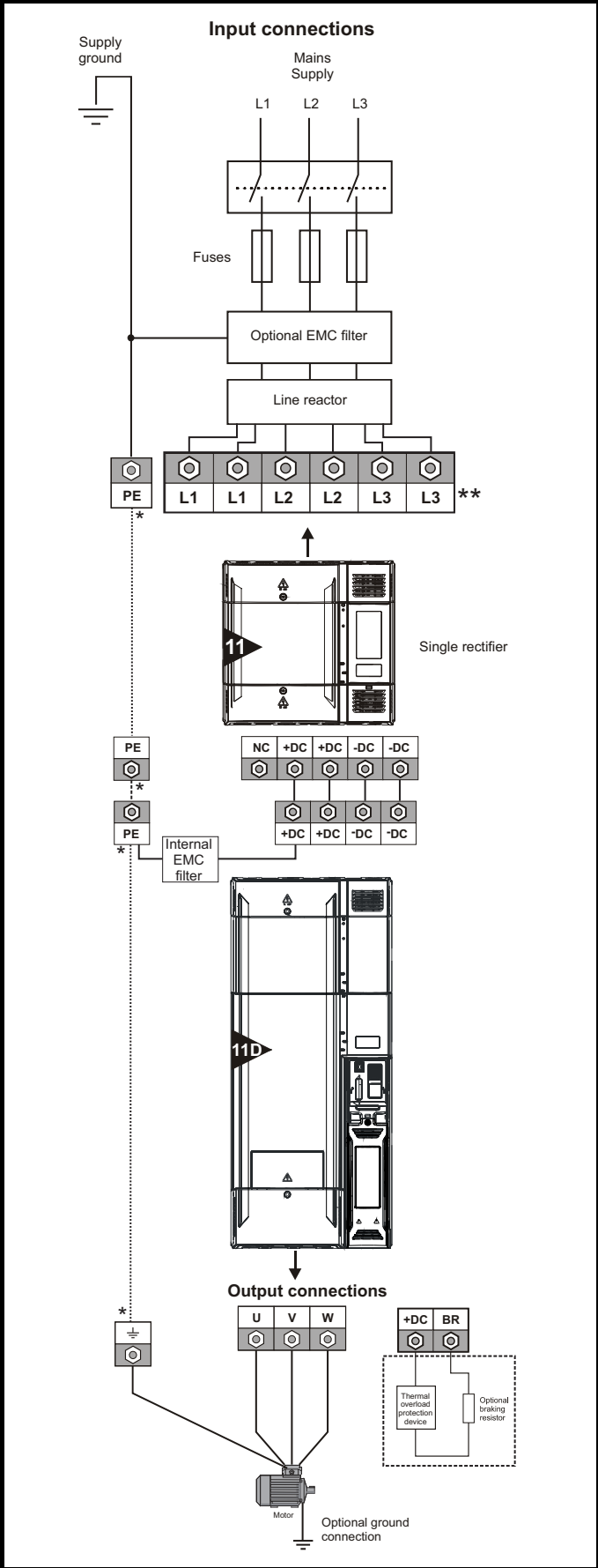
* See section 6.1.3 Ground connections on page 90.

Figure 6-4 Unidrive M/Unidrive HS size 11E power connections



* Connect to either terminal.

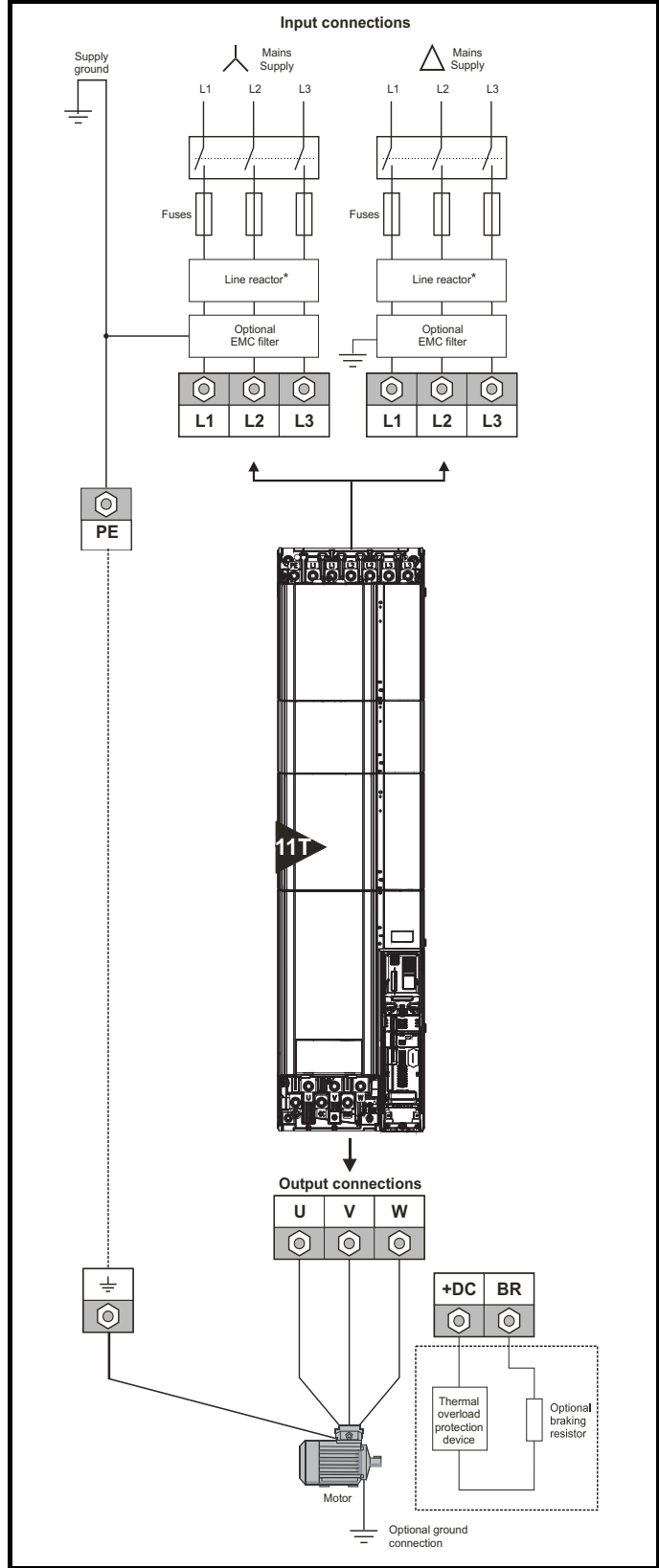
Figure 6-5 Unidrive M/Unidrive HS size 11D power connections



* See section 6.1.3 Ground connections on page 90.

** Connect to either terminal.

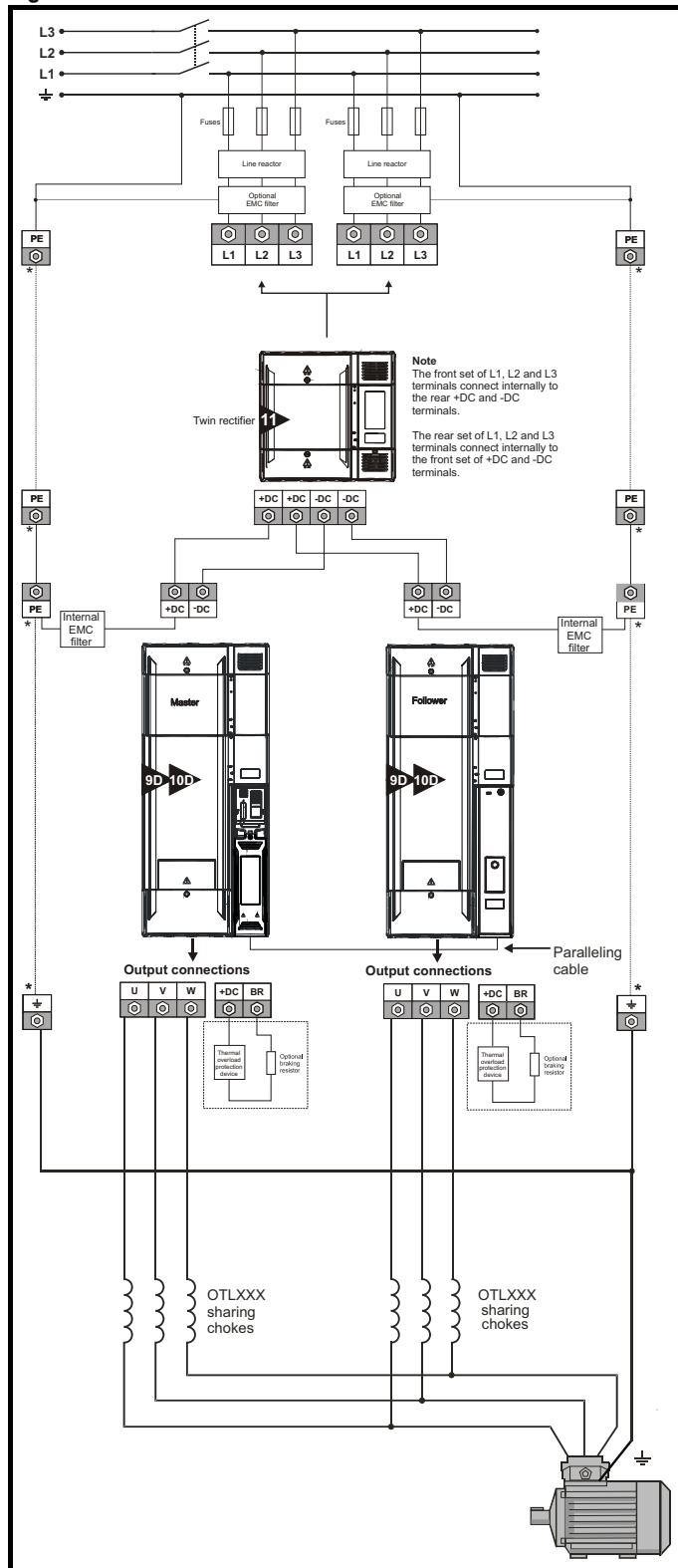
Figure 6-6 Unidrive M/Unidrive HS size 11T power connections



* INL chokes may be omitted if:

1. The transformer is dedicated to the drive i.e. not shared with other equipment.
2. The transformer has reactances from primary to secondary and between secondaries of at least 4 % based on the drive rating. This represents a fully wound transformer with loosely coupled secondaries whose rating (kVA) does not match the drive rating.

Figure 6-7 Twin size 11 rectifier connections

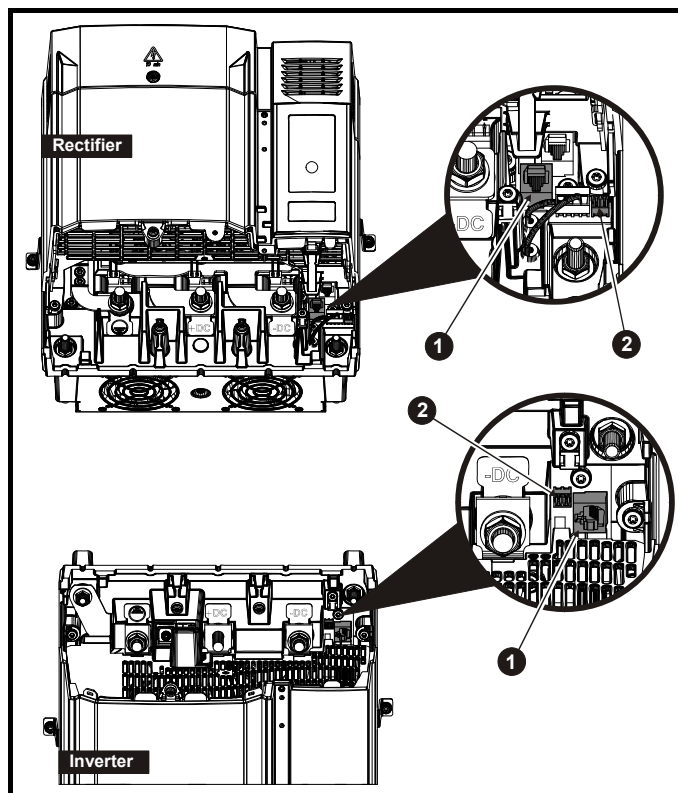


* See section 6.1.3 Ground connections on page 90.

6.1.2 Connecting the RJ45 communication cable and 24 V supply cable between inverter and rectifier

An RJ45 patch cable and a 24 V supply cable must be connected between the rectifier and the inverter. The RJ45 cable carries control signal and start-up command signal from the inverter to the rectifier.

Figure 6-8 Locations of the connections for the connecting cables



1. RJ45 connection.
2. 24 Vdc supply connection.

Inverter

Terminal 67 (24/26 V)

Terminal 66 (0V)

Rectifier

Terminal 64 (0V)


Terminal 65 (24/26 V)

For RS485 connection between rectifier and inverter, connect RJ45 connector into terminal 60 'comms in' on rectifier.

The second RJ45 connector (61 - comms out) is for daisy-chaining inverters.


6.1.3 Ground connections

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

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

WARNING 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.

 **Electrochemical corrosion of earthing terminals**

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

On a Unidrive M/Unidrive HS size 9, 10, 11 and rectifiers, the supply and motor ground connections are made using an M10 bolt at the top (supply) and bottom (motor) of the drive. See Figure 6-9 to Figure 6-14.

The supply ground and motor ground connections to the drive are connected internally by a copper conductor with a cross-sectional area given below:

Frame size	Cable cross sectional area	
	mm ²	
9E/10E	32	
9A/9D/10D	46	
Frame 10 rectifier	32	
11E/D	42	
Frame 11 rectifier (6 pulse)	64	
Frame 11 rectifier (12 pulse)	60	

Figure 6-9 Unidrive M/Unidrive HS size 9A/9E/10E ground connections

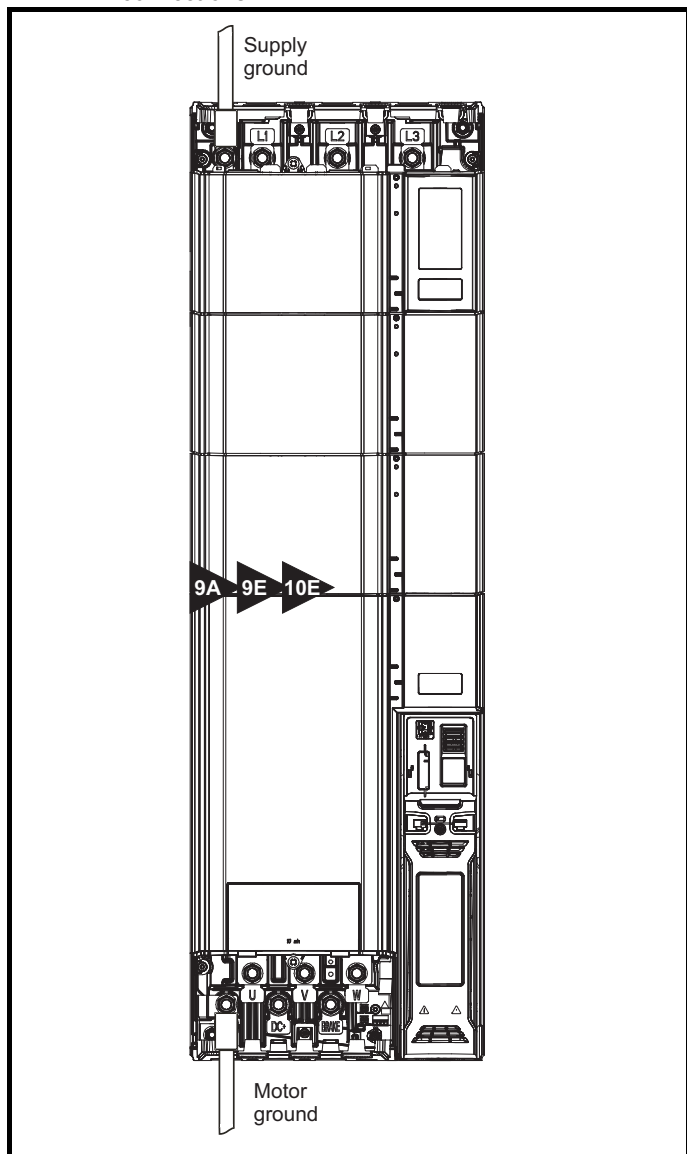


Figure 6-10 Unidrive M/Unidrive HS size 9D/10D ground connections

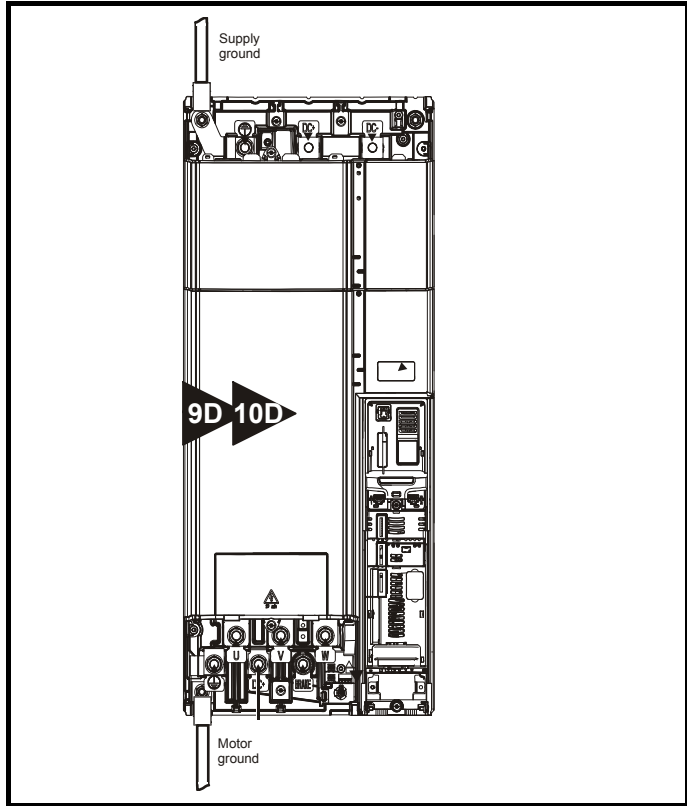


Figure 6-11 Unidrive M/Unidrive HS size 11E/11T ground connections

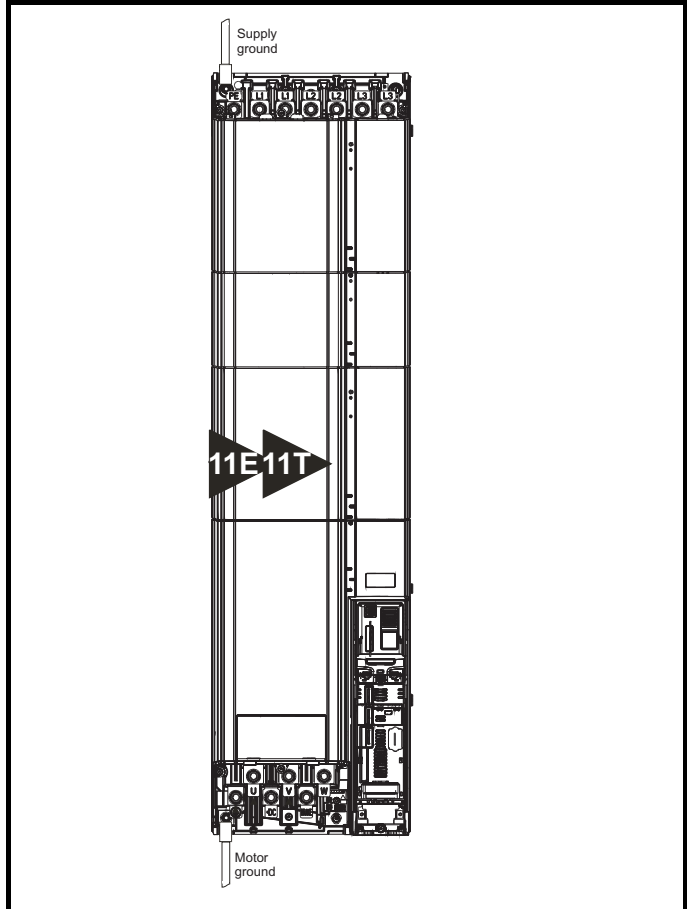


Figure 6-12 Unidrive M/Unidrive HS size 11D ground connections

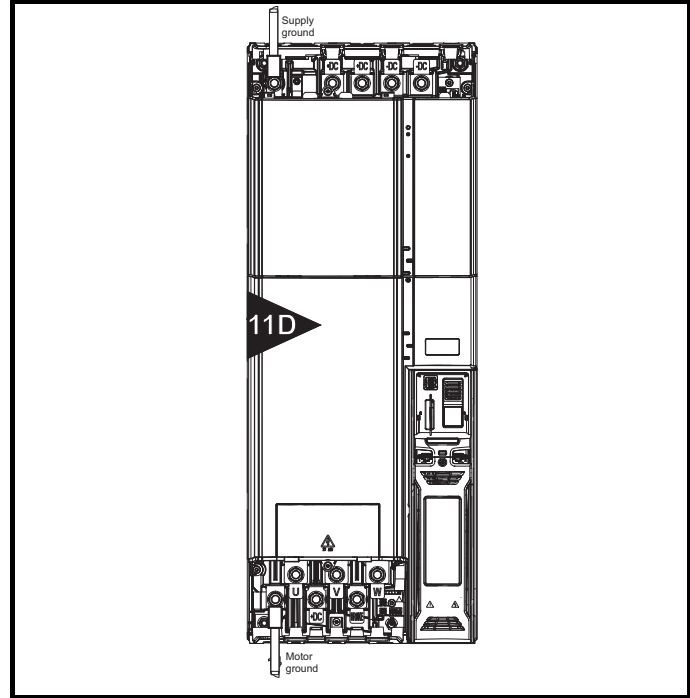


Figure 6-13 Unidrive M/Unidrive HS size 10 rectifier ground connections

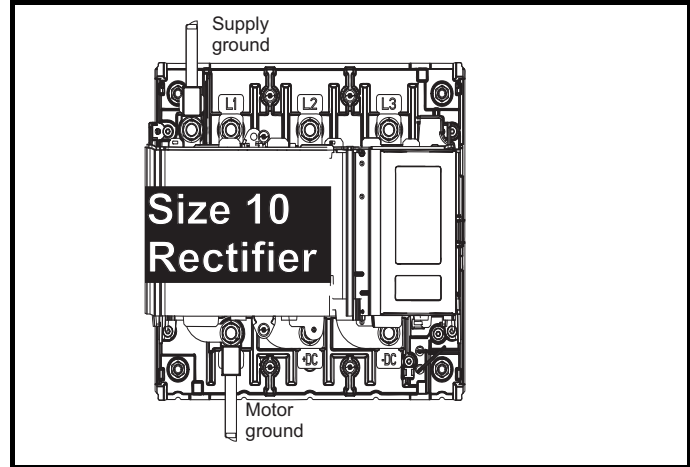
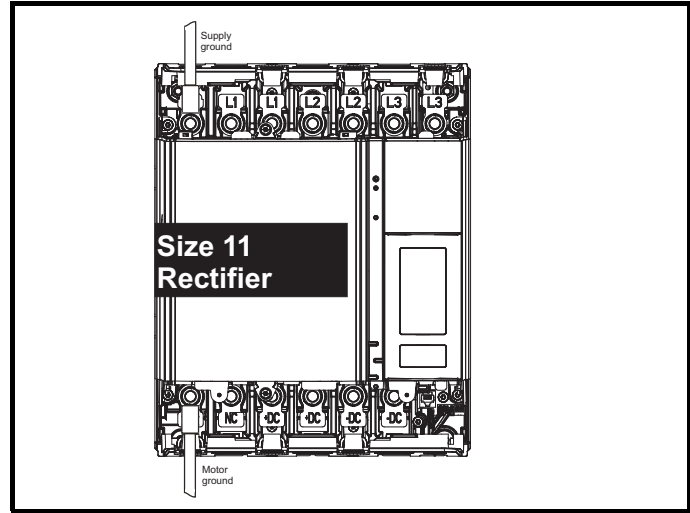


Figure 6-14 Unidrive M/Unidrive HS size 11 rectifier ground connections



6.2 AC supply requirements

Voltage:

200 V drive: 200 V to 240 V ±10%

400 V drive: 380 V to 480 V ±10%

575 V drive: 500V to 575 V ±10%

690 V drive: 500 V to 690 V ±10%

Number of phases: 3

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

Frequency range: 45 to 66 Hz


The maximum supply symmetrical fault current must be limited to 100 kA (also required for UL compliance).

6.2.1 Supply types

Drives rated for supply voltage up to 575 V are suitable for use with any supply type, i.e. TN-S, TN-C-S, TT, IT, with grounding at any potential, i.e. neutral, centre or corner ("grounded-delta").

Grounded delta supplies >575 V are not permitted.

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

 WARNING	<p>Operation with IT (ungrounded) supplies: Special attention is required when using internal or external EMC filters with ungrounded supplies, because in the event of a ground (earth) fault in the motor circuit the drive may not trip and the filter could be over-stressed. In this case, either the filter must not be used (removed) or additional independent motor ground fault protection must be provided, refer to Table 6-1. For details of ground fault protection contact the supplier of the drive.</p>
--	---

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

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

Table 6-1 Behavior of the drive in the event of a ground (earth) fault with an IT supply

Drive size	Internal filter only	External filter (with internal)
(All sizes)	May not trip – precautions required: <ul style="list-style-type: none"> • Remove the EMC filter* • Use ground leakage relay 	May not trip – precautions required: <ul style="list-style-type: none"> • Do not use EMC filter • Use ground leakage relay

* Please note that the internal filter is not removable on size 9E/T, 10E/T and 11E/T.

6.2.2 Input line reactor specifications



A separate input line reactor of at least the value shown in Table 6-2 to Table 6-4 must be used with all modular drives other than size 9A (which has an internal line reactor). Failure to provide sufficient reactance could damage or reduce the service life of the rectifier or inverter.

Figure 6-15 Input line reactor/output sharing choke dimensions

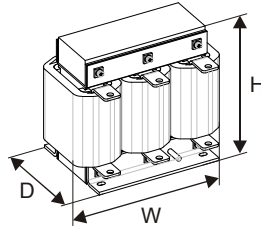


Table 6-2 Model and line reactor part numbers

Inverter model	Reactor model number	CT part number
200 V		
09021760	INL 401	4401-0181
09202190	INL 401	4401-0181
10202830	INL 402	4401-0182
10203000	INL 402	4401-0182
400 V		
09402000	INL 401	4401-0181
09402240	INL 401	4401-0181
10402700	INL 402	4401-0182
10403200	INL 402	4401-0182
11403770	INL 403	4401-0259
	INL 403L*	4401-0274
11404170	INL 403	4401-0259
11404640	INL 403	4401-0259
575 V		
09501040	INL 601	4401-0183
09501310	INL 601	4401-0183
10501520	INL 602	4401-0184
10501900	INL 602	4401-0184
11502000	INL 603	4401-0261
11502540	INL 603	4401-0261
11502850	INL 603	4401-0261
690 V		
09601040	INL 601	4401-0183
09601310	INL 601	4401-0183
10601500	INL 602	4401-0184
10601780	INL 602	4401-0184
11602100	INL 603	4401-0261
11602380	INL 603	4401-0261
11602630	INL 603	4401-0261

* May represent a more economic solution when operating within heavy duty ratings.

Table 6-3 400 V input line reactor ratings

Model	Current A	Inductance μ H	Overall width (W) mm	Overall depth (D) mm	Overall height (H) mm	Weight kg	Max ambient temp (°C)	Min airflow (m/s)	Quantity required	Part No.
INL 401	245	63	240	190	225	32	50	1	1	4401-0181
INL 402	370	44	276	200	225	36	50	1	1	4401-0182
INL 403L	420	30	300	216	264	57	50*	1	1	4401-0274
INL 403	557	30	300	216	264	57	50*	1	1	4401-0259

* With forced cooling (40°C with natural cooling)

Table 6-4 690 V input line reactor ratings

Model	Current A	Inductance μ H	Overall width (W) mm	Overall depth (D) mm	Overall height (H) mm	Weight kg	Max ambient temp (°C)	Min airflow (m/s)	Quantity required	Part No.
INL 601	145	178	240	190	225	33	50	1	1	4401-0183
INL 602	202	133	276	200	225	36	50	1	1	4401-0184
INL 603	331	93	300	216	264	58	50*	0	1	4401-0261

* With forced cooling (40°C with natural cooling)

6.2.3 Supplies requiring additional line reactance

Additional line reactance reduces the risk of damage to the drive resulting from poor phase balance or severe disturbances on the supply network. It also reduces harmonic current emission.

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

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

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

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

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

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

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

Reactor current ratings

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

Continuous current rating:

Not less than the continuous input current rating of the drive

Repetitive peak current rating:

Not less than twice the continuous input current rating of the drive

6.2.4 Additional input inductance calculation

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

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

Where:

I = drive rated input current (A)

L = inductance (H)

f = supply frequency (Hz)

V = voltage between lines

6.3 Output sharing choke specification

In order to achieve the best possible current sharing between paralleled Unidrive M/Unidrive HS modules, sharing chokes must be installed between the motor output connections and the drive's motor connections.

Table 6-5 200 V and 400 V output sharing choke ratings

Model	Current A	Inductance μ H	Width (W) mm	Depth (D) mm	Height (H) mm	Weight kg	Max ambient temp ($^{\circ}$ C)	Min airflow m/s	Drive size	Part No.
OTL401	221	40.1	240	220	210	20	50	1	09402000	4401-0197
OTL402	267	34	242	220	205	20	50	1	09402240	4401-0198
OTL403	313	28.5	242	220	205	25	50	1	10402700	4401-0199
OTL404	378	23.9	242	220	205	20	50	1	10403200	4401-0200
OTL405	472	18.8	300	264	277	43	50	1	11403770	4401-0270
OTL407	632	14.9	300	262	318	55	50	1	11404170 11404640	4401-0267

Table 6-6 575 V and 690 V output sharing choke ratings

Model	Current A	Inductance μ H	Width (W) mm	Depth (D) mm	Height (H) mm	Weight kg	Max ambient temp ($^{\circ}$ C)	Min airflow m/s	Drive size	Part No.
OTL601	135	103.9	242	170	203	20	50	1	09501040 09601040	4401-0201
OTL602	156	81.8	242	170	203	20	50	1	09501310 09601310	4401-0202
OTL603	181	70.1	242	200	203	20	50	1	10501520 10601500	4401-0203
OTL604	207	59.2	242	200	203	20	50	1	10501900 10601780	4401-0204
OTL605	268	48.4	300	242	278	29	50	1	11502000 11602100	4401-0271
OTL607	378	37.8	300	262	266	45	50	1	11502540 11602380 11502850 11602630	4401-0266

6.3.1 Dual output sharing chokes



The OTLX1X parallel output sharing chokes can only be used when two Unidrive M/Unidrive HS Modular drives are paralleled together. For all other combinations the OTLX0X output sharing choke must be used. OTLX1X dual paralleling output sharing chokes should only be used up to the published current ratings outlined in Table 6-7 and Table 6-8 below. If the full rating of the drive is required then single sharing chokes should be used.

Table 6-7 200 V and 400 V dual output sharing choke ratings

Model	Current A	Inductance μ H	Width (W) mm	Depth (D) mm	Height (H) mm	Weight kg	Max ambient temp $^{\circ}$ C	Min airflow m/s	Part No.
OTL411	390	42.8	300	150	160	8	50	1	4401-0188
OTL412	470	36.7	300	150	160	8	50	1	4401-0189
OTL413	551	31.1	300	150	160	8	50	1	4401-0192
OTL414	665	26.6	300	150	160	9	50	1	4401-0186

Table 6-8 575 V and 690 V dual output sharing choke ratings

Model	Current A	Inductance μ H	Width (W) mm	Depth (D) mm	Height (H) mm	Weight kg	Max ambient temp $^{\circ}$ C	Min airflow m/s	Part No.
OTL611	238	110.4	300	150	160	8	50	1	4401-0193
OTL612	274	88.4	300	150	160	8	50	1	4401-0194
OTL613	319	76.7	300	150	160	8	50	1	4401-0195
OTL614	365	65.7	300	150	160	8	50	1	4401-0196

6.3.2 Cooling requirements for higher output frequencies

Single OTL output sharing chokes - OTLX0X

Up to output frequencies of 300 Hz, 1 m/s airflow provides adequate cooling.

Above 300 Hz, the following equation must be used to calculate the required airflow:

$$S = (f^{0.75}/72)$$

Where:

S is the airflow in metres per second

f is the drive output frequency in Hz

Example:

Output frequency is 450 Hz

$$S = (450^{0.75}/72)$$

$$= 1.4 \text{ m/s}$$

Dual OTL output sharing chokes - OTLX1X

The OTLX1X dual output sharing choke core does not see the change in drive output frequency as this choke is a current cancelling choke. Only the drives switching frequency has an affect on the core loss.

Therefore motor frequency is not an issue until higher frequencies cause high copper losses due to skin effect.

Therefore with the dual OTL chokes, only 1 m/s airflow is required.

Maximum output frequency for OTL chokes

The maximum allowable output frequency for OTL output sharing chokes, singles or duals, should be limited to 1000 Hz.

6.4 Supplying the Unidrive M/Unidrive HS size 9A, 9D, 10D and 11D drives with DC / DC bus paralleling

The drive may be supplied with DC instead of 3 phase AC.

The connecting of the DC bus between several drives is typically used to:

1. Return energy from a drive which is being overhauled by the load to a second motoring drive.
2. Allow the use of one braking resistor to dissipate regenerative energy from several drives.

There are limitations to the combinations of drives which can be used in this configuration.

For further information, contact the supplier of the drive.

NOTE

It is not possible to supply Unidrive M/Unidrive HS size 9E/T, 10E/T and 11E/T drives with DC due to the lack of an accessible negative DC terminal.

6.5 Heatsink fan supply

When operating on normal mains supply the heatsink fan on all drive sizes is supplied internally by the drive. When operating in low voltage mode it is necessary to connect an external 24V supply to terminal 61 and 62 if heatsink fan operation is required. Please see section 6.7 *Low voltage operation* on page 98 for more details.

6.6 24 Vdc supply

The 24 Vdc supply connected to control terminals 1 & 2* provides the following functions:

- It can be used to supplement the drive's own internal 24 V supply when multiple option modules are being used and the current drawn by these module is greater than the drive can supply.
- It can be used as a back-up power supply to keep the control circuits of the drive powered up when the line power supply is removed. This allows any fieldbus modules, application modules, encoders or serial communications to continue to operate.
- It can be used to commission the drive when the line power supply is not available, as the display operates correctly. However, the drive will be in the Under voltage state unless either line power supply or low voltage DC operation is enabled, therefore diagnostics may not be possible. (Power down save parameters are not saved when using the 24 V back-up power supply input).
- If the DC bus voltage is too low to run the main SMPS in the drive, then the 24 V supply can be used to supply all the low voltage power requirements of the drive. *Low Under Voltage Threshold Select* (06.067) must also be enabled for this to happen.

NOTE

On size 9 and larger, the power 24 Vdc supply (terminals 51, 52) must be connected to enable the 24 V dc supply to be used as a backup supply, when the line power supply is removed. If the power 24 Vdc supply is not connected none of the above mentioned functions can be used, "Waiting For Power System" will be displayed on the keypad and no drive operations are possible. The location of the power 24 Vdc can be identified from Figure 6-16 *Location of the 24 Vdc power supply connection on size 9 to 11* on page 97

Table 6-9 24 Vdc Supply connections

Function	Sizes 9-11
Supplement the drive's internal supply	Terminal 1, 2*
Back-up supply for the control circuit	Terminal 1, 2* 51, 52

* Terminal 9 on Unidrive M702 and HS72

The working voltage range of the control 24 V power supply is as follows:

1	0V common
2	+24 Vdc *
Nominal operating voltage	24.0 Vdc
Minimum continuous operating voltage	19.2 V
Maximum continuous operating voltage	28.0 V
Minimum start up voltage	21.6 V
Maximum power supply requirement at 24 V	40 W
Recommended fuse	3 A, 50 Vdc

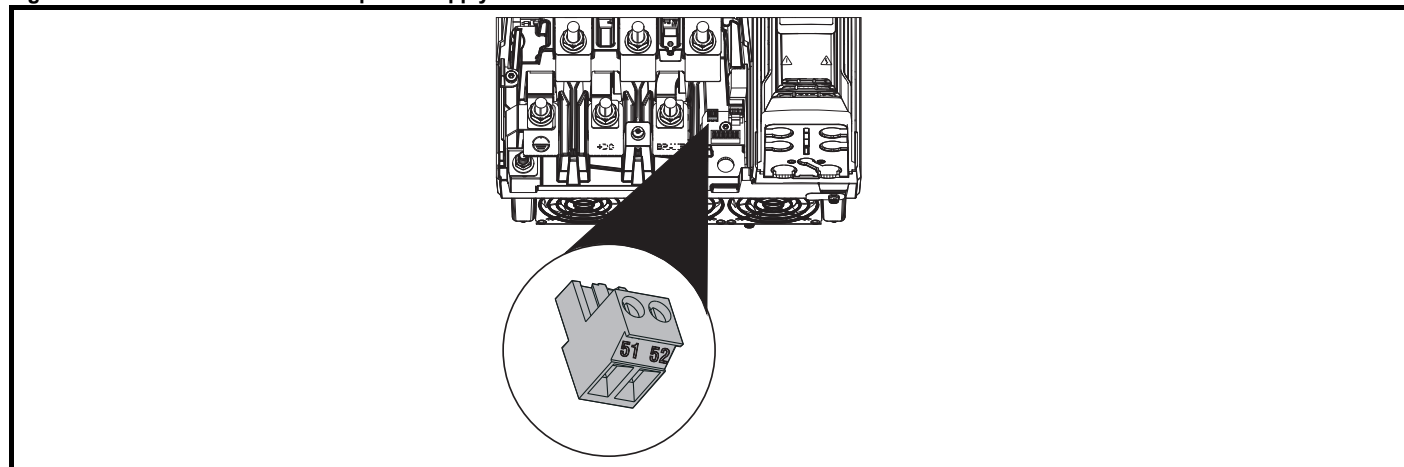
* Terminal 9 on Unidrive M702 and HS72

Minimum and maximum voltage values include ripple and noise. Ripple and noise values must not exceed 5 %.

The working range of the 24 V power supply is as follows:

51	0V common
52	+24 Vdc
Size 9 to 11	
Nominal operating voltage	24.0 Vdc
Minimum continuous operating voltage	19.2 Vdc
Maximum continuous operating voltage	30 Vdc (IEC), 26 Vdc (UL)
Minimum startup voltage	21.6 Vdc
Maximum power supply requirement	60 W
Recommended fuse	4 A @ 50 Vdc

Figure 6-16 Location of the 24 Vdc power supply connection on size 9 to 11



6.7 Low voltage operation

With the addition of a 24 Vdc power supply to supply the control circuits, the drive is able to operate from a low voltage DC supply with a range from 24 Vdc to the maximum DC volts. It is possible for the drive to go from operating on a normal line power supply voltage to operating on a much lower supply voltage without interruption.

Going from low voltage operation to normal mains operation requires the inrush current to be controlled. This may be provided externally. If not, the drive supply can be interrupted to utilise the normal soft starting method in the drive.

To fully exploit the new low voltage mode of operation, the under voltage level is now user programmable. For application data, contact the supplier of the drive.

The working voltage range of the low voltage DC power supply is as follows:

Size 9 to 11

Minimum continuous operating voltage:	26 V
Minimum start up voltage:	32 V
Maximum over voltage trip threshold:	230 V drives: 415 V
	400 V drives: 830 V
	575 V drives: 990 V
	690 V drives: 1190 V

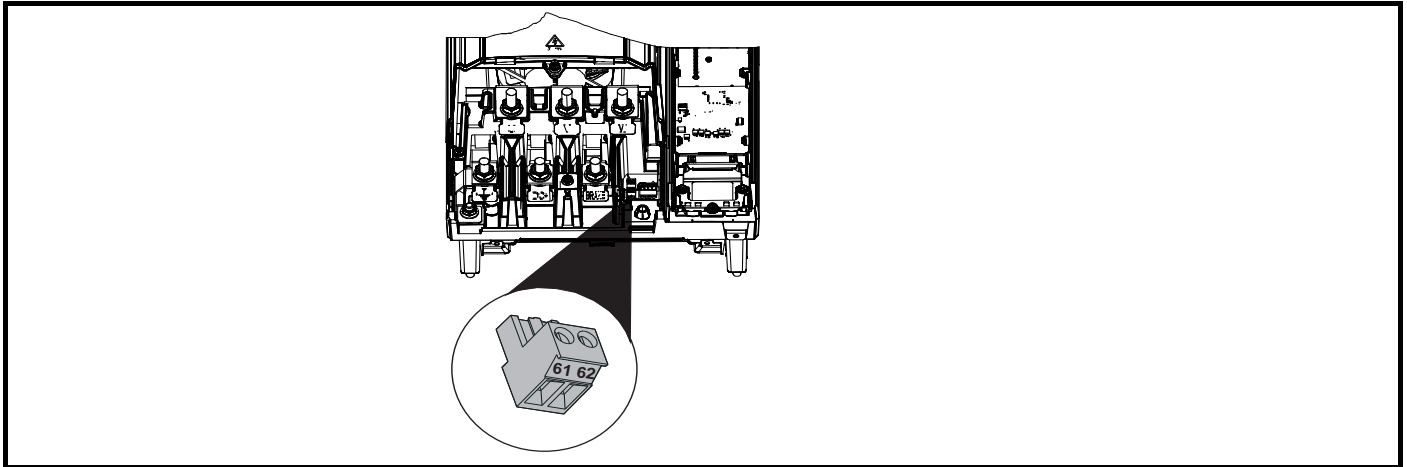
NOTE

It is not possible to supply Unidrive M/Unidrive HS size 9E/T, 10E/T and 11E/T drives with DC due to the lack of an accessible negative DC terminal.

In low voltage mode only, with frame size 9 to 11, a 24 V supply needs to be provided for the heatsink fan. The fan supply should be connected to terminal 61 and 62.

61	0V common
62	+24 Vdc heatsink fan supply
Size 9 to 11	
Nominal operating voltage	24.0 Vdc
Minimum continuous operating voltage	23.5 Vdc
Maximum continuous operating voltage	27 Vdc
Current consumption	Size 9 to 11 (all): 6A
Recommended power supply	24 V, 7 A
Recommended fuse	8A fast blow

Figure 6-17 Location of the heatsink fan supply connector on size 9 to 11



6.8 Status LED

6.8.1 Master status LED

- 1 flash / second: Trip condition
- Continually ON: Healthy

6.8.2 Rectifier status LED

- Continually ON: indicates that the rectifier has not been initialized by the inverter, i.e. there is no communication between them.
- A flashing LED: indicates a rectifier fault.

6.8.3 Follower status LED

- 10 Flashes / second: module not recognized by the master.
- 1 Flash / sec: Trip condition
- Continually OFF: missing power supply
- Continually ON: module Healthy

6.9 Ratings

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

Typical input current

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

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

Maximum continuous input current

The values of maximum continuous input current are given to aid the selection of cables and fuses. These values are stated for the worst case condition with the unusual combination of stiff supply with bad balance. The value stated for the maximum continuous input current would only be seen in one of the input phases. The current in the other two phases would be significantly lower.

The values of maximum input current are stated for a supply with a 2 % negative phase-sequence imbalance and rated at the supply fault current given in Table 6-10.

Table 6-10 Supply fault current used to calculate maximum input currents

Model	Symmetrical fault level (kA)
All sizes	100



Fuses

The AC supply to the drive must be installed with suitable protection against overload and short-circuits. Table 6-11 shows recommended fuse ratings. Failure to observe this requirement will cause risk of fire.

WARNING

Table 6-11 Unidrive M / Unidrive HS size 10 and 11 rectifier current and fuse ratings

Model	Typical input current	Maximum continuous input current	Maximum overload input current	Fuse rating					
				IEC			UL/USA		
				Nominal	Maximum	Class	Nominal	Maximum	Class
A	A	A	A	A		A	A		
10204100	333	361	494	450	450	gR	450	450	HSJ
10404520	370	396	523	450	450		450	450	
10502430	202	225	313	250	250		250	250	
10602480	202	225	313	250	250		250	250	
11406840	502	539	752	630	630	gR	600	600	HSJ
11503840	313	338	473	400	400		400	400	
11604060	298	329	465	400	400		400	400	
1142X400*	2 x 326	2 x 358	2 x 516	400	400		400	400	
1162X380*	2 x 308	2 x 339	2 x 488	400	400		400	400	

Table 6-12 Cable ratings for Unidrive M / Unidrive HS size 10 and 11 rectifiers

Model	Cable size (IEC)						Cable size (UL)			
	mm ²						AWG or kcmil			
	Input			Output			Input		Output	
	Nominal	Maximum	Installation method	Nominal	Maximum	Installation method	Nominal	Maximum	Nominal	Maximum
10204100	2 x 150	2 x 185	C	2 x 120	2 x 150	C	2 x 300	2 x 500	2 x 400	2 x 500
10404520	2 x 150	2 x 185	C	2 x 150	2 x 150	C	2 x 350	2 x 500	2 x 500	2 x 500
10502430	2 x 95	2 x 185	B2	2 x 95	2 x 150	B2	2 x 3/0	2 x 500	2 x 3/0	2 x 500
10602480	2 x 95	2 x 185	B2	2 x 95	2 x 150	B2	2 x 3/0	2 x 500	2 x 3/0	2 x 500
11406840	4 x 120	4 x 120	C	4 x 150	4 x 150	C	2 x 250	2 x 250	2 x 300	2 x 300
11503840	2 x 120	2 x 120	C	2 x 120	2 x 120	C	2 x 250			
11604060	2 x 120	2 x 120	C	2 x 120	2 x 120	C	2 x 300	2 x 300	2 x 400	2 x 400
1142X400*	2 x 2 x 120	2 x 2 x 120	C	2 x 2 x 120	2 x 2 x 120	C	2 x 2 x 300			
1162X380*	2 x 2 x 120	2 x 2 x 120	C	2 x 2 x 120	2 x 2 x 120	C	2 x 2 x 300			

* Twin rectifier

Table 6-13 AC input current and fuse ratings for Unidrive M / Unidrive HS size 9, 10 and 11 inverters

Model	Typical input current A	Maximum continuous input current A	Maximum overload input current A	Fuse rating					
				IEC			UL / USA		
				Nominal A	Maximum A	Class	Nominal A	Maximum A	Class
09201760	172	205	270	250	250	gR	250	250	HSJ
09202190	228	260	319	315	315		300	300	
10202830	277	305	421	400	400	gR	400	400	HSJ
10203000	333	361	494	450	450		450	450	
09402000	211	232	306	315	315	gR	300	300	HSJ
09402240	245	267	359	315	315	gR	350	350	HSJ
10402700	306	332	445	400	400	gR	400	400	HSJ
10403200	370	397	523	450	450		450	450	
11403770	424	449	579	500	500	gR	600	600	HSJ
11404170	455	492	613						
11404640	502	539	752	630	630				
09501040	145	166	190	150	150	gR	150	150	HSJ
09501310	145	166	221	200	200		175	175	
10501520	177	197	266	250	250	gR	250	250	HSJ
10501900	199	218	310						
11502000	240	265	327	400	400	gR	400	400	HSJ
11502540	285	310	395						
11502850	313	338	473						
09601040	124	149	194	150	150	gR	150	150	HSJ
09601310	145	171	226	200	200		200	200	
10601500	180	202	268	225	225	gR	250	250	HSJ
10601780	202	225	313	250	250	gR	250	250	
11602100	225	256	379	400	400	gR	400	400	HSJ
11602380	271	302	425						
11602630	298	329	465						

Table 6-14 Cable ratings for Unidrive M / Unidrive HS size 9, 10 and 11 inverters

Model	Cable size (IEC)						Cable size (UL)			
	mm ²						AWG or kcmil			
	Input			Output			Input		Output	
	Nominal	Maximum	Installation method	Nominal	Maximum	Installation method	Nominal	Maximum	Nominal	Maximum
09201760	2 x 70	2 x 185	B1	2 x 95	2 x 150	B2	2 x 2/0	2 x 500	2 x 2/0	2 x 350
09202190	2 x 95	2 x 185	B1	2 x 120	2 x 150	B2	2 x 4/0	2 x 500	2 x 4/0	2 x 350
10202830	2 x 120	2 x 185	B1	2 x 120	2 x 150	C	2 x 250	2 x 500	2 x 250	2 x 350
10203000	2 x 150	2 x 185	C	2 x 120	2 x 150	C	2 x 300	2 x 500	2 x 300	2 x 350
09402000	2 x 70	2 x 185	B1	2 x 95	2 x 150	B2	2 x 3/0	2 x 500	2 x 2/0	2 x 350
09402240	2 x 95	2 x 185	B1	2 x 120	2 x 150	B2	2 x 4/0	2 x 500	2 x 4/0	2 x 350
10402700	2 x 120	2 x 185	C	2 x 120	2 x 150	C	2 x 300	2 x 500	2 x 250	2 x 350
10403200	2 x 150	2 x 185	C	2 x 150	2 x 150	C	2 x 350	2 x 500	2 x 300	2 x 350
11403770	4 x 95	4 x 95	C	2 x 185	2 x 185	C	4 x 3/0	4 x 3/0	2 x 400	2 x 400
11404170	4 x 95	4 x 95	C	2 x 240	2 x 240	C	4 x 4/0	4 x 4/0	2 x 400	2 x 400
11404640	4 x 95	4 x 95	C	2 x 240	2 x 240	C	4 x 4/0	4 x 4/0	2 x 400	2 x 400
09501040	2 x 70	2 x 185	B2	2 x 35	2 x 150	B2	2 x 1	2 x 500	2 x 3	2 x 350
09501310	2 x 70	2 x 185	B2	2 x 50	2 x 150	B2	2 x 1	2 x 500	2 x 1	2 x 350
10501520	2 x 70	2 x 185	B2	2 x 70	2 x 150	B2	2 x 2/0	2 x 500	2 x 2/0	2 x 350
10501900	2 x 95	2 x 185	B2	2 x 70	2 x 150	B2	2 x 2/0	2 x 500	2 x 2/0	2 x 350
11502000	2 x 70	2 x 70	C	2 x 70	2 x 70	C	2 x 3/0			
11502540	2 x 95	2 x 95	C	2 x 95	2 x 95	C	2 x 4/0			
11502850	2 x 120	2 x 120	C	2 x 120	2 x 120	C	2 x 250			
09601040	2 x 50	2 x 185	B2	2 x 35	2 x 150	B2	2 x 1	2 x 500	2 x 3	2 x 350
09601310	2 x 70	2 x 185	B2	2 x 50	2 x 150	B2	2 x 1/0	2 x 500	2 x 1	2 x 350
10601500	2 x 70	2 x 185	B2	2 x 70	2 x 150	B2	2 x 2/0	2 x 500	2 x 1/0	2 x 350
10601780	2 x 95	2 x 185	B2	2 x 70	2 x 150	B2	2 x 3/0	2 x 500	2 x 2/0	2 x 350
11602100	2 x 70	2 x 70	C	2 x 70	2 x 70	C	2 x 3/0			
11602380	2 x 95	2 x 95	C	2 x 95	2 x 95	C	2 x 4/0			
11602630	2 x 95	2 x 95	C	2 x 95	2 x 95	C	2 x 250			

Table 6-15 DC fuse and cable ratings for Unidrive M / HS size 9, 10 and 11 inverters

Model	Maximum continuous dc input current [Arms]	Maximum overload dc input current [Arms]	DC fuse IEC class aR [Arms]	Max fuse clearing i^2t at operating condition [A ² s]	DC voltage rating	Cable Size DC Input		
						mm ²	AWG or Kcmil	IEC installation Method
09201760	220	300	315	330000	415	2 x 70	2 x 2/0	B1
09202190	287	359	350		415	2 x 95	2 x 4/0	B1
10202830	345	488	450		415	2 x 120	2 x 250	B1
10203000	413	578	500		415	2 x 150	2 x 300	C
09402000	261	351	315	330000	830	2 x 70	2 x 3/0	B1
09402240	303	418	400		830	2 x 95	2 x 4/0	B1
10402700	378	517	450		830	2 x 120	2 x 300	C
10403200	456	614	500		830	2 x 150	2 x 350	C
11403770	525	711	630	594000	830	4 x 95	4 x 250	C
11404170	564	753	700		830	4 x 95	4 x 250	C
11404640	621	925	800		830	4 x 120	4 x 300	C
09501040	181	212	250		137000	990	2 x 70	2 x 1
09501310	181	248	250	990		2 x 70	2 x 1	B2
10501520	220	306	315	990		2 x 70	2 x 2/0	B2
10501900	246	360	315	990		2 x 95	2 x 2/0	B2
11502000	299	402	350	330000	990	2 x 70	2 x 4/0	C
11502540	353	485	450		990	2 x 95	2 x 250	C
11502850	387	583	500		990	2 x 120	2 x 300	C
09601040	158	211	200		137000	1190	2 x 50	2 x 1
09601310	183	252	250	1190		2 x 70	2 x 1/0	B2
10601500	223	303	315	1190		2 x 70	2 x 2/0	B2
10601780	252	359	315	1190		2 x 95	2 x 3/0	B2
11602100	282	466	400	330000	1190	2 x 70	2 x 4/0	C
11602380	332	522	450		1190	2 x 95	2 x 250	C
11602630	371	573	500		1190	2 x 120	2 x 300	C

NOTE

Please refer to section 4.1.1 *DC fusing* on page 37 for further information about DC fusing.

NOTE

The cable sizes noted in Table 6-12 to Table 6-15 are typical cable sizes based on UL508C and IEC60364-5-52:2001. Maximum cable sizes are 2 x 240 mm² or 2 x 400 kcmil per pole. The user will have to decide what size of cable to use in any given application based on the local wiring regulations. Use of high temperature cables that are thinner than those stated in the typical cable chart maybe possible, contact the supplier of the drive for advice.

Installation method (ref:IEC60364-5-52:2001)

- B1 - Separate cables in conduit
- B2 - Multicore cable in conduit
- C - Multicore cable in free air

NOTE

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

Cable size may be reduced if a different installation method is used, or if the ambient temperature is lower.

NOTE

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

NOTE

The recommended output cable sizes assume that the motor maximum current matches that of the drive. Where a motor of reduced rating is used the cable rating may be chosen to match that of the motor. To ensure that the motor and cable are protected against over-load, the drive must be programmed with the correct motor rated current.

A fuse or other protection must be included in all live connections to the AC supply.

Fuse types

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

IEC Fuse types

- IEC class gG - Full range breaking capability in general application. Slow acting.
- IEC class gR - Dual rated: semiconductor protection (ultra-fast acting) and cable protection.
- IEC class aR - Semiconductor Protection, fast acting. Provides no protection from slow, small overloads, so cable must be protected by using a gG fuse or circuit breaker.
- HRC- **H**igh **R**upturing **C**apacity – Denotes the ability of the fuse link to interrupt extremely high fault currents.

North American Fuse Types

- UL class J - Full range breaking capability in general application. Slow acting. Up to 600 V only.
- Ferraz HSJ -High speed class J fuses. Dual rated: semiconductor protection (ultra-fast acting) and cable protection. Up to 600 V only and only from Ferraz.

6.9.1 Main AC supply contactor

The recommended AC supply contactor type is AC1.

6.10 Output circuit and motor protection

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

The drive provides overload protection for the motor and its cable. For this to be effective, Pr **00.046** *Motor rated current* must be set to suit the motor.



Pr **00.046** Motor rated current must be set correctly to avoid a risk of fire in the event of motor overload.

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

6.10.1 Cable types and lengths

Since capacitance in the motor cable causes loading on the output of the drive, ensure the cable length does not exceed the values given in Table 6-16 to Table 6-19.

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

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

Table 6-16 Maximum motor cable lengths (200 V drives)

200 V Nominal AC supply voltage							
Model	Maximum permissible motor cable length for each of the following switching frequencies						
	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
09201760	250 m (820 ft)	187 m (614 ft)	125 m (410 ft)	93 m (305 ft)	62 m (203 ft)	46 m (151 ft)	
09202190							
10202830	250 m (820 ft)	187 m (614 ft)	125 m (410 ft)	93 m (305 ft)	62 m (203 ft)	46 m (151 ft)	
10203000							

Table 6-17 Maximum motor cable lengths (400 V drives)

400 V Nominal AC supply voltage							
Model	Maximum permissible motor cable length for each of the following switching frequencies						
	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
09402000	250 m (820 ft)	187 m (614 ft)	125 m (410 ft)	93 m (305 ft)	62 m (203 ft)	46 m (151 ft)	
09402240							
10402700	250 m (820 ft)	187 m (614 ft)	125 m (410 ft)	93 m (305 ft)	62 m (203 ft)	46 m (151 ft)	
10403200							
11403770	250 m (820 ft)	187 m (614 ft)	125 m (410 ft)	93 m (305 ft)			
11404170							
11404640							

Table 6-18 Maximum motor cable lengths (575 V drives)

575 V Nominal AC supply voltage							
Model	Maximum permissible motor cable length for each of the following switching frequencies						
	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
09501040	250 m (820 ft)	187 m (614 ft)	125 m (410 ft)	93 m (305 ft)	62 m (203 ft)	46 m (151 ft)	
09501310							
10501500	250 m (820 ft)	187 m (614 ft)	125 m (410 ft)	93 m (305 ft)	62 m (203 ft)	46 m (151 ft)	
10501780							
11502000	250 m (820 ft)	187 m (614 ft)					
11502540							
11502850							

Table 6-19 Maximum motor cable lengths (690 V drives)

690 V Nominal AC supply voltage							
Model	Maximum permissible motor cable length for each of the following switching frequencies						
	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
09601040	250 m (820 ft)	187 m (614 ft)	125 m (410 ft)	93 m (305 ft)	62 m (203 ft)	46 m (151 ft)	
09601310							
10601500	250 m (820 ft)	187 m (614 ft)	125 m (410 ft)	93 m (305 ft)	62 m (203 ft)	46 m (151 ft)	
10601780							
11602100	250 m (820 ft)	187 m (614 ft)					
11602380							
11602630							

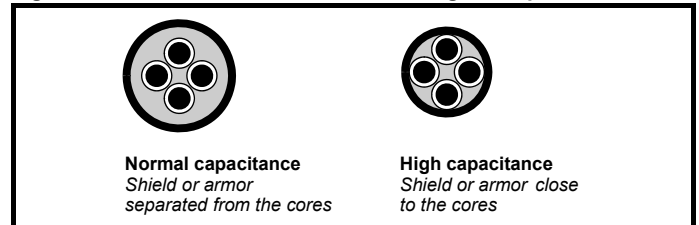
- Cable lengths in excess of the specified values may be used only when special techniques are adopted; refer to the supplier of the drive.
- The default switching frequency is 3 kHz for open-loop and closed-loop vector and 6 kHz for servo.

6.10.2 High-capacitance cables

The maximum cable length is reduced from that shown in Table 6-16 to Table 6-19 if high capacitance motor cables are used.

Most cables have an insulating jacket between the cores and the armor or shield; these cables have a low capacitance and are recommended. Cables that do not have an insulating jacket tend to have high capacitance; if a cable of this type is used, the maximum cable length is half that quoted in the tables. (Figure 6-18 shows how to identify the two types.)

Figure 6-18 Cable construction influencing the capacitance



The cable used for Table 6-16 to Table 6-19 is shielded and contains four cores. Typical capacitance for this type of cable is 130 pF/m (i.e. from one core to all others and the shield connected together).

6.10.3 Motor winding voltage

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

For normal operation with AC supplies up to 500 Vac and a standard motor with a good quality insulation system, there is no need for any special precautions. In case of doubt the motor supplier should be consulted.

Special precautions are recommended under the following conditions, but only if the motor cable length exceeds 10 m:

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

For multiple motors, the precautions given in *section 6.10.4 Multiple motors* should be followed.

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

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

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

6.10.4 Multiple motors

Open-loop only

If the drive is to control more than one motor, one of the fixed V/F modes should be selected (Pr **05.014** = Fd or SrE). Make the motor connections as shown in Figure 6-19 and Figure 6-20. The maximum cable lengths in Table 6-16 and Table 6-19 apply to the sum of the total cable lengths from the drive to each motor.

It is recommended that each motor is connected through a protection relay since the drive cannot protect each motor individually. For A connection, a sinusoidal filter or an output inductor must be connected as shown in Figure 6-20, even when the cable lengths are less than the maximum permissible. For high DC voltages or when supplied by a regen system, a sinusoidal filter is recommended. For details of filter or inductor sizes refer to the supplier of the drive.

Figure 6-19 Preferred chain connection for multiple motors

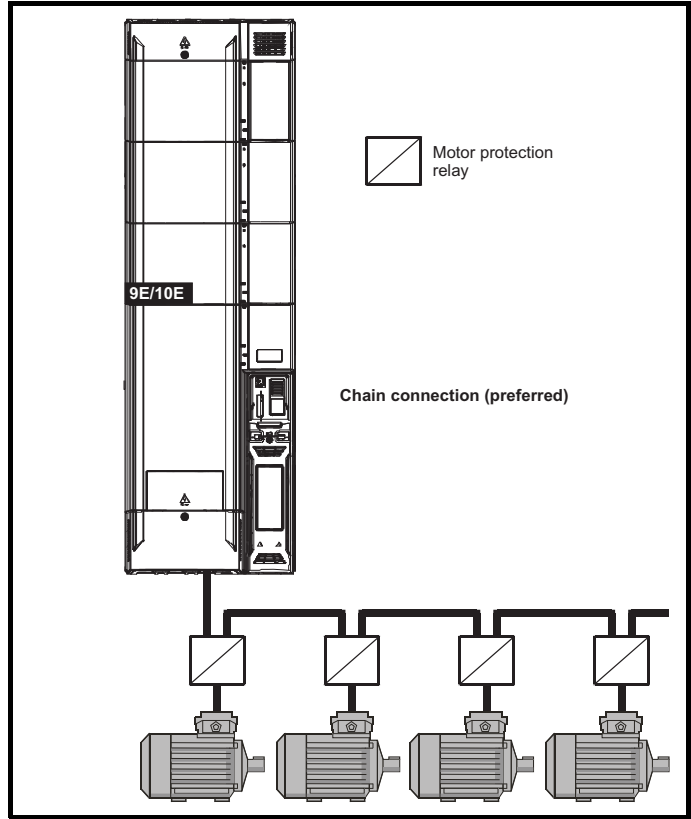
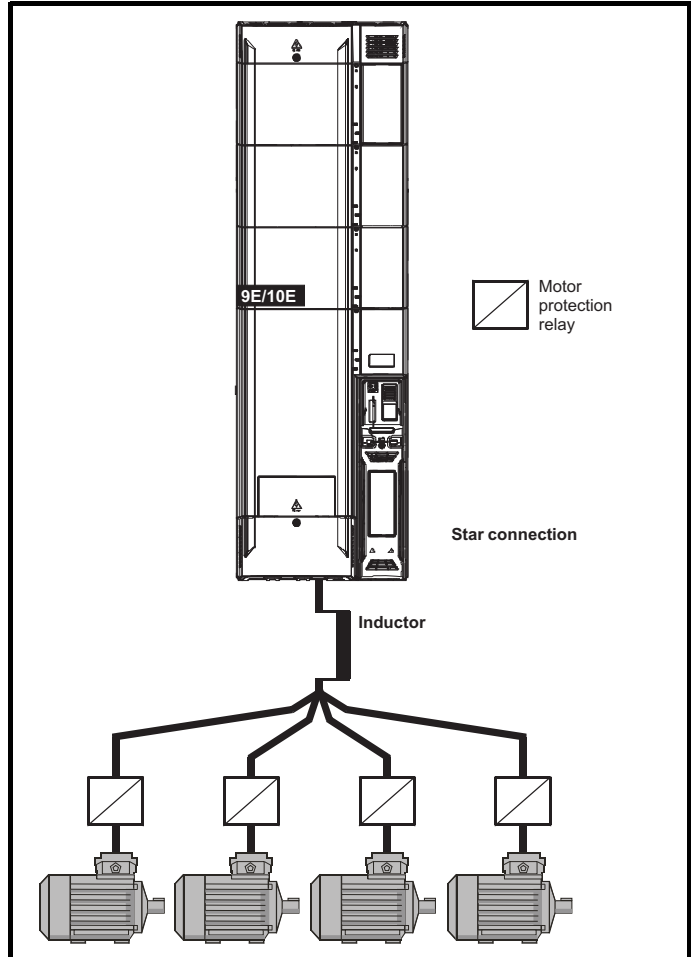


Figure 6-20 Alternative connection for multiple motors



6.10.5 Y / Δ motor operation

The voltage rating for Y and Δ connections of the motor should always be checked before attempting to run the motor.

The default setting of the motor rated voltage parameter is the same as the drive rated voltage, i.e.

400 V drive 400 V rated voltage

A typical 3 phase motor would be connected in Y for 400 V operation or Δ for 200 V operation, however, variations on this are common e.g.

Y 690 V Δ 400 V

Incorrect connection of the windings will cause severe under or over fluxing of the motor, leading to a very poor output torque or motor saturation and overheating respectively.

6.10.6 Output contactor



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

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

The recommended motor contactor is the AC3 type.

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

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

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

The Drive Enable (terminal 31 on *Unidrive M700 / M701 / HS70 / HS71* and terminal 11 and 13 on *Unidrive M702 / HS72*) when opened provides a Safe Torque Off function. This can in many cases replace output contactors. For further information see the *Control User Guide*.

6.11 Braking

Braking occurs when the drive is decelerating the motor, or is preventing the motor from gaining speed due to mechanical influences. During braking, energy is returned to the drive from the motor.

When the motor is being braked by the drive, the maximum regenerated power that the drive can absorb is equal to the power dissipation (losses) of the drive.

When the regenerated power is likely to exceed these losses, the DC bus voltage of the drive increases. Under default conditions, the drive brakes the motor under PI control, which extends the deceleration time as necessary in order to prevent the DC bus voltage from rising above a user defined set-point.

If the drive is expected to rapidly decelerate a load, or to hold back an overhauling load, a braking resistor must be installed.

Table 6-20 shows the DC voltage level at which the drive turns on the braking transistor.

Table 6-20 Braking transistor turn on voltage

Drive voltage rating	DC bus voltage level
200 V	390 V
400 V	780 V
575 V	930 V
690 V	1120 V

NOTE

When a braking resistor is used, Pr **00.015** should be set to FAST ramp mode.



High temperatures

Braking resistors can reach high temperatures. Locate braking resistors so that damage cannot result. Use cable having insulation capable of withstanding high temperatures.

6.11.1 External braking resistor



Overload protection

When an external braking resistor is used, it is essential that an overload protection device is incorporated in the braking resistor circuit; this is described in Figure 6-21 on page 106.

When a braking resistor is to be mounted outside the enclosure, ensure that it is mounted in a ventilated metal housing that will perform the following functions:

- Prevent inadvertent contact with the resistor
- Allow adequate ventilation for the resistor

When compliance with EMC emission standards is required, external connection requires the cable to be armored or shielded, since it is not fully contained in a metal enclosure. See section 6.13.4 *Compliance with generic emission standards* on page 113 for further details.

Internal connection does not require the cable to be armored or shielded.

Minimum resistances and power ratings

Table 6-21 Minimum resistance values and peak power rating for the braking resistor at 40°C (104°F)

Model	Minimum resistance* Ω	Instantaneous power rating kW	Continuous power rating kW
09201760 (9A)	2	84.5	45
09202190 (9A)	2	84.5	55
09201760 (9E)	1.4	120.8	45
09202190 (9E)	1.4	120.8	55
10202830	1.7	99.5	75
10203000	1.7	99.5	90
09402000 (9A)	3.6	187.8	90
09402240 (9A)	3.6	187.8	110
09402000 (9E)	2.6	260	90
09402240 (9E)	2.6	260	110
10402700	3.1	218.1	132
10403200	3.1	218.1	160
11403770	1.83	369.4	185
11404170	1.2	563.4	200
11404640	1.2	563.4	250
09501040 (9A)	5.1	188.5	75
09501310 (9A)	5.1	188.5	90
09501040 (9E)	3.3	291.3	75
09501310 (9E)	3.3	291.3	90
10501520	3.3	291.3	110
10501900	3.3	291.3	132
11502000	1.83	525.2	150
11502540	1.83	525.2	185
11502850	1.83	525.2	225
09601040 (9A)	6.5	214.5	90
09601310 (9A)	6.5	214.5	110
09601040 (9E)	4.2	331.9	90
09601310 (9E)	4.2	331.9	110
10601500	4.2	331.9	132
10601780	3.8	366.8	160
11602100	2.2	633.6	185
11602380	2.2	633.6	200
11602630	2.2	633.6	250

* Resistor tolerance: ±10 %

In parallel systems without the DC bus connected, the resistors must be matched to within ±5 %.

For high-inertia loads or under continuous braking, the *continuous power* dissipated in the braking resistor may be as high as the power rating of the drive. The total *energy* dissipated in the braking resistor is dependent on the amount of energy to be extracted from the load.

The instantaneous power rating refers to the short-term maximum power dissipated during the *on* intervals of the pulse width modulated braking control cycle. The braking resistor must be able to withstand this dissipation for short intervals (milliseconds). Higher resistance values require proportionately lower instantaneous power ratings.

In most applications, braking occurs only occasionally. This allows the continuous power rating of the braking resistor to be much lower than the power rating of the drive. It is essential, though, that the instantaneous power rating and energy rating of the braking resistor are sufficient for the most extreme braking duty that is likely to be encountered.

Optimization of the braking resistor requires a careful consideration of the braking duty.

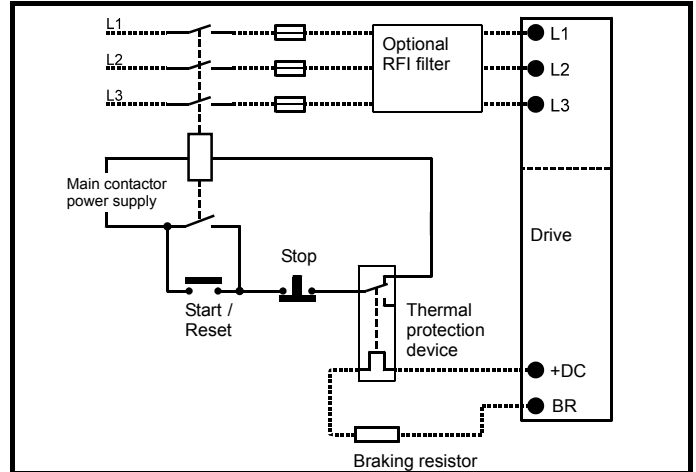
Select a value of resistance for the braking resistor that is not less than the specified minimum resistance. Larger resistance values may give a cost saving, as well as a safety benefit in the event of a fault in the

braking system. Braking capability will then be reduced, which could cause the drive to trip during braking if the value chosen is too large.

Thermal protection circuit for the braking resistor

The thermal protection circuit must disconnect the AC supply from the drive if the resistor becomes overloaded due to a fault. Figure 6-21 shows a typical circuit arrangement.

Figure 6-21 Typical protection circuit for a braking resistor



See Figure 6-1 to Figure 6-7 on page 89 for the location of the +DC and braking resistor connections.

6.11.2 Braking resistor software overload protection

The Unidrive M / Unidrive HS software contains an overload protection function for a braking resistor. In order to enable and set-up this function, it is necessary to enter two values into the drive:

- Resistor short-time overload time (Pr **10.030**)
- Resistor minimum time between repeated short-time overloads (Pr **10.031**)

This data should be obtained from the manufacturer of the braking resistors.

Pr **10.039** gives an indication of braking resistor temperature based on a simple thermal model. Zero indicates the resistor is close to ambient and 100 % is the maximum temperature the resistor can withstand. A 'Brake Resistor' alarm is given if this parameter is above 75 % and the braking IGBT is active. A Brake R Too Hot trip will occur if Pr **10.039** reaches 100 %, when Pr **10.307** is set to 0 (default value) or 1.

If Pr **10.037** is equal to 2 or 3 a Brake Resistor Too Hot trip will not occur when Pr **10.039** reaches 100%, but instead the braking IGBT will be disabled until Pr **10.039** falls below 95 %. This option is intended for applications with parallel connected DC buses where there are several braking resistors, each of which cannot withstand full DC bus voltage continuously. With this type of application it is unlikely the braking energy will be shared equally between the resistors because of voltage measurement tolerances within the individual drives. Therefore with Pr **10.037** set to 2 or 3, then as soon as a resistor has reached its maximum temperature the drive will disable the braking IGBT, and another resistor on another drive will take up the braking energy. Once Pr **10.039** has fallen below 95 % the drive will allow the braking IGBT to operate again.

See the *Unidrive M / Unidrive HS Parameter Reference Guide* for more information on Pr **10.030**, Pr **10.031**, Pr **10.037** and Pr **10.039**.

This software overload protection should be used in addition to an external overload protection device.

Braking Resistor Connections

This section details the rules that govern the connection of braking resistors to a parallel application. The braking resistor should be connected across the brake and +DC terminals.

1. The brake terminals must not be connected together. Each module must have its own resistor if required.
2. The resistor connected to each module must not have a value less than the recommended minimum value for that module size.

3. The total power rating must not be less than the maximum expected regenerative power.
4. If the DC buses are separate and the modules are all the same rating, the brake resistors must match to better than 5% at all power flows. (If the temperature coefficient and/or temperature rise of the resistor is significant then the cooling must also match to ensure the resistors are at similar temperatures and hence similar resistance values.)
5. If the DC buses are common the brake resistors do not need to match. However to use the drive's brake resistor protection algorithm it must be set up to protect the most vulnerable resistor.

6.12 Ground leakage

The ground leakage current depends upon whether the internal EMC filter is installed. The drive is supplied with the filter installed.

With internal filter installed:

56 mA AC at 400 V 50 Hz (proportional to supply voltage and frequency)

18 μ A DC with a 600 V DC bus (33 M Ω)

With internal filter removed*:

<1mA

Note that in both cases there is an internal voltage surge protection device connected to ground. Under normal circumstances this carries negligible current.

*Please note that the internal filter is not removable on size 9E/T, 10E/T and 11E/T.



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

6.12.1 Use of residual current device (RCD)

There are three common types of ELCB / RCD:

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



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

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

6.13 EMC (Electromagnetic compatibility)

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

Section 6.13.2, General requirements for all applications, to ensure reliable operation of the drive and minimise the risk of disturbing nearby equipment. The immunity standards specified in section 7.1.27 *Electromagnetic compatibility (EMC)* on page 150 will be met, but no specific emission standards. Note also the special requirements given in *Surge immunity of control circuits - long cables and connections outside a building* on page 115 for increased surge immunity of control circuits where control wiring is extended.

Section 6.13.3, Requirements for meeting the EMC standard for power drive systems, IEC61800-3 (EN 61800-3:2004+A1:2012).

Section 6.13.4, Requirements for meeting the generic emission standards for the industrial environment, IEC61000-6-4, EN 61000-6-4:2007+A1:2011.

The recommendations of section 6.13.2 will usually be sufficient to avoid causing disturbance to adjacent equipment of industrial quality. If particularly sensitive equipment is to be used nearby, or in a non-industrial environment, then the recommendations of section 6.13.3 or section 6.13.4 should be followed to give reduced radio-frequency emission.

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

- The EMC data sheet available from the supplier of the drive
- The Declaration of Conformity at the front of this manual

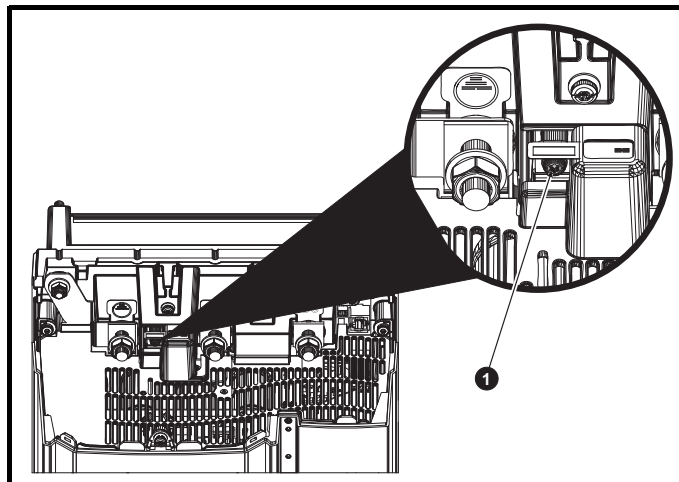
The correct external EMC filter must be used and all of the guidelines in section 6.13.2 and section 6.13.4 must be followed.



WARNING

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

Figure 6-22 Removal of the Unidrive M/Unidrive HS size 9D, 10D and 11D inverter internal EMC filter



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

NOTE

The internal filter is not removable on size 9E/T, 10E/T and 11E/T.



WARNING

High ground leakage current

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

NOTE

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

6.13.1 Internal EMC filter

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



WARNING

When the drive is used with ungrounded (IT) supplies the internal EMC filter must be removed unless additional motor ground fault protection is installed.

For instructions on removal, refer to Figure 6-22 *Removal of the Unidrive M/Unidrive HS size 9D, 10D and 11D inverter internal EMC filter* on page 108. Please note that the internal filter is not removable on size 9E/T, 10E/T and 11E/T. For details of ground fault protection contact the supplier of the drive.

If the drive is used as part of a regen system, 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+A1:2012 to be met for the second environment - see section 6.13.3. 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 ground leakage current of 56 mA is unacceptable or the above conditions are true. See Figure 6-22 on page 108 for details of removing and installing the internal EMC filter.

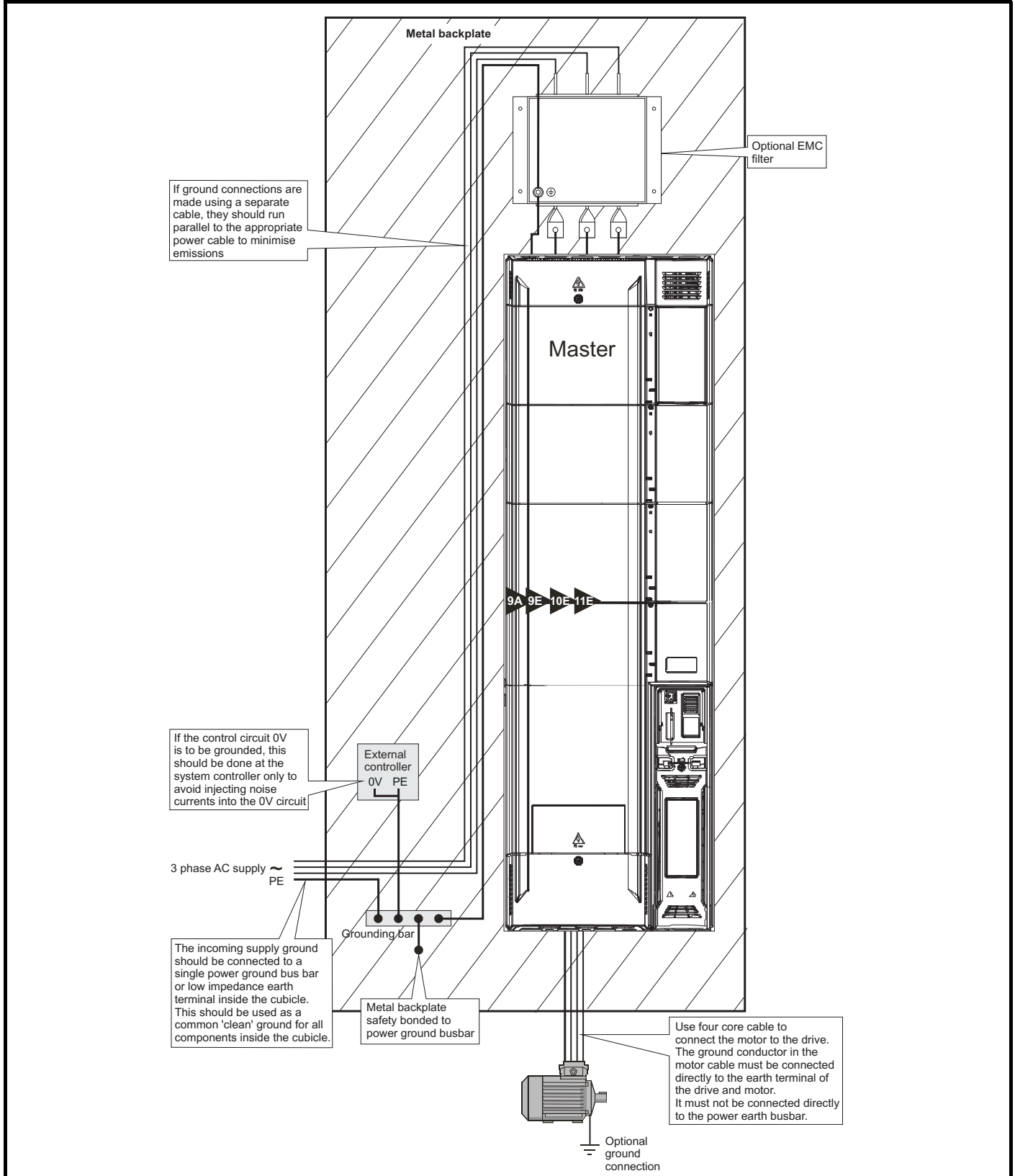
6.13.2 General requirements for EMC

Ground (earth) connections

The grounding arrangements should be in accordance with Figure 6-23, which shows a single drive on a back-plate with or without an additional enclosure.

Figure 6-23 shows how to manage EMC when using an unshielded motor cable. However a shielded cable is preferable, in which case it should be installed as shown in section 6.13.4 *Compliance with generic emission standards* on page 113.

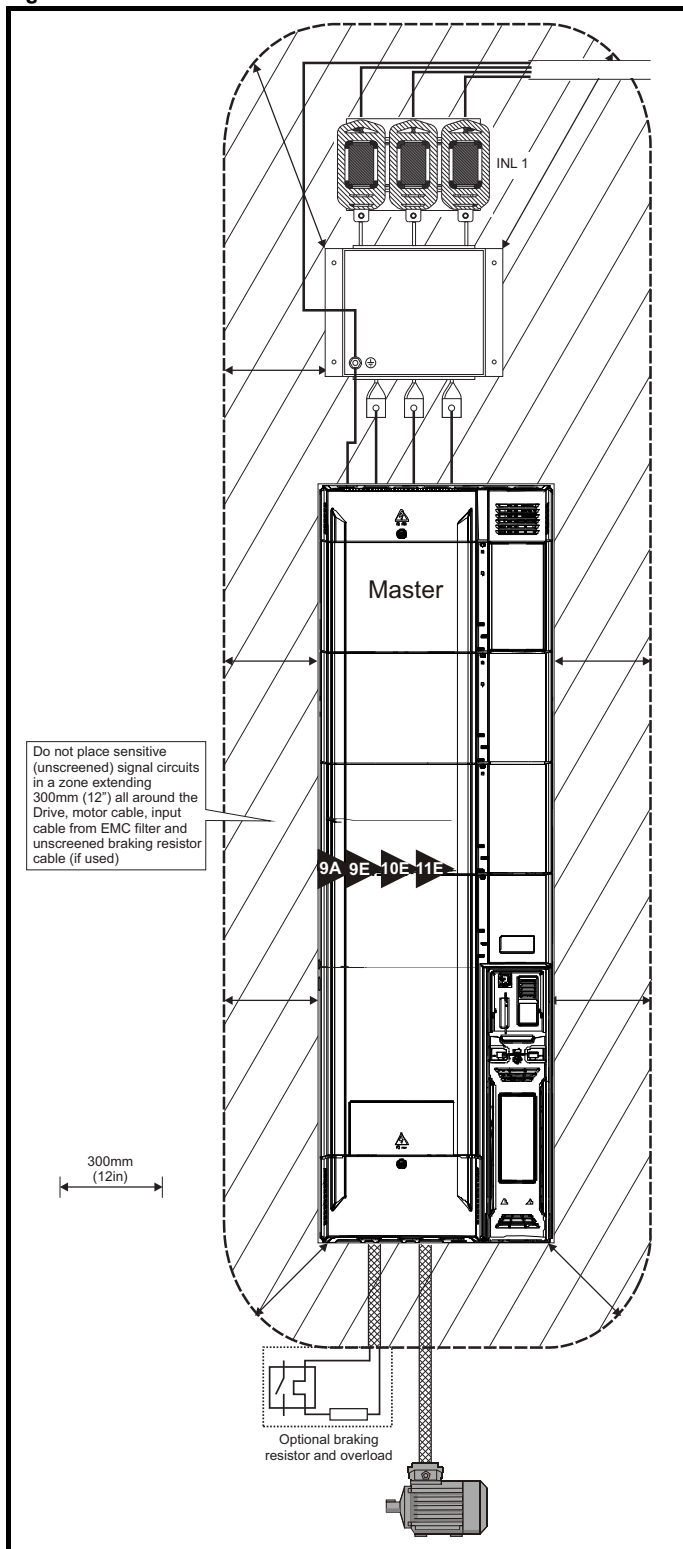
Figure 6-23 General EMC enclosure layout showing ground connections



Cable layout

Figure 6-24 indicates the clearances which should be observed around the drive and related 'noisy' power cables by all sensitive control signals / equipment.

Figure 6-24 Drive cable clearances



NOTE

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

Feedback device cable shielding

Shielding considerations are important for PWM drive installations due to the high voltages and currents present in the output (motor) circuit with a very wide frequency spectrum, typically from 0 to 20 MHz.

The following guidance is divided into two parts:

1. Ensuring correct transfer of data without disturbance from electrical noise originating either within the drive or from outside.
2. Additional measures to prevent unwanted emission of radio frequency noise. These are optional and only required where the installation is subject to specific requirements for radio frequency emission control.

To ensure correct transfer of data, observe the following:

Resolver connections:

- Use a cable with an overall shield and twisted pairs for the resolver signals
- Connect the cable shield to the drive 0V connection by the shortest possible link ("pigtail")
- It is generally preferable not to connect the cable shield to the resolver. However in cases where there is an exceptional level of common-mode noise voltage present on the resolver body, it may be helpful to connect the shield there. If this is done then it becomes essential to ensure the absolute minimum length of "pigtails" at both shield connections, and possibly to clamp the cable shield directly to the resolver body and to the drive grounding bracket.
- The cable should preferably not be interrupted. If interruptions are unavoidable, ensure the absolute minimum length of "pigtail" in the shield connections at each interruption.

Encoder connections:

- Use a cable with the correct impedance
- Use a cable with individually shielded twisted pairs
- Connect the cable shields to 0V at both the drive and the encoder, using the shortest possible links ("pigtails")
- The cable should preferably not be interrupted. If interruptions are unavoidable, ensure the absolute minimum length of "pigtail" in the shield connections at each interruption. Preferably, use a connection method which provides substantial metallic clamps for the cable shield terminations.

The above applies where the encoder body is isolated from the motor and where the encoder circuit is isolated from the encoder body. Where there is no isolation between the encoder circuits and the motor body, and in case of doubt, the following additional requirement must be observed. This gives the best possible noise immunity.

- The shields must be directly clamped to the encoder body (no pigtail) and to the drive grounding bracket. This may be achieved by clamping of the individual shields or by providing an additional overall shield which is clamped.

NOTE

The recommendations of the encoder manufacturer must also be adhered to for the encoder connections.

NOTE

In order to guarantee maximum noise immunity for any application double shielded cable as shown should be used.

In some cases single shielding of each pair of differential signals cables, or a single overall shield with individual shield on the thermistor connections is sufficient. In these cases all the shields should be connected to ground and 0V at both ends.

If the 0V is required to be left floating a cable with individual shields and an overall shield must be used.

Figure 6-26 and Figure 6-27 illustrate the preferred construction of cable and the method of clamping. The outer sheath of the cable should be stripped back enough to allow the clamp to be installed. The shield must not be broken or opened at this point. The clamps should be installed close to the drive or feedback device, with the ground connections made to a ground plate or similar metallic ground surface.

Figure 6-25 Drive cable clearances with undocked rectifier (size 10/11) and undocked inverter (size 9D/10D/11D)

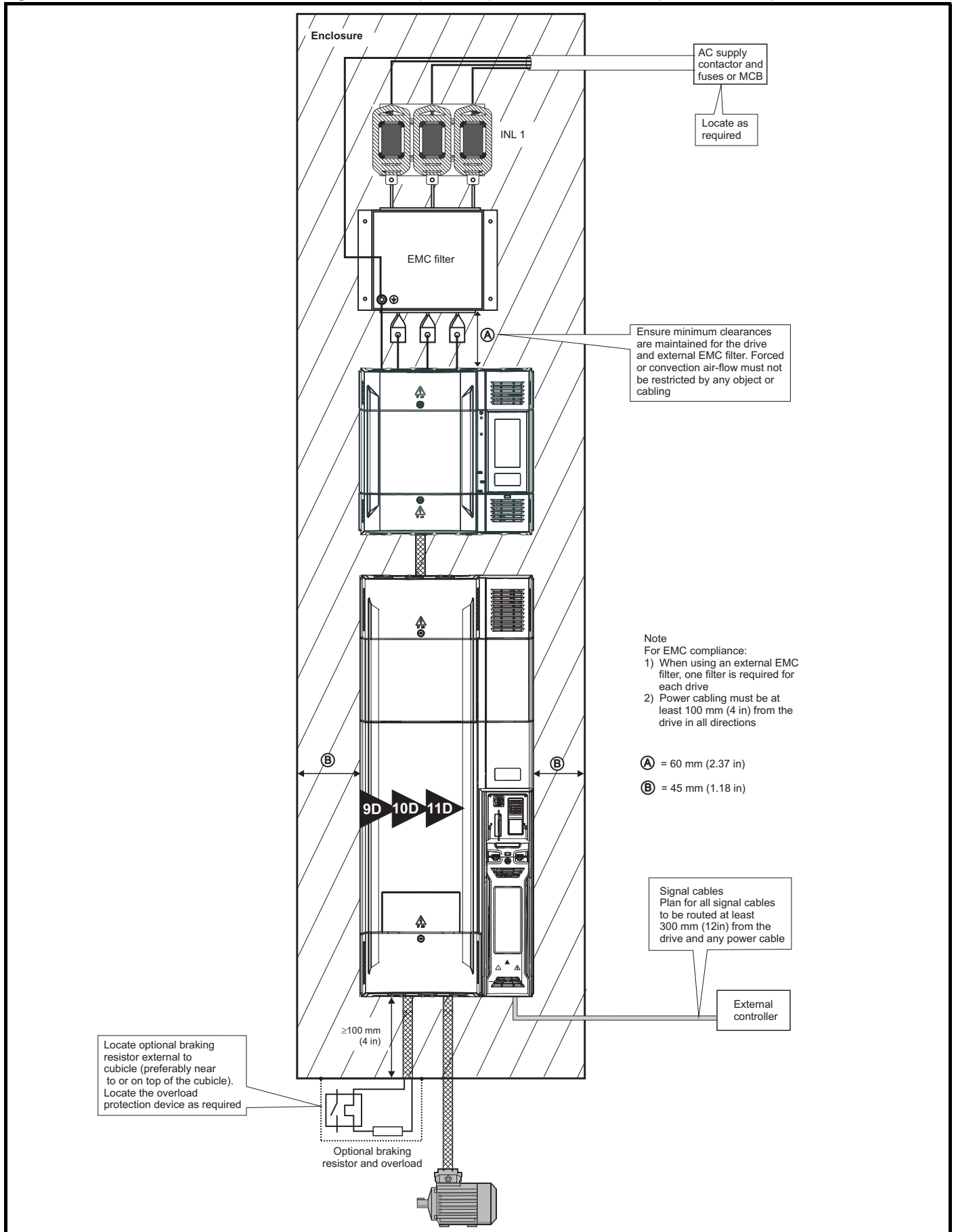


Figure 6-26 Feedback cable, twisted pair

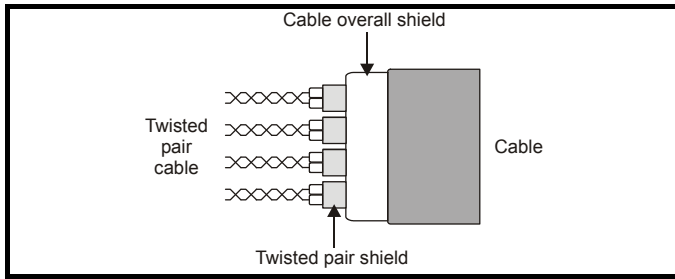
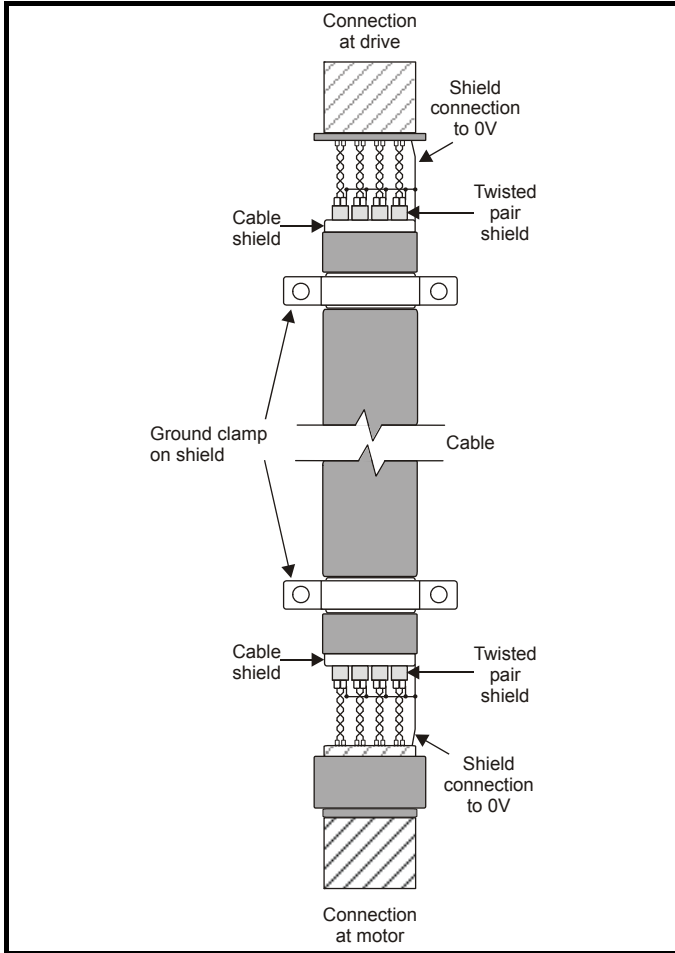


Figure 6-27 Feedback cable connections



To ensure suppression of radio frequency emission, observe the following:

- Use a cable with an overall shield
- Clamp the overall shield to grounded metallic surfaces at both the encoder and the drive, as illustrated in Figure 6-27

6.13.3 Compliance with EN 61800-3:2004+A1:2012 (standard for Power Drive Systems)

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

Operation in the first environment

Observe the guidelines given in section 6.13.4 *Compliance with generic emission standards* on page 113. An external EMC filter will always be required.



This is a product of the restricted distribution class according to EN 61800-3:2004+A1:2012

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

Operation in the second environment

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

The drive contains an in-built filter for basic emission control. In some cases feeding the motor cables (U, V and W) once through a ferrite ring can maintain compliance for longer cable lengths. The requirements of operating in the second environment are met, depending on the motor cable length for 3 kHz switching frequency as stated in Table 6-22.

The table summarizes the performance of in-built filters when used with Unidrive M / Unidrive HS size 9, 10 and 11 drives and single pairs of Unidrive M / Unidrive HS size 9, 10 and 11 drives and Unidrive M / Unidrive HS rectifiers, assembled in the standard recommended configuration.

Table 6-22 Second environment emission compliance

Drive size	Filter	Voltage	Motor cable length 0 - 100 (m)
All sizes	In-built	Any	Unrestricted

Key:

Unrestricted: EN 61800-3:2004+A1:2012 second environment, unrestricted distribution.

For longer motor cables, an external filter is required. Where a filter is required, follow the guidelines in section 6.13.4 *Compliance with generic emission standards*.

Where a filter is not required, follow the guidelines given in section 6.13.2 *General requirements for EMC* on page 109.



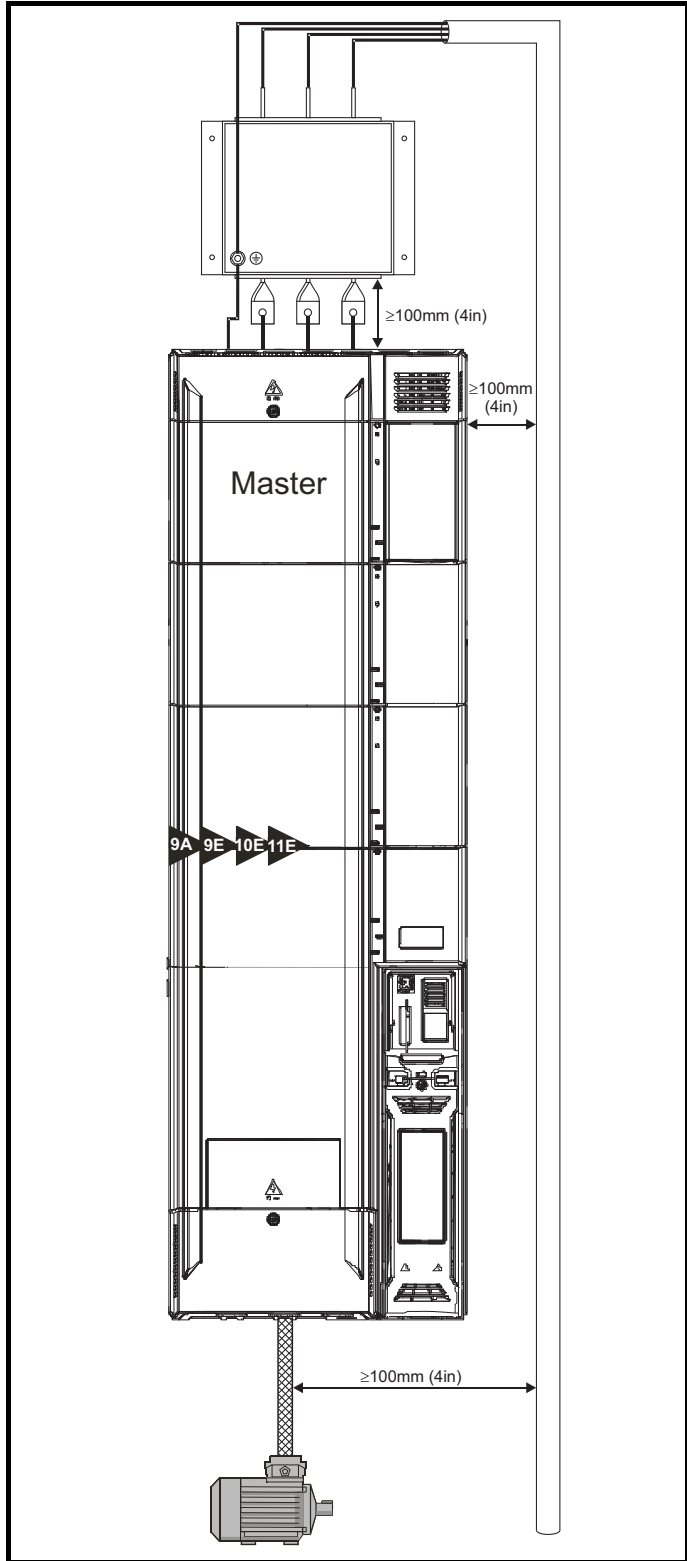
The second environment typically includes an industrial low-voltage power supply network which does not supply buildings used for residential purposes. Operating the drive in this environment without an external EMC filter may cause interference to nearby electronic equipment whose sensitivity has not been appreciated. The user must take remedial measures if this situation arises. If the consequences of unexpected disturbances are severe, it is recommended that the guidelines in section 6.13.4 *Compliance with generic emission standards* be adhered to.

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

6.13.4 Compliance with generic emission standards

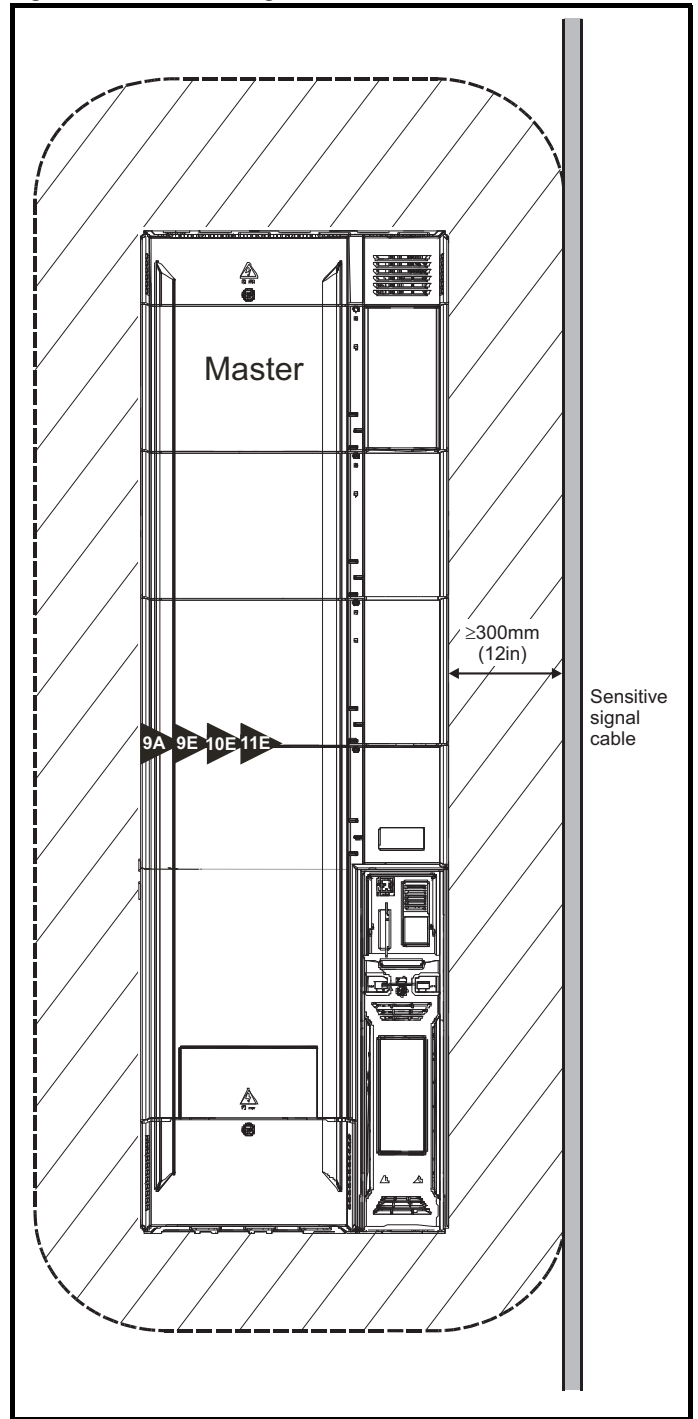
Use the recommended filter and shielded motor cable. Observe the layout rules given in Figure 6-28. Ensure the AC supply and ground cables are at least 100 mm from the power module and motor cable.

Figure 6-28 Supply and ground cable clearance



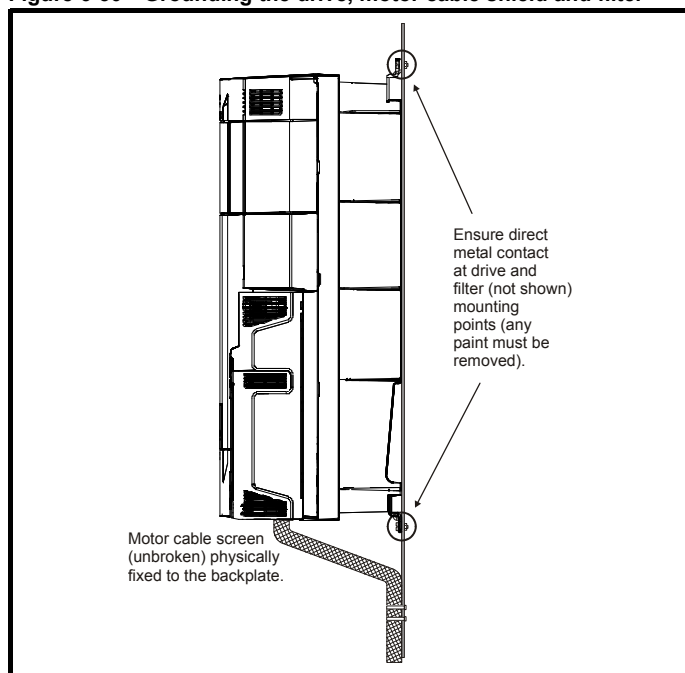
Avoid placing sensitive signal circuits in a zone 300 mm (12 in) all around the power module.

Figure 6-29 Sensitive signal circuit clearance



6.13.5 Ensure good EMC grounding.

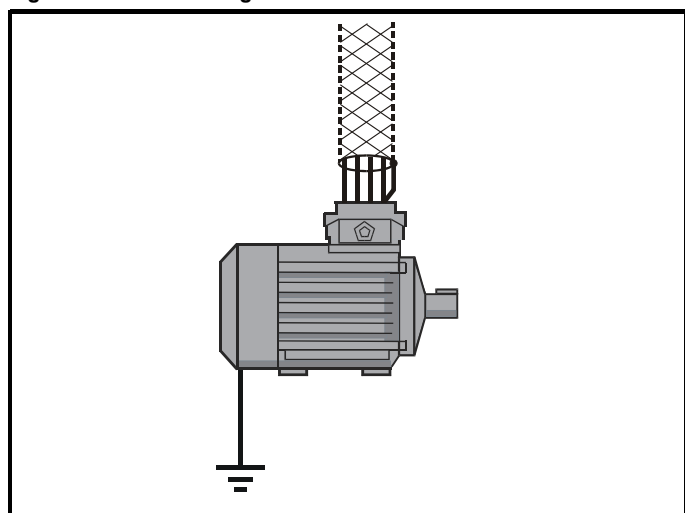
Figure 6-30 Grounding the drive, motor cable shield and filter



Connect the shield of the motor cable to the ground terminal of the motor frame using a link that is as short as possible and not exceeding 50 mm (2 in) long. A full 360° termination of the shield to the terminal housing of the motor is beneficial.

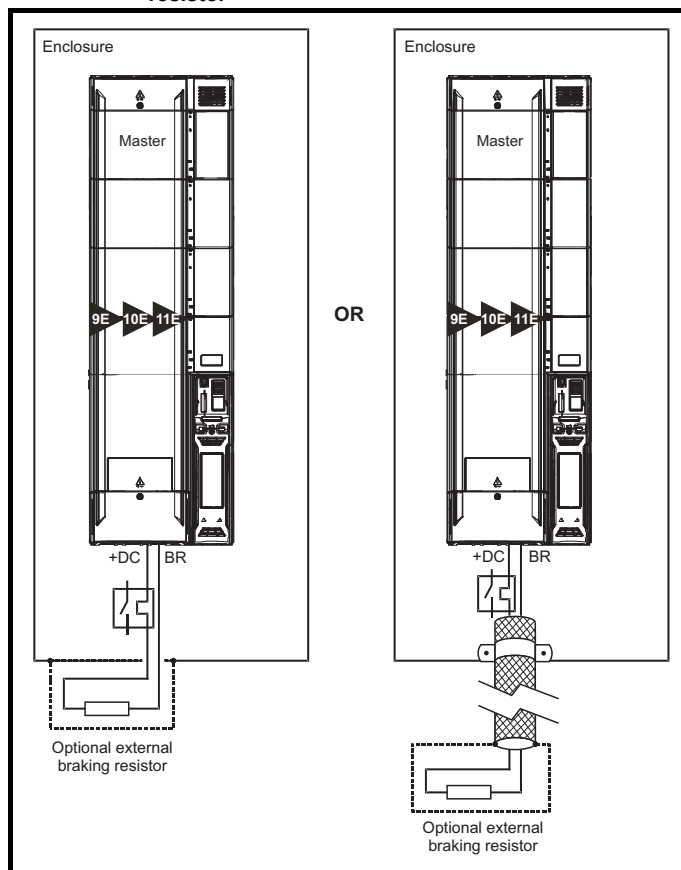
It is unimportant for EMC purposes whether the motor cable contains an internal (safety) ground core, or there is a separate external ground conductor, or grounding is through the shield alone. An internal ground core will carry a high noise current and therefore it must be terminated as close as possible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

Figure 6-31 Grounding the motor cable shield



Unshielded wiring to the optional braking resistor(s) may be used, provided the wiring does not run external to the enclosure. Ensure a minimum spacing of 300 mm (12 in) from signal wiring and the AC supply wiring to the external EMC filter. Otherwise this wiring must be shielded.

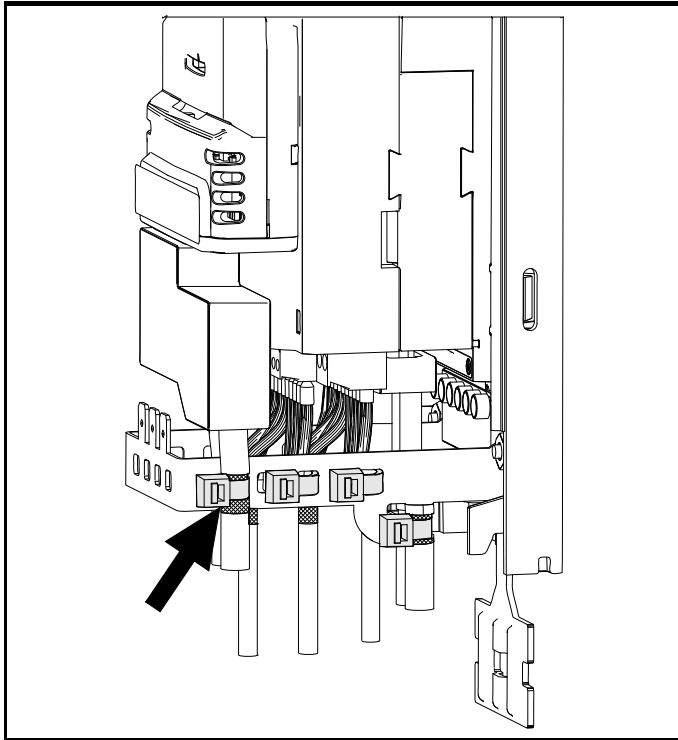
Figure 6-32 Shielding requirements of optional external braking resistor



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 as shown in Figure 6-33. 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

Alternatively, wiring may be passed through a ferrite ring, part no. 3225-1004.

Figure 6-33 Grounding of signal cable shields using the grounding bracket



6.13.6 Variations in the EMC wiring Interruptions to the motor cable

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

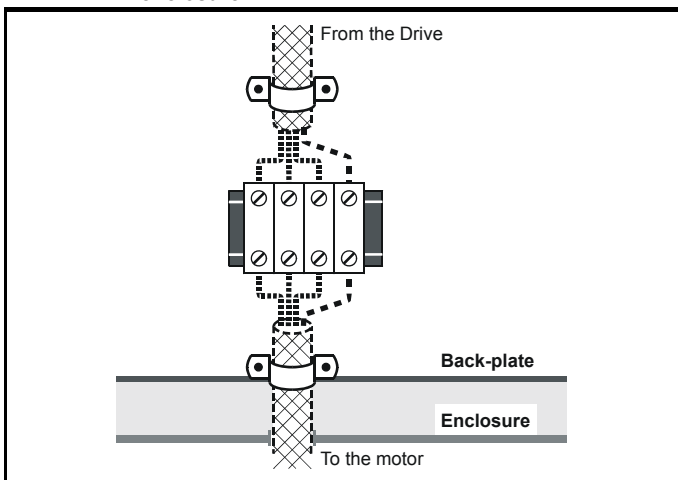
- Connecting the motor cable to a terminal block in the drive enclosure
- Installing a motor isolator/disconnect switch for safety when work is done on the motor

In these cases the following guidelines should be followed.

Terminal block in the enclosure

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

Figure 6-34 Connecting the motor cable to a terminal block in the enclosure



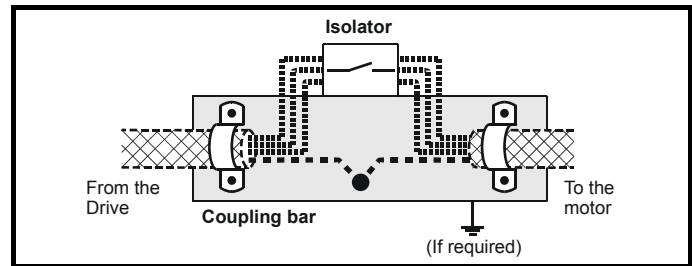
Using a motor isolator/disconnect-switch

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

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

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

Figure 6-35 Connecting the motor cable to an isolator/disconnect switch



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

The input/output ports for the control circuits are designed for general use within machines and small systems without any special precautions. These circuits meet the requirements of EN 61000-6-2:2005 (1 kV surge) provided the 0V connection is not grounded.

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

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

1. Galvanic isolation, i.e. do not connect the control 0V terminal to ground. Avoid loops in the control wiring, i.e. ensure every control wire is accompanied by its return (0V) wire.
2. Shielded cable with additional power ground bonding. The cable shield may be connected to ground at both ends, but in addition the ground conductors at both ends of the cable must be bonded together by a power ground cable (equipotential bonding cable) with cross-sectional area of at least 10 mm², or 10 times the area of the signal cable shield, or to suit the electrical safety requirements of the plant. This ensures that fault or surge current passes mainly through the ground cable and not in the signal cable shield. If the building or plant has a well-designed common bonded network this precaution is not necessary.
3. Additional over-voltage suppression - for the analog and digital inputs and outputs, a zener diode network or a commercially available surge suppressor may be connected in parallel with the input circuit as shown in Figure 6-36 and Figure 6-37.

If a digital port experiences a severe surge its protective trip may operate (I/O Overload trip code 26). For continued operation after such an event, the trip can be reset automatically by setting Pr **10.034** to 5.

Figure 6-36 Surge suppression for digital and unipolar inputs and outputs

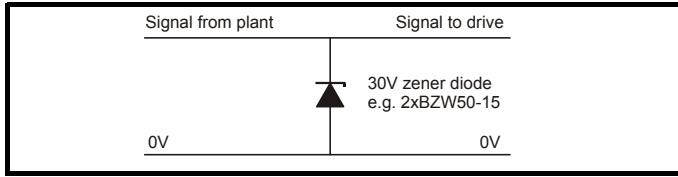
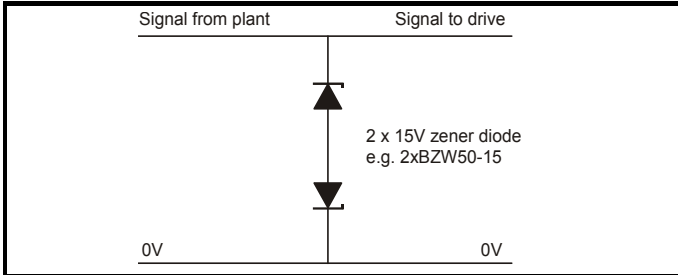


Figure 6-37 Surge suppression for analog and bipolar inputs and outputs



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

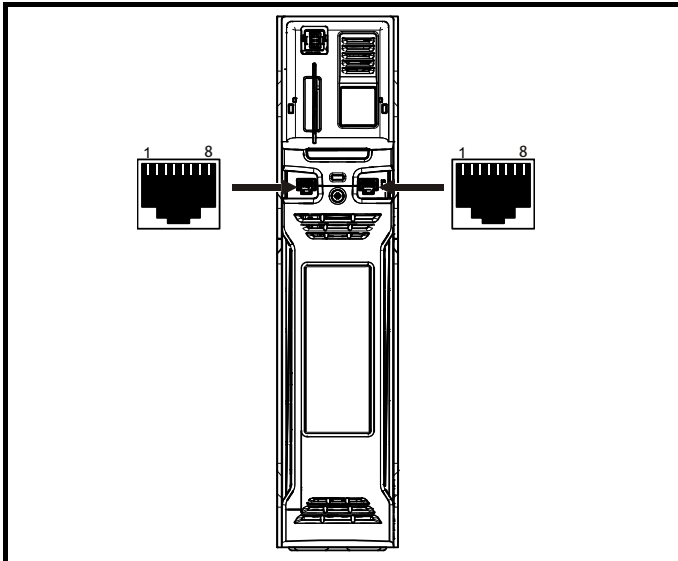
- Unipolar TT-UKK5-D/24 DC
- Bipolar TT-UKK5-D/24 AC

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

6.14 Communication connections

The *Unidrive M700/HS70/M702/HS72* drive offers Ethernet fieldbus communications and the *Unidrive M701/HS71* drive offers a 2 wire EIA 485 interface. This enables the drive set-up, operation and monitoring to be carried out with a PC or controller if required.

Figure 6-38 Location of the comms connectors



6.14.1 Unidrive M700/HS70/M702/HS72 Ethernet fieldbus communications

The Ethernet option provides two RJ45 connections with an Ethernet switch for easy network creation.

Standard UTP (unshielded twisted pair) or STP (shielded twisted pair) cables are supported. It is recommended that a minimum specification CAT5e is used in new installations. As the drive supports the 'Auto cross-over detection' a cross-over cable is not required.

NOTE

The shell of the RJ45 connector is isolated from the 0V of the drive control terminals but it is connected to ground.

6.14.2 Unidrive M701/HS71 EIA 485 serial communications

The EIA 485 interface provides two parallel RJ45 connectors allowing easy daisy chaining. The drive only supports Modbus RTU protocol. See Table 6-23 for the connection details.

NOTE

Standard Ethernet cables must not be used when connecting drives on a EIA 485 network as they do not have the correct twisted pairs for the pinout of the serial comms port.


Table 6-23 Serial communication port pin-outs

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

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

6.14.3 Unidrive M701/HS71 Isolation of the EIA 485 serial communications port

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



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

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

Table 6-24 Isolated serial comms lead details

Part number	Description
4500-0096	CT USB Comms cable

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

6.15 Control connections

6.15.1 Unidrive M600 / M700/HS70 / M701/HS71 control connections

Table 6-25 The control connections consist of:

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

Key:

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

All analog terminal functions can be programmed in menu 7.

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



WARNING

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



WARNING

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



CAUTION

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



CAUTION

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

NOTE

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

NOTE

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

NOTE

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

NOTE

When using Unidrive M600 / M700/HS70 / M701/HS71 (all models other than M702 / HS72), a two wire motor thermistor can be connected to analog input 3 by connecting the thermistor between terminal 8 and any 0V common terminal. It is also possible to connect a 4-wire thermistor to analog input 3 as shown below. Pr **07.015** and Pr **07.046** need to be set-up for the thermistor type required.

Figure 6-39 Connection of 4-wire thermistors

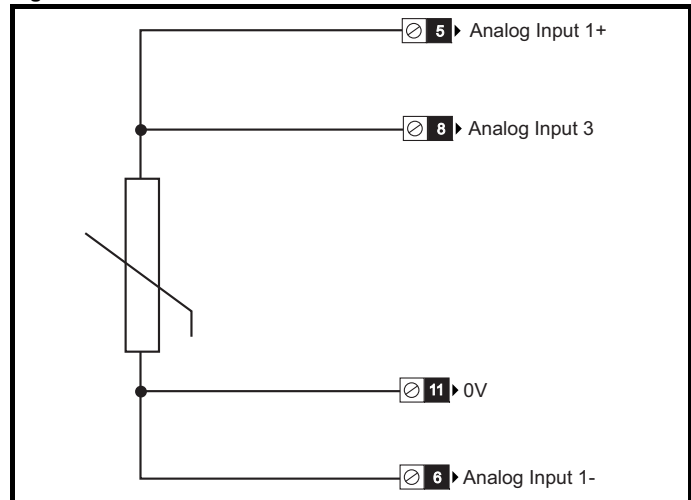
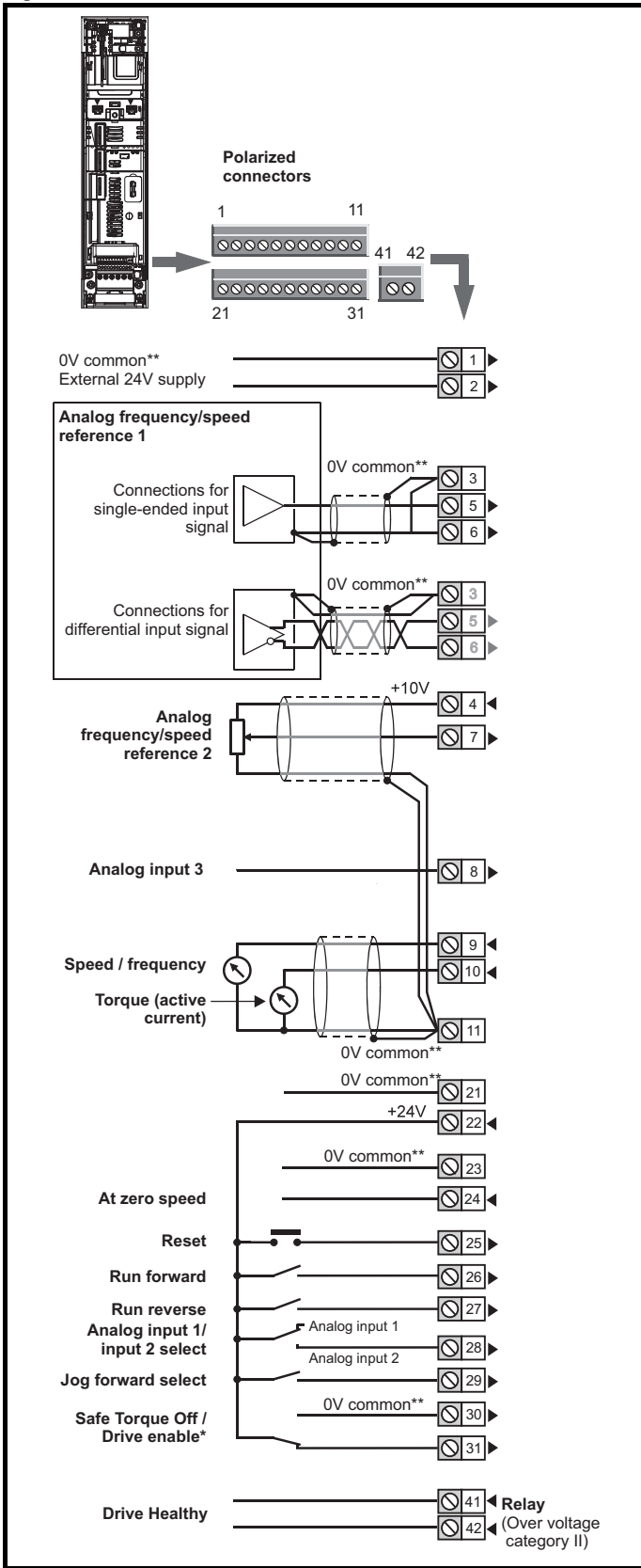


Figure 6-40 Default terminal functions



* The Safe Torque Off / Drive enable terminal is a positive logic input only.

** 0Vcommon is connected to ground internally in size 9 to 11 modular drives.

6.15.2 Unidrive M600 / M700/HS70 / M701/HS71 control terminal specification

1	0V common
Function	Common connection for all external devices

2	+24V external input
Function	To supply the control circuit without providing a supply to the power stage
Programmability	Can be used as digital input when using an external 24 V supply
Sample / update	2 ms
Nominal voltage	+24.0 Vdc
Minimum continuous operating voltage*	+19.2 Vdc
Maximum continuous operating voltage*	+28.0 Vdc
Minimum start-up voltage	21.6 Vdc
Recommended power supply	40 W 24 Vdc nominal
Recommended fuse	3 A, 50 Vdc

* Minimum and maximum voltage values include ripple and noise. Ripple and noise values must not exceed 5 %.

3	0V common
Function	Common connection for all external devices

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

Precision reference Analog input 1	
5	Non-inverting input
6	Inverting input
Default function	Frequency/speed reference
Type of input	Bipolar differential analog voltage or current, thermistor input
Mode controlled by:	Pr 07.007
Operating in Voltage mode	
Full scale voltage range	$\pm 10\text{ V} \pm 2\%$
Maximum offset	$\pm 10\text{ mV}$
Absolute maximum voltage range	$\pm 36\text{ V}$ relative to 0V
Working common mode voltage range	$\pm 13\text{ V}$ relative to 0V
Input resistance	$\geq 100\text{ k}\Omega$
Monotonic	Yes (including 0V)
Dead band	None (including 0V)
Jumps	None (including 0V)
Maximum offset	20 mV
Maximum non linearity	0.3% of input
Maximum gain asymmetry	0.5 %
Input filter bandwidth single pole	$\sim 3\text{ kHz}$
Operating in current mode	
Current ranges	0 to 20 mA $\pm 5\%$, 20 to 0 mA $\pm 5\%$, 4 to 20 mA $\pm 5\%$, 20 to 4 mA $\pm 5\%$
Maximum offset	250 μA
Absolute maximum voltage (reverse biased)	$\pm 36\text{ V}$ relative to 0V
Equivalent input resistance	$\leq 300\ \Omega$
Absolute maximum current	$\pm 30\text{ mA}$
Operating in thermistor input mode (in conjunction with analog input 3)	
Internal pull-up voltage	2.5 V
Trip threshold resistance	User defined in Pr 07.048
Short-circuit detection resistance	50 $\Omega \pm 40\%$
Common to all modes	
Resolution	12 bits (11 bits plus sign)
Sample / update period	250 μs with destinations Pr 01.036 , Pr 01.037 , Pr 03.022 or Pr 04.008 in RFC-A and RFC-S modes. 4 ms for open loop mode and all other destinations in RFC-A or RFC-S modes.

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

8 Analog input 3	
Default function	Voltage input
Type of input	Bipolar single-ended analog voltage, or thermistor input
Mode controlled by...	Pr 07.015
Operating in Voltage mode (default)	
Voltage range	$\pm 10\text{ V} \pm 2\%$
Maximum offset	$\pm 10\text{ mV}$
Absolute maximum voltage range	$\pm 36\text{ V}$ relative to 0V
Input resistance	$\geq 100\text{ k}\Omega$
Operating in thermistor input mode	
Supported thermistor types	Din 4408, KTY 84, PT100, PT 1000, PT 2000, 2.0mA
Internal pull-up voltage	2.5 V
Trip threshold resistance	User defined in Pr 07.048
Reset resistance	User defined in Pr 07.048
Short-circuit detection resistance	50 $\Omega \pm 40\%$
Common to all modes	
Resolution	12 bits (11 bits plus sign)
Sample / update period	4 ms

9	Analog output 1
10	Analog output 2
Terminal 9 default function	OL> Motor FREQUENCY output signal RFC> SPEED output signal
Terminal 10 default function	Motor active current
Type of output	Bipolar single-ended analog voltage
Operating in Voltage mode (default)	
Voltage range	±10 V ±5 %
Maximum offset	±120 mV
Maximum output current	±20 mA
Load resistance	≥1 k Ω
Protection	20 mA max. Short circuit protection
Common to all modes	
Resolution	10-bit
Sample / update period	250 μs (output will only change at update the rate of the source parameter if slower)

11	0V common
Function	Common connection for all external devices

21	0V common
Function	Common connection for all external devices

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

23	0V common
Function	Common connection for all external devices

24	Digital I/O 1
25	Digital I/O 2
26	Digital I/O 3
Terminal 24 default function	AT ZERO SPEED output
Terminal 25 default function	DRIVE RESET input
Terminal 26 default function	RUN FORWARD input
Type	Positive or negative logic digital inputs, positive logic voltage source outputs
Input / output mode controlled by...	Pr 08.031, Pr 08.032 and Pr 08.033
Operating as an input	
Logic mode controlled by...	Pr 08.029
Absolute maximum applied voltage range	-3 V to +30 V
Impedance	>2 mA @15 V (IEC 61131-2, type 1, 6.6 k Ω)
Input thresholds	10 V ±0.8 V (IEC 61131-2, type 1)
Operating as an output	
Nominal maximum output current	100 mA (DIO1 & 2 combined) 100 mA (DIO3 & 24 V User Output Combined)
Maximum output current	100 mA 200 mA (total including all Digital I/O)
Common to all modes	
Voltage range	0V to +24 V
Sample / Update period	2 ms (output will only change at the update rate of the source parameter)

27	Digital Input 4
28	Digital Input 5
Terminal 27 default function	RUN REVERSE input
Terminal 28 default function	Analog INPUT 1 / INPUT 2 select
Type	Negative or positive logic digital inputs
Logic mode controlled by...	Pr 08.029
Voltage range	0V to +24 V
Absolute maximum applied voltage range	-3 V to +30 V
Impedance	>2 mA @15 V (IEC 61131-2, type 1, 6.6 k Ω)
Input thresholds	10 V ±0.8 V (IEC 61131-2, type 1)
Sample / Update period	250 μs when configured as an input with destinations Pr 06.035 or Pr 06.036. 600 μs when configured as an input with destination Pr 06.029. 2 ms in all other cases.

29	Digital Input 6
Terminal 29 default function	JOG SELECT input
Type	Negative or positive logic digital inputs
Logic mode controlled by...	Pr 08.029
Voltage range	0V to +24 V
Absolute maximum applied voltage range	-3 V to +30 V
Impedance	>2 mA @15 V (IEC 61131-2, type 1, 6.6 k Ω)
Input thresholds	10 V ±0.8 V (IEC 61131-2, type 1)
Sample / Update period	2 ms


30	0V common
Function	Common connection for all external devices

Refer to section 6.17 *Safe Torque Off (STO)* on page 131 for further information.

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

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

51	0V common
52	+24 Vdc
Size 9 to 11	
Nominal operating voltage	24.0 Vdc
Minimum continuous operating voltage	19.2 Vdc
Maximum continuous operating voltage	30 Vdc (IEC), 26 Vdc (UL)
Minimum startup voltage	21.6 Vdc
Maximum power supply requirement	60 W
Recommended fuse	4 A @ 50 Vdc

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

6.15.3 Unidrive M702/HS72 control connections

Table 6-26 The control connections consist of:

Function	Qty	Control parameters available	Terminal number
Digital input	2	Destination, invert, logic select	7, 8
Digital input / output	2	Input / output mode select, destination / source, invert, logic select	4, 5
Relay	1	Source, invert	41, 42
Safe Torque Off (drive enable)	2		11, 13
+24 V User output	1	Source, invert	2
0V common	5		1, 3, 6, 10, 12
+24 V External input	1	Destination, invert	9

Key:

Destination parameter:	Indicates the parameter which is being controlled by the terminal / function
Source parameter:	Indicates the parameter being output by the terminal
Mode parameter:	Digital - indicates the mode of operation of the terminal, i.e. positive / negative logic (the Drive Enable terminal is fixed in positive logic), open collector.

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

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

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

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

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

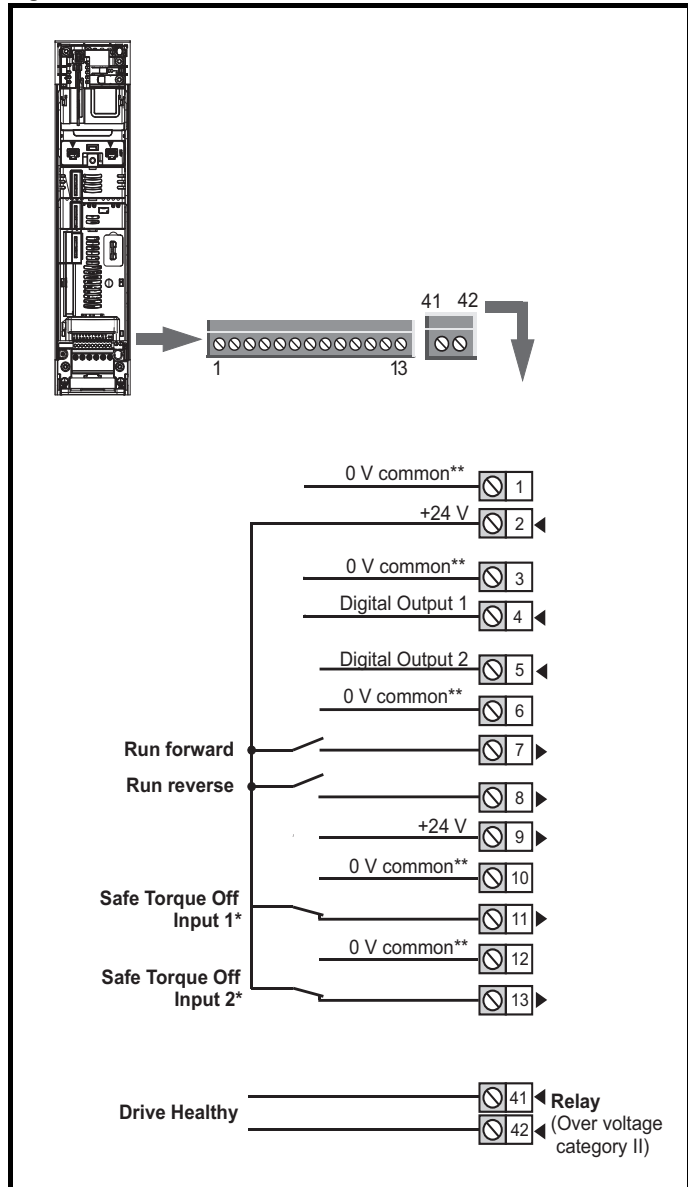
NOTE

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

NOTE

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

Figure 6-41 Default terminal functions



* The Safe Torque Off / Drive enable terminal is a positive logic input only.

** 0V common is connected to ground internally in size 9 to 11 modular drives.

6.15.4 Unidrive M702/HS72 control terminal specification

1	0V common
Function	Common connection for all external devices

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

3	0V common
Function	Common connection for all external devices

4	Digital Output 1
5	Digital Output 2
Terminal 4 default function	AT ZERO SPEED output
Terminal 5 default function	
Type	Positive logic voltage source outputs
Input / output mode controlled by...	Pr 08.031 , Pr 08.032
Nominal maximum output current	100 mA (DIO1 & 2 combined)
Maximum output current	100 mA 200 mA (total including all Digital I/O)
Voltage range	0V to +24 V
Sample / Update period	2 ms (output will only change at the update rate of the source parameter)

6	0V common
Function	Common connection for all external devices

7	Digital Input 4
8	Digital Input 5
Terminal 7 default function	RUN FORWARD input
Terminal 8 default function	RUN REVERSE input
Type	Negative or positive logic digital inputs
Logic mode controlled by...	Pr 08.029
Voltage range	0V to +24 V
Absolute maximum applied voltage range	-3 V to +30 V
Impedance	>2 mA @15 V (IEC 61131-2, type 1, 6.6 k Ω)
Input thresholds	10 V ±0.8 V (IEC 61131-2, type 1)
Sample / Update period	250 μs when configured as an input with destinations Pr 06.035 or Pr 06.036 . 600 μs when configured as an input with destination Pr 06.029 . 2 ms in all other cases.

9	+24 V external input
Function	To supply the control circuit without providing a supply to the power stage
Programmability	Can be used as a digital input when using an external 24 Vdc
Sample / Update period	2 ms
Nominal voltage	+24.0 Vdc
Minimum continuous operating voltage	+19.2 Vdc
Maximum continuous operating voltage	+28.0 Vdc
Minimum start-up voltage	21.6 Vdc
Recommended power supply	40 W 24 Vdc nominal
Recommended fuse	3 A, 50 Vdc


10	0V common
Function	Common connection for all external devices

12	0V common
Function	Common connection for all external devices

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

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

51	0V common
52	+24 Vdc
Size 9 to 11	
Nominal operating voltage	24.0 Vdc
Minimum continuous operating voltage	19.2 Vdc
Maximum continuous operating voltage	30 Vdc (IEC), 26 Vdc (UL)
Minimum startup voltage	21.6 Vdc
Maximum power supply requirement	60 W
Recommended fuse	4 A @ 50 Vdc

 WARNING	<p>To prevent the risk of a fire hazard in the event of a fault, a fuse or other over-current protection must be installed in the relay circuit.</p>
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6.16 M70X/HS7X Position feedback connections

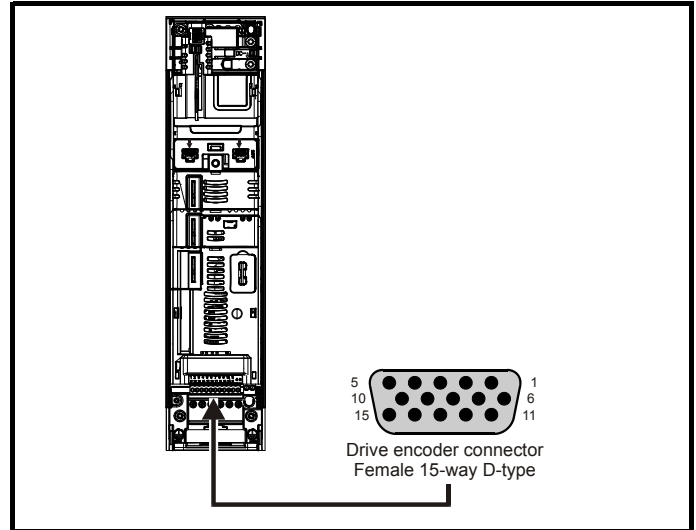
The following functions are provided via the 15-way high density D-type connector on the drive:

- Two position feedback interfaces (P1 and P2).
- One encoder simulation output.
- Two freeze trigger inputs (marker inputs).
- One thermistor input.

The P1 position interface is always available but the availability of the P2 position interface and the encoder simulation output depends on the position feedback device used on the P1 position interface, as shown in Table 6-29.

6.16.1 Location of position feedback connector

Figure 6-42 Location of the position feedback



6.16.2 Compatible position feedback devices

Table 6-27 Supported feedback devices on the P1 position interface

Encoder type	Pr 3.038 setting
Quadrature incremental encoders with or without marker pulse	AB (0)
Quadrature incremental encoders with UVW commutation signals for absolute position for permanent magnet motors with or without marker pulse	AB Servo (3)
Forward / reverse incremental encoders with or without marker pulse	FR (2)
Forward / reverse incremental encoders with UVW commutation signals for absolute position for permanent magnet motors with or without marker pulse	FR Servo (5)
Frequency and direction incremental encoders with or without marker pulse	FD (1)
Frequency and direction incremental encoders with UVW commutation signals for absolute position for permanent magnet motors with or without marker pulse	FD Servo (4)
Sincos incremental encoders	SC (6)
Sincos incremental with commutation signals	SC Servo (12)
Heidenhain sincos encoders with EnDat comms for absolute position	SC EnDat (9)
Stegmann sincos encoders with Hiperface comms for absolute position	SC Hiperface (7)
Sincos encoders with SSI comms for absolute position	SC SSI (11)
Sincos incremental with absolute position from single sin and cosine signals	SC SC (15)
SSI encoders (Gray code or binary)	SSI (10)
EnDat communication only encoders	EnDat (8)
Resolver	Resolver (14)
UVW commutation only encoders* (not currently supported)	Commutation only (16)

* This feedback device provides very low resolution feedback and should not be used for applications requiring a high level of performance

Table 6-28 Supported feedback devices on the P2 position interface

Encoder type	Pr 3.138 setting
Quadrature incremental encoders with or without marker pulse	AB (1)
Frequency and direction incremental encoders with or without marker pulse	FD (2)
Forward / reverse incremental encoders with or without marker pulse	FR (3)
EnDat communication only encoders	EnDat (4)
SSI encoders (Gray code or binary)	SSI (5)

Table 6-29 shows the possible combinations of position feedback device types connected to the P1 and P2 position interfaces and the availability of the encoder simulation output.

Table 6-29 Availability of the P2 position feedback interface and the encoder simulation output

Functions		
P1 Position feedback interface	P2 Position feedback interface	Encoder Simulation Output
AB Servo FD Servo FR Servo SC Servo SC SC Commutation only	None	None
AB FD FR SC Resolver SC Hiperface	AB, FD, FR EnDat, SSI None	None Full
SC EnDat SC SSI	AB, FD, FR (No Z marker pulse input)	None
	EnDat, SSI (with freeze input)	
	None	No Z marker pulse output
EnDat SSI	AB, FD, FR EnDat, SSI	None
	None	Full
	EnDat, SSI	No Z marker pulse output

The priority of the position feedback interfaces and the encoder simulation output on the 15-way D-type is assigned in the following order from the highest priority to the lowest.

- P1 position interface (highest)
- Encoder simulation output
- P2 position interface (lowest)

For example, if an AB Servo type position feedback device is selected for use on the P1 position interface, then both the encoder simulation output and the P2 position interface will not be available as this device uses all connections of the 15-way D-type connector. Also, if an AB type position feedback device is selected for use on the P1 position interface and Pr **03.085** is set to a valid source for the encoder simulation output, then the P2 position interface will not be available.

Depending on the device type used on the P1 position interface, the encoder simulation output may not be able support a marker pulse output (e.g. SC EnDat or SC SSI device types). Pr **03.086** shows the status of the encoder simulation output indicating whether the output is disabled, no marker pulse is available or full encoder simulation is available.

NOTE

When using the P1 and P2 position interfaces and the encoder simulation output together, the P2 position interface uses alternative connections on the 15-way D-type connector. Pr **03.172** shows the status of the P2 position interface and indicates if alternative connections are being used for the P2 position interface.

6.16.3 Position feedback connection details

Table 6-30 P1 Position feedback connection details

P1 Position feedback interface Pr 03.038	Connections														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
AB (0)	A	A\	B	B\	Z	Z\							+V	0V	Th
FD (1)	F	F\	D	D\	Z	Z\									
FR (2)	F	F\	R	R\	Z	Z\									
AB Servo (3)	A	A\	B	B\	Z	Z\	U	U\	V	V\	W	W\			
FD Servo (4)	F	F\	D	D\	Z	Z\	U	U\	V	V\	W	W\			
FR Servo (5)	F	F\	R	R\	Z	Z\	U	U\	V	V\	W	W\			
SC (6)	A (Cos)	A\ (Cos\)	B (Sin)	B\ (Sin\)	Z	Z\									
SC Hiperface (7)	Cos	Cosref	Sin	Sinref	DATA	DATA\									
EnDat (8)	DATA	DATA\	CLK	CLK\	Freeze	Freeze\									
SC EnDat (9)	A	A\	B	B\	DATA	DATA\					CLK	CLK\			
SSI (10)	DATA	DATA\	CLK	CLK\	Freeze	Freeze\									
SC SSI (11)	A (Cos)	A\ (Cos\)	B (Sin)	B\ (Sin\)	DATA	DATA\					CLK	CLK\			
SC Servo (12)	A (Cos)	A\ (Cos\)	B (Sin)	B\ (Sin\)	Z	Z\	U	U\	V	V\	W	W\			
Resolver (14)	Cos H	Cos L	Sin H	Sin L	Ref H	Ref L									
SC SC (15)	A (Cos)	A\ (Cos\)	B (Sin)	B\ (Sin\)	Z	Z\	C*1	C*1	D*2	D*2	Freeze2	Freeze2\			
Commutation Only (16)							U	U\	V	V\	W	W\			

*1 - One cosine wave per revolution

*2 - One sine wave per revolution

Greyed cells are for P2 position feedback connections or simulated encoder outputs.

NOTE

Freeze and Freeze\ on terminals 5 and 6 are for Freeze input 1. Freeze2 and Freeze2\ on terminals 11 and 12 are for Freeze input 2.

Table 6-31 P2 Position feedback and encoder simulation output connection details

P1 Position feedback interface Pr 03.038	P2 Position feedback interface Pr 03.138	Encoder Simulation Output	Connections							
			5	6	7	8	9	10	11	12
AB (0) FD (1) FR (2) SC (6) SC Hiperface (7) Resolver (14)	AB (1)	Disabled* ¹			A	A\	B	B\	Z	Z\
	FD (2)		F	F\	D	D\	Z	Z\		
	FR (3)		F	F\	R	R\	Z	Z\		
	EnDat (4) SSI (5)		DATA	DATA\	CLK	CLK\	Freeze2	Freeze2\		
	None (0)	AB	Asim	Asim\	Bsim	Bsim\	Zsim	Zsim\		
		FD	Fsim	Fsim\	Dsim	Dsim\	Zsim	Zsim\		
		FR	Fsim	Fsim\	Rsim	Rsim\	Zsim	Zsim\		
		SSI	DATAsim	DATAsim\	CLKsim	CLKsim\				
SC EnDat (9) SC SSI (11)	AB (1)	Disabled* ¹			A	A\	B	B\		
	FD (2)		F	F\	D	D\				
	FR (3)		F	F\	R	R\				
	EnDat (4) SSI (5)		DATA	DATA\	CLK	CLK\				
	None (0)	AB	Asim	Asim\	Bsim	Bsim\				
		FD	Fsim	Fsim\	Dsim	Dsim\				
		FR	Fsim	Fsim\	Rsim	Rsim\				
		SSI	DATAsim	DATAsim\	CLKsim	CLKsim\				
EnDat (8) SSI (10)	AB (1)	Disabled* ¹			A	A\	B	B\	Z	Z\
	FD (2)		F	F\	D	D\	Z	Z\		
	FR (3)		F	F\	R	R\	Z	Z\		
	EnDat (4) SSI (5)		DATA	DATA\	CLK	CLK\	Freeze2	Freeze2\		
	None (0)	AB	Asim	Asim\	Bsim	Bsim\	Zsim	Zsim\		
		FD	Fsim	Fsim\	Dsim	Dsim\	Zsim	Zsim\		
		FR	Fsim	Fsim\	Rsim	Rsim\	Zsim	Zsim\		
		SSI	DATAsim	DATAsim\	CLKsim	CLKsim\				
EnDat (8) SSI (10) (with no Freeze inputs)	EnDat (4) SSI (5)	AB	DATA	DATA\	Asim	Asim\	Bsim	Bsim\	CLK	CLK\
		FD	DATA	DATA\	Fsim	Fsim\	Dsim	Dsim\	CLK	CLK\
		FR	DATA	DATA\	Fsim	Fsim\	Rsim	Rsim\	CLK	CLK\
		SSI	DATA	DATA\	DATAsim	DATAsim\	CLKsim	CLKsim\	CLK	CLK\

*¹ The encoder simulation output is disabled when Pr 03.085 is set to zero.

NOTE

The termination resistors are always enabled on the P2 position interface. Wire break detection is not available when using AB, FD or FR position feedback device types on the P2 position interface.

6.16.4 Position feedback terminal specifications

1	A,F, Cosref, Data, Cos H
2	A\,F\ Cosref\, Data\, Cos L
AB (0), FD (1), FR (2), AB Servo (3), FD Servo (4), FR Servo (5)	
Type	EIA 485 differential receivers
Maximum input frequency	500 kHz
Line loading	< 2 unit loads
Line termination components	120 Ω (switchable)
Working common mode range	-7 V to +12 V
SC Hiperface (7), SC EnDat (9), SC SSI (11), SC Servo (12), SC SC (15)	
Type	Differential voltage
Maximum Signal level	1.25 V peak to peak (sin with regard to sinref and cos with regard to cosref)
Maximum input frequency	See Table 6-32
Maximum applied differential voltage and common mode voltage range	±4 V
Resolution: The sine wave frequency can be up to 500 kHz but the resolution is reduced at high frequency. Table shows the number of bits of interpolated information at different frequencies and with different voltage levels at the drive encoder port	
EnDat (8), SSI (10)	
Type	EIA 485 differential receivers
Maximum input frequency	4 MHz
Line termination components	120 Ω (switchable)
Working common mode range	-7 V to +12 V
Resolver (14)	
Type	2 Vrms sinusoidal signal
Operating Frequency	6 - 8 kHz
Input voltage	0.6 Vrms
Minimum impedance	85 Ω
Common to All	
Absolute maximum applied voltage relative to 0V	-9 V to 14 V

NOTE

The position feedback input will accept 5 V TTL differential signals.

3	B, D, R Sinref, Clock, Sin H
4	B\, D\, R\, Sinref\, Clock\, Sin L
AB (0), FD (1), FR (2), AB Servo (3), FD Servo (4), FR Servo (5)	
Type	EIA 485 differential receivers
Maximum input frequency	500 kHz
Line loading	< 2 unit loads
Line termination components	120 Ω (switchable)
Working common mode range	-7 V to +12 V
SC Hiperface (7), SC EnDat (9), SC SSI (11), SC Servo (12), SC SC (15)	
Type	Differential voltage
Maximum Signal level	1.25 V peak to peak (sin with regard to sinref and cos with regard to cosref)
Maximum input frequency	See Table 6-32
Maximum applied differential voltage and common mode voltage range	±4 V
Resolution: The sine wave frequency can be up to 500 kHz but the resolution is reduced at high frequency. Table shows the number of bits of interpolated information at different frequencies and with different voltage levels at the drive encoder port	
EnDat (8), SSI (10)	
Type	EIA 485 differential receivers
Maximum input frequency	4 MHz
Line termination components	120 Ω (switchable)
Working common mode range	-7 V to +12 V
Resolver (14)	
Type	2 Vrms sinusoidal signal
Operating Frequency	6 - 8 kHz
Input voltage	0.6 Vrms
Minimum impedance	85 Ω
Common to All	
Absolute maximum applied voltage relative to 0V	-9 V to 14 V

5	Z, Data, Freeze, Ref H
6	ZI, DataI, FreezeI, Ref L
AB (0), FD (1), FR (2), AB Servo (3), FD Servo (4), FR Servo (5), SC SC (15)	
Type	EIA 485 differential receivers
Maximum input frequency	512 kHz
Line loading	< 2 unit loads
Line termination components	120 Ω (switchable)
Working common mode range	-7 V to +12 V
SC Hiperface (7), SC EnDat (9), SC SSI (11), SC Servo (12)	
Type	EIA 485 differential receivers
Maximum input frequency	4 MHz
Line termination components	120 Ω (switchable)
Working common mode range	-7 V to +12 V
EnDat (8), SSI (10)	
Type	EIA 485 differential receivers
Maximum input frequency	4 MHz
Line termination components	120 Ω (switchable)
Working common mode range	-7 V to +12 V
Resolver (14)	
Type	Differential voltage
Nominal voltage	0 – 2 Vrms depending on turns ratio
Operating frequency	6 - 8 KHz
Minimum impedance	85 Ω
Common to All	
Absolute maximum applied voltage relative to 0V	-9 V to 14 V

7	U, C, Not used, Not used
8	UI, CI, Not used, Not used
AB Servo (3), FD Servo (4), FR Servo (5), SC Servo (12)	
Type	EIA 485 differential receivers
Maximum input frequency	512 kHz
Line loading	1 unit load
Line termination components	120 Ω (switchable)
Working common mode range	-7 V to +12 V
SC SC (15)	
Type	Differential voltage
Maximum Signal level	1.25 V peak to peak (sin with regard to sinref and cos with regard to cosref)
Maximum input frequency	See Table 6-32
Maximum applied differential voltage and common mode voltage range	±4 V
EnDat (8), SSI (10)	
Not used	
Resolver (14)	
Not used	
Common to All	
Absolute maximum applied voltage relative to 0V	-9 V to 14 V

9	V, D, Not used, Not used
10	VI, DI, Not used, Not used
AB Servo (3), FD Servo (4), FR Servo (5), SC Servo (12)	
Type	EIA 485 differential receivers
Maximum input frequency	512 kHz
Line loading	1 unit load
Line termination components	120 Ω (switchable)
Working common mode range	-7 V to +12 V
SC SC (15)	
Type	Differential voltage
Maximum Signal level	1.25 V peak to peak (sin with regard to sinref and cos with regard to cosref)
Maximum input frequency	See Table 6-32
Maximum applied differential voltage and common mode voltage range	±4 V
EnDat (8), SSI (10)	
Not used	
Resolver (14)	
Not used	
Common to All	
Absolute maximum applied voltage relative to 0V	-9 V to 14 V

11	W, Clock, Not used, Not used
12	W, Clock, Not used, Not used
AB Servo (3), FD Servo (4), FR Servo (5), SC Servo (12)	
Type	EIA 485 differential receivers
Maximum input frequency	512 kHz
Line loading	1 unit load
Line termination components	120 Ω (switchable)
Working common mode range	-7 V to +12 V
SC EnDat (9), SC SSI (11)	
Type	Differential voltage
Maximum Signal level	1.25 V peak to peak (sin with regard to sinref and cos with regard to cosref)
Maximum input frequency	See Table 6-32
Maximum applied differential voltage and common mode voltage range	±4 V
EnDat (8), SSI (10)	
Not used	
Resolver (14)	
Not used	
Common to All	
Absolute maximum applied voltage relative to 0V	-9 V to 14 V

Common to all Feedback types

13	Feedback device supply
Supply voltage	5.15 V ±2 %, 8 V ±5 % or 15 V ±5 %
Maximum output current	300 mA for 5 V and 8 V 200 mA for 15 V
The voltage on Terminal 13 is controlled by Pr 03.036 . The default for this parameter is 5 V (0) but this can be set to 8 V (1) or 15 V (2). Setting the encoder voltage too high for the encoder could result in damage to the feedback device. The termination resistors should be disabled if the outputs from the encoder are higher than 5 V.	

14	0V Common
-----------	------------------

15	Motor thermistor input
Thermistor type is selected in <i>P1 Thermistor Type</i> (03.118).	

Sincos encoder resolution

The sine wave frequency can be up to 500 kHz but the resolution is reduced at high frequency. Table 6-32 shows the number of bits of interpolated information at different frequencies and with different voltage levels at the drive encoder port. The total resolution in bits per revolution is the ELPR plus the number of bits of interpolated information. Although it is possible to obtain 11 bits of interpolation information, the nominal design value is 10 bits.

Table 6-32 Feedback resolution based on frequency and voltage level

Volt/Freq	1 kHz	5 kHz	50 kHz	100 kHz	200 kHz	500 kHz
1.2	11	11	10	10	9	8
1.0	11	11	10	9	9	7
0.8	10	10	10	9	8	7
0.6	10	10	9	9	8	7
0.4	9	9	9	8	7	6

6.17 Safe Torque Off (STO)

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

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

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

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

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

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

Machinery Applications

The Safe Torque Off function has been independently assessed by Notified Body, TÜV Rheinland for use as a safety component of a machine:

Prevention of unintended motor operation: The safety function "Safe Torque Off" can be used in applications up to Cat 4, PL e according to EN ISO 13849-1, SIL 3 according to EN 61800-5-2/ EN 62061/ IEC 61508 and in lift applications according to EN 81-1 and EN81-2.

Type examination certificate number	Date of issue	Models
01.205/5270.01/14	11-11-2014	M700, M701, M702, HS70, HS71, HS72

This certificate is available for download from the TÜV Rheinland website at: <http://www.tuv.com>

Safety Parameters as verified by TÜV Rheinland:

According to IEC 61508-1 to 07 / EN 61800-5-2 / EN 62061

Type	Value	Percentage of SIL 3 allowance
Proof test interval	20 years	
High demand or a continuous mode of operation		
PFH (1/h)	4.21×10^{-11} 1/h	<1 %
Low demand mode of operation (not EN 61800-5-2)		
PFDavg	3.68×10^{-6}	< 1 %

According to EN ISO 13849-1

Type	Value	Classification
Category	4	
Performance Level (PL)	e	
MTTF _D (STO1)	>2500 years	High
MTTF _D (STO2)	>2500 years	High
MTTFD (Single channel STO)	>2500 years	High
DC _{avg}	≥99 %	High
Mission time	20 years	

NOTE

Logic levels comply with IEC 61131-2:2007 for type 1 digital inputs rated at 24 V. Maximum level for logic low to achieve SIL3 and PL e 5 V and 0.5 mA.

Lift (Elevator) Applications

The Safe Torque Off function has been independently assessed for use as a safety component in lift (elevator) applications by Notified Body, TÜV Nord:

The Unidrive M drives series with Safe Torque Off (STO) function if applied according to the "Conditions of application" fulfil the safety requirements of the standards EN81-1, EN81-2, EN 81-50 and EN60664-1 and are in conformity with all relevant requirements of the Directive 95/16/EC.

Certificate of Conformity number	Date of issue	Models
44799 13196202	04-08-2015	M700, M701, M702, HS70, HS71, HS72

The Safe Torque Off function can be used to eliminate electro-mechanical contactors, including special safety contactors, which would otherwise be required for safety applications.

For further information contact the supplier of the drive.

UL Approval

The Safe Torque Off function has been independently assessed by Underwriters Laboratories (UL). The on-line certification (yellow card) reference is: FSPC.E171230.

Safety Parameters as verified by UL:

According to IEC 61508-1 to 7

Type	Value
Safety Rating	SIL 3
SFF	> 99 %
PFH (1/h)	4.43×10^{-10} 1/h (<1 % of SIL 3 allowance)
HFT	1
Beta Factor	2 %
CFF	Not applicable

According to EN ISO 13849-1

Type	Value
Category	4
Performance Level (PL)	e
MTTF _D	2574 years
Diagnostic coverage	High
CCF	65

Two-channel Safe Torque Off

Models M700, M701, HS70 and HS71 have a single channel STO, whereas the M702 and HS72 have dual channel STO.

The dual channel STO has two fully independent channels.

Each input meets the requirements of the standards as defined above.

If either or both inputs are set at a logic low state, there are no single faults in the drive which can permit the motor to be driven.

It is not necessary to use both channels to meet the requirements of the standards. The purpose of the two channels is to allow connection to machine safety systems where two channels are required, and to facilitate protection against wiring faults.

For example, if each channel is connected to a safety-related digital output of a safety related controller, computer or PLC, then on detection of a fault in one output the drive can still be disabled safely through the other output.

Under these conditions, there are no single wiring faults which can cause a loss of the safety function, i.e. inadvertent enabling of the drive.

In the event that the two-channel operation is not required, the two inputs can be connected together to form a single Safe Torque Off input.

One-channel Safe Torque Off (Including Two-channel Safe Torque off with the inputs connected together.)

In a single channel Safe Torque Off application there are no single faults in the drive which can permit the motor to be driven. Therefore it is not necessary to have a second channel to interrupt the power connection, nor a fault detection circuit.

It is important to note that a single short-circuit from the Safe Torque Off input to a DC supply of > 5V could cause the drive to be enabled.

This might occur through a fault in the wiring. This can be excluded according to EN ISO 13849-2 by the use of protected wiring. The wiring can be protected by either of the following methods:

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

or

- By providing the wiring with a grounded (0V of the Drive) shield in a positive-logic grounded control circuit. The shield is provided to avoid a hazard from an electrical fault. It may be grounded by any convenient method; no special EMC precautions are required.

Note on response time of Safe Torque Off, and use with safety controllers with self-testing outputs:

Safe Torque Off has been designed to have a response time of greater than 1 ms so that it is compatible with safety controllers whose outputs are subject to a dynamic test with a pulse width not exceeding 1 ms.

Note on the use of servo motors, other permanent-magnet motors, reluctance motors and salient-pole induction motors:

When the drive is disabled through Safe Torque Off, a possible (although highly unlikely) failure mode is for two power devices in the inverter circuit to conduct incorrectly.

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



WARNING

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



WARNING

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



WARNING

Safe Torque Off does not provide electrical isolation. The supply to the drive must be disconnected by an approved isolation device before gaining access to power connections.



WARNING

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

Safe Torque Off over-ride

The drive does not provide any facility to over-ride the Safe Torque Off function, for example for maintenance purposes.

SISTEMA software utility

A library for use with the SISTEMA software utility providing relevant parameters for Unidrive M Safe Torque Off function and SI-Safety Module is available, please contact the supplier of the drive for further info.

7 Technical data

7.1 Drive technical data

7.1.1 Power and current ratings (Derating for switching frequency and temperature)

For a full explanation of 'Normal Duty' and 'Heavy Duty' refer to section 3.1 *Ratings* on page 16.

5 % derating should be applied when paralleling two or more inverters.

Table 7-1 Maximum permissible continuous output current @ 40 °C (104 °F) ambient

Model	Normal Duty									Heavy Duty									
	Nominal rating		Maximum permissible continuous output current (A) for the following switching frequencies							Nominal rating		Maximum permissible continuous output current (A) for the following switching frequencies							
	kW	hp	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz	kW	hp	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz	
200 V																			
09201760	55	75	216				184	128	93	45	60	176			153	110	81		
09202190	75	100	266	258	218	184	128	93	55	75	219	212	180	153	110	81			
10202830	90	125	325			313	266	194	144	75	100	283		264	228	170	127		
10203000	110	150	360			313	266	194	144	90	125	300		264	228	171	129		
400 V																			
09402000	110	150	221			192	159	108	77	90	150	200	180		157	130	92	65	
09402240	132	200	266	255	231	192	160	109	77	110	150	224	211	190	157	130	92	65	
10402700	160	250	320			285	238	173	124	132	200	270			237	200	147	108	
10403200	200	300	361	339		285	238	173	126	160	250	320	307	282	237	202	147	109	
11403770	225	350	437		415	336	272			185	300	377		372	296	245			
11404170	250	400	487	460	415	336	272			200	350	417	415	372	296	245			
11404640	280	400	507	460	415	336	272			250	400	464	415	372	296	245			
575 V																			
09501040	110	125	125				101	71	54	75	100	104			85	61	47		
09501310	110	150	150			126	100	70	54	90	125	131		106	85	61	47		
10501520	130	200	200	168	126	100	70	54	110	150	152	138	106	85	61	47			
10501900	150	200	200			152	116	76	54	132	200	190	186	137	106	70	51		
11502000	185	250	248		220					150	200	200		184					
11502540	225	300	288	265	220					185	250	254	221	184					
11502850	250	350	315	265	220					225	300	285	221	184					
690 V																			
09601040	110	150	125				100	71	54	90	125	104			85	61	47		
09601310	132	175	155			126	100	71	54	110	150	131		105	85	62	47		
10601500	160	200	172	169	126	100	71	55	132	175	150	138	105	86	62	47			
10601780	185	250	197			154	114	75	55	160	200	178		137	105	69	52		
11602100	200	250	225		220					185	250	210		184					
11602380	250	300	275	265	220					200	250	238	221	184					
11602630	280	400	305	265	220					250	300	263	221	184					

Table 7-2 Maximum permissible continuous output current @ 50 °C (122 °F)

Model	Normal Duty							Heavy Duty						
	Maximum permissible continuous output current (A) for the following switching frequencies							Maximum permissible continuous output current (A) for the following switching frequencies						
	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
200 V														
09201760	216			197	168	117	84	176			165	140	100	72
09202190	253	237	221	197	168	117	85	219	210	195	166	140	101	72
10202830	325	320	302	266	241	176	130	283		279	241	207	153	114
10203000	346	320	302	266	241	176	130	300		279	243	207	153	114
400 V														
09402000	221		213	175	144	97	69	200	180	174	143	119	83	58
09402240	253	237	213	176	144	98	69	213	193	175	143	119	83	58
10402700	320		300	259	217	154	112	270		259	214	182	131	97
10403200	343	321	300	260	217	155	112	307	282	259	214	182	131	99
11403770	437	415	374	298	240			377		343	274	223		
11404170	462	415	374	298	240			415	380	343	274	223		
11404640	462	415	374	298	240			418	380	343	274	223		
575 V														
09501040	125			114	90	62	48	104			97	77	55	42
09501310	150			114	90	62	48	131		126	97	77	55	42
10501520	200	184	154	114	90	62	48	152	150	126	97	78	55	43
10501900	200		196	134	102	66	48	190		171	124	95	63	46
11502000	226		198					200		166				
11502540	262	241	198					240	200	166				
11502850	296	241	198					245	200	166				
690 V														
09601040	125			114	90	62	48	104			97	77	55	42
09601310	155		153	113	89	62	48	131		127	97	77	55	42
10601500	172		153	114	89	62	48	150		128	96	78	56	42
10601780	197		195	134	102	67	48	178		171	125	94	62	44
11602100	205		198					210	200	166				
11602380	250	241	198					238	200	166				
11602630	296	241	198					245	200	166				

NOTE 55 °C ratings are available on request.

Table 7-3 Rectifier current ratings at 40° C (104° F)

Model	Voltage rating	Typical input current	Maximum continuous input current	Maximum overload input current	Typical continuous DC output current	Maximum continuous DC output current
	V	A	A	A	A	A
10204100	200	333	361	494	409	413
10404520	400	370	396	523	452	455
10502430	575	202	218	313	243	246
10602480	690	202	225	313	247	251
11406840	400	557	594	752	684	689
11503840	575	313	338	473	384	387
11604060	690	331	362	465	406	411
1142X400*	400	2 x 326	2 x 358	2 x 516	2 x 395	2 x 400
1162X380*	690	2 x 308	2 x 339	2 x 488	2 x 375	2 x 380

* Twin rectifier

Table 7-4 Rectifier current ratings at 50° C (122° F)

Model	Voltage rating	Typical input current	Maximum continuous input current	Maximum overload input current	Typical continuous DC output current	Maximum continuous DC output current
	V	A	A	A	A	A
10204100	200	333	361	494	409	413
10404520	400	370	396	523	452	455
10502430	575	202	218	313	243	246
10602480	690	202	225	313	247	251
11406840	400	451	481	610	554	558
11503840	575	284	307	429	349	351
11604060	690	285	312	401	350	354
1142X400*	400	2 x 264	2 x 290	2 x 418	2 x 320	2 x 324
1162X380*	690	2 x 265	2 x 292	2 x 421	2 x 323	2 x 327

* Twin rectifier

7.1.2 Power dissipation

Table 7-5 Losses @ 40° C (104° F) ambient (A models)

Model	Normal Duty									Heavy Duty								
	Nominal rating		Drive losses (W) taking into account any current derating for the given conditions							Nominal rating		Drive losses (W) taking into account any current derating for the given conditions						
	kW	hp	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz	kW	hp	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
200 V																		
09201760A	55	75	2028	2170	2312	2596	2448	2160	2031	45	60	1580	1701	1822	2065	2022	1881	1820
09202190A	75	100	2585	2754	2822	2623	2448	2156	2034	55	75	2016	2160	2227	2107	2025	1874	1821
400 V																		
09402000A	110	150	2431	2710	2989	3075	2992	2842	2833	90	150	2132	2136	2370	2492	2475	2501	2538
09402240A	132	200	3016	3191	3143	3063	3000	2856	2828	110	150	2424	2532	2511	2489	2474	2498	2537
575 V																		
09501040A	110	125	1707	1977	2247	2787	2723	2731	2859	75	100	1372	1601	1830	2288	2305	2422	2603
09501310A	110	150	2087	2410	2734	2810	2692	2697	2859	90	125	1752	2034	2316	2332	2302	2412	2607
690 V																		
09601040A	110	150	1878	2213	2548	3218	3155	3266	3465	90	125	1513	1798	2083	2653	2714	2910	3161
09601310A	132	175	2384	2797	3211	3232	3155	3267	3474	110	150	1931	2281	2631	2677	2711	2917	3174

Table 7-6 Losses @ 40° C (104° F) ambient (E/T models)

Model	Normal Duty									Heavy Duty								
	Nominal rating		Drive losses (W) taking into account any current derating for the given conditions							Nominal rating		Drive losses (W) taking into account any current derating for the given conditions						
	kW	hp	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz	kW	hp	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
200 V																		
09201760E	55	75	1889	2031	2174	2458	2348	2112	2006	45	60	1488	1609	1730	1973	1952	1845	1801
09202190E	75	100	2375	2554	2625	2482	2348	2108	2009	55	75	1874	2017	2093	2011	1956	1839	1802
10202830E	90	125	2478	2672	2867	2123	2952	2701	2554	75	100	2068	2240	2413	2561	2494	2376	2303
10203000E	110	150	2802	3016	3230	3126	2957	2706	2554	90	125	2213	2394	2576	2561	2494	2389	2323
400 V																		
09402000E/T	110	150	2286	2565	2844	2966	2917	2807	2815	90	150	2014	2039	2274	2418	2425	2476	2526
09402240E/T	132	200	2806	2998	2984	2955	2925	2821	2811	110	150	2275	2400	2403	2416	2424	2473	2525
10402700E/T	160	250	3210	3582	3954	4148	4034	3939	3843	132	200	2604	2923	3242	3401	3391	3438	3469
10403200E/T	200	300	3703	4121	4226	4154	4038	3947	3874	160	250	3166	3376	3393	3398	3419	3442	3485
11403770E/T	225	350	4182	4576	4708	4444	4246			185	300	3553	3905	4200	3960	3907		
11404170E/T	250	400	4734	4843	4708	4444	4246			200	350	3968	4325	4200	3960	3907		
11404640E/T	280	400	4962	4843	4708	4444	4246			250	400	4477	4325	4200	3960	3907		
575 V																		
09501040E/T	110	125	1595	1865	2135	2675	2644	2687	2831	75	100	1290	1519	1748	2206	2246	2387	2580
09501310E/T	110	150	1933	2256	2580	2696	2616	2654	2831	90	125	1630	1913	2195	2247	2244	2378	2584
10501520E/T	130	200	2692	3137	2923	2696	2616	2654	2831	110	150	1970	2245	2324	2253	2243	2373	2583
10501900E/T	150	200	2384	2797	3209	3072	2946	2990	3189	132	200	2213	2605	2933	2750	2713	2818	3076
11502000E/T	185	250	3391	3999	4097					150	200	2706	3204	3438				
11502540E/T	225	300	4004	4296	4097					185	250	3481	3544	3438				
11502850E/T	250	350	4439	4296	4097					225	300	3957	3544	3438				
690 V																		
09601040E/T	110	150	1730	2065	2400	3070	3058	3215	3434	90	125	1409	1694	1979	2549	2643	2872	3138
09601310E/T	132	175	2160	2573	2986	3083	3058	3216	3443	110	150	1769	2119	2469	2571	2639	2878	3150
10601500E/T	160	200	2420	2882	3270	3083	3052	3192	3472	132	175	2042	2441	2604	2571	2648	2876	3128
10601780E/T	185	250	2614	3132	3649	3667	3495	3633	3993	160	200	2305	2774	3242	3265	3237	3442	3839
11602100E/T	200	250	3225	3893	4497					185	200	3043	3670	3814				
11602380E/T	250	300	4023	4640	4497					200	250	3470	3865	3814				
11602630E/T	280	400	4576	4684	4540					250	300	3869	3865	3814				

Table 7-7 Losses @ 40° C (104° F) ambient (D models)

Model	Normal Duty									Heavy Duty								
	Nominal rating		Drive losses (W) taking into account any current derating for the given conditions							Nominal rating		Drive losses (W) taking into account any current derating for the given conditions						
	kW	hp	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz	kW	hp	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
200 V																		
09201760D	55	75	1340	1482	1624	1909	1878	1773	1748	45	60	1036	1157	1278	1521	1555	1548	1571
09202190D	75	100	1701	1871	1971	1928	1877	1770	1751	55	75	1317	1461	1553	1550	1558	1543	1572
10202830D	90	125	1995	2190	2384	2658	2555	2404	2324	75	100	1647	1819	1991	2167	2150	2111	2095
10203000D	110	150	2266	2480	2694	2660	2559	2408	2324	90	125	1767	1948	2130	2167	2150	2124	2113
400 V																		
09402000D	110	150	1689	1968	2247	2448	2488	2507	2590	90	150	1475	1555	1790	1995	2071	2216	2330
09402240D	132	200	2080	2303	2358	2439	2494	2519	2586	110	150	1670	1831	1891	1993	2070	2214	2329
10402700D	160	250	2321	2693	3065	3366	3389	3473	3502	132	200	1866	2185	2505	2759	2853	3041	3170
10403200D	200	300	2684	3102	3276	3371	3392	3481	3530	160	250	2277	2527	2621	2757	2876	3044	3184
11403770D	225	350	2957	3351	3545	3505	3484			185	300	2499	2851	3160	3132	3218		
11404170D	250	400	3364	3552	3545	3505	3484			200	350	2800	3163	3160	3132	3218		
11404640D	280	400	3534	3552	3545	3505	3484			250	400	3174	3163	3160	3132	3218		
575 V																		
09501040D	110	125	1238	1508	1778	2318	2354	2476	2663	75	100	992	1221	1450	1908	1999	2201	2428
09501310D	110	150	1500	1823	2146	2336	2329	2446	2663	90	125	1255	1537	1820	1944	1997	2193	2432
10501520D	130	200	2094	2539	2433	2336	2329	2446	2663	110	150	1478	1806	1926	1949	1996	2188	2431
10501900D	150	200	1886	2298	2710	2690	2648	2781	3028	132	200	1739	2131	2469	2403	2437	2622	2921
11502000D	185	250	2703	3311	3303					150	200	2142	2639	2759				
11502540D	225	300	3213	3370	3303					185	250	2777	2780	2759				
11502850D	250	350	3579	3370	3303					225	300	3173	2780	2759				
690 V																		
09601040D	110	150	1342	1677	2012	2682	2743	2979	3246	90	125	1082	1367	1652	2222	2369	2663	2968
09601310D	132	175	1682	2095	2509	2693	2743	2981	3254	110	150	1364	1714	2064	2241	2366	2669	2980
10601500D	160	200	1890	2352	2750	2693	2737	2959	3280	132	175	1579	1979	2177	2241	2373	2667	2959
10601780D	185	250	2005	2522	3039	3193	3139	3388	3801	160	200	1756	2225	2693	2841	2907	3211	3656
11602100D	200	250	2608	3276	3698					185	200	2465	3092	3130				
11602380D	250	300	3271	3707	3698					200	250	2818	3098	3130				
11602630D	280	400	3742	3751	3741					250	300	3149	3098	3130				

Table 7-8 Rectifier losses @ 40/50° C (104/122° F) ambient

Rectifier Model	Voltage rating (V)	Maximum Losses (W)
10204100	200	535
10404520	400	1019
10502430	575	499
10602480	690	609
11406840	400	1627
11503840	575	935
11604060	690	661
1142X400*	400	1773
1162X380*	690	1679

* Twin rectifier

Table 7-9 Losses @ 50° C (122° F) ambient (A models)

Model	Normal Duty									Heavy Duty								
	Nominal rating		Drive losses (W) taking into account any current derating for the given conditions							Nominal rating		Drive losses (W) taking into account any current derating for the given conditions						
	kW	hp	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz	kW	hp	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
200 V																		
09201760A	55	75	2028	2170	2312	2354	2256	2010	1910	45	60	1580	1701	1822	1943	1867	1757	1700
09202190A	75	100	2431	2405	2368	2358	2245	2015	1922	55	75	2016	2063	2029	1954	1868	1763	1701
400 V																		
09402000A	110	150	2431	2710	2872	2799	2737	2639	2652	90	150	2132	2136	2290	2289	2305	2342	2399
09402240A	132	200	2837	2926	2870	2814	2737	2660	2665	110	150	2286	2294	2300	2294	2300	2340	2404
575 V																		
09501040A	110	125	1707	1977	2247	2538	2456	2495	2699	75	100	1372	1601	1830	2139	2122	2258	2455
09501310A	110	150	2087	2410	2734	2544	2456	2482	2676	90	125	1752	2034	2222	2143	2128	2258	2453
690 V																		
09601040A	110	150	1878	2213	2548	2933	2882	2974	3248	90	125	1513	1798	2083	2483	2502	2721	2994
09601310A	132	175	2384	2797	3175	2918	2855	2974	3249	110	150	1931	2281	2548	2488	2509	2718	2991

Table 7-10 Losses @ 50° C (122° F) ambient (E/T models)

Model	Normal Duty									Heavy Duty								
	Nominal rating		Drive losses (W) taking into account any current derating for the given conditions							Nominal rating		Drive losses (W) taking into account any current derating for the given conditions						
	kW	hp	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz	kW	hp	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
200 V																		
09201760E	55	75	1889	2031	2174	2240	2172	1970	1889	45	60	1488	1609	1730	1862	1808	1728	1684
09202190E	75	100	2241	2239	2223	2243	2161	1975	1900	55	75	1874	1932	1916	1872	1810	1733	1686
10202830E	90	125	2478	2625	2641	2625	2671	2490	2379	75	100	2068	2240	2375	2326	2271	2185	2141
10203000E	110	150	2666	2629	2643	2629	2678	2495	2374	90	125	2213	2394	2375	2350	2275	2187	2141
400 V																		
09402000E/T	110	150	2286	2565	2738	2709	2675	2611	2638	90	150	2014	2039	2200	2228	2262	2322	2389
09402240E/T	132	200	2648	2760	2735	2723	2675	2632	2651	110	150	2152	2184	2209	2233	2258	2320	2394
10402700E/T	160	250	3210	3582	3681	3765	3700	3597	3591	132	200	2604	2923	3105	3081	3125	3165	3262
10403200E/T	200	300	3482	3598	3676	3776	3694	3625	3589	160	250	3018	3062	3105	3087	3131	3168	3300
11403770E/T	225	350	4182	4329	4228	3988	3843			185	300	3553	3905	3876	3699	3634		
11404170E/T	250	400	4456	4329	4228	3988	3843			200	350	3968	3943	3876	3699	3634		
11404640E/T	280	400	4456	4329	4228	3988	3843			250	400	3974	3943	3876	3699	3634		
575 V																		
09501040E/T	110	125	1595	1865	2135	2443	2392	2460	2674	75	100	1290	1519	1748	2067	2072	2229	2436
09501310E/T	110	150	1933	2256	2580	2448	2392	2447	2652	90	125	1630	1913	2109	2071	2078	2229	2434
10501520E/T	130	200	2692	2841	2654	2448	2392	2447	2652	110	150	1917	2220	2112	2077	2083	2222	2452
10501900E/T	150	200	2384	2797	3141	2743	2672	2766	3036	132	200	2213	2605	2686	2516	2496	2651	2933
11502000E/T	185	250	3391	3678	3532					150	200	2706	3036	2985				
11502540E/T	225	300	3965	3678	3532					185	250	3273	3036	2985				
11502850E/T	250	350	3965	3678	3632					225	300	3273	3036	2985				
690 V																		
09601040E/T	110	150	1730	2065	2400	2810	2803	2934	3223	90	125	1409	1694	1979	2392	2443	2690	2974
09601310E/T	132	175	2160	2573	2955	2796	2778	2934	3225	110	150	1769	2119	2395	2397	2450	2687	2972
10601500E/T	160	200	2420	2882	2947	2805	2789	2932	3229	132	175	2042	2441	2403	2377	2467	2701	2974
10601780E/T	185	250	2614	3132	3610	3243	3221	3420	3771	160	200	2305	2774	3111	3007	2996	3253	3621
11602100E/T	200	250	3225	3893	4048					185	200	3043	3495	3468				
11602380E/T	250	300	4023	4186	4048					200	250	3470	3495	3468				
11602630E/T	280	400	4421	4230	4091					250	300	3580	3495	3468				

Table 7-11 Losses @ 50° C (122° F) ambient (D models)

Model	Normal Duty									Heavy Duty								
	Nominal rating		Drive losses (W) taking into account any current derating for the given conditions							Nominal rating		Drive losses (W) taking into account any current derating for the given conditions						
	kW	hp	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz	kW	hp	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
200 V																		
09201760D	55	75	1340	1482	1624	1738	1738	1658	1651	45	60	1036	1157	1278	1435	1442	1453	1474
09202190D	75	100	1601	1639	1662	1740	1729	1662	1661	55	75	1317	1397	1418	1443	1443	1457	1476
10202830D	90	125	1995	2149	2192	2228	2310	2218	2167	75	100	1647	1819	1959	1965	1957	1943	1950
10203000D	110	150	2153	2153	2193	2231	2316	2222	2163	90	125	1767	1948	1959	1986	1961	1945	1950
400 V																		
09402000D	110	150	1689	1968	2163	2239	2287	2338	2434	90	150	1475	1555	1732	1841	1936	2084	2210
09402240D	132	200	1961	2118	2161	2250	2286	2356	2446	110	150	1578	1665	1739	1845	1933	2082	2214
10402700D	160	250	2321	2693	2853	3059	3114	3182	3282	132	200	1866	2185	2398	2504	2635	2808	2990
10403200D	200	300	2521	2705	2849	3067	3109	3206	3280	160	250	2168	2289	2398	2508	2640	2811	3023
11403770D	225	350	2957	3166	3181	3153	3168			185	300	2499	2851	2917	2932	3005		
11404170D	250	400	3159	3166	3181	3153	3168			200	350	2800	2879	2917	2932	3005		
11404640D	280	400	3159	3166	3181	3153	3168			250	400	2805	2879	2917	2932	3005		
575 V																		
09501040D	110	125	1238	1508	1778	2118	2133	2270	2518	75	100	992	1221	1450	1789	1846	2058	2295
09501310D	110	150	1500	1823	2146	2122	2133	2259	2498	90	125	1255	1537	1748	1792	1852	2058	2293
10501520D	130	200	2094	2298	2209	2122	2133	2259	2498	110	150	1478	1786	1751	1798	1856	2052	2310
10501900D	150	200	1886	2298	2652	2404	2406	2579	2888	132	200	1739	2131	2259	2200	2246	2471	2789
11502000D	185	250	2703	3039	2995					150	200	2142	2499	2529				
11502540D	225	300	3180	3039	2995					185	250	2606	2499	2529				
11502850D	250	350	3180	3039	2995					225	300	2606	2499	2529				
690 V																		
09601040D	110	150	1342	1677	2012	2455	2516	2724	3050	90	125	1082	1367	1652	2086	2192	2498	2818
09601310D	132	175	1682	2095	2482	2443	2494	2724	3052	110	150	1364	1714	2001	2090	2198	2496	2815
10601500D	160	200	1890	2352	2475	2450	2503	2722	3055	132	175	1579	1979	2008	2073	2213	2508	2818
10601780D	185	250	2005	2522	3007	2829	2899	3196	3598	160	200	1756	2225	2584	2621	2697	3042	3457
11602100D	200	250	2608	3276	3501					185	200	2465	2944	3005				
11602380D	250	300	3271	3526	3501					200	250	2818	2944	3005				
11602630D	280	400	3612	3569	3545					250	300	2909	2944	3005				

Table 7-12 Power losses from the front of the drive when through-panel mounted

Frame size	Power loss
All sizes	≤ 480 W
Rectifier (all models)	≤ 50 W

Table 7-13 Input line reactor losses @ 40/50° C (104/122° F)

Part number	Model	Maximum Losses
4401-0181	INL401	148 W
4401-0182	INL402	205 W
4401-0259	INL403	330 W
4401-0274	INL403L	289 W
4401-0183	INL601	88 W
4401-0184	INL602	116 W
4401-0261	INL603	320 W

Table 7-14 Output sharing choke losses @ 40/50° C (104/122° F)

Part number	Model	Maximum Losses
4401-0197	OTL401	113 W
4401-0198	OTL402	145 W
4401-0199	OTL403	122 W
4401-0200	OTL404	156 W
4401-0270	OTL405	315 W
4401-0267	OTL407	396 W
4401-0201	OTL601	63 W
4401-0202	OTL602	74 W
4401-0203	OTL603	61 W
4401-0204	OTL604	71 W
4401-0271	OTL605	350 W
4401-0266	OTL607	292 W

7.1.3 Supply requirements

AC supply voltage:

- 200 V drive: 200 V to 240 V ± 10 %
- 400 V drive: 380 V to 480 V ± 10 %
- 575 V drive: 500 V to 575 V ± 10 %
- 690 V drive: 500 V to 690 V ± 10 %

Number of phases: 3

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

Frequency range: 45 to 66 Hz

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

7.1.4 Line reactors

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

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

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

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

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

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

Drive sizes 9E/T, 10E/T and 11E/T do not have internal input line reactors hence an external input line reactor must be used. For more information refer to section 6.2.2 *Input line reactor specifications* on page 93.

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

Reactor current ratings

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

Continuous current rating:

Not less than the continuous input current rating of the drive

Repetitive peak current rating:

Not less than twice the continuous input current rating of the drive

7.1.5 Motor requirements

No. of phases: 3

Maximum voltage:

- 200 V drive: 265 V
- 400 V drive: 530 V
- 575 V drive: 635 V
- 690 V drive: 765 V

7.1.6 Temperature, humidity and cooling method

Ambient temperature operating range:

- 20 °C to 55 °C (- 4 °F to 131 °F).

Output current derating must be applied at ambient temperatures >40 °C (104 °F).

Cooling method: Forced convection

Maximum humidity: 95 % non-condensing at 40 °C (104 °F)

7.1.7 Storage

-40 °C (-40 °F) to +55 °C (131 °F) for long term storage, or to +70 °C (158 °F) for short term storage.

Storage time is 2 years.

Electrolytic capacitors in any electronic product have a storage period after which they require reforming or replacing.

The DC bus capacitors have a storage period of 10 years.

The low voltage capacitors on the control supplies typically have a storage period of 2 years and are thus the limiting factor.

Low voltage capacitors cannot be reformed due to their location in the circuit and thus may require replacing if the drive is stored for a period of 2 years or greater without power being applied.

It is therefore recommended that drives are powered up for a minimum of 1 hour after every 2 years of storage.

This process allows the drive to be stored for a further 2 years.

7.1.8 Altitude

Altitude range: 0 to 3,000 m (9,900 ft), subject to the following conditions:

- 1,000 m to 3,000 m (3,300 ft to 9,900 ft) above sea level: de-rate the maximum output current from the specified figure by 1% per 100 m (330 ft) above 1,000 m (3,300 ft)

For example at 3,000 m (9,900 ft) the output current of the drive would have to be de-rated by 20 %.

7.1.9 IP / UL Rating

The drive is rated to IP20 pollution degree 2 (dry, non-conductive contamination only) (NEMA 1). However, it is possible to configure the drive to achieve IP55 rating (size 9,10 and 11) (NEMA 12) at the rear of the heatsink for through-panel mounting.

The IP rating of a product is a measure of protection against ingress and contact to foreign bodies and water. It is stated as IP XX, where the two digits (XX) indicate the degree of protection provided as shown in Table 7-15.

Table 7-15 IP Rating degrees of protection

First digit		Second digit	
Protection against foreign bodies and access to hazardous parts		Protection against ingress of water	
0	Non-protected	0	Non-protected
1	Protected against solid foreign objects of 50 mm \varnothing and greater (back of a hand)	1	Protected against vertically falling water drops
2	Protected against solid foreign objects of 12.5mm \varnothing and greater (finger)	2	Protected against vertically falling water drops when enclosure tilted up to 15 °
3	Protected against solid foreign objects of 2.5 mm \varnothing and greater (tool)	3	Protected against spraying water
4	Protected against solid foreign objects of 1.0mm \varnothing and greater (wire)	4	Protected against splashing water
5	Dust-protected (wire)	5	Protected against water jets
6	Dust-tight (wire)	6	Protected against powerful water jets
7	-	7	Protected against the effects of temporary immersion in water
8	-	8	Protected against the effects of continuous immersion in water

Table 7-16 UL enclosure ratings

UL rating	Description
Type 1	Enclosures are intended for indoor use, primarily to provide a degree of protection against limited amounts of falling dirt.
Type 12	Enclosures are intended for indoor use, primarily to provide a degree of protection against dust, falling dirt and dripping non-corrosive liquids.

7.1.10 Corrosive gasses

Concentrations of corrosive gases must not exceed the levels given in:

- Table A2 of EN 50178:1998
- Class 3C2 of IEC 60721-3-3

This corresponds to the levels typical of urban areas with industrial activities and/or heavy traffic, but not in the immediate neighborhood of industrial sources with chemical emissions.

7.1.11 RoHS compliance

The drive meets EU directive 2011/65/EU for RoHS compliance.

7.1.12 Vibration

Maximum recommended continuous vibration level 0.14 g r.m.s. broadband 5 to 200 Hz.

NOTE

This is the limit for broad-band (random) vibration. Narrow-band vibration at this level which coincides with a structural resonance could result in premature failure.

Bump Test

Testing in each of three mutually perpendicular axes in turn.
Referenced standard: IEC 60068-2-29: Test Eb:
Severity: 18 g, 6 ms, half sine
No. of Bumps: 600 (100 in each direction of each axis)

Random Vibration Test

Testing in each of three mutually perpendicular axes in turn.
Referenced standard: IEC 60068-2-64: Test Fh:
Severity: 1.0 m²/s³ (0.01 g²/Hz) ASD from 5 to 20 Hz
-3 dB/octave from 20 to 200 Hz
Duration: 30 minutes in each of 3 mutually perpendicular axes.

Sinusoidal Vibration Test

Testing in each of three mutually perpendicular axes in turn.
Referenced standard: IEC 60068-2-6: Test Fc:
Frequency range: 5 to 500 Hz
Severity: 3.5 mm peak displacement from 5 to 9 Hz
10 m/s² peak acceleration from 9 to 200 Hz
15 m/s² peak acceleration from 200 to 500 Hz
Sweep rate: 1 octave/minute
Duration: 15 minutes in each of 3 mutually perpendicular axes.

EN 61800-5-1:2007, Section 5.2.6.4. referring to IEC 60068-2-6

Frequency range: 10 to 150 Hz
Amplitude: 10 to 57 Hz at 0.075 mm pk
57 to 150 Hz at 1g p
Sweep rate: 1 octave/minute
Duration: 10 sweep cycles per axis in each of 3 mutually perpendicular axes

7.1.13 Starts per hour

By electronic control: unlimited

By interrupting the AC supply: ≤20 (equally spaced)

7.1.14 Start up time

This is the time taken from the moment of applying power to the drive, to the drive being ready to run the motor:

Size 9 to 11: 5s

7.1.15 Output frequency / speed range

Unidrive Mxxx models:

In all operating modes (Open loop, RFC-A, RFC-S) the maximum output frequency is limited to 550 Hz.

Unidrive HSxx models:

In open loop mode the maximum achievable output frequency is 3,000 Hz.

In RFC-A and RFC-S modes, the maximum achievable output frequency is 1,250Hz.

In RFC-S mode the speed is also limited by the voltage constant (Ke) of the motor unless field weakening operation is enabled. 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).

It is recommended that a minimum ratio of 12:1 is maintained between the switching frequency and the maximum output frequency to maintain the quality of the output waveform. If this minimum ratio is exceeded, extra motor losses will result due to the increased harmonic content of the output waveform.

7.1.16 Accuracy and resolution

Speed:

The absolute frequency and speed accuracy depends on the accuracy of the crystal used with the drive microprocessor. The accuracy of the crystal is 100 ppm, and so the absolute frequency/speed accuracy is 100 ppm (0.01 %) of the reference, when a preset speed is used. If an analog input is used the absolute accuracy is further limited by the absolute accuracy of the analog input.

The following data applies to the drive only; it does not include the performance of the source of the control signals.

Open loop resolution:

Preset frequency reference: 0.1 Hz
Precision frequency reference: 0.001 Hz

Closed loop resolution

Preset speed reference: 0.1 rpm
Precision speed reference: 0.001 rpm
Analog input 1: 11 bit plus sign
Analog input 2: 11 bit plus sign

Current:

The resolution of the current feedback is 10 bit plus sign.

Accuracy: typical 2 %

worst case 5 %

7.1.17 Acoustic noise

The heatsink fan generates the majority of the sound pressure level at 1 m produced by the drive. The heatsink fan on size 9, 10 and 11 is a variable speed fan. The drive controls the speed at which the fan runs based on the temperature of the heatsink and the drive's thermal model system.

Table 7-17 gives the sound pressure level at 1 m produced by the drive for the heatsink fan running at the maximum and minimum speeds.

Table 7-17 Acoustic noise data

Size	Max speed dBA	Min speed dBA
9A/9E/9T/10E/10T	75.0	52.6
9D/10D	77.1	53.8
9/10 rectifier	67.1	40.7
11E/11T	82.5	58
11D	79.5	60.4
11 rectifier (single or twin)	66.5	44.8

7.1.18 Overall dimensions

- H Height including surface mounting brackets
- W Width
- D Projection forward of panel when surface mounted
- F Projection forward of panel when through-panel mounted
- R Projection rear of panel when through-panel mounted

Table 7-18 Overall drive dimensions

Size	Dimension				
	H	W	D	F	R
9A	1108 mm (43.61 in)	310 mm (12.21 in)	290 mm (11.42 in)	190 mm (7.48 in)	100 mm (3.94 in)
9E/10E	1069 mm (42.09 in)	310 mm (12.21 in)	290 mm (11.42 in)	190 mm (7.48 in)	99 mm (3.90 in)
9T/10T	1159 mm (45.63 in)	310 mm (12.21 in)	290 mm (11.42 in)	190 mm (7.48 in)	100 mm (3.94 in)
11E/T	1242 mm (48.9 in)	310 mm (12.21 in)	313 mm (12.32 in)	190 mm (7.48 in)	123 mm (4.84 in)
9D/10D	773 mm (30.43 in)	310 mm (12.21 in)	290 mm (11.42 in)	190 mm (7.48 in)	100 mm (3.94 in)
11D	863 mm (33.97 in)	310 mm (12.21 in)	312 mm (12.28 in)	190 mm (7.48 in)	122 mm (4.8 in)
10 rectifier	355 mm (13.98 in)	310 mm (12.21 in)	290 mm (11.42 in)	190 mm (7.48 in)	99 mm (3.90 in)
11 rectifier	405.5 mm (15.96 in)	310 mm (12.21 in)	290 mm (11.42 in)	190 mm (7.48 in)	100 mm (3.94 in)

7.1.19 Weights

Table 7-19 Overall drive weights

Size	kg	lb
9E/10E	46	101.40
9T/10T	60	132.3
9D/10D	34	74.9
9A	66.5	146.6
10 rectifier	13	28.7
11E	63	138.9
11D	42	92.6
11T	65	143.3
Size 11 single rectifier	21	46.3
Size 11 twin rectifier	23	50.7

7.1.20 Safe Torque Off data

For full details of the Safe Torque Off (STO) function please refer to section 6.17 *Safe Torque Off (STO)* on page 131.

7.1.21 Input current, fuse and cable size ratings

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

Typical input current

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

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

Maximum continuous input current

The values of maximum continuous input current are given to aid the selection of cables and fuses. These values are stated for the worst case condition with the unusual combination of stiff supply with bad balance. The value stated for the maximum continuous input current would only be seen in one of the input phases. The current in the other two phases would be significantly lower.

The values of maximum input current are stated for a supply with a 2 % negative phase-sequence imbalance and rated at the maximum supply fault current given in Table 7-20.

Table 7-20 Supply fault current used to calculate maximum input currents

Model	Symmetrical fault level (kA)
All	100


 WARNING	Fuses The AC supply to the drive must be installed with suitable protection against overload and short-circuits. Table 7-21 and Table 7-23 show the recommended fuse ratings. Failure to observe this requirement will cause risk of fire.
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Table 7-21 Unidrive M / Unidrive HS size 10 and 11 rectifier current and fuse ratings

Model	Typical input current A	Maximum continuous input current A	Maximum overload input current A	Fuse rating					
				IEC			UL/USA		
				Nominal A	Maximum A	Class	Nominal A	Maximum A	Class
10204100	333	361	494	450	450	gR	450	450	HSJ
10404520	370	396	523	450	450		450	450	
10502430	202	218	313	250	250		250	250	
10602480	202	225	313	250	250		250	250	
11406840	557	594	752	630	630	gR	600	600	HSJ
11503840	313	338	473	400	400		400	400	
11604060	331	362	465	400	400		400	400	
1142X400*	2 x 326	2 x 358	2 x 516	400	400		400	400	
1162X380*	2 x 308	2 x 339	2 x 488	400	400		400	400	

Table 7-22 Cable ratings for Unidrive M / Unidrive HS size 10 and 11 rectifiers

Model	Cable size (IEC)						Cable size (UL)			
	mm ²						AWG or kcmil			
	Input			Output			Input		Output	
	Nominal	Maximum	Installation method	Nominal	Maximum	Installation method	Nominal	Maximum	Nominal	Maximum
10204100	2 x 150	2 x 185	C	2 x 120	2 x 150	C	2 x 300	2 x 500	2 x 400	2 x 500
10404520	2 x 150	2 x 185	C	2 x 150	2 x 150	C	2 x 350	2 x 500	2 x 500	2 x 500
10502430	2 x 95	2 x 185	B2	2 x 95	2 x 150	B2	2 x 3/0	2 x 500	2 x 3/0	2 x 500
10602480	2 x 95	2 x 185	B2	2 x 95	2 x 150	B2	2 x 3/0	2 x 500	2 x 3/0	2 x 500
11406840	4 x 120	4 x 120	C	4 x 150	4 x 150	C	2 x 250	2 x 250	2 x 300	2 x 300
11503840	2 x 120	2 x 120	C	2 x 120	2 x 120	C	2 x 250			
11604060	2 x 120	2 x 120	C	2 x 120	2 x 120	C	2 x 300	2 x 300	2 x 400	2 x 400
1142X400*	2 x 2 x 120	2 x 2 x 120	C	2 x 2 x 120	2 x 2 x 120	C	2 x 2 x 300			
1162X380*	2 x 2 x 120	2 x 2 x 120	C	2 x 2 x 120	2 x 2 x 120	C	2 x 2 x 300			

* Twin rectifier

Table 7-23 AC input current and fuse ratings for Unidrive M / Unidrive HS size 9, 10 and 11 inverters

Model	Typical input current A	Maximum continuous input current A	Maximum overload input current A	Fuse rating					
				IEC			UL / USA		
				Nominal A	Maximum A	Class	Nominal A	Maximum A	Class
09201760	172	205	270	250	250	gR	250	250	HSJ
09202190	228	260	319	315	315		300	300	
10202830	277	305	421	400	400	gR	400	400	HSJ
10203000	333	361	494	450	450		450	450	
09402000	211	232	306	315	315	gR	300	300	HSJ
09402240	245	267	359	315	315	gR	350	350	HSJ
10402700	306	332	445	400	400	gR	400	400	HSJ
10403200	370	397	523	450	450		450	450	
11403770	424	449	579	500	500	gR	600	600	HSJ
11404170	455	492	613						
11404640	502	539	752	630	630				
09501040	145	166	190	150	150	gR	150	150	HSJ
09501310	145	166	221	200	200		175	175	
10501520	177	197	266	250	250	gR	250	250	HSJ
10501900	199	218	310						
11502000	240	265	327	400	400	gR	400	400	HSJ
11502540	285	310	395						
11502850	313	338	473						
09601040	124	149	194	150	150	gR	150	150	HSJ
09601310	145	171	226	200	200		200	200	
10601500	180	202	268	225	225	gR	250	250	HSJ
10601780	202	225	313	250	250	gR	250	250	
11602100	225	256	379	400	400	gR	400	400	HSJ
11602380	271	302	425						
11602630	298	329	465						

Table 7-24 Cable ratings for Unidrive M / Unidrive HS size 9, 10 and 11 inverters

Model	Cable size (IEC)						Cable size (UL)			
	mm ²						AWG or kcmil			
	Input			Output			Input		Output	
	Nominal	Maximum	Installation method	Nominal	Maximum	Installation method	Nominal	Maximum	Nominal	Maximum
09201760	2 x 70	2 x 185	B1	2 x 95	2 x 150	B2	2 x 2/0	2 x 500	2 x 2/0	2 x 350
09202190	2 x 95	2 x 185	B1	2 x 120	2 x 150	B2	2 x 4/0	2 x 500	2 x 4/0	2 x 350
10202830	2 x 120	2 x 185	B1	2 x 120	2 x 150	C	2 x 250	2 x 500	2 x 250	2 x 350
10203000	2 x 150	2 x 185	C	2 x 120	2 x 150	C	2 x 300	2 x 500	2 x 300	2 x 350
09402000	2 x 70	2 x 185	B1	2 x 95	2 x 150	B2	2 x 3/0	2 x 500	2 x 2/0	2 x 350
09402240	2 x 95	2 x 185	B1	2 x 120	2 x 150	B2	2 x 4/0	2 x 500	2 x 4/0	2 x 350
10402700	2 x 120	2 x 185	C	2 x 120	2 x 150	C	2 x 300	2 x 500	2 x 250	2 x 350
10403200	2 x 150	2 x 185	C	2 x 150	2 x 150	C	2 x 350	2 x 500	2 x 300	2 x 350
11403770	4 x 95	4 x 95	C	2 x 185	2 x 185	C	4 x 3/0	4 x 3/0	2 x 400	2 x 400
11404170	4 x 95	4 x 95	C	2 x 240	2 x 240	C	4 x 4/0	4 x 4/0	2 x 400	2 x 400
11404640	4 x 95	4 x 95	C	2 x 240	2 x 240	C	4 x 4/0	4 x 4/0	2 x 400	2 x 400
09501040	2 x 70	2 x 185	B2	2 x 35	2 x 150	B2	2 x 1	2 x 500	2 x 3	2 x 350
09501310	2 x 70	2 x 185	B2	2 x 50	2 x 150	B2	2 x 1	2 x 500	2 x 1	2 x 350
10501520	2 x 70	2 x 185	B2	2 x 70	2 x 150	B2	2 x 2/0	2 x 500	2 x 2/0	2 x 350
10501900	2 x 95	2 x 185	B2	2 x 70	2 x 150	B2	2 x 2/0	2 x 500	2 x 2/0	2 x 350
11502000	2 x 70	2 x 70	C	2 x 70	2 x 70	C	2 x 3/0			
11502540	2 x 95	2 x 95	C	2 x 95	2 x 95	C	2 x 4/0			
11502850	2 x 120	2 x 120	C	2 x 120	2 x 120	C	2 x 250			
09601040	2 x 50	2 x 185	B2	2 x 35	2 x 150	B2	2 x 1	2 x 500	2 x 3	2 x 350
09601310	2 x 70	2 x 185	B2	2 x 50	2 x 150	B2	2 x 1/0	2 x 500	2 x 1	2 x 350
10601500	2 x 70	2 x 185	B2	2 x 70	2 x 150	B2	2 x 2/0	2 x 500	2 x 1/0	2 x 350
10601780	2 x 95	2 x 185	B2	2 x 70	2 x 150	B2	2 x 3/0	2 x 500	2 x 2/0	2 x 350
11602100	2 x 70	2 x 70	C	2 x 70	2 x 70	C	2 x 3/0			
11602380	2 x 95	2 x 95	C	2 x 95	2 x 95	C	2 x 4/0			
11602630	2 x 95	2 x 95	C	2 x 95	2 x 95	C	2 x 250			

Table 7-25 DC fuse and cable ratings for Unidrive M / HS size 9, 10 and 11 inverters

Model	Maximum continuous dc input current [Arms]	Maximum overload dc input current [Arms]	DC fuse IEC class aR [Arms]	Max fuse clearing I ² t at operating condition [A ² s]	DC voltage rating	Cable Size DC Input		
						mm ²	AWG or Kcmil	IEC installation Method
09201760	220	300	315	330000	415	2 x 70	2 x 2/0	B1
09202190	287	359	350		415	2 x 95	2 x 4/0	B1
10202830	345	488	450		415	2 x 120	2 x 250	B1
10203000	413	578	500		415	2 x 150	2 x 300	C
09402000	261	351	315	330000	830	2 x 70	2 x 3/0	B1
09402240	303	418	400		830	2 x 95	2 x 4/0	B1
10402700	378	517	450		830	2 x 120	2 x 300	C
10403200	456	614	500		830	2 x 150	2 x 350	C
11403770	525	711	630	594000	830	4 x 95	4 x 250	C
11404170	564	753	700		830	4 x 95	4 x 250	C
11404640	621	925	800		830	4 x 120	4 x 300	C
09501040	181	212	250	137000	990	2 x 70	2 x 1	B2
09501310	181	248	250		990	2 x 70	2 x 1	B2
10501520	220	306	315		990	2 x 70	2 x 2/0	B2
10501900	246	360	315		990	2 x 95	2 x 2/0	B2
11502000	299	402	350	330000	990	2 x 70	2 x 4/0	C
11502540	353	485	450		990	2 x 95	2 x 250	C
11502850	387	583	500		990	2 x 120	2 x 300	C
09601040	158	211	200	137000	1190	2 x 50	2 x 1	B2
09601310	183	252	250		1190	2 x 70	2 x 1/0	B2
10601500	223	303	315		1190	2 x 70	2 x 2/0	B2
10601780	252	359	315		1190	2 x 95	2 x 3/0	B2
11602100	282	466	400	330000	1190	2 x 70	2 x 4/0	C
11602380	332	522	450		1190	2 x 95	2 x 250	C
11602630	371	573	500		1190	2 x 120	2 x 300	C

NOTE

The cable sizes noted in Table 7-22 to Table 7-25 are typical cable sizes based on UL508C and IEC60364-5-52:2001. Maximum cable sizes are 2 x 240 mm² or 2 x 400 kcmil per pole. The user will have to decide what size of cable to use in any given application based on the local wiring regulations. Use of high temperature cables that are thinner than those stated in the typical cable chart maybe possible, contact the supplier of the drive for advice.

Installation method (ref:IEC60364-5-52:2001)

- B1 - Separate cables in conduit
- B2 - Multicore cable in conduit
- C - Multicore cable in free air

NOTE

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

Cable size may be reduced if a different installation method is used, or if the ambient temperature is lower.

NOTE

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

NOTE

The recommended output cable sizes assume that the motor maximum current matches that of the drive. Where a motor of reduced rating is used the cable rating may be chosen to match that of the motor. To ensure that the motor and cable are protected against over-load, the drive must be programmed with the correct motor rated current.

A fuse or other protection must be included in all live connections to the AC supply.

Fuse types

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

IEC Fuse types

- IEC class gG - Full range breaking capability in general application. Slow acting.
- IEC class gR - Dual rated: semiconductor protection (ultra-fast acting) and cable protection.
- IEC class aR - Semiconductor Protection, fast acting. Provides no protection from slow, small overloads, so cable must be protected by using a gG fuse or circuit breaker.
- HRC- High Rupturing Capacity – Denotes the ability of the fuse link to interrupt extremely high fault currents.

North American Fuse Types

- UL class J - Full range breaking capability in general application. Slow acting. Up to 600 V only.

Ferraz HSJ -High speed class J fuses. Dual rated: semiconductor protection (ultra-fast acting) and cable protection. Up to 600 V only and only from Ferraz.

7.1.22 Protective ground cable ratings

Table 7-26 Protective ground cable ratings

Input phase conductor size	Minimum ground conductor size
$\leq 10 \text{ mm}^2$	Either 10 mm^2 or two conductors of the same cross-sectional area as the input phase conductor.
$> 10 \text{ mm}^2$ and $\leq 16 \text{ mm}^2$	The same cross-sectional area as the input phase conductor
$> 16 \text{ mm}^2$ and $\leq 35 \text{ mm}^2$	16 mm^2
$> 35 \text{ mm}^2$	Half of the cross-sectional area of the input phase conductor

7.1.23 Input line reactor specification for size 9E, 10E and 11E



A separate line reactor (INLXXX) of at least the value shown in Table 7-27 and Table 7-28 must be used with size 9E/T, 10E/T and 11E/T. Failure to provide sufficient reactance could damage or reduce the service life of the drive.

Table 7-27 Size 9E, 10E and 11E Model and Line reactor part number

Size	Drive model	Inductor model	Line reactor part number
9E/T	09201760, 09202190, 09402000, 09402240	INL 401	4401-0181
	09501040, 09501310, 09601040, 09601310	INL 601	4401-0183
10E/T	10202830, 10203000, 10402700, 10403200	INL 402	4401-0182
	10501520, 10501900, 10601500, 10601780	INL 602	4401-0184
11E/T	11403770	INL 403L*	4401-0274
	11403770, 11404170, 11404640	INL 403	4401-0259
	11502000, 11502540, 11502850, 11602100, 11602380, 11602630	INL 603	4401-0261

* May represent a more economic solution when operating within heavy duty ratings.

Figure 7-1 Input line reactor dimensions

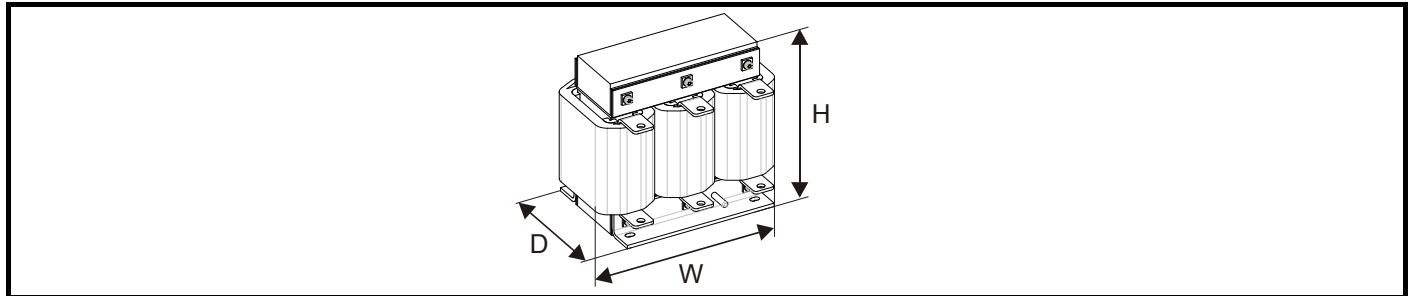


Table 7-28 Input line reactor ratings

Part number	Model	Current	Inductance	Overall width (W)	Overall depth (D)	Overall height (H)	Weight	Max ambient temp	Min airflow	Maximum losses	Quantity required
		A	μH	mm	mm	mm		$^{\circ}\text{C}$			
4401-0181	INL 401	245	63	240	190	225	32	50	1	148	1
4401-0182	INL 402	370	44	276	200	225	36	50	1	205	1
4401-0259	INL 403	557	30	300	216	264	57	50*	1	330	1
4401-0274	INL 403L	420	30	300	216	264	57	50*	1	289	1
4401-0183	INL 601	145	178	240	190	225	33	50	1	88	1
4401-0184	INL 602	202	133	276	200	225	36	50	1	116	1
4401-0261	INL 603	331	93	300	216	264	58	50*	1	320	1

* With forced cooling ($40 \text{ }^{\circ}\text{C}$ with natural cooling).

7.1.24 Maximum motor cable lengths

Table 7-29 Maximum motor cable lengths (200 V drives)

Model	Maximum permissible motor cable length for each of the following switching frequencies						
	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
09201760	250 m (820 ft)		187 m (614 ft)	125 m (410 ft)	93 m (203 ft)	62 m (203 ft)	46 m (151 ft)
09202190							
10202830	250 m (820 ft)		187 m (614 ft)	125 m (410 ft)	93 m (203 ft)	62 m (203 ft)	46 m (151 ft)
10203000							

Table 7-30 Maximum motor cable lengths (400 V drives)

Model	Maximum permissible motor cable length for each of the following switching frequencies						
	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
09402000	250 m (820 ft)		187 m (614 ft)	125 m (410 ft)	93 m (203 ft)	62 m (203 ft)	46 m (151 ft)
09402240							
10402700	250 m (820 ft)		187 m (614 ft)	125 m (410 ft)	93 m (203 ft)	62 m (203 ft)	46 m (151 ft)
10403200							
11403770	250 m (820 ft)		187 m (614 ft)	125 m (410 ft)	93 m (203 ft)		
11404170							
11404640							

Table 7-31 Maximum motor cable lengths (575 V drives)

Model	Maximum permissible motor cable length for each of the following switching frequencies						
	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
09501040	250 m (820 ft)		187 m (614 ft)	125 m (410 ft)	93 m (203 ft)	62 m (203 ft)	46 m (151 ft)
09501310							
10501520	250 m (820 ft)		187 m (614 ft)	125 m (410 ft)	93 m (203 ft)	62 m (203 ft)	46 m (151 ft)
10501900							
11502000	250 m (820 ft)		187 m (614 ft)				
11502540							
11503020							

Table 7-32 Maximum motor cable lengths (690 V drives)

Model	Maximum permissible motor cable length for each of the following switching frequencies						
	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
09601040	250 m (820 ft)		187 m (614 ft)	125 m (410 ft)	93 m (203 ft)	62 m (203 ft)	46 m (151 ft)
09601310							
10601500	250 m (820 ft)		187 m (614 ft)	125 m (410 ft)	93 m (203 ft)	62 m (203 ft)	46 m (151 ft)
10601780							
11602100	250 m (820 ft)		187 m (614 ft)				
11602380							
11602630							

- Cable lengths in excess of the specified values may be used only when special techniques are adopted; refer to the supplier of the drive.
 - The default switching frequency is 3 kHz for Open-loop and RFC-A and 6 kHz for RFC-S mode.
- The maximum cable length is reduced from that shown in Table 7-30 to Table 7-32 if high capacitance or reduced diameter motor cables are used. For further information, refer to section 6.10.2 *High-capacitance cables* on page 103.

7.1.25 Braking resistor values

Table 7-33 Minimum resistance values and peak power rating for the braking resistor at 40°C (104°F)

Model	Minimum resistance* Ω	Instantaneous power rating kW	Continuous power rating kW
09201760 (9A)	2	84.5	45
09202190 (9A)	2	84.5	55
09201760 (9E)	1.4	120.8	45
09202190 (9E)	1.4	120.8	55
10202830	1.7	99.5	75
10203000	1.7	99.5	90
09402000 (9A)	3.6	187.8	90
09402240 (9A)	3.6	187.8	110
09402000 (9E)	2.6	260	90
09402240 (9E)	2.6	260	110
10402700	3.1	218.1	132
10403200	3.1	218.1	160
11403770	1.83	369.4	185
11404170	1.2	563.4	200
11404640	1.2	563.4	250
09501040 (9A)	5.1	188.5	75
09501310 (9A)	5.1	188.5	90
09501040 (9E)	3.3	291.3	75
09501310 (9E)	3.3	291.3	90
10501520	3.3	291.3	110
10501900	3.3	291.3	132
11502000	1.83	525.2	150
11502540	1.83	525.2	185
11502850	1.83	525.2	225
09601040 (9A)	6.5	214.5	90
09601310 (9A)	6.5	214.5	110
09601040 (9E)	4.2	331.9	90
09601310 (9E)	4.2	331.9	110
10601500	4.2	331.9	132
10601780	3.8	366.8	160
11602100	2.2	633.6	185
11602380	2.2	633.6	200
11602630	2.2	633.6	250

* Resistor tolerance: ±10 %

NOTE

In parallel systems without the DC bus connected, the resistors must be matched to within ±5 %.

7.1.26 Torque settings

Table 7-34 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 7-35 Drive power terminal data

Frame size	AC and motor terminals		DC and braking		Ground terminal	
	Recommended	Maximum	Recommended	Maximum	Recommended	Maximum
All sizes	M10 Nut (17 mm AF)		M10 Nut (17 mm AF)		M10 Nut (17 mm AF)	
	15 N m (11.1 lb ft)	20 N m (14.8 lb ft)	15 N m (11.1 lb ft)	20 N m (14.8 lb ft)	15 N m (11.1 lb ft)	20 N m (14.8 lb ft)

Table 7-36 Plug-in terminal block maximum cable sizes

Model size	Terminal block description	Max cable size
9	2 way low voltage power / 24 V supply connector	1.5 mm ² (16 AWG)
10		
11		

7.1.27 Electromagnetic compatibility (EMC)

This is a summary of the EMC performance of the drive. For full details, refer to the *EMC Data Sheet* which can be obtained from the supplier of the drive.

Table 7-37 Immunity compliance

Standard	Type of immunity	Test specification	Application	Level
IEC61000-4-2 EN61000-4-2	Electrostatic discharge	6 kV contact discharge 8 kV air discharge	Module enclosure	Level 3 (industrial)
IEC61000-4-3 EN61000-4-3	Radio frequency radiated field	10 V/m prior to modulation 80 - 1000 MHz 80 % AM (1 kHz) modulation	Module enclosure	Level 3 (industrial)
IEC61000-4-4 EN61000-4-4	Fast transient burst	5/50 ns 2 kV transient at 5 kHz repetition frequency via coupling clamp	Control lines	Level 4 (industrial harsh)
		5/50 ns 2 kV transient at 5 kHz repetition frequency by direct injection	Power lines	Level 3 (industrial)
IEC61000-4-5 EN61000-4-5	Surges	Common mode 4 kV 1.2/50 µs waveshape	AC supply lines: line to ground	Level 4
		Differential mode 2 kV 1.2/50 µs waveshape	AC supply lines: line to line	Level 3
		Lines to ground	Signal ports to ground ¹	Level 2
IEC61000-4-6 EN61000-4-6	Conducted radio frequency	10V prior to modulation 0.15 - 80 MHz 80 % AM (1 kHz) modulation	Control and power lines	Level 3 (industrial)
IEC61000-4-11 EN61000-4-11	Voltage dips and interruptions	-30 % 10 ms +60 % 100 ms -60 % 1 s <-95 % 5 s	AC power ports	
IEC61000-6-1 EN61000-6-1:2007	Generic immunity standard for the residential, commercial and light - industrial environment			Complies
IEC61000-6-2 EN61000-6-2:2005	Generic immunity standard for the industrial environment			Complies
IEC61800-3 EN 61800-3:2004+A1:2012	Product standard for adjustable speed power drive systems (immunity requirements)		Meets immunity requirements for first and second environments	

¹ See section 6.13.6 *Variations in the EMC wiring* on page 115 for possible requirements regarding grounding and external surge protection of control ports.

Emission

The drive contains an in-built filter for basic emission control. An additional optional external filter provides further reduction of emission. The requirements of the following standards are met, depending on the motor cable length and switching frequency.

Table 7-38 Size 9 and 10 emission compliance

Motor cable length (m)	Switching Frequency (kHz)						
	2	3	4	6	8	12	16
Using internal filter:							
0 - 100	C3	C3	C3	C3	C3	C3	C4
No advantage using a ferrite ring							
Using external filter:							
0 - 20	C2	C2	C2	C2	C2	C2	C2
20 - 100	C2	C2	C3	C3	C3	C3	C3

Table 7-39 Size 11 emission compliance

Motor cable length (m)	Switching Frequency (kHz)				
	2	3	4	6	8
Using internal filter:					
0 - 50	C3	C3	C3	C3	C3
100	C3	C3	C3	C3	C4
Using external filter:					
20	C2	C2	C2	C2	C2
100	C2	C2	C3	C3	C3

Key (shown in decreasing order of permitted emission level):

- E2R EN 61800-3 second environment, restricted distribution (Additional measures may be required to prevent interference)
- E2U EN 61800-3 second environment, unrestricted distribution.
- I Industrial generic standard EN 61000-6-4
EN 61800-3 first environment restricted distribution (The following caution is required by EN 61800-3)



This is a product of the restricted distribution class according to EN 61800-3. In a residential environment this product may cause radio interference in which case the user may be required to take adequate measures.

- R Residential generic standard EN 61000-6-3
EN 61800-3 first environment unrestricted distribution

EN 61800-3 defines the following:

- The first environment is one that includes residential premises. It also includes establishments directly connected without intermediate transformers to a low-voltage power supply network which supplies buildings used for residential purposes.
- The second environment is one that includes all establishments other than those directly connected to a low-voltage power supply network which supplies buildings used for residential purposes.
- Restricted distribution is defined as a mode of sales distribution in which the manufacturer restricts the supply of equipment to suppliers, customers or users who separately or jointly have technical competence in the EMC requirements of the application of drives.

EN 61800-3:2004+A1:2012

The 2004 revision of the standard uses different terminology to align the requirements of the standard better with the EC EMC Directive.

Power drive systems are categorized C1 to C4:

Category	Definition	Corresponding code used above
C1	Intended for use in the first or second environments	R
C2	Not a plug-in or movable device, and intended for use in the first environment only when installed by a professional, or in the second environment	I
C3	Intended for use in the second environment, not the first environment	E2U
C4	Intended for use in the second environment in a system rated at over 400 A, or in a complex system	E2R

Note that category 4 is more restrictive than E2R, since the rated current of the PDS must exceed 400 A or the supply voltage exceed 1000 V, for the complete PDS.

7.2 Optional external EMC filters

Table 7-40 EMC filter cross reference

Model	CT part number
200 V	
09201760 to 09202190 (9A)	4200-3021
09201760 to 09202190 (9E)	4200-4460
10202830 to 10203000	4200-4460
400 V	
09402000 to 09402240 (9A)	4200-3021
09402000 to 09402240 (9E)	4200-4460
10402700 to 10403200	4200-4460
11403770 to 11404640	4200-0400
575 V	
09501040 to 09501310 (9A)	4200-1660
09501040 to 09501310 (9E)	4200-2210
10501520 to 10501900	4200-2210
11502000 to 11502850	4200-0690
690 V	
09601040-09601310 (9A)	4200-1660
09601040 to 09601310 (9E)	4200-2210
10601500 to 1061780	4200-2210
11602100 to 11602630	4200-0690

7.2.1 EMC filter ratings

Table 7-41 Optional external EMC filter details

CT part number	Maximum continuous current		Voltage rating		IP rating	Power dissipation at rated current		Ground leakage		Discharge resistors
	@ 40 °C (104 °F)	@ 50 °C (122 °F)	IEC	UL		@ 40 °C (104 °F)	@ 50 °C (122 °F)	Balanced supply phase-to-phase and phase-to-ground	Worst case	
	A	A	V	V		W	W	mA	mA	
4200-3021	302	277	480	480	00	34	29.7	30	202	1.68
4200-4460	446	409	480			37	32.4	30	283	
4200-0400	685	551	480			44	38.5	60.7	275	
4200-1660	166	152	690	N/A		13	11.4	21	332	2.72
4200-2210	221	203	690			16	14	21	434	
4200-0690	403	370	690			28	24.5	25	583	

7.2.2 Overall EMC filter dimensions

Table 7-42 Optional external EMC filter dimensions

CT part number	Dimension (mm)						Weight	
	H		W		D		kg	lb
	mm	inch	mm	inch	mm	inch		
4200-3021	339	13.3	230	9.06	120	4.72	11	24.25
4200-4460	105	4.13	360	14.2	245	9.65	12	26.5
4200-0400	135	5.32	386	15.2	260	10.2	14.7	32.41
4200-1660	360	14.2	245	9.6	105	4.13	5.2	11.5
4200-2210	105	4.13	360	14.7	245	9.65	10.3	22.71
4200-0690	135	5.32	386	15.2	260	10.2	16.75	36.9

7.2.3 EMC filter torque settings

Table 7-43 Optional external EMC Filter terminal data

CT part number	Power connections		Ground connections	
	Bar hole diameter	Max torque	Ground stud size	Max torque
4200-3021	10.8 mm	30 N m (22.1 lb ft)	M10	18 N m (13.3 lb ft)
4200-4460	11 mm			
4200-1660	10.8 mm			
4200-2210	11 mm			
4200-0400	10.5 mm		M12	25 N m (18.4 lb ft)
4200-0690	10.5 mm			

8 UL Information

8.1 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.

8.2 Option modules, kits and accessories

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

8.3 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.

8.4 Mounting

Drives can be mounted directly onto a vertical surface. This is known as 'surface' or 'standard' mounting. Refer to section 5.5 *Dimensions and mounting methods* on page 47.

Drives can be installed side by side with recommended spacing between them. This is known as 'bookcase' mounting. Refer to section 5.5 *Dimensions and mounting methods* on page 47.

Some drives can be mounted on their side. This is known as 'tile' mounting. Suitable tile mounting kits are available from Emerson Industrial Automation. Refer to section 5.5 *Dimensions and mounting methods* on page 47.

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 Emerson Industrial Automation.

Some drives may be through-hole mounted. Mounting brackets and sealing kits are available from Emerson Industrial Automation. Refer to section 5.5 *Dimensions and mounting methods* on page 47.

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

8.5 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 with model numbers beginning M100, M101, M200, M201, M300 or M400, with frame sizes 1 to 4 may be operated in surrounding air temperatures up to 50 °C at de-rated current. All other drives, for example M600, M700, M701, M702 etc. may be operated in surrounding air temperatures up to 55 °C at de-rated current.

8.6 Electrical Installation

TERMINAL TORQUE

Terminals must be tightened to the rated torque as specified in the Installation Instructions. Refer to section 5.11.2 *Terminal sizes and torque settings* on page 79.

WIRING TERMINALS

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

GROUND CONNECTION INSTRUCTIONS

UL Listed closed-loop connectors sized according to the field wiring shall be used for grounding. Refer to the relevant *section 6.1.3 Ground connections* on page 90.

BRANCH CIRCUIT PROTECTION

The fuses and circuit breakers required for branch circuit protection are contained in the Installation Instructions.

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".

DYNAMIC BRAKING

Drives with model numbers beginning M100, M101, M200, M201, M300 or M400, with frame sizes 1 to 4 have been evaluated for dynamic braking applications.

All other drives have not been evaluated for dynamic braking.

8.7 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. 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 (variable up to a maximum of 3000 seconds). 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.

8.8 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.

8.9 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.

8.10 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.

8.11 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 Emerson Industrial Automation.

Alternatively, the inverters may be supplied by converters from the Unidrive-M range manufactured by Emerson 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 Emerson Industrial Automation for further details.

Index

Symbols

+10V user output	118
+24 Vdc	121
+24V external input	97, 98, 118, 123
+24V user output	120, 123

Numerics

0 V	121, 124
0V common	118, 123

A

AC supply contactor	103
AC supply requirements	91
Access	39
Accuracy	141
Acoustic noise	141
Alternative enclosure layout	63
Altitude	140
Analog input 2	119
Analog input 3	119
Analog output 1	120
Analog output 2	120

B

Braking	105
Braking resistor values	149

C

Cable clearances	110
Cable lengths (maximum)	147
Cable size ratings	142
Cable types and lengths	103
Calculation of temperature rise in enclosure Inputs	66
Cautions	8
Control connections	117
Cooling	39
Cooling method	140
Current ratings	133

D

DC bus voltage	105
Deceleration	105
Derating	133
Destination parameter	117, 121
Digital I/O 1	120
Digital I/O 2	120
Digital I/O 3	120
Digital Input 4	120, 123
Digital Input 5	120, 123
Digital Input 6	120
Digital Output 1	123
Digital Output 2	123
Dimensions (overall)	142
Drive enable	121
Dual output sharing chokes	95

E

Electrical Installation	85
Electrical safety	39
Electrical terminals	77
Electromagnetic compatibility (EMC)	40, 108, 150
EMC - Compliance with generic emission standards	113
EMC - General requirements	109
EMC - Variations in the wiring	114
EMC filter dimensions (external, overall)	151
EMC filter torque settings (external)	152
EMC filters (optional external)	151
Emission	150
EN61800-3:2004 (standard for Power Drive Systems)	112
Enclosing drive for high environmental protection	68
Enclosure	61
Enclosure ambient temperature	64
Enclosure design to prevent recirculation of hot air	65
Enclosure Layout	61
Enclosure sizing	64
Encoder connections	110
Encoder types	125
Environmental protection	39
External EMC filter	70

F

Feedback device cable shielding	110
Fire protection	39
Fuse ratings	142
Fuse types	102, 146

G

General requirements for EMC	109
Ground connections	103, 109
Ground leakage	107
Ground terminals	77

H

Heatsink fan operation	67
Humidity	140

I

Input current ratings	142
Internal EMC filter	108
IP Rating (Ingress protection)	140
Items supplied with the drive	25

L

Line reactor mounting dimensions	72
Line reactors	94, 140
Location and identification of terminal covers	41

M

Maximum speed / frequency	141
Mechanical Installation	39
Model number	15
Motor cable - interruptions	115
Motor requirements	140
Motor winding voltage	104
Mounting brackets	60
Mounting methods	47
Mounting of control master/follower pod	44
Mounting of the control master/follower/standard pod	44
Multiple motors	104

N

Nameplate description	21
NEMA rating	68, 140
Notes	8

O

Open loop mode	19
Open loop vector mode	19
Operating modes	19
Output circuit and motor protection	103
Output contactor	105
Output frequency	141

P

Parts supplied with the size 9E/D and 10E/D	25
Planning the installation	39
Position feedback connections	124
Power options available for Unidrive M	24
Power ratings	106, 133
Power terminals	77
Precision reference Analog input 1	119
Pressure drop	67
Product information	10, 16, 17

Q

Quadratic V/F mode	19
--------------------------	----

R

Ratings	10, 16, 99
Reactor current ratings	94, 140
Relay contacts	121, 124
Residual current device (RCD)	107
Resistances (minimum)	106
Resolution	141
RFC-A mode	19
RFC-S mode	19
Routine maintenance	79

S

Safe Torque Off function input 1 (drive enable)	124
Safe Torque Off function input 2 (drive enable)	124
Safe Torque Off/drive enable	121, 124
Safety Information	8, 39
Selecting fan	67
Serial comms lead	116
Speed range	141
Start up time	141
Starts per hour	141
Storage	140
Supply requirements	140
Supply types	92
Surge immunity of control circuits - long cables and connections outside a building	115
Surge suppression for analog and bipolar inputs and outputs	116
Surge suppression for digital and unipolar inputs and outputs	116

T

Technical data	133
Temperature	140
Terminal block in the enclosure	115
Terminal cover removal	40
Terminal sizes	77
Thermal protection circuit for the braking resistor	106
Torque settings	79, 149

U

UL Listing Information	153
Unidrive M600 / M700/HS70 /M701/HS71 control terminal specification	118
Unidrive M700/HS71 / M702/HS72 Ethernet fieldbus communications	116
Unidrive M701/HS71 EIA 485 serial communications	116
Unidrive M702/HS72 Control terminal specification	123

V

Variations in the EMC wiring	115
Ventilation	67
Vibration	141

W

Warnings	8
Weights	142



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