



Frame 1 to 4 ***Power Installation Guide***

KBG2, KBG3 ***Series***

For applications that require ratings higher than 30 HP (22.5 kW), contact our Sales Department.



Original Instructions

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

Documentation

Manuals are available to download from the following locations: <http://www.kbelectronics.com>

The information contained in this manual is believed to be correct at the time of printing and does not form part of any contract. The manufacturer reserves the right to change the specification of the product and its performance, and the contents of the manual, without notice.

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In no event and under no circumstances shall the manufacturer be liable for damages and failures due to misuse, abuse, improper installation, or abnormal conditions of temperature, dust, or corrosion, or failures due to operation outside the published ratings. The manufacturer is not liable for consequential and incidental damages. Contact the supplier of the dive for full details of the warranty terms.

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KB Electronics, Inc. operates an Environmental Management System (EMS) that conforms to the International Standard ISO 14001.

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Further information on our compliance with REACH can be found at: <http://www.kbelectronics.com>

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EU Declaration of Conformity

KB Electronics, Inc.
12095 NW 39th Street
Coral, Springs, FL 33065-2516 USA

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 (**Example:** KBG2-11017-1):

Model number	Interpretation	Nomenclature
KBG2, KBG3	Basic series	KBG2, KBG3
1	Voltage rating	1 = 115 V, 2 = 230 V, 4 = 460 V, 5 = 575 V
1	Input phase	1 = Single Phase, 2 = Single or Three Phase, 3 = Three Phase
017	Current rating	Example: 017 = 1.7 A, 100 = 10.0 A
1	Frame size	1, 2, 3, 4, 5, 6

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).



Tom Dalton
President, KB Electronics, Inc.
Date: 15th March 2018

Phil Blakeley
KB Electronics, Inc. (UK)
Tanner Business Centre
Waterside Mills, Greenfield,
Saddleworth. OL3 7NH. UK

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)

KB Electronics, Inc.
12095 NW 39th Street
Coral, Springs, FL 33065-2516 USA

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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

Person authorised to complete the technical file:

Wesley Bernstein, QC Manager
KB Electronics, Inc.



Tom Dalton
President, KB Electronics, Inc.
Date: 15th March 2018

Phil Blakeley
KB Electronics, Inc. (UK)
Tanner Business Centre
Waterside Mills, Greenfield,
Saddleworth. OL3 7NH. 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



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



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

NOTE

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

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

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

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

Drives and controllers are intended as components for professional incorporation into complete systems. If installed incorrectly they may present a safety hazard. The drive uses high voltages and currents, carries a high level of stored electrical energy, and is used to control equipment which can cause injury. Close attention is required to the electrical installation and the system design to avoid hazards either in normal operation or in the event of equipment malfunction. System design, installation, commissioning/start-up and maintenance must be carried out by personnel who have the necessary training and competence. They must read this safety information and this guide carefully.

1.3 Responsibility

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

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

1.4 Compliance with regulations

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

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

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

2006/42/EC Safety of machinery.

2014/30/EU: Electromagnetic Compatibility.

1.5 Electrical hazards

The voltages used in the drive can cause severe electrical shock and/or burns, and could be lethal. Extreme care is necessary at all times when working with or adjacent to the drive. Hazardous voltage may be present in any of the following locations:

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

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

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

The STOP and Safe Torque Off functions of the drive do not isolate dangerous voltages from the output of the drive or from any external option unit.

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

1.6 Stored electrical charge

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

1.7 Mechanical hazards

Careful consideration must be given to the functions of the drive or controller which might result in a hazard, either through their intended behaviour or through incorrect operation due to a fault. In any application where a malfunction of the drive or its control system could lead to or allow damage, loss or injury, a risk analysis must be carried out, and where necessary, further measures taken to reduce the risk - for example, an over-speed protection device in case of failure of the speed control, or a fail-safe mechanical brake in case of loss of motor braking.

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

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

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

1.8 Access to equipment

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

1.9 Environmental limits

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

1.10 Hazardous environments

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

1.11 Motor

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

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

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

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

1.12 Mechanical brake control

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

1.13 Adjusting parameters

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

1.14 Electromagnetic compatibility (EMC)

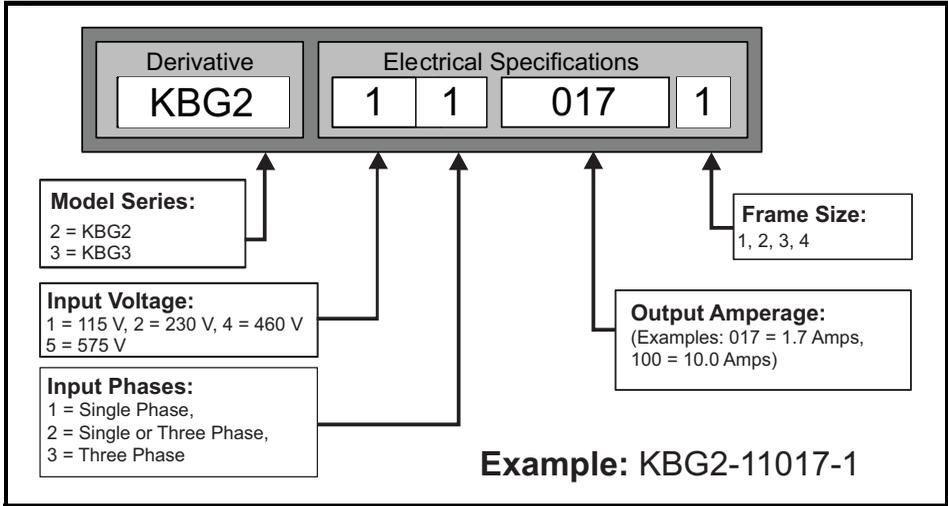
Installation instructions for a range of EMC environments are provided in the relevant Power Installation Guide. If the installation is poorly designed or other equipment does not comply with suitable standards for EMC, the product might cause or suffer from disturbance due to electromagnetic interaction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

2 Product information

2.1 Model number

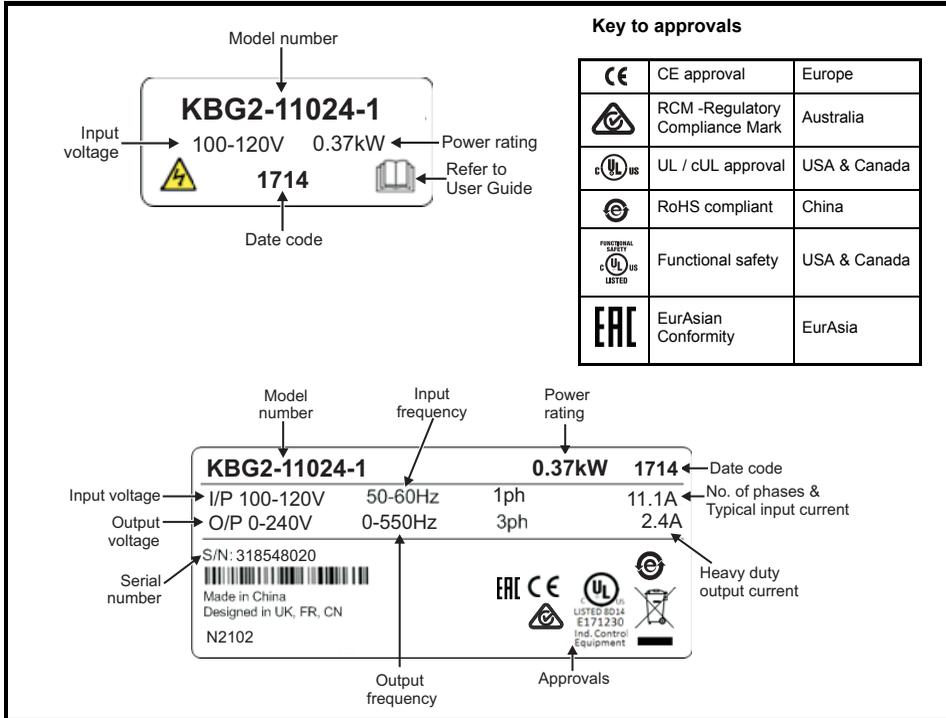
The way in which the model numbers for the KBG2, and KBG3 Series product range is formed is illustrated below:

Figure 2-1 Model number



2.2 Nameplate description

Figure 2-2 Typical drive rating labels



NOTE Date code format

The date code is four numbers. The first two numbers indicate the year and the remaining numbers indicate the week of the year in which the drive was built. This new format started in 2017.

Example:

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

2.3 Ratings

NOTE

The continuous current ratings given are for maximum 40 °C (104 °F), 1000 m altitude and 3 kHz switching frequency. Derating is required for higher switching frequencies, ambient temperature > 40 °C (104 °F) and high altitude. For further information, refer to Chapter 5 *Technical data* on page 75.

Table 2-1 115 V drive ratings (100 V to 120 V \pm 10 %)

Model	Input phases	Heavy Duty				
		Maximum continuous output current	Open loop peak current	RFC peak current	Nominal power at 115 V	Motor power at 115 V
	ph	A	A	A	kW	hp
11017-1	1	1.7	2.6	3.1	0.25	0.33
11024-1		2.4	3.6	4.3	0.37	0.5
11042-2		4.2	6.3	7.6	0.75	1
11056-2		5.6	8.4	10.1	1.1	1.5

Table 2-2 230 V drive ratings (200 V to 240 V \pm 10 %)

Model	Input phases	Heavy Duty				
		Maximum continuous output current	Open loop peak current	RFC peak current	Nominal power at 230 V	Motor power at 230 V
	ph	A	A	A	kW	hp
21017-1	1	1.7	2.6	3.1	0.25	0.33
21024-1	1	2.4	3.6	4.3	0.37	0.5
21033-1	1	3.3	5	5.9	0.55	0.75
21042-1	1	4.2	6.3	7.6	0.75	1
22024-2	1/3	2.4	3.6	4.3	0.37	0.5
22033-2	1/3	3.3	5	5.9	0.55	0.75
22042-2	1/3	4.2	6.3	7.6	0.75	1
22056-2	1/3	5.6	8.4	10.1	1.1	1
22075-2	1/3	7.5	11.3	13.5	1.5	2
22100-3	1/3	10	15	18	2.2	3
22133-4	1/3	13.3	20	23.9	3	3
23176-4	3	17.6	26.4	31.7	4	5

Table 2-3 460 V drive ratings (380 V to 480 V \pm 10 %)

Model	Input phases	Heavy Duty				
		Maximum continuous output current	Open loop peak current	RFC peak current	Nominal power at 400 V	Motor power at 460 V
	ph	A	A	A	kW	hp
43013-2	3	1.3	2	2.3	0.37	0.5
43018-2		1.8	2.7	3.2	0.55	0.75
43023-2		2.3	3.5	4.1	0.75	1
43032-2		3.2	4.8	5.8	1.1	1.5
43041-2		4.1	6.2	7.4	1.5	2
43056-3	3	5.6	8.4	10.1	2.2	3
43073-3		7.3	11	13.1	3	3
43094-3		9.4	14.1	16.9	4	5
43135-4	3	13.5	20.3	24.3	5.5	7.5
43170-4		17	25.5	30.6	7.5	10

2.3.1 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-A and open loop (OL) modes:

Table 2-4 Typical overload limits

Operating mode	RFC From cold	RFC From 100 %	Open loop from cold	Open loop from 100 %
Heavy Duty overload with motor rated current = drive rated current	180 % for 3 s	180 % for 3 s	150 % for 60 s	150 % for 8 s

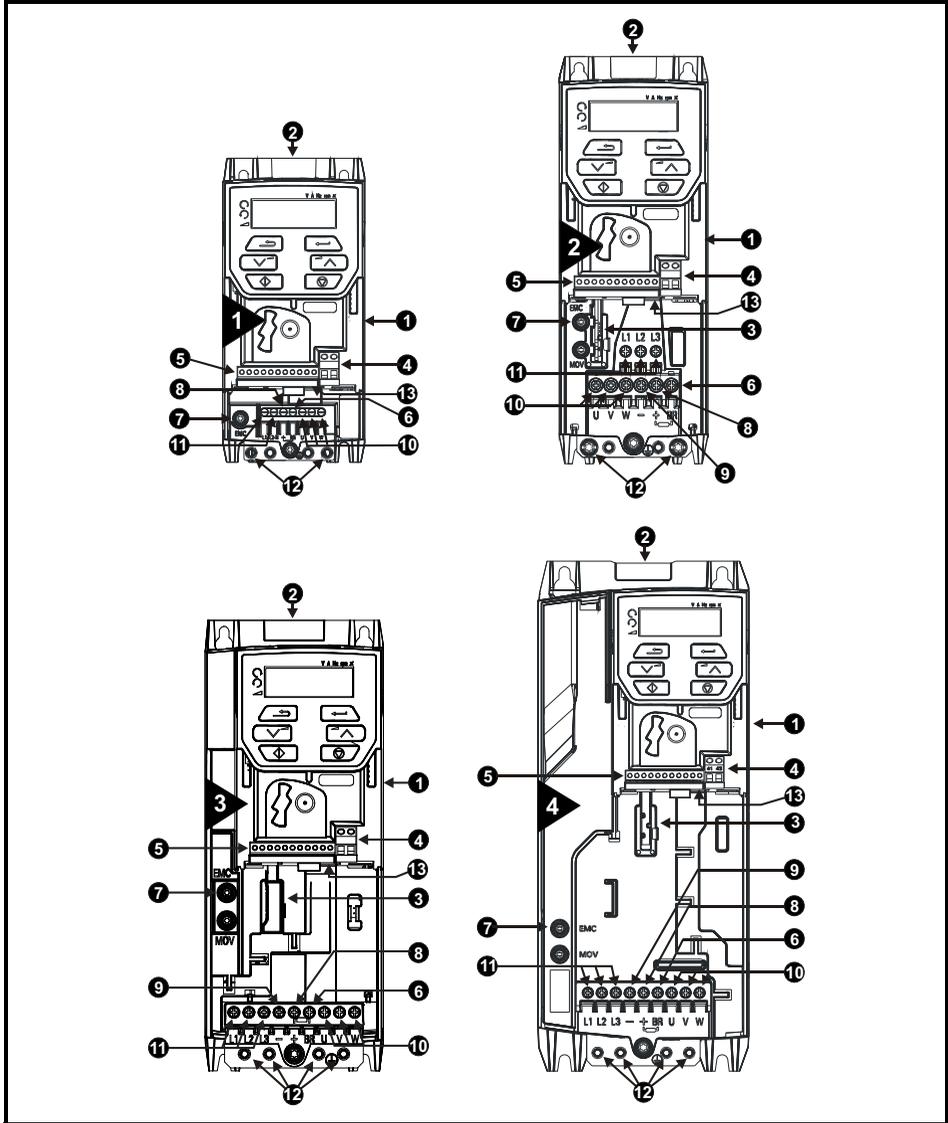
Generally the drive rated current is higher than the matching motor rated current allowing a higher level of overload than the default setting.

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.

2.4 Drive features

Figure 2-3 Features of the drive



Key

- | | | |
|------------------------------------|------------------------------|---------------------------------|
| 1. Rating label (On side of drive) | 6. Braking terminal | 11. AC supply connections |
| 2. Identification label | 7. Internal EMC filter screw | 12. Ground connections |
| 3. Option module connection | 8. DC bus + | 13. Safe Torque Off connections |
| 4. Relay connections | 9. DC bus - | |
| 5. Control connections | 10. Motor connections | |

2.5 Items supplied with the drive

The drive is supplied with a copy of the Step-by-Step Guide and the items shown in Table 2-5.

Table 2-5 Parts supplied with the drive

Description	Size 1	Size 2	Size 3	Size 4
STO connector *			 x 1	
Grounding bracket			 x 1	
M4 x 8 Double Sem Torx screw			 x 4	

* KBG3 Series only.

3 Mechanical installation

3.1 Safety information

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

- High IP as standard
- Enclosure sizing and layout
- Terminal location and torque settings



Follow the instructions

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



Stored charge

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

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



Competence of the installer

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



Enclosure

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

3.2 Planning the installation

The following considerations must be made when planning the installation:

3.2.1 Access

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

The IP (Ingress Protection) rating of the drive is installation dependent.

3.2.2 Environmental protection

The drive must be protected from:

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

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

3.2.3 Cooling

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

For further information, refer to section 3.5.1 *Enclosure sizing* on page 24.

3.2.4 Electrical safety

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

3.2.5 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.

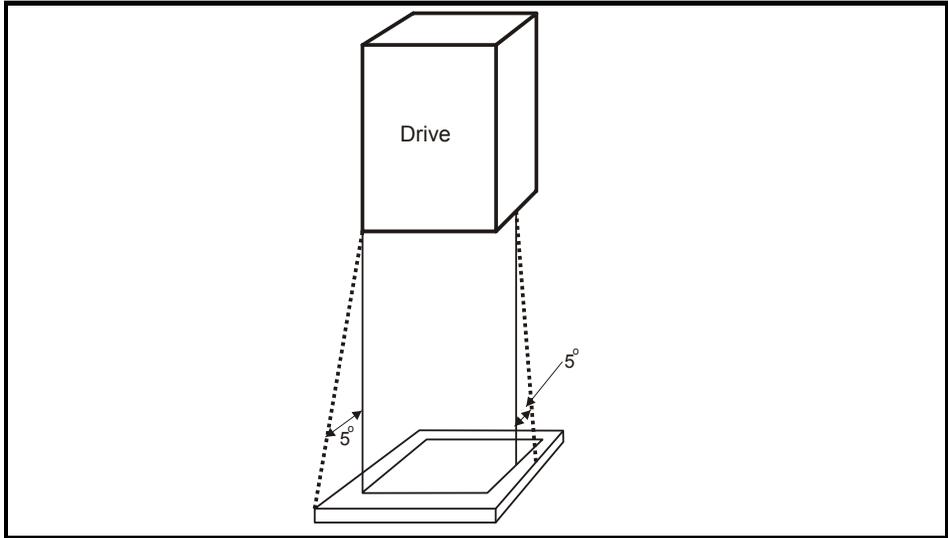
For installation outside the USA, the following (based on IEC 62109-1, standard for PV inverters) is recommended.

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.

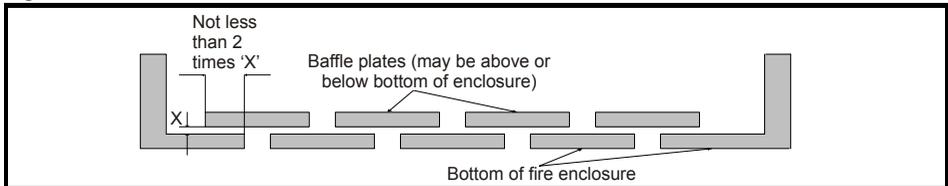
The location and size of the bottom shall cover the area shown in Figure 3-1. Any part of the side which is within the area traced out by the 5° angle is also considered to be part of the bottom of the fire enclosure.

Figure 3-1 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 3-2 for acceptable baffle construction. This does not apply for mounting in an enclosed electrical operating area (restricted access) with concrete floor.

Figure 3-2 Fire enclosure baffle construction



3.2.6 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 4.7 *EMC (Electromagnetic compatibility)* on page 61.

3.2.7 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.

3.3 Terminal cover removal



Isolation device

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



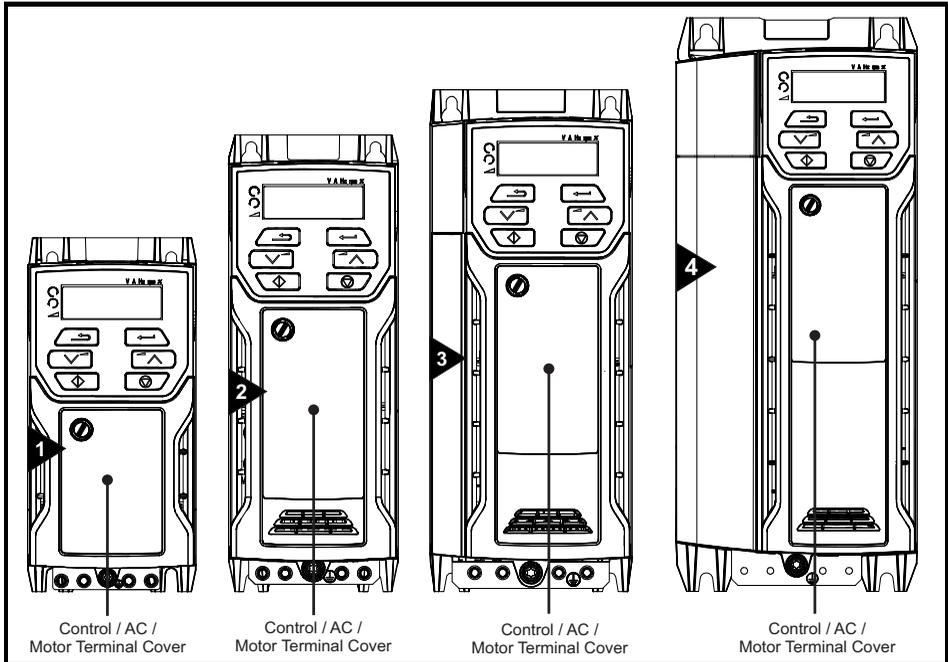
Stored charge

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

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

3.3.1 Removing the terminal covers

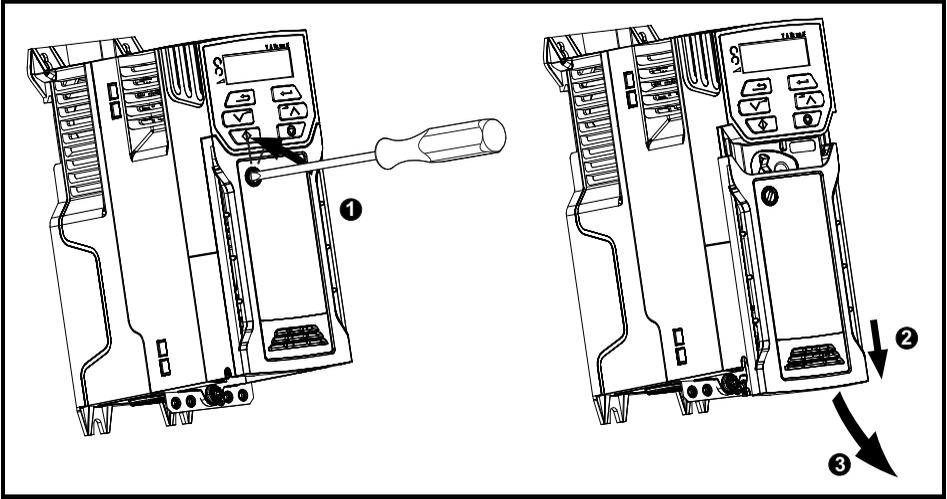
Figure 3-3 Location and identification of terminal covers (KBG3 size 1 to 4 shown)



NOTE

The drives shown in Figure 3-3 above, have a single removable terminal cover which provides access to all electrical connections, i.e. Control, AC, Motor and Brake functions. Figure 3-4 illustrates the three steps required to remove the drive terminal covers.

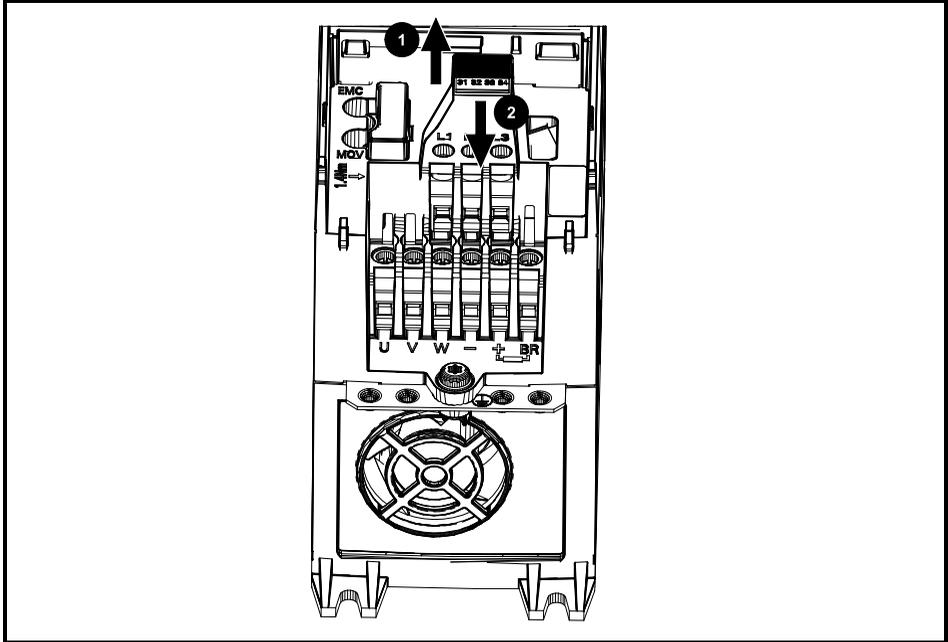
Figure 3-4 Removing the terminal cover (KBG3 shown)



1. Using a flat bladed screwdriver, turn the terminal cover locking clip anti-clockwise by approximately 30°.
2. Slide the terminal cover down.
3. Remove terminal cover in direction shown.

3.3.2 Removal of the STO (Safe Torque Off) connector *

Figure 3-5 Removing the STO connector



To remove the STO terminal block (* KBG3 only):

1. Using tab on STO terminal block, pull upwards.
2. Pull away from the control module as shown on the tab as shown in Figure 3-5 above.

3.4 Drive dimensions and mounting methods

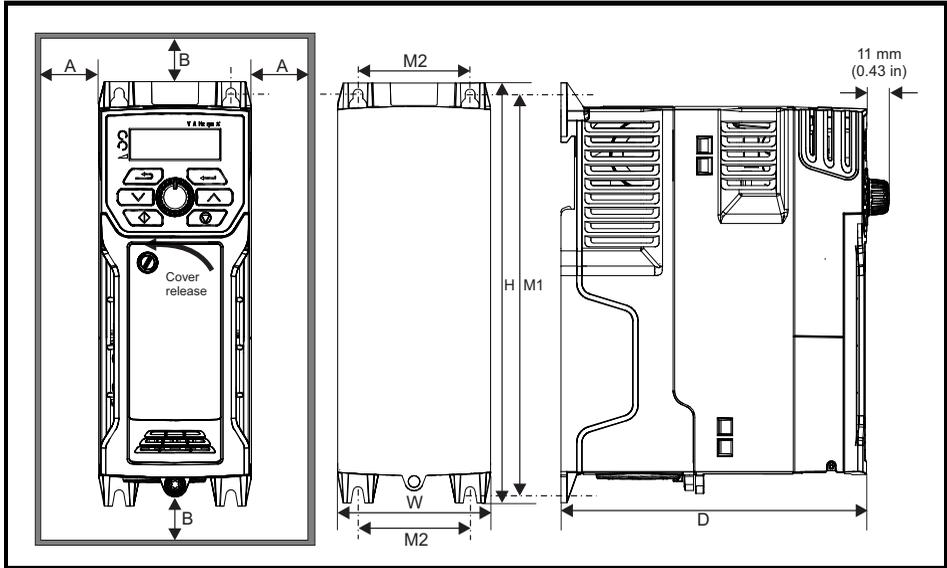
The following drawings show the dimensions of the drive and mounting holes to allow a back-plate to be prepared.



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.

The drives can be panel mounted with 0 mm space between the drives.

Figure 3-6 Dimensions (KBG2 shown)



To remove the terminal cover, use a flat bladed screwdriver to rotate the terminal cover locating clip by approximately 30° in a counter clockwise direction, and then slide the cover down.

Drive Size	H		W		D		M1		M2		Ø		A		B*	
	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in
1	160	6.30	75	2.95	130	5.12	143	5.70	53	2.08	5	0.2	0	0.00	100	3.93
2	205	8.07	78	3.07	150	5.91	194	7.63	55	2.17	5	0.2				
3	226	8.90	90	3.54	160	6.30	215	8.46	70.7	2.80	5	0.2				
4	277	10.91	115	4.53	175	6.89	265	10.43	86	3.40	6	0.23				

NOTE A minimum clearance of 100 mm above and below Frame 01 to 04 products is required for applications where the product is subjected to rated load and rated ambient temperature.

NOTE * A minimum clearance of 50 mm above and below Frame 01 to 04 products is permissible in applications where either the ambient operating temperature is 35 °C or less or the average output current is derated by 20 %.

NOTE Derating for reduced clearances is to be applied in addition to the derating for increased switching frequency if operating above 3 kHz.

NOTE We recommend that cables are routed carefully to ensure that the airflow in and out of the product is not impeded, when using the reduced clearances.

NOTE If DIN rail mounting is used in an installation where the drive is to be subjected to shock or vibration, it is recommended that the bottom mounting screws are used to secure the drive to the back-plate. If the installation is going to be subjected to heavy shock or vibration, then it is recommended that the drive is surface mounted rather than DIN rail mounted.

NOTE

The DIN rail mounting mechanism has been designed so no tools are required to install and remove the drive from a DIN rail. Please ensure the top mounting lugs are located correctly on the DIN rail before installation is initiated. The DIN rail used should conform to DIN46277-3.

3.5 Enclosure layout

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

Figure 3-7 Enclosure layout (KBG3 illustrated)

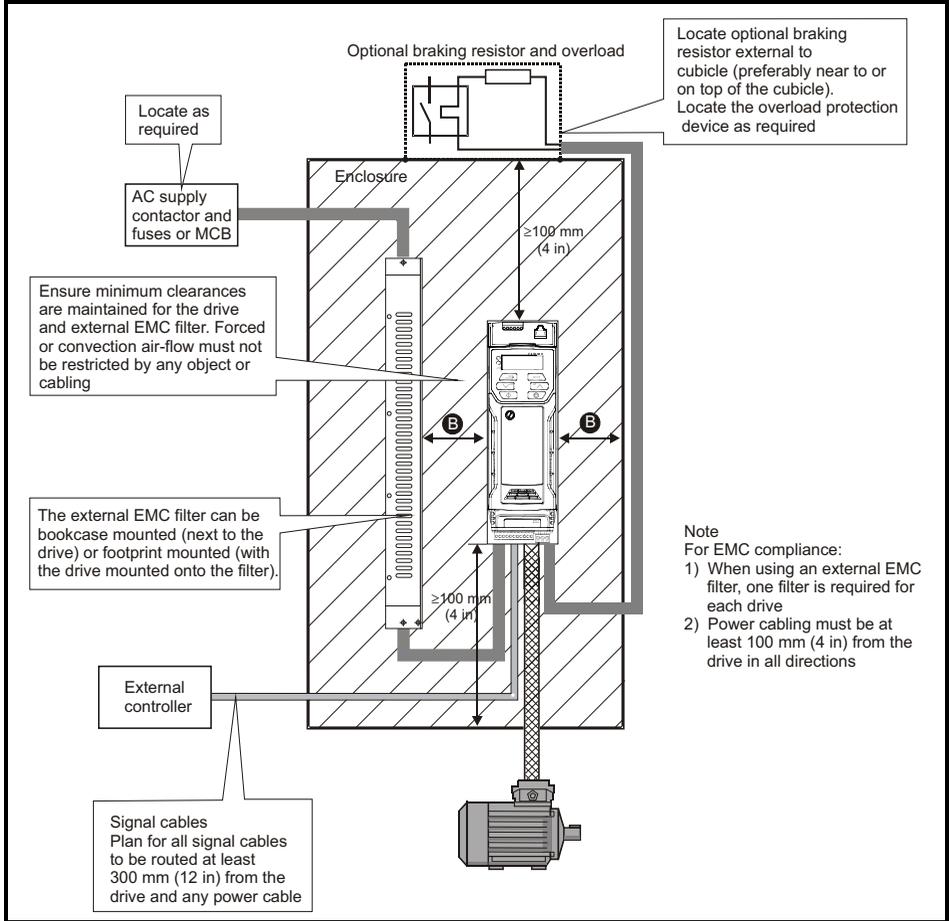


Table 3-1 Spacing required between drive / enclosure and drive / EMC filter

Drive size	Spacing (B)
All	0 mm (0.00 in)

3.5.1 Enclosure sizing

1. Add the dissipation figures from section 5.1.2 *Power dissipation* on page 77 for each drive that is to be installed in the enclosure.
2. If an external EMC filter is to be used with each drive, add the dissipation figures from section 5.2.1 *EMC filter ratings* on page 97 for each external EMC filter that is to be installed in the enclosure.
3. If the braking resistor is to be mounted inside the enclosure, add the average power figures for each braking resistor that is to be installed in the enclosure.
4. Calculate the total heat dissipation (in Watts) of any other equipment to be installed in the enclosure.
5. Add the heat dissipation figures obtained above. This gives a figure in Watts for the total heat that will be dissipated inside the enclosure.

Calculating the size of a sealed enclosure

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

Calculate the minimum required unobstructed surface area A_e for the enclosure from:

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

Where:

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

Example

To calculate the size of an enclosure for the following:

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

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

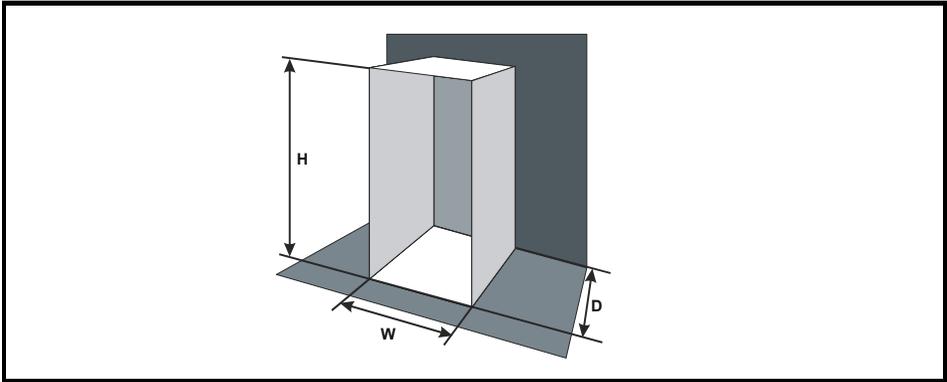
Total dissipation: $2 \times (187 + 9.2) = 392.4 W$

NOTE Power dissipation for the drives and the external EMC filters can be obtained from Chapter 5 *Technical data* on page 75.

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

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

Figure 3-8 Enclosure having front, sides and top panels free to dissipate heat



Insert the following values:

$$T_{\text{int}} \quad 40 \text{ }^{\circ}\text{C}$$

$$T_{\text{ext}} \quad 30 \text{ }^{\circ}\text{C}$$

$$k \quad 5.5$$

$$P \quad 392.4 \text{ W}$$

The minimum required heat conducting area is then:

$$A_e = \frac{392,4}{5,5(40 - 30)}$$

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

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

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

Inserting $H = 2 \text{ m}$ and $D = 0.6 \text{ m}$, obtain the minimum width:

$$W = \frac{7,135 - (2 \times 2 \times 0,6)}{2 + 0,6}$$

$$= 1.821 \text{ m (71.7 in)}$$

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

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

Calculating the air-flow in a ventilated enclosure

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

Calculate the minimum required volume of ventilating air from:

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

Where:

- V** Air-flow in m³ per hour (1 m³/hr = 0.59 ft³/min)
- T_{ext}** Maximum expected temperature in °C *outside* the enclosure
- T_{int}** Maximum permissible temperature in °C *inside* the enclosure
- P** Power in Watts dissipated by *all* heat sources in the enclosure
- k** Ratio of $\frac{P_o}{P_i}$

Where:

- P₀** is the air pressure at sea level
- P₁** is the air pressure at the installation

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

Example

To calculate the size of an enclosure for the following:

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

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

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

Insert the following values:

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

Then:

$$V = \frac{3 \times 1.3 \times 323.7}{40 - 30}$$
$$= 126.2 \text{ m}^3/\text{hr} \text{ (74.5 ft}^3/\text{min)} \text{ (1 m}^3/\text{hr} = 0.59 \text{ ft}^3/\text{min)}$$

3.5.2 Enclosure design and drive ambient temperature

Drive derating is required for operation in high ambient temperatures

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

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

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

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

Where:

T_{ext} = Temperature outside the cabinet

T_{int} = Temperature inside the cabinet

T_{rate} = Temperature used to select current rating from tables in Chapter 5 *Technical data* on page 75.

3.6 Heatsink fan operation

The drive is ventilated by an internal heatsink fan. The fan channels air through the heatsink chamber.

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

The heatsink fan on all drive sizes is a variable speed fan (except for size 1 which has a single speed fan). The drive controls the speed at which the fan runs based on the temperature of the heatsink and the drive's thermal model system. The maximum speed at which the fan operates can be limited in Pr **06.045**. This could incur an output current derating.

Table 3-2 Environmental considerations

Environment	Comments
Clean	
Dry, dusty (non-conductive)	Regular cleaning recommended
Dry, dusty (conductive)	

3.7 External EMC filter

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

Model	Part number	Weight	
		kg	lb
115 V			
11017-1 to 11024-1	4200-1000	0.49	1.08
	4200-1001 (low leakage)		
11042-2 to 11056-2	4200-2000	0.90	1.98
230 V			
21017-1 to 21042-1	4200-1000	0.49	1.08
	4200-1001 (low leakage)		
22024-2 to 22075-2	4200-2001	0.86	1.89
	4200-2002 (low leakage)		
	4200-2003	0.88	1.94
4200-2004 (low leakage)			
22100-3	4200-3000	0.92	2.02
	4200-3001 (low leakage)		
	4200-3004	0.95	2.09
4200-3005 (low leakage)			
22133-4 to 23176-4	4200-4000	1.3	2.86
	4200-4001 (low leakage)		
	4200-4002	1.4	3.08
4200-4003 (low leakage)			
460 V			
43013-2 to 43041-2	4200-2005	0.82	1.80
	4200-2006 (low leakage)		
43056-3 to 43094-3	4200-3008	1	2.20
	4200-3009 (low leakage)		
43135-4 to 43170-4	4200-4004	1.4	3.08
	4200-4005 (low leakage)		

Mount the external EMC filter following the guidelines in section 4.7.5 *Compliance with generic emission standards* on page 69

Figure 3-9 Footprint mounting the EMC filter

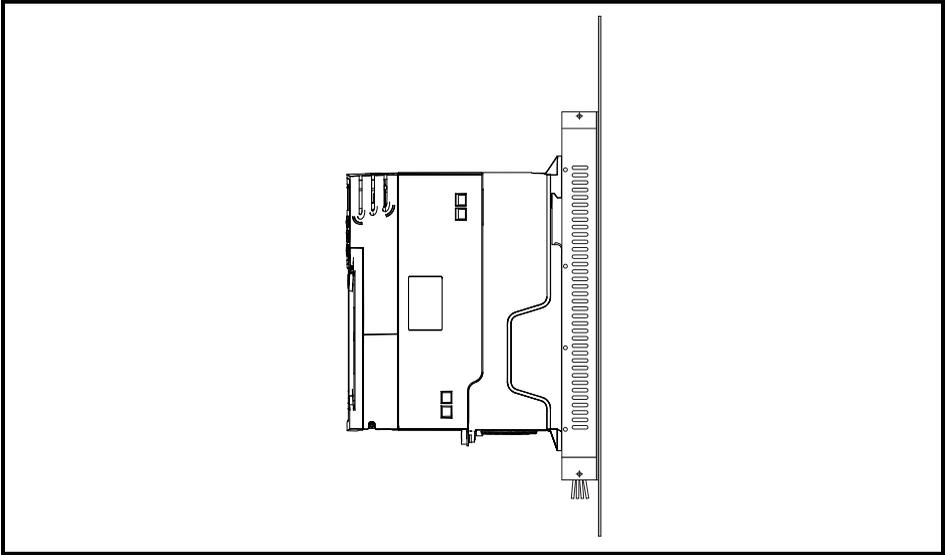


Figure 3-10 Bookcase mounting the EMC filter

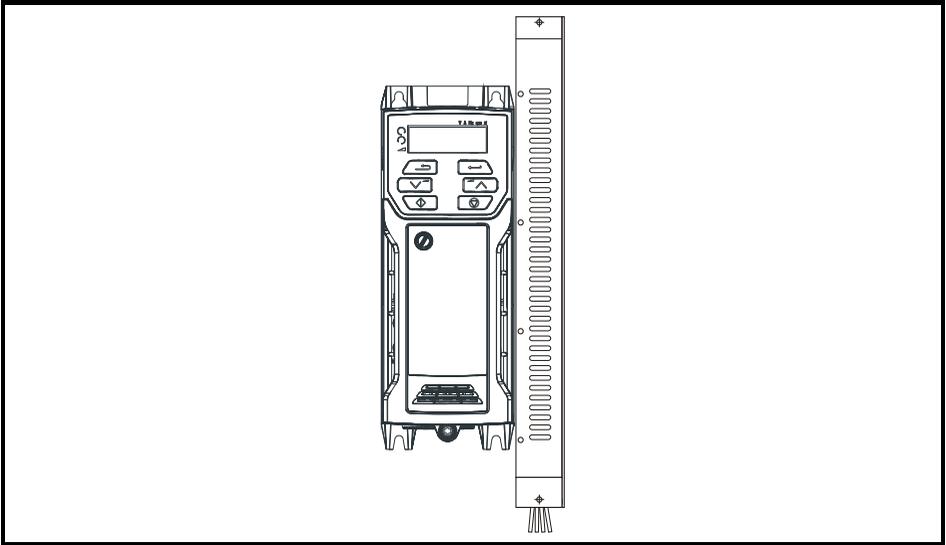
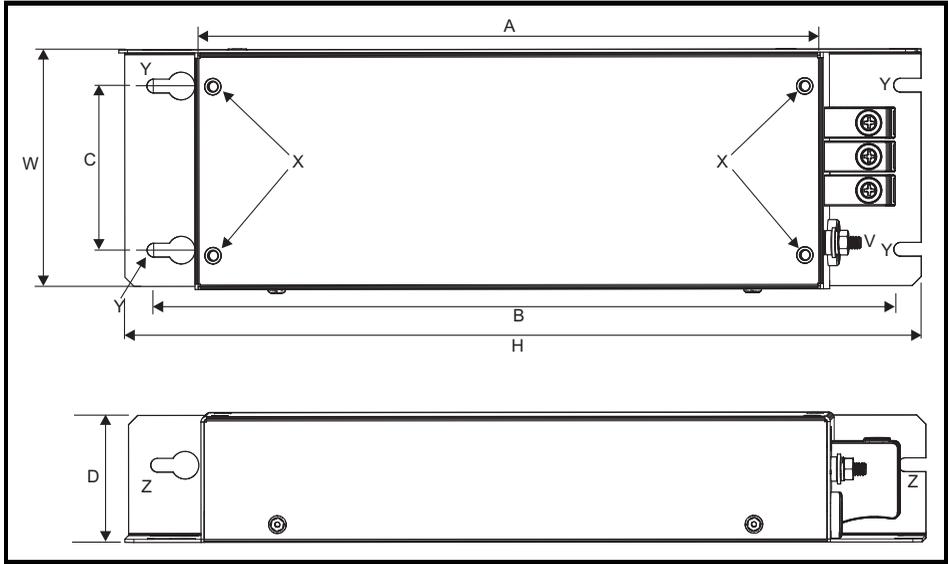


Figure 3-11 Size 1 to 4 external EMC filter



V: Ground stud

X: Threaded holes for footprint mounting of the drive

Y: Footprint mounting hole diameter

Z: Bookcase mounting slot diameter

CS: Cable size

Table 3-3 Size 1 external EMC filter dimensions

Part number	A	B	C	D	H	W	V/X	Y	Z	CS
4200-1000	160 mm (6.30 in)	198.8 mm (7.83 in)	52.4 mm (2.06 in)	41 mm (1.61 in)	215 mm (8.46 in)	75 mm (2.95 in)	M4	4.5 mm (0.18 in)	4.5 mm (0.18 in)	1.5 mm ² (16 AWG)
4200-1001										

Table 3-4 Size 2 external EMC filter dimensions

Part number	A	B	C	D	H	W	V/X	Y	Z	CS
4200-2000	206 mm (8.11 in)	244.8 mm (9.64 in)	53.4 mm (2.10 in)	41 mm (1.61 in)	261 mm (10.2 in)	78 mm (3.07 in)	M4	4.5 mm (0.18 in)	4.5 mm (0.18 in)	4.0 mm ² (12 AWG)
4200-2001										
4200-2002										
4200-2003										
4200-2004										
4200-2005										
4200-2006										1.5 mm ² (16 AWG)

Table 3-5 Size 3 external EMC filter dimensions

Part number	A	B	C	D	H	W	V/X	Y	Z	CS
4200-3000	227 mm (8.94 in)	265.8 mm (10.4 in)	59 mm (2.32 in)	41 mm (1.61 in)	282 mm (11.1 in)	90 mm (3.54 in)	M4	4.5 mm (0.18 in)	4.5 mm (0.18 in)	4.0 mm ² (12 AWG)
4200-3001										2.5 mm ² (14 AWG)
4200-3004										
4200-3005										
4200-3008										
4200-3009										

Table 3-6 Size 4 external EMC filter dimensions

Part number	A	B	C	D	H	W	V/X	Y	Z	CS
4200-4000	279 mm (10.9 in)	318.8 mm (12.5 in)	80.5 mm (3.17 in)	41 mm (1.61 in)	334 mm (13.1 in)	115 mm (4.53 in)	M5	5.5 mm (0.22 in)	5.5 mm (0.22 in)	4.0 mm ² (12 AWG)
4200-4001										2.5 mm ² (14 AWG)
4200-4002										
4200-4003										
4200-4004										
4200-4005										

3.7.1 EMC filter torque settings

Table 3-7 Optional external EMC filter terminal data

Part number	Power connections		Ground connections	
	Max cable size*	Max torque	Ground stud size	Max torque
4200-1000	10 mm ² (6 AWG)	1.8 N m (1.4 lb ft)	M4	1.7 N m (1.3 lb ft)
4200-1001				
4200-2000				
4200-2001				
4200-2002	6 mm ² (8 AWG)	1.8 N m (1.4 lb ft)	M4	1.7 N m (1.3 lb ft)
4200-2003				
4200-2004				
4200-2005				
4200-2006	10 mm ² (6 AWG)	1.8 N m (1.4 lb ft)	M4	1.7 N m (1.3 lb ft)
4200-3000				
4200-3001	6 mm ² (8 AWG)	1.8 N m (1.4 lb ft)	M4	1.7 N m (1.3 lb ft)
4200-3004				
4200-3005	6 mm ² (8 AWG)	1.8 N m (1.4 lb ft)	M4	1.7 N m (1.3 lb ft)
4200-3008				
4200-3009				
4200-4000	6 mm ² (8 AWG)	1.8 N m (1.4 lb ft)	M5	2.2 N m (1.6 lb ft)
4200-4001				
4200-4002				
4200-4003				
4200-4004				
4200-4005				

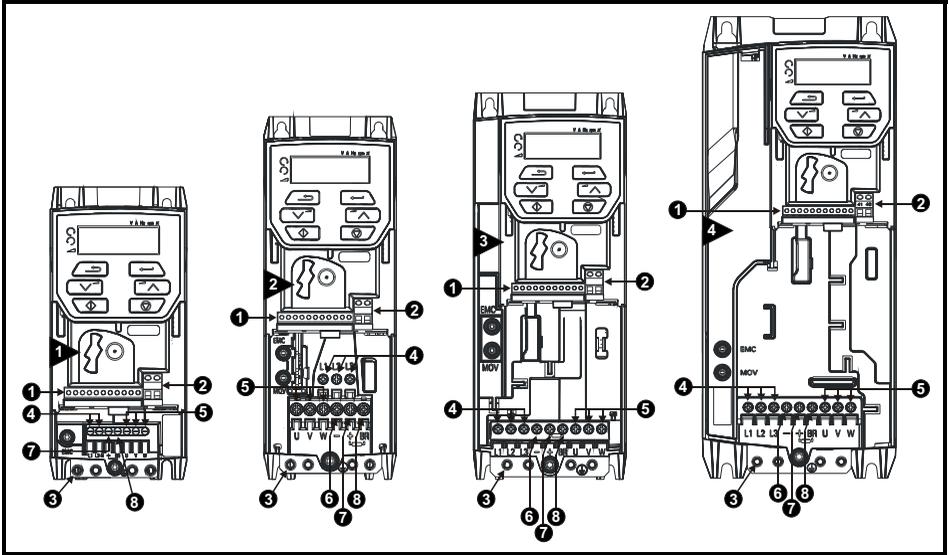
* Flex wire.

Table 3-8 Fastener details for drive footprint mounting on external EMC filter

Type	Size 1	Size 2	Size 3	Size 4
Thread size	M4	M4	M4	M5
Length (mm)	12	12	12	12

3.8 Electrical terminals

Figure 3-12 Location of the power and ground terminals (KBG3 size 1 to 4 shown)



Key:

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

3.8.1 Terminal sizes and torque settings



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

Table 3-9 Drive control terminal data

Model	Connection type	Torque setting
All	Screw terminals	0.2 N m (0.15 lb ft)

Table 3-10 Drive relay terminal data

Model	Connection type	Torque setting
All	Screw terminals	0.5 N m (0.4 lb ft)

Table 3-11 Drive power terminal data

Model size	AC and motor terminals		DC and braking		Ground terminal	
	Recommended	Maximum	Recommended	Maximum	Recommended	Maximum
1	0.5 N m (0.4 lb ft)		0.5 N m (0.4 lb ft)		1.5 N m (1.1 lb ft)	
2	1.4 N m (1 lb ft)		1.4 N m (1 lb ft)			
3						
4						

Table 3-12 Terminal block maximum cable sizes

Model size	Terminal block description	Max cable size
All	Control connector	1.5 mm ² (16 AWG)
All	2-way relay connector	2.5 mm ² (12 AWG)
1 to 4	STO connector	0.5 mm ² (20 AWG)
1	AC input / output power connector	2.5 mm ² (12 AWG)
2 to 4	AC input / output power connector	4.0 mm ² (10 AWG)

3.9 Routine maintenance

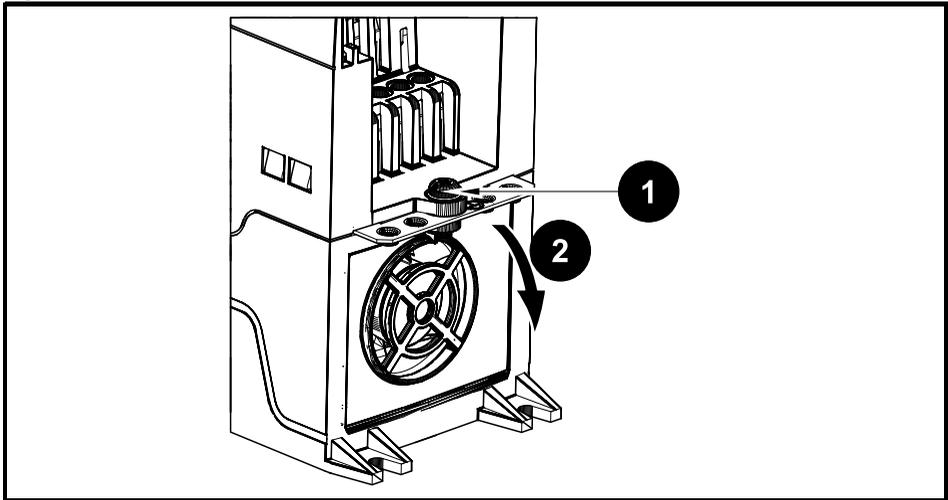
The drive should be installed in a cool, clean, well ventilated location. Contact with moisture and/or dust with the drive should be avoided.

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

3.9.1 Fan removal procedure

Figure 3-13 Removal of the size 1 to 4 heatsink fan (size 2 illustrated)



1. Remove the screw from the drive (size 1: Torx 10, size 2 to 4: Torx 20).
2. Tilt the fan guard, then withdraw the fan assembly from the drive housing. Finally disconnect the fan cable from the drive.

NOTE Replace the fan by reversing the above instructions.

Table 3-13 Heatsink fan replacement kits

Model	Part number
Size 1	3470-0092
Size 2	3470-0095
Size 3	3470-0099
Size 4	3470-0103

4 Electrical installation

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

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



WARNING

Electric shock risk

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

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

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



WARNING

Isolation device

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



WARNING

STOP function

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



WARNING

Safe Torque Off function

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



WARNING

Stored charge

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



WARNING

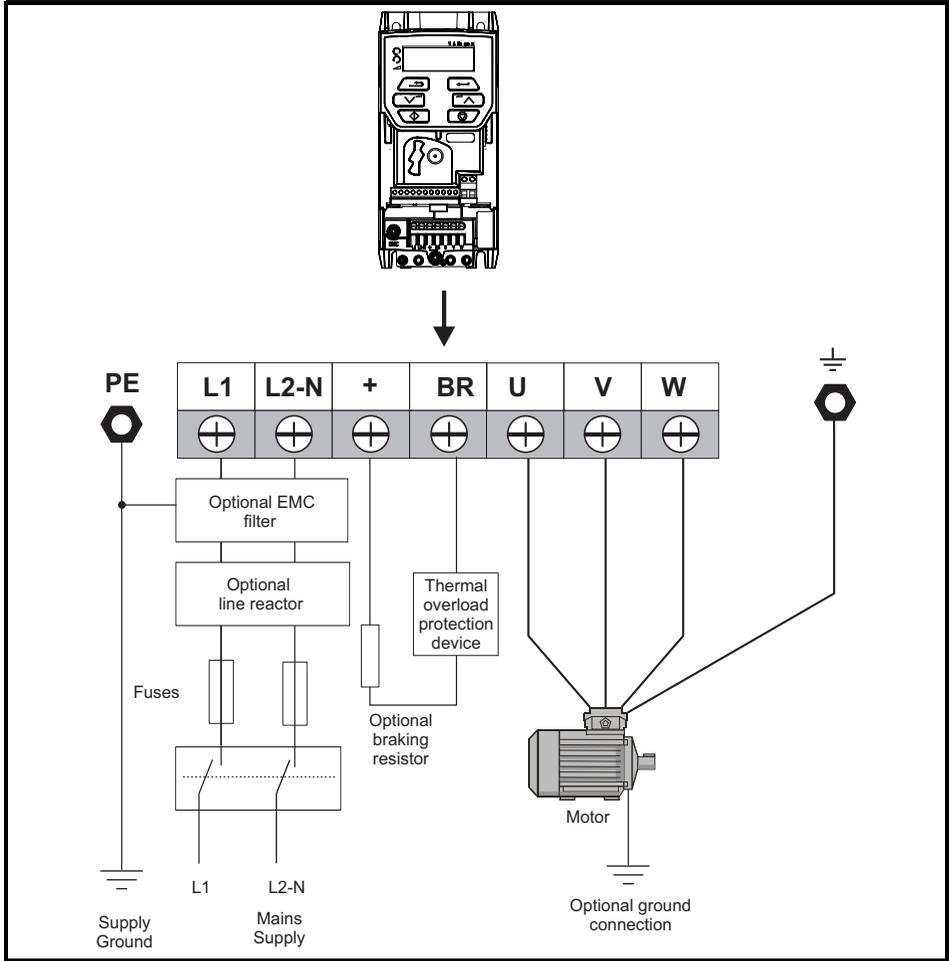
Equipment supplied by plug and socket

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

4.1 Power connections

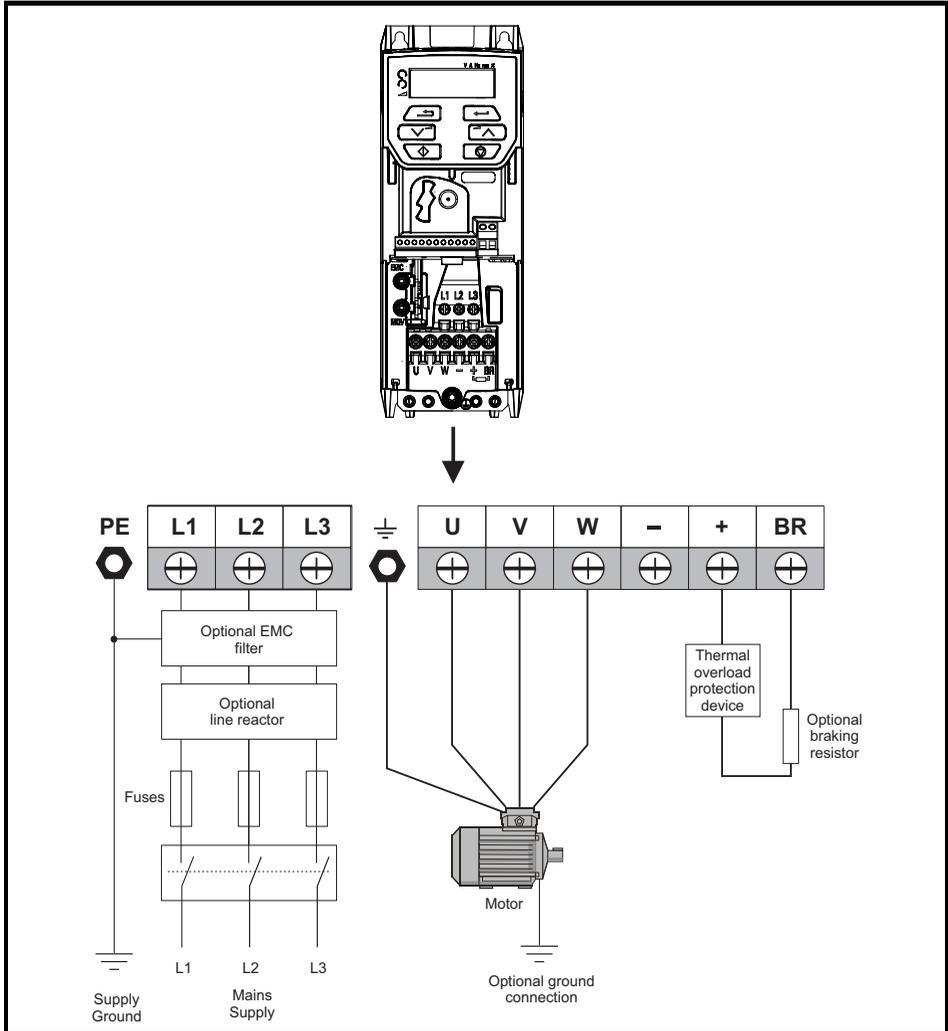
4.1.1 AC and DC connections

Figure 4-1 Size 1 power connections (KBG3 shown)



See Figure 4-5 *Size 1 to 4 ground connections (KBG3 size 2 shown)* on page 42 for further information on ground connections.

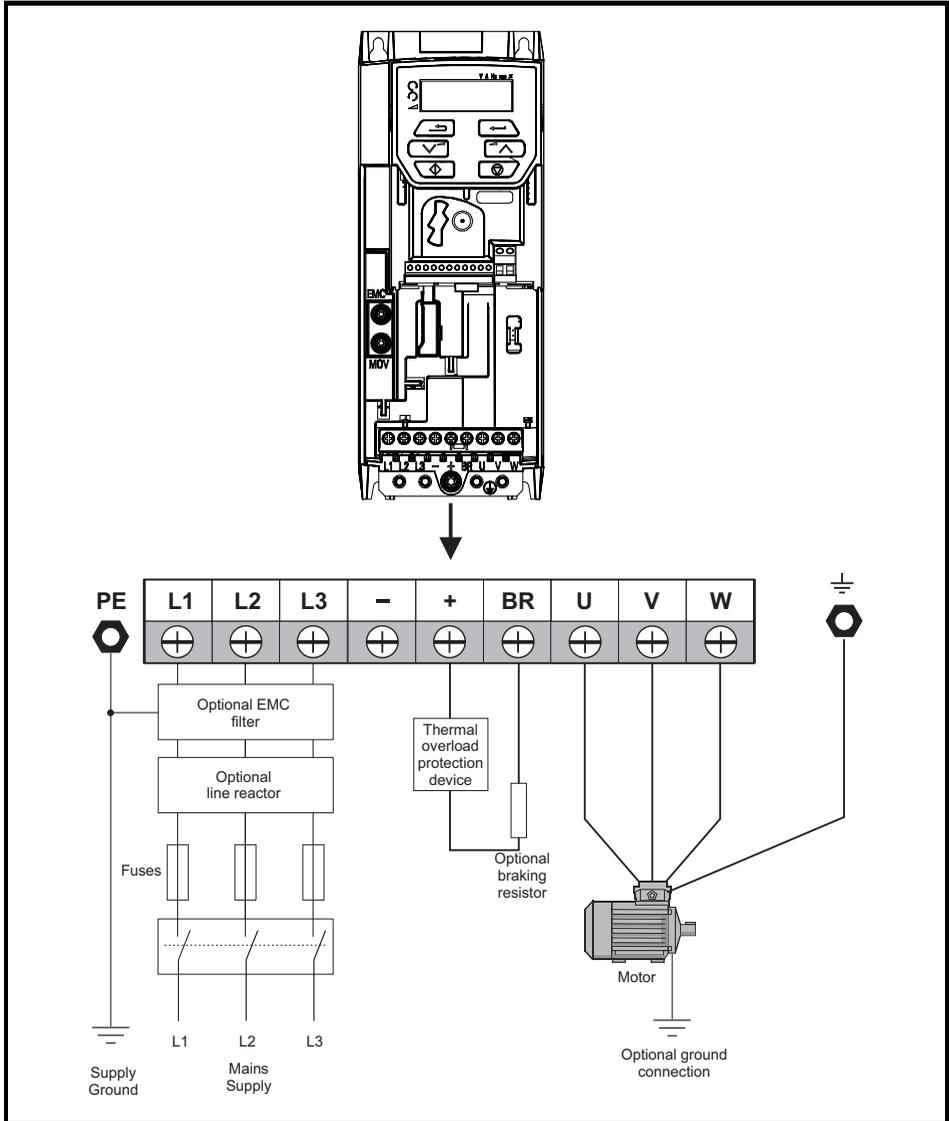
Figure 4-2 Size 2 power connections (KBG3 shown)



See Figure 4-5 *Size 1 to 4 ground connections (KBG3 size 2 shown)* on page 42 for further information on ground connections.

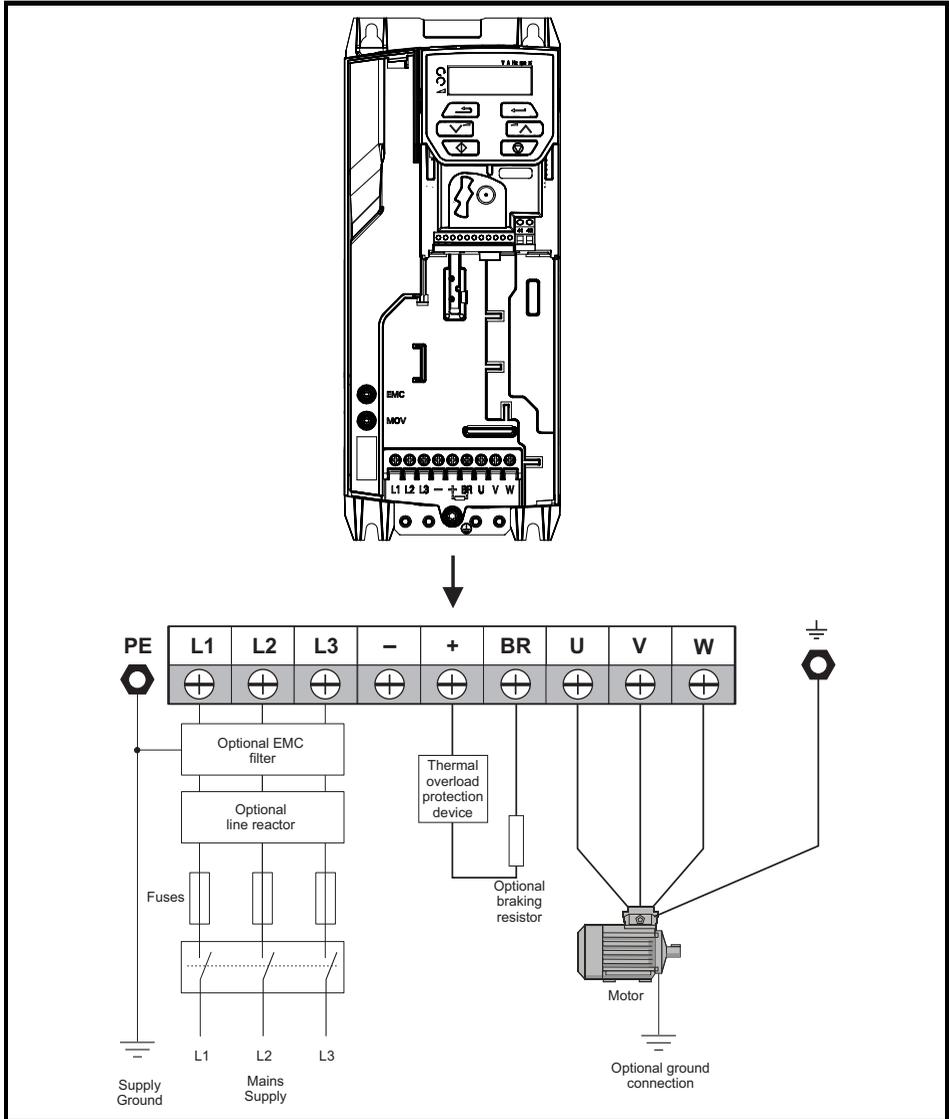
NOTE On the size 2 115 V drives or when connecting single phase to a dual rated 230 V unit, the supply should be connected to L1 and L3. Also the -DC bus (-) terminal on 115 V drives has no internal connection. The 115 V drives use a voltage doubler circuit on the input, therefore the default for *Motor Rated Voltage (Pr 05.009)* is 230 V.

Figure 4-3 Size 3 power connections (KBG3 shown)



See Figure 4-5 *Size 1 to 4 ground connections (KBG3 size 2 shown)* on page 42 for further information on ground connections.

Figure 4-4 Size 4 power connections (KBG3 shown)



See Figure 4-5 *Size 1 to 4 ground connections (KBG3 size 2 shown)* on page 42 for further information on ground connections.

4.1.2 Ground connections



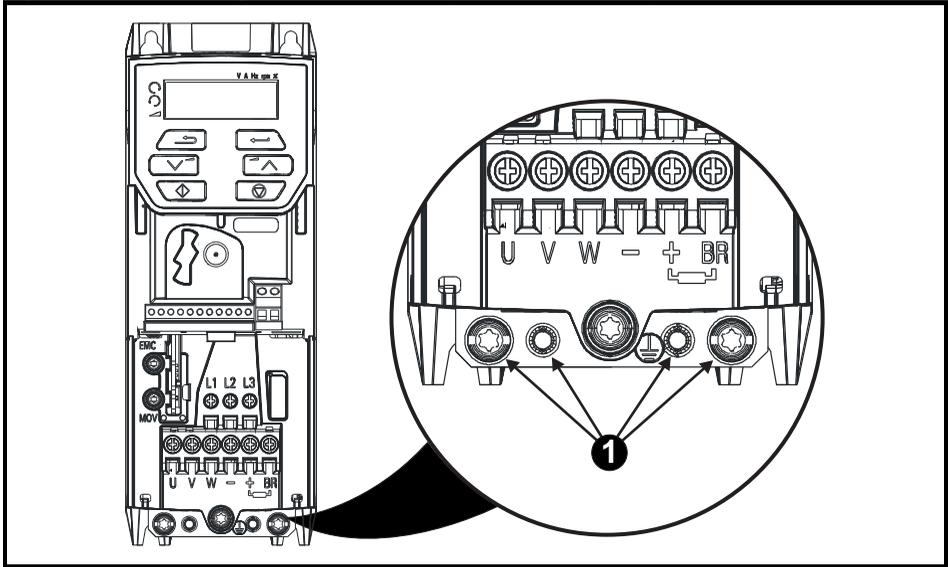
Electrochemical corrosion of grounding terminals

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

Size 1 to 4

The supply and motor ground connections are made using the ground busbar located at the bottom of the drive as shown in Figure 4-5.

Figure 4-5 Size 1 to 4 ground connections (KBG3 size 2 shown)



1: 4 x M4 threaded holes for the ground connection busbar



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

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

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

4.1.3 Protective ground cable ratings

Minimum ground conductor size

Either 10 mm² or two conductors of the same cross-sectional area as the input phase conductor.

4.2 AC supply requirements

Voltage:

115 V drive:	100 V to 120 V ± 10 %
230 V drive:	200 V to 240 V ± 10 %
460 V drive:	380 V to 480 V ± 10 %

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

Frequency range: 45 to 66 Hz

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

4.2.1 Supply types

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

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



Operation with IT (ungrounded) supplies:

Special attention is required when using internal or external EMC filters with ungrounded supplies, because in the event of a ground (earth) fault in the motor circuit the drive may not trip and the filter could be over-stressed. In this case, either the filter must not be used i.e. removed, or additional independent motor ground fault protection must be provided.

For instructions on removal, refer to Figure 4-13 *Removal of the size 1 internal EMC filter* on page 64 to Figure 4-16 *Removal of the size 4 internal EMC filter* on page 65.

For details of ground fault protection contact the supplier of the drive.

A ground fault in the supply has no effect in any case. If the motor must continue to run with a ground fault in its own circuit then an input isolating transformer must be provided and if an EMC filter is required it must be located in the primary circuit. Unusual hazards can occur on ungrounded supplies with more than one source, for example on ships. Contact the supplier of the drive for more information

4.2.2 Supplies requiring line reactors

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

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

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

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

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

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

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

Line reactors are particularly recommended for use with the following drive models when one of the above factors exists, or when the supply capacity exceeds 175 kVA: Size 1 to 3.

Model sizes 22133-4 to 43170-4 have an internal DC choke so they do not require AC line reactors except for cases of excessive phase unbalance or extreme supply conditions.

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

Reactor current ratings

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

Continuous current rating:

Not less than the continuous input current rating of the drive

Repetitive peak current rating:

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

4.2.3 Input inductor calculation

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

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

Where:

I = drive rated input current (A)

L = inductance (H)

f = supply frequency (Hz)

V = voltage between lines

4.2.4 Input line reactor specification for size 1 to 4

Table 4-1 AC line reactor values

Drives used with	Reactor part number	Input phases	Inductance mH	Continuous rms current A	Peak current A	Weight kg	Dimensions (mm)		
							L	D	H
							mm	mm	mm
21017-1 21024-1	4402-0224	1	2.25	6.5	13	0.8	72	65	90
21033-1 21042-1	4402-0225	1	1.0	15.1	30.2	1.1	82	75	100
21024-2 21033-2 21042-2 21056-2	4402-0224	1	2.25	6.5	13	0.8	72	65	90
21075-2 21100-3 21133-4 23176-4	4402-0225	1	1.0	15.1	30.2	1.1	82	75	100
21075-2 21100-3 21133-4 23176-4	4402-0226	1	0.5	26.2	52.4	1.5	82	90	105
23024-2 23033-2 23042-2	4401-0224	3	1.96	4.3	8.6	1.1	65	110	70
23056-2 23075-2	4401-0225	3	1.12	7.5	15	1.2	80	130	65
23100-3 23133-4 23176-4	4401-0143	3	0.79	13.5	27	1.8	156	70	125
43013-2 43018-2 43023-2	4401-0144	3	0.48	20.6	41.2	2.4	156	80	125
43032-2 43041-2	4401-0232	3	6.1	2.4	4.8	1.1	65	110	70
43056-3 43073-3	4401-0233	3	5.1	3.5	7	1.2	80	130	65
43094-3 43135-4	4401-0148	3	2.94	6.6	13.2	1.3	80	130	75
43170-4	4401-0149	3	1.62	9.1	18.2	1.8	156	70	125
	4401-0234	3	1.12	13	26	2.5	156	72	114
	4401-0151	3	1.05	15.8	31.6	2.6	156	80	125
	4401-0235	3	0.71	21	42	3.6	156	68	133

Safety information

Product information

Mechanical installation

Electrical installation

Technical data

UL listing information

Figure 4-6 Input line reactor 4402-0224, 4402-0225 and 4402-0226

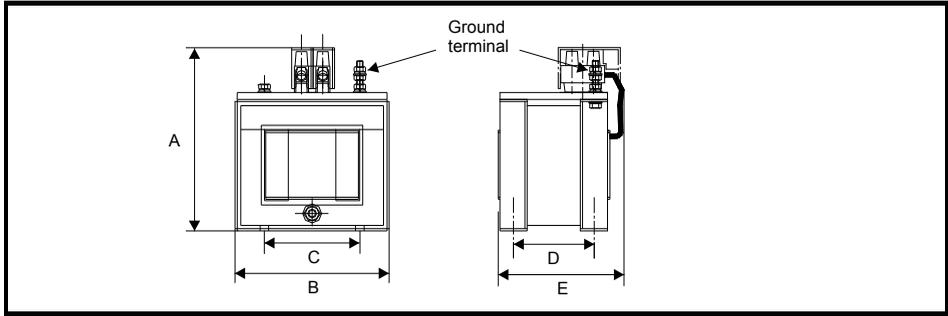


Table 4-2 Input line reactor dimensions

Part number	Dimensions						Ground terminal
	A	B	C	D	E	Mounting hole	
4402-0224	90 mm (3.54 in)	72 mm (2.84 in)	44.5 mm (1.75 in)	35 mm (1.38 in)	65 mm (2.56 in)	8 mm x 4 mm (0.32 in x 0.16 in)	M3
4402-0225	100 mm (3.94 in)	82 mm (3.23 in)	54 mm (2.13 in)	40 mm (1.58 in)	75 mm (2.95 in)		
4402-0226	105 mm (4.13 in)			53 mm (2.09 in)	90 mm (3.54 in)		

Figure 4-7 Input line reactor

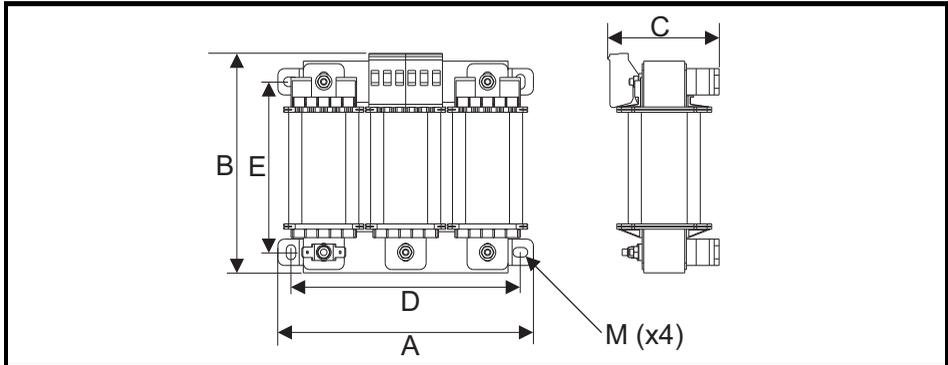


Table 4-3 Input line reactor dimensions

Part number	Dimensions					Mounting hole (M)
	A	B	C	D	E	
4401-0224	65 mm (2.56 in)	110 mm (4.33 in)	70 mm (2.76 in)	55 mm (2.17 in)	90 mm (3.54 in)	6 mm x 4 mm (0.24 in x 0.16 in)
4401-0225	80 mm (3.15 in)	130 mm (5.12 in)	65 mm (2.56 in)	60.5 mm (2.38 in)	111 mm (4.37 in)	
4401-0143	156 mm (6.14 in)	125 mm (4.92 in)	70 mm (2.76 in)	140 mm (5.51 in)	83 mm (3.27 in)	5.8 mm x 9 mm (0.23 in x 0.35 in)
4401-0144	156 mm (6.14 in)	125 mm (4.92 in)	80 mm (3.15 in)	140 mm (5.51 in)	83 mm (3.27 in)	
4401-0232	65 mm (2.56 in)	110 mm (4.33 in)	70 mm (2.76 in)	55 mm (2.17 in)	90 mm (3.54 in)	6 mm x 4 mm (0.24 in x 0.16 in)
4401-0233	80 mm (3.15 in)	130 mm (5.12 in)	65 mm (2.56 in)	60.5 mm (2.38 in)	111 mm (4.37 in)	
4401-0148	80 mm (3.15 in)	130 mm (5.12 in)	75 mm (2.95 in)	60.5 mm (2.38 in)	111 mm (4.37 in)	
4401-0149	156 mm (6.14 in)	125 mm (4.92 in)	70 mm (2.76 in)	140 mm (5.51 in)	83 mm (3.27 in)	5.8 mm x 9 mm (0.23 in x 0.35 in)
4401-0234	156 mm (6.14 in)	114 mm (4.49 in)	72 mm (2.83 in)	140 mm (5.51 in)	83 mm (3.27 in)	
4401-0151	156 mm (6.14 in)	125 mm (4.92 in)	80 mm (3.15 in)	140 mm (5.51 in)	83 mm (3.27 in)	
4401-0235	156 mm (6.14 in)	133 mm (5.24 in)	68 mm (2.68 in)	140 mm (5.51 in)	104 mm (4.09 in)	

4.3 Ratings

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

Typical input current

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

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

Maximum continuous input current

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

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

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

Model	Symmetrical fault level (kA)
All	10



Fuses

The AC supply to the drive must be installed with suitable protection against overload and short-circuits. Table 4-5, Table 4-6 and Table 4-7 show the recommended fuse ratings. Failure to observe this requirement will cause risk of fire.

Table 4-5 AC Input current and fuse ratings (115 V)

Model	Maximum continuous input current A	Maximum overload input current A	Fuse rating					MCB rating**	
			IEC		UL			Nominal	
			Maximum A	Class	Nominal A	Maximum A	Class	A	
11017-1	8.7	12.6	10	gG	15	15	CC, J or T*	15	
11024-1	11.1	15.2	16		15	15		15	
11042-2	18.8	28.2	20		20	20		15	
11056-2	24.0	37.4	25		25	25		15	

Table 4-6 AC Input current and fuse ratings (230 V)

Model	Typical input current A	Maximum continuous input current A	Maximum overload input current A	Fuse rating									MCB rating**	
				IEC					UL / USA				Nominal	
				Nominal		Maximum		Class	Nominal	Maximum		Class	Nominal	
				1ph	3ph	1ph	3ph			1ph	3ph		1ph	3ph
A		A		A		A		A		A				
21017-1		4.5	6.9	6		6		gG	6	6		CC, J or T*	15	
21024-1		5.3	8.4	6		6			6	6			15	
21033-1		8.3	14.2	10		10			15	15			15	
21042-1		10.4	16.8	16		16			15	15			15	
22024-2	- / 3.2	5.3/4.1	8.1/5.9	6		6		gG	6	6	6	CC, J or T*	15	
22033-2	- / 4.3	8.3/6.7	14/9.2	10		10			10	10			15	
22042-2	- / 5.4	10.4/7.5	16.4/10.8	16	10	16	10		15/10	15	10		15	
22056-2	- / 8.1	16.0/12.9	24.0/17.5	20	16	20	16		20/15	20	15		15	
22075-2	- / 9.1	18.1/13.5	30.4/19.5						20/15				15	15
22100-3	- / 12.8	23.9/17.7	30/25	25	20	25	20	gG	25/20	25	20	CC, J or T*	25	20
22133-4	- / 13.5	23.7/16.9	43.3/23.5	25	20	25	20	gG	25/20	25	20	CC, J or T*	25	20
23176-4	- / 17.0	23.7/21.3	43.3/28.6	25	25	25	25	gG	25	25	25	CC, J or T*	25	

* These are fast acting fuses.

** UL Listed DIVQ / DIVQ7 listed, rated voltage is 600 Vac (for USA and Canada). Short circuit rating is 10 kA. In other countries, EN IEC circuit breakers can be used with 10 kA supply rating.

Table 4-7 AC Input current and fuse ratings (460 V)

Model	Typical input current A	Maximum continuous input current A	Maximum overload input current A	Fuse rating						MCB rating**
				IEC			UL / USA			
				Nominal	Maximum	Class	Nominal	Maximum	Class	Nominal
				A	A		A	A		A
43013-2	2.1	2.4	4.2	6	6	gG	6	6	CC, J or T*	15
43018-2	2.6	2.9	5.2							
43023-2	3.1	3.5	6.1							
43032-2	4.7	5.1	7.5							
43041-2	5.8	6.2	9	10	10	gG	15	15	CC, J or T*	15
43056-3	8.3	8.7	13	10	10					
43073-3	10.2	12.2	18	16	16					
43094-3	13.1	14.8	20.7							
43135-4	14.0	16.3	24.7	20	20	gG	20	20	CC, J or T*	20
43170-4	18.5	20.7	32.4	25	25		25	25		25

* These are fast acting fuses.

** UL Listed DIVQ / DIVQ7 listed, rated voltage is 600 Vac (for USA and Canada). Short circuit rating is 10 kA. In other countries, EN IEC circuit breakers can be used with 10 kA supply rating.

NOTE Ensure cables used suit local wiring regulations.



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

Table 4-8 Cable ratings (115 V)

Model	Cable size (IEC 60364-5-52) mm ²				Cable size (UL508C) AWG			
	Input		Output		Input		Output	
	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum
11017-1	1	2.5	1	2.5	16	12	16	12
11024-1	1.5		1		14			
11042-2	2.5	4	1	4	12	10	16	10
11056-2	4		1		10			

Table 4-9 Cable ratings (230 V)

Model	Cable size (IEC 60364-5-52) mm ²				Cable size (UL508C) AWG							
	Input		Output		Input		Output					
	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum				
21017-1	1	2.5	1	2.5	16	12	16	12				
21024-1												
21033-1												
21042-1												
22024-2	1	4	1	4	16	10	16	10				
22033-2												
22042-2					2.5/1.5				4	1	4	12/14
22056-2												12
22075-2	2.5	4	1.5	4	10/12	10	14	10				
22100-3	4											
22133-4	4/2.5	4	2.5	4	10	10	12	10				
23176-4	4											

Table 4-10 Cable ratings (460 V)

Model	Cable size (IEC 60364-5-52) mm ²				Cable size (UL508C) AWG							
	Input		Output		Input		Output					
	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum				
43013-2	1	4	1	4	16	10	16	10				
43018-2												
43023-2												
43032-2												
43041-2	1	4	1	4	14	10	16	10				
43056-3					12							
43073-3			1.5		4		1.5		4	10	10	14
43094-3			2.5									
43135-4	2.5	4	2.5	4	10	10	12	10				
43170-4	4											

NOTE PVC insulated cable should be used.

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

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

B1 - Separate cables in conduit.

B2 - Multicore cable in conduit.

C - Multicore cable in free air.

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

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

Fuse types

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

Ground connections

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

NOTE For information on ground cable sizes, refer to Table 4.1.3 *Protective ground cable ratings* on page 42.

4.3.1 Main AC supply contactor

The recommended AC supply contactor type for size 1 to 4 is AC1.

4.4 Output circuit and motor protection

The output circuit has fast-acting electronic short-circuit protection which limits the fault current to typically no more than 2.5 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, *Rated Current (00.006)* must be set to suit the motor.



Motor Rated Current (00.006) must be set correctly to avoid a risk of fire in the event of motor overload.

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

4.4.1 Cable types and lengths

Since capacitance in the motor cable causes loading on the output of the drive, ensure the cable length does not exceed the values given in Table 4-11 to Table 4-13.

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

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

Table 4-11 Maximum motor cable lengths (115 V drives)

Model	115 V Nominal AC supply voltage								
	Maximum permissible motor cable length for each of the following switching frequencies								
	0.667 kHz	1 kHz	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
11017-1	75 m (245 ft)				37.5 m	25 m	18.75 m	12.5 m	9 m
11024-1					(122 ft)	(82.5 ft)	(61.9 ft)	(41.25 ft)	(29.7 ft)
11042-2	100 m (330 ft)				75 m	50 m	37.5 m	25 m	18 m
11056-2					(245 ft)	(165 ft)	(122 ft)	(82.5 ft)	(59.4ft)

Table 4-12 Maximum motor cable lengths (230 V drives)

Model	230 V Nominal AC supply voltage								
	Maximum permissible motor cable length for each of the following switching frequencies								
	0.667 kHz	1 kHz	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
21017-1	75 m (245 ft)				37.5 m	25 m	18.75 m	12.5 m	9 m
21024-1					(122 ft)	(82.5 ft)	(61 ft)	(41 ft)	(30 ft)
21033-1									
21042-1									
22024-2	100 m (330 ft)				75 m	50 m	37.5 m	25 m	18 m
22033-2					(245 ft)	(165 ft)	(122 ft)	(82.5 ft)	(60 ft)
22042-2									
22056-2									
22075-2									
22100-3	100 m (330 ft)				75 m	50 m	37.5 m	25 m	18 m
22133-4	100 m (330 ft)				75 m	50 m	37.5 m	25 m	18 m
23176-4					(245 ft)	(165 ft)	(122 ft)	(82.5 ft)	(60 ft)

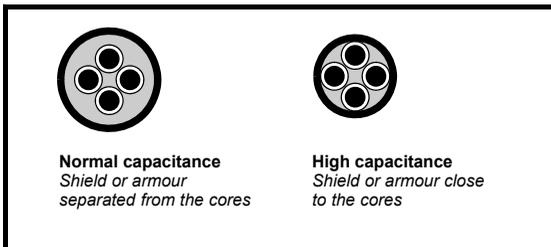
Table 4-13 Maximum motor cable lengths (460 V drives)

Model	460 V Nominal AC supply voltage								
	Maximum permissible motor cable length for each of the following switching frequencies								
	0.667 kHz	1 kHz	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
43013-2	100 m (330 ft)				75 m (245 ft)	50 m (165 ft)	37.5 m (122 ft)	25 m (82.5 ft)	18.25 m (60 ft)
43018-2									
43023-2									
43032-2									
43041-2									
43056-3	100 m (330 ft)				75 m (245 ft)	50 m (165 ft)	37.5 m (122 ft)	25 m (82.5 ft)	18.25 m (60 ft)
43073-3									
43094-3									
43135-4	100 m (330 ft)				75 m (245 ft)	50 m (165 ft)	37.5 m (122 ft)	25 m (82.5 ft)	18.25 m (60 ft)
43170-4									

4.4.2 High-capacitance / reduced diameter cables

The maximum cable length is reduced from that shown in section 4.4.1 *Cable types and lengths* on page 52, if high capacitance or reduced diameter motor cables are used.

Most cables have an insulating jacket between the cores and the armor or shield; these cables have a low capacitance and are recommended. Cables that do not have an insulating jacket tend to have high capacitance; if a cable of this type is used, the maximum cable length is half that quoted in the tables, (Figure 4-8 shows how to identify the two types).

Figure 4-8 Cable construction influencing the capacitance

The maximum motor cable lengths specified in section 4.4.1 *Cable types and lengths* on page 52 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).

4.4.3 Motor winding voltage

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

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

- AC supply voltage exceeds 500 V
- DC supply voltage exceeds 670 V (i.e. Regenerative / AFE supply)
- Operation of 460 V drive with continuous or very frequent sustained braking
- Multiple motors connected to a single drive

For multiple motors, the precautions given in section 4.4.4 *Multiple motors* should be followed. For the other cases listed, it is recommended that an inverter-rated motor be used taking into account the voltage rating of the inverter. This has a reinforced insulation system intended by the manufacturer for repetitive fast-rising pulsed voltage operation.

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

4.4.4 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** = Fixed or Squared). Make the motor connections as shown in Figure 4-9 and Figure 4-10. The maximum cable lengths in Table 4-11 to Table 4-13 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 Δ connection, a sinusoidal filter or an output inductor must be connected as shown in Figure 4-10, 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 4-9 Preferred chain connection for multiple motors

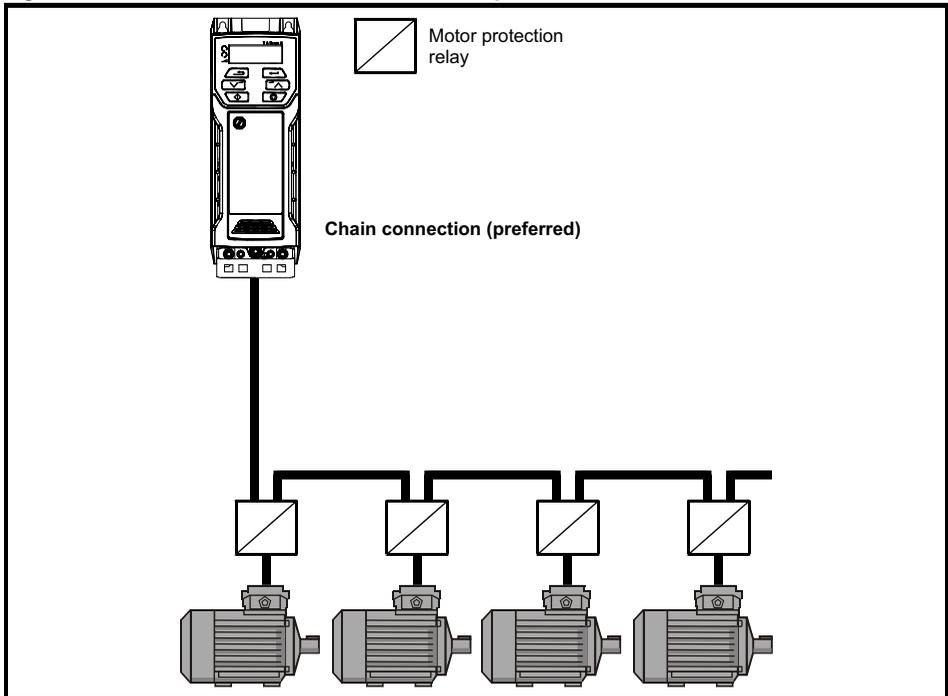
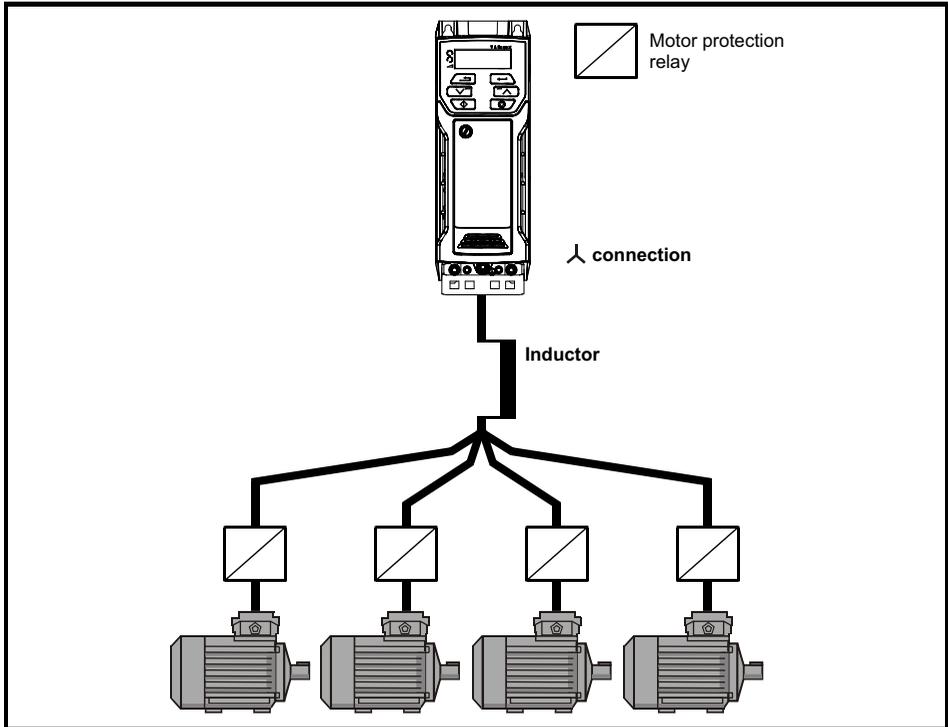


Figure 4-10 Alternative connection for multiple motors



4.4.5 ⋈ / Δ motor operation

The voltage rating for ⋈ 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.

460 V drive 400 V rated voltage

230 V drive 230 V rated voltage

A typical 3 phase motor would be connected in ⋈ for 460 V operation or Δ for 230 V operation.

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.

4.4.6 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 when opened, provides a Safe Torque Off function (KBG3 Series only). This can in many cases replace output contactors.

For further information see the *Control User Guide*.

4.5 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 motor braking is applied 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 4-14 shows the default DC voltage level at which the drive turns on the braking transistor. However the braking resistor turn on and the turn off voltages are programmable with *Braking IGBT Lower Threshold* (06.073) and *Braking IGBT Upper Threshold* (06.074).

Table 4-14 Default braking transistor turn on voltage

Drive voltage rating	DC bus voltage level
115 & 230 V	390 V
460 V	780 V

NOTE When a braking resistor is used, Pr **02.004** 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.



Braking resistor overload protection parameter settings

Failure to observe the following information may damage the resistor.

The drive software contains an overload protection function for a braking resistor.

For more information on the braking resistor software overload protection, see Pr **10.030**, Pr **10.031** and Pr **10.061** full descriptions in the *Parameter Reference Guide*.

4.5.1 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 4-11 on page 59.

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 4.7.5 *Compliance with generic emission standards* on page 69 for further details.

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

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

Table 4-15 Braking resistor resistance and power rating (115 V)

Model	Minimum resistance* Ω	Instantaneous power rating kW	Continuous power rating kW
11017-1	130	1.1	0.25
11024-1			0.37
11042-2	68	2.2	0.75
11056-2			1.1

Table 4-16 Braking resistor resistance and power rating (230 V)

Model	Minimum resistance* Ω	Instantaneous power rating kW	Continuous power rating kW
21017-1	130	1.1	0.25
21024-1			0.37
21033-1			0.55
21042-1			0.75
22024-2	68	2.2	0.37
22033-2			0.55
22042-2			0.75
22056-2			1.1
22075-2			1.5
22100-3	45	3.3	2.2
22133-4	22	6.0	3
23176-4			4

Table 4-17 Braking resistor resistance and power rating (460 V)

Model	Minimum resistance* Ω	Instantaneous power rating kW	Continuous power rating kW
43013-2	270	2.2	0.37
43018-2			0.55
43023-2			0.75
43032-2			1.1
43041-2			1.5
43056-3	100	6.0	2.2
43073-3			3
43094-3			4
43135-4	50	11.2	5.5
43170-4			7.5

* Resistor tolerance: $\pm 10\%$

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 therefore essential 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.

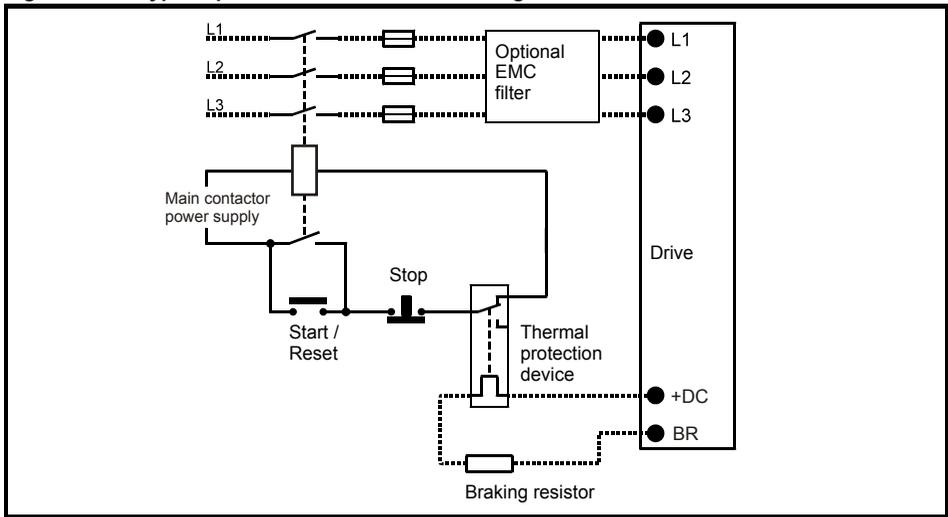
Optimization of the braking resistor requires careful consideration of the braking duty.

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 4-11 shows a typical circuit arrangement.

Figure 4-11 Typical protection circuit for a braking resistor



See Figure 4-1 on page 38 to Figure 4-4 on page 41 for the location of the +DC and braking resistor connections.

4.5.2 Braking resistor software overload protection

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

- *Braking Resistor Rated Power* (10.030)
- *Braking Resistor Thermal Time Constant* (10.031)
- *Braking Resistor Resistance* (10.061)

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 **10.037** is set to 0 (default value) or 1.

If Pr **10.037** is equal to 2 or 3, a Brake R 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 *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.

4.6 Ground leakage

The ground leakage current depends upon whether the internal EMC filter is installed or not. The drive is supplied with the filter installed. Instructions for removing the internal filter are given in section 4.7.2 *Internal EMC filter and line to ground varistors (MOVs)* on page 63.

With internal filter installed:

Size 1:

8.1 mA* AC at 115 V 50 Hz

9.5 mA* AC at 230 V 50 Hz

Size 2:

13 mA* AC at 115 V 50 Hz (1 phase)

17.5 mA* AC at 230 V 50 Hz (1 phase)

6.3 mA* AC at 230 V 50 Hz (3 phase)

9.2 mA* AC at 460 V 50 Hz (3 phase)

Size 3:

17.1 mA* AC at 230 V 50 Hz (1 phase)

5.9 mA* AC at 230 V 50 Hz (3 phase)

5.7 mA* AC at 460 V 50 Hz (3 phase)

Size 4:

21.3 mA* AC at 230 V 50 Hz (1 phase)

9.7 mA* AC at 230 V 50 Hz (3 phase)

13.3 mA* AC at 460 V 50 Hz (3 phase)

* Proportional to the supply voltage and frequency.

With internal filter removed:

Size 1: < 1 mA

Size 2: **115 V:** < 1.2 mA

230 V: < 1 mA

460 V: < 2.3 mA

Size 3: **230 V:** < 1.6 mA

460 V: < 1 mA

Size 4: < 1 mA

NOTE

The above leakage currents are just the leakage currents of the drive with the internal EMC filter connected and do not take into account any leakage currents of the motor or motor cable.



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.



When the leakage current exceeds 3.5 mA, a permanent fixed ground connection must be provided using two independent conductors each with a cross-section equal to or exceeding that of the supply conductors. The drive is provided with two ground connections to facilitate this. Both ground connections are necessary to meet EN 61800-5-1: 2007.

4.6.1 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 with an ELCB / RCD, a delay of at least 50 ms should be incorporated to ensure spurious trips are not seen. The leakage current is likely to exceed the trip level if all of the phases are not energized simultaneously.

4.7 EMC (Electromagnetic compatibility)

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

section 4.7.3 *General requirements for EMC* for all applications, to ensure reliable operation of the drive and minimise the risk of disturbing nearby equipment. The immunity standards specified in Chapter 5 *Technical data* on page 75 will be met, but no specific emission standards are applied. Note also the special requirements given in *Surge immunity of control circuits - long cables and connections outside a building* on page 73 for increased surge immunity of control circuits where control wiring is extended.

section 4.7.4 *Compliance with IEC 61800-3 (EN 61800-3:2004+A1:2012 standard for Power Drive Systems)* section 4.7.5 *Compliance with generic emission standards*

The recommendations of section 4.7.3 *General requirements for EMC* will usually be sufficient to avoid causing disturbance to adjacent equipment of industrial quality. If particularly sensitive equipment is to be used nearby, or in a non-industrial environment, then the recommendations of section 4.7.4 *Compliance with IEC 61800-3 (EN 61800-3:2004+A1:2012 standard for Power Drive Systems)* on page 68 or section 4.7.5 *Compliance with generic emission standards* on page 69 should be followed to give reduced radio-frequency emission.

The correct external EMC filter must be used and all of the guidelines in section 4.7.3 *General requirements for EMC* and section 4.7.5 *Compliance with generic emission standards* on page 69 must be followed in order to ensure the installation meets the various emission standards described in:

- The EMC data sheet available from the supplier of the drive
- The Declaration of Conformity at the front of this manual
- Chapter 5 *Technical data* on page 75

Table 4-18 Drive and EMC filter cross reference

Model	Part number
115 V	
11017-1 to 11024-1	4200-1000, 4200-1001 (low leakage)
11042-2 to 11056-2	4200-2000
230 V	
21017-1 to 21042-1	4200-1000, 4200-1001 (low leakage)
22024-2 to 22075-2	4200-2001, 4200-2002 (low leakage)
	4200-2003, 4200-2004 (low leakage)
22100-3	4200-3000, 4200-3001 (low leakage)
	4200-3004, 4200-3005 (low leakage)
22133-4 to 23176-4	4200-4000, 4200-4001 (low leakage)
	4200-4002, 4200-4003 (low leakage)
460 V	
43013-2 to 43041-2	4200-2005, 4200-2006 (low leakage)
43056-3 to 43094-3	4200-3008, 4200-3009 (low leakage)
43135-4 to 43170-4	4200-4004, 4200-4005 (low leakage)



High ground leakage current

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

NOTE

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

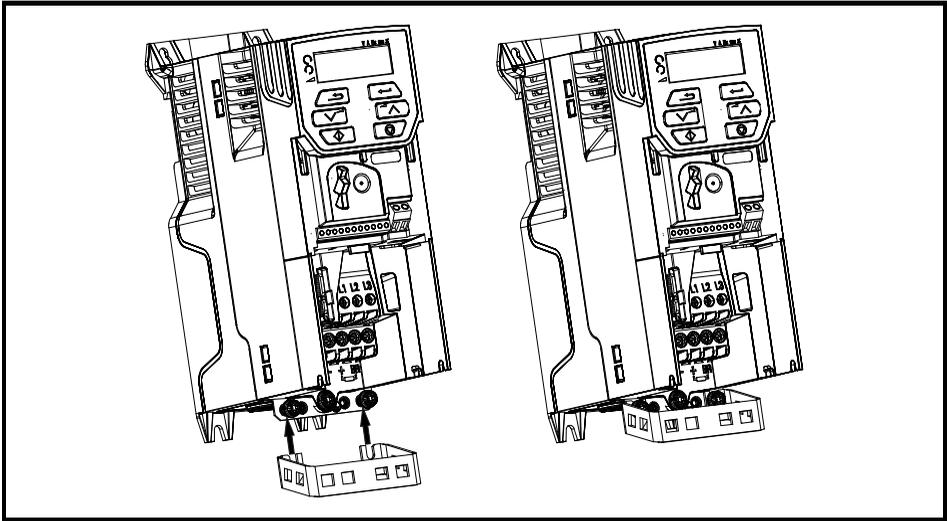
4.7.1 Grounding hardware

The drive is supplied with a grounding bracket / clamp to facilitate EMC compliance. This provides a convenient method for direct grounding of cable shields without the use of “pig-tails”. Cable shields can be bared and clamped to the grounding bracket using metal clips or clamps¹ (not supplied) or cable ties. Note that the shield must in all cases be continued through the clamp to the intended terminal on the drive, in accordance with the connection details for the specific signal.

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

See Figure 4-12 for details regarding the installation of the grounding bracket.

Figure 4-12 Installation of grounding bracket (size 1 to 4)



Loosen the ground connection screws and slide the grounding bracket in the direction shown. Once in place, the ground connection screws should be tightened with a maximum torque of 1.5 N m (1.1 lb ft).

4.7.2 Internal EMC filter and line to ground varistors (MOVs)

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

If the drive is used as a motoring drive 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 4.7.4 *Compliance with IEC 61800-3 (EN 61800-3:2004+A1:2012 standard for Power Drive Systems)* on page 68 and section 5.1.25 *Electromagnetic compatibility (EMC)* on page 93. For longer motor cables the filter continues to provide a useful reduction in emission levels, and when used with any length of shielded motor cable up to the limit for the drive, it is unlikely that nearby industrial equipment will be disturbed. It is recommended that the filter be used in all applications unless the instructions given above require it to be removed, or where the ground leakage current is unacceptable. As shown in Figure 4-13 to Figure 4-16, the internal EMC filter is removed by removing the screw (1).

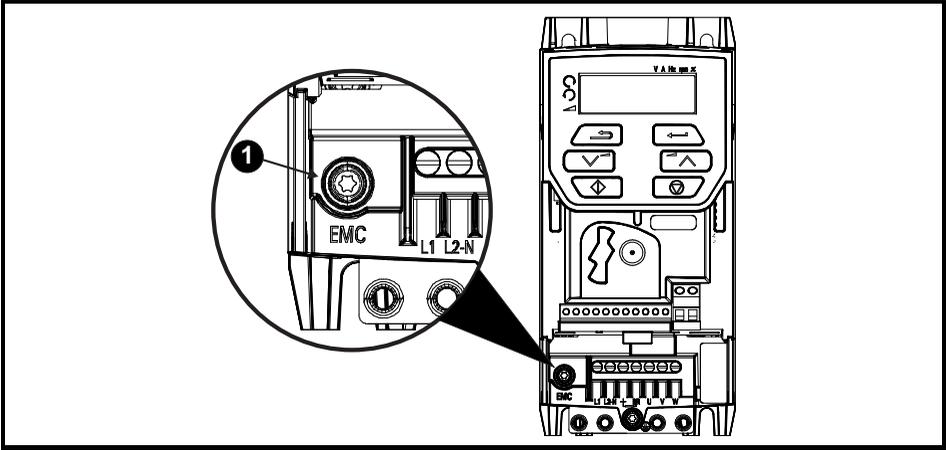


The supply must be disconnected before removing the internal EMC filter.



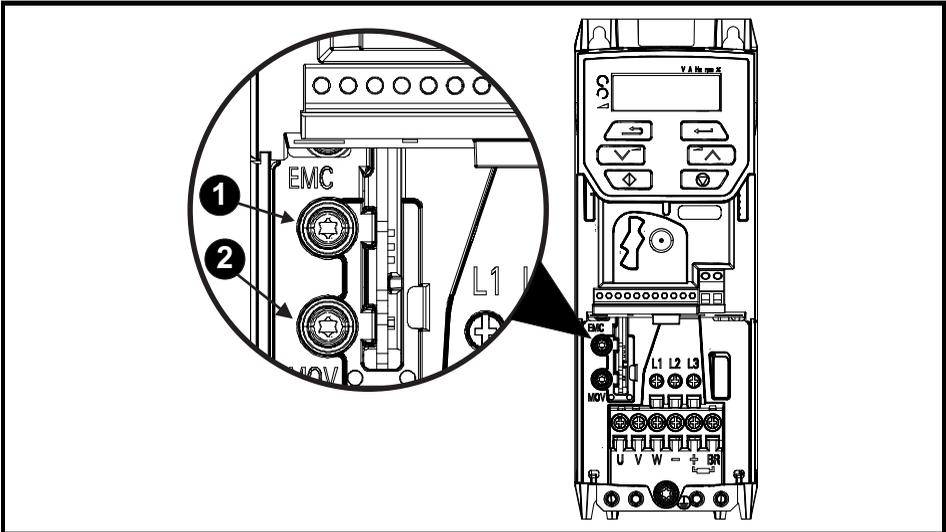
The line to ground varistors should only be removed in special circumstances such as ungrounded supplies with more than one source, for example on ships. Where the line to ground varistors are removed, ensure that line to ground transients are limited to values of category II. This is to ensure that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

Figure 4-13 Removal of the size 1 internal EMC filter



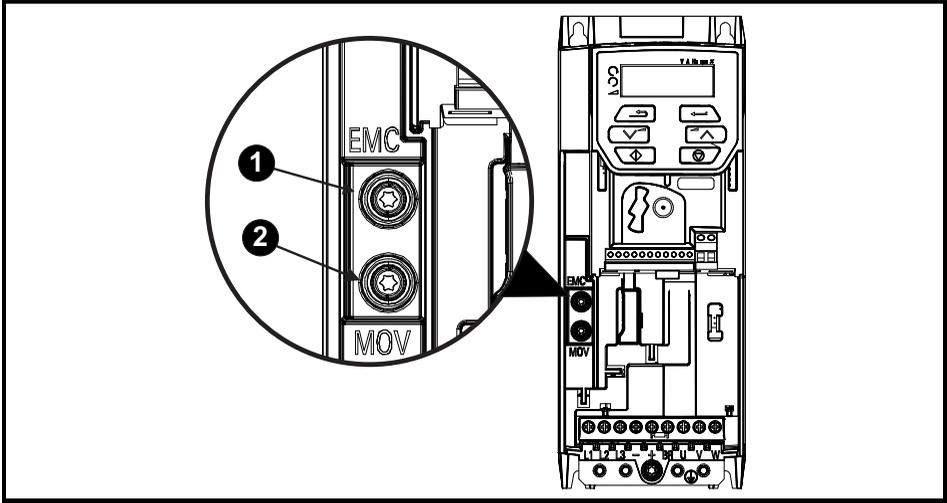
To electrically disconnect the internal EMC filter, remove the screw as shown above (1).

Figure 4-14 Removal of the size 2 internal EMC filter and Varistor (MOV)



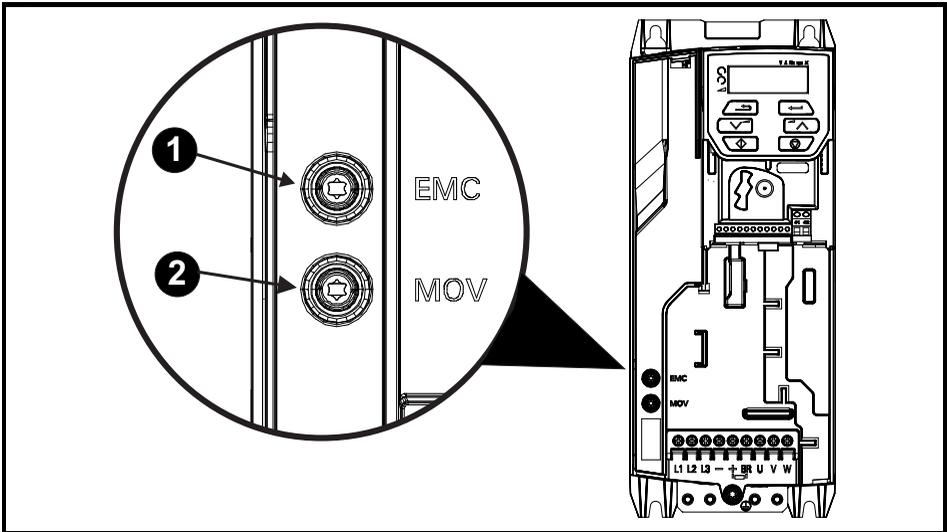
- To electrically disconnect the internal EMC filter, remove the screw as shown above (1).
- To electrically disconnect the varistor (MOV), remove the screw as shown above (2).

Figure 4-15 Removal of the size 3 internal EMC filter and line to ground varistors (MOV)



- To electrically disconnect the internal EMC filter, remove the screw as shown above (1).
- To electrically disconnect the line to ground varistor (MOV), remove the screw as shown above (2).

Figure 4-16 Removal of the size 4 internal EMC filter



- To electrically disconnect the internal EMC filter, remove the screw as shown above (1).
- To electrically disconnect the line to ground varistor (MOV), remove the screw as shown above (2).

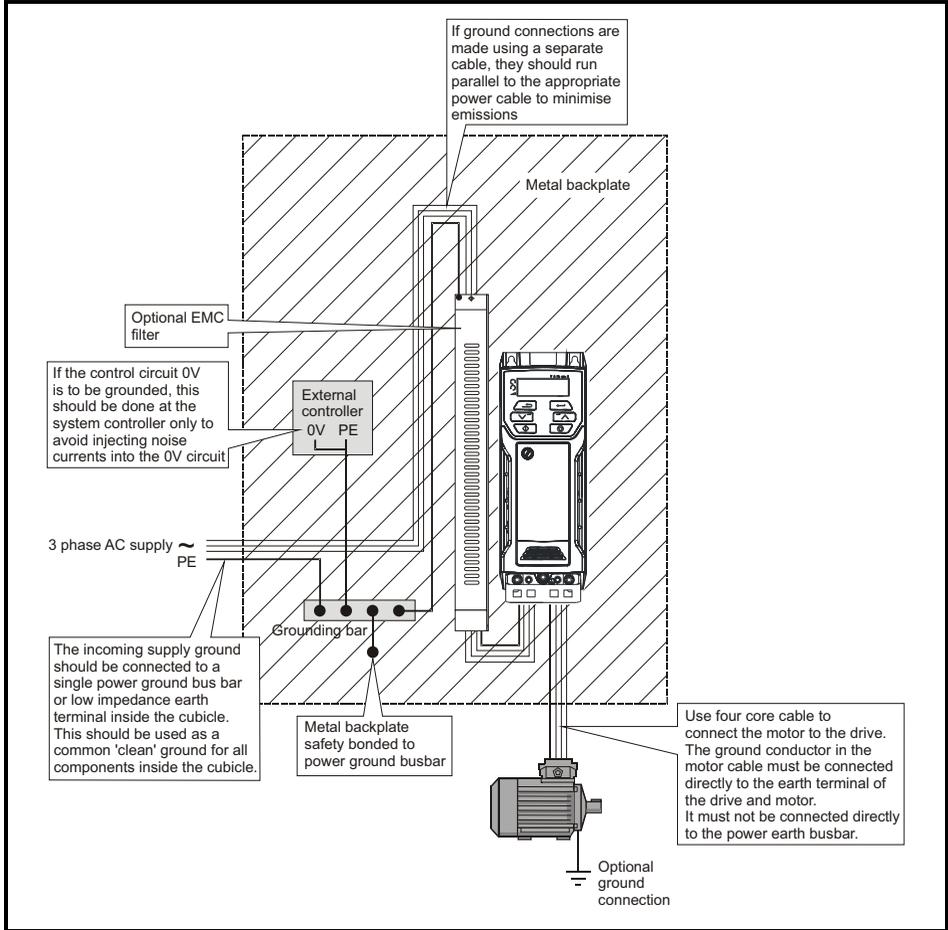
4.7.3 General requirements for EMC

Ground (earth) connections

The grounding arrangements should be in accordance with Figure 4-17, which shows a single drive on a back-plate with or without an additional enclosure.

Figure 4-17 shows how to configure and minimise EMC when using unshielded motor cable. However shielded cable is a better option, in which case it should be installed as shown in section 4.7.5 *Compliance with generic emission standards* on page 69.

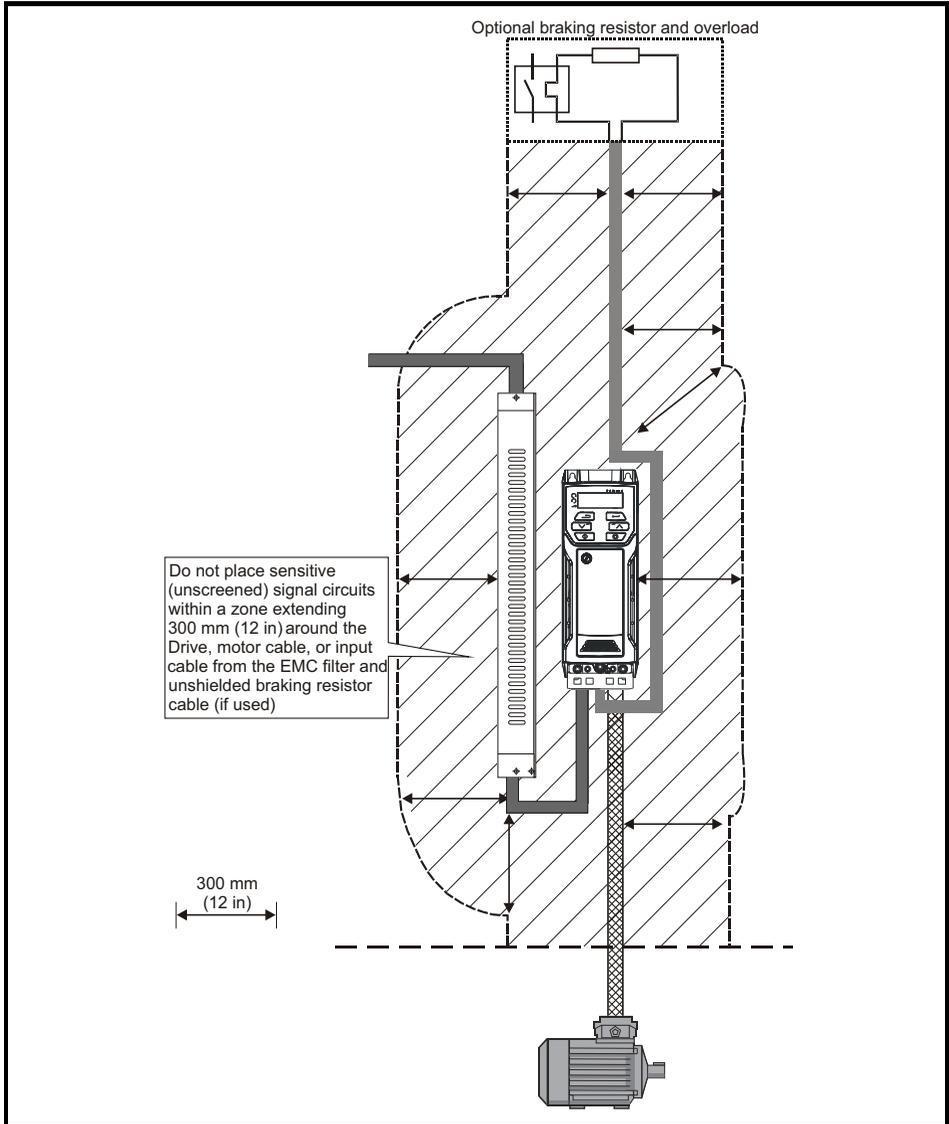
Figure 4-17 General EMC enclosure layout showing ground connections



Cable layout

Figure 4-18 indicates the clearances which should be observed around the drive and related 'noisy' power cables by all sensitive control signals / equipment.

Figure 4-18 Drive cable clearances



NOTE

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

4.7.4 Compliance with IEC 61800-3 (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 4.7.5 *Compliance with generic emission standards* on page 69. 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 drives with a rated input current of less than 100 A.

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

For longer motor cables, an external filter is required. Where a filter is required, follow the guidelines in section 4.7.5 *Compliance with generic emission standards* on page 69.

Where a filter is not required, follow the guidelines given in section 4.7.3 *General requirements for EMC* on page 66.



The second environment typically includes an industrial low-voltage power supply network which does not supply buildings used for residential purposes. Operating the drive in this environment without an external EMC filter may cause interference to nearby electronic equipment whose sensitivity has not been appreciated. The user must take remedial measures if this situation arises. If the consequences of unexpected disturbances are severe, it is recommended that the guidelines in section 4.7.5 *Compliance with generic emission standards* on page 69 be adhered to.

Refer to section 5.1.25 *Electromagnetic compatibility (EMC)* on page 93 for further information on compliance with EMC standards and definitions of environments.

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

4.7.5 Compliance with generic emission standards

Use the recommended filter and shielded motor cable. Observe the layout rules given in Figure 4-19. Ensure the AC supply and ground cables are at least 100 mm from the power module and motor cable.

Figure 4-19 Supply and ground cable clearance (sizes 1 to 4)

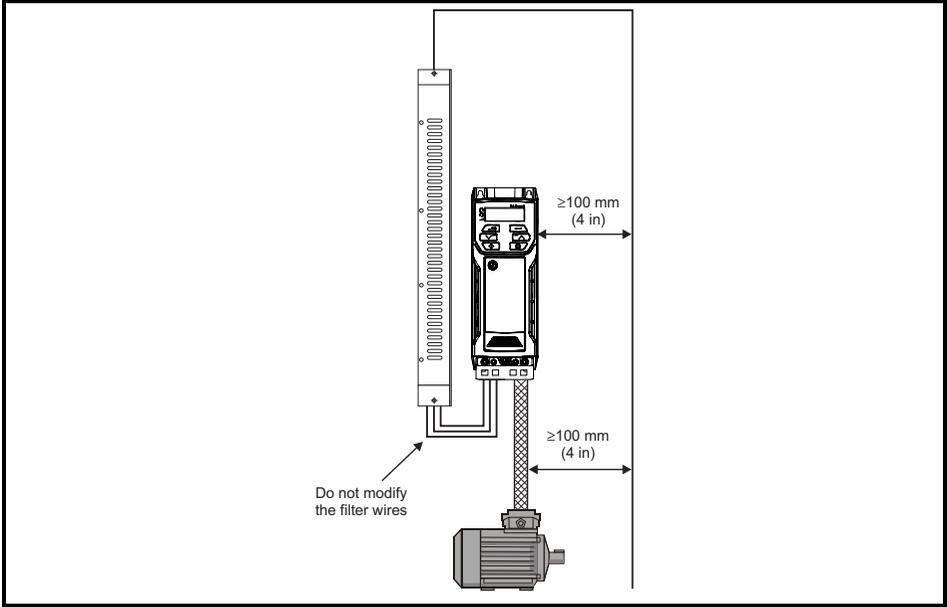
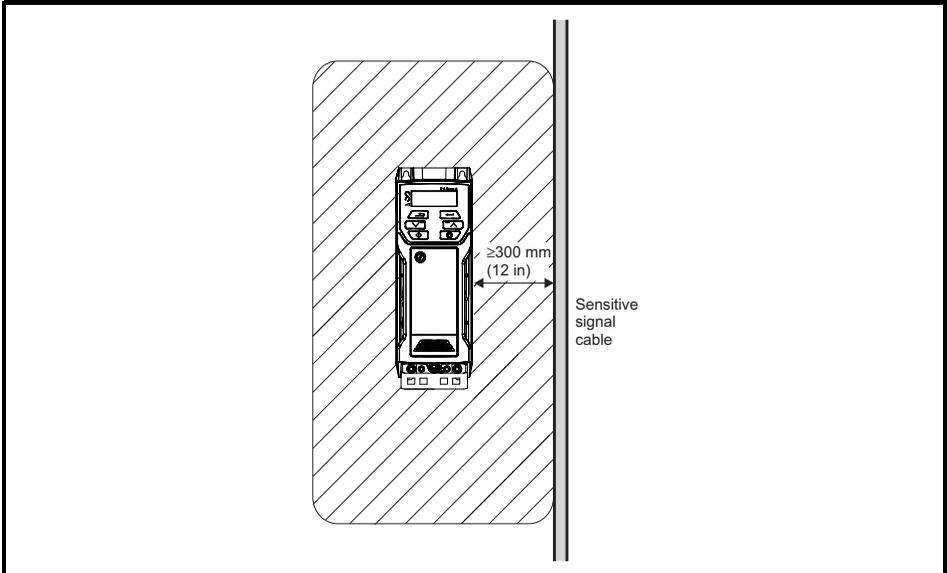
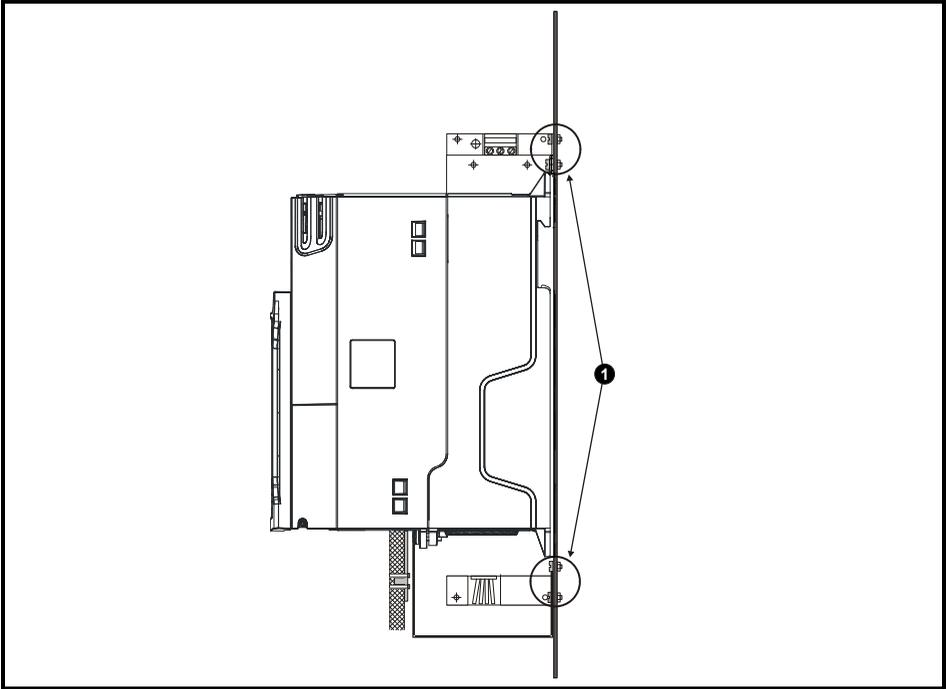


Figure 4-20 Sensitive signal circuit clearance



Ensure good EMC grounding.

Figure 4-21 Grounding the drive, motor cable shield and filter



NOTE

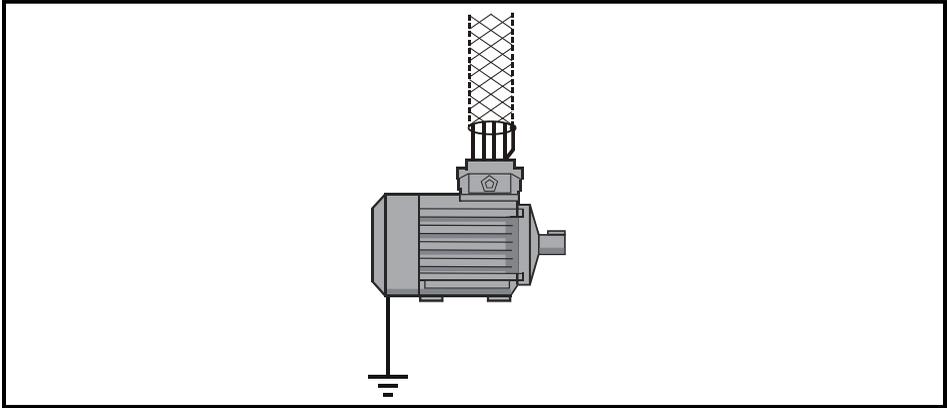
1. Ensure direct metal contact at the drive and filter mounting points. Any paint must be removed beforehand.

The unbroken motor cable shield (unbroken) electrically connected to and held in place by means of the grounding bracket.

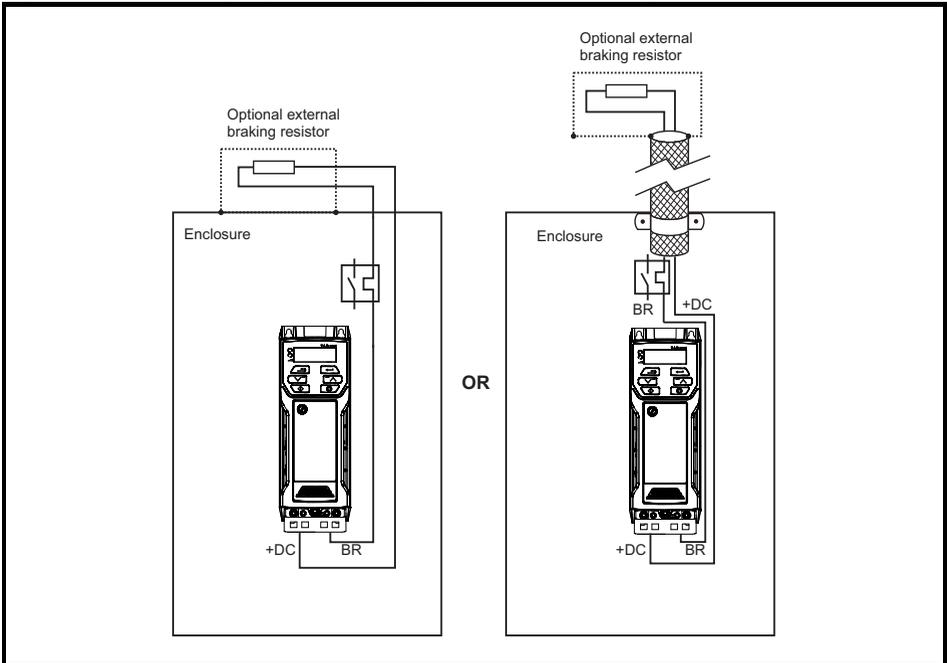
Connect the shield of the motor cable to the ground terminal of the motor frame using a link that is as short as possible and not exceeding 50 mm (2 in) long.

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

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

Figure 4-22 Grounding the motor cable shield

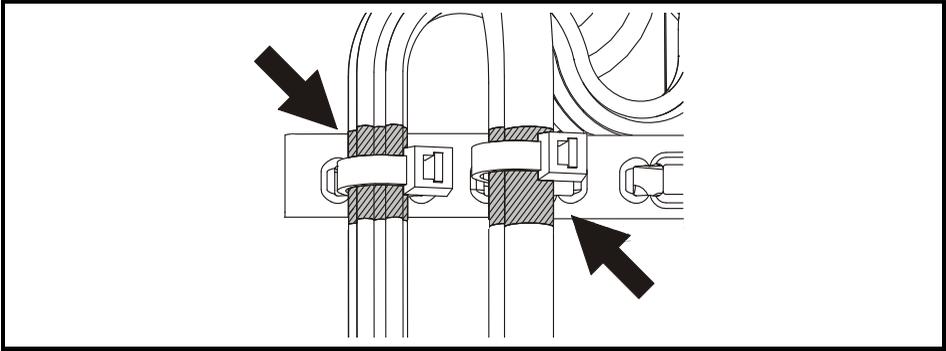
Unshielded wiring to the optional braking resistor(s) may be used provided the wiring runs internally to the enclosure. Ensure a minimum spacing of 300 mm (12 in) from the signal wiring and the AC supply wiring to the external EMC filter. If this condition cannot be met then the wiring must be shielded.

Figure 4-23 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 4-24. Remove the outer insulating cover of the cable to ensure the shield(s) make direct contact with the bracket, but keep the shield(s) intact until as close as possible to the terminals

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

Figure 4-24 Grounding of signal cable shields using the grounding bracket



4.7.6 Variations in the EMC wiring

Interruptions to the motor cable

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

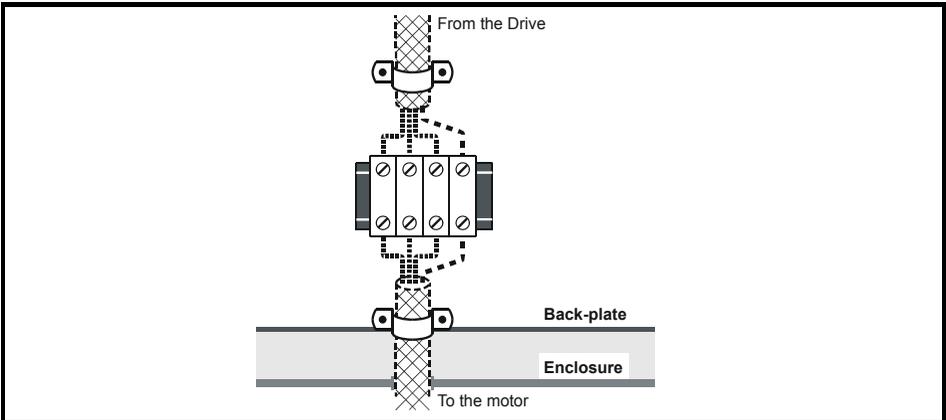
- Connecting the motor cable to a terminal block in the drive enclosure
- Installing a motor isolator / disconnect switch for safety when work is done on the motor

In these cases the following guidelines should be followed.

Terminal block in the enclosure

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

Figure 4-25 Connecting the motor cable to a terminal block in the enclosure



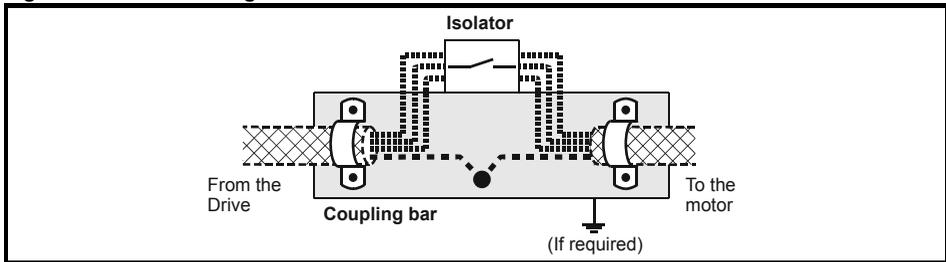
Using a motor isolator / disconnect-switch

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

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

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

Figure 4-26 Connecting the motor cable to an isolator / disconnect switch



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

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

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

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

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

1. Galvanic isolation, i.e. do not connect the control 0 V terminal to ground. Avoid loops in the control wiring, i.e. ensure every control wire is accompanied by its return (0 V) wire.
2. Shielded cable with additional power ground bonding. The cable shield may be connected to ground at both ends, but in addition the ground conductors at both ends of the cable must be bonded together by a power ground cable (equipotential bonding cable) with cross-sectional area of at least 10 mm^2 , or 10 times the area of the signal cable shield, or to suit the electrical safety requirements of the plant. This ensures that fault or surge current passes mainly through the ground cable and not in the signal cable shield. If the building or plant has a well-designed common bonded network this precaution is not necessary.
3. Additional over-voltage suppression - for the analog and digital inputs and outputs, a zener diode network or a commercially available surge suppressor may be connected in parallel with the input circuit as shown in Figure 4-27 and Figure 4-28.

If a digital port experiences a severe surge its protective trip may operate (I/O Overload trip).

For continued operation after such an event, the trip can be reset automatically by setting Pr **10.034** to 5.

Figure 4-27 Surge suppression for digital and unipolar inputs and outputs

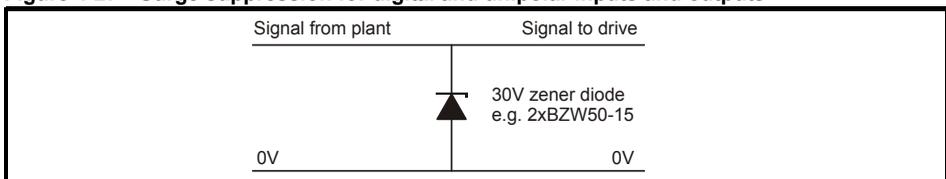
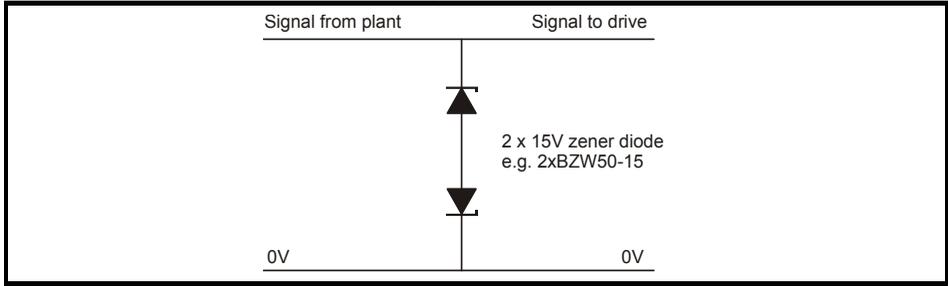


Figure 4-28 Surge suppression for analog and bipolar inputs and outputs



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.

5 Technical data

5.1 Drive technical data

5.1.1 Power and current ratings (Derating for switching frequency and temperature)

For a full explanation of 'Normal Duty' and 'Heavy Duty' refer to the *Control User Guide*.

Table 5-1 Maximum permissible continuous output current @ 40 °C (104 °F) ambient

Model	Heavy Duty										
	Nominal rating		Maximum permissible continuous output current (A) for the following switching frequencies								
	kW	hp	0.667 kHz	1 kHz	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
115 V											
11017-1	0.25	0.33	1.7								
11024-1	0.37	0.5	2.4								
11042-2	0.75	1.0	4.2								
11056-2	1.1	1.5	5.6								
230 V											
21017-1	0.25	0.33	1.7								
21024-1	0.37	0.5	2.4								
21033-1	0.55	0.75	3.3								
21042-1	0.75	1.0	4.2								
22024-2	0.37	0.5	2.4								
22033-2	0.55	0.75	3.3								
22042-2	0.75	1.0	4.2								
22056-2	1.1	1.5	5.6								
22075-2	1.5	2.0	7.5								7.0
22100-3	2.2	3.0	10						9	7.3	
22133-4	3.0	3.0	13.3								
23176-4	4.0	5.0	17.6								17.0
460 V											
43013-2	0.37	0.5	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	
43018-2	0.55	0.75	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	
43023-2	0.75	1.0	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.0	
43032-2	1.1	1.5	3.2	3.2	3.2	3.2	3.2	3.2	3.2	2.0	
43041-2	1.5	2.0	4.1	4.1	4.1	4.1	4.1	4.1	3.8	2.0	
43056-3	2.2	3.0	5.6	5.6	5.6	5.6	5.6	5.6	5.1	3.7	2.4
43073-3	3.0	3.0	7.3	7.3	7.3	7.3	7.3	7.1	5.6	3.8	
43094-3	4.0	5.0	9.4	9.4	9.4	9.4	9.4	8.5	7	4.6	
43135-4	5.5	7.5	13.5								10.7
43170-4	7.5	10.0	17						13.5	10.7	

Table 5-2 Maximum permissible continuous output current @ 50 °C (122 °F) (size 1 to 4)

Model	Heavy Duty									
	Maximum permissible continuous output current (A) for the following switching frequencies									
	0.667 kHz	1 kHz	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz	
115 V										
11017-1*	1.7									
11024-1*	2.4									
11042-2	4.2									
11056-2	5.6					5.5	5.3	5.1	4.9	
230 V										
21017-1*	1.7									
21024-1*	2.4									
21033-1*	3.3									
21042-1*	4.2									
22024-2	2.4									
22033-2	3.3									
22042-2	4.2									4.0
22056-2	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.4
22075-2	7.5	7.5	7.4	7.2	6.8	6.6	6.3	5.8	5.4	
22100-3	10	10	10	10	9.5	8.6	7.5	6.1	5	
22133-4	13.3									
23176-4	17.6							17	15.5	
460 V										
43013-2	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.1		
43018-2	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.1		
43023-2	2.3	2.3	2.3	2.3	2.3	2.3	2.3	1.1		
43032-2	3.2	3.2	3.2	3.2	3.2	3.2	2.5	1.1		
43041-2	4.1	4.1	4.1	4.1	3.7	3.2	2.5	1.1		
43056-3	5.6	5.6	5.6	5.6	5	3.5	2.8	1.9		
43073-3	7.3	7.3	7.3	7.3	6.2	4.5	3.4			
43094-3	9.4	9.4	9.4	9.4	7.9	6.2	4.7			
43135-4	13.5							12	9.3	
43170-4	17					15.3	15.2	12	9.3	

* CI-Keypad not installed.

NOTE Ratings at 55 °C are available on request.

5.1.2 Power dissipation

Table 5-3 Losses @ 40 °C (104 °F) ambient (size 1 to 4)

Model	Heavy Duty										
	Nominal rating		Drive losses (W) taking into account any current derating for the given conditions								
	kW	hp	0.667 kHz	1 kHz	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
115 V											
11017-1	0.25	0.33	23	23	24	24	25	27	28	32	35
11024-1	0.37	0.5	27	27	29	30	31	33	35	39	44
11042-2	0.75	1.0	39	40	41	42	43	45	47	51	55
11056-2	1.1	1.5	51	51	53	54	55	58	61	67	73
230 V											
21017-1	0.25	0.33	21	21	22	22	23	25	27	30	33
21024-1	0.37	0.5	24	25	26	27	28	30	33	37	41
21033-1	0.55	0.75	31	32	33	35	36	39	42	47	53
21042-1	0.75	1.0	38	39	40	42	44	47	51	58	65
22024-2	0.37	0.5	25	25	25	26	26	28	29	31	33
22033-2	0.55	0.75	32	33	33	34	35	36	38	41	44
22042-2	0.75	1.0	39	40	41	42	43	45	47	51	55
22056-2	1.1	1.5	46	47	48	50	51	54	57	63	69
22075-2	1.5	2.0	62	62	65	67	69	73	77	86	87
22100-3	2.2	3.0	85	87	91	96	101	110	117	121	117
22133-4*	3.0	3.0	101	102	106	110	114	121	129	144	160
23176-4	4.0	5.0	149	150	156	161	166	176	186	207	220
460 V											
43013-2	0.37	0.5	25	26	30	33	36	42	48	60	
43018-2	0.55	0.75	29	30	34	37	40	47	53	67	
43023-2	0.75	1.0	33	34	38	41	45	52	59	69	
43032-2	1.1	1.5	41	42	46	50	54	63	71	70	
43041-2	1.5	2.0	49	50	55	60	64	74	78	70	
43056-3	2.2	3.0	55	57	62	68	75	86	90	86	77
43073-3	3.0	3.0	72	74	82	90	98	113	101	92	
43094-3	4.0	5.0	95	99	108	116	129	128	125	113	
43135-4	5.5	7.5	142	146	159	172	169	196	239	294	292
43170-4	7.5	10.0	165	170	186	202	218	251	284	294	292

* Different losses with single-phase supply (available on request).

Table 5-4 Losses @ 50 °C (122 °F) ambient (size 1 to 4)

Model	Heavy Duty										
	Nominal rating		Drive losses (W) taking into account any current derating for the given conditions								
	kW	hp	0.667 kHz	1 kHz	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
115 V											
11017-1	0.25	0.33	23	23	24	24	25	27	28	32	35
11024-1	0.37	0.5	27	27	29	30	31	33	35	39	44
11042-2	0.75	1.0	34	34	35	36	37	39	41	46	50
11056-2	1.1	1.5	42	43	44	46	47	49	47	47	57
230 V											
21017-1	0.25	0.33	21	21	22	22	23	25	27	30	33
21024-1	0.37	0.5	24	25	26	27	28	30	33	37	41
21033-1	0.55	0.75	31	32	33	35	36	39	42	47	53
21042-1	0.75	1.0	38	39	40	42	44	47	51	58	65
22024-2	0.37	0.5	24	24	24	25	25	26	27	30	32
22033-2	0.55	0.75	31	31	32	33	34	35	37	40	43
22042-2	0.75	1.0	37	37	38	39	39	40	42	45	46
22056-2	1.1	1.5	44	44	46	46	47	48	44	46	50
22075-2	1.5	2.0	44	44	45	46	47	48	44	46	50
22100-3	2.2	3.0	86	88	92	96	96	97	93	90	86
22133-4	3.0	3.0	101	102	106	110	114	121	129	144	160
23176-4	4.0	5.0	149	150	156	161	166	176	186	199	199
460 V											
43013-2	0.37	0.5	25	26	30	33	36	42	48	58	
43018-2	0.55	0.75	29	30	34	37	40	47	53	58	
43023-2	0.75	1.0	33	34	38	41	45	52	59	58	
43032-2	1.1	1.5	41	42	46	50	54	63	62	70	
43041-2	1.5	2.0	49	50	55	60	60	63	62	58	
43056-3	2.2	3.0	57	58	64	70	73	63	60	60	
43073-3	3.0	3.0	73	75	82	91	87	77	71		
43094-3	4.0	5.0	96	98	109	122	111	104	97		
43135-4	5.5	7.5	142	146	159	172	169	196	239	260	263
43170-4	7.5	10.0	165	170	186	202	202	206	260	260	263

5.1.3 Supply requirements

AC supply voltage:

- 115 V drive: 100 V to 120 V \pm 10 %
- 230 V drive: 200 V to 240 V \pm 10 %
- 460 V drive: 380 V to 480 V \pm 10 %

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

5.1.4 Line reactors

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

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

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

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

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

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

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

Line reactors are particularly recommended for use with the following drive models when one of the above factors exists, or when the supply capacity exceeds 175 kVA: Size 1 to 3.

Model sizes 22133-4 to 43170-4 have an internal DC choke so they do not require AC line reactors except for cases of excessive phase unbalance or extreme supply conditions.

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

Reactor current ratings

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

Continuous current rating:

Not less than the continuous input current rating of the drive

Repetitive peak current rating:

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

The recommended AC line reactors are shown in section 4.2.4 *Input line reactor specification for size 1 to 4* on page 45.

5.1.5 Motor requirements

No. of phases: 3

Maximum voltage:

- 230 V drive: 240 V
- 460 V drive: 480 V

5.1.6 Temperature, humidity and cooling method

Size 1 to 4:

Ambient temperature operating range:

- 20 °C to 60 °C (- 4 °F to 140 °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)

5.1.7 Storage

Size 1 to 4:

-40 °C (-40 °F) to +60 °C (140 °F) for long 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.

5.1.8 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 %.

5.1.9 IP / UL Rating

The drive is rated to IP20 pollution degree 2 (non-conductive contamination only).

In addition to this, drives are rated to IP21 standard (without an Adaptor Interface module installed).

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 5-5.

Table 5-5 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 Ø and greater (back of a hand)	1	Protected against vertically falling water drops
2	Protected against solid foreign objects of 12.5 mm Ø 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 Ø and greater (tool)	3	Protected against spraying water
4	Protected against solid foreign objects of 1.0 mm Ø 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 5-6 UL enclosure ratings

UL rating	Description
Type 1	Enclosures are intended for indoor use, primarily to provide a degree of protection against limited amounts of falling dirt.
Type 12	Enclosures are intended for indoor use, primarily to provide a degree of protection against dust, falling dirt and dripping non-corrosive liquids.

5.1.10 Corrosive gasses

Concentrations of corrosive gases must not exceed the levels given in:

- Table A2 of EN 50178:1998

Printed Circuit Board & Component Solder technology of KBG1, KBG2, KBG3 Series are conformal coated to survive environments as described by IEC60721-3-3 3C3 and EN60068-2-60 Meth. 4. This corresponds to the levels typical of urban areas with industrial activities and/or heavy traffic and in the immediate neighborhood of industrial sources with chemical emissions.

5.1.11 RoHS compliance

The drive meets EU directive 2011/65/EU for RoHS compliance.

5.1.12 Vibration

Bump Test

Testing in each of three mutually perpendicular axes in turn.

Referenced standard: IEC 60068-2-27: Test Ea:

Severity: 15 g peak, 11 ms pulse duration, half sine.

No. of Bumps: 18 (3 in each direction of each axis).

Referenced standard: IEC 60068-2-29: Test Eb:

Severity: 18 g peak, 6 ms pulse duration, 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: $1.0 \text{ m}^2/\text{s}^3$ ($0.01 \text{ g}^2/\text{Hz}$) ASD from 5 to 20 Hz

-3 db/octave from 20 to 200 Hz

Duration: 30 minutes in each of 3 mutually perpendicular axes.

Sinusoidal Vibration Test

Testing in each of three mutually perpendicular axes in turn.

Referenced standard: IEC 60068-2-6: Test Fc:

Frequency range: 5 to 500 Hz

Severity: 3.5 mm peak displacement from 5 to 9 Hz

10 m/s^2 peak acceleration from 9 to 200 Hz

15 m/s^2 peak acceleration from 200 to 500 Hz

Sweep rate: 1 octave/minute

Duration: 15 minutes in each of 3 mutually perpendicular axes.

Referenced standard: EN 61800-5-1: 2007, Section 5.2.6.4. referring to IEC 60068-2-6:

Frequency range: 10 to 150 Hz

Severity: 0.075 mm amplitude from 10 to 57 Hz

1 g peak acceleration from 57 to 150 Hz

Sweep rate: 1 octave/minute

Duration: 10 sweep cycles per axis in each of 3 mutually perpendicular axes.

Testing to Environmental Category ENV3

Subjected to resonance search in the range listed. If no natural frequencies found then subjected only to endurance test.

Referenced standard: Environment Category ENV3:

Frequency range: 5 to 13.2 Hz ± 1.0 mm

13.2 to 100 Hz ± 0.7 g (6.9 ms⁻²)

For more information, please refer to section 12 *Vibration Test 1* of the Lloyds Register Test Specification Number 1.

5.1.13 Starts per hour

By electronic control: unlimited

By interrupting the AC supply: ≤ 20 (equally spaced)

5.1.14 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: 1.5 s

5.1.15 Output frequency / speed range

In all operating modes (Open loop, RFC-A) the maximum output frequency is limited to 550 Hz.

5.1.16 Accuracy and resolution

Frequency:

The absolute frequency accuracy depends on the accuracy of the oscillator used with the drive microprocessor. The accuracy of the oscillator is $\pm 0.02\%$, and so the absolute frequency accuracy is $\pm 0.02\%$ of the reference, when a preset frequency 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 & closed loop resolution:

Preset frequency reference: 0.01 Hz

Analog input 1: 11 bit plus sign

Analog input 2: 11 bit

Current:

The resolution of the current feedback is 10 bit plus sign.

Accuracy: typical 2 %

worst case 5 %

5.1.17 Acoustic noise

The heatsink fan generates the majority of the sound produced by the drive. The heatsink fan on all drives is a variable speed fan (except size 1, which is a single 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 5-7 gives the sound pressure level at 1 m produced by the drive for the heatsink fan running at the maximum and minimum speeds.

Table 5-7 Acoustic noise data

Size	Max speed dBA	Min speed dBA
1*	46.7	N/A
2	45	42
3	58.6	49
4	58	48

* Single speed fan.

5.1.18 Overall dimensions

- H Height including surface mounting brackets
- W Width
- D Projection forward of panel when surface mounted

Table 5-8 Overall drive dimensions

Size	Dimension		
	H	W	D
1	160 mm (6.3 in)	75 mm (2.95 in)	130 mm (5.1 in)
2	205 mm (8.07 in)		150 mm (5.9 in)
3	226 mm (8.9 in)	90 mm (3.54 in)	160 mm (6.3 in)
4	277 mm (10.9 in)	115 mm (4.5 in)	175 mm (6.9 in)

5.1.19 Weights

Table 5-9 Overall drive weights

Size	Model	kg	lb
1	All	0.75	1.65
2		1.0	2.2
3		1.5	3.3
4		3.13	6.9

5.1.20 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 5-10.

Table 5-10 Supply fault current used to calculate maximum input currents

Model	Symmetrical fault level (kA)
All	10



Fuses

The AC supply to the drive must be installed with suitable protection against overload and short-circuits. Table 5-11, Table 5-12, Table 5-13 show the recommended fuse ratings. Failure to observe this requirement will cause risk of fire.

Table 5-11 AC Input current and fuse ratings (115 V)

Model	Maximum continuous input current A	Maximum overload input current A	Fuse rating					MCB rating**	
			IEC		UL			Nominal A	
			Maximum A	Class	Nominal A	Maximum A	Class		
11017-1	8.7	12.6	10	gG	15	15	CC, J or T*	15	
11024-1	11.1	15.2	16		15	15		15	
11042-2	18.8	28.2	20		20	20		15	
11056-2	24.0	37.4	25		25	25		15	

Table 5-12 AC Input current and fuse ratings (230 V)

Model	Typical input current A	Maximum continuous input current A	Maximum overload input current A	Fuse rating										MCB rating**	
				IEC					UL / USA					Nominal 1ph 3ph A A	
				Nominal		Maximum		Class	Nominal A	Maximum		Class			
				1ph A	3ph A	1ph A	3ph A			1ph A	3ph A				
21017-1		4.5	6.9	6		6		gG	6	6		CC, J or T*	15		
21024-1		5.3	8.4	6		6		6	6		15				
21033-1		8.3	14.2	10		10		15	15		15				
21042-1		10.4	16.8	16		16		15	15		15				
22024-2	- / 3.2	5.3/4.1	8.1/5.9	6		6		gG	6	6	6	CC, J or T*	15		
22033-2	- / 4.3	8.3/6.7	14/9.2	10		10			10	10			15		
22042-2	- / 5.4	10.4/7.5	16.4/10.8	16	10	16	10		15/10	15	10		15		
22056-2	- / 8.1	16.0/12.9	24.0/17.5	20	16	20	16		20/15	20	15		15		
22075-2	- / 9.1	18.1/13.5	30.4/19.5					20/15	15						
22100-3	- / 12.8	23.9/17.7	30/25	25	20	25	20	gG	25/20	25	20	CC, J or T*	25	20	
22133-4	- / 13.5	23.7/16.9	43.3/23.5	25	20	25	20	gG	25/20	25	20	CC, J or T*	25	20	
23176-4	- / 17.0	23.7/21.3	43.3/28.6	25	25	25	25		25	25	25		25	25	

* These are fast acting fuses.

** UL Listed DIVQ / DIVQ7 listed, rated voltage is 600 Vac (for USA and Canada). Short circuit rating is 10 kA. In other countries, EN IEC circuit breakers can be used with 10 kA supply rating.

Table 5-13 AC Input current and fuse ratings (460 V)

Model	Typical input current A	Maximum continuous input current A	Maximum overload input current A	Fuse rating						MCB rating**
				IEC			UL / USA			
				Nominal A	Maximum A	Class	Nominal A	Maximum A	Class	Nominal A
43013-2	2.1	2.4	4.2	6	6	gG	6	6	CC, J or T*	15
43018-2	2.6	2.9	5.2							
43023-2	3.1	3.5	6.1							
43032-2	4.7	5.1	7.5							
43041-2	5.8	6.2	9	10	10	gG	15	15	CC, J or T*	15
43056-3	8.3	8.7	13	10	10					
43073-3	10.2	12.2	18	16	16					
43094-3	13.1	14.8	20.7							
43135-4	14.0	16.3	24.7	20	20	gG	20	20	CC, J or T*	20
43170-4	18.5	20.7	32.4	25	25		25	25		25

* These are fast acting fuses.

** UL Listed DIVQ / DIVQ7 listed, rated voltage is 600 Vac (for USA and Canada). Short circuit rating is 10 kA. In other countries, EN IEC circuit breakers can be used with 10 kA supply rating.

NOTE Ensure cables used suit local wiring regulations.

 CAUTION	<p>The nominal cable sizes below are only a guide. The mounting and grouping of cables affects their current-carrying capacity, in some cases smaller cables may be acceptable but in other cases a larger cable is required to avoid excessive temperature or voltage drop. Refer to local wiring regulations for the correct size of cables.</p>
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Table 5-14 Cable ratings (115 V)

Model	Cable size (IEC 60364-5-52) mm ²				Cable size (UL508C) AWG			
	Input		Output		Input		Output	
	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum
11017-1	1	2.5	1	2.5	16	12	16	12
11024-1	1.5		1		14			
11042-2	2.5	4	1	4	12	10	16	10
11056-2	4		1		10			

Table 5-15 Cable ratings (230 V)

Model	Cable size (IEC 60364-5-52) mm ²				Cable size (UL508C) AWG			
	Input		Output		Input		Output	
	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum
21017-1	1	2.5	1	2.5	16	12	16	12
21024-1								
21033-1								
21042-1								
22024-2	1	4	1	4	16	10	16	10
22033-2								
22042-2								
22056-2					2.5/1.5			
22075-2	2.5	12						
22100-3	4	4	1.5	4	10/12	10	14	10
22133-4	4/2.5	4	2.5	4	10	10	12	10
23176-4	4							

Table 5-16 Cable ratings (460 V)

Model	Cable size (IEC 60364-5-52) mm ²				Cable size (UL508C) AWG				
	Input		Output		Input		Output		
	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal	Maximum	
43013-2	1	4	1	4	16	10	16	10	
43018-2									
43023-2									
43032-2									
43041-2	1	4	1	4	14	10	16	10	
43056-3									
43073-3					1.5				12
43094-3					2.5				14
43135-4	2.5	4	2.5	4	10	10	12	10	
43170-4	4								

NOTE PVC insulated cable should be used.

5.1.21 Protective ground cable ratings

Minimum ground conductor size

Either 10 mm² or two conductors of the same cross-sectional area as the input phase conductor.

Table 5-17 Inrush current

Model	Peak Inrush Current (A)
11017-1	8.5
11024-1	8.5
21017-1	17
21024-1	17
21033-1	17
21042-1	17
11042-2	28.3
11056-2	28.3
22024-2	27.5
22033-2	27.5
22042-2	27.5
22056-2	27.5
22075-2	27.5
43013-2	17
43018-2	17
43023-2	17
43032-2	17
43041-2	17
22100-3	18.3
43056-3	11.3
43073-3	11.3
43094-3	11.3
22133-4	18.3
23176-4	18.3
43135-4	11.3
43170-4	11.3

5.1.22 Maximum motor cable lengths

Table 5-18 Maximum motor cable lengths (115 V drives)

Model	115 V Nominal AC supply voltage								
	Maximum permissible motor cable length for each of the following switching frequencies								
	0.667 kHz	1 kHz	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
11017-1	75 m (245 ft)				37.5 m (122 ft)	25 m (82.5 ft)	18.75 m (61.9 ft)	12.5 m (41.25 ft)	9 m (29.7 ft)
11024-1									
11042-2	100 m (330 ft)				75 m (245 ft)	50 m (165 ft)	37.5 m (122 ft)	25 m (82.5 ft)	18 m (59.4 ft)
11056-2									

Table 5-19 Maximum motor cable lengths (230 V drives)

Model	230 V Nominal AC supply voltage								
	Maximum permissible motor cable length for each of the following switching frequencies								
	0.667 kHz	1 kHz	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
21017-1	75 m (245 ft)				37.5 m (122 ft)	25 m (82.5 ft)	18.75 m (61 ft)	12.5 m (41 ft)	9 m (30 ft)
21024-1									
21033-1									
21042-1									
22024-2	100 m (330 ft)				75 m (245 ft)	50 m (165 ft)	37.5 m (122 ft)	25 m (82.5 ft)	18 m (60 ft)
22033-2									
22042-2									
22056-2									
22075-2									
22100-3	100 m (330 ft)				75 m (245 ft)	50 m (165 ft)	37.5 m (122 ft)	25 m (82.5 ft)	18 m (60 ft)
22133-4	100 m (330 ft)				75 m (245 ft)	50 m (165 ft)	37.5 m (122 ft)	25 m (82.5 ft)	18 m (60 ft)
23176-4									

Table 5-20 Maximum motor cable lengths (460 V drives)

Model	460 V Nominal AC supply voltage								
	Maximum permissible motor cable length for each of the following switching frequencies								
	0.667 kHz	1 kHz	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
43013-2	100 m (330 ft)				75 m (245 ft)	50 m (165 ft)	37.5 m (122 ft)	25 m (82.5 ft)	18.25 m (60 ft)
43018-2									
43023-2									
43032-2									
43041-2									
43056-3	100 m (330 ft)				75 m (245 ft)	50 m (165 ft)	37.5 m (122 ft)	25 m (82.5 ft)	18.25 m (60 ft)
43073-3									
43094-3									
43135-4	100 m (330 ft)				75 m (245 ft)	50 m (165 ft)	37.5 m (122 ft)	25 m (82.5 ft)	18.25 m (60 ft)
43170-4									

- 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.

The maximum cable length is reduced from that shown in Table 5-18, Table 5-19 and Table 5-20 if high capacitance motor cables are used. For further information, refer to section 4.4.2 *High-capacitance / reduced diameter cables* on page 53.

5.1.23 Minimum resistance values and peak power rating for the braking resistor at 40 °C (104 °F)

Table 5-21 Braking resistor resistance and power rating (115 V)

Model	Minimum resistance* Ω	Instantaneous power rating kW	Continuous power rating kW
11017-1	130	1.1	0.25
11024-1			0.37
11042-2	68	2.2	0.75
11056-2			1.1

Table 5-22 Braking resistor resistance and power rating (230 V)

Model	Minimum resistance* Ω	Instantaneous power rating kW	Continuous power rating kW
21017-1	130	1.1	0.25
21024-1			0.37
21033-1			0.55
21042-1			0.75
22024-2	68	2.2	0.37
22033-2			0.55
22042-2			0.75
22056-2			1.1
22075-2			1.5
22100-3	45	3.3	2.2
22133-4	22	6.0	3
23176-4			4

Table 5-23 Braking resistor resistance and power rating (460 V)

Model	Minimum resistance* Ω	Instantaneous power rating kW	Continuous power rating kW
43013-2	270	2.2	0.37
43018-2			0.55
43023-2			0.75
43032-2			1.1
43041-2			1.5
43056-3	100	6.0	2.2
43073-3			3
43094-3			4
43135-4	50	11.2	5.5
43170-4			7.5

* Resistor tolerance: ±10 %

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 therefore essential 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 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.

5.1.24 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 5-24 Drive control terminal data

Model	Connection type	Torque setting
All	Screw terminals	0.2 N m (0.15 lb ft)

Table 5-25 Drive relay terminal data

Model	Connection type	Torque setting
All	Screw terminals	0.5 N m (0.4 lb ft)

Table 5-26 Drive power terminal data

Model size	AC and motor terminals		DC and braking		Ground terminal	
	Recommended	Maximum	Recommended	Maximum	Recommended	Maximum
1	0.5 N m (0.4 lb ft)		0.5 N m (0.4 lb ft)		1.5 N m (1.1 lb ft)	
2	1.4 N m (1 lb ft)		1.4 N m (1 lb ft)			
3						
4						

Table 5-27 Terminal block maximum cable sizes

Model size	Terminal block description	Max cable size
All	Control connector	1.5 mm ² (16 AWG)
All	2-way relay connector	2.5 mm ² (12 AWG)
1 to 4	STO connector	0.5 mm ² (20 AWG)
1	AC input / output power connector	2.5 mm ² (12 AWG)
2 to 4	AC input / output power connector	4.0 mm ² (10 AWG)

5.1.25 Electromagnetic compatibility (EMC)

This is a summary of the EMC performance of the drive. For full details, refer to the EMC Data Sheet which can be obtained from the supplier of the drive.

Table 5-28 Immunity compliance

Standard	Type of immunity	Test specification	Application	Level
IEC 61000-4-2 EN61000-4-2:2009	Electrostatic discharge	6 kV contact discharge 8 kV air discharge	Module enclosure	Level 3 (industrial)
IEC 61000-4-3 EN61000-4-3:2006+A2:2010	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 EN61000-4-4:2012	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 EN61000-4-5:2014	Surges	Common mode 4 kV 1.2/50 μ s waveshape	AC supply lines: line to ground	Level 4
		Differential mode 2 kV1.2/50 μ s waveshape	AC supply lines: line to line	Level 3
		Lines to ground	Signal ports to ground*	Level 2
IEC61000-4-6 EN61000-4-6:2014	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 EN61000-4-11:2004	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	

* See section 4.7.6 *Variations in the EMC wiring* on page 72 for control ports for possible requirements regarding grounding and external surge protection.

Emission

The drive contains an in-built filter for basic emission control. An additional optional external filter provides further reduction of emission. The requirements of the following standards are met, depending on the motor cable length and switching frequency.

Table 5-29 Size 1 emission compliance

Motor cable length (m)	Switching Frequency (kHz)								
	0.667	1	2	3	4	6	8	12	16
Using internal filter only:									
2	C3	C3	C3	C3	C3	C3	C3	C3	C3
10	C3	C3	C3	C3	C4	C4	C4	C4	C4
Using external filter and internal filter:									
2	C1	C1	C1	C1	C1	C1	C1	C1	C1
20	C1	C1	C1	C1	C2	C2	C2	C2	C2
50	C2	C2	C2	C2	-	-	-	-	-
Using low leakage external filter:									
10	C1	C1	C1	C1	-	-	-	-	-

Table 5-30 Size 2 emission compliance

Motor cable length (m)	Switching Frequency (kHz)								
	0.667	1	2	3	4	6	8	12	16
Using internal filter only:									
2	C3	C3	C3	C3	C3	C4	C4	C4	C4
10	C4	C4	C4	C4	C4	C4	C4	C4	C4
Using external filter and internal filter:									
2	C1	C1	C1	C1	C1	C1	C1	C1	C1
20	C1	C1	C1	C1	C2	C2	C2	C2	C2
100	C2	C2	C2	C2	-	-	-	-	-
Using low leakage external filter:									
10	C1	C1	C1	C1	-	-	-	-	-

Table 5-31 Size 3 emission compliance

Motor cable length (m)	Switching Frequency (kHz)								
	0.667	1	2	3	4	6	8	12	16
Using internal filter only:									
2	C3	C3	C3	C3	C3	C3	C4	C4	C4
10	C4	C4	C4	C4	C4	C4	C4	C4	C4
Using external filter and internal filter:									
2	C1	C1	C1	C1	C1	C1	C1	C1	C1
20	C1	C1	C1	C1	C2	C2	C2	C2	C2
100	C2	C2	C2	C2	-	-	-	-	-
Using low leakage external filter:									
10	C1	C1	C1	C1	-	-	-	-	-

Table 5-32 Size 4 emission compliance

Motor cable length (m)	Switching Frequency (kHz)								
	0.667	1	2	3	4	6	8	12	16
Using internal filter only:									
2	C3	C3	C3	C3	C3	C3	C4	C4	C4
5	C3	C3	C3	C3	C3	C3	C3	C3	C4
10	C3	C3	C3	C3	C3	C3	C4	C4	C4
Using external filter and internal filter:									
2	C1	C1	C1	C1	C1	C1	C1	C1	C1
20	C1	C1	C1	C1	C2	C2	C2	C2	C2
100	C2	C2	C2	C2	-	-	-	-	-
Using low leakage external filter:									
10	C1	C1	C1	C1	-	-	-	-	-



This is a product of the restricted distribution class according to IEC 61800-3. In a residential environment this product may cause radio interference in which case the user may be required to take adequate measures.

Residential generic standard EN 61000-6-3:2007+A1:2011

EN 61800-3:2004+A1:2012 first environment unrestricted distribution

EN 61800-3:2004+A1:2012 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.

IEC 61800-3:2004 and 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 previously
C1	Intended for use in the first or second environments	R
C2	Not a plug-in or movable device, and intended for use in the first environment only when installed by a professional, or in the second environment	I
C3	Intended for use in the second environment, not the first environment	E2U
C4	Rated at over 1000 V or over 400 A, intended for use in complex systems in the second environment	E2R

5.2 Optional external EMC filters

Table 5-33 Drive and EMC filter cross reference

Model	Part number
115 V	
11017-1 to 11024-1	4200-1000, 4200-1001 (low leakage)
11042-2 to 11056-2	4200-2000
230 V	
21017-1 to 21042-1	4200-1000, 4200-1001 (low leakage)
22024-2 to 22075-2	4200-2001, 4200-2002 (low leakage)
	4200-2003, 4200-2004 (low leakage)
22100-3	4200-3000, 4200-3001 (low leakage)
	4200-3004, 4200-3005 (low leakage)
22133-4 to 23176-4	4200-4000, 4200-4001 (low leakage)
	4200-4002, 4200-4003 (low leakage)
460 V	
43013-2 to 43041-2	4200-2005, 4200-2006 (low leakage)
43056-3 to 43094-3	4200-3008, 4200-3009 (low leakage)
43135-4 to 43170-4	4200-4004, 4200-4005 (low leakage)

5.2.1 EMC filter ratings

Table 5-34 Optional external EMC filter details

Part number	Maximum continuous current		Voltage rating		Phases	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 & phase-to-ground	Worst case	
	A	A	V	V	ph		W	W	mA	mA	
4200-1000	11	9.7	250	250	1	20	6	4.7	24.6	43.5	
4200-1001	11	9.7	250	250			6.7	5.2	2.38	5.82	
4200-2000	25	22	110	250			12.1	9.4	11.7	20.8	
4200-2001	18	15.8	250	250			7.5	5.8	24.6	43.5	
4200-2002	18	15.8	250	250			7.5	5.8	2.38	5.82	
4200-2003	13	11.4	250	250	3		10.7	8.3	1.84	43.4	
4200-2004	13	11.4	250	250			10.7	8.3	1.84	43.4	
4200-2005	6	5.3	480	480			4	3.1	3.6	77.5	
4200-2006	6	5.3	480	480			4	3.1	1.2	30.5	
4200-3000	23	20.2	250	250			1	11.1	8.6	24	43
4200-3001	23	20.2	250	250	11.1			8.6	3.4	8.3	
4200-3004	17	15	250	250	3		11.7	9.1	0.7	16	
4200-3005	17	15	250	250			11.7	9.1	0.7	16	
4200-3008	14	12.3	480	480			8.8	6.8	3.6	77.5	
4200-3009	14	12.3	480	480			8.8	6.8	1.32	33.2	
4200-4000	24	21.1	250	250			1	13.8	10.7	24	43
4200-4001	24	21.1	250	250	13.8			10.7	3.4	8.3	
4200-4002	20	17.6	250	250	3		13.8	10.7	0.7	16	
4200-4003	20	17.6	250	250			13.8	10.7	0.7	16	
4200-4004	17	15	480	480			14.3	11.1	3.6	77.5	
4200-4005	17	15	480	480		14.3	11.1	1.3	33.2		

Safety information

Product information

Mechanical installation

Electrical installation

Technical data

UL listing information

5.2.2 Overall EMC filter dimensions

Table 5-35 Optional external EMC filter dimensions

Part number	Dimension (mm)						Weight	
	H		W		D			
	mm	inch	mm	inch	mm	inch	kg	lb
4200-1000	215	8.46	75	2.95	41	1.61	0.49	1.08
4200-1001	215	8.46	75	2.95	41	1.61	0.49	1.08
4200-2000	261	10.28	78	3.07	41	1.61	0.90	1.98
4200-2001	261	10.28	78	3.07	41	1.61	0.86	1.89
4200-2002	261	10.28	78	3.07	41	1.61	0.86	1.89
4200-2003	261	10.28	78	3.07	41	1.61	0.88	1.94
4200-2004	261	10.28	78	3.07	41	1.61	0.88	1.94
4200-2005	261	10.28	78	3.07	41	1.61	0.82	1.80
4200-2006	261	10.28	78	3.07	41	1.61	0.82	1.80
4200-3000	282	11.10	90	3.54	41	1.61	0.92	2.02
4200-3001	282	11.10	90	3.54	41	1.61	0.92	2.02
4200-3004	282	11.10	90	3.54	41	1.61	0.95	2.09
4200-3005	282	11.10	90	3.54	41	1.61	0.95	2.09
4200-3008	282	11.10	90	3.54	41	1.61	1	2.20
4200-3009	282	11.10	90	3.54	41	1.61	1	2.20
4200-4000	334	13.15	115	4.53	41	1.61	1.3	2.86
4200-4001	334	13.15	115	4.53	41	1.61	1.3	2.86
4200-4002	334	13.15	115	4.53	41	1.61	1.4	3.08
4200-4003	334	13.15	115	4.53	41	1.61	1.4	3.08
4200-4004	334	13.15	115	4.53	41	1.61	1.4	3.08
4200-4005	334	13.15	115	4.53	41	1.61	1.4	3.08

6 UL listing information

6.1 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.

6.2 Option modules, kits and accessories

All Option Modules, Control Pods and Installation Kits supplied by KB Electronics, Inc. for use with these drives are UL Listed.

6.3 Enclosure ratings

Drives are UL Open Type as supplied.

Drives fitted with a conduit box are UL Type 1.

Remote Keypads are UL Type 12.

6.4 Mounting

Drives can be mounted directly onto a vertical surface. This is known as 'surface' or 'standard' mounting. Refer to section 3.4 *Drive dimensions and mounting methods* on page 21 for further information.

Drives can be installed side by side with recommended spacing between them. This is known as 'bookcase' mounting. Refer to section 3.5 *Enclosure layout* on page 23 for further information.

Drives fitted with a conduit box can be mounted directly onto a wall or other vertical surface without additional protection. Suitable conduit boxes are available from KB Electronics, Inc.

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

6.5 Environment

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

Drives may be operated in surrounding air temperatures up to 50 °C or 55 °C at de-rated current, depending on the model number. Refer to Chapter 5 *Technical data* on page 75 for further information.

6.6 Electrical Installation

TERMINAL TORQUE

Terminals must be tightened to the rated torque as specified in the Installation Instructions. Refer to section 3.8.1 *Terminal sizes and torque settings* on page 34 for further information.

WIRING TERMINALS

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

UL Listed closed-loop connectors sized according to the field wiring shall be used for all field wiring connections. Refer to section 4.1.2 *Ground connections* on page 42 for further information.

BRANCH CIRCUIT PROTECTION

The fuses and circuit breakers required for branch circuit protection are contained in the Installation Instructions. Refer to section 4.3 *Ratings* on page 47 for further information.

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 have been evaluated for dynamic braking applications.

6.7 Motor overload protection and thermal memory retention

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

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

The duration of the overload is dependent on motor thermal time constant. The time constant is programmable. The default overload protection is typically set to 150 % of the motor rated current for 120 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.

6.8 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. Refer to section 4.3 *Ratings* on page 47 for further information.

6.9 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.

6.10 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 converters from the KBG1, KBG2, KBG3 Series range manufactured by KB Electronics, Inc.

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 KB Electronics, Inc. for further details.



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KB Electronics, Inc.

12095 NW 39 Street, Coral Springs, FL 33065-2516

Phone: 954-346-4900 | **Fax:** 954-346-3377 | **Toll Free:** 800-221-6570

E-Mail: info@kbelectronics.com | **Website:** www.kbelectronics.com