



**CONTROL
TECHNIQUES**

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Installation Guide

Unidrive Regen

Model sizes 1 to 6

Part Number: 0471-0029-01

Issue: 1

General Information

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

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

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Drive software version

This product is supplied with the latest version of software. If this product is to be used in a new or existing system with other drives, there may be some differences between their software and the software in this product. These differences may cause this product to function differently. This may also apply to drives returned from a Control Techniques Service Centre.

The software version of the drive can be checked by looking at Pr **11.29** (or Pr **0.50**) and Pr **11.34**. The software version takes the form of zz.yy.xx, where Pr **11.29** displays zz.yy and Pr **11.34** displays xx, i.e. for software version 01.01.00, Pr **11.29** would display 1.01 and Pr **11.34** would display 0.

If there is any doubt, contact a Control Techniques Drive Centre.

Environmental statement

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

The electronic variable-speed drives manufactured by Control Techniques have the potential to save energy and (through increased machine/process efficiency) reduce raw material consumption and scrap throughout their long working lifetime. In typical applications, these positive environmental effects far outweigh the negative impacts of product manufacture and end-of-life disposal.

Nevertheless, when the products eventually reach the end of their useful life, they can very easily be dismantled into their major component parts for efficient recycling. Many parts snap together and can be separated without the use of tools, while other parts are secured with conventional screws. Virtually all parts of the product are suitable for recycling.

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

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

How to use this guide

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

NOTE

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

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

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7 Getting started	●		●	●
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1 Safety Information

1.1 Warnings, Cautions and Notes



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

WARNING



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

CAUTION

NOTE

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

1.2 Electrical safety - general warning

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

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

1.3 System design and safety of personnel

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

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

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

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

None of the drive functions must be used to ensure safety of personnel, i.e. they must not be used for safety-related functions.

Careful consideration must be given to the functions of the drive which might result in a hazard, either through their intended 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.

1.4 Environmental limits

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

1.5 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 earth (ground) connections.

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

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

98/37/EC: Safety of machinery.

89/336/EEC: Electromagnetic Compatibility.

1.6 Special note on SECURE DISABLE/ENABLE function in regen operation

In regen operation the enable input of the Regen drive stage has no safety functions. It only enables the active rectifier operation. It does not disable any operation of the motoring drive(s) and it does not prevent the regen stage from producing DC power.

The enable input of the motoring drive stage can be used for safety functions if required. Consult the *Unidrive SP User Guide* for information on SECURE DISABLE.

1.7 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.

2 Introduction

The following installation guide should be read in conjunction with the *Unidrive SP User Guide*.

Any Unidrive SP drive can be configured as an AC Regenerative Unit (hereafter referred to as a Regen drive).

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 optimisation of the completed system

At least two Unidrive SP drives are required to form a complete regenerative system - one connected to the supply and the second one connected to the motor. A Unidrive SP 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 for a regen configuration could be another drive other than a Unidrive SP, e.g. Unidrive classic or Commander SK etc.

NOTE

The following regen components are also required in addition to the Unidrive SP 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 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 SP operating in regen mode

The main advantages for an AC Regen system are:

- Energy saving
- The input current waveform is sinusoidal
- The input current has a near unity power factor
- Power factor variation through user Pr 4.08
- The output voltage for the motor can be higher than the available AC mains voltage
- The Regen drive will synchronise to any frequency between 30 and 100Hz, provided the supply voltage is between 380Vac -10% and 480Vac +10% (operating frequency range of 48Hz to 65Hz)
- Under conditions of AC mains instability, a Unidrive SP Regen system can continue to operate down to approximately 150Vac supply voltage without any effect on the DC bus voltage and hence on the operation of the motoring drives (increased current will be taken from the AC supply to compensate up to the current limit of the Regen drive)
- Transient operation possible between 40 and 72Hz down to 150Vac for approximately 1 second.

- The Regen and motoring drives are identical
- Power feed-forward term, using analogue I/O set-up
- A fast transient response is possible using the power feed forward term.

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 SP), 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 SP 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.

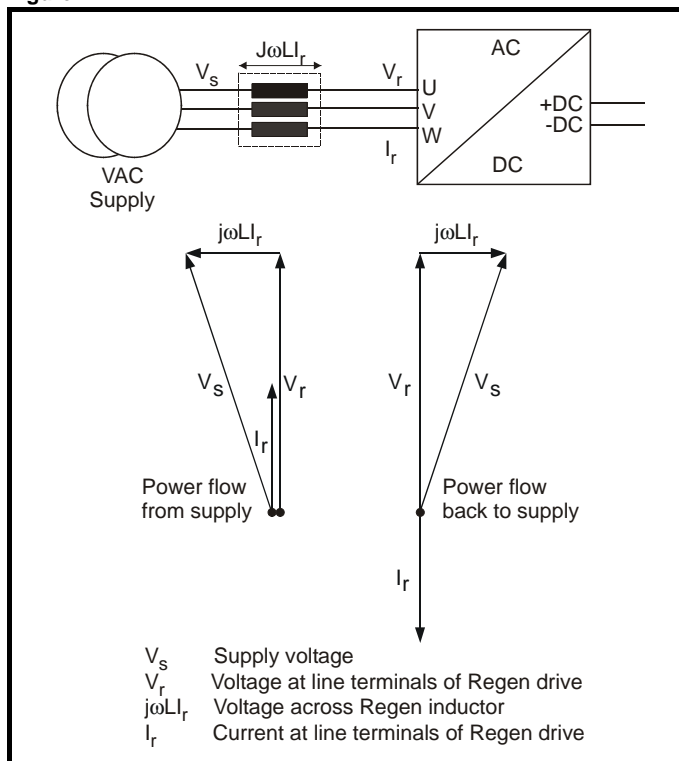
Regen inductors must be used to ensure a minimum source impedance, these being selected and specified later in the guide.

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.

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 results in a near unity power factor of 0.996.

Figure 2-1



Safety Information	Introduction	Product information	System design	Mechanical installation	Electrical installation	Getting started	Optimisation	Parameters	Technical data	Component sizing	Diagnostics
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The direction of the power flow can be changed relative to the supply voltage, by making small changes to the Regen drive output voltage and phase.

2.5 Synchronisation

The synchronisation 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 synchronisation 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 synchronisation on enable

- The first stage of the pre-start tests is to measure the initial DC Bus voltage, which 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 T_d 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.

2.6 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.

There are three possible configurations for Unidrive SP Regen:

- Single Regen, single motoring (Figure 4-1 on page 20)
- Single Regen multiple motoring (Figure 4-3 on page 24)
- Regen as a brake resistor replacement (Figure 4-4 on page 26)

Refer to Table 3-1 on page 11, for the specifications of the Regen drive.

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 the drive 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 synchronisation with the mains and trip. If the Regen drive is unable to regenerate the full power from the motoring drive into the DC bus, then the Regen/motoring drive will trip on over-voltage.

2.7 Regen drive system types

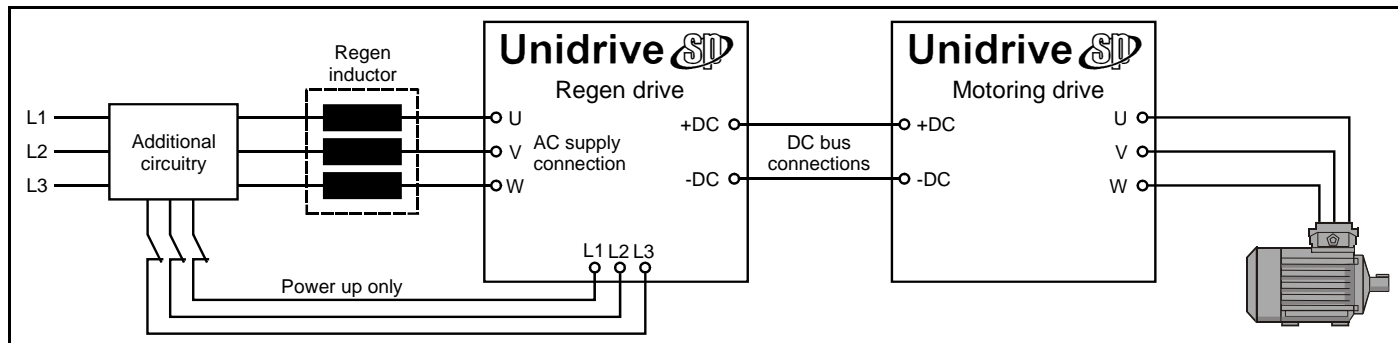
2.7.1 Single Regen, single motoring system

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 charging supply 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 supply 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.

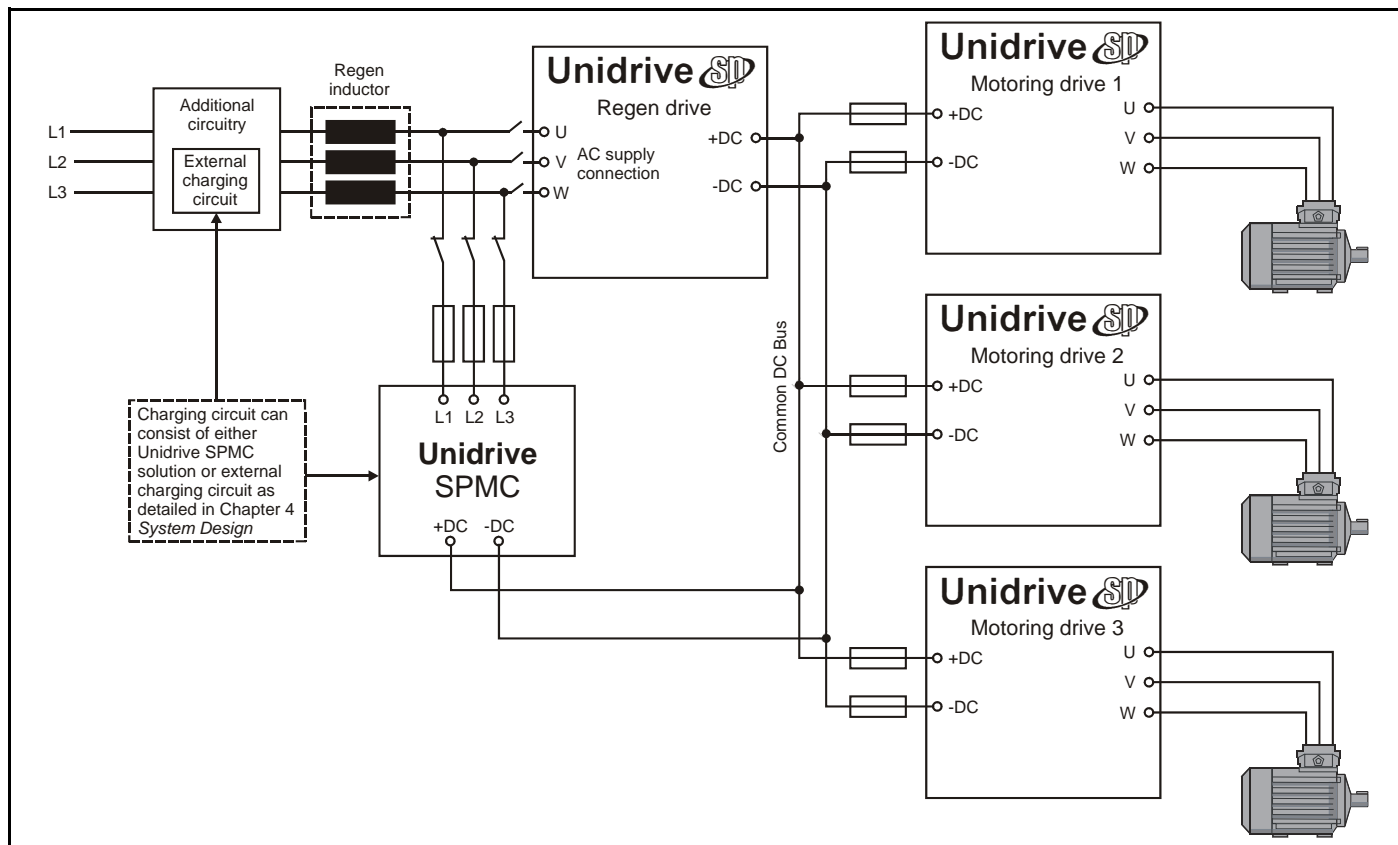
2.7.2 Single Regen, multiple motoring system

Figure 2-3 shows 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 the motoring drives.

NOTE

For a single Regen and multiple motoring drive arrangement an alternative charging circuit can be used due to the increased inrush current generated by the additional capacitance of the multiple motoring drives. The alternative charging circuit can be either a Unidrive SPMC or an external charging resistor as detailed in Chapter 4 *System design*.

Figure 2-3 Single Regen, multiple motoring system



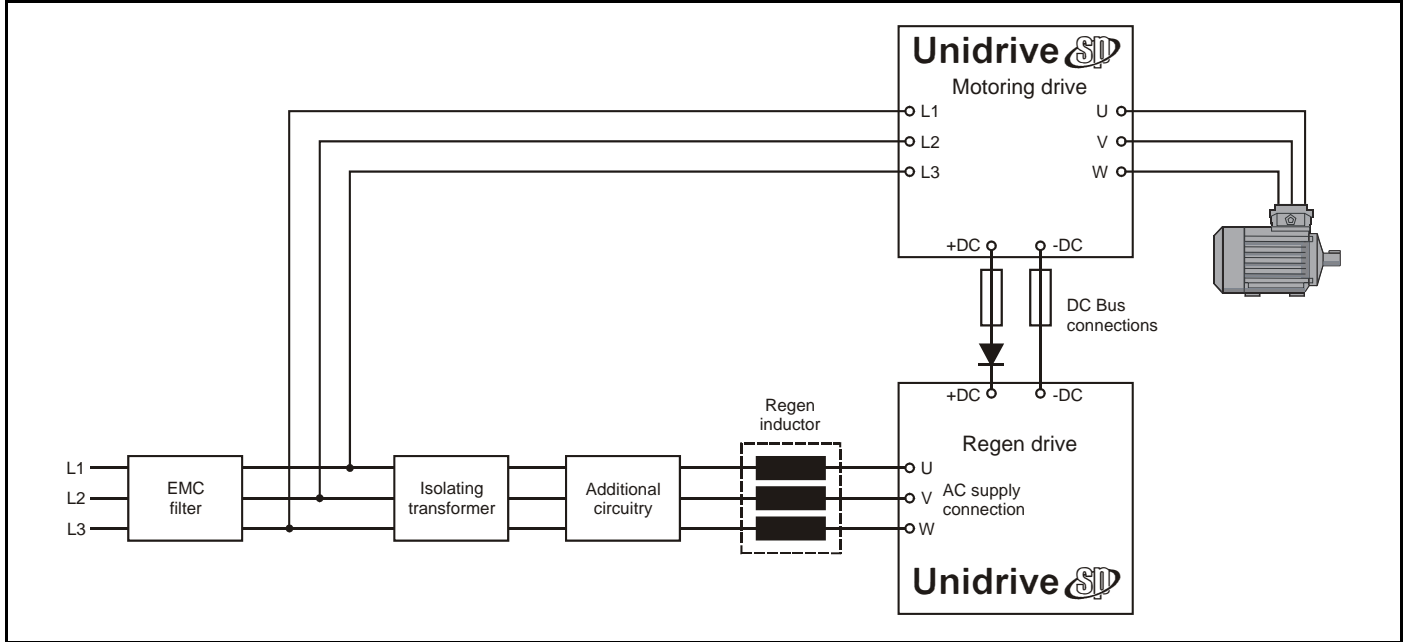
2.7.3 Regen brake resistor replacement drive system

Figure 2-4 shows the layout for a brake resistor replacement system. Here the kW rating of the Regen drive is smaller than that of the motoring drive. The Regen drive in this system is used to regenerate the braking energy back onto the mains supply and does not supply power to the motoring drive.

NOTE

Both the motoring drive and Regen drive in this configuration are powered up via the AC supply connections (L1, L2, L3) to the motoring drive.

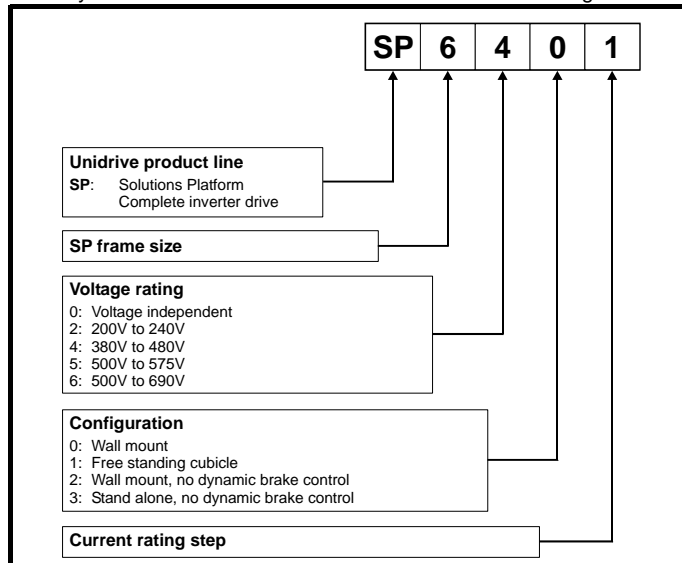
Figure 2-4 Unidrive SP Regen as brake resistor replacement



3 Product Information







3.1 Model number

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



3.2 Ratings

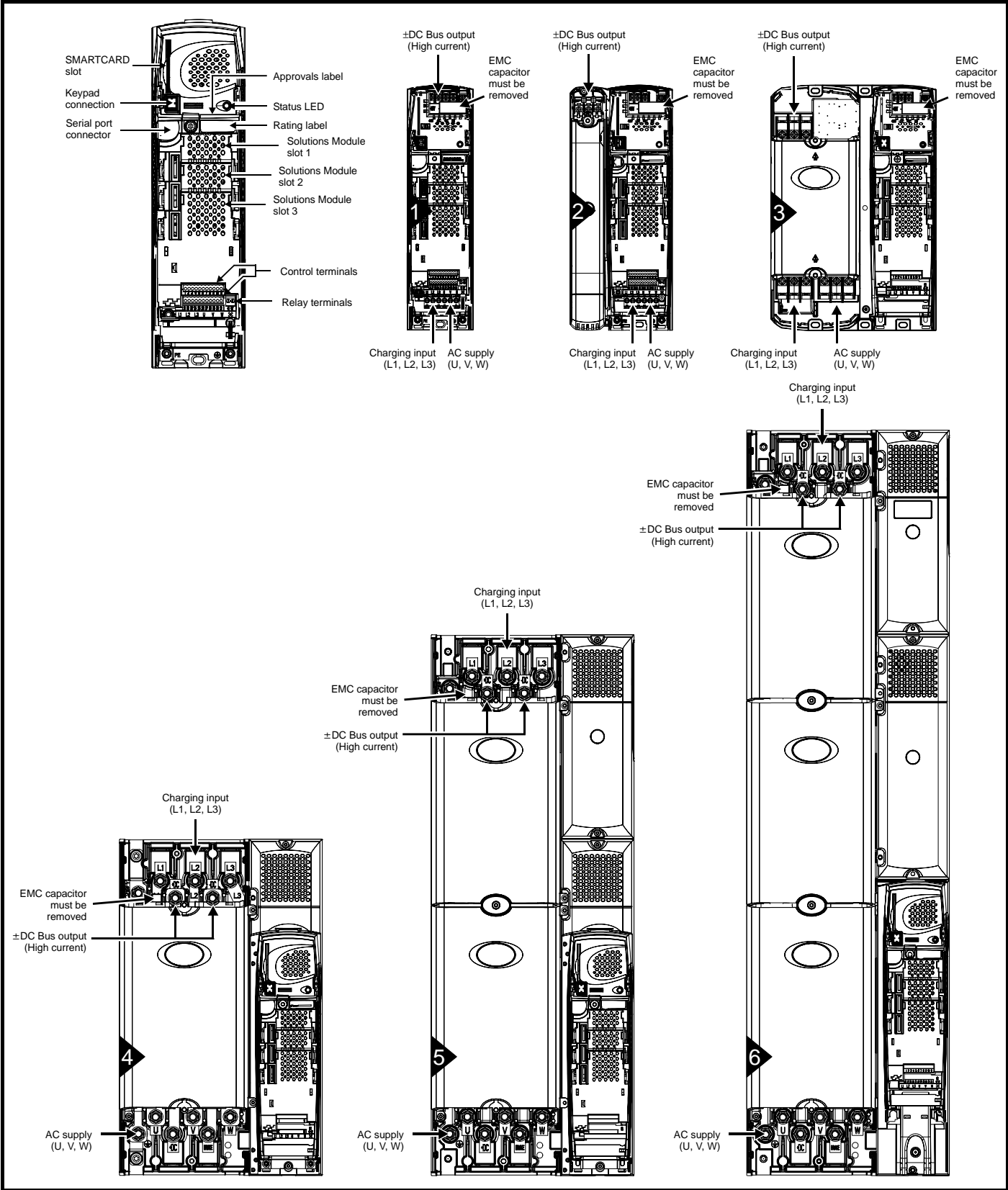
Table 3-1 400V drive ratings (380V to 480V $\pm 10\%$)

Model		Normal Duty			Heavy Duty		
		Maximum continuous input current	Typical motor power at 400V	Typical motor power at 460V	Maximum continuous input current	Typical motor power at 400V	Typical motor power at 460V
		A	kW	hp	A	kW	hp
 1	1405	8.8	4.0	5.0	7.6	3.0	5.0
	1406	11	5.5	7.5	9.5	4.0	5.0
 2	2401	15.3	7.5	10	13	5.5	10
	2402	21	11	15	16.5	7.5	10
	2403	29	15	20	25	11	20
	2404				29	15	20
 3	3401	35	18.5	25	32	15	25
	3402	43	22	30	40	18.5	30
	3403	56	30	40	46	22	30
 4	4401	68	37	50	60	30	50
	4402	83	45	60	74	37	60
	4403	104	55	75	96	45	75
 5	5401	138	75	100	124	55	100
	5402	168	90	125	156	75	125
 6	6401	202	110	150	180	90	150
	6402	236	132	200	210	110	150

The above current ratings are given for max 40°C (104°F), and 3.0 kHz switching. Derating is required for higher switching frequencies, ambient temperature >40°C (104°F) and high altitude. For further information, refer to *Unidrive SP User Guide*.

3.3 Drive features

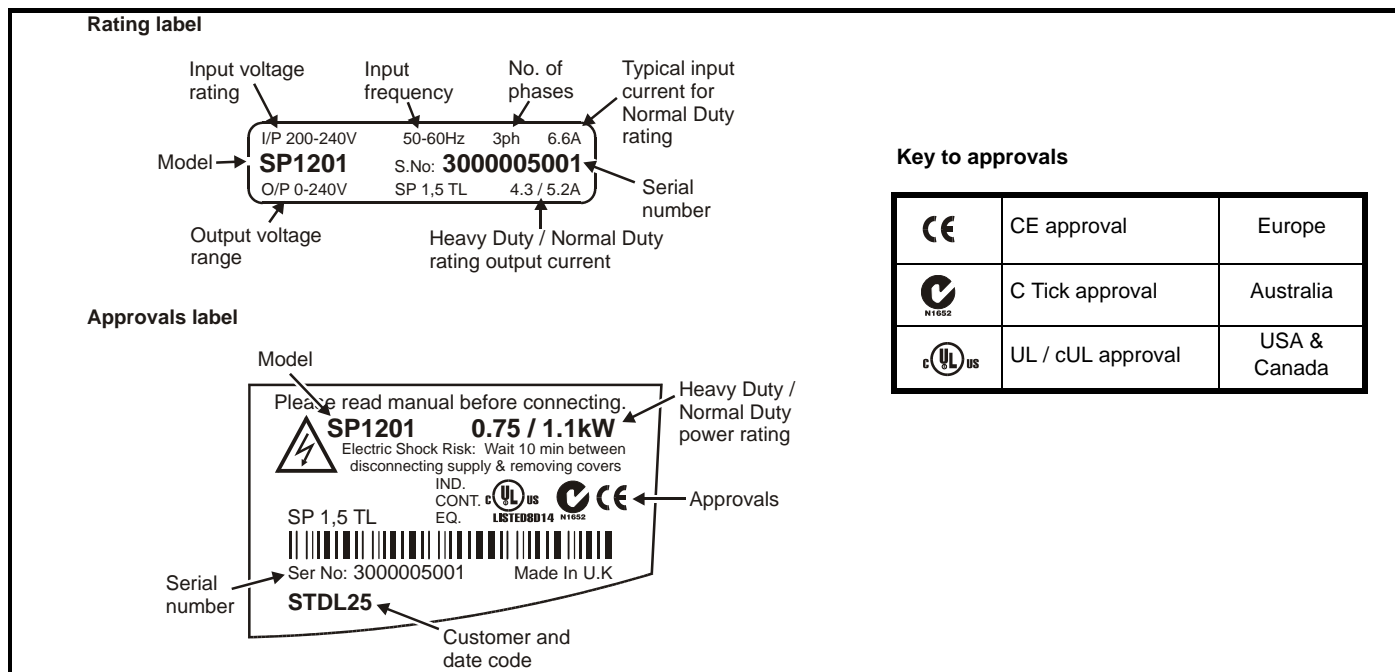
Figure 3-1 Features of the drive



3.4 Nameplate description

See Figure 3-1 on page 12 for location of rating labels.

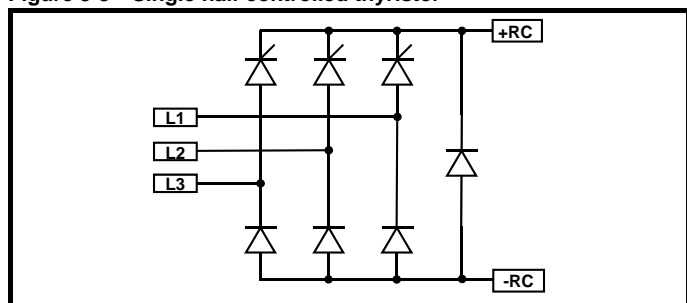
Figure 3-2 Typical drive rating labels



3.5 Unidrive SPMC 1402, Single half controlled thyristor rectifier

The Unidrive SPMC is a controlled thyristor rectifier.

Figure 3-3 Single half controlled thyristor



The half controlled thyristor bridge can be used as an external charging module for a regen system consisting of multiple motoring drives. Softstart is built in. An external 24V, 3A power supply is required in addition to the AC supply to allow the rectifier to operate. Control wiring is required between the rectifier and motoring drive(s) so that if the rectifier indicates a fault the motoring drive(s) will be disabled.

The 24V supply must be protected using a 4A slow-blow fuse, one for each supply pole.

Control connections to the Unidrive SPMC should be made with 0.5mm² cable.

The status relay contacts are rated for switching non-inductive loads at 250Vac 6A non-inductive, up to 4Adc if the voltage is limited to 40V or up to 400mA dc if the voltage is limited to 250Vdc. Protection from overcurrent must be provided.

Figure 3-4 SPMC rating label

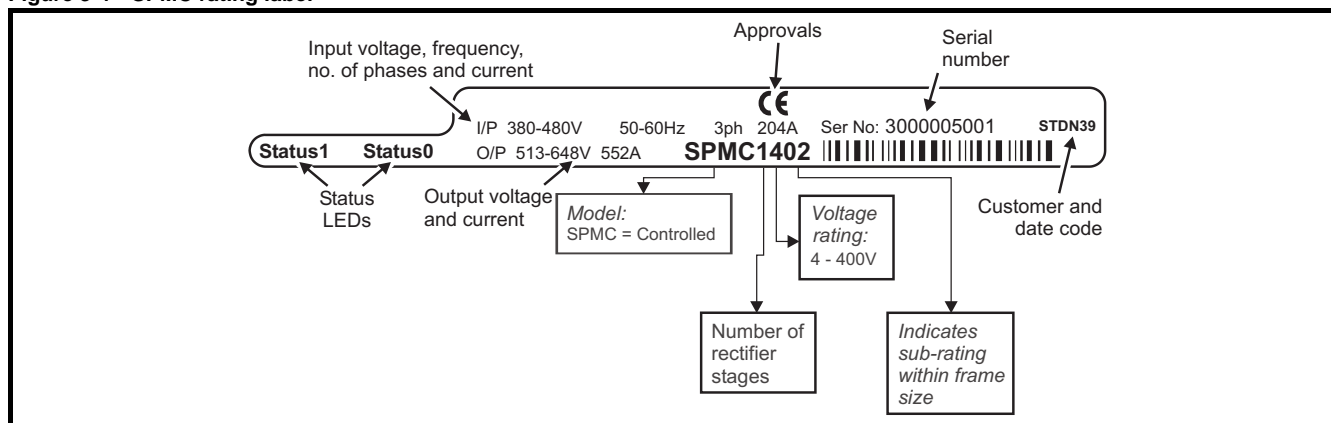


Table 3-2 Unidrive SPMC 400V input current, fuse and cable size ratings

Model	Typical input current	Continuous DC output current	Fuses: HRC <u>AND</u> Semi-conductor		Cable size (per input)			
			HRC IEC class gG UL class J	Semi-conductor IEC class aR	AC input		DC output cable	
	A	A	A	A	mm ²	AWG	mm ²	AWG
SPMC1402	339	379	400	400	2 x 120	2 x 4/0	2 x 120	2 x 4/0

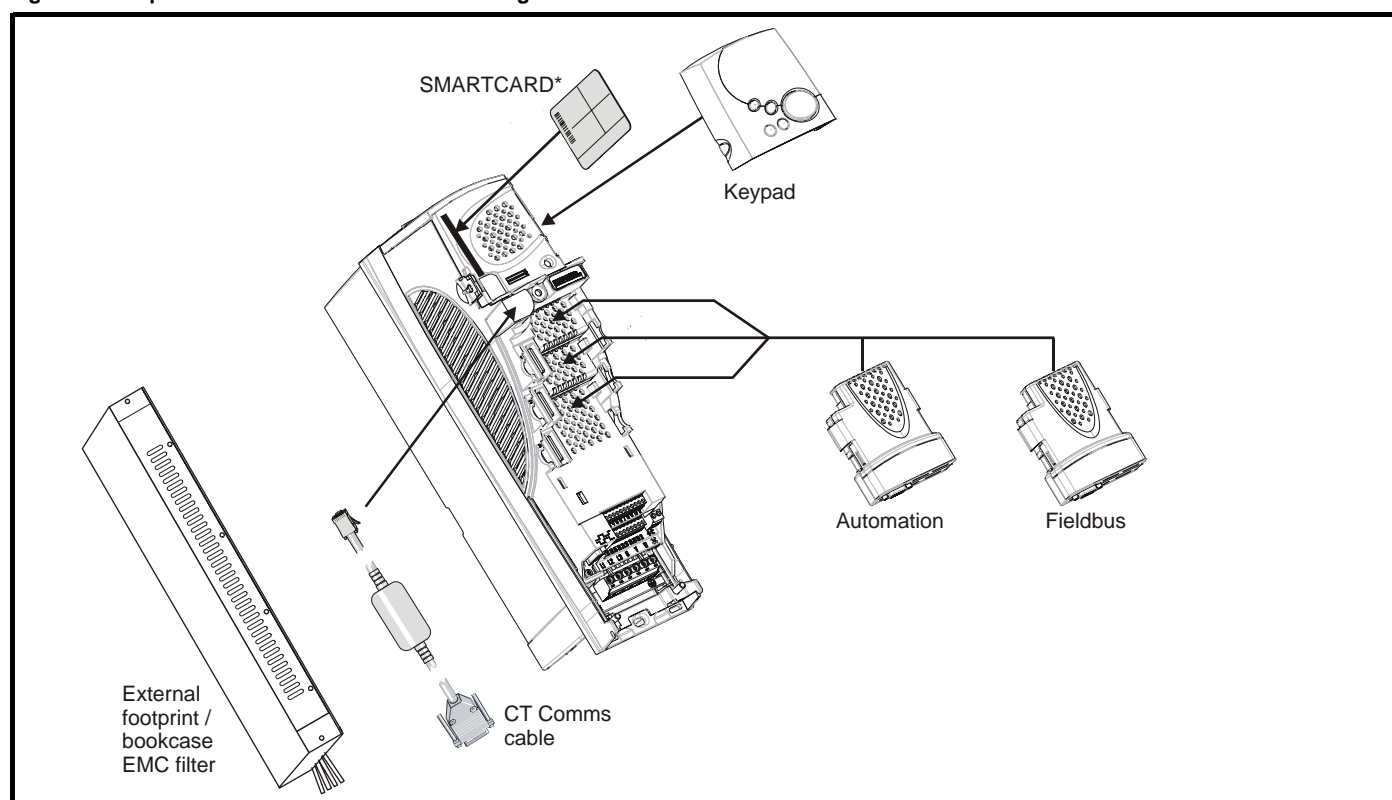
Also refer to the Unidrive SPM User Guide for further detailed information on the Unidrive SPMC mechanical and electrical installation along with control connections.



- 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.
- Input fuses as specified must be provided.

3.6 Options













Figure 3-5 Options available with Unidrive SP Regen



* A SMARTCARD is provided with the Unidrive SP as standard. Only one SMARTCARD can be fitted at any one time.

All Unidrive SP Solutions Modules are colour-coded in order to make identification easy. The following table shows the colour-code key and gives further details on their function.

Table 3-3 Solutions Module identification

Type	Solutions Module	Colour	Name	Further Details
Automation		Yellow	SM-I/O Plus	Extended I/O interface Increases the I/O capability by adding the following to the existing I/O in the drive: <ul style="list-style-type: none"> digital inputs x 3 digital I/O x 3 analogue inputs (voltage) x 2 analogue output (voltage) x 1 relay x 2
		Dark Green	SM-Applications	Applications Processor (with CTNet) 2 nd processor for running pre-defined and /or customer created application software with CTNet support
		White	SM-Applications Lite	Applications Processor 2 nd processor for running pre-defined and /or customer created application software
Fieldbus		Purple	SM-PROFIBUS-DP	Profibus option PROFIBUS DP adapter for communications with the Unidrive SP.
		Medium Grey	SM-DeviceNet	DeviceNet option Devicenet adapter for communications with the Unidrive SP
		Dark Grey	SM-INTERBUS	Interbus option Interbus adapter for communications with the Unidrive SP
		Pink	SM-CAN	CAN option CAN adapter for communications with the Unidrive SP
		Light Grey	SM-CANopen	CANopen option CANopen adapter for communications with the Unidrive SP
		Red	SM-SERCOS	SERCOS option Class B compliant. Torque velocity and position control modes supported with data rates (bit/sec): 2MB, 4MB, 8MB and 16MB. Minimum 250µsec network cycle time. Two digital high speed probe inputs 1µsec for position capture
		Beige	SM-Ethernet	Ethernet option 10 base-T / 100 base-T; Supports web pages, SMTP mail and multiple protocols: DHCP IP addressing; Standard RJ45 connection
Keypad		N/A	SM-Keypad	LED keypad option Keypad with a LED display
		N/A	SM-Keypad Plus	LCD keypad option Keypad with an alpha-numeric LCD display with Help function

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 Solutions Module slots for the motoring drive.


- Unidrive SP User Guide (English, French, German, Italian, Spanish)
- Unidrive SP Advanced User Guide
- Unidrive SP Regen Installation Guide
- Solutions Module User Guides
- Unidrive SPM User Guide

3.7 Items supplied with the drive

The drive is supplied with a copy of the *Unidrive SP Short Form Guide*, a SMARTCARD, the safety booklet, the certificate of quality, an accessory kit box (see the *Unidrive SP User Guide* for details) and a CD ROM containing the following user guides:

3.8 Regen components

3.8.1 Regen inductor



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.

CAUTION

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

Table 3-4 Regen inductor data

Drive		Part number	mH	Arms
Heavy Duty	Normal Duty			
SP1405 SP1406	SP1405	4401-0001	6.3	9.5
	SP1406	4401-0002	5	12
SP2401 SP2402	SP2401	4401-0003	3.75	16
SP2403	SP2402	4401-0004	2.4	25
SP2404 SP3401	SP2403 SP2404	4401-0005	1.76	34
SP3402	SP3401	4401-0006	1.5	40
SP3403	SP3402	4401-0007	1.3	46
SP4401	SP3403	4401-0008	1	60
	SP4401	4401-0009	0.78	70
SP4402 SP4403	SP4402	4401-0010	0.63	96
SP5401	SP4403	4401-0011	0.48	124
SP5402	SP5401	4401-0012	0.38	156
SP6401	SP5402	4401-0013	0.33	180
SP6402	SP6401	4401-0014	0.3	202
	SP6402	4401-0015	0.24	300

3.8.2 Switching frequency filter

These components are used to form the filter, preventing 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.

Table 3-5 SFF inductor data

Drive		Part number	mH	Arms
Heavy Duty	Normal Duty			
SP1405 SP1406	SP1405	4401-0162	3.16	9.5
	SP1406	4401-0163	2.5	12
SP2401	SP2401	4401-0164	1.875	16
SP2402 SP2403	SP2402	4401-0165	1.2	25
SP2404 SP3401	SP2403 SP2404	4401-0166	0.88	34
SP3402	SP3401	4401-0167	0.75	40
SP3403	SP3402	4401-0168	0.65	46
SP4401	SP3403	4401-0169	0.5	60
	SP4401	4401-0170	0.39	70
SP4402 SP4403	SP4402	4401-0171	0.315	96
SP5401	SP4403	4401-0172	0.24	124
SP5402	SP5401	4401-0173	0.16	156
SP6401	SP5402	4401-0174	0.165	180
SP6402	SP6401	4401-0175	0.135	202
	SP6402	4401-0176	0.1	300

The inductors are standard three phase inductors (rated at Unidrive SP Regen drive rated current). They carry only 50/60Hz current with a negligible amount of high frequency current.

Table 3-6 SFF capacitor data

Drive		Part number	μF	Arms
Heavy Duty	Normal Duty			
SP1405 SP1406 SP2401 SP2402 SP2403	SP1405 SP1406 SP2401 SP2402	1610-7609	5.7	2.1
SP2404 SP3401 SP3402 SP3403 SP4401	SP2403 SP2404 SP3401 SP3402 SP3403 SP4401	1665-2244	24	15
SP4402 SP4403 SP5401 SP5402 SP6401	SP4402 SP4403 SP5401 SP5402 SP6401	1665-2484	48	25
SP6402	SP6402	1665-8774	77	35

3.8.3 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.

Table 3-7 Varistor data

Drive	Varistor part no.	Vac	Type
All sizes	2482-1501	550	Z500LNS
	2482-0680	680	Z680LNS

3.8.4 EMC filters

In order to provide customers with a degree of flexibility, external EMC filters have been sourced from two manufacturers, Schaffner and Epcos, as detailed in Chapter 3 *Mechanical Installation* in the *Unidrive SP User Guide*.



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

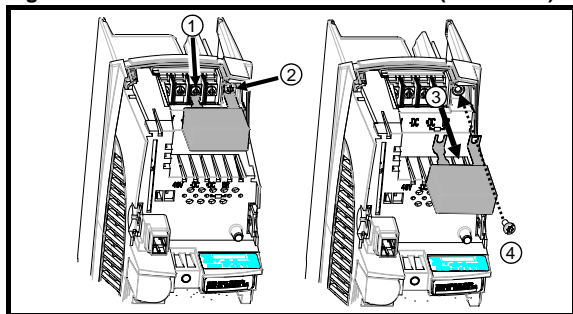
CAUTION



The internal EMC filter must be removed from the drive.

CAUTION

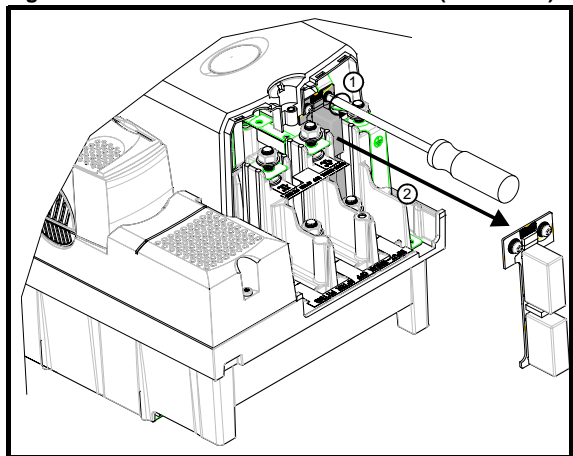
Figure 3-6 Removal of internal EMC filter (size 1 to 3)



Loosen / remove screws as shown (1) and (2).

Remove filter (3), and ensure the screws are replaced and re-tightened (4).

Figure 3-7 Removal of internal EMC filter (size 4 to 6)



Loosen screws (1). Remove EMC filter in the direction shown (2).

3.8.5 External charging resistor

The following external charging resistors are available from Control Techniques and can be used with a regen system consisting of multiple motoring drives. For correct sizing of the charging resistor required, refer to section 11.2 *Resistor sizing for multiple motoring systems* on page 152. Also, see section 10.4.2 *Softstart resistor - type TG series* on page 149 for further technical data and thermal protection information on the following resistors.

Table 3-8 External charging resistor (single Regen, multiple motoring drives)

Drive	External charging resistor part no.	Ω
All sizes	1270-3157	150
	1270-2483	48

Safety Information	Introduction	Product information	System design	Mechanical installation	Electrical installation	Getting started	Optimisation	Parameters	Technical data	Component sizing	Diagnostics
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4 System design

4.1 Introduction

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

1. Line 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 supply conditions the Regen drive is able to supply or absorb all the required power including 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 synchronisation with the AC 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 23A (**Normal Duty**), SP2403 operating in regen mode from a 400V supply, and a SP2403 driving a 400V rated, 0.85 pf motor:

The rated power of the Regen drive is:

$$\begin{aligned} & \sqrt{3} \times \text{Rated current} \times \text{Supply voltage} \\ &= 1.73 \times 23 \times 400 \\ &= 15.9\text{kW} \end{aligned}$$

The motoring drive can supply power:

$$\begin{aligned} & \sqrt{3} \times \text{Rated current} \times \text{Motor voltage} \times \text{Power factor} \\ &= 1.73 \times 23 \times 400 \times 0.85 \\ &= 13.5\text{kW} \end{aligned}$$

Drive losses

$$2 \times \text{Unidrive SP 2403} = 626\text{W}$$

When the motoring drive is supplying rated current to the motor, the Regen drive needs to provide 13.5kW, plus drive losses = 14.126kW. The Regen drive can supply 15.9kW 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 96A (**Heavy Duty**), SP4403 operating in regen mode, and a SP4403 driving a 75kW, 400V, 0.95pf motor:

If the motoring drive is supplying 175% maximum current, and the Regen drive has its 380V supply at the lower limits of -10% (342Vac), then, at the regen current limit of 150%:

The Regen drive max available power is:

$$\begin{aligned} & \sqrt{3} \times 150\% \times \text{Rated current} \times \text{Supply voltage} \\ &= 1.73 \times 1.5 \times 96 \times 342 \\ &= 85.1\text{kW} \end{aligned}$$

The motoring drive max. power is:

$$\begin{aligned} & \sqrt{3} \times 175\% \times \text{Rated current} \times \text{Motor voltage} \times \text{Power factor} \\ &= 1.73 \times 1.75 \times 96 \times 400 \times 0.95 \\ &= 110.4\text{kW} \end{aligned}$$

Drive losses

$$2 \times \text{Unidrive SP 4403} = 1.952\text{kW}$$

The Regen drive is also required to supply the Regen and motoring drive losses in this example 1.952kW brings total power requirement to

112.352kW. However, this Regen drive is only capable of supplying approximately 85.1kW and therefore a drive of a larger current 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.

4.1.3 Regen drive as brake resistor replacement

The important factor when considering the use of a Regen drive as a brake-resistor replacement is the ratio of motoring power to braking power, as this has implications for the power rating of the Regen drive.

If motoring power < 1.5 x Braking power

The maximum motoring and braking power are approximately equal, a Regen drive should be used as the main supply and not solely as a brake resistor replacement. In this instance, the Regen drive and motoring drive ratings are equal, so the full standard regen configuration can be exploited.

If 1.5 x Braking power < Motoring power < 4 x Braking power

In this range of motoring and braking power, a Regen drive will work well as a brake-resistor replacement. The Regen drive power rating is equal to the braking power.

If motoring power > 4 x Braking power

If the motoring power is greater than approximately four times the braking power, it is not possible to use a Regen drive rated only for its braking power. This is because the small Regen drive is unsuitable for connection to the large capacitance of the motoring drives. If the motoring power is greater than four times the braking power, then the following should be used.

- An over-rated Regen drive with a current rating at least equal to: 0.25 x motoring drive power
- Conventional brake resistor

Example

Two 30kW motoring drives are each driving 30kW motors. The load is such that only one drive is braking at a time. If each motor supplies between 20 and 30kW motoring, and the braking power varies from 0 to 30kW, the maximum total braking power is:

$$30 - 20 = 10\text{kW}, \text{ which is what the Regen drive should be rated for.}$$

Example

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.

The motoring drive is an SP4403 75kW the motoring power is 75kW and steady state braking power is 20kW. From these figures, it may appear that a 22kW Regen drive will provide sufficient braking power. However, dynamically the peak braking power could be much greater.

If the SP4403 75kW drives current limits are set at 150% for both motoring and braking, the peak brake power could be:

$$\sqrt{3} \times 156\text{A} \times 400\text{V} \times 150\% = 162\text{kW}$$

This is much greater than the 22kW 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.

4.2 Power connections

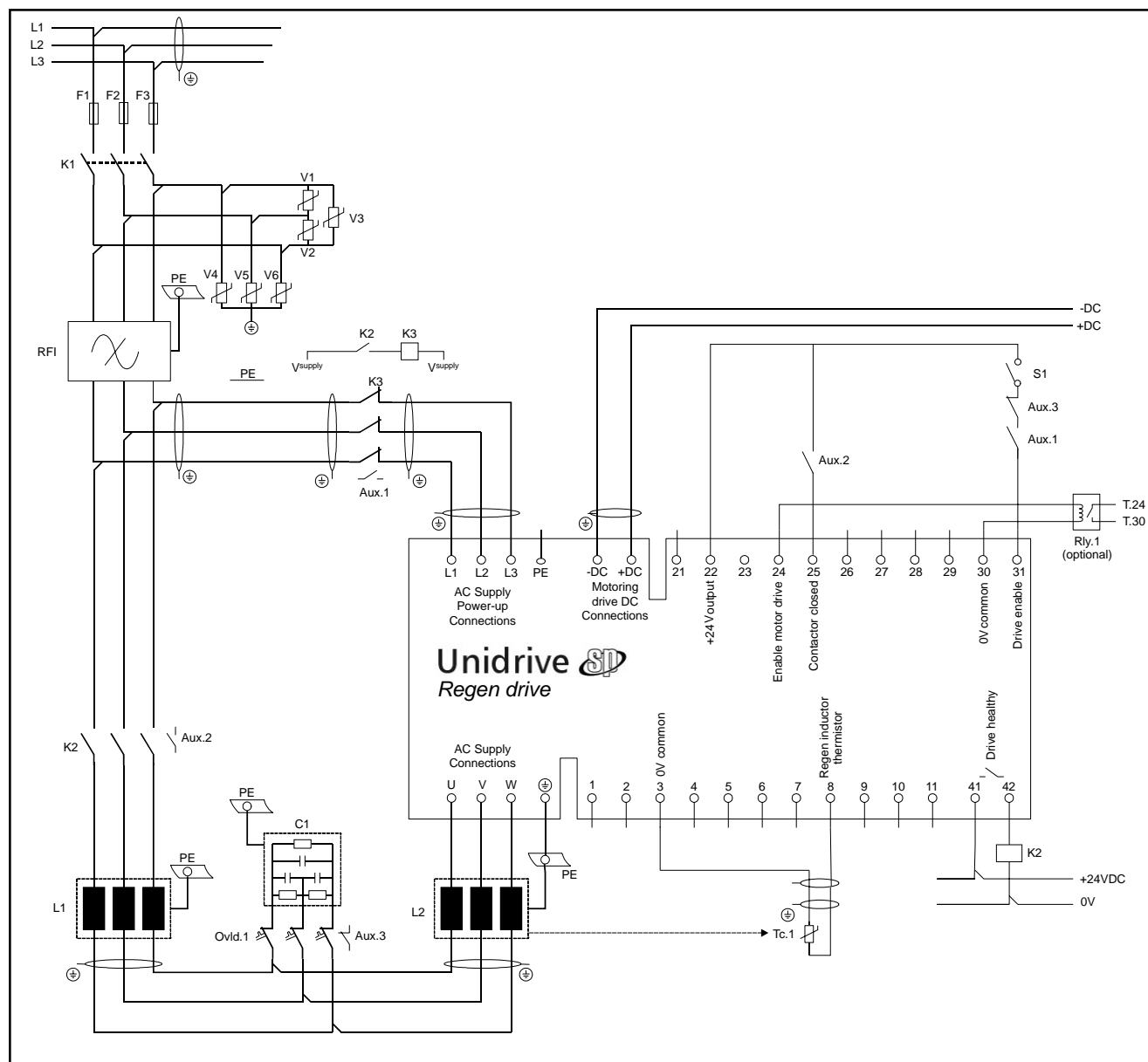
The following section covers the power connections required for Unidrive SP regen systems.

- 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 system may require an external charging circuit due to the extra capacitance from the additional motoring drives and therefore no AC connections are made to the Regen drive's L1, L2 and L3 terminals. The external charging circuit can consist of either the SPMC solution or an external charging resistor as shown in the following.
- 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 6.5 *Control connections* on page 54.

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.

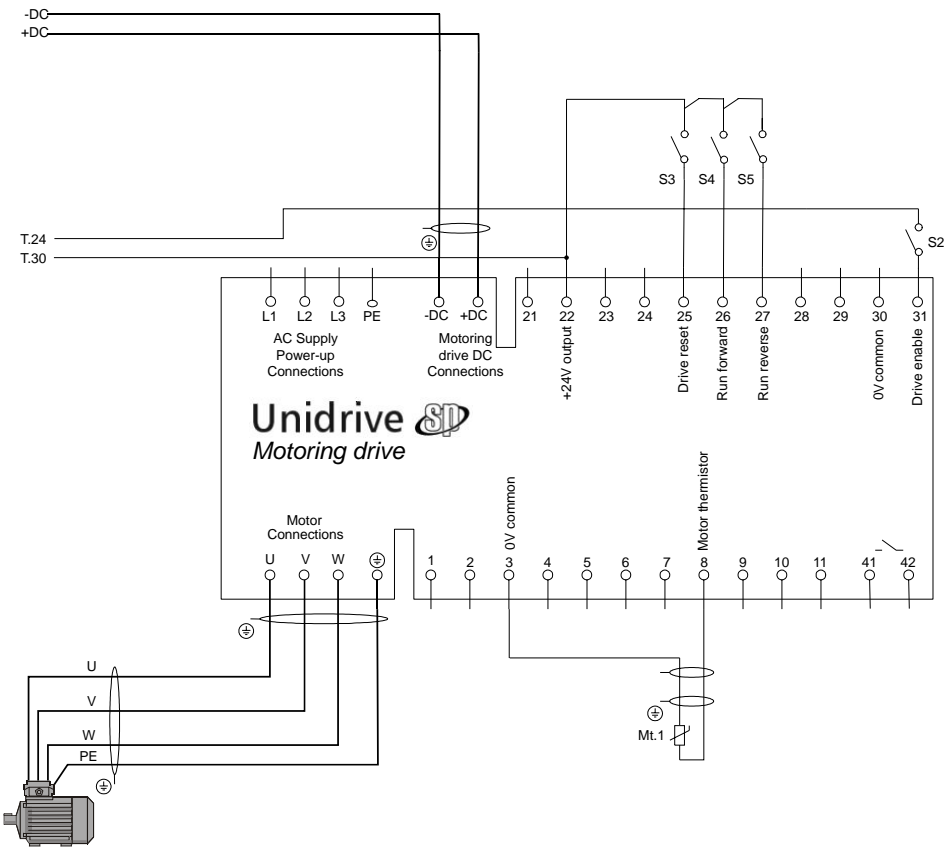


Key	Description
L1, L2, L3	Three phase supply
F1, F2, F3	Main regen system supply fuses
V1, V2, V3	Varistor network line-to-line 550Vac
V4, V5, V6	Varistor network line-to-ground 680Vac
RFI	EMC Filter
C1	Switching frequency filter capacitor
L1	Switching frequency filter inductor
L2	Regen inductor
K1	Main supply contactor
K2	Regen drive main contactor
K3	Charging contactor
Ovld.1	Switching frequency filter capacitor overload
Aux.1	Charging contactor auxiliary
Aux.2	Main contactor auxiliary
Aux.3	Switching frequency filter capacitor auxiliary
Rly.1	Optional isolation for enable between Regen and motoring drive
Mt.1	Motor thermistor

Key	Description
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

NOTE

The regen inductor duty is very arduous and therefore selection is critical as a result only Regen inductors specified in this guide should be used.



4.2.2 Single Regen, multiple motoring system using a Unidrive SPMC

Figure 4-2 Power connections: Single Regen, multiple motoring system

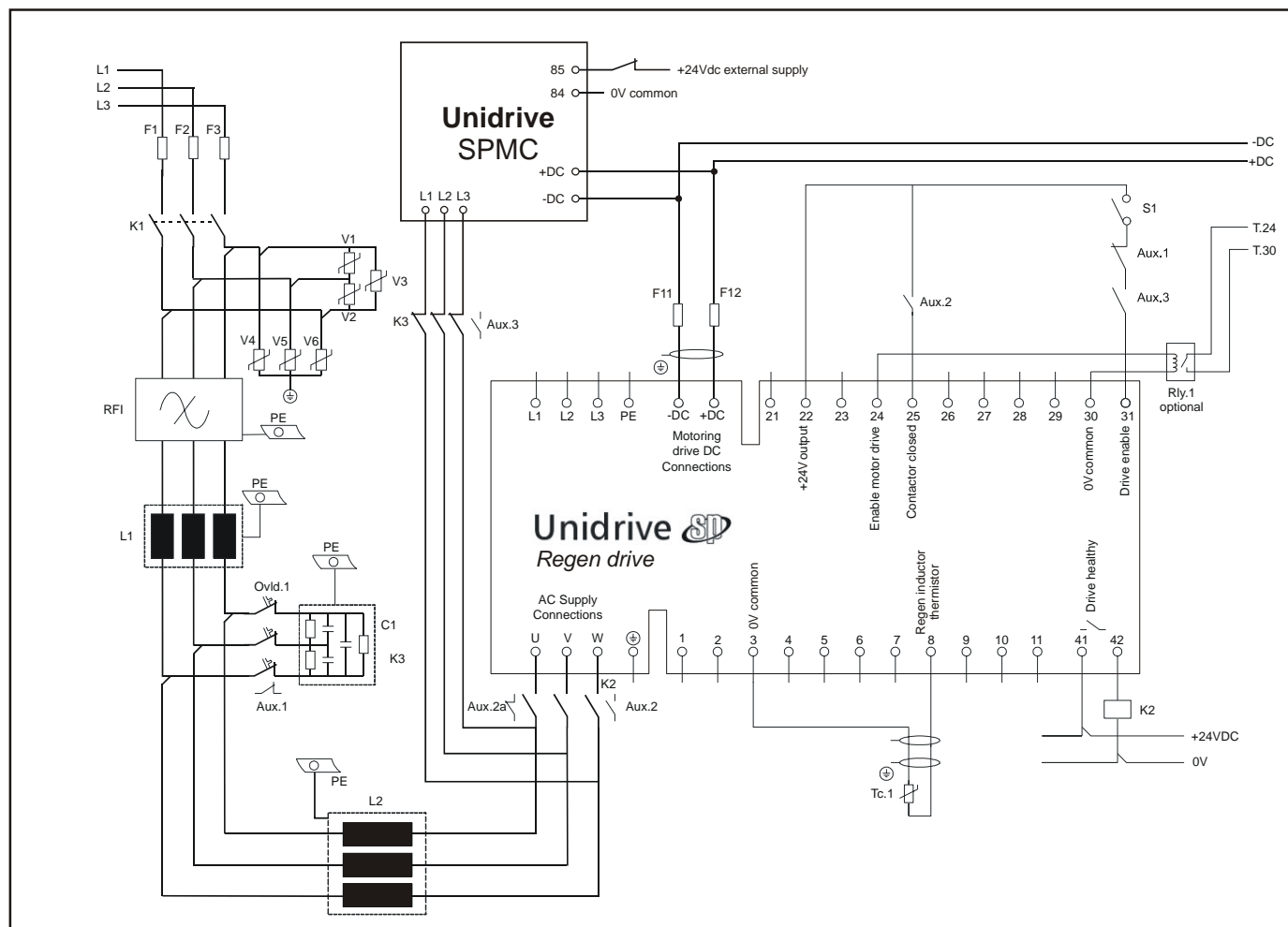


Table 4-2 Key to Figure 4-3

Key	Description
L1, L2, L3	Three phase supply
F1, F2, F3	Main regen system supply fuses
V1, V2, V3	Varistor network line-to-line 550Vac
V4, V5, V6	Varistor network line-to-ground 680Vac
F4, F5, F6	Unidrive SPMC main fusing
F7, F8, F9, F10	DC bus fusing to motoring drive
F11, F12	DC bus fusing to Regen drive
RFI	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	Softstart contactor
Ovld.1	Switching frequency filter capacitor overload
Aux.1	Switching frequency filter capacitor auxiliary
Aux.2a	SPMC +24V control (optional)
Aux.2	Regen drive main contactor auxiliary
Aux.3	Softstart contactor
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

Figure 4-2 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 SPMC module. Refer to section 3.5 *Unidrive SPMC 1402, Single half controlled thyristor rectifier* on page 13 for further details of the Unidrive SPMC.

NOTE

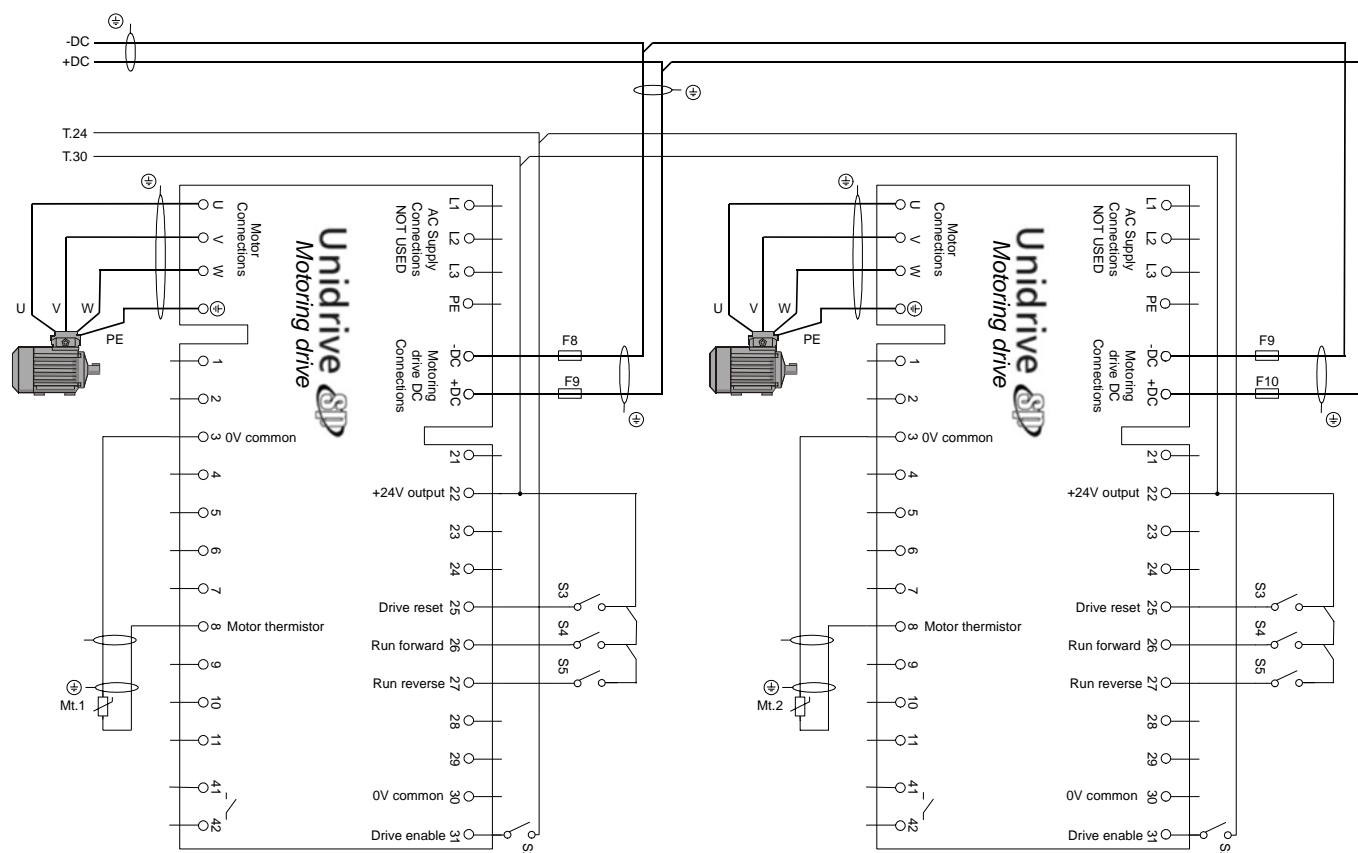
For the multiple motoring drive solution, the Regen drive and associated Unidrive SPMC must be sized to the total power requirements of all motoring drives.

NOTE

The regen inductor duty is very arduous and therefore selection is critical. As a result only regen inductors specified in this guide should be used.

NOTE

Fusing F4, F5, F6 is only required where fusing F1, F2, F3 exceed these. For example in a multiple regen drive system, where F1, F2, F3 equal total system current rating.



NOTE

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

See Chapter 10 *Technical data* on page 147 for fuse rating information.

Unidrive SPMC

For a regen system, the SPMC 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 Unidrive SPMC must be supplied with 24Vdc to feed both the fans and control circuits. This 24Vdc can also be used as a means of starting and stopping the SPMC rectifier as the SPMC will only fire its thyristors when the 24Vdc is present.

Fitting a 5A relay interlocked (or a normally closed auxiliary contact) to the Regen drives main contactor to switch the 24V supply will allow the SPMC to charge the common DC bus then be disabled (optional).

The total amount of capacitance on the common DC bus that the SPMC can drive is limited due to the inrush current (produced during power up and during brownouts).

See the following Table for the capacitance limit.

Unidrive SP drive DC bus capacitance levels are available in Table 11-1 on page 152.

	SPMC 1402
Max capacitance on 25kA supply.	66mF

4.2.3 Single Regen, multiple motoring system using an external charging resistor

Figure 4-3 Power connections: Single Regen, multiple motoring system

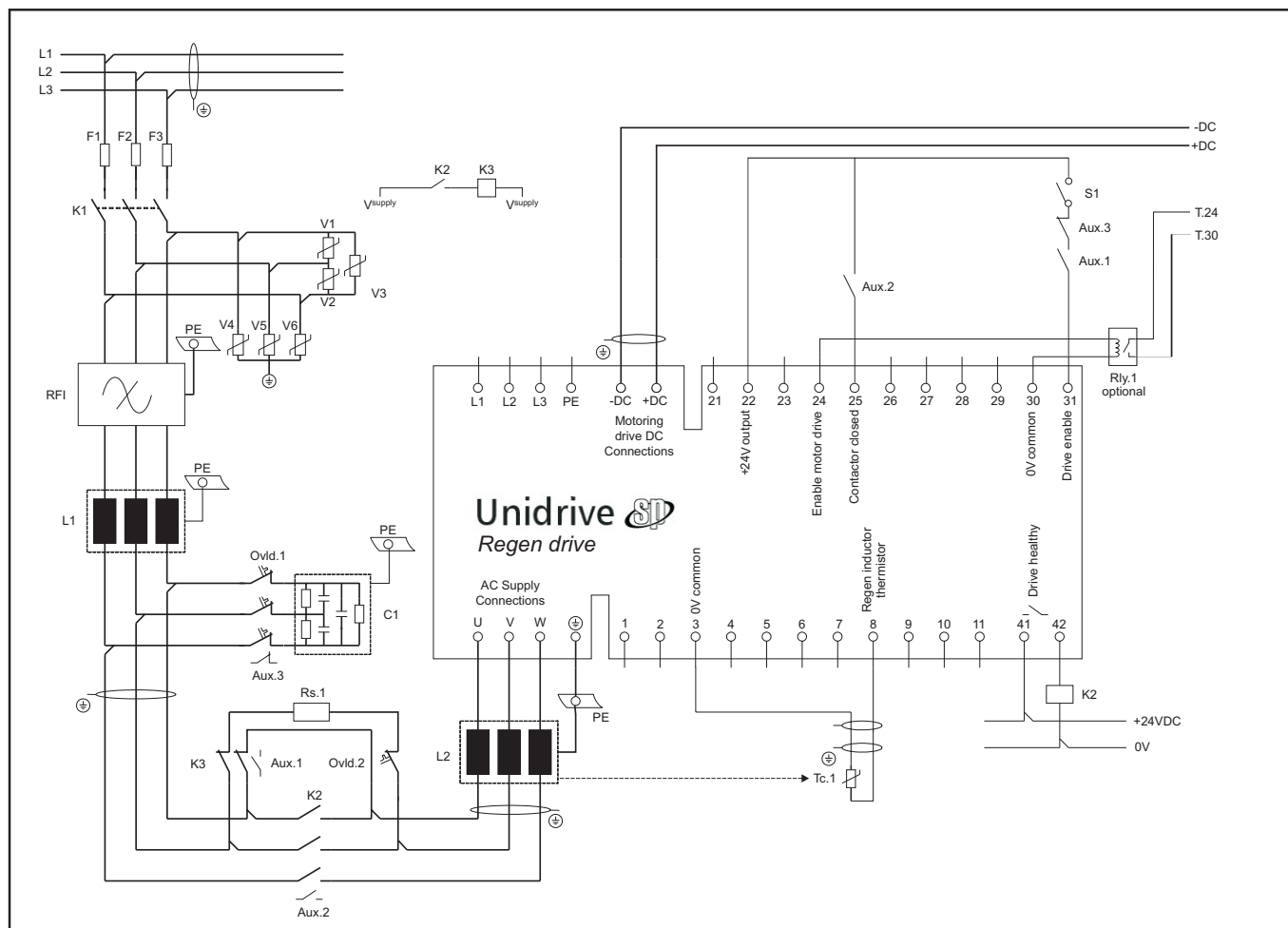


Table 4-3 Key to Figure 4-3

Key	Description
L1, L2, L3	Three phase supply
F1, F2, F3	Main regen system supply fuses
V1, V2, V3	Varistor network line-to-line 550Vac
V4, V5, V6	Varistor network line-to-ground 680Vac
F4, F5, F6, F7	DC bus fusing to motoring drive
RFI	EMC Filter
C1	Switching frequency filter capacitor
L1	Switching frequency filter inductor
K1	Regen inductor
K2	Main supply contactor
K3	Regen drive main contactor
Ovid.1	Switching frequency filter capacitor overload
Ovid.2	Charging contactor overload
Aux.1	Charging contactor auxiliary
Aux.2	Regen drive main contactor auxiliary
Aux.3	Switching frequency filter capacitor auxiliary
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	Charging resistor
+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

Figure 4-3 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.

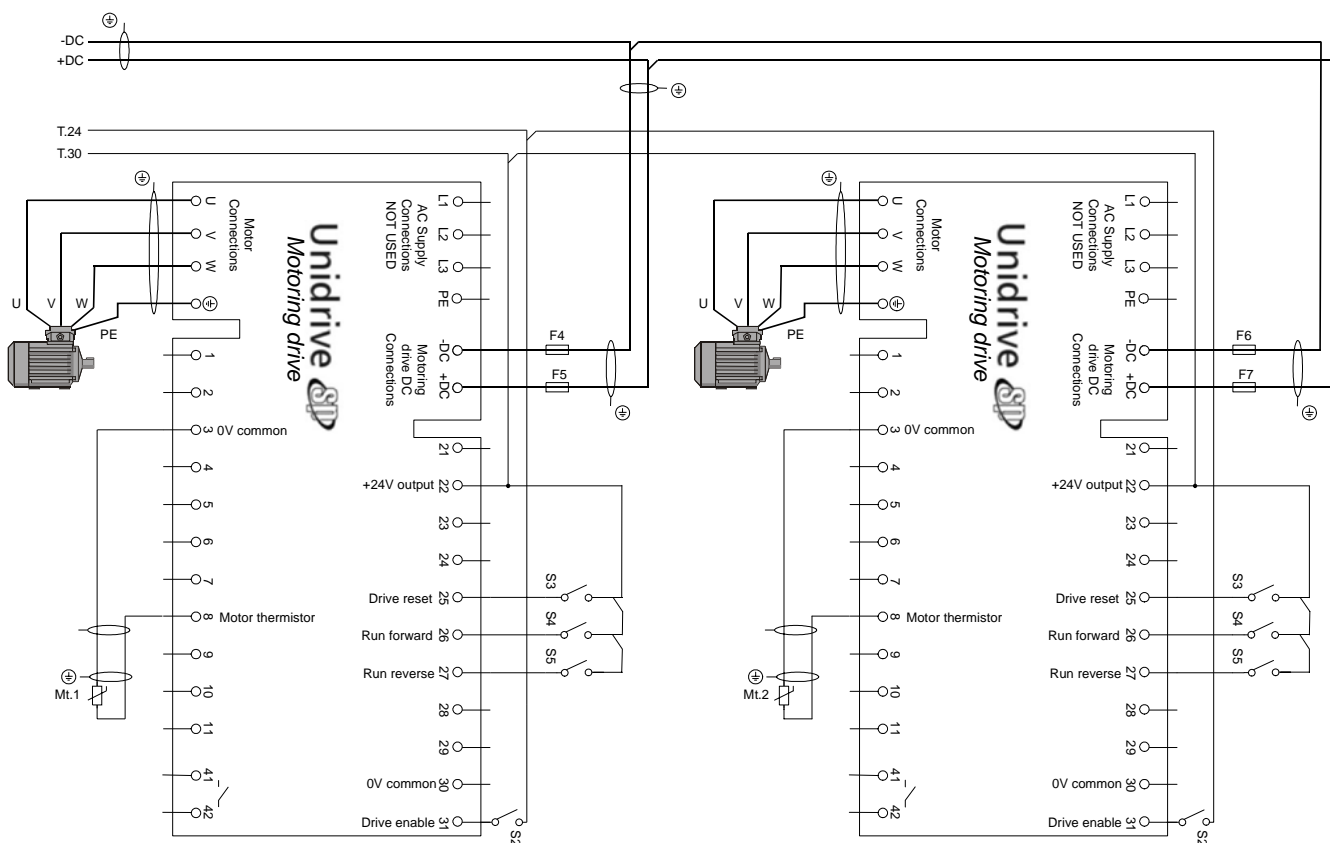
For sizing of the external charging circuit required for the multiple motoring drive system, refer to Chapter 11 *Component sizing* on page 152. For details on charging resistors and protection refer to section 10.4.2 *Softstart resistor - type TG series* on page 149.

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.

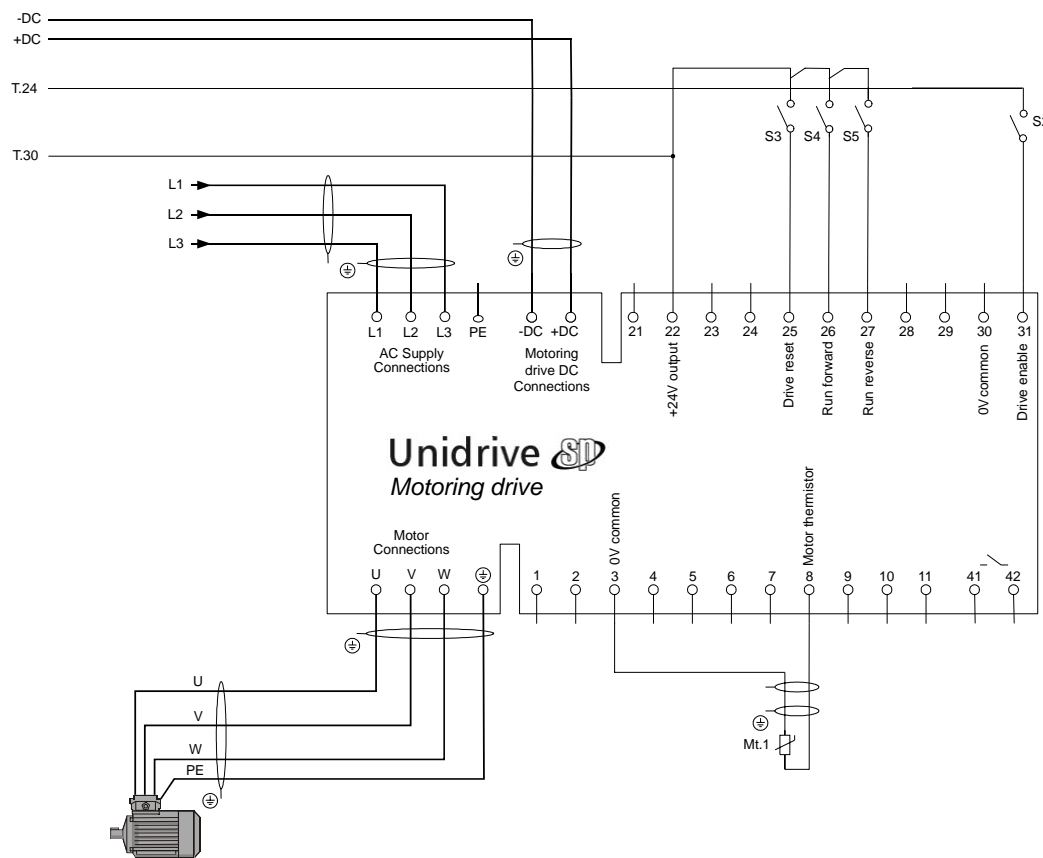
NOTE

The regen inductor duty is very arduous and therefore selection is critical. As a result only regen inductors specified in this guide should be used.



NOTE

DC bus fusing is required for all motoring drives in a single Regen, multiple drive system in both the +DC and -DC.
See Chapter 10 *Technical data* on page 147 for fuse rating information.



NOTE

The single EMC filter shown in the above configuration should be rated to the motoring drive's rated current.

The AC supply is connected to both the Regen drive and the motoring drive. **Note, however, that the Regen drive receives its supply via an isolating transformer.** This is necessary because when the Regen drive is switching, its DC bus voltage moves with respect to both ground and the supply neutral point. However, on the motoring drive, the DC bus voltage remains relatively fixed with respect to ground. As a result of the difference between the two voltages, it is not possible to connect both drives to the same AC supply. **A DC bus diode is fitted to ensure that power flows from the motoring drive to the Regen drive only.**

NOTE

The Regen inductor duty is very arduous and therefore only Regen inductors specified in this guide should be used.

4.2.5 Regen and motoring drive ratings

NOTE

The Regen drive's current limits are detailed in section 3.2 *Ratings* on page 11.

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

Example:

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

If each motor supplies between 20 and 30kW motoring, and the braking power varies from 0 to 30kW, the maximum total braking power is $30 - 20 = 10\text{kW}$, 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 75kW Unidrive SP. Motoring power is 75kW. Steady state braking power is 20kW.

From these figures, it may appear that a 22kW Regen drive will provide sufficient braking power. However, dynamically the peak braking power could be much greater. If the 75kW drive current limits are set at 150% for motoring and braking (default settings), the peak brake power could be:

$$\sqrt{3} \times 156\text{A} \times 400\text{V} \times 150\% = 162\text{kW}$$

This is much greater than the 22kW 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.

4.2.6 Isolating transformer and diode

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 diode D1.
- The switching frequency filter inductors are replaced with an isolating transformer T1 with a leakage inductance $\geq 4\%$.

DC bus diode

Table 4-5 DC bus diode

Diode type	Recovery time μs	Current rating A	Voltage rating V
Fast or Ultra Fast	<1	3 x current rating of Regen drive	1,200

A suitable supplier for the above diode can be Semikron™ with the **SKKD xxx F 12** or **SKKE xxx F 12** diode modules.

The diode must be mounted on a suitable heatsink. Heatsink sizing should be based on:

- Maximum device case temperature of 80°C
- Power loss = 2V x Regen drive rated current

Isolating transformer T1

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 10.4.3 *Switching frequency filter on page 150*, any value equalling 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.

4.3 Non standard applications

4.3.1 Omitting the switching frequency filter

If the supply to the Regen drive is shared with other equipment, then it is generally recommended that a switching frequency filter should be incorporated in order to avoid the risk of interference or damage to the other equipment. However some saving in cost and space is possible by omitting the filter if the supply impedance is very low compared to that of the drive, i.e. if the drive current rating is much less than that of the supply where it is shared with other equipment.

4.3.2 Supply assessment

The following guidelines should be used when assessing whether or not a switching frequency filter is required.

Symbols used are:

- I_{Drive} Nominal drive 100% current rating.
 I_{sc} Short circuit current of supply at point of coupling with other equipment.
 I_{Supply} Rated current of supply.

The switching frequency filter may be omitted if the following relation is true:

$$\frac{I_{\text{Drive}}}{I_{\text{sc}}} < \frac{1}{140}$$

If the short-circuit current is not known, then a reasonable estimate can be made if it is assumed that the fault current of the supply is 20 times the rated current. This is very commonly the case where the supply is derived through a distribution transformer from a higher voltage supply with a high fault level.

Then:

$$\frac{I_{\text{Drive}}}{I_{\text{Supply}}} < \frac{1}{7}$$

Note that the short-circuit current data used must be realistic, it must not be the maximum likely value which is sometimes used when selecting the interrupting capacity of switchgear and protection devices.

This second relation is helpful if the short-circuit current of the supply is not known, but must be used with care. It is reliable where the Regen drive is supplied through its own cable run from a point close to the distribution transformer terminals. If the Regen drive shares a long cable run with other equipment, then the effect of the cable impedance on the fault level must be taken into account if a risk of disturbance to the other equipment is to be avoided.

This procedure will normally be applied when assessing a non-dedicated low-voltage supply. It may also be applied to the medium/high voltage supply where the low-voltage supply is dedicated to the drive. In that case the currents used must be referred to the high voltage side of the transformer.

If the supply to the regen system has an unusually high impedance, for example because it derives from a generator whose rating is not much greater than that of the drive, then a more complex filter might be required to ensure stability of the current control loops. Please contact the supplier of the drive if it is to be used with a generator whose rating is less than twice that of the drive.

4.4 Cable length restrictions

There are 3 significant cable lengths which must be taken into account when designing a regen system. Refer to Figure 4-5 on page 29.

4.4.1 AC supply connection

A is the AC cable length between the regen inductor and the Regen drives terminals.

In general, no special precautions are necessary for the AC supply wiring in respect to the Regen drive. Ideally, the regen inductors should be mounted close to the drive terminals.

If it is necessary to use a cable longer than 5m, a screened cable should be used with the screen grounded.

4.4.2 DC bus connection

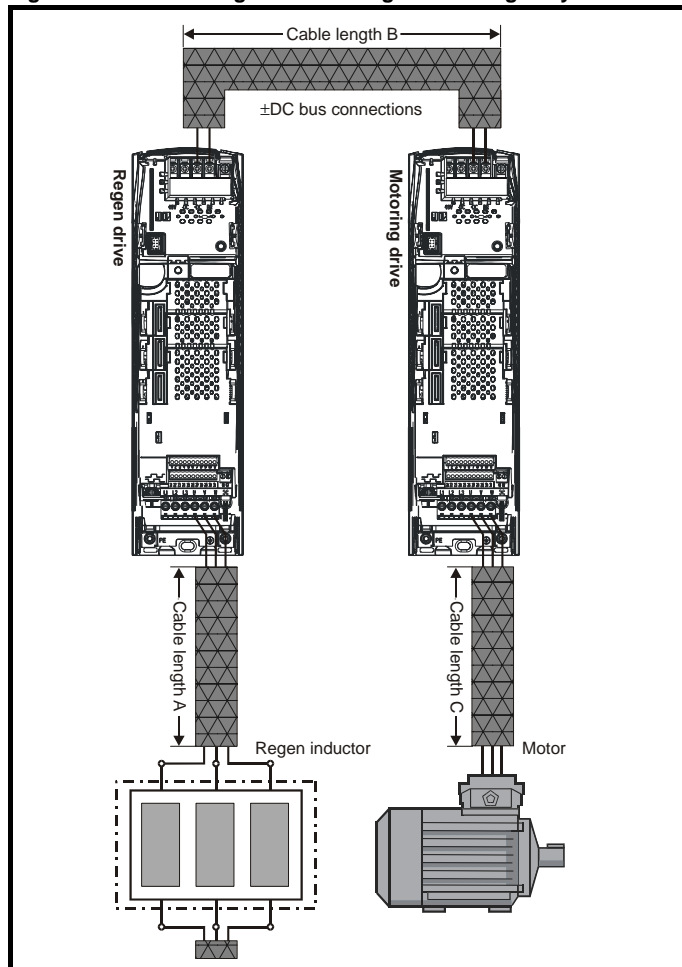
B is the length of the DC bus connection between the Regen and motoring drive, the + DC bus connections between the drives should be treated as a single two core cable and not two individual cable / bus bar lengths.

The DC power output from the Unidrive SP 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.

4.4.3 Motor connection

C is the AC cable length between the motoring drive and the motor.

Figure 4-5 Calculating the cable length of the regen system



4.4.4 Cable length

The sum total length of the DC bus and motor cables (B and C in Figure 4-5) must not exceed the values shown in the table below:

Table 4-6 Cable lengths

Regen drive size	Power rating kW	Maximum cable length m
1	4	50
2	5.5 to 15	100
3	15 to 30	200
4	30 to 55	200
5	55 to 90	200
6	90 to 132	200

If the cable length in the above table is exceeded, additional components are required. Refer to section 4.6 *Maximum cable length*.

4.5 Cable types and lengths

Since capacitance in the cabling causes loading, ensure the cable length does not exceed the values given in Table 4-7.

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 Maximum cable length

If the total maximum 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.

4.6.1 Regen inductor

If the maximum cable length specified is exceeded this will introduce increased heating of the regen inductor. To overcome the additional heating forced cooling should be introduced into the system as specified in the following table.

The forced cooling should be positioned as shown below to provide the specified airflow directly onto the regen inductor windings.

Figure 4-6 Location of forced cooling

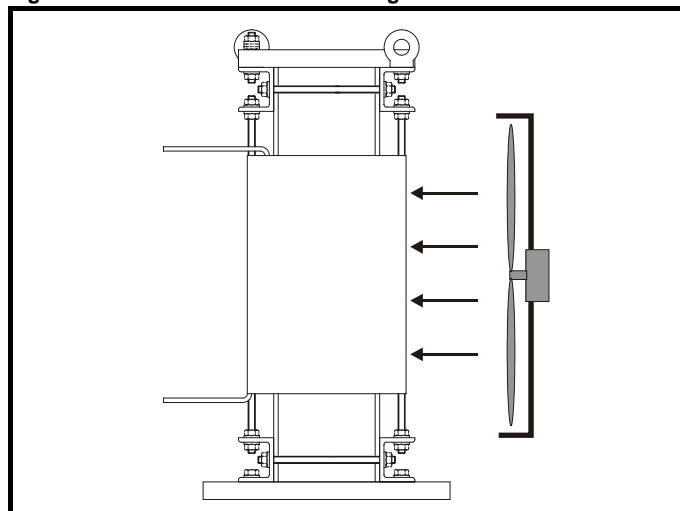


Table 4-7

Drive size	Maximum cable length		Cooling requirement
	Without additional ventilation m	With additional cooling m	
1	50	250	air flow $\geq 160\text{m}^3 / \text{hr.}$
2	100	500	air flow $\geq 160\text{m}^3 / \text{hr.}$
3	200	1,000	air flow $\geq 160\text{m}^3 / \text{hr.}$
4	200	1,000	air flow $\geq 160\text{m}^3 / \text{hr.}$
5	200	1,000	air flow $\geq 160\text{m}^3 / \text{hr.}$
6	200	1,000	air flow $\geq 160\text{m}^3 / \text{hr.}$

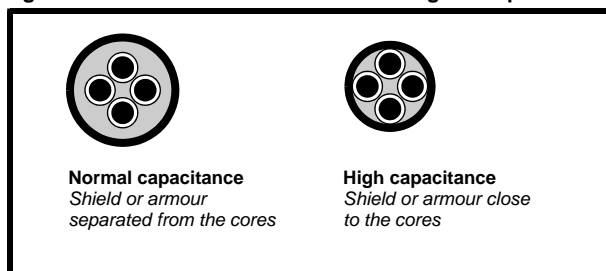
Cable lengths in excess of the above specified values may be used only when special techniques are adopted; refer to the supplier of the drive.

4.6.2 High-capacitance cables

The maximum cable length is reduced from that shown if high capacitance cables are used.

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

Figure 4-7 Cable construction influencing the capacitance



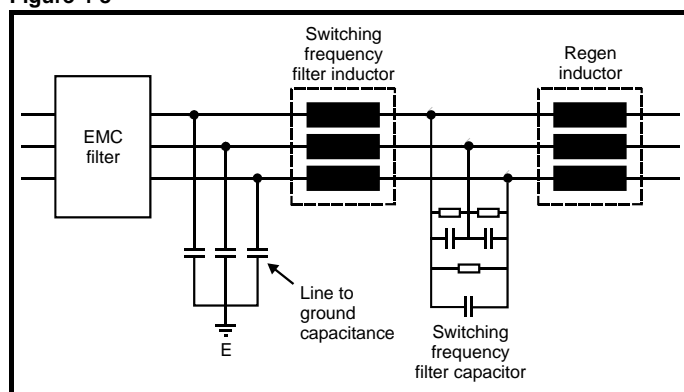
The cable used is shielded and contains four cores. Typical capacitance for this type of cable is 130pF/m (i.e. from one core to all others and the shield connected together).

4.6.3 EMC filter

When an EMC filter is used the capacitors to ground carry common mode current.

When the maximum cable length without additional ventilation specified is exceeded, extra circulating currents can result in heating and saturation of the EMC filter. To prevent this, some capacitance line to ground should be provided as an additional path for this current, as shown in Figure 4-8. See also section 4.4.3 *Motor connection* on page 29.

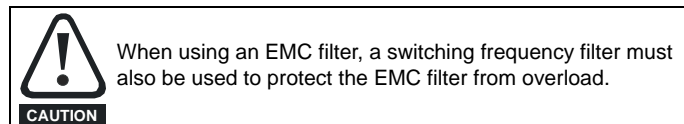
Figure 4-8



NOTE

If the cable length exceeds the maximum cable length with additional cooling, Control Techniques Technical Support must be consulted.

Whether or not an EMC filter is required is dependent upon the user requirements and the AC supply network. For further details refer to section 6.4 *EMC (Electromagnetic compatibility)* on page 50.



4.6.4 Line to ground capacitors for multi-drive systems

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.

A minimum capacitance value of 1μF per phase should be used with the final capacitance value being determined by the value of the current line to ground. In practice, to carry the required level of current the capacitor will generally have a higher capacitive value. The current rating of the capacitors should be at a high frequency such as 100kHz at the relevant supply voltage. Polypropylene type capacitors are the most suitable

because of their low loss at high frequency.

The rms value of the current can be estimated from the following formula:

$$I_{RMS} = 2.8 \times 10^{-4} \times K \times V_{DC} \sqrt{\sum I f_s}$$

Where:

k is 1 for simple rectifier-input systems, $\sqrt{2}$ for regen systems

V_{DC} is DC bus voltage

ΣIf_s is the sum of the products of motor cable lengths and switching frequencies of all drives in the system, including in the case of regenerative systems the Regen drive with the total DC cable length

I is total cable length in m

f_s is switching frequency in kHz

If all drives operate at 3kHz, the expression can be simplified to:

$$I_{RMS} = 4.85 \times 10^{-4} \times K \times V_{DC} \times \sqrt{I}$$

Example

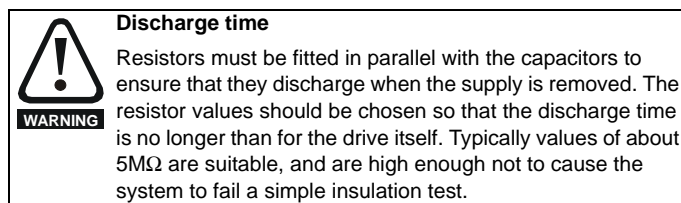
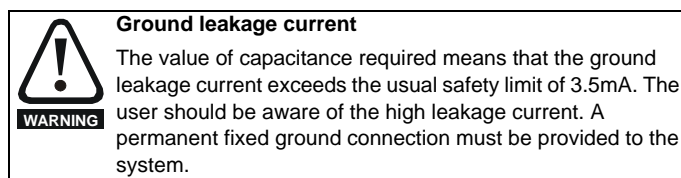
A regen system operating with a supply of 400Vac giving a DC bus voltage of 620V at 3kHz switching frequency and a cable length of 1km (motors + DC) has an **I_{RMS}** of:

$$I_{RMS} = 4.85 \times 10^{-4} \times K \times V_{DC} \times \sqrt{I}$$

$$I_{RMS} = 4.85 \times 10^{-4} \times \sqrt{2} \times 620 \times \sqrt{1.000}$$

$$I_{RMS} = 13.4A$$

The **I_{RMS}** is the total current line to ground, therefore each capacitor will have to carry 4.5A.



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
- Cubicle design with high ambient temperatures

See the Chapter 3 *Mechanical Installation* in the *Unidrive SP User 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.

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 *Unidrive SP User 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

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 5.4.2 *Enclosure sizing* on page 38.

NOTE

Through hole mounting is possible for all Unidrive SP modules and the Unidrive SPMC which can reduce cubicle heating and cooling requirements. Refer to Unidrive SP User Guide and Unidrive SPM User 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 41.

5.2.5 Fire protection

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

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 section 6.4 *EMC (Electromagnetic compatibility)* on page 50.

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 energised, the AC supply must be isolated at least ten minutes before work may continue.


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

5.3.1 Regen inductor



The following regen inductors can produce significant losses with a normal operating temperature in the region of 170°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.

Figure 5-1 Top view of fixing type A

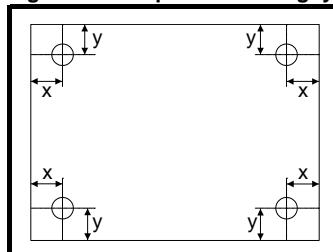


Table 5-1 Regen inductor specifications

Inductor part no.	Amps	mH	Losses W	L mm	D mm	H mm	Weight kg	Fixing centres (x * y) mm	Fixing mm	Fixing type	Type no.
4401-0001	9.5	6.32	125.0	200	180	215	12	120 x 140	9	A	1
4401-0002	12	5.00	146.0				14	120 x 140	9	A	
4401-0003	16	3.75	175.0	240	180	270	17	160 x 140	9	A	
4401-0004	25	2.40	210.0				24	160 x 160	9	A	2
4401-0005	34	1.76	285.0	320	220	325	32	200 x 180	11	A	
4401-0006	40	1.50	310.0				33	200 x 180	11	A	
4401-0007	46	1.30	320.0				39	200 x 180	11	A	
4401-0008	60	1.00	345.0				55	240 x 220	11	A	
4401-0009	70	0.78	415.0	360	260	370	65	240 x 240	11	A	
4401-0010	96	0.63	515.0				75	240 x 240	11	A	3
4401-0011	124	0.48	585.0				95	240 x 240	11	A	
4401-0012	156	0.38	645.0				110	280 x 260	11	A	
4401-0013	180	0.33	775.0	410	300	430	120	280 x 260	11	A	
4401-0014	220	0.30	845.0				130	320 x 260	11	A	
4401-0015	300	0.24	1760.0	480	320	490	140	320 x 240	11	A	

Figure 5-2 Regen inductor type 1 dimensions

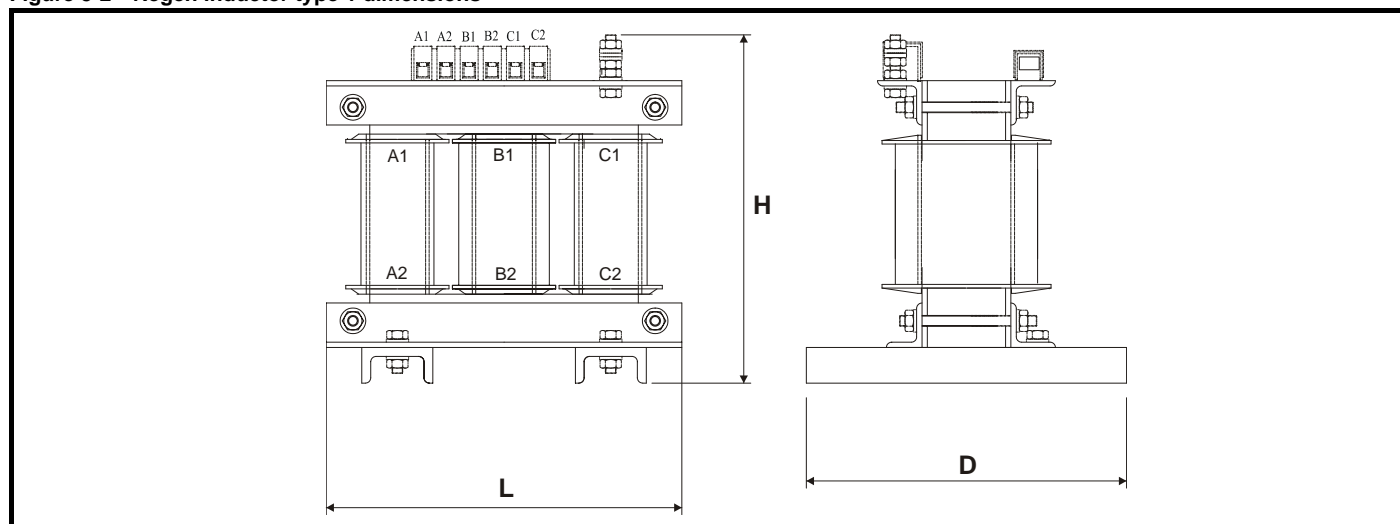


Figure 5-3 Regen inductor type 2 dimensions

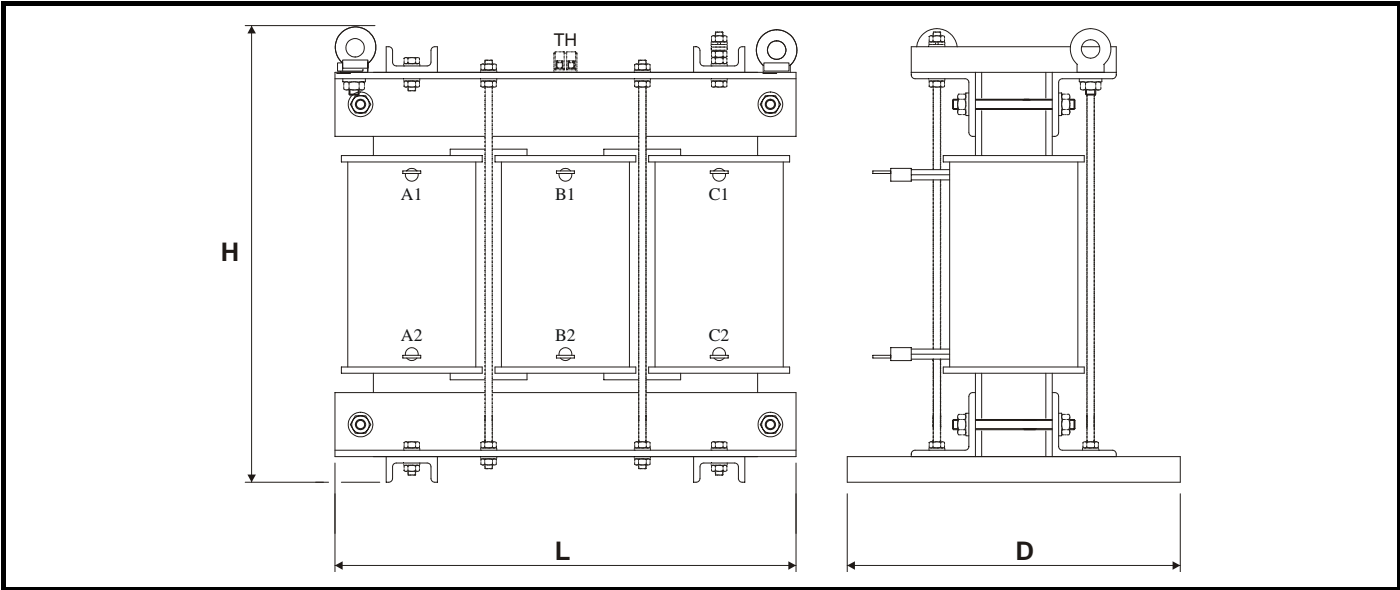
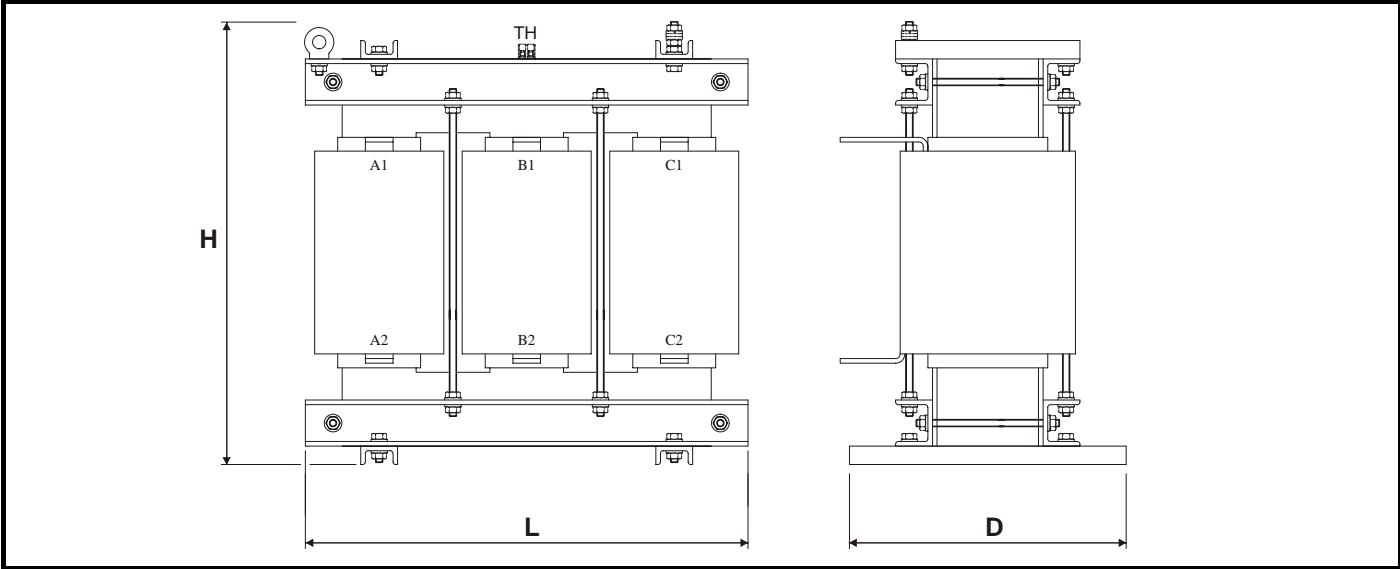


Figure 5-4 Regen inductor type 3 dimensions



5.3.2 Switching frequency filter inductor

Table 5-2 Switching frequency filter specifications

SFF part no.	A	mH	Losses W	L mm	D mm	H mm	Weight kg	Fixing centres (x * y) mm	Fixing mm	Fixing type	Type no.
4401-0162	9.5	3.160	28	150	90	150	4	120 x 47	8 x 18	B	1
4401-0163	12	2.500	35				4	120 x 47	8 x 18	B	
4401-0164	16	1.875	37				6	130 x 54	8 x 20	B	
4401-0165	25	1.200	40	180	150	190	10	130 x 74	8 x 20	B	2
4401-0166	34	0.880	52	180	160	190	12	130 x 84	8 x 20	B	
4401-0167	40	0.750	60				12	130 x 84	8 x 20	B	
4401-0168	46	0.650	60				13	130 x 84	8 x 20	B	
4401-0169	60	0.500	80	240	160	255	16	200 x 80	10 x 20	B	
4401-0170	70	0.390	90	240	170	255	20	200 x 90	10 x 20	B	
4401-0171	96	0.315	100	240	180	255	22	200 x 100	10 x 20	B	
4401-0172	124	0.240	110	240	190	255	25	200 x 100	10 x 20	B	3
4401-0173	156	0.190	130	300	180	300	37	204 x 113	10 x 20	B	
4401-0174	180	0.165	170				37	204 x 113	10 x 20	B	
4401-0175	220	0.135	180	300	190	300	49	204 x 123	10 x 20	B	
4401-0176	300	0.100	220	300	200	300	50	204 x 130	10 x 20	B	
4401-0177	600	0.050	400	410	300	430	110	280 x 260	11	A	4
4401-0178	900	0.034	530	480	320	500	140	320 x 240	11	A	
4401-0179	1200	0.025	700	480	320	560	170	320 x 240	11	A	

Figure 5-5 Top view of fixing type A Figure 5-6 Top view of fixing type B

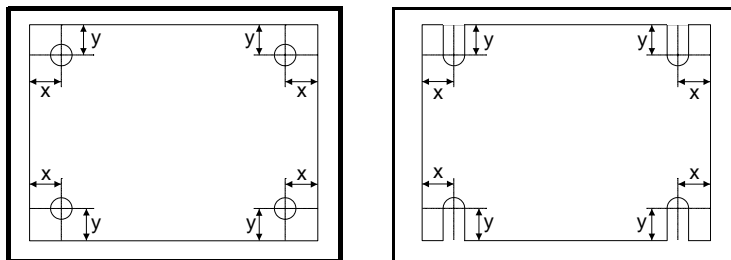


Figure 5-7 Switching frequency filter inductor type 1 dimensions

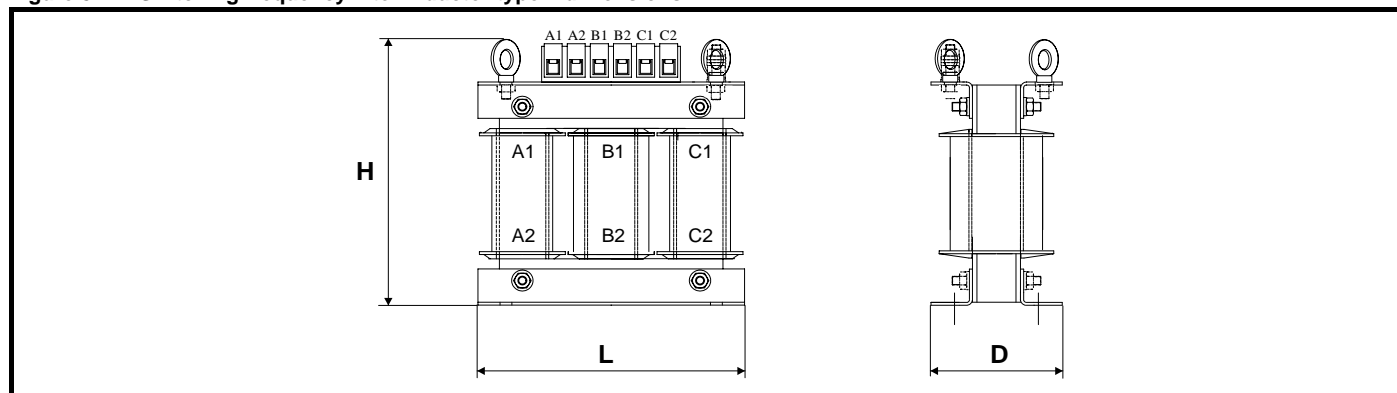


Figure 5-8 Switching frequency filter inductor type 2 dimensions

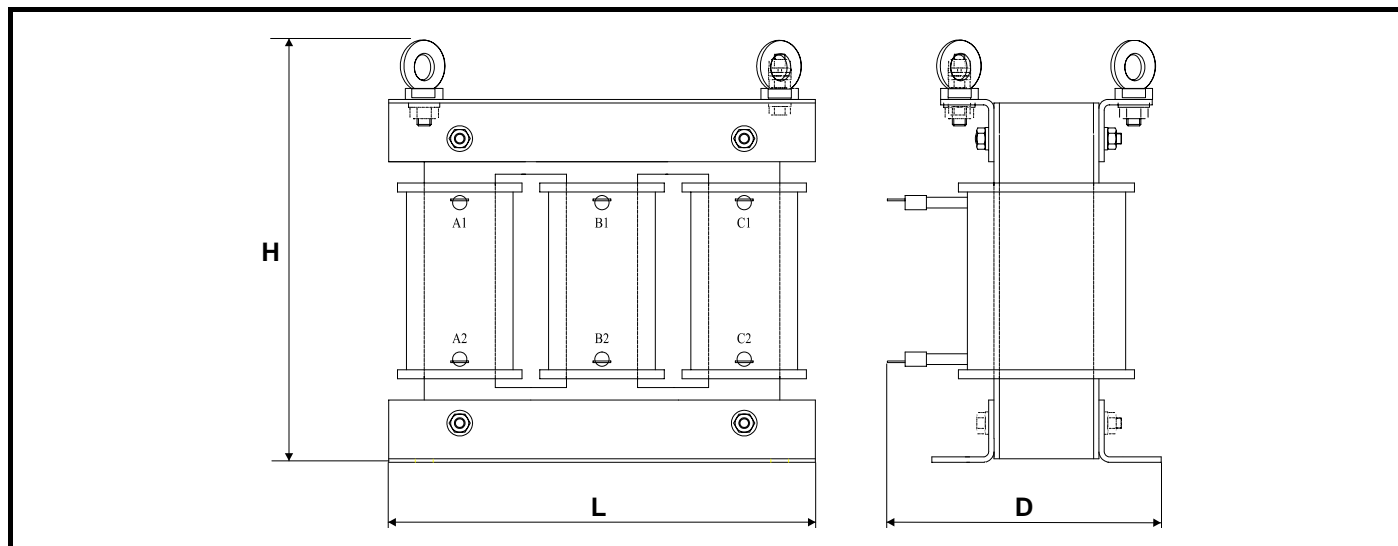


Figure 5-9 Switching frequency filter inductor type 3 dimensions

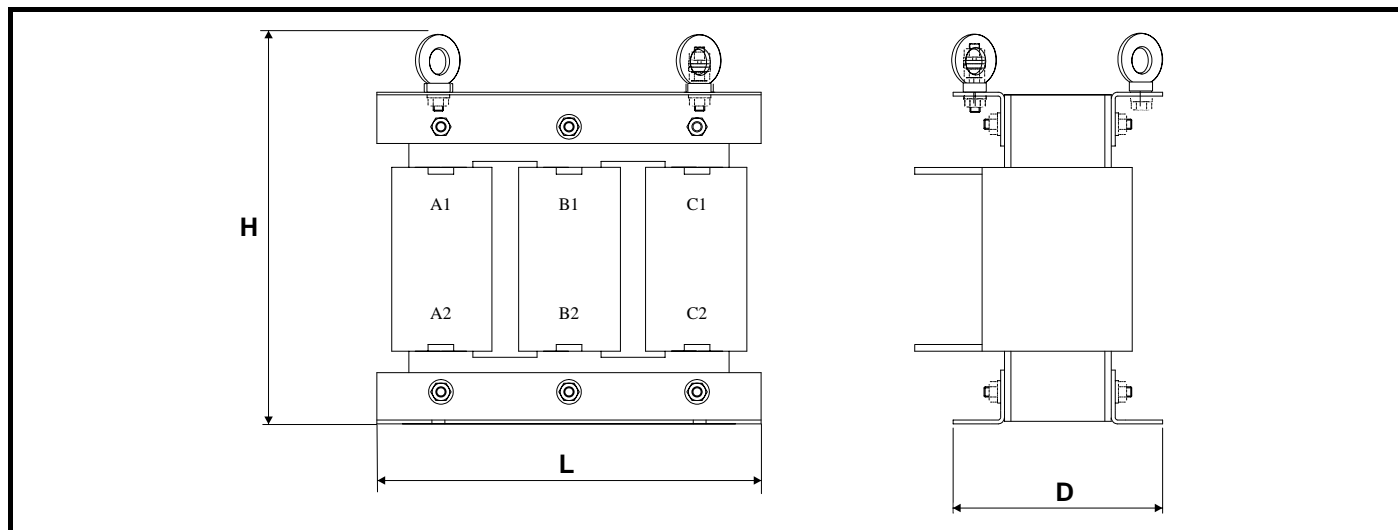
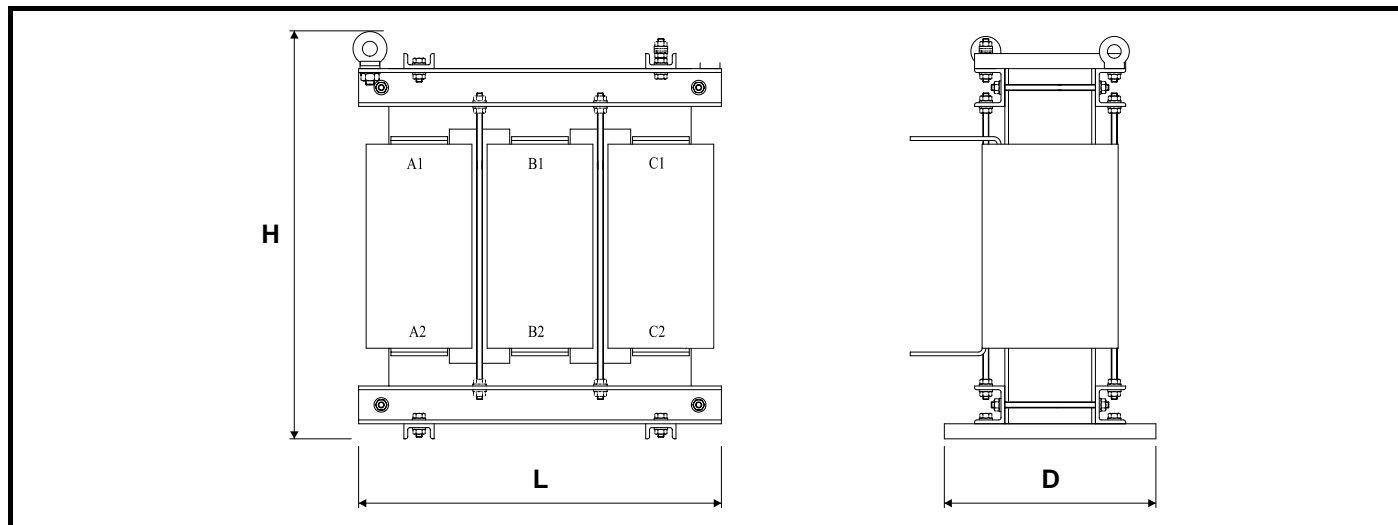


Figure 5-10 Switching frequency filter inductor type 4 dimensions



5.3.3 Switching frequency filter capacitors

Figure 5-11 3-phase capacitors dimensions

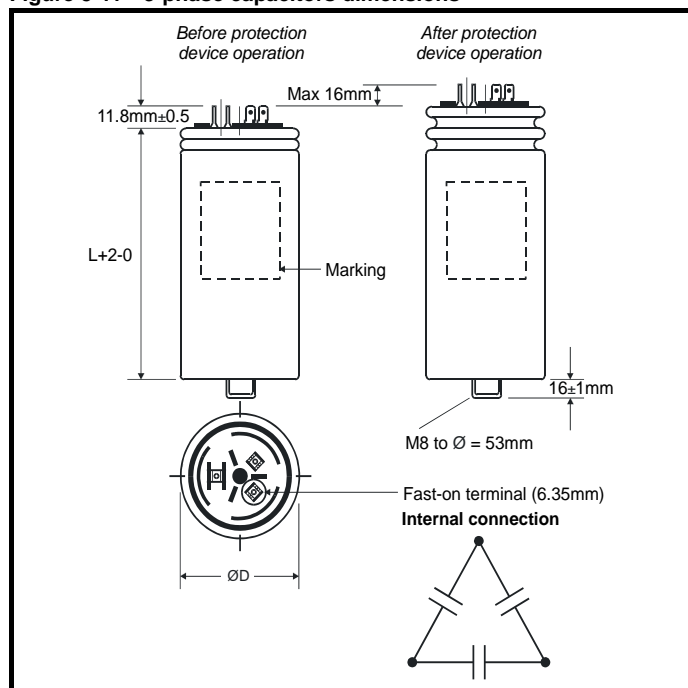


Table 5-3 Smaller 3-phase capacitor specifications

3-phase capacitor part no.	CN μ F	\varnothing x L mm	Weight kg	Mounting
1610-7609	3 x 5.7	53 x 116	0.3	M8 Stud

NOTE

For switching frequency filter capacitor 1610-7609 the discharge resistors are fitted internally to the capacitor.

Figure 5-12 3-phase capacitors dimensions

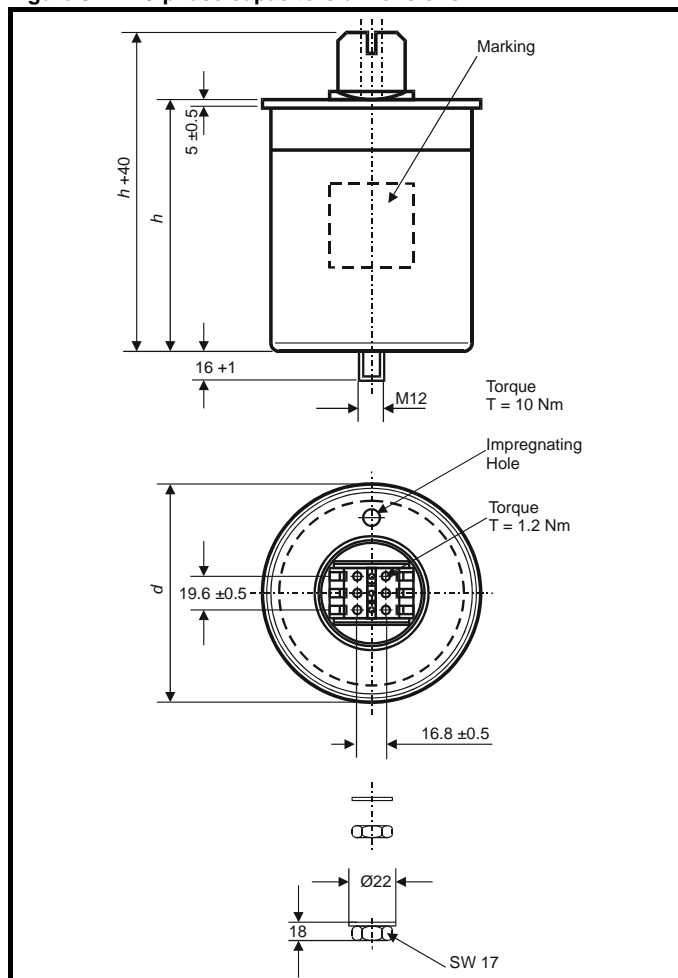


Table 5-4 Larger 3-phase capacitor specifications

3-phase capacitor part no.	CN μ F	d x h mm	Weight kg	Mounting
1665-2244	3 x 24	121 x 164	1.1	M12 Stud
1665-2484	3 x 48	121 x 164	1.5	
1665-8774	3 x 77	142 x 200	2.2	

Discharge resistors

Discharge resistors are supplied for the following switching frequency filter capacitors: 1665-2244, 1665-2484, 1665-8774

These should be fitted during installation as shown in Figure .

Table 5-5 Discharge resistor values

Discharge resistor arrangement	Capacitor value μ F	Resistor value k Ω
	24	3 x 390
	48	3 x 390
	77	3 x 270

5.3.4 External charging resistor - type TG series

Figure 5-13 External charging resistor dimensions

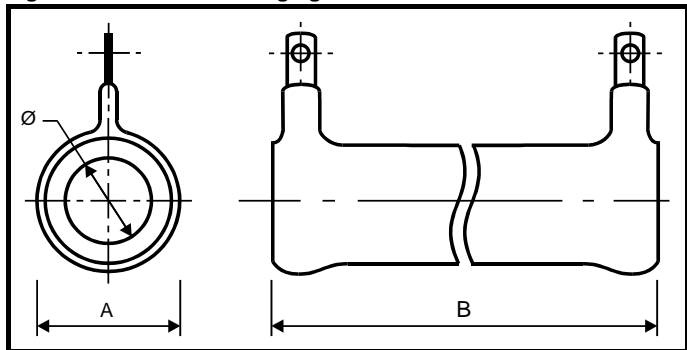


Table 5-6 External charging resistor specifications

External charging resistor part no.	Resistance	Diameter (A) mm	Length (B) mm
1270-3157	150Ω	19.1	73
1270-2483	48Ω x 1	22.2	165.1

Figure 5-14 Resistor mounting bracket dimensions

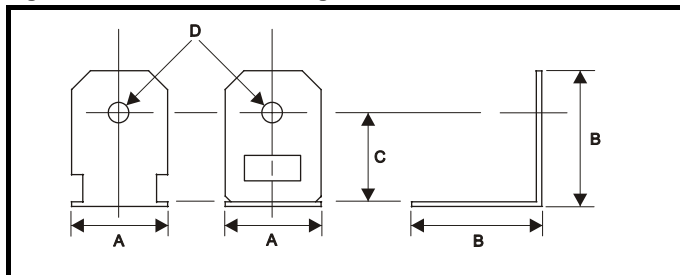


Table 5-7 Resistor mounting bracket dimensions

A	B	C	D
24.0mm	33.5mm	21.45mm±0.2	Ø5.0

NOTE

For component selection refer to either Chapter 10 *Technical data* on page 147 or section 3.8 *Regen components* on page 16.

5.3.5 Varistors

Figure 5-15 Varistor dimensions

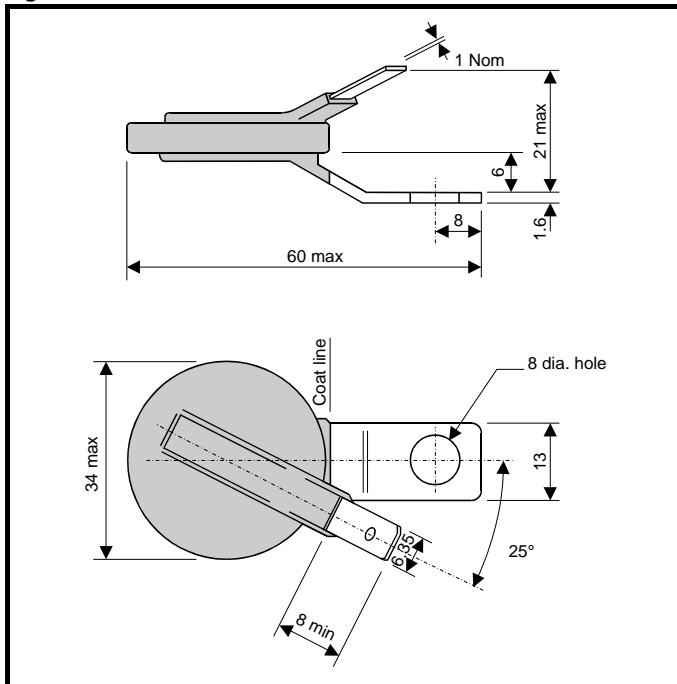


Table 5-8 Varistor specifications

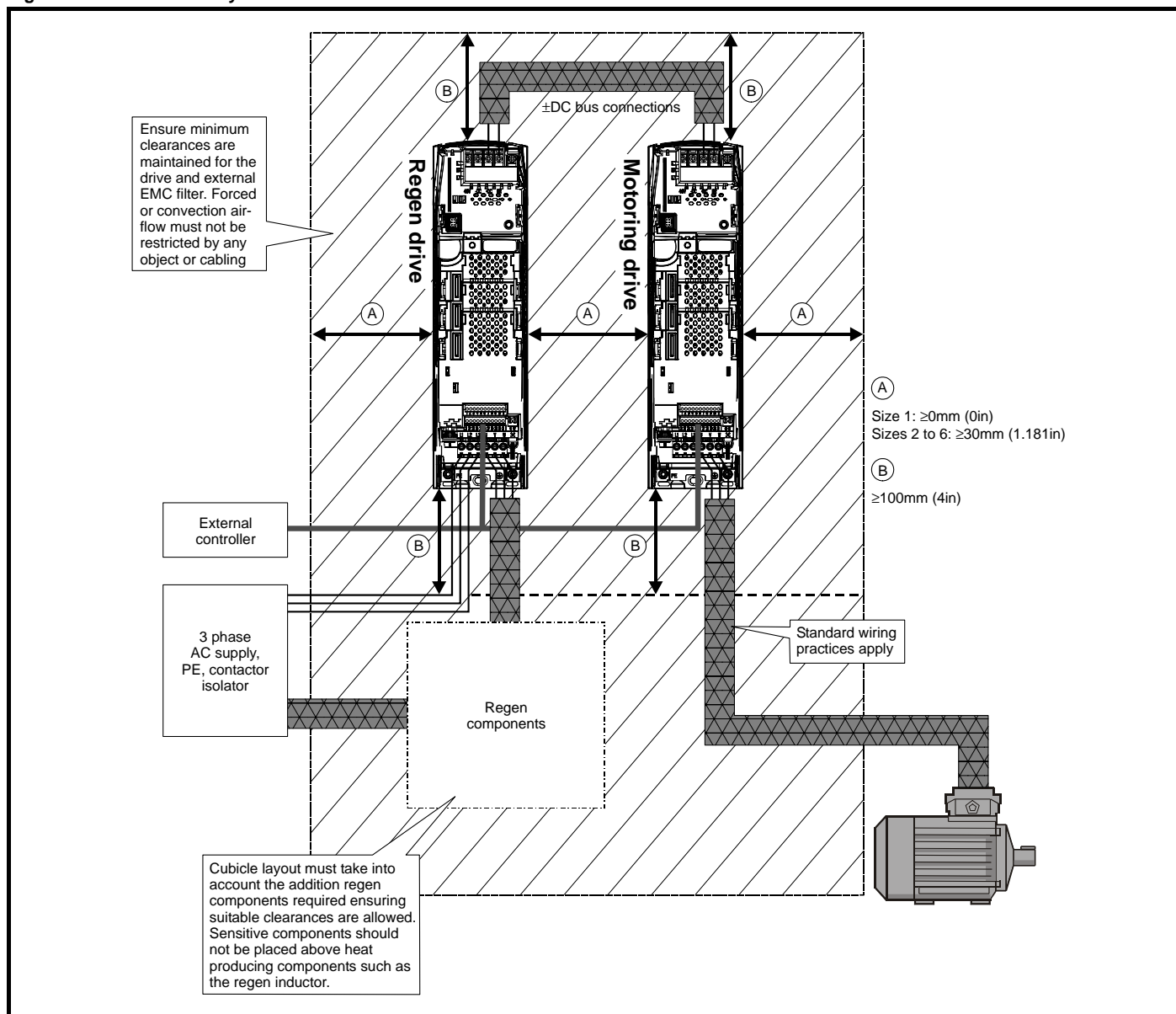
Varistor part no.	Voltage Vac	Energy J	Type
2482-1501	550	400	Z500LNS
2482-0680	680	450	Z680LNS

5.4 Enclosure

5.4.1 Enclosure layout

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

Figure 5-16 Enclosure layout



5.4.2 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 A_e for the enclosure from:

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

Where:

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

Example

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

- Two SP 1405 (1 x Regen and 1 x motoring drive) models operating at the Normal Duty rating
- Each drive to operate at 6kHz PWM switching frequency
- Schaffner 16 A (4200-6119) external EMC filter for each drive
- Maximum ambient temperature inside the enclosure: 40°C
- Maximum ambient temperature outside the enclosure: 30°C

Dissipation of each drive: 147 W (see Chapter 12 *Technical Data* in the *Unidrive SP User Guide*)

Dissipation of external EMC filter: 9.2 W (max) (see Chapter 12 *Technical Data* in the *Unidrive SP User Guide*)

Dissipation of each external regen inductor: 125 W x 1 (see section 10.4.1 *Regen inductors* on page 149)

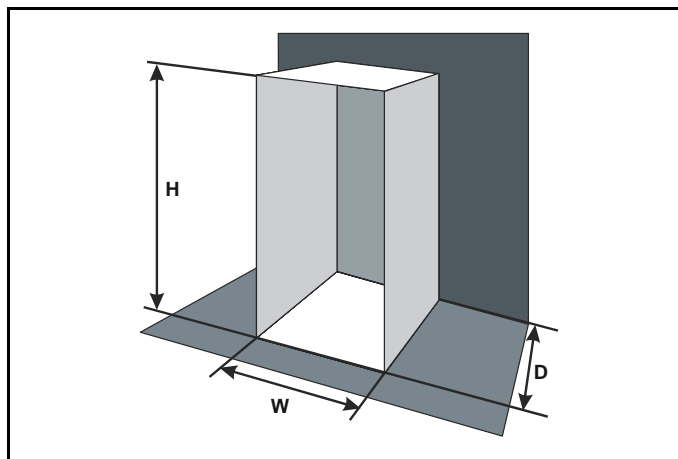
Dissipation of external switching frequency filter: 28 W x 1 (see section 10.4.3 *Switching frequency filter* on page 150)

Total dissipation: $((147 \times 2) + 9.2 + 125 + 28) = 456.2 \text{ W}$

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

The value of $5.5 \text{ W/m}^2/\text{°C}$ 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 5-17 Enclosure having front, sides and top panels free to dissipate heat



Insert the following values:

T_{int}	40°C
T_{ext}	30°C
k	5.5
P	456.2 W

The minimum required heat conducting area is then:

$$A_e = \frac{456.2}{5.5(40 - 30)}$$

$$= 8.294 \text{ m}^2 (90.36 \text{ ft}^2) \quad (1 \text{ m}^2 = 10.9 \text{ ft}^2)$$

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

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

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

$$W = \frac{10.72 - (2 \times 2 \times 0.6)}{2 + 0.6}$$

$$= 3.2 \text{ m (126.02 in)}$$

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

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

Calculating the air-flow in a ventilated enclosure

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

Calculate the minimum required volume of ventilating air from:

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

Where:

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

Where:

P_o is the air pressure at sea level

P_i 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 SP1406 (1 x Regen and 1 x motoring drive) models operating at the Normal Duty rating
- Each drive to operate at 6kHz PWM switching frequency
- Schaffner 16A (4200-6119) external EMC filter for each drive
- Maximum ambient temperature inside the enclosure: 40°C
- Maximum ambient temperature outside the enclosure: 30°C

Dissipation of each drive: 147 W (see Chapter 12 *Technical Data* in the *Unidrive SP User Guide*)

Dissipation of external EMC filter: 9.2 W (max) (see Chapter 12 *Technical Data* in the *Unidrive SP User Guide*)

Dissipation of external regen inductor: 125 W x 1 (see section 10.4.1 *Regen inductors* on page 149)

Dissipation of external switching frequency filter: 28 W x 1 (see section 10.4.3 *Switching frequency filter* on page 150)

Total dissipation: $((147 \times 2) + (9.2 + 125 + 28)) = 456.2 \text{ W}$

Insert the following values:

T_{int}	40°C
T_{ext}	30°C
k	1.3
P	456.2 W

Then:

$$V = \frac{2 \times 1.3 \times 456.2}{40 - 30}$$

$$= 118.6 \text{ m}^3/\text{hr (70.05 ft}^3/\text{min)} \quad (1 \text{ m}^3/\text{hr} = 0.59 \text{ ft}^3/\text{min})$$

5.5 Cubicle design and drive ambient temperature

Drive derating is required for operation in high ambient temperatures

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

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

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


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

Where:

T_{ext} = Temperature outside the cabinet

T_{int} = Temperature inside the cabinet

T_{rate} = Temperature used to select current rating from tables in Chapter 10 *Technical data* on page 147.



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.

CAUTION


5.6 External EMC filter

In order to provide our customers with a degree of flexibility, external EMC filters have been sourced from two manufacturers: Schaffner and Epcos. The external EMC Filter ratings and dimensions information are available in the *Unidrive SP User Guide*.

For currents exceeding 300A up to 2500A, suitable filters are also available from both Epcos and Schaffner as detailed.

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

These filters may not give strict conformity with EN6000-6-4 but in conjunction with EMC installation guidelines they will reduce emissions to sufficiently low levels to minimise the risk of disturbance.



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. Refer to section 6.4 *EMC (Electromagnetic compatibility)* on page 50.

CAUTION

6 Electrical Installation



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 energised, the AC supply must be isolated at least ten minutes before work may continue.

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

6.1 Power connections

6.1.1 AC and DC regen connections

Figure 6-1 Unidrive SP size 1 Regen drive power connections

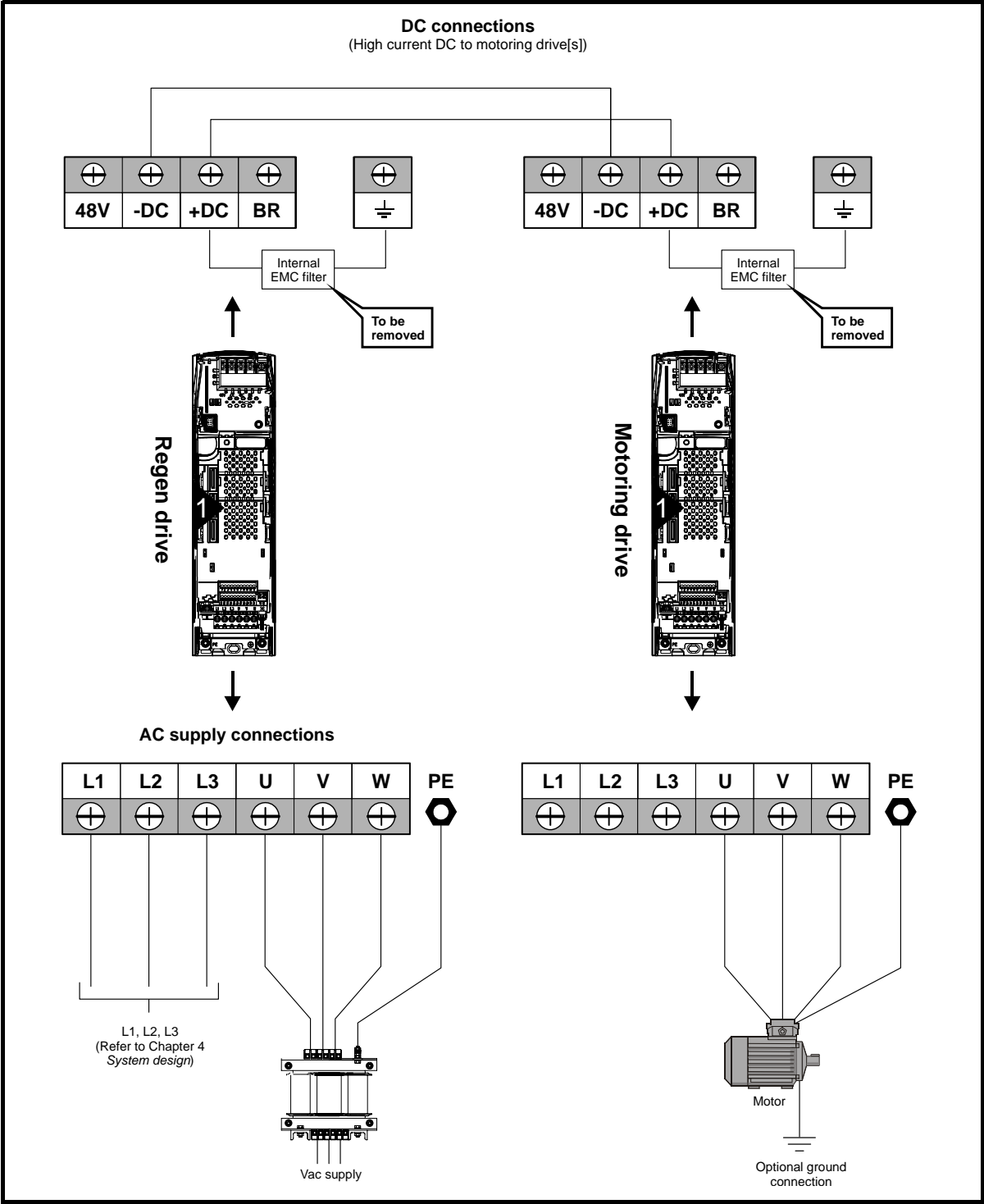
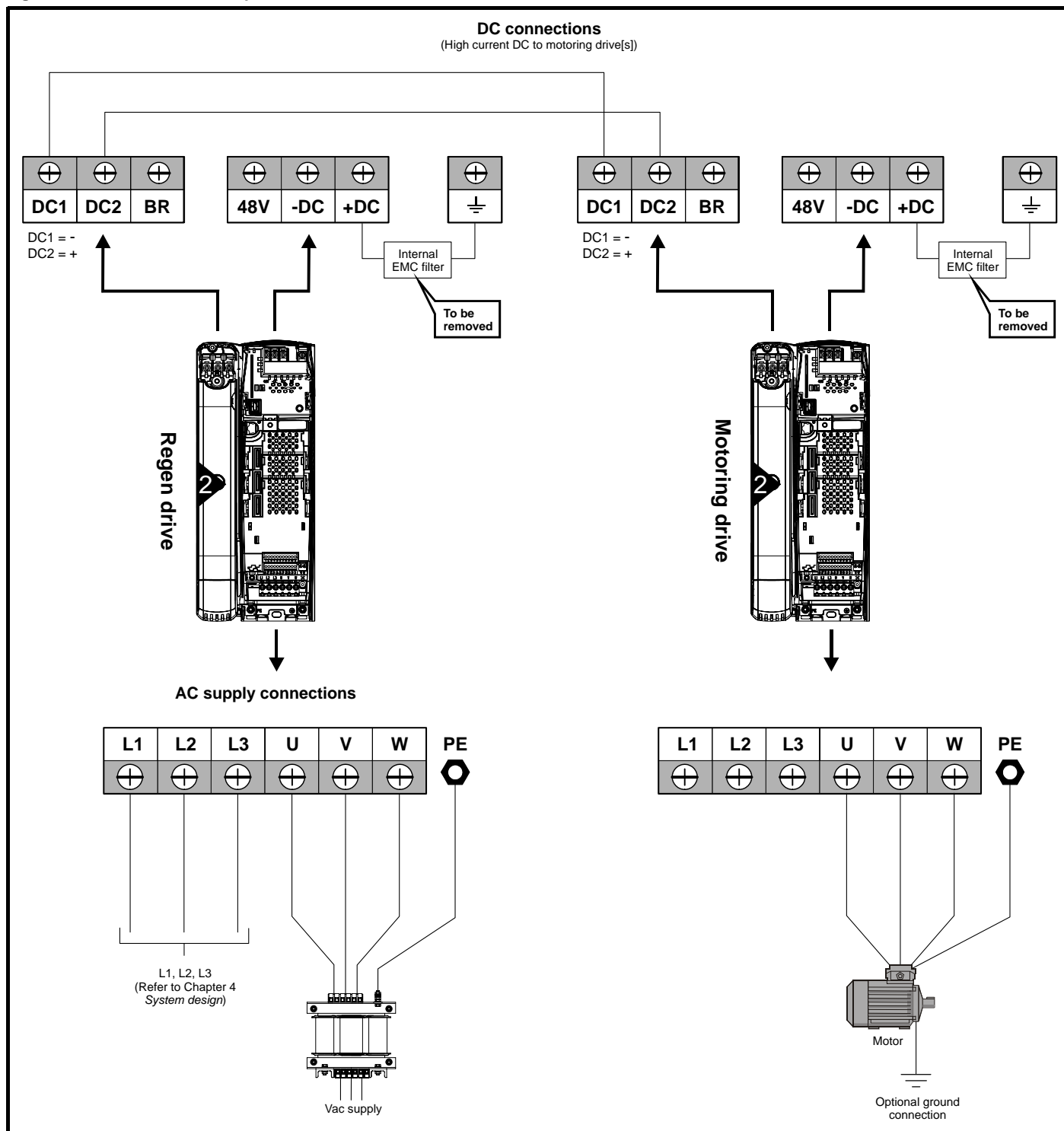


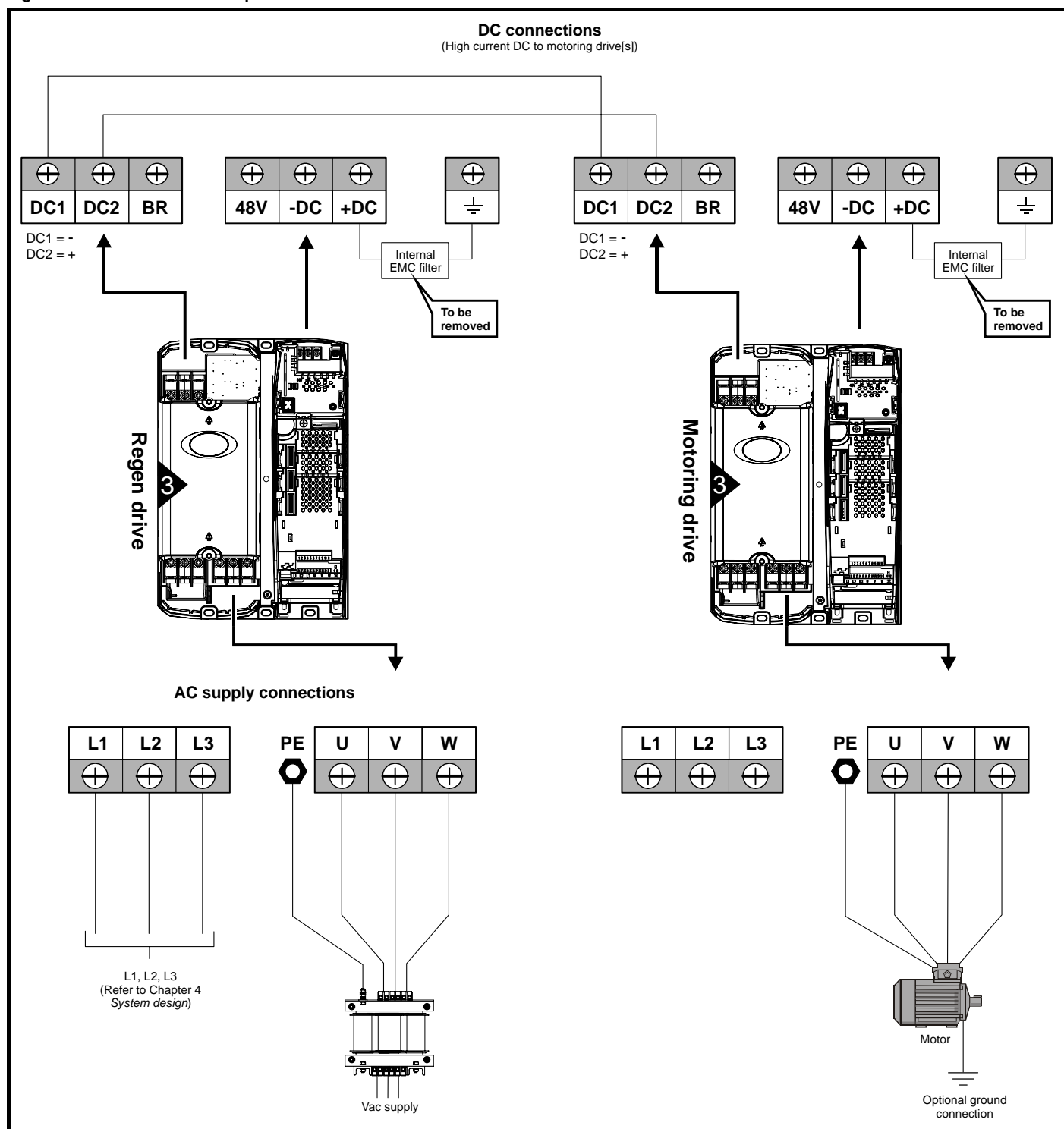
Figure 6-2 Unidrive SP size 2 power connections



If the heatsink mounted resistor is used (size 1 and 2 only), an overload protection device is not required. The resistor is designed to fail safely under fault conditions.

See Figure 6-6 for further information on ground connections.

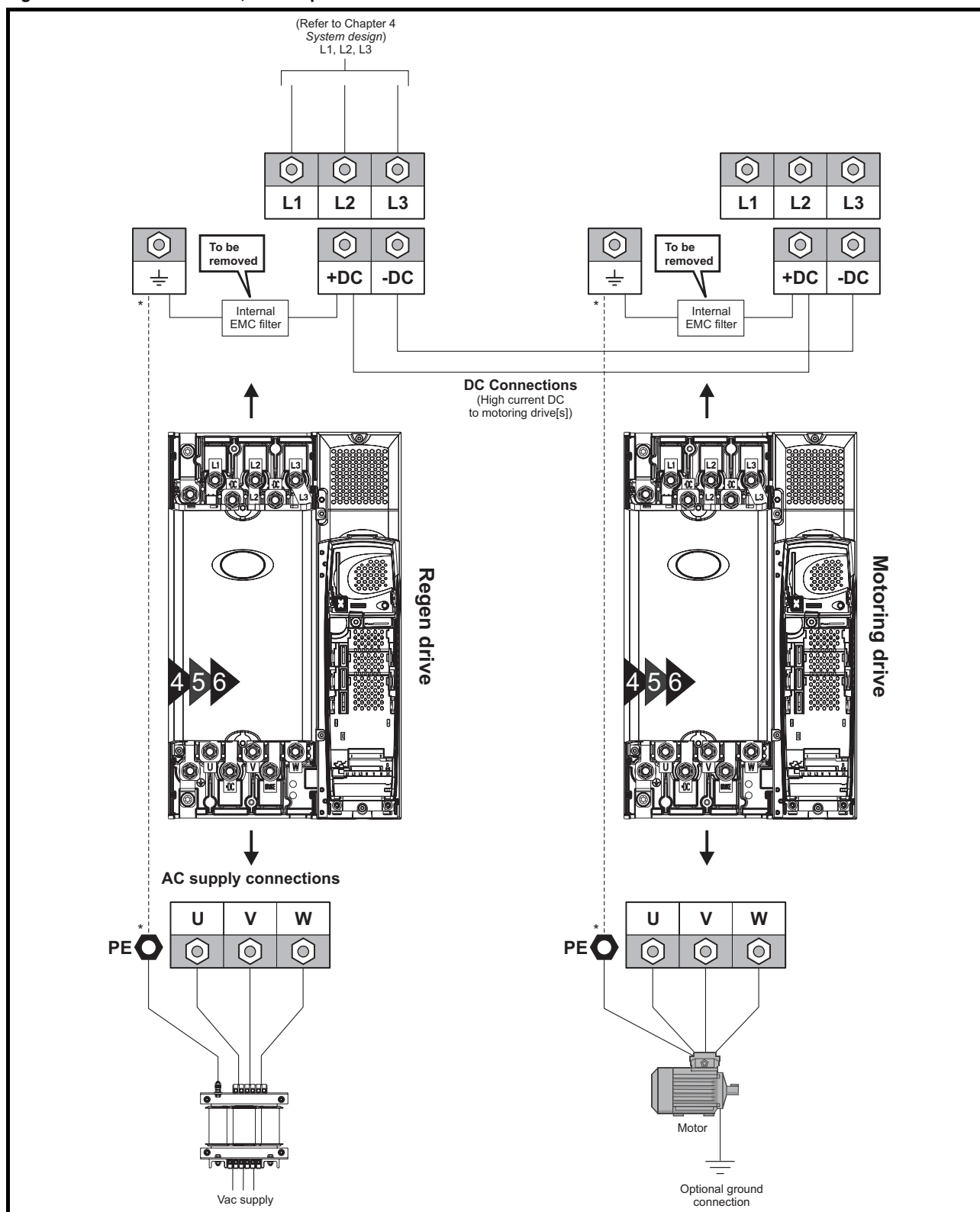
Figure 6-3 Unidrive SP size 3 power connections



On Unidrive SP size 2 and 3, the high current DC connections must always be used when using a braking resistor, supplying the drive from DC (low voltage 48V or high voltage) or using the drive in a parallel DC bus system. The low current DC connection is used only to connect the internal EMC filter.

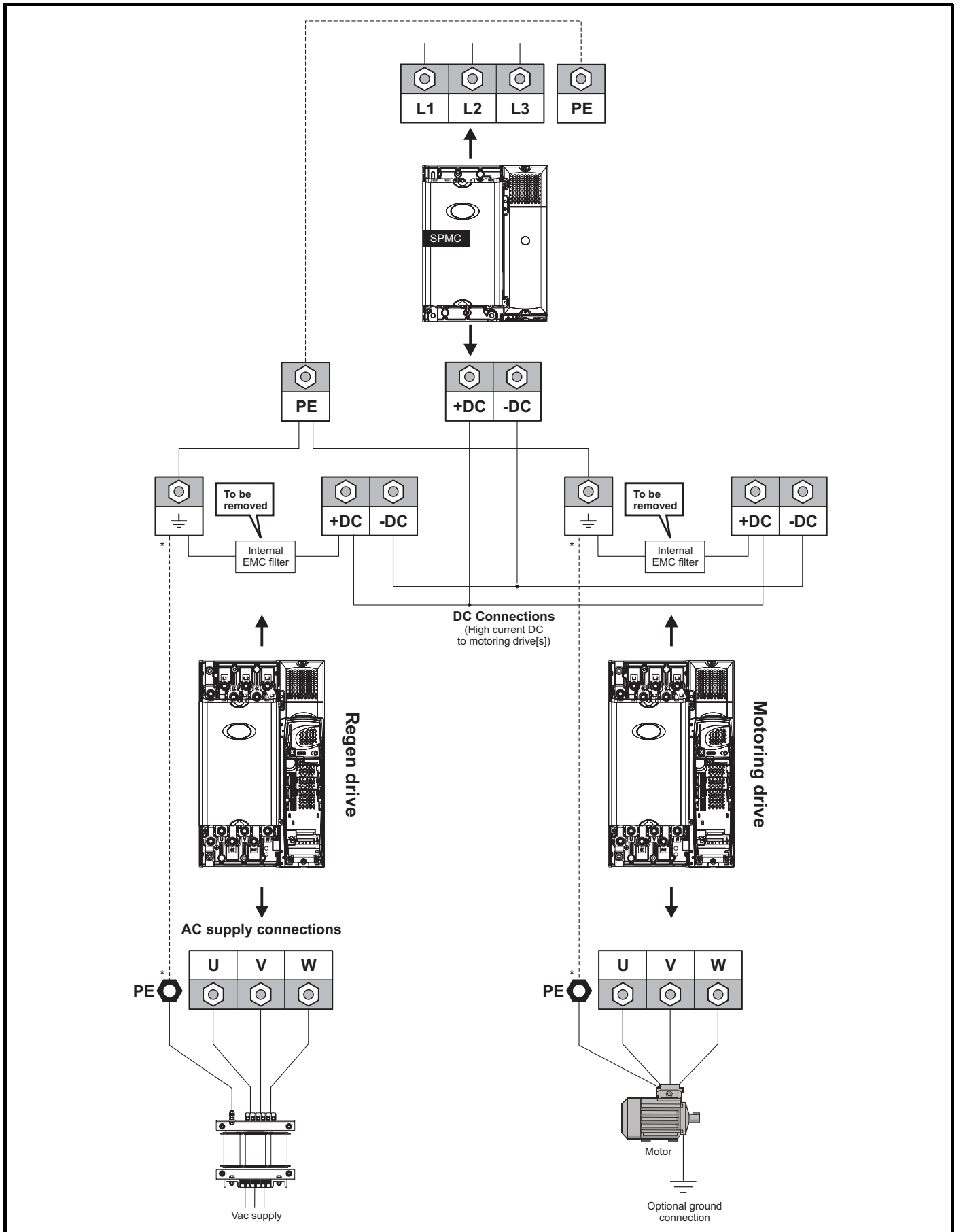
See Figure 6-7 for further information on ground connections.

Figure 6-4 Unidrive SP size 4, 5 and 6 power connections



* See section 6.1.2 Ground connections .

Figure 6-5 Unidrive SPMC power connections



* See section 6.1.2 Ground connections .

6.1.2 Ground connections

Size 1

On a Unidrive SP size 1, the supply and motor ground connections are made using the studs located either side of the drive near the plug-in power connector. Refer to Figure 6-1 on page 42.

Size 2

On a Unidrive SP size 2, the supply and motor ground connections are made using the grounding bridge that locates at the bottom of the drive. See Figure 6-6 for details.

Size 3

On a Unidrive SP size 3, the supply and motor ground connections are made using an M6 nut and bolt that locates in the fork protruding from the heatsink between the AC supply and motor output terminals. See Figure 6-7 for details.

Size 4, 5 and 6

On a Unidrive SP size 4, 5 and 6, the supply and motor ground connections are made using an M10 bolt at the top (supply) and bottom (motor) of the drive. See Figure 6-8.

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

Size 4: 19.2mm^2 (0.03in^2 , or slightly bigger than 6 AWG)

Size 5: 60mm^2 (0.09in^2 , or slightly bigger than 1 AWG)

Size 6: 75mm^2 (0.12in^2 , or slightly bigger than 2/0 AWG)

This connection is sufficient to provide the ground (equipotential bonding) connection for the motor circuit under the following conditions:

To standard	Conditions
IEC 60204-1 & EN 60204-1	Supply phase conductors having cross-sectional area not exceeding: Size 4: 38.4mm^2 Size 5: 120mm^2 Size 6: 150mm^2
NFPA 79	Supply protection device rating not exceeding: Size 4: 200A Size 5: 600A Size 6: 1000A

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



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 6-6 Unidrive SP size 2 ground connections

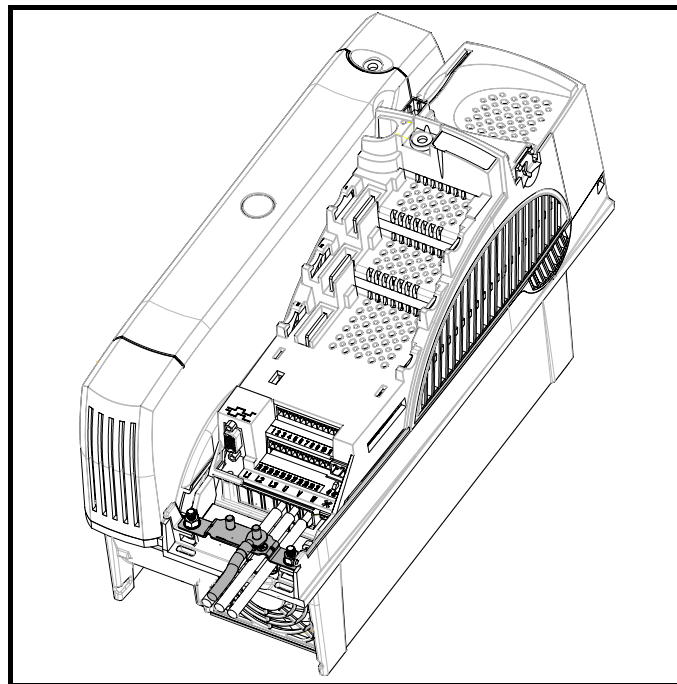


Figure 6-7 Unidrive SP size 3 ground connections

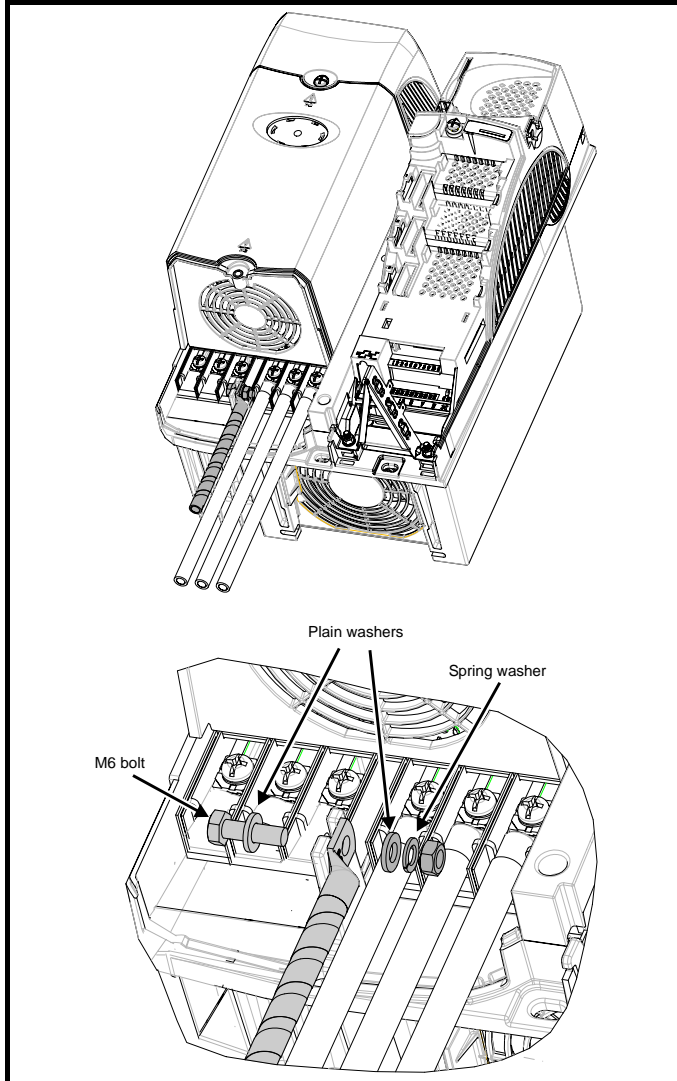


Figure 6-8 Unidrive SP size 4, 5 and 6 ground connections

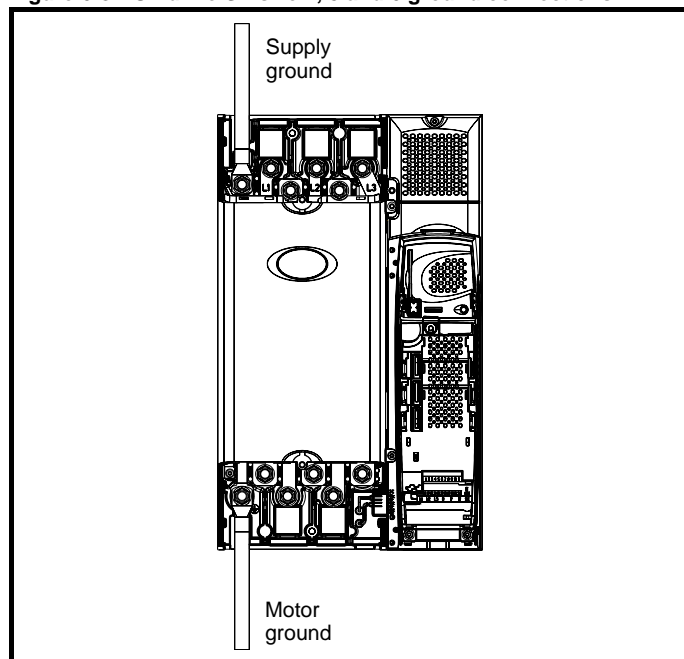
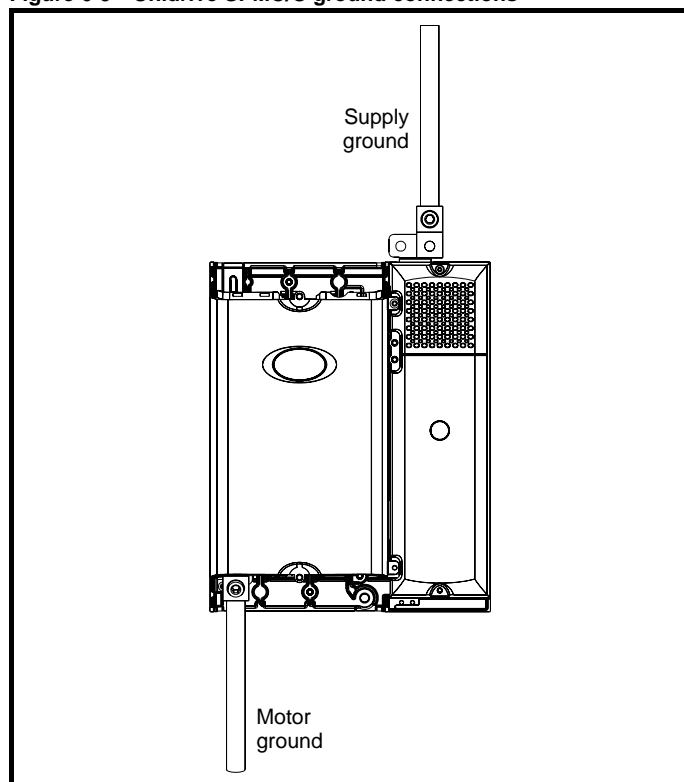


Figure 6-9 Unidrive SPMC/U ground connections



6.2 AC supplies

6.2.1 Supply types

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

6.2.2 Dedicated supplies

The nature of the mains supply has an important effect on the EMC arrangements. For a dedicated supply, i.e. one which has no other electrical equipment fed from the secondary of its distribution

transformer, normally neither an EMC filter or a switching frequency filter are required. Refer to *section 4.3.1 Omitting the switching frequency filter* on page 28.

6.2.3 Other supplies

Wherever other equipment shares the same low voltage supply, i.e. 400Vac, careful consideration must be given to the likely need for both switching frequency and EMC filters, as explained in *section 6.4.11 Switching frequency emission* and *section 6.4.12 Conducted RF emission*.

6.2.4 Supply voltage notching

Because of the use of input inductors and an active rectifier the drive causes no notching - but see *section 6.4.11 Switching frequency emission* for advice on switching frequency emission.

6.2.5 Supply harmonics

When operated from a balanced sinusoidal three-phase supply, the regenerative Unidrive SP 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.

6.3 Ratings

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

Typical input current

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

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

Maximum continuous input current

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

The values of maximum input current are stated for a supply with a 2% negative phase-sequence imbalance and rated at the maximum supply fault current given in Table 6-1 to Table 6-2.

Table 6-1 Size 1 to 3 input current, fuse and cable size ratings (European)

Model	Maximum continuous input current A	Fuse rating IEC gG A	Cable size EN60204
			Input mm ²
SP1405	8.8	12	1.0
SP1406	11	16	1.5
SP2401	15.3	20	2.5
SP2402	21	25	4.0
SP2403	29	32	6.0
SP2404	29	32	6.0
SP3401	35	40	10
SP3402	43	50	16
SP3403	56	63	25

Table 6-2 Size 1 to 3 input current, fuse and cable size ratings (USA)

Model	Maximum continuous input current A	Fuse rating A	Cable size UL508C
			Input AWG
SP1405	8.8	15	14
SP1406	11	15	14
SP2401	15.3	20	14
SP2402	21	25	10
SP2403	29	30	8
SP2404	29	30	8
SP3401	35	40	6
SP3402	43	45	6
SP3403	56	60	4

Table 6-3 Size 4, 5 and 6 input current, fuse and cable size ratings (universal)

Model	Max input current	Fuse option 1 IEC class gR <u>QR</u> North American Ferraz HSJ		Fuse option 2 HRC <u>AND</u> Semi-conductor		Cable size	
		IEC class gR	North American Ferraz HSJ	HRC IEC class gG UL class J	Semi-conductor IEC class aR	Input	
	A	A	A	A	A	mm ²	AWG
SP4401	68	80	80	80	160	25	3
SP4402	83	110	110	100	200	35	2
SP4403	104	125	125	125	200	50	1
SP5401	138	200	175	160	200	95	2/0
SP5402	168	250	225	200	250	120	4/0
SP6401	202	315	300	250	315	2 x 50	2 x 1
SP6402	236	315	300	315	350	2 x 50	2 x 1

The recommended cable sizes above 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 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.



Fuses

The AC supply to the drive must be fitted with suitable protection against overload and short-circuits. Table 6-1 to Table 6-2 shows recommended fuse ratings. Failure to observe this requirement will cause risk of fire.

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

An MCB (miniature circuit breaker) or MCCB (moulded-case circuit-breaker) with type C may be used in place of fuses on Unidrive SP sizes 1 to 3 under the following conditions:

- The fault-clearing capacity must be sufficient for the installation
- For frame sizes 2 and 3, the drive must be mounted in an enclosure which meets the requirements for a fire enclosure.

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.

6.3.1 Main AC supply contactor

The recommended AC supply contactor type for sizes 1 to 6 is AC1.

6.3.2 Motor winding voltage

Refer to the guidelines given in section 4.7.2 of the *Unidrive SP User Guide*. The DC bus voltage in a regen system with a 400V supply is usually 700V, which corresponds to an AC supply voltage of 519V. Unless the motor cable is less than 10m 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.

6.3.3 Use of residual current device (RCD)

There are three common types of ELCB / RCD:

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



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

6.4 EMC (Electromagnetic compatibility)

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

Section 6.4.2, General requirements for all applications, to ensure reliable operation of the drive and minimise the risk of disturbing nearby equipment. The immunity standards specified in section 11 will be met, but no specific emission standards. Note also the special requirements given in *Surge immunity of control circuits - long cables and connections outside a building* in the EMC section of the *Unidrive SP User Guide* for increased surge immunity of control circuits where control wiring is extended.

Section 6.4.3, Requirements for meeting the EMC standard for power drive systems, IEC61800-3 (EN61800-3).

Section 6.4.4, Requirements for meeting the generic emission standards for the industrial environment, IEC61000-6-4, EN61000-6-4, EN50081-2.

The recommendations of section 6.4.2 will usually be sufficient to avoid causing disturbance to adjacent equipment of industrial quality. If particularly sensitive equipment is to be used nearby, or in a non-industrial environment, then the recommendations of section 6.4.3 or section 6.4.4 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*

...the correct external EMC filter must be used and all of the guidelines in section 6.4.2 *General requirements for EMC* and section 6.4.4 *Compliance with generic emission standards* must be followed.

Table 6-4 Unidrive SP and EMC filter cross reference

Drive	Schaffner	Epcos
	CT part no.	CT part no.
SP1405 to SP1406	4200-6119	4200-6120
SP2401 to SP2404	4200-6210	4200-6211
SP3401 to SP3403	4200-6305	4200-6306
SP4401 to SP4403	4200-6406	4200-6405
SP5401 to SP5402	4200-6503	4200-6501
SP6401 to SP6402	4200-6603	



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



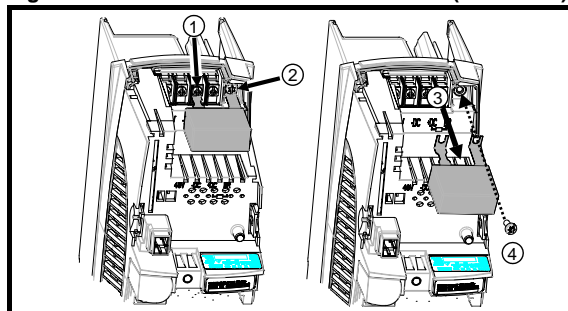
The installer of the drive is responsible for ensuring compliance with the EMC regulations that apply where the drive is to be used.

6.4.1 Removal of internal EMC filter



The internal EMC filter must be removed from the drive.

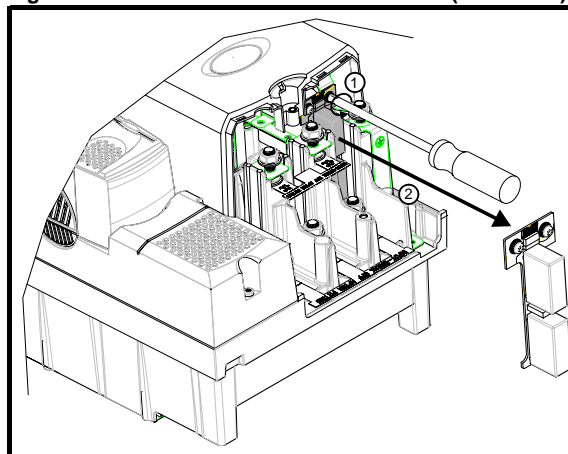
Figure 6-10 Removal of internal EMC filter (size 1 to 3)



Loosen / remove screws as shown (1) and (2).

Remove filter (3), and ensure the screws are replaced and re-tightened (4).

Figure 6-11 Removal of internal EMC filter (size 4 to 6)



Loosen screws (1). Remove EMC filter in the direction shown (2).

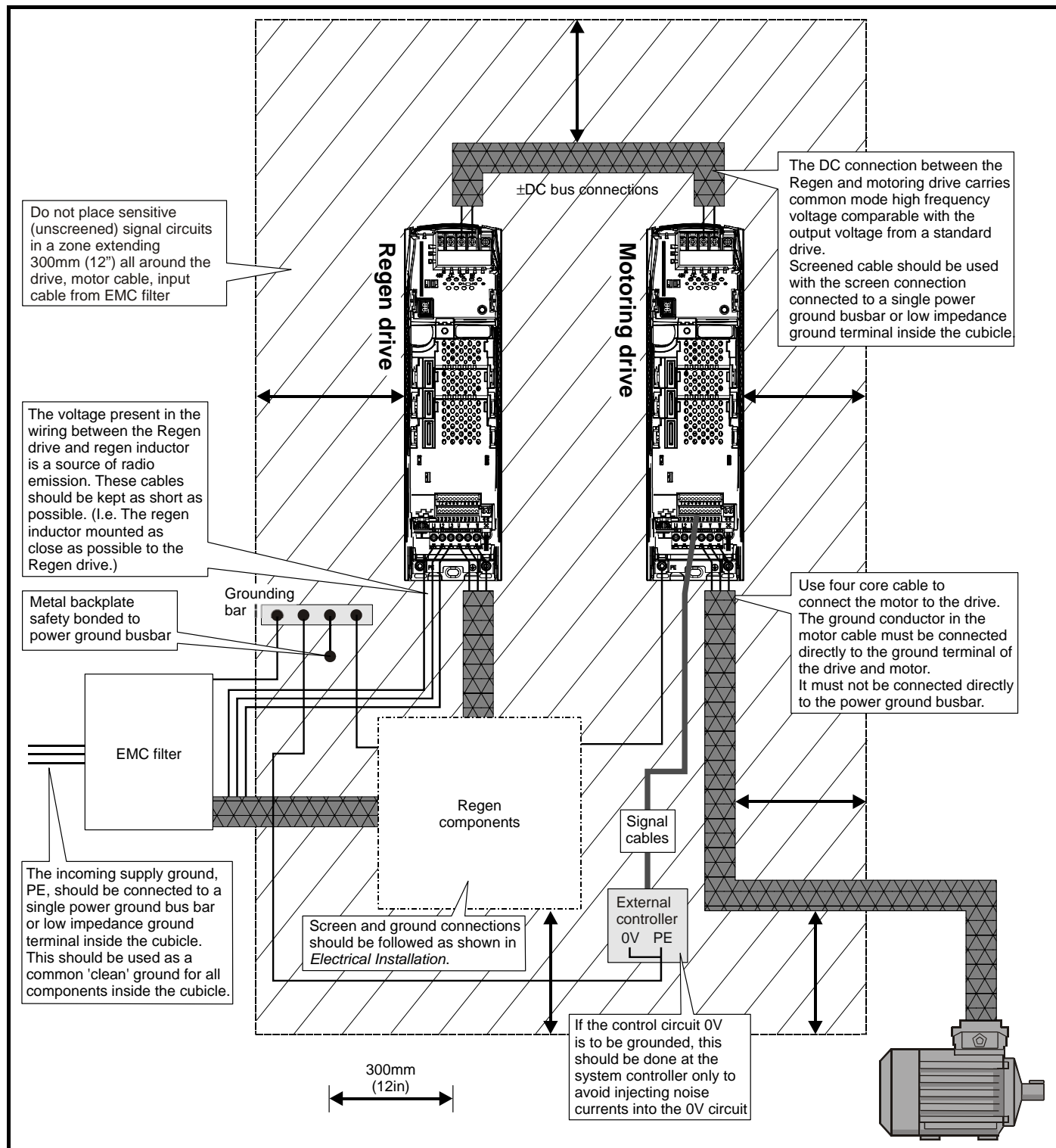
6.4.2 General requirements for EMC

Ground (earth) connections

The grounding arrangements should be in accordance with Figure 6-12, which shows both drives mounted on a back-plate with or without an additional enclosure.

Figure 6-12 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.

Figure 6-12 General EMC enclosure layout showing earth / ground connections




6.4.3 Compliance with EN61800-3 (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 6.4.4 *Compliance with generic emission standards* on page 52. An external EMC filter will always be required.



This is a product of the restricted distribution class according to IEC61800-3

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

CAUTION

Operation in the second environment

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


Size 1

Where a filter is required, follow the guidelines in section 6.4.2 *General requirements for EMC* on page 51.

For cable lengths up to 10m compliance can be maintained by fitting a ferrite ring, part no. 4200-0000, 4200-0001 or 4200-3608, to the drive output. Feed the motor cables (U,V,W) through the ring once.

Size 2 and 3

Where a filter is required, follow the guidelines in section 6.4.2 *General requirements for EMC* on page 51.



The second environment typically includes an industrial low-voltage power supply network which does not supply buildings used for domestic 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 6.4.4 *Compliance with generic emission standards* be adhered to.

CAUTION

Refer to section 6.4 *EMC (Electromagnetic compatibility)* on page 50 for further information on compliance with EMC standards and definitions of environments.

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

6.4.4 Compliance with generic emission standards

Use the recommended filter and shielded motor cable. Observe the layout rules given in the current *Unidrive SP User Guide*.

6.4.5 Immunity

The immunity of the individual drive modules is not affected by operation in the regenerative mode. 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 synchronised to the supply, there is a limit to the permitted rate of change of supply frequency. If rates of change exceeding 100Hz/s are expected then C.T. Technical Support should be consulted. This would only arise under exceptional circumstances e.g. where the power system is supplied from an individual generator.

6.4.6 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 30MHz where emission is predominantly by conduction
- High frequency emission above 30MHz where emission is predominantly by radiation

6.4.7 Dedicated supplies

The nature of the mains supply has an important effect on the EMC arrangements. For a dedicated supply, i.e. one which has no other electrical equipment fed from the secondary of its distribution transformer, normally neither an EMC filter or a switching frequency filter are required. Refer to section 4.3.1 *Omitting the switching frequency filter* on page 28.

6.4.8 Other supplies

Wherever other equipment shares the same low voltage supply, i.e. 400Vac, careful consideration must be given to the likely need for both switching frequency and EMC filters, as explained in section 6.4.11 *Switching frequency emission* and section 6.4.12 *Conducted RF emission*.

6.4.9 Supply voltage notching

Because of the use of input inductors and an active rectifier the drive causes no notching - but see section 6.4.11 *Switching frequency emission* for advice on switching frequency emission.


6.4.10 Supply harmonics

When operated from a balanced sinusoidal three-phase supply, the regenerative Unidrive SP 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.

6.4.11 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 3kHz switching frequency and 50Hz supply frequency there is current at 2.90, 3.10, 5.95, 6.05kHz 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; *Supply assessment* on page 28 gives guidelines to help in assessing whether a switching-frequency filter is required. In case of doubt, unless the drive operates from a dedicated supply not shared with other loads, it is strongly recommended that the filter be fitted.



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.

CAUTION

6.4.12 Conducted RF emission

Radio frequency emission in the frequency range from 150kHz to 30MHz is mainly conducted out of the equipment through electrical wiring. It is essential for compliance with all emission standards, except for IEC61800-3 second environment, 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 screen. For example, the screen formed by the armouring of steel wired armoured 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 screened.



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

When used with the recommended filters, the Regen drive system complies with the requirements for conducted emission in the following standards:

Table 6-5 Requirements for conducted emission

Motor cable length (m)	Switching frequency (kHz)
0 to 100	3
	1

Key to table	Standard	Description	Frequency range	Limits	Application
I	EN50081-2	Generic emission standard for the industrial environment	0.15 to 0.5MHz	79dB μ V quasi peak 66dB μ V average	AC supply lines
			0.5 to 30MHz	73dB μ V quasi peak 60dB μ V average	
	EN61800-3 IEC1800-3	Product standard for adjustable speed power drive systems	Requirements for the first environment ¹ : restricted distribution ² Requirements for the second environment: unrestricted distribution		
1	The first environment is one where the low voltage supply network also supplies domestic premises				
2	Restricted distribution means that drives are available only to installers with EMC competence				

For installation in the "second environment", i.e. where the low voltage supply network does not supply domestic premises, no filter is required in order to meet IEC61800-3 (EN61800-3):1996.



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 6-6 Recommended filters

Drive	Motor cable length m	Schaffner	Epcos
		CT part no.	CT part no.
SP1401 to SP1404	100	4200-6118	4200-6121
SP1405 to SP1406		4200-6119	4200-6120
SP2401 to SP2404		4200-6210	4200-6211
SP3401 to SP3403		4200-6305	4200-6306
SP4401 to SP4403		4200-6406	4200-6405
SP5401 to SP5402		4200-6503	4200-6501
SP6401 to SP6402		4200-6603	

Related product standards

The conducted emission levels specified in EN50081-2 are equivalent to the levels required by the following product specific standards:

Table 6-7 Conducted emission from 150kHz to 30MHz

Generic standard	Product standard	
EN61000-6-4	EN55011 Class A Group 1 CISPR 11 Class A Group 1	Industrial, scientific and medical equipment
	EN55022 Class A CISPR 22 Class A	Information technology equipment

6.4.13 Radiated emission

Radio frequency emission in the frequency range from 30MHz to 1GHz is mainly radiated directly from the equipment and from the wiring in its immediate vicinity. Operation in regenerative mode does not alter the radiated emission behaviour, and the EMC data sheet for the individual Unidrive SPs used should be consulted for further information.

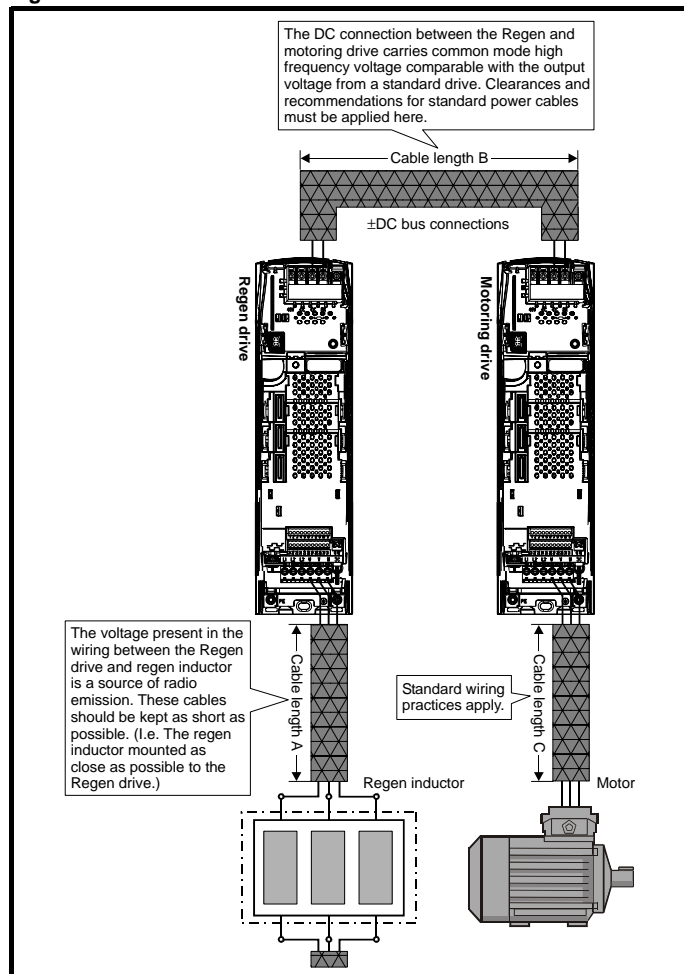
NOTE

Theoretically the use of two drives physically close together can cause an increase in emission level of 3dB compared with a single drive, although this is usually not observed in practice. All Unidrive SPs have sufficient margin in respect of the generic standard for the industrial environment EN61000-6-4 to allow for this increase.

6.4.14 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 6-13 Power cable considerations



6.4.15 Main contactors K2 with SPMC

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

6.4.16 Multi-drive systems

It is common for regenerative drive systems to be constructed using numbers of drives with a single input stage, or other more complex arrangements. It is generally not possible to lay down specific EMC requirements for such systems, since they are too large for standardised tests to be carried out. In many cases the environment corresponds to the “second environment” as described in IEC61800-3, in which case no specific limit to conducted emission is required. National legislation such as the European Union EMC Directive does not usually require that complex installations meet specific standards, but only that they meet the essential protection requirements, i.e. not to cause or suffer from electromagnetic interference.

Where the environment is known to include equipment which is sensitive to electromagnetic disturbance, or the low voltage supply network is shared with domestic dwellings, then precautions should be taken to minimise conducted radio frequency emission by the use of a filter at the system power input.

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

Epcos B84143-B250-5xx (range up to 2500A)

Schaffner FN3359-300-99 (range up to 2400A)

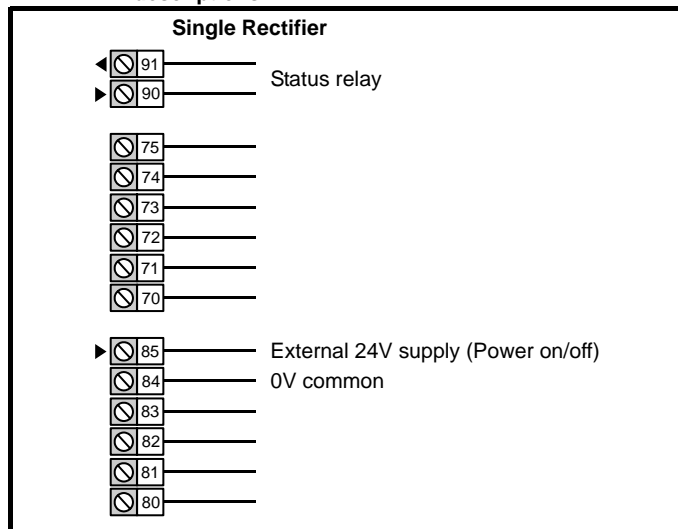
These filters may not give strict conformity with EN61000-6-4, but in conjunction with the relevant EMC installation guidelines they will reduce emission to sufficiently low levels to minimise the risk of disturbance.

6.5 Control connections

6.5.1 Unidrive SPMC control terminals

The following diagram shows the required connections for the SPMC to T.84 and T.85. Also shown is the status relay which can be utilised if required.

Figure 6-14 Unidrive SPMC (single rectifier) control terminals and descriptions



6.5.2 Unidrive SP control terminals

Table 6-8 The Unidrive SP control connections consist of:

Function	Qty	Control parameters	Terminal No.
Differential analogue input	1	Destination, offset, offset trim, invert, scaling	5,6
Single ended analogue input	2	Mode, offset, scaling, invert, destination	7,8
Analogue output	2	Source, mode, scaling,	9,10
Digital input	3	Destination, invert, logic select	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 (Secure Disable)	1		31
+10V User output	1		4
+24V User output	1	Source, invert	22
0V common	6		1, 3, 11, 21, 23, 30
+24V External input	1		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: analogue - indicates the mode of operation of the terminal, i.e. voltage 0-10V, current 4-20mA 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 analogue 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 auxilliary 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 Unidrive SP.

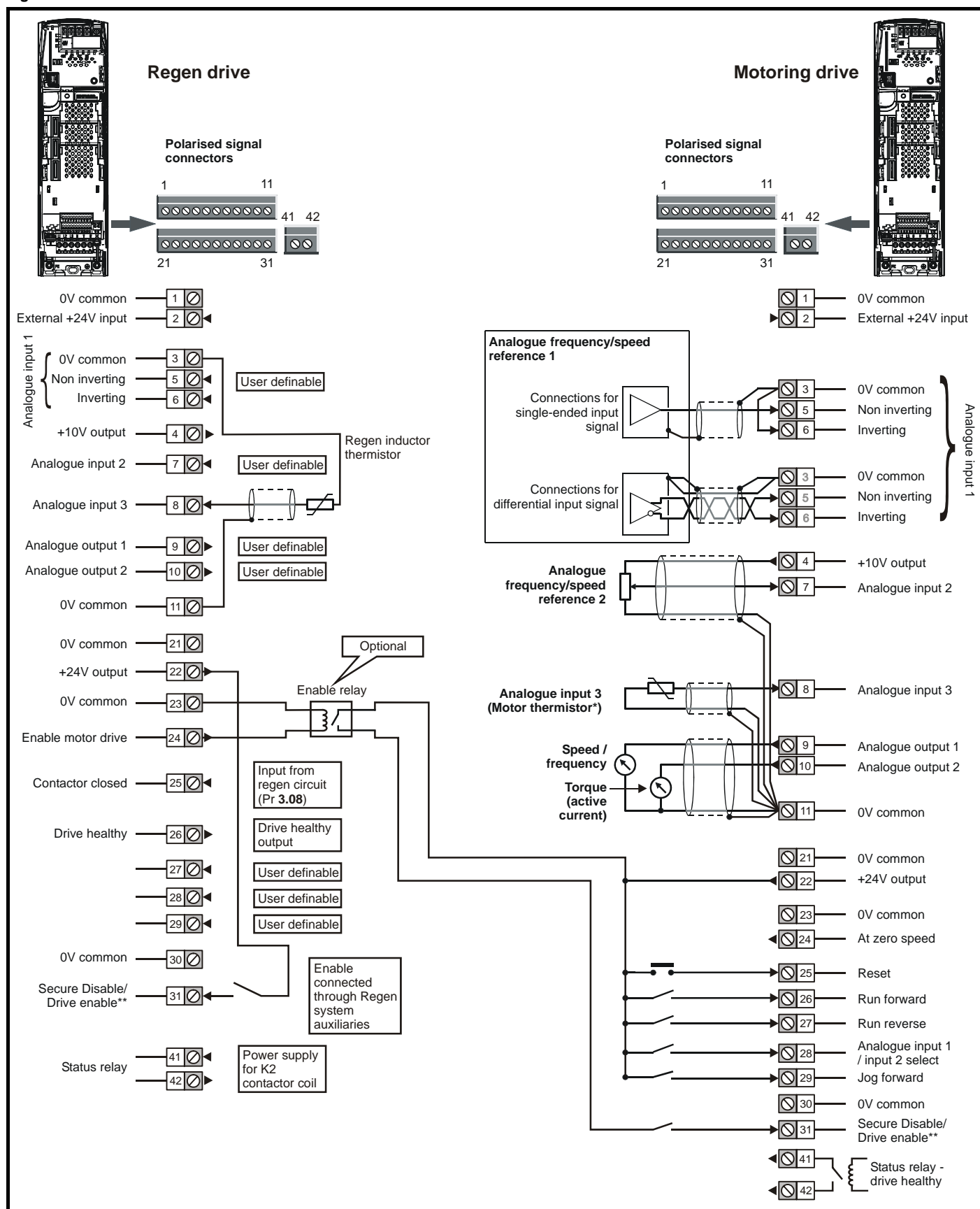
NOTE

The Secure Disable / drive enable terminal is a positive logic input only. It is not affected by the setting of Pr **8.29 Positive logic select**.

NOTE

The common 0V from analogue signals should, wherever possible, not be connected to the same 0V terminal as the common 0V from digital signals. Terminals 3 and 11 should be used for connecting the 0V common of analogue 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 analogue signals.

Figure 6-15 Default terminal functions



* Analogue input 3 can be configured as a motor thermistor input, refer to the *Unidrive SP User Guide*.

**The Secure Disable / Drive enable terminal is a positive logic input only.

7 Getting started

7.1 Regen parameter settings

7.1.1 Switching frequency Pr 5.18 (Pr 0.41)

Set the switching frequency on the Regen drive to the required value (3kHz 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 3kHz results in current derating. Refer to Chapter 12 *Technical Data* in the *Unidrive SP User Guide*.

7.1.2 DC bus voltage set point

The table below defines these levels, assuming a tolerance of $\pm 10\%$ on the supply voltage (default value is 700V). 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. Note that Pr 3.05 (Pr 0.01) can be set to any value between 0 and 800V.

Table 7-1 DC bus voltage set point - Pr 3.05 (Pr 0.01)

Supply Voltage Vac	Default Vdc	Recommended Vdc	Maximum Vdc
380	650	700	800
415	680	700	800
480	780	780	800

The DC bus voltage set point, see Pr 3.05 (Pr 0.01), 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 3.05 (Pr 0.01) is set above the peak AC supply voltage

7.2 Regen drive sequencing

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

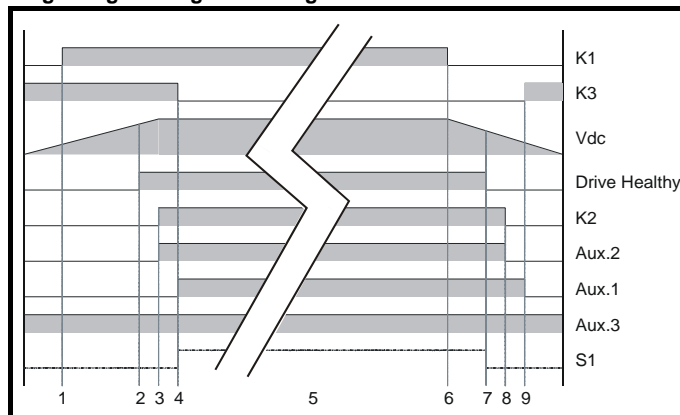
Only when all of these stages have been completed successfully is the motoring drive enabled. If at any time there is a fault, or the Regen drive is disabled, the motoring drive will also be disabled.

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

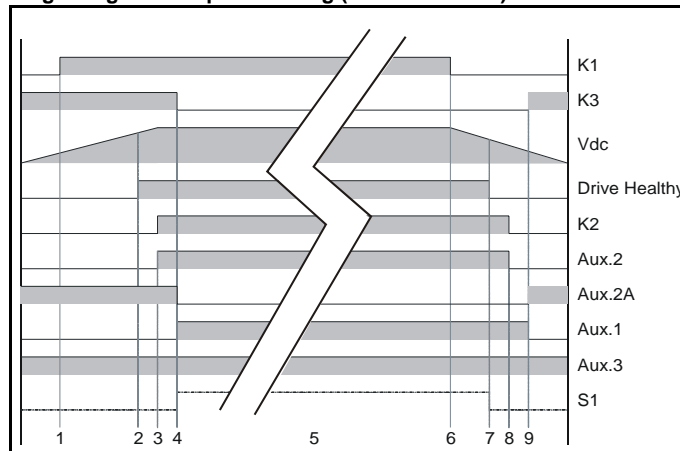
Single Regen: Single Motoring



1. K1 (main supply contactor / isolator) 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 > 430Vdc 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 410Vdc 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

Single Regen: Multiple Motoring (Unidrive SPMC)

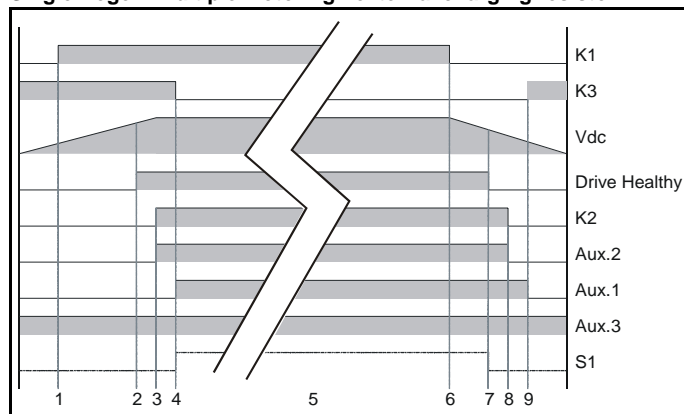


1. K1 (main supply contactor / isolator) is closed with charging circuit active (K3 closed).
2. DC bus charges through Unidrive SPMC (charging circuit).
3. If the DC Bus > 430Vdc then K2 Regen drive main contactor and Aux.2 are closed via Regen drives relay, control terminals 41, 42.
4. K3 charging contactor is opened via K2 (Regen drive main contactor), SPMC 24Vdc is removed Aux.2A 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.

- DC bus discharges to 410Vdc 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.
- 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. K3 charging contactor is closed and Aux.1 opens.

Power applied and power removed

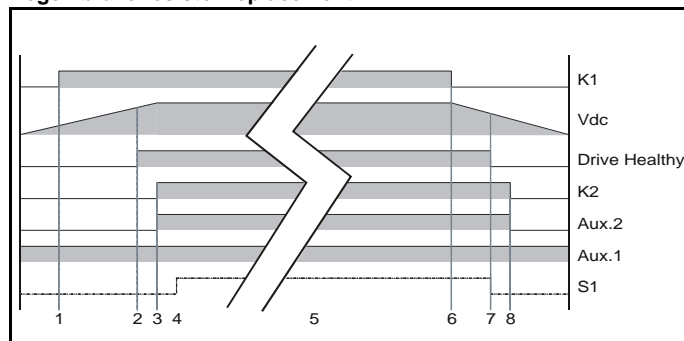
Single Regen: Multiple Motoring - external charging resistor



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

Power applied and power removed

Regen brake resistor replacement



- K1 (main supply contactor / isolator) is closed.
- DC bus charges through motoring drives L1, L2, L3 Vac inputs.
- If the DC Bus > 430Vdc then K2 Regen drive main contactor and Aux.2 are closed via Regen drives relay, control terminals 41, 42.
- Regen drive enable, S1 can now be applied.
- The Regen drive and motoring drives can be enabled (enable signal from Regen drive to motoring drives active, control terminal 24).

- K1 (main supply contactor / isolator) is opened removing power from the regen system.
- DC bus discharges to 410Vdc 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.
- 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.

NOTE

When the Regen drive has powered-up and the DC bus voltage has exceeded 430Vdc, Pr 3.07 changes from 0 to 1 activating the drives relay which in turn closes the Regen drive main contactor. If either the DC bus voltage falls below the contactor open voltage (410Vdc) or the system is synchronised and the AC voltage falls below contactor open voltage (150Vac), Pr 3.07 will change from a 1 to 0 opening the Regen drive main contactor.

Synchronisation:

- Apply test pulses to line to determine magnitude and phase.
- Attempt to synchronise to the line.
- If synchronisation 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 energised 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 synchronises to the Vac supply and therefore knows the supply voltage (Pr 5.02)
- OR the DC bus voltage goes out of regulation
DC bus drops below the contactor open voltage level (410 Vdc)
- OR there is any trip on the Regen drive
Drive healthy no longer active. Regen and motoring drive(s) enable removed
- OR the supply contactor is de-energised
Aux.2 connected to control terminal 25 of Regen drive
- OR the Regen drive is disabled
- OR the MCB trips
Switching frequency filter or external charging 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

7.3 Regen brake drives in operation

7.3.1 Sequence

The motoring drive must only be enabled when the Regen drive is enabled, healthy, and synchronised to the AC supply. This will prevent any damage to the regen drive start-up circuit and prevent OV trips.

7.4 Regen drive commissioning

- Ensure power and control connections are made as specified in this Installation 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 11.31 (Pr 0.48) 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* . Save the parameters.

- The Regen drive can now be enabled, the Regen drive should display *ACT*.
- The commissioning of the motoring drive(s) can now be carried out.

7.5 Motoring drive commissioning

7.5.1 Motoring drive enable

When the Regen drive has been successfully synchronised, Pr **3.09** on the Regen drive will become active and digital output F1 on terminal 24 also becomes active allowing the motoring drive(s) to be enabled. If the Regen drive trips or attempts to re-synchronise to the supply, Pr **3.09** 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.

7.5.2 Ramp Mode - Pr 2.04 (Pr 0.15)

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.

7.5.3 Voltage Control Mode - Open loop only Pr 5.14 (Pr 0.07)

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 synchronises 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*.

7.5.4 AC Supply Loss Mode - Pr 6.03

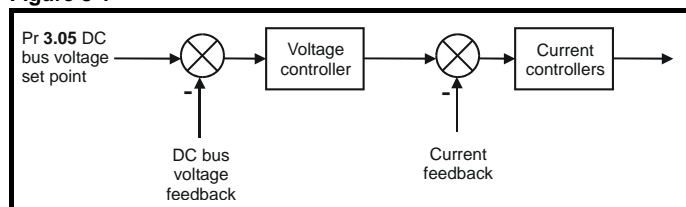
The motoring drive will not operate correctly if the AC supply loss mode is set to *STOP*. If the AC supply is lost, the Regen drive disables the motoring drive and prevents a controlled stop from being completed.

8 Optimisation

The following section covers optimisation of the Regen drive that can be carried out by the user.

The Regen drive uses a DC bus voltage controller with inner current controllers as shown in Figure 8-1:

Figure 8-1



The gains of the voltage and current controllers affect the stability of the Regen drive control system with incorrect settings resulting in over-voltage or over-current trips.

8.1 Power feed-forward compensation (Pr 3.10)

Power feed-forward compensation can be used to reduce the transient DC bus voltage produced when a fast load transient occurs on drives connected to the Regen drive.

100.0% power feed-forward is equivalent to an active current of:

Drive rated current / 0.45 (i.e. over current trip level)

and a Vac terminal peak phase voltage equal to:

DC_VOLTAGE_MAX / 2

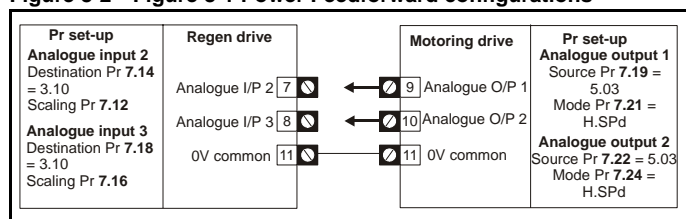
This scaling is the same as the power output from Pr 5.03 when high-speed output mode is used (Refer to section 9.7 *Menu 7: Analogue I/O*). Therefore an analogue output from the drive supplying the load, and analogue input 2 or 3 of the drive acting as the supply Regen drive can be connected together to give power feed-forward compensation without further scaling if the two drives are of equal rating.

If the ratings are different the analogue input scaling must be used to give the correct power feed-forward, where the scaling is given by (*load drive*) drive rated current / (*Regen drive*) drive rated current.

Figure 8-1 shows the Regen drives analogue inputs and motoring drives analogue outputs which can be used to pass Pr 5.03 (motoring drive output power) to the Regen drive which is then used for the power feedforward.

Only one analogue output from the motoring drive and one analogue input to the Regen drive is required to configure the power feedforward term.

Figure 8-2 Figure 8-1 Power Feedforward configurations



8.2 Current loop gains Kp (Pr 4.13) and Ki (Pr 4.14)

The defaults Kp, Pr 4.13 and Ki, Pr 4.14 gains 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 4.13. The required value for this is dependent upon the Regen drive 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 4.13 should be adjusted as described following using the total inductance per phase.

The **proportional gain**, Pr 4.13 can be set by the user so that

$$\text{Pr 4.13} = K_p = (L / T) \times (I_{fs} / V_{fs}) \times (256 / 5)$$

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 167µs.

L is the total input inductance. This is the inductance value in Pr 3.02 at power-up this parameter is zero. Each time the Regen drive is enabled the total input inductance is measured and displayed in Pr 3.02. The value given is only approximate, and will give an indication as whether the input inductance is correct for the sinusoidal rectifier unit size. The measured value should include the supply inductance as well as the Regen drive input inductance, however, the supply filter capacitance, masks the effect of the supply inductance. Therefore the value measured is usually the Regen drive input inductor value.

I_{fs} is the peak full-scale current feedback

$$I_{fs} = \text{Drive rated current} \times \sqrt{2} / 0.45 \text{ (Drive rated current [Pr 11.32])}$$

V_{fs} is the maximum DC bus voltage.

Therefore:

$$\begin{aligned} \text{Pr 4.13} &= K_p = (L / 167\mu\text{s}) \times (\text{Drive rated current} \times \sqrt{2} / 0.45 / V_{fs}) \times (256 / 5) \\ &= K \times L \times \text{Rated drive current} \end{aligned}$$

Where:

$$K = \sqrt{2} / (0.45 \times V_{fs} \times 167\mu\text{s}) \times (256 / 5)$$

Table 8-1

Drive voltage rating	V _{fs}	K
400V	830V	1161

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 8-2

Switching frequency kHz	Current control sample time (T) µs
3	167
4	125
6	83
8	125
12	83
16	125

As previously detailed the current controller **integral gain**, Pr 4.14 is not so critical with the recommended value being the default setting.

8.3 Voltage controller gain (Pr 3.06)

Even when the gains are set correctly there will be a transient change of DC bus voltage when there is a change in the load on any motoring drive connected to the Regen drive. This can be reduced substantially by using an analogue input for power feed forward compensation.

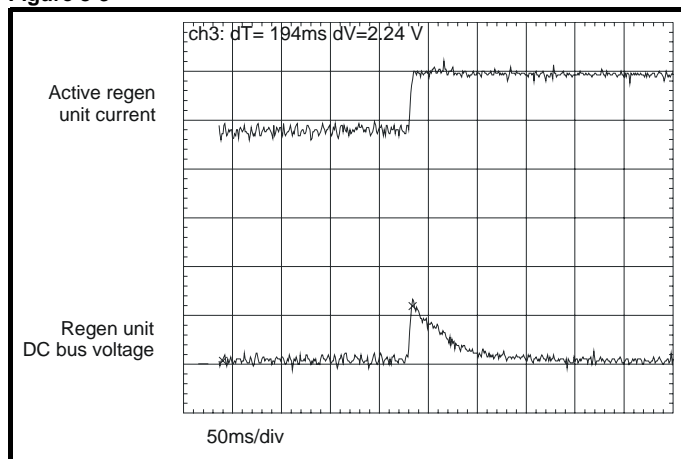
The following discussion relates to a system without power feed-forward compensation.

If the power flow from the supply is increased (i.e. more power is taken from the supply or less power is fed back into the supply) 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 from the supply is reduced (i.e. less power is taken from the supply or more power is fed back into the supply) the DC bus voltage will rise. During a rapid transient the DC bus will rise and then fall as shown in Figure 8-3.

Figure 8-3



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 proportional gain of the voltage controller, K_p , Pr 3.06, defines the voltage transient because the integral term is too slow to have an effect. (In applications where the motor drive is operating under speed control, the speed controller may only require a limited rate of change of torque demand, and so the transient voltage may be less than covered in the discussion below.)

If the set point voltage Pr 3.05, plus the transient rise exceed the over-voltage trip level the Regen drive will trip.

When a 400V motor is operated above base speed from a drive in closed loop vector mode, fed from the Regen drive with the same rating, supplying a DC voltage of 700V, and an instantaneous change of torque is demanded (i.e. -100% to +100%) the peak of the voltage transient (ΔV) is approximately 80V if the current controllers are set up correctly and the voltage controller uses the default gain. (Operating with maximum voltage on the motor, i.e. above base speed, gives the biggest transient of power and hence the biggest value of ΔV .)

If the load change, drive voltage rating, motor voltage or DC Bus set point are different then ΔV is calculated from:

$$\Delta V = 80V \times K_L \times K_{RAT} \times K_{MV} \times K_{SP}$$

Where:

$$K_L = \text{Load change} / 200\%$$

$$K_{RAT} = \text{Drive voltage rating} / 400$$

$$K_{MV} = \text{Motor voltage} / 400$$

$$K_{SP} = 700 / \text{DC bus voltage set point}$$

In some applications, particularly with a high DC bus voltage set point and low switching frequency it may be necessary to limit the rate of change of power flow to prevent over voltage trips. A first order filter on the torque reference of the motor drive (Pr 4.12) is the most effective method to reduce the transient further. (A fixed limit of the rate of change of torque demand is less effective.) Table 8-3 gives an approximate indication of the reduction in ΔV for different time constants. (As already mentioned the value of ΔV given is for an instantaneous change of torque representing the worst case. In applications where a speed controller is used in the motor drive the transient will already include an inherent filter).

Table 8-3

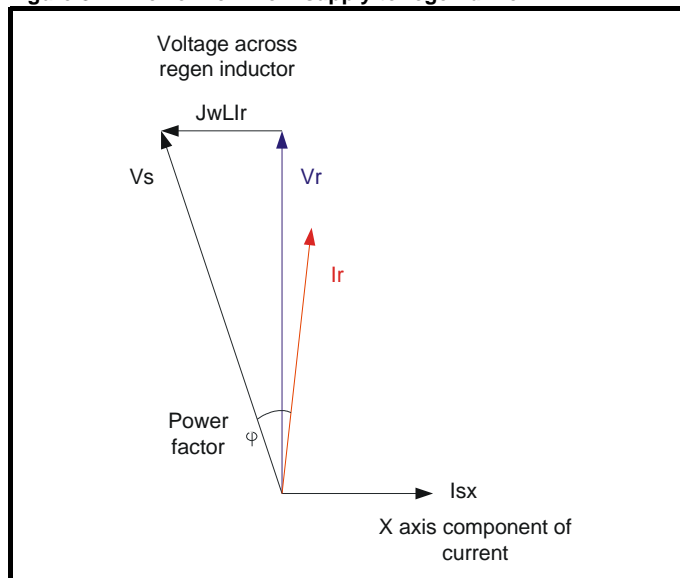
Time constant	Change in ΔV
20ms	x 0.75
40ms	x 0.5

The transient produced is approximately proportional to the voltage controller gain Pr 3.06. The default voltage controller gain is set to give a value that is suitable for most applications. The gain may need to be increased if the DC bus capacitance is high compared to two drives of similar rating coupled together. However, care must be taken to ensure that the gain is not too high as this can cause excessive ripple in the DC bus voltage.

8.4 Power factor correction (Pr 4.08)

In regen mode it is possible to produce some current in the x axis of the reference frame so that the Regen drive can be made to produce or consume reactive power. Pr 4.08 defines the level of reactive current as a percentage of the regen mode rated current (Pr 5.07). Positive reactive current produces a component of current flowing from the supply to the drive at the Regen drive terminals that lags the respective phase voltage, and negative reactive current produces a component of current that leads the respective voltage. It should be noted that the maximum current in regen mode is limited to DRIVE_CURRENT_MAX, and so the drive applies a limit to this parameter (REGEN_REACTIVE_MAX) to limit the current magnitude. Therefore the symmetrical current limit (Pr 4.07) must be reduced below its maximum value before this parameter can be increased from zero.

Figure 8-4 Power flow from supply to regen drive



V_s Supply voltage

V_r Voltage at regen drive terminals

I_r Total current at regen drive terminals

$JwLlr$ Voltage across regen inductor

ϕ Power factor

The advantages of the power factor correction are for example, to compensate for supply voltage drops in "soft" supplies and inductive loads elsewhere in a factory.

9 Parameters

9.1 Parameter ranges and variable maximums:

The two values provided define the minimum and maximum values for the given parameter. In some cases the parameter range is variable and dependant on either:

- other parameters
- the drive rating
- drive mode
- or a combination of these

The values given in Table 9-1 are the variable maximums used in the drive.

Table 9-1 Definition of parameter ranges & variable maximums

Maximum	Definition
RATED_CURRENT_MAX [9999.99A]	Maximum motor rated current RATED_CURRENT_MAX = 1.36 x Rated drive current. The rated current can be increased above the Regen drive rated current up to a level not exceeding 1.36 x Regen drive rated current. (Maximum rated current is the maximum Normal Duty current rating.) The actual level varies from one drive size to another, refer to Table 3-1 on page 11.
DRIVE_CURRENT_MAX [9999.99A]	Maximum drive current The maximum drive current is the current at the over current trip level and is given by: DRIVE_CURRENT_MAX = Regen drive rated current / 0.45
CURRENT_LIMIT_MAX [1000.0%]	Unidrive SP in regen mode operates in a reference frame that is aligned to the voltage at the drive terminals. As the phase shift across the input inductors is small, the reference frame is approximately aligned with the supply voltage. The maximum normal operating current is controlled by the current limits. DRIVE_CURRENT_MAX is used in calculating the maximum of some parameters and is fixed at 1.75 x rated drive current. The drive can operate up to this level under normal conditions. CURRENT_LIMIT_MAX is used as the maximum for some parameters such as the user current limits. The maximum current limit is defined as follows (with a maximum of 1000%): $\text{CURRENT_LIMIT_MAX} = \left(\frac{\text{Maximum current}}{\text{Regen drive rated current}} \right) \times 100\%$ Where: The Regen drive rated current is give by Pr 5.07 The maximum current is either 1.75 x rated drive current when the rated current set by Pr 5.07 is ≤ maximum Heavy Duty current rating, otherwise it is 1.1 x maximum rated current. The rated active and rated magnetising currents are calculated from regen mode rated current (Pr 5.07) as: Rated active current = Regen mode rated current Rated magnetising current = 0 In this mode, the drive only requires the regen mode rated current to set the maximum current limit correctly and scale the current limits, and so no user autotuning is required to set these accurately. It is possible to set a level of reactive current with Pr 4.08 in regen mode. This parameter has a limit defined as REGEN_REACTIVE_MAX that is provided to limit the total current to DRIVE_CURRENT_MAX. $\text{REGEN_REACTIVE_MAX} = \sqrt{\left(\left[\frac{\text{Reactive drive current} \times 1.75}{\text{Regen drive rated current}} \right]^2 - \text{Pr 4.07}^2 \right)} \times 100\%$ Motor rated current is given by Pr 5.07
TORQUE_PROD_CURRENT_MAX [1000.0%]	Maximum torque producing current This is used as a maximum for the real current (active current) in a Regen drive.
USER_CURRENT_MAX [1000.0%]	Current parameter limit selected by the user The user can select a maximum for Pr 4.08 (reactive current reference) and Pr 4.20 (active current reference) to give suitable scaling for analogue I/O with Pr 4.24. This maximum is subject to a limit of MOTOR1_CURRENT_LIMIT_MAX. USER_CURRENT_MAX = Pr 4.24
DC_VOLTAGE_SET_MAX [1150V]	Maximum DC voltage set-point 400V rating drive: 0 to 800V
DC_VOLTAGE_MAX [1190V]	Maximum DC bus voltage The maximum measurable DC bus voltage 400V drives: 830V
POWER_MAX [9999.99kW]	Maximum power in kW The maximum power has been chosen to allow for the maximum power that can be output by the drive with maximum AC output voltage, maximum controlled current and unity power factor. Therefore: Software V01.07.01 and earlier: POWER_MAX = $\sqrt{3}$ x AC_VOLTAGE_MAX x RATED_CURRENT x 1.75 Software V01.08.00 and later: POWER_MAX = $\sqrt{3}$ x AC_VOLTAGE_MAX x DRIVE_CURRENT_MAX

The values given in square brackets indicate the absolute maximum value allowed for the variable maximum.

9.2 Menu 0: Basic parameters

Table 9-2 Unidrive SP Regen menu 0 parameter descriptions

Parameter		Range(⇅)	Default(⇒)	Type					
0.00	xx.00	0 to 32,767	0	RW	Uni				
0.01	Voltage setpoint {3.05}	0 to DC_VOLTAGE_SET_MAX V	700 Vdc	RW	Uni				US
0.02	Voltage controller Kp gain {3.06}	0 to 65535	4000	RW	Bi				US
0.03	Enable motor drive {3.09}	OFF (0) or On (1)		RO	Uni		NC		
0.04	DC bus voltage {5.05}	0 to +DC_VOLTAGE_MAX V		RO	Uni	FI	NC	PT	
0.05	Output / supply voltage {5.02}	0 to AC_VOLTAGE_MAX V		RO	Uni	FI	NC	PT	
0.06	Regen drive status {3.03}	0 to 15		RO	Uni		NC	PT	
0.07	Regen restart mode {3.04}	0 to 2	1	RW	Uni				US
0.08	Close soft start contactor {3.07}	OFF (0) or On (1)		RO	Uni		NC		
0.09	Soft start contactor closed {3.08}	OFF (0) or On (1)	0	RO	Uni		NC		
0.10	Power feed forward compensation {3.10}	±100.0 %	0.0	RW	Bi		NC		
0.11	Output / supply frequency {5.01}	±100.0 Hz		RO	Bi	FI	NC	PT	
0.12	Current magnitude {4.01}	0 to DRIVE_CURRENT_MAX A		RO	Uni	FI	NC	PT	
0.13	Active current {4.02}	±DRIVE_CURRENT_MAX A		RO	Bi	FI	NC	PT	
0.14	Output / supply power {5.03}	±POWER_MAX kW		RO	Bi	FI	NC	PT	
0.15	Reactive power {3.01}	±POWER_MAX kVAR's		RO	Bi	FI	NC	PT	
0.16	Input inductance {3.02}	0.000 to 500.000 mH		RO	Uni		NC	PT	
0.17	Reactive current reference {4.08}	±REGEN_REACTIVE_MAX %	0.0	RW	Bi				US
0.18	Positive logic select {8.29}	OFF (0) or On (1)	On (1)	RW	Bit			PT	US
0.19	T7 analogue input 2 mode {7.11}	0-20 (0), 20-0 (1), 4-20.tr (2), 20-4.tr (3), 4-20 (4), 20-4 (5), VOLT (6)	VOLT (6)	RW	Txt				US
0.20	T7 analogue input 2 destination {7.14}	Pr 0.00 to 21.51	Pr 3.10	RW	Uni	DE		PT	US
0.21	T8 analogue input 3 mode {7.15}	0-20 (0), 20-0 (1), 4-20.tr (2), 20-4.tr (3), 4-20 (4), 20-4 (5), VOLT (6), th.SC (7), th (8), th.diSP (9)	VOLT (6)	RW	Txt				US
0.22	Not used								
0.23	Not used								
0.24	Not used								
0.25	Not used								
0.26	Not used								
0.27	Not used								
0.28	Not used								
0.29	SMARTCARD parameter data previously loaded {11.36}	0 to 999	0	RO	Uni		NC	PT	US
0.30	Parameter cloning {11.42}	nonE (0), rEAd (1), Prog (2), AutO (3), boot (4)	nonE (0)	RW	Txt		NC		*
0.31	Drive voltage rating {11.33}	200 (0), 400 (1), 575 (2), 690 (3)		RO	Txt		NC	PT	
0.32	Maximum Heavy Duty current rating {11.32}	0.00 to 9999.99A		RO	Uni		NC	PT	
0.33	Not used								
0.34	User security code {11.30}	0 to 999	0	RW	Uni		NC	PT	PS
0.35	Serial mode {11.24}	AnSI (0), rtU (1)	rtU (1)	RW	Txt				US
0.36	Baud rate {11.25}	300 (0), 600 (1), 1200 (2), 2400 (3), 4800 (4), 9600 (5), 19200 (6), 38400 (7), 57600 (8)*, 115200 (9)* *Modbus RTU only	19200 (6)	RW	Txt				US
0.37	Serial address {11.23}	0 to 247	1	RW	Uni				US
0.38	Current controller Kp gain {4.13}	0 to 30,000	45	RW	Uni				US
0.39	Current controller Ki gain {4.14}	0 to 30,000	1,000	RW	Uni				US
0.40	Not used								
0.41	Maximum switching frequency {5.18}	0 to 5 (3, 4, 6, 8, 12, 16 kHz)	0	RW	Uni				US
0.42	Not used								
0.43	Not used								
0.44	Not used								
0.45	Thermal time constant {4.15}	0.0 to 400.0	89.0	RW	Uni				US
0.46	Regen drive rated current {5.07}	0 to RATED_CURRENT_MAX A		RW	Uni				US
0.47	Not used								
0.48	User drive mode {11.31}	OPEn LP (1), CL VECt (2), SErVO (3), rEGEn (4)	rEGEn (4)	RW	Txt		NC	PT	
0.49	Security status {11.44}	L1 (0), L2 (1), Loc (2)	L2 (1)	RW	Txt			PT	US
0.50	Software version {11.29}	1.00 to 99.99		RO	Uni		NC	PT	
0.51 to 0.59	Not used								

RW	Read / Write	RO	Read only	Uni	Unipolar	Bi	Bi-polar	Bit	Bit parameter	Txt	Text string		
FI	Filtered	DE	Destination	NC	Not cloned	RA	Rating dependent	PT	Protected	US	User save	PS	Power down save

* Modes 1 and 2 are not user saved, Modes 0, 3 and 4 are user saved

9.3 Menu 3: Regen sequencer

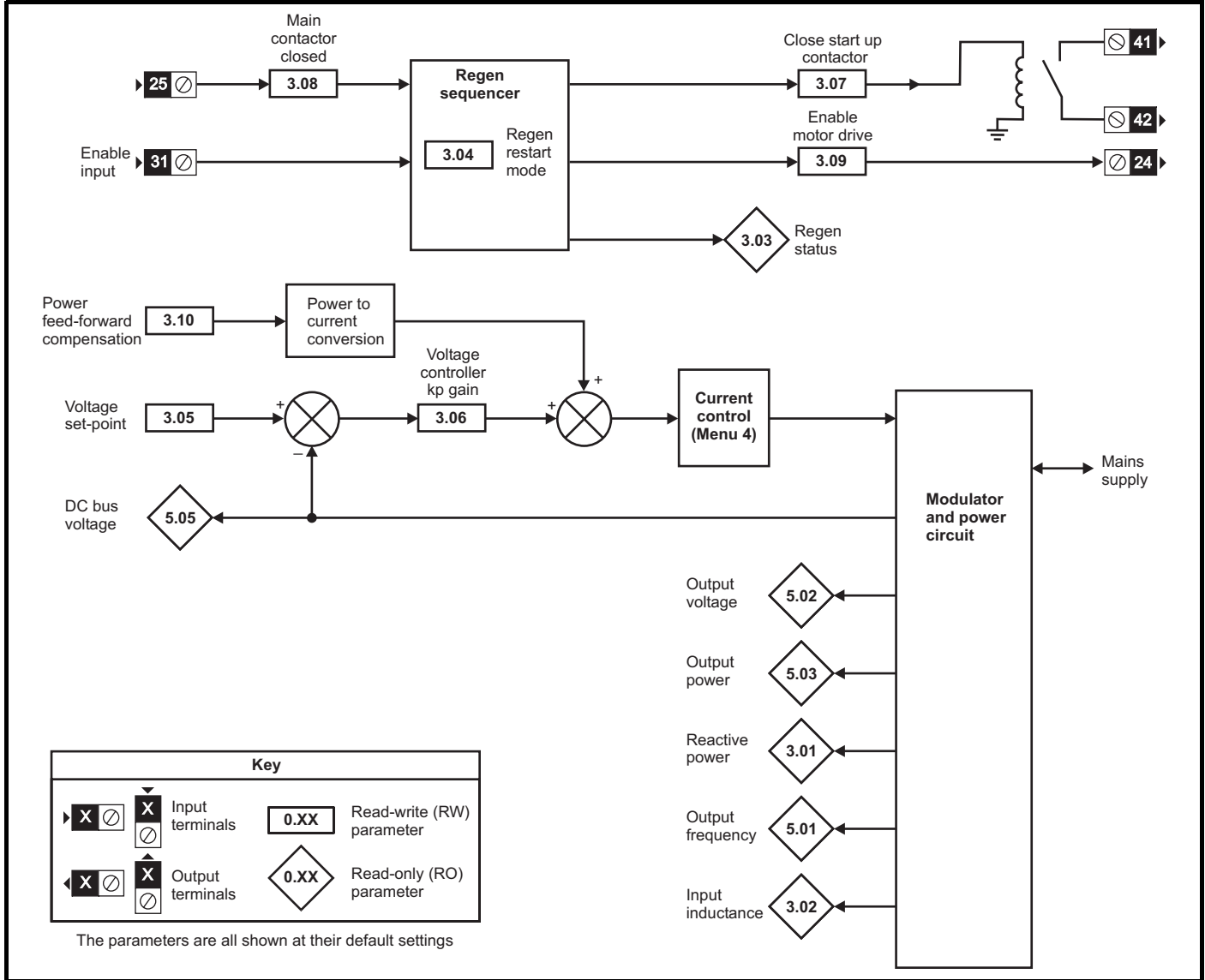
In regen mode the drive assumes the mains is lost, it does not close the input, and does not attempt synchronisation if the DC bus voltage is below the levels given in the table below.

If the unit is synchronised 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
400 V	410 Vdc	150 Vac

Figure 9-1 Menu 3 Regen logic diagram



Safety Information	Introduction	Product information	System design	Mechanical installation	Electrical installation	Getting started	Optimisation	Parameters	Technical data	Component sizing	Diagnostics
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Table 9-3 Menu 3 Regen parameter descriptions

Parameter		Range(⇅)	Default(⇌)	Type					
3.01	Reactive power	±POWER_MAX kVAR's		RO	Bi	FI	NC	PT	
3.02	Input inductance	0.000 to 500.000 mH		RO	Uni		NC	PT	
3.03	Regen drive status	0 to 15		RO	Uni		NC	PT	
3.04	Regen restart mode	0 to 2	1	RW	Uni				US
3.05	Voltage setpoint	0 to DC_VOLTAGE_SET_MAX V	700 Vdc	RW	Uni				US
3.06	Voltage controller Kp gain	0 to 65535	4000	RW	Bi				US
3.07	Close start up contactor	OFF (0) or On (1)		RO	Uni		NC		
3.08	Main contactor closed	OFF (0) or On (1)	0	RO	Uni		NC		
3.09	Enable motor drive	OFF (0) or On (1)		RO	Uni		NC		
3.10	Power feed forward compensation	±100.0 %	0.0	RW	Bi		NC		

RW	Read / Write	RO	Read only	Uni	Unipolar	Bi	Bi-polar	Bit	Bit parameter	Txt	Text string		
FI	Filtered	DE	Destination	NC	Not cloned	RA	Rating dependent	PT	Protected	US	User save	PS	Power down save

3.01	Reactive power															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
			1			1	2	1		1		1				
Range	Regen							±POWER_MAX kVAR's								
Update rate	Background															

The power (Pr 5.03) and the reactive power are the power or VAR's respectively that flow from the supply to the drive. Therefore when this parameter is positive the phase current flowing from the supply to the drive contains a component that lags the respective phase voltage, and when this parameter is negative the phase current contains a component which leads the respective phase voltage at the drive terminals.

3.02	Input inductance															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3	1		1		1			1	
Range	Regen							0.000 to 500.000mH								
Update rate	Background															

At power-up this parameter is zero. Each time the Regen drive is enabled the supply inductance is measured and displayed by this parameter. The value given is only approximate, but will give an indication as whether the input inductance is correct for the sinusoidal rectifier unit size. The measured value should include the supply inductance as well as the Regen drive input inductance, however, the supply filter capacitance, masks the effect of the supply inductance. Therefore the value measured is usually the Regen drive input inductor value.

3.03	Regen status															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1			1	
Range	Regen							0 to 15								
Update rate	4ms															

If an L.Sync trip occurs Pr 3.03 indicates the reason. At power-up and on trip reset this parameter is set to zero. Once an L.Sync trip has occurred this parameter shows when the trip occurred and the reason for the last L.Sync trip as indicated by the bits in the table below. The reasons for the trip are either because the supply frequency is out of range or the PLL (phase lock loop) within the drive cannot synchronise to the supply waveforms.

Bit	Status
0	Tripped during synchronisation
1	Tripped while running
2	Reason for trip was supply frequency <30.0Hz
3	Reason for trip was supply frequency >100.0Hz
4	Reason for trip was PLL could not be synchronised

3.04	Regen restart mode															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1							1	1	1	1	
Range	Regen								0 to 2							
Default	Regen								1							
Update rate	Background															

Pr 3.04 defines the action taken after enable and when a synchronisation failure occurs.

0, rESynC: Continuously attempt to re-synchronise

1, del.triP: delayed trip

Attempt to synchronise for 30s. If unsuccessful after this time then give a LI.SynC trip. After a failure during running attempt to re-synchronise for 30s before tripping.

2, triP: immediate trip

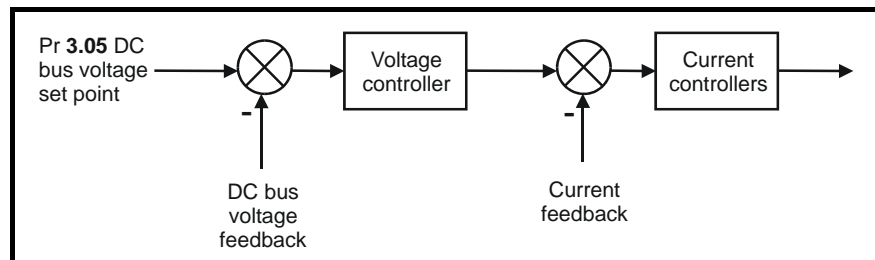
Attempt to synchronise for 30s. If unsuccessful after this time then give a LI.SynC trip. After a failure during running, trip immediately.

3.05	Voltage set-point															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
						1			1				1	1	1	
Range	Regen								0 to DC_VOLTAGE_SET_MAX V							
Default	Regen								400V rating drive: 700							
Update rate	Background															

The Regen drive will attempt to hold the DC bus at the level specified by this parameter. The DC bus voltage 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.

3.06	Voltage controller Kp gain															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Regen							0 to 65,535								
Default	Regen							4,000								
Update rate	Background															

When the drive is operated as a Regen drive it uses a DC bus voltage controller with inner current controllers as shown below.



The gains of the voltage and current controllers affect the stability of the Regen drive control system and incorrect gain settings can result in over-voltage or over-current trips. In many applications the default gains given for the current controllers (Pr 4.13 and Pr 4.14) will be suitable, however, it may be necessary for the user to change these if the inductance or resistance of the supply plus the regen inductors varies significantly from the expected values. For setting of the current controller gains, refer to the optimisation section in the guide.

3.07	Close start up contactor															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1						
Update rate	4ms															

When the Regen drive has powered-up through the soft-start and the DC Bus voltage has stopped rising and is higher than the contactor close voltage (see table) this bit changes from 0 to 1. If the DC Bus voltage falls below the contactor open voltage DC or the system is synchronised and the AC voltage falls below contactor open voltage AC. (see table) this bit changes to zero. When regen mode is selected this bit is routed to the drive relay output (Terminals 41/42) as default.

This output, or an alternative output, can be used to control the soft-start contactor.

Drive Rating Vac	Contactor Close Vdc	Contactor Open Vdc	Contactor Open Vac
400V	430V	410V	150V

3.08	Main contactor closed															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1						
Default	Regen								0							
Update rate	4ms															

When regen mode is selected Pr 3.08 is the destination for the digital input on terminal 25 (T25) as default. This input, or an alternative input, should be connected to an auxiliary contact on the soft-start contactor so that it follows the state of the contactor. The Regen drive will only attempt to synchronise to the supply when this parameter is one. This parameter is also used to monitor the contactor when the Regen drive is running. If at any time this parameter is zero the Regen drive is immediately disabled.

3.09	Enable motor drive															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1						
Update rate	4ms															

When the unit has been enabled and successfully synchronised this bit will become active. If the Regen drive attempts to re-synchronise or trips, this bit becomes inactive. When regen mode is selected this bit is routed to a the digital output on terminal 24 (T24) as default. The output, or an alternative output, should be used to enable the motor drive(s) connected to the DC bus of the Regen drive.

3.10	Power feed-forward compensation															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
						1	2			1				1		
Range	Regen								±100 %							
Default	Regen								0.00							
Update rate	4ms															

Power feed-forward compensation can be used to reduce the transient DC bus voltage produced when a fast load transient occurs on drives connected to the Regen drive. 100.0% power feed-forward is equivalent to an active current of Rated drive current / 0.45 (i.e. over current trip level) and an AC terminal peak phase voltage equal to DC_VOLTAGE_MAX / 2. This scaling is the same as the power output from Pr 5.03 when high speed output mode is used (see section 9.7 Menu 7: Analogue I/O). Therefore an analogue output of the drive supplying the load and analogue input 2 or 3 of the drive acting as the supply Regen drive can be connected together to give power feed-forward compensation without further scaling if the two drives are of equal rating. If the ratings are different the analogue input scaling must be used to give the correct power feed-forwards, where the scaling is given by:

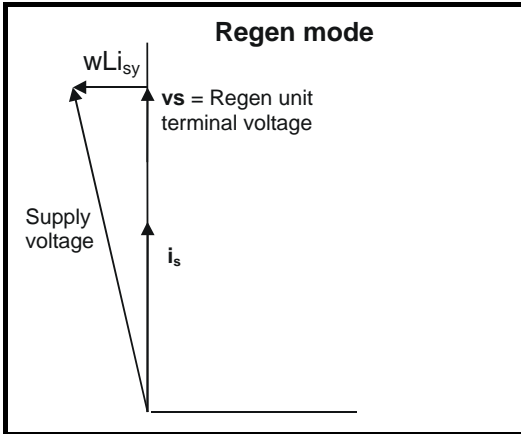
Load drive Rated drive current / Regen drive rated drive current

9.4 Menu 4: Current control

In Regen mode the drive operates in a reference frame that is aligned to the voltage at the drive terminals. Because the phase shift across the input inductors is small, the reference frame is approximately aligned with the supply voltage. The maximum normal operating current is controlled by the current limits.

DRIVE_CURRENT_MAX is used in calculating the maximum of some parameters and is fixed at 1.75 x rated drive current. The drive can operate up to this level under normal conditions.

The relationship between the voltage and current for Regen mode operation is shown in the following vector diagram.



Definitions:

i_s = Regen drive terminal voltage vector

vs = Regen drive current vector

CURRENT_LIMIT_MAX is used as the maximum for some parameters such as the user current limits. The maximum current limit is defined as follows (with a maximum of 1000%):

$$\text{CURRENT_LIMIT_MAX} = \left[\frac{\text{Maximum current}}{\text{Motor rated current}} \right] \times 100\%$$

Where:

Regen drive rated current is given by Pr 5.07

The Maximum current is either (1.75 x Rated drive current) when the rated current set by Pr 5.07 (or Pr 21.07 if motor map 2 is selected) is less than or equal to the maximum Heavy Duty current rating, otherwise it is (1.1 x Maximum rated current).

The rated active and rated magnetising currents are calculated from regen mode rated current (Pr 5.07) as:

rated active current = regen mode rated current

rated magnetising current = 0

In this mode the drive only requires the regen mode rated current to set the maximum current limit correctly and scale the current limits, and so no auto-tuning is required to set these accurately.

It is possible to set a level of reactive current with Pr 4.08 in regen mode. This parameter has a limit defined as REGEN_REACTIVE_MAX that is provided to limit the total current to DRIVE_CURRENT_MAX.

$$\text{REGEN_REACTIVE_MAX} = \sqrt{\left[\frac{\text{Rated drive current} \times 1.75}{\text{Regen unit rated current}} \right]^2 - \text{Pr 4.07}^2} \times 100\%$$

Safety Information	Introduction	Product information	System design	Mechanical installation	Electrical installation	Getting started	Optimisation	Parameters	Technical data	Component sizing	Diagnostics
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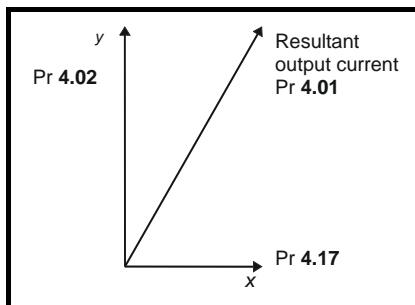
Table 9-4 Menu 4 Regen parameter descriptions

Parameter		Range(⇅)	Default(⇒)	Type					
4.01	Current magnitude	0 to DRIVE_CURRENT_MAX A		RO	Uni	FI	NC	PT	
4.02	Active current	±DRIVE_CURRENT_MAX A		RO	Bi	FI	NC	PT	
4.04	Current demand	±TORQUE_PROD_CURRENT_MAX %		RO	Uni	FI	NC	PT	
4.07	Symmetrical current limit	0 to MOTOR1_CURRENT_LIMIT_MAX %	175.0	RW	Uni				
4.08	Reactive current reference	±REGEN_REACTIVE_MAX %	0.0	RW	Bi				US
4.13	Current controller Kp gain	0 to 30,000	90	RW	Uni				US
4.14	Current controller Ki gain	0 to 30,000	2,000	RW	Uni				US
4.15	Thermal time constant	0.0 to 400.0	89.0	RW	Uni				US
4.16	Thermal protection mode	0 to 1	0	RW	Uni				US
4.17	Reactive current	±DRIVE_CURRENT_MAX A		RO	Bi	FI	NC	PT	
4.18	Overriding current limit	0 to TORQUE_PROD_CURRENT_MAX %		RO	Uni		NC	PT	
4.19	Overload accumulator	0 to 100.0 %		RO	Uni		NC	PT	
4.20	Percentage load	±USER_CURRENT_MAX %		RO	Bi	FI	NC	PT	
4.24	User current maximum scaling	0.0 to TORQUE_PROD_CURRENT_MAX %	175.0	RW	Uni				US

RW	Read / Write	RO	Read only	Uni	Unipolar	Bi	Bi-polar	Bit	Bit parameter	Txt	Text string		
FI	Filtered	DE	Destination	NC	Not cloned	RA	Rating dependent	PT	Protected	US	User save	PS	Power down save

4.01	Current magnitude															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
			1			1	2	1		1		1			1	
Range	Regen								0 to DRIVE_CURRENT_MAX A							
Update rate	4ms															

This parameter is the r.m.s. input current to the drive. The phase currents consist of an active component and a reactive component. The three phase currents can be combined to form a resultant current vector as shown below:



The resultant current magnitude is displayed by this parameter. The active current is the torque producing current for a motor drive and the real current for a Regen drive. The reactive current is the magnetising or flux producing current for a motor drive.

4.02	Active current															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
			1			1	2	1		1		1				
Range	Regen								±DRIVE_CURRENT_MAX A							
Update rate	4ms															

The active current is the real current in a Regen drive.

Direction of active current	Power flow
+	From supply
-	Into supply

The active current is aligned with the y axis of the reference frame. The y axis of the reference frame is aligned with the Regen drive terminal voltage vector.

4.04	Current demand															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
			1			1	1	1		1		1				
Range	Regen								±TORQUE_PROD_CURRENT_MAX %							
Update rate	4ms															

The current demand is the output of the voltage controller in Menu 3 subject to the current limits.

4.07	Symmetrical current limit															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
						1	1		1				1	1	1	
Range	Regen								0 to MOTOR1_CURRENT_LIMIT_MAX %							
Default	Regen								175.0							
Update rate	Background															

Current limits are provided in regen mode, however, if the current limits are active the DC bus voltage can no longer be controlled.

4.08	Reactive current reference															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
						1	1						1	1		
Range	Regen								±REGEN_REACTIVE_MAX %							
Default	Regen								0.0							
Update rate	4ms															

In regen mode it is possible to produce some current in the x axis of the reference frame so that the Regen drive can be made to produce or consume reactive power. This parameter defines the level of reactive current as a percentage of the regen mode rated current (Pr 5.07). Positive reactive current produces a component of current flowing from the supply to the drive at the Regen drive terminals that lags the respective phase voltage, and negative reactive current produces a component of current that leads the respective voltage. It should be noted that the maximum current in regen mode is limited to DRIVE_CURRENT_MAX, and so the drive applies a limit to this parameter (REGEN_REACTIVE_MAX) to limit the current magnitude. Therefore the symmetrical current limit (Pr 4.07) must be reduced below its maximum value before this parameter can be increased from zero.

4.13	Current controller Kp gain															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Regen								0 to 30,000							
Default	Regen								45							
Update rate	Background															

4.14	Current controller Ki gain															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Regen								0 to 30,000							
Default	Regen								1,000							
Update rate	Background															

The defaults Kp and Ki gains should be suitable for the standard regen inductors. If the input inductance is significantly higher the gains should be adjusted as described for the Closed-loop vector and Servo modes. See Pr 3.06 on page 66 for guidelines on setting the Regen drive current controller gains.

4.15	Thermal time constant															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Regen							0.0 to 400.0								
Default	Regen							89.0								
Second motor parameter	Regen							Pr 21.16								
Update rate	Background															

4.16	Thermal protection mode															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1	1	
Range	Regen							0 to 1								
Default	Regen							0								
Update rate	Background															

Pr 4.25 for the standard drive is used to select the *Low Speed Thermal Protection Mode*. This is not applicable for Regen drive because operation below 30Hz is not possible as synchronisation to the AC supply is lost. Therefore Pr 4.25 should be left at the default 0.

If the rated current (Pr 5.07) is less or equal to the maximum Heavy Duty rating then the maximum value for K is 1.05, so the regen inductor can operate continuously up to 105% current across the whole operating frequency range (48Hz to 65Hz).

If the rated current (Pr 5.07) is above the maximum Heavy Duty rating the maximum value for K is 1.01, so the regen inductor can operate continuously up to 101% current across the whole operating frequency range (48Hz to 65Hz).

When the estimated temperature reaches 100% the drive takes some action depending on the setting of Pr 4.16. If Pr 4.16 is 0, the drive trips when the threshold is reached. If Pr 4.16 is 1, the current limit is reduced to $(K - 0.05) \times 100\%$ when the temperature is 100%. The current limit is set back to the user defined level when the temperature falls below 95%. In servo and regen modes the current magnitude and the active current controlled by the current limits should be similar, and so this system should ensure that the regen inductor operates just below its thermal limit.

The time for some action to be taken by the drive from cold with constant current is given by:

$$T_{\text{trip}} = -(\text{Pr } 4.15) \times \ln(1 - (K \times \text{Pr } 5.07 / \text{Pr } 4.01)^2)$$

Alternatively the thermal time constant can be calculated from the trip time with a given current from

$$\text{Pr } 4.15 = -T_{\text{trip}} / \ln(1 - (K / \text{Overload})^2)$$

For example, if the drive should trip after supplying 150% overload for 60seconds with $K = 1.05$ then

$$\text{Pr } 4.15 = -60 / \ln(1 - (1.05 / 1.50)^2) = 89$$

The thermal protection system can be used in regen mode to protect the regen inductors. The rated current (Pr 5.07) should be set to the rated current for the inductors.

The thermal model temperature accumulator is reset to zero at power-up and accumulates the temperature of the regen inductor whilst the drive remains powered-up. Each time Pr 11.45 is changed, or the rated current defined by Pr 5.07 is altered, the accumulator is reset to zero.

4.17	Reactive current															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
			1			1	2	1		1		1				
Range	Regen							±DRIVE_CURRENT_MAX A								
Update rate	4ms															

The drive reactive current is shown in this parameter for all modes.

4.18	Overriding current limit															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
						1	1	1		1		1			1	
Range	Regen								0 to TORQUE_PROD_CURRENT_MAX %							
Update rate	Background															

The current limit applied at any time depends on whether the drive is motoring or regenerating and also on the level of the symmetrical current limit. Pr 4.18 gives the limit level that applies at any instant.

4.19	Overload accumulator															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1	1		1		1			1	
Range	Regen								0 to 100.0 %							
Update rate	Background															

See Pr 4.16 on page 72.

4.20	Percentage load															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
			1			1	1	1		1		1				
Range	Regen								±USER_CURRENT_MAX %							
Update rate	Background															

This parameter displays the active current (Pr 4.02) as a percentage of the rated current (Pr 5.07 or Pr 21.07). Positive values indicate power flow from the supply and negative values indicate power into the supply.

4.24	User current maximum scaling															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
						1	1						1	1	1	
Range	Regen								0.0 to TORQUE_PROD_CURRENT_MAX %							
Default	Regen								175.0							
Update rate	Background															

The maximum for Pr 4.08 and Pr 4.20 is defined by this parameter.

9.5 Menu 5: Regen control

Figure 9-3 Menu 5 Regen control flow diagram

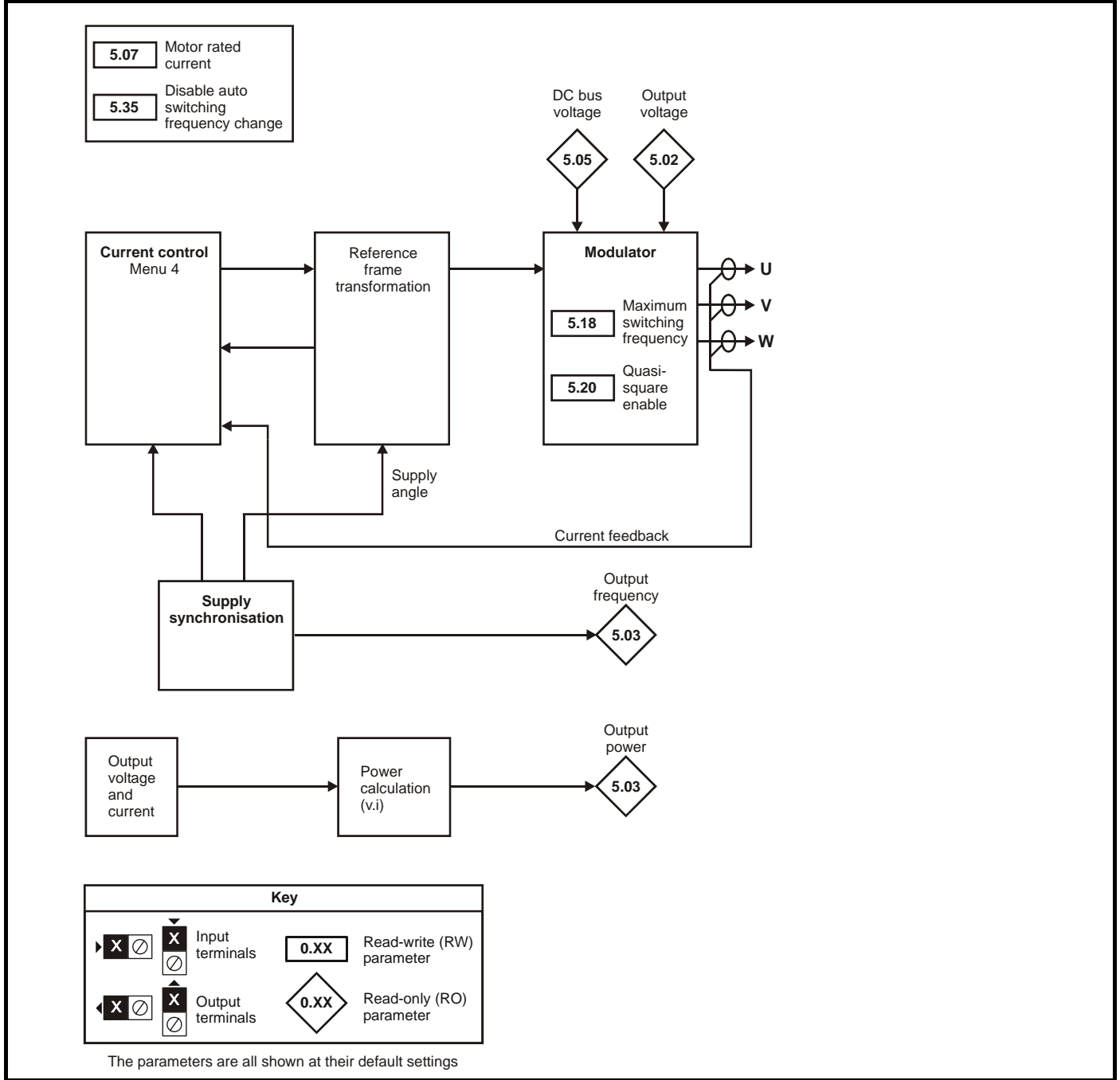


Table 9-5 Menu 5 Regen parameter descriptions

Parameter		Range(⇅)	Default(⇒)		Type					
5.01	Output / supply frequency	±100.0 Hz			RO	Bi	FI	NC	PT	
5.02	Output / supply voltage	0 to AC_VOLTAGE_MAX V			RO	Uni	FI	NC	PT	
5.03	Output / supply power	±POWER_MAX kW			RO	Bi	FI	NC	PT	
5.05	DC bus voltage	0 to +DC_VOLTAGE_MAX V			RO	Uni	FI	NC	PT	
5.07	Regen drive rated current	0 to RATED_CURRENT_MAX A			RW	Uni				US
5.18	Maximum switching frequency	0 to 5 (3, 4, 6, 8, 12, 16 kHz)	0		RW	Uni				US
5.35	Disable auto-switching frequency	0 to 1	0		RW	Uni				US

RW	Read / Write	RO	Read only	Uni	Unipolar	Bi	Bi-polar	Bit	Bit parameter	Txt	Text string		
FI	Filtered	DE	Destination	NC	Not cloned	RA	Rating dependent	PT	Protected	US	User save	PS	Power down save

5.01	Output / supply frequency															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
			1				1	1		1		1				
Range	Regen							±100.0 Hz								
Update rate	250μs															

In Regen mode the supply frequency is shown. Negative values indicate negative phase rotation of the supply.

5.02	Output / supply voltage															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
			1			1		1		1		1				
Range	Regen							0 to AC_VOLTAGE_MAX V								
Update rate	Background															

This is the modulus of the r.m.s. fundamental line to line voltage at the inverter output.

5.03	Output / supply power															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
			1			1	2	1		1		1				
Range	Regen							±POWER_MAX kW								
Update rate	Background															

The output power is the dot product of the output voltage and current vectors. Positive power indicates power flowing from the supply to the drive, and negative power indicates power flowing from the drive to the supply.

5.05	DC bus voltage															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
			1			1		1		1		1			1	
Range	Regen								0 to +DC_VOLTAGE_MAX V							
Update rate	Background															

Voltage across the internal DC bus of the drive.

5.07	Regen drive rated current															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
						1	2		1				1	1	1	
Range	Regen								0 to RATED_CURRENT_MAX A							
Default	Regen								Drive rated current (Pr 11.32)							
Second motor parameter	Regen								Pr 21.07							
Update rate	Background															

5.18	Maximum switching frequency															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1				1				1	1	1	
Range	Regen								0 to 5 (3, 4, 6, 8, 12, 16 kHz)							
Default	Regen								0 (3 kHz)							
Update rate	Background															

This parameter defines the required switching frequency. The drive may automatically reduce the actual switching frequency (without changing this parameter) if the power stage becomes too hot. The switching frequency can reduce from 12kHz to 6kHz to 3kHz, or 16kHz to 8kHz to 4kHz. An estimate of the IGBT junction temperature is made based on the heatsink temperature and an instantaneous temperature drop using the drive output current and switching frequency. The estimated IGBT junction temperature is displayed in Pr 7.34. If the temperature exceeds 135°C the switching frequency is reduced if this is possible (i.e >4kHz) and this mode is enabled (see Pr 5.35 on page 76). Reducing the switching frequency reduces the drive losses and the junction temperature displayed in Pr 7.34 also reduces. If the load condition persists the junction temperature may continue to rise. If the temperature exceeds 145°C and the switching frequency cannot be reduced the drive will initiate an O.h1 trip. Every 20ms the drive will attempt to restore the switching frequency if the higher switching frequency will not take the IGBT temperature above 135°C. The following table gives the sampling rate for different sections of the control system for different switching frequencies.

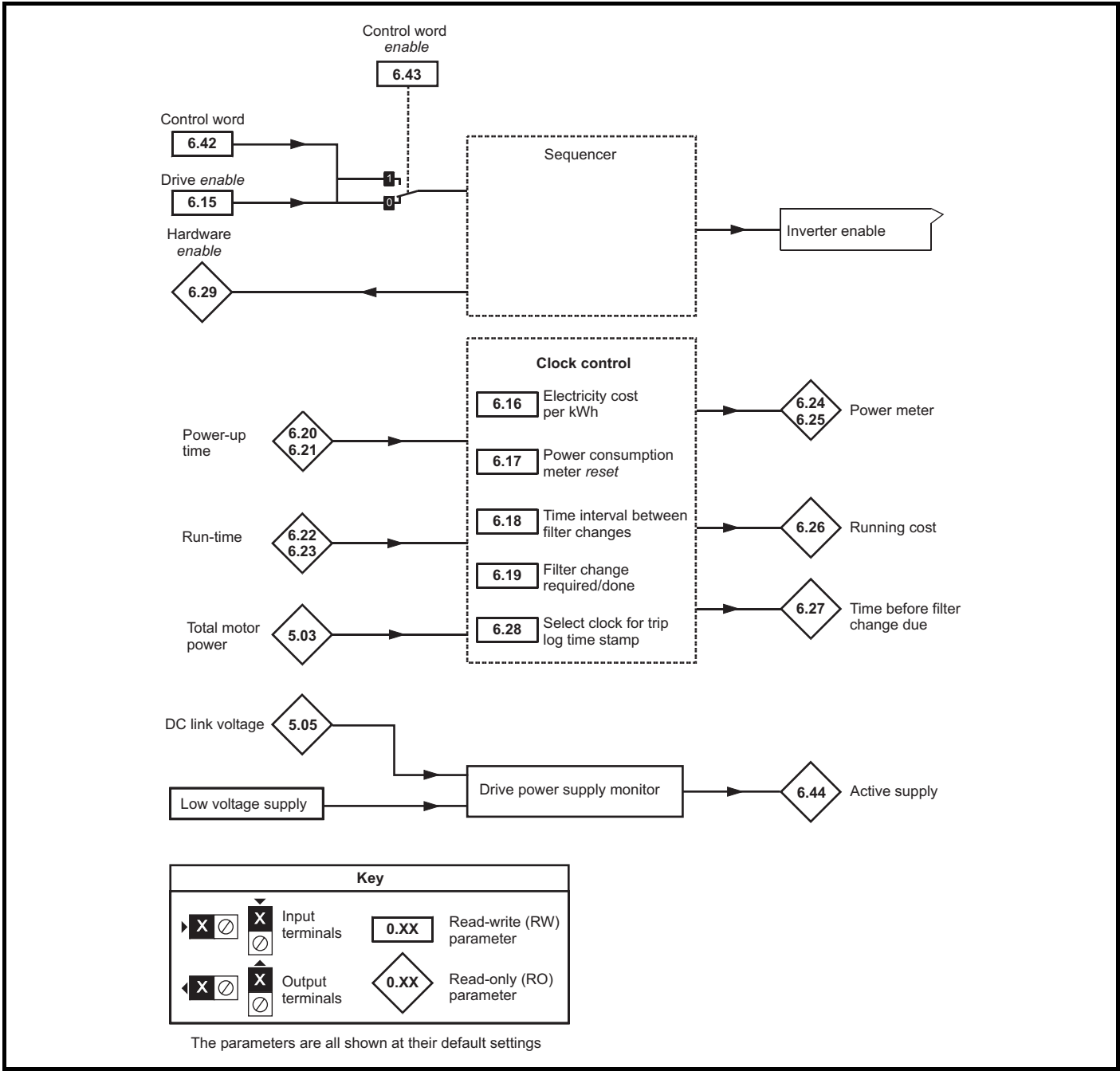
	3, 6, 12kHz	4, 8, 16kHz	Regen
Level 1	3 = 167µs, 6 = 83µs, 12 = 83µs	125µs	Current controllers
Level 2	250µs	250µs	Voltage controller
Level 3	1ms	1ms	
Level 4	4ms	4ms	Voltage controller
Background	N/A	N/A	Non-time critical user interface

5.35	Disable auto-switching frequency change															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Regen								0							
Update rate	Background															

The drive thermal protection scheme (see Pr 5.18 on page 76) reduces the switching frequency automatically when necessary to prevent the drive from overheating. It is possible to disable this feature by setting this bit parameter to one. If the feature is disabled the drive trips immediately when the IGBT temperature is too high.

9.6 Menu 6: Clock

Figure 9-4 Menu 6 logic diagram



Safety Information	Introduction	Product information	System design	Mechanical installation	Electrical installation	Getting started	Optimisation	Parameters	Technical data	Component sizing	Diagnostics
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Table 9-6 Regen mode state diagram

State	Actions	Exit conditions
DISABLE	Disable inverter	1. TripState! = NO_TRIP THEN TRIP_STATE 2. Enable THEN SYNC_STATE
REGEN_SYNC	Enable inverter	1. TripState! = NO_TRIP THEN TRIP_STATE 2. Not Enable THEN DISABLE_STATE 3. Supply not okay THEN DISABLE_STATE 4. Synchronised THEN ACTIVE_STATE
REGEN_ACTIVE		1. TripState! = NO_TRIP THEN TRIP_STATE 2. Not Enable OR NOT synchronised THEN DISABLE_STATE
TRIP	Disable inverter	1. TripState! = NO_TRIP THEN DISABLE_STATE

Table 9-7 Regen mode states

Drive Status	Conditions	Display
INHIBIT	DISABLE_STATE	inh
READY	Not used	
STOP	Not used	
SCAN	SYNC_STATE	SCAn
RUN	Not used	
ACUU	Not used	
DECEL	Not used	
DC_INJ	Not used	
ORIENTING	Not used	
TRIPPED	TRIPPED_STATE	trip
REGEN_ACTIVE	ACTIVE_STATE	act

Table 9-8 Menu 6 Regen parameter descriptions

Parameter		Range(⇅)	Default(⇒)	Type				
6.15	Drive enable	OFF (0) or On (1)	On (1)	RW	Bit			US
6.16	Electricity cost per kWh	0.0 to 600.0 currency units per kWh	0.0	RW	Uni			US
6.17	Reset energy meter	OFF (0) or On (1)	OFF (0)	RW	Bit		NC	
6.18	Time between filter changes	0 to 30,000 hrs	0	RW	Uni		NC	US
6.19	Filter change required / change done	OFF (0) or On (1)	OFF (0)	RW	Bit			PT
6.20	Powered-up time: years.days	0 to 9.364 years.days		RW	Uni		NC	PT
6.21	Powered-up time: hours.minutes	0 to 23.59 hours.minutes		RW	Uni		NC	PT
6.22	Run time: years.days	0 to 9.364 years.days		RO	Uni		NC	PT PS
6.23	Run time: hours.minutes	0 to 23.59 hours.minutes		RO	Uni		NC	PT PS
6.24	Energy meter: MWh	±999.9 MWh		RO	Bi		NC	PT PS
6.25	Energy meter: kWh	±99.99 kWh		RO	Bi		NC	PT PS
6.26	Running cost	±32,000		RO	Bi		NC	PT
6.27	Time before filter change due	0 to 30,000 hrs		RO	Uni		NC	PT PS
6.28	Select clock for trip log time sampling	OFF (0) or On (1)	OFF (0)	RW	Bit			US
6.29	Hardware enable	OFF (0) or On (1)		RO	Bit		NC	PT
6.41	Drive event flags	0 to 65,535	0	RW	Uni		NC	
6.42	Control word	0 to 32,767	0	RW	Uni		NC	
6.43	Control word enable	OFF (0) or On (1)	OFF (0)	RW	Bit			US
6.44	Active supply	OFF (0) or On (1)		RO	Bit		NC	PT
6.45	Force cooling fan to run at full speed	OFF (0) or On (1)	OFF (0)	RW	Bit			US
6.46	Normal low voltage supply	Size 1: 48V, Size 2 and 3: 48V to 72V	48	RW	Uni			PT US
6.49	Disable multi-module drive module number storing on trip	OFF (0) or On (1)	OFF (0)	RW	Bit			US
6.50	Drive comms state	0 to 3		RO	Txt		NC	PT

RW	Read / Write	RO	Read only	Uni	Unipolar	Bi	Bi-polar	Bit	Bit parameter	Txt	Text string		
FI	Filtered	DE	Destination	NC	Not cloned	RA	Rating dependent	PT	Protected	US	User save	PS	Power down save

6.15	Drive enable															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1	1	
Default	Regen								1							
Update rate	4ms															

Setting this parameter to 0 will disable the drive. It must be at 1 for the drive to run.

6.16	Electricity cost per kWh															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Regen								0.0 to 600.0 currency units per kWh							
Default	Regen								0.0							
Update rate	Background															

When this parameter is set up correctly for the local currency, Pr 6.26 will give an instantaneous read out of running cost.

6.17	Reset energy meter															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	TE	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Regen								0							
Update rate	Background															

If this parameter is one the energy meter (Pr 6.24 and Pr 6.25) is reset and held at zero.

6.18	Time between filter changes															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
										1			1	1	1	
Range	Regen								0 to 30,000 hrs							
Default	Regen								0							
Update rate	Background															

6.19	Filter change required / change done															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1											1		1		
Default	Regen							0								
Update rate	Background															

To enable the feature that indicates to the user when a filter change is due Pr 6.18 should be set to the time between filter changes. When the drive is running, Pr 6.27 is reduced each time the runtime timer hour increments (Pr 6.23) until Pr 6.27 reaches 0, at which point Pr 6.19 is set to 1 to inform the user that a filter change is required. When the user has changed the filter, resetting Pr 6.19 to 0 will indicate to the drive that the change has been done and Pr 6.27 will be reloaded with the value of Pr 6.18. Pr 6.27 can be updated with the value of Pr 6.18 at any time by setting and clearing this parameter manually.

6.20	Powered-up time: years.days															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3	1		1		1		1	1	
Range	Regen							0 to 9.364 Years.Days								
Update rate	Background															

6.21	Powered-up time: hours.minutes															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2	1		1		1		1	1	
Range	Regen							0 to 23.59 Hours.Minutes								
Update rate	Background															

The powered-up clock always starts at zero each time the drive is powered-up. The time can be changed by the user from the keypad, serial comms or an application module. If the data is not written with the various parts in the correct range (i.e. minutes are greater than 59, etc.) the clock is set to zero on the next minute. This clock may be used for time stamping the trip log if Pr 6.28 = 0.

6.22	Run time: years.days															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3	1		1		1			1	1
Range	Regen							0 to 9.364 Years.Days								
Update rate	Background															

6.23	Run time: hours.minutes															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2	1		1		1			1	1
Range	Regen							0 to 23.59 Hours.Minutes								
Update rate	Background															

The run time clock increments when the drive inverter is active to indicate the number of minutes that the drive has been running since leaving the Control Techniques factory. This clock may be used for time stamping the trip log if Pr 6.28 = 1.

6.24	Energy meter: MWh															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1	1		1		1				1
Range	Regen							±999.9 MWh								
Update rate	Background															

6.25	Energy meter: kWh															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2	1		1		1				1
Range	Regen							±99.99 kWh								
Update rate	Background															

Pr 6.24 and Pr 6.25 form the energy meter that indicates energy supplied to/from the drive in kWh. For motor control modes a positive value indicates net transfer of energy from the drive to the motor. For regen mode a positive value indicates a net transfer of energy from the supply to the drive. The energy meter is reset and held at zero when Pr 6.17 is one.

6.26	Running cost															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
			1					1		1		1				
Range	Regen							±32,000								
Update rate	Background															

Instantaneous read out of the cost/hour of running the drive. This requires Pr 6.16 to be set up correctly.

6.27	Time before filter change due															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1			1	1
Range	Regen							0 to 30,000 hrs								
Update rate	Background															

See Pr 6.18 on page 79.

6.28	Select clock for trip log time stamping															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Regen								0							
Update rate	Background															

The trip log includes time stamping for individual trips. If Pr 6.28 = 0, the powered-up clock is used for time stamping. If Pr 6.28 = 1, the run time clock is used for time stamping. It should be noted that changing this parameter clears the trip and trip time logs.

6.29	Hardware enable															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1		1				
Update rate	4ms															

This bit is a duplicate of Pr 8.09 and reflects the state of the enable input.

6.41	Drive event flags															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
										1				1	1	
Range	Regen								0 to 65535							
Default	Regen								0							
Update rate	Background															

The drive event flags indicate certain actions have occurred within the drive as described below.

Defaults loaded (Bit 0)

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. This flag is intended to be used by SM-Applications option module programs to determine when the default loading process is complete. For example an application may require defaults that are different from the standard drive defaults. These may be loaded and another parameter save initiated by the SM-Applications module when this flag is set. The flag should then be cleared so that the next event can be detected.

Drive mode changed (Bit 1)

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. This flag is intended to be used in a similar way as bit 0.

6.42	Control word															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
										1				1	1	
Range	Regen								0 to 32,767							
Default	Regen								0							
Update rate	Bits 0 –7: 4ms, Bits 8-15: Background															

6.43	Control word enable															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Regen								0							
Update rate	Related to bits 0-7: 4ms, related to bits 8-15: Background															

Pr 6.42 and Pr 6.43 provide a method of controlling the sequencer inputs and other functions directly from a single control word. If Pr 6.43 = 0 the control word has no effect, if Pr 6.43 = 1 the control word is enabled. Each bit of the control word corresponds to a sequencing bit or function as shown below.

Bits marked with * have no effect in regen mode.

Bit	Function	Equivalent parameter
0	Drive enable	Pr 6.15
1*	Run forward	Pr 6.30
2*	Jog	Pr 6.31
3*	Run reverse	Pr 6.32
4*	Forward/reverse	Pr 6.33
5*	Run	Pr 6.34
6*	Not stop	Pr 6.39
7	Auto/manual	
8*	Analogue/Preset reference	Pr 1.42
9*	Jog reverse	Pr 6.37
10	Reserved	
11	Reserved	
12	Trip drive	
13	Reset drive	Pr 10.33
14	Keypad watchdog	

Bits 0-7 and bit 9: sequencing control

When the control word is enabled (Pr 6.43 = 1), and the Auto/manual bit (bit7) are both one, bits 0 to 6 and bit 9 of the control word become active. The equivalent parameters are not modified by these bits, but become inactive when the equivalent bits in the control word are active. When the bits are active they replace the functions of the equivalent parameters. For example, if Pr 6.43 = 1 and bit 7 of Pr 6.42 = 1 the drive enable is no longer controlled by Pr 6.15, but by bit 0 of the control word. If either Pr 6.43 = 0, or bit 7 of Pr 6.42 = 0, the drive enable is controlled by Pr 6.15.

Bit 8: Analogue/preset reference

When the control word is enabled (Pr 6.43) bit 8 of the control word becomes active. (Bit 7 of the control word has no effect on this function.) The state of bit 8 is written to Pr 1.42. With default drive settings this selects analogue reference 1 (bit8 = 0) or preset reference 1 (bit8 = 1). If any other drive parameters are routed to Pr 1.42 the value of Pr 1.42 is undefined.

Bit12: Trip drive

When the control word is enabled (Pr 6.43) bit 12 of the control word becomes active. (Bit 7 of the control word has no effect on this function.) When bit 12 is set to one a CL.bit trip is initiated. The trip cannot be cleared until the bit is set to zero

Bit 13: Reset drive

When the control word is enabled (Pr 6.43) bit 13 of the control word becomes active. (Bit 7 of the control word has no effect on this function.) When bit 13 is changed from 0 to 1 the drive is reset. This bit does not modify the equivalent parameter (Pr 10.33).

Bit 14: Keypad watchdog

When the control word is enabled (Pr 6.43) bit 14 of the control word becomes active. (Bit 7 of the control word has no effect on this function.) A watchdog is provided for an external keypad or other device where a break in the communication link must be detected. The watchdog system can be enabled and/or serviced if bit 14 of the control word is changed from zero to one with the control word enabled. Once the watchdog is enabled it must be serviced at least once every second or an "SCL" trip occurs. The watchdog is disabled when an "SCL" trip occurs, and so it must be re-enabled when the trip is reset.

6.44	Active supply															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	Background															

The drive can operate from the following supplies as indicated by this parameter. The drive will only change between supply modes as the UU trip is reset.

0: main power terminals

The drive power circuit, gate drives, control circuits and Solutions Modules are using the main power terminals to derive their supplies. The drive will operate normally. Parameters that are saved at power-down are saved when the supply is removed in this mode and a UU trip occurs.

1: Low voltage supply

The gate drives, control circuits and Solutions Modules use the low voltage auxiliary power input to derive their supplies. The main power terminals can be connected to a different supply of any voltage up to the maximum normal supply level. The drive will operate normally except that mains loss detection is disabled, and all parameters that are calculated based on voltage on the auxiliary supply and not the supply from the main power terminals. If the auxiliary supply and the main supply are different then these parameters will not be correct. Parameters that are saved at power-down are not saved when the power is removed in this mode. In this mode 24V must also be supplied via the 24V power supply input. When operating with the low voltage supply the voltage levels contained in the following table are used instead of the normal high voltage levels whatever the voltage rating of the drive.

Voltage level	
DC_VOLTAGE_MAX	Pr 6.46 x 1.45
Braking IGBT threshold voltage	Pr 6.46 x 1.325
Under voltage trip level	36V
Restart voltage level after UU trip	40V

6.45	Force cooling fan to run at full speed															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Update rate	Background															

The drive thermal model system normally controls the fan speed, however the fan can be forced to operate at full speed if this parameter is set to 1. When this is set to 1 the fan remains at full speed until 10s after this parameter is set to zero.

6.46	Nominal low voltage supply															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
												1	1	1	1	
Range	Open-loop, Closed-loop vector, Servo, Regen								Size 1: 48 V Size 2 & 3: 48 to 72 V							
Default	Open-loop, Closed-loop vector, Servo, Regen								48							
Update rate	Background															

This parameter defines the nominal supply voltage when operating in low voltage mode. The actual value of the parameter is not used directly by the drive, but is used to define the braking IGBT switching threshold and the over voltage trip level for low voltage mode (see Pr 6.44).

6.49	Disable multi-module drive module number storing on trip															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Regen								0 (OFF)							
Update rate	Background															

When power modules are connected in parallel various trips can be initiated from the power modules themselves. To aid identification of the source of the trip the module number of the source can be stored in the module number and trip time log (Pr 10.41 to Pr 10.51). If the drive is a single module drive the module number that is stored is normally zero. However, a UNISP6xxx or UNISP7xxx drive can be fitted with the interface circuits normally intended for parallel operation, but it is a single module drive. In this case a module number of 1 is stored.

Safety Information	Introduction	Product information	System design	Mechanical installation	Electrical installation	Getting started	Optimisation	Parameters	Technical data	Component sizing	Diagnostics
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If Pr 6.49 is zero the module number is stored in the module number and trip time log. If this parameter is one, either the powered-up clock or run time clock is stored in the module number and trip time log as defined by Pr 6.28. It should be noted that changing this parameter clears the trip, and module number and trip time logs.

6.50	Drive comms state															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1			1		1		1			1	
Range	Regen							0 to 3								
Update rate	Background															

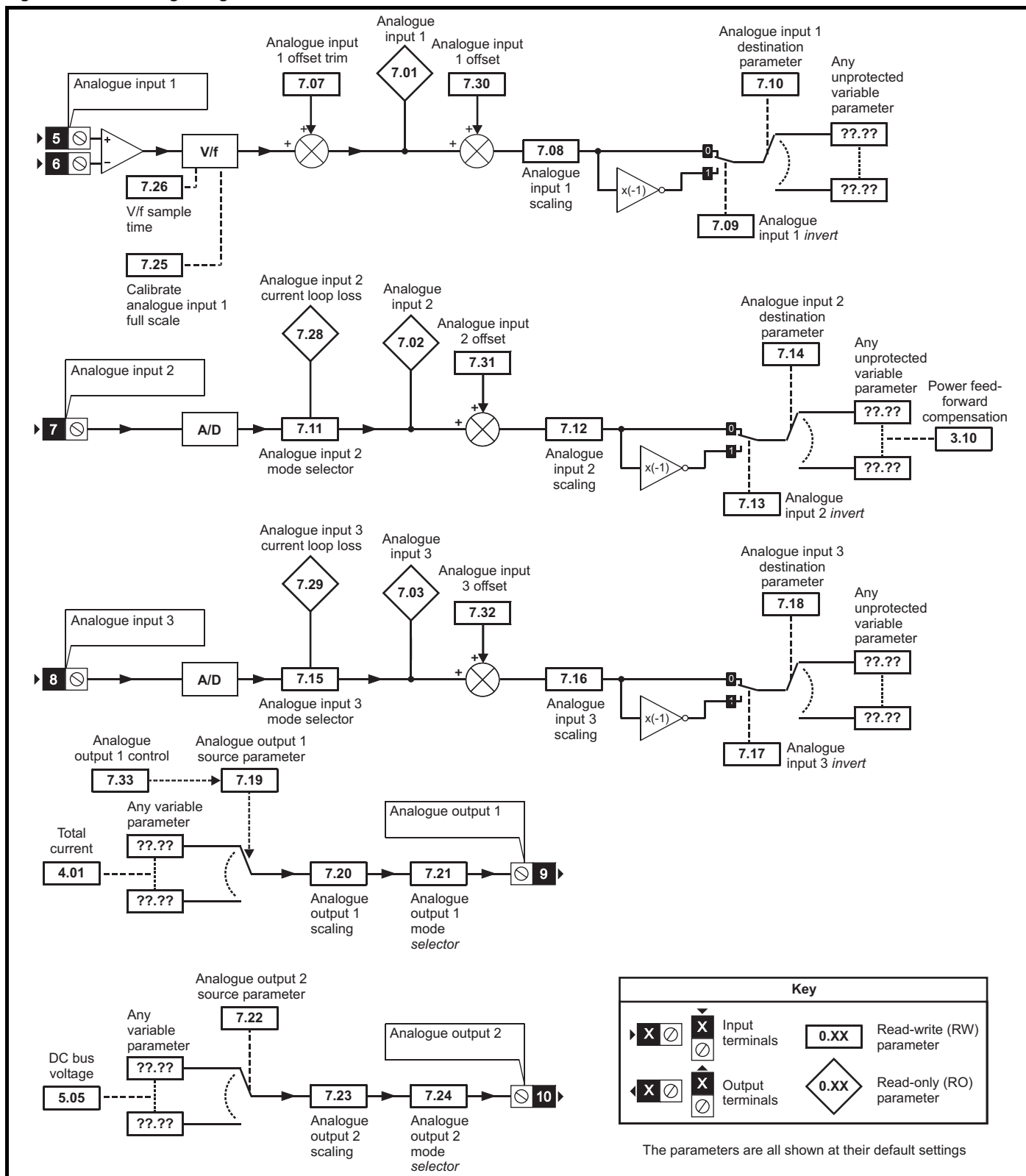
The drive comms system 128 bytes buffer used with ANSI or Modbus rtu protocols via the 485 connector can be controlled by a Solutions Module under certain circumstances. This parameter shows which node has control of the buffer (0 (drv) = drive, 1 (Slot1) = Solutions Module in slot 1, etc. If a Solutions Module has control of the buffer the drive will use an alternative buffer for 485 comms and the following restrictions will apply:

1. Comms messages via the 485 port are limited to a maximum of 32 bytes
2. The 6 pin keypad port will operate correctly with an LED keypad, but it will no longer operate with an LCD keypad

Modbus messages using the CMP protocol can only route messages to nodes within the drive. It will not be possible for these to be routed further, i.e. via CT Net on an SM-Applications module.

9.7 Menu 7: Analogue I/O

Figure 9-5 Menu 7 logic diagram



Safety Information	Introduction	Product information	System design	Mechanical installation	Electrical installation	Getting started	Optimisation	Parameters	Technical data	Component sizing	Diagnostics
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The drive has three analogue inputs (AI1 to AI3) and two analogue outputs (AO1 and AO2). Each input has a similar parameter structure and each output has a similar parameter structure. The nominal full scale level for inputs in voltage mode is 9.8V. This ensures that when the input is driven from a voltage produced from the drive's own 10V supply, the input can reach full scale.

Terminal	Input	Input modes	Resolution
5/6	AI1	Voltage only	12 bit plus sign (16 bit plus sign as a speed reference)
7	AI2	0 to 6	10 bit plus sign
8	AI3	0 to 9	10 bit plus sign

Terminal	Output	Output modes	Resolution
9	AO1	0 to 3	10 bit plus sign
10	AO2	0 to 3	10 bit plus sign

Update rate

The analogue inputs are sampled every 4ms except where the destinations shown in the table below are chosen, the input is in voltage mode and other conditions necessary for short cutting are met.

Input destination	Regen mode sample rate
Pr 1.36 - Analogue reference	
Pr 1.37 - Analogue reference	
Pr 3.14 - Power ff comp	AI1 - 4ms AI2 or 3 - 1ms
Pr 3.19 - Hard speed ref	
Pr 4.08 - Torque reference	

The window filter applied to analogue input 1 (see Pr 7.26) can be set to a time that is shorter than 4ms. There is no advantage in doing this, as it simply reduces the resolution of the input data, which is still only sampled and routed to its destination parameter every 4ms.

Analogue outputs are updated every 4ms except when one of the following is the source and high speed update mode is selected. In high speed mode the output operates in voltage mode, is updated every 250µs, special scaling is used as described in the table and the user scaling is ignored.

Output source	Scaling
Pr 4.02 - torque prod current	$10.0V = \text{Rated drive current} / 0.45$
Pr 4.17 - magnetising current	$10.0V = \text{Rated drive current} / 0.45$
Pr 5.03 - output power	The output is the product of the active current and the voltage component in phase with the active current ($v_{sy} \times i_{sy}$). 10V would be produced when: Active current = Rated drive current / 0.45 Peak phase voltage in phase with the active current = $DC_VOLTAGE_MAX / 2$

Menu 7 Regen parameter descriptions

Parameter		Range(↕)	Default(⇒)	Type					
7.01	T5/6 analogue input 1 level	±100.00 %		RO	Bi		NC	PT	
7.02	T7 analogue input 2 level	±100.0 %		RO	Bi		NC	PT	
7.03	T8 analogue input 3 level	±100.0 %		RO	Bi		NC	PT	
7.04	Stack temperature 1	-128 to 127 °C		RO	Bi		NC	PT	
7.05	Stack temperature 2	-128 to 127 °C		RO	Bi		NC	PT	
7.06	Control board temperature	-128 to 127 °C		RO	Bi		NC	PT	
7.07	T5/6 analogue input 1 offset trim {0.13}	±10.000 %	0.000	RW	Bi				US
7.08	T5/6 analogue input 1 scaling	0 to 4.000	1.000	RW	Uni				US
7.09	T5/6 analogue input 1 invert	OFF (0) or On (1)	OFF (0)	RW	Bit				US
7.10	T5/6 analogue input 1 destination	Pr 0.00 to 21.51	Pr 0.00	RW	Uni	DE		PT	US
7.11	T7 analogue input 2 mode {0.19}	0-20 (0), 20-0 (1), 4-20.tr (2), 20-4.tr (3), 4-20 (4), 20-4 (5), VOLT (6)	VOLT (6)	RW	Txt				US
7.12	T7 analogue input 2 scaling	0 to 4.000	1.000	RW	Uni				US
7.13	T7 analogue input 2 invert	OFF (0) or On (1)	OFF (0)	RW	Bit				US
7.14	T7 analogue input 2 destination {0.20}	Pr 0.00 to 21.51	Pr 3.10	RW	Uni	DE		PT	US
7.15	T8 analogue input 3 mode {0.21}	0-20 (0), 20-0 (1), 4-20.tr (2), 20-4.tr (3), 4-20 (4), 20-4 (5), VOLT (6), th.SC (7), th (8), th.diSP (9)	VOLT (6)	RW	Txt				US
7.16	T8 analogue input 3 scaling	0 to 4.000	1.000	RW	Uni				US
7.17	T8 analogue input 3 invert	OFF (0) or On (1)	OFF (0)	RW	Bit				US
7.18	T8 analogue input 3 destination	Pr 0.00 to 21.51	Pr 0.00	RW	Uni	DE		PT	US
7.19	T9 analogue output 1 source	Pr 0.00 to 21.51	Pr 4.01	RW	Uni			PT	US
7.20	T9 analogue output 1 scaling	0.000 to 4.000	1.000	RW	Uni				US
7.21	T9 analogue output 1 mode	VOLT (0), 0-20 (1), 4-20 (2), H.SPd (3)	VOLT (0)	RW	Txt				US
7.22	T10 analogue output 2 source	Pr 0.00 to 21.51	Pr 5.05	RW	Uni			PT	US
7.23	T10 analogue output 2 scaling	0.000 to 4.000	1.000	RW	Uni				US
7.24	T10 analogue output 2 mode	VOLT (0), 0-20 (1), 4-20 (2), H.SPd (3)	VOLT (0)	RW	Txt				US
7.25	Calibrate T5/6 analogue input 1 full scale	OFF (0) or On (1)	OFF (0)	RW	Bit		NC		
7.26	T5/6 analogue input 1 sample time	0 to 8.0 ms	4.0	RW	Uni				US
7.28	T7 analogue input 2 current loop loss	OFF (0) or On (1)		RO	Bit		NC	PT	
7.29	T8 analogue input 3 current loop loss	OFF (0) or On (1)		RO	Bit		NC	PT	
7.30	T5/6 analogue input 1 offset	±100.00 %	0.00	RW	Bi				US
7.31	T7 analogue input 2 offset	±100.0 %	0.0	RW	Bi				US
7.32	T8 analogue input 3 offset	±100.0 %	0.0	RW	Bi				US
7.33	T9 analogue output 1 control	Fr (0), Ld (1), AdV (2)	AdV (2)	RW	Txt				US
7.34	IGBT junction temperature	±200 °C		RO	Bi		NC	PT	
7.35	Drive thermal protection accumulator	0 to 100.0 %		RO	Uni		NC	PT	

RW	Read / Write	RO	Read only	Uni	Unipolar	Bi	Bi-polar	Bit	Bit parameter	Txt	Text string		
FI	Filtered	DE	Destination	NC	Not cloned	RA	Rating dependent	PT	Protected	US	User save	PS	Power down save

7.01	T5/6 analogue input 1 level															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2	1		1		1				
Range	Regen							±100.00 %								
Update rate	4ms															

7.02	T7 analogue input 2 level															
7.03	T8 analogue input 3 level															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1	1		1		1				
Range	Regen							±100.0 %								
Update rate	4ms															

When analogue input 3 is in thermistor mode the display indicates the resistance of the thermistor as a percentage of 10KΩ

7.04	Stack temperature 1															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1				
Range	Regen							-128 to 127°C								
Update rate	Background															

7.05	Stack temperature 2															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1				
Range	Regen							-128 to 127°C								
Update rate	Background															

7.06	Control board temperature															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1			1	
Range	Regen							-128 to 127°C								
Update rate	Background															

These parameters display the temperature of various parts of the drive in degrees Celsius. The power stage is monitored at two points (Pr 7.04 and Pr 7.05) and the control board is also monitored (Pr 7.06). The following trips and alarms can be produced from the values in these parameters.

Parameter	Trip	Alarm
Pr 7.04 Stack temperature 1 (IGBT)	"O.ht2" if Pr 7.04 > Trip threshold (Can be reset if Pr 7.04 < Trip threshold – 5°C)	"hot" if Pr 7.04 > Alarm threshold
Pr 7.05 Stack temperature 2 (power PCB)	"O.ht2" if Pr 7.05 > Trip threshold (Can be reset if Pr 7.05 < Trip threshold – 5°C)	"hot" if Pr 7.05 > Alarm threshold
Pr 7.06 Control board temperature	"O.Ctl" if Pr 7.06 > 90°C (Can be reset if Pr 7.06 < 85°C)	"hot" if Pr 7.06 > 85°C

The threshold levels for the stack temperature trips and alarm vary between drive sizes.

The values displayed in the parameter are normally between -20 and +127°C. If the value measured from the thermistor exceeds the range from -20 to +150°C it is assumed that the device is either open-circuit or short-circuit.

If this occurs the following hardware fault trips are initiated: Stack temperature 1 - HF27, Stack temperature 2 - HF28, Control board temperature - HF29.

The drive cooling fan is controlled as follows:

1. If Pr 6.45 = 1 the fan is at full speed for at least 10s.
2. If a Solutions Module indicates that it is too hot the fan is at full speed for at least 10s.
3. If the highest of the two stack temperatures is above the alarm level (i.e. hot alarm is being displayed) the fan is at full speed.
4. If the drive is enabled and the highest of the two stack temperatures is above a level defined for each drive size (lower than the alarm level) the fan is at full speed.
5. Otherwise the fan is set to its low speed with 5° hysteresis (drive sizes 1 and 2) or variable speed controlled between its low and high speed (drive sizes 3 to 6).

7.07	T5/6 analogue input 1 offset trim															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1		
Range	Regen								±10.000 %							
Default	Regen								0.000							
Update rate	Background															

This value can be used to trim out any offset from the user input signal

7.08	T5/6 analogue input 1 scaling															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1	1	
Range	Regen								0.000 to 4.000							
Default	Regen								1.000							
Update rate	Background															

7.09	T5/6 analogue input 1 invert															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Regen								0							
Update rate	Background read															

7.10	T5/6 analogue input 1 destination															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
				1			2					1	1	1	1	
Range	Regen								Pr 0.00 to Pr 21.51							
Default	Regen								Pr 0.00							
Update rate	Background															

7.11	T7 analogue input 2 mode															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Regen								0 to 6							
Default	Regen								6							
Update rate	Background read															

The following modes are available for the analogue input 2. A current loop loss trip is generated if the input current falls below 3mA. In modes 4 and 5 the analogue input level goes to 0.0% if the input current falls below 3mA.

Parameter value	Parameter string	Mode	Comments
0	0-20	0 - 20mA	
1	20-0	20 - 0mA	
2	4-20.tr	4 -20mA with trip on loss	Trip if I < 3mA
3	20-4.tr	20 - 4mA with trip on loss	Trip if I < 3mA
4	4-20	4 - 20mA with no trip on loss	
5	20-4	20 - 4mA with no trip on loss	0.0% if I < 4mA
6	VOLt	Voltage mode	

7.12	T7 analogue input 2 scaling															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1	1	
Range	Regen							0.000 to 4.000								
Default	Regen							1.000								
Update rate	Background															

7.13	T7 analogue input 2 invert															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Regen								0							
Update rate	Background															

7.14	T7 analogue input 2 destination															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
				1			2					1	1	1	1	
Range	Regen							Pr 0.00 to Pr 21.51								
Default	Regen							Pr 3.10								
Update rate	Background															

7.15	T8 analogue input 3 mode															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Regen							0 to 9								
Default	Regen							6								
Update rate	Background															

The following modes are available for the analogue input 3. A current loop loss trip is generated if the input current falls below 3mA. In modes 4 and 5 the analogue input level goes to 0.0% if the input current falls below 3mA.

Parameter value	Parameter string	Mode	Comments
0	0-20	0 - 20mA	
1	20-0	20 - 0mA	
2	4-20.tr	4 - 20mA with trip on loss	Trip if I < 3mA
3	20-4.tr	20 - 4mA with trip on loss	Trip if I < 3mA
4	4-20	4 - 20mA with no trip on loss	
5	20-4	20 - 4mA with no trip on loss	0.0% if I < 4mA
6	VOLt	Voltage mode	
7	th.SC	Thermistor with short circuit detection	TH trip if R > 3k3 TH reset if R < 1k8 THS trip if R < 50R
8	th	Thermistor without short circuit detection	TH trip if R > 3k3 TH reset if R < 1k8
9	th.diSp	Thermistor display only with no trip	

7.16	T8 analogue input 3 scaling															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1	1	
Range	Regen							0.000 to 4.000								
Default	Regen							1.000								
Update rate	Background															

7.17	T8 analogue input 3 invert															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Regen							0								
Update rate	Background															

7.18	T8 analogue input 3 destination															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
				1			2					1	1	1	1	
Range	Regen							Pr 0.00 to Pr 21.51								
Default	Regen							Pr 0.00								
Update rate	Background															

7.19	T9 analogue output 1 source															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2					1	1	1	1	
Range	Regen							Pr 0.00 to Pr 21.51								
Default	Regen							Pr 4.01								
Update rate	Background															

7.20	T9 analogue output 1 scaling															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1	1	
Range	Regen							0.000 to 4.000								
Default	Regen							1.000								
Update rate	Background															

7.21	T9 analogue output 1 mode															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Regen							0 to 3								
Default	Regen							0								
Update rate	Background read															

The following modes are available for the analogue outputs.

Parameter value	Parameter string	Mode
0	VOLt	Voltage mode
1	0-20	0 - 20mA
2	4-20	4 - 20mA
3	H.Spd	High speed up date mode

If high speed update mode is selected and the source for the output is one of the parameters designated for high speed analogue output operation (see start of this section) the output is updated at a higher rate with special scaling. If the parameter selected is not designated for this mode the output is updated at the normal rate. If speed feedback or power is selected for high speed mode for both analogue output 1 and analogue output 2 the setting is ignored for analogue output 2. If the high speed mode is selected the output is always a voltage signal.

7.22	T10 analogue output 2 source															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2					1	1	1	1	
Range	Regen							Pr 0.00 to Pr 21.51								
Default	Regen							Pr 5.05								
Update rate	Background															

7.23	T10 analogue output 2 scaling															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1	1	
Range	Regen							0.000 to 4.000								
Default	Regen							1.000								
Update rate	Background															

7.24	T10 analogue output 2 mode															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Regen								0 to 3							
Default	Regen								0							
Update rate	Background															

The following modes are available for the analogue outputs.

Parameter value	Parameter string	Mode
0	VOLt	Voltage mode
1	0-20	0 - 20mA
2	4-20	4 - 20mA
3	H.Spd	High speed up date mode

If high speed update mode is selected and the source for the output is one of the parameters designated for high speed analogue output operation (see start of this section) the output is updated at a higher rate with special scaling. If the parameter selected is not designated for this mode the output is updated at the normal rate. If speed feedback or power is selected for high speed mode for both analogue output 1 and analogue output 2 the setting is ignored for analogue output 2. If the high speed mode is selected the output is always a voltage signal.

7.25	Calibrate T5/6 analogue input 1 full scale															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Regen								0							
Update rate	Background															

Setting this bit will cause the drive to re-calibrate the full scale level of analogue input 1 provided the input voltage is below +1.5V or above +2.5V. This parameter is cleared by the software automatically when the calibration is complete. If the input voltage is above +2.5V the input voltage itself is used for calibration, and so after calibration this level will be full scale for the input. If the input voltage is below +1.5V the internal reference is used for calibration, and so the full scale will be nominally 9.8V after calibration. The calibration level is automatically stored on power-down. It should be noted that the Analogue input 1 offset trim is included in the input voltage when the input voltage itself is used for calibration, but this trim is not included when the internal reference is used for calibration.

7.26	T5/6 analogue input 1 sample time															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Regen							0 to 8.0 ms								
Default	Regen							4.0								
Update rate	Background															

Analogue input 1 is filtered using a window filter to remove quantisation noise and adjust the resolution of this input. The length of the window can be adjusted with this parameter. The shortest possible window is 250µs. It should be noted that if this input is not used as a speed reference (Pr 1.36, Pr 1.37) or as a hard speed reference (Pr 3.22) the sample time affects the resolution. The nominal resolution is given by $\text{Pr } 7.26 \times 10^6$, therefore the default setting gives approximately 12 bit resolution.

7.28	T5/6 analogue input 1 current loop loss															
7.29	T7 analogue input 2 current loop loss															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	Background															

If an analogue input is used with 4-20mA or 20-4mA current loop modes the respective bit (Pr 7.28 - analogue input 2 and Pr 7.29 -3) is set to one if the current falls below 3mA. If the current is above 3mA with these modes or another mode is selected the respective bit is set to zero.

7.30	T5/6 analogue input 1 offset															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2						1	1		
Range	Regen							±100.00 %								
Default	Regen							0.00								
Update rate	Background															

7.31	T7 analogue input 2 offset															
7.32	T8 analogue input 3 offset															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1		
Range	Regen								±100.0 %							
Default	Regen								0.0							
Update rate	Background															

An offset can be added to each analogue input with a range from -100% to 100%. If the sum of the input and the offset exceeds ±100% the results is limited to ±100%.

7.33	T9 analogue output 1 control															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Regen								0 to 2							
Default	Regen								2							
Update rate	Background															

This offers a simple control of Pr 7.19 to change the source for the analogue output for use from Menu 0. When this parameter is set to 0 or 1 the drive constantly writes Pr 5.01 or Pr 4.02 to Pr 7.19 respectively.

Parameter value	Parameter string	Action
0	Fr	Write Pr 7.19 = Pr 5.01
1	Ld	Write Pr 7.19 = Pr 4.02
2	AdV	No action

7.34	IGBT junction temperature															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1				
Range	Regen							±200 °C								
Update rate	Background															

The IGBT junction temperature is calculated using Stack 1 temperature (Pr 7.04) and a thermal model of the drive power stage. The resulting temperature is displayed in this parameter. The calculated IGBT junction temperature is used to modify the drive switching frequency to reduce losses if the devices become too hot (see Pr 5.18 on page 76).

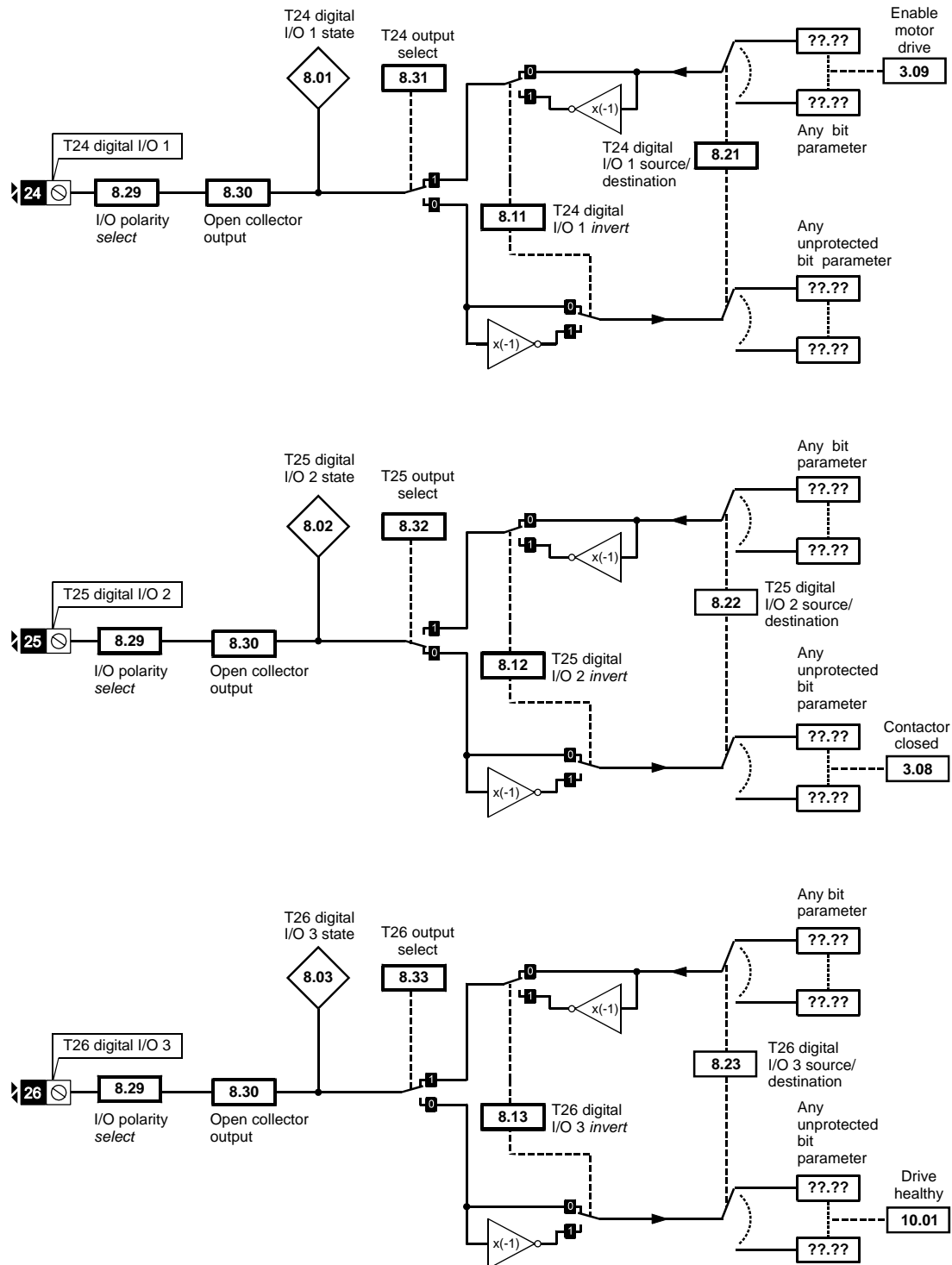
7.35	Drive thermal protection accumulator															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1	1		1		1			1	
Range	Regen							0 to 100 %								
Update rate	Background															

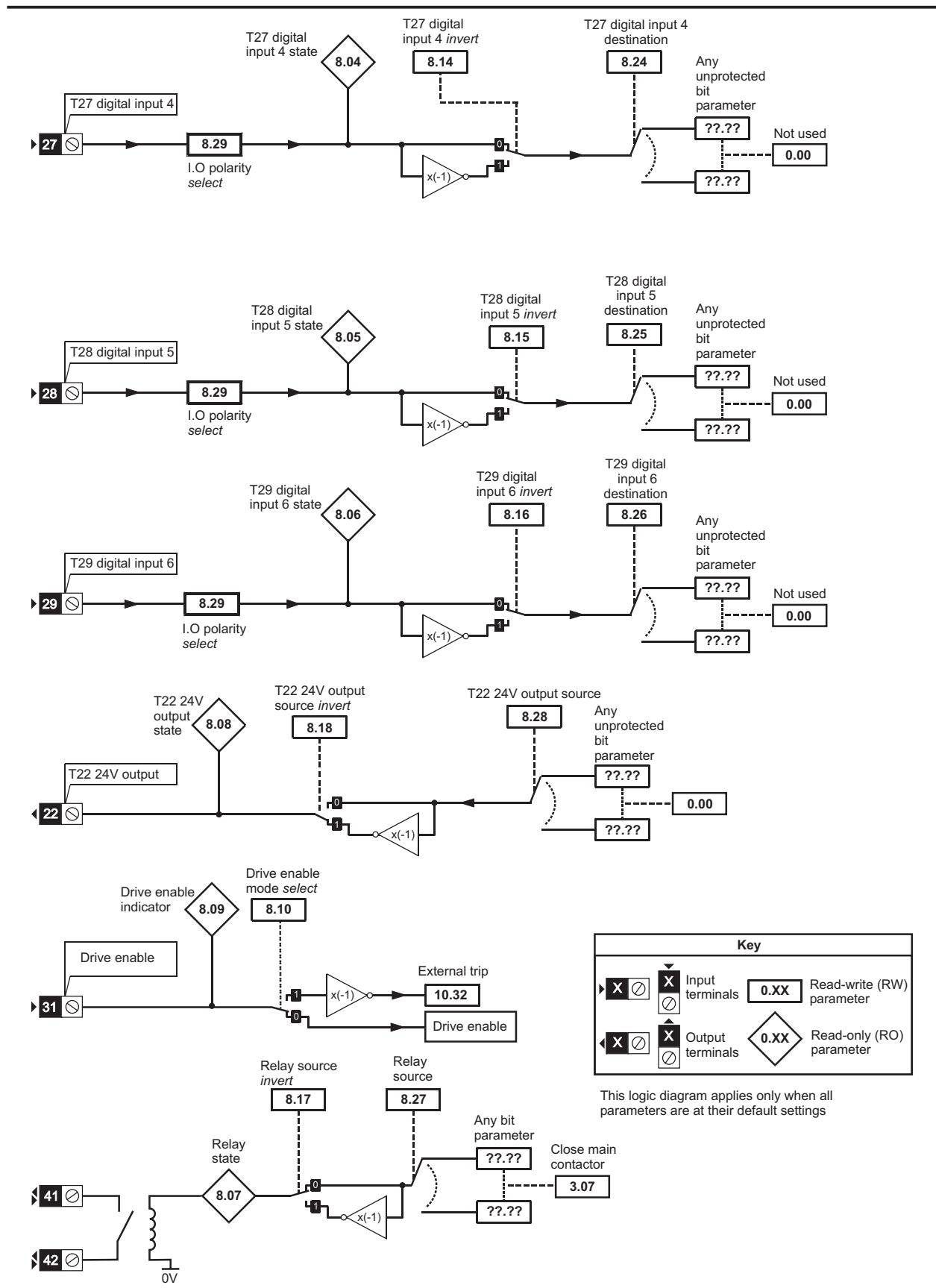
In addition to monitoring the IGBT junction temperatures the drive includes a thermal protection system to protect the other components within the drive. This includes the effects of drive output current and DC bus ripple. The estimated temperature is displayed as a percentage of the trip level in this parameter. If the parameter value reaches 100% an Oht3 trip is initiated.

Safety Information	Introduction	Product information	System design	Mechanical installation	Electrical installation	Getting started	Optimisation	Parameters	Technical data	Component sizing	Diagnostics
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9.8 Menu 8: Digital I/O

Figure 9-6 Menu 8 logic diagram





Safety Information	Introduction	Product information	System design	Mechanical installation	Electrical installation	Getting started	Optimisation	Parameters	Technical data	Component sizing	Diagnostics
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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 4ms, except when inputs are routed to the limit switches Pr 6.35 and Pr 6.36 when the sample time is reduced to 250µs. Any changes to the source/destination parameters only become effect after drive reset is activated.

I/O	Sample rate	Function
T24 to T26	4ms	Digital input or output
T27 to T29	4ms	Digital input
Relay	Background	
T22	Background	24V output

Table 9-9

Terminal type	I/O state	Invert		Source / destination		Output select	
	Pr	Pr	Default	Pr	Default	Pr	Default
T24 input / output 1	Pr 8.01	Pr 8.11	0	Pr 8.21	Pr 3.09 - Enable motor drive	Pr 8.31	1
T25 input / output 2	Pr 8.02	Pr 8.12	0	Pr 8.22	Pr 3.08 - Contactor closed	Pr 8.32	0
T26 input / output 3	Pr 8.03	Pr 8.13	0	Pr 8.23	Pr 10.01 – Drive healthy	Pr 8.33	1
T27 input 4	Pr 8.04	Pr 8.14	0	Pr 8.24	Pr 0.00 - Not used		
T28 input 5	Pr 8.05	Pr 8.15	0	Pr 8.25	Pr 0.00 - Not used		
T29 input 6	Pr 8.06	Pr 8.16	0	Pr 8.26	Pr 0.00 - Not used		
T41 / 42 Relay	Pr 8.07	Pr 8.17	0	Pr 8.27	Pr 3.07 – Close contactor		
T22 24V output	Pr 8.08	Pr 8.18	1	Pr 8.28	Pr 0.00 - Not used		
T31 Enable	Pr 8.09						

Table 9-10 Menu 8 Regen parameter descriptions

Parameter		Range(⇅)	Default(⇒)	Type			
8.01	T24 digital I/O 1 state	OFF (0) or On (1)		RO	Bit	NC	PT
8.02	T25 digital I/O 2 state	OFF (0) or On (1)		RO	Bit	NC	PT
8.03	T26 digital I/O 3 state	OFF (0) or On (1)		RO	Bit	NC	PT
8.04	T27 digital input 4 state	OFF (0) or On (1)		RO	Bit	NC	PT
8.05	T28 digital input 5 state	OFF (0) or On (1)		RO	Bit	NC	PT
8.06	T29 digital input 6 state	OFF (0) or On (1)		RO	Bit	NC	PT
8.07	Relay state	OFF (0) or On (1)		RO	Bit	NC	PT
8.08	T22 24V output state	OFF (0) or On (1)		RO	Bit	NC	PT
8.09	Drive enable indicator	OFF (0) or On (1)		RO	Bit	NC	PT
8.10	Drive enable mode select	OFF (0) or On (1)	OFF (0)	RW	Bit		US
8.11	T24 digital I/O 1 invert	OFF (0) or On (1)	OFF (0)	RW	Bit		US
8.12	T25 digital I/O 2 invert	OFF (0) or On (1)	OFF (0)	RW	Bit		US
8.13	T26 digital I/O 3 invert	OFF (0) or On (1)	OFF (0)	RW	Bit		US
8.14	T27 digital input 4 invert	OFF (0) or On (1)	OFF (0)	RW	Bit		US
8.15	T28 digital input 5 invert	OFF (0) or On (1)	OFF (0)	RW	Bit		US
8.16	T29 digital input 6 invert	OFF (0) or On (1)	OFF (0)	RW	Bit		US
8.17	Relay source invert	OFF (0) or On (1)	OFF (0)	RW	Bit		US
8.18	T22 24V output source invert	OFF (0) or On (1)	On (1)	RW	Bit		US
8.20	Digital I/O read word	0 to 511		RO	Uni	NC	PT
8.21	T24 digital I/O 1 source/destination	Pr 0.00 to 21.51	Pr 3.09	RW	Uni	DE	PT US
8.22	T25 digital I/O 2 source/destination	Pr 0.00 to 21.51	Pr 3.08	RW	Uni	DE	PT US
8.23	T26 digital I/O 3 source/destination	Pr 0.00 to 21.51	Pr 10.01	RW	Uni	DE	PT US
8.24	T27 digital input 4 destination	Pr 0.00 to 21.51	Pr 0.00	RW	Uni	DE	PT US
8.25	T28 digital input 5 destination	Pr 0.00 to 21.51	Pr 0.00	RW	Uni	DE	PT US
8.26	T29 digital input 6 destination {0.17}	Pr 0.00 to 21.51	Pr 0.00	RW	Uni	DE	PT US
8.27	Relay source	Pr 0.00 to 21.51	Pr 3.07	RW	Uni		PT US
8.28	T22 24V output source	Pr 0.00 to 21.51	Pr 0.00	RW	Uni		PT US
8.29	Positive logic select {0.18}	OFF (0) or On (1)	On (1)	RW	Bit		PT US
8.30	Open collector output	OFF (0) or On (1)	OFF (0)	RW	Bit		US
8.31	T24 digital I/O 1 output select	OFF (0) or On (1)	On (1)	RW	Bit		US
8.32	T25 digital I/O 2 output select	OFF (0) or On (1)	OFF (0)	RW	Bit		US
8.33	T26 digital I/O 3 output select	OFF (0) or On (1)	On (1)	RW	Bit		US
8.39	T28 & T29 digital input auto-selection disable {0.16}	OFF (0) or On (1)	OFF (0)	RW	Bit		US

RW	Read / Write	RO	Read only	Uni	Unipolar	Bi	Bi-polar	Bit	Bit parameter	Txt	Text string		
FI	Filtered	DE	Destination	NC	Not cloned	RA	Rating dependent	PT	Protected	US	User save	PS	Power down save

8.01	T24 digital I/O 1 state															
8.02	T25 digital I/O 2 state															
8.03	T26 digital I/O 3 state															
8.04	T27 digital input 4 state															
8.05	T28 digital input 5 state															
8.06	T29 digital input 6 state															
8.07	Relay status															
8.08	T22 24V output state															
8.09	Drive enable indicator															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	4ms															

8.10	Drive enable mode select															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Regen								OFF (0)							
Update rate	Background read															

Unidrive SP has a dedicated hardware enable input which always controls Pr 6.29. If the enable is inactive the IGBT firing signals are turned off without software intervention. As default (Pr 8.10 = 0) the drive is in the inhibit mode when the enable is inactive. Setting this parameter to one causes the enable to behave as an Et trip input. When the input becomes inactive an Et trip is initiated. This does not affect Pr 10.32 (Et trip parameter), therefore an Et trip can be initiated in this mode either by making the enable inactive or setting Pr 10.32 to one.

8.11	T24 digital I/O 1 invert															
8.12	T25 digital I/O 2 invert															
8.13	T26 digital I/O 3 invert															
8.14	T27 digital input 4 invert															
8.15	T28 digital input 5 invert															
8.16	T29 digital input 6 invert															
8.17	Relay source invert															
8.18	T22 24V output source invert															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Regen								Pr 8.11 to Pr 8.17 = OFF (0), Pr 8.18 = On (1)							
Update rate	4ms															

8.20	Digital I/O read word															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1			1	
Range	Regen							0 to 511								
Update rate	Background															

This word is used to determine the status of the digital I/O by reading one parameter. The bits in this word reflect the state of Pr **8.01** to Pr **8.09**.

Bit	Digital I/O
0	T24 input / output 1
1	T25 input / output 2
2	T26 input / output 3
3	T27 input 4
4	T28 input 5
5	T29 input 6
6	Relay
7	T22 24V output
8	Enable

8.21	T24 digital I/O 1 source/destination															
8.22	T25 digital I/O 2 source/destination															
8.23	T26 digital I/O 3 source/destination															
8.24	T27 digital input 4 destination															
8.25	T28 digital input 5 destination															
8.26	T29 digital input 6 destination															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
				1			2					1	1	1	1	
Default	Regen								See Table 9-9 on page 98							
Range	Regen								Pr 0.00 to Pr 21.51							
Update rate	Background															

8.27	Relay source															
8.28	T22 24V output source															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2					1	1	1	1	
Default	Regen								See Table 9-9 on page 98							
Range	Regen								Pr 0.00 to Pr 21.51							
Update rate	Background															

8.29	Positive logic select															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1											1	1	1	1	
Default	Regen								On (1)							
Update rate	Background															

This parameter changes the logic polarity for digital inputs and digital outputs, but not the enable input, the relay output or the 24V output.

	Pr 8.29 = 0 (negative logic)	Pr 8.29 = 1 (positive logic)
Inputs	<5V = 1, >15V = 0	<5V = 0, >15V = 1
Non-relay Outputs	On (1) = <5V, OFF (0) = >15V	OFF (0) = <5V, On (1) = >15V
Relay outputs	OFF (0) = open, On (1) = closed	OFF (0) = open, On (1) = closed
24V output (T22)	OFF (0) = 0V, On (1) = 24V	OFF (0) = 0V, On (1) = 24V

8.30	Open collector output															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Regen								OFF (0)							
Update rate	Background															

When this parameter is zero digital outputs are in push-pull mode. When this parameter is one either the high-side drive (negative logic polarity) or the low-side driver (positive logic polarity) is disabled. This allows outputs to be connected in a wire-ORed configuration.

8.31	T24 digital I/O 1 output select															
8.32	T25 digital I/O 2 output select															
8.33	T26 digital I/O 3 output select															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Regen								Pr 8.31 and Pr 8.33 = On (1) Pr 8.32 = OFF (0)							
Update rate	Background															

8.39	T28 & T29 digital input auto-selection disable															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Regen								OFF (0)							
Update rate	Background															

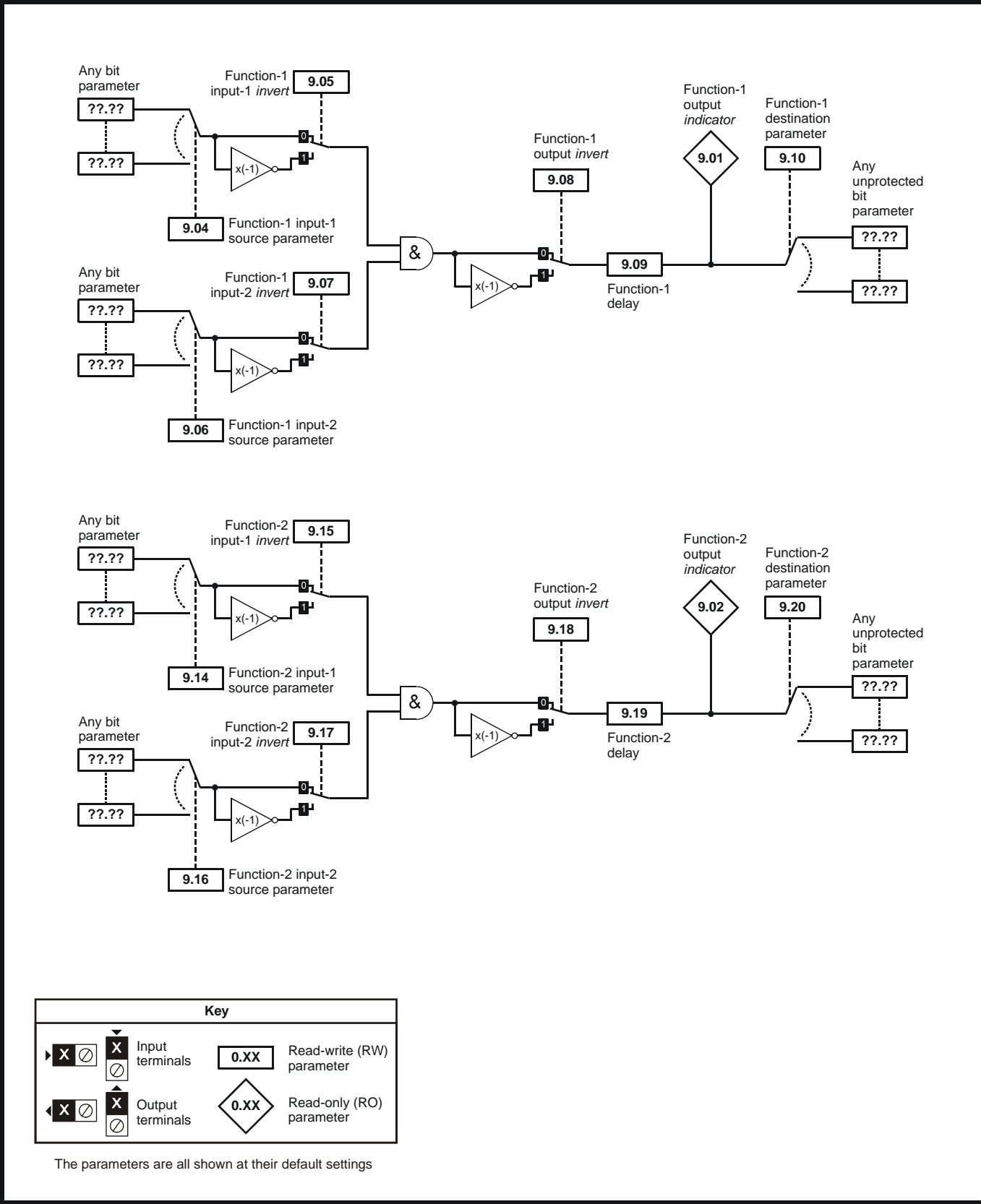
When this parameter is 0, Pr 8.25 and Pr 8.26 are set up automatically according to the setting of the reference select Pr 1.14. Setting this parameter to 1 disables this function.

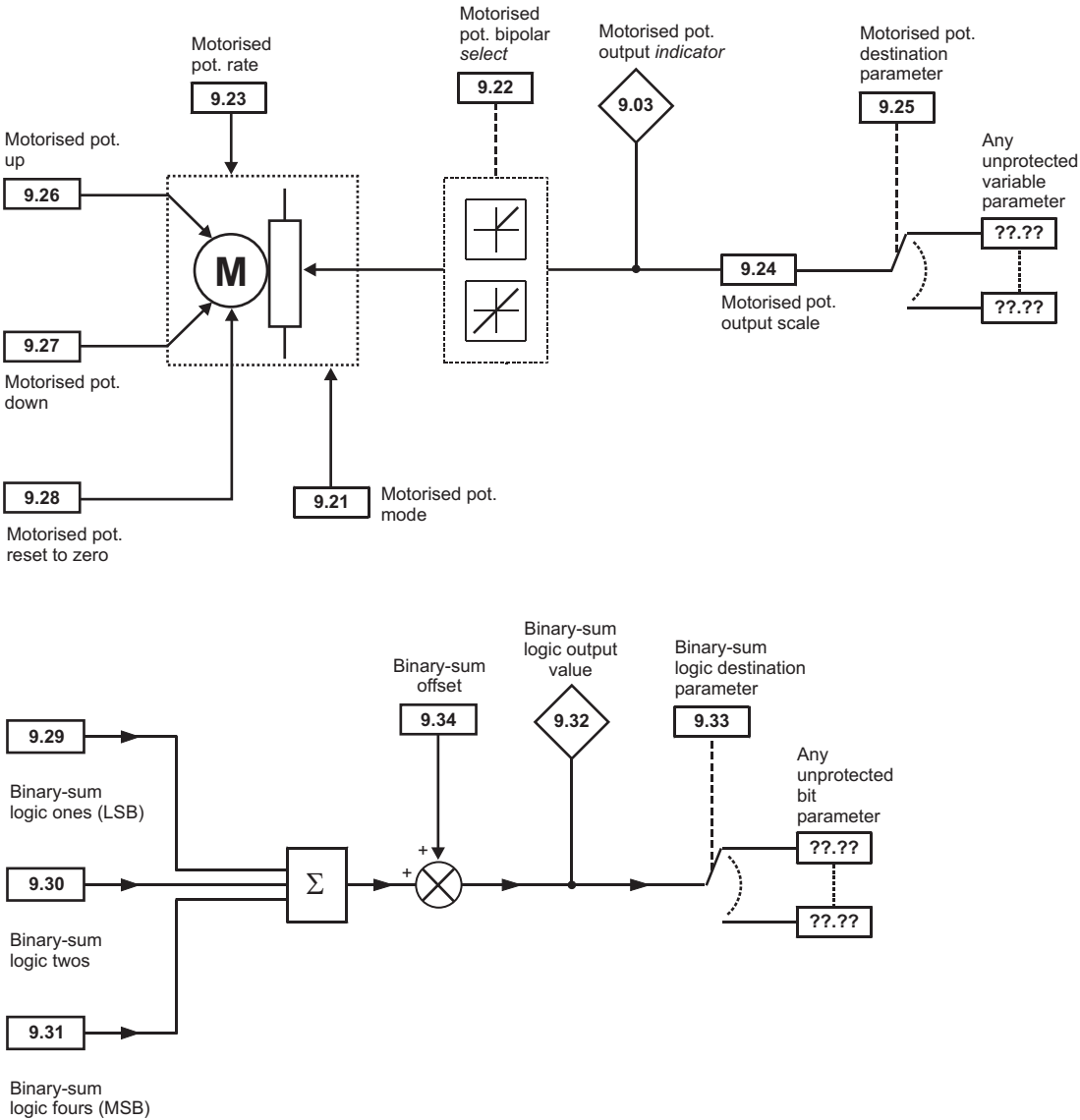
Reference select Pr 1.14		Pr 8.25 set to:	Pr 8.26 set to:
0, A1.A2	Reference selection by terminal input	Pr 1.41 - Analogue ref 2 select	Pr 6.31 - jog
1, A1.Pr	Analogue reference 1 or presets selected by terminal input	Pr 1.45 - preset select bit 0	Pr 1.46 - preset select bit 1
2, A2.Pr	Analogue reference 2 or presets selected by terminal input	Pr 1.45 - preset select bit 0	Pr 1.46 - preset select bit 1
3, Pr	Preset reference selected by terminal input	Pr 1.45 - preset select bit 0	Pr 1.46 - preset select bit 1
4, Pad	Keypad reference selected	Pr 1.41 - Analogue ref 2 select	Pr 6.31 - jog
5, Prc	Precision reference selected	Pr 1.41 - Analogue ref 2 select	Pr 6.31 - jog

This parameter has no effect in Regen mode.

9.9 Menu 9: Programmable logic, motorised pot and binary sum

Figure 9-7 Menu 9 logic diagram





Safety Information	Introduction	Product information	System design	Mechanical installation	Electrical installation	Getting started	Optimisation	Parameters	Technical data	Component sizing	Diagnostics
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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 motorised pot function and a binary sum block. One menu 9 or one menu 12 function is executed every 4ms. Therefore the sample time of these functions is 4ms x number of menu 9 and 12 functions active. The logic functions are active if one or both the sources are routed to a valid parameter. The other functions are active if the output destination is routed to a valid unprotected parameter.

Table 9-11 Menu 9 Regen parameter descriptions

Parameter	Range(⇅)	Default(⇒)	Type					
9.01 Logic function 1 output	OFF (0) or On (1)		RO	Bit		NC	PT	
9.02 Logic function 2 output	OFF (0) or On (1)		RO	Bit		NC	PT	
9.03 Motorised pot output	±100.00 %		RO	Bi		NC	PT	PS
9.04 Logic function 1 source 1	Pr 0.00 to 21.51	Pr 0.00	RW	Uni			PT	US
9.05 Logic function 1 source 1 invert	OFF (0) or On (1)	OFF (0)	RW	Bit				US
9.06 Logic function 1 source 2	Pr 0.00 to 21.51	Pr 0.00	RW	Uni			PT	US
9.07 Logic function 1 source 2 invert	OFF (0) or On (1)	OFF (0)	RW	Bit				US
9.08 Logic function 1 output invert	OFF (0) or On (1)	OFF (0)	RW	Bit				US
9.09 Logic function 1 delay	±25.0 s	0.0	RW	Bi				US
9.10 Logic function 1 destination	Pr 0.00 to 21.51	Pr 0.00	RW	Uni	DE		PT	US
9.14 Logic function 2 source 1	Pr 0.00 to 21.51	Pr 0.00	RW	Uni			PT	US
9.15 Logic function 2 source 1 invert	OFF (0) or On (1)	OFF (0)	RW	Bit				US
9.16 Logic function 2 source 2	Pr 0.00 to 21.51	Pr 0.00	RW	Uni			PT	US
9.17 Logic function 2 source 2 invert	OFF (0) or On (1)	OFF (0)	RW	Bit				US
9.18 Logic function 2 output invert	OFF (0) or On (1)	OFF (0)	RW	Bit				US
9.19 Logic function 2 delay	±25.0 s	0.0	RW	Bi				US
9.20 Logic function 2 destination	Pr 0.00 to 21.51	Pr 0.00	RW	Uni	DE		PT	US
9.21 Motorised pot mode	0 to 3	2	RW	Uni				US
9.22 Motorised pot bipolar select	OFF (0) or On (1)	OFF (0)	RW	Bit				US
9.23 Motorised pot rate	0 to 250 s	20	RW	Uni				US
9.24 Motorised pot scale factor	0.000 to 4.000	1.000	RW	Uni				US
9.25 Motorised pot destination	Pr 0.00 to 21.51	Pr 0.00	RW	Uni	DE		PT	US
9.26 Motorised pot up	OFF (0) or On (1)	OFF (0)	RW	Bit		NC		
9.27 Motorised pot down	OFF (0) or On (1)	OFF (0)	RW	Bit		NC		
9.28 Motorised pot reset	OFF (0) or On (1)	OFF (0)	RW	Bit		NC		
9.29 Binary sum ones input	OFF (0) or On (1)	OFF (0)	RW	Bit		NC		
9.30 Binary sum twos input	OFF (0) or On (1)	OFF (0)	RW	Bit		NC		
9.31 Binary sum fours input	OFF (0) or On (1)	OFF (0)	RW	Bit		NC		
9.32 Binary sum output	0 to 255		RO	Uni		NC	PT	
9.33 Binary sum destination	Pr 0.00 to 21.51	Pr 0.00	RW	Uni	DE		PT	US
9.34 Binary sum offset	0 to 248	0	RW	Uni				US

RW	Read / Write	RO	Read only	Uni	Unipolar	Bi	Bi-polar	Bit	Bit parameter	Txt	Text string		
FI	Filtered	DE	Destination	NC	Not cloned	RA	Rating dependent	PT	Protected	US	User save	PS	Power down save

9.01	Logic function 1 output															
9.02	Logic function 2 output															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	4ms x number of menu 9 or 12 functions active															

9.03	Motorised pot output															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2	1		1		1				1
Range	Regen								±100.00 %							
Update rate	4ms x number of menu 9 or 12 functions active															

Indicates the level of the motorised pot prior to scaling. If Pr 9.21 is set to 0 or 2 this parameter is set to 0 at power-up, otherwise it retains its value at the last power-down.

9.04	Logic function 1 source 1															
9.14	Logic function 2 source 1															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2					1	1	1	1	
Range	Regen								Pr 0.00 to Pr 21.51							
Default	Regen								Pr 0.00							
Update rate	Background															

9.05	Logic function 1 source 1 invert															
9.15	Logic function 2 source 1 invert															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Regen								0							
Update rate	4ms x number of menu 9 or 12 functions active															

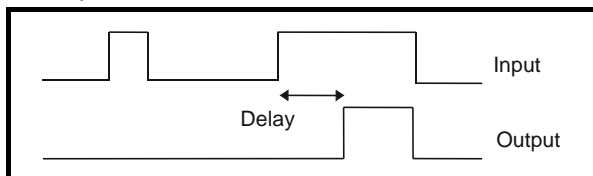
9.06	Logic function 1 source 2															
9.16	Logic function 2 source 2															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2					1	1	1	1	
Range	Regen								Pr 0.00 to Pr 21.51							
Default	Regen								Pr 0.00							
Update rate	Background															

9.07	Logic function 1 source 2 invert															
9.17	Logic function 2 source 2 invert															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Regen								0							
Update rate	4ms x number of menu 9 or 12 functions active															

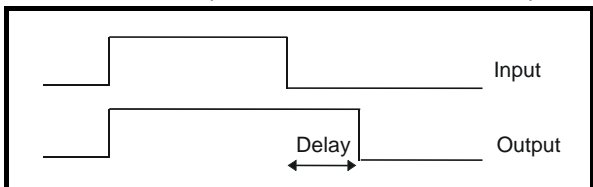
9.08	Logic function 1 output invert															
9.18	Logic function 2 output invert															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Regen								0							
Update rate	4ms x number of menu 9 or 12 functions active															

9.09	Logic function 1 delay															
9.19	Logic function 2 delay															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1		
Range	Regen								±25.0 s							
Default	Regen								0.0							
Update rate	4ms x number of menu 9 or 12 functions active															

If the delay parameter is positive, the delay ensures that the output does not become active until an active condition has been present at the input for the delay time as shown below.



If the delay parameter is negative, the delay holds the output active for the delay period after the active condition has been removed as shown below. Therefore an active input that lasts for 4ms or more will produce an output that lasts at least as long as the delay time.



9.10	Logic function 1 destination															
9.20	Logic function 2 destination															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
				1			2					1	1	1	1	
Range	Regen								Pr 0.00 to Pr 21.51							
Default	Regen								Pr 0.00							
Update rate	Background															

9.21	Motorised pot mode															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Regen								0 to 3							
Default	Regen								2							
Update rate	Background															

The motorised pot modes are given in the following table.

Pr 9.21	Mode	Comments
0	Zero at power-up	Reset to zero at each power-up. Up, down and reset are active at all times.
1	Last value at power-up	Set to value at power-down when drive powered-up. Up, down and reset are active at all times.
2	Zero at power-up and only change when drive running	Reset to zero at each power-up. Up and down are only active when the drive is running (i.e. inverter active). Reset is active at all times.
3	Last value at power-up and only change when drive running	Set to value at power-down when drive powered-up. Up and down are only active when the drive is running (i.e. inverter active). Reset is active at all times.

9.22	Motorised pot bipolar select															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Regen								0							
Update rate	4ms x number of menu 9 or 12 functions active															

When this bit is set to 0 the motorised pot output is limited to positive values only (i.e. 0 to 100.0%). Setting it to 1 allows negative outputs (i.e. $\pm 100.0\%$).

9.23	Motorised pot rate															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Regen								0 to 250 s							
Default	Regen								20							
Update rate	Background															

This parameter defines the time taken for the motorised pot function to ramp from 0 to 100.0%. Twice this time will be taken to adjust the output from -100.0 % to +100.0 %.

9.24	Motorised pot scale factor															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1	1	
Range	Regen							0.000 to 4.000								
Default	Regen							1.000								
Update rate	4ms x number of menu 9 or 12 functions active															

This parameter can be used to restrict the output of the motorised pot to operate over a reduced range so that it can be used as a trim, for example.

9.25	Motorised pot destination															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
				1			2					1	1	1	1	
Range	Regen							Pr 0.00 to Pr 21.51								
Default	Regen							Pr 0.00								
Update rate	Background															

9.26	Motorised pot up															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Regen								0							
Update rate	4ms x number of menu 9 or 12 functions active															

9.27	Motorised pot down															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Regen								0							
Update rate	4ms x number of menu 9 or 12 functions active															

9.28	Motorised pot reset															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Regen								0							
Update rate	4ms x number of menu 9 or 12 functions active															

These three bits control the motorised pot. The up and down inputs increase and decrease the output at the programmed rate respectively. If both up and down are active together the up function dominates and the output increases. If the reset input is one, the motorised pot output is reset and held at 0.0%.

9.29	Binary sum ones input															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Regen								0							
Update rate	4ms x number of menu 9 or 12 functions active															

9.30	Binary sum twos input															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Regen								0							
Update rate	4ms x number of menu 9 or 12 functions active															

9.31	Binary sum fours input															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Regen								0							
Update rate	4ms x number of menu 9 or 12 functions active															

9.32	Binary sum output															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1			1	
Range	Regen								0 to 255							
Default	Regen								0							
Update rate	4ms x number of menu 9 or 12 functions active															

9.33	Binary sum destination															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
				1			2					1	1	1	1	
Range	Regen								Pr 0.00 to Pr 21.51							
Default	Regen								Pr 0.00							
Update rate	Background															

9.34	Binary sum offset															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
				1			2					1	1	1	1	
Range	Regen								0 to 248							
Default	Regen								0							
Update rate	4ms x number of menu 9 or 12 functions active															

The binary sum output is given by:

$$\text{Offset} + \text{ones input} + (2 \times \text{twos input}) + (4 \times \text{fours input})$$

The value written to the destination parameter is defined as follows:

If destination parameter maximum $\leq (7 + \text{Offset})$:

$$\text{Destination parameter} = \text{Binary sum output}$$

If destination parameter maximum $> (7 + \text{Offset})$:

$$\text{Destination parameter} = \text{Destination parameter maximum} \times \text{Binary sum output} / (7 + \text{Offset})$$

9.10 Menu 10: Status and trips

Table 9-12 Menu 10 Regen parameter descriptions

Parameter		Range(⇅)	Default(⇌)	Type			
10.01	Drive healthy	OFF (0) or On (1)		RO	Bit	NC	PT
10.02	Drive active	OFF (0) or On (1)		RO	Bit	NC	PT
10.09	Drive output is at current limit	OFF (0) or On (1)		RO	Bit	NC	PT
10.10	Regenerating	OFF (0) or On (1)		RO	Bit	NC	PT
10.11	Braking IGBT active	OFF (0) or On (1)		RO	Bit	NC	PT
10.12	Braking resistor alarm	OFF (0) or On (1)		RO	Bit	NC	PT
10.15	Mains loss	OFF (0) or On (1)		RO	Bit	NC	PT
10.16	Under voltage active	OFF (0) or On (1)		RO	Bit	NC	PT
10.17	Overload alarm	OFF (0) or On (1)		RO	Bit	NC	PT
10.18	Drive over temperature alarm	OFF (0) or On (1)		RO	Bit	NC	PT
10.19	Drive warning	OFF (0) or On (1)		RO	Bit	NC	PT
10.20	Trip 0	0 to 230*		RO	Txt	NC	PT PS
10.21	Trip 1	0 to 230*		RO	Txt	NC	PT PS
10.22	Trip 2	0 to 230*		RO	Txt	NC	PT PS
10.23	Trip 3	0 to 230*		RO	Txt	NC	PT PS
10.24	Trip 4	0 to 230*		RO	Txt	NC	PT PS
10.25	Trip 5	0 to 230*		RO	Txt	NC	PT PS
10.26	Trip 6	0 to 230*		RO	Txt	NC	PT PS
10.27	Trip 7	0 to 230*		RO	Txt	NC	PT PS
10.28	Trip 8	0 to 230*		RO	Txt	NC	PT PS
10.29	Trip 9	0 to 230*		RO	Txt	NC	PT PS
10.30	Full power braking time	0.00 to 400.00 s	See Pr 10.30 on page 113	RW	Uni		US
10.31	Full power braking period	0.0 to 1500.0 s	Size 1 and 2: 2.0 Size 3 upwards: 0.0	RW	Uni		US
10.32	External trip	OFF (0) or On (1)	OFF (0)	RW	Bit	NC	
10.33	Drive reset	OFF (0) or On (1)	OFF (0)	RW	Bit	NC	
10.34	No. of auto-reset attempts	0 to 5	0	RW	Uni		US
10.35	Auto-reset delay	0.0 to 25.0 s	1.0	RW	Uni		US
10.36	Hold drive healthy until last attempt	OFF (0) or On (1)	OFF (0)	RW	Bit		US
10.37	Action on trip detection	0 to 3	0	RW	Uni		US
10.38	User trip	0 to 255	0	RW	Uni		US
10.40	Status word	0 to 32,767		RO	Uni	NC	PT
10.41	Trip 0 time: years.days	0.000 to 9.365 years.days		RO	Uni	NC	PT PS
10.42	Trip 0 time: hours.minutes	00.00 to 23.59 hours.minutes		RO	Uni	NC	PT PS
10.43	Trip 1 time	0 to 600.00 hours.minutes		RO	Uni	NC	PT PS
10.44	Trip 2 time	0 to 600.00 hours.minutes		RO	Uni	NC	PT PS
10.45	Trip 3 time	0 to 600.00 hours.minutes		RO	Uni	NC	PT PS
10.46	Trip 4 time	0 to 600.00 hours.minutes		RO	Uni	NC	PT PS
10.47	Trip 5 time	0 to 600.00 hours.minutes		RO	Uni	NC	PT PS
10.48	Trip 6 time	0 to 600.00 hours.minutes		RO	Uni	NC	PT PS
10.49	Trip 7 time	0 to 600.00 hours.minutes		RO	Uni	NC	PT PS
10.50	Trip 8 time	0 to 600.00 hours.minutes		RO	Uni	NC	PT PS
10.51	Trip 9 time	0 to 600.00 hours.minutes		RO	Uni	NC	PT PS

RW	Read / Write	RO	Read only	Uni	Unipolar	Bi	Bi-polar	Bit	Bit parameter	Txt	Text string		
FI	Filtered	DE	Destination	NC	Not cloned	RA	Rating dependent	PT	Protected	US	User save	PS	Power down save

*The value given for the range is that obtained via serial communication. For the text string displayed on the drive, see Table 12.1 *Trip indications* on page 155.

10.01	Drive healthy															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	Background															

Indicates the drive is not in the trip state. If Pr 10.36 is one and auto-reset is being used, this bit is not cleared until all auto-resets have been attempted and the next trip occurs. The control board LED reflects the state of this parameter: LED on continuously = 1, LED flashing = 0.

10.02	Drive active															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	4ms															

Indicates that the drive inverter is active.

10.09	Drive output is at current limit															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	4ms															

Indicates that the current limits are active.

10.10	Regenerating															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	4ms															

Indicates that power is being transferred from the drive to the supply.

10.11	Braking IGBT active															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	4ms															

Indicates that the Braking IGBT is active. If the IGBT becomes active this parameter is held on for at least 0.5s so that it can be seen on the display.

10.12	Braking resistor alarm															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	Background															

This parameter is set when the braking IGBT is active and the braking energy accumulator is greater than 75%. This parameter is held on for at least 0.5s so that it can be seen on the display.

10.15	Mains loss															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	4ms															

This parameter is the inverse of Pr 3.07.

10.16	Under voltage active															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	Background															

This parameter indicates that the under voltage condition is active. Normally this condition exists when the UU trip is also active. However, when the drive first powers up it remains in the under voltage state (i.e. this parameter is active) until the DC bus voltage exceeds the under voltage restart level (see Pr 10.16 on page 112). As the UU trip voltage level is lower than the under voltage restart level this parameter is active, but a UU trip is not active at power up until the DC bus voltage exceeds the under voltage restart level.

10.17	Overload alarm															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	Background															

This parameter is set if the drive output current is larger than 105% of rated current (Pr 5.07) and the overload accumulator is greater than 75% to warn that if the motor current is not reduced the drive will trip on an Ixt overload. (If the rated current (Pr 5.07) is set to a level above the rated drive current (Pr 11.32) the overload alarm is given when the current is higher than 100% of rated current.)

10.18	Drive over temperature alarm															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	Background															

Indicates that either the heatsink temperature is greater than or equal to 90°C, or the control board temperature is greater than or equal to 90°C, or the IGBT junction temperature calculated from the drive thermal model is above 135°C (see Pr 5.18 on page 76 and Pr 7.06 on page 88).

10.19	Drive warning															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	Background															

Indicates that one of the drive alarms is active, i.e. Pr 10.19 = Pr 10.12 OR Pr 10.17 OR Pr 10.18.

10.20	Trip 0															
10.21	Trip 1															
10.22	Trip 2															
10.23	Trip 3															
10.24	Trip 4															
10.25	Trip 5															
10.26	Trip 6															
10.27	Trip 7															
10.28	Trip 8															
10.29	Trip 9															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1			1		1		1			1	1
Range	Regen								0 to 230							
Update rate	Background															

Contains the last 10 drive trips. Pr 10.20 is the most recent trip and Pr 10.29 the oldest. When a new trip occurs all the parameters move down one, the current trip is put in Pr 10.20 and the oldest trip is lost off the bottom of the log.

10.30	Full power braking time															
Drive modes	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2						1	1	1	
Range	Regen							0.00 to 400.00 s								
Default	Regen							See below								
Update rate	Background read															

For SP1xxx and SP2xxx drives the default value is a suitable value for standard braking resistors that can be mounted within the drive heatsink as given in the table below. For larger drives the default is 0.00.

Drive voltage rating	Parameter default
200V	0.09s
400V	0.02s
575V and 690V	0.01s

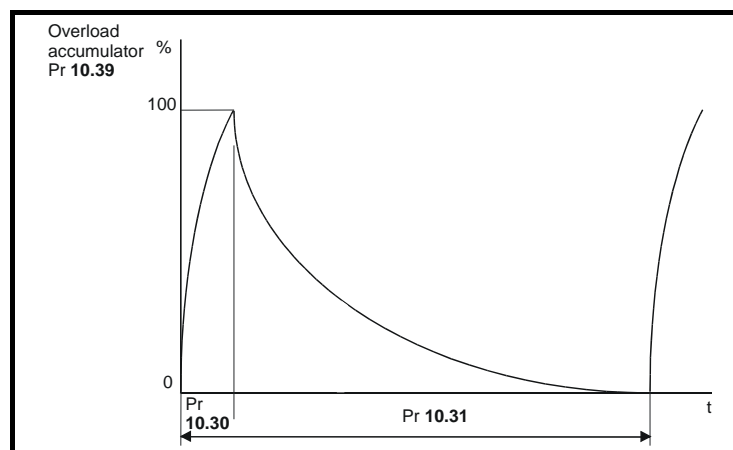
This parameter defines the time period that the braking resistor fitted can stand full braking volts without damage. The setting of this parameter is used in determining the braking overload time.

Drive voltage rating	Full braking volts
200V	390V
400V	780V
575V	930V
690V	1120V

10.31	Full power braking period															
Drive modes	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Regen							0.0 to 1500.0 s								
Default	Regen							SP1xxx and SP2xxx: 2.0s Larger drive sizes: 0.0s								
Update rate	Background read															

This parameter defines the time period which must elapse between consecutive braking periods of maximum braking power as defined by Pr 10.30. The setting of this parameter is used in determining the thermal time constant of the resistor fitted. It is assumed that the temperature will fall by 99% in this time, and so the time constant is Pr 10.30 / 5. If either Pr 10.30 or Pr 10.31 are set to 0 then no braking resistor protection is implemented.

The braking resistor temperature is modelled by the drive as shown below. The temperature rises in proportion to the power flowing into the resistor and falls in proportion to the difference between the resistor temperature and ambient.



Safety Information	Introduction	Product information	System design	Mechanical installation	Electrical installation	Getting started	Optimisation	Parameters	Technical data	Component sizing	Diagnostics
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Assuming that the full power braking time is much shorter than the full power braking period (which is normally the case) the values for Pr **10.30** and Pr **10.31** can be calculated as follows:

Power flowing into the resistor when the braking IGBT is on, $P_{on} = \text{Full braking volts}^2 / R$

Where:

Full braking volts is defined in the table and R is the resistance of the braking resistor.

Full power braking time (Pr **10.30**), $T_{on} = E / P_{on}$

Where:

E is the total energy that can be absorbed by the resistor when its initial temperature is ambient temperature.

Therefore full power braking time (Pr **10.30**), $T_{on} = E \times R / \text{Full braking volts}^2$

If the cycle shown in the diagram above is repeated, where the resistor is heated to its maximum temperature and then cools to ambient.

The average power in the resistor, $P_{av} = P_{on} \times T_{on} / T_p$

Where:

T_p is the full power braking period

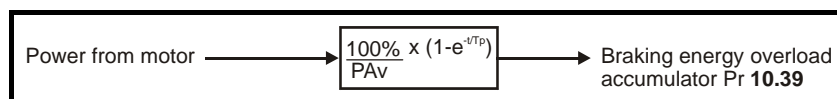
$P_{on} = E / T_{on}$

Therefore $P_{av} = E / T_p$

Therefore full power braking period (Pr **10.31**), $T_p = E / P_{av}$

The resistance and the braking resistor R, the total energy E and the average power P_{av} can normally be obtained for the resistor and used to calculate Pr **10.30** and Pr **10.31**.

If the profile of the power flowing from the motor is known then the instantaneous temperature can be calculated at any point by simulating the braking resistor with the model shown below.



The temperature of the resistor is monitored by the braking energy accumulator (Pr **10.39**). When this parameter reaches 100% the drive will trip if Pr **10.37** is 0 or 1, or will disable the braking IGBT until the accumulator falls below 95% if Pr **10.37** is 2 or 3. The second option is intended for applications with parallel connected DC buses where there are several braking resistors, each of which cannot withstand full DC bus voltage continuously. The braking load will probably not be shared equally between the resistors because of voltage measurement tolerances within the individual drives. However, once a resistor reaches its maximum temperature its load will be reduced, and be taken up by another resistor.

10.32	External trip															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Regen								0							
Update rate	Background															

If this flag is set to one then the drive will trip (Et). If an external trip function is required, a digital input should be programmed to control this bit.

10.33	Drive reset															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Regen								0							
Update rate	Background															

A zero to one change in this parameter will cause a drive reset. If a drive reset terminal is required on the drive the required terminal must be programmed to control this bit.

10.34	No. of auto-reset attempts															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Regen								0 to 5							
Default	Regen								0							
Update rate	Background															

10.35	Auto-reset delay															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Regen							0.0 to 25.0 s								
Default	Regen							1.0								
Update rate	Background															

If Pr 10.34 is set to zero 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. Pr 10.35 defines the time between the trip and the auto reset (this time is always at least 10s for Ol.AC, Ol.br trips, etc.). The reset count is only incremented when the trip is the same as the previous trip, otherwise it is reset to 0. When the reset count reaches the programmed value, any further trip of the same value will not cause an auto-reset. If there has been no trip for 5 minutes then the reset count is cleared. Auto reset will not occur on a UU, Et, EEF or HFxx trips. When a manual reset occurs the auto reset counter is reset to zero.

10.36	Hold drive healthy until last attempt															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Regen								0							
Update rate	Background															

If this parameter is 0 then Pr 10.01 (Drive healthy) is cleared every time the drive trips regardless of any auto-reset that may occur. When this parameter is set the 'Drive healthy' indication is not cleared on a trip if an auto-reset is going to occur.

10.37	Action on trip detection															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Regen								0 to 3							
Default	Regen								0							
Update rate	Background															

	Braking IGBT trip mode	Stop on low priority trips
0	Trip	No
1	Trip	Yes
2	Disable	No
3	Disable	Yes

If stop on low priority trips is selected the drive will stop before tripping except in regen mode where the drive trips immediately. Low priority trips are: th, ths, Old1, cL2, cL3, SCL.

10.38	User trip															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Regen								0 to 255							
Default	Regen								0							
Update rate	Background															

When a value other than zero is written to the user trip parameter the actions described in the following table are performed. The drive immediately writes the value back to zero.

Value written to Pr 10.38	Action
1	No action
2 to 30	Trip with same number as value written
31	No action
32 to 99	Trip with same number as value written
100	Drive reset
101 to 199	Trip with same number as value written
200	No action
201 to 204	Trip with same number as value written
205	No action
206 to 209	Trip with same number as value written
210	No action
211 to 219	Trip with same number as value written
220 to 254	No action
255	Clear trip and trip time logs

10.40	Status word															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1			1	
Range	Regen							0 to 32,767								
Update rate	Background															

The bits in this parameter correspond to the status bits in menu 10 as follows.

15	14	13	12	11	10	9	8
Not used	Pr 10.15	Pr 10.14	Pr 10.13	Pr 10.12	Pr 10.11	Pr 10.10	Pr 10.09

7	6	5	4	3	2	1	0
Pr 10.08	Pr 10.07	Pr 10.06	Pr 10.05	Pr 10.04	Pr 10.03	Pr 10.02	Pr 10.01

10.41	Trip 0 time: years.days															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3	1		1		1			1	1
Range	Regen								0.000 to 9.365 Years.Days							
Update rate	Background															

10.42	Trip 0 time: hours.minutes															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
		1					2	1		1		1			1	1
Range	Regen							00.00 to 23.59 Hours.Minutes								
Update rate	Background															

10.43	Trip 1 time															
10.44	Trip 2 time															
10.45	Trip 3 time															
10.46	Trip 4 time															
10.47	Trip 5 time															
10.48	Trip 6 time															
10.49	Trip 7 time															
10.50	Trip 8 time															
10.51	Trip 9 time															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2	1		1		1			1	1
Range	Regen								0 to 600.00 Hours.Minutes							
Update rate	Background															

When a trip occurs the reason for the trip is put into the top location in the trip log (Pr 10.20). At the same time either the time from the powered-up clock (if Pr 6.28 = 0) or from the run time clock (if Pr 6.28 = 1) is put into Trip 0 time (Pr 10.41 and Pr 10.42). The times for earlier trips (Trip 1 to 9) are moved to the next parameter in the same way that trips move down the trip log. The time for Trips 1 to 9 are stored as the time difference between when Trip 0 occurred and the relevant trip in hours and minutes. The maximum time difference that can be stored is 600 hours. If this time is exceeded the value stored is 600.00.

If the powered-up clock is used as the source for this function all the times in the log are reset to zero at power-up because they were related to the time since the drive was powered-up last time. If the runtime clock is used the times are saved at power-down and then retained when the drive powers up again. If Pr 6.28, which defines the clock source, is changed by the user the whole trip and trip time logs are cleared. It should be noted that the powered-up time can be modified by the user at any time. If this is done the values in the trip time log remain unchanged until a trip occurs. The new values put in the log for earlier trips (Trip 1 to 9) will become the time difference between the value of the power-up clock when the trip occurred and the value of the powered-up clock when the latest trip occurred. It is possible that this time difference may be negative, in which case the value will be zero.

9.11 Menu 11: General drive set-up

11.01	Parameter 0.11 set-up															
11.02	Parameter 0.12 set-up															
11.03	Parameter 0.13 set-up															
11.04	Parameter 0.14 set-up															
11.05	Parameter 0.15 set-up															
11.06	Parameter 0.16 set-up															
11.07	Parameter 0.17 set-up															
11.08	Parameter 0.18 set-up															
11.09	Parameter 0.19 set-up															
11.10	Parameter 0.20 set-up															
11.11	Parameter 0.21 set-up															
11.12	Parameter 0.22 set-up															
11.13	Parameter 0.23 set-up															
11.14	Parameter 0.24 set-up															
11.15	Parameter 0.25 set-up															
11.16	Parameter 0.26 set-up															
11.17	Parameter 0.27 set-up															
11.18	Parameter 0.28 set-up															
11.19	Parameter 0.29 set-up															
11.20	Parameter 0.30 set-up															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2					1	1	1	1	
Range	Regen								Pr 1.00 to Pr 21.51							
Default	Regen								See Table 9-13							
Update rate	Background															

These parameters define the parameters that reside in the programmable area in menu 0.

Table 9-13 Default settings:

Parameter	Regen	Description
Pr 11.01	Pr 5.01	Output / supply frequency
Pr 11.02	Pr 4.01	Current magnitude
Pr 11.03	Pr 5.03	Output / supply power
Pr 11.04	Pr 0.00	
Pr 11.05	Pr 0.00	
Pr 11.06	Pr 0.00	
Pr 11.07	Pr 0.00	
Pr 11.08	Pr 0.00	
Pr 11.09	Pr 0.00	
Pr 11.10	Pr 0.00	
Pr 11.11	Pr 0.00	
Pr 11.12	Pr 0.00	
Pr 11.13	Pr 0.00	
Pr 11.14	Pr 0.00	
Pr 11.15	Pr 0.00	
Pr 11.16	Pr 0.00	
Pr 11.17	Pr 0.00	
Pr 11.18	Pr 0.00	
Pr 11.19	Pr 11.36	SMARTCARD parameter data previously loaded
Pr 11.20	Pr 11.42	Parameter cloning

11.21	Parameter scaling															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1	1	
Range	Regen								0.000 to 9.999							
Default	Regen								1.000							
Update rate	Background															

This parameter may be used to scale the value of Pr **0.30** seen via the LED keypad (not via serial comms). Any parameter routed to Pr **0.30** may be scaled. 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.

11.22	Parameter displayed at power-up															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
												1	1	1	1	
Range	Regen							Pr 0.00 to Pr 0.50								
Default	Regen							Pr 0.11								
Update rate	Background															

This parameter defines which menu 0 parameter is displayed on power-up.

11.23	Serial address															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Regen							00 to 247								
Default	Regen							1								
Update rate	Background															

Used to define the unique address for the drive for the serial interface. The drive is always a slave.

ANSI

When the ANSI protocol is used the first digit is the group and the second digit is the address within a group. The maximum permitted group number is 9 and the maximum permitted address within a group is 9. Therefore, Pr **11.23** is limited to 99 in this mode. The value 00 is used to globally address all slaves on the system, and x0 is used to address all slaves of group x, therefore these addresses should not be set in this parameter.

Modbus RTU

When the Modbus RTU protocol is used addresses between 0 and 247 are permitted. Address 0 is used to globally address all slaves, and so this address should not be set in this parameter.

11.24	Serial mode															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1							1	1	1	1	
Range	Regen							0 to 2								
Default	Regen							1								
Update rate	Background															

This parameter defines the communications protocol used by the 485 comms port on the drive. This parameter can be changed via the drive keypad, via a Solutions Module or via the comms interface itself. If it is changed via the comms interface, the response to the command uses the original protocol. The master should wait at least 20ms before sending a new message using the new protocol. (Note: ANSI uses 7 data bits, 1 stop bit and even parity; Modbus RTU uses 8 data bits, 2 stops bits and no parity.)

Parameter value	String	Comms mode
0	AnSI	ANSI3.28 protocol
1	rtU	Modbus RTU protocol
2	Lcd	Modbus RTU protocol, but only with an LCD keypad

ANSI3.28 protocol

Full details of the CT implementation of ANSI3.28 are given in Chapter 7 *Serial communications protocol* in the *Unidrive SP Advanced User Guide*.

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Modbus RTU protocol

Full details of the CT implementation of Modbus RTU are given in Chapter 7 *Serial communications protocol* in the *Unidrive SP Advanced User Guide*.

The protocol provides the following facilities:

- Drive parameter access with basic Modbus RTU
- Drive parameter access via CMP extensions
- Option module internal parameter access via CMP extensions
- Access via an option module onto a network via CMP extensions (see specific Solutions Module User Guides for details)
- Drive parameter database upload via CMP extensions
- Drive Onboard PLC program upload/download via CMP extensions
- The protocol supports access to 32 bit floating point parameters

The following product specific limitations apply:

- Maximum slave response time when accessing the drive is 100ms
- Maximum slave response time when accessing option module internal parameters or via an option module to a network may be longer than 100ms (see specific Solutions Module specifications for details)
- Maximum number of 16 bit registers that can be written to, or read from, the drive itself is limited to 16
- Maximum number of 16 bit registers that can be written to, or read from, a Solutions Module or via a Solutions Module - see Solutions Module User Guide
- The communications buffer can hold a maximum of 128bytes

Modbus RTU protocol, but with SM-Keypad Plus only

This setting is used for disabling comms access when the SM-Keypad Plus is used as a hardware key. See section 2.6.2 '*Hardware key*' feature in the *Unidrive SP Advanced User Guide* for more information.

11.25	Baud rate															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1								1	1	1	
Range	Regen								0 to 9							
Default	Regen								6							
Update rate	Background															

Used in all comms modes to define the baud rate.

Parameter value	String/baud rate
0	300
1	600
2	1200
3	2400
4	4800
5	9600
6	19200
7	38400
8*	57600
9*	115200

*Modbus RTU only

This parameter can be changed via the drive keypad, via a Solutions Module or via the comms interface itself. If it is changed via the comms interface, the response to the command uses the original baud rate. The master should wait at least 20ms before sending a new message using the new baud rate.

11.26	Minimum comms transmit delay															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Regen								0 to 250 ms							
Default	Regen								2							
Update rate	Background															

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 delay can be extended using Pr 11.26 if required for both ANSI and Modbus RTU protocols.

Pr 11.26	Action
0	The transmit buffers are turned on and data transmission begins immediately.
1	The transmit buffers are turned on and data transmission begins after 1ms.
2 or more	The transmit buffers are turned on after an additional delay of (Pr 11.26 – 1)ms and data transmission begins after a further 1ms delay.

Note that the drive holds its own transmit buffers active for up to 1ms after it has transmitted data before switching to the receive mode, and so the host should not send any data during this time.

Modbus RTU uses a silent period detection system to detect the end of a message. This silent period is either the length of time for 3.5 characters at the present baud rate or the length of time set in Pr 11.26, whichever is the longest.

11.28	Drive derivative															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1			1	
Range	Regen							0 to 16								
Update rate	Background															

If this parameter is zero the drive is a standard Unidrive SP product. If this parameter is non-zero then the product is a derivative product. Derivatives can have different defaults from the standard product and restrictions on the values allowed for some parameters.

11.29	Software version															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2	1		1		1			1	
Range	Regen							1.00 to 99.99								
Update rate	Background															

The drive software version consists of three numbers xx.yy.zz. Pr 11.29 displays xx.yy and zz is displayed in Pr 11.34. Where xx specifies a change that affects hardware compatibility, yy specifies a change that affects product documentation, and zz specifies a change that does not affect the product documentation.

11.30	User security code															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1		1	1	1
Range	Regen							0 to 999								
Default	Regen							0								
Update rate	Background															

If any number other than 0 is programmed into this parameter user security is applied so that no parameters except Pr 11.44 can be adjusted with the LED keypad. When this parameter is read via an LED keypad and security is locked it appears as zero. The security code can be modified via serial comms etc. by setting this parameter to the required value, setting Pr 11.44 to 2 and initiating a reset by setting Pr 10.38 to 100. However security can only be cleared via the LED keypad.

11.31	User drive mode															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1			1		1		1		1	1	
Range	Regen							0 to 4								
Default	Regen							4								
Update rate	Background															

This parameter defines the drive mode. If this parameter is changed from the current drive mode, Pr x.00 is set to 1253, 1254, 1255 or 1256, and then the drive is reset the drive mode is changed to the mode defined by this parameter. After the mode change the default settings of all parameters will be set according to drive mode. The drive mode will not be changed if the drive is running. If the parameter value is changed and a reset is initiated, but Pr x.00 is not equal to 1253, 1254, 1255 or 1256, or the drive is running, this parameter is set back to the value for the current drive mode and the

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drive mode is not changed.

Parameter value	String	Drive mode
1	OPEn LP	Open-loop
2	CL VECt	Closed-loop vector
3	SErVO	Servo
4	rEgEn	Regen

11.32	Maximum Heavy Duty current rating															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2	1		1		1			1	
Range	Regen								0.00 to 9999.99 A							
Update rate	Background															

This parameter indicates the continuous current rating of the drive for Heavy Duty operation. See section 9.4 *Menu 4: Current control* for more details.

11.33	Drive voltage rating															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1			1		1		1			1	
Range	Regen							0 (200) to 3 (690)								
Update rate	Background															

This parameter has four possible values (200, 400, 575, 690) and indicates the voltage rating of the drive.

11.34	Software sub-version															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1			1	
Range	Regen							0 to 99								
Update rate	Background															

The drive software version consists of three numbers xx.yy.zz. Pr 11.29 displays xx.yy and zz is displayed in Pr 11.34. Where xx specifies a change that affects hardware compatibility, yy specifies a change that affects product documentation, and zz specifies a change that does not affect the product documentation.

11.35	Number of modules															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1			1	
Range	Regen							1 to 10								
Update rate	Background															

Indicates the number of modules fitted in a system. If the drive cannot be used in a multi-module system the value is always 1.

11.36	SMARTCARD parameter data previously loaded															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
										1		1	1		1	
Range	Regen								0 to 999							
Default	Regen								0							
Update rate	Background															

This parameter shows the number of the data block last transferred from a SMARTCARD to the drive.

11.37	SMARTCARD data number															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
										1				1	1	
Range	Regen								0 to 1,000							
Default	Regen								0							
Update rate	Background															

Data blocks are stored on a SMARTCARD with header information which includes a number which identifies the block. The header information also includes the type of data stored in the block, the drive mode if the data is parameter data, the version number and a checksum. This data can be viewed through Pr 11.38 to Pr 11.40 by increasing or decreasing Pr 11.37. This parameter jumps between the data numbers of the data blocks present on the card inserted into the drive. If this parameter is set to 1000 the checksum parameter shows the number of bytes left on the card. If there is no data on the card Pr 11.37 can only have values of 0 or 1000.

The actions of erasing a card, erasing a file, changing a menu 0 parameter, or inserting a new card will effectively set Pr 11.37 to 0 or the lowest data block number in the card.

Data transfer and erasing can be performed by entering a code in Pr x.00 and then resetting the drive as shown in the table below.

Code	Action
3yyy	Transfer drive EEPROM data to a SMARTCARD block number yyy
4yyy	Transfer drive data as difference from defaults to SMARTCARD block number yyy
5yyy	Transfer drive ladder program to SMARTCARD block number yyy
6yyy	Transfer SMARTCARD data block yyy to the drive
7yyy	Erase SMARTCARD data block yyy
8yyy	Compare drive parameters with block yyy
9999	Erase SMARTCARD
9888	Set SMARTCARD read-only flag
9777	Clear SMARTCARD read-only flag

Data blocks with numbers from 1 to 499 can be created or erased by the user. Data block with numbers 500 and above are read only and cannot be created or erased by the user. The whole card may be protected from writing or erasing by setting the read-only flag (i.e if the flag is set then only codes 6yyy or 9777 are effective).

If the destination drive has a different drive mode to the parameters on the card, the drive mode will be changed by the action of transferring parameters from the card to the drive.

After an attempt to read, write or erase a trip may occur, see Pr 10.20 on page 112 for details. If the card is removed during data transfer from the card for a data block that was saved with code 3yyy, the drive EEPROM checksum will be set up to be incorrect and an EEF trip will be initiated. If the card is removed during data transfer from the card for a data block that was saved with code 4yyy then no data will be saved to EEPROM and a C.Acc trip will be initiated. It should be noted that in both cases the parameters held in drive parameter RAM are likely to be incorrect.

During SMARTCARD or EEPROM data transfer the user will not be able to exit keypad edit mode when the current parameter is in menu 0.

Parameter data block when 3yyy is used to transfer data to a card

The data blocks contain the complete data from the drive EEPROM, i.e. all user save (US) except the parameters with the NC coding bit set. Power-down save (PS) are not saved to the SMARTCARD. A SMARTCARD can hold up to 4 data blocks of this type.

When the data is transferred back to a drive, using 6yyy in Pr x.00, it is transferred to the drive RAM and drive EEPROM. A parameter save is not required to retain the data after power-down. (When parameters are copied to the drive RAM this action is performed twice to prevent interdependent parameters from being copied incorrectly.) Before the data is taken from the card, defaults are loaded in the destination drive using the same default code as was last used in the source drive.

The categories of modules fitted to the card data source drive are stored on the card. If these are different from the destination drive, the menus for the slots where the Solutions Module categories are different, are not modified and so they will contain their default values, and the drive will produce a C.Optn trip. If the data is transferred to a drive of a different voltage, or current rating from the source drive, all parameters with the RA coding bit set (as given in the table below) are not modified and a C.Rtg trip occurs.

Parameter number	Function
Pr 2.08	Standard ramp voltage
Pr 3.05	Regen drive voltage setpoint
Pr 4.05 to Pr 4.07, Pr 21.27 to Pr 21.29	Current limits
Pr 5.07, Pr 21.07	Motor rated current
Pr 5.09, Pr 21.09	Motor rated voltage
Pr 5.17, Pr 21.12	Stator resistance
Pr 5.18	Switching frequency
Pr 5.23, Pr 21.13	Voltage offset
Pr 5.24, Pr 21.14	Transient inductance
Pr 5.25, Pr 21.24	Stator inductance
Pr 6.06	DC injection braking current

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A compare action on this data block type, setting 8yyy in Pr **x.00**, will compare the SMARTCARD data block with the data in the EEPROM. If the compare is successful Pr **x.00** is simply set to 0. If the compare fails a C.cpr trip is initiated.

Parameter data block when 4yyy is used to transfer data to a card

The only parameter data stored on the SMARTCARD is the number for the last set of defaults loaded and the differences from the last defaults loaded. This requires six bytes for each parameter difference. The data density is not as high as when using the data format described in the previous section, but in most cases the number of differences from default is small and the data blocks are therefore smaller. This method can be used for creating drive macros. Parameters that are not transferred when using 3yyy are also not transferred with this method. Also parameters that do not have a default value (attribute ND is set) cannot be transferred with this method (i.e. Pr **3.25** or Pr **21.20** which are the servo mode phasing angle have no default value). Parameter RAM is used as the source of this information.

When the data is transferred back to a drive, using 6yyy in Pr **x.00**, it is transferred to the drive RAM and the drive EEPROM. A parameter save is not required to retain the data after power-down. (When parameters are copied to the drive RAM this action is performed twice to prevent interdependent parameters from not being set correctly.) The categories of modules fitted to the card data source drive are stored on the card. If these are different from the destination drive, the menus for the slots where the Solutions Module categories are different are not modified and will contain their default values, and the drive will produce a C.Optn trip if any of the parameters from the card are in the option menus. If the data is transferred to a drive of a different voltage or current rating from the source drive then parameters with the RA coding bit set (see table above) will not be written to the drive and these parameters will contain their default values. The drive will produce a C.rtg trip whether any of the parameters from the card are parameters with the RA coding bit set or not if the current or voltage rating are different.

A compare action on this data block type, setting 8yyy in Pr **x.00**, will compare the SMARTCARD data block with the data in the drive RAM. If the compare is successful Pr **x.00** is simply set to 0. If the compare fails a C.cpr trip is initiated.

Drive Onboard PLC program data blocks

The Onboard PLC program from a drive may be transferred to/from internal flash memory from/to a SMARTCARD. If the ladder program is transferred from a drive with no ladder program loaded the block is still created on the card, but contains no data. If this is then transferred to a drive, the drive will then have no ladder program. A SMARTCARD has a capacity of 4K bytes and each block of this type can take up to 4K bytes.

SMARTCARD compare function

If 8yyy is entered in Pr **x.00** and the drive is reset, data block yyy on the SMARTCARD is compared with the relevant parameters in the drive. If the compare is successful Pr **x.00** is simply set to 0. If the compare fails a C.cpr trip is initiated. This function can be used with all data block types except type 18. If a compare is requested with data block type 18 the result will always be a C.cpr trip.

11.38	SMARTCARD data type/mode															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1			1		1		1			1	
Range	Regen								0 to 18							
Update rate	Background															

Indicates the type/mode of the data block selected with Pr **11.37** as shown in the following table.

Pr 11.38	String	Type/mode	Data stored
0	FrEE	Value when Pr 11.37 = 0	
2	3OpEn.LP	Open-loop mode parameters	Data from EEPROM
3	3CL.VEct	Closed-loop vector mode parameters	Data from EEPROM
4	3SErVO	Servo mode parameters	Data from EEPROM
5	3rEgEn	Regen mode parameters	Data from EEPROM
6 to 8	3Un	Unused	
10	4OpEn.LP	Open-loop mode parameters	Defaults last loaded and differences
11	4CL.VEct	Closed-loop vector mode parameters	Defaults last loaded and differences
12	4SErVO	Servo mode parameters	Defaults last loaded and differences
13	4rEgEn	Regen mode parameters	Defaults last loaded and differences
14 to 16	4Un	Unused	
17	LAddEr	Drive Onboard PLC program	Drive Onboard PLC program
18	Option	A file containing user defined data (normally created by an SM-Applications option module)	User defined

11.39	SMARTCARD data version															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
										1				1	1	
Range	Regen								0 to 9,999							
Default	Regen								0							
Update rate	Background															

Indicates the version number of the data block. This is intended to be used when data blocks are used as drive macros. If a version number is to be stored with a data block this parameter should be set to the required version number before the data is transferred. Each time Pr 11.37 is changed by the user the drive puts the version number of the currently viewed data block in this parameter.

11.40	SMARTCARD data checksum															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1			1	
Range	Regen							0 to 65,335								
Update rate	Background															

Gives the checksum of the data block or the bytes left on the card if Pr 11.37 = 1000.

11.41	Status mode time-out															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Regen								0 to 250 s							
Default	Regen								240							
Update rate	Background															

Sets the timeout for the drive display to revert to status mode from edit mode following no key presses. Although this parameter can be set to less than 2s, the minimum timeout is 2s.

11.42	Parameter cloning															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1					1			*	1	1	
Range	Regen								0 to 4							
Default	Regen								0							
Update rate	Background															

* Modes 1 and 2 are not US (i.e. not saved when drive parameters are saved), mode 3 and 4 are US.

Therefore this parameter can only be saved to EEPROM if it has a value of 0, 3 or 4.

Reading (1)

Setting Pr 11.42 to 1 and resetting the drive will load the parameters from the card into the drive parameter set and the drive EEPROM. All SMARTCARD trips apply. When the action is complete this parameter is automatically reset to zero. Parameters are saved to drive EEPROM after this action is complete.

NOTE

This operation is only performed if block 1 on the card is a complete copy of the EEPROM (i.e. types 1 to 5) and not a difference from default file. If block 1 does not exist or the type is incorrect a C.typ trip occurs.

Programming (2)

Setting Pr 11.42 to 2 and resetting the drive will save the parameters in the drive EEPROM to a card, i.e. equivalent to writing 3001 to Pr x.00. All SMARTCARD trips apply except C.Chg. If the data block already exists it is automatically over-written. When the action is complete this parameter is automatically reset to zero.

Auto (3)

Changing Pr 11.42 to 3 and resetting the drive will save the complete parameter set from the EEPROM to the card. All SMARTCARD trips apply, except C.Chg. If the data block already exists it is automatically overwritten.

If the card is removed when Pr 11.42 is set to 3 Pr 11.42 will be set to 0. If a card with a file 1 is inserted into a drive the drive must overwrite the file to

Safety Information	Introduction	Product information	System design	Mechanical installation	Electrical installation	Getting started	Optimisation	Parameters	Technical data	Component sizing	Diagnostics
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ensure that the data is correct. The action of setting Pr 11.42 to 0 when a card is removed will force the user to change Pr 11.42 if auto mode is still required. Therefore the user will need to set Pr 11.42 to 3 and press reset to write the complete parameter set to the new card. (When a parameter in menu zero is changed, and a card is fitted, a save to EEPROM, is initiated. Only the new value of the modified parameter is written to the EEPROM and card. If Pr 11.42 were not cleared automatically when a card is removed, then when a new card is inserted that contains data block 1 the modified parameter would be written to the existing data block 1 on the new card. The rest of the parameters in this data block may not be the same as those in the drive.)

When Pr 11.42 is equal to 3 and the parameters in the drive are saved, the card is also updated, therefore the card becomes a copy of the drives stored configuration.

At power up, if Pr 11.42 is set to 3, the drive will save the 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.

Boot (4)

When Pr 11.42 is set 4 the drive operates in the same way as for Auto mode except when the drive is powered-up. At power up provided a card is inserted in the drive and parameter data block 1 exists, it is type 1 to 5, with Pr 11.42 on the card set to 4, the parameters are automatically transferred to the drive. If the drive mode is different from that on the card the drive gives a C.Typ trip and the data is not transferred. If the 'boot' mode is stored in the cloning card this makes the cloning the master device This provides a very fast and efficient way of re-programming a number of drives. This parameter is reset to 0 after the parameters have been transferred.

NOTE

This parameter has the NC (not clonable attribute) set, and so its value is not stored on a SMART card. Therefore the value of this parameter taken from a card is always zero. However, when data is transferred to a card from the source drive the value of this parameter is held in the data block header so that the destination drive can detect when boot transfer is required on power-up (i.e. the source drive had this parameter set to 4).

11.43	Load defaults															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1					1				1	1	
Range	Regen								0 to 2							
Default	Regen								0							
Update rate	Background															

Setting this parameter to a non-zero value and resetting the drive loads defaults as follows. This parameter is automatically reset to zero when the action is complete.

Parameter value	Equivalent Pr x.00 value	Defaults loaded
1 (Eur)	1233	Normal defaults
2 (USA)	1244	US defaults

11.44	Security status															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1			1				1	1	1	1	
Range	Regen								0 to 2							
Default	Regen								0							
Update rate	Background															

This parameter controls access via the drive LED keypad as follows:

Value	String	Action
0	L1	Only menu 0 can be accessed
1	L2	All menus can be accessed
2	Loc	Lock user security when drive is reset. (This parameter is set to L1 after reset.)

The LED keypad can adjust this parameter even when user security is set.

11.45	Motor 2 parameters select															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Regen								0							
Update rate	Background															

When this bit is set to one the motor 2 parameters in menu 21 become active instead of the equivalent parameters in other menus. Changes will only be implemented when the drive is disabled. When the motor 2 parameters are active the decimal point that is second from the right on the 1st row of the display is lit. If this parameter is one when an auto-tune is carried out (Pr 5.12 = 1), the results of the auto-tune are written to the equivalent second motor parameters instead of the normal parameters. Each time this parameter is changed the accumulator for motor thermal protection is reset to zero.

11.46	Defaults previously loaded															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
										1		1	1		1	
Range	Regen								0 to 2,000							
Default	Regen								Number of defaults loaded, i.e. 1,233 etc.							
Update rate	Background															

Displays the number of the last set of defaults loaded, i.e. 1233, 1244, etc.

11.47	Drive Onboard PLC program enable															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Regen								0 to 2							
Default	Regen								2							
Update rate	Background															

This parameter is used to start and stop the drive Onboard PLC program.

Value	Description
0	Halt the drive Onboard PLC program.
1	Run the drive Onboard PLC program (if fitted). Any out-of-range parameter writes attempted will be clipped to the maximum / minimum values valid for that parameter before being written.
2	Run the drive Onboard PLC program (if fitted). Any out-of-range parameter writes attempted will cause a drive trip.

11.48	Drive Onboard PLC program status															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1				
Range	Regen								-128 to +127							
Update rate	Background															

The drive Onboard PLC program status parameter indicates to the user the actual state of the drive Onboard PLC program. (not fitted / running / stopped / tripped.)

Value	Description
-n	Onboard PLC program caused a drive trip due to an error condition while running rung n. Note that the rung number is shown on the display as a negative number.
0	Onboard PLC program is not fitted.
1	Onboard PLC program is fitted but stopped.
2	Onboard PLC program is fitted and running.

11.49	Drive Onboard PLC programming events															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1			1	1
Range	Regen							0 to 65,535								
Update rate	Background															

The drive Onboard PLC programming events parameter holds the number of times a Onboard PLC program download has taken place and is 0 on dispatch from the factory. If the drive Onboard PLC programming events is greater than the maximum value which may be represented by this parameter the value will be clipped to the maximum value. This parameter is not altered when defaults are loaded.

11.50	Drive Onboard PLC program maximum scan time															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1		1			1	
Range	Regen							0 to 65,535 ms								
Update rate	Onboard PLC program execution period															

The Onboard PLC program maximum scan time parameter gives the longest scan time within the last ten scans of the drive Onboard PLC program. If the scan time is greater than the maximum value which may be represented by this parameter the value will be clipped to the maximum value.

11.51	Drive Onboard PLC program first run															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Range	Regen								0 or 1							
Update rate	Onboard PLC program execution period															

The drive Onboard PLC program first run parameter is set for the duration of the first ladder diagram scan from the ladder diagram stopped state. This enables the user to perform any required initialisation every time the ladder diagram is run. This parameter is set every time the ladder is stopped.

9.12 Menu 12: Threshold detectors and variable selectors

Menu 12 includes two threshold detectors which produce logic signals depending on the level of a variable value with respect to a threshold, and two variable selectors which allow two input parameters to be selected or combined to produce a variable output. One menu 9 or one menu 12 function is executed every 4ms. Therefore the sample time of these functions is 4ms x number of menu 9 and 12 functions active. A function is active if one or more sources are routed to a valid parameter.

Figure 9-8 Menu 12 logic diagram

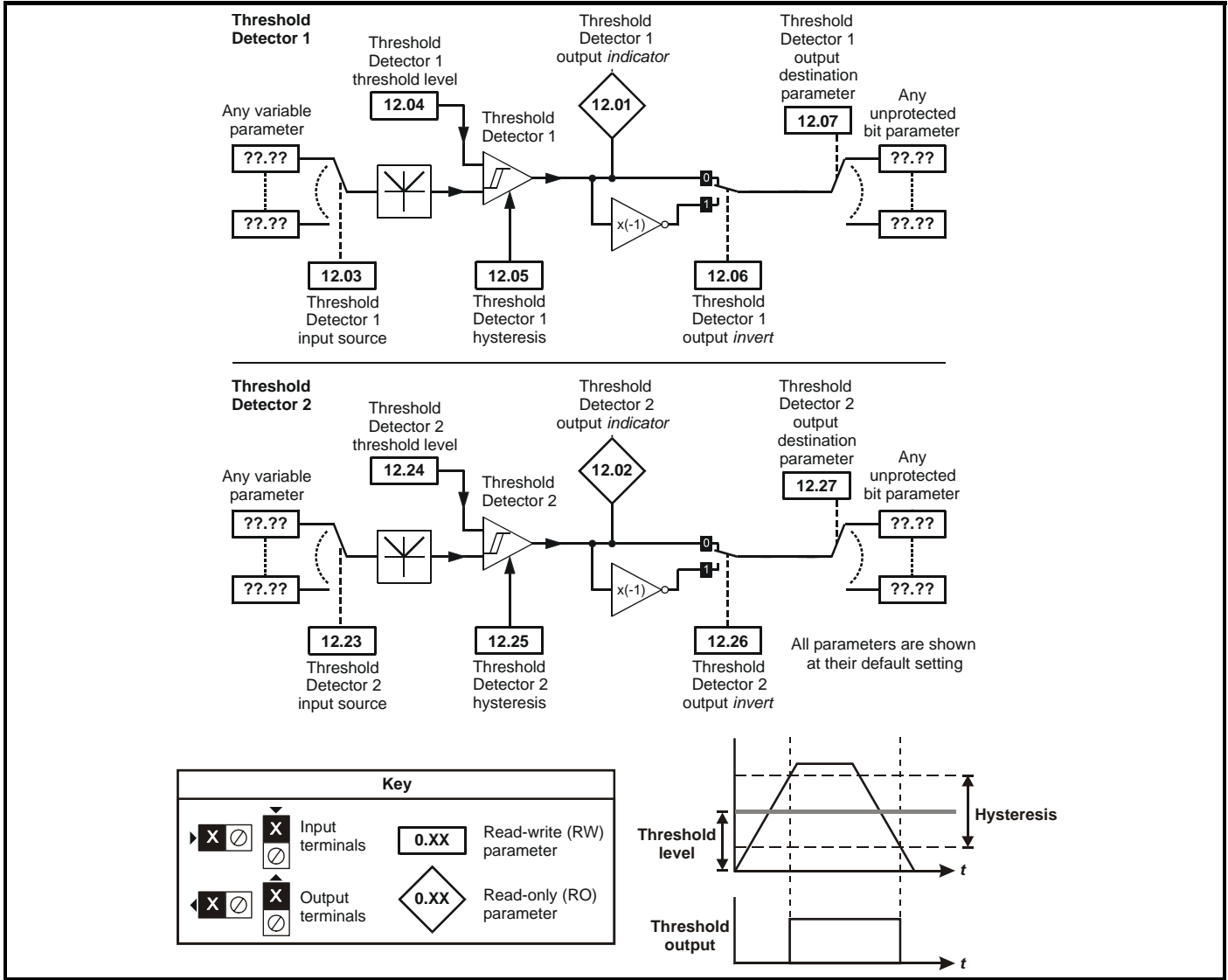
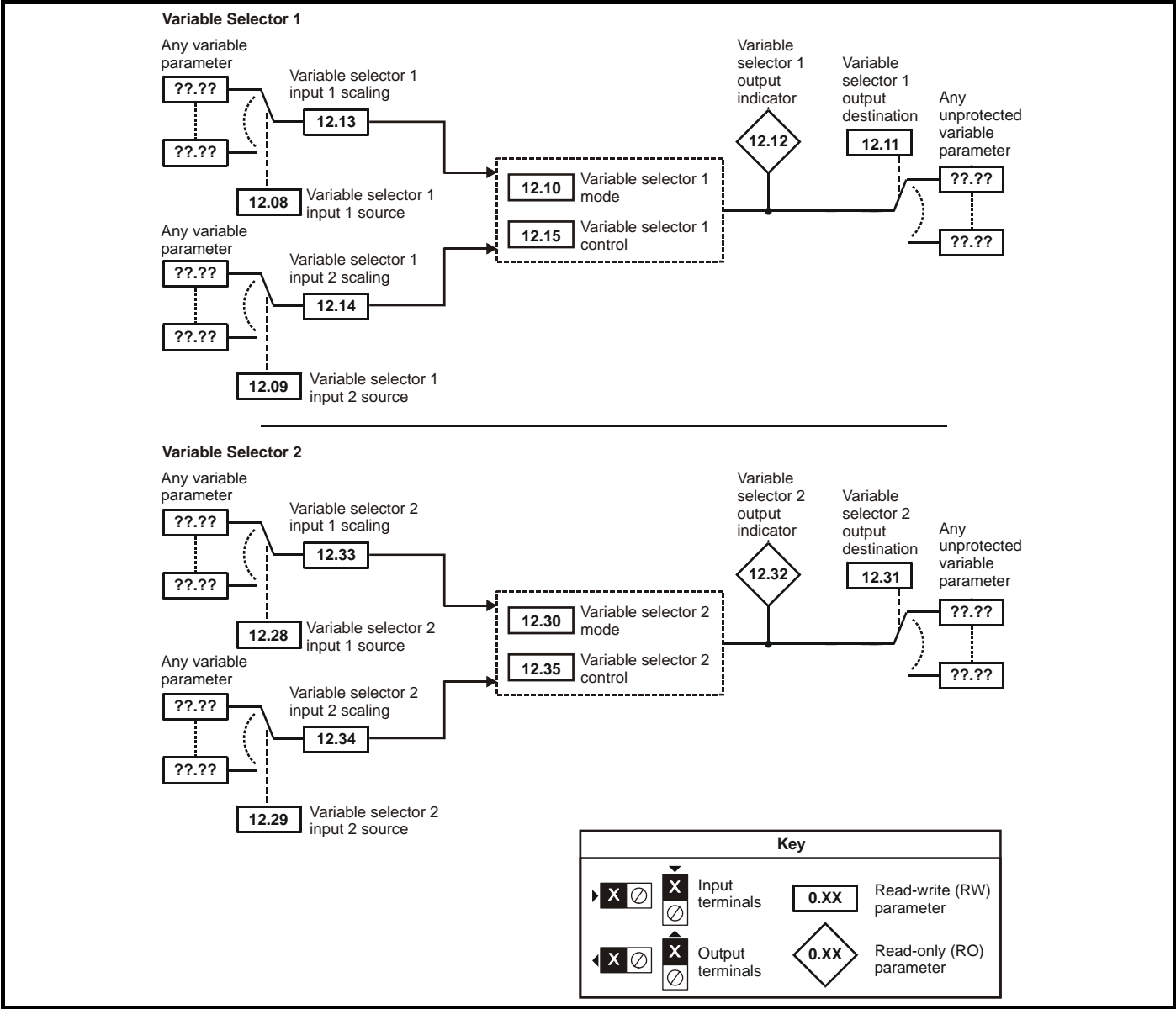


Figure 9-9 Menu 12 Logic diagram (continued)



12.01	Threshold detector 1 output															
12.02	Threshold detector 2 output															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1							1		1		1				
Update rate	4ms x number of menu 9 or 12 functions active															

12.03	Threshold detector 1 source															
12.23	Threshold detector 2 source															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2					1	1	1	1	
Range	Regen							Pr 0.00 to Pr 21.51								
Default	Regen							Pr 0.00								
Update rate	Background															

12.04	Threshold detector 1 level															
12.24	Threshold detector 2 level															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2						1	1	1	
Range	Regen								0.00 to 100.00 %							
Default	Regen								0.00							
Update rate	4ms x number of menu 9 or 12 functions active															

12.05	Threshold detector 1 hysteresis															
12.25	Threshold detector 2 hysteresis															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2						1	1	1	
Range	Regen							0.00 to 25.00 %								
Default	Regen							0.00								
Update rate	4ms x number of menu 9 or 12 functions active															

12.06	Threshold detector 1 output invert															
12.26	Threshold detector 2 output invert															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Regen								0							
Update rate	4ms x number of menu 9 or 12 functions active															

12.07	Threshold detector 1 destination															
12.27	Threshold detector 2 destination															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
				1			2					1	1	1	1	
Range	Regen								Pr 0.00 to Pr 21.51							
Default	Regen								Pr 0.00							
Update rate	Background															

The threshold detector compares the modulus of the source input value (defined by Pr 12.03, Pr 12.23), converted to a percentage of its maximum value, with the threshold level (Pr 12.04, Pr 12.24). If the value is greater or equal to the threshold plus half the hysteresis band (Pr 12.05, Pr 12.25) the output becomes active, or if the value is less than the threshold minus half the hysteresis band the output becomes inactive. The output may be inverted if required by setting the invert flag (Pr 12.06, Pr 12.26). The result is routed to the destination (defined by Pr 12.07, Pr 12.27).

12.08	Variable selector 1 source 1															
12.28	Variable selector 2 source 1															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2					1	1	1	1	
Range	Regen								Pr 0.00 to Pr 21.51							
Default	Regen								Pr 0.00							
Update rate	Background															

12.09	Variable selector 1 source 2															
12.29	Variable selector 2 source 2															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2					1	1	1	1	
Range	Regen								Pr 0.00 to Pr 21.51							
Default	Regen								Pr 0.00							
Update rate	Background															

12.10	Variable selector 1 mode															
12.30	Variable selector 2 mode															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1	1	
Range	Regen								0 to 10							
Default	Regen								0							
Update rate	4ms x number of menu 9 or 12 functions active															

12.11	Variable selector 1 destination															
12.31	Variable selector 2 destination															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
				1			2					1	1	1	1	
Range	Regen								Pr 0.00 to Pr 21.51							
Default	Regen								Pr 0.00							
Update rate	Background															

12.12	Variable selector 1 output															
12.32	Variable selector 2 output															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2	1		1		1				
Range	Regen								±100.00 %							
Update rate	4ms x number of menu 9 or 12 functions active															

12.13	Variable selector 1 source 1 scaling															
12.33	Variable selector 2 source 1 scaling															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1		
Range	Regen								±4.000							
Default	Regen								1.000							
Update rate	4ms x number of menu 9 or 12 functions active															

12.14	Variable selector 1 source 2 scaling															
12.34	Variable selector 2 source 2 scaling															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1		
Range	Regen								±4.000							
Default	Regen								1.000							
Update rate	4ms x number of menu 9 or 12 functions active															

12.15	Variable selector 1 control															
12.35	Variable selector 2 control															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2						1	1	1	
Range	Regen								0.00 to 100.00							
Default	Regen								0.00							
Update rate	Background															

The variable selectors allow two source values (defined by Pr 12.08, Pr 12.28 and Pr 12.09, Pr 12.29) to be combined as defined by the mode (Pr 12.10, Pr 12.30) to produce an output (Pr 12.12, Pr 12.32) which can be routed to the destination parameter (defined by Pr 12.11, Pr 12.31). The actions of the variable selector are defined by the mode parameter as given below. If the mode parameter is changed or the variable selector is disabled because neither source is routed to a valid parameter all the internal state variables (i.e. time constant accumulator, etc.) within the selector are reset. When the Sectional control mode is selected the function is also reset, and the output is held at zero, when the control (Pr 12.15 or Pr 12.35) is zero. It is active when the control has a non-zero value.

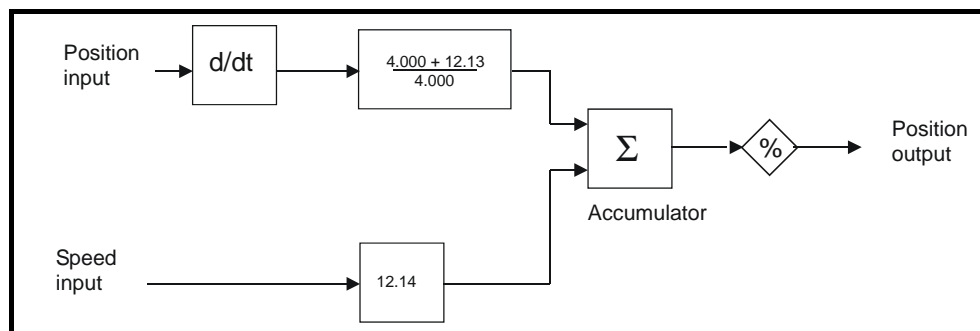
Mode value	Action	Result
0	Select input 1	output = input1
1	Select input 2	output = input2
2	Add	output = input1 + input2
3	Subtract	output = input1 - input 2
4	Multiply	output = (input1 x input2) / 100.0
5	Divide	output = (input1 x 100.0) / input2
6	Time constant	output = input1 / ((control param)s + 1)
7	Linear ramp	output = input1 via a ramp with a ramp time of (control param) seconds from 0 to 100%
8	Modulus	output = input1
9	Powers	control = 0.02: output = input1 ² / 100.0 control = 0.03: output = input1 ³ / 100.0 ² control has any other value: output = input1
10	Sectional control	control = 0.00: disabled, accumulator reset and output zero control <> 0.00: output as defined below

NOTE

A loss of resolution can be seen when routing parameter values through the variable selectors due to the maximum available resolution being two decimal places. The variable select output is scaled to ensure a 100.00% output gives full scale output to the destination parameter. This results in the destination parameter jumping in steps equivalent to 0.01% resolution if the destination parameter has a greater resolution than two decimal places.

Sectional control

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 position controller (menu 13) or to generate an encoder simulation output via the SM-Universal encoder plus module. This function can be selected for either variable selector, but the description below relates to variable selector 1.



The position input 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. The input is scaled so that as Pr 12.13 is varied between -4.000 and 4.000 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 Pr 12.13 is 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 input 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 the output of the accumulator 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.

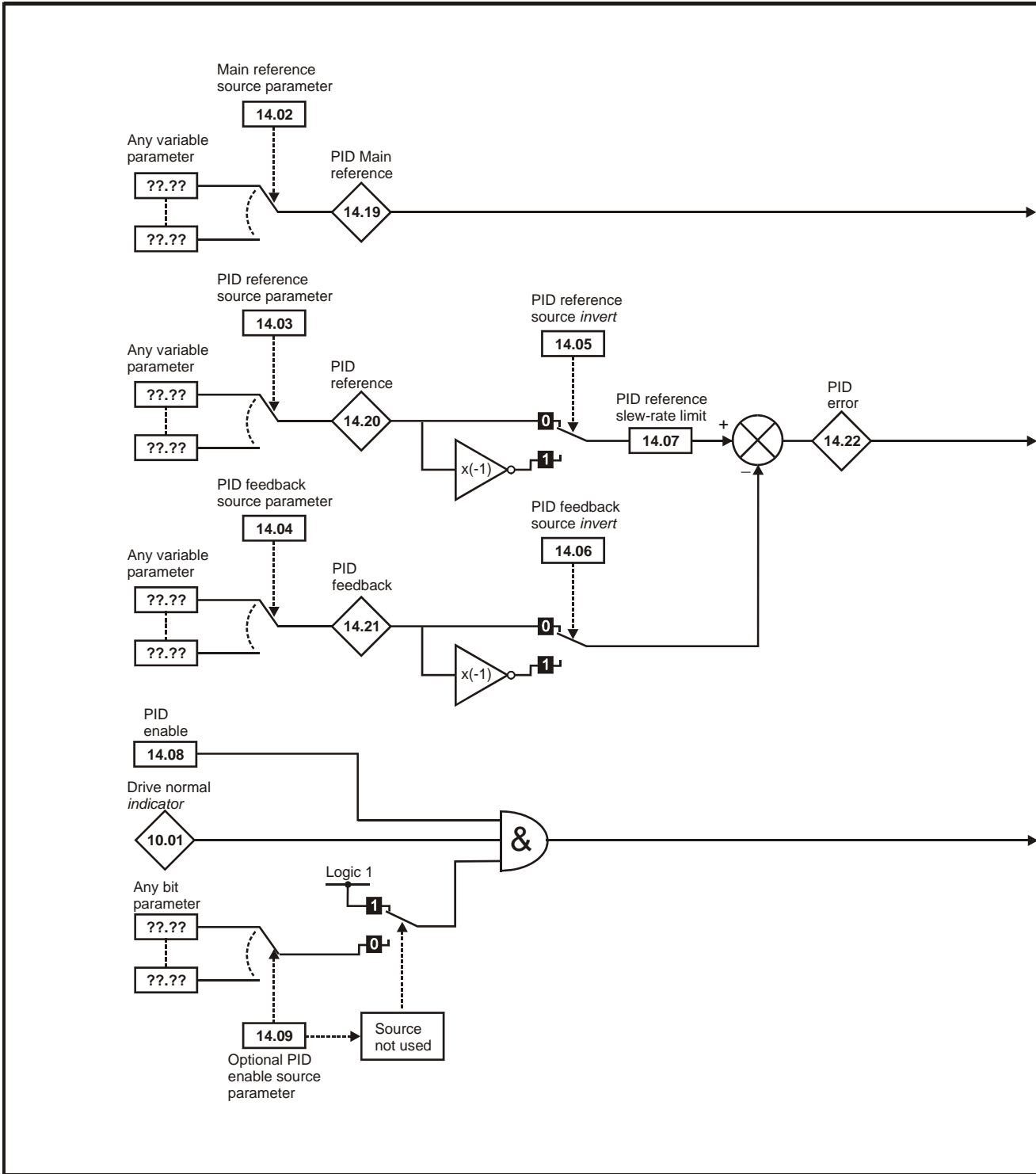
The speed input defines a speed offset with a resolution of 0.1rpm. Full scale of the source parameter corresponds to 1000.0rpm. Scaling may be applied using Pr 12.14 to give a full scale value of 4000.0rpm. The speed input is added to the accumulator to move the output position forwards or backwards with respect to the position input.

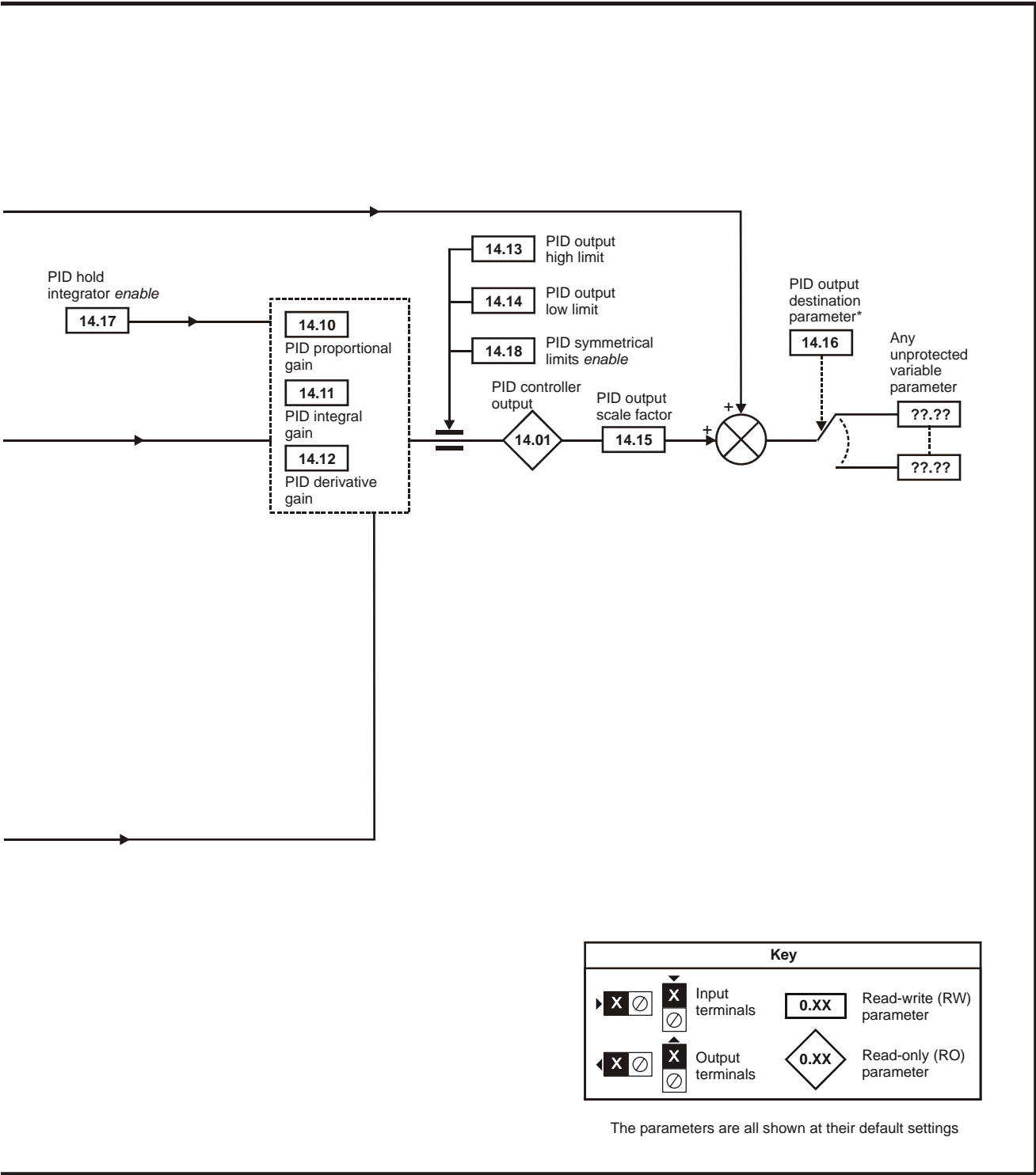
This sample time for this function is 4ms x number of menu 9 and 12 functions active. Extending the sample time does not cause any overflow errors within the function, however, care must be taken to ensure that the input or output positions do not change by more than half a revolution within the sample time, i.e. for a sample time of 4ms the input or output speed should not exceed 7500rpm, for a sample time of 8ms the speed should not exceed 3750rpm, etc. If the output of this function is to supply a reference to the position controller in menu 13 it must be the only user function in menu 9 or 12 enabled. **If another function is enabled the input to the position controller will only change every 8ms (i.e. every 2 samples of the position controller) and the speed reference applied to the drive could be very noisy.**

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 4ms.

Figure 9-10 Menu 14 logic diagram





14.01	PID output															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2	1		1		1				
Range	Regen								±100.00 %							
Update rate	4ms															

Subject to the limits the PID controller output is given by

$$\text{output} = \text{error} \times [P + I/s + Ds/(0.064s + 1)]$$

Where:

error = reference - feedback

P = proportional gain = Pr 14.10

I = integral gain = Pr 14.11

D = differential gain = Pr 14.12

Therefore with an error of 100% and P = 1.000 the output produced by the proportional term is 100%. With an error of 100% and I = 1.000 the output produced by the integral term will increase linearly by 100% every second. With an error that is increasing by 100% per second and D = 1.000 the output produced by the D term will be 100%.

14.02	PID main reference source															
14.03	PID reference source															
14.04	PID feedback source															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2					1	1	1	1	
Range	Regen								Pr 0.00 to Pr 21.51							
Default	Regen								Pr 0.00							
Update rate	Background															

14.05	PID reference source invert															
14.06	PID feedback source invert															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Regen								0							
Update rate	4ms															

14.07	PID reference slew rate limit															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							1						1	1	1	
Range	Regen							0.0 to 3,200.0 s								
Default	Regen							0.0								
Update rate	Background															

This parameter defines the time taken for the reference input to ramp from 0 to 100.0% following a 0 to 100% step change in input.

14.08	PID enable															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Regen								0							
Update rate	4ms															

14.09	PID optional enable source															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2					1	1	1	1	
Range	Regen							Pr 0.00 to Pr 21.51								
Default	Regen							Pr 0.00								
Update rate	Background															

To enable the PID controller the drive must be healthy (Pr 10.01 = 1) and the PID enable (Pr 14.08) must be one. If the option enable source (Pr 14.09) is 00.00 or routed to a non-existent parameter the PID controller is still enabled provided Pr 10.01 = 1 and Pr 14.08 = 1. If the optional enable source (Pr 14.09) is routed to an existing parameter the source parameter must be one before the PID controller can be enabled. If the PID controller is disabled the output is zero and the integrator is set to zero.

14.10	PID P gain															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1	1	
Range	Regen							0.000 to 4.000								
Default	Regen							1.000								
Update rate	Background															

14.11	PID I gain															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1	1	
Range	Regen							0.000 to 4.000								
Default	Regen							0.500								
Update rate	Background															

14.12	PID D gain															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1	1	
Range	Regen							0.000 to 4.000								
Default	Regen							0.000								
Update rate	Background															

14.13	PID upper limit															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2						1	1	1	
Range	Regen							0.00 to 100.00 %								
Default	Regen							100.00								
Update rate	Background															

14.14	PID lower limit															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2						1	1		
Range	Regen								±100.00 %							
Default	Regen								-100.00							
Update rate	Background															

If Pr 14.18 = 0, the upper limit (Pr 14.13) defines the maximum positive output for the PID controller and the lower limit (Pr 14.14) defines the minimum positive or maximum negative output. If Pr 14.18 = 1, the upper limit defines the maximum positive or negative magnitude for the PID controller output. When any of the limits are active the integrator is held.

14.15	PID scaling															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							3						1	1	1	
Range	Regen							0.000 to 4.000								
Default	Regen							1.000								
Update rate	4ms															

14.16	PID destination															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
				1			2					1	1	1	1	
Range	Regen								Pr 0.00 to Pr 21.51							
Default	Regen								Pr 0.00							
Update rate	Background															

The value written to the destination parameter is (PID controller output x scaling) + PID main reference.

14.17	PID hold integrator															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1									1				1		
Default	Regen								0							
Update rate	4ms															

When this parameter is set to 0 the integrator operates normally. Setting this parameter to 1 will cause the integrator value to be held. Setting this parameter does not prevent the integrator from being reset to zero if the PID controller is disabled.

14.18	PID symmetrical limit enable															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Regen								0							
Update rate	Background															

See Pr 14.13 and Pr 14.14.

14.19	PID main reference															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2	1		1		1				
Range	Regen								±100.00 %							
Update rate	4ms															

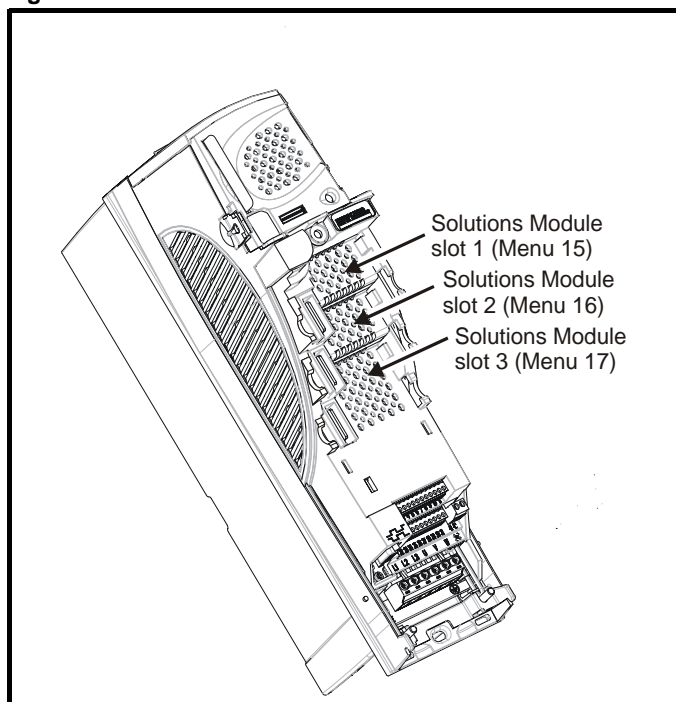
14.20	PID reference															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2	1		1		1				
Range	Regen								±100.00 %							
Update rate	4ms															

14.21	PID feedback															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2	1		1		1				
Range	Regen								±100.00 %							
Update rate	4ms															

14.22	PID error															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2	1		1		1				
Range	Regen								±100.00 %							
Update rate	4ms															

9.14 Menus 15, 16 and 17: Solutions Module set-up

Figure 9-11 Location of Solutions Module slots and their corresponding menu numbers



9.14.1 Parameters common to all categories

Parameter	Range(⇅)	Default(⇒)	Type					
x.01 Solutions Module ID	0 to 499		RO	Uni			PT	US
x.02 Solutions Module software version	0.00 to 99.99		RO	Uni		NC	PT	
x.50 Solutions Module error status	0 to 255		RO	Uni		NC	PT	
x.51 Solutions Module software sub-version	0 to 99		RO	Uni		NC	PT	

The Solutions Module ID indicates the type of module that is fitted in the corresponding slot.

Solutions Module ID	Module	Category
0	No module fitted	
101	SM-Resolver	Feedback
102	SM-Universal Encoder Plus	
104	SM-Encoder Plus	
201	SM-I/O Plus	Automation
203	SM-I/O Timer	
204	SM-PELV	
206	SM-I/O 120V	
207	SM-I/O Lite	
301	SM-Applications	
302	SM-Applications Lite	
303	SM-EZMotion	
403	SM-PROFIBUS-DP	Fieldbus
404	SM-Interbus	
406	SM-CAN	
407	SM-DeviceNet	
408	SM-CANopen	
409	SM-SERCOS	
410	SM-Ethernet	
501	SM-SLM	SLM

For full parameter descriptions for Menus 15, 16 and 17, refer to the *Unidrive SP Advanced User Guide* or the individual Solutions Module User Guide.

9.15 Menu 18: Application menu 1

Menu 18 contains parameters that do not affect the operation of the drive. These general purpose parameters are intended for use with fieldbus and application Solutions Modules. The read write parameters in this menu can be saved in the drive.

18.01	Application menu 1 power-down saved integer															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
										1				1		1
Range	Regen								-32,768 to 32,767							
Default	Regen								0							
Update rate	N/A															

18.02 to 18.10	Application menu 1 read-only integer															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
										1						
Range	Regen								-32,768 to 32,767							
Default	Regen								0							
Update rate	N/A															

18.11 to 18.30	Application menu 1 read-write integer															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1		
Range	Regen								-32,768 to 32,767							
Default	Regen								0							
Update rate	N/A															

18.31 to 18.50	Application menu 1 read-write bit															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Regen								0							
Update rate	N/A															

9.16 Menu 19: Application menu 2

Menu 19 contains parameters that do not affect the operation of the drive. These general purpose parameters are intended for use with fieldbus and application Solutions Modules. The read write parameters in this menu can be saved in the drive.

19.01	Application menu 2 power-down saved integer															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
										1				1		1
Range	Regen								-32,768 to 32,767							
Default	Regen								0							
Update rate	N/A															

19.02 to 19.10	Application menu 2 read-only integer															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
										1						
Range	Regen								-32,768 to 32,767							
Default	Regen								0							
Update rate	N/A															

19.11 to 19.30	Application menu 2 read-write integer															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
													1	1		
Range	Regen								-32,768 to 32,767							
Default	Regen								0							
Update rate	N/A															

19.31 to 19.50	Application menu 2 read-write bit															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Regen								0							
Update rate	N/A															

9.17 Menu 20: Application menu 3

Menu 20 contains parameters that do not affect the operation of the drive. These general purpose parameters are intended for use with fieldbus and application Solutions Modules. The read write parameters in this menu cannot be saved in the drive.

20.01 to 20.20	Application menu 3 read-write integer																
Drive mode	Regen																
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS	
										1				1			
Range	Regen								-32,768 to 32,767								
Default	Regen								0								
Update rate	N/A																

20.21 to 20.40	Application menu 3 read-write long integer																
Drive mode	Regen																
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS	
										1				1			
Range	Regen								-2 ³¹ to 2 ³¹ -1								
Default	Regen								0								
Update rate	N/A																

9.18 Menu 22: Additional menu 0 set-up

Menu 22 contains parameters that are used to set up the source parameters for menu 0 in addition to those that are set up from within Menu 11.

22.01 to 22.07 22.10 to 22.11 22.18 22.20 to 22.29	Parameter 00.xy set-up															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2					1	1	1	1	
Range	Regen							Pr 1.00 to Pr 21.51								
Default	Regen							See Table 9-14								
Update rate	Background read															

These parameters define the parameters that reside in the programmable area in menu 0.

Table 9-14 Menu 22 default settings

Parameter	Menu 0 parameter	Regen
Pr 22.01	Pr 031	Pr 11.33
Pr 22.02	Pr 0.32	Pr 11.32
Pr 22.03	Pr 0.33	Pr 0.00
Pr 22.04	Pr 0.34	Pr 11.30
Pr 22.05	Pr 0.35	Pr 11.24
Pr 22.06	Pr 0.36	Pr 11.25
Pr 22.07	Pr 0.37	Pr 11.23
Pr 22.10	Pr 0.40	Pr 0.00
Pr 22.11	Pr 0.41	Pr 5.18
Pr 22.18	Pr 0.48	Pr 11.31
Pr 22.20	Pr 0.50	Pr 11.29
Pr 22.21	Pr 0.51	Pr 0.00
Pr 22.22	Pr 0.52	Pr 0.00
Pr 22.23	Pr 0.53	Pr 0.00
Pr 22.24	Pr 0.54	Pr 0.00
Pr 22.25	Pr 0.55	Pr 0.00
Pr 22.26	Pr 0.56	Pr 0.00
Pr 22.27	Pr 0.57	Pr 0.00
Pr 22.28	Pr 0.58	Pr 0.00
Pr 22.29	Pr 0.59	Pr 0.00

It should be noted that if the parameter values saved in the drive EEPROM or on a SMARTCARD are all zero for menu 22 the drive will automatically load defaults for this menu when the drive is powered up or the parameters are transferred from the SMARTCARD. This ensures that defaults are used for this menu if the saved parameters are from a software version which did not include this menu.

10 Technical data

10.1 Supply requirements

Voltage:

SPX40X 380V to 480V $\pm 10\%$

Number of phases: 3

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

Frequency range: 48 to 65Hz

Synchronisation frequency: 30 to 100Hz

AC mains instability operation possible down to: 150Vac.

AC mains loss detection level: 150Vac

Unidrive SP size 6 heatsink fan supply requirements

Nominal voltage: 24V

Minimum voltage: 23.5V

Maximum voltage: 27V

Current drawn: 3.3A

Recommended power supply: 24V, 100W, 4.5A

Recommended fuse: 4A fast blow (I^2t less than $20A^2s$)

10.1.1 DC Bus voltage setpoint

The DC Bus voltage setpoint is user definable through Pr 3.05, this must be set to 50V above $V_{ac}\sqrt{2}$.

Supply	DC Bus voltage setpoint (Vdc)		
Vac	Min	Default	Max
380	590	650	800
480	730	780	800

10.1.2 Temperature, humidity and cooling method

Ambient temperature operating range:

0°C to 50°C (32°F to 122°F).

Output current derating must be applied at ambient temperatures $> 40^\circ\text{C}$ (104°F).

Minimum temperature at power-up:

-15°C (5°F), the supply must be cycled when the drive has warmed up to 0°C (32°F).

Cooling method: Forced convection

Maximum humidity: 95% non-condensing at 40°C (104°F)

10.1.3 Storage

-40°C (-40°F) to +50°C (122°F) for long term storage, or to +70°C (158°F) for short term storage.

10.1.4 Altitude

Altitude range: 0 to 3,000m (9,900 ft), subject to the following conditions:

1,000m to 3,000m (3,300 ft to 9,900 ft) above sea level: de-rate the maximum output current from the specified figure by 1% per 100m (330 ft) above 1,000m (3,300 ft)

For example at 3,000m (9,900ft) the output current of the drive would have to be de-rated by 20%.

10.1.5 IP Rating (Ingress Protection)

The Unidrive SP is rated to IP20 pollution degree 2 (dry, non-conductive contamination only) (NEMA 1). However, it is possible to configure the drive to achieve IP54 rating (NEMA 12) at the rear of the heatsink for through-panel mounting (some current derating is required).

In order to achieve the high IP rating at the rear of the heatsink with Unidrive SP size 1 and 2, it is necessary to seal a heatsink vent by fitting the IP54 insert as shown in the *Unidrive SP User Guide*. For increased fan life time in a dirty environment the heatsink fan must be replaced with an IP54 rated fan on size 1 to 4. Sizes 5 and 6 are fitted with IP54 heatsink fans as standard. Contact the supplier of the drive for details. Fitting of the IP54 insert and/or IP54 rated fan on sizes 1 and 2 requires

output current derating to be applied, see the *Unidrive SP User Guide* for further details.

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 the *Unidrive SP User Guide*.

Table 10-1 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 $\phi > 50\text{mm}$ (large area contact with the hand)	1 -
2 Protection against medium size foreign bodies $\phi > 12\text{mm}$ (finger)	2 -
3 Protection against small foreign bodies $\phi > 2.5\text{mm}$ (tools, wires)	3 Protection against spraywater (up to 60° from the vertical)
4 Protection against granular foreign bodies $\phi > 1\text{mm}$ (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 10-2 NEMA enclosure ratings

NEMA rating	Description
Type 1	Enclosures are intended for indoor use, primarily to provide a degree of protection against contact with the enclosed equipment or locations where unusual service conditions do not exist.
Type 12	Enclosures are intended for indoor use, primarily to provide a degree of protection against dust, falling dirt and dripping non-corrosive liquids.

10.2 AC Fusing

Table 10-3 Size 1 to 3 input current, fuse and cable size ratings (European)

Model	Maximum continuous input current A	Fuse rating IEC gG A	Cable size EN60204
			Input mm ²
SP1405	8.8	12	1.0
SP1406	11	16	1.5
SP2401	15.3	20	2.5
SP2402	21	25	4.0
SP2403	29	32	6.0
SP2404	29	32	6.0
SP3401	35	40	10
SP3402	43	50	16
SP3403	56	63	25

Table 10-4 Size 1 to 3 input current, fuse and cable size ratings (USA)

Model	Maximum continuous input current A	Fuse rating A	Cable size UL508C
			Input AWG
SP1405	8.8	15	14
SP1406	11	15	14
SP2401	15.3	20	14
SP2402	21	25	10
SP2403	29	30	8
SP2404	29	30	8
SP3401	35	40	6
SP3402	43	45	6
SP3403	56	60	4

Table 10-5 Size 4, 5 and 6 input current, fuse and cable size ratings (universal)

Model	Max input current	Fuse option 1 IEC class gR <u>OR</u> North American Ferraz HSJ		Fuse option 2 HRC <u>AND</u> Semi-conductor		Cable size	
		IEC class gR	North American Ferraz HSJ	HRC IEC class gG UL class J	Semi-conductor IEC class aR	Input	
	A	A	A	A	A	mm ²	AWG
SP4401	68	80	80	80	160	25	3
SP4402	83	110	110	100	200	35	2
SP4403	104	125	125	125	200	50	1
SP5401	138	200	175	160	200	95	2/0
SP5402	168	250	225	200	250	120	4/0
SP6401	202	315	300	250	315	2 x 50	2 x 1
SP6402	236	315	300	315	350	2 x 50	2 x 1



Fuses

The AC supply to the drive must be fitted with suitable protection against overload and short-circuits. Table 10-3 to Table 10-4 shows recommended fuse ratings. Failure to observe this requirement will cause risk of fire.

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

An MCB (miniature circuit breaker) or MCCB (moulded-case circuit-breaker) with type C may be used in place of fuses on Unidrive SP sizes 1 to 3 under the following conditions:

- The fault-clearing capacity must be sufficient for the installation
- For frame sizes 2 and 3, the drive must be mounted in an enclosure which meets the requirements for a fire enclosure

10.3 DC Fusing

DC Bus fusing is required where there are multiple motoring drives in a regen system. In a multiple motoring drive regen system the Regen drives rating is larger than that of the motor drives resulting in the AC fusing being unable to protect the smaller rated motoring drives. Fuses should be fitted in both the + DC Bus connections.

Fuse Type:

Ferraz 6,9xx CP GRC
750vdc at 100kA
L/R=100mSec

NOTE

Ferraz fuse xx may be 00 (fuse with no trip indicator fitted) or 21 (fuse fitted with trip indicator).

Table 10-6 DC bus fusing

Model	Fuse Vdc	Fuse Adc
SP 1405	≥ 750Vdc	10
SP 1406		16
SP 2401		20
SP 2402		32
SP 2403		40
SP 2404		50
SP 3401		50
SP 3402		50
SP 3403		63
SP 4401		125
SP 4402		160
SP 4403		200
SP 5401		250
SP 5402		315
SP 6401		400
SP 6402		450

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 SP Regen *Brake Resistor replacement* system:

- Isolating transformer
- DC bus diode



The internal EMC filter must be removed from drive.

CAUTION

10.4.1 Regen inductors

NOTE

The regen inductor duty is very arduous, and therefore, correct component selection is critical. The most sensitive aspect being the inductor linearity. Only inductors specified in this installation 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 170°C thermistor mounted in the centre coil. The thermistor is set to 170°C at which point the resistance is 1000Ω, beyond 170°C a rapid rise in resistance will be seen.



The regen inductors have a normal operating temperature of approximately 170°C depending upon the ambient and the motor cable lengths. Care must be taken so that this does not create a fire risk.

CAUTION

NOTE

If the permissible cable lengths are exceeded additional cooling may be required for the regen inductors, refer to section 4.4.4 *Cable length* on page 29.

Table 10-7 Regen inductors

Rated current	Inductance	Losses	CT part number
A	mH	W	
9.5	6.30	125.0	4401-0001
12	5.00	146.0	4401-0002
16	3.75	175.0	4401-0003
25	2.40	210.0	4401-0004
34	1.76	285.0	4401-0005
40	1.50	310.0	4401-0006
46	1.30	320.0	4401-0007
60	1.00	345.0	4401-0008
70	0.78	415.0	4401-0009
96	0.63	515.0	4401-0010
124	0.48	585.0	4401-0011
156	0.38	645.0	4401-0012
180	0.33	775.0	4401-0013
202	0.30	845.0	4401-0014
300	0.24	1760.0	4401-0015

10.4.2 Softstart resistor - type TG series

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.

The softstart resistors required for single regen multiple motoring applications are as specified in the following table. Resistor energy pulse rating and overload are non-standard and therefore important.

The following resistors can be configured to meet the required resistance (series parallel arrangements).

Table 10-8 Softstart resistor

CT part no	Resistance
1270-3157	150
1270-2483	48

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 10-9 Softstart resistor MCB

CT part number	Rated current	Rated Voltage	No of poles
4133-0117	0.3	480	1
4133-0217	1	480	1
4133-0277	2	480	1

Safety Information	Introduction	Product information	System design	Mechanical installation	Electrical installation	Getting started	Optimisation	Parameters	Technical data	Component sizing	Diagnostics
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10.4.3 Switching frequency filter

The AC input terminals of a Regen drive produce a PWM output voltage, which has a sinusoidal component at line frequency, plus significant harmonics at the switching frequency and its multiples.

Switching frequency filter inductors

The following inductors are standard 3-phase inductors, rated at drive rated current for a single regen system. They carry only 50/60Hz current with a negligible amount of high frequency current.

Table 10-10 Switching frequency filter inductors

Rated current	Inductance	Losses	CT part number
A	mH	W	
9.5	3.160	28	4401-0162
12	2.500	35	4401-0163
16	1.875	37	4401-0164
25	1.200	40	4401-0165
34	0.880	52	4401-0166
40	0.750	60	4401-0167
46	0.650	60	4401-0168
60	0.500	80	4401-0169
70	0.390	90	4401-0170
96	0.315	100	4401-0171
124	0.240	110	4401-0172
156	0.190	130	4401-0173
180	0.165	170	4401-0174
202	0.135	180	4401-0175
300	0.100	220	4401-0176
600	0.050	400	4401-0177
900	0.034	530	4401-0178
1200	0.025	700	4401-0179

NOTE

The switching frequency filter inductors need to be rated to the total current requirement of the system.

10.4.4 Switching frequency filter capacitors

The capacitors specified below are suitable for operation at any switching frequency. These being sized for operation at 3kHz, however, operation above 3kHz is possible with the capacitors being more effective.

Table 10-11 Switching frequency filter capacitors: Heavy Duty ratings

Rated current	μF	A	CT part number
A			
7.6 to 25	5.7	2.1	1610-7609
29 to 68	24	15	1665-2244
74 to 202	48	25	1665-2484
210 to 290	77	35	1665-8774



CAUTION

The 3-phase switching frequency filter capacitors are situated on the input of the regen system. As a result the capacitor can also absorb harmonics if present from the supply, and in worst case conditions result in the capacitors running hot or even failure.

Switching frequency filter capacitor MCB



CAUTION

An MCB should be fitted between the AC supply and the 3-phase switching frequency filter capacitor. This is to protect the capacitor and the wiring to the mains busbar from damage by faults or overloads.

NOTE

The 3-phase switching frequency filter capacitors can absorb harmonics from the supply or notching currents from DC drives which can result in spurious tripping of the MCB. Therefore considerations must be made to the supply when sizing the MCB, if these are present at high levels. In this situation consult the drive supplier for advice.

Discharge resistors

The discharge resistors for the switching frequency filter capacitors 1665-2244, 1665-2484 and 1665-8774 are supplied along with the three phase capacitors. These should be fitted during installation as shown following.

The discharge resistors are fitted internally to the switching frequency filter capacitor 1610-5752.

Table 10-12 Switching frequency filter capacitor discharge resistors

CT part number	Capacitor value μF	Resistor value kΩ
1610-7609	5.7	Internal
1665-2244	24	3 x 390
1665-2484	48	3 x 390
1665-8774	77	3 x 270

10.4.5 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 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 10-13 Varistors

Model size	Voltage rating Vac	Energy rating J	Type	Qty per system	Configuration	CT part number
1 to 6	550	400	Z500LNS	3	Line to line	2482-1501
	680	450	Z680LNS	3	Line to ground	2482-0680

10.4.6 Isolating transformer (brake resistor replacement only)

The Regen drive is supplied via an isolating transformer. This is required because when the Regen drive is switching its DC bus voltage moves with respect to ground and the supply neutral point. On the motor drive, however, the DC bus voltage remains relatively fixed with respect to ground.

This difference in voltages means that the two drives cannot be connected directly to the same AC supply. The additional DC bus diode required also ensures that power only flows from the motor drive to the Regen drive.

The isolating transformer is fitted in the supply side of the system, and therefore, the isolating transformers inductance can be used to form the switching frequency filter, reducing the overall cost of the system.

Table 10-14 Isolating transformer

Isolating transformer	Voltage rating Vac	Current rating A	Inductance H
3 phase	AC supply rated (Max 480V +10%)	Equal to the Regen drive's current rating plus overload capability	Equal to the inductance required for the switching frequency filter. This should be selected dependant upon Regen drive rating



CAUTION

The isolating transformer must be fitted when configuring Regen as a *brake resistor replacement*.

10.4.7 DC bus diode (brake resistor replacement only)

A suitable supplier for the DC bus diode can be Semikron™ with the SKKD xxx F 12 or SKKE xxx F 12 diode modules (for details of description see Figure 10-1).

Figure 10-1 Type designation system

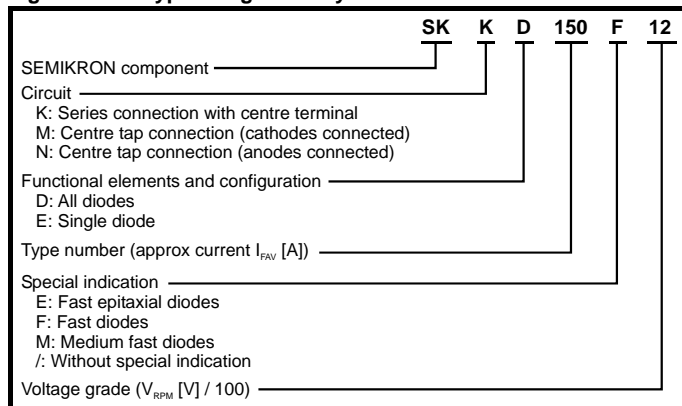


Table 10-15 Diode

Diode type	Recovery time μs	Current rating A	Voltage rating V
FAST or ULTRA FAST	<1	3 x current rating of Regen drive	1200

The diode must be mounted on a suitable heatsink. The heatsinks sizing is based upon the following:

- Maximum device case temperature of 80°C
- Power loss = 2V x Regen drive rated current

Table 10-16 shows various SEMIPACK® devices, heatsink types, cooling modes and thermal resistance. Heatsinks are available directly from the supplier of SEMIPACK® devices.

Table 10-16 Available heatsinks

SEMIPACK®			Heatsink	Length	Weight	Cooling mode	Thermal resistance heatsink - air R _{thha} °C/W
				mm	kg		1
SKKD 40 F	SKMD 40 F	SKND 42 F	P 14/120	120	1.15	Natural cooling	0.84
SKKD 42 F	SKMD 42 F		P 3/120	120	2.1		0.57
			P 3/180	180	3.1		0.48
SKKD 50 E	SKMD 105 F	SKND 50 E	P 14/120	120	1.15		0.79
SKKD 105 F		SKND 105 F	P 3/120	120	2.1		0.55
SKKD 115 F		SKND 202 E	P 3/180	180	3.1		0.47
SKKD 40 F	SKMD 40 F	SKND 42 F	P 3/180 F	180	3.1	Forced air cooling	0.145
SKKD 42 F	SKMD 42 F		P 14/120 F	120	1.2		0.134
SKKD 50 E	SKMD 105 F	SKND 50 E	P 14/180 F	180	1.8		0.126
SKKD 105 F		SKND 105 F	P 14/300 F	300	3.0		-
SKKD 115 F		SKND 202 E	P 16/170 F	170	3.9		-
	SKMD 202 E	SKND 202 E	P 16/200 F	200	4.6		-
SKKD 160 M	SKMD 202 E	SKND 202 E	P 16/170 F	170	3.9		0.062
			P 16/200 F	200	4.6		0.059
SKFT 150			SKFH 150	P 16/300 F	300		6.9

Thermal resistances heatsink: air R_{thha} (without contact thermal resistances SEMIPACK® -heatsink R_{thch}) for a selection of available heatsinks in standard lengths with natural cooling and with associated fan.

11 Component sizing

11.1 Sizing of MCB for switching frequency filter

The current rating of the MCB must be calculated; taking into account the switching frequency filter inductance and capacitance, the initial charging current and the AC supply voltage. switching frequency filter inductance and capacitance values can be found in section 10.4 Component data on page 149.

$$L = 2 \times L_f \quad L_f = \text{Switching frequency filter inductance}$$

$$C = 3C_f / 2 \quad C_f = \text{Switching frequency filter capacitance}$$

$$V_c = V_{LL} \text{ peak} \quad V_c = \text{Charging voltage}$$

$$Z_c = \sqrt{\frac{L}{C}} \quad Z_c = \text{Charging impedance}$$

$$T_c = \pi \sqrt{LC} \quad T_c = \text{Charging time}$$

$$I_c = V_c / Z_c \quad I_c = \text{Charging current}$$

Example:

SP6402 Regen

Switching frequency filter Inductance 240μH

Switching frequency filter Capacitance 77μF

Supply Voltage 480v + 10%

$$L = 2 \times 240\mu H = 480\mu H$$

$$C = 3 \times 77\mu F / 2 = 116\mu F$$

$$V_c = 480 + 10\% \times \sqrt{2} = 747V \text{ pk}$$

$$Z_c = \sqrt{\frac{480\mu H}{116\mu F}} = 2.04\Omega$$

$$T_c = \pi \sqrt{480\mu H \times 77\mu F} = 603\mu s$$

$$I_c = 747 / 1.29 = 579A$$

The MCB should be rated to the peak charging current of 366A for 740μs, with an rms current of 35A. A suitable MCB should have the following ratings and features:

Voltage rating: 480 + 10%
Peak current rating: 579A
rms current rating: 35A
3 pole with auxiliary (for enable)

Table 11-1

Drive	DC bus capacitance μF
1405	410
1406	
2401	705
2402	
2403	
2404	
3401	
3402	1350
3403	
4401	
4402	2200
4403	
5401	3300
5402	
6401	4400
6402	5500

11.2 Resistor sizing for multiple motoring systems

The softstart resistor must be calculated for a multiple motoring system due to the increased inrush current and where a Unidrive SPMC cannot be used.

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). The following procedure and data should be used to recalculate the resistor(s) required:

11.2.1 Procedure

1. Calculate the total capacitor bank energy rating of the system (Table 11-3).
2. Calculate the minimum number of resistors required to meet this energy value (round up to the nearest one), (Table 11-2).
3. Calculate the series parallel arrangement of resistors to produce the total resistor value in the required range (Table 11-4 and Table 11-2).

Table 11-2

Resistor data			
Resistor value Ω	Power rating W	Energy rating J	CT part number
150	53	170	1270-3157
48	148	1,700	1270-2483

Capacitor bank energy is calculated from $0.5 \times C \times V^2$. Where C is the total capacitance of all drives, and V is the DC bus voltage (Pr 3.05)

Table 11-3

DC bus Capacitor bank	
Drive size	Energy per drive J @ 700Vdc
1	100.45
2	172.725
3	330.75
4401	269.5
4402	539
4403	
5401	808.5
6401	1078
6402	1347.5

Table 11-4 Softstart resistor

Softstart resistor range	
Drive size	Total softstart resistor value Ω
1	12 to 252
2	5 to 158
3	3 to 83
4	2 to 50
5	1 to 34
6	1 to 20

Example:

SP6402 Regen with (3 x SP3403) and (5 x SP1406) motoring drives

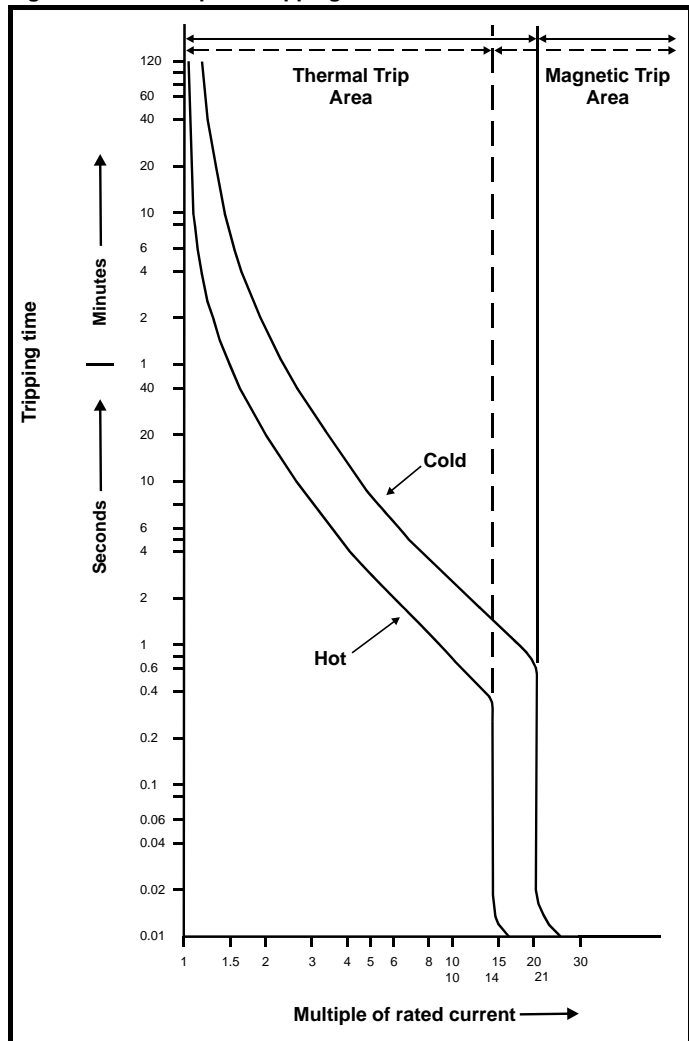
1. Capacitor bank energy = $1800 + (3 \times 600) + (5 \times 95) = 4075J$
2. Using resistors 1270-2483 (4,075 / 1,700) you will need at least 2.39 resistors = 3
3. Three 48Ω resistors can be arranged to achieve 16Ω. In this case 16Ω is satisfactory for a Unidrive SP size 4, so parallel connection can be used.

11.3 Thermal / magnetic overload protection for soft start circuit

Thermal / magnetic protection for the softstart resistor should be provided to protect against a high / low impedance short circuit and the risk of fire. A recommended device being a thermal magnetic overload. The overload should be sized as following to provide thermal and magnetic protection:

11.3.1 Thermal / magnetic overload characteristics

Figure 11-1 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 20A peak current a 1A overload 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 as shown in Figure 11-2.

The peak current and charge time during power up can be calculated using the following formula.

Example: Peak current

480Vac supply +10%, total softstart resistance of 24Ω (2 x 48Ω in parallel):

$$I_{\text{peak}} = V_{\text{ac}} (+10\%) \times 1.414 / \text{Resistance}_{\text{softstart}} \\ = (480 + 48) \times 1.414 / 24 = 31.108\text{A } I_{\text{peak}}$$

Example: Charging time

Total softstart resistance of 24Ω (2 x 48Ω) in parallel, and a total DC bus capacitance of 3465μF

$$T_{\text{constant}} = \text{Resistance}_{\text{softstart}} \times \text{Total Capacitance}_{\text{DC bus}}$$

$$24 \times (3465 \times 10^{-6}) = 0.08316$$

$$T_{\text{constant}} \times 5 = T_{\text{charge}}$$

$$0.08316 \times 5 = 415.8\text{ms}$$

Selection

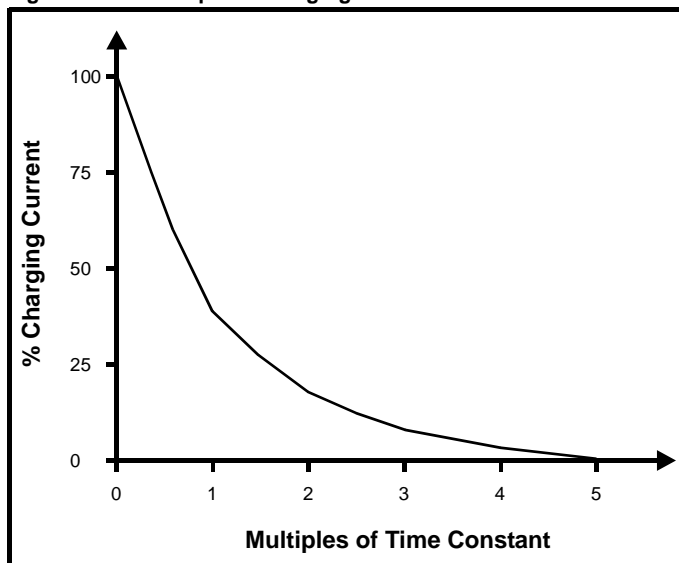
From the above calculations for a peak charging current of 31.108A with a charge time of 415.8ms a magnetic overload with the following characteristics could be used:

$$2\text{A nominal rating } (31.108/20 = 1.5554 \text{ rounded to } 2\text{A})$$

$$\text{O/L} = 15.5 \text{ (2 x 15.5 = 31)}$$

Plotting the exponential charging current for the soft start circuit against the trip characteristic curve for the overload will also ensure no spurious tripping during charging time.

Figure 11-2 Example of charging characteristics



Calculating current level on exponential curve

As shown in Figure 11-2, after 5 time constants the charging current is approximately zero. In some cases, due to the characteristic of the overload, the current may have to be calculated after 4 time constants to ensure that the thermal trip area of the overload is not activated. Refer to the following formula:

$$I \text{ at given Time Constant} = \text{Exp} [-1 (\text{Time Constants})] \times I_{\text{peak}}$$

The following example calculates the current level after 3 time constants with a peak charging current of 100A:

$$\text{Exp} [-1 (3)] \times 100 = 4.97\text{A}$$

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.

$$\text{Calculation to convert from power to current: } \sqrt{\frac{P}{R}} = I$$

Example:

Assuming a system fault which results in a continuous power of 10 x the nominal power being dissipated by the resistor.

Resistor, 24Ω 296W

Peak current at power up = $528\text{Vac} / 24\Omega = 22\text{A}$

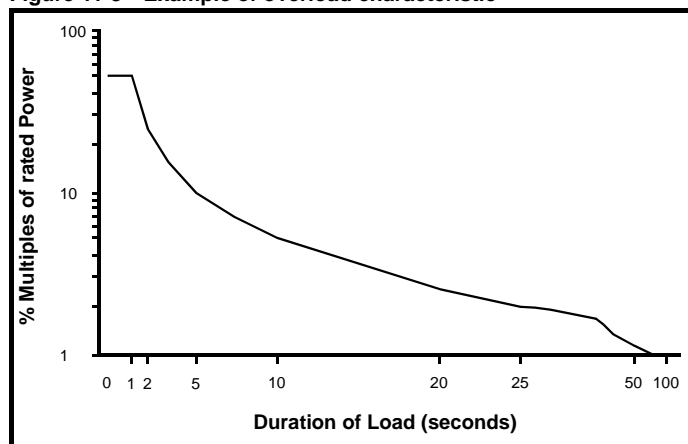
Thermal / Magnetic overload current rating = $22\text{A} / 20 = 1.1\text{A}$ (use 1.6A)

10 x nominal power = 2.960kW

Current flowing during overload = $\sqrt{\frac{2960}{24}} = 11.01\text{A}$

From Figure 11-3 it can be seen that an overload of 10 times the nominal power is allowable for 5 seconds. From this plotting the 10 times overload on Figure 11-1 it can be seen that for a current of 11.10A when using a 1.6A breaker that the overload will trip at 7 x the nominal current ($11.10/1.6 = 6.9$), which equates to approximately 5 seconds trip level worst case.

Figure 11-3 Example of overload characteristic



12 Diagnostics

The display on the drive gives various information about the status of the drive. These fall into three categories:

- Trip indications
- Alarm indications
- Status indications



Users must not attempt to repair a drive if it is faulty, nor carry out fault diagnosis other than through the use of the diagnostic features described in this chapter.
If a drive is faulty, it must be returned to an authorized Control Techniques distributor for repair.

12.1 Trip indications

If the drive trips, the output of the drive is disabled so that the drive stops controlling the motor. The lower display indicates that a trip has occurred and the upper display shows the trip.

Trips are listed alphabetically in Table 12-2 based on the trip indication shown on the drive display. Refer to Figure 12-1.

If a display is not used, the drive LED Status indicator will flash if the drive has tripped. Refer to Figure 12-2.

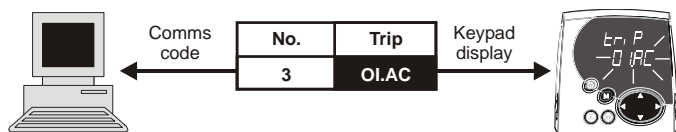
The trip indication can be read in Pr 10.20 providing a trip number. Trip numbers are listed in numerical order in Table 12-3 so the trip indication can be cross referenced and then diagnosed using Table 12-2.

NOTE

Trips beginning with a number are given at the end of Table 12-2 where the number is replaced with an X ($1 \leq X \leq 8$). The number indicates the tripped module in a multi-module drive.

Example

1. Trip code 3 is read from Pr 10.20 via serial communications.
2. Checking Table 12-3 shows Trip 3 is an OI.AC trip.



3. Look up OI.AC in Table 12-2.
4. Perform checks detailed under *Diagnosis*.

NOTE

Below is the trip code which is specific to Unidrive SP in regen mode. These are in addition to the trips listed in Table 12-2 on page 156.

Table 12-1 Regen drive specific trip code

Trip	Diagnosis
LI.SYNC	Regen drive failed to synchronise to supply
39	Pr 3.03 displays the reason for the synchronisation failure: <ul style="list-style-type: none"> 0: Tripped during synchronisation 1: Tripped while running 2: Line frequency too low (<30.0Hz) 3: Line frequency too high (>100.0Hz) 4: Error during synchronisation of PLL to supply

NOTE

For the above synchronisation failures also refer to: Pr 3.04 Regen restart mode.

Figure 12-1 Keypad status modes

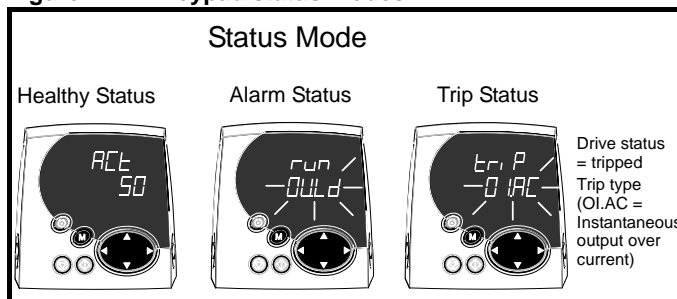


Figure 12-2 Location of the status LED

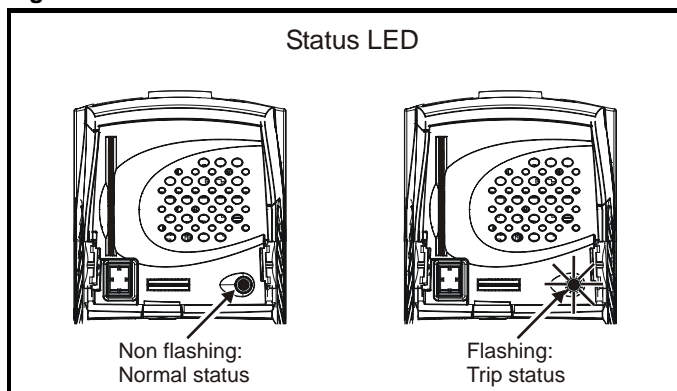





Table 12-2 General trip indications

Trip	Diagnosis																						
C.Acc	SMARTCARD trip: SMARTCARD Read / Write fail																						
185	Check SMARTCARD is fitted / located correctly Replace SMARTCARD																						
C.Chg	SMARTCARD trip: Data location already contains data																						
179	Erase data in data location Write data to an alternative data location																						
C.Cpr	SMARTCARD trip: The values stored in the drive and the values in the data block on the SMARTCARD are different																						
188	Press the red  reset button																						
C.dat	SMARTCARD trip: Data location specified does not contain any data																						
183	Ensure data block number is correct																						
C.Err	SMARTCARD trip: SMARTCARD data is corrupted																						
182	Ensure the card is located correctly Erase data and retry Replace SMARTCARD																						
C.Full	SMARTCARD trip: SMARTCARD full																						
184	Delete a data block or use different SMARTCARD																						
cL2	Analogue input 2 current loss (current mode)																						
28	Check analogue input 2 (terminal 7) current signal is present (4-20mA, 20-4mA)																						
cL3	Analogue input 3 current loss (current mode)																						
29	Check analogue input 3 (terminal 8) current signal is present (4-20mA, 20-4mA)																						
CL.bit	Trip initiated from the control word (Pr 6.42)																						
35	Disable the control word by setting Pr 6.43 to 0 or check setting of Pr 6.42																						
C.Optn	SMARTCARD trip: Solutions Modules fitted are different between source drive and destination drive																						
180	Ensure correct Solutions Modules are fitted Ensure Solutions Modules are in the same Solutions Module slot Press the red  reset button																						
C.rdo	SMARTCARD trip: SMARTCARD has the Read Only bit set																						
181	Enter 9777 in Pr xx.00 to allow SMARTCARD Read / Write access Ensure card is not writing to data locations 500 to 999																						
C.rtg	SMARTCARD trip: SMARTCARD attempting to change the destination drive ratings No drive rating parameters have been transferred																						
186	<p>Press the red  reset button Drive rating parameters are:</p> <table border="1"> <thead> <tr> <th>Parameter</th><th>Function</th></tr> </thead> <tbody> <tr> <td>2.08</td><td>Standard ramp voltage</td></tr> <tr> <td>4.05/6/7, 21.27/8/9</td><td>Current limits</td></tr> <tr> <td>5.07, 21.07</td><td>Motor rated current</td></tr> <tr> <td>5.09, 21.09</td><td>Motor rated voltage</td></tr> <tr> <td>5.17, 21.12</td><td>Stator resistance</td></tr> <tr> <td>5.18</td><td>Switching frequency</td></tr> <tr> <td>5.23, 21.13</td><td>Voltage offset</td></tr> <tr> <td>5.24, 21.14</td><td>Transient inductance</td></tr> <tr> <td>5.25, 21.24</td><td>Stator inductance</td></tr> <tr> <td>6.06</td><td>DC injection braking current</td></tr> </tbody> </table> <p>The above parameters will be set to their default values.</p>	Parameter	Function	2.08	Standard ramp voltage	4.05/6/7, 21.27/8/9	Current limits	5.07, 21.07	Motor rated current	5.09, 21.09	Motor rated voltage	5.17, 21.12	Stator resistance	5.18	Switching frequency	5.23, 21.13	Voltage offset	5.24, 21.14	Transient inductance	5.25, 21.24	Stator inductance	6.06	DC injection braking current
Parameter	Function																						
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5.18	Switching frequency																						
5.23, 21.13	Voltage offset																						
5.24, 21.14	Transient inductance																						
5.25, 21.24	Stator inductance																						
6.06	DC injection braking current																						
C.Typ	SMARTCARD trip: SMARTCARD parameter set not compatible with drive																						
187	Press the reset button Ensure destination drive type is the same as the source parameter file drive type																						
dESt	Two or more parameters are writing to the same destination parameter																						
199	Set Pr xx.00 = 12001 check all visible parameters in the menus for duplication																						
EEF	EEPROM data corrupted - Drive mode becomes open loop and serial comms will timeout with remote keypad on the drive RS485 comms port.																						
31	This trip can only be cleared by loading default parameters and saving parameters																						

Safety Information	Introduction	Product information	System design	Mechanical installation	Electrical installation	Getting started	Optimisation	Parameters	Technical data	Component sizing	Diagnostics
Trip	Diagnosis										
EEF1	EEPROM data corrupted										
36	Indicates the power was removed when parameters were being saved The drive will revert back to the parameters set that was last saved successfully										
Et	External trip from input on terminal 31										
6	Check terminal 31 signal Check value of Pr 10.32 Enter 12001 in Pr xx.00 and check for parameter controlling Pr 10.32 Ensure Pr 10.32 or Pr 10.38 (=6) are not being controlled by serial comms										
HF01	Data processing error: CPU address error										
	Hardware fault - return drive to supplier										
HF02	Data processing error: DMAC address error										
	Hardware fault - return drive to supplier										
HF03	Data processing error: Illegal instruction										
	Hardware fault - return drive to supplier										
HF04	Data processing error: Illegal slot instruction										
	Hardware fault - return drive to supplier										
HF05	Data processing error: Undefined exception										
	Hardware fault - return drive to supplier										
HF06	Data processing error: Reserved exception										
	Hardware fault - return drive to supplier										
HF07	Data processing error: Watchdog failure										
	Hardware fault - return drive to supplier										
HF08	Data processing error: Level 4 crash										
	Hardware fault - return drive to supplier										
HF09	Data processing error: Heap overflow										
	Hardware fault - return drive to supplier										
HF10	Data processing error: Router error										
	Hardware fault - return drive to supplier										
HF11	Data processing error: Access to EEPROM failed										
	Hardware fault - return drive to supplier										
HF20	Power stage recognition: serial code error										
220	Hardware fault - return drive to supplier										
HF21	Power stage recognition: unrecognised frame size										
221	Hardware fault - return drive to supplier										
HF22	Power stage recognition: multi module frame size mismatch										
222	Hardware fault - return drive to supplier										
HF23	Power stage recognition: multi module voltage rating mismatch										
223	Hardware fault - return drive to supplier										
HF24	Power stage recognition: unrecognised drive size										
224	Hardware fault - return drive to supplier										
HF25	Current feedback offset error										
225	Hardware fault - return drive to supplier										
HF26	Soft start relay failed to close, soft start monitor failed or braking IGBT short circuit at power up										
226	Hardware fault - return drive to supplier										
HF27	Power stage thermistor 1 fault										
227	Hardware fault - return drive to supplier										
HF28	Power stage thermistor 2 fault or internal fan fault (size 3 only)										
228	Hardware fault - return drive to supplier										
HF29	Control board thermistor fault										
229	Hardware fault - return drive to supplier										
HF30	DCCT wire break trip from power module										
230	Hardware fault - return drive to supplier										

Safety Information	Introduction	Product information	System design	Mechanical installation	Electrical installation	Getting started	Optimisation	Parameters	Technical data	Component sizing	Diagnostics
Trip	Diagnosis										
HF31	Aux fan failure from power module										
231	Replace auxiliary fan										
HF32	Power stage - a module has not powered up in a multi-module parallel drive										
232	Check AC power supply										
It.AC	Output current overload timed out (I^2t) - accumulator value can be seen in Pr 4.19										
20	Ensure the load is not jammed / sticking Check the load on the motor has not changed										
LI.SYNC	Regen drive failed to synchronise to supply										
39	Pr 3.03 displays the reason for the synchronisation failure: 0: Tripped during synchronisation 1: Tripped while running 2: Line frequency too low (<30.0Hz) 3: Line frequency too high (>100.0Hz) 4: Error during synchronisation of PLL to supply										
O.CtL	Drive control board over temperature										
23	Check cubicle / drive fans are still functioning correctly Check cubicle ventilation paths Check cubicle door filters Check ambient temperature Reduce drive switching frequency										
O.ht1	Power device over temperature based on thermal model										
21	Reduce drive switching frequency Reduce duty cycle Reduce motor load										
O.ht2	Heatsink over temperature										
22	Check cubicle / drive fans are still functioning correctly Check cubicle ventilation paths Check cubicle door filters Increase ventilation Reduce drive switching frequency Reduce duty cycle Reduce motor load										
Oht2.P	Power module heatsink over temperature										
105	Check cubicle / drive fans are still functioning correctly Check cubicle ventilation paths Check cubicle door filters Increase ventilation Reduce drive switching frequency Reduce duty cycle Reduce motor load										
O.ht3	Drive over-temperature based on thermal model										
27	Check cubicle / drive fans are still functioning correctly Check cubicle ventilation paths Check cubicle door filters Increase ventilation Reduce duty cycle Reduce motor load										
Oht4.P	Power module rectifier over temperature or input snubber resistor over temperature (size 4 and above)										
102	Check for supply imbalance Check for supply disturbance such as notching from a DC drive Check cubicle / drive fans are still functioning correctly Check cubicle ventilation paths Check cubicle door filters Increase ventilation Reduce drive switching frequency Reduce duty cycle Reduce motor load										

Safety Information	Introduction	Product information	System design	Mechanical installation	Electrical installation	Getting started	Optimisation	Parameters	Technical data	Component sizing	Diagnostics						
Trip	Diagnosis																
OI.AC	Instantaneous input over current detected: peak input current greater than 225%																
3	Check correct regen inductor fitted Check for short circuit on regen component circuitry Check DC connections: Regen to motoring drive for short circuit Check line synchronisation status Reduce the values in current loop gain parameters - Pr 4.13 and Pr 4.14 (closed loop vector and servo modes only)																
OIAC.P	Power module over current detected from the module input currents																
104	Check correct regen inductor fitted Check for short circuit on regen component circuitry Check DC connections: Regen to motoring drive for short circuit Check line synchronisation status Reduce the values in current loop gain parameters - Pr 4.13 and Pr 4.14 (closed loop vector and servo modes only)																
OldC.P	Power module over current detected from IGBT on state voltage monitoring																
109	Vce IGBT protection activated. Check motor and cable insulation.																
O.Ld1	Digital output overload: total current drawn from 24V supply and digital outputs exceeds 200mA																
26	Check total load on digital outputs (terminals 24,25,26)and +24V rail (terminal 22)																
OV	DC bus voltage has exceeded the peak level or the maximum continuous level for 15 seconds																
2	Check nominal AC supply level Check for supply disturbances which could cause the DC bus to rise – voltage overshoot after supply recovery from a notch induced by DC drives. <table><tr><td>Drive voltage rating</td><td>Peak voltage</td><td>Maximum continuous voltage level</td></tr><tr><td>400</td><td>830</td><td>815</td></tr></table>											Drive voltage rating	Peak voltage	Maximum continuous voltage level	400	830	815
Drive voltage rating	Peak voltage	Maximum continuous voltage level															
400	830	815															
OV.P	Power module over voltage has exceeded the peak level or the maximum continuous level for 15 seconds																
106	Check nominal AC supply level Check for supply disturbances which could cause the DC bus to rise – voltage overshoot after supply recovery from a notch induced by DC drives. <table><tr><td>Drive voltage rating</td><td>Peak voltage</td><td>Maximum continuous voltage level</td></tr><tr><td>400</td><td>830</td><td>815</td></tr></table>											Drive voltage rating	Peak voltage	Maximum continuous voltage level	400	830	815
Drive voltage rating	Peak voltage	Maximum continuous voltage level															
400	830	815															
PAd	Keypad has been removed when the drive is receiving the speed reference from the keypad																
34	Fit keypad and reset Change speed reference selector to select speed reference from another source																
PS	Internal power supply fault																
5	Remove any Solutions Modules and reset Check integrity of interface ribbon cables and connections (size 4,5,6 only) Hardware fault - return drive to supplier																
PS.10V	10V user power supply current greater than 10mA																
8	Check wiring to terminal 4 Reduce load on terminal 4																
PS.24V	24V internal power supply overload																
9	The total user load of the drive and Solutions Modules has exceeded the internal 24V power supply limit. The user load consists of the drive's digital outputs plus the SM-I/O Plus digital outputs, or the drive's main encoder supply plus the SM-Universal Encoder Plus and SM-Encoder Plus encoder supply. <ul style="list-style-type: none">• Reduce load and reset• Provide an external 24V >50W power supply• Remove any Solutions Modules and reset																
PS.P	Power module power supply fail																
108	Remove any Solutions Modules and reset Check integrity of interface ribbon cables and connections (size 4,5,6 only) Hardware fault - return drive to supplier																
SCL	Drive RS485 serial comms loss to remote keypad																
30	Refit the cable between the drive and keypad Check cable for damage Replace cable Replace keypad																
SLX.dF	Solutions Module slot X trip: Solutions Module type fitted in slot X changed																
204,209,214	Save parameters and reset																

Trip	Diagnosis																																																																										
SLX.Er	Solutions Module slot X trip: Solutions Module in slot X has detected a fault																																																																										
202,207,212	Automation module category Check value in Pr 15/16/17.50 . The following table lists the possible error codes for the SM-Applications and SM-Applications Lite.																																																																										
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74	Module over temperature																																																																										

Trip	Diagnosis																																							
SLX.Er	Solutions Module slot X trip: Solutions Module in slot X has detected a fault																																							
202,207,212	Fieldbus module category Check value in Pr 15/16/17.50. The following table lists the possible error codes for the Fieldbus modules.																																							
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	74	All	The Solutions Module has overheated.																																					
	98	All	The Solutions Module background task has not been completed.																																					
99	All	Software Fault.																																						
SLX.HF	Solutions Module slot X trip: Solutions Module X hardware fault																																							
200,205,210	Ensure Solutions Module is fitted correctly Return Solutions Module to supplier																																							
SLX.nF	Solutions Module slot X trip: Solutions Module has been removed																																							
203,208,213	Ensure Solutions Module is fitted correctly Re-fit Solutions Module Save parameters and reset drive																																							
SL.rtd	Solutions Module trip: Drive mode has changed and Solutions Module parameter routing is now incorrect																																							
215	Press reset. If the trip persists, contact the supplier of the drive.																																							
SLX.tO	Solutions Module slot X trip: Solutions Module watchdog timeout																																							
201,206,211	Press reset. If the trip persists, contact the supplier of the drive.																																							
t010	User trip defined in 2 nd processor Solutions Module code																																							
10	SM-Applications program must be interrogated to find the cause of this trip																																							
t036 to t038	User trip defined in 2 nd processor Solutions Module code																																							
36 to 38	SM-Applications program must be interrogated to find the cause of this trip																																							
t040 to t089	User trip defined in 2 nd processor Solutions Module code																																							
40 to 89	SM-Applications program must be interrogated to find the cause of this trip																																							
t099	User trip defined in 2 nd processor Solutions Module code																																							
99	SM-Applications program must be interrogated to find the cause of this trip																																							
t111 to t160	User trip defined in 2 nd processor Solutions Module code																																							
111 to 160	SM-Applications program must be interrogated to find the cause of this trip																																							
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t216 to t217	User trip defined in 2 nd processor Solutions Module code																																							
216 to 217	SM-Applications program must be interrogated to find the cause of this trip																																							

Safety Information	Introduction	Product information	System design	Mechanical installation	Electrical installation	Getting started	Optimisation	Parameters	Technical data	Component sizing	Diagnostics
Trip	Diagnosis										
th	Motor thermistor trip										
24	Check regen inductor temperature Check thermistor continuity Set Pr 7.15 = VOLT and reset the drive to disable this function										
thS	Motor thermistor short circuit										
25	Check regen inductor wiring Replace regen inductor thermistor Set Pr 7.15 = VOLT and reset the drive to disable this function										
Unid.P	Power module unidentified trip										
110	Check all interconnecting cables between power modules Ensure cables are routed away from electrical noise sources										
UP ACC	Onboard PLC program: cannot access Onboard PLC program file on drive										
98	Disable drive - write access is not allowed when the drive is enabled Another source is already accessing Onboard PLC program - retry once other action is complete										
UP div0	Onboard PLC program attempted divide by zero										
90	Check program										
UP OFL	Onboard PLC program variables and function block calls using more than the allowed RAM space (stack overflow)										
95	Check program										
UP ovr	Onboard PLC program attempted out of range parameter write										
94	Check program										
UP PAr	Onboard PLC program attempted access to a non-existent parameter										
91	Check program										
UP ro	Onboard PLC program attempted write to a read-only parameter										
92	Check program										
UP So	Onboard PLC program attempted read of a write-only parameter										
93	Check program										
UP udf	Onboard PLC program un-defined trip										
97	Check program										
UP uSEr	Onboard PLC program requested a trip										
96	Check program										
UV	DC bus under voltage threshold reached										
1	Check AC supply voltage level <div> <div>Drive voltage rating (Vac)</div> <div>Under voltage threshold (Vdc)</div> <div>200175</div> <div>400350</div> <div>575435</div> <div>690435</div> </div>										

Table 12-3 Serial communications look-up table

No.	Trip	No.	Trip	No.	Trip
1	UU	90	UP div0	184	C.FULL
2	OU	91	UP PAr	185	C.Acc
3	OI.AC	92	UP ro	186	C.rtg
5	PS	93	UP So	187	C.Typ
6	Et	94	UP ovr	188	C.cpr
8	PS.10V	95	UP OFL	199	DESt
9	PS.24V	96	UP uSEr	200	SL1.HF
10	t010	97	UP udf	201	SL1.tO
20	It.AC	98	UP ACC	202	SL1.Er
21	O.ht1	99	t099	203	SL1.nF
22	O.ht2	100		204	SL1.dF
23	O.CtL	102	Oht4.P	205	SL2.HF
24	th	104	OIAC.P	206	SL2.tO
25	thS	105	Oht2.P	207	SL2.Er
26	O.Ld1	106	OV.P	208	SL2.nF
27	O.ht3	108	PS.P	209	SL2.dF
28	CL2	109	OldC.P	210	SL3.HF
29	CL3	110	Unid.P	211	SL3.tO
30	SCL	111 to 160	t111 to t160	212	SL3.Er
31	EEF	168 to 175	t168 to t175	213	SL3.nF
34	Pad	177 to 178	t177 to t178	214	SL3.dF
35	CL.bit	179	C.Chg	215	SL.rtd
36	EEF1	180	C.Optn	216 to 217	t216 to t217
37 to 38	t036 to t038	181	C.RdO	220 to 232	HF20 to HF32
39	LI.SYNC	182	C.Err		
40 to 89	t040 to t089	183	C.dat		

Trips can be grouped into the following categories:

Category	Trips	Comments
Hardware faults	HF01 to HF19	These indicate fatal problems and cannot be reset. The drive is inactive after one of these trips and the display shows HFxx.
Self resetting trips	UU	Under voltage trip cannot be reset by the user, but is automatically reset by the drive when the supply voltage is with specification.*
Non-resettable trips	HF20 to HF30, SL1.HF, SL2.HF, SL3.HF	Cannot be reset.
EEF trip	EEF	Cannot be reset unless a code to load defaults is first entered in Pr x.00 or Pr 11.43.
Normal trips	All other trips	Can be reset after 1.0s
Normal trips with extended reset	OI.AC, x.OIAC,	Can be reset after 10.0s
Low priority trips	Old1, cL2, cL3, SCL	If Pr 10.37 is 1 or 3 the drive will stop before tripping.
Phase loss	PH	The drive stops before tripping provided the drive motoring power is suitably reduced after 500ms of detecting phase loss
Drive over-heat based on thermal model	O.ht3	The drive stops before tripping, but if it does not stop within 10s the drive will automatically trip.

*Under voltage trip and restart levels are as follows:

Drive voltage rating	UU trip level	UU restart level
400	330	425

12.2 Alarm indications

In any mode an alarm flashes alternately with the data displayed on the 2nd row when one of the following conditions occur. If action is not taken to eliminate any alarm except "Autotune" the drive may eventually trip.

Table 12-4 Alarm indications

Lower display	Description
Hot	Heatsink or control board or inverter IGBT over temperature alarms are active <ul style="list-style-type: none"> The drive heatsink temperature has reached a threshold and the drive will trip 'Oh2' if the temperature continues to rise (see the 'Oh2' trip). Or <ul style="list-style-type: none"> The ambient temperature around the control PCB is approaching the over temperature threshold (see the 'O.CtL' trip).
OVLd	Motor overload
The motor I ² t accumulator in the drive has reached 75% of the value at which the drive will be tripped and the load on the drive is >100%	

12.3 Status indications

Table 12-5 Status indications

Upper display	Description	Drive output stage
ACt	Regeneration mode active	Enabled
The Regen drive is enabled and synchronised to the supply.		
inh	Inhibit	Disabled
The drive is inhibited and cannot be run. The drive enable signal is not applied to terminal 31 or Pr 6.15 is set to 0.		
PLC	Onboard PLC program is running	Not applicable
An Onboard PLC program is fitted and running. The lower display will flash 'PLC' once every 10s.		
SCAn	Scanning	Enabled
OL> The drive is searching for the motor frequency when synchronising to a spinning motor. Regen> The drive is enabled and is synchronising to the line.		
triP	Trip condition	Disabled
The drive has tripped and is no longer controlling the motor. The trip code appears on the lower display.		

Table 12-6 Solutions Module and SMARTCARD status indications at power-up

Lower display	Description
boot	A parameter set is being transferred from the SMARTCARD to the drive during power-up. For further information, refer to the <i>Unidrive SP User Guide</i> .
cArd	The drive is writing a parameter set to the SMARTCARD during power-up. For further information, refer to the <i>Unidrive SP User Guide</i> .
IoAAding	The drive is writing information to a Solutions Module.

12.4 Displaying the trip history

The drive retains a log of the last 10 trips that have occurred in Pr 10.20 to Pr 10.29 and the corresponding time for each trip in Pr 10.43 to Pr 10.51. The time of the trip is recorded from the powered-up clock (if Pr 6.28 = 0) or from the run time clock (if Pr 6.28 = 1).

Pr 10.20 is the most recent trip, or the current trip if the drive is in a trip condition (with the time of the trip stored in Pr 10.43). Pr 10.29 is the oldest trip (with the time of the trip stored in Pr 10.51). Each time a new trip occurs, all the parameters move down one, such that the current trip (and time) is stored in Pr 10.20 (and Pr 10.43) and the oldest trip (and time) is lost out of the bottom of the log.

If any parameter between Pr 10.20 and Pr 10.29 inclusive is read by serial communications, then the trip number in Table 12-2 *General trip indications* on page 156 is the value transmitted.

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