*Installation Guide*

# Unidrive SP Regen

200V, 400V, 575V, 690V

Part Number: 0471-0029-02
Issue: 2

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.

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



## Drive software version

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

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

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

## Environmental statement

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

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

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

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

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



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:

| | Familiarisation | System design | Programming and commissioning | Troubleshooting |
|---|---|---|---|---|
| 1 Safety information | ● | ● | ● | ● |
| 2 Introduction | ● | | | |
| 3 Product information | ● | | | |
| 4 System design | ● | ● | | |
| 5 Mechanical Installation | ● | ● | | |
| 6 Electrical installation | ● | ● | ● | |
| 7 Getting started | ● | | ● | ● |
| 8 Optimisation | | | ● | |
| 9 Parameters | | | ● | ● |
| 10 Technical data | ● | ● | | ● |
| 11 Component sizing calculations | ● | ● | | |
| 12 Diagnostics | | | | ● |

# Contents

# 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.

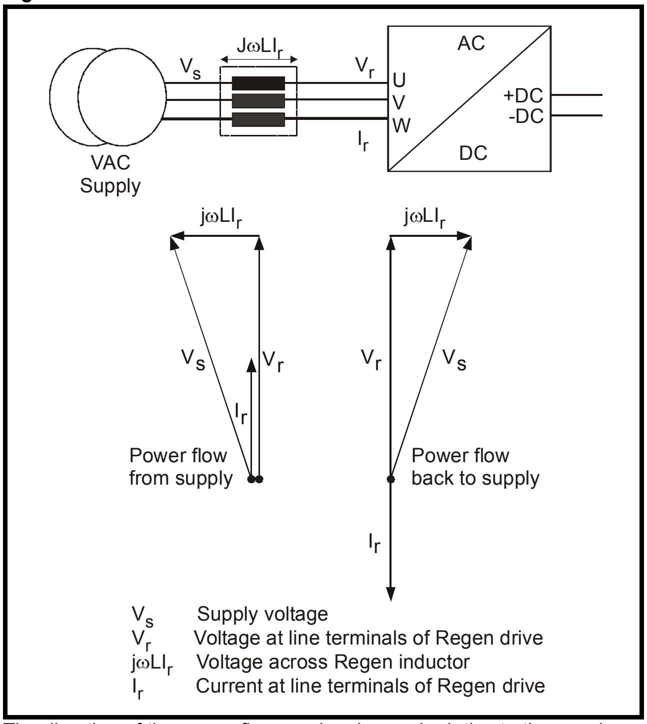
Regen inductors must be used to ensure a minimum source impedance, these being selected and specified later in the guide.

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

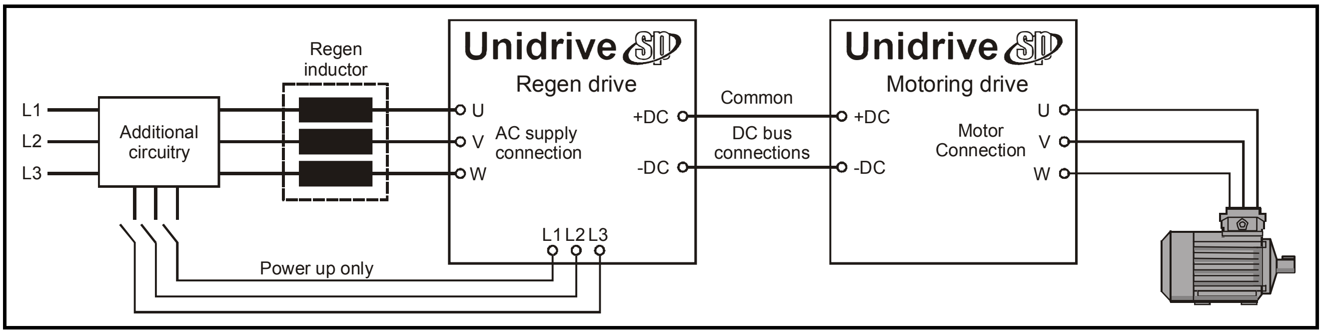
### 2.8.1 Single Regen, single motoring system

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**



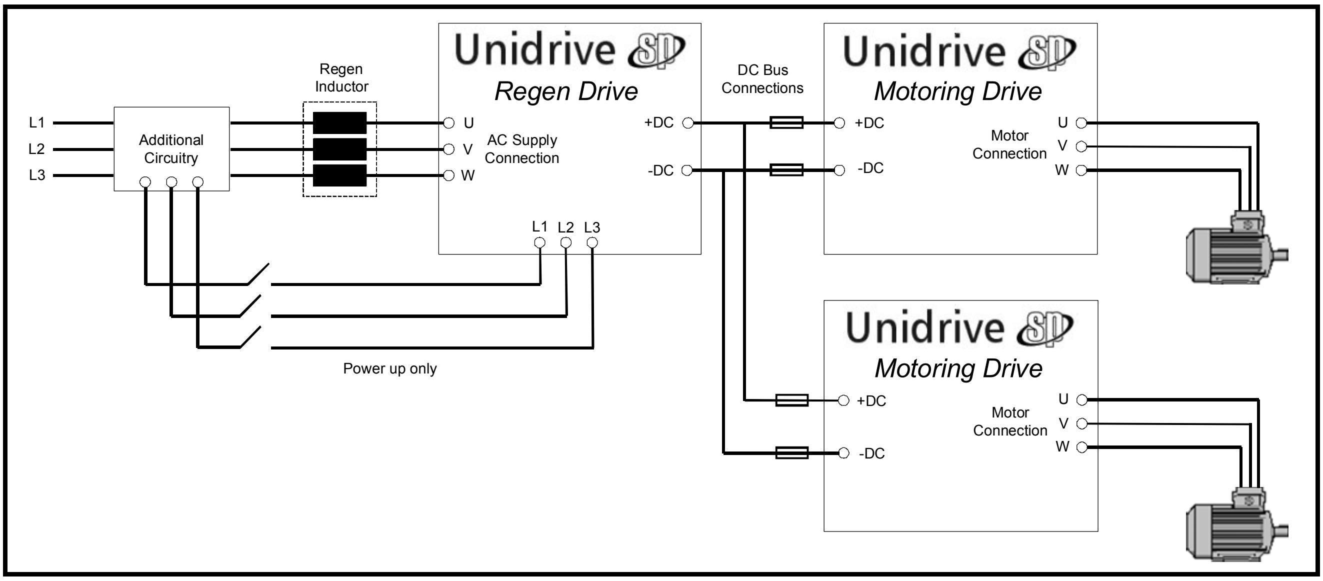

**NOTE**

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.

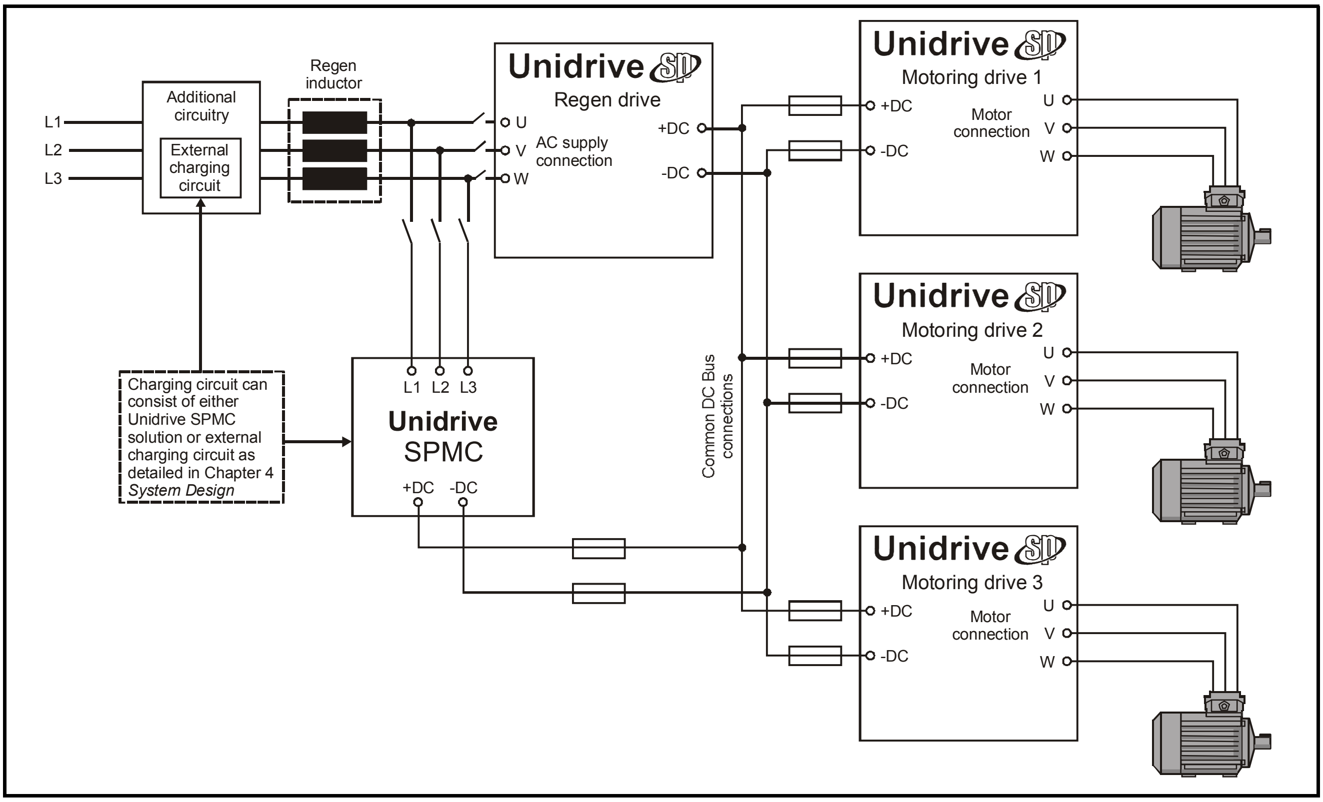
**Figure 2-3 Single Regen, multiple motoring system**




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

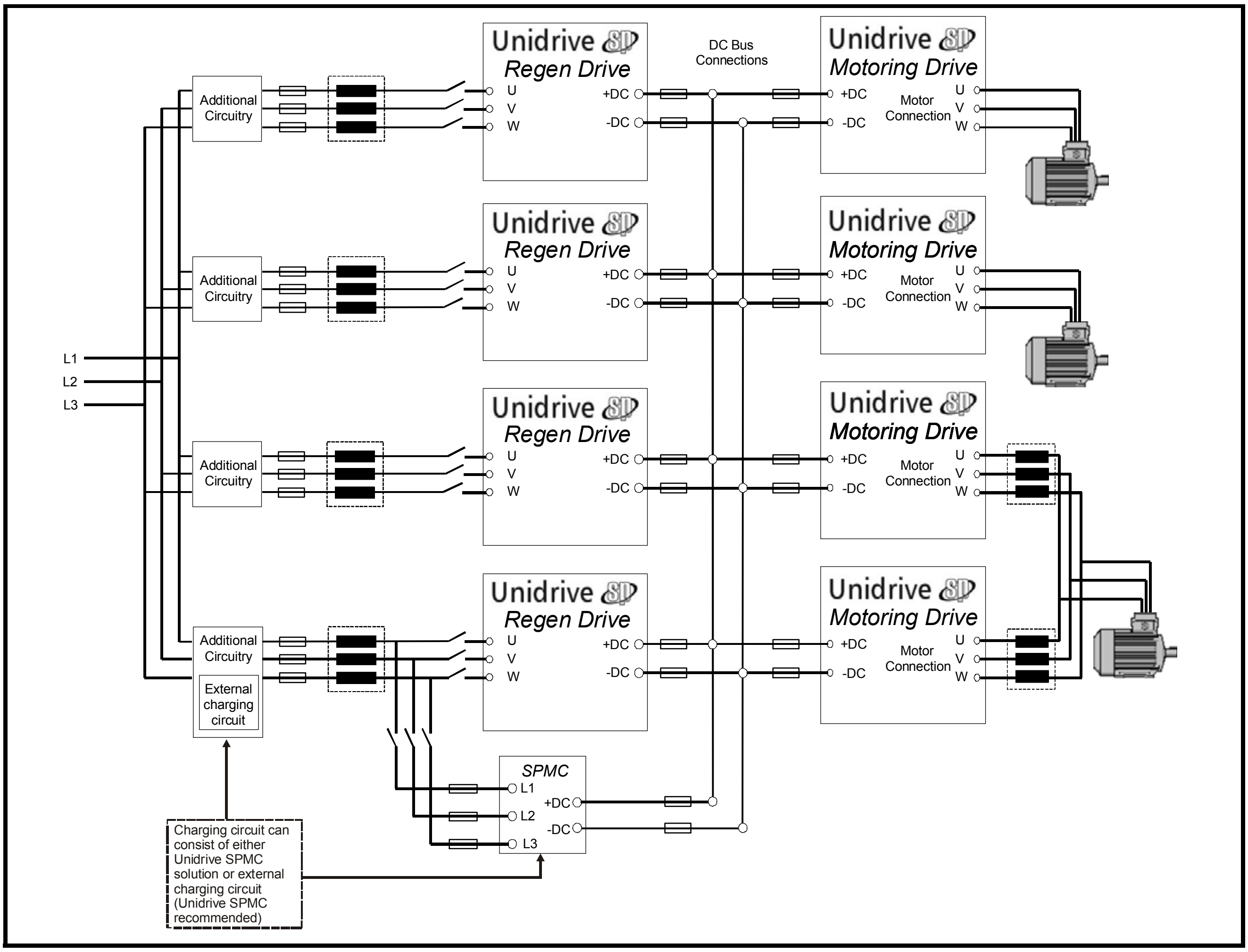
Figure 2-5 shows a multiple regen drive system with multiple motoring drives. For this configuration the regen drives are sized to the total power requirement of all motoring drives.

**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**



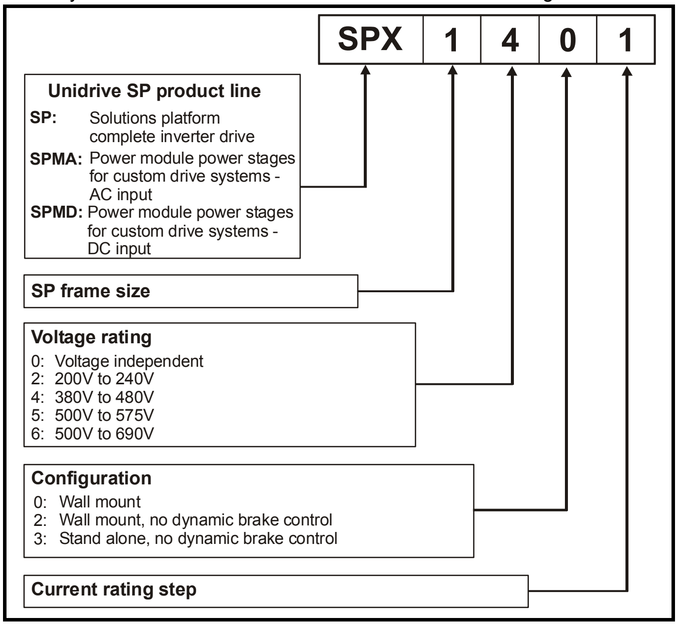

**NOTE**

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

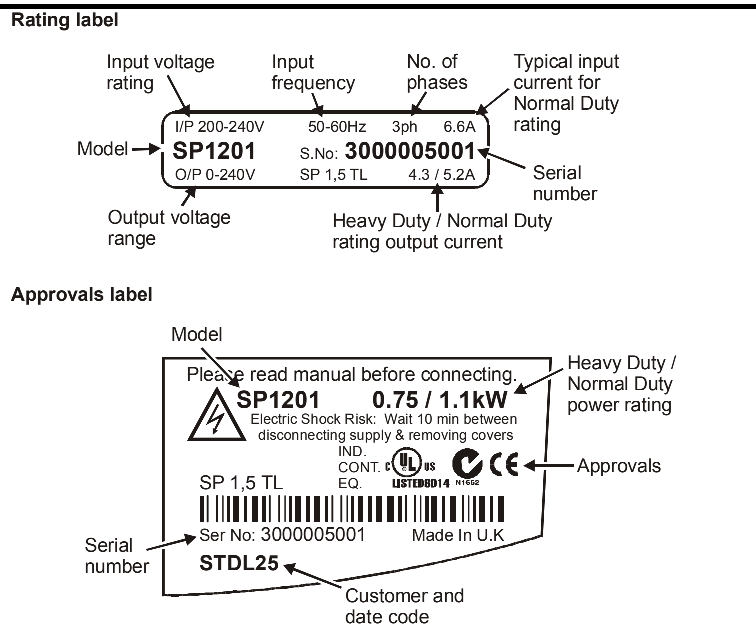
The way in which the model numbers for the Unidrive SP range are formed is illustrated below.




## 3.2 Nameplate description

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

**Figure 3-1 Typical drive rating labels**

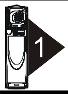
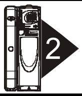
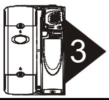
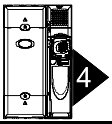
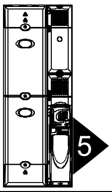



**Key to approvals**

| | | |
|---|---|---|
| CE | CE approval | Europe |
| N1652 | C Tick approval | Australia |
| c UL us | UL / cUL approval | USA & Canada |

## 3.3 Ratings

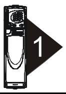
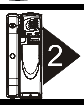
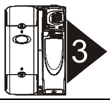
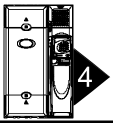
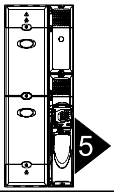
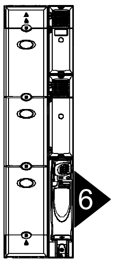
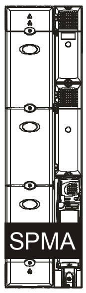
**Table 3-1 200V Drive ratings (200V to 240V ±10%)**

| 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%)**

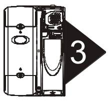
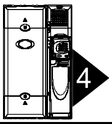
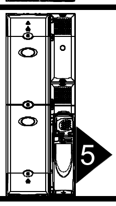
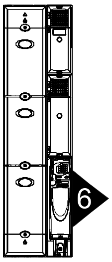
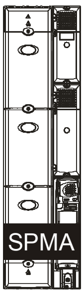
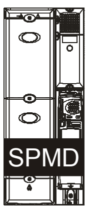
| Model | | Normal Duty | | | Heavy Duty | | |
|---|---|---|---|---|---|---|---|
| | | Maximum continuous input current | Typical motor power at 400V | Typical motor power at 460V | Maximum continuous input current | Typical motor power at 400V | Typical motor power at 460V |
| | | A | kW | hp | A | 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%)**

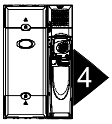
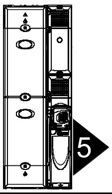
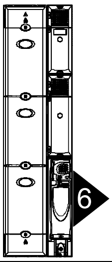
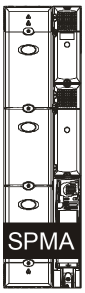
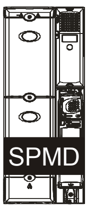
| Model | | Normal Duty | | | Heavy Duty | | |
|---|---|---|---|---|---|---|---|
| | | **Maximum continuous output current** | **Nominal power at 575V** | **Motor power at 575V** | **Maximum continuous output current** | **Nominal power at 575V** | **Motor power at 575V** |
| | | **A** | **kW** | **hp** | **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**

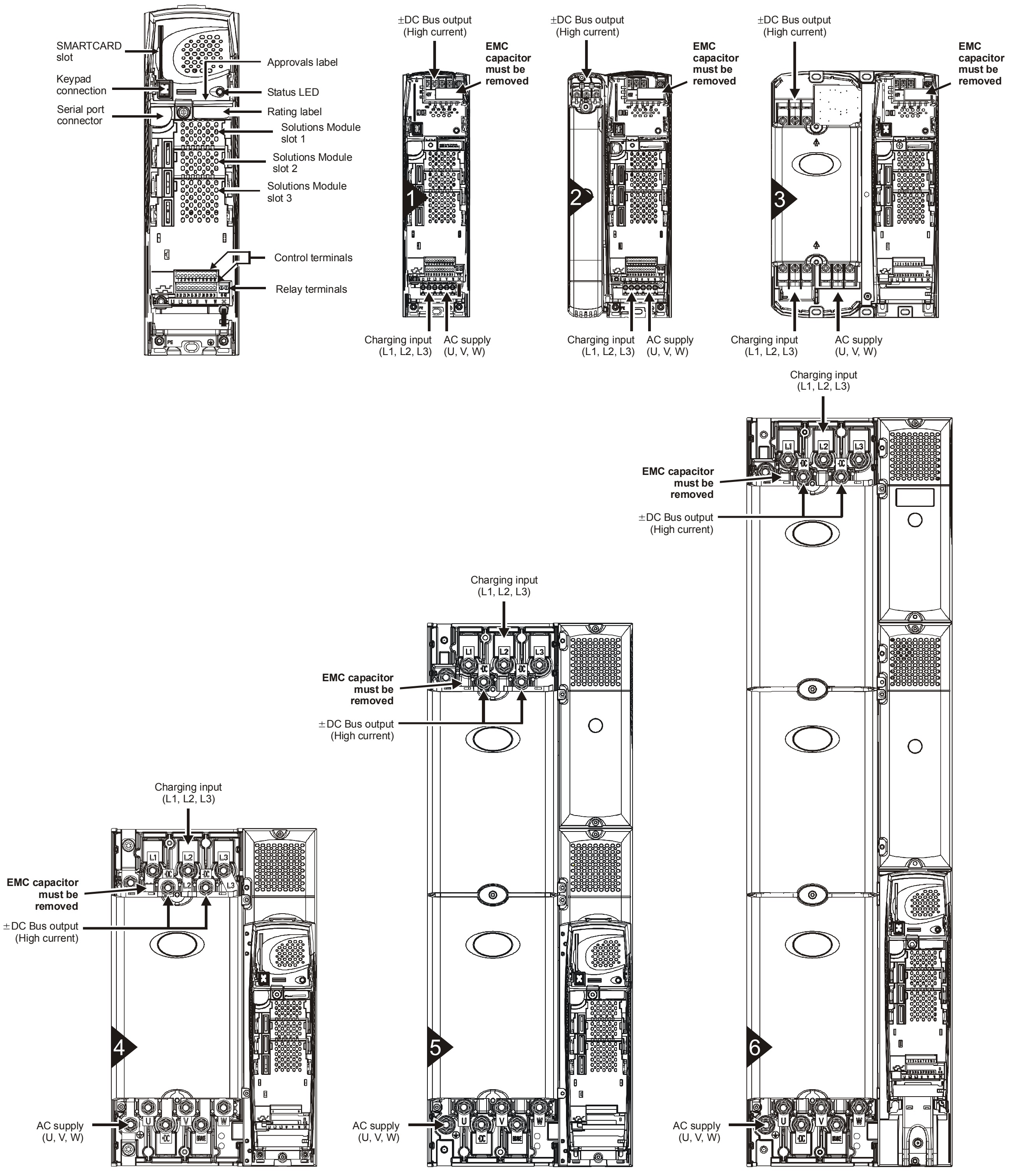
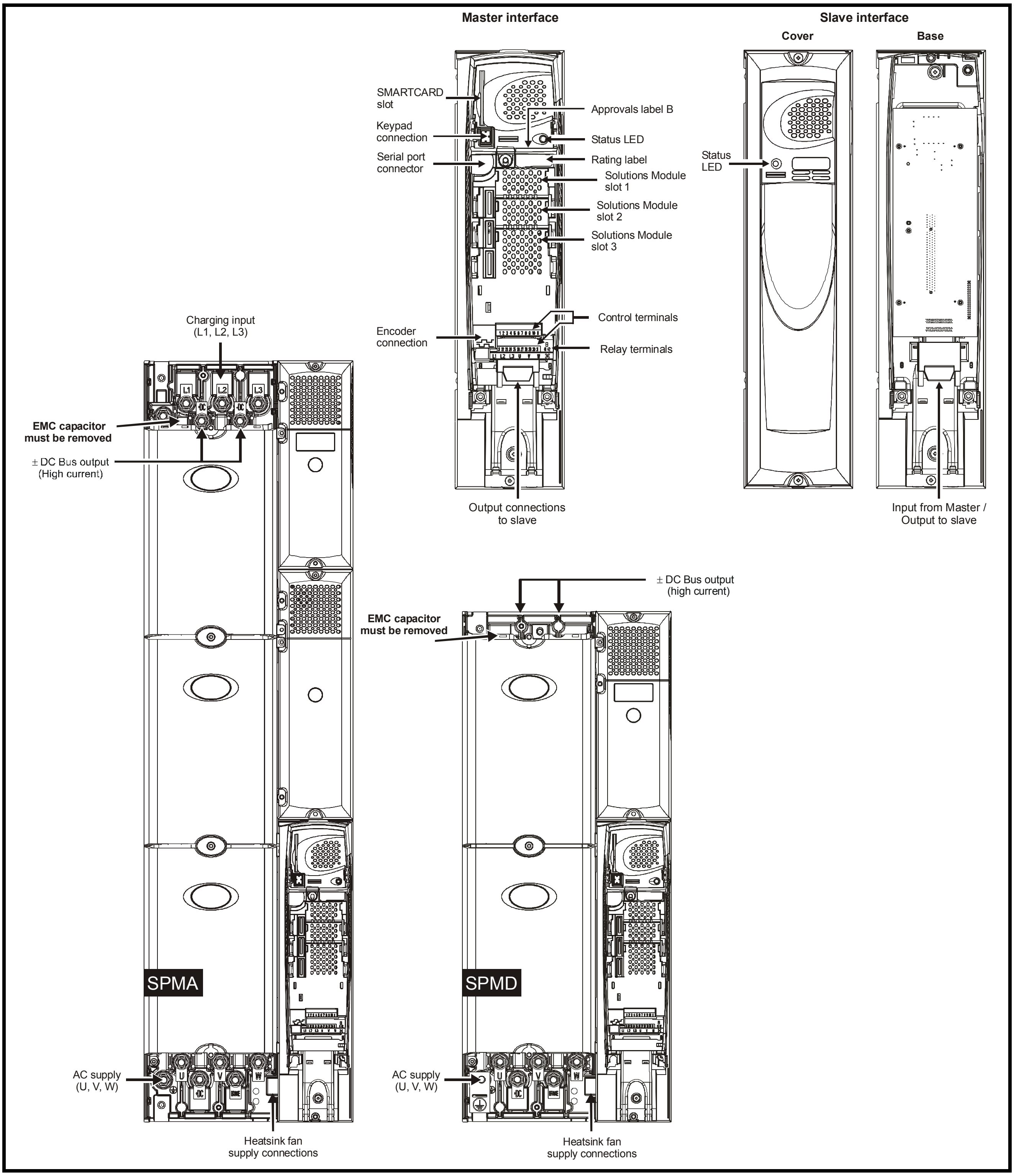


**Figure 3-3 Features of the drive sizes SPMA and SPMD**

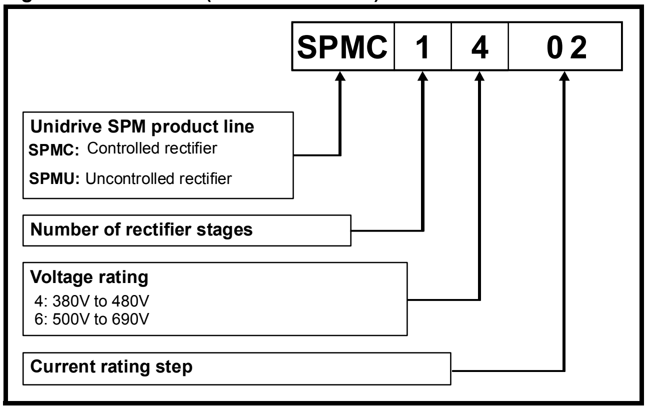


## 3.5 Unidrive SPMC half controlled thyristor rectifier

**NOTE**

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

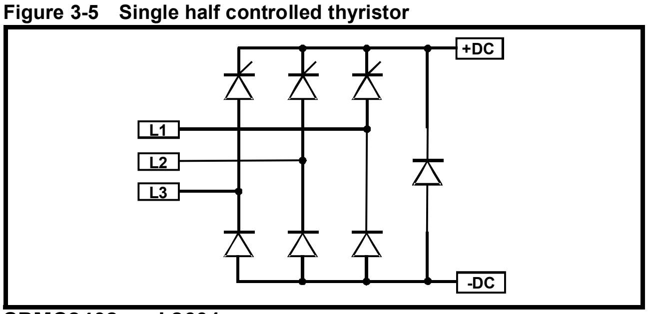
**Figure 3-4 Rectifier (SPMC and SPMU)**




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

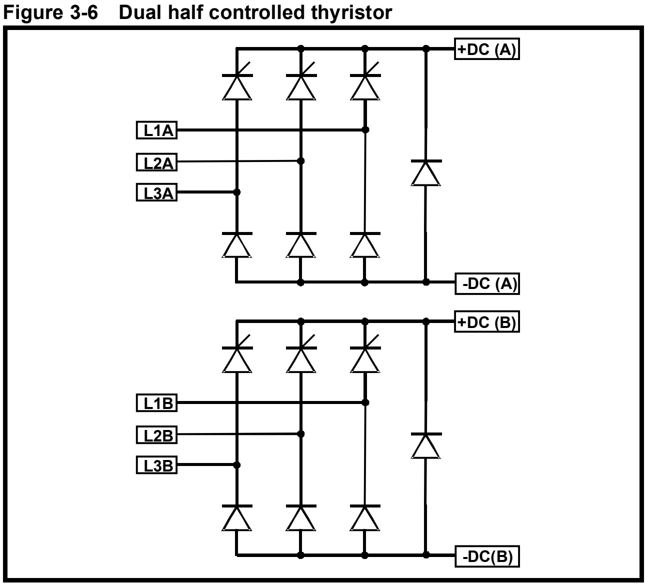
**SPMC1402 and 1601**

**Figure 3-5 Single half controlled thyristor**



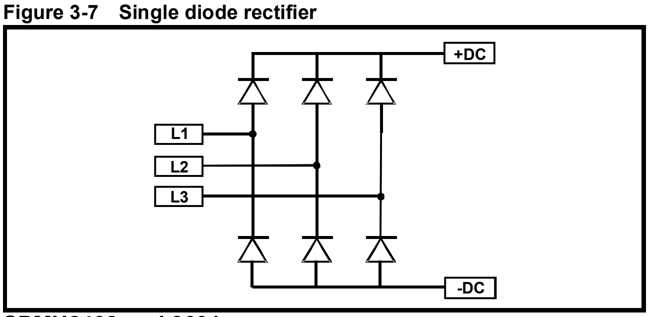

**SPMC2402 and 2601**

**Figure 3-6 Dual half controlled thyristor**



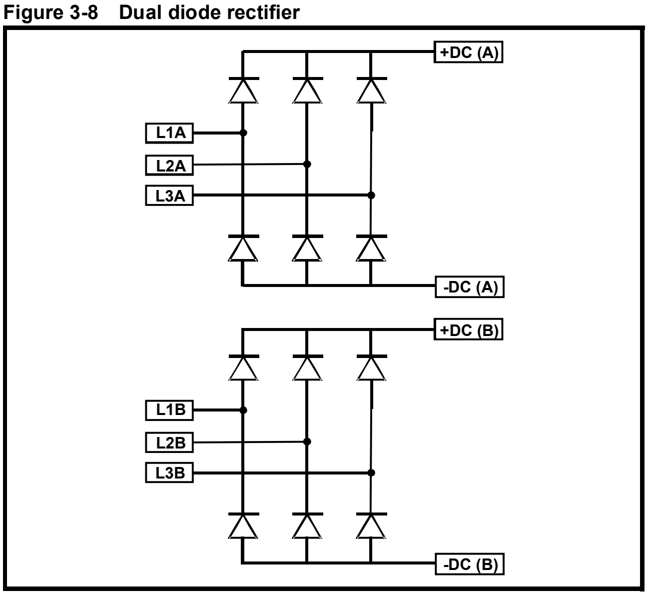

**SPMU1401, 1402 and 1601**

**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**.

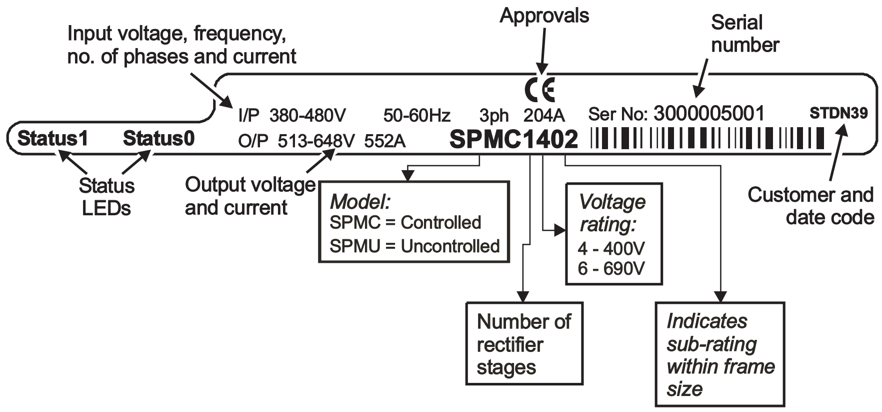
An external 24V, 3A power supply is required in addition to the AC supply to allow the rectifier to operate. Control wiring is required between the rectifier and motoring drive(s) so that if the rectifier indicates a fault the motoring drive(s) will be disabled.

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:<br>• Snubber overheating due to excessive cable charging current or supply notching<br>• Rectifier heatsink over temperature<br>• Rectifier PCB over temperature<br>• 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:<br>• Internal fault<br>• Check that rectifier is an SPMU. This could indicate that unit is an SPMC |
| ON | OFF | Any of the following:<br>• Rectifier heatsink over temperature<br>• Rectifier PCB over temperature<br>• 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.

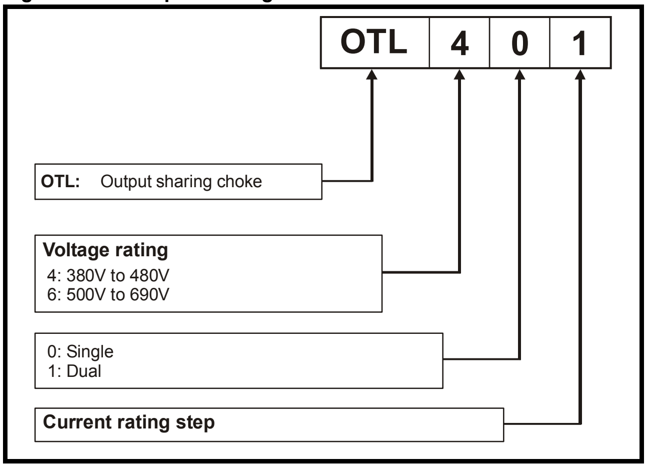
WARNING

- 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.
- 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**

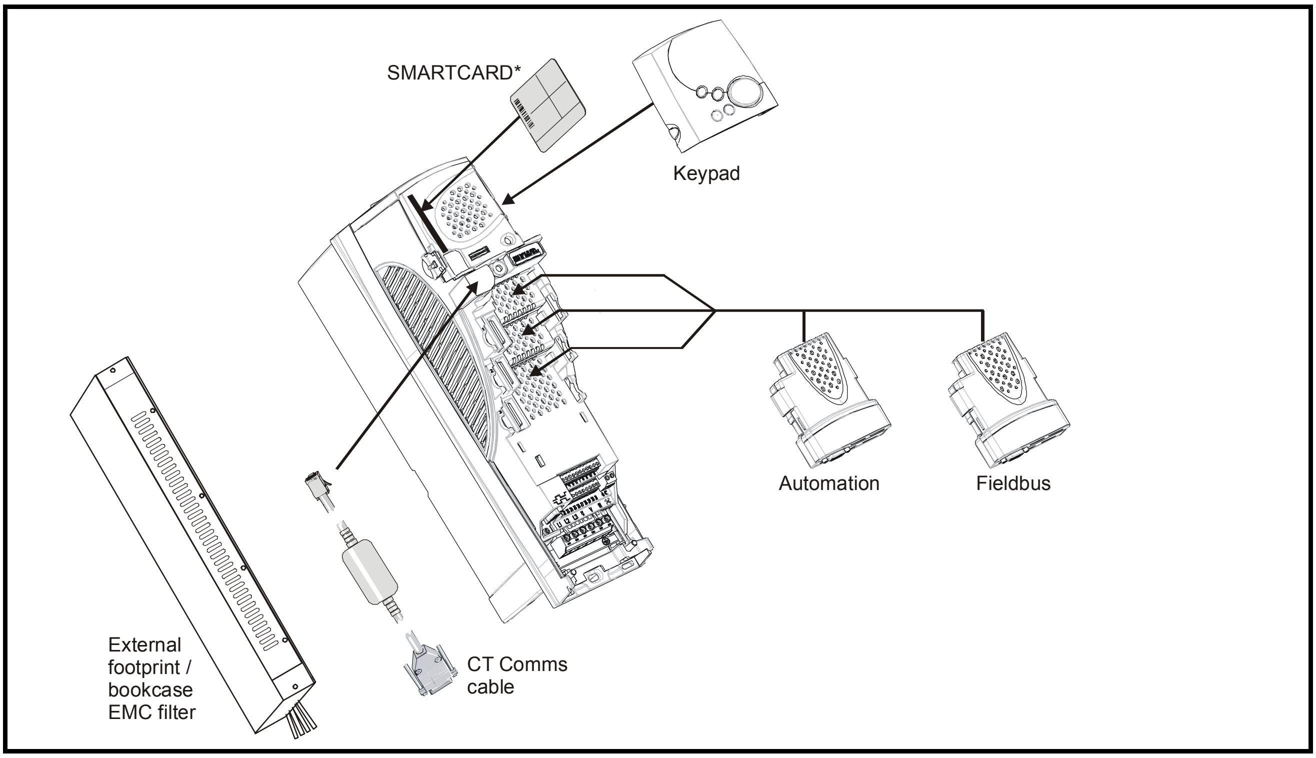
| Model | Current A | Inductance µH | Width (W) mm | Depth (D) mm | Height (H) mm | Weight kg | Part No. |
|---|---|---|---|---|---|---|---|
| OTL411 | 389.5 | 42.8 | 300 | 150 | 160 | 8 | 4401-0188-00 |
| OTL412 | 470.3 | 36.7 | 300 | 150 | 160 | 8 | 4401-0189-00 |
| OTL413 | 551 | 31.1 | 300 | 150 | 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**



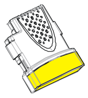
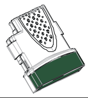
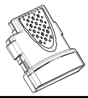
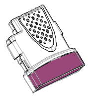
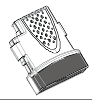
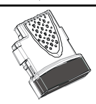
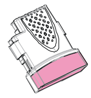
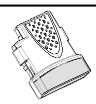
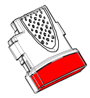
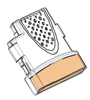
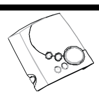
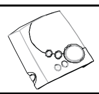

* A SMARTCARD is provided with the Unidrive SP as standard. Only one SMARTCARD can be fitted at any one time.

**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**<br>Increases the I/O capability by adding the following to the existing I/O in the drive:<br>• digital inputs x 3<br>• digital I/O x 3<br>• analogue inputs (voltage) x 2<br>• analogue output (voltage) x 1<br>• relay x 2 |
| |  | Dark Green | SM-Applications | **Applications Processor (with CTNet)**<br>2nd processor for running pre-defined and /or customer created application software with CTNet support |
| |  | White | SM-Applications Lite | **Applications Processor**<br>2nd processor for running pre-defined and /or customer created application software |
| Fieldbus |  | Purple | SM-PROFIBUS-DP | **Profibus option**<br>PROFIBUS DP adapter for communications with the Unidrive SP. |
| |  | Medium Grey | SM-DeviceNet | **DeviceNet option**<br>Devicenet adapter for communications with the Unidrive SP |
| |  | Dark Grey | SM-INTERBUS | **Interbus option**<br>Interbus adapter for communications with the Unidrive SP |
| |  | Pink | SM-CAN | **CAN option**<br>CAN adapter for communications with the Unidrive SP |
| |  | Light Grey | SM-CANopen | **CANopen option**<br>CANopen adapter for communications with the Unidrive SP |
| |  | Red | SM-SERCOS | **SERCOS option**<br>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**<br>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**<br>Keypad with a LED display |
| |  | N/A | SM-Keypad Plus | **LCD keypad option**<br>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

CAUTION

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

The regen inductor supports the difference between the PWM voltage from the Unidrive 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.

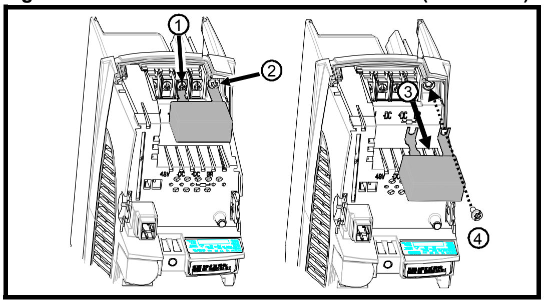
CAUTION

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.

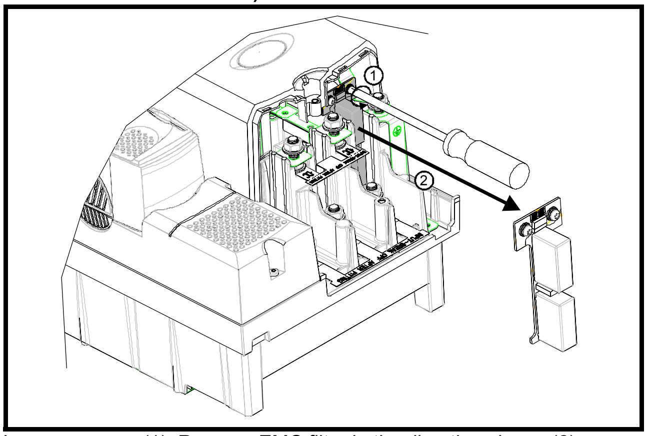
**Figure 3-12 Removal of internal EMC filter (size 1 to 3)**




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:

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

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

The motoring drive can supply power:

$\sqrt{3} \times$ **Rated current** $\times$ **Motor voltage** $\times$ **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:

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

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

The motoring drives maximum. power is:

$\sqrt{3} \times$ **175%** $\times$ **Rated current** $\times$ **Motor voltage** $\times$ **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**

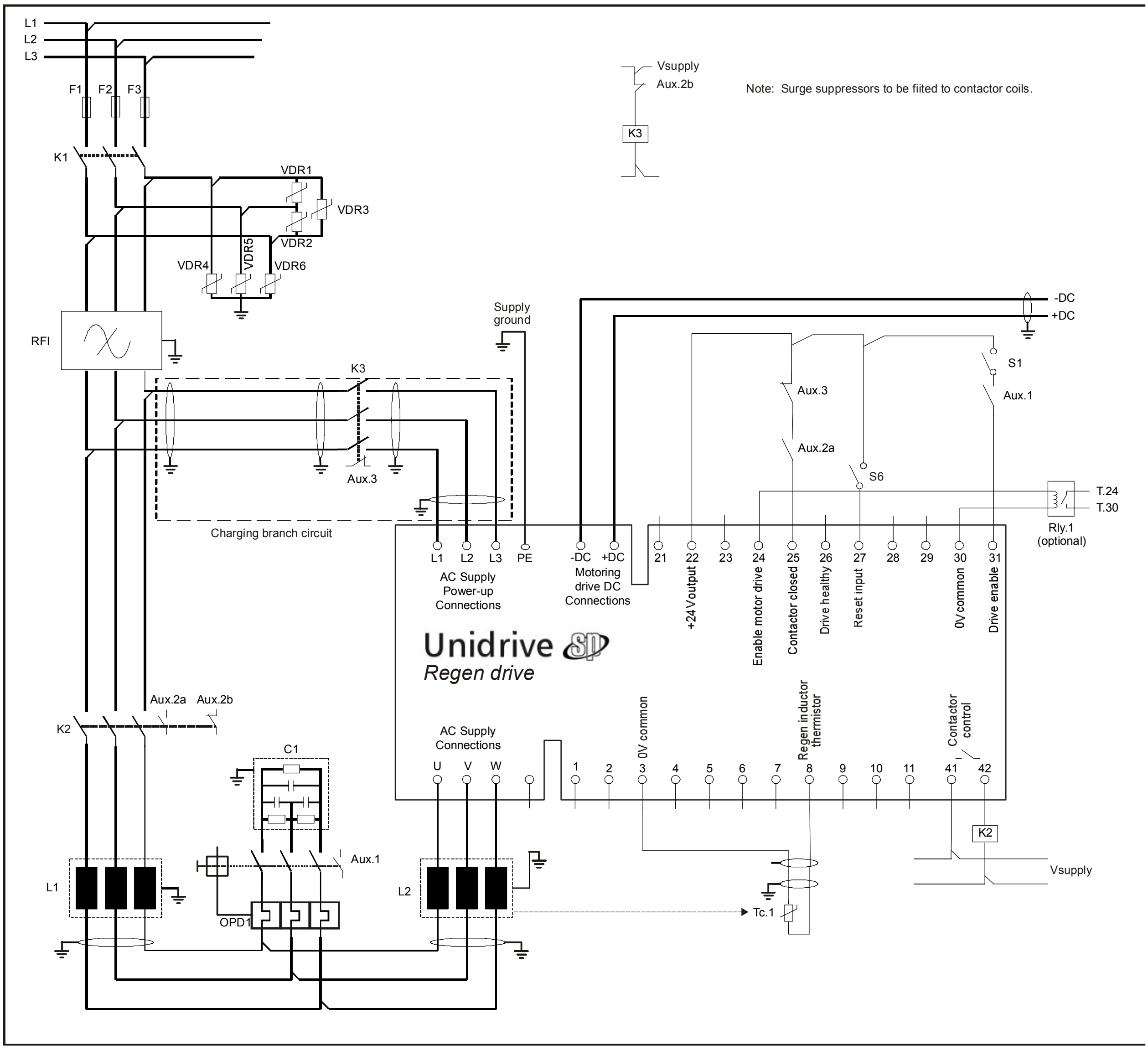



**Table 4-1 Key to Figure 4-1**

| 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**

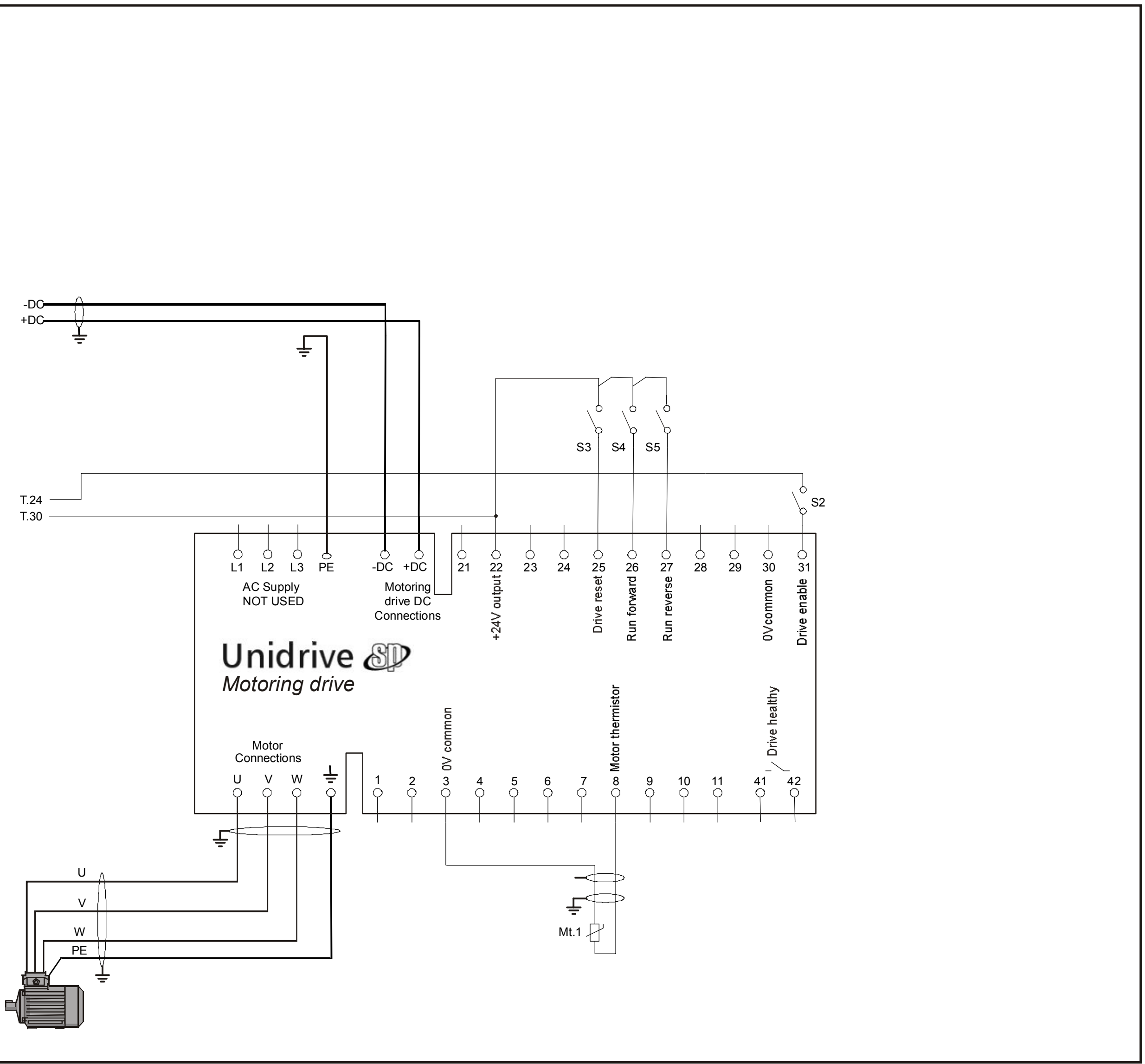
| Key | Description |
|---|---|
| Vsupply | System control supply |
| +DC, -DC | Motoring drive power connection to Regen drive |
| S1 | Regen drive enable |
| S2 | Motoring drive enable |
| S3 | Motoring drive reset |
| S4 | Motoring drive run forward |
| S5 | Motoring drive run reverse |
| S6 | Regen 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**

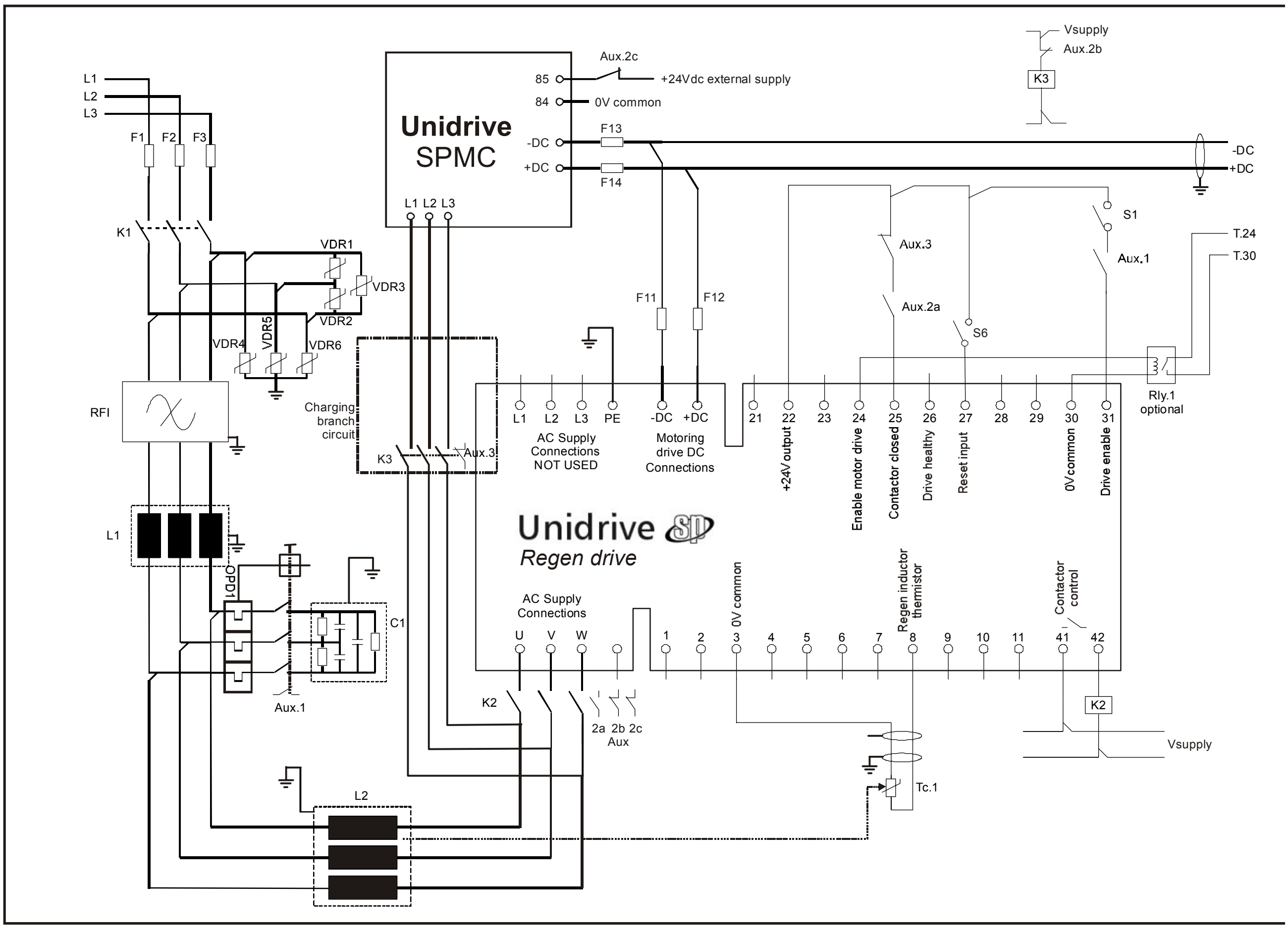



**Table 4-2 Key to Figure 4-3**

| 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**

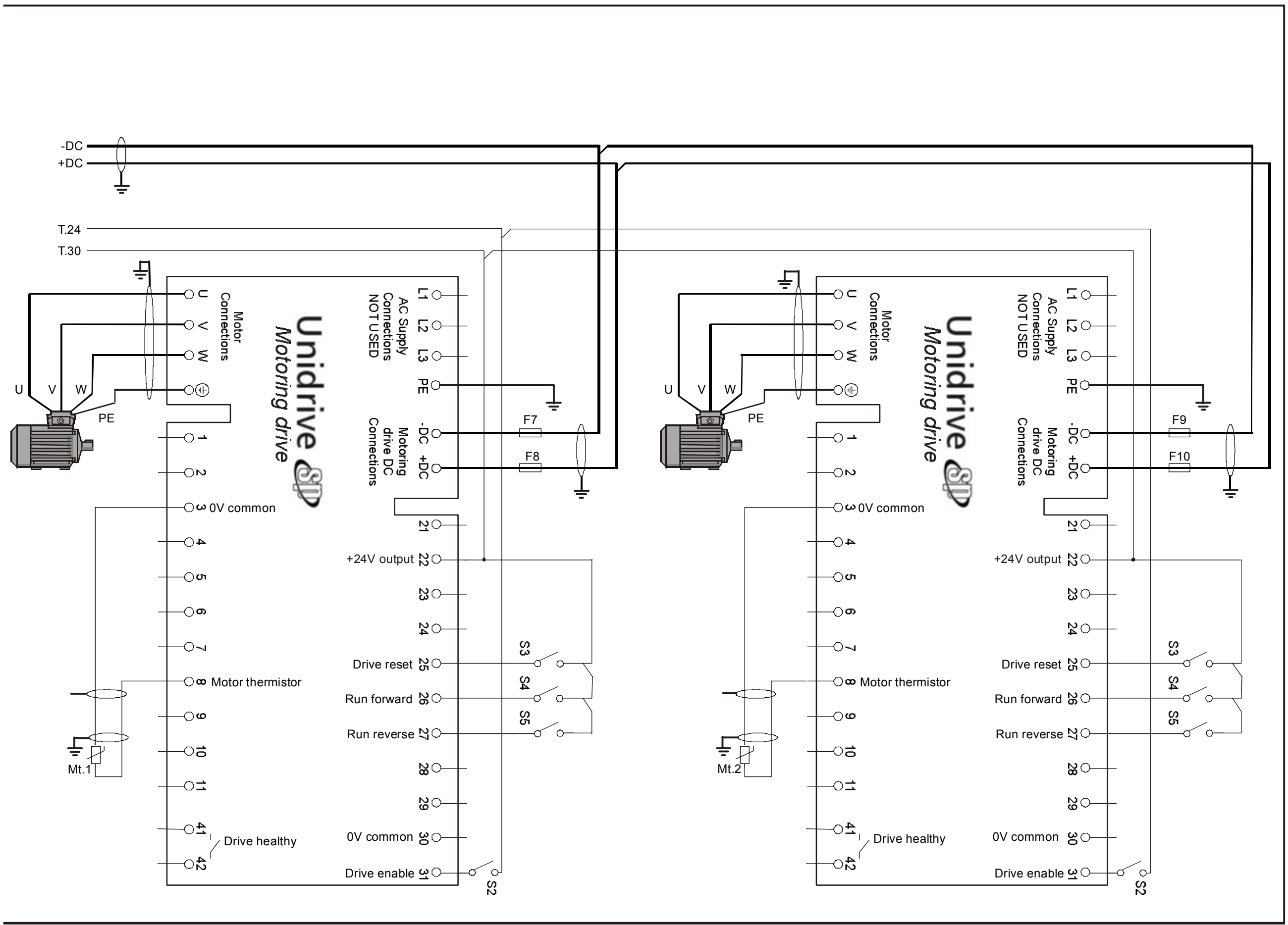
The regen inductor duty is very arduous and therefore selection is critical. As a result only regen inductors specified in this guide should be used.

**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**

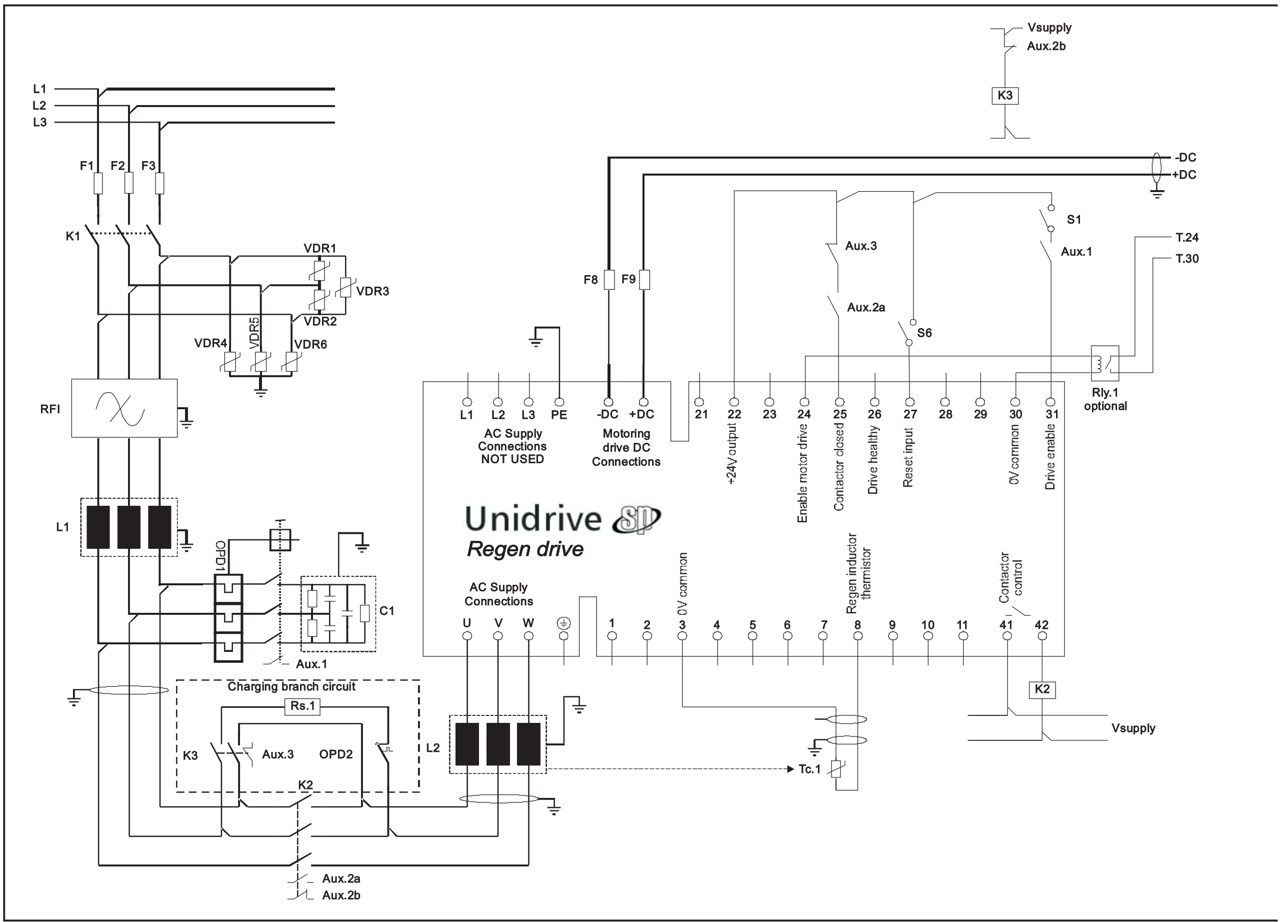



**Table 4-3 Key to Figure 4-3**

| 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.

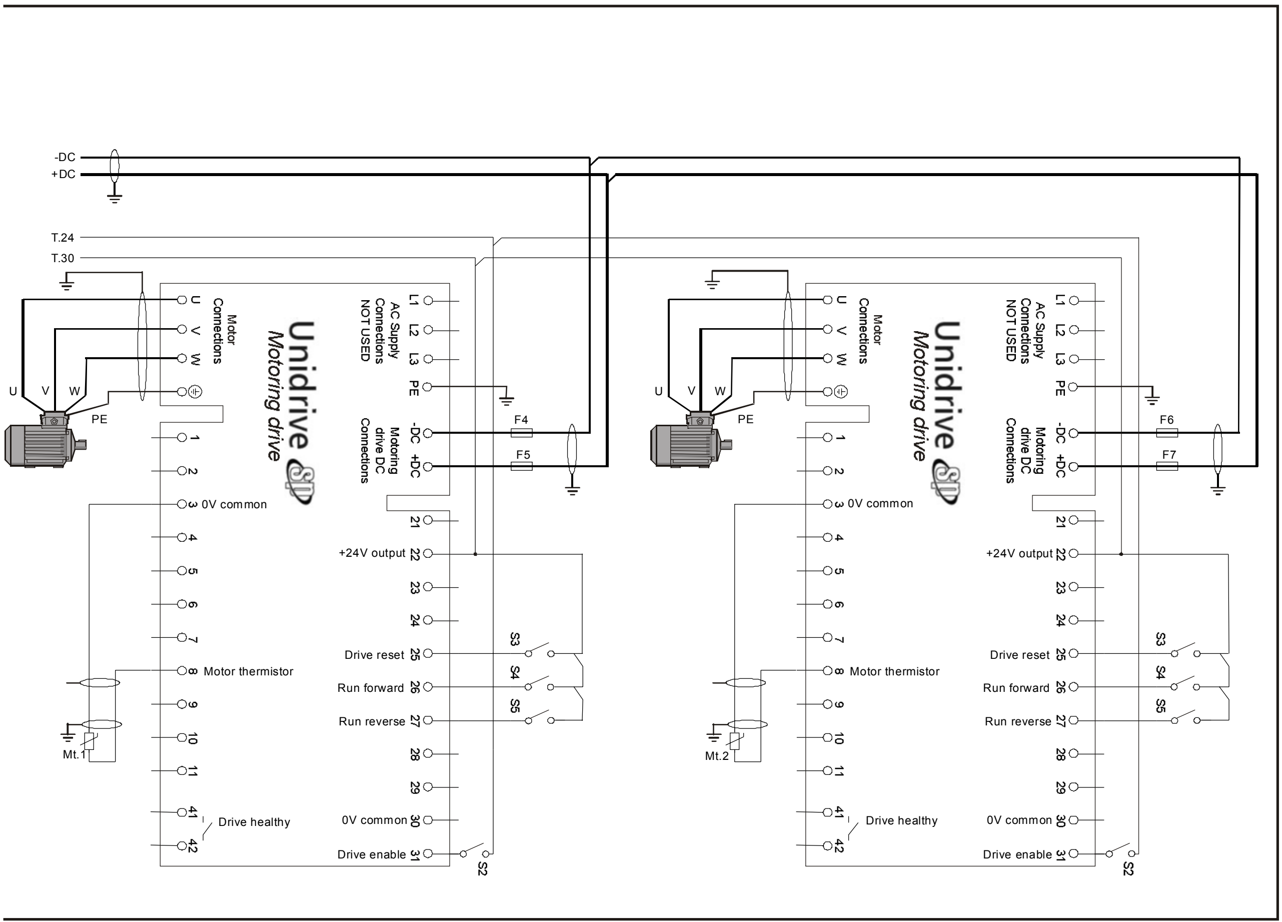
For sizing of the external charging circuit required for the multiple motoring drive system, refer to Chapter 11 *Component sizing* on page 203. For details on charging resistors and protection refer to section 10.4.2 *Softstart resistor - type TG series* on page 197.

**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.

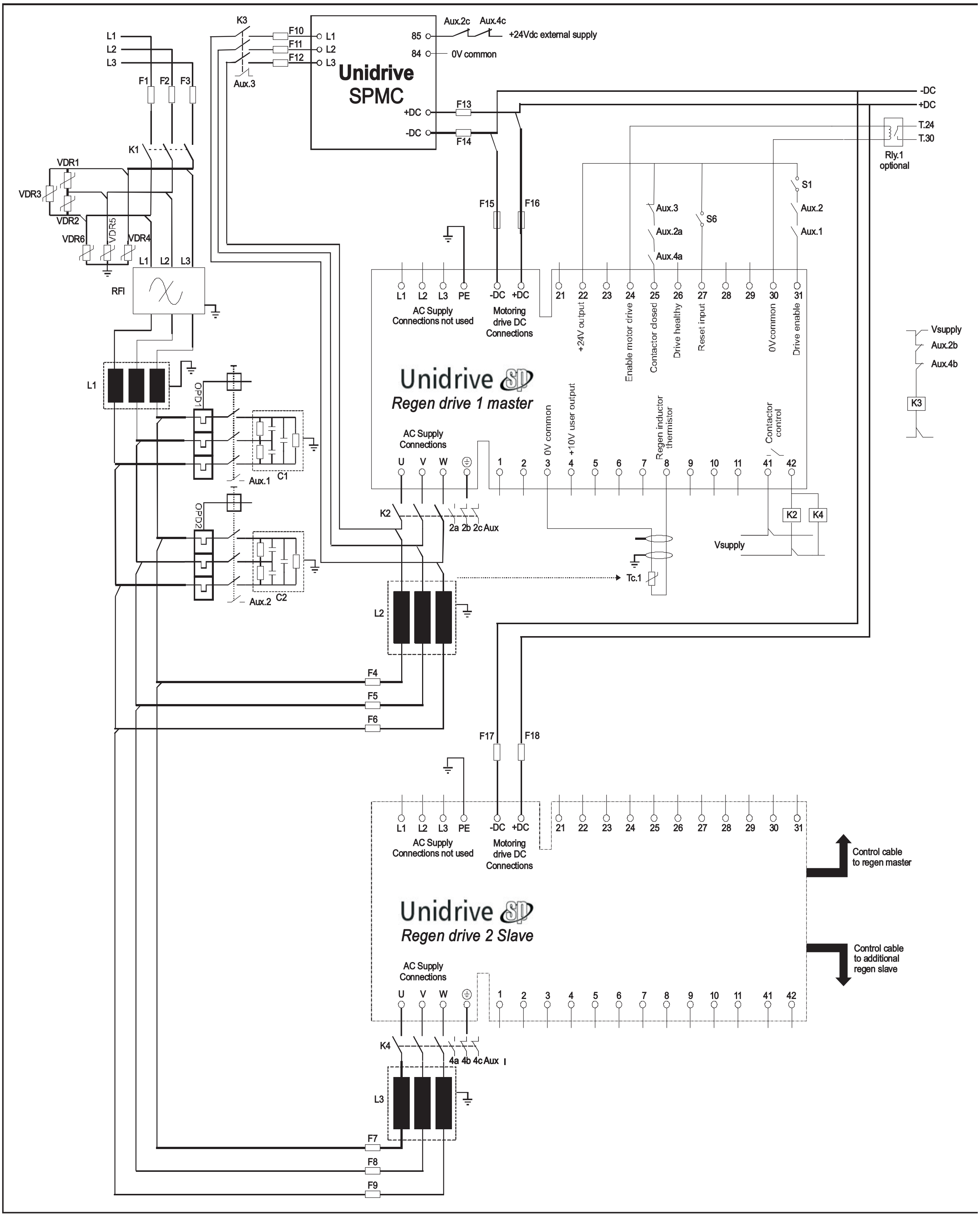
**NOTE**

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**



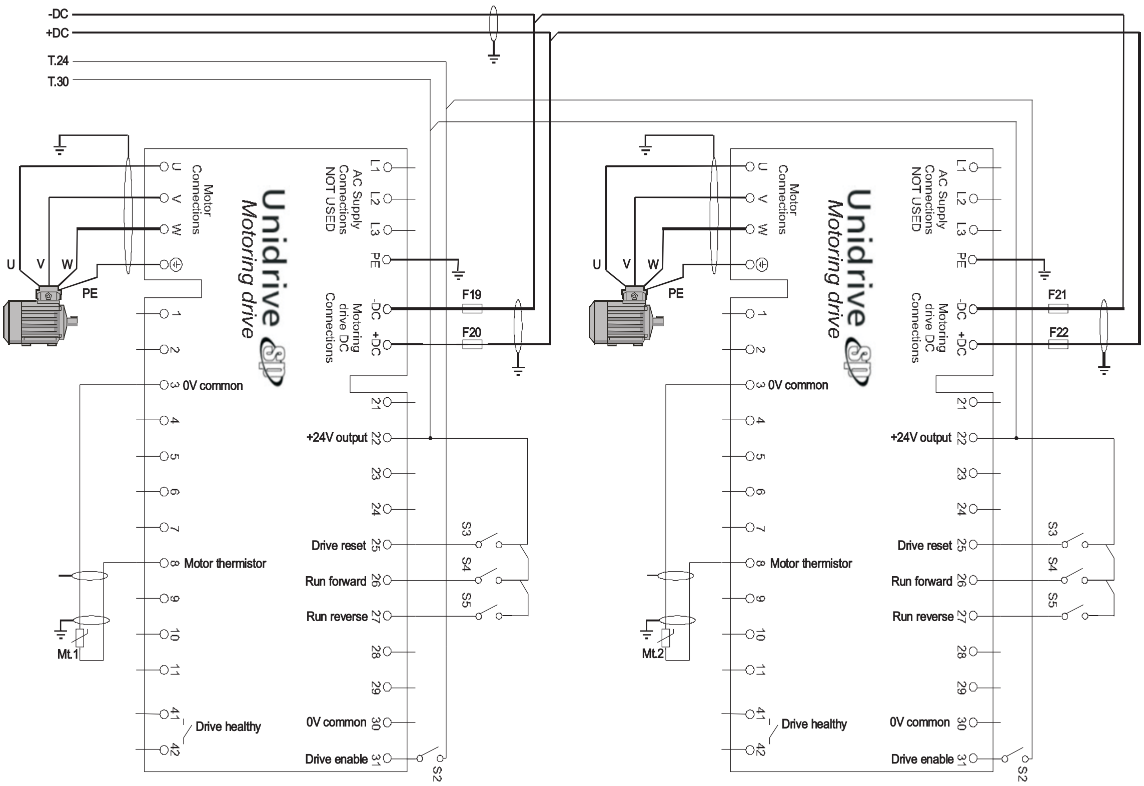



**Table 4-4 Key to Figure 4-4**

| 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

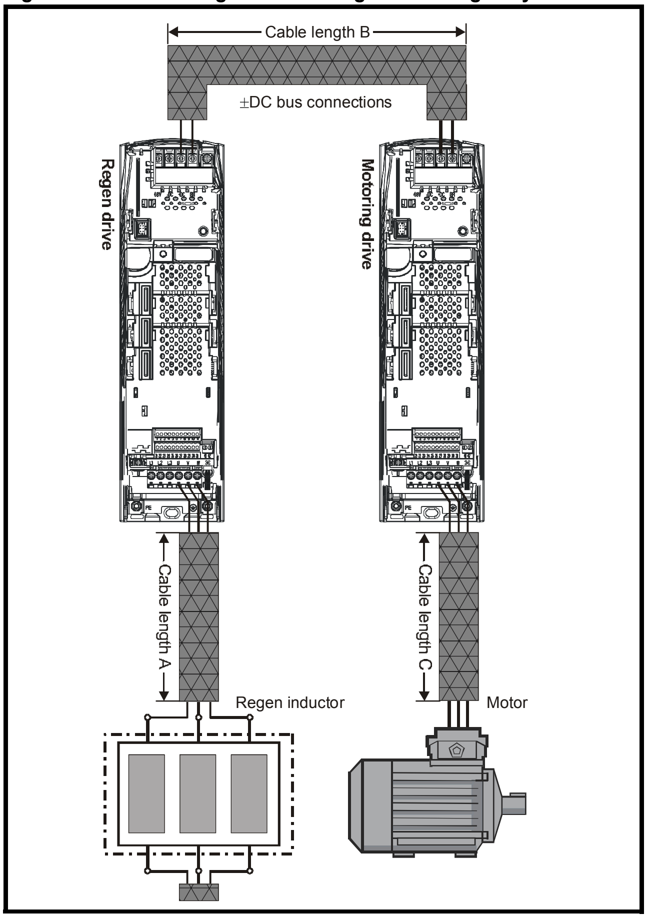
B is the length of the DC bus connection between the Regen and motoring drive, the + DC bus connections between the drives should be treated as a single two core cable and not two individual cable / bus bar lengths.

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**

<table>
<tr><th rowspan="3">Model</th><th colspan="6">200V Nominal AC supply voltage</th></tr>
<tr><th colspan="6">Maximum permissible cable length</th></tr>
<tr><th>3kHz</th><th>4kHz</th><th>6kHz</th><th>8kHz</th><th>12kHz</th><th>16kHz</th></tr>
<tr><td>SP1201</td><td colspan="4">65m (210ft)</td><td rowspan="9">50m (165ft)</td><td rowspan="7">37m (120ft)</td></tr>
<tr><td>SP1202</td><td colspan="3">100m (330ft)</td><td rowspan="8">75m (245ft)</td></tr>
<tr><td>SP1203</td><td colspan="2">130m (425ft)</td><td rowspan="7">100m (330ft)</td></tr>
<tr><td>SP1204</td><td rowspan="6">200m (660ft)</td><td rowspan="6">150m (490ft)</td></tr>
<tr><td>SP2201</td></tr>
<tr><td>SP2202</td></tr>
<tr><td>SP2203</td></tr>
<tr><td>SP3201</td><td rowspan="2"></td></tr>
<tr><td>SP3202</td></tr>
<tr><td>SP4201</td><td rowspan="3">65m (210ft)</td><td rowspan="3">65m (210ft)</td><td rowspan="3">65m (210ft)</td><td rowspan="3">65m (210ft)</td><td rowspan="3"></td><td rowspan="3"></td></tr>
<tr><td>SP4202</td></tr>
<tr><td>SP4203</td></tr>
<tr><td>SP5201</td><td rowspan="2">250m (820ft)</td><td rowspan="2">185m (607ft)</td><td rowspan="2">125m (410ft)</td><td rowspan="2">90m (295ft)</td><td></td><td></td></tr>
<tr><td>SP5202</td><td></td><td></td></tr>
<tr><td>SPMD1201</td><td rowspan="4">250m (820ft)</td><td rowspan="4">185m (607ft)</td><td rowspan="4">125m (410ft)</td><td></td><td></td><td></td></tr>
<tr><td>SPMD1202</td><td></td><td></td><td></td></tr>
<tr><td>SPMD1203</td><td></td><td></td><td></td></tr>
<tr><td>SPMD1204</td><td></td><td></td><td></td></tr>
</table>

**Table 4-6 400V Regen system maximum cable lengths**

<table>
<tr><th rowspan="3">Model</th><th colspan="6">400V Nominal AC supply voltage</th></tr>
<tr><th colspan="6">Maximum permissible cable length</th></tr>
<tr><th>3kHz</th><th>4kHz</th><th>6kHz</th><th>8kHz</th><th>12kHz</th><th>16kHz</th></tr>
<tr><td>SP1405</td><td rowspan="9">200m (660ft)</td><td rowspan="9">150m (490ft)</td><td rowspan="9">100m (330ft)</td><td rowspan="9">75m (245ft)</td><td rowspan="9">50m (165ft)</td><td rowspan="8">37m (120ft)</td></tr>
<tr><td>SP1406</td></tr>
<tr><td>SP2401</td></tr>
<tr><td>SP2402</td></tr>
<tr><td>SP2403</td></tr>
<tr><td>SP2404</td></tr>
<tr><td>SP3401</td></tr>
<tr><td>SP3402</td></tr>
<tr><td>SP3403</td><td rowspan="14"></td></tr>
<tr><td>SP4401</td><td rowspan="13">250m (820ft)</td><td rowspan="13">185m (607ft)</td><td rowspan="13">125m (410ft)</td><td rowspan="5">90m (295ft)</td><td rowspan="13"></td></tr>
<tr><td>SP4402</td></tr>
<tr><td>SP4403</td></tr>
<tr><td>SP5401</td></tr>
<tr><td>SP5402</td></tr>
<tr><td>SP6401</td><td rowspan="8"></td></tr>
<tr><td>SP6402</td></tr>
<tr><td>SPMA1401</td></tr>
<tr><td>SPMA1402</td></tr>
<tr><td>SPMD1401</td></tr>
<tr><td>SPMD1402</td></tr>
<tr><td>SPMD1403</td></tr>
<tr><td>SPMD1404</td></tr>
</table>

**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**

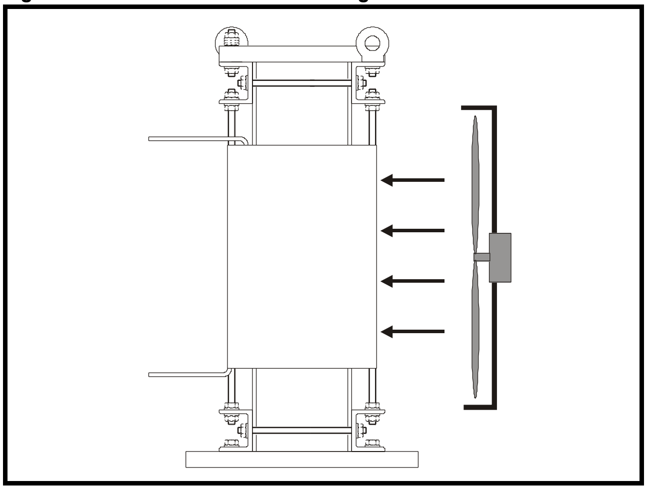


**Table 4-9 200V Regen system exceeding maximum cable lengths**

| 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) | | | | 50m (165ft) | 37m (120ft) | Air flow ≥ 160m$^3$ / hr |
| 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 4-10 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 | 200m (660ft) | 150m (490ft) | 100m (330ft) | 75m (245ft) | 50m (165ft) | 37m (120ft) | Air flow ≥160m³ / hr |
| SP2401 | 200m (660ft) | 150m (490ft) | 100m (330ft) | 75m (245ft) | 50m (165ft) | 37m (120ft) | Air flow ≥160m³ / hr |
| SP2402 | 200m (660ft) | 150m (490ft) | 100m (330ft) | 75m (245ft) | 50m (165ft) | 37m (120ft) | Air flow ≥160m³ / hr |
| SP2403 | 200m (660ft) | 150m (490ft) | 100m (330ft) | 75m (245ft) | 50m (165ft) | 37m (120ft) | Air flow ≥160m³ / hr |
| SP2404 | 200m (660ft) | 150m (490ft) | 100m (330ft) | 75m (245ft) | 50m (165ft) | 37m (120ft) | Air flow ≥160m³ / hr |
| SP3401 | 200m (660ft) | 150m (490ft) | 100m (330ft) | 75m (245ft) | 50m (165ft) | 37m (120ft) | Air flow ≥160m³ / hr |
| SP3402 | 200m (660ft) | 150m (490ft) | 100m (330ft) | 75m (245ft) | 50m (165ft) | 37m (120ft) | Air flow ≥160m³ / hr |
| SP3403 | 200m (660ft) | 150m (490ft) | 100m (330ft) | 75m (245ft) | 50m (165ft) | | Air flow ≥160m³ / hr |
| SP4401 | 250m (820ft) | 185m (607ft) | 125m (410ft) | 90m (295ft) | | | Air flow ≥160m³ / hr |
| SP4402 | 250m (820ft) | 185m (607ft) | 125m (410ft) | 90m (295ft) | | | Air flow ≥160m³ / hr |
| SP4403 | 250m (820ft) | 185m (607ft) | 125m (410ft) | 90m (295ft) | | | Air flow ≥160m³ / hr |
| SP5401 | 250m (820ft) | 185m (607ft) | 125m (410ft) | 90m (295ft) | | | Air flow ≥160m³ / hr |
| SP5402 | 250m (820ft) | 185m (607ft) | 125m (410ft) | 90m (295ft) | | | Air flow ≥160m³ / hr |
| SP6401 | 250m (820ft) | 185m (607ft) | 125m (410ft) | | | | Air flow ≥160m³ / hr |
| SP6402 | 250m (820ft) | 185m (607ft) | 125m (410ft) | | | | Air flow ≥160m³ / hr |
| SPMA1401 | 250m (820ft) | 185m (607ft) | 125m (410ft) | | | | Air flow ≥160m³ / hr |
| SPMA1402 | 250m (820ft) | 185m (607ft) | 125m (410ft) | | | | Air flow ≥160m³ / hr |
| SPMD1401 | 250m (820ft) | 185m (607ft) | 125m (410ft) | | | | Air flow ≥160m³ / hr |
| SPMD1402 | 250m (820ft) | 185m (607ft) | 125m (410ft) | | | | Air flow ≥160m³ / hr |
| SPMD1403 | 250m (820ft) | 185m (607ft) | 125m (410ft) | | | | Air flow ≥160m³ / hr |
| SPMD1404 | 250m (820ft) | 185m (607ft) | 125m (410ft) | | | | Air flow ≥160m³ / hr |

**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 | 200m (660ft) | 150m (490ft) | 100m (330ft) | 75m (245ft) | | | Air flow ≥ 160m³ / hr |
| SP3503 | 200m (660ft) | 150m (490ft) | 100m (330ft) | 75m (245ft) | | | Air flow ≥ 160m³ / hr |
| SP3504 | 200m (660ft) | 150m (490ft) | 100m (330ft) | 75m (245ft) | | | Air flow ≥ 160m³ / hr |
| SP3505 | 200m (660ft) | 150m (490ft) | 100m (330ft) | 75m (245ft) | | | Air flow ≥ 160m³ / hr |
| SP3506 | 200m (660ft) | 150m (490ft) | 100m (330ft) | 75m (245ft) | | | Air flow ≥ 160m³ / hr |
| SP3507 | 200m (660ft) | 150m (490ft) | 100m (330ft) | 75m (245ft) | | | Air flow ≥ 160m³ / hr |

**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 | 200m (660ft) | 185m (607ft) | 125m (410ft) | 90m (295ft) | | | Air flow ≥ 160m³ / hr |
| SP4603 | 200m (660ft) | 185m (607ft) | 125m (410ft) | 90m (295ft) | | | Air flow ≥ 160m³ / hr |
| SP4604 | 200m (660ft) | 185m (607ft) | 125m (410ft) | 90m (295ft) | | | Air flow ≥ 160m³ / hr |
| SP4605 | 200m (660ft) | 185m (607ft) | 125m (410ft) | 90m (295ft) | | | Air flow ≥ 160m³ / hr |
| SP4606 | 200m (660ft) | 185m (607ft) | 125m (410ft) | 90m (295ft) | | | Air flow ≥ 160m³ / hr |
| SP5601 | 200m (660ft) | 185m (607ft) | 125m (410ft) | 90m (295ft) | | | Air flow ≥ 160m³ / hr |
| SP5602 | 200m (660ft) | 185m (607ft) | 125m (410ft) | 90m (295ft) | | | Air flow ≥ 160m³ / hr |
| SP6601 | 200m (660ft) | 185m (607ft) | 125m (410ft) | | | | Air flow ≥ 160m³ / hr |
| SP6602 | 200m (660ft) | 185m (607ft) | 125m (410ft) | | | | Air flow ≥ 160m³ / hr |
| SPMA1601 | 200m (660ft) | 185m (607ft) | 125m (410ft) | | | | Air flow ≥ 160m³ / hr |
| SPMA1602 | 200m (660ft) | 185m (607ft) | 125m (410ft) | | | | Air flow ≥ 160m³ / hr |
| SPMD1601 | 200m (660ft) | 185m (607ft) | 125m (410ft) | | | | Air flow ≥ 160m³ / hr |
| SPMD1602 | 200m (660ft) | 185m (607ft) | 125m (410ft) | | | | Air flow ≥ 160m³ / hr |
| SPMD1603 | 200m (660ft) | 185m (607ft) | 125m (410ft) | | | | Air flow ≥ 160m³ / hr |
| SPMD1604 | 200m (660ft) | 185m (607ft) | 125m (410ft) | | | | Air flow ≥ 160m³ / hr |

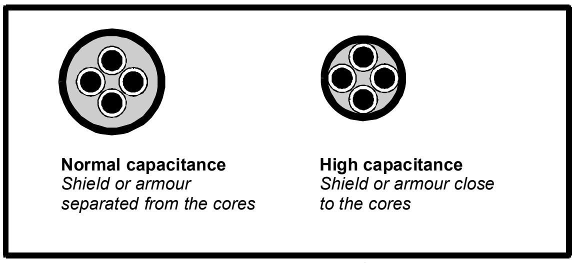
Cable lengths in excess of the above specified values may be used only when special techniques are adopted; refer to the supplier of the drive.

### 4.6.2 High-capacitance cables

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

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

**Figure 4-7 Cable construction influencing the capacitance**



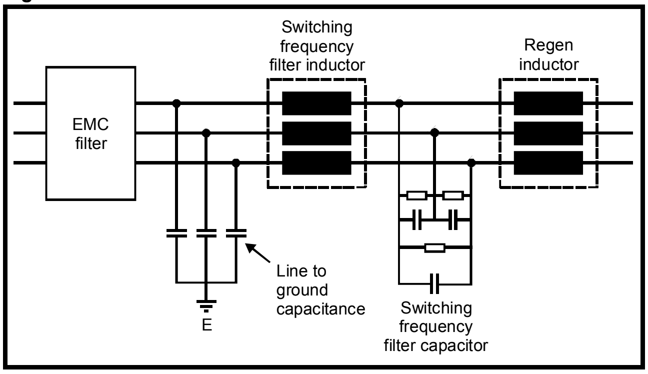

The cable used is shielded and contains four cores. Typical capacitance for this type of cable is 130pF/m (i.e. from one core to all others and the shield connected together).

### 4.6.3 EMC filter

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

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

WARNING

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

WARNING

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

## 5.2 Planning the installation

The following considerations must be made when planning the installation:

### 5.2.1 Access

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

The IP (Ingress Protection) rating of the drive is installation dependent. For further information, please refer to the *Unidrive SP 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.

WARNING

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

WARNING

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

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

## 5.3 Regen component dimensions

The dimensions listed are for the following items:

- Regen inductor
- Switching frequency filter inductor
- Switching frequency filter capacitor
- Varistors
- External charging resistor (used in multiple motoring configurations)

### 5.3.1 Regen inductor

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

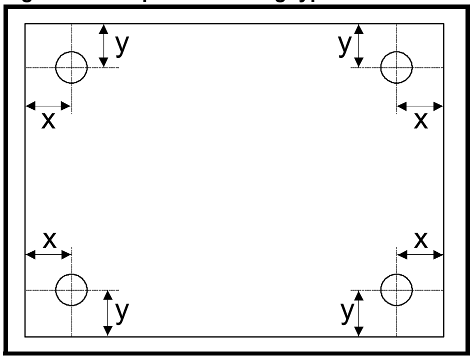



Table 5-1 200V Regen inductor specifications

| 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 | A |
| 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 | |
| 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**

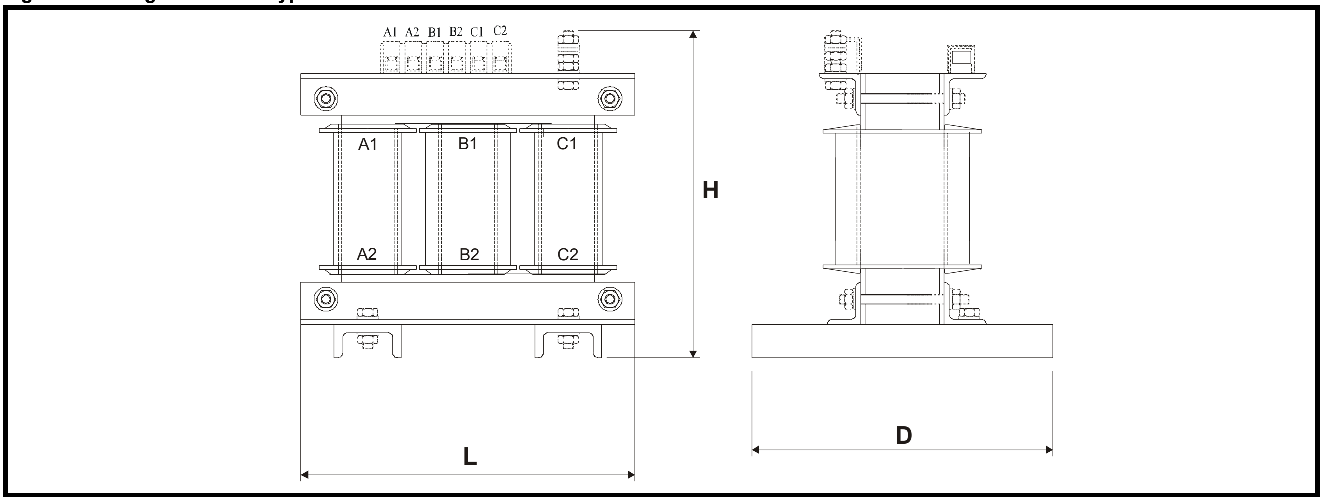



**Figure 5-3 Regen inductor type 2 dimensions**

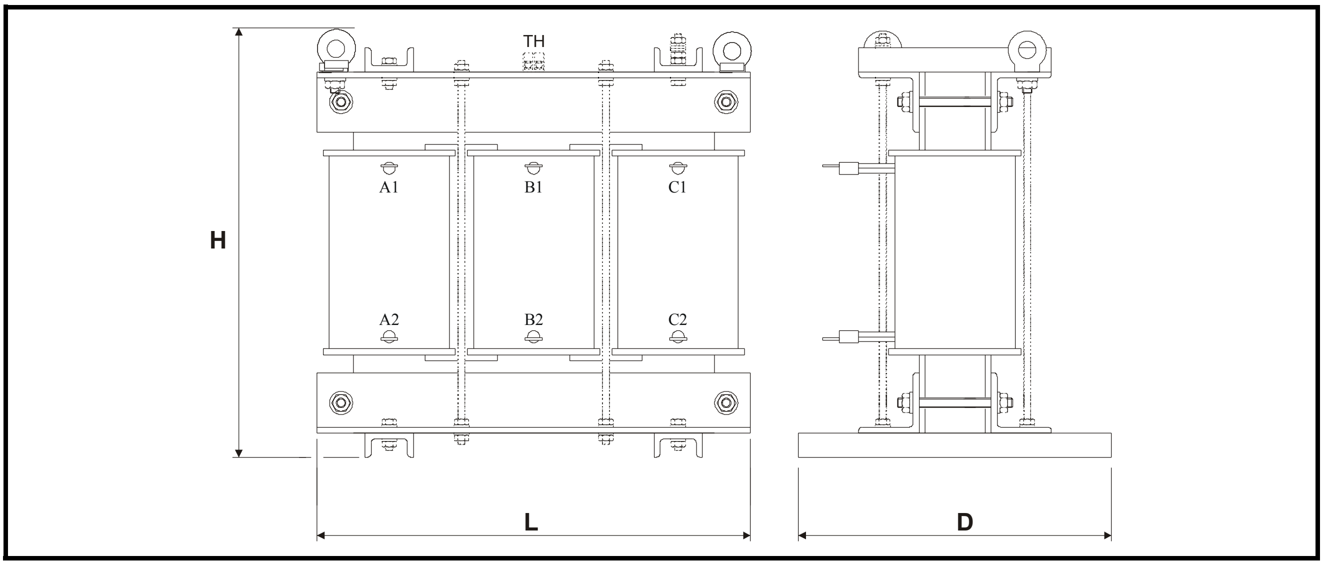
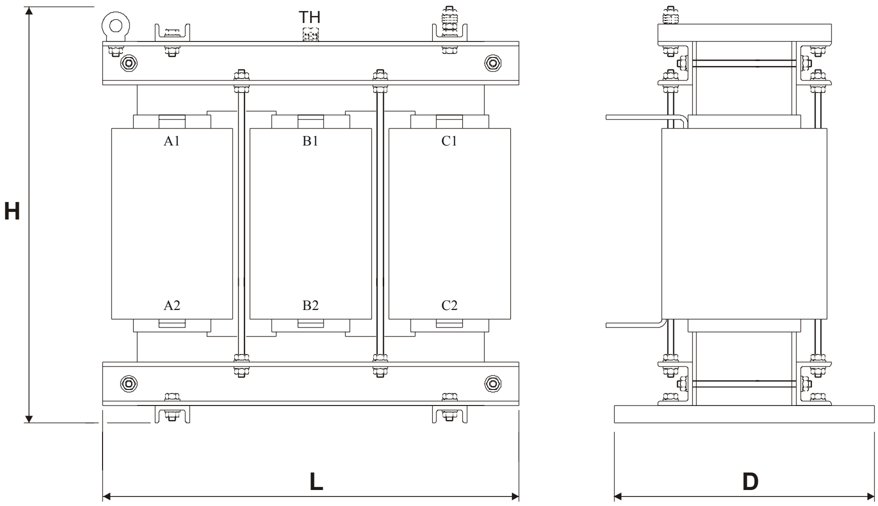


**Figure 5-4 Regen inductor type 3 dimensions**




### 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**

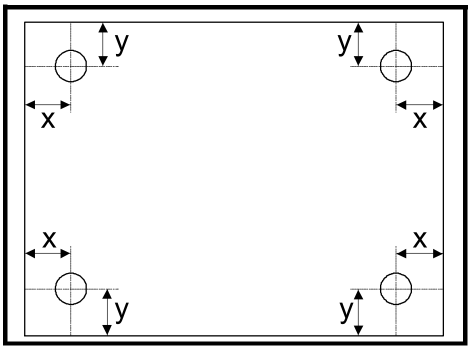



**Figure 5-6 Top view of fixing type B**

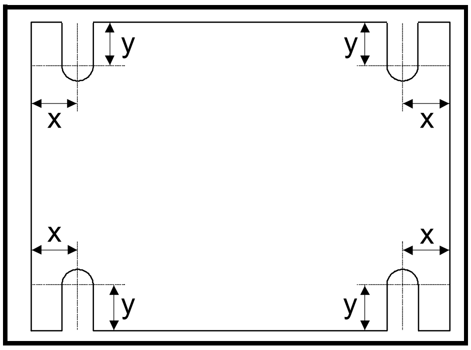


**Figure 5-7 Switching frequency filter inductor type 1 dimensions**

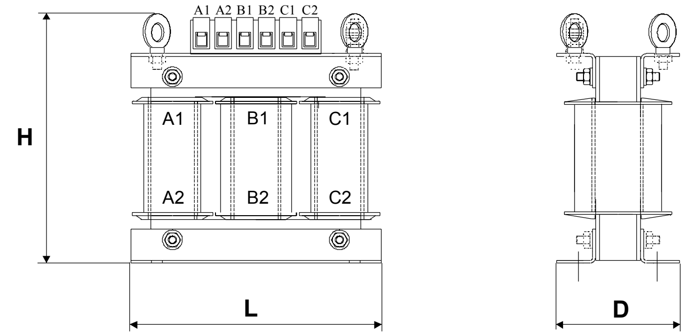



**Figure 5-8 Switching frequency filter inductor type 2 dimensions**

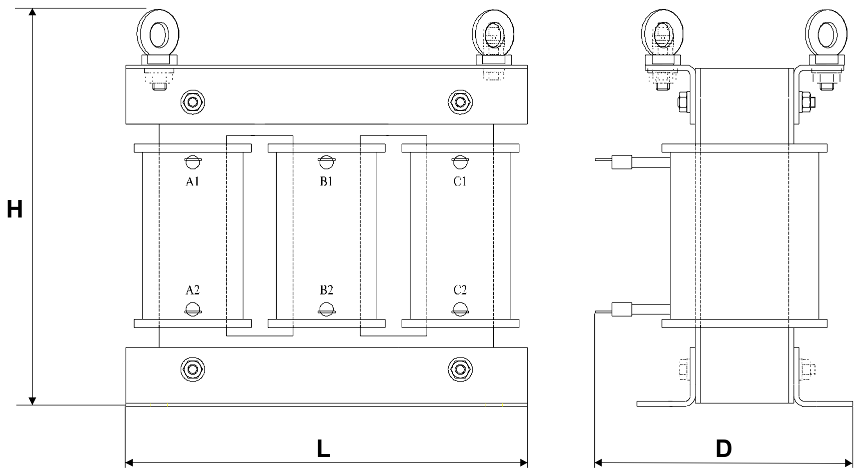



**Figure 5-9 Switching frequency filter inductor type 3 dimensions**

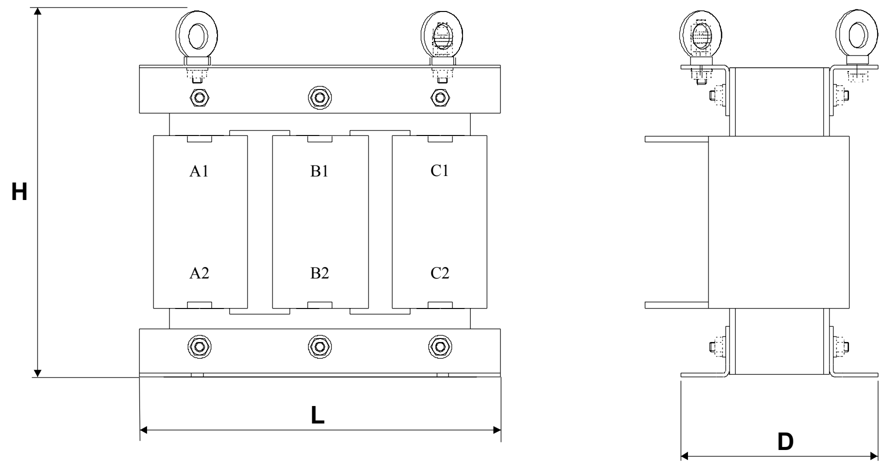
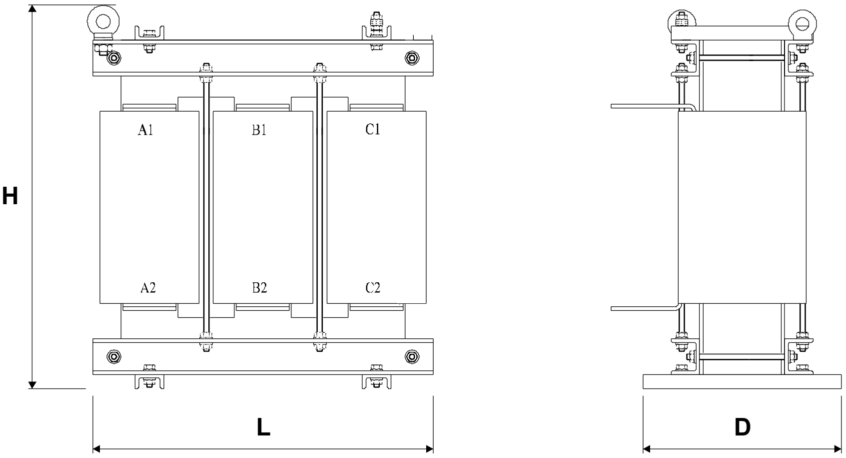


**Figure 5-10 Switching frequency filter inductor type 4 dimensions**

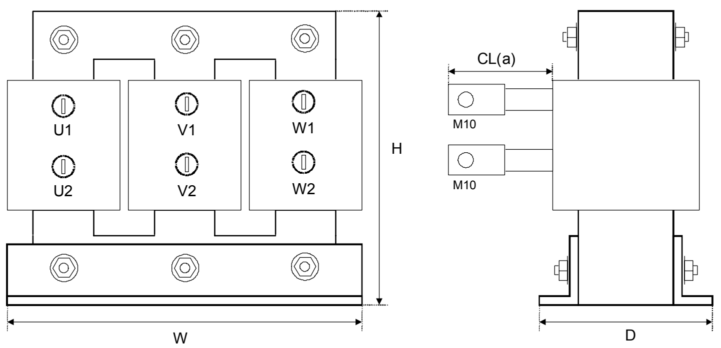



### 5.3.3 Output sharing choke (for motoring drives only)

**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**

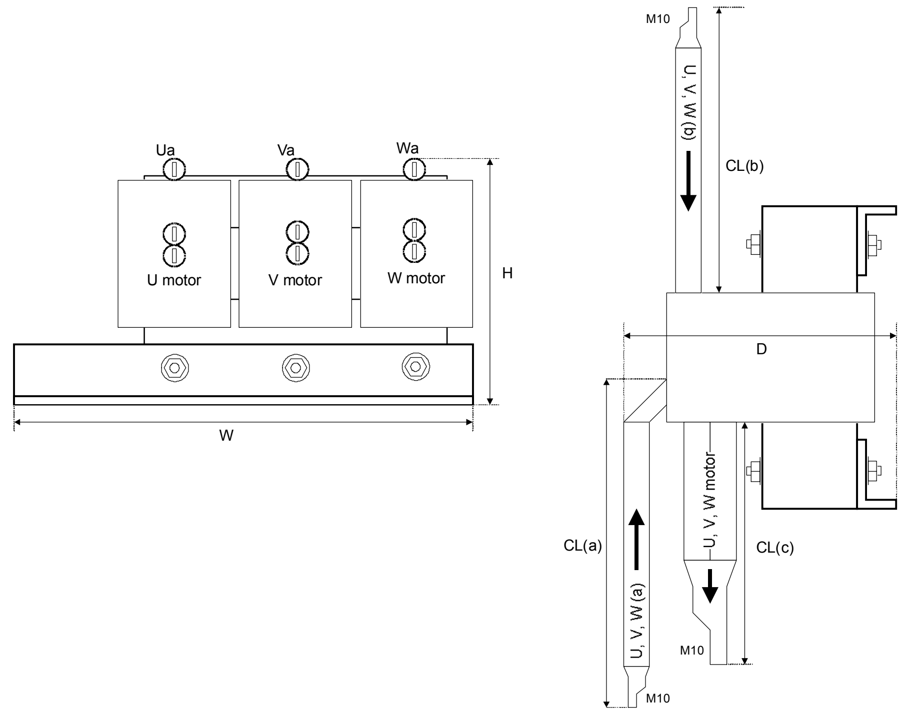
CAUTION

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

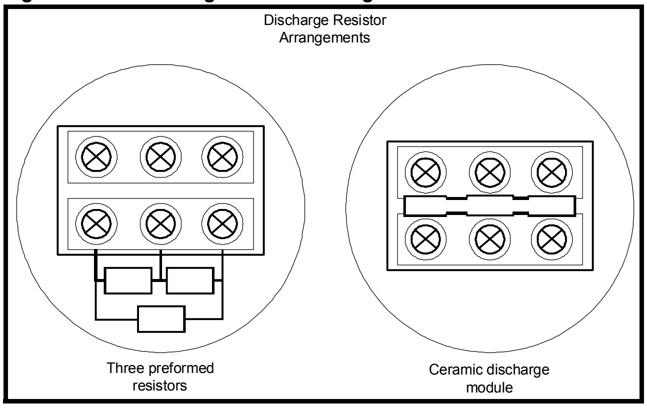
**Table 5-9 Switching frequency filter capacitors**

| 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**

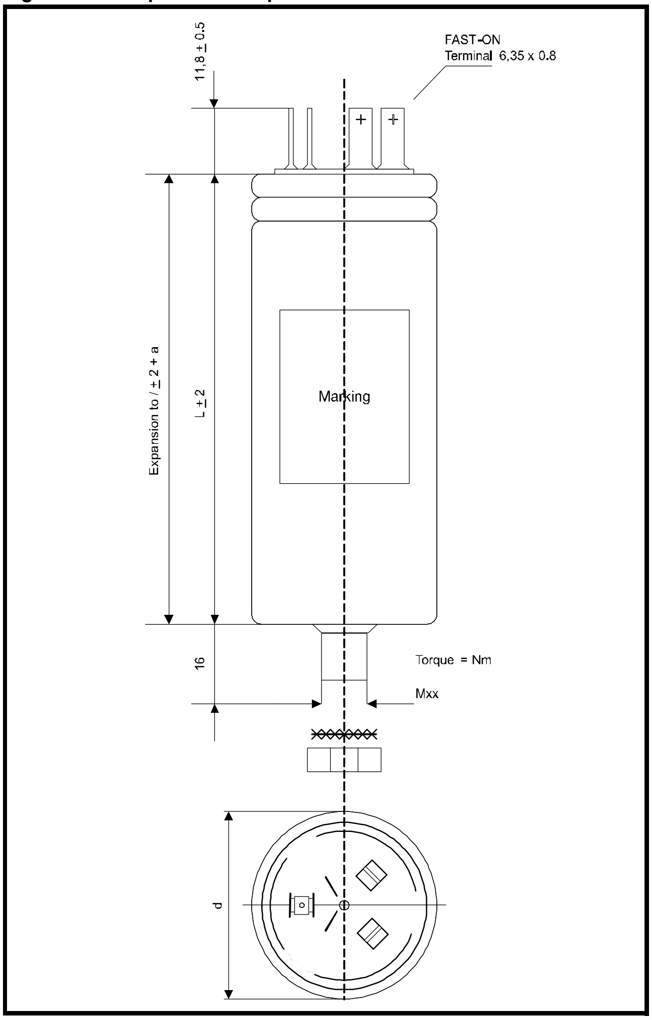


**Figure 5-15 3-phase Polecap dimensions**

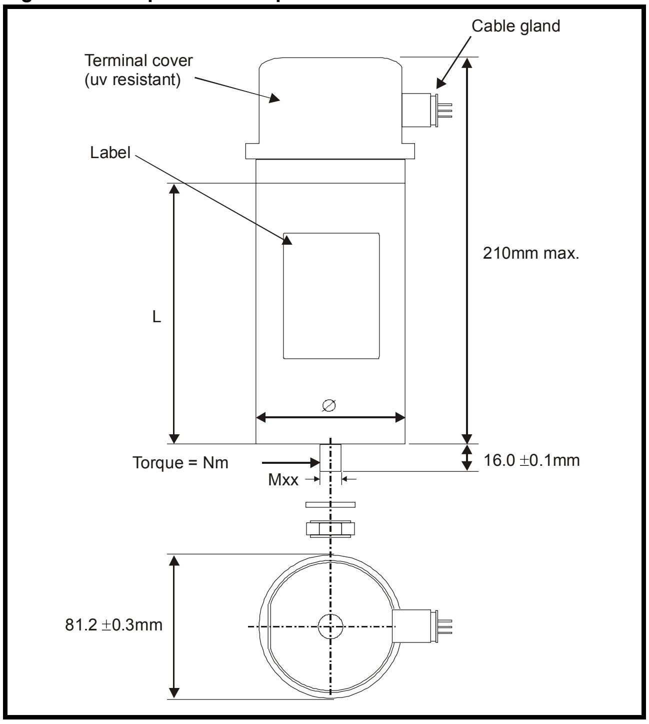
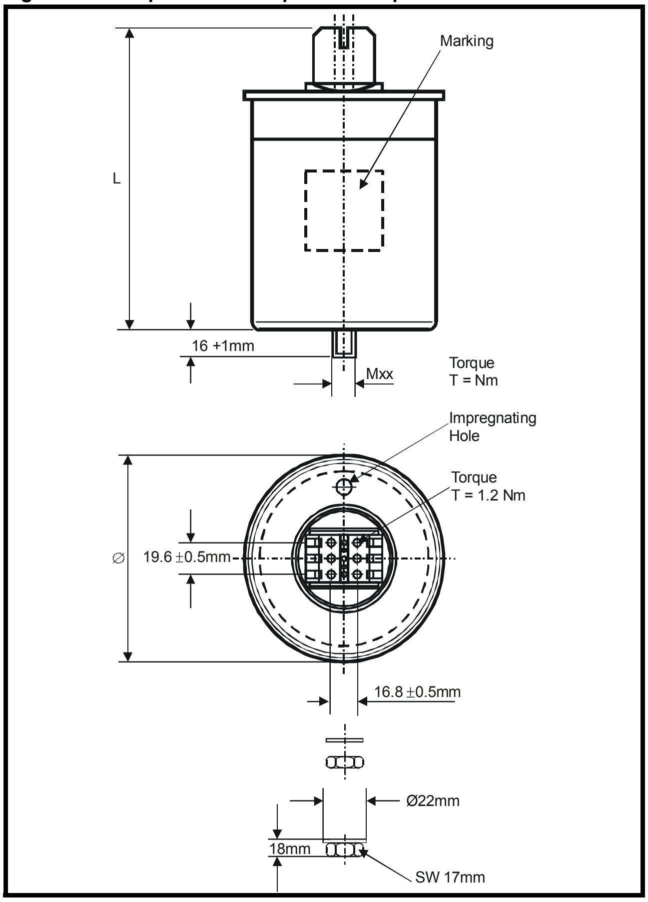



**Figure 5-16 3-phase Windcap / Phasecap dimensions**



## 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**

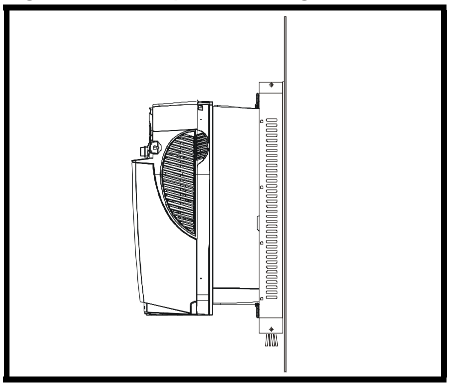


**Figure 5-18 Bookcase mounting the EMC filter**

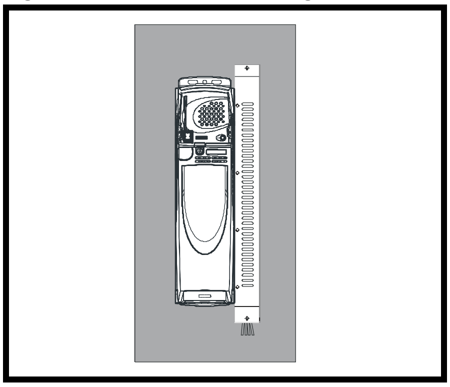


**Figure 5-19 Size 4 to 6 mounting of EMC filter**

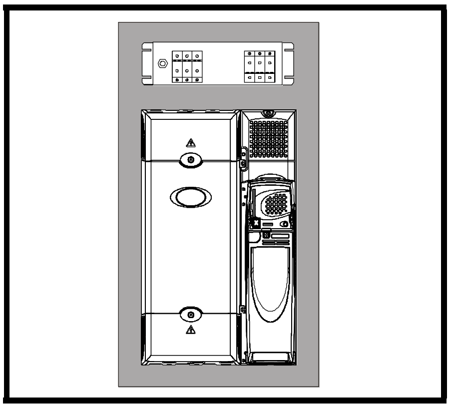
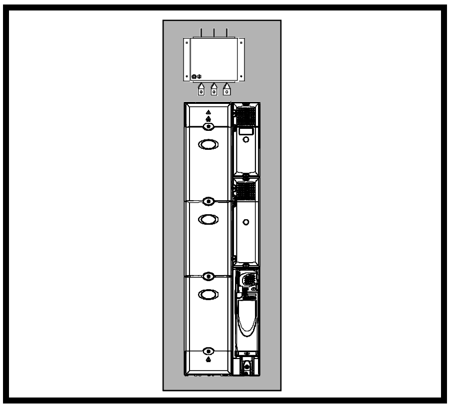
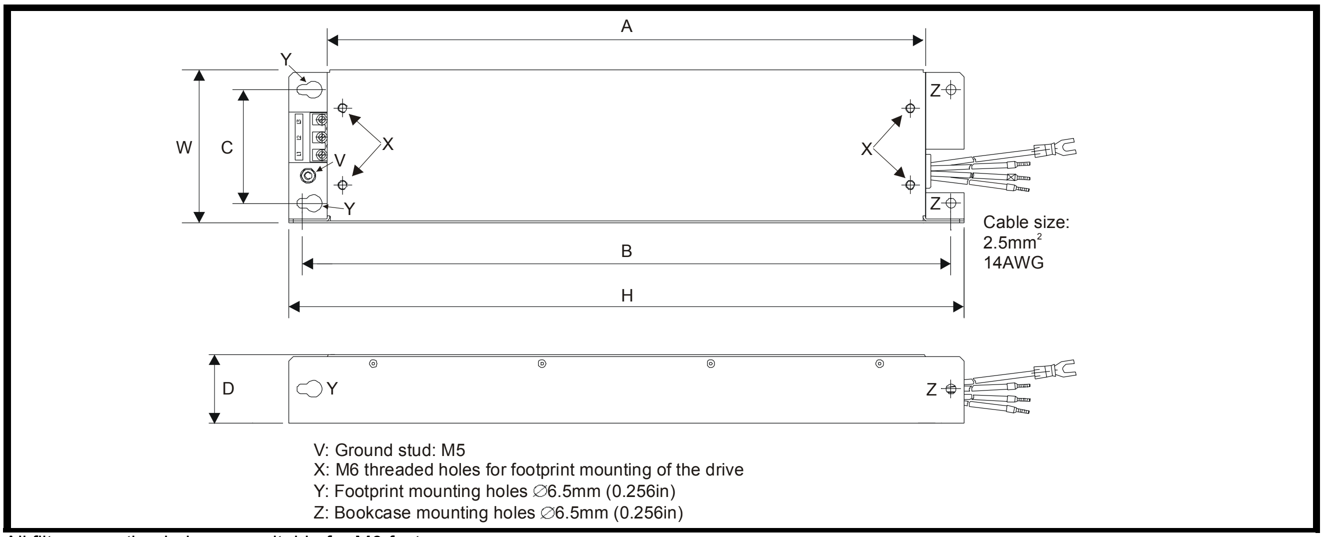


**Figure 5-20 Mounting the external EMC filter**



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

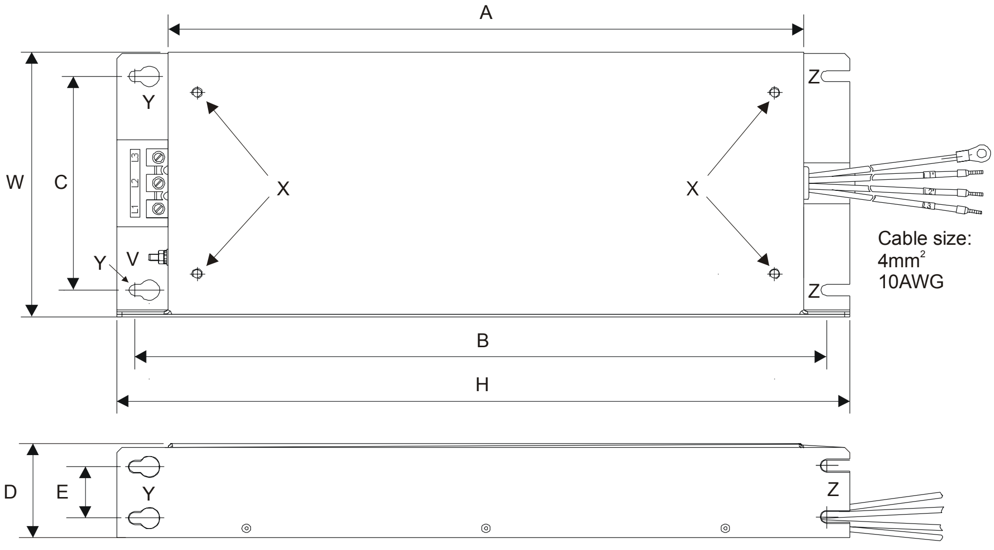
**Figure 5-21 Size 1 external EMC filter**




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 | | | | | | | |

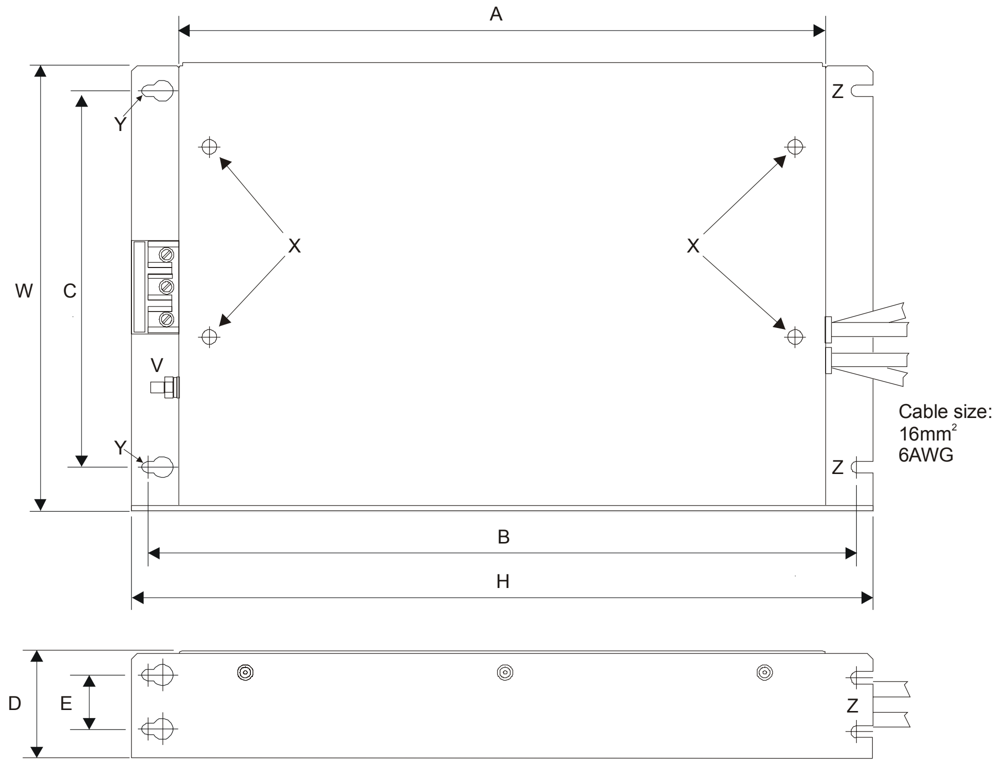
**Figure 5-22 Size 2 external EMC filter**




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) | |

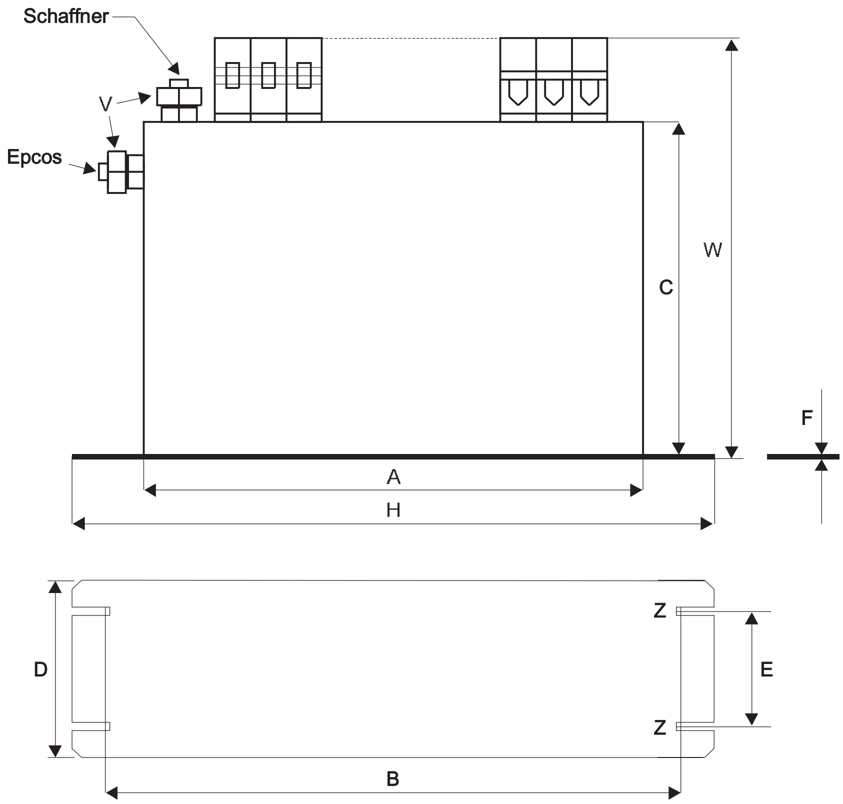
**Figure 5-23 Size 3 external EMC filter**




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 | | | | | | | | |

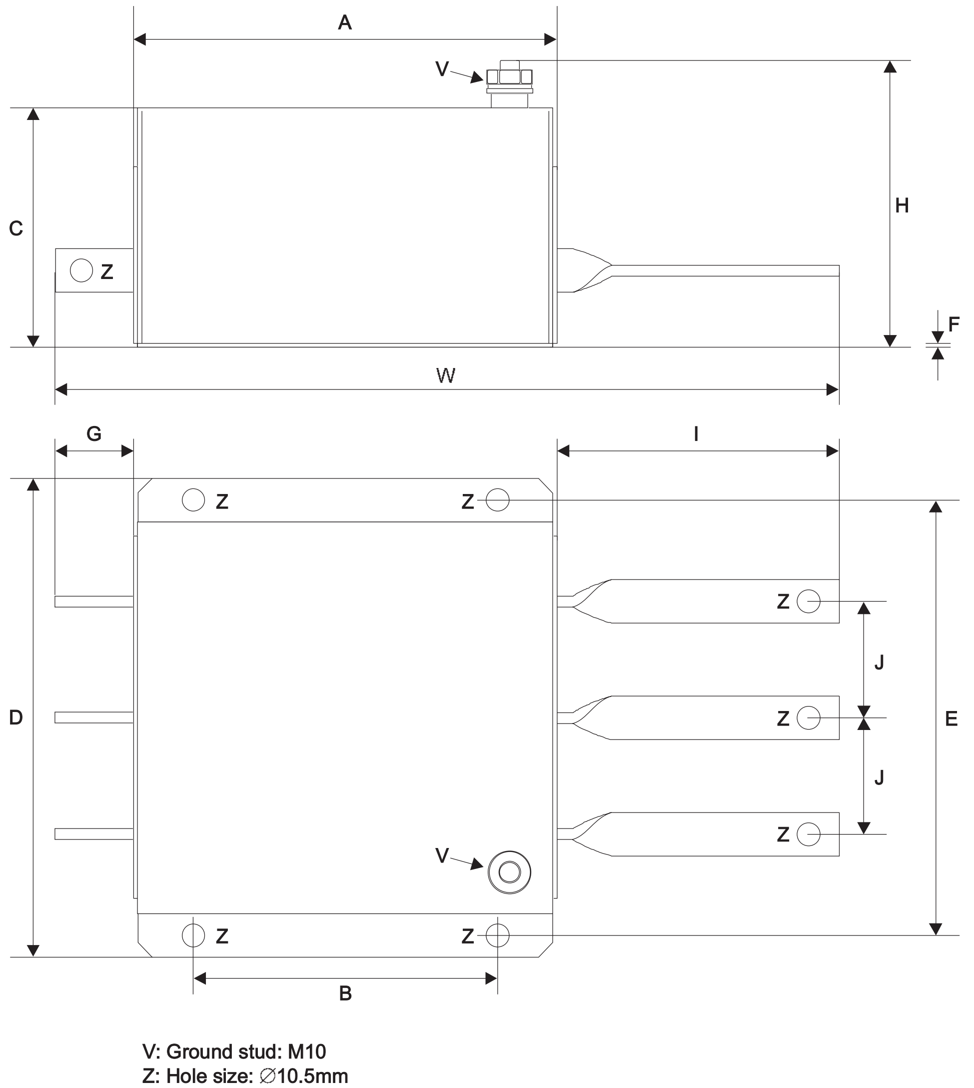
**Figure 5-24 Size 4 and 5 external EMC filter**




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

<table>
<tr><th>CT part no.</th><th>Manufacturer</th><th>A</th><th>B</th><th>C</th><th>D</th><th>E</th><th>F</th><th>H</th><th>W</th></tr>
<tr><td>4200-6406</td><td rowspan="4">Schaffner</td><td rowspan="8">260 mm (10.236 in)</td><td rowspan="8">275 mm (10.827 in)</td><td rowspan="4">170 mm (6.693 in)</td><td rowspan="2">100 mm (3.937 in)</td><td rowspan="2">65 mm (2.559 in)</td><td rowspan="4">1.5 mm (0.059in)</td><td rowspan="8">300 mm (11.811 in)</td><td>225 mm (8.858 in)</td></tr>
<tr><td>4200-6408</td><td>208 mm (8.189 in)</td></tr>
<tr><td>4200-6503</td><td>120 mm (4.724 in)</td><td>85 mm (3.346 in)</td><td>249 mm (9.803 in)</td></tr>
<tr><td>4200-6504</td><td>100 mm (3.937 in)</td><td>65 mm (2.559 in)</td><td>225 mm (8.858 in)</td></tr>
<tr><td>4200-6405</td><td rowspan="4">Epcos</td><td rowspan="2">150 mm (5.906 in)</td><td rowspan="2">90 mm (3.543in)</td><td rowspan="2">65 mm (2.559 in)</td><td rowspan="2">2 mm (0.079 in)</td><td>207 mm (8.150 in)</td></tr>
<tr><td>4200-6407</td><td>205 mm (8.071 in)</td></tr>
<tr><td>4200-6501</td><td rowspan="2">170 mm (6.693 in)</td><td rowspan="2">120 mm (4.724 in)</td><td rowspan="2">85 mm (3.346 in)</td><td rowspan="2">1 mm (0.039 in)</td><td rowspan="2">249 mm (9.803 in)</td></tr>
<tr><td>4200-6502</td></tr>
</table>

**Figure 5-25 Size 6 external EMC filter**




| CT part no. | Manufacturer | A | B | C | D | E | F | G | H | I | J | W |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4200-6601<br>4200-6602<br>4200-6603<br>4200-6604<br>4200-6313<br>4200-6314<br>4200-6315<br>4200-6316 | 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) |

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**

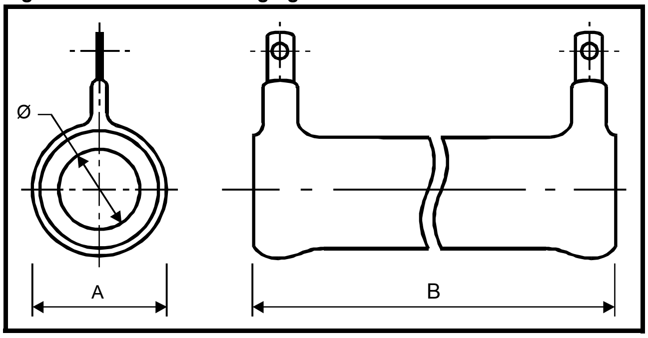



**Table 5-12 External charging resistor specifications**

| 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**

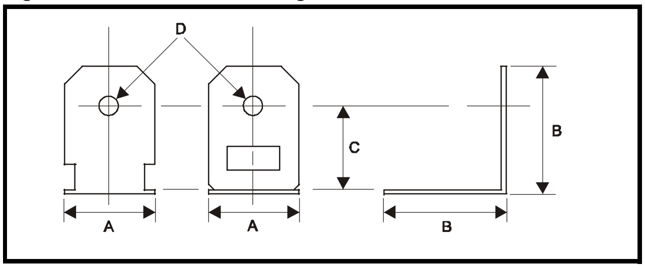



**Table 5-13 Resistor mounting bracket dimensions**

| 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**

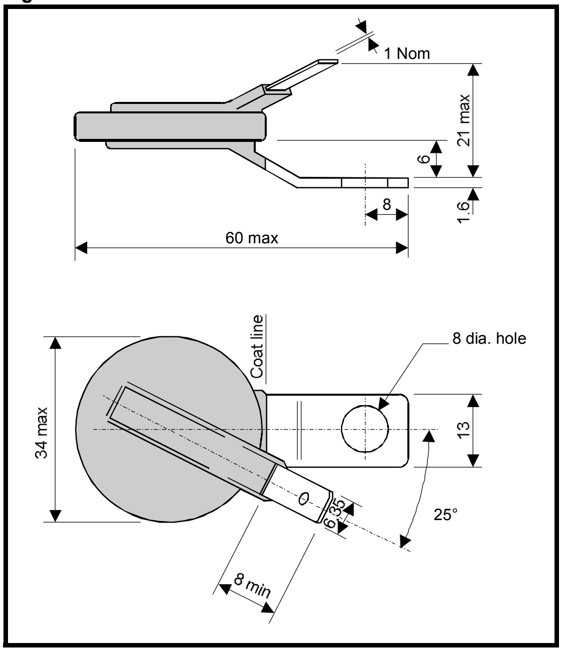



**Table 5-14 Varistor specifications**

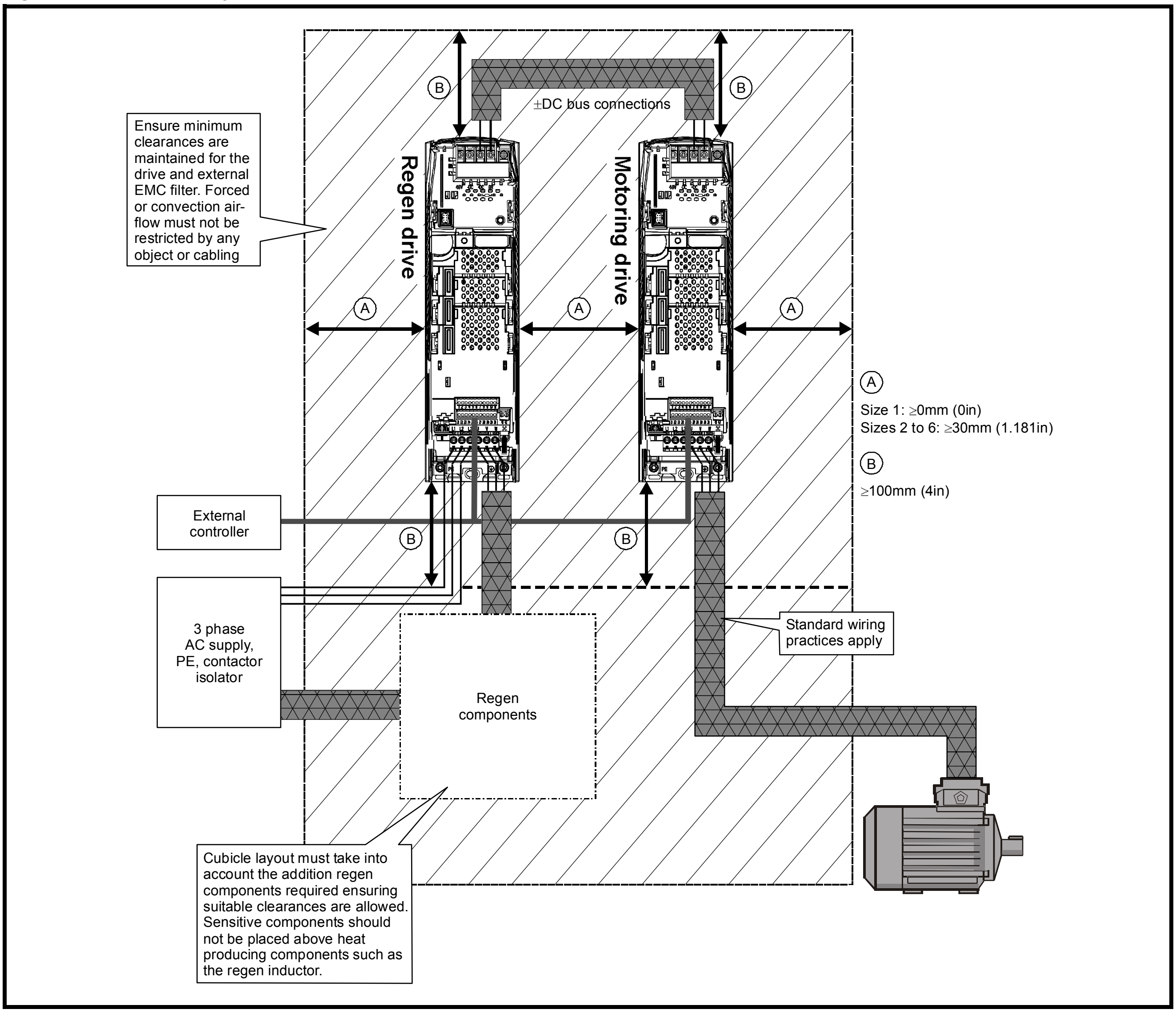
| Drive rating | Varistor voltage rating $V_{RMS}$ | Energy rating J | Quantity per system | Configuration | CT part number |
|---|---|---|---|---|---|
| 200V (200V to 240V±10%) | 550 | 620 | 3 | Line to line | 2482-3291 |
| | 680 | 760 | 3 | Line to ground | 2482-3211 |
| 400V (380V to 480V±10%) | 550 | 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:

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

Where:

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

**Example**

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

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

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

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

Dissipation of each external regen inductor: 125 W x 1 (see section 10.4.1 *Regen inductors* on page 196)

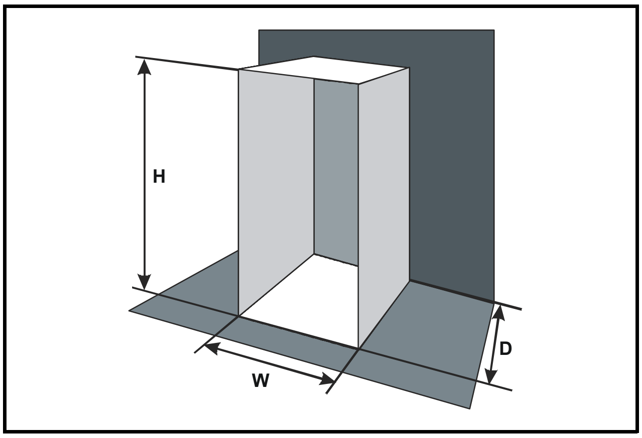
Dissipation of external switching frequency filter: 28 W x 1 (see Chapter 10 *Technical data* on page 183)

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$^2$/ºC. Only the top, front, and two sides of the enclosure are free to dissipate heat.

The value of 5.5 W/m$^2$/ºC 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 $\frac{P_o}{P_I}$ |

Where:

$P_0$ is the air pressure at sea level

$P_I$ is the air pressure at the installation

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

**Example**

To calculate the size of an enclosure for the following:

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

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

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

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

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

# 6 Electrical Installation

WARNING

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

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

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

WARNING

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

WARNING

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

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

WARNING

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

# 6.1 Power connections

## 6.1.1 AC and DC regen connections

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

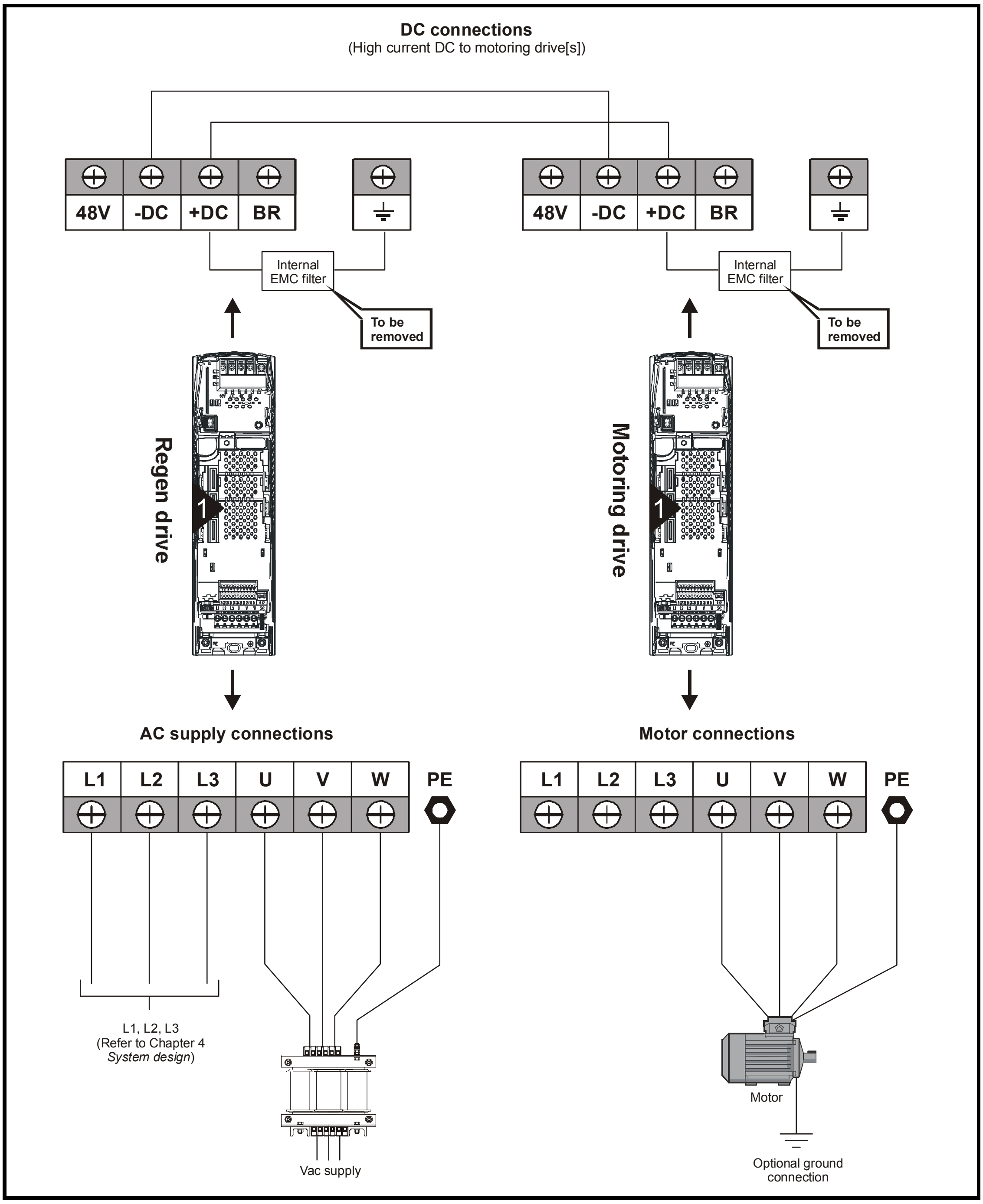
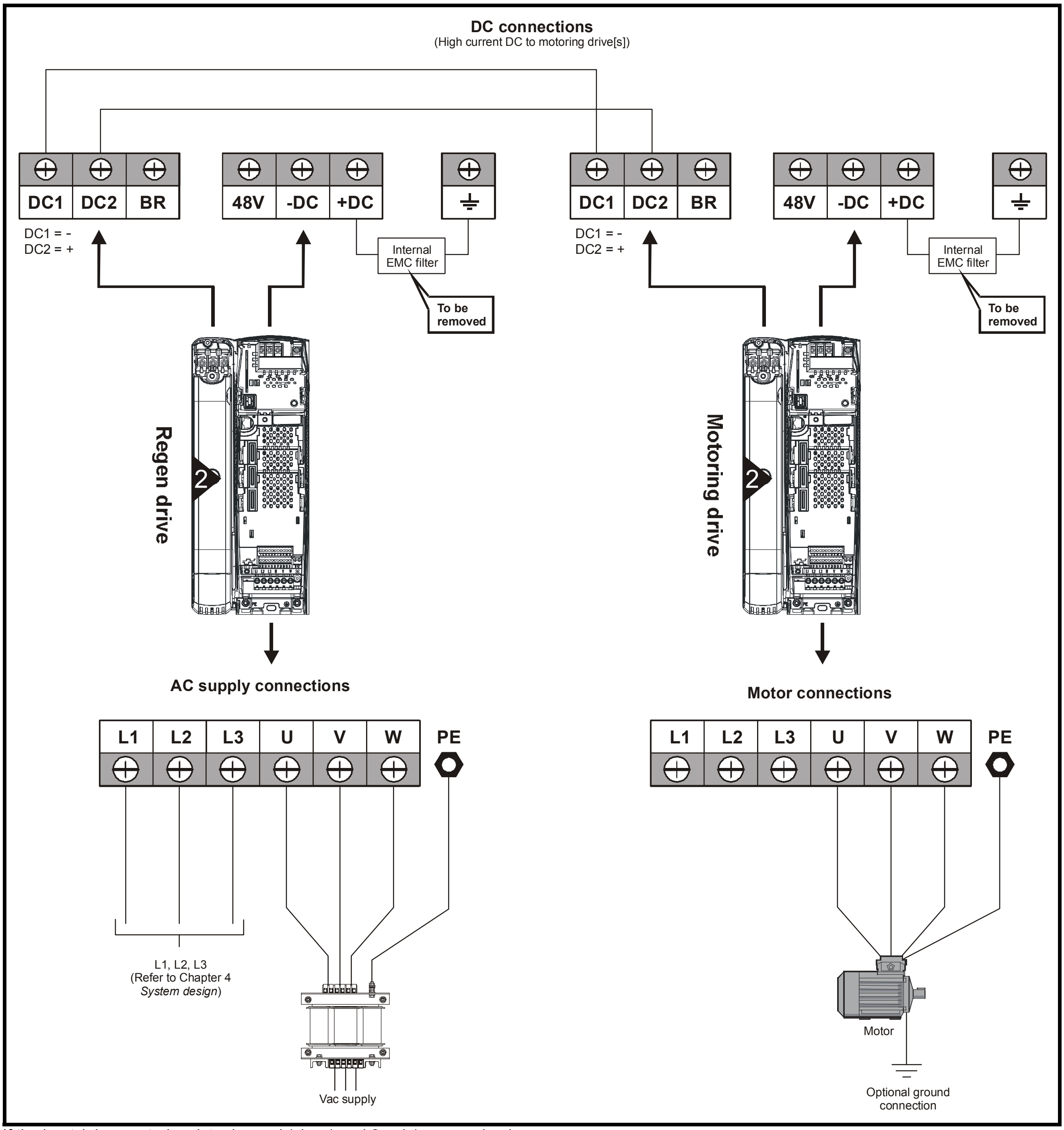


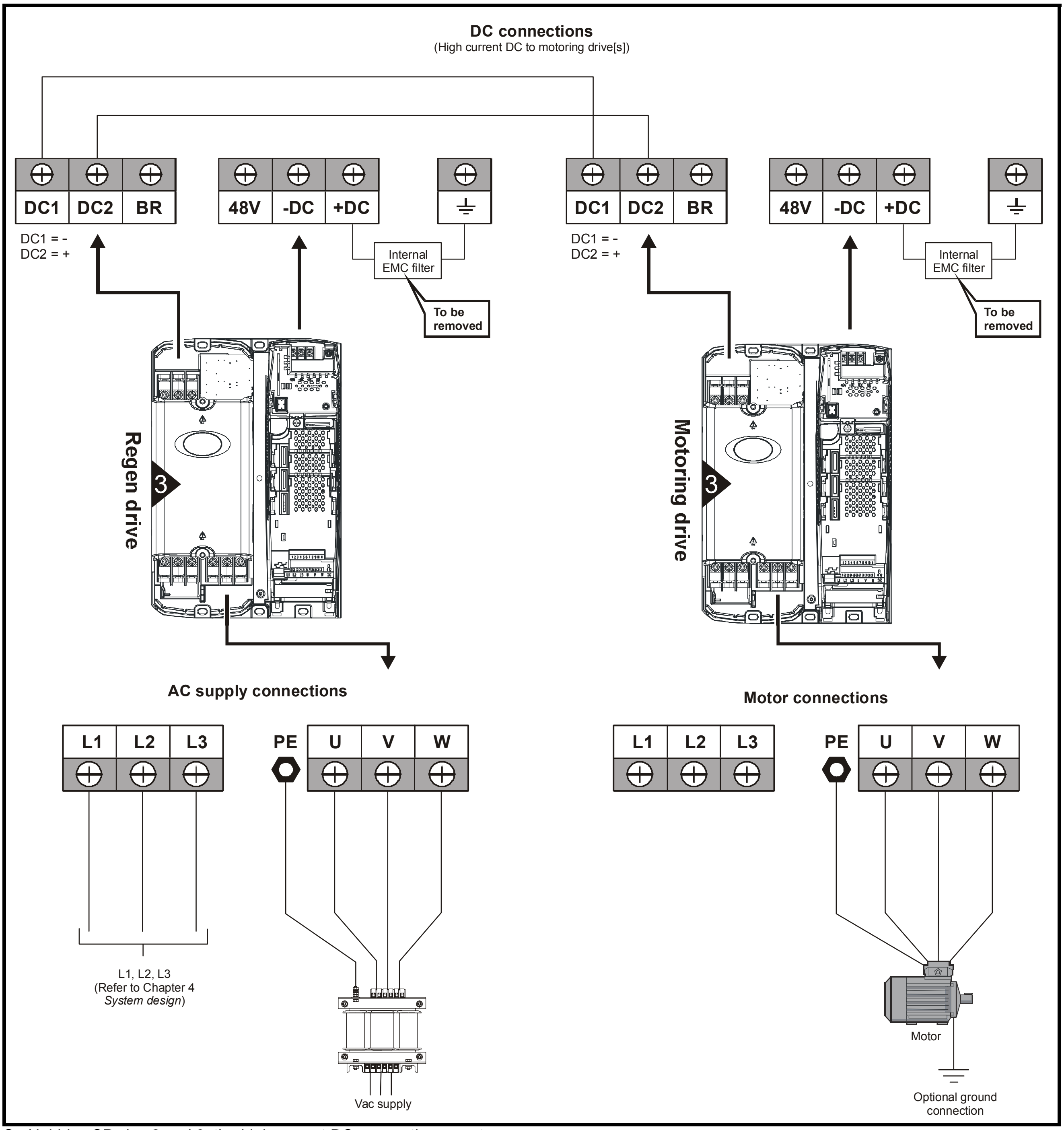
**Figure 6-2 Unidrive SP size 2 power connections**




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

See Figure 6-8 for further information on ground connections.

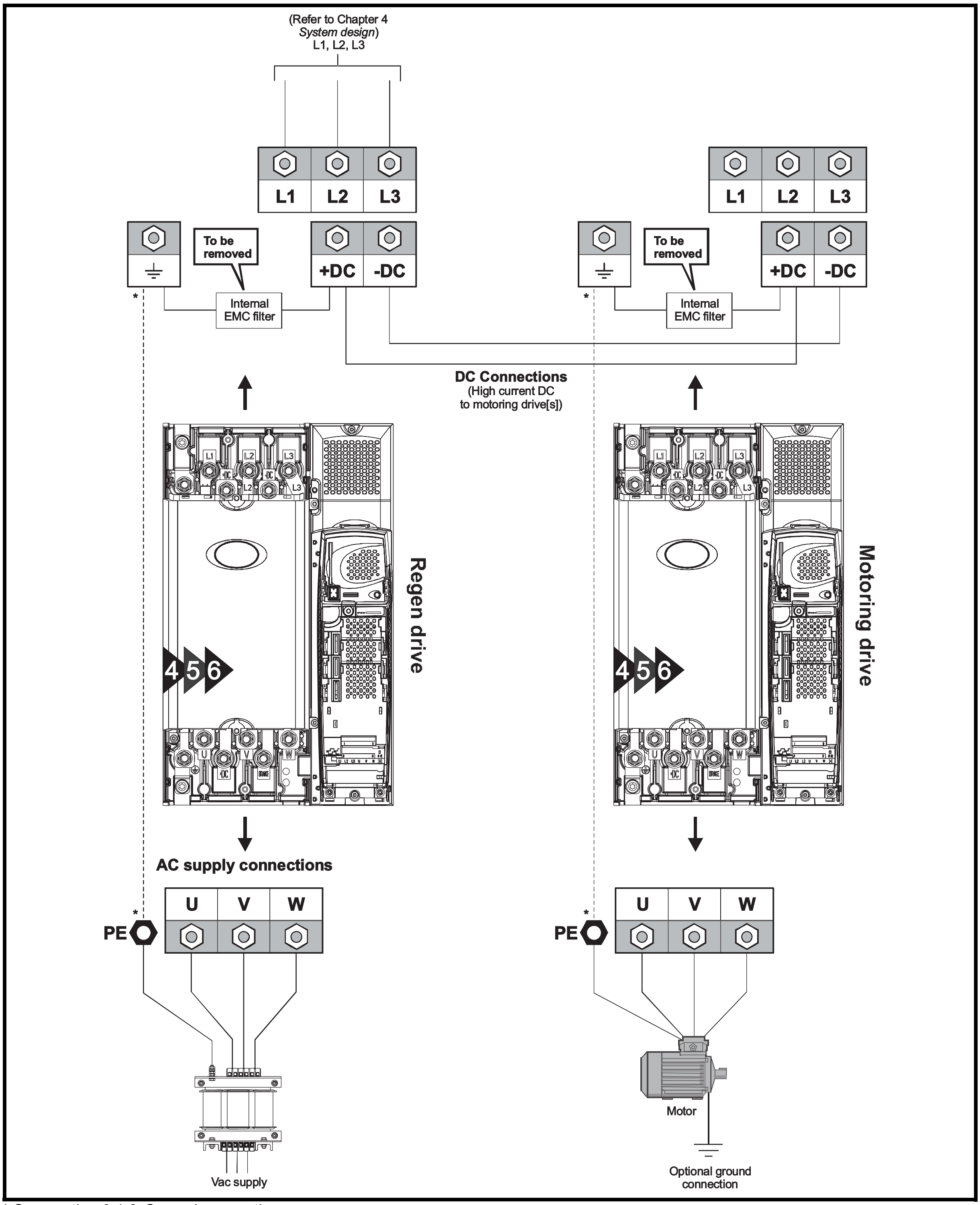
**Figure 6-3 Unidrive SP size 3 power connections**




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**

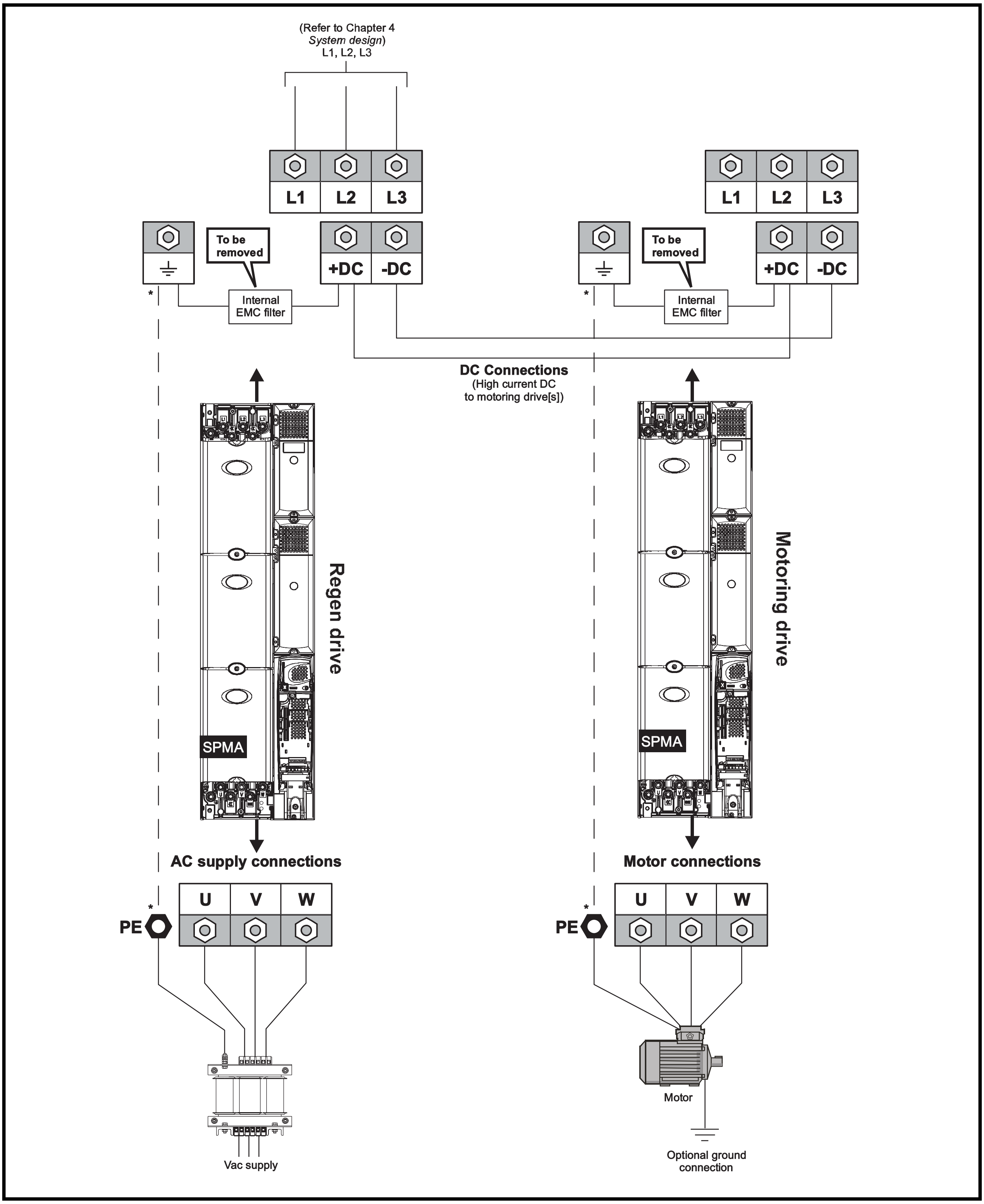


**Figure 6-6 Unidrive SPMD power connections**

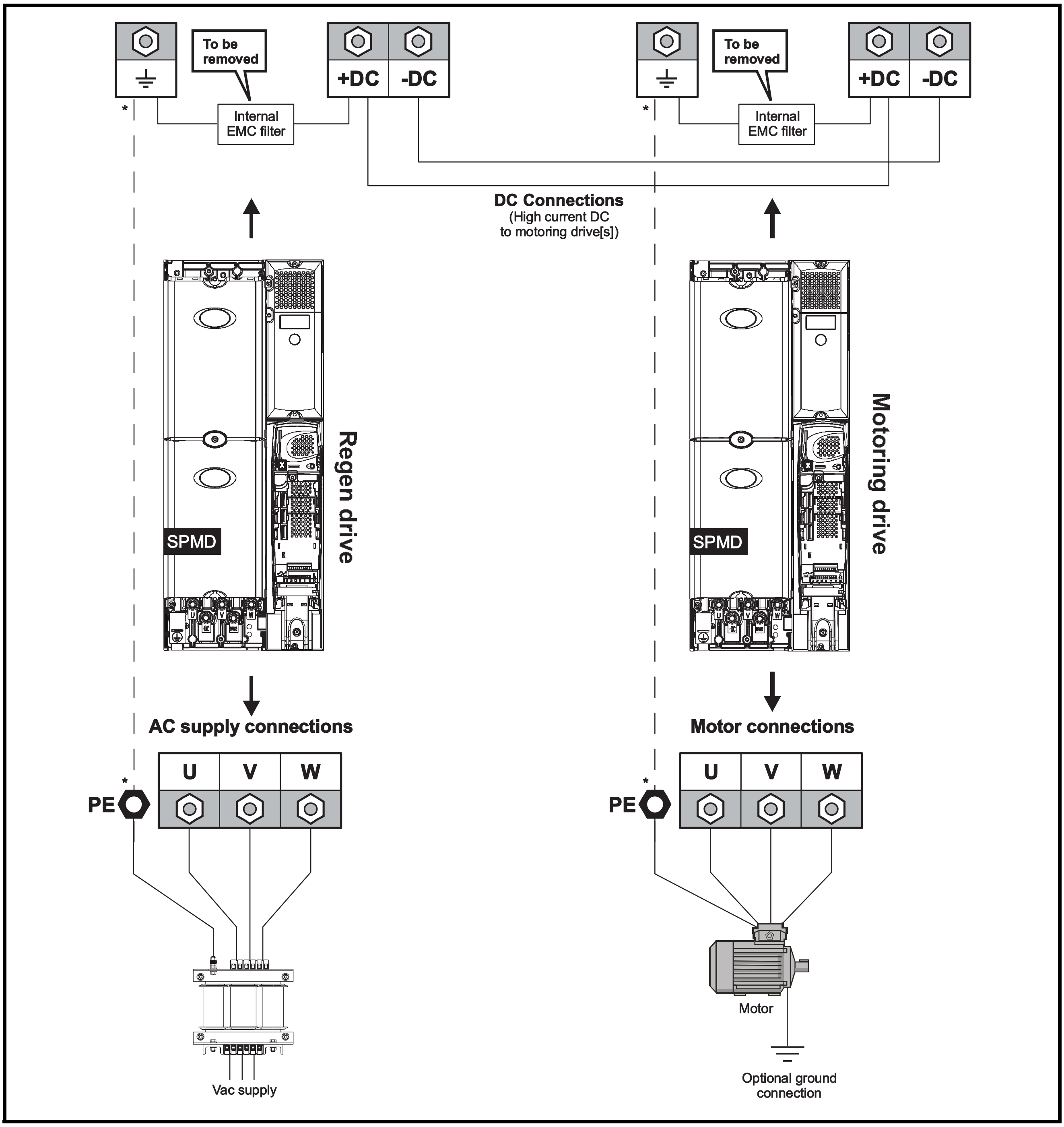
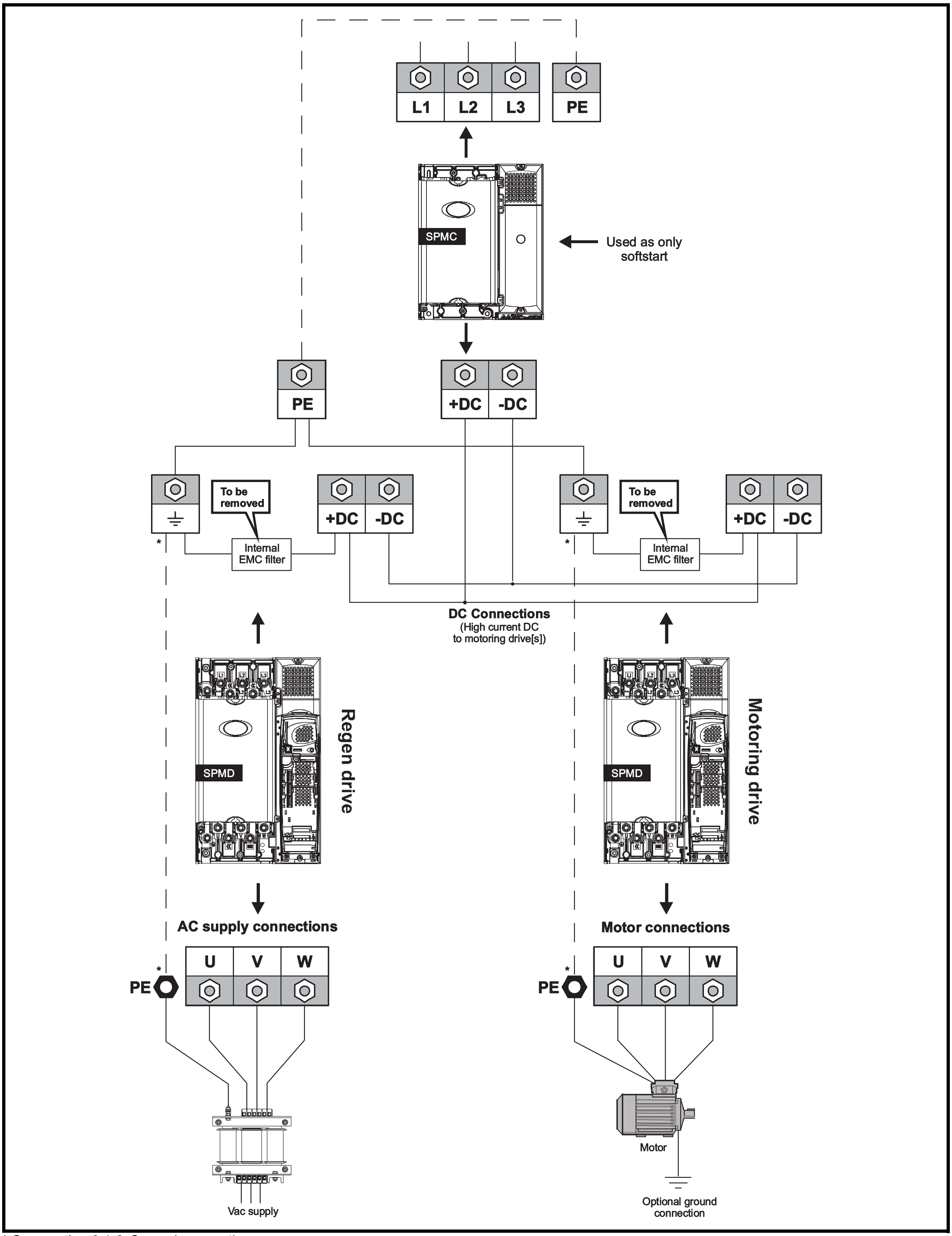


**Figure 6-7 Unidrive SPMC power connections**




* 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:<br>Size 4: 38.4mm$^2$<br>Size 5: 120mm$^2$<br>Size 6: 150mm$^2$<br>SPMA: 150mm$^2$<br>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**

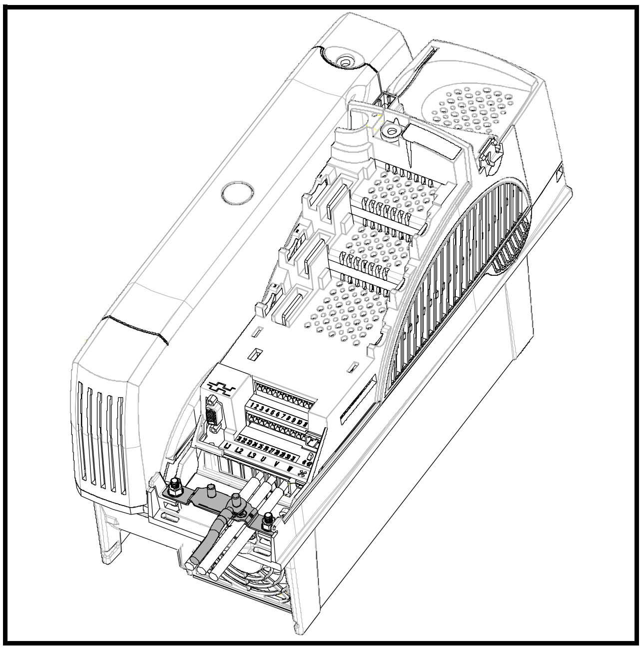


**Figure 6-9 Unidrive SP size 3 ground connections**

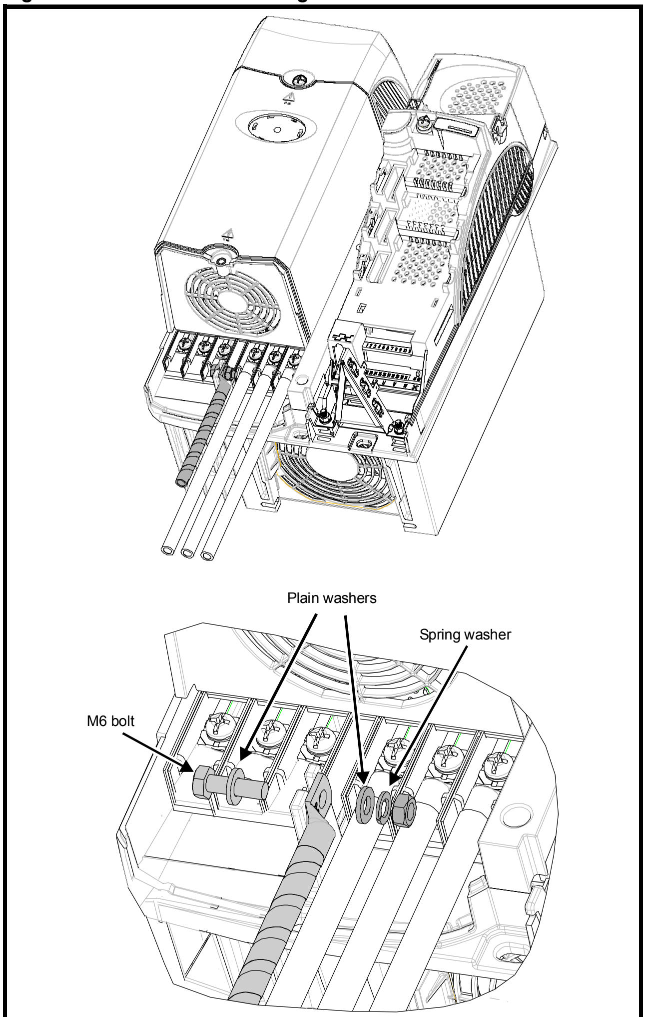


**Figure 6-10 Unidrive SP size 4, 5, 6, SPMA and SPMD ground connections**

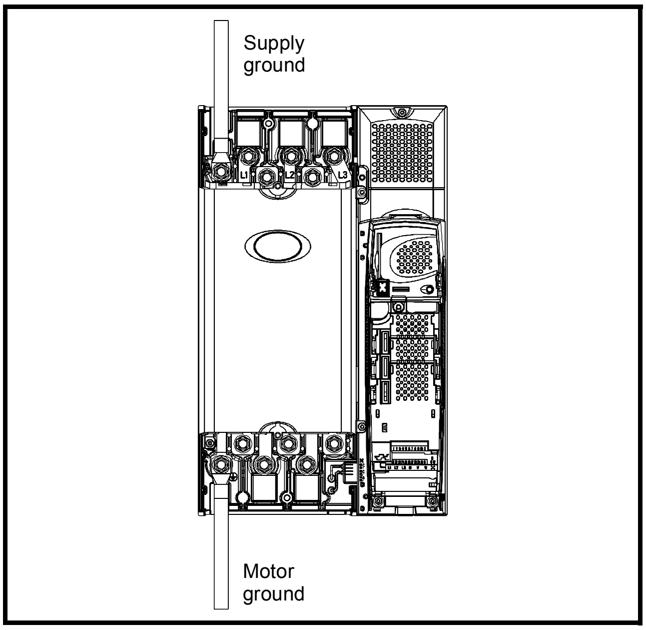
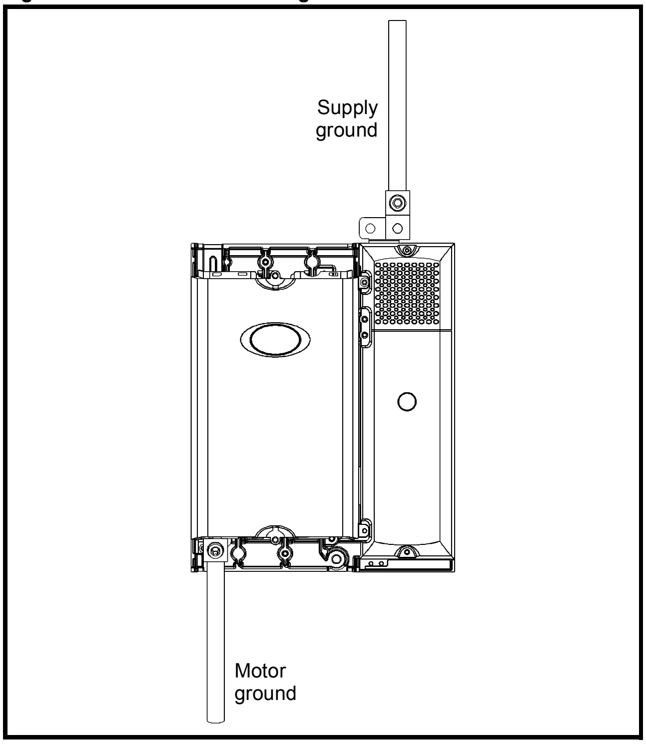



**Figure 6-11 Unidrive SPMC/U ground connections**




## 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**

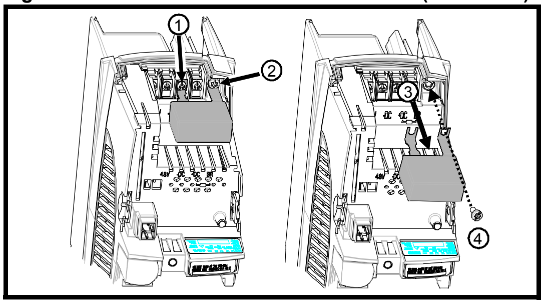
The installer of the drive is responsible for ensuring compliance with the EMC regulations that apply where the drive is to be used.

### 6.5.1 Removal of internal EMC filter

**CAUTION**

The internal EMC filter must be removed from the drive.

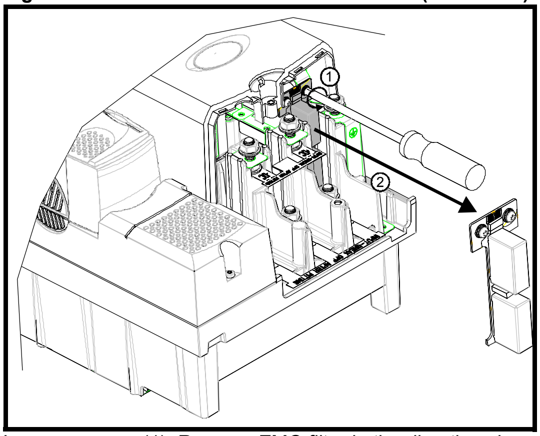
**Figure 6-12 Removal of internal EMC filter (size 1 to 3)**




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).

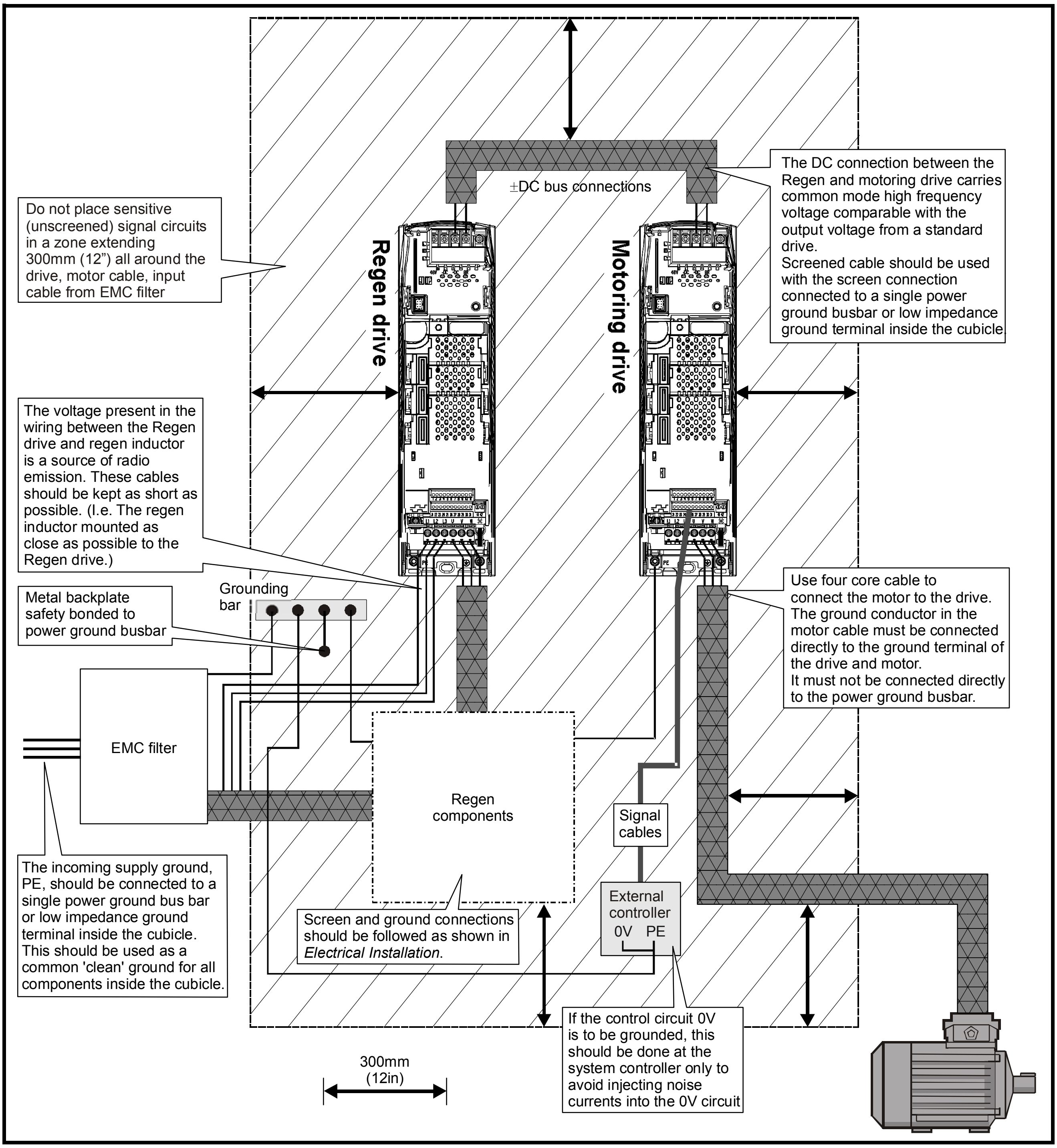
### 6.5.2 General requirements for EMC

#### 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<br>66dBμV average | AC supply lines |
| | | | 0.5 to 30MHz | 73dBμV quasi peak<br>60dBμV average | |
| | EN61800-3<br>IEC1800-3 | Product standard for adjustable speed power drive systems | Requirements for the first environment[1]: restricted distribution[2]<br>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 | | 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 | 100 | 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<br>CISPR 11 Class A Group 1 | Industrial, scientific and medical equipment |
| | EN55022 Class A<br>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.

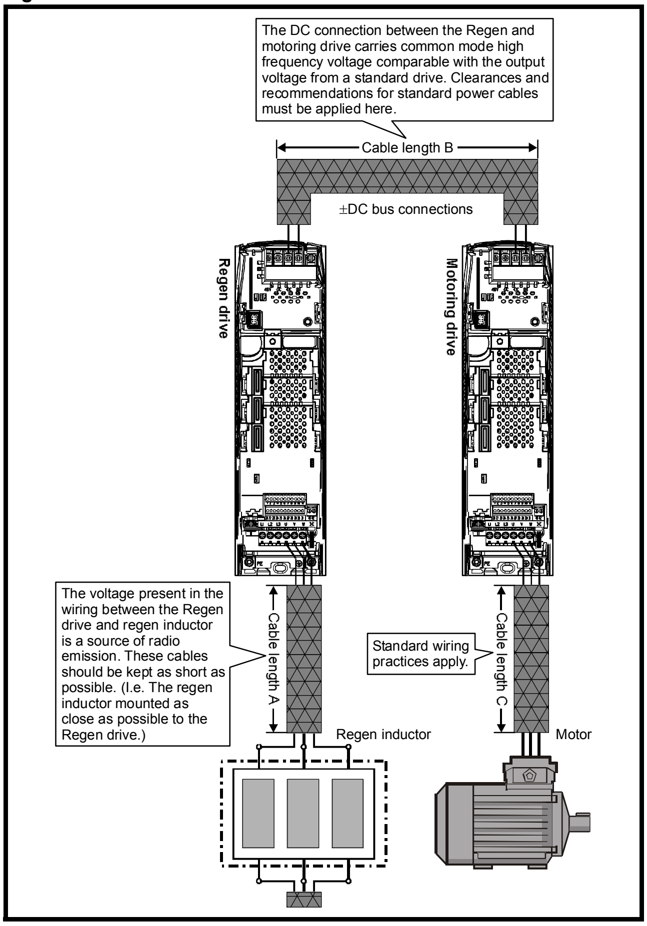
**NOTE**

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**

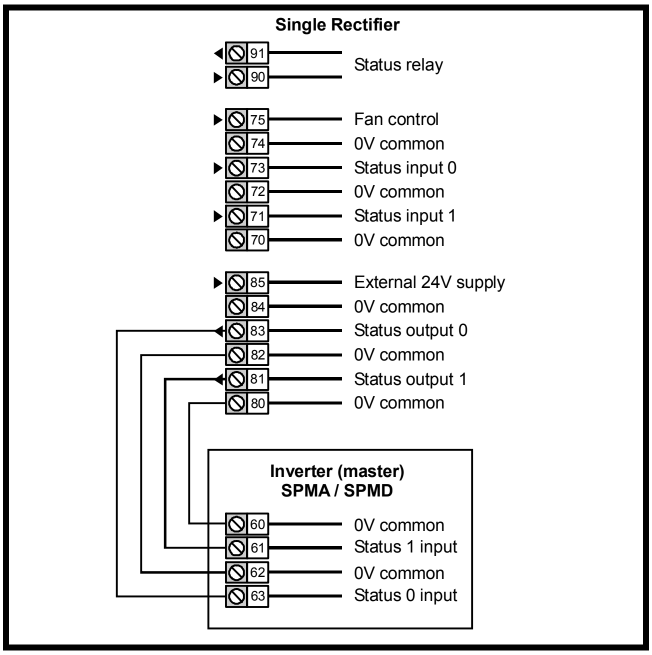
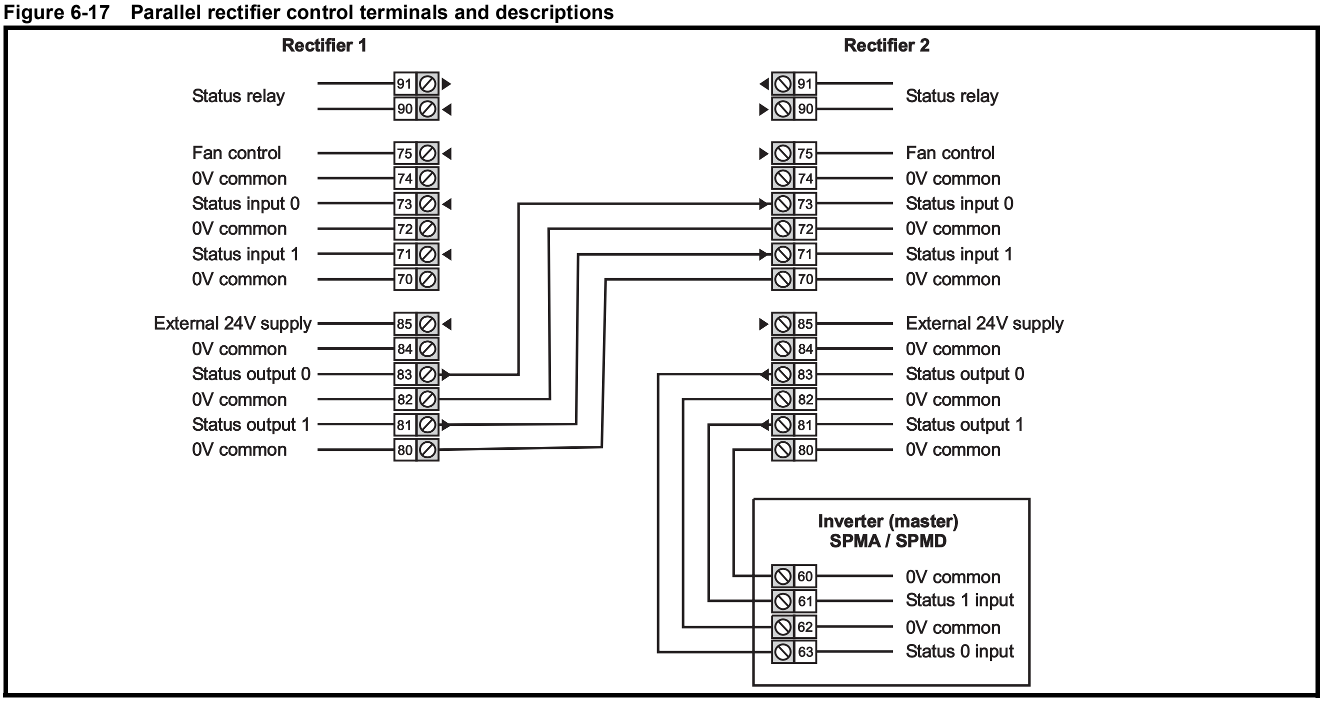



**Figure 6-17 Parallel rectifier control terminals and descriptions**




### 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$^2$s) |

### 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.

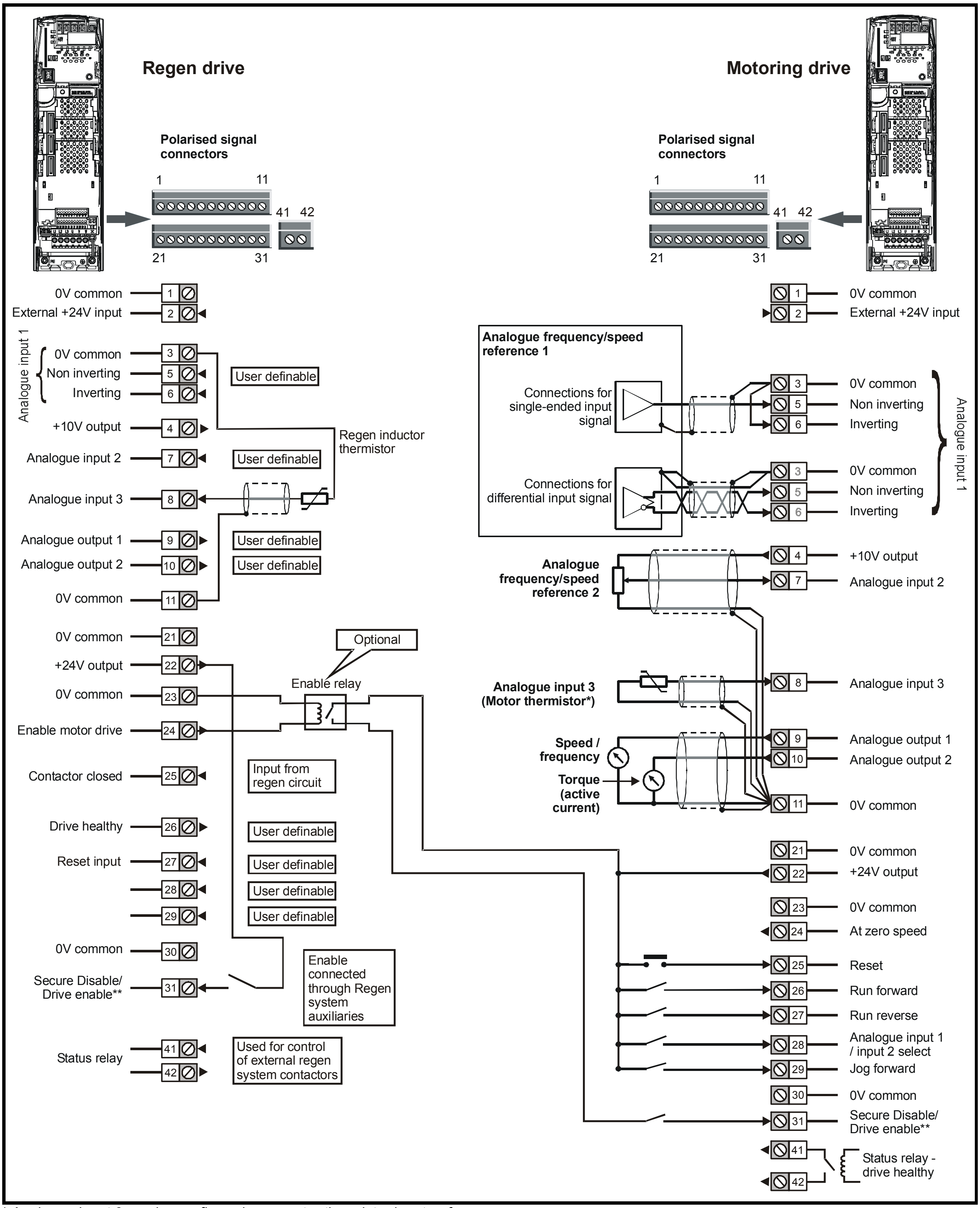
**NOTE**

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.

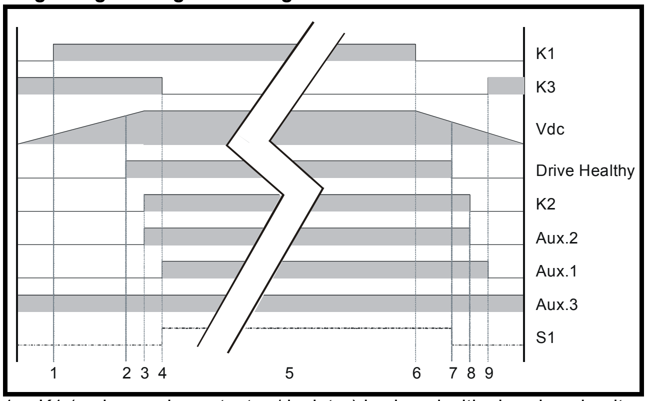
Only when all of these stages have been completed successfully is the motoring drive enabled. If at any time there is a fault, or the Regen drive is disabled, the motoring drive will also be disabled.

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**

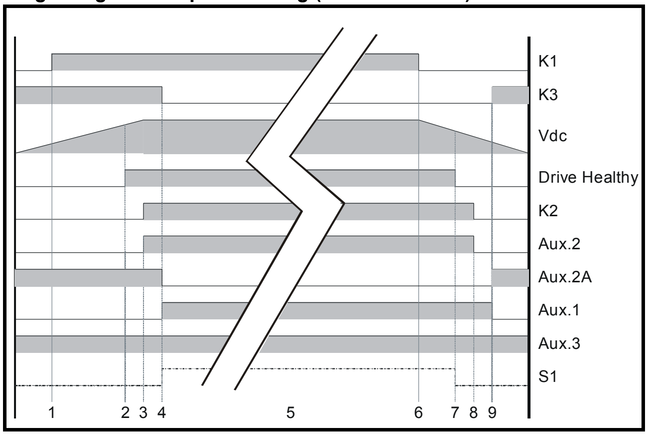
**Single Regen: Single Motoring**




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)**

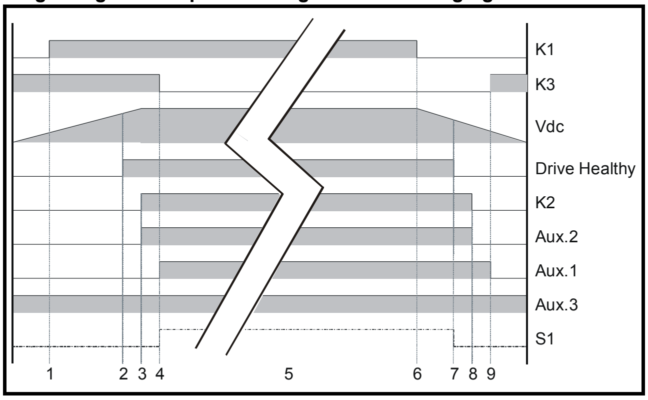



1. K1 (main supply contactor / isolator) is closed with charging circuit active (K3 closed).
2. DC bus charges through Unidrive SPMC (charging circuit).
3. If the DC Bus > 430Vdc then K2 Regen drive main contactor and Aux.2 are closed via Regen drives relay, control terminals 41, 42.
4. K3 charging contactor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

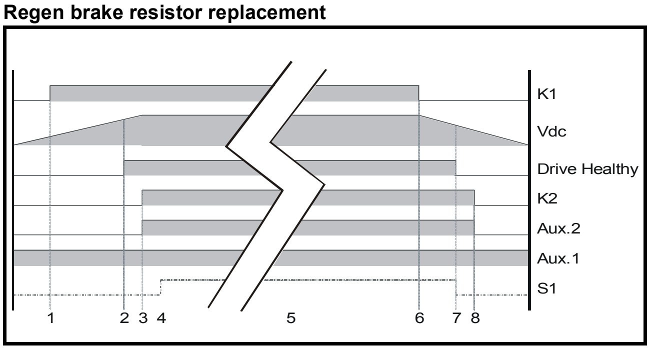
**Single Regen: Multiple Motoring - external charging resistor**




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.

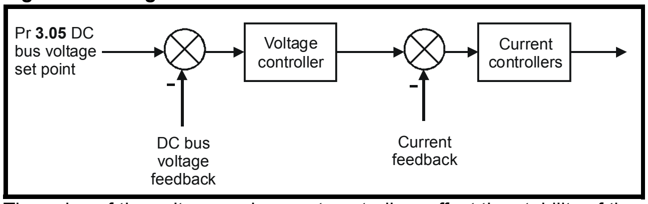
# 8 Optimisation

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<br>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,<br>• A brake resistor replacement system where the ratio between regen brake drive and motoring drive(s) DC Bus capacitance is large<br>• With multiple motoring drive(s) where the ratio between the regen drive(s) and motor drive(s) DC Bus capacitance is large.<br>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.<br>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.<br>• Will introduce cost saving (electricity bill), compensate for inductive loads on the same supply, and overcome voltage drops due to “soft supplies”.<br>• A separate power factor correction unit may not be required.<br>• 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

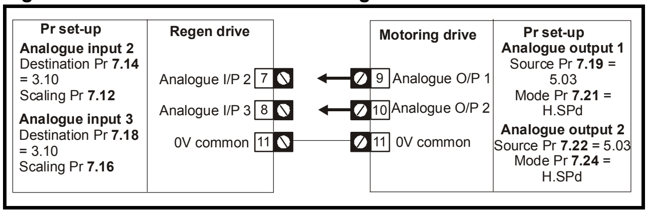
This scaling is the same as the power output from Pr **5.03** when high-speed output mode is used (Refer to section 9.7 *Menu 7: Analogue I/O* ). Therefore an analogue output from the drive supplying the load, and analogue input 2 or 3 of the drive acting as the supply Regen drive can be connected together 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 = $(L / T) \times (I_{fs} / V_{fs}) \times (256 / 5)$

Where:

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

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

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

$I_{fs}$ = 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)

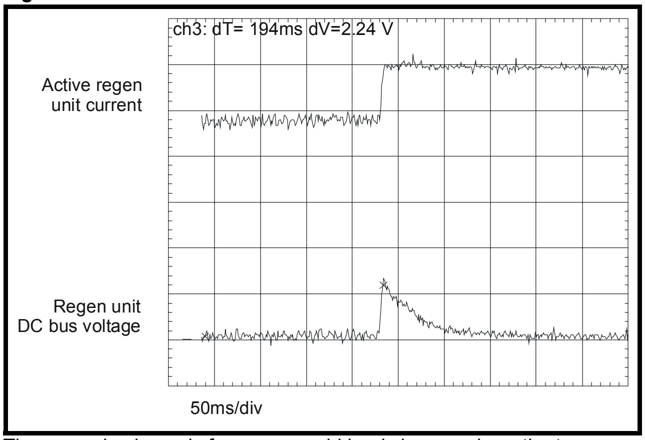
Even when the voltage controller gain is set correctly there will be a transient change of DC bus voltage when there is a change in the load on any motoring drive connected to the Regen drive. This can be reduced substantially by using an analogue input for power feed forward compensation.

*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 (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 voltage 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 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 ΔV for different time constants. (As already mentioned the value of ΔV given is for an instantaneous change of torque representing the worst case. In applications where a speed controller is used in the motor drive the transient will already include an inherent filter).

**Table 8-2 Rate of change**

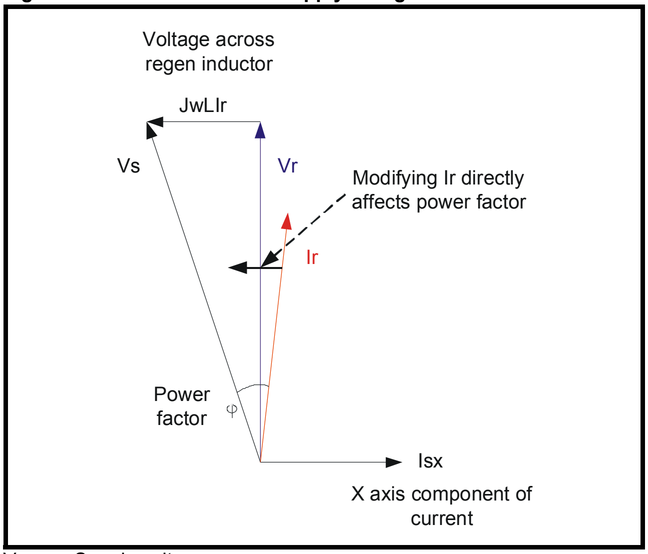
| Time constant | Change in ΔV |
|---|---|
| 20ms | x 0.75 |
| 40ms | x 0.5 |

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

## 8.4 Power factor correction (Pr 4.08)

In regen mode it is possible to produce some current in the x axis of the reference frame so that the Regen drive can be made to produce or consume reactive power. Pr **4.08** defines the level of reactive current as a percentage of the regen 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.

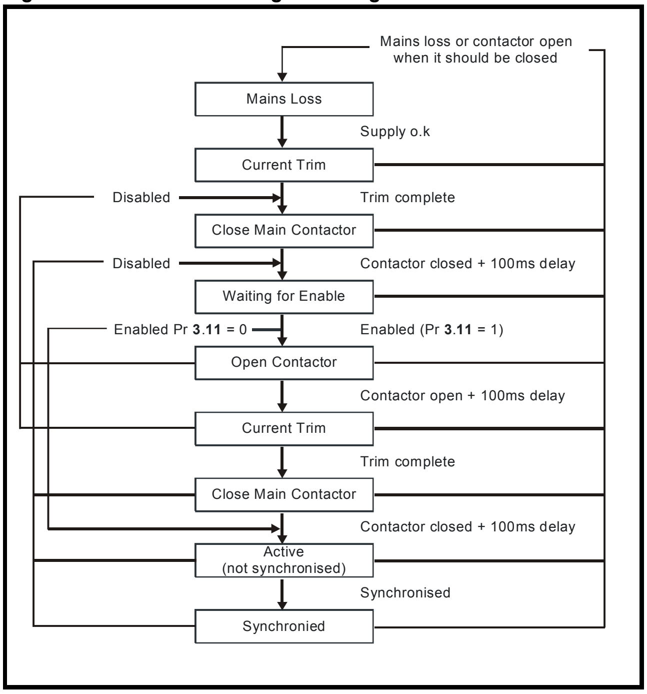
**Mode 2** - At power up and on each enable [Pr **3.11** = 1]
Current trimming is carried out as previously available, once after power-up, and now in addition it is also carried out before the drive runs each time it is enabled (software V1.10 onwards) with Unidrive SP Regen.

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**<br>RATED_CURRENT_MAX = 1.36 x Rated drive current.<br>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.)<br>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**<br>The maximum drive current is the current at the over current trip level and is given by:<br>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.<br>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.<br>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%):<br>$\mathbf{CURRENT\_LIMIT\_MAX} = \left(\frac{\mathbf{Maximum\ current}}{\mathbf{Regen\ drive\ rated\ current}}\right) \times \mathbf{100\%}$<br>Where:<br>The Regen drive rated current is give by Pr **5.07**<br>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.<br>The rated active and rated magnetising currents are calculated from regen mode rated current (Pr **5.07**) as:<br>Rated active current = Regen mode rated current<br>Rated magnetising current = 0<br>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.<br>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.<br>$\mathbf{REGEN\_REACTIVE\_MAX} = \sqrt{\left(\left[\frac{\mathbf{Reactive\ drive\ current} \times \mathbf{1.75}}{\mathbf{Regen\ drive\ rated\ current}}\right]^2 - \mathbf{Pr\ 4.07^2}\right)} \times \mathbf{100\%}$<br>Motor rated current is given by Pr **5.07** |
| TORQUE_PROD_CURRENT_MAX [1000.0%] | **Maximum torque producing current**<br>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**<br>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**<br>400V rating drive: 0 to 800V |
| DC_VOLTAGE_MAX [1190V] | **Maximum DC bus voltage**<br>The maximum measurable DC bus voltage<br>400V drives: 830V |
| POWER_MAX [9999.99kW] | **Maximum power in kW**<br>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:<br>Software V01.07.01 and earlier: POWER_MAX = √3 x AC_VOLTAGE_MAX x RATED_CURRENT x 1.75<br>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**

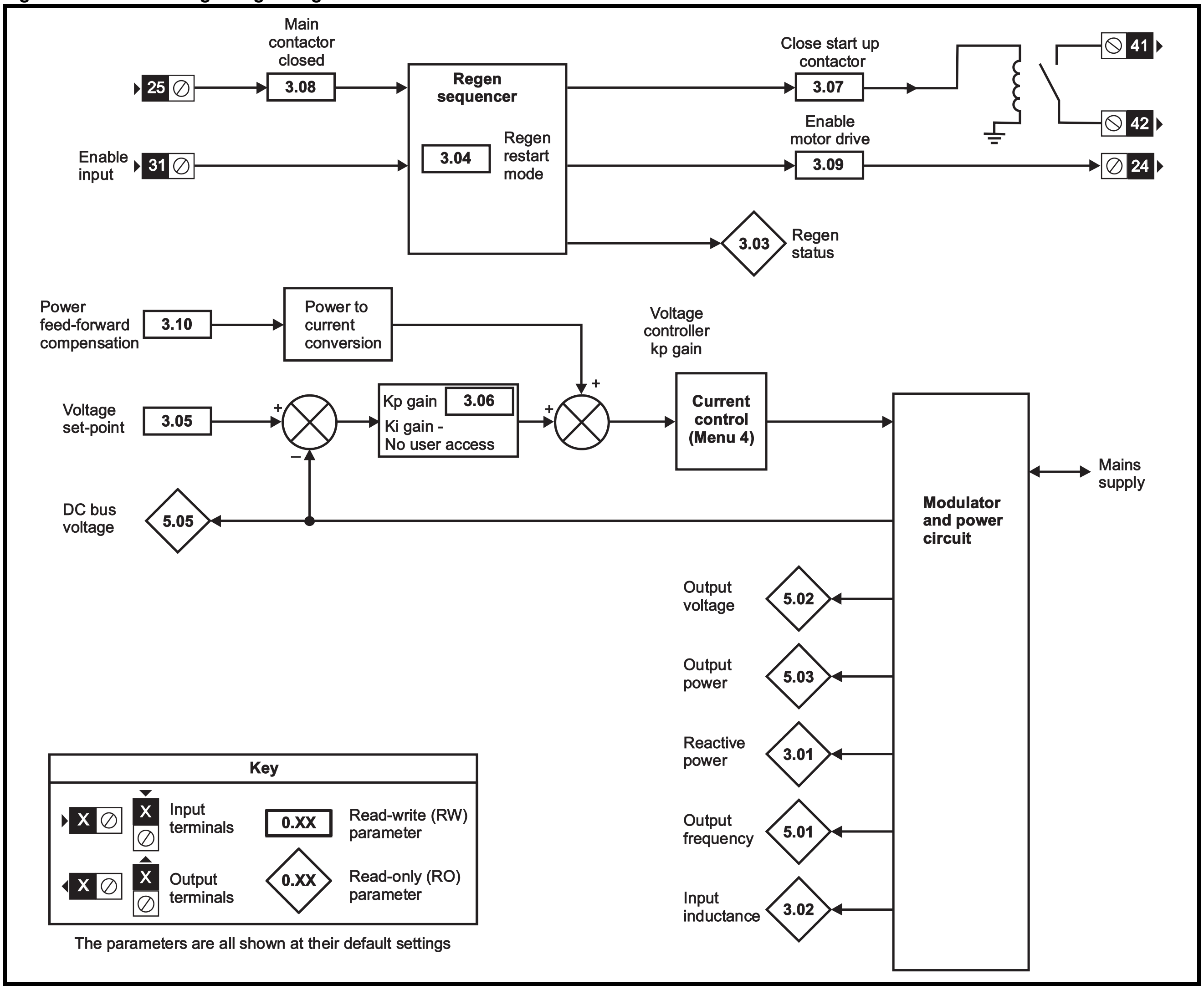
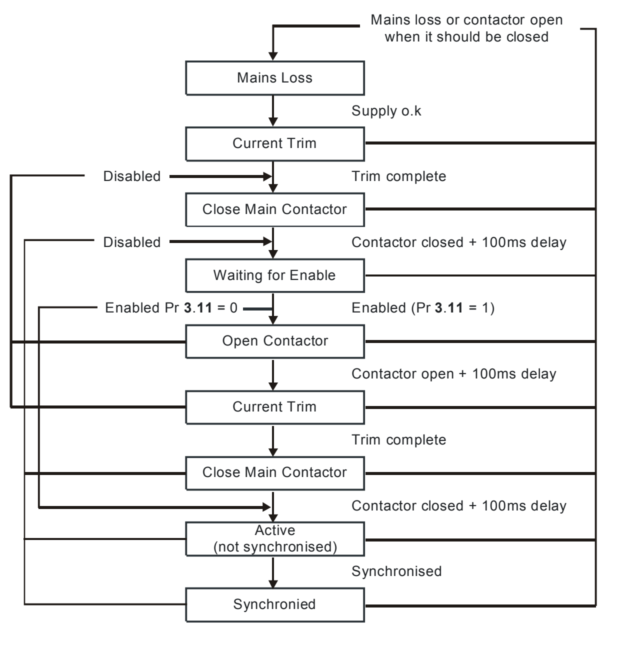


**Table 9-3 Menu 3 Regen parameter descriptions**

| 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 | |
| **Range** | Regen | 0 to DC_VOLTAGE_SET_MAX V |
| **Default** | Regen | 200V rating drive: 350<br>400V rating drive: 700<br>575V rating drive: 835<br>690V rating drive: 1005 |
| **Update rate** | Background | |

**Coding**

| Bit | SP | FI | DE | Txt | VM | DP | ND | RA | NC | NV | PT | US | RW | BU | PS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1 | | | 1 | | | | 1 | 1 | 1 | |

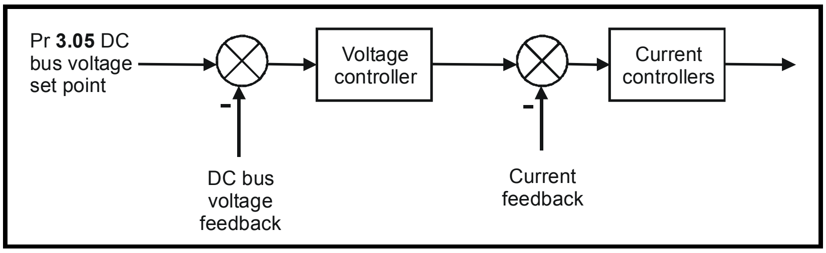
The Regen drive will attempt to hold the DC bus at the level specified by this parameter. The DC bus voltage must always be higher than the peak of the line to line supply voltage if the unit is to operate correctly. The default values can be used with most supplies giving a reasonable level of control headroom. However, with higher voltage supplies the set-point must be raised.

| **3.06** | **Voltage controller Kp gain** | |
|---|---|---|
| **Drive mode** | Regen | |
| **Range** | Regen | 0 to 65,535 |
| **Default** | Regen | 4,000 |
| **Update rate** | Background | |

**Coding**

| Bit | SP | FI | DE | Txt | VM | DP | ND | RA | NC | NV | PT | US | RW | BU | PS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | 1 | 1 | 1 | |

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 = $Kc \times \sqrt{2} / 0.45$. 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

$\tau_m$ is the time constant (L / R).
R is the resistance of the supply for one phase.

Therefore

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

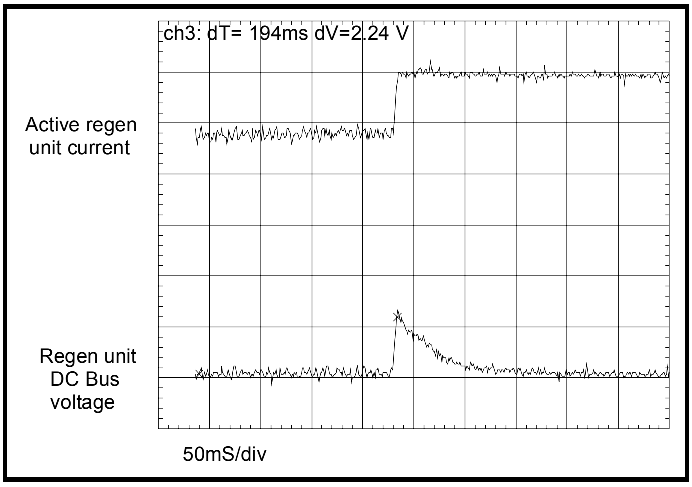
The above equations give the gain values that should give the best response at all switching frequencies with minimal overshoot. If required the gains can be adjusted to improve performance as follows:

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 ($\Delta V$) 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 $\Delta V$.)

If the load change, drive voltage rating, motor voltage or DC Bus 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 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 ∆V for different time constants. (As already mentioned the value of ∆V 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 ∆V |
|---|---|
| 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 | | | | | | | | | | | | | | | |

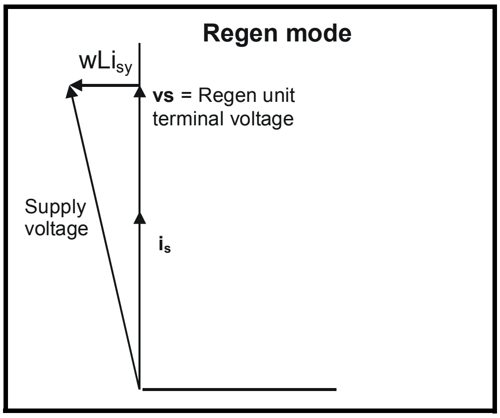
This parameter defines the strategy used for current trimming in regen mode. If Pr **3.11**=0 then current trimming is only carried out once after power-up. If Pr **3.11**=1 current trimming is carried out after power-up and then before the drive runs each time it is enabled.

## 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.

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

**Figure 9-3 Menu 4 Regen logic diagram**

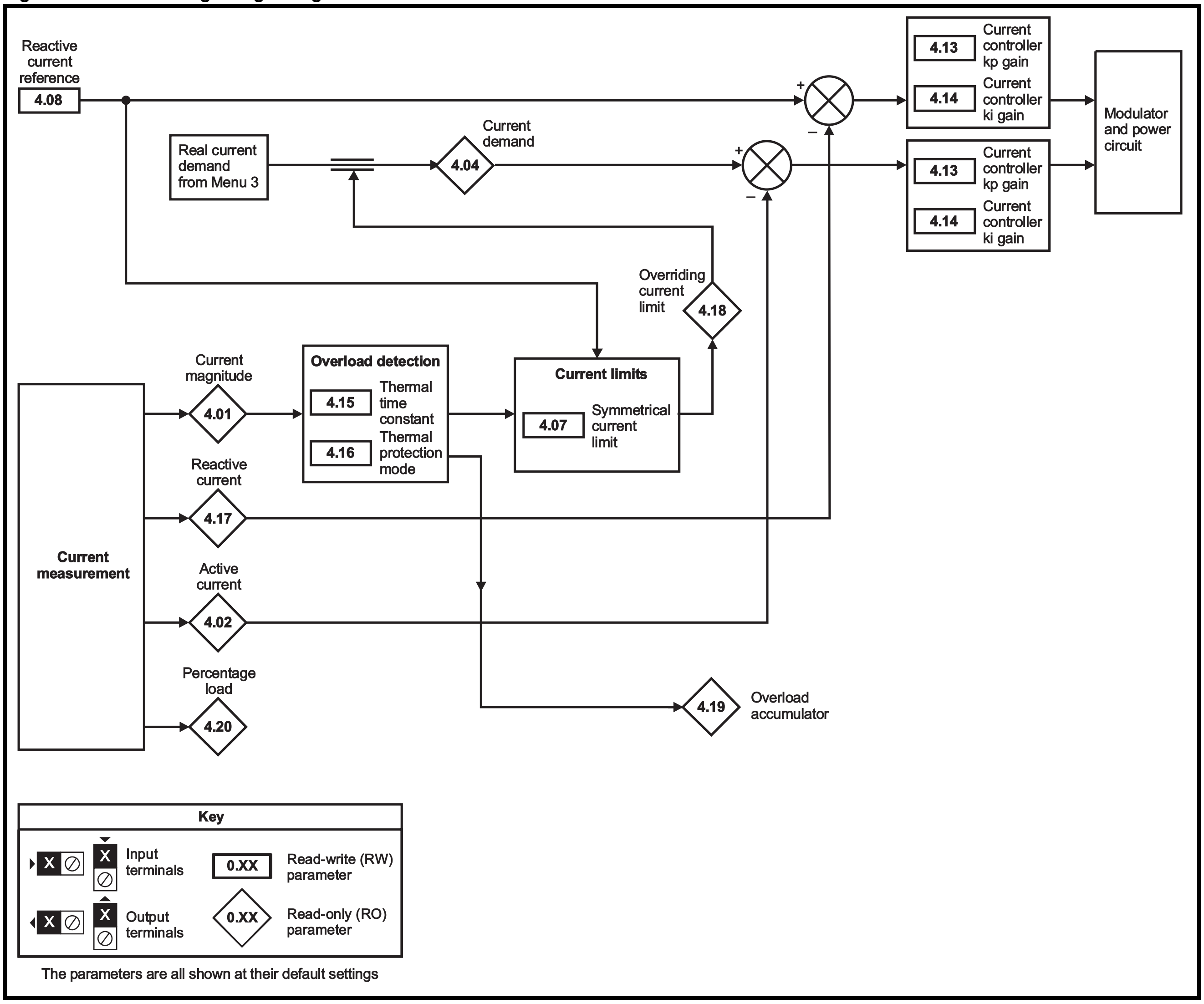


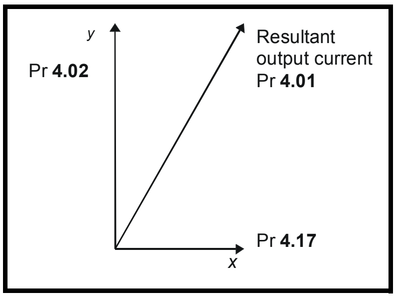
**Table 9-4 Menu 4 Regen parameter descriptions**

| 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<br>400V: 90<br>575V: 110<br>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<br>400V: 2000<br>575V: 2400<br>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:

$\tau_m$ 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:

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

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

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

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

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

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

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

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

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

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

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

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

See Pr **4.16** on page 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**

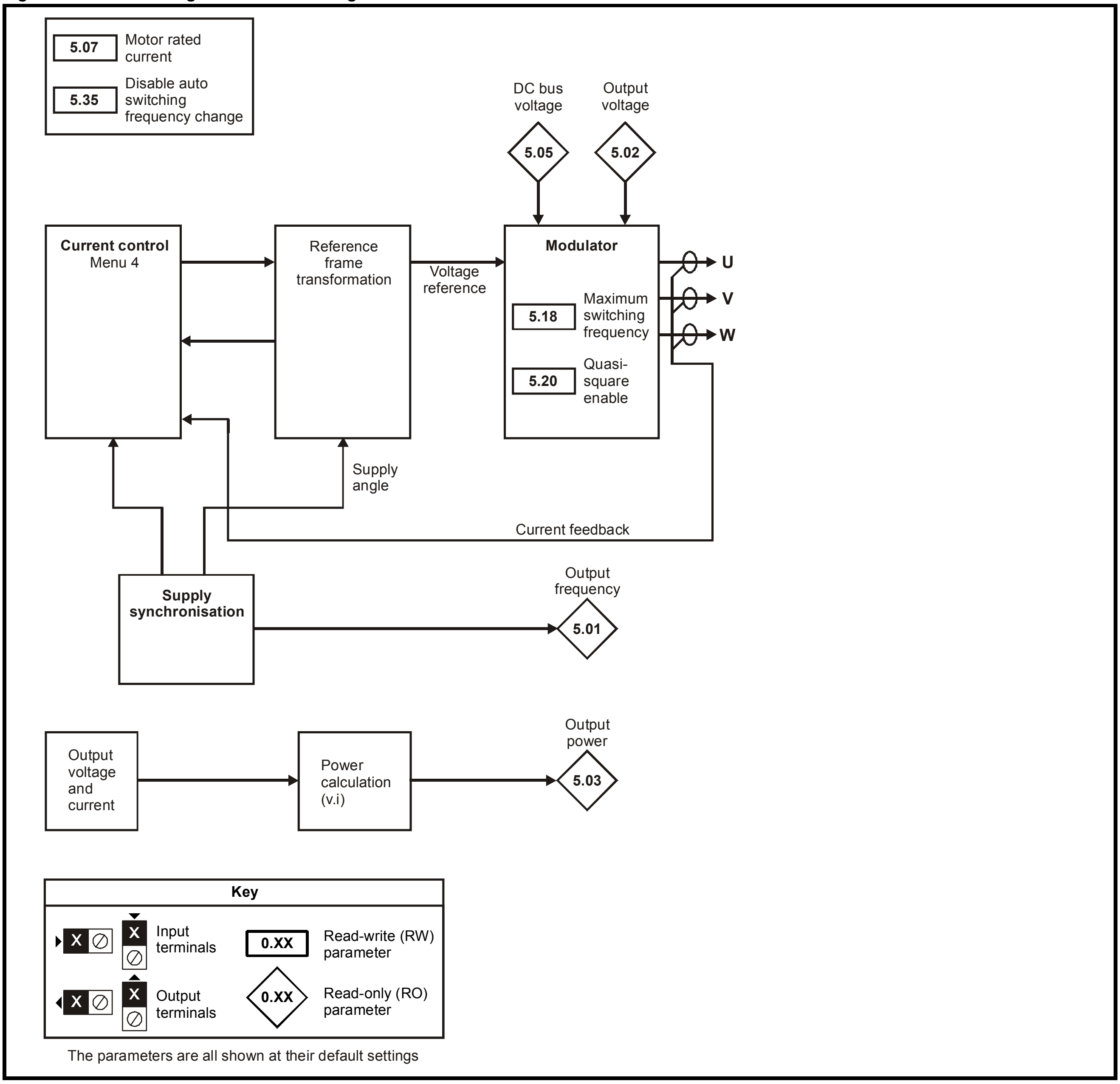


**Table 9-5 Menu 5 Regen parameter descriptions**

| 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**

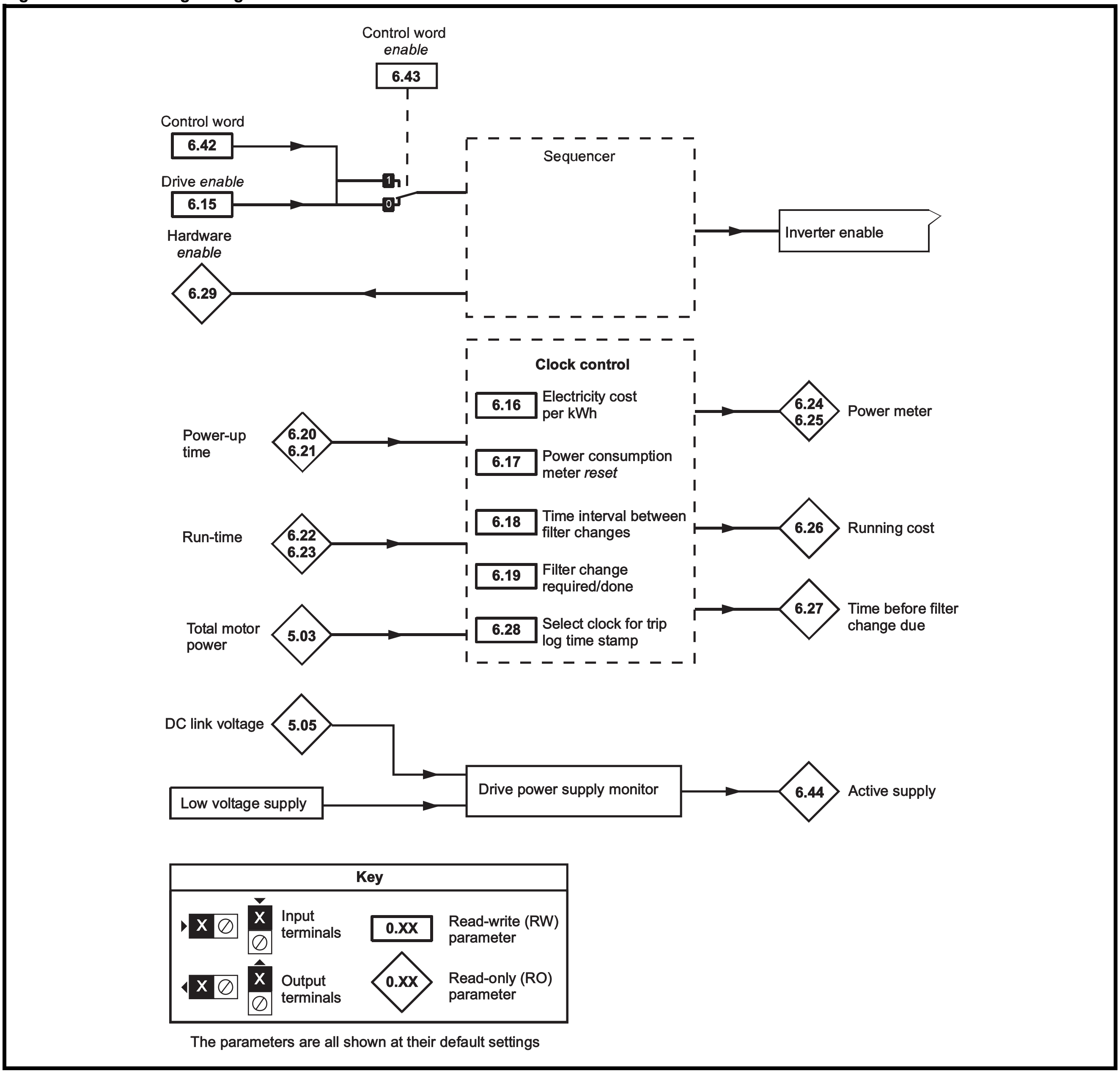


**Table 9-6 Regen mode state diagram**

| State | Actions | Exit conditions |
|---|---|---|
| DISABLE | Disable inverter | 1. TripState! = NO_TRIP THEN TRIP_STATE<br>2. Enable THEN SYNC_STATE |
| REGEN_SYNC | Enable inverter | 1. TripState! = NO_TRIP THEN TRIP_STATE<br>2. Not Enable THEN DISABLE_STATE<br>3. Supply not okay THEN DISABLE_STATE<br>4. Synchronised THEN ACTIVE_STATE |
| REGEN_ACTIVE | | 1. TripState! = NO_TRIP THEN TRIP_STATE<br>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<br>48 - 72 - SP2, SP3 drives<br>48 - 72 - For all other 200V drives<br>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.

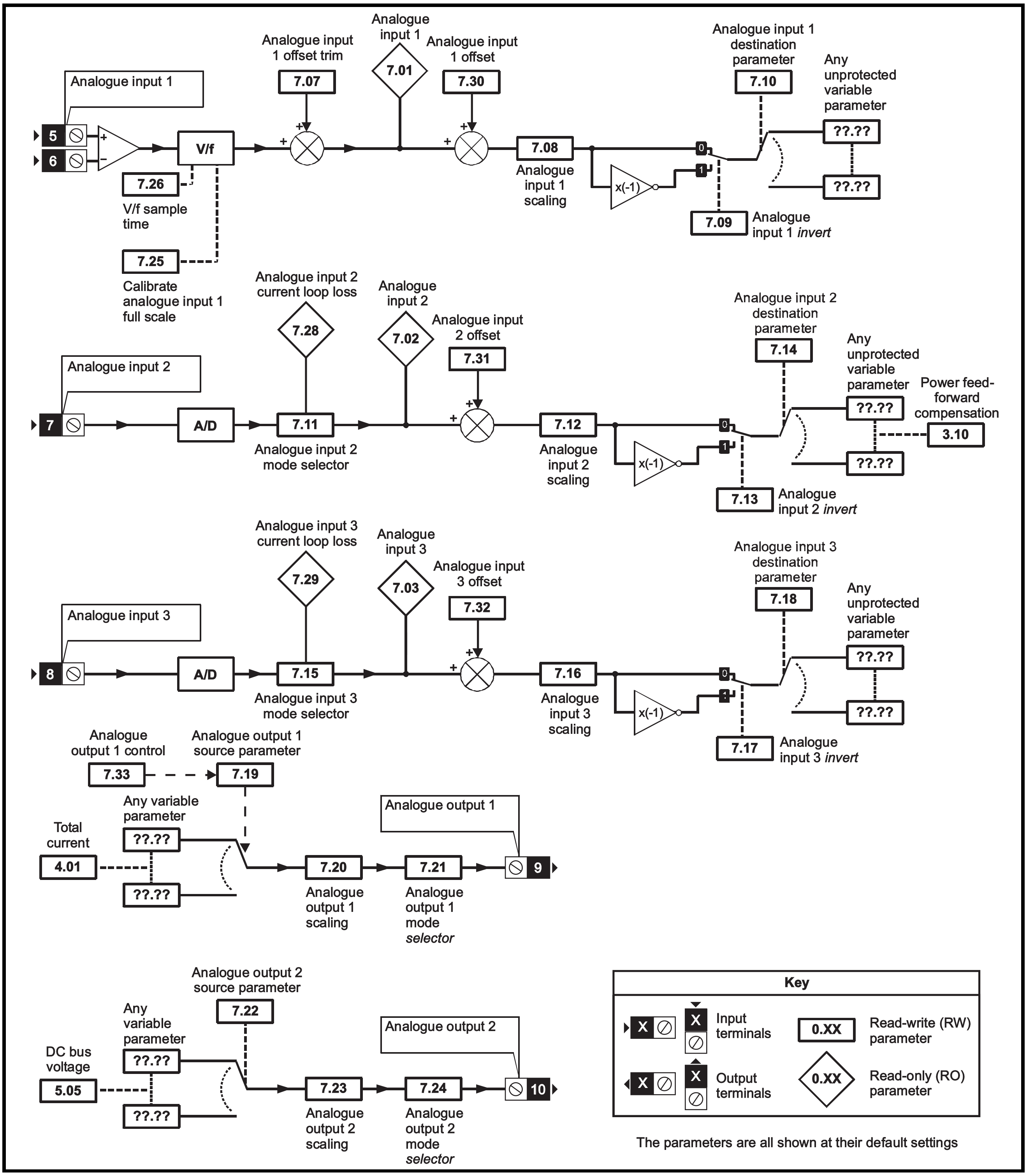
| 6.50 | Drive comms state | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Drive mode** | Regen | | | | | | | | | | | | | | | |
| **Coding** | Bit | SP | FI | DE | Txt | VM | DP | ND | RA | NC | NV | PT | US | RW | BU | PS |
| | | | | | 1 | | | 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 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<br>(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<br>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).<br>10V would be produced when:<br>Active current = Rated drive current / 0.45<br>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<br>TH reset if R < 1k8<br>THS trip if R < 50R |
| 8 | th | Thermistor without short circuit detection | TH trip if R > 3k3<br>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 250$\mu$s. 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 | | | | | | | | | | | | | | | |

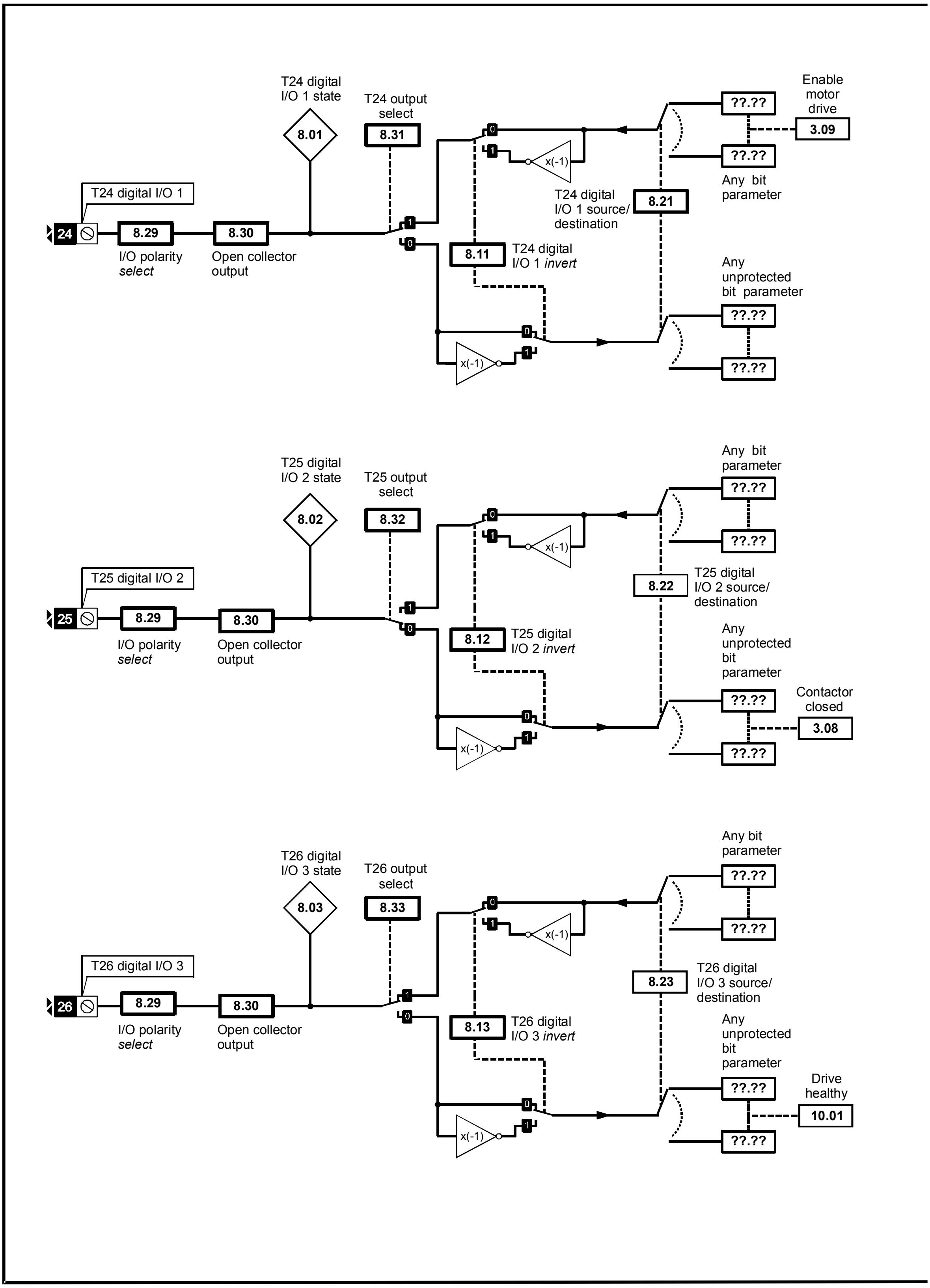
An additional thermal monitoring point is provided in UNISP6xxx and UNISP7xxx drives. The temperature is displayed in this parameter in degrees C. See Pr **7.04** to Pr **7.06** for more details.

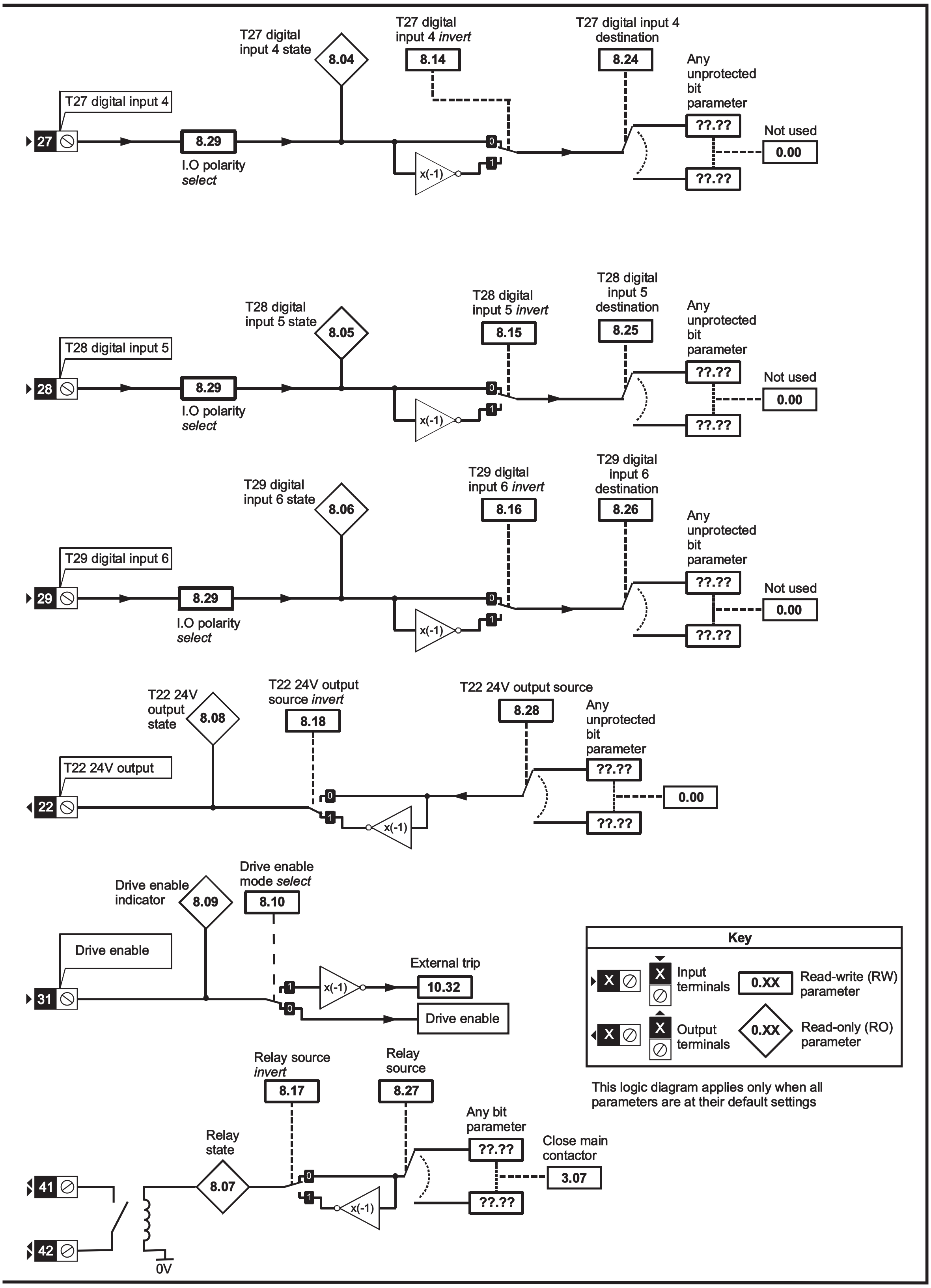
| **7.51** | **Analogue input 1 full scale** | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Drive mode** | Regen | | | | | | | | | | | | | | | |
| **Coding** | Bit | SP | FI | DE | Txt | VM | DP | ND | RA | NC | NV | PT | US | RW | BU | PS |
| | | | | | | | | 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 state
8.04
T27 digital input 4 *invert*
8.14
T27 digital input 4 destination
8.24
Any unprotected bit parameter
??.??
Not used
0.00
??.??
T27 digital input 4
27
8.29
I.O polarity *select*
x(-1)
T28 digital input 5 state
8.05
T28 digital input 5 *invert*
8.15
T28 digital input 5 destination
8.25
Any unprotected bit parameter
??.??
Not used
0.00
??.??
T28 digital input 5
28
8.29
I.O polarity *select*
T29 digital input 6 state
8.06
T29 digital input 6 *invert*
8.16
T29 digital input 6 destination
8.26
Any unprotected bit parameter
??.??
Not used
0.00
??.??
T29 digital input 6
29
8.29
I.O polarity *select*
T22 24V output state
8.08
T22 24V output source *invert*
8.18
T22 24V output source
8.28
Any unprotected bit parameter
??.??
0.00
??.??
T22 24V output
22
Drive enable indicator
8.09
Drive enable mode *select*
8.10
Drive enable
31
External trip
10.32
Drive enable
Relay source *invert*
8.17
Relay source
8.27
Any bit parameter
??.??
Close main contactor
3.07
??.??
Relay state
8.07
41
42
0V
Key
Input terminals
0.XX
Read-write (RW) parameter
Output terminals
0.XX
Read-only (RO) parameter
This logic diagram applies only when all parameters are at their default settings

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)<br>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.

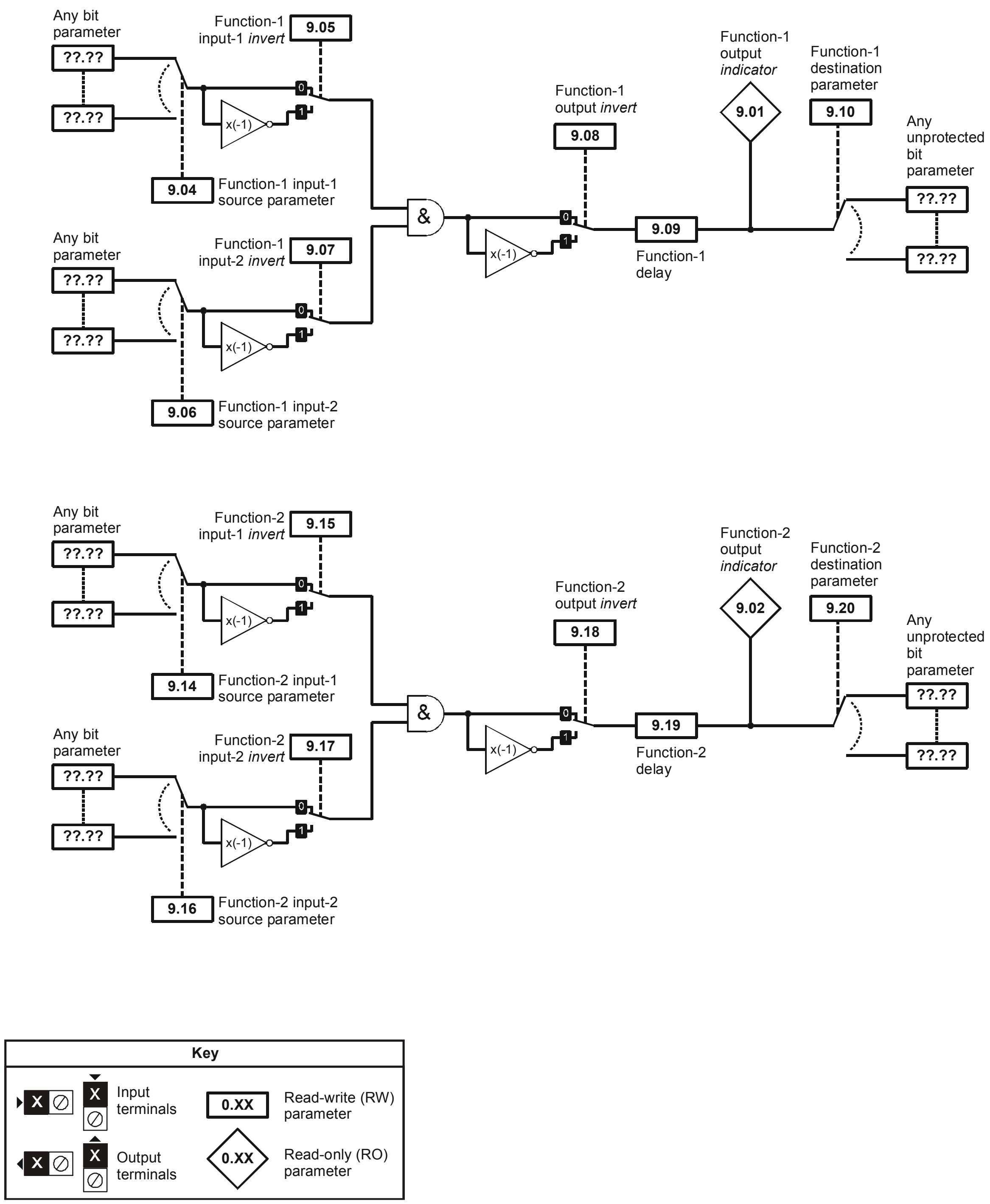
| **Reference select Pr 1.14** | | **Pr 8.25 set to:** | **Pr 8.26 set to:** |
|---|---|---|---|
| 0, A1.A2 | Reference selection by terminal input | Pr **1.41** - Analogue ref 2 select | Pr **6.31** - jog |
| 1, A1.Pr | Analogue reference 1 or presets selected by terminal input | Pr **1.45** - preset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

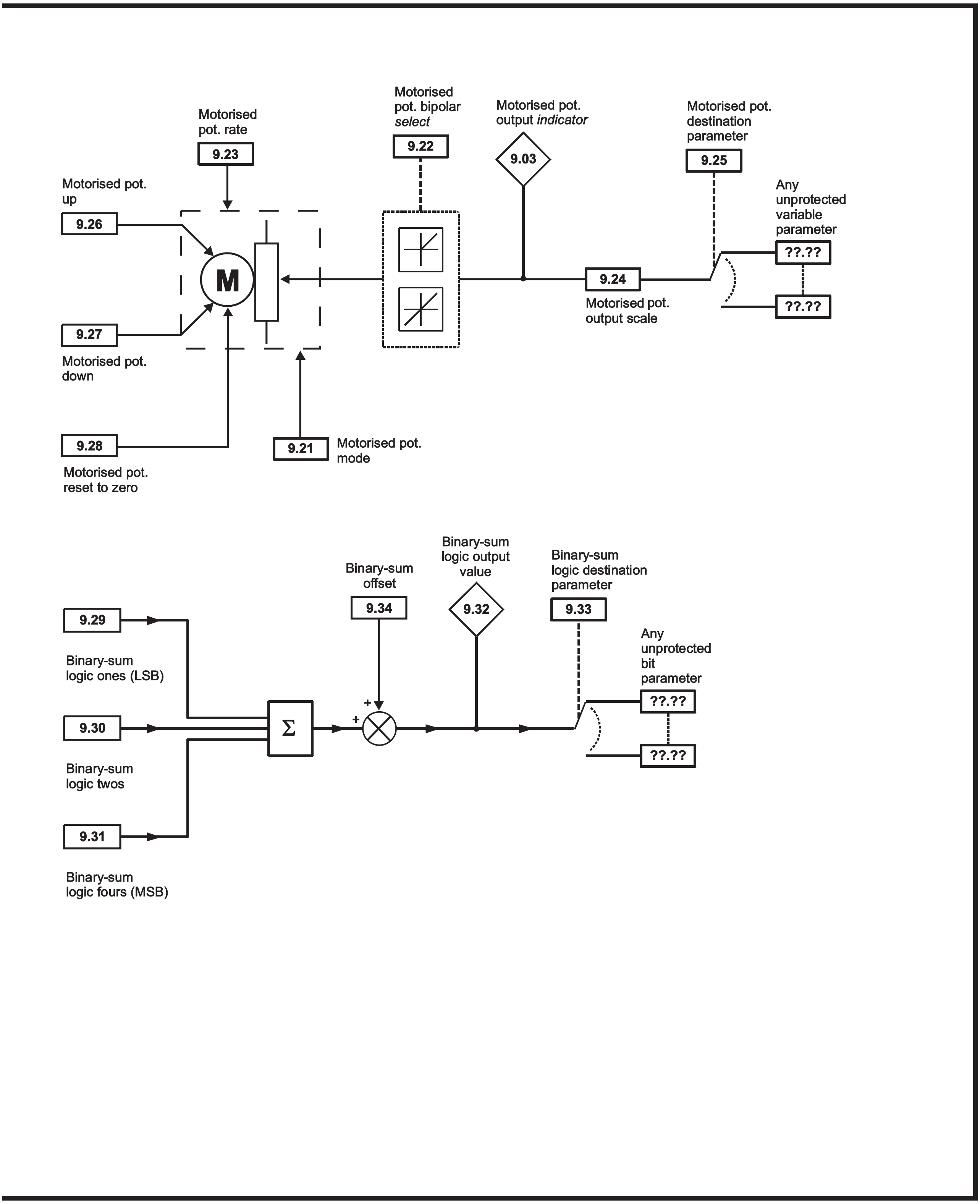
This parameter has no effect in Regen mode.

## 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
Motorised pot. up
9.26
Any unprotected variable parameter
??.??
M
9.24
??.??
Motorised pot. output scale
9.27
Motorised pot. down
9.28
9.21
Motorised pot. mode
Motorised pot. reset to zero
Binary-sum logic output value
Binary-sum offset
Binary-sum logic destination parameter
9.34
9.32
9.33
9.29
Any unprotected bit parameter
Binary-sum logic ones (LSB)
??.??
9.30
Σ
??.??
Binary-sum logic twos
9.31
Binary-sum logic fours (MSB)

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 | | | | | | | | | | | | | | | |

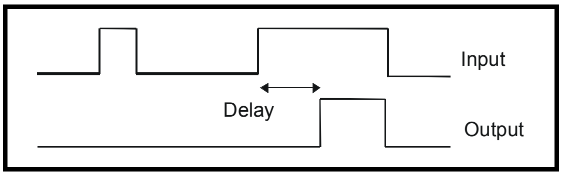
| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **9.06** | **Logic function 1 source 2** | | | | | | | | | | | | | | | |
| **9.16** | **Logic function 2 source 2** | | | | | | | | | | | | | | | |
| **Drive mode** | Regen | | | | | | | | | | | | | | | |
| 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 | | | | | | | | | | | | | | | |

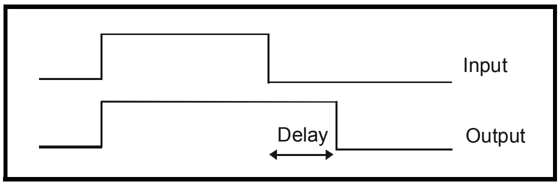
| **9.08** | **Logic function 1 output invert** | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **9.18** | **Logic function 2 output invert** | | | | | | | | | | | | | | | |
| **Drive mode** | Regen | | | | | | | | | | | | | | | |
| Coding | Bit | 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.<br>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.<br>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.<br>Up and down are only active when the drive is running (i.e. inverter active).<br>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.<br>Up and down are only active when the drive is running (i.e. inverter active).<br>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<br>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 |

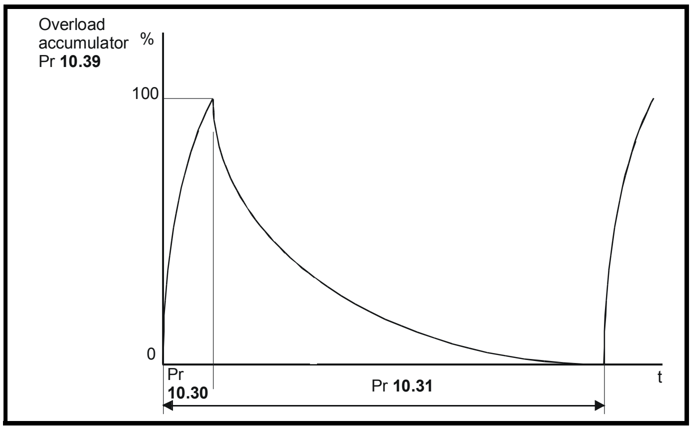
This parameter defines the time period that the braking resistor fitted can stand full braking volts without damage. The setting of this parameter is used in determining the braking overload time.

| 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<br>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

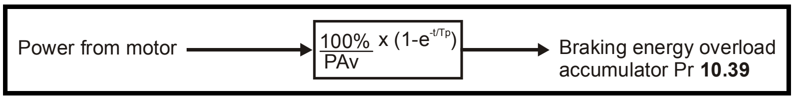
$P_{on} = E / T_{on}$

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.<br>(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**

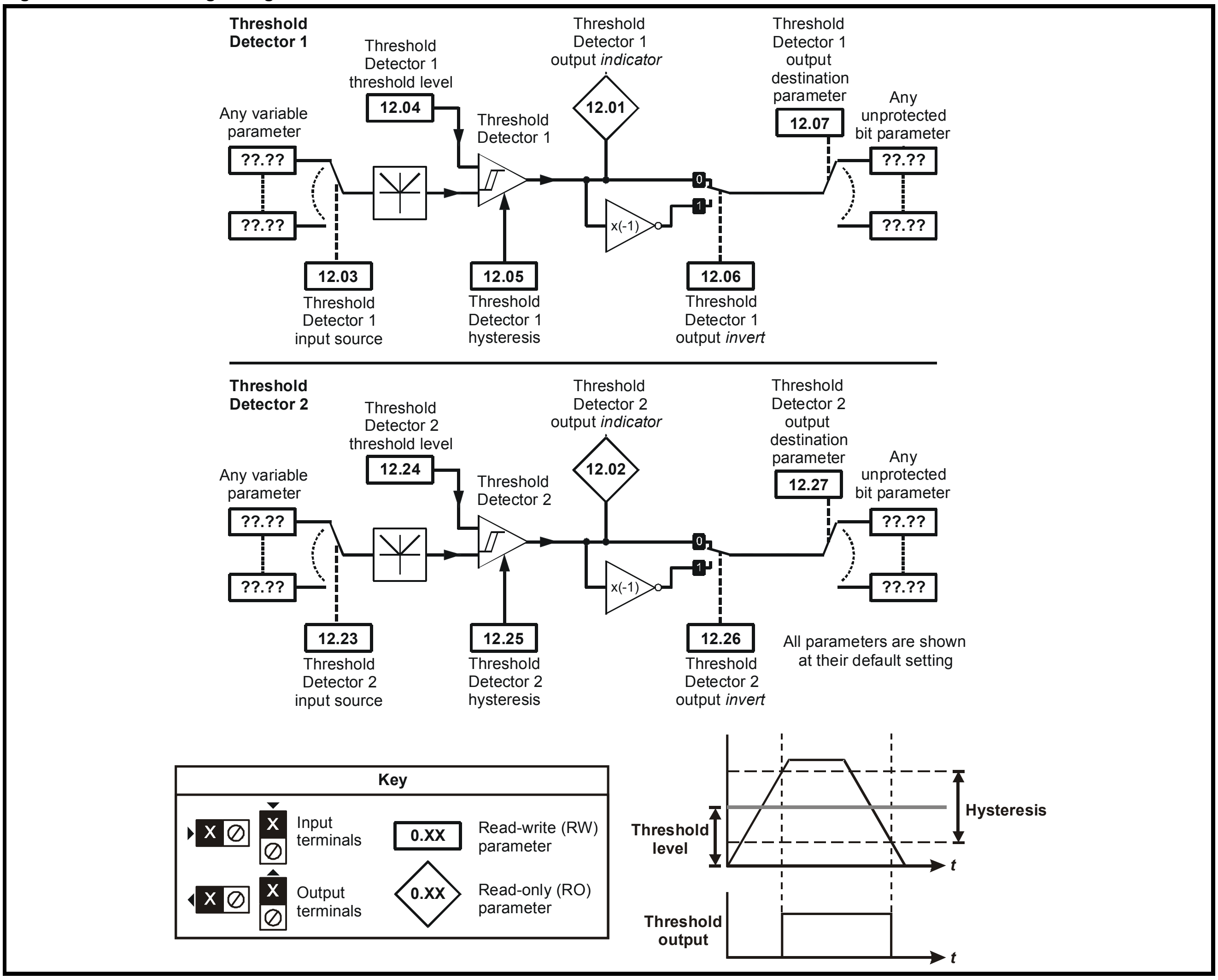
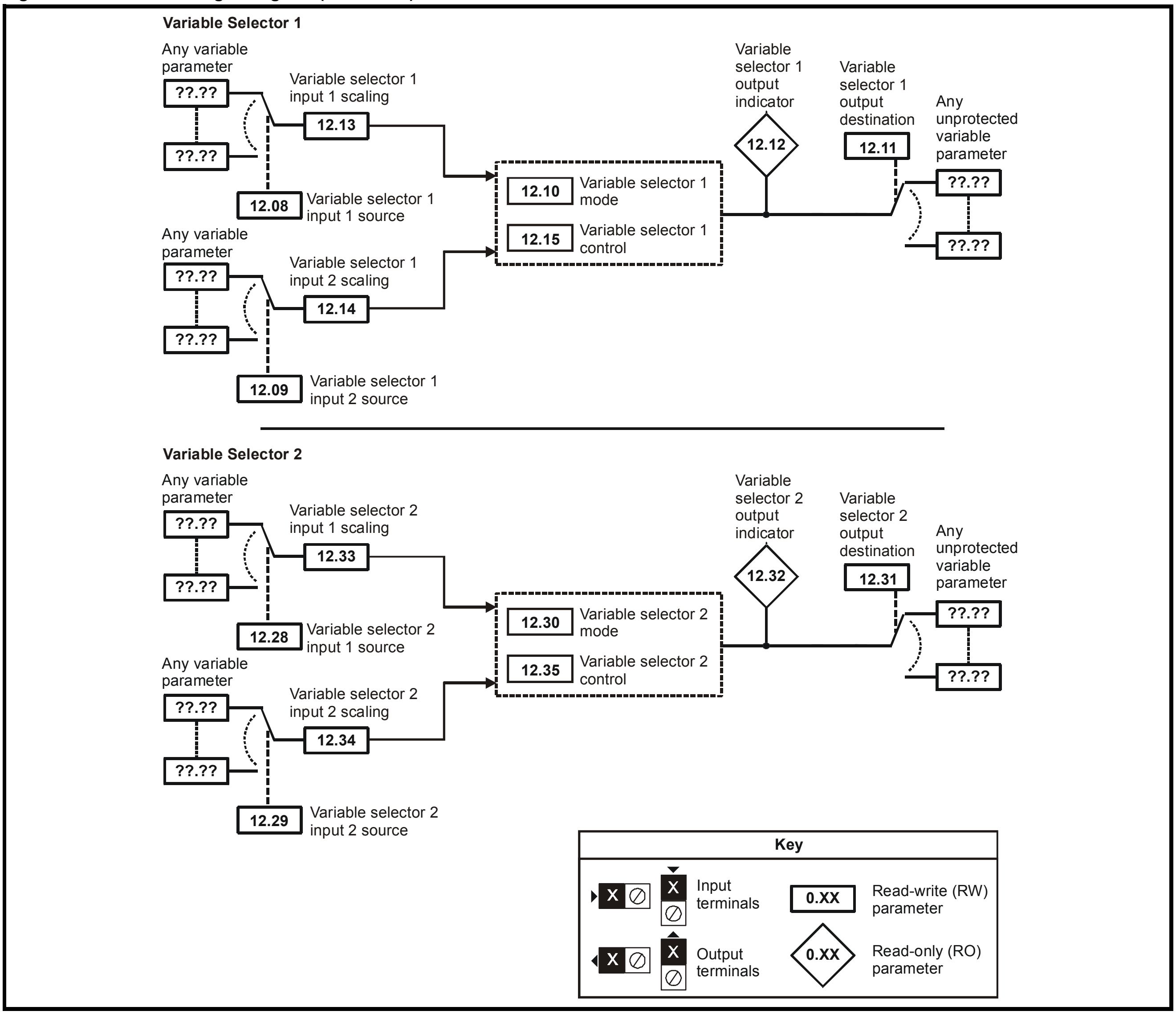


**Figure 9-10 Menu 12 Logic diagram (continued)**



| **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.

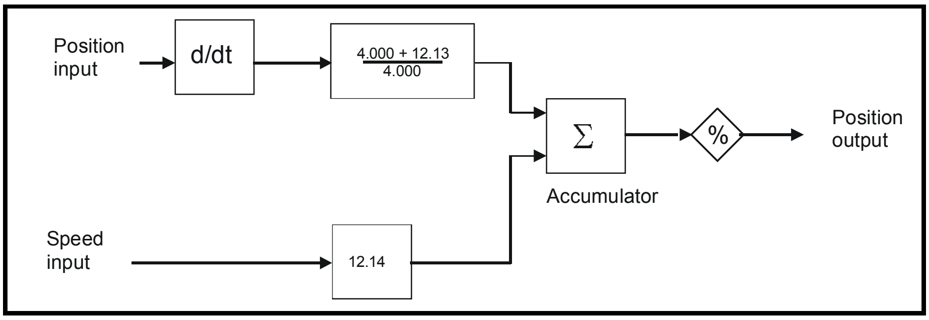
| Mode value | Action | Result |
|---|---|---|
| 0 | Select input 1 | output = input1 |
| 1 | Select input 2 | output = input2 |
| 2 | Add | output = input1 + input2 |
| 3 | Subtract | output = input1 - input 2 |
| 4 | Multiply | output = (input1 x input2) / 100.0 |
| 5 | Divide | output = (input1 x 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<br>control = 0.03: output = $input1^3$ / $100.0^2$<br>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.

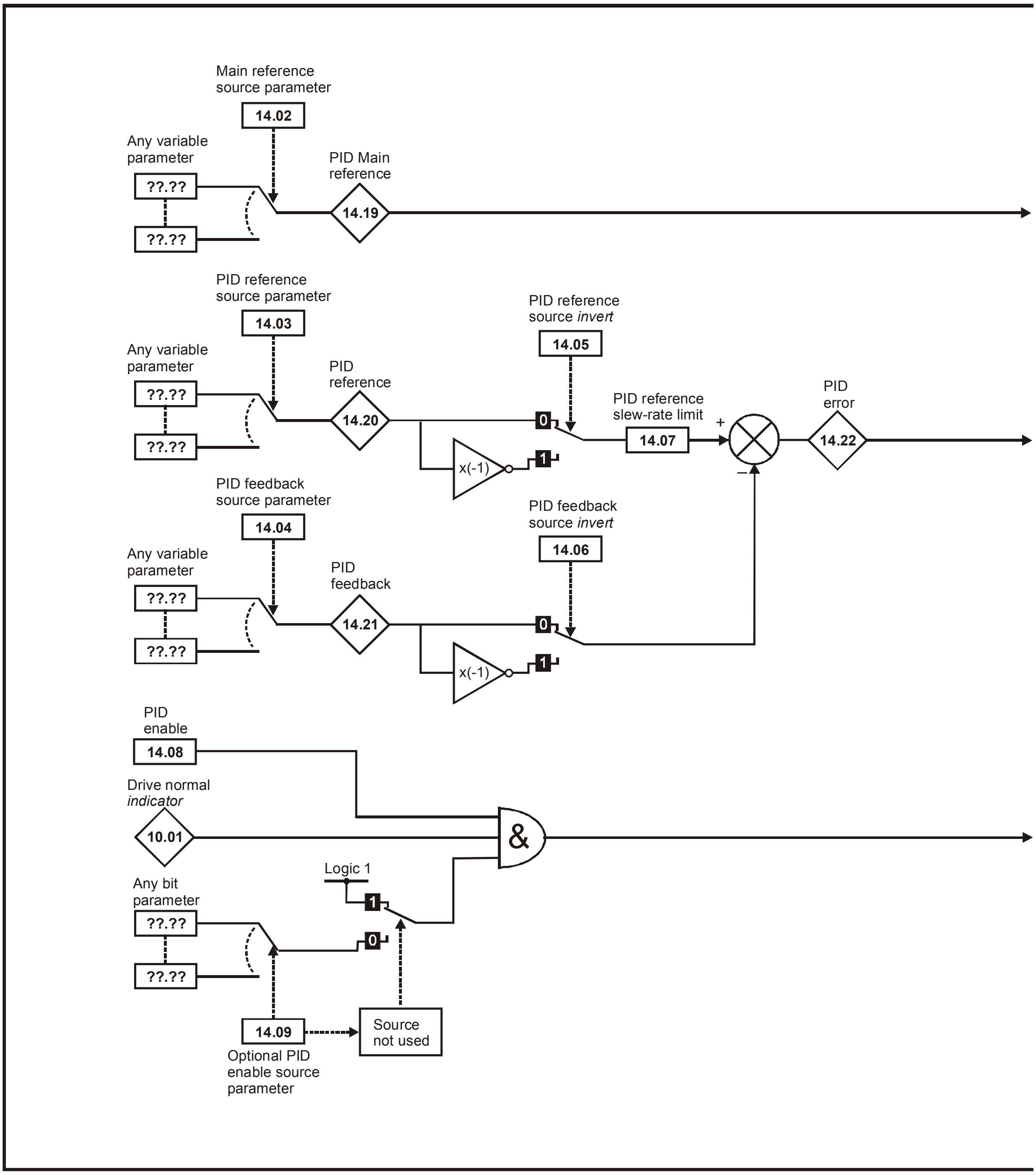
The speed input defines a speed offset with a resolution of 0.1rpm. Full scale of the source parameter corresponds to 1000.0rpm. Scaling may be applied using Pr **12.14** to give a full scale value of 4000.0rpm. The speed input is added to the accumulator to move the output position forwards or backwards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

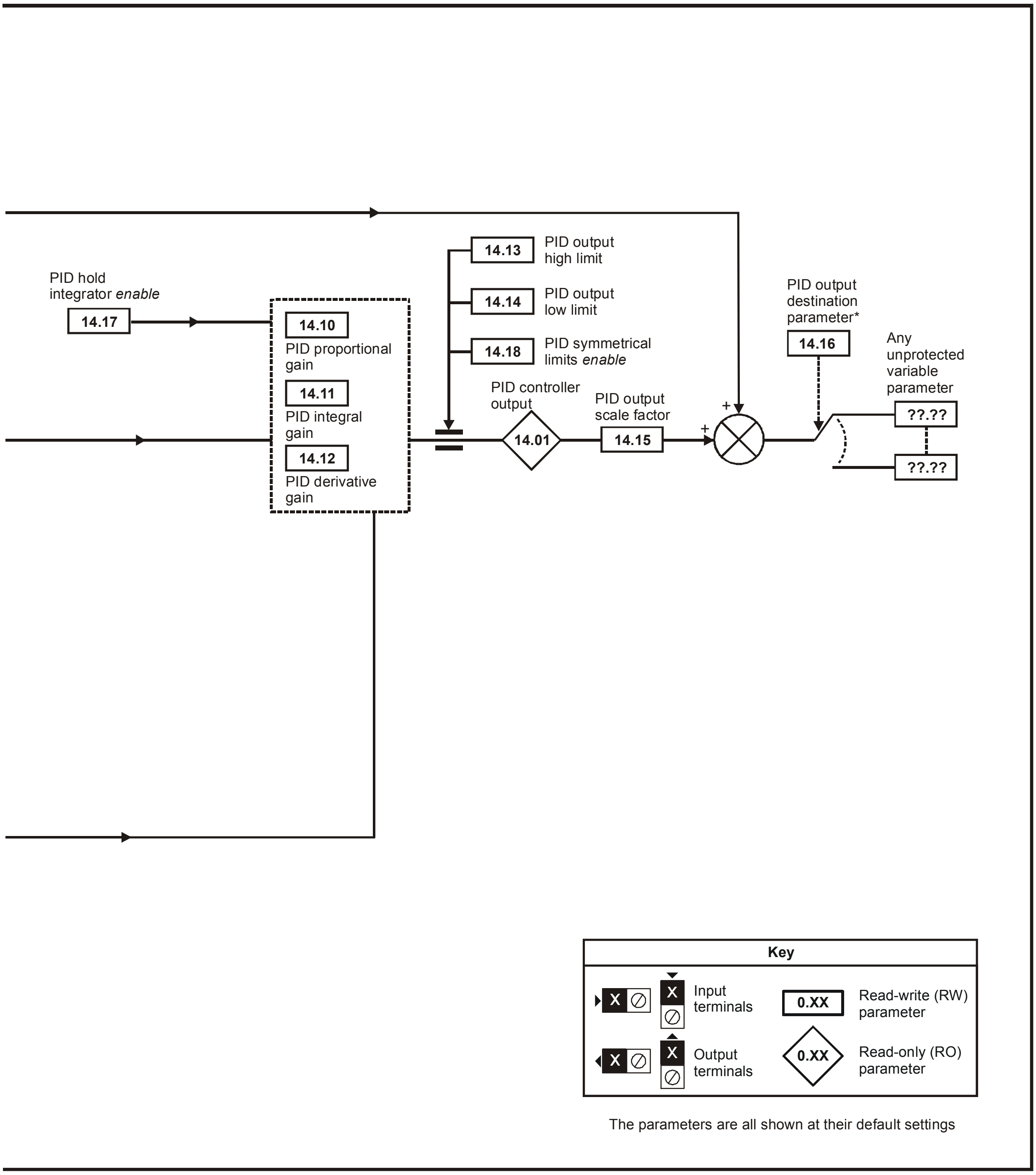
This sample time for this function is 4ms x number of menu 9 and 12 functions active. Extending the sample time does not cause any overflow errors within the function, however, care must be taken to ensure that the input or output positions do not change by more than half a revolution within the sample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




PID hold
integrator *enable*
14.17
14.10
PID proportional gain
14.11
PID integral gain
14.12
PID derivative gain
14.13
PID output high limit
14.14
PID output low limit
14.18
PID symmetrical limits *enable*
PID controller output
14.01
PID output scale factor
14.15
PID output destination parameter*
14.16
Any unprotected variable parameter
??.??
??.??
Key
Input terminals
Output terminals
0.XX
Read-write (RW) parameter
0.XX
Read-only (RO) parameter
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 | | | | | | | | | | | | | | | |

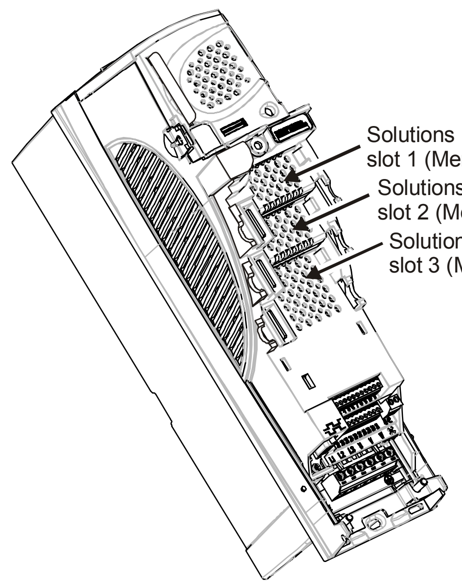
| **14.20** | **PID reference** | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Drive mode** | Regen | | | | | | | | | | | | | | | |
| **Coding** | Bit | SP | FI | DE | Txt | VM | DP | ND | RA | NC | NV | PT | US | RW | BU | PS |
| | | | | | | | 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<br>22.10 to 22.11<br>22.18<br>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**

<table>
<tr><th rowspan="3">Model</th><th colspan="8">Normal Duty</th><th colspan="8">Heavy Duty</th></tr>
<tr><th colspan="2">Nominal rating</th><th colspan="6">Maximum permissible continuous output current (A) for the following switching frequencies</th><th colspan="2">Nominal rating</th><th colspan="6">Maximum permissible continuous output current (A) for the following switching frequencies</th></tr>
<tr><th>kW</th><th>hp</th><th>3kHz</th><th>4kHz</th><th>6kHz</th><th>8kHz</th><th>12kHz</th><th>16kHz</th><th>kW</th><th>hp</th><th>3kHz</th><th>4kHz</th><th>6kHz</th><th>8kHz</th><th>12kHz</th><th>16kHz</th></tr>
<tr><td>SP1201</td><td>1.1</td><td>1.5</td><td colspan="6">5.2</td><td>0.75</td><td>1.0</td><td colspan="6">4.3</td></tr>
<tr><td>SP1202</td><td>1.5</td><td>2.0</td><td colspan="6">6.8</td><td>1.1</td><td>1.5</td><td colspan="6">5.8</td></tr>
<tr><td>SP1203</td><td>2.2</td><td>3.0</td><td colspan="5">9.6</td><td>9.0</td><td>1.5</td><td>2.0</td><td colspan="6">7.5</td></tr>
<tr><td>SP1204</td><td>3.0</td><td>3.0</td><td colspan="3">11.0</td><td>10.9</td><td>9.5</td><td>8.3</td><td>2.2</td><td>3.0</td><td colspan="4">10.6</td><td>9.5</td><td>8.3</td></tr>
<tr><td>SP2201</td><td>4.0</td><td>5.0</td><td colspan="4">15.5</td><td>13.5</td><td>11.5</td><td>3.0</td><td>3.0</td><td colspan="5">12.6</td><td>11.4</td></tr>
<tr><td>SP2202</td><td>5.5</td><td>7.5</td><td>19.7</td><td>18.9</td><td>17.3</td><td>15.9</td><td>13.5</td><td>11.5</td><td>4.0</td><td>5.0</td><td colspan="3">17.0</td><td>15.7</td><td>13.4</td><td>11.4</td></tr>
<tr><td>SP2203</td><td>7.5</td><td>10</td><td>19.5</td><td>18.6</td><td>17.2</td><td>15.8</td><td>13.4</td><td>11.5</td><td>5.5</td><td>7.5</td><td>19.2</td><td>18.4</td><td>17.0</td><td>15.7</td><td>13.3</td><td>11.4</td></tr>
<tr><td>SP3201</td><td>11</td><td>15</td><td colspan="4">42.0</td><td>38.2</td><td></td><td>7.5</td><td>10</td><td colspan="5">31.0</td><td></td></tr>
<tr><td>SP3202</td><td>15</td><td>20</td><td colspan="2">54.0</td><td>52.8</td><td>47.0</td><td>38.2</td><td></td><td>11</td><td>15</td><td colspan="4">42.0</td><td>37.2</td><td></td></tr>
<tr><td>SP4201</td><td>18.5</td><td>25</td><td colspan="4">68.0</td><td colspan="2"></td><td>15</td><td>20</td><td colspan="4">56.0</td><td colspan="2"></td></tr>
<tr><td>SP4202</td><td>22</td><td>30</td><td colspan="4">80.0</td><td colspan="2"></td><td>18.5</td><td>25</td><td colspan="4">68.0</td><td colspan="2"></td></tr>
<tr><td>SP4203</td><td>30</td><td>40</td><td colspan="4">87.4</td><td colspan="2"></td><td>22</td><td>30</td><td colspan="4">80.0</td><td colspan="2"></td></tr>
<tr><td>SP5201</td><td>37</td><td>50</td><td colspan="4">130</td><td colspan="2"></td><td>30</td><td>40</td><td colspan="4">105</td><td colspan="2"></td></tr>
<tr><td>SP5202</td><td>45</td><td>60</td><td colspan="4">154</td><td colspan="2"></td><td>37</td><td>50</td><td colspan="4">130</td><td colspan="2"></td></tr>
<tr><td>SP1401</td><td>1.1</td><td>1.5</td><td colspan="6">2.8</td><td>0.75</td><td>1.0</td><td colspan="6">2.1</td></tr>
<tr><td>SP1402</td><td>1.5</td><td>2.0</td><td colspan="6">3.8</td><td>1.1</td><td>2.0</td><td colspan="6">3.0</td></tr>
<tr><td>SP1403</td><td>2.2</td><td>3.0</td><td colspan="5">5.0</td><td>3.9</td><td>1.5</td><td>3.0</td><td colspan="5">4.2</td><td>3.8</td></tr>
<tr><td>SP1404</td><td>3.0</td><td>5.0</td><td colspan="4">6.9</td><td>5.1</td><td>3.9</td><td>2.2</td><td>3.0</td><td colspan="4">5.8</td><td>4.8</td><td>3.7</td></tr>
<tr><td>SP1405</td><td>4.0</td><td>5.0</td><td colspan="2">8.8</td><td>7.3</td><td>6.0</td><td>4.2</td><td>3.1</td><td>3.0</td><td>5.0</td><td colspan="2">7.6</td><td>7.2</td><td>6.0</td><td>4.2</td><td>3.1</td></tr>
<tr><td>SP1406</td><td>5.5</td><td>7.5</td><td>10.1</td><td>9.0</td><td>7.3</td><td>6.0</td><td>4.2</td><td>3.1</td><td>4.0</td><td>5.0</td><td>9.5</td><td>9.0</td><td>7.2</td><td>6.0</td><td>4.2</td><td>3.1</td></tr>
<tr><td>SP2401</td><td>7.5</td><td>10</td><td>15.3</td><td>14.2</td><td>11.8</td><td>10.0</td><td>7.3</td><td>5.5</td><td>5.5</td><td>10</td><td colspan="2">13.0</td><td>11.7</td><td>9.9</td><td>7.3</td><td>5.5</td></tr>
<tr><td>SP2402</td><td>11</td><td>15</td><td>15.7</td><td>14.2</td><td>11.8</td><td>10.0</td><td>7.3</td><td>5.5</td><td>7.5</td><td>10</td><td>15.5</td><td>14.1</td><td>11.7</td><td>9.9</td><td>7.3</td><td>5.5</td></tr>
<tr><td>SP2403</td><td>15</td><td>20</td><td>16.8</td><td>15.0</td><td>12.2</td><td>10.1</td><td>7.1</td><td></td><td>11</td><td>20</td><td>16.7</td><td>15.0</td><td>12.2</td><td>10.1</td><td>7.1</td><td>5.1</td></tr>
<tr><td>SP2404*</td><td>15</td><td>20</td><td>22.3</td><td>19.8</td><td>15.8</td><td>12.8</td><td>8.6</td><td>5.9</td><td>15</td><td>20</td><td>22.3</td><td>19.8</td><td>14.0</td><td>11.2</td><td>7.3</td><td>4.6</td></tr>
<tr><td>SP3401</td><td>18.5</td><td>25</td><td colspan="2">35.0</td><td>33.5</td><td>28.5</td><td>21.5</td><td>16.9</td><td>15</td><td>25</td><td colspan="2">32.0</td><td>30.7</td><td>26.1</td><td>19.7</td><td>15.4</td></tr>
<tr><td>SP3402</td><td>22</td><td>30</td><td>43.0</td><td>41.5</td><td>34.2</td><td>28.7</td><td>21.0</td><td>16.0</td><td>18.5</td><td>30</td><td colspan="2">40.0</td><td>34.1</td><td>28.4</td><td>20.7</td><td>16.0</td></tr>
<tr><td>SP3403</td><td>30</td><td>40</td><td>46.0</td><td>41.5</td><td>34.2</td><td>28.7</td><td>21.0</td><td></td><td>22</td><td>30</td><td>46.0</td><td>41.5</td><td>33.6</td><td>28.3</td><td>20.8</td><td></td></tr>
<tr><td>SP4401</td><td>37</td><td>50</td><td colspan="2">68.0</td><td>66.8</td><td>54.9</td><td colspan="2"></td><td>30</td><td>50</td><td colspan="2">60.0</td><td>46.7</td><td>38.3</td><td colspan="2"></td></tr>
<tr><td>SP4402</td><td>45</td><td>60</td><td>83.0</td><td>81.6</td><td>66.5</td><td>52.3</td><td colspan="2"></td><td>37</td><td>60</td><td>68.2</td><td>58.6</td><td>46.0</td><td>37.7</td><td colspan="2"></td></tr>
<tr><td>SP4403</td><td>55</td><td>75</td><td>86.5</td><td>86.2</td><td>71.3</td><td>59.3</td><td colspan="2"></td><td>45</td><td>75</td><td>86.5</td><td>74.7</td><td>60.1</td><td>49.8</td><td colspan="2"></td></tr>
<tr><td>SP5401</td><td>75</td><td>100</td><td colspan="2">138</td><td>105.9</td><td>87.4</td><td colspan="2"></td><td>55</td><td>100</td><td>112.7</td><td>96.4</td><td>74.5</td><td>59.9</td><td colspan="2"></td></tr>
<tr><td>SP5402</td><td>90</td><td>125</td><td>141</td><td>140</td><td>112</td><td>92</td><td colspan="2"></td><td>75</td><td>125</td><td>140</td><td>123</td><td>99.0</td><td>82.0</td><td colspan="2"></td></tr>
<tr><td>SP6401</td><td>110</td><td>150</td><td>191.5</td><td>190.1</td><td>147.6</td><td colspan="3"></td><td>90</td><td>150</td><td>180</td><td>157.9</td><td>121.5</td><td colspan="3"></td></tr>
<tr><td>SP6402</td><td>132</td><td>200</td><td>198.4</td><td>180.6</td><td>138.1</td><td colspan="3"></td><td>110</td><td>150</td><td>190</td><td>157.9</td><td>116.2</td><td colspan="3"></td></tr>
<tr><td>SP3501</td><td>3.0</td><td>3.0</td><td colspan="4">5.4</td><td colspan="2"></td><td>2.2</td><td>2.0</td><td colspan="4">4.1</td><td colspan="2"></td></tr>
<tr><td>SP3502</td><td>4.0</td><td>5.0</td><td colspan="4">6.1</td><td colspan="2"></td><td>3.0</td><td>3.0</td><td colspan="4">5.4</td><td colspan="2"></td></tr>
<tr><td>SP3503</td><td>5.5</td><td>7.5</td><td colspan="4">8.4</td><td colspan="2"></td><td>4.0</td><td>5.0</td><td colspan="4">6.1</td><td colspan="2"></td></tr>
<tr><td>SP3504</td><td>7.5</td><td>10</td><td colspan="4">11.0</td><td colspan="2"></td><td>5.5</td><td>7.5</td><td colspan="4">9.5</td><td colspan="2"></td></tr>
<tr><td>SP3505</td><td>11</td><td>15</td><td colspan="3">16.0</td><td>14.7</td><td colspan="2"></td><td>7.5</td><td>10</td><td colspan="4">12.0</td><td colspan="2"></td></tr>
<tr><td>SP3506</td><td>15</td><td>20</td><td colspan="2">22.0</td><td>17.8</td><td>14.7</td><td colspan="2"></td><td>11</td><td>15</td><td colspan="2">18.0</td><td>16.8</td><td>13.9</td><td colspan="2"></td></tr>
<tr><td>SP3507</td><td>18.5</td><td>25</td><td>24.6</td><td>22.0</td><td>17.8</td><td>14.7</td><td colspan="2"></td><td>15</td><td>20</td><td>22.0</td><td>20.4</td><td>16.7</td><td>13.9</td><td colspan="2"></td></tr>
<tr><td>SP4601</td><td>18.5</td><td>25</td><td colspan="4">22.0</td><td colspan="2"></td><td>15</td><td>20</td><td colspan="4">19.0</td><td colspan="2"></td></tr>
<tr><td>SP4602</td><td>22</td><td>30</td><td colspan="3">27.0</td><td>24.7</td><td colspan="2"></td><td>18.5</td><td>25</td><td colspan="4">22.0</td><td colspan="2"></td></tr>
<tr><td>SP4603</td><td>30</td><td>40</td><td colspan="2">36.0</td><td>30.7</td><td>24.7</td><td colspan="2"></td><td>22</td><td>30</td><td colspan="4">27.0</td><td colspan="2"></td></tr>
<tr><td>SP4604</td><td>37</td><td>50</td><td>43.0</td><td>39.6</td><td>30.7</td><td>24.7</td><td colspan="2"></td><td>30</td><td>40</td><td colspan="2">36.0</td><td>30.7</td><td>24.7</td><td colspan="2"></td></tr>
<tr><td>SP4605</td><td>45</td><td>60</td><td>45.6</td><td>39.5</td><td>30.7</td><td>24.7</td><td colspan="2"></td><td>37</td><td>50</td><td>43.0</td><td>39.6</td><td>30.7</td><td>24.7</td><td colspan="2"></td></tr>
<tr><td>SP4606</td><td>55</td><td>75</td><td>51.9</td><td>44.9</td><td>34.7</td><td>27.7</td><td colspan="2"></td><td>45</td><td>60</td><td>51.9</td><td>44.9</td><td>34.7</td><td>27.7</td><td colspan="2"></td></tr>
<tr><td>SP5601</td><td>75</td><td>100</td><td>83</td><td>69</td><td>51</td><td>40</td><td colspan="2"></td><td>55</td><td>75</td><td>63</td><td>63</td><td>47</td><td>38</td><td colspan="2"></td></tr>
<tr><td>SP5602</td><td>90</td><td>125</td><td>83</td><td>69</td><td>51</td><td>40</td><td colspan="2"></td><td>75</td><td>100</td><td>75</td><td>62</td><td>45</td><td>36</td><td colspan="2"></td></tr>
<tr><td>SP6601</td><td>110</td><td>150</td><td>98</td><td>81</td><td>59</td><td></td><td colspan="2"></td><td>90</td><td>125</td><td>98</td><td>81</td><td>59</td><td></td><td colspan="2"></td></tr>
<tr><td>SP6602</td><td>132</td><td>175</td><td>98</td><td>81</td><td>59</td><td></td><td colspan="2"></td><td>110</td><td>150</td><td>98</td><td>81</td><td>59</td><td></td><td colspan="2"></td></tr>
</table>

**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 $\phi$ > 50mm (large area contact with the hand) | 1 | - |
| 2 | Protection against medium size foreign bodies $\phi$ > 12mm (finger) | 2 | - |
| 3 | Protection against small foreign bodies $\phi$ > 2.5mm (tools, wires) | 3 | Protection against spraywater (up to 60° from the vertical) |
| 4 | Protection against granular foreign bodies $\phi$ > 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.

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 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 | |
| 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 | A |
| 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 | |
| 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 | A |
| 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 | A |
| 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 | |
| 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 x $I_{rated}$

$I_{inrush}$ = 200 x $I_{rated}$

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 CT part no. | Epcos 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 @ 40°C (104°F) A | Maximum continuous current @ 50°C (122°F) A | Voltage rating V | IP rating | Power dissipation at rated current W | Ground leakage: Balanced supply phase-to-phase and phase-to-ground mA | Ground leakage: Worst case mA | Discharge resistors |
|---|---|---|---|---|---|---|---|---|---|
| 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 | $4mm^2$ 12AWG | 0.8 N m (0.6 lb ft) | M5 | 3.5 N m (2.6 lb ft) |
| 4200-6119 | | | | | |
| 4200-6210 | | $10mm^2$ 8AWG | 2.0 N m (1.5 lb ft) | | |
| 4200-6305 | | $16mm^2$ 6AWG | 2.2 N m (1.6 lb ft) | M6 | 3.9 N m (2.9 lb ft) |
| 4200-6307 | | | | | |
| 4200-6309 | | | | | |
| 4200-6406 | | $50mm^2$ 0AWG | 8 N m (5.9 lb ft) | M10 | 25 N m (18.4 lb ft) |
| 4200-6408 | | $25mm^2$ 4AWG | 2.3 N m (1.7 lb ft) | M6 | 3.9 N m (2.9 lb ft) |
| 4200-6503 | | $95mm^2$ 4/0AWG | 20 N m (14.7 lb ft) | M10 | 25 N m (18.4 lb ft) |
| 4200-6504 | | $50mm^2$ 0AWG | 8 N m (5.9 lb ft) | | |
| 4200-6603 | | Busbar arrangement | | | |
| 4200-6604 | | | | | |
| 4200-6316 | | | | | |
| 4200-6315 | | | | | |
| 4200-6120 | Epcos | $4mm^2$ 12AWG | 0.6 N m (0.4 lb ft) | M5 | 3.0 N m (2.2 lb ft) |
| 4200-6121 | | | | | |
| 4200-6211 | | $10mm^2$ 8AWG | 1.35 N m (1.0 lb ft) | | |
| 4200-6306 | | $16mm^2$ 6AWG | 2.2 N m (1.6 lb ft) | M6 | 5.1 N m (3.8 lb ft) |
| 4200-6308 | | $10mm^2$ 8AWG | 1.35 N m (1.0 lb ft) | | |
| 4200-6405 | | $50mm^2$ 0AWG | 6.8 N m (5.0 lb ft) | M10 | 10 N m (7.4 lb ft) |
| 4200-6407 | | | | | |
| 4200-6501 | | $95mm^2$ 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 x $C_N$ x 1.2 x $V^2_{BUS}$. Where $C_N$ is the nominal DC bus capacitance (Table 11-1) and the 1.2 factor allows for capacitance tolerance. $V_{BUS}$ is calculated from √2 x $V_{LL}$ (+10%) where $V_{LL}$ is the nominal line to line AC voltage.

**Table 11-3 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 | 1 to 24 |
| SPMD | 1 to 24 |

**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 x 13200 x $10^{-6}$ x 1.2 x $(747)^2$

= 4419J

Select resistor CT part number 1270-2483.

Number of resistors required =

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

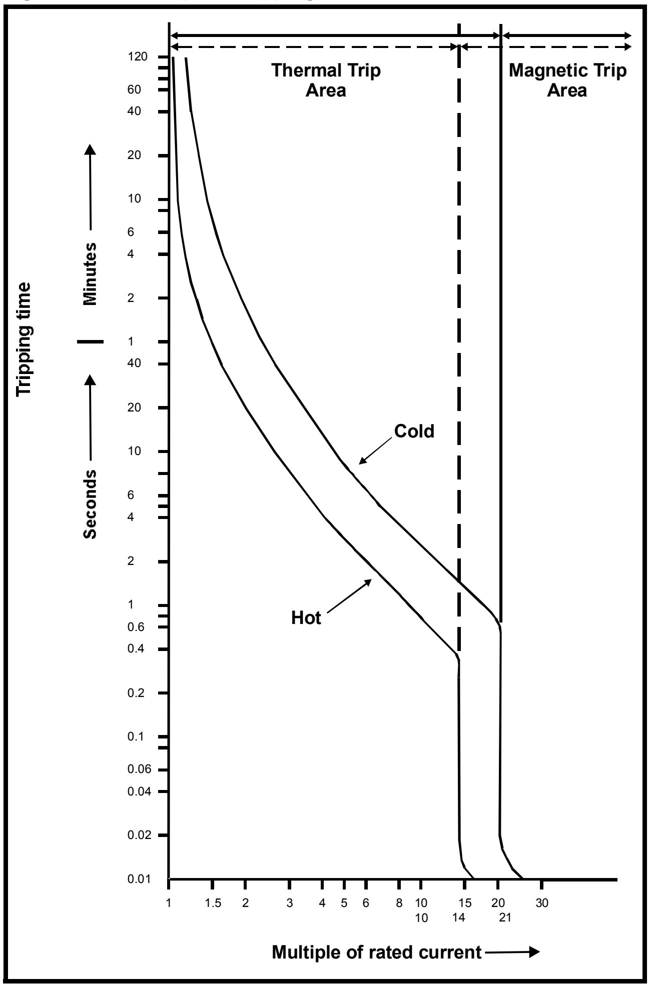
Three resistors are therefore required which may be connected in parallel.

## 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 x$10^{-6}$) = 0.278

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

0.2784 x 5 = 1.39s

**Selection**

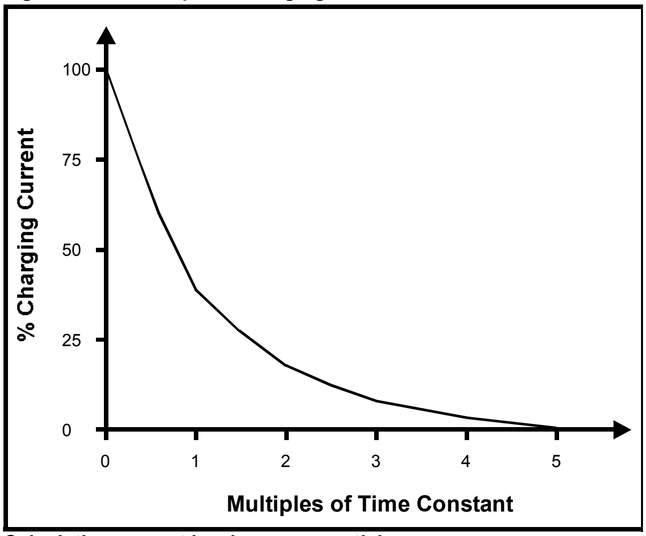
From the above calculations for a peak charging current of 31.108A with a charge time of 1.392s a magnetic overload with the following characteristics could be used:

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

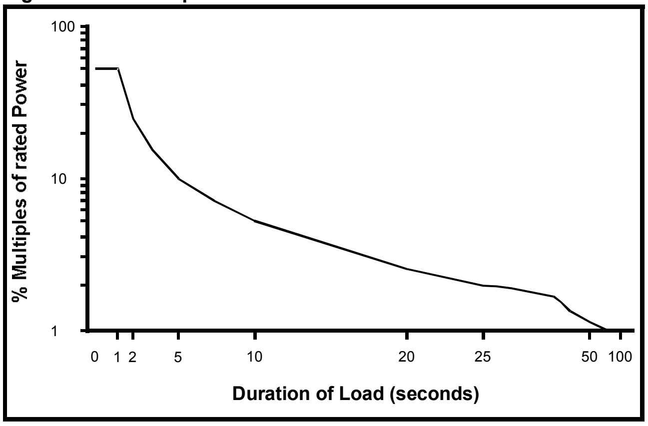
Thermal / Magnetic overload current rating = 22A / 20 = 1.1A (use 1.6A)

10 x nominal power = 2.960kW

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

From Figure 11-3 it can be seen that an overload of 10 times the nominal power is allowable for 5 seconds. From this plotting the 10 times overload on Figure 11-1 it can be seen that for a current of 11.10A when using a 1.6A breaker that the overload will trip at 7 x the nominal current (11.10/1.6 = 6.9), which equates to approximately 5 seconds trip level worst case.

**Figure 11-3 Example of overload characteristic**



# 12 Diagnostics

The display on the drive gives various information about the status of the drive. These fall into three categories:

- Trip indications
- Alarm indications
- Status indications

> **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.

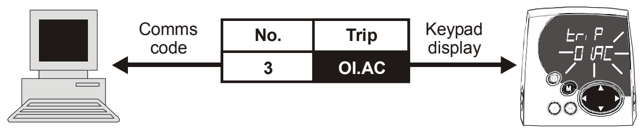
The trip indication can be read in Pr **10.20** providing a trip number. Trip numbers are listed in numerical order in Table 12-3 so the trip indication can be cross referenced and then diagnosed using Table 12-2.

**NOTE**

Trips beginning with a number are given at the end of Table 12-2 where the number is replaced with an X (1 ≤ X ≤ 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**

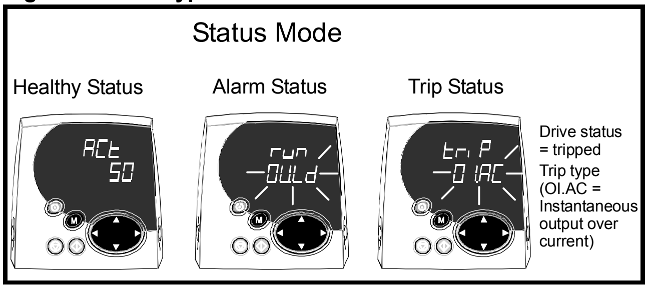
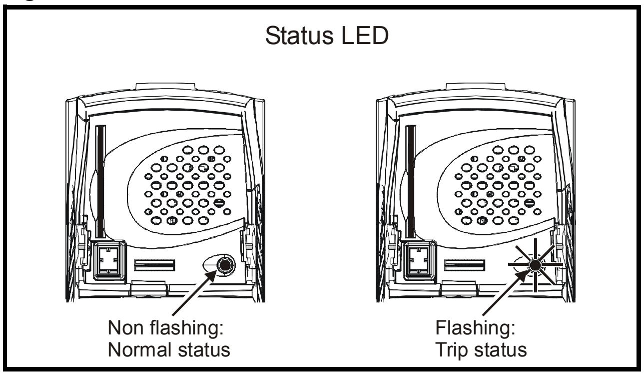



**Figure 12-2 Location of the status LED**




**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:<br>0: Tripped during synchronisation<br>1: Tripped while running<br>2: Line frequency too low (<30.0Hz)<br>3: Line frequency too high (>100.0Hz)<br>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**

<table>
<tr><th>Trip</th><th>Diagnosis</th></tr>
<tr><td>C.Acc</td><td>SMARTCARD trip: SMARTCARD Read / Write fail</td></tr>
<tr><td>185</td><td>Check SMARTCARD is fitted / located correctly<br>Replace SMARTCARD</td></tr>
<tr><td>C.Chg</td><td>SMARTCARD trip: Data location already contains data</td></tr>
<tr><td>179</td><td>Erase data in data location<br>Write data to an alternative data location</td></tr>
<tr><td>C.Cpr</td><td>SMARTCARD trip: The values stored in the drive and the values in the data block on the SMARTCARD are different</td></tr>
<tr><td>188</td><td>Press the red reset button</td></tr>
<tr><td>C.dat</td><td>SMARTCARD trip: Data location specified does not contain any data</td></tr>
<tr><td>183</td><td>Ensure data block number is correct</td></tr>
<tr><td>C.Err</td><td>SMARTCARD trip: SMARTCARD data is corrupted</td></tr>
<tr><td>182</td><td>Ensure the card is located correctly<br>Erase data and retry<br>Replace SMARTCARD</td></tr>
<tr><td>C.Full</td><td>SMARTCARD trip: SMARTCARD full</td></tr>
<tr><td>184</td><td>Delete a data block or use different SMARTCARD</td></tr>
<tr><td>cL2</td><td>Analogue input 2 current loss (current mode)</td></tr>
<tr><td>28</td><td>Check analogue input 2 (terminal 7) current signal is present (4-20mA, 20-4mA)</td></tr>
<tr><td>cL3</td><td>Analogue input 3 current loss (current mode)</td></tr>
<tr><td>29</td><td>Check analogue input 3 (terminal 8) current signal is present (4-20mA, 20-4mA)</td></tr>
<tr><td>CL.bit</td><td>Trip initiated from the control word (Pr 6.42)</td></tr>
<tr><td>35</td><td>Disable the control word by setting Pr 6.43 to 0 or check setting of Pr 6.42</td></tr>
<tr><td>C.Optn</td><td>SMARTCARD trip: Solutions Modules fitted are different between source drive and destination drive</td></tr>
<tr><td>180</td><td>Ensure correct Solutions Modules are fitted<br>Ensure Solutions Modules are in the same Solutions Module slot<br>Press the red reset button</td></tr>
<tr><td>C.rdo</td><td>SMARTCARD trip: SMARTCARD has the Read Only bit set</td></tr>
<tr><td>181</td><td>Enter 9777 in Pr xx.00 to allow SMARTCARD Read / Write access<br>Ensure card is not writing to data locations 500 to 999</td></tr>
<tr><td>C.rtg</td><td>SMARTCARD trip: SMARTCARD attempting to change the destination drive ratings<br>No drive rating parameters have been transferred</td></tr>
<tr><td>186</td><td>Press the red reset button<br>Drive rating parameters are:
<table>
<tr><th>Parameter</th><th>Function</th></tr>
<tr><td>2.08</td><td>Standard ramp voltage</td></tr>
<tr><td>4.05/6/7, 21.27/8/9</td><td>Current limits</td></tr>
<tr><td>5.07, 21.07</td><td>Motor rated current</td></tr>
<tr><td>5.09, 21.09</td><td>Motor rated voltage</td></tr>
<tr><td>5.17, 21.12</td><td>Stator resistance</td></tr>
<tr><td>5.18</td><td>Switching frequency</td></tr>
<tr><td>5.23, 21.13</td><td>Voltage offset</td></tr>
<tr><td>5.24, 21.14</td><td>Transient inductance</td></tr>
<tr><td>5.25, 21.24</td><td>Stator inductance</td></tr>
<tr><td>6.06</td><td>DC injection braking current</td></tr>
</table>
The above parameters will be set to their default values.</td></tr>
<tr><td>C.Typ</td><td>SMARTCARD trip: SMARTCARD parameter set not compatible with drive</td></tr>
<tr><td>187</td><td>Press the reset button<br>Ensure destination drive type is the same as the source parameter file drive type</td></tr>
<tr><td>dESt</td><td>Two or more parameters are writing to the same destination parameter</td></tr>
<tr><td>199</td><td>Set Pr xx.00 = 12001 check all visible parameters in the menus for duplication</td></tr>
<tr><td>EEF</td><td>EEPROM data corrupted - Drive mode becomes open loop and serial comms will timeout with remote keypad on the drive RS485 comms port.</td></tr>
<tr><td>31</td><td>This trip can only be cleared by loading default parameters and saving parameters</td></tr>
</table>

| Trip | Diagnosis |
|---|---|
| **EEF1** | **EEPROM data corrupted** |
| **36** | Indicates the power was removed when parameters were being saved<br>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<br>Check value of Pr **10.32**<br>Enter 12001 in Pr **xx.00** and check for parameter controlling Pr **10.32**<br>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<br>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:<br>0: Tripped during synchronisation<br>1: Tripped while running<br>2: Line frequency too low (<30.0Hz)<br>3: Line frequency too high (>100.0Hz)<br>4: Error during synchronisation of PLL to supply |
| **O.CtL** | **Drive control board over temperature** |
| **23** | Check cubicle / drive fans are still functioning correctly<br>Check cubicle ventilation paths<br>Check cubicle door filters<br>Check ambient temperature<br>Reduce drive switching frequency |
| **O.ht1** | **Power device over temperature based on thermal model** |
| **21** | Reduce drive switching frequency<br>Reduce duty cycle<br>Reduce motor load |
| **O.ht2** | **Heatsink over temperature** |
| **22** | Check cubicle / drive fans are still functioning correctly<br>Check cubicle ventilation paths<br>Check cubicle door filters<br>Increase ventilation<br>Reduce drive switching frequency<br>Reduce duty cycle<br>Reduce motor load |
| **Oht2.P** | **Power module heatsink over temperature** |
| **105** | Check cubicle / drive fans are still functioning correctly<br>Check cubicle ventilation paths<br>Check cubicle door filters<br>Increase ventilation<br>Reduce drive switching frequency<br>Reduce duty cycle<br>Reduce motor load |
| **O.ht3** | **Drive over-temperature based on thermal model** |
| **27** | Check cubicle / drive fans are still functioning correctly<br>Check cubicle ventilation paths<br>Check cubicle door filters<br>Increase ventilation<br>Reduce duty cycle<br>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<br>Check for supply disturbance such as notching from a DC drive<br>Check cubicle / drive fans are still functioning correctly<br>Check cubicle ventilation paths<br>Check cubicle door filters<br>Increase ventilation<br>Reduce drive switching frequency<br>Reduce duty cycle<br>Reduce motor load |

| Trip | Diagnosis |
|---|---|
| **OI.AC** | **Instantaneous input over current detected: peak input current greater than 225%** |
| **3** | Check correct regen inductor fitted<br>Check for short circuit on regen component circuitry<br>Check DC connections: Regen to motoring drive for short circuit<br>Check line synchronisation status<br>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<br>Check for short circuit on regen component circuitry<br>Check DC connections: Regen to motoring drive for short circuit<br>Check line synchronisation status<br>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.<br>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<br>Check for supply disturbances which could cause the DC bus to rise – voltage overshoot after supply recovery from a notch induced by DC drives.<br>**Drive voltage rating / Peak voltage [0V] / Maximum continuous voltage level**<br>200 / 415 / 410<br>400 / 830 / 815<br>575 / 990 / 970<br>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<br>Check for supply disturbances which could cause the DC bus to rise – voltage overshoot after supply recovery from a notch induced by DC drives.<br>**Drive voltage rating / Peak voltage [0V] / Maximum continuous voltage level**<br>200 / 415 / 410<br>400 / 830 / 815<br>575 / 990 / 970<br>690 / 1190 / 1175 |
| **PAd** | **Keypad has been removed when the drive is receiving the speed reference from the keypad** |
| **34** | Fit keypad and reset<br>Change speed reference selector to select speed reference from another source |
| **PS** | **Internal power supply fault** |
| **5** | Remove any Solutions Modules and reset<br>Check integrity of interface ribbon cables and connections (size 4,5,6 only)<br>Hardware fault - return drive to supplier |
| **PS.10V** | **10V user power supply current greater than 10mA** |
| **8** | Check wiring to terminal 4<br>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.<br>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.<br>• Reduce load and reset<br>• Provide an external 24V >50W power supply<br>• Remove any Solutions Modules and reset |
| **PS.P** | **Power module power supply fail** |
| **108** | Remove any Solutions Modules and reset<br>Check integrity of interface ribbon cables and connections (size 4,5,6 only)<br>Hardware fault - return drive to supplier |
| **SCL** | **Drive RS485 serial comms loss to remote keypad** |
| **30** | Refit the cable between the drive and keypad<br>Check cable for damage<br>Replace cable<br>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**<br>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<br>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<br>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<br>Re-fit Solutions Module<br>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.<br>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.<br>If the trip persists, contact the supplier of the drive.</td></tr>
<tr><td>t010</td><td>User trip defined in 2$^{nd}$ 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 2$^{nd}$ 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 2$^{nd}$ 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 2$^{nd}$ 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 2$^{nd}$ 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 2$^{nd}$ 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 2$^{nd}$ 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 2$^{nd}$ 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<br>Check thermistor continuity<br>Set Pr **7.15** = VOLt and reset the drive to disable this function |
| **thS** | **Motor thermistor short circuit** |
| **25** | Check regen inductor wiring<br>Replace regen inductor thermistor<br>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<br>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<br>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<br>**Drive voltage rating (Vac)** / **Under voltage threshold (Vdc)**<br>200 / 175<br>400 / 350<br>575 / 435<br>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 | OIdC.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).<br>Or<br>• 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.<br>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.<br>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.<br>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.<br>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.

# Index

## E



## F



## G



## H



## I



## K



## L



## M



## N



## O



## P

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