Regen Design Guide

Unidrive M600
Unidrive M700
Unidrive M701

Part Number: 0478-0366-04
Issue: 4

Original Instructions

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

Documentation

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

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How to use this guide

This user guide provides complete information for installing and operating a Unidrive M from start to finish.

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

NOTE

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

This guide should be read in-line with the relevant *Control User Guide* also, which contains additional information which may be required whilst designing and commissioning a regen system.

This map of the user guide helps to find the right sections for the task you wish to complete:

	Familiarisation	System design	Programming and commissioning	Troubleshooting
1 Safety information	●	●	●	●
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4 System design	●	●		
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Contents

EU Declaration of Conformity

Nidec Control Techniques Ltd,
The Gro,
Newtown,
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UK

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

Model number	Interpretation	Nomenclature aaaa - bbc ddddde
aaaa	Basic series	M100, M101, M200, M201, M300, M400, M600, M700, M701, M702, M708, M709, M751, M753, M754, F300, H300, E200, E300, HS30, HS70, HS71, HS72, M000, RECT
bb	Frame size	01, 02, 03, 04, 05, 06, 07, 08, 09, 10, 11
c	Voltage rating	1 = 100 V, 2 = 200 V, 4 = 400 V, 5 = 575 V, 6 = 690 V
ddddd	Current rating	Example 01000 = 100 A
e	Drive format	A = 6P Rectifier + Inverter (internal choke), D = Inverter, E = 6P Rectifier + Inverter (external choke), T = 12P Rectifier + Inverter (external choke)

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

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

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

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

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

Jonathan Holman-White
Director of R&D
Date: 17th May 2018
Place: Newtown, Powys, 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)

Nidec Control Techniques Ltd, The Gro, Newtown, Powys, SY16 3BE. UK

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

Model No.	Interpretation	Nomenclature aaaa - bbc ddddde
aaaa	Basic series	M600, M700, M701, M702, M708, M709, M751, M753, M754, F300, H300, E200, E300, HS70, HS71, HS72, M000, RECT
bb	Frame size	01, 02, 03, 04, 05, 06, 07, 08, 09, 10, 11
c	Voltage rating	1 = 100 V, 2 = 200 V, 4 = 400 V, 5 = 575 V, 6 = 690 V
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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
Notified body identification number: 0035

The harmonized standards used are shown below:

EC type-examination certificate numbers:

01/205/5270.02/17 dated 2017-08-28

EN 61800-5-1:2016	Adjustable speed electrical power drive systems - Part 5-2: Safety requirements - Functional
EN 61800-5-1:2016 (in extracts)	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 ISO 13849-1:2015	Safety of Machinery, Safety-related parts of control systems, General principles for design
EN 62061:2005 + AC:2010 + A1:2013 + A2:2015	Safety of machinery, Functional safety of safety related electrical, electronic and programmable electronic control systems
IEC 61508 Parts 1 - 7:2010	Functional safety of electrical/ electronic/programmable electronic safety-related systems

Person authorised to complete the technical file:

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Conformity Engineer
Newtown, Powys, UK

DoC authorised by:

Jonathan Holman-White
Director of R&D
Date: 17th May 2018
Place: Newtown, Powys, UK

IMPORTANT NOTICE

These electronic drive products are intended to be used with appropriate motors, controllers, electrical protection components and other equipment to form complete end products or systems. It is the responsibility of the installer to ensure that the design of the complete machine, including its safety-related control system, is carried out in accordance with the requirements of the Machinery Directive and any other relevant legislation. The use of a safety-related drive in itself does not ensure the safety of the machine. Compliance with safety and EMC regulations depends upon installing and configuring drives correctly, including using the specified input filters. The drive must be installed only by professional installers who are familiar with requirements for safety and EMC. The assembler is responsible for ensuring that the end product or system complies with all relevant laws in the country where it is to be used. For more information regarding Safe Torque Off, refer to the Product Documentation.

1 Safety information

1.1 Warnings, Cautions and Notes

WARNING

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

CAUTION

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 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 motor 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 this 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 Introduction

The following Design Guide should be read in conjunction with the relevant *Unidrive M Control User Guide* and *Power Installation Guide*.

Any Unidrive M600/M700/M701 drive can be configured as an AC Regenerative Unit (hereafter referred to as a Regen drive).

It is possible to operate a Unidrive M702 in Regen Mode although it is not recommended due to the lack of control connections required to fully support Regen operation.

This Design Guide gives instructions for the drive connected to the supply. For instructions regarding the drive connected to the motor, please refer to the relevant *Unidrive M Control User Guide* and *Power Installation Guide*.

WARNING

Safe Torque Off function
The drive enable input is designed to offer the Safe Torque Off safety function only when the drive is connected directly to the motor. The enable input for the drive which is connected to the AC supply works only as a simple enable input for regenerative operation. It does not prevent power from reaching the motor and it does not offer the Safe Torque Off safety function. No attempt must be made to use it for a safety function. Failure to observe this warning could result a dangerous failure of a machinery safety function.
Any reference in this Design Guide to Safe Torque Off should be taken to refer only to the enable function and not to any safety function.

This guide covers the following:

- Principles and advantages of operation in Regen mode
- Safety information
- EMC information
- Detailed information on additional components required
- System design
- Special considerations
- Installation
- Commissioning and optimization of the completed system

At least two Unidrive M drives are required to form a complete regenerative system - one connected to the supply and the second one connected to the motor. A Unidrive M in Regen mode converts the AC mains supply to a controlled DC voltage, which is then fed into another drive(s) to control a motor(s).

NOTE

The motoring drive(s) in a Regen configuration could be another drive other than a Unidrive M, e.g. Unidrive SP or Commander SK etc.

NOTE

The following Regen components are also required in addition to the Unidrive M drives.

1. Regen inductor
2. Switching frequency filter inductor
3. Switching frequency filter capacitor
4. Softstart resistor
5. Varistors
6. MCBs
7. Overload relays

2.1 Regen operation

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

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

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

2.2 Advantages of Unidrive M operating in Regen mode

The main advantages of an AC Regen system are:

- Energy saving.
- The input current waveform is sinusoidal.
- The input current has a near unity power factor.
- Harmonic reduction feature.
- The output voltage for the motor can be higher than the available AC mains supply.
- Possible to control reactive current or power (kVAr units).
- The Regen drive will synchronize to any frequency between 10 and 200 Hz, provided the supply voltage is within the supply requirements (operating frequency range of 45 Hz to 66 Hz) refer to section 6.2 *Supply requirements* on page 117.
- It is possible to configure the drive to continue operating for short periods of time during supply dips and faults i.e. ride through.
- Island detection feature to prevent unwanted islanded operation, where part of the power distribution network becomes separated from the power grid and is unintentionally maintained by an inverter.
- The Regen and motoring drives are identical (when using *Unidrive M*).
- Power feed-forward term available, using analog I/O set-up or fast synchronous communications.
- A fast transient response is possible using the power feed forward term.
- Voltage and frequency limits configurable.

2.3 Principles of operation

The input stage of a non-regenerative AC drive is usually an uncontrolled diode rectifier, therefore power cannot be fed back onto the AC mains supply. By replacing the diode input rectifier with a voltage source PWM input converter (Unidrive M), AC supply power flow can be bi-directional with full control over the input current waveform and power factor. Currents can now be controlled to give near unity power factor and a low level of line frequency harmonics.

In the case of a *Unidrive M* operating in regenerative mode, the IGBT stage is used as a sinusoidal rectifier converting the AC supply to a controlled DC voltage.

Furthermore, by maintaining the DC bus voltage above the peak supply voltage the load motor can be operated at a higher speed without field weakening. Alternatively, the higher output voltage available can be exploited by using a motor with a rated voltage higher than the AC mains supply, thus reducing the current for a given power.

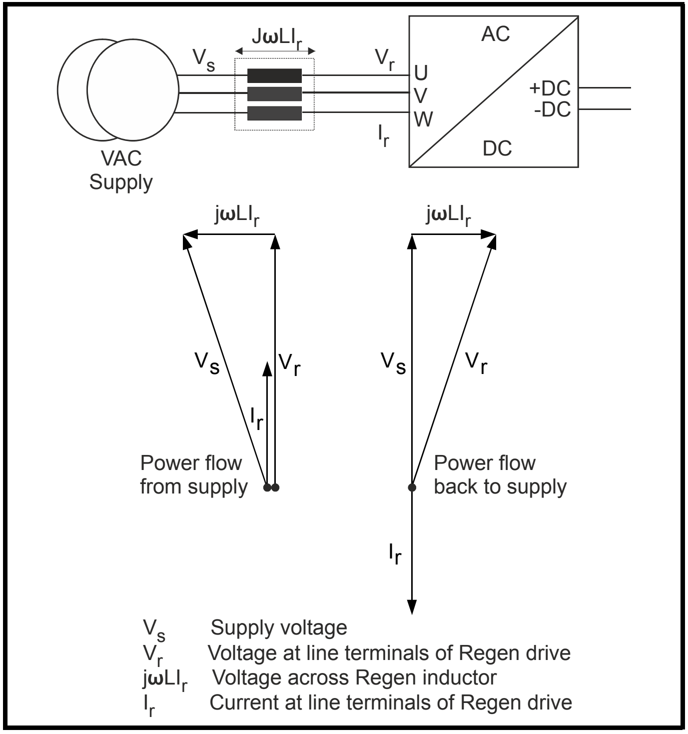
The difference between the PWM line voltage and the supply voltage occurs across the Regen inductors at the Regen drive. This voltage has a high frequency component, which is blocked by the Regen inductor, and a sinusoidal component at line frequency. As a result currents flowing in these inductors are sinusoidal with a small high frequency ripple component.

Regen inductors must be used to ensure a minimum source impedance, these being selected and specified later in the guide.

2.4 Power flow

The following phasor diagram illustrates the relationship between the supply voltage and the Regen drive voltage. The angle between the two voltage vectors is approximately 5° at full load, this can result in a near unity power factor of 0.996, depending on the grid supply conditions.

Figure 2-1



The direction of the power flow can be changed relative to the supply voltage, by making small changes to the Regen drives output voltage and phase.

2.5 Synchronization

The synchronization of the Regen drive to the supply does not require additional hardware. The space vector modulator within the Regen drive represents the angle and magnitude of the AC supply at all times. This however is not the case when the AC supply is first connected or when the Regen drive is disabled.

Unless some form of synchronization is carried out the current controllers will start with values of zero resulting in zero volts being applied to the inverter output terminals. The phase locked loop (PLL) would also start with zero and so would not lock onto the supply.

To overcome these problems the following information must be obtained before the Regen drive attempts to start:

1. The mains supply voltage vector magnitude
2. The angle of the supply voltage vector
3. The frequency of the supply

These values are obtained by carrying out a synchronization on enable

- The first stage of the pre-start tests is to measure the initial DC bus voltage, which by default, is assumed to be equal to the peak line-to-line voltage of the supply.
- The second stage of the pre-start test is to apply two short pulses of zero volts at the converter input. These pulses must be short enough so that the peak current is less than the over current trip level of the converter. The time between the pulses must also be long enough so that the current built up in the input inductors during the first pulse has decayed to a low level before the second pulse is applied. These are used to calculate the instantaneous angle of the supply voltage vector during the first test pulse. The second test pulse is then applied at time Td later to allow the supply frequency to be calculated. At this stage the supply inductance is also calculated.
- Once the synchronization is complete the phase locked loop (PLL) is set-up. At this point the whole control system could be started and should operate without any large transients.
- To improve the robustness of the start-up phase a further short test pulse voltage vector, with the same magnitude and phase as the estimated supply voltage vector is applied. This is to detect measurement errors that could have occurred because of supply distortion present during the pre-start tests. The Regen drive may not synchronize to the supply if the grid voltage is highly distorted.

2.6 Current trimming

A current feedback trimming routine runs before the drive is enabled to minimise offsets in the current feedback. This feature can be user configured, for more details refer to section 8.6 *Current trimming* on page 144.

2.7 Regen system configurations

The Regen drive has been designed to provide a regulated DC supply to other motoring drives. The Regen drive gives bi-directional power flow with sinusoidal currents and a near unity power factor.

Following are the possible configurations for Unidrive M Regen:

- Single Regen, single motoring (Figure 4-4 on page 42).
- Single Regen, multiple motoring using a Unidrive M Rectifier (Figure 4-5 on page 44).
- Single Regen, multiple motoring using an external softstart resistor (Figure 4-6 on page 46).
- Multiple Regen, multiple motoring using a Unidrive M Rectifier (Figure 4-7 on page 48).
- Regen drive as brake resistor replacement (Figure 4-8 on page 52).

Refer to section 3.3 *Ratings* on page 17, for the Regen drive ratings.

The sizing of a Regen system must take into account the following factors:

- Line voltage
- Motor rated current, rated voltage and power factor
- Maximum load power and overload conditions

In general, when designing a Regen system, equal Regen and motoring drive rated currents will work correctly. However, care must be taken to ensure that under worst case supply conditions the Regen drive is able to supply or absorb all the required power. In multi-drive configurations, the Regen drive must be of a sufficient size to supply the net peak power demanded by the combined load of all the motoring drives and total system losses.

If the Regen drive is unable to supply the full power required by the motoring drive, the DC bus voltage will drop and in severe cases may lose synchronization with the mains and trip. If the Regen drive is unable to regenerate the full power from the motoring drive on the DC bus, then the Regen and motoring drive(s) will trip on over-voltage.

2.8 Regen drive system types

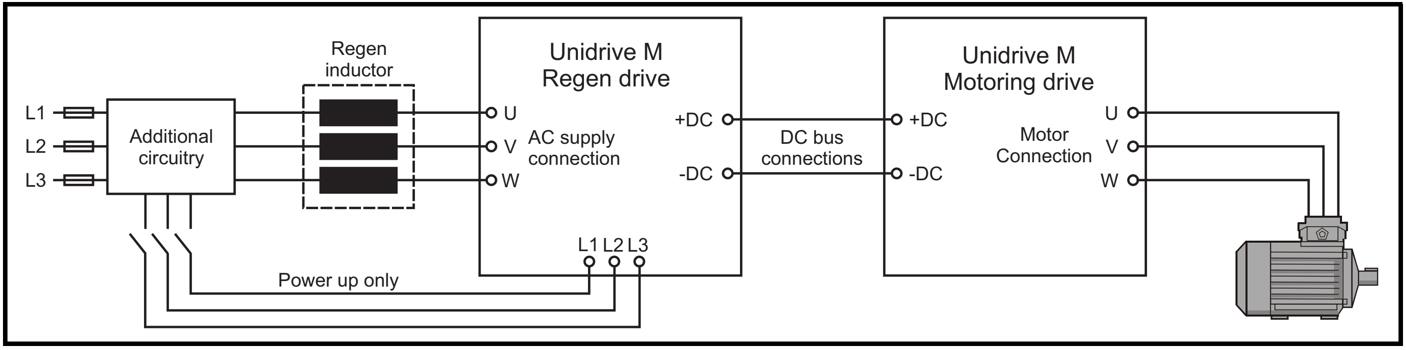
2.8.1 Single Regen, single motoring system

Figure 2-2 shows a typical layout for a standard Regen system consisting of a single Regen drive and single motoring drive. In this configuration the Regen drive is supplying the motoring drive and passing the regenerative energy back to the mains supply.

NOTE

The power up connections to L1, L2, L3 of the Regen drive are only made during power-up. Once both drives are powered up, this is switched out and the main Regen supply switched in. The auxiliary on the charging circuit to the Regen drive’s L1, L2, L3 connections for power up must be closed (charging supply removed) before the Regen drive can be enabled.

Figure 2-2 Single Regen, single motoring system



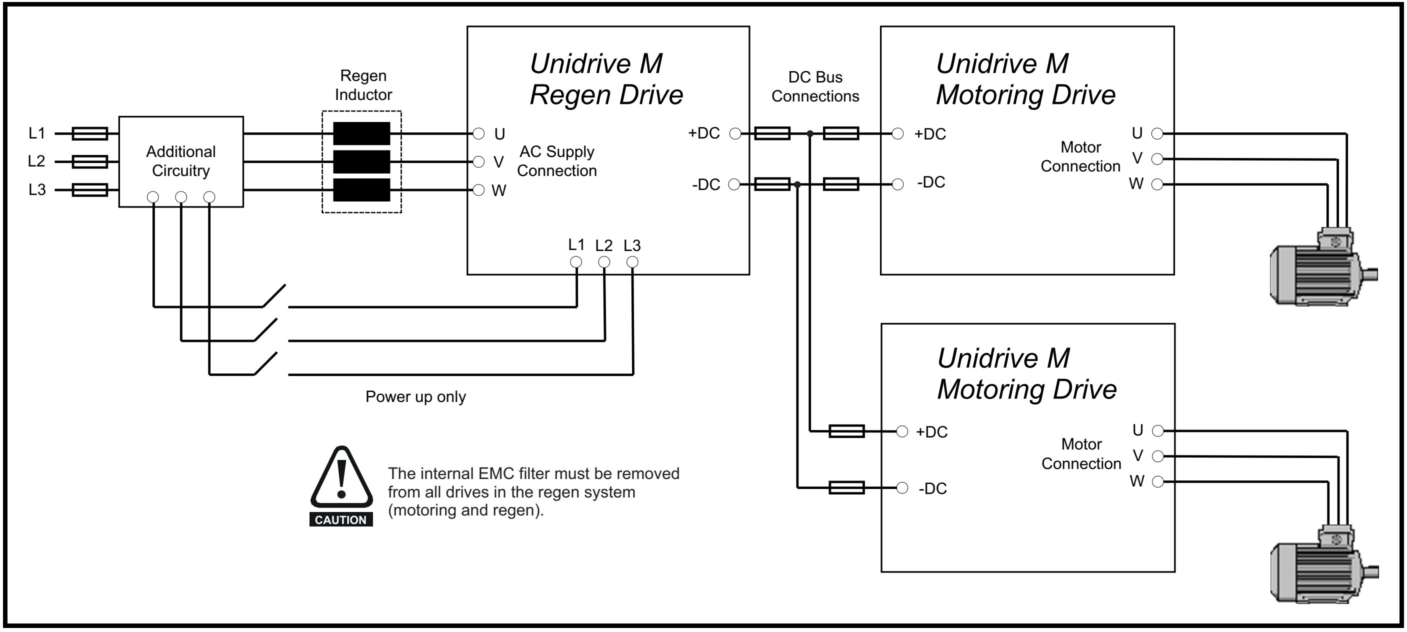
NOTE

For the above single Regen, single motoring configuration; the Regen drive must be of the same frame size or larger.

2.8.2 Single Regen, multiple motoring system

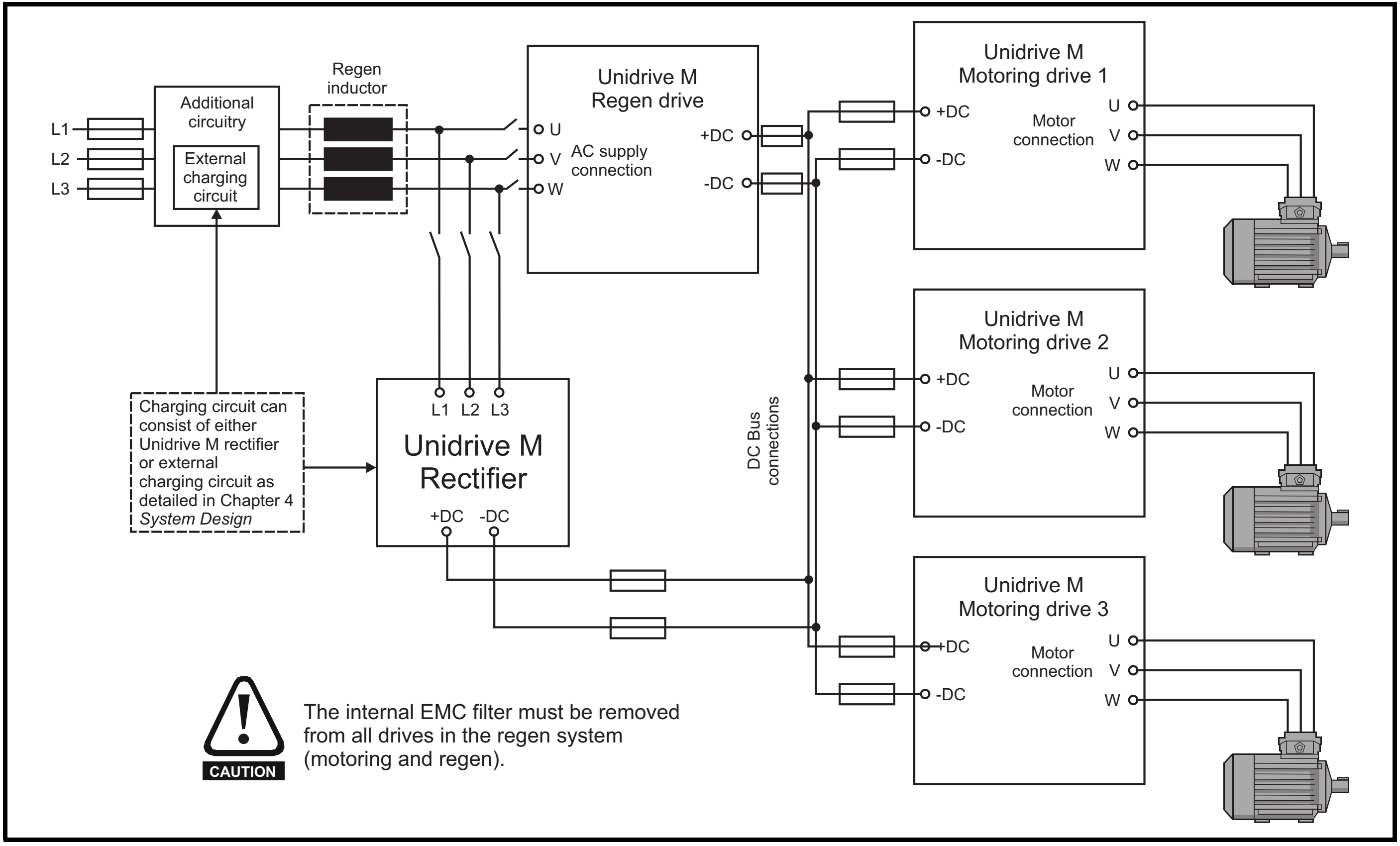
Figure 2-3 and Figure 2-4 show the layout for a Regen system consisting of a single Regen drive with multiple motoring drives. In this configuration the Regen drive is sized to the total power of all motoring drives.

Figure 2-3 Single Regen, multiple motoring system using an external softstart resistor



It is also possible to have a single Regen drive powering multiple motoring drives as shown with the power up connections also being provided via the Regen drives L1, L2, L3 inputs and using the Regen drives own internal softstart.

Figure 2-4 Single Regen, multiple motoring system using a Unidrive M rectifier



NOTE

For a single Regen and multiple motoring drive arrangement optional charging circuits can be used for the increased inrush current generated by the additional capacitance of the multiple motoring drives. The charging circuit can consist of either a Unidrive M rectifier module or an external softstart resistor as detailed in Chapter 4 *System design* on page 40.

2.8.3 Multiple Regen, multiple motoring system

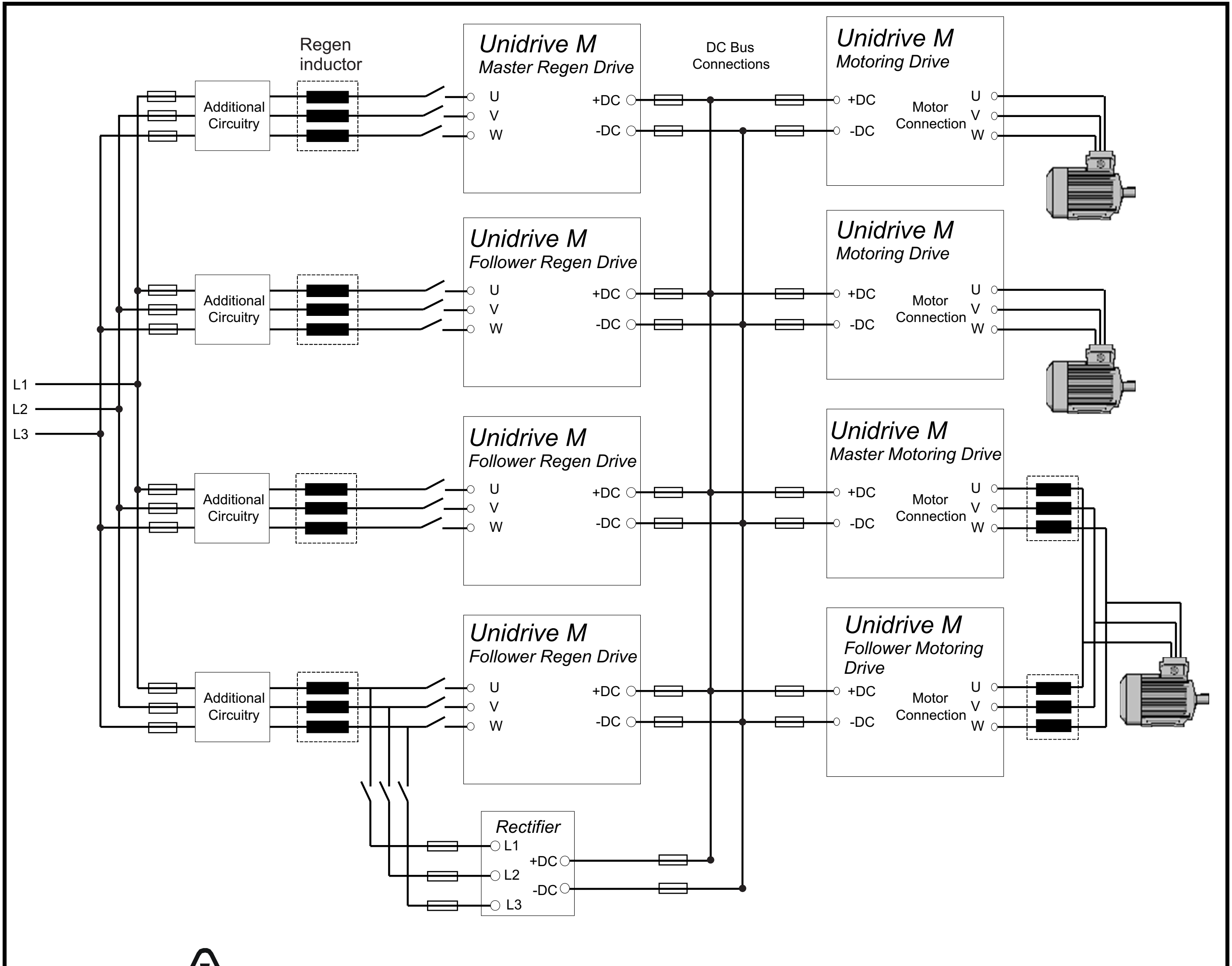
Figure 2-5 shows a multiple Regen drive system with multiple motoring drives. For this configuration the Regen drives are sized to the total power requirement of all motoring drives. The multiple Regen configuration is only possible with Unidrive M modular drives in master / follower configuration.

NOTE

For the multiple Regen and multiple motoring drives arrangement the required start-up circuit consists of a Unidrive M rectifier module (for example a 10404520 is capable of charging a maximum DC Bus capacitance of 70.2 mF).

Special care should be taken when designing a multiple Regen and multiple motoring drive system ensuring that all the required fusing is in place on both the common DC bus connections and the AC supply to all Regen drives.

Figure 2-5 Multiple Regen, multiple motoring system



CAUTION

The internal EMC filter must be removed from all drives in the regen system (motoring and regen).

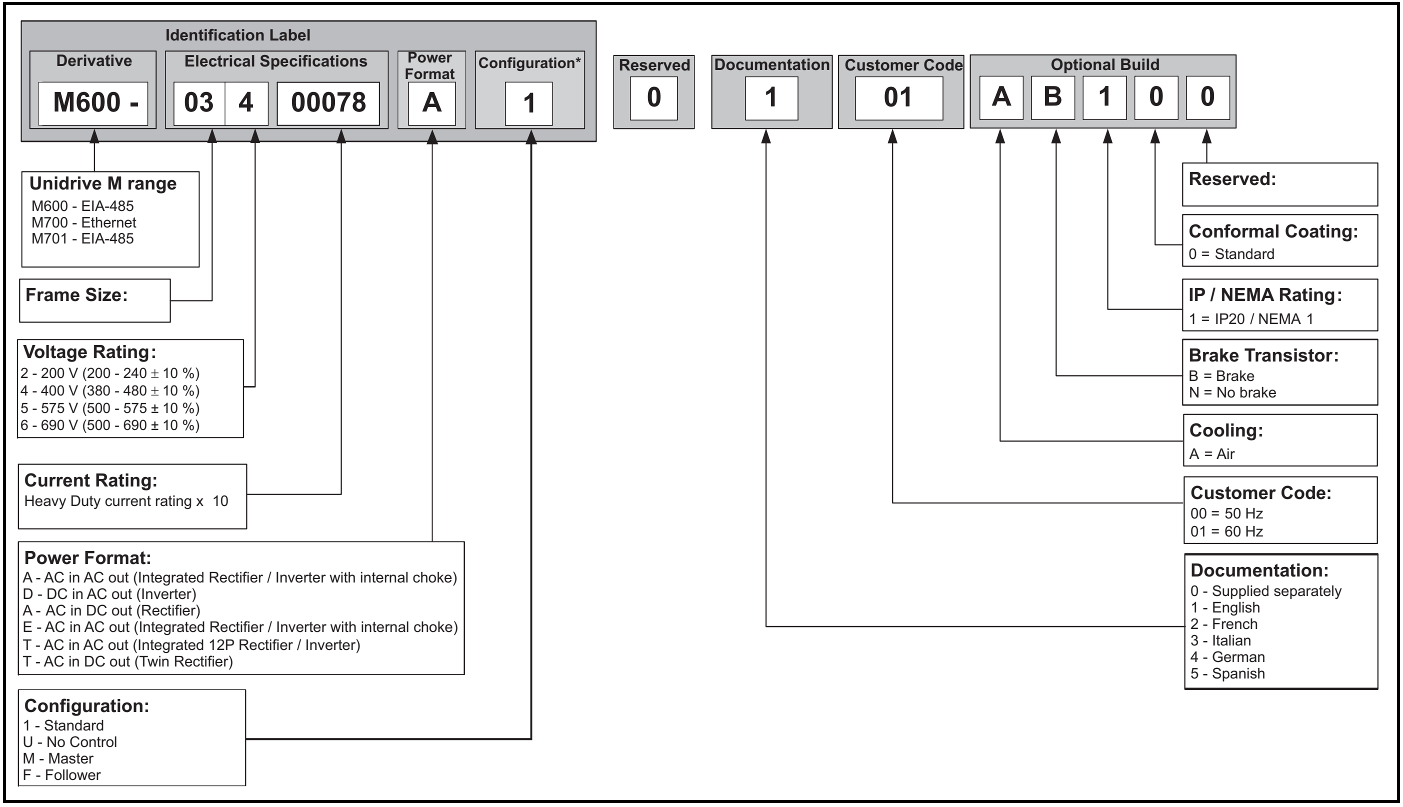
NOTE

All drives paralleled must be of the same frame size, and a derating also applies in Chapter 3, section 3.3 *Ratings* on page 17.

3 Product Information

3.1 Model number

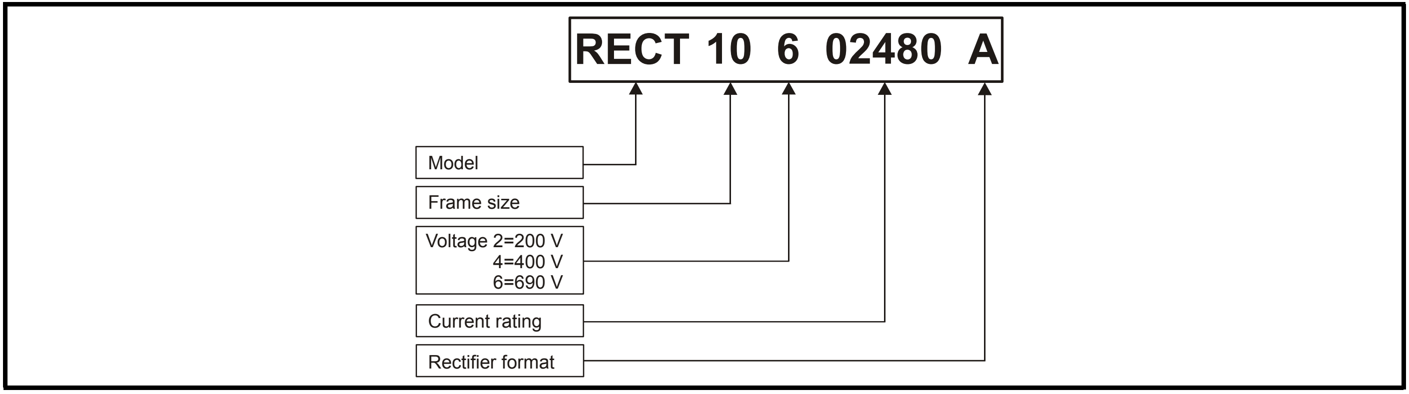
The way in which the model numbers for the Unidrive M range are formed is illustrated below.



NOTE

The internal EMC filter and negative DC terminal are not accessible on Unidrive M frames 9E/T, 10E/T and 11E/T. These power formats are therefore not suitable for Regen systems.

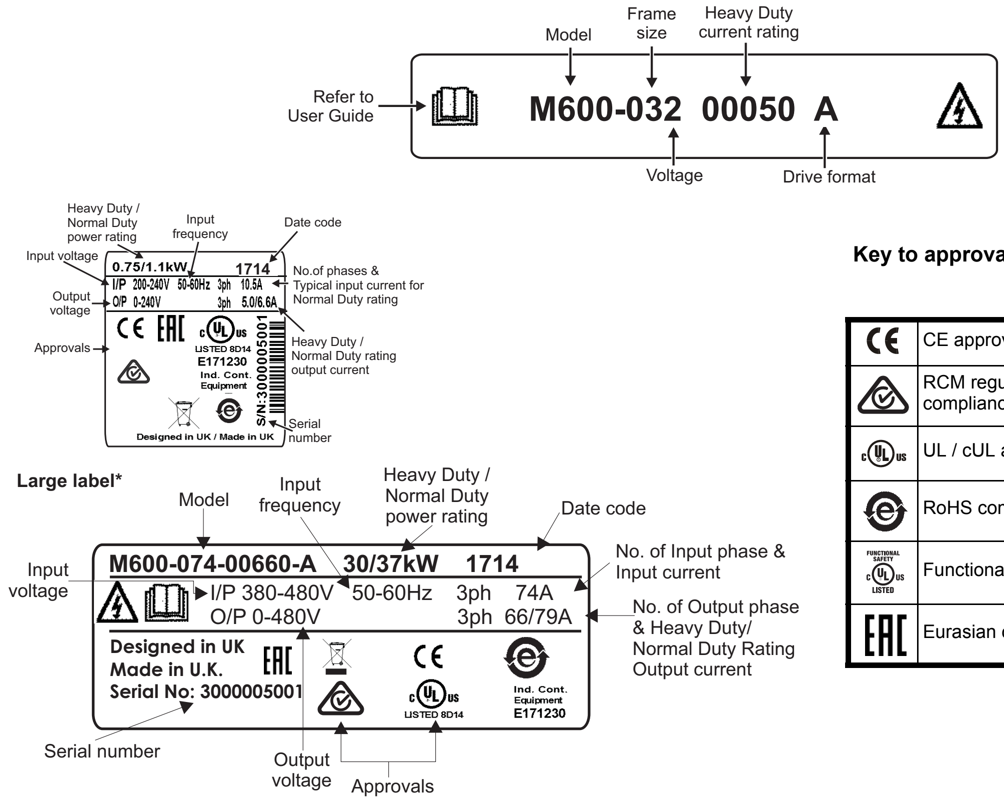
Figure 3-1 Rectifier model number



3.2 Nameplate description

See Figure 3-3 on page 20 for location of rating labels.

Figure 3-2 Typical drive rating labels



Key to approvals

CE	CE approval	Europe
✓	RCM regulatory compliance mark	Australia
c UL us	UL / cUL approval	USA & Canada
e	RoHS compliant	China
FUNCTIONAL SAFETY c UL us LISTED	Functional safety	USA & Canada
EAC	Eurasian conformity	Eurasia

NOTE

Date code format

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

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

3.3 Ratings

The continuous current ratings given are for maximum 40 °C (104 °F), 1000 m altitude and 3 kHz switching frequency. Output current derating has been applied based on Regen and switching frequency filter inductor capability. Additional derating is required for higher switching frequencies, ambient temperature >40 °C (104 °F) and high altitude. For further information, refer to Chapter 10 *Technical data* on page 276.

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

Model	Normal Duty				Heavy Duty			
	Max cont current	Nominal power at 230 V	Motor power at 230 V	Peak current	Max cont current	Peak current	Nominal power at 230 V	Motor power at 230 V
	A	kW	hp	A	A	A	kW	hp
03200066	8	1.5	2	8.8	6.6	13.2	1.1	1.5
03200080	11	2.2	3	12.1	8	16	1.5	2
03200106	11	3	3	13.9	10.6	19.2	2.2	3
04200137	15.5	4	5	19.8	13.7	27.1	3	3
04200185	22	5.5	7.5	27.5	15.5	27.1	4	5
05200250	30	7.5	10	33	22	38.5	5.5	7.5
06200330	50	11	15	55	31	54.2	7.5	10
06200440	56	15	20	63.8	42	73.5	11	15
07200610	75	18.5	25	82.5	56	98	15	20
07200750	94	22	30	103.4	75	140	18.5	25
07200830	105	30	40	128.7	80	140	22	30
08201160	149	37	50	163.9	105	183.7	30	40
08201320	180	45	60	198	132	264	37	50
09201760*	192	55	75	237.6	176	308	45	60
09202190*	250	75	100	292.6	192	336	55	75
10202830*	312	90	125	357.5	283	495.3	75	100
10203000*	350	110	150	396	300	525	90	125

* The internal EMC filter and negative DC terminal are not accessible on Unidrive M Frames 9E/T, 10E/T and 11E/T. These power formats are therefore not suitable for Regen systems. Select 9A/D or 10D power formats only.

Table 3-2 400 V drive ratings (380 V to 480 V ±10 %)

Model	Normal Duty				Heavy Duty			
	Max cont current	Nominal power at 400 V	Motor power at 460 V	Peak current	Max cont current	Peak current	Nominal power at 400 V	Motor power at 460 V
	A	kW	hp	A	A	A	kW	hp
03400078	9.5	4	5.0	11.4	7.8	15.6	3	5
03400100	12	5.5	7.5	13.5	9.5	16.6	4	5
04400150	16	7.5	10	20.3	15	28	5.5	10
04400172	24	11	15	26.4	16	28	7.5	10
05400270	30	15	20	33	25	43.7	11	20
05400300	31	15	20	34.1	30	60	15	20
06400350	38	18.5	25	41.8	34	60	15	25
06400420	46	22	30	52.8	40	70	18.5	30
06400470	60	30	40	69.3	46	80.5	22	30
07400660	70	37	60	86.9	66	122.5	30	50
07400770	94	45	60	103.4	70	122.5	37	60
07401000	112	55	75	123.2	96	168	45	75
08401340	155	75	100	170.5	124	217	55	100
08401570	180	90	150	202.4	156	273	75	125
09402000*	200	110	150	243.1	180	315	90	150
09402240*	255	132	200	280.5	200	353.5	110	150
10402700*	300	160	250	352	270	472.5	132	200
10403200*	350	200	300	397.1	300	525	160	250
11403770*	437	225	350	481	377	660	185	300
11404170*	460	250	400	506	415	726.2	200	350
11404640*	460	280	450	506	415	726.2	250	400

* The internal EMC filter and negative DC terminal are not accessible on Unidrive M Frames 9E/T, 10E/T and 11E/T. These power formats are therefore not suitable for Regen systems. Select 9A/D, 10D or 11D power formats only.

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

Model	Normal Duty				Heavy Duty			
	Max cont current	Nominal power at 575 V	Motor power at 575 V	Peak current	Max cont current	Peak current	Nominal power at 575 V	Motor power at 575 V
	A	kW	hp	A	A	A	kW	hp
06500150	17	11	15	18.7	15	30	7.5	10
06500190	22	15	20	24.2	19	33.2	11	15
06500230	27	18.5	25	29.7	22	38.5	15	20
06500290	34	22	30	37.4	27	47.2	18.5	25
06500350	43	30	40	47.3	34	63	22	30
07500440	52	45	50	58.3	43	75.2	30	40
07500550	63	55	60	80.3	52	91	37	50
08500630	85	75	75	94.6	63	110.2	45	60
08500860	100	90	100	118.8	85	148.7	55	75
09501040*	125	110	125	137.5	100	175	75	100
09501310*	144	110	150	165	125	218.7	90	125
10501520*	192	130	200	220	144	252	110	150
10501900*	192	150	200	220	190	332.5	132	200
11502000*	248	185	250	273	200	350	150	200
11502540*	265	225	300	291.5	221	386.7	185	250
11502850*	265	250	350	291.5	221	386.7	225	300

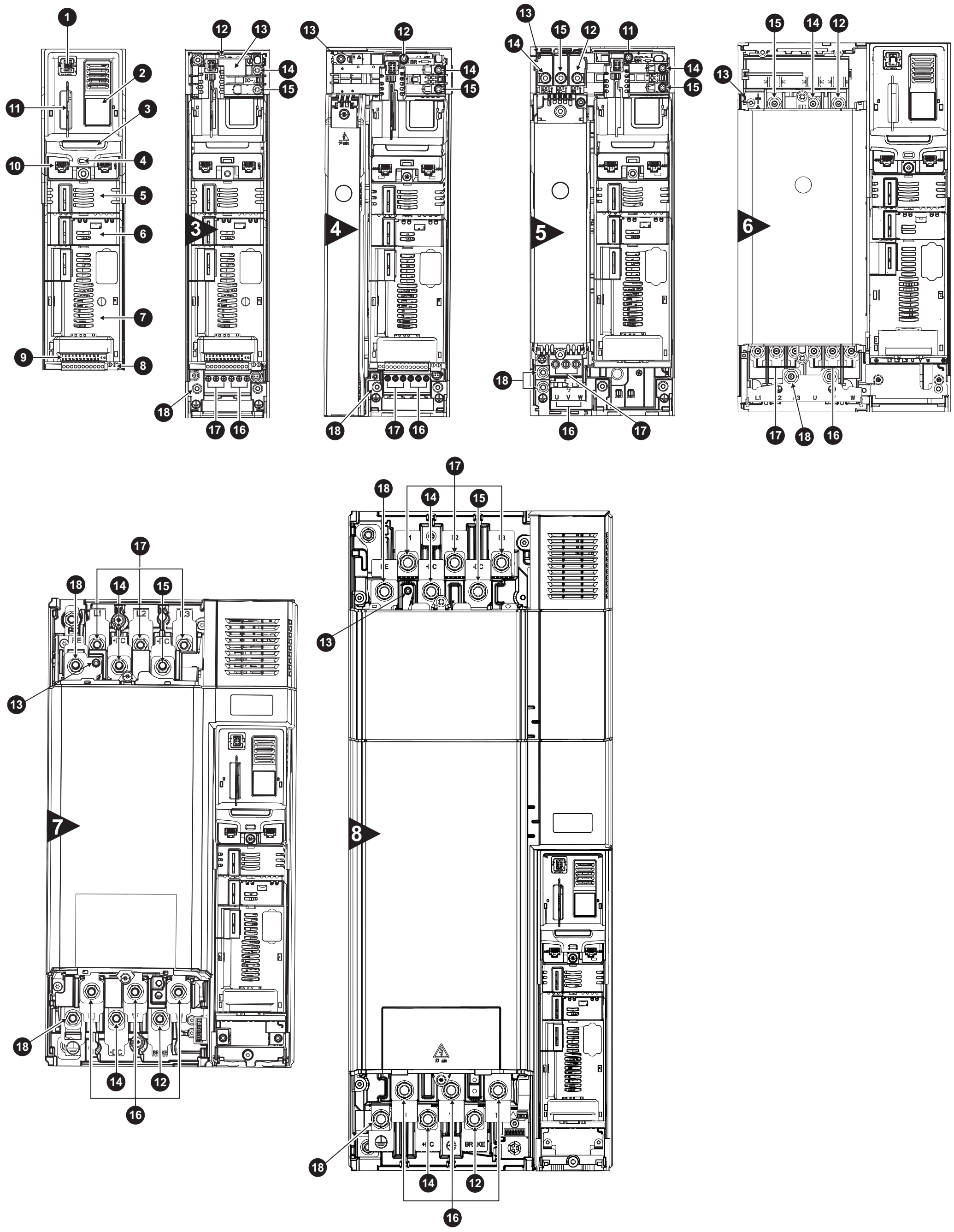
Table 3-4 690 V Drive ratings (500 V to 690 V ±10 %)

Model	Normal Duty				Heavy Duty			
	Max cont current	Nominal power at 690 V	Motor power at 690 V	Peak current	Max cont current	Peak current	Nominal power at 690 V	Motor power at 690 V
	A	kW	hp	A	A	A	kW	hp
07600190	22	18.5	25	25.3	19	33.2	15	20
07600240	27	22	30	33	22	38.5	18.5	25
07600290	36	30	40	39.6	27	47.2	22	30
07600380	43	37	50	50.6	36	63	30	40
07600440	52	45	60	57.2	43	75.2	37	50
07600540	63	55	75	80.3	52	91	45	60
08600630	85	75	100	94.6	63	110.2	55	75
08600860	100	90	125	118.8	85	148.7	75	100
09601040*	125	110	150	137.5	100	175	90	125
09601310*	144	132	175	170.5	125	218.7	110	150
10601500*	168	160	200	189.2	144	252	132	175
10601780*	192	185	250	216.7	168	294	160	200
11602100*	225	200	250	247	210	367	185	250
11602380*	265	250	300	291.5	221	386.7	200	250
11602630*	265	280	400	291.5	221	386.7	250	300

* The internal EMC filter and negative DC terminal are not accessible on Unidrive M Frames 9E/T, 10E/T and 11E/T. These power formats are therefore not suitable for Regen systems. Select 9A/D, 10D or 11D power formats only.

3.4 Drive features

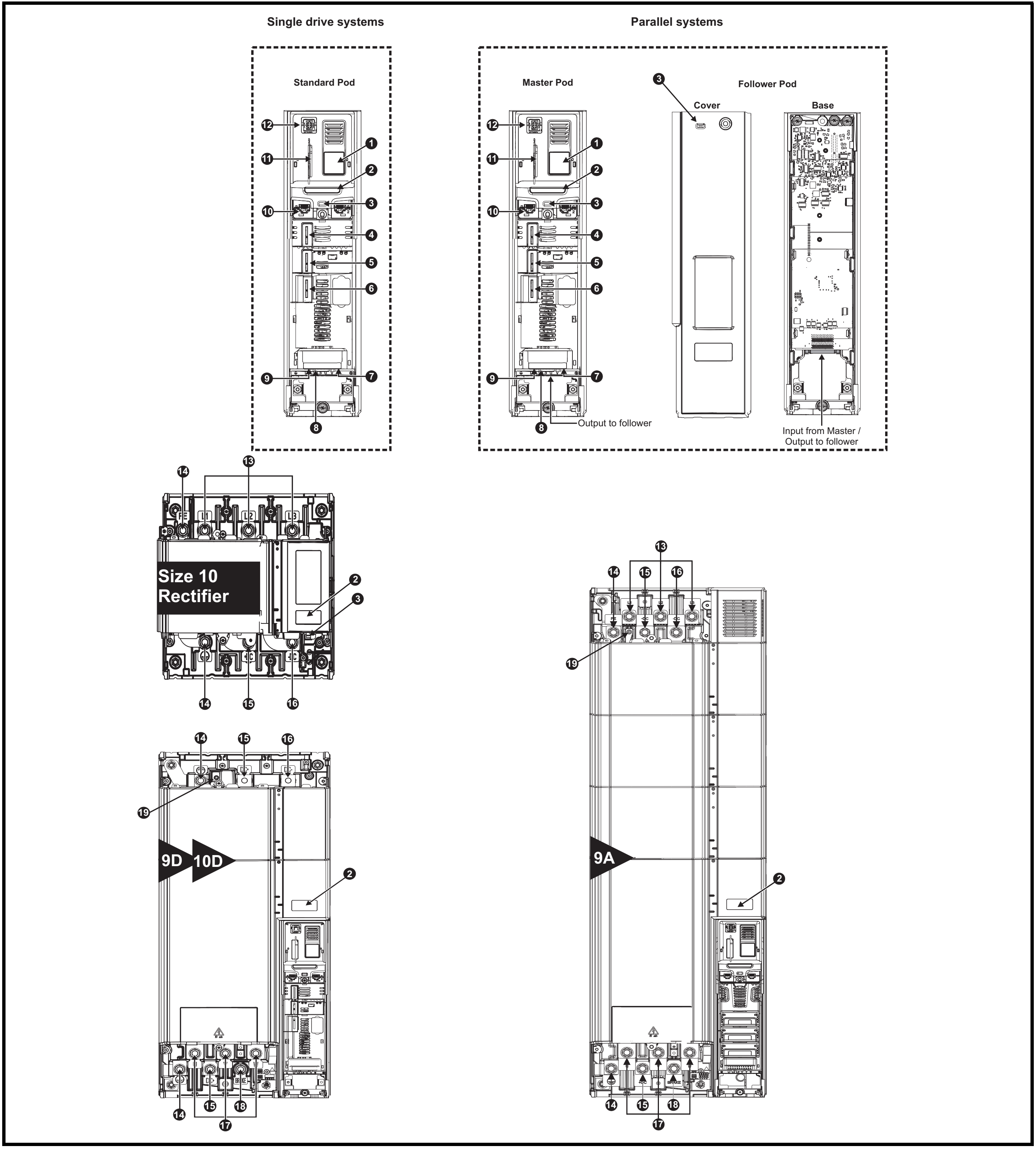
Figure 3-3 Features of the drive sizes 3 to 8



Key

1. Keypad connection
2. Rating label
3. Identification label
4. Status LED
5. Option module slot 1
6. Option module slot 2
7. Option module slot 3
8. Relay connections
9. Control connections
10. Communications port
11. NV media card slot
12. Braking terminal
13. Internal EMC filter (**must be removed**)
14. DC bus output +
15. DC bus output -
16. AC supply connections (U, V, W)
17. Charging inputs (L1, L2, L3)
18. Ground connections

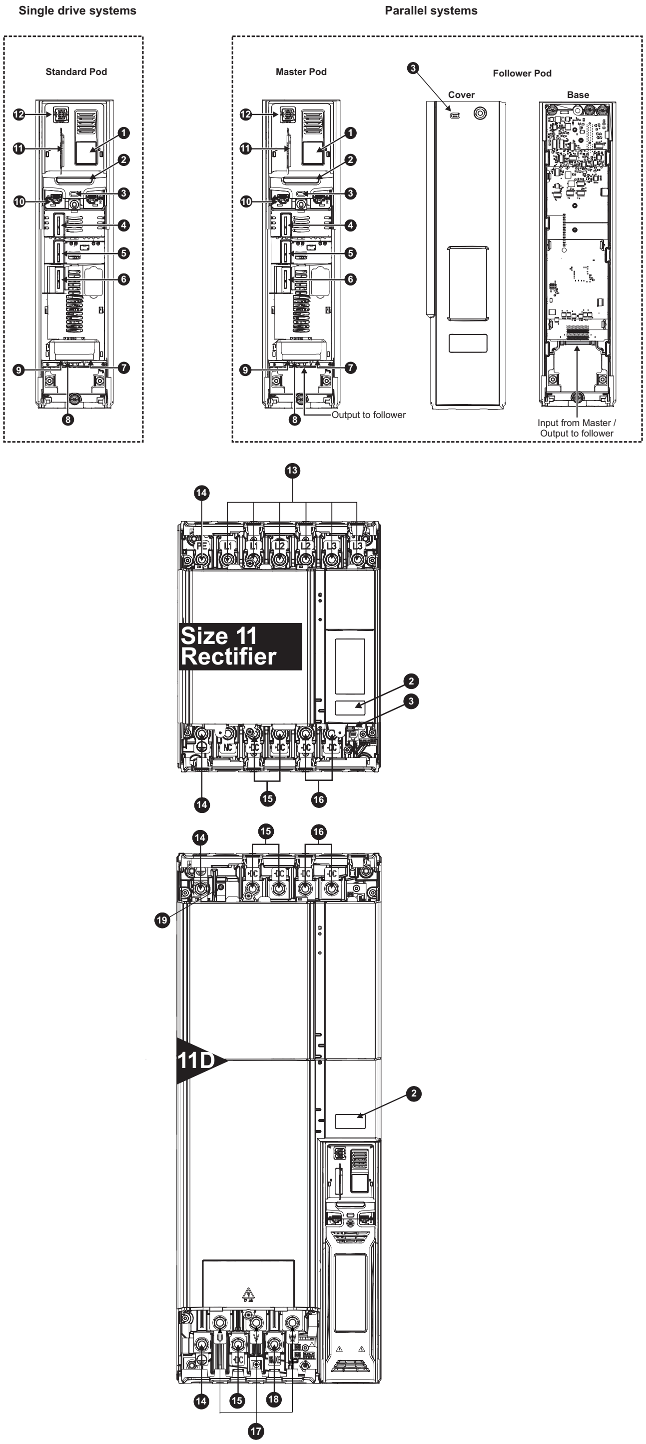
Figure 3-4 Features of the Unidrive M size 9 and 10



Key

1. Rating label
2. Identification label
3. Status LED
4. Option module slot 1
5. Option module slot 2
6. Option module slot 3
7. Relay connections
8. Position feedback connections
9. Control connections
10. Communications port
11. NV media card slot
12. Keypad connection
13. Charging input (L1, L2, L3)
14. Ground connections
15. DC bus output +
16. DC bus output -
17. AC supply connections (U, V, W)
18. Braking terminal
19. Internal EMC filter (**must be removed**)

Figure 3-5 Features of the Unidrive M size 11



NOTE

The rectifier and Unidrive 11D are fitted with dual input power terminals (2 x L1, L2, L3 on the rectifier and 2 x +DC, -DC on the inverter). Ensure that cables to both of the terminals are installed.

Key

1. Rating label
2. Identification label
3. Status LED
4. Option module slot 1
5. Option module slot 2
6. Option module slot 3
7. Relay connections
8. Position feedback connections
9. Control connections
10. Communications port
11. NV media card slot
12. Keypad connection
13. Charging input (L1, L2, L3)
14. Ground connections
15. DC bus output +
16. DC bus output -
17. AC supply connections (U, V, W)
18. Braking terminal
19. Internal EMC filter (**must be removed**)

3.5 Unidrive M Rectifier

The Unidrive M Rectifier is a half controlled SCR/thyristor bridge.

Figure 3-6 Frame 10 single half controlled SCR/thyristor

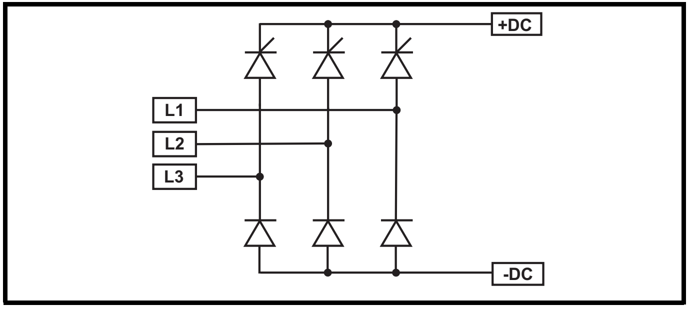


Figure 3-7 Frame 11 single half controlled SCR/thyristor

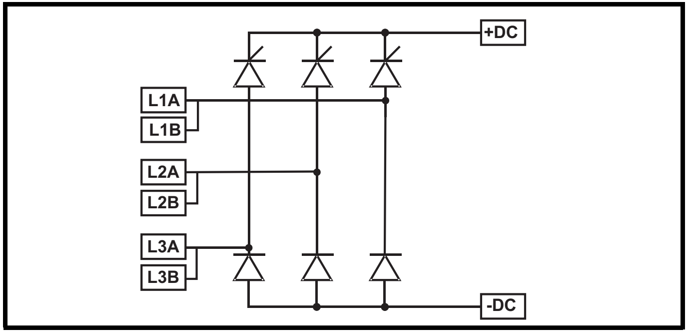
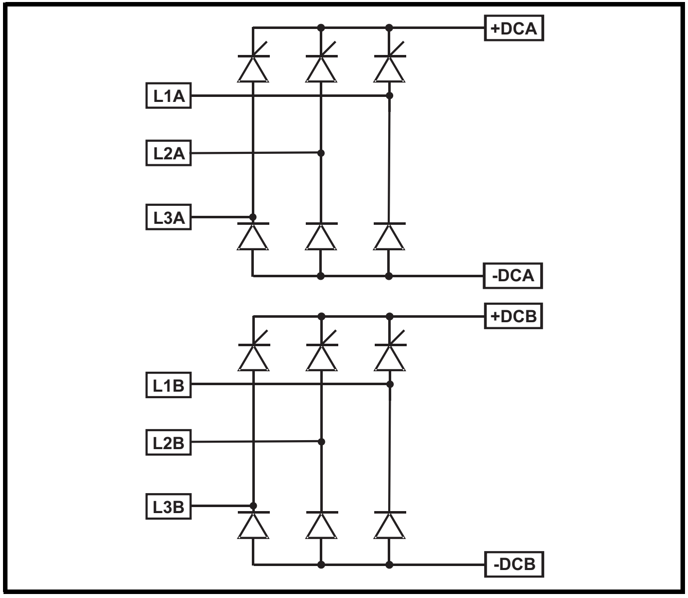
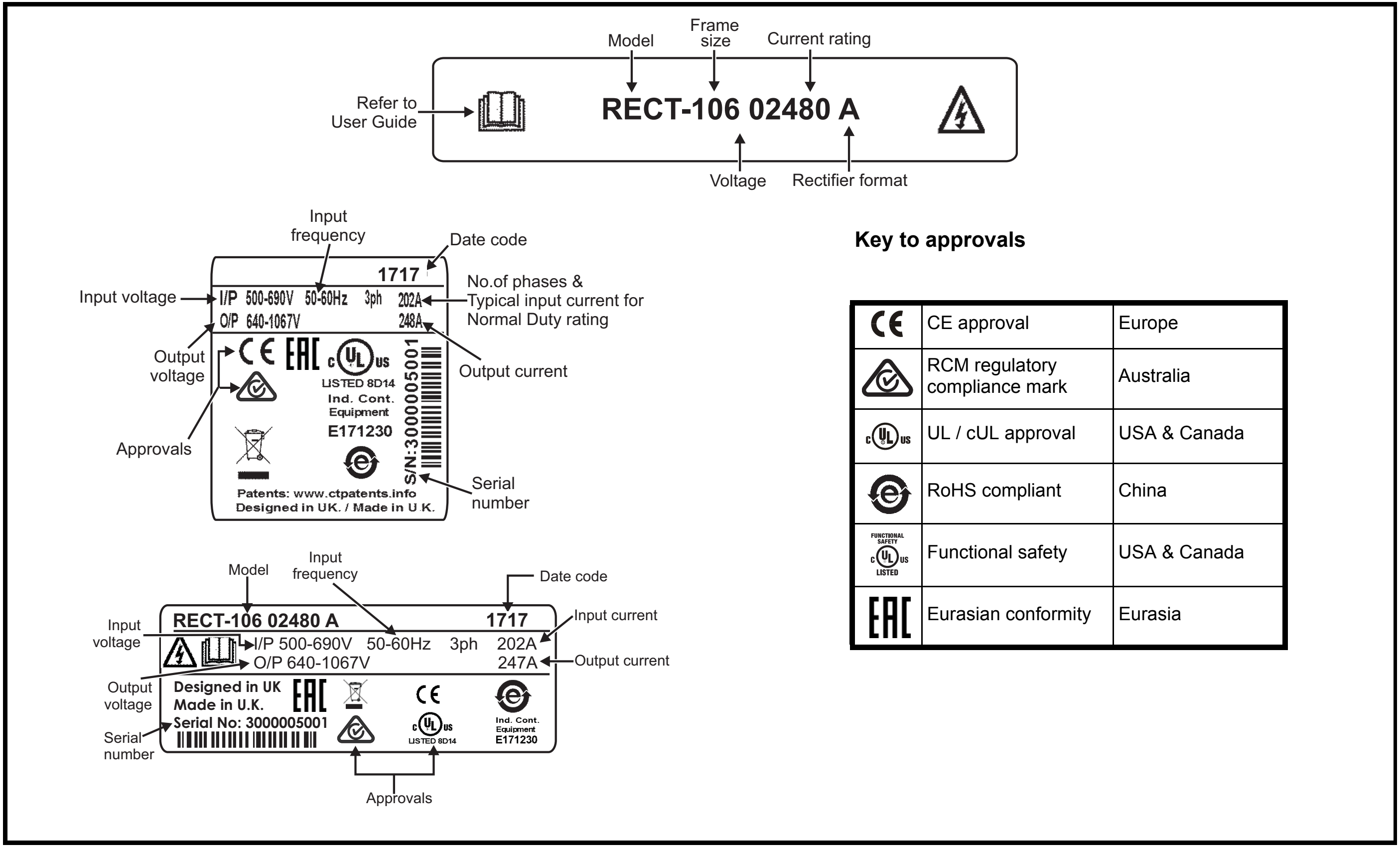


Figure 3-8 Frame 11 twin half controlled SCR/thyristor



The Unidrive M rectifier is a half controlled SCR/thyristor bridge.
The rectifier cannot be used as a stand alone rectifier to supply several smaller drives, but can be used to soft-start or pre-charge single or multiple inverters connected via a common DC bus.

Figure 3-9 Typical rectifier rating labels



Key to approvals

CE	CE approval	Europe
RCM	RCM regulatory compliance mark	Australia
cULus	UL / cUL approval	USA & Canada
e	RoHS compliant	China
FUNCTIONAL SAFETY cULus LISTED	Functional safety	USA & Canada
EAC	Eurasian conformity	Eurasia

3.6 Unidrive M Rectifier technical data

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

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

* Twin rectifier

NOTE

The fuse and cable data in Table 3-5 are based on continuous operation of the Unidrive M rectifier. When using a Unidrive M rectifier to soft start a regen system the charging currents for the system should be calculated.

Table 3-6 Unidrive M rectifier current and fuse ratings

Model	Typical input current	Maximum continuous input current	Maximum overload input current	Fuse rating					
				IEC			UL/USA		
				Nominal	Maximum	Class	Nominal	Maximum	Class
	A	A	A	A	A		A	A	
10204100	333	361	494	450	450	gR	450	450	HSJ
10404520	370	396	523	450	450		450	450	
10502430	202	218	313	250	250		250	250	
10602480	202	225	313	250	250		250	250	
11406840	557	594	752	630	630	gR	600	600	HSJ
11503840	313	338	473	400	400		400	400	
11604060	331	362	465	400	400		400	400	
1142X400*	2 x 326	2 x 358	2 x 516	400	400		400	400	
1162X380*	2 x 308	2 x 339	2 x 488	400	400		400	400	

Table 3-7 Unidrive M rectifier cable ratings

Model	Cable size (IEC)						Cable size (UL)			
	mm^2						AWG or kcmil			
	Input			Output			Input		Output	
	Nominal	Maximum	Installation method	Nominal	Maximum	Installation method	Nominal	Maximum	Nominal	Maximum
10204100	2 x 150	2 x 185	C	2 x 120	2 x 150	C	2 x 300	2 x 500	2 x 400	2 x 500
10404520	2 x 150	2 x 185	C	2 x 150	2 x 150	C	2 x 350	2 x 500	2 x 500	2 x 500
10502430	2 x 95	2 x 185	B2	2 x 95	2 x 150	B2	2 x 3/0	2 x 500	2 x 3/0	2 x 500
10602480	2 x 95	2 x 185	B2	2 x 95	2 x 150	B2	2 x 3/0	2 x 500	2 x 3/0	2 x 500
11406840	4 x 120	4 x 120	C	4 x 150	4 x 150	C	2 x 250	2 x 250	2 x 300	2 x 300
11503840	2 x 120	2 x 120	C	2 x 120	2 x 120	C	2 x 250			
11604060	2 x 120	2 x 120	C	2 x 120	2 x 120	C	2 x 300	2 x 300	2 x 400	2 x 400
1142X400*	2 x 2 x120	2 x 2 x120	C	2 x 2 x 120	2 x 2 x 120	C	2 x 2 x 300			
1162X380*	2 x 2 x120	2 x 2 x120	C	2 x 2 x 120	2 x 2 x 120	C	2 x 2 x 300			

* Twin rectifier

WARNING

The user must provide a means of preventing live parts from being touched. A cover around the electrical connections at the top of the inverter and the bottom of the rectifier where the cables enter is required.

WARNING

Input fuses as specified must be installed.

Table 3-8 Key to Unidrive M rectifier LED

Status Output	Definition
LED	
ON	Mains loss
Flashing	*Temp Feedback* trip
OFF	System healthy

The half controlled thyristor rectifier can be used as an external charging module for a Regen system consisting of multiple drives. The required soft-start function is built into the *Unidrive M* rectifier module as standard.

Table 3-9 Unidrive M external rectifier maximum DC bus capacitance charging capability

Model	AC line current (100 % Normal Duty Motor Current)	DC bus current (100 % Normal Duty Motor Current)	Maximum DC bus capacitance (mF)
10204100	333 A	409 A	109.2
10404520	370 A	452 A	70.2
10502430	202 A	243 A	31.2
10602480	202 A	247 A	31.2
11406840	557 A	684 A	93.6
11503840	313 A	384 A	41.6
11604060	331 A	406 A	41.6
1142X400*	2 x 326 A	2 x 395 A	2 x 93.6
1162X380*	2 x 308 A	2 x 375 A	2 x 41.6

* Twin rectifier

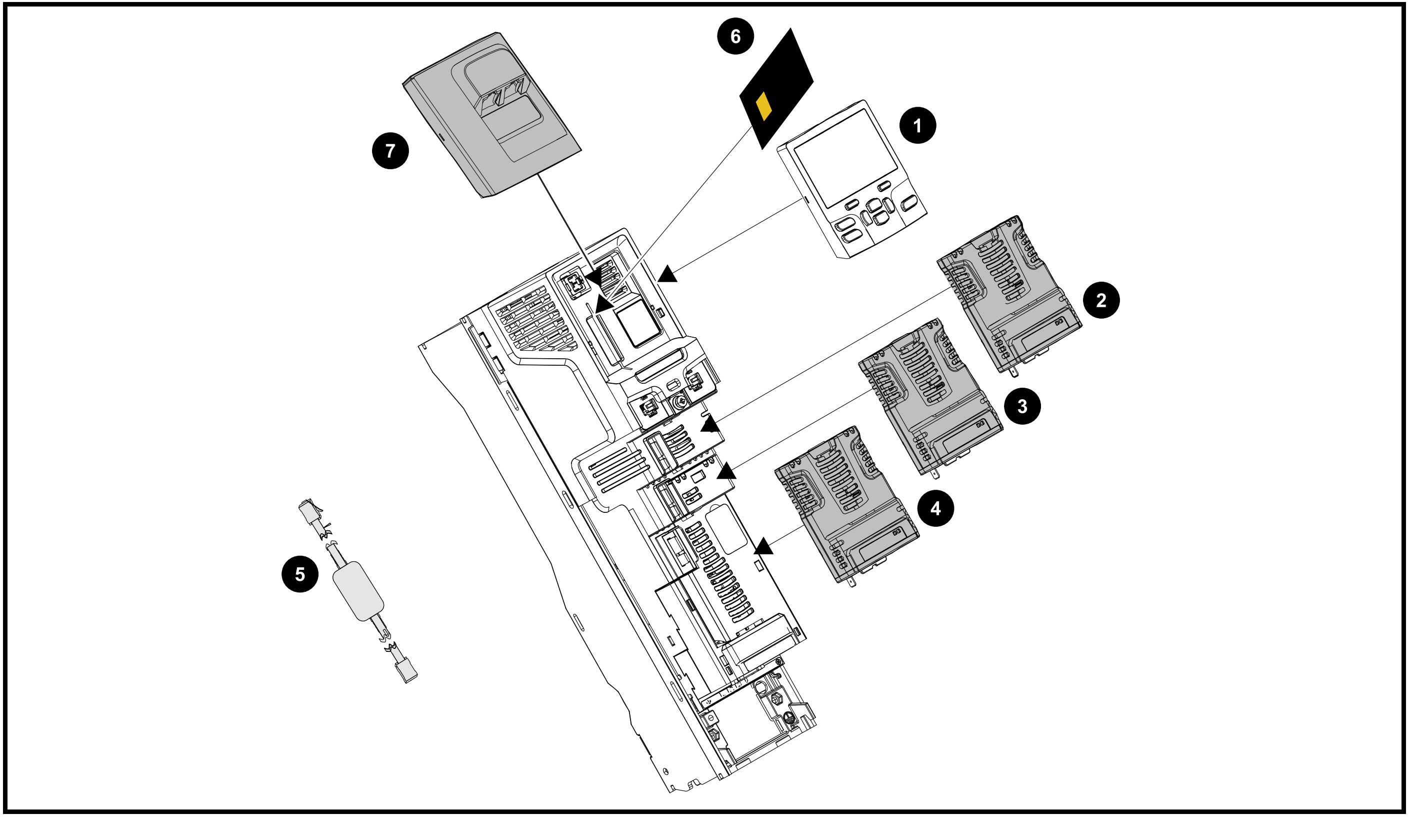
Table 3-10 Maximum DC bus capacitance charging capability for Unidrive M Frame 7 to 9A

Model	Maximum DC bus capacitance (mF)
07200610	47
07200750	47
07200830	47
07400660	23
07400770	23
07401000	23
07500440	8
07500550	8
07600190	8
07600240	8
07600290	8
07600380	8
07600440	8
07600540	8
08201160	70
08201320	70
08401340	35
08401570	35
08500630	13
08500860	13
08600630	13
08600860	13
09201760A	109
09202190A	109
09402000A	55
09402240A	55
09501040A	31
09501310A	31
09601040A	31
09601310A	31

Also refer to the relevant *Unidrive M / Unidrive HS Modular Installation Guide* for further detailed information on the *Unidrive M* rectifier mechanical and electrical installation.

3.7 Options

Figure 3-10 Options available for Unidrive M Regen



1. Keypad
2. Option module slot 1
3. Option module slot 2
4. Option module slot 3
5. USB Comms cable
6. NV media card
7. KI-485 comms adaptor

WARNING

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

NOTE

Position feedback option modules will still function with a drive configured in Regen mode, however, this would only be required where the Regen drive is to be used to provide additional option Module slots for the motoring drive.

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

Table 3-11 Option module identification

Type	Option module	Color	Name	Further Details
Fieldbus		N/A	KI-485 Adaptor	**EIA-485 Comms Adaptor** EIA-485 Comms adaptor provides EIA-485 communication interface. This adaptor supports 115 k Baud, node addresses between 1 to 16 and 8 1 NP M serial mode.
		Purple	SI-PROFIBUS	**PROFIBUS option** PROFIBUS adapter for communications with the drive
		Medium Grey	SI-DeviceNet	**DeviceNet option** DeviceNet adapter for communications with the drive
		Light Grey	SI-CANopen	**CANopen option** CANopen adapter for communications with the drive
		Beige	SI-Ethernet	External Ethernet module that supports EtherNet/IP, Modbus TCP/IP and RTMoE. The module can be used to provide high speed drive access, global connectivity and integration with IT network technologies, such as wireless networking
		Yellow Green	SI-PROFINET V2	**PROFINET V2 option** PROFINET V2 adapter for communications with the drive Note: PROFINET V2 replaces PROFINET RT.
		Brown Red	SI-EtherCAT	**EtherCAT option** EtherCAT adapter for communications with the drive
Automation (I/O expansion)		Orange	SI-I/O	**Extended I/O** Increases the I/O capability by adding the following combinations: • Digital I/O • Digital Inputs • Analog Inputs (differential or single ended) • Analog Output • Relays
Automation (Applications)		Moss Green	MCi200	**Machine Control Studio Compatible Applications Processor** 2nd processor for running pre-defined and/or customer created application software.
		Moss Green	MCi210	**Machine Control Studio Compatible Applications Processor (with Ethernet communications)** 2nd processor for running pre-defined and/or customer created application software with Ethernet communications.
		Black	SI-Applications Plus	**SyPTPro Compatible Applications Processor (with CTNet)** 2nd processor for running pre-defined and/or customer created application software with CTNet support (can only be used on Slot 3).

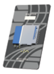
NOTE

Position feedback modules will still function with a drive configured in Regen mode, however, this would only be required where the Regen drive is to be used to provide additional System Integration Module slots for the motoring drive.

Table 3-12 Keypad identification

Type	Keypad	Name	Further Details
Keypad		KI-Keypad	Keypad with an LCD display
		KI-Keypad RTC	Keypad with an LCD display and real time clock
		Remote-Keypad RTC	Remote Keypad with an LCD display and real time clock

Table 3-13 Additional options

Type	Option	Name	Further Details
Back-up		SD Card Adaptor	Allows the drive to use an SD card for drive back-up
		SMARTCARD	Used for parameter back-up with the drive

3.8 Items supplied with the drive

The drive is supplied with a copy of the *Power Installation Guide* and a copy of the *Control Getting Started Guide*, a safety information booklet and an accessory kit box (see the relevant *Power Installation Guide* for details).

3.9 Regen components

NOTE

The Regen filter components listed in this manual are the best match between the currently available filters and the Unidrive M ratings. In some cases it is necessary to reduce Pr **05.007** (Rated Current) to avoid exceeding the filter current rating.

3.9.1 Regen inductor

CAUTION

The following Regen inductors are special parts being designed for very high levels of harmonic voltage and having a high saturation current with good linearity below saturation. Under no circumstances must a part be used other than those listed.

The Regen inductor supports the difference between the PWM voltage from the Unidrive M Regen drive and sinusoidal voltage from the supply.

3.9.2 Switching frequency filter inductor

The inductors are standard three phase inductors. They carry only 50/60 Hz current with a negligible amount of high frequency current. The switching frequency filter inductors are calculated at 4 % of the Regen drives rating using the following formula. A tolerance can be applied to the calculated value in the range of, -10 % to +30 %.

L switching frequency filter mH = VLL / √3 x 1 / Irated x 0.04 x 1 / (2 x pi x f). Where:

VLL = Supply voltage line-to-line
f = Supply frequency
Irated = Drive rated current (normal or heavy duty)

NOTE

SFF inductors should be wound with copper windings and a current density of no more than 2.5 Arms / mm².

NOTE

This calculation also gives the correct inductance value for a 480 V, 60 Hz supply.

WARNING

When specifying a Switching Frequency Filter Inductor, ensure that it is fitted with thermal protection to disable the system in the event of a thermal overload.

3.9.3 Switching frequency filter capacitor

CAUTION

The switching frequency filter capacitors are special parts which are used for filtering of the Regen drives PWM and only the recommended parts should be used.

CAUTION

The 3-phase switching frequency filter (SFF) capacitors are situated on the input of the Regen system. If the harmonic distortion of the supply is high for extended periods then this can cause a reduction of the service life of the capacitors. The effect of this is to reduce the capacitance value. If high levels of harmonic distortion are expected then it is recommended that the capacitance values be checked periodically, and capacitors which have fallen outside of their tolerance range be replaced.

NOTE

This guide contains details for two types of switching frequency filter capacitors.

1. A capacitor that is designed to support lower quality power supply conditions with up to 8 % THD_V on the grid. These capacitors are listed in Table 3-14 to Table 3-17 and Table 10-20 to Table 10-23**.** The system drawings for these capacitors are found in Figure 4-4 to Figure 4-8.
2. A capacitor that is designed to support high quality, low harmonic supplies with up to 2 % THD_V on the grid. These capacitors are listed in Table 3-18 to Table 3-21 and Table 10-24 to Table 10-27. The system drawings for these capacitors can be found in Figure 4-9 to Figure 4-13.

To determine which filter capacitors are best suited, the distortion level of the supply can be measured using a spectrum analyzer or distortion analyzer.

3.9.4 Optional switching frequency filter capacitor fusing

The switching frequency filter capacitors are designed to function without the need for additional branch fusing provided the following conditions are met.

- SFF capacitor cable length is less than or equal to 3 metres.
- SFF capacitor cable length is greater than 3 metres with cables sized for the main regen system supply fuses, where practical.

If the above criteria is not met then fuses must be installed.

If fuses are not installed, under fault conditions the main regen system supply fuses will clear to isolate the system from the mains supply.

3.9.5 Regen filter components for low quality/high harmonic power supplies

These components are used to form the regen input filter and prevent switching frequency harmonic currents getting back onto the supply. If the filter is not fitted, the presence of currents in the kHz region could cause supply problems or disturbance to other equipment.
The SFF capacitors listed in tables 3-14 to 3-17 are also available from the supplier, Kemet. The suppliers part numbers are listed in these tables.

Table 3-14 200 V (200 V to 240 V ±10 %) Regen filter components to support up to 8 % THD$_V$ on the grid

Drive mode		**Regen inductor**			**SFF inductor**			**SFF capacitor**						
Heavy Duty	**Normal Duty**	**mH**	**Arms**	**Part number**	**mH**	**Arms**	**Part number**	**Capacitor combination**		**Capacitor connection**	**Rated voltage Vac**	**CT part number/ supplier part number**	**Max. capacitor current per can @ 50 °C (Arms)**	**Fuse rating (A)**
								Cap bank A µF	**Cap bank B µF**					
03200080	03200066	3.500	9.6	4401-0310	0.880	9.6	4401-1310	10	Not fitted	Delta	780	1610-8104 C20AQGR5100AASK	15	12
03200106	03200080	2.700	11	4401-0311	1.500	11	4401-1311							8
	03200106	2.700	11											8
04200137	04200137*	2.200	15.5	4401-0312	1.100	15.5	4401-1312							10
04200185*		2.200	15.5											10
05200250*	04200185*	1.600	22	4401-0313	0.700	22	4401-1313							8
06200330*		1.100	31	4401-0314	0.500	31	4401-1314	22		Star	550	1610-8224 C20AKGR5220AASK	25	8
	05200250							10		Delta	780	1610-8104 C20AQGR5100AASK	15	8
	06200330	0.600	56	4401-0316	0.300	56	4401-1316	33		Star	550	1610-8334 C20AKGR5330AASK	30	16
06200440*		0.810	42	4401-0315	0.400	42	4401-1315							10
07200610*		0.600	56	4401-0316	0.300	56	4401-1316	15		Delta	640	1610-8154 C20ALGR5150AASK	20	12
	06200440*							33			550	1610-8334 C20AKGR5330AASK	30	10
07200750	07200610	0.400	80	4401-0318	0.200	80	4401-1318	22				1610-8224 C20AKGR5220AASK	25	20
	07200750	0.320	105	4401-0319	0.160	105	4401-1319							25
07200830*		0.400	80	4401-0318	0.200	80	4401-1318							20
08201160*		0.320	105	4401-0319	0.160	105	4401-1319	33				1610-8334 C20AKGR5330AASK	30	25
	07200830*							22				1610-8224 C20AKGR5220AASK	25	25
08201320	08201160	0.220	156	4401-0321	0.110	156	4401-1321	33				1610-8334 C20AKGR5330AASK	30	32
09201760		0.180	192	4401-0322	0.088	192	4401-1322	68				1610-8684 C20AKGR5680AASK	40	40
	08201320	0.180	192					47				1610-8474 C20AKGR5470AASK	35	40
09202190*	09201760*	0.180	192					68				1610-8684 C20AKGR5680AASK	40	40
	09202190*	0.140	250	4401-0323	0.068	250	4401-1323							50
10202830	10202830*	0.110	312	4401-0324	0.055	312	4401-1324	47	47			1610-8474 C20AKGR5470AASK	35	63
10203000		0.110	312											63
	10203000*	0.100	350	4401-0325	0.048	350	4401-1325							80

* Modify *Rated Current* (05.007) to match current rating of inductor.

Table 3-15 400 V (380 V to 480 V ±10 %) Regen filter components to support up to 8 % THD$_V$ on the grid

Drive mode		Regen inductor			SFF inductor			SFF capacitor						
								Capacitor combination						
Heavy Duty	Normal Duty	mH	Arms	Part number	mH	Arms	Part number	Cap bank A µF	Cap bank B µF	Capacitor connection	Rated voltage Vac	CT part number/ supplier part number	Max. capacitor current per can @ 50 °C (Arms)	Fuse rating (A)
03400078	03400078*	6.300	9.5	4401-0405	3.160	9.5	4401-0162	10	Not fitted	Delta	780	1610-8104 C20AQGR 5100AASK	15	20
03400100*														20
	03400100*	5.000	12	4401-0406	2.500	12	4401-0163							20
04400150	04400150*	3.750	16	4401-0407	1.875	16	4401-0164							20
04400172*														20
05400270*	04400172	2.400	25	4401-0408	1.200	25	4401-0165							10
05400300	05400270	1.760	34	4401-0409	0.880	34	4401-0166							16
06400350*								15		Star	640	1610-8154 C20ALGR 5150AASK	20	10
	05400300							10		Delta	780	1610-8104 C20AQGR 5100AASK	15	16
06400420*	06400350	1.500	40	4401-0410	0.750	40	4401-0167	15		Star	640	1610-8154 C20ALGR 5150AASK	20	10
06400470*	06400420*	1.300	46	4401-0411	0.650	46	4401-0168							16
	06400470*	1.000	60	4401-0412	0.500	60	4401-0169	22			550	1610-8224 C20AKGR 5220AASK	25	16
07400660	07400660*	0.780	74	4401-0413	0.390	77	4401-0170	10		Delta	780	1610-8104 C20AQGR 5100AASK	15	20
07400770*														25
07401000*	07400770	0.630	96	4401-0414	0.315	96	4401-0171							25
08401340*		0.480	124	4401-0415	0.240	124	4401-0172	47		Star	550	1610-8474 C20AKGR 5470AASK	35	32
	07401000							15		Delta	640	1610-8154 C20ALGR 5150AASK	20	32
08401570*	08401340	0.380	156	4401-0416	0.190	156	4401-0173	68		Star	550	1610-8684 C20AKGR 5680AASK	40	40
	08401570*	0.330	180	4401-0417	0.165	180	4401-0174							50
09402000*	09402000*	0.300	210	4401-0418	0.135	220	4401-0175	33		Delta		1610-8334 C20AKGR 5330AASK	30	50
09402240*														50
10402700		0.200	300	4401-0419	0.100	300	4401-0176	22	22			1610-8224 C20AKGR 5220AASK	25	63
	09402240							47	Not fitted			1610-8474 C20AKGR 5470AASK	35	63
10403200*	10402700*							22	22			1610-8224 C20AKGR 5220AASK	25	63
	10403200*	0.168	350	4401-0420	0.080	350	4401-1205	33	33			1610-8334 C20AKGR 5330AASK	30	80
11403770	11403770	0.135	437	4401-0292	0.067	437	4401-0301	47	47			1610-8474 C20AKGR 5470AASK	35	100
11404170														125
11404640														125
	11404170	0.121	487	4401-0293	0.060	487	4401-0302							125
	11404640													125

* Modify *Rated Current* (05.007) to match current rating of inductor.

Table 3-16 575 V (500 V to 575 V ±10 %) Regen filter components to support up to 8 % THD_v on the grid

Drive mode		Regen inductor			SFF inductor			SFF capacitor						
Heavy Duty	Normal Duty	mH	Arms	Part number	mH	Arms	Part number	Capacitor combination		Capacitor connection	Rated voltage Vac	CT part number/ supplier part number	Max. capacitor current per can @ 50 °C (Arms)	Fuse rating (A)
								Cap bank A µF	Cap bank B µF					
06500150	06500150	5.300	19	4401-0210	1.400	22	4401-1211	10	Not fitted	Star	780	1610-8104 C20AQGR 5100AASK	15	6
06500190														6
06500230*	06500190	4.600	22	4401-0211										6
06500290*	06500230	3.800	27	4401-0212		36	4401-1213							6
06500350	06500290	2.800	36	4401-0213	1.200	43	4401-1214							8
07500440*	06500350	2.400	43	4401-0214	1.000	52	4401-1215							8
07500550*	07500440*	1.900	52	4401-0215	0.800	63	4401-1216							10
08500630	07500550*	1.600	63	4401-0216	0.600	85	4401-1217	15			640	1610-8154 C20ALGR 5150AASK	20	12
08500860*	08500630*	1.200	85	4401-0217	0.510	100	4401-1218	22			550	1610-8224 C20AKGR 5220AASK	25	16
09501040*	08500860*	1.000	100	4401-0218	0.400	125	4401-1219	33				1610-8334	30	20
09501310*	09501040	0.810	125	4401-0219	0.350	144	4401-1220	47				C20AKGR 5330AASK	35	25
10501520*		0.700	144	4401-0220	0.300	168	4401-1221	22	22			1610-8224 C20AKGR 5220AASK	25	25
	09501310*							47	Not fitted			1610-8474 C20AKGR 5470AASK	35	25
10501900	10501520*	0.530	192	4401-0421	0.210	192	4401-1223	33	33			1610-8334 C20AKGR 5330AASK	30	32
	10501900*			4401-0421										32
11502000		0.441	230	4401-0297	0.221	230	4401-0306	47	47			1610-8474 C20AKGR 5470AASK	35	40
	11502000	0.361	281	4401-0298	0.181	281	4401-0307							63
11502540		0.441	230	4401-0297	0.221	230	4401-0306							40
	11502540	0.361	281	4401-0298	0.181	281	4401-0307							63
11502850		0.441	230	4401-0297	0.221	230	4401-0306							40
	11502850	0.361	281	4401-0298	0.181	281	4401-0307							63

* Modify *Rated Current* (05.007) to match current rating of inductor.

Table 3-17 690 V (500 V to 690 V ±10 %) Regen filter components to support up to 8 % THD_v on the grid

Drive mode		Regen inductor			SFF inductor			SFF capacitor						
Heavy Duty	**Normal Duty**	**mH**	**Arms**	**Part number**	**mH**	**Arms**	**Part number**	**Capacitor combination**		**Capacitor connection**	**Rated voltage Vac**	**CT part number/ supplier part number**	**Max. capacitor current per can @ 50 °C (Arms)**	**Fuse rating (A)**
								Cap bank A µF	**Cap bank B µF**					
07600190		5.300	19	4401-0210	1.400	22	4401-1211	10	Not fitted	Star	780	1610-8104 C20AQGR 5100AASK	15	6
07600240*	07600190*	4.600	22	4401-0211										6
07600290*	07600240*	3.800	27	4401-0212		36	4401-1213							8
07600380*	07600290*	2.800	36	4401-0213			4401-1213							8
07600440*	07600380*	2.400	43	4401-0214	1.200	43	4401-1214							10
07600540*	07600440	1.900	52	4401-0215	1.000	52	4401-1215							12
08600630		1.600	63	4401-0216	0.800	63	4401-1216	15			640	1610-8154 C20ALGR 5150AASK	20	16
	07600540*							10			780	1610-8104 C20AQGR 5100AASK	15	20
08600860*	08600630*	1.200	85	4401-0217	0.600	85	4401-1217	22			550	1610-8224 C20AKGR 5220AASK	25	20
09601040*		1.000	100	4401-0218	0.510	100	4401-1218	33				1610-8334 C20AKGR 5330AASK	30	20
	08600860*							22				1610-8224 C20AKGR 5220AASK	25	25
09601310*		0.810	125	4401-0219	0.400	125	4401-1219	47				1610-8474 C20AKGR 5470AASK	35	32
	09601040													32
10601500*		0.700	144	4401-0220	0.350	144	4401-1220	22	22			1610-8224 C20AKGR 5220AASK	25	32
	09601310*							47	Not fitted			1610-8474 C20AKGR 5470AASK	35	32
10601780*	10601500*	0.600	168	4401-0221	0.300	168	4401-1221	22	33			1610-8224 C20AKGR 5220AASK 1610-8334 C20AKGR 5330AASK	25	32
	10601780*	0.530	192	4401-0421	0.260	192	4401-1222							40
11602100	11602100	0.441	230	4401-0297	0.221	230	4401-0306	47	47			1610-8474 C20AKGR 5470AASK	35	50
11602380		0.441	230	4401-0297										50
	11602380	0.361	281	4401-0298	0.181	281	4401-0307							63
11602630		0.441	230	4401-0297	0.221	230	4401-0306							50
	11602630	0.361	281	4401-0298	0.181	281	4401-0307							63

* Modify *Rated Current* (05.007) to match current rating of inductor.

3.9.6 Regen filter components for high quality/low harmonic power supplies

These components are used to form the regen input filter and prevent switching frequency harmonic currents getting back onto the supply. If the filter is not fitted, the presence of currents in the kHz region could cause supply problems or disturbance to other equipment. The capacitors listed in Table 3-14 to Table 3-17 are designed for high quality power supplies with up to 2 % THD_V on the grid.

Table 3-18 200 V (200 V to 240 V ±10 %) Regen filter components to support up to 2 % THD_V on grid

Drive mode		Regen inductor			SFF inductor			SFF capacitor				
Heavy Duty	Normal Duty	mH	Arms	Part number	mH	Arms	Part number	Capacitor value	Rated voltage	Part number	Capacitor current per can	Fuse rating (A)
								µF	Vac		Arms	
03200080	03200066	3.500	9.6	4401-0310	0.880	9.6	4401-1310	7	400	1664-1074	1.6	2
03200106	03200080	2.700	11	4401-0311	1.500	11	4401-1311	7	400	1664-1074	1.8	4
	03200106	2.700	11									4
04200137	04200137*	2.200	15.5	4401-0312	1.100	15.5	4401-1312	7	400	1664-1074	2	4
04200185*		2.200	15.5									4
05200250*	04200185*	1.600	22	4401-0313	0.700	22	4401-1313	17	400	1664-2174	3.8	6
06200330*	05200250	1.100	31	4401-0314	0.500	31	4401-1314	17	400	1664-2174	4.4	8
	06200330	0.600	56	4401-0316	0.300	56	4401-1316	32	525	1665-8324	8.1	16
06200440*		0.810	42	4401-0315	0.400	42	4401-1315	17	400	1664-2174	5.2	8
07200610*	06200440*	0.600	56	4401-0316	0.300	56	4401-1316	32	525	1665-8324	8.1	16
07200750	07200610	0.400	80	4401-0318	0.200	80	4401-1318	32	525	1665-8324	9.9	16
	07200750	0.320	105	4401-0319	0.160	105	4401-1319	64	400	1664-2644	15.8	25
07200830*		0.400	80	4401-0318	0.200	80	4401-1318	32	525	1665-8324	9.9	16
08201160*	07200830*	0.320	105	4401-0319	0.160	105	4401-1319	64	400	1664-2644	15.8	25
08201320	08201160	0.220	156	4401-0321	0.110	156	4401-1321	64	400	1664-2644	19.2	32
09201760	08201320	0.180	192	4401-0322	0.088	192	4401-1322	2 x 64	400	2 x 1664-2644	15.2	25
09202190*	09201760*	0.180	192									25
	09202190*	0.140	250	4401-0323	0.068	250	4401-1323	2 x 64	400	2 x 1664-2644	16.8	32
10202830	10202830*	0.110	312	4401-0324	0.055	312	4401-1324	2 x 64	400	2 x 1664-2644	19.2	32
10203000		0.110	312									32
	10203000*	0.100	350	4401-0325	0.048	350	4401-1325	2 x 64	400	2 x 1664-2644	20.5	32

* Modify *Rated Current* (05.007) to match current rating of inductor.

Table 3-19 400 V (380 V to 480 V ±10 %) Regen filter components to support up to 2 % THD_v on grid

Drive mode		Regen inductor			SFF inductor			SFF capacitor				
Heavy Duty	Normal Duty	mH	Arms	Part number	mH	Arms	Part number	Capacitor value	Rated voltage	Part number	Capacitor current per can	Fuse rating (A)
								µF	Vac		Arms	
03400078	03400078*	6.300	9.5	4401-0405	3.160	9.5	4401-0162	8	525	1610-7804	3.3	6
03400100*						9.5						6
	03400100*	5.000	12	4401-0406	2.500	12	4401-0163					6
04400150	04400150*	3.75	16	4401-0407	1.875	16	4401-0164				3.5	6
04400172*												6
05400270*	04400172	2.400	25	4401-0408	1.200	25	4401-0165				4.1	6
05400300	05400270	1.760	34	4401-0409	0.880	34	4401-0166	32		1665-8324	13	20
06400350*	05400300											20
06400420*	06400350	1.500	40	4401-0410	0.750	40	4401-0167				13.1	20
06400470*	06400420*	1.300	46	4401-0411	0.650	46	4401-0168				13.3	25
	06400470*	1.000	60	4401-0412	0.500	60	4401-0169				13.9	25
07400660	07400660*	0.780	74	4401-0413	0.390	77	4401-0170				14.8	25
07400770*		0.780										25
07401000*	07400770	0.630	96	4401-0414	0.315	96	4401-0171	39		1665-8394	18.1	32
08401340*	07401000	0.480	124	4401-0415	0.240	124	4401-0172				20.1	32
08401570*	08401340	0.380	156	4401-0416	0.190	156	4401-0173				22.7	40
	08401570*	0.330	180	4401-0417	0.165	180	4401-0174				24.8	40
09402000*	09402000*	0.300	202	4401-0418	0.135	200	4401-0175	2 x 39		2 x 1665-8394	18.4	32
09402240*												32
10402700	09402240	0.200	300	4401-0419	0.100	300	4401-0176				20.1	32
10403200*	10402700*											32
	10403200*	0.168	350	4401-0420	0.080	350	4401-1205				25.4	40
11403770	11403770	0.135	437	4401-0292	0.067	437	4401-0301	3x 64		3 x 1665-8644	33.5	50
11404170												50
11404640												50
	11404170	0.121	487	4401-0293	0.060	487	4401-0302					50
	11404640											50

* Modify *Rated Current* (05.007) to match current rating of inductor.

Table 3-20 575 V (500 V to 575 V ±10 %) Regen filter components to support up to 2 % THD_v on grid

Drive mode		Regen inductor			SFF inductor			SFF capacitor				
Heavy Duty	Normal Duty	mH	Arms	Part number	mH	Arms	Part number	Capacitor value	Rated voltage	Part number	Capacitor current per can	Fuse rating (A)
								µF	Vac		Arms	
06500150	06500150	5.300	19	4401-0210	1.400	22	4401-1211	11.2	690	1666-8113	5.2	8
06500190												8
06500230*	06500190	4.600	22	4401-0211								8
06500290*	06500230	3.800	27	4401-0212		36	4401-1213				5.3	8
06500350	06500290	2.800	36	4401-0213	1.200	43	4401-1214				5.6	10
07500440*	06500350	2.400	43	4401-0214	1.000	52	4401-1215				5.9	10
07500550*	07500440*	1.900	52	4401-0215	0.800	63	4401-1216				6.4	10
08500630	07500550*	1.600	63	4401-0216	0.600	85	4401-1217				6.9	12
08500860*	08500630*	1.200	85	4401-0217	0.510	100	4401-1218				8.2	16
09501040*	08500860*	1.000	100	4401-0218	0.400	125	4401-1219	22.5		1666-8223	12.5	20
09501310*	09501040	0.810	125	4401-0219	0.350	144	4401-1220				13.8	25
10501520*	09501310*	0.700	144	4401-0220	0.300	168	4401-1221				14.9	25
10501900	10501520*	0.530	192	4401-0421	0.210	192	4401-1223	2 x 22.5		2 x 1666-8223	12.2	20
	10501900*			4401-0421			4401-1223					20
11502000		0.441	230	4401-0297	0.221	230	4401-0306	2 x 46.2***	800	2 x 1668-8464	24	40
	11502000	0.361	281	4401-0298	0.181	281	4401-0307	3 x 46.2***		3 x 1668-8464		40
11502540		0.441	230	4401-0297	0.221	230	4401-0306	2 x 46.2***		2 x 1668-8464		40
	11502540	0.361	281	4401-0298	0.181	281	4401-0307	3 x 46.2***		3 x 1668-8464		40
11502850		0.441	230	4401-0297	0.221	230	4401-0306	2 x 46.2***		2 x 1668-8464		40
	11502850	0.361	281	4401-0298	0.181	281	4401-0307	3 x 46.2***		3 x 1668-8464		40

* Modify *Rated Current* (05.007) to match current rating of inductor.

*** Delta connection

Table 3-21 690 V (500 V to 690 V ±10 %) Regen filter components to support up to 2 % THD_V on grid

Drive mode		Regen inductor			SFF inductor			SFF capacitor				
Heavy Duty	**Normal Duty**	**mH**	**Arms**	**Part number**	**mH**	**Arms**	**Part number**	**Capacitor value** **µF**	**Rated voltage** **Vac**	**Part number**	**Capacitor current per can Arms**	**Fuse rating (A)**
07600190		5.300	19	4401-0210	1.400	22	4401-1211	8.3	800	1668-7833	4.7	8
07600240*	07600190*	4.600	22	4401-0211							4.8	8
07600290*	07600240*	3.800	27	4401-0212		36	4401-1213				5	8
07600380*	07600290*	2.800	36	4401-0213			4401-1213				5.5	8
07600440*	07600380*	2.400	43	4401-0214	1.200	43	4401-1214				5.8	10
07600540*	07600440	1.900	52	4401-0215	1.000	52	4401-1215				6.6	10
08600630	07600540*	1.600	63	4401-0216	0.800	63	4401-1216				7.3	12
08600860*	08600630*	1.200	85	4401-0217	0.600	85	4401-1217	16.6		1668-8163	11.6	20
09601040*	08600860*	1.000	100	4401-0218	0.510	100	4401-1218				12.8	20
09601310*	09601040	0.810	125	4401-0219	0.400	125	4401-1219				14.5	25
10601500*	09601310*	0.700	144	4401-0220	0.350	144	4401-1220	2 x 16.6		2 x 1668-8163	10.9	20
10601780*	10601500*	0.600	168	4401-0221	0.300	168	4401-1221				11.6	20
	10601780*	0.530	192	4401-0421	0.260	192	4401-1222				12.4	20
11602100	11602100	0.441	230	4401-0297	0.221	230	4401-0306	2 x 46.2**		2 x 1668-8464	28	40
11602380		0.441	230	4401-0297								40
	11602380	0.361	281	4401-0298	0.181	281	4401-0307	3 x 46.2**		3 x 1668-8464		40
11602630		0.441	230	4401-0297	0.221	230	4401-0306	2 x 46.2**		2 x 1668-8464		40
	11602630	0.361	281	4401-0298	0.181	281	4401-0307	3 x 46.2**		3 x 1668-8464		40

* Modify *Rated Current* (05.007) to match current rating of inductor.

CAUTION

The 3-phase switching frequency filter (SFF) capacitors are situated on the input of the Regen system. If the harmonic distortion of the supply is high for extended periods then this can cause a reduction of the service life of the capacitors. The effect of this is to reduce the capacitance value. If high levels of harmonic distortion are expected then it is recommended that the capacitance values be checked periodically, and capacitors which have fallen outside of their tolerance range be replaced.

NOTE

SFF capacitor current is the total rms line current per can, calculated the respective rated voltage +10 % 60 Hz, maximum capacitor tolerance (+10 %), and 3 kHz switching frequency.

** Delta connection.

NOTE

* SFF circuit protection is provided by the main Regen system supply fuses, providing the conditions outlined in section 11.1 *Switching frequency filter (SFF) protection* on page 308 are met.

3.9.7 Varistors

AC line voltage transients can typically be caused by the switching of large items of plant or by lightning strikes on another part of the supply system. If these transients are not suppressed they can cause damage to the insulation of the Regen input inductors, or to the Regen drive electronics.

The varistors shown in the table below are available from the supplier of the drive and should therefore be fitted as shown in section 4.2 *Power connections* on page 40.

Table 3-22 Varistor data

Drive rating	Voltage rating V_{RMS}	Energy rating J	Quantity per system	Configuration	Part number
200 V (200 V to 240 V ±10 %)	550	620	3	Line to line	2482-3291
	680	760		Line to ground	2482-3211
400 V (380 V to 480 V ±10 %)	550	620		Line to line	2482-3291
	680	760		Line to ground	2482-3211
500 V (500 V to 575 V ±10 %)	680	760		Line to line	
	1000	1200		Line to ground	2482-3218
690 V (500 V to 690 V ±10 %)	385	550	6	2 in series line to line	2482-3262
	1000	1200	3	Line to ground	2482-3218

Suitable DIN rail mounted surge protectors are also available from CITEL (DS40 series)

3.9.8 External softstart resistor

The Regen drive inrush current can be controlled by an external softstart resistor/ bypass circuit, this configuration can be used with a Regen system consisting of multiple Regen, multiple motoring or single Regen, multiple motoring drives.

For correct sizing of the softstart resistor, refer to section 11.2 *Softstart resistor sizing* on page 308.

CAUTION

Only pulse withstanding resistors should be used for charging the inverter system.

A range of suitable pulse withstanding resistors are available from Metallux (PWR-R).

3.10 Combined Regen input filters (combi filter)

The combi filter is a simplified solution consisting of a combined EMC filter and switching frequency filter, refer to section 4.7.2 *Combined Regen input filters (combi filter)* on page 75 for further information.

CAUTION

Combi filters listed in Table 3-23 below are equipped with an internal thermal switch to prevent the EMC filter inductor from overheating. The thermal switch must be configured to open the main supply contactor in the event of a thermal overload.

CAUTION

Regen inverter output current derating must be applied where necessary based on Regen inductor and combi filter capability. Models affected are denoted with * in Table 3-23 below. Combi filters listed in Table 3-23 are suitable for use in systems with less than 2 % THD_V on the grid.

Table 3-23 Combi filter selection

Model		Schaffner model number	Current rating	Voltage rating	Rated frequency
Heavy duty	Normal duty		A	Vac	Hz
07400660 & 07400770	06400470 & 074000660	FS6085-83-35-2	83	480	50/60
07401000 & 08401340*	07400770 & 07401000	FS6085-125-35-2	125	480	50/60
08401570	08401340	FS6085-168-40-2	168	480	50/60
09402000 & 09402240*	08401570 & 09402000*	FS6085-205-40-2	205	480	50/60
10402700 & 10403200*	09402240 & 10402700*	FS6085-300-99-2	300	480	50/60
	10403200*	FS6085-350-99-2	350	480	50/60
10601780	10601500 & 10601780	FS6085**HV**-200-40-2	200	690	50/60

* Regen inverter output current derating must be applied where necessary based on Regen inductor and combi filter capability.

NOTE

The range of combi filters covered in this section are available from Schaffner, the filters are not stocked by the supplier of the drive.

4 System design

4.1 Introduction

The sizing of a Regen system must take into account the following factors:

1. AC power supply voltage variation
2. Motor rated current, rated voltage and power factor
3. Maximum required power and overload requirements
4. Heavy Duty / Normal Duty Regen drive ratings

In general, when designing a Regen system, equal Regen and motoring drive rated currents will work correctly. However, care must be taken to ensure that under worst case AC supply conditions the Regen drive is able to supply / absorb all the required power including total system losses.

If the Regen drive is unable to supply the full power required by the motoring drive(s), the DC bus voltage will drop, and in severe cases may lose synchronization with the AC power supply and trip. If the Regen drive is unable to regenerate the full power from the motoring drive(s) into the DC bus, then the Regen drive and motoring drive(s) will trip on over-voltage.

4.1.1 Single Regen, single motoring drive

The following calculations can be carried out for either a single Regen drive, motoring drive system or single Regen drive, multiple motoring drive system.

Example
In the case of a 30 A (***Normal Duty***), M600-05400270 operating in Regen mode from a 400 V supply, and a M600-05400270 driving a 400 V rated, 0.85 pf motor:

The rated power of the Regen drive is:

$$\sqrt{3} \times \textbf{Rated current} \times \textbf{Supply voltage}$$

= 1.73 x **30** x **400**
= 20.8 kW

The motoring drive can supply power:

$$\sqrt{3} \times \textbf{Rated current} \times \textbf{Motor voltage} \times \textbf{Power factor}$$

= 1.73 x **30** x **400** x **0.85**
= 17.7 kW

Drive losses:

2 x Unidrive M600-05400270 = 648 W

When the motoring drive is supplying rated current to the motor, the Regen drive needs to provide 17.7 kW, plus drive losses = 18.348 kW. The Regen drive can supply 20.8 kW at rated current, which is ample, in this case.

Conversely, in some cases, a Regen drive of the same rating as the motoring drive, may not be able to supply enough power, as the following example shows:

Example
In the case of a 100 A (***Heavy Duty***), M600-07401000 operating in Regen mode, and a M600-07401000 driving a 75 kW, 400 V, 0.95 pf motor:

If the motoring drive is supplying 175 % maximum current, and the Regen drive has its 380 V supply at the lower limits of -10 % (342 Vac), then, with a Regen current limit of 175 %:

The Regen drive maximum available power is:

$$\sqrt{3} \times \textbf{175 \%} \times \textbf{Rated current} \times \textbf{Supply voltage}$$

= 1.73 x **1.75** x **100** x **342**
= 103.5 kW

The motoring drives maximum power is:

$$\sqrt{3} \times \textbf{175 \%} \times \textbf{Rated current} \times \textbf{Motor voltage} \times \textbf{Power factor}$$

= 1.73 x **1.75** x **100** x **400** x **0.95**
= 115 kW

Drive losses

2 x Unidrive M600-07401000 = 2.034 kW

The Regen drive is also required to supply the Regen and motoring drive losses in this example 2.034 kW which brings the total power requirement to 117.034 kW. However, this Regen drive is only capable of supplying approximately 103.5 kW and therefore a drive of a larger rating is required.

4.1.2 Multiple motoring drives

In multi-drive configurations, the Regen drive must be of a sufficient size to supply the net peak power demanded by the combined load of all motoring drives plus the combined losses, including its own losses.

Due to the effects of increased DC bus capacitance, there is a limit to the number of motoring drives that can be supplied from a Regen drive. This is true irrespective of the balance of power between the motoring drives and the Regen drive.

The previous calculations can be used for the sizing of multiple motoring drives also.

4.2 Power connections

The following section covers the power connections required for Unidrive M Regen systems.

- For single Regen, single motoring systems, AC supply connections are made to L1, L2 and L3 drive terminals and the drive's internal soft start circuit is used for power-up.
- The single Regen, multiple motoring and multiple Regen, multiple motoring systems require an external charging circuit due to the extra capacitance from the additional drives. No AC connections are made to the Regen drive's L1, L2 and L3 terminals. The external charging circuit can consist of either the Unidrive M rectifier solution or an external softstart resistor as shown in Figure 4-5, Figure 4-6 and Figure 4-7.
- For the Regen brake resistor replacement system, the motoring drive's internal soft start is used for power-up with no AC connections to L1, L2, L3 on the Regen drive.

For control circuit connections refer to section 6.6 *Control connections* on page 133.

NOTE

If the Regen system is not a standard configuration or changes are required to the following systems and set ups, contact the supplier of the drive.

4.3 Switching frequency filter capacitor wiring configuration to support 8 % THD_V (Total Harmonic Distortion Voltage)

The wiring configuration of SFF capacitors is dependent on the regen drive size. For all drive sizes there is either one or two banks of capacitors, Cap bank A and Cap bank B. For certain drive sizes only Cap bank A is used and for other drive sizes Cap bank A and Cap bank B are used. Cap bank A and Cap bank B can be wired in either a Star or Delta configuration, depending on the drive size. Refer to Table 3-14 to Table 3-17 for further information.

There are 4 configurations of capacitor wiring:

- Cap bank A wired in Star, Cap bank B not fitted
- Cap bank A wired in Delta, Cap bank B not fitted
- Cap bank A and Cap bank B both wired in Star
- Cap bank A and Cap bank B both wired in Delta

Figure 4-1 Example of SFF capacitor bank

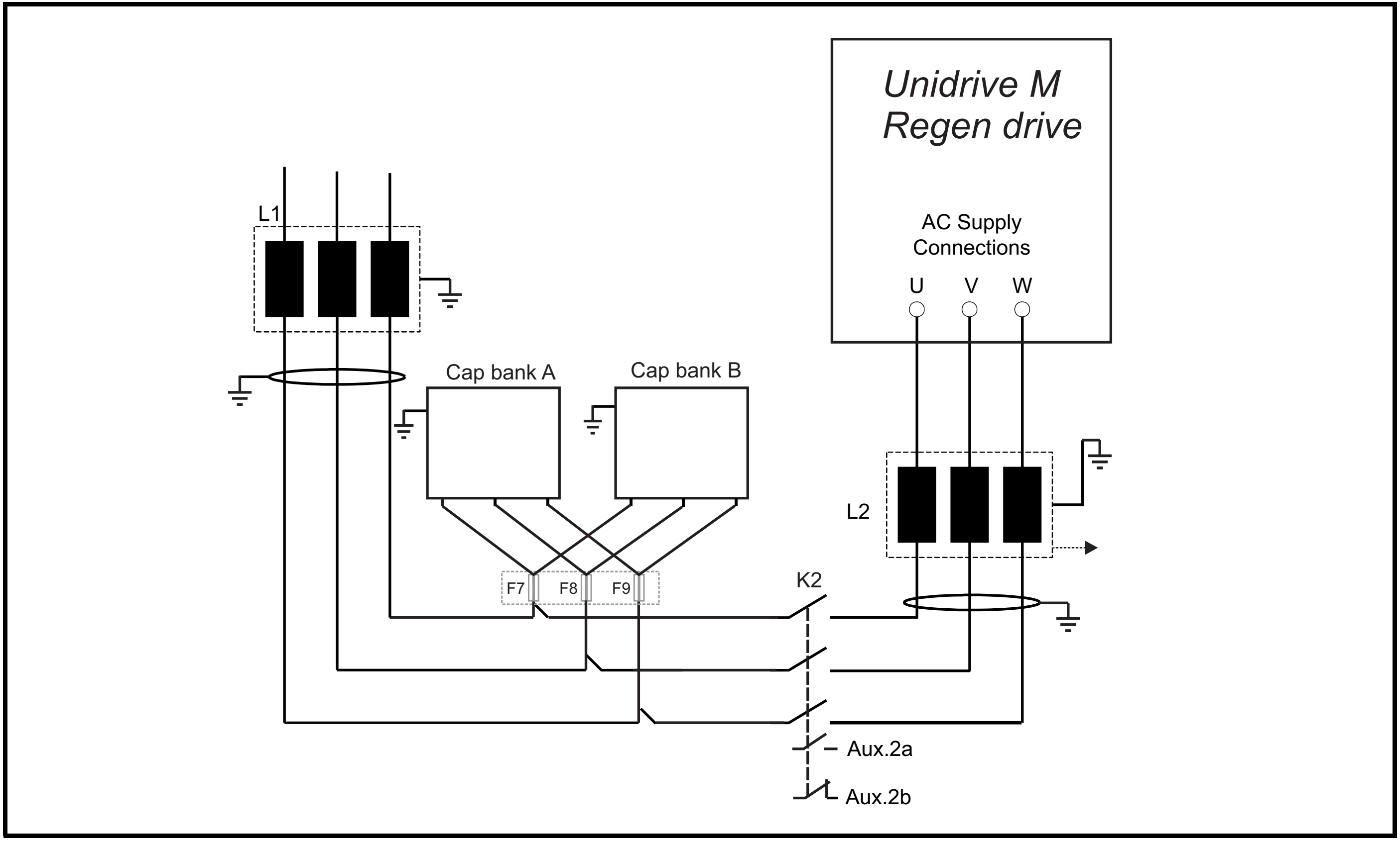


Figure 4-2 Star configuration

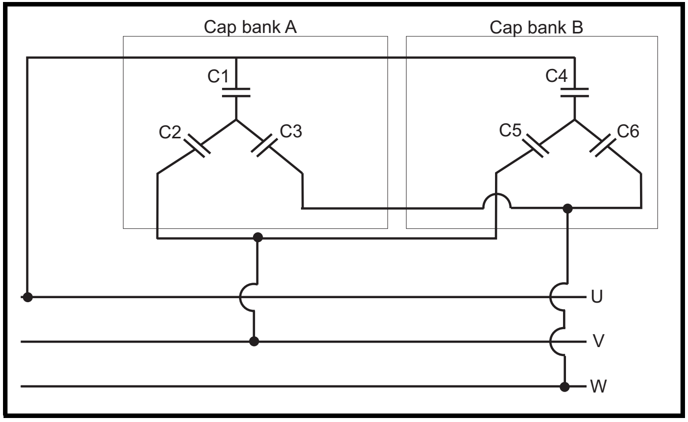
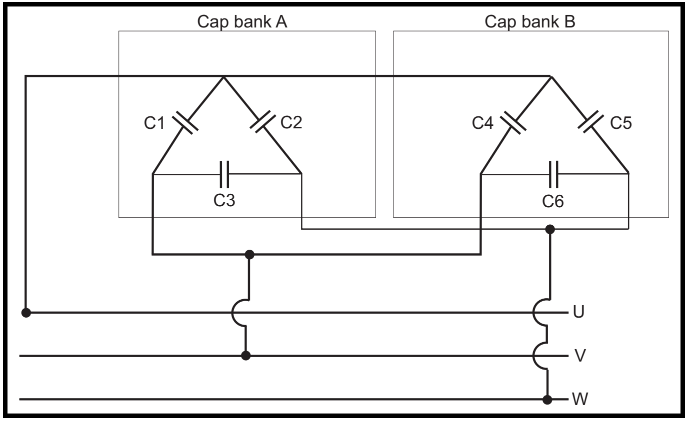


Figure 4-3 Delta configuration



4.3.1 Single Regen, single motoring system to support up to 8 % THD_V

Figure 4-4 Power connections: Single Regen, single motoring system

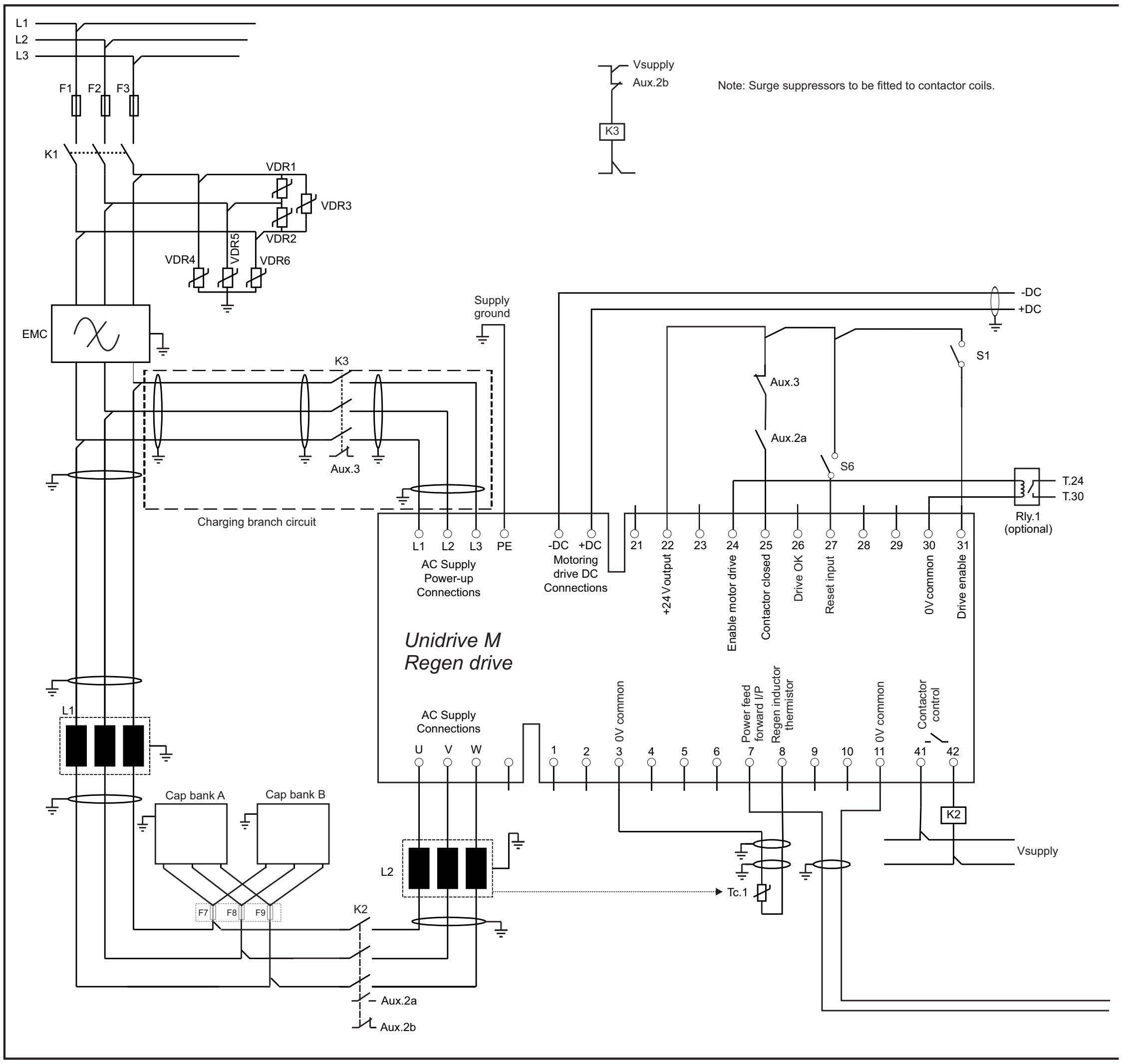


Table 4-1 Key to Figure 4-4

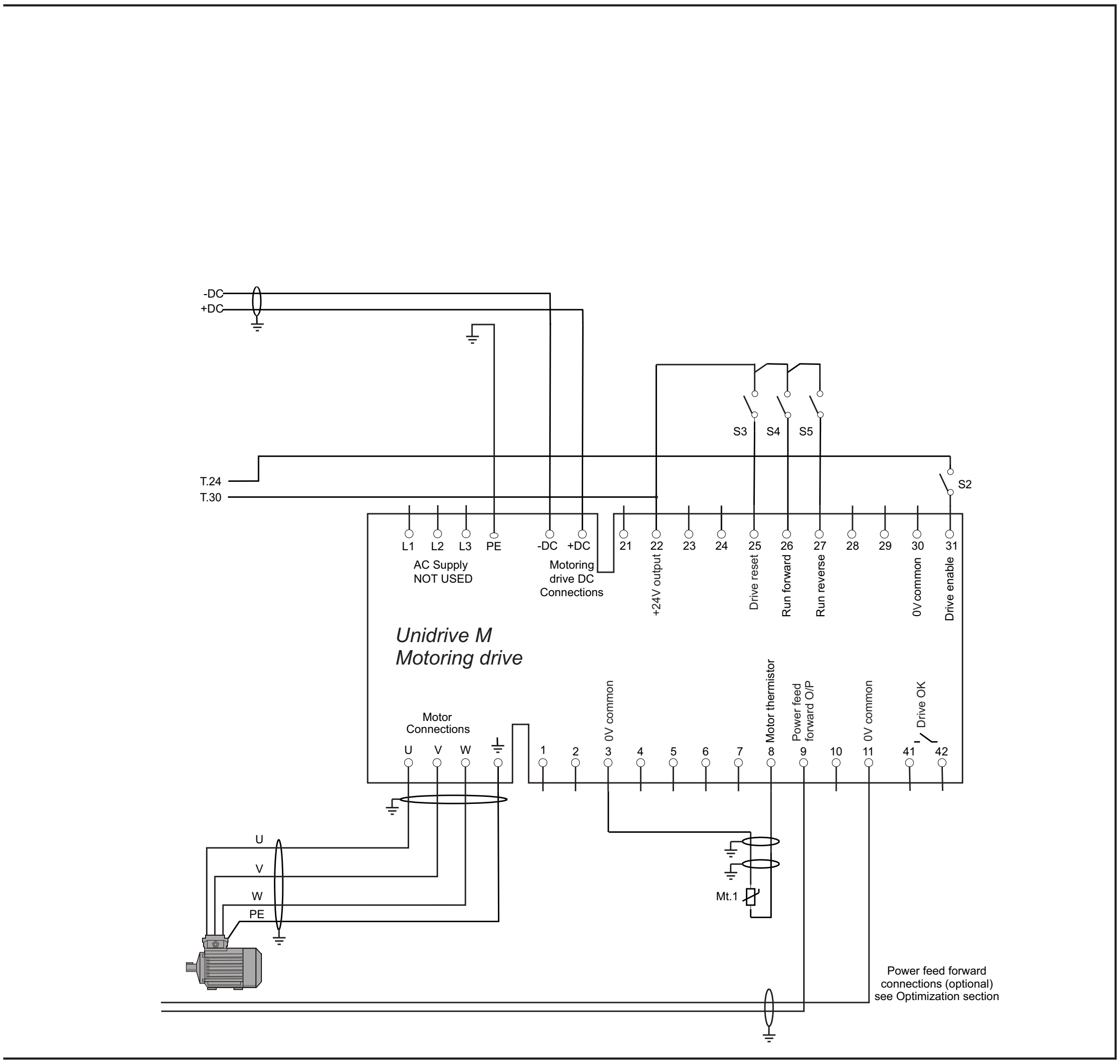
Key	Description
L1, L2, L3	Three phase supply
F1, F2, F3	Main Regen system supply fuses
VDR1, VDR2, VDR3	Varistor network line-to-line
VDR4, VDR5, VDR6	Varistor network line-to-ground
EMC	Optional EMC Filter
CBA	Switching frequency filter capacitor bank A
CBB	Switching frequency filter capacitor bank B
L1	Switching frequency filter inductor
L2	Regen inductor
K1	Main supply switch or contactor
K2	Regen drive main contactor
K3	Charging contactor
Aux.3	K3 NC auxiliary contact
Aux.2a	K2 NO auxiliary contact
Aux.2b	K2 NC auxiliary contact
Rly.1	Optional isolation for enable between Regen and motoring drive
Mt.1	Motor thermistor
Tc.1	Regen inductor thermistor
Vsupply	System control supply
+DC, -DC	Motoring drive power connection to Regen drive
S1	Regen drive enable
S2	Motoring drive enable
S3	Motoring drive reset
S4	Motoring drive run forward
S5	Motoring drive run reverse
S6	Regen drive reset input (Pr **08.024** = Pr **10.033**)
F7, F8, F9	Optional switching frequency filter capacitor fuses

* Unidrive M Frame 11 and all new generation Inductors only.

Figure 4-4 shows both the power and control connections for the standard Regen solution this being a single Regen and single motoring drive system. For this solution the Vac supply is temporarily connected to the Regen drive's L1, L2, L3 inputs for initial power-up only, removing the need for an external charging circuit. The main AC supply to L1, L2, L3 on the Regen drive (K3) is interlocked with the Regen drive's enable preventing operation when the charging circuit is still connected.

WARNING

Regen inductor thermistor must be configured to disable the drive in the event of a thermal overload. The switching frequency filter inductor thermistor must be configured to open the main supply contactor in the event of a thermal overload. This can be achieved through the use of an external thermal protection device/relay.



NOTE

If K2 is installed in the position shown in Figure 4-4 then discharge resistors should be installed to the SFF Cap Bank A and where installed, Cap Bank B. If K2 is installed on the supply side of Cap Bank A and Cap Bank B then a discharge resistor is not required. Refer to Table 10-35 *Discharge resistor details for SFF capacitors to support 8 % THDv* on page 300.

NOTE

Where varistors other than those listed in Table 3-22 are fitted branch circuit protection may be required, where this is the case, follow the manufacturers recommendations.

NOTE

VDR1, VDR2 and VDR3 when operating with a 690 Vac supply should consist of two varistors each in series as detailed in Table 3-22 on page 38.

NOTE

To prevent inductive voltage spikes surge suppressors should be fitted to the contactor coils.

NOTE

The Regen inductor core losses are directly dependent on the switching frequency and specific core material and therefore selection is critical. As a result only Regen inductors specified in this guide should be used.

NOTE

SFF branch circuit protection may be required, refer to section 3.9.3 *Switching frequency filter capacitor* on page 30.

NOTE

Ensure that cables from both capacitor banks to the fuses, where fitted, are of a similar length.

4.3.2 Single Regen, multiple motoring system using a Unidrive M Rectifier to support up to 8 % THD$_V$

Figure 4-5 Power connections: Single Regen, multiple motoring system

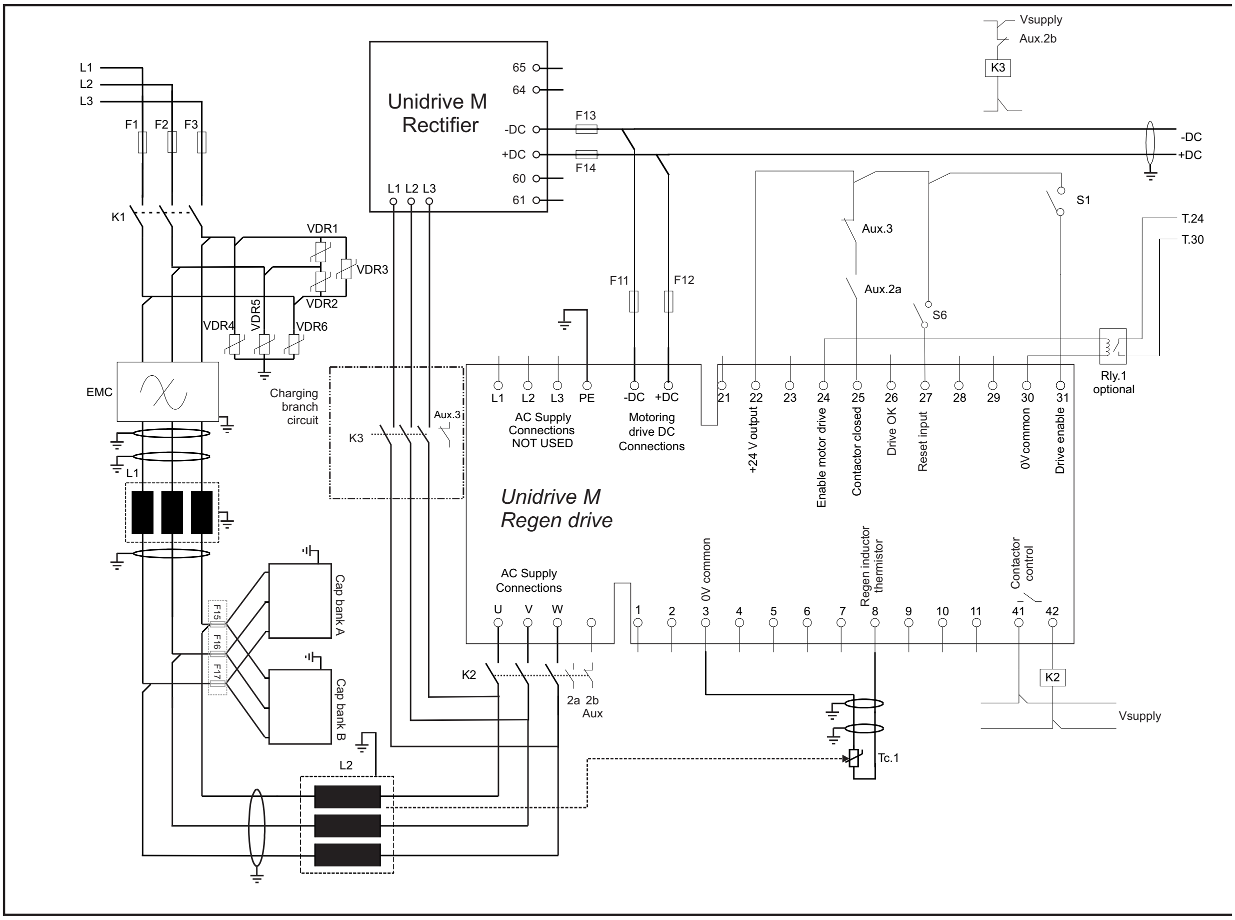


Table 4-2 Key to Figure 4-5

Key	Description
L1, L2, L3	Three phase supply
F1, F2, F3	Main Regen system supply fuses
VDR1, VDR2, VDR3	Varistor network line-to-line
VDR4, VDR5, VDR6	Varistor network line-to-ground
F7, F8, F9, F10	DC bus fusing to motoring drive
F11, F12	DC bus fusing to Regen drive
F13, F14	Rectifier DC fuse protection
EMC	Optional EMC filter
CBA	Switching frequency filter capacitor bank A
CBB	Switching frequency filter capacitor bank B
L1	Switching frequency filter inductor
L2	Regen inductor
K1	Main supply contactor
K2	Regen drive main contactor
K3	Charging contactor
Aux.2a	K2 NO auxiliary contact
Aux.2b	K2 NC auxiliary contact
Aux.3	K3 NC auxiliary contact
Rly.1	Optional isolation for enable between Regen and motoring drive(s)
Mt.1	Motor thermistor 1
Mt.2	Motor thermistor 2
Tc.1	Regen inductor thermistor
+DC, -DC	Motoring drive power connection to Regen drive
S1	Regen drive enable
S2	Motoring drive enable
S3	Motoring drive reset
S4	Motoring drive run forward
S5	Motoring drive run reverse
S6	Regen drive reset input (Pr **08.024** = Pr **10.033**)
Vsupply	System control supply
F15, F16, F17	Optional switching frequency filter capacitor fuses

* Unidrive M Frame 11 and all new generation Inductors only.

Figure 4-5 shows both the power and control connections for the multiple motoring Regen solution. For the multiple motoring system an external charging circuit is required due to the additional capacitance from the multiple motoring drives. The external charging circuit is interlocked with the Regen drive enable to prevent operation with this circuit still connected. In this example, the external charging circuit consists of a Unidrive M Rectifier module. Refer to section 3.5 *Unidrive M Rectifier* on page 23 for further details of the Unidrive M Rectifier.

NOTE

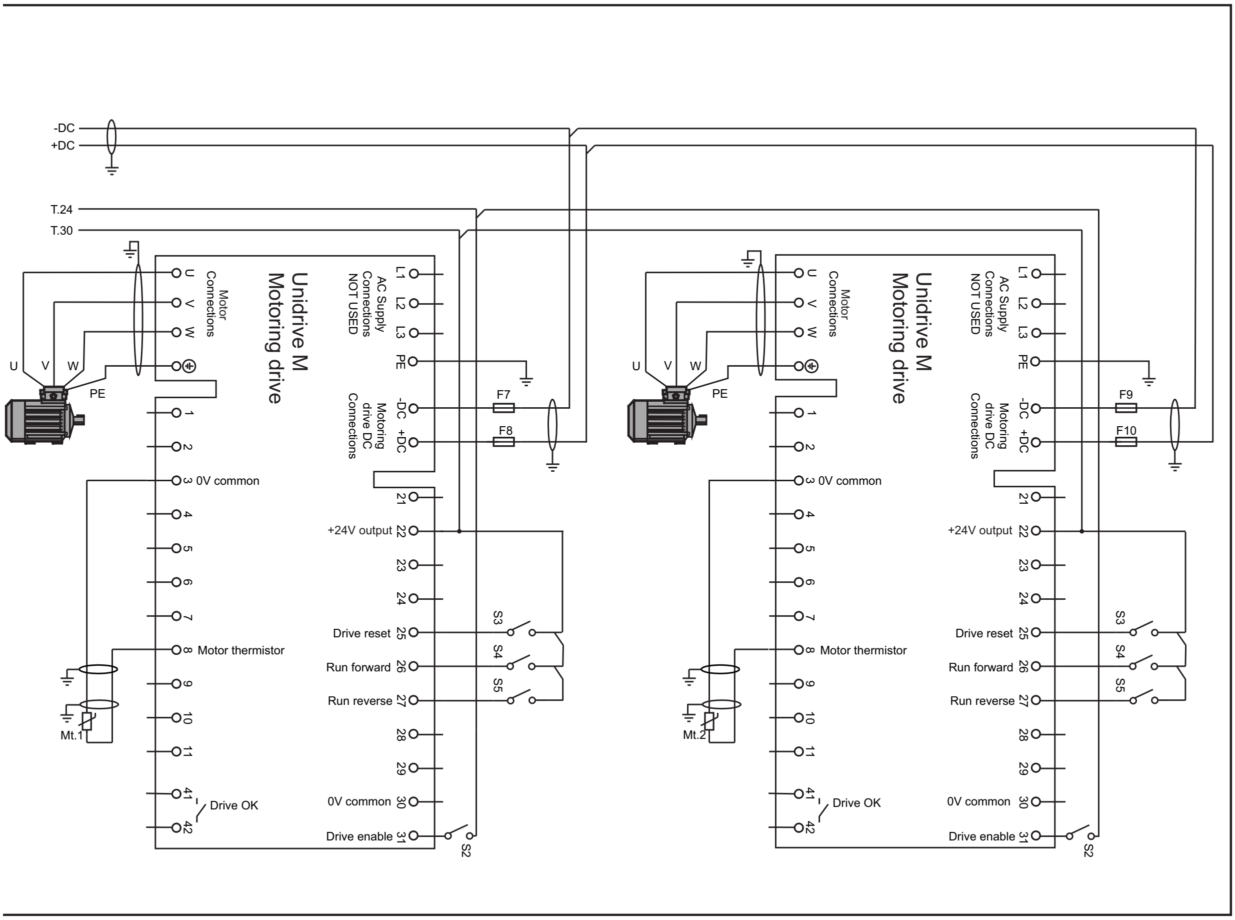
For the multiple motoring drive solution, the Regen drive and associated Unidrive M Rectifier must be sized to the total power requirements of all motoring drives.

WARNING

Regen inductor thermistor must be configured to disable the drive in the event of a thermal overload. The switching frequency filter inductor thermistor must be configured to open the main supply contactor in the event of a thermal overload. This can be achieved through the use of an external thermal protection device/relay.

NOTE

The rectifier uses the Regen inductor as line reactors. The rectifier may be powered from the incoming supply using a standard line reactor if required.



NOTE

Ensure that cables from both capacitor banks to the fuses, where fitted, are of a similar length.

NOTE

Where varistors other than those listed in Table 3-22 are fitted branch circuit protection may be required, where this is the case, follow the manufacturers recommendations.

NOTE

DC bus fusing is required for all motoring drives in a single Regen, multiple drive system in both the +DC and -DC.

NOTE

VDR1, VDR2 and VDR3 when operating with a 690 Vac supply should consist of two varistors each in series as detailed in Table 3-22 on page 38.

NOTE

To prevent inductive voltage spikes surge suppressors should be fitted to the contactor coils.

NOTE

The Regen inductor core losses are directly dependant on the switching frequency and specific core material and therefore selection is critical. As a result only Regen inductors specified in this guide should be used.

NOTE

SFF branch circuit protection may be required, refer to section 3.9.3 *Switching frequency filter capacitor* on page 30.

NOTE

If K2 is installed in the position shown in Figure 4-5 then discharge resistors should be installed to the SFF Cap Bank A and where installed, Cap Bank B. If K2 is installed on the supply side of Cap Bank A and Cap Bank B then a discharge resistor is not required. Refer to Table 10-35 *Discharge resistor details for SFF capacitors to support 8 % THDv* on page 300.
See Chapter 10 *Technical data* on page 276 for fuse rating information.

Unidrive M Rectifier

For a Regen system, the rectifier can be used to charge the common DC bus when the power is first applied, however this will once the Regen system is powered up no longer be required.

The total amount of capacitance on the common DC bus that the rectifier can drive is limited due to the inrush current (produced during power up and during brownouts). See Table 3-9 on page 26 for the capacitance limit. Unidrive M drive DC bus capacitance levels are available in Table 11-1 on page 308.

4.3.3 Single Regen, multiple motoring system using an external softstart resistor to support up to 8 % THD_V

Figure 4-6 Power connections: Single Regen, multiple motoring system

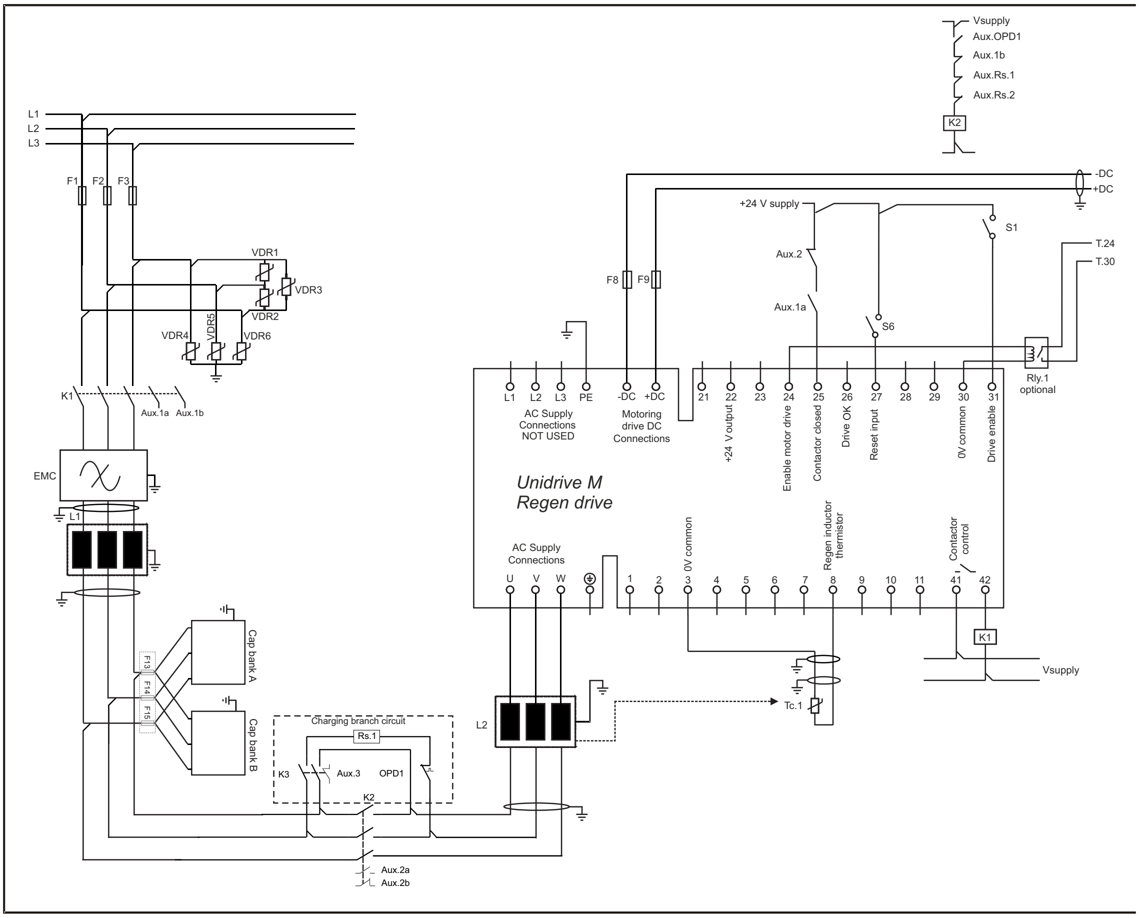


Table 4-3 Key to Figure 4-6

Key	Description
L1, L2, L3	Three phase supply
F1, F2, F3	Main Regen system supply fuses
VDR1, VDR2, VDR3	Varistor network line-to-line
VDR4, VDR5, VDR6	Varistor network line-to-ground
F4, F5, F6, F7	DC bus fusing to motoring drive
F8, F9	DC bus fusing to Regen drive
EMC	Optional EMC filter
CBA	Switching frequency filter capacitor bank A
CBB	Switching frequency filter capacitor bank B
L1	Switching frequency filter inductor
L2	Regen inductor
K1	Main supply contactor
K2	Pre-charge contactor
OPD1	Overload protection device for Rs.1
Aux.1a	K1 NO auxiliary contact
Aux.2	K2 NO auxiliary contact
Aux.1b	K1 NC auxiliary contact
Aux.OPD1	OPD1 NO auxiliary contact
Rly.1	Optional isolation for enable between Regen and motoring drive(s)
Mt.1	Motor thermistor 1
Mt.2	Motor thermistor 2
Tc.1	Regen inductor thermistor
Rs.1	Softstart resistor 1
+DC, -DC	Motoring drive power connection to Regen drive
S1	Regen drive enable
S2	Motoring drive enable
S3	Motoring drive reset
S4	Motoring drive run forward
S5	Motoring drive run reverse
S6	Regen drive reset input (Pr **08.024** = Pr **10.033**)
K3	Charging contactor
Aux.3	SFF capacitor auxiliary contact
Vsupply	System control supply
F13, F14, F15	Optional switching frequency filter capacitor fuses

* Unidrive M Frame 11 and all new generation Inductors only.

Figure 4-6 shows both the power and control connections for the multiple motoring Regen solution. For this multiple motoring system solution an external charging circuit is required due to the additional capacitance from the multiple motoring drives. The external charging circuit is interlocked with the Regen drive enable to prevent operation with this circuit still connected. For sizing of the external charging circuit required for the multiple motoring drive system, refer to Chapter 11 *Component sizing* on page 308. For details on softstart resistors and protection refer to section 10.4.5 *Switching frequency filter capacitors* on page 299.

NOTE

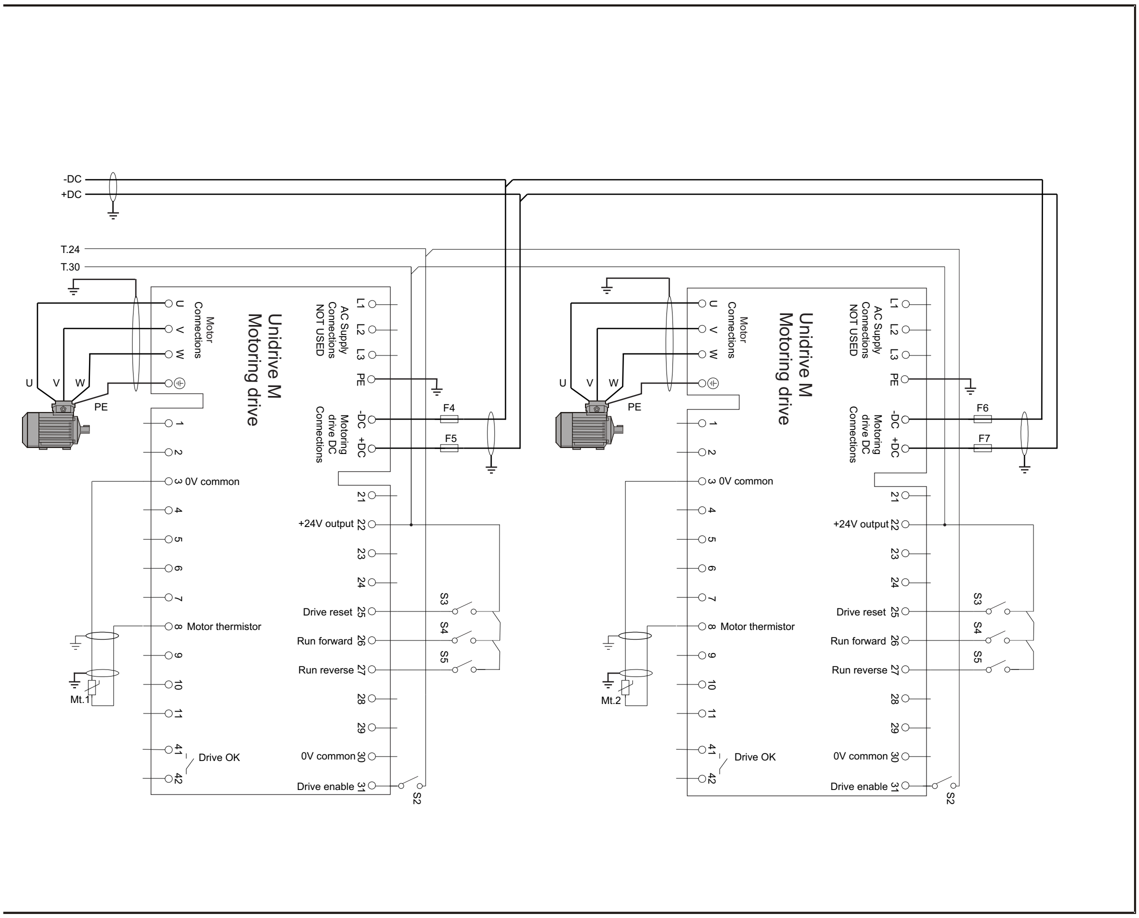
For the multiple motoring drive solution, the Regen drive and associated external components must be sized to the total power requirements of all motoring drives.

NOTE

The Regen inductor core losses are directly dependant on the switching frequency and specific core material and therefore selection is critical. As a result only Regen inductors specified in this guide should be used.

WARNING

Regen inductor thermistor must be configured to disable the drive in the event of a thermal overload. The switching frequency filter inductor thermistor must be configured to open the main supply contactor in the event of a thermal overload. This can be achieved through the use of an external thermal protection device/relay.



NOTE

Where varistors other than those listed in Table 3-22 are fitted branch circuit protection may be required, where this is the case, follow the manufacturers recommendations.

NOTE

DC bus fusing is required for all motoring drives in a single Regen, multiple motoring drive system in both the +DC and -DC.

NOTE

VDR1, VDR2 and VDR3 when operating with a 690 Vac supply should consist of two varistors each in series as detailed in Table 3-22 on page 38.

NOTE

To prevent inductive voltage spikes surge suppressors should be fitted to the contactor coils.

See Chapter 10 *Technical data* on page 276 for fuse rating information.

NOTE

SFF branch circuit protection may be required, refer to section 3.9.3 *Switching frequency filter capacitor* on page 30.

NOTE

Ensure that cables from both capacitor banks to the fuses, where fitted, are of a similar length.

4.3.4 Multiple Regen, multiple motoring using Unidrive M Rectifier to support up to 8 % THD$_V$

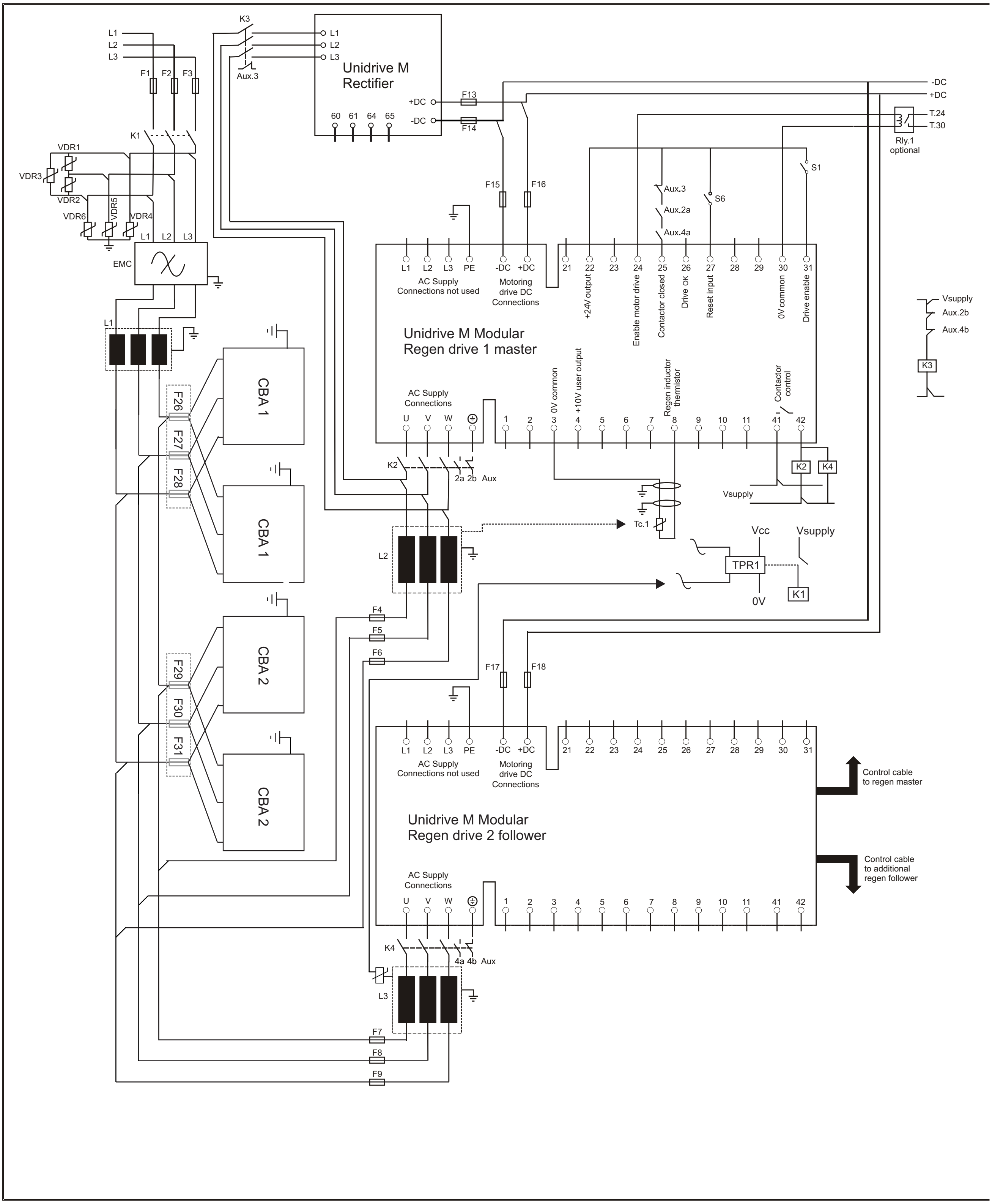


Figure 4-7 Power connections: Multiple Regen, multiple motoring system

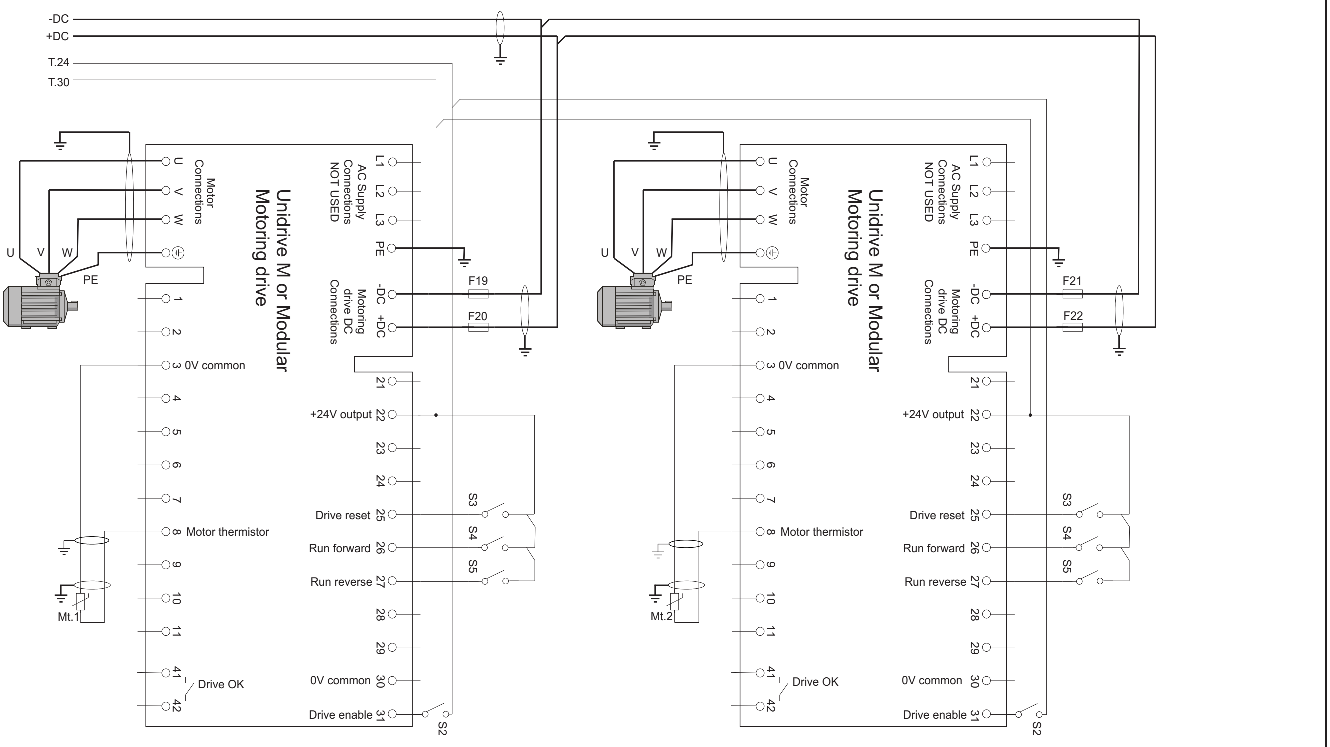


Table 4-4 Key to Figure 4-7

Key	Description
L1, L2, L3	Three phase supply
F1, F2, F3	Main Regen system supply AC fuses
F4, F5, F6	Regen drive 1 AC fuses
F7, F8, F9	Regen drive 2 AC fuses
F13, F14	DC Bus fusing to rectifier
F15, F16, F17, F18	DC Bus fusing to Regen drives
F19, F20, F21, F22	DC Bus fusing to motoring drive
VDR1, 2, 3	Varistor network line-to-line
VDR4, 5, 6	Varistor network line-to-ground
EMC	Optional EMC filter
L1	Switching frequency filter inductor
L2	Regen inductor (Regen 1)
L3	Regen inductor (Regen 2)
CBA 1	Switching frequency filter capacitor bank A (Regen 1)
CBB 1	Switching frequency filter capacitor bank B (Regen 1)
CBA 2	Switching frequency filter capacitor bank A (Regen 2)
CBB 2	Switching frequency filter capacitor bank B (Regen 2)
K1	Main supply contactor
K2	Regen drive 1 main contactor
K3	Charging contactor
K4	Regen drive 2 main contactor
Aux.2	OPD2 NO auxiliary contact
Aux.2a	K2 NO auxiliary contact Regen 1
Aux.2b	K2 NC auxiliary contact Regen 1
Aux.2c	K2 NC auxiliary contact Regen 1
Aux.3	K3 NC auxiliary contact
Aux.4a	K4 NO auxiliary contact Regen 2
Aux.4b	K4 NC auxiliary contact Regen 2
Aux.4c	K4 NC auxiliary contact Regen 2
Rly.1	Optional isolation for enable between Regen and motoring drive(s)
Mt.1	Motor thermistor 1
Mt.2	Motor thermistor 2
Tc.1	Regen inductor thermistor
+DC, -DC	Motoring drive power connection to Regen drive
S1	Regen drive enable
S2	Motoring drive enable
S3	Motoring drive reset
S4	Motoring drive run forward
S5	Motoring drive run reverse
S6	Regen drive reset (user programmed)
TPR1	Thermal protection relay
Vsupply	System control supply
F26, F27, F28, F29, F30, F31	Optional switching frequency filter capacitor fuses

* Unidrive M Frame 11 and all new generation inductors only.

WARNING

Regen inductor thermistor must be configured to disable the drive in the event of a thermal overload. The switching frequency filter inductor thermistor must be configured to open the main supply contactor in the event of a thermal overload. This can be achieved through the use of an external thermal protection device/relay.

NOTE

Where varistors other than those listed in Table 3-22 are fitted branch circuit protection may be required, where this is the case, follow the manufacturers recommendations.

NOTE

For the multiple motoring drive solution, the Regen drive and associated external components must be sized to the total power requirements of all motoring drives.

NOTE

The Regen inductor core losses are directly dependant on the switching frequency and specific core material and therefore selection is critical. As a result only Regen inductors specified in this guide should be used.

NOTE

VDR1, VDR2 and VDR3 when operating with a 690 Vac supply should consist of two varistors each in series as detailed in Table 3-22 on page 38.

NOTE

To prevent inductive voltage spikes surge suppressors should be fitted to the contactor coils.

NOTE

Multiple switching frequency filter inductors and EMC filters are permissible.

NOTE

SFF branch circuit protection may be required, refer to section 3.9.3 *Switching frequency filter capacitor* on page 30.

NOTE

If K2 is installed in the position shown in Figure 4-7 then discharge resistors should be installed to the SFF Cap Bank A and where installed, Cap Bank B. If K2 is installed on the supply side of Cap Bank A and Cap Bank B then a discharge resistor is not required. Refer to Table 10-35 *Discharge resistor details for SFF capacitors to support 8 % THDv* on page 300.

NOTE

Ensure that cables from both capacitor banks to the fuses, where fitted, are of a similar length.

4.3.5 Brake resistor replacement to support up to 8 % THD_V

Figure 4-8 Power connections: Regen drive as a brake resistor replacement

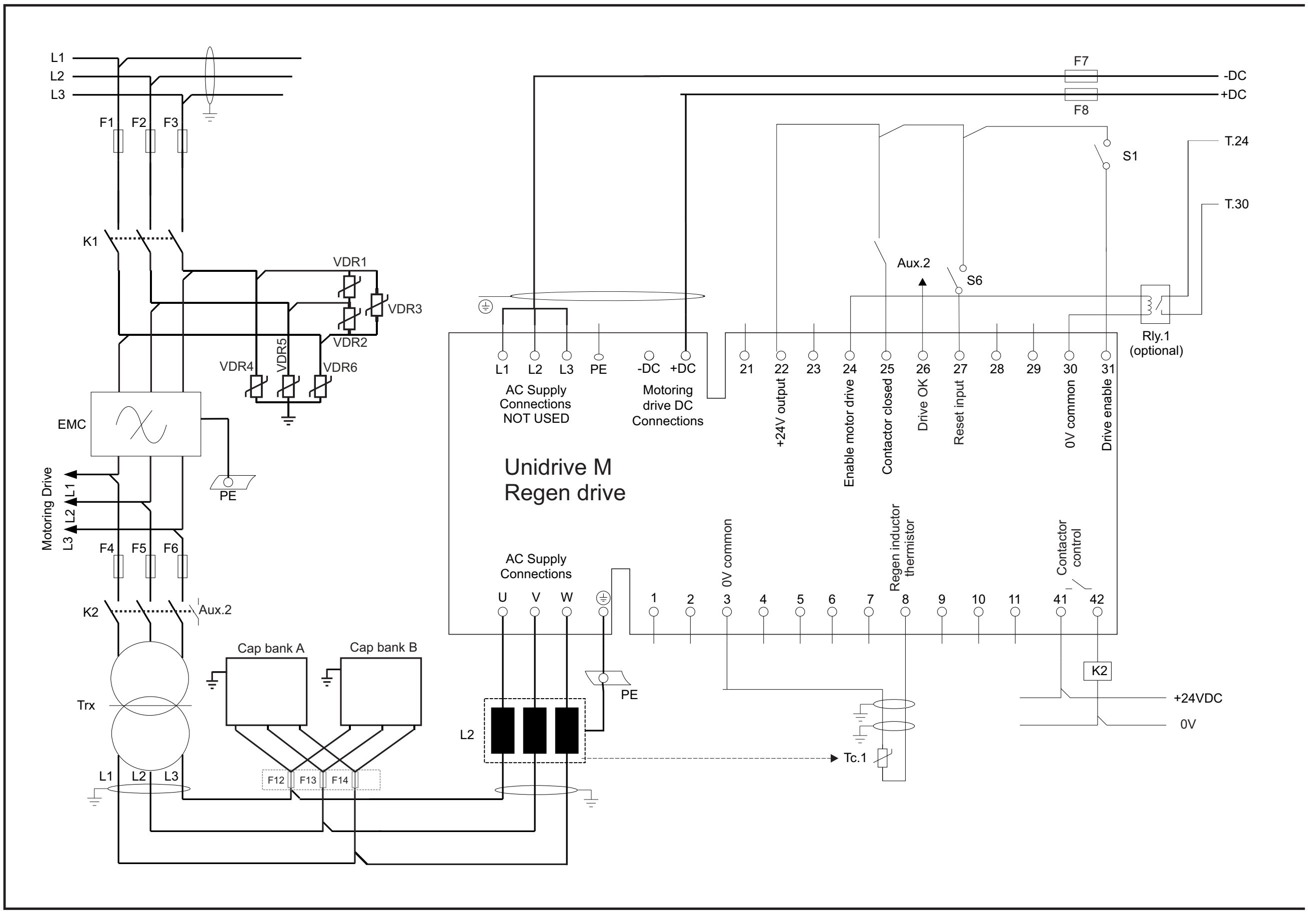
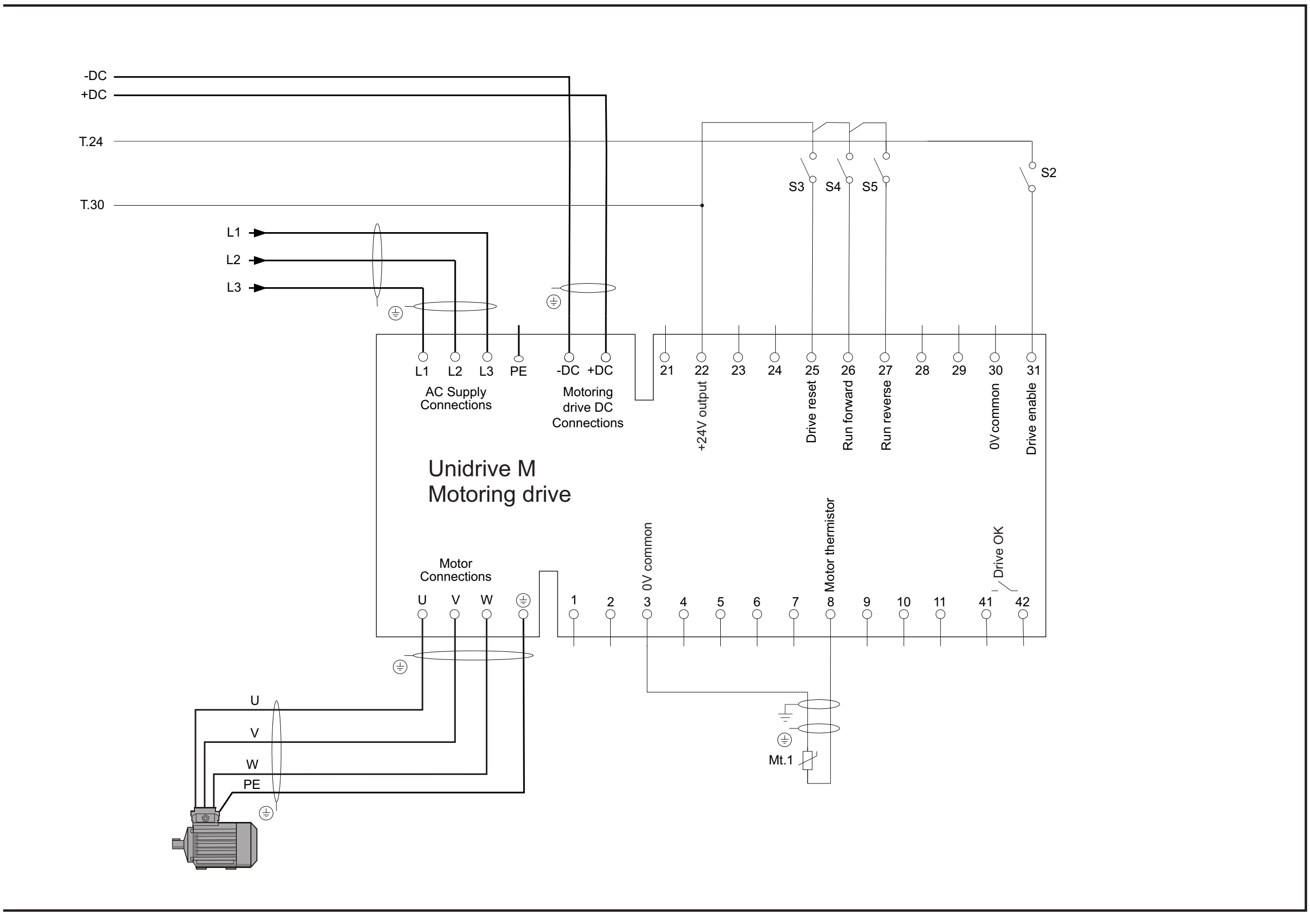


Table 4-5 Key to Figure 4-8

Key	Description
L1, L2, L3	Three phase supply
F1, F2, F3	Main Regen system supply fuses
F4, F5, F6	Regen drive fusing
F7, F8	DC Fusing (see Note)
VDR1, VDR2, VDR3	Varistor network line-to-line 550Vac
VDR4, VDR5, VDR6	Varistor network line-to-ground 680Vac
EMC	EMC Filter
CBA	Switching frequency filter capacitor bank A
CBB	Switching frequency filter capacitor bank B
L2	Regen inductor
K1	Main supply switch or contactor
K2	Regen drive main contactor
Trx	Isolating transformer
Aux.2	Regen drive main contactor auxiliary
Rly.1	Optional isolation for enable between Regen and motoring drive(s)
Mt.1	Motor thermistor
Tc.1	Regen inductor thermistor
+DC, -DC	Motoring drive power connection to Regen drive
S1	Regen drive enable
S2	Motoring drive enable
S3	Motoring drive reset
S4	Motoring drive run forward
S5	Motoring drive run reverse
S6	Regen drive reset input (Pr **08.024** = Pr **10.033**)
F12, F13, F14	Optional switching frequency filter capacitor fuses



In many applications, the motoring power can be significantly higher than the braking power. If sinusoidal input currents are not required, it is difficult to justify the cost of a Regen drive rated at the full motoring power. In these applications it may be desirable to take the lower cost option of a smaller Regen drive which is only used to return the braking energy to the AC supply. When a Regen drive is used as a dynamic brake resistor replacement, connections must be made as shown in Figure 4-8.

NOTE

Where varistors other than those listed in Table 3-22 are fitted branch circuit protection may be required, where this is the case, follow the manufacturers recommendations.

NOTE

DC bus fusing is required where the Regen drive is smaller than the motoring drives. See Chapter 10 *Technical data* on page 276 for fuse rating information.

NOTE

For the multiple motoring drive solution, the Regen drive and associated external components must be sized to the total power requirements of all motoring drives.

NOTE

The Regen inductor core losses are directly dependant on the switching frequency and specific core material and therefore selection is critical. As a result only Regen inductors specified in this guide should be used.

NOTE

To prevent inductive voltage spikes surge suppressors should be fitted to the contactor coils.

NOTE

SFF branch circuit protection may be required, refer to section 3.9.3 *Switching frequency filter capacitor* on page 30.

NOTE

Ensure that cables from both capacitor banks to the fuses, where fitted, are of a similar length.

WARNING

The Isolating transformer, Trx, can be prone to thermal overload. Ensure that thermal overload protection is fitted.

4.4 Switching frequency filter capacitor wiring configuration to support 2 % THD_v

4.4.1 Single Regen, single motoring system to support up to 2 % THD_v

Figure 4-9 Power connections: Single Regen, single motoring system

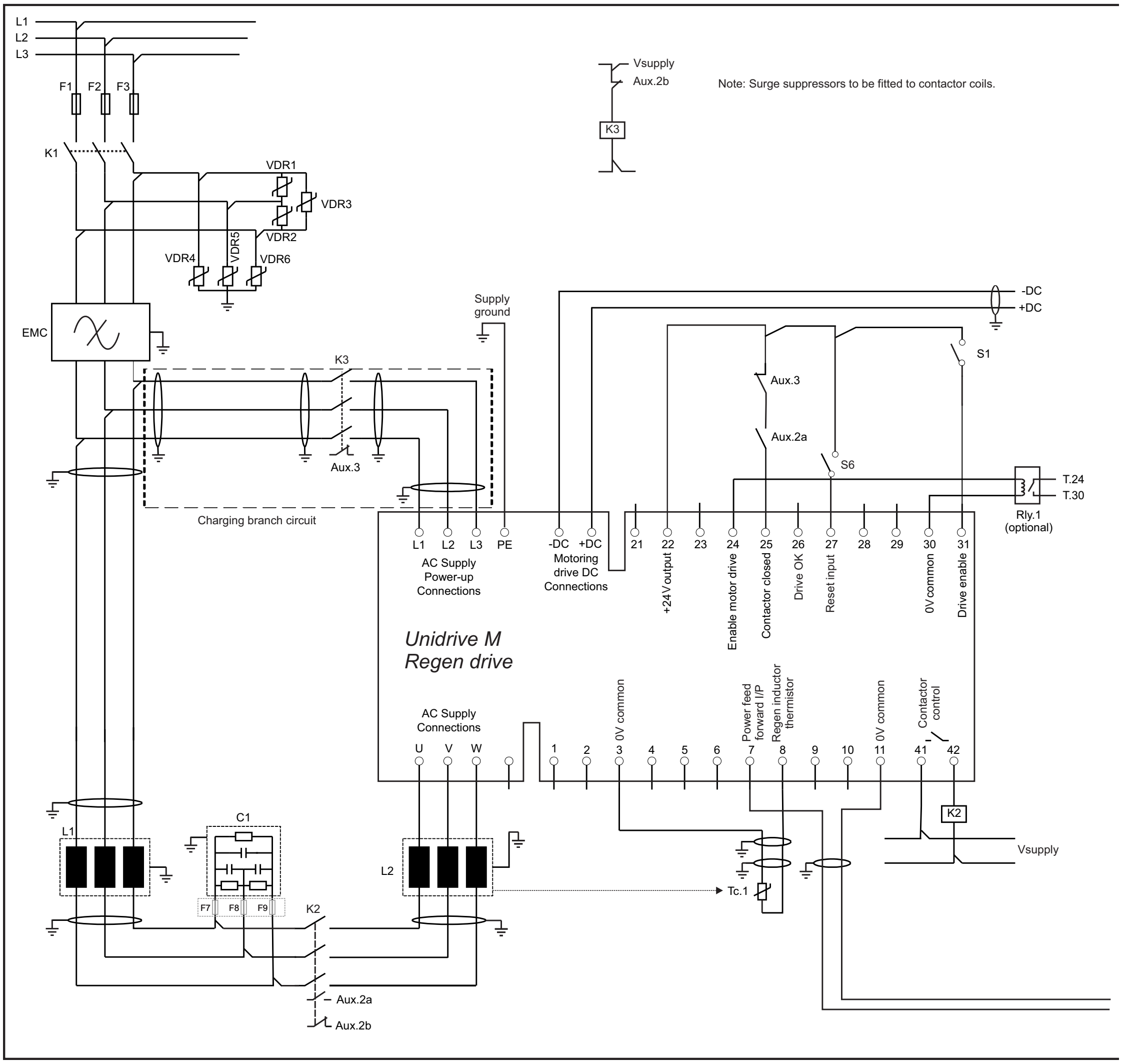


Table 4-6 Key to Figure 4-9

Key	Description
L1, L2, L3	Three phase supply
F1, F2, F3	Main Regen system supply fuses
VDR1, VDR2, VDR3	Varistor network line-to-line
VDR4, VDR5, VDR6	Varistor network line-to-ground
EMC	Optional EMC Filter
C1	Switching frequency filter capacitor
L1	Switching frequency filter inductor
L2	Regen inductor
K1	Main supply switch or contactor
K2	Regen drive main contactor
K3	Charging contactor
Aux.3	K3 NC auxiliary contact
Aux.2a	K2 NO auxiliary contact
Aux.2b	K2 NC auxiliary contact
Rly.1	Optional isolation for enable between Regen and motoring drive
Mt.1	Motor thermistor
Tc.1	Regen inductor thermistor
Vsupply	System control supply
+DC, -DC	Motoring drive power connection to Regen drive
F7, F8, F9	Optional switching frequency filter capacitor fuses
S1	Regen drive enable
S2	Motoring drive enable
S3	Motoring drive reset
S4	Motoring drive run forward
S5	Motoring drive run reverse
S6	Regen drive reset input (Pr **08.024** = Pr **10.033**)

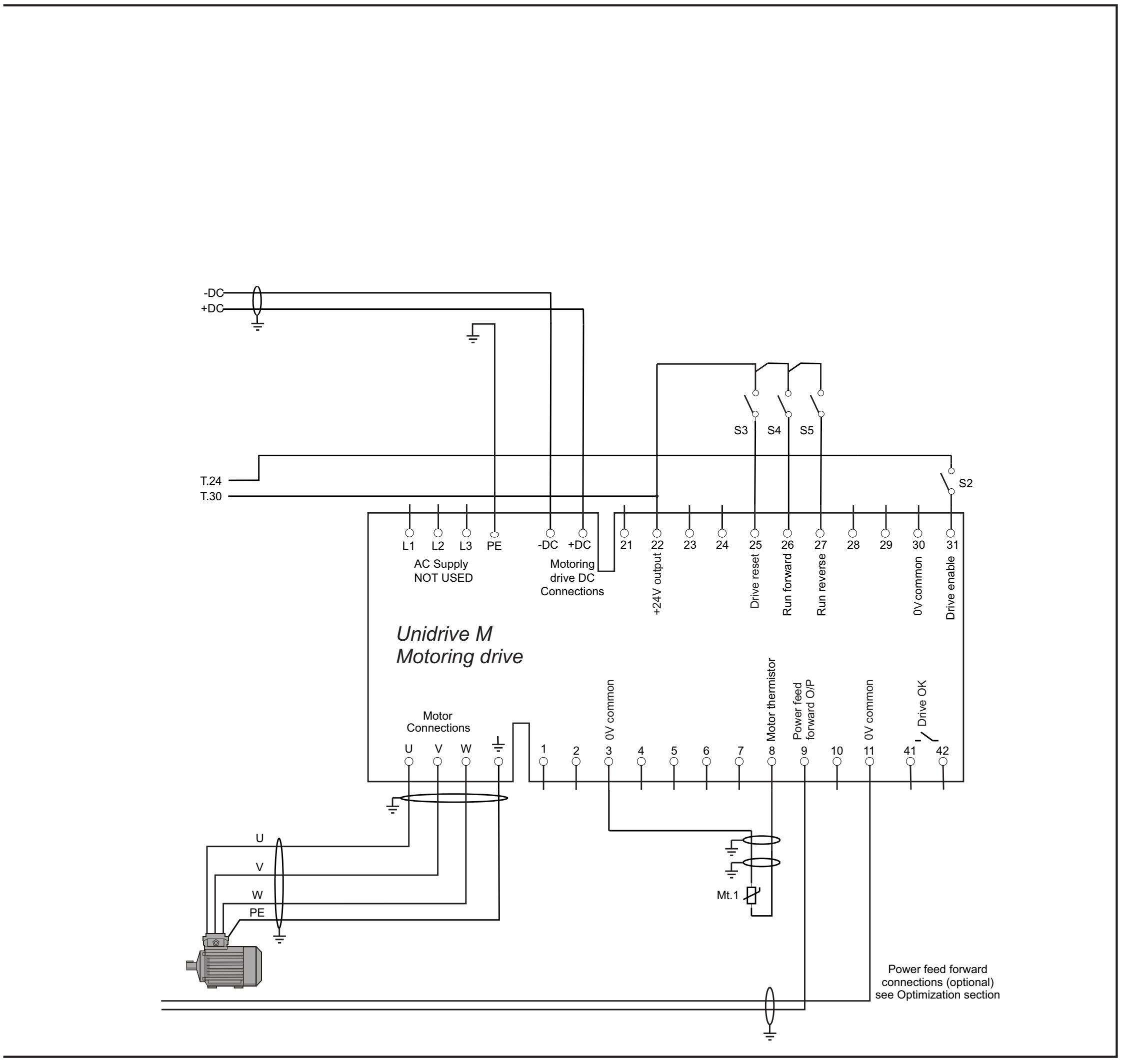
* Unidrive M Frame 11 and all new generation Inductors only.

Figure 4-9 shows both the power and control connections for the standard Regen solution this being a single Regen and single motoring drive system.

For this solution the Vac supply is temporarily connected to the Regen drive's L1, L2, L3 inputs for initial power-up only, removing the need for an external charging circuit. The main AC supply to L1, L2, L3 on the Regen drive (K3) is interlocked with the Regen drive's enable preventing operation when the charging circuit is still connected.

WARNING

Regen inductor thermistor must be configured to disable the drive in the event of a thermal overload. The switching frequency filter inductor thermistor must be configured to open the main supply contactor in the event of a thermal overload. This can be achieved through the use of an external thermal protection device/relay.



NOTE

Where varistors other than those listed in Table 3-22 are fitted branch circuit protection may be required, where this is the case, follow the manufacturers recommendations.

NOTE

VDR1, VDR2 and VDR3 when operating with a 690 Vac supply should consist of two varistors each in series as detailed in Table 3-22 on page 38.

NOTE

To prevent inductive voltage spikes surge suppressors should be fitted to the contactor coils.

NOTE

The Regen inductor core losses are directly dependent on the switching frequency and specific core material and therefore selection is critical. As a result only Regen inductors specified in this guide should be used.

NOTE

SFF branch circuit protection may be required, refer to section 3.9.3 *Switching frequency filter capacitor* on page 30.

4.4.2 Single Regen, multiple motoring system using a Unidrive M Rectifier to support up to 2 % THD$_V$

Figure 4-10 Power connections: Single Regen, multiple motoring system

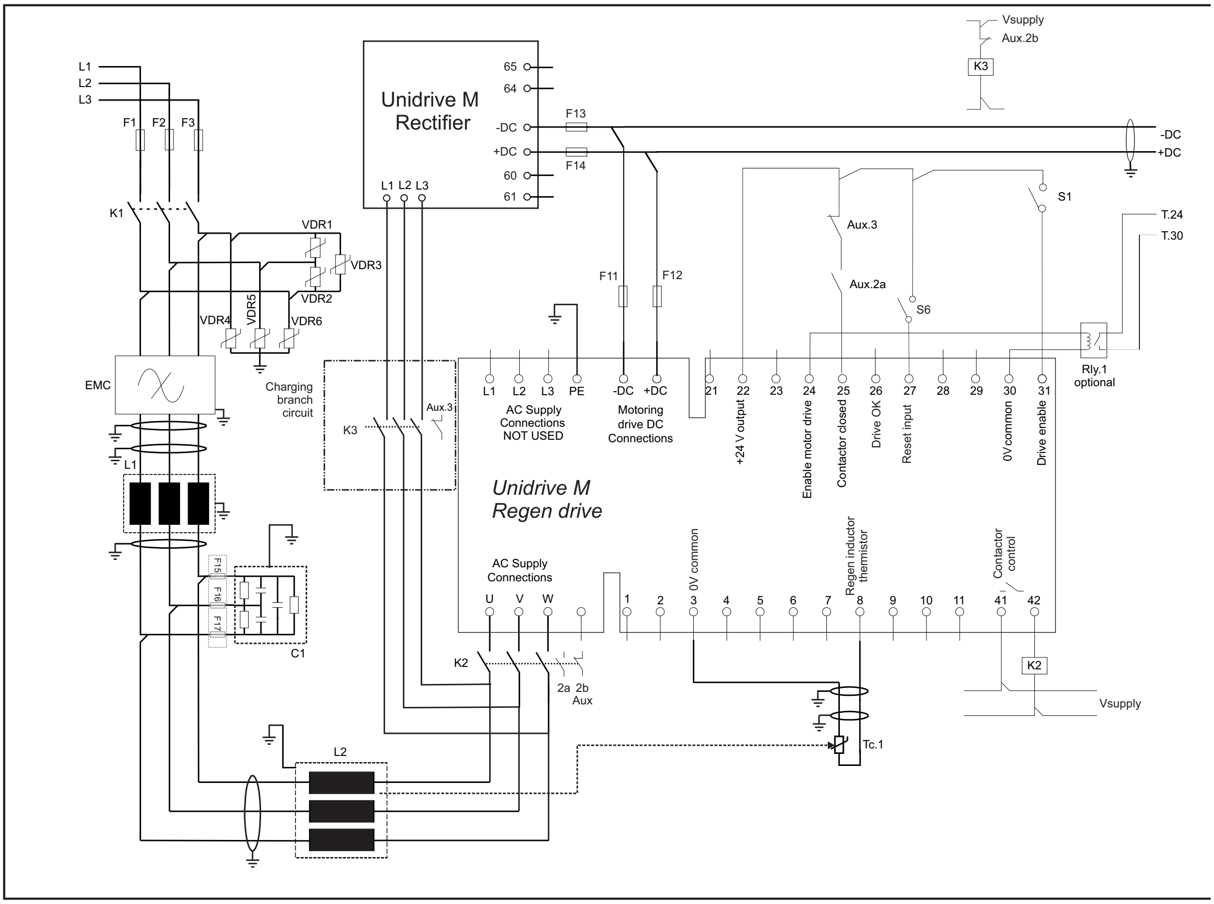


Table 4-7 Key to Figure 4-10

Key	Description
L1, L2, L3	Three phase supply
F1, F2, F3	Main Regen system supply fuses
VDR1, VDR2, VDR3	Varistor network line-to-line
VDR4, VDR5, VDR6	Varistor network line-to-ground
F7, F8, F9, F10	DC bus fusing to motoring drive
F11, F12	DC bus fusing to Regen drive
F13, F14	Rectifier DC fuse protection
EMC	Optional EMC filter
C1	Switching frequency filter capacitor
L1	Switching frequency filter inductor
L2	Regen inductor
K1	Main supply contactor
K2	Regen drive main contactor
K3	Charging contactor
Aux.2a	K2 NO auxiliary contact
Aux.2b	K2 NC auxiliary contact
Aux.3	K3 NC auxiliary contact
Rly.1	Optional isolation for enable between Regen and motoring drive(s)
Mt.1	Motor thermistor 1
Mt.2	Motor thermistor 2
Tc.1	Regen inductor thermistor
+DC, -DC	Motoring drive power connection to Regen drive
S1	Regen drive enable
S2	Motoring drive enable
S3	Motoring drive reset
S4	Motoring drive run forward
S5	Motoring drive run reverse
S6	Regen drive reset input (Pr **08.024** = Pr **10.033**)
Vsupply	System control supply
F15, F16, F17	Optional switching frequency filter capacitor fuses

* Unidrive M Frame 11 and all new generation Inductors only.

Figure 4-10 shows both the power and control connections for the multiple motoring Regen solution. For the multiple motoring system an external charging circuit is required due to the additional capacitance from the multiple motoring drives. The external charging circuit is interlocked with the Regen drive enable to prevent operation with this circuit still connected.

In this example, the external charging circuit consists of a Unidrive M Rectifier module. Refer to section 3.5 *Unidrive M Rectifier* on page 23 for further details of the Unidrive M Rectifier.

NOTE

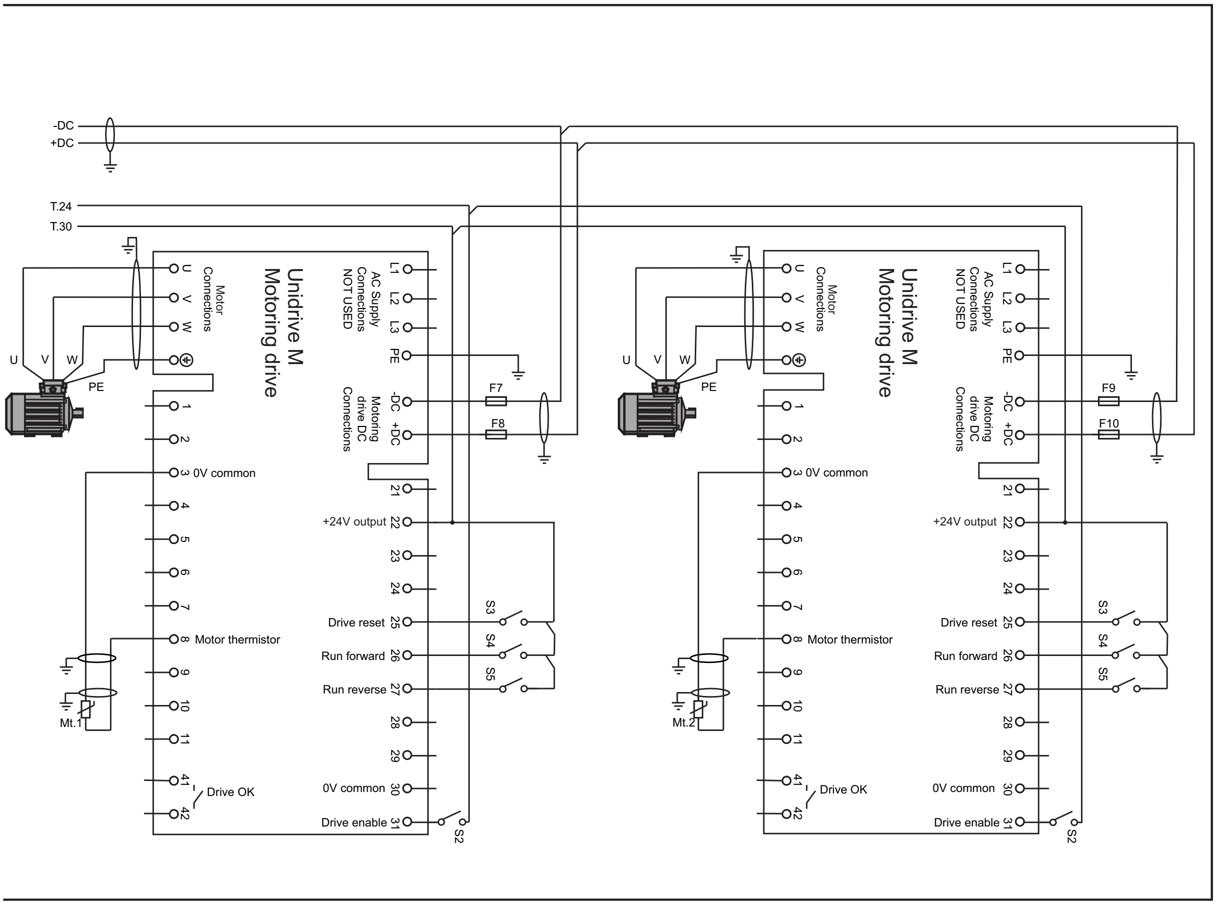
For the multiple motoring drive solution, the Regen drive and associated Unidrive M Rectifier must be sized to the total power requirements of all motoring drives..

WARNING

Regen inductor thermistor must be configured to disable the drive in the event of a thermal overload. The switching frequency filter inductor thermistor must be configured to open the main supply contactor in the event of a thermal overload. This can be achieved through the use of an external thermal protection device/relay.

NOTE

The rectifier uses the Regen inductor as line reactors. The rectifier may be powered from the incoming supply using a standard line reactor if required.



NOTE

Where varistors other than those listed in Table 3-22 are fitted branch circuit protection may be required, where this is the case, follow the manufacturers recommendations.

NOTE

DC bus fusing is required for all motoring drives in a single Regen, multiple drive system in both the +DC and -DC.

NOTE

VDR1, VDR2 and VDR3 when operating with a 690 Vac supply should consist of two varistors each in series as detailed in Table 3-22 on page 38.

NOTE

To prevent inductive voltage spikes surge suppressors should be fitted to the contactor coils.

NOTE

The Regen inductor core losses are directly dependant on the switching frequency and specific core material and therefore selection is critical. As a result only Regen inductors specified in this guide should be used.

NOTE

SFF branch circuit protection may be required, refer to section 3.9.3 *Switching frequency filter capacitor* on page 30.

See Chapter 10 *Technical data* on page 276 for fuse rating information.

4.4.3 Single Regen, multiple motoring system using an external softstart resistor to support up to 2 % THD$_V$

Figure 4-11 Power connections: Single Regen, multiple motoring system

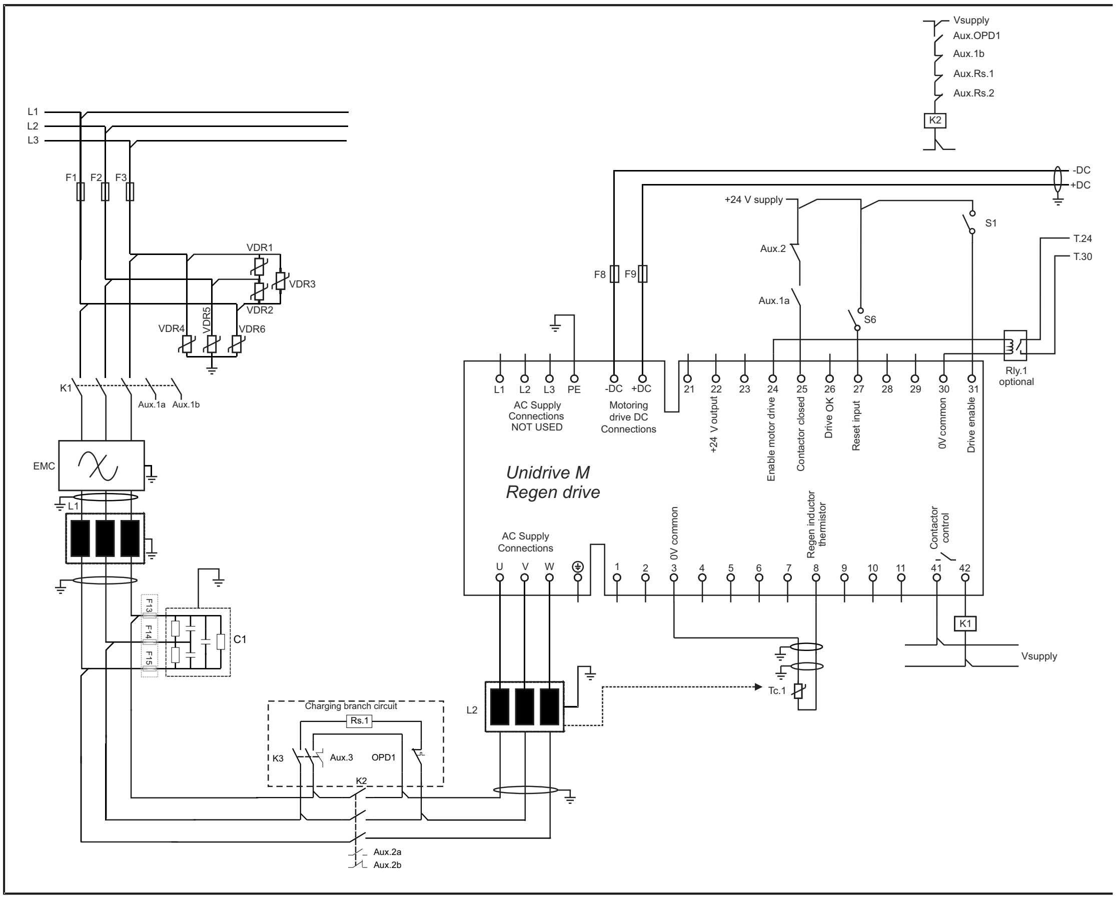


Table 4-8 Key to Figure 4-11

Key	Description
L1, L2, L3	Three phase supply
F1, F2, F3	Main Regen system supply fuses
VDR1, VDR2, VDR3	Varistor network line-to-line
VDR4, VDR5, VDR6	Varistor network line-to-ground
F4, F5, F6, F7	DC bus fusing to motoring drive
F8, F9	DC bus fusing to Regen drive
EMC	Optional EMC filter
C1	Switching frequency filter capacitor
L1	Switching frequency filter inductor
L2	Regen inductor
K1	Main supply contactor
K2	Pre-charge contactor
OPD1	Overload protection device for Rs.1
Aux.1a	K1 NO auxiliary contact
Aux.2	K2 NO auxiliary contact
Aux.1b	K1 NC auxiliary contact
Aux.OPD1	OPD1 NO auxiliary contact
Rly.1	Optional isolation for enable between Regen and motoring drive(s)
Mt.1	Motor thermistor 1
Mt.2	Motor thermistor 2
Tc.1	Regen inductor thermistor
Rs.1	Softstart resistor 1
+DC, -DC	Motoring drive power connection to Regen drive
S1	Regen drive enable
S2	Motoring drive enable
S3	Motoring drive reset
S4	Motoring drive run forward
S5	Motoring drive run reverse
S6	Regen drive reset input (Pr **08.024** = Pr **10.033**)
Vsupply	System control supply
K3	Charging contactor
Aux.3	SFF capacitor auxiliary contact
F13, F14, F15	Optional switching frequency filter capacitor fuses

* Unidrive M Frame 11 and all new generation Inductors only.

Figure 4-11 shows both the power and control connections for the multiple motoring Regen solution. For this multiple motoring system solution an external charging circuit is required due to the additional capacitance from the multiple motoring drives. The external charging circuit is interlocked with the Regen drive enable to prevent operation with this circuit still connected.

For sizing of the external charging circuit required for the multiple motoring drive system, refer to Chapter 11 *Component sizing* on page 308. For details on softstart resistors and protection refer to section 10.4.5 *Switching frequency filter capacitors* on page 299.

NOTE

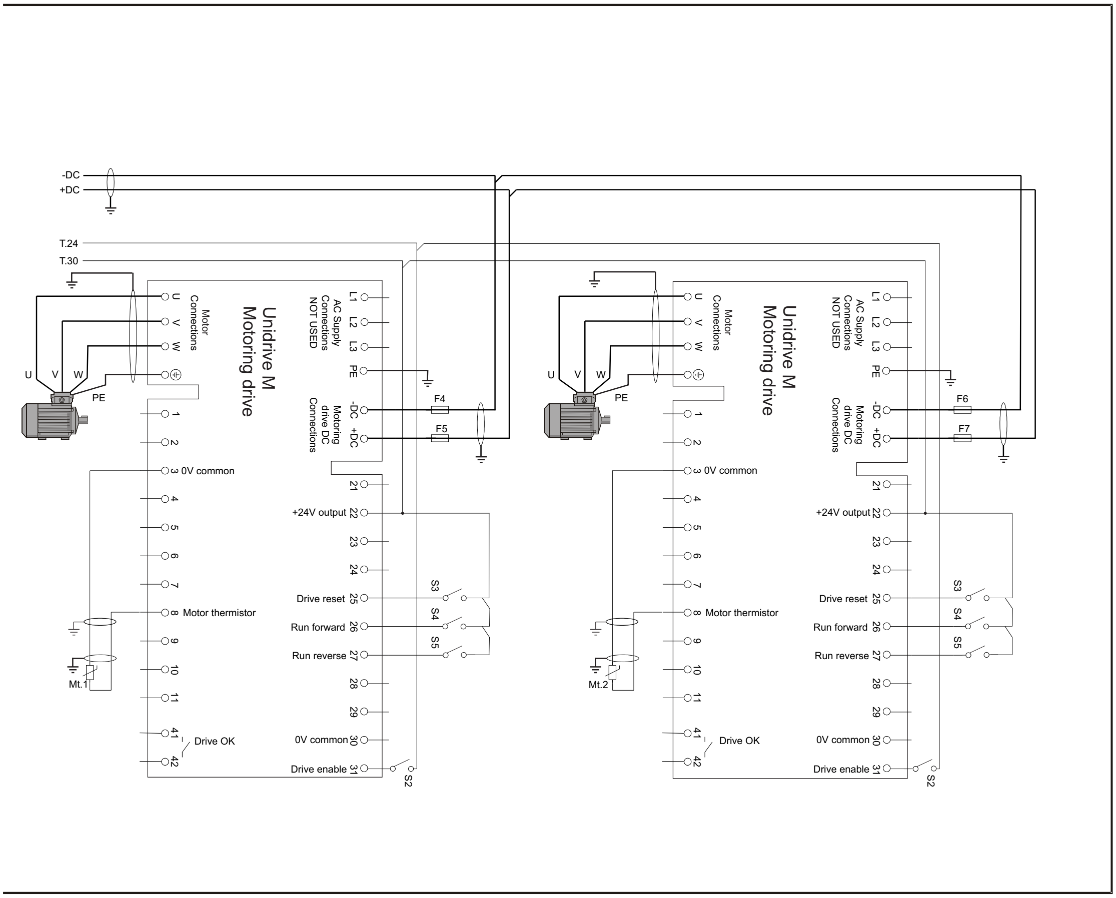
For the multiple motoring drive solution, the Regen drive and associated external components must be sized to the total power requirements of all motoring drives.

NOTE

The Regen inductor core losses are directly dependant on the switching frequency and specific core material and therefore selection is critical. As a result only Regen inductors specified in this guide should be used.

WARNING

Regen inductor thermistor must be configured to disable the drive in the event of a thermal overload. The switching frequency filter inductor thermistor must be configured to open the main supply contactor in the event of a thermal overload. This can be achieved through the use of an external thermal protection device/relay.



NOTE

Where varistors other than those listed in Table 3-22 are fitted branch circuit protection may be required, where this is the case, follow the manufacturers recommendations.

NOTE

DC bus fusing is required for all motoring drives in a single Regen, multiple motoring drive system in both the +DC and -DC.

NOTE

VDR1, VDR2 and VDR3 when operating with a 690 Vac supply should consist of two varistors each in series as detailed in Table 3-22 on page 38.

NOTE

To prevent inductive voltage spikes surge suppressors should be fitted to the contactor coils.

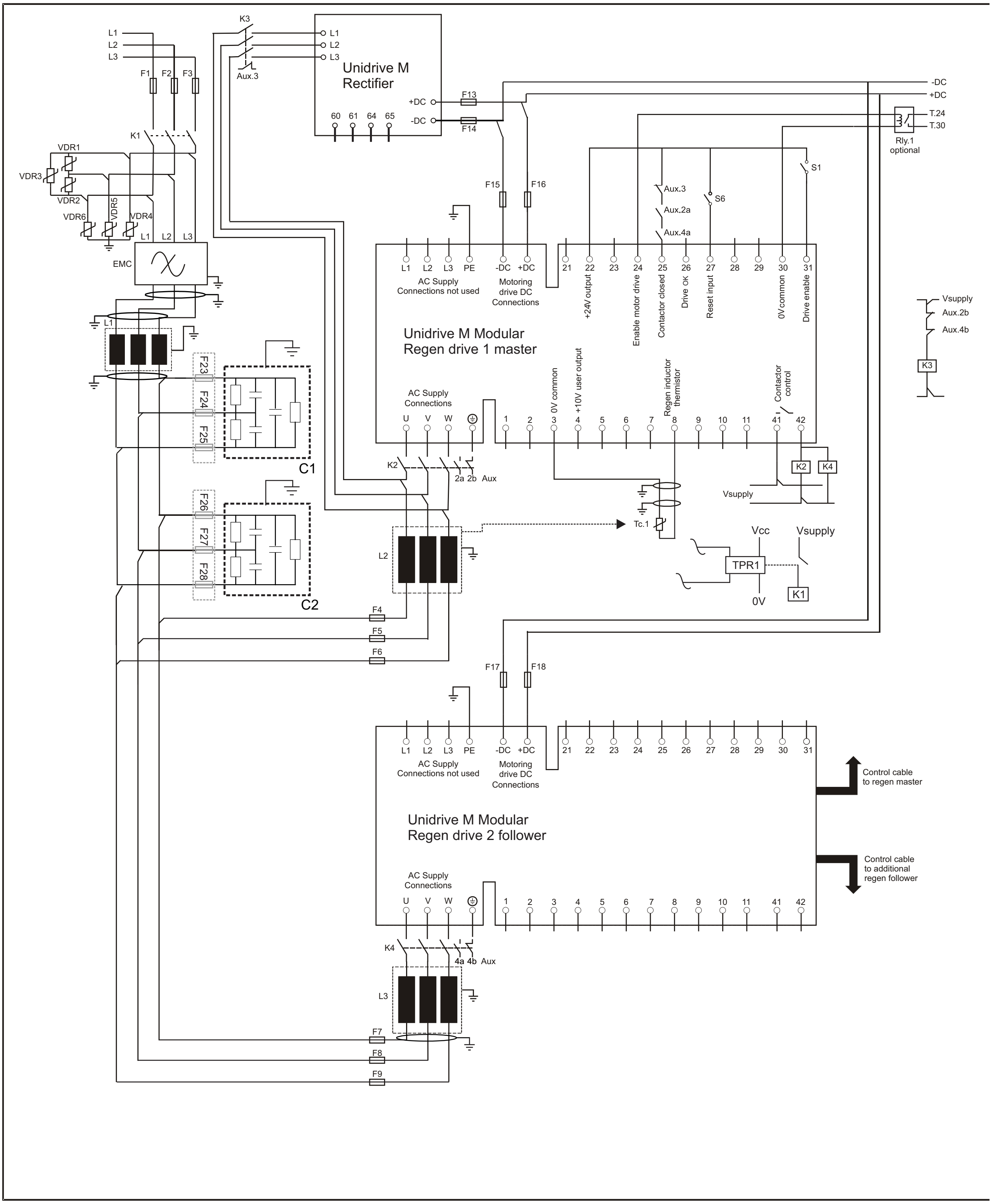
See Chapter 10 *Technical data* on page 276 for fuse rating information.

NOTE

SFF branch circuit protection may be required, refer to section 3.9.3 *Switching frequency filter capacitor* on page 30.

4.4.4 Multiple Regen, multiple motoring using Unidrive M Rectifier to support up to 2 % THD_V

Figure 4-12 Power connections: Multiple Regen, multiple motoring system



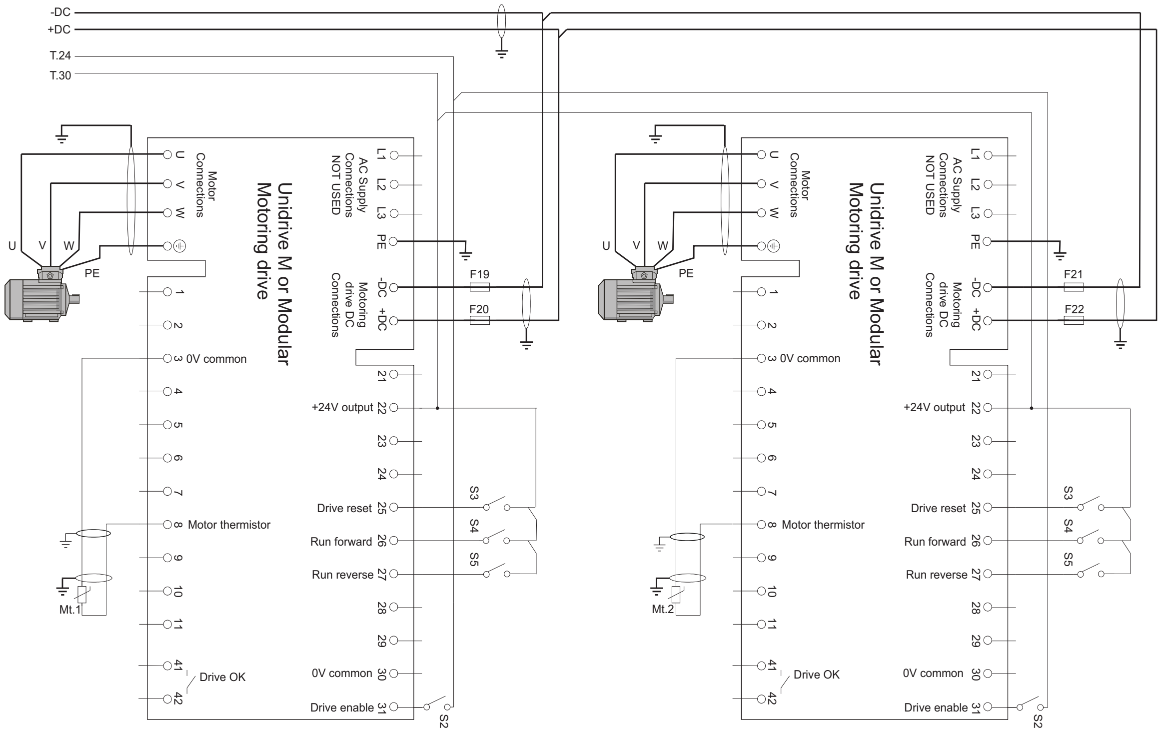


Table 4-9 Key to Figure 4-12

Key	Description
L1, L2, L3	Three phase supply
F1, F2, F3	Main Regen system supply AC fuses
F4, F5, F6	Regen drive 1 AC fuses
F7, F8, F9	Regen drive 2 AC fuses
F13, F14	DC Bus fusing to rectifier
F15, F16, F17, F18	DC Bus fusing to Regen drives
F19, F20, F21, F22	DC Bus fusing to motoring drive
VDR1, 2, 3	Varistor network line-to-line
VDR4, 5, 6	Varistor network line-to-ground
EMC	Optional EMC filter
L1	Switching frequency filter inductor
L2	Regen inductor (Regen 1)
L3	Regen inductor (Regen 2)
C1	Switching frequency filter capacitor (Regen 1)
C2	Switching frequency filter capacitor (Regen 1)
K1	Main supply contactor
K2	Regen drive 1 main contactor
K3	Charging contactor
K4	Regen drive 2 main contactor
Aux.2	OPD2 NO auxiliary contact
Aux.2a	K2 NO auxiliary contact Regen 1
Aux.2b	K2 NC auxiliary contact Regen 1
Aux.2c	K2 NC auxiliary contact Regen 1
Aux.3	K3 NC auxiliary contact
Aux.4a	K4 NO auxiliary contact Regen 2
Aux.4b	K4 NC auxiliary contact Regen 2
Aux.4c	K4 NC auxiliary contact Regen 2
Rly.1	Optional isolation for enable between Regen and motoring drive(s)
Mt.1	Motor thermistor 1
Mt.2	Motor thermistor 2
Tc.1	Regen inductor thermistor
+DC, -DC	Motoring drive power connection to Regen drive
S1	Regen drive enable
S2	Motoring drive enable
S3	Motoring drive reset
S4	Motoring drive run forward
S5	Motoring drive run reverse
S6	Regen drive reset (user programmed)
TPR1	Thermal protection relay
Vsupply	System control supply
F23, F24, F25, F26, F27, F28	Optional switching frequency filter capacitor fuses

* Unidrive M Frame 11 and all new generation inductors only.

WARNING

Regen inductor thermistor must be configured to disable the drive in the event of a thermal overload. The switching frequency filter inductor thermistor must be configured to open the main supply contactor in the event of a thermal overload. This can be achieved through the use of an external thermal protection device/relay.

NOTE

Where varistors other than those listed in Table 3-22 are fitted branch circuit protection may be required, where this is the case, follow the manufacturers recommendations.

NOTE

For the multiple motoring drive solution, the Regen drive and associated external components must be sized to the total power requirements of all motoring drives.

NOTE

The Regen inductor core losses are directly dependant on the switching frequency and specific core material and therefore selection is critical. As a result only Regen inductors specified in this guide should be used.

NOTE

VDR1, VDR2 and VDR3 when operating with a 690 Vac supply should consist of two varistors each in series as detailed in Table 3-22 on page 38.

NOTE

To prevent inductive voltage spikes surge suppressors should be fitted to the contactor coils.

NOTE

Multiple switching frequency filter inductors and EMC filters are permissible.

NOTE

SFF branch circuit protection may be required, refer to section 3.9.3 *Switching frequency filter capacitor* on page 30.

4.4.5 Brake resistor replacement to support up to 2 % THD_V

Figure 4-13 Power connections: Regen drive as a brake resistor replacement

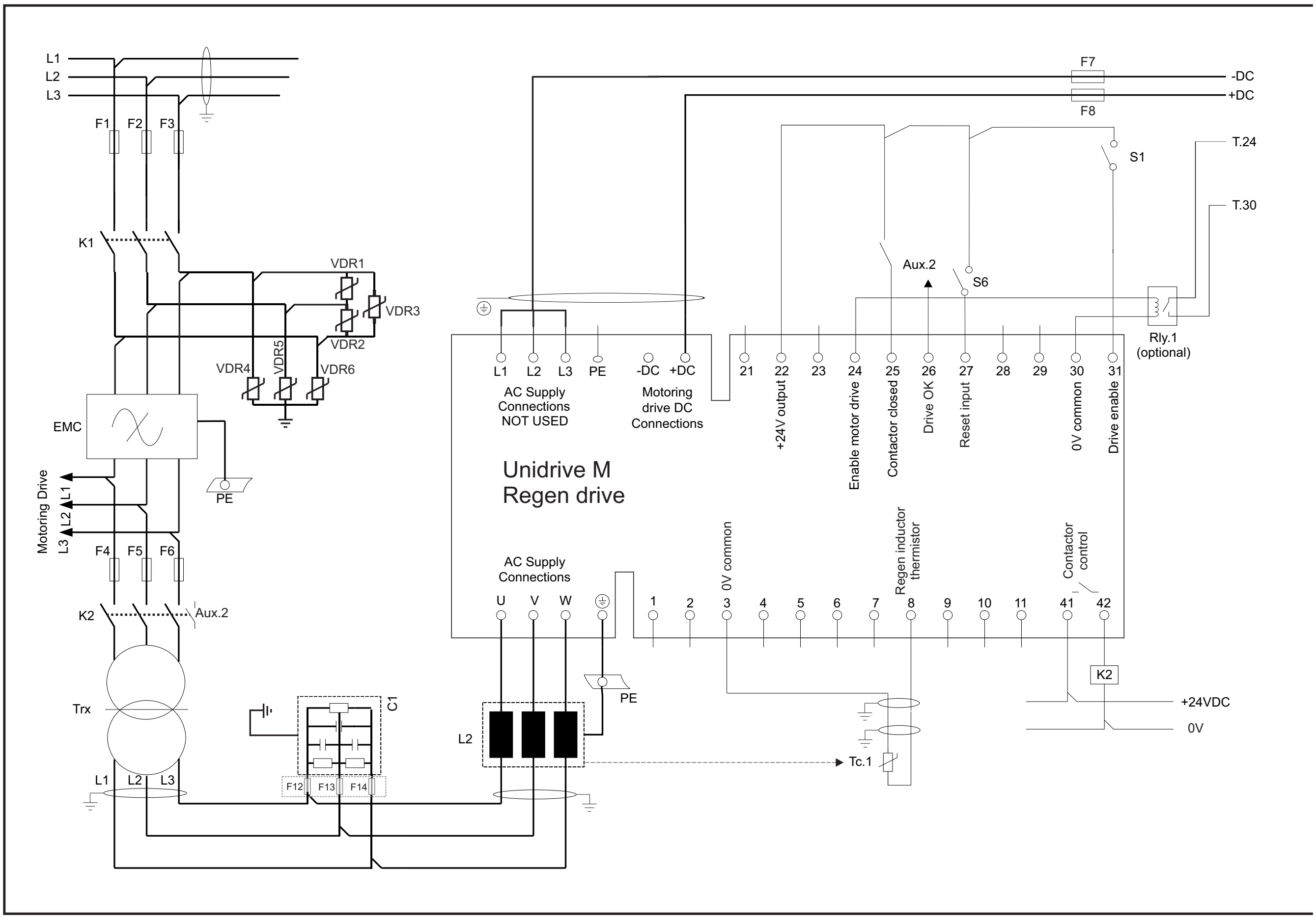
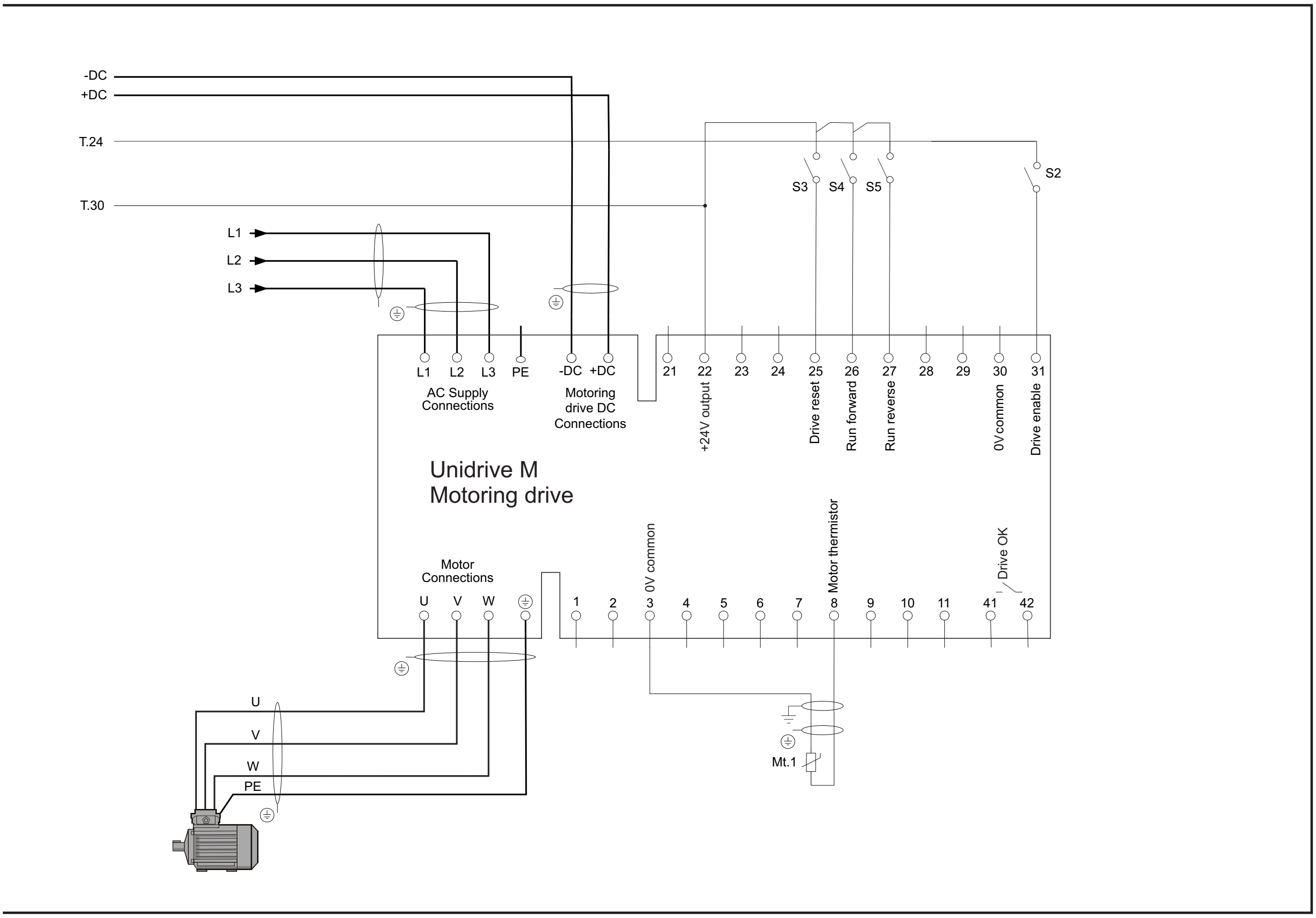


Table 4-10 Key to Figure 4-8

Key	Description
L1, L2, L3	Three phase supply
F1, F2, F3	Main Regen system supply fuses
F4, F5, F6	Regen drive fusing
F7, F8	DC Fusing (see Note)
VDR1, VDR2, VDR3	Varistor network line-to-line 550 Vac
VDR4, VDR5, VDR6	Varistor network line-to-ground 680 Vac
EMC	EMC Filter
C1	Switching frequency filter capacitor
L2	Regen inductor
K1	Main supply switch or contactor
K2	Regen drive main contactor
Trx	Isolating transformer
Aux.2	Regen drive main contactor auxiliary
Rly.1	Optional isolation for enable between Regen and motoring drive(s)
Mt.1	Motor thermistor
Tc.1	Regen inductor thermistor
+DC, -DC	Motoring drive power connection to Regen drive
S1	Regen drive enable
S2	Motoring drive enable
S3	Motoring drive reset
S4	Motoring drive run forward
S5	Motoring drive run reverse
S6	Regen drive reset input (Pr **08.024** = Pr **10.033**)
F12, F13, F14	Optional switching frequency filter capacitor fuses



In many applications, the motoring power can be significantly higher than the braking power. If sinusoidal input currents are not required, it is difficult to justify the cost of a Regen drive rated at the full motoring power. In these applications it may be desirable to take the lower cost option of a smaller Regen drive which is only used to return the braking energy to the AC supply. When a Regen drive is used as a dynamic brake resistor replacement, connections must be made as shown in Figure 4-13.

NOTE

Where varistors other than those listed in Table 3-22 are fitted branch circuit protection may be required, where this is the case, follow the manufacturers recommendations.

NOTE

DC bus fusing is required where the Regen drive is smaller than the motoring drives. See Chapter 10 *Technical data* on page 276 for fuse rating information.

NOTE

For the multiple motoring drive solution, the Regen drive and associated external components must be sized to the total power requirements of all motoring drives.

NOTE

The Regen inductor core losses are directly dependant on the switching frequency and specific core material and therefore selection is critical. As a result only Regen inductors specified in this guide should be used.

NOTE

To prevent inductive voltage spikes surge suppressors should be fitted to the contactor coils.

NOTE

SFF branch circuit protection may be required, refer to section 3.9.3 *Switching frequency filter capacitor* on page 30.

WARNING

The Isolating transformer, Trx, can be prone to thermal overload. Ensure that thermal overload protection is fitted.

4.4.6 Regen and motoring drive ratings - brake resistor replacement

NOTE

The Regen drive's current limits are detailed in section 3.3 *Ratings* on page 17.

In general the Regen drive must be rated at a power greater than, or equal to, the maximum braking power.

Example:

- Two 30 kW motoring drives are each driving 30 kW motors. The load is such that only one drive is braking at a time.

If each motor supplies between 20 and 30 kW motoring, and the braking power varies from 0 to 30 kW, the maximum total braking power is 30 - 20 = 10 kW, which is what the Regen drive should be rated for.

In drive configurations where the motoring drive power rating is several times the expected braking power, it is necessary to consider the peak braking power returned from the load.

Example:

- The motoring drive is a 75 kW Unidrive M. Motoring power is 75 kW. Steady state braking power is 20 kW.

From these figures, it may appear that a 22 kW Regen drive will provide sufficient braking power. However, dynamically the peak braking power could be much greater. If the 75 kW drive current limits are set at 175 % for motoring and braking (default settings), the peak brake power could be:

$\sqrt{3} \times 157\text{ A} \times 400\text{ V} \times 175\ \% = 190.4\text{ kW}$

This is much greater than the 22 kW Regen drive is able to return to the supply, hence a larger drive is required.

NOTE

If the Regen drive is not rated for the required braking power, then the drives will trip on DC bus over-voltage.

WARNING

It is not possible to use the Combi filter solution in a braking resistor replacement system.
When using the Regen drive as a braking resistor replacement, the Regen input must have an isolating transformer installed so that the Regen drive input can float with respect to ground.
The Combi filter combines the switching frequency filter and EMC filter into one item. A significant part of an EMC filter are the capacitors between line and ground.
The result of placing a Combi filter in circuit between the Regen drive and isolating transformer is that the ground connection to the Combi filter prevents the Regen drive input from floating and damage to the system will occur.

4.4.7 Isolating transformer and diode - brake resistor replacement

There are three main connection differences compared with normal operation.

- There are AC supply connections to both the Regen and motoring drives.
- The DC bus connection between the Regen and motoring drives is via the rectifier diodes shorting the line input connectors (L1, L2 and L3) and connecting them to the –DC connection (as detailed in figure 4-5) ensures that power flows from the motoring drive to the regen drive only.
- The switching frequency filter inductors are replaced with an isolating transformer Trx with a leakage inductance ≥ 4 %.

Isolating transformer Trx

This is a three phase transformer which provides isolation between the AC supply and the Regen drive. One isolating transformer can only supply one Regen drive with the current rating equal to the Regen drive continuous current rating. The transformers leakage inductance forms the switching frequency filter inductance. The optimum inductance value is specified in section 10.4.5 *Switching frequency filter capacitors* on page 299, any value equaling or exceeding this by up to 100 % is acceptable. The required reactance is 4 % and a standard transformer has a reactance in the range 4 % to 6 %. It should not be necessary to specify a special transformer for this purpose.

NOTE

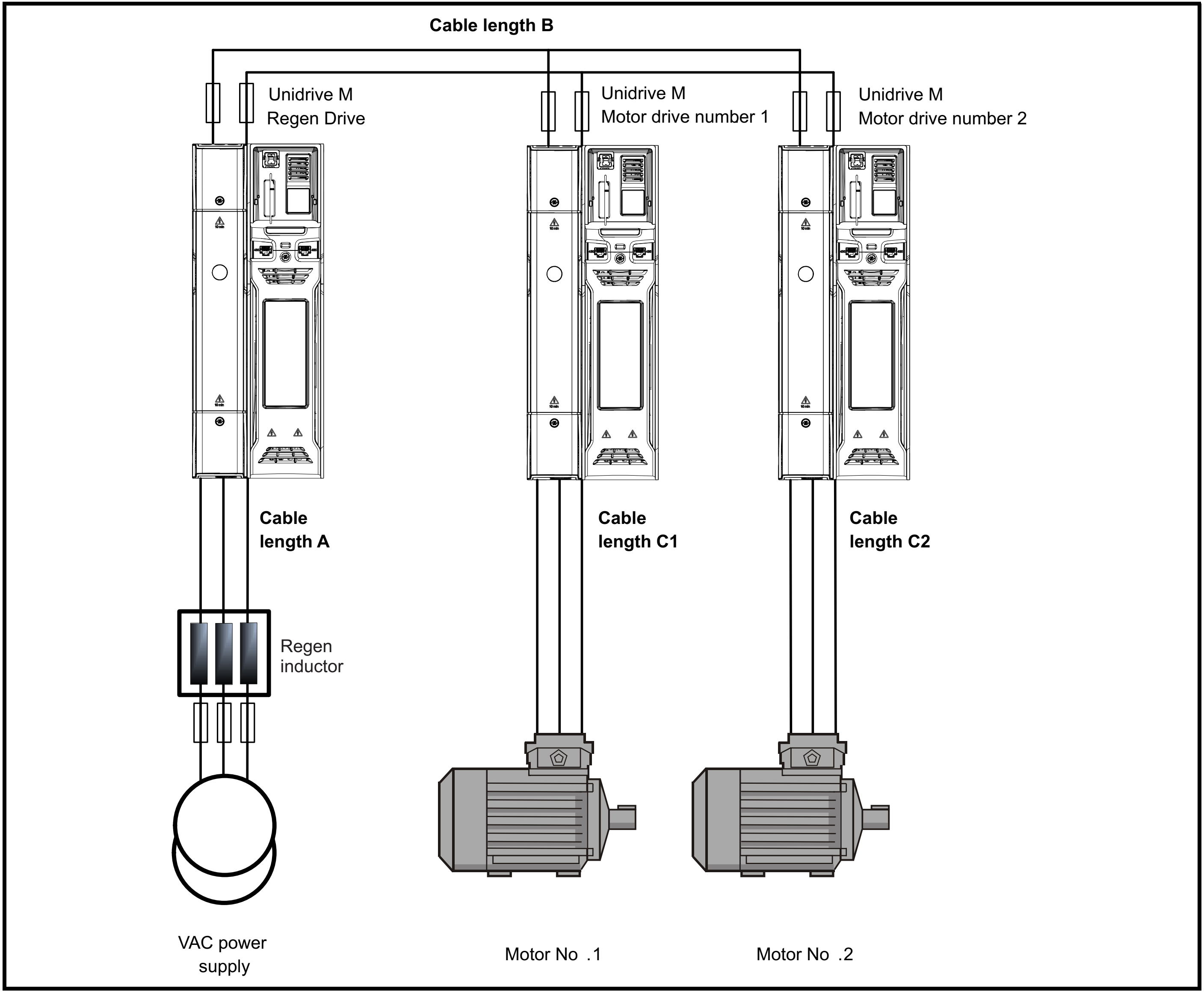
A non isolating transformer should not be used under any circumstances.

4.5 Cable lengths

Since capacitance in the cabling causes loading, the Regen/motoring system cable length should not exceed the values given in Table 4-11 to Table 4-14 Regen system maximum cable lengths, without the addition of extra components.

To determine cable length, the Regen/motoring system should be considered as a number of sections as detailed in Figure 4-14 and the description below.

Figure 4-14 Unidrive M Regen system cables



Cable length A is the Vac cable situated between the Regen inductor and the Regen drives power terminals, U, V and W. In general no special precautions are necessary for the AC supply wiring to the Regen drive however it should be noted the high frequency PWM is present here. Ideally the Regen inductor should be mounted close to the Regen drive terminals. If a cable length longer than 5 m is used, a shielded cable with the grounded shield should be used. Where the Regen inductor is situated close to the Regen drive, **Cable length A** need not be considered when calculating the total cable length.

Cable length B is the length of the DC bus connection between the Regen drive and motoring drive(s). The common +/- DC bus connections between all drives should be treated as a single two core cable when calculating the length, and not two individual cables lengths. The DC power output from the Unidrive M Regen drive which is used as the input stage to the Motoring drive(s) carries a common-mode high frequency voltage comparable with the output voltage from a standard drive. All precautions recommended for motor cables must also be applied to all cables connected to this DC circuit, cable length, shield, grounding and segregation.

Cable length C (C1 and C2) is the total AC cable length between all Motoring drive(s) and their motors. Figure 4-14 shows a Regen system and the cable connections A, B and C1 + C2.

Therefore the cable length for the Regen system will be, **Total cable length = Cable length B + Cable length C1 + Cable length C2.**

The total system cable length for the Regen system should be compared with the maximum cable length listed for the Regen drive in Table 4-11 to Table 4-14, if the total system cable length exceeds this value additional measures will be required, refer to section 4.6 *Exceeding maximum cable length* on page 70.

The sum total length of the DC bus and motor cables (B and C in Figure 4-14) should not exceed the values shown in the tables below:

Table 4-11 200 V Regen system maximum cable lengths

Model	200 V Nominal AC supply voltage					
	Maximum permissible cable length					
	Motoring drive switching frequency					
	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
03200050	65 m (210 ft)				50 m (165 ft)	37 m (120 ft)
03200066	100 m (330 ft)			75 m (245 ft)		
03200080	130 m (425 ft)		100 m (330 ft)			
03200106	200 m (660 ft)	150 m (490 ft)				
04200137						
04200185						
05200250						
06200330						
06200440						
07200610	250 m (820 ft)	187 m (614 ft)	125 m (410 ft)	93 m (305 ft)	62 m (203 ft)	46 m (151 ft)
07200750						
07200830						
08201160						
08201320						
09201760						
09202190						
10202830						
10203000						

Table 4-12 400 V Regen system maximum cable lengths

Model	400 V Nominal AC supply voltage					
	Maximum permissible cable length					
	Motoring drive switching frequency					
	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
03400025	65 m (210 ft)				50 m (165 ft)	37 m (120 ft)
03400031	100 m (330 ft)			75 m (245 ft)		
03400045	130 m (425 ft)		100 m (330 ft)			
03400062	200 m (660 ft)	150 m (490 ft)				
03400078						
03400100						
04400150						
04400172						
05400270						
05400300						
06400350						
06400420						
06400470						
07400660	250 m (820 ft)	187 m (614 ft)	125 m (410 ft)	93 m (305 ft)	62 m (203 ft)	46 m (151 ft)
07400770						
07401000						
08401340						
08401570						
09402000						
09402240						
10402700						
10403200						
11403770						
11404170						
11404640						

Table 4-13 575 V Regen system maximum cable length

Model	575 V Nominal AC supply voltage					
	Maximum permissible cable length					
	Motoring drive switching frequency					
	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
05500030	200 m (660 ft)	150 m (490 ft)	100 m (330 ft)	75 m (245 ft)	50 m (165 ft)	37 m (120 ft)
05500040						
05500069						
06500100						
06500150						
06500190						
06500230						
06500290						
06500350						
07500440	250 m (820 ft)	187 m (614 ft)	125 m (410 ft)	93 m (305 ft)	62 m (203 ft)	46 m (151 ft)
07500550						
08500630						
08500860						
09501040						
09501310						
10501520						
10501900						
11502000						
11502540						
11502850						

Table 4-14 690 V Regen system maximum cable length

Model	690 V Nominal AC supply voltage					
	Maximum permissible cable length					
	Motoring drive switching frequency					
	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
07600190	250 m (820 ft)	187 m (614 ft)	125 m (410 ft)	93 m (305 ft)	62 m (203 ft)	46 m (151 ft)
07600240						
07600290						
07600380						
07600440						
07600540						
08600630						
08600860						
09601040						
09601310						
10601500						
10601780						
11602100						
11602380						
11602630						

If the cable length in the above tables are exceeded, additional components are required. Refer to section 4.6.1 *Available preventative measures* on page 72.

4.5.1 Cable type

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 Regen drive
- Regen drive to motoring drive (or busbar arrangement could be used)
- Motoring drive to motor

4.6 Exceeding maximum cable length

If the maximum cable length specified is exceeded, the increased circulating currents caused by the extra cable capacitance will have an effect on the other parts of the system. This will necessitate additional components to be added to the standard arrangement. Refer to section 4.6.1 *Available preventative measures* on page 72.

When the maximum Regen system cable length is exceeded the effect of the additional capacitance of this cable to ground can become significant. At every switching edge the capacitance must be charged and subsequently discharged on the falling edge. This leads to a capacitive high frequency current flowing in the common mode, i.e. returning through the ground connections, which must be supported by the EMC filter, inverter output and for a Regen system the Regen inductor.

This charging current is sensed by the drive current sensing circuit and may affect the drive current control system or protection, causing a loss of torque or over-current trip. It may also have heating effects on the EMC filter and Regen inductor.

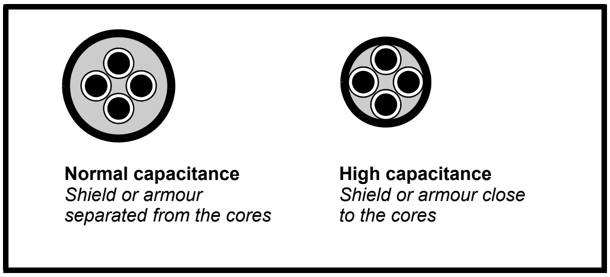
The effect of the charging current on the standard inverter can be managed by connecting an inductor in series with the output, and where necessary additional filter capacitors between the DC bus and ground. For a Regen system the inductor is effectively already present in the system, the Regen inductor, and capacitance to ground at the DC bus is not permitted because of the PWM action of the Regen input stage.

When operating with a Unidrive M Regen system with a total system cable length that exceeds the maximum cable lengths listed in Table 4-11 to Table 4-14 the following considerations must be made:

1. Exceeding the maximum allowed cable lengths in a Unidrive M Regen system can result in both heating of the Regen inductor and also heating and saturation of the EMC filter if fitted due to the increased common mode currents.
2. Cable types should also be considered along with the increased losses generated in the long cable application, these can be calculated for the given cable type and length to ensure these do not exceed the rating of the Regen inductor.

Cable types should be considered with the long cable applications due to the increased losses generated with certain cable types. The absolute maximum allowable cable length (cable length allowed with long cable modifications) can be limited if high capacitance cables are used. The high capacitance cables result in increased cable-induced losses which can exceed the Regen inductor rating. 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 absolute maximum cable length could be limited. (Figure 4-14 shows two types of cables). Typical cable capacitance for a shielded cable containing four cores is 130 pF/m (i.e. from one core to all others and the shield connected together).

Figure 4-15 Cable construction influencing the capacitance



Long cable lengths if routed through a plant can be a source for radiated emissions due to the PWM present on all three cables sections A, B and C. Refer to Figure 4-14, Unidrive M Regen system cables. In addition there can be increased common mode currents due to the increased cable length and capacitance. The correct choice of screened cable and cable segregation should be followed.

NOTE

The absolute maximum cable length achievable for the Regen system will be limited by the increased losses and the rating of the Regen inductor. Excessive cable lengths will result in unacceptable losses in the Regen inductor.

The increased cable losses generated due to the long cable lengths can be calculated and compared with a threshold for the Regen inductor using the calculations below (**the loss should not exceed 0.1 of the VA in the Regen inductor**):

Regen system, long cable calculations

1	Estimate cable capacitances - from all cores to ground. If no data is available the following typical values can be used: multi-core cables, and screened/armoured cables where there is a plastic sheath between the phases and the screen: 300 pF/m. Screened cables with no plastic sheath between cores and screen, mineral insulated cables: 600pF/m Note bus bars using mainly air insulation have negligible capacitance. C_{DC} = total capacitance of DC link cable(s) C_{COP} = total capacitance of all motor cables	C_{DC} C_{COP}
2	Add an allowance for system motor capacitances. This depends on the motor size, but we suggest a value of 1 nF per motor is a reasonable estimate. This will usually be rather smaller than the cable capacitance. For unusual motors such as those with very high pole numbers, the capacitance may be much higher and it is worth trying to get the actual data. Add the total motor capacitance to C_{COP} to obtain the total output capacitance C_{OP}	C_{OP}
3	The cable capacitances cause additional high-frequency losses which are mainly dissipated in the Regen inductor. The loss can be estimated from the following expression: $$P = 0.27 V_{DC}{}^2 \left[f_{s1}(C_{DC} + C_{OP}) + f_{s2} \frac{C_{OP}{}^2}{C_{DC} + C_{OP}} \right]$$ where f_{s1} and f_{s2} are the switching frequencies of the Regen and motor inverters respectively. For the common situation where is small compared with C_{DC} C_{COP} , this expression simplifies to: $$P = 0.27 V_{DC}{}^2 C_{OP} \left[f_{s1} + f_{s2} \right]$$ Note that this expression is intended as a worst-case estimate of the loss. It is exactly correct for a single motor drive. Where large numbers of motor drives are connected to a single Regen inverter it gives an over-estimate because the high-frequency currents caused by the drives have effectively random relative phase angles and tend to cancel. This reduces the term in the expression. It is difficult to calculate this situation with any certainty so it is recommended that the above expressions should be used unless the number of motors connected to a single Regen inverter exceeds 10. For over 10 motors the alternative expression can be used with confidence: $$P = 0.27 V_{DC}{}^2 C_{OP} f_{s1}$$	P
4	Estimate whether the Regen inductor is able to tolerate these losses, which will appear primarily as additional iron loss. This is a difficult judgement since it depends on the closeness of its operating temperature to its material limits. For the standard inductors recommended by Control Techniques the following guideline can be applied: **The loss should not exceed 0.1 of the VA in the Regen inductor** $$P \le 0.2 \pi f_I L I_{nchk}^2$$ where f_I = Input supply frequency I_{nchk} = Regen inductor nominal rated current L = Regen inductance	
5	If the loss exceeds this limit, the following measures should be considered: • Reduce switching frequency • Consider using an isolating transformer at the input	

NOTE

Busbar connections which are common in Regen drive system cubicles are normally of short lengths and have minimal capacitive effects to ground therefore power loss does not need to be taken into consideration.

NOTE

For Regen applications which have multiple motoring drives and therefore multiple motor cable lengths consideration should be made to the routing of these cables, e.g. bunched, separate cable trays or layered as this can affect the final cable rating.

4.6.1 Available preventative measures

1. Regen inductor forced cooling

If the maximum cable length specified for a Regen system is exceeded this will introduce heating of the Regen inductor due to the increased common mode currents. To overcome the additional heating of the Regen inductor, forced cooling should be provided into the system as specified to provide an airflow of at least 160 m³ / hr or greater. The forced cooling should be configured as shown in Figure 4-16 and Figure 4-17.

Figure 4-16 Location of forced cooling - base mounted inductor

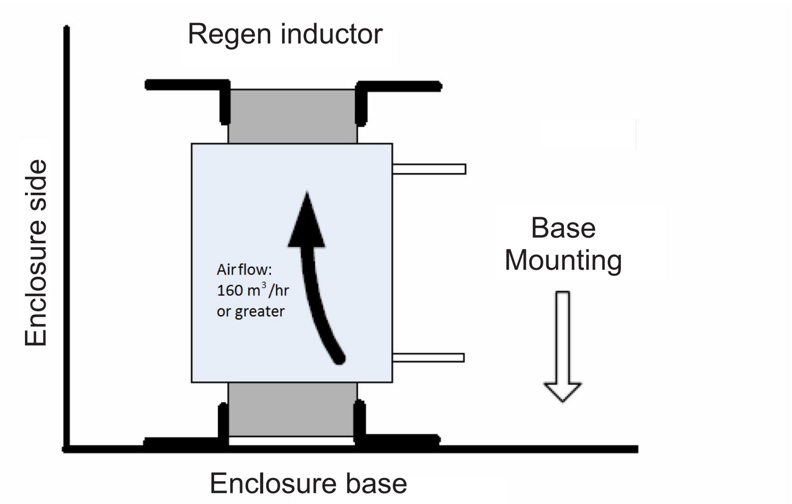
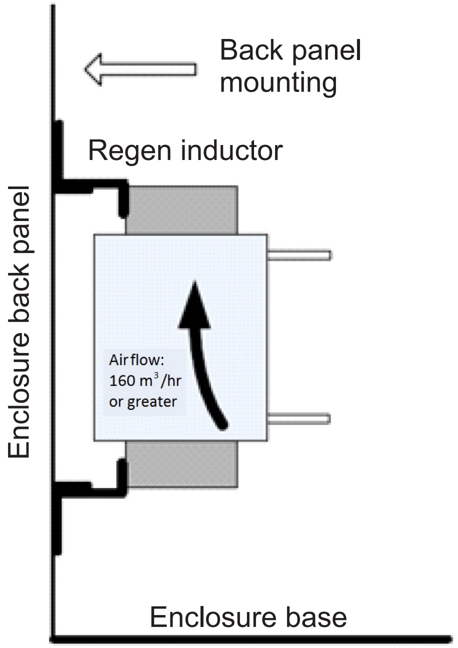


Figure 4-17 Location of forced cooling - back panel mounted inductor



2. Capacitors line to ground to support EMC filter

WARNING

When using an EMC filter, a switching frequency filter must also be used to protect the EMC filter from overload.

WARNING

Ground leakage current

The value of capacitance required means that the ground leakage current exceeds the usual safety limit of 3.5 mA. The user should be aware of the high leakage current. A permanent fixed ground connection must be provided to the system.

WARNING

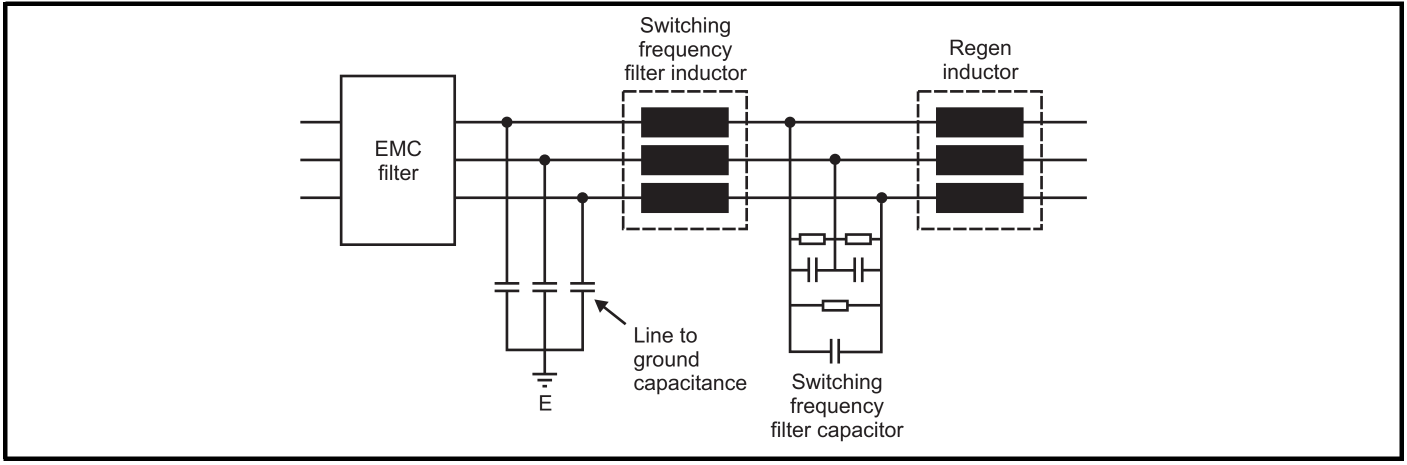
Discharge time

Resistors must be fitted in parallel with the capacitors to ensure that they discharge when the supply is removed. The resistor values should be chosen so that the discharge time is no longer than for the drive itself. Typically values of about 5 MΩ are suitable, and are high enough not to cause the system to fail a simple insulation test.

When an EMC filter is used in a Unidrive M Regen system with long cables the increased common mode currents can result in both heating and saturation of the EMC filter. As a result of this additional capacitors are required line to ground when the maximum cable length is exceeded.

To prevent heating, saturation and damage to the EMC filter the capacitance line to ground should be implemented as shown in Figure 4-17. Whether or not an EMC filter is required is dependent upon the user requirements and local compliance.

Figure 4-18 Long cable Regen application capacitors to ground



Selection of line to ground capacitors for Regen systems with long cables, in order to select the appropriate capacitors, the rms value of the current line to ground, the AC supply voltage and minimum capacitance values are required. The current rating of the capacitors should be at a high frequency such as 100 kHz at the relevant supply voltage. Polypropylene type capacitors (x type) are the most suitable because of their low loss at high frequency.

A minimum capacitance value of 1 µF per phase should be used with the final capacitance value being determined by the level of current line to ground. In practice, to carry the required level of current the capacitor will generally have a higher capacitive value. Multiple parallel capacitors can be used if convenient.

The rms value of the current can be estimated from the following formula: $\mathbf{I_{rms} = 8.28 \times 10^{-6} \times K \times V \times \sqrt{(\Sigma lfs)}}$

Where;

K is 1 for √2 for Regen systems
V is the DC Bus voltage
Σlfs is the sum of the products of motor cable lengths and switching frequency of all drives in the system, including in the case of Regen systems the Regen drive with the total DC bus cable length
l is the total cable length in metre's
fs is the switching frequency

If all drives are operating at 3 kHz then the expression can be simplified to

$$\mathbf{I_{rms} = 4.85 \times 10^{-4} \times K \times V \times \sqrt{l}}$$

Example

A Unidrive M Regen system operating with a power supply of 400 Vac providing a DC Bus of 700 Vdc at 3 kHz switching frequency with a total cable length of 1,000 m (cable lengths including A + B +C) the capacitor I_{rms} current can be calculated as follows

$$\mathbf{I_{rms} = 4.85 \times 10^{-4} \times K \times V \times \sqrt{l}}$$

$$\mathbf{I_{rms} = 4.85 \times 10^{-4} \times \sqrt{2} \times 700 \times \sqrt{1000}}$$

$$\mathbf{I_{rms} = 15.2\ A}$$

Select a Polypropylene X type capacitor at 15.2 A with a current rating at 100 kHz and > 1 uF

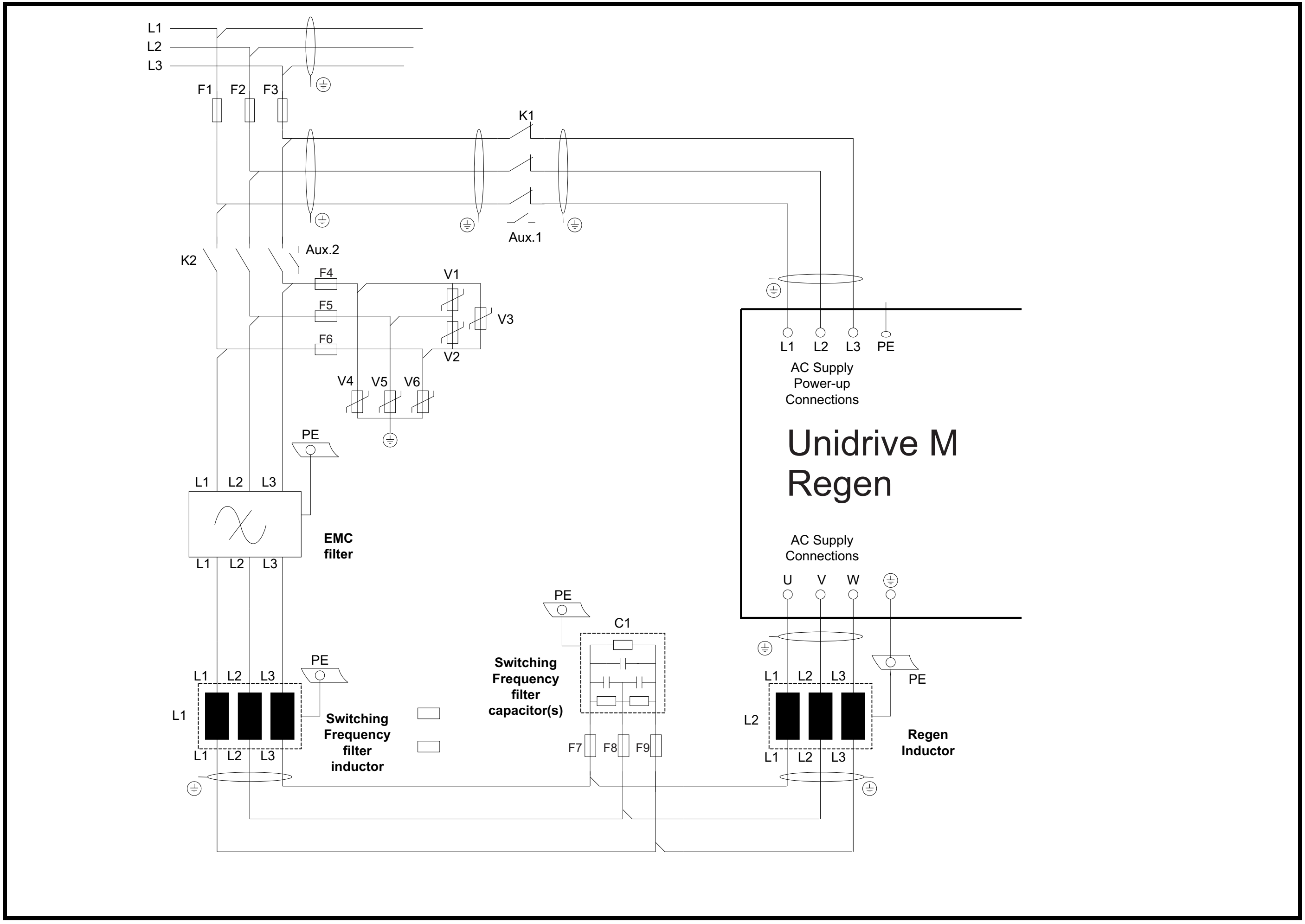
4.7 Regen input filter configuration

The Unidrive M input stage filtering arrangement consists of multiple components including an EMC filter and switching frequency filter (SFF). The SFF is made up from a switching frequency filter inductor and capacitor(s). The standard Regen input filtering configuration consists of separate EMC and SFF filter components, a more compact solution is available that combines both the EMC filter and switching frequency filter components into a single package. The combined filter can simplify installation and provide a compact Regen solution.

4.7.1 Standard Regen input filter

The standard Unidrive M Regen solution requires both an EMC filter and a switching frequency filter which comprises an inductor and capacitor(s). The following diagram shows the standard arrangement. When referring to the switching frequency filter capacitance, this can consist of either a single 3 phase capacitor or dual 3 phase capacitors.

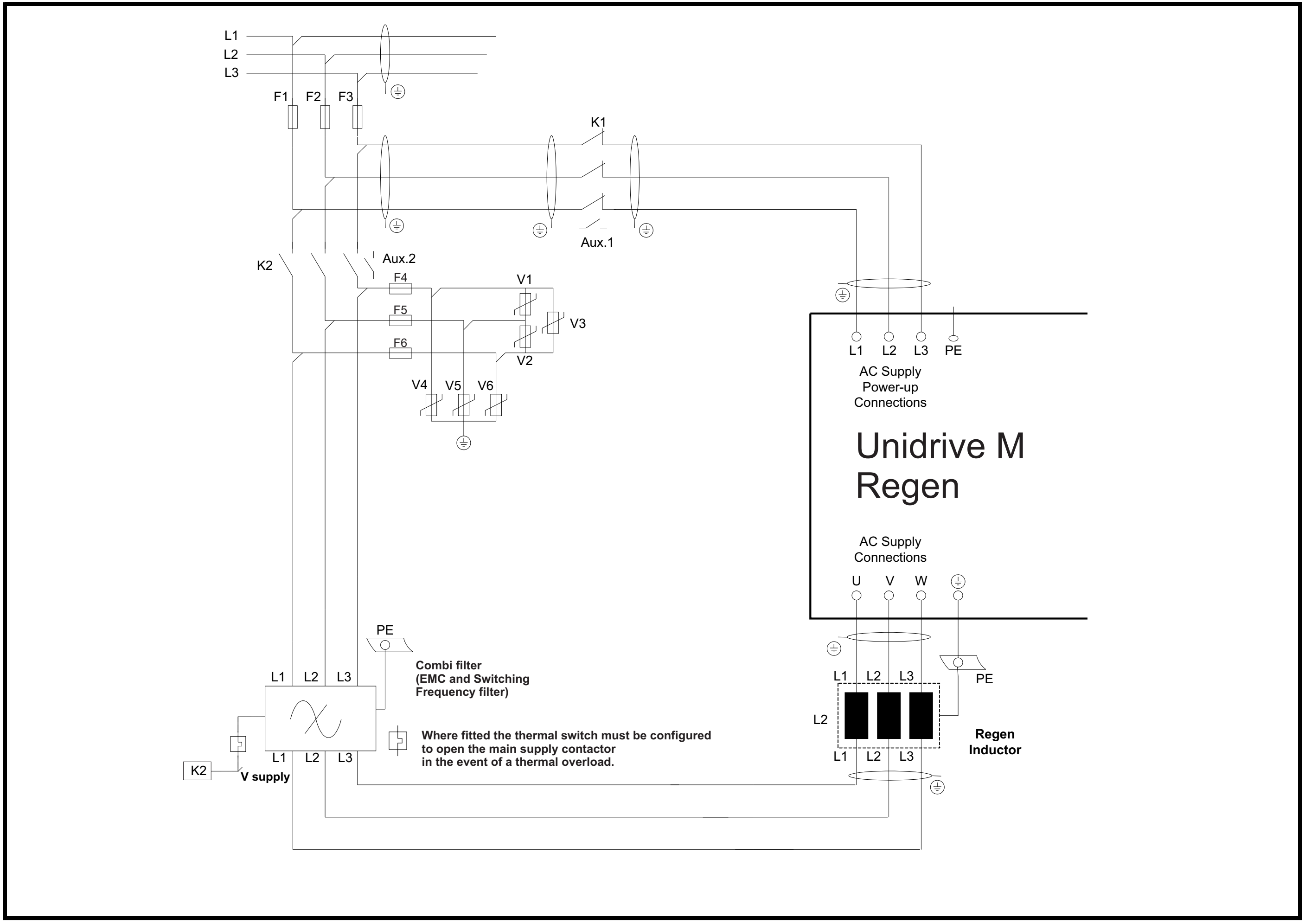
Figure 4-19 Standard Unidrive M Regen input filter arrangement



4.7.2 Combined Regen input filters (combi filter)

The combi filter is a simplified solution consisting of a combined EMC filter and switching frequency filter. The combined filter is shown in the power configuration below (single Regen Unidrive M).

Figure 4-20 Unidrive M Regen input combi filter arrangement



The combi filter combines the standard EMC filter, SFF capacitor(s) and SFF inductor into a single package. With the combi filter the Regen system front end has a total of 2 major components (Regen inductor + Combi filter) where as previously this would have required 4 components (Regen inductor + SFF capacitor(s) + SFF inductor + EMC filter).

NOTE

The range of combi filters covered in this section are available from Schaffner, the filters are not stocked by the supplier of the drive.

CAUTION

Combi filters listed in Table 3-23 *Combi filter selection* on page 39 are equipped with an internal thermal switch to prevent the EMC filter inductor from overheating. The thermal switch must be configured to open the main supply contactor in the event of a thermal overload.

5 Mechanical Installation

This chapter describes the installation of the Regen drive components. Key features of this chapter include:

- Regen component dimensions
- Enclosure sizing and layout
- Enclosure ventilation
- Enclosure design with high ambient temperatures

Refer to the *Mechanical Installation sections* in the relevant *Unidrive M Power Installation Guide* for drive mechanical information.

5.1 Safety information

WARNING

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

WARNING

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

WARNING

Enclosure

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

5.2 Planning the installation

The following considerations must be made when planning the installation:

5.2.1 Access

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

The IP (Ingress Protection) rating of the drive is installation dependent. For further information, please refer to the relevant *Unidrive M Power Installation Guide*.

5.2.2 Environmental protection

The drive must be protected from:

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

NOTE

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

5.2.3 Cooling

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

For further information, please refer to section 5.5.2 *Enclosure sizing* on page 102.

NOTE

Through hole mounting is possible for all Unidrive M modules and the Unidrive M Rectifier which can reduce cubicle heating and cooling requirements. Refer to relevant Unidrive M Power Installation Guide or Unidrive M Modular Installation Guide.

5.2.4 Electrical safety

The installation must be safe under normal and fault conditions. Electrical installation instructions are given in Chapter 6 *Electrical Installation* on page 105.

5.2.5 Fire protection

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

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

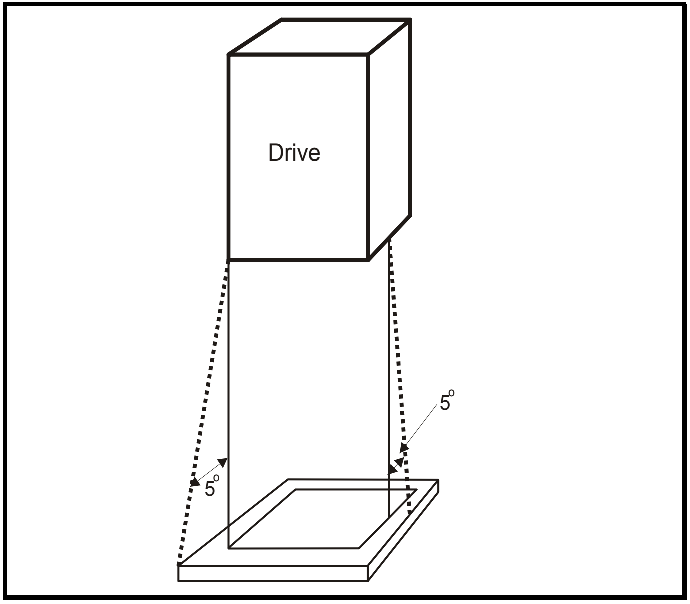
For installation outside the USA, the following (based on IEC 62109-1, standard for PV inverters) is recommended.

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

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

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

Figure 5-1 Fire enclosure bottom layout

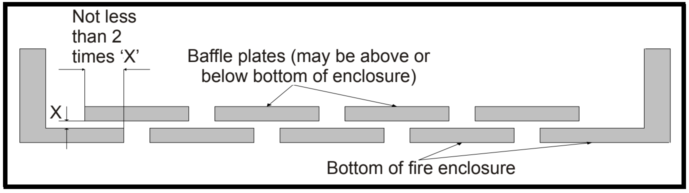


The bottom, including the part of the side considered to be part of the bottom, must be designed to prevent escape of burning material - either by having no openings or by having a baffle construction.

This means that openings for cables etc. must be sealed with materials meeting the 5VB requirement, or else have a baffle above.

See Figure 5-2 for acceptable baffle construction. This does not apply for mounting in an enclosed electrical operating area (restricted access) with concrete floor.

Figure 5-2 Fire enclosure baffle construction



5.2.6 Electromagnetic compatibility

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

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

If it is necessary to meet strict emission limits, or if it is known that electromagnetically sensitive equipment is located nearby, then full precautions must be observed. Refer to the guidelines given in the relevant *Unidrive M Power Installation Guide.* The DC bus voltage in a Regen system with a 400 V supply is usually 700 V, which corresponds to an AC supply voltage of 519 V. Unless the motor cable is less than 10 m long it is recommended that either an inverter-grade motor is used or else output chokes should be installed to protect the motor from the effect of the fast-rising output voltage pulses.

5.2.7 Hazardous areas

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

WARNING

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

WARNING

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 the supplier of the drive or their authorised distributor.

5.3 Regen component dimensions

The dimensions listed are for the following items:

- Regen inductor
- Switching frequency filter inductor
- Switching frequency filter capacitor
- Varistors
- External EMC filter
- Combined regen input filters

5.3.1 Regen inductor

CAUTION

The following Regen inductors can produce significant losses with a normal operating temperature in the region of 150 °C dependant upon the ambient temperature. Location of the Regen inductor should be considered to avoid damage to heat sensitive components or create a fire risk.

NOTE

When installing the following Regen inductors into the system, ensure no enclosures are fitted directly around the inductors thereby preventing air flow and natural cooling.

NOTE

All Regen inductors can be mounted in the base of the enclosure as shown in Figure 5-6, with relevant details in Table 5-1, Table 5-2 and Table 5-3.

Regen inductors which are only suitable for base mounting i.e. not back panel mounting as shown in Figure 5-7, are highlighted with an * Table 5-1, Table 5-2 and Table 5-3.

Table 5-1 200 V Regen inductor specifications

Inductor part number	Ratings		L	D	H	Weight	Fixing centres (x * y)	Fixing	Fixing type	Termination size	Type
	A	mH	mm	mm	mm	kg	mm	mm			
4401-0310	9.6	3.500	200	180	215	10	120 x 140	9	A	6 way terminal block	1
4401-0311	11.0	2.700				11					
4401-0312	15.5	2.200				12					
4401-0313	22	1.600				15					
4401-0314	31	1.100	240		270	17	160 x 140			Ø 9 mm hole	2
4401-0315	42	0.810		200		24					
4401-0316	56	0.600	320	220	325	32	200 x 180	11		Ø 11 mm hole	
4401-0318	80	0.400				39					
4401-0319*	105	0.320	360	260	370	55	240 x 220				3
4401-0321*	156	0.220			395	77					
4401-0322*	192	0.180				97					
4401-0323*	250	0.140	410	300	430	110	280 x 260				
4401-0324*	312	0.110		310		120					
4401-0325*	350	0.100	480	320	490	130	320 x 260				

* Regen inductors can only be horizontally base mounted.

Table 5-2 400 V Regen inductor specifications

Inductor part number	Ratings		L	D	H	Weight	Fixing centres (x *y)	Fixing	Fixing type	Termination size	Type
	A	mH	mm	mm	mm	kg	mm	mm			
4401-0405	9.5	6.300	190	82	161	6	170 x 58	8 x 12	C	6 way terminal block	1
4401-0406	12	5.000	190	91	161	7.5	170 x 168				
4401-0407	16	3.750	230	124	229	11	180 x 98 180 x 98	9 x 12			2
4401-0408	25	2.400	230	130	243	15					
4401-0409	34	1.760	230	154	242	18	180 x 122				
4401-0410	40	1.500	240	156	245	23	190 x 125	11 x 15			
4401-0411	46	1.300	265	160	263	28	215 x 126				
4401-0412	60	1.000	300	176	276	30	240 x 110	11 x 25		Ø 9 mm hole	
4401-0413	74	0.780	300	200	275	30	240 x 135				
4401-0414	96	0.630	360	230	325	62	310 x 140	11 x 30			3
4401-0415	124	0.480	360	217	322	62	310 x 140				
4401-0416	156	0.380	360	237	318	80	310 x 155			Ø 11 mm hole	
4401-0417	180	0.330	420	230	370	85	370 x 151				
4401-0418	210	0.300	420	257	372	90	370 x 166	13 x 20			
4401-0419	300	0.20	480	260	429	160	430 x 210			Ø 13 mm hole	
4401-0420	355	0.168	480	250	447	165	430 x 210				
4401-0292	437	0.135	480	280	435	185	430 x 240	13			
4401-0293	487	0.121									

* Regen inductors can only be horizontally base mounted.

Table 5-3 575 V / 690 V Regen inductor specifications

Inductor part number	Ratings		L	D	H	Weight	Fixing centres (x * y)	Fixing	Fixing type	Termination size	Type
	A	mH	mm	mm	mm	kg	mm	mm			
4401-0210	19	5.300	320	220	325	32	200 x 180	11	A	Ø 11 mm hole	2
4401-0211	22	4.600				33					
4401-0212	27	3.800				39					
4401-0213	36	2.800	360	260	370	55	240 x 220				
4401-0214*	43	2.400		280	375	65	240 x 240				
4401-0215*	52	1.900			395	77					
4401-0216*	63	1.600				97					
4401-0217*	85	1.200	410	300	430	110	280 x 260				3
4401-0218*	100	1.000		350	500	170	320 x 260				
4401-0219*	125	0.810		320	490	130					
4401-0220*	144	0.700			500	140					
4401-0121*	168	0.600		330	570	150	320 x 240				
4401-0421*	192	0.530	480	223	429	180	430 x 183	13	C	Ø 13 mm hole	
4401-0297*	230	0.441		280	435	130	430 x 240				
4401-0298*	281	0.361				185					

*Regen inductors can only be horizontally base mounted.

Figure 5-3 Regen inductor type 1 dimensions

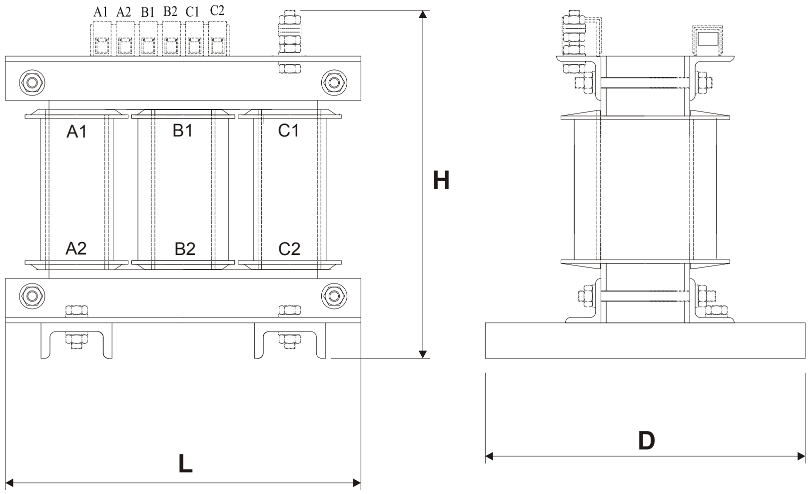


Figure 5-4 Regen inductor type 2 dimensions

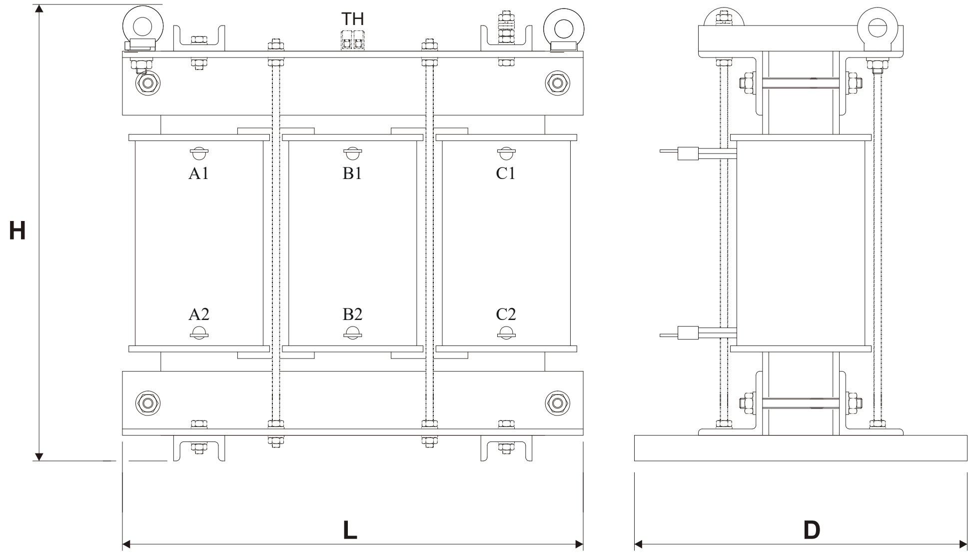
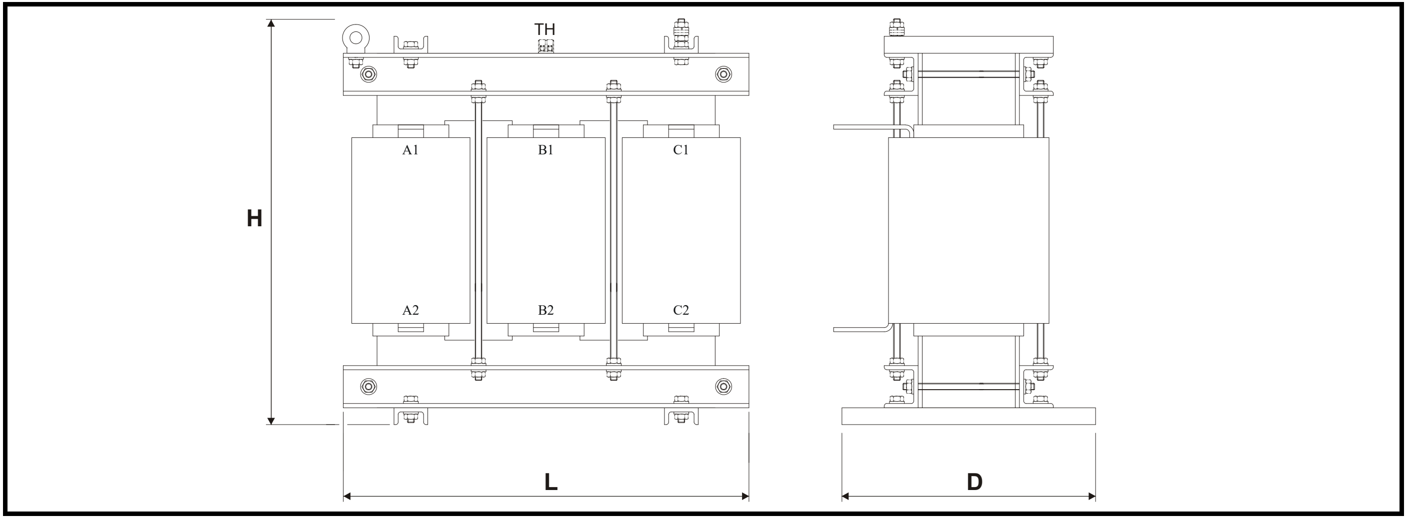


Figure 5-5 Regen inductor type 3 dimensions

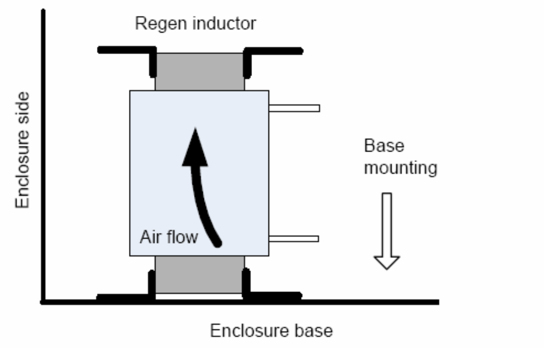


Location and mounting of the Regen inductor must be considered to ensure the following:

1. Natural cooling is present with no enclosures or guards fitted around the Regen inductor.
2. Natural cooling can travel through and over the Regen inductor as designed with the correct mounting.
3. For long cable applications forced cooling may be required, therefore additional space is required.
4. Regen chokes are suitably located to prevent damage to heat sensitive components.
5. Regen chokes are located away from flammable components to prevent fire risk.

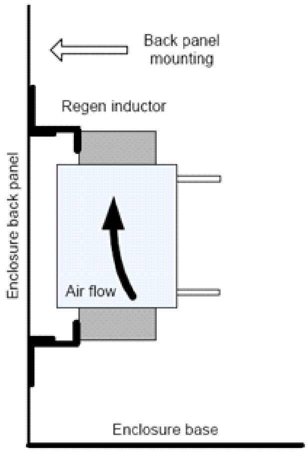
Mounting of the Regen inductor in the base of the enclosure is possible as shown below. The mounting brackets as standard are located on the bottom of the Regen inductor allowing the base mounting. Base mounting is the standard configuration and can be used with the complete range of Regen inductors.

Figure 5-6 Standard Regen inductor base mounting



The Regen inductor can also be mounted on the back panel of the enclosure as shown following with the windings in a vertical orientation. If mounting on the back panel is required the Regen inductor must be located as shown to ensure correct air flow across the Regen inductor and to maintain correct mechanical support.

Figure 5-7 Back panel Regen inductor mounting



5.3.2 Switching frequency filter inductor

Table 5-4 200 V SFF inductor specifications

Inductor part number	Ratings		L	D	H	Weight	Fixing centres (x * y)	Fixing	Fixing type	Termination size	Type
	A	mH	mm	mm	mm	kg	mm	mm			
4401-1310	9.6	0.880	150	90	150	4	120 x 47	8 x 18	B	6 way terminal block	1
4401-1311	11	1.500									
4401-1312	15.5	1.100									
4401-1313	22	0.700									
4401-1314	31	0.500	180	100	190	6	130 x 54	8 x 20		Ø 9 mm hole	2
4401-1315	42	0.400		120		10	130 x 74				
4401-1316	56	0.300		160		12	130 x 184				
4401-1318	80	0.200				13				Ø 11 mm hole	
4401-1319	105	0.160	240		255	16	200 x 180	10 x 20			3
4401-1321	156	0.110		180		22	200 x 100				
4401-1322	192	0.088		190		25					
4401-1323	250	0.068	300	180	300	37	204 x 113				4
4401-1324	312	0.055									
4401-1325	350	0.048		190		49	204 x 123				

Table 5-5 400 V SFF inductor specifications

Inductor part number	Amps	mH	L	D	H	Weight	Fixing centres (x * y)	Fixing	Fixing type	Termination size	Type
	Amps	mH	mm	mm	mm	kg	mm	mm			
4401-0162	9.5	3.160	150	75	135	3.1	120 x 47	8 x 12	C	6 way terminal block	1
4401-0163	12	2.500				3.3			C		
4401-0164	16	1.875	180	82	158	5.3	130 x 58		C		
4401-0165	25	1.200	180	140	179	10	130 x 74	8 x 12	C	Ø 9 mm hole	2
4401-0166	34	0.880	180	179	151	12	130 x 84	8 x 12	C	Ø 9 mm hole	2
4401-0167	40	0.750	180	179	151	11	130 x 84	8 x 12	C	Ø 9 mm hole	2
4401-0168	46	0.650	180	116	179	9.8	130 x 84	8 x 12	C	Ø 9 mm hole	2
4401-0169	60	0.500	240	110	247	20	200 x 80	11 x 20	C		
4401-0170	77	0.390	240	168	247	17	200 x 90	11 x 15	C	Ø 9 mm hole	2
4401-0171	96	0.315	240	180	258	18	200 x 100	11 x 20	C	Ø 9 mm hole	2
4401-0172	124	0.240	240	185	260	20			C		
4401-0173	156	0.190	300	177	300	24	204 x 113		B	Ø 11 mm hole	3
4401-0174	180	0.165				25					
4401-0175	220	0.135									
4401-0176	300	0.100		195		40	204 x 130				
4401-1205	350	0.080	360	250	317	55	204 x 160	11 x 30	C	Ø 13 mm hole	3
4401-0301	437	0.067	348	176	317	55	328 x 265	9 x 14	C	Ø 13 mm hole	3
4401-0302	487	0.060	357	175	322	58	328 x 267	9 x 14	A	Ø 14 mm hole	2

Table 5-6 575 V / 690 V SFF inductor specifications

Inductor part number	Ratings		L	D	H	Weight	Fixing centres (x * y)	Fixing	Fixing type	Termination size	Type
	A	mH	mm	mm	mm	kg	mm	mm			
4401-1211	22	1.400	200	120	190	10	130 x 74	8 x 20	B	6 way terminal block	1
4401-1213	36			160	255	16	200 x 80	10 x 20		Ø 9 mm hole	2
4401-1214	43	1.200		170		20	200 x 90				
4401-1215	52	1.000		160		22	200 x 100				
4401-1216	63	0.800	240			25				Ø 11 mm hole	
4401-1217	85	0.600			300	37	204 x 113				3
4401-1218	100	0.510	300	180		37	204 x 120	4 x 10			
4401-1219	125	0.400		190		49	204 x 123	10 x 20			
4401-1220	144	0.350		200		50	204 x 130				
4401-1221	168	0.300				50					
4401-1222	192	0.260	325	220	325	55	204 x 160	4 x 10			
4401-1223		0.210	300	200	300	50	204 x 130	10 x 20			
4401-0306	230	0.221	360	173	322	58	328 x 263	11 x 17	A	Ø 14 mm hole	2
4401-0307	281	0.181		176		66					

Figure 5-8 Top view of fixing type A

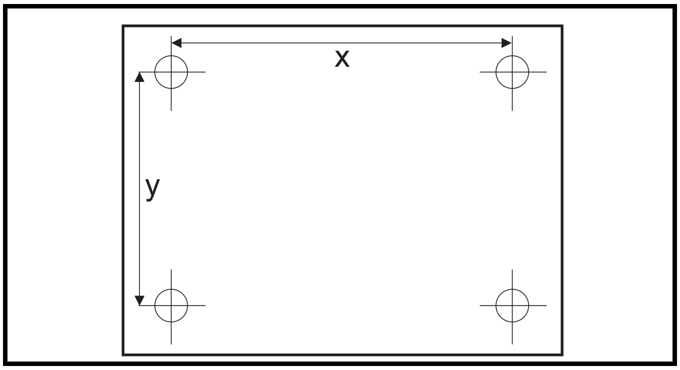


Figure 5-9 Top view of fixing type B

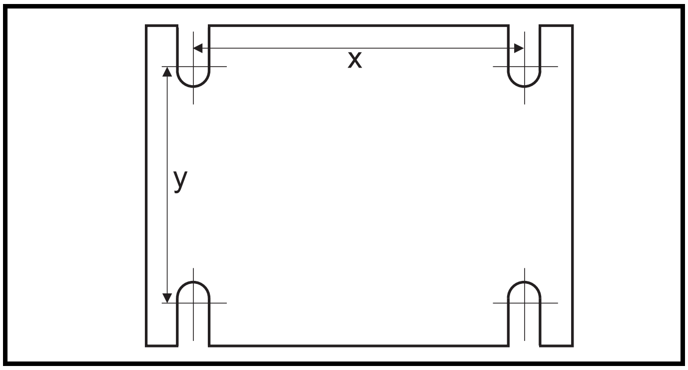


Figure 5-10 Top view of fixing type C

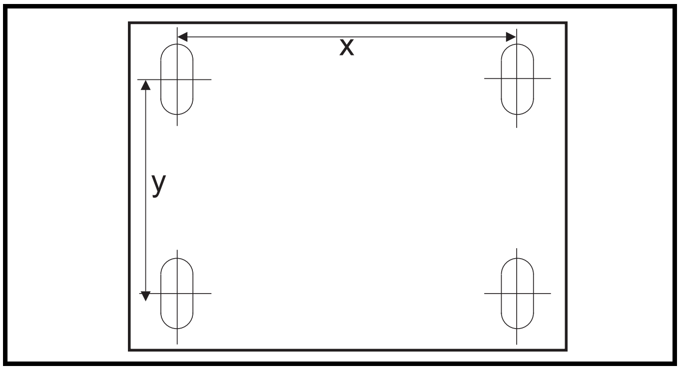


Figure 5-11 Switching frequency filter inductor type 1 dimensions

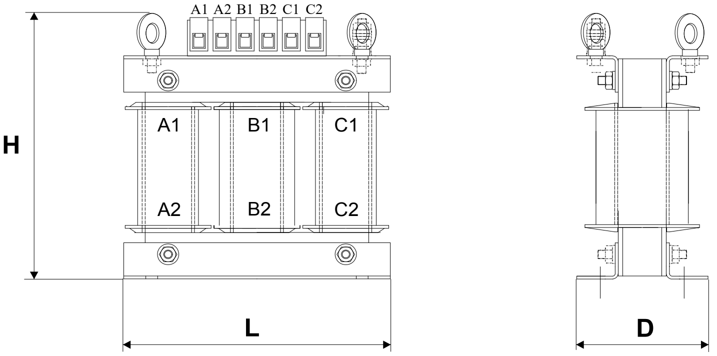


Figure 5-12 Switching frequency filter inductor type 2 dimensions

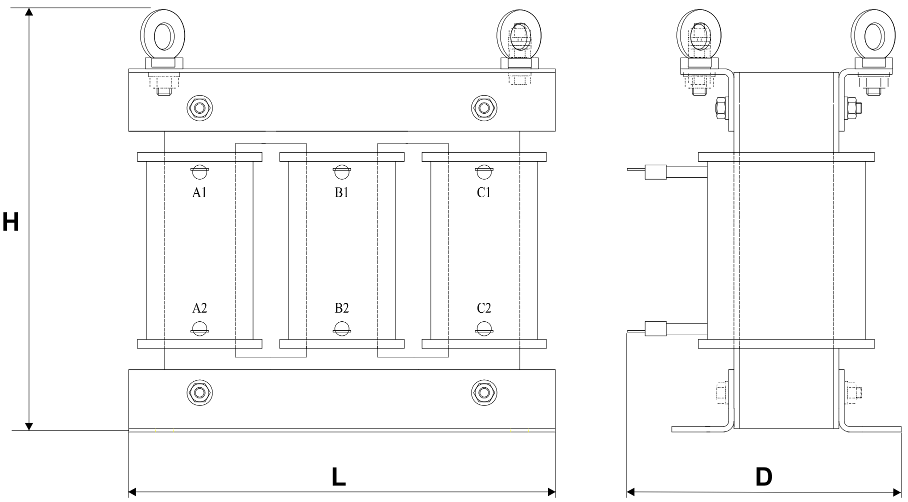


Figure 5-13 Switching frequency filter inductor type 3 dimensions

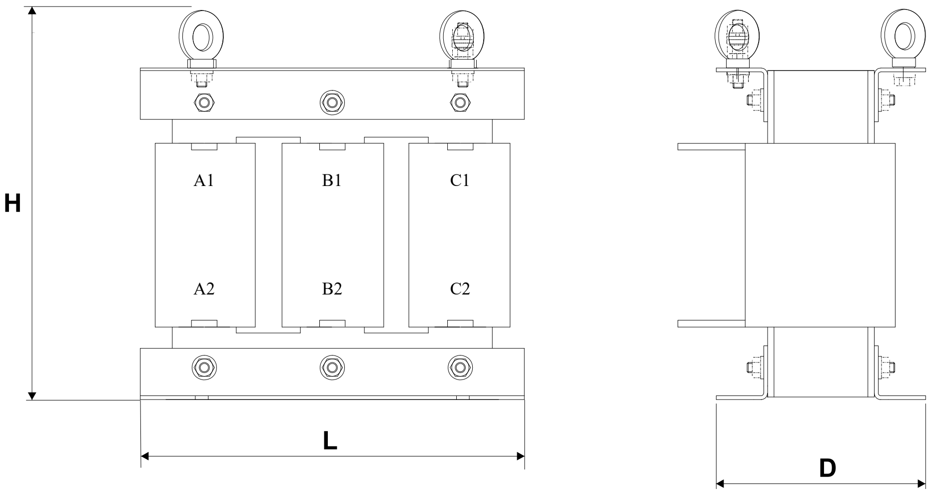
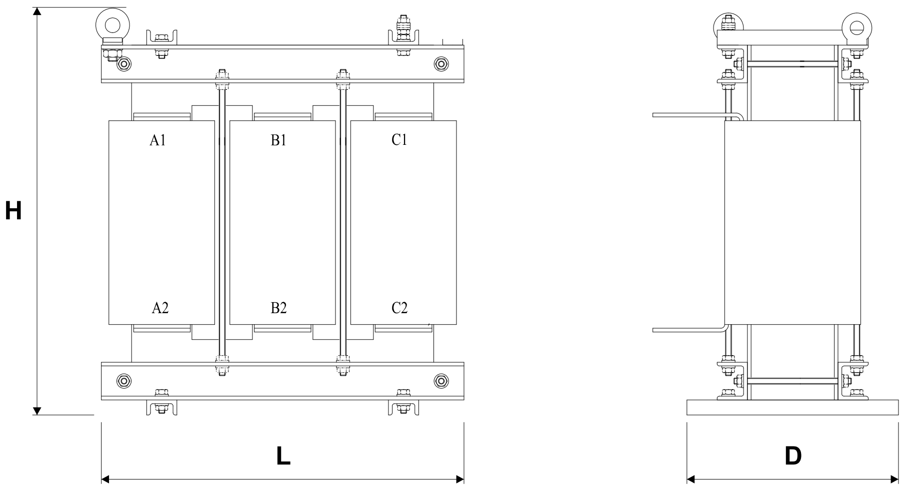


Figure 5-14 Switching frequency filter inductor type 4 dimensions



5.3.3 Switching frequency filter capacitors

Table 5-7 Switching frequency filter capacitors

3-phase capacitor part number	CN µF	Ø x L mm	Discharge resistor Ω	Weight kg	Mounting	Max torque N m (lb in)	Type
1664-1074	3 x 7.0	53 x 114	2.2 M	0.3	M8 Stud	4 (35.4)	PhiCap
1664-2174	3 x 17.0	63.5 x 129	1 M	0.4	M12 Stud	10 (88.6)	
1610-7804	3 x 8.0	82 x 210	620 k	0.5			PoleCap
1668-7833	3 x 8.3	116 x 164	390 k	1.2			PhaseCap
1666-8113	3 x 11.2			1.3			
1668-8163	3 x 16.6			1.3			
1666-8223	3 x 22.5		620 k	1.4			
1665-8324	3 x 32			1.1			
1665-8394	3 x 39		390 k	1.2			
1664-2644	3 x 64		270 k	1.2			
1665-8644	3 x 64.3	116 x 243	3 x 390 k*	2.2			
1668-8464	3 x 46.4	136 x 250	3 x 150 k**	3.2			

* Connected in delta.

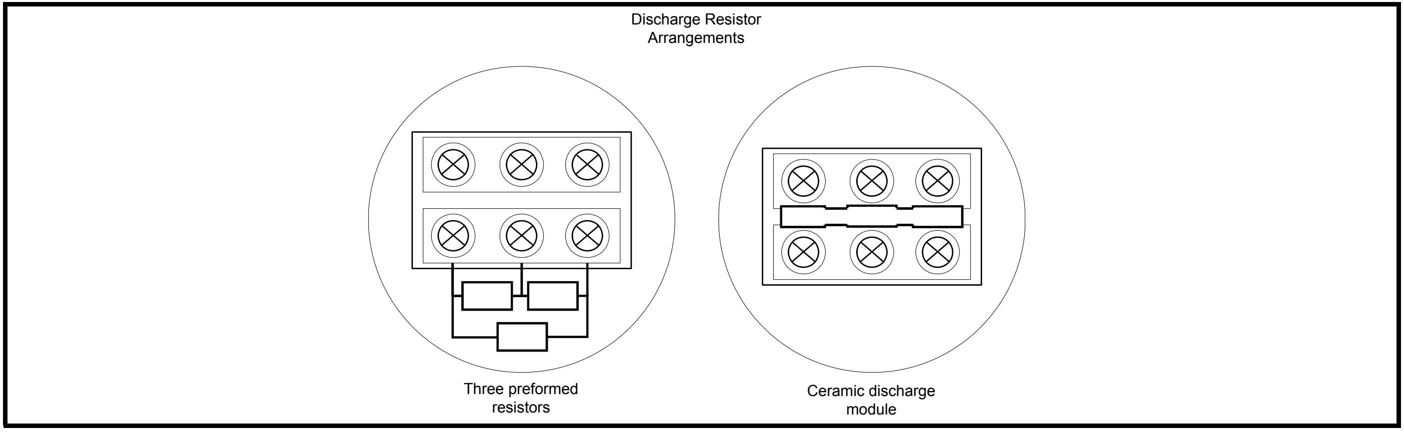
** Connected in star.

CAUTION

The switching frequency filter capacitors are special parts which are used for filtering of the Regen drives PWM and only the recommended parts should be used.

Discharge resistors for SFF capacitors rated to 2 % THD_V

Figure 5-15 Discharge resistor arrangement



Cautions and warnings

In case of dents of more than 2 mm depth or any other mechanical damage, capacitors must not be used at all.

NOTE

Care should be taken to ensure that there is still electrical clearance of 15 mm between terminations and other live or earthed parts above the capacitor, in case of safety device activation. It is recommended that the capacitors are to be mounted vertically.

Discharging

Capacitors must be discharged to a maximum of 10 % of rated voltage before they are switched in again.

The capacitor must be discharged to 75 V or less within 3 minutes.

There must be not any switch, fuse or any other disconnecting device in the circuit between the power capacitor and the discharging device.

Figure 5-16 3-phase PHIcap dimensions

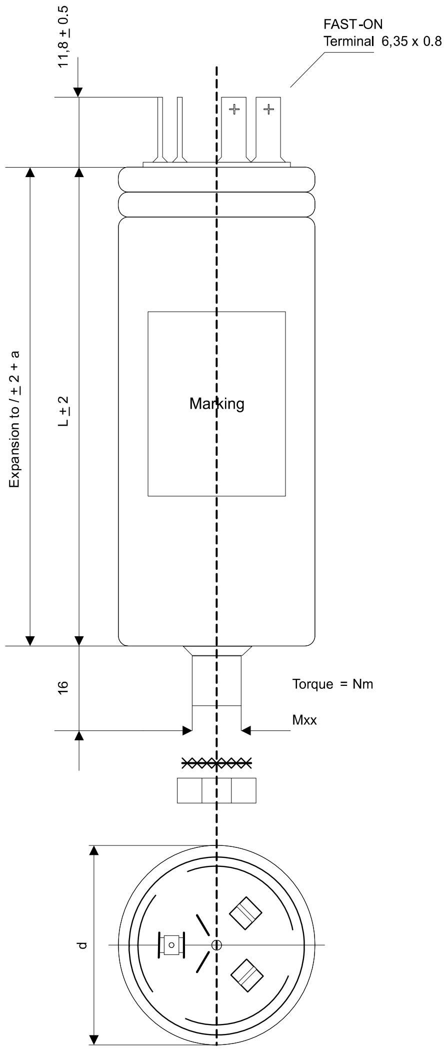


Figure 5-17 3-phase Polecap dimensions

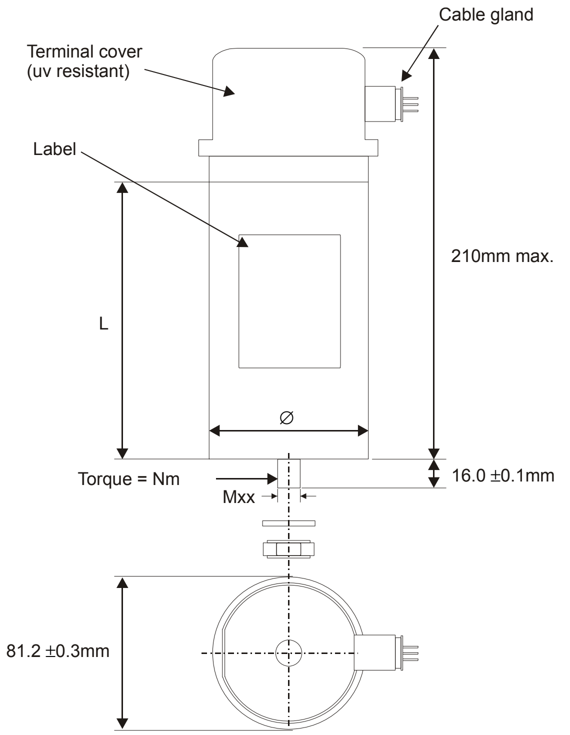


Figure 5-18 3-phase Phasecap dimensions

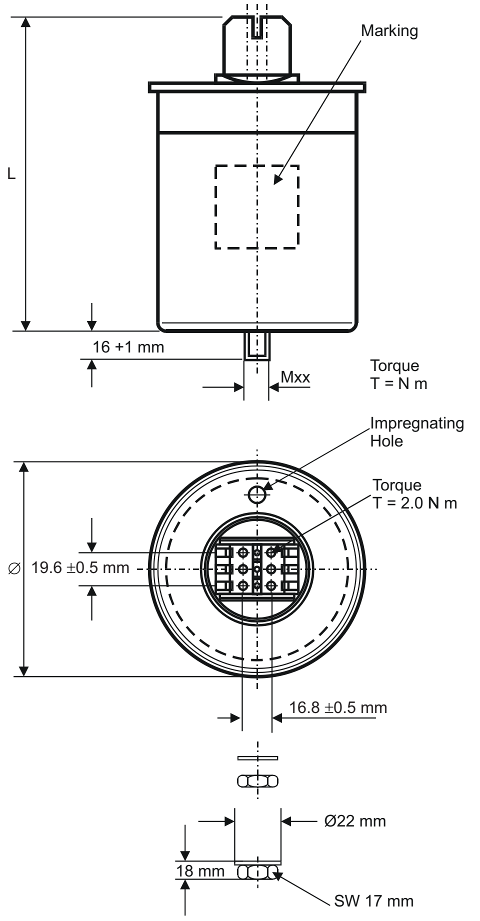


Figure 5-19 SFF capacitor dimensions (rated to 8 % THD_v)

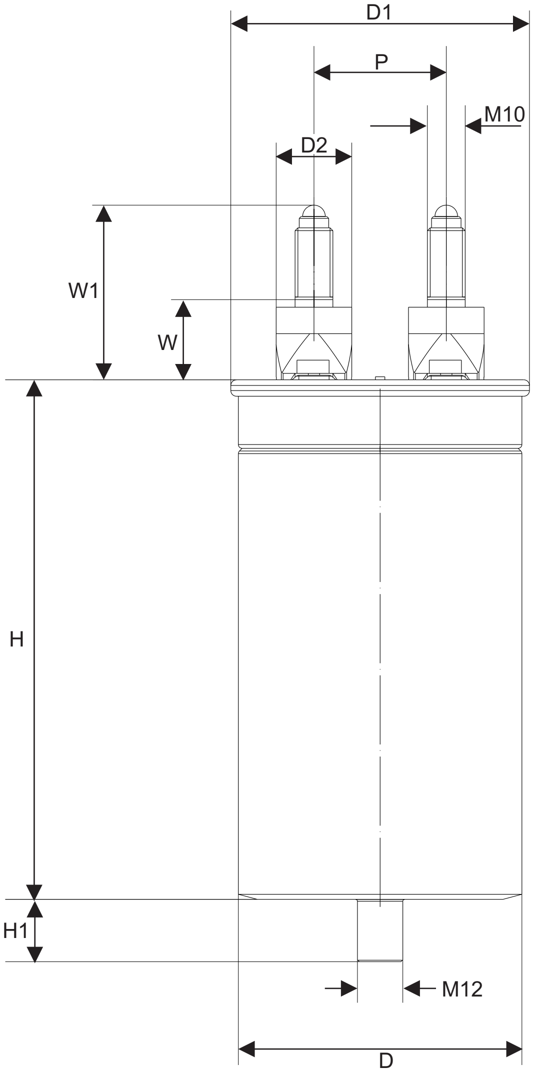


Table 5-8 SFF capacitor dimensions by part number

Part number	D	D1	D2	H	H1	P	W	W1	Weight
	mm	mm	mm	mm	mm	mm	mm	mm	kg
1610-8224	65	69	20	117	16	28	18	40	0.4
1610-8334	75	79	20	117	16	35	21	45	0.5
1610-8474	65	69	20	247	16	28	18	40	0.8
1610-8684	65	69	20	247	16	28	18	40	1
1610-8154	65	69	20	117	16	28	18	40	0.4
1610-8104	65	69	20	147	16	28	18	40	0.4

Mounting

Mounting vertically only.

NOTE

To allow sufficient cooling space:

> 10 mm space is required between caps.

> 15 mm space is required above the capacitor to allow the overpressure disconnector to extend.

5.4 External EMC filter

Table 5-9 Drive EMC filter details (size 3 to 11)

Model	Part number	Weight
03200066 to 03200106	4200-3230	1.9 kg (4.20 lb)
04200137 to 04200185	4200-0272	4.0 kg (8.82 lb)
05200250	4200-0312	5.5 kg (12.13 lb)
06200330 to 06200440	4200-2300	6.5 kg (14.30 lb)
07200610 to 07200830	4200-1132	6.0 kg (13.20 lb)
08201160 to 08201320	4200-1972	9.6 kg (21.20 lb)
09201760 to 09202190 (9A)	4200-3021	11.0 kg (24.30 lb)
10202830 to 10203000	4200-4460	12.0 kg (26.50 lb)
03400078 to 03400100	4200-3480	2.0 kg (4.40 lb)
04400150 to 04400172	4200-0252	4.1 kg (9.04 lb)
05400270 to 05400300	4200-0402	5.5 kg (12.13 lb)
06400350 to 06400470	4200-4800	6.7 kg (14.80 lb)
07400660 to 07401000	4200-1132	6.0 kg (13.20 lb)
08401340 to 08401570	4200-1972	9.6 kg (21.20 lb)
09402000 to 09402240 (9A)	4200-3021	11.0 kg (24.30 lb)
10402700 to 10403200	4200-4460	12.0 kg (26.50 lb)
11403770 to 11404640	4200-0400	14.7 kg (32.41 lb)
06500150 to 06500350	4200-3690	7.0 kg (15.40 lb)
07500440 to 07500550	4200-0672	6.2 kg (13.70 lb)
08500630 to 08500860	4200-1662	9.4 kg (20.70 lb)
09501040 to 09501310 (9A)	4200-1660	5.2 kg (11.50 lb)
10501520 to 10501900	4200-2210	10.3 kg (22.70 lb)
11502000 to 11502850	4200-0690	16.8 kg (36.90 lb)
07600190 to 07600540	4200-0672	6.2 kg (13.70 lb)
08600630 to 08600860	4200-1662	9.4 kg (20.70 lb)
09601040 to 09601310 (9A)	4200-1660	5.2 kg (11.50 lb)
10601500 to 10601780	4200-2210	10.3 kg (22.70 lb)
11602100 to 11602630	4200-0690	16.8 kg (36.90 lb)

CAUTION

When an EMC filter is used, the switching frequency filter detailed must also be used. Failure to observe this precaution may result in damage to the EMC filter thereby rendering it ineffective.

The external EMC filters for sizes 3 to 6 can be footprint or bookcase mounted, see Figure 5-20 and Figure 5-21. The external EMC filters for sizes 7 to 11 are designed to be mounted above the drive, as shown in Figure 5-22.

Mount the external EMC filter following the guidelines in section 6.5.4 *Compliance with generic emission standards* on page 131.

Figure 5-20 Footprint mounting the EMC filter

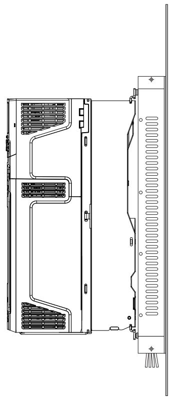


Figure 5-21 Bookcase mounting the EMC filter

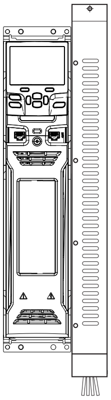
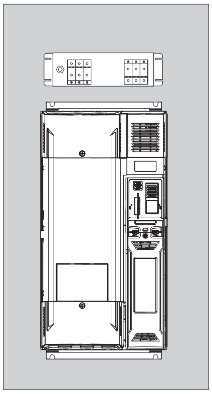
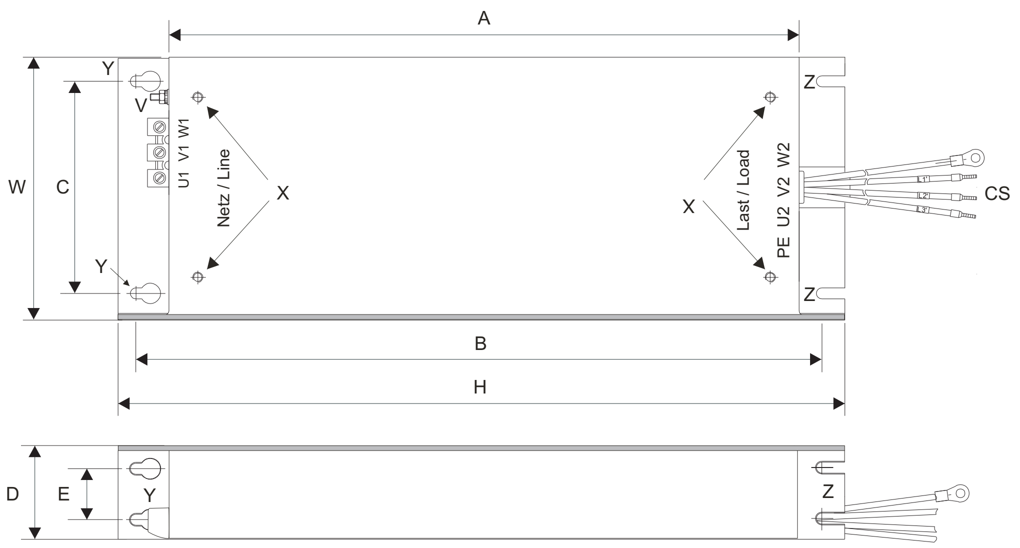


Figure 5-22 Size 7 to 11 mounting of EMC filter



Mount the external EMC filter following the guidelines in section 6.5.4 *Compliance with generic emission standards* on page 131.

Figure 5-23 Size 3 and 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

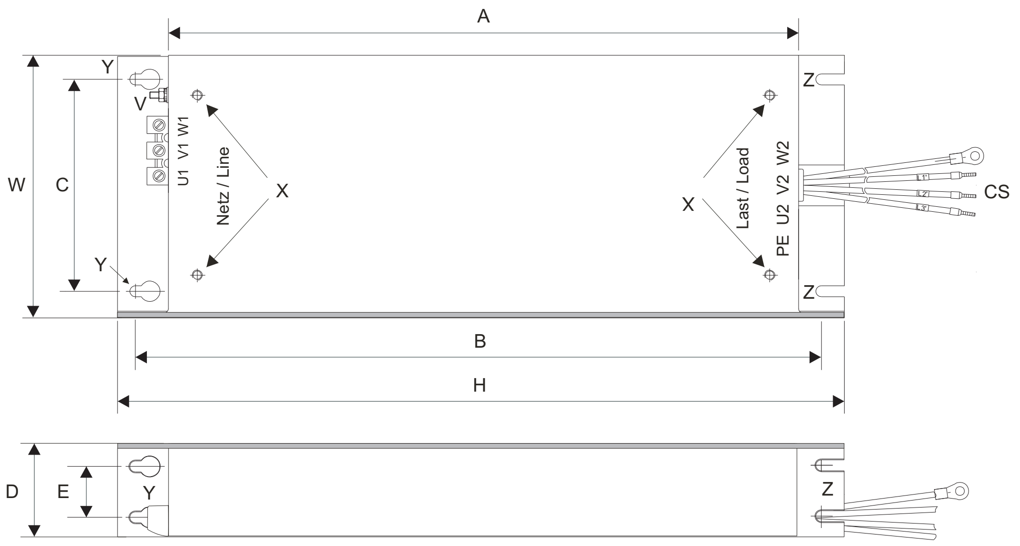
Table 5-10 Size 3 external EMC filter dimensions

Part number	A	B	C	D	E	H	W	V/X	Y/Z	CS
4200-3230	384 mm (15.12 in)	414 mm (16.30 in)	56 mm (2.21 in)	41 mm (1.61 in)		426 mm (16.77 in)	83 mm (3.27 in)	M5	5.5 mm (0.22 in)	2.5 mm² (14 AWG)
4200-3480										

Table 5-11 Size 4 external EMC filter dimensions

Part number	A	B	C	D	E	H	W	V/X	Y/Z	CS
4200-0272	395 mm (15.55 in)	425 mm (16.73 in)	100 mm (3.94 in)	60 mm (2.36 in)	33 mm (1.30 in)	437 mm (17.2 in)	123 mm (4.84 in)	M6	6.5 mm (0.26 in)	6 mm² (10 AWG)
4200-0252										

Figure 5-24 Size 5 and 6 external EMC filter



V: Ground stud
X: Threaded holes for footprint mounting of the drive
Y: Footprint mounting hole diameter
Z: Bookcase mounting slot diameter.
CS: Cable size

Table 5-12 Size 5 external EMC filter dimensions

Part number	A	B	C	D	E	H	W	V/X	Y/Z	CS
4200-0312	395 mm (15.55 in)	425 mm (16.73 in)	106 mm (4.17 in)	60 mm (2.36 in)	33 mm (1.30 in)	437 mm (17.2 in)	143 mm (5.63 in)	M6	6.5 mm (0.26 in)	10 mm^2 (8 AWG)
4200-0402										
4200-0122										2.5 mm^2 (14 AWG)

Table 5-13 Size 6 external EMC filter dimensions

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

Figure 5-25 Size 7 and 8 external EMC filter

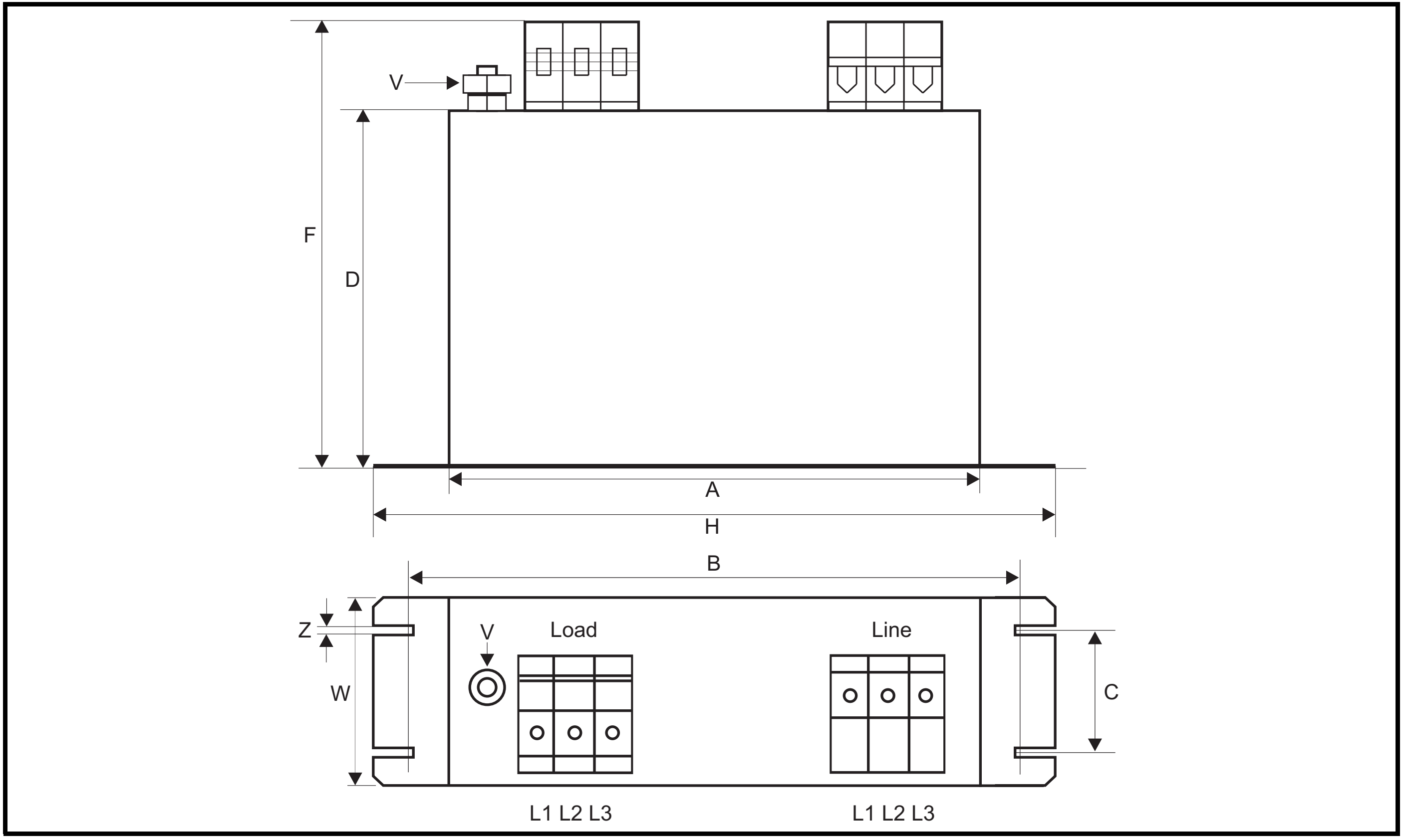


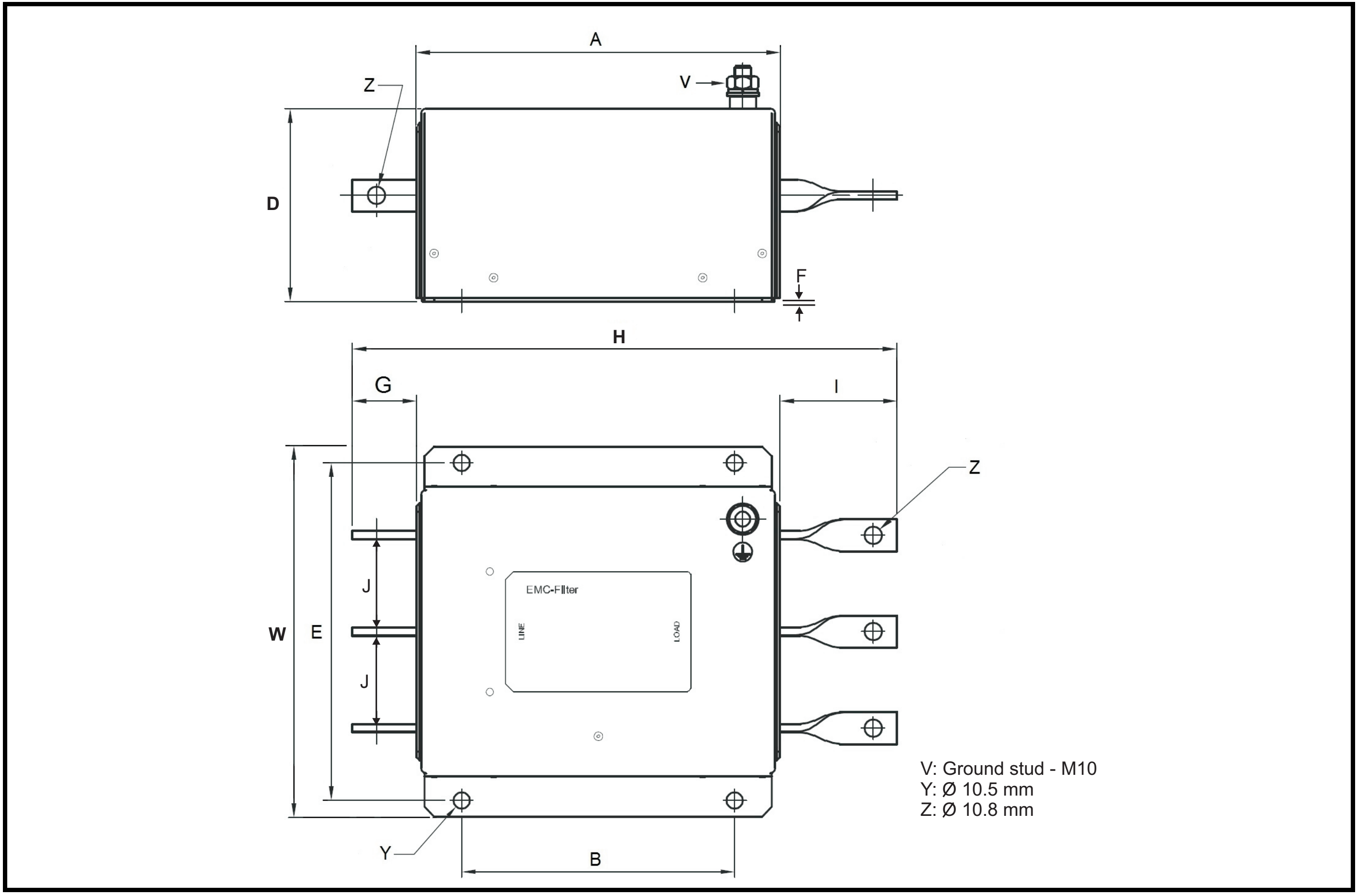
Table 5-14 Size 7 external EMC filter dimensions

Part number	A	B	C	D	E	F	H	W	V	X	Y	Z
4200-1132	240 mm (9.45 in)	255 mm (10.04 in)	55 mm (2.17 in)	150 mm (5.90 in)		205 mm (8.07 in)	270 mm (10.63 in)	90 mm (3.54 in)	M10			6.5 mm (0.26 in)
4200-0672												

Table 5-15 Size 8 external EMC filter dimensions

Part number	A	B	C	D	E	F	H	W	V	X	Y	Z
4200-1972	260 mm (10.24 in)	275 mm (10.83 in)	85 mm (3.35 in)	170 mm (6.69 in)		249 mm (9.79 in)	300 mm (11.81 in)	120 mm (4.72 in)	M10			6.5 mm (10.26 in)
4200-1662												

Figure 5-26 Size 9A external EMC filter

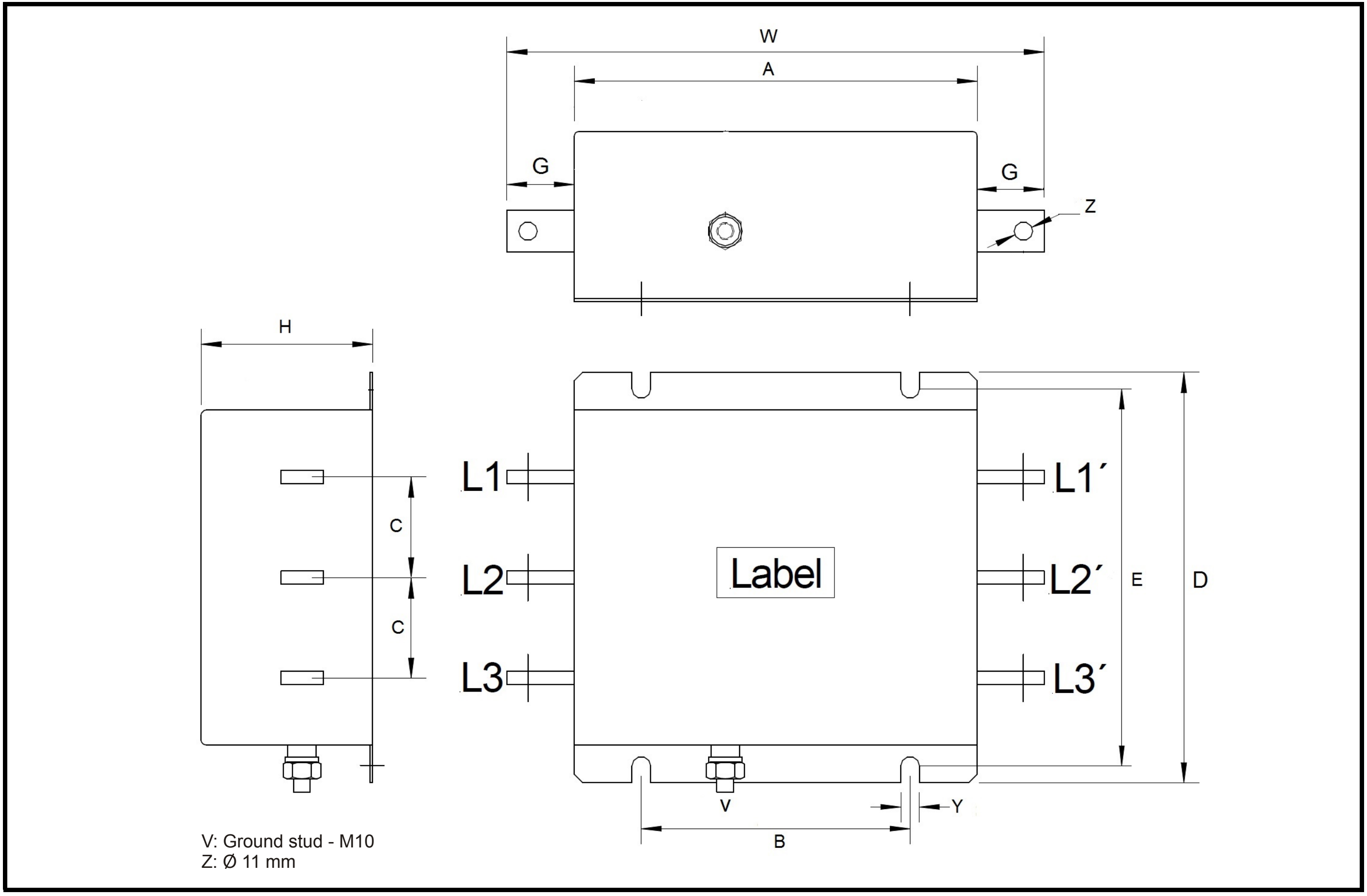


V: Ground stud - M10
Y: Ø 10.5 mm
Z: Ø 10.8 mm

Table 5-16 Size 9A external EMC filter dimensions

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

Figure 5-27 External EMC filter (size 9 and 10)

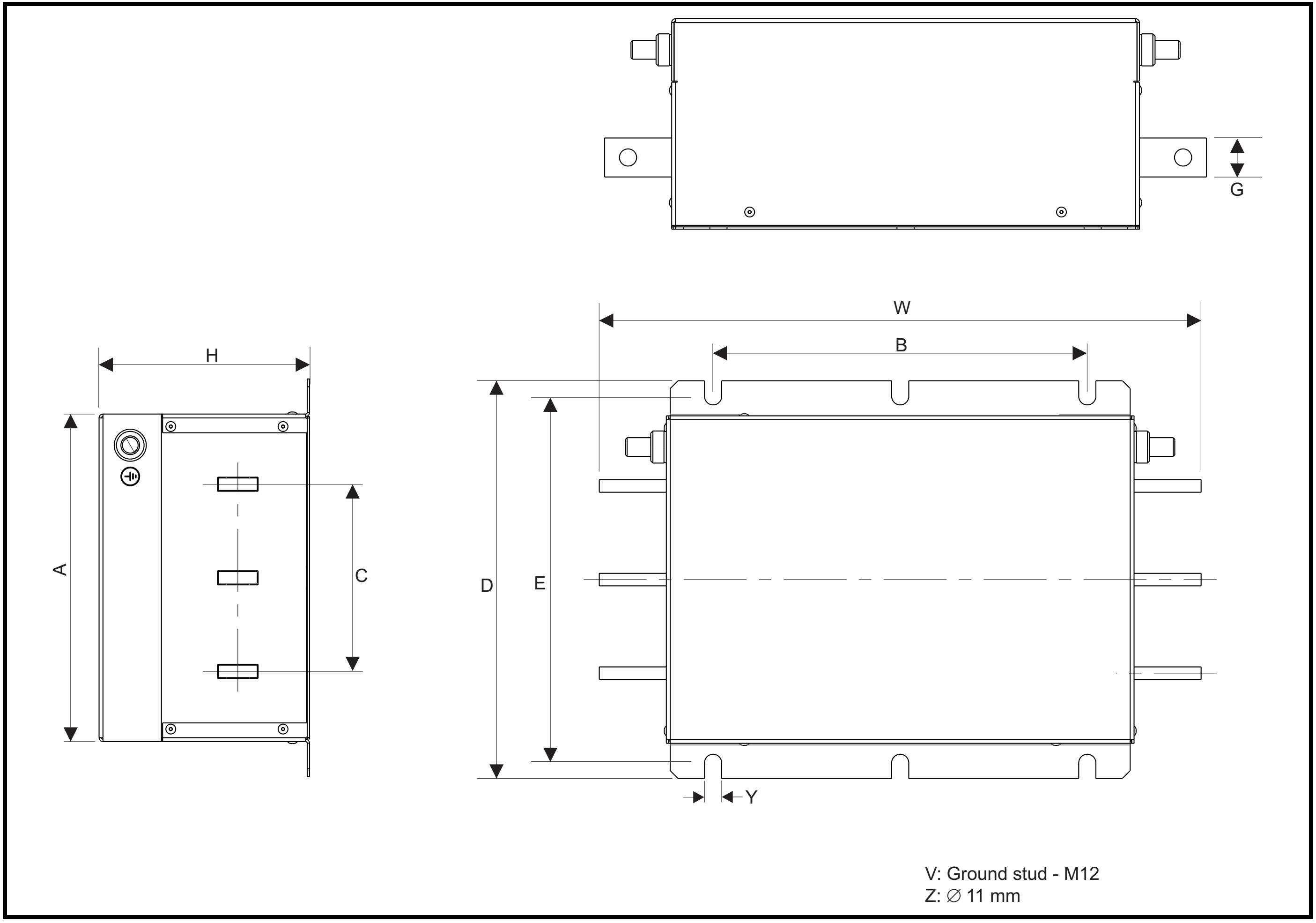


V: Ground stud - M10
Z: Ø 11 mm

Table 5-17 Unidrive M size 9 and 10 external EMC filter dimensions

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

Figure 5-28   External EMC filter (size 9 and 10)



V: Ground stud - M12
Z: ∅ 11 mm

Table 5-18   Unidrive M size 9 and 10 external EMC filter dimensions

Part number	A	B	C	D	E	G	H	W	Y
4200-4460	210 mm (8.27 in)	240 mm (9.45 in)	120 mm (4.72 in)	255 mm (10.04 in)	235 mm (9.25 in)	25 mm (0.98 in)	135 mm (5.32 in)	386 mm (14.02 in)	11 mm (0.43 in)

Figure 5-29 Size 11 external EMC filter

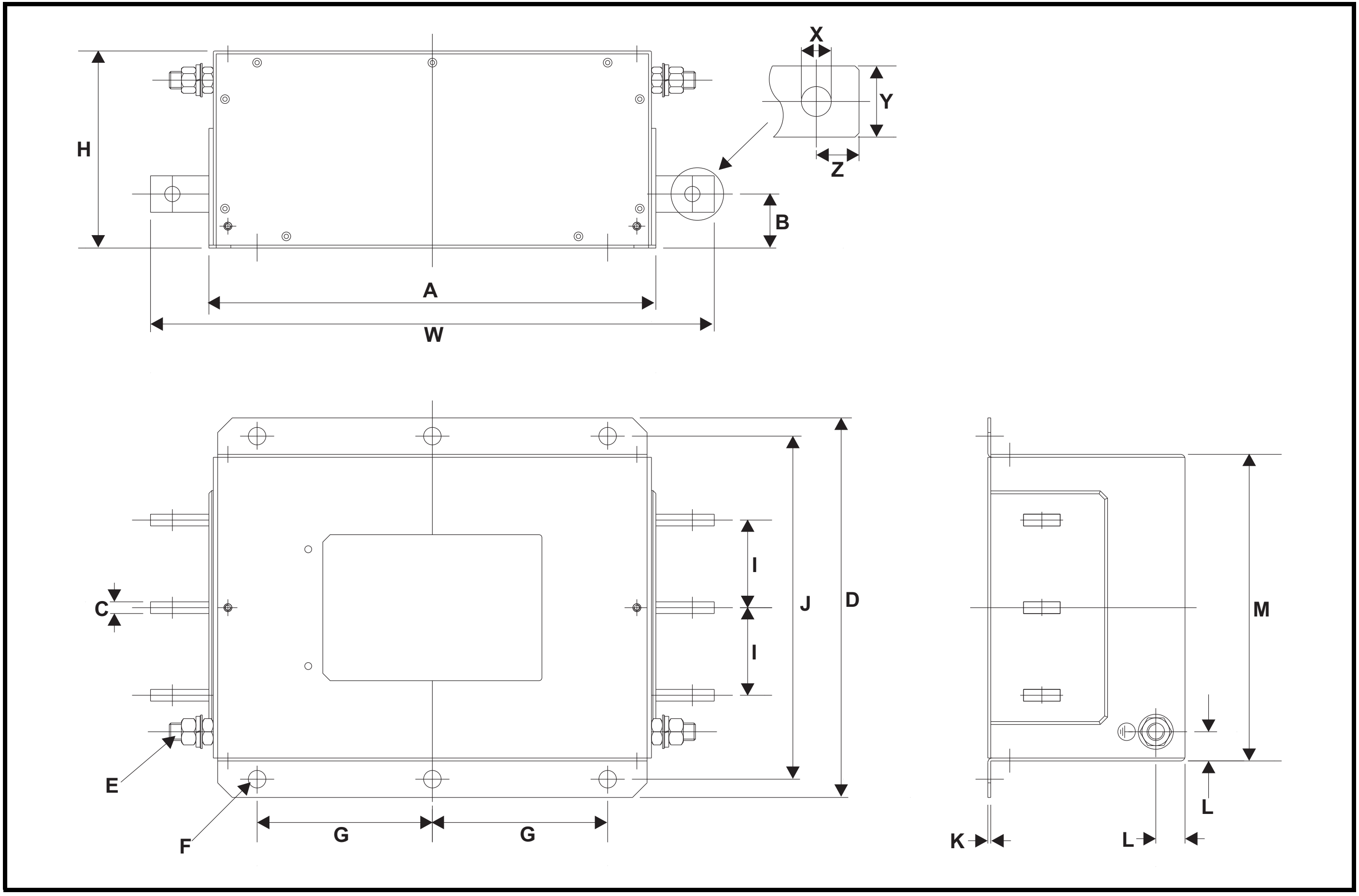


Table 5-19 Size 11 external EMC filter dimensions

Part number	A	B	C	D	E	F	G	H	I	J	K
4200-0400	306 mm (12.05 in)	37 mm (1.46 in)	8 mm (0.32 in)	260 mm (10.2 in)	M12	12 mm (0.47 in)	120 mm (4.72 in)	135 mm (5.32 in)	60 mm (2.36 in)	235 mm (9.25 in)	2 mm (0.08 in)
4200-0690											

Part number	L	M	X	Y	Z	W
4200-0400	20 mm (0.79 in)	210 mm (8.27 in)	10.5 mm (0.41 in)	25 mm (0.98 in)	15 mm (0.59 in)	386 mm (15.20 in)
4200-0690						

CAUTION

When a EMC filter is used, the switching frequency filter detailed must also be used. Failure to observe this may result in the EMC filter becoming ineffective and being damaged.

Table 5-20 Resistor mounting bracket dimensions

A	B	C	D
24.0 mm	33.5 mm	21.45 mm ±0.2	Ø 5.0

NOTE

For component selection refer to either Chapter 10 *Technical data* on page 276 or section 3.9 *Regen components* on page 29.

5.4.1 Varistors

Figure 5-30 Varistor dimensions

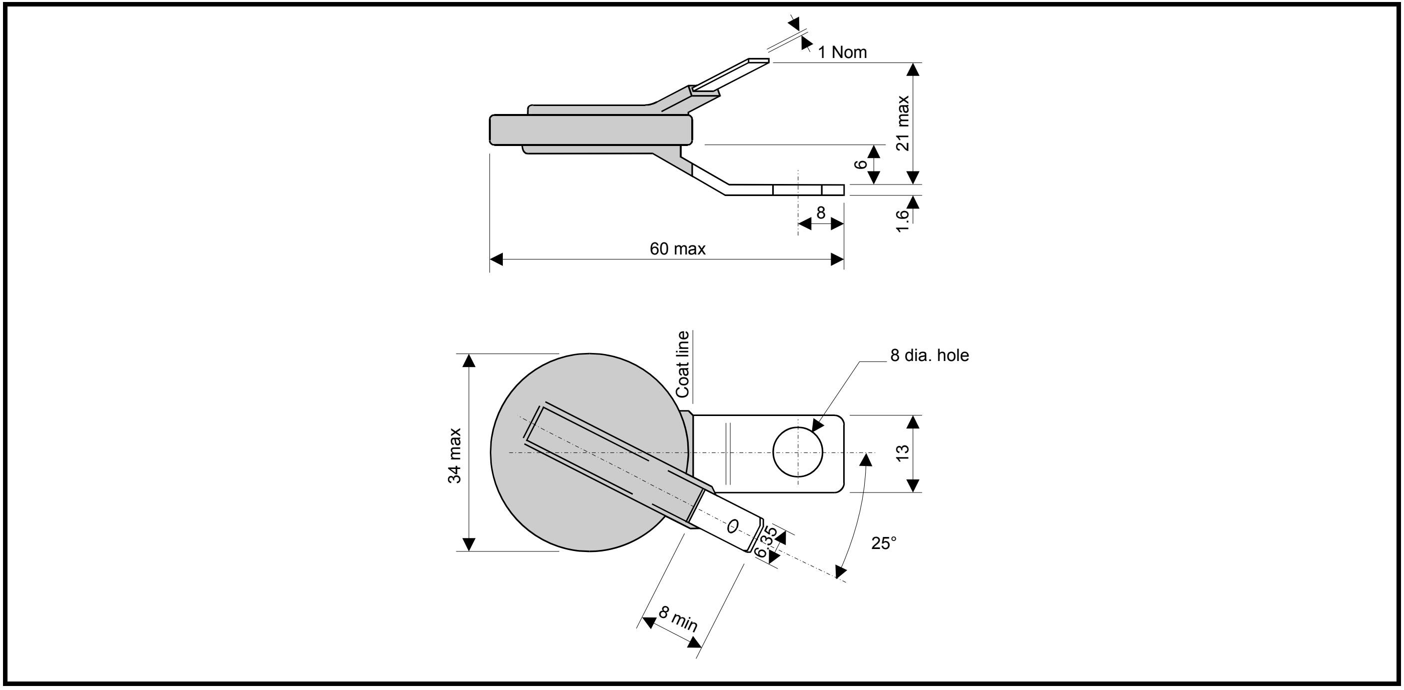


Table 5-21 Varistor specifications

Drive rating	Varistor voltage rating V_{RMS}	Energy rating J	Quantity per system	Configuration	Part number
200 V (200 V to 240 V ±10 %)	550	620	3	Line to line	2482-3291
	680	760	3	Line to ground	2482-3211
400 V (380 V to 480 V ±10 %)	550	620	3	Line to line	2482-3291
	680	760	3	Line to ground	2482-3211
575 V (500 V to 575 V ±10 %)	680	760	3	Line to line	2482-3211
	1000	1200	3	Line to ground	2482-3218
690 V (500 V to 690 V ±10 %)	385	550	6	2 in series line to line	2482-3262
	1000	1200	3	Line to ground	2482-3218

5.5 Combined Regen input filters (combi filter)

WARNING

Combi filters listed in Table 3-23 *Combi filter selection* on page 39 are equipped with an internal thermal switch to prevent the EMC filter inductor from overheating. The thermal switch must be configured to open the main supply contactor in the event of a thermal overload.

Figure 5-31 Schaffner combi filter dimensions (FS6085-83-35-2 and FS6085-125-35-2)

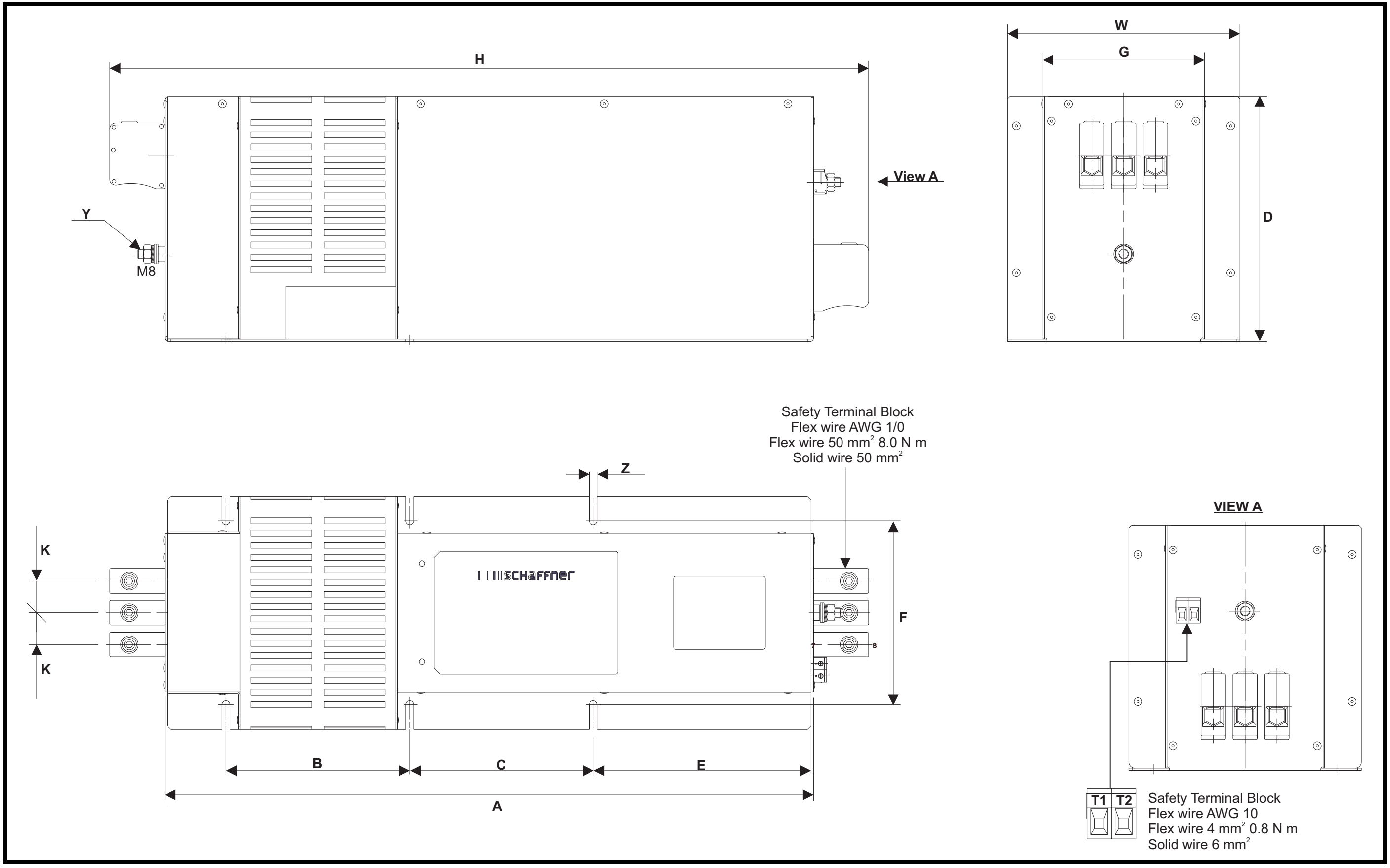
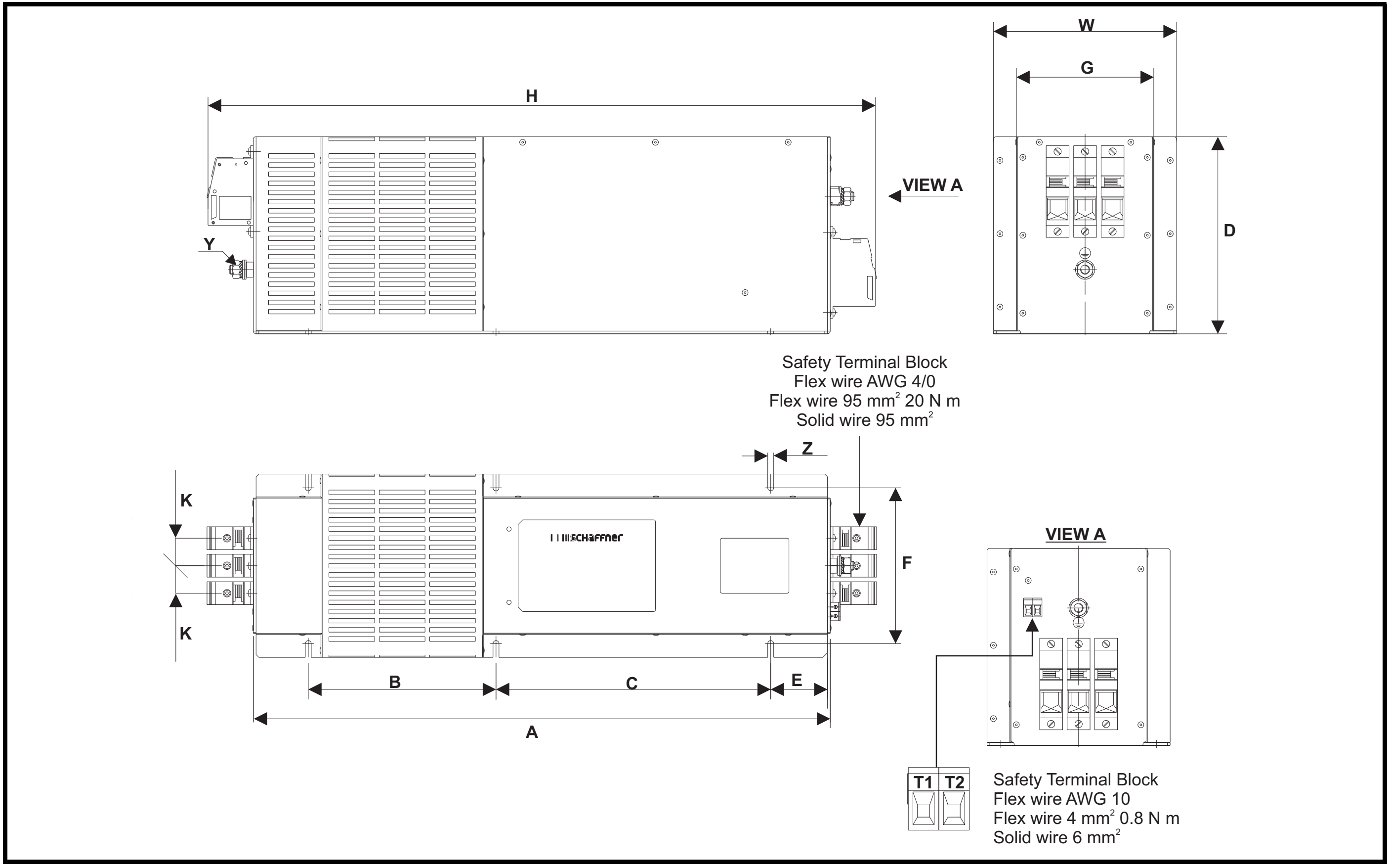


Table 5-22 Schaffner combi filter dimensions (FS6085-83-35-2 and FS6085-125-35-2)

Schaffner model number	A	B	C	D	E	F	G	H	K	W	Y	Z
FS6085-83-35-2	530 mm (20.87 in)	150 mm (5.91 in)	150 mm (5.91 in)	200 mm (7.87 in)	178 mm (7.01 in)	150 mm (5.91 in)	132 mm (5.20 in)	620 mm (24.41 in)	26 mm (1.02 in)	190 mm (7.48 in)	M8	6.5 mm (0.26 in)
FS6085-125-35-2												

Figure 5-32 Schaffner combi filter dimensions (FS6085-168-40-2 and FS6085-205-40-2)



Safety Terminal Block
Flex wire AWG 4/0
Flex wire 95 mm^2 20 N m
Solid wire 95 mm^2

Safety Terminal Block
Flex wire AWG 10
Flex wire 4 mm^2 0.8 N m
Solid wire 6 mm^2

Table 5-23 Schaffner combi filter dimensions (FS6085-168-40-2 and FS6085-205-40-2)

Schaffner model number	A	B	C	D	E	F	G	H	K	W	Y	Z
FS6085-168-40-2	630 mm (24.80 in)	205 mm (8.07 in)	300 mm (11.81 in)	215 mm (8.47 in)	62 mm (2.44 in)	170 mm (6.69 in)	150 mm (5.91 in)	730 mm (28.74 in)	30 mm (1.18 in)	200 mm (7.87 in)	M10	6.5 mm (0.26 in)
FS6085-205-40-2												

Figure 5-33 Schaffner combi filter dimensions (FS6085-300-99-2)

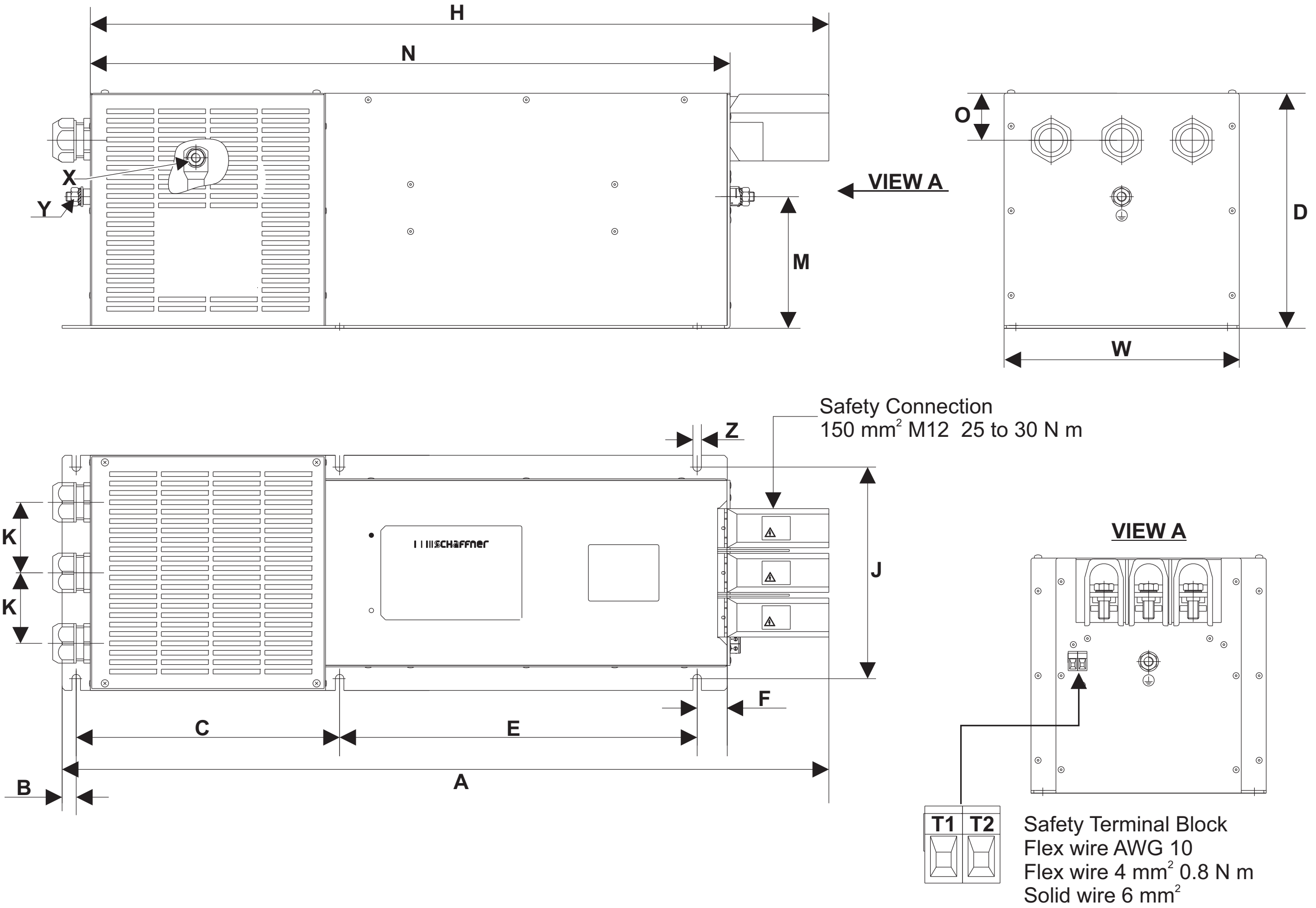
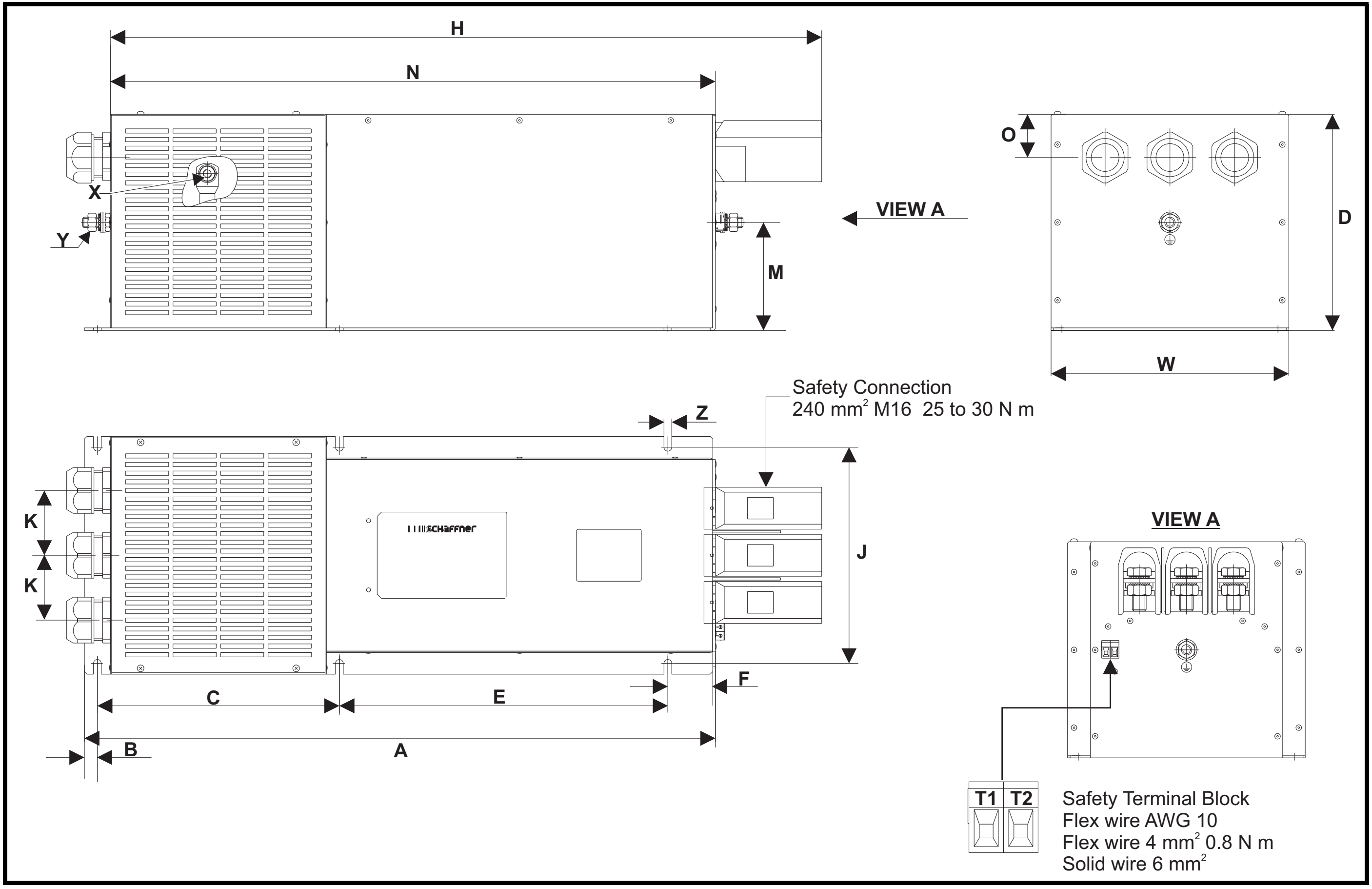


Table 5-24 Schaffner combi filter dimensions (FS6085-300-99-2)

Schaffner model number	A	B	C	D	E	F	H	J
FS6085-300-99-2	815 mm (32.09 in)	15 mm (0.59 in)	280 mm (11.02 in)	250 mm (9.84 in)	380 mm (14.96 in)	32 mm (1.26 in)	785 mm (30.91 in)	225 mm (8.86 in)
	K	**M**	**N**	**O**	**W**	**X**	**Y**	**Z**
	75 mm (2.95 in)	140 mm (5.51 in)	680 mm (26.77 in)	50 mm (1.97 in)	250 mm (9.84 in)	M12	M10	9 mm (0.35 in)

Figure 5-34 Schaffner combi filter dimensions (FS6085-350-99-2)



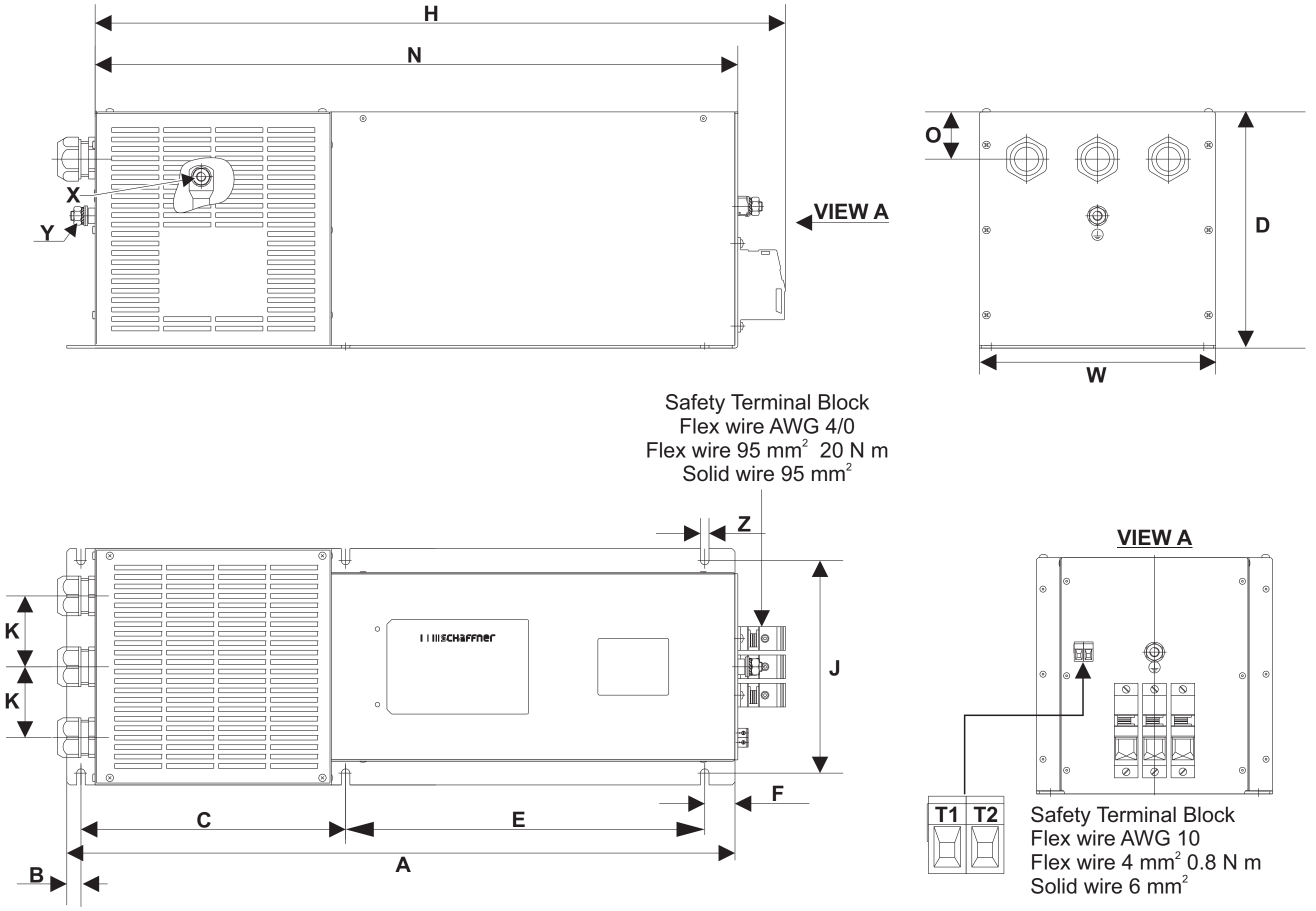
Safety Connection
240 mm² M16 25 to 30 N m

Safety Terminal Block
Flex wire AWG 10
Flex wire 4 mm² 0.8 N m
Solid wire 6 mm²

Table 5-25 Schaffner combi filter dimensions (FS6085-350-99-2)

Schaffner model number	A	B	C	D	E	F	H	J
FS6085-350-99-2	730 mm (28.74 in)	15 mm (0.59 in)	280 mm (11.02 in)	250 mm (9.84 in)	380 mm (14.96 in)	52 mm (2.05 in)	823 mm (32.40 in)	250 mm (9.84 in)
	K	**M**	**N**	**O**	**W**	**X**	**Y**	**Z**
	75 mm (2.95 in)	125 mm (4.92 in)	700 mm (27.56 in)	50 mm (1.97 in)	275 mm (10.83 in)	M12	M12	9 mm (0.35 in)

Figure 5-35 Schaffner combi filter dimensions (FS6085HV-200-40-2)



Safety Terminal Block
Flex wire AWG 4/0
Flex wire 95 mm^2 20 N m
Solid wire 95 mm^2

Safety Terminal Block
Flex wire AWG 10
Flex wire 4 mm^2 0.8 N m
Solid wire 6 mm^2

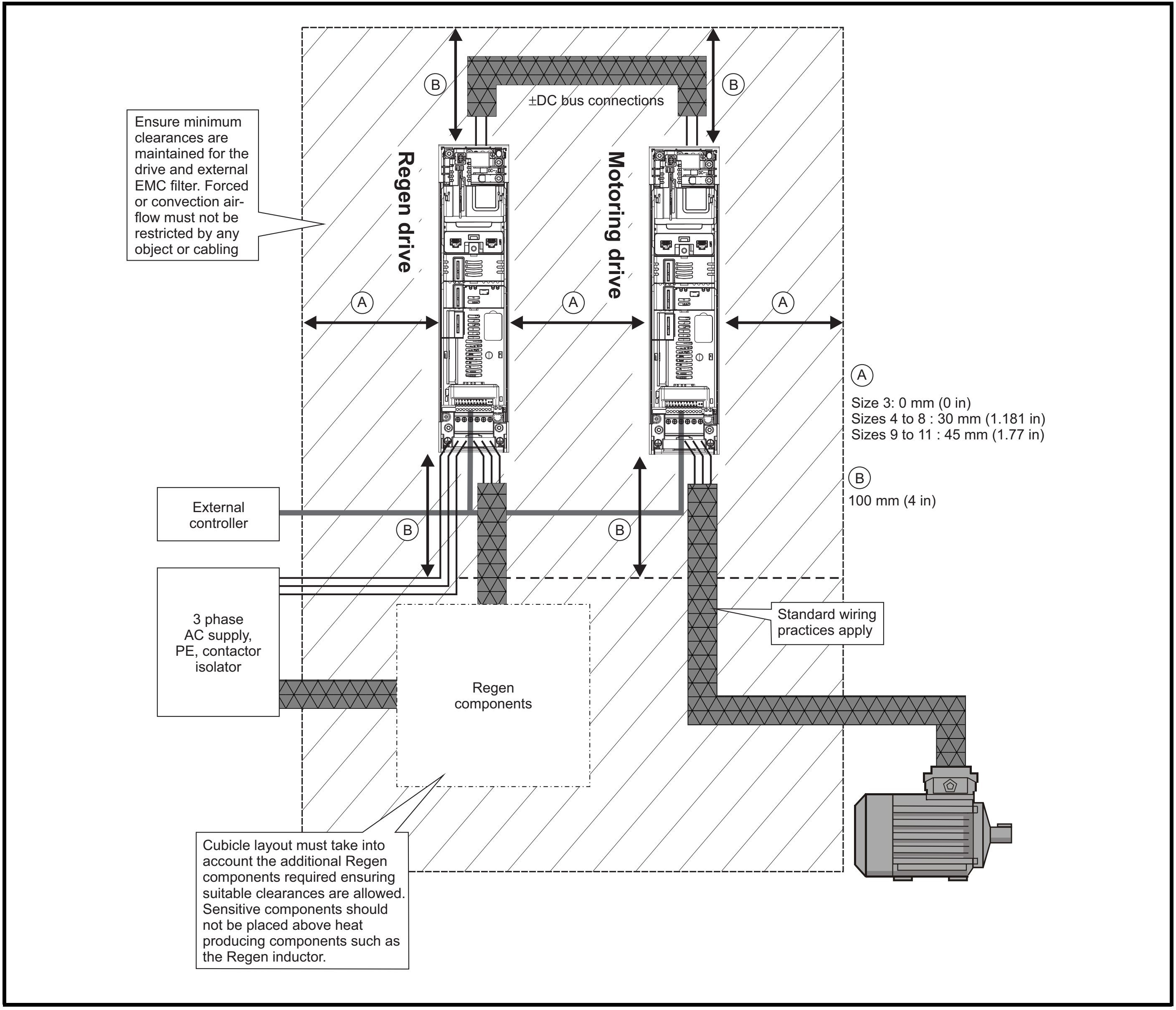
Table 5-26 Schaffner combi filter dimensions (FS6085HV-200-40-2)

Schaffner model number	A	B	C	D	E	F	H	J
FS6085**HV**-200-40-2	710 mm (27.95 in)	15 mm (0.59 in)	280 mm (11.02 in)	250 mm (9.84 in)	380 mm (14.96 in)	35 mm (1.38 in)	730 mm (28.74 in)	225 mm (8.86 in)
	K	**M**	**N**	**O**	**W**	**X**	**Y**	**Z**
	75 mm (2.95 in)	140 mm (5.51 in)	680 mm (26.77 in)	50 mm (1.97 in)	250 mm (9.84 in)	M10	M10	9 mm (0.35 in)

5.5.1 Enclosure layout

Please observe the clearances in the diagram below for the Unidrive M plus also take into account any clearances required for other devices / auxiliary equipment when planning the installation.

Figure 5-36 Enclosure layout



5.5.2 Enclosure sizing

1. Add the dissipation figures from Chapter 10 *Technical data* for each drive that is to be installed in the enclosure.
2. Calculate the total heat dissipation (in Watts) of any other equipment to be installed in the enclosure.
    - EMC filter
    - Switching frequency filter
    - Regen choke
3. Add the heat dissipation figures obtained above. This gives a figure in Watts for the total heat that will be dissipated inside the enclosure.

Calculating the size of a sealed enclosure

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

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

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

Where:

$\mathbf{A_e}$	Unobstructed surface area in m² (1 m² = 10.9 ft²)
$\mathbf{T_{ext}}$	Maximum expected temperature in °C *outside* the enclosure
$\mathbf{T_{int}}$	Maximum permissible temperature in °C *inside* the enclosure
P	Power in Watts dissipated by *all* heat sources in the enclosure
k	Heat transmission coefficient of the enclosure material in W/m²/°C

Example

To calculate the size of a non-ventilated enclosure for the following:

- Two Unidrive M600-03400078 (1 x Regen and 1 x motoring drive) models operating at the Normal Duty rating
- Each drive to operate at 6 kHz PWM switching frequency
- External EMC filter (4200-3480) for each drive
- Maximum ambient temperature inside the enclosure: 40 °C
- Maximum ambient temperature outside the enclosure: 30 °C

Dissipation of each drive: 186 W (see Chapter 10 *Technical Data*).

Dissipation of external EMC filter: 13 W (max) (see Chapter 10 *Technical Data*)

Dissipation of each external Regen inductor (4401-0001): 125 W x 1 (see section 10.4.2 *Regen filter components for high quality/low harmonic power supplies* on page 294)

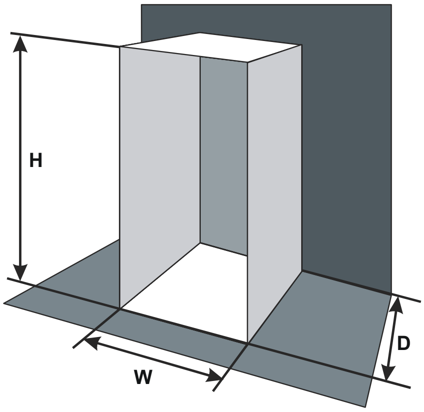
Dissipation of external switching frequency filter (4401-0162): 28 W x 1 (see Chapter 10 *Technical data* on page 276)

Total dissipation: ((186 x 2) + 13 + 125 + 28) = 538 W

The enclosure is to be made from painted 2 mm (0.079 in) sheet steel having a heat transmission coefficient of 5.5 W/m²/°C. Only the top, front, and two sides of the enclosure are free to dissipate heat.

The value of 5.5 W/m²/°C can generally be used with a sheet steel cubicle (exact values can be obtained by the supplier of the material). If in any doubt, allow for a greater margin in the temperature rise.

Figure 5-37 Enclosure having front, sides and top panels free to dissipate heat



Insert the following values:

$\mathbf{T_{int}}$	40 °C
$\mathbf{T_{ext}}$	30 °C
k	5.5
P	538 W

The minimum required heat conducting area is then:

$$\mathbf{A_e = \frac{538}{5{,}5(40 - 30)}}$$

= 9.782 m² (106.62 ft²) (1 m² = 10.9 ft²)

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

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

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

$$\mathbf{W} = \frac{\mathbf{9{,}782 - (2 \times 2 \times 0{,}6)}}{\mathbf{2 + 0{,}6}}$$

= 2.8 m (111.78 in)

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

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

Calculating the air-flow in a ventilated enclosure

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

Calculate the minimum required volume of ventilating air from:

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

Where:

V	Air-flow in 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 $\frac{\mathbf{P_o}}{\mathbf{P_l}}$

Where:

P_0 is the air pressure at sea level

P_l is the air pressure at the installation

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

Example

To calculate the size of an enclosure for the following:

- Two M600-03400100 (1 x Regen and 1 x motoring drive) models operating at the Normal Duty rating
- Each drive to operate at 6kHz PWM switching frequency
- External EMC filter (4200-3480) for each drive
- Maximum ambient temperature inside the enclosure: 40 °C
- Maximum ambient temperature outside the enclosure: 30 °C

Dissipation of each drive: 209 W (see Chapter 10 *Technical data* on page 276).

Dissipation of external EMC filter: 13 W (max) (see Chapter 10 *Technical data* on page 276).

Dissipation of external Regen inductor (4401-0002): 146 W x 1 (see section 10.4.2 *Regen filter components for high quality/low harmonic power supplies* on page 294)

Dissipation of external switching frequency filter (4401-0163): 35 W x 1 (see switching frequency filter (4401-0163): 35 W x 1 (see Chapter 10 *Technical data* on page 276).

Total dissipation: ((209 x 2) + (13 + 146 + 35) = 612 W

Insert the following values:

T_{int}	40 °C
T_{ext}	30 °C
k	1.3
P	612 W

Then:

$$\mathbf{V} = \frac{\mathbf{3 \times 1{,}3 \times 612}}{\mathbf{40 - 30}}$$

= **238.68 m³/hr (140.82 ft³/min)** (1 m³/hr = 0.59 ft³/min)

5.6 Cubicle design and drive ambient temperature

Drive derating is required for operation in high ambient temperatures (derating information is provided in Chapter 10 *Technical data* on page 276).

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

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

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

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

Where:

T_{ext} = Temperature outside the cabinet

T_{int} = Temperature inside the cabinet

T_{rate} = Temperature used to select current rating from tables in Chapter 10 *Technical data* on page 276.

CAUTION

Regen inductors can produce significant losses with a normal operating temperature in the region of 150 °C dependant upon the ambient temperature. Location of the Regen inductors should be considered to prevent damage to heat sensitive components or create a fire risk.

6 Electrical Installation

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

- Internal EMC filter (**MUST BE REMOVED**)
- EMC compliance with shielding / grounding accessories
- Product rating, fusing and cabling information

WARNING

STOP function

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

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

WARNING

Stored charge

The drive contains capacitors that remain charged to a potentially lethal voltage after the AC 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 the supplier of the drive or their authorised distributor.

WARNING

Equipment supplied by plug and socket

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

WARNING

Permanent magnet motors

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

If the motor load is capable of rotating the motor when the supply is disconnected, then the motor must be isolated from the drive before gaining access to any live parts.

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.

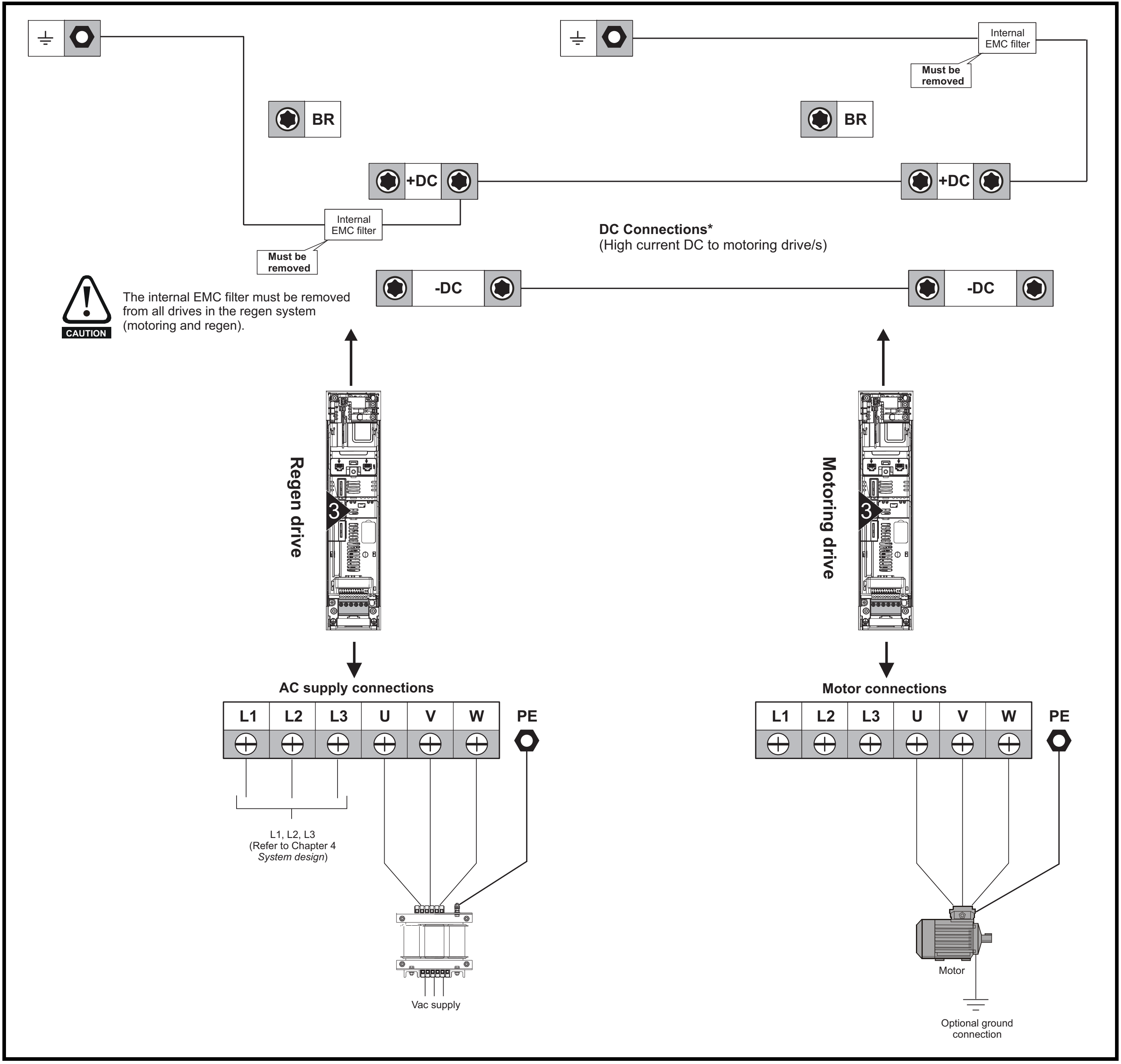
WARNING

Fusing as specified must be provided.

6.1 Power connections

6.1.1 AC and DC Regen connections

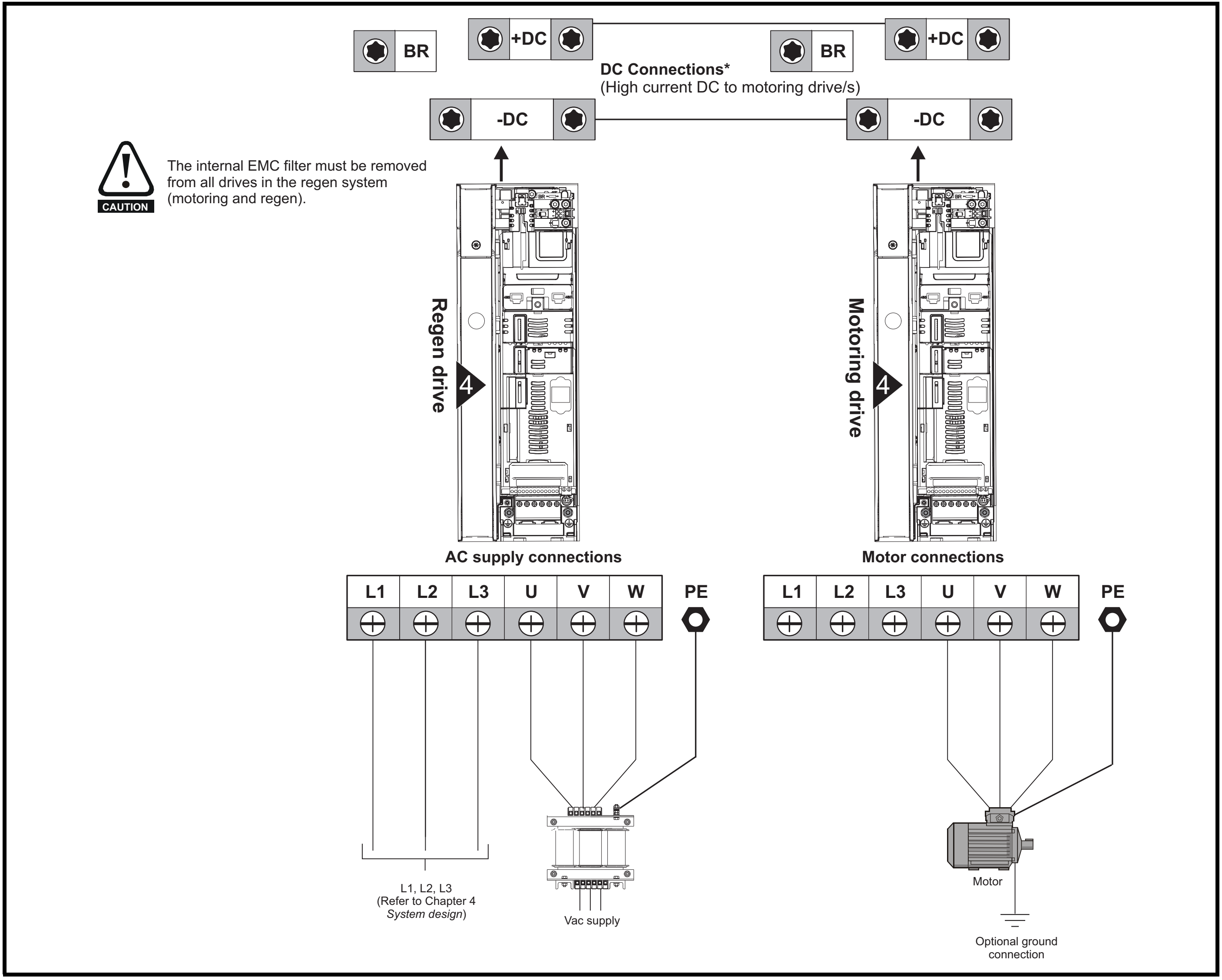
Figure 6-1 Unidrive M size 3 Regen drive power connections



* It is possible to connect the DC bus of a number of drives using a busbar kit (part number: 3470-0048), where DC bus fusing is not required.

See section 6.1.2 *Ground connections* on page 115.

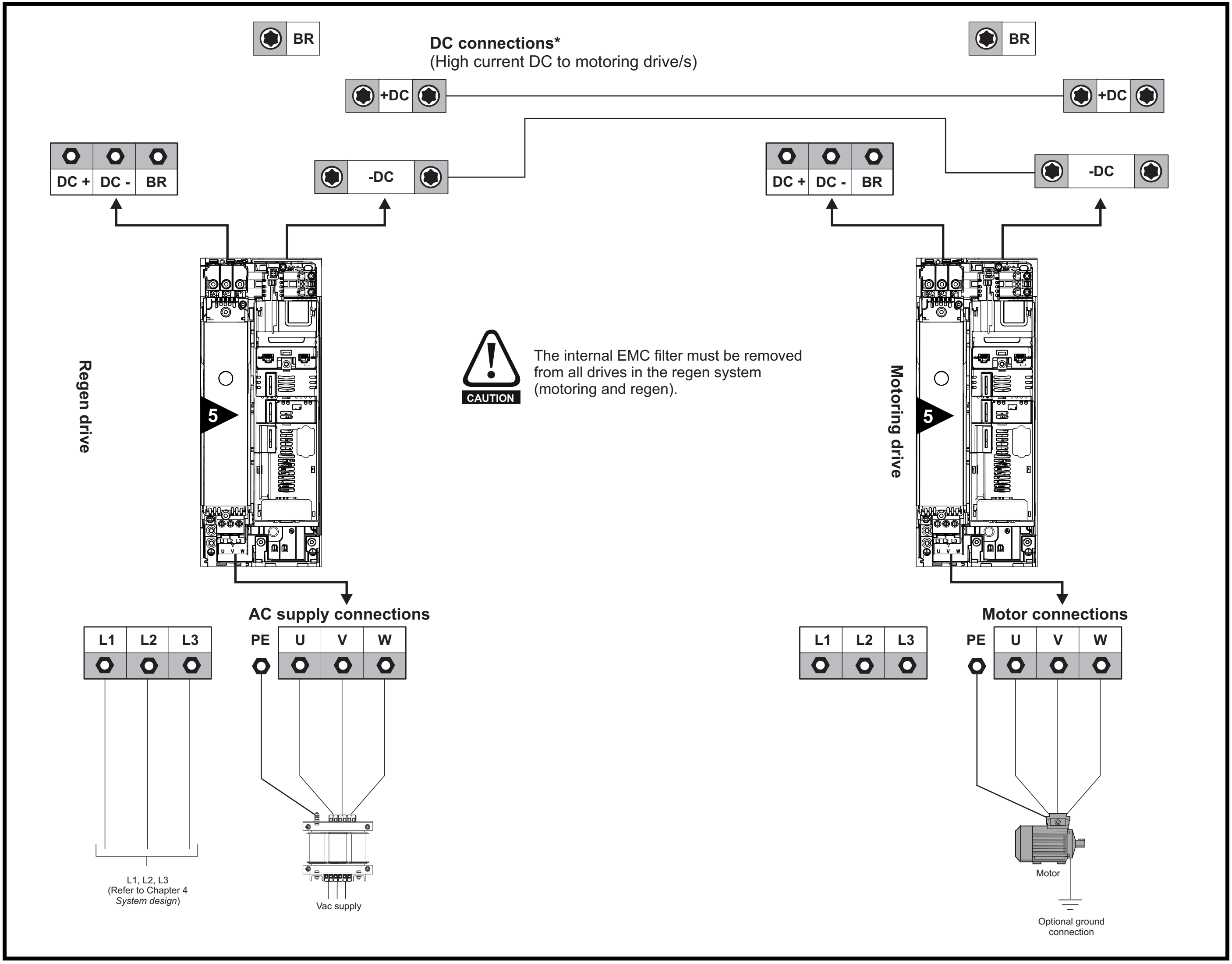
Figure 6-2 Unidrive M size 4 power connections



* It is possible to connect the DC bus of a number of drives using a busbar kit (part number: 3470-0061), where DC bus fusing is not required.

See section 6.1.2 *Ground connections* on page 115.

Figure 6-3 Unidrive M size 5 power connections

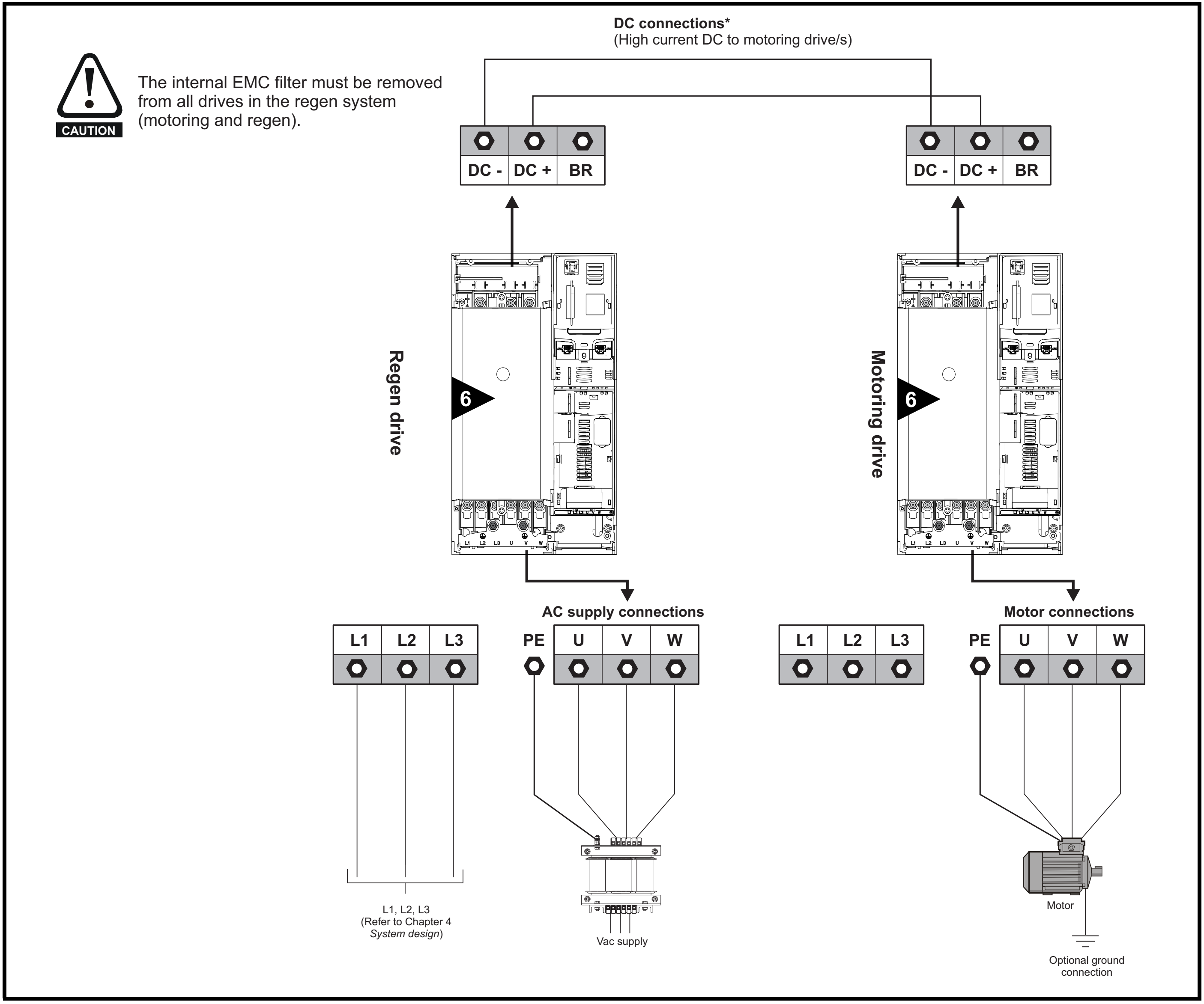


The internal EMC filter must be removed from all drives in the regen system (motoring and regen).

* It is possible to connect the DC bus of a number of drives using a busbar kit (part number: 3470-0068), where DC bus fusing is not required.

See section 6.1.2 *Ground connections* on page 115.

Figure 6-4 Unidrive M size 6 power connections



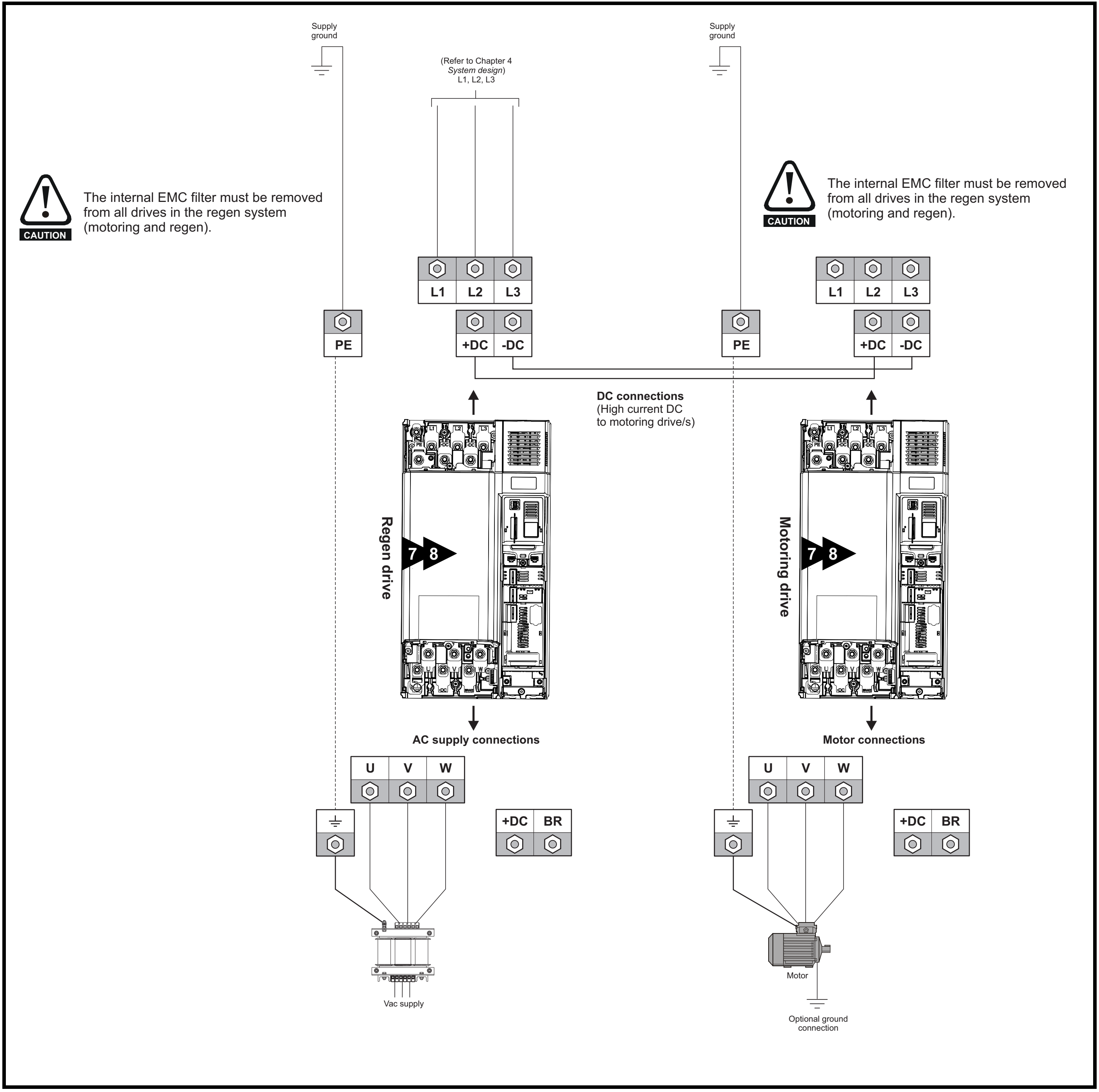
CAUTION

The internal EMC filter must be removed from all drives in the regen system (motoring and regen).

DC connections*
(High current DC to motoring drive/s)

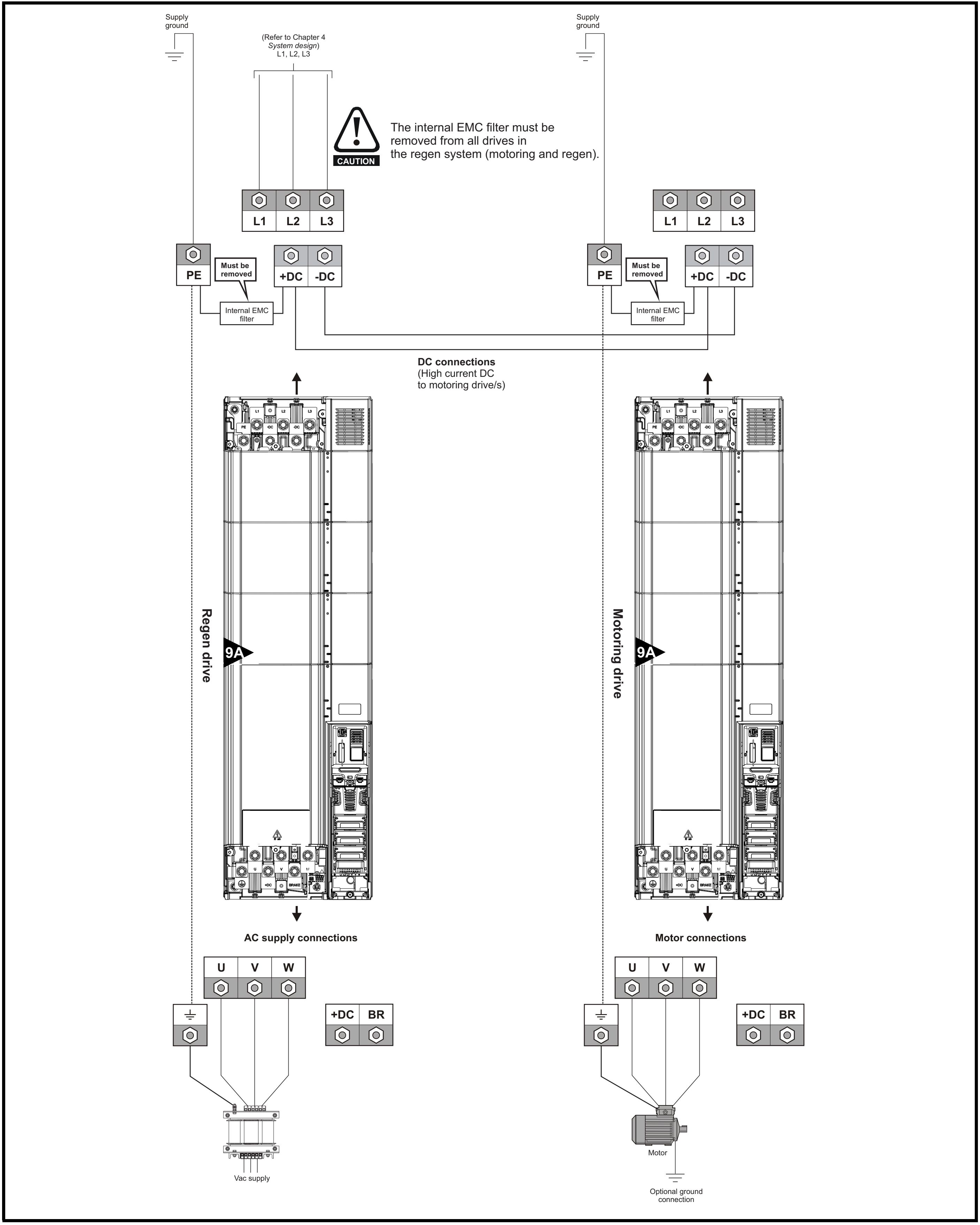
* It is possible to connect the DC bus of a number of drives using a busbar kit (part number: 3470-0063), where DC bus fusing is not required. See section 6.1.2 *Ground connections* on page 115.

Figure 6-5 Unidrive M size 7 and 8 power connections



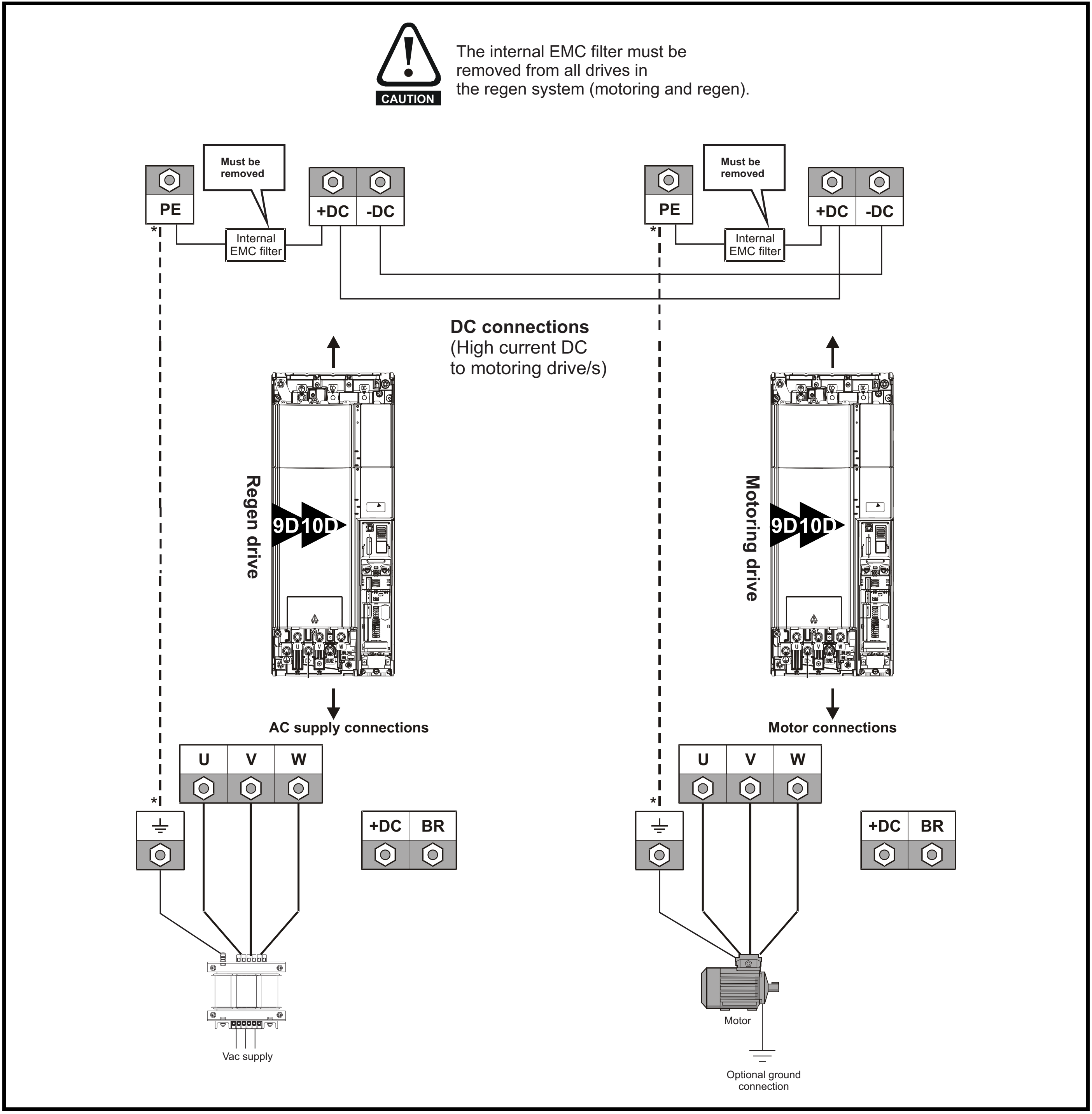
See section 6.1.2 *Ground connections* on page 115.

Figure 6-6 Unidrive M size 9A power connections



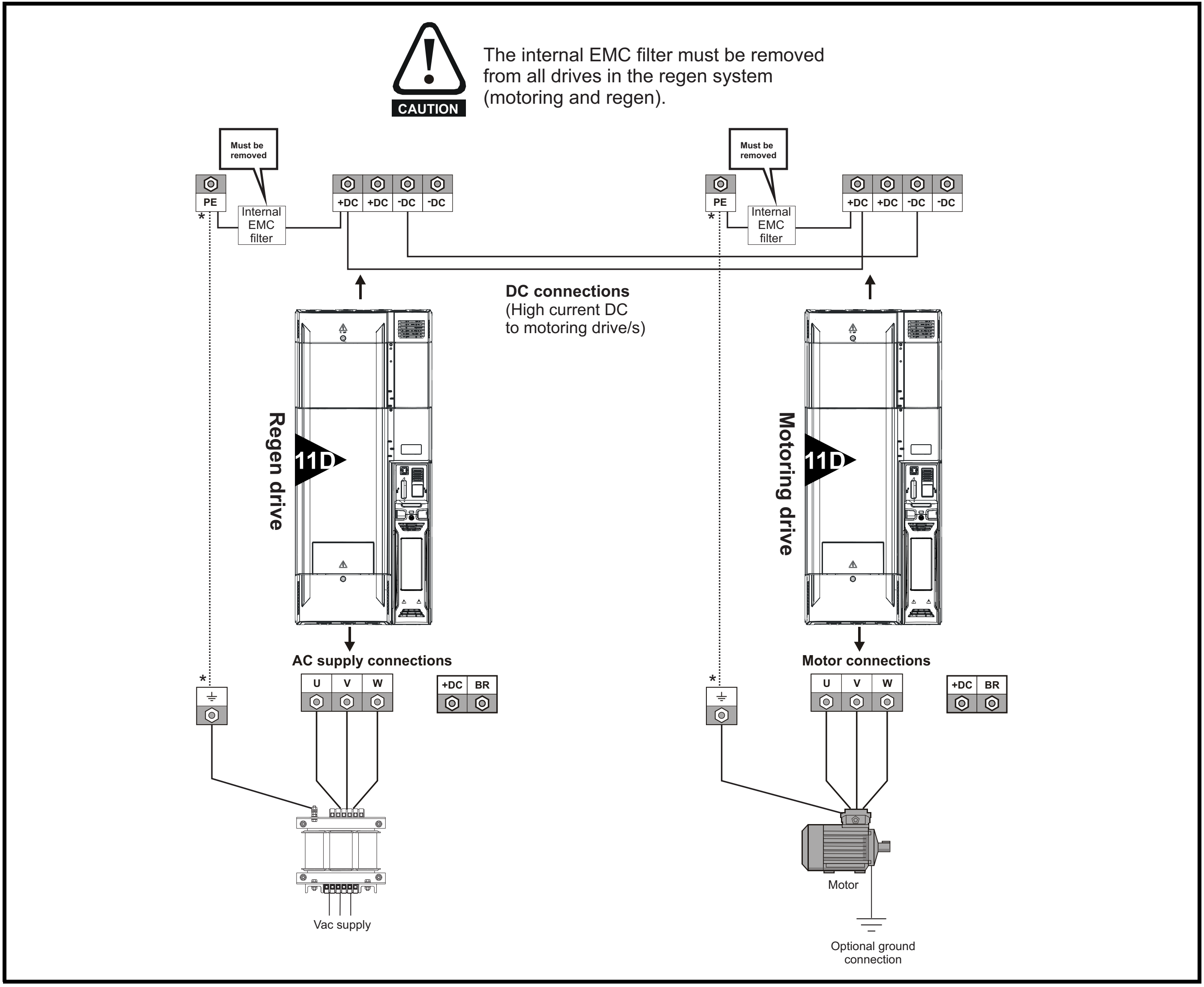
See section 6.1.2 *Ground connections* on page 115.

Figure 6-7 Unidrive M size 9D/10D power connections



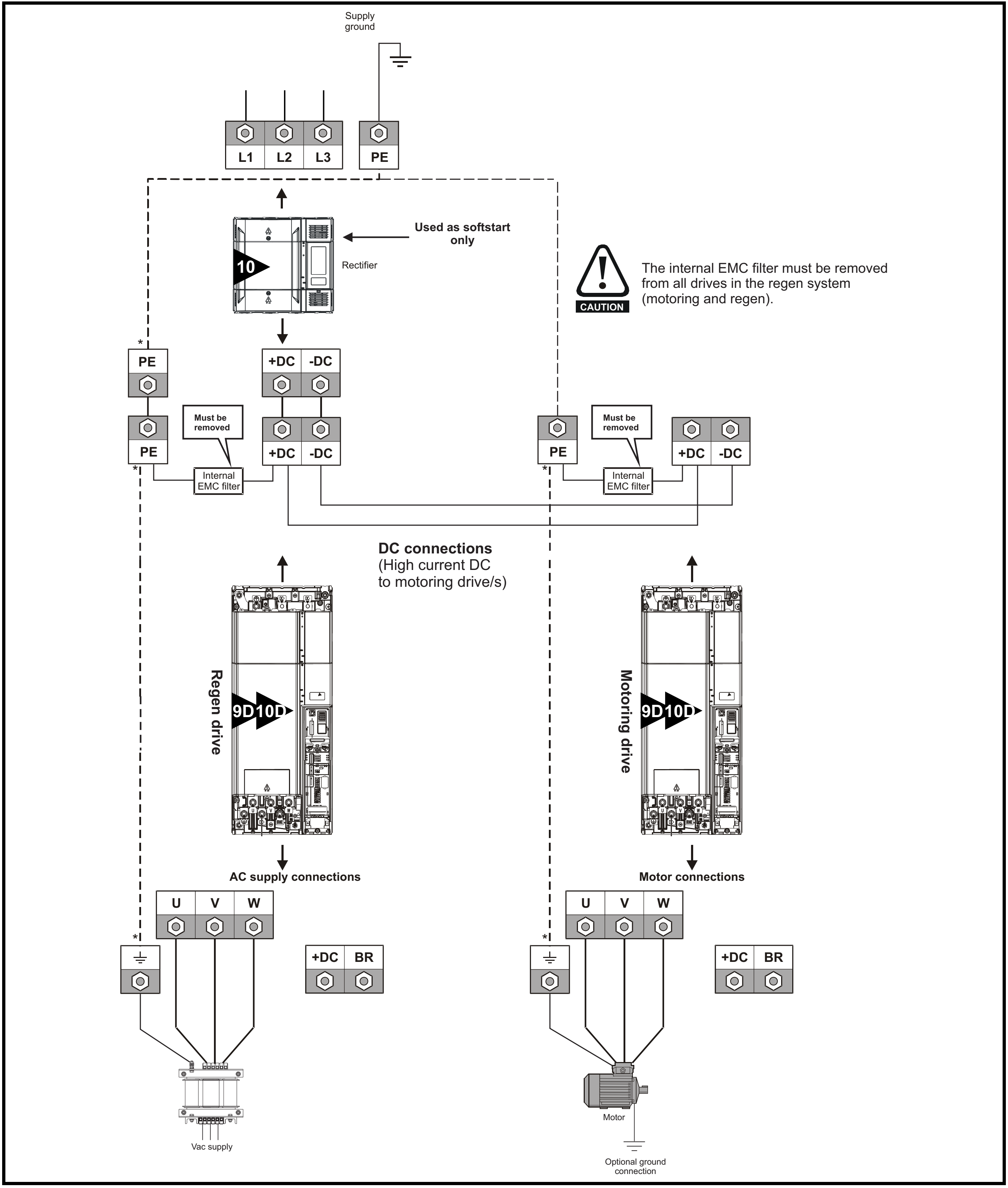
* See section 6.1.2 *Ground connections* on page 115.

Figure 6-8 Unidrive M size 11D power connections



* See section 6.1.2 *Ground connections* on page 115.

Figure 6-9 Unidrive M rectifier power connections



The internal EMC filter must be removed from all drives in the regen system (motoring and regen).

* See section 6.1.2 *Ground connections* on page 115.

WARNING

- The user must provide a means of preventing live parts from being touched. A cover around the electrical connections at the top of the inverter and the bottom of the rectifier where the cables enter is required.

6.1.2 Ground connections

WARNING

Electrochemical corrosion of earthing terminals

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

The drives in the Regen system must be connected to the system ground of the AC power supply. The ground wiring must also conform to local regulations and codes of practice.

Size 3 and 4

On size 3 and 4, the supply and motor ground connections are made using the M4 studs located either side of the drive near the plug-in power connectors. Refer to Figure 6-10 on page 115.

Size 5

On size 5, the supply and motor ground connections are made using the M5 studs located near the plug-in power connector. See Figure 6-11 for details.

Size 6

On a size 6, the supply and motor ground connections are made using the M6 studs located above the supply and motor terminals.
See Figure 6-12 for details.

Size 7 to 10

On size 7, the supply and motor ground connections are made using the M8 studs located by the supply and motor connection terminals.

On size 8 to 10, the supply and motor ground connections are made using the M10 studs located by the supply and motor connection terminals. See Figure 6-13.

Size 11D

On a Unidrive M 11D, the supply and motor ground connections are made using an M10 bolt at the top (supply) and bottom (motor) of the drive. See Figure 6-14.

Rectifier

On a size 10 or 11 rectifier, the supply and DC bus ground connections are made using an M10 bolt at the top (supply) and bottom (DC bus) of the drive. See Figure 6-15 and Figure 6-16.

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

Frame size	Cable cross sectional area mm²
9A/9D/10D	46
Frame 10 rectifier	32
11D	42
Frame 11 rectifier (6 pulse)	64

If the necessary conditions are not met, an additional ground connection must be provided to link the motor circuit ground and the supply ground.

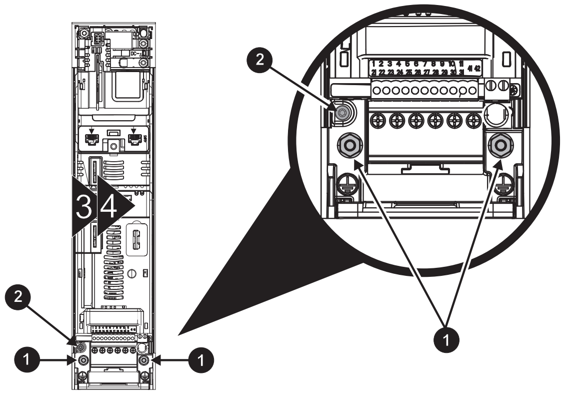
WARNING

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.

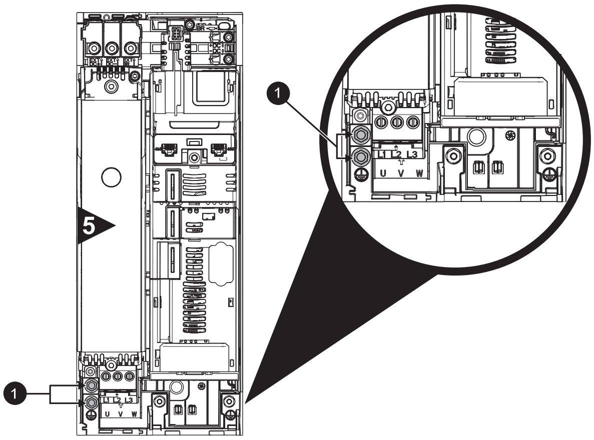
The ground connections must be inspected and tested at appropriate intervals.

Figure 6-10 Unidrive M size 3 and 4 ground connections



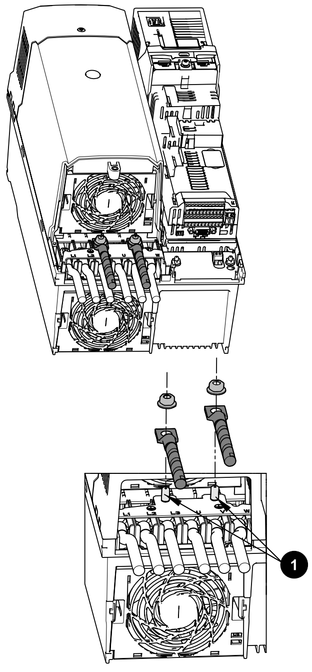
1. Ground connection studs.
2. Additional ground connection.

Figure 6-11 Unidrive M size 5 ground connections



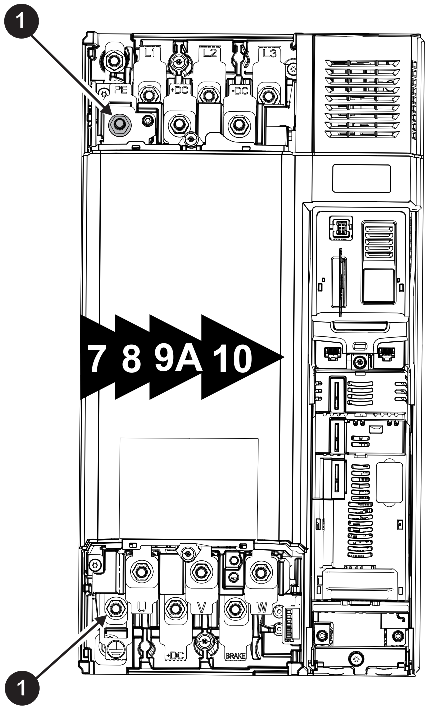
1. Ground connection studs.

Figure 6-12 Unidrive M size 6 ground connections



1. Ground connection studs.

Figure 6-13 Unidrive M size 7 to 10 ground connections



1. Ground connection studs.

Figure 6-14 Unidrive M size 11D ground connections

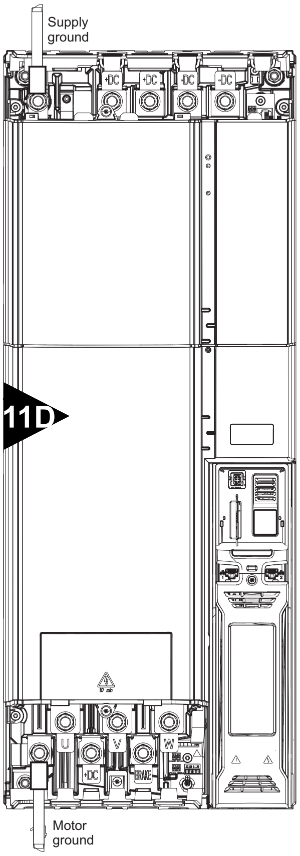


Figure 6-15 Unidrive M size 10 rectifier ground connections

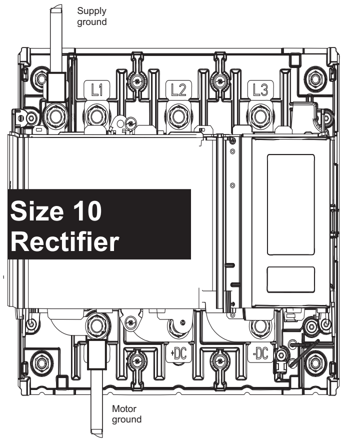
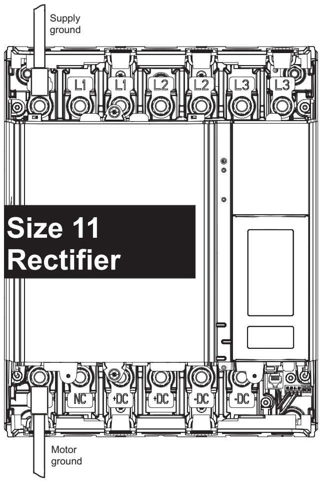


Figure 6-16 Unidrive M size 11 rectifier ground connections



6.2 Supply requirements

Voltage:
200 V drive: 200 V to 240 V ±10%
400 V drive: 380 V to 480 V ±10%
575 V drive: 500 V to 575 V ±10%
690 V drive: 500 V to 690 V ±10%
Number of phases: 3

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

Frequency range: 45 to 66 Hz

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

6.2.1 Supply types

Drives rated for supply voltages up to 690 V are suitable for use with supply types with neutral or centre grounding i.e. TN-S, TN-C-S, TT.

The following supplies are not permitted with Unidrive M Regen

1. Corner grounded supplies (grounded Delta).
2. Ungrounded supplies (IT) > 575 V.

6.2.2 Other supplies

Wherever other equipment shares the same low voltage supply, i.e. 400 Vac, careful consideration must be given to the likely need for both switching frequency and EMC filters, as explained in section 6.5.10 *Switching frequency emission* and section 6.5.11 *Conducted and radiated RF emission* on page 132.

6.2.3 Supply voltage notching

Because of the use of input inductors and an active rectifier the drive causes no notching - but see section 6.5.10 *Switching frequency emission* on page 131 for advice on switching frequency emission.

6.2.4 Supply harmonics

When operated from a balanced sinusoidal three-phase supply, the regenerative Unidrive M generates minimal harmonic current.

Imbalance between phase voltages will cause the drive to generate some harmonic current. Existing voltage harmonics on the power system will cause some harmonic current to flow from the supply into the drive.

CAUTION

If the harmonic distortion of the supply is high for extended periods then this can cause a reduction of the service life of the switching frequency filter capacitors. The effect of this is to reduce the capacitance value. If high levels of harmonic distortion are expected then it is recommended that the capacitance values be checked periodically, and capacitors which have fallen outside of their tolerance range be replaced.

NOTE

This latter effect is not an emission, but it may be difficult to distinguish between incoming and outgoing harmonic current in a site measurement unless accurate phase angle data is available for the harmonics. No general rule can be given for these effects, but the generated harmonic current levels will always be small compared with those caused by a conventional drive with rectifier input.

6.3 Cable and fuse 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 6-2 to Table 6-5.

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

NOTE

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

Fuse protection is required in the following Regen systems:
1. Single Regen, multiple motoring drives
2. Multiple Regen, multiple motoring drives
3. Unidrive M Regen brake resistor replacement
4. Regen systems using a Unidrive M rectifier

Fuse protection required could range from AC supply fusing to DC bus fusing (some systems requiring both AC and DC fusing) for protection of both the Regen and motoring drives along with the Unidrive M rectifier module. For further information on the fusing required for the above systems refer to section 4 *System design* on page 40.

Table 6-1 Supply fault current used to calculate maximum input currents

Model	Symmetrical fault level (kA)
All	100

6.3.1 Unidrive M AC fusing and cable size ratings

WARNING

Fuses
The AC supply to the drive must be installed with suitable protection against overload and short-circuits. Table 6-2 to Table 6-5 show recommended fuse ratings. Failure to observe this requirement will cause risk of fire.

Table 6-2 AC Input current and fuse ratings (200 V)

Model	Typical input current	Maximum continuous input current	Maximum overload input current	Fuse rating					
				IEC			UL / USA		
				Nominal	Maximum	Class	Nominal	Maximum	Class
	A	A	A	A	A		A	A	
03200066	9.9	12.6	20.9	20	25	gG	20	25	CC, J or T*
03200080	14	17	25				25		
03200106	16	20	34	25					
04200137	17	20	30	25	25	gG	25	25	CC, J or T*
04200185	23	28	41	32	32		30	30	
05200250	24	31	52	40	40	gG	40	40	CC, J or T*
06200330	42	48	64	63	63	gG	60	60	CC, J or T*
06200440	49	56	85				60		
07200610	58	67	109	80	80	gG	80	80	CC, J or T*
07200750	73	84	135	100	100		100	100	
07200830	91	105	149	125	125		125	125	
08201160	123	137	213	200	200	gR	200	200	HSJ
08201320	149	166	243				225	225	
09201760	172	205	270	250	250	gR	250	250	HSJ
09202190	228	260	319	315	315		300	300	
10202830	277	305	421	400	400	gR	400	400	HSJ
10203000	333	361	494	450	450		450	450	

* These fuses are fast acting.

Table 6-3 AC Input current and fuse ratings (400 V)

Model	Typical input current	Maximum continuous input current	Maximum overload input current	Fuse rating					
				IEC			UL / USA		
				Nominal	Maximum	Class	Nominal	Maximum	Class
	A	A	A	A	A		A	A	
03400078	12	13	20	20	20	gG	20	20	CC, J or T*
03400100	14	16	25						
04400150	17	19	30	25	25	gG	25	25	CC, J or T*
04400172	22	24	35	32	32		30	30	
05400270	26	29	52	40	40	gG	35	35	CC, J or T*
05400300	27	30	58						
06400350	32	36	67	63	63	gR	40	60	CC, J or T*
06400420	41	46	80				50		
06400470	54	60	90				60		
07400660	67	74	124	100	100	gG	80	80	CC, J or T*
07400770	80	88	145				100	100	
07401000	96	105	188	125	125		125	125	
08401340	137	155	267	250	250	gR	225	225	HSJ
08401570	164	177	303						
09402000	211	232	306	315	315	gR	300	300	HSJ
09402240	245	267	359				350	350	
10402700	306	332	445	400	400	gR	400	400	HSJ
10403200	370	397	523	450	450		450	450	
11403770	424	449	579	500	500	gR	600	600	HSJ
11404170	455	492	613						
11404640	502	539	752	550	550				

* These fuses are fast acting.

Table 6-4 AC Input current and fuse ratings (575 V)

Model	Typical input current	Maximum continuous input current	Maximum overload input current	Fuse rating					
				IEC			UL / USA		
				Nominal	Maximum	Class	Nominal	Maximum	Class
	A	A	A	A	A		A	A	
06500150	17	19	33	32	40	gG	25	30	CC, J or T*
06500190	22	24	41	40			30		
06500230	26	29	50	50	63		35	50	
06500290	33	37	63				40		
06500350	41	47	76	63			50		
07500440	41	45	75	50	50	gG	50	50	CC, J or T*
07500550	57	62	94	80	80		80	80	
08500630	74	83	121	125	125	gR	100	100	HSJ
08500860	92	104	165	160	160		150	150	
09501040	145	166	190	150	150	gR	150	150	HSJ
09501310	145	166	221	200	200		175	175	
10501520	177	197	266	250	250	gR	250	250	HSJ
10501900	199	218	310						
11502000	240	265	327	400	400	gR	400	400	HSJ
11502540	285	310	395						
11502850	313	338	473						

* These fuses are fast acting.

Table 6-5 AC Input current and fuse ratings (690 V)

Model	Typical input current	Maximum continuous input current	Maximum overload input current	Fuse rating					
				IEC			UL / USA		
				Nominal	Maximum	Class	Nominal	Maximum	Class
	A	A	A	A	A		A	A	
07600190	18	20	32	25	50	gG	25	50	CC, J or T*
07600240	23	26	41	32			30		
07600290	28	31	49	40			35		
07600380	36	39	65	50			50		
07600440	40	44	75		80			80	
07600540	57	62	92	80			80		
08600630	74	83	121	125	125	gR	100	100	HSJ
08600860	92	104	165	160	160		150	150	
09601040	124	149	194	150	150	gR	150	150	HSJ
09601310	145	171	226	200	200		200	200	
10601500	180	202	268	225	225	gR	250	250	HSJ
10601780	202	225	313	250	250	gR	250	250	
11602100	225	256	379	400	400	gR	400	400	HSJ
11602380	271	302	425						
11602630	298	329	465						

* These fuses are fast acting.

Table 6-6 Unidrive M Rectifier AC Input current and fuse ratings

Model	Typical input current	Maximum continuous input current	Maximum overload input current	Fuse rating					
				IEC			UL/USA		
				Nominal	Maximum	Class	Nominal	Maximum	Class
	A	A	A	A	A		A	A	
10204100	333	361	494	450	450	gR	450	450	HSJ
10404520	370	396	523	450	450		450	450	
10502430	202	218	313	250	250		250	250	
10602480	202	225	313	250	250		250	250	
11406840	557	594	752	630	630	gR	600	600	HSJ
11503840	313	338	473	400	400		400	400	
11604060	331	362	465	400	400		400	400	
1142X400*	2 x 326	2 x 358	2 x 516	400	400		400	400	
1162X380*	2 x 308	2 x 339	2 x 488	400	400		400	400	

* Twin rectifier

NOTE

Ensure cables used suit local wiring regulations.

CAUTION

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

Table 6-7 AC cable ratings (200 V)

Model	Cable size (IEC) mm^2						Cable size (UL) AWG			
	Input			Output			Input		Output	
	Nominal	Max	Install method	Nominal	Max	Install method	Nominal	Max	Nominal	Max
03200066	1.5	4	B2	1.5	4	B2	14	10	14	10
03200080	4			4			12		12	
03200106										
04200137	6	8	B2	6	8	B2	10	8	10	8
04200185	8			8			8		8	
05200250	10	10	B2	10	10	B2	8	8	8	8
06200330	16	25	B2	16	25	B2	4	3	4	3
06200440	25			25			3		3	
07200610	35	70	B2	35	70	B2	2	1/0	2	1/0
07200750							1		1	
07200830	70			70			1/0		1/0	
08201160	95	2 x 70	B2	95	2 x 70	B2	3/0	2 x 1	3/0	2 x 1
08201320	2 x 70			2 x 70			2 x 1		2 x 1	
09201760	2 x 70	2 x 185	B1	2 x 95	2 x 150	B2	2 x 2/0	2 x 500	2 x 2/0	2 x 350
09202190	2 x 95	2 x 185		2 x 120	2 x 150		2 x 4/0	2 x 500	2 x 4/0	2 x 350
10202830	2 x 120	2 x 185	B1	2 x 120	2 x 150	C	2 x 250	2 x 500	2 x 250	2 x 350
10203000	2 x 150	2 x 185	C	2 x 120	2 x 150		2 x 300	2 x 500	2 x 250	2 x 350

Table 6-8 AC cable ratings (400 V)

Model	Cable size (IEC) mm^2						Cable size (UL) AWG			
	Input			Output			Input		Output	
	Nominal	Max	Install method	Nominal	Max	Install method	Nominal	Max	Nominal	Max
03400078	2.5	4	B2	2.5	4	B2	14	10	14	10
03400100							12		12	
04400150	4	6	B2	4	6	B2	10	8	10	8
04400172	6			6			8		8	
05400270	6	6	B2	6	6	B2	8	8	8	8
05400300										
06400350	10	25	B2	10	25	B2	6	3	6	3
06400420	16			16			4		4	
06400470	25			25			3		3	
07400660	35	70	B2	35	70	B2	1	1/0	1	1/0
07400770	50			50			2		2	
07401000	70			70			1/0		1/0	
08401340	2 x 50	2 x 70	B2	2 x 50	2 x 70	B2	2 x 1	2 x 1/0	2 x 1	2 x 1/0
08401570	2 x 70			2 x 70			2 x 1/0		2 x 1/0	
09402000	2 x 70	2 x 185	B1	2 x 95	2 x 150	B2	2 x 3/0	2 x 500	2 x 2/0	2 x 350
09402240	2 x 95	2 x 185		2 x 120	2 x 150		2 x 4/0	2 x 500	2 x 4/0	2 x 350
10402700	2 x 120	2 x 185	C	2 x 120	2 x 150	C	2 x 300	2 x 500	2 x 250	2 x 350
10403200	2 x 150	2 x 185		2 x 150	2 x 150		2 x 350	2 x 500	2 x 300	2 x 350
11403770	4 x 95		C	2 x 185		C	4 x 3/0		2 x 400	
11404170				2 x 240			4 x 4/0			
11404640				2 x 240			4 x 4/0			

Table 6-9 AC cable ratings (575 V)

Model	Cable size (IEC) mm^2						Cable size (UL) AWG			
	Input			Output			Input		Output	
	Nominal	Max	Install method	Nominal	Max	Install method	Nominal	Max	Nominal	Max
06500150	4	25	B2	4	25	B2	10	3	10	3
06500190	6			6			10		10	
06500230	10			10			8		8	
06500290							6		6	
06500350	16						6		6	
07500440	16	25	B2	16	25	B2	4	3	4	3
07500550	25			25			3		3	
08500630	35	50	B2	35	50	B2	1	1	1	1
08500860	50			50						
09501040	2 x 70	2 x 185	B2	2 x 35	2 x 150	B2	2 x 1	2 x 500	2 x 3	2 x 350
09501310	2 x 70	2 x 185		2 x 50	2 x 150		2 x 1	2 x 500	2 x 1	2 x 350
10501520	2 x 70	2 x 185	B2	2 x 70	2 x 150	B2	2 x 2/0	2 x 500	2 x 2/0	2 x 350
10501900	2 x 95	2 x 185		2 x 70	2 x 150		2 x 2/0	2 x 500	2 x 2/0	2 x 350
11502000	2 x 70		C	2 x 70		C	2 x 3/0		2 x 3/0	
11502540	2 x 95			2 x 95			2 x 4/0		2 x 4/0	
11502850	2 x 120			2 x 120			2 x 250		2 x 250	

Table 6-10 AC cable ratings (690 V)

Model	Cable size (IEC) mm^2						Cable size (UL) AWG or Kcmil			
	Input			Output			Input		Output	
	Nominal	Max	Install method	Nominal	Max	Install method	Nominal	Max	Nominal	Max
07600190	10	25	B2	10	25	B2	8	3	8	3
07600240							6		6	
07600290							6		6	
07600380	16			16			4		4	
07600440	16			16			4		4	
07600540	25			25			3		3	
08600630	50	70	B2	50	70	B2	2	1/0	2	1/0
08600860	70			70			1/0		1/0	
09601040	2 x 50	2 x 185	B2	2 x 35	2 x 150	B2	2 x 1	2 x 500	2 x 3	2 x 350
09601310	2 x 70	2 x 185		2 x 50	2 x 150		2 x 1/0	2 x 500	2 x 1	2 x 350
10601500	2 x 70	2 x 185	B2	2 x 70	2 x 150	B2	2 x 2/0	2 x 500	2 x 1/0	2 x 350
10601780	2 x 95	2 x 185		2 x 70	2 x 150		2 x 3/0	2 x 500	2 x 2/0	2 x 350
11602100	2 x 70		C	2 x70		C	2 x 3/0		2 x 3/0	
11602380	2 x 95			2 x 95			2 x 4/0		2 x 4/0	
11602630	2 x 95			2 x 95			2 x 250		2 x 250	

Table 6-11 Unidrive M Rectifier AC cable ratings

Model	Cable size (IEC)			Cable size (UL)	
	mm^2			AWG or kcmil	
	Input			Input	
	Nominal	Maximum	Installation method	Nominal	Maximum
10204100	2 x 150	2 x 185	C	2 x 300	2 x 500
10404520	2 x 150	2 x 185	C	2 x 350	2 x 500
10502430	2 x 95	2 x 185	B2	2 x 3/0	2 x 500
10602480	2 x 95	2 x 185	B2	2 x 3/0	2 x 500
11406840	4 x 120	4 x 120	C	2 x 250	2 x 250
11503840	2 x 120	2 x 120	C	2 x 250	
11604060	2 x 120	2 x 120	C	2 x 300	2 x 300
1142X400*	2 x 2 x120	2 x 2 x120	C	2 x 2 x 300	
1162X380*	2 x 2 x120	2 x 2 x120	C	2 x 2 x 300	

* Twin rectifier

NOTE

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

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

NOTE

The cable sizes noted in Table 6-7 to Table 6-10 are typical cable sizes based on UL508C and IEC60364-5-52:2001. Maximum cable sizes for size 11 are 2 x 240 mm² or 2 x 400 kcmil per pole. The user will have to decide what size of cable to use in any given application based on the local wiring regulations. Use of high temperature cables that are thinner than those stated in the typical cable chart maybe possible, contact the supplier of the drive for advice.

Installation method (ref:IEC60364-5-52:2001)
B1 - Separate cables in conduit
B2 - Multicore cable in conduit
C - Multicore cable in free air

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

Fuse types

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

IEC Fuse types

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

North American Fuse Types

- UL class J - Full range breaking capability in general application. Slow acting. Up to 600 V only.

Ferraz HSJ -High speed class J fuses. Dual rated: semiconductor protection (ultra-fast acting) and cable protection. Up to 600 V only and only from Ferraz.

6.3.2 Unidrive M DC fusing and cable size ratings

DC bus fusing is required in the following systems for both the Regen and motoring drives, and the rectifier if used as the external soft start circuit.

1. Single Regen, multiple motoring drives
2. Multiple Regen, multiple motoring drives
3. Unidrive M Regen brake resistor replacement
4. Regen systems using a rectifier

DC bus fuses as detailed following, must be installed in both the positive and negative branches of DC bus connections to each of the Regen and motoring drives, and the rectifier if used as the external soft start circuit.

NOTE

Ferraz have a range of DC fuses which could be used to provide the required protection, types (00 and 21) may be used.

00 - Fuse with no trip indicator installed
21 - Fuse installed with trip indicator

NOTE

The DC bus voltage set-point on a 400 V Regen system (default) is set to 700 Vdc, this can be up to a maximum 800 Vdc. Therefore ensure the selected DC bus fusing is of the correct voltage rating with regards to the DC bus voltage level (Pr **03.005** DC bus voltage set-point).

Table 6-12 DC current, fuse and cable ratings (200 V)

Model	Maximum continuous dc input current (Arms)	Maximum overload dc input current (Arms)	DC fuse IEC class aR (Arms)	Maximum fuse clearing I^2t at operating condition (A^2s)	Inverter DC voltage trip threshold	Cable size DC Input		
						mm^2	AWG or Kcmil	IEC Installation Method
03200066	13.3	20.9	16	190	415	4	12	B2
03200080	18.4	25.3	25	480	415	6	10	B2
03200106	21.2	33.5	25	480	415	8	8	B2
04200137	21.2	30.3	25	480	415	8	8	B2
04200185	29.4	40.9	32	1500	415	10	8	B2
05200250	32.6	52.0	40	1500	415	10	8	B2
06200330	53.1	63.8	63	3080	415	16	4	B2
06200440	61.6	85.0	63	3080	415	35	2	B2
07200610	73.8	109.5	80	6600	415	35	1	B2
07200750	92.4	134.6	100	12500	415	35	1	B2
07200830	115.1	148.9	125	12500	415	70	1/0	B2
08201160	153.4	213.6	160	16700	415	2 x 50	2 x 1	B2
08201320	185.3	243.0	200	22000	415	2 x 70	2 x 1/0	B2
09201760A	220	300	315	330000	415	2 x 70	2 x 2/0	B1
09202190A	287	359	350		415	2 x 95	2 x 4/0	B1
09201760D	220	300	315		415	2 x 70	2 x 2/0	B1
09202190D	287	359	350		415	2 x 95	2 x 4/0	B1
10202830	345	488	450	330000	415	2 x 120	2 x 250	B1
10203000	413	578	500		415	2 x 150	2 x 300	C

Table 6-13 DC current, fuse and cable ratings (400 V)

Model	Maximum continuous dc input current (Arms)	Maximum overload dc input current (Arms)	DC fuse IEC class aR (Arms)	Maximum fuse clearing I^2t at operating condition (A^2s)	Inverter DC voltage trip threshold	Cable Size DC Input		
						mm^2	AWG or Kcmil	IEC Installation Method
03400078	14.5	19.7	16	190	830	4	12	B2
03400100	17.2	25.3	20	360	830	6	10	B2
04400150	21.1	30.4	25	480	830	8	8	B2
04400172	27.3	34.8	32	1500	830	10	8	B2
05400270	32.8	52.1	40	1500	830	10	8	B2
05400300	33.9	57.9	40	1500	830	10	8	B2
06400350	40.5	66.7	63	3080	830	10	6	B2
06400420	51.2	80.0	63	3080	830	16	4	B2
06400470	73.8	109.5	80	6600	830	35	1	B2
07400660	92.4	134.6	100	12500	830	35	1	B2
07400770	92.4	134.6	100	12500	830	35	1	B2
07401000	118.4	187.9	125	12500	830	70	1/0	B2
08401340	171.6	267.4	200	22000	830	2 x 70	2 x 1/0	B2
08401570	199.2	302.6	200	22000	830	2 x 70	2 x 2/0	B1
09402000A	261	351	315	330000	830	2 x 70	2 x 3/0	B1
09402240A	303	418	400		830	2 x 95	2 x 4/0	B1
09402000D	261	351	315		830	2 x 70	2 x 3/0	B1
09402240D	303	418	400		830	2 x 95	2 x 4/0	B1
10402700	378	517	450	330000	830	2 x 120	2 x 300	C
10403200	456	614	500		830	2 x 150	2 x 350	C
11403770	525	711	630	594000	830	4 x 95	4 x 250	C
11404170	564	753	700		830	4 x 95	4 x 250	C
11404640	621	925	700		830	4 x 120	4 x 300	C

Table 6-14 DC current, fuse and cable ratings (575 V)

Model	Maximum continuous dc input current (Arms)	Maximum overload dc input current (Arms)	DC fuse IEC class aR (Arms)	Maximum fuse clearing I^2t at operating condition (A^2s)	Inverter DC voltage trip threshold	Cable Size DC Input		
						mm^2	AWG or Kcmil	IEC Installation Method
06500150	20.5	32.8	25	480	990	6	10	B2
06500190	26.6	41.5	32	1500	990	10	8	B2
06500230	32.2	49.8	40	1500	990	10	8	B2
06500290	40.6	62.7	63	3080	990	10	6	B2
06500350	51.4	75.7	63	3080	990	16	4	B2
07500440	51.1	75.0	63	3080	990	16	4	B2
07500550	73.8	109.5	80	6600	990	35	1	B2
08500630	92.4	134.6	100	12500	990	35	1	B2
08500860	115.3	165.2	125	12500	990	70	2 x 1/0	B2
09501040	181	212	250	137000	990	2 x 70	2 x 1	B2
09501310	181	248	250		990	2 x 70	2 x 1	B2
10501520	220	306	315	137000	990	2 x 70	2 x 2/0	B2
10501900	246	360	315		990	2 x 95	2 x 2/0	B2
11502000	299	402	350	330000	990	2 x 70	2 x 4/0	C
11502540	353	485	450		990	2 x 95	2 x 250	C
11502850	387	583	500		990	2 x 120	2 x 300	C

Table 6-15 DC current, fuse and cable ratings (690 V)

Model	Maximum continuous dc input current (Arms)	Maximum overload dc input current (Arms)	DC fuse IEC class aR (Arms)	Maximum fuse clearing I^2t at operating condition (A^2s)	Inverter DC voltage trip threshold	Cable Size DC Input		
						mm^2	AWG or Kcmil	IEC Installation Method
07600190	22.2	32.4	25	480	1190	10	8	B2
07600240	28.9	40.9	32	1500	1190	10	8	B2
07600290	34.7	49.4	40	1500	1190	10	8	B2
07600380	44.4	64.8	50	3080	1190	16	4	B2
07600440	50.2	75.0	63	3080	1190	16	4	B2
07600540	70.4	92.1	80	6600	1190	35	1	B2
08600630	91.8	121.0	100	12500	1190	35	1	B2
08600860	115.3	165.2	125	12500	1190	70	2 x 1/0	B2
09601040	158	211	200	137000	1190	2 x 50	2 x 1	B2
09601310	183	252	250		1190	2 x 70	2 x 1/0	B2
10601500	223	303	315	137000	1190	2 x 70	2 x 2/0	B2
10601780	252	359	315		1190	2 x 95	2 x 3/0	B2
11602100	282	466	400	330000	1190	2 x 70	2 x 4/0	C
11602380	332	522	450		1190	2 X 95	2 X 250	C
11602630	371	573	500		1190	2 X 120	2 X 300	C

Table 6-16 Unidrive M Rectifier DC current, fuse and cable size ratings

Model	Maximum continuous DC output current (A)	DC fuse IEC class aR (A)	Typical cable size (IEC)			Typical cable size (UL)	
			mm^2			AWG or kcmil	
			DC output			DC output	
			Nominal	Maximum	Installation method	Nominal	Maximum
10204100	413	500	2 x 120	2 x 150	C	2 X 400	2 X 500
10404520	455	500	2 X 150	2 X 150	C	2 X 500	2 X 500
10502430	246	315	2 X 95	2 X 150	B2	2 X 3/0	2 X 500
10602480	251	315	2 X 95	2 X 150	B2	2 X 3/0	2 X 500
11406840	689	800	4 X 150	4 X 150	C	2 X 300	2 X 300
11503840	387	500	2 X 120	2 X 120	C	2 X 250	
11604060	411	500	2 X 120	2 X 120	C	2 X 400	
1142X400*	2 x 400	2 x 450	2 X 2 X 120	2 X 2 X 120	C	2 X2 X 300	
1162X380*	2 x 380	2 x 500	2 X 2 X 120	2 X 2 X 120	C	2 X 2 X 300	

* Twin rectifier

NOTE

The DC fuse voltage rating must be suitable for the drive's DC bus voltage range.

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.

6.3.3 Main AC supply contactor

The recommended AC supply contactor type is AC1.

6.3.4 Motor winding voltage

Refer to the guidelines given in the relevant *Unidrive M Power Installation Guide*. The DC bus voltage in a Regen system with a 400 V supply is usually 700V, which corresponds to an AC supply voltage of 519 V. Unless the motor cable is less than 10 m long it is recommended that either an inverter-grade motor should be used or else output chokes should be fitted to protect the motor from the effect of the fast-rising output voltage pulses.

6.3.5 Use of residual current device (RCD)

There are three common types of ELCB / RCD:

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

WARNING

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

If an external EMC filter is used 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.

6.4 EMC (Electromagnetic compatibility)

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

- section 6.5.2, General requirements for EMC, this is for all applications, to ensure reliable operation of the drive and minimise the risk of disturbing nearby equipment. The immunity standards specified in section 10.5 *Electromagnetic compatibility (EMC)* on page 303 will be met, but no specific emission standards are applied.
- section 6.5.3, Requirements for meeting the EMC standard for power drive systems, IEC61800-3 (EN 61800-3:2004+A1:2012).
- section 6.5.4, Requirements for meeting the generic emission standards for the industrial environment, IEC61000-6-4, EN 61000-6-4:2007+A1:2011.

The recommendations of section 6.5.2 *General requirements for EMC* on page 130 will usually be sufficient to avoid causing disturbance to adjacent equipment of industrial quality. If particularly sensitive equipment is to be used nearby, or in a non-industrial environment, then the recommendations of section 6.5.3 or section 6.5.4 should be followed to give reduced radio-frequency emission.

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

- The EMC data sheet available from the supplier of the drive
- The Declaration of Conformity at the front of this manual
- Chapter 10 *Technical data* on page 276

The correct external EMC filter must be used and all of the guidelines in section 6.5.2 *General requirements for EMC* on page 130 and section 6.5.4 *Compliance with generic emission standards* on page 131 must be followed.

Table 6-17 Drive and EMC filter cross reference

Model	Part number
200 V	
03200066 to 03200106	4200-3230
04200137 to 04200185	4200-0272
05200250	4200-0312
06200330 to 06200440	4200-2300
07200610 to 07200830	4200-1132
08201160 to 08201320	4200-1972
09201760 to 09202190 (9A)	4200-3021
10202830 to 10203000	4200-4460
400 V	
03400078 to 03400100	4200-3480
04400150 to 04400172	4200-0252
05400270 to 05400300	4200-0402
06400350 to 06400470	4200-4800
07400660 to 07401000	4200-1132
08401340 to 08401570	4200-1972
09402000 to 09402240 (9A)	4200-3021
10402700 to 10403200	4200-4460
11403770 to 11404640	4200-0400
575 V	
06500150 to 06500350	4200-3690
07500440 to 07500550	4200-0672
08500630 to 08500860	4200-1662
09501040 to 09501310 (9A)	4200-1660
10501520 to 10501900	4200-2210
11502000 to 11502850	4200-0690
690 V	
07600190 to 07600540	4200-0672
08600630 to 08600860	4200-1662
09601040 to 09601310 (9A)	4200-1660
10601500 to 10601780	4200-2210
11602100 to 11602630	4200-0690

6.5 External EMC filter

CAUTION

When a EMC filter is used, the switching frequency filter detailed must also be used. Failure to observe this may result in the EMC filter becoming ineffective and being damaged.

CAUTION

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. Refer to section 6.3.5 *Use of residual current device (RCD)* on page 126.

WARNING

It is not possible to use the combi filter solution in a braking resistor replacement system.
When using the Regen drive as a braking resistor replacement, the Regen input must have an isolating transformer installed so that the Regen drive input can float with respect to ground.
The combi filter combines the switching frequency filter and EMC filter into one item. A significant part of an EMC filter are the capacitors between line and ground.
The result of placing a combi filter in circuit between the Regen drive and isolating transformer is that the ground connection to the combi filter prevents the Regen drive input from floating and damage to the system will therefore occur.

WARNING

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

CAUTION

Compliance with local EMC regulations
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.

6.5.1 Removal of internal EMC filter

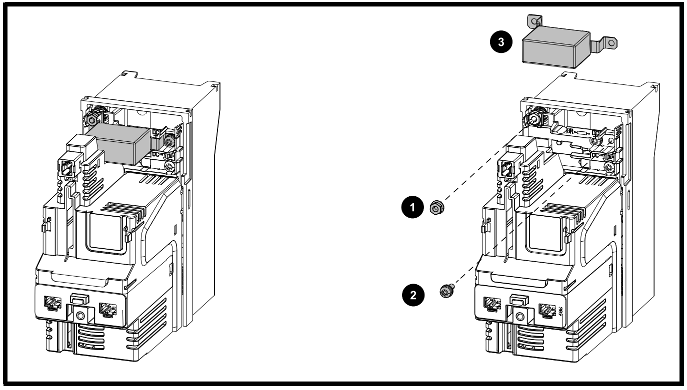
CAUTION

The internal EMC filter must be removed from the drive.

WARNING

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

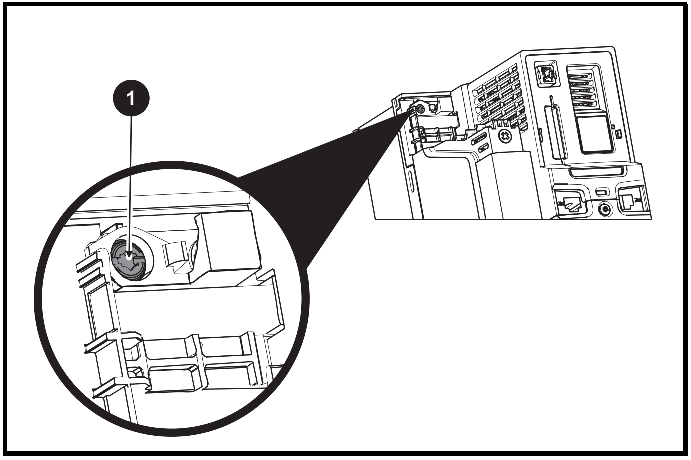
Figure 6-17 Removal of the size 3 internal EMC filter



Remove the screw and nut (1) and (2) as shown above.

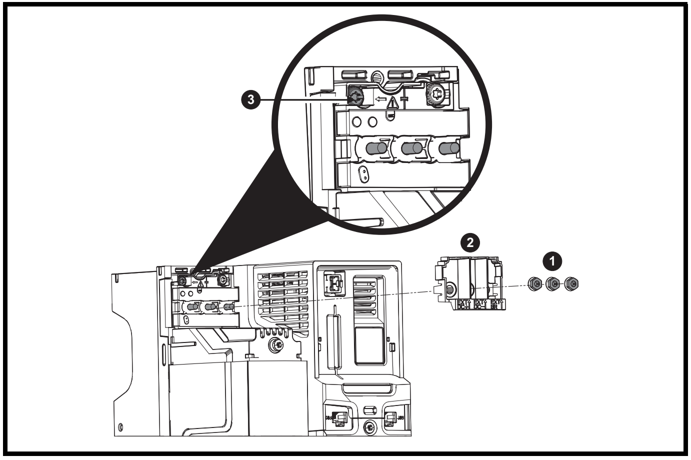
Lift away from the securing points and rotate away from the drive.
Ensure the screw and nut are replaced and re-tightened with a maximum torque of 2 N m (17.7 lb in).

Figure 6-18 .Removal of the size 4 internal EMC filter



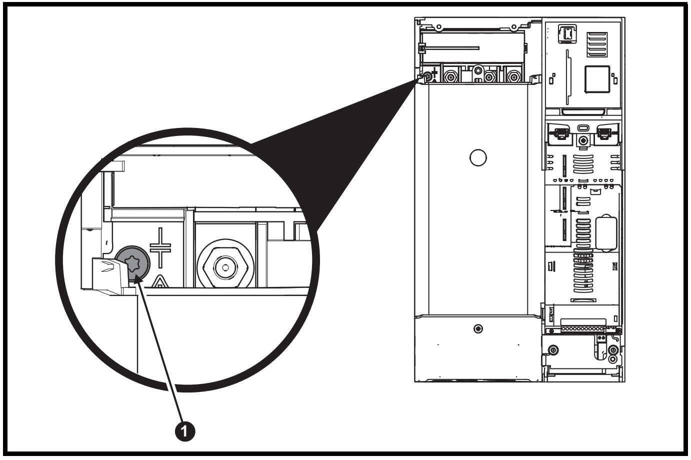
To electrically disconnect the Internal EMC filter, remove the screw as highlighted above (1).

Figure 6-19 Removal of the size 5 internal EMC filter



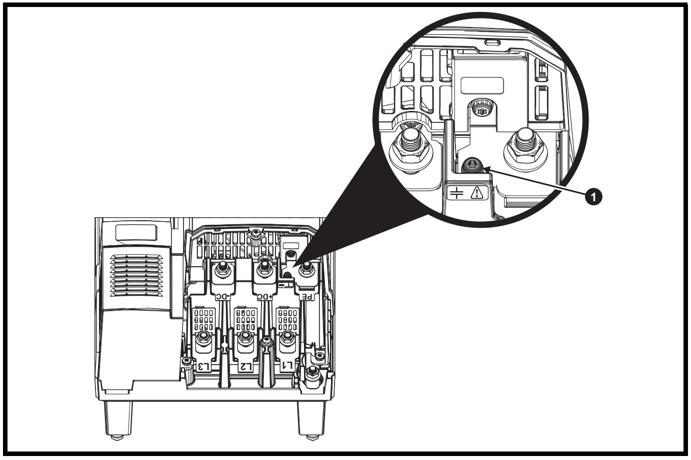
Remove the three M4 terminal nuts (1). Lift away the cover (2) to expose the M4 Torx internal EMC filter removal screw. Finally remove the M4 Torx internal EMC filter removal screw (3) to electrically disconnect the internal EMC filter.

Figure 6-20 Removal of the size 6 internal EMC filter



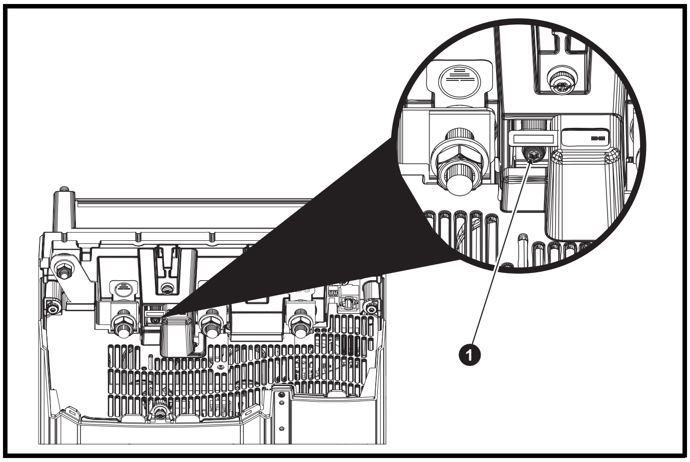
To electrically disconnect the Internal EMC filter, remove the screw as highlighted above (1).

Figure 6-21 Removal of the size 7, 8 and 9A internal EMC filter (size 7 shown)



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

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



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

NOTE

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

These power formats are therefore not suitable for Regen systems. Select 9A/D, 10D or 11D power formats only.

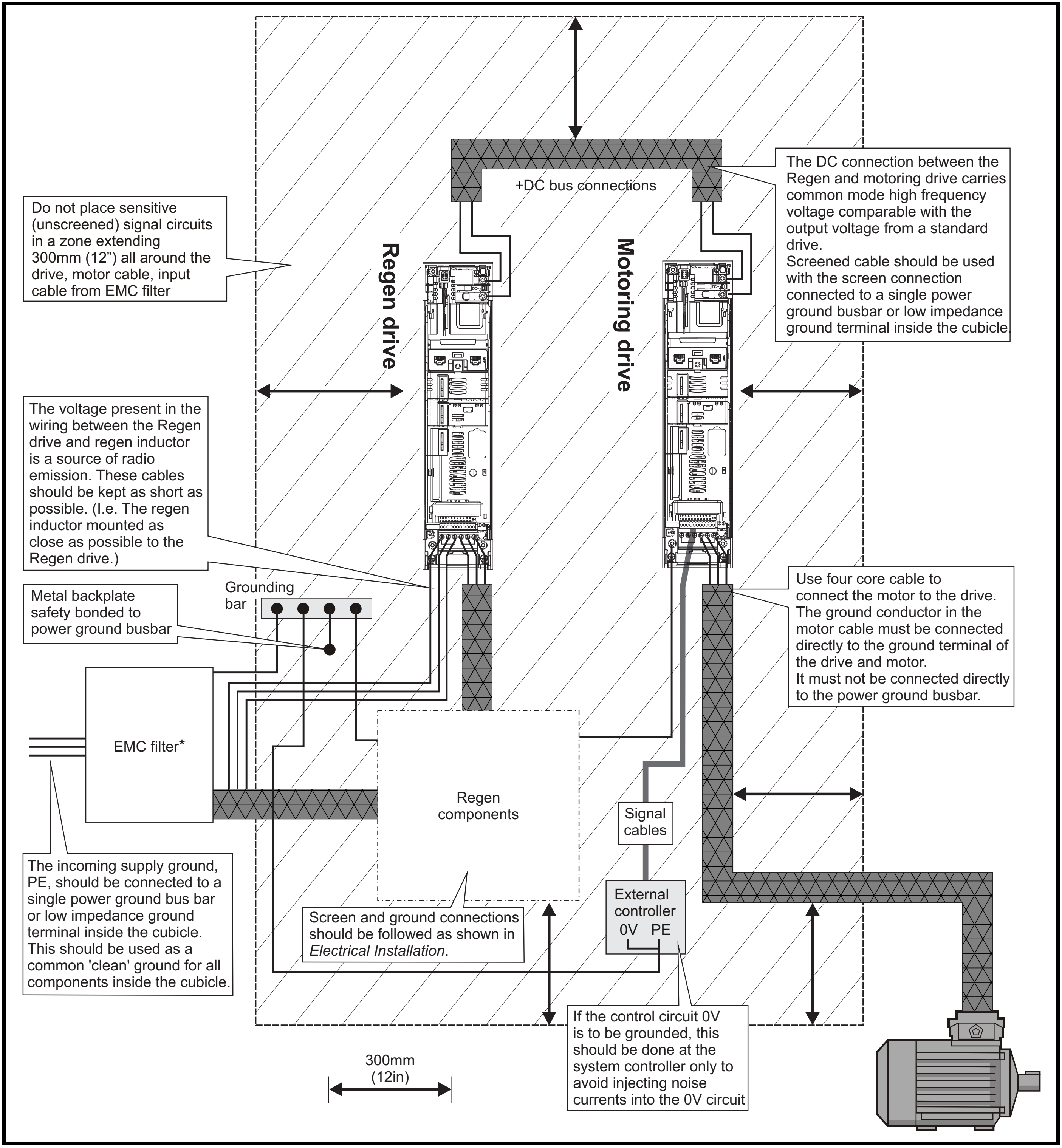
6.5.2 General requirements for EMC

Ground (earth) connections

The grounding arrangements should be in accordance with Figure 6-23, which shows both drives mounted on a back-plate with or without an additional enclosure. These precautions are necessary to ensure reliable operation and minimal interference with other equipment.

Figure 6-23 shows how to manage EMC when using a shielded motor cable, and indicates the clearances which should be observed around the drive and related ‘noisy’ power cables by all sensitive control signals / equipment in order to prevent coupling between the power wiring of the drives and the mains input cables.

Figure 6-23 General EMC enclosure layout showing earth / ground connections



* Where required.

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

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

Operation in the first environment

Observe the guidelines given in section 6.5.4 *Compliance with generic emission standards* on page 131. An external EMC filter will always be required.

> **CAUTION**
>
> This is a product of the restricted distribution class according to IEC61800-3
>
> In a residential environment this product may cause radio interference in which case the user may be required to take adequate measures.

Operation in the second environment

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

For longer cables, an external filter is required. Where a filter is required, follow the guidelines in section 6.5.4 *Compliance with generic emission standards* on page 131.
Where a filter is not required, follow the guidelines given in section 6.5.2 *General requirements for EMC* on page 130.

> **CAUTION**
>
> The second environment typically includes an industrial low-voltage power supply network which does not supply buildings used for residential purposes. Operating the drive in this environment without an external EMC filter may cause interference to nearby electronic equipment whose sensitivity has not been appreciated. The user must take remedial measures if this situation arises. If the consequences of unexpected disturbances are severe, it is recommended that the guidelines in section 6.5.4 *Compliance with generic emission standards* be adhered to.

Refer to the Regen configuration EMC data sheet for further information on compliance with EMC standards and definitions of environments.

Unidrive M EMC Data Sheets are available from the supplier of the drive.

6.5.4 Compliance with generic emission standards

Use the recommended filter and shielded motor cable. Observe the layout rules given in the relevant *Unidrive M Power Installation Guide*.

6.5.5 Immunity

The immunity of the individual drive modules is not affected by operation in the regenerative mode, refer to Table 10-42 *Immunity compliance* on page 303. See drive EMC data sheets for further information.

This guide recommends the use of varistors between the incoming AC supply lines. These are strongly recommended to protect the drive from surges caused by lightning activity and/or mains supply switching operations.

Since the regenerative input stage must remain synchronized to the supply, there is a limit to the permitted rate of change of supply frequency. If rates of change exceeding 100 Hz/s are expected then the supplier of the drive should be consulted. This would only arise under exceptional circumstances e.g. where the power system is supplied from an individual generator.

The behaviour of the drive during dips and supply disturbances can be modified by changing the following drive parameters:

- *Regen Synchronization Mode* (03.004). *Auto-synchronize* (03.004 = 3) allows the drive to continue operating during symmetrical (balanced) and asymmetrical (unbalanced) supply faults of up to 2 seconds duration.
- *Island Detection Enable* (03.030)
- *Regen Supply Loss AC Level* (03.023)
- *Regen Minimum Frequency* (03.024) / *Regen Maximum Frequency* (03.025). Supply frequency monitoring.
- *Regen Minimum Voltage* (03.026) / *Regen Maximum Voltage* (03.027). Supply voltage monitoring.

Refer to the individual parameter descriptions for more information.

6.5.6 Emission

Emission occurs over a wide range of frequencies. The effects are divided into three main categories:

- Low frequency effects, such as supply harmonics and notching
- High frequency emission below 30 MHz where emission is predominantly by conduction
- High frequency emission above 30 MHz where emission is predominantly by radiation

When running at constant load the drive does not generate voltage fluctuations or flicker except if island detection / protection is enabled, since it injects reactive current into the supply. The injection current does not change with the Regen unit load. Care must be taken to ensure that the application does not cause the load to vary rapidly, resulting in flicker.

6.5.7 Other supplies

Wherever other equipment shares the same low voltage supply, i.e. 400 Vac, careful consideration must be given to the likely need for both switching frequency and EMC filters, as explained in section 6.5.10 *Switching frequency emission* and section 6.5.11 *Conducted and radiated RF emission*.

6.5.8 Supply voltage notching

Because of the use of input inductors and an active rectifier the drive causes no notching - but see section 6.5.10 *Switching frequency emission* for advice on switching frequency emission.

6.5.9 Supply harmonics

When operated from a balanced sinusoidal three-phase supply, the regenerative Unidrive M generates minimal harmonic current.

Imbalance between phase voltages will cause the drive to generate some harmonic current. Existing voltage harmonics on the power system will cause some harmonic current to flow from the supply into the drive.

Note that this latter effect is not an emission, but it may be difficult to distinguish between incoming and outgoing harmonic current in a site measurement unless accurate phase angle data is available for the harmonics. No general rule can be given for these effects, but the generated harmonic current levels will always be small compared with those caused by a conventional drive with rectifier input.

6.5.10 Switching frequency emission

The Regen drive uses a PWM technique to generate a sinusoidal input voltage phase-locked to the mains supply. The input current therefore contains no harmonics of the supply unless the supply itself contains harmonics or is unbalanced. It does however contain current at the switching frequency and its harmonics, modulated by the supply frequency. For example, with a 3 kHz switching frequency and 50 Hz supply frequency there is current at 2.90, 3.10, 5.95, 6.05 kHz etc. The switching frequency is not related to that of the supply, so the emission will not be a true harmonic - it is sometimes referred to as an “interharmonic”. The possible effect of this current is similar to that of a high-order harmonic, and it spreads through the power system in a manner depending on the associated impedances. The internal impedance of the Regen drive is dominated by the series inductors at the input. The voltage produced at switching frequency at the supply point is therefore determined by the potential divider action of the series inductors and the supply impedance.

> **CAUTION**
>
> Failure to fit a switching frequency filter may result in damage to other equipment, e.g. fluorescent light fittings, power factor correction capacitors and EMC filters.

6.5.11 Conducted and radiated RF emission

Radio frequency emission in the frequency range from 150 kHz to 30 MHz is mainly conducted out of the equipment through electrical wiring. It is essential for compliance with all emission standards that the recommended EMC filter and a shielded (screened) motor cable are used. Most types of cable can be used provided it has an overall shield. For example, the shield formed by the armoring of steel wired armored cable is acceptable. The capacitance of the cable forms a load on the drive and should be kept to a minimum. The same considerations apply to any cables connecting the DC bus between drives, except that short direct wiring within the same enclosure need not be shielded.

In addition to motor cable length, conducted emission also varies with drive switching frequency. Selecting the lowest switching frequency will produce the lowest level of emission but will increase ripple in the Regen filter and switching frequency filter. In order to meet the emission standards the drive, filter and motor cable must be installed correctly. Refer to the guidelines given in section 6.5.2 *General requirements for EMC* on page 130.

CAUTION

When an EMC filter is used, the switching frequency filter must also be used. Failure to observe this may result in the EMC filter becoming ineffective and being damaged.

Single regenerative drive

When used in a simple integrated regenerative drive arrangement, i.e. a pair of drive modules back-to-back with all of the associated auxiliary components such as Regen chokes and filters located on the same panel, the radio frequency emission behaviour of a regenerative system is similar to that of a single conventional drive. The recommended arrangements given in the individual drive EMC data sheets should be followed. If used, the input RFI filter must be connected upstream of the switching-frequency filter as shown in the power connection diagrams (Figure 4-4 to Figure 4-8 on page 52). The switching-frequency filter is essential in this case to protect the RFI filter from switching-frequency current which would otherwise over-stress its capacitors.

NOTE

Theoretically the use of two drives physically close together can cause an increase in emission level of 3 dB compared with a single drive, although this is usually not observed in practice. All drives have sufficient margin in respect of the generic standard for the industrial environment EN 61000-6-4:2007+A1:2011 to allow for this increase.

Multi-drive and other more complex systems

Refer to the Unidrive M Regen configuration EMC data sheet.

For currents exceeding 300 A up to 2500 A suitable filters are available from the following manufacturers:

Epcos B84143-B250-5xx (range up to 2500 A)
Schaffner FN3359-300-99 (range up to 2400 A)

These filters may not give strict conformity with EN 61000-6-4:2007+A1:2011, but in conjunction with the relevant EMC installation guidelines they will reduce emission to sufficiently low levels to minimise the risk of disturbance.

CAUTION

Operation without a filter is a practical cost-effective possibility in an industrial installation where existing levels of electrical noise are likely to be high, and any electronic equipment in operation has been designed for such an environment. There is some risk of disturbance to other equipment, and in this case the user and supplier of the drive system must jointly take responsibility for correcting any problem which occurs.

Recommended EMC filters

These are the same filters as recommended for standard (non-regenerative) operation:

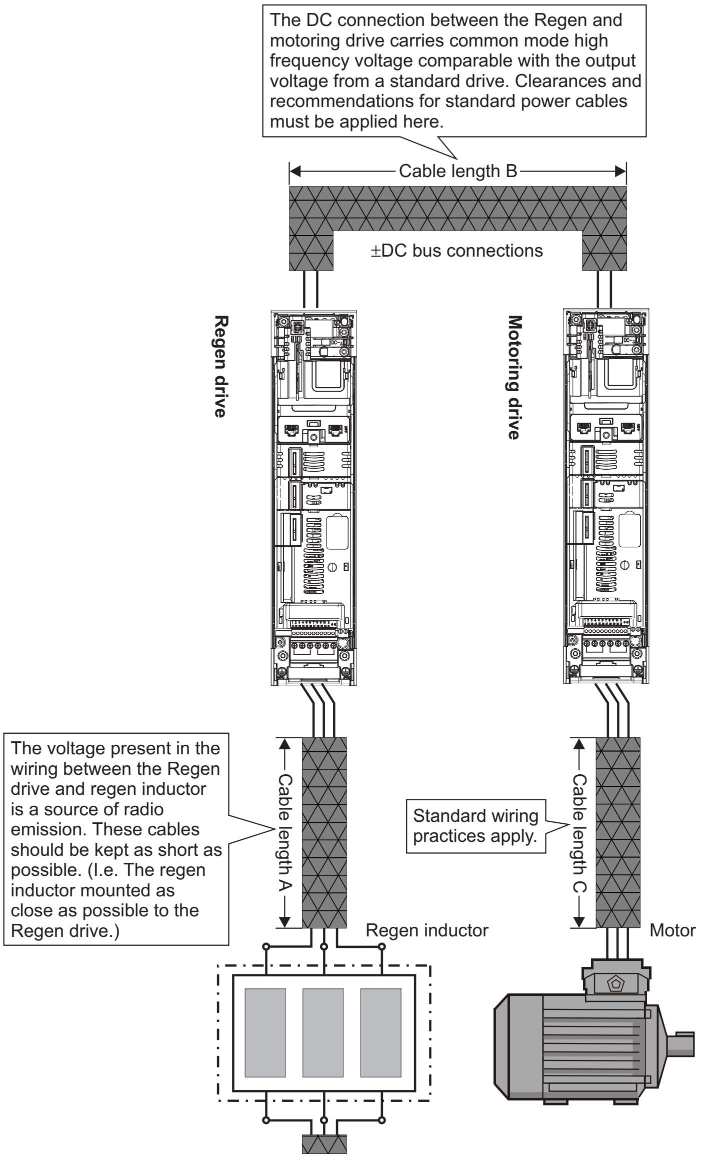
Table 6-18 Recommended filters

Drive	Motor cable length m	Part number
03200066 to 03200106	100	4200-3230
04200137 to 04200185		4200-0272
05200250		4200-0312
06200330 to 06200440		4200-2300
07200610 to 07200830		4200-1132
08201160 to 08201320		4200-1972
09201760 to 09202190 (9A)		4200-3021
10202830 to 10203000		4200-4460
03400078 to 03400100		4200-3480
04400150 to 04400172		4200-0252
05400270 to 05400300		4200-0402
06400350 to 06400470		4200-4800
07400660 to 07401000		4200-1132
08401340 to 08401570		4200-1972
09402000 to 09402240 (9A)		4200-3021
10402700 to 10403200		4200-4460
11403770 to 11404640		4200-0400
06500150 to 06500350		4200-3690
07500440 to 07500550		4200-0672
08500630 to 08500860		4200-1662
09501040 to 09501310 (9A)		4200-1660
10501520 to 10501900		4200-2210
11502000 to 11502850		4200-0690
07600190 to 07600540		4200-0672
08600630 to 08600860		4200-1662
09601040 to 09601310 (9A)		4200-1660
10601500 to 10601780		4200-2210
11602100 to 11602630		4200-0690

6.5.12 Wiring guidelines

The wiring guidelines provided for the individual drives also apply to regenerative operation, except that the switching frequency filter must be interposed between the input drive and the EMC filter. The same principles apply, the most important aspect being that the input connections to the EMC filter should be carefully segregated from the power wiring of the drives which carries a relatively high “noise” voltage.

Figure 6-24 Power cable considerations



The DC connection between the Regen and motoring drive carries common mode high frequency voltage comparable with the output voltage from a standard drive. Clearances and recommendations for standard power cables must be applied here.

The voltage present in the wiring between the Regen drive and regen inductor is a source of radio emission. These cables should be kept as short as possible. (I.e. The regen inductor mounted as close as possible to the Regen drive.)

Standard wiring practices apply.

6.5.13 Main contactors K2 with Rectifier

When using a rectifier for the charging of a Regen system the main contactor, K2 should be positioned as close as possible to the Regen drives power terminals.

6.6 Control connections

6.6.1 Unidrive M frame 10 and frame 11 external rectifier

When a Unidrive M frame 10 or frame 11 external rectifier is used to pre-charge a Regen system, the 24 V supply cable and RJ45 cable between the rectifier and the inverter must not be connected. This prevents the inverter generating a power comms or PSU trip when the supply to the rectifier is removed during the system start up sequence.

6.6.2 Unidrive M600/M700/M701 control terminals

Table 6-19 The Unidrive M600/M700/M701 control connections consist of:

Function	Qty	Control parameters available	Terminal number
Differential analog input	1	Mode, offset, invert, scaling	5, 6
Single ended analog input	2	Mode, offset, invert, scaling, destination	7, 8
Analog output	2	Source, scaling	9, 10
Digital input	3	Terminal 27 setup as reset input	27, 28, 29
Digital input / output	3	Not user available, used for Regen configuration	24, 25, 26
Relay	1	Relay configured for contactor coil power supply	41, 42
Drive enable (Safe Torque Off)	1		31
+10 V User output	1		4
+24 V User output	1	Source, invert	22
0V common	6		1, 3, 11, 21, 23, 30
+24 V External input	1	Destination, invert	2

Key:

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

All analog terminal functions can be programmed in menu 7.

Available digital terminal functions can be programmed in menu 8.

NOTE

The digital I/O at default has been configured to accept external signals from main and auxiliary contactors to allow the Regen mode to function correctly. Before changing any routing, refer to Menu 8 descriptions.

WARNING

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

WARNING

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

CAUTION

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

CAUTION

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

NOTE

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

NOTE

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

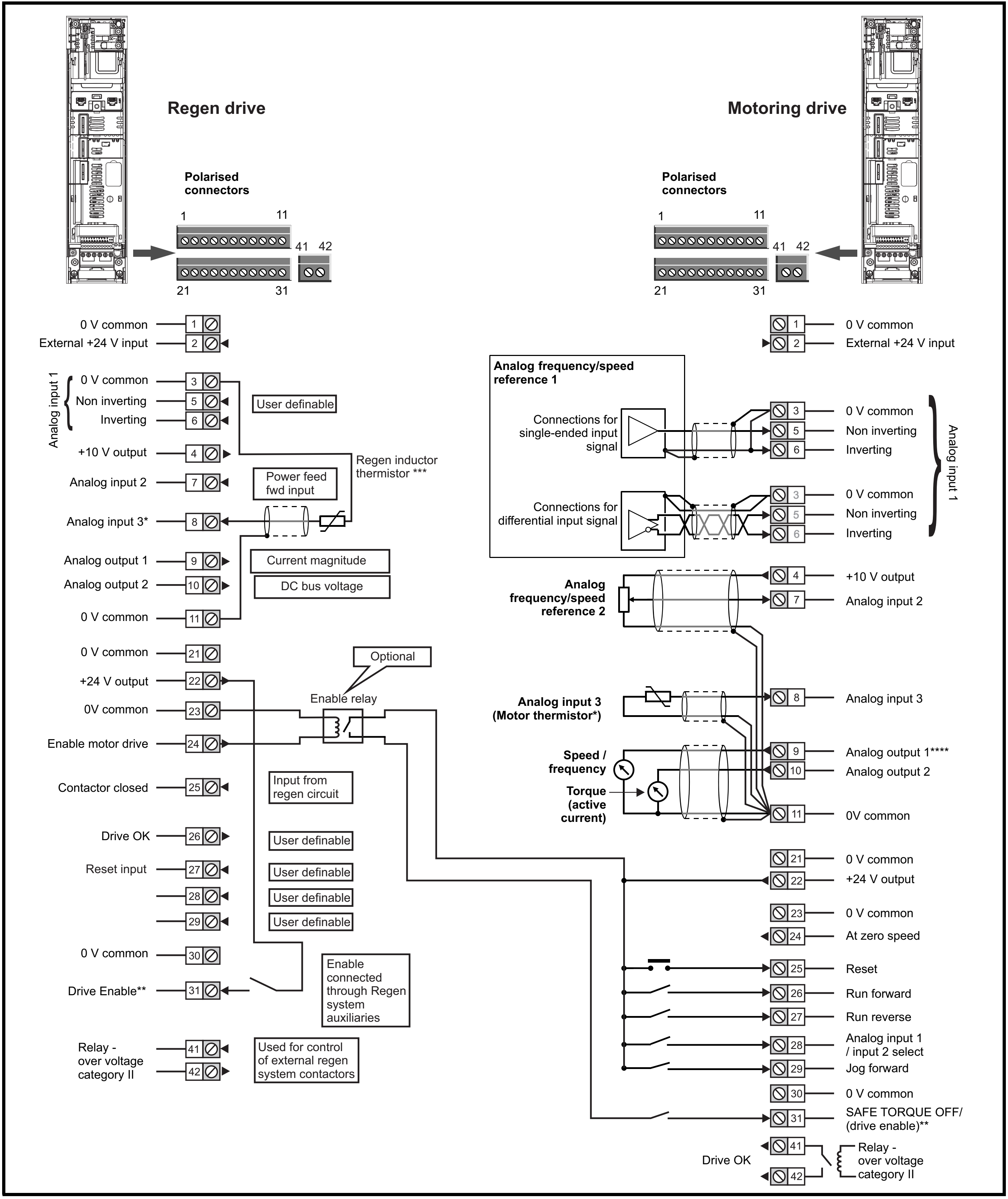
NOTE

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

NOTE

When using Unidrive M600 / M700 / M701 (not available on M702), a two wire Regen inductor / motor thermistor can be connected to analog input 3 by connecting the thermistor between terminal 8 and any 0 V common terminal.

Figure 6-25 Default terminal functions



* Analog input 3 can be configured as a Regen inductor / motor thermistor input.

** The Safe Torque Off (drive enable) terminal is a positive logic input only.

*** Pr **07.015** must be changed to Therm Short Cct or Thermistor mode to enable protection against Regen inductor over-heating.

**** Analog output 1 can be configured as a power feed-forward output (Pr **07.019** = 05.003).

6.6.3 Control terminal specification

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

2	**+24 V external input**
Function	**To supply the control circuit without providing a supply to the power stage**
Programmability	Can be switched on or off to act as a digital input by setting the source Pr **08.063** and input invert Pr **08.053**
Nominal voltage	+24.0 Vdc
Minimum continuous operating voltage	+19.2 Vdc
Maximum continuous operating voltage	+28.0 Vdc
Minimum start-up voltage	21.6 Vdc
Recommended power supply	40 W 24 Vdc nominal
Recommended fuse	3 A, 50 Vdc

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

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

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

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

7	**Analog input 2**
Default function	**Power input 1**
Type of input	Bipolar single-ended analog voltage or unipolar current
Mode controlled by...	Pr **07.011**
Operating in voltage mode	
Full scale voltage range	±10 V ±2 %
Maximum offset	±10 mV
Absolute maximum voltage range	±36 V relative to 0 V
Input resistance	≥ 100 k Ω
Operating in current mode	
Current ranges	0 to 20 mA ±5 %, 20 to 0 mA ±5 %, 4 to 20 mA ±5 %, 20 to 4 mA ±5 %
Maximum offset	250 µA
Absolute maximum voltage (reverse bias)	±36 V relative to 0 V
Absolute maximum current	±30 mA
Equivalent input resistance	≤ 300 Ω
Common to all modes	
Resolution	12 bits (11 bits plus sign)
Sample / update	250 µs with destinations Pr **01.036**, Pr **01.037** or Pr **03.022,** Pr **04.008** in RFC-A or RFC-S. 4ms for open loop mode and all other destinations in RFC-A or RFC-S mode.

8	**Analog input 3**
Default function	**Voltage input**
Type of input	Bipolar single-ended analog voltage, or thermistor input
Mode controlled by...	Pr **07.015**
Operating in Voltage mode (default)	
Voltage range	±10 V ±2 %
Maximum offset	±10 mV
Absolute maximum voltage range	±36 V relative to 0 V
Input resistance	≥100 k Ω
Operating in thermistor input mode	
Supported thermistor types	Din 44082, KTY 84, PT100, PT 1000, PT 2000, 2.0 mA
Internal pull-up voltage	2.5 V
Trip threshold resistance	User defined in Pr **07.048**
Reset resistance	User defined in Pr **07.048**
Short-circuit detection resistance	50 Ω ±40 %
Common to all modes	
Resolution	12 bits (11 bits plus sign)
Sample / update period	4 ms

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

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

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

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

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

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

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

29	**Digital Input 6**
Terminal 29 default function	**User definable input**
Type	Negative or positive logic digital inputs
Logic mode controlled by...	Pr **08.029**
Voltage range	0 V to +24 V
Absolute maximum applied voltage range	-3 V to +30 V
Impedance	>2 mA @15 V (IEC 61131-2, type 1, 6.6 k Ω)
Input thresholds	10 V ±0.8 V (IEC 61131-2, type 1)
Sample / Update period	250 µs when configured as an input with destinations Pr **06.035** or Pr **06.036**. 2 ms in all other cases.

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

31	**Drive Enable**
Type	Positive logic only digital input
Voltage range	0 V to +24 V
Absolute maximum applied voltage	30 V
Logic Threshold	10 V ±5 V
Low state maximum voltage for disable to SIL3 and PL e	5 V
Impedance	>4 mA @15 V (IEC 61131-2, type 1, 3.3 k Ω)
Low state maximum current for disable to SIL3 and PL e	0.5 mA
Response time	Nominal: 8 ms Maximum: 20 ms

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

WARNING

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

51	**0V common**
52	**+24 Vdc**
Size 6	
Nominal operating voltage	24.0 Vdc
Minimum continuous operating voltage	18.6 Vdc
Maximum continuous operating voltage	28.0 Vdc
Minimum startup voltage	18.4 Vdc
Maximum power supply requirement	40 W
Recommended fuse	4 A @ 50 Vdc
Size 7 to 11	
Nominal operating voltage	24.0 Vdc
Minimum continuous operating voltage	19.2 Vdc
Maximum continuous operating voltage	30 Vdc (IEC), 26 Vdc (UL)
Minimum startup voltage	21.6 Vdc
Maximum power supply requirement	60 W
Recommended fuse	4 A @ 50 Vdc

7 Getting started

7.1 Regen parameter settings

7.1.1 Switching frequency Pr 05.018 (Pr 00.041)

Set the switching frequency on the Regen drive to the required value (3 kHz default value).

A higher switching frequency setting has the following advantages:

- Line current ripple at the switching frequency is reduced, giving improved waveform quality.
- Acoustic noise produced by the line inductors is reduced.
- Dynamic DC bus voltage response is improved.

NOTE

In some cases, setting the switching frequency to a value greater than the default 3 kHz results in current derating. Refer to Chapter 10 *Technical data* on page 276.

7.1.2 DC bus voltage set point

The table below defines the DC Bus voltage set point levels, assuming a tolerance of ±10 % on the given supply voltage. The minimum value is defined as the peak input voltage plus some headroom. Headroom is required by the drive to allow correct control of the current. It is advisable to set the voltage below the maximum value to give more allowance for transient voltage overshoots.

Table 7-1 DC bus voltage set point - Pr 03.005 (Pr 00.001)

Voltage levels	DC Bus voltage set-point	
Supply voltage Vac	**Default Vdc**	**Minimum Vdc**
200	350	350
400	700	700
575	835	835
690	1100	1100

The DC bus voltage set point, see Pr **03.005** (Pr **00.001**), should be set to a level that is suitable for the AC supply voltage being used. It is very important that the Regen drive DC bus voltage set point Pr **03.005** (Pr **00.001**) is set above the peak AC supply voltage by at least 50 Vac.

7.2 Regen drive sequencing

When a Regen drive is enabled, it goes through a line synchronization sequence. During this procedure, test pulses are applied to the incoming line to determine the voltage and phase. When it has been successfully synchronized to the line, the DC bus voltage controller is enabled and the DC bus voltage rises to the target voltage.

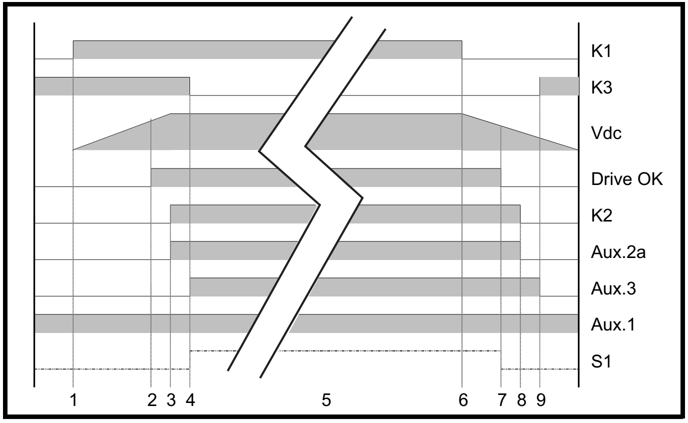
Only when all of these stages have been completed successfully is the motoring drive enabled. If at any time there is a fault, or the Regen drive is disabled, the motoring drive will also be disabled.

This sequence of events is important to prevent damage to the Regen drive, motoring drive or external power circuit components.

The sequence of events is as follows:

Power applied and power removed 400 V system (refer to Figure 4-4 on page 42)

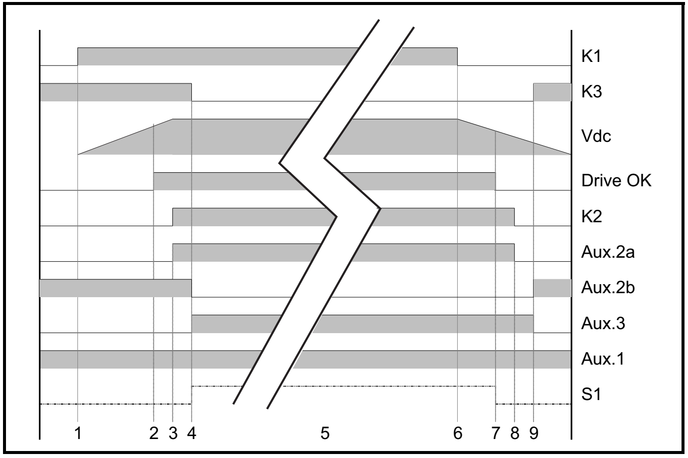
Figure 7-1 Single Regen: Single Motoring



1. K1 (main supply contactor / isolator / disconnect) is closed with charging circuit active (K3 closed).
2. DC bus charges through the Regen drives Vac inputs L1, L2, L3 (charging circuit).
3. If the DC Bus > the UV threshold then K2 Regen drive main contactor and Aux.2a are closed via Regen drives relay, control terminals 41, 42.
4. K3 charging contactor is opened via K2 (Regen drive main contactor as Aux.2b opens) and Aux.3 closes. The Regen drive enable, S1 can now be applied.
5. The Regen drive and motoring drives can be enabled (enable signal from Regen drive to motoring drives active, control terminal 24).
6. K1 (main supply contactor / isolator / disconnect) is opened removing power from the Regen system.
7. DC bus discharges to the UV threshold at which point the drive OK relay becomes in-active. The Regen drives enable is removed. The motoring drives enable signal from Regen drive becomes in-active.
8. Regen drive main contactor, K2 is opened via the drive OK relay, control terminals 41, 42. Aux.2a opens informing the drive that the Regen drives main contactor K2 is open.
9. K3 charging contactor is closed and Aux.3 opens.

Power applied and power removed 400 V system (refer to Figure 4-5 on page 44)

Figure 7-2 Single Regen: Multiple Motoring (Unidrive M Rectifier)

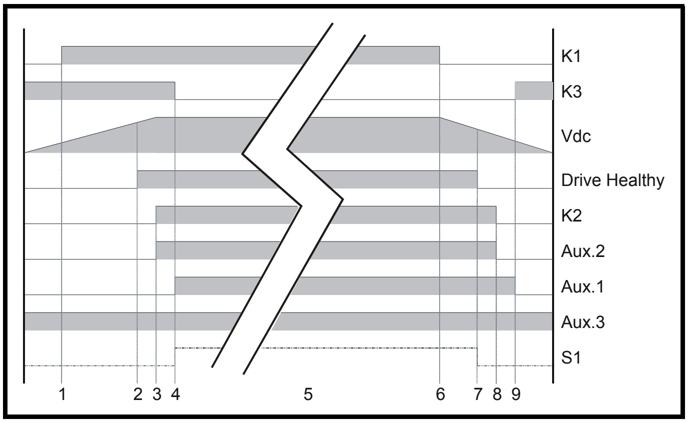


1. K1 (main supply contactor / isolator / disconnect) is closed with charging circuit active (K3 closed).
2. DC bus charges through Unidrive M Rectifier (charging circuit).
3. If the DC Bus > the UV threshold then K2 Regen drive main contactor and Aux.2a are closed via Regen drives relay, control terminals 41, 42.

4. K3 charging contactor is opened via K2 (Regen drive main contactor), as Aux.2b opens and Aux.3 closes. The Regen drive enable, S1 can now be applied.
5. The Regen drive and motoring drives can be enabled (enable signal from Regen drive to motoring drives active, control terminal 24).
6. K1 (main supply contactor / isolator / disconnect) is opened removing power from the Regen system.
7. DC bus discharges to the UV threshold at which point the drive OK relay becomes in-active. The Regen drives enable is removed. The motoring drives enable signal from Regen drive becomes in-active.
8. Regen drive main contactor, K2 is opened via the drive OK relay, control terminals 41, 42.
9. Aux.2a opens informing the drive that the Regen drives main contactor K2 is open. K3 charging contactor is closed and Aux.3 opens.

Power applied and power removed 400 V system (refer to Figure 4-6 on page 46)

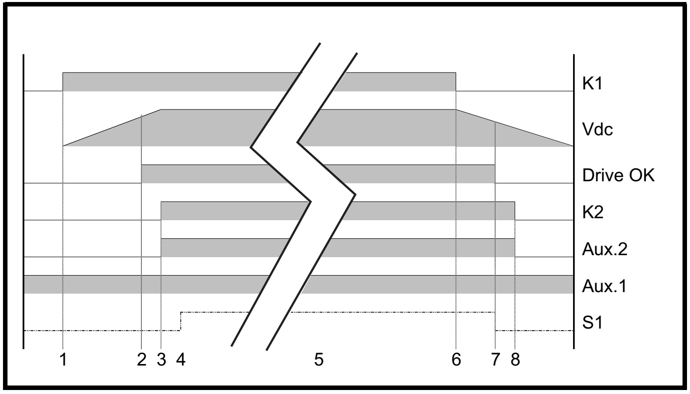
Figure 7-3 Single Regen: Multiple Motoring - external softstart resistor



1. K1 (main supply contactor / isolator) is closed with charging circuit active (K3 closed).
2. DC bus charges through the external charging resistors (charging circuit).
3. If the DC Bus > 430 Vdc then K2 Regen drive main contactor and Aux.2 are closed via Regen drives relay, control terminals 41, 42.
4. K3 charging contactor is opened via K2 (Regen drive main contactor) and Aux.1 closes. The Regen drive enable, S1 can now be applied.
5. The Regen drive and motoring drives can be enabled (enable signal from Regen drive to motoring drives active, control terminal 24).
6. K1 (main supply contactor / isolator) is opened removing power from the regen system.
7. DC bus discharges to 410 Vdc at which point drive the healthy relay becomes in-active. The Regen drives enable is removed.
   The motoring drives enable signal from Regen drive becomes in-active.
8. Regen drive main contactor, K2 is opened via the drive healthy relay, control terminals 41, 42. Aux.2 opens informing the drive that the Regen drives main contactor K2 is open.
9. K3 charging contactor is closed and Aux.1 opens.

Power applied and power removed 400 V system (refer to Figure 4-8 on page 52)

Figure 7-4 Regen brake resistor replacement



1. K1 (main supply contactor / isolator / disconnect) is closed.
2. DC bus charges through motoring drives L1, L2, L3 Vac inputs.
3. If the DC Bus > the UV threshold then K2 Regen drive main contactor and Aux.2 are closed via Regen drives relay, control terminals 41, 42.
4. Regen drive enable, S1 can now be applied.
5. The Regen drive and motoring drives can be enabled (enable signal from Regen drive to motoring drives active, control terminal 24).
6. K1 (main supply contactor / isolator / disconnect) is opened removing power from the Regen system.
7. DC bus discharges to the UV threshold at which point the drive OK relay becomes in-active. The Regen drives enable is removed. The motoring drives enable signal from Regen drive becomes in-active.
8. Regen drive main contactor, K2 is opened via the drive OK relay, control terminals 41, 42. Aux.2 opens informing the drive that the Regen drives main contactor K2 is open.

NOTE

When the Regen drive has powered-up and the DC bus voltage has exceeded the UV threshold, Pr **03.007** changes from 0 to 1 activating the drives relay which in turn closes the Regen drive main contactor (charging circuit disconnected using contactor / relay logic). If either the DC bus voltage falls below the UV threshold or the system is synchronized and the AC voltage falls below *Regen Supply AC Level* (Pr **03.023**), Pr **03.007** will change from a 1 to 0 opening the Regen drive main contactor (charging circuit re-connected using contactor / relay logic).

Synchronization:

- Apply test pulses to line to determine magnitude and phase.
- Attempt to synchronize to the line.
- If synchronization is successful then enable the DC bus voltage controller.

DC bus voltage controller active:

- DC bus voltage rises to reference level.
- Motoring drive enabled by digital output from Regen drive.

Motoring drive active:

- The motor may now be energized and rotated.
- Power flows to and from the line as necessary via the Regen drive.
- DC bus voltage remains stable.

Whilst running if:

- The line voltage dips too low:
  The Regen drive synchronizes to the Vac supply and therefore knows the supply voltage (Pr **05.002**).
- OR the DC bus voltage goes out of regulation:
  DC bus drops below the UV threshold.
- OR there is any trip on the Regen drive:
  Drive OK no longer active. Regen and motoring drive(s) enable removed.

- OR the supply contactor is de-energized:
  Main supply contactor auxiliary contact connected to control terminal 25 of Regen drive opens.
- OR the Regen drive is disabled:
- OR the MCB trips:
  External softstart resistor.

Then:

- the Regen drive will inhibit.
- the motoring drive will be disabled by the Regen drive.
- the Regen drive main contactor will be opened.

7.2.1 Sequence

The motoring drive must only be enabled when the Regen drive is enabled, healthy, and synchronized to the AC supply. This will prevent any damage to the Regen drive start-up circuit and prevent OV trips.

7.3 Regen drive commissioning / start-up

- Ensure power and control connections are made as specified in this Design Guide.
- Ensure the Regen and motoring drives are not enabled.
- Switch on the AC supply.
- Both the Regen and motoring drives should now power up through the relevant start-up circuits in standard open loop mode.
- On the Regen drive, configure the drive type Pr **11.031** (Pr **00.048**) to Regen.
- The main contactors should now close; the relevant start-up circuit is disabled at this point.
- On the Regen drive, set up the switching frequency and DC bus set point voltage to the required values in either Menu 0 or Menu 3, refer to section 7.1.2 *DC bus voltage set point*. If the Regen inductor thermistor has been connected to analog input 3, Pr **07.015** must be changed to Therm Short Cct or Thermistor mode to enable protection against inductor overheating. Save the parameters.
- The Regen drive can now be enabled, the Regen drive should display *Active*.
- The commissioning / start-up of the motoring drive(s) can now be carried out.

7.4 Motoring drive commissioning

7.4.1 Motoring drive enable

When the Regen drive has been successfully synchronized, Pr **03.009** on the Regen drive will become active and digital I/O 1 on terminal 24 also becomes active allowing the motoring drive(s) to be enabled. If the Regen drive trips or attempts to re-synchronize to the supply, Pr **03.009** becomes zero and the enable signal for the motoring drive(s) is removed.

The setting of certain parameters in the motoring drive must be given special consideration when used in a Regen system.

7.4.2 Ramp Mode - Pr 02.004 (Pr 00.015)

When a motoring drive is used in a Regen system, the ramp mode should be set to *Fast*. The default setting of standard control will result in incorrect operation.

7.4.3 Open-loop Control Mode - Open loop only Pr 05.014 (Pr 00.007)

The default setting of *UR I* does not function correctly in the motoring drive when used in a Regen system. When the system is powered up, the motoring drive is disabled while the Regen drive synchronizes to the AC supply. The resultant delay before the motoring drive is enabled means that the stator resistance test cannot be completed. When open loop vector operation is required the voltage mode should be set to *UR S*.

7.4.4 AC Supply Loss Mode - Pr 06.003

The motoring drive will not operate correctly if the AC supply loss mode is set to *Ramp Stop*. If the AC supply is lost, the Regen drive disables the motoring drive and prevents a controlled stop from being completed.

8 Optimization

The following section covers optimization of the Regen system which can be carried out by the user.

Feature	Detail
Power feed-forward	Power feed-forward can be used to reduce fast transient DC bus voltage effects produced by transient load conditions on motoring drives mainly in Dynamic applications where spurious over-voltage and/or over-current trips are experienced.
Voltage controller gain	The voltage controller gain can be implemented to overcome instability in the DC voltage on the common DC bus in the following conditions, • A brake resistor replacement system where the ratio between Regen brake drive and motoring drive(s) DC bus capacitance is large • With multiple motoring drive(s) where the ratio between the Regen drive(s) and motor drive(s) DC bus capacitance is large. Ensure the voltage controller gain is not increased too high as this can also introduce excessive ripple and instability on the DC bus.
Current loop gains	The current loop gains can be optimized to overcome spurious over-current trips during either synchronization to the power supply, or during operation. The default gain settings are sufficient for most applications however these can be modified with the proportional (Kp) being the most critical for stability.
Power factor correction	This does not optimize the Regen system but improves the power factor of the supply that is connected to the Regen system. • Will introduce cost saving (electricity bill), compensate for inductive loads on the same supply, and overcome voltage drops due to “soft supplies”. • A separate power factor correction unit may not be required. • The symmetrical current limit must be below its maximum in order for power factor correction to work (therefore may be limited due to Regen drive size).
Voltage ramp time	The ramp time for the DC bus voltage to reach the *Voltage Set Point* (03.005) can be controlled by *Voltage Ramp Time* (03.022) which allows a shorter synchronization time if required.

8.1 Power feed-forward compensation (Pr 03.010)

Power feed-forward compensation can be used to reduce the transient DC bus voltages produced when a fast load transient occurs on the motoring drives connected to the Regen drive.

If *Power Output* (07.033) from a motor drive is routed to an analog output with unity scaling it will produce full scale output when the power is equal to 3 x (VM_DC_VOLTAGE[MAX] / 2√2) x *Full Scale Current Kc* (11.061). If this signal is connected to an analog input on the Regen drive, the input is routed to *Power Input 1* (03.010) and *Power Input 1 Scaling* (03.015) is set to the ratio of the current scaling values for the motor drive and Regen drives (i.e. Motor drive *Full Scale Current Kc* (11.061) / Regen drive *Full Scale Current Kc* (11.061)) then the correct power feed-forward term will be provided. The default value for *Power Input 1 Scaling* (03.015) is 1.000, and so unless the Regen and motor drives are the same size this parameter will need to be adjusted.

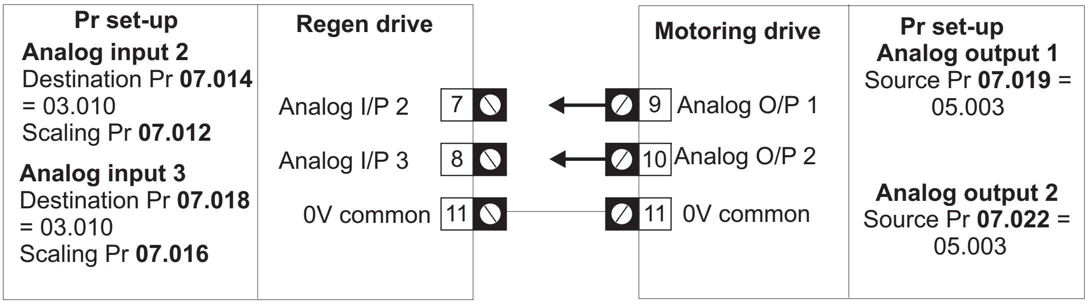
Up to 3 motor drives connected to the Regen drive DC terminals can use this system to provide power feed-forward as each of the power inputs are summed to give the final power feed-forward term. (It should be noted that a maximum of two analog inputs are provided on the drive with 250 μs update rate. If the third input is used the update rate is 4 ms, and so this should only be used for a motor drive with limited dynamic performance.)
If more motor drives are connected to the DC terminals of the Regen drive, or a digital power feed-forward system is required, then *Power Input kW* (03.018) should be used. The power in kW can be transferred from each motor drive using fast synchronous communications to an application module in the Regen drive. The total power in kW should be calculated by the applications module and then written to the *Power Input kW* (03.018). For the power feed-forward to be effective data should be transferred every 250 μs with the minimum delay (i.e. 500 μs) and the total power written to *Power Input kW* (03.018) every 250 μs.

It should be noted that the polarity of all the power feed-forward parameters is that positive values cause power to flow from the supply and negative values cause power to flow into the supply.

Figure 8-1 shows the Regen drives analog inputs and motoring drives analog outputs which can be used to pass Pr **05.003** (motoring drive output power) to the Regen drive which is then used for the power feed-forward.

Only one analog output from the motoring drive and one analog input to the Regen drive is required to configure the power feed-forward term.

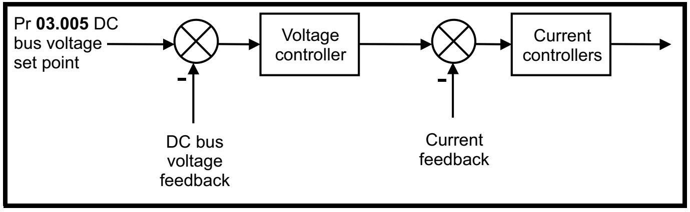
Figure 8-1 Power Feed-forward configurations



8.2 Regen controllers

The Regen drive uses a DC bus voltage controller with inner current controllers as shown in Figure 8-2:

Figure 8-2 Regen controllers



The gains of the voltage and current controllers affect the stability of the Regen system, with incorrect settings resulting in over-voltage or over-current trips.

8.3 Current loop gains

The defaults current loop gains (Kp, Pr **04.013** and Ki, Pr **04.014**) are suitable for most standard Regen systems. However if the input inductance is significantly higher the proportional gain may need to be adjusted as described following.

The most critical parameter for stability is the current controller ***proportional gain***, Pr **04.013**. The required value for this is dependent upon the Regen drives input inductance. If the inductance of the supply is a significant proportion of the recommended Regen inductor

i.e. $60/I_{DR}$ mH per phase,

Where:

I_{DR} is the drive rated current

then the proportional gain may need to be increased.

The supply inductance is likely to be negligible compared to the Regen inductor value with small drives, but is likely to be significant with larger drives. The proportional gain, Pr **04.013** should be adjusted as described following using the total inductance per phase.

The ***proportional gain***, Pr **04.013** can be set by the user so that

Pr **04.013** = $Kp = (L / T) \times (I_{fs} / V_{fs}) \times (256 / 5)$

Where:

T is the sample time of the current controllers. The drive compensates for any change of sample time, and so it should be assumed that the sample time is equivalent to the lowest sample rate of 167 µs.

L is the total input inductance.

$\mathbf{I_{fs}}$ is the peak full-scale current feedback

$\mathbf{I_{fs}}$ = *Full Scale Current Kc* (11.061) x √2

Vfs is the maximum DC bus voltage.

Therefore:

Pr **04.013** = $Kp = (L / 167\ \mu s) \times (Kc \times \sqrt{2} / Vfs) \times (256 / 5)$

$= K \times L \times Kc$

Where:

$K = [\sqrt{2} / (Vfs \times 167\ \mu s)] \times (256 / 5)$

There is one value of the scaling factor K for each drive voltage rating as shown in the table below.

Drive voltage rating (11.033)	Vfs	K
200 V	415 V	1045
400 V	830 V	522
575 V	990 V	438
690 V	1190 V	364

This set-up will give a step response with minimum overshoot after a step change of current reference. The approximate performance of the current controllers will be as given below. The proportional gain can be increased by a factor of 1.5 giving a similar increase in bandwidth, however, this gives a step response with approximately 12.5 % overshoot.

Table 8-1 Current loop sample times

Switching frequency kHz	Current control sample time (T) µs
3	167
4	125
6	83
8	62.5
12	83
16	62.5

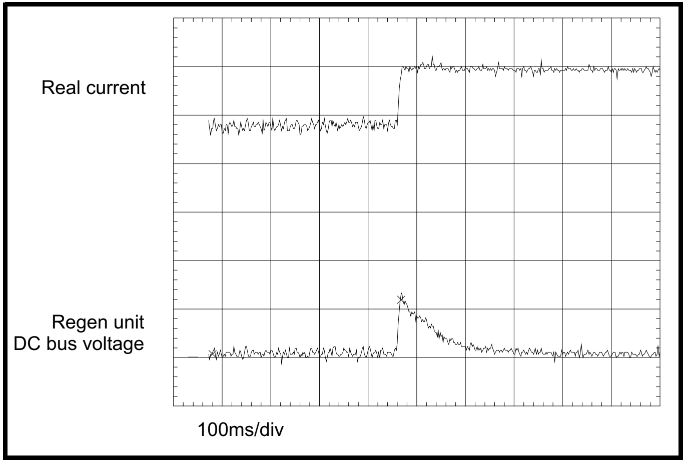
As previously detailed the current controller ***integral gain***, Pr **04.014** is not so critical with the recommended value being the default setting.

8.4 Voltage controller proportional gain Kp (Pr 03.006)

The DC bus voltage is controlled by a PI controller, which provides the reference for the real component of current from the inverter terminals to the supply. The power input parameters (*Power Input 1* (03.010), *Power Input 2* (03.013), *Power Input 3* (03.014) or *Power Input kW* (03.018)) are provided to give a power feed forward term, at the output of the PI controller, from the motor drives connected to the DC bus.
If possible the power feed forwards should be used so that the PI controller is simply providing a trim to the DC bus voltage. In most cases the default voltage controller gains can be used, however the effect of the gains and the response of the voltage controller is discussed below.

For the purpose of analyzing the voltage controller response it is assumed that a power feed-forward term is not provided. If the power flow from the DC bus is increased (i.e. motor is accelerated by a motor drive connected to the DC bus) the DC bus voltage will fall, but the minimum level will be limited to just below the peak rectified level of the supply provided the maximum rating of the unit is not exceeded. If the power flow to the DC bus is increased (i.e. motor is decelerated by a motor drive connected to the DC bus) the DC bus voltage will rise. If the peak of the DC bus voltage reaches the over voltage level the Regen drive will trip. A rapid transient where power into the DC bus is increased is shown below in Figure 8-3.

Figure 8-3 DC Bus transient



The example shown is for a very rapid load change where the torque reference of the motor drive has been changed instantly from one value to another.

The peak of the resulting transient is

ΔVdc = 191680 x Pd / (vll x Kp x Kc) Volts

and the time constant of the recovery is Kp / 30520 seconds.

where:

Pd is the transient change of power flow

vll is the line to line supply voltage

Kp = *Voltage Controller Proportional Gain Kp* (03.006)

Kc = *Full Scale Current Kc* (11.061)

For example, if Pd = 7.5 kW, vll = 400 V, Kp = 4000, Kc = 38.222 A then ΔVdc = 23.5 V and the time constant is 131 ms.

In the example given there is a very rapid change of power flow. The transient DC bus voltage change can be substantially reduced by introducing a time constant into the power transient. For example a filter could be included between the speed controller and current controller in the motor drive with *Current Reference Filter 1 Time Constant* (04.012). A time constant of 20 ms reduces the voltage transient by 25 % and a time constant of 40 ms reduces the voltage transient by 50 %. In most cases it is not desirable to reduce the performance of the motor drive, and so as already mentioned the best solution is to use a power feed forward term from the motor drive.

So far the discussion has been related to the DC bus voltage controller gain, however, the controller provides the real current reference to the Regen drive current controllers, and so the current controller gains affect the response of the voltage controller. If the default voltage controller gain is used and it is possible to obtain a stable response from the current controllers with their default gains then the voltage controller response will be stable. However, in some cases it will be necessary to reduce the current controller gains to make these controllers stable, in which case it is likely that the voltage controller gain will need to be reduced to make this controller stable.

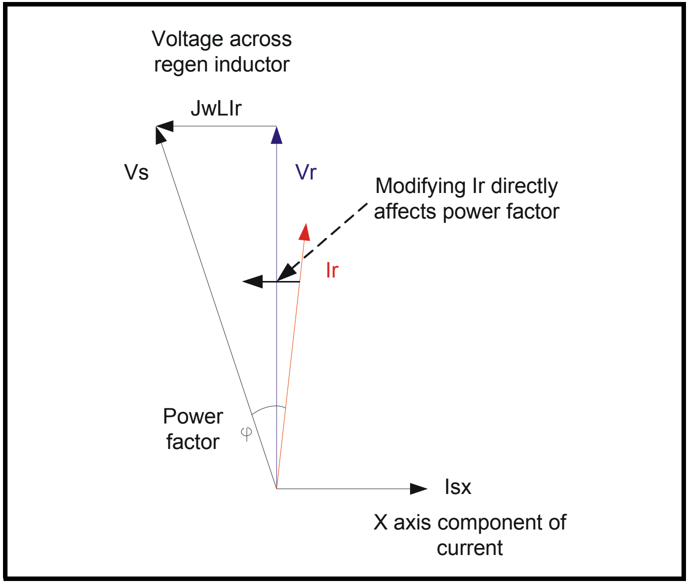
It is possible to disable the DC bus voltage controller by setting *Voltage Controller Proportional Gain Kp* (03.006) to zero. This sets both the proportional and integral gains to zero. Once the controller is disabled the flow of power through the Regen drive can be defined using the power input parameters (*Power Input 1* (03.010), *Power Input 2* (03.013), *Power Input 3* (03.014), *Power Input kW* (03.018)) or *Active Current* (04.002). This method of control can only be used if the DC bus voltage is defined at a voltage above the level of the rectified AC supply to the Regen drive by another system connected to the DC terminals.

8.5 Power factor correction (Pr 04.008)

Reactive Current Reference (04.008) can be used to define a level of reactive current other than the default value of zero, so that the Regen drive can be made to produce or consume reactive power.
Reactive Current Reference (04.008) defines the level of reactive current as a percentage of the *Rated Current* (05.007). Positive reactive current produces a component of current flowing from the supply to the Regen that lags the respective phase voltage, and negative reactive current produces a component of current that leads the respective voltage.

The variable maximum applied to *Reactive Current Reference* (04.008) is used to ensure that the total current does not exceed the maximum allowed. If the current limits are at their maximum values then no reactive current is allowed and
VM_REGEN_REACTIVE_REFERENCE[MIN] = 0 and
VM_REGEN_REACTIVE_REFERENCE[MAX] = 0. As the *Final Current Limit* (04.018) is reduced then more reactive current is allowed.

Figure 8-4 Power flow from supply to Regen drive



Vs	Supply voltage
Vr	Voltage at Regen drive terminals
Ir	Total current at Regen drive terminals
JwLIr	Voltage across Regen inductor
φ	Power factor

NOTE

The drive can control the reactive current / power, but not the real power.

8.6 Current trimming

A current feedback trimming routine runs before the Regen drive is enabled to minimise offsets in the current feedback. If *Current Trim Mode* (03.011) = 0 the current offset trim is only carried out once when the drive comes out of the under voltage state and is not repeated unless the supply is removed and re-applied. The current offset trim is only carried out when the charge system is enabled (contactor open) as this minimizes current flowing into the inverter terminals due to noise on the supply that may disturb the current offset trimming.

Current Trim Mode (03.011) should be set to one if the current offset trim is required each time when the Regen drive is enabled. To ensure that the current offset trim is not disturbed by noise on the supply, the charge system is enabled before the current offset trim and then disabled again before the Regen drive goes into its active state. This causes the charge system contactors to switch each time the Regen drive is enabled.

8.7 Voltage ramp time control (Pr 03.022)

When a Regen drive is enabled and has synchronized to the supply, the DC bus voltage is at a level equal to the peak line to line voltage.
The voltage controller is then enabled and attempts to raise the DC bus voltage to the set-point defined by *Voltage Set Point* (03.005).
The voltage reference is ramped up to the requried level at a rate defined by *Voltage Ramp Time* (03.022) in V/ms. The default value of 1.0 V/ms ensures limited over-shoot when the DC bus voltage reaches the required level. If a shorter synchronization time is required then the ramp rate can be increased, however care must be taken to avoid over-voltage trips particularly if a high level is used for the DC bus voltage set-point. If a faster ramp rate and high set-point are required it may be necessary the increase *Voltage Controller Proportional Gain Kp* (03.006) to minimise over-shoot.

8.8 Frequency limits

Frequency limits have been applied to the Regen system output (defined in *Regen Minimum Frequency* (03.024) and *Regen Maximum Frequency* (03.025)). These are enabled as default. If the Regen system supply frequency is within approximately 5 Hz of either limit for 100 ms, the system will not remain synchronized and will attempt to re-synchronize. The frequency limits are important if the supply is removed when the Regen system is active, as the system could remain active, particularly if energy is fed into the dc bus, with an uncontrolled output frequency and voltage.

8.9 Voltage limits

Voltage limits are available (defined in *Regen Minimum Voltage (03.026) and Regen Maximum Voltage* (03.027)). These are not enabled as default. If the voltage limits are active, a *Voltage Range* trip is generated when the voltage is outside the range defined for 100 ms. The voltage limits are important if the supply is removed when the Regen system is active, as the system could remain active, particularly if energy is fed into the dc bus, with an uncontrolled output frequency and voltage.

8.10 Supply voltage detection

Synchronization issues can be seen when the dc bus voltage is not proportional to the supply voltage, for example, a PV application. There are modes in *Supply Voltage Detection Mode* (03.029) which provide a robust and fast synchronization for these non standard applications.

8.11 Island detection

The purpose of this feature is to prevent unwanted islanded operation, where part of the power distribution network becomes separated from the power grid and is unintentionally maintained by an inverter.

An island detection system designed to meet the requirements of IEEE1547 and VDE 0126-1-1 has been included. Both IEEE and VDE standards describe an unintentional islanding test that uses a parallel resonant RLC load to create a worst case condition for the formation of unintentional islands. When the detection system is enabled, a small reactive current is injected that allows the inverter to detect this resonant condition. A system has been included that allows the reactive current injected by a number of Regen drives to be synchronized to a suitable master clock (required in some large scale PV applications).

8.12 Synchronization headroom (Pr 03.035)

Synchronization Headroom (03.035) allows more control to prevent over-voltage trips occurring during synchronization due to non-standard filter components or high impedance power supply.

8.13 Harmonic reduction

Even with the optimum DC bus voltage and current controller set-up, it is possible for supply voltage distortion to cause harmonic distortion in the AC currents between the supply and the Regen drive. The Regen drive includes an additional system to reduce imbalance, 5th harmonics and 7th harmonics in the AC currents. This system is enabled with *Harmonic Reduction Enable* (03.021). Distortion reduction due to voltage imbalance is enabled as default.

8.14 Active current reference

It is possible for the user to define the active current reference via *Active Current Reference* (04.009). It should be noted that the Regen drive can no longer control its own DC bus voltage and so this must be controlled by an external system e.g. the voltage master module in a SPV system.

8.15 Current feedback filter disable (Pr 04.021)

The filtering applied to the active and reactive current parameters can be disabled using *Current Feedback Filter Disable* (04.021). This is provided for SPV applications where the drive current measurement is used by an external controller.

8.16 DC bus voltage high range (Pr 05.023)

DC bus Voltage High Range (05.023) provides voltage feedback that has lower resolution and a higher range than *DC bus Voltage* (05.005) and so it is possible to determine the DC bus voltage even if this exceeds the level of the over-voltage trip.

9 Parameters

This is a quick reference to all parameters in the drive showing units, ranges limits etc, with block diagrams to illustrate their function. Full descriptions of the parameters can be found in the *Parameter Reference Guide*.

WARNING

These advanced parameters are listed for reference purposes only. The lists in this chapter do not include sufficient information for adjusting these parameters. Incorrect adjustment can affect the safety of the system, and damage the drive and or external equipment. Before attempting to adjust any of these parameters, refer to the *Parameter Reference Guide*.

Table 9-1 Menu descriptions

Menu	Description
0	Commonly used basic set up parameters for quick / easy programming
3	Regen control
4	Current control
5	Regen status
6	Sequencer and clock
7	Analog I/O, Temperature monitoring
8	Regen digital I/O
9	Programmable logic, motorized pot, binary sum, timers and scope
10	Status and trips
11	Drive set-up and identification, serial communications
12	Threshold detectors and variable selectors
14	User PID controller
15	Option module slot 1 set-up menu
16	Option module slot 2 set-up menu
17	Option module slot 3 set-up menu
18	General option module application menu 1
19	General option module application menu 2
20	General option module application menu 3
22	Menu 0 set-up
23	Not allocated
28	Reserved menu
29	Reserved menu
30	Onboard user programming application menu
Slot 1	Slot 1 option menus*
Slot 2	Slot 2 option menus*
Slot 3	Slot 3 option menus*

* Only displayed when the option modules are installed.

Default abbreviations:

Standard default value (50 Hz AC supply frequency)

USA default value (60 Hz AC supply frequency)

In some cases, the function or range of a parameter is affected by the setting of another parameter. The information in the lists relates to the default condition of any parameters affected in this way.

Table 9-2 Key to parameter table coding

Coding	Attribute
RW	Read/Write: can be written by the user
RO	Read only: can only be read by the user
Bit	1 bit parameter. 'On' or 'Off' on the display
Num	Number: can be uni-polar or bi-polar
Txt	Text: the parameter uses text strings instead of numbers.
Bin	Binary parameter
IP	IP Address parameter
Mac	Mac Address parameter
Date	Date parameter
Time	Time parameter
Chr	Character parameter
FI	Filtered: some parameters which can have rapidly changing values are filtered when displayed on the drive keypad for easy viewing.
DE	Destination: This parameter selects the destination of an input or logic function.
RA	Rating dependent: this parameter is likely to have different values and ranges with drives of different voltage and current ratings. Parameters with this attribute will be transferred to the destination drive by non-volatile storage media when the rating of the destination drive is different from the source drive and the file is a parameter file. However, the values will be transferred if only the current rating is different and the file is a difference from default type file.
ND	No default: The parameter is not modified when defaults are loaded
NC	Not copied: not transferred to or from non-volatile media during copying.
PT	Protected: cannot be used as a destination.
US	User save: parameter saved in drive EEPROM when the user initiates a parameter save.
PS	Power-down save: parameter automatically saved in drive EEPROM when the under volts (UV) state occurs.

9.1 Parameter ranges and variable maximums

Some parameters in the drive have a variable range with a variable minimum and a variable maximum value which is dependent on one of the following:

- The settings of other parameters
- The drive rating
- The drive mode
- Combination of any of the above

The tables below give the definition of variable minimum/maximum and the maximum range of these.

VM_AC_VOLTAGE	Range applied to parameters showing AC voltage
Units	V
Range of [MIN]	0
Range of [MAX]	0 to 930
Definition	VM_AC_VOLTAGE[MAX] is drive voltage rating dependent. See Table 9-3. VM_AC_VOLTAGE[MIN] = 0

VM_AC_VOLTAGE_SET	Range applied to the AC voltage set-up parameters
Units	V
Range of [MIN]	0
Range of [MAX]	0 to 690
Definition	VM_AC_VOLTAGE_SET[MAX] is drive voltage rating dependent. See Table 9-3. VM_AC_VOLTAGE_SET[MIN] = 0

VM_DC_VOLTAGE	Range applied to parameters showing DC voltage
Units	V
Range of [MIN]	0
Range of [MAX]	0 to 1190
Definition	VM_DC_VOLTAGE[MAX] is the full scale DC bus voltage feedback (over voltage trip level) for the drive. This level is drive voltage rating dependent. See Table 9-3. VM_DC_VOLTAGE[MIN] = 0

VM_DC_VOLTAGE_SET	Range applied to DC voltage reference parameters
Units	V
Range of [MIN]	0
Range of [MAX]	0 to 1150
Definition	VM_DC_VOLTAGE_SET[MAX] is drive voltage rating dependent. See Table 9-3. VM_DC_VOLTAGE_SET[MIN] = 0

VM_DRIVE_CURRENT	Range applied to parameters showing current in A
Units	A
Range of [MIN]	-99999.999 to 0.000
Range of [MAX]	0.000 to 99999.999
Definition	VM_DRIVE_CURRENT[MAX] is equivalent to the full scale (over current trip level) or Kc value for the drive and is given by *Full Scale Current Kc* (11.061). VM_DRIVE_CURRENT[MIN] = - VM_DRIVE_CURRENT[MAX]

VM_DRIVE_CURRENT_UNIPOLAR	Unipolar version of VM_DRIVE_CURRENT
Units	A
Range of [MIN]	0.000
Range of [MAX]	0.000 to 99999.999
Definition	VM_DRIVE_CURRENT_UNIPOLAR[MAX] = VM_DRIVE_CURRENT[MAX] VM_DRIVE_CURRENT_UNIPOLAR[MIN] = 0.000

VM_HIGH_DC_VOLTAGE	Range applied to parameters showing high DC voltage
Units	V
Range of [MIN]	0
Range of [MAX]	0 to 1500
Definition	VM_HIGH_DC_VOLTAGE[MAX] is the full scale DC bus voltage feedback for the high DC bus voltage measurement which can measure the voltage if it goes above the normal full scale value. This level is drive voltage rating dependent. See Table 9-3. VM_HIGH_DC_VOLTAGE[MIN] = 0

VM_LOW_UNDER_VOLTS	Range applied the low under-voltage threshold
Units	V
Range of [MIN]	24
Range of [MAX]	24 to 1150
Definition	If *Back-up Mode Enable* (06.068) = 0: VM_LOW_UNDER_VOLTS[MAX] = VM_STD_UNDER_VOLTS[MIN] If *Back-up Mode Enable* (06.068) = 1: VM_LOW_UNDER_VOLTS[MAX] = VM_STD_UNDER_VOLTS[MIN] / 1.1. VM_LOW_UNDER_VOLTS[MIN] = 24.

VM_MIN_SWITCHING_FREQUENCY	Range applied to the minimum switching frequency parameter
Units	User units
Range of [MIN]	0
Range of [MAX]	0 to 6
Definition	VM_MIN_SWITCHING_FREQUENCY[MAX] = *Maximum Switching Frequency* (05.018) VM_MIN_SWITCHING_FREQUENCY[MIN] = 1 for Regen mode (subject to the maximum)

VM_MOTOR1_CURRENT_LIMIT	Range applied to current limit parameters
Units	%
Range of [MIN]	0.0
Range of [MAX]	0.0 to 1000.0
Definition	VM_MOTOR1_CURRENT_LIMIT[MIN] = 0.0 **Regen** VM_MOTOR1_CURRENT_LIMIT[MAX] = (I_{MaxRef} / Pr **05.007**) x 100 % Where: I_{MaxRef} is 0.9 x Pr **11.061** when the motor rated current set in Pr **05.007** is less than or equal to Pr **11.032** (i.e. Heavy duty), otherwise it is the lower of 0.9 x Pr **11.061** or 1.1 x Pr **11.060** (i.e. Normal duty).

VM_POWER	Range applied to parameters that either set or display power
Units	kW
Range of [MIN]	-99999.999 to 0.000
Range of [MAX]	0.000 to 99999.999
Definition	VM_POWER[MAX] is rating dependent and is chosen to allow for the maximum power that can be output by the drive with maximum AC output voltage, at maximum controlled current and unity power factor. VM_POWER[MAX] = √3 x VM_AC_VOLTAGE[MAX] x VM_DRIVE_CURRENT[MAX] / 1000 VM_POWER[MIN] = -VM_POWER[MAX]

VM_RATED_CURRENT	Range applied to rated current parameters
Units	A
Range of [MIN]	0.000
Range of [MAX]	0.000 to 99999.999
Definition	VM_RATED_CURRENT [MAX] = *Maximum Rated Current* (11.060) and is dependent on the drive rating. This is the Normal Duty rating of the drive. VM_RATED_CURRENT [MIN] = 0.00

VM_REGEN_REACTIVE	Range applied to the reactive current reference in Regen mode
Units	%
Range of [MIN]	-1000.0 to 0.0
Range of [MAX]	0.0 to 1000.0
Definition	A maximum is applied to the reactive current reference parameter so that the combined current reference for the active and reactive currents does not exceed IMaxRef. VM_REGEN_REACTIVE = v(VM_MOTOR1_CURRENT_LIMIT2 – ILimit2) where: ILimit is gives the highest level of the active current reference that can occur. This value is defined by the current limit values. If the current limits are all set to their maximum values (i.e. VM_MOTOR1_CURRENT_LIMIT) then there is no current capability left for the reactive current. However, if the current limits are reduced the resulting headroom can be used for the reactive current. ILimit is defined by a combination of all the current limits excluding any reduction of the current limit due to the motor thermal model, It should be noted that if *Island Detection Enable* (03.030) = 1 then VM_REGEN_REACTIVE is reduced by 5% to allow for the islanding system injection current. VM_REGEN_REACTIVE[MIN] = - VM_REGEN_REACTIVE[MAX]

VM_STD_UNDER_VOLTS	Range applied the standard under-voltage threshold
Units	V
Range of [MIN]	0 to 1150
Range of [MAX]	0 to 1150
Definition	VM_STD_UNDER_VOLTS[MAX] = VM_DC_VOLTAGE_SET / 1.1 VM_STD_UNDER_VOLTS[MIN] is voltage rating dependent. See Table 9-3.

VM_SWITCHING_FREQUENCY	Range applied to the maximum switching frequency parameters
Units	User units
Range of [MIN]	0
Range of [MAX]	0 to 6
Definition	VM_SWITCHING_FREQUENCY[MAX] = Power stage dependent VM_SWITCHING_FREQUENCY[MIN] = 1 for Regen mode (subject to the maximum)

VM_TORQUE_CURRENT	Range applied to the active current
Units	%
Range of [MIN]	-1000.0 to 0.0
Range of [MAX]	0.0 to 1000.0
Definition	VM_TORQUE_CURRENT[MAX] = VM_MOTOR1_CURRENT_LIMIT[MAX] VM_TORQUE_CURRENT[MIN] = -VM_TORQUE_CURRENT[MAX]

VM_TORQUE_CURRENT_UNIPOLAR	Unipolar version of VM_TORQUE_CURRENT
Units	%
Range of [MIN]	0.0
Range of [MAX]	0.0 to 1000.0
Definition	VM_TORQUE_CURRENT_UNIPOLAR[MAX] = VM_TORQUE_CURRENT[MAX] VM_TORQUE_CURRENT_UNIPOLAR[MIN] =0.0 *User Current Maximum Scaling* (04.024) defines the variable maximum/minimums VM_USER_CURRENT and VM_USER_CURRENT_HIGH_RES which are applied to *Percentage Load* (04.020), *Torque Reference* (04.008) and *Torque Offset* (04.009). This is useful when routing these parameters to an analog output as it allows the full scale output value to be defined by the user. This maximum is subject to a limit of MOTOR1_CURRENT_LIMIT or MOTOR2_CURRENT_LIMIT depending on which motor map is currently active. The maximum value (VM_TORQUE_CURRENT_UNIPOLAR [MAX] varies between drive sizes with default parameters loaded. For some drive sizes the default value may be reduced below the value given by the parameter range limiting.

VM_USER_CURRENT	Range applied to torque reference and percentage load parameters with one decimal place
Units	%
Range of [MIN]	-1000.0 to 0.0
Range of [MAX]	0.0 to 1000.0
Definition	VM_USER_CURRENT[MAX] = *User Current Maximum Scaling* (04.024) VM_USER_CURRENT[MIN] = -VM_USER_CURRENT[MAX] *User Current Maximum Scaling* (04.024) defines the variable maximum/minimums VM_USER_CURRENT and VM_USER_CURRENT_HIGH_RES which are applied to *Percentage Load* (04.020), *Torque Reference* (04.008) and *Torque Offset* (04.009). This is useful when routing these parameters to an analog output as it allows the full scale output value to be defined by the user. This maximum is subject to a limit of MOTOR1_CURRENT_LIMIT or MOTOR2_CURRENT_LIMIT depending on which motor map is currently active. The maximum value (VM_TORQUE_CURRENT_UNIPOLAR [MAX] varies between drive sizes with default parameters loaded. For some drive sizes the default value may be reduced below the value given by the parameter range limiting.

VM_USER_CURRENT_HIGH_RES	Range applied to torque reference and percentage load parameters with two decimal places
Units	%
Range of [MIN]	-1000.00 to 0.00
Range of [MAX]	0.00 to 1000.00
Definition	VM_USER_CURRENT_HIGH_RES[MAX] = *User Current Maximum Scaling* (04.024) with an additional decimal place VM_USER_CURRENT_HIGH_RES[MIN] = -VM_USER_CURRENT_HIGH_RES[MAX] *User Current Maximum Scaling* (04.024) defines the variable maximum/minimums VM_USER_CURRENT and VM_USER_CURRENT_HIGH_RES which are applied to *Percentage Load* (04.020), *Torque Reference* (04.008) and *Torque Offset* (04.009). This is useful when routing these parameters to an analog output as it allows the full scale output value to be defined by the user. This maximum is subject to a limit of MOTOR1_CURRENT_LIMIT or MOTOR2_CURRENT_LIMIT depending on which motor map is currently active. The maximum value (VM_TORQUE_CURRENT_UNIPOLAR [MAX] varies between drive sizes with default parameters loaded. For some drive sizes the default value may be reduced below the value given by the parameter range limiting.

Table 9-3 Voltage ratings dependant values

Variable min/max	Voltage level (V)			
	200 V	**400 V**	**575 V**	**690 V**
VM_DC_VOLTAGE_SET[MAX]	400	800	955	1150
VM_DC_VOLTAGE[MAX]	415	830	990	1190
VM_AC_VOLTAGE_SET[MAX]	265	530	635	765
VM_AC_VOLTAGE[MAX]	325	650	780	930
VM_STD_UNDER_VOLTS[MIN]	175	330	435	435
VM_SUPPLY_LOSS_LEVEL[MIN]	205	410	540	540
VM_HIGH_DC_VOLTAGE	1500	1500	1500	1500

9.2 Menu 0: Basic parameters

Table 9-4 Unidrive M Regen menu 0 parameter descriptions

Parameter		Range(⇳)	Default(⇨)	Type					
00.001	Voltage Set Point **{03.005}**	0 to VM_DC_VOLTAGE_SET V	200 V: 350 Vdc 400 V: 700 Vdc 575 V: 835 Vdc 690 V: 1100 Vdc	RW	Num		RA		US
00.002	Voltage Controller Proportional Gain Kp **{03.006}**	0 to 65535	4000	RW	Num				US
00.003	Synchronized **{03.009}**	Off (0) or On (1)		RO	Bit	ND	NC	PT	
00.004	Voltage Set Point **{03.005}**	0 to VM_DC_VOLTAGE_SET V	200 V: 350 Vdc 400 V: 700 Vdc 575 V: 835 Vdc 690 V: 1100 Vdc	RW	Num		RA		US
00.005	Output Voltage **{05.002}**	0 to VM_AC_VOLTAGE V		RO	Num	ND	NC	PT	
00.006	Not used								
00.007	Regen Synchronization Mode **{03.004}**	Re-synchronize (0), Delayed Trip (1), Trip (2), Auto-synchronize (3)	Re-synchronize (0)	RW	Txt				US
00.008	Disable Charge System / Close Contactor **{03.007}**	Off (0) or On (1)		RO	Bit	ND	NC	PT	
00.009	Charge System Disabled / Contactor Closed **{03.008}**	Off (0) or On (1)		RO	Bit	ND	NC		
00.010	Power Input 1 **{03.010}**	±100.0 %	0.0 %	RW	Num		NC		
00.011	Output Frequency **{05.001}**	±200.0 Hz		RO	Num	ND	NC	PT	
00.012	Current Magnitude **{04.001}**	0 to VM_DRIVE_CURRENT_UNIPOLAR A		RO	Num	ND	NC	PT	
00.013	Active Current **{04.002}**	VM_DRIVE_CURRENT A		RO	Num	ND	NC	PT	
00.014	Output Power **{05.003}**	VM_POWER kW		RO	Num	ND	NC	PT	
00.015	Reactive Power **{03.001}**	VM_POWER kVAr		RO	Num	ND	NC	PT	
00.016	Not used								
00.017	Reactive Current Reference **{04.008}**	VM_REGEN_REACTIVE %	0.0 %	RW	Num				US
00.018	Not used								
00.019	T7 Analog Input 2 Mode **{07.011}**	4-20mA Low (-4), 20-4mA Low (-3), 4-20mA Hold (-2), 20-4mA Hold (-1), 0-20mA (0), 20-0mA (1), 4-20mA Trip (2), 20-4mA Trip (3), 4-20mA (4), 20-4mA (5), Volt (6)	Volt (6)	RW	Txt				US
00.020	T7 Analog Input 2 Destination **{07.014}**	0.000 to 59.999	3.010	RW	Num	DE		PT	US
00.021	T8 Analog Input 3 Mode **{07.015}**	Volt (6), Therm Short Cct (7), Thermistor (8), Therm No trip (9)	Volt (6)	RW	Txt				US
00.022 to 00.028	Not used								
00.029	NV Media Card File Previously Loaded **{11.036}**	0 to 999	0	RO	Num		NC	PT	
00.030	Parameter Cloning **{11.042}**	None (0), Read (1), Program (2), Auto (3), Boot (4)	None (0)	RW	Txt		NC		
00.031	Drive Rated Voltage **{11.033}**	200V (0), 400V (1), 575V (2), 690V (3)		RO	Txt	ND	NC	PT	
00.032	Maximum Heavy Duty Rating **{11.032}**	0.000 to 99999.999 A		RO	Num	ND	NC	PT	
00.033	Not used								
00.034	User Security Code **{11.030}**	0 to 2147483647	0	RW	Num	ND	NC	PT	US
00.035	Serial Mode* **{11.024}**	8 2 NP (0), 8 1 NP (1), 8 1 EP (2), 8 1 OP (3), 8 2 NP M (4), 8 1 NP M (5), 8 1 EP M (6), 8 1 OP M (7), 7 2 NP (8), 7 1 NP (9), 7 1 EP (10), 7 1 OP (11), 7 2 NP M (12), 7 1 NP M (13), 7 1 EP M (14), 7 1 OP M (15)	8 2 NP (0)	RW	Txt				US
00.036	Serial Baud Rate* **{11.025}**	300 (0), 600 (1), 1200 (2), 2400 (3), 4800 (4), 9600 (5), 19200 (6), 38400 (7), 57600 (8), 76800 (9), 115200 (10)	19200 (6)	RW	Txt				US
00.037	Serial Address **{11.023}**	1 to 247	1	RW	Num				US
00.038	Current Controller Kp Gain **{04.013}**	0 to 30,000	90	RW	Num				US
00.039	Current Controller Ki Gain **{04.014}**	0 to 30,000	2,000	RW	Num				US
00.040	Not used								
00.041	Maximum Switching Frequency **{05.018}**	3 (1) kHz, 4 (2) kHz, 6 (3) kHz, 8 (4) kHz, 12 (5) kHz, 16 (6) kHz	3 (1) kHz	RW	Txt		RA		US
00.042	Not used								
00.043	Not used								
00.044	Not used								
00.045	Inductor Thermal Time Constant **{04.015}**	1.0 to 3000.0	89.0	RW	Num				US
00.046	Rated Current **{05.007}**	0.000 to VM_RATED_CURRENT A	Maximum Heavy Duty Rating (Pr 00.032 {11.032}) A	RW	Num		RA		US
00.047	Not used								
00.048	User Drive Mode **{11.031}**	Open-loop (1), RFC-A (2), RFC-S (3), Regen (4)	Regen (4)	RW	Txt	ND	NC	PT	
00.049	User Security Status **{11.044}**	Menu 0 (0), All Menus (1), Read-only Menu 0 (2), Read-only (3), Status Only (4), No Access (5)	Menu 0 (0)	RW	Txt	ND		PT	
00.050	Software Version **{11.029}**	0 to 99999999		RO	Num	ND	NC	PT	
00.051	Action On Trip Detection **{10.037}**	00000 to 11111	00000	RW	Bin				US
00.052	Reset Serial Communications* **{11.020}**	Off (0) or On (1)	Off (0)	RW	Bit	ND	NC		

* Not available on Unidrive M700.

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

9.3 Menu 3: Regen Control

In Regen mode the drive assumes the mains is lost, it does not close the input, and does not attempt synchronization if the DC bus voltage is below the levels given in the table below.

If the unit is synchronized and the DC bus voltage falls below this level the unit is disabled and the Regen drive main contactor is opened.

The Regen drive also monitors the voltage at it's AC terminals (U, V and W) for mains loss and if this falls below the levels given in the table, the unit is disabled and the Regen drive main contactor is opened.

Voltage rating	DC voltage mains loss detection level	AC voltage mains loss detection level	DC voltage for supply healthy
200 V	205 Vdc	75 Vac	215 Vdc
400 V	410 Vdc	150 Vac	430 Vdc
575 V	540 Vdc	225 Vac	565 Vdc
690 V	540 Vdc	225 Vac	565 Vdc

Figure 9-1 Menu 3 Regen logic diagram

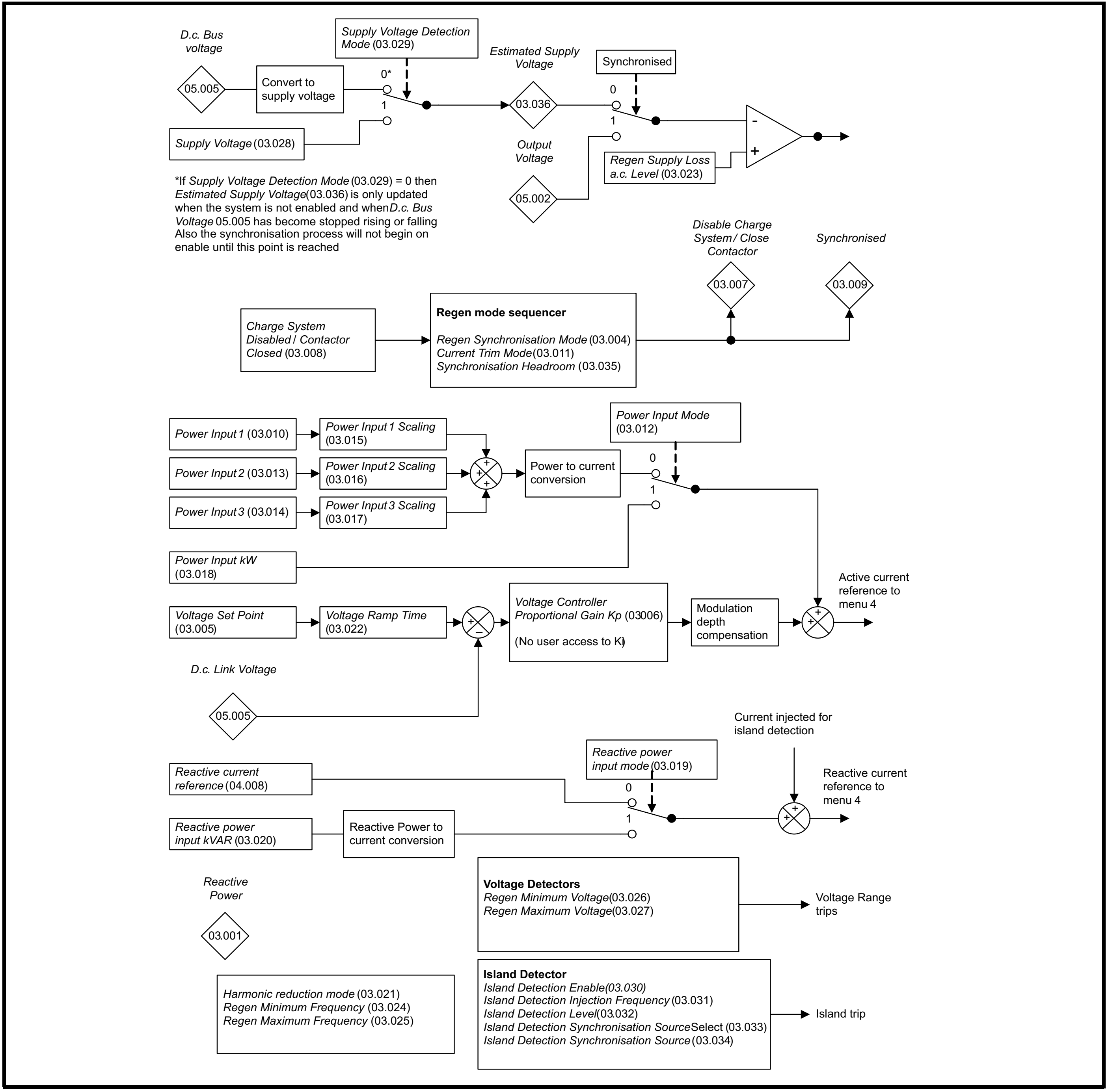


Table 9-5 Menu 3 Regen parameter descriptions

Parameter		Range	Default	Type					
03.001	Reactive Power	VM_POWER kVAr		RO	Num	ND	NC	PT	FI
03.004	Regen Synchronization Mode	Re-synchronize (0), Delayed Trip (1), Trip (2), Auto-synchronize (3)	Re-synchronize (0)	RW	Txt				US
03.005	Voltage Set Point	VM_DC_VOLTAGE_SET V	200V drive: 350 V 400V drive: 700 V 575V drive: 835 V 690V drive: 1100 V	RW	Num		RA		US
03.006	Voltage Controller Proportional Gain Kp	0 to 65535	4000	RW	Num				US
03.007	Disable Charge System / Close Contactor	Off (0) or On (1)		RO	Bit	ND	NC	PT	
03.008	Charge System Disabled / Contactor Closed	Off (0) or On (1)		RO	Bit	ND	NC		
03.009	Synchronized	Off (0) or On (1)		RO	Bit	ND	NC	PT	
03.010	Power Input 1	±100.0 %	0.0 %	RW	Num		NC		
03.011	Current Trim Mode	Off (0) or On (1)	Off (0)	RW	Bit				US
03.012	Power Input Mode	Off (0) or On (1)	Off (0)	RW	Bit				US
03.013	Power Input 2	±100.0 %	0.0 %	RW	Num		NC		
03.014	Power Input 3	±100.0 %	0.0 %	RW	Num		NC		
03.015	Power Input 1 Scaling	0.000 to 4.000	1.000	RW	Num				US
03.016	Power Input 2 Scaling	0.000 to 4.000	1.000	RW	Num				US
03.017	Power Input 3 Scaling	0.000 to 4.000	1.000	RW	Num				US
03.018	Power Input kW	VM_POWER kW	0.000 kW	RW	Num		NC		
03.019	Reactive Power Input Mode	Off (0) or On (1)	Off (0)	RW	Bit				US
03.020	Reactive Power Input kVAR	VM_POWER kVAr	0.000 kVAr	RW	Num		NC		US
03.021	Harmonic Reduction Enable	Disabled (0), Imbalance Only (1), All (2)	Imbalance Only (1)	RW	Txt				US
03.022	Voltage Ramp Time	0.1 to 100.0 V/ms	1.0 V/ms	RW	Num				US
03.023	Regen Supply Loss AC Level	VM_AC_VOLTAGE_SET V	200V drive: 75 V 400V drive: 150 V 575V drive: 225 V 690V drive: 225 V	RW	Num		RA		US
03.024	Regen Minimum Frequency	10 to 200 Hz	40 Hz	RW	Num				US
03.025	Regen Maximum Frequency	10 to 200 Hz	70 Hz	RW	Num				US
03.026	Regen Minimum Voltage	VM_AC_VOLTAGE V	0 V	RW	Num		RA		US
03.027	Regen Maximum Voltage	VM_AC_VOLTAGE V	0 V	RW	Num		RA		US
03.028	Supply Voltage	VM_AC_VOLTAGE_SET V	200V drive: 230 V 50 Hz - 400V drive: 400 V 60 Hz - 400V drive: 460 V 575V drive: 575 V 690V drive: 690 V	RW	Num		RA		US
03.029	Supply Voltage Detection Mode	Measured (0), User (1), User Delayed (2)	User Delayed (2)	RW	Txt				US
03.030	Island Detection Enable	Off (0) or On (1)	Off (0)	RW	Bit				US
03.031	Island Detection Injection Frequency	1Hz (0), 2Hz (1), 4Hz (2)	1Hz (0)	RW	Txt				US
03.032	Island Detection Level	0 to 100 %		RO	Num	ND	NC	PT	
03.033	Island Detection Synchronization Source Select	Disabled (0), Slot 1 (1), Slot 2 (2), Slot 3 (3), Slot 4 (4)	Disabled (0)	RW	Txt				US
03.034	Island Detect Synchronization Source	Disabled (0), Slot 1 (1), Slot 2 (2), Slot 3 (3), Slot 4 (4)		RO	Txt	ND	NC	PT	
03.035	Synchronization Headroom	0.0 to 25.0 %	5.0 %	RW	Num				US
03.036	Estimated Supply Voltage	VM_AC_VOLTAGE V		RO	Num	ND	NC	PT	
03.037	Positive Phase Sequence Volts	VM_AC_VOLTAGE V		RO	Num	ND	NC	PT	FI
03.038	Negative Phase Sequence Volts	VM_AC_VOLTAGE V		RO	Num	ND	NC	PT	FI
03.039	Negative Phase Sequence Current Gain	0.00 to 1.00	0.05	RW	Num				US

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

03.001	**Reactive Power**								
RO	Num				ND	NC	PT		FI
⇳	VM_POWER kVAr				⇨	▨			

Output Power (05.003) and *Reactive Power* (03.001) are the power and VAR's respectively that flow from the supply to the drive. When *Reactive Power* (03.001) is positive the phase current flowing from the supply to the drive contains a component that lags the respective phase voltage, and so the Regen system appears like and inductance connected to the supply and imports VARs. When *Reactive Power* (03.001) is negative the phase current flowing from the supply contains a component which leads the respective phase voltage, and so the Regen system appears like a capacitance connected to the supply and exports VARs.

03.004	**Regen Synchronization Mode**								
RW	Txt								US
⇳	Re-synchronize (0), Delayed Trip (1), Trip (2), Auto-synchronize (3)				⇨	Re-synchronize (0)			

When the system is enabled it attempts to synchronize to the supply. If the supply has significant distortion then the synchronization process may fail and cause an over-current condition to be detected. The system will automatically reset the detected over-current condition and continue to attempt to synchronize. Once the system is synchronized, then if synchronization is subsequently lost, or an over-current condition caused by a supply transient occurs, or supply loss is detected (i.e. *Supply Loss* (10.015) = 1), then the action taken is defined by *Regen Syncronization Mode* (03.004) as given below. (It should be noted that the over-current condition will only be reset automatically ten times in any 10 s period before an *OI ac* trip is produced.)

0: Re-synchronize

If supply loss is detected the system will attempt to re-synchronize when the supply loss condition is no longer active. If an over-current trip occurs the system will attempt to re-synchronize. If *Supply Voltage Detection Mode* (03.029) = 0 or 2 re-synchronization will only begin if *D.c. Bus Voltage* (05.005) has stopped rising or falling. For *Supply Voltage Detection Mode* (03.029) = 0, this is so the supply voltage can be estimated from the level of the DC bus voltage. If *Supply Voltage Detection Mode* (03.029) = 1 rapid re-synchronization is possible because the system does not wait for the DC bus voltage to stop falling before attempting to re-synchronize.

1: Delayed Trip

The system operates in the same way as "Re-synchronize" mode except that a *Line Sync* trip is initiated if synchronization takes more than 30 s.

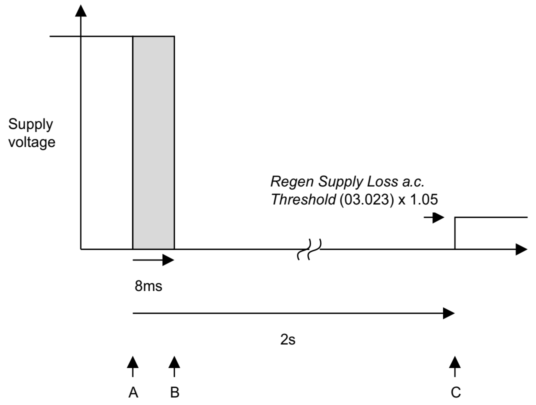
2: Immediate Trip

The system operates in the same way as "Re-synchronize" mode except that a *Line Sync* trip is initiated if synchronization takes more than 30 s, and *Line Sync* trip is produced immediately if supply loss is detected while the system is synchronized.

3: Auto-synchronize

If an over-current condition is detected then this is reset. The system will simulate the supply angle based on the supply conditions before the over-current condition and restart the system within 10 ms.

If supply loss is detected the system will simulate the supply angle based on the supply conditions before supply loss was detected. This allows the inverter to remain active during the supply loss period and it is possible for reactive current to flow into the supply in the normal way, but the active current is held at zero. As the active current is held at zero the DC bus must be held at the required level externally, therefore this mode is only suitable for an application where an external system connected to the DC terminals and holds the DC voltage at a suitable level. *Regen Supply Loss AC Level* (03.023) should be set to a level that is higher than the likely voltage seen at the inverter terminals due to any current being fed into the supply (e.g. 10 % of nominal supply voltage) or else the system will attempt to synchronize to its own output voltage. If *Supply Loss* (10.015) remains active for more than 2.0 s then an *Island.2* trip is initiated. The diagram below shows the timing and minimum voltage envelope for auto-synchronization. If the required timing and voltage for transient fault ride-through lies within this envelope then the auto-synchronization can be used to meet the requirements.



Transient fault ride through envelope

At point 'A' the fault occurs and the voltage falls below *Regen Supply Loss AC Level* (03.023). During the period from point 'A' to point 'B' the Regen system does not allow either active or reactive power to flow to/from the supply. The maximum time between point 'A' and point 'B' is 8 ms, but this may be shorter depending on the size of the current transient caused by the fault. If the current transient exceeds the over-current threshold then the system will take 8 ms to recover, otherwise there is no delay and the Regen system will remain active throughout the fault. From point 'B' to point 'C', where the supply voltage remains below *Regen Supply Loss AC Level* (03.023) x 1.05, auto-synchronization is active and it is possible to request reactive power flow either using *Reactive Power Input kVAR* (03.020) or *Reactive Current Reference* (04.008). During this period active power flow is not possible as it is disabled by the Regen system. If the supply voltage remains below *Regen Supply Loss AC Level* (03.023) x 1.05 for more than 2 s the Regen system will trip. Once the supply voltage has risen above *Regen Supply Loss AC Level* (03.023) x 1.05 auto-synchronization is disabled and active power flow is re-enabled. The request for reactive and active power must be made by the user during supply transient ride-through. It is also likely that the supply voltage recovery characteristic envelope must lie within the envelope given and that additional supply voltage monitoring will be required to take action if the required recover does not occur.

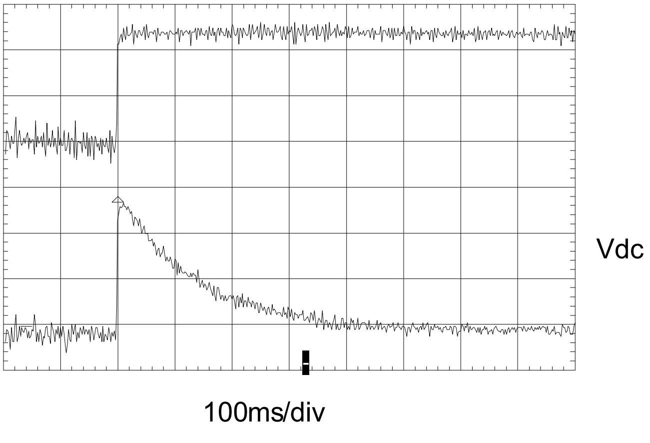
03.005		**Voltage Set Point**							
RW	Num						RA		US
⇳	VM_DC_VOLTAGE_SET V				⇨	200V drive: 350 V 400V drive: 700 V 575V drive: 835 V 690V drive: 1100 V			

The Regen drive attempts to hold the DC bus voltage at the level specified by *Voltage Set Point* (03.005). The *Voltage Set Point* (03.005) must always be higher than the peak of the line to line supply voltage if the unit is to operate correctly. The default values can be used with most supplies giving a reasonable level of control headroom. However, with higher voltage supplies the set-point must be raised.

03.006		**Voltage Controller Proportional Gain Kp**							
RW	Num								US
⇳	0 to 65535				⇨	4000			

The DC bus voltage is controlled by a PI controller, which provides the reference for the real component of current from the inverter terminals to the supply. The power input parameters (*Power Input 1* (03.010), *Power Input 2* (03.013), *Power Input 3* (03.014) or *Power Input kW* (03.018)) are provided to give a power feed forward term, at the output of the PI controller, from the motor drives connected to the DC bus. If possible the power feed forwards should be used so that the PI controller is simply providing a trim to the DC bus voltage. In most cases the default voltage controller gains can be used, however the effect of the gains and the response of the voltage controller is discussed below.

For the purpose of analysing the voltage controller response it is assumed that a power feed-forward term is not provided. If the power flow from the DC bus is increased (i.e. motor is accelerated by a motor drive connected to the DC bus) the DC bus voltage will fall, but the minimum level will be limited to just below the peak rectified level of the supply provided the maximum rating of the unit is not exceeded. If the power flow to the DC bus is increased (i.e. motor is decelerated by a motor drive connected to the DC bus) the DC bus voltage will rise. If the peak of the DC bus voltage reaches the over voltage level the Regen drive will trip. A rapid transient where power into the DC bus is increased is shown below.



D.c. bus voltage transient

The example shown is for a very rapid load change where the torque reference of the motor drive has been changed instantly from one value to another. The peak of the resulting transient is

ΔVdc = 191680 x Pd / (vll x Kp x Kc) Volts

and the time constant of the recovery is Kp / 30520 seconds.

where:

Pd is the transient change of power flow

vll is the line to line supply voltage

Kp = *Voltage Controller Proportional Gain Kp* (03.006)

Kc = *Full Scale Current Kc* (11.061)

For example, if Pd=7.5 kW, vll=400 V, Kp=4000, Kc=38.222 A then ΔVdc=23.5 V and the time constant is 131 ms.

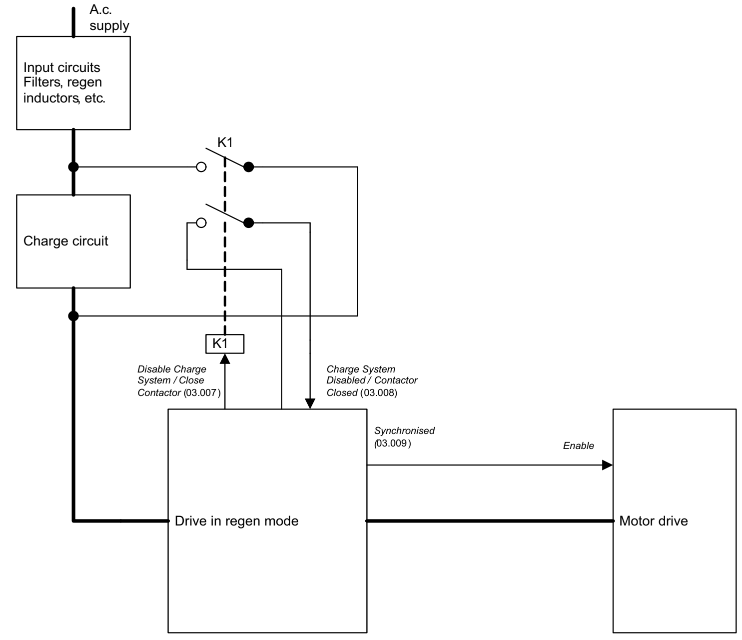
In the example given there is a very rapid change of power flow. The transient DC bus voltage change can be substantially reduced by introducing a time constant into the power transient. For example a filter could be included between the speed controller and current controller in the motor drive with *Current Reference Filter 1 Time Constant* (04.012). A time constant of 20 ms reduces the voltage transient by 25 % and a time constant of 40 ms reduces the voltage transient by 50 %. In most cases it is not desirable to reduce the performance of the motor drive, and so as already mentioned the best solution is to use a power feed forward term from the motor drive.

So far the discussion has been related to the DC bus voltage controller gain, however, the controller provides the real current reference to the Regen drive current controllers, and so the current controller gains affect the response of the voltage controller. If the default voltage controller gain is used and it is possible to obtain a stable response from the current controllers with their default gains then the voltage controller response will be stable. However, in some cases it will be necessary to reduce the current controller gains to make these controllers stable, in which case it is likely that the voltage controller gain will need to be reduced to make this controller stable.

It is possible to disable the DC bus voltage controller by setting *Voltage Controller Proportional Gain Kp* (03.006) to zero. This sets both the proportional and integral gains to zero. Once the controller is disabled the flow of power through the Regen drive can be defined using the power input parameters (*Power Input 1* (03.010), *Power Input 2* (03.013), *Power Input 3* (03.014), *Power Input kW* (03.018)) or *Active Current* (04.002). This method of control can only be used if the DC bus voltage is defined at a voltage above the level of the rectified AC supply to the Regen drive by another system connected to the DC terminals.

03.007		**Disable Charge System / Close Contactor**							
RO	Bit				ND	NC	PT		
⇳	Off (0) or On (1)				⇨				

In Regen mode some form of charging system must be used to limit the current taken from the supply to charge the DC bus capacitors when the supply is first connected to the inverter terminals (i.e. UVW). An external soft start resistor or the thyristor charging system in the drive may be used. The Regen mode sequencer provides an output which should be used to disable or enable the charge system (*Disable Charge System / Close Contactor* (03.007)). This should be routed to a digital output, so that when *Disable Charge System / Close Contactor* (03.007) = 0 the charge system is connected between the supply and the Regen system, and when *Disable Charge System / Close Contactor* (03.007) = 1 the charge system is bypassed and the inverter terminals are connected to the supply. This is demonstrated by the simplified charge system diagram below. It should be noted that this is used to show the connections required between the charge system and the drive, and does not show a complete power circuit.



Charge system control

It is possible that the charge circuit could be damaged if the motor drive is active while the charge circuit has not been bypassed or disconnected. To prevent damage from occurring, the state of the charge system should be passed to *Charge System Disabled / Contactor Closed* (03.008) via a digital input so that the Regen system can monitor the actual charge system state. It is also necessary to pass an indication of the state of the charge system and the Regen system to the motor drive. The "synchronized" indication is used to enable the motor drive, so that it will only be enabled when the charge system is disabled and the Regen system is enabled and fully synchronized.

03.008	**Charge System Disabled / Contactor Closed**								
RO	Bit				ND	NC			
⇳	Off (0) or On (1)	⇨							

See *Disable Charge System / Close Contactor* (03.007).

03.009	**Synchronized**								
RO	Bit				ND	NC	PT		
⇳	Off (0) or On (1)	⇨							

See *Disable Charge System / Close Contactor* (03.007).

03.010	**Power Input 1**								
RW	Num					NC			
⇳	±100.0 %	⇨	0.0 %						

Power feed-forward compensation can be used to reduce the transient DC bus voltage produced when a fast load transient occurs on a drive connected to the DC terminals of the Regen drive. If *Power Output* (07.033) from a motor drive is routed to an analog output with unity scaling it will produce full scale output when the power is equal to 3 x (VM_DC_VOLTAGE[MAX] / 2√2) x *Full Scale Current Kc* (11.061). If this signal is connected to an analog input on the Regen drive, the input is routed to *Power Input 1* (03.010) and *Power Input 1 Scaling* (03.015) is set to the ratio of the current scaling values for the motor drive and Regen drives (i.e. Motor drive *Full Scale Current Kc* (11.061) / Regen drive *Full Scale Current Kc* (11.061)) then the correct power feed-forward term will be provided. The default value for *Power Input 1 Scaling* (03.015) is 1.000, and so unless the Regen and motor drives are the same size this parameter will need to be adjusted.

Up to 3 motor drives connected to the Regen drive DC terminals can use this system to provide power feed-forward as each of the power inputs are summed to give the final power feed-forward term. (It should be noted that a maximum of two analog inputs are provided on the drive with 250 μs update rate. If the third input is used the update rate is 4 ms, and so this should only be used for a motor drive with limited dynamic performance.) If more motor drives are connected to the DC terminals of the Regen drive, or a digital power feed-forward system is required, then *Power Input kW* (03.018) should be used. The power in kW can be transferred from each motor drive using fast synchronous communications to an application module in the Regen drive. The total power in kW should be calculated by the applications module and then written to the *Power Input kW* (03.018). For the power feed-forward to be effective data should be transferred every 250 μs with the minimum delay (i.e. 500 μs) and the total power written to *Power Input kW* (03.018) every 250 μs.

It should be noted that the polarity of all the power feed-forward parameters is that positive values cause power to flow from the supply and negative values cause power to flow into the supply.

03.011	**Current Trim Mode**								
RW	Bit								US
⇳	Off (0) or On (1)	⇨	Off (0)						

A current feedback trimming routine runs before the Regen drive is enabled to minimise offsets in the current feedback. If *Current Trim Mode* (03.011) = 0 the current offset trim is only carried out once when the drive comes out of the under voltage state and is not repeated unless the supply is removed and reapplied. The current offset trim is only carried out when the charge system is enabled (contactor open) as this minimizes current flowing into the inverter terminals due to noise on the supply that may disturb the current offset trimming.

Current Trim Mode (03.011) should be set to one if the current offset trim is required each time when the Regen drive is enabled. To ensure that the current offset trim is not disturbed by noise on the supply, the charge system is enabled before the current offset trim and then disabled again before the Regen drive goes into its active state. This causes the charge system contactors to switch each time the Regen drive is enabled.

03.012	**Power Input Mode**								
RW	Bit								US
⇳	Off (0) or On (1)	⇨	Off (0)						

If *Power Input Mode* (03.012) = 0 the power feed-forward is provided by the parameters that are intended for use with analog inputs. If *Power Input Mode* (03.012) = 1 the power feed-forward is provided by *Power Input kW* (03.018).

03.013	**Power Input 2**								
RW	Num					NC			
⇳	±100.0 %	⇨	0.0 %						

See *Power Input 1* (03.010).

<table>
<tr><th colspan="2">03.014</th><th colspan="8">Power Input 3</th></tr>
<tr><td>RW</td><td>Num</td><td></td><td></td><td></td><td></td><td>NC</td><td></td><td></td><td></td></tr>
<tr><td>⇕</td><td colspan="4">±100.0 %</td><td>⇨</td><td colspan="4">0.0 %</td></tr>
</table>

See *Power Input 1* (03.010).

<table>
<tr><th colspan="2">03.015</th><th colspan="8">Power Input 1 Scaling</th></tr>
<tr><td>RW</td><td>Num</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>US</td></tr>
<tr><td>⇕</td><td colspan="4">0.000 to 4.000</td><td>⇨</td><td colspan="4">1.000</td></tr>
</table>

See *Power Input 1* (03.010).

<table>
<tr><th colspan="2">03.016</th><th colspan="8">Power Input 2 Scaling</th></tr>
<tr><td>RW</td><td>Num</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>US</td></tr>
<tr><td>⇕</td><td colspan="4">0.000 to 4.000</td><td>⇨</td><td colspan="4">1.000</td></tr>
</table>

See *Power Input 1* (03.010).

<table>
<tr><th colspan="2">03.017</th><th colspan="8">Power Input 3 Scaling</th></tr>
<tr><td>RW</td><td>Num</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>US</td></tr>
<tr><td>⇕</td><td colspan="4">0.000 to 4.000</td><td>⇨</td><td colspan="4">1.000</td></tr>
</table>

See *Power Input 1* (03.010).

<table>
<tr><th colspan="2">03.018</th><th colspan="8">Power Input kW</th></tr>
<tr><td>RW</td><td>Num</td><td></td><td></td><td></td><td></td><td>NC</td><td>RA</td><td></td><td></td></tr>
<tr><td>⇕</td><td colspan="4">VM_POWER kW</td><td>⇨</td><td colspan="4">0.000 kW</td></tr>
</table>

See *Power Input 1* (03.010).

<table>
<tr><th colspan="2">03.019</th><th colspan="8">Reactive Power Input Mode</th></tr>
<tr><td>RW</td><td>Bit</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>US</td></tr>
<tr><td>⇕</td><td colspan="4">Off (0) or On (1)</td><td>⇨</td><td colspan="4">Off (0)</td></tr>
</table>

It is possible to control the reactive component of current from the AC terminals of the Regen drive. When this component is positive the reactive current flowing from the supply to the Regen drive lags the voltage. When this component is negative the reactive current flowing from the supply to the Regen drive leads the voltage. Reactive component control can be used even if the DC bus voltage controller is active, because the voltage controller only affects the real current component. If *Reactive Power Input Mode* (03.019) = 0 the reactive current can be defined with *Reactive Current Reference* (04.008). If *Reactive Power Input Mode* (03.019) = 1 the reactive kVAR can be specified with *Reactive Power Input kVAR* (03.020).

<table>
<tr><th colspan="2">03.020</th><th colspan="8">Reactive Power Input kVAR</th></tr>
<tr><td>RW</td><td>Num</td><td></td><td></td><td></td><td></td><td>NC</td><td>RA</td><td></td><td>US</td></tr>
<tr><td>⇕</td><td colspan="4">VM_POWER kVAr</td><td>⇨</td><td colspan="4">0.000 kVAr</td></tr>
</table>

See Reactive Power Input Mode (03.019).

<table>
<tr><th colspan="2">03.021</th><th colspan="8">Harmonic Reduction Enable</th></tr>
<tr><td>RW</td><td>Txt</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>US</td></tr>
<tr><td>⇕</td><td colspan="4">Disabled (0), Imbalance Only (1), All (2)</td><td>⇨</td><td colspan="4">Imbalance Only (1)</td></tr>
</table>

Even with the optimum DC bus voltage and current controller set-up it is possible for supply voltage distortion to cause harmonic distortion in the AC currents between the supply and the Regen drive. The Regen drive includes an additional system to reduce imbalance, 5th harmonics and 7th harmonics in the AC currents. *Harmonic Reduction Enable* (03.021) defines the type of distortion reduction required. It should be noted that the Regen system input filter will absorb 5th and 7th harmonic currents if there is 5th or 7th harmonic supply voltage distortion. The Regen drive cannot reduce this current, but can minimise the 5th and 7th harmonic current due to 5th and 7th harmonic voltage distortion between the supply and the inverter.

Harmonic Reduction Enable (03.021)	**Distortion reduced**
0	None
1	Due to voltage imbalance
2	Due to voltage imbalance, 5th and 7th harmonics

If *Harmonic Reduction Enable* (03.021) > 0 then *Phase Loss* (10.081) is set if *Negative Phase Sequence Volts* (03.038) > *Positive Phase Sequence Volts* (03.037) / 2 for more than 100 ms. It should be noted that *Phase Loss* (10.081) is only set when the Regen drive is active, so if the transient caused by an asymmetrical fault causes the system to trip then *Phase Loss* (10.081) is not set.

Each of the additional controllers used to minimise currents due to imbalance, 5th and 7th harmonic distortion have an integral controller similar to the controller for normal supply frequency currents. The gains for the 5th and 7th harmonic current control are at a fixed low level, however, the gain for minimization of currents due to imbalance can be adjusted by the user with *Negative Phase Sequence Current Gain* (03.039). The default value is low, and so the response due to a change in supply imbalance is relatively slow. For most applications the gain can be left at the default level, but where a fast response is required, i.e. continued operation in the presence of an asymmetrical fault, the level should be increased. *Negative Phase Sequence Current Gain* (03.039) defines the gain used for control of currents due to imbalance as a proportion of *Current Controller Ki Gain* (04.014). Care should be taken when increasing this value as the system stability may be reduced particularly with a weak supply.

03.022	**Voltage Ramp Time**								
RW	Num								US
⇕	0.1 to 100.0 V/ms			⇨	1.0 V/ms				

When a Regen drive is enabled and has synchronized to the supply, the DC bus voltage is at a level equal to the peak line to line voltage. The voltage controller is then enabled and attempts to raise the DC bus voltage to the set-point defined by *Voltage Set Point* (03.005). The voltage reference is ramped up to the required level at a rate defined by *Voltage Ramp Time* (03.022) in V/ms. The default value of 1.0 V/ms ensures limited over-shoot when the DC bus voltage reaches the required level. If a shorter synchronization time is required then the ramp rate can be increased, however care must be taken to avoid over-voltage trips particularly if a high level is used for the DC bus voltage set-point. If a faster ramp rate and high set-point are required it may be necessary the increase *Voltage Controller Proportional Gain Kp* (03.006) to minimise over-shoot.

03.023	**Regen Supply Loss AC Level**								
RW	Num								US
⇕	VM_AC_VOLTAGE_SET V			⇨	200V drive: 75 V 400V drive: 150 V 575V drive: 225 V 690V drive: 225 V				

If the supply voltage falls below *Regen Supply Loss AC Level* (03.023) x 0.95 then supply loss is detected and *Supply Loss* (10.015) is set to one. The supply voltage must rise above *Regen Supply Loss AC Level* (03.023) x 1.05 to remove the supply loss condition and for *Supply Loss* (10.015) to be reset to zero. When the system is not synchronized, *Estimated Supply Voltage* (03.036) is used to represent the supply voltage, but when the system is synchronized the output of the inverter (*Output Voltage* (05.002)) is used.

If *Supply Voltage Detection Mode* (03.029) = 0 (Measured) then *Estimated Supply Voltage* (03.036) is derived from the DC bus voltage. When the system is not synchronized, *Estimated Supply Voltage* (03.036) is set up with a derived value, but only after the DC bus voltage has stopped rising or falling. This ensures a correct estimate because the supply voltage has stopped causing the DC bus voltage to rise and the DC bus voltage is not still falling because the system was previously active. When the system synchronizes, *Estimated Supply Voltage* (03.036) is left at the value derived before synchronization and will only be modified again when the system is not synchronized and the DC bus voltage is stable. It should be noted that if the supply is removed and then re-applied before the DC bus voltage falls below the under-voltage threshold, it is possible for the transient caused by re-applying the supply to give an indication that the DC bus voltage is stable. If this occurs the measured DC bus supply voltage may be higher than the actual supply voltage. As the accuracy of measured supply voltage is not critical in setting up the current controllers etc. this will not generally cause a problem. If it is a problem then *Supply Voltage Detection Mode* (03.029) should be set to a value other than zero, so that the estimated supply voltage can be defined by the user.

If *Supply Voltage Detection Mode* (03.029) = 1 (User) then *Estimated Supply Voltage* (03.036) is set directly from *Supply Voltage* (03.028). This can either be set to a fixed value or it can be controlled from voltage magnitude feedback via an analog input. When this setting is used the system does not wait for the DC bus voltage to stop rising or falling, and so re-synchronization is quicker when the supply is restored after a short supply loss, or the system is disabled and then re-enabled rapidly. However, the system will continuously attempt to re-synchronize after the supply is removed. It is likely that some transient voltages will occur at the inverter terminals as the DC bus voltage decays.

If *Supply Voltage Detection Mode* (03.029) = 2 (User Delayed) the system operates in the same way as when *Supply Voltage Detection Mode* (03.029) = 1 (User) except that re-synchronization when the supply is restored after supply loss, or when the system is enabled, does not start until the DC bus voltage has stopped rising or falling.

As well as being used to give the supply loss condition, *Estimated Supply Voltage* (03.036) is also used to pre-set the current controllers during synchronization and after the system has automatically reset an over-current condition when synchronized (i.e. when *Regen Synchronization Mode* (03.004) = 3). During synchronization the full value of *Estimated Supply Voltage* (03.036) is used to give the minimum current transient.
After automatic reset of an over-current condition then *Estimated Supply Voltage* (03.036) / 2 is used because this mode can be used to ride through supply short circuits and the supply voltage may change rapidly between the normal supply voltage and zero. By using half the nominal supply voltage the current transient is minimized for either condition.

03.024	**Regen Minimum Frequency**								
RW	Num								US
⇕	10 to 200 Hz	⇨	40 Hz						

Frequency limits defined by *Regen Minimum Frequency* (03.024) and *Regen Maximum Frequency* (03.025) are applied to the Regen system output. A margin of 5 Hz or more should be allowed outside the likely supply frequency range to enable the Regen system to operate. If the Regen system supply frequency is within approximately 5 Hz of either limit for 100 ms the system will not remain synchronized and will attempt to re-synchronize.While the supply frequency remains within approximately 5 Hz of either limit the system will not be able to synchronize successfully. The frequency limits are important if the supply is removed when the Regen system is active, as the system could remain active, particularly if energy is fed into the DC bus, with an uncontrolled output frequency and voltage.

03.025	**Regen Maximum Frequency**								
RW	Num								US
⇕	10 to 200 Hz	⇨	70 Hz						

See *Regen Minimum Frequency* (03.024).

03.026	**Regen Minimum Voltage**								
RW	Num						RA		US
⇕	VM_AC_VOLTAGE V	⇨	0 V						

Supply voltage range detection can be provided. If *Regen Maximum Voltage* (03.027) is set to its default of zero, then additional supply voltage checking is disabled. If *Regen Minimum Voltage* (03.026) is set to any other value and the supply voltage is outside the range defined by *Regen Maximum Voltage* (03.027) and *Regen Minimum Voltage* (03.026) for more than 100 ms a *Voltage Range* trip is initiated with sub-trip 1 for a voltage below the minimum threshold or sub-trip 2 for voltage above the maximum threshold. If *Regen Maximum Voltage* (03.027) ≤ *Regen Minimum Voltage* (03.026) then the trip is initiated repeatedly.

03.027	**Regen Maximum Voltage**								
RW	Num						RA		US
⇕	VM_AC_VOLTAGE V	⇨	0 V						

See *Regen Minimum Voltage* (03.026).

03.028	**Supply Voltage**								
RW	Num						RA		US
⇕	VM_AC_VOLTAGE_SET V	⇨	200V drive: 230 V 50 Hz - 400V drive: 400 V 60 Hz - 400V drive: 460 V 575V drive: 575 V 690V drive: 690 V						

See *Regen Supply Loss AC Level* (03.023).

03.029	**Supply Voltage Detection Mode**								
RW	Txt								US
⇕	Measured (0), User (1), User Delayed (2)	⇨	User Delayed (2)						

See *Regen Supply Loss AC Level* (03.023).

03.030	**Island Detection Enable**								
RW	Bit								US
⇕	Off (0) or On (1)	⇨	Off (0)						

If *Island Detection Enable* (03.030) is set to one then the detection system is enabled and injects a test current with a frequency defined by *Island Detection Injection Frequency* (03.031). The *Island Detection Level* (03.032) shows the detection level with respect to the threshold, and if the level reaches 100 % an *Island.1* trip is initiated.

The following should be noted:

1. It is possible that high levels of active current that contain components similar to the injection frequency may cause false detection of an island condition and this is more likely the higher the injection frequency.
2. The detection system will detect an island condition in a time from 3 to 4 cycles of the injection frequency, therefore a higher injection frequency gives faster detection.
3. Changing *Island Detection Injection Frequency* (03.031) while the system is running may cause an *Island.1* trip.

The injection frequency used by the island detection system affects the maximum island detection time as given in the table below:

Injection frequency	Maximum detection time
1 Hz	4 s
2 Hz	2 s
4 Hz	1 s

For the island detection system to comply with IEEE 1547 the detection time must be 2 s or less, and so an injection frequency of 2 or 4 Hz must be used. For the island detection system to comply with VDE 0126-1-1 the detection time must be 5 s or less, and so any of the injection frequencies may be used.

03.031	**Island Detection Injection Frequency**								
RW	Txt								US
⇳	1Hz (0), 2Hz (1), 4Hz (2)				⇨	1Hz (0)			

See *Island Detection Enable* (03.030).

03.032	**Island Detection Level**								
RO	Num				ND	NC	PT		
⇳	0 to 100 %				⇨				

See *Island Detection Enable* (03.030).

03.033	**Island Detection Synchronization Source Select**								
RW	Txt								US
⇳	Disabled (0), Slot 1 (1), Slot 2 (2), Slot 3 (3), Slot 4 (4)				⇨	Disabled (0)			

If *Island Detection Synchronization Source Select* (03.033) is set to its default value of zero then the frequency of the current injected to detect an island condition is defined by the Regen system. If *Island Detection Synchronization Source Select* (03.033) is set to a non-zero value to select an option module, and the option module provides a suitable clock, then the injected current is synchronized to the clock. This allows the injected current from a number of Regen systems to be synchronized to a master clock. If the option module does not provide a suitable clock then the frequency is defined by the Regen system. The source being used is given in *Island Detect Synchronization Source* (03.034).

03.034	**Island Detect Synchronization Source**								
RO	Txt				ND	NC	PT		
⇳	Disabled (0), Slot 1 (1), Slot 2 (2), Slot 3 (3), Slot 4 (4)				⇨				

See *Island Detection Synchronization Source Select* (03.033).

03.035	**Synchronization Headroom**								
RW	Num								US
⇳	0.0 to 25.0 %				⇨	5.0 %			

Each time a synchronization attempt is made the DC bus voltage is increased because of current that is built up in the inductors connected between the supply and the Regen system. As the current decays energy is transferred from the supply to the DC bus capacitors, and the energy stored in the inductors is also transferred to the DC bus capacitors. To prevent an over-voltage trip during synchronization or re-synchronization the system will prevent this process from starting if the DC bus voltage is above the level defined by Maximum DC bus voltage x *Synchronization Headroom* (03.035). For example the full scale DC bus voltage for a 400 V drive is 830 V, so with the default setting of 5 % the DC bus voltage must be less than 830 V x 95 % = 788.5 V before the synchronization process will begin. If the recommended components are connected between the supply and the Regen system the rise in the DC bus voltage during synchronization requires less than 5 % headroom. If alternative inductors are used that are significantly larger than the recommended values or the supply inductance is very high it may be necessary to increase the headroom.

03.036	Estimated Supply Voltage								
RO	Num				ND	NC	PT		
⇕	VM_AC_VOLTAGE V	⇨							

See *Regen Supply Loss AC Level* (03.023).

03.037	Positive Phase Sequence Volts								
RO	Num				ND	NC	PT		FI
⇕	VM_AC_VOLTAGE V	⇨							

The supply voltage at its fundamental frequency can be represented as a combination of positive, negative and zero sequence components. The Regen system supply voltage cannot contain any zero sequence components because there is no neutral connection. The negative phase sequence component is an indication of the level of supply imbalance. *Positive Phase Sequence Volts* (03.037) and *Negative Phase Sequence Volts* (03.038) show the positive and negative phase sequence components of voltage at the inverter terminals in r.m.s. line to line Volts. Note that *Negative Phase Sequence Volts* (03.038) is zero unless *Harmonic Reduction Enable* (03.021) > 0.

03.038	Negative Phase Sequence Volts								
RO	Num				ND	NC	PT		FI
⇕	VM_AC_VOLTAGE V	⇨							

See *Positive Phase Sequence Volts* (03.037).

03.039	Negative Phase Sequence Current Gain								
RW	Num								US
⇕	0.00 to 1.00	⇨	0.05						

See *Harmonic Reduction Enable* (03.021).

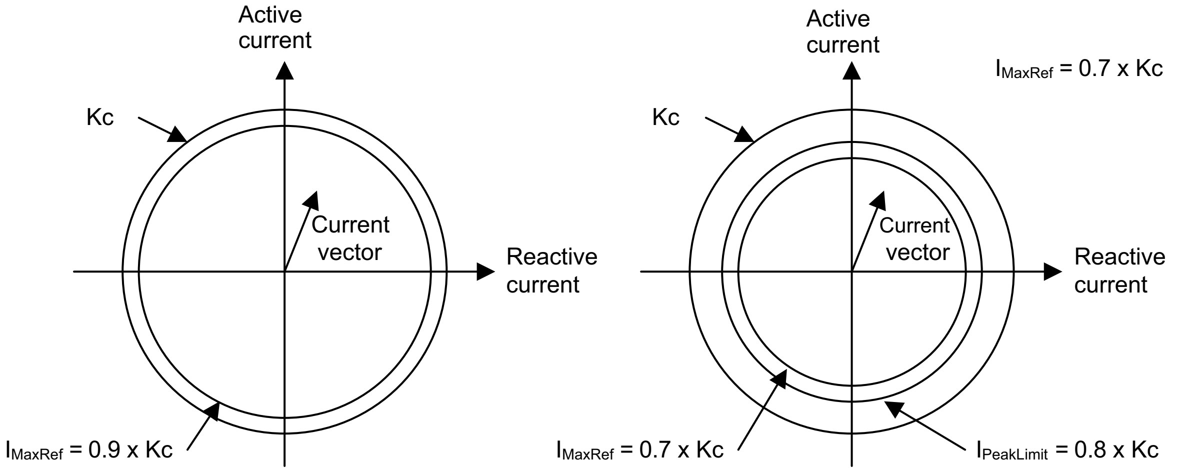
9.4 Menu 4: Current control

In Regen mode separate current control is provided for the active and reactive currents. The active current reference is normally produced by the DC bus voltage controller and power feed-forwards system, although it is possible for the user to define the active current reference if required. The reactive current reference is either defined directly from the *Reactive Current Reference* (04.008) or from the *Reactive Power Input kVAR* (03.020). See Menu 3 for more details.

Drive rating information

Current rating

The drive output currents can be represented as a vector. The limits and the scaling applied to the drive output currents are defined by the magnitude of this vector as shown below.



All modes except open loop mode

Open loop current control mode

Drive output current vector scaling and limits

Throughout this section *Rated Current* (05.007) and other parameters related to motor 1 are used.

The full scale current is the maximum current that the drive can measure and if the current exceeds this level the drive produces an over current trip. Kc is the current scaling for the drive and is used in determining the control performance of the drive. This is given in *Full Scale Current Kc* (11.061) and Kc is equal the full scale current in r.m.s. Amps. (Note that this is a change from Unidrive SP which used the full scale current multiplied by 0.45 for Kc.)

The maximum current reference is the highest magnitude of the current reference vector in the drive under any circumstances. The area between the maximum current reference and the full scale current provides headroom to allow for overshoot in the current controllers without tripping the drive. In all modes except Open-loop mode, the current limits can be adjusted so that the maximum current reference vector (IMaxRef) is equal to 0.9 x Kc provided *Rated Current* (05.007) is set to the *Maximum Heavy Duty Rating* (11.032) or less. If *Rated Current* (05.007) is set to a higher level then the current limits can be adjusted so that the maximum current reference vector (IMaxRef) is equal to 1.1 x *Maximum Rated Current* (11.060) or 0.9 x Kc whichever is lower.

The drive can have a heavy duty rating intended for applications where high overload current may be required under transient conditions, or it can have a normal duty rating where a lower level of overload current is required. The duty rating is selected automatically by the drive based on the setting of *Rated Current* (05.007). The *Maximum Heavy Duty Rating* (11.032) and *Maximum Rated Current* (11.060) are fixed for each drive size and the table below shows the possible duty ratings that can be selected depending on the levels of these parameters.

Conditions	Possible duty ratings
Maximum Heavy Duty Rating (11.032) = 0.00	Normal duty operation only
Maximum Heavy Duty Rating (11.032) < *Maximum Rated Current* (11.060)	Heavy duty operation if rated current > MAX, otherwise normal duty operation
Maximum Heavy Duty Rating (11.032) = *Maximum Rated Current* (11.060)	Heavy duty operation only

The different duty ratings modify the inductor protection characteristic (see *Inductor Thermal Time Constant* (04.015)). The different duty ratings can also change the level of IMaxRef as described previously.

In a drive that contains multiple power modules *Full Scale Current Kc* (11.061) is the full scale current of an individual module multiplied by the number of modules. *Maximum Heavy Duty Rating* (11.032) and *Maximum Rated Current* (11.060) are the value for an individual module multiplied by the number of modules.

Variable Maximums applied to the current limits

In Regen mode the drive orientates the output current vector to align with the voltage vector that represents the voltage at its terminals, and so unless specifically required, all the current is active current and there is no reactive current. Therefore the maximum value for the current limit parameters is calculated as:

VM_MOTOR1_CURRENT_LIMIT = (I_{MaxRef} / I_{Rated}) x 100%

where:

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

A maximum is applied to the reactive current reference parameter so that the combined current reference for the active and reactive currents does not exceed I_{MaxRef}.

VM_REGEN_REACTIVE = $\sqrt{(\text{VM\_MOTOR1\_CURRENT\_LIMIT}^2 - I_{Limit}^2)}$

where

I_{Limit} is gives the highest level of the active current reference that can occur. This value is defined by the current limit values. If the current limits are all set to their maximum values (i.e. VM_MOTOR1_CURRENT_LIMIT) then there is no current capability left for the reactive current. However, if the current limits are reduced the resulting headroom can be used for the reactive current. I_{Limit} is defined by a combination of all the current limits excluding any reduction of the current limit due to the motor thermal model, It should be noted that if *Island Detection Enable* (03.030) = 1 then VM_REGEN_REACTIVE is reduced by 5 % to allow for the islanding system injection current.

Figure 9-2 Menu 4 Regen logic diagram

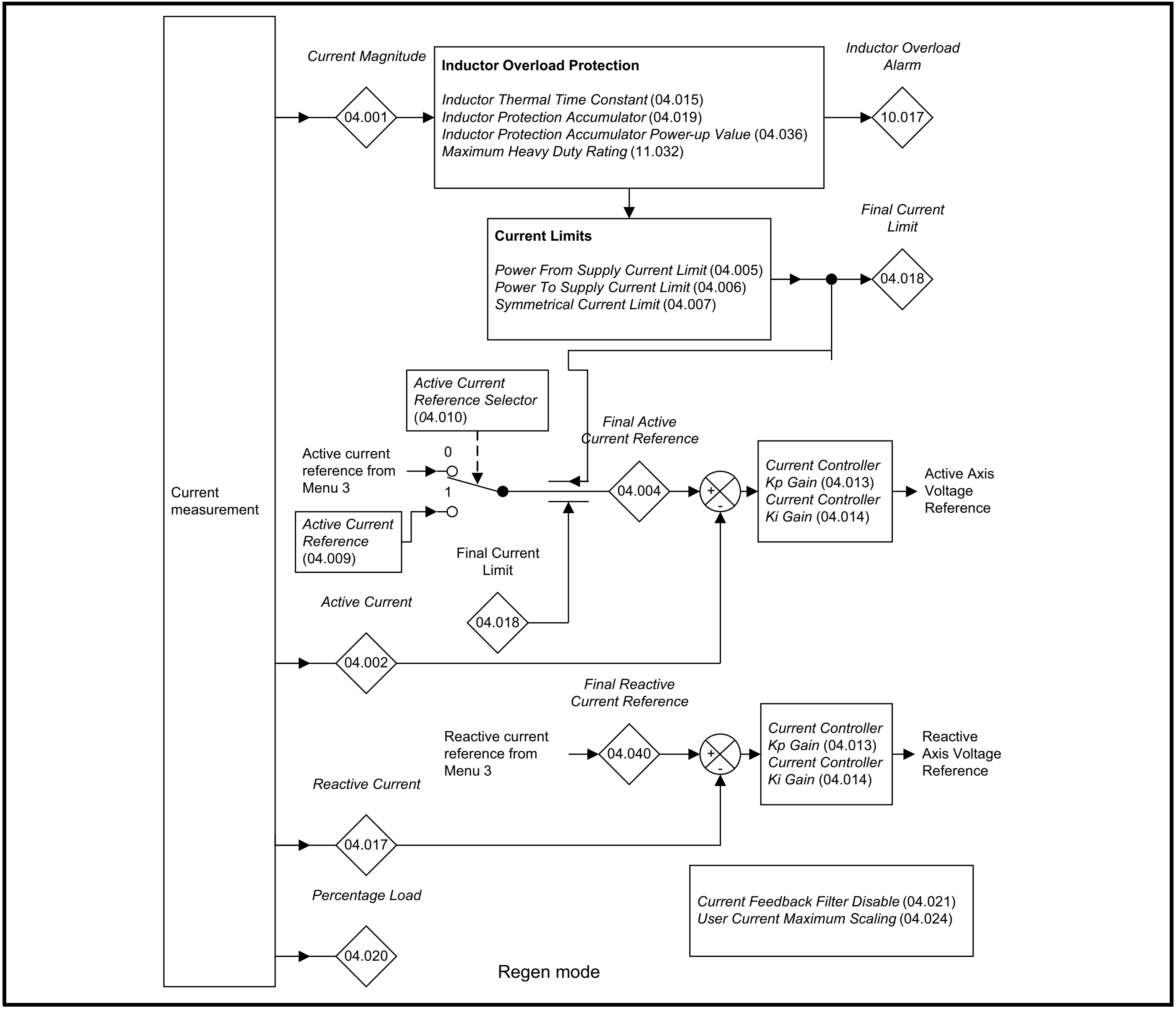


Table 9-6 Menu 4 Regen parameter descriptions

Parameter		Range(⇳)	Default (⇨)	Type					
04.001	Current Magnitude	0.000 to VM_DRIVE_CURRENT_UNIPOLAR A		RO	Num	ND	NC	PT	FI
04.002	Active Current	VM_DRIVE_CURRENT A		RO	Num	ND	NC	PT	FI
04.004	Final Active Current Reference	VM_TORQUE_CURRENT %		RO	Num	ND	NC	PT	FI
04.005	Power From Supply Current Limit	0.0 to VM_MOTOR1_CURRENT_LIMIT %	175.0 % *	RW	Num		RA		US
04.006	Power To Supply Current Limit	0.0 to VM_MOTOR1_CURRENT_LIMIT %	175.0 % *	RW	Num		RA		US
04.007	Symmetrical Current Limit	0.0 to VM_MOTOR1_CURRENT_LIMIT %	175.0 % *	RW	Num		RA		US
04.008	Reactive Current Reference	VM_REGEN_REACTIVE%	0.0 %	RW	Num				US
04.009	Active Current Reference	VM_USER_CURRENT %	0.0 %	RW	Num				US
04.010	Active Current Reference Selector	Off (0) or On (1)	Off (0)	RW	Bit				US
04.013	Current Controller Kp Gain	0 to 30000	90	RW	Num				US
04.014	Current Controller Ki Gain	0 to 30000	2000	RW	Num				US
04.015	Inductor Thermal Time Constant	1.0 to 3000.0 s	89.0 s	RW	Num				US
04.017	Reactive Current	VM_DRIVE_CURRENT A		RO	Num	ND	NC	PT	FI
04.018	Final Current Limit	VM_TORQUE_CURRENT %		RO	Num	ND	NC	PT	
04.019	Inductor Protection Accumulator	0.0 to 100.0 %		RO	Num	ND	NC	PT	PS
04.020	Percentage Load	VM_USER_CURRENT %		RO	Num	ND	NC	PT	FI
04.021	Current Feedback Filter Disable	Off (0) or On (1)	Off (0)	RW	Bit				US
04.024	User Current Maximum Scaling	0.0 to VM_TORQUE_CURRENT_UNIPOLAR %	175.0 % *	RW	Num		RA		US
04.036	Inductor Protection Accumulator Power-up Value	Power down (0), Zero (1), Real time (2)	Power down (0)	RW	Txt				US
04.040	Final Reactive Current Reference	±200.0 %		RO	Num	ND	NC	PT	FI

* For size 9 and above the default is 150.0 %

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

04.001	**Current Magnitude**								
RO	Num				ND	NC	PT		FI
⇳	0.000 to VM_DRIVE_CURRENT_UNIPOLAR A	⇨							

Current Magnitude (04.001) is the instantaneous Regen drive output current scaled so that it represents the r.m.s. phase current in Amps under steady state conditions.

04.002	**Active Current**								
RO	Num				ND	NC	PT		FI
⇳	VM_DRIVE_CURRENT A	⇨							

Active Current (04.002) is the instantaneous level of active current scaled so that it represents the r.m.s. level of active current under steady state conditions. The *Active Current* (04.002) is positive when power is flowing from the supply and negative when power is flowing into the supply.

04.004	**Final Active Current Reference**								
RO	Num				ND	NC	PT		FI
⇳	VM_TORQUE_CURRENT %	⇨							

The *Final Active Current Reference* (04.004) is the active current reference from the DC bus voltage controller and power feed-forward system or user defined value with the current limits applied.

04.005	**Power From Supply Current Limit**								
RW	Num						RA		US
⇳	0.0 to VM_MOTOR1_CURRENT_LIMIT %	⇨	175.0 %						

The *Power From Supply Current Limit* (04.005) limits the active current when power is being taken from the supply. The *Power To Supply Current Limit* (04.006) limits the active current when power is being fed back into the supply. If the *Symmetrical Current Limit* (04.007) is below the *Power From Supply Current Limit* (04.005) then it is used instead of the *Power From Supply Current Limit* (04.005). If the *Symmetrical Current Limit* (04.007) is below the *Power To Supply Current Limit* (04.006) then it is used instead of the *Power To Supply Current Limit* (04.006). It should be noted that if the current limits become active it is no longer possible for the DC bus voltage to be controlled.

The maximum possible current limit (VM_MOTOR1_CURRENT_LIMIT [MAX]) varies between drive sizes with default parameters loaded. For some drive sizes the default value may be reduced below the value given by the parameter range limiting.

04.006		**Power To Supply Current Limit**							
RW	Num						RA		US
⇳	0.0 to VM_MOTOR1_CURRENT_LIMIT %				⇨	175.0 %			

See *Power From Supply Current Limit* (04.005).

04.007		**Symmetrical Current Limit**							
RW	Num						RA		US
⇳	0.0 to VM_MOTOR1_CURRENT_LIMIT %				⇨	175.0 %			

See *Power From Supply Current Limit* (04.005).

04.008		**Reactive Current Reference**							
RW	Num								US
⇳	VM_ REGEN_REACTIVE %				⇨	0.0 %			

Reactive Current Reference (04.008) can be used to define a level of reactive current other than the default value of zero, so that the Regen drive can be made to produce or consume reactive power. *Reactive Current Reference* (04.008) defines the level of reactive current as a percentage of the *Rated Current* (05.007). Positive reactive current produces a component of current flowing from the supply to the Regen that lags the respective phase voltage, and negative reactive current produces a component of current that leads the respective voltage.

The variable maximum applied to *Reactive Current Reference* (04.008) is used to ensure that the total current does not exceed the maximum allowed. If the current limits are at their maximum values then no reactive current is allowed and VM_REGEN_REACTIVE_REFERENCE[MIN] = 0 and VM_REGEN_REACTIVE_REFERENCE[MAX] = 0. As the *Final Current Limit* (04.018) is reduced then more reactive current is allowed.

04.009		**Active Current Reference**							
RW	Num								US
⇳	VM_USER_CURRENT %				⇨	0.0 %			

If *Active Current Reference Selector* (04.010) = 0 then the active current reference is defined by the DC bus voltage controller and the power feed-forward system. If *Active Current Reference Selector* (04.010) = 1 then the user can define the active current reference. The polarity of *Reactive Current Reference* (04.008) is the same as *Active Current* (04.002), and so a positive value causes power to flow from the supply to the Regen drive, and a negative values causes power to flow from the Regen drive to the supply. It should be noted that the Regen drive can no longer control its own DC bus voltage, and so this must be controlled by some external system.

04.010		**Active Current Reference Selector**							
RW	Bit								US
⇳	Off (0) or On (1)				⇨	Off (0)			

See *Active Current Reference* (04.009).

04.013		**Current Controller Kp Gain**							
RW	Num								US
⇳	0 to 30000				⇨	90			

Current Controller Kp Gain (04.013) and *Current Controller Ki Gain* (04.014) are the proportional and integral gains of the current controllers. In many applications the default gains can be used, but under certain supply conditions it is necessary to reduce the *Current Controller Kp Gain* (04.013) to prevent instability.

Refer to section 8.3 *Current loop gains* on page 143.

04.014		**Current Controller Ki Gain**							
RW	Num								US
⇳	0 to 30000				⇨	2000			

See Current Controller Kp Gain (04.013).

04.015		**Inductor Thermal Time Constant**							
RW	Num								US
⇳	1.0 to 3000.0 s				⇨	89.0 s			

A single time constant thermal model is provided that can be use to estimate the temperature of the Regen inductors connected between the Regen drive and the supply. The input to the model is the *Current Magnitude* (04.001). The *Inductor Protection Accumulator* (04.019) is given by the following equation.

$T = 100.0\% \times [I / (K_1 \times I_{Rated})]^2 \times (1 - e^{-t/\tau})$

where:

T = *Inductor Protection Accumulator* (04.019)

I = *Current Magnitude* (04.001)

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

τ = *Inductor Thermal Time Constant* (04.015)

If *Rated Current* (05.007) ≤ *Maximum Heavy Duty Rating* (11.032) then K_1 = 1.05, otherwise K_1 = 1.01.

Inductor Protection Accumulator Reset

The initial value in the *Inductor Protection Accumulator* (04.019) at power-up is defined by *Inductor Protection Accumulator Power-up Value* (04.036) as given in the table below.

***Inductor Protection Accumulator Power-up Value* (04.036)**	***Inductor Protection Accumulator* (04.019) at power-up**
Power Down	The value is saved at power-down and is used as the initial value at power-up.
Zero	The value is set to zero.
Real Time	If a real-time clock is present and if *Date/Time Selector* (06.019) is set up to select the real-time clock then the value saved at power-down is modified to include the effect of the inductor thermal protection time constants over the time between power-down and power-up. This modified value is then used as the initial value at power-up. If no real time clock is present then and this option is selected then the value saved at power-down is used as the initial value.

The *Inductor Protection Accumulator* (04.019) is reset under the following conditions:

Inductor Thermal Time Constant (04.015) is set to 0.0. Note that this is not possible in the standard product as the minimum parameter value is 1.0.

Rated Current (05.007) is modified.

Inductor Protection Accumulator Warning

If $[I / (K_1 \times I_{Rated})]^2 > 1.0$ then eventually the *Inductor Protection Accumulator* (04.019) will reach 100% causing the Regen drive to trip. If this is the case and *Inductor Protection Accumulator* (04.019) > 75.0% then [*Ind Overload*] alarm indication is given and *Inductor Overload Alarm* (10.017) is set to one.

04.017		**Reactive Current**							
RO	Num				ND	NC	PT		FI
⇳	VM_DRIVE_CURRENT A				⇨				

Reactive Current (04.017) is the instantaneous level of reactive current scaled so that it represents the r.m.s. level of reactive current under steady state conditions.

04.018		**Final Current Limit**							
RO	Num				ND	NC	PT		
⇳	VM_TORQUE_CURRENT %				⇨				

Final Current Limit (04.018) is the current limit level that is applied to the active current.

04.019		**Inductor Protection Accumulator**							
RO	Num				ND	NC	PT		PS
⇳	0.0 to 100.0 %				⇨				

See *Inductor Thermal Time Constant* (04.015).

04.020	**Percentage Load**								
RO	Num				ND	NC	PT		FI
⇳	VM_USER_CURRENT %				⇨				

Percentage Load (04.020) gives the *Active Current* (04.002) as a percentage of the *Rated Current* (05.007). Positive values indicate power flow from the supply to the Regen drive and negative values indicate power flow from the Regen drive to the supply.

04.021	**Current Feedback Filter Disable**								
RW	Bit								US
⇳	Off (0) or On (1)				⇨	Off (0)			

If *Current Feedback Filter Disable* (04.021) = 0, a 4 ms filter is applied to the current feedback components measured by the drive to be used in *Active Current* (04.002) and *Reactive Current* (04.017). This filter removes ripple components associated with the PWM switching.
If *Current Feedback Filter Disable* (04.021) = 1, the filter is disabled and the user parameters are based on the current components sampled every 250 µs.

04.024	**User Current Maximum Scaling**								
RW	Num						RA		US
⇳	0.0 to VM_TORQUE_CURRENT_UNIPOLAR %				⇨	175.0 %			

User Current Maximum Scaling (04.024) defines the variable maximum/minimum VM_USER_CURRENT which is applied to *Percentage Load* (04.020) and *Active Current Reference* (04.009). This is useful when routing these parameters to an analog output as it allows the full scale output value to be defined by the user.

The maximum value (VM_TORQUE_CURRENT_UNIPOLAR [MAX]) varies between drive sizes with default parameters loaded. For some drive sizes the default value may be reduced below the value given by the parameter range limiting.

04.036	**Inductor Protection Accumulator Power-up value**								
RW	Txt								US
⇳	Power down (0), Zero (1), Real time (2)				⇨	Power down (0)			

See *Inductor Thermal Time Constant* (04.015).

04.040	**Final Reactive Current Reference**								
RO	Num				ND	NC	PT		FI
⇳	±200.0 %				⇨				

Final Reactive Current Reference (04.040) gives the reactive current reference that is defined by the user plus any current that is injected by the island detection system.

9.5 Menu 5: Regen Status

Figure 9-3 Menu 5 Regen status flow diagram

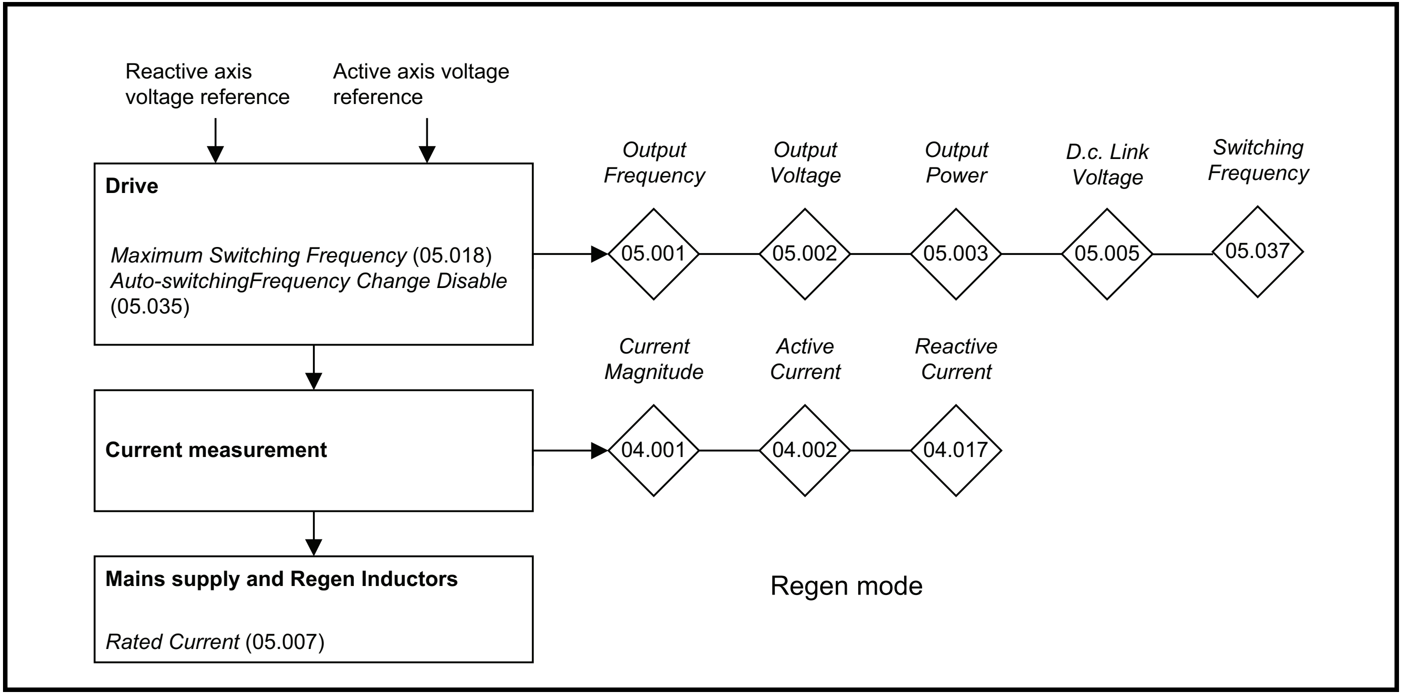


Table 9-7 Menu 5 Regen parameter descriptions

Parameter		Range(⇳)	Default(⇨)	Type					
05.001	Output Frequency	±200.0 Hz		RO	Num	ND	NC	PT	FI
05.002	Output Voltage	0 to VM_AC_VOLTAGE V		RO	Num	ND	NC	PT	FI
05.003	Output Power	VM_POWER kW		RO	Num	ND	NC	PT	FI
05.005	DC Bus Voltage	0 to VM_DC_VOLTAGE V		RO	Num	ND	NC	PT	FI
05.007	Rated Current	0.000 to VM_RATED_CURRENT A	Maximum Heavy Duty Rating (11.032)	RW	Num		RA		US
05.018	Maximum Switching Frequency	3 (1) kHz, 4 (2) kHz, 6 (3) kHz, 8 (4) kHz, 12 (5) kHz, 16 (6) kHz	3 (1) kHz	RW	Txt		RA		US
05.023	DC Bus Voltage High Range	0 to VM_HIGH_DC_VOLTAGE V		RO	Num	ND	NC	PT	FI
05.035	Auto-switching Frequency Change	Enabled (0), Disabled (1), No Ripple Detect (2)	Enabled (0)	RW	Txt				US
05.036	Auto-switching Frequency Step Size	1 to 2	2	RW	Num				US
05.037	Switching Frequency	3 (1) kHz, 4 (2) kHz, 6 (3) kHz, 8 (4) kHz, 12 (5) kHz, 16 (6) kHz		RO	Txt	ND	NC	PT	
05.038	Minimum Switching Frequency	0 to VM_MIN_SWITCHING_FREQUENCY kHz	3 (1) kHz	RW	Txt				US
05.039	Maximum Inverter Temperature Ripple	20 to 60 °C	60 °C	RW	Num				US

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

05.001	**Output Frequency**								
RO	Num				ND	NC	PT		FI
⇳	±200.0 Hz				⇨				

The *Output Frequency* (05.001) is a measure of the supply frequency. If the frequency shown is positive it indicates that the supply phase sequence is U-V-W. If it is negative it indicates that the supply phase sequence is W-V-U.

05.002	**Output Voltage**								
RO	Num				ND	NC	PT		FI
⇳	0 to VM_AC_VOLTAGE V				⇨				

The *Output Voltage* (05.002) is the r.m.s. line to line voltage at the AC terminals of the drive.

05.003	**Output Power**								
RO	Num				ND	NC	PT		FI
⇳	VM_POWER kW				⇨				

The *Output Power* (05.003) is the power flowing via the AC terminals of the drive. The power is derived as the dot product of the output voltage and current vectors. For Regen mode a positive value of power indicates power flowing from the supply to the Regen drive.

05.005	**DC Bus Voltage**								
RO	Num				ND	NC	PT		FI
⇳	0 to VM_DC_VOLTAGE V				⇨				

DC Bus Voltage (05.005) gives the voltage across the DC bus of the drive.

05.007	**Rated Current**								
RW	Num						RA		US
⇳	0.000 to VM_RATED_CURRENT A				⇨	Maximum Heavy Duty Rating (11.032)			

Rated Current (05.007) is used to define rated operating conditions for Regen inductor thermal protection. See *Inductor Thermal Time Constant* (04.015).

05.018	**Maximum Switching Frequency**								
RW	Txt						RA		US
⇳	3 (1) kHz, 4 (2) kHz, 6 (3) kHz, 8 (4) kHz, 12 (5) kHz, 16 (6) kHz				⇨	3 (1) kHz			

Maximum Switching Frequency (05.018) should be set to the required PWM switching frequency. The drive inverter will operate at this frequency unless the inverter temperature becomes too hot. Under these conditions the drive will reduce the switching frequency in an attempt to avoid tripping (see *Auto-switching Frequency Change* (05.035)). The actual switching frequency is shown in *Switching Frequency* (05.037). The switching frequency has a direct effect on the sample rate for the current controllers (see *Current Controller Kp Gain* (04.013)). All other control tasks are at a fixed rate.

05.023	**DC Bus Voltage High Range**								
RO	Num				ND	NC	PT		FI
⇳	0 to VM_HIGH_DC_VOLTAGE V				⇨				

D.c. Bus Voltage High Range (05.023) provides voltage feedback that has lower resolution and a higher range than *D.c. Bus Voltage* (05.005), and so it is possible to determine the DC bus voltage even if this exceeds the level of the over-voltage trip. It should be noted that due to tolerances, *D.c. Bus Voltage High Range* (05.023) may not correspond exactly with the level given by *DC Bus Voltage* (05.005). In a system with parallel power modules where the control pod is remote from any of the power modules, this parameter always shows zero.

05.035	**Auto-switching Frequency Change**								
RW	Txt								US
⇳	Enabled (0), Disabled (1), No Ripple Detect (2)				⇨	Enabled (0)			

The drive inverter can be damaged if the temperature is too high. The inverter can also be damaged or the lifetime of the power devices reduced, if the temperature ripple of the devices is too high. *Auto-switching Frequency Change* (05.035) defines the action taken if the drive inverter becomes too hot or the temperature ripple becomes too high.

Enabled:

If the inverter becomes too hot or the ripple temperature is higher than the level defined by *Maximum Inverter Temperature Ripple* (05.039) the switching frequency is reduced in an attempt to prevent tripping.

Disabled:

The switching frequency is not reduced, and so the drive will trip if the inverter is too hot or the temperature ripple is too high.

No Ripple Detect:

The switching frequency is reduced if the inverter temperature, but not the temperature ripple is too high. If the temperature ripple exceeds the level defined by *Maximum Inverter Temperature Ripple* (05.039) then the drive will trip.

The switching frequency is changed in steps defined by *Auto-switching Frequency Step Size* (05.036). For example with a switching frequency of 16 kHz and a step size of two, the frequency will be reduced to 8 kHz, then 4 kHz etc. *Minimum Switching Frequency* (05.038) defines the minimum switching frequency that the system will attempt to use. If the switching frequency needs to switch to a lower level, then the drive will trip. If *Minimum Switching Frequency* is changed the new value will only become active when *Switching Frequency* is at or above the minimum value.

05.036		**Auto-switching Frequency Step Size**							
RW	Num								US
⇳	1 to 2				⇨	2			

See *Auto-switching Frequency Change* (05.035).

05.037		**Switching Frequency**							
RO	Txt				ND	NC	PT		
⇳	3 (1) kHz, 4 (2) kHz, 6 (3) kHz, 8 (4) kHz, 12 (5) kHz, 16 (6) kHz				⇨				

Shows the actual inverter switching frequency after the auto-change function.

05.038		**Minimum Switching Frequency**							
RW	Txt								US
⇳	0 to VM_MIN_SWITCHING_FREQUENCY kHz				⇨	3 (1) kHz			

See *Auto-switching Frequency Change* (05.035).

05.039		**Maximum Inverter Temperature Ripple**							
RW	Num								US
⇳	20 to 60 °C				⇨	60 °C			

Maximum Inverter Temperature Ripple (05.039) defines the maximum inverter temperature ripple allowed before the switching frequency is reduced. See *Auto-switching Frequency Change* (05.035).

9.6 Menu 6: Sequencer and Clock

Figure 9-4 Menu 6 logic diagram

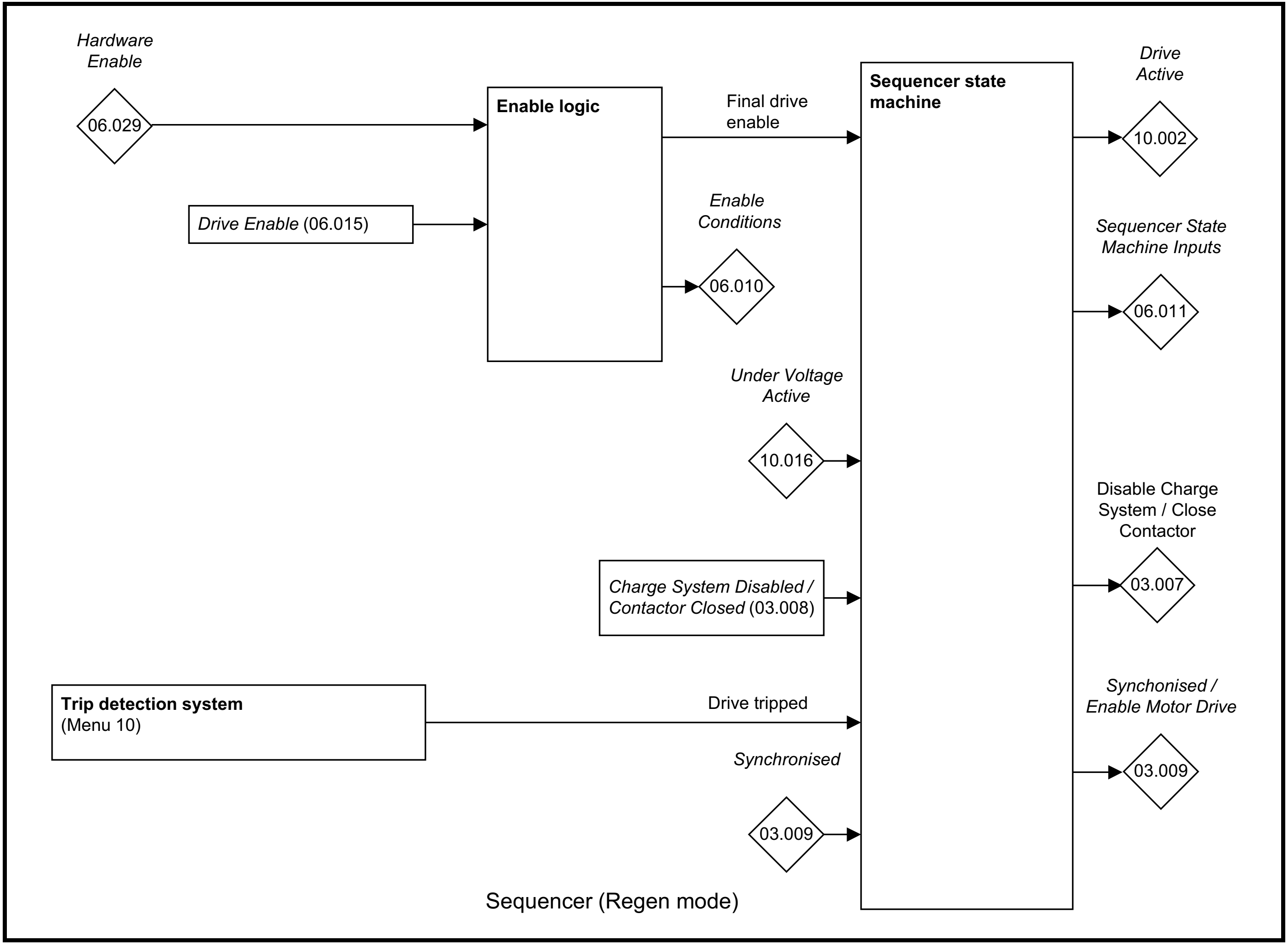


Table 9-8 Menu 6 Regen parameter descriptions

Parameter		Range(⇳)	Default(⇨)	Type					
06.010	Enable Conditions	000000000000 to 111111111111		RO	Bin	ND	NC	PT	
06.011	Sequencer State Machine Inputs	000000 to 111111		RO	Bin	ND	NC	PT	
06.015	Drive Enable	Off (0) or On (1)	On (1)	RW	Bit				US
06.016	Date	00-00-00 to 31-12-99	00-00-00	RW	Date	ND	NC	PT	
06.017	Time	00:00:00 to 23:59:59	00:00:00	RW	Time	ND	NC	PT	
06.018	Day Of Week	Sunday (0), Monday (1), Tuesday (2), Wednesday (3), Thursday (4), Friday (5), Saturday (6)		RO	Txt	ND	NC	PT	
06.019	Date/Time Selector	Set (0), Powered (1), Running (2), Acc Powered (3), Local Keypad (4), Remote Keypad (5), Slot 1 (6), Slot 2 (7), Slot 3 (8), Slot 4 (9)	Powered (1)	RW	Txt				US
06.020	Date Format	Std (0) or US (1)	Std (0)	RW	Txt				US
06.021	Time Between Filter Changes	0 to 30000 Hours	0 Hours	RW	Num				US
06.022	Filter Change Required / Change Done	Off (0) or On (1)	Off (0)	RW	Bit	ND	NC		
06.023	Time Before Filter Change Due	0 to 30000 Hours		RO	Num	ND	NC	PT	PS
06.024	Reset Energy Meter	Off (0) or On (1)	Off (0)	RW	Bit				
06.025	Energy Meter: MWh	±999.9 MWh		RO	Num	ND	NC	PT	PS
06.026	Energy Meter: kWh	±99.99 kWh		RO	Num	ND	NC	PT	PS
06.027	Energy Cost Per kWh	0.0 to 600.0	0.0	RW	Num				US
06.028	Running Cost	±32000		RO	Num	ND	NC	PT	
06.029	Hardware Enable	Off (0) or On (1)		RO	Bit	ND	NC	PT	
06.041	Drive Event Flags	00 to 11	00	RW	Bin		NC		
06.042	Control Word	000000000000000 to 111111111111111	000000000000000	RW	Bin		NC		
06.043	Control Word Enable	Off (0) or On (1)	Off (0)	RW	Bit				US
06.044	Active Supply	Off (0) or On (1)		RO	Bit	ND	NC	PT	
06.045	Cooling Fan control	-10 to 11	10	RW	Num				US
06.046	Cooling Fan Speed	0 to 10		RO	Num	ND	NC	PT	
06.060	Standby Mode Enable	Off (0) or On (1)	Off (0)	RW	Bit				US
06.061	Standby Mode Mask	0000000 to 1111111	0000000	RW	Bin				US
06.065	Standard Under Voltage Threshold	0 to VM_STD_UNDER_VOLTS V	200 V drive: 175 V 400 V drive: 330 V 575 V drive: 435 V 690 V drive: 435 V	RW	Num		RA		US
06.066	Low Under Voltage Threshold	24 to VM_LOW_UNDER_VOLTS V	200 V drive: 175 V 400 V drive: 330 V 575 V drive: 435 V 690 V drive: 435 V	RW	Num		RA		US
06.067	Low Under Voltage Threshold Select	Off (0) or On (1)	Off (0)	RW	Bit				US
06.071	Slow Rectifier Charge Rate Enable	Off (0) or On (1)	Off (0)	RW	Bit				US
06.072	User Supply Select	Off (0) or On (1)	Off (0)	RW	Bit				US
06.073	Braking IGBT Lower Threshold	0 to VM_DC_VOLTAGE_SET V	200 V drive: 390 V 400 V drive: 780 V 575 V drive: 930 V 690 V drive: 1120 V	RW	Num		RA		US
06.074	Braking IGBT Upper Threshold	0 to VM_DC_VOLTAGE_SET V	200 V drive: 390 V 400 V drive: 780 V 575 V drive: 930 V 690 V drive: 1120 V	RW	Num		RA		US
06.075	Low Voltage Braking IGBT Threshold	0 to VM_DC_VOLTAGE_SET V	0 V	RW	Num		RA		US
06.076	Low Voltage Braking IGBT Threshold Select	Off (0) or On (1)	Off (0)	RW	Bit				
06.084	Date And Time Offset	±24.00 Hours	0.00 Hours	RW	Num				US

RW	Read / Write	RO	Read only	Num	Number parameter	Bit	Bit parameter	Txt	Text string	Bin	Binary parameter	FI	Filtered
ND	No default value	NC	Not copied	PT	Protected parameter	RA	Rating dependent	US	User save	PS	Power-down save	DE	Destination
IP	IP address	Mac	Mac address	Date	Date parameter	Time	Time parameter	SMP	Slot,menu,parameter	Chr	Character parameter	Ver	Version number

06.010	**Enable Conditions**								
RO	Bin				ND	NC	PT		
⇕	000000000000 to 111111111111				⇨				

The Final drive enable is a combination of the *Hardware Enable* (06.029), *Drive Enable* (06.015) and other conditions that can prevent the drive from being enabled. All of these conditions are shown as bits in *Enable Conditions* (06.010) as given in the table below.

***Enable Conditions* (06.010) bits**	**Enable condition**
0	*Hardware Enable* (06.029)
1	*Drive Enable* (06.015)
2	Always 1 in Regen mode.
3	NA
4	Set to 1
5	Zero until the drive thermal model has obtained temperatures from all drive thermistors at least once.
6	Zero until all option modules that are present in the drive have indicated that they are ready to run or the system has timed out waiting for this.
7-10	Zero if an option module has forced the drive to be disabled if for example it is updating its user program. Bit 7 corresponds to slot 1, bit 8 to slot 2, etc.
11	Zero if the drive is in standby mode. See *Standby Mode Enable* (06.060)

06.011	**Sequencer State Machine Inputs**								
RO	Bin				ND	NC	PT		
⇕	000000 to 111111				⇨				

The bits in *Sequencer State Machine Inputs* (06.011) show the state of the inputs to the sequencer state machine as given in the table below.

***Sequencer State Machine Inputs* (06.011)**	**Signal**	**Indicates**
0	Final drive enable	The drive inverter is allowed to be enabled
1	Not used	Always zero.
2	*Under Voltage Active* (10.016)	The under voltage condition has been detected.
3	*Charge System Disabled / Contactor Closed* (03.008)	Indicates when the external charge system contactor is closed.
4	Drive tripped	The drive is tripped.
5	*Synchronized* (03.009)	Regen system is synchronized to the supply.

06.015	**Drive Enable**								
RW	Bit								US
⇕	Off (0) or On (1)				⇨	On (1)			

Drive Enable (06.015) must be active for the drive to be enabled.

06.016	**Date**								
RW	Date				ND	NC	PT		
⇕	00-00-00 to 31-12-99				⇨	00-00-00			

Date (06.016), *Time* (06.017) and *Day Of Week* (06.018) show the date and time as selected by *Date/Time Selector* (06.019). *Date* (06.016) stores the date in dd.mm.yy format regardless of the setting made in *Date Format* (06.020) however if the parameter is viewed using a keypad the date will be displayed in the format selected in *Date Format* (06.020). If a real time clock is selected from an option module then the days, months and years are from the real time clock and the day of the week is displayed in *Day Of Week* (06.018). Otherwise the days have a minimum value of 0 and roll over after 30, the months have a minimum value of 0 and roll over after 11, and *Day Of Week* (06.018) is always 0 (Sunday).

If when setting the date/time this parameter is being written via comms or from and applications module then the value should be written in standard dd/mm/yy format as described below.

The value of this parameter as seen over comms or to an applications module is as follows.

Value = (day[1..31] x 10000) + (month[1..12] x 100) + year[0..99]

06.017	**Time**								
RW	Time				ND	NC	PT		
⇳	00:00:00 to 23:59:59				⇨	00:00:00			

See *Date* (06.016).

The value of this parameter as seen over comms or to an applications module is as follows.

Value = (hour[0..23] x 10000) + (minute[0..59] x 100) + seconds[0..59]

06.018	**Day Of Week**								
RO	Txt				ND	NC	PT		
⇳	Sunday (0), Monday (1), Tuesday (2), Wednesday (3), Thursday (4), Friday (5), Saturday (6)				⇨				

See *Date* (06.016).

06.019	**Date/Time Selector**								
RW	Txt								US
⇳	Set (0), Powered (1), Running (2), Acc Powered (3), Local Keypad (4), Remote Keypad (5), Slot 1 (6), Slot 2 (7), Slot 3 (8), Slot 4 (9)				⇨	Powered (1)			

Date/Time Selector (06.019) is used to select the drive date and time as shown in the table below.

***Date/Time Selector* (06.019)**	**Date/Time Source**
0: Set	Date and time parameters can be written by the user.
1: Power	Time since the drive was powered up.
2: Running	Accumulated drive running time since the drive was manufactured.
3: Acc Power	Accumulated powered-up time since the drive was manufactured.
4: Local Keypad	If a keypad fitted to the front of the drive includes a real-time clock then the date/time from this clock is displayed, otherwise the date/time is set to zero.
5: Remote Keypad	If a keypad connected to the user comms port of a drive with a 485 includes a real-time clock then the date/time from this clock is displayed, otherwise the date/time is set to zero.
6: Slot 1	As 4 above, but for option slot 1
7: Slot 2	As 4 above, but for option slot 2
8: Slot 3	As 4 above, but for option slot 3
9: Slot 4	As 4 above, but for option slot 4

When *Date/Time Selector* (06.019) = 0 the *Date* (06.016) and *Time* (06.017) can be written by the user and the values in these parameters are transferred to the real time clocks in the keypad or any option modules that support this feature that are fitted to the drive. When *Date/Time Selector* (06.019) is changed to any other value, the real time clocks are allowed to run normally again. When *Date/Time Selector* (06.019) is changed from any value to 0 the date and time from a real time clock, if present, is automatically loaded into *Date* (06.016) and *Time* (06.017), so that this date and time is used as the initial value for editing. If more than one real time clock is present the date/time from the keypad is used, if present, and if not then the date/time from the lowest number slot with a real time clock is used.

Date (06.016) and *Time* (06.017) are used by the timers in Menu 09 and for time stamping trips. These features will continue to use the originally selected clock even if *Date/Time Selector* (06.019) is changed until a drive reset is initiated. If *Date/Time Selector* (06.019) has been changed and a reset is initiated *Timer 1 Repeat Function* (09.039) and *Timer 2 Repeat Function* (09.049) are set to zero to disable the timers, and the trip dates and times (10.041 to 10.060) are reset to zero.

06.020	**Date Format**								
RW	Txt								US
⇳	Std (0), US (1)				⇨	Std (0)			

Date Format (06.020) selects the display style for *Date* (06.016), *Timer 1 Start Date* (09.035), *Timer 1 Stop Date* (09.037), *Timer 2 Start Date* (09.045), *Timer 2 Stop Date* (09.047), and for the trip time stamping date parameters (10.041, 10.043, 10.045, 10.047, 10.049, 10.051, 10.053, 10.055, 10.057 and 10.059) when displayed on a keypad connected to the drive. The format selection made in this parameter does not affect the value of these parameters if they are read using comms or by an applications program.

If *Date Format* (06.020) is 0 then standard format is used and the date is displayed on the keypad as dd.mm.yy and if *Date Format* (06.020) is 1 then US format is used and the date is displayed on the keypad as mm.dd.yy.

06.021	**Time Between Filter Changes**								
RW	Num								US
⇳	0 to 30000 Hours	⇨	0 Hours						

Time Between Filter Changes (06.021) should be set to a non-zero value to enable the filter change timer system. Each time *Filter Change Required / Change Done* (06.022) is changed by the user from 1 to 0 the value of *Time Between Filter Changes* (06.021) is copied to *Time Before Filter Change Due* (06.023). For each hour while *Drive Active* (10.002) = 1 the *Time Before Filter Change Due* (06.023) is reduced by 1 until it reaches zero. When *Time Before Filter Change Due* (06.023) changes from 1 to 0 *Filter Change Required / Change Done* (06.022) is set to 1 to indicate that a filter change is required. The filter should be changed and the system reset again by resetting *Filter Change Required / Change Done* (06.022) to 0.

06.022	**Filter Change Required / Change Done**								
RW	Bit				ND	NC			
⇳	Off (0) or On (1)	⇨	Off (0)						

See *Time Between Filter Changes* (06.021).

06.023	**Time Before Filter Change Due**								
RO	Num				ND	NC	PT		PS
⇳	0 to 30000 Hours	⇨							

See *Time Between Filter Changes* (06.021).

06.024	**Reset Energy Meter**								
RW	Bit								
⇳	Off (0) or On (1)	⇨	Off (0)						

Energy Meter: MWh (06.025) and *Energy Meter: kWh* (06.026) accumulate the energy transferred through the drive. If *Reset Energy Meter* (06.024) = 1 then *Energy Meter: MWh* (06.025) and *Energy Meter: kWh* (06.026) are held at zero. If *Reset Energy Meter* (06.024) = 0 then the energy meter is enabled and will accumulate the energy flow. If the maximum or minimum of *Energy Meter: MWh* (06.025) is reached the parameter does not rollover and is instead clamped at the maximum or minimum value. For Regen mode, a positive energy flow indicates that power is flowing from the supply to the AC drive terminals.

06.025	**Energy Meter: MWh**								
RO	Num				ND	NC	PT		PS
⇳	±999.9 MWh	⇨							

See *Reset Energy Meter* (06.024).

06.026	**Energy Meter: kWh**								
RO	Num				ND	NC	PT		PS
⇳	±99.99 kWh	⇨							

See *Reset Energy Meter* (06.024).

06.027	**Energy Cost Per kWh**								
RW	Num								US
⇳	0.0 to 600.0	⇨	0.0						

Running Cost (06.028) is derived from the *Output Power* (05.003) and the *Energy Cost Per kWh* (06.027) in cost per hour. The sign of *Running Cost* (06.028) is the same as the sign of *Output Power* (05.003).

06.028	**Running Cost**								
RO	Num				ND	NC	PT		
⇳	±32000	⇨							

See *Energy Cost Per kWh* (06.027).

06.029	**Hardware Enable**								
RO	Bit				ND	NC	PT		
⇳	Off (0) or On (1)				⇨				

Hardware Enable (06.029) normally shows the hardware enable state based on the state of the safe torque off system. However, drive I/O can be routed to *Hardware Enable* (06.029) to reduce the disable time.

06.041	**Drive Event Flags**								
RW	Bin					NC			
⇳	00 to 11				⇨	00			

Drive Event Flags (06.041) indicates that certain actions have occurred within the drive as described below.

Bit	Corresponding event
0	Defaults loaded
1	Drive mode changed

Bit 0: Defaults loaded

The drive sets bit 0 when defaults have been loaded and the associated parameter save has been completed. The drive does not reset this flag except at power-up.

Bit 1: Drive mode changed

The drive sets bit 1 when the drive mode has changed and the associated parameter save has been completed. The drive does not reset this flag except at power-up.

06.042	**Control Word**								
RW	Bin					NC			
⇳	000000000000000 to 111111111111111				⇨	000000000000000			

If *Control Word Enable* (06.043) = 0 then *Control Word* (06.042) has no effect. If *Control Word Enable* (06.043) = 1 the bits in *Control Word* (06.042) are used instead of their corresponding parameters or to initiate drive functions as shown in the table below.

Bit	Corresponding parameter or function
0	*Drive Enable* (06.015)
1	Not used
2	Not used
3	Not used
4	Not used
5	Not used
6	Not used
7	Auto/manual
8	Analog/Preset reference
9	Not used
10	Not used
11	Not used
12	Trip drive
13	Reset drive
14	Watchdog

Bits 0-7 and bit 9: Sequencer control

When Auto/manual bit (bit7) = 1 then bit 0 of the *Control Word* (06.042) becomes active. The equivalent parameters are not modified by these bits, but become inactive when the equivalent bits in the *Control Word* (06.042) are active. When the bits are active they replace the functions of the equivalent parameters.

Bit 8: Analog/1preset reference

The value of this bit has no effect on the drive.

Bit 10 and bit 11: Not used

The values of these bits have no effect on the drive.

Bit 12: Trip drive

If bit 12 = 1 then a *Control Word* trip is repeatedly initiated. The trip cannot be cleared until bit 12 = 0.

Bit 13: Reset drive

If bit 13 is changed from 0 to 1 a drive reset is initiated. Bit 13 does not modify *Drive Reset* (10.033).

Bit 14: Watchdog

A watchdog system can be enabled or serviced each time bit 14 is changed from 0 to 1. Once bit 14 has been changed from 0 to 1 to enable the watchdog, this must be repeated every 1 s or else a *Watchdog* trip will be initiated. The watchdog is disabled when the trip occurs and must be re-enabled if required when the trip is reset.

<table>
<tr><td colspan="2">06.043</td><td colspan="8">Control Word Enable</td></tr>
<tr><td>RW</td><td>Bit</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>US</td></tr>
<tr><td>⇳</td><td colspan="4">Off (0) or On (1)</td><td>⇨</td><td colspan="4">Off (0)</td></tr>
</table>

See *Control Word* (06.042).

<table>
<tr><td colspan="2">06.044</td><td colspan="8">Active Supply</td></tr>
<tr><td>RO</td><td>Bit</td><td></td><td></td><td></td><td>ND</td><td>NC</td><td>PT</td><td></td><td></td></tr>
<tr><td>⇳</td><td colspan="4">Off (0) or On (1)</td><td>⇨</td><td colspan="4"></td></tr>
</table>

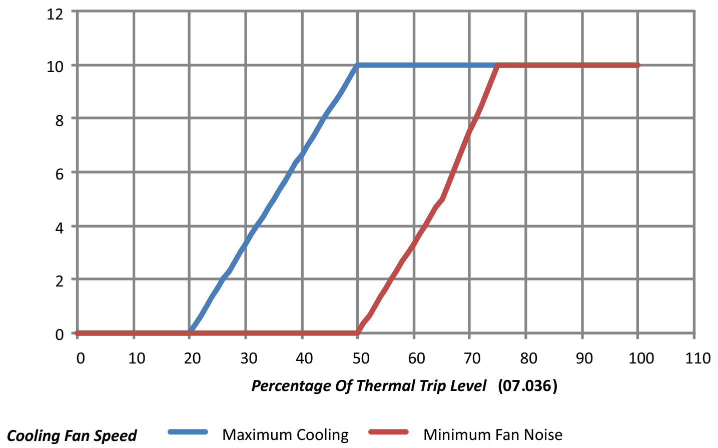
In Regen mode Active Supply (06.044) is always zero.

<table>
<tr><td colspan="2">06.045</td><td colspan="8">Cooling Fan Control</td></tr>
<tr><td>RW</td><td>Num</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>US</td></tr>
<tr><td>⇳</td><td colspan="4">-10 to 11</td><td>⇨</td><td colspan="4">10</td></tr>
</table>

Cooling Fan Control (06.045) can be used to select various fan control functions as shown in the table below. The actual control speed of the fan(s) is given in *Cooling Fan Speed* (06.046). There are 10 control speeds for the fan(s) in the drive, however the actual hardware control is more coarse than this, and so there may not be an actual change of fan speed as *Cooling Fan Speed* (06.046) changes from one value to the next. The default value for *Cooling Fan Control* (06.045) is 10, which gives maximum cooling and does not limit the fan speed below its maximum. It should be noted that if the speed is limited, by setting a lower value, then the drive may trip prematurely under load.

***Cooling Fan Control* (06.045)**	**Function Selected**
-10 to -1	Minimum fan noise function with fan speed limited to the value of *Cooling Fan Control* (06.045).
0	Fan does not run.
1 to 10	Maximum cooling with fan speed limited to the modulus of *Cooling Fan Control* (06.045).
11	Fan runs continuously at full speed.

The two possible control characteristics are shown in the diagram below.



The fan speed is derived from *Percentage Of Drive Thermal Trip Level* (07.036) which shows the percentage to the trip level of the hottest monitored point in the drive. The "Maximum Cooling" characteristic brings the fan(s) on at a relatively low temperature to give maximum cooling. The "Minimum Fan Noise" characteristic does not switch on the fan(s) until the drive temperature has risen significantly, and the characteristic has a lower gradient. Therefore with lighter continuous loads the fan noise is kept to a minimum. This characteristic also prevents the fan(s) from coming on when the drive is disabled and operating in a high ambient. With both characteristics a filter is applied to *Percentage Of Drive Thermal Trip Level* (07.036) to avoid the fans switching on and off during short high transient loads. The "Minimum Fan Noise" characteristic also includes a hysteresis band of 15 % that is applied to the percentage of drive thermal trip level at the input to the control algorithm to prevent the feedback from changing the speed back again. This reduces the chance of the fan repetitively changing speed under constant load conditions.

06.046	**Cooling Fan Speed**								
RO	Num				ND	NC	PT		
⇳	0 to 10			⇨	▨				

See *Cooling Fan Control* (06.045).

06.060	**Standby Mode Enable**								
RW	Bit								US
⇳	Off (0) or On (1)			⇨	Off (0)				

If *Standby Mode Enable* (06.060) = 1 then the drive will go into the standby power state whenever *Drive Active* (10.002) = 0 with a delay of 30 s. In this state the LED on the front of the drive flashes 0.5 s on and 5 s off, the drive cannot be enabled and the following actions are taken as defined by the *Standby Mode Mask* (06.061). Actions are enabled by setting the appropriate bit to 1. Once standby mode has become active it will remain active, even if an attempt is made subsequently to enable the drive, until *Standby Mode Enable* (06.060) is set to 0.

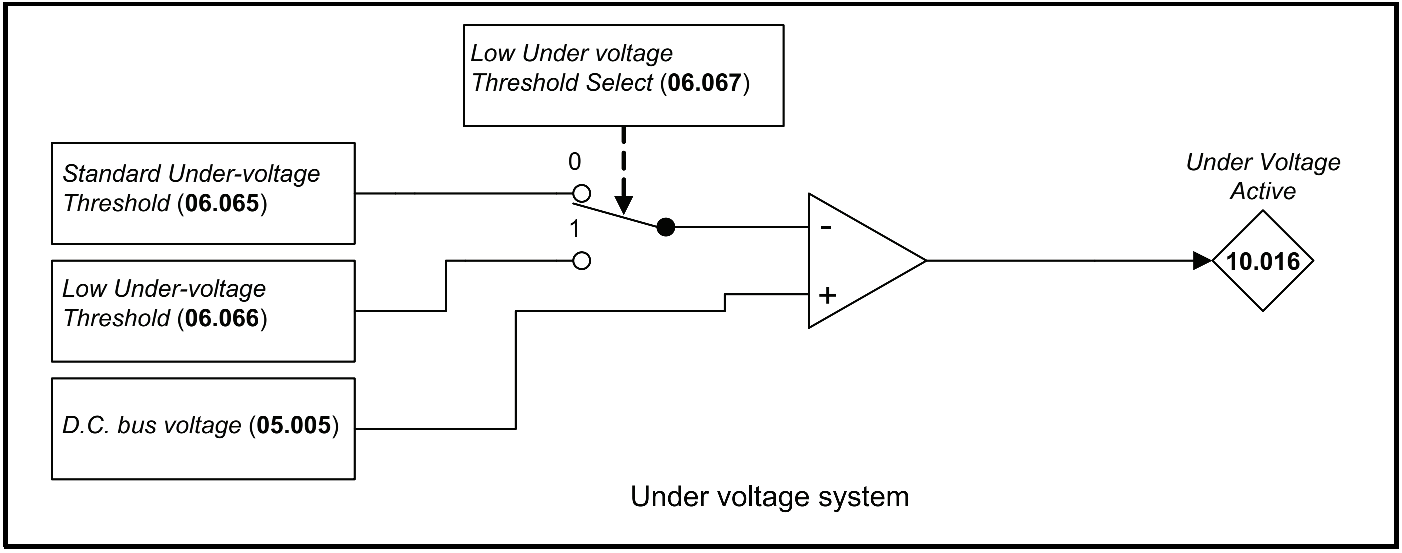
***Standby Mode Mask* (06.061) bits**	**Action**
0	NA
1	Turn off the power supply to a keypad fitted to the drive.
2	Turn off the drive 24 V output
3	Request that the option module in option slot 1 to go into the standby power mode
4	Request that the option module in option slot 2 to go into the standby power mode
5	Request that the option module in option slot 3 to go into the standby power mode
6	Request that the option module in option slot 4 to go into the standby power mode

06.061	**Standby Mode Mask**								
RW	Bin								US
⇳	0000000 to 1111111			⇨	0000000				

See *Standby Mode Enable* (06.060).

06.065	**Standard Under Voltage Threshold**								
RW	Num						RA		US
⇳	0 to VM_STD_UNDER_VOLTS V			⇨	200 V drive: 175 V 400 V drive: 330 V 575 V drive: 435 V 690 V drive: 435 V				

Under-voltage and power supply control



Under voltage system

Under-voltage system

The under-voltage system controls the state of *Under Voltage Active* (10.016) which is then used by the sequencer state machine. Each under voltage threshold detection system includes hysteresis of 5 % of the actual threshold level therefore:

DC Bus Voltage **(05.005)**	**Under voltage detection**
Vdc	Active
Threshold ≤ Vdc	No change
Vdc ≥ Threshold x 1.05*	Not active

* Hysteresis is 5 % subject to a minimum of 5 V

When *Under Voltage Active* (10.016) = 1 the sequencer state machine will change to the UNDER_VOLTAGE state and when the UNDER_VOLTAGE state is active it is not possible to enable the drive inverter.

If the low under-voltage threshold is used the internal drive power supplies are normally powered from the 24 V supply input (i.e. Digital I/O 13). *User Supply Select* (06.072) should be set to one to select this supply and its monitoring system.

If *Low Under Voltage Threshold Select* (06.067) = 0 then the under voltage threshold is defined by *Standard Under Voltage Threshold* (06.065).
If *Low Under Voltage Threshold Select* (06.067) = 1 then the under voltage threshold is defined by *Low Under Voltage Threshold* (06.066).

06.066	**Low Under Voltage Threshold**								
RW	Num						RA		US
⇳	24 to VM_LOW_UNDER_VOLTS V	⇨	200 V drive: 175 V 400 V drive: 330 V 575 V drive: 435 V 690 V drive: 435 V						

See *Standard Under Voltage Threshold* (06.065).

06.067	**Low Under Voltage Threshold Select**								
RW	Bit								US
⇳	Off (0) or On (1)	⇨	Off (0)						

See *Standard Under Voltage Threshold* (06.065). Also see *User Supply Select* (06.072) for details of when and how drive parameters can be saved, and when a *User 24V* trip can occur.

06.071	**Slow Rectifier Charge Rate Enable**								
RW	Bit								US
⇳	Off (0) or On (1)	⇨	Off (0)						

For frame size 07 drives and larger, which use a DC bus charge system based on a half controlled thyristor input bridge, the rate at which the DC bus is charged can be reduced by setting *Slow Rectifier Charge Rate Enable* (06.071) to one. This will reduce the charging current which may be required if significant additional capacitance is added to the DC bus to prevent rupturing of input fuses.

06.072	**User Supply Select**								
RW	Bit								US
⇳	Off (0) or On (1)	⇨	Off (0)						

The power for the drive control system is either taken from the user 24 V power supply or the main supply (a combination of the AC mains supply and DC bus). If *Low Under Voltage Threshold Select* (06.067) = 0 and User Supply Select (06.072) = 0 then the supply used is determined as follows for drive sizes 5 and below. (For drive sizes 6 and above a diode OR system is used to select the required power supply, and so this is done automatically in hardware.)

When the drive first powers up it tries to use the main supply or the user 24 V supply in turn until the drive starts up, beginning with the main supply.

If the main supply is active and the DC bus voltage (*D.c. Bus Voltage* (05.005)) falls to a level where it is no longer possible to communicate with the power stage then the drive attempts to switch over to the user 24 V supply. If the user 24 V supply is not present then the drive will power down, otherwise it will continue to run off the user 24 V supply. The level at which the power stage powers down depends on whether the user 24 V supply is present or not. However this maybe below half the minimum for *Standard Under Voltage Threshold* (06.065) depending on the drive power supply loading from option modules, I/O etc.

If the user 24 V supply is being used and the DC bus voltage (*D.c. Bus Voltage* (05.005)) rises above 95 % of the minimum for *Standard Under Voltage Threshold* (06.065) then the drive attempts to switch to the main supply.

The following should be noted:

Parameters can be saved by setting *Parameter mm.000* (mm.000) to 1000 (not in under-voltage state), or to 1 or 1001 (in any state) and initiating a drive reset. Power-down save parameters are saved when the under-voltage state becomes active.

If the drive is powered from the user 24 V supply and then the main supply is activated but is not above 95 % of the minimum for *Standard Under Voltage Threshold* (06.065) then the drive will continue to be powered from the user 24 V supply. If the user 24 V supply is subsequently removed the drive will power down, but then if the main supply is high enough will power up again on the main supply.

Although the drive can be maintained in the standby condition by power derived from its DC bus at a level well below the minimum for *Standard Under Voltage Threshold* (06.065) the level down to which it will operate depends on the loading applied by option modules and I/O. For reliable operation it is advisable that the DC bus voltage is above 90 % of the minimum for *Standard Under Voltage Threshold* (06.065) when the 24 V supply is not present.

It is possible to initiate saving power-down save parameters by forcing the drive into the under-voltage state by changing *Low Under Voltage Threshold Select* (06.067) from 1 to 0 when the DC bus voltage is below 90 % of the minimum of *Standard Under Voltage Threshold* (06.065). This is not advisable because failure of the 24 V supply or the main supply at this point could result in corruption of the drive parameters saved in non-volatile memory.

If *Low Under Voltage Threshold Select* (06.067) = 1 or *User Supply Select* (06.072) = 1 then the 24 V user supply is always selected. If the user 24 V supply is not present then a *User 24V* trip is initiated. The following should be noted:

The drive will still power-up on the main supply even if the user 24 V supply is not present because the drive tries each supply in turn to power up, however the drive will remain in the tripped state until the user 24 V supply is activated.

Parameters can only be saved by setting *Parameter mm.000* (mm.000) to 1001 and initiating a drive reset. Power-down save parameters are not saved when the under-voltage state becomes active.

06.073		**Braking IGBT Lower Threshold**							
RW	Num						RA		US
⇳	0 to VM_DC_VOLTAGE_SET V				⇨	200 V drive: 390 V 400 V drive: 780 V 575 V drive: 930 V 690 V drive: 1120 V			

Braking IGBT Lower Threshold (06.073) defines the lowest level of *D.c. Bus Voltage* (05.005) where the braking IGBT will become active and *Braking IGBT Upper Threshold* (06.074) defines the level of *D.c. Bus Voltage* (05.005) where the braking IGBT will be on continuously. When the braking IGBT is turned on it will remain on for at least 1 ms. The braking IGBT on-time is defined by the thresholds and the DC bus voltage as given in the table below where L = *Braking IGBT Lower Threshold* (06.073) and U = *Braking IGBT Upper Threshold* (06.074).

DC bus voltage level	**On-time**
D.c. Bus Voltage (05.005)	0 %
L ≤ *D.c. Bus Voltage* (05.005)	[(*D.c. Bus Voltage* (05.005) - L) / (U - L)] x 100 %
D.c. Bus Voltage (05.005) ≥ U	100 %

As the *D.c. Bus Voltage* (05.005) rises above the lower threshold the braking IGBT is active with an on/off ratio of 1/100. As the voltage rises further, the on/off ratio increases until at the upper threshold the braking IGBT is on continuously. The upper and lower voltage threshold can be set up so that braking resistors in drives with parallel connected DC buses will share the braking load.

If *Braking IGBT Lower Threshold* (06.073) ≥ *Braking IGBT Upper Threshold* (06.074) then the braking IGBT is off when *D.c. Bus Voltage* (05.005) < *Braking IGBT Upper Threshold* (06.074) and on if *D.c. Bus Voltage* (05.005) ≥ *Braking IGBT Upper Threshold* (06.074). This method of control is the same as that used in Unidrive SP and the default values for the braking thresholds are equal to the braking thresholds in Unidrive SP.

Unless sharing between braking resistors is required the braking thresholds do not normally need to be adjusted. Care should be taken when reducing the thresholds because if either threshold is below the maximum value of the peak rectified supply voltage the braking resistor could take power from the supply.

The braking IGBT can become active under the following conditions:

1. The Regen drive is unable to regenerate power from the motoring drive on the DC bus due to a mains loss condition.
2. The Regen drive is in current limit and is unable to capture the peak power returned from the motoring drive.

The list below gives conditions that will disable the braking IGBT:

1. *Braking IGBT Upper Threshold* (06.074) = 0, or *Low Voltage Braking IGBT Threshold Select* (06.076) = 1 and *Low Voltage Braking IGBT Threshold* (06.075) = 0
2. The drive is in the under-voltage state.
3. A priority 1, 2 or 3 trip is active (see *Trip 0* (10.020)).
4. One of the following trips is active or would be active if another trip is not already active: *OI Brake*, *PSU*, *Th Brake Res* or *OHt Inverter*.
5. *Percentage Of Drive Thermal Trip Level* (07.036) = 100 %. This is an indication that some part of the drive is too hot and is used to indicate if an internally fitted braking resistor is too hot.
6. *Brake R Too Hot* is active or the system has been set up to disable the braking IGBT based on the braking resistor temperature and the resistor is too hot (i.e. bit 2 of *Action On Trip Detection* (10.037) is set).

06.074		**Braking IGBT Upper Threshold**							
RW	Num						RA		US
⇳	0 to VM_DC_VOLTAGE_SET V				⇨	200 V drive: 390 V 400 V drive: 780 V 575 V drive: 930 V 690 V drive: 1120 V			

See *Braking IGBT Lower Threshold* (06.073).

06.075	**Low Voltage Braking IGBT Threshold**								
RW	Num						RA		US
⇕	0 to VM_DC_VOLTAGE_SET V	⇨	0 V						

If *Low Voltage Braking IGBT Threshold Select* (06.076) = 0 the normal thresholds are used. If *Low Voltage Braking IGBT Threshold Select* (06.076) = 1 then *Low Voltage Braking IGBT Threshold* (06.075) is used, so that the braking IGBT is on with a minimum on time of 1 ms is the DC bus voltage is above this level, or off if the DC bus voltage is below this level.

06.076	**Low Voltage Braking IGBT Threshold Select**								
RW	Bit								
⇕	Off (0) or On (1)	⇨	Off (0)						

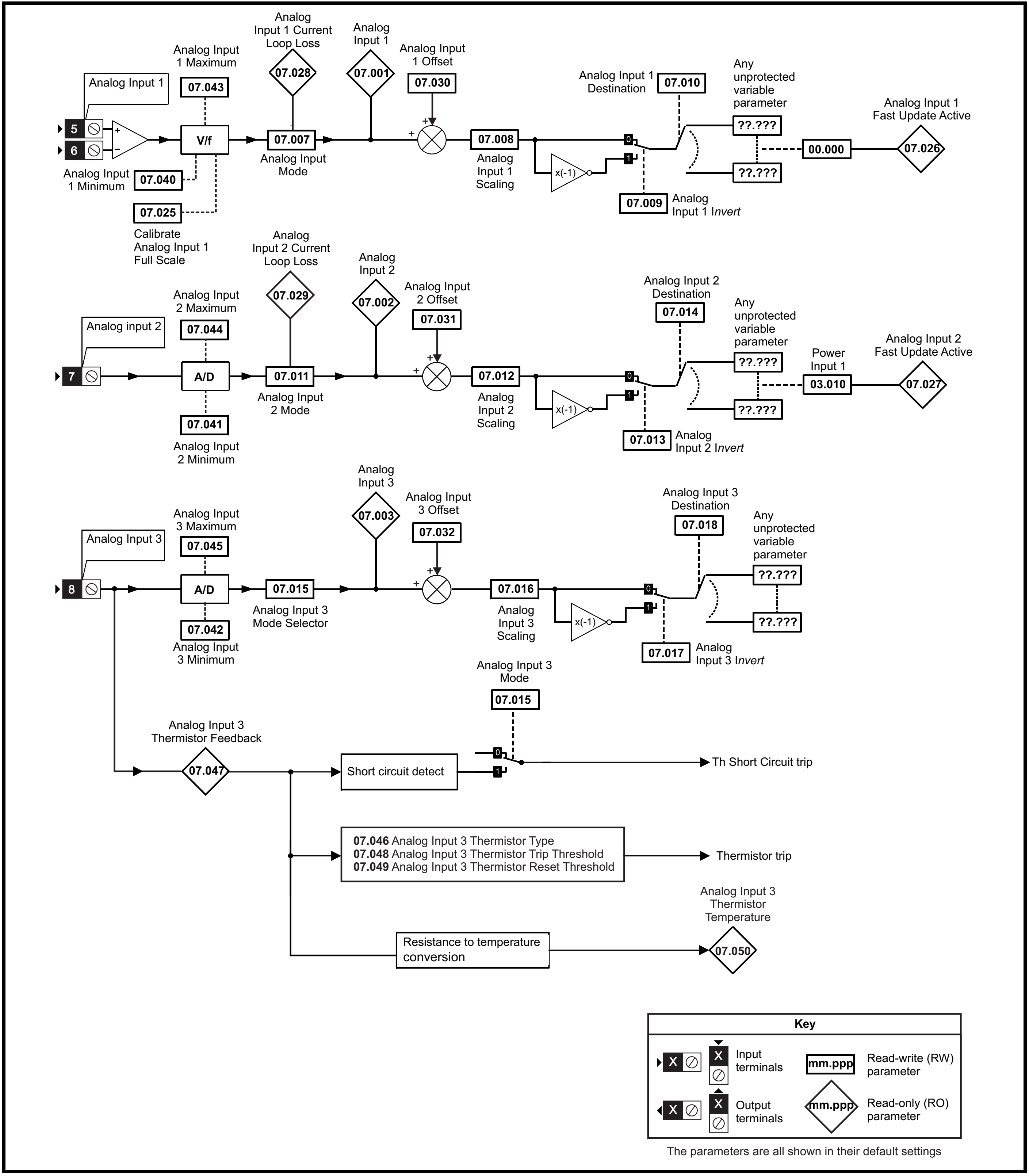
See *Low Voltage Braking IGBT Threshold* (06.075).

06.084	**Date And Time Offset**								
RW	Num								US
⇕	±24.00 Hours	⇨	0.00 Hours						

Date And Time Offset (06.084) is an offset, specified in hours, that can be applied to the *Time* (06.017). If the offset applied causes the time to roll-over midnight then the *Date* (06.016) and *Day Of Week* (06.018) are also modified. The offset is only applied when the clock source is a clock derived from a keypad or option module, i.e. *Date/Time Selector* (06.019) > 3. The offset can be used for time zone offsets or daylight saving time etc. It should be noted that when the date and time is derived from an option module this may be in the form of UTC (Coordinated Universal Time) with an additional offset also provided by the option module. The data and time is derived by adding the additional offset and the time from the option module and then adding *Date And Time Offset* (06.084).

9.7 Menu 7: Analog I/O

Figure 9-5 Menu 7 logic diagram



The parameters are all shown in their default settings

Figure 9-6 Menu 7 analog outputs diagram

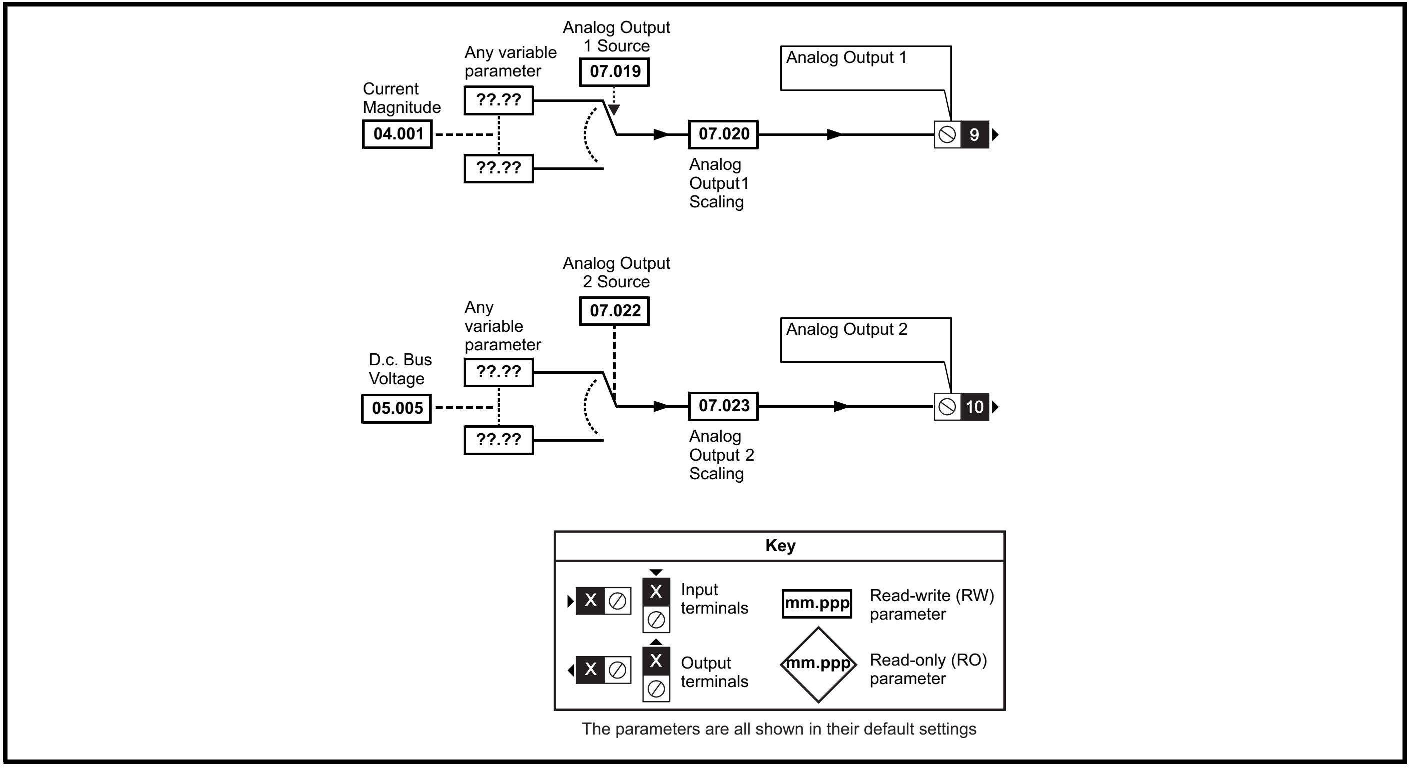
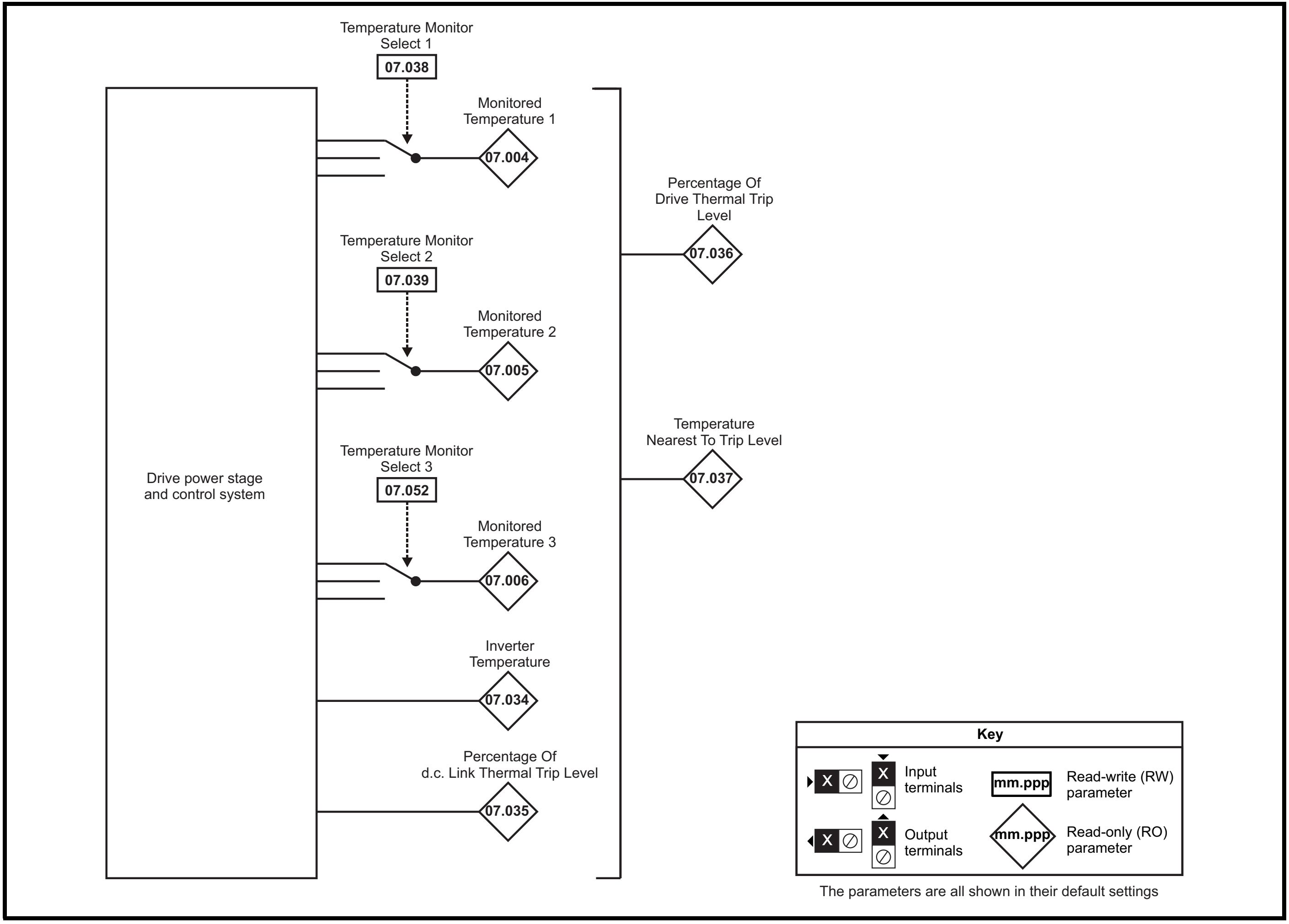


Figure 9-7 Menu 7 thermal monitoring diagram



The drive has three analog inputs (AI1 to AI3) and two analog outputs (AO1 and AO2). Each input has a similar parameter structure and each output has a similar parameter structure.

Terminal	Input	Input modes	Resolution
5/6	AI1	-4 to 6	12 bits (11 bits plus sign)
7	AI2	-4 to 6	12 bits (11 bits plus sign)
8	AI3	6 to 9	12 bits (11 bits plus sign)

Terminal	Output	Output modes	Resolution
9	AO1	Bipolar single-ended voltage only	10 bit
10	AO2	Bipolar single-ended voltage only	10 bit

Update rate

The normal sample rate for the analog inputs is 4 ms, however this is increased to 250 us for analog inputs 1 and 2 under the following conditions:

1. The maximum and the minimum for the input are at their default values of 100.00 % and -100.00 % respectively.
2. The input is set to voltage mode.
3. One of the destinations selected is *Power Input 1* (03.010), *Power Input 2* (03.013) or *Power Input 3* (03.014).

NOTE

Analog Input 1 Fast Update Active (07.026) and *Analog Input 2 Fast Update Active* (07.027) indicate if fast updating is active for each input.

Analog outputs are updated every 250 µs; although the output will only change at the update rate defined by the source parameter for the input.

Table 9-9 Menu 7 Regen parameter descriptions

Parameter		Range(⇕)	Default(⇨)	Type					
07.001	Analog Input 1	±100.00 %		RO	Num	ND	NC	PT	FI
07.002	Analog Input 2	±100.00 %		RO	Num	ND	NC	PT	FI
07.003	Analog Input 3	±100.00 %		RO	Num	ND	NC	PT	FI
07.004	Monitored Temperature 1	±250 °C		RO	Num	ND	NC	PT	
07.005	Monitored Temperature 2	±250 °C		RO	Num	ND	NC	PT	
07.006	Monitored Temperature 3	±250 °C		RO	Num	ND	NC	PT	
07.007	Analog Input 1 Mode	4-20 mA Low (-4), 20-4 mA Low (-3), 4-20 mA Hold (-2), 20-4 mA Hold (-1), 0-20 mA (0), 20-0 mA (1), 4-20 mA Trip (2), 20-4 mA Trip (3), 4-20 mA (4), 20-4 mA (5), Volt (6)	Volt (6)	RW	Txt				US
07.008	Analog Input 1 Scaling	0.000 to 10.000	1.000	RW	Num				US
07.009	Analog Input 1 Invert	Off (0) or On (1)	Off (0)	RW	Bit				US
07.010	Analog Input 1 Destination	0.000 to 59.999	0.000	RW	Num	DE		PT	US
07.011	Analog Input 2 Mode	4-20 mA Low (-4), 20-4 mA Low (-3), 4-20 mA Hold (-2), 20-4 mA Hold (-1), 0-20 mA (0), 20-0 mA (1), 4-20 mA Trip (2), 20-4 mA Trip (3), 4-20 mA (4), 20-4 mA (5), Volt (6)	Volt (6)	RW	Txt				US
07.012	Analog Input 2 Scaling	0.000 to 10.000	1.000	RW	Num				US
07.013	Analog Input 2 Invert	Off (0) or On (1)	Off (0)	RW	Bit				US
07.014	Analog Input 2 Destination	0.000 to 59.999	3.010	RW	Num	DE		PT	US
07.015	Analog Input 3 Mode	Volt (6), Therm Short Cct (7), Thermistor (8), Therm No Trip (9)	Volt (6)	RW	Txt				US
07.016	Analog Input 3 Scaling	0.000 to 10.000	1.000	RW	Num				US
07.017	Analog Input 3 Invert	Off (0) or On (1)	Off (0)	RW	Bit				US
07.018	Analog Input 3 Destination	0.000 to 59.999	0.000	RW	Num	DE		PT	US
07.019	Analog Output 1 Source	0.000 to 59.999	4.001	RW	Num			PT	US
07.020	Analog Output 1 Scaling	0.000 to 10.000	1.000	RW	Num				US
07.022	Analog Output 2 Source	0.000 to 59.999	5.005	RW	Num			PT	US
07.023	Analog Output 2 Scaling	0.000 to 10.000	1.000	RW	Num				US
07.025	Calibrate Analog Input 1 Full Scale	Off (0) or On (1)	Off (0)	RW	Bit		NC		
07.026	Analog Input 1 Fast Update Active	Off (0) or On (1)		RO	Bit	ND	NC	PT	
07.027	Analog Input 2 Fast Update Active	Off (0) or On (1)		RO	Bit	ND	NC	PT	
07.028	Analog Input 1 Current Loop Loss	Off (0) or On (1)		RO	Bit	ND	NC	PT	
07.029	Analog Input 2 Current Loop Loss			RO	Bit	ND	NC	PT	
07.030	Analog Input 1 Offset	±100.00 %	0.00 %	RW	Num				US
07.031	Analog Input 2 Offset	±100.00 %	0.00 %	RW	Num				US
07.032	Analog Input 3 Offset	±100.00 %	0.00 %	RW	Num				US
07.033	Power Output	±100.0 %		RO	Num	ND	NC	PT	
07.034	Inverter Temperature	±250 °C		RO	Num	ND	NC	PT	
07.035	Percentage Of DC bus Thermal Trip Level	0 to 100 %		RO	Num	ND	NC	PT	
07.036	Percentage Of Drive Thermal Trip Level	0 to 100 %		RO	Num	ND	NC	PT	
07.037	Temperature Nearest To Trip Level	0 to 20999		RO	Num	ND	NC	PT	
07.038	Temperature Monitor Select 1	0 to 1999	1001	RW	Num				US
07.039	Temperature Monitor Select 2	0 to 1999	1002	RW	Num				US
07.040	Analog Input 1 Minimum	±100.00 %	-100.00 %	RW	Num				US
07.041	Analog Input 2 Minimum	±100.00 %	-100.00 %	RW	Num				US
07.042	Analog Input 3 Minimum	±100.00 %	-100.00 %	RW	Num				US
07.043	Analog Input 1 Maximum	±100.00 %	100.00 %	RW	Num				US
07.044	Analog Input 2 Maximum	±100.00 %	100.00 %	RW	Num				US
07.045	Analog Input 3 Maximum	±100.00 %	100.00 %	RW	Num				US
07.046	Analog Input 3 Thermistor Type	DIN44082 (0), KTY84 (1), PT100 (4W) (2), PT1000 (4W) (3), PT2000 (4W) (4), 2.0 mA (4W) (5), PT100 (2W) (6), PT1000 (2W) (7), PT2000 (2W) (8), 2.0 mA (2W) (9)	DIN44082 (0)	RW	Txt				US
07.047	Analog Input 3 Thermistor Feedback	0 to 5000 Ω		RO	Num	ND	NC	PT	
07.048	Analog Input 3 Thermistor Trip Threshold	0 to 5000 Ω	3300 Ω	RW	Num				US
07.049	Analog Input 3 Thermistor Reset Threshold	0 to 5000 Ω	1800 Ω	RW	Num				US
07.050	Analog Input 3 Thermistor Temperature	-50 to 300 °C		RO	Num	ND	NC	PT	
07.051	Analog Input 1 Full Scale	0 to 65535		RO	Num	ND	NC	PT	PS
07.052	Temperature Monitor Select 3	0 to 1999	1	RW	Num				US

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

07.001	**Analog Input 1**								
RO	Num				ND	NC	PT		FI
⇳	±100.00 %	⇨							

Each analog input has a resolution of 11 bits plus sign. The inputs can operate in different modes (defined by *Analog Input 1 Mode* (07.007) for analog input 1). These modes include voltage, current and thermistor modes.

***Internal I/O Identifier* (11.068)**	**Analog Input 1**	**Analog Input 2**	**Analog Input 3**
0	Bipolar voltage, current & thermistor input	Bipolar voltage or current	Bipolar voltage or thermistor input

The "Input Level" is defined for the different modes in the table below.

Mode	**Input level**
Voltage	(Input Voltage / 10 V) x 100.00 %
0-20mA	(Input Current / 20 mA) x 100.00 %
20-0mA	((20 mA - Input Current) / 20 mA) x 100.00 %
4-20mA	((Input Current - 4 mA) / 16 mA) x 100.00 %
20-4mA	((20 mA - Input Current) / 16 mA) x 100.00 %
Thermistor	(Input resistance / 10 K Ohm) x 100 %

For thermistor modes it should be noted that *Analog Input 1 Minimum* (07.040) and *Analog Input 3 Minimum* (07.042) have no effect and that the input resistance is limited between 0 and 5K Ohms.

07.002	**Analog Input 2**								
RO	Num				ND	NC	PT		FI
⇳	±100.00 %	⇨							

See *Analog Input 1* (07.001).

07.003	**Analog Input 3**								
RO	Num				ND	NC	PT		FI
⇳	±100.00 %	⇨							

See *Analog Input 1* (07.001).

07.004	**Monitored Temperature 1**								
RO	Num				ND	NC	PT		
⇳	±250 °C	⇨							

Thermal monitoring is provided within the drive to protect the power stage and the control system from over temperature.

Monitored Temperature 1 (07.004), *Monitored Temperature 2* (07.005) and *Monitored Temperature 3* (07.006) give an indication of the temperature of three selected monitoring points within the drive power system or control system. The required monitoring points can be selected using *Temperature Monitor Select 1* (07.038), *Temperature Monitor Select 2* (07.039) and *Temperature Monitor Select 3* (07.052) respectively. The default values give two monitoring points in the power system in *Monitored Temperature 1* (07.004) and *Monitored Temperature 2* (07.005), and control board temperature 1 in *Monitored Temperature 3* (07.006).

07.005	**Monitored Temperature 2**								
RO	Num				ND	NC	PT		
⇳	±250 °C	⇨							

See *Monitored Temperature 1* (07.004) for details.

07.006	**Monitored Temperature 3**								
RO	Num				ND	NC	PT		
⇳	±250 °C	⇨							

See *Monitored Temperature 1* (07.004) for details.

07.007	**Analog Input 1 Mode**							
RW	Txt							US
⇕	4-20 mA Low (-4), 20-4 mA Low (-3), 4-20 mA Hold (-2), 20-4 mA Hold (-1), 0-20 mA (0), 20-0 mA (1), 4-20 mA Trip (2), 20-4 mA Trip (3), 4-20 mA (4), 20-4 mA (5), Volt (6)	⇨	Volt (6)					

The table below gives all the possible input modes for analog inputs 1 and 2.

Mode	Function
4-20mA Low	4-20mA low value on current loss (1)
20-4mA Low	20-4mA low value on current loss (1)
4-20mA Hold	4-20mA hold at level before loss on current loss (2)
20-4mA Hold	20-4mA hold at level before loss on current loss (2)
0-20mA	0-20mA
20-0mA	20-4mA
4-20mA Trip	4-20mA trip on current loss (1), (3)
20-4mA Trip	20-4mA trip on current loss (1), (3)
4-20mA	4-20mA no action on loss (1)
20-4mA	20-4mA no action on loss (1)
Volt	Voltage

(1) Analog input level is 0.00 % if the current is below 3 mA.

(2) Analog input level remains at the value it had in the previous sample before the current fell below 3 mA.

(3) *An Input 1 Loss* trip is initiated if the current falls below 3 mA.

07.008	**Analog Input 1 Scaling**							
RW	Num							US
⇕	0.000 to 10.000	⇨	1.000					

Analog Input 1 (07.001) is modified by *Analog Input 1 Scaling* (07.008), *Analog Input 1 Offset* (07.030) and *Analog Input 1 Invert* (07.009) before it is routed to its destination as follows:

A_{1O} = *Analog Input 1* (07.001) + *Analog Input 1 Offset* (07.030)

A_{1O} is the value after the offset has been applied and is limited between -100.00 % and 100.00 %

$A_{1S} = A_{1O}$ x *Analog Input 1 Scaling* (07.008)

A_{1S} is the value after the scaling and the offset have been applied and is limited between -100.00 % and 100.00 %

If *Analog Input 1 Invert* (07.009) = 0 then $A_{1I} = A_{1S}$ otherwise $A_{1I} = -A_{1S}$

A_{1I} is the value after the invert, scaling and offset have been applied and is the final value that is routed to the destination defined by *Analog Input 1 Destination* (07.010).

07.009	**Analog Input 1 Invert**							
RW	Bit							US
⇕	Off (0) or On (1)	⇨	Off (0)					

See Analog Input 1 Scaling (07.008).

07.010	**Analog Input 1 Destination**							
RW	DE					PT		US
⇕	0.000 to 59.999	⇨	0.000					

Defines the output parameter for analog input 1.

07.011	**Analog Input 2 Mode**							
RW	Txt							US
⇕	4-20 mA Low (-4), 20-4 mA Low (-3), 4-20 mA Hold (-2), 20-4 mA Hold (-1), 0-20 mA (0), 20-0 mA (1), 4-20 mA Trip (2), 20-4 mA Trip (3), 4-20 mA (4), 20-4 mA (5), Volt (6)	⇨	Volt (6)					

See *Analog Input 1 Mode* (07.007).

07.012	**Analog Input 2 Scaling**								
RW	Num								US
⇳	0.000 to 10.000	⇨	1.000						

The scaling, offset and invert functions for analog input 2 are defined in the same way as for analog input 1. See *Analog Input 1 Scaling* (07.008).

07.013	**Analog Input 2 Invert**								
RW	Bit								US
⇳	Off (0) or On (1)	⇨	Off (0)						

The scaling, offset and invert functions for analog input 2 are defined in the same way as for analog input 1. See *Analog Input 1 Scaling* (07.008).

07.014	**Analog Input 2 Destination**								
RW	DE						PT		US
⇳	0.000 to 59.999	⇨	3.010						

Defines the output parameter for analog input 2.

07.015	**Analog Input 3 Mode**								
RW	Txt								US
⇳	Volt (6), Therm Short Cct (7), Thermistor (8), Therm No Trip (9)	⇨	Volt (6)						

The table below gives all the possible input modes for analog input 3.

Mode	Function
Voltage	Voltage
Therm Short Cct	Temperature measurement input with short circuit detection
Thermistor	Temperature measurement without short circuit detection
Therm No Trip	Temperature measurement input with no trips

07.016	**Analog Input 3 Scaling**								
RW	Num								US
⇳	0.000 to 10.000	⇨	1.000						

The scaling, offset and invert functions for analog input 3 are defined in the same way as for analog input 1. See *Analog Input 1 Scaling* (07.008).

07.017	**Analog Input 3 Invert**								
RW	Bit								US
⇳	Off (0) or On (1)	⇨	Off (0)						

The scaling, offset and invert functions for analog input 3 are defined in the same way as for analog input 1. See *Analog Input 1 Scaling* (07.008).

07.018	**Analog Input 3 Destination**								
RW	DE						PT		US
⇳	0.000 to 59.999	⇨	0.000						

Defines the output parameter for analog input 3.

07.019	**Analog Output 1 Source**								
RW	Num						PT		US
⇳	0.000 to 59.999	⇨	4.001						

Analog Output 1 Source (07.019) defines the source parameter for analog output 1. The value of the sour ce parameter is scaled with *Analog Output 1 Scaling* (07.020) and if the scaling is greater than 1.000 the value is clamped between -100 % and +100% or between 0 % and 100 % depending on whether the output is bipolar or unipolar. The resulting value is then used to control the output. It should be noted that the normal rules for parameter routing do not apply, but the scaling always makes -100 % to +100 % correspond to the range from minus source parameter maximum to plus source parameter maximum, and 0 % corresponds to the source parameter value of zero. This means for example that a parameter with a minimum of 1 and a maximum of 10 will produce an output that changes from 10 % to 100 % as the parameter is change from minimum to maximum.

Analog output 1 provides bipolar voltage output (-10 V to + 10 V).

07.020	**Analog Output 1 Scaling**								
RW	Num								US
⇕	0.000 to 10.000				⇨	1.000			

See *Analog Output 1 Source* (07.019).

07.022	**Analog Output 2 Source**								
RW	Num						PT		US
⇕	0.000 to 59.999				⇨	5.005			

Analog Output 2 Source (07.022) defines the source parameter for analog output 1. The value of the source parameter is scaled with *Analog Output 2 Scaling* (07.023) and if the scaling is greater than 1.000 the value is clamped between -100 % and +100 % or between 0 % and 100 % depending on whether the output is bipolar or unipolar. The resulting value is then used to control the output.

Analog output 2 provides bipolar voltage output (-10 V to + 10 V).

07.023	**Analog Output 2 Scaling**								
RW	Num								US
⇕	0.000 to 10.000				⇨	1.000			

See *Analog Output 2 Source* (07.022).

07.025	**Calibrate Analog Input 1 Full Scale**								
RW	Bit					NC			
⇕	Off (0) or On (1)				⇨	Off (0)			

For analog input 1, and in voltage mode only, the full scale value used to determine the input level can be changed from 10 V by calibrating the input. The calibration process is triggered by setting *Calibrate Analog Input 1 Full Scale* (07.025) to one. *Calibrate Analog Input 1 Full Scale* (07.025) is cleared automatically when the calibration process is complete. After calibration the actions are as follows:

Input voltage during calibration	Result
V < 1.5 V	The calibration result is ignored and the full scale is set to 10 V. *Analog Input 1 Full Scale* (07.051) is set to zero.
1.5 V < V < 2.5 V	The calibration result is ignored and the full scale or *Analog Input 1 Full Scale* (07.051) are not affected.
V > 2.5 V	The calibration result is used to set full scale and the value is also stored in *Analog Input 1 Full Scale* (07.051).

It should be noted that *Analog Input 1 Full Scale* (07.051) is a power-down save parameter, and so the result is automatically retained after power-down.

07.026	**Analog Input 1 Fast Update Active**								
RO	Bit				ND	NC	PT		
⇕	Off (0) or On (1)				⇨				

Analog Input 1 Fast Update Active (07.026) is one if the destination for analog input 1 is being updated at the fast rate of 250 µs.

07.027	**Analog Input 2 Fast Update Active**								
RO	Bit				ND	NC	PT		
⇕	Off (0) or On (1)				⇨				

Analog Input 2 Fast Update Active (07.027) is one if the destination for analog input 2 is being updated at the fast rate of 250 µs.

07.028	**Analog Input 1 Current Loop Loss**								
RO	Bit				ND	NC	PT		
⇕	Off (0) or On (1)				⇨				

If *Analog Input 1 Mode* (07.007) is set to any of the 4-20mA or 20-4mA modes and the current falls below 3 mA then *Analog Input 1 Current Loop Loss* (07.028) is set to one. If the current is more than 3 mA or any other mode is selected then *Analog Input 1 Current Loop Loss* (07.028) is set to zero.

07.029	**Analog Input 2 Current Loop Loss**								
RO	Bit				ND	NC	PT		
⇳	Off (0) or On (1)				⇨				

See *Analog Input 1 Current Loop Loss* (07.028).

07.030	**Analog Input 1 Offset**								
RW	Num								US
⇳	±100.00 %				⇨	0.00 %			

See *Analog Input 1 Scaling* (07.008).

07.031	**Analog Input 2 Offset**								
RW	Num								US
⇳	±100.00 %				⇨	0.00 %			

The scaling, offset and invert functions for analog input 2 are defined in the same way as for analog input 1. See *Analog Input 1 Scaling* (07.008).

07.032	**Analog Input 3 Offset**								
RW	Num								US
⇳	±100.00 %				⇨	0.00 %			

The scaling, offset and invert functions for analog input 3 are defined in the same way as for analog input 1. See *Analog Input 1 Scaling* (07.008).

07.033	**Power Output**								
RO	Num				ND	NC	PT		
⇳	±100.0 %				⇨				

This is an instantaneous power output with fast update rate that is primarily intended to be used as a power feed-forward for applications with a Regen system front end. The full scale (100.0 %) value is equal to a power of 3 x (VM_DC_VOLTAGE[MAX] / 2√2) x *Full Scale Current Kc* (11.061). This is compatible with the power output provided in Unidrive SP and is directly compatible with *Power Input 1* (03.010) (and the other power feed-forward parameters) in Regen mode. The scaling is intended to cover the maximum range of likely power in the drive. For example with a 400 V, 7.5 kW drive the full scale DC bus voltage is 831 V and Kc=38.222 A, and so the full scale value of this parameter is 3 x (831 / 2√2) x 38.222 = 33.689 kW. For Regen mode a positive value of power indicates power flowing from the supply to the Regen drive.

07.034	**Inverter Temperature**								
RO	Num				ND	NC	PT		
⇳	±250 °C				⇨				

Inverter Temperature (07.034) shows the estimated junction temperature of the hottest power device within the drive inverter. If this temperature exceeds the switch down threshold defined for the power stage the switching frequency is reduced provided this feature has not been disabled (see *Auto-switching Frequency Change* (05.035)).

07.035	**Percentage Of DC Bus Thermal Trip Level**								
RO	Num				ND	NC	PT		
⇳	0 to 100 %				⇨				

Percentage Of DC Bus Thermal Trip Level (07.035) gives the percentage of the maximum allowed temperature as estimated by the thermal model of the DC bus components.

07.036	**Percentage Of Drive Thermal Trip Level**								
RO	Num				ND	NC	PT		
⇳	0 to 100 %				⇨				

Percentage Of Drive Thermal Trip Level (07.036) gives the percentage of the thermal trip level of the temperature monitoring point or thermal model in the drive that is highest. This includes all thermal monitoring points (not just those selected by *Monitored Temperature 1* (07.004), *Monitored Temperature 2* (07.005) and *Monitored Temperature 3* (07.006)), *Inverter Temperature* (07.034) and *Percentage Of DC Bus Thermal Trip Level* (07.035).

Percentage Of DC Bus Thermal Trip Level (07.035) is used directly to give *Percentage Of Drive Thermal Trip Level* (07.036), but for all other monitored values which are temperatures this is given by Percentage of thermal trip level = (Temperature - 40 °C) / (Trip temperature - 400 °C) x 100 %

The location of the measurement or the thermal model that is related to this temperature is given in *Temperature Nearest To Trip Level* (07.037).
If *Percentage Of Drive Thermal Trip Level* (07.036) exceeds 90 %, *Drive Over-temperature Alarm* (10.018) is set to one. If *Percentage Of Drive Thermal Trip Level* (07.036) reaches 100 %, one of the trips given in the table below is initiated. The trip can be reset when the percentage of thermal trip level fall below 95 %.

Temperature	Trip
Inverter Temperature (07.034)	OHt Inverter
Power system temperature	OHt Power
Percentage Of DC Bus Thermal Trip Level (07.035)	OHt dc bus
Control system temperature	OHt Control

07.037	**Temperature Nearest To Trip Level**								
RO	Num				ND	NC	PT		
⇕	0 to 20999				⇨				

Temperature Nearest To Trip Level (07.037) shows the thermistor location or the model that corresponds to the value shown in *Percentage Of Drive Thermal Trip Level* (07.036) in the form xxyzz as shown in the table below.

Source	xx	y	zz
Control system	00	0	01: Control board thermistor 1
Control system	00	0	02: Control board thermistor 2
Control system	00	0	03: I/O board thermistor
Control system	00	1	00: Inverter thermal model
Control system	00	2	00: DC bus thermal model
Control system	00	3	00: Braking IGBT thermal model
Power system	01	0	zz: Thermistor location defined by zz in the power system
Power system	01	Rectifier number	zz: Thermistor location defined by zz in the rectifier

07.038	**Temperature Monitor Select 1**								
RW	Num								US
⇕	0 to 1999				⇨	1001			

Temperature Monitor Select 1 (07.038) selects the temperature to be monitored in *Monitored Temperature 1* (07.004) using the format given for *Temperature Nearest To Trip Level* (07.037). If the monitoring point selected does not exist then the monitored temperature is always zero. The table below shows the monitoring points that can be selected.

Source	xx	y	zz
Control system	00	0	01: Control board thermistor 1
Control system	00	0	02: Control board thermistor 2
Control system	00	0	03: I/O board thermistor
Control system	00	1	00: Inverter thermal model
Control system	00	3	00: Braking IGBT thermal model
Power system	01	0	zz: Thermistor location defined by zz in the power system
Power system	01	Rectifier number	zz: Thermistor location defined by zz in the rectifier

For a multi-module power system the power system measurement that can be selected is shown in the table below. It should be noted that the specific power module cannot be selected and that the highest temperature from each of the power modules is given.

Source	xx	y	zz
Power system	01	0	01: U phase power device thermistor
Power system	01	0	02: V phase power device thermistor
Power system	01	0	03: W phase power device thermistor
Power system	01	0	04: General rectifier thermistors
Power system	01	0	05: General power system thermistor

07.039	**Temperature Monitor Select 2**								
RW	Num								US
⇕	0 to 1999				⇨	1002			

See *Temperature Monitor Select 1* (07.038).

07.040	**Analog Input 1 Minimum**								
RW	Num								US
⇕	±100.00 %	⇨	-100.00 %						

See *Analog Input 1* (07.001).

07.041	**Analog Input 2 Minimum**								
RW	Num								US
⇕	±100.00 %	⇨	-100.00 %						

See *Analog Input 1* (07.001).

07.042	**Analog Input 3 Minimum**								
RW	Num								US
⇕	±100.00 %	⇨	-100.00 %						

See *Analog Input 1* (07.001).

07.043	**Analog Input 1 Maximum**								
RW	Num								US
⇕	±100.00 %	⇨	100.00 %						

See *Analog Input 1* (07.001).

07.044	**Analog Input 2 Maximum**								
RW	Num								US
⇕	±100.00 %	⇨	100.00 %						

See *Analog Input 1* (07.001).

07.045	**Analog Input 3 Maximum**								
RW	Num								US
⇕	±100.00 %	⇨	100.00 %						

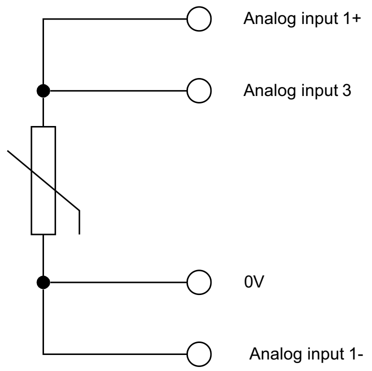
See *Analog Input 1* (07.001).

07.046	**Analog Input 3 Thermistor Type**								
RW	Txt								US
⇕	DIN44082 (0), KTY84 (1), PT100 (4W) (2), PT1000 (4W) (3), PT2000 (4W) (4), 2.0 mA (4W) (5), PT100 (2W) (6), PT1000 (2W) (7), PT2000 (2W) (8), 2.0 mA (2W) (9)	⇨	DIN44082 (0)						

Analog Input 3 Thermistor Type (07.046) defines the operation of the temperature feedback interface for analog input 3 when *Analog Input 3 Mode* (07.015) is set up for a temperature feedback mode. When a temperature feedback mode is selected a 2 mA current source is connected to analog input 3 to supply the temperature feedback device that is connected to the input.

***Analog Input 3 Thermistor Type* (07.046)**	**Compatible devices**
0: DIN44082	Three thermistors in series as specified in DIN44082 standard
1: KTY84	KTY84 PTC thermistor
2: PT100 (4W)	PT100 PTC thermistor with 4 wire connection
3: PT1000 (4W)	PT1000 PTC thermistor with 4 wire connection
4:PT2000 (4W)	PT2000 PTC thermistor with 4 wire connection
5: 2.0 mA (4W)	Any device. Full scale equivalent to a resistance of 5 k Ohms with 4 wire connection
6: PT100 (2W)	PT100 PTC thermistor with 2 wire connection
7: PT1000 (2W)	PT1000 PTC thermistor with 2 wire connection
8: PT2000 (2W)	PT2000 PTC thermistor with 2 wire connection
9: 2.0 mA (2W)	Any device. Full scale equivalent to a resistance of 5 kΩ with 2 wire connection

DIN44082 and KTY84 devices should always be connected directly to analog input 3. The other devices can be connected directly to analog input 3 if the 2 wire connection option is selected. Alternatively these devices can be used with a 4 wire connection to remove the effect of voltage drops due to the 2 mA supply current as shown below. If a 4 wire connection is selected analog input 1 is disabled and *Analog Input 1* (07.001) always reads as 0.0 %.



Connection for PT100, PT1000 and PT2000 thermistors

07.047	**Analog Input 3 Thermistor Feedback**								
RO	Num				ND	NC	PT		
⇳	0 to 5000 Ω	⇨							

Analog Input 3 Thermistor Feedback (07.047) shows the measured resistance.

07.048	**Analog Input 3 Thermistor Trip Threshold**								
RW	Num								US
⇳	0 to 5000 Ω	⇨	3300 Ω						

Over-temperature detection becomes active for input 3 if *Analog Input 3 Thermistor Feedback* (07.047) > *Analog Input 3 Thermistor Trip Threshold* (07.048). Over-temperature becomes inactive for input 3 if *Analog Input 3 Thermistor Feedback* (07.047) < *Analog Input 3 Thermistor Reset Threshold* (07.049). If *Analog Input 3 Mode* (07.015) is 7 or 8 (i.e. tripping is enabled) a *Thermistor.003* trip is initiated. The default values for *Analog Input 3 Thermistor Trip Threshold* (07.048) and *Analog Input 3 Thermistor Reset Threshold* (07.049) are the levels specified in the DIN 44082 standard.

07.049	**Analog Input 3 Thermistor Reset Threshold**								
RW	Num								US
⇳	0 to 5000 Ω	⇨	1800 Ω						

See *Analog Input 3 Thermistor Trip Threshold* (07.048).

07.050	**Analog Input 3 Thermistor Temperature**								
RO	Num				ND	NC	PT		
⇳	-50 to 300 °C	⇨							

If a KTY84, PT100, PT1000 or PT2000 type device is selected for temperature feedback then *Analog Input 3 Thermistor Temperature* (07.050) shows the temperature of the device based on the resistance to temperature characteristic specified for this device. Otherwise *Analog Input 3 Thermistor Temperature* (07.050) = 0.0.

07.051	**Analog Input 1 Full Scale**								
RO	Num				ND	NC	PT		PS
⇳	0 to 65535	⇨							

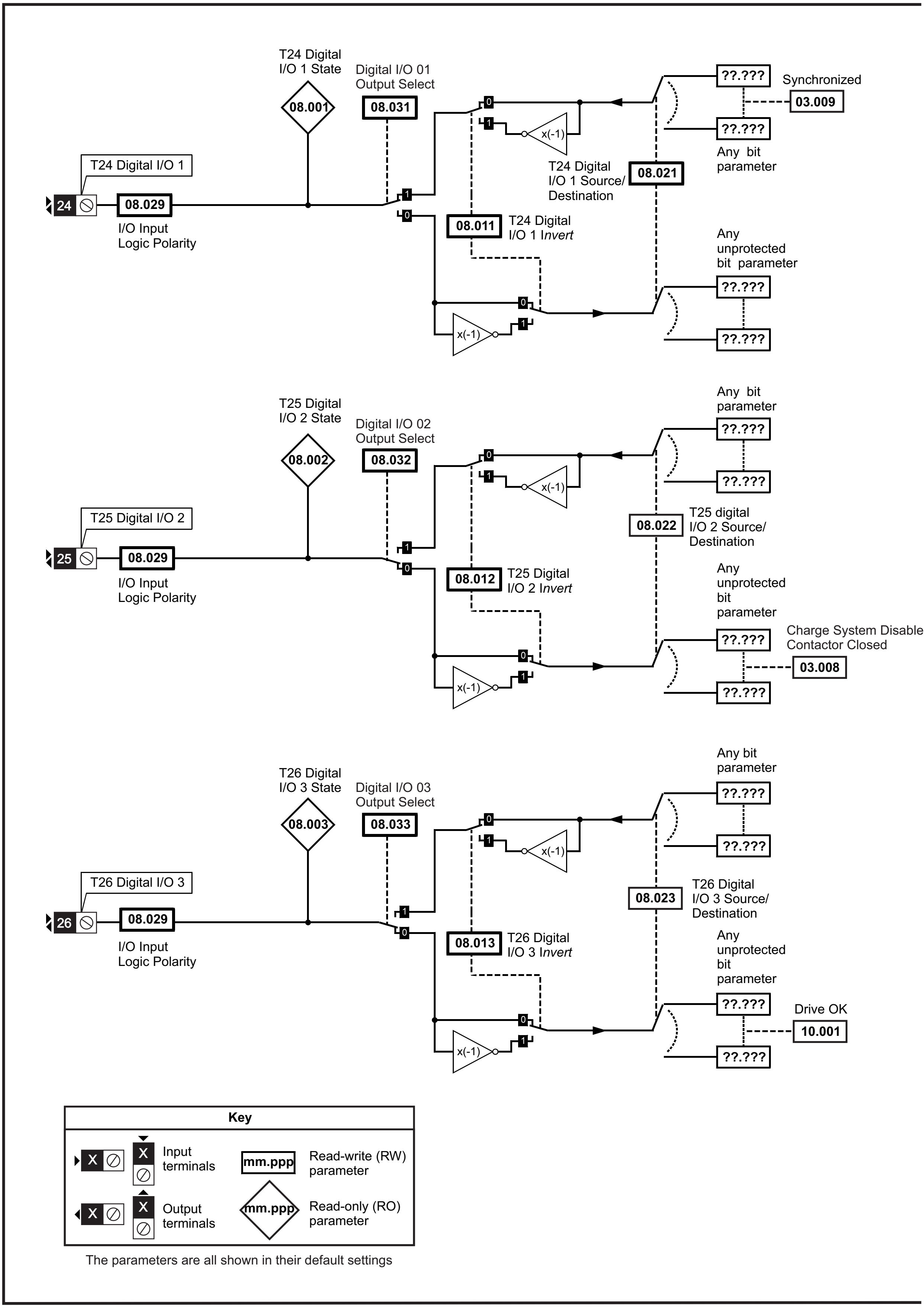
See *Calibrate Analog Input 1 Full Scale* (07.025).

07.052	**Temperature Monitor Select 3**								
RW	Num								US
⇳	0 to 1999	⇨	1						

See *Temperature Monitor Select 1* (07.038).

9.8 Menu 8: Digital I/O

Figure 9-8 Menu 8 logic diagram



The parameters are all shown in their default settings

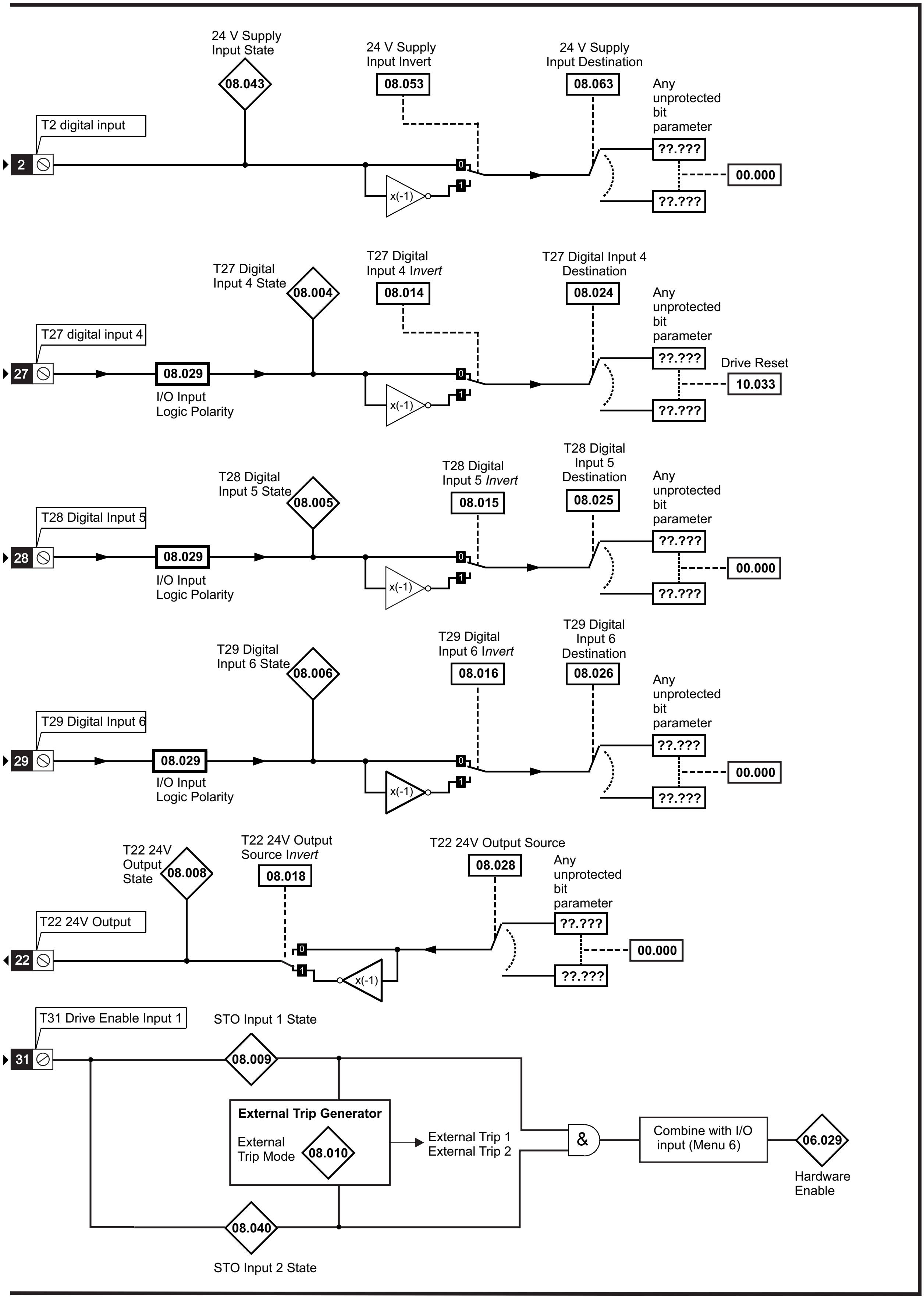
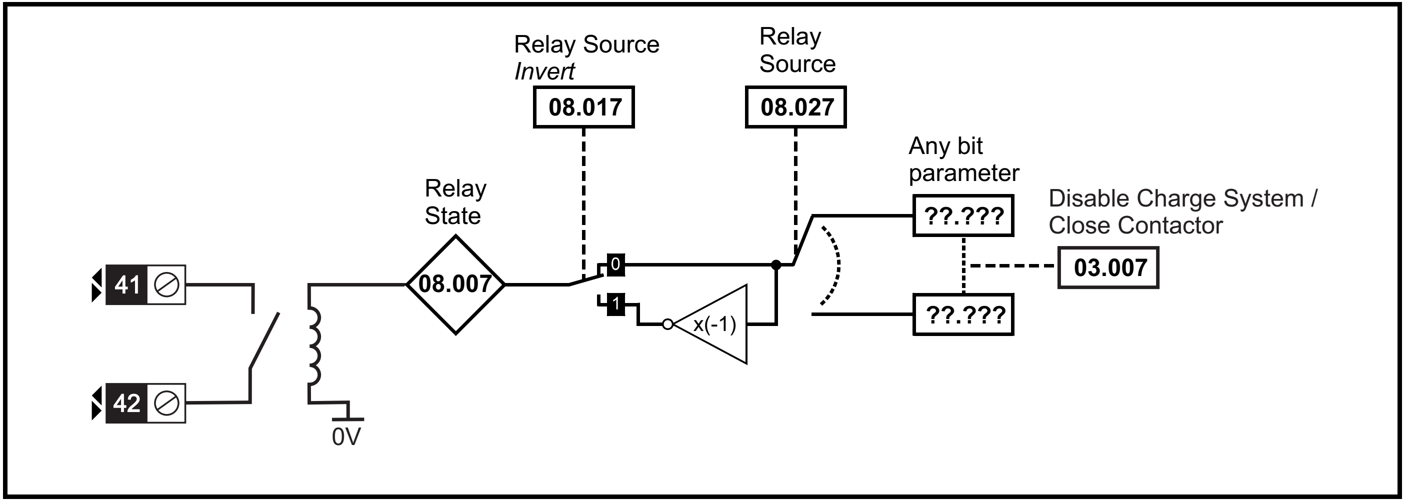

24 V Supply Input State
08.043
24 V Supply Input Invert
08.053
24 V Supply Input Destination
08.063
Any unprotected bit parameter
??.???
00.000
??.???
T2 digital input
2
x(-1)
0
1
T27 Digital Input 4 State
08.004
T27 Digital Input 4 Invert
08.014
T27 Digital Input 4 Destination
08.024
Any unprotected bit parameter
??.???
Drive Reset
10.033
??.???
T27 digital input 4
27
08.029
I/O Input Logic Polarity
T28 Digital Input 5 State
08.005
T28 Digital Input 5 Invert
08.015
T28 Digital Input 5 Destination
08.025
Any unprotected bit parameter
??.???
00.000
??.???
T28 Digital Input 5
28
08.029
I/O Input Logic Polarity
T29 Digital Input 6 State
08.006
T29 Digital Input 6 Invert
08.016
T29 Digital Input 6 Destination
08.026
Any unprotected bit parameter
??.???
00.000
??.???
T29 Digital Input 6
29
08.029
I/O Input Logic Polarity
T22 24V Output State
08.008
T22 24V Output Source Invert
08.018
T22 24V Output Source
08.028
Any unprotected bit parameter
??.???
00.000
??.???
T22 24V Output
22
T31 Drive Enable Input 1
31
STO Input 1 State
08.009
External Trip Generator
External Trip Mode
08.010
External Trip 1
External Trip 2
&
Combine with I/O input (Menu 6)
06.029
Hardware Enable
08.040
STO Input 2 State

Figure 9-9 Menu 8 Relay output logic diagram



The drive has eight digital I/O terminals (T22, T24 to T29 and the relay) and an enable input. Each input has the same parameter structure. The digital I/O is sampled every 2 ms, except when inputs are routed to the limit switches Pr **06.035** and Pr **06.036** when the sample time is reduced to 250 µs. Any changes to the source/destination parameters only become effect after drive reset is activated.

I/O	Sample rate	Function
T24 to T26	2 ms	Digital input or output
T27 to T29	2 ms	Digital input
Relay	4 ms	
T22	2 ms	24 V output

Table 9-10 Digital I/O

Terminal type	I/O state	Invert		Source / destination		Output select	
	Parameter	Parameter	Default	Parameter	Default	Parameter	Default
T24 input / output 1	Pr **08.001**	Pr **08.011**	0	Pr **08.021**	Pr **03.009** – Synchronized	Pr **08.031**	1
T25 input / output 2	Pr **08.002**	Pr **08.012**	0	Pr **08.022**	Pr **03.008** – Contactor closed	Pr **08.032**	0
T26 input / output 3	Pr **08.003**	Pr **08.013**	0	Pr **08.023**	Pr **10.001** – Drive OK	Pr **08.033**	1
T27 input 4	Pr **08.004**	Pr **08.014**	0	Pr **08.024**	Pr **10.033** – Drive reset		
T28 input 5	Pr **08.005**	Pr **08.015**	0	Pr **08.025**	Pr **0.000** – Not used		
T29 input 6	Pr **08.006**	Pr **08.016**	0	Pr **08.026**	Pr **0.000** – Not used		
T41 / 42 Relay	Pr **08.007**	Pr **08.017**	0	Pr **08.027**	Pr **03.007** – Close contactor		
T22 24 V output	Pr **08.008**	Pr **08.018**	1	Pr **08.028**	Pr **0.000** – Not used		
T31 Safe Torque Off / Drive enable	Pr **08.009** and Pr **08.040**						

Table 9-11 Menu 8 Regen parameter descriptions

Parameter		Range(⇕)	Default(⇨)	Type					
08.001	Digital I/O 01 State	Off (0) or On (1)		RO	Bit	ND	NC	PT	
08.002	Digital I/O 02 State	Off (0) or On (1)		RO	Bit	ND	NC	PT	
08.003	Digital I/O 03 State	Off (0) or On (1)		RO	Bit	ND	NC	PT	
08.004	Digital Input 04 State	Off (0) or On (1)		RO	Bit	ND	NC	PT	
08.005	Digital Input 05 State	Off (0) or On (1)		RO	Bit	ND	NC	PT	
08.006	Digital Input 06 State	Off (0) or On (1)		RO	Bit	ND	NC	PT	
08.007	Relay Output State	Off (0) or On (1)		RO	Bit	ND	NC	PT	
08.008	24V Supply Output State	Off (0) or On (1)		RO	Bit	ND	NC	PT	
08.009	STO Input 01 State	Off (0) or On (1)		RO	Bit	ND	NC	PT	
08.010	External Trip Mode	Disable (0), STO 1 (1), STO 2 (2), STO 1 OR STO 2 (3)	Disable (0)	RW	Txt				US
08.011	Digital I/O 01 Invert	Not Invert (0) or Invert (1)	Not Invert (0)	RW	Txt				US
08.012	Digital I/O 02 Invert	Not Invert (0) or Invert (1)	Not Invert (0)	RW	Txt				US
08.013	Digital I/O 03 Invert	Not Invert (0) or Invert (1)	Not Invert (0)	RW	Txt				US
08.014	Digital Input 04 Invert	Not Invert (0) or Invert (1)	Not Invert (0)	RW	Txt				US
08.015	Digital Input 05 Invert	Not Invert (0) or Invert (1)	Not Invert (0)	RW	Txt				US
08.016	Digital Input 06 Invert	Not Invert (0) or Invert (1)	Not Invert (0)	RW	Txt				US
08.017	Relay Invert	Not Invert (0) or Invert (1)	Not Invert (0)	RW	Txt				US
08.018	24V Supply Output Invert	Not Invert (0) or Invert (1)	Invert (1)	RW	Txt				US
08.020	Digital I/O Read Word	0 to 511		RO	Num	ND	NC	PT	
08.021	Digital I/O 01 Source/Destination	0.000 to 59.999	3.009	RW	Num	DE		PT	US
08.022	Digital I/O 02 Source/Destination	0.000 to 59.999	3.008	RW	Num	DE		PT	US
08.023	Digital I/O 03 Source/Destination	0.000 to 59.999	10.001	RW	Num	DE		PT	US
08.024	Digital Input 04 Destination	0.000 to 59.999	10.033	RW	Num	DE		PT	US
08.025	Digital Input 05 Destination	0.000 to 59.999	0.000	RW	Num	DE		PT	US
08.026	Digital Input 06 Destination	0.000 to 59.999	0.000	RW	Num	DE		PT	US
08.027	Relay Output Source	0.000 to 59.999	3.007	RW	Num			PT	US
08.028	24V Supply Output Source	0.000 to 59.999	0.000	RW	Num			PT	US
08.029	Input Logic Polarity	Negative Logic (0) or Positive Logic (1)	Positive Logic (1)	RW	Txt				US
08.031	Digital I/O 01 Output Select	Off (0) or On (1)	On (1)	RW	Bit				US
08.032	Digital I/O 02 Output Select	Off (0) or On (1)	Off (0)	RW	Bit				US
08.033	Digital I/O 03 Output Select	Off (0) or On (1)	On (1)	RW	Bit				US
08.040	STO Input 02 State	Off (0) or On (1)		RO	Bit	ND	NC	PT	
08.041	Keypad Run Button State	Off (0) or On (1)		RO	Bit	ND	NC	PT	
08.042	Keypad Auxiliary Button State	Off (0) or On (1)		RO	Bit	ND	NC	PT	
08.043	24V Supply Input State	Off (0) or On (1)		RO	Bit	ND	NC	PT	
08.044	Keypad Stop Button State	Off (0) or On (1)		RO	Bit	ND	NC	PT	
08.051	Keypad Run Button Invert/Toggle	Not Invert (0), Invert (1) or Toggle (2)	Not Invert (0)	RW	Txt				US
08.052	Keypad Auxiliary Button Invert/Toggle	Not Invert (0), Invert (1) or Toggle (2)	Not Invert (0)	RW	Txt				US
08.053	24V Supply Input Invert	Not Invert (0) or Invert (1)	Not Invert (0)	RW	Txt				US
08.061	Keypad Run Button Destination	0.000 to 59.999	0.000	RW	Num	DE		PT	US
08.062	Keypad Auxiliary Button Destination	0.000 to 59.999	0.000	RW	Num	DE		PT	US
08.063	24V Supply Input Destination	0.000 to 59.999	0.000	RW	Num	DE		PT	US
08.071	DI/O Output Enable Register 1	0000000000000000 to 1111111111111111	0000000000000000	RW	Bin			PT	US
08.072	DI/O Input Register 1	0000000000000000 to 1111111111111111		RO	Bin	ND	NC	PT	
08.073	DI/O Output Register 1	0000000000000000 to 1111111111111111	0000000000000000	RW	Bin			PT	

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

08.001	**Digital I/O 01 State**								
08.002	**Digital I/O 02 State**								
08.003	**Digital I/O 03 State**								
08.004	**Digital Input 04 State**								
08.005	**Digital Input 05 State**								
08.006	**Digital Input 06 State**								
08.007	**Relay Output State**								
08.008	**24V Supply Output State**								
08.009	**STO Input 01 State**								
RO	Bit				ND	NC	PT		
⇕	Off (0) or On (1)				⇨				

The Digital I/O State parameter shows the state of digital I/O on the drive. All I/O except Digital Input 11 (Keypad Run Button), Digital Input 12 (Keypad Auxiliary Button), Digital Input 13 (24V Supply Input) and Digital Input 14 (Keypad Stop Button) use IEC61131-2 logic levels. As default the inputs use positive logic, and so the state parameter is 0 if the digital I/O is low or 1 if the digital I/O is high. *Input Logic Polarity* (08.029) can be set to zero to change the logic for Digital I/O1-6 to negative logic, so that the state parameter is 0 if the digital I/O is high or 1 if the digital I/O is low. The state parameter represents the digital I/O state whether it is an input or an output. If the digital I/O is configured as an output to be controlled using the *Digital I/O Output Register 1* (08.073) then the state parameter will still show the state of the output even though the route source is zero and the invert parameter has no effect.

Digital Input 11 (Keypad Run Button), Digital Input 12 (Keypad Auxiliary Button) and Digital Input 14 (Keypad Stop Button) represent the state of the Run, Auxiliary and Stop buttons on any keypad fitted to the drive; the input state is determined by ORing the state of the button on each keypad connected to the drive, if the button is pressed the state parameter is one otherwise it is zero. If a keypad is not fitted the state parameters are zero.

Digital Input 13 (24 V Supply Input) is an external 24 V supply input that is monitored and can be used as a 24 V digital input if an external 24 V supply is not required. The state parameter is low for the voltage range from 0 V to 17 V and high for the voltage range above 18 V. As the input is a power supply it will consume significant current if the level is taken above 24 V when the drive is running from its internal power supply, or at any voltage level if this input is the only power supply to the drive.

Digital Input 09 (STO input 1) and Digital Input 10 (STO input 2) correspond to two safe torque off channels within the drive. Both channels must be in the high state for the drive to be enabled. The state parameters are 0 if the digital input is low, or 1 if the digital input is high. If option slot 3 does not contain an option module providing safety functions then both safe torque off channels are connected to their state parameters and the safe torque off input can enable/disable the drive. If an option module providing safety functions is fitted in option slot 3 then the option module can disable the drive by breaking the path of either one or both safe torque off channels. See Menu 6 for details of the drive enable system.

In Regen mode the enable input of the Regen drive has no Safe Torque Off safety function. Refer to section 2 *Introduction*and Safe Torque Off warning on page 8.

08.010	**External Trip Mode**								
RW	Txt								US
⇕	Disable (0), STO 1 (1), STO 2 (2), STO 1 OR STO 2 (3)				⇨	Disable (0)			

If *External Trip Mode* (08.010) = 0 the safe torque off inputs simply enable or disable the drive. If *External Trip Mode* (08.010) > 0 it is possible to enable the following trip functions.

***External Trip Mode* (08.010)**	**Actions**
0	Safe torque off inputs do not initiate trips
1	*External Trip.001* if Safe Torque Off Input 1 is low
2	*External Trip.002* if Safe Torque Off Input 2 is low
3	*External Trip.001* if Safe Torque Off is low OR *External Trip.002* if Safe Torque Off Input 2 is low

08.011	**Digital I/O 01 Invert**								
08.012	**Digital I/O 02 Invert**								
08.013	**Digital I/O 03 Invert**								
08.014	**Digital Input 04 Invert**								
08.015	**Digital Input 05 Invert**								
08.016	**Digital Input 06 Invert**								
08.017	**Relay Invert**								
RW	Txt								US
⇳	Not Invert (0) or Invert (1)				⇨	Not Invert (0)			

A value of 0 or 1 allows the digital I/O to be non-inverted or inverted respectively.

08.018	**24V Supply Output Invert**								
RW	Txt								US
⇳	Not Invert (0) or Invert (1)				⇨	Invert (1)			

See *Digital I/O 01 Invert* (08.011).

08.020	**Digital I/O Read Word**								
RO	Num				ND	NC	PT		
⇳	0 to 511				⇨				

Digital I/O Read Word (08.020) reflects the state of digital input/output 1 to STO input 1 as given below. Each bit matches the value of the state parameter for the respective digital input or output.

***Digital I/O Read Word* (08.020) bit**	**Digital I/O**
0	Digital I/O 1
1	Digital I/O 2
2	Digital I/O 3
3	Digital Input 4
4	Digital Input 5
5	Digital Input 6
6	Relay
7	24 V Output
8	STO Input 1

08.021	**Digital I/O 01 Source/Destination**								
RW	Num	DE					PT		US
⇳	0.000 to 59.999				⇨	3.009			

The Digital I/O Source/Destination parameters provide the routing for the source and/or destination for the digital I/O.

08.022	**Digital I/O 02 Source/Destination**								
RW	Num	DE					PT		US
⇳	0.000 to 59.999				⇨	3.008			

See *Digital I/O 01 Source/Destination* (08.021).

08.023	**Digital I/O 03 Source/Destination**								
RW	Num	DE					PT		US
⇳	0.000 to 59.999				⇨	10.001			

See *Digital I/O 01 Source/Destination* (08.021).

08.024	**Digital Input 04 Destination**								
RW	Num	DE					PT		US
⇳	0.000 to 59.999				⇨	10.033			

See *Digital I/O 01 Source/Destination* (08.021).

08.025		**Digital Input 05 Destination**							
RW	Num	DE					PT		US
⇳	0.000 to 59.999				⇨	0.000			

See *Digital I/O 01 Source/Destination* (08.021).

08.026		**Digital Input 06 Destination**							
RW	Num	DE					PT		US
⇳	0.000 to 59.999				⇨	0.000			

See *Digital I/O 01 Source/Destination* (08.021).

08.027		**Relay Output Source**							
RW	Num						PT		US
⇳	0.000 to 59.999				⇨	3.007			

See *Digital I/O 01 Source/Destination* (08.021).

08.028		**24V Supply Output Source**							
RW	Num						PT		US
⇳	0.000 to 59.999				⇨	0.000			

See *Digital I/O 01 Source/Destination* (08.021).

08.029		**Input Logic Polarity**							
RW	Txt								US
⇳	Negative Logic (0) or Positive Logic (1)				⇨	Positive Logic (1)			

See *Digital I/O 01 State* (08.001).

08.031		**Digital I/O 01 Output Select**							
RW	Bit								US
⇳	Off (0) or On (1)				⇨	On (1)			

The Digital I/O Output Select parameters allow the I/O to be selected as an input (0) or an output (1). These parameters are only present for digital I/O that can be used as an input or output.

08.032		**Digital I/O 02 Output Select**							
RW	Bit								US
⇳	Off (0) or On (1)				⇨	Off (0)			

See *Digital I/O 01 Output Select* (08.031).

08.033		**Digital I/O 03 Output Select**							
RW	Bit								US
⇳	Off (0) or On (1)				⇨	On (1)			

See *Digital I/O 01 Output Select* (08.031).

08.040		**STO Input 02 State**							
RO	Bit				ND	NC	PT		
⇳	Off (0) or On (1)				⇨	▨			

See Digital I/O 01 State (08.001).

08.041		**Keypad Run Button State**							
08.042		**Keypad Auxiliary Button State**							
08.043		**24V Supply Input State**							
08.044		**Keypad Stop Button State**							
RO	Bit				ND	NC	PT		
⇕	Off (0) or On (1)				⇨				

See Digital I/O 01 State (08.001).

08.051		**Keypad Run Button Invert/Toggle**							
08.052		**Keypad Auxiliary Button Invert/Toggle**							
RW	Txt								US
⇕	Not Invert (0), Invert (1), Toggle (2)				⇨	Not Invert (0)			

A value of 0 or 1 allows the input state to be non-inverted or inverted respectively. An additional toggle function is provided for Keypad Run button/ Keypad Auxiliary button inputs. The toggle function output changes state on each rising edge (0 to 1 change) at its input.

08.053		**24V Supply Input Invert**							
RW	Txt								US
⇕	Not Invert (0) or Invert (1)				⇨	Not Invert (0)			

See *Digital I/O 01 Source/Destination* (08.021).

08.061		**Keypad Run Button Destination**							
08.062		**Keypad Auxiliary Button Destination**							
08.063		**24V Supply Input Destination**							
RW	Num	DE					PT		US
⇕	0.000 to 59.999				⇨	0.000			

See *Digital I/O 01 Source/Destination* (08.021).

08.071		**Digital I/O Output Enable Register 1**							
RW	Bin						PT		US
⇕	0000000000000000 to 1111111111111111				⇨	0000000000000000			

The bits in the *Digital I/O Output Enable Register 1* (08.071), *Digital I/O Input Register 1* (08.072) and *Digital I/O Output Register 1* (08.073) each correspond with one digital I/O as shown below. The update rate of the individual bits in these registers differs depending upon the I/O.

DI/O	Bit	Function	Bit update rate		
			Input Register	**Output Register**	**Output Enable Register**
1	0	Digital Input/Output	2 ms	250 µs	Background
2	1	Digital Input/Output	2 ms	250 µs	Background
3	2	Digital Input/Output	2 ms	2 ms	Background
4	3	Digital Input	250 µs	Not applicable	Not applicable
5	4	Digital Input	250 µs	Not applicable	Not applicable
6	5	Digital Input	2 ms	Not applicable	Not applicable
7	6	Relay Output	Bit always 0	2 ms	Background
8	7	24V Supply Output	Bit always 0	2 ms	Background
9	8	Safe Torque Off 1	2 ms	Not applicable	Not applicable
10	9	Safe Torque Off 2	2 ms	Not applicable	Not applicable
11	10	Keypad Run Button	Background	Not applicable	Not applicable
12	11	Keypad Auxiliary Button	Background	Not applicable	Not applicable
13	12	24V Supply Input	2 ms	Not applicable	Not applicable
14	13	Keypad Stop Button	Background	Not applicable	Not applicable
15	14	Not applicable	Not applicable	Not applicable	Not applicable
16	15	Drive Reset Button	Background	Not applicable	Not applicable

The *Digital I/O Input Register 1* (08.072) is always active and shows the value in the Digital I/O State parameter for all digital I/O configured as inputs. Bits in the *Digital I/O Output Register 1* (08.073) can be used to control the digital I/O directly. The bits control the output directly and are not modified by the corresponding Digital I/O Invert/Toggle function. The bits in the *Digital I/O Output Register 1* (08.073) only control the corresponding digital output if all the conditions below are met:

1. The corresponding bit in the *Digital I/O Output Enable Register 1* (08.071) must be set to 1.
2. The digital I/O must be an output, or it must be an input/output and the corresponding Digital I/O Output Select parameter must be one.
3. The corresponding Digital I/O Source/Destination parameter is not as valid source (e.g. 0.000) and the drive has been powered-up or reset since it was first selected.

If the above conditions are not met, the digital output is controlled by the normal logic.

08.072	**Digital I/O Input Register 1**								
RO	Bin						PT		
⇕	0000000000000000 to 1111111111111111			⇨					

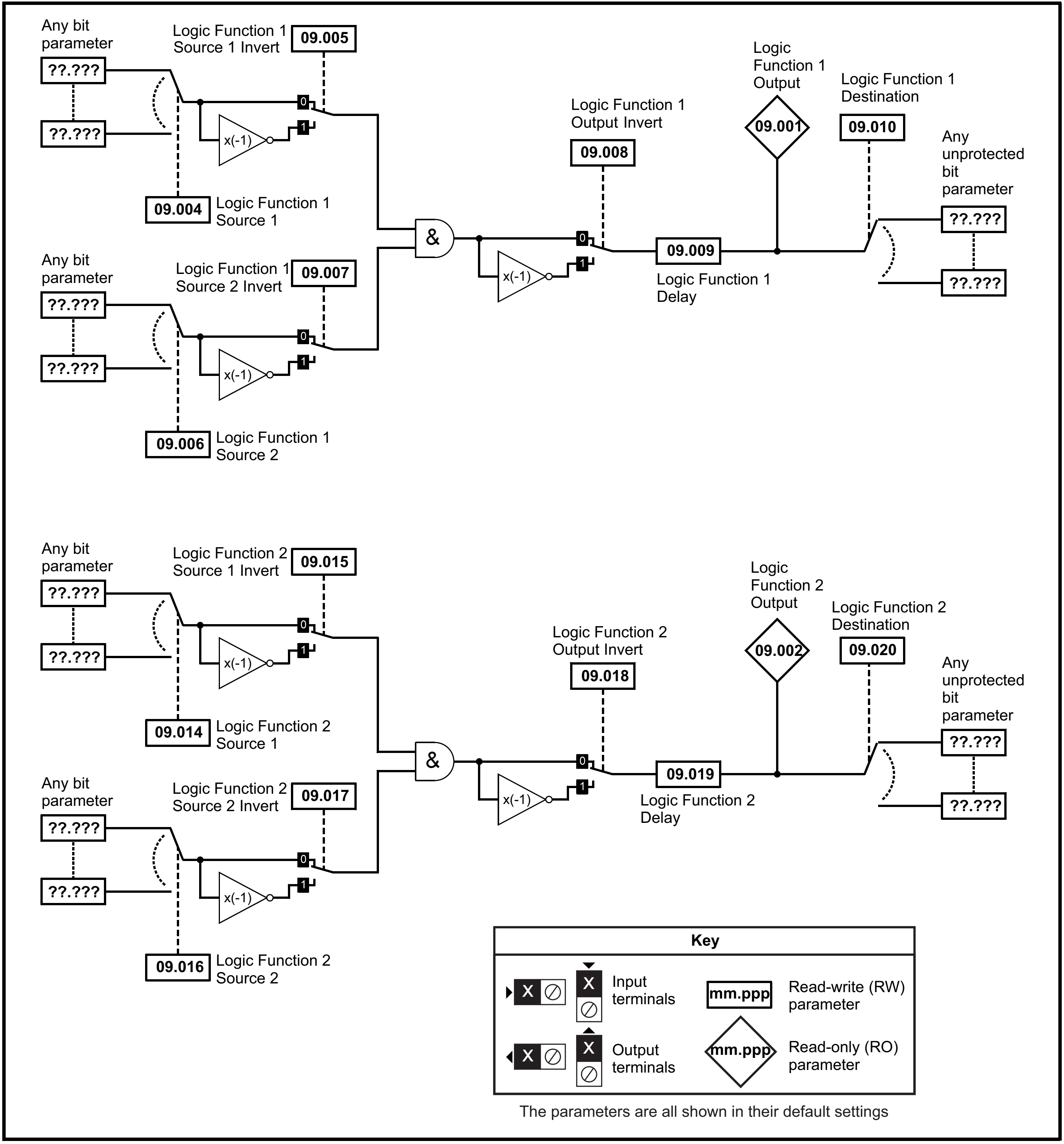
See *Digital I/O Output Enable Register 1* (08.071).

08.073	**Digital I/O Output Register 1**								
RW	Bin						PT		
⇕	0000000000000000 to 1111111111111111			⇨	0000000000000000				

See *Digital I/O Output Enable Register 1* (08.071).

9.9 Menu 9: Programmable logic, motorized pot and binary sum

Figure 9-10 Menu 9 logic diagram: Programmable logic



9.9.1 Logic functions

The logic functions are always active even if the sources and destinations are not routed to valid parameters. If the sources are not valid parameters then the source values are taken as 0. The update rate for each of the logic functions is always 4 ms.

The logic function consists of an AND gate with inverters on each input and an inverter on the output. Some of the other standard logic functions can be produced as shown in the table below.

Logic function	Source 1 Invert	Source 2 Invert	Output Invert
AND	0	0	0
NAND	0	0	1
OR	1	1	1
NOR	1	1	0

A delay function is provided at the output of the logic functions. If *Logic Function 1 Delay* (09.009) or *Logic Function 2 Delay* (09.019) is positive then the output does not become 1 until the input to the delay has been at 1 for the delay time. If *Logic Function 1 Delay* (09.009) or *Logic Function 2 Delay* (09.019) is negative then the output remains at 1 until the input to the delay has been 0 for the delay time.

Figure 9-11 Logic function delay

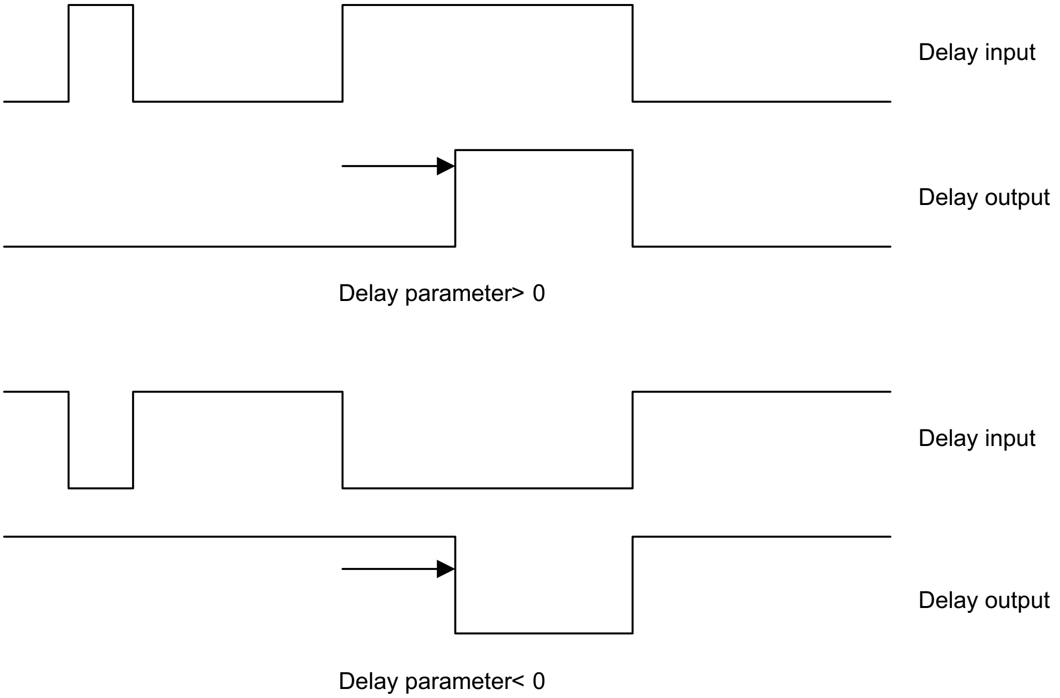
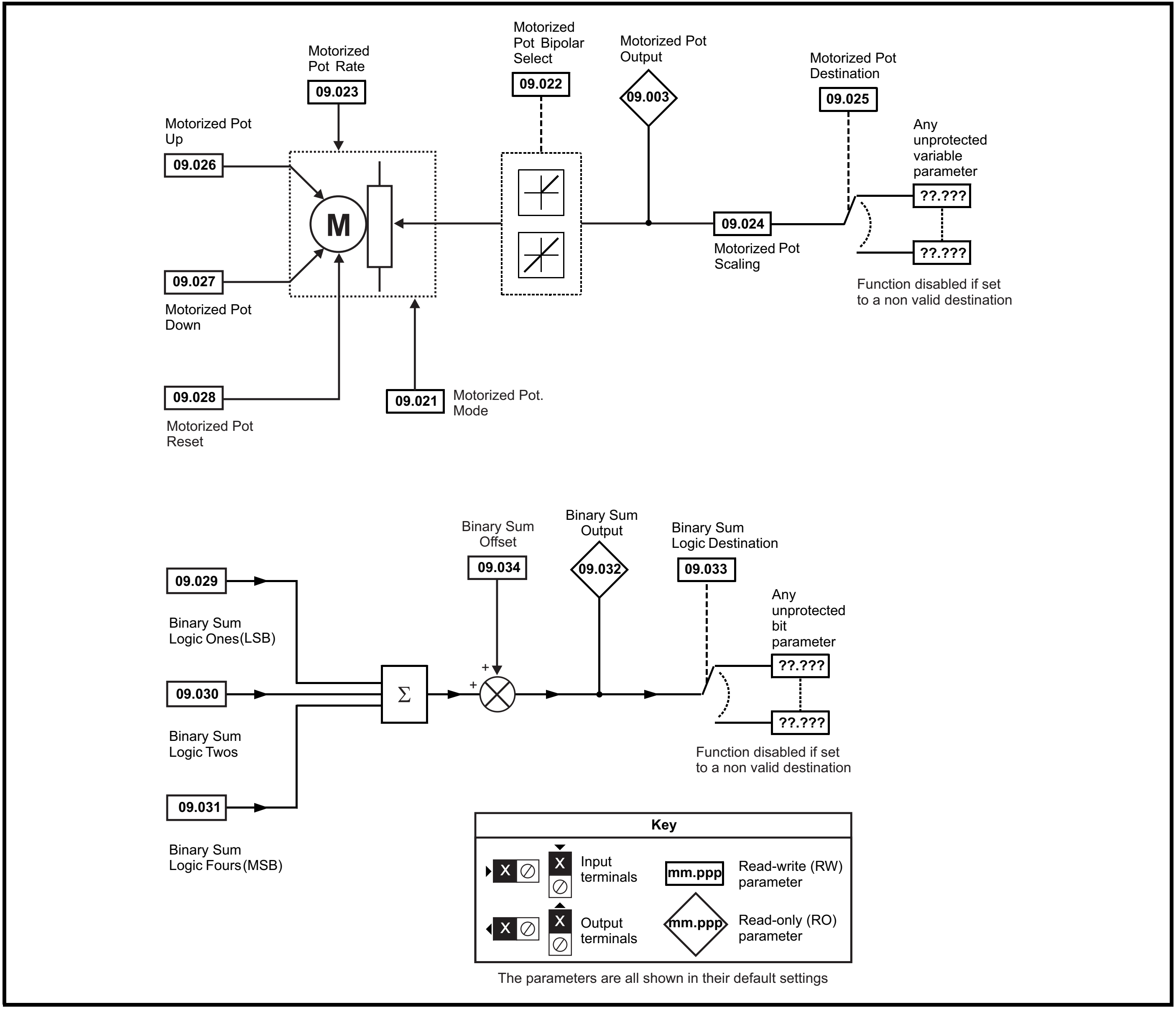


Figure 9-12 Menu 9 logic diagram: Motorized pot and binary sum



9.9.2 Motorised pot

If *Motorised Pot Reset* (09.028) = 1 then the motorised pot is disabled and held in its reset state with *Motorised Pot Output* (09.003) = 0.0 %.
If *Motorised Pot Reset* (09.028) = 0 the motorised pot is enabled even if *Motorised Pot Destination* (09.025) is not routed to a valid parameter.
The sample rate of the motorised pot is always 4 ms.

When the motorised pot is active *Motorised Pot Output* (09.003) can be increased or decreased by setting *Motorised Pot Up* (09.026) or *Motorised Pot Down* (09.027) to 1 respectively. If both *Motorised Pot Up* (09.026) and *Motorised Pot Down* (09.027) are 1 then *Motorised Pot Output* (09.003) is increased. The rate of change of *Motorised Pot Output* (09.003) is defined by *Motorised Pot Rate* (09.023) which gives the time to change from 0 to 100 %. The time to change from -100 % to 100 % is *Motorised Pot Rate* (09.023) x 2. If *Motorised Pot Bipolar Select* (09.022) = 0 then *Motorised Pot Output* (09.003) is limited in the range 0.00 % to 100.00 %, otherwise it is allowed to change in the range from -100.00 % to 100.00 %.

Motorised Pot Mode (09.021) defines the mode of operation as given in the table below.

Motorised Pot Mode **(09.021)**	***Motorised Pot Output*** **(09.003)**	***Motorised Pot Up*** **(09.026) and** ***Motorised Pot Down*** **(09.027) active**
0	Reset to zero at power-up	Always
1	Set to power-down value at power-up	Always
2	Reset to zero at power-up	When *Drive Active* (10.002) = 1
3	Set to power-down value at power-up	When *Drive Active* (10.002) = 1
4	Reset to zero at power-up and when *Drive Active* (10.002) = 0	When *Drive Active* (10.002) = 1

Motorised Pot Scaling (09.024) introduces a scaling factor at the output of the motorised pot before the output is routed to the destination. If *Motorised Pot Scaling* (09.024) *Motorised Pot Scaling* (09.024) > 1.000 the output will exceed the range of the destination parameter, and so the destination parameter will be at its maximum or minimum before the output of the motorised pot reaches the limits of its range.

9.9.3 Binary sum function

The binary sum function is always active even if the destination is not routed to valid a parameter. The update rate for the binary sum is always 4 ms.

The output of the binary sum block is given by:

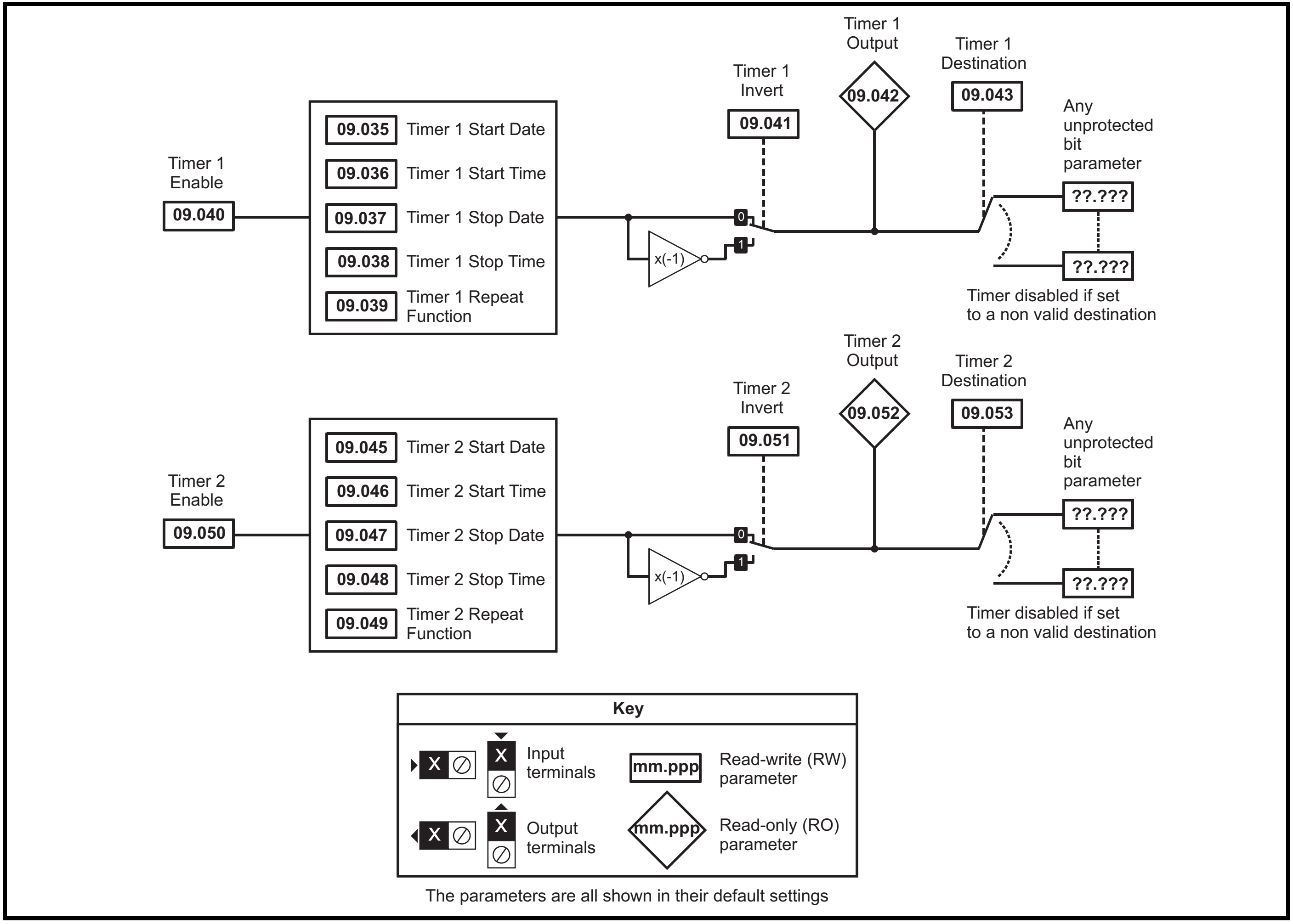
Binary Sum Output (09.032) = *Binary Sum Offset* (09.034) + (*Binary Sum Ones* (09.029) x 1) + (*Binary Sum Twos* (09.030) x 2) + (*Binary Sum Fours* (09.031) x 4)

Binary Sum Destination (09.033) defines the destination for the binary sum output. The routing for this destination is special if the maximum of the destination parameter = 7 + *Binary Sum Offset* (09.034) as follows:

Destination parameter = *Binary Sum Output* (09.032), subject to the parameter minimum.

If the maximum of the destination parameter > 7, *Binary Sum Output* (09.032) is routed in the same way as any other destination where the destination target is at its full scale value when the *Binary Sum Output* (09.032) = 7 + *Binary Sum Offset* (09.034).

Figure 9-13 Menu 9 logic diagram: Timers



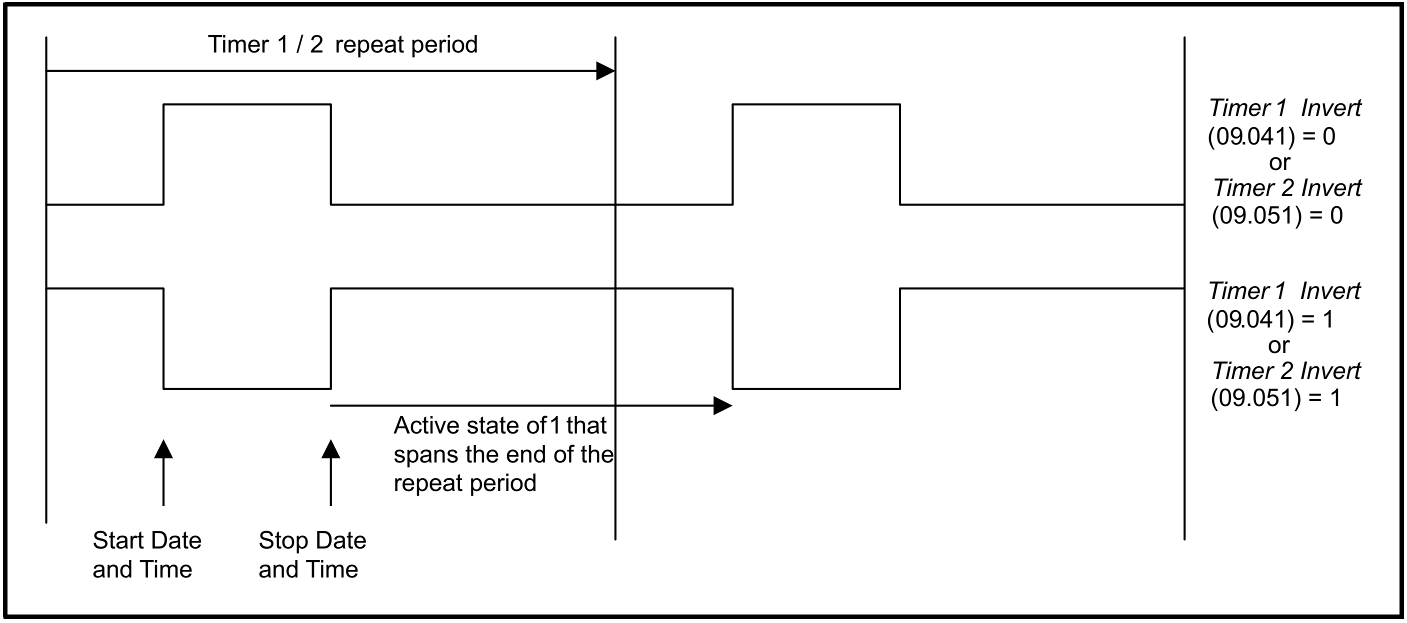
The parameters are all shown in their default settings

9.9.4 Timers

If the enable input to a timer is active and the repeat function is set to a non-zero value then the timer is active even if the destination is not routed to valid a parameter. The timers are updated in the background task and have a resolution of 1 s.

The following is a description of Timer 1, but Timer 2 behaves in the same way. If *Timer 1 Invert* (09.041) = 0 then *Timer 1 Output* (09.042) is inactive before the *Timer 1 Start Date* (09.035) / *Timer 1 Start Time* (09.036), active between this date/time and *Timer 1 Stop Date* (09.037) / *Timer 1 Stop Time* (09.038) and then inactive after the stop time/date within the timer 1 repeat period as shown in the diagram below.

Figure 9-14 Timer 1 and 2 output



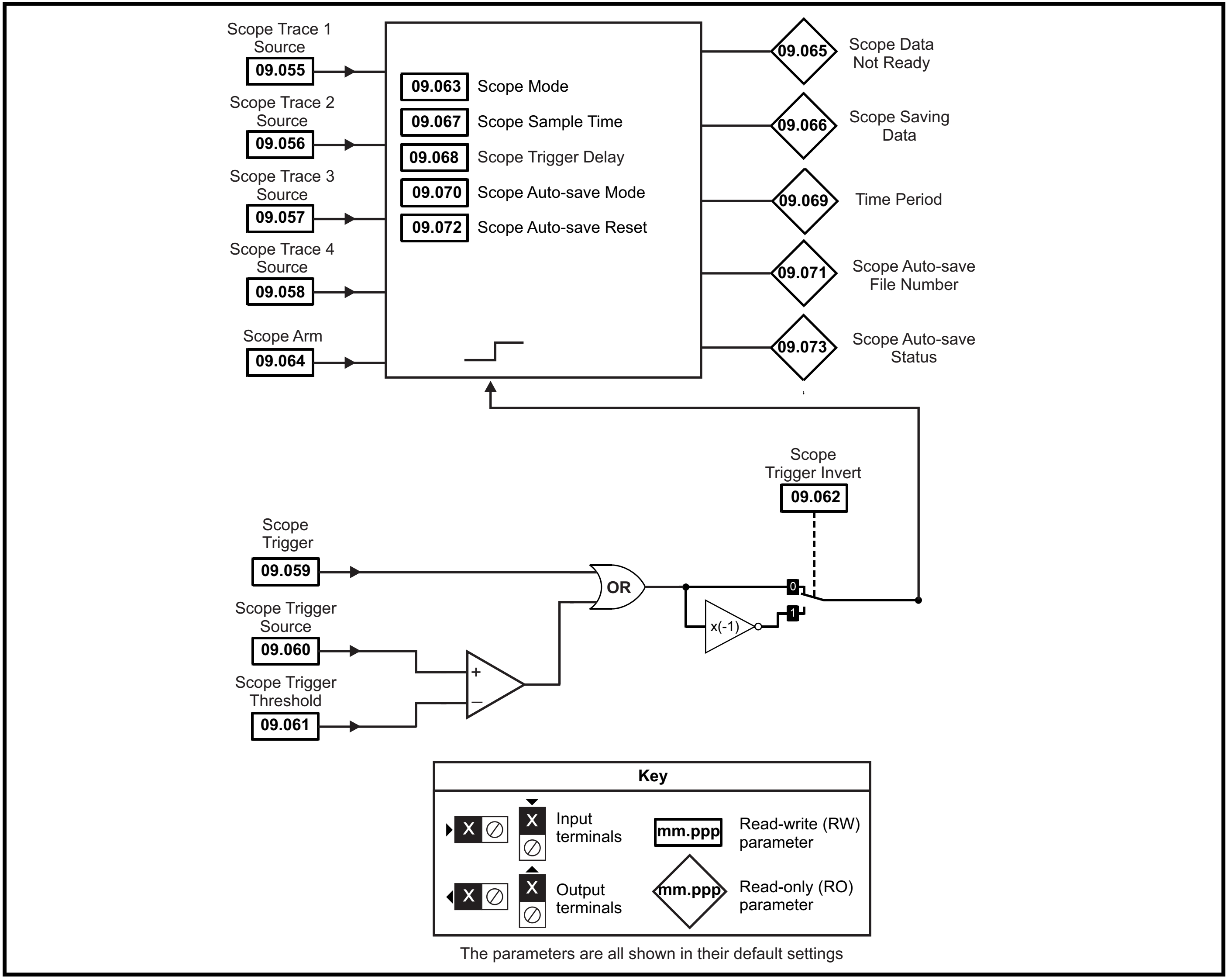
Timer 1 Repeat Function (09.039) defines the length of the repeat period. For example, if *Timer 1 Repeat Function* (09.039) = 2 then the repeat period is one day. The output is inactive until the time reaches the hour, minute and second defined in *Timer 1 Start Time* (09.036), and remains active until the time reaches the hour, minute and second defined in *Timer 1 Stop Time* (09.038). Different repeat periods may be selected as given in the table below. The table shows the constituent parts of the date and time that are used to determine the start and stop events. If the repeat period is set to every week then *Timer 1 Start Date* (09.035) and *Timer 1 Stop Date* (09.037) define the day of the week and not the date (i.e. 00.00.00 = Sunday, 00.00.01 = Monday, etc.). If the stop time event is set to occur at or before the start time event or the *Timer 1 Repeat Function* (09.039) = 0 or *Timer 1 Enable* (09.040) = 0 the output remains inactive at all times (i.e. *Timer 1 Output* (09.042) = 0 if *Timer 1 Invert* (09.041) = 0)

***Timer 1 Repeat Function* (09.039)**	**Repeat period**	**Second**	**Minute**	**Hour**	**Day**	**Month**	**Year**	**Day of week**
0	None							
1	Hour	•	•					
2	Day	•	•	•				
3	Week	•	•	•				•
4	Month	•	•	•	•			
5	Year	•	•	•	•	•		
6	One off	•	•	•	•	•	•	
7	Minute	•						

As *Timer 1 Invert* (09.041) inverts the timer output it can be used to give an active state of 0 instead of 1. Alternatively it can be used to give an active state of 1, but for a time period that spans the ends of the repeat period as shown in the example above. It should be noted that if this method is used to allow the active period to span the ends of the repeat period then if the timer is disabled the output of the timer block before the invert becomes 0, and so the final output of the timer after the invert is 1.

If *Date/Time Selector* (06.019) is changed and the drive is reset then the source for the timers will change, therefore *Timer 1 Repeat Function* (09.039) and *Timer 2 Repeat Function* (09.049) are reset to 0 to disable the timers, and the date and time entries in the trip log are cleared.

Figure 9-15 Menu 9 logic diagram: Scope function



Menu 9 contains 2 logic block functions (which can be used to produce any type of 2 input logic gate, with or without a delay), a motorized pot function and a binary sum block. One menu 9 or one menu 12 function is executed every 4 ms. Therefore the sample time of these functions is 4 ms x number of menu 9 and 12 functions active. The logic functions are always active even if the sources and destinations are not routed to valid parameters. If the sources are not valid parameters then the source values are taken as 0.

Table 9-12 Menu 9 Regen parameter descriptions

Parameter		Range(⇳)	Default(⇨)	Type					
09.001	Logic Function 1 Output	Off (0) or On (1)		RO	Bit	ND	NC	PT	
09.002	Logic Function 2 Output	Off (0) or On (1)		RO	Bit	ND	NC	PT	
09.003	Motorized Pot Output	±100.00 %		RO	Num	ND	NC	PT	PS
09.004	Logic Function 1 Source 1	0.000 to 59.999	0.000	RW	DE			PT	US
09.005	Logic Function 1 Source 1 Invert	Off (0) or On (1)	Off (0)	RW	Bit				US
09.006	Logic Function 1 Source 2	0.000 to 59.999	0.000	RW	DE			PT	US
09.007	Logic Function 1 Source 2 Invert	Off (0) or On (1)	Off (0)	RW	Bit				US
09.008	Logic Function 1 Output Invert	Off (0) or On (1)	Off (0)	RW	Bit				US
09.009	Logic Function 1 Delay	±25.0 s	0.0 s	RW	Num				US
09.010	Logic Function 1 Destination	0.000 to 59.999	0.000	RW	DE			PT	US
09.014	Logic Function 2 Source 1	0.000 to 59.999	0.000	RW	Num			PT	US
09.015	Logic Function 2 Source 1 Invert	Off (0) or On (1)	Off (0)	RW	Bit				US
09.016	Logic Function 2 Source 2	0.000 to 59.999	0.000	RW	Num			PT	US
09.017	Logic Function 2 Source 2 Invert	Off (0) or On (1)	Off (0)	RW	Bit				US
09.018	Logic Function 2 Output Invert	Off (0) or On (1)	Off (0)	RW	Bit				US
09.019	Logic Function 2 Delay	±25.0 s	0.0 s	RW	Num				US
09.020	Logic Function 2 Destination	0.000 to 59.999	0.000	RW	DE			PT	US
09.021	Motorized Pot Mode	0 to 4	0	RW	Num				US
09.022	Motorized Pot Bipolar Select	Off (0) or On (1)	Off (0)	RW	Bit				US
09.023	Motorized Pot Rate	0 to 250 s	20 s	RW	Num				US
09.024	Motorized Pot Scaling	0.000 to 4.000	1.000	RW	Num				US
09.025	Motorized Pot Destination	0.000 to 59.999	0.000	RW	DE			PT	US
09.026	Motorized Pot Up	Off (0) or On (1)	Off (0)	RW	Bit		NC		
09.027	Motorized Pot Down	Off (0) or On (1)	Off (0)	RW	Bit		NC		
09.028	Motorized Pot Reset	Off (0) or On (1)	Off (0)	RW	Bit		NC		
09.029	Binary Sum Ones	Off (0) or On (1)	Off (0)	RW	Bit		NC		
09.030	Binary Sum Twos	Off (0) or On (1)	Off (0)	RW	Bit		NC		
09.031	Binary Sum Fours	Off (0) or On (1)	Off (0)	RW	Bit		NC		
09.032	Binary Sum Output	0 to 255		RO	Num	ND	NC	PT	
09.033	Binary Sum Destination	0.000 to 59.999	0.000	RW	DE			PT	US
09.034	Binary Sum Offset	0 to 248	0	RW	Num				US
09.035	Timer 1 Start Date	00-00-00 to 31-12-99	00-00-00	RW	Date				US
09.036	Timer 1 Start Time	00:00:00 to 23:59:59	00:00:00	RW	Time				US
09.037	Timer 1 Stop Date	00-00-00 to 31-12-99	00-00-00	RW	Date				US
09.038	Timer 1 Stop Time	00:00:00 to 23:59:59	00:00:00	RW	Time				US
09.039	Timer 1 Repeat Function	None (0), Hour (1), Day (2), Week (3), Month (4), Year (5), One off (6), Minute (7)	None (0)	RW	Txt				US
09.040	Timer 1 Enable	Off (0) or On (1)	Off (0)	RW	Bit				US
09.041	Timer 1 Invert	Off (0) or On (1)	Off (0)	RW	Bit				US
09.042	Timer 1 Output	Off (0) or On (1)		RO	Bit	ND	NC	PT	
09.043	Timer 1 Destination	0.000 to 59.999	0.000	RW	DE			PT	US
09.045	Timer 2 Start Date	00-00-00 to 31-12-99	00-00-00	RW	Date				US
09.046	Timer 2 Start Time	00:00:00 to 23:59:59	00:00:00	RW	Time				US
09.047	Timer 2 Stop Date	00-00-00 to 31-12-99	00-00-00	RW	Date				US
09.048	Timer 2 Stop Time	00:00:00 to 23:59:59	00:00:00	RW	Time				US
09.049	Timer 2 Repeat Function	None (0), Hour (1), Day (2), Week (3), Month (4), Year (5), One off (6), Minute (7)	None (0)	RW	Txt				US
09.050	Timer 2 Enable	Off (0) or On (1)	Off (0)	RW	Bit				US
09.051	Timer 2 Invert	Off (0) or On (1)	Off (0)	RW	Bit				US
09.052	Timer 2 Output	Off (0) or On (1)		RO	Bit	ND	NC	PT	
09.053	Timer 2 Destination	0.000 to 59.999	0.000	RW	DE			PT	US
09.055	Scope Trace 1 Source	0.000 to 59.999	0.000	RW	Num			PT	US
09.056	Scope Trace 2 Source	0.000 to 59.999	0.000	RW	Num			PT	US
09.057	Scope Trace 3 Source	0.000 to 59.999	0.000	RW	Num			PT	US
09.058	Scope Trace 4 Source	0.000 to 59.999	0.000	RW	Num			PT	US
09.059	Scope Trigger	Off (0) or On (1)	Off (0)	RW	Bit				
09.060	Scope Trigger Source	0.000 to 59.999	0.000	RW	Num			PT	US

Parameter		**Range(⇕)**	**Default(⇨)**	**Type**					
09.061	Scope Trigger Threshold	-2147483648 to 2147483647	0	RW	Num				US
09.062	Scope Trigger Invert	Off (0) or On (1)	Off (0)	RW	Bit				US
09.063	Scope Mode	Single (0), Normal (1), Auto (2)	Single (0)	RW	Txt				US
09.064	Scope Arm	Off (0) or On (1)	Off (0)	RW	Bit		NC		
09.065	Scope Data Not Ready	Off (0) or On (1)		RO	Bit	ND	NC	PT	
09.066	Scope Saving Data	Off (0) or On (1)		RO	Bit	ND	NC	PT	
09.067	Scope Sample Time	1 to 200	1	RW	Num				US
09.068	Scope Trigger Delay	0 to 100 %	0 %	RW	Num				US
09.069	Scope Time Period	0.00 to 200000.00 ms		RO	Num	ND	NC	PT	
09.070	Scope Auto-save Mode	Disabled (0), Overwrite (1), Keep (2)	Disabled (0)	RW	Txt				US
09.071	Scope Auto-save File Number	0 to 99	0	RO	Num				PS
09.072	Scope Auto-save Reset	Off (0) or On (1)	Off (0)	RW	Bit				
09.073	Scope Auto-save Status	Disabled (0), Active (1), Stopped (2), Failed (3)	Disabled (0)	RO	Txt				PS

RW	Read / Write	RO	Read only	Num	Number parameter	Bit	Bit parameter	Txt	Text string	Bin	Binary parameter	FI	Filtered
ND	No default value	NC	Not copied	PT	Protected parameter	RA	Rating dependent	US	User save	PS	Power-down save	DE	Destination
IP	IP address	Mac	Mac address	Date	Date parameter	Time	Time parameter	SMP	Slot,menu,parameter	Chr	Character parameter	Ver	Version number

09.001		**Logic Function 1 Output**							
RO	Bit				ND	NC	PT		
⇕	Off (0) or On (1)				⇨				

Logic Function 1 Output (09.001) shows the output of logic function 1.

09.002		**Logic Function 2 Output**							
RO	Bit				ND	NC	PT		
⇕	Off (0) or On (1)				⇨				

Logic Function 2 Output (09.002) shows the output of logic function 2.

09.003		**Motorized Pot Output**							
RO	Num				ND	NC	PT		PS
⇕	±100.00 %				⇨				

Motorised Pot Output (09.003) shows the output of the motorised pot function.

09.004		**Logic Function 1 Source 1**							
RW	DE						PT		US
⇕	0.000 to 59.999				⇨	0.000			

Logic Function 1 Source 1 (09.004) defines input source 1 of logic function 1.

09.005		**Logic Function 1 Source 1 Invert**							
RW	Bit								US
⇕	Off (0) or On (1)				⇨	Off (0)			

Setting *Logic Function 1 Source 1 Invert* (09.005) inverts input 1 of logic function 1.

09.006		**Logic Function 1 Source 2**							
RW	DE						PT		US
⇕	0.000 to 59.999				⇨	0.000			

Logic Function 1 Source 2 (09.006) defines input source 2 of logic function 1.

09.007	**Logic Function 1 Source 2 Invert**								
RW	Bit								US
⇳	Off (0) or On (1)	⇨	Off (0)						

Setting *Logic Function 1 Source 2 Invert* (09.007) inverts input 2 of logic function 1.

09.008	**Logic Function 1 Output Invert**								
RW	Bit								US
⇳	Off (0) or On (1)	⇨	Off (0)						

Setting *Logic Function 1 Output Invert* (09.008) inverts the output of logic function 1.

09.009	**Logic Function 1 Delay**								
RW	Num								US
⇳	±25.0 s	⇨	0.0 s						

Logic Function 1 Delay (09.009) defines the delay at the output of logic function 1. If *Logic Function 1 Delay* (09.009) is positive then the output does not become 1 until the input to the delay has been at 1 for the delay time. If *Logic Function 1 Delay* (09.009) is negative then the output remains at 1 until the input to the delay has been 0 for the delay time. See Figure 9-11 *Logic function delay* on page 206.

09.010	**Logic Function 1 Destination**								
RW	DE						PT		US
⇳	0.000 to 59.999	⇨	0.000						

Logic Function 1 Destination (09.010) defines the output destination of logic function 1.

09.014	**Logic Function 2 Source**								
RW	Num						PT		US
⇳	0.000 to 59.999	⇨	0.000						

Logic Function 2 Source 1 (09.014) defines input source 1 of logic function 2.

09.015	**Logic Function 2 Source 1 Invert**								
RW	Bit								US
⇳	Off (0) or On (1)	⇨	Off (0)						

Setting *Logic Function 2 Source 1 Invert* (09.015) inverts input 1 of logic function 2.

09.016	**Logic Function 2 Source 2**								
RW	Bit						PT		US
⇳	0.000 to 59.999	⇨	0.000						

Logic Function 2 Source 2 (09.016) defines input source 2 of logic function 2.

09.017	**Logic Function 2 Source 2 Invert**								
RW	Bit								US
⇳	Off (0) or On (1)	⇨	Off (0)						

Setting *Logic Function 2 Source 2 Invert* (09.017) inverts input 2 of logic function 2.

09.018	**Logic Function 2 Output Invert**								
RW	Bit								US
⇳	Off (0) or On (1)	⇨	Off (0)						

Setting *Logic Function 2 Output Invert* (09.018) inverts the output of logic function 2.

09.019	**Logic Function 2 Delay**								
RW	Num								US
⇕	±25.0 s				⇨	0.0 s			

Logic Function 2 Delay (09.019) defines the delay at the output of logic function 2. If *Logic Function 2 Delay* (09.019) is positive then the output does not become 1 until the input to the delay has been at 1 for the delay time. If *Logic Function 2 Delay* (09.019) is negative then the output remains at 1 until the input to the delay has been 0 for the delay time. Figure 9-11 *Logic function delay* on page 206.

09.020	**Logic Function 2 Destination**								
RW	DE						PT		US
⇕	0.000 to 59.999				⇨	0.000			

Logic Function 2 Destination (09.020) defines the output destination of logic function 2.

09.021	**Motorized Pot Mode**								
RW	Num								US
⇕	0 to 4				⇨	0			

Motorised Pot Mode (09.021) defines the mode of operation as given in the table below.

***Motorised Pot Mode* (09.021)**	***Motorised Pot Output* (09.003)**	***Motorised Pot Up* (09.026) and *Motorised Pot Down* (09.027) active**
0	Reset to zero at power-up	Always
1	Set to power-down value at power-up	Always
2	Reset to zero at power-up	When *Drive Active* (10.002) = 1
3	Set to power-down value at power-up	When *Drive Active* (10.002) = 1
4	Reset to zero at power-up and when *Drive Active* (10.002) = 0	When *Drive Active* (10.002) = 1

09.022	**Motorized Pot Bipolar Series**								
RW	Bit								US
⇕	Off (0) or On (1)				⇨	Off (0)			

If *Motorised Pot Bipolar Select* (09.022) = 0 then *Motorised Pot Output* (09.003) is limited in the range 0.00 % to 100.00 %, otherwise it is allowed to change in the range from -100.00 % to 100.00 %.

09.023	**Motorized Pot Rate**								
RW	Num								US
⇕	0 to 250 s				⇨	20 s			

The rate of change of *Motorised Pot Output* (09.003) is defined by *Motorised Pot Rate* (09.023) which gives the time to change from 0 to 100 %. The time to change from -100 % to 100 % is *Motorised Pot Rate* (09.023) x 2.

09.024	**Motorized Pot Scaling**								
RW	Num								US
⇕	0.000 to 4.000				⇨	1.000			

Motorised Pot Scaling (09.024) introduces a scaling factor at the output of the motorised pot before the output is routed to the destination. If *Motorised Pot Scaling* (09.024) *Motorised Pot Scaling* (09.024) > 1.000 the output will exceed the range of the destination parameter, and so the destination parameter will be at its maximum or minimum before the output of the motorised pot reaches the limits of its range.

09.025	**Motorized Pot Destination**								
RW	DE						PT		US
⇕	0.000 to 59.999				⇨	0.000			

Logic Function 2 Destination (09.020) defines the output destination of the motorised pot function.

09.026	**Motorized Pot Up**								
RW	Bit					NC			
⇕	Off (0) or On (1)				⇨	Off (0)			

If *Motorised Pot Up* (09.026) = 1, then the *Motorised Pot Output* (09.003) will increase.

09.027		**Motorized Pot Down**							
RW	Bit					NC			
⇕	Off (0) or On (1)				⇨	Off (0)			

If *Motorised Pot Down* (09.027) = 1, then the *Motorised Pot Output* (09.003) will decrease.

09.028		**Motorized Pot Reset**							
RW	Bit					NC			
⇕	Off (0) or On (1)				⇨	Off (0)			

If *Motorised Pot Reset* (09.028) = 1 then the motorised pot is disabled and held in its reset state with *Motorised Pot Output* (09.003) = 0.0 %.
If *Motorised Pot Reset* (09.028) = 0 the motorised pot is enabled even if *Motorised Pot Destination* (09.025) is not routed to a valid parameter.

09.029		**Binary Sum Ones**							
RW	Bit					NC			
⇕	Off (0) or On (1)				⇨	Off (0)			

09.030		**Binary Sum Twos**							
RW	Bit					NC			
⇕	Off (0) or On (1)				⇨	Off (0)			

09.031		**Binary Sum Fours**							
RW	Bit					NC			
⇕	Off (0) or On (1)				⇨	Off (0)			

09.032		**Binary Sum Output**							
RO	Num				ND	NC	PT		
⇕	0 to 255				⇨				

The output of the binary sum block is given by:

Binary Sum Output (09.032) = *Binary Sum Offset* (09.034) + (*Binary Sum One*s (09.029) x 1) + (*Binary Sum Twos* (09.030) x 2) + (*Binary Sum Fours* (09.031) x 4).

Binary Sum Destination (09.033) defines the destination for the binary sum output. The routing for this destination is special if the maximum of the destination parameter ≤ 7 + *Binary Sum Offset* (09.034) as follows:

Destination parameter = *Binary Sum Output* (09.032), subject to the parameter minimum.

If the maximum of the destination parameter > 7, *Binary Sum Output* (09.032) is routed in the same way as any other destination where the destination target is at its full scale value when the *Binary Sum Output* (09.032) = 7 + *Binary Sum Offset* (09.034).

09.033		**Binary Sum Destination**							
RW	DE						PT		US
⇕	0.000 to 59.999				⇨	0.000			

Binary Sum Destination (09.033) defines the destination for the binary sum output.

09.034		**Binary Sum Offset**							
RW	Num								US
⇕	0 to 248				⇨	0			

09.035		**Timer 1 Start Date**							
RW	Date								US
⇕	00-00-00 to 31-12-99				⇨	00-00-00			

Timer 1 Start Date (09.035) defines the start date within the repeat period of timer 1.

09.036	**Timer 1 Start Time**								
RW	Time								US
⇕	00:00:00 to 23:59:59				⇨	00:00:00			

Timer 1 Start Time (09.036) defines the start time within the repeat period of timer 1.

09.037	**Timer 1 Stop Date**								
RW	Date								US
⇕	00-00-00 to 31-12-99				⇨	00-00-00			

Timer 1 Stop Date (09.037) defines the stop date within the repeat period of timer 1.

09.038	**Timer 1 Stop Time**								
RW	Time								US
⇕	00:00:00 to 23:59:59				⇨	00:00:00			

Timer 1 Stop Time (09.038) defines the stop time within the repeat period of timer 1.

09.039	**Timer 1 Repeat Function**								
RW	Txt								US
⇕	None (0), Hour (1), Day (2), Week (3), Month (4), Year (5), One off (6), Minute (7)				⇨	None (0)			

Value	Text
0	None
1	Hour
2	Day
3	Week
4	Month
5	Year
6	One off
7	Minute

Timer 1 Repeat Function (09.039) defines the length of the repeat period. For example, if *Timer 1 Repeat Function* (09.039) = 2 then the repeat period is one day. The output is inactive until the time reaches the hour, minute and second defined in *Timer 1 Start Time* (09.036), and remains active until the time reaches the hour, minute and second defined in *Timer 1 Stop Time* (09.038). Different repeat periods may be selected as given in the table below.

The table shows the constituent parts of the date and time that are used to determine the start and stop events. If the repeat period is set to every week then *Timer 1 Start Date* (09.035) and *Timer 1 Stop Date* (09.037) define the day of the week and not the date (i.e. 00.00.00 = Sunday, 00.00.01 =Monday, etc.). If the stop time event is set to occur at or before the start time event or the *Timer 1 Repeat Function* (09.039) = 0 or *Timer 1 Enable* (09.040) = 0 the output remains inactive at all times (i.e. *Timer 1 Output* (09.042) = 0 if *Timer 1 Invert* (09.041) = 0).

Timer 1 Repeat Function **(09.039)**	Repeat period	Second	Minute	Hour	Day	Month	Year	Day of week
0	None							
1	Hour	•	•					
2	Day	•	•	•				
3	Week	•	•	•				•
4	Month	•	•	•	•			
5	Year	•	•	•	•	•		
6	One off	•	•	•	•	•	•	
7	Minute	•						

09.040	**Timer 1 Enable**								
RW	Bit								US
⇕	Off (0) or On (1)				⇨	Off (0)			

Timer 1 Enable (09.040) enables the timer 1 function. If *Timer 1 Enable* (09.040) = 0, then the output of the timer is always inactive, i.e. *Timer 1 Output* (09.042) = 0.

09.041	**Timer 1 Invert**								
RW	Bit								US
⇕	Off (0) or On (1)	⇨	Off (0)						

Timer 1 Invert (09.041) inverts the timer output to give an active state of 0 instead of 1. Alternatively it can be used to give an active state of 1, but for a time period that spans the ends of the repeat period as shown in the example above. It should be noted that if this method is used to allow the active period to span the ends of the repeat period then if the timer is disabled the output of the timer block before the invert becomes 0, and so the final output of the timer after the invert is 1.

09.042	**Timer 1 Output**								
RW	Bit				ND	NC	PT		US
⇕	Off (0) or On (1)	⇨							

Timer 1 Output (09.042) shows the output of timer function 1.

09.043	**Timer 1 Destination**								
RW	DE						PT		US
⇕	0.000 to 59.999	⇨	0.000						

Timer 1 Destination (09.043) defines the output destination of timer function 1.

09.045	**Timer 2 Start Date**								
RW	Date								US
⇕	00-00-00 to 31-12-99	⇨	00-00-00						

Timer 2 Start Date (09.045) defines the start date within the repeat period of timer 2.

09.046	**Timer 2 Start Time**								
RW	Time								US
⇕	00:00:00 to 23:59:59	⇨	00:00:00						

Timer 2 Start Time (09.046) defines the start time within the repeat period of timer 2.

09.047	**Timer 2 Stop Date**								
RW	Date								US
⇕	00-00-00 to 31-12-99	⇨	00-00-00						

Timer 2 Stop Date (09.047) defines the stop date within the repeat period of timer 2.

09.048	**Timer 2 Stop Time**								
RW	Time								US
⇕	00:00:00 to 23:59:59	⇨	00:00:00						

Timer 2 Stop Time (09.048) defines the stop time within the repeat period of timer 2.

09.049	**Timer 2 Repeat Function**								
RW	Txt								US
⇕	None (0), Hour (1), Day (2), Week (3), Month (4), Year (5), One off (6), Minute (7)	⇨	None (0)						

Value	**Text**
0	None
1	Hour
2	Day
3	Week
4	Month
5	Year
6	One off
7	Minute

09.050		**Timer 2 Enable**							
RW	Bit								US
⇕	Off (0) or On (1)				⇨	Off (0)			

Timer 2 Enable (09.050) enables the timer 2 function. If *Timer 2 Enable* (09.050) = 0, then the output of the timer is always inactive, i.e. T*imer 2 Output* (09.052) = 0.

09.051		**Timer 2 Invert**							
RW	Bit								US
⇕	Off (0) or On (1)				⇨	Off (0)			

Timer 2 Invert (09.051) inverts the timer output to give an active state of 0 instead of 1.

09.052		**Timer 2 Output**							
RO	Bit				ND	NC	PT		US
⇕	Off (0) or On (1)				⇨				

Timer 2 Output (09.052) shows the output of timer function 2.

09.053		**Timer 2 Destination**							
RW	Bit								US
⇕	0.000 to 59.999				⇨	0.000			

Timer 2 Destination (09.053) defines the output destination of timer function 2.

09.055		**Scope Trace 1 Source**							
RW	Num						PT		US
⇕	0.000 to 59.999				⇨	0.000			

Up to four scope sources can be selected using *Scope Trace 1 Source* (09.055) to *Scope Trace 4 Source* (09.058). If the source value is set to 0.000, or the source parameter does not exist or is non-visible, then no source is selected. The sources do not operate in the same way as normal source parameters in that the input to the scope is the actual value of the parameter and not a value scaled to a percentage based on the range of the parameter. If a scope trace source parameter is modified the actual change is not effective until the drive is reset.

09.056		**Scope Trace 2 Source**							
RW	Num						PT		US
⇕	0.000 to 59.999				⇨	0.000			

09.057		**Scope Trace 3 Source**							
RW	Num						PT		US
⇕	0.000 to 59.999				⇨	0.000			

09.058		**Scope Trace 4 Source**							
RW	Num						PT		US
⇕	0.000 to 59.999				⇨	0.000			

09.059		**Scope Trigger**							
RW	Bit								
⇕	Off (0) or On (1)				⇨	Off (0)			

The scope is triggered by a rising edge at the input to the main scope block. If *Scope Trigger Source* (09.060) is set at its default value of 0.000 then the output of the trigger threshold comparator is 0, and so the scope can be triggered with *Scope Trigger* (09.059). *Scope Trigger Invert* (09.062) can be used to invert the trigger signal.

09.060		**Scope Trigger Source**							
RW	Num						PT		US
⇕	0.000 to 59.999				⇨	0.000			

If *Scope Trigger* (09.059) = 0, the scope can be triggered based on the level of a parameter defined by *Scope Trigger Source* (09.060) and the *Scope Trigger Threshold* (09.061). This source operates in the same way as the trace sources and a direct comparison is made between the actual parameter value and the threshold. Decimal places are ignored. The threshold detector output is 1 when the value from the scope trigger source is greater than *Scope Trigger Threshold* (09.061). If *Scope Trigger Source* (09.060) = 0.000, or it is used to select a parameter that does not exist or is non-visible, then the output of the threshold detector is 0.

09.061	**Scope Trigger Threshold**								
RW	Num								US
⇳	-2147483648 to 2147483647	⇨	0						

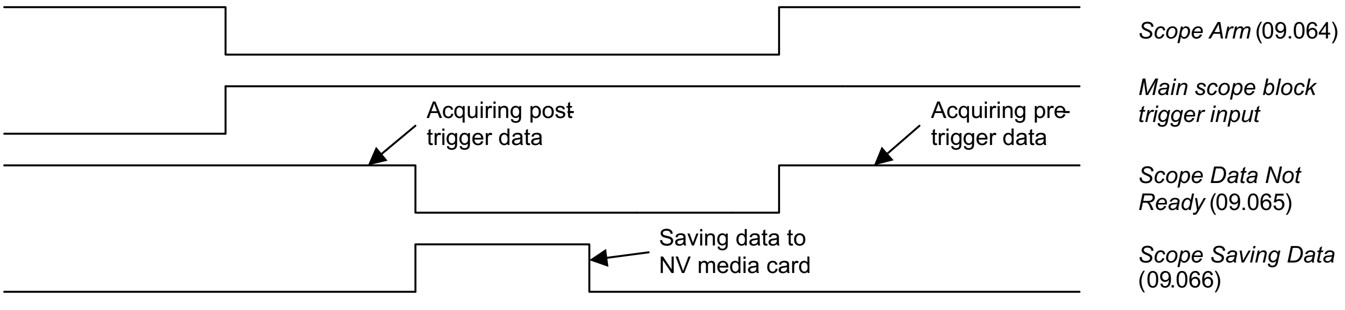
09.062	**Scope Trigger Invert**								
RW	Bit								US
⇳	Off (0) or On (1)	⇨	Off (0)						

09.063	**Scope Mode**								
RW	Txt								US
⇳	Single (0), Normal (1), Auto (2)	⇨	Single (0)						

Value	Text
0	Single
1	Normal
2	Auto

Single (0):

If *Scope Arm* (09.064) is set to 1 the scope starts to acquire pre-trigger data (i.e. enough data to provide information for the pre-trigger period) and *Scope Data Not Ready* (09.065) is set to 1. The scope can then be triggered on the next trigger event (i.e. a rising edge on the trigger input of the main scope block). Note that the scope can only be triggered once the required amount of pre-trigger data has been sampled. Failure to do this will result in the scope function not triggering correctly. When the trigger event occurs *Scope Arm* (09.064) is set to 0, and when the post-trigger data has been stored *Scope Data Not Ready* (09.065) is set to 0. If *Scope Auto-save Mode* (09.070) is non-zero, the data in the scope trace buffer is saved to a non-volatile media card fitted in the drive. When the save is complete (or data cannot be saved, i.e. no card fitted or no space left) the scope is ready again to receive data. If *Scope Arm* (09.064) is set to 1 the scope will start to acquire data again.



Scope trigger with *Scope Mode* (09.063) = Single (0) and *Scope Auto-save Mode* (09.070) > 0

It is possible to read scope files via comms or into an option module. However, scope file transfer can only be initiated when *Scope Arm* (09.064) = 0, *Scope Data Not Ready* (09.065) = 0, *Scope Saving Data* (09.066) = 0 and at least one trace has been set up. While the file transfer is in progress *Scope Saving Data* (09.066) is set to 1.

The scope system is reset under any of the following conditions:

1. At power-up.
2. If the drive is reset when *Scope Trace 1 Source* (09.055) to *Scope Trace 4 Source* (09.058) have been modified.
3. The drive mode is changed.
4. If *Scope Mode* (09.063), *Scope Sample Time* (09.067) or *Scope Trigger Delay* (09.068) are modified.

When the scope is reset *Scope Arm* (09.064) is reset to 0 and the trace data is all cleared to 0.

Normal (1):

The scope operates in the same way as single mode except that *Scope Arm* (09.064) is automatically set back to 1 after a time delay of 1s once the post-trigger data has been acquired, and the scope data has been saved to a non-volatile media card if *Scope Auto-save Mode* (09.070) > 0.

Auto (2):

After the scope system is reset *Scope Data Not Ready* (09.065) is set to 1 and the scope begins to acquire data. Once the buffer is full *Scope Data Not Ready* (09.065) is set to 0 and the scope continues to acquire data. *Scope Arm* (09.064) has no effect on data acquisition. Provided *Scope Data Not Ready* (09.065) = 0 and *Scope Saving Data* (09.066) = 0 it is possible to read the data from the scope buffer as a scope file. Data acquisition is stopped when the file transfer begins. When the file transfer is complete, data acquisition begins again and *Scope Data Not Ready* (09.065) is set to 1 for a period that is long enough to fill the scope buffer with new data.

09.064		**Scope Arm**							
RW	Bit					NC			US
⇳	Off (0) or On (1)				⇨	Off (0)			

09.065		**Scope Data Not Ready**							
RO	Bit				ND	NC	PT		
⇳	Off (0) or On (1)				⇨				

09.066		**Scope Saving Data**							
RO	Bit				ND	NC	PT		
⇳	Off (0) or On (1)				⇨				

09.067		**Scope Sample Time**							
RW	Num								US
⇳	1 to 200				⇨	1			

Scope Sample Time (09.067) defines the sample rate of the scope function for all traces in 250 μs units (i.e. if *Scope Sample Time* (09.067) = 4, the sample time is 1 ms).

09.068		**Scope Trigger Delay**							
RW	Num								US
⇳	0 to 100 %				⇨	0 %			

Scope Trigger Delay (09.068) defines how much data is stored before and after the scope is triggered. If *Scope Trigger Delay* (09.068) = 0 % then no data is stored before the trigger and all the data is after the trigger. If *Scope Trigger Delay* (09.068) = 100 % then no data is stored after the trigger, but all the data is before the trigger.

09.069		**Scope Time Period**							
RO	Num				ND	NC	PT		
⇳	0.00 to 200000.00 ms				⇨				

The scope function can capture up to 4000 bytes of parameter data. The *Scope Time Period* (09.069) gives the length of the time period covered by the scope buffer in milliseconds which depends on the number of traces stored, the sample time and the size of the parameters used as trace sources.

Sample time in milliseconds = (250 x 10^{-6} x *Scope Sample Time* (09.067)) x 1000

Size of trace data is the sum of the number of bytes in each of the trace sources selected by *Scope Trace 1 Source* (09.055) to *Scope Trace 4 Source* (09.058).

Scope Time Period (09.069) (ms) = 4000 x Sample time in milliseconds / Size of trace data.

09.070		**Scope Auto-save Mode**							
RW	Txt						PS		
⇳	Disabled (0), Overwrite (1), Keep (2)				⇨	Disabled (0)			

Value	Text
0	Disabled
1	Overwrite
2	Keep

Auto-save mode can be used to store a scope file on a non-volatile media card at each trigger event. The auto-save system is held in reset if *Scope Auto-save Reset* (09.072) = 1. When the auto-save system is reset all the scope files in scope file folder on the NV media card are deleted, *Scope Auto-save File Number* (09.071) is reset to 0 and the auto-save system is inactive. If any of the file operations fail during reset *Scope Auto-save Status* (09.073) is 3 (Failed) when the reset is removed.

The following conditions must be met for auto-saving to be active:

1. *Scope Auto-save Mode* (09.070) is non-zero
2. *Scope Auto-save Reset* (09.072) = 0
3. *Scope Auto-save Status* (09.073) = 1 (Active)
4. *Scope Mode* (09.063) = 0 (Single) or 1 (Normal)

If auto-saving is active an attempt is made to copy the scope file to a non-volatile media card fitted to the drive each time the post-trigger data has been acquired. The file name is SCP00XY.DAT, where XY is defined by *Scope Auto-save File Number* (09.071). If *Scope Auto-save Mode* (09.070) = 1 (Overwrite) then a file is over-written if it already exists. If *Scope Auto-save Mode* (09.070) = 2 (Keep) then if the file already exists the auto-save process is aborted. *Scope Auto-save File Number* (09.071) is incremented after a file is saved successfully and rolls over to 0 if it exceeds its maximum value.

If *Scope Auto-save Status* (09.073) = 0 (Disabled) and all the other conditions listed above for auto-saving to be active are met, then *Scope Auto-save Status* (09.073) changes to 1 (Active), so that auto-saving becomes active. If the scope file cannot be saved because the file exists and *Scope Auto-save Mode* (09.070) = 2 (Keep) then *Scope Auto-save Status* (09.073) is set to 2 (Stopped). If the scope file cannot be saved for any other reason then *Scope Auto-save Status* (09.073) is set to 3 (Failed). If *Scope Auto-save Status* (09.073) is no longer 1 (Active), auto-saving is aborted. Auto-saving can be made active again by setting *Scope Auto-save Reset* (09.072) to 1 and then to 0. If *Scope Auto-save Mode* (09.070) = 0 (Disabled) then *Scope Auto-save Status* (09.073) is set to 0 (Disabled), or if *Scope Auto-save Mode* (09.070) is non-zero then *Scope Auto-save Status* (09.073) is set to 1 (Active). It should be noted that *Scope Auto-save Status* (09.073) is a power-down save parameter, and so auto-save will remain inactive if *Scope Auto-save Status* (09.073) is 2 or 3 even if the drive is powered down and then powered up again.

09.071		**Scope Auto-save File Number**							
RO	Num						PS		
⇳	0 to 99				⇨	0			

09.072		**Scope Auto-save Reset**							
RW	Bit						PS		
⇳	Off (0) or On (1)				⇨	Off (0)			

09.073		**Scope Auto-save Status**							
RO	Txt						PS		
⇳	Disabled (0), Active (1), Stopped (2), Failed (3)				⇨	Disabled (0)			

9.10 Menu 10: Status and trips

Table 9-13 Menu 10 Regen parameter descriptions

Parameter		Range	Default	Type					
10.001	Drive Healthy	Off (0) or On (1)		RO	Bit	ND	NC	PT	
10.002	Drive Active	Off (0) or On (1)		RO	Bit	ND	NC	PT	
10.008	Rated Load Reached	Off (0) or On (1)		RO	Bit	ND	NC	PT	
10.009	Current Limit Active	Off (0) or On (1)		RO	Bit	ND	NC	PT	
10.010	Regenerating	Off (0) or On (1)		RO	Bit	ND	NC	PT	
10.011	Braking IGBT Active	Off (0) or On (1)		RO	Bit	ND	NC	PT	
10.012	Braking Resistor Alarm	Off (0) or On (1)		RO	Bit	ND	NC	PT	
10.015	Supply Loss	Off (0) or On (1)		RO	Bit	ND	NC	PT	
10.016	Under Voltage Active	Off (0) or On (1)		RO	Bit	ND	NC	PT	
10.017	Inductor Overload Alarm	Off (0) or On (1)		RO	Bit	ND	NC	PT	
10.018	Drive Over-temperature Alarm	Off (0) or On (1)		RO	Bit	ND	NC	PT	
10.019	Drive Warning	Off (0) or On (1)		RO	Bit	ND	NC	PT	
10.020	Trip 0	0 to 255		RO	Txt	ND	NC	PT	PS
10.021	Trip 1	0 to 255		RO	Txt	ND	NC	PT	PS
10.022	Trip 2	0 to 255		RO	Txt	ND	NC	PT	PS
10.023	Trip 3	0 to 255		RO	Txt	ND	NC	PT	PS
10.024	Trip 4	0 to 255		RO	Txt	ND	NC	PT	PS
10.025	Trip 5	0 to 255		RO	Txt	ND	NC	PT	PS
10.026	Trip 6	0 to 255		RO	Txt	ND	NC	PT	PS
10.027	Trip 7	0 to 255		RO	Txt	ND	NC	PT	PS
10.028	Trip 8	0 to 255		RO	Txt	ND	NC	PT	PS
10.029	Trip 9	0 to 255		RO	Txt	ND	NC	PT	PS
10.030	Braking Resistor Rated Power	0.000 to 99999.999 kW	See Table 9-14	RW	Num				US
10.031	Braking Resistor Thermal Time Constant	0.000 to 1500.000 s	See Table 9-14	RW	Num				US
10.032	External Trip	Off (0) or On (1)	Off (0)	RW	Bit		NC		
10.033	Drive Reset	Off (0) or On (1)	Off (0)	RW	Bit		NC		
10.034	Number Of Auto-reset Attempts	None (0), 1 (1), 2 (2), 3 (3), 4 (4), 5 (5), Infinite (6)	None (0)	RW	Txt				US
10.035	Auto-reset Delay	1.0 to 600.0 s	1.0 s	RW	Num				US
10.036	Auto-reset Hold Drive Healthy	Off (0) or On (1)	Off (0)	RW	Bit				US
10.037	Action On Trip Detection	00000 to 11111	00000	RW	Bin				US
10.038	User Trip	0 to 255		RW	Num	ND	NC		
10.039	Braking Resistor Thermal Accumulator	0.0 to 100.0 %		RO	Num	ND	NC	PT	
10.040	Status Word	0 to 32767		RO	Num	ND	NC	PT	
10.041	Trip 0 Date	00-00-00 to 31-12-99		RO	Date	ND	NC	PT	PS
10.042	Trip 0 Time	00:00:00 to 23:59:59		RO	Time	ND	NC	PT	PS
10.043	Trip 1 Date	00-00-00 to 31-12-99		RO	Date	ND	NC	PT	PS
10.044	Trip 1 Time	00:00:00 to 23:59:59		RO	Time	ND	NC	PT	PS
10.045	Trip 2 Date	00-00-00 to 31-12-99		RO	Date	ND	NC	PT	PS
10.046	Trip 2 Time	00:00:00 to 23:59:59		RO	Time	ND	NC	PT	PS
10.047	Trip 3 Date	00-00-00 to 31-12-99		RO	Date	ND	NC	PT	PS
10.048	Trip 3 Time	00:00:00 to 23:59:59		RO	Time	ND	NC	PT	PS
10.049	Trip 4 Date	00-00-00 to 31-12-99		RO	Date	ND	NC	PT	PS
10.050	Trip 4 Time	00:00:00 to 23:59:59		RO	Time	ND	NC	PT	PS
10.051	Trip 5 Date	00-00-00 to 31-12-99		RO	Date	ND	NC	PT	PS
10.052	Trip 5 Time	00:00:00 to 23:59:59		RO	Time	ND	NC	PT	PS
10.053	Trip 6 Date	00-00-00 to 31-12-99		RO	Date	ND	NC	PT	PS
10.054	Trip 6 Time	00:00:00 to 23:59:59		RO	Time	ND	NC	PT	PS
10.055	Trip 7 Date	00-00-00 to 31-12-99		RO	Date	ND	NC	PT	PS
10.056	Trip 7 Time	00:00:00 to 23:59:59		RO	Time	ND	NC	PT	PS
10.057	Trip 8 Date	00-00-00 to 31-12-99		RO	Date	ND	NC	PT	PS
10.058	Trip 8 Time	00:00:00 to 23:59:59		RO	Time	ND	NC	PT	PS
10.059	Trip 9 Date	00-00-00 to 31-12-99		RO	Date	ND	NC	PT	PS
10.060	Trip 9 Time	00:00:00 to 23:59:59		RO	Time	ND	NC	PT	PS
10.061	Braking Resistor Resistance	0.00 to 10000.00 Ω	See Table 9-14	RW	Num				US
10.063	Local Keypad Battery Low	Off (0) or On (1)		RO	Bit	ND	NC	PT	
10.064	Remote Keypad Battery Low	Off (0) or On (1)		RO	Bit	ND	NC	PT	
10.067	Fire Mode Active	Off (0) or On (1)		RO	Bit	ND	NC	PT	

Parameter		Range	Default	Type					
10.068	Hold Drive Healthy on Under Voltage	Off (0) or On (1)	Off (0)	RW	Bit				US
10.069	Additional Status Bits	0 to 1023		RO	Num	ND	NC	PT	
10.070	Trip 0 Sub-trip Number	0 to 65535		RO	Num	ND	NC	PT	PS
10.071	Trip 1 Sub-trip Number	0 to 65535		RO	Num	ND	NC	PT	PS
10.072	Trip 2 Sub-trip Number	0 to 65535		RO	Num	ND	NC	PT	PS
10.073	Trip 3 Sub-trip Number	0 to 65535		RO	Num	ND	NC	PT	PS
10.074	Trip 4 Sub-trip Number	0 to 65535		RO	Num	ND	NC	PT	PS
10.075	Trip 5 Sub-trip Number	0 to 65535		RO	Num	ND	NC	PT	PS
10.076	Trip 6 Sub-trip Number	0 to 65535		RO	Num	ND	NC	PT	PS
10.077	Trip 7 Sub-trip Number	0 to 65535		RO	Num	ND	NC	PT	PS
10.078	Trip 8 Sub-trip Number	0 to 65535		RO	Num	ND	NC	PT	PS
10.079	Trip 9 Sub-trip Number	0 to 65535		RO	Num	ND	NC	PT	PS
10.081	Phase Loss	Off (0) or On (1)		RO	Bit	ND	NC	PT	
10.101	Drive Status	Inhibit (0), Ready (1), Stop (2), Scan (3), Run (4), Supply Loss (5), Deceleration (6), dc Injection (7), Position (8), Trip (9), Active (10), Off (11), Hand (12), Auto (13), Heat (14), Under Voltage (15)		RO	Txt	ND	NC	PT	
10.102	Trip Reset Source	0 to 1023		RO	Num	ND	NC	PT	PS
10.103	Trip Time Identifier	-2147483648 to 2147483647 ms		RO	Num	ND	NC	PT	
10.104	Active Alarm	None (0), Brake Resistor (1), Motor Overload (2), Ind Overload (3), Drive Overload (4), Auto Tune (5), Limit Switch (6), Fire Mode (7), Low Load (8), Option Slot 1 (9), Option Slot 2 (10), Option Slot 3 (11), Option Slot 4 (12)		RO	Txt	ND	NC	PT	
10.106	Potential Drive Damage Conditions	0000 to 1111		RO	Bin	ND	NC	PT	PS

RW	Read / Write	RO	Read only	Num	Number parameter	Bit	Bit parameter	Txt	Text string	Bin	Binary parameter	FI	Filtered
ND	No default value	NC	Not copied	PT	Protected parameter	RA	Rating dependent	US	User save	PS	Power-down save	DE	Destination
IP	IP address	Mac	Mac address	Date	Date parameter	Time	Time parameter	SMP	Slot,menu,parameter	Chr	Character parameter	Ver	Version number

Table 9-14 Defaults for Pr 10.030, Pr 10.031 and Pr 10.061

Drive size	Pr 10.030	Pr 10.031	Pr 10.061
3	50 W	3.3 s	75 Ω
4 and 5	100 W	2.0 s	38 Ω
All other ratings and frame sizes	0.000		0.00

10.001	**Drive Healthy**								
RO	Bit				ND	NC	PT		
⇕	Off (0) or On (1)	⇨							

Drive Healthy (10.001) indicates that the drive is not in the trip or the under voltage state if it is set to one. If *Auto-reset Hold Drive Healthy* (10.036) = 1 and auto-reset is being used, *Drive Healthy* (10.001) is not cleared until all auto-resets have been attempted and the next trip occurs. The LED on the front of the drive gives an indication of the drive state as shown in the table below.

Drive State	LED
Normal power and *Drive Healthy* (10.001) = 1	On continuously
Normal power and *Drive Healthy* (10.001) = 0	Flashing: 0.5 s on and 0.5 s off
Standby power state	Flashing: 0.5 s on and 7.5 s off

10.002	**Drive Active**								
RO	Bit				ND	NC	PT		
⇕	Off (0) or On (1)	⇨							

If the drive inverter is active *Drive Active* (10.002) is set to one, otherwise it is zero.

10.008		**Rated Load Reached**							
RO	Bit				ND	NC	PT		
⇳	Off (0) or On (1)				⇨				

In Regen mode *Rated Load Reached* (10.008) indicates that the real component of current is at or above the *Rated Current* (05.007). This condition is also detected when the modulus of *Percentage Load* (04.020) is greater or equal to 100.0 %.

10.009		**Current Limit Active**							
RO	Bit				ND	NC	PT		
⇳	Off (0) or On (1)				⇨				

Current Limit Active (10.009) is set to one if the current limit is active.

10.010		**Regenerating**							
RO	Bit				ND	NC	PT		
⇳	Off (0) or On (1)				⇨				

In Regen mode *Regenerating* (10.010) is set to one if power is being transferred from the Regen drive to the supply.

10.011		**Braking IGBT Active**							
RO	Bit				ND	NC	PT		
⇳	Off (0) or On (1)				⇨				

Braking IGBT Active (10.011) is set to one if the braking IGBT is active. As the braking IGBT active periods may be short, each time the braking IGBT is switched on *Braking IGBT Active* (10.011) is set to one and remains at one for at least 0.5 s.

10.012		**Braking Resistor Alarm**							
RO	Bit				ND	NC	PT		
⇳	Off (0) or On (1)				⇨				

Braking Resistor Alarm (10.012) is set when the braking IGBT is active and *Braking Resistor Thermal Accumulator* (10.039) is greater than 75.0 %. As the braking IGBT on periods may be short *Braking Resistor Alarm* (10.012) is always held on for at least 0.5 s.

10.015		**Supply Loss**							
RO	Bit				ND	NC	PT		
⇳	Off (0) or On (1)				⇨				

In Regen mode *Supply Loss* (10.015) always indicates that the Regen drive is in the supply loss state. See *Regen Supply Loss AC Level* (03.023) for details.

10.016		**Under Voltage Active**							
RO	Bit				ND	NC	PT		
⇳	Off (0) or On (1)				⇨				

Under Voltage Active (10.016) indicates that the drive is in the under voltage state. See *Standard Under Voltage Threshold* (06.065) for more details.

10.017		**Inductor Overload Alarm**							
RO	Bit				ND	NC	PT		
⇳	Off (0) or On (1)				⇨				

Motor Overload Alarm (10.017) is set if the drive output current is higher than the level that will eventually cause an Motor Too Hot trip and the *Inductor Protection Accumulator* (04.019) is higher than 75.0 %. See *Inductor Thermal Time Constant* (04.015) for more details.

10.018		**Drive Over-temperature Alarm**							
RO	Bit				ND	NC	PT		
⇳	Off (0) or On (1)				⇨				

Drive Over-temperature Alarm (10.018) is set if *Percentage Of Drive Thermal Trip Level* (07.036) is greater than 90 %.

10.019	**Drive Warning**								
RO	Bit				ND	NC	PT		
⇳	Off (0) or On (1)				⇨				

Drive Warning (10.019) is set to one if any of the drive warnings is active, and is defined as:

Drive Warning (10.019) = *Braking Resistor Alarm* (10.012) OR *Motor Overload Alarm* (10.017) OR *Drive Over-temperature Alarm* (10.018).

10.020	**Trip 0**								
10.021	**Trip 1**								
10.022	**Trip 2**								
10.023	**Trip 3**								
10.024	**Trip 4**								
10.025	**Trip 5**								
10.026	**Trip 6**								
10.027	**Trip 7**								
10.028	**Trip 8**								
10.029	**Trip 9**								
RO	Txt				ND	NC	PT		
⇳	0 to 255				⇨				

Trip 0 (10.020) to *Trip 9* (10.029) store the most recent 10 trips that have occurred where *Trip 0* (10.020) is the most recent and *Trip 9* (10.029) is the oldest. When a new trip occurs it is written to *Trip 0* (10.020) and all the other trips move down the log, with oldest being lost. The date and time when each trip occurs are also stored in the date and time log, i.e. *Trip 0 Date* (10.041) to *Trip 9 Time* (10.060). The date and time are taken from *Date* (06.016) and *Time* (06.017). Some trips have sub-trip numbers which give more detail about the reason for the trip. If a trip has a sub-trip number its value is stored in the sub-trip log, i.e. *Trip 0 Sub-trip Number* (10.070) to *Trip 9 Sub-trip Number* (10.079). If the trip does not have a sub-trip number then zero is stored in the sub-trip log.

Trip categories and priorities

Trips are grouped into the categories given in the table below. A trip can only occur when the drive is not tripped, or if it is already tripped and the new trip has a higher priority than the active trip (i.e. lower priority number). Unless otherwise stated a trip cannot be reset until 1.0 s after it has been initiated.

Priority	Category	Trips	Comments
1	Internal faults	*HF01 – HF20*	These are fatal problems that cannot be reset. All drive features are inactive after any of these trips occur. If a basic keypad is fitted it will show the trip, but the keypad will not function. These trips are not stored in the trip log.
1	Stored HF trip	Stored HF	This trip cannot be cleared unless 1299 is entered into *Pr* ***mm.000*** (mm.000) and a reset is initiated.
2	Non-resettable trips	Trip numbers 218 to 247, Slot1 HF, Slot2 HF, Slot3 HF or Slot4 HF	These trips cannot be reset.
3	Volatile memory failure	EEPROM Fail	This can only be reset if *Parameter mm.000* (mm.000) is set to 1233 or 1244, or if *Load Defaults* (11.043) is set to a non-zero value.
4	Internal 24V power supply	PSU 24V	
5	Non-volatile media trips	Trip numbers 174, 175 and 177 to 188	These trips are priority 6 during power-up.
5	Position feedback interface power supply	Encoder 1	This trip can override Encoder 2 to Encoder 6 trips.
6	Trips with extended reset times	OI ac, OI Brake and OI dc	These trips cannot be reset until 10 s after the trip was initiated.
6	Phase loss and DC link power circuit protection	Phase Loss and *OHt dc bus*	The drive will attempt to stop the motor before tripping if a *Phase Loss*.000 trip occurs unless this feature has been disabled (see *Action On Trip Detection* (10.037). The drive will always attempt to stop the motor before tripping if an *OHt dc bus* occurs.
6	Standard trips	All other trips	

Similar trips that can be initiated by the control system or the power system

Trips shown in the table below can be generated either from the drive control system or from the power system. The sub-trip number which is in the form xxyzz is used to identify the source of the trip. The digits xx are 00 for a trip generated by the control system or the number of a power module if generated by the power system. If the drive is not a multi-power module drive then xx will always have a value of 1 the trip is related to the power system. The y digit is used to identify the location of a trip which is generated by a rectifier module connected to a power module. Where the y digit is relevant it will have a value of 1 or more, otherwise it will be 0. The zz digits give the reason for the trip and are defined in each trip description.

Over Volts	*OHt dc bus*
OI ac	*Phase Loss*
OI Brake	*Power Comms*
PSU	*OI Snubber*
OHt Inverter	*Reserved 102*
OHt Power	*Temp Feedback*
OHt Control	*Power Data*

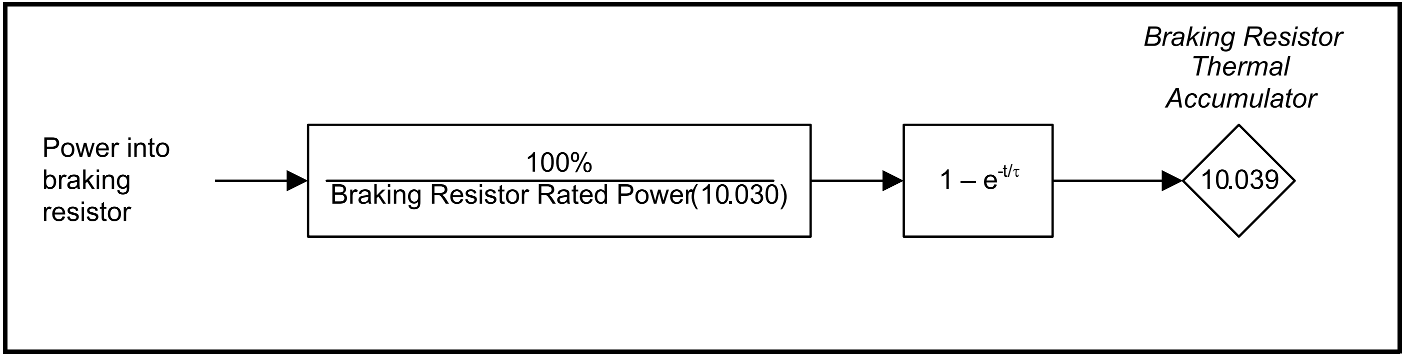
10.030	**Braking Resistor Rated Power**								
RW	Num								US
⇳	0.000 to 99999.999	⇨	See Table 9-14						

A thermal protection system is provided for the braking resistor. If *Braking Resistor Rated Power* (10.030) is set to zero this protection system is disabled and the *Braking Resistor Thermal Accumulator* (10.039) is held at zero. If braking resistor thermal protection is required the *Braking Resistor Rated Power* (10.030), *Braking Resistor Thermal Time Constant* (10.031) and *Braking Resistor Resistance* (10.061) should be set up with the braking resistor parameters. The thermal time constant of the resistor can be calculated from the single pulse energy rating (E) and continuous power rating (P) of the resistor.

Braking Resistor Thermal Time Constant (10.031) = t = E / P

The braking resistor is protected with a single time constant model as shown overleaf.

Figure 9-16 Braking resistor protection system



The drive monitors the power flowing into the braking resistor and updates the *Braking Resistor Thermal Accumulator* (10.039). If bit 1 of *Action On Trip Detection* (10.037) = 0 and the accumulator reaches 100 % an *Brake R Too Hot* trip is initiated. If bit 1 of *Action On Trip Detection* (10.037) = 1 and the accumulator reaches 100 % the braking IGBT is disabled until the accumulator falls below 95.0 %.

10.031	**Braking Resistor Thermal Time Constant**								
RW	Num								US
⇳	0.000 to 1500.000	⇨	See Table 9-14						

10.032	**External Trip**								
RW	Bit					NC			
⇳	Off (0) or On (1)	⇨	Off (0)						

If *External Trip* (10.032) is set to one an *External Trip.003* is initiated. A digital input can be routed to *External Trip* (10.032) to provide an external trip input function.

10.033	**Drive Reset**								
RW	Bit					NC			
⇳	Off (0) or On (1)	⇨	Off (0)						

A 0 to 1 transition in *Drive Reset* (10.033) causes a drive reset. If a drive reset terminal is required a digital input should be routed to *Drive Reset* (10.033).

10.034	**Number Of Auto-reset Attempts**								
RW	Txt								US
⇳	0 to 6			⇨	0				

Value	Text
0	None
1	1
2	2
3	3
4	4
5	5
6	Infinite

If *Number Of Auto-reset Attempts* (10.034) = 0 then no auto-reset attempts are made. Any other value will cause the drive to automatically reset following a trip for the number of times programmed after a delay defined by *Auto-reset Delay* (10.035) subject to the minimum reset time allowed for the type of trip. Note that for some trips the minimum is 10s. The auto-reset count is only incremented when the trip is the same as the previous trip otherwise it is reset to 0. When the auto-reset count reaches the programmed value, any further trip of the same value will not cause an auto-reset. If the number of auto-reset attempts defined by *Number Of Auto-reset Attempts* (10.034) has not been reached and there has been no trip for 5 minutes then the auto-reset count is cleared. Auto reset will not occur after any trips with priority levels 1, 2 or 3 as defined in *Trip 0* (10.020). When a manual reset occurs the auto-reset counter is reset to zero.

If *Number Of Auto-reset Attempts* (10.034) = 6 the auto-reset counter is held at zero, and so there is no limit on the number of auto-reset attempts.

10.035	**Auto-reset Delay**								
RW	Num								US
⇳	1.0 to 600.0 s			⇨	1.0 s				

10.036	**Auto-reset Hold Drive Healthy**								
RW	Bit								US
⇳	Off (0) or On (1)			⇨	Off (0)				

If *Auto-reset Hold Drive Healthy* (10.036) = 0 then *Drive Healthy* (10.001) is cleared every time the drive trips regardless of any auto-reset that may occur. If *Auto-reset Hold Drive Healthy* (10.036) = 1 then *Drive Healthy* (10.001) is not cleared on a trip if any further auto-reset attempts are possible. Note that if the under voltage state becomes active *Drive Healthy* (10.001) will be set to zero unless *Hold Drive Healthy on Under Voltage* (10.068) = 1.

10.037	**Action On Trip Detection**								
RW	Bin								US
⇳	0 (Display: 00000) to 31 (Display: 11111)			⇨	0 (Display: 00000)				

The bits in *Action On Trip Detection* (10.037) are defined as follows:

Bit 0: Stop on defined non-important trips

If bit 0 is set to one the drive will attempt to stop before tripping if any of the following trip conditions are detected: *I/O Overload*, *An Input 1 Loss*, *An Input 2 Loss* or *Keypad Mode*. (This bit has no effect in Regen mode.)

Bit 1: Disable braking resistor overload detection

See *Braking Resistor Rated Power* (10.030).

Bit 2: Disable phase loss stop

Normally the drive will stop when the input phase loss condition is detected. If this bit is set to 1 the drive will continue to run and will only trip when the drive is brought to a stop by the user. (This bit has no effect in Regen mode.)

Bit 3: Not Used

Bit 4: Disable parameter freeze on trip

If this bit is 0 then the parameters listed below are frozen on trip until the trip is cleared. If this bit is 1 then this feature is disabled.

Parameter number	Parameter name
03.001	*Reactive Power*
04.001	*Current Magnitude*
04.002	*Active Current*
04.017	*Reactive Current*
05.001	*Output Frequency*
05.002	*Output Voltage*
05.003	*Output Power*
05.005	*D.c. Bus Voltage*
07.001	*Analog Input 1*
07.002	*Analog Input 2*
07.003	*Analog Input 3*

10.038		**User Trip**							
RW	Num				ND	NC			US
⇳	0 to 255				⇨				

When a value other than zero is written to the *User Trip* (10.038) the actions described in the following table are performed. The drive immediately writes the value back to zero. If the value is not included in the table, then the action is the same as if the trip with the same number (with sub-trip zero) occurred provided the drive is not already tripped.

Action	User Trip (10.038)
No action	Numbers corresponding to priority 1, 2 or 3 trips.
Drive reset	100
Clear trip logs (parameters **10.020** to **10.029**, **10.041** to **10.060** and **10.070** to **10.079**)	255

10.039		**Braking Resistor Thermal Accumulator**							
RO	Num				ND	NC	PT		
⇳	0.0 to 100.0 %				⇨				

10.040		**Status Word**							
RO	Num				ND	NC	PT		
⇳	0 to 32767				⇨				

The bits in *Status Word* (10.040) mirror the status bit parameters as shown below. Where the parameters do not exist in any mode the bit remains at zero.

Bit	Status parameter
0	*Drive Healthy* (10.001)
1	*Drive Active* (10.002)
2	*Zero Speed* (10.003)
3	*Running At Or Below Minimum Speed* (10.004)
4	*Below Set Speed* (10.005)
5	*At Speed* (10.006)
6	*Above Set Speed* (10.007)
7	*Rated Load Reached* (10.008)
8	*Current Limit Active* (10.009)
9	*Regenerating* (10.010)
10	*Braking IGBT Active* (10.011)
11	*Braking Resistor Alarm* (10.012)
12	*Reverse Direction Commanded* (10.013)
13	*Reverse Direction Running* (10.014)
14	*Supply Loss* (10.015)

10.041	**Trip 0 Date**								
RO	Date				ND	NC	PT		PS
⇳	0 (Display: 00-00-00) to 311299 (Display: 31-12-99)				⇨				

10.042	**Trip 0 Time**								
RO	Time				ND	NC	PT		PS
⇳	0 (Display: 00:00:00) to 235959 (Display: 23:59:59)				⇨				

10.043	**Trip 1 Date**								
RO	Date				ND	NC	PT		PS
⇳	0 (Display: 00-00-00) to 311299 (Display: 31-12-99)				⇨				

10.044	**Trip 1 Time**								
RO	Time				ND	NC	PT		PS
⇳	0 (Display: 00:00:00) to 235959 (Display: 23:59:59)				⇨				

10.045	**Trip 2 Date**								
RO	Date				ND	NC	PT		PS
⇳	0 (Display: 00-00-00) to 311299 (Display: 31-12-99)				⇨				

10.046	**Trip 2 Time**								
RO	Time				ND	NC	PT		PS
⇳	0 (Display: 00:00:00) to 235959 (Display: 23:59:59)				⇨				

10.047	**Trip 3 Date**								
RO	Date				ND	NC	PT		PS
⇳	0 (Display: 00-00-00) to 311299 (Display: 31-12-99)				⇨				

10.048	**Trip 3 Time**								
RO	Time				ND	NC	PT		PS
⇳	0 (Display: 00:00:00) to 235959 (Display: 23:59:59)				⇨				

10.049	**Trip 4 Date**								
RO	Date				ND	NC	PT		PS
⇳	0 (Display: 00-00-00) to 311299 (Display: 31-12-99)				⇨				

10.050	**Trip 4 Time**								
RO	Time				ND	NC	PT		PS
⇳	0 (Display: 00:00:00) to 235959 (Display: 23:59:59)				⇨				

10.051	**Trip 5 Date**								
RO	Date				ND	NC	PT		PS
⇳	0 (Display: 00-00-00) to 311299 (Display: 31-12-99)				⇨				

10.052		**Trip 5 Time**							
RO	Time				ND	NC	PT		PS
⇕	0 (Display: 00:00:00) to 235959 (Display: 23:59:59)				⇨				

10.053		**Trip 6 Date**							
RO	Date				ND	NC	PT		PS
⇕	0 (Display: 00-00-00) to 311299 (Display: 31-12-99)				⇨				

10.054		**Trip 6 Time**							
RO	Time				ND	NC	PT		PS
⇕	0 (Display: 00:00:00) to 235959 (Display: 23:59:59)				⇨				

10.055		**Trip 7 Date**							
RO	Date				ND	NC	PT		PS
⇕	0 (Display: 00-00-00) to 311299 (Display: 31-12-99)				⇨				

10.056		**Trip 7 Time**							
RO	Time				ND	NC	PT		PS
⇕	0 (Display: 00:00:00) to 235959 (Display: 23:59:59)				⇨				

10.057		**Trip 8 Date**							
RO	Date				ND	NC	PT		PS
⇕	0 (Display: 00-00-00) to 311299 (Display: 31-12-99)				⇨				

10.058		**Trip 8 Time**							
RO	Time				ND	NC	PT		PS
⇕	0 (Display: 00:00:00) to 235959 (Display: 23:59:59)				⇨				

10.059		**Trip 9 Date**							
RO	Date				ND	NC	PT		PS
⇕	0 (Display: 00-00-00) to 311299 (Display: 31-12-99)				⇨				

10.060		**Trip 9 Time**							
RO	Time				ND	NC	PT		PS
⇕	0 (Display: 00:00:00) to 235959 (Display: 23:59:59)				⇨				

10.061		**Braking Resistor Resistance**							
RW	Num								US
⇕	0.00 to 10000.00 Ω				⇨	See Table 9-14			

10.063		**Local Keypad Battery Low**							
RO	Bit				ND	NC	PT		
⇕	Off (0) or On (1)				⇨				

Local Keypad Battery Low (10.063) is set to one when a keypad is fitted to the front of the drive with an internal real-time clock and the battery is not fitted or the voltage is below the minimum threshold.

10.064	**Remote Keypad Battery Low**								
RO	Bit				ND	NC	PT		
⇳	Off (0) or On (1)				⇨				

Remote Keypad Battery Low (10.064) is set to one when a keypad is connected to the drive user comms port with an internal real-time clock and the battery is not fitted or the voltage is below the minimum threshold.

10.067	**Fire Mode Active**								
RO	Bit				ND	NC	PT		
⇳	Off (0) or On (1)				⇨				

10.068	**Hold Drive Healthy on Under Voltage**								
RW	Bit								US
⇳	Off (0) or On (1)				⇨	Off (0)			

Hold Drive Healthy on Under Voltage (10.068) can be used to hold the drive healthy active (*Drive Healthy* (10.001) = 1 and not flash the status LED on the front of the drive) when the drive is in the under voltage state (*Under Voltage Active* (10.016) = 1).

If *Hold Drive Healthy on Under Voltage* (10.068) = 0 and *Under Voltage Active* (10.016) = 1, then *Drive Healthy* (10.001) will be set to 0 and the status LED on the front of the drive will flash.

If *Hold Drive Healthy on Under Voltage* (10.068) = 1, *Under Voltage Active* (10.016) = 1 and the drive is not tripped (i.e. *Drive Status* (10.101) does not equal 9), then *Drive Healthy* (10.001) will be set to 1 and the status LED on the front of the drive will not flash.

If the drive is tripped then *Drive Healthy* (10.001) will be set to 0 and the status LED will flash independent of what Hold Drive Healthy on *Under Voltage* (10.068) is set to.

10.069	**Additional Status Bits**								
RO	Num				ND	NC	PT		
⇳	0 to 1023				⇨				

The bits in *Additional Status Bits* (10.069) mirror the status bits parameters as shown below. Where the parameters do not exist in any mode the bit remains at zero.

Bit	Status parameter
0	*Under Voltage Active* (10.016)
1	*Motor Overload Alarm* (10.017) or *Inductor Overload Alarm* (10.017)
2	*Drive Over-temperature Alarm* (10.018)
3	*Drive Warning* (10.019)
4	*Low Load Detected Alarm* (10.062)
5	*Local Keypad Battery Low* (10.063)
6	*Remote Keypad Battery Low* (10.064)
8	*Limit Switch Active* (10.066)
9	*Fire Mode Active* (10.067)

10.070	**Trip 0 Sub-trip Number**								
10.071	**Trip 1 Sub-trip Number**								
10.072	**Trip 2 Sub-trip Number**								
10.073	**Trip 3 Sub-trip Number**								
10.074	**Trip 4 Sub-trip Number**								
10.075	**Trip 5 Sub-trip Number**								
10.076	**Trip 6 Sub-trip Number**								
10.077	**Trip 7 Sub-trip Number**								
10.078	**Trip 8 Sub-trip Number**								
10.079	**Trip 9 Sub-trip Number**								
RO	Num				ND	NC	PT		PS
⇳	0 to 65535				⇨				

10.081		**Phase Loss**							
RO	Bit				ND	NC	PT		
⇳	Off (0) or On (1)				⇨				

If a supply phase is disconnected, or two phases are shorted together, the negative phase sequence component of supply voltage (*Negative Phase Sequence Volts* (03.038)) increases significantly. *Phase Loss* (10.081) gives an indication of either of these conditions, or a high level of supply imbalance. If Harmonic Reduction Enable (03.021) > 0 then this parameter is set to one if *Negative Phase Sequence Volts* (03.038) > *Positive Phase Sequence Volts* (03.037) / 2 for more than 100 ms. It should be noted that *Phase Loss* (10.081) is only set when the Regen drive is active, so if the transient caused by an asymmetrical fault causes the system to trip then *Phase Loss* (10.081) is not set.

10.101		**Drive Status**							
RO	Txt				ND	NC	PT		
⇳	0 to 15				⇨				

Value	Text
0	Inhibit
1	Ready
2	Stop
3	Scan
4	Run
5	Supply Loss
6	Deceleration
7	dc Injection
8	Position
9	Trip
10	Active
11	Off
12	Hand
13	Auto
14	Heat
15	Under Voltage

Drive Status (10.101) shows the present status of the drive. The strings from this parameter are also used by the basic keypad to provide the status display text.

10.102		**Trip Reset Source**							
RO	Num				ND	NC	PT		PS
⇳	0 to 1023				⇨				

The bits in *Trip Reset Source* (10.102) correspond to each of the trips in the trip log (i.e. bit 0 corresponds to trip 0, bit 1 corresponds to trip 1, etc.). When a trip occurs, bit 0 is set to one and the other bits corresponding to the trips already in the trip log are shifted left one bit. If the trip is reset then bit 0 is set back to zero, otherwise if a higher priority trip occurs bit 0 is shifted left by one bit. The result is that each of the bits in *Trip Reset Source* (10.102) show whether trips in the trip log were reset or moved up the trip log by a higher priority trip.

10.103		**Trip Time Identifier**							
RO	Num				ND	NC	PT		
⇳	-2147483648 to 2147483647				⇨				

When a trip occurs the time in milliseconds since the drive powered up is stored in *Trip Time Identifier* (10.103). The time rolls-over when it reaches 2^{31} - 1, but if the time is 0 a value of 1 is written. *Trip Time Identifier* (10.103) can be used to determine when a new trip has occurred as the value will change (unless there were exactly 2^{32} ms between trips) and will be non-zero.

10.104		**Active Alarm**							
RO	Txt				ND	NC	PT		
⇳	0 to 12				⇨				

Value	Text
0	None
1	Brake Resistor
2	Motor Overload
3	Ind Overload
4	Drive Overload
5	Auto Tune
6	Limit Switch
7	Fire Mode
8	Low Load
9	Option Slot 1
10	Option Slot 2
11	Option Slot 3
12	Option Slot 4

If there is no alarm then *Active Alarm* (10.104) = 0. If one alarm is active then *Active Alarm* (10.104) shows the value of the alarm. If more than one alarm is active then *Active Alarm* (10.104) shows the active alarm with the lowest value. The strings from this parameter are also used by the basic keypad to provide the status display text except for option slot warnings where the option module may supply the string.

10.106	**Potential Drive Damage Conditions**								
RO	Bin				ND	NC	PT		PS
⇕	0 (Display: 0000) to 15 (Display: 1111)				⇨				

The bits in *Potential Drive Damage Conditions* (10.106) are set under the conditions shown in the table below to indicate that the user has put the drive in a condition that could potentially damage the drive. The bits in this parameter cannot be cleared by users.

***Potential Drive Damage Conditions* (10.106) bit**	**Condition**
0	Fire mode has been active. See *Fire Mode Reference* (01.053).
1	*Low Under Voltage Threshold* (06.066) has been reduced from its default value.
2	High speed RFC-S mode has been used. See *Enable High Speed Mode* (05.022).
3	Not used.

9.11 Menu 11: General drive set-up

Parameter		Range	Default	Type					
11.001	Option Synchronisation Select	Not Active (0), Slot 1 (1), Slot 2 (2), Slot 3 (3), Slot 4 (4), Automatic (5)	Slot 4 (4)	RW	Txt				US
11.002	Option synchronisation Active	Not Active (0), Slot 1 (1), Slot 2 (2), Slot 3 (3), Slot 4 (4)		RO	Txt	ND	NC	PT	
11.018	Status Mode Parameter 1	0.000 to 59.999	0.000	RW	Num			PT	US
11.019	Status Mode Parameter 2	0.000 to 59.999	0.000	RW	Num			PT	US
11.020	Reset Serial Communications*	Off (0) or On (1)		RW	Bit	ND	NC		
11.021	Parameter 00.030 Scaling	0.000 to 10.000	1.000	RW	Num				US
11.022	Parameter Displayed At Power-up	0.000 to 0.080	0.011	RW	Num			PT	US
11.023	Serial Address*	1 to 247	1	RW	Num				US
11.024	Serial Mode*	8 2 NP (0), 8 1 NP (1), 8 1 EP (2), 8 1 OP (3), 8 2 NP M (4), 8 1 NP M (5), 8 1 EP M (6), 8 1 OP M (7), 7 2 NP (8), 7 1 NP (9), 7 1 EP (10), 7 1 OP (11), 7 2 NP M (12), 7 1 NP M (13), 7 1 EP M (14), 7 1 OP M (15)	8 2 NP (0)	RW	Txt				US
11.025	Serial Baud Rate*	300 (0), 600 (1), 1200 (2), 2400 (3), 4800 (4), 9600 (5), 19200 (6), 38400 (7), 57600 (8), 76800 (9), 115200 (10)	19200 (6)	RW	Txt				US
11.026	Minimum Comms Transmit Delay*	0 to 250 ms	2 ms	RW	Num				US
11.027	Silent Period*	0 to 250 ms	0 ms	RW	Num				US
11.028	Drive Derivative	0 to 255		RO	Num	ND	NC	PT	
11.029	Software Version	0 to 99999999		RO	Num	ND	NC	PT	
11.030	User Security Code	0 to 2147483647		RW	Num	ND	NC	PT	US
11.031	User Drive Mode	Open-loop (1), RFC-A (2), RFC-S (3), Regen (4)		RW	Txt	ND	NC	PT	
11.032	Maximum Heavy Duty Rating	0.000 to 99999.999 A		RO	Num	ND	NC	PT	
11.033	Drive Rated Voltage	200 V (0), 400 V (1), 575 V (2), 690 V (3)		RO	Txt	ND	NC	PT	
11.034	Software Sub-version	0 to 99		RO	Num	ND	NC	PT	
11.035	Number Of Power Modules Test	-1 to 20	-1	RW	Num				US
11.036	NV Media Card File Previously Loaded	0 to 999	0	RO	Num		NC	PT	
11.037	NV Media Card File Number	0 to 999	0	RW	Num				
11.038	NV Media Card File Type	None (0), Open-loop (1), RFC-A (2), RFC-S (3), Regen (4), User Prog (5), Option App (6)		RO	Txt	ND	NC	PT	
11.039	NV Media Card File Version	0 to 9999		RO	Num	ND	NC	PT	
11.040	NV Media Card File Checksum	-2147483648 to 2147483647		RO	Num	ND	NC	PT	
11.042	Parameter Cloning	None (0), Read (1), Program (2), Auto (3), Boot (4)	None (0)	RW	Txt		NC		US
11.043	Load Defaults	None (0), Standard (1), US (2)	None (0)	RW	Txt		NC		
11.044	User Security Status	Menu 0 (0), All Menus (1), Read-only Menu 0 (2), Read-only (3), Status Only (4), No Access (5)		RW	Txt	ND		PT	
11.045	Select Motor 2 Parameters	Motor 1 (0), Motor 2 (1)	Motor 1 (0)	RW	Txt				US
11.046	Defaults Previously Loaded	0 to 2000		RO	Num	ND	NC	PT	US
11.047	Onboard User Program: Enable	Stop (0), Run (1)	Run (1)	RW	Txt				US
11.048	Onboard User Program: Status	-2147483648 to 2147483647		RO	Num	ND	NC	PT	
11.049	Onboard User Program: Programming Events	0 to 65535		RO	Num	ND	NC	PT	
11.050	Onboard User Program: Freewheeling Tasks Per Second	0 to 65535		RO	Num	ND	NC	PT	
11.051	Onboard User Program: Clock Task Time Used	0.0 to 100.0 %		RO	Num	ND	NC	PT	
11.052	Serial Number LS	000000000 to 999999999		RO	Num	ND	NC	PT	
11.053	Serial Number MS	0 to 999999999		RO	Num	ND	NC	PT	
11.054	Drive Date Code	0 to 65535		RO	Num	ND	NC	PT	
11.055	Onboard User Program: Clock Task Scheduled Interval	0 to 262140 ms		RO	Num	ND	NC	PT	
11.056	Option Slot Identifiers	1234 (0), 1243 (1), 1324 (2), 1342 (3), 1423 (4), 1432 (5), 4123 (6), 3124 (7), 4132 (8), 2134 (9), 3142 (10), 2143 (11), 3412 (12), 4312 (13), 2413 (14), 4213 (15), 2314 (16), 3214 (17), 2341 (18), 2431 (19), 3241 (20), 3421 (21), 4231 (22), 4321 (23)	1234 (0)	RW	Txt			PT	
11.060	Maximum Rated Current	0.000 to 99999.999 A		RO	Num	ND	NC	PT	
11.061	Full Scale Current Kc	0.000 to 99999.999 A		RO	Num	ND	NC	PT	
11.062	Power Board Software Version Number	0.00 to 99.99		RO	Num	ND	NC	PT	
11.063	Product Type	0 to 255		RO	Num	ND	NC	PT	

Parameter		Range	Default	Type					
11.064	Product Identifier Characters	1295396912 to 2147483647		RO	Num	ND	NC	PT	
11.065	Drive Rating And Configuration	00000000 to 99999999		RO	Num	ND	NC	PT	
11.066	Power Stage Identifier	0 to 255		RO	Num	ND	NC	PT	
11.067	Control Board Identifier	0.000 to 65.535		RO	Num	ND	NC	PT	
11.068	Internal I/O Identifier	0 to 255		RO	Num	ND	NC	PT	
11.069	Position Feedback Interface Identifier	0 to 255		RO	Num	ND	NC	PT	
11.070	Core Parameter Database Version	0.00 to 99.99		RO	Num	ND	NC	PT	
11.071	Number Of Power Modules Detected	0 to 20		RO	Num	ND	NC	PT	US
11.072	NV Media Card Create Special File	0 to 1	0	RW	Num		NC		
11.073	NV Media Card Type	None (0), SMART Card (1), SD Card (2)		RO	Txt	ND	NC	PT	
11.075	NV Media Card Read-only Flag	Off (0) or On (1)		RO	Bit	ND	NC	PT	
11.076	NV Media Card Warning Suppression Flag	Off (0) or On (1)		RO	Bit	ND	NC	PT	
11.077	NV Media Card File Required Version	0 to 9999		RW	Num	ND	NC	PT	
11.079	Drive Name Characters 1-4	-2147483648 to 2147483647	0	RW	Num			PT	US
11.080	Drive Name Characters 5-8	-2147483648 to 2147483647	0	RW	Num			PT	US
11.081	Drive Name Characters 9-12	-2147483648 to 2147483647	0	RW	Num			PT	US
11.082	Drive Name Characters 13-16	-2147483648 to 2147483647	0	RW	Num			PT	US
11.084	Drive Mode	Open-loop (1), RFC-A (2), RFC-S (3), Regen (4)		RO	Txt	ND	NC	PT	US
11.085	Security Status	None (0), Read-only (1), Status-only (2), No Access (3)		RO	Txt	ND	NC	PT	PS
11.086	Menu Access Status	Menu 0 (0), All Menus (1)		RO	Txt	ND	NC	PT	PS
11.090	Keypad Port Serial Address	1 to 16	1	RW	Num				US
11.091	Additional Identifier Characters 1	-2147483648 to 2147483647		RO	Num	ND	NC	PT	
11.092	Additional Identifier Characters 2	-2147483648 to 2147483647		RO	Num	ND	NC	PT	
11.093	Additional Identifier Characters 3	-2147483648 to 2147483647		RO	Num	ND	NC	PT	
11.095	Number Of Rectifiers Detected	0 to 9		RO	Num	ND	NC	PT	
11.096	Number Of Rectifiers Expected	0 to 9	0	RW	Num				US

* Not available on *Unidrive M700*.

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

11.001	**Option Synchronisation Select**								
RW	Txt								US
⇳	Not Active (0), Slot 1 (1), Slot 2 (2), Slot 3 (3), Slot 4 (4), Automatic (5)			⇨	Slot 4 (4)				

Option Synchronisation Select (11.001) is used to select and enable timing synchronisation between the communications system associated with an option module fitted to the drive and the drive control system. If "Not Active" is selected then the drive control system operates using it's own processor crystal for control sample timing. If one of the option modules is selected and is making a request to provide synchronisation then the drive control sample timing will be synchronised to the communication system. *Option synchronisation Active* (11.002) shows the synchronisation source, where "Not Active" indicates that the drive is providing the timing for the control system. Any other value indicates if an option module is providing synchronisation. If required the synchronisation source can be selected automatically by setting *Option Synchronisation Select* (11.001) to "Automatic". In this case the option module in the lowest numbered slot that is making a request to provide synchronisation will be selected.

11.002	**Option synchronisation Active**								
RO	Txt				ND	NC	PT		US
⇳	Not Active (0), Slot 1 (1), Slot 2 (2), Slot 3 (3), Slot 4 (4)			⇨					

See *Option Synchronisation Select* (11.001).

11.018	**Status Mode Parameter 1**								
RW	Num						PT		US
⇳	0.000 to 59.999			⇨	0.000				

See *Parameter Displayed At Power-up* (11.022).

11.019	**Status Mode Parameter 2**								
RW	Num						PT		US
⇕	0.000 to 59.999			⇨	0.000				

See *Parameter Displayed At Power-up* (11.022).

11.020	**Reset Serial Communications**								
RW	Bit				ND	NC			
⇕	Off (0) or On (1)			⇨					

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

11.021	**Parameter 00.030 Scaling**								
RW	Num								US
⇕	0.000 to 10.000			⇨	1.000				

Parameter 00.030 Scaling (11.021) defines the scaling applied to parameter 00.030 when it is displayed on a basic keypad. The scaling is only applied in the status and view modes. If the parameter is edited via the keypad it reverts to its un-scaled value during editing.

11.022	**Parameter Displayed At Power-up**								
RW	Num						PT		US
⇕	0.000 to 0.080			⇨	0.011				

If *Status Mode Parameter 1* (11.018) and *Status Mode Parameter 2* (11.019) are set to zero, then *Parameter Displayed At Power-up* (11.022) defines which Menu 0 parameter is initially displayed at power-up. If *Status Mode Parameter 1* (11.018) or *Status Mode Parameter 2* (11.019) are set to valid parameter numbers, then *Parameter Displayed At Power-up* (11.022) defines the active parameter at power-up, i.e. the parameter first displayed when going in to parameter view mode on the keypad.

If *Status Mode Parameter 1* (11.018) and *Status Mode Parameter 2* (11.019) define the parameter values to be display on the upper and lower rows of the keypad respectively, when in status mode. If only one of these parameters is set correctly the other row will display the value of the current active parameter. If both *Status Mode Parameter 1* (11.018) and *Status Mode Parameter 2* (11.019) are set to the parameter number then the parameter value is displayed as double height characters.

11.023	**Serial Address**								
RW	Num								US
⇕	1 to 247			⇨	1				

Serial Address (11.023) defines the node address for the serial comms interface in the range from 1 to 247.

Changing the parameters does not immediately change the serial communications settings. See *Reset Serial Communications* (11.020) for more details.

11.024	**Serial Mode**								
RW	Txt								US
⇕	8 2 NP (0), 8 1 NP (1), 8 1 EP (2), 8 1 OP (3), 8 2 NP M (4), 8 1 NP M (5), 8 1 EP M (6), 8 1 OP M (7), 7 2 NP (8), 7 1 NP (9), 7 1 EP (10), 7 1 OP (11), 7 2 NP M (12), 7 1 NP M (13), 7 1 EP M (14), 7 1 OP M (15)			⇨	8 2 NP (0)				

The core drive always uses the Modbus rtu protocol and is always a slave. *Serial Mode* (11.024) defines the data format used by the serial comms interface. The bits in the value of *Serial Mode* (11.024) define the data format as follows. Bit 3 is always 0 in the core product as 8 data bits are required for Modbus RTU. The parameter value can be extended in derivative products which provide alternative communications protocols if required.

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

Bit 2 selects either standard or modified register mode. The menu and parameter numbers are derived for each mode as given in the table below. Standard mode is compatible with Unidrive SP. Modified mode is provided to allow register numbers up to 255 to be addressed. If any menus with numbers above 63 should contain more than 99 parameters, then these parameters cannot be accessed via Modbus RTU.

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

Changing the parameters does not immediately change the serial communications settings. See *Reset Serial Communications* (11.020) for more details.

11.025	**Serial Baud Rate**								
RW	Txt								US
⇕	300 (0), 600 (1), 1200 (2), 2400 (3), 4800 (4), 9600 (5), 19200 (6), 38400 (7), 57600 (8), 76800 (9), 115200 (10)	⇨	19200 (6)						

Serial Baud Rate (11.025) defines the baud rate used by the serial comms interface.

Changing the parameters does not immediately change the serial communications settings. See *Reset Serial Communications* (11.020) for more details.

11.026	**Minimum Comms Transmit Delay**								
RW	Num								US
⇕	0 to 250 ms	⇨	2 ms						

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

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

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

Changing the parameters does not immediately change the serial communications settings. See *Reset Serial Communications* (11.020) for more details.

11.027	**Silent Period**								
RW	Num								US
⇕	0 to 250 ms	⇨	0 ms						

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

Changing the parameters does not immediately change the serial communications settings. See *Reset Serial Communications* (11.020) for more details.

11.028	**Drive Derivative**								
RO	Num				ND	NC	PT		
⇳	0 to 255				⇨				

Drive Derivative (11.028) shows the derivative identifier.

11.029	**Software Version**								
RO	Num				ND	NC	PT		
⇳	0 to 99999999				⇨				

Software Version (11.029) displays the drive software version number as a decimal number wwxxyyzz. A keypad will display the value in this parameter as ww.xx.yy.zz.

11.030	**User Security Code**								
RW	Num				ND	NC	PT		US
⇳	0 to 2147483647				⇨				

See *User Security Status* (11.044).

11.031	**User Drive Mode**								
RW	Txt				ND	NC	PT		
⇳	Open-loop (1), RFC-A (2), RFC-S (3), Regen (4)				⇨				

User Drive Mode (11.031) is set to the current drive mode at power-up. The user can change the drive mode as follows:

1. Set Pr **mm.000** (mm.000) to 1253, 1254, 1255 or 1256
2. Change User Drive Mode (11.031) to the required mode
3. Initiate a drive reset

Provided Drive Active (10.002) = 0 the drive will change to the new drive mode, and then load and save parameters to non-volatile memory. If Pr **mm.000** (mm.000) is not set to one of the specified values then the drive mode does not change on drive reset. The value in Pr **mm.000** (mm.000) determines which defaults are loaded as follows.

Pr mm.000 (mm.000)	Defaults loaded
1253	50Hz defaults to all menus
1254	60Hz defaults to all menus
1255	50Hz defaults to all menus except 15 to 20 and 24 to 28
1256	60Hz defaults to all menus except 15 to 20 and 24 to 28

11.032	**Maximum Heavy Duty Rating**								
RO	Num					NC	PT		
⇳	0.000 to 99999.999 A				⇨				

Maximum Heavy Duty Rating (11.032) defines the maximum setting for Rated Current (05.007) that gives heavy duty operation. If *Maximum Heavy Duty Rating* (11.032) = 0.000 then heavy duty operation is not possible. If *Maximum Heavy Duty Rating* (11.032) = VM_RATED_CURRENT[MAX] then normal duty operation is not possible.

11.033	**Drive Rated Voltage**								
RO	Txt				ND	NC	PT		
⇳	200 V (0), 400 V (1), 575 V (2), 690 V (3)				⇨				

Value	Text
0	200 V
1	400 V
2	575 V
3	690 V

Drive Rated Voltage (11.033) shows the voltage rating of the drive.

11.034	**Software Sub-version**								
RO	Num				ND	NC	PT		
⇳	0 to 99				⇨				

For legacy applications *Software Sub-version* (11.034) shows the yy part of *Software Version* (11.029).

11.035	**Number Of Power Modules Test**								
RO	Num								US
⇳	-1 to 20				⇨	-1			

Number Of Power Modules Detected (11.071) shows the number of power modules detected in the drive when communications with the power system is established. The number of modules can be checked and a trip initiated depending on the value of *Number Of Power Modules Test* (11.035) as follows:

***Number Of Power Modules Test* (11.035)**	**Test**	**Trip if test fails**
-1	The number of modules detected is compared to the value in *Number Of Power Modules Detected* (11.071) before it is updated with the number of modules present	Configuration.*mmm* where mmm is the value of *Number Of Power Modules Detected* (11.071) before it is updated
0	None	None
>0	The number of modules detected is compared to the value in *Number Of Power Modules Test* (11.035)	Configuration.*mmm* where mmm is the value of *Number Of Power Modules Test* (11.035)

If *Number Of Power Modules Test* (11.035) = -1 a test is being carried out to see if the number of modules detected has changed. *Number Of Power Modules Detected* (11.071) is a user save parameter, and so on power-up the number of modules can be compared with the number last saved when the system last powered up correctly.

If *Number Of Power Modules Test* (11.035) > 0 the expected number of modules are stored in *Number Of Power Modules Test* (11.035), and if the number powering up successfully changes then this can be detected.

The sub-trip number always indicates the expected number of power modules. The actual number detected can always be seen in *Number Of Power Modules Detected* (11.071).

11.036	**NV Media Card File Previously Loaded**								
RO	Num					NC	PT		
⇳	0 to 999				⇨	0			

NV Media Card File Previously Loaded (11.036) shows the number of the last parameter file transferred from an NV Media Card to the drive. If defaults are subsequently reloaded *NV Media Card File Previously Loaded* (11.036) is set to 0.

11.037	**NV Media Card File Number**								
RO	Num								
⇳	0 to 999				⇨	0			

NV Media Card File Number (11.037) is used to select a file by its file identification number and can only be changed to values that correspond to files that are recognized by the drive on the NV media card or a value of 0. When *NV Media Card File Number* (11.037) corresponds to the number of a file the following data about the file is shown.

Parameter
NV Media Card File Type (11.038)
NV Media Card File Version (11.039)
NV Media Card File Checksum (11.040)

The actions of erasing a card, erasing a file, creating a new file, changing a Menu 0 parameter or removing a card resets *NV Media Card File Number* (11.037) to 0.

11.038	**NV Media Card File Type**								
RO	Txt				ND	NC	PT		
⇳	None (0), Open-loop (1), RFC-A (2), RFC-S (3), Regen (4), User Prog (5), Option App (6)				⇨				

NV Media Card File Type (11.038) shows the file type of the file selected with *NV Media Card File Number* (11.037) as shown in the table below.

NV Media Card File Type (11.038)	File
0	No file selected
1	Open-loop mode parameter file
2	RFC-A mode parameter file
3	RFC-S mode parameter file
4	Regen mode parameter file
5	Onboard user program file
6	Option module applications file

11.039	**NV Media Card File Version**								
RO	Num				ND	NC	PT		
⇕	0 to 9999				⇨				

NV Media Card File Version (11.039) shows the version number stored with the file selected with *NV Media Card File Number* (11.037).

To set a file version number on a NV media card, the number required must be set in *NV Media Card File Required Version* (11.077) and then the data must be written to the NV media card. Failure to do this will result in no version number being displayed when selecting the NV media card file number in *NV Media Card File Number* (11.037).

11.040	**NV Media Card File Checksum**								
RO	Num				ND	NC	PT		
⇕	-2147483648 to 2147483647				⇨				

NV Media Card File Checksum (11.040) shows the checksum from the file selected with *NV Media Card File Number* (11.037). If the media file is a Unidrive SP SMARTCARD file, the checksum is (Σ All bytes except the checksum) modulo 65536. If the file was generated by a Unidrive M, a value of zero will be displayed.

11.042	**Parameter Cloning**								
RW	Txt					NC			US
⇕	None (0), Read (1), Program (2), Auto (3), Boot (4)				⇨	None (0)			

Value	Text
0	None
1	Read
2	Program
3*	Auto
4*	Boot

* Only a value of 3 or 4 in this parameter is saved.

Parameter Cloning (11.042) can also be used to initiate data transfer to or from an NV media card as described below for each possible value of this parameter.

1: Read

Provided a parameter file with file identification number 1 exists on the NV media card then setting *Parameter Cloning* (11.042) = 1 and initiating a drive reset will transfer the parameter data to the drive (i.e. the same action as writing 6001 to Pr **mm.000** (mm.000)). When the action is complete *Parameter Cloning* (11.042) is automatically reset to zero.

2: Program

Setting *Parameter Cloning* (11.042) and initiating a drive reset will transfer the parameter data from the drive to a parameter file with file identification number 1. This is the same action as writing 4001 to Pr **mm.000** (mm.000) except that the file will be overwritten if it already exists. When the action is complete *Parameter Cloning* (11.042) is automatically reset to zero.

3: Auto

Setting *Parameter Cloning* (11.042) = 3 and initiating a drive reset will transfer the parameter data from the drive to a parameter file with file identification number 1. This is the same action as writing 4001 to Pr **mm.000** (mm.000) except that the file will be overwritten if it already exists. When the action is complete *Parameter Cloning* (11.042) remains at 3.

If the card is removed when *Parameter Cloning* (11.042) = 3, then *Parameter Cloning* (11.042) is set to 0, which forces the user to change *Parameter Cloning* (11.042) back to 3 if auto mode is still required. The user will need to set *Parameter Cloning* (11.042) = 3 and initiate a drive reset to write the complete parameter set to the new card.

When a parameter in Menu zero is changed via the keypad and *Parameter Cloning* (11.042) = 3 the parameter is saved both to the drive non-volatile memory and to the parameter file with identification number 1 on the card. Only the new value of the modified parameter, and not the value of all the other drive parameters, is stored each time. If *Parameter Cloning* (11.042) is not cleared automatically when a card is removed, then when a new card is inserted that contains a parameter file with identification number 1 the modified parameter would be written to the existing file on the new card and the rest of the parameters in this file may not be the same as those in the drive.

When *Parameter Cloning* (11.042) = 3 and the drive parameters are saved to non-volatile memory, the file on the card is also updated, therefore this file becomes a copy of the drive parameters. At power up, if *Parameter Cloning* (11.042) = 3, the drive will save its complete parameter set to the card. This is done to ensure that if a card is inserted whilst the drive is powered down the new card will have the correct data after the drive is powered up again.

4: Boot

When *Parameter Cloning* (11.042) = 4 the drive operates in the same way as with *Parameter Cloning* (11.042) = 3 and automatically creates a copy of its parameters on the NV Media card. The NC (not clonable) attribute for *Parameter Cloning* (11.042) is 1, and so it does not have a value stored in the parameter file on the card in the normal way. However, the value of Parameter Cloning (11.042) is held in the parameter file header. If *Parameter Cloning* (11.042) = 4 in the parameter file with a file identification value of 1 on an NV media card fitted to a drive at power-up then the parameters from the parameter file with file identification number 1 are transferred to the drive and then saved in non-volatile memory. *Parameter Cloning* (11.042) is then set to 0 after the data transfer is complete.

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

When the drive is powered up it detects which option modules are fitted before loading parameters from an NV media card which has been set up for boot mode. If a new option module has been fitted since the last time the drive was powered up, a Slot1 Different trip is initiated and then the parameters are transferred from the card. If the parameter file includes the parameters for the newly fitted option module then these are also transferred to the drive and the Slot1 Different trip is reset. If the parameter file does not include the parameters for the newly fitted option module then the drive does not reset the Slot1 Different trip. Once the transfer is complete the drive parameters are saved to non-volatile memory. The trip can be reset either by initiating a drive reset or by powering down and then powering up again.

<table>
<tr><th colspan="2">11.043</th><th colspan="8">Load Defaults</th></tr>
<tr><td>RW</td><td>Txt</td><td></td><td></td><td></td><td></td><td>NC</td><td></td><td></td><td></td></tr>
<tr><td>⇳</td><td colspan="4">None (0), Standard (1), US (2)</td><td>⇨</td><td colspan="4">None (0)</td></tr>
</table>

Value	Text
0	None
1	Standard
2	US

If *Load Defaults* (11.043) is non-zero and a drive reset is initiated then the drive will load and save default parameters. If *Load Defaults* (11.043) = 1 then 50Hz defaults are loaded and if *Load Defaults* (11.043) = 2 then 60 Hz defaults are loaded. This parameter has priority over actions defined by Pr **mm.000** (mm.000) and *Parameter Cloning* (11.042). If *Load Defaults* (11.043) is used to initiate loading defaults the it is cleared along with Pr **mm.000** (mm.000) and *Parameter Cloning* (11.042) when the action is completed.

<table>
<tr><th colspan="2">11.044</th><th colspan="8">User Security Status</th></tr>
<tr><td>RW</td><td>Txt</td><td></td><td></td><td></td><td></td><td>NC</td><td></td><td></td><td></td></tr>
<tr><td>⇳</td><td colspan="4">Menu 0 (0), All Menus (1),
Read-only Menu 0 (2), Read-only (3),
Status Only (4), No Access (5)</td><td>⇨</td><td colspan="4"></td></tr>
</table>

Security

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

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

When security has been set up the drive can either be in the locked or unlocked state. In the locked state the security level that has been set up applies. In the unlocked state the security is not active, but when the drive is powered down and powered up again the drive will be in the locked state. The drive may be re-locked without powering down by selecting the required security level with the *User Security Status* (11.044) and initiating a drive reset.

Security can be set up as follows:

1. The *User Security Code* (11.030) should be set to the desired security unlock code (not zero). For security to remain set after power down then a parameter save should be performed to retain the set value.
2. If no further action is taken when the drive is powered down and then powered up read-only security will be set up and locked.
3. If at any time the *User Security Status* (11.044) is set to a value corresponding the one of the security levels shown in the table above and a drive reset is performed the security level is changed to that level. The desired security level is automatically saved and retained after power down, the keypad state changes to status mode and security is locked. (The security level that is active, provided *User Security Code* (11.030) has been saved as a non-zero value, if shown in *Security Status* (11.085).

When security is set up and locked:

1. Parameter access is restricted as shown in the table above.
2. *User Security Code* (11.030) reads as zero except in parameter edit mode. Therefore it is not possible to read the value of the security code when any level of security is active and locked.

Security can be unlocked as follows:

1. If read-only security is set and locked then any attempt to edit any read/write parameter causes "Security code" to be displayed on the first row of the display. When the Up or Down keys are pressed the second row shows the code being adjusted. On setting the code the user presses the Enter key. If the correct code has been entered then the drive switches to Parameter edit mode on the parameter the user selected to edit, but if the correct code has not been entered the notification "Incorrect security code" is displayed for 2 s and the drive returns to Parameter view mode.
2. If Status only or No access security is set and locked then any attempt to leave status mode causes the security code to be requested as per the process described above. If the security code entered must be correct for the keypad state machine to switch to the Parameter view mode. It is then possible to access all parameters normally.

Security can be cleared as follows:

1. Security must be unlocked.
2. The *User Security Code* (11.030) should be set to zero. For security to remain cleared after power down then a parameter save should be performed.

At any time *Security Status* (11.085) can be changed between 0 and 1 to restrict access to Menu 0 alone or to all menus. If the change is made by a keypad the new value becomes active on leaving parameter edit mode.

It should be that *Security Status* (11.085) is a volatile parameter and that the actual state of the security system is stored in *Security Status* (11.085) and *Menu Access Status* (11.086), which are both power-down save parameters. Therefore the security status will be stored when the drive goes into the under-voltage state. If the drive is already in the under-voltage state the security state should be saved by writing 1000 to Pr **mm.000** (mm.000) and initiating a reset.

11.045		**Select Motor 2 Parameters**							
RW	Txt								US
⇕	0 to 1				⇨	0			

11.046		**Defaults Previously Loaded**							
RO	Num				ND	NC	PT		US
⇕	0 to 2000				⇨				

Defaults Previously Loaded (11.046) shows the value used to load the previously loaded defaults (i.e. 1233 for 50 Hz defaults, or 1244 for 60 Hz defaults).

11.047		**Onboard User Program: Enable**							
RW	Txt								US
⇕	Stop (0), Run (1)				⇨	Run (1)			

Onboard user programming provided a background task that loops continuously and a timed task that is executed each time at a defined rate.

Onboard User Program: Enable (11.047) allows the onboard user program to the stopped or run.

0: Stop

The onboard user program is stopped. If it is restarted by setting *Onboard User Program: Enable* (11.047) to a non-zero value the background task starts from the beginning.

1: Run

The onboard user program will run.

11.048		**Onboard User Program: Status**							
RO	Num				ND	NC	PT		
⇕	-2147483648 to 2147483647				⇨	Run (1)			

Onboard User Program: Status (11.048) shows the status of the onboard user program.

Value	Description
0	A user program is present but is stopped
1	The user program is running
2	The user program has an exception
3	No user program is present

11.049	**Onboard User Program: Programming Events**								
RO	Num				ND	NC	PT		
⇳	0 to 65535				⇨				

Onboard User Program: Programming Events (11.049) = 0 when the drive is manufactured and is incremented each time an onboard user program image is written to the drive. If an onboard user program image is written more than 65535 times *Onboard User Program: Programming Events* (11.049) = 65535. *Onboard User Program: Programming Events* (11.049) shows how many times the flash memory within the drive has been reprogrammed.

11.050	**Onboard User Program: Freewheeling Tasks Per Second**								
RO	Num				ND	NC	PT		
⇳	0 to 65535				⇨				

During each scan in a freewheeling task it is possible to give an indication to the drive that the scan loop is starting. If this indication is given then Onboard User Program: *Freewheeling Tasks Per Second* (11.050) will give the number of times this indication is given per second.

11.051	**Onboard User Program: Clock Task Time Used**								
RO	Num				ND	NC	PT		
⇳	0.0 to 100.0 %				⇨				

Onboard User Program: Clock Task Time Used (11.051) shows the percentage of the available time used by the onboard user program clock task.

11.052	**Serial Number LS**								
RO	Num				ND	NC	PT		
⇳	0 (Display: 000000000) to 999999999 (Display: 999999999)				⇨				

The drive serial number is available as a pair of 32 bit values where *Serial Number LS* (11.052) provides the least significant 9 decimal digits and *Serial Number MS* (11.053) provides the most significant 9 decimal digits. The reconstructed serial number is ((11.053 x 1000000000) + 11.052).

Example 1

Serial number "1234567898765" would be stored as 11.053 = 1234, 11.052 = 567898765.

Example 2

Serial number "1234000056789" would be stored as 11.053 = 1234, 11.052 = 56789. *Serial Number LS* (11.052) will be shown on the keypad as 000056789 (i.e. including the leading zeros).

11.053	**Serial Number LS**								
RO	Num				ND	NC	PT		
⇳	0 to 999999999				⇨				

See *Serial Number LS* (11.052).

11.054	**Drive Date Code**								
RO	Num				ND	NC	PT		
⇳	0 to 65535				⇨				

Drive Date Code (11.054) is a four-digit number in the form yyww where yy is the year and ww the week number.

11.055	**Onboard User Program: Clock Task Scheduled Interval**								
RO	Num				ND	NC	PT		
⇳	0 to 262140 ms				⇨				

Onboard User Program: Clock Task Scheduled Interval (11.055) shows the interval at which the clock task is scheduled to run at in ms.

11.056	**Option Slot Identifiers**								
RW	Txt						PT		
⇳	1234 (0), 1243 (1), 1324 (2), 1342 (3), 1423 (4), 1432 (5), 4123 (6), 3124 (7), 4132 (8), 2134 (9), 3142 (10), 2143 (11), 3412 (12), 4312 (13), 2413 (14), 4213 (15), 2314 (16), 3214 (17), 2341 (18), 2431 (19), 3241 (20), 3421 (21), 4231 (22), 4321 (23)	⇨	1234 (0)						

If *Option Slot Identifiers* (11.056) is set to its default value of 0 each option module is assigned the same slot number as its physical slot. For example the module in physical slot 1 appears in slot 1 to all drive and option module software systems (i.e. it uses Menu 15 as its set-up menu and Menu 25 as its application menu etc). This arrangement can be changed by selecting a different value for *Option Slot Identifiers* (11.056). Although *Option Slot Identifiers* (11.056) is a volatile parameter its value is saved in non-volatile memory when parameters are saved. If *Option Slot Identifiers* (11.056) is changed the drive must be powered down and then powered up again for the change to take effect.

11.060	**Maximum Rated Current**								
RO	Num				ND	NC	PT		
⇳	0.000 to 99999.999 A	⇨							

Maximum Rated Current (11.060) defines the variable maximum VM_RATED_CURRENT[MAX] which defines the *Maximum Rated Current* (05.007). Therefore *Maximum Rated Current* (11.060) is the maximum rated current for normal duty operation (if normal duty operation is allowed).

11.061	**Full Scale Current Kc**								
RO	Num				ND	NC	PT		
⇳	0.000 to 99999.999 A	⇨							

Full Scale Current Kc (11.061) shows the full scale current in r.m.s. Amps. If the drive current exceeds this level it will cause an over current trip.

11.062	**Power Board Software Version Number**								
RO	Num				ND	NC	PT		
⇳	0.00 to 99.99	⇨							

Power Board Software Version Number (11.062) gives the version for the power board connected to the control board or the power board in node 1 of a multi-power module drive.

11.063	**Product Type**								
RO	Num				ND	NC	PT		
⇳	0 to 255	⇨							

Product Type (11.063) shows the core product type as given in the table below. The drive could be the basic product or a derivative of the basic product as defined by *Drive Derivative* (11.028).

Product Type (11.063)	**Core Product Range**
0	Unidrive M

11.064	**Product Identifier Characters**								
RO	Num				ND	NC	PT		
⇳	1295396912 to 2147483647	⇨							

Example

The model number M700-03400078 A001 00 AB100 would be displayed in parameters as follows:

Parameter	**Value**
Product Identifier Characters (11.064)	M700
Drive Rating And Configuration (11.065)	03400078
Additional Identifier Characters 1 (11.091)	A001
Additional Identifier Characters 2 (11.092)	00AB
Additional Identifier Characters 3 (11.093)	100-

11.065	**Drive Rating And Configuration**								
RO	Num				ND	NC	PT		
⇕	0 (Display: 00000000) to 99999999 (Display: 99999999)				⇨				

Drive Rating And Configuration (11.065) is split into a number of fields as defined in the table below.

Digits	Meaning
7 and 6	Frame size
5	Voltage code (2 = 200 V, 4 = 400 V, 5 = 575 V, 6 = 690 V)
4 and 0	Current rating multiplied by 10. If the drive has a heavy and normal duty rating (i.e. *Maximum Heavy Duty Rating* (11.032) > 0 and *Maximum Rated Current* (11.060) > *Maximum Heavy Duty Rating* (11.032), or the drive only has a heavy duty rating (i.e. *Maximum Heavy Duty Rating* (11.032) = *Maximum Rated Current* (11.060), then the current rating is derived from *Maximum Heavy Duty Rating* (11.032). Otherwise if the drive only has a normal duty rating (i.e. *Maximum Heavy Duty Rating* (11.032) = 0) then the current rating is derived from *Maximum Rated Current* (11.060)

11.066	**Power Stage Identifier**								
RO	Num				ND	NC	PT		
⇕	0 to 255				⇨				

Power Stage Identifier (11.066) is used to show power stages that require changes to the drive user parameters (i.e. visibility, range or defaults). It should be noted that this parameter does not identify the rating of the power stage.

***Power Stage Identifier* (11.066)**	Power Stage
0	Standard Unidrive M
1	Unidrive M with no braking IGBT
2	Servo drive

11.067	**Control Board Identifier**								
RO	Num				ND	NC	PT		
⇕	0.000 to 65.535				⇨				

Control Board Identifier (11.067) identifies the control board hardware in the form A.BBB. BBB is the hardware identifier from the control board and A indicates whether this is a standard or high speed product as given in the table below.

A	BBB	Control Board
0	002 or 003	Unidrive M - Standard
1	002 or 003	Unidrive M - High Speed
0	004	Servo

11.068	**Internal I/O Identifier**								
RO	Num				ND	NC	PT		
⇕	0 to 255				⇨				

Internal I/O Identifier (11.068) identifies the internally fitted I/O option as given in the table below.

Internal I/O Identifier (11.068)	Internal I/O
0	Analog and digital I/O
1	Digtial only I/O
2	Analog and digital I/O with additional relay
3	Servo drive I/O

The tables below show which I/O functions are available for each of the internally fitted I/O options.

AI/O	0	1	2	3
Analog Input 1	All except Disable	All except Disable		Voltage
Analog Input 2	All except Disable	All except Disable		
Analog Input 3	Voltage, Thermistor	Voltage	Thermistor, Disable	
Analog Output 1	Voltage	All		
Analog Output 2	Voltage	All		

DI/O	Function	0	1	2	3
1	Input/Output	Input/Output	Output	Input/Output	Output
2	Input/Output	Input/Output	Output	Input/Output	Output
3	Input/Output	Input/Output		Input/Output	
4	Input	Input	Input	Input	Input
5	Input	Input	Input	Input	Input
6	Input	Input		Input	
7	Relay Output	Output	Output	Output	
8	24V Supply Output	Output	Output	Output	Output
9	Safe Torque Off 1	Input	Input	Input	Input
10	Safe Torque Off 2	Input*	Input	Input*	Input
11	Keypad Run Button	Input	Input	Input	
12	Keypad Auxiliary Button	Input	Input	Input	
13	24V Supply Input	Input	Input	Input	
14	Keypad Stop Button	Input	Input	Input	
15	Relay 2 Output			Output	
16	Reset button				Input

* Only one hardware input is provided which is shared by STO1 and STO2.

11.069	**Position Feedback Interface Identifier**								
RO	Num				ND	NC	PT		
⇳	0 to 255				⇨				

11.070	**Core Parameter Database Version**								
RO	Num				ND	NC	PT		
⇳	0.00 to 99.99				⇨				

Core Parameter Database Version (11.070) gives the version number of the parameter database used to define the core parameter menus in the drive (Menu 1 to 14 and 21 to 23) in 2 digit BCD format. All other menus are customizable and if these menus are changed their default values are automatically loaded. However, if the drive software is changed it may be necessary to load defaults for all menus, although this will only be required rarely. Defaults for all menus are loaded when the most significant digit of *Core Parameter Database Version* (11.070) changes. Therefore if the drive firmware is modified and the most significant digit of the core database version has changed an EEPROM Fail.001 trip is initiated and default parameters are loaded.

11.071	**Number Of Power Modules Detected**								
RO	Num				ND	NC	PT		US
⇳	0 to 20				⇨				

Number Of Power Modules Detected (11.071) shows the number of power modules detected in a drive. See *Number Of Power Modules Test* (11.035) for details.

11.072	**NV Media Card Create Special File**								
RW	Num					NC			
⇳	0 to 1				⇨	0			

If *NV Media Card Create Special File* (11.072) = 1 when a parameter file is transferred to an NV media card the file is created as a macro file. *NV Media Card Create Special File* (11.072) is reset to 0 after the file is created or the transfer fails.

11.073		**NV Media Card Type**							
RO	Txt				ND	NC	PT		
⇕	0 to 2				⇨				

Value	Text	Description
0	None	No media card has been inserted
1	SMARTCARD	A SMARTCARD has been inserted
2	SD Card	A FAT formatted SD card has been inserted

NV Media Card File Type (11.038) shows the type of non-volatile media card inserted in the drive.

11.075		**NV Media Card Read-only Flag**							
RO	Bit				ND	NC	PT		
⇕	Off (0) or On (1)				⇨				

NV Media Card Read-only Flag (11.075) shows the state of the read-only flag for the currently fitted card.

11.076		**NV Media Card Read-only Flag**							
RO	Bit				ND	NC	PT		
⇕	Off (0) or On (1)				⇨				

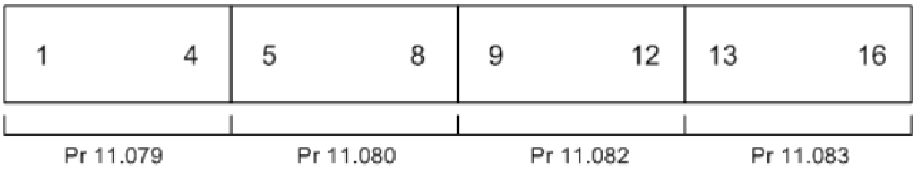
NV Media Card Warning Suppression Flag (11.076) shows the state of the warning flag for the currently fitted card.

11.077		**NV Media Card File Required Version**							
RW	Num				ND	NC	PT		
⇕	0 to 999				⇨				

The value of *NV Media Card File Required Version* (11.077) is used as the version number for a file when it is created on an NV media card. *NV Media Card File Required Version* (11.077) is reset to 0 when the file is created or the transfer fails.

11.079		**Drive Name Characters 1-4**							
RW	Num						PT		US
⇕	-2147483648 to 2147483647				⇨				

Drive Name Characters 1-4 (11.079) to *Drive Name Characters 13-16* (11.082) can be used to store a 16 character string which can be used to identify the drive. The string is arranged as shown below.



This uses the standard ASCII character set.

11.080		**Drive Name Characters 5-8**							
RW	Num						PT		US
⇕	-2147483648 to 2147483647				⇨				

See *Drive Name Characters 1-4* (11.079).

11.081		**Drive Name Characters 9-12**							
RW	Num						PT		US
⇕	-2147483648 to 2147483647				⇨	0			

See *Drive Name Characters 1-4* (11.079).

11.082		**Drive Name Characters 13-16**							
RW	Num						PT		US
⇳	-2147483648 to 2147483647				⇨	0			

See *Drive Name Characters 1-4* (11.079).

11.084		**Drive Mode**							
RO	Txt				ND	NC	PT		US
⇳	Open-loop (1), RFC-A (2), RFC-S (3), Regen (4)				⇨				

Drive Mode (11.084) is used to hold the currently active drive mode.

11.085		**Security Status**							
RO	Txt				ND	NC	PT		PS
⇳	None (0), Read-only (1), Status-only (2), No Access (3)				⇨				

Value	Text
0	None
1	Read-only
2	Status-only
3	No Access

Security Status (11.085) shows the security that will apply when security is enabled by setting a non-zero value for *User Security Code* (11.030).

11.086		**Menu Access Status**							
RO	Txt				ND	NC	PT		PS
⇳	Menu 0 (0), All Menus (1)				⇨				

If *Menu Access Status* (11.086) = 0 then only Menu 0 can be accessed with a keypad. If *Menu Access Status* (11.086) = 1 then all menus can be accessed with a keypad.

11.090		**Keypad Port Serial Address**							
RW	Num								US
⇳	1 to 16				⇨	1			

Keypad Port Serial Address (11.090) defines the node address for the keypad port serial comms interface. Normally the default value of 1 is used, but this can be changed if required. The keypad attached to the port will sense the address automatically.

11.091		**Additional Identifier Characters 1**							
RO	Num				ND	NC	PT		
⇳	-2147483648 to 2147483647				⇨				

See *Product Identifier Characters* (11.064).

11.092		**Additional Identifier Characters 2**							
RO	Num				ND	NC	PT		
⇳	-2147483648 to 2147483647				⇨				

See *Product Identifier Characters* (11.064).

11.093		**Additional Identifier Characters 3**							
RO	Num				ND	NC	PT		
⇳	-2147483648 to 2147483647				⇨				

See *Product Identifier Characters* (11.064).

11.095		**Number Of Rectifiers Detected**							
RO	Num				ND	NC	PT		
⇳	0 to 9				⇨				

Indicates how many controlled rectifiers connected to the drive have been detected. See *Number Of Rectifiers Expected* (11.096).

11.096		**Number Of Rectifiers Expected**							
RW	Num								US
⇳	0 to 9				⇨	0			

Number Of Rectifiers Expected (11.096) defines how many controlled rectifiers are expected on each power module. Within a complete drive with a diode input stage there are no controlled rectifiers. Within a complete drive with a controlled rectifier input stage there is one controlled rectifier. For a drive where external rectifiers are used the system can register up to nine controlled rectifiers. If *Number Of Rectifiers Expected* (11.096) = 0 then the rectifier monitoring system is disabled and the drive does not check how many controlled rectifiers are present. This is the default setting and should be used for complete drives with internal rectifiers because the monitoring function is not necessary. If *Number Of Rectifiers Expected* (11.096) is set to a non-zero value a check is made to ensure that at least this number of external rectifiers are connected to each power module. If there are less external rectifiers than defined by *Number Of Rectifiers Expected* (11.096) then a Configuration is initiated with the sub-trip indicating how many rectifiers should be present. See *Trip 0* (10.020).

9.12 Menu 12: Threshold detectors and variable selectors

Figure 9-17 Menu 12 logic diagram

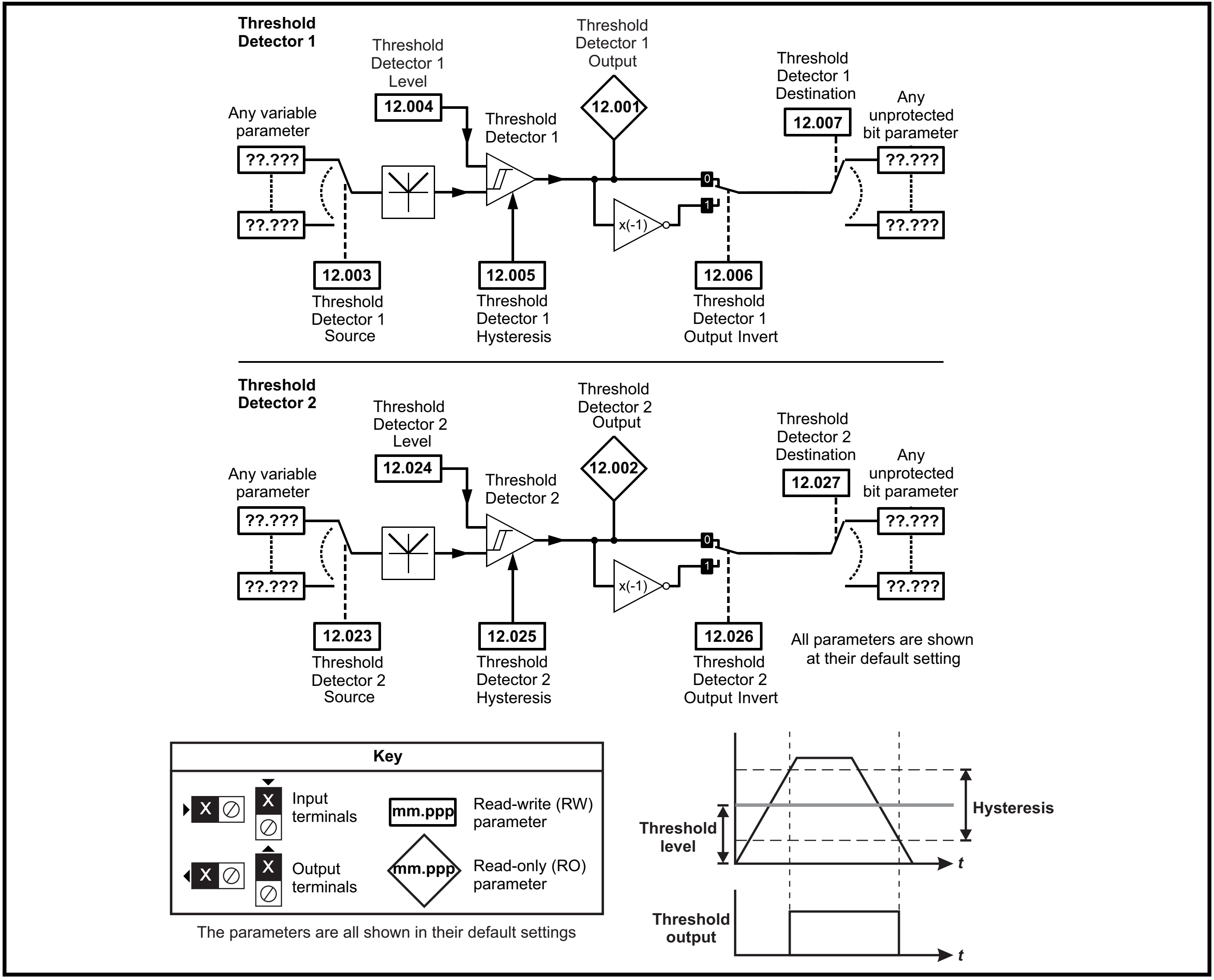


Figure 9-18 Menu 12 logic diagram (continued)

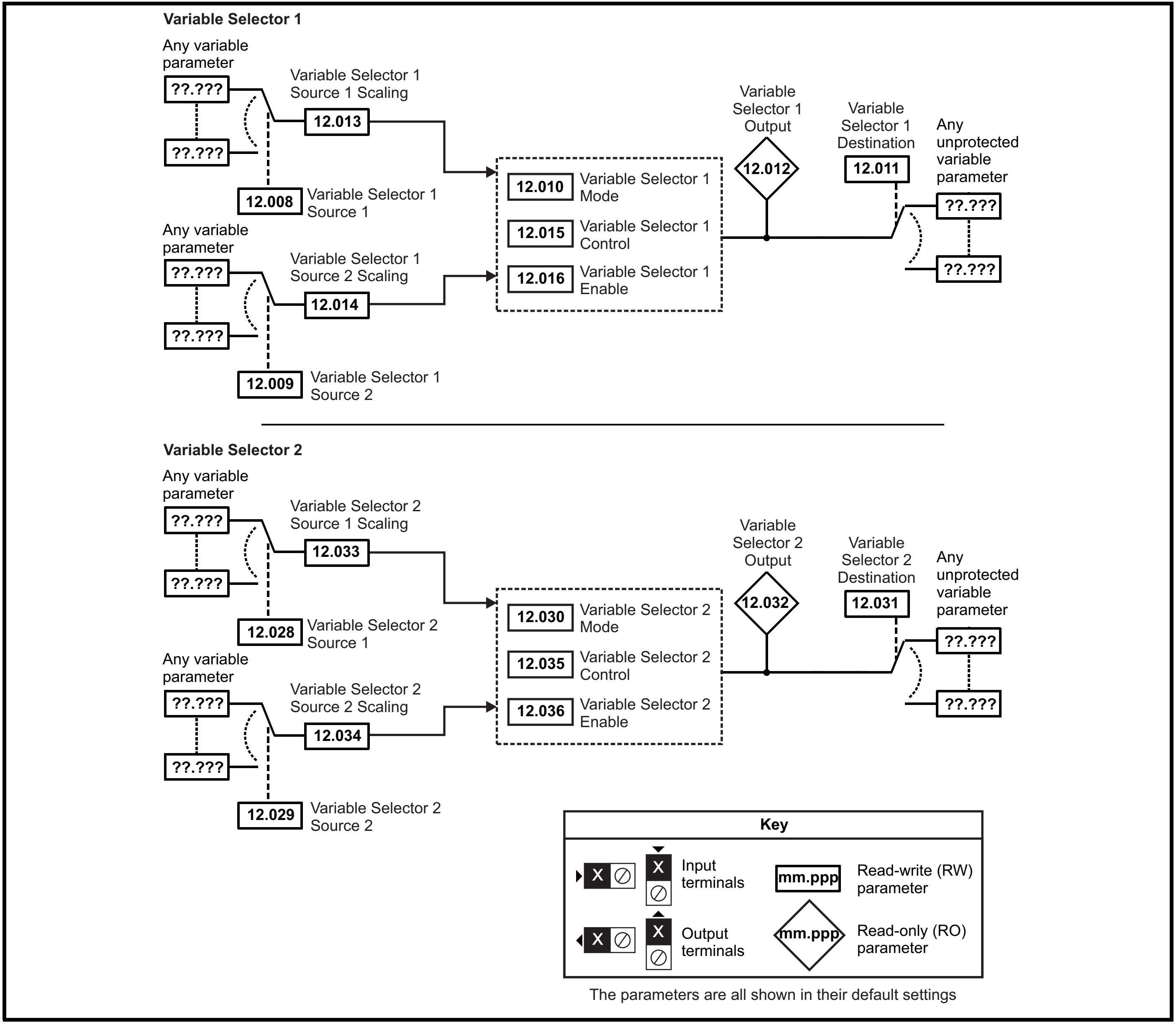


Table 9-15 Menu 12 Regen parameter descriptions

Parameter		Range	Default	Type					
12.001	Threshold Detector 1 Output	Off (0) or On (1)		RO	Bit	ND	NC	PT	
12.002	Threshold Detector 2 Output	Off (0) or On (1)		RO	Bit	ND	NC	PT	
12.003	Threshold Detector 1 Source	0.000 to 59.999	0.000	RW	Num			PT	US
12.004	Threshold Detector 1 Level	0.00 to 100.00 %	0.00 %	RW	Num				US
12.005	Threshold Detector 1 Hysteresis	0.00 to 25.00 %	0.00 %	RW	Num				US
12.006	Threshold Detector 1 Output Invert	Off (0) or On (1)	Off (0)	RW	Bit				US
12.007	Threshold Detector 1 Destination	0.000 to 59.999	0.000	RW	Num	DE		PT	US
12.008	Variable Selector 1 Source 1	0.000 to 59.999	0.000	RW	Num			PT	US
12.009	Variable Selector 1 Source 2	0.000 to 59.999	0.000	RW	Num			PT	US
12.010	Variable Selector 1 Mode	Input 1 (0), Input 2 (1), Add (2), Subtract (3), Multiply (4), Divide (5), Time Const (6), Ramp (7), Modulus (8), Powers (9), Sectional (10)	Input 1 (0)	RW	Txt				US
12.011	Variable Selector 1 Destination	0.000 to 59.999	0.000	RW	Num	DE		PT	US
12.012	Variable Selector 1 Output	±100.00 %		RO	Num	ND	NC	PT	
12.013	Variable Selector 1 Source 1 Scaling	±4.000	1.000	RW	Num				US
12.014	Variable Selector 1 Source 2 Scaling	±4.000	1.000	RW	Num				US
12.015	Variable Selector 1 Control	0.00 to 100.00	0.00	RW	Num				US
12.016	Variable Selector 1 Enable	Off (0) or On (1)	On (1)	RW	Bit				US
12.023	Threshold Detector 2 Source	0.000 to 59.999	0.000	RW	Num			PT	US
12.024	Threshold Detector 2 Level	0.00 to 100.00	0.00	RW	Num				US
12.025	Threshold Detector 2 Hysteresis	0.00 to 25.00	0.00	RW	Num				US
12.026	Threshold Detector 2 Output Invert	Off (0) or On (1)	Off (0)	RW	Bit				US
12.027	Threshold Detector 2 Destination	0.000 to 59.999	0.000	RW	Num	DE		PT	US
12.028	Variable Selector 2 Source 1	0.000 to 59.999	0.000	RW	Num			PT	US
12.029	Variable Selector 2 Source 2	0.000 to 59.999	0.000	RW	Num			PT	US
12.030	Variable Selector 2 Mode	Input 1 (0), Input 2 (1), Add (2), Subtract (3), Multiply (4), Divide (5), Time Const (6), Ramp (7), Modulus (8), Powers (9), Sectional (10)	Input 1 (0)	RW	Txt				US
12.031	Variable Selector 2 Destination	0.000 to 59.999	0.000	RW	Num	DE		PT	US
12.032	Variable Selector 2 Output	±100.00 %		RO	Num	ND	NC	PT	
12.033	Variable Selector 2 Source 1 Scaling	±4.000	1.000	RW	Num				US
12.034	Variable Selector 2 Source 2 Scaling	±4.000	1.000	RW	Num				US
12.035	Variable Selector 2 Control	0.00 to 100.00	0.00	RW	Num				US
12.036	Variable Selector 2 Enable	Off (0) or On (1)	On (1)	RW	Bit				US

12.001	**Threshold Detector 1 Output**								
RO	Bit				ND	NC	PT		
⇳	Off (0) or On (1)				⇨				

The threshold detector functions are always active even if the source and destination are not routed to valid parameters. If the source is not a valid parameter then the source value is taken as 0. The update rate for each of the threshold detector functions is always 4 ms.

The following description is for threshold detector 1, but threshold detector 2 operates in the same way. The level of the parameter defined by *Threshold Detector 1 Source* (12.003) is converted to a percentage and compared to *Threshold Detector 1 Level* (12.004) with hysteresis to give *Threshold Detector 1 Output* (12.001) as follows:

Source	Threshold Detector 1 Output (12.001)
Source	0
Lower threshold ≤ Source	No change of state
Source ≥ Upper threshold	1

Lower threshold = *Threshold Detector 1 Level* (12.004) - *Threshold Detector 1 Hysteresis* (12.005)

Upper threshold = *Threshold Detector 1 Level* (12.004) + *Threshold Detector 1 Hysteresis* (12.005)

The output value can then be inverted with *Threshold Detector 1 Output Invert* (12.006) before being routed to the destination defined by *Threshold Detector 1 Destination* (12.007).

12.002		**Threshold Detector 2 Output**							
RO	Bit				ND	NC	PT		
⇕	Off (0) or On (1)				⇨				

12.003		**Threshold Detector 1 Source**							
RW	Num						PT		US
⇕	0.000 to 59.999				⇨	0.000			

12.004		**Threshold Detector 1 Level**							
RW	Num								US
⇕	0.00 to 100.00				⇨	0.00			

12.005		**Threshold Detector 1 Hysteresis**							
RW	Num								US
⇕	0.00 to 25.00				⇨	0.00			

12.006		**Threshold Detector 1 Output Invert**							
RW	Bit								US
⇕	Off (0) or On (1)				⇨	Off (0)			

12.007		**Threshold Detector 1 Destination**							
RW	Num						PT		US
⇕	0.000 to 59.999				⇨	0.000			

12.008		**Variable Selector 1 Source 1**							
RW	Num						PT		US
⇕	0.000 to 59.999				⇨	0.000			

The variable selector functions are always active even if the source and destination are not routed to valid parameters. If a source is not a valid parameter then the source value is taken as 0. The update rate for each of the variable selector functions is always 4 ms.

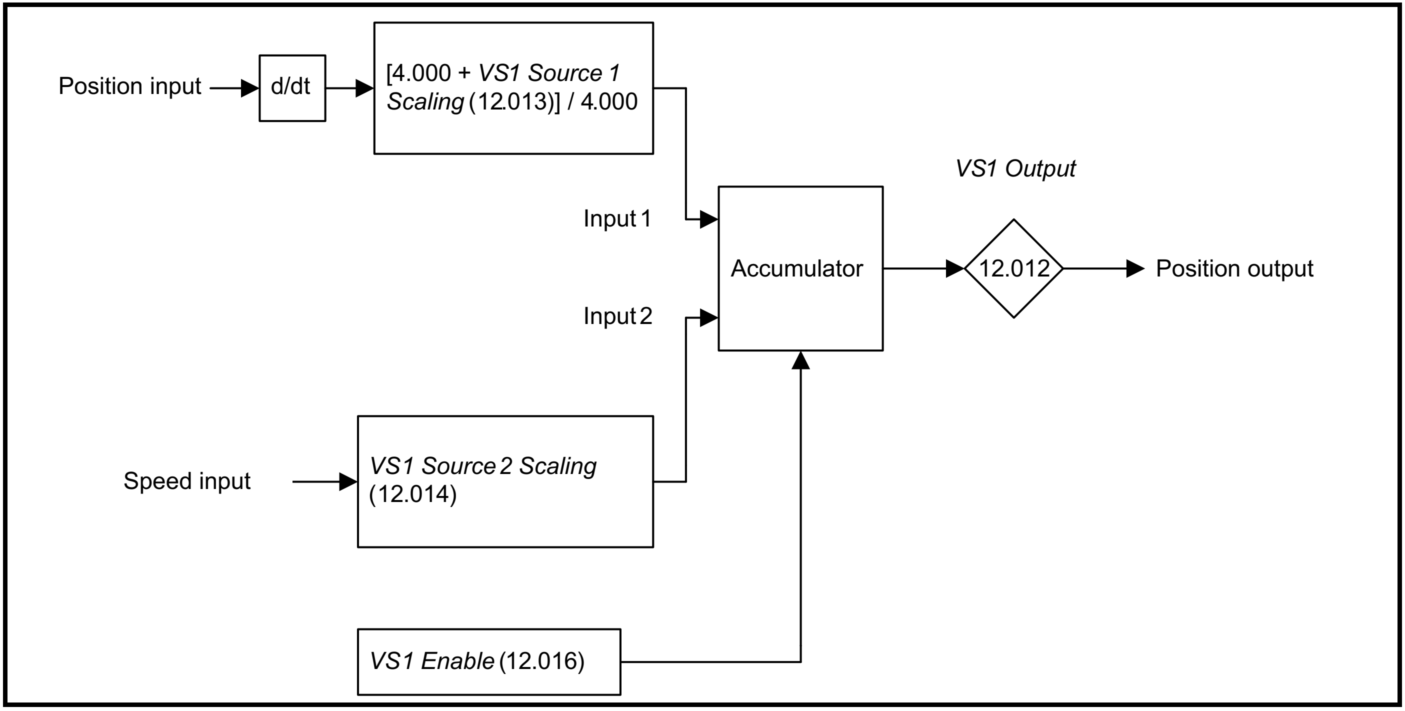
The following description is for variable selector 1, but variable selector 2 operates in the same way. The source parameters selected with *Variable Selector 1 Source 1* (12.008) and *Variable Selector 1 Source 2* (12.009) are converted to a percentage value, scaled with *Variable Selector 1 Source 1 Scaling* (12.013) and *Variable Selector 1 Source 2 Scaling* (12.014) respectively and then combined with a function defined by *Variable Selector 1 Mode* (12.010) to give *Variable Selector 1 Output* (12.012) as a percentage value. If *Variable Selector 1 Enable* (12.016) = 1 then the function operates normally. If *Variable Selector 1 Enable* (12.016) = 0 then *Variable Selector 1 Output* (12.012) = 0.00 % and any states within the function are reset (i.e. the time constant function accumulator is held at zero). If the value of *Variable Selector 1 Mode* (12.010) is changed then all internal function state are also reset.

The table below shows the functions that can be selected with *Variable Selector 1 Mode* (12.010).

***Variable Selector 1 Mode* (12.010)**	***Variable Selector 1 Output* (12.012)**
0: Input 1	Input 1
1: Input 2	Input 2
2: Add	Input 1 + Input 2
3: Subtract	Input 1 - Input 2
4: Multiply	(Input 1 x Input 2) / 100.00 %
5: Divide	(Input 1 x 100.00 %) / Input 2
6: Time Const	Input 1 / (1 + τs) where τ = *Variable Selector 1 Control* (12.015) seconds
7: Ramp	Input 1 as an input to a linear ramp function where the time to ramp from 0.00 % to 100.00 % is defined by *Variable Selector 1 Control* (12.015) seconds
8: Modulus	Input1
9: Powers	If *Variable Selector 1 Control* (12.015) = 0.02 then Input^2 / 100.00 % Else if *Variable Selector 1 Control* (12.015) = 0.03 then Input^3 / 100.00 % Else Input 1
10: Sectional	See description below

Sectional Controller

If *Variable Selector 1 Mode* (12.010) = 10 then the variable selector can be used to provide a sectional control function. (Variable selector 2 operates in the same way.) The sectional control function is intended to apply scaling and a speed offset to a 16 bit position value to generate a new 16 bit position value. The output can be used as an input to the Standard motion controller (Menu 13) and to generate an encoder simulation output (Menu 3).



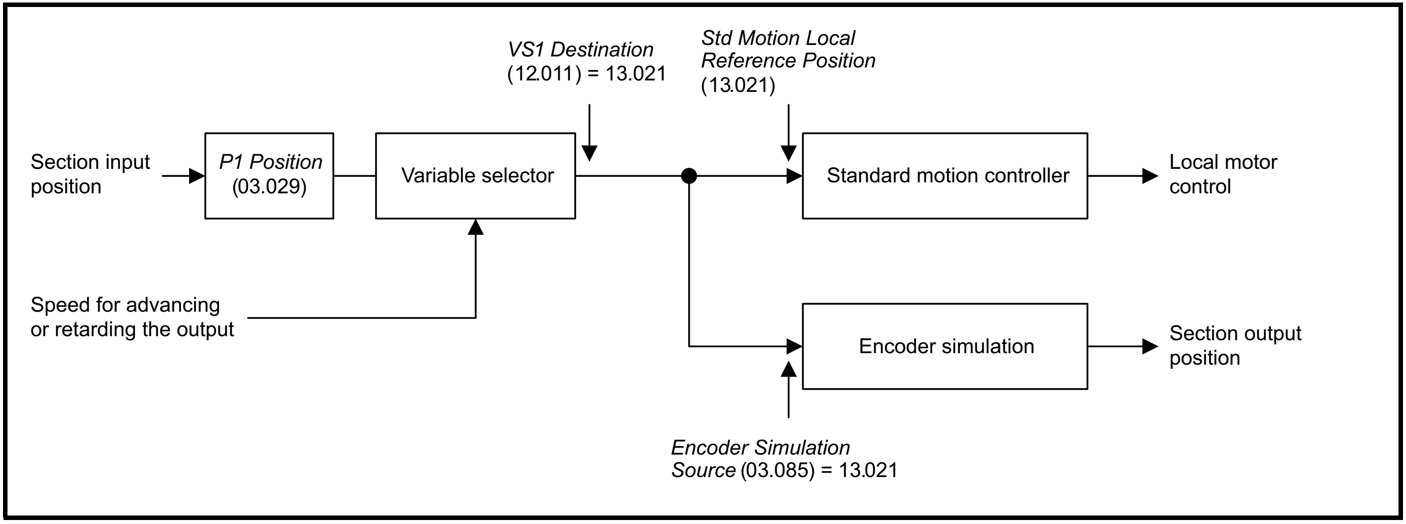
The position input is selected with *Variable Selector 1 Source 1* (12.008) and can be derived from any parameter. However, it is intended to be used with a position value that has a range from 0 to 65535 (e.g. *P1 Position* (03.029)). The input is scaled so that as Variable Selector 1 Source 1 Scaling (12.013) is changed between -4.000 and 4.000 so the proportion of the input position change added to the accumulator varies from 0.000 to 2.000 (i.e. the change of position input value is added without scaling if *Variable Selector 1 Source 1 Scaling* (12.013) = 0.000). The remainder from the scaling division is stored and then added at the next sample to maintain an exact ratio between the position input and the position output, provided the speed from source 2 is zero. The controller only takes the change of position from the input source parameter, and not the absolute value, so that when the controller is first made active the output does not jump to the source position, but only moves with any changes of source position after that point in time.

The range of *Variable Selector 1 Output* (12.012) is 0.00 % and 100.00 %. Unlike other functions the value is not simply limited, but rolls under or over respectively. Although the output destination can be any parameter it is intended to be used with a position value that has a range from 0 to 65535.

The speed input defines a speed offset with a resolution of 0.1rpm. Full scale of the source parameter corresponds to 1000.0 rpm. Scaling may be applied using *Variable Selector 1 Source 2 Scaling* (12.014) to give a full scale value up to 4000.0 rpm. The speed input is added to the accumulator to move the output position forwards or backwards with respect to the position input.

The sample time for the variable selector is 4ms and the input or output position must not change by more than half a revolution over this time. Therefore the input or output speed must not exceed 7500 rpm.

The diagram below shows an example of how the sectional controller function could be configured. The section input position is provided from the previous section via the P1 position feedback interface. The destination of the variable selector is the Standard Motion Local Reference Position (13.021) in the standard motion controller which is used to provide the speed reference and to control the local motor attached to the drive.
The encoder simulation system is used to generate the section output to be fed into the next drive. The source for the encoder simulation is *Standard Motion Local Reference Position* (13.021).



12.009	**Variable Selector 1 Source 2**								
RW	Num						PT		US
⇳	0.000 to 59.999				⇨	0.000			

12.010	**Variable Selector 1 Mode**								
RW	Txt								US
⇳	0 to 10				⇨	0			

Value	Text
0	Input 1
1	Input 2
2	Add
3	Subtract
4	Multiply
5	Divide
6	Time Const
7	Ramp
8	Modulus
9	Powers
10	Sectional

12.011	**Variable Selector 1 Destination**								
RW	Num						PT		US
⇳	0.000 to 59.999				⇨	0.000			

12.012	**Variable Selector 1 Output**								
RO	Num				ND	NC	PT		
⇳	0.000 to 59.999				⇨	0.000			

12.013	**Variable Selector 1 Source 1 Scaling**								
RW	Num								US
⇕	-4.000 to 4.000				⇨	1.000			

12.014	**Variable Selector 1 Source 2 Scaling**								
RW	Num								US
⇕	-4.000 to 4.000				⇨	1.000			

12.015	**Variable Selector 1 Control**								
RW	Num								US
⇕	0.00 to 100.00				⇨	0.00			

12.016	**Variable Selector 1 Control**								
RW	Bit								US
⇕	Off (0) or On (1)				⇨	On (1)			

Variable Selector 1 Enable (12.016) and *Variable Selector 2 Enable* (12.036) have a default of 1 so that if these parameters are not used the variable selectors will still function.

12.023	**Threshold Detector 2 Source**								
RW	Num						PT		US
⇕	0.000 to 59.999				⇨	0.000			

12.024	**Threshold Detector 2 Level**								
RW	Num								US
⇕	0.00 to 100.00				⇨	0.00			

12.025	**Threshold Detector 2 Hysteresis**								
RW	Num								US
⇕	0.00 to 25.00				⇨	0.00			

12.026	**Threshold Detector 2 Output Invert**								
RW	Bit								US
⇕	Off (0) or On (1)				⇨	Off (0)			

12.027	**Threshold Detector 2 Destination**								
RW	Num						PT		US
⇕	0.000 to 59.999				⇨	0.000			

12.028	**Threshold Detector 2 Destination**								
RW	Num						PT		US
⇕	0.000 to 59.999				⇨	0.000			

12.029	**Variable Selector 2 Source 2**								
RW	Num						PT		US
⇕	0.000 to 59.999				⇨	0.000			

12.030	**Variable Selector 2 Mode**								
RW	Txt								US
⇕	0 to 10				⇨	0			

Value	Text
0	Input 1
1	Input 2
2	Add
3	Subtract
4	Multiply
5	Divide
6	Time Const
7	Ramp
8	Modulus
9	Powers
10	Sectional

12.031	Variable Selector 2 Destination								
RW	Num						PT		US
⇕	0.000 to 59.999				⇨	0.000			

12.032	Variable Selector 2 Output								
RO	Num				ND	NC	PT		
⇕	-100.00 to 100.00				⇨	0.000			

12.033	Variable Selector 2 Source 1 Scaling								
RW	Num								US
⇕	-4.000 to 4.000				⇨	1.000			

12.034	Variable Selector 2 Source 2 Scaling								
RW	Num								US
⇕	-4.000 to 4.000				⇨	1.000			

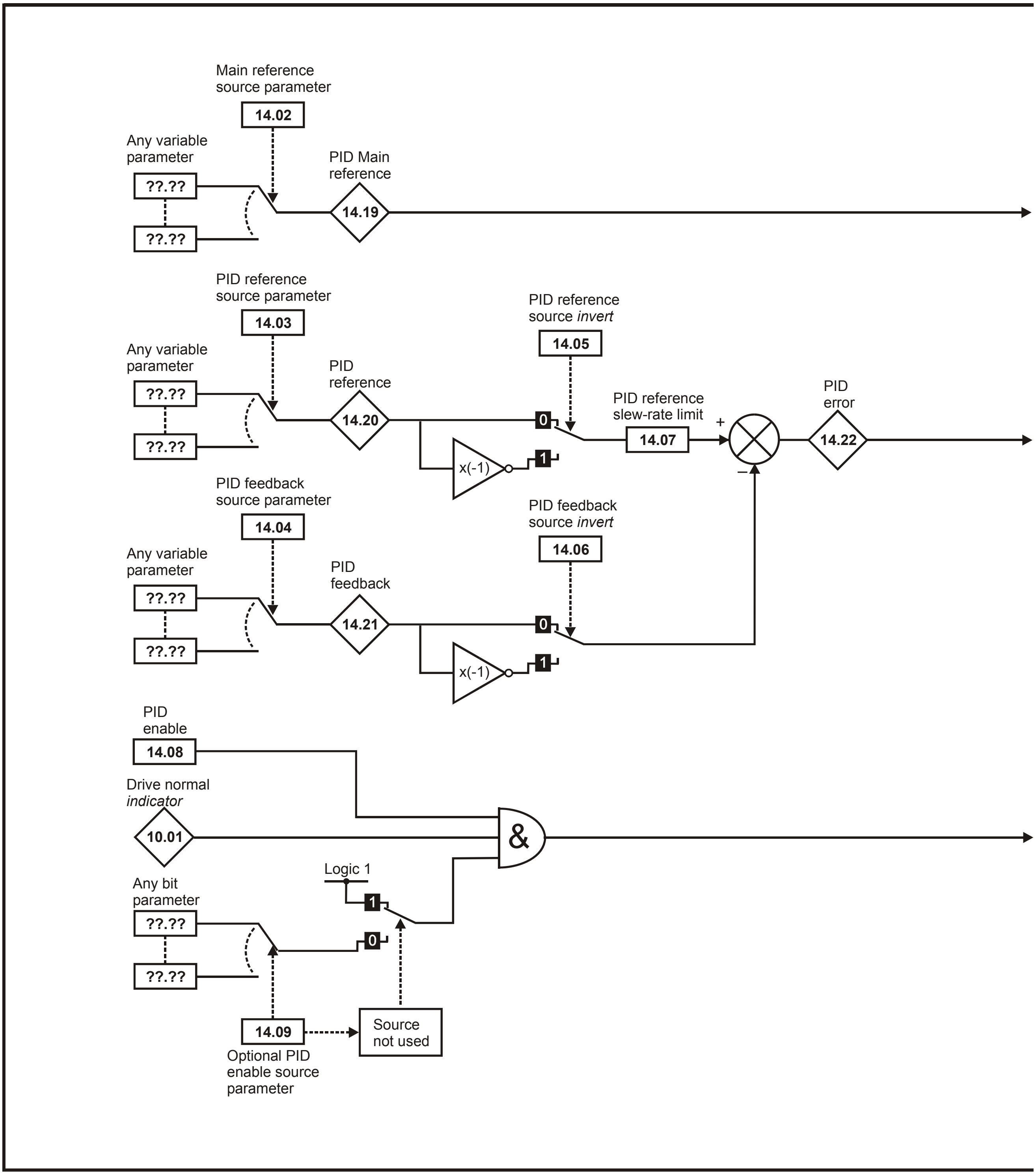
12.035	Variable Selector 2 Source 2 Scaling								
RW	Num								US
⇕	0.00 to 100.00				⇨	0.00			

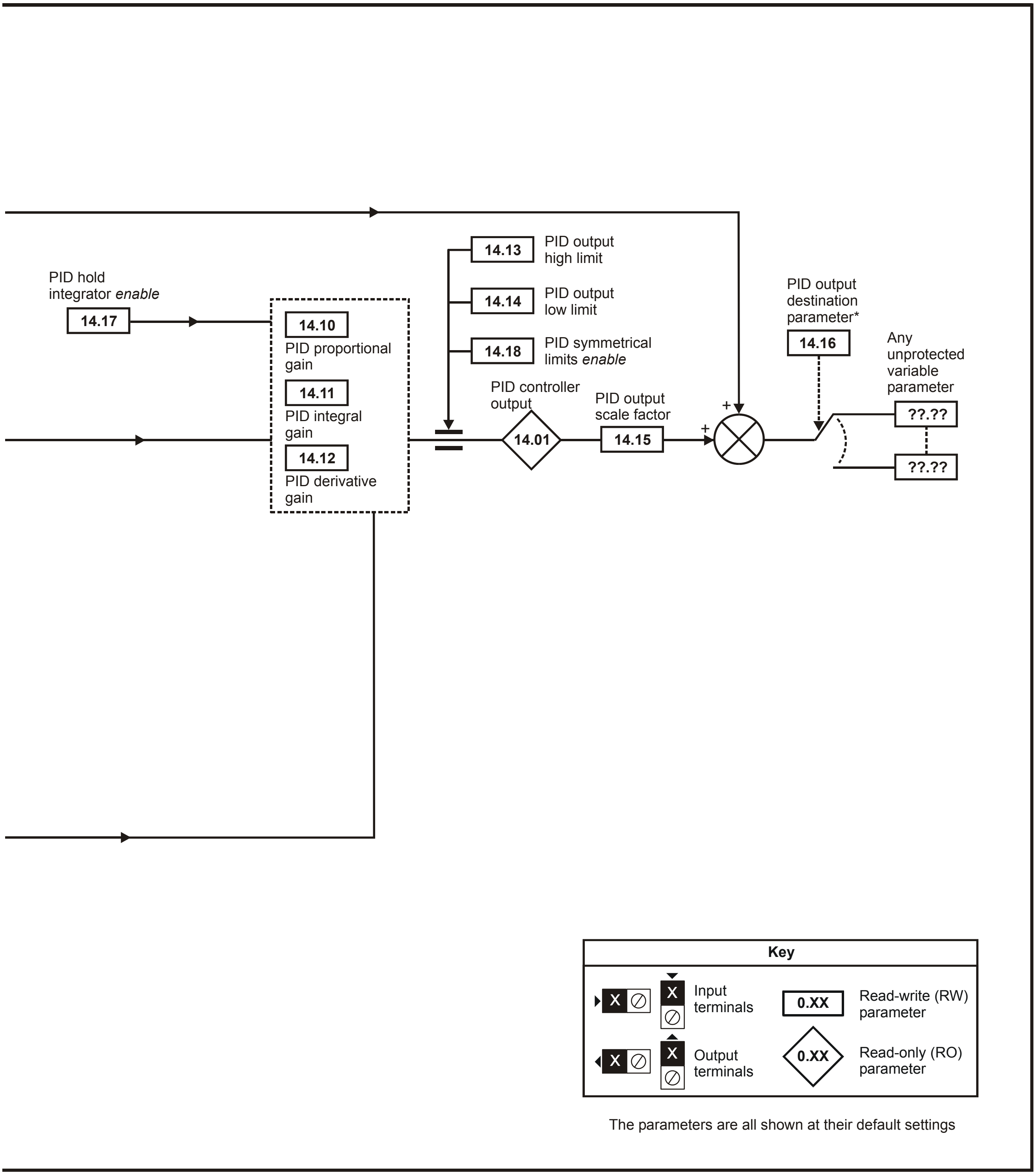
12.036	Variable Selector 2 Enable								
RW	Bit								US
⇕	Off (0) or On (1)				⇨	On (1)			

9.13 Menu 14: User PID controller

This menu contains a PID controller which has programmable reference and feedback inputs, programmable enable bit, reference slew rate limiting, variable clamp levels and programmable destination. The sample rate of the PID controller is 4 ms.

Figure 9-19 Menu 14 logic diagram





The parameters are all shown at their default settings

Two general purpose PID controllers are provided as shown in the diagram below. Both operate in the same way except that PID controller 2 does not include alternative feedback and error selection. In the following sections a description is given for PID controller 1. The descriptions also apply to PID controller 2 except where stated. The sample rate for the PID controllers is always 4 ms.

Figure 9-20 PID controllers

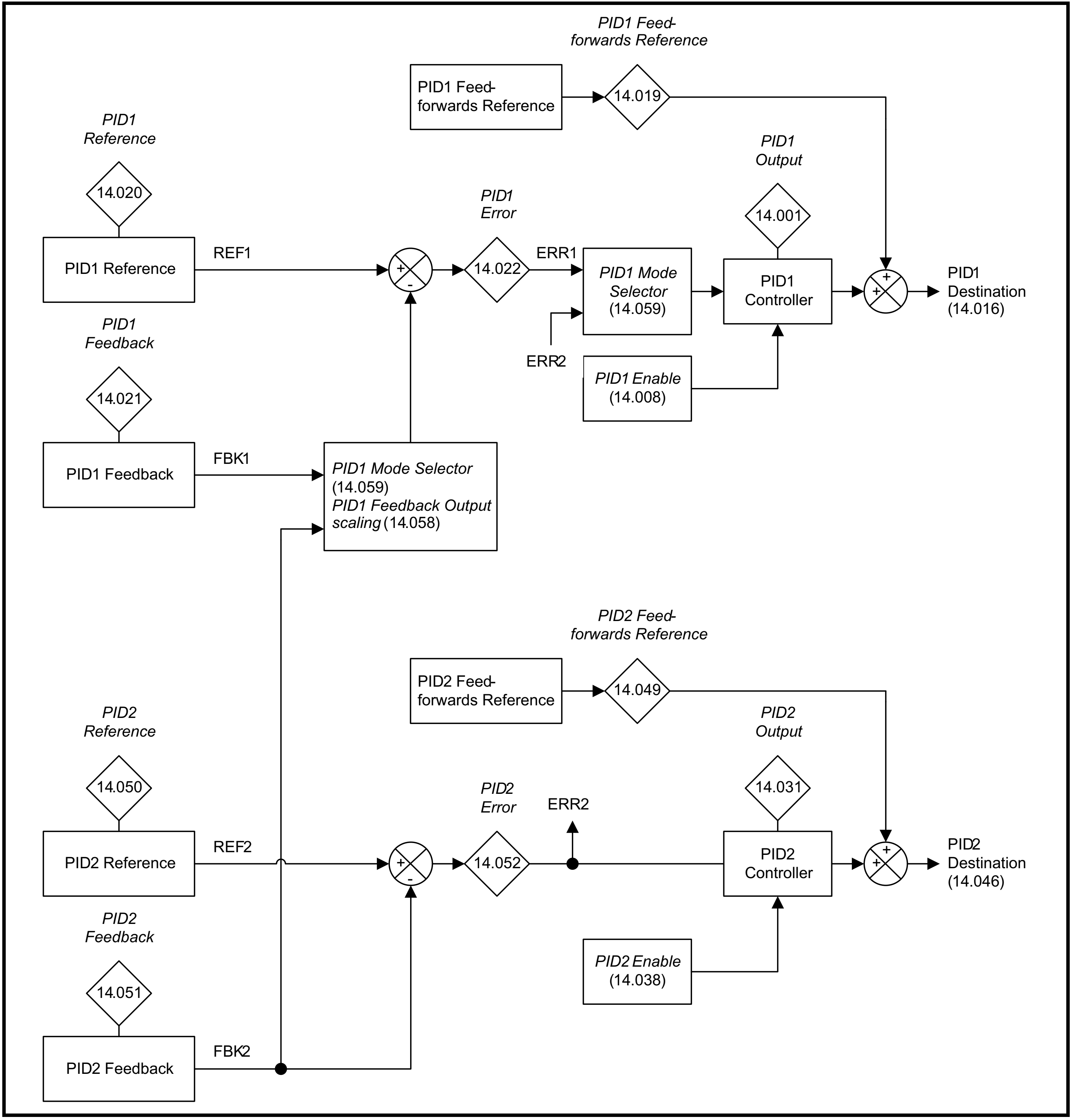


Figure 9-21 PID references

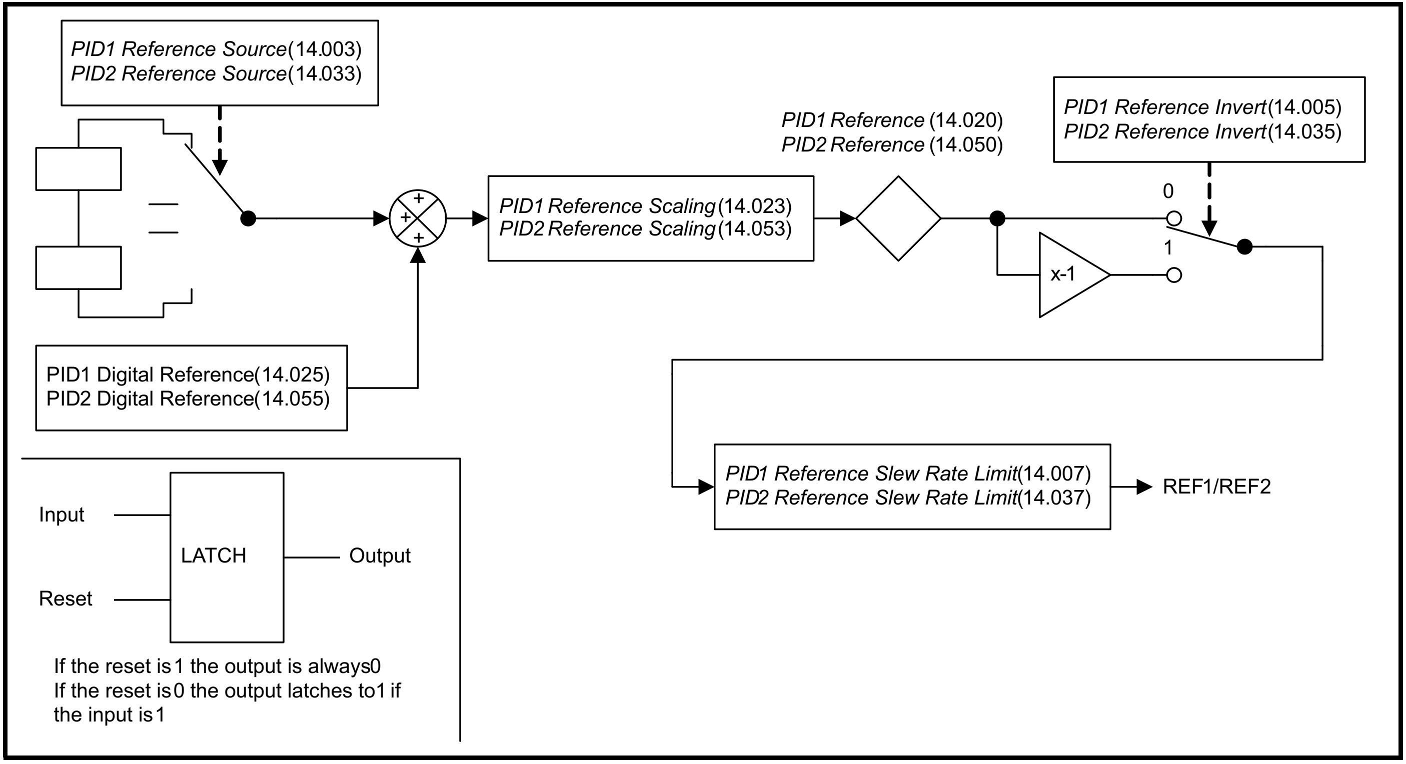


Figure 9-22 PID feedback

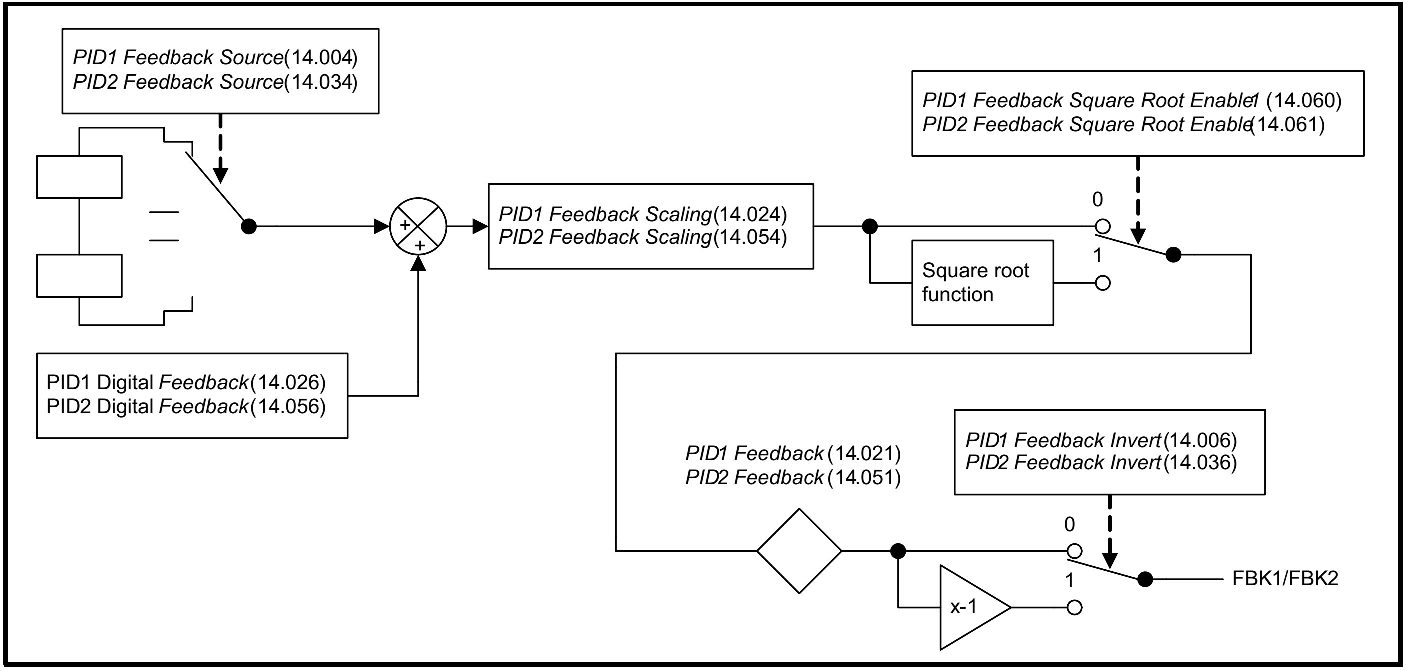
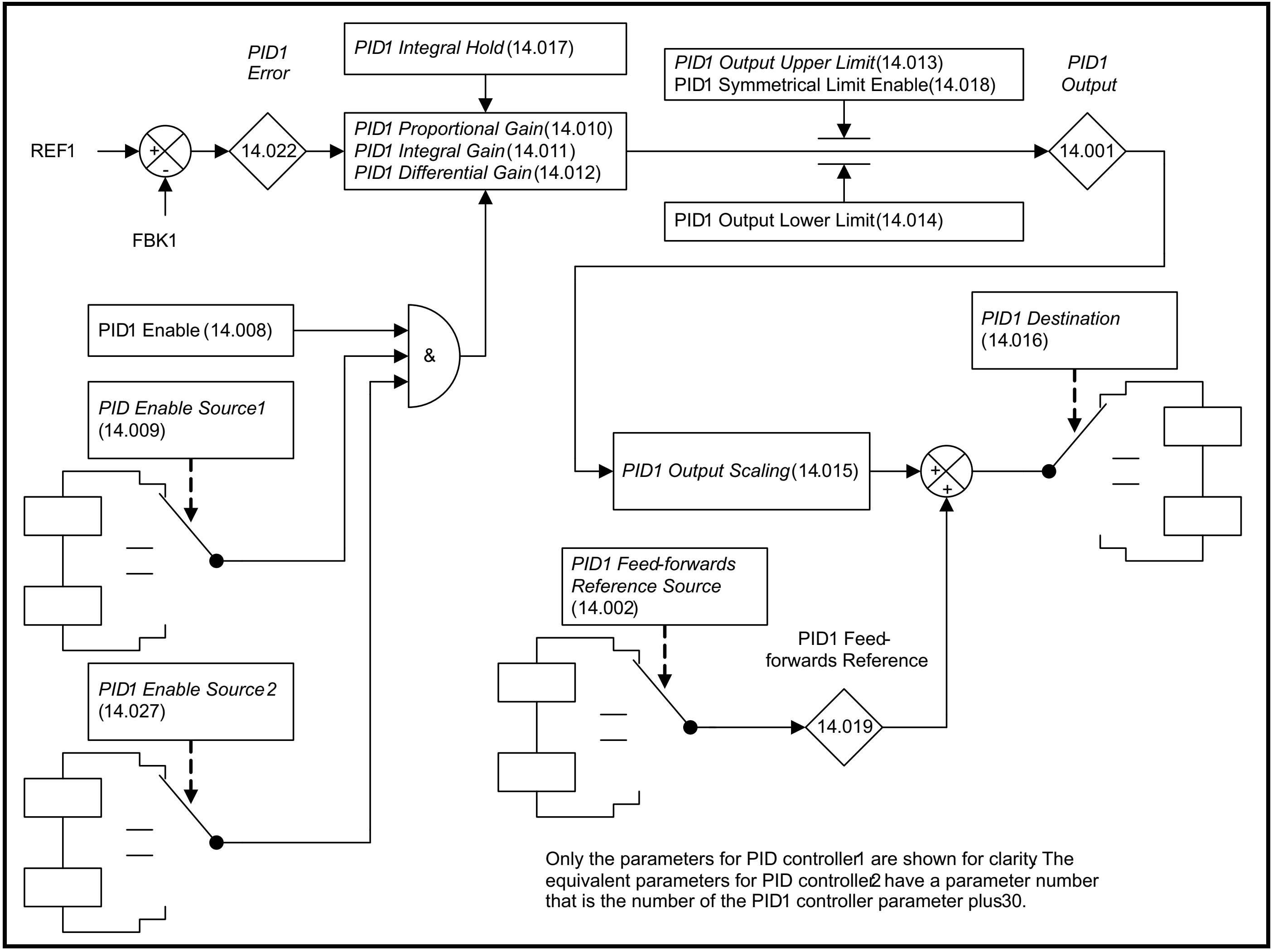


Figure 9-23 PID controllers (standard mode)



Only the parameters for PID controller 1 are shown for clarity. The equivalent parameters for PID controller 2 have a parameter number that is the number of the PID1 controller parameter plus 30.

Figure 9-24 PID1 alternative feedback and error selectors

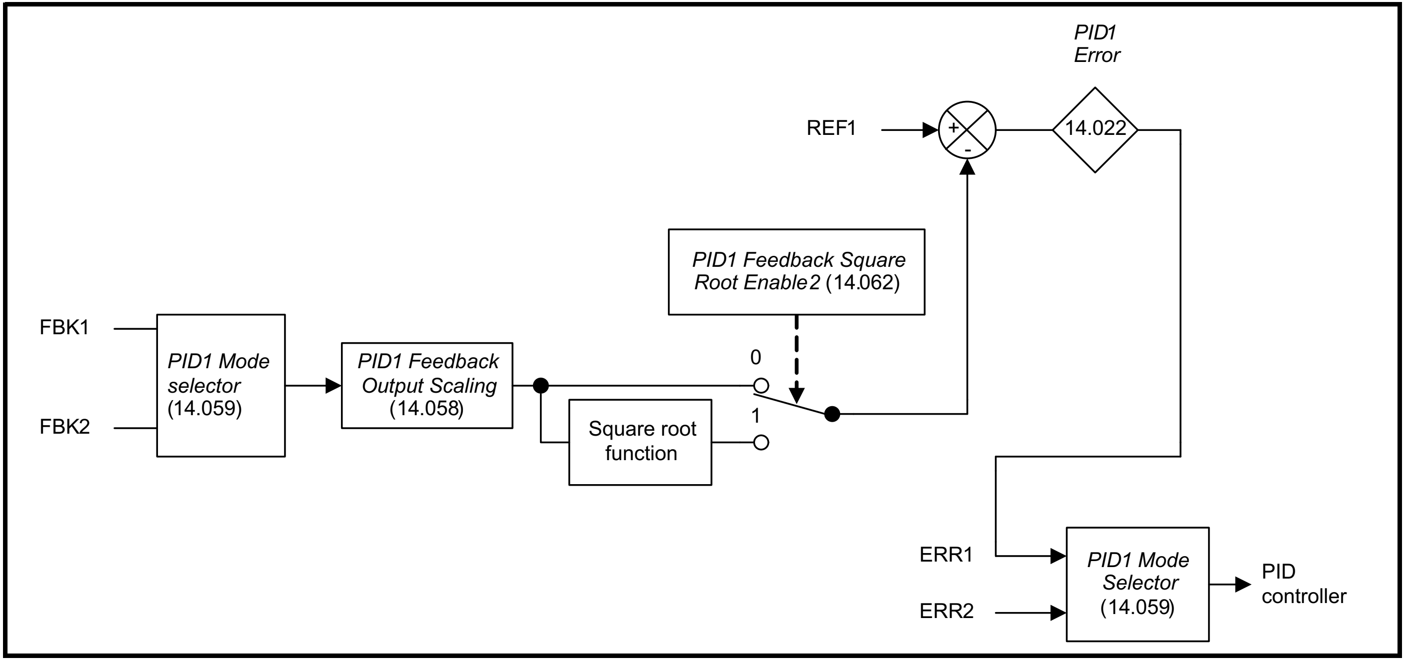


Table 9-16 Menu 14 Regen parameter descriptions

Parameter		Range	Default	Type					
14.001	PID1 Output	±100.00 %		RO	Num	ND	NC	PT	
14.002	PID1 Feed-forwards Reference Source	0.000 to 59.999	0.000	RW	Num			PT	US
14.003	PID1 Reference Source	0.000 to 59.999	0.000	RW	Num			PT	US
14.004	PID1 Feedback Source	0.000 to 59.999	0.000	RW	Num			PT	US
14.005	PID1 Reference Invert	Off (0) or On (1)	Off (0)	RW	Bit				US
14.006	PID1 Feedback Invert	Off (0) or On (1)	Off (0)	RW	Bit				US
14.007	PID1 Reference Slew Rate	0.0 to 3200.0 s	0.0 s	RW	Num				US
14.008	PID1 Enable	Off (0) or On (1)	Off (0)	RW	Bit				US
14.009	PID1 Enable Source 1	0.000 to 59.999	0.000	RW	Num			PT	US
14.010	PID1 Proportional Gain	0.000 to 4.000	1.000	RW	Num				US
14.011	PID1 Integral Gain	0.000 to 4.000	0.500	RW	Num				US
14.012	PID1 Differential Gain	0.000 to 4.000	0.000	RW	Num				US
14.013	PID1 Output Upper Limit	0.00 to 100.00	100.00	RW	Num				US
14.014	PID1 Output Lower Limit	±100.00	-100.00	RW	Num				US
14.015	PID1 Output Scaling	0.000 to 4.000	1.000	RW	Num				US
14.016	PID1 Destination	0.000 to 59.999	0.000	RW	Num	DE		PT	US
14.017	PID1 Integral Hold	Off (0) or On (1)	Off (0)	RW	Bit				
14.018	PID1 Symmetrical Limit Enable	Off (0) or On (1)	Off (0)	RW	Bit				US
14.019	PID1 Feed-forwards Reference	±100.00 %		RO	Num	ND	NC	PT	
14.020	PID1 Reference	±100.00 %		RO	Num	ND	NC	PT	
14.021	PID1 Feedback	±100.00 %		RO	Num	ND	NC	PT	
14.022	PID1 Error	±100.00 %		RO	Num	ND	NC	PT	
14.023	PID1 Reference Scaling	0.000 to 4.000	1.000	RW	Num				US
14.024	PID1 Feedback Scaling	0.000 to 4.000	1.000	RW	Num				US
14.025	PID1 Digital Reference	±100.00 %	0.00 %	RW	Num				US
14.026	PID1 Digital Feedback	±100.00 %	0.00 %	RW	Num				US
14.027	PID1 Enable Source 2	0.000 to 59.999	0.000	RW	Num			PT	US
14.031	PID2 Output	±100.00 %		RO	Num	ND	NC	PT	
14.032	PID2 Feed-forwards Reference Source	0.000 to 59.999	0.000	RW	Num			PT	US
14.033	PID2 Reference Source	0.000 to 59.999	0.000	RW	Num			PT	US
14.034	PID2 Feedback Source	0.000 to 59.999	0.000	RW	Num			PT	US
14.035	PID2 Reference Invert	Off (0) or On (1)	Off (0)	RW	Bit				US
14.036	PID2 Feedback Invert	Off (0) or On (1)	Off (0)	RW	Bit				US
14.037	PID2 Reference Slew Rate Limit	0.0 to 3200.0 s	0.0 s	RW	Num				US
14.038	PID2 Enable	Off (0) or On (1)	Off (0)	RW	Bit				US
14.039	PID2 Enable Source 1	0.000 to 59.999	0.000	RW	Num			PT	US
14.040	PID2 Proportional Gain	0.000 to 4.000	1.000	RW	Num				US
14.041	PID2 Integral Gain	0.000 to 4.000	0.500	RW	Num				US
14.042	PID2 Differential Gain	0.000 to 4.000	0.000	RW	Num				US
14.043	PID2 Output Upper Limit	0.00 to 100.00	100.00	RW	Num				US
14.044	PID2 Output Lower Limit	±100.00	-100.00	RW	Num				US
14.045	PID2 Output Scaling	0.000 to 4.000	1.000	RW	Num				US
14.046	PID2 Destination	0.000 to 59.999	0.000	RW	Num	DE		PT	US
14.047	PID2 Integral Hold	Off (0) or On (1)	Off (0)	RW	Bit				
14.048	PID2 Symmetrical Limit Enable	Off (0) or On (1)	Off (0)	RW	Bit				US
14.049	PID2 Feed-forwards Reference	±100.00 %		RO	Num	ND	NC	PT	
14.050	PID2 Reference	±100.00 %		RO	Num	ND	NC	PT	
14.051	PID2 Feedback	±100.00 %		RO	Num	ND	NC	PT	
14.052	PID2 Error	±100.00 %		RO	Num	ND	NC	PT	
14.053	PID2 Reference Scaling	0.000 to 4.000	1.000	RW	Num				US
14.054	PID2 Feedback Scaling	0.000 to 4.000	1.000	RW	Num				US
14.055	PID2 Digital Reference	±100.00 %	0.00 %	RW	Num				US
14.056	PID2 Digital Feedback	±100.00 %	0.00 %	RW	Num				US
14.057	PID2 Enable Source 2	0.000 to 59.999	0.000	RW	Num			PT	US
14.058	PID1 Feedback Output Scaling	0.000 to 4.000	1.000	RW	Num				US
14.059	PID1 Mode Selector	Fbk1 (0), Fbk2 (1), Fbk1 + Fbk2 (2), Min Fbk (3), Max Fbk (4), Av Fbk (5), Min Error (6), Max Error (7)	Fbk1 (0)	RW	Txt				US

14.060	PID1 Feedback Square Root Enable 1	Off (0) or On (1)	Off (0)	RW	Bit				US
14.061	PID2 Feedback Square Root Enable	Off (0) or On (1)	Off (0)	RW	Bit				US
14.062	PID1 Feedback Square Root Enable 2	Off (0) or On (1)	Off (0)	RW	Bit				US

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

14.001	**PID1 Output**								
RO	Num				ND	NC	PT		
⇳	-100.00 to 100.00 %				⇨				

Controller

The controller section for the PID controllers and the structure of PID controller 1 in Figure 9-20 is shown when *PID1 Mode Selector* (14.059) = 0, *PID1 Feedback Output Scaling* (14.058) = 1.000, and *PID1 Feedback Square Root Enable 2* (14.062) = 0. The additional features provided by these parameters are not available for PID controller 2, and so this controller always has the structure shown. If the combined enable is inactive then all internal states are held at zero and the destination parameter will be defined by *PID1 Feed-forwards Reference* (14.019) alone. If the enable is active the PID controller is active even if the destination is not routed to a valid parameter or to 0.000. It should be noted that if either of the enable sources is routed to 0.000 or to a non-valid parameter the source value is taken as 1, therefore with default settings, *PID1 Enable Source 1* (14.009) = 0.000 and *PID1 Enable Source 2* (14.027) = 0.000, the PID controller can be enabled by simply setting *PID1 Enable* (14.008).

PID1 Error (14.022) is the difference between the reference and feedback produced by the reference and feedback systems described in the previous sections. The PID controller output is defined as follows:

PID1 Output (14.001) = *PID1 Error* (14.022) x [Kp + Ki/s + sKd/(0.064 s + 1)]

Kp = *PID1 Proportional Gain* (14.010)

Ki = *PID1 Integral Gain* (14.011)

Kd = *PID1 Differential Gain* (14.012)

Therefore:

1. If *PID1 Error* (14.022) = 100.00 % the proportional term gives a value of 100.00 % if *PID1 Proportional Gain* (14.010) = 1.000.
2. If PID1 Error (14.022) = 100.00 % the integral term gives a value that increases linearly by 100.00 % per second if *PID1 Integral Gain* (14.011) = 1.000.
3. If *PID1 Error* (14.022) increases linearly by 100.00 % per second the differential term gives a value of 100.00 % if *PID1 Differential Gain* (14.012) = 1.000. (A filter with a time constant of 64 ms is provided on the differential gain to reduce the noise produced by this term).

The output may be limited to a range that is less than the maximum range of *PID1 Output* (14.001) using *PID1 Output Upper Limit* (14.013) and *PID1 Output Lower Limit* (14.014). If PID1 Output Lower Limit (14.014) > PID1 Output Upper Limit (14.013) then the output is held at the value defined by PID1 Output Upper Limit (14.013). If PID1 Symmetrical Limit Enable (14.018) = 1 then the lower limit = -(PID1 Output Upper Limit (14.013)). If the output reaches either of these limits the integral term accumulator is frozen until the output moves away from the limit to prevent integral wind-up. The integral hold function can also be enabled by the user by setting PID1 Integral Hold (14.017) = 1.

PID1 Output Scaling (14.015) can be used to scale the output, which is limited to a range from -100.00 % to 100.00 % after this function. The output is then added to *PID1 Feed-forwards Reference* (14.019) and is again limited to the range from -100.00 % to 100.00 % before being routed to the destination defined by *PID1 Destination* (14.016).

14.002	**PID1 Feed-forwards Reference Source**								
RW	Num						PT		US
⇳	0.000 to 59.999				⇨	0.000			

14.003	**PID1 Reference Source**								
RW	Num						PT		US
⇳	0.000 to 59.999				⇨	0.000			

The reference section for the PID controllers is shown in Figure 9-21. The reference sections are always active even if the PID controller itself is disabled or the reference sources are not routed to valid parameters. If a reference source is not a valid parameter or is 0.000 then the value is taken as zero.

The reference is the sum of the reference source, the *PID1 Digital Reference* (14.025) when it is active. The result is multiplied by *PID1 Reference Scaling* (14.023) and then limited to +/-100.00 %. The reference can then be inverted if required (*PID1 Reference Invert* (14.005) = 1) and then a slew rate limit is applied with *PID1 Reference Slew Rate* (14.007). This limits the maximum rate of change so that a change from 0.00 to 100.00 % takes the time given in PID1 Reference Slew Rate (14.007).

14.004	**PID1 Feedback Source**								
RW	Num						PT		US
⇳	0.000 to 59.999				⇨	0.000			

Feedback

The feedback section for the PID controllers is shown in Figure 9-22. The feedback sections are always active even if the PID controller itself is disabled or the feedback sources are not routed to valid parameters. If a reference source is not a valid parameter or is 0.000 then the value is taken as zero.

The feedback is the sum of the feedback source and the *PID1 Digital Feedback* (14.026). The result is multiplied by *PID1 Feedback Scaling* (14.024) and then limited to +/-100.00 %. A square root function can be applied (*PID1 Feedback Square Root Enable 1* (14.060) = 1) and the feedback can then be inverted if required (*PID1 Feedback Invert* (14.006) = 1). The square root function is defined as follows.

Square root function output = Sign (Input) x 100.00 % x √ (|Input| / 100.00 %)

where Sign (Input) = 1 if Input = 0 or -1 otherwise

The square root function is useful in applications where the PID controller is operating with air flow as its reference and feedback and the motor is controlling a fan. It is easier to use a pressure transducer than a flow transducer, and so the feedback from the transducer needs to be converted from pressure to flow. As flow = Constant x √ Pressure the square root function can be used in the conversion.

14.005	**PID1 Feedback Source**								
RW	Bit								US
⇕	Off (0) or On (1)	⇨	Off (0)						

See *PID1 Reference Source* (14.003).

14.006	**PID1 Feedback Invert**								
RW	Bit								US
⇕	Off (0) or On (1)	⇨	Off (0)						

See *PID1 Feedback Source* (14.004).

14.007	**PID1 Reference Slew Rate**								
RW	Num								US
⇕	0.0 to 3200.0 s	⇨	0.0 s						

See *PID1 Reference Source* (14.003).

14.008	**PID1 Enable**								
RW	Bit								US
⇕	Off (0) or On (1)	⇨	Off (0)						

See *PID1 Output* (14.001).

14.009	**PID1 Enable Source 1**								
RW	Num						PT		US
⇕	0.000 to 59.999	⇨	0.000						

See *PID1 Output* (14.001).

14.010	**PID1 Proportional Gain**								
RW	Num								US
⇕	0.000 to 4.000	⇨	1.000						

See *PID1 Output* (14.001).

14.011	**PID1 Integral Gain**								
RW	Num								US
⇕	0.000 to 4.000	⇨	0.500						

See *PID1 Output* (14.001).

14.012	**PID1 Differential Gain**								
RW	Num								US
⇕	0.000 to 4.000	⇨	0.000						

See *PID1 Output* (14.001).

14.013	**PID1 Output Upper Limit**								
RW	Num								US
⇕	0.00 to 100.00			⇨	100.00				

See *PID1 Output* (14.001).

14.014	**PID1 Output Lower Limit**								
RW	Num								US
⇕	-100.00 to 100.00			⇨	-100.00				

See *PID1 Output* (14.001).

14.015	**PID1 Output Scaling**								
RW	Num								US
⇕	0.000 to 4.000			⇨	1.000				

See *PID1 Output* (14.001).

14.016	**PID1 Destination**								
RW	Num						PT		US
⇕	0.000 to 59.999			⇨	0.000				

See *PID1 Output* (14.001).

14.017	**PID1 Integral Hold**								
RW	Bit								
⇕	Off (0) or On (1)			⇨	Off (0)				

See *PID1 Output* (14.001).

14.018	**PID1 Symmetrical Limit Enable**								
RW	Bit								US
⇕	Off (0) or On (1)			⇨	Off (0)				

See *PID1 Output* (14.001).

14.019	**PID1 Feed-forwards Reference**								
RO	Num				ND	NC	PT		
⇕	-100.00 to 100.00 %			⇨					

See *PID1 Output* (14.001).

14.020	**PID1 Reference**								
RO	Num				ND	NC	PT		
⇕	-100.00 to 100.00 %			⇨					

See *PID1 Reference Source* (14.003).

14.021	**PID1 Feedback**								
RO	Num				ND	NC	PT		
⇕	-100.00 to 100.00 %			⇨					

See *PID1 Feedback Source* (14.004).

14.022	**PID1 Error**								
RO	Num				ND	NC	PT		
⇕	-100.00 to 100.00 %			⇨					

See *PID1 Output* (14.001).

14.023	**PID1 Reference Scaling**								
RW	Num								US
⇕	0.000 to 4.000				⇨	1.000			

See *PID1 Reference Source* (14.003).

14.024	**PID1 Feedback Scaling**								
RW	Num								US
⇕	0.000 to 4.000				⇨	1.000			

See *PID1 Feedback Source* (14.004).

14.025	**PID1 Digital Reference**								
RW	Num								US
⇕	-100.00 to 100.00 %				⇨	0.00 %			

See *PID1 Reference Source* (14.003).

14.026	**PID1 Digital Feedback**								
RW	Num								US
⇕	-100.00 to 100.00 %				⇨	0.00 %			

See *PID1 Feedback Source* (14.004).

14.027	**PID1 Enable Source 2**								
RW	Num						PT		US
⇕	0.000 to 59.999				⇨	0.000			

See *PID1 Output* (14.001).

14.031	**PID2 Output**								
RO	Num				ND	NC	PT		
⇕	-100.00 to 100.00 %				⇨				

See *PID1 Output* (14.001).

14.032	**PID2 Feed-forwards Reference Source**								
RW	Num						PT		US
⇕	0.000 to 59.999				⇨	0.000			

See *PID1 Feed-forwards Reference Source* (14.002).

14.033	**PID2 Reference Source**								
RW	Num						PT		US
⇕	0.000 to 59.999				⇨	0.000			

See *PID1 Reference Source* (14.003).

14.034	**PID2 Feedback Source**								
RW	Num						PT		US
⇕	0.000 to 59.999				⇨	0.000			

See *PID1 Feedback Source* (14.004).

14.035	**PID2 Reference Invert**								
RW	Bit								US
⇕	Off (0) or On (1)				⇨	Off (0)			

See *PID1 Reference Invert* (14.005).

14.036		**PID2 Feedback Invert**							
RW	Bit								US
⇕	Off (0) or On (1)				⇨	Off (0)			

See *PID1 Feedback Invert* (14.006).

14.037		**PID2 Reference Slew Rate Limit**							
RW	Num								US
⇕	0.0 to 3200.0 s				⇨	0.0 s			

See *PID1 Reference Slew Rate* (14.007).

14.038		**PID2 Enable**							
RW	Bit								US
⇕	Off (0) or On (1)				⇨	Off (0)			

See *PID1 Enable* (14.008).

14.039		**PID2 Enable Source 1**							
RW	Num						PT		US
⇕	0.000 to 59.999				⇨	0.000			

See *PID1 Enable Source 1* (14.009).

14.040		**PID2 Proportional Gain**							
RW	Num								US
⇕	0.000 to 4.000				⇨	1.000			

See *PID1 Proportional Gain* (14.010).

14.041		**PID2 Integral Gain**							
RW	Num								US
⇕	0.000 to 4.000				⇨	0.500			

See *PID1 Integral Gain* (14.011).

14.042		**PID2 Differential Gain**							
RW	Num								US
⇕	0.000 to 4.000				⇨	0.000			

See *PID1 Differential Gain* (14.012).

14.043		**PID2 Output Upper Limit**							
RW	Num								US
⇕	0.00 to 100.00				⇨	100.00			

See *PID1 Output Upper Limit* (14.013).

14.044		**PID2 Output Lower Limit**							
RW	Num								US
⇕	-100.00 to 100.00				⇨	-100.00			

See *PID1 Output Lower Limit* (14.014).

14.045		**PID2 Output Scaling**							
RW	Num								US
⇕	0.000 to 4.000				⇨	1.000			

See *PID1 Output Scaling* (14.015).

14.046		**PID2 Destination**							
RW	Num						PT		US
⇳	0.000 to 59.999				⇨	0.000			

See *PID1 Destination* (14.016).

14.047		**PID2 Integral Hold**							
RW	Bit								
⇳	Off (0) or On (1)				⇨	Off (0)			

See *PID1 Integral Hold* (14.017).

14.048		**PID2 Symmetrical Limit Enable**							
RW	Bit								US
⇳	Off (0) or On (1)				⇨	Off (0)			

See *PID1 Symmetrical Limit Enable* (14.018).

14.049		**PID2 Feed-forwards Reference**							
RO	Num				ND	NC	PT		
⇳	-100.00 to 100.00 %				⇨				

See *PID1 Feed-forwards Reference* (14.019).

14.050		**PID2 Reference**							
RO	Num				ND	NC	PT		
⇳	-100.00 to 100.00 %				⇨				

See *PID1 Reference* (14.020).

14.051		**PID2 Feedback**							
RO	Num				ND	NC	PT		
⇳	-100.00 to 100.00 %				⇨				

See *PID1 Feedback* (14.021).

14.052		**PID2 Error**							
RO	Num				ND	NC	PT		
⇳	-100.00 to 100.00 %				⇨				

See *PID1 Error* (14.022).

14.053		**PID2 Reference Scaling**							
RW	Num								US
⇳	0.000 to 4.000				⇨	1.000			

See *PID1 Reference Scaling* (14.023).

14.054		**PID2 Feedback Scaling**							
RW	Num								US
⇳	0.000 to 4.000				⇨	1.000			

See *PID1 Feedback Scaling* (14.024).

14.055		**PID2 Digital Reference**							
RW	Num								US
⇳	-100.00 to 100.00 %				⇨	0.00 %			

See *PID1 Digital Reference* (14.025).

14.056	**PID2 Digital Feedback**								
RW	Num								US
⇕	-100.00 to 100.00 %				⇨	0.00 %			

See *PID1 Digital Feedback* (14.026).

14.057	**PID2 Enable Source 2**								
RW	Num						PT		US
⇕	0.000 to 59.999				⇨	0.000			

See *PID1 Enable Source 2* (14.027).

14.058	**PID1 Feedback Output Scaling**								
RW	Num								US
⇕	0.000 to 4.000				⇨	1.000			

PID1 alternative feedback and error selection

The description given in *PID1 Output* (14.001) assumed that *PID1 Mode Selector* (14.059) = 0 so that PID controller 1 uses its own feedback (FBK1). It is possible to select alternative configurations that allow various combinations of feedback or error from either PID controller to be used as shown below.

PID1 Mode Selector (14.059) can be used to select the feedback and error as shown in the table below. It should be noted that PID controller 2 will operate normally even when its feedback or error has been selected for PID controller 1. However, if *PID1 Mode Selector* (14.059) is non-zero PID controller 2 enable is controlled directly by the enable state of PID controller 1.

PID1 Mode Selector (14.059)	Feedback	Error
0: Fbk1	FBK1	ERR1
1: Fbk2	FBK2	ERR1
2: Fbk1 + Fbk2	FBK1 + FBK2	ERR1
3: Min Fbk	Lowest of FBK1 or FBK2	ERR1
4: Max Fbk	Highest of FBK1 or FBK2	ERR1
5: Av Fbk	(FBK1 + FBK2) / 2	ERR1
6: Min Error	FBK1	If |ERR1| ≤ |ERR2| then ERR1 Else ERR2
7: Max Error	FBK1	If |ERR1| ≥ |ERR2| then ERR1 Else ERR2

PID1 Feedback Output Scaling (14.058) can then be used to scale the results. *PID1 Feedback Square Root Enable 2* (14.062) can be used in converting the output of the combined feedback from pressure to flow. It is easier to use a pressure transducer than a flow transducer, and so the feedback from the transducer needs to be converted from pressure to flow. As flow = Constant x √ Pressure the square root function can be used in the conversion.

14.059	**PID1 Mode Selector**								
RW	Txt								US
⇕	Fbk1 (0), Fbk2 (1), Fbk1 + Fbk2 (2), Min Fbk (3), Max Fbk (4), Av Fbk (5), Min Error (6), Max Error (7)				⇨	Fbk1 (0)			

Value	Text
0	Fbk1
1	Fbk2
2	Fbk1 + Fbk2
3	Min Fbk
4	Max Fbk
5	Av Fbk
6	Min Error
7	Max Error

See *PID1 Feedback Output Scaling* (14.058).

14.060		**PID1 Feedback Square Root Enable 1**							
RW	Bit								US
⇕	Off (0) or On (1)				⇨	Off (0)			

See *PID1 Feedback Source* (14.004).

14.061		**PID2 Feedback Square Root Enable 1**							
RW	Bit								US
⇕	Off (0) or On (1)				⇨	Off (0)			

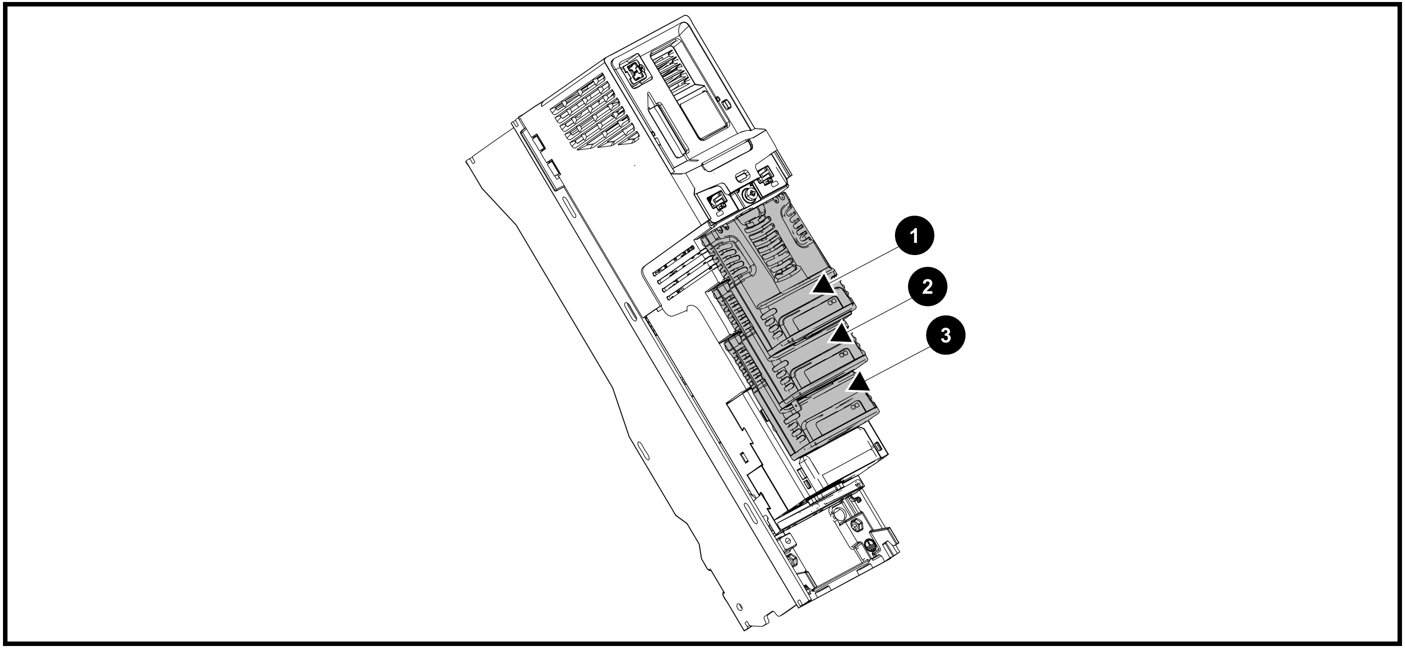
See *PID1 Feedback Square Root Enable 1* (14.060)

14.062		**PID1 Feedback Square Root Enable 2**							
RW	Bit								US
⇕	Off (0) or On (1)				⇨	Off (0)			

See *PID1 Feedback Output Scaling* (14.058).

9.14 Menus 15, 16 and 17: Option module set-up

Figure 9-25 Location of option module slots and their corresponding menu numbers



1. Solutions Module Slot 1 - Menu 15
2. Solutions Module Slot 2 - Menu 16
3. Solutions Module Slot 3 - Menu 17

9.14.1 Parameters common to all categories

Parameter		Range(⇳)	Default(⇨)	Type					
mm.001	Module ID	0 to 65535		RO	Num	ND	NC	PT	
mm.002	Software Version	00.00.00.00 to 99.99.99.99		RO	Ver	ND	NC	PT	
mm.003	Hardware Version	0.00 to 99.99		RO	Num	ND	NC	PT	
mm.004	Serial Number LS	0 to 99999999		RO	Num	ND	NC	PT	
mm.005	Serial Number MS			RO	Num	ND	NC	PT	
mm.006	Module Status	-2 to 3		RO	Num	ND	NC	PT	
mm.007	Module Reset	Off (0) to On (1)	Off (0)	RW	Bit		NC		

The option module ID indicates the type of module that is installed in the corresponding slot. See the relevant option module user guide for more information regarding the module.

Option module ID	Module	Category
0	No module installed	
209	SI-I/O	Automation (I/O Expansion)
311	MCi200	Automation (Applications)
310	MCi210	
304	SI-Applications Plus	
443	SI-PROFIBUS	Fieldbus
447	SI-DeviceNet	
448	SI-CANopen	
433	SI-Ethernet	
434	SI-PROFINET V2	
431	SI-EtherCAT	
105	SI-Encoder	Feedback
106	SI-Universal Encoder	
0*	SI-Safety	Safety

* There is no communication between the SI-Safety option module and the host drive via the option module connector, this is why the SI-Safety module ID is displayed as zero.

9.15 Menu 18: Application menu 1

Parameter		**Range(⇳)**	**Default(⇨)**	**Type**					
18.001	Application Menu 1 Power-down Save Integer	-32768 to 32767	0	RW	Num				PS
18.002 to 18.010	Application Menu 1 Read-only Integer	-32768 to 32767		RO	Num	ND	NC		US
18.011 to 18.030	Application Menu 1 Read-write Integer	-32768 to 32767	0	RW	Num				US
18.031 to 18.050	Application Menu 1 Read-write bit	Off (0) or On (1)	Off (0)	RW	Bit				US
18.051 to 18.054	Application Menu 1 Power-down Save long Integer	-2147483648 to 2147483647	0	RW	Num				PS

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

9.16 Menu 19: Application menu 2

Parameter		**Range(⇳)**	**Default(⇨)**	**Type**					
19.001	Application Menu 2 Power-down Save Integer	-32768 to 32767	0	RW	Num				PS
19.002 to 19.010	Application Menu 2 Read-only Integer	-32768 to 32767		RO	Num	ND	NC		US
19.011 to 19.030	Application Menu 2 Read-write Integer	-32768 to 32767	0	RW	Num				US
19.031 to 19.050	Application Menu 2 Read-write bit	Off (0) or On (1)	Off (0)	RW	Bit				US
19.051 to 19.054	Application Menu 2 Power-down Save long Integer	-2147483648 to 2147483647	0	RW	Num				PS

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

9.17 Menu 20: Application menu 3

Parameter		**Range(⇳)**	**Default(⇨)**	**Type**					
20.001 to 20.020	Application Menu 3 Read-write Integer	-32768 to 32767	0	RW	Num				
20.021 to 20.040	Application Menu 3 Read-write Long Integer	-2147483648 to 2147483647	0	RW	Num				

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

9.18 Menu 22: Additional Menu 0 set-up

The parameters in this menu are used to set up which parameters are shown in Menu 0.

Each parameter is used to set up the equivalent parameter in Menu 0, for example Pr **00.001** Set-up (22.001) is used to set up which parameter is shown in Menu 0 Parameter 1 (00.001), etc. 80 selectable Menu 0 parameters (**00.001** to **00.080**) and equivalent set-up parameters (**22.001** to **22.080**) are provided. When a Menu 0 set-up parameter is set to **00.000** or a value that is not a valid parameter outside Menu 0, the equivalent Menu 0 parameter is not visible.

Parameter		**Range(⇳)**	**Default(⇨)**		**Type**					
			M600 / M701	**M700**						
22.001	Parameter 00.001 Set-up	00.000 to 59.999	**03.005**		RW	Num			PT	US
22.002	Parameter 00.002 Set-up		**03.006**		RW	Num			PT	US
22.003	Parameter 00.003 Set-up		**03.009**		RW	Num			PT	US
22.004	Parameter 00.004 Set-up		**03.005**		RW	Num			PT	US
22.005	Parameter 00.005 Set-up		**05.002**		RW	Num			PT	US
22.006	Parameter 00.006 Set-up		**03.003**		RW	Num			PT	US
22.007	Parameter 00.007 Set-up		**03.004**		RW	Num			PT	US
22.008	Parameter 00.008 Set-up		**03.007**		RW	Num			PT	US
22.009	Parameter 00.009 Set-up		**03.008**		RW	Num			PT	US
22.010	Parameter 00.010 Set-up		**03.010**		RW	Num			PT	US
22.011	Parameter 00.011 Set-up		**05.001**		RW	Num			PT	US
22.012	Parameter 00.012 Set-up		**04.001**		RW	Num			PT	US
22.013	Parameter 00.013 Set-up		**04.002**		RW	Num			PT	US
22.014	Parameter 00.014 Set-up		**05.003**		RW	Num			PT	US
22.015	Parameter 00.015 Set-up		**03.001**		RW	Num			PT	US
22.016	Parameter 00.016 Set-up		**03.002**		RW	Num			PT	US
22.017	Parameter 00.017 Set-up		**04.008**		RW	Num			PT	US
22.018	Parameter 00.018 Set-up		**00.000**		RW	Num			PT	US
22.019	Parameter 00.019 Set-up		**07.011**		RW	Num			PT	US
22.020	Parameter 00.020 Set-up		**07.014**		RW	Num			PT	US
22.021	Parameter 00.021 Set-up		**07.015**		RW	Num			PT	US
22.022	Parameter 00.022 Set-up		**00.000**		RW	Num			PT	US
22.023	Parameter 00.023 Set-up		**00.000**		RW	Num			PT	US
22.024	Parameter 00.024 Set-up		**00.000**		RW	Num			PT	US
22.025	Parameter 00.025 Set-up		**00.000**		RW	Num			PT	US
22.026	Parameter 00.026 Set-up		**00.000**		RW	Num			PT	US
22.027	Parameter 00.027 Set-up		**00.000**		RW	Num			PT	US
22.028	Parameter 00.028 Set-up		**00.000**		RW	Num			PT	US
22.029	Parameter 00.029 Set-up		**11.036**		RW	Num			PT	US
22.030	Parameter 00.030 Set-up		**11.042**		RW	Num			PT	US
22.031	Parameter 00.031 Set-up		**11.033**		RW	Num			PT	US
22.032	Parameter 00.032 Set-up		**11.032**		RW	Num			PT	US
22.033	Parameter 00.033 Set-up		**00.000**		RW	Num			PT	US
22.034	Parameter 00.034 Set-up		**11.030**		RW	Num			PT	US
22.035	Parameter 00.035 Set-up		**11.024**	**00.000**	RW	Num			PT	US
22.036	Parameter 00.036 Set-up		**11.025**	**00.000**	RW	Num			PT	US
22.037	Parameter 00.037 Set-up		**11.023**	**24.010**	RW	Num			PT	US
22.038	Parameter 00.038 Set-up		**04.013**		RW	Num			PT	US
22.039	Parameter 00.039 Set-up		**04.014**		RW	Num			PT	US
22.040	Parameter 00.040 Set-up		**00.000**		RW	Num			PT	US
22.041	Parameter 00.041 Set-up		**05.018**		RW	Num			PT	US
22.042	Parameter 00.042 Set-up		**00.000**		RW	Num			PT	US
22.043	Parameter 00.043 Set-up		**00.000**		RW	Num			PT	US
22.044	Parameter 00.044 Set-up		**00.000**		RW	Num			PT	US
22.045	Parameter 00.045 Set-up		**04.015**		RW	Num			PT	US
22.046	Parameter 00.046 Set-up		**05.007**		RW	Num			PT	US
22.047	Parameter 00.047 Set-up		**00.000**		RW	Num			PT	US
22.048	Parameter 00.048 Set-up		**11.031**		RW	Num			PT	US
22.049	Parameter 00.049 Set-up		**11.044**		RW	Num			PT	US
22.050	Parameter 00.050 Set-up		**11.029**		RW	Num			PT	US

Parameter		**Range(⇳)**	**Default(⇨)**		**Type**					
			M600 / M701	**M700**						
22.051	Parameter 00.051 Set-up	00.000 to 59.999	**10.037**		RW	Num			PT	US
22.052	Parameter 00.052 Set-up		**11.020**	**00.000**	RW	Num			PT	US
22.053	Parameter 00.053 Set-up		**00.000**		RW	Num			PT	US
22.054	Parameter 00.054 Set-up				RW	Num			PT	US
22.055	Parameter 00.055 Set-up				RW	Num			PT	US
22.056	Parameter 00.056 Set-up				RW	Num			PT	US
22.057	Parameter 00.057 Set-up				RW	Num			PT	US
22.058	Parameter 00.058 Set-up				RW	Num			PT	US
22.059	Parameter 00.059 Set-up				RW	Num			PT	US
22.060	Parameter 00.060 Set-up				RW	Num			PT	US
22.061	Parameter 00.061 Set-up				RW	Num			PT	US
22.062	Parameter 00.062 Set-up				RW	Num			PT	US
22.063	Parameter 00.063 Set-up				RW	Num			PT	US
22.064	Parameter 00.064 Set-up				RW	Num			PT	US
22.065	Parameter 00.065 Set-up				RW	Num			PT	US
22.066	Parameter 00.066 Set-up				RW	Num			PT	US
22.067	Parameter 00.067 Set-up				RW	Num			PT	US
22.068	Parameter 00.068 Set-up				RW	Num			PT	US
22.069	Parameter 00.069 Set-up				RW	Num			PT	US
22.070	Parameter 00.070 Set-up				RW	Num			PT	US
22.071	Parameter 00.071 Set-up				RW	Num			PT	US
22.072	Parameter 00.072 Set-up				RW	Num			PT	US
22.073	Parameter 00.073 Set-up				RW	Num			PT	US
22.074	Parameter 00.074 Set-up				RW	Num			PT	US
22.075	Parameter 00.075 Set-up				RW	Num			PT	US
22.076	Parameter 00.076 Set-up				RW	Num			PT	US
22.077	Parameter 00.077 Set-up				RW	Num			PT	US
22.078	Parameter 00.078 Set-up				RW	Num			PT	US
22.079	Parameter 00.079 Set-up				RW	Num			PT	US
22.080	Parameter 00.080 Set-up				RW	Num			PT	US

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

10 Technical data

10.1 Drive

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

Output current derating has been applied based on Regen and switching frequency filter inductor capability

Table 10-1 Maximum permissible continuous output current @ 40 °C (104 °F) ambient

<table>
<tr><th rowspan="3">Model</th><th colspan="8">Normal Duty</th><th colspan="8">Heavy Duty</th></tr>
<tr><th colspan="2">Nominal rating</th><th colspan="6">Maximum permissible continuous output current (A) for the following switching frequencies</th><th colspan="2">Nominal rating</th><th colspan="6">Maximum permissible continuous output current (A) for the following switching frequencies</th></tr>
<tr><th>kW</th><th>hp</th><th>3 kHz</th><th>4 kHz</th><th>6 kHz</th><th>8 kHz</th><th>12 kHz</th><th>16 kHz</th><th>kW</th><th>hp</th><th>3 kHz</th><th>4 kHz</th><th>6 kHz</th><th>8 kHz</th><th>12 kHz</th><th>16 kHz</th></tr>
<tr><td colspan="17">200 V</td></tr>
<tr><td>03200066</td><td>1.5</td><td>2.0</td><td colspan="6">8.0</td><td>1.1</td><td>1.5</td><td colspan="6">6.6</td></tr>
<tr><td>03200080</td><td>2.2</td><td>3.0</td><td colspan="5">11</td><td>10.2</td><td>1.5</td><td>2.0</td><td colspan="5">8.0</td><td>7.5</td></tr>
<tr><td>03200106</td><td>3.0</td><td>3.0</td><td colspan="5">11</td><td>10.2</td><td>2.2</td><td>3.0</td><td colspan="4">10.6</td><td>8.8</td><td>7.5</td></tr>
<tr><td>04200137</td><td>4.0</td><td>5.0</td><td colspan="6">15.5</td><td>3.0</td><td>3.0</td><td colspan="6">13.7</td></tr>
<tr><td>04200185</td><td>5.5</td><td>7.5</td><td colspan="6">22</td><td>4.0</td><td>5.0</td><td colspan="6">15.5</td></tr>
<tr><td>05200250</td><td>7.5</td><td>10</td><td colspan="4">30</td><td>27.6</td><td>23.7</td><td>5.5</td><td>7.5</td><td colspan="4">22</td><td>21.5</td><td>18.8</td></tr>
<tr><td>06200330</td><td>11</td><td>15</td><td colspan="4">50</td><td>42.3</td><td>24.5</td><td>7.5</td><td>10</td><td colspan="5">31</td><td>27</td></tr>
<tr><td>06200440</td><td>15</td><td>20</td><td colspan="3">56</td><td>53</td><td>42.3</td><td>32.5</td><td>11</td><td>15</td><td colspan="3">42</td><td>40</td><td>33</td><td>27.3</td></tr>
<tr><td>07200610</td><td>18.5</td><td>25</td><td colspan="4">75</td><td>74.3</td><td>59.7</td><td>15</td><td>20</td><td colspan="5">56</td><td>53.1</td></tr>
<tr><td>07200750</td><td>22</td><td>30</td><td colspan="4">94</td><td>74.3</td><td>59.7</td><td>18.5</td><td>25</td><td colspan="4">75</td><td>65.3</td><td>53.1</td></tr>
<tr><td>07200830</td><td>30</td><td>40</td><td colspan="3">105</td><td>96</td><td>74.3</td><td>59.7</td><td>22</td><td>30</td><td colspan="4">80</td><td>65.6</td><td>53.1</td></tr>
<tr><td>08201160</td><td>37</td><td>50</td><td colspan="3">149</td><td>146</td><td>125.2</td><td>93</td><td>30</td><td>40</td><td colspan="3">105</td><td>103</td><td>89.3</td><td>80.5</td></tr>
<tr><td>08201320</td><td>45</td><td>60</td><td colspan="2">180</td><td>160.2</td><td>148.8</td><td>126</td><td>93</td><td>37</td><td>50</td><td>132</td><td>126.7</td><td>114</td><td>103</td><td>89.8</td><td>80.5</td></tr>
<tr><td>09201760</td><td>55</td><td>75</td><td colspan="3">192</td><td>184</td><td>128</td><td>93</td><td>45</td><td>60</td><td colspan="3">176</td><td>153</td><td>110</td><td>81</td></tr>
<tr><td>09202190</td><td>75</td><td>100</td><td colspan="2">250</td><td>218</td><td>184</td><td>128</td><td>93</td><td>55</td><td>75</td><td colspan="2">192</td><td>180</td><td>153</td><td>110</td><td>81</td></tr>
<tr><td>10202830</td><td>90</td><td>125</td><td colspan="3">312</td><td>266</td><td>194</td><td>144</td><td>75</td><td>100</td><td colspan="2">283</td><td>264</td><td>228</td><td>170</td><td>127</td></tr>
<tr><td>10203000</td><td>110</td><td>150</td><td colspan="2">350</td><td>313</td><td>266</td><td>194</td><td>144</td><td>90</td><td>125</td><td colspan="2">300</td><td>264</td><td>228</td><td>171</td><td>129</td></tr>
<tr><td colspan="17">400 V</td></tr>
<tr><td>03400078</td><td>4.0</td><td>5.0</td><td colspan="4">9.5</td><td>7.6</td><td>5.7</td><td>3.0</td><td>5.0</td><td colspan="3">7.8</td><td>7.6</td><td>5.7</td><td>4.4</td></tr>
<tr><td>03400100</td><td>5.5</td><td>7.5</td><td colspan="3">12</td><td>10.5</td><td>7.6</td><td>5.8</td><td>4.0</td><td>5.0</td><td colspan="2">9.5</td><td>9.2</td><td>7.7</td><td>5.7</td><td>4.4</td></tr>
<tr><td>04400150</td><td>7.5</td><td>10</td><td colspan="4">16</td><td>14.6</td><td>11.1</td><td>5.5</td><td>10</td><td colspan="3">15.0</td><td>14.4</td><td>11.5</td><td>9.4</td></tr>
<tr><td>04400172</td><td>11</td><td>15</td><td colspan="2">24</td><td>21.8</td><td>19.2</td><td>14.6</td><td>11.2</td><td>7.5</td><td>10</td><td colspan="3">16</td><td>14.4</td><td>11.5</td><td>9.4</td></tr>
<tr><td>05400270</td><td>15</td><td>20</td><td colspan="2">30</td><td>25.8</td><td>22.2</td><td>17.1</td><td>13.5</td><td>11</td><td>20</td><td>25.4</td><td>23.7</td><td>20.3</td><td>17.6</td><td>13.8</td><td>11.1</td></tr>
<tr><td>05400300</td><td>15</td><td>20</td><td colspan="2">31</td><td>30.7</td><td>26.4</td><td>18.3</td><td>14.1</td><td>15</td><td>20</td><td>30</td><td>27.9</td><td>24</td><td>21</td><td>14.9</td><td>12.2</td></tr>
<tr><td>06400350</td><td>18.5</td><td>25</td><td colspan="4">38</td><td>31</td><td>24.3</td><td>15</td><td>25</td><td colspan="3">34</td><td>30</td><td>23</td><td>18.5</td></tr>
<tr><td>06400420</td><td>22</td><td>30</td><td colspan="3">46</td><td>41</td><td>31</td><td>24.5</td><td>18.5</td><td>30</td><td colspan="2">40</td><td>35</td><td>30</td><td>23</td><td>18.5</td></tr>
<tr><td>06400470</td><td>30</td><td>40</td><td>60</td><td>57</td><td>48</td><td>41</td><td>31</td><td>24.5</td><td>22</td><td>30</td><td>46</td><td>42</td><td>35</td><td>30</td><td>23</td><td>18.5</td></tr>
<tr><td>07400660</td><td>37</td><td>50</td><td colspan="4">70</td><td>63</td><td>53.6</td><td>30</td><td>50</td><td colspan="2">66</td><td>57</td><td>48</td><td>41</td><td>34</td></tr>
<tr><td>07400770</td><td>45</td><td>60</td><td colspan="3">94</td><td>80.6</td><td>63</td><td>53.6</td><td>37</td><td>60</td><td colspan="2">70</td><td>59</td><td>51</td><td>44</td><td>37</td></tr>
<tr><td>07401000</td><td>55</td><td>75</td><td colspan="2">112</td><td>95.2</td><td>80.6</td><td>63</td><td>53.8</td><td>45</td><td>75</td><td>96</td><td>88</td><td>73</td><td>61</td><td>48</td><td>41</td></tr>
<tr><td>08401340</td><td>75</td><td>100</td><td colspan="3">155</td><td>132</td><td>98</td><td>77</td><td>55</td><td>100</td><td>124</td><td>130</td><td>109</td><td>91</td><td>72</td><td>57</td></tr>
<tr><td>08401570</td><td>90</td><td>125</td><td colspan="2">180</td><td>169</td><td>142</td><td>106.7</td><td>77</td><td>75</td><td>125</td><td>156</td><td>143</td><td>121</td><td>104</td><td>80.1</td><td>65</td></tr>
<tr><td>09402000</td><td>110</td><td>150</td><td colspan="2">200</td><td>192</td><td>159</td><td>108</td><td>77</td><td>90</td><td>150</td><td colspan="2">180</td><td>157</td><td>130</td><td>92</td><td>65</td></tr>
<tr><td>09402240</td><td>132</td><td>200</td><td>255</td><td>231</td><td>192</td><td>160</td><td>109</td><td>77</td><td>110</td><td>150</td><td>200</td><td>190</td><td>157</td><td>130</td><td>92</td><td>65</td></tr>
<tr><td>10402700</td><td>160</td><td>250</td><td colspan="2">300</td><td>285</td><td>238</td><td>173</td><td>124</td><td>132</td><td>200</td><td colspan="2">270</td><td>237</td><td>200</td><td>147</td><td>108</td></tr>
<tr><td>10403200</td><td>200</td><td>300</td><td>350</td><td>339</td><td>285</td><td>238</td><td>173</td><td>126</td><td>160</td><td>250</td><td>300</td><td>282</td><td>237</td><td>202</td><td>147</td><td>109</td></tr>
</table>

Model	Normal Duty								Heavy Duty							
	Nominal rating		Maximum permissible continuous output current (A) for the following switching frequencies						Nominal rating		Maximum permissible continuous output current (A) for the following switching frequencies					
	kW	hp	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz	kW	hp	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
11403770	225	350	437	415	336	272			185	300	377	372	296	245		
11404170	250	400	460	415	336	272			200	350	415	372	296	245		
11404640	280	400	460	415	336	272			250	400	415	372	296	245		
575 V																
06500150	11.0	15.0	17					14.8	7.5	10	15					11.6
06500190	15.0	20.0	22				20.5	15	11	15	19				15.4	11.6
06500230	18.5	25.0	27			26.2	20	16	15	20	22			20	15.4	12.8
06500290	22.0	30.0	34		31	26.2	20	16.8	18.5	25	27		23.8	20	15.4	12.8
06500350	30.0	40.0	43	39.6	31	26.2	20	16.8	22	30	34	29.8	23.8	20	15.4	13
07500440	45	50	52		51.8	40.2	27.7	21.2	30	40	43		39.2	30.8	21.6	16.7
07500550	55	60	63		51.8	40.2	27.7	21.2	37	50	52		39.2	30.8	21.6	17.1
08500630	75	75	85			73.1	49.7	37.8	45	60	63			53.3	37.2	28.4
08500860	90	100	100		91.8	73.1	49.7	37.8	55	75	85		67.1	53.3	37.8	28.4
09501040	110	125	125			101	71	54	75	100	100			85	61	47
09501310	110	150	144		126	100	70	54	90	125	125		106	85	61	47
10501520	130	200	192	168	126	100	70	54	110	150	144	138	106	85	61	47
10501900	150	200	192		152	116	76	54	132	200	190	186	137	106	70	51
11502000	185	250	248	220					150	200	200	184				
11502540	225	300	265	220					185	250	221	184				
11502850	250	350	265	220					225	300	221	184				
690 V																
07600190	18.5	25	22					21.2	15	20	19					16.7
07600240	22	30	27				27.9	21.2	18.5	25	22				21.8	16.6
07600290	30	40	36				28.1	21.2	22	30	27				21.8	16.5
07600380	37	50	43			40.5	28.1	21.2	30	40	36			30.8	21.7	16.7
07600440	45	60	52		51.5	40.6	28.1	21.2	37	50	43		38.7	30.8	21.6	16.7
07600540	55	75	63		51.8	40.6	28.1	21.2	45	60	52		39	31	21.6	16.7
08600630	75	100	85			72.2	49.7	37.8	55	75	63			53.3	37	28.4
08600860	90	125	100		91.8	72.4	49.7	37.8	75	100	85		67.1	53.3	37	28.4
09601040	110	150	125			100	71	54	90	125	100			85	61	47
09601310	132	175	144		126	100	71	54	110	150	125		105	85	62	47
10601500	160	200	168	169	126	100	71	55	132	175	144	138	105	86	62	47
10601780	185	250	192		154	114	75	55	160	200	168		137	105	69	52
11602100	200	250	225	220					185	250	210	184				
11602380	250	300	265	220					200	250	221	184				
11602630	280	400	265	220					250	300	221	184				

Table 10-2 Maximum permissible continuous output current @ 40 °C (104 °F) ambient with high IP insert installed

Model	Normal Duty						Heavy Duty					
	Maximum permissible continuous output current (A) for the following switching frequencies						Maximum permissible continuous output current (A) for the following switching frequencies					
	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
200 V												
03200066	8.0						6.6					
03200080	11.0					9.7	8.0					6.9
03200106	11.9	11.1	10.0	9.0	6.4	4.7	10.6		10.4	9.3	7.8	6.8
04200137	14.5		13.5	12.2	10.5	9.6	13.7		13.5	12.2	10.5	9.6
04200185	14.5		13.5	12.2	10.5	9.6	14.5		13.5	12.2	10.5	9.6
05200250	25.2	24.9	24.3	23.7	22.5	21.6	25.0	24.8	24.3	23.8	22.5	20.0
400 V												
03400078	8.3		7.6	6.9	6.0	5.2	7.8		7.6	6.9	5.3	4.0
03400100	8.3		7.6	6.9	6.0	5.2	8.3		7.6	6.9	5.3	4.0
04400150	8.6				8.4	6.9	8.6				8.4	6.9
04400172	8.6				8.4	6.9	8.6				8.4	6.9
05400270	15.6	14.4	12.6	11.4	9.6	8.7	15.7	14.6	12.7	11.3	9.7	8.6
05400300	19.5	18.9	17.7	16.4	14.0	11.8	19.5	18.9	17.7	16.2	13.8	11.7

Table 10-3 Maximum permissible continuous output current @ 50 °C (122 °F)

Model	Normal Duty						Heavy Duty					
	Maximum permissible continuous output current (A) for the following switching frequencies						Maximum permissible continuous output current (A) for the following switching frequencies					
	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
200 V												
03200066	8.0						6.6					
03200080	11				10.5	9.1	8.0					7.0
03200106	11				10.5	9.1	10.6			9.6	8.1	7.0
04200137	15.5						13.7					
04200185	22					20.2	15.5					14.8
05200250	30			29.7	25.2	21.6	22				19.8	17.3
06200330	50			49	38	30	31				29	24.6
06200440	56			49	38	30.2	42		41	36	29	24.6
07200610	75				59.7	48.8	56				53.1	43.2
07200750	94		92.1	80	59.7	48.9	75			69.8	53.1	43.2
07200830	105		92.4	80	59.7	49.1	80			69.7	53.1	43.2
08201160	149		147	133	113	84	105		104	95.1	81.8	72
08201320	180	167	148	133	113	84	125	117	104	95.1	81.8	72
09201760	192		197	168	117	84	176		165	140	100	72
09202190	237	221	197	168	117	85	192		166	140	101	72
10202830	312	302	266	241	176	130	283	279	241	207	153	114
10203000	320	302	266	241	176	130	300	279	243	207	153	114

Model	Normal Duty						Heavy Duty					
	Maximum permissible continuous output current (A) for the following switching frequencies						Maximum permissible continuous output current (A) for the following switching frequencies					
	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
400 V												
03400078	9.5		9.3	8.5	6.9	5.1	7.8			7.0	5.1	3.9
03400100	11.2	10.5	9.3	8.5	6.9	5.2	9.5		8.3	7.0	5.2	3.9
04400150	16		16	15.8	12.2	9.3	15		14.8	13.2	10.6	8.6
04400172	17.5	17	16.3	15.8	12.2	9.3	16		14.8	13.2	10.6	8.6
05400270	25.5		23.6	20.4	15.6	12.3	23.5	21.6	18.6	16.2	12.7	10
05400300	25.5		23.6		15.9	12.3	24		21.9	19.2	13.8	10.5
06400350	38			37	28	21.4	34		32	27	21	16.5
06400420	46		43	36.5	27.4	21.4	40	38	32	27	21	16.5
06400470	58	52	43	37	28	21.4	42	38	32	27	21	16.5
07400660	70			73.5	57.7	49	66		55	45	38	30
07400770	94		86.5	73.3	58.3	49	70		57	48	41	34
07401000	112	109	87.4	72.8	58.3	49.3	91	80	65	55	44	37
08401340	155		146	123	93	69	124	120	99	85	69	55
08401570	180		146	123	93.8	69	146	132	110	94.2	73.8	58
09402000	200	213	175	144	97	69	180	174	143	119	83	58
09402240	237	213	176	144	98	69	193	175	143	119	83	58
10402700	300	300	259	217	154	112	270	259	214	182	131	97
10403200	321	300	260	217	155	112	282	259	214	182	131	99
11403770	415	374	298	240			377	343	274	223		
11404170	415	374	298	240			380	343	274	223		
11404640	415	374	298	240			380	343	274	223		

Model	Normal Duty						Heavy Duty					
	Maximum permissible continuous output current (A) for the following switching frequencies						Maximum permissible continuous output current (A) for the following switching frequencies					
	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
575 V												
06500150	17					13.4	15				14	10.3
06500190	22				17.8	13.4	19				14	10.3
06500230	27			23.5	17.8	15	22		21.6	19	14	11.5
06500290	34		28.2	23.5	18	15	27		22	19	14	11.6
06500350	41.7	36.1	28	23.7	18	15	31.2	27.3	21.8	19	14	11.6
07500440	52		46.7	35.8	24.8	19	43		35.2	28.1	19.3	15
07500550	63		46.7	35.8	24.8	19	52	48.4	35.2	28.1	19.3	15
08500630	86		76.7	64.5	44.3	31.3	63		61.1	48.5	33.4	24.9
08500860	97.2	90.7	76.7	64.8	44.3	31.3	85	80.8	61.1	49	33.4	24.9
09501040	125		114	90	62	48	100		97	77	55	42
09501310	144		114	90	62	48	125	126	97	77	55	42
10501520	184	154	114	90	62	48	144	126	97	78	55	43
10501900	192	196	134	102	66	48	190	171	124	95	63	46
11502000	226	198					200	166				
11502540	241	198					200	166				
11502850	241	198					200	166				

Model	Normal Duty						Heavy Duty					
	Maximum permissible continuous output current (A) for the following switching frequencies						Maximum permissible continuous output current (A) for the following switching frequencies					
	3 kHz	**4 kHz**	**6 kHz**	**8 kHz**	**12 kHz**	**16 kHz**	**3 kHz**	**4 kHz**	**6 kHz**	**8 kHz**	**12 kHz**	**16 kHz**
690 V												
07600190	22					19	19					14.5
07600240	27				24.8	19	22				19.4	14.5
07600290	36			35.8	24.8	19	27			27.7	19.4	14.5
07600380	43			35.8	24.8	19	36		35.3	27.7	19.4	14.5
07600440	52		46.7	35.8	25	19	43		35.6	27.7	19.4	14.5
07600540	63		46.7	35.8	25	19	52	48.1	35.6	27.7	19.4	14.6
08600630	85		76.7	64.5	44.3	31.3	63		61.1	48.2	33.4	24.9
08600860	97.2	90.7	76.7	64.8	44.3	31.3	85	80.8	61.1	48.2	33.5	24.9
09601040	125		114	90	62	48	100		97	77	55	42
09601310	144	153	113	89	62	48	125	127	97	77	55	42
10601500	168	153	114	89	62	48	144	128	96	78	56	42
10601780	192	195	134	102	67	48	168	171	125	94	62	44
11602100	205	198					200	166				
11602380	241	198					200	166				
11602630	241	198					200	166				

10.1.2 Power dissipation

Table 10-4 Losses @ 40 °C (104 °F) ambient

Model	Normal Duty								Heavy Duty							
	Nominal rating		Drive losses (W) taking into account any current derating for the given conditions						Nominal rating		Drive losses (W) taking into account any current derating for the given conditions					
	kW	hp	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz	kW	hp	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
200 V																
03200066	1.5	2	100	102	107	113	122	133	1.1	1.5	89	91	94	99	108	116
03200080	2.2	3	123	126	133	139	151	146	1.5	2	97	99	105	109	118	111
03200106	3	3	136	141	149	158	168	157	2.2	3	115	118	126	134	124	116
04200137	4	5	180	187	201	216	244	273	3	3	145	151	163	174	198	221
04200185	5.5	7.5	239	248	266	284	308	314	4	5	185	192	207	221	237	241
05200250	7.5	10	291	302	324	344	356	342	5.5	7.5	245	254	272	288	284	282
06200330	11	15	394	413	452	490	480	485	7.5	10	277	290	316	342	382	386
06200440	15	20	463	484	528	522	481	486	11	15	366	382	417	410	388	392
07200610	18.5	25	570	597	650	703	885	894	15	20	466	488	532	575	666	715
07200750	22	30	718	751	815	881	890	899	18.5	25	570	597	650	703	710	717
07200830	30	40	911	951	1004	911	920	929	22	30	634	663	720	755	763	770
08201160	37	50	1433	1536	1765	1943	1962	1982	30	40	1105	1193	1343	1373	1387	1401
08201320	45	60	1753	1894	1914	1985	2005	2025	37	50	1269	1306	1349	1372	1386	1400
09201760A	55	75	2170	2312	2596	2448	2160	2031	45	60	1701	1822	2065	2022	1881	1820
09202190A	75	100	2754	2822	2623	2448	2156	2034	55	75	2160	2227	2107	2025	1874	1821
09201760D	55	75	1482	1624	1909	1878	1773	1748	45	60	1157	1278	1521	1555	1548	1571
09202190D	75	100	1871	1971	1928	1877	1770	1751	55	75	1461	1553	1550	1558	1543	1572
10202830D	90	125	2672	2867	3123	2952	2701	2554	75	100	2240	2413	2561	2494	2376	2303
10203000D	110	150	3016	3230	3126	2957	2706	2554	90	125	2394	2576	2561	2494	2389	2323
400 V																
03400078	4	5	145	158	186	212	201	197	3	5	115	125	145	161	166	165
03400100	5	7.5	163	179	209	208	201	200	4	5	138	151	163	163	166	165
04400150	7.5	10	225	244	283	322	325	310	5.5	10	189	205	238	262	274	286
04400172	11	15	283	307	325	329	325	315	7.5	10	210	227	249	262	274	286
05400270	15	20	324	353	356	355	359	362	11	20	276	282	285	290	301	310
05400300	15	20	332	367	434	441	417	424	15	20	322	333	352	374	372	439
06400350	18.5	25	417	456	532	613	652	645	15	25	389	424	498	496	502	513
06400420	22	30	515	561	657	651	646	650	18.5	30	455	497	487	486	495	513
06400470	30	40	656	659	650	646	643	649	22	30	500	496	487	486	495	500
07400660	37	60	830	907	1062	1218	1230	1242	30	50	692	758	773	763	771	778
07400770	45	60	999	1088	1264	1241	1253	1266	37	60	812	802	800	811	819	827
07401000	55	75	1152	1247	1218	1170	1182	1194	45	75	1017	968	936	907	916	925
08401340	75	100	1652	1817	2154	2121	2142	2164	55	100	1374	1509	1521	1510	1525	1540
08401570	90	150	2004	2191	2333	2279	2302	2325	75	125	1541	1670	1674	1673	1690	1707
09402000A	110	150	2710	2989	3075	2992	2842	2833	90	150	2136	2370	2492	2475	2501	2538
09402240A	132	200	3191	3143	3063	3000	2856	2828	110	150	2532	2511	2489	2474	2498	2537
09402000D	110	150	1968	2247	2448	2488	2507	2590	90	150	1555	1790	1995	2071	2216	2330
09402240D	132	200	2303	2358	2439	2494	2519	2586	110	150	1831	1891	1993	2070	2214	2329
10402700D	160	250	3582	3954	4148	4034	3939	3843	132	200	2923	3242	3401	3391	3438	3469
10403200D	200	300	4121	4226	4154	4038	3947	3874	160	250	3376	3393	3398	3419	3442	3485

Model	Normal Duty								Heavy Duty							
	Nominal rating		Drive losses (W) taking into account any current derating for the given conditions						Nominal rating		Drive losses (W) taking into account any current derating for the given conditions					
	kW	hp	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz	kW	hp	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
11403770D	225	350	4576	4708	4444	4246			185	300	3905	4200	3960	3907		
11404170D	250	400	4843	4708	4444	4246			200	350	4325	4200	3960	3907		
11404640D	280	400	4843	4708	4444	4246			250	400	4325	4200	3960	3907		
575 V																
06500150	11	15	284	315	376	438	563	569	7.5	10	265	294	351	410	501	506
06500190	15	20	362	399	484	569	575	580	11	15	317	350	418	496	501	506
06500230	18.5	25	448	505	596	682	689	696	15	20	382	421	508	523	641	648
06500290	22	30	623	712	810	822	830	839	18.5	25	533	610	628	635	641	648
06500350	30	40	798	836	813	823	831	840	22	30	546	624	622	627	633	640
07500440	45	50	1004	1139	1358	1262	1275	1287	30	40	817	929	1028	967	977	986
07500550	55	60	1248	1375	1209	1122	1133	1145	37	50	886	1002	914	863	872	880
08500630	75	75	1861	2180	2814	2982	3012	3042	45	60	1345	1585	2136	2284	2307	2330
08500860	90	100	2374	2753	2947	2963	2993	3023	55	75	1813	2174	2212	2218	2240	2263
09501040A	110	125	1977	2247	2787	2723	2731	2859	75	100	1601	1830	2288	2305	2422	2603
09501310A	110	150	2410	2734	2810	2692	2697	2859	90	125	2034	2316	2332	2302	2412	2607
09501040D	110	125	1508	1778	2318	2354	2476	2663	75	100	1221	1450	1908	1999	2201	2428
09501310D	110	150	1823	2146	2336	2329	2446	2663	90	125	1537	1820	1944	1997	2193	2432
10501520D	130	200	3137	2923	2696	2616	2654	2831	110	150	2245	2324	2253	2243	2373	2583
10501900D	150	200	2797	3209	3072	2946	2990	3189	132	200	2605	2933	2750	2713	2818	3076
11502000D	185	250	3999	4097					150	200	3204	3438				
11502540D	225	300	4296	4097					185	250	3544	3438				
11502850D	250	350	4296	4097					225	300	3544	3438				
690 V																
07600190	18.5	25	428	491	617	743	793	970	15	20	360	413	519	625	683	790
07600240	22	30	551	631	791	952	962	971	18.5	25	446	513	644	776	784	792
07600290	30	40	660	754	941	1129	1140	1152	22	30	533	610	765	920	929	938
07600380	37	50	854	971	1206	1271	1284	1297	30	40	697	796	993	966	976	985
07600440	45	60	985	1117	1350	1275	1288	1301	37	50	817	929	1015	967	977	986
07600540	55	75	1248	1375	1209	1122	1133	1145	45	60	888	1004	909	869	878	886
08600630	75	100	1861	2180	2814	2945	2974	3004	55	75	1345	1585	2136	2284	2307	2330
08600860	90	125	2374	2753	2947	2935	2964	2994	75	100	1813	2174	2212	2218	2240	2263
09601040A	110	150	2213	2548	3218	3155	3266	3465	90	125	1798	2083	2653	2714	2910	3161
09601310A	132	175	2797	3211	3232	3155	3267	3474	110	150	2281	2631	2677	2711	2917	3174
09601040D	110	150	1677	2012	2682	2743	2979	3246	90	125	1367	1652	2222	2369	2663	2968
09601310D	132	175	2095	2509	2693	2743	2981	3254	110	150	1714	2064	2241	2366	2669	2980
10601500D	160	200	2882	3270	3083	3052	3192	3472	132	175	2441	2604	2571	2648	2876	3128
10601780D	185	250	3132	3649	3667	3495	3633	3993	160	200	2774	3242	3265	3237	3442	3839
11602100D	200	250	3893	4497					185	200	3670	3814				
11602380D	250	300	4640	4497					200	250	3865	3814				
11602630D	280	400	4684	4540					250	300	3865	3814				

Table 10-5 Losses @ 40 °C (104 °F) ambient with high IP insert installed

Model	Normal Duty						Heavy Duty					
	Drive losses (W) taking into consideration any current derating for the given conditions						Drive losses (W) taking into consideration any current derating for the given conditions					
	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
200 V												
03200066	100	102	107	113	122	133	89	91	94	99	108	116
03200080	123	126	133	140	158	157	97	99	105	109	118	112
03200106	128	124	122	118	98	84	115	119	127	122	120	122
04200137	145	151	151	146	142	146	153	160	161	155	152	155
04200185	215	205	194	189	187	199	185	192	202	193	191	200
05200250	194	201	212	222	240	262	195	201	214	226	247	256
400 V												
03400078	118	134	155	173	221	267	115	126	155	173	195	205
03400100	118	134	155	173	221	267	112	126	155	173	195	205
04400150	105	114	132	153	197	207	108	118	136	156	202	214
04400172	101	111	131	152	197	207	105	114	133	157	202	214
05400270	118	119	124	132	152	183	120	123	129	137	162	187
05400300	159	174	200	225	268	304	159	176	210	239	295	310

Table 10-6 Losses @ 50 °C (122 °F) ambient

Model	Normal Duty						Heavy Duty					
	Drive losses (W) taking into account any current derating for the given conditions						Drive losses (W) taking into account any current derating for the given conditions					
	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
200 V												
03200066	100	102	107	113	122	133	89	91	94	99	108	116
03200080	123	126	133	139	144	139	97	99	105	109	118	113
03200106	136	140	143	147	151	150	115	118	126	121	117	116
04200137	180	187	201	216	253	297	145	151	163	174	198	228
04200185	214	223	244	265	312	334	185	192	207	217	230	247
05200250	291	302	324	341	325	312	245	254	272	268	261	264
06200330	394	413	452	480	431	594	277	290	316	342	346	352
06200440	463	484	510	483	432	451	366	382	389	369	341	353
07200610	570	597	650	703	710	717	466	488	532	575	581	587
07200750	718	751	799	750	758	765	570	597	650	654	661	667
07200830	898	898	805	751	759	766	634	663	705	653	660	666
08201160	1433	1536	1741	1770	1788	1806	1105	1193	1228	1277	1290	1303
08201320	1737	1740	1759	1771	1789	1807	1202	1206	1228	1278	1291	1304
09201760A	2170	2312	2354	2256	2010	1910	1701	1822	1943	1867	1757	1700
09202190A	2405	2368	2358	2245	2015	1922	2063	2029	1954	1868	1763	1701
09201760D	1482	1624	1738	1738	1658	1651	1157	1278	1435	1442	1453	1474
09202190D	1639	1662	1740	1729	1662	1661	1397	1418	1443	1443	1457	1476
10202830D	2625	2641	2625	2671	2490	2379	2240	2375	2326	2271	2185	2141
10203000D	2629	2643	2629	2678	2495	2374	2394	2375	2350	2275	2187	2141
400 V												
03400078	145	158	175	194	225	225	115	125	148	160	166	172
03400100	152	160	175	194	225	230	138	152	158	160	170	172
04400150	213	227	262	300	323	325	189	205	240	253	276	297
04400172	212	227	262	300	318	321	211	226	240	253	276	297
05400270	275	300	326	326	328	330	255	257	262	268	277	274
05400300	273	302	334	395	362	370	258	286	321	342	345	323
06400350	417	456	532	597	589	568	389	424	455	446	458	452
06400420	515	561	589	580	571	568	455	450	445	437	452	446
06400470	604	601	582	583	581	567	457	449	445	437	452	446
07400660	830	907	1062	1141	1152	1164	692	758	751	725	732	740
07400770	999	1087	1163	1138	1149	1161	808	804	779	773	781	789
07401000	1136	1200	1118	1074	1085	1096	922	878	838	828	836	845
08401340	1652	1815	2016	1970	1990	2010	1410	1392	1391	1432	1446	1461
08401570	1957	2114	1998	1979	1999	2019	1564	1539	1518	1531	1546	1562
09402000A	2710	2872	2799	2737	2639	2652	2136	2290	2289	2305	2342	2399
09402240A	2926	2870	2814	2737	2660	2665	2294	2300	2294	2300	2340	2404
09402000D	1968	2163	2239	2287	2338	2434	1555	1732	1841	1936	2084	2210
09402240D	2118	2161	2250	2286	2356	2446	1665	1739	1845	1933	2082	2214
10402700D	3582	3681	3765	3700	3597	3591	2923	3105	3081	3125	3165	3262
10403200D	3598	3676	3776	3694	3625	3589	3062	3105	3087	3131	3168	3300
11403770D	4329	4228	3988	3843			3905	3876	3699	3634		
11404170D	4329	4228	3988	3843			3943	3876	3699	3634		
11404640D	4329	4228	3988	3843			3943	3876	3699	3634		

Model	Normal Duty						Heavy Duty					
	Drive losses (W) taking into account any current derating for the given conditions						Drive losses (W) taking into account any current derating for the given conditions					
	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz	3 kHz	4 kHz	6 kHz	8 kHz	12 kHz	16 kHz
575 V												
06500150	284	315	376	438	563	515	265	294	351	410	466	449
06500190	362	399	482	569	500	519	317	350	418	496	455	449
06500230	448	505	596	612	613	652	382	421	478	497	583	582
06500290	623	712	737	737	747	749	533	573	581	603	583	587
06500350	774	763	734	742	748	750	501	573	568	595	576	571
07500440	988	1115	1225	1144	1155	1167	817	923	923	898	907	916
07500550	1225	1228	1098	1030	1040	1051	923	914	828	809	817	825
08500630	1850	2172	2540	2672	2699	2726	1345	1585	2292	2242	2264	2287
08500860	2090	2291	2540	2684	2711	2738	1845	2029	2039	2047	2067	2088
09501040A	1977	2247	2538	2456	2495	2699	1601	1830	2139	2122	2258	2455
09501310A	2410	2734	2544	2456	2482	2676	2034	2222	2143	2128	2258	2453
09501040D	1508	1778	2118	2133	2270	2518	1221	1450	1789	1846	2058	2295
09501310D	1823	2146	2122	2133	2259	2498	1537	1748	1792	1852	2058	2293
10501520D	2841	2654	2448	2392	2447	2652	2220	2112	2077	2083	2222	2452
10501900D	2797	3141	2743	2672	2766	3036	2605	2686	2516	2496	2651	2933
11502000D	3678	3532					3036	2985				
11502540D	3678	3532					3036	2985				
11502850D	3678	3632					3036	2985				
690 V												
07600190	428	491	617	743	750	758	360	413	519	625	631	638
07600240	551	631	791	958	968	977	446	513	644	776	784	792
07600290	660	754	944	1144	1155	1167	533	610	765	809	817	825
07600380	854	965	1206	1144	1155	1167	697	796	926	885	894	903
07600440	969	1094	1225	1144	1155	1167	817	923	933	885	894	903
07600540	1225	1228	1098	1030	1040	1051	906	908	837	797	805	813
08600630	1850	2172	2540	2672	2699	2726	1345	1585	2292	2229	2251	2274
08600860	2090	2291	2540	2684	2711	2738	1845	2029	2039	2014	2034	2054
09601040A	2213	2548	2933	2882	2974	3248	1798	2083	2483	2502	2721	2994
09601310A	2797	3175	2918	2855	2974	3249	2281	2548	2488	2509	2718	2991
09601040D	1677	2012	2455	2516	2724	3050	1367	1652	2086	2192	2498	2818
09601310D	2095	2482	2443	2494	2724	3052	1714	2001	2090	2198	2496	2815
10601500D	2882	2947	2805	2789	2932	3229	2441	2403	2377	2467	2701	2974
10601780D	3132	3610	3243	3221	3420	3771	2774	3111	3007	2996	3253	3621
11602100D	3893	4048					3495	3468				
11602380D	4186	4048					3495	3468				
11602630D	4230	4091					3495	3468				

Table 10-7 Power losses from the front of the drive when through-panel mounted

Frame size	Power loss
3	≤ 50 W
4	≤ 75 W
5	≤ 100 W
6	≤ 100 W
7	≤ 204 W
8	≤ 347 W
9	≤ 480 W
10	≤ 480 W
11	≤ 480 W

Table 10-8 Unidrive M Rectifier losses @ 40/50 °C (104/122 °F) ambient

Rectifier Model	Voltage rating (V)	Maximum Losses (W)
10204100	200	535
10404520	400	1019
10502430	575	499
10602480	690	609
11406840	400	1627
11503840	575	935
11604060	690	661
1142X400*	400	1773
1162X380*	690	1679

* Twin rectifier

NOTE

For Regen inductor and switching frequency filter inductor losses refer to section 10.4.2 *Regen filter components for high quality/low harmonic power supplies* on page 294 onwards.

10.2 Supply requirements

Voltage:

200 V to 240 V ±10 %
380 V to 480 V ±10 %
500 V to 575 V ±10 %
500 V to 690 V ±10 %

Number of phases: 3

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

Frequency range: 45 to 66 Hz

NOTE

Drives rated for supply voltages up to 690 V are suitable for use with supply types with neutral or centre grounding i.e. TN-S, TN-C-S, TT

The following supplies are not permitted with Unidrive M Regen:

1. Corner grounded supplies (grounded Delta)
2. Ungrounded supplies (IT) > 575 V

10.2.1 DC bus voltage set-point

The DC bus voltage set-point is user definable through Pr **03.005**, this must be set to 50 V above Vac* √2.

Drive voltage rating (11.033)	Vfs	K
200 V	415 V	1045
400 V	830 V	522
575 V	990 V	438
690 V	1190 V	364

10.2.2 Temperature, humidity and cooling method

Ambient temperature operating range:

-20 °C to 55 °C (-4 °F to 131 °F).

Output current derating must be applied at ambient temperatures >40 °C (104 °F).

Cooling method: Forced convection

Maximum humidity: 95 % non-condensing at 40 °C (104 °F)

10.2.3 Storage

-40 °C (-40 °F) to +55 °C (131 °F) for long term storage, or to +70 °C (158 °F) for short term storage.

Storage time is 2 years.

Electrolytic capacitors in any electronic product have a storage period after which they require reforming or replacing.
The DC bus capacitors have a storage period of 10 years.
The low voltage capacitors on the control supplies typically have a storage period of 2 years and are thus the limiting factor.
Low voltage capacitors cannot be reformed due to their location in the circuit and thus may require replacing if the drive is stored for a period of 2 years or greater without power being applied.
It is therefore recommended that drives are powered up for a minimum of 1 hour after every 2 years of storage. This process allows the drive to be stored for a further 2 years.

10.2.4 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 %.

10.2.5 IP Rating (Ingress Protection)

The drive is rated to IP20 pollution degree 2 (dry, non-conductive contamination only) (NEMA 1). However, it is possible to configure the drive to achieve IP65 rating (NEMA 12) at the rear of the heatsink for through-panel mounting (some current derating is required).

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 10-9.

Table 10-9 IP Rating degrees of protection

First digit		Second digit	
Protection against contact and ingress of foreign bodies		Protection against ingress of water	
0	No protection	0	No protection
1	Protection against large foreign bodies ϕ > 50 mm (large area contact with the hand)	1	Protection against vertically falling drops of water
2	Protection against medium size foreign bodies ϕ > 12 mm (finger)	2	Protection against spraywater (up to 15° from the vertical)
3	Protection against small foreign bodies ϕ > 2.5 mm (tools, wires)	3	Protection against spraywater (up to 60° from the vertical)
4	Protection against granular foreign bodies ϕ > 1 mm (tools, wires)	4	Protection against splashwater (from all directions)
5	Protection against dust deposit, complete protection against accidental contact.	5	Protection against heavy splash water (from all directions, at high pressure)
6	Protection against dust ingress, complete protection against accidental contact.	6	Protection against deckwater (e.g. in heavy seas)
7	-	7	Protection against immersion
8	-	8	Protection against submersion

Table 10-10 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.

10.3 Protection

Fuse protection is required in the following Regen systems

1. Single Regen, multiple motoring drives
2. Multiple Regen, multiple motoring drives
3. Unidrive M Regen brake resistor replacement
4. Regen systems using a rectifier

Fuse protection required could range from AC supply fusing to DC bus fusing (some systems requiring both AC and DC fusing) for protection of both the Regen and motoring drives along with the Unidrive M rectifier module. For further information on the fusing required for the above systems refer to section 4 *System design* on page 40.

10.3.1 AC Supply fusing

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 10-11

Table 10-11 Supply fault current used to calculate maximum input currents

Model	Symmetrical fault level (kA)
All	100

Cable sizes are from IEC60364-5-52:2001 table A.52.C with correction factor for 40 °C ambient of 0.87 (from table A52.14) for cable installation method B2 (multicore cable in conduit). Cable size may be reduced if a different installation method is used, or if the ambient temperature is lower. The recommended cable sizes above are only a guide.
The mounting and grouping of cables affects their current-carrying capacity, in some cases smaller cables may be acceptable but in other cases a larger cable is required to avoid excessive temperature or voltage drop.
Refer to local wiring regulations for the correct size of cables.

NOTE

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

NOTE

UL listing is dependent on the use of the correct type of UL-listed fuse.

> **WARNING**
>
> **Fuses**
> The AC supply to the drive must be fitted with suitable protection against overload and short-circuits. Failure to observe this requirement will cause risk of fire.

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

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.

Table 10-12 Supply fault current used to calculate maximum input currents

Model	Symmetrical fault level (kA)
Unidrive M Rectifier	100

NOTE

Fuse ratings are for a DC supply or paralleled DC bus arrangements.

Table 10-13 Unidrive M size 10 and 11 rectifier current and fuse ratings

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

* Twin rectifier

Table 10-14 Cable ratings for Unidrive size 10 and 11 rectifiers

Model	Cable size (IEC)						Cable size (UL)			
	mm^2						AWG or kcmil			
	Input			Output			Input		Output	
	Nominal	Maximum	Installation method	Nominal	Maximum	Installation method	Nominal	Maximum	Nominal	Maximum
10204100	2 x 150	2 x 185	C	2 x 120	2 x 150	C	2 x 300	2 x 500	2 x 400	2 x 500
10404520	2 x 150	2 x 185	C	2 x 150	2 x 150	C	2 x 350	2 x 500	2 x 500	2 x 500
10502430	2 x 95	2 x 185	B2	2 x 95	2 x 150	B2	2 x 3/0	2 x 500	2 x 3/0	2 x 500
10602480	2 x 95	2 x 185	B2	2 x 95	2 x 150	B2	2 x 3/0	2 x 500	2 x 3/0	2 x 500
11406840	4 x 120	4 x 120	C	4 x 150	4 x 150	C	2 x 250	2 x 250	2 x 300	2 x 300
11503840	2 x 120	2 x 120	C	2 x 120	2 x 120	C	2 x 250			
11604060	2 x 120	2 x 120	C	2 x 120	2 x 120	C	2 x 300	2 x 300	2 x 400	2 x 400
1142X400*	2 x 2 x120	2 x 2 x120	C	2 x 2 x 120	2 x 2 x 120	C	2 x 2 x 300			
1162X380*	2 x 2 x120	2 x 2 x120	C	2 x 2 x 120	2 x 2 x 120	C	2 x 2 x 300			

* Twin rectifier

10.3.2 Common DC bus fusing

DC bus fusing is required in the following systems for both the Regen and motoring drives, and the rectifier if used as the external soft start circuit.

1. Single Regen, multiple motoring drives
2. Multiple Regen, multiple motoring drives
3. Unidrive M Regen brake resistor replacement
4. Regen systems using a rectifier

DC bus fuses as detailed following must be fitted in both the positive and negative branches of DC bus connections to each of the Regen and motoring drives, and the rectifier if used as the external soft start circuit.

NOTE

Ferraz have a range of DC fuses which could be used to provide the required protection, types (00 and 21) may be used.

00 - Fuse with no trip indicator fitted
21 - Fuse fitted with trip indicator

NOTE

The DC bus voltage set-point on a Regen system (default) is set to 700 Vdc, this can be up to a maximum 800 Vdc. Therefore ensure the selected DC bus fusing is of the correct voltage rating with regards to the DC bus voltage level (Pr **03.005** DC Bus Voltage Set-point).

Table 10-15 DC current, fuse and cable ratings (200 V)

Model	Maximum continuous dc input current	Maximum overload dc input current	DC fuse IEC class aR	Maximum fuse clearing I²t at operating condition	Inverter DC voltage trip threshold	Cable size DC Input		
	Arms	Arms	Arms	A^2s		mm²	AWG or Kcmil	IEC Installation Method
03200066	13.3	20.9	16	190	415	4	12	B2
03200080	18.4	25.3	25	480	415	6	10	B2
03200106	21.2	33.5	25	480	415	8	8	B2
04200137	21.2	30.3	25	480	415	8	8	B2
04200185	29.4	40.9	32	1500	415	10	8	B2
05200250	32.6	52.0	40	1500	415	10	8	B2
06200330	53.1	63.8	63	3080	415	16	4	B2
06200440	61.6	85.0	63	3080	415	35	2	B2
07200610	73.8	109.5	80	6600	415	35	1	B2
07200750	92.4	134.6	100	12500	415	35	1	B2
07200830	115.1	148.9	125	12500	415	70	1/0	B2
08201160	153.4	213.6	160	16700	415	2 x 50	2 x 1	B2
08201320	185.3	243.0	200	22000	415	2 x 70	2 x 1/0	B2
09201760A	220	300	315	330000	415	2 x 70	2 x 2/0	B1
09202190A	287	359	350		415	2 x 95	2 x 4/0	B1
09201760D	220	300	315		415	2 x 70	2 x 2/0	B1
09202190D	287	359	350		415	2 x 95	2 x 4/0	B1
10202830	345	488	450	330000	415	2 x 120	2 x 250	B1
10203000	413	578	500		415	2 x 150	2 x 300	C

Table 10-16 DC current, fuse and cable ratings (400 V)

Model	Maximum continuous dc input current	Maximum overload dc input current	DC fuse IEC class aR	Maximum fuse clearing I²t at operating condition	Inverter DC voltage trip threshold	Cable Size DC Input		
	Arms	Arms	Arms	A^2s		mm²	AWG or Kcmil	IEC Installation Method
03400078	14.5	19.7	16	190	830	4	12	B2
03400100	17.2	25.3	20	360	830	6	10	B2
04400150	21.1	30.4	25	480	830	8	8	B2
04400172	27.3	34.8	32	1500	830	10	8	B2
05400270	32.8	52.1	40	1500	830	10	8	B2
05400300	33.9	57.9	40	1500	830	10	8	B2
06400350	40.5	66.7	63	3080	830	10	6	B2
06400420	51.2	80.0	63	3080	830	16	4	B2
06400470	73.8	109.5	80	6600	830	35	1	B2
07400660	92.4	134.6	100	12500	830	35	1	B2
07400770	92.4	134.6	100	12500	830	35	1	B2
07401000	118.4	187.9	125	12500	830	70	1/0	B2
08401340	171.6	267.4	200	22000	830	2 x 70	2 x 1/0	B2
08401570	199.2	302.6	200	22000	830	2 x 70	2 x 2/0	B1
09402000A	261	351	315	330000	830	2 x 70	2 x 3/0	B1
09402240A	303	418	400		830	2 x 95	2 x 4/0	B1
09402000D	261	351	315		830	2 x 70	2 x 3/0	B1
09402240D	303	418	400		830	2 x 95	2 x 4/0	B1
10402700	378	517	450	330000	830	2 x 120	2 x 300	C
10403200	456	614	500		830	2 x 150	2 x 350	C
11403770	525	711	630	594000	830	4 x 95	4 x 250	C
11404170	564	753	700		830	4 x 95	4 x 250	C
11404640	621	925	800		830	4 x 120	4 x 300	C

Table 10-17 DC current, fuse and cable ratings (575 V)

Model	Maximum continuous dc input current	Maximum overload dc input current	DC fuse IEC class aR	Maximum fuse clearing I²t at operating condition	Inverter DC voltage trip threshold	Cable Size DC Input		
						mm²	AWG or Kcmil	IEC Installation Method
	Arms	Arms	Arms	A^2s				
06500150	20.5	32.8	25	480	990	6	10	B2
06500190	26.6	41.5	32	1500	990	10	8	B2
06500230	32.2	49.8	40	1500	990	10	8	B2
06500290	40.6	62.7	63	3080	990	10	6	B2
06500350	51.4	75.7	63	3080	990	16	4	B2
07500440	51.1	75.0	63	3080	990	16	4	B2
07500550	73.8	109.5	80	6600	990	35	1	B2
08500630	92.4	134.6	100	12500	990	35	1	B2
08500860	115.3	165.2	125	12500	990	70	2 x 1/0	B2
09501040	181	212	250	137000	990	2 x 70	2 x 1	B2
09501310	181	248	250		990	2 x 70	2 x 1	B2
10501520	220	306	315	137000	990	2 x 70	2 x 2/0	B2
10501900	246	360	315		990	2 x 95	2 x 2/0	B2
11502000	299	402	350	330000	990	2 x 70	2 x 4/0	C
11502540	353	485	450		990	2 x 95	2 x 250	C
11502850	387	583	500		990	2 x 120	2 x 300	C

Table 10-18 DC current, fuse and cable ratings (690 V)

Model	Maximum continuous dc input current	Maximum overload dc input current	DC fuse IEC class aR	Maximum fuse clearing I²t at operating condition	Inverter DC voltage trip threshold	Cable Size DC Input		
						mm²	AWG or Kcmil	IEC Installation Method
	Arms	Arms	Arms	A^2s				
07600190	22.2	32.4	25	480	1190	10	8	B2
07600240	28.9	40.9	32	1500	1190	10	8	B2
07600290	34.7	49.4	40	1500	1190	10	8	B2
07600380	44.4	64.8	50	3080	1190	16	4	B2
07600440	50.2	75.0	63	3080	1190	16	4	B2
07600540	70.4	92.1	80	6600	1190	35	1	B2
08600630	91.8	121.0	100	12500	1190	35	1	B2
08600860	115.3	165.2	125	12500	1190	70	2 x 1/0	B2
09601040	158	211	200	137000	1190	2 x 50	2 x 1	B2
09601310	183	252	250		1190	2 x 70	2 x 1/0	B2
10601500	223	303	315	137000	1190	2 x 70	2 x 2/0	B2
10601780	252	359	315		1190	2 x 95	2 x 3/0	B2
11602100	282	466	400	330000	1190	2 x 70	2 x 4/0	C
11602380	332	522	450		1190	2 X 95	2 X 250	C
11602630	371	573	500		1190	2 X 120	2 X 300	C

Table 10-19 Unidrive M Rectifier DC current, fuse and cable size ratings

Model	Maximum continuous DC output current	DC fuse IEC class aR	Typical cable size (IEC)			Typical cable size (UL)	
			mm²			AWG or kcmil	
			DC output			DC output	
	A	A	Nominal	Maximum	Installation method	Nominal	Maximum
10204100	413	500	2 x 120	2 x 150	C	2 X 400	2 X 500
10404520	455	500	2 X 150	2 X 150	C	2 X 500	2 X 500
10502430	246	315	2 X 95	2 X 150	B2	2 X 3/0	2 X 500
10602480	251	315	2 X 95	2 X 150	B2	2 X 3/0	2 X 500
11406840	689	800	4 X 150	4 X 150	C	2 X 300	2 X 300
11503840	387	500	2 X 120	2 X 120	C	2 X 250	
11604060	411	500	2 X 120	2 X 120	C	2 X 400	
1142X400*	2 x 400	2 x 450	2 X 2 X 120	2 X 2 X 120	C	2 X2 X 300	
1162X380*	2 x 380	2 x 500	2 X 2 X 120	2 X 2 X 120	C	2 X 2 X 300	

* Twin rectifier

10.4 Component data

The following parts may be used:

- Motoring drive
- Regen drive
- Regen inductor
- Softstart resistor
- Switching frequency filter (optional)
- EMC filter (optional)
- Varistors
- Fusing
- Contactors
- Overloads

In addition to the above the additional items are also required to assemble a Unidrive *M* Regen *Brake Resistor replacement* system:

- Isolating transformer

CAUTION

The internal EMC filter must be removed from drive.

10.4.1 Regen filter components for low quality/high harmonic power supplies

Table 10-20 200 V (200 V to 240 V ±10 %) Regen filter components to support up to 8 % THD_V on the grid

Drive mode		Regen inductor			SFF inductor			SFF capacitor						
Heavy Duty	Normal Duty	mH	Arms	Part number	mH	Arms	Part number	Capacitor combination		Capacitor connection	Rated voltage Vac	Part number	Max. capacitor current per can @ 50 °C (Arms)	Fuse rating (A)
								Cap bank A µF	Cap bank B µF					
03200080	03200066	3.500	9.6	4401-0310	0.880	96	4401-1310	10	Not fitted	Delta	780	1610-8104	15	12
03200106	03200080	2.700	11	4401-0311	1.500	11	4401-1311							8
	03200106	2.700	11											8
04200137	04200137*	2.200	15.5	4401-0312	1.100	15.5	4401-1312							10
04200185*		2.200	15.5											10
05200250*	04200185*	1.600	22	4401-0313	0.700	22	4401-1313							8
06200330*		1.100	31	4401-0314	0.500	31	4401-1314	22		Star	550	1610-8224	25	8
	05200250							10		Delta	780	1610-8104	15	8
	06200330	0.600	56	4401-0316	0.300	56	4401-1316	33		Star	550	1610-8334	30	16
06200440*		0.810	42	4401-0315	0.400	42	4401-1315							10
07200610*		0.600	56	4401-0316	0.300	56	4401-1316	15		Delta	640	1610-8154	20	12
	06200440*							33			550	1610-8334	30	10
07200750	07200610	0.400	80	4401-0318	0.200	80	4401-1318	22				1610-8224	25	20
	07200750	0.320	105	4401-0319	0.160	105	4401-1319							25
07200830*		0.400	80	4401-0318	0.200	80	4401-1318							20
08201160*		0.320	105	4401-0319	0.160	105	4401-1319	33				1610-8334	30	25
	07200830*							22				1610-8224	25	25
08201320	08201160	0.220	156	4401-0321	0.110	156	4401-1321	33				1610-8334	30	32
09201760		0.180	192	4401-0322	0.088	192	4401-1322	68				1610-8684	40	40
	08201320	0.180	192					47				1610-8474	35	40
09202190*	09201760*	0.180	192					68				1610-8684	40	40
	09202190*	0.140	250	4401-0323	0.068	250	4401-1323							50
10202830	10202830*	0.110	312	4401-0324	0.055	312	4401-1324	47	47			1610-8474	35	63
10203000		0.110	312											63
	10203000*	0.100	350	4401-0325	0.048	350	4401-1325							80

* Modify *Rated Current* (05.007) to match current rating of inductor.

Table 10-21 400 V (380 V to 480 V ±10 %) Regen filter components to support up to 8 % THD$_V$ on the grid

Drive mode		Regen inductor			SFF inductor			SFF capacitor						
Heavy Duty	Normal Duty	mH	Arms	Part number	mH	Arms	Part number	Capacitor combination		Capacitor connection	Rated voltage Vac	Part number	Max. capacitor current per can @ 50 °C (Arms)	Fuse rating (A)
								Cap bank A µF	Cap bank B µF					
03400078	03400078*	6.300	9.5	4401-0405	3.160	9.5	4401-0162	10	Not fitted	Delta	780	1610-8104	15	20
03400100*														20
	03400100*	5.000	12	4401-0406	2.500	12	4401-0163							20
04400150	04400150*	3.750	16	4401-0407	1.875	16	4401-0164							20
04400172*														20
05400270*	04400172	2.400	25	4401-0408	1.200	25	4401-0165							10
05400300	05400270	1.760	34	4401-0409	0.880	34	4401-0166							16
06400350*								15		Star	640	1610-8154	20	10
	05400300							10		Delta	780	1610-8104	15	16
06400420*	06400350	1.500	40	4401-0410	0.750	40	4401-0167	15		Star	640	1610-8154	20	10
06400470*	06400420*	1.300	46	4401-0411	0.650	46	4401-0168							16
	06400470*	1.000	60	4401-0412	0.500	60	4401-0169	22			550	1610-8224	25	16
07400660	07400660*	0.780	74	4401-0413	0.390	77	4401-0170	10		Delta	780	1610-8104	15	20
07400770*														25
07401000*	07400770	0.630	96	4401-0414	0.315	96	4401-0171							25
08401340*		0.480	124	4401-0415	0.240	124	4401-0172	47		Star	550	1610-8474	35	32
	07401000							15		Delta	640	1610-8154	20	32
08401570*	08401340	0.380	156	4401-0416	0.190	156	4401-0173	68		Star	550	1610-8684	40	40
	08401570*	0.330	180	4401-0417	0.165	180	4401-0174							50
09402000*	09402000*	0.300	210	4401-0418	0.135	220	4401-0175	33		Delta		1610-8334	30	50
09402240*														50
10402700		0.200	300	4401-0419	0.100	300	4401-0176	22	22			1610-8224	25	63
	09402240							47	Not fitted			1610-8474	35	63
10403200*	10402700*							22	22			1610-8224	25	63
	10403200*	0.168	350	4401-0420	0.080	350	4401-1205	33	33			1610-8334	30	80
11403770	11403770	0.135	437	4401-0292	0.067	437	4401-0301	47	47			1610-8474	35	100
11404170														125
11404640														125
	11404170	0.121	487	4401-0293	0.060	487	4401-0302							125
	11404640													125

* Modify *Rated Current* (05.007) to match current rating of inductor.

Table 10-22 575 V (500 V to 575 V ±10 %) Regen filter components to support up to 8 % THD_V on the grid

Drive mode		Regen inductor			SFF inductor			SFF capacitor						
Heavy Duty	Normal Duty	mH	Arms	Part number	mH	Arms	Part number	Capacitor combination		Capacitor connection	Rated voltage Vac	Part number	Max. capacitor current per can @ 50 °C (Arms)	Fuse rating (A)
								Cap bank A µF	Cap bank B µF					
06500150	06500150	5.300	19	4401-0210	1.400	22	4401-1211	10	Not fitted	Star	780	1610-8104	15	6
06500190														6
06500230*	06500190	4.600	22	4401-0211										6
06500290*	06500230	3.800	27	4401-0212		36	4401-1213							6
06500350	06500290	2.800	36	4401-0213	1.200	43	4401-1214							8
07500440*	06500350	2.400	43	4401-0214	1.000	52	4401-1215							8
07500550*	07500440*	1.900	52	4401-0215	0.800	63	4401-1216							10
08500630	07500550*	1.600	63	4401-0216	0.600	85	4401-1217	15			640	1610-8154	20	12
08500860*	08500630*	1.200	85	4401-0217	0.510	100	4401-1218	22			550	1610-8224	25	16
09501040*	08500860*	1.000	100	4401-0218	0.400	125	4401-1219	33				1610-8334	30	20
09501310*	09501040	0.810	125	4401-0219	0.350	144	4401-1220	47					35	25
10501520*		0.700	144	4401-0220	0.300	168	4401-1221	22	22			1610-8224	25	25
	09501310*							47	Not fitted			1610-8474	35	25
10501900	10501520*	0.530	192	4401-0421	0.210	192	4401-1223	33	33			1610-8334	30	32
	10501900*			4401-0421										32
11502000		0.441	230	4401-0297	0.221	230	4401-0306	47	47			1610-8474	35	40
	11502000	0.361	281	4401-0298	0.181	281	4401-0307							63
11502540		0.441	230	4401-0297	0.221	230	4401-0306							40
	11502540	0.361	281	4401-0298	0.181	281	4401-0307							63
11502850		0.441	230	4401-0297	0.221	230	4401-0306							40
	11502850	0.361	281	4401-0298	0.181	281	4401-0307							63

* Modify *Rated Current* (05.007) to match current rating of inductor.

Table 10-23 690 V (500 V to 690 V ±10 %) Regen filter components to support up to 8 % THD_V on the grid

Drive mode		Regen inductor			SFF inductor			SFF capacitor						
Heavy Duty	Normal Duty	mH	Arms	Part number	mH	Arms	Part number	Capacitor combination		Capacitor connection	Rated voltage Vac	Part number	Max. capacitor current per can @ 50 °C (Arms)	Fuse rating (A)
								Cap bank A µF	Cap bank B µF					
07600190		5.300	19	4401-0210	1.400	22	4401-1211	10	Not fitted	Star	780	1610-8104	15	6
07600240*	07600190*	4.600	22	4401-0211										6
07600290*	07600240*	3.800	27	4401-0212		36	4401-1213							8
07600380*	07600290*	2.800	36	4401-0213			4401-1213							8
07600440*	07600380*	2.400	43	4401-0214	1.200	43	4401-1214							10
07600540*	07600440	1.900	52	4401-0215	1.000	52	4401-1215							12
08600630		1.600	63	4401-0216	0.800	63	4401-1216	15			640	1610-8154	20	16
	07600540*							10			780	1610-8104	15	20
08600860*	08600630*	1.200	85	4401-0217	0.600	85	4401-1217	22			550	1610-8224	25	20
09601040*		1.000	100	4401-0218	0.510	100	4401-1218	33				1610-8334	30	20
	08600860*							22				1610-8224	25	25
09601310*		0.810	125	4401-0219	0.400	125	4401-1219	47				1610-8474	35	32
	09601040													32
10601500*		0.700	144	4401-0220	0.350	144	4401-1220	22	22			1610-8224	25	32
	09601310*							47	Not fitted			1610-8474	35	32
10601780*	10601500*	0.600	168	4401-0221	0.300	168	4401-1221	22	33			1610-8224 1610-8334	25	32
	10601780*	0.530	192	4401-0421	0.260	192	4401-1222							40
11602100	11602100	0.441	230	4401-0297	0.221	230	4401-0306	47	47			1610-8474	35	50
11602380		0.441	230	4401-0297										50
	11602380	0.361	281	4401-0298	0.181	281	4401-0307							63
11602630		0.441	230	4401-0297	0.221	230	4401-0306							50
	11602630	0.361	281	4401-0298	0.181	281	4401-0307							63

* Modify *Rated Current* (05.007) to match current rating of inductor.

10.4.2 Regen filter components for high quality/low harmonic power supplies

Table 10-24 200 V (200 V to 240 V ±10 %) Regen filter components to support up to 2 % THD_v on grid

Drive mode		Regen inductor			SFF inductor			SFF capacitor				
Heavy Duty	**Normal Duty**	**mH**	**Arms**	**Part number**	**mH**	**Arms**	**Part number**	**Capacitor value**	**Rated voltage**	**Part number**	**Capacitor current per can**	**Fuse rating (A)**
								µF	**Vac**		**Arms**	
03200080	03200066	3.500	9.6	4401-0310	0.880	9.6	4401-1310	7	400	1664-1074	1.6	2
03200106	03200080	2.700	11	4401-0311	1.500	11	4401-1311	7	400	1664-1074	1.8	4
	03200106	2.700	11									4
04200137	04200137*	2.200	15.5	4401-0312	1.100	15.5	4401-1312	7	400	1664-1074	2	4
04200185*		2.200	15.5									4
05200250*	04200185*	1.600	22	4401-0313	0.700	22	4401-1313	17	400	1664-2174	3.8	6
06200330*	05200250	1.100	31	4401-0314	0.500	31	4401-1314	17	400	1664-2174	4.4	8
	06200330	0.600	56	4401-0316	0.300	56	4401-1316	32	525	1665-8324	8.1	16
06200440*		0.810	42	4401-0315	0.400	42	4401-1315	17	400	1664-2174	5.2	8
07200610*	06200440*	0.600	56	4401-0316	0.300	56	4401-1316	32	525	1665-8324	8.1	16
07200750	07200610	0.400	80	4401-0318	0.200	80	4401-1318	32	525	1665-8324	9.9	16
	07200750	0.320	105	4401-0319	0.160	105	4401-1319	64	400	1664-2644	15.8	25
07200830*		0.400	80	4401-0318	0.200	80	4401-1318	32	525	1665-8324	9.9	16
08201160*	07200830*	0.320	105	4401-0319	0.160	105	4401-1319	64	400	1664-2644	15.8	25
08201320	08201160	0.220	156	4401-0321	0.110	156	4401-1321	64	400	1664-2644	19.2	32
09201760	08201320	0.180	192	4401-0322	0.088	192	4401-1322	2 x 64	400	2 x 1664-2644	15.2	25
09202190*	09201760*	0.180	192									25
	09202190*	0.140	250	4401-0323	0.068	250	4401-1323	2 x 64	400	2 x 1664-2644	16.8	32
10202830	10202830*	0.110	312	4401-0324	0.055	312	4401-1324	2 x 64	400	2 x 1664-2644	19.2	32
10203000		0.110	312									32
	10203000*	0.100	350	4401-0325	0.048	350	4401-1325	2 x 64	400	2 x 1664-2644	20.5	32

* Modify *Rated Current* (05.007) to match current rating of inductor.

Table 10-25 400 V (380 V to 480 V ±10 %) Regen filter components to support up to 2 % THD_V on grid

Drive mode		Regen inductor			SFF inductor			SFF capacitor				
Heavy Duty	Normal Duty	mH	Arms	Part number	mH	Arms	Part number	Capacitor value	Rated voltage	Part number	Capacitor current per can	Fuse rating (A)
								µF	Vac		Arms	
03400078	03400078*	6.300	9.5	4401-0405	3.160	9.5	4401-0162	8	525	1610-7804	3.3	6
03400100*						9.5						6
	03400100*	5.000	12	4401-0406	2.500	12	4401-0163					6
04400150	04400150*	3.750	16	4401-0407	1.875	16	4401-0164				3.5	6
04400172*												6
05400270*	04400172	2.400	25	4401-0408	1.200	25	4401-0165				4.1	6
05400300	05400270	1.760	34	4401-0409	0.880	34	4401-0166	32		1665-8324	13	20
06400350*	05400300											20
06400420*	06400350	1.500	40	4401-0410	0.750	40	4401-0167				13.1	20
06400470*	06400420*	1.300	46	4401-0411	0.650	46	4401-0168				13.3	25
	06400470*	1.000	60	4401-0412	0.500	60	4401-0169				13.9	25
07400660	07400660*	0.780	74	4401-0413	0.390	77	4401-0170				14.8	25
07400770*		0.780										25
07401000*	07400770	0.630	96	4401-0414	0.315	96	4401-0171	39		1665-8394	18.1	32
08401340*	07401000	0.480	124	4401-0415	0.240	124	4401-0172				20.1	32
08401570*	08401340	0.380	156	4401-0416	0.190	156	4401-0173				22.7	40
	08401570*	0.330	180	4401-0417	0.165	180	4401-0174				24.8	40
09402000*	09402000*	0.300	202	4401-0418	0.135	200	4401-0175	2 x 39		2 x 1665-8394	18.4	32
09402240*												32
10402700	09402240	0.200	300	4401-0419	0.100	300	4401-0176				20.1	32
10403200*	10402700*											32
	10403200*	0.168	350	4401-0420	0.080	350	4401-1205				25.4	40
11403770	11403770	0.135	437	4401-0292	0.067	437	4401-0301	3x 64		3 x 1665-8644	33.5	50
11404170												50
11404640												50
	11404170	0.121	487	4401-0293	0.060	487	4401-0302					50
	11404640											50

* Modify *Rated Current* (05.007) to match current rating of inductor.

Table 10-26 575 V (500 V to 575 V ±10 %) Regen filter components to support up to 2 % THD$_V$ on grid

Drive mode		Regen inductor			SFF inductor			SFF capacitor				
Heavy Duty	Normal Duty	mH	Arms	Part number	mH	Arms	Part number	Capacitor value	Rated voltage	Part number	Capacitor current per can	Fuse rating (A)
								µF	Vac		Arms	
06500150	06500150	5.300	19	4401-0210	1.400	22	4401-1211	11.2	690	1666-8113	5.2	8
06500190												8
06500230*	06500190	4.600	22	4401-0211								8
06500290*	06500230	3.800	27	4401-0212		36	4401-1213				5.3	8
06500350	06500290	2.800	36	4401-0213	1.200	43	4401-1214				5.6	10
07500440*	06500350	2.400	43	4401-0214	1.000	52	4401-1215				5.9	10
07500550*	07500440*	1.900	52	4401-0215	0.800	63	4401-1216				6.4	10
08500630	07500550*	1.600	63	4401-0216	0.600	85	4401-1217				6.9	12
08500860*	08500630*	1.200	85	4401-0217	0.510	100	4401-1218				8.2	16
09501040*	08500860*	1.000	100	4401-0218	0.400	125	4401-1219	22.5		1666-8223	12.5	20
09501310*	09501040	0.810	125	4401-0219	0.350	144	4401-1220				13.8	25
10501520*	09501310*	0.700	144	4401-0220	0.300	168	4401-1221				14.9	25
10501900	10501520*	0.530	192	4401-0421	0.210	192	4401-1223	2 x 22.5		2 x 1666-8223	12.2	20
	10501900*			4401-0421			4401-1223					20
11502000		0.441	230	4401-0297	0.221	230	4401-0306	2 x 46.2	800	2 x 1668-8464	24	40
	11502000	0.361	281	4401-0298	0.181	281	4401-0307	3 x 46.2		3 x 1668-8464		40
11502540		0.441	230	4401-0297	0.221	230	4401-0306	2 x 46.2		2 x 1668-8464		40
	11502540	0.361	281	4401-0298	0.181	281	4401-0307	3 x 46.2		3 x 1668-8464		40
11502850		0.441	230	4401-0297	0.221	230	4401-0306	2 x 46.2		2 x 1668-8464		40
	11502850	0.361	281	4401-0298	0.181	281	4401-0307	3 x 46.2		3 x 1668-8464		40

* Modify *Rated Current* (05.007) to match current rating of inductor.

Table 10-27 690 V (500 V to 690 V ±10 %) Regen filter components to support up to 2 % THD$_V$ on grid

Drive mode		Regen inductor			SFF inductor			SFF capacitor				
Heavy Duty	Normal Duty	mH	Arms	Part number	mH	Arms	Part number	Capacitor value	Rated voltage	Part number	Capacitor current per can Arms	Fuse rating (A)
								µF	Vac			
07600190		5.300	19	4401-0210	1.400	22	4401-1211	8.3	800	1668-7833	4.7	8
07600240*	07600190*	4.600	22	4401-0211							4.8	8
07600290*	07600240*	3.800	27	4401-0212		36	4401-1213				5	8
07600380*	07600290*	2.800	36	4401-0213			4401-1213				5.5	8
07600440*	07600380*	2.400	43	4401-0214	1.200	43	4401-1214				5.8	10
07600540*	07600440	1.900	52	4401-0215	1.000	52	4401-1215				6.6	10
08600630	07600540*	1.600	63	4401-0216	0.800	63	4401-1216				7.3	12
08600860*	08600630*	1.200	85	4401-0217	0.600	85	4401-1217	16.6		1668-8163	11.6	20
09601040*	08600860*	1.000	100	4401-0218	0.510	100	4401-1218				12.8	20
09601310*	09601040	0.810	125	4401-0219	0.400	125	4401-1219				14.5	25
10601500*	09601310*	0.700	144	4401-0220	0.350	144	4401-1220	2 x 16.6		2 x 1668-8163	10.9	20
10601780*	10601500*	0.600	168	4401-0221	0.300	168	4401-1221				11.6	20
	10601780*	0.530	192	4401-0421	0.260	192	4401-1222				12.4	20
11602100	11602100	0.441	230	4401-0297	0.221	230	4401-0306	2 x 46.2		2 x 1668-8464	28	40
11602380		0.441	230	4401-0297								40
	11602380	0.361	281	4401-0298	0.181	281	4401-0307	3 x 46.2		3 x 1668-8464		40
11602630		0.441	230	4401-0297	0.221	230	4401-0306	2 x 46.2		2 x 1668-8464		40
	11602630	0.361	281	4401-0298	0.181	281	4401-0307	3 x 46.2		3 x 1668-8464		40

* Modify *Rated Current* (05.007) to match current rating of inductor.

10.4.3 Regen inductors

NOTE

The Regen inductor core losses are directly dependent on the switching frequency and specific core material and therefore selection is critical. As a result only Regen inductors specified in this guide should be used.

The Regen inductor supports the difference between the PWM voltage from the Regen drive and the sinusoidal voltage from the supply. One three-phase Regen inductor is required per Regen drive.

Each Regen inductor is fitted with a thermistor mounted in the centre coil. Thermistor characteristics are set in accordance with DIN 44082 (triplet).

WARNING

The Regen inductors have a normal operating temperature in excess of 100 °C depending upon the ambient and the motor cable lengths. Care must be taken so that this does not create a fire risk. The Regen inductor thermistor must be configured to disable the drive in the event of thermal overload.

NOTE

If the permissible cable lengths are exceeded additional cooling may be required for the Regen inductors, refer to section 4.6 *Exceeding maximum cable length* on page 70 for more information.

Table 10-28 200 V Regen inductor specifications

Inductor part number	Amps	mH	Losses	L	D	H	Weight	Fixing centres (x * y)	Fixing	Fixing type
			W	mm	mm	mm	kg	mm	mm	
4401-0310	9.6	3.500	71	200	180	215	10	120 x 140	9	A
4401-0311	11.0	2.700	72	200	180	215	11	120 x 140	9	
4401-0312	15.5	2.200	116	200	180	215	12	120 x 140	9	
4401-0313	22	1.600	157	200	180	215	15	120 x 140	9	
4401-0314	31	1.100	193	240	180	270	17	160 x 140	9	
4401-0315	42	0.810	200	240	200	270	24	160 x 160	9	
4401-0316	56	0.600	264	320	220	325	32	200 x 180	11	
4401-0318	80	0.400	298	320	220	325	39	200 x 180	11	
4401-0319	105	0.320	338	360	260	370	55	240 x 220	11	
4401-0321	156	0.220	475	360	280	395	77	240 x 240	11	
4401-0322	192	0.180	526	360	280	395	97	240 x 240	11	
4401-0323	250	0.140	610	410	300	430	110	280 x 260	11	
4401-0324	312	0.110	776	410	300	430	120	280 x 260	11	
4401-0325	350	0.100	863	480	320	490	130	320 x 260	11	

Table 10-29 400 V Regen inductor specifications

Inductor part number	Amps	mH	Losses	L	D	H	Weight	Fixing centres (x *y)	Fixing	Fixing type
			W	mm	mm	mm	kg	mm	mm	
4401-0405	9.5	6.300	105	190	82	161	6	170 x 58	7	A
4401-0406	12	5.000	115	190	91	161	7.5	170 x 168	8	
4401-0407	16	3.750	155	230	124	229	11	180 x 98	8	
4401-0408	25	2.400	205	230	130	230	15	180 x 98	8	
4401-0409	34	1.760	215	230	154	242	18	180 x 122	8	
4401-0410	40	1.500	215	240	156	245	23	190 x 125	11	
4401-0411	46	1.300	325	265	160	263	28	215 x 126	11	
4401-0412	60	1.000	245	300	176	276	30	240 x 120	11	
4401-0413	74	0.780	400	300	200	275	30	240 x 135	11	
4401-0414	96	0.630	540	360	230	352	62	310 x 140	11	
4401-0415	124	0.480	580	360	217	322	62	310 x 140	11	
4401-0416	156	0.380	565	360	237	318	80	310 x 155	11	
4401-0417	180	0.330	685	420	230	370	85	370 x 151	11	
4401-0418	210	0.300	805	420	257	372	90	370 x 166	11	
4401-0419	300	0.200	950	480	260	429	160	430 x 210	11	
4401-0420	350	0.168	1500	480	250	447	165	430 x 210	13	
4401-0262	585	0.101	1500	480	280	435	185	430 x 240	13	
4401-0292	437	0.135	1500	480	280	435	185	430 x 240	13	
4401-0293	487	0.121	1500	480	280	435	185	430 x 240	13	

Table 10-30 575 V / 690 V Regen inductor specifications

Inductor part number	Amps	mH	Losses	L	D	H	Weight	Fixing centres (x * y)	Fixing	Fixing type
			W	mm	mm	mm	kg	mm	mm	
4401-0210	19	5.300	268	325	220	320	32	200 x 180	11	A
4401-0211	22	4.600	288	325	220	320	33	200 x 180	11	
4401-0212	27	3.800	322	325	220	320	39	200 x 180	11	
4401-0213	36	2.800	348	370	260	360	55	240 x 220	11	
4401-0214	43	2.400	398	375	280	360	65	240 x 240	11	
4401-0215	52	1.900	456	395	280	360	77	240 x 240	11	
4401-0216	63	1.600	503	395	280	360	97	240 x 240	11	
4401-0217	85	1.200	605	430	300	410	110	280 x 260	11	
4401-0218	100	1.000	950	500	350	480	170	320 x 260	11	
4401-0219	125	0.810	880	490	320	480	130	320 x 260	11	
4401-0220	144	0.700	1022	500	320	480	140	320 x 260	11	
4401-0221	168	0.600	1656	555	300	480	165	320 x 240	11	
4401-0421	192	0.530	1350	600	223	480	180	430 x 183	13	C
4401-0297	230	0.441	1500	480	280	435	130	430 x 240	13	A
4401-0298	281	0.361	1500	480	280	435	130	430 x 240	13	

10.4.4 Switching frequency filter inductors

Table 10-31 200 V SFF inductor specifications

Inductor part number	Amps	mH	Losses	L	D	H	Weight	Fixing centres (x * y)	Fixing	Fixing type
			W	mm	mm	mm	kg	mm	mm	
4401-1310	9.6	0.880	10	150	90	150	4	120 x 47	8 x 18	B
4401-1311	11.0	1.500	18	150	90	150	4	120 x 47	8 x 18	
4401-1312	15.5	1.100	26	150	90	150	4	120 x 47	8 x 18	
4401-1313	22	0.700	33	150	90	150	4	120 x 47	8 x 18	
4401-1314	31	0.500	37	190	100	180	6	130 x 54	8 x 20	
4401-1315	42	0.400	38	190	120	180	10	130 x 74	8 x 20	
4401-1316	56	0.300	48	190	160	180	12	130 x 184	8 x 20	
4401-1318	80	0.200	60	190	160	180	13	130 x 184	8 x 20	
4401-1319	105	0.160	78	255	160	240	16	200 x 180	10 x 20	
4401-1321	156	0.110	92	255	180	240	22	200 x 100	10 x 20	
4401-1322	192	0.088	97	255	190	240	25	200 x 100	10 x 20	
4401-1323	250	0.068	119	300	180	300	37	204 x 113	10 x 20	
4401-1324	312	0.055	170	300	180	300	37	204 x 113	10 x 20	
4401-1325	350	0.048	162	300	190	300	49	204 x 123	10 x 20	

Table 10-32 400 V SFF inductor specifications

Inductor part number	Amps	mH	Losses	L	D	H	Weight	Fixing centres (x * y)	Fixing	Fixing type
			W	mm	mm	mm	kg	mm	mm	
4401-0162	9.5	3.160	27	150	75	135	3.1	120 x 47	8 x 12	C
4401-0163	12	2.500	33	150	75	135	3.3	120 x 47	8 x 12	C
4401-0164	16	1.875	48	180	82	158	5.3	130 x 58	8 x 12	C
4401-0165	25	1.200								
4401-0166	34	0.880								
4401-0167	40	0.750								
4401-0168	46	0.650	69	180	116	179	9.8	130 x 84	8 x 12	C
4401-0169	60	0.500	98	240	110	247	20	200 x 80	11 x 20	C
4401-0170	77	0.390								
4401-0171	96	0.315	147	240	180	258	18	200 x 100	11 x 20	C
4401-0172	124	0.240	178	240	185	260	20	200 x 100	11 x 20	C
4401-0173	156	0.190	224	300	177	300	24	204 x 113	11 x 20	B
4401-0174	180	0.165	251	300	177	300	25	204 x 113	11 x 20	B
4401-0175	220	0.135	229	300	177	300	25	204 x 113	11 x 20	B
4401-0176	300	0.100	273	300	195	300	40	204 x 130	11 x 20	B
4401-1205	350	0.080								
4401-0301	437	0.067								
4401-0302	487	0.060	357	357	175	322	58	328 x 267	9 x 14	A

Table 10-33 575 V / 690 V SFF inductor specifications

Inductor part number	Amps	mH	Losses	L	D	H	Weight	Fixing centres (x * y)	Fixing	Fixing type
			W	mm	mm	mm	kg	mm	mm	
4401-1211	22	1.400	36	190	120	180	10	130 x 74	8 x 20	B
4401-1213	36	1.400	81	255	160	240	16	200 x 80	10 x 20	
4401-1214	43	1.200	86	255	170	240	20	200 x 90	10 x 20	
4401-1215	52	1.000	93	255	180	240	22	200 x 100	10 x 20	
4401-1216	63	0.800	95	255	190	240	25	200 x 100	10 x 20	
4401-1217	85	0.600	122	300	180	300	37	204 x 113	10 x 20	
4401-1218	100	0.510	190	300	180	300	37	204 x 120	4 x 10	
4401-1219	125	0.400	172	300	190	300	49	204 x 123	10 x 20	
4401-1220	144	0.350	177	300	200	300	50	204 x 130	10 x 20	
4401-1221	168	0.300	207	300	200	300	50	204 x 130	10 x 20	
4401-1222	192	0.260	220	325	220	325	55	204 x 160	4 x 10	
4401-1223	192	0.210	189	300	200	300	50	204 x 130	10 x 20	
4401-0306	230	0.221	357	360	176	322	58	328 x 263	11 x 17	A
4401-0307	281	0.181	375	360	176	322	66	328 x 263	11 x 17	A

10.4.5 Switching frequency filter capacitors

The capacitors specified below are suitable for operation at any switching frequency. These being sized for operation at 3 kHz, however, operation above 3 kHz is possible with the capacitors being more effective.

Table 10-34 200 V / 400 V / 575 V / 690 V Switching frequency filter capacitor to support up to 8 % THD_V

Capacitor part no.	Capacitance	Max current at 50 °C	Max Ø	Max L	Weight	Fixing stud
	µF	ARMS	mm	mm	kg	mm
1610-8104	10	15	65	117	0.4	M12 @ 12 N m (106.3 lb in)
1610-8154	15	20	65	117	0.4	
1610-8224	22	25	65	117	0.4	
1610-8334	33	30	75	117	0.5	
1610-8474	47	35	65	197	0.8	
1610-8684	68	40	65	247	1	

NOTE

SFF capacitors designed to support supplies of up to 8 % THD_V do not require discharge resistors to be installed if the regen drive main contactor is at the supply side of the capacitor. (See Figure 4-5 and Figure 4-7). Refer to the table below for further details.

Table 10-35 Discharge resistor details for SFF capacitors to support 8 % THD_v

Drive voltage	Resistance	Power rating
V	MΩ	W
200	2	0.25
400	2	0.25
575	2	0.5
690	2	1

Table 10-36 200 V Switching frequency filter capacitor to support up to 2 % THD_v

Capacitor part no.	Capacitance	I_{rated}	Max Ø	Max L	Weight	Fixing stud	Discharge resistor
	uF	A	mm	mm	kg	mm	Ω
1664-1074	7	1.7	53	114	0.3	M 12 @ 15 N m (132.9 lb in)	390 k
1664-2174	17	4.3	116.2	204	0.4	M 12 @ 10 N m (88.6 lb in)	
1665-8324	32	11	116.2	204	1.3		
1664-2644	64	16.6	116.2	204	1.2		

Table 10-37 400 V Switching frequency filter capacitor to support up to 2 % THD_v

Capacitor part no.	Capacitance	I_{rated}	Max Ø	Max L	Weight	Fixing stud	Discharge resistor
	uF	A	mm	mm	kg	mm	Ω
1610-7804	8	2.64	82	204	0.5	M 12 @ 15 N m (132.9 lb in)	390 k
1665-8324	32	11.0	121	204	1.1	M 12 @ 10 N m (88.6 lb in)	390 k
1665-8484	48	14.0	121	204	1.3		390 k
1665-8774	77	24.0	121	204	1.5		390 k
1665-8394	39	20	121	204	1.5		390 k
1665-8644	64.3	22	116	200	2.2		3 x 390 k*

* Connected in delta.

Table 10-38 575 V / 690 V Switching frequency filter capacitor to support up to 2 % THD_v

Capacitor part no.	Capacitance	I_{rated}	Max Ø	Max L	Weight	Fixing stud	Discharge resistor
	uF	A	mm	mm	kg	mm	Ω
1666-8113	11	5	116.2	204	1.3	M 12 @ 10 N m (88.6 lb in)	390 k
1666-8223	23	10	116.2	204	1.4		390 k
1668-7833	8.3	7.3	116.2	204	1.2		390 k
1668-8163	16.6	12.4	116.2	204	1.2		390 k
1668-8464	46.4	24.2	136	200	3.2		3 x 150 k**

** Connected in star.

NOTE

The discharge resistors listed in Table 10-36 to Table 10-38 are supplied pre-installed to the SFF capacitor. These resistors are a requirement and should remain installed.

CAUTION

The 3-phase switching frequency filter (SFF) capacitors are situated on the input of the Regen system. If the harmonic distortion of the supply is high for extended periods then this can cause a reduction of the service life of the capacitors. The effect of this is to reduce the capacitance value. If high levels of harmonic distortion are expected then it is recommended that the capacitance values be checked periodically, and capacitors which have fallen outside of their tolerance range be replaced.

10.4.6 Softstart resistor

The start-up circuit limits the amount of current flowing into the DC bus of the Regen drive and motoring drive(s) when the supply is first switched on.

For correct sizing of the softstart resistor, refer to section 11.2.1 *Procedure* on page 309.

CAUTION

Only pulse withstanding resistors should be used for charging the inverter system.

A range of suitable pulse withstanding resistors are available from Metallux (PWR-R).

10.4.7 Softstart resistor MCB

Protection for the softstart circuit is provided using a thermal overload to protect against a high impedance short circuit, and a separate magnetic overload to protect against a direct short circuit.

Table 10-39 200 V SFF inductor specifications

Inductor part number	Amps	mH	Losses	L	D	H	Weight	Fixing centres (x * y)	Fixing	Fixing type
			W	mm	mm	mm	kg	mm	mm	
4401-1310	9.6	0.880	10	150	90	150	4	120 x 47	8 x 18	B
4401-1311	11.0	1.500	18	150	90	150	4	120 x 47	8 x 18	
4401-1312	15.5	1.100	26	150	90	150	4	120 x 47	8 x 18	
4401-1313	22	0.700	33	150	90	150	4	120 x 47	8 x 18	
4401-1314	31	0.500	37	190	100	180	6	130 x 54	8 x 20	
4401-1315	42	0.400	38	190	120	180	10	130 x 74	8 x 20	
4401-1316	56	0.300	48	190	160	180	12	130 x 184	8 x 20	
4401-1318	80	0.200	60	190	160	180	13	130 x 184	8 x 20	
4401-1319	105	0.160	78	255	160	240	16	200 x 180	10 x 20	
4401-1321	156	0.110	92	255	180	240	22	200 x 100	10 x 20	
4401-1322	192	0.088	97	255	190	240	25	200 x 100	10 x 20	
4401-1323	250	0.068	119	300	180	300	37	204 x 113	10 x 20	
4401-1324	312	0.055	170	300	180	300	37	204 x 113	10 x 20	
4401-1325	350	0.048	162	300	190	300	49	204 x 123	10 x 20	

Table 10-40 400 V SFF inductor specifications

Inductor part number	Amps	mH	Losses	L	D	H	Weight	Fixing centres (x * y)	Fixing	Fixing type
			W	mm	mm	mm	kg	mm	mm	
4401-0162	9.5	3.160	27	150	75	135	3.1	120 x 47	8 x 12	C
4401-0163	12	2.500	33	150	75	135	3.3	120 x 47	8 x 12	C
4401-0164	16	1.875	48	180	82	158	5.3	130 x 58	8 x 12	C
4401-0165	25	1.200								
4401-0166	34	0.880								
4401-0167	40	0.750								
4401-0168	46	0.650	69	180	116	179	9.8	130 x 84	8 x 12	C
4401-0169	60	0.500	98	240	110	247	20	200 x 80	11 x 20	C
4401-0170	77	0.390								
4401-0171	96	0.315	147	240	180	258	18	200 x 100	11 x 20	C
4401-0172	124	0.240	178	240	185	260	20	200 x 100	11 x 20	C
4401-0173	156	0.190	224	300	177	300	24	204 x 113	11 x 20	B
4401-0174	180	0.165	251	300	177	300	25	204 x 113	11 x 20	B
4401-0175	220	0.135	229	300	177	300	25	204 x 113	11 x 20	B
4401-0176	300	0.100	273	300	195	300	40	204 x 130	11 x 20	B
4401-1205	350	0.080								
4401-0301	437	0.067								
4401-0302	487	0.060	357	357	175	322	58	328 x 267	9 x 14	A

Table 10-41 575 V / 690 V SFF inductor specifications

Inductor part number	Amps	mH	Losses	L	D	H	Weight	Fixing centres (x * y)	Fixing	Fixing type
			W	mm	mm	mm	kg	mm	mm	
4401-1211	22	1.400	36	190	120	180	10	130 x 74	8 x 20	B
4401-1213	36	1.400	81	255	160	240	16	200 x 80	10 x 20	
4401-1214	43	1.200	86	255	170	240	20	200 x 90	10 x 20	
4401-1215	52	1.000	93	255	180	240	22	200 x 100	10 x 20	
4401-1216	63	0.800	95	255	190	240	25	200 x 100	10 x 20	
4401-1217	85	0.600	122	300	180	300	37	204 x 113	10 x 20	
4401-1218	100	0.500	190	300	180	300	37	204 x 120	4 x 10	
4401-1219	125	0.400	172	300	190	300	49	204 x 123	10 x 20	
4401-1220	144	0.350	177	300	200	300	50	204 x 130	10 x 20	
4401-1221	168	0.300	207	300	200	300	50	204 x 130	10 x 20	
4401-1222	192	0.260	220	325	220	325	55	204 x 160	4 x 10	
4401-1223	192	0.210	189	300	200	300	50	204 x 130	10 x 20	
4401-0306	230	0.221	357	360	176	322	58	328 x 263	11 x 17	A
4401-0307	281	0.181	375	360	176	322	66	328 x 263	11 x 17	A

Switching frequency filter inductors

The following inductors are standard 3-phase inductors. They carry only 50/60 Hz current with a negligible amount of high frequency current.

NOTE

The switching frequency filter inductors need to be rated to the total current requirement of the system.

10.4.8 Switching frequency filter capacitors

Switching frequency filter capacitor specification

Overload - I_{max} = 1.3 x I_{rated}

I_{inrush} = 200 x I_{rated}

10.5 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 10-42 Immunity compliance

Standard	Type of immunity	Test specification	Application	Level
IEC 61000-4-2 EN 61000-4-2:2009	Electrostatic discharge	6 kV contact discharge 8 kV air discharge	Module enclosure	Level 3 (industrial)
IEC 61000-4-3 EN 61000-4-3:2006+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)
IEC 61000-4-4 EN 61000-4-4:2012	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)
IEC 61000-4-5 EN 61000-4-5:2014	Surges	Common mode 4 kV 1.2/50 ms waveshape	AC supply lines: line to ground	Level 4
		Differential mode 2 kV1.2/50 ms waveshape	AC supply lines: line to line	Level 3
		Lines to ground	Signal ports to ground [1]	Level 2
IEC 61000-4-6 EN 61000-4-6:2014	Conducted radio frequency	10V prior to modulation 0.15 - 80 MHz 80 % AM (1 kHz) modulation	Control and power lines	Level 3 (industrial)
IEC 61000-4-11 EN 61000-4-11:2004	Voltage dips and interruptions	-30 % 10 ms +60 % 100 ms -60 % 1 s <-95 % 5 s	AC power ports	
IEC 61000-6-1 EN 61000-6-1:2007	Generic immunity standard for the residential, commercial and light - industrial environment			Complies
IEC 61000-6-2 EN 61000-6-2:2005	Generic immunity standard for the industrial environment			Complies
IEC 61800-3 EN 61800-3:2004+A1:2012	Product standard for adjustable speed power drive systems (immunity requirements)		Meets immunity requirements for first and second environments	

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 above
C1	Intended for use in the first or second environments	R
C2	Not a plug-in or movable device, and intended for use in the first environment only when installed by a professional, or in the second environment	I
C3	Intended for use in the second environment, not the first environment	E2U
C4	Intended for use in the second environment in a system rated at over 400A, or in a complex system.	E2R

Note that category 4 is more restrictive than E2R, since the rated current of the PDS must exceed 400 A or the supply voltage exceed 1000 V, for the complete PDS.

10.5.1 Optional external EMC filters

Table 10-43 EMC filter cross reference

Drive (model)	Part number
03200066 to 03200106	4200-3230
04200137 to 04200185	4200-0272
05200250	4200-0312
06200330 to 06200440	4200-2300
07200610 to 07200830	4200-1132
08201160 to 08201320	4200-1972
09201760 to 09202190 (9A)	4200-3021
10202830 to 10203000	4200-4460
03400078 to 03400100	4200-3480
04400150 to 04400172	4200-0252
05400270 to 05400300	4200-0402
06400350 to 06400470	4200-4800
07400660 to 07401000	4200-1132
08401340 to 08401570	4200-1972
09402000 to 09402240 (9A)	4200-3021
10402700 to 10403200	4200-4460
11403770 to 11404640	4200-0400
06500150 to 06500350	4200-3690
07500440 to 07500550	4200-0672
08500630 to 08500860	4200-1662
09501040 to 09501310 (9A)	4200-1660
10501520 to 10501900	4200-2210
11502000 to 11502850	4200-0690
07600190 to 07600540	4200-0672
08600630 to 08600860	4200-1662
09601040 to 09601310 (9A)	4200-1660
10601500 to 10601780	4200-2210
11602100 to 11602630	4200-0690

Table 10-44 Optional external EMC filter details

Part number	Maximum continuous current		Voltage rating		IP rating	Power dissipation at rated current		Ground leakage		Discharge resistors
	@ 40 °C (104 °F)	@ 50 °C (122 °F)	IEC	UL		@ 40 °C (104 °F)	@ 50 °C (122 °F)	Balanced supply phase-to-phase and phase-to-ground	Worst case	
	A	A	V	V		W	W	mA	mA	MΩ
4200-3230	20	18.5	250	300	20	20	17	2.4	60	1.68
4200-0272	27	24.8	250	300		33	28	6.8	137	
4200-0312	31	28.5	250	300		20	17	2.0	80	
4200-2300	55	51	250	300		41	35	4.2	69	
4200-1132	117	102.7*	528	480		50	43.7	11.7	188	
4200-1972	197	172.8*	528	480		42	36.7	18.7	210	
4200-3021	302	277	528	480	00	34	29.7	30	202	
4200-4460	446	409	528	480		37	32.4	30	283	
4200-3480	16	15	528	600	20	13	11	10.7	151	
4200-0252	25	23	528	600		28	24	11.1	182	
4200-0402	40	36.8	528	600		47	40	18.7	197	
4200-4800	63	58	528	600		54	46	11.2	183	
4200-0400	685	551	480	480	00	44	38.5	60.7	275	
4200-3690	42	39	760	600	20	45	39	12	234	
4200-0672	67	58.8*	759	600		25	21.9	24.5	395	2.72
4200-1662	114	100*	759	600		39	34.1	24.3	364	
4200-1660	166	152	759	600	00	13	11.4	21	332	
4200-2210	221	203	759	600		16	14	21	434	
4200-0690	403	368	690	N/A		28	24.5	25	583	

* At 55 °C (131 °F).

Table 10-45 Optional external EMC filter dimensions

Part number	Dimension						Weight	
	H		W		D			
	mm	inch	mm	inch	mm	inch	kg	lb
4200-3230	426	16.77	83	3.27	41	1.61	1.9	4.20
4200-0272	437	17.20	123	4.84	60	2.36	4.0	8.82
4200-0312	437	17.20	143	5.63	60	2.36	5.5	12.13
4200-2300	434	17.09	210	8.27	60	2.36	6.5	14.30
4200-1132	270	10.63	90	3.54	150	5.90	6	13.2
4200-1972	300	11.81	120	4.72	170	6.69	9.6	21.2
4200-3021	339	13.3	230	9.06	120	4.72	11	24.3
4200-4460	105	4.13	360	14.2	245	9.6	12	26.5
4200-3480	426	16.77	83	3.27	41	1.61	2.0	4.40
4200-0252	437	17.20	123	4.84	60	2.36	4.1	9.04
4200-0402	437	17.20	143	5.63	60	2.36	5.5	12.13
4200-4800	434	17.09	210	8.27	60	2.36	6.7	14.80
4200-0400	135	5.32	386	15.2	260	10.2	14.7	32.41
4200-3690	434	17.09	210	8.27	60	2.36	7.0	15.40
4200-0672	270	10.63	90	3.54	150	5.90	6.2	13.7
4200-1662	300	11.81	120	4.72	170	6.69	9.4	20.7
4200-1660	360	14.2	245	9.6	105	4.13	5.2	11.5
4200-2210	105	4.13	360	14.2	245	9.6	10.3	22.7
4200-0690	135	5.32	386	15.2	260	10.2	16.75	36.9

Table 10-46 Optional external EMC Filter terminal data

Part number	Power connections		Ground connections	
	Max cable size / Bar hole diameter	**Max torque**	**Ground stud size**	**Max torque**
4200-0272	16 mm^2 (6 AWG)	1.8 N m (15.9 lb in)	M6	5.0 N m (44.3 lb in)
4200-3230	4 mm^2 (12 AWG)	0.8 N m (7.1 lb in)	M5	2.5 N m (22.1 lb in)
4200-3480				
4200-0122	16 mm^2 (6 AWG)	2.3 N m (20.4 lb in)	M6	5.0 N m (44.3 lb in)
4200-0312		1.8 N m (15.9 lb in)		
4200-0402				
4200-2300		2.3 N m (20.4 lb in)		
4200-4800				
4200-3690				
4200-1132	50 mm^2 (1/0 AWG)	8.0 N m (70.9 lb in)	M10	18 N m (159.4 lb in)
4200-0672				
4200-1972	95 mm^2 (3/0 AWG)	20 N m (177.1 lb in)		
4200-1662				
4200-3021	10.8 mm	30 N m (265.7 lb in)		
4200-1660				
4200-4460	11 mm			
4200-2210				
4200-0400	10.5 mm		M12	25 N m (221.4 lb in)
4200-0690				

10.5.2 Varistors

AC line voltage transients can typically be caused by the switching of large items of plant, or by lightening strikes on another part of the supply network. If these transients are not suppressed, they can cause damage to the insulation of the Regen inductors, or to the Regen drive electronics. Varistors should be fitted after the supply fuses and before the EMC filter as shown in the following.

Table 10-47 Varistors

Drive rating	Varistor voltage rating V_{RMS}	Energy rating J	Quantity per system	Configuration	Part number
200 V (200 V to 240 V±10 %)	550	620	3	Line to line	2482-3291
	680	760	3	Line to ground	2482-3211
400 V (380 V to 480 V±10 %)	550	620	3	Line to line	2482-3291
	680	760	3	Line to ground	2482-3211
575 V (500 V to 575 V±10 %)	680	760	3	Line to line	2482-3211
	1000	1200	3	Line to ground	2482-3218
690 V (690 V±10 %)	385	550	6	2 in series line to line	2482-3262
	1000	1200	3	Line to ground	2482-3218

Suitable DIN rail mounted surge protectors are also available from CITEL (DS40 series).

10.6 Combined Regen input filters (combi filter)

Table 10-48 Combi filter selection

Model		Schaffner model number	Current rating
Heavy duty	**Normal duty**		**A**
07400660 & 07400770	06400470 & 07400660	FS6085-83-35-2	83
07401000 & 08401340*	07400770 & 07401000	FS6085-125-35-2	125
08401570	08401340	FS6085-168-40-2	168
09402000 & 09402240*	08401570 & 09402000*	FS6085-205-40-2	205
10402700 & 10403200*	09402240 & 10402700*	FS6085-300-99-2	300
	10403200*	FS6085-350-99-2	350
10601780	10601500 & 10601780	FS6085**HV**-200-40-2	200

* Output current derating must be applied based on Regen inductor and combi filter capability.

Table 10-49 Combi filter ratings

Schaffner model number	Current rating A	Voltage rating Vac	Rated frequency Hz
FS6085-83-35-2	83	480	50/60
FS6085-125-35-2	125	480	50/60
FS6085-168-40-2	168	480	50/60
FS6085-205-40-2	205	480	50/60
FS6085-300-99-2	300	480	50/60
FS6085-350-99-2	350	480	50/60
FS6085**HV**-200-40-2	200	690	50/60

Table 10-50 Combi filter SFF component values

Schaffner model number	Component values		Losses
	SFF Ind uH	SFF Cap uF*	W
FS6085-83-35-2	84	3 x 20	98
FS6085-125-35-2	70	3 x 30	92
FS6085-168-40-2	44	3 x 40	133
FS6085-205-40-2	40	3 x 50	133
FS6085-300-99-2	25	3 x 80	180
FS6085-350-99-2	20	3 x 80	235
FS6085**HV**-200-40-2	63	3 x 90	120

Table 10-51 Combi filter leakage current

Schaffner model number	Ground leakage	
	Balanced supply (mA)**	Worst case (mA)
FS6085-83-35-2	4.3	220
FS6085-125-35-2	12.5	619
FS6085-168-40-2	4.3	221
FS6085-205-40-2	12.5	631
FS6085-300-99-2	12.5	636
FS6085-350-99-2	12.5	636
FS6085**HV**-200-40-2	16.5	820

* SFF caps wired in Delta configuration

** In accordance with IEC 60939-1

NOTE

The range of combi filters covered in this section are available from Schaffner, the filters are not stocked by supplier of the drive.

WARNING

Combi filters listed in Table 3-23 *Combi filter selection* on page 39 are equipped with an internal thermal switch to prevent the EMC filter inductor from overheating. The thermal switch must be configured to open the main supply contactor in the event of a thermal overload.

CAUTION

Regen inverter output current derating must be applied where necessary based on Regen inductor and combi filter capability.
Models affected are denoted with * in Table 3-23 *Combi filter selection* on page 39. Combi filters listed in Table 3-23 are suitable for use in systems with less than 2 % THD_V on the grid.

11 Component sizing

11.1 Switching frequency filter (SFF) protection

For SFF branch circuit protection refer to section 3.9.3 *Switching frequency filter capacitor* on page 30.

11.2 Softstart resistor sizing

Table 11-1 DC bus capacitance and inductance values

Voltage	Model	Total DC bus capacitance	Total DC bus inductance	AC inductance per phase
		µF	mH	µH
200 V	03200050	1560		
	03200066 to 03200106	1560		
	04200137 & 04200185	1760	0.5	
	05200250	1560	1.1	
	06200330 & 06200440	3000	0.322	
	07200610 to 07200830	4680	0.253	
	08201160 & 08201320	7020		110
	09201760 & 09202190	10920		82*
	10202830 & 10203000	10920		
400 V	03400025 to 0300045	220		
	0300062	390		
	03400078 & 03400106	390	1	
	04400150 & 04400172	660	1.331	
	05400270 & 05400300	780	1.1	
	06400350 to 06400470	1500	0.644	
	07400660 to 07401000	2340	0.423	
	08401340 & 08401570	3510		170
	09402000 & 09402240	5460		82*
	10402700 & 10403200	7020		
	11403770	8585		
	11404170 & 11404640	9360		
575 V	05500030 to 05500069	260	2.685	
	06500150 & 06500190	500	1.57	
	06500230 to 06500350	1000	0.785	
	07500440 & 07500550	780	1.27	
	08500630 & 08500860	1300		520
	09501040 & 09501310	3120		240*
	10501520 & 10501900	3120		
	11502000 to 11502850	4160		
690 V	07600190 to 07600540	780	1.27	
	08600630 & 08600860	1300		520
	09601040 & 09601310	3120		240*
	10601500 & 10601780	3120		
	11602100 to 11602630	4160		

* Frame size 9A only.

Where the Regen drive inrush current is to be controlled by an external softstart resistor / bypass circuit, the softstart resistance can be calculated using the procedure detailed in section 11.2.1 *Procedure* on page 309.

The softstart resistor must be calculated for multiple drive systems due to the increased inrush current where a Unidrive M Rectifier is not used.

A softstart resistor will also be required for applications where the total DC bus capacitance of the motoring drives is greater than that of the Regen drive (one large drive supplying several smaller drives).

CAUTION

Only pulse withstanding resistors should be used for charging the inverter system.

11.2.1 Procedure

The following procedure and data should be used to calculate the resistor(s) required:

1. Calculate the total DC bus capacitance of the system (refer to Table 11-1).
2. Calculate the energy stored in the systems DC bus capacitance at the maximum supply voltage.
3. Calculate the minimum number of resistors required to meet this energy value (round up to the nearest one).
4. Calculate the series parallel arrangement of resistors ensuring the total resistance is ≥ the minimum values given in Table 11-2.

DC bus capacitor energy is calculated from 0.5 x C_N x 1.2 x V^2_{BUS}. Where C_N is the nominal DC bus capacitance (Table 11-1) and the 1.2 factor allows for capacitance tolerance. V_{BUS} is calculated from √2 x V_{LL} (+10 %) where V_{LL} is the nominal line to line AC voltage.

Table 11-2 Minimum softstart resistor value

Drive	Recommended minimum resistor value (Ω)
03200066	20
03200080	
03200106	
03400025	
03400031	
03400045	
03400062	
03400078	
03400100	
04200137	30
04200185	
04400150	
04400172	
05200250	14
05400270	29
05400300	26
05500030	30
05500040	30
05500069	30
06200330	12
06200440	9
06400350	22
06400420	19
06400470	14
06500100	33
06500150	33
06500190	33
06500230	33
06500290	28
06500350	23
07200610	5
07200750	5
07200830	5
07400660	11
07400770	11
07401000	8
07500440	16
07500550	16
07600190	33
07600240	33
07600290	33
07600380	33
07600440	23
07600540	23
08201160	3

Drive	Recommended minimum resistor value (Ω)
08201320	3
08401340	5
08401570	5
08500630	11
08500860	11
08600630	13
08600860	13
09201760	2
09202190	2
09402000	3
09402240	3
09501040	8
09501310	7
09601040	10
09601310	8
10202830	1
10203000	1
10402700	2
10403200	2
10501520	5
10501900	4
10601500	6
10601780	5
11403770	1
11404170	1
11404640	1
11502000	3
11502540	3
11502850	3
11602100	4
11602380	4
11602630	4

Example:

Unidrive M 10403200 regenerating onto a 480 Vac + 10 % supply with Unidrive M 10403200 motoring drive.

C_N = 2 x 7020 μF

= 14040 μF

V_{BUS} = $\sqrt{2}$ x 480 x 1.1

= 747 V

Energy = 0.5 x 14040 x 10^{-6} x 1.2 x $(747)^2$

= 4701 J

Using Metallux resistor PWR- R 500, 48 Ω

Energy rating = 1700 J (see Figure 11-1 *Pulse energy* on page 311).

Number of resistors required =

$$\frac{\mathbf{4701}}{\mathbf{1700}} = \mathbf{2,8}$$

Three resistors are therefore required which may be connected in parallel. The equivalent resistance is 16 Ω which is above the minimum limit of 2 Ω for the Unidrive M 10403200.

Figure 11-1 Pulse energy

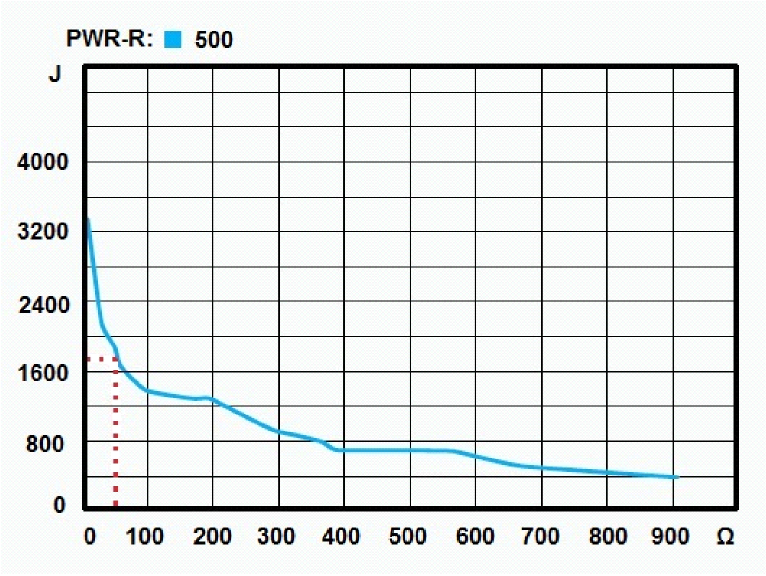


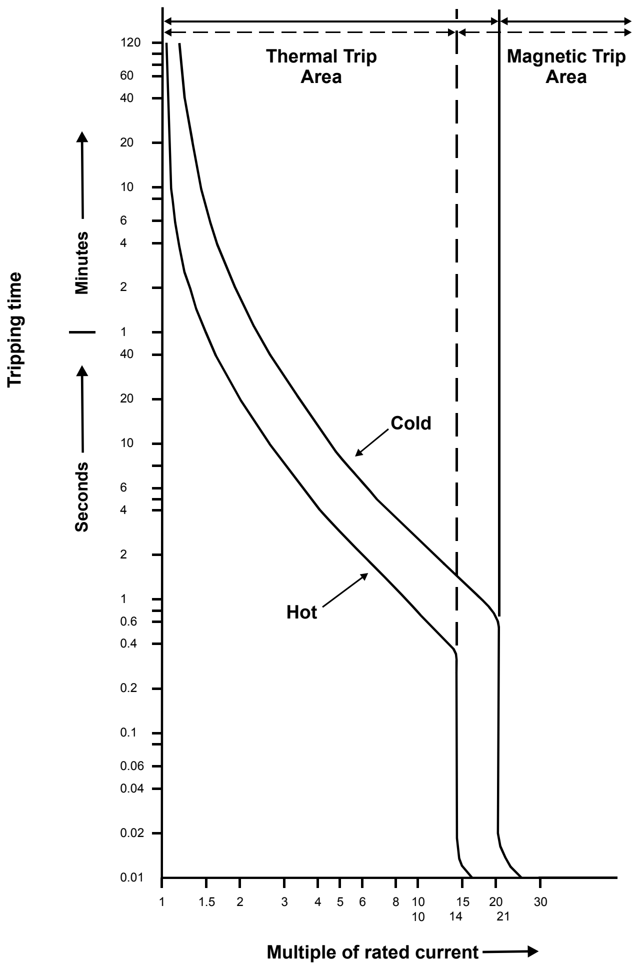
Figure 11-1 shows the relationship between the Metallux softstart resistor value and the energy rating. The recommended 48 Ω value gives an energy rating of 1700 J.

11.3 Thermal / magnetic overload protection for soft start circuit

Protection for the softstart circuit must be provided. The recommended protection is to use a miniature circuit breaker (MCB) having a thermal magnetic trip. The thermal part of the tripping mechanism protects against a high impedance short circuit and the magnetic part of the trip protects the resistor against a direct short circuit. The overload should be sized as following to provide thermal and magnetic protection:

11.3.1 Thermal / magnetic overload characteristics

Figure 11-2 Example of tripping characteristic



11.3.2 Sizing of magnetic overload

The magnetic overload should be selected to the peak current and charging time at power up with the trip being at for example 20 times the nominal rated current of the overload. Therefore for a 20 A peak current an MCB with a 1 A nominal current rating could be used.

The charging of a system takes a total of 5 time constants with this having a decaying exponential current due to the RC network, therefore at 5 time constants the system will have charged up with the current being at approximately zero.

The peak current and charge time during power up can be calculated using the following formula.

Example: Peak current

480 Vac supply +10 %, total softstart resistance of 16 Ω (3 x 48 Ω in parallel):

I_{peak} = Vac (+10 %) x 1.414 / $\text{Resistance}_{softstart}$

= (480 + 48) x 1.414 / 16 = 46.7A I_{peak}

Example: Charging time

Total softstart resistance of 16 Ω (3 x 48 Ω) in parallel, and a total DC bus capacitance of 14040 μF

$T_{constant}$ = $\text{Resistance}_{softstart}$ x Total $\text{Capacitance}_{DC\ bus}$

0.225 = 16 x (14040 x 10^{-6})

T_{charge} = $T_{constant}$ x 5

1.13 s = 0.225 x 5

MCB Selection

From the above calculations for a peak charging current of 46.7 A with a charge time of 1.13 s a magnetic overload with the following characteristics could be used:

3 A nominal rating (46.7/20 = 2.335)

The exponential charging current for the soft start circuit must be checked against the MCB trip characteristic curve for the overload to ensure no spurious trips occur during charging time. Calculate the supply current throughout the start-up time (5 time constants):

Calculate the supply current at 0.1 s, 0.2 s, 0.4, 0.7 s and 1 s.

$$\mathbf{I(t)} = \mathbf{I_{pk}} \times \mathbf{e}^{\left(\frac{-\mathbf{t}}{\mathbf{R} \times \mathbf{C}}\right)}$$

Where:

I(t): Peak current at time = t seconds.

t = Time in seconds

Example: supply current throughout the start-up time

$$\mathbf{I(t)} = \mathbf{46{,}7} \times \mathbf{e}^{\left(\frac{-\mathbf{t}}{\mathbf{16} \times \mathbf{14040} \times \mathbf{10}^{-6}}\right)}$$

Table 11-3 Supply current throughout the start-up time

Time s	Supply Current Apk
0.1	29.9
0.2	19.2
0.3	12.3
0.4	7.9
0.7	2.1
1	0.5

Note that these calculation times are based on a 1 s charge time. If the charge time not 1 s, then the time steps can be calculated as follows.

Time interval
$t1 = 0.1 \times t_{charge}$
$t2 = 0.2 \times t_{charge}$
$t3 = 0.4 \times t_{charge}$
$t4 = 0.7 \times t_{charge}$
$t5 = t_{charge}$

Compare the supply currents at time t1 to t5 with the circuit breaker worst-case trip characteristic. Make sure that the current is less than the trip curve for all the time intervals calculated.

Comparing the data from Table 11-3 with the tripping characteristic of the selected MCB, Figure 11-2 shows that the supply current is less than the MCB trip curves for each time interval.

11.3.3 Sizing of thermal overload

The thermal overload should be sized to provide protection against a high impedance short circuit. Under this condition the current flowing would not be high enough to result in the magnetic overload tripping, but the power dissipated would exceed the nominal power rating resulting in heating of the resistor.

In order to size the thermal overload correctly, the power rating and overload characteristics of the resistor are required. The power characteristic curve for the resistor should be converted from multiples of power to current in order to size the thermal overload correctly.

Check that the MCB prevents the resistor from overheating assume a system fault which results in a continuous power of 10 x the nominal power being dissipated by the resistor.

Resistor selected earlier was 3 x 48 Ω which is 16 Ω 1500 W

10 x nominal power = 15000 W

$$\mathbf{I_{P10}} = \sqrt{\frac{\mathbf{15000}}{\mathbf{16}}} = \mathbf{30{,}6A}$$

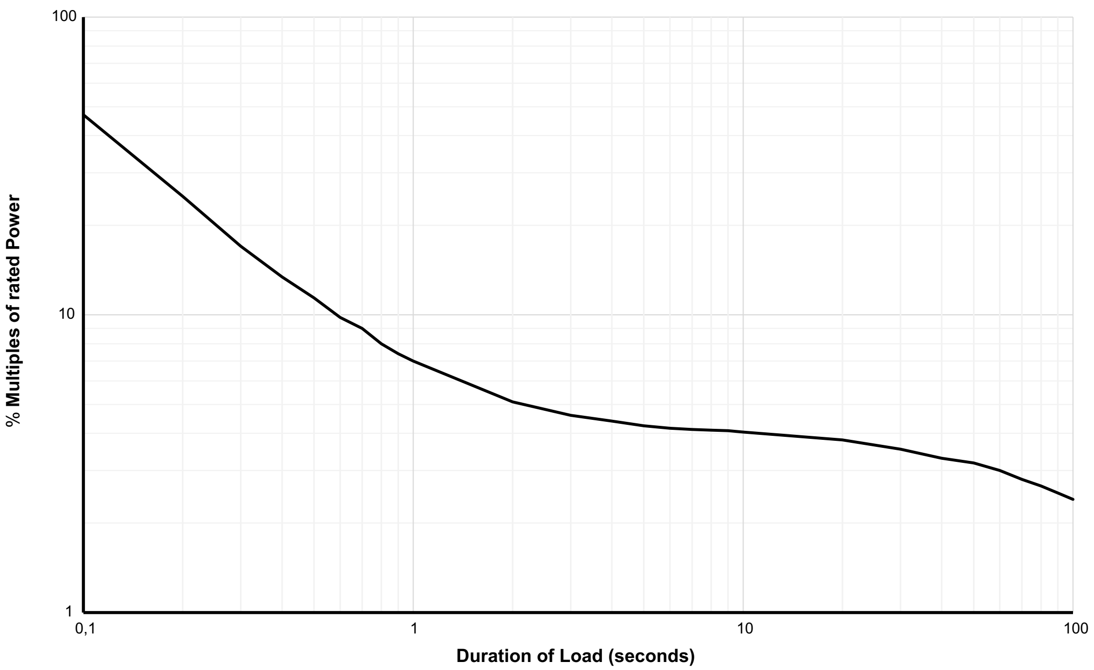
MCB rating from previous selection was 3 A.

30.6 A is 10.2 x rated current.

From Figure 11-2 the MCB will trip in 3 s.

From the resistor manufacturers data shown in Figure 11-3,10.2 x rated power can be withstood for 3 s.

Figure 11-3 Example of overload characteristic



The MCB will protect the resistor.

12 Diagnostics

The keypad display on the drive gives various information about the status of the drive. The keypad display provides information on the following categories:

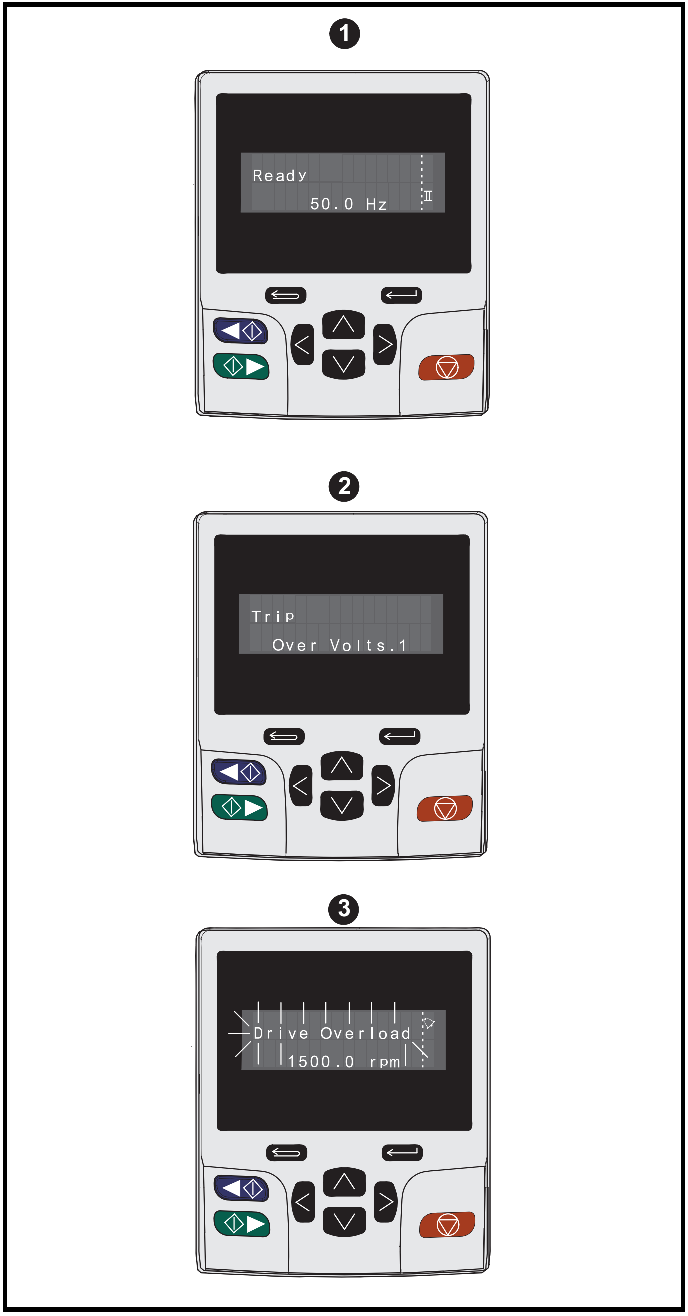
- Trip indications
- Alarm indications
- Status indications

WARNING

Users must not attempt to repair a drive if it is faulty, nor carry out fault diagnosis other than through the use of the diagnostic features described in this chapter.
If a drive is faulty, it must be returned to an authorized distributor for repair.

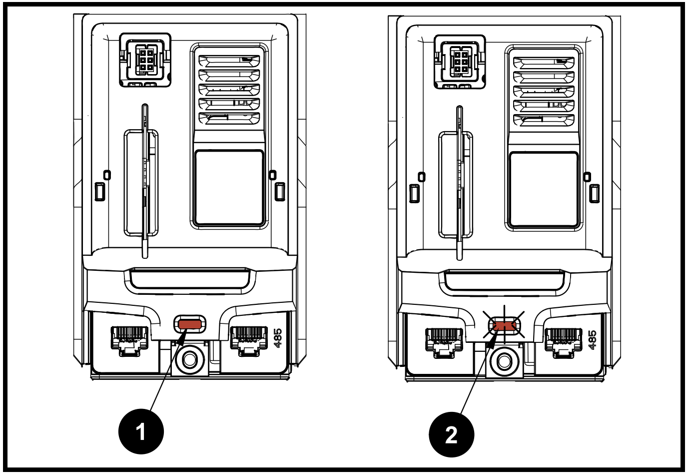
12.1 Status modes (Keypad and LED status)

Figure 12-1 Keypad status modes



1. Drive healthy status
2. Trip status
3. Alarm status

Figure 12-2 Location of the status LED



1. Non flashing: Normal status
2. Flashing: Trip status

12.2 Trip indications

The output of the drive is disabled under any trip condition so that the drive stops controlling the motor. If the motor is running when the trip occurs it will coast to a stop.

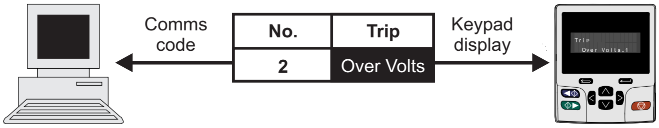
During a trip condition, where a KI-Keypad is being used, the upper row of the display indicates that a trip has occurred and the lower row of the keypad display will display the trip string. Some trips have a sub-trip number to provide additional information about the trip. If a trip has a sub-trip number, the sub-trip number is flashed alternately with the trip string unless there is space on the second row for both the trip string and the sub-trip number in which case both the trip string and sub-trip information is displayed separated by a decimal place.

The back-light of the KI-Keypad display will also flash during a trip condition. If a display is not being used, the drive LED Status indicator will flash with 0.5 s duty cycle if the drive has tripped. Refer to Figure 12-2.

Trips are listed alphabetically in Table 12-3 based on the trip indication shown on the drive display. Alternatively, the drive status can be read in Pr **10.001** 'Drive healthy' using communication protocols. The most recent trip can be read in Pr **10.020** providing a trip number. It must be noted that the hardware trips (HF01 to HF20) do not have trip numbers. The trip number must be checked in Table 12-3 to identify the specific trip.

Example

1. Trip code 2 is read from Pr **10.020** via serial communications.
2. Checking Table shows Trip 2 is an Over Volts trip.



3. Look up Over Volts in Table 12-3.
4. Perform checks detailed under *Diagnosis*.

12.3 Identifying a trip / trip source

Some trips only contain a trip string whereas some other trips have a trip string along with a sub-trip number which provides the user with additional information about the trip.

A trip can be generated from a control system or from a power system. The sub-trip number associated with the trips listed in Table 12-1 is in the form xxyzz and used to identify the source of the trip.

Table 12-1 Trips associated with xxyzz sub-trip number

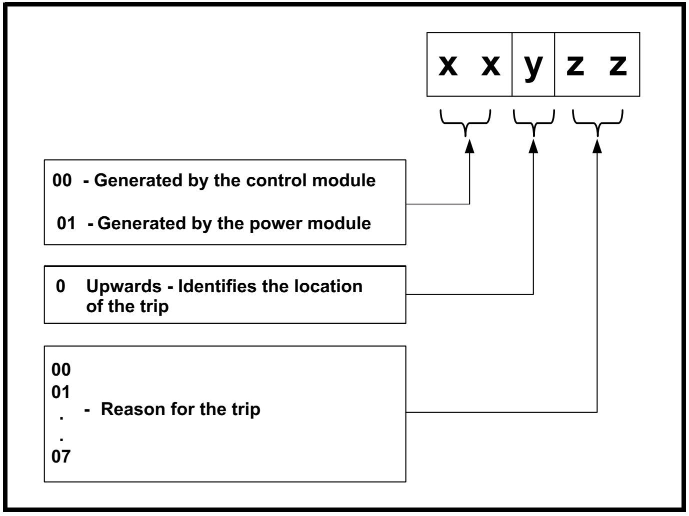
Over Volts	OHt dc bus
OI ac	Phase Loss
OI Brake	Power Comms
PSU	OI Snubber
OHt Inverter	Temp Feedback
OHt Power	Power Data
OHt Control	

The digits xx are 00 for a trip generated by the control system. For a single drive (not part of a multi-power module drive), if the trip is related to the power system then xx will have a value of 01, when displayed the leading zeros are suppressed.

The y digit is used to identify the location of a trip which is generated by a rectifier module connected to a power module (if xx is non zero). For a control system trip (xx is zero), the y digit, where relevant is defined for each trip. If not relevant, the y digit will have a value of zero.

The zz digits give the reason for the trip and are defined in each trip description.

Figure 12-3 Key to sub-trip number



For example, if the drive has tripped and the lower line of the display shows 'OHt Control.2', with the help of Table 12-2 below the trip can be interpreted as; an over temperature has been detected; the trip was generated by fault in the control module, the control board thermistor 2 over temperature.

Table 12-2 Sub-trip identification

Source	xx	y	zz	Description
Control system	00	0	01	Control board thermistor 1 over temperature
Control system	00	0	02	Control board thermistor 2 over temperature
Control system	00	0	03	Control board thermistor 3 over temperature

12.4 Trips, Sub-trip numbers

Table 12-3 Trip indications

<table>
<tr><th>Trip</th><th>Diagnosis</th></tr>
<tr><td>An Input 1 Loss</td><td>Analog input 1 current loss</td></tr>
<tr><td>28</td><td><i>An Input 1 Loss</i> trip indicates that a current loss was detected in current mode on Analog input 1 (Terminal 5, 6). In 4-20 mA and 20-4 mA modes loss of input is detected if the current falls below 3 mA.
Recommended actions:
• Check control wiring is correct
• Check control wiring is undamaged
• Check the <i>Analog Input 1 Mode</i> (07.007)
• Current signal is present and greater than 3 mA</td></tr>
<tr><td>An Input 2 Loss</td><td>Analog input 2 current loss</td></tr>
<tr><td>29</td><td><i>An Input 2 Loss</i> indicates that a current loss was detected in current mode on Analog input 2 (Terminal 7). In 4-20 mA and 20-4 mA modes loss of input is detected if the current falls below 3 mA.
Recommended actions:
• Check control wiring is correct
• Check control wiring is undamaged
• Check the <i>Analog Input 2 Mode</i> (07.011)
• Current signal is present and greater than 3 mA</td></tr>
<tr><td>An Output Calib</td><td>Analog output calibration failed</td></tr>
<tr><td>219</td><td>The zero offset calibration of one or both of the analog outputs has failed. This indicates that the drive hardware has failed or a voltage is applied to the output via a low impedance, possibly due to a wiring error. The failed output can be identified by the sub-trip number.
<table>
<tr><th>Sub-trip</th><th>Reason</th></tr>
<tr><td>1</td><td>Output 1 failed (Terminal 9)</td></tr>
<tr><td>2</td><td>Output 2 failed (Terminal 10)</td></tr>
</table>
Recommended actions:
• Check the wiring associated with analog outputs
• Remove all the wiring that is connected to analog outputs and perform a re-calibration by power cycling the drive.
• If trip persists replace the drive</td></tr>
<tr><td>App Menu Changed</td><td>Customization table for an application module has changed</td></tr>
<tr><td>217</td><td>The <i>App Menu Changed</i> trip indicates that the customization table for an application menu has changed. The menu that has been changed can be identified by the sub-trip number.
<table>
<tr><th>Sub-trip</th><th>Reason</th></tr>
<tr><td>1</td><td>Menu 18</td></tr>
<tr><td>2</td><td>Menu 19</td></tr>
<tr><td>3</td><td>Menu 20</td></tr>
</table>
If more than one menu has changed the lowest menu has priority. Drive user parameters must be saved to prevent this trip on the next power-up.
Recommended actions:
• Reset the trip and perform a parameter save to accept the new settings</td></tr>
<tr><td>Brake R Too Hot</td><td>Braking resistor overload timed out (I^2t)</td></tr>
<tr><td>19</td><td>The <i>Brake R Too Hot</i> indicates that braking resistor overload has timed out. The value in <i>Braking Resistor Thermal Accumulator</i> (10.039) is calculated using <i>Braking Resistor Rated Power</i> (10.030), <i>Braking Resistor Thermal Time Constant</i> (10.031) and <i>Braking Resistor Resistance</i> (10.061). The <i>Brake R Too Hot</i> trip is initiated when <i>Braking Resistor Thermal Accumulator</i> (10.039) reaches 100 %.
Recommended actions:
• Ensure the values entered in Pr 10.030, Pr 10.031 and Pr 10.061 are correct
• If an external thermal protection device is being used and the braking resistor software overload protection is not required, set Pr 10.030, Pr 10.031 or Pr 10.061 to 0 to disable the trip.</td></tr>
<tr><td>Card Access</td><td>NV Media Card Write fail</td></tr>
<tr><td>185</td><td>The <i>Card Access</i> trip indicates that the drive was unable to access the NV Media Card. If the trip occurs during the data transfer to the card then the file being written may be corrupted. If the trip occurs when the data being transferred to the drive then the data transfer may be incomplete. If a parameter file is transferred to the drive and this trip occurs during the transfer, the parameters are not saved to non-volatile memory, and so the original parameters can be restored by powering the drive down and up again.
Recommended actions:
• Check NV Media Card is installed / located correctly
• Replace the NV Media Card</td></tr>
</table>

<table>
<tr><th>Trip</th><th>Diagnosis</th></tr>
<tr><td>Card Boot</td><td>The Menu 0 parameter modification cannot be saved to the NV Media Card</td></tr>
<tr><td>177</td><td>Menu 0 changes are automatically saved on exiting edit mode.
The <i>Card Boot</i> trip will occur if a write to a Menu 0 parameter has been initiated via the keypad by exiting edit mode and Pr 11.042 is set for auto or boot mode, but the necessary boot file has not been created on the NV Media Card to take the new parameter value. This occurs when Pr 11.042 is changed to Auto (3) or Boot (4) mode, but the drive is not subsequently reset.
Recommended actions:
• Ensure that Pr 11.042 is correctly set, and then reset the drive to create the necessary file on the NV Media Card
• Re-attempt the parameter write to the Menu 0 parameter</td></tr>
<tr><td>Card Busy</td><td>NV Media Card cannot be accessed as it is being accessed by an option module</td></tr>
<tr><td>178</td><td>The <i>Card Busy</i> trip indicates that an attempt has been made to access a file on NV Media Card, but the NV Media Card is already being accessed by an option module. No data is transferred.
Recommended actions:
• Wait for the option module to finish accessing the NV Media Card and re-attempt the required function</td></tr>
<tr><td>Card Compare</td><td>NV Media Card file/data is different to the one in the drive</td></tr>
<tr><td>188</td><td>A compare has been carried out between a file on the NV Media Card, a Card Compare trip is initiated if the parameters on the NV Media Card are different to the drive.
Recommended actions:
• Set Pr mm.000 to 0 and reset the trip
• Check to ensure the correct data block on the NV Media Card has been used for the compare.</td></tr>
<tr><td>Card Data Exists</td><td>NV Media Card data location already contains data</td></tr>
<tr><td>179</td><td>The <i>Card Data Exists</i> trip indicates that an attempt has been made to store data on a NV Media Card in a data block which already contains data. The data should be erased from the card first to prevent this trip.
Recommended actions:
• Erase the data in data location
• Write data to an alternative data location</td></tr>
<tr><td>Card Drive Mode</td><td>NV Media Card parameter set not compatible with current drive mode</td></tr>
<tr><td>187</td><td>The <i>Card Drive Mode</i> trip is produced during a compare if the drive mode in the data block on the NV Media Card is different from the current drive mode. This trip is also produced if an attempt is made to transfer parameters from a NV Media Card to the drive if the operating mode in the data block is outside the allowed range of operating modes.
Recommended actions:
• Ensure the destination drive supports the drive operating mode in the parameter file.
• Clear the value in Pr mm.000 and reset the drive
• Ensure destination drive operating mode is the same as the source parameter file</td></tr>
<tr><td>Card Error</td><td>NV Media Card data structure error</td></tr>
<tr><td>182</td><td>The <i>Card Error</i> trip indicates that an attempt has been made to access a NV media card, but an error has been detected in the data structure on the card. Resetting this trip will cause the drive to erase the <MCDF> folder from the NV media card (if it exists) and create the correct folder structure. On an SD card, whilst this trip is still present, missing directories will be created, and if the header file is missing it will be created. The following sub-trip numbers are used with this trip:
<table>
<tr><th>Sub-trip</th><th>Reason</th></tr>
<tr><td>1</td><td>The required folder and file structure is not present</td></tr>
<tr><td>2</td><td>The <000> file is corrupted.</td></tr>
<tr><td>3</td><td>Two or more files in the <MCDF\> folder have the same file identification number.</td></tr>
</table>
Recommended actions:
• Erase all the data block and re-attempt the process
• Ensure the card is located correctly
• Replace the NV Media Card</td></tr>
<tr><td>Card Full</td><td>NV Media Card full</td></tr>
<tr><td>184</td><td>The <i>Card Full</i> trip indicates that an attempt has been made to create a data block on a NV Media Card, but there is not enough space left on the card.
Recommended actions:
• Delete a data block or the entire NV Media Card to create space
• Use a different NV Media Card</td></tr>
<tr><td>Card No Data</td><td>NV Media Card data not found</td></tr>
<tr><td>183</td><td>The <i>Card No Data</i> trip indicates that an attempt has been made to access non-existent file or block on a NV Media Card. No data is transferred.
Recommended actions:
• Ensure data block number is correct</td></tr>
</table>

<table>
<tr><th>Trip</th><th>Diagnosis</th></tr>
<tr><td>Card Option</td><td>NV Media Card trip; option modules installed are different between source drive and destination drive</td></tr>
<tr><td>180</td><td>The <i>Card Option</i> trip indicates that parameter data or default difference data is being transferred from a NV Media Card to the drive, but the option module categories are different between source and destination drives. This trip does not stop the data transfer, but is a warning that the data for the option modules that are different will be set to the default values and not the values from the card. This trip also applies if a compare is attempted between the data block and the drive.
Recommended actions:
• Ensure the correct option modules are installed.
• Ensure the option modules are in the same option module slot as the parameter set stored.
• Press the red reset button to acknowledge that the parameters for one or more of the option modules installed will be at their default values
• This trip can be suppressed by setting Pr mm.000 to 9666 and resetting the drive.</td></tr>
<tr><td>Card Product</td><td>NV Media Card data blocks are not compatible with the drive derivative</td></tr>
<tr><td>175</td><td>If <i>Drive Derivative</i> (11.028) or <i>Product Type</i> (11.063) are different between the source and target drives then this trip is initiated either at power-up or when the card is accessed. It will have one of the following sub-trip numbers:
<table>
<tr><th>Sub-trip</th><th>Reason</th></tr>
<tr><td>1</td><td>If <i>Drive Derivative</i> (11.028) is different between the source and target drives, this trip is initiated either at power-up or when the SD Card is accessed. Data is still transferred, since this is a warning trip; the trip can be suppressed by entering code 9666 in parameter xx.000, and resetting the drive (this applies the warning suppression flag to the card).</td></tr>
<tr><td>2</td><td>If <i>Product Type</i> (11.063) is different between the source and target drives or if corruption is detected in the parameter file, this trip is initiated either at power-up or when the SD Card is accessed. This trip can be reset but no data are transferred in either direction between the drive and the card.</td></tr>
<tr><td>3</td><td>A Unidrive SP parameter value was found that has no equivalent parameter on the destination drive. Data is still transferred, since this is a warning trip; the trip can be suppressed by entering code 9666 in Pr xx.000, and resetting the drive (this applies the warning suppression flag to the card).</td></tr>
</table>
Recommended actions:
• Use a different NV Media Card
• This trip can be suppressed by setting Pr mm.000 to 9666 and resetting the drive</td></tr>
<tr><td>Card Rating</td><td>NV Media Card Trip; The voltage and / or current rating of the source and destination drives are different</td></tr>
<tr><td>186</td><td>The <i>Card Rating</i> trip indicates that parameter data is being transferred from a NV Media Card to the drive, but the current and / or voltage ratings are different between source and destination drives. This trip also applies if a compare (using Pr mm.000 set to 8yyy) is attempted between the data block on a NV Media Card and the drive. The Card Rating trip does not stop the data transfer but is a warning that rating specific parameters with the RA attribute may not be transferred to the destination drive.
Recommended actions:
• Reset the drive to clear the trip
• Ensure that the drive rating dependent parameters have transferred correctly
• This trip can be suppressed by setting Pr mm.000 to 9666 and resetting the drive.</td></tr>
<tr><td>Card Read Only</td><td>NV Media Card has the Read Only bit set</td></tr>
<tr><td>181</td><td>The <i>Card Read Only</i> trip indicates that an attempt has been made to modify a read-only NV Media Card or a read-only data block. A NV Media Card is read-only if the read-only flag has been set.
Recommended actions:
• Clear the read only flag by setting Pr mm.000 to 9777 and reset the drive. This will clear the read-only flag for all data blocks in the NV Media Card
• This trip can be suppressed by setting Pr mm.000 to 9666 and resetting the drive.</td></tr>
<tr><td>Card Slot</td><td>NV Media Card Trip; Option module application program transfer has failed</td></tr>
<tr><td>174</td><td>The <i>Card Slot</i> trip is initiated, if the transfer of an option module application program to or from an application module failed because the option module does not respond correctly. If this happens this trip is produced with the sub-trip indicating the option module slot number.
Recommended actions:
• Ensure the source / destination option module is installed on the correct slot</td></tr>
</table>

<table>
<tr><th>Trip</th><th>Diagnosis</th></tr>
<tr><td>Configuration</td><td>The number of power modules installed is different from the modules expected</td></tr>
<tr><td>111</td><td>The <i>Configuration</i> trip indicates that the <i>Number Of Power Modules Detected</i> (11.071) does not match the previous value stored. The sub-trip value indicates the number of power modules expected.
Recommended actions:
• Ensure that all the power modules are correctly connected
• Ensure all the power modules have powered up correctly
• Ensure that the value in Pr 11.071 is set to the number of power modules connected
• Set Pr 11.035 to 0 to disable the trip if it is not required
This trip is also initiated if the number of external rectifiers connected to each power module is less than the number defined by Number Of Rectifiers Expected (11.096). If this is the reason for the trip the sub-trip is 10x where x is the number of external rectifiers that should be connected.
Recommended actions:
• Ensure that all the external rectifiers are connected correctly.
• Ensure that the value in <i>Number Of Rectifiers Expected</i> (11.096) is correct.</td></tr>
<tr><td>Control Word</td><td>Trip initiated from the <i>Control Word</i> (06.042)</td></tr>
<tr><td>35</td><td>The <i>Control Word</i> trip is initiated by setting bit 12 on the control word in Pr 06.042 when the control word is enabled (Pr 06.043 = On).
Recommended actions:
• Check the value of Pr 06.042.
• Disable the control word in <i>Control Word Enable</i> (Pr 06.043)
Bit 12 of the control word set to a one causes the drive to trip on Control Word
When the control word is enabled, the trip can only be cleared by setting bit 12 to zero</td></tr>
<tr><td>Current Offset</td><td>Current feedback offset error</td></tr>
<tr><td>225</td><td>The current feedback offset is too large to be trimmed correctly. The sub-trip relates to the output phase for which the offset error has been detected.
<table>
<tr><th>Sub-trip</th><th>Phase</th></tr>
<tr><td>1</td><td>U</td></tr>
<tr><td>2</td><td>V</td></tr>
<tr><td>3</td><td>W</td></tr>
</table>
Recommended actions:
• Ensure that there is no possibility of current flowing in the output phases of the drive when the drive is not enabled
• Hardware fault – Contact the supplier of the drive</td></tr>
<tr><td>Data Changing</td><td>Drive parameters are being changed</td></tr>
<tr><td>97</td><td>A user action or a file system write is active that is changing the drive parameters and the drive has been commanded to enable, i.e. <i>Drive Active</i> (10.002) = 1.The user actions that change drive parameters are loading defaults, changing drive mode, or transferring data from an NV memory card or a position feedback device to the drive. The file system actions that will cause this trip to be initiated if the drive is enabled during the transfer are writing a parameter or macro file to the drive, or transferring a derivative or user program to the drive. It should be noted that none of these actions can be started if the drive is active, and so the trip only occurs if the action is started and then the drive is enabled.
Recommended actions:
Ensure the drive is not enabled when one of he following is being carried out:
• Loading defaults
• Changing drive mode
• Transferring data from NV Media Card or position feedback device
• Transferring user programs</td></tr>
<tr><td>Derivative ID</td><td>There is a problem with the identifier associated with derivative image which customizes the drive.</td></tr>
<tr><td>247</td><td>There is a problem with the identifier associated with derivative image which customizes the drive. The reason for the trip is given by the sub-trip as follows:
<table>
<tr><th>Sub-trip</th><th>Reason</th></tr>
<tr><td>1</td><td>There should be a derivative image in the product but this has been erased.</td></tr>
<tr><td>2</td><td>The identifier is out of range.</td></tr>
<tr><td>3</td><td>The derivative image has been changed.</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><th>Trip</th><th>Diagnosis</th></tr>
<tr><td>Derivative Image</td><td>Derivative Image error</td></tr>
<tr><td>248</td><td>The <i>Derivative Image</i> trip indicates that an error has been detected in the derivative image. The sub-trip number indicates the reason for the trip.
<table>
<tr><th>Sub-trip</th><th>Reason</th><th>Comments</th></tr>
<tr><td>1 to 52</td><td>An error has been detected in the derivative image, contact the supplier of the drive.</td><td></td></tr>
<tr><td>61</td><td>The option module fitted in slot 1 is not allowed with the derivative image</td><td rowspan="4">Occurs when the drive powers-up or the image is programmed. The image tasks will not run.</td></tr>
<tr><td>62</td><td>The option module fitted in slot 2 is not allowed with the derivative image</td></tr>
<tr><td>63</td><td>The option module fitted in slot 3 is not allowed with the derivative image</td></tr>
<tr><td>64</td><td>The option module fitted in slot 4 is not allowed with the derivative image</td></tr>
<tr><td>70</td><td>An option module that is required by the derivative image is not fitted in any slot</td><td rowspan="5">Occurs when the drive powers-up or the image is programmed. The image tasks will not run.</td></tr>
<tr><td>71</td><td>An option module specifically required to be fitted in slot 1 not present</td></tr>
<tr><td>72</td><td>An option module specifically required to be fitted in slot 2 not present</td></tr>
<tr><td>73</td><td>An option module specifically required to be fitted in slot 3 not present</td></tr>
<tr><td>74</td><td>An option module specifically required to be fitted in slot 4 not present</td></tr>
<tr><td>80 to 81</td><td>An error has been detected in the derivative image, contact the supplier of the drive.</td><td></td></tr>
</table>
Recommended action:
Contact the supplier of the drive</td></tr>
<tr><td>Destination</td><td>Two or more parameters are writing to the same destination parameter</td></tr>
<tr><td>199</td><td>The <i>Destination</i> trip indicates that destination output parameters of two or more logic functions (Menus 5, 7, 8, 9, 12 or 14) within the drive are writing to the same parameter.
Recommended actions:
• Set Pr mm.000 to ‘Destinations’ or 12001 and check all visible parameters in all menus for parameter write conflicts</td></tr>
<tr><td>Drive Size</td><td>Power stage recognition: Unrecognized drive size</td></tr>
<tr><td>224</td><td>The <i>Drive Size</i> trip indicates that the control PCB has not recognized the drive size of the power circuit to which it is connected.
Recommended action:
• Ensure the drive is programmed to the latest firmware version
• Hardware fault - return drive to supplier</td></tr>
</table>

<table>
<tr><th>Trip</th><th>Diagnosis</th></tr>
<tr><td>EEPROM Fail</td><td>Default parameters have been loaded</td></tr>
<tr><td>31</td><td>
The <i>EEPROM Fail</i> trip indicates that default parameters have been loaded. The exact cause/reason of the trip can be identified from the sub-trip number.
<table>
<tr><th>Sub-trip</th><th>Reason</th></tr>
<tr><td>1</td><td>The most significant digit of the internal parameter database version number has changed</td></tr>
<tr><td>2</td><td>The CRC's applied to the parameter data stored in internal non-volatile memory indicate that a valid set of parameters cannot be loaded</td></tr>
<tr><td>3</td><td>The drive mode restored from internal non-volatile memory is outside the allowed range for the product or the derivative image does not allow the previous drive mode</td></tr>
<tr><td>4</td><td>The drive derivative image has changed</td></tr>
<tr><td>5</td><td>The power stage hardware has changed</td></tr>
<tr><td>6</td><td>The internal I/O hardware has changed</td></tr>
<tr><td>7</td><td>The position feedback interface hardware has changed</td></tr>
<tr><td>8</td><td>The control board hardware has changed</td></tr>
<tr><td>9</td><td>The checksum on the non-parameter area of the EEPROM has failed</td></tr>
</table>
<p>The drive holds two banks of user save parameters and two banks of power down save parameters in non-volatile memory. If the last bank of either set of parameters that was saved is corrupted a User Save or Power Down Save trip is produced. If one of these trips occurs the parameters values that were last saved successfully are used. It can take some time to save parameters when requested by the user and if the power is removed from the drive during this process it is possible to corrupt the data in the non-volatile memory.</p>
<p>If both banks of user save parameters or both banks of power down save parameters are corrupted or one of the other conditions given in the table above occurs EEPROM Fail.xxx trip is produced. If this trip occurs it is not possible to use the data that has been saved previously, and so the drive will be in lowest allowed drive mode with default parameters. The trip can only be reset if Pr mm.000 (mm.000) is set to 10, 11, 1233 or 1244 or if <i>Load Defaults</i> (11.043) is set to a non-zero value.</p>
<p>Recommended actions:</p>

Default the drive and perform a reset
Allow sufficient time to perform a save before the supply to the drive is removed
If the trip persists - return drive to supplier

</td></tr>
<tr><td>External Trip</td><td>An External trip is initiated</td></tr>
<tr><td>6</td><td>
An <i>External Trip</i> has occurred. The cause of the trip can be identified from the sub trip number displayed after the trip string. See table below. An external trip can also be initiated by writing a value of 6 in Pr 10.038.
<table>
<tr><th>Sub-trip</th><th>Reason</th></tr>
<tr><td>1</td><td><i>External Trip Mode</i> (08.010) = 1 or 3 and Safe Torque Off input 1 is low</td></tr>
<tr><td>2</td><td><i>External Trip Mode</i> (08.010) = 2 or 3 and Safe Torque Off input 2 is low</td></tr>
<tr><td>3</td><td><i>External Trip</i> (10.032) = 1</td></tr>
</table>
<p>Recommended actions:</p>

Check the Safe Torque Off signal voltage on terminal 31 equals to 24 V
Check the value of Pr 08.009 which indicates the digital state of terminal 31, equates to ‘on’.
If external trip detection of the Safe Torque Off input is not required, set Pr 08.010 to Off (0).
Check the value of Pr 10.032.
Select ‘Destinations’ (or enter 12001) in Pr mm.000 and check for a parameter controlling Pr 10.032.
Ensure Pr 10.032 or Pr 10.038 (= 6) is not being controlled by serial comms

</td></tr>
<tr><td>HF01</td><td>Data processing error: CPU address error</td></tr>
<tr><td></td><td>
<p>The <i>HF01</i> trip indicates that a CPU address error has occurred. This trip indicates that the control PCB on the drive has failed.</p>
<p>Recommended actions:</p>
Hardware fault – Contact the supplier of the drive
</td></tr>
<tr><td>HF02</td><td>Data processing error: DMAC address error</td></tr>
<tr><td></td><td>
<p>The <i>HF02</i> trip indicates that a DMAC address error has occurred. This trip indicates that the control PCB on the drive has failed.</p>
<p>Recommended actions:</p>
Hardware fault – Contact the supplier of the drive
</td></tr>
<tr><td>HF03</td><td>Data processing error: Illegal instruction</td></tr>
<tr><td></td><td>
<p>The <i>HF03</i> trip indicates that an illegal instruction has occurred. This trip indicates that the control PCB on the drive has failed.</p>
<p>Recommended actions:</p>
Hardware fault – Contact the supplier of the drive
</td></tr>
</table>

<table>
<tr><th>Trip</th><th>Diagnosis</th></tr>
<tr><td>HF04</td><td>Data processing error: Illegal slot instruction</td></tr>
<tr><td></td><td>The <i>HF04</i> trip indicates that an illegal slot instruction has occurred.This trip indicates that the control PCB on the drive has failed.
Recommended actions:
• Hardware fault – Contact the supplier of the drive</td></tr>
<tr><td>HF05</td><td>Data processing error: Undefined exception</td></tr>
<tr><td></td><td>The <i>HF05</i> trip indicates that an undefined exception error has occurred. This trip indicates that the control PCB on the drive has failed.
Recommended actions:
• Hardware fault – Contact the supplier of the drive</td></tr>
<tr><td>HF06</td><td>Data processing error: Reserved exception</td></tr>
<tr><td></td><td>The <i>HF06</i> trip indicates that a reserved exception error has occurred. This trip indicates that the control PCB on the drive has failed.
Recommended actions:
• Hardware fault – Contact the supplier of the drive</td></tr>
<tr><td>HF07</td><td>Data processing error: Watchdog failure</td></tr>
<tr><td></td><td>The <i>HF07</i> trip indicates that a watchdog failure has occurred. This trip indicates that the control PCB on the drive has failed.
Recommended actions:
• Hardware fault – Contact the supplier of the drive</td></tr>
<tr><td>HF08</td><td>Data processing error: CPU Interrupt crash</td></tr>
<tr><td></td><td>The <i>HF08</i> trip indicates that a CPU interrupt crash has occurred. This trip indicates that the control PCB on the drive has failed.
Recommended actions:
• Hardware fault – Contact the supplier of the drive</td></tr>
<tr><td>HF09</td><td>Data processing error: Free store overflow</td></tr>
<tr><td></td><td>The <i>HF09</i> trip indicates that a free store overflow has occurred. This trip indicates that the control PCB on the drive has failed.
Recommended actions:
• Hardware fault – Contact the supplier of the drive</td></tr>
<tr><td>HF10</td><td>Data processing error: Parameter routing system error</td></tr>
<tr><td></td><td>The <i>HF10</i> trip indicates that a Parameter routing system error has occurred. This trip indicates that the control PCB on the drive has failed.
Recommended actions:
• Hardware fault – Contact the supplier of the drive</td></tr>
<tr><td>HF11</td><td>Data processing error: Access to EEPROM failed</td></tr>
<tr><td></td><td>The <i>HF11</i> trip indicates that access to the drive EEPROM has failed. This trip indicates that the control PCB on the drive has failed.
Recommended actions:
• Hardware fault – Contact the supplier of the drive</td></tr>
<tr><td>HF12</td><td>Data processing error: Main program stack overflow</td></tr>
<tr><td></td><td>The <i>HF12</i> trip indicates that the main program stack over flow has occurred. The stack can be identified by the sub-trip number. This trip indicates that the control PCB on the drive has failed.
<table>
<tr><th>Sub-trip</th><th>Stack</th></tr>
<tr><td>1</td><td>Background tasks</td></tr>
<tr><td>2</td><td>Timed tasks</td></tr>
<tr><td>3</td><td>Main system interrupts</td></tr>
</table>
Recommended actions:
• Hardware fault – Contact the supplier of the drive</td></tr>
<tr><td>HF13</td><td>Data processing error: Firmware incompatible with hardware</td></tr>
<tr><td></td><td>The <i>HF13</i> trip indicates that the drive firmware is not compatible with the hardware. This trip indicates that the control PCB on the drive has failed. The sub-trip number gives the actual ID code of the control board hardware.
Recommended actions:
• Re-program the drive with the latest version of the drive firmware
• Hardware fault – Contact the supplier of the drive</td></tr>
</table>

<table>
<tr><th>Trip</th><th>Diagnosis</th></tr>
<tr><td>HF14</td><td>Data processing error: CPU register bank error</td></tr>
<tr><td></td><td>The <i>HF14</i> trip indicates that a CPU register bank error has occurred. This trip indicates that the control PCB on the drive has failed.
Recommended actions:
• Hardware fault – Contact the supplier of the drive</td></tr>
<tr><td>HF15</td><td>Data processing error: CPU divide error</td></tr>
<tr><td></td><td>The <i>HF15</i> trip indicates that a CPU divide error has occurred. This trip indicates that the control PCB on the drive has failed.
Recommended actions:
• Hardware fault – Contact the supplier of the drive</td></tr>
<tr><td>HF16</td><td>Data processing error: RTOS error</td></tr>
<tr><td></td><td>The <i>HF16</i> trip indicates that a RTOS error has occurred. This trip indicates that the control PCB on the drive has failed.
Recommended actions:
• Hardware fault – Contact the supplier of the drive</td></tr>
<tr><td>HF17</td><td>Data processing error: Clock supplied to the control board is out of specification</td></tr>
<tr><td></td><td>The <i>HF17</i> trip indicates that the clock supplied to the control board logic is out of specification. This trip indicates that the control PCB on the drive has failed.
Recommended actions:
• Hardware fault – Contact the supplier of the drive</td></tr>
<tr><td>HF18</td><td>Data processing error: Internal flash memory has failed</td></tr>
<tr><td></td><td>The <i>HF18</i> trip indicates that the internal flash memory has failed when writing option module parameter data. The reason for the trip can be identified by the sub-trip number.
<table>
<tr><th>Sub-trip</th><th>Reason</th></tr>
<tr><td>1</td><td>Option module initialization timed out</td></tr>
<tr><td>2</td><td>Programming error while writing menu in flash</td></tr>
<tr><td>3</td><td>Erase flash block containing setup menus failed</td></tr>
<tr><td>4</td><td>Erase flash block containing application menus failed</td></tr>
<tr><td>5</td><td>Incorrect setup menu CRC contained in flash</td></tr>
<tr><td>6</td><td>Incorrect application menu CRC contained in flash</td></tr>
<tr><td>7</td><td>Incorrect common application menu 18 CRC contained in flash</td></tr>
<tr><td>8</td><td>Incorrect common application menu 19 CRC contained in flash</td></tr>
<tr><td>9</td><td>Incorrect common application menu 20 CRC contained in flash</td></tr>
</table>
Recommended actions:
• Hardware fault - Contact the supplier of the drive.</td></tr>
<tr><td>HF19</td><td>Data processing error: CRC check on the firmware has failed</td></tr>
<tr><td></td><td>The <i>HF19</i> trip indicates that the CRC check on the drive firmware has failed.
Recommended actions:
• Re-program the drive
• Hardware fault - Contact the supplier of the drive</td></tr>
<tr><td>HF20</td><td>Data processing error: ASIC is not compatible with the hardware</td></tr>
<tr><td></td><td>The <i>HF20</i> trip indicates that the ASIC version is not compatible with the drive firmware. The ASIC version can be identified from the sub-trip number.
Recommended actions:
• Hardware fault - Contact the supplier of the drive</td></tr>
<tr><td>HF23 to HF25</td><td>Hardware fault</td></tr>
<tr><td></td><td>Recommended actions:
• Hardware fault - Contact the supplier of the drive</td></tr>
</table>

<table>
<tr><th>Trip</th><th>Diagnosis</th></tr>
<tr><td>I/O Overload</td><td>Digital output overload</td></tr>
<tr><td>26</td><td>The <i>I/O Overload</i> trip indicates that the total current drawn from 24 V user supply or from the digital output has exceeded the limit. A trip is initiated if one or more of the following conditions:
• Maximum output current from one digital output is 100 mA.
• The combined maximum output current from outputs 1 and 2 is 100 mA
• The combined maximum output current from output 3 and +24 V output is 100 mA
Recommended actions:
• Check total loads on digital outputs
• Check control wiring is correct
• Check output wiring is undamaged</td></tr>
<tr><td>Inductor Too Hot</td><td>The Regen inductor has overloaded</td></tr>
<tr><td>93</td><td>In Regen mode, this trip indicates a Regen inductor thermal overload based on the <i>Rated Current</i> (Pr 05.007) and the <i>Inductor Thermal Time Constant</i> (Pr 04.015). Pr 04.019 displays the inductor temperature as a percentage of the maximum value. The drive will trip on <i>Inductor Too Hot</i> when Pr 04.019 gets to 100 %.
Recommended actions:
• Check the load / current through the inductor has not changed.
• Ensure the <i>Rated Current</i> (Pr 05.007) is not zero.</td></tr>
<tr><td>Inter-connect</td><td>Multi-power module drive interconnection cable error</td></tr>
<tr><td>103</td><td>The sub-trip "xx.0.00" indicates which power module has detected the fault where xx is the power module number. It should be noted that this trip is also initiated if the communication fails either when a rectifier signals a fault or a trip is reset. In this case, the sub-trip is the number of modules that are still communicating correctly.</td></tr>
<tr><td>Island</td><td>Island condition detected in Regen mode</td></tr>
<tr><td>160</td><td>The <i>Island</i> trip indicates that the AC mains is no longer present and the inverter would be on ‘islanded’ power supply if it continued to operate.
The sub-trips indicate the reason for the trip:
<table>
<tr><th>Sub-trip</th><th>Description</th></tr>
<tr><td>1</td><td>Island detection system has been enabled and detected an island condition</td></tr>
<tr><td>2</td><td>The minimum synchronization voltage is non-zero and the supply voltage has been below this threshold and been simulating its own supply synchronization for more than 2.0 s.</td></tr>
</table>
Recommended actions:
• Check the supply / supply connections to the Regen drive</td></tr>
<tr><td>Keypad Mode</td><td>Keypad has been removed when the drive is receiving the speed reference from the keypad</td></tr>
<tr><td>34</td><td>The <i>Keypad Mode</i> trip indicates that the drive is in keypad mode [<i>Reference Selector</i> (01.014) = 4 or 6 or M2 reference selector (21.003 = 4 or 6 if motor map 2 is selected] and the keypad has been removed or disconnected from the drive.
Recommended actions:
• Re-install keypad and reset
• Change <i>Reference Selector</i> (01.014) to select the reference from another source</td></tr>
<tr><td>Line Sync</td><td>Synchronization to the power supply has been lost</td></tr>
<tr><td>39</td><td>The <i>Line Sync</i> trip indicates that the inverter has lost the synchronization with the ac supply in Regen mode.
Recommended actions:
• Check the supply / supply connections to the Regen drive</td></tr>
<tr><td>OHt Brake</td><td>Braking IGBT over-temperature</td></tr>
<tr><td>101</td><td>The <i>OHt Brake</i> over-temperature trip indicates that braking IGBT over-temperature has been detected based on software thermal model.
Recommended actions:
• Check braking resistor value is greater than or equal to the minimum resistance value</td></tr>
</table>

Trip	Diagnosis

OHt Control | **Control stage over temperature**

23

This *OHt Control* trip indicates that a control stage over-temperature has been detected. From the sub-trip ‘xxyzz’, the Thermistor location is identified by ‘zz’.

Source	xx	y	zz	Description
Control system	00	0	01	Control board thermistor 1 over temperature
Control system	00	0	02	Control board thermistor 2 over temperature
Control system	00	0	03	I/O board thermistor over temperature

Recommended actions:

- Check enclosure / drive fans are still functioning correctly
- Check enclosure ventilation paths
- Check enclosure door filters
- Increase ventilation
- Reduce the drive switching frequency
- Check ambient temperature

OHt dc bus | **DC bus over temperature**

27

The *OHt dc bus* trip indicates a DC bus component over temperature based on a software thermal model. The drive includes a thermal protection system to protect the DC bus components within the drive. This includes the effects of the output current and DC bus ripple. The estimated temperature is displayed as a percentage of the trip level in Pr **07.035**.
If this parameter reaches 100 % then an *OHt dc bus* trip is initiated. The drive will attempt to stop the motor before tripping.
If the motor does not stop in 10 seconds the drive trips immediately.

Source	xx	y	zz	Description
Control system	00	2	00	DC bus thermal model gives trip with sub-trip 0

It is also possible in a multi-power module system for DC bus over-temperature to be detected from within the power stage. From this source the estimated temperature as a percentage of trip is not available and the trip is indicated as follows:

Source	xx	y	zz	Description
Control system	01	0	00	Power stage gives trip with sub-trip 0

Recommended actions:

- Check the AC supply voltage balance and levels
- Check DC bus ripple level
- Reduce duty cycle
- Reduce load

OHt Inverter | **Inverter over temperature based on thermal model**

21

This trip indicates that an IGBT junction over-temperature has been detected based on a firmware thermal model. The sub-trip indicates which model has initiated the trip in the form xxyzz as given below:

Source	xx	y	zz	Description
Control system	00	1	00	Inverter thermal model
Control system	00	3	00	Braking IGBT thermal model

Recommended actions with sub-trip 100:

- Reduce the selected drive switching frequency
- Ensure *Auto-switching Frequency Change Disable* (05.035) is set to Off
- Reduce duty cycle
- Increase acceleration / deceleration rates
- Reduce motor load
- Check DC bus ripple
- Ensure all three input phases are present and balanced

Recommended actions with sub-trip 300:

- Reduce the braking load.

Trip	Diagnosis
OHt Power	**Power stage over temperature**
22	This trip indicates that a power stage over-temperature has been detected. The sub-trip "xxyzz" indicates which thermistor is indicating the over-temperature. The thermsitor numbering is different for a single module type drive (i.e. no parallel board fitted) and a multi-module type drive (i.e. parallel board fitted with one or more power modules) as shown below:

Single module type drive:

Source	xx	y	zz	Description
Power system	01	0	zz	Thermistor location defined by zz in the power board
Power system	01	Rectifier number number	zz	Thermistor location defined by zz in the rectifier

Multi-module type system:

Source	xx	y	zz	Description
Power system	power module number	0	01	U phase power device
Power system	power module number	0	02	V phase power device
Power system	power module number	0	03	W phase power device
Power system	power module number	0	04	Rectifier
Power system	power module number	0	05	General power system
Power system	power module number	0	00	Braking IGBT

Note that the power module that has caused the trip cannot be identified except for the braking IGBT temperature measurement

Recommended actions:

- Check enclosure / drive fans are still functioning correctly
- Force the heatsink fans to run at maximum speed
- Check enclosure ventilation paths
- Check enclosure door filters
- Increase ventilation
- Reduce the drive switching frequency
- Reduce duty cycle
- Decrease acceleration / deceleration rates
- Reduce motor load
- Check the derating tables and confirm the drive is correctly sized for the application.
- Use a drive with larger current / power rating

Trip	Diagnosis
OI ac	**Instantaneous output over current detected**
3	The instantaneous drive output current has exceeded VM_DRIVE_CURRENT_MAX. This trip cannot be reset until 10 s after the trip was initiated.

Source	xx	y	zz	Description
Control system	00	0	00	Instantaneous over-current trip when the measured AC current exceeds VM_DRIVE_CURRENT[MAX].
Power system	Power module number	0		

Recommended actions:

- Check for short circuit on the Regen component circuitry
- Check DC connections: Regen to motoring drive for short circuit
- Check the synchronisation status
- Is power cable length within limits for the frame size

<table>
<tr><th>Trip</th><th>Diagnosis</th></tr>
<tr><td>OI Brake</td><td>Braking IGBT over current detected: short circuit protection for the braking IGBT activated</td></tr>
<tr><td>4</td><td>The <i>OI Brake</i> trip indicates that over current has been detected in braking IGBT or braking IGBT protection has been activated. This trip cannot be reset until 10 s after the trip was initiated.
<table>
<tr><th>Source</th><th>xx</th><th>y</th><th>zz</th><th>Description</th></tr>
<tr><td>Power system</td><td>Power module number</td><td>0</td><td>00</td><td>Braking IGBT instantaneous over-current trip</td></tr>
</table>
Recommended actions:

Check brake resistor wiring
Check braking resistor value is greater than or equal to the minimum resistance value
Check braking resistor insulation
</td></tr>
<tr><td>OI dc</td><td>Power module over current detected from IGBT on state voltage monitoring</td></tr>
<tr><td>109</td><td>The <i>OI dc</i> trip indicates that the short circuit protection for the drive output stage has been activated. The table below shows where the trip has been detected..This trip cannot be reset until 10 s after the trip was initiated.
<table>
<tr><th>Source</th><th>xx</th><th>y</th><th>zz</th></tr>
<tr><td>Control system</td><td>00</td><td>0</td><td>00</td></tr>
<tr><td>Power system</td><td>Power module number</td><td>0</td><td>00</td></tr>
</table>
Recommended actions:

Disconnect the motor cable at the drive end and check the motor and cable insulation with an insulation tester
Replace the drive
</td></tr>
<tr><td>OI Snubber</td><td>Snubber over-current detected</td></tr>
<tr><td>92</td><td>The <i>OI Snubber</i> trip indicates that an over-current condition has been detected in the rectifier snubber circuit. The reason for the trip can be identified by the sub-trip number.
<table>
<tr><th>Source</th><th>xx</th><th>y</th><th>zz</th><th>Description</th></tr>
<tr><td>Power system</td><td>01</td><td>Rectifier number*</td><td>00</td><td>Rectifier snubber over-current trip detected.</td></tr>
</table>
* For a parallel power-module system the rectifier number will be one as it is not possible to determine which rectifier has detected the fault.
Recommended actions:

Ensure the motor cable length does not exceed the maximum for selected switching frequency
Check for supply voltage imbalance

Check for supply disturbance such as notching from a DC drive
Check the motor and motor cable insulation with an insulation tester
Fit an output line reactor or sinusoidal filter
</td></tr>
<tr><td>Option Disable</td><td>Option module does not acknowledge during drive mode changeover</td></tr>
<tr><td>215</td><td>During drive mode changeover option modules must acknowledge that they have stopped accessing the communications system between the option slots and the drive. If an option module does not do this in the allowed time then this trip is produced.
Recommended trip:

Reset the trip
If the trip persists replace the option module
</td></tr>
</table>

Trip | **Diagnosis**

Out Phase Loss

98

Output phase loss detected

The *Out Phase Loss* trip indicates that a phase loss has been detected at the drive output.

Note that if Reverse Output Phase Sequence (05.042) = 1 the physical output phases are reversed, and so sub-trip 3 refers to physical output phase V and sub-trip 2 refers to physical output phase W.

Sub-trip	Reason
1	U phase detected as disconnected when drive enabled to run
2	V phase detected as disconnected when drive enabled to run
3	W phase detected as disconnected when drive enabled to run
4	Output phase loss detected when the drive is running

Recommended action:

- Check motor and drive connections
- To disable the trip set *Output Phase Loss Detection Enable* (06.059) = 0

Over Volts

2

DC bus voltage has exceeded the peak level or maximum continuous level for 15 seconds

The *Over Volts* trip indicates that the DC bus voltage has exceeded the VM_DC_VOLTAGE[MAX] or VM_DC_VOLTAGE_SET[MAX] for 15 s. The trip threshold varies depending on voltage rating of the drive as shown below.

Voltage rating	VM_DC_VOLTAGE[MAX]	VM_DC_VOLTAGE_SET[MAX]
200	415	410
400	830	815
575	990	970
690	1190	1175

Sub-trip Identification

Source	xx	y	zz
Control system	00	0	01: Instantaneous trip when the DC bus voltage exceeds VM_DC_VOLTAGE[MAX].
Control system	00	0	02: Time delayed trip indicating that the DC bus voltage is above VM_DC_VOLTAGE_SET[MAX].

Recommended actions:

- Increase deceleration ramp (Pr **00.004**)
- Decrease the braking resistor value (staying above the minimum value)
- Check nominal AC supply level
- Check for supply disturbances which could cause the DC bus to rise
- Check motor insulation using an insulation tester

Phase Loss

32

Supply phase loss

This trip indicates that the drive has detected an input phase loss or large supply imbalance. Phase loss can be detected directly from the supply where the drive has a thyristor base charge system (Frame size 7 and above). If phase loss is detected using this method the drive trips immediately and the xx part of the sub-trip is set to 01. In all sizes of drive phase loss is also detected by monitoring the ripple in the DC bus voltage in which case the drive attempts to stop the drive before tripping unless bit 2 of *Action On Trip Detection* (10.037) is set to one. When phase loss is detected by monitoring the ripple in the DC bus voltage the xx part of the sub-trip is zero.

Source	xx	y	zz
Control system	00	0	00: Phase loss detected from DC bus ripple
Power system (1)	Power module number	Rectifier number (2)	00: Phase loss detected directly from the supply

(1) Input phase loss detection can be disabled when the drive required to operate from the DC supply or from a single phase supply in *Input Phase Loss Detection Mode* (06.047).

(2) For a parallel power-module system the rectifier number will be one as it is not possible to determine which rectifier has detected the fault.

This trip does not occur in Regen mode.

Recommended actions:

- Check the AC supply voltage balance and level at full load
- Check the DC bus ripple level with an isolated oscilloscope
- Check the output current stability
- Reduce the duty cycle
- Reduce the motor load
- Disable the phase loss detection, set Pr **06.047** to 2.
- Check for mechanical resonance with the load

<table>
<tr><th>Trip</th><th>Diagnosis</th></tr>
<tr><td>Power Comms</td><td>A Power Comms trip indicates a communications problem within the power system of the drive</td></tr>
<tr><td>90</td><td>A <i>Power Comms</i> trip indicates a communications problem within the power system of the drive. The reason for the trip can be identified by the sub-trip number.
<table>
<tr><th>Type of drive</th><th>xx</th><th>y</th><th>zz</th></tr>
<tr><td>Control system</td><td>Power module number</td><td>Rectifier number*</td><td>00: Excessive communications errors detected by the rectifier module</td></tr>
</table>
* For a parallel power-module system the rectifier number will be one as it is not possible to determine which rectifier has detected the fault.
Recommended actions:
• Hardware fault – Contact the supplier of the drive</td></tr>
<tr><td>Power Data</td><td>Power system configuration data error</td></tr>
<tr><td>220</td><td>The <i>Power Data</i> trip indicates that there is an error in the configuration data stored in the power system.
<table>
<tr><th>Source</th><th>xx</th><th>y</th><th>zz</th><th>Description</th></tr>
<tr><td>Control system</td><td>00</td><td>0</td><td>02</td><td>There is no data table to be uploaded to the control board</td></tr>
<tr><td>Control system</td><td>00</td><td>0</td><td>03</td><td>The power system data table is bigger than the space available in the control pod to store it.</td></tr>
<tr><td>Control system</td><td>00</td><td>0</td><td>04</td><td>The size of the table given in the table is incorrect.</td></tr>
<tr><td>Control system</td><td>00</td><td>0</td><td>05</td><td>Table CRC error.</td></tr>
<tr><td>Control system</td><td>00</td><td>0</td><td>06</td><td>The version number of the generator software that produced the table is too low. i.e. a table from a newer generator is required that includes features that have been added to the table that may not be present.</td></tr>
<tr><td>Power system</td><td>Power module number</td><td>0</td><td>00</td><td>The power data table used internally by the power module has an error. (For a multi-power module drive this indicates any error with the code tables in the power system).</td></tr>
<tr><td>Power system</td><td>Power module number</td><td>0</td><td>01</td><td>The power data table that is uploaded to the control system on power up has an error.</td></tr>
<tr><td>Power system</td><td>Power module number</td><td>0</td><td>02</td><td>The power data table used internally by the power module does not match the hardware identification of the power module.</td></tr>
</table>
Recommended actions:
• Hardware fault – Contact the supplier of the drive</td></tr>
<tr><td>Power Down Save</td><td>Power down save error</td></tr>
<tr><td>37</td><td>The <i>Power Down Save</i> trip indicates that an error has been detected in the power down save parameters saved in non-volatile memory.
Recommended actions:
• Perform a 1001 save in Pr mm.000 to ensure that the trip doesn’t occur the next time the drive is powered up.</td></tr>
<tr><td>PSU</td><td>Internal power supply fault</td></tr>
<tr><td>5</td><td>The <i>PSU</i> trip indicates that one or more internal power supply rails are outside limits or overloaded.
<table>
<tr><th>Source</th><th>xx</th><th>y</th><th>Description</th></tr>
<tr><td>Control system</td><td>00</td><td>0</td><td>Internal power supply overload</td></tr>
<tr><td>Power system</td><td>Power module number</td><td>Rectifier number*</td><td>Rectifier internal power supply overload</td></tr>
</table>
* For a parallel power-module system the rectifier number will be zero as it is not possible to determine which rectifier has detected the fault.
Recommended actions:
• Remove any option modules and perform a reset
• Remove encoder connection and perform a reset
• Hardware fault within the drive – return the drive to the supplier</td></tr>
</table>

<table>
<tr><th>Trip</th><th>Diagnosis</th></tr>
<tr><td>PSU 24V</td><td>24V internal power supply overload</td></tr>
<tr><td>9</td><td>The total user load of the drive and option modules has exceeded the internal 24 V power supply limit. The user load consists of the drive digital outputs and main encoder supply.
Recommended actions:
• Reduce the load and reset
• Provide an external 24 V power supply on control terminal 2
• Remove all option modules</td></tr>
<tr><td>Rating Mismatch</td><td>Power stage recognition: Multi module voltage or current rating mismatch</td></tr>
<tr><td>223</td><td>The <i>Rating Mismatch</i> trip indicates that there is a voltage rating or current rating mismatch in a multi-module drive system. This trip is only applicable to modular drives that are connected in parallel. A mixture of power modules with different voltage or current ratings within the same multi-module drive system is not allowed and will cause a Rating Mismatch trip.
Recommended action:
• Ensure that all modules in a multi-modular drive system are of the same frame size and rating (voltage and current)
• Hardware fault – Contact the supplier of the drive</td></tr>
<tr><td>Rectifier Set-up</td><td>A rectifier has not been set-up correctly in a multi-power module system.</td></tr>
<tr><td>94</td><td>A rectifier has not been set-up correctly in a multi-power module system.
Recommended action:
• Check the inter-power module wiring</td></tr>
<tr><td>Reserved</td><td>Reserved trips</td></tr>
<tr><td>01
95
102
104 - 108
161-168
170-173
222
228-246</td><td>These trip numbers are reserved trip numbers for future use. These trips should not be used by the user application programs.</td></tr>
<tr><td>Slot App Menu</td><td>Application menu Customization conflict error</td></tr>
<tr><td>216</td><td>The Slot App Menu trip indicates that more than one option slot has requested to customize the application menus 18, 19 and 20. The sub-trip number indicates which option slot has been allowed to customize the menus.
Recommended actions:
• Ensure that only one of the Application modules is configured to customize the application menus 18, 19 and 20</td></tr>
<tr><td>SlotX Different</td><td>Option module in option slot X has changed</td></tr>
<tr><td>204
209
214</td><td>The <i>SlotX Different</i> trip indicates that the option module in option slot X on the drive is a different type to that installed when parameters were last saved on the drive. The reason for the trip can be identified by the sub-trip number.
<table>
<tr><th>Sub-trip</th><th>Reason</th></tr>
<tr><td>1</td><td>No module was installed previously</td></tr>
<tr><td>2</td><td>A module with the same identifier is installed, but the set-up menu for this option slot has been changed, and so default parameters have been loaded for this menu.</td></tr>
<tr><td>3</td><td>A module with the same identifier is installed, but the applications menu for this option slot has been changed, and so default parameters have been loaded for this menu.</td></tr>
<tr><td>4</td><td>A module with the same identifier is installed, but the set-up and applications menu for this option slot have been changed, and so default parameters have been loaded for these menus.</td></tr>
<tr><td>>99</td><td>Shows the identifier of the module previously installed.</td></tr>
</table>
Recommended actions:
• Turn off the power, ensure the correct option modules are installed in the correct option slots and re-apply the power.
• Confirm that the currently installed option module is correct, ensure option module parameters are set correctly and perform a user save in Pr mm.000.</td></tr>
<tr><td>SlotX Error</td><td>Option module in option slot X has detected a fault</td></tr>
<tr><td>202
207
212</td><td>The <i>SlotX Error</i> trip indicates that the option module in option slot X on the drive has detected an error. The reason for the error can be identified by the sub-trip number.
Recommended actions:
• See relevant <i>Option Module User Guide</i> for details of the trip</td></tr>
</table>

<table>
<tr><th>Trip</th><th>Diagnosis</th></tr>
<tr><td>SlotX HF</td><td>Option module X hardware fault</td></tr>
<tr><td>200
205
210</td><td>The <i>SlotX HF</i> trip indicates that the option module in option slot X on the drive has indicated a hardware fault. The possible causes of the trip can be identified by the sub-trip number.
<table>
<tr><th>Sub-trip</th><th>Reason</th></tr>
<tr><td>1</td><td>The module category cannot be identified</td></tr>
<tr><td>2</td><td>All the required customized menu table information has not been supplied or the tables supplied are</td></tr>
<tr><td>3</td><td>There is insufficient memory available to allocate the comms buffers for this module</td></tr>
<tr><td>4</td><td>The module has not indicated that it is running correctly during drive power-up</td></tr>
<tr><td>5</td><td>Module has been removed after power-up or it has stopped working</td></tr>
<tr><td>6</td><td>The module has not indicated that it has stopped accessing drive parameters during a drive mode</td></tr>
<tr><td>7</td><td>The module has failed to acknowledge that a request has been made to reset the drive processor</td></tr>
<tr><td>8</td><td>The drive failed to correctly read the menu table from the module during drive power up</td></tr>
<tr><td>9</td><td>The drive failed to upload menu tables from the module and timed out (5 s)</td></tr>
<tr><td>10</td><td>Menu table CRC invalid</td></tr>
</table>
Recommended actions:
• Ensure the option module is installed correctly
• Replace the option module
• Replace the drive</td></tr>
<tr><td>SlotX Not Fitted</td><td>Option module in option slot X has been removed</td></tr>
<tr><td>203
208
213</td><td>The <i>SlotX Not Fitted</i> trip indicates that the option module in option slot X on the drive has been removed since the last power up.
Recommended actions:
• Ensure the option module is installed correctly.
• Re-install the option module.
• To confirm that the removed option module is no longer required perform a save function in Pr mm.000.</td></tr>
<tr><td>SlotX Watchdog</td><td>Option module watchdog function service error</td></tr>
<tr><td>201
206
211</td><td>The <i>SlotX Watchdog</i> trip indicates that the option module installed in Slot X has started the option watchdog function and then failed to service the watchdog correctly.
Recommended actions:
• Replace the option module</td></tr>
<tr><td>Soft Start</td><td>Soft start relay failed to close, soft start monitor failed</td></tr>
<tr><td>226</td><td>The <i>Soft Start</i> trip indicates that the soft start relay in the drive failed to close or the soft start monitoring circuit has failed.
Recommended actions:
• Hardware fault – Contact the supplier of the drive</td></tr>
<tr><td>Stored HF</td><td>Hardware trip has occurred during last power down</td></tr>
<tr><td>221</td><td>The <i>Stored HF</i> trip indicates that a hardware trip (HF01 –HF19) has occurred and the drive has been power cycled.
The sub-trip number identifies the HF trip i.e. stored HF.17.
Recommended actions:
• Enter 1299 in Pr mm.000 and press reset to clear the trip</td></tr>
</table>

Trip	Diagnosis
Sub-array RAM	**RAM allocation error**
227	The *Sub-array RAM* trip indicates that an option module, derivative image or user program image has requested more parameter RAM than is allowed. The RAM allocation is checked in order of resulting sub-trip numbers, and so the failure with the highest sub-trip number is given. The sub-trip is calculated as (parameter size) + (parameter type) + sub-array number.

Parameter size	Value
1 bit	1000
8 bit	2000
16 bit	3000
32 bit	4000
64 bit	5000

Parameter type	Value
Volatile	0
User save	100
Power-down save	200

Sub-array	Menus	Value
Applications menus	18-20	1
Derivative image	29	2
User program image	30	3
Option slot 1 set-up	15	4
Option slot 1 applications	25	5
Option slot 2 set-up	16	6
Option slot 2 applications	26	7
Option slot 3 set-up	17	8
Option slot 3 applications	27	9

Trip	Diagnosis
Temp Feedback	**Internal thermistor has failed**
218	The *Temp Feedback* trip indicates that an internal thermistor has failed. The thermistor location can be identified by the sub-trip number.

Source	xx	y	zz
Control board	**00**	**00**	**01: Control board thermistor 1** **02: Control board thermistor 2** **03: I/O board thermistor**
Power system	Power module number	0	Zero for temperature feedback provided via power system comms.21, 22 and 23 for direct ELV temperature feedback.
Power system	Power module number	Rectifier number*	Always zero

* For a parallel power-module system the rectifier number will be one as it is not possible to determine which rectifier has detected the fault.

Recommended actions:

- Hardware fault – Contact the supplier of the drive

Trip	Diagnosis
Th Brake Res	**Brake resistor over temperature**
10	The *Th Brake Res* is initiated, If hardware based braking resistor thermal monitoring is connected and the resistor overheats. If the braking resistor is not used then this trip must be disabled with bit 3 of Action *On Trip Detection* (10.037) to prevent this trip.

Recommended actions:

- Check brake resistor wiring
- Check braking resistor value is greater than or equal to the minimum resistance value
- Check braking resistor insulation

Trip	Diagnosis
Th Short Circuit	**Motor thermistor short circuit**
25	This trip indicates that a temperature sensor connected to an analog input or terminal 15 on the position feedback interface has a low impedance (i.e. < 50 Ω). The cause of the trip can be identified by the sub-trip number.

Sub-trip	Reason
3	*Analog Input 3 Mode* (07.015) = 7 and the resistance of the thermistor connected to analog input 3 is less than 50 Ω.
4	*P1 Thermistor Short Circuit Detect* (03.123) = 1 and the resistance of the thermistor connected to the drive P1 position feedback interface is less than 50 Ω.

Recommended actions:

- Check thermistor continuity
- Replace motor / motor thermistor

<table>
<tr><th>Trip</th><th>Diagnosis</th></tr>
<tr><td>Thermistor</td><td>Motor thermistor over-temperature</td></tr>
<tr><td>24</td><td>The <i>Thermistor</i> trip indicates that the motor thermistor connected to terminal 8 (analog input 3) on the control connections or terminal 15 on the encoder terminal (15 way D-type connector) has indicated a motor over temperature. The cause of the trip can be identified by the sub-trip number
<table>
<tr><th>Sub-trip</th><th>Reason</th></tr>
<tr><td>3</td><td>Trip initiated from analog input 3</td></tr>
<tr><td>4</td><td>Trip initiated from P1 position feedback interface</td></tr>
</table>
Recommended actions:
• Check motor temperature
• Check threshold level (07.048)
• Check thermistor continuity</td></tr>
<tr><td>Undefined</td><td>Drive has tripped and the cause of the trip is Undefined</td></tr>
<tr><td>110</td><td>The <i>Undefined</i> trip indicates that the power system has generated but did not identify the trip the power system. The cause of the trip is unknown.
Recommended actions:
• Hardware fault – return the drive to the supplier</td></tr>
<tr><td>User 24V</td><td>User 24 V supply is not present on control terminals (1,2)</td></tr>
<tr><td>91</td><td>A <i>User 24 V</i> trip is initiated, if <i>User Supply Select</i> (Pr 06.072) is set to 1 or <i>Low Under Voltage Threshold Select</i> (06.067) = 1 and no user 24 V supply is present on control terminals 1 and 2.
Recommended actions:
• Ensure the user 24 V supply is present on control terminals 1 (0 V) and 2 (24 V)</td></tr>
</table>

<table>
<tr><th>Trip</th><th>Diagnosis</th></tr>
<tr><td>User Program</td><td>On board user program error</td></tr>
<tr><td>249</td><td>The <i>User Program</i> trip indicates that an error has been detected in the onboard user program image. The reason for the trip can be identified by the sub-trip number.
<table>
<tr><th>Sub-trip</th><th>Reason</th><th>Comments</th></tr>
<tr><td>1</td><td>Divide by zero</td><td></td></tr>
<tr><td>2</td><td>Undefined trip</td><td></td></tr>
<tr><td>3</td><td>Attempted fast parameter access set-up with non-existent parameter</td><td></td></tr>
<tr><td>4</td><td>Attempted access to non-existent parameter</td><td></td></tr>
<tr><td>5</td><td>Attempted write to read-only parameter</td><td></td></tr>
<tr><td>6</td><td>Attempted and over-range write</td><td></td></tr>
<tr><td>7</td><td>Attempted read from write-only parameter</td><td></td></tr>
<tr><td>30</td><td>The image has failed because either its CRC is incorrect, or there are less than 6 bytes in the image or the image header version is less than 5.</td><td>Occurs when the drive powers-up or the image is programmed. The image tasks will not run</td></tr>
<tr><td>31</td><td>The image requires more RAM for heap and stack than can be provided by the drive.</td><td>As 30</td></tr>
<tr><td>32</td><td>The image requires an OS function call that is higher than the maximum allowed</td><td>As 30</td></tr>
<tr><td>33</td><td>The ID code within the image is not valid</td><td>As 30</td></tr>
<tr><td>40</td><td>The timed task has not completed in time and has been suspended</td><td></td></tr>
<tr><td>41</td><td>Undefined function called, i.e. a function in the host system vector table that has not been assigned.</td><td>As 40</td></tr>
<tr><td>52</td><td>Customized menu table CRC check failed</td><td>As 30</td></tr>
<tr><td>53</td><td>Customized menu table changed</td><td>Occurs when the drive powers-up or the image is programmed and the table has changed. Defaults are loaded for the derivative menu and the trip will keep occurring until drive parameters are saved.</td></tr>
<tr><td>61</td><td>The option module installed in slot 1 is not allowed with the derivative image</td><td>As 30</td></tr>
<tr><td>62</td><td>The option module installed in slot 2 is not allowed with the derivative image</td><td>As 30</td></tr>
<tr><td>63</td><td>The option module installed in slot 3 is not allowed with the derivative image</td><td>As 30</td></tr>
<tr><td>64</td><td>The option module installed in slot 4 is not allowed with the derivative image</td><td>As 30</td></tr>
<tr><td>70</td><td>An option module that is required by the derivative image is not installed in any slot.</td><td>As 30</td></tr>
<tr><td>71</td><td>An option module specifically required to be installed in slot 1 not present</td><td>As 30</td></tr>
<tr><td>72</td><td>An option module specifically required to be installed in slot 2 not present</td><td>As 30</td></tr>
<tr><td>73</td><td>An option module specifically required to be installed in slot 3 not present</td><td>As 30</td></tr>
<tr><td>74</td><td>An option module specifically required to be installed in slot 4 not present</td><td>As 30</td></tr>
<tr><td>80</td><td>Image is not compatible with the control board</td><td>Initiated from within the image code</td></tr>
<tr><td>81</td><td>Image is not compatible with the control board serial number</td><td>As 80</td></tr>
</table></td></tr>
<tr><td>User Prog Trip</td><td>Trip generated by an onboard user program</td></tr>
<tr><td>96</td><td>This trip can be initiated from within an onboard user program using a function call which defines the sub-trip number.
Recommended actions:
• Check the user program</td></tr>
</table>

Trip	Diagnosis
User Save	**User Save error / not completed**
36	The *User Save* trip indicates that an error has been detected in the user save parameters saved in non-volatile memory. For example, following a user save command, If the power to the drive was removed when the user parameters were being saved. **Recommended actions:** • Perform a user save in Pr **mm.000** to ensure that the trip doesn't occur the next time the drive is powered up. • Ensure that the drive has enough time to complete the save before removing the power to the drive.
User Trip	**User generated trip**
41 -89 **112 -159**	These trips are not generated by the drive and are to be used by the user to trip the drive through an application program. **Recommended actions:** • Check the user program
Voltage Range	**Supply voltage out of range detected in Regen mode**
169	The *Voltage Range* trip is initiated, if the Regen *Minimum Voltage* (03.026) is set to a non-zero value and the supply voltage is outside the range defined by *Regen Maximum Voltage* (03.027) and *Regen Minimum Voltage* (03.026) for more than 100 ms. **Recommended actions:** • Ensure the supply voltage is operating within the drive specification. • Ensure Pr **03.026** and Pr **03.027** are set correctly • Check the supply voltage waveform using an oscilloscope • Reduce the level of supply disturbance • Set *Maximum Voltage* (03.027) to zero to disable the trip.
Watchdog	**Control word watchdog has timed out**
30	The *Watchdog* trip indicates that the control word has been enabled and has timed out **Recommended actions:** Once Pr **06.042** bit 14 has been changed from 0 to 1 to enable the watchdog, this must be repeated every 1 s or a Watchdog trip will be initiated. The watchdog is disabled when the trip occurs and must be re-enabled if required when the trip is reset.

Table 12-4 Serial communications look up table

No	Trip	No	Trip	No	Trip
1	Reserved 001	93	Inductor Too Hot	197	Reserved 197
2	Over Volts	94	Rectifier Set-Up	198	Reserved 198
3	OI ac	95	Reserved 95	199	Destination
4	OI Brake	96	User Prog Trip	200	Slot1 HF
5	PSU	97	Data Changing	201	Slot1 Watchdog
6	External Trip	98	Out Phase Loss	202	Slot1 Error
7	Reserved 7	99	Reserved 99	203	Slot1 Not installed
8	Reserved 8	100	Reset	204	Slot1 Different
9	PSU 24	101	OHt Brake	205	Slot2 HF
10	Th Brake Res	102	Reserved 102	206	Slot2 Watchdog
11	Reserved 11	103	Inter-connect	207	Slot2 Error
12	Reserved 12	104 - 108	Reserved 104 - 108	208	Slot2 Not installed
13	Reserved 13	109	OI dc	209	Slot2 Different
14	Reserved 14	110	Undefined	210	Slot3 HF
15	Reserved 15	111	Configuration	211	Slot3 Watchdog
16	Reserved 16	112 - 159	User Trip 112 - 159	212	Slot3 Error
17	Reserved 17	160	Island	213	Slot3 Not installed
18	Reserved 18	161 - 168	Reserved 161 - 168	214	Slot3 Different
19	Brake R Too Hot	169	Voltage Range	215	Option Disable
20	Reserved 20	170 - 173	Reserved 170 - 173	216	Slot App Menu
21	OHt Inverter	174	Card Slot	217	App Menu Changed
22	OHt Power	175	Card Product	218	Temp Feedback
23	OHt Control	176	Reserved 176	219	An Output Calib
24	Thermistor	177	Card Boot	220	Power Data
25	Th Short Circuit	178	Card Busy	221	Stored HF
26	I/O Overload	179	Card Data Exists	222	Reserved 222
27	OHt dc bus	180	Card Option	223	Rating Mismatch
28	An Input Loss 1	181	Card Read Only	224	Drive Size
29	An Input Loss 2	182	Card Error	225	Current Offset
30	Watchdog	183	Card No Data	226	Soft Start
31	EEPROM Fail	184	Card Full	227	Sub-array RAM
32	Phase Loss	185	Card Access	228 - 246	Reserved 228 - 246
33	Reserved 33	186	Card Rating	247	Derivative ID
34	Keypad Mode	187	Card Drive Mode	248	Derivative Image
35	Control Word	188	Card Compare	249	User Program
36	User Save	189	Reserved 189	250	Slot4 HF
37	Power Down Save	190	Reserved 190	251	Slot4 Watchdog
38	Reserved 38	191	Reserved 191	252	Slot4 Error
39	Line Sync	192	Reserved 192	253	Slot4 Not installed
40 -89	User Trip 40 - 89	193	Reserved 193	254	Slot4 Different
90	Power Comms	194	Reserved 194	255	Reset Logs
91	User 24V	195	Reserved 195		
92	OI Snubber	196	Reserved 196		

The trips can be grouped into the following categories. It should be noted that a trip can only occur when the drive is not tripped or is already tripped but with a trip with a lower priority number.

Table 12-5 Trip categories

Priority	Category	Trips	Comments
1	Internal faults	HFxx	These indicate internal problems and cannot be reset. All drive features are inactive after any of these trips occur. If an KI-Keypad is installed it will show the trip, but the keypad will not function.
1	Stored HF trip	{Stored HF}	This trip cannot be cleared unless 1299 is entered into *Parameter* (**mm.000**) and a reset is initiated.
2	Non-resettable trips	Trip numbers 218 to 247, {Slot1 HF}, {Slot2 HF}, {Slot3 HF} or {Slot4 HF}	These trips cannot be reset.
3	Volatile memory failure	{EEPROM Fail}	This can only be reset if Parameter mm**.000** is set to 1233 or 1244, or if *Load Defaults* (11.043) is set to a non-zero value.
3	Internal 24 V power supply	{PSU 24V}	
4	NV Media Card trips	Trip numbers 174, 175 and 177 to 188	These trips are priority 5 during power-up.
5	Trips with extended reset times	{OI ac}, {OI Brake}, and {OI dc}	These trips cannot be reset until 10 s after the trip was initiated.
5	Phase loss and DC bus power circuit protection	{Phase Loss} and {Oht dc bus}	The drive will attempt to stop the motor before tripping if a {Phase Loss}. 000 trip occurs unless this feature has been disabled (see *Action On Trip Detection* (10.037). The drive will always attempt to stop the motor before tripping if an {Oht dc bus} occurs.
5	Standard trips	All other trips	

Table 12-6 DC voltage trip and restart levels

Drive voltage rating	UU trip level Vdc	UU restart level Vdc
200	175	215
400	330	425
575	435	590
690	435	590

12.5 Internal / Hardware trips

Trips {HF01} to {HF25} are internal faults that do not have trip numbers. If one of these trips occurs, the main drive processor has detected an irrecoverable error. All drive functions are stopped and the trip message will be displayed on the drive keypad. If a non permanent trip occurs this may be reset by power cycling the drive. On power up after it has been power cycled the drive will trip on Stored HF. The sub-trip code is the number of the original HF trip. Enter 1299 in mm**.000** to clear the Stored HF trip.

12.6 Alarm indications

In any mode, an alarm is an indication given on the display by alternating the alarm string with the drive status string on the first row and showing the alarm symbol in the last character in the first row. If an action is not taken to eliminate any alarm except "Limit Switch" the drive may eventually trip. Alarms are not displayed when a parameter is being edited, but the user will still see the alarm character on the upper row.

Table 12-7 Alarm indications

Alarm string	Description
Brake Resistor	Brake resistor overload. *Braking Resistor Thermal Accumulator* (10.039) in the drive has reached 75.0 % of the value at which the drive will trip.
Ind Overload	Regen inductor overload. *Inductor Protection Accumulator* (04.019) in the drive has reached 75.0 % of the value at which the drive will trip and the load on the drive is > 100 %.
Drive Overload	Drive over temperature. *Percentage Of Drive Thermal Trip Level* (07.036) in the drive is greater than 90 %.
Limit Switch	Limit switch active. Indicates that a limit switch is active and that is causing the motor to be stopped.

12.7 Status idincations

Table 12-8 Status indications

Upper row string	Description	Drive output stage
Inhibit	The drive is inhibited and cannot be run. The Safe Torque Off signal is not applied to Safe Torque Off terminals or Pr **06.015** is set to 0	Disabled
Run	The drive is active and running	Enabled
Scan	The drive is enabled in Regen mode and is trying to synchronize to the supply	Enabled
Supply Loss	Supply loss condition has been detected	Enabled
Trip	The drive has tripped and no longer controlling the motor. The trip code appears in the lower display	Disabled
Active	The Regen unit is enabled and synchronized to the supply	Enabled
Under Voltage	The drive is in the under voltage state either in low voltage or high voltage mode	Disabled

Table 12-9 Option module and NV Media Card and other status indications at power-up

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

12.8 Programming error indications

The following are the error messages displayed on the drive keypad when an error occurs during programming of drive firmware.

Table 12-10 Programming error indications

Error String	Reason	Solution
Error 1	There is not enough drive memory requested by all the option modules.	Power down drive and remove some of the option modules until the message disappears.
Error 2	At least one option module did not acknowledge the reset request.	Power cycle drive
Error 3	The boot loader failed to erase the processor flash	Power cycle drive and try again. If problem persists, return drive
Error 4	The boot loader failed to program the processor flash	Power cycle drive and try again. If problem persists, return drive
Error 5	One option module did not initialize correctly. Option module did not set Ready to Run flag.	Remove faulty option module.

12.9 Displaying the trip history

The drive retains a log of the last ten trips that have occurred. *Trip 0* (**10.020**) to *Trip 9* (**10.029**) store the most recent 10 trips that have occurred where *Trip 0* (**10.020**) is the most recent and *Trip 9* (**10.029**) is the oldest. When a new trip occurs it is written to *Trip 0* (**10.020**) and all the other trips move down the log, with oldest being lost. The date and time when each trip occurs are also stored in the date and time log, i.e. *Trip 0 Date* (**10.041**) to *Trip 9 Time* (**10.060**). The date and time are taken from *Date* (**06.016**) and *Time* (**06.017**). The date / time source can be selected with *Date / Time Selector* (**06.019**). Some trips have sub-trip numbers which give more detail about the reason for the trip. If a trip has a sub-trip number its value is stored in the sub-trip log, i.e. *Trip 0 Sub-trip Number* (**10.070**) to *Trip 9 Sub-trip Number* (**10.079**). If the trip does not have a sub-trip number then zero is stored in the sub-trip log.

If any parameter between Pr **10.020** and Pr **10.029** inclusive is read by serial communication, then the trip number in Table 12-3 is the value transmitted.

NOTE

The trip logs can be reset by writing a value of 255 in Pr **10.038**.

12.10 Behavior of the drive when tripped

If the drive trips, the output of the drive is disabled so the load coasts to a stop. If any trip occurs the following read only parameters are frozen until the trip is cleared. This is to help in diagnose the cause of the trip.

Parameter	Description
04.001	Current magnitude
04.002	Active current
04.017	Reactive current
05.001	Output frequency
05.002	Output voltage
05.003	Output power
05.005	DC bus voltage
07.001	Analog input 1
07.002	Analog input 2
07.003	Analog input 3

If the parameters are not required to be frozen then this can be disabled by setting bit 4 of Pr **10.037**.

13 UL Information

13.1 UL file reference

Unidrive M Frame size 3, 4, 5, 6, 7, 8, 9, 10 and 11 are UL Listed to both Canadian and US requirements'. The UL file reference is: NMMS/7.E171230.

Products that incorporate the Safe Torque Off (STO) function are Certified for Functional Safety. The UL file reference is: FSPC.E171230.

13.2 Option modules, kits and accessories

Option Modules, Control Pods, Installation Kits and other accessories for use with these drives are UL Listed.

13.3 Enclosure ratings

With the exception of free-standing cubicle drives, all models are Open Type as supplied.

The drive enclosure is not classified as a fire enclosure. A separate fire enclosure must be provided. A UL/ NEMA Type 12 enclosure is suitable.

When fitted with a conduit box the drives meet the requirements for UL Type 1. Type 1 enclosures are intended for indoor use, primarily to provide a degree of protection against limited amounts of falling dirt.

The drives meet the requirements for UL Type 12 when installed inside a Type 12 enclosure and through-hole mounted using the sealing kit and the high-IP insert (where provided).

When through-hole mounted, the drives have been evaluated as suitable for use in surrounding air temperatures up to 40 °C.

Remote Keypads are UL Type 12 when installed with the sealing washer and fixing kit provided.

When installed in a Type 1 or Type 12 enclosure, the drives may be operated in a compartment handling conditioned air.

13.4 Mounting

Drives may be surface, through-panel or tile mounted using the appropriate brackets. Drives may be mounted singly or side by side with suitable space between them (bookcase mounting).

13.5 Environment

Drives must be installed in a Pollution Degree 2 environment or better (dry, non-conductive pollution only).

The drives have been evaluated for use at ambient temperatures up to 40 °C. The drives have additionally been evaluated for 50 °C and 55 °C ambient air temperatures with a derated output.

13.6 Electrical Installation

OVERVOLTAGE CATEGORY

OVC III

SUPPLY

The drives are suitable for use on a circuit capable of delivering not more than 100,000 RMS symmetrical amperes, 600 Vac Maximum.

TERMINAL TORQUE

Terminals must be tightened to the rated torque as specified in the Installation Instructions.

WIRING TERMINALS

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

Where possible, UL Listed closed-loop connectors sized according to the field wiring shall be used for all field power wiring connections.

GROUND CONNECTION INSTRUCTIONS

UL Listed closed-loop connectors sized according to the field wiring shall be used for grounding connections.

BRANCH CIRCUIT PROTECTION

The fuses and circuit breakers required for branch circuit protection are specified in the Installation Instructions.

OPENING OF BRANCH CIRCUIT

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

Integral solid state short circuit protection does not provide branch circuit protection. Branch circuit protection must be provided in accordance with the National Electrical Code (NEC), The Canadian Electrical Code, and any additional local codes.

DYNAMIC BRAKING

M100, M101, M200, M201, M300 or M400, frame sizes 1 to 4 have been evaluated for dynamic braking applications. Other drive models have not been evaluated for dynamic braking.

REGENERATIVE OPERATION

Drives can be configured as an AC Regenerative Unit (also known as a Regen drive). Regen operation allows bi-directional power flow to and from the AC supply. The AC supply voltage must not exceed 600 Vac.

In these systems the inverter output is connected to the AC supply via a reactor and switching frequency filter. The drives are required to be protected by listed branch fuses as specified in the installation instructions. For grid feed applications, further evaluation may be required to other standards, such as, but not limited to UL1741, CSA C22.2 No. 107.1-01, IEEE 1547 etc.

13.7 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 relevant *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 maximum programmable time constant depends on the drive model. The method of adjustment of the overload protection is provided.

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.

13.8 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.

13.9 Modular Drive Systems

Drives with DC+ and DC- supply connections, rated 230 V or 480 V have been investigated for use in Modular Drive Systems as inverters when supplied by the converter sections from the Unidrive-M range. In these applications the inverters are required to be additionally protected by supplemental fuses.

Alternatively, the inverters may be supplied by converter models: Mentor MP25A, 45A, 75A, 105A, 155A or 210A.

Contact the supplier of the drive for more information.

13.10 Requirement for Transient Surge Suppression

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

TRANSIENT SURGE SUPPRESSION SHALL BE INSTALLED ON THE LINE SIDE OF THIS EQUIPMENT AND SHALL BE RATED 575 Vac (PHASE TO GROUND), 575 Vac (PHASE TO PHASE), SUITABLE FOR OVERVOLTAGE CATEGORY III, AND SHALL PROVIDE PROTECTION FOR A RATED IMPULSE VOLTAGE TO WITHSTAND VOLTAGE PEAK OF 6 kV AND A CLAMPING VOLTAGE OF MAXIMUM 2400 V.

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