

EMERSON
Industrial Automation

Installation Guide

Unidrive SP Regen

200V, 400V, 575V, 690V

Part Number: 0471-0029-02
Issue: 2

CONTROL TECHNIQUES
www.controltechniques.com

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.

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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.

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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.

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Issue Number: 2

Software: 01.07.01 onwards

How to use this guide

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

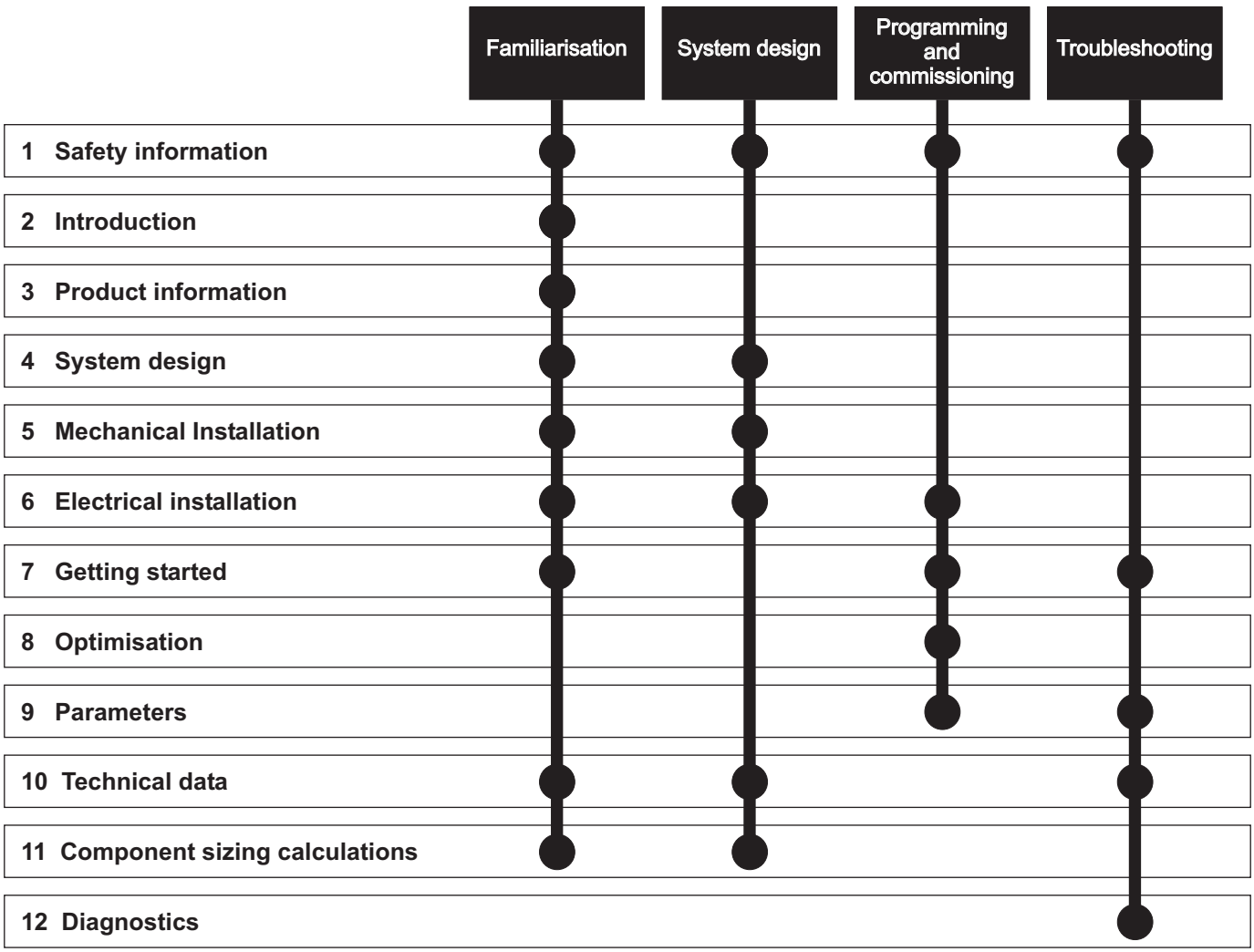
The information is in logical order, taking the reader from receiving the drive through to fine tuning the performance.

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

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



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1 Safety Information

1.1 Warnings, Cautions and Notes



WARNING

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



CAUTION

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

NOTE

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

1.2 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(s) in 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 of an AC Regen system are:

- Energy saving
- The input current waveform is sinusoidal
- The input current has a near unity power factor
- Power factor correction can be implemented using Pr **4.08**
- The output voltage for the motor can be higher than the available AC mains supply.
- The Regen drive will synchronise to any frequency between 30 and 100Hz, provided the supply voltage is within the supply requirements (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 75Vac (200V product) 150Vac (400V product) 225Vac (575V and 690V product) 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 during this condition to compensate up to the current limit of the Regen drive)
- Transient operation is possible between 40 and 72Hz down to the above supply voltage levels for approximately 1 second.
- The Regen and motoring drives are identical (when using Unidrive SP).
- Power feed-forward term available, 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.

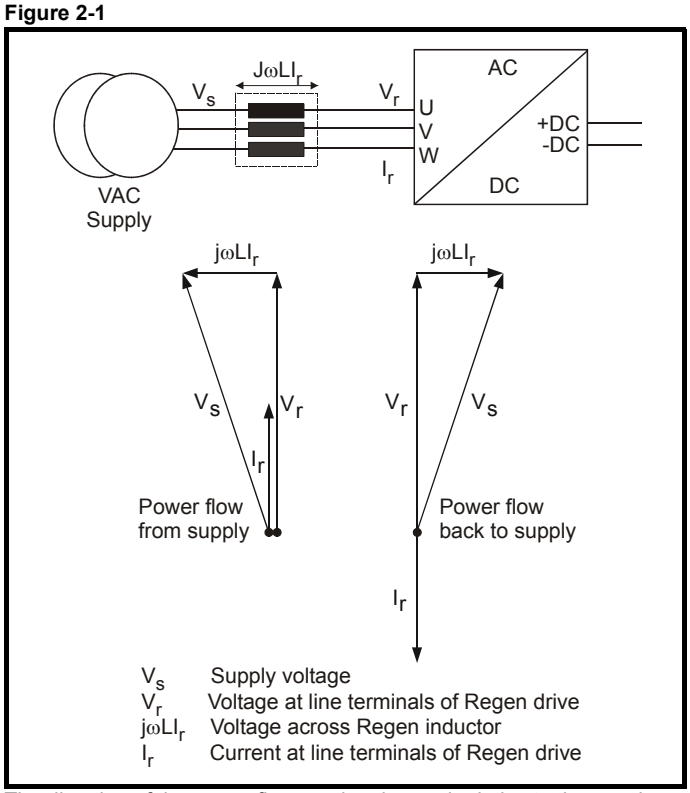
Regen inductors must be used to ensure a minimum source impedance, these being selected and specified later in the guide.

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



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

2.5 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 Td later to allow the supply frequency to be calculated.
  At this stage the supply inductance is also calculated
- Once the synchronization is complete the phase locked loop (PLL) is set-up. At this point the whole control system could be started and should operate without any large transients.
- To improve the robustness of the start-up phase a further short test pulse voltage vector, with the same magnitude and phase as the estimated supply voltage vector is applied. This is to detect measurement errors that could have occurred because of supply distortion present during the pre-start tests.

2.6 Current trimming

A current feedback trimming routine runs before the drive is enabled to minimise offsets in the current feedback. This feature can be user configured, for more details refer to section 8.5 *Current trimming* on page 91.

2.7 Regen system configurations

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

Following are the possible configurations for Unidrive SP Regen:

- Single Regen, single or multiple motoring (Figure 4-1 on page 32)
- Single Regen, multiple motoring using a Unidrive SPMC (Figure 4-2 on page 34)
- Single Regen, multiple motoring using an external charging resistor (Figure 4-3 on page 36)
- Multiple Regen, multiple motoring using a Unidrive SPMC (Figure 4-4 on page 38)

Refer to Table 3-2 on page 14, for the Regen drive ratings.

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

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

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

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

2.8 Regen drive system types

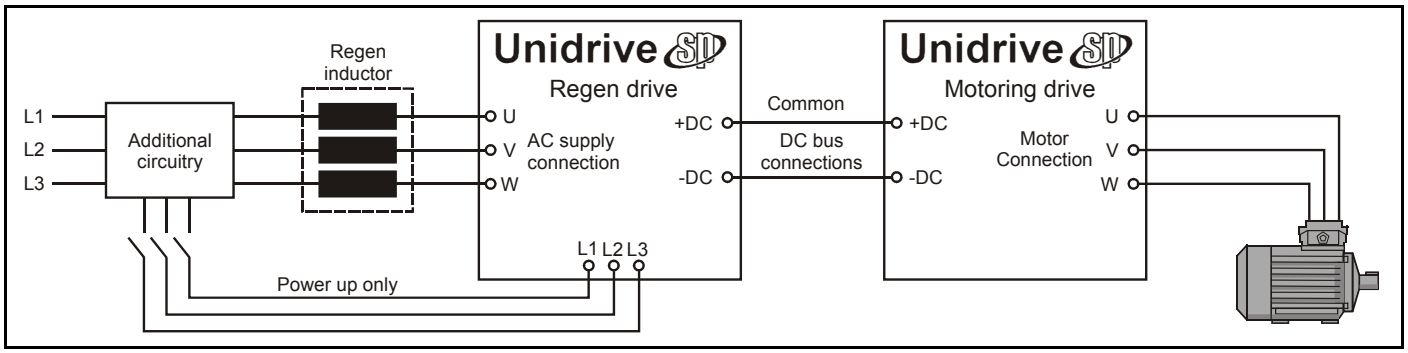
2.8.1 Single Regen, single motoring system

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

NOTE

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

Figure 2-2 Single Regen, single motoring system



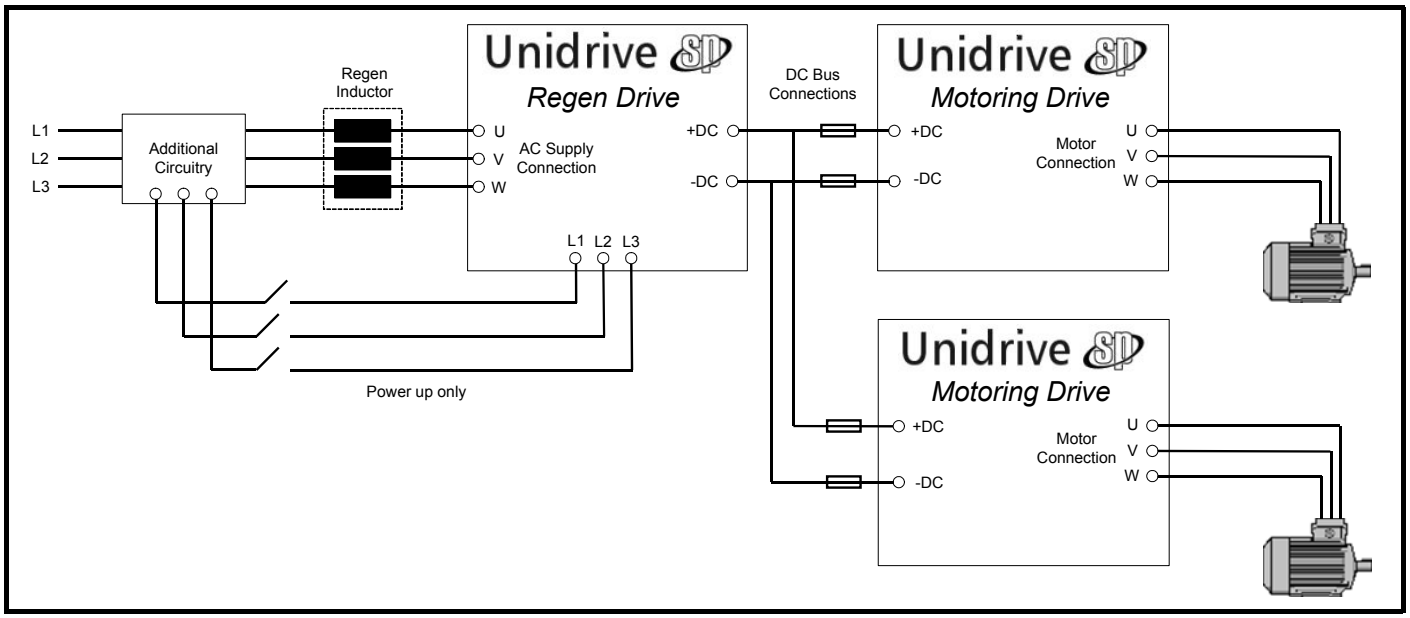
NOTE

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

2.8.2 Single Regen, multiple motoring system

Figure 2-4 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 all motoring drives.

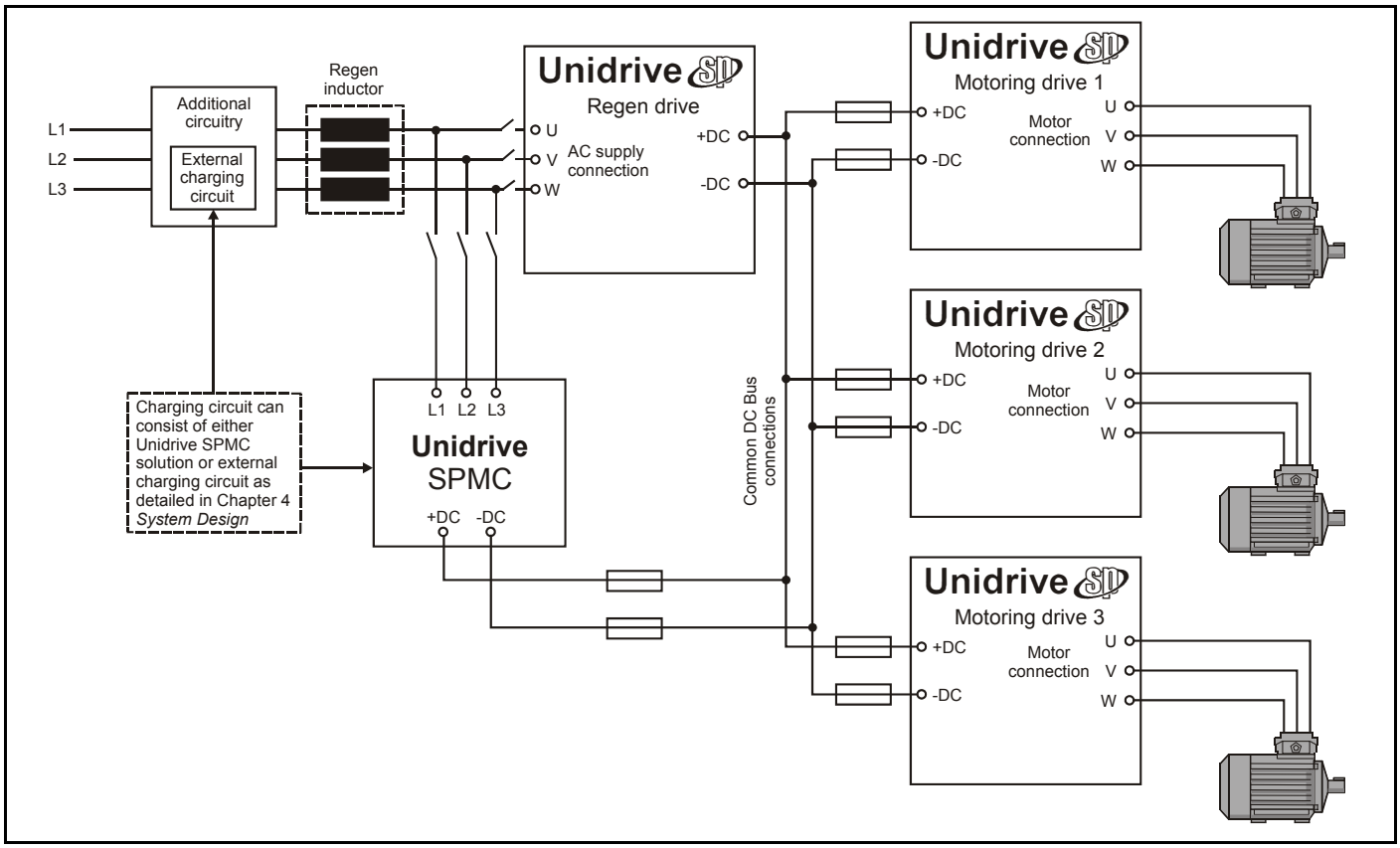
Figure 2-3 Single Regen, multiple motoring system



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

In this arrangement the total capacitance of the motoring drives must not exceed the capacitance of the Regen drive, in cases where this does please contact Technical Support.

Figure 2-4 Single Regen, multiple motoring system



NOTE

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

2.8.3 Multiple Regen, multiple motoring system

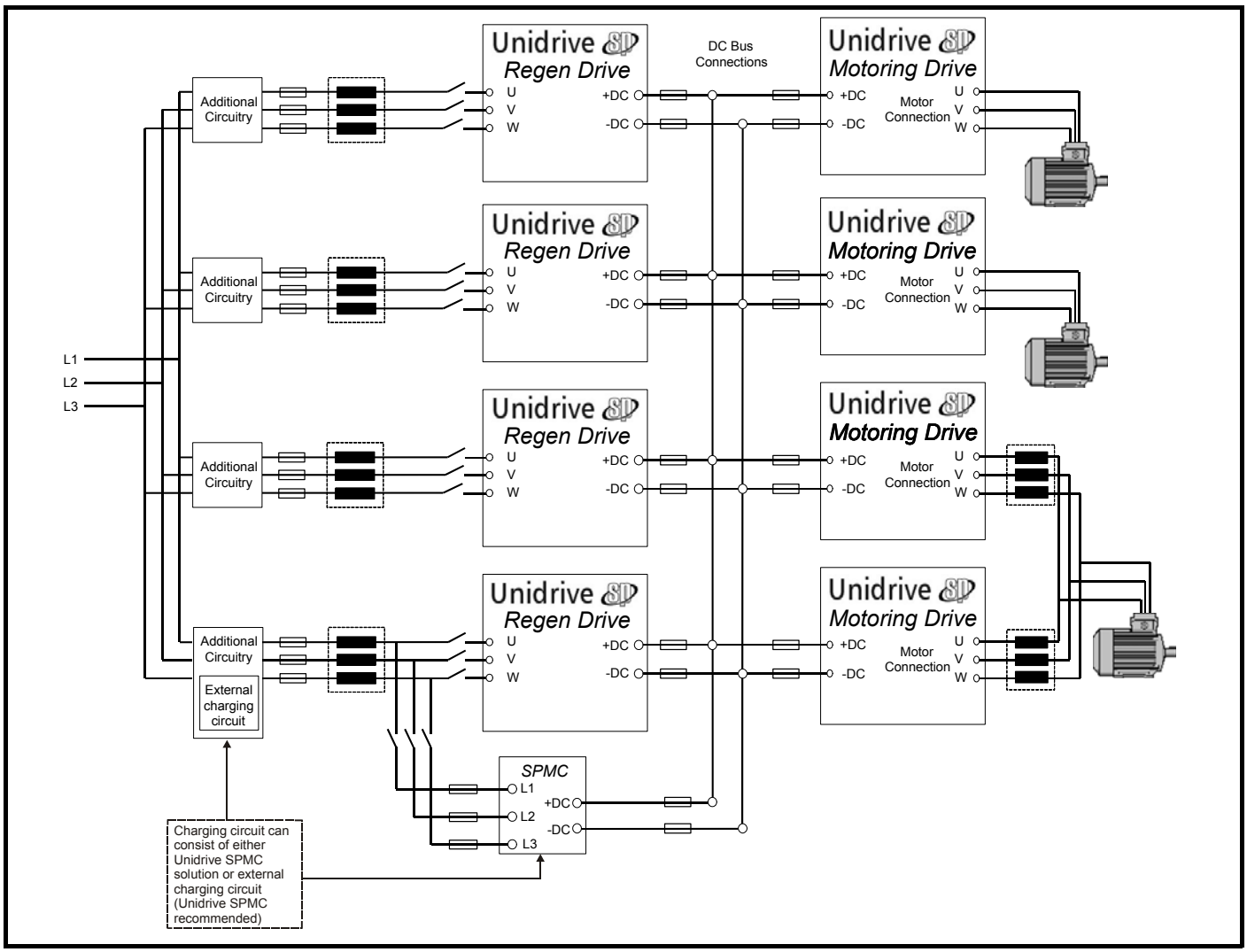
Figure 2-5 shows a multiple regen drive system with multiple motoring drives. For this configuration the regen drives are sized to the total power requirement of all motoring drives.

NOTE

For the multiple regen and multiple motoring drives arrangement there are two possible options for the required start-up circuit. This can either consist of a Unidrive SPMC rectifier module (for example an SPMC 1402 is capable of charging a maximum DC Bus capacitance of 66mF) or an external charging resistor as detailed in Chapter 4 *System design* on page 30.

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

Figure 2-5 Multiple Regen, multiple motoring system



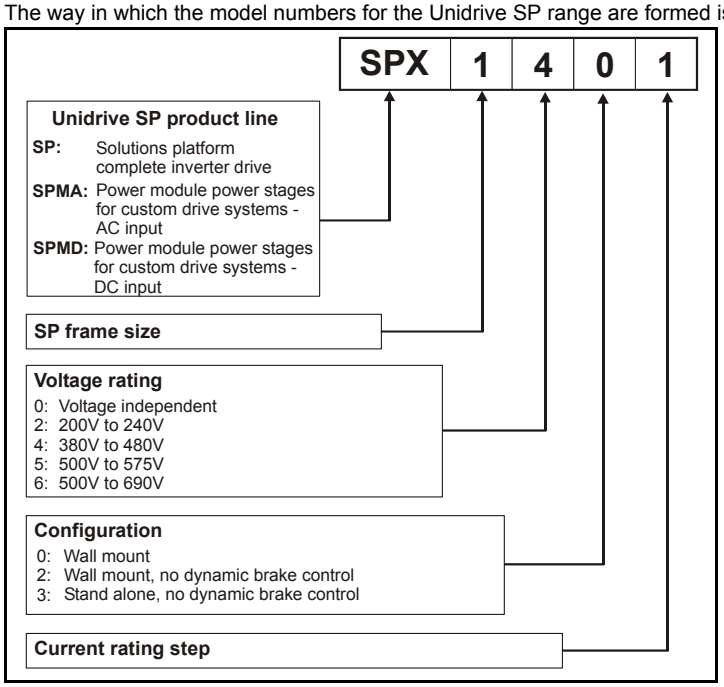
NOTE

All drives paralleled must be of the same frame size, and a derating also applies as specified in Chapter 3 *Product Information* on page 12

3 Product Information

3.1 Model number

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

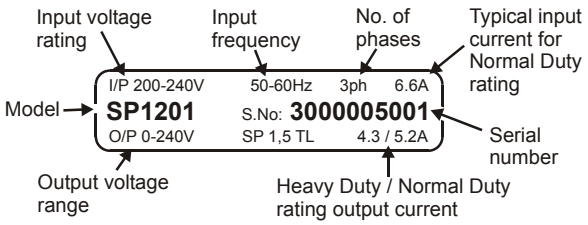


3.2 Nameplate description

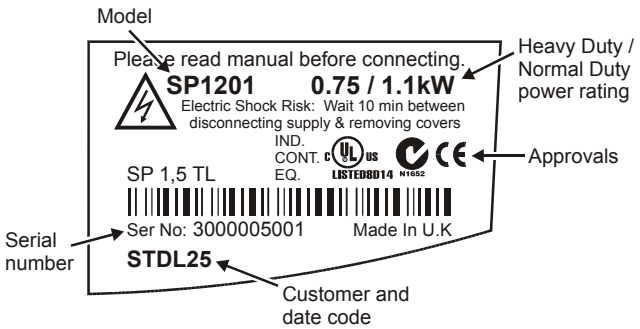
See Figure 3-2 on page 17 for location of rating labels.

Figure 3-1 Typical drive rating labels

Rating label



Approvals label

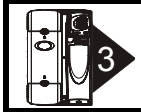
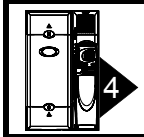
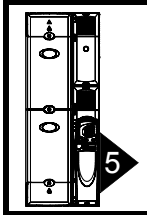


Key to approvals

CE	CE approval	Europe
C Tick	C Tick approval	Australia
cULus	UL / cUL approval	USA & Canada

3.3 Ratings

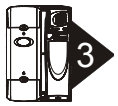
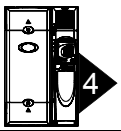
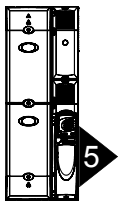
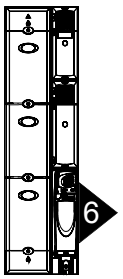
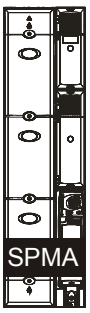
Table 3-1 200V Drive ratings (200V to 240V ±10%)

Model		Normal Duty			Heavy Duty		
		Maximum continuous output current	Nominal power at 220V	Motor power at 230V	Maximum continuous output current	Nominal power at 220V	Motor power at 230V
		A	kW	hp	A	kW	hp
	1201	5.2	1.1	1.5	4.3	0.75	1.0
	1202	6.8	1.5	2.0	5.8	1.1	1.5
	1203	9.6	2.2	3.0	7.5	1.5	2.0
	1204	11	3.0	3.0	10.6	2.2	3.0
	2201	15.5	4.0	5.0	12.6	3.0	3.0
	2202	22	5.5	7.5	17	4.0	5.0
	2203	28	7.5	10	25	5.5	7.5
	3201	42	11	15	31	7.5	10
	3202	54	15	20	42	11	15
	4201	68	18.5	25	56	15	20
	4202	80	22	30	68	18.5	25
	4203	104	30	40	80	22	30
	5201	130	37	50	105	30	40
	5202	154	45	60	130	37	50
	1201	192	55	175	156	45	60
	1202	248	75	100	192	55	75
	1203	312	90	125	250	75	100
	1204	350	110	150	290	90	125

NOTE

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 both the *Unidrive SP and SPM User Guides*.

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

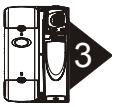
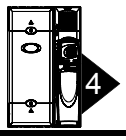
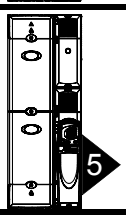
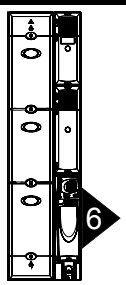
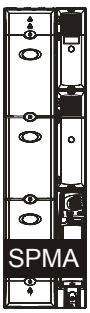
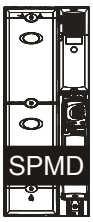
Model		Normal Duty			Heavy Duty		
		Maximum continuous input current	Typical motor power at 400V	Typical motor power at 460V	Maximum continuous input current	Typical motor power at 400V	Typical motor power at 460V
		A	kW	hp	A	kW	hp
	1405	8.8	4.0	5.0	7.6	3.0	5.0
	1406	11	5.5	7.5	9.5	4.0	5.0
	2401	15.3	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
	3401	35	18.5	25	32	15	25
	3402	43	22	30	40	18.5	30
	3403	56	30	40	46	22	30
	4401	68	37	50	60	30	50
	4402	83	45	60	74	37	60
	4403	104	55	75	96	45	75
	5401	138	75	100	124	55	100
	5402	168	90	125	156	75	125
	6401	202	110	150	180	90	150
	6402	236	132	200	210	110	150
	1401	205	110	150	180	90	150
	1402	236	132	200	210	110	150
	1401	205	110	150	180	90	150
	1402	246	132	200	210	110	150
	1403	290	160	250	246	132	200
	1404	350	200	300	290	160	250

NOTE

The SPMD1404 can deliver 350A continuously only if the ambient is 35°C or lower and it is docked to the SPMC. Under all other circumstances the current rating is 335A.

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 both the *Unidrive SP and SPM User Guides*.

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

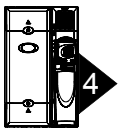
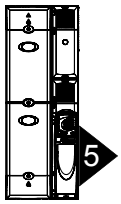
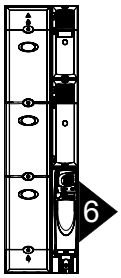
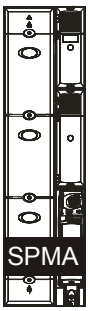
Model		Normal Duty			Heavy Duty		
		Maximum continuous output current	Nominal power at 575V	Motor power at 575V	Maximum continuous output current	Nominal power at 575V	Motor power at 575V
		A	kW	hp	A	kW	hp
	3501	5.4	3.0	3.0	4.1	2.2	2.0
	3502	6.1	4.0	5.0	5.4	3.0	3.0
	3503	8.4	5.5	7.5	6.1	4.0	5.0
	3504	11	7.5	10	9.5	5.5	7.5
	3505	16	11	15	12	7.5	10
	3506	22	15	20	18	11	15
	3507	27	18.5	25	22	15	20
	4603	36	22	30	27	18.5	25
	4604	43	30	40	36	22	30
	4605	52	37	50	43	30	40
	4606	62	45	60	52	37	50
	5601	84	55	75	63	45	60
	5602	99	75	100	85	55	75
	6601	125	90	125	100	75	100
	6602	144	110	150	125	90	125
	1601	125	90	125	100	75	100
	1602	144	110	150	125	90	125
	1601	125	110	150	100	90	125
	1602	144	132	175	125	110	150
	1603	168	160	200	144	132	175
	1604	192	185	250	168	160	200

The power ratings above for model size 4 and larger are for the 690V drives when used on a 500V to 575V supply.

NOTE

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 both the *Unidrive SP and SPM User Guides*.

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

Model		Normal Duty			Heavy Duty		
		Maximum continuous output current	Nominal power at 690V	Motor power at 690V	Maximum continuous output current	Nominal power at 690V	Motor power at 690V
		A	kW	hp	A	kW	hp
	4601	22	18.5	25	19	15	20
	4602	27	22	30	22	18.5	25
	4603	36	30	40	27	22	30
	4604	43	37	50	36	30	40
	4605	52	45	60	43	37	50
	4606	62	55	75	52	45	60
	5601	84	75	100	63	55	75
	5602	99	90	125	85	75	100
	6601	125	110	150	100	90	125
	6602	144	132	175	125	110	150
	1601	125	110	150	100	90	125
	1602	144	132	175	125	110	150
	1601	125	110	150	100	90	125
	1602	144	132	175	125	110	150
	1603	168	160	200	144	132	175
	1604	192	185	250	168	160	200

NOTE

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 both the *Unidrive SP and SPM User Guides*.

3.4 Drive features

Figure 3-2 Features of the drive sizes 1 to 6

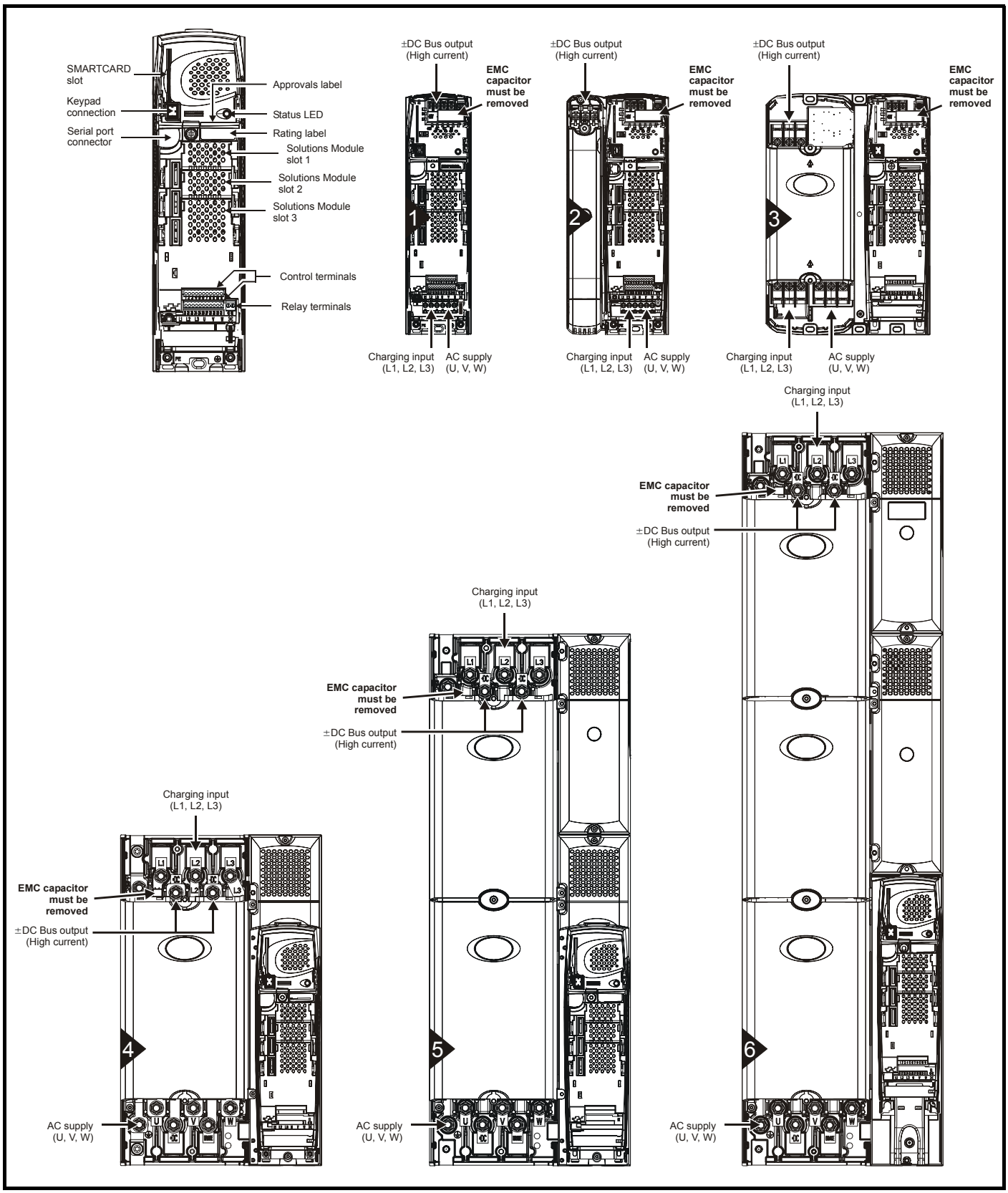
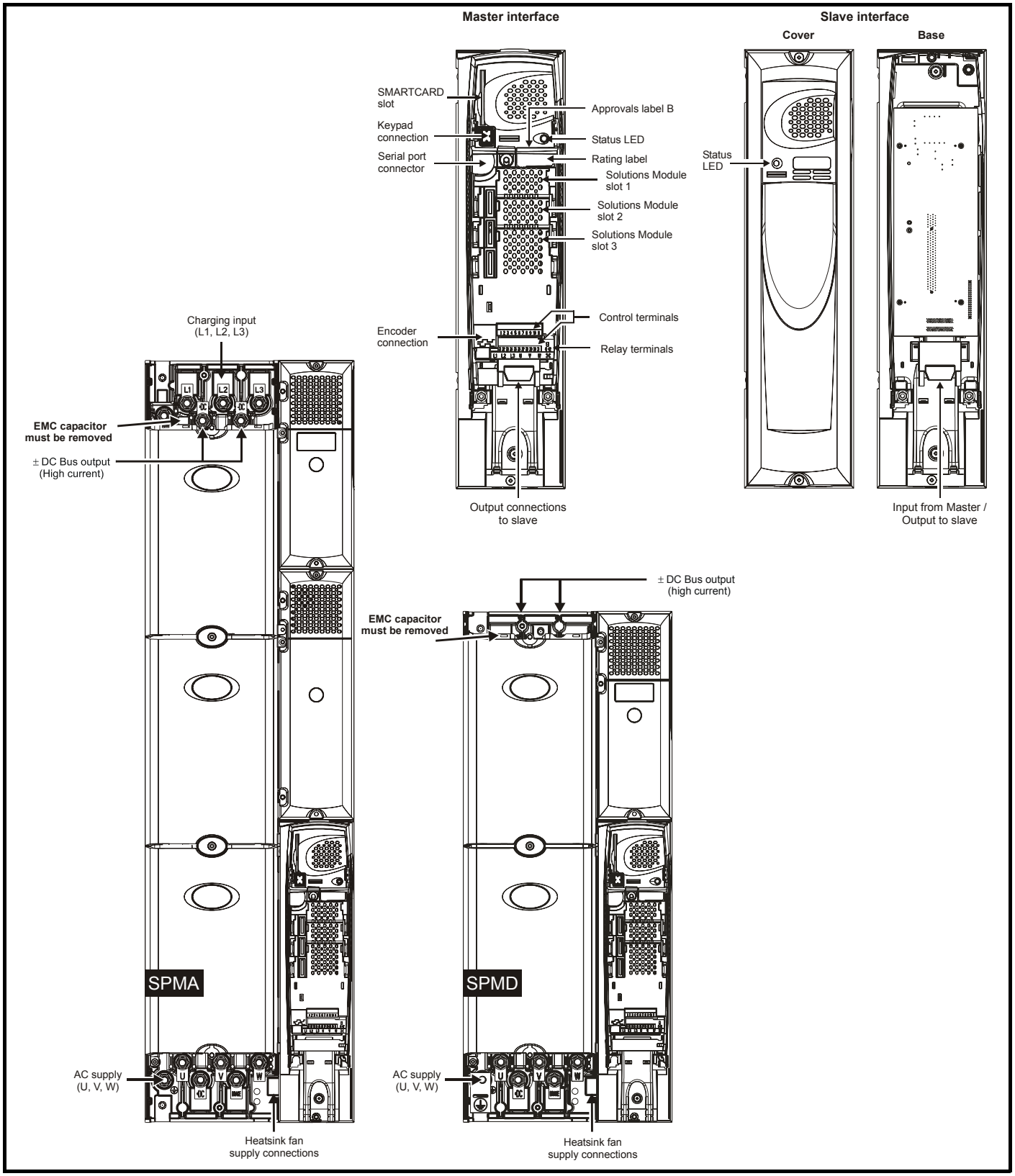


Figure 3-3 Features of the drive sizes SPMA and SPMD

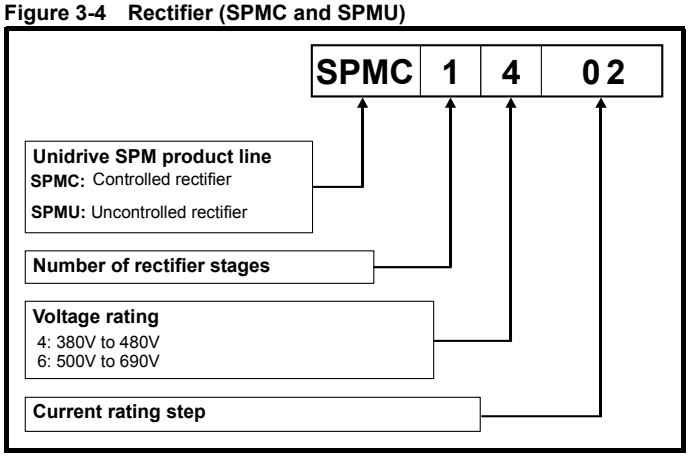


3.5 Unidrive SPMC half controlled thyristor rectifier

NOTE

For the 200V modules where an external charging circuit is required the SPMU1401, SPMU1402 and SPMU2402 can be used as detailed following:

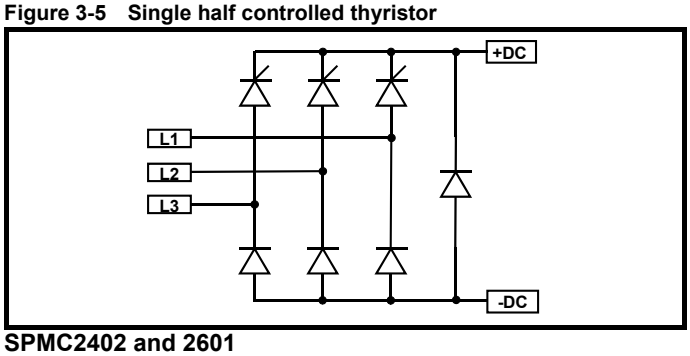
Figure 3-4 Rectifier (SPMC and SPMU)



The Unidrive SPMC is a controlled thyristor rectifier and the SPMU is an uncontrolled rectifier.

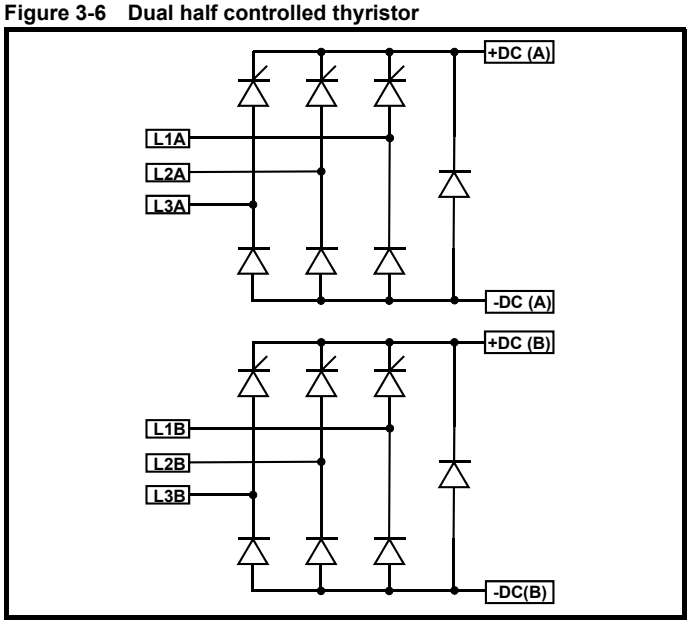
SPMC1402 and 1601

Figure 3-5 Single half controlled thyristor



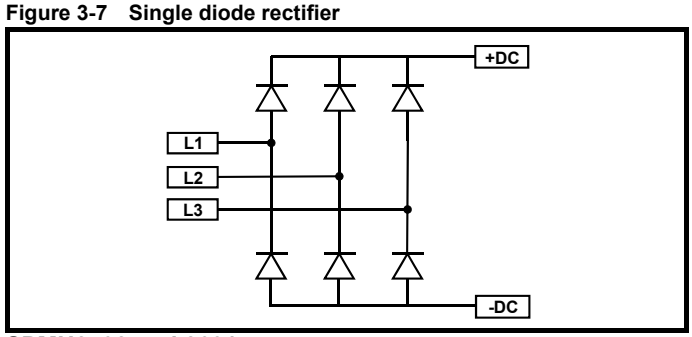
SPMC2402 and 2601

Figure 3-6 Dual half controlled thyristor



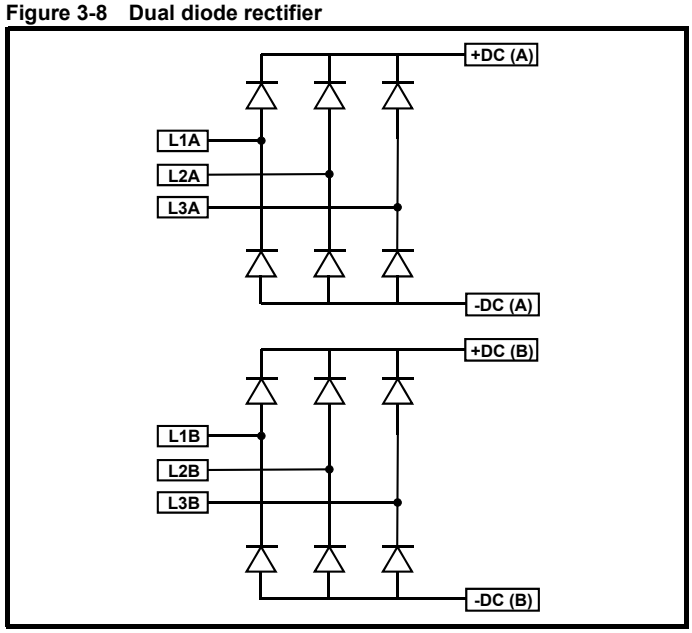
SPMU1401, 1402 and 1601

Figure 3-7 Single diode rectifier



SPMU2402 and 2601

Figure 3-8 Dual diode rectifier



The Unidrive SPMC is a half controlled thyristor bridge is used as a front end to the SPMD inverter module or as a stand alone rectifier for several smaller drives. Soft-start is built in.

The Unidrive SPMU is used as a front end to the SPMD inverter module or as a stand alone rectifier for several smaller drives. **Softstart must be supplied externally using a resistor and contactor or SPMC**.

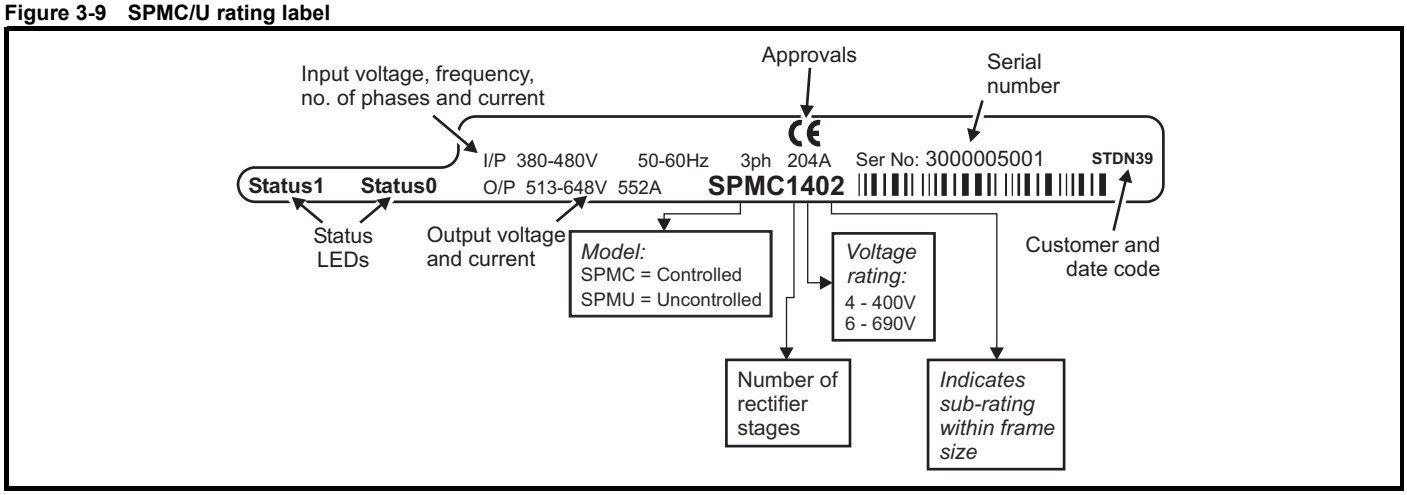
An external 24V, 3A power supply is required in addition to the AC supply to allow the rectifier to operate. Control wiring is required between the rectifier and motoring drive(s) so that if the rectifier indicates a fault the motoring drive(s) will be disabled.

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

Control connections to the Unidrive SPMC/U should be made with 0.5mm^2 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 3-9 SPMC/U rating label



3.6 Unidrive SPMC/U technical data

Table 3-5 Unidrive SPMC / U input current, fuse and cable ratings

Model	Typical input current A	Maximum input current A	Typical DC current Adc	Semi-conductor fuse in series with HRC fuse		Cable sizes			
						AC input		DC output	
				HRC IEC class gG UL class J	Semi-conductor IEC class aR	mm^2	AWG	mm^2	AWG
SPMC1402	339	344	379	540	400	2 x 120	2 x 4/0	2 x 120	2 x 4/0
SPMC2402	2 x 308	2 x 312	2 x 345	450	400	2 x 120	2 x 4/0	2 x 120	2 x 4/0
SPMU1401	207	210	222	250	315	2 x 70	2 x 2/0	2 x 70	2 x 2/0
SPMU1402	339	344	379	540	400	2 x 120	2 x 4/0	2 x 120	2 x 4/0
SPMU2402	2 x 339	609	2 x 379	450	400	2 x 120	2 x 4/0	2 x 120	2 x 4/0
SPMC1601	192	195	209	250	250	2 x 70	2 x 2/0	2 x 120	2 x 4/0
SPMC2601	2 x 170	2 x 173	2 x 185	250	250	2 x 70	2 x 2/0	2 x 120	2 x 4/0
SPMU1601	192	195	209	250	250	2 x 70	2 x 2/0	2 x 120	2 x 4/0
SPMU2601	2 x 170	2 x 173	2 x 185	250	250	2 x 70	2 x 2/0	2 x 120	2 x 4/0

WARNING

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

WARNING

Input fuses as specified must be provided.

WARNING

The Unidrive SPMC/U depends on the drive for protection. Status outputs must be linked to the drive enable regen drive(s) and circuit to ensure that when the rectifier indicates a fault the motoring drive(s) are disabled.

Table 3-6 Key to Unidrive SPMC (rectifier) LEDs

Status Output		Definition
1: Left LED	0: Right LED	
OFF	OFF	Mains loss or 24V supply to the rectifier has been lost
OFF	ON	Phase loss
ON	OFF	Any of the following: • Snubber overheating due to excessive cable charging current or supply notching • Rectifier heatsink over temperature • Rectifier PCB over temperature • Status input wire break
ON	ON	System healthy

Table 3-7 Key to Unidrive SPMU (rectifier) LEDs

Status Output		Definition
1: Left LED	0: Right LED	
OFF	OFF	24V supply to the rectifier has been lost
OFF	ON	Any of the following: • Internal fault • Check that rectifier is an SPMU. This could indicate that unit is an SPMC
ON	OFF	Any of the following: • Rectifier heatsink over temperature • Rectifier PCB over temperature • Status input wire break
ON	ON	System healthy

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

Table 3-8 SPM rectifier charging data

Model		SPMU 1401	SPMU 1402	SPMU 2402	SPMC 1402	SPMC 2402	SPMU 1601	SPMU 2601	SPMC 1601	SPMC 2601
AC line current (100% Normal Duty Motor Current)		207	339	677	339	677	192	385	192	385
DC link current (100% Normal Duty Motor Current)		222	379	758	379	758	209	418	209	418
Maximum DC bus capacitance on a supply <25kA	Max capacitance (mF)	44	66	132	66	132	29.3	59	29.3	59
	When used with line reactor	INL401	INL402	2 x INL402	INL402	2 x INL402	INL602	2 x INL602	INL602	2 x INL602
Maximum DC bus capacitance on a supply <25kA	Max capacitance (mF)	44	66	66	66	66	29.3	29.3	29.3	29.3
	When used with line reactor	INL401	INL402	INL412	INL402	INL412	INL602	INL612	INL602	INL612

Also refer to the *Unidrive SPM User Guide* for further detailed information on the Unidrive SPMC mechanical and electrical installation.

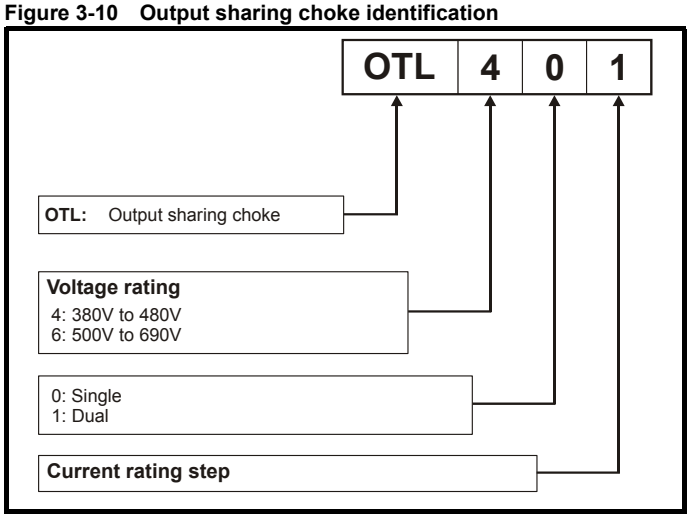


- The user must provide a means of preventing live parts from being touched. A cover around the electrical connections at the top of the inverter and the bottom of the rectifier where the cables enter is required.
- Fusing as specified must be provided.

3.7 Output Sharing Chokes (for motoring drives only)

The following section covers the output sharing chokes which are currently available for Unidrive SP. These being used for the motoring drives in a regen system only (between drive and motor).

Figure 3-10 Output sharing choke identification



NOTE

For the 200V SPMx modules used in parallel configurations and where output sharing chokes are required the 400V OTL output sharing chokes should be used.

The following tables detail the output chokes required for the various configurations of paralleled SPMA and SPMD power modules.

CAUTION

When connecting either SPMA or SPMD drives in parallel they must be de-rated by 5%

NOTE

In order to achieve the best possible current sharing between paralleled Unidrive SPM modules, sharing chokes must be fitted.

Table 3-9 400 / 600V output sharing choke ratings

Model	Current A	Inductance µH	Width (W) mm	Depth (D) mm	Height (H) mm	Weight kg	Part No.
OTL401	221	40.1	240	220	210	20	4401-0197-00
OTL402	267	34	242	220	205	20	4401-0198-00
OTL403	313	28.5	242	220	205	25	4401-0199-00
OTL404	378	23.9	242	220	205	25	4401-0200-00
OTL601	135	103.9	242	170	203	20	4401-0201-00
OTL602	156	81.8	242	170	203	20	4401-0202-00
OTL603	181	70.1	242	200	203	20	4401-0203-00
OTL604	207	59.2	242	200	203	20	4401-0204-00

Table 3-10 400 / 600V centre tapped output sharing choke ratings

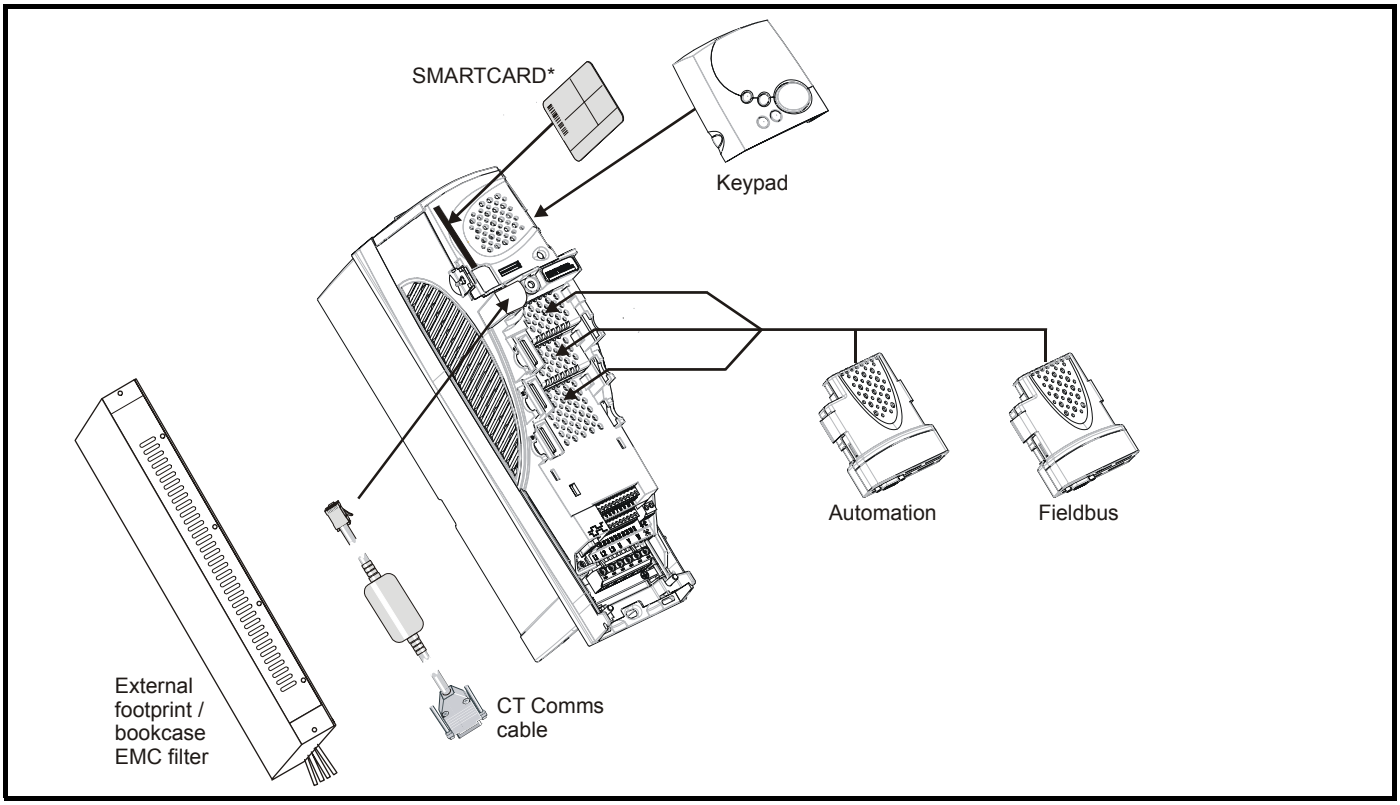
Model	Current A	Inductance µH	Width (W) mm	Depth (D) mm	Height (H) mm	Weight kg	Part No.
OTL411	389.5	42.8	300	150	160	8	4401-0188-00
OTL412	470.3	36.7	300	150	160	8	4401-0189-00
OTL413	551	31.1	300	150	160	8	4401-0192-00
OTL414	665	26.6	300	150	160	9	4401-0186-00
OTL611	237.5	110.4	300	150	160	8	4401-0193-00
OTL612	273.6	88.4	300	150	160	8	4401-0194-00
OTL613	319.2	76.7	300	150	160	8	4401-0195-00
OTL614	364.8	65.7	300	150	160	8	4401-0196-00

CAUTION

The OTLX1X centre tapped output sharing chokes can only be used when two Unidrive SPM drives are paralleled together. For all other combinations the OTLX0X output sharing choke must be used.

3.8 Options

Figure 3-11 Options available for Unidrive SP Regen



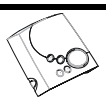
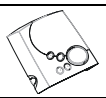
* A SMARTCARD is provided with the Unidrive SP as standard. Only one SMARTCARD can be fitted at any one time.

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.

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 3-11 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: • 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)** 2nd processor for running pre-defined and /or customer created application software with CTNet support
		White	SM-Applications Lite	**Applications Processor** 2nd 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.

3.9 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:

- *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*

3.10 Regen components

3.10.1 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.

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

Table 3-12 200V (200V to 240V ± 10%) Regen Inductors

Drive		Part number	mH	Arms
Heavy Duty	Normal Duty			
SP1203	SP1203	4401-0310	3.50	9.6
SP1204	SP1204	4401-0311	2.70	11.0
SP2201	SP2201	4401-0312	2.20	15.5
SP2202	SP2202	4401-0313	1.60	22.0
SP2203	SP2203	4401-0314	1.10	31.0
SP3201		4401-0314	1.10	31.0
SP3202	SP3201	4401-0315	0.81	42.0
SP4201	SP3202	4401-0316	0.60	56.0
SP4202	SP4201	4401-0317	0.50	68.0
SP4203	SP4202	4401-0318	0.40	80.0
SP5201	SP4203	4401-0319	0.32	105.0
SP5202	SP5201	4401-0320	0.26	130.0
SPMD1201	SP5202	4401-0321	0.22	156.0
SPMD1202	SPMD1201	4401-0322	0.18	192.0
SPMD1203	SPMD1202	4401-0323	0.14	250.0
SPMD1204	SPMD1203	4401-0324	0.11	312.0
	SPMD1204	4401-0325	0.10	350.0

Table 3-13 400V (380V to 480V ± 10%) Regen Inductor

Drive		Part number	mH	Arms
Heavy Duty	Normal Duty			
SP1405	SP1405	4401-0001	6.30	9.5
SP1406		4401-0001	6.30	9.5
	SP1406	4401-0002	5.00	12.0
SP2401	SP2401	4401-0003	3.75	16.0
SP2402		4401-0003	3.75	16.0
SP2403	SP2402	4401-0004	2.40	25.0
SP2404	SP2403	4401-0005	1.76	34.0
SP3401	SP2404	4401-0005	1.76	34.0
SP3402	SP3401	4401-0006	1.50	40.0
SP3403	SP3402	4401-0007	1.30	46.0
SP4401	SP3403	4401-0008	1.00	60.0
	SP4401	4401-0009	0.78	70.0
SP4402	SP4402	4401-0010	0.63	96.0
SP4403		4401-0010	0.63	96.0
SP5401	SP4403	4401-0011	0.48	124.0
SP5402	SP5401	4401-0012	0.38	156.0
SP6401	SP5402	4401-0013	0.33	180.0
SP6402	SP6401	4401-0014	0.30	200.0
	SP6402	4401-0015	0.20	300.0
SPMA1401		4401-0013	0.33	180.0
SPMA1402	SPMA1401	4401-0014	0.30	200.0
	SPMA1402	4401-0015	0.20	300.0
SPMD1401		4401-0013	0.33	180.0
SPMD1402	SPMD1401	4401-0014	0.30	200.0
	SPMD1402	4401-0015	0.20	300.0
SPMD1403	SPMD1403	4401-0015	0.20	300.0
SPMD1404		4401-0015	0.20	300.0
	SPMD1404	4401-0205-00	0.16	350.0

Table 3-14 575V (500V to 575V ± 10%) Regen Inductor

Drive		Part number	mH	Arms
Heavy Duty	Normal Duty			
SP3505	SP3505	4401-0210	5.30	19.0
SP3506		4401-0211	4.60	22.0
SP3507	SP3506	4401-0212	3.80	27.0
	SP3507	4401-0212	3.80	27.0
SP4601		4401-0211	4.60	22.0
SP4602	SP4601	4401-0212	3.80	27.0
SP4603	SP4602	4401-0212	3.80	27.0
SP4604	SP4603	4401-0213	2.80	36.0
SP4605	SP4604	4401-0214	2.40	43.0
SP4606	SP4605	4401-0215	1.90	52.0
SP5601	SP4606	4401-0216	1.60	63.0
SP5602	SP5601	4401-0217	1.20	85.0
SP6601	SP5602	4401-0218	1.00	100.0
SP6602	SP6601	4401-0219	0.80	125.0
SPMA1601		4401-0218	1.00	100.0
SPMD1601		4401-0218	1.00	100.0
SPMA1602	SPMA1601	4401-0219	0.80	125.0
SPMD1602	SPMD1601	4401-0219	0.80	125.0
	SPMA1602	4401-0220	0.70	144.0
	SPMD1602	4401-0220	0.70	144.0
SPMD1603	SP6602	4401-0220	0.70	144.0
SPMD1604	SPMD1603	4401-0221	0.60	168.0
	SPMD1604	4401-0222	0.53	192.0

Table 3-15 690V (690V ± 10%) Regen Inductor

Drive		Part number	mH	Arms
Heavy Duty	Normal Duty			
SP4601		4401-0210	5.30	19.0
SP4602	SP4601	4401-0211	4.60	22.0
SP4603	SP4602	4401-0212	3.80	27.0
SP4604	SP4603	4401-0213	2.80	36.0
SP4605	SP4604	4401-0214	2.40	43.0
SP4606	SP4605	4401-0215	1.90	52.0
SP5601	SP4606	4401-0216	1.60	63.0
SP5602	SP5601	4401-0217	1.20	85.0
SP6601	SP5602	4401-0218	1.00	100.0
SP6602	SP6601	4401-0219	0.80	125.0
SPMA1601		4401-0218	1.00	100.0
SPMD1601		4401-0218	1.00	100.0
SPMA1602	SPMA1601	4401-0219	0.80	125.0
SPMD1602	SPMD1601	4401-0219	0.80	125.0
	SPMA1602	4401-0220	0.70	144.0
	SPMD1602	4401-0220	0.70	144.0
SPMD1603	SP6602	4401-0220	0.70	144.0
SPMD1604	SPMD1603	4401-0221	0.60	168.0
	SPMD1604	4401-0222	0.53	192.0

3.10.2 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 3-16 200V (200V to 240V ± 10%) SFF Inductors

Drive		Part number	mH	Arms
Heavy Duty	Normal Duty			
SP1203	SP1203	4401-1310	0.88	9.6
SP1204	SP1204	4401-1311	1.50	11.0
SP2201	SP2201	4401-1312	1.10	15.5
SP2202	SP2202	4401-1313	0.70	22.0
SP2203	SP2203	4401-1314	0.50	31.0
SP3201		4401-1314	0.50	31.0
SP3202	SP3201	4401-1315	0.40	42.0
SP4201	SP3202	4401-1316	0.30	56.0
SP4202	SP4201	4401-1317	0.25	68.0
SP4203	SP4202	4401-1318	0.20	80.0
SP5201	SP4203	4401-1319	0.16	105.0
SP5202	SP5201	4401-1320	0.13	130.0
SPMD1201	SP5202	4401-1321	0.11	156.0
SPMD1202	SPMD1201	4401-1322	0.088	192.0
SPMD1203	SPMD1202	4401-1323	0.068	250.0
SPMD1204	SPMD1203	4401-1324	0.055	312.0
	SPMD1204	4401-1325	0.048	350.0

Table 3-17 400V (380V to 480V ± 10%) SFF Inductor

Drive		Part number	mH	Arms
Heavy Duty	Normal Duty			
SP1405	SP1405	4401-0162	3.16	9.5
SP1406		4401-0162	3.16	9.5
	SP1406	4401-0163	2.50	12.0
SP2401	SP2401	4401-0164	1.875	16.0
SP2402	SP2402	4401-0165	1.20	25.0
SP2403		4401-0165	1.20	25.0
SP2404	SP2403	4401-0166	0.88	34.0
SP3401	SP2404	4401-0166	0.88	34.0
SP3402	SP3401	4401-0167	0.75	40.0
SP3403	SP3402	4401-0168	0.65	46.0
SP4401	SP3403	4401-0169	0.50	60.0
	SP4401	4401-0170	0.39	70.0
SP4402	SP4402	4401-0171	0.315	96.0
SP4403		4401-0171	0.315	96.0
SP5401	SP4403	4401-0172	0.24	124.0
SP5402	SP5401	4401-0173	0.19	156.0
SP6401	SP5402	4401-0174	0.165	180.0
SP6402	SP6401	4401-0175	0.135	220.0
	SP6402	4401-0176	0.10	300.0
SPMA1401		4401-0174	0.165	180.0
SPMA1402	SPMA1401	4401-0175	0.135	220.0
	SPMA1402	4401-0176	0.10	300.0
SPMD1401		4401-0174	0.165	180.0
SPMD1402	SPMD1401	4401-0175	0.135	220.0
SPMD1403	SPMD1402	4401-0176	0.10	300.0
SPMD1404	SPMD1403	4401-0176	0.10	300.0
	SPMD1404	4401-1205	0.08	350.0

Table 3-18 575V (500V to 575V ± 10%) SFF Inductor

Drive		Part number	mH	Arms
Heavy Duty	Normal Duty			
SP3505	SP3505	4401-1211	1.40	22.0
SP3506		4401-1211	1.40	22.0
	SP3506	4401-1213	1.40	36.0
SP3507	SP3507	4401-1213	1.40	36.0
SP4601	SP4601	4401-1211	1.40	22.0
SP4602		4401-1211	1.40	22.0
SP4603	SP4602	4401-1213	1.40	36.0
SP4604	SP4603	4401-1214	1.20	43.0
SP4605	SP4604	4401-1215	1.00	52.0
SP4606	SP4605	4401-1216	0.80	63.0
SP5601	SP4606	4401-1217	0.60	85.0
SP5602	SP5601	4401-1218	0.50	100.0
SP6601	SP5602	4401-1219	0.40	125.0
SP6602	SP6601	4401-1220	0.35	144.0
SPMA1601		4401-1219	0.40	125.0
SPMD1601		4401-1219	0.40	125.0
SPMA1602	SPMA1601	4401-1220	0.35	144.0
SPMD1602	SPMD1601	4401-1220	0.35	144.0
	SPMA1602	4401-1221	0.30	168.0
	SPMD1602	4401-1221	0.30	168.0
SPMD1603	SP6602	4401-1221	0.30	168.0
SPMD1604	SPMD1603	4401-1222	0.26	192.0
	SPMD1604	4401-1223	0.21	192.0

Table 3-19 690V (690V ± 10%) SFF Inductor

Drive		Part number	mH	Arms
Heavy Duty	Normal Duty			
SP4601	SP4601	4401-1211	1.40	22.0
SP4602		4401-1211	1.40	22.0
SP4603	SP4602	4401-1213	1.40	36.0
SP4604	SP4603	4401-1213	1.40	36.0
SP4605	SP4604	4401-1214	1.20	43.0
SP4606	SP4605	4401-1215	1.00	52.0
SP5601	SP4606	4401-1216	0.80	63.0
SP5602	SP5601	4401-1217	0.60	85.0
SP6601	SP5602	4401-1218	0.50	100.0
SP6602	SP6601	4401-1219	0.40	125.0
SPMA1601		4401-1218	0.50	100.0
SPMD1601		4401-1218	0.50	100.0
SPMA1602	SPMA1601	4401-1219	0.40	125.0
SPMD1602	SPMD1601	4401-1219	0.40	125.0
	SPMA1602	4401-1220	0.35	144.0
	SPMD1602	4401-1220	0.35	144.0
SPMD1603	SP6602	4401-1220	0.35	144.0
SPMD1604	SPMD1603	4401-1221	0.30	168.0
	SPMD1604	4401-1222	0.26	192.0

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. The above switching frequency filter inductors are calculated at 4% of the regen drives rating using the following formula. A tolerance can be applied to the calculated value in the range of, -10% to +30%.

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

Where:

VLL = Supply voltage line-to-line
f = Supply frequency
Irated = Drive rated current

NOTE

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

Table 3-20 200V (200V to 240V ± 10%) SFF Capacitors

Drive		Part number	uF	Arms
Heavy Duty	Normal Duty			
SP1203	SP1203	1664-1074	7	1.7
SP1204	SP1204			
SP2201	SP2201			
SP2202	SP2202	1664-2174	16.6	4.3
SP2203	SP2203			
SP3201	SP3201			
SP3202				
SP4201	SP3202	1665-8324	32	11
SP4202	SP4201			
SP4203	SP4202			
SP5201	SP4203	1664-2644	64	17
SP5202	SP5201			
SPMD1201	SP5202			
SPMD1202	SPMD1201	2 x 1664-2644	2 x 64	2 x 17
SPMD1203	SPMD1202			
SPMD1204	SPMD1203			
	SPMD1204			

Table 3-21 400V (380V to 480V ± 10%) SFF Capacitors

Drive		Part number	uF	Arms
Heavy Duty	Normal Duty			
SP1405	SP1405	1610-7804	8	4.3
SP1406	SP1406			
SP2401	SP2401			
SP2402	SP2402			
SP2403				
SP2404	SP2403	1665-8324	32	11
SP3401	SP2404			
SP3402	SP3401			
SP3403	SP3402			
SP4401	SP3403			
	SP4401			
SP4402	SP4402	1665-8484	48	17
SP4403	SP4403			
SP5401	SP5401			
SP5402	SP5402			
SP6401	SP6401			
SP6402				
SPMA1401	SPMA1401			
SPMA1402				
SPMD1401	SPMD1401			
SPMD1402				
	SP6402	1665-8774	77	26
SPMA1402	SPMA1402			
	SPMD1402			
SPMD1403	SPMD1403			
SPMD1404				
	SPMD1404	2 x 1665-8394	2 x 39	2 x 13

Table 3-22 575V (500V to 575V ± 10%) SFF Capacitors

Drive		Part number	uF	Arms
Heavy Duty	Normal Duty			
SP3505	SP3505	1666-8113	11.2	5
SP3506	SP3506			
SP3507	SP3507			
SP4601	SP4601			
SP4602	SP4602			
SP4603	SP4603			
SP4604	SP4604			
SP4605	SP4605			
SP4606	SP4606			
SP5601	SP5601			
SP5602				
SP6601	SP5602	1666-8223	22.5	10
SP6602	SP6601			
SPMA1601	SP6602			
SPMA1602	SPMA1601			
SPMD1601	SPMA1602			
SPMD1602	SPMD1601			
SPMD1603	SPMD1602			
SPMD1604	SPMD1603	2 x 1666-8233	2 x 22.5	2 x 10
	SPMD1604			

Table 3-23 690V (690V ± 10%) SFF Capacitors

Drive		Part number	uF	Arms
Heavy Duty	**Normal Duty**			
SP4601	SP4601	1668-7833	8.3	4.3
SP4602	SP4602			
SP4603	SP4603			
SP4604	SP4604			
SP4605	SP4605			
SP4606	SP4606			
SP5601				
SP5602	SP5601	1668-8163	16.6	8.6
SP6601	SP5602			
SP6602	SP6601			
SPMA1601	SPMA1601			
SPMA1602	SPMD1601			
SPMD1601				
SPMD1602				
	SP6602	2 x 1668-8163	2 x 16.6	2 x 8.6
	SPMA1602			
	SPMD1602			
SPMD1603	SPMD1603			
SPMD1604	SPMD1604			

3.10.3 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.

The following varistors should therefore be fitted as shown in section 4.2 *Power connections* .

Table 3-24 Varistor data

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

3.10.4 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 both the *Unidrive SP, and SPM User Guides*.

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

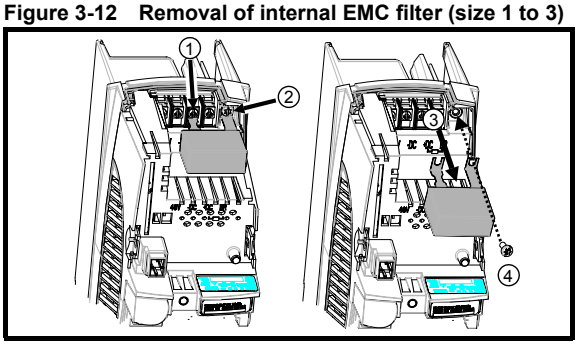
- Epcos B84143-B250-5xx (range up to 2500A)
- Schaffner FN3359-300-99 (range up to 2400A)

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.

CAUTION When a EMC filter is used, the switching frequency filter detailed must also be used. Failure to observe this may result in the EMC filter becoming ineffective and being damaged. Refer to section 6.4 *EMC (Electromagnetic compatibility)* on page 77.

CAUTION The internal EMC filter must be removed from the drive.

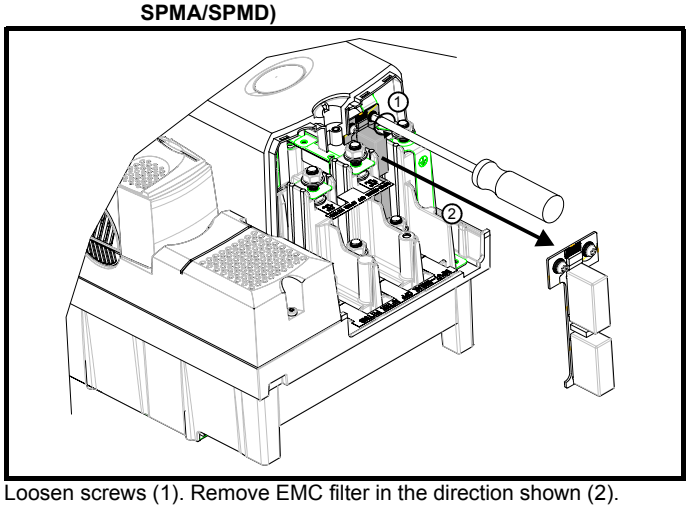
Figure 3-12 Removal of internal EMC filter (size 1 to 3)



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

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

Figure 3-13 Removal of internal EMC filter (size 4 to 6 and the SPMA/SPMD)



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

3.10.5 External charging resistor

The following external charging resistors are available from Control Techniques and can be used with a regen system consisting of multiple regen, multiple motoring or single regen, multiple motoring drives. For correct sizing of the charging resistor required, refer to section 11.2 *Resistor sizing for multiple drive systems* on page 204. Also, see section 10.4.2 *Softstart resistor - type TG series* on page 197 for further technical data and thermal protection information on the following resistors.

Table 3-25 External charging resistors

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

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 / absorb all the required power including total system losses.

If the Regen drive is unable to supply the full power required by the motoring drive(s), the DC bus voltage will drop, and in severe cases may lose 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:

$\sqrt{3}$ × **Rated current** × **Supply voltage**

= 1.73 x **23** x **400**
= 15.9kW

The motoring drive can supply power:

$\sqrt{3}$ × **Rated current** × **Motor voltage** × **Power factor**

= 1.73 x **23** x **400** x **0.85**
= 13.5kW

Drive losses

2 x Unidrive SP 2403 = 626W

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, with a regen current limit of 150%:

The Regen drive maximum available power is:

$\sqrt{3}$ × **150%** × **Rated current** × **Supply voltage**

= 1.73 x **1.5** x **96** x **342**
= 85.1kW

The motoring drives maximum. power is:

$\sqrt{3}$ × **175%** × **Rated current** × **Motor voltage** × **Power factor**

= 1.73 x **1.75** x **96** x **400** x **0.95**
= 110.4kW

Drive losses

2 x Unidrive SP 4403 = 1.952kW

The Regen drive is also required to supply the Regen and motoring drive losses in this example 1.952kW which brings the 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 rating is required.

4.1.2 Multiple motoring drives

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

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

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

4.2 Power connections

The following section covers the power connections required for Unidrive 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 and multiple regen, multiple motoring systems require an external charging circuit due to the extra capacitance from the additional drives. No AC connections are made to the Regen drive's L1, L2 and L3 terminals. The external charging circuit can consist of either the 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 6.6 *Control connections* on page 83.

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

4.2.1 Single Regen, single / multiple motoring system

Figure 4-1 Power connections: Single Regen, single / multiple motoring system

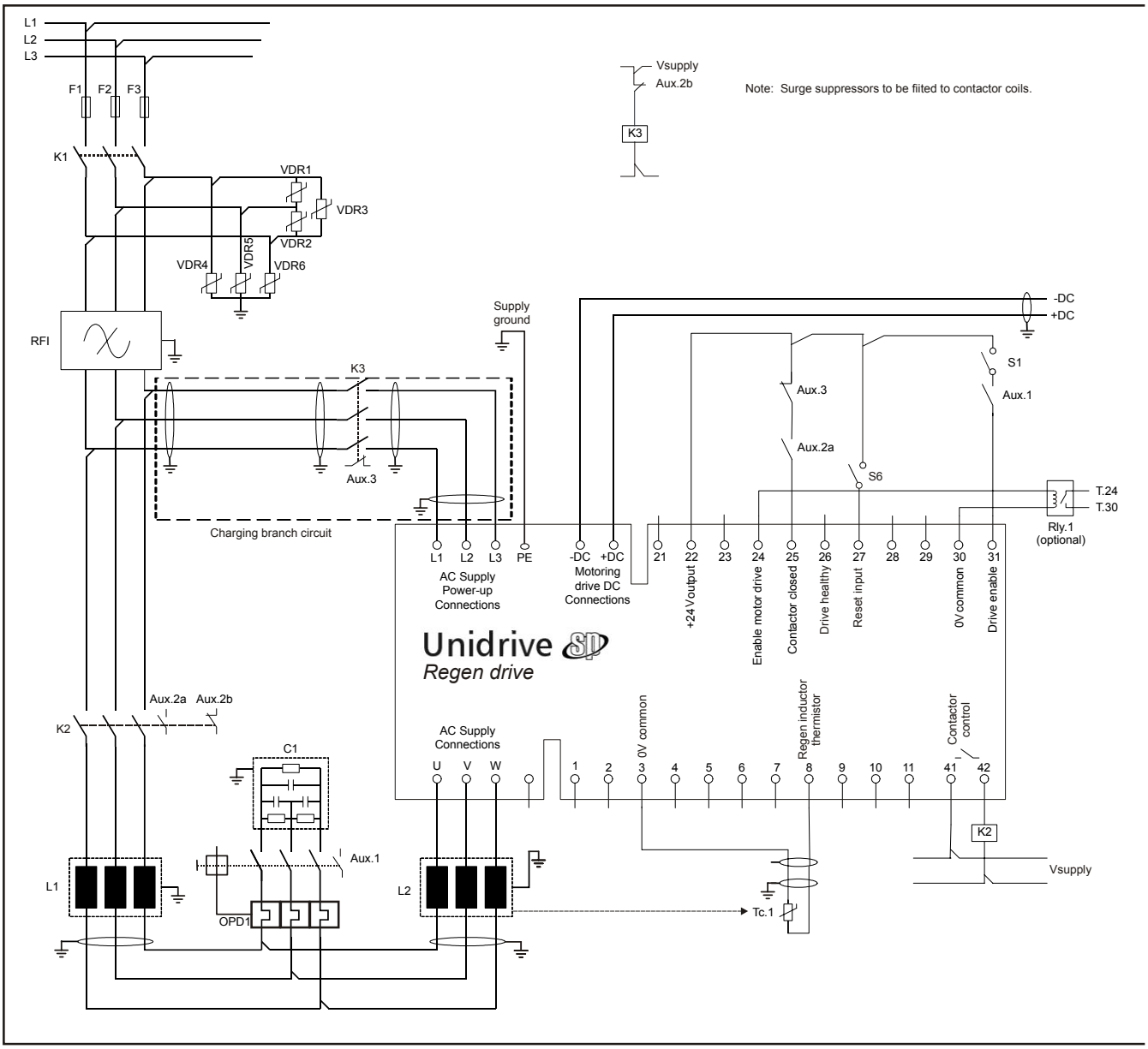


Table 4-1 Key to Figure 4-1

Key	Description
L1, L2, L3	Three phase supply
F1, F2, F3	Main regen system supply fuses
VDR1, VDR2, VDR3	Varistor network line-to-line
VDR4, VDR5, VDR6	Varistor network line-to-ground
RFI	Optional RFI Filter
C1	Switching frequency filter capacitor
L1	Switching frequency filter inductor
L2	Regen inductor
K1	Main supply switch or contactor
K2	Regen drive main contactor
K3	Charging contactor
OPD1	Overload protection device for C1
Aux.3	K3 NC auxiliary contact
Aux.2a	K2 NO auxiliary contact
Aux.2b	K2 NC auxiliary contact
Aux.1	OPD1 NO auxiliary contact
Rly.1	Optional isolation for enable between Regen and motoring drive
Mt.1	Motor thermistor
Tc.1	Regen inductor thermistor

Table 4-1 Key to Figure 4-1

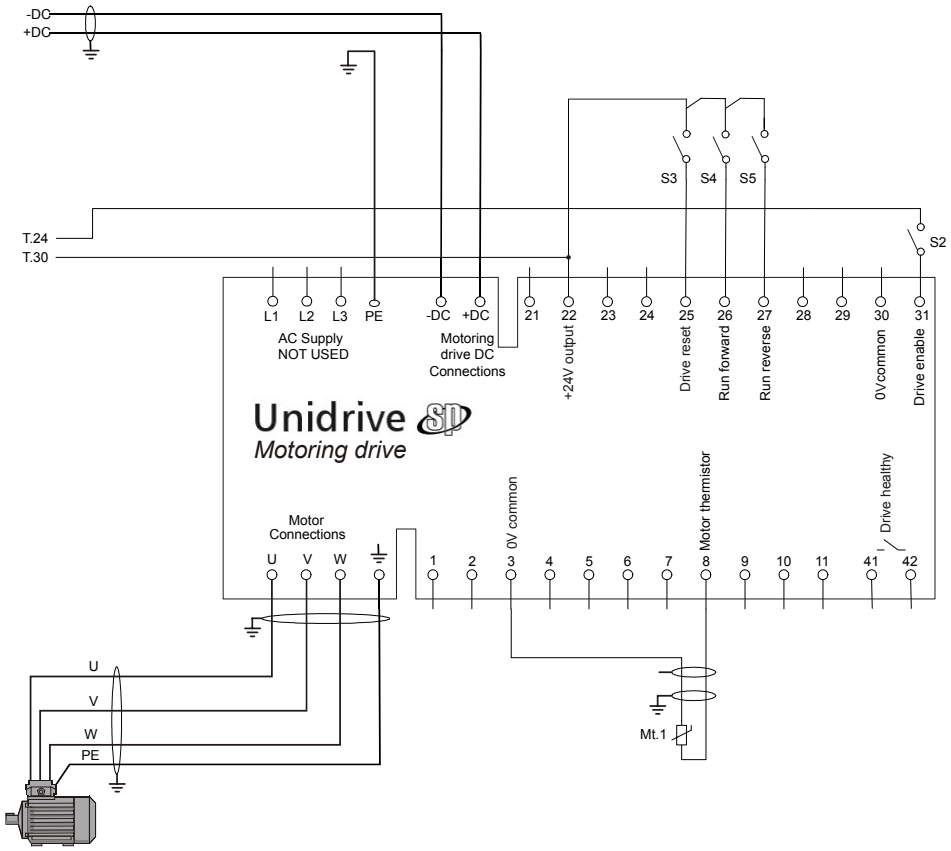
Key	Description
Vsupply	System control supply
+DC, -DC	Motoring drive power connection to Regen drive
S1	Regen drive enable
S2	Motoring drive enable
S3	Motoring drive reset
S4	Motoring drive run forward
S5	Motoring drive run reverse
S6	Regen drive reset input (Pr **8.24** = Pr **10.33**)

Figure 4-1 shows both the power and control connections for the standard regen solution this being a single regen and single motoring drive system.

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

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

VDR4, VDR5 and VDR6 when operating with a 690Vac supply should consist of two varistors each in series as detailed in Table 3-24 on page 28.

4.2.2 Single Regen, multiple motoring system using a Unidrive SPMC

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

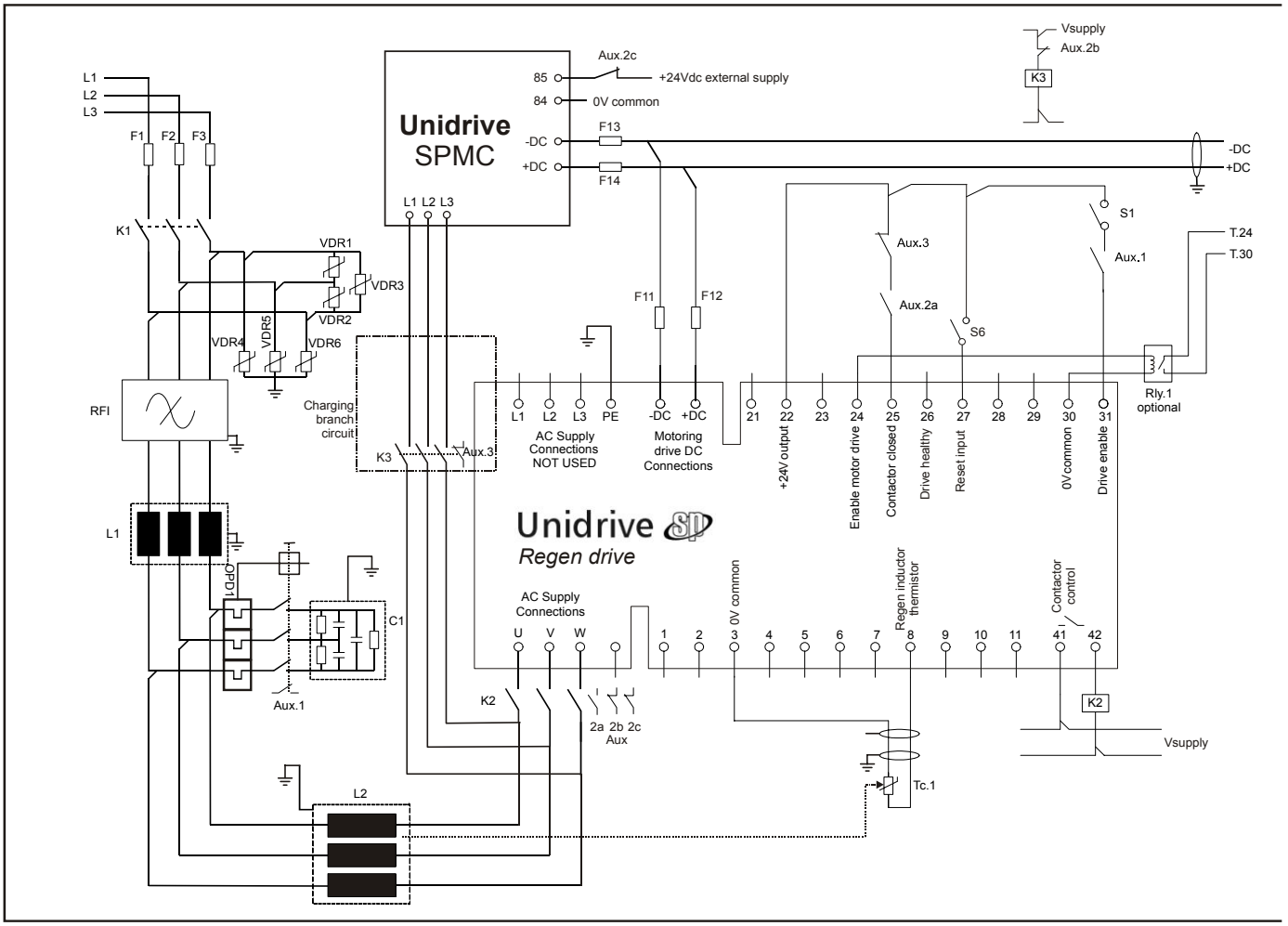


Table 4-2 Key to Figure 4-3

Key	Description
L1, L2, L3	Three phase supply
F1, F2, F3	Main regen system supply fuses
VDR1, VDR2, VDR3	Varistor network line-to-line
VDR4, VDR5, VDR6	Varistor network line-to-ground
F7, F8, F9, F10	DC bus fusing to motoring drive
F11, F12	DC bus fusing to Regen drive
F13, F14	SPMC DC fuse protection
RFI	Optional RFI 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
OPD1	Overload protection device for C1
Aux.1	OPD NO auxiliary contact
Aux.2a	K2 NO auxiliary contact
Aux.2b	K2 NC auxiliary contact
Aux.2c	NC auxiliary for SPMC (optional)
Aux.3	K3 NC auxiliary contact
Rly.1	Optional isolation for enable between Regen and motoring drive(s)
Mt.1	Motor thermistor 1
Mt.2	Motor thermistor 2
Tc.1	Regen inductor thermistor
+DC, -DC	Motoring drive power connection to Regen drive
S1	Regen drive enable
S2	Motoring drive enable
S3	Motoring drive reset
S4	Motoring drive run forward
S5	Motoring drive run reverse
S6	Regen drive reset input (Pr **8.24** = Pr **10.33**)
Vsupply	System control supply

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 half controlled thyristor rectifier* on page 19 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

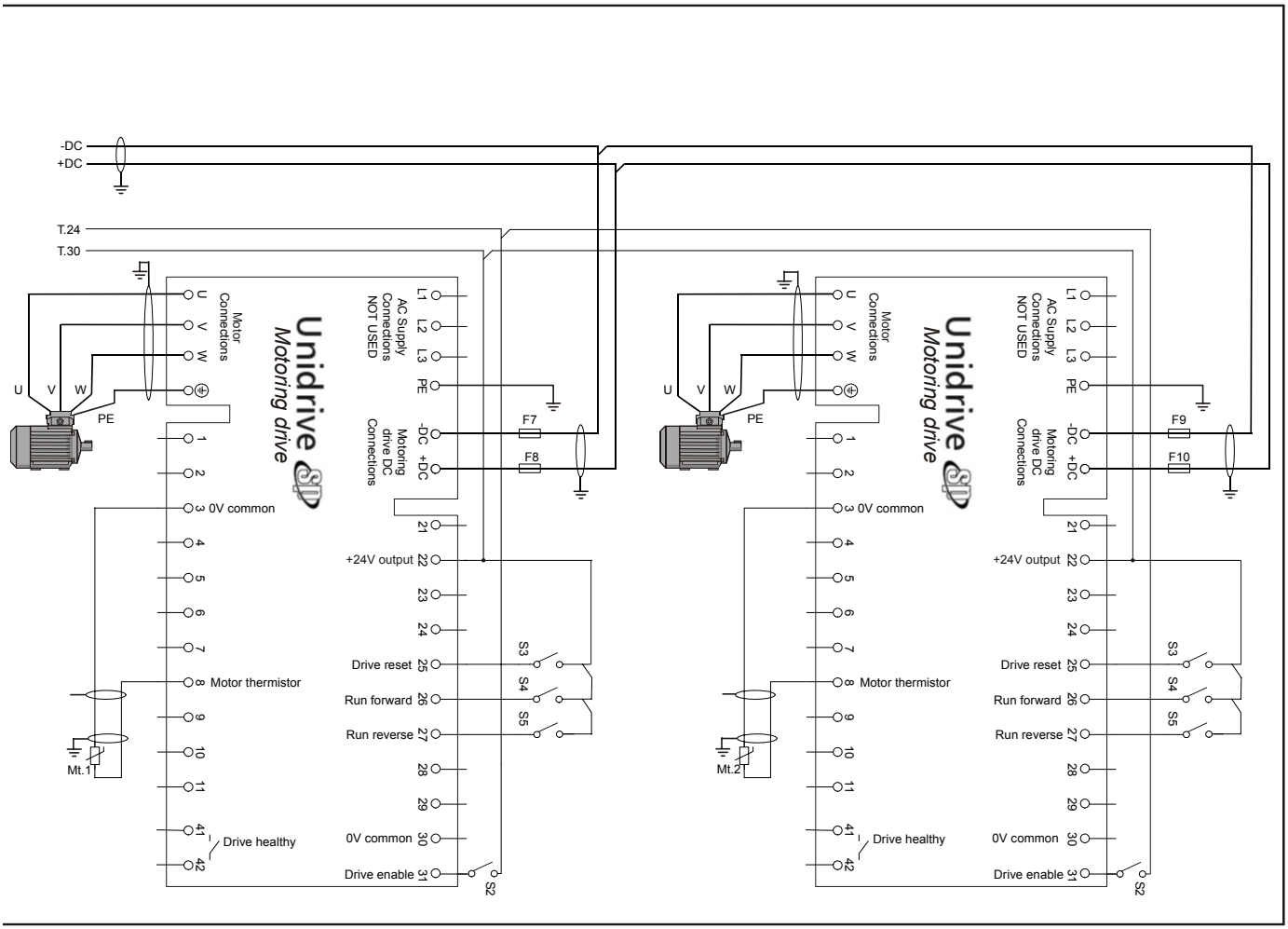
The regen inductor duty is very arduous and therefore selection is critical. As a result only regen inductors specified in this guide should be used.

NOTE

Fusing F4, F5, F6 are 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

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



NOTE

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

NOTE

VDR4, VDR5 and VDR6 when operating with a 690Vac supply should consist of two varistors each in series as detailed in Table 3-24 on page 28.

See Chapter 10 *Technical data* on page 183 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 203.

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

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

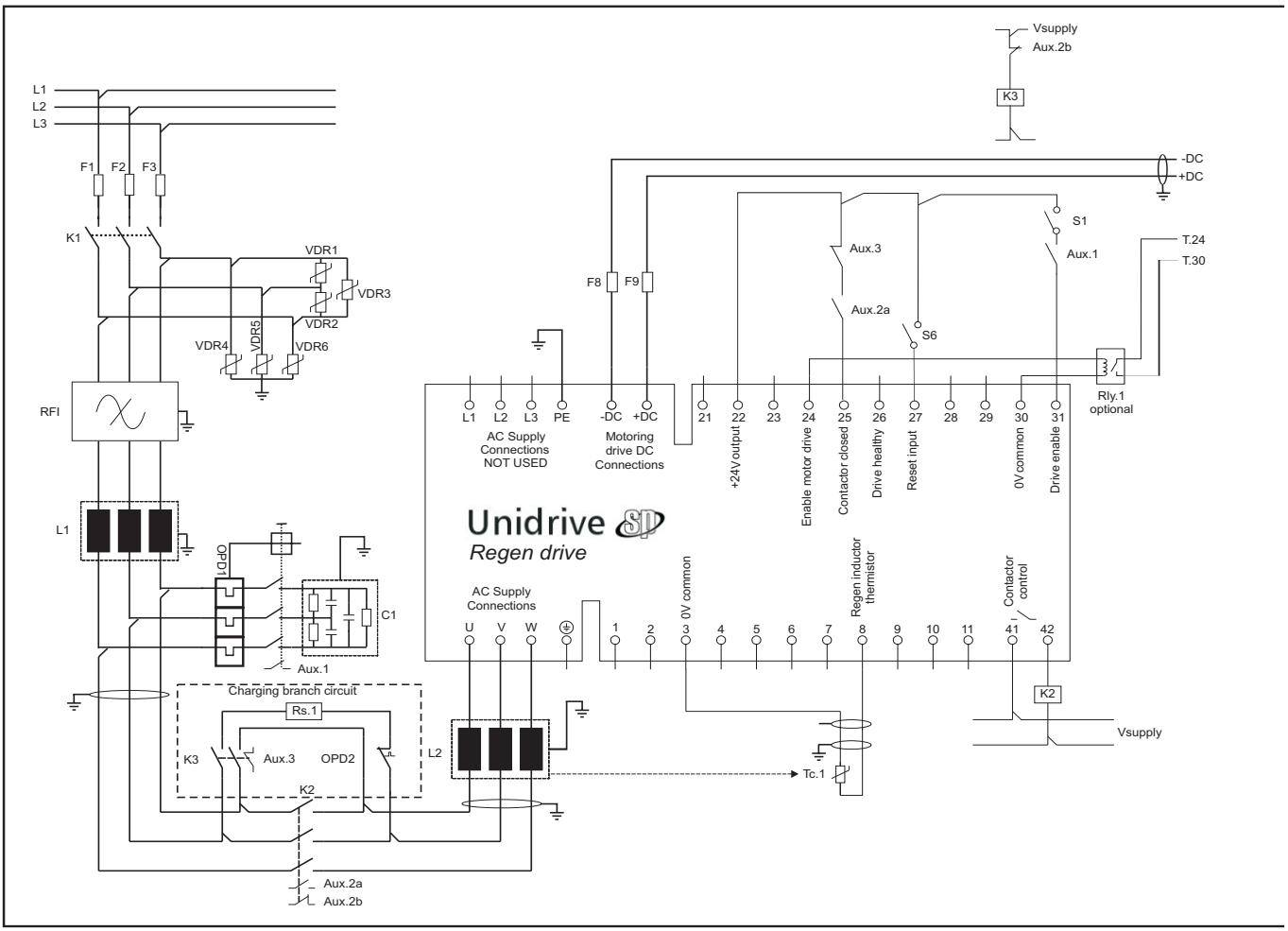


Table 4-3 Key to Figure 4-3

Key	Description
L1, L2, L3	Three phase supply
F1, F2, F3	Main regen system supply fuses
VDR1, VDR2, VDR3	Varistor network line-to-line
VDR4, VDR5, VDR6	Varistor network line-to-ground
F4, F5, F6, F7	DC bus fusing to motoring drive
F8, F9	DC Bus fusing to regen drive
RFI	Optional RFI 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
OPD1	Overload protection device for C1
OPD2	Overload protection device for Rs.1
Aux.1	OPD1 NO auxiliary contact
Aux.2a	K2 NO auxiliary contact
Aux.2b	K2 NC auxiliary contact
Aux.3	K3 NC auxiliary contact
Rly.1	Optional isolation for enable between Regen and motoring drive(s)
Mt.1	Motor thermistor 1
Mt.2	Motor thermistor 2
Tc.1	Regen inductor thermistor
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
S6	Regen drive reset input (Pr **8.24** = Pr **10.33**)
Vsupply	System control suply

Figure 4-3 shows both the power and control connections for the multiple motoring regen solution. For this multiple motoring system solution an external charging circuit is required due to the additional capacitance from the multiple motoring drives. The external charging circuit is interlocked with the Regen drive enable to prevent operation with this circuit still connected.

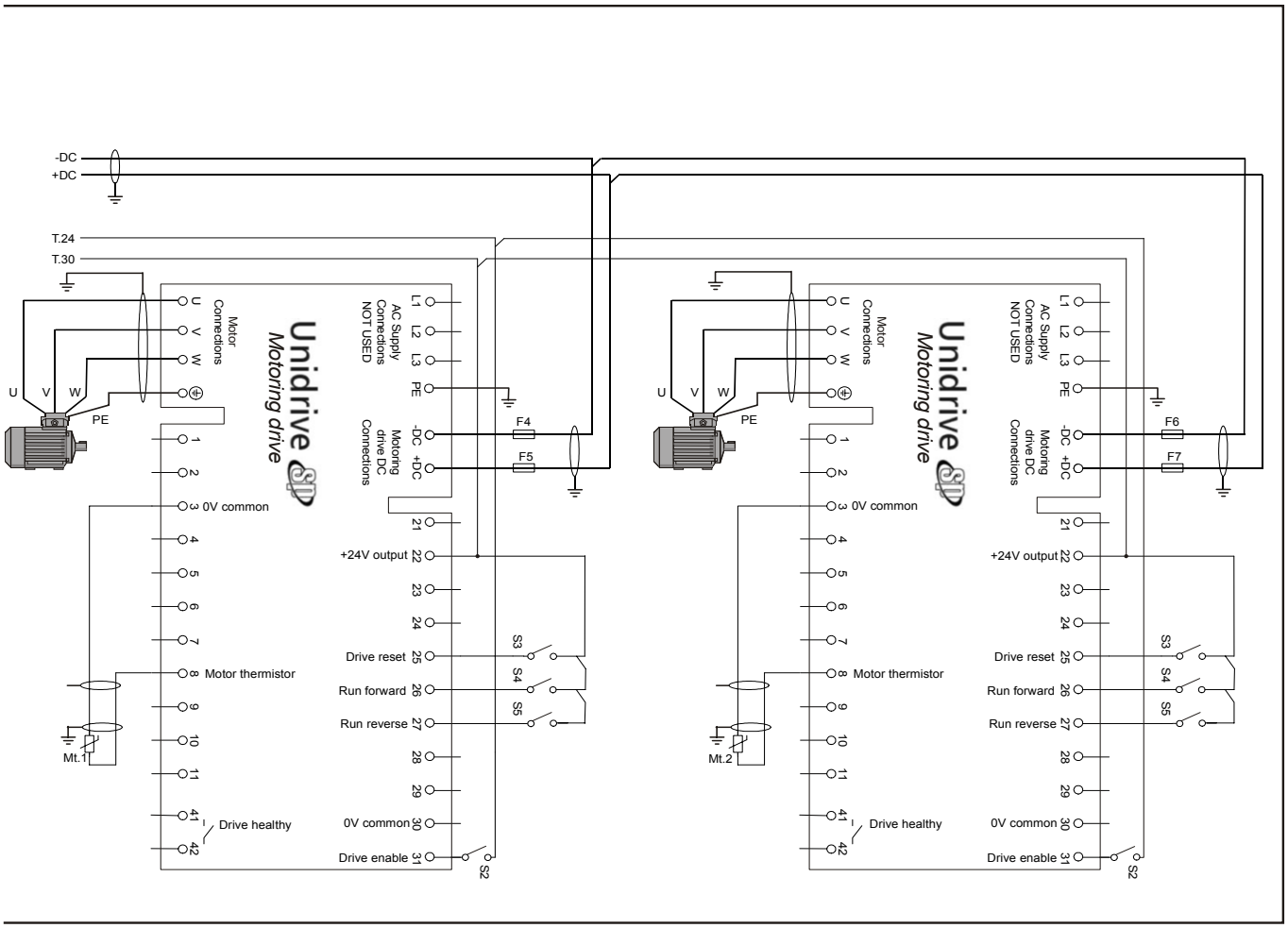
For sizing of the external charging circuit required for the multiple motoring drive system, refer to Chapter 11 *Component sizing* on page 203. For details on charging resistors and protection refer to section 10.4.2 *Softstart resistor - type TG series* on page 197.

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 motoring drive system in both the +DC and -DC.

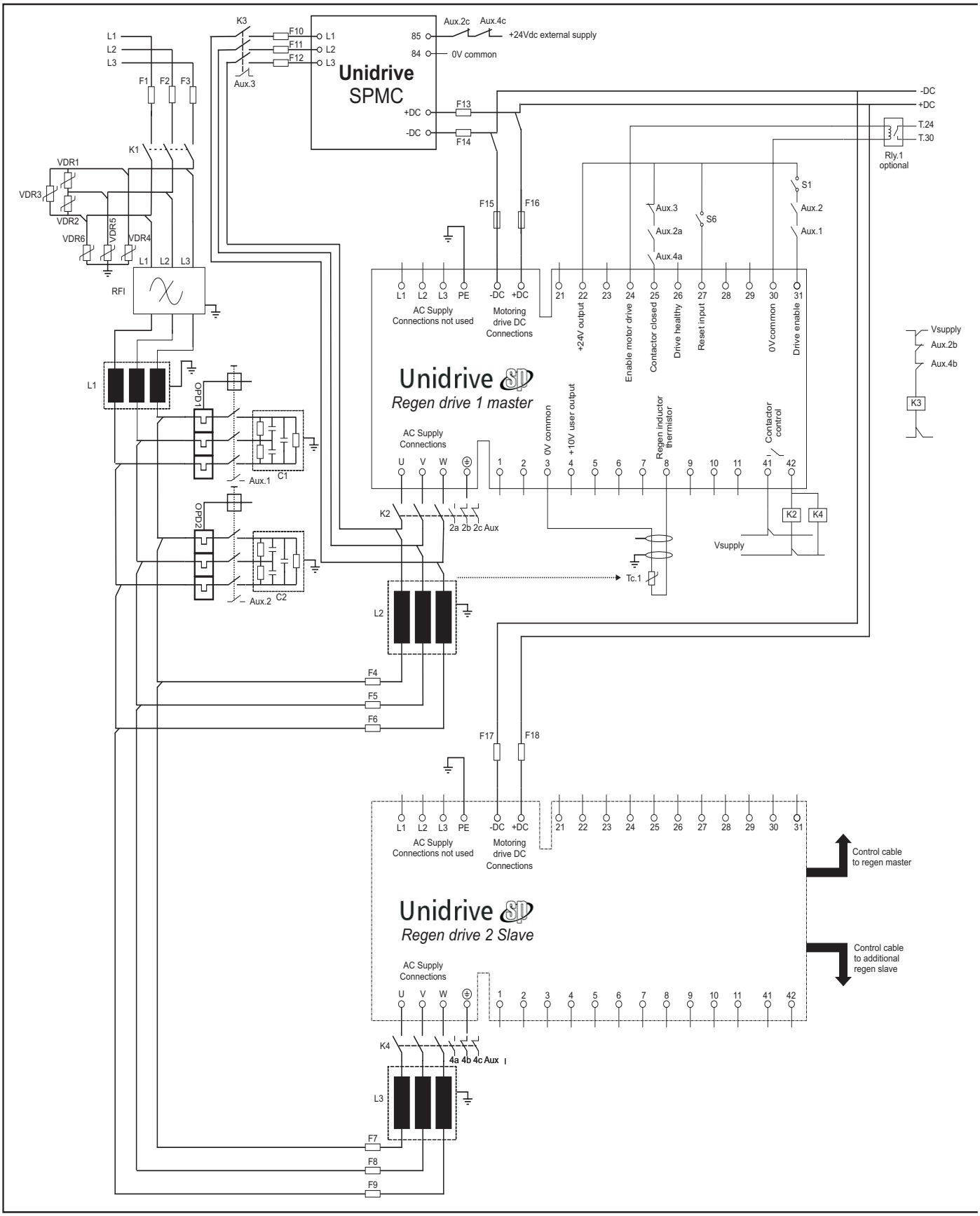
NOTE

VDR4, VDR5 and VDR6 when operating with a 690Vac supply should consist of two varistors each in series as detailed in Table 3-24 on page 28.

See Chapter 10 *Technical data* on page 183 for fuse rating information.

4.2.4 Multiple Regen, multiple motoring using Unidrive SPMC

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



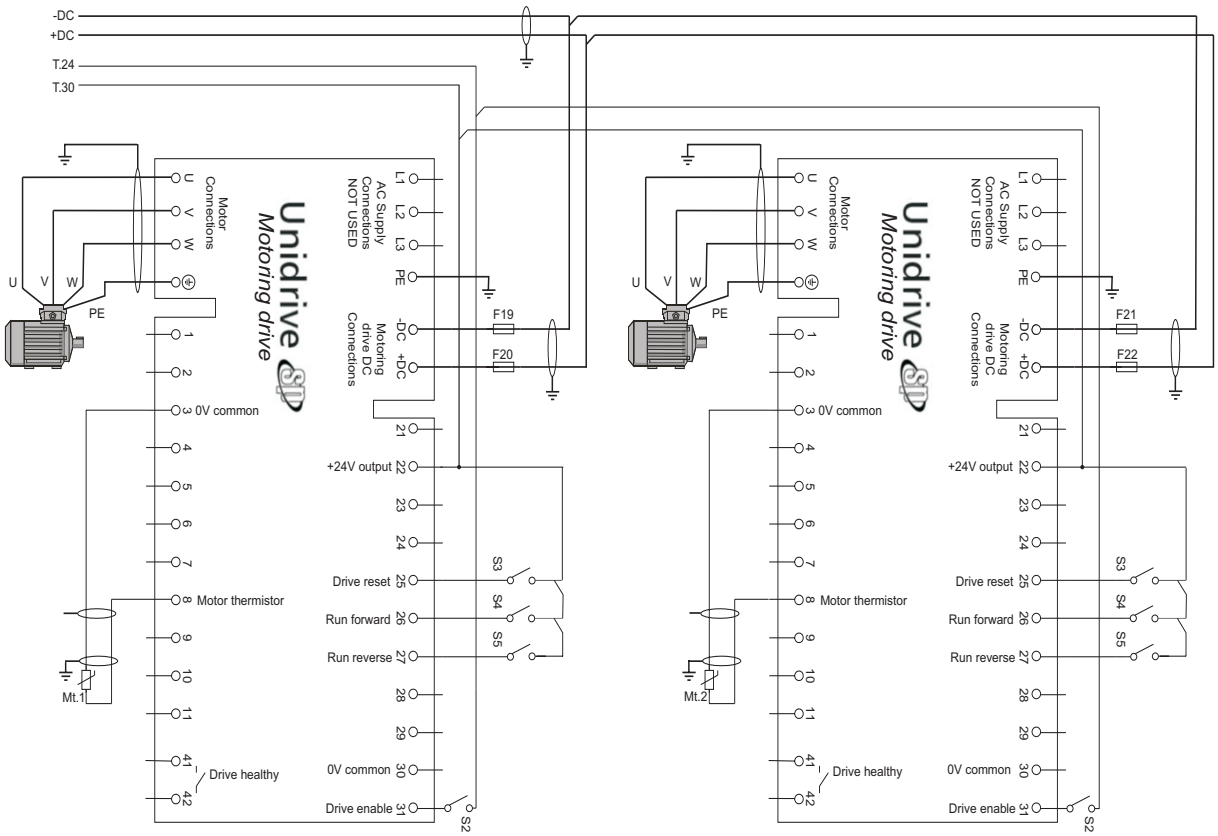


Table 4-4 Key to Figure 4-4

Key	Description
L1, L2, L3	Three phase supply
F1, F2, F3	Main regen system supply AC fuses
F4, F5, F6	Regen drive 1 AC fuses
F7, F8, F9	Regen drive 2 AC fuses
F10, F11, F12	SPMC AC fusing
F13, F14	DC Bus fusing to SPMC
F15, F16, F17, F18	DC Bus fusing to regen drives
F19, F20, F21, F22	DC Bus fusing to motoring drive
VDR1, 2, 3	Varistor network line-to-line
VDR4, 5, 6	Varistor network line-to-ground
RFI	Optional RFI filter
L1	Switching frequency filter inductor
L2	Regen inductor (regen 1)
L3	Regen inductor (regen 2)
C1	Switching frequency filter capacitor (regen 1)
C2	Switching frequency filter capacitor (regen 2)
K1	Main supply contactor
K2	Regen drive 1 main contactor
K3	Charging contactor
K4	Regen drive 2 main contactor
OPD1	Overload protection device for C1
OPD2	Overload protection device for C2

Key	Description
Aux.1	OPD1 NO auxiliary contact
Aux.2	OPD2 NO auxiliary contact
Aux.2a	K2 NO auxiliary contact regen 1
Aux.2b	K2 NC auxiliary contact regen 1
Aux.2c	K2 NC auxiliary contact regen 1
Aux.3	K3 NC auxiliary contact
Aux.4a	K4 NO auxiliary contact regen 2
Aux.4b	K4 NC auxiliary contact regen 2
Aux.4c	K4 NC auxiliary contact regen 2
Rly.1	Optional isolation for enable between Regen and motoring drive(s)
Mt.1	Motor thermistor 1
Mt.2	Motor thermistor 2
Tc.1	Regen inductor thermistor
Tc.2	Regen inductor thermistor
+DC, -DC	Motoring drive power connection to Regen drive
S1	Regen drive enable
S2	Motoring drive enable
S3	Motoring drive reset
S4	Motoring drive run forward
S5	Motoring drive run reverse
S6	Regen drive reset (user programmed)
Vsupply	System control supply

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

VDR4, VDR5 and VDR6 when operating with a 690Vac supply should consist of two varistors each in series as detailed in Table 3-24 on page 28.

4.2.5 Regen and motoring drive ratings

NOTE

The Regen drive's current limits are detailed in section 3.3 *Ratings* on page 13.

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 = 10kW, 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:

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

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.

4.3 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:

$$\frac{I_{Drive}}{I_{SC}} < \frac{1}{140}$$

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:

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

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 41.

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

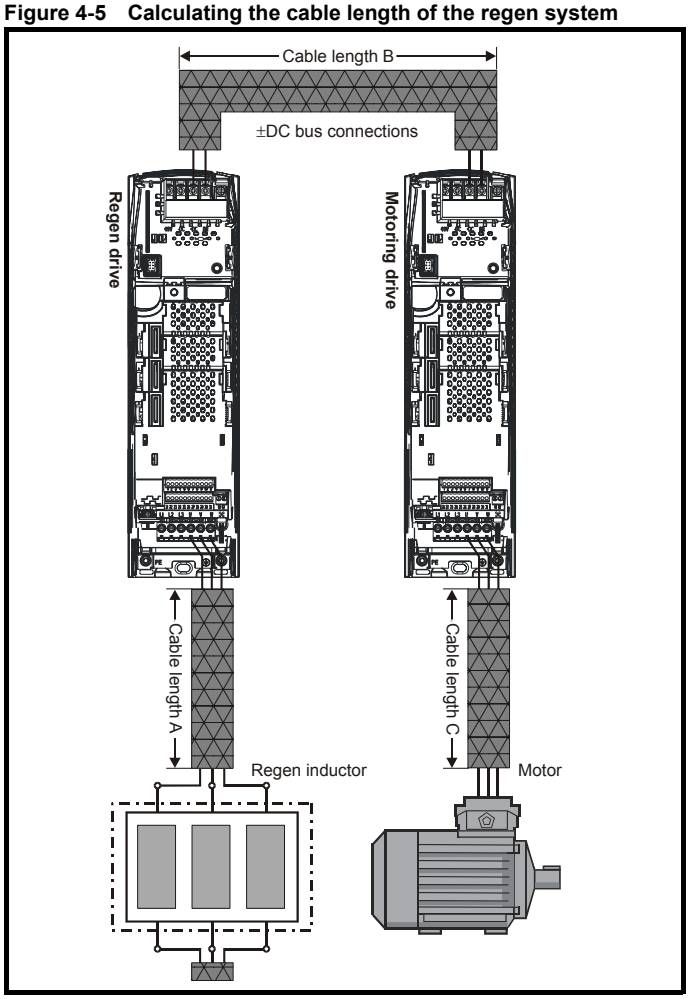
B is the length of the DC bus connection between the Regen and motoring drive, the + DC bus connections between the drives should be treated as a single two core cable and not two individual cable / bus bar lengths.

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 4-5 200V Regen system maximum cable lengths

Model	200V Nominal AC supply voltage					
	Maximum permissible cable length					
	3kHz	4kHz	6kHz	8kHz	12kHz	16kHz
SP1201	65m (210ft)				50m (165ft)	37m (120ft)
SP1202	100m (330ft)			75m (245ft)		
SP1203	130m (425ft)		100m (330ft)			
SP1204	200m (660ft)	150m (490ft)				
SP2201						
SP2202						
SP2203						
SP3201						
SP3202						
SP4201	65m (210ft)	65m (210ft)	65m (210ft)	65m (210ft)		
SP4202						
SP4203						
SP5201	250m (820ft)	185m (607ft)	125m (410ft)	90m (295ft)		
SP5202						
SPMD1201	250m (820ft)	185m (607ft)	125m (410ft)			
SPMD1202						
SPMD1203						
SPMD1204						

Table 4-6 400V Regen system maximum cable lengths

Model	400V Nominal AC supply voltage					
	Maximum permissible cable length					
	3kHz	4kHz	6kHz	8kHz	12kHz	16kHz
SP1405	200m (660ft)	150m (490ft)	100m (330ft)	75m (245ft)	50m (165ft)	37m (120ft)
SP1406						
SP2401						
SP2402						
SP2403						
SP2404						
SP3401						
SP3402						
SP3403						
SP4401	250m (820ft)	185m (607ft)	125m (410ft)	90m (295ft)		
SP4402						
SP4403						
SP5401						
SP5402						
SP6401						
SP6402						
SPMA1401						
SPMA1402						
SPMD1401						
SPMD1402						
SPMD1403						
SPMD1404						

Table 4-7 575V Regen system maximum cable length

Model	575V Nominal AC supply voltage					
	Maximum permissible cable length					
	3kHz	4kHz	6kHz	8kHz	12kHz	16kHz
SP3501	200m (660ft)	150m (490ft)	100m (330ft)	75m (245ft)		
SP3502						
SP3503						
SP3504						
SP3505						
SP3506						
SP3507						

Table 4-8 690V Regen system maximum cable length

Model	690V Nominal AC supply voltage					
	Maximum permissible cable length					
	3kHz	4kHz	6kHz	8kHz	12kHz	16kHz
SP4601	200m (660ft)	185m (607ft)	125m (410ft)	90m (295ft)		
SP4602						
SP4603						
SP4604						
SP4605						
SP4606						
SP5601						
SP5602						
SP6601						
SP6602						
SPMA1601						
SPMA1602						
SPMD1601						
SPMD1602						
SPMD1603						
SPMD1604						

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

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

- AC supply to external EMC filter (when used)
- AC supply (or external EMC filter) to Regen drive
- Regen drive to motoring drive (or busbar arrangement could be used)
- Motoring drive to motor

4.6 Exceeding maximum cable length

If the 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

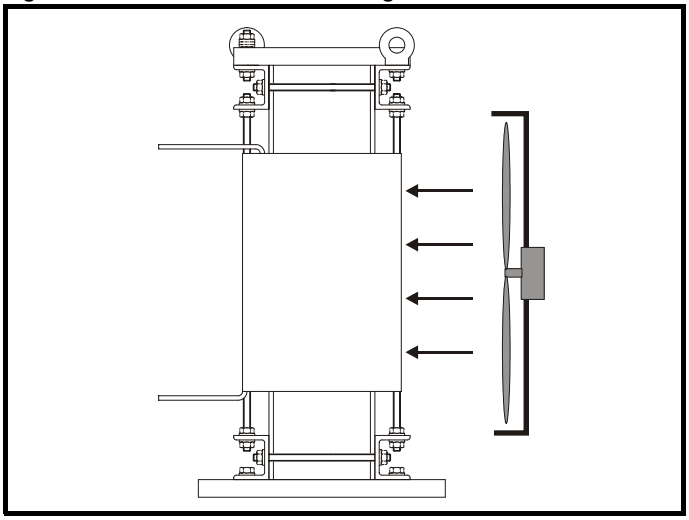


Table 4-9 200V Regen system exceeding maximum cable lengths

Model	200V Nominal AC supply voltage						
	Maximum permissible cable length with forced cooling						
	3kHz	4kHz	6kHz	8kHz	12kHz	16kHz	Forced cooling required
SP1201	65m (210ft)						
SP1202	100m (330ft)						
SP1203	130m (425ft)						
SP1204	200m (660ft)	150m (490ft)	100m (330ft)	75m (245ft)	50m (165ft)	37m (120ft)	Air flow ≥ 160m^3 / hr
SP2201							
SP2202							
SP2203							
SP3201							
SP3202							
SP4201	65m (210ft)	65m (210ft)	65m (210ft)	65m (210ft)			
SP4202							
SP4203							
SP5201	250m (820ft)	185m (607ft)	125m (410ft)	90m (295ft)			
SP5202							
SPMD1201	250m (820ft)	185m (607ft)	125m (410ft)				
SPMD1202							
SPMD1203							
SPMD1204							

Table 4-10 400V Regen system maximum cable lengths

Model	400V Nominal AC supply voltage						
	Maximum permissible cable length with forced cooling						
	3kHz	4kHz	6kHz	8kHz	12kHz	16kHz	Forced cooling requirements
SP1405	200m (660ft)	150m (490ft)	100m (330ft)	75m (245ft)	50m (165ft)	37m (120ft)	Air flow ≥160m³ / hr
SP1406							
SP2401							
SP2402							
SP2403							
SP2404							
SP3401							
SP3402							
SP3403							
SP4401	250m (820ft)	185m (607ft)	125m (410ft)	90m (295ft)			
SP4402							
SP4403							
SP5401							
SP5402							
SP6401							
SP6402							
SPMA1401							
SPMA1402							
SPMD1401							
SPMD1402							
SPMD1403							
SPMD1404							

Table 4-11 575V Regen system maximum cable length

Model	575V Nominal AC supply voltage						
	Maximum permissible cable length with forced cooling						
	3kHz	4kHz	6kHz	8kHz	12kHz	16kHz	Forced cooling requirements
SP3501	200m (660ft)	150m (490ft)	100m (330ft)	75m (245ft)			Air flow ≥ 160m³ / hr
SP3502							
SP3503							
SP3504							
SP3505							
SP3506							
SP3507							

Table 4-12 690V Regen system maximum cable length

Model	690V Nominal AC supply voltage						
	Maximum permissible cable length with forced cooling						
	3kHz	4kHz	6kHz	8kHz	12kHz	16kHz	Forced cooling requirements
SP4601	200m (660ft)	185m (607ft)	125m (410ft)	90m (295ft)			Air flow ≥ 160m³ / hr
SP4602							
SP4603							
SP4604							
SP4605							
SP4606							
SP5601							
SP5602							
SP6601							
SP6602							
SPMA1601							
SPMA1602							
SPMD1601							
SPMD1602							
SPMD1603							
SPMD1604							

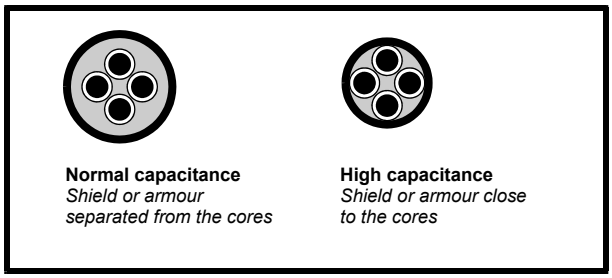
Cable lengths in excess of the above specified values may be used only when special techniques are adopted; refer to the supplier of the drive.

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



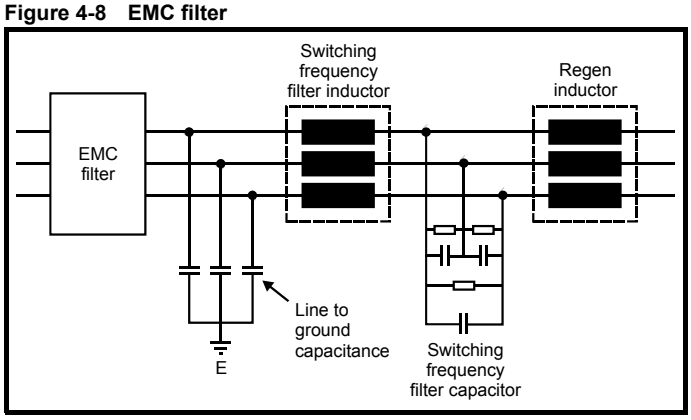
The cable used is shielded and contains four cores. Typical capacitance for this type of cable is 130pF/m (i.e. from one core to all others and the shield connected together).

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 41.

Figure 4-8 EMC filter



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 77.

CAUTION

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

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 level of 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 (x type) 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:

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

Where:

k is 1 for simple rectifier-input systems, √2 for regen systems

V_{DC} is DC bus voltage

$\Sigma l f_s$ 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

l 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:

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

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:

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

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

$$I_{RMS} = 13.4A$$

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

WARNING

Ground leakage current

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

WARNING

Discharge time

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

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

Refer to the *Mechanical Installation sections* in both the *Unidrive SP and Unidrive SPM User Guides* for drive mechanical information.

5.1 Safety information



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



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 and Unidrive SPM User Guides*.

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 5.5.2 *Enclosure sizing* on page 62.

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 65*.

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 77.

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.



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.



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

CAUTION

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

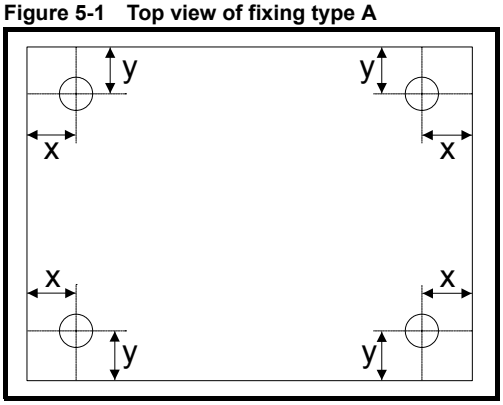


Table 5-1 200V Regen inductor specifications

Inductor part number	Amps	mH	Losses W	L mm	D mm	H mm	Weight kg	Fixing centres (x * y) mm	Fixing mm	Fixing type
4401-0310	9.6	3.5	71	215	180	200	10	120 x 140	9	A
4401-0311	11.0	2.7	72	215	180	200	11	120 x 140	9	
4401-0312	15.5	2.2	116	215	180	200	12	120 x 140	9	
4401-0313	22	1.6	157	215	180	200	15	120 x 140	9	
4401-0314	31	1.10	193	270	180	240	17	160 x 140	9	
4401-0315	42	0.81	200	270	200	240	24	160 x 160	9	
4401-0316	56	0.6	264	325	220	320	32	200 x 180	11	
4401-0317	68	0.5	299	325	220	320	33	200 x 180	11	
4401-0318	80	0.4	298	325	220	320	39	200 x 180	11	
4401-0319	105	0.32	338	370	260	360	55	240 x 220	11	
4401-0320	130	0.26	394	375	280	360	65	240 x 240	11	
4401-0321	156	0.22	475	395	280	360	77	240 x 240	11	
4401-0322	192	0.18	526	395	280	360	97	240 x 240	11	
4401-0323	250	0.14	610	430	300	410	110	280 x 260	11	
4401-0324	312	0.11	776	430	300	410	120	280 x 260	11	
4401-0325	350	0.10	863	490	320	480	130	320 x 260	11	

Table 5-2 400V Regen inductor specifications

Inductor part number	Amps	mH	Losses W	L mm	D mm	H mm	Weight kg	Fixing centres (x * y) mm	Fixing mm	Fixing type
4401-0001	9.5	6.32	125.0	200	180	215	12	120 x 140	9	A
4401-0002	12	5.00	146.0	200	180	215	14	120 x 140	9	
4401-0003	16	3.75	175.0	240	180	270	17	160 x 140	9	
4401-0004	25	2.40	210.0	240	180	270	24	160 x 160	9	
4401-0005	34	1.76	285.0	320	220	325	32	200 x 180	11	
4401-0006	40	1.50	310.0	320	220	325	33	200 x 180	11	
4401-0007	46	1.30	320.0	320	220	325	39	200 x 180	11	
4401-0008	60	1.00	345.0	360	260	370	55	240 x 220	11	
4401-0009	70	0.78	415.0	360	260	370	65	240 x 240	11	
4401-0010	96	0.63	515.0	360	260	370	75	240 x 240	11	
4401-0011	124	0.48	585.0	360	260	370	95	240 x 240	11	
4401-0012	156	0.38	645.0	410	300	430	110	280 x 260	11	
4401-0013	180	0.33	775.0	410	300	430	120	280 x 260	11	
4401-0014	200	0.30	845.0	480	320	490	130	320 x 260	11	
4401-0015	300	0.20	1760.0	480	320	490	140	320 x 240	11	
4401-0205-00	350	0.16	2169.0	500	320	570	165	320 x 260	11	

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

Inductor part number	Amps	mH	Losses W	L mm	D mm	H mm	Weight kg	Fixing centres (x * y) mm	Fixing mm	Fixing type
4401-0210	19	5.3	268	325	220	320	32	200 x 180	11	
4401-0211	22	4.6	288	325	220	320	33	200 x 180	11	
4401-0212	27	3.8	322	325	220	320	39	200 x 180	11	
4401-0213	36	2.8	348	370	260	360	55	240 x 220	11	
4401-0214	43	2.4	398	375	280	360	65	240 x 240	11	
4401-0215	52	1.9	456	395	280	360	77	240 x 240	11	
4401-0216	63	1.6	503	395	280	360	97	240 x 240	11	A
4401-0217	85	1.20	605	430	300	410	110	280 x 260	11	
4401-0218	100	1.00	950	500	350	480	170	320 x 260	11	
4401-0219	125	0.80	880	490	320	480	130	320 x 260	11	
4401-0220	144	0.70	1022	500	320	480	140	320 x 260	11	
4401-0221	168	0.60	1656	555	300	480	165	320 x 240	11	
4401-0222	192	0.53	1350	600	350	480	180	320 x 260	11	

Figure 5-2 Regen inductor type 1 dimensions

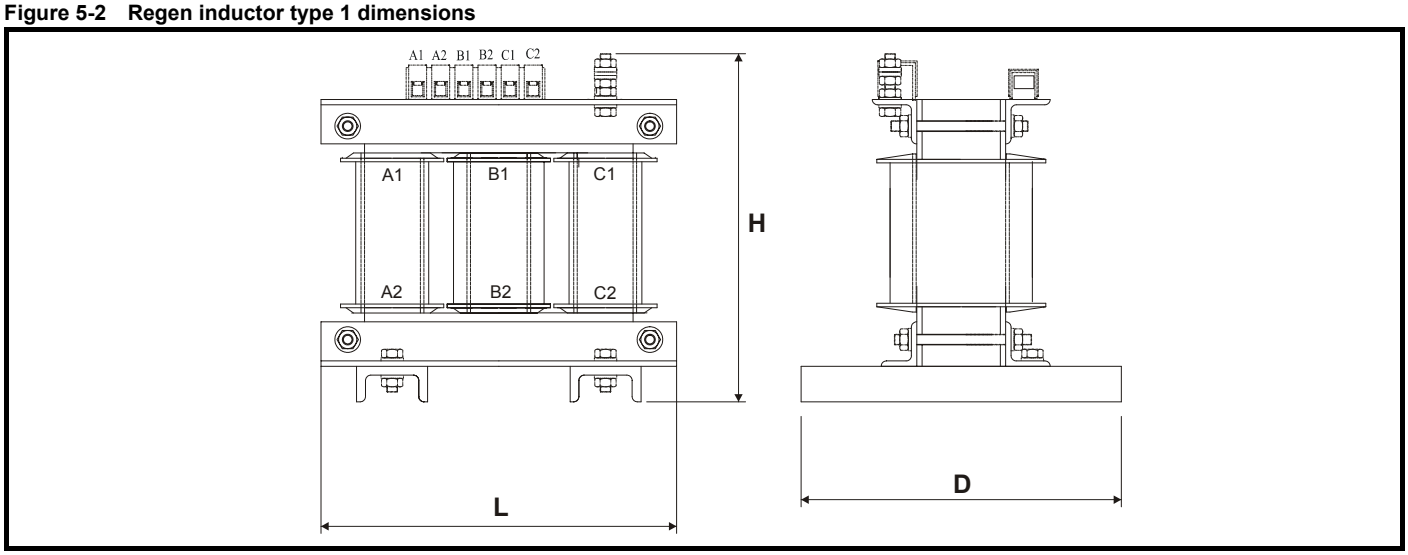


Figure 5-3 Regen inductor type 2 dimensions

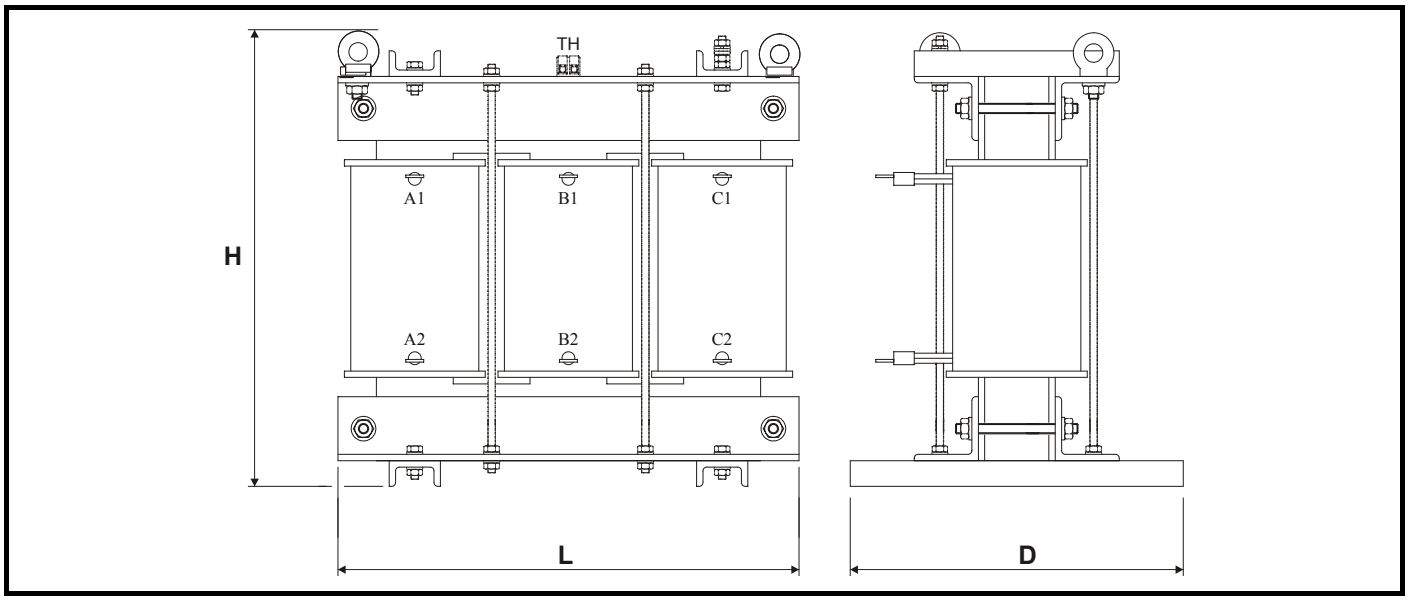
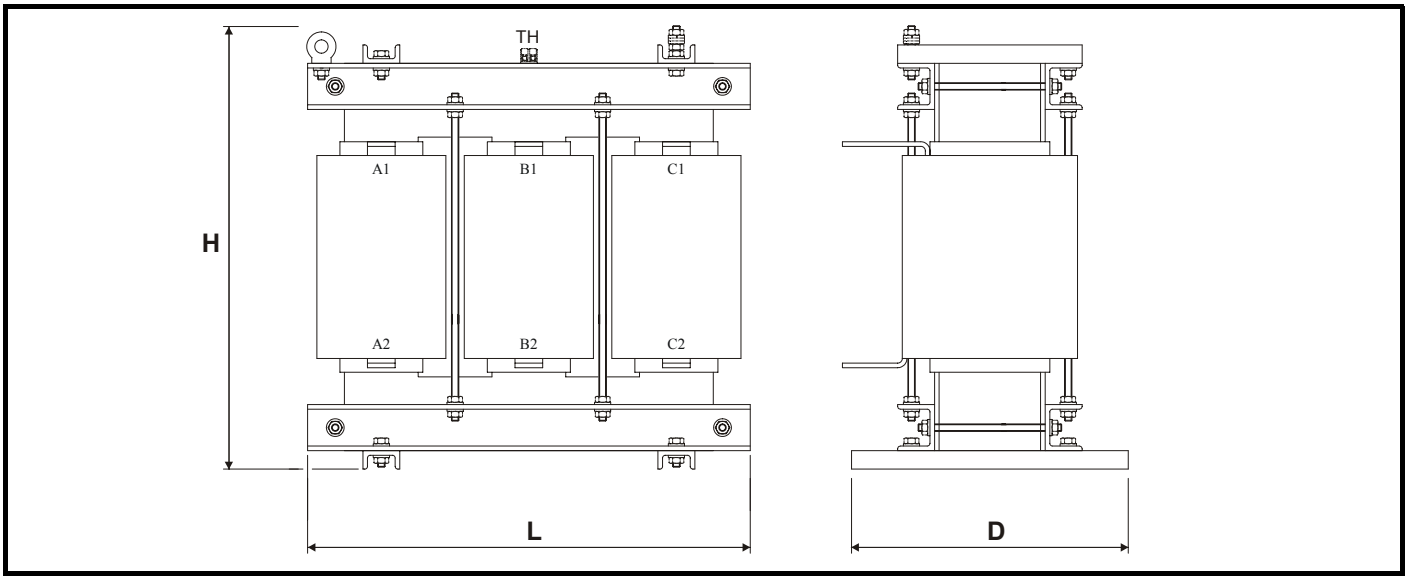


Figure 5-4 Regen inductor type 3 dimensions



5.3.2 Switching frequency filter inductor

Table 5-4 200V SFF inductor specifications

Inductor part number	Amps	mH	Losses W	L mm	D mm	H mm	Weight kg	Fixing centres (x * y) mm	Fixing mm	Fixing type
4401-1310	9.6	0.88	10	150	90	150	4	120 x 47	8 x 18	B
4401-1311	11.0	1.50	18	150	90	150	4	120 x 47	8 x 18	
4401-1312	15.5	1.10	26	150	90	150	4	120 x 47	8 x 18	
4401-1313	22	0.70	33	150	90	150	4	120 x 47	8 x 18	
4401-1314	31	0.50	37	190	100	180	6	130 x 54	8 x 20	
4401-1315	42	0.40	38	190	120	180	10	130 x 74	8 x 20	
4401-1316	56	0.30	48	190	160	180	12	130 x 184	8 x 20	
4401-1317	68	0.25	58	190	160	180	12	130 x 184	8 x 20	
4401-1318	80	0.20	60	190	160	180	13	130 x 184	8 x 20	
4401-1319	105	0.16	78	255	160	240	16	200 x 180	10 x 20	
4401-1320	130	0.13	86	255	170	240	20	200 x 90	10 x 20	
4401-1321	156	0.11	92	255	180	240	22	200 x 100	10 x 20	
4401-1322	192	0.088	97	255	190	240	25	200 x 100	10 x 20	
4401-1323	250	0.068	119	300	180	300	37	204 x 113	10 x 20	
4401-1324	312	0.055	170	300	180	300	37	204 x 113	10 x 20	
4401-1325	350	0.048	162	300	190	300	49	204 x 123	10 x 20	

Table 5-5 400V SFF inductor specifications

Inductor part number	Amps	mH	Losses W	L mm	D mm	H mm	Weight kg	Fixing centres (x * y) mm	Fixing mm	Fixing type
4401-0162	9.5	3.160	28	150	90	150	4	120 x 47	8 x 18	B
4401-0163	12	2.500	35	150	90	150	4	120 x 47	8 x 18	
4401-0164	16	1.875	37	180	100	190	6	120 x 54	8 x 20	
4401-0165	25	1.200	40	180	150	190	10	120 x 74	8 x 20	
4401-0166	34	0.880	52	180	160	190	12	120 x 84	8 x 20	
4401-0167	40	0.750	60	180	160	190	12	120 x 84	8 x 20	
4401-0168	46	0.650	60	180	160	190	13	120 x 84	8 x 20	
4401-0169	60	0.500	80	240	160	255	16	200 x 80	10 x 20	
4401-0170	70	0.390	90	240	170	255	20	200 x 90	10 x 20	
4401-0171	96	0.315	100	240	180	255	22	200 x 100	10 x 20	
4401-0172	124	0.240	110	240	190	255	25	200 x 100	10 x 20	
4401-0173	156	0.190	130	300	180	300	37	204 x 113	10 x 20	
4401-0174	180	0.165	170	300	180	300	37	204 x 113	10 x 20	
4401-0175	220	0.135	180	300	190	300	49	204 x 123	10 x 20	
4401-0176	300	0.100	220	300	200	300	50	204 x 130	10 x 20	
4401-1205	350	0.08	300	325	220	325	55	204 x 160	4 x 10	
4401-0176	600	0.050	400	410	300	430	110	280 x 260	11	A
4401-0176	900	0.034	530	480	320	500	140	320 x 240	11	
4401-0176	1200	0.025	700	480	320	560	170	320 x 240	11	

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

Inductor part number	Amps	mH	Losses W	L mm	D mm	H mm	Weight kg	Fixing centres (x * y) mm	Fixing mm	Fixing type
4401-1211	22	1.40	36	190	120	180	10	130 x 74	8 x 20	B
4401-1213	36	1.40	81	255	160	240	16	200 x 80	10 x 20	
4401-1214	43	1.20	86	255	170	240	20	200 x 90	10 x 20	
4401-1215	52	1.00	93	255	180	240	22	200 x 100	10 x 20	
4401-1216	63	0.80	95	255	190	240	25	200 x 100	10 x 20	
4401-1217	85	0.60	122	300	180	300	37	204 x 113	10 x 20	
4401-1218	100	0.50	190	300	180	300	37	204 x 120	4 x 10	
4401-1219	125	0.40	172	300	190	300	49	204 x 123	10 x 20	
4401-1220	144	0.35	177	300	200	300	50	204 x 130	10 x 20	
4401-1221	168	0.30	207	300	200	300	50	204 x 130	10 x 20	
4401-1222	192	0.26	220	325	220	325	55	204 x 160	4 x 10	
4401-1223	192	0.21	189	300	200	300	50	204 x 130	10 x 20	

Figure 5-5 Top view of fixing type A

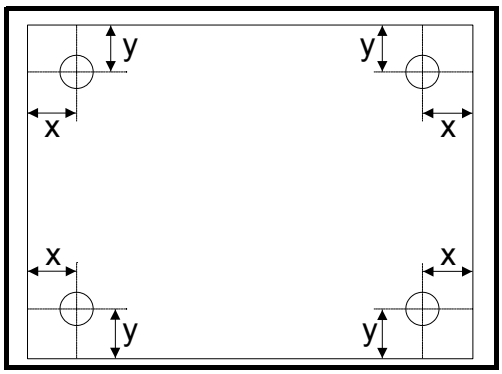


Figure 5-6 Top view of fixing type B

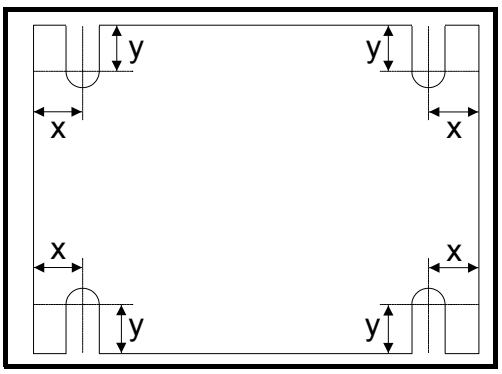


Figure 5-7 Switching frequency filter inductor type 1 dimensions

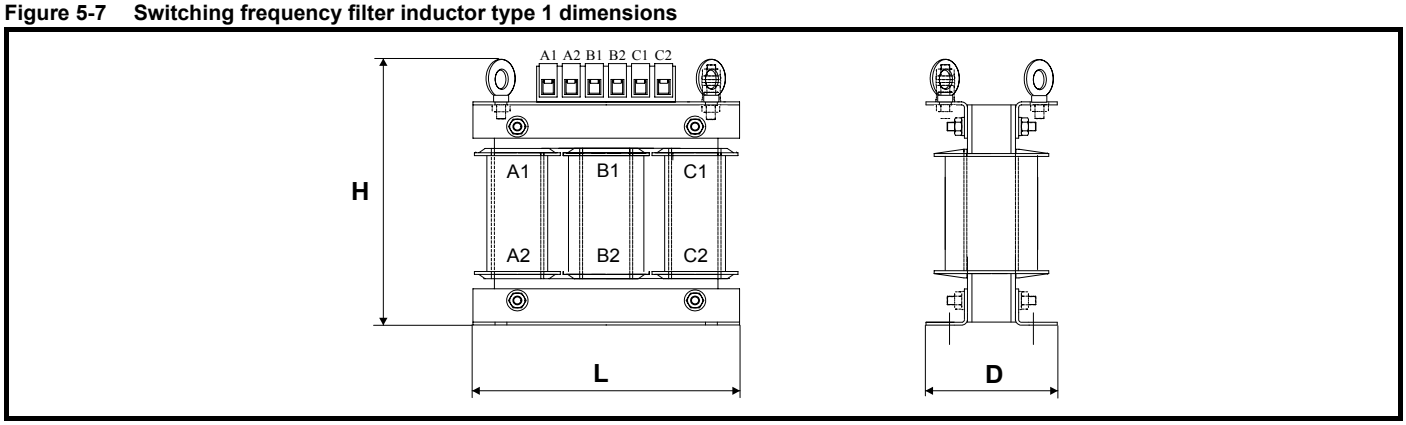


Figure 5-8 Switching frequency filter inductor type 2 dimensions

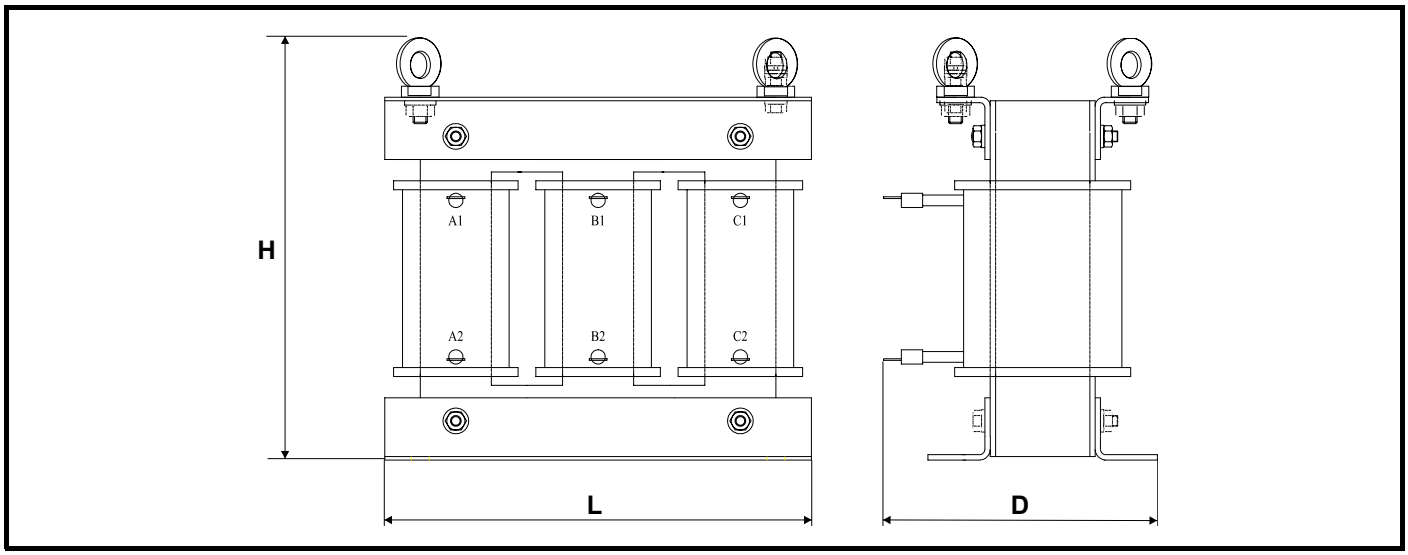


Figure 5-9 Switching frequency filter inductor type 3 dimensions

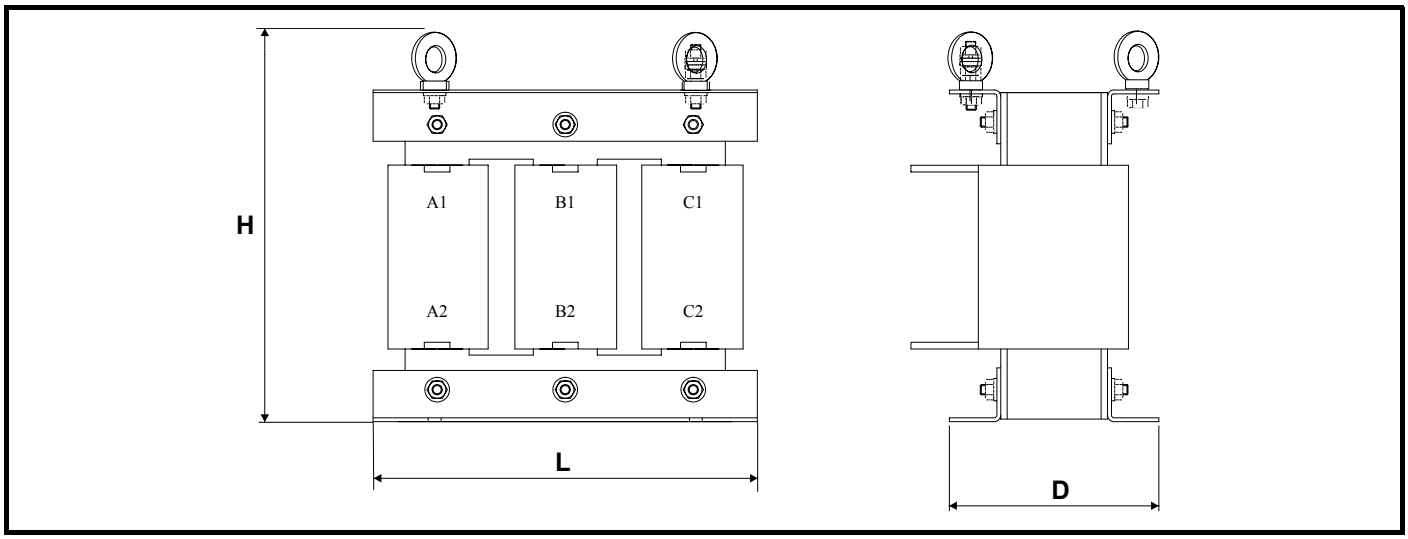
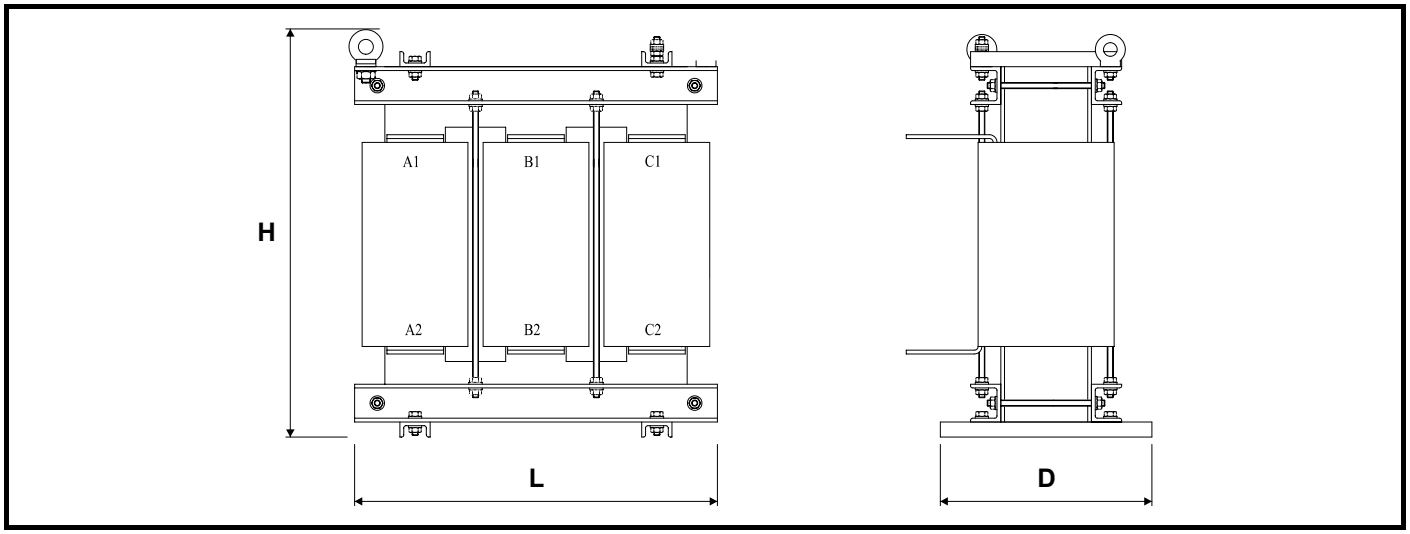


Figure 5-10 Switching frequency filter inductor type 4 dimensions

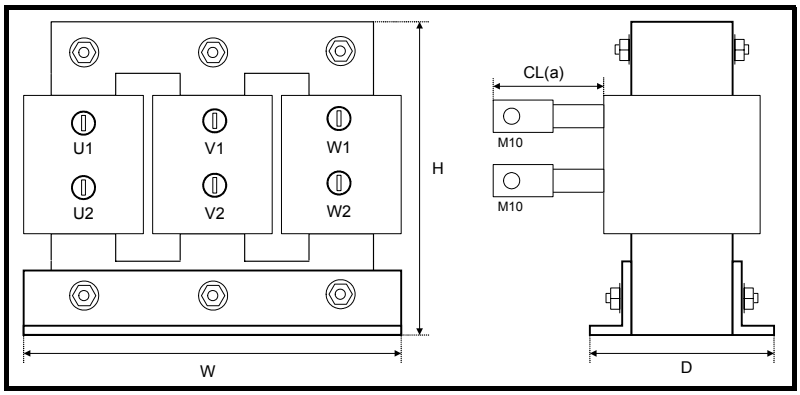


5.3.3 Output sharing choke (for motoring drives only)

Table 5-7 400 / 600V output sharing choke ratings

Model	Current A	Inductance μH	Width (W) mm	Depth (D) mm	Height (H) mm	Cable length (CLa) mm	Weight kg	Part No.
OTL401	221	40.1	240	220	210	71.5	20	4401-0197-00
OTL402	267	34	242	220	205		20	4401-0198-00
OTL403	313	28.5	242	220	205		25	4401-0199-00
OTL404	378	23.9	242	220	205		25	4401-0200-00
OTL601	135	103.9	242	170	203		20	4401-0201-00
OTL602	156	81.8	242	170	203		20	4401-0202-00
OTL603	181	70.1	242	200	203		20	4401-0203-00
OTL604	207	59.2	242	200	203		20	4401-0204-00

Figure 5-11 OTLx0x output sharing choke



Centre tapped output sharing chokes

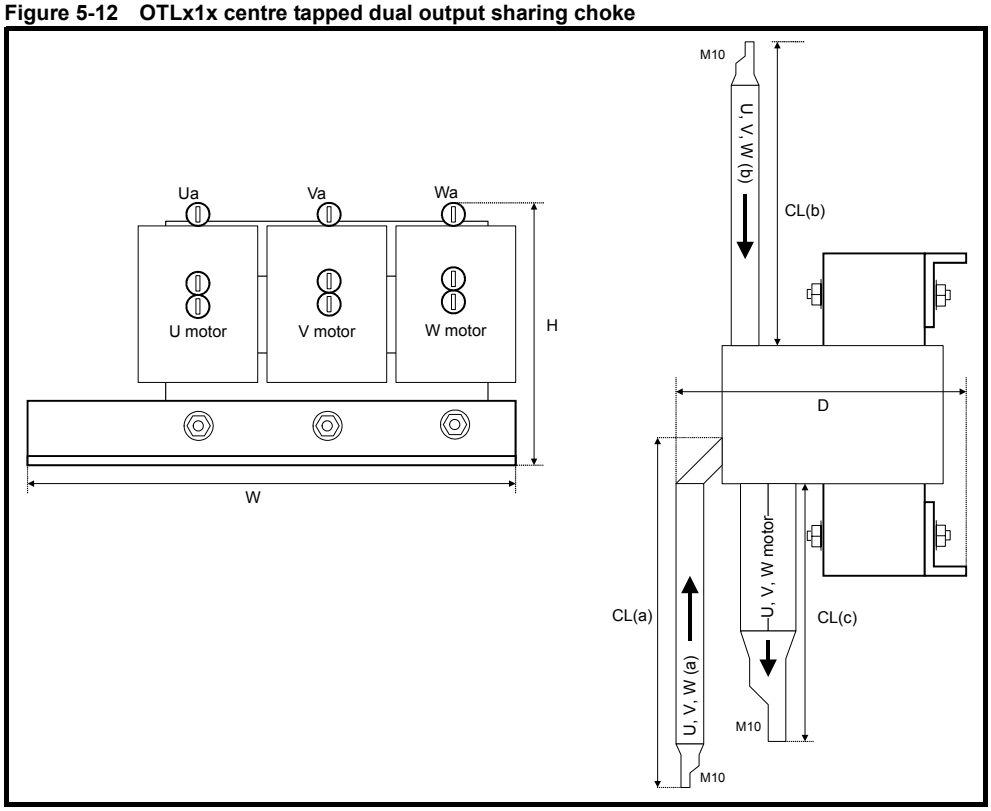
CAUTION

The OTLX1X centre tapped output sharing chokes can only be used when two Unidrive SPM drives are paralleled together. For all other combinations the OTLX0X output sharing choke must be used.

Table 5-8 400 / 600V centre tapped output sharing choke ratings

Model	Current A	Inductance μH	Width (W) mm	Depth (D) mm	Height (H) mm	Cable length mm			Weight kg	Part No.
						CLa	CLb	CLc		
OTL411	389.5	42.8	300	150	160	335	335	265	8	4401-0188-00
OTL412	470.3	36.7	300	150	160				8	4401-0189-00
OTL413	551	31.1	300	150	160				8	4401-0192-00
OTL414	665	26.6	300	150	160				9	4401-0186-00
OTL611	237.5	110.4	300	150	160				8	4401-0193-00
OTL612	273.6	88.4	300	150	160				8	4401-0194-00
OTL613	319.2	76.7	300	150	160				8	4401-0195-00
OTL614	364.8	65.7	300	150	160				8	4401-0196-00

Figure 5-12 OTLx1x centre tapped dual output sharing choke



5.3.4 Switching frequency filter capacitors

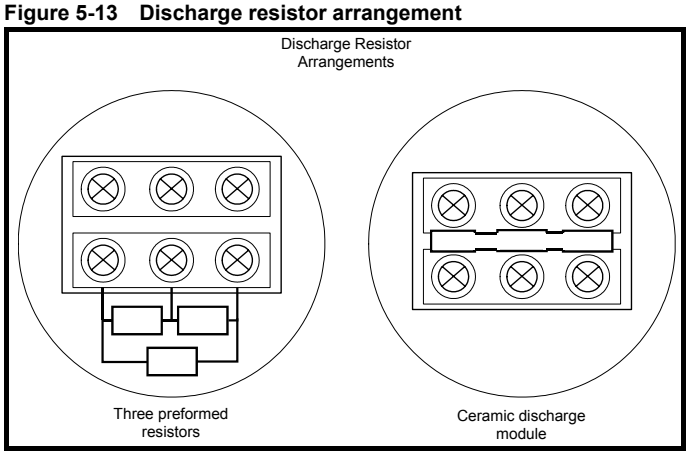
Table 5-9 Switching frequency filter capacitors

3-phase capacitor Pt No.	CN (uF)	∅ x L (mm)	Discharge resistor (kΩ)	Weight (kg)	Mounting	Max torque (Nm)	Type No
1664-1074	3 x 7.0	53 x 114	390	0.3	M8 Stud	4	PHIcap
1664-2174	3 x 16.6	63.5 x 129	390	0.4	M12 Stud	10	PHIcap
1610-7804	3 x 8.0	75 x 210	390	0.5	M12 Stud	15	Polecap
1668-7833	3 x 8.3	116.2 x 204	390	1.2	M12 Stud	10	Windcap
1666-8113	3 x 11.2	116.2 x 204	390	1.3	M12 Stud	10	Windcap
1668-8163	3 x 16.6	116.2 x 204	390	1.2	M12 Stud	10	Windcap
1666-8223	3 x 22.5	116.2 x 204	390	1.4	M12 Stud	10	Windcap
1665-8324	3 x 32	116.2 x 204	390	1.1	M12 Stud	10	Phasecap
1665-8394	3 x 39	116.2 x 204	390	1.2	M12 Stud	10	Phasecap
1665-8484	3 x 48	116.2 x 204	390	1.3	M12 Stud	10	Phasecap
1664-2644	3 x 64	116.2 x 204	390	1.2	M12 Stud	10	Phasecap
1665-8774	3 x 77	116.2 x 204	390	1.8	M12 Stud	10	Phasecap

Discharge resistors

PoleCap capacitors have a pre-mounted ceramic discharge module, all other capacitor types (Windcap, Phasecap or PHI capacitors) can have either three preformed discharge resistors or a pre-mounted ceramic discharge module supplied with capacitors.

Figure 5-13 Discharge resistor arrangement



Cautions and warnings

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

To ensure the full functionality of the overpressure disconnector, elastic elements must not be hindered and a minimum space of 5 cm has to be kept above each capacitor.

Protection should be provided to prevent over current and short circuit.

Discharging

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

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

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

Over current and short circuit protection

Use HRC fuses or MCCBs for short circuit protection. Short circuit protection and connecting cables should be selected so that 1.5 times the rated capacitor current can be permanently handled.

HRC fuses do not protect a capacitor against overload - they are only for short circuit protection.

The HRC fuse rating should be 1.6 to 1.8 times rated capacitor current.

Figure 5-14 3-phase PHIcap dimensions

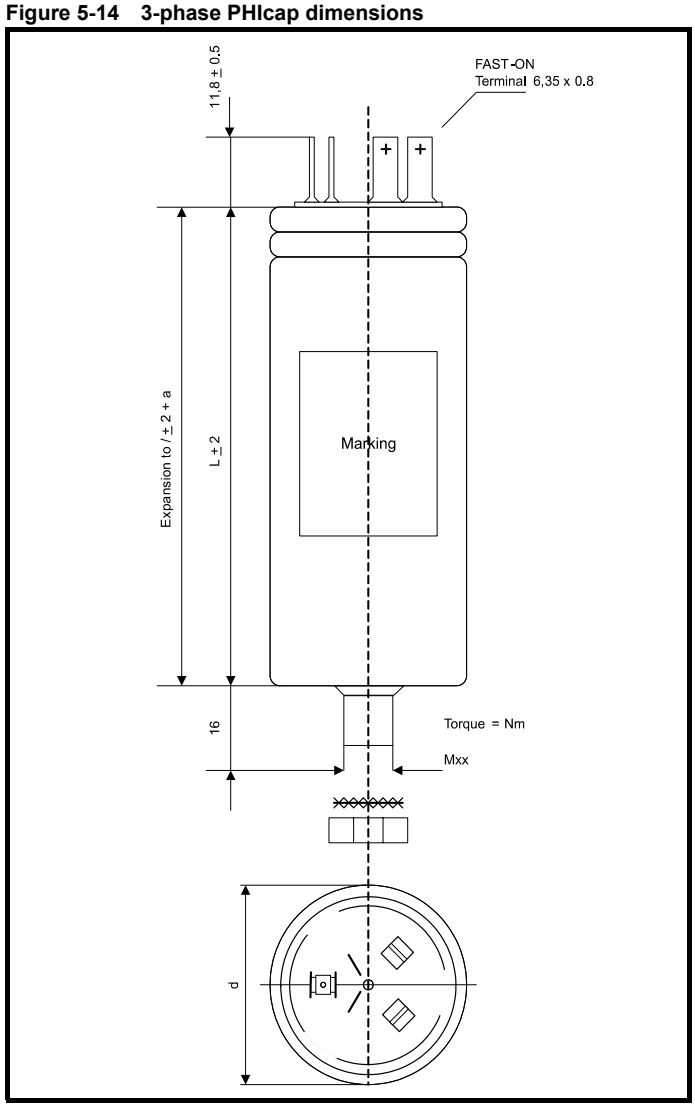


Figure 5-15 3-phase Polecap dimensions

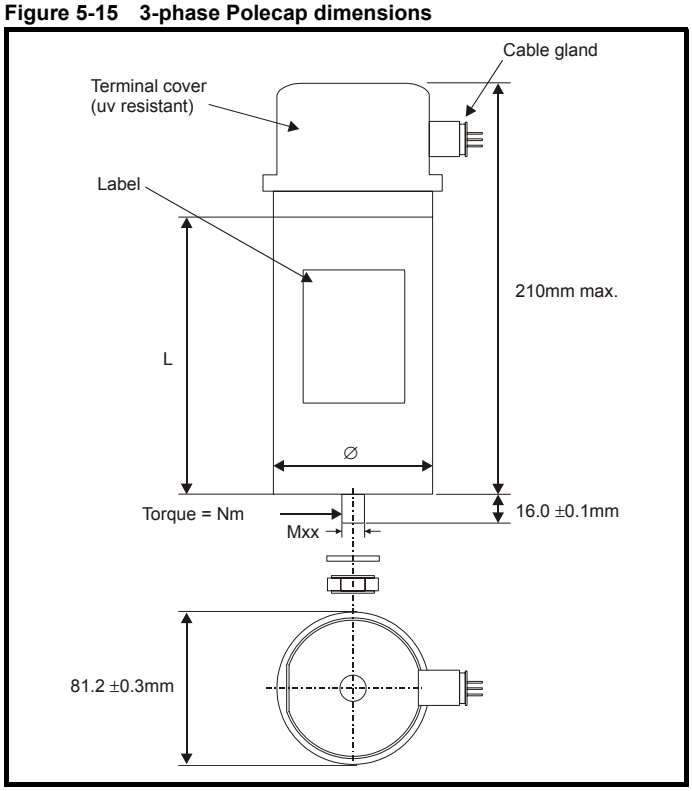
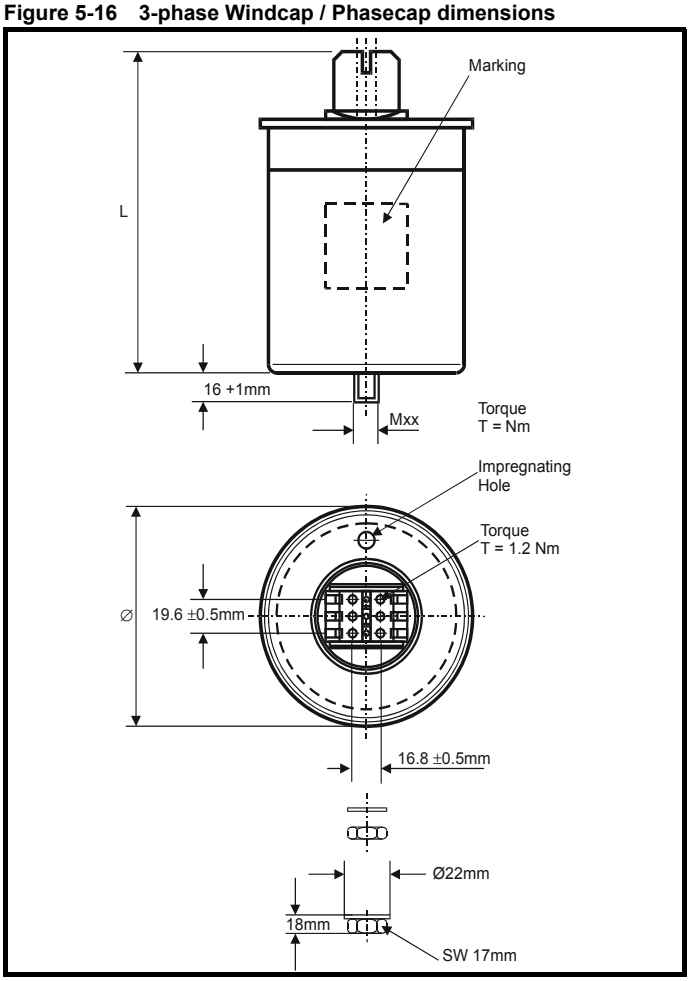


Figure 5-16 3-phase Windcap / Phasecap dimensions



5.4 External EMC filter

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

Table 5-10 Drive EMC filter details (size 1 to 6)

Drive	Schaffner		Epcos	
	CT part no.	Weight	CT part no.	Weight
SP1201 to SP1204	4200-6118	1.4 kg (3.1 lb)	4200-6121	2.1 kg (4.6 lb)
	4200-6119		4200-6120	
SP2201 to SP2203	4200-6210	2.0 kg (4.4 lb)	4200-6211	3.3 kg (7.3 lb)
SP3201 to SP3202	4200-6307	3.5 kg (7.7 lb)	4200-6306	5.1 kg (11.2 lb)
SP4201 to SP4203	4200-6406	4.0 kg (8.8 lb)	4200-6405	7.8 kg (17.2 lb)
SP5201 to SP5202	4200-6503	6.8 kg (15.0 lb)	4200-6501	12.0 kg (26.5 lb)
SP1401 to SP1404	4200-6118	1.4 kg (3.1 lb)	4200-6121	2.1 kg (4.6 lb)
SP1405 to SP1406	4200-6119		4200-6120	
SP2401 to SP2404	4200-6210	2.0 kg (4.4 lb)	4200-6211	3.3 kg (7.3 lb)
SP3401 to SP3403	4200-6305	3.5 kg (7.7 lb)	4200-6306	5.1 kg (11.2 lb)
SP4401 to SP4403	4200-6406	4.0 kg (8.8 lb)	4200-6405	7.8 kg (17.2 lb)
SP5401 to SP5402	4200-6503	6.8 kg (15.0 lb)	4200-6501	12.0 kg (26.5 lb)
SP6401 to SP6402	4200-6603	5.25 kg (11.6 lb)	4200-6601	10.0 kg (22.0 lb)
SP3501 to SP3507	4200-6309	3.5 kg (7.7 lb)	4200-6308	5.1 kg (11.2 lb)
SP4601 to SP4606	4200-6408	3.8 kg (8.4 lb)	4200-6407	8.0 kg (17.6 lb)
SP5601 to SP5602	4200-6504	4.4 kg (9.7 lb)	4200-6502	10.0 kg (22.0 lb)
SP6601 to SP6602	4200-6604	5.25 kg (11.6 lb)	4200-6602	8.6 kg (18.9 lb)

In order to provide our customers with a degree of flexibility, external EMC filters have been sourced from two manufacturers: Schaffner & Epcos.

Filter details for each drive rating are provided in the tables below. Both the Schaffner and Epcos filters meet the same specifications.

Table 5-11 Drive EMC filter details

Drive	Schaffner		Epcos	
	CT part no.	Weight	CT part no.	Weight
SPMD1201 to SPMD1204	4200-6315	5.5 kg (12.1 lb)	4200-6313	8.6 kg (18.9 lb)
SPMA1401 to SPMA1402	4200-6603	5.25 kg (11.6 lb)	4200-6601	10.0 kg (22.0 lb)
SPMD1401 to SPMD1404	4200-6315	5.5 kg (12.1 lb)	4200-6313	8.6 kg (18.9 lb)
SPMD1601 to SPMD1602	4200-6604	5.25 kg (11.6 lb)	4200-6602	8.6 kg (18.9 lb)
SPMD1601 to SPMD1604	4200-6316	5.5 kg (12.1 lb)	4200-6314	8.5 kg (18.7 lb)

The external EMC filters for sizes 1 to 3 can be footprint or bookcase mounted, see Figure 5-17 and Figure 5-18. The external EMC filters for sizes 4 to 6 are designed to be mounted above the drive, as shown in Figure 5-19.

Mount the external EMC filter following the guidelines in section 4.11.5 *Compliance with generic emission standards* on page 88.

Figure 5-17 Footprint mounting the EMC filter

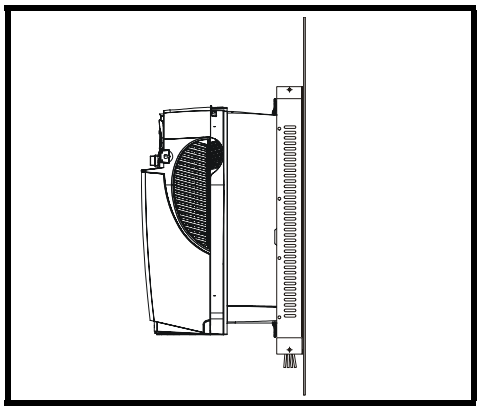


Figure 5-18 Bookcase mounting the EMC filter

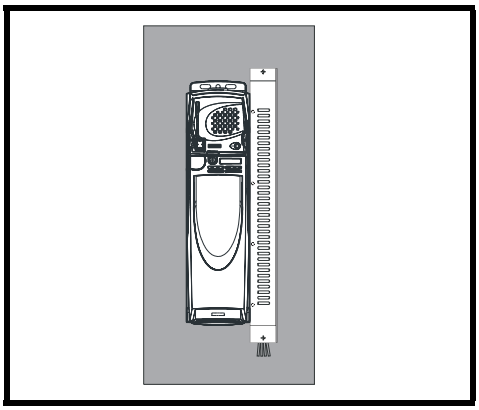


Figure 5-19 Size 4 to 6 mounting of EMC filter

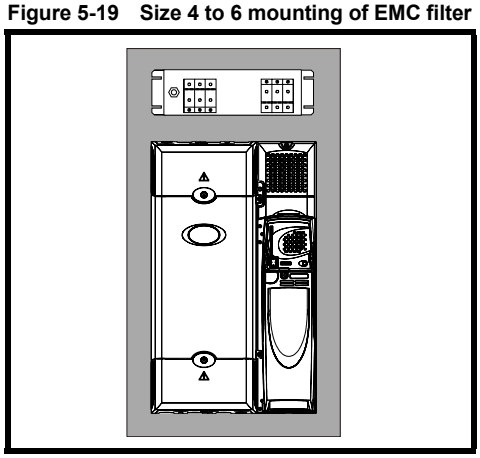
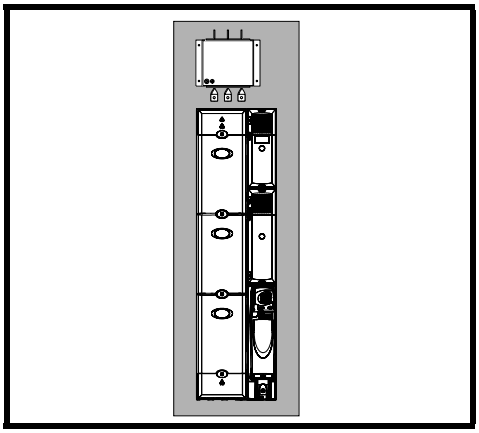
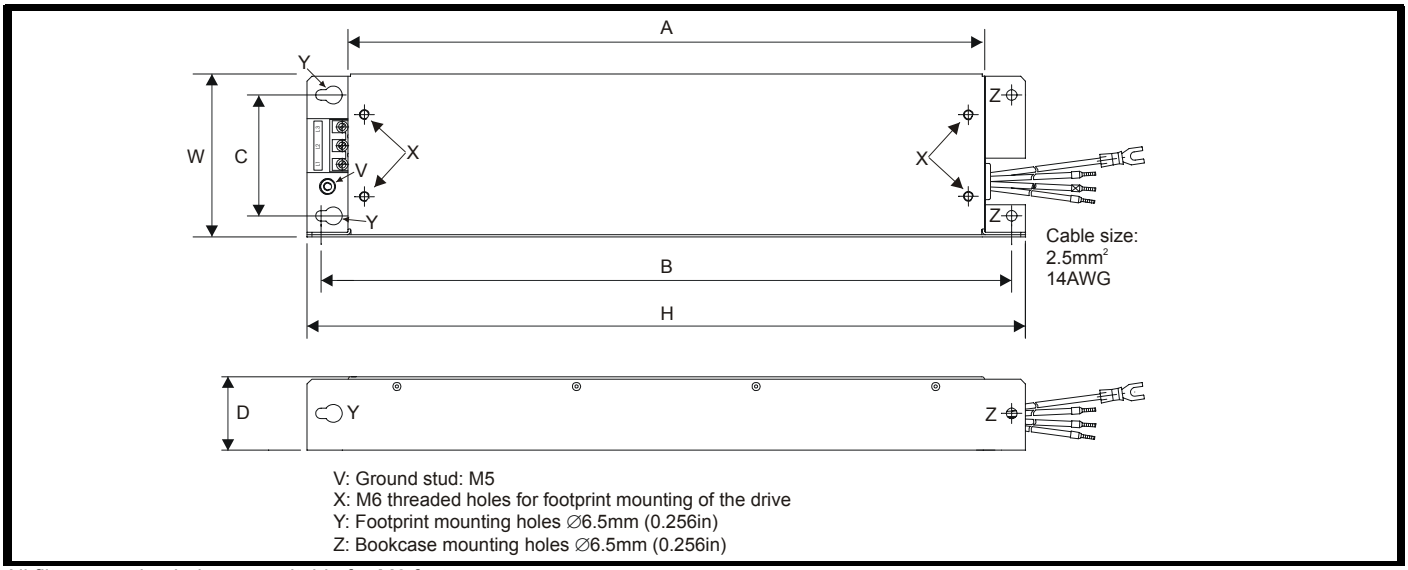


Figure 5-20 Mounting the external EMC filter



Mount the external EMC filter following the guidelines in section 6.12.5 *Compliance with generic emission standards* on page 62

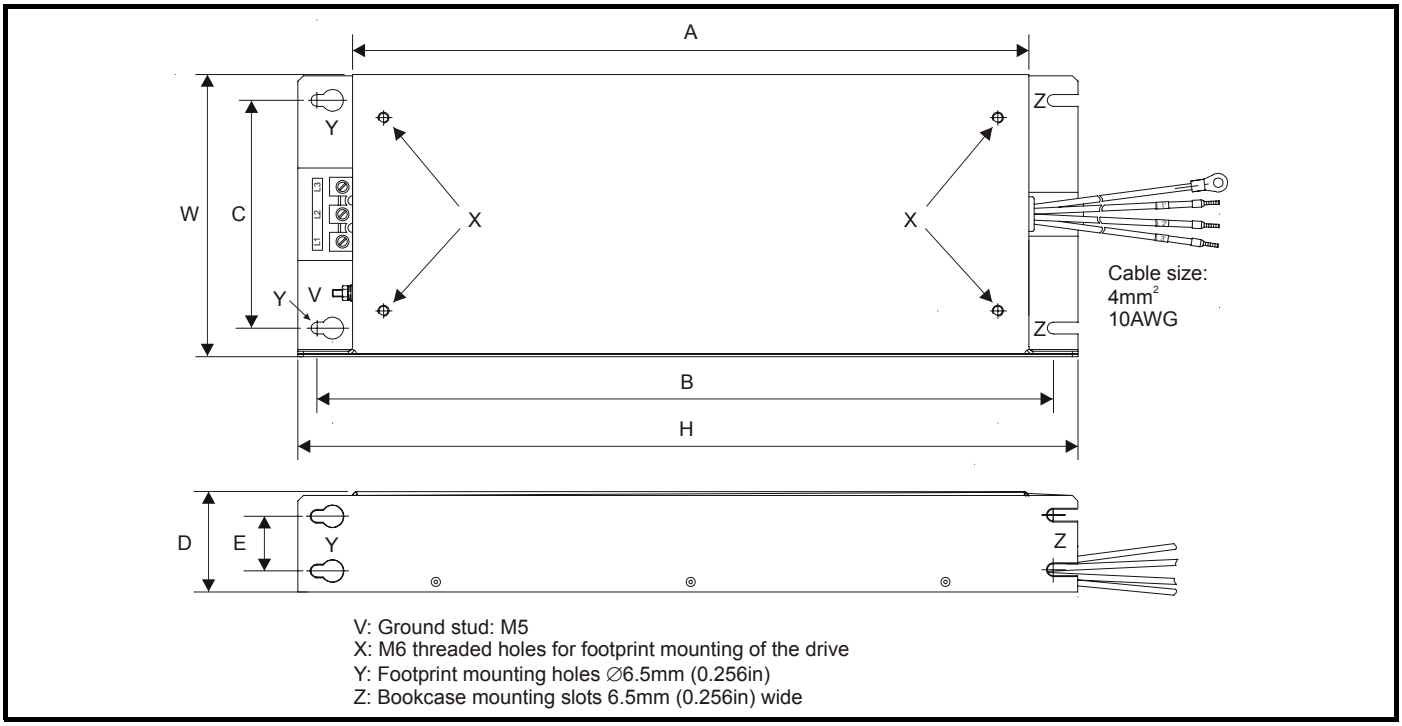
Figure 5-21 Size 1 external EMC filter



All filter mounting holes are suitable for M6 fasteners.

CT part no.	Manufacturer	A	B	C	D	H	W
4200-6118	Schaffner	390 mm (15.354 in)	423 mm (16.654 in)	74 mm (2.913 in)	45 mm (1.772 in)	440 mm (17.323 in)	100 mm (3.937 in)
4200-6119							
4200-6121	Epcos					450 mm (17.717 in)	
4200-6120							

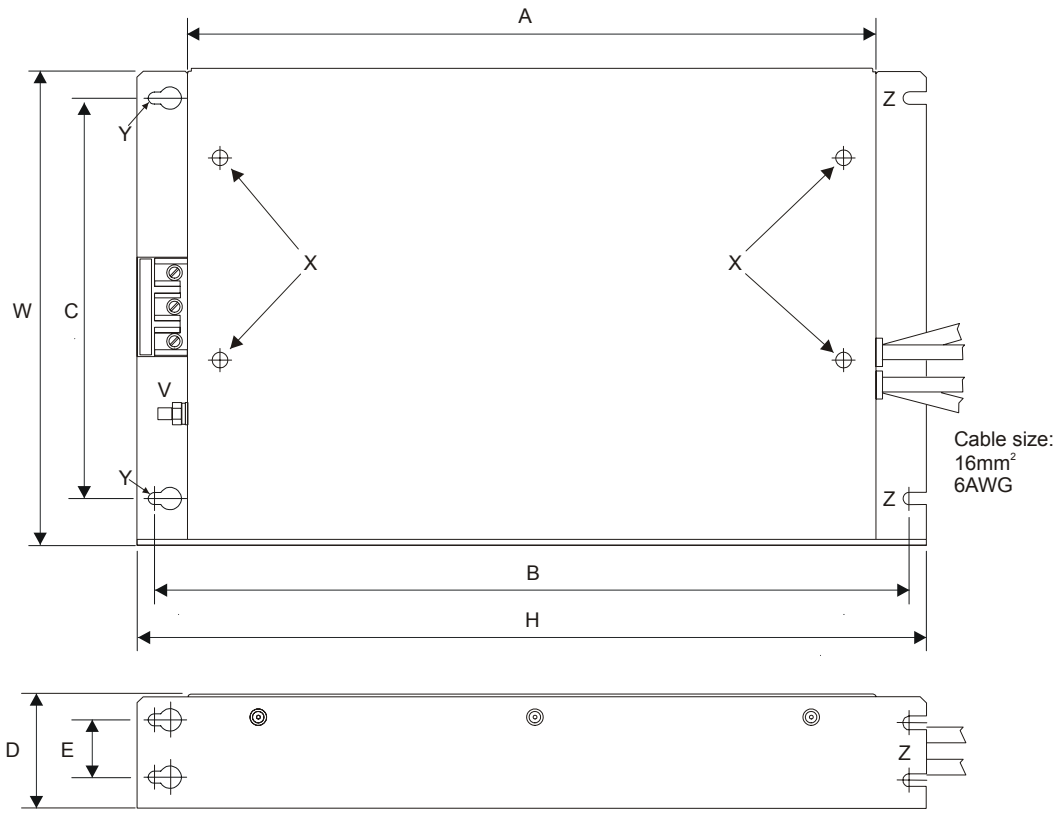
Figure 5-22 Size 2 external EMC filter



All filter mounting holes are suitable for M6 fasteners.

CT part no.	Manufacturer	A	B	C	D	E	H	W
4200-6210	Schaffner	371.5 mm (14.626 in)	404.5 mm (15.925 in)	125 mm (4.921 in)	55 mm (2.165 in)	30 mm (1.181 in)	428.5 mm (16.870 in)	155 mm (6.102 in)
4200-6211	Epcos						431.5 mm (16.988 in)	

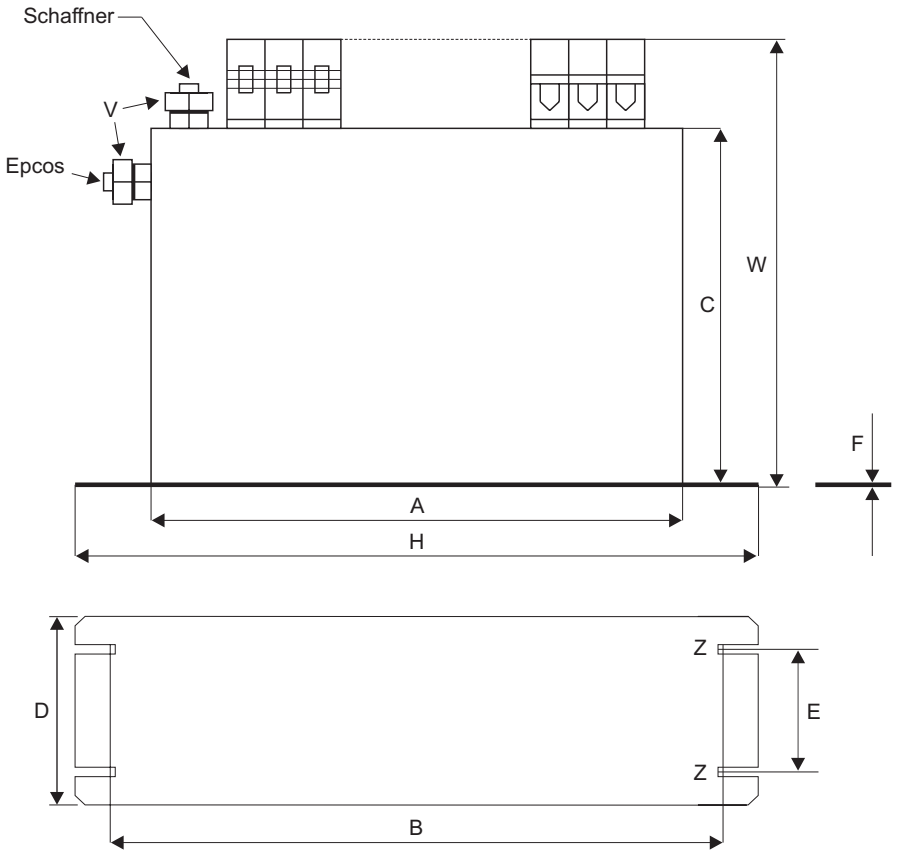
Figure 5-23 Size 3 external EMC filter



V: Ground stud: M6
X: M6 threaded holes for footprint mounting of the drive
Y: Footprint mounting holes ∅6.5mm (0.256in)
Z: Bookcase mounting slots 6.5mm (0.256in) wide

CT part no.	Manufacturer	A	B	C	D	E	H	W
4200-6305	Schaffner	361 mm (14.213 in)	396 mm (15.591 in)	210 mm (8.268 in)	60 mm (2.362 in)	30 mm (1.181 in)	414 mm (16.299 in)	250 mm (9.843 in)
4200-6307								
4200-6309								
4200-6306	Epcos	365 mm (14.370 in)					425 mm (16.732 in)	
4200-6308								

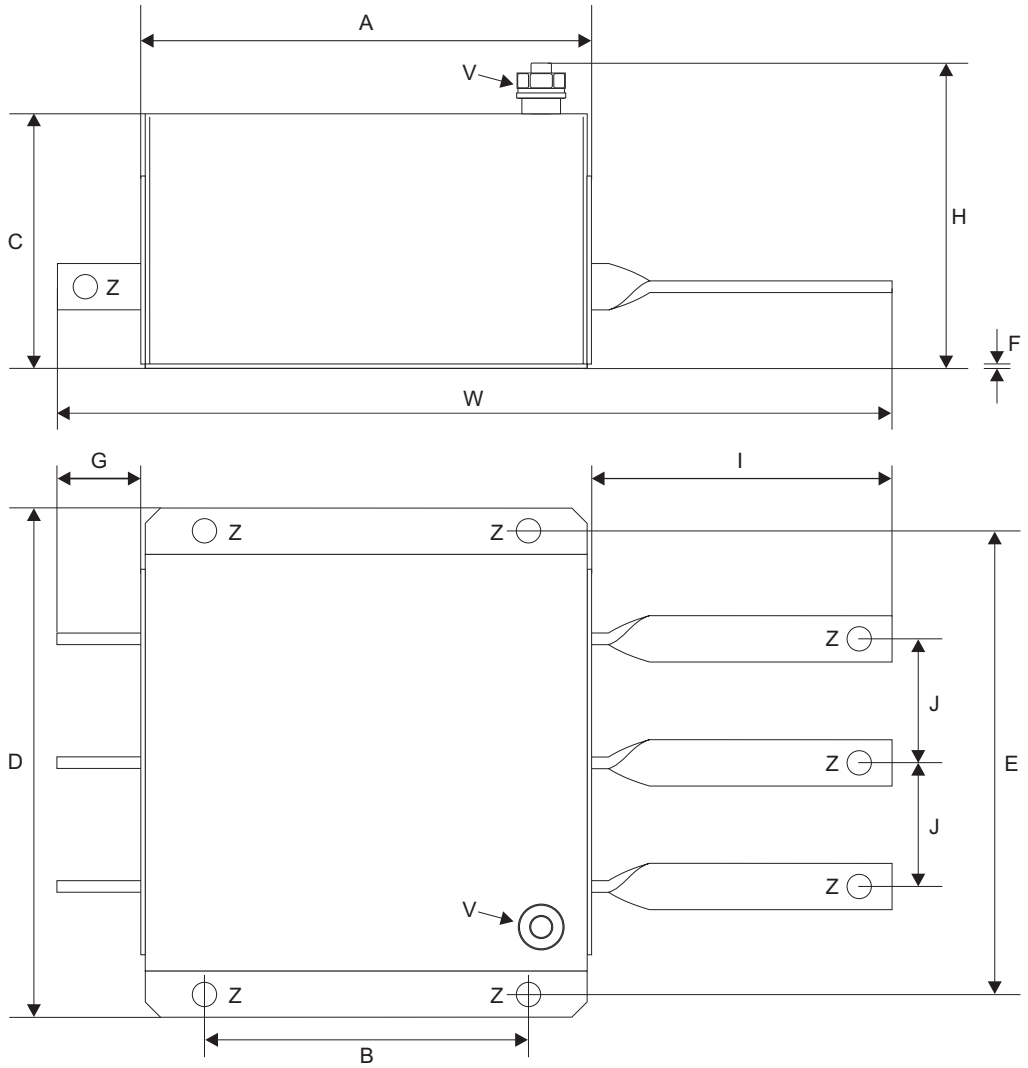
Figure 5-24 Size 4 and 5 external EMC filter



V: Ground stud: M10
Z: Bookcase mounting slots 6.5mm (0.256in wide)

CT part no.	Manufacturer	A	B	C	D	E	F	H	W
4200-6406	Schaffner	260 mm (10.236 in)	275 mm (10.827 in)	170 mm (6.693 in)	100 mm (3.937 in)	65 mm (2.559 in)	1.5 mm (0.059in)	300 mm (11.811 in)	225 mm (8.858 in)
4200-6408									208 mm (8.189 in)
4200-6503					120 mm (4.724 in)	85 mm (3.346 in)			249 mm (9.803 in)
4200-6504					100 mm (3.937 in)	65 mm (2.559 in)			225 mm (8.858 in)
4200-6405	Epcos			150 mm (5.906 in)	90 mm (3.543in)	65 mm (2.559 in)	2 mm (0.079 in)		207 mm (8.150 in)
4200-6407									205 mm (8.071 in)
4200-6501				170 mm (6.693 in)	120 mm (4.724 in)	85 mm (3.346 in)	1 mm (0.039 in)		249 mm (9.803 in)
4200-6502									

Figure 5-25 Size 6 external EMC filter



V: Ground stud: M10
Z: Hole size: ∅10.5mm

CT part no.	Manufacturer	A	B	C	D	E	F	G	H	I	J	W
4200-6601	Schaffner	196 mm (7.717 in)	139.9 mm (5.508 in)	108 mm (4.252 in)	230 mm (9.055 in)	210 mm (8.268 in)	2 mm (0.079in)	38 mm (1.496 in)	136 mm (5.354 in)	128 mm (5.039 in)	53.5 mm (2.106 in)	364 mm (14.331 in)
4200-6602												
4200-6603												
4200-6604												
4200-6313												
4200-6314												
4200-6315												
4200-6316												

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.

CAUTION

When a EMC filter is used, the switching frequency filter detailed must also be used. Failure to observe this may result in the EMC filter becoming ineffective and being damaged. Refer to section 6.4 *EMC (Electromagnetic compatibility)* on page 77.

5.4.1 External charging resistor - type TG series

Figure 5-26 External charging resistor dimensions

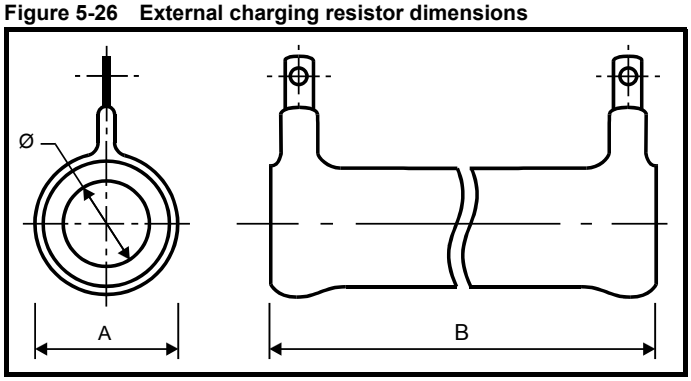


Table 5-12 External charging resistor specifications

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 5-27 Resistor mounting bracket dimensions

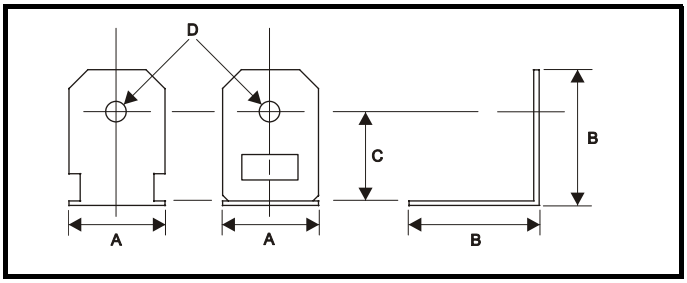


Table 5-13 Resistor mounting bracket dimensions

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

NOTE

For component selection refer to either Chapter 10 *Technical data* on page 183 or section 3.10 *Regen components* on page 25.

5.4.2 Varistors

Figure 5-28 Varistor dimensions

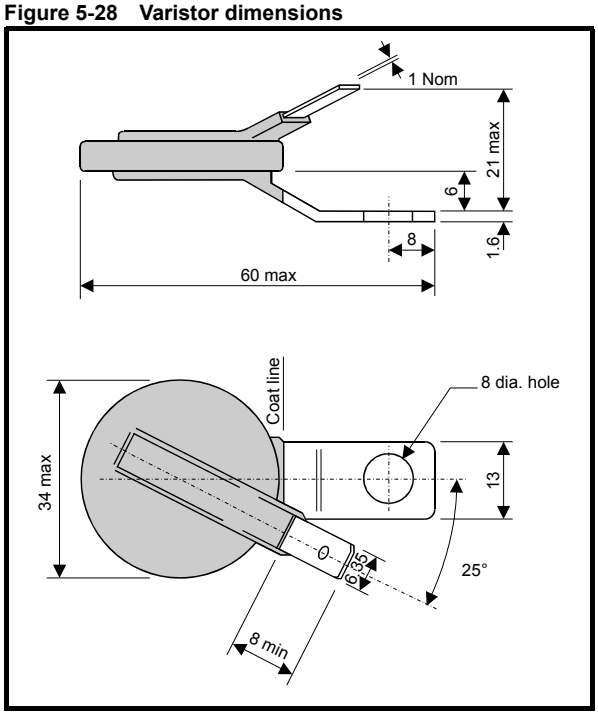


Table 5-14 Varistor specifications

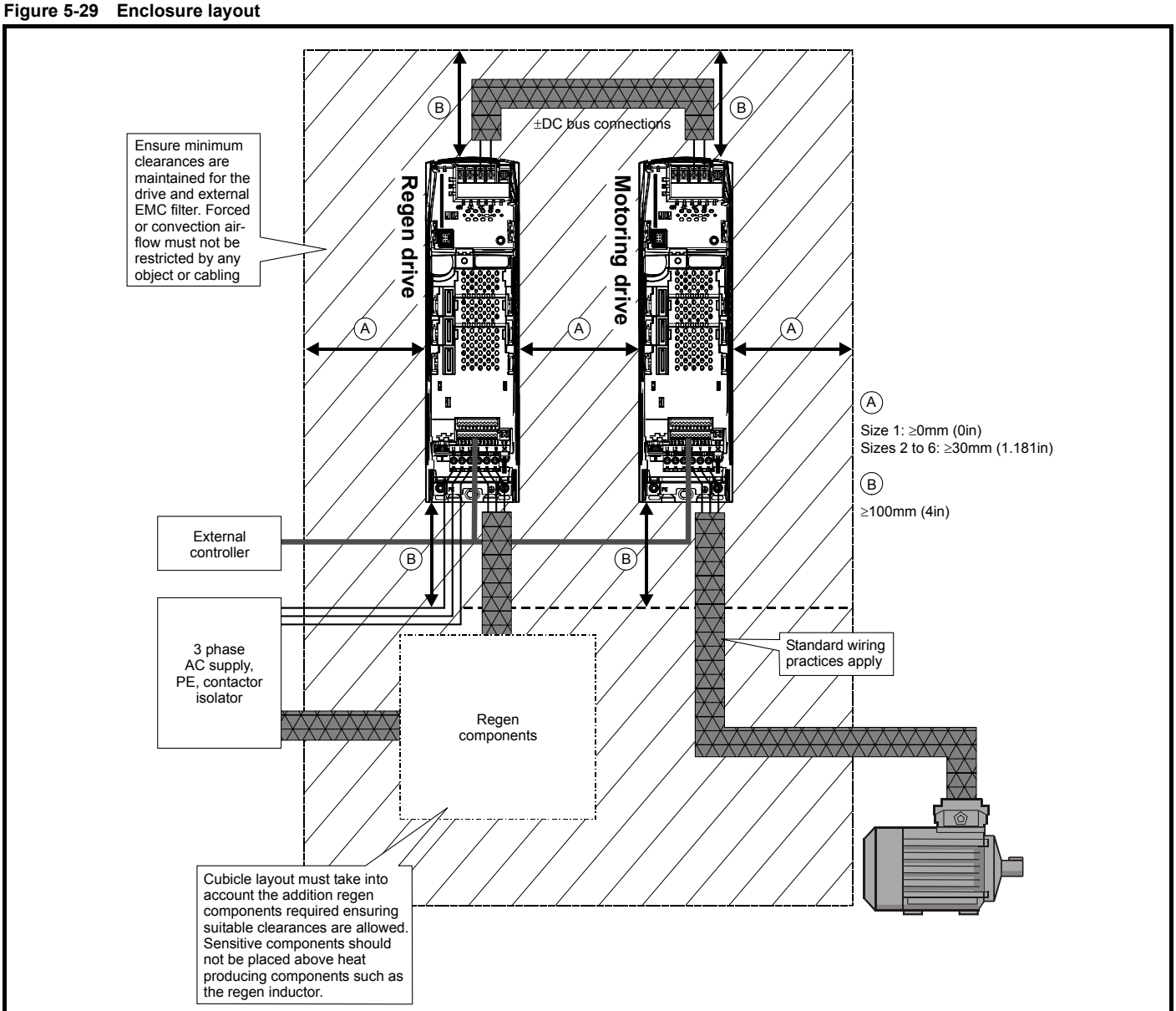
Drive rating	Varistor voltage rating V_{RMS}	Energy rating J	Quantity per system	Configuration	CT part number
200V (200V to 240V±10%)	550	620	3	Line to line	2482-3291
	680	760	3	Line to ground	2482-3211
400V (380V to 480V±10%)	550	620	3	Line to line	2482-3291
	680	760	3	Line to ground	2482-3211
575V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

5.5 Enclosure

5.5.1 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 5-29 Enclosure layout



5.5.2 Enclosure sizing

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

Calculating the size of a sealed enclosure

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

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

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

Where:

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

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 196)

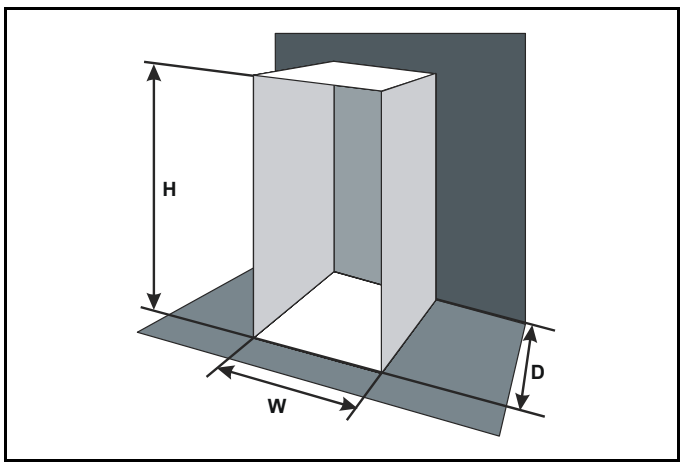
Dissipation of external switching frequency filter: 28 W x 1 (see Chapter 10 *Technical data* on page 183)

Total dissipation: ((147 x 2) + 9.2 + 125 + 28) = 456.2 W

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

The value of 5.5 W/m^2/°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 5-30 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 m^2 (90.36 ft^2) (1 m^2 = 10.9 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** = 2m and **D** = 0.6m, obtain the minimum width:

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

=3.2 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:

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

Where:

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

Where:

P_0 is the air pressure at sea level

P_l is the air pressure at the installation

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

Example

To calculate the size of an enclosure for the following:

- Two 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 196)

Dissipation of external switching frequency filter: 28 W x 1 (see Chapter 10 *Technical data* on page 183)

Total dissipation: ((147 x 2) + (9.2 + 125 + 28) = 456.2 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 m^3/hr (70.05 ft^3 /min) (1 m^3/ hr = 0.59 ft^3/min)

5.6 Cubicle design and drive ambient temperature

Drive derating is required for operation in high ambient temperatures (derating information is provided in the *Unidrive SP User Guide*).

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

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

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

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

Where:

T_{ext} = Temperature outside the cabinet

T_{int} = Temperature inside the cabinet

T_{rate} = Temperature used to select current rating from tables in Chapter 10 *Technical data* on page 183.



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

6 Electrical Installation

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.

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.

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.

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

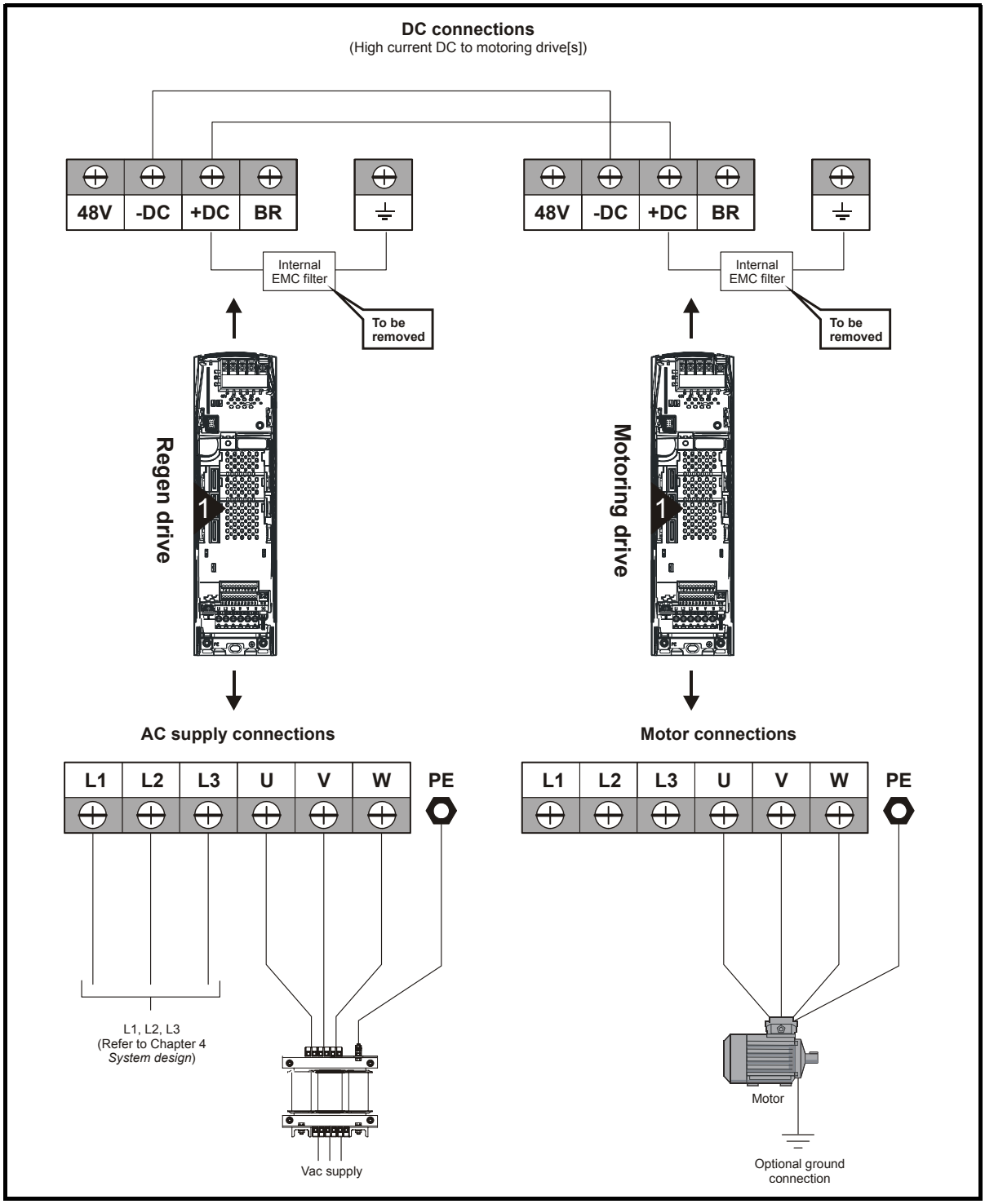
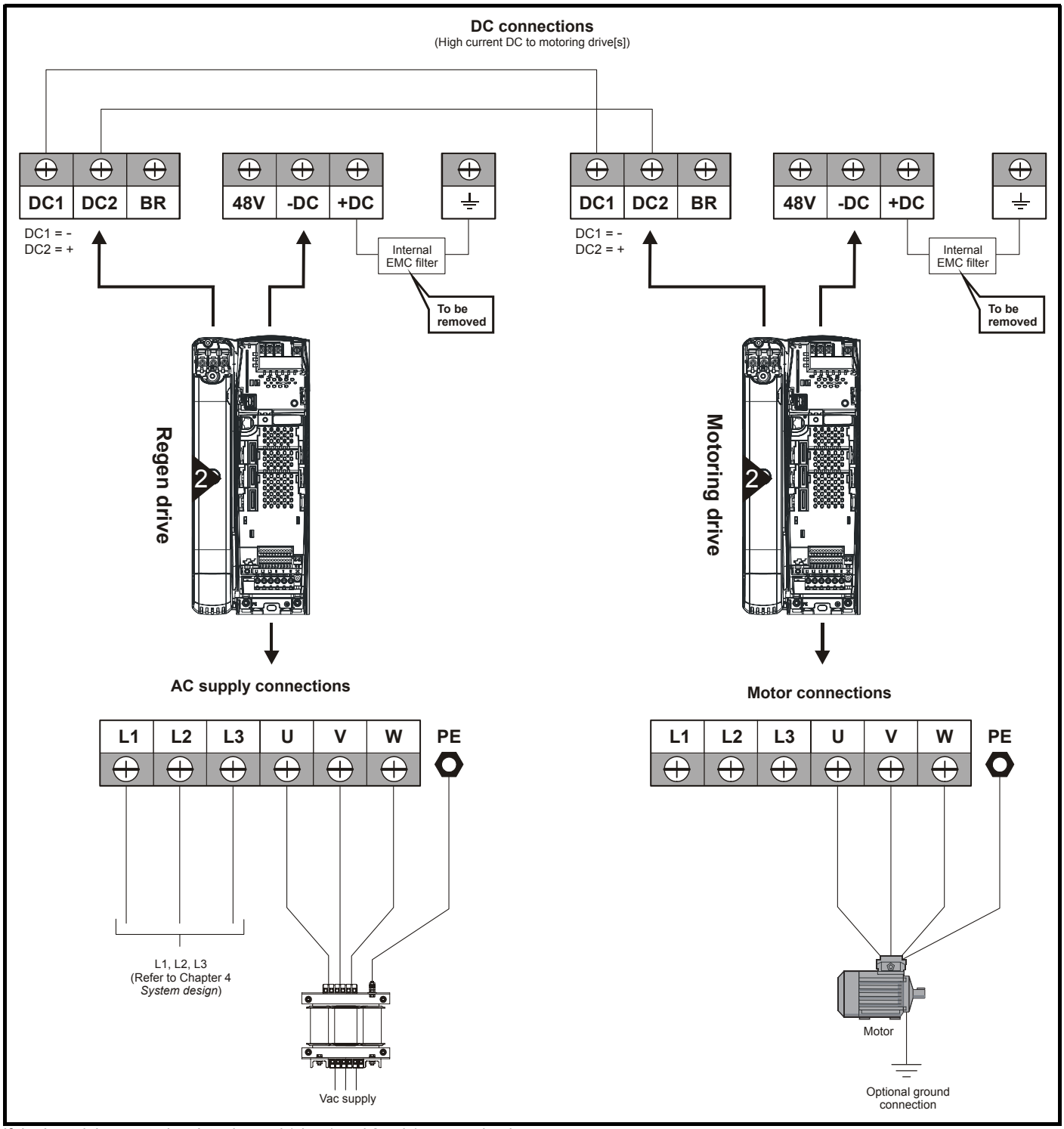


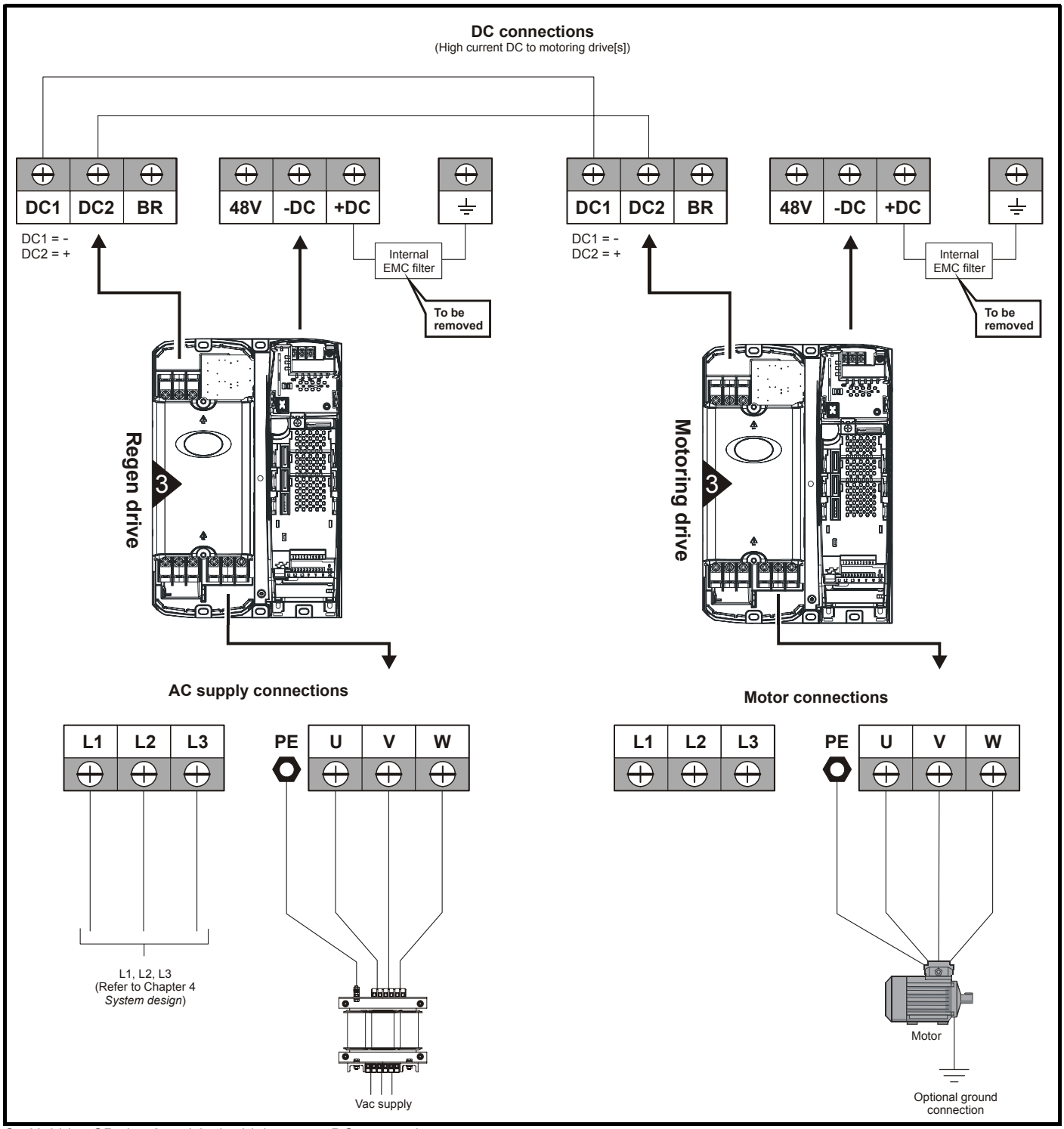
Figure 6-2 Unidrive SP size 2 power connections



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 6-8 for further information on ground connections.

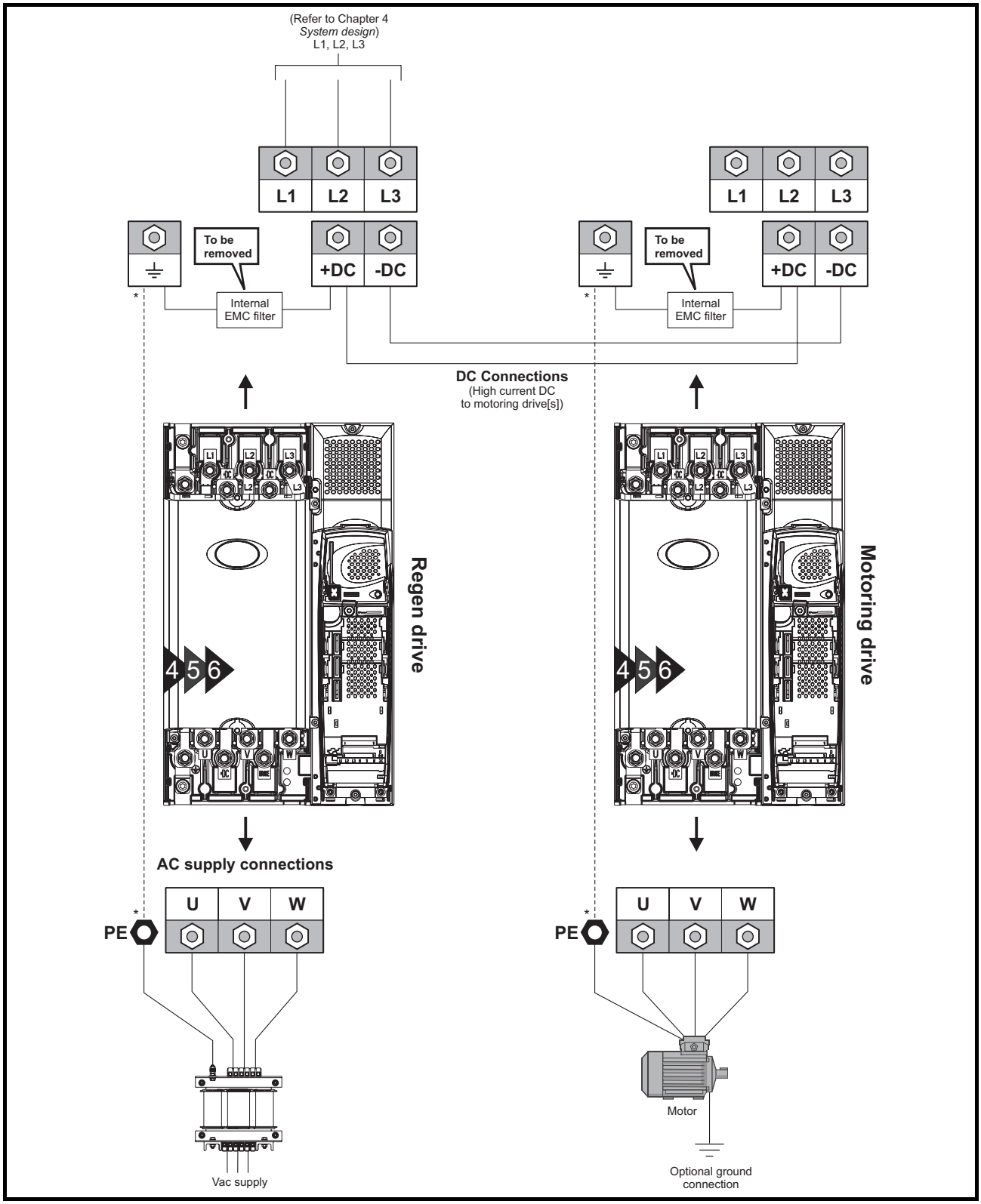
Figure 6-3 Unidrive SP size 3 power connections



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 6-9 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 SPMA power connections

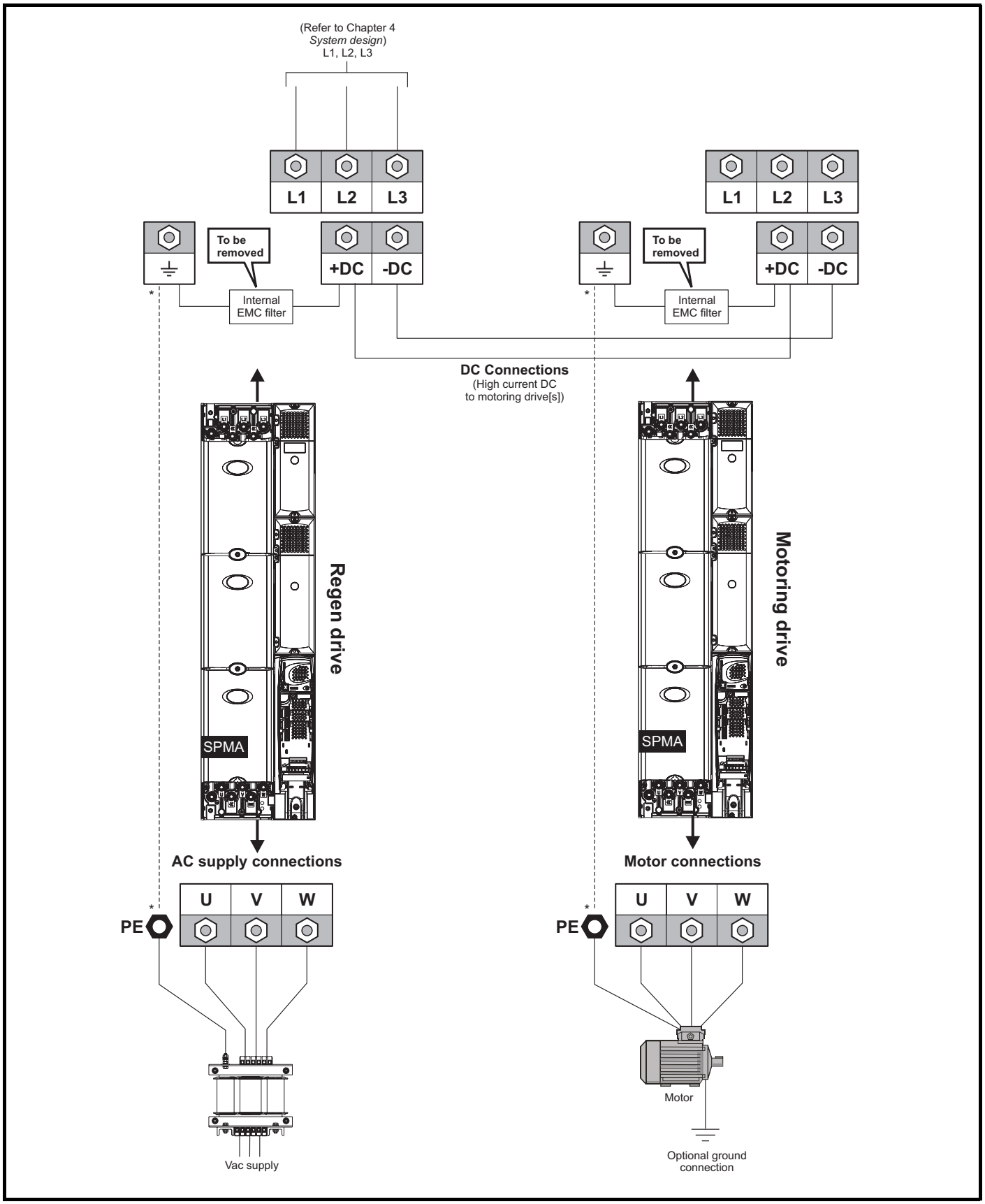


Figure 6-6 Unidrive SPMD power connections

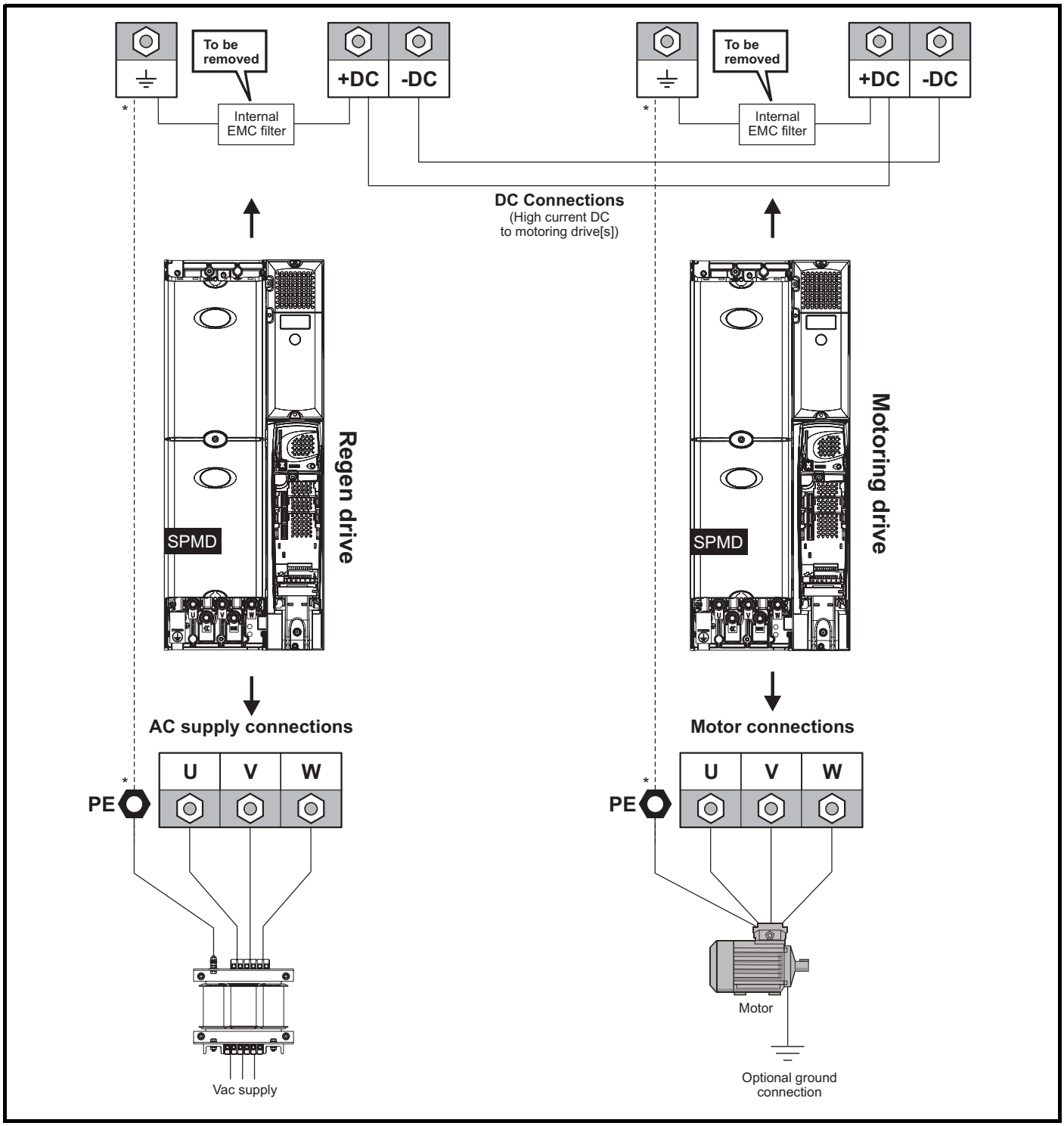
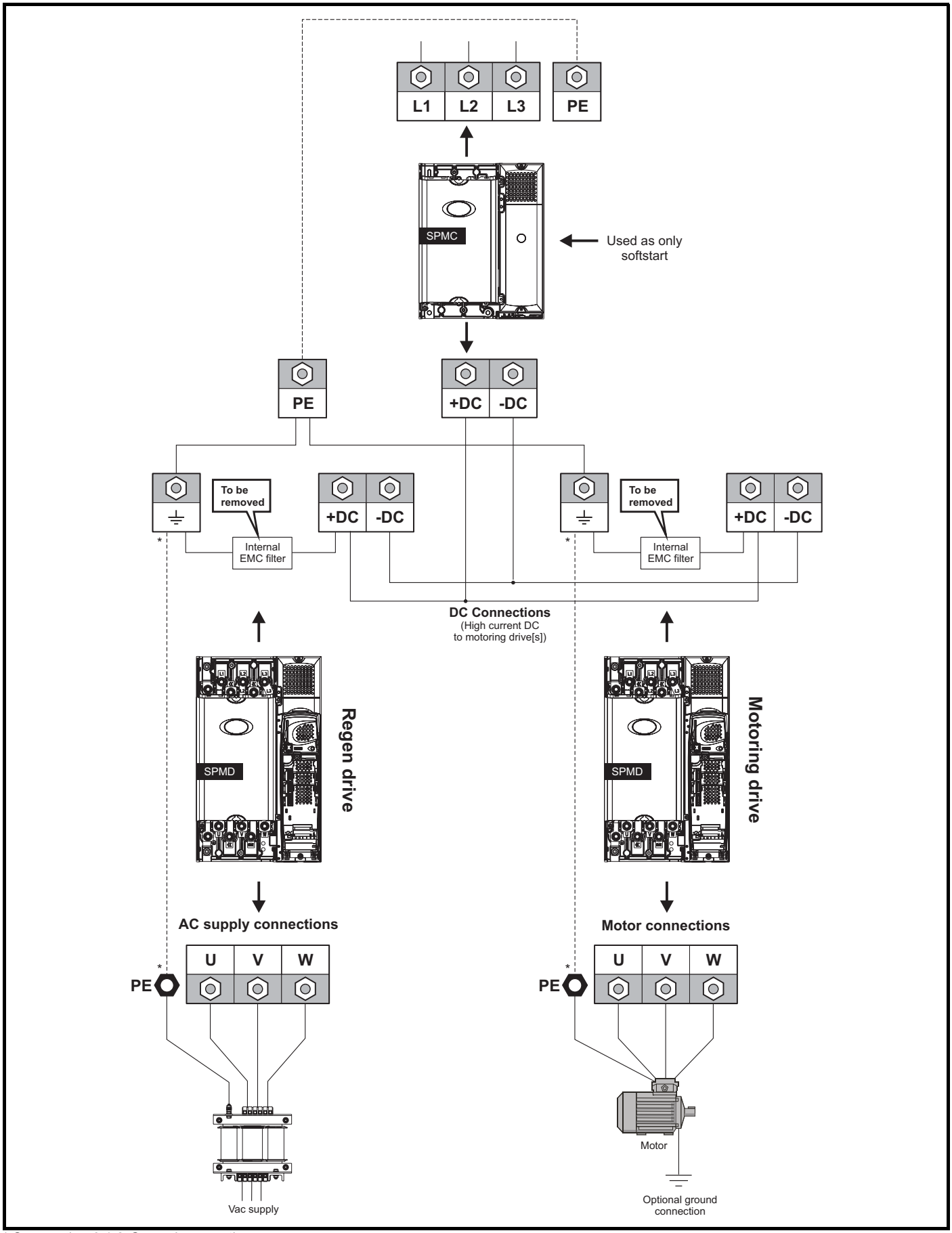


Figure 6-7 Unidrive SPMC power connections



* 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 66.

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 6-8 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 6-9 for details.

Size 4, 5, 6, SPMA and SPMD

On a Unidrive SP size 4, 5, 6, SPMA and SPMD the supply and motor ground connections are made using an M10 bolt at the top (supply) and bottom (motor) of the drive. See Figure 6-10.

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)

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

SPMD: 120mm^2 (0.18in^2, or slightly bigger than 2 AWG)

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

Table 6-1 Cables and standards

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 SPMA: 150mm^2 SPMD: 240mm^2

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

WARNING

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

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

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

Figure 6-8 Unidrive SP size 2 ground connections

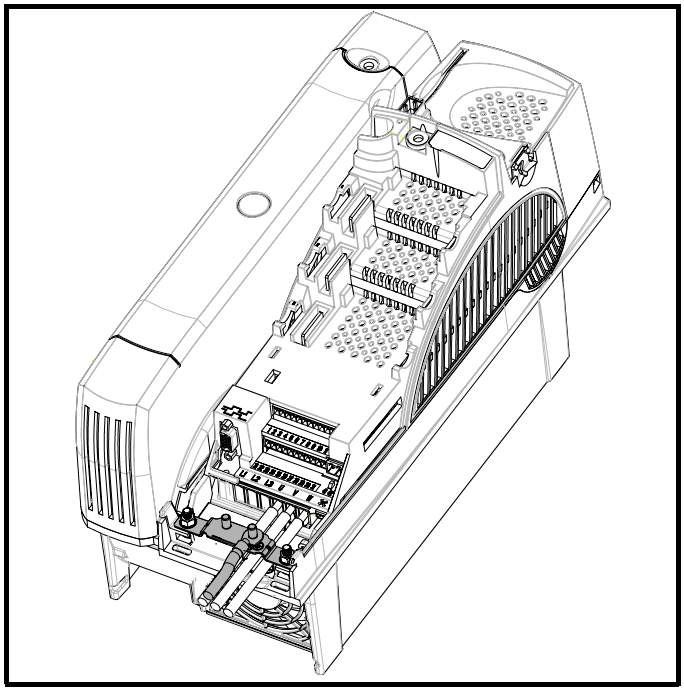


Figure 6-9 Unidrive SP size 3 ground connections

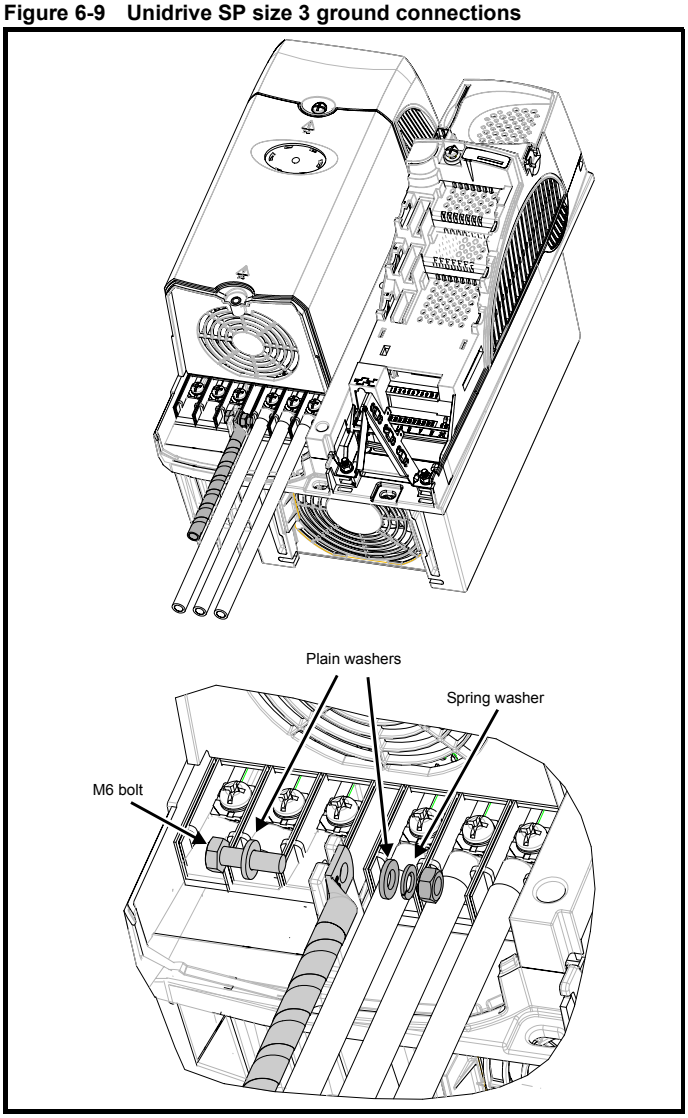


Figure 6-10 Unidrive SP size 4, 5, 6, SPMA and SPMD ground connections

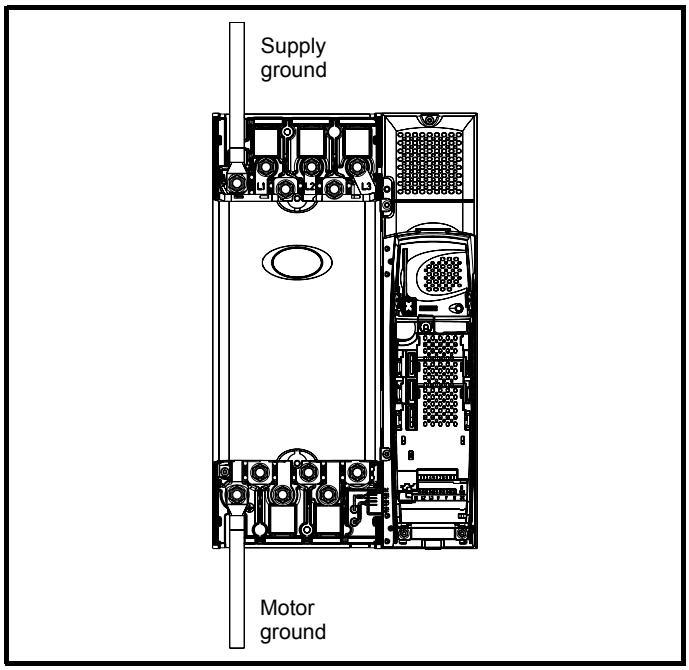
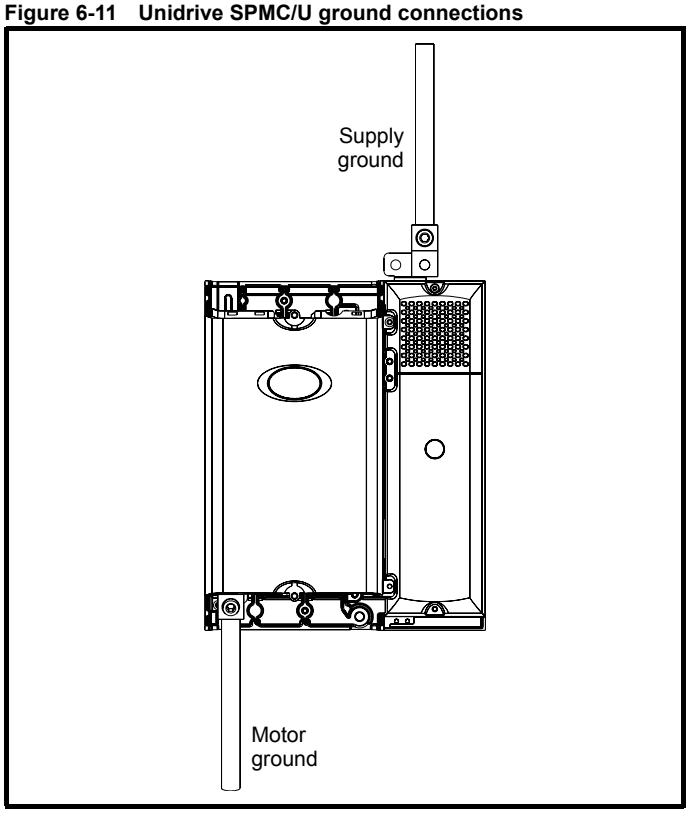


Figure 6-11 Unidrive SPMC/U ground connections



6.2 AC supplies

NOTE

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

The following supplies are not permitted with Unidrive SP Regen

1. Corner grounded supplies (grounded Delta)

2. Ungrounded supplies (IT) > 575V

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 40.

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 6.5.11 *Switching frequency emission* and section 6.5.12 *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 6.5.11 *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 Cable and fuse ratings

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

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

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

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

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

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

Model	Maximum continuous input current A	European		USA	
		Fuse rating IEC gG A	Cable size EN60204 Input mm^2	Fuse rating IEC gG A	Cable size UL508C Input AWG
SP1201	5.2	10	1.0	10	18
SP1202	6.8	10	1.0	10	16
SP1203	9.6	12	1.0	12	14
SP1204	11	12	1.0	12	14
SP2201	15.5	20	2.5	20	14
SP2202	22	25	4.0	25	10
SP2203	28	32	6.0	32	8
SP3201	42	50	16	50	16
SP3202	54	63	25	63	25
SP1405	8.8	12	1.0	15	14
SP1406	11	16	1.5	15	14
SP2401	15.3	20	2.5	20	14
SP2402	21	25	4.0	25	10
SP2403	29	32	6.0	30	8
SP2404	29	32	6.0	30	8
SP3401	35	40	10	40	6
SP3402	43	50	16	45	6
SP3403	56	63	25	60	4
SP3501	5.4	8	1.0	8	18
SP3502	6.1	8	1.0	8	16
SP3503	8.4	12	1.0	12	14
SP3504	11	12	1.0	12	14
SP3505	16	20	2.5	20	14
SP3506	22	25	4.0	25	10
SP3507	27	32	6.0	32	8

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

Model	Maximum continuous input current A	IEC class gR OR North American Ferraz HSJ		HRC AND Semi-conductor		Cable size	
		IEC class gR	North American Ferraz HSJ	HRC IEC class gG UL class J	Semi- Conductor IEC class aR	mm^2	AWG
SP4201	68	100	90	90	160	25	3
SP4202	80	100	100	100	160	35	3
SP4203	104	125	125	125	200	70	1
SP5201	130	200	175	160	200	95	210
SP5202	154	250	225	200	250	120	410
SP4401	68	80	80	80	160	25	3
SP4402	83	110	110	100	200	35	2
SP4403	104	125	125	125	200	70	1
SP5401	138	200	175	160	200	95	2/0
SP5402	168	250	225	200	250	120	4/0
SP6401	205	250	250	250	315	2 x 70	2 x 2/0
SP6402	236	315	300	300	350	2 x 120	2 x 4/0
SPMA1401	205	315	300	250	315	2 x 70	2 x 2/0
SPMA1402	246	315	300	300	350	2 x 120	2 x 4/0
SPMD1201	192	Refer to SPMC					
SPMD1202	248						
SPMD1203	312						
SPMD1204	350						
SPMD1401	205	Refer to SPMC					
SPMD1402	246						
SPMD1403	290						
SPMD1404	350						
SP4601	22	63	60	32	125	4	10
SP4602	27	63	60	40	125	6	8
SP4603	36	63	60	50	125	10	8
SP4604	43	63	60	50	125	16	6
SP4605	52	63	60	63	125	16	6
SP4606	62	80	60	63	125	25	4
SP5601	84	125	100	90	160	35	2
SP5602	99	125	100	125	160	50	1
SP6601	125	160	175	150	315	2 x 50	2 x 1
SP6602	144	160	175	160	315	2 x 50	2 x 1
SPMA1601	125	200	200	200	200	2 x 50	2 x 1
SPMA1602	144	200	200	200	200	2 x 50	2 x 1
SPMD1601	125	Refer to SPMC					
SPMD1602	144						
SPMD1603	168						
SPMD1604	192						

Table 6-4 Unidrive SPMD input current, fuse and cabling ratings

Model	Typical DC Input current A	Maximum DC Input current A	Maximum DC Input voltage Vdc	DC fuse IEC class aR A	DC Cable size	
					mm^2	AWG
SPMD1401	222	343	800	400	2 x 70	2 x 2/0
SPMD1402	268	400	800	560	2 x 95	2 x 4/0
SPMD1403	314	457	800	560	2 x 120	2 x 4/0
SPMD1404	379	552	800	560	2 x 120	2 x 4/0
SPMD1601	135	191	1150	250	2 x 95	2 x 4/0
SPMD1602	157	240	1150	315	2 x 120	2 x 4/0
SPMD1603	184	275	1150	350	2 x 120	2 x 4/0
SPMD1604	209	323	1150	400	2 x 120	2 x 4/0

Table 6-5 SPMC / U input current, fuse and cable ratings

Model	Typical input current A	Maximum input current A	Typical DC current Adc	Semi-conductor fuse in series with HRC fuse		Cable sizes			
						AC input		DC output	
				HRC IEC class gG UL class J	Semi-conductor IEC class aR	mm^2	AWG	mm^2	AWG
SPMC1402	339	344	379	540	400	2 x 120	2 x 4/0	2 x 120	2 x 4/0
SPMC2402	2 x 308	2 x 312	2 x 345	450	400	2 x 120	2 x 4/0	2 x 120	2 x 4/0
SPMU1401	207	210	222	250	315	2 x 70	2 x 2/0	2 x 70	2 x 2/0
SPMU1402	339	344	379	540	400	2 x 120	2 x 4/0	2 x 120	2 x 4/0
SPMU2402	2 x 339	609	2 x 379	450	400	2 x 120	2 x 4/0	2 x 120	2 x 4/0
SPMC1601	192	195	209	250	250	2 x 70	2 x 2/0	2 x 120	2 x 4/0
SPMC2601	2 x 170	2 x 173	2 x 185	250	250	2 x 70	2 x 2/0	2 x 120	2 x 4/0
SPMU1601	192	195	209	250	250	2 x 70	2 x 2/0	2 x 120	2 x 4/0
SPMU2601	2 x 170	2 x 173	2 x 185	250	250	2 x 70	2 x 2/0	2 x 120	2 x 4/0

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.

WARNING

Fuses
The AC supply to the drive must be fitted with suitable protection against overload and short-circuits. Failure to observe this requirement will cause risk of fire.

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

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

WARNING

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 6.5.2, 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 6.5.3, Requirements for meeting the EMC standard for power drive systems, IEC61800-3 (EN61800-3).

Section 6.5.4, Requirements for meeting the generic emission standards for the industrial environment, IEC61000-6-4, EN61000-6-4, EN50081-2.

The recommendations of section 6.5.2 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 6.5.3 or section 6.5.4 should be followed to give reduced radio-frequency emission.

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

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

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

Table 6-6 Unidrive SP / EMC filter cross reference

Drive	Schaffner	Epcos
	CT part no.	CT part no.
SP1201 to SP1202	4200-6118	4200-6121
SP1203 to SP1204	4200-6119	4200-6120
SP2201 to SP2203	4200-6210	4200-6211
SP3201 to SP3202	4200-6307	4200-6306
SP4201 to SP4203	4200-6406	4200-6405
SP5201 to SP5202	4200-6503	4200-6501
SPMD1201 to SPMD1204	4200-6315	4200-6313
SP1401 to SP1404	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	4200-6601
SPMA1401 to SPMA1402	4200-6603	4200-6601
SPMD1401 to SPMD1404	4200-6315	4200-6313
SP3501 to SP3507	4200-6309	4200-6308
SP4601 to SP4606	4200-6408	4200-6407
SP5601 to SP5602	4200-6504	4200-6502
SP6601 to SP6602	4200-6604	4200-6602
SPMA1601 to SPMA1602	4200-6604	4200-6602
SPMD1601 to SPMD1604	4200-6316	4200-6314

6.5 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.

CAUTION When a EMC filter is used, the switching frequency filter detailed must also be used. Failure to observe this may result in the EMC filter becoming ineffective and being damaged. Refer to section 6.4 *EMC (Electromagnetic compatibility)* on page 77.

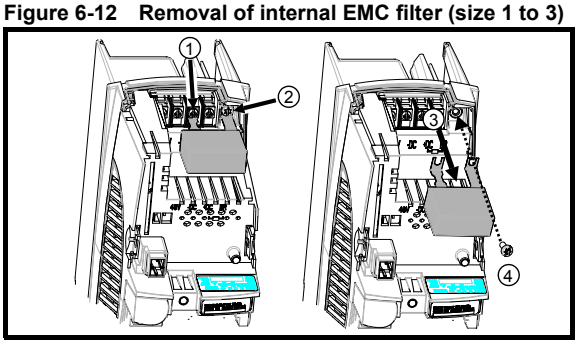
WARNING When an EMC filter is used, a permanent fixed ground connection must be provided which does not pass through a connector or flexible power cord. This includes the internal EMC filter.

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

6.5.1 Removal of internal EMC filter

CAUTION The internal EMC filter must be removed from the drive.

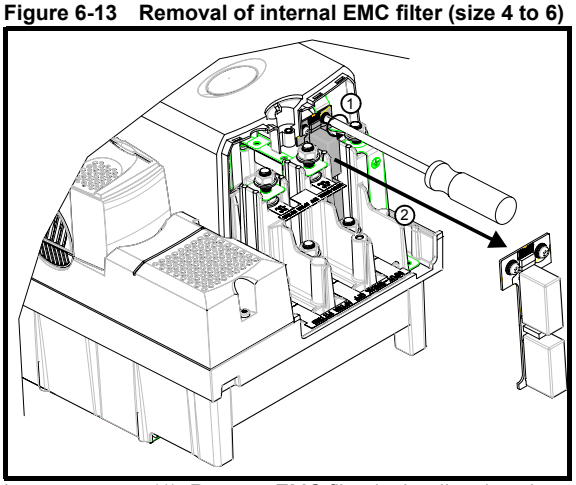
Figure 6-12 Removal of internal EMC filter (size 1 to 3)



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

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

Figure 6-13 Removal of internal EMC filter (size 4 to 6)



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

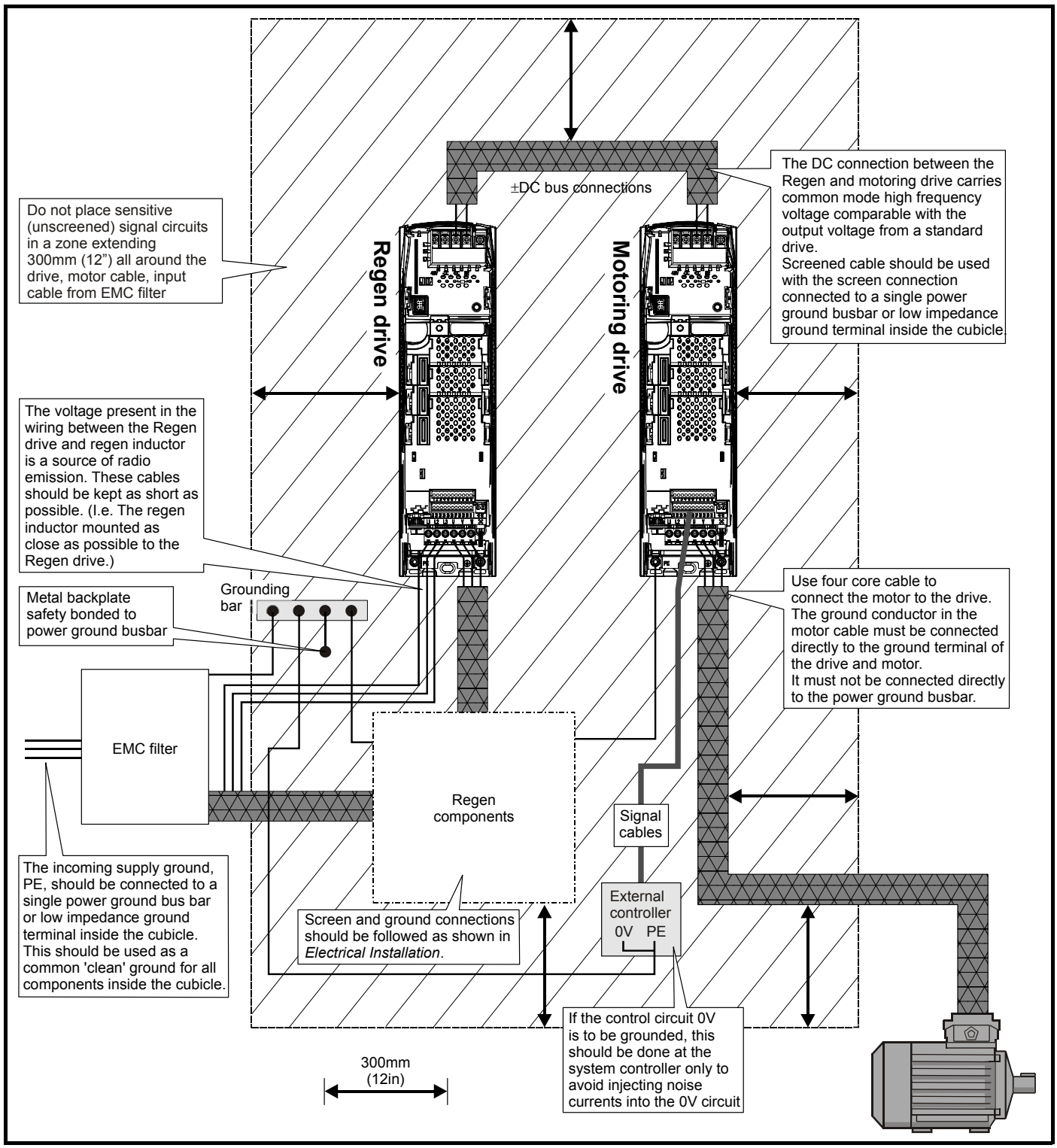
6.5.2 General requirements for EMC

Ground (earth) connections

The grounding arrangements should be in accordance with Figure 6-14, which shows both drives mounted on a back-plate with or without an additional enclosure.

Figure 6-14 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 6-14 General EMC enclosure layout showing earth / ground connections



6.5.3 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 6.5.4 *Compliance with generic emission standards* on page 80. An external EMC filter will always be required.

CAUTION

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.

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 6.5.2 *General requirements for EMC* on page 79.

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 6.5.2 *General requirements for EMC* on page 79.

CAUTION

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 6.5.4 *Compliance with generic emission standards* be adhered to.

Refer to section 6.4 *EMC (Electromagnetic compatibility)* on page 77 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.

6.5.4 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*.

6.5.5 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.

6.5.6 Emission

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

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

6.5.7 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 40.

6.5.8 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 6.5.11 *Switching frequency emission* and section 6.5.12 *Conducted RF emission* .

6.5.9 Supply voltage notching

Because of the use of input inductors and an active rectifier the drive causes no notching - but see section 6.5.11 *Switching frequency emission* for advice on switching frequency emission.

6.5.10 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.

6.5.11 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 40 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.

CAUTION

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

6.5.12 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.

CAUTION

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 6-7 Requirements for conducted emission

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

Key to table	Standard	Description	Frequency range	Limits	Application
I	EN50081-2	Generic emission standard for the industrial environment	0.15 to 0.5MHz	79dBμV quasi peak 66dBμV average	AC supply lines
			0.5 to 30MHz	73dBμV quasi peak 60dBμV 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.

CAUTION

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

Recommended EMC filters

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

Table 6-8 Recommended filters

Drive	Motor cable length m	Schaffner	Epcos
		CT part no.	CT part no.
SP1201 to SP1202	100	4200-6118	4200-6121
SP1203 to SP1204		4200-6119	4200-6120
SP2201 to SP2203		4200-6210	4200-6211
SP3201 to SP3202		4200-6307	4200-6306
SP4201 to SP4203		4200-6406	4200-6405
SP5201 to SP5202		4200-6503	4200-6501
SPMD1201 to SPMD1204		4200-6315	4200-6313
SP1401 to SP1404		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	4200-6601
SPMA1401 to SPMA1402		4200-6603	4200-6601
SPMD1401 to SPMD1404		4200-6315	4200-6313
SP3501 to SP3507		4200-6309	4200-6308
SP4601 to SP4606		4200-6408	4200-6407
SP5601 to SP5602		4200-6504	4200-6502
SP6601 to SP6602		4200-6604	4200-6602
SPMA1601 to SPMA1602		4200-6604	4200-6602
SPMD1601 to SPMD1604		4200-6316	4200-6314

Related product standards

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

Table 6-9 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

6.5.13 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.

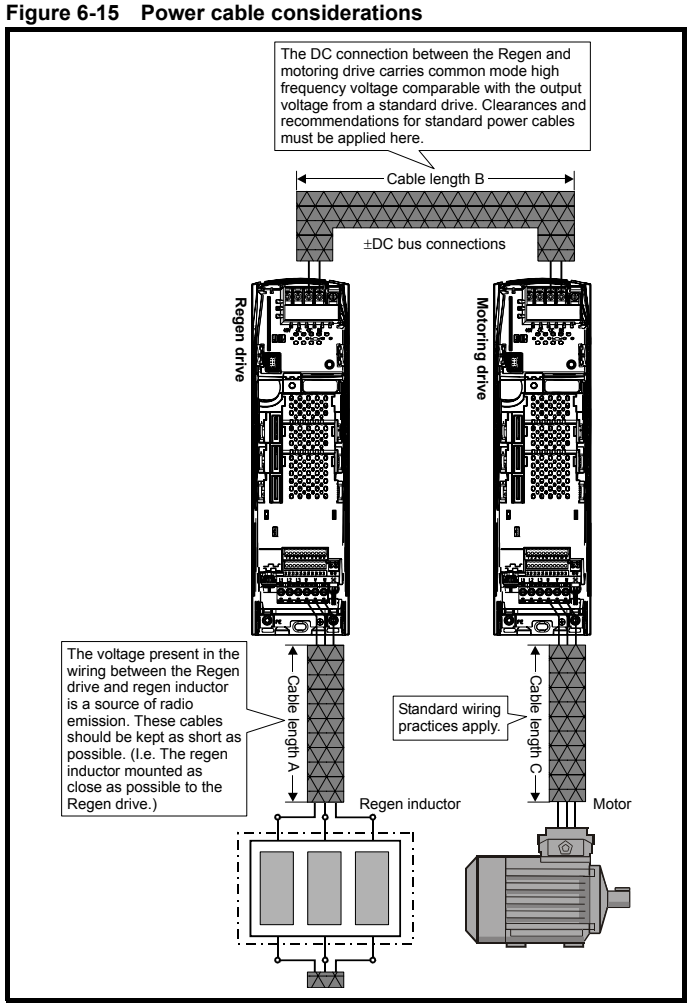
NOTE

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.

6.5.14 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 6-15 Power cable considerations



6.5.15 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.

6.5.16 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.

6.6 Control connections

6.6.1 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 6-16 Single rectifier control terminals and descriptions

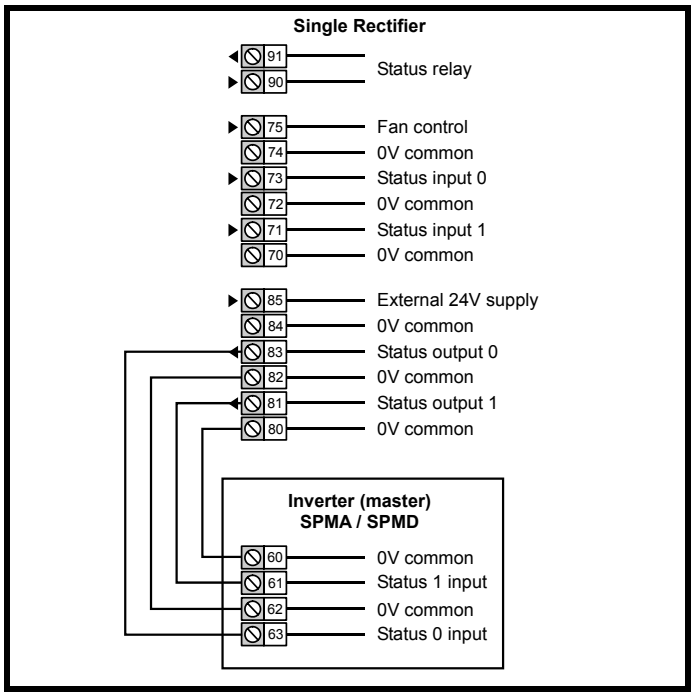
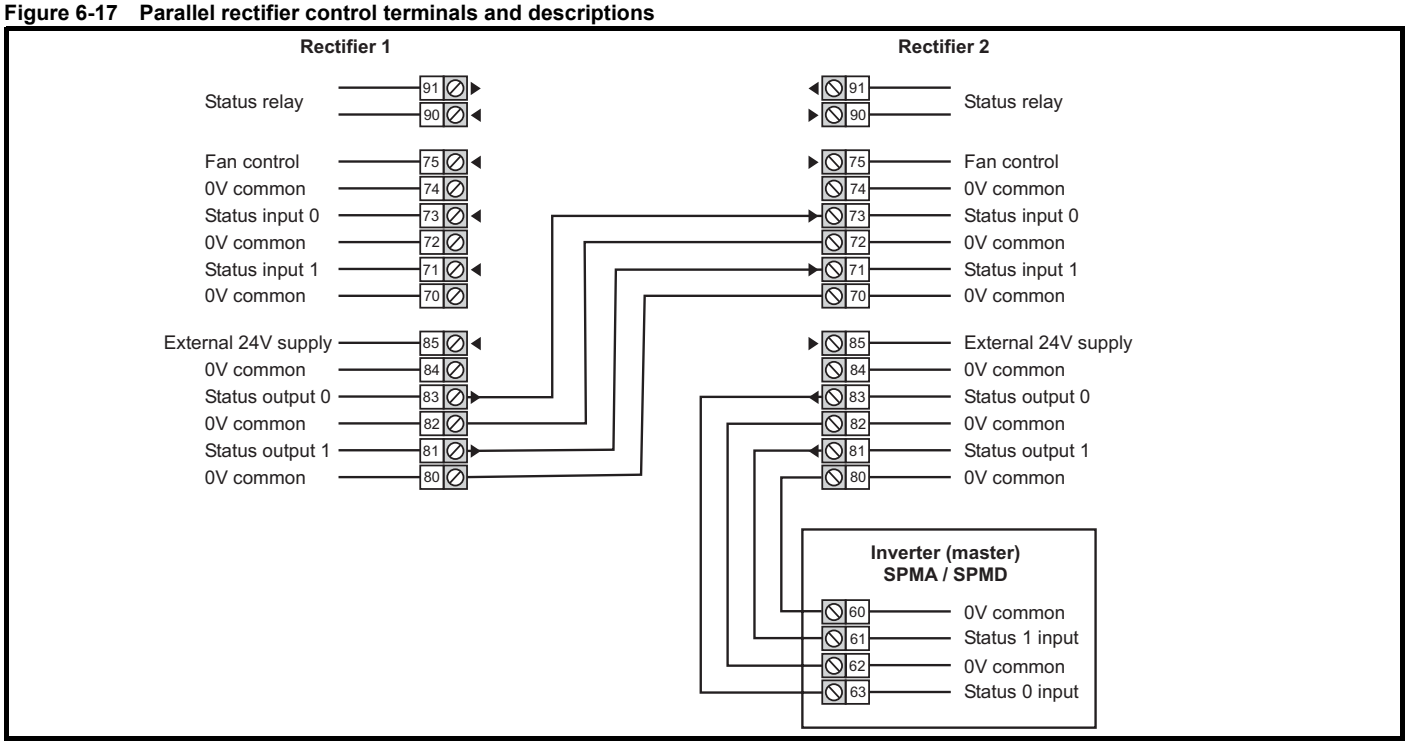


Figure 6-17 Parallel rectifier control terminals and descriptions



Unidrive SPMC/U external 24V supply requirements

Nominal voltage:	24V
Minimum voltage:	23V
Maximum voltage:	28V
Current drawn:	3A
Minimum start-up voltage:	18V
Recommended power supply:	24V, 100W, 4.5A
Recommended fuse:	4A fast blow (I^2t <20A^2s)

6.6.2 Unidrive SP control terminals

Table 6-10 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

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 auxiliary contactors to allow the regen mode to function correctly. Before changing any routing, refer to Menu 8 descriptions.

WARNING

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

WARNING

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

CAUTION

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

CAUTION

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

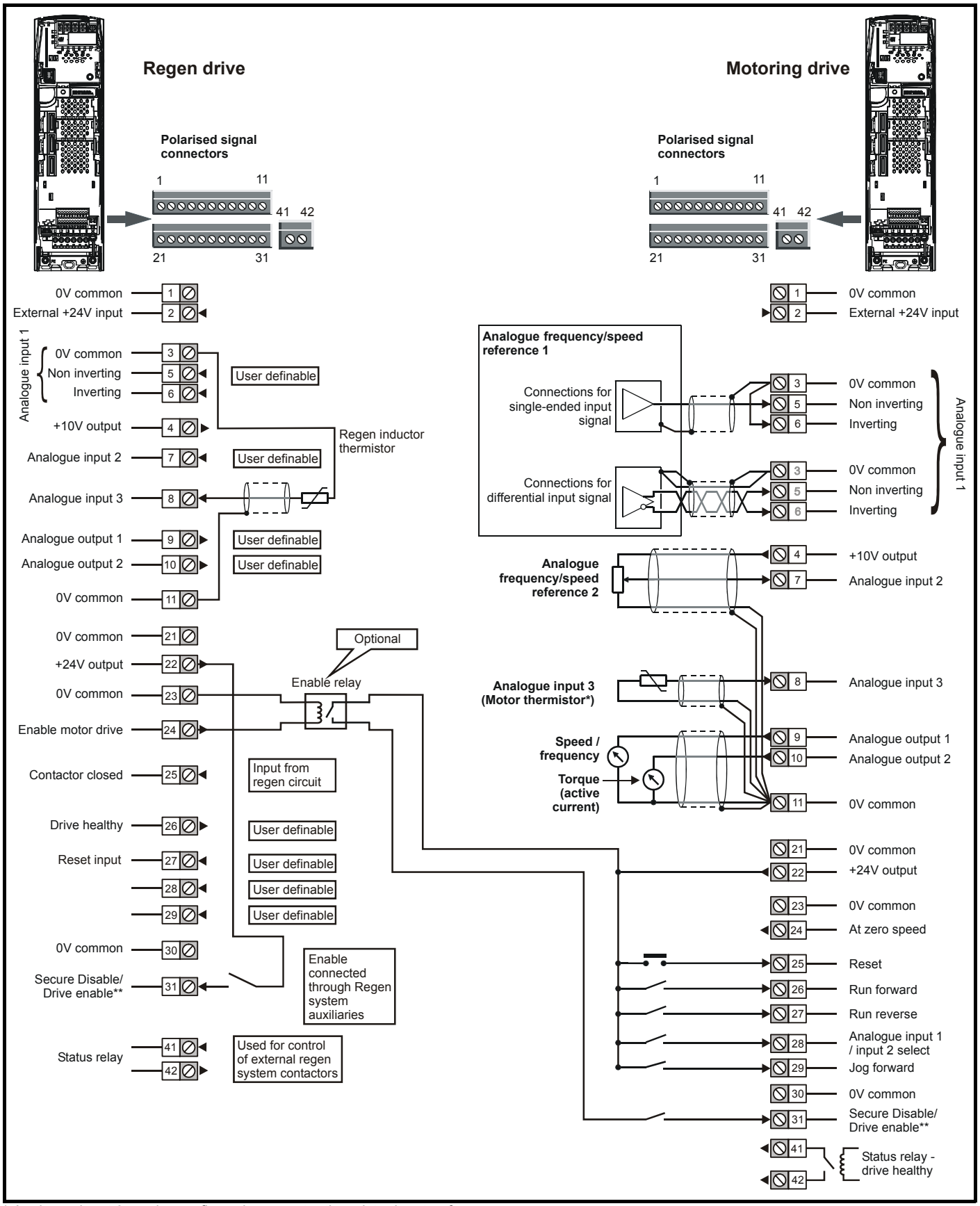
NOTE

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 6-18 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 the DC Bus voltage set point levels, assuming a tolerance of ±10% on the given supply voltage. The minimum value is defined as the peak input voltage plus some headroom. Headroom is required by the drive to allow correct control of the current. It is advisable to set the voltage below the maximum value to give more allowance for transient voltage overshoots.

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

Voltage levels	DC Bus voltage set-point	
Supply voltage Vac	**Default Vdc**	**Recommended Vdc**
200	350	350
400	700	700
575	835	835
690	1005	1005

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 by at least 50Vac.

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.

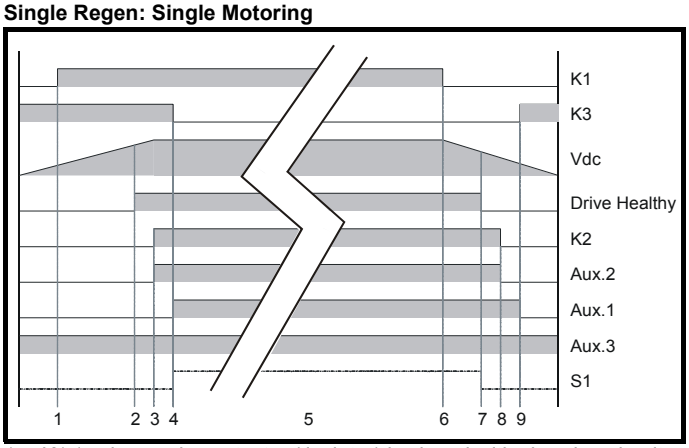
Only when all of these stages have been completed successfully is the motoring drive enabled. If at any time there is a fault, or the Regen drive is disabled, the motoring drive will also be disabled.

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 400V system

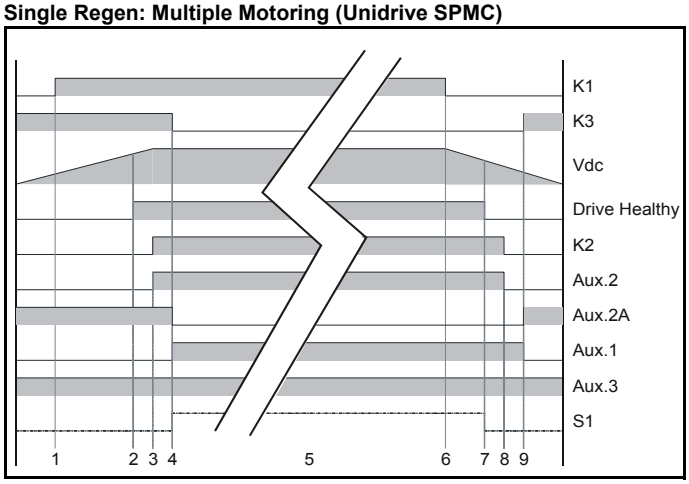
Single Regen: Single Motoring



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 400V system

Single Regen: Multiple Motoring (Unidrive SPMC)

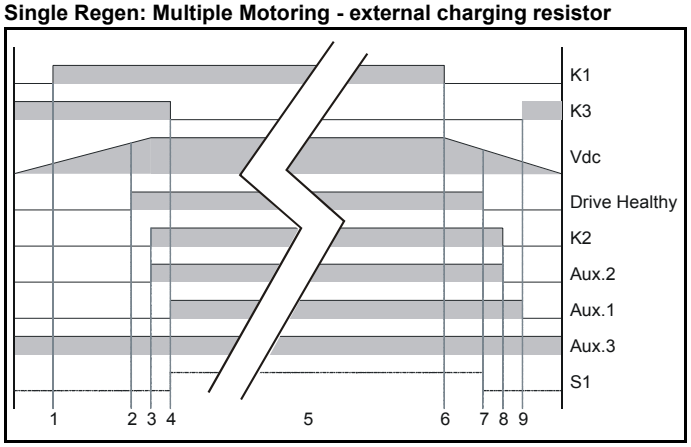


1. K1 (main supply contactor / isolator) is closed with charging circuit active (K3 closed).
2. DC bus charges through Unidrive SPMC (charging circuit).
3. If the DC Bus > 430Vdc then K2 Regen drive main contactor and Aux.2 are closed via Regen drives relay, control terminals 41, 42.
4. K3 charging contactor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

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.
9. 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 400V system

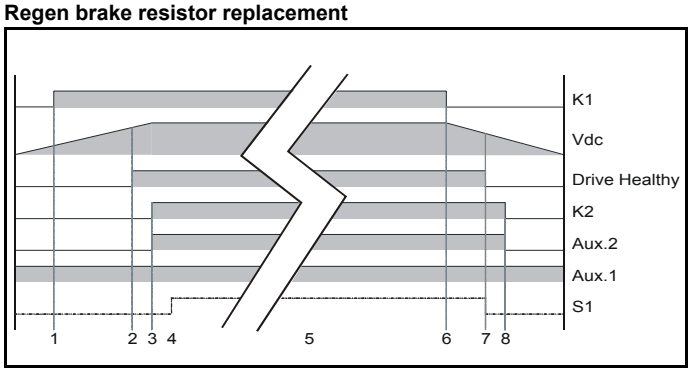
Single Regen: Multiple Motoring - external charging resistor



1. K1 (main supply contactor / isolator) is closed with charging circuit active (K3 closed).
2. DC bus charges through the external charging resistors (charging circuit).
3. If the DC Bus > 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 400V system

Regen brake resistor replacement



1. K1 (main supply contactor / isolator) is closed.
2. DC bus charges through motoring drives L1, L2, L3 Vac inputs.
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. 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.

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

7.2.1 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.

7.3 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.

7.4 Motoring drive commissioning

7.4.1 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.

7.4.2 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.

7.4.3 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*.

7.4.4 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.

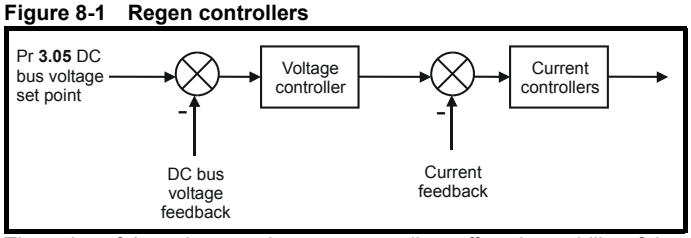
8 Optimisation

The following section covers optimisation of the regen system which can be carried out by the user.

Feature	Detail
Power feed-forward	Power feed-forward can be used to reduce fast transient DC Bus voltage effects produced by transient load conditions on motoring drives mainly in Dynamic applications where spurious over-voltage and/or over-current trips are experienced.
Voltage controller gain	The voltage controller gain can be implemented to overcome instability in the DC voltage on the common DC Bus in the following conditions, • A brake resistor replacement system where the ratio between regen brake drive and motoring drive(s) DC Bus capacitance is large • With multiple motoring drive(s) where the ratio between the regen drive(s) and motor drive(s) DC Bus capacitance is large. Ensure the voltage controller gain is not increased to high as this can also introduce excessive ripple and instability on the DC Bus.
Current loop gains	The current loop gains can be optimised to overcome spurious over-current trips during either synchronisation to the power supply, or during operation. The default gain settings are sufficient for most applications however these can be modified with the proportional (Kp) being the most critical for stability.
Power factor correction	This does not optimize the regen system but improves the power factor of the supply that is connected to the regen system. • Will introduce cost saving (electricity bill), compensate for inductive loads on the same supply, and overcome voltage drops due to “soft supplies”. • A separate power factor correction unit may not be required. • The symmetrical current limit must be below its maximum in order for power factor correction to work (therefore may be limited due to regen drive size).

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

Figure 8-1 Regen controllers



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

8.1 Power feed-forward compensation (Pr 3.10)

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

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

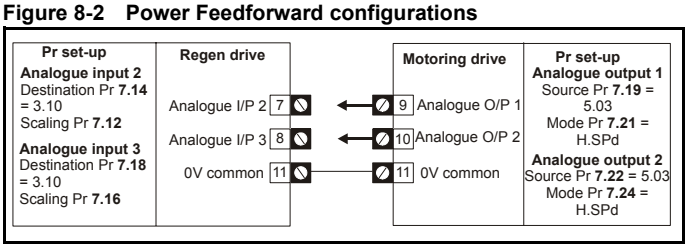
This scaling is the same as the power output from Pr **5.03** when high-speed output mode is used (Refer to section 9.7 *Menu 7: Analogue I/O*). Therefore an analogue output from the drive supplying the load, and analogue input 2 or 3 of the drive acting as the supply Regen drive can be connected together 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 8-2 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 Power Feedforward configurations



8.2 Current loop gains

The defaults current loop gains (Kp, Pr **4.13** and Ki, Pr **4.14**) 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 drives input inductance. If the inductance of the supply is a significant proportion of the recommended regen inductor

i.e. $60/I_{DR}$ mH per phase,

Where:

I_{DR} is the drive rated current

then the proportional gain may need to be increased.

The supply inductance is likely to be negligible compared to the regen inductor value with small drives, but is likely to be significant with larger drives. The proportional gain, Pr **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

Pr **4.13** = Kp = (L / T) x (I_{fs} / V_{fs}) x (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 drives input inductors, however, the supply filter capacitance, masks the effect of the supply inductance. Therefore the value measured is usually the Regen drive regen inductor value.

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

$\mathbf{I_{fs}}$ = Drive rated current x √2 / 0.45 (Drive rated current [Pr **11.32**])

Vfs is the maximum DC bus voltage.

Therefore:

Pr **4.13** = Kp = (L / 167µs) x (Drive rated current x √2 / 0.45 / Vfs) x (256 / 5)

= K x L x Rated drive current

Where:

K = √2 / (0.45 x Vfs x 167µs) x (256 / 5)

Drive voltage rating	Vfs	K
200V	415V	2322
400V	830V	1161
575V	990V	973
690V	1190V	809

This set-up will give a step response with minimum overshoot after a step change of current reference. The approximate performance of the current controllers will be as given below. The proportional gain can be increased by a factor of 1.5 giving a similar increase in bandwidth, however, this gives a step response with approximately 12.5% overshoot.

Table 8-1 Current loop sample times

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

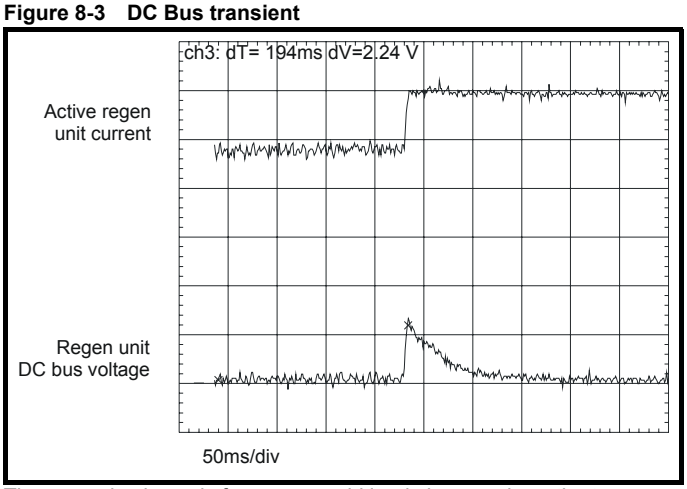
Even when the voltage controller gain is set correctly there will be a transient change of DC bus voltage when there is a change in the load on any motoring drive connected to the Regen drive. This can be reduced substantially by using an analogue input for power feed forward compensation.

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 *DC Bus transient* .

Figure 8-3 DC Bus transient



The example shown is for a very rapid load change where the torque reference of the motor drive has been changed instantly from one value to another.

The proportional gain of the voltage controller, Kp, 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 DC Bus voltage 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 (∆V) 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 (∆V.)

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

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

Where:

K_L = Load change / 200%

K_{RAT} = Drive voltage rating / 400

K_{MV} = Motor voltage / 400

K_{SP} = 700 / 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 8-2 *Rate of change* gives an approximate indication of the reduction in ∆V for different time constants. (As already mentioned the value of ∆V 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 8-2 Rate of change

Time constant	Change in ∆V
20ms	x 0.75
40ms	x 0.5

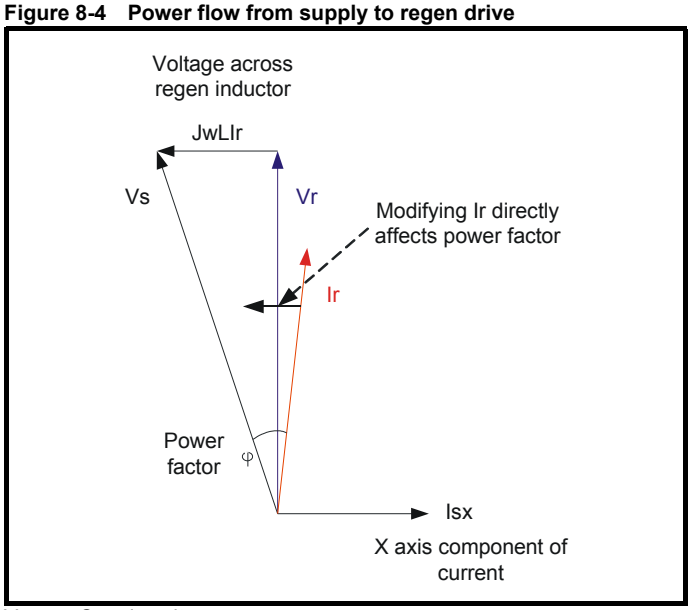
The transient produced is approximately proportional to the voltage controller gain Pr **3.06**. The default voltage controller gain is set to give a value that is suitable for most applications. The gain may need to be increased if the DC bus capacitance is high compared to two drives of

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 drives 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 Pr **4.08** can be increased from zero.

Figure 8-4 Power flow from supply to regen drive



Vs	Supply voltage
Vr	Voltage at regen drive terminals
Ir	Total current at regen drive terminals
JwLIr	Voltage across regen inductor
φ	Power factor

8.5 Current trimming

From software V1.10 for Unidrive SP the current trimming can be user configurable. The default setting for the current trimming in software V1.10 is as with previous software versions.

The current trimming mode parameter (Pr **3.11**) defines the strategy used for trimming the current feedback when operating in regen mode with Unidrive SP.

The two modes that can be selected are as detailed following

Mode 1 - At power up only [Pr **3.11** = 0]
Current trimming is only carried out once after power-up, as previously available (pre software V1.10) with Unidrive SP Regen.

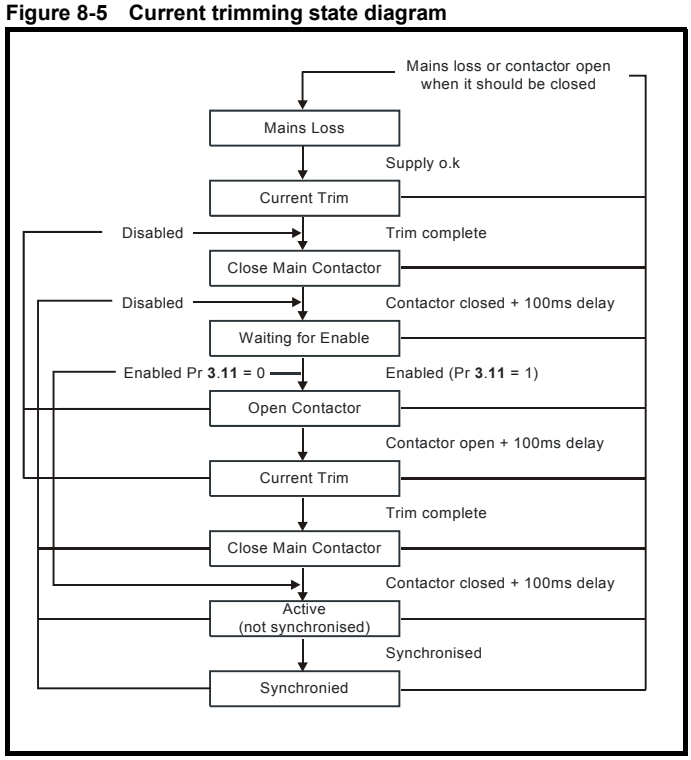
Mode 2 - At power up and on each enable [Pr **3.11** = 1]
Current trimming is carried out as previously available, once after power-up, and now in addition it is also carried out before the drive runs each time it is enabled (software V1.10 onwards) with Unidrive SP Regen.

Mode 2 (Pr **3.11** = 1) is available to allow the current trimming to be optimised, and overcome any inaccuracies due to noise / harmonics from the AC Supply connected to the regen system.

If operating in Mode 2 (Pr **3.11** = 1) the auxiliary contact on the "Regen drive main contactor" as shown in this installation guide needs to be moved from T.31 to T.25 to allow the current trimming to be carried out during each enable. The current trimming only occurs when the main contactor is open, therefore when the regen drive enable signal is given with Mode 2 (Pr **3.11** = 1) the main contactor will open and close before the regen drive becomes active.

Both strategies are shown in the following state machine

Figure 8-5 Current trimming state diagram



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 3-2 on page 14.
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%): $\textbf{CURRENT_LIMIT_MAX} = \left(\frac{\textbf{Maximum current}}{\textbf{Regen drive rated current}}\right) \times \textbf{100\%}$ 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. $\textbf{REGEN_REACTIVE_MAX} = \sqrt{\left(\left[\frac{\textbf{Reactive drive current} \times \textbf{1.75}}{\textbf{Regen drive rated current}}\right]^2 - \textbf{Pr 4.07}^2\right)} \times \textbf{100\%}$ 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 = √3 x AC_VOLTAGE_MAX x RATED_CURRENT x 1.75 Software V01.08.00 and later: POWER_MAX = √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)		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 (3kHz)	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	DC voltage for supply healthy
200 V	205 Vdc	75 Vac	215 Vdc
400 V	410 Vdc	150 Vac	430 Vdc
575 V	540 Vdc	225 Vac	565 Vdc
690 V	540 Vdc	225 Vac	565 Vdc

Figure 9-1 Menu 3 Regen logic diagram

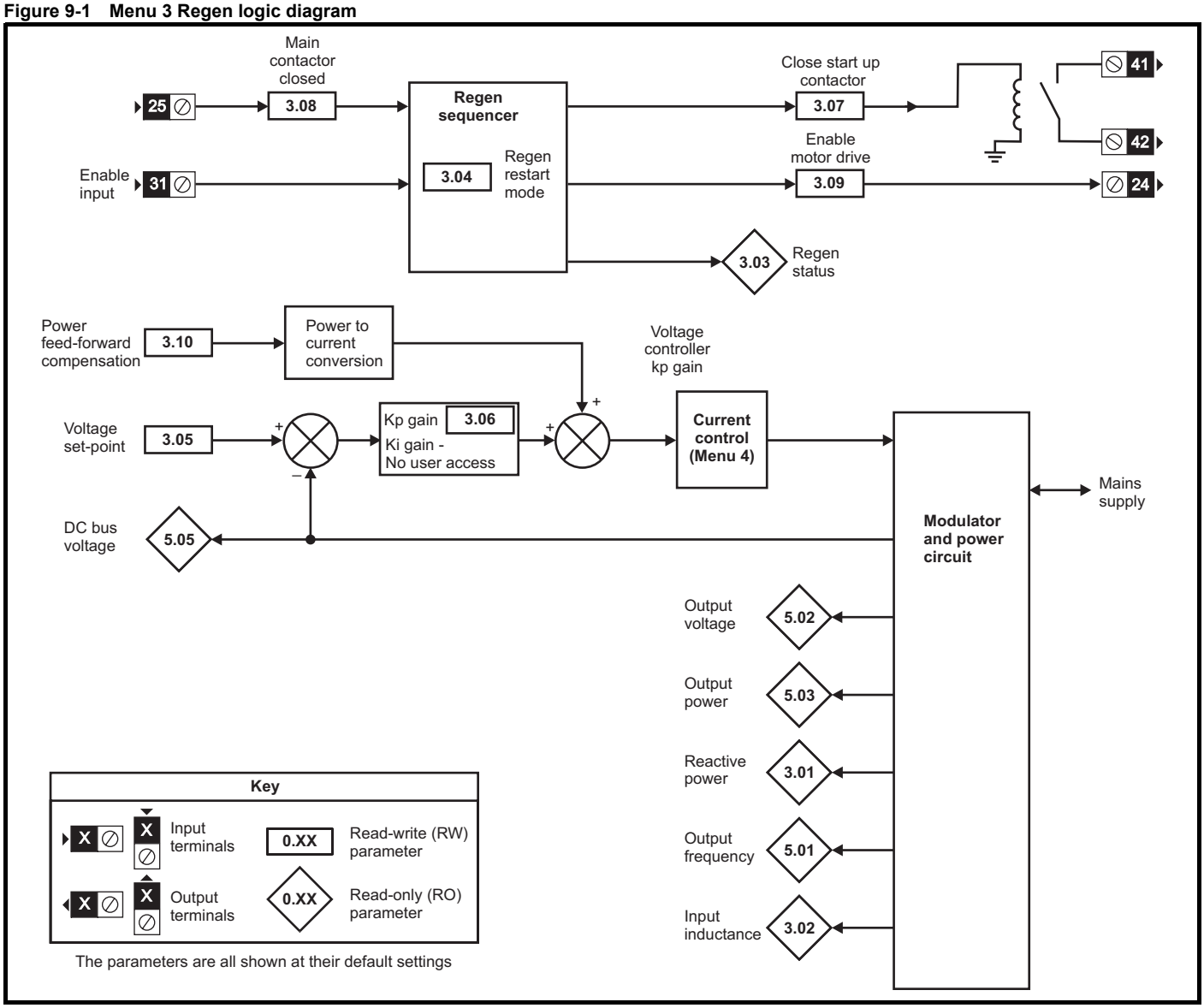
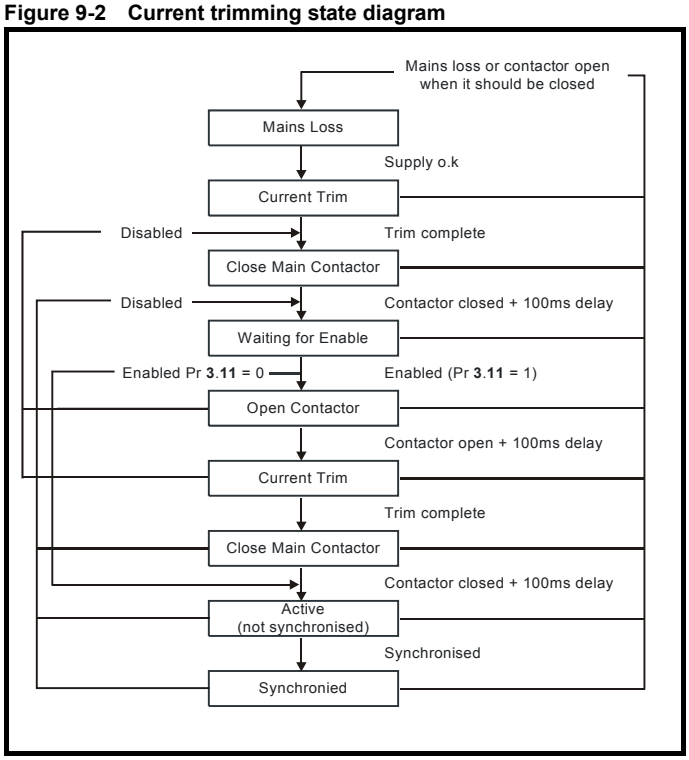


Table 9-3 Menu 3 Regen parameter descriptions

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		
3.11	Current trimming mode	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

Figure 9-2 Current trimming state diagram



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

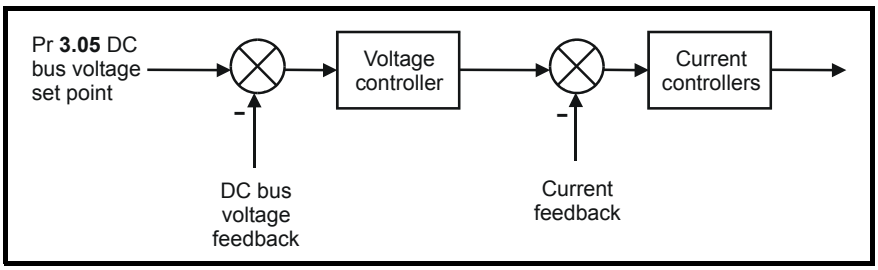
Attempt to synchronise for 30s. If unsuccessful after this time then give a LI.SYnC trip. After a failure during running, trip immediately.

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								200V rating drive: 350 400V rating drive: 700 575V rating drive: 835 690V rating drive: 1005							
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 unit 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.

Setting the current controller gains

The most critical parameter for stability is the current controller proportional gain (Pr **4.13**). The required value for this is dependent on the Regen unit input inductance. If the inductance of the supply is a significant proportion of the recommended regen inductor (i.e. 60/IDR mH per phase, where IDR is equivalent to Kc), 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 below using the total inductance per phase. The current controller integral gain Pr **4.14** is not so critical, and in a majority of cases the default value is suitable. However, if it is necessary to adjust this parameter it should be set up as described below using the supply resistance for one phase.

The proportional gain Kp (Pr **4.13**) is the most critical value in controlling the performance of the current controllers. The value can be set by the user so that

$Kp = (L / T) \times (I_{fs} / V_{fs}) \times (256 / 5)$

Where:

T is the sample time of the current controllers. The drive compensates for any change of sample time, and so it should be assumed that the sample time is equivalent to the lowest sample rate of 167µs.

L is the total inductance per phase

I_{fs} is the peak full scale current feedback = Kc x √2 / 0.45. Where Kc is the current scaling for each size of drive.

V_{fs} is the maximum DC link voltage.

Therefore:

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

Where:

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

There is one value of the scaling factor K for each drive voltage rating as shown in the table below.

Drive voltage rating	Vfs	K
200V	415V	2322
400V	830V	1161
575V	990V	973
690V	1190V	809

The integral gain Ki (Pr **4.14**) is less critical and should be set so that

$Ki = Kp \times 256 \times T / \tau_m$

where

τ_m is the time constant (L / R).

R is the resistance of the supply for one phase.

Therefore

$Ki = (K \times L \times Kc) \times 256 \times 167\mu s \times R / L = 0.0427 \times K \times R \times Kc$

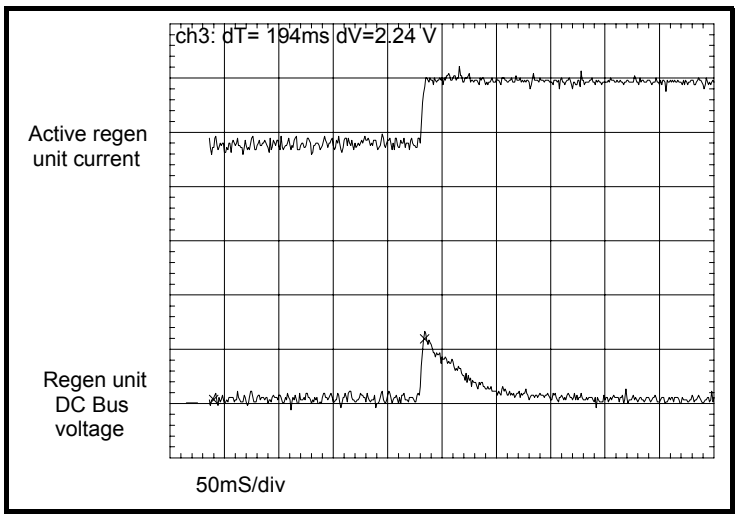
The above equations give the gain values that should give the best response at all switching frequencies with minimal overshoot. If required the gains can be adjusted to improve performance as follows:

1. The integral gain (Ki) can be used to improve the performance of the current controllers by reducing the effects of inverter non-linearity. These effects become more significant with higher switching frequency. These effects will more significant for drives with higher current ratings and higher voltage ratings. If Ki is increased by a factor of 4 it is possible to get up to 10% overshoot in response to a step change of current reference. For high performance applications, it is recommended that Ki is increased by a factor of 4 from the auto-tuned values. As the inverter non-linearity is worse with higher switching frequencies it is may be necessary to increase Ki by a factor of 8 for operation with 16kHz switching frequency.
2. It is possible to increase the proportional gain (Kp) to reduce the response time of the current controllers. If Kp is increased by a factor of 1.5 then the response to a step change of reference will give 12.5% overshoot. It is recommended that Ki is increased in preference to Kp.

Setting the voltage controller gain

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 drive connected to the Regen unit. This can be reduced substantially by using an analogue input for power feed forward compensation (see Pr **3.10**). 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 bus will rise and then fall as shown below.



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 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 unit will trip.

When a 400V motor is operated above base speed from a drive in vector mode, fed from the Regen unit 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 = load change / 200%

K_{RAT} = Drive voltage rating / 400

K_{MV} = motor voltage / 400

K_{SP} = 700 / DC Bus voltage set point

In some applications, particularly with a high d.c. 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 (i.e. using 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.) The following table gives an approximate indication of the reduction in ΔV for different time constants. (As already mentioned the value of ΔV given if 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).

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

The transient produced is approximately proportional to the voltage controller gain. 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.

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 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 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
200V	215	205	75
400V	430	410	150
575V	565	540	225
690V	565	540	225

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

3.11	**Current trimming 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 1								
Default	Regen							0								
Update rate	4ms read															

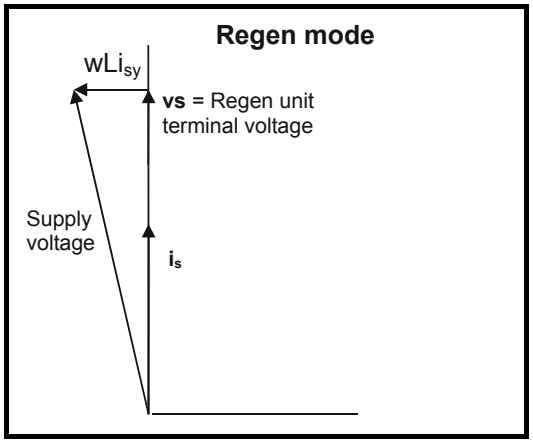
This parameter defines the strategy used for current trimming in regen mode. If Pr **3.11**=0 then current trimming is only carried out once after power-up. If Pr **3.11**=1 current trimming is carried out after power-up and then before the drive runs each time it is enabled.

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%):

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

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.

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

Figure 9-3 Menu 4 Regen logic diagram

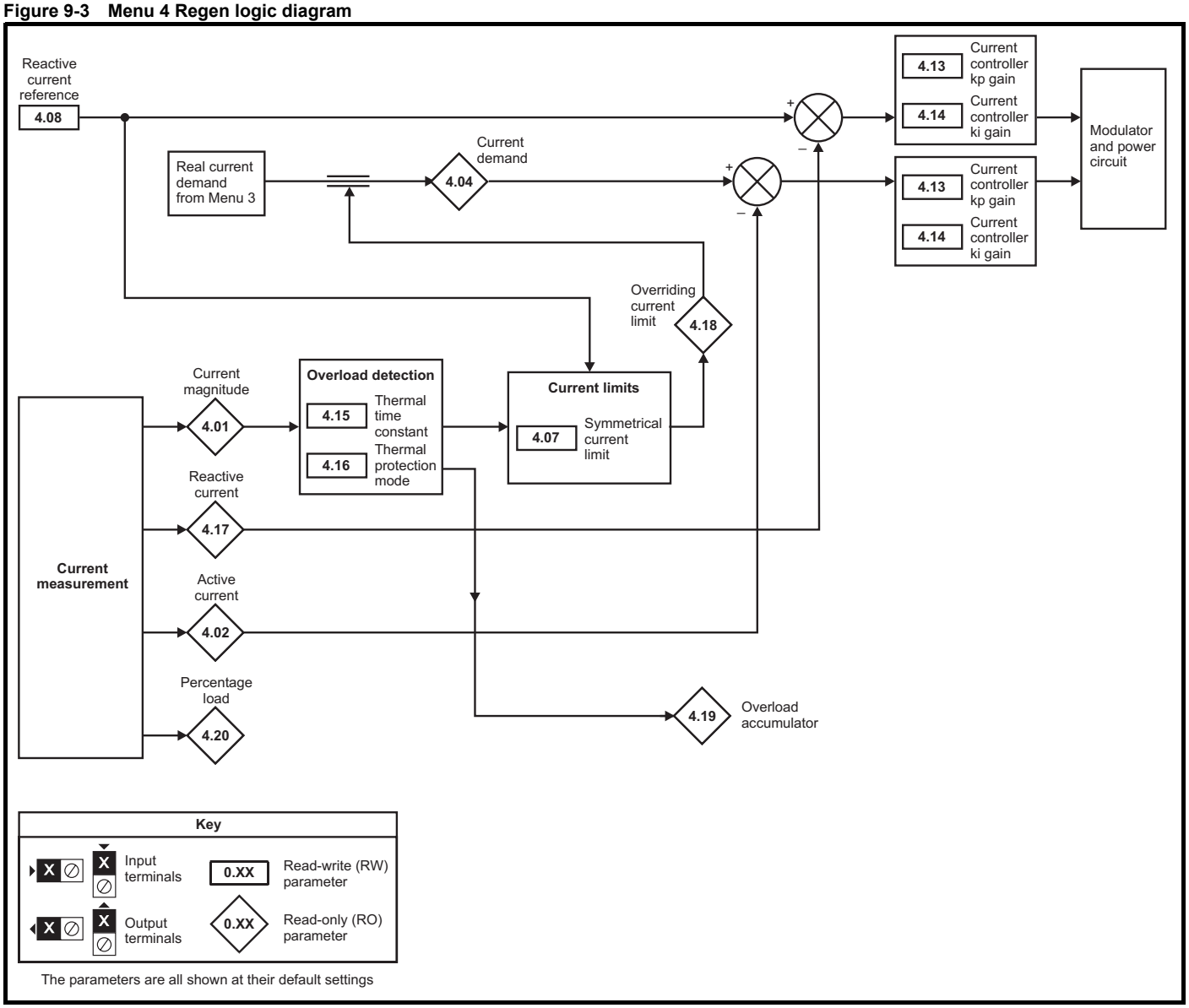


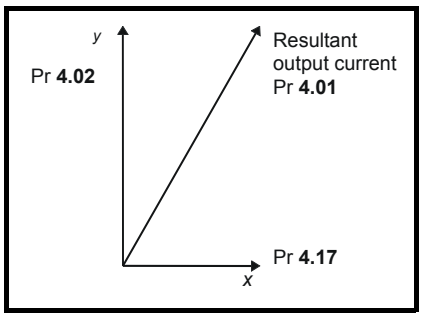
Table 9-4 Menu 4 Regen parameter descriptions

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	
4.05									
4.06									
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.

4.05	Motoring 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															

4.06	Regen 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															

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 link voltage can no longer be controlled. The motoring current limit applies with either phase rotation at the input when power is being taken from the supply. Similarly the regen current limit applies with either phase rotation at the input when power is being fed back into the supply. The symmetrical current limit can override either motoring or regenerating current limit if it is set at a lower value than either limit.

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							200V: 45 400V: 90 575V: 110 690V: 130								
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							200V: 1000 400V: 2000 575V: 2400 690V: 3000								
Update rate	Background															

The defaults Kp and Ki gains should be suitable for the standard regen inductors.

Setting the current controller gains

The most critical parameter for stability is the current controller proportional gain (Pr **4.13**). The required value for this is dependent on the Regen unit 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 equivalent to Kc), 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 below using the total inductance per phase. The current controller integral gain Pr **4.14** is not so critical, and in a majority of cases the default value is suitable. However, if it is necessary to adjust this parameter it should be set up as described below using the supply resistance for one phase.

The proportional gain Kp (Pr **4.13**) is the most critical value in controlling the performance of the current controllers. The value can be set by the user so that :

$$Kp = (L / T) \times (I_{fs} / V_{fs}) \times (256 / 5)$$

Where:

T is the sample time of the current controllers. The drive compensates for any change of sample time, and so it should be assumed that the sample time is equivalent to the lowest sample rate of 167µs.

L is the total inductance per phase.

I_{fs} is the peak full scale current feedback = Kc x √2 / 0.45. Where Kc is the current scaling for each size of drive.

V_{fs} is the maximum DC link voltage.

Therefore:

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

Where:

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

There is one value of the scaling factor K for each drive voltage rating as shown in the table below.

Drive voltage rating	V_{fs}	K
200V	415V	2322
400V	830V	1161
575V	990V	973
690V	1190V	809

The integral gain Ki (Pr **4.14**) is less critical and should be set so that:

$$Ki = Kp \times 256 \times T / \tau_m$$

Where:

τ_m is the time constant (L / R).

R is the resistance of the supply for one phase.

Therefore:

Ki = (K x L x Kc) x 256 x 167µs x R / L = 0.0427 x K x R x Kc

The above equations give the gain values that should give the best response at all switching frequencies with minimal overshoot. If required the gains can be adjusted to improve performance as follows:

1. The integral gain (Ki) can be used to improve the performance of the current controllers by reducing the effects of inverter non-linearity. These effects become more significant with higher switching frequency. These effects will more significant for drives with higher current ratings and higher voltage ratings. If Ki is increased by a factor of 4 it is possible to get up to 10% overshoot in response to a step change of current reference. For high performance applications, it is recommended that Ki is increased by a factor of 4 from the auto-tuned values. As the inverter non-linearity is worse with higher switching frequencies it is may be necessary to increase Ki by a factor of 8 for operation with 16kHz switching frequency.
2. It is possible to increase the proportional gain (Kp) to reduce the response time of the current controllers. If Kp is increased by a factor of 1.5 then the response to a step change of reference will give 12.5% overshoot. It is recommended that Ki is increased in preference to Kp.

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) x 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:

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

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

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

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

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

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 105.

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															

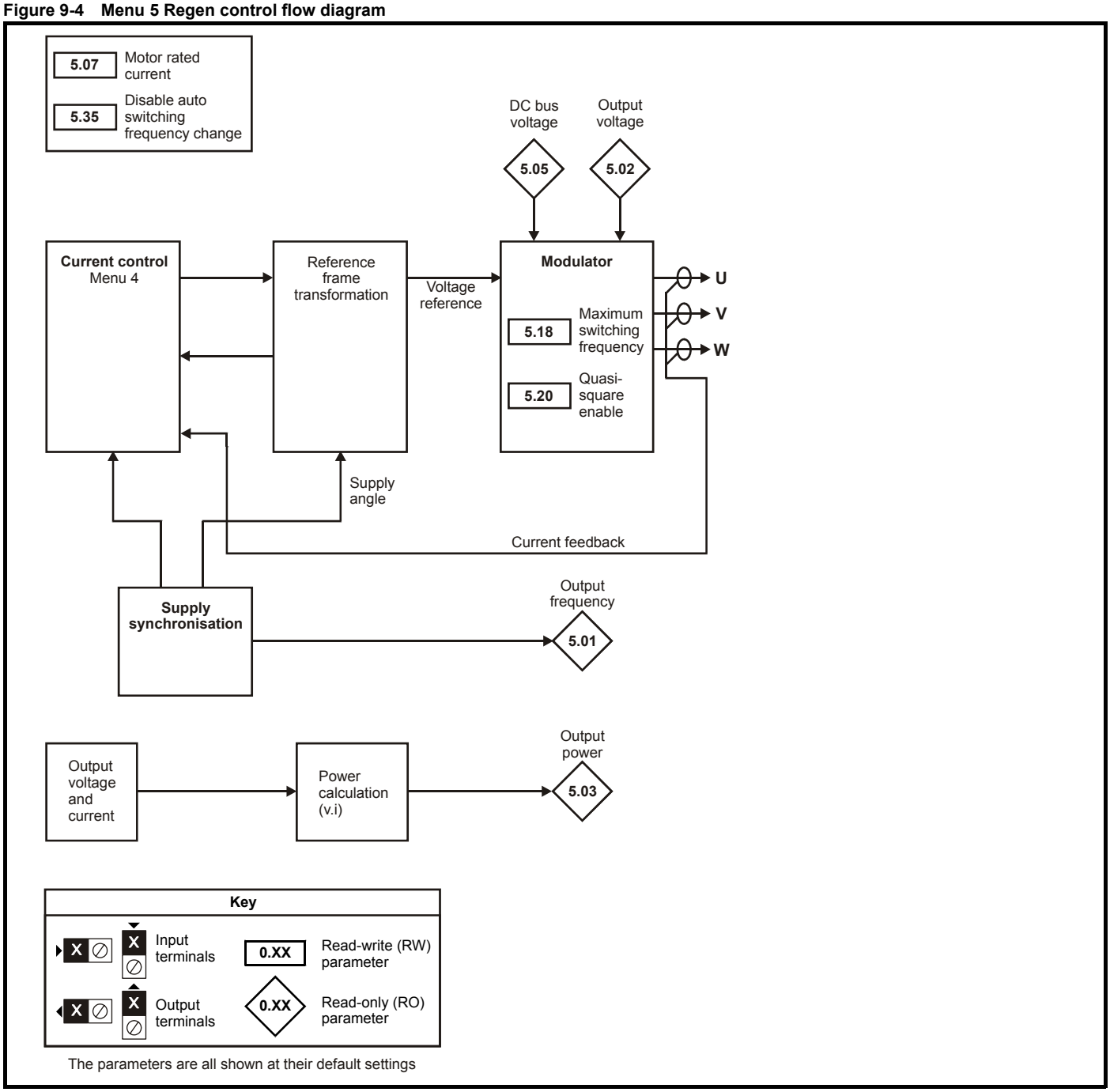
This parameter displays the active current (Pr **4.02**) as a percentage of the rated current (Pr **5.07** or Pr **21.07**). Positive values indicate power flow from the supply and negative values indicate power into the supply.

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 9-4 Menu 5 Regen control flow diagram



The parameters are all shown at their default settings

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	**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	**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	**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															

The value of this parameter is used for the thermal protection in regen mode.

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 109). 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.ht1 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	Time critical user interface
Background	N/A	N/A	Non-time critical user interface

NOTE

All switching frequencies can be used in regen mode with reduced losses at the higher switching frequencies.

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 109) 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.

5.37	Actual 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	
Default	Regen							0 to 7								
Update rate	Background Write															

Pr **5.37** shows the actual switching frequency used by the inverter. The maximum switching frequency is set with Pr **5.18**, but this may be reduced by the drive if automatic switching frequency changes are allowed (Pr **5.35**=1).

Value	String	Switching frequency (kHz)	Current controller Sample time (us)
0	3	3	167
1	4	4	125
2	6	6	83
3	8	8	125
4	12	12	83
5	16	16	125
6	6 rEd	6	167
7	12 rEd	12	167

5.49	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		1	
Default	Regen							0 to 4								
Update rate	Background read															

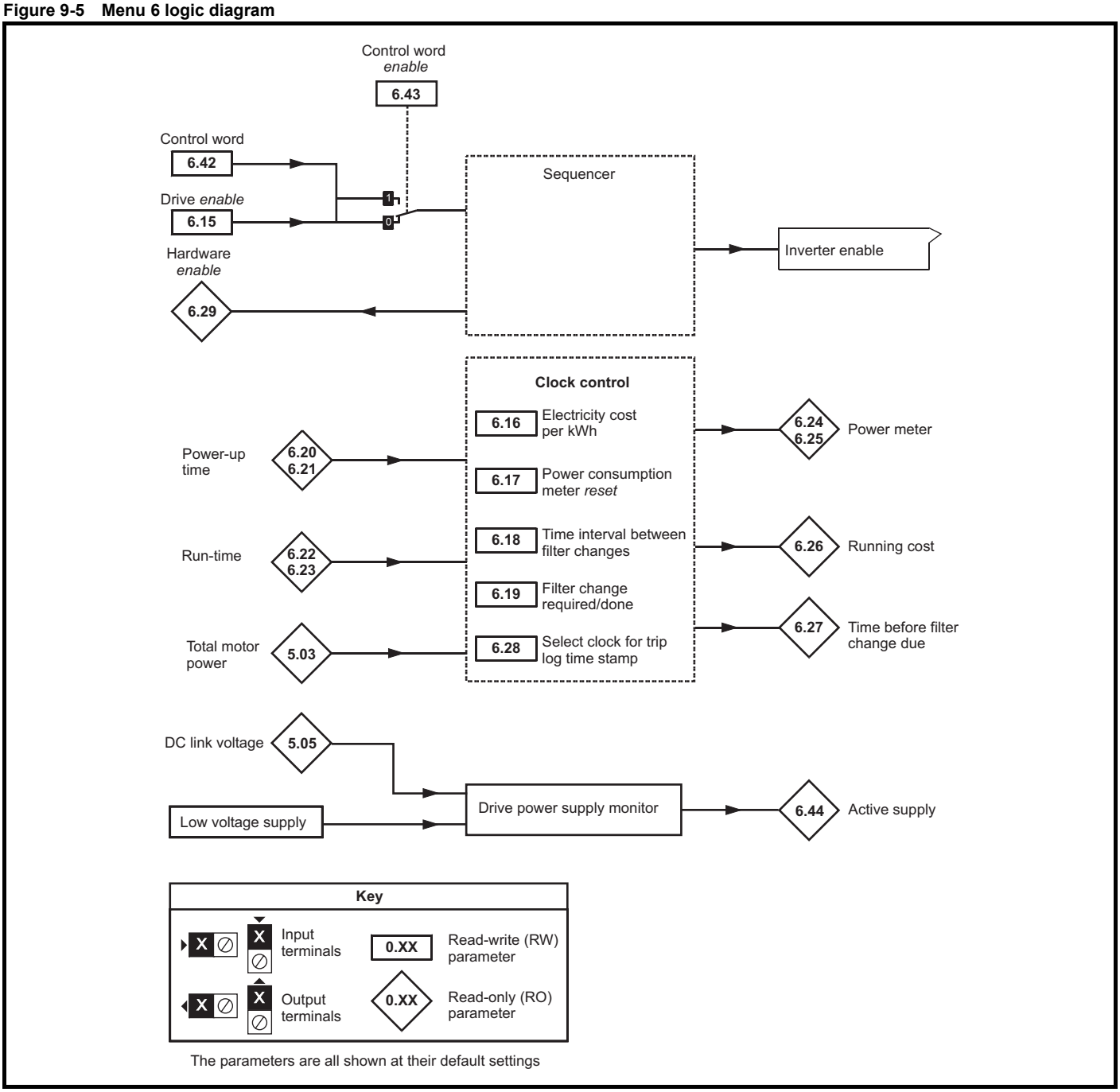
5.50	Security unlock															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1	1	1		1	1	
Default	Regen							0 to 999								
Update rate	Background read															

Pr **5.49** and Pr **5.50** are not visible from the keypad and are intended for internal use by the drive.

Parameter	Function
5.49	Holds the actual drive mode that is active. The user can change the required drive mode in Pr **11.31**, but the value in Pr **11.31** is only copied to this parameter when the drive mode is changed.
5.50	Holds the value of the security entered to allow parameters to be edited when security is enabled.

9.6 Menu 6: Clock

Figure 9-5 Menu 6 logic diagram



The parameters are all shown at their default settings

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 113.

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. If the destination of one of the drive digital I/O (Pr **8.21** to Pr **8.26**) is set to Pr **6.29** and the I/O is set as an input the state of the input does not affect the value of this parameter as it is protected, however, it does provide a fast disable function. The secure disable input to the drive (T31) disables the drive in hardware by removing the gate drive signals from the inverter IGBT's and also disables the drive via the software system. When the drive is disabled by de-activating the secure disable input there can be a delay of up to 20ms. However, if a digital I/O is set up to provide the fast disable function it is possible to disable the drive within 600µs of de-activating the input. To do this the enable signal should be connected to both the secure disable (T31) and to the digital I/O selected for the fast disable function. The state of the digital I/O including the effect of its associated invert parameter is ANDed with the secure disable to enable the drive.

If the safety function of the Secure Disable input is required then there must not be a direct connection between the Secure Disable input (T31) and any other digital I/O on the drive. If the safety function of the Secure Disable input and the fast disable function is required then the drive should be given two separate independent enable signals. A safety related enable from a safe source connected to the Secure Disable input on the drive. A second enable connected to the digital I/O on the drive selected for the fast disable function. The circuit must be arranged so that a fault which causes the fast input to be forced high cannot cause the Secure Disable input to be forced high, including the case where a component such as a blocking diode has failed.

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 either a high voltage supply or a low voltage supply, usually from a battery. Different methods are used to connect the low voltage battery supply depending on the frame size of the drive. This parameter, which indicates which supply is active, is set up to the correct value just as the UU trip is reset. A low voltage battery supply should not be used without first consulting the appropriate documentation on the power and control connections required for this mode.

0: Normal high voltage supply

The drive is operating in normal high voltage supply mode.

SP1xxx, SP2xxx, SP3xxx:

The drive is using the main power terminals to derive its control supplies. The drive will operate normally. Parameters that are saved at power-down are saved when the supply is removed and a UU trip occurs.

SP4xxx, SP5xxx, SP6xxx, SPMxxxx:

The drive is using the main power terminals to derive its control supplies and the battery mode enable power supply input has no supply connected. The drive will operate normally. Parameters that are saved at power-down are saved when the supply is removed and a UU trip occurs

1: Low voltage battery supply

The drive is operating in low voltage battery supply mode.

SP1xxx, SP2xxx, SP3xxx:

The drive is using the low voltage auxiliary power input to derive the power circuit supplies (i.e. gate drives, fans, etc.). The main power terminals can be connected to a different supply of any voltage up to the maximum normal supply level. All parameters voltage based parameters are calculated from the auxiliary supply level 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.

SP4xxx and larger:

The drive is using the battery mode enable input to derive the power circuit supplies (i.e. gate drives, fans, etc.) A low voltage DC supply is connected to the DC power terminals. All parameters that are calculated based on voltage are derived from the voltage connected to the power terminals. Parameters that are saved at power-down are not saved when the power is removed in this mode.

For all sizes of drive in low voltage battery mode, 24V must also be supplied via the 24V control board power supply input. The drive will operate normally except that mains loss detection is disabled, the braking IGBT will only operate when the drive is enabled, and 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

Full scale voltage measurement and the over voltage trip level are defined by DC_VOLTAGE_MAX. However, the maximum level of the low voltage battery supply voltage should not normally exceed 90% of this value to avoid spurious over voltage trips.

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	Regen							48 - 48 - SP1 drives 48 - 72 - SP2, SP3 drives 48 - 72 - For all other 200V drives 48 - 96 - For all other 400V, 575V and 690V drives								
Default	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.

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.

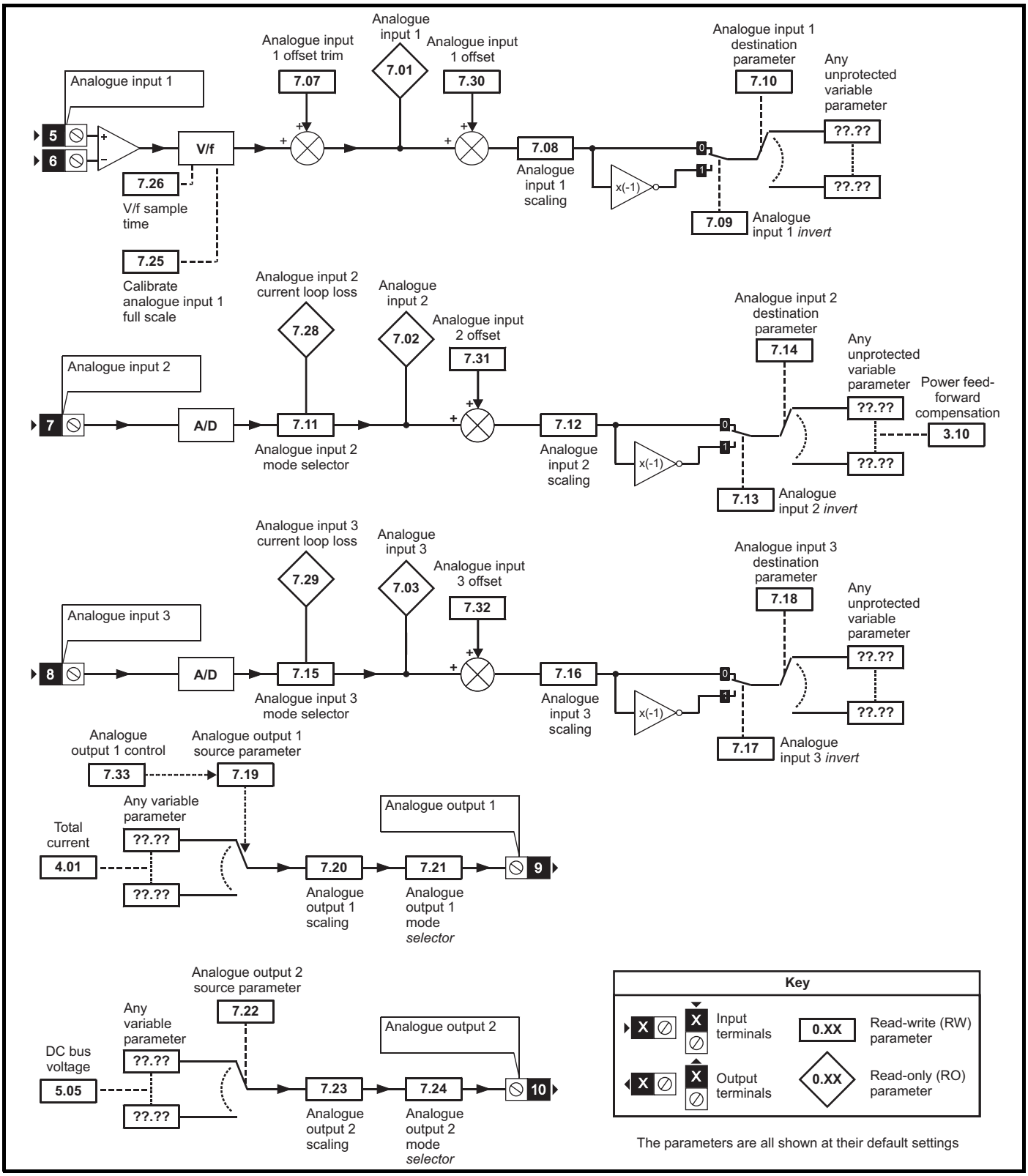
6.50	Drive comms state															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
					1			1		1		1			1	
Range	Regen							0 to 3								
Update rate	Background															

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
3. 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 9-6 Menu 7 logic diagram



The parameters are all shown at their default settings

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 **3.10** - 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 = Rated drive current / 0.45
Pr **4.17** - magnetising current	10.0V = 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 (vsy x isy). 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															

This input operates in voltage mode only where -9.8V and +9.8V at the input correspond with -100.0% and 100.0% respectively in this parameter.

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															

These inputs can operate in different modes defined by Pr **7.11** and Pr **7.15**.

In current modes (modes 0 to 5) the minimum and maximum current values given in mA correspond with 0.0% and 100.0% respectively in Pr **7.02** and Pr **7.03**. Therefore in modes 2 and 4 the parameter is at 0.0% when the input current is less than 4mA, and in modes 3 and 5 the parameter is at 100.0% when the input current is less than 4mA.

In voltage mode (mode 6) -9.8V and +9.8V at the input correspond with -100.0% and 100.0% respectively in Pr **7.02** and Pr **7.03**.

When analogue input 3 is in thermistor mode (modes 7 to 9) the display indicates the resistance of the thermistor as a percentage of 10kΩ

7.04	Power circuit 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	Power circuit 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															

For drive sizes SP1xxx to SP5xxx two temperatures are available from the power circuit, and these are displayed in Pr **7.04** and Pr **7.05**. For drive sizes SP0xxx, SP6xxx and SPMxxxx three temperatures are available from the power circuit, and these are displayed in Pr **7.04**, Pr **7.05** and Pr **7.36**. If SPMxxxx drives consist of more that one parallel power module the temperatures displayed are the highest value from any of the parallel modules.

If the temperature displayed in Pr **7.04**, Pr **7.05** or Pr **7.36** exceeds the trip threshold for the parameter, the drive does not have parallel power modules and is not a single power module that uses the parallel power module hardware, an Oht2 trip is initiated. This trip can only be reset if the parameter that has caused the trip falls below the trip reset level. If the temperature exceeds the alarm level a "hot" alarm is displayed. If the temperature for any of these monitoring points is outside the range -20°C to 150°C it is assumed that the monitoring thermistor has failed and a hardware fault trip is initiated (Pr **7.04** - HF27, Pr **7.05** and Pr **7.36** - HF28).

Table 9-9 Power stage temperature 1 (Pr 7.04) in °C

Drive size	Trip temperature	Trip reset temperature	Alarm temperature
SP0xxx	TBA	TBA	TBA
SP1xxx	110	105	100
SP2xxx	115	110	100
SP3xxx	120	115	100
SP4xxx	72	67	68
SP5xxx	72	67	68
SP6xxx	92	87	85
SPMxxxx	96	91	88

Table 9-10 Power stage temperature (Oht2)

Drive size	Trip temperature
SP6xxx	67
SPMxxxx	71

Additional monitoring is used with drives sizes SP6xxx and SPMxxxx to detect failure of the power stage cooling fan. If this fan fails the monitoring point used to derive power stage temperature 1 that is nearest the fan will rise temperature above it s normal level, but not above the trip temperature for power stage. This is detected and can initiate an Oht2 trip. The trip thresholds are show below.

Table 9-11 Power stack temperature 2 (Pr 7.05) in °C

Drive size	Trip temperature	Trip reset temperature	Alarm temperature
SP0xxx	TBA	TBA	TBA
SP1xxx	92	87	85
SP2xxx	100	95	95
SP3xxx	98	93	94
SP4xxx	78	73	72
SP5xxx	78	73	72
SP6xxx	78	73	72
SPMxxxx	78	73	72

Table 9-12 Power stack temperature 3 (Pr 7.36) in °C

Drive size	Trip temperature	Trip reset temperature	Alarm temperature
SP0xxx	TBA	TBA	TBA
SP1xxx	N/A	N/A	N/A
SP2xxx	N/A	N/A	N/A
SP3xxx	N/A	N/A	N/A
SP4xxx	N/A	N/A	N/A
SP5xxx	N/A	N/A	N/A
SP6xxx	85	80	80
SPMxxxx	125	100	120

The control board temperature is also monitored and displayed in Pr **7.06**. If the temperature displayed exceeds 92°C an O.Ctl trip is initiated, and this trip can only be reset if the temperature falls below 87°C. If the temperature exceeds 85°C a "hot" alarm is displayed. If the temperature is outside the range from -20°C to 150°C it is assumed that the monitoring thermistor has failed and an HF29 hardware fault trip is initiated.

Drive cooling fan

The drive cooling fan is controlled by the temperature from monitoring points and other actions as follows:

1. If Pr **6.45** = 1 the fan is at full speed for at least 10s.
2. If an option module indicates that it is too hot the fan is at full speed for at least 10s.
3. For drive sizes SP0xxx to SP2xxx the fan is at full speed if the drive is enabled and the highest power circuit temperature (Pr **7.04** or Pr **7.05**) or the temperature calculated for the case of the IGBT package exceed the threshold for the drive. The fan is at its low speed if this temperature falls to 5°C below the threshold or the drive is disabled and the temperature is below the alarm level for Pr **7.04** and Pr **7.05**.
4. For drive sizes SP3xxx to SPMxxxx the fan speed is controlled above its minimum level if the drive is enabled and the highest power circuit temperature (Pr **7.04**, Pr **7.05** or Pr **7.36**) or the temperature calculated for the case of the IGBT package exceed the lower threshold for the drive. The maximum fan speed is reached when the highest of these temperatures exceeds the upper threshold. The fan is at its minimum speed if the drive is disabled and the temperature is below the alarm level for Pr **7.04**, Pr **7.05** and Pr **7.36**.

The thresholds are given in Table 9-13 in °C.

Table 9-13 Temperature thresholds for fan operation

Drive size	Fan threshold	Lower fan threshold	Upper fan threshold
SP0xxx	TBA	N/A	N/A
SP1xxx	60	N/A	N/A
SP2xxx	60	N/A	N/A
SP3xxx	N/A	55	70
SP4xxx	N/A	55	62
SP5xxx	N/A	55	62
SP6xxx	N/A	55	65
SPMxxxx	N/A	55	65

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

In voltage mode the output range is -10V to 10V. If the scaling parameter is 1.000 then -10V and 10V are produced when the source parameter is at -maximum and maximum respectively. Different scaling can be applied with Pr **7.23**. If the result of the scaling produces an output of more than +/-100% the output is clamped within the +/-10V range.

In current modes with a scaling parameter of 1.000 the minimum and maximum current are produced when the source parameter is at 0 and maximum respectively. Therefore in 4 - 20mA mode the output is 4mA when the source parameter is zero. Different scaling can be applied with Pr **7.23**. If the result of the scaling produces an output of more than 100% the output is clamped at 20mA

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

In voltage mode the output range is -10V to 10V. If the scaling parameter is 1.000 then -10V and 10V are produced when the source parameter is at - maximum and maximum respectively. Different scaling can be applied with Pr **7.23**. If the result of the scaling produces an output of more than +/- 100% the output is clamped within the +/-10V range.

In current modes with a scaling parameter of 1.000 the minimum and maximum current are produced when the source parameter is at 0 and maximum respectively. Therefore in 4 - 20mA mode the output is 4mA when the source parameter is zero. Different scaling can be applied with Pr **7.23**. If the result of the scaling produces an output of more than 100% the output is clamped at 20mA

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 Pr **7.26** x 500 x 103, therefore the default setting gives approximately 11 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 109).

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.

7.36	**Power circuit temperature 3**															
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 write															

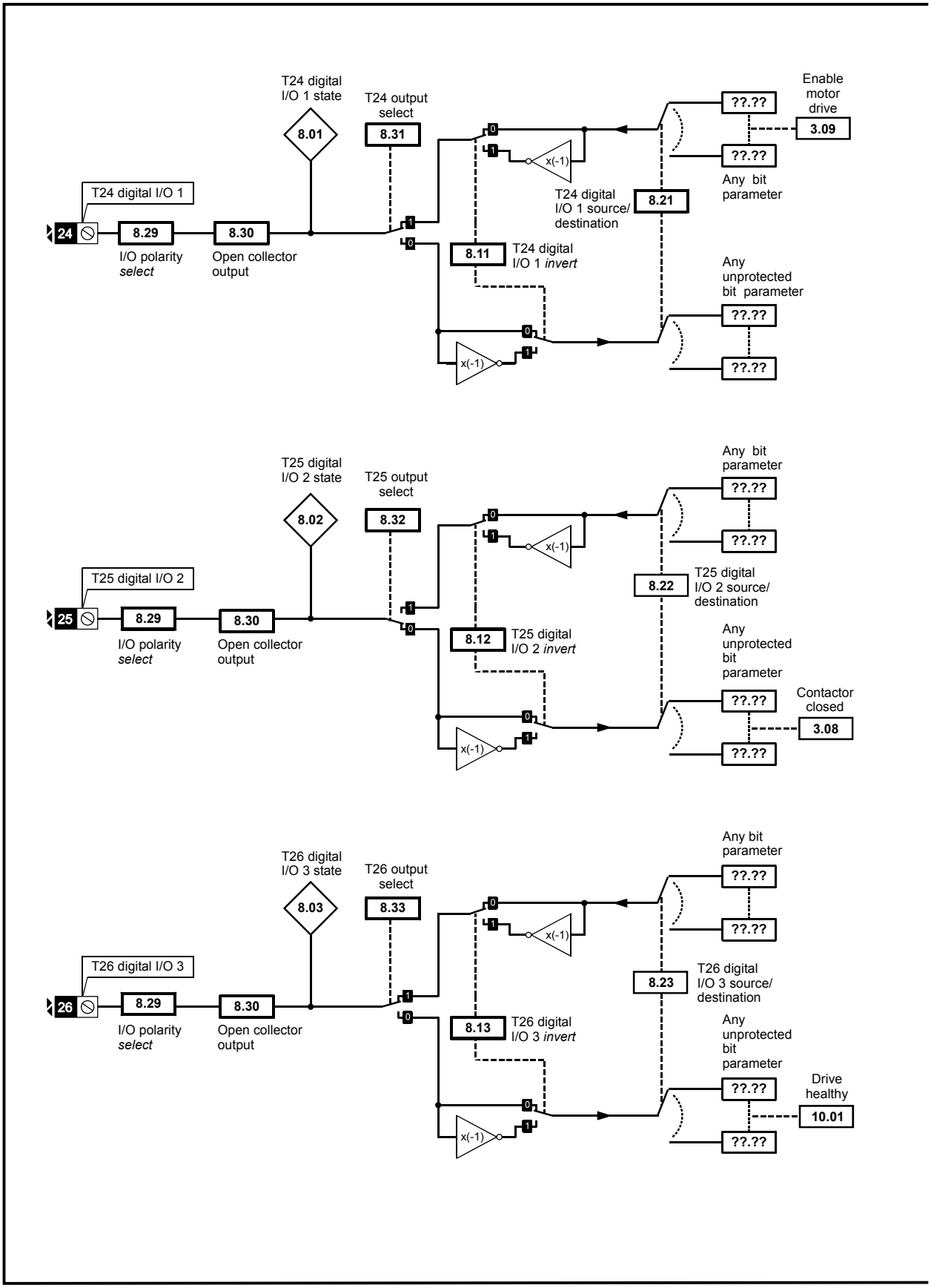
An additional thermal monitoring point is provided in UNISP6xxx and UNISP7xxx drives. The temperature is displayed in this parameter in degrees C. See Pr **7.04** to Pr **7.06** for more details.

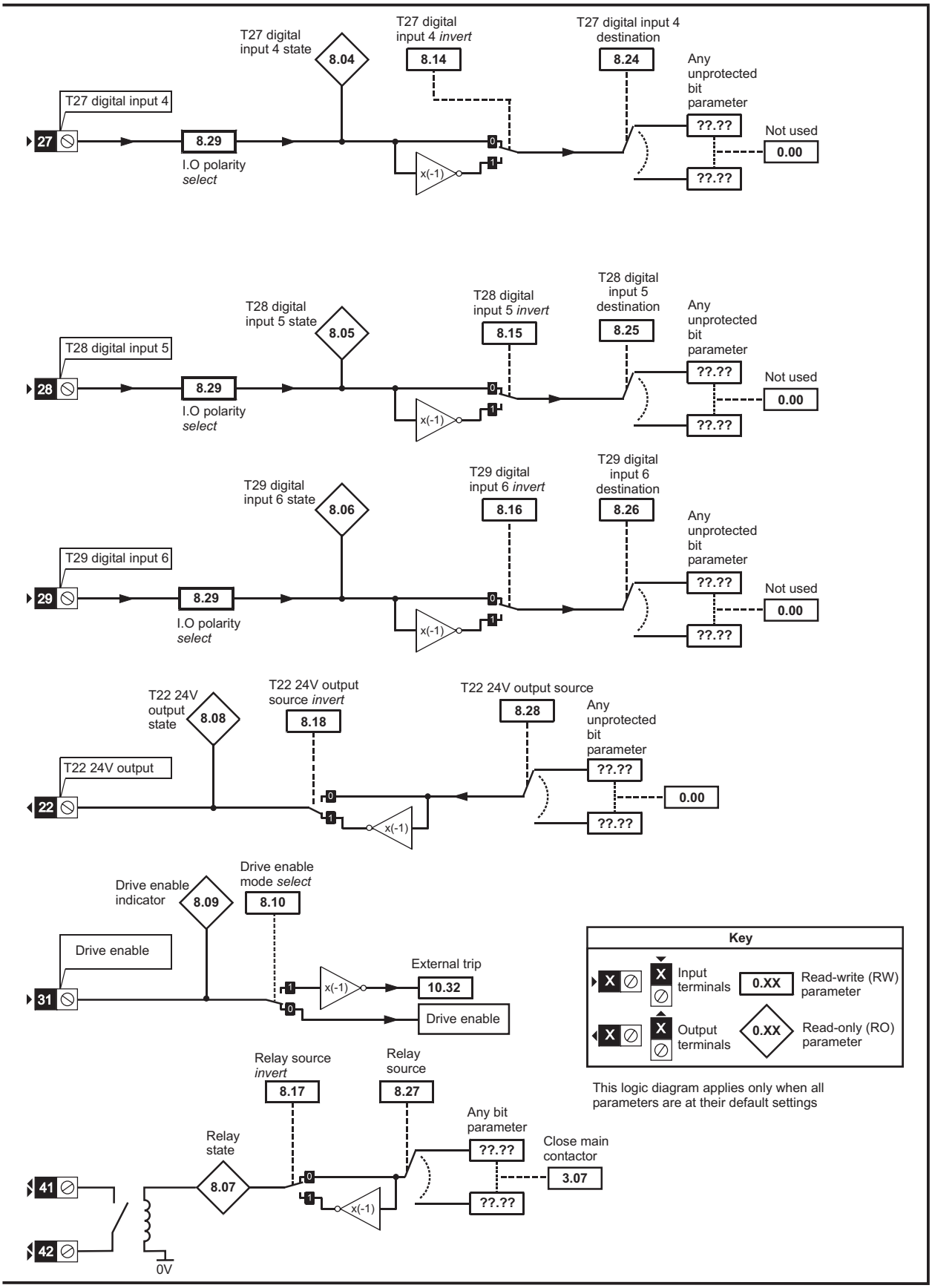
7.51	**Analogue input 1 full scale**															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
								1		1	1	1			1	
Range	Regen							0 to 153600								
Update rate	Background read															

When analogue input 1 is calibrated the number of V to F converter counts is measured by the drive over 64ms and the result is stored in this parameter. The maximum input frequency is 2.4MHz, and so the maximum for this parameter is 153600. If calibration is performed so that the drive 10V reference is used this parameter is zero. It should be noted that although the input frequency for a 10V input is nominally 2.0MHz the resolution is not given by 2.0MHz x sample period, but due to the structure of the V to F system the resolution is 500kHz x sample period.

9.8 Menu 8: Digital I/O

Figure 9-7 Menu 8 logic diagram




T27 digital input 4
27
8.29
I.O polarity select
T27 digital input 4 state
8.04
T27 digital input 4 invert
8.14
x(-1)
T27 digital input 4 destination
8.24
Any unprotected bit parameter
??.??
??.??
Not used
0.00
T28 digital input 5
28
8.29
I.O polarity select
T28 digital input 5 state
8.05
T28 digital input 5 invert
8.15
x(-1)
T28 digital input 5 destination
8.25
Any unprotected bit parameter
??.??
??.??
Not used
0.00
T29 digital input 6
29
8.29
I.O polarity select
T29 digital input 6 state
8.06
T29 digital input 6 invert
8.16
x(-1)
T29 digital input 6 destination
8.26
Any unprotected bit parameter
??.??
??.??
Not used
0.00
T22 24V output
22
T22 24V output state
8.08
T22 24V output source invert
8.18
x(-1)
T22 24V output source
8.28
Any unprotected bit parameter
??.??
??.??
0.00
Drive enable
31
Drive enable indicator
8.09
Drive enable mode select
8.10
x(-1)
External trip
10.32
Drive enable
Key
Input terminals
Output terminals
0.XX
Read-write (RW) parameter
Read-only (RO) parameter
This logic diagram applies only when all parameters are at their default settings
41
42
0V
Relay state
8.07
Relay source invert
8.17
Relay source
8.27
x(-1)
Any bit parameter
??.??
??.??
Close main contactor
3.07

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 9-14 Digital I/O

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 Secure disable	Pr **8.09**						

Table 9-15 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 9-14 on page 134								
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 9-14 on page 134								
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															

NOTE

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.

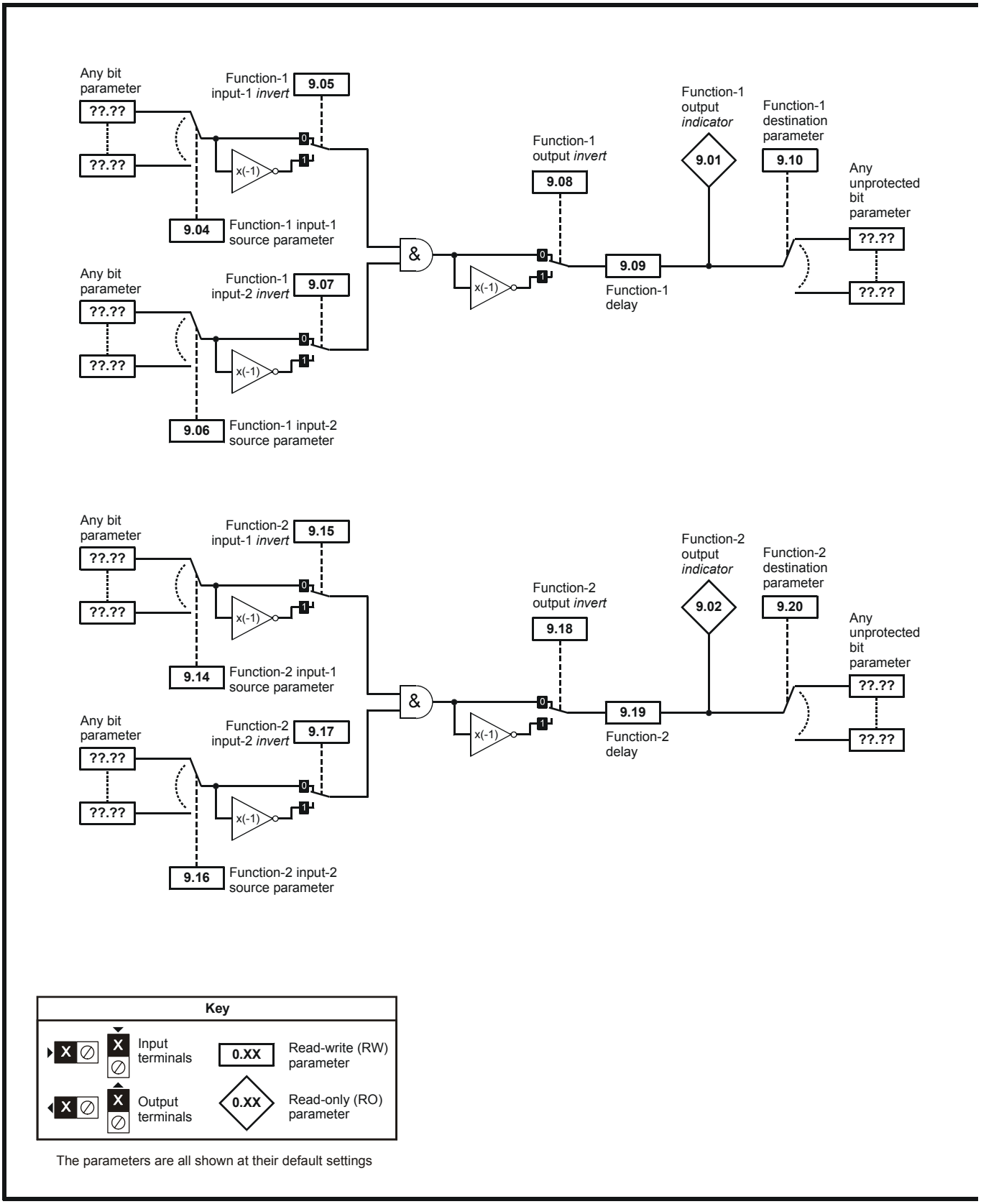
Reference select Pr 1.14		Pr 8.25 set to:	Pr 8.26 set to:
0, A1.A2	Reference selection by terminal input	Pr **1.41** - Analogue ref 2 select	Pr **6.31** - jog
1, A1.Pr	Analogue reference 1 or presets selected by terminal input	Pr **1.45** - preset select bit 0	Pr **1.46** - preset select bit 1
2, A2.Pr	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

NOTE

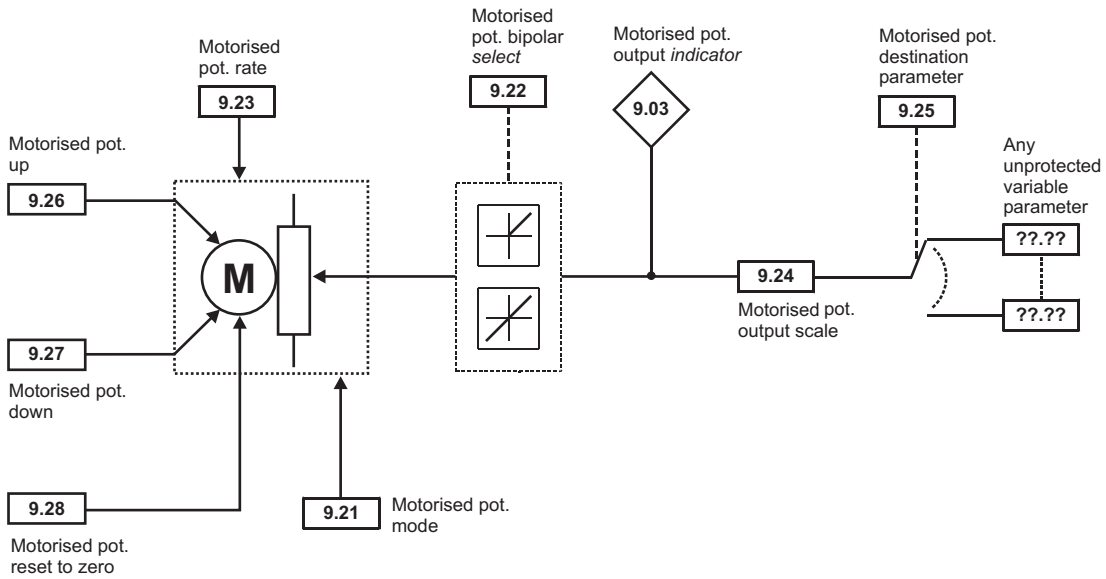
This parameter has no effect in Regen mode.

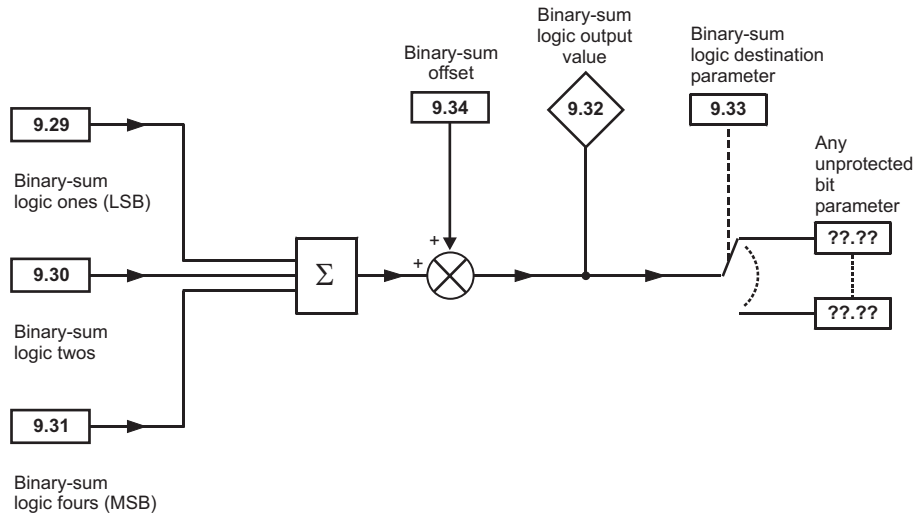
9.9 Menu 9: Programmable logic, motorised pot and binary sum

Figure 9-8 Menu 9 logic diagram



The parameters are all shown at their default settings


Motorised pot. rate
9.23
Motorised pot. bipolar *select*
9.22
Motorised pot. output *indicator*
9.03
Motorised pot. destination parameter
9.25
Any unprotected variable parameter
??.??
??.??
Motorised pot. up
9.26
M
9.24
Motorised pot. output scale
9.27
Motorised pot. down
9.28
Motorised pot. reset to zero
9.21
Motorised pot. mode


Binary-sum offset
9.34
Binary-sum logic output value
9.32
Binary-sum logic destination parameter
9.33
Any unprotected bit parameter
??.??
??.??
9.29
Binary-sum logic ones (LSB)
9.30
Binary-sum logic twos
9.31
Binary-sum logic fours (MSB)
Σ
+
+

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 9-16 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															

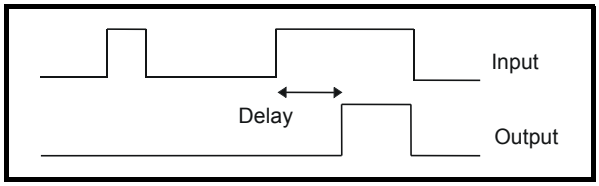
9.06	**Logic function 1 source 2**															
9.16	**Logic function 2 source 2**															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2					1	1	1	1	
Range	Regen							Pr **0.00** to Pr **21.51**								
Default	Regen							Pr **0.00**				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

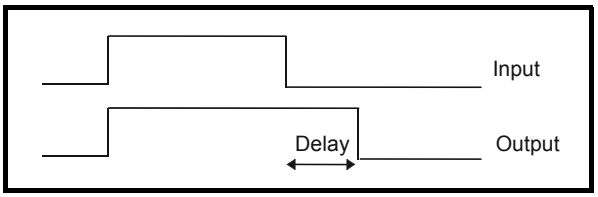
9.08	**Logic function 1 output invert**															
9.18	**Logic function 2 output invert**															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
	1												1	1		
Default	Regen							0								
Update rate	4ms x number of menu 9 or 12 functions active															

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. ±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:

Offset + ones input + (2 x twos input) + (4 x fours input)

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

If destination parameter maximum ≤ (7 + Offset):
Destination parameter = Binary sum output

If destination parameter maximum > (7 + Offset):
Destination parameter = Destination parameter maximum x Binary sum output / (7 + Offset)

9.10 Menu 10: Status and trips

Table 9-17 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 149	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 206.

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 148). 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 109 and Pr **7.06** on page 122).

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

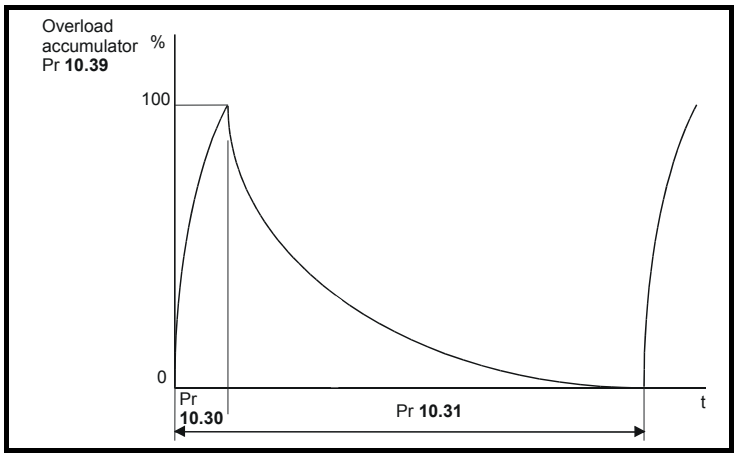
This parameter defines the time period that the braking resistor fitted can stand full braking volts without damage. The setting of this parameter is used in determining the braking overload time.

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.



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} = 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 x R / 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, $P_{av} = P_{on} \times T_{on} / Tp$

Where:

Tp is the full power braking period

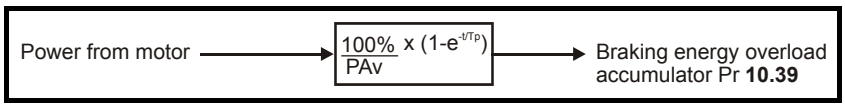
$P_{on} = E / T_{on}$

Therefore $P_{av} = E / Tp$

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

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 know 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 OI.AC, OI.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 9-18								
Update rate	Background															

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

Table 9-18 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	ANSIx3.28 protocol
1	rtU	Modbus RTU protocol
2	Lcd	Modbus RTU protocol, but only with an LCD keypad

ANSIx3.28 protocol

Full details of the CT implementation of ANSIx3.28 are given in Chapter 7 *Serial communications protocol* in the *Unidrive SP Advanced User Guide*.

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 drive mode is not changed.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 148 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

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

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 9-9 Menu 12 logic diagram

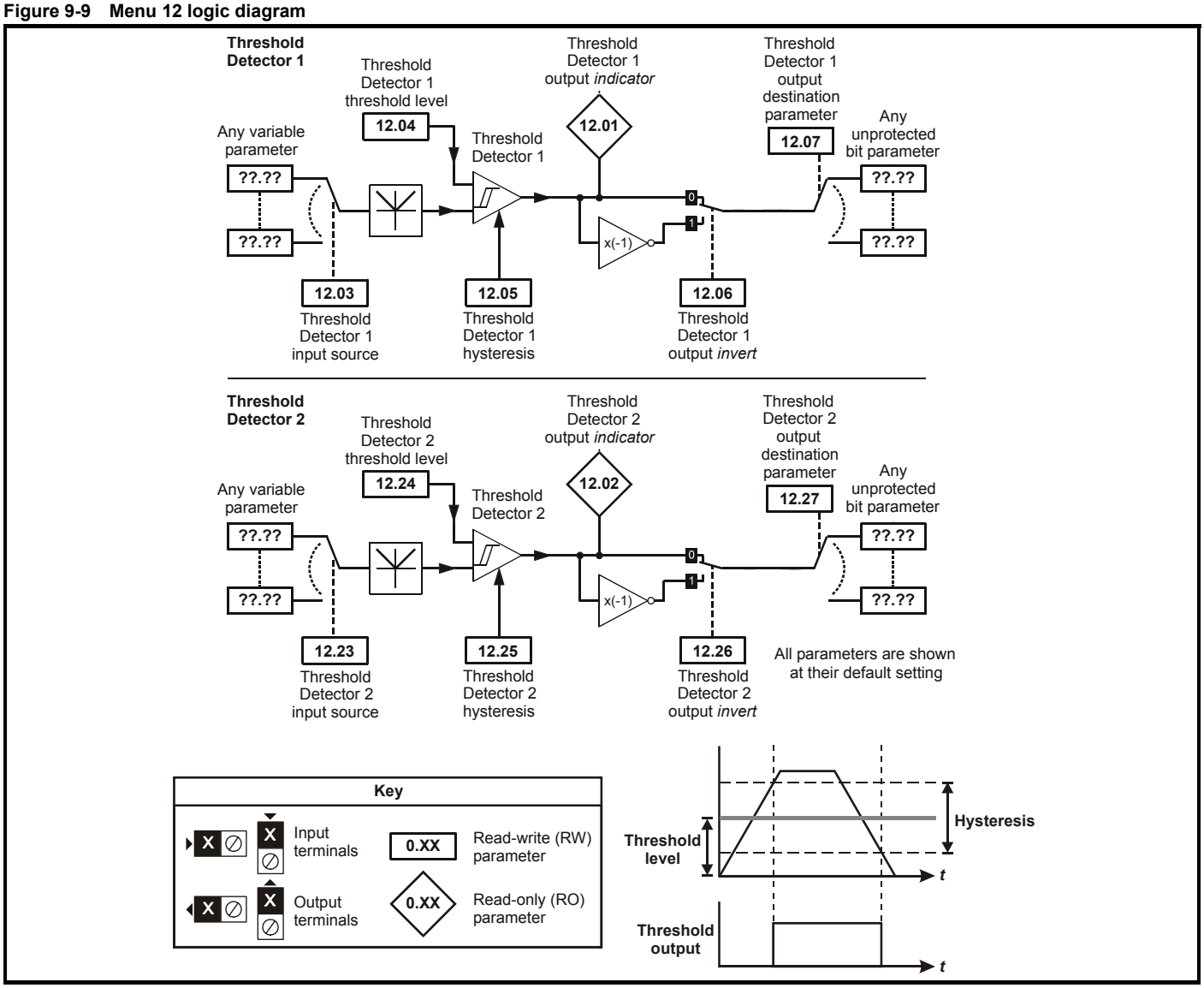
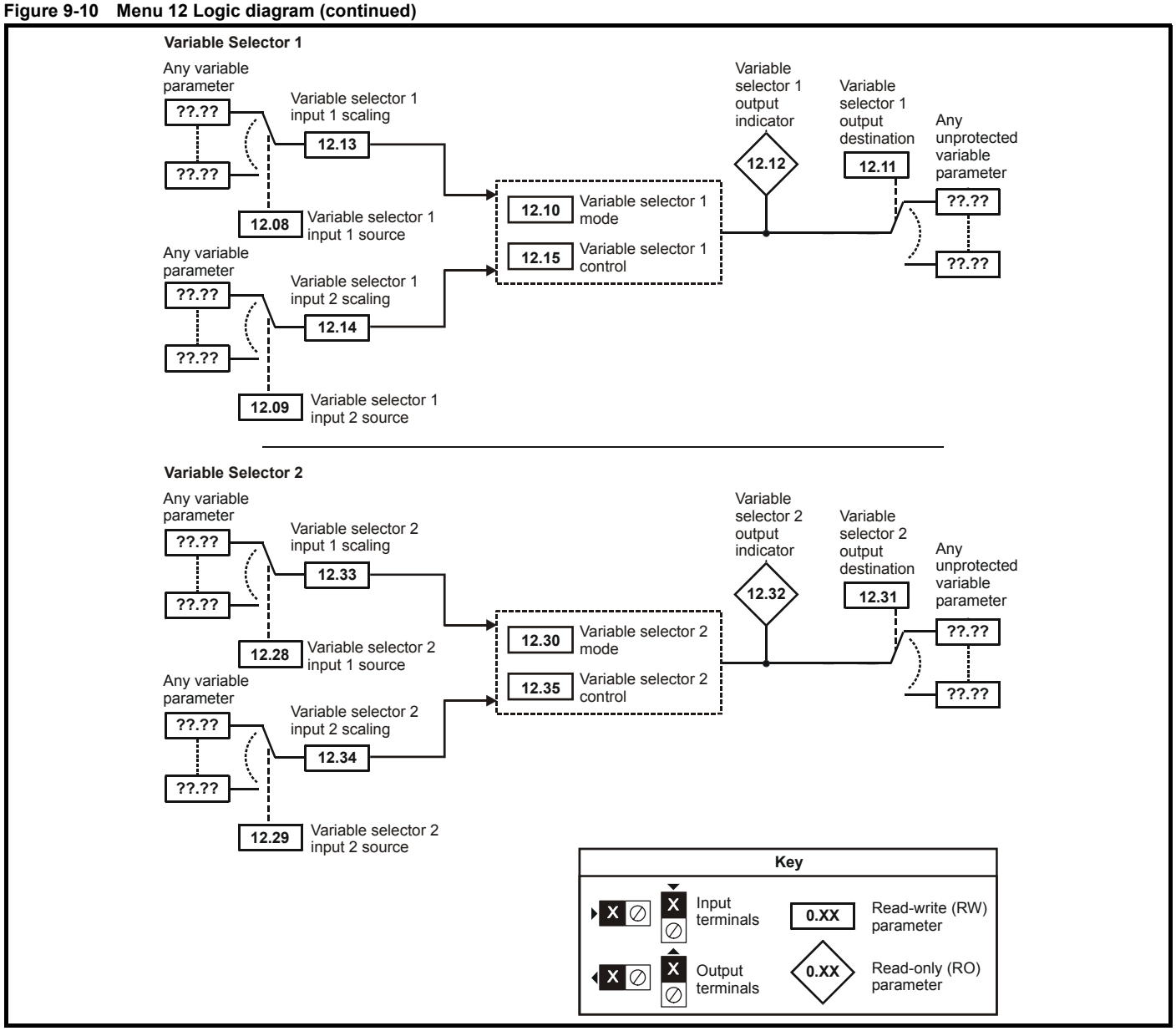


Figure 9-10 Menu 12 Logic diagram (continued)



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.

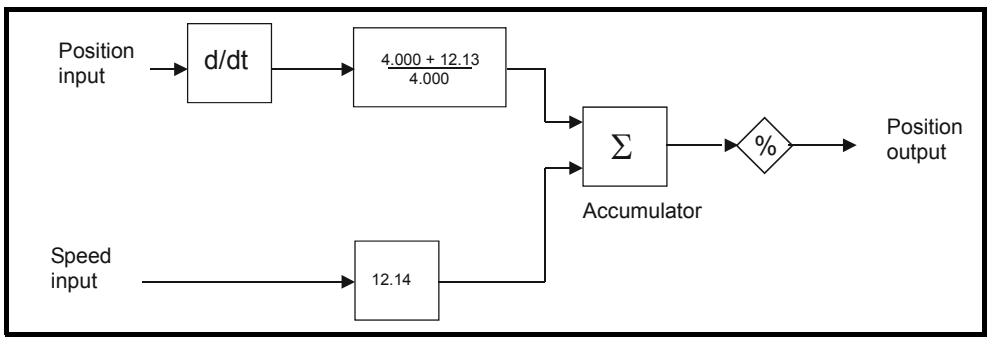
Mode value	Action	Result
0	Select input 1	output = input1
1	Select input 2	output = input2
2	Add	output = input1 + input2
3	Subtract	output = input1 - input 2
4	Multiply	output = (input1 x input2) / 100.0
5	Divide	output = (input1 x 100.0) / input2
6	Time constant	output = input1 / ((control param)s + 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 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.

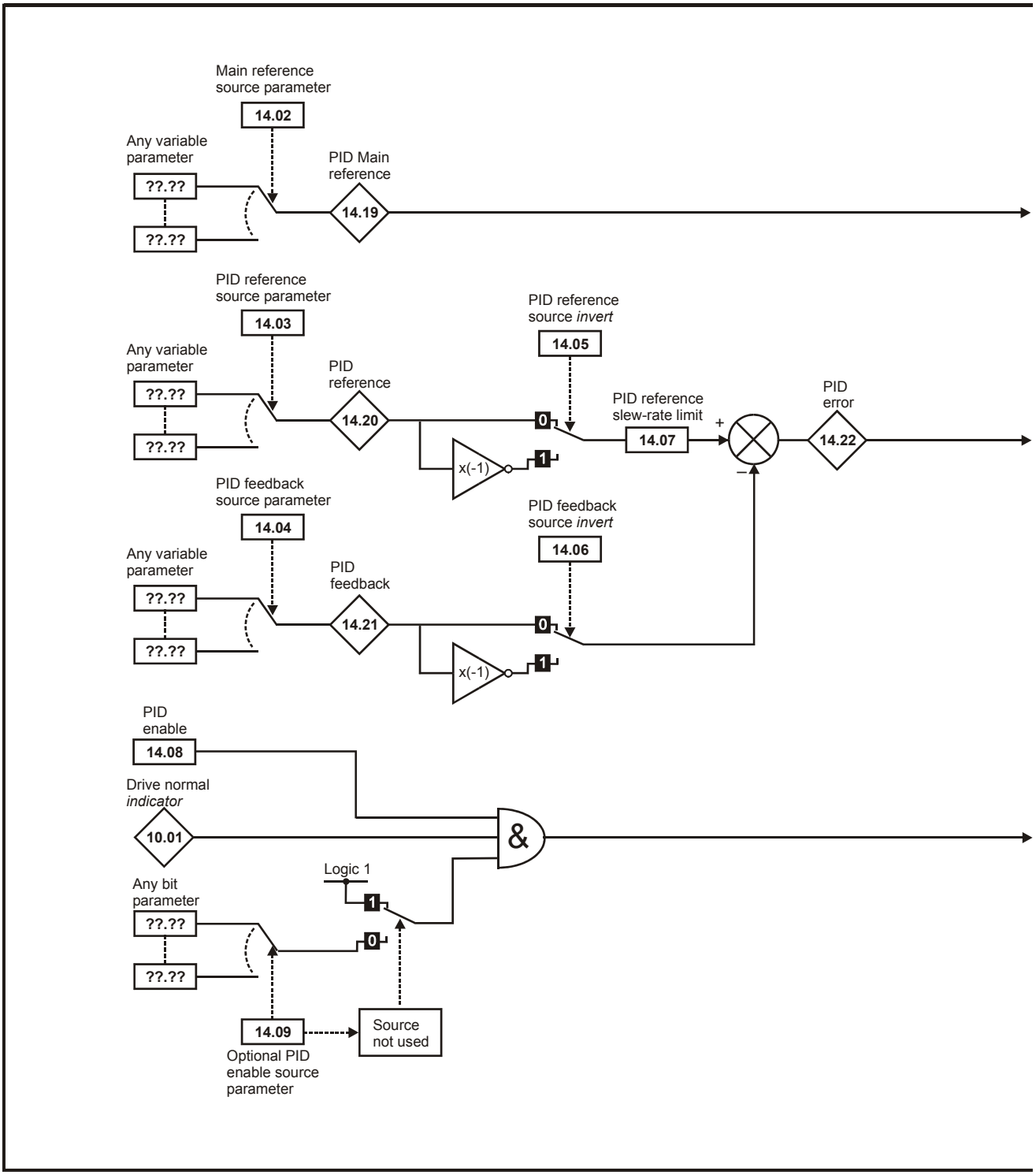
The speed input defines a speed offset with a resolution of 0.1rpm. Full scale of the source parameter corresponds to 1000.0rpm. Scaling may be applied using Pr **12.14** to give a full scale value of 4000.0rpm. The speed input is added to the accumulator to move the output position forwards or backwards with respect to the position input.

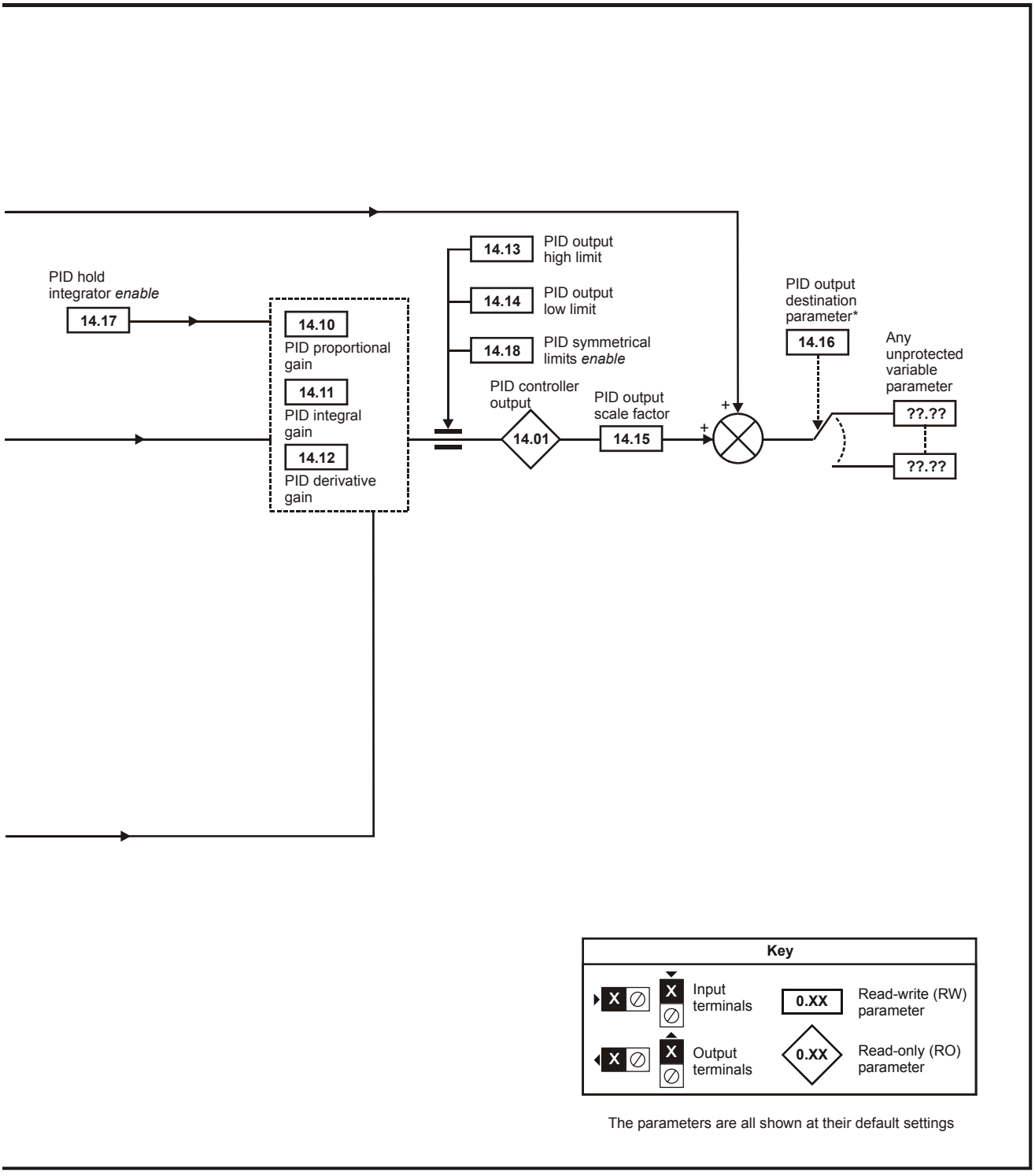
This sample time for this function is 4ms x number of menu 9 and 12 functions active. Extending the sample time does not cause any overflow errors within the function, however, care must be taken to ensure that the input or output positions do not change by more than half a revolution within the sample 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 9-11 Menu 14 logic diagram





The parameters are all shown at their default settings

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

output = error x [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															

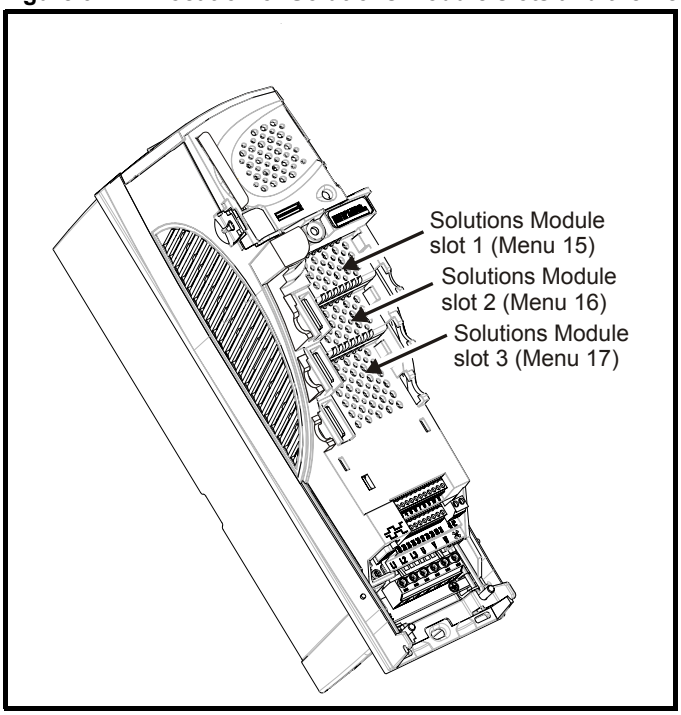
14.20	PID reference															
Drive mode	Regen															
Coding	Bit	SP	FI	DE	Txt	VM	DP	ND	RA	NC	NV	PT	US	RW	BU	PS
							2	1		1		1				
Range	Regen							±100.00 %								
Update rate	4ms															

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 9-12 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 9-19								
Update rate	Background read															

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

Table 9-19 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 Drive

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

Table 10-1 Maximum permissible continuous output current @ 40°C (104°F) ambient for wall mounted drives

Model	Normal Duty								Heavy Duty							
	Nominal rating		Maximum permissible continuous output current (A) for the following switching frequencies						Nominal rating		Maximum permissible continuous output current (A) for the following switching frequencies					
	kW	hp	3kHz	4kHz	6kHz	8kHz	12kHz	16kHz	kW	hp	3kHz	4kHz	6kHz	8kHz	12kHz	16kHz
SP1201	1.1	1.5	5.2						0.75	1.0	4.3					
SP1202	1.5	2.0	6.8						1.1	1.5	5.8					
SP1203	2.2	3.0	9.6						1.5	2.0	7.5					
SP1204	3.0	3.0	11.0						2.2	3.0	10.6					
SP2201	4.0	5.0	15.5						3.0	3.0	12.6					
SP2202	5.5	7.5	22.0						4.0	5.0	17.0					
SP2203	7.5	10	28.0			27.9	24.8	21.8	5.5	7.5	25.0		24.2	22.5	19.6	17.2
SP3201	11	15	42.0						7.5	10	31.0					
SP3202	15	20	54.0				48.5		11	15	42.0				41.3	
SP4201	18.5	25	68.0						15	20	56.0					
SP4202	22	30	80.0						18.5	25	68.0					
SP4203	30	40	104						22	30	80.0					
SP5201	37	50	130						30	40	105					
SP5202	45	60	154						37	50	130					
SP1401	1.1	1.5	2.8						0.75	1.0	2.1					
SP1402	1.5	2.0	3.8						1.1	2.0	3.0					
SP1403	2.2	3.0	5.0						1.5	3.0	4.2					
SP1404	3.0	5.0	6.9					5.9	2.2	3.0	5.8				5.4	4.3
SP1405	4.0	5.0	8.8				7.4	5.7	3.0	5.0	7.6				5.6	4.4
SP1406	5.5	7.5	11.0			10.0	7.4	5.7	4.0	5.0	9.5		9.2	7.7	5.6	4.4
SP2401	7.5	10	15.3				12.7	10.1	5.5	10	13.0			12.6	9.6	7.6
SP2402	11	15	21.0		19.5	16.7	12.7	10.0	7.5	10	16.5		14.9	12.6	9.6	7.6
SP2403	15	20	29.0	27.2	23.2	20.0	15.0	11.8	11	20	25.0	23.7	19.9	16.9	12.8	10.1
SP2404*	15	20	29.0		26.6	22.5	16.5	12.5	15	20	29.0	25.8	20.5	16.8	12.1	7.9
SP3401	18.5	25	35.0			34.5	26.3	21.0	15	25	32.0			28.9	22.0	17.5
SP3402	22	30	43.0			37.9	28.6	22.5	18.5	30	40.0		38.3	32.5	24.5	19.2
SP3403	30	40	56.0	53.4	44.6	37.9	28.6		22	30	46.0	45.9	38.3	32.5	24.4	
SP4401	37	50	68.0			62.0			30	50	60.0		51.9	42.4		
SP4402	45	60	83.0		74.0	61.0			37	60	74.0	65.0	50.9	41.7		
SP4403	55	75	104		95.1	78.8			45	75	96.0	83.6	66.6	55.2		
SP5401	75	100	138		118	97.1			55	100	124	106.5	82.4	67.0		
SP5402	90	125	168	158	129	107			75	125	156	137	109	91.0		
SP6401	110	150	202		164.1				90	150	180	174.4	134.5			
SP6402	132	200	236	210.4	157.7				110	150	210	174.8	129.7			
SP3501	3.0	3.0	5.4						2.2	2.0	4.1					
SP3502	4.0	5.0	6.1						3.0	3.0	5.4					
SP3503	5.5	7.5	8.4						4.0	5.0	6.1					
SP3504	7.5	10	11.0						5.5	7.5	9.5					
SP3505	11	15	16.0						7.5	10	12.0					
SP3506	15	20	22.0		21.6	18.2			11	15	18.0			15.5		
SP3507	18.5	25	27.0	26.0	21.6	18.1			15	20	22.0		18.4	15.5		
SP4601	18.5	25	22.0						15	20	19.0					
SP4602	22	30	27.0						18.5	25	22.0					
SP4603	30	40	36.0			33.9			22	30	27.0					
SP4604	37	50	43.0		41.3	33.7			30	40	36.0			33.9		
SP4605	45	60	52.0	51.9	41.2	33.7			37	50	43.0		41.3	33.7		
SP4606	55	75	62.0	61.3	48.4	39.6			45	60	52.0		44.7	36.5		
SP5601	75	100	84	84	69	54			55	75	63	63	52	41		
SP5602	90	125	99	91	69	54			75	100	85	69	52	41		
SP6601	110	150	125	100	74				90	125	100	100	74			
SP6602	132	175	144	100	74				110	150	125	100	74			

Table 10-2 Maximum permissible continuous output current @ 40°C (104°F) ambient with IP54 insert and standard fan fitted

Model	Normal Duty								Heavy Duty							
	Nominal rating		Maximum permissible continuous output current (A) for the following switching frequencies						Nominal rating		Maximum permissible continuous output current (A) for the following switching frequencies					
	kW	hp	3kHz	4kHz	6kHz	8kHz	12kHz	16kHz	kW	hp	3kHz	4kHz	6kHz	8kHz	12kHz	16kHz
SP1201	1.1	1.5	5.2						0.75	1.0	4.3					
SP1202	1.5	2.0	6.8						1.1	1.5	5.8					
SP1203	2.2	3.0	9.6			9.3	8.2	7.3	1.5	2.0	7.5					7.3
SP1204	3.0	3.0	11.0	10.6	9.7	9.0	7.7	6.6	2.2	3.0	10.6	10.5	9.7	9.0	7.7	6.6
SP2201	4.0	5.0	15.5						3.0	3.0	12.6					
SP2202	5.5	7.5	22.0			20.7	18.0	15.7	4.0	5.0	17.0					15.5
SP2203	7.5	10	24.5	23.7	22.0	20.5	17.9	15.6	5.5	7.5	24.2	23.4	21.8	20.3	17.7	15.5
SP1401	1.1	1.5	2.8						0.75	1.0	2.1					
SP1402	1.5	2.0	3.8					2.9	1.1	2.0	3.0					2.9
SP1403	2.2	3.0	5.0				3.9	2.9	1.5	3.0	4.2				3.9	2.9
SP1404	3.0	5.0	6.9		6.5	5.4	3.9	2.9	2.2	3.0	5.8			5.4	3.9	2.9
SP1405	4.0	5.0	8.3	7.3	5.8	4.7	3.2	2.3	3.0	5.0	7.6	7.3	5.8	4.7	3.2	2.3
SP1406	5.5	7.5	8.3	7.3	5.8	4.7	3.2	2.3	4.0	5.0	8.2	7.3	5.8	4.7	3.2	2.3
SP2401	7.5	10	15.3			13.3	10.1	7.9	5.5	10	13.0			12.6	9.4	7.3
SP2402	11	15	20.1	18.4	15.6	13.4	10.1	7.9	7.5	10	16.5		14.9	12.3	9.3	7.2
SP2403	15	20	21.7	19.7	16.4	13.9	10.2	7.7	11	20	21.6	19.6	16.4	13.8	10.2	7.7
SP2404*	15	20	20.1	17.7	14.0	11.2	7.3	4.6	15	20	20.1	17.7	14.0	11.2	7.3	4.6

***SP2404 Power and current ratings**

All Unidrive SP models are dual rated except for the SP2404 which only has a Heavy Duty rating. However, if the current limits in Pr **4.05** to Pr **4.07** are set to a maximum of 110% and the switching frequency is greater than 3kHz, then the drive can be used at a maximum continuous current higher than the Heavy Duty rating. See the Normal Duty ratings in Table 10-1, Table 10-2 and Table 10-3. Normal Duty ratings exist for the SP2404 above 3kHz when the overload is reduced from the default value 165% in open loop or 175% in closed loop, to 110%.

If the current limits in Pr **4.05** to Pr **4.07** are set higher than 110% then the Heavy Duty current ratings are applicable.

Table 10-3 Maximum permissible continuous output current @ 50°C (122°F) ambient for wall mounted drives

Model	Normal Duty								Heavy Duty							
	Nominal rating		Maximum permissible continuous output current (A) for the following switching frequencies						Nominal rating		Maximum permissible continuous output current (A) for the following switching frequencies					
	kW	hp	3kHz	4kHz	6kHz	8kHz	12kHz	16kHz	kW	hp	3kHz	4kHz	6kHz	8kHz	12kHz	16kHz
SP1201	1.1	1.5	5.2						0.75	1.0	4.3					
SP1202	1.5	2.0	6.8						1.1	1.5	5.8					
SP1203	2.2	3.0	9.6					9.0	1.5	2.0	7.5					
SP1204	3.0	3.0	11.0			10.9	9.5	8.3	2.2	3.0	10.6				9.5	8.3
SP2201	4.0	5.0	15.5				13.5	11.5	3.0	3.0	12.6					11.4
SP2202	5.5	7.5	19.7	18.9	17.3	15.9	13.5	11.5	4.0	5.0	17.0			15.7	13.4	11.4
SP2203	7.5	10	19.5	18.6	17.2	15.8	13.4	11.5	5.5	7.5	19.2	18.4	17.0	15.7	13.3	11.4
SP3201	11	15	42.0				38.2		7.5	10	31.0					
SP3202	15	20	54.0		52.8	47.0	38.2		11	15	42.0				37.2	
SP4201	18.5	25	68.0						15	20	56.0					
SP4202	22	30	80.0						18.5	25	68.0					
SP4203	30	40	87.4						22	30	80.0					
SP5201	37	50	130						30	40	105					
SP5202	45	60	154						37	50	130					
SP1401	1.1	1.5	2.8						0.75	1.0	2.1					
SP1402	1.5	2.0	3.8						1.1	2.0	3.0					
SP1403	2.2	3.0	5.0					3.9	1.5	3.0	4.2					3.8
SP1404	3.0	5.0	6.9				5.1	3.9	2.2	3.0	5.8				4.8	3.7
SP1405	4.0	5.0	8.8		7.3	6.0	4.2	3.1	3.0	5.0	7.6		7.2	6.0	4.2	3.1
SP1406	5.5	7.5	10.1	9.0	7.3	6.0	4.2	3.1	4.0	5.0	9.5	9.0	7.2	6.0	4.2	3.1
SP2401	7.5	10	15.3	14.2	11.8	10.0	7.3	5.5	5.5	10	13.0		11.7	9.9	7.3	5.5
SP2402	11	15	15.7	14.2	11.8	10.0	7.3	5.5	7.5	10	15.5	14.1	11.7	9.9	7.3	5.5
SP2403	15	20	16.8	15.0	12.2	10.1	7.1		11	20	16.7	15.0	12.2	10.1	7.1	5.1
SP2404*	15	20	22.3	19.8	15.8	12.8	8.6	5.9	15	20	22.3	19.8	14.0	11.2	7.3	4.6
SP3401	18.5	25	35.0		33.5	28.5	21.5	16.9	15	25	32.0		30.7	26.1	19.7	15.4
SP3402	22	30	43.0	41.5	34.2	28.7	21.0	16.0	18.5	30	40.0		34.1	28.4	20.7	16.0
SP3403	30	40	46.0	41.5	34.2	28.7	21.0		22	30	46.0	41.5	33.6	28.3	20.8	
SP4401	37	50	68.0		66.8	54.9			30	50	60.0		46.7	38.3		
SP4402	45	60	83.0	81.6	66.5	52.3			37	60	68.2	58.6	46.0	37.7		
SP4403	55	75	86.5	86.2	71.3	59.3			45	75	86.5	74.7	60.1	49.8		
SP5401	75	100	138		105.9	87.4			55	100	112.7	96.4	74.5	59.9		
SP5402	90	125	141	140	112	92			75	125	140	123	99.0	82.0		
SP6401	110	150	191.5	190.1	147.6				90	150	180	157.9	121.5			
SP6402	132	200	198.4	180.6	138.1				110	150	190	157.9	116.2			
SP3501	3.0	3.0	5.4						2.2	2.0	4.1					
SP3502	4.0	5.0	6.1						3.0	3.0	5.4					
SP3503	5.5	7.5	8.4						4.0	5.0	6.1					
SP3504	7.5	10	11.0						5.5	7.5	9.5					
SP3505	11	15	16.0			14.7			7.5	10	12.0					
SP3506	15	20	22.0		17.8	14.7			11	15	18.0		16.8	13.9		
SP3507	18.5	25	24.6	22.0	17.8	14.7			15	20	22.0	20.4	16.7	13.9		
SP4601	18.5	25	22.0						15	20	19.0					
SP4602	22	30	27.0			24.7			18.5	25	22.0					
SP4603	30	40	36.0		30.7	24.7			22	30	27.0					
SP4604	37	50	43.0	39.6	30.7	24.7			30	40	36.0		30.7	24.7		
SP4605	45	60	45.6	39.5	30.7	24.7			37	50	43.0	39.6	30.7	24.7		
SP4606	55	75	51.9	44.9	34.7	27.7			45	60	51.9	44.9	34.7	27.7		
SP5601	75	100	83	69	51	40			55	75	63	63	47	38		
SP5602	90	125	83	69	51	40			75	100	75	62	45	36		
SP6601	110	150	98	81	59				90	125	98	81	59			
SP6602	132	175	98	81	59				110	150	98	81	59			

Table 10-4 Maximum permissible continuous output current @ 40°C (104°F) ambient

Model	Normal Duty					Heavy Duty				
	Nominal rating		Maximum permissible continuous output current (A) for the following switching frequencies			Nominal rating		Maximum permissible continuous output current (A) for the following switching frequencies		
	kW	hp	3kHz	4kHz	6kHz	kW	hp	3kHz	4kHz	6kHz
SPMA1401	110	150	205		164.1	90	150	180	174.4	134.5
SPMA1402	132	200	236	210.4	157.7	110	150	210	174.8	129.7
SPMA1601	110	150	125	100	74	90	125	100	100	74
SPMA1602	132	175	144	100	74	110	150	125	100	74
SPMD1201	55	75	192	187	143	45	60	156	150	110
SPMD1202	75	100	248	225	172	55	75	192	175	128
SPMD1203	90	125	312	264	202	75	100	250	206	151
SPMD1204	110	150	350	305	233	90	125	290	241	177
SPMD1401	110	150	205	187	143	90	150	180	150	110
SPMD1402	132	175	248	225	172	110	150	210	175	128
SPMD1403	160	200	290	264	202	132	175	248	206	151
SPMD1404	185	300	335	305	233	160	200	290	241	177
SPMD1601	110	150	125	109	79	90	125	100	95	68
SPMD1602	132	175	144	128	96	110	150	125	119	89
SPMD1603	160	200	168	142	107	132	175	144	126	95
SPMD1604	185	250	192	158	119	160	200	168	144	109

NOTE

An additional derating of 5% is required for parallel applications.

Table 10-5 Maximum permissible continuous output current @ 50°C (122°F) ambient

Model	Normal Duty					Heavy Duty				
	Nominal rating		Maximum permissible continuous output current (A) for the following switching frequencies			Nominal rating		Maximum permissible continuous output current (A) for the following switching frequencies		
	kW	hp	3kHz	4kHz	6kHz	kW	hp	3kHz	4kHz	6kHz
SPMA1401	110	150	191.5	190.1	147.6	90	150	180	157.9	121.5
SPMA1402	132	200	198.4	180.6	138.1	110	150	190	157.9	116.2
SPMA1601	110	150	98	81	59	90	125	98	81	59
SPMA1602	132	175	98	81	59	110	150	98	81	59
SPMD1201	55	75	172	157	120	45	60	156	135	100
SPMD1202	75	100	208	189	145	55	75	190	158	116
SPMD1203	90	125	244	222	170	75	100	224	186	137
SPMD1204	110	150	282	256	196	90	125	262	218	160
SPMD1401	110	150	172	157	120	90	150	163	135	100
SPMD1402	132	175	208	189	145	110	150	190	158	116
SPMD1403	160	200	244	222	170	132	175	224	186	137
SPMD1404	185	300	282	256	196	160	200	262	218	160
SPMD1601	110	150	121	99	71	90	125	100	86	62
SPMD1602	132	175	135	114	85	110	150	125	108	81
SPMD1603	160	200	154	127	95	132	175	137	115	86
SPMD1604	185	250	157	133	100	160	200	155	129	97

NOTE

An additional derating of 5% is required for parallel applications.

10.1.2 Power dissipation

Table 10-6 Losses @ 40°C (104°F) ambient for wall mounted drives

Model	Drive losses (W) taking into consideration any current derating for the given conditions															
	Normal Duty								Heavy Duty							
	Nominal rating		3kHz	4kHz	6kHz	8kHz	12kHz	16kHz	Nominal rating		3kHz	4kHz	6kHz	8kHz	12kHz	16kHz
	kW	hp							kW	hp						
SP1201	1.1	1.5	33	35	38	42	49	56	0.75	1	27	29	32	35	41	47
SP1202	1.5	2.0	45	47	51	56	64	73	1.1	1.5	38	40	43	47	55	62
SP1203	2.2	3.0	67	70	76	81	92	104	1.5	2.0	51	53	58	62	71	81
SP1204	3.0	3.0	78	82	89	97	113	129	2.2	3.0	75	78	86	94	109	124
SP2201	4.0	5.0	155	161	173	186	210	235	3.0	3.0	133	139	150	160	182	203
SP2202	5.5	7.5	210	218	234	250	282	314	4.0	5.0	170	176	190	203	229	256
SP2203	7.5	10	272	282	302	320		315	5.5	7.5	245	254	263	261	259	258
SP3201	11	15	331	347	380	412	477		7.5	10	260	272	297	321	370	
SP3202	15	20	431	451	492	532	551		11	15	349	365	398	430	486	
SP4201	18.5	25	517	541	589	637			15	20	428	448	488	528		
SP4202	22	30	611	639	694	750			18.5	25	517	541	589	637		
SP4203	30	40	810	845	916	987			22	30	611	639	694	750		
SP5201	37	50							30	40						
SP5202	45	60							37	50						
SP1401	1.1	1.5	26	29	37	45	61	76	0.75	1.0	20	24	30	37	51	64
SP1402	1.5	2.0	34	38	48	57	76	95	1.1	2.0	27	31	39	48	64	80
SP1403	2.2	3.0	44	50	61	72	95	117	1.5	3.0	37	42	52	62	82	102
SP1404	3.0	5.0	62	69	83	97	126	134	2.2	3.0	52	58	70	83	101	104
SP1405	4.0	5.0	83	94	117	139	156	157	3.0	5.0	72	82	101	121	123	125
SP1406	5.5	7.5	106	120	147	158	156	157	4.0	5.0	91	103	123			125
SP2401	7.5	10	186	202	234	266	283	282	5.5	10	164	178	206	229		231
SP2402	11	15	248	269	291	286	283	281	7.5	10	201	218	230	229		231
SP2403	15	20	313	320			315	316	11	20	272	282	279	278	279	282
SP2404	15	20	311	343	376				15	20	311	308	301	299	302	284
SP3401	18.5	25	364	392	449	499	477	465	15	25	337	363	415	424	408	401
SP3402	22	30	437	471	540	538	514	501	18.5	30	411	443	485	469	452	444
SP3403	30	40	567	580	552	533	510		22	30	474	509	485	469	452	
SP4401	37	50	714	781	914	956			30	50	629	689	704	674		
SP4402	45	60	882	961	995	941			37	60	780	745	690	663		
SP4403	55	75	1070	1158	1217	1144			45	75	976	920	854	821		
SP5401	75	100	1471	1618	1640	1560			55	100	1311	1236	1150	1112		
SP5402	90	125	1830	1881	1781	1717			75	125	1681	1600	1508	1464		
SP6401	110	150	2058	2259	2153				90	150	1817	1935	1772			
SP6402	132	200	2477	2455	2255				110	150	2192	2042	1888			
SP3501	3.0	3.0	127	141	168	196			2.2	2.0	112	124	148	172		
SP3502	4.0	5.0	135	150	180	209			3.0	3.0	127	141	168	196		
SP3503	5.5	7.5	163	181	218	254			4.0	5.0	135	150	180	209		
SP3504	7.5	10	197	219	263	306			5.5	7.5	178	198	237	276		
SP3505	11	15	267	296	354	412			7.5	10	212	235	281	328		
SP3506	15	20	362	399	475	471			11	15	300	332	396	405		
SP3507	18.5	25	448	486	477	471			15	20	365	403	406	405		
SP4601	18.5	25	409	470	590	711			15	20	360	413	519	625		
SP4602	22	30	496	568	712	857			18.5	25	409	470	590	711		
SP4603	30	40	660	754	941	1063			22	30	496	568	712	857		
SP4604	37	50	798	908	1083	1058			30	40	660	754	941	1063		
SP4605	45	60	985	1115	1080	1058			37	50	798	908	1083	1058		
SP4606	55	75	1060	1179	1130	1105			45	60	873	987	1042	1023		
SP5601	75	100	1818	2129	2258	2203			55	75	1345	1585	1763	1757		
SP5602	90	125	2176	2320	2215	2189			75	100	1792	1744	1714	1706		
SP6601	110	150	2573	2512	2438				90	125	2573	2512	2438			
SP6602	132	175	3106	2512	2438				110	150	3106	2512	2438			

Table 10-7 Losses @ 40°C (104°F) ambient with IP54 insert and standard fan fitted

Model	Drive losses (W) taking into consideration any current derating for the given conditions															
	Normal Duty								Heavy Duty							
	Nominal rating		3kHz	4kHz	6kHz	8kHz	12kHz	16kHz	Nominal rating		3kHz	4kHz	6kHz	8kHz	12kHz	16kHz
	kW	hp							kW	hp						
SP1201	1.1	1.5	33	35	38	42	49	56	0.75	1.0	27	29	32	35	41	47
SP1202	1.5	2.0	45	47	51	56	64	73	1.1	1.5	38	40	43	47	55	62
SP1203	2.2	3.0	67	70	76	78			1.5	2.0	51	53	58	62	71	78
SP1204	3.0	3.0	78						2.2	3.0	75	78				
SP2201	4.0	5.0	155	161	173	186	210	235	3.0	3.0	133	139	150	160	182	203
SP2202	5.5	7.5	210	218	234	237			4.0	5.0	170	176	190	203	229	237
SP2203	7.5	10	237						5.5	7.5	237					
SP1401	1.1	1.5	26	29	37	45	61	76	0.75	1.0	20	24	30	37	51	64
SP1402	1.5	2.0	34	38	48	57	76	78	1.1	2.0	27	31	39	48	64	78
SP1403	2.2	3.0	44	50	61	72	78		1.5	3.0	37	42	52	62	78	
SP1404	3.0	5.0	62	69	78				2.2	3.0	52	58	70	78		
SP1405	4.0	5.0	78						3.0	5.0	72	78				
SP1406	5.5	7.5	78						4.0	5.0	78					
SP2401	7.5	10	186	202	234	237			5.5	10	164	178	206	229	226	
SP2402	11	15	237						7.5	10	201	218	230	224		223
SP2403	15	20	237						11	20	237					
SP2404	15	20	225					220	15	20	225					220

Table 10-8 Losses @ 50°C (122°F) ambient for wall mounted drives

Model	Drive losses (W) taking into consideration any current derating for the given conditions															
	Normal Duty								Heavy Duty							
	Nominal rating		3kHz	4kHz	6kHz	8kHz	12kHz	16kHz	Nominal rating		3kHz	4kHz	6kHz	8kHz	12kHz	16kHz
	kW	hp							kW	hp						
SP1201	1.1	1.5	33	35	38	42	49	56	0.75	1	27	29	32	35	41	47
SP1202	1.5	2.0	45	47	51	56	64	73	1.1	1.5	38	40	43	47	55	62
SP1203	2.2	3.0	67	70	76	81	92	97	1.5	2.0	51	53	58	62	71	81
SP1204	3.0	3.0	78	82	89	97			2.2	3.0	75	78	86	94	97	
SP2201	4.0	5.0	155	161	173	186	190		3.0	3.0	133	139	150	160	182	190
SP2202	5.5	7.5	190						4.0	5.0	170	176	190			
SP2203	7.5	10	190						5.5	7.5	190					
SP3201	11	15	331	347	380	412	436		7.5	10	260	272	297	321	370	
SP3202	15	20	431	451	480	463	439		11	15	349	365	398	430	439	
SP4201	18.5	25	517	541	589	637			15	20	428	448	488	528		
SP4202	22	30	611	639	694	750			18.5	25	517	541	589	637		
SP4203	30	40	671	701	761	821			22	30	611	639	694	750		
SP5201	37	50							30	40						
SP5202	45	60							37	50						
SP1401	1.1	1.5	26	29	37	45	61	76	0.75	1.0	20	24	30	37	51	64
SP1402	1.5	2.0	34	38	48	57	76	95	1.1	2.0	27	31	39	48	64	80
SP1403	2.2	3.0	44	50	61	72	95	97	1.5	3.0	37	42	52	62	82	95
SP1404	3.0	5.0	62	69	83	97			2.2	3.0	52	58	70	83	92	
SP1405	4.0	5.0	83	94	97				3.0	5.0	72	82	97			
SP1406	5.5	7.5	97						4.0	5.0	91	97				
SP2401	7.5	10	186	190					5.5	10	164	178	190			
SP2402	11	15	190						7.5	10	190					
SP2403	15	20	190						11	20	190					
SP2404	15	20	245						15	20	245					229
SP3401	18.5	25	364	392	430	417	399	389	15	25	337	363	399	387	373	364
SP3402	22	30	437	455	435	418	399	388	18.5	30	411	443	435	417	396	388
SP3403	30	40	474	459	429	415	397		22	30	474	459	429	415	397	
SP4401	37	50	714	781	898	852			30	50	629	689	638	617		
SP4402	45	60	882	944	894	814			37	60	716	673	629	607		
SP4403	55	75	877	949	912	875			45	75	876	820	775	750		
SP5401	75	100	1471	1616	1462	1411			55	100	1186	1118	1047	1009		
SP5402	90	125	1500	1644	1543	1480			75	125	1500	1434	1366	1333		
SP6401	110	150	1942	2118	1939				90	150	1817	1747	1610			
SP6402	132	200	2068	2108	1997				110	150	1979	1851	1715			
SP3501	3.0	3.0	127	141	168	196			2.2	2.0	112	124	148	172		
SP3502	4.0	5.0	135	150	180	209			3.0	3.0	127	141	168	196		
SP3503	5.5	7.5	163	181	218	254			4.0	5.0	135	150	180	209		
SP3504	7.5	10	197	219	263	306			5.5	7.5	178	198	237	276		
SP3505	11	15	267	296	354	383			7.5	10	212	235	281	328		
SP3506	15	20	362	399	390	384			11	15	300	332	372	369		
SP3507	18.5	25	405	399	390	384			15	20	365	374	369			
SP4601	18.5	25	409	470	590	711			15	20	360	413	519	625		
SP4602	22	30	496	568	712	789			18.5	25	409	470	590	711		
SP4603	30	40	660	754	805	789			22	30	496	568	712	789		
SP4604	37	50	798	831	805	789			30	40	660	754	805	789		
SP4605	45	60	850	831	805	789			37	50	798	831	805	789		
SP4606	55	75	871	848	816	797			45	60	871	848	816	797		
SP5601	75	100	1785	1743	1689	1657			55	75	1345	1585	1763	1757		
SP5602	90	125	1785	1743	1689	1657			75	100	1609	1557	1502	1504		
SP6601	110	150	2084	2036	1978				90	125	2084	2036	1978			
SP6602	132	175	2084	2036	1978				110	150	2084	2036	1978			

Table 10-9 Losses @ 40°C (104°F) ambient

Model	Drive losses (W) taking into consideration any current derating for the given conditions									
	Normal Duty					Heavy Duty				
	Nominal rating		3kHz	4kHz	6kHz	Nominal rating		3kHz	4kHz	6kHz
	kW	hp				kW	hp			
SPMA1401	110	150	2058	2259	2153	90	150	1817	1935	1772
SPMA1402	132	200	2477	2455	2255	110	150	2192	2042	1888
SPMA1601	110	150	2573	2512	2438	90	125	2573	2512	2438
SPMA1602	132	175	3106	2512	2438	110	150	3106	2512	2438
SPMD1201	55	75	2058	2259	2153	45	60	1817	1935	1772
SPMD1202	75	100	2477	2455	2255	55	75	2192	2042	1888
SPMD1203	90	125	3221	3286	3132	75	100	2652	2450	2265
SPMD1204	110	150	3462	3799	3621	90	125	3189	2970	2746
SPMD1401	110	150	2058	2259	2153	90	150	1817	1935	1772
SPMD1402	132	175	2477	2455	2255	110	150	2192	2042	1888
SPMD1403	160	200	2994	3286	3132	132	175	2631	2450	2265
SPMD1404	185	300	3462	3799	3621	160	200	3189	2970	2746
SPMD1601	90	125	2737	2779	2630	75	100	2155	2413	2293
SPMD1602	110	150	3203	3305	3212	90	125	2737	3062	2975
SPMD1603	132	175	3378	3269	3145	110	150	2844	2887	2788
SPMD1604	160	200	3784	2656	3494	132	175	3378	3303	3191

Table 10-10 Losses @ 50°C (122°F) ambient

Model	Drive losses (W) taking into consideration any current derating for the given conditions									
	Normal Duty					Heavy Duty				
	Nominal rating		3kHz	4kHz	6kHz	Nominal rating		3kHz	4kHz	6kHz
	kW	hp				kW	hp			
SPMA1401	110	150	1942	2118	1939	90	150	1817	1747	1610
SPMA1402	132	200	2068	2108	1997	110	150	1979	1851	1715
SPMA1601	110	150	2084	2036	1978	90	125	2084	2036	1978
SPMA1602	132	175	2084	2036	1978	110	150	2084	2036	1978
SPMD1201	55	75	1942	2118	1939	45	60	1817	1747	1610
SPMD1202	75	100	2068	2108	1997	55	75	1979	1851	1715
SPMD1203	90	125	2500	2822	2774	75	100	2375	2221	2057
SPMD1204	110	150	2890	3262	3207	90	125	2879	2692	2494
SPMD1401	110	150	1942	2118	1939	90	150	1817	1747	1610
SPMD1402	132	175	2068	2108	1997	110	150	1979	1851	1715
SPMD1403	160	200	2500	2822	2774	132	175	2375	2221	2057
SPMD1404	185	300	2890	3262	3207	160	200	2879	2692	2494
SPMD1601	90	125	2644	2510	2387	75	100	2155	2184	2085
SPMD1602	110	150	2987	2912	2830	90	125	2737	2764	2690
SPMD1603	132	175	3053	2909	2796	110	150	2694	2607	2526
SPMD1604	160	200	3132	3048	2941	132	175	3074	2946	2858

Table 10-11 Power losses from the front of the drive when through-panel mounted

Frame size	Power loss
1	≤50W
2	≤75W
3	≤100W
4	≤204W
5	≤347W
6	≤480W
SPMA	≤480W
SPMD	≤300W
SPMC/U	≤50W

Table 10-12 Unidrive SPMC/U losses @ 40°C (104°F) ambient

Model	Maximum Losses W
SPMU1401	442
SPMU1402	765
SPMU2402	1524
SPMC1402	871
SPMC2402	1737
SPMU1601	481
SPMU2601	956
SPMC1601	503
SPMC2601	1001

Table 10-13 Output inductor losses @ 40°C (104°F) ambient

Part number	Model	Maximum Losses W
4401-0197-00	OTL401	113
4401-0198-00	OTL402	145
4401-0199-00	OTL403	122
4401-0200-00	OTL404	156
4401-0188-00	OTL411	71
4401-0189-00	OTL412	85
4401-0192-00	OTL413	83
4401-0186-00	OTL414	100
4401-0201-00	OTL601	63
4401-0202-00	OTL602	74
4401-0203-00	OTL603	61
4401-0204-00	OTL604	70
4401-0193-00	OTL611	74
4401-0194-00	OTL612	85
4401-0195-00	OTL613	88
4401-0196-00	OTL614	100

NOTE

For Regen inductor and switching frequency filter inductor losses refer to section 10.4.1 *Regen inductors* on page 196 onwards.

10.2 Supply requirements

Voltage:

SPX20X 200V to 240V ±10%
SPX40X 380V to 480V ±10%
SPX50X 500V to 575V ±10%
SPX60X 690V ±10%

Number of phases: 3

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

Frequency range: 48 to 65Hz

NOTE

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

The following supplies are not permitted with Unidrive SP Regen

1. Corner grounded supplies (grounded Delta)

2. Ungrounded supplies (IT) > 575V

Unidrive SP size 6, Unidrive SPMA/D 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 $20A^2s$)

Unidrive SPMC/U external 24V supply requirements

The heatsink fan supply requirements are as follows:

Nominal voltage: 24V
Minimum voltage: 23V
Maximum voltage: 28V
Current drawn: 3A
Minimum start up voltage: 18V
Recommended power supply: 24V, 100W, 4.5A
Recommended fuse: 4A fast blow (I^2t less than $20A^2s$)

10.2.1 DC Bus voltage setpoint

The DC Bus voltage setpoint is user definable through Pr **3.05**, this must be set to 50V above Vac*√2.

Drive voltage rating	Vfs	K
200V	415V	2322
400V	830V	1161
575V	990V	973
690V	1190V	809

10.2.2 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°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)

10.2.3 Storage

-40°C (-40°F) to +50°C (122°F) for long term storage, or to +70°C (158°F) for short term storage.

10.2.4 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%.

10.2.5 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 10-14 IP Rating degrees of protection

First digit		Second digit	
Protection against contact and ingress of foreign bodies		Protection against ingress of water	
0	No protection	0	No protection
1	Protection against large foreign bodies ϕ > 50mm (large area contact with the hand)	1	-
2	Protection against medium size foreign bodies ϕ > 12mm (finger)	2	-
3	Protection against small foreign bodies ϕ > 2.5mm (tools, wires)	3	Protection against spraywater (up to 60° from the vertical)
4	Protection against granular foreign bodies ϕ > 1mm (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 10-15 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.

10.3 Protection

Fuse protection is required in the following regen systems

1. Single regen, multiple motoring drives
2. Multiple regen, multiple motoring drives
3. Unidrive SP regen brake resistor replacement
4. Regen systems using an SPMC

Fuse protection required could range from AC supply fusing to DC Bus fusing (some systems requiring both AC and DC fusing) for protection of both the regen and motoring drives along with the SPMC rectifier module. For further information on the fusing required for the above systems refer to section 4 *System design* on page 30.

10.3.1 AC Supply fusing

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

Typical input current

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

Maximum continuous input current

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

The values of maximum input current are stated for a supply with a 2% negative phase-sequence imbalance and rated at the supply fault current given in Table 10-16

Table 10-16 Supply fault current used to calculate maximum input currents

Model	Symmetrical fault level (kA)
All	100

Cable sizes are from IEC60364-5-52:2001 table A.52.C with correction factor for 40°C ambient of 0.87 (from table A52.14) for cable installation method B2 (multicore cable in conduit). Cable size may be reduced if a different installation method is used, or if the ambient temperature is lower. The recommended cable sizes above are only a guide. The mounting and grouping of cables affects their current-carrying capacity, in some cases smaller cables may be acceptable but in other cases a larger cable is required to avoid excessive temperature or voltage drop. Refer to local wiring regulations for the correct size of cables.

NOTE

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

NOTE

UL listing is dependent on the use of the correct type of UL-listed fuse, and applies when symmetrical short-circuit current does not exceed 5kA for sizes 1 to 3.



Fuses
The AC supply to the drive must be fitted with suitable protection against overload and short-circuits. Failure to observe this requirement will cause risk of fire.

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

An MCB (miniature circuit breaker) or MCCB (moulded-case circuitbreaker) 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.

Table 10-17 Supply fault current used to calculate maximum input currents

Model	Symmetrical fault level (kA)
SPMA	100
SPMD	
SPMC	

NOTE

Fuse ratings are for a DC supply or paralleled DC bus arrangements. When supplied by a single or dual SPMC of the correct rating, the AC input fuses provide protection for the drive and no DC fuse is required.

Table 10-18 SPMC / U input current, fuse and cable ratings

Model	Typical input current A	Maximum input current A	Typical DC current Adc	Semi-conductor fuse in series with HRC fuse		Cable sizes			
						AC input		DC output	
				HRC IEC class gG UL class J	Semi-conductor IEC class aR	mm^2	AWG	mm^2	AWG
SPMC1402	339	344	379	540	400	2 x 120	2 x 4/0	2 x 120	2 x 4/0
SPMC2402	2 x 308	2 x 312	2 x 345	450	400	2 x 120	2 x 4/0	2 x 120	2 x 4/0
SPMU1401	207	210	222	250	315	2 x 70	2 x 2/0	2 x 70	2 x 2/0
SPMU1402	339	344	379	540	400	2 x 120	2 x 4/0	2 x 120	2 x 4/0
SPMU2402	2 x 339	609	2 x 379	450	400	2 x 120	2 x 4/0	2 x 120	2 x 4/0
SPMC1601	192	195	209	250	250	2 x 70	2 x 2/0	2 x 120	2 x 4/0
SPMC2601	2 x 170	2 x 173	2 x 185	250	250	2 x 70	2 x 2/0	2 x 120	2 x 4/0
SPMU1601	192	195	209	250	250	2 x 70	2 x 2/0	2 x 120	2 x 4/0
SPMU2601	2 x 170	2 x 173	2 x 185	250	250	2 x 70	2 x 2/0	2 x 120	2 x 4/0

10.3.2 Common DC Bus Fusing

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

1. Single regen, multiple motoring drives
2. Multiple regen, multiple motoring drives
3. Unidrive SP regen brake resistor replacement
4. Regen systems using an SPMC

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

NOTE

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

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

NOTE

The DC Bus voltage set-point on a regen system (default) is set to 700Vdc, this can be up to a maximum 800Vdc. Therefore ensure the selected DC Bus fusing is of the correct voltage rating with regards to the DC Bus voltage level (Pr **3.05** DC Bus Voltage Set-point).

Table 10-19 DC fuse and cable ratings (European)

Model	DC - current A dc	DC voltage V dc	DC fuses		DC Cable size	
			HRC IEC class gG UL class J	Semi-conductor IEC class aR	mm^2	AWG
SP1201	6.3	350				
SP1202	8.3					
SP1203	11.6					
SP1204	13.3					
SP2201	18.7	350				
SP2202	26.6					
SP2203	33.9					
SP3201	50.8	350				
SP3202	65.3					
SP4201	82.3	350				
SP4202	96.8					
SP4203	125.8					
SP5201						
SP5202						
SPMD1201	343	700		400	2 x 70	2 x 2/0
SPMD1202	400			560	2 x 95	2 x 4/0
SPMD1203	457			560	2 x 120	2 x 4/0
SPMD1204	552			560	2 x 120	2 x 4/0
SP1405	10.7	700				
SP1406	134.					
SP2401	18.7	700				
SP2402	25.6					
SP2403	35.4					
SP2404	35.4					
SP3401	42.8	700				
SP3402	52.5					
SP3403	68.3					
SP4401	82.9	700				
SP4402	101.3					
SP4403	126.9					
SP5401	168.4	700				
SP5402	204.9					
SP6401	250.1	700				
SP6402	287.9					
SPMA1401	250.1	700				
SPMA1402	287.9					
SPMD1401	343	700		400	2 x 70	2 x 2/0
SPMD1402	400			560	2 x 95	2 x 4/0
SPMD1403	457			560	2 x 120	2 x 4/0
SPMD1404	552			560	2 x 120	2 x 4/0
SP3501	6.5	835				
SP3502	7.4					
SP3503	10.2					
SP3504	13.3					
SP3505	19.4					
SP3506	26.6					
SP3507	32.7					
SP4601	26.6	1005				
SP4602	32.7					
SP4603	43.6					
SP4604	52.0					
SP4605	62.9					
SP4606	75.0					
SP5601	101.6	1005				
SP5602	119.8					
SP6601	151.3	1005		250	2 x 95	2 x 4/0
SP6602	174.2			315	2 x 120	2 x 4/0
SPMA1601	151.3	1005		250	2 x 95	2 x 4/0
SPMA1602	174.2			315	2 x 120	2 x 4/0
SPMD1601	151.3	1005		250	2 x 95	2 x 4/0
SPMD1602	174.2			315	2 x 120	2 x 4/0
SPMD1603	203.3			350	2 x 120	2 x 4/0
SPMD1604	232.4			400	2 x 120	2 x 4/0

Table 10-20 DC fuse and cable ratings (USA)

Model	DC - current A dc	DC voltage V dc	DC fuses		DC Cable size	
			HRC IEC class gG UL class J	Semi-conductor IEC class aR	mm^2	AWG
SP1201	6.3	350				
SP1202	8.3					
SP1203	11.6					
SP1204	13.3					
SP2201	18.7	350				
SP2202	26.6					
SP2203	33.9					
SP3201	50.8	350				
SP3202	65.3					
SP4201	82.3	350				
SP4202	96.8					
SP4203	125.8					
SP5201						
SP5202						
SPMD1201	343	700		400	2 x 70	2 x 2/0
SPMD1202	400			560	2 x 95	2 x 4/0
SPMD1203	457			560	2 x 120	2 x 4/0
SPMD1204	552			560	2 x 120	2 x 4/0
SP1405	10.7	700				
SP1406	134.					
SP2401	18.7	700				
SP2402	25.6					
SP2403	35.4					
SP2404	35.4					
SP3401	42.8	700				
SP3402	52.5					
SP3403	68.3					
SP4401	82.9	700				
SP4402	101.3					
SP4403	126.9					
SP5401	168.4	700				
SP5402	204.9					
SP6401	250.1	700				
SP6402	287.9					
SPMA1401	250.1	700				
SPMA1402	287.9					
SPMD1401	343	700		400	2 x 70	2 x 2/0
SPMD1402	400			560	2 x 95	2 x 4/0
SPMD1403	457			560	2 x 120	2 x 4/0
SPMD1404	552			560	2 x 120	2 x 4/0
SP3501	6.5	835				
SP3502	7.4					
SP3503	10.2					
SP3504	13.3					
SP3505	19.4					
SP3506	26.6					
SP3507	32.7					
SP4601	26.6	1005				
SP4602	32.7					
SP4603	43.6					
SP4604	52.0					
SP4605	62.9					
SP4606	75.0					
SP5601	101.6	1005				
SP5602	119.8					
SP6601	151.3	1005		250	2 x 95	2 x 4/0
SP6602	174.2			315	2 x 120	2 x 4/0
SPMA1601	151.3	1005		250	2 x 95	2 x 4/0
SPMA1602	174.2			315	2 x 120	2 x 4/0
SPMD1601	151.3	1005		250	2 x 95	2 x 4/0
SPMD1602	174.2			315	2 x 120	2 x 4/0
SPMD1603	203.3			350	2 x 120	2 x 4/0
SPMD1604	232.4			400	2 x 120	2 x 4/0

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

CAUTION

The internal EMC filter must be removed from drive.

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.

CAUTION

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.

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 41.

Table 10-21 200V Regen inductor specifications

Inductor part number	Amps	mH	Losses W	L mm	D mm	H mm	Weight kg	Fixing centres (x * y) mm	Fixing mm	Fixing type
4401-0310	9.6	3.5	71	215	180	200	10	120 x 140	9	A
4401-0311	11.0	2.7	72	215	180	200	11	120 x 140	9	
4401-0312	15.5	2.2	116	215	180	200	12	120 x 140	9	
4401-0313	22	1.6	157	215	180	200	15	120 x 140	9	
4401-0314	31	1.10	193	270	180	240	17	160 x 140	9	
4401-0315	42	0.81	200	270	200	240	24	160 x 160	9	
4401-0316	56	0.6	264	325	220	320	32	200 x 180	11	
4401-0317	68	0.5	299	325	220	320	33	200 x 180	11	
4401-0318	80	0.4	298	325	220	320	39	200 x 180	11	
4401-0319	105	0.32	338	370	260	360	55	240 x 220	11	
4401-0320	130	0.26	394	375	280	360	65	240 x 240	11	
4401-0321	156	0.22	475	395	280	360	77	240 x 240	11	
4401-0322	192	0.18	526	395	280	360	97	240 x 240	11	
4401-0323	250	0.14	610	430	300	410	110	280 x 260	11	
4401-0324	312	0.11	776	430	300	410	120	280 x 260	11	
4401-0325	350	0.10	863	490	320	480	130	320 x 260	11	

Table 10-22 400V Regen inductor specifications

Inductor part number	Amps	mH	Losses W	L mm	D mm	H mm	Weight kg	Fixing centres (x * y) mm	Fixing mm	Fixing type
4401-0001	9.5	6.32	125.0	200	180	215	12	120 x 140	9	A
4401-0002	12	5.00	146.0	200	180	215	14	120 x 140	9	
4401-0003	16	3.75	175.0	240	180	270	17	160 x 140	9	
4401-0004	25	2.40	210.0	240	180	270	24	160 x 160	9	
4401-0005	34	1.76	285.0	320	220	325	32	200 x 180	11	
4401-0006	40	1.50	310.0	320	220	325	33	200 x 180	11	
4401-0007	46	1.30	320.0	320	220	325	39	200 x 180	11	
4401-0008	60	1.00	345.0	360	260	370	55	240 x 220	11	
4401-0009	70	0.78	415.0	360	260	370	65	240 x 240	11	
4401-0010	96	0.63	515.0	360	260	370	75	240 x 240	11	
4401-0011	124	0.48	585.0	360	260	370	95	240 x 240	11	
4401-0012	156	0.38	645.0	410	300	430	110	280 x 260	11	
4401-0013	180	0.33	775.0	410	300	430	120	280 x 260	11	
4401-0014	200	0.30	845.0	480	320	490	130	320 x 260	11	
4401-0015	300	0.20	1760.0	480	320	490	140	320 x 240	11	
4401-0205-00	350	0.16	1500	500	320	570	165	320 x 260	11	

Table 10-23 575V / 690V Regen inductor specifications

Inductor part number	Amps	mH	Losses W	L mm	D mm	H mm	Weight kg	Fixing centres (x * y) mm	Fixing mm	Fixing type
4401-0210	19	5.3	268	325	220	320	32	200 x 180	11	
4401-0211	22	4.6	288	325	220	320	33	200 x 180	11	
4401-0212	27	3.8	322	325	220	320	39	200 x 180	11	
4401-0213	36	2.8	348	370	260	360	55	240 x 220	11	
4401-0214	43	2.4	398	375	280	360	65	240 x 240	11	
4401-0215	52	1.9	456	395	280	360	77	240 x 240	11	
4401-0216	63	1.6	503	395	280	360	97	240 x 240	11	A
4401-0217	85	1.20	605	430	300	410	110	280 x 260	11	
4401-0218	100	1.00	950	500	350	480	170	320 x 260	11	
4401-0219	125	0.80	880	490	320	480	130	320 x 260	11	
4401-0220	144	0.70	1022	500	320	480	140	320 x 260	11	
4401-0221	168	0.60	1656	555	300	480	165	320 x 240	11	
4401-0222	192	0.53	1350	600	350	480	180	320 x 260	11	

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 10-24 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 10-25 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

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.

NOTE

The switching frequency filter inductors need to be rated to the total current requirement of the system.

Table 10-26 200V SFF inductor specifications

Inductor part number	Amps	mH	Losses W	L mm	D mm	H mm	Weight kg	Fixing centres (x * y) mm	Fixing mm	Fixing type
4401-1310	9.6	0.88	10	150	90	150	4	120 x 47	8 x 18	B
4401-1311	11.0	1.50	18	150	90	150	4	120 x 47	8 x 18	
4401-1312	15.5	1.10	26	150	90	150	4	120 x 47	8 x 18	
4401-1313	22	0.70	33	150	90	150	4	120 x 47	8 x 18	
4401-1314	31	0.50	37	190	100	180	6	130 x 54	8 x 20	
4401-1315	42	0.40	38	190	120	180	10	130 x 74	8 x 20	
4401-1316	56	0.30	48	190	160	180	12	130 x 184	8 x 20	
4401-1317	68	0.25	58	190	160	180	12	130 x 184	8 x 20	
4401-1318	80	0.20	60	190	160	180	13	130 x 184	8 x 20	
4401-1319	105	0.16	78	255	160	240	16	200 x 180	10 x 20	
4401-1320	130	0.13	86	255	170	240	20	200 x 90	10 x 20	
4401-1321	156	0.11	92	255	180	240	22	200 x 100	10 x 20	
4401-1322	192	0.088	97	255	190	240	25	200 x 100	10 x 20	
4401-1323	250	0.068	119	300	180	300	37	204 x 113	10 x 20	
4401-1324	312	0.055	170	300	180	300	37	204 x 113	10 x 20	
4401-1325	350	0.048	162	300	190	300	49	204 x 123	10 x 20	

Table 10-27 400V SFF inductor specifications

Inductor part number	Amps	mH	Losses W	L mm	D mm	H mm	Weight kg	Fixing centres (x * y) mm	Fixing mm	Fixing type
4401-0162	9.5	3.160	28	150	90	150	4	120 x 47	8 x 18	B
4401-0163	12	2.500	35	150	90	150	4	120 x 47	8 x 18	
4401-0164	16	1.875	37	180	100	190	6	120 x 54	8 x 20	
4401-0165	25	1.200	40	180	150	190	10	120 x 74	8 x 20	
4401-0166	34	0.880	52	180	160	190	12	120 x 84	8 x 20	
4401-0167	40	0.750	60	180	160	190	12	120 x 84	8 x 20	
4401-0168	46	0.650	60	180	160	190	13	120 x 84	8 x 20	
4401-0169	60	0.500	80	240	160	255	16	200 x 80	10 x 20	
4401-0170	70	0.390	90	240	170	255	20	200 x 90	10 x 20	
4401-0171	96	0.315	100	240	180	255	22	200 x 100	10 x 20	
4401-0172	124	0.240	110	240	190	255	25	200 x 100	10 x 20	
4401-0173	156	0.190	130	300	180	300	37	204 x 113	10 x 20	
4401-0174	180	0.165	170	300	180	300	37	204 x 113	10 x 20	
4401-0175	220	0.135	180	300	190	300	49	204 x 123	10 x 20	
4401-0176	300	0.100	220	300	200	300	50	204 x 130	10 x 20	
4401-1205	350	0.08								
4401-0176	600	0.050	400	410	300	430	110	280 x 260	11	A
4401-0176	900	0.034	530	480	320	500	140	320 x 240	11	
4401-0176	1200	0.025	700	480	320	560	170	320 x 240	11	

Table 10-28 575V / 690V SFF inductor specifications

Inductor part number	Amps	mH	Losses W	L mm	D mm	H mm	Weight kg	Fixing centres (x * y) mm	Fixing mm	Fixing type
4401-1211	22	1.40	36	190	120	180	10	130 x 74	8 x 20	B
4401-1213	36	1.40	81	255	160	240	16	200 x 80	10 x 20	
4401-1214	43	1.20	86	255	170	240	20	200 x 90	10 x 20	
4401-1215	52	1.00	93	255	180	240	22	200 x 100	10 x 20	
4401-1216	63	0.80	95	255	190	240	25	200 x 100	10 x 20	
4401-1217	85	0.60	122	300	180	300	37	204 x 113	10 x 20	
4401-1218	100	0.50	190	300	180	300	37	204 x 120	4 x 10	
4401-1219	125	0.40	172	300	190	300	49	204 x 123	10 x 20	
4401-1220	144	0.35	177	300	200	300	50	204 x 130	10 x 20	
4401-1221	168	0.30	207	300	200	300	50	204 x 130	10 x 20	
4401-1222	192	0.26	220	325	220	325	55	204 x 160	4 x 10	
4401-1223	192	0.21	189	300	200	300	50	204 x 130	10 x 20	

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 10-29 200V Switching frequency filter capacitor

Capacitor part no.	Capacitance uF	I_{rated} A	Max ∅ mm	Max L mm	Weight kg	Fixing stud mm	Discharge resistor Ω
1664-1074	7	1.7	53	114	0.3	M 12 @ 15Nm	390k
1664-2174	17	4.3	116.2	204	0.4	M 12 @ 10Nm	390k
1665-8324	32	11	116.2	204	1.3	M 12 @ 10Nm	390k
1664-2644	64	16.6	116.2	204	1.2	M 12 @ 10Nm	390k

Table 10-30 400V Switching frequency filter capacitor

Capacitor part no.	Capacitance uF	I_{rated} A	Max ∅ mm	Max L mm	Weight kg	Fixing stud mm	Discharge resistor Ω
1610-7804	8	2.64	82	204	0.5	M 12 @ 15Nm	390k
1665-8324	32	11.0	121	204	1.1	M 12 @ 10Nm	390k
1665-8484	48	14.0	121	204	1.3	M 12 @ 10Nm	390k
1665-8774	77	24.0	121	204	1.5	M 12 @ 10Nm	390k
1665-8394	39	20	121	204	1.5	M 12 @ 10Nm	390k

Table 10-31 575V / 690V Switching frequency filter capacitor

Capacitor part no.	Capacitance uF	I_{rated} A	Max ∅ mm	Max L mm	Weight kg	Fixing stud mm	Discharge resistor Ω
1666-8113	11	5	116.2	204	1.3	M 12 @ 10Nm	390k
1666-8223	23	10	116.2	204	1.4	M 12 @ 10Nm	390k
1668-7833	8.3	7.3	116.2	204	1.2	M 12 @ 10Nm	390k
1668-8163	16.6	12.4	116.2	204	1.2	M 12 @ 10Nm	390k

Switching frequency filter capacitor specification

Overload - $I_{max} = 1.3 \times I_{rated}$

$I_{inrush} = 200 \times I_{rated}$

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.

10.5 Optional external EMC filters

Table 10-32 Unidrive SP / EMC filter cross reference

Drive	Schaffner	Epcos
	CT part no.	CT part no.
SP1201 to SP1202	4200-6118	4200-6121
SP1203 to SP1204	4200-6119	4200-6120
SP2201 to SP2203	4200-6210	4200-6211
SP3201 to SP3202	4200-6307	4200-6306
SP4201 to SP4203	4200-6406	4200-6405
SP5201 to SP5202	4200-6503	4200-6501
SPMD1201 to SPMD1204	4200-6315	4200-6313
SP1401 to SP1404	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	4200-6601
SP3501 to SP3507	4200-6309	4200-6308
SP4601 to SP4606	4200-6408	4200-6407
SP5601 to SP5602	4200-6504	4200-6502
SP6601 to SP6602	4200-6604	4200-6602
SPMA1401 to SPMA1402	4200-6603	4200-6601
SPMD1401 to SPMD1404	4200-6315	4200-6313
SPMA1601 to SPMA1602	4200-6604	4200-6602
SPMD1601 to SPMD1604	4200-6316	4200-6314

Table 10-33 Optional external EMC filter details

CT part number	Manufacturer	Maximum continuous current		Voltage rating	IP rating	Power dissipation at rated current	Ground leakage		Discharge resistors
		@ 40°C (104°F) A	@ 50°C (122°F) A	V		W	Balanced supply phase-to-phase and phase-to-ground mA	Worst case mA	
4200-6118	Schaffner	10	10	400	20	6.9	29.4	153	See Note 1
4200-6119		16	16			9.2	38.8	277	
4200-6210		32	28.2			11	38.0	206	
4200-6305		62	56.6	400		23	66.0	357	
4200-6307		75	68.5	200		29	24.0	170	
4200-6309		30	30	575		15	102.0	557	See Note 3
4200-6406		101	92.2	400		25	73.0	406	See Note 1
4200-6408		58	52.8	690		31	66.0	344	See Note 1
4200-6503		164	150	480		30	39.1	216	See Note 4
4200-6504		95	86.7	690		30	66.0	344	See Note 1
4200-6603		260	237	480	00	14.2	41.0	219	See Note 1
4200-6604		160	146	690		5.4	88.0	296	
4200-6316		200	182	690		4.8	72.0	406	
4200-6315		340	310	690		13.8	52.0	293	
4200-6121	Epcos	10	9.1	400	20	4.2	<30.0	186.5	See Note 2
4200-6120		16	14.6			10.8			
4200-6211		32	29.1			17.8			
4200-6306		75	68.3			19.4		238	
4200-6308		30	22.5	660		17.6	<35.0	230	
4200-6405		101	75	480		30	<30.0	180	
4200-6407		58	44	690		15	<40.0	<340	See Note 5
4200-6501		165	125	480		27	<20.0	<120	See Note 2
4200-6502		95	71	690		19	<55.0	<450	See Note 5
4200-6601		260	195	480	0	13	<45.0	<375	
4200-6602		160	120	690		5	<60.0	<520	
4200-6314		200	150	690		7.2	<79.0	<635	
4200-6313		340	255	480		20.8	<74.0	<653	

NOTE

1. 1MΩ in a star connection between phases, with the star point connected by a 680kΩ resistor to ground (i.e. line to line 2MΩ, line to ground 1.68MΩ)
2. 1MΩ in a star connection between phases, with the star point connected by a 1.5MΩ resistor to ground (i.e. line to line 2MΩ, line to ground 2.5MΩ)
3. 2MΩ between phases with each phase connected by a 660kΩ resistance to ground.
4. 1.5MΩ in a star connection between phases, with the star point connected by a 680kΩ resistor to ground (i.e. line to line 3MΩ, line to ground 2.18MΩ)
5. 1.8MΩ in a star connection between phases, with the star point connected by a 1.5MΩ resistor to ground (i.e. line to line 3.6MΩ, line to ground 3.3MΩ)

Table 10-34 Optional external EMC filter dimensions

CT part number	Manufacturer	Dimension			Weight	
		H	W	D	kg	lb
4200-6118	Schaffner	440 mm (17.323 in)	100 mm (3.937 in)	45 mm (1.772in)	1.4	3.1
4200-6119						
4200-6210		428.5 mm (16.870 in)	155 mm (6.102 in)	55 mm (2.165 in)	2	4.4
4200-6305		414 mm (16.299 in)	250 mm (9.842 in)	60 mm (2.362 in)	3.5	7.7
4200-6307						
4200-6309						
4200-6406		300 mm (11.811 in)	225 mm (8.858 in)	100 mm (3.937 in)	4	8.8
4200-6408			208 mm (8.189 in)		3.8	8.4
4200-6503			249 mm (9.803 in)	120 mm (4.724 in)	6.8	15
4200-6504			225 mm (8.858 in)	100 mm (3.937 in)	4.4	9.7
4200-6603		135 mm (5.315 in)	295 mm (11.614 in)	230 mm (9.055 in)	5.25	11.6
4200-6604		191mm (7.519 in)	230 mm (9.055 in)	110mm (4.33 in)	5.25	11.6
4200-6316		226mm (8.897 in)			5.5	12.1
4200-6315		220mm (8.661 in)				
4200-6121	Epcos	450 mm (17.717 in)	100 mm (3.937 in)	45 mm (1.772 in)	2.1	4.6
4200-6120						
4200-6211		431.5 mm (16.988 in)	155 mm (6.102 in)	55 mm (2.165 in)	3.3	7.3
4200-6306		425 mm (16.732 in)	250 mm (9.843 in)	60 mm (2.362 in)	5.1	11.2
4200-6308						
4200-6405		300 mm (11.811 in)	207 mm (8.150 in)	90 mm (3.543 in)	7.8	17.2
4200-6407			205 mm (8.071 in)		8.0	17.6
4200-6501			249 mm (9.803 in)	120 mm (4.724 in)	12.0	26.5
4200-6502					10.0	22.0
4200-6601		364mm (9.055 in)	230 mm (9.055 in)	108mm (4.251 in)	10.0	22.0
4200-6602					8.6	18.9
4200-6314		339mm (13.34 in)		110mm (4.33 in)	8.5	18.7
4200-6313					8.6	18.9

Table 10-35 Optional external EMC Filter terminal data

CT part number	Manufacturer	Power connections		Ground connections	
		Max cable size	Max torque	Ground stud size	Max torque
4200-6118	Schaffner	4mm² 12AWG	0.8 N m (0.6 lb ft)	M5	3.5 N m (2.6 lb ft)
4200-6119					
4200-6210		10mm² 8AWG	2.0 N m (1.5 lb ft)		
4200-6305		16mm² 6AWG	2.2 N m (1.6 lb ft)	M6	3.9 N m (2.9 lb ft)
4200-6307					
4200-6309					
4200-6406		50mm² 0AWG	8 N m (5.9 lb ft)	M10	25 N m (18.4 lb ft)
4200-6408		25mm² 4AWG	2.3 N m (1.7 lb ft)	M6	3.9 N m (2.9 lb ft)
4200-6503		95mm² 4/0AWG	20 N m (14.7 lb ft)	M10	25 N m (18.4 lb ft)
4200-6504		50mm² 0AWG	8 N m (5.9 lb ft)		
4200-6603		Busbar arrangement			
4200-6604					
4200-6316					
4200-6315					
4200-6120	Epcos	4mm² 12AWG	0.6 N m (0.4 lb ft)	M5	3.0 N m (2.2 lb ft)
4200-6121					
4200-6211		10mm² 8AWG	1.35 N m (1.0 lb ft)		
4200-6306		16mm² 6AWG	2.2 N m (1.6 lb ft)	M6	5.1 N m (3.8 lb ft)
4200-6308		10mm² 8AWG	1.35 N m (1.0 lb ft)		
4200-6405		50mm² 0AWG	6.8 N m (5.0 lb ft)	M10	10 N m (7.4 lb ft)
4200-6407					
4200-6501		95mm² 4/0AWG	20 N m (14.7 lb ft)		
4200-6502					
4200-6601		Busbar arrangement			
4200-6602					
4200-6314					
4200-6313					

10.5.1 Varistors

AC line voltage transients can typically be caused by the switching of large items of plant, or by lightening strikes on another part of the supply network. If these transients are not suppressed, they can cause damage to the insulation of the Regen inductors, or to the Regen drive electronics. Varistors should be fitted after the supply fuses and before the EMC filter as shown in the following.

Table 10-36 Varistors

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

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 3.10 *Regen components* on page 25.

$L = 2 \times L_f$ L_f = Switching frequency filter inductance

$C = 3C_f / 2$ C_f = Switching frequency filter capacitance

$V_c = V_{LL}$ peak V_c = Charging voltage

$Z_c = \sqrt{\frac{L}{C}}$ Z_c = Charging impedance

$T_c = \pi\sqrt{LC}$ T_c = Charging time

$I_c = V_c / Z_c$ I_c = Charging current

Example:

SP5402 (Heavy Duty) Regen

Switching frequency filter Inductance 190µH

Switching frequency filter Capacitance 77µF

Supply Voltage 480v + 10%

L = 2 x 190µH = **380µH**

C = 3 x 48µF / 2 = **96µF**

V_c = 480 + 10% x √2 = **747V pk**

$Z_c = \sqrt{\frac{380\mu H}{96\mu F}}$ = **1.98Ω**

$T_c = \pi\sqrt{380\mu H \times 96\mu F}$ = **600µs**

I_c = 747 / 1.98 = **377A**

The MCB should be rated to the peak charging current of 377A for 600µs, with an rms current of 35A. A suitable MCB should have the following ratings and features:

Voltage rating: 480 + 10%
Peak current rating: 377A
rms current rating:35A
3 pole with auxiliary (for enable)

NOTE

The rms current rating specified is taken from the rated continuous current for the selected switching frequency filter capacitor data sheet.

The MCB is sized both for the system current and voltage, and must also take into account the cable size from the capacitor branch circuit to the main circuit.

Table 11-1 DC bus capacitance and inductance values

Voltage	Model	Total DC bus capacitance µF	Total DC bus inductance mH
200V	SP1201 SP1202	940	
	SP1203 SP1204	1640	
	SP2201 SP2202 SP2203	2820	1.4
	SP3201 SP3202	5400	0.7
	SP4201 SP4202 SP4203	4400	0.211
	SP5201 SP5202	3300	0.150
	SPMD1201	4400	
	SPMD1202	5500	
	SPMD1203 SPMD1204	6600	
400V	SP1401 SP1402 SP1403	235	
	SP1404	410	
	SP1405 SP1406	410	1.25
	SP2401 SP2402 SP2403 SP2404	705	1.4
	SP3401 SP3402 SP3403	1350	0.7
	SP4401	1100	0.85
	SP4402 SP4403	2200	0.423
	SP5401 SP5402	3300	0.150
	SP6401	4400	L1, L2, L3 0.054
	SP6402 SPMA1402	5500	L1, L2, L3 0.054
	SPMA1401	4400	L1, L2, L3 0.054
	SPMD1401	4400	
	SPMD1402	5500	
	SPMD1403 SPMD1404	6600	
575V	SP3501 SP3502 SP3503 SP3504	1000	4
	SP3505 SP3506 SP3507		
690V	SP4601 SP4602 SP4603	733	1.27
	SP4604 SP4605 SP4606		
	SP5601 SP5602	1467	0.470
	SP6601 SP6602	2200	L1, L2, L3 0.313
	SPMA1601 SPMA1602		
	SPMD1601 SPMD1602	2200	
	SPMD1603 SPMD1604	2933	

11.2 Resistor sizing for multiple drive systems

The charging resistor must be calculated for a multiple drive systems or SPMD 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 DC bus capacitance of the system.
2. Calculate the energy stored in the systems DC bus capacitance at the maximum supply voltage.
3. Calculate the minimum number of resistors required to meet this energy value (round up to the nearest one), (Table 11-2).
4. Calculate the series parallel arrangement of resistors to produce the total resistor value in the required range (Table 11-3 and Table 11-2).

Table 11-2 Charging resistors

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

DC bus capacitor energy is calculated from $0.5 \times C_N \times 1.2 \times V^2_{BUS}$. Where C_N is the nominal DC bus capacitance (Table 11-1) and the 1.2 factor allows for capacitance tolerance. V_{BUS} is calculated from $\sqrt{2} \times V_{LL}$ (+10%) where V_{LL} is the nominal line to line AC voltage.

Table 11-3 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 24
SPMA	
SPMD	

Example:

SPMD 1404 regenerating onto a 480Vac + 10% supply with SPMD 1404 motoring drive.

C_N = 2 x 6600µF
= 13200µF

V_{BUS} = √2 x 480 x 1.1
= 747V

Energy = $0.5 \times 13200 \times 10^{-6} \times 1.2 \times (747)^2$
= 4419J

Select resistor CT part number 1270-2483.

Number of resistors required =

$$\frac{4419}{1700} = 2.6$$

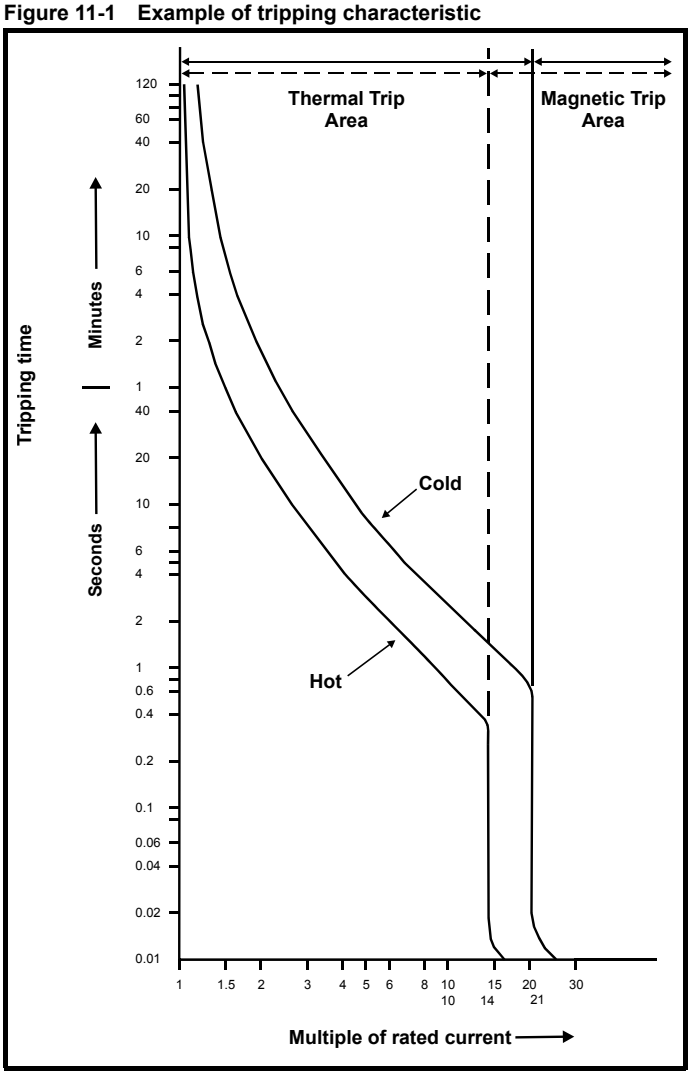
Three resistors are therefore required which may be connected in parallel.

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_{peak} = Vac (+10%) x 1.414 / $Resistance_{softstart}$
= (480 + 48) x 1.414 / 24 = 31.1A I_{peak}

Example: Charging time

Total softstart resistance of 24Ω (2 x 48Ω) in parallel, and a total DC bus capacitance of 11600µF

$T_{constant}$ = Resistance$_{softstart}$ x Total Capacitance$_{DC\ bus}$

24 x (11600 x10^{-6}) = 0.278

$T_{constant}$ x 5 = T_{charge}

0.2784 x 5 = 1.39s

Selection

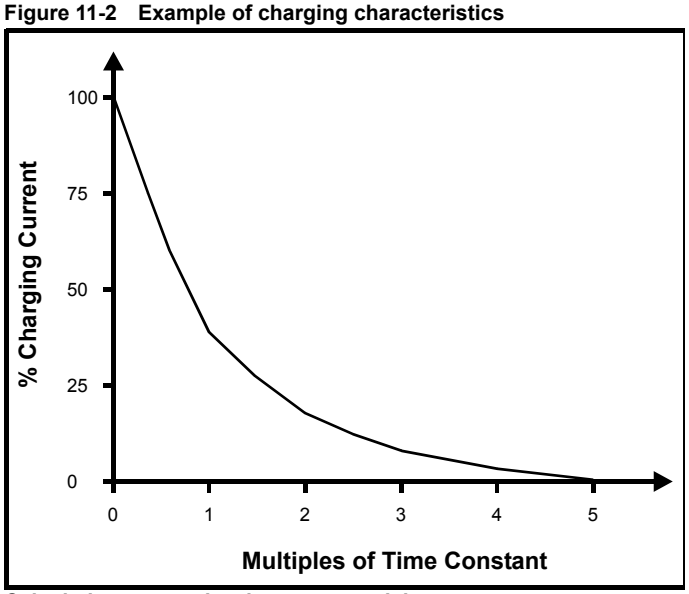
From the above calculations for a peak charging current of 31.108A with a charge time of 1.392s a magnetic overload with the following characteristics could be used:

2A nominal rating (31.108/20 = 1.5554 rounded to 2A)

O/L = 15.5 (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 at given Time Constant = Exp [-1 (Time Constants)] x I_{peak}

The following example calculates the current level after 3 time constants with a peak charging current of 100A:

Exp [-1 (3)] x 100 = 4.97A

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.

Calculation to convert from power to current: $\sqrt{\frac{P}{R}} = I$

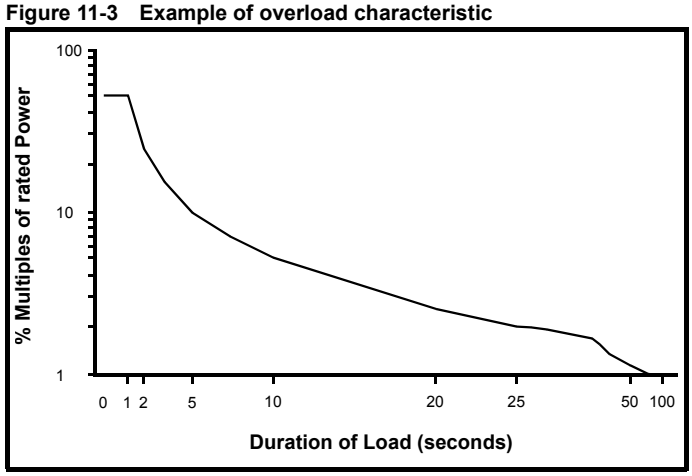
Example:

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 = 528Vac / 24Ω = 22A
Thermal / Magnetic overload current rating = 22A / 20 = 1.1A (use 1.6A)
10 x nominal power = 2.960kW

Current flowing during overload = $\sqrt{\frac{2960}{24}} = \mathbf{11.01A}$

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

WARNING

Users must not attempt to repair a drive if it is faulty, nor carry out fault diagnosis other than through the use of the diagnostic features described in this chapter.
If a drive is faulty, it must be returned to an authorized 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.

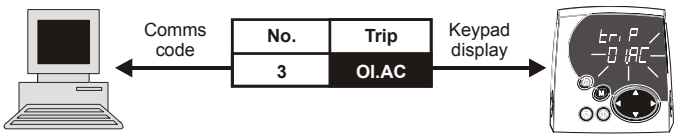
The trip indication can be read in Pr **10.20** providing a trip number. Trip numbers are listed in numerical order in Table 12-3 so the trip indication can be cross referenced and then diagnosed using Table 12-2.

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*.

Figure 12-1 Keypad status modes

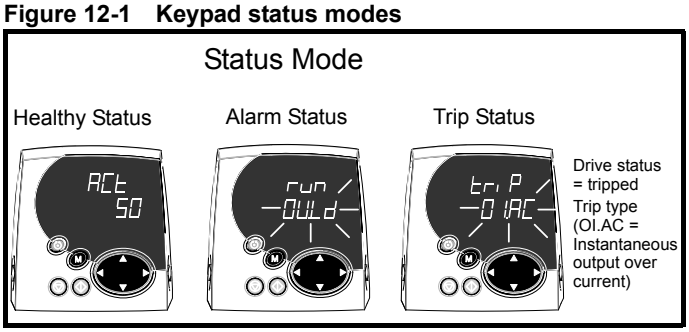
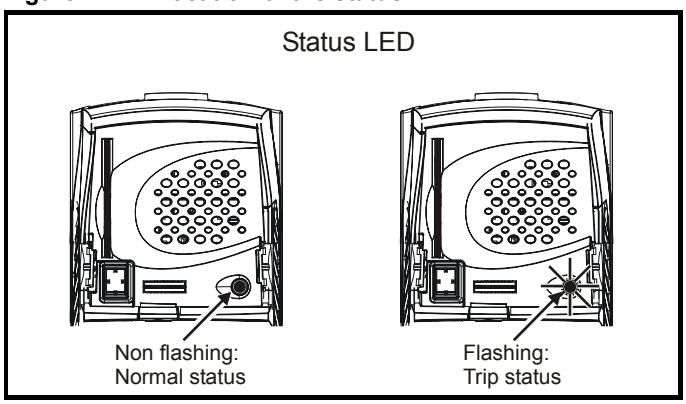


Figure 12-2 Location of the status LED



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 207.

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: 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.

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	Press the red reset button Drive rating parameters are: **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 The above parameters will be set to their default values.
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

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

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

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)
OIdC.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. **Drive voltage rating** / **Peak voltage [0V]** / **Maximum continuous voltage level** 200 / 415 / 410 400 / 830 / 815 575 / 990 / 970 690 / 1190 / 1175
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. **Drive voltage rating** / **Peak voltage [0V]** / **Maximum continuous voltage level** 200 / 415 / 410 400 / 830 / 815 575 / 990 / 970 690 / 1190 / 1175
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. • 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

Trip	Diagnosis
SLX.dF	**Solutions Module slot X trip: Solutions Module type fitted in slot X changed**
204,209,214	Save parameters and reset
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.

Error code	Reason for fault
39	User stack overflow
40	Unknown error
41	Parameter does not exist
42	Parameter read only
43	Parameter write only
44	Parameter value over range
45	Invalid synchronisation modes
46	Not Used
47	Sync lost with Virtual Master
48	RS485 not in user mode
49	Invalid RS485 configuration
50	Math fault
51	Array index out of range
52	Control word user trip
53	DPL program not compatible with this target
54	Processor overload/ Task Overrun
55	Invalid encoder configuration
56	Invalid timer unit configuration
57	Function block not supported by system
58	Corrupted Non-volatile flash
59	Drive rejected application module as Sync master
60	CTNet hardware error
61	Invalid CTNet configuration
62	CTNet baud rate does not match network
63	CTNet node ID already in use
64	Digital Output Overload
65	Invalid Function Block parameters
66	User Heap Requirement too large
67	File Does Not Exist
68	File Not Associated
69	Flash Access Failed during DB upload from drive
70	User Program download while drive enabled
71	Failed to change drive mode
72	Invalid CTNet Buffer Operation
73	Fast Parameter Initialisation Failure
74	Solutions Module over temperature

Check value in Pr **15**/**16**/**17.50**. The following table lists the possible error codes for the I/O module.

Error code	Reason for fault
0	No errors
1	Digital output short circuit
74	Module over temperature

<table>
<tr><th>Trip</th><th>Diagnosis</th></tr>
<tr><td>SLX.Er</td><td>Solutions Module slot X trip: Solutions Module in slot X has detected a fault</td></tr>
<tr><td>202,207,212</td><td>Fieldbus module category
Check value in Pr 15/16/17.50. The following table lists the possible error codes for the Fieldbus modules.
<table>
<tr><th>Error code</th><th>Fieldbus Option</th><th>Reason for fault</th></tr>
<tr><td>52</td><td>All except DPLCAN</td><td>Control word user trip</td></tr>
<tr><td>61</td><td>All</td><td>Invalid configuration parameters.</td></tr>
<tr><td>65</td><td>All except DPLCAN</td><td>Network loss</td></tr>
<tr><td>66</td><td>DeviceNet, CANopen and DPLCAN</td><td>"Bus-Off" Node sees an excessive number of transmission errors.</td></tr>
<tr><td>67</td><td>CANopen</td><td>Node has not received a SYNC telegram within a specified time - to be defined.</td></tr>
<tr><td>68</td><td>CANopen</td><td>Node has not received the guarding telegram within the time period specified.</td></tr>
<tr><td>69</td><td>DPLCAN</td><td>Node sends a data frame and no other node acknowledges receipt of the frame message.</td></tr>
<tr><td>70</td><td>All</td><td>No valid Fieldbus Menu data available in the module to download to the drive – The user may not have saved any data, or the data save may not have been completed successfully.</td></tr>
<tr><td>71</td><td>DeviceNet</td><td>The External power supply has been lost. This trip will only occur if the module was on line with a master when the loss occurs. i.e. will not occur if the power supply is not present during module initialisation.</td></tr>
<tr><td>74</td><td>All</td><td>The Solutions Module has overheated.</td></tr>
<tr><td>98</td><td>All</td><td>The Solutions Module background task has not been completed.</td></tr>
<tr><td>99</td><td>All</td><td>Software Fault.</td></tr>
</table></td></tr>
<tr><td>SLX.HF</td><td>Solutions Module slot X trip: Solutions Module X hardware fault</td></tr>
<tr><td>200,205,210</td><td>Ensure Solutions Module is fitted correctly
Return Solutions Module to supplier</td></tr>
<tr><td>SLX.nF</td><td>Solutions Module slot X trip: Solutions Module has been removed</td></tr>
<tr><td>203,208,213</td><td>Ensure Solutions Module is fitted correctly
Re-fit Solutions Module
Save parameters and reset drive</td></tr>
<tr><td>SL.rtd</td><td>Solutions Module trip: Drive mode has changed and Solutions Module parameter routing is now incorrect</td></tr>
<tr><td>215</td><td>Press reset.
If the trip persists, contact the supplier of the drive.</td></tr>
<tr><td>SLX.tO</td><td>Solutions Module slot X trip: Solutions Module watchdog timeout</td></tr>
<tr><td>201,206,211</td><td>Press reset.
If the trip persists, contact the supplier of the drive.</td></tr>
<tr><td>t010</td><td>User trip defined in 2nd processor Solutions Module code</td></tr>
<tr><td>10</td><td>SM-Applications program must be interrogated to find the cause of this trip</td></tr>
<tr><td>t036 to t038</td><td>User trip defined in 2nd processor Solutions Module code</td></tr>
<tr><td>36 to 38</td><td>SM-Applications program must be interrogated to find the cause of this trip</td></tr>
<tr><td>t040 to t089</td><td>User trip defined in 2nd processor Solutions Module code</td></tr>
<tr><td>40 to 89</td><td>SM-Applications program must be interrogated to find the cause of this trip</td></tr>
<tr><td>t099</td><td>User trip defined in 2nd processor Solutions Module code</td></tr>
<tr><td>99</td><td>SM-Applications program must be interrogated to find the cause of this trip</td></tr>
<tr><td>t111 to t160</td><td>User trip defined in 2nd processor Solutions Module code</td></tr>
<tr><td>111 to 160</td><td>SM-Applications program must be interrogated to find the cause of this trip</td></tr>
<tr><td>t168 to t175</td><td>User trip defined in 2nd processor Solutions Module code</td></tr>
<tr><td>168 to 175</td><td>SM-Applications program must be interrogated to find the cause of this trip</td></tr>
<tr><td>t177 to t178</td><td>User trip defined in 2nd processor Solutions Module code</td></tr>
<tr><td>177 to 178</td><td>SM-Applications program must be interrogated to find the cause of this trip</td></tr>
<tr><td>t216 to t217</td><td>User trip defined in 2nd processor Solutions Module code</td></tr>
<tr><td>216 to 217</td><td>SM-Applications program must be interrogated to find the cause of this trip</td></tr>
</table>

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 **Drive voltage rating (Vac) / Under voltage threshold (Vdc)** 200 / 175 400 / 350 575 / 435 690 / 435

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		

Table 12-4 Trip group catergories

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.

Table 12-5 DC voltage trip and restart levels

Drive voltage rating	UU trip level Vdc	UU restart level Vdc
200	175	215
400	330	425
575	435	590
690	435	590

12.2 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 12-6 Alarm indications

Lower display	Description
Hot	Heatsink or control board or inverter IGBT over temperature alarms are active
• 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 • The ambient temperature around the control PCB is approaching the over temperature threshold (see the 'O.CtL' trip).	
OVLd	Motor overload
The motor I^2t 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 12-7 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 12-8 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 *Unidrive SP User Guide*.	
cArd	
The drive is writing a parameter set to the SMARTCARD during power-up. For further information, refer to the *Unidrive SP User Guide*.	
loAding	
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 207 is the value transmitted.

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